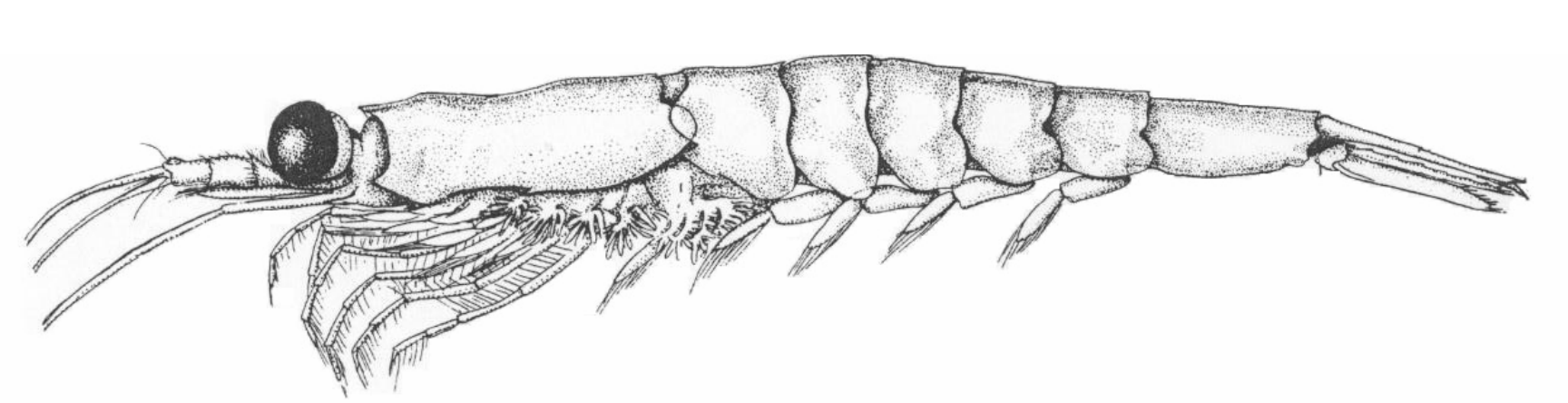
Growth and recruitment of *Euphausia pacifica* off the Oregon Coast



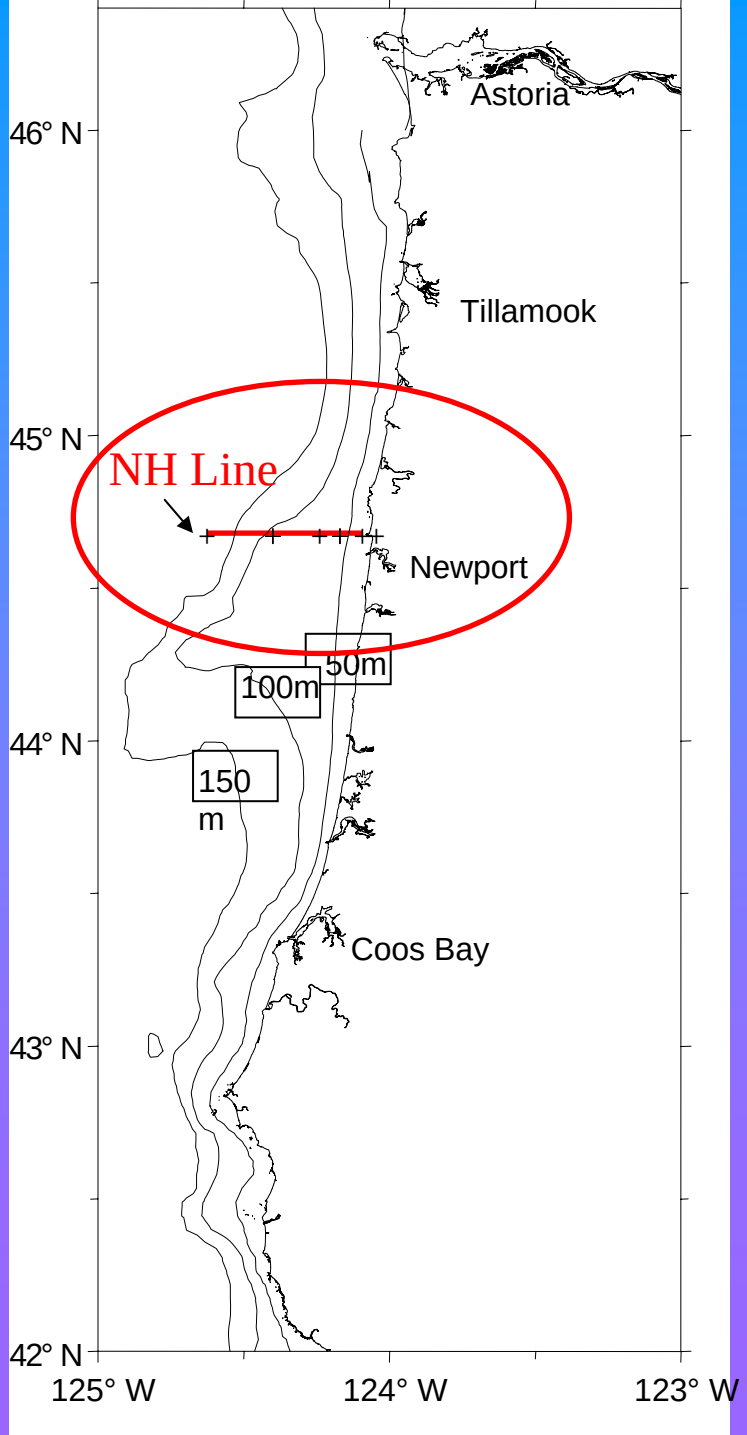
C. Tracy Shaw, Leah R. Feinberg, Hongsheng Bi and William T. Peterson

Hatfield Marine Science Center, Newport, Oregon, USA

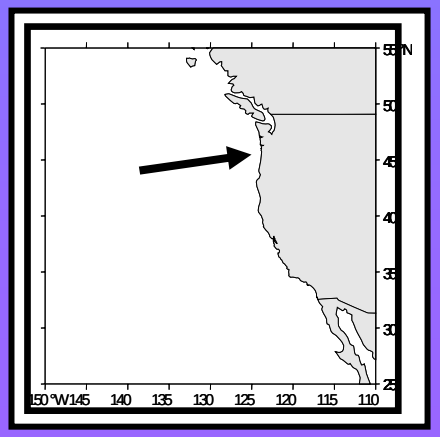
Introduction

- *E. pacifica* is a keystone species in marine food webs in the north Pacific
- Understanding growth and recruitment of this species is important to understanding population dynamics and for incorporating this species into models
- Biweekly time-series of euphausiid data off Newport: 10yr of early larval samples and 6 yr of juv/adult samples (sampling is ongoing)
- Experiments to determine molting and growth rates conducted on most cruises
- Can we determine anything about the growth or recruitment of euphausiids from preserved samples?

