Euphausiid Reproduction off the Oregon Coast, USA

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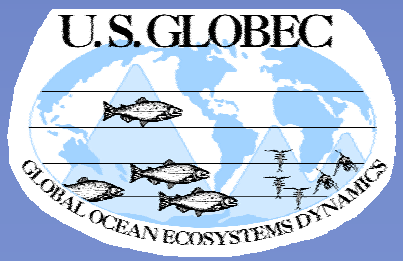
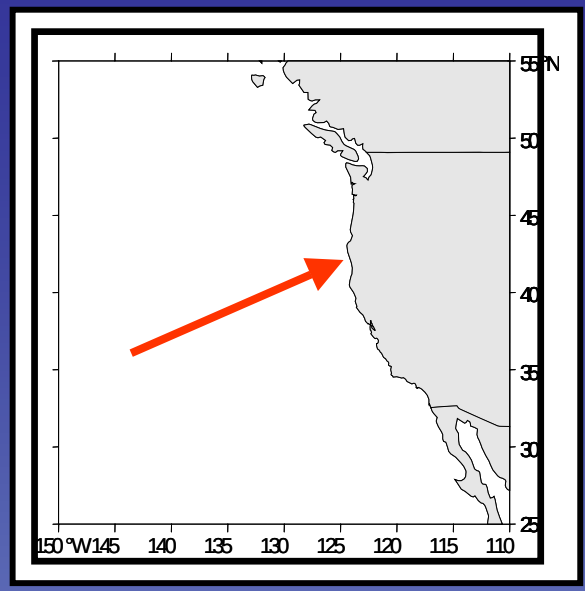


Background



- The Oregon shelf is a dynamic upwelling region
- *Euphausia pacifica* and *Thysanoessa spinifera* are the two dominant euphausiid species
- Euphausiids play a key role in the ecosystem both as predators and prey

Why study euphausiids?

- Keystone species in food chains
- Sentinel species for climate studies

Why study reproduction?

- Seasonality of spawning and egg production rates are basic information needed for study of comparative life history and population dynamics

- Trying to estimate euphausiid biomass in the NCC for stock assessment purposes; we have been exploring the idea of estimating spawning stock biomass using the egg-ratio method. More on this later.

What we have to share today…

- We have: 10 yr of biweekly sampling of eggs and larvae
  5 yr of egg production incubations

- We will show:
  - egg abundances from field sampling
  - duration of spawning season from field sampling
  - female abundances from field sampling
  - brood size from incubations
  - interbrood period from incubations
  - calculations of fecundity

- Variability is extremely high for all parameters making it difficult to make general conclusions!

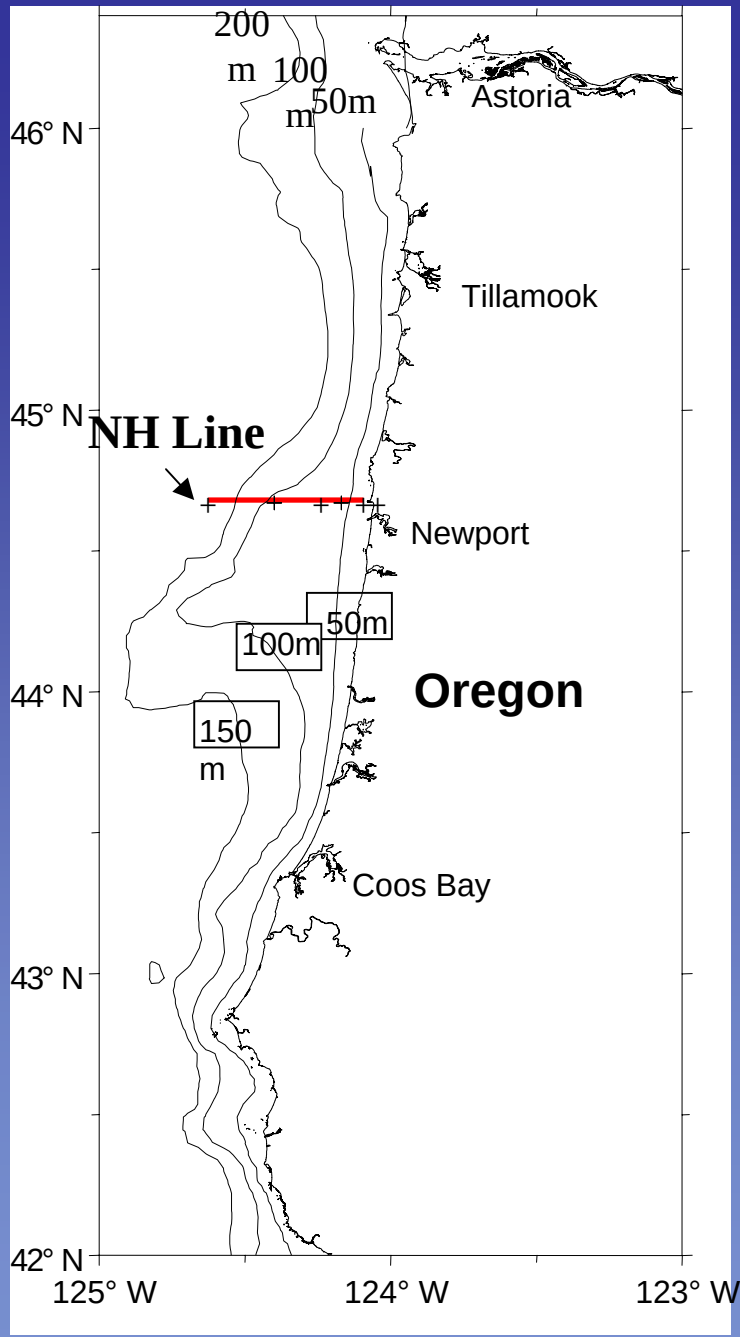
Sampling for Euphausiids

Biweekly sampling on NH line:

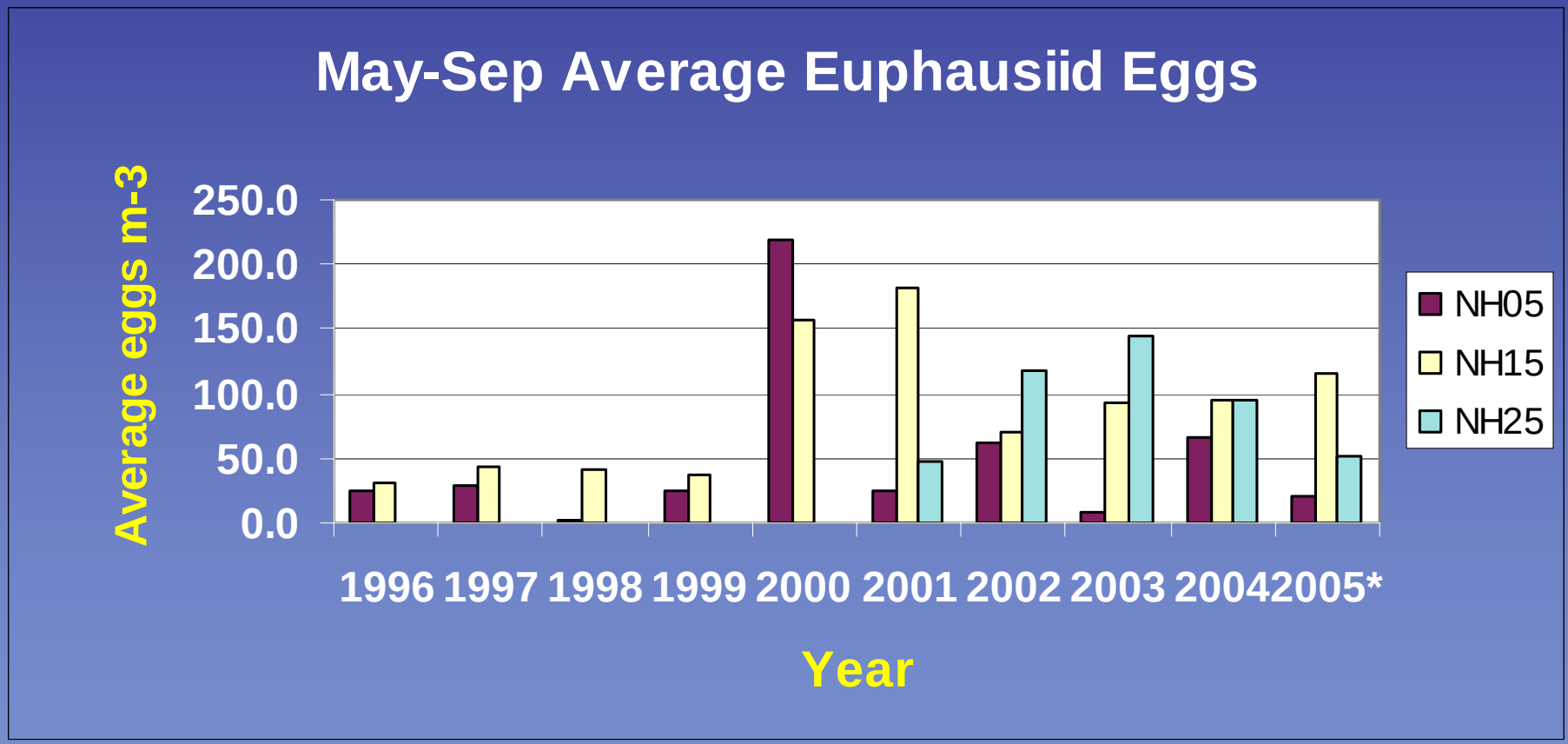
- 1996-2000: day sampling NH 1-15
- 2001-2005: nighttime sampling NH 1-25
  - 200 µm vertical net for eggs and larvae
  - 200 µm bongo net for adults and juveniles
  - Collect live animals for experiments
- CTD, chlorophyll, nutrients

