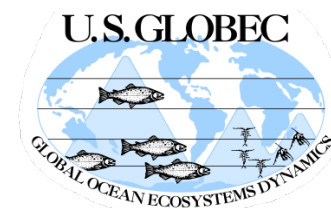


Calanus life histories:

Data: Needs, Wants, Haves, and Synthesis

Calanus Life Histories PRS Team: Jamie Pierson, Jeff Runge, Andrew Leising, David Kimmel, Andrew Pershing, Catherine Johnson, Stéphane Plourde



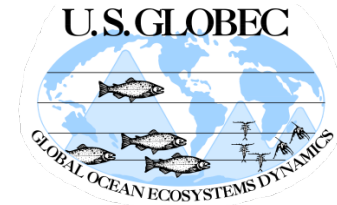


Calanus workshop objectives

1. Compile demographic and vital rate data for *C. finmarchicus* and *C. helgolandicus*, across their ranges
2. Compile metadata for unrepresented data sets, specifically:
 - ▶ Temporal & spatial extent
 - ▶ developmental stage determination
 - ▶ ancillary data collected simultaneously
3. Identify participants for large scale comparative studies
4. Develop timetable for analysis and data access



Runge et al. GLOBEC PRS Objective and Hypothesis

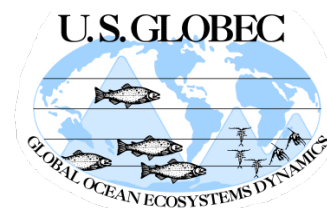


Review and synthesize knowledge for sibling species:
C. finmarchicus and *C. helgolandicus* in the North Atlantic

Hypothesis:

“The timing of **entry and exit from dormancy**, as modulated by species-specific physiology and effects of climate-forced variability of food and ambient temperature on lipid accumulation, exerts an important control on population dynamics. ”





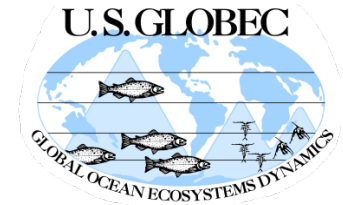
Population metrics

- ▶ timing of the abundance peak
- ▶ reproductive period
- ▶ population growth rate
 - ▶ Between dormancy emergence and the population abundance peak
- ▶ the relative timing of emergence from dormancy and the spring bloom

compare populations at different locations



McGillicuddy et al. GLOBEC PRS Objective and Hypothesis



Hypothesis: There are three main population centers of *Calanus finmarchicus* in the North Atlantic

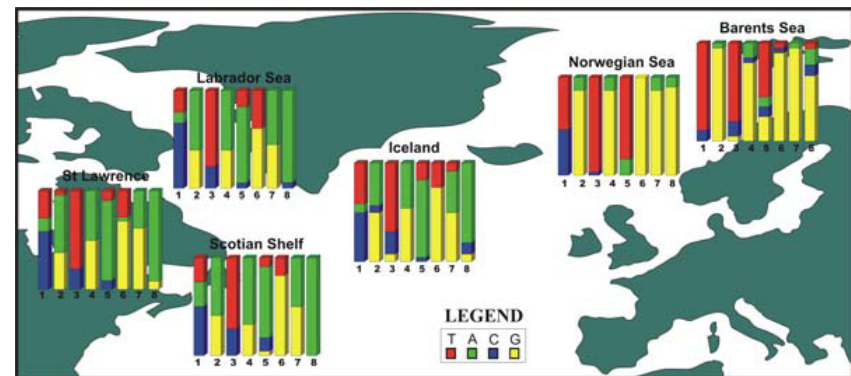
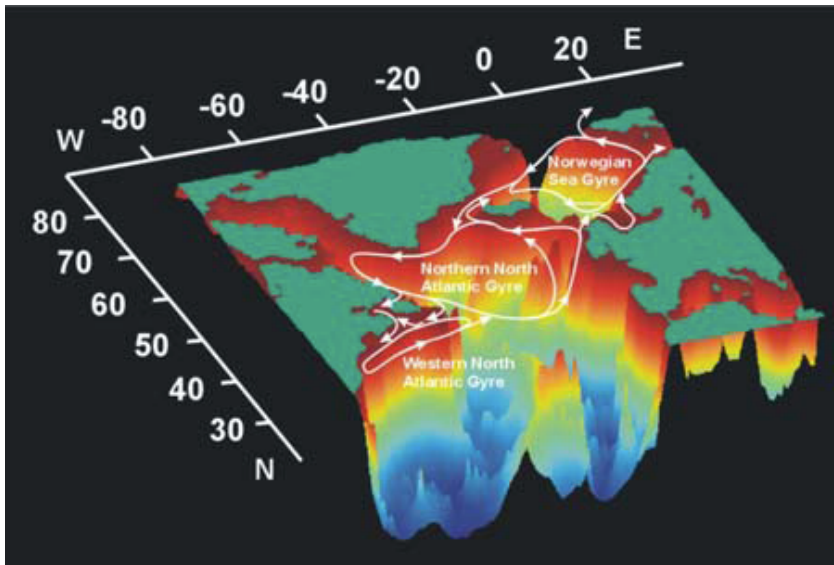
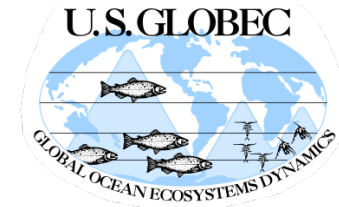
Approach:

Explore connectedness of the three gyres using independent evidence from modeling and genetics

- ▶ Combined physical-biological modeling:
 - ▶ Assimilate observations of *C. finmarchicus* from the (CPR) into the North Atlantic Regional Ocean Modeling System using the adjoint method
- ▶ Genetic analysis of *C. finmarchicus* populations

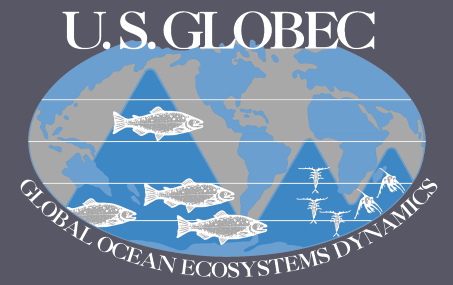


Circulation and genetics: three-gyre system for *C. finmarchicus*

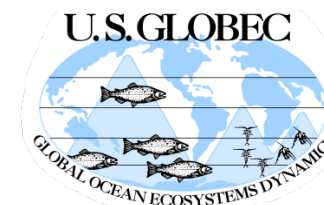


Schematic diagram of the three-gyre conceptual model for *C. finmarchicus* in the North Atlantic.

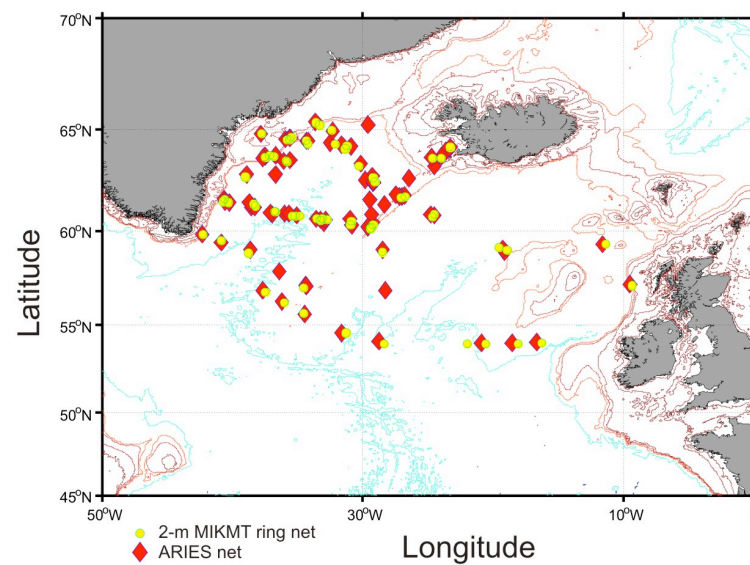
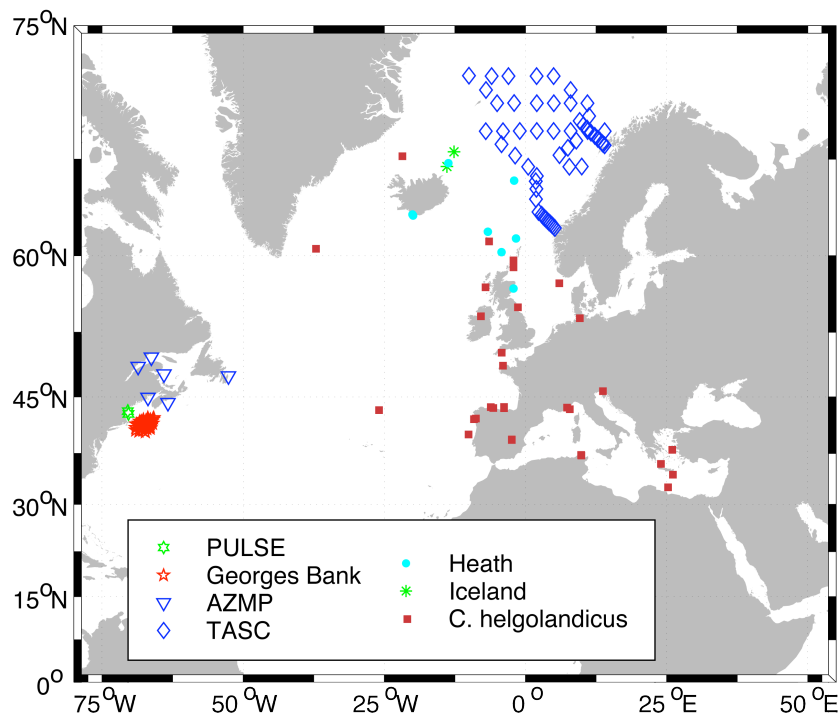
Allele frequencies for eight SNPs in the gene encoding a heat shock protein (HSP-70) for six geographic populations of *C. finmarchicus*