Sampling Area



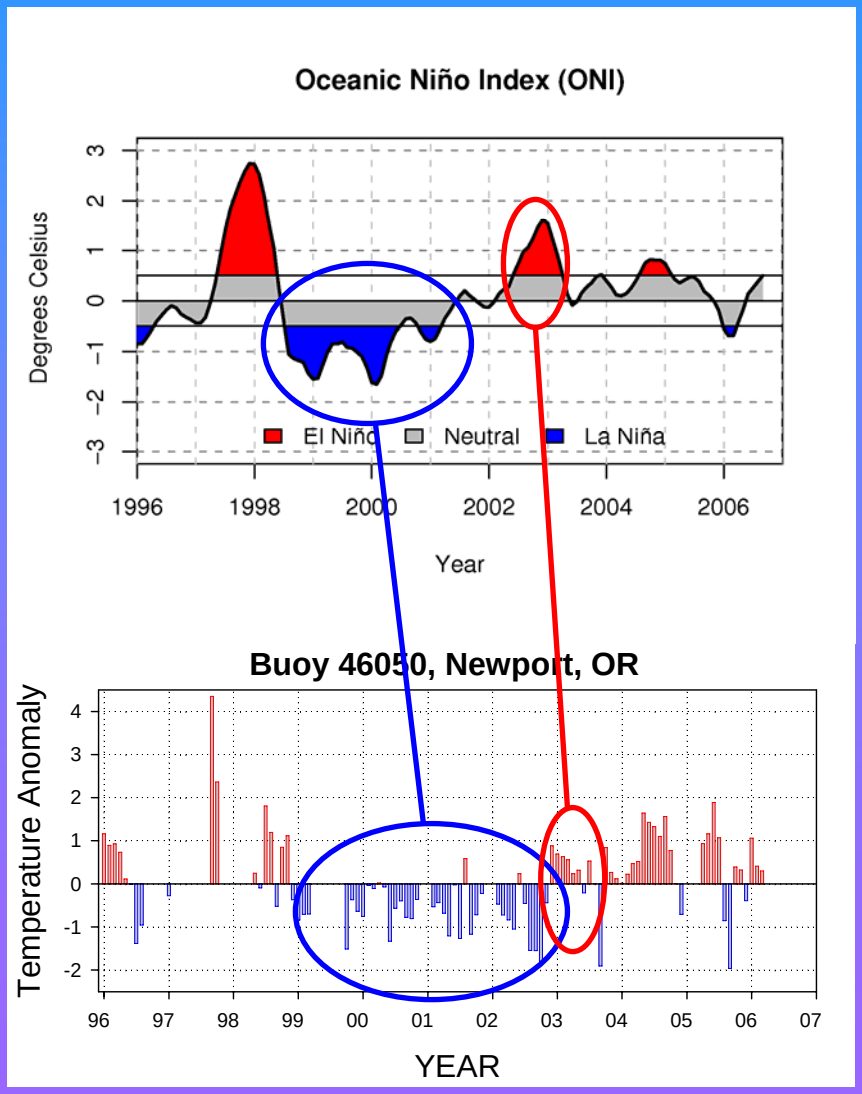
- Adult data from NH25 night bongo net samples (max depth 20m), 2001-06
- Early larval stage data from NH05 & NH15, day samples, using 1/2m vertical net (max depth 100m), 1996-2005



Considerations

- Assume conditions at sampled stations are reflective of larger ocean area (upwelling events affect entire coast, not just the NH line)
- Eggs found at inshore stations probably not from animals at NH25 (i.e. advected from the north)
- Can reliably speciate all developmental stages of *E. pacifica* and *T. spinifera*
- Can’t reliable speciate preserved eggs