Biweekly time series supplemented by coast wide cruises during 1998-2005

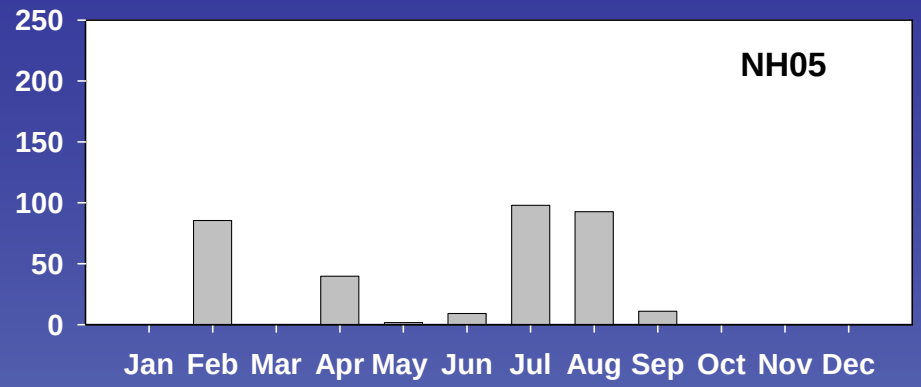
This presentation will focus on results from 3 stations:
NH05: inner shelf
NH15: outer shelf
NH25: just beyond shelf break