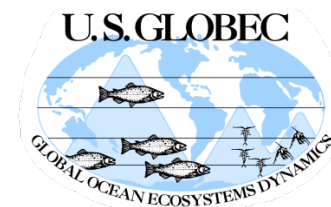


Demographic Data



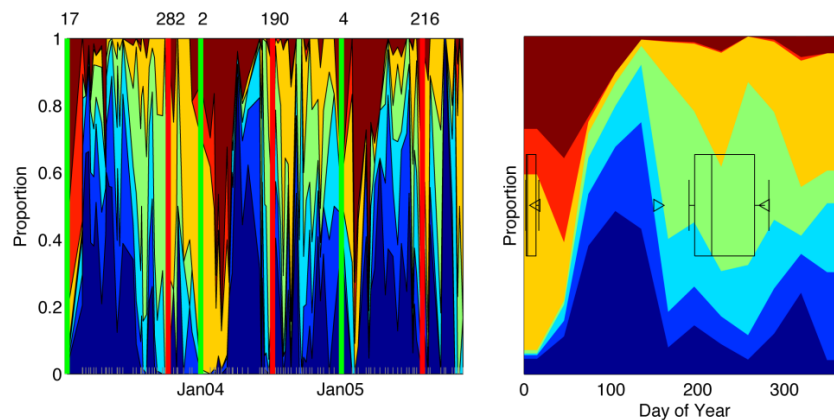
Calanus data mapped



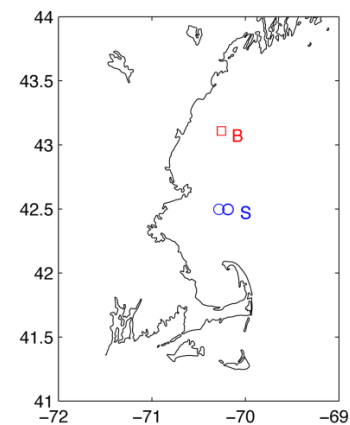
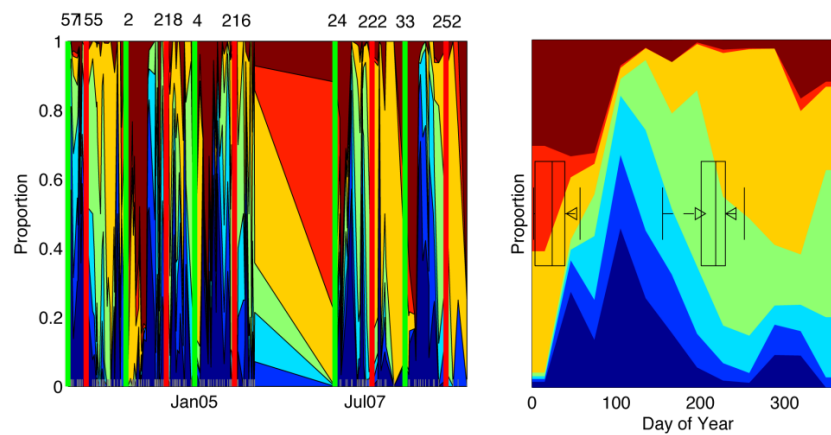