Warm and Cold Years

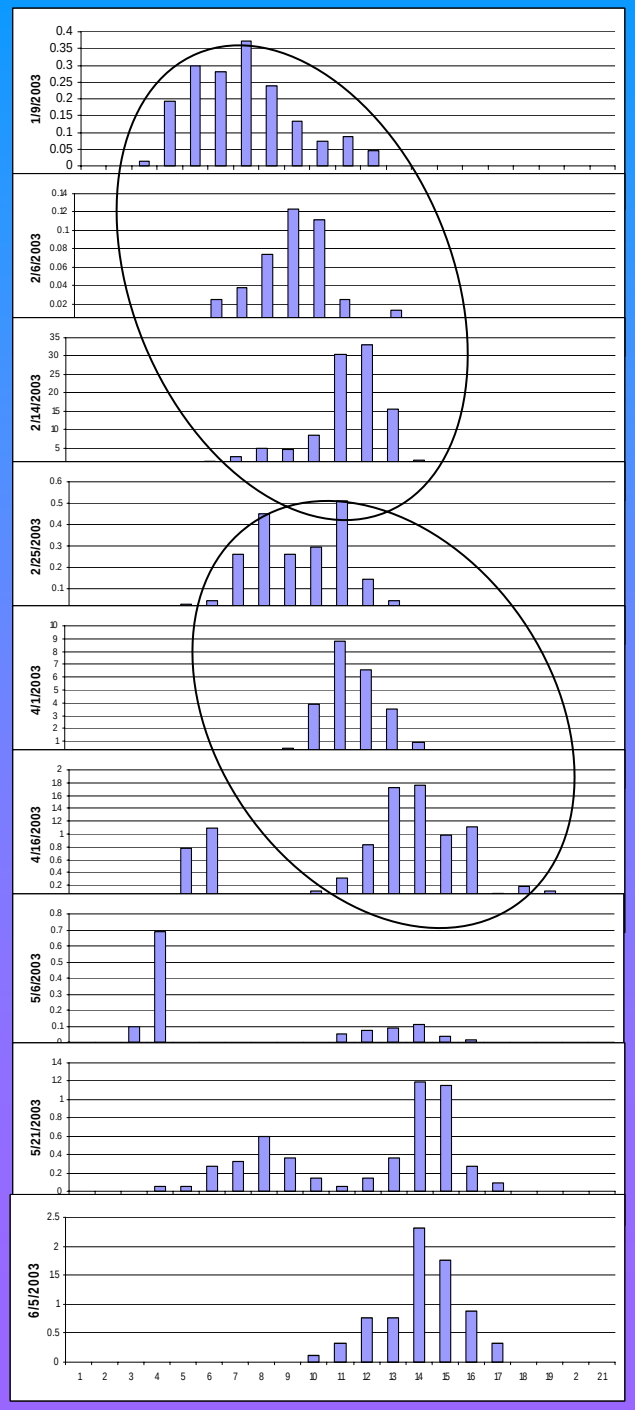


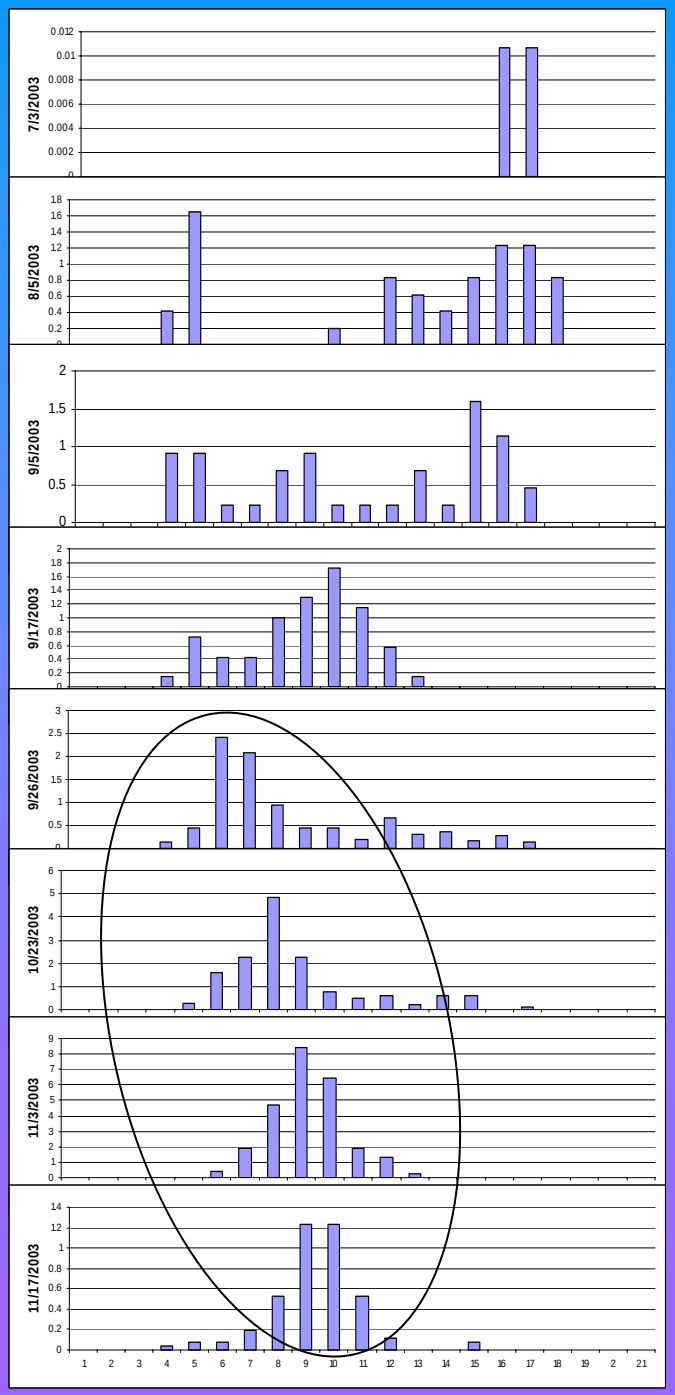
We use local temperature data to designate warm and cold years due to the lag between when an effect occurs at the equator and when it manifests off Oregon. PDO shows similar lags (Peterson talk on Friday).

Raw Cohort Data 2003

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

This gives us a way to compare calculated growth from **cohort analysis** with growth measured in **molting rate experiments**





Matlab Basics

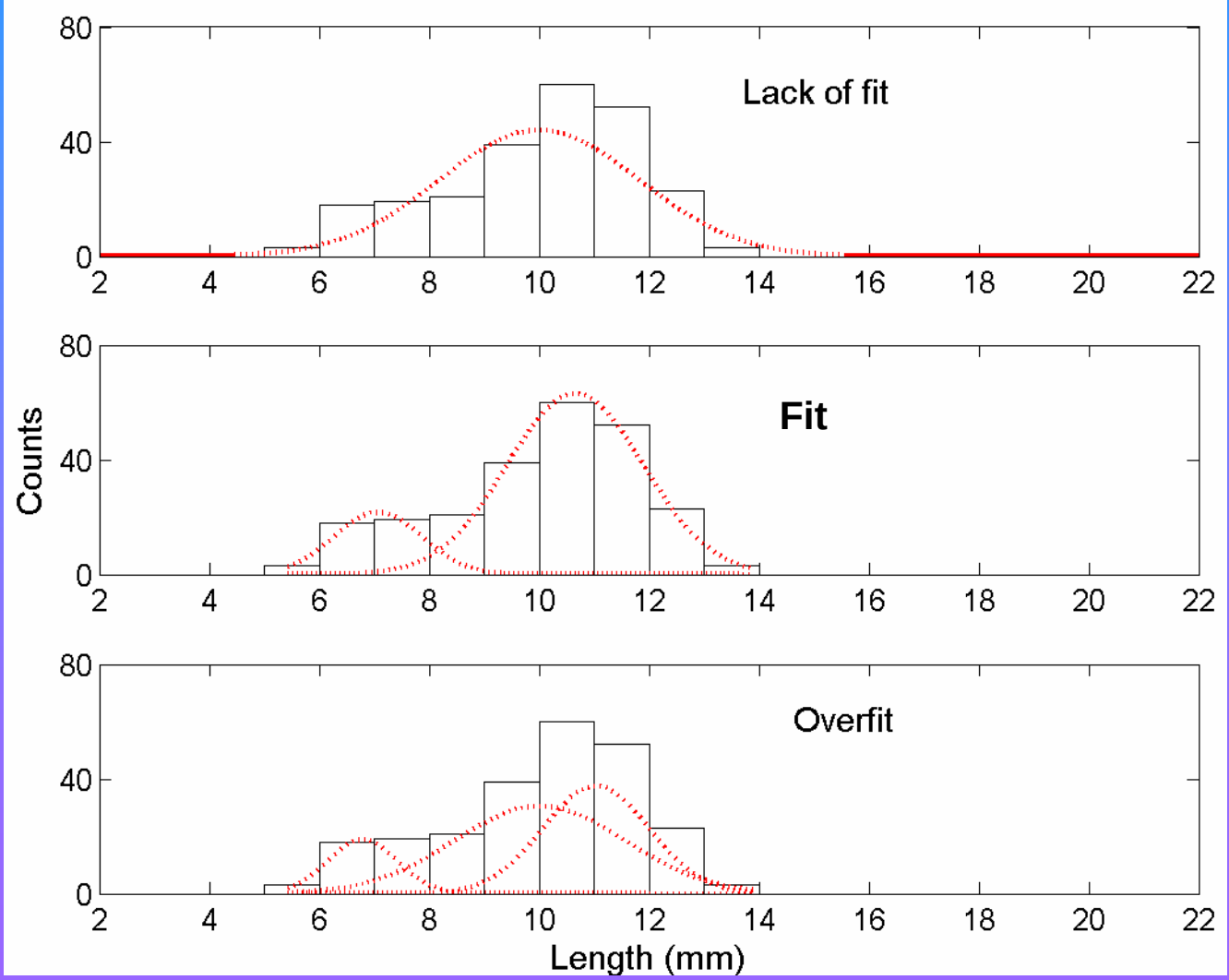
We used the maximum likelihood fitting procedure to fit a mixture of normal distribution. This was done by using normmix function in STIXBOX within Matlab. User chooses initial number of cohorts to fit.

