Growth and Fecundity of *Euphausia pacifica* off the Oregon Coast, Compared With Populations Around the North Pacific

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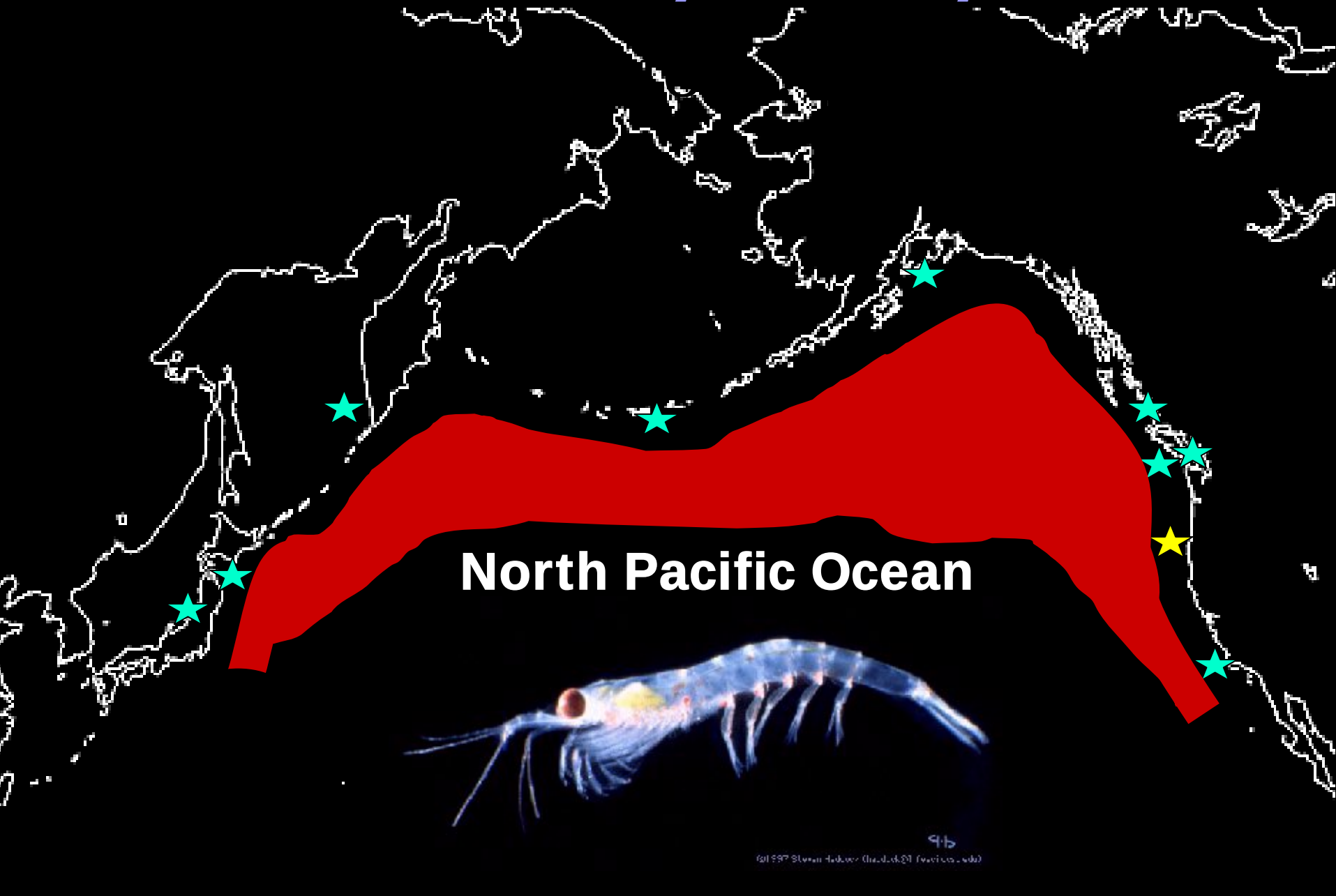
Introduction to *Euphausia pacifica*



Purpose:

1. Compare vital rates for *E. pacifica* determined from our study of the population off Oregon to those from published studies around the North Pacific

2. Compare and discuss vital rates derived from field census data and laboratory experiments

3. Provide data for population dynamics modelling within GLOBEC program

Background: Our Current Research

- Part of Northeast Pacific **GLOBEC** program
  - **Biweekly cruises** (8+ year time series)
    - 25 mile transect off Newport, Oregon
  - **Coast-wide Survey cruises**
    - At least 3 times/year, Newport to N. California
  - **Laboratory Experiments**
    (at sea and on land, 10.5 °C)
    - Growth
    - Fecundity
    - Development
    - Feeding
    - Reared animals for age determination using lipofuscin