PULSE Data

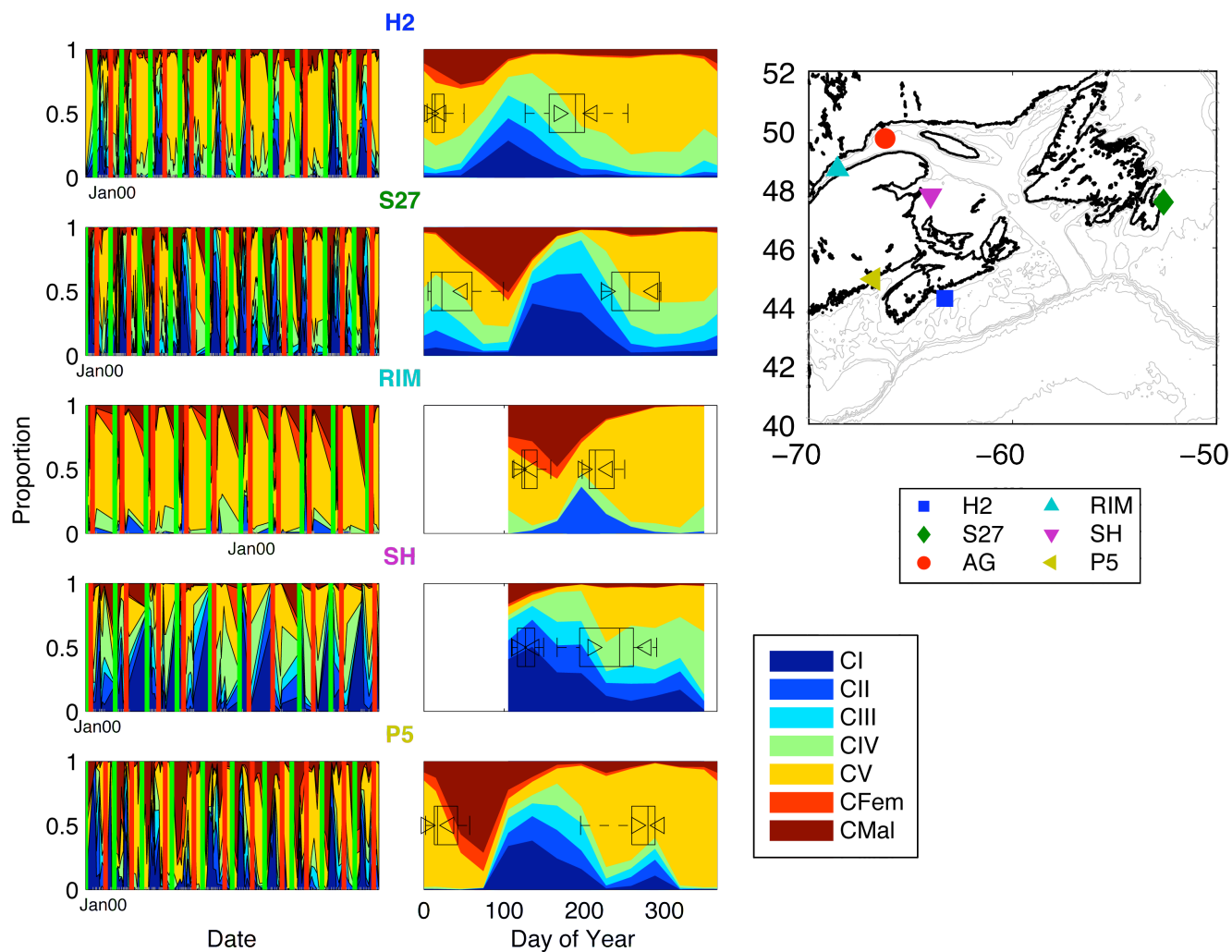
Pulse Station B

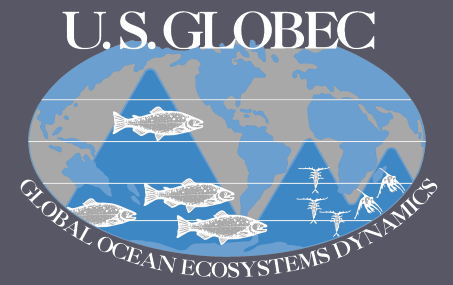


Pulse Station S



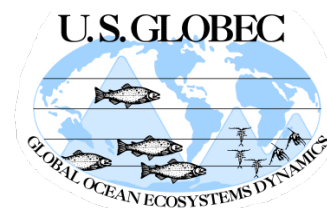
AZMP Time Series Data





Egg production

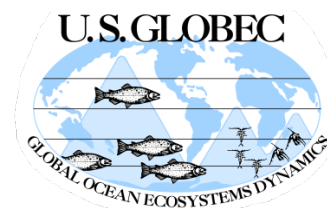
Data and goals



Egg Production metrics I

- ▶ Egg production rate (EPR)
 - ▶ Eggs female⁻¹ day⁻¹
 - ▶ Mass specific rates: %C day⁻¹ , %C day⁻¹
- ▶ Relate to Chlorophyll *a* → Ivlev function
 - ▶ cf. Runge et al. 2006
- ▶ Critical concentration → 90% of the fitted maximum EPR.



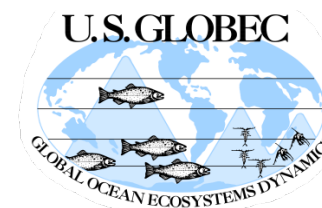


Egg Production metrics II

- ▶ **Also test**
 - ▶ Mixed layer temperature
 - ▶ Other measures of food availability

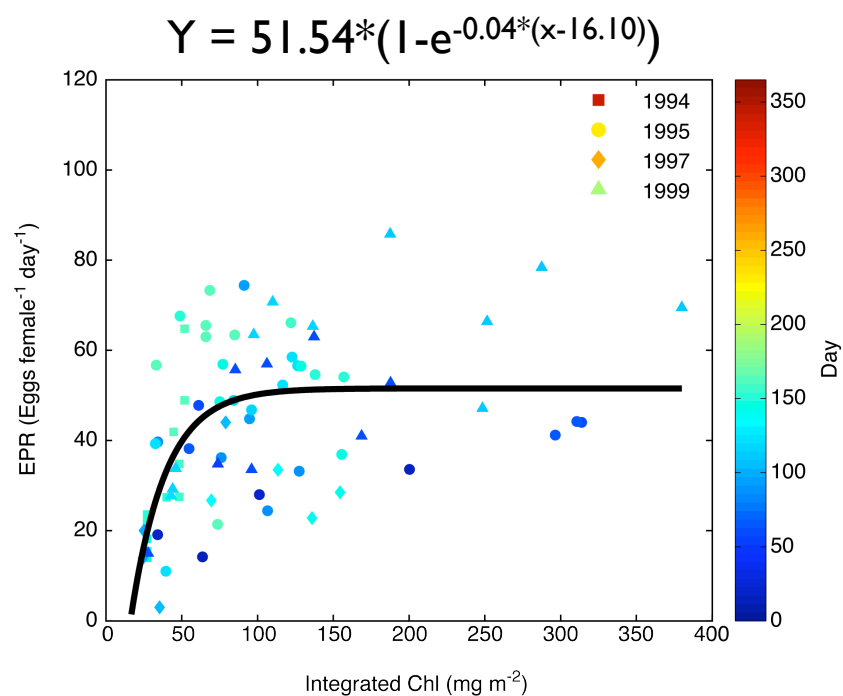
- ▶ **Generalized linear model (GLM) approach (Bonnet et al. 2005)**
 - ▶ Predictors are
 - ▶ Mixed layer temperature
 - ▶ Chlorophyll a concentration
 - ▶ Latitude, longitude
 - ▶ Time of year