Lack of fit
1) Skewed distribution

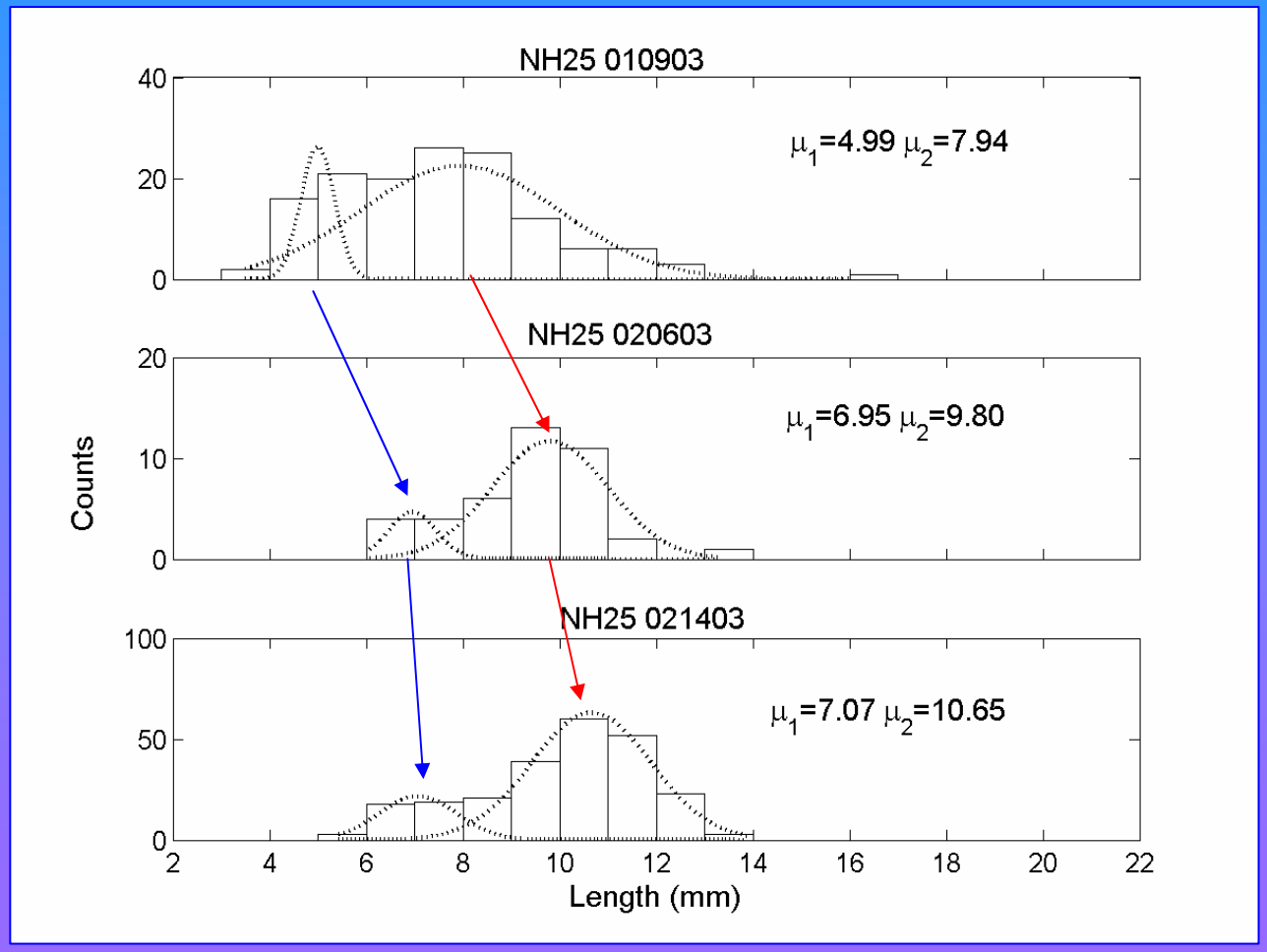
Fit
1) Cohorts don't overlap

Overfit
1) Algorithm would not converge

2) Distributions would overlap with each other



Cohort Analysis

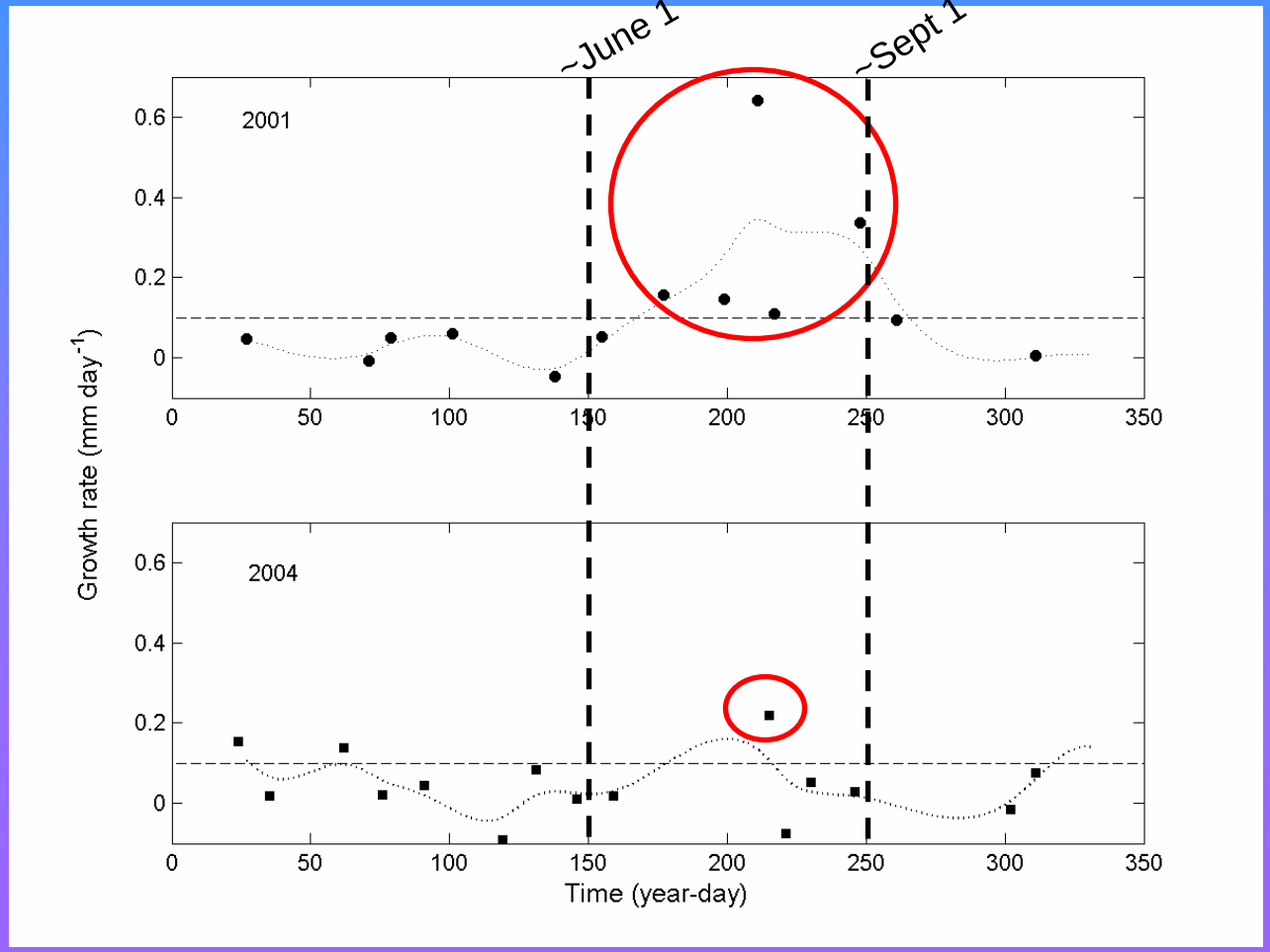


- Length data from each night bongo sample from NH25 (~2 per month)
- Calculated growth rates from change in mean length of cohort from one sampling date to the next