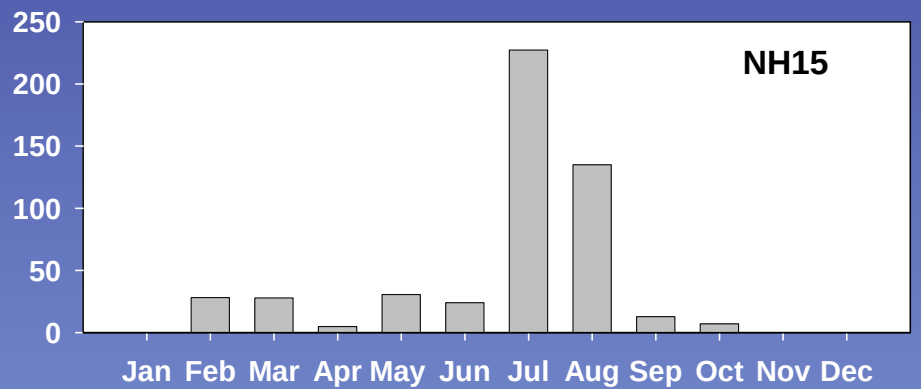


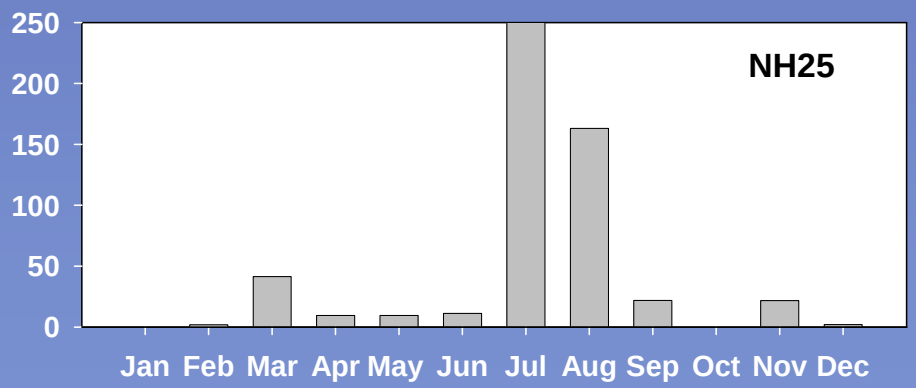
10 yr time series of egg abundances



Climatological monthly abundance of euphausiid eggs at three stations

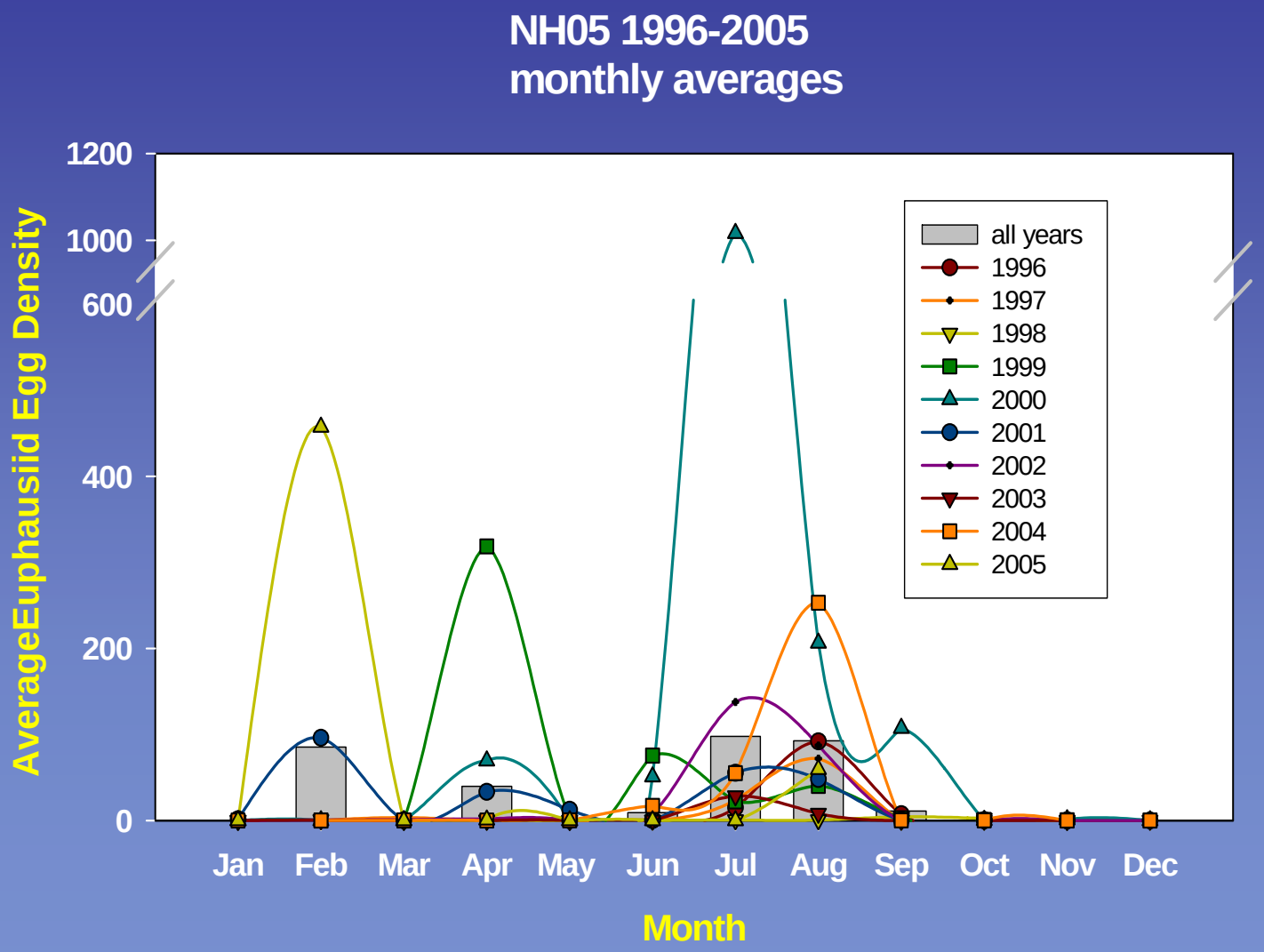






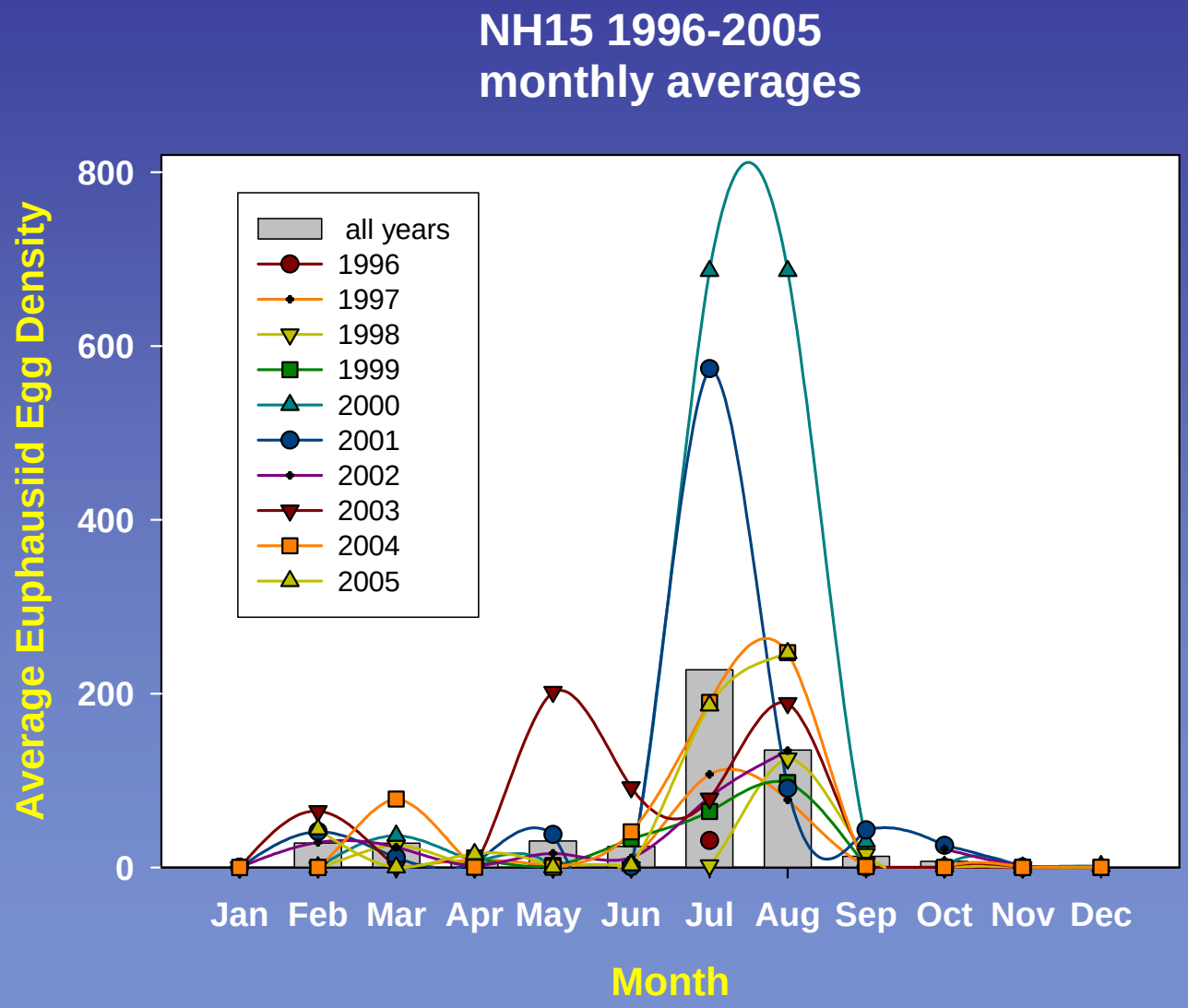
Interannual variations in abundance of euphausiid eggs at NH 05

- **NH05** (60m)
- NH15
- NH25



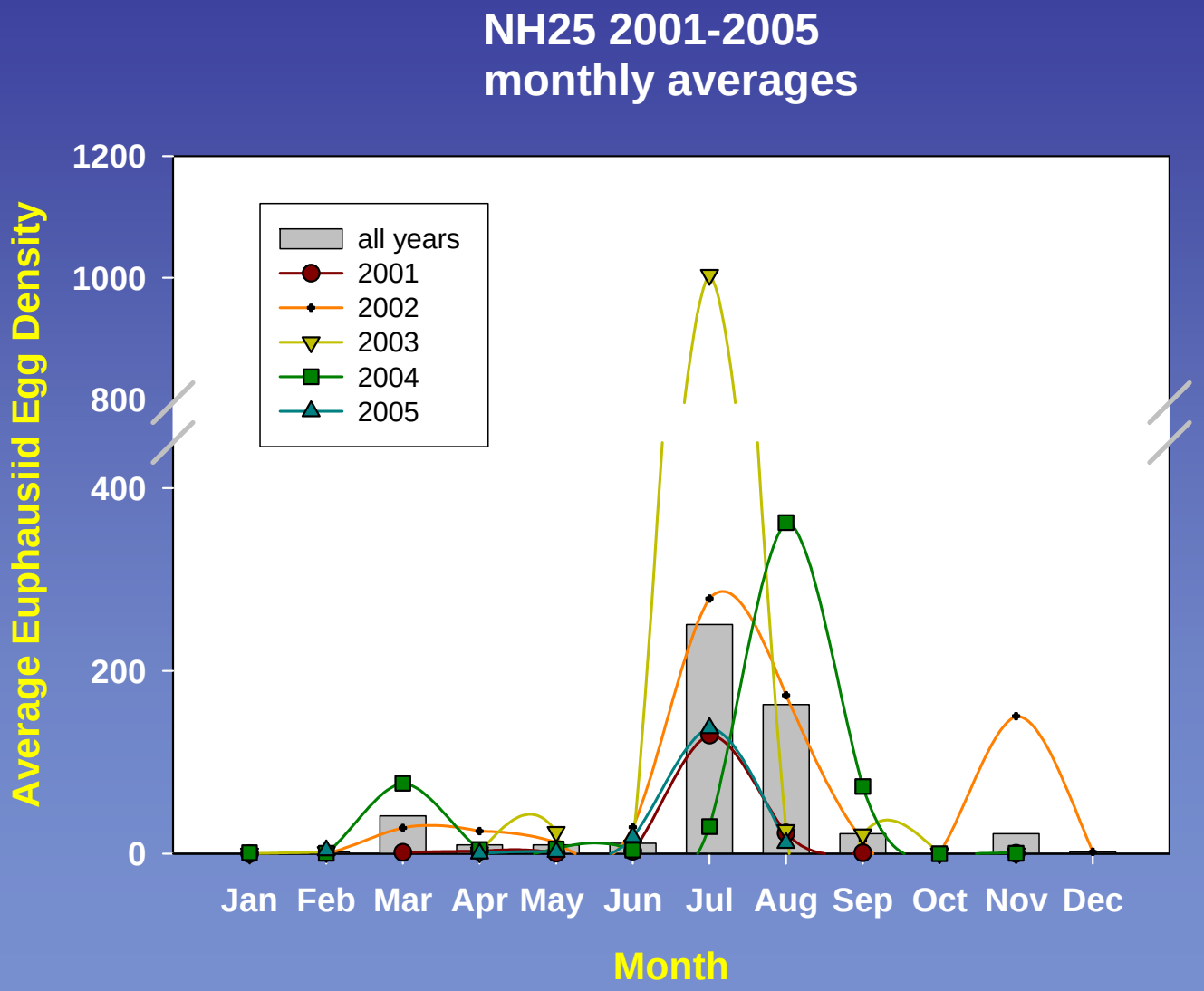
Interannual variations in abundance of euphausiid eggs at NH 15