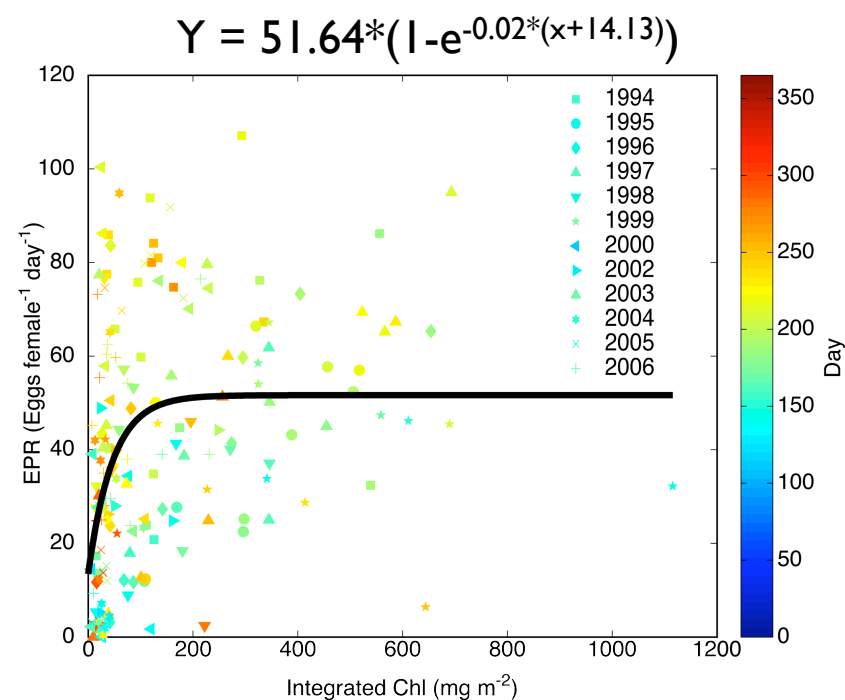


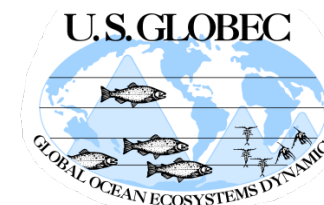
EPR Relationships II

Georges Bank

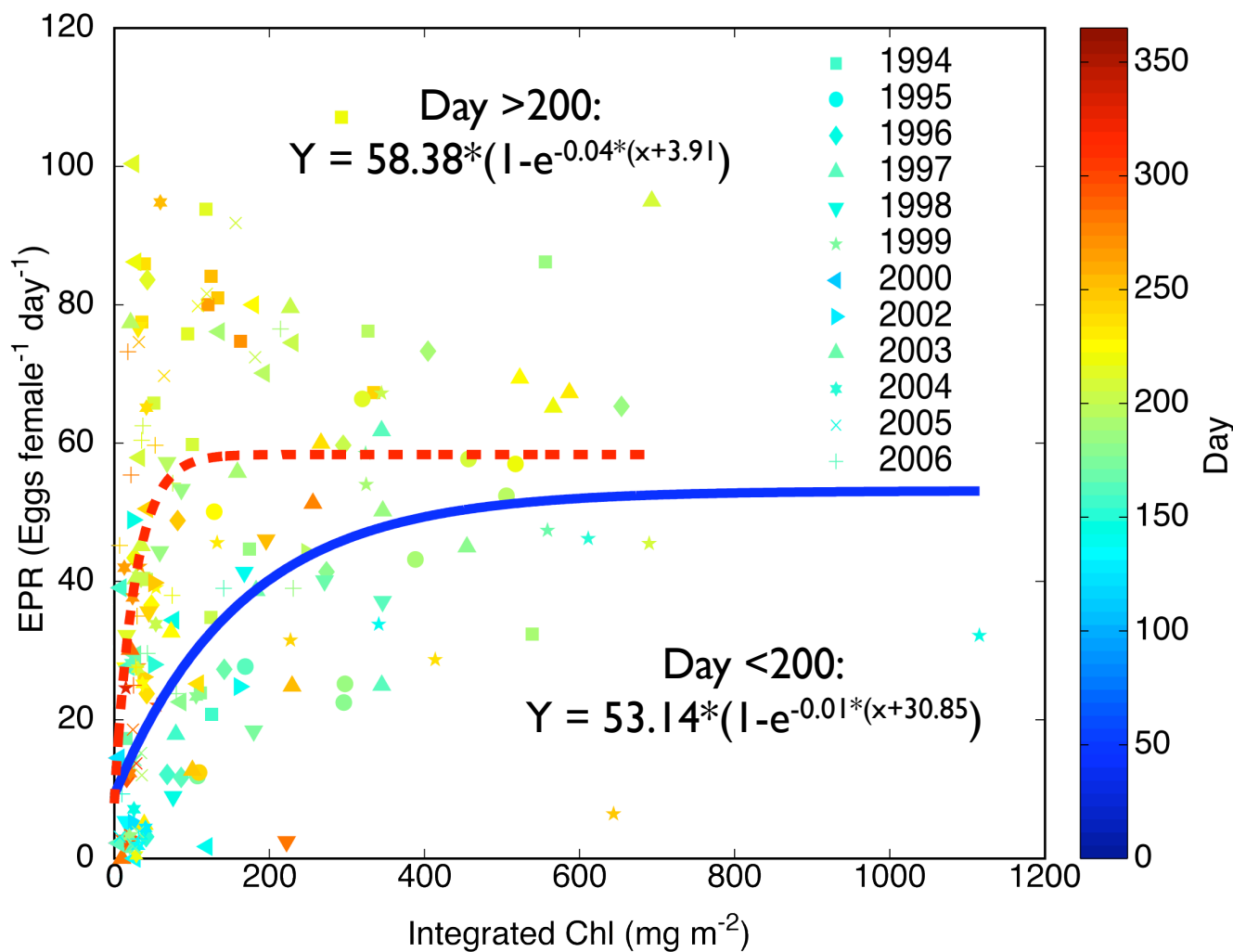