Calculated Growth Rates from cohort analysis

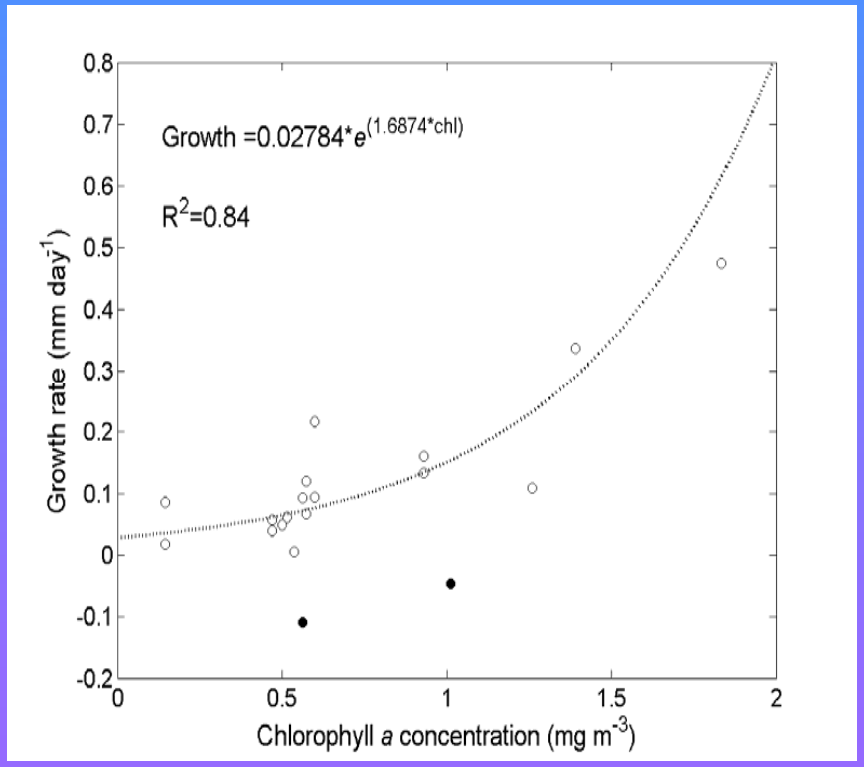
2001
(cold year)

2004
(warm year)

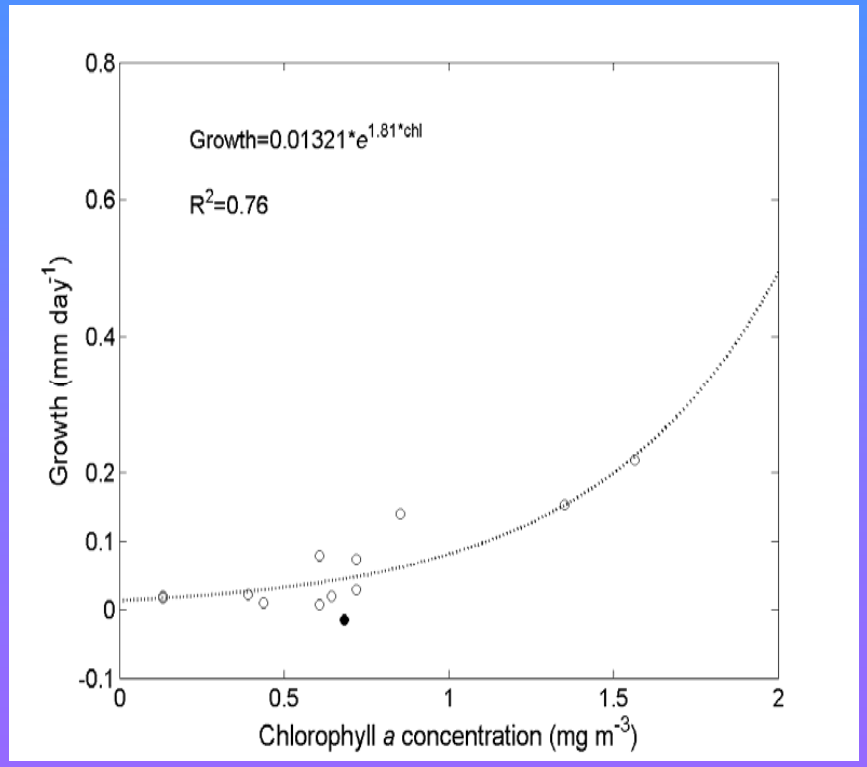


Chlorophyll vs Growth Calculated from cohort analysis

Similar curves in cold and warm years suggest chlorophyll is related to growth regardless of other conditions