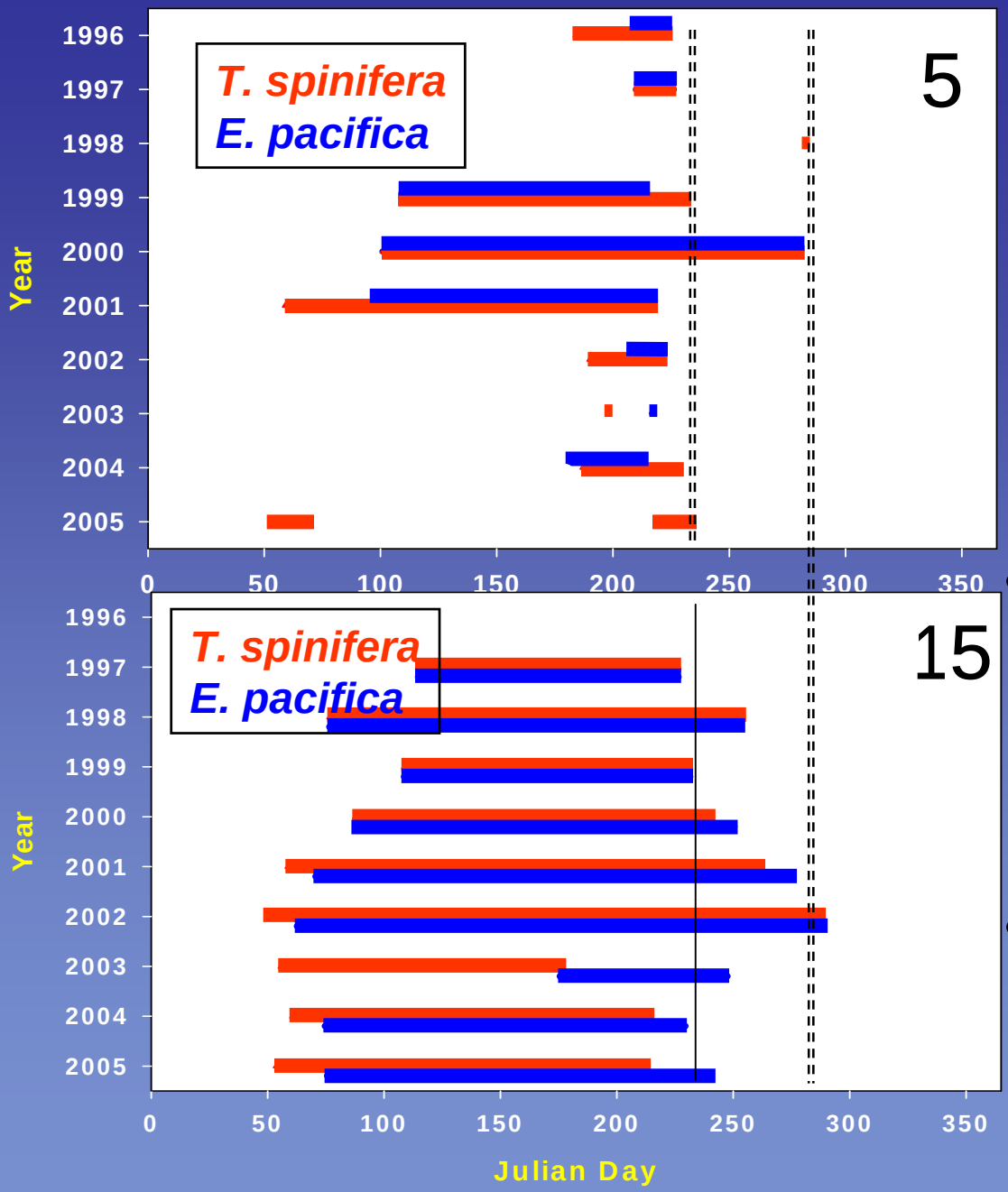
- NH05
- **NH15** (90m)
- NH25



Interannual variations in abundance of euphausiid eggs at NH 25

- NH05
- NH15
- **NH25** (240m)