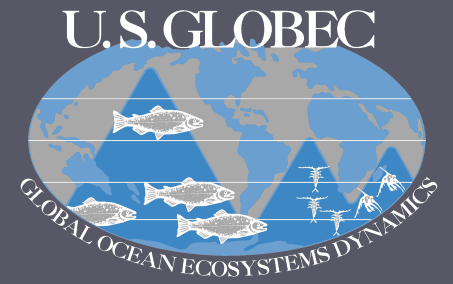
Gulf of St. Lawrence



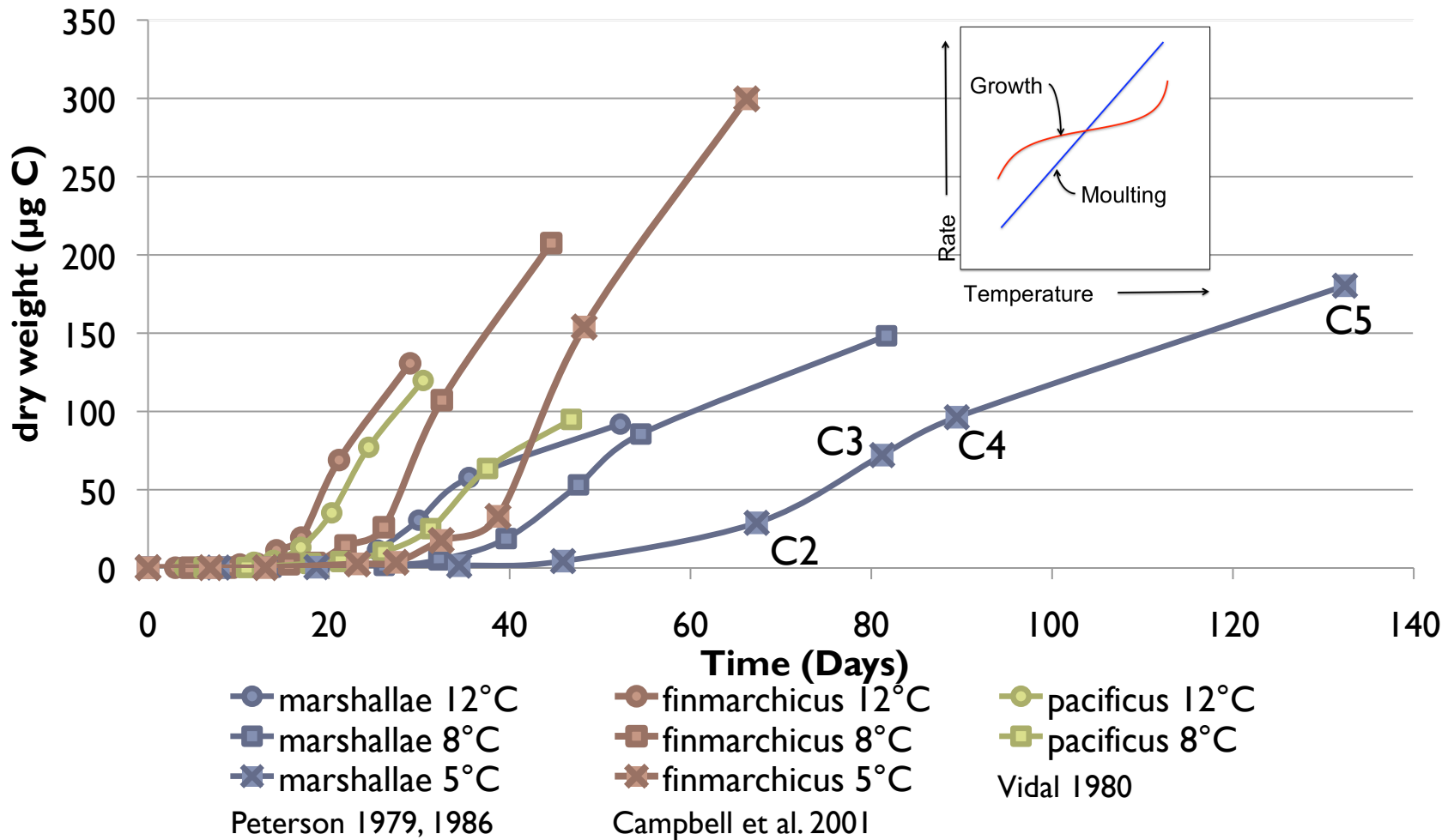
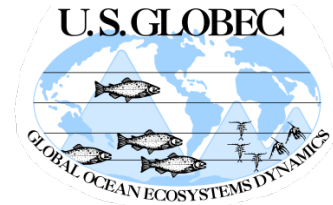


GSL: Seasonal differences?