Outline:

- Growth Rates (Total Length)
- Longevity
- Age at Maturity
- Fecundity
  - Brood size (BS)
  - Egg size
  - Interbrood period (IBP)

Growth measured in 3 ways

- **Cohort Analysis** (Modal Progression)
  - Repeated sampling of a field population over regular intervals
- **Instantaneous Growth Rate** (IGR)
  - Incubations of individual animals to determine inter-molt period (IMP) and molt increment (mm) in 24 h incubations
- **Observation of Laboratory Reared Animals**
  - Follow growth of animals for extended periods in the laboratory by measuring molts

Growth Rates: Current Study

Cohort Analysis:	**Per Day**
Sub-adult (spring/summer)	**0.07mm**
Sub-adult (winter)	**0.03mm**
Adult (winter and spring)	**0.04mm**

IGR (averages):	
Sub-adult (spring/summer)	**0.07mm**
Adult (winter)	**0.03mm**
Adult (spring/summer)	**0.04mm**
range:	**(0 – 0.09mm)**

Laboratory Development Experiments 10.5°C:	
Egg-Juvenile (0→2 months)	**0.09mm**
Juvenile→1yr (<~17mm)	**0.04mm**
1→2yr (>~17mm)	**0.01mm**

Growth Rates: Adults vs. Sub-adults

0.09
0.06
0.03
0
Iguchi et al. 1993

0.09
0.06
0.03
0
Heath 1977

0.09
0.06
0.03
0
Bollens et al. 1992

0.09
0.06
0.03
0
Cooney 1971

12C
8C
0.09
0.06
0.03
0
Ross 1982

0.09
0.06
0.03
0
Hulsizer 1971

10.5C
0.09
0.06
0.03
0
Current Study

0.09
0.06
0.03
0
Smiles & Pearcy 1971

10C
0.09
0.06
0.03
0
Lasker 1966

0.09
0.06
0.03
0
Brinton 1976

Growth in mm/day (Total length)

Adults

Sub-adults

Growth Rates : Winter vs. Spring/Summer

Growth Conclusions:

- Growth is greater for sub-adults than adults and greater in spring/summer than in winter.
- All methods give a similar range of growth rates. Cohort analysis often suggests faster growth rates for adults than experimental rates.
- Growth rates may not be regionally specific.
- Shrinkage can occur in any season.

Age at Maturity:

- 1+ for most field studies (4-7 months S. California)
  - maturity often determined indirectly in preserved animals (spermatophores, ovarian maturity)
  - age was determined by size
- Our work on living animals: Spawn at 9 months
- Smallest spawner in our field incubations ~9 months!

Longevity:

- NW Pacific, Japan: ~2+
- S. California: 6-13 months
- NE Pacific 1 - 1+

} Derived from Cohort Analysis

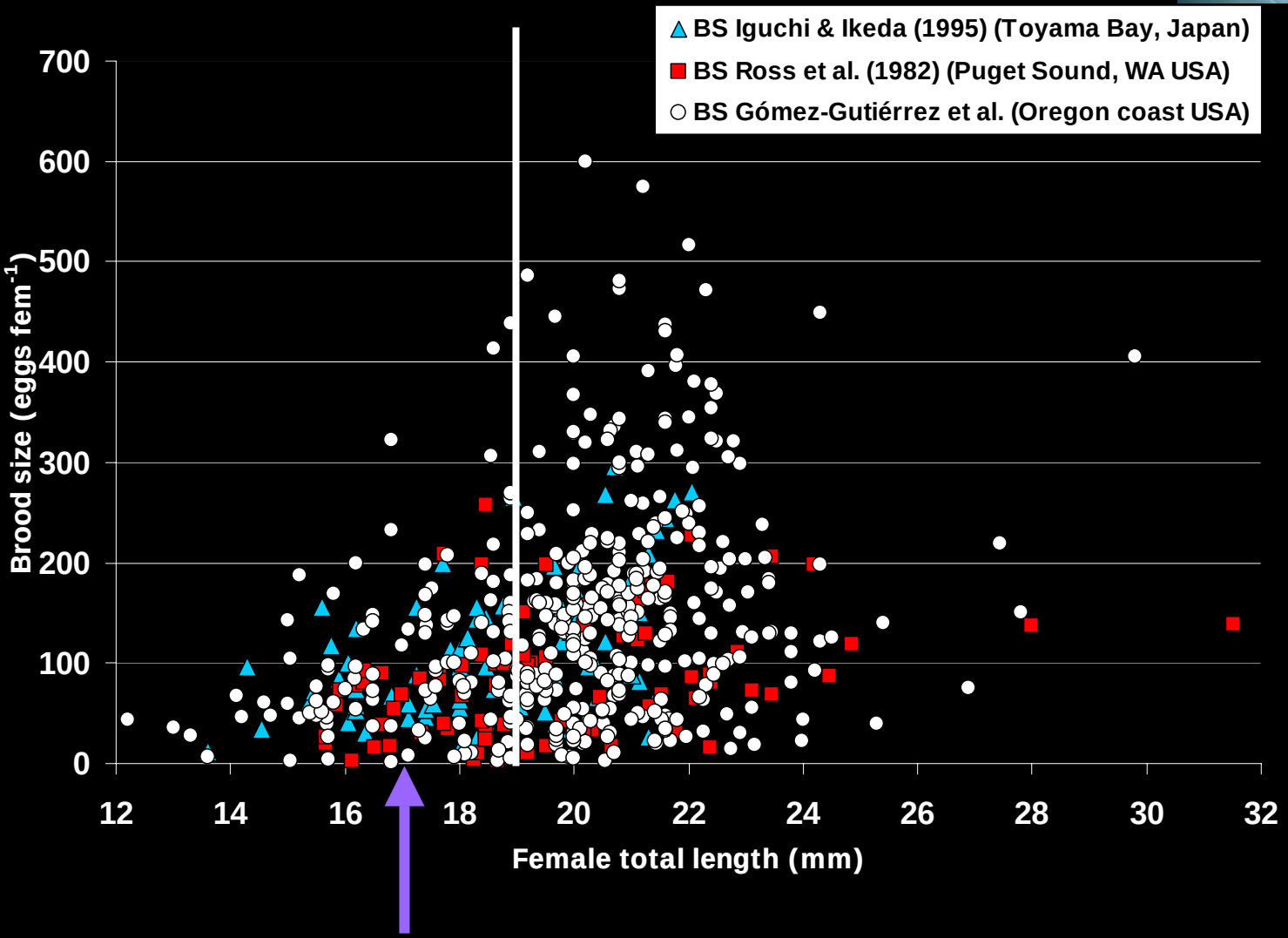
- "Uncle Chester" (maintained in our lab)
  was ~ 32 months old when he died in May 03!

Fecundity Methods:

F = (Spawning Season / IBP)* avg.BS

- Regular Sampling of Eggs and Females
  - Length of spawning season, egg and female abundance, & proportion of ripe females → IBP (Ross, Current Study)
- Egg Production Incubations
  - 12-48 hour incubations of gravid females (from field) to determine BS (Ross et al., Iguchi & Ikeda, Current Study)
- Fecundity Measured in the Laboratory
  - Daily observations of BS and IBP for laboratory maintained animals, >30 days. (Current Study)
- Enumerate Eggs in Ovaries of Preserved Females
  - Count and stage oocytes to estimate BS and number of broods (Brinton, Mauchline, Ponomareva)