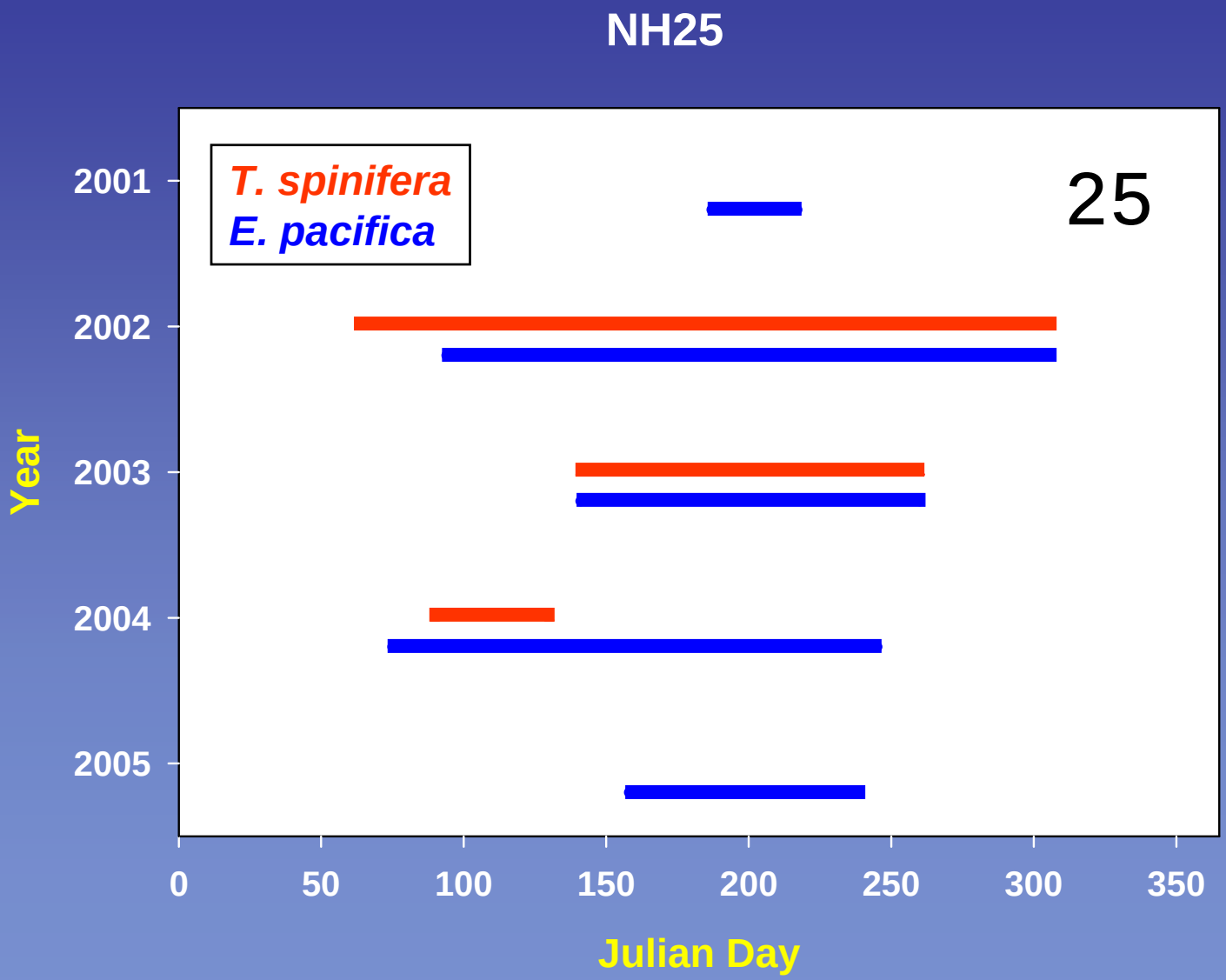




Duration of spawning season by species

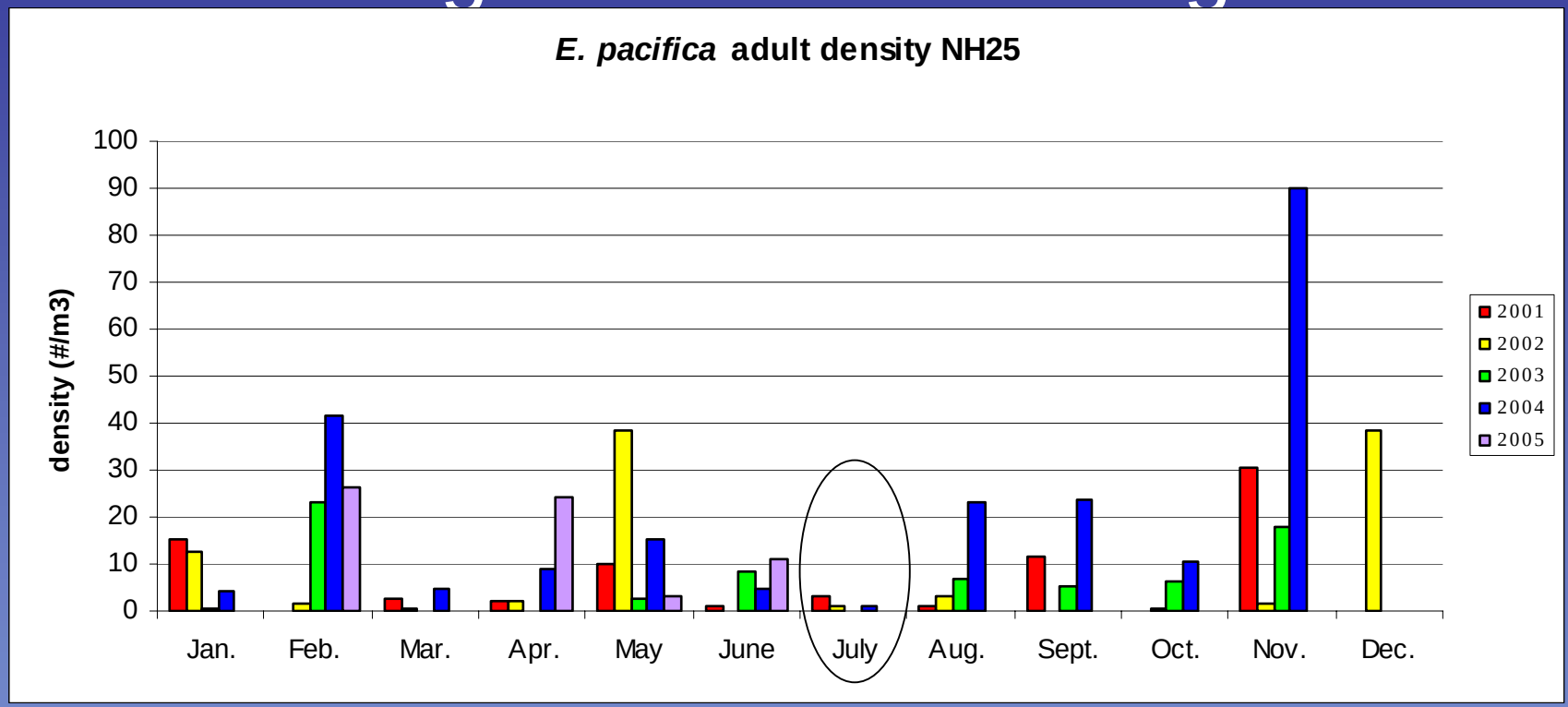
- At NH 05, spring spawning seen in both species but only in 1999-2001 (and one event in 2005).
- Spawning ends by first of August at NH05, but not until end of September at NH 15

Duration of Spawning Season



- No spawning by *T. spinifera* in 2001 or 2005 and only spring 2004

Time series of adult female abundance at NH 25
Bongo tows made at night



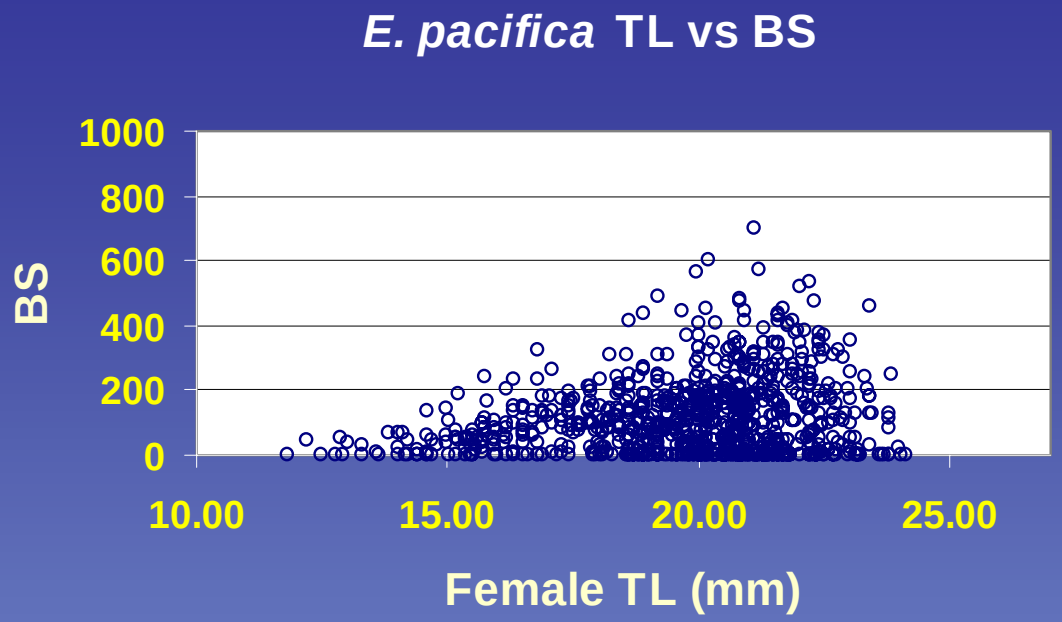
- Don't catch many females in summer, but…
- We do find the greatest abundance of eggs in summer.
- Why is that?

And now results from some studies carried out in the laboratory

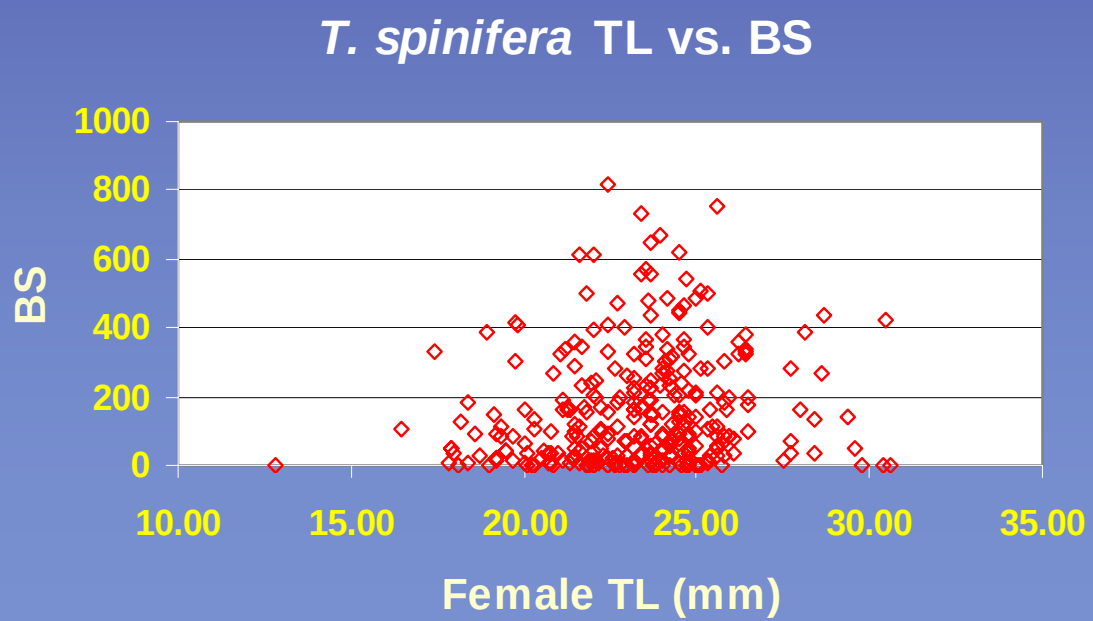
- For measurement of brood size, incubations of females with purple ovaries for 48 hours (but checked every 12 h)
- Brood size by females kept in the laboratory and checked every day, for seven months
- Duration of interbrood period estimated from the brood size time series