Growth and Development



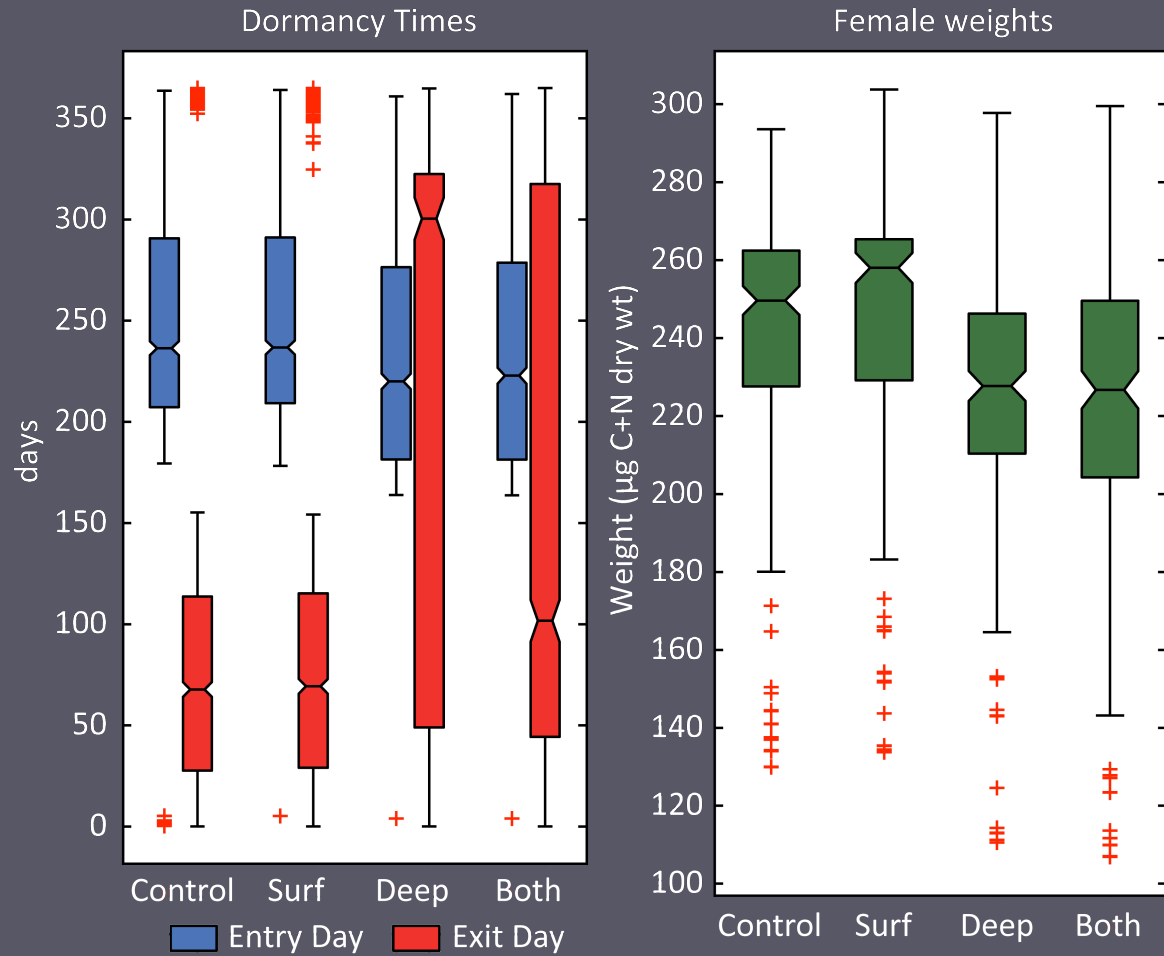
Leising unpublished

IBM suggests dormancy changes vary with warming water scenarios

C. Finmarchicus forced with climatology from Anacosti Gyre (AZMP).

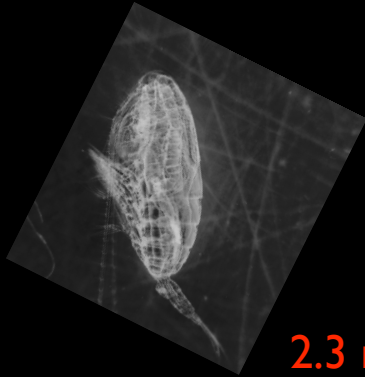
2°C warming in upper and/or deep layers

Earlier exit from dormancy by >60 days



Relative sizes of 4 ♀♀ *Calanus* spp.