Brood Size: EP incubations



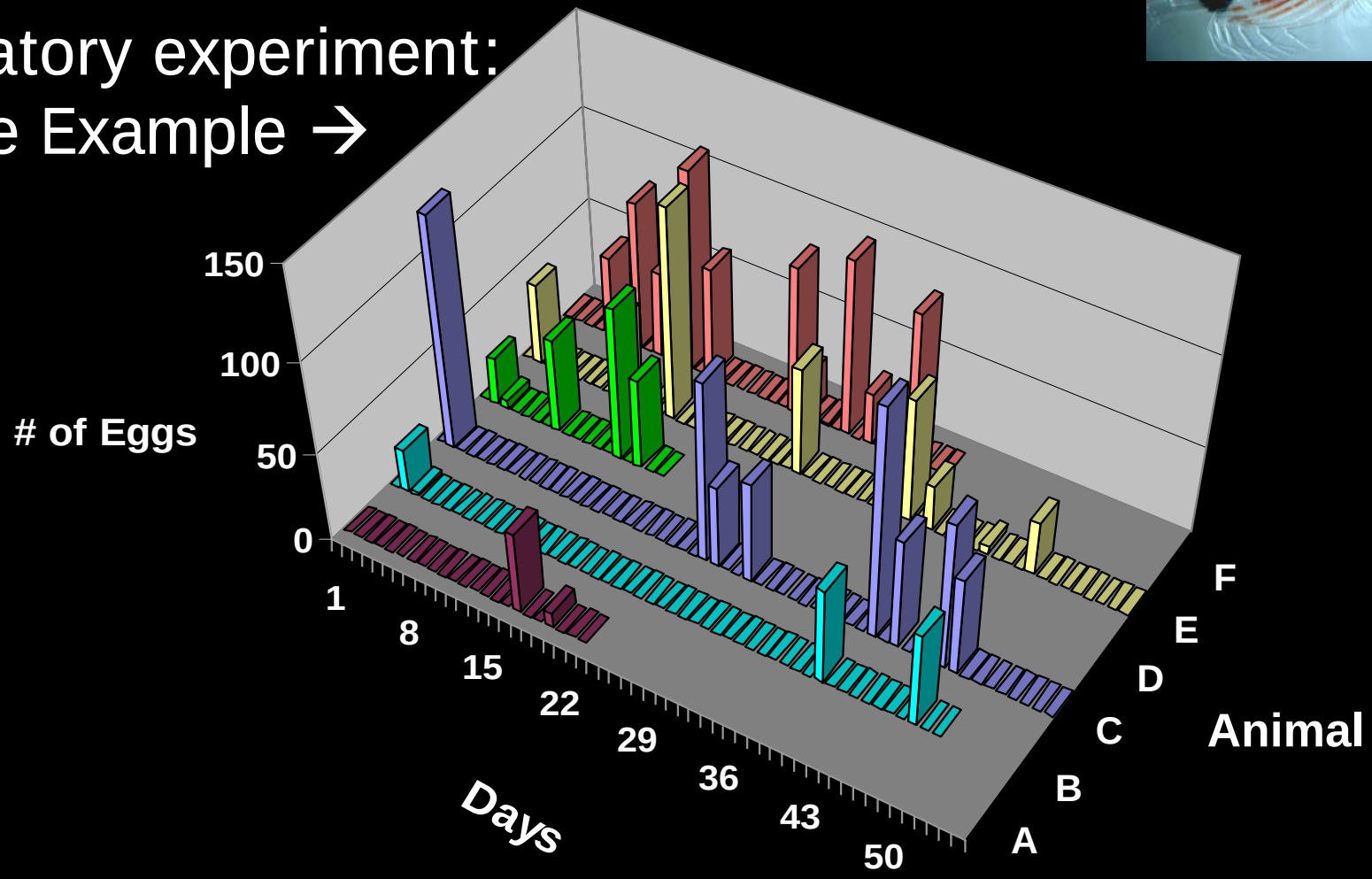
Egg Weights

Oregon:	3.2 µg carbon	Our work
Puget Sound:	2.5 µg carbon	Ross 1982
S. California:		Lasker 1967
Toyama Bay:		Iguchi & Ikeda 1999
Toyama Bay:	1.5 µg carbon	Iguchi & Ikeda 1994

Implications for calculation of daily or annual production.

Interbrood Period:

Laboratory experiment:
One Example →



Six small females, 9 months old, raised in the lab from eggs

Interbrood Period Results

Experimental IBP (results from 6 long-term experiments)

Oregon:	6.5 ± 1.5 (SE) days, Range: 1-37 days
Santa Barbara:	4.8 ± 0.8 (SE) days, Range: 1-78 days
Barkley Sound:	Poor survival, few eggs
Dabob Bay:	Poor survival, no eggs

Calculated IBP (based on ovary ripeness of preserved females)

Oregon:	5.9 ± 1.5 (SE) days, Range: 1-40 days
Washington:	4.2 days (Ross et al.)

Calculation of Fecundity in one spawning season:

Locations	Mean BS (eggs)	Mean IBP (days)	Length of Season (days)	Fecundity (Eggs/female /season)
Oregon, Field	Small:95 Large:161	5.9	244	Small: **3929** Large: **6658**
Oregon, Laboratory	Small:66 Large:156	6.5	244	Small: **2478** Large: **5856**
S. Barbara Laboratory	140	4.8	365? 180	**10,646?** **5,250**
Puget Sound, Laboratory (Ross)	Small:60 Large:132	4.2	73	Small: **1043** Large: **2294**

Fecundity Conclusions:

- Brood sizes are significantly greater for the largest females (>19mm) in Oregon and Japan as compared to Puget Sound in Washington
- Most spawning may occur in animals > 1 year
- *E. pacifica* females spawn multiple broods
- Interbrood Period and Brood Size vary greatly.
- Average field estimates and experimentally determined IBPs were quite similar.
  - Range nearly identical

The Year of the Euphausiid

- Expand our BS and IBP (fecundity) measurements to other populations from the N. Pacific under the same laboratory conditions.
  - Dabob Bay, Gulf of Alaska, Russia, Japan, Korea

- Expand our measurements of development, survival and mortality to other populations.

- Compare latitudinal differences in *E. pacifica* with several populations of *Thysanoessa spinifera* in the coastal waters of the Eastern Pacific.

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