Brood Size

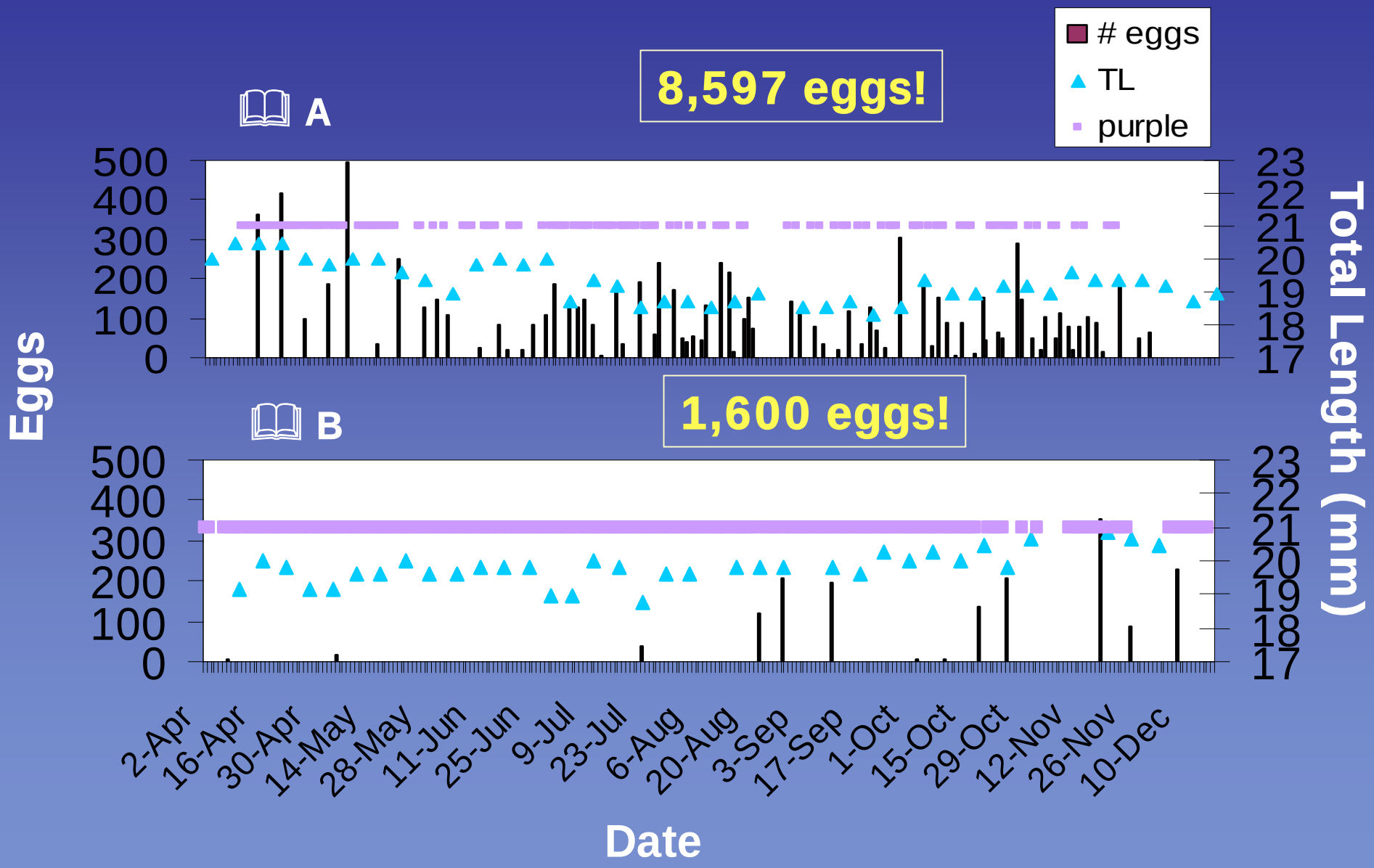
E. pacifica: 972 females incubated in 24-48 hr experiments
Mean BS = **140.8**
Range: **2 – 697**
Peak: 20-22 mm



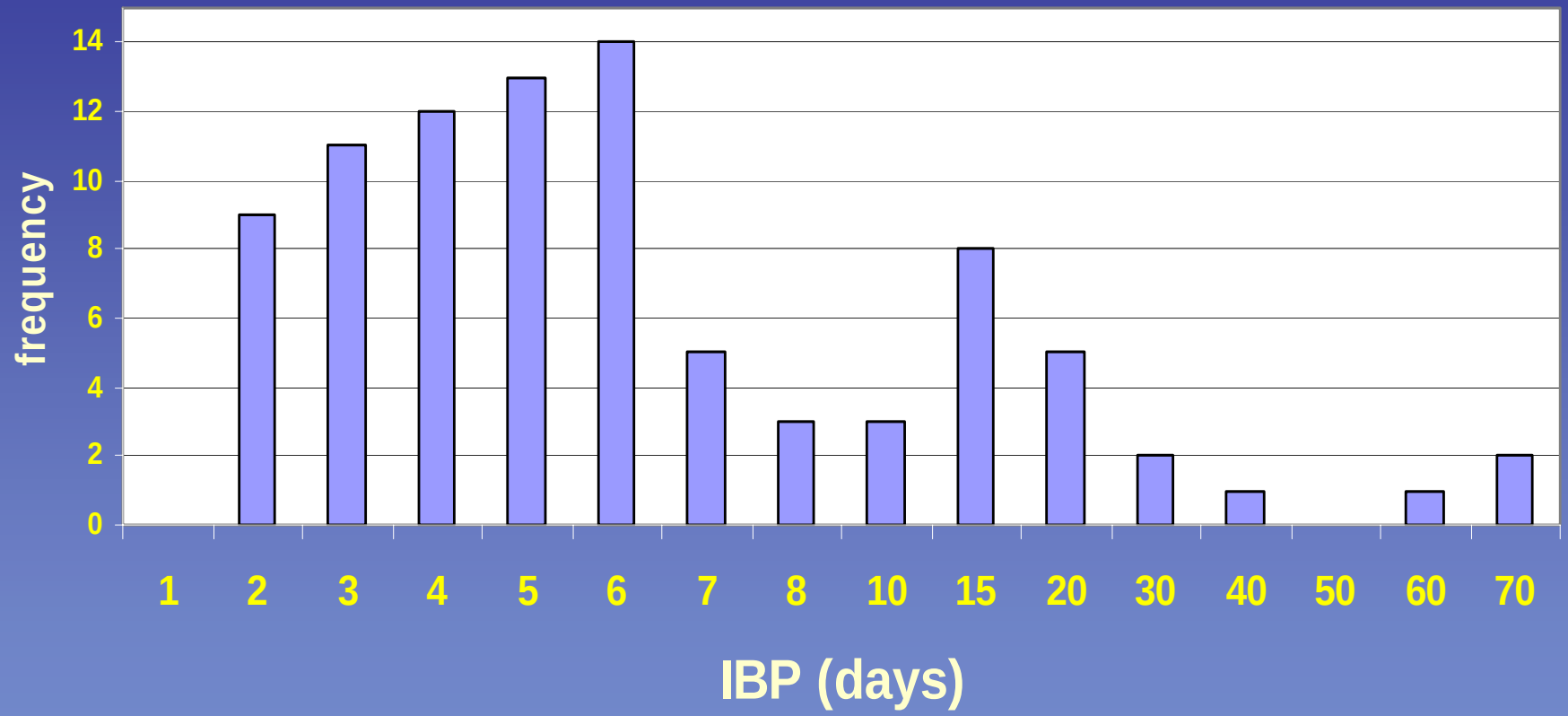
T. spinifera: 351 females incubated in 24-48 hr experiments
Mean BS = **168.7**
Range: **2 – 818**
Peak: 22-25 mm



Variability in Spawning Patterns: two of 27 females



Euphausia pacifica Interbrood Period



7 month laboratory experiment, 27 females, 10.5 °C
Median IBP = 5 days
Range in IBP: 2- 64 days

Sorry, no data for *T. spinifera*

Calculation of Fecundity

- For individual females:

  Fecundity = (Duration of Spawning Season ÷ IBP) * BS

  Can use median values, minimum, or max.