Sizes scaled to 8°C



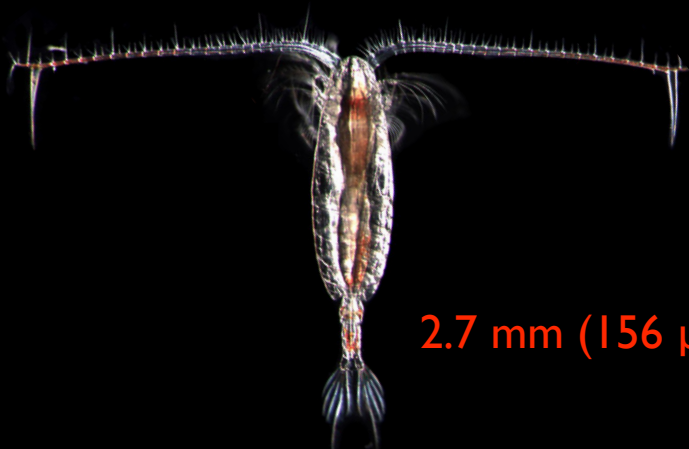
2.3 mm (90 µg C)

pacificus (Pierson)



2.4 mm (100 µg C)

helgolandicus (Morgane Gallinari)



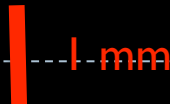
2.7 mm (156 µg C)

marshallae (Hopcroft)



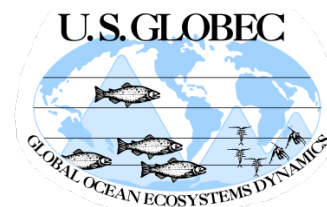
2.9 mm (200 µg C)

finmarchicus (Dan Mayor)



1 mm





Dormancy Metrics

Johnson et al. 2008 ICES J. Mar. Sci

▶ **Dormancy onset:**

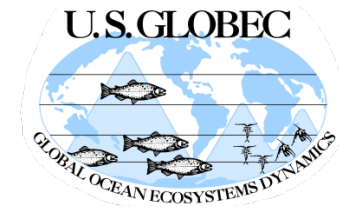
- ▶ “...date when the proportion of CVs in the population rose to half its overall maximum, calculated as each year’s maximum CV proportion averaged over all years at that station.”

▶ **Emergence:**

- ▶ “...first date when adults were more than 10% of the population of stages from copepodid stage I to adult.”
- ▶ “...back-calculating the spawning dates of the first early copepodid stages to appear in spring.



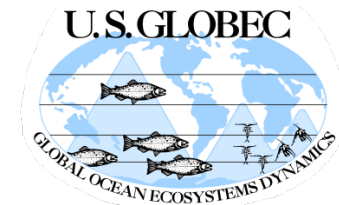
Calanus Demographic data: proposal list



Study	Location	Temp. resolution	Horiz. resolution
PULSE Runge (unpubl.)	(Jeffrey's Ledge)	weekly	one station
GLOBEC	Georges Bank	monthly	ca. 40-50 km
AZMP	Scotian Shelf / Shelf / Anticosti Gyre (GSL)	monthly/ bi-monthly	one station
Plourde et al. (2001, 2002, unpubl.)	Lower St. Lawrence Estuary (LSLE)	bi-monthly composite	one station / grid of 29 stations
TASC	E. Atlantic	monthly / several months	ca. 10s-100s kms
Hirst et al (2007)	English Channel	weekly	one station
Lindeque et al (2006)	Irminger Sea	several months	ca. 10s-1000s km
Gislason & Astthorsson (1996, 1998) Gislason et al. (2000, 2007) Astthorson & Gislason (2003)	Iceland	monthly/ bi-monthly	several stations



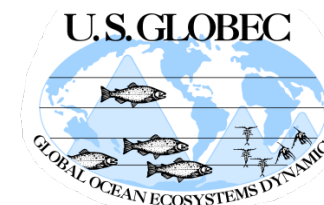
Egg production data: Proposal List



Species & Location	Reference
<i>Calanus</i> spp.	Harris et al 2000
<i>Calanus finmarchicus</i>	Melle and Skjoldal 1998
Faroe shelf	Rey-Rassat et al. 2002a Debes and Eliassen Ohman and Runge 1994 Plourde and Runge 1993 Plourde et al. 2001 Starr et al. 1999
Icelandic shelf	Gislason 2005 Gislason and Astthorsson 2000 Mayor et al. 2006 Biegala et al 1999 Hirche et al 1997 Koski 2007 Richardson et al. 1999 Jonasdottir et al 2005 Niehoff 2000 Niehoff et al 1999 Pasternak et al 2004
NW	Cabal et al 1997 Campbell and Head 2000 Runge and Plourde 1996
NW Atlantic/Georges Bank	Runge et al. 2006
NW Atlantic/GoM	Campbell et al. 2001 Durbin et al 1997 Durbin et al 2003 Jonasdottir et al 2002 Helland et al. 2003 Hirche 1996

Species & Location	Reference
<i>Calanus finmarchicus</i> (cont.) mesocosm	Nejstgaard et al. 1997 Nejstgaard et al. 2001
<i>Calanus helgolandicus</i>	Hirst et al 2007 Irigoien et al. 2000a Irigoien et al. 2000b Pond et al 2006 Rey-Rassat et al. 2004 Rey-Rassat et al. 2002a Rey-Rassat et al. 2002b Biegala et al 1999 Bonnet et al 2005 Jonasdottir et al 2005 Kang and Poulet 2000
<i>Calanus marshallae</i> upwelling	Peterson et al 2002 Gomez Gutierrez & Peterson 1999 Baier and Napp 2003
Chukchi/	Plourde et al 2005
<i>Calanus pacificus</i> upwelling	Gomez Gutierrez & Peterson 1999 Peterson et al 2002 Uye 1996
Puget Sound/Dabob Bay	Runge 1984 Frost 1988 Pierson et al 2005 Ohman et al 1998 Mullin 1991





TASC Time Series Data