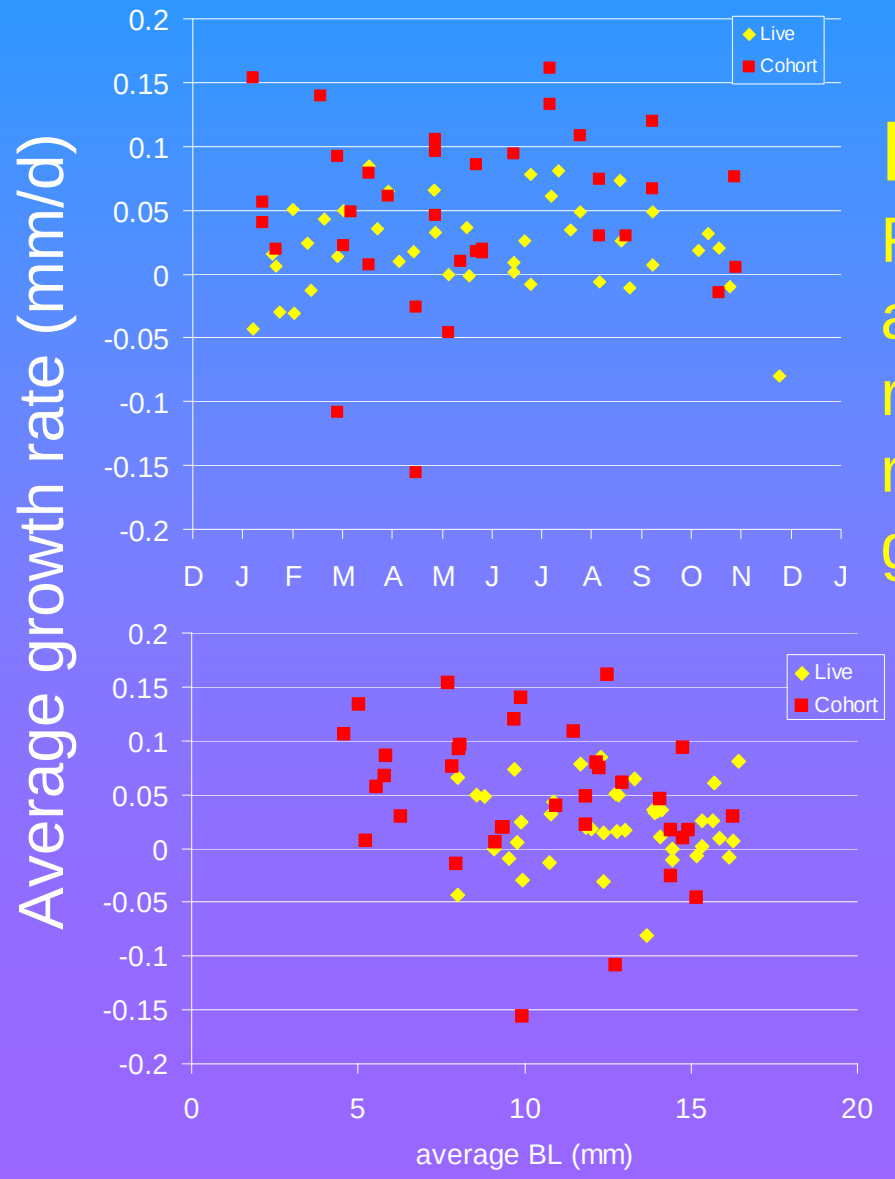


2001, COLD



2004, WARM

Calculated and Measured Growth



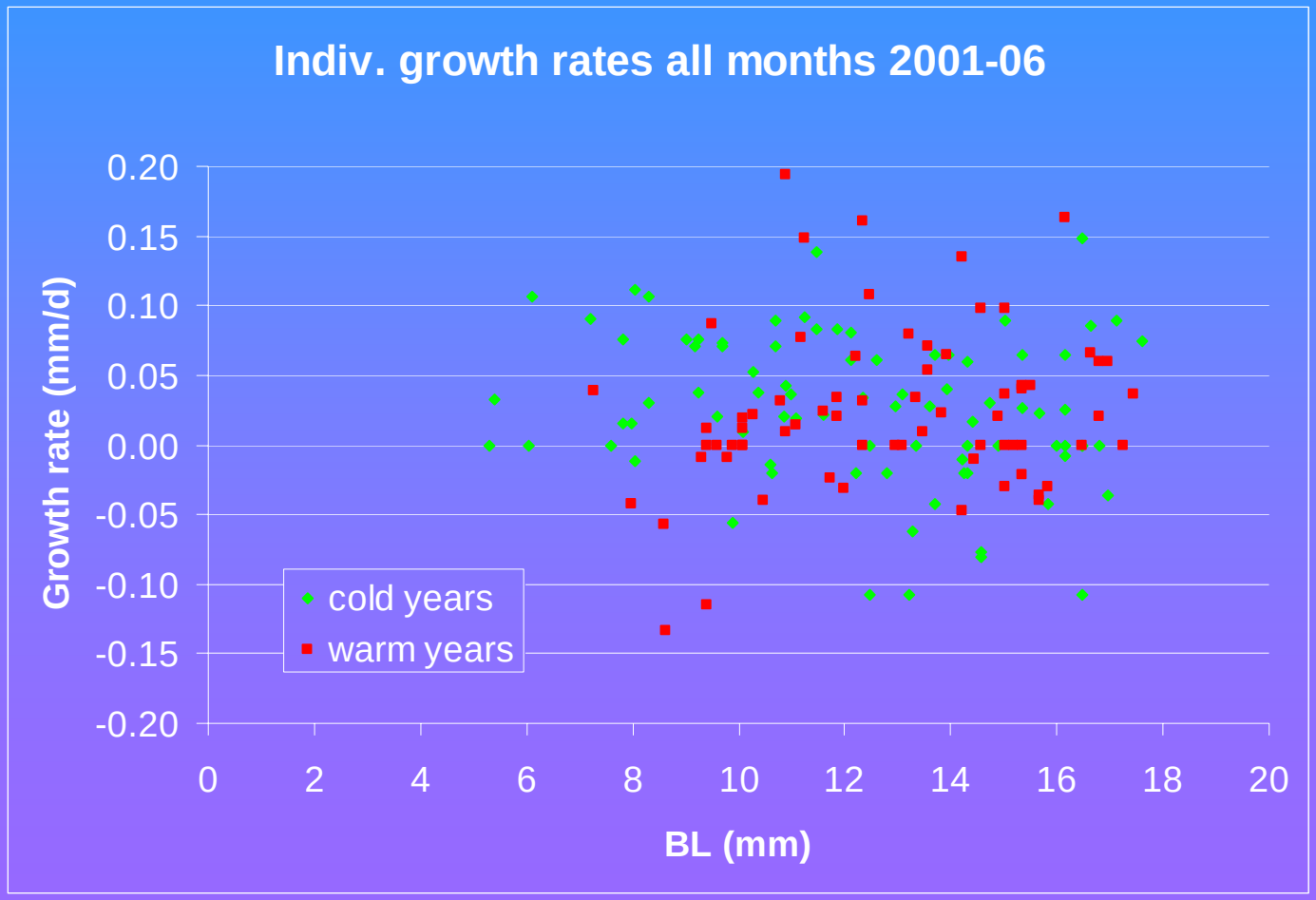
By month:

Rates calculated from cohort analysis show slightly wider range, but are well within the range of rates measured in growth experiments

By length:

Cohort data shows slight tendency for growth rate to decrease with increased length