  Calculations using median values at NH15

  E. pacifica = 4,241 eggs/female/season

  T. spinifera = 5,373 eggs/female/season

- For population fecundity calculations, we must have a reasonable estimate of mature female abundances. Summer is especially challenging!

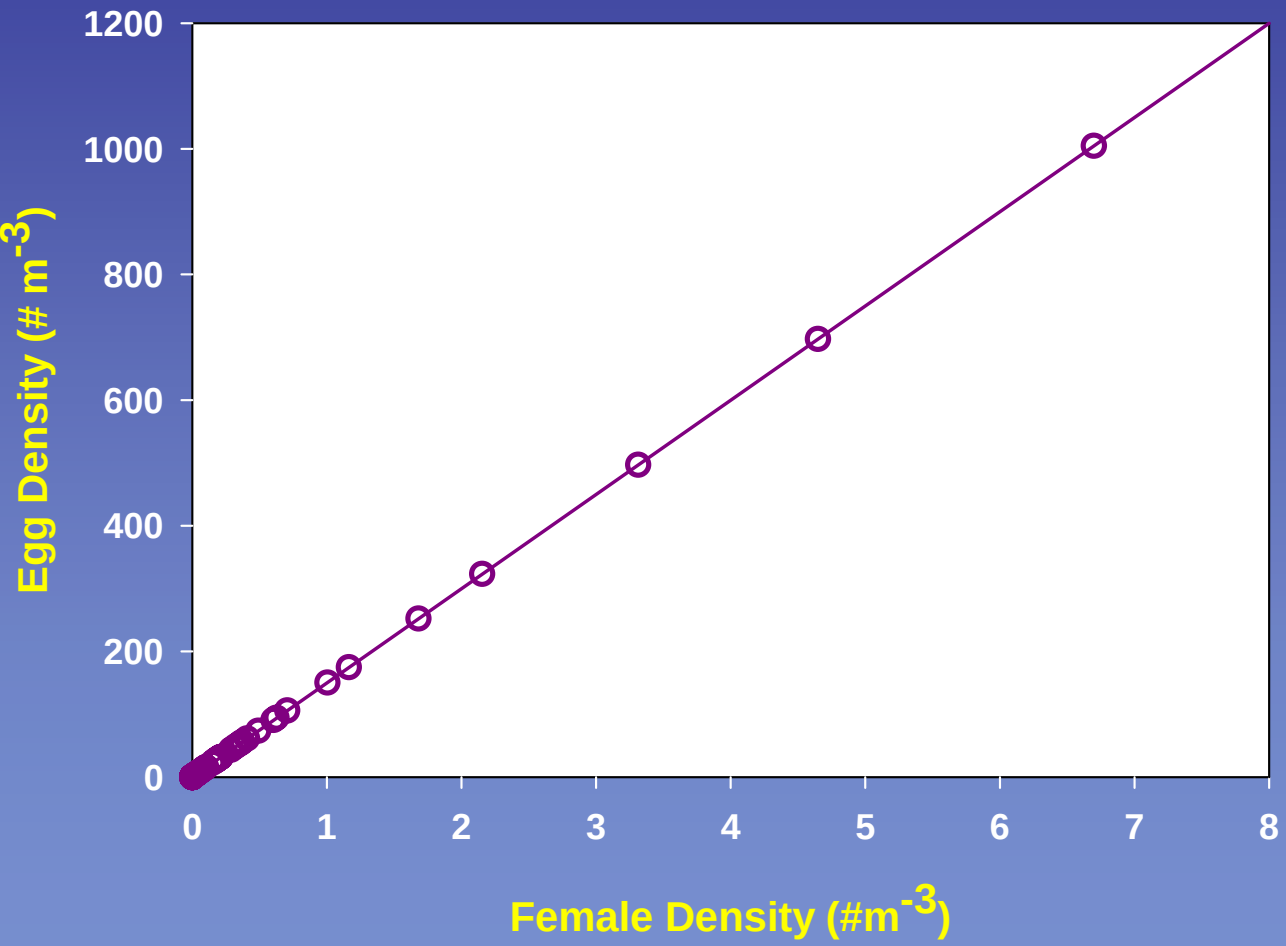
Can we estimate female abundance from eggs in the water column?

- Assuming an average of 150 eggs per female (the average BS for both *E. pacifica* and *T. spinifera*)

- Eggs m^{-3} / 150 eggs $female^{-1}$ = expected females m^{-3}

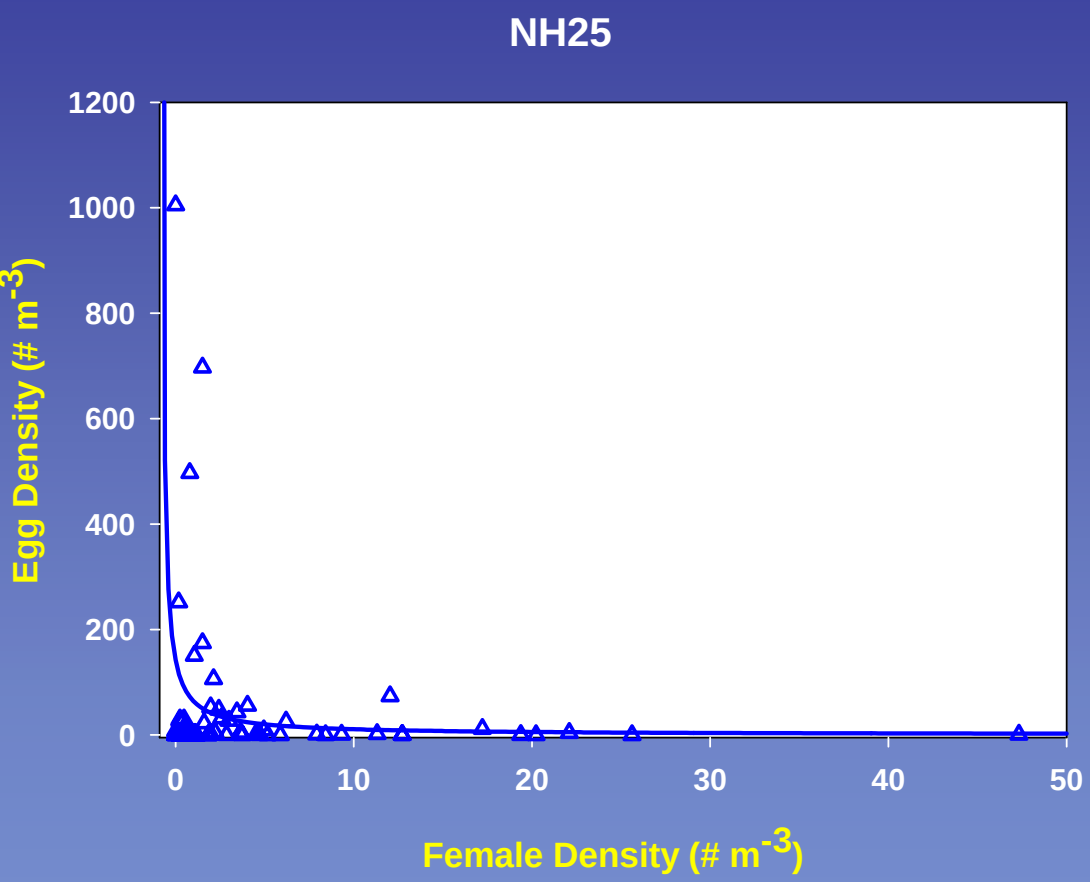
Expected Eggs per Female

NH25



Calculated from actual egg densities and mean brood size

Eggs per female (egg ratios)



- Best fit is a negative hyperbola not a linear model
- Seldom catch females at NH 15 where egg density are usually highest!
- Spatial disconnect between females and their eggs due to (a) advection of eggs (hatch time is 38 h), (b) high sinking rates of eggs (120 m/day, and (c) extreme patchiness of females (swarms).

Final thoughts (1)

- Given the high degree of variability within and among females, seasons, years and locations for all aspects of spawning, in order to model population dynamics, we suggest the use of individual based models for euphausiids.

- Since *Euphausia pacifica* inhabits waters ranging from the subtropical Yellow Sea to the subarctic Pacific, from coastal waters to the deep sea, we suspect that it has a very plastic life history.