Individual growth: cold vs warm years

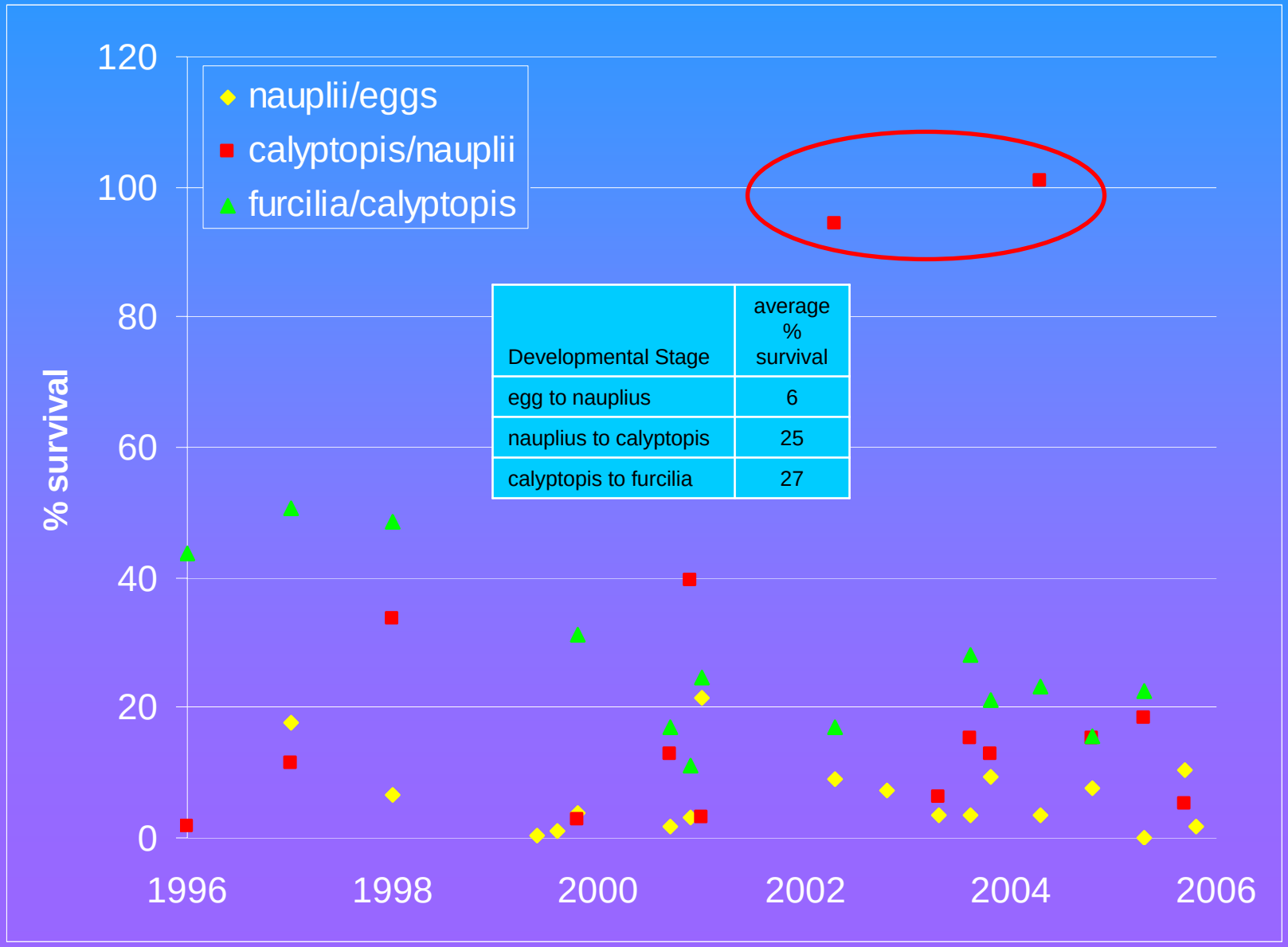


- 3 cold and 3 warm years
- Similar scatter in both groups
- Growth affected by food availability & reproductive activity

Early larval data

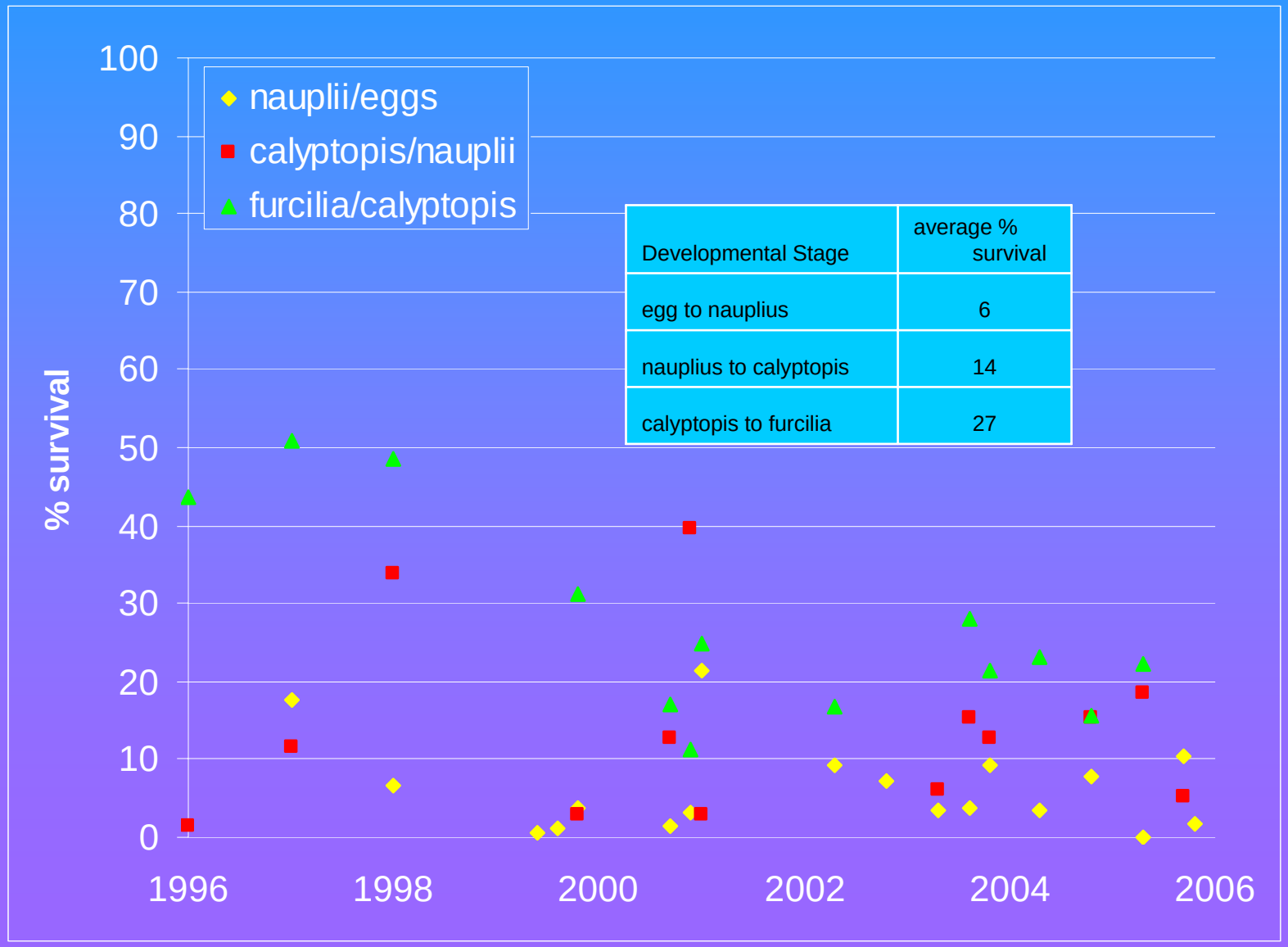
- Eggs, nauplii, calyptopis, furcilia I-III
- Grouped data from NH05 & NH15
- Integrated data between dates to account for unequal time intervals between samples
- Stage duration: nauplius ~6d, calyptopis ~15d, furcilia ~22d
- Divided integrated data by stage duration to account for animals spending more time at particular stages
- Percent survival between stages is an indicator of recruitment success
- High mortality in lab during early stages, expect similar in field (Feinberg, Shaw and Peterson 2006)

Early larval stage recruitment



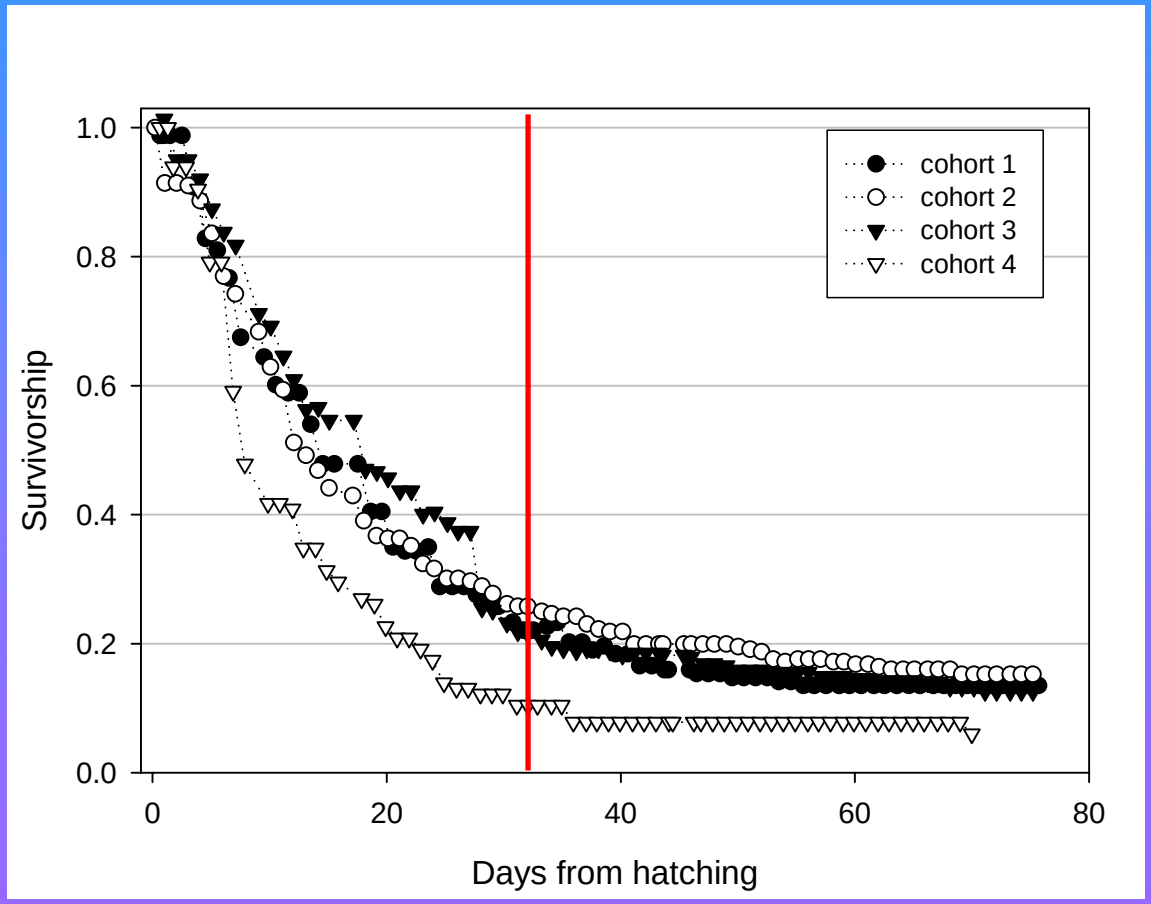
Developmental Stage	average % survival
egg to nauplius	6
nauplius to calyptopis	25
calyptopis to furcilia	27

Early larval stage recruitment



Developmental Stage	average % survival
egg to nauplius	6
nauplius to calyptopis	14
calyptopis to furcilia	27

Survivorship in Laboratory *E. pacifica* Development Experiment



- Median development time to FIII is 32 days (red line)
- Almost no mortality in the laboratory once animals reached FIII

Feinberg, Shaw and Peterson. 2006. MEPS 316:127-137.

Conclusions

- In spite of high individual variability, general growth trends were captured by cohort analysis of *E. pacifica* in preserved samples
- Cohort analysis yielded growth rates consistent with those measured during live experiments
- Recruitment is difficult to study in an open ocean environment, but early larvae in preserved samples showed similar survival to larvae raised in the laboratory
- How we incorporate euphausiids into models will depend on the goal of the model: individual-based models (IBM) account for high variability observed among individuals, general population trends may be captured by cohorts

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

Tracy Shaw
2030 S. Marine Science Drive
Newport, OR 97365
tracy.shaw@noaa.gov

Leah Feinberg
2030 S. Marine Science Drive
Newport, OR 97365
leah.feinberg@noaa.gov

Bill Peterson
2030 S. Marine Science Drive
Newport, OR 97365
bill.peterson@noaa.gov

- Everything you always wanted to know about working with live euphausiids!
- Now available on the PICES website! (www.pices.int)

  Click on “Projects”

Year of the Euphausiid (YOTE)

- Get as many researchers as possible (PICES and non-PICES nations) to conduct live euphausiid experiments using our protocols over a period of several years
- These data would then be comparable among regions
- Conducting all studies during the same years would allow study of the effect of year-to-year variability due to ocean conditions on euphausiid population dynamics
- We will submit a proposal for this project to the U.S. National Science Foundation (PIRE Program) at the end of October 2006

Acknowledgements

- Research vessels: *R/V Elakha, R/V Wecoma, R/V Atlantis, R/V Frosti, R/V Miller Freeman, R/V McArthur II, R/V New Horizon*
- Funding sources: NOAA/NWFSC, ONR/NOPP, NSF/CoOP/COAST NOAA-GLOBEC, NSF/CoOP/RISE, NOAA-SAIP

Future Work

- Expand this data set by conducting cohort analysis for other years
- Egg data: on the NH line we have seen a peak in egg abundance around year-day 200 for 2001-2004. This is remarkably consistent, yet the population of juveniles is highly variable. What is happening to these eggs and the recruits from this pulse of egg production?

Recruitment vs Egg Production