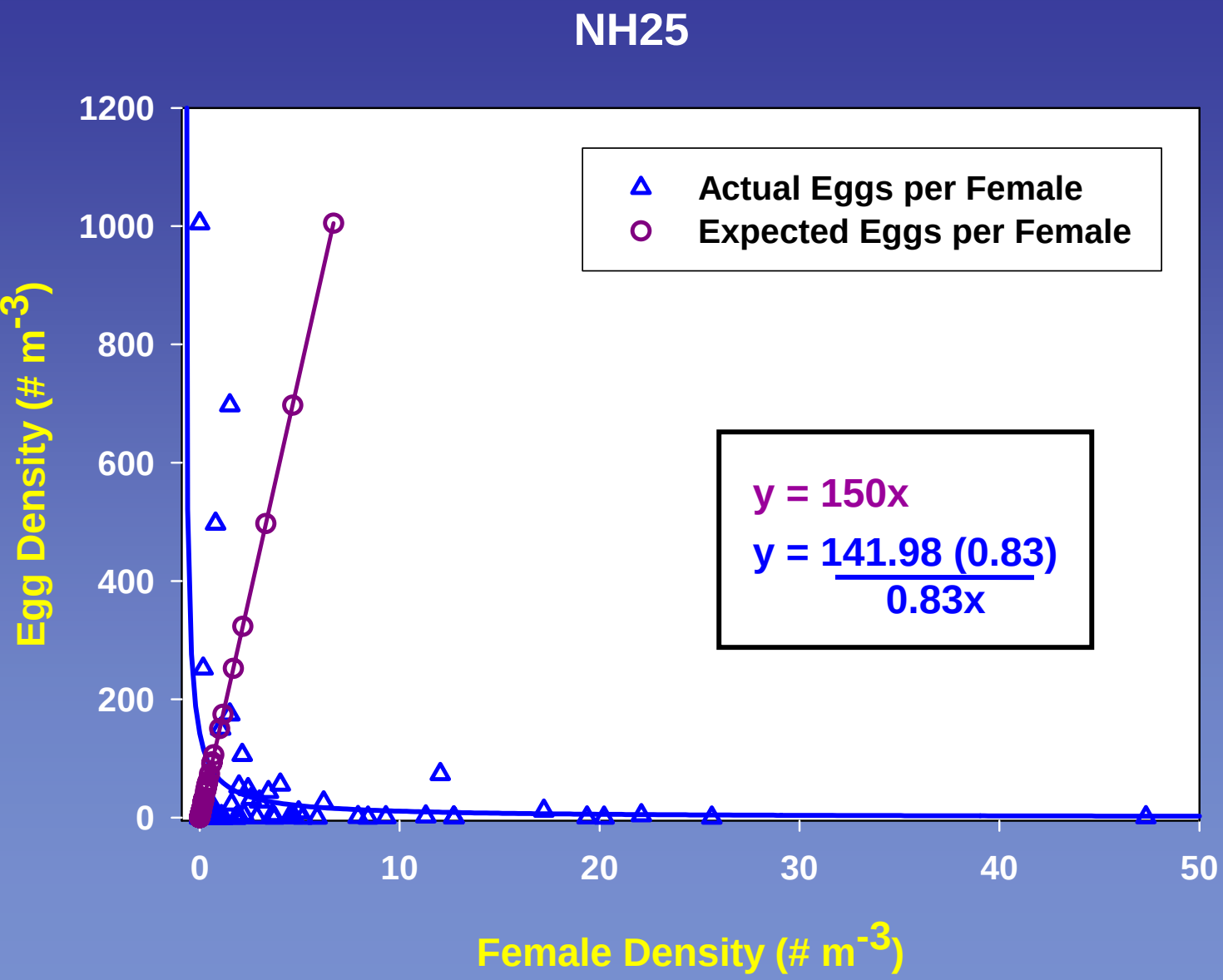
- Given the highly variable nature of our data, we do not recommend that you apply our results to your region. We will need Pan-Pacific comparisons in order to develop a better understanding of life history and population dynamics of this species.

Final Thoughts (2)

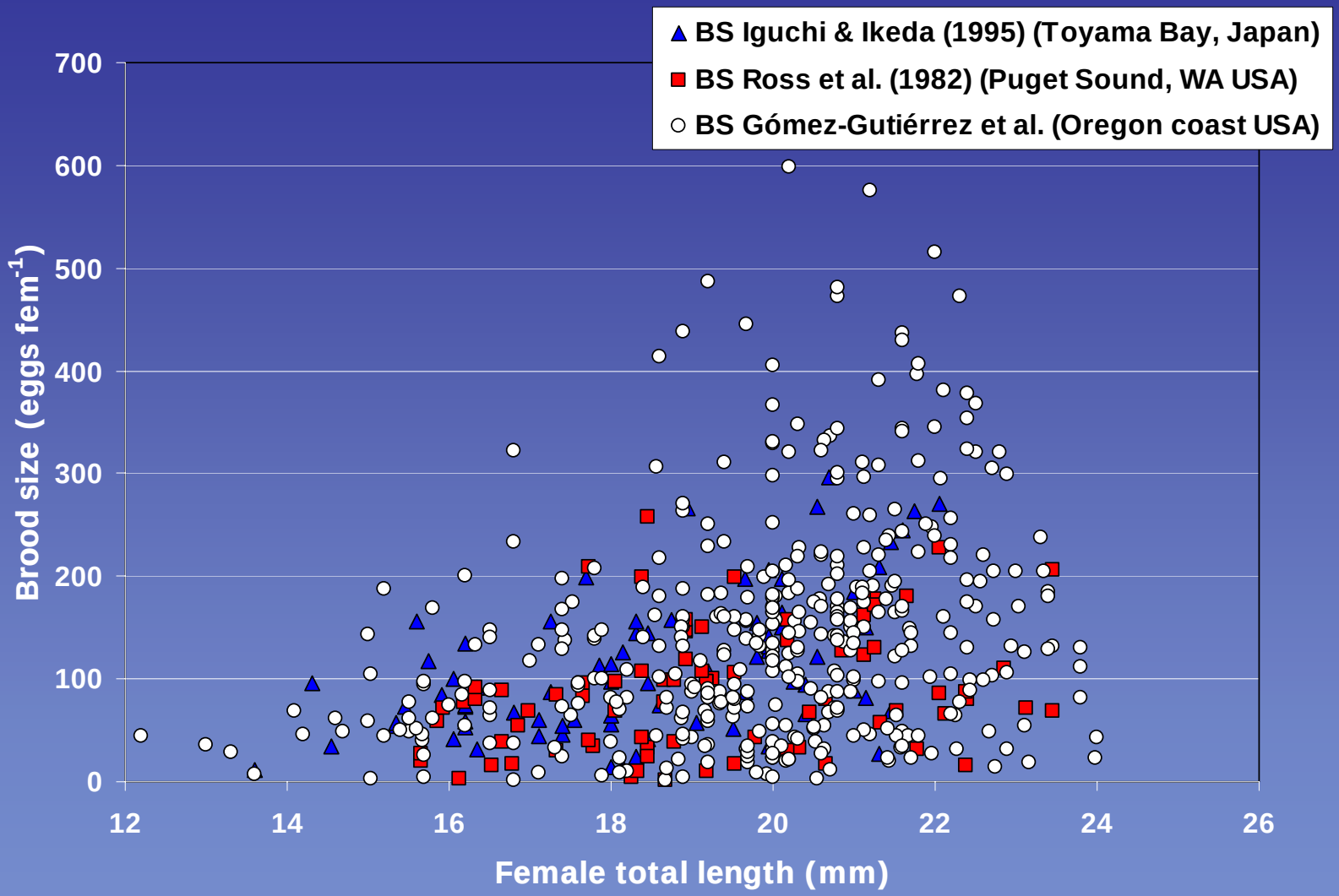
- Due to the high variability in just about everything: seasonal variations in abundance, spawning season, brood size, interbrood period, development rates and developmental pathways (MEPS paper submitted), we wonder each day what we have learned about these animals.

- Is the variability in all of the above due to their occupying a highly-variable upwelling environment?

- Need more studies on *E. pacifica* from other points around the Pacific Rim in order to address this problem.


NH25
Actual Eggs per Female
Expected Eggs per Female
y = 150x
y = 141.98 (0.83) / 0.83x
Egg Density (# m-3)
Female Density (# m-3)
0
200
400
600
800
1000
1200
0
10
20
30
40
50

E. Pacifica Brood Sizes from 3 Populations



Duration of Spawning Season