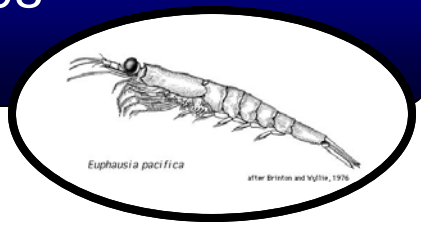


Modeled Krill Distribution in in the California Current, 1991 – 2008

Jeffrey G. Dorman[1], Thomas Powell[1], William Sydeman[2], Steven Bograd[3], Jarrod Santora[2]

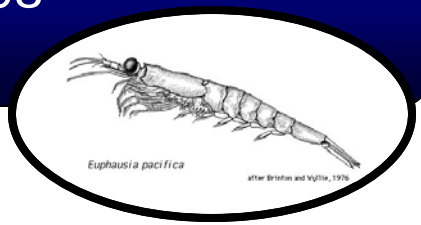
[1]University of California, Berkeley - Berkeley, CA

[2]Farallon Institute for Advanced Ecosystem Research - Petaluma, CA

[3]NOAA-NMFS, Environmental Research Division - Pacific Grove, CA

Modeled Krill Distribution in the California Current, 1991-2008

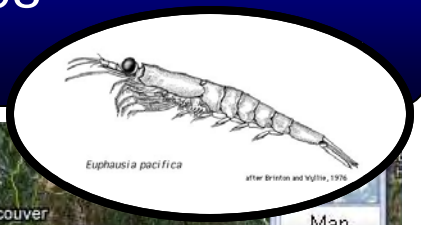
Roadmap

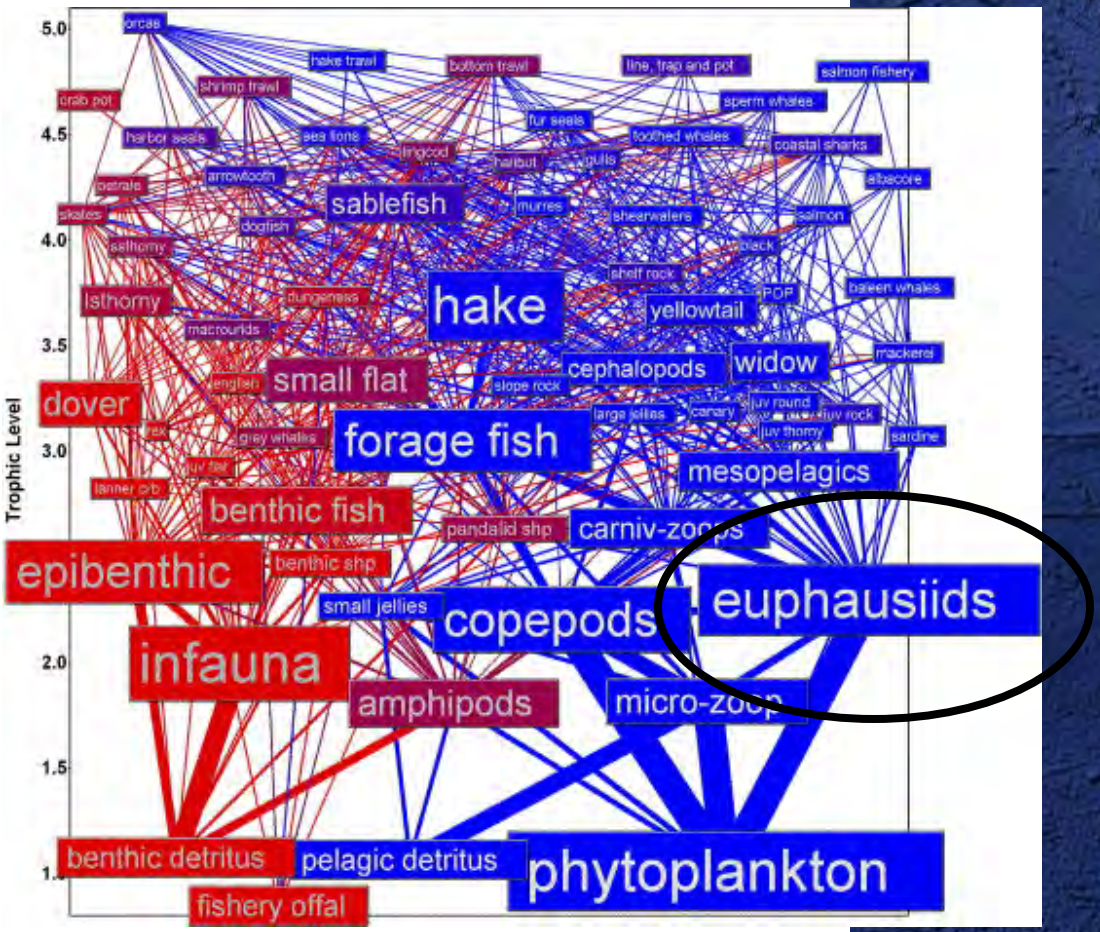


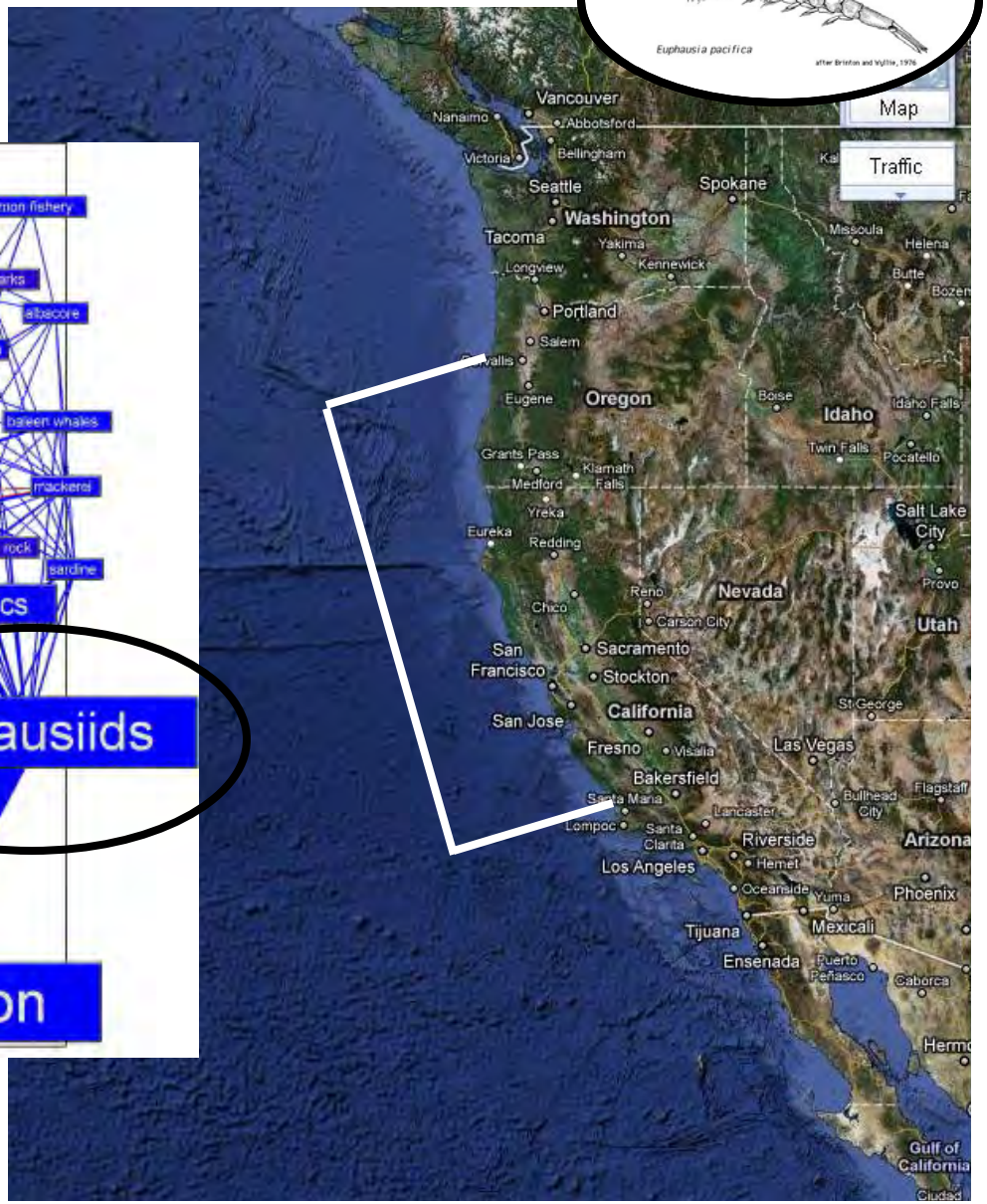
1. Overview of Study Area
2. Methodology
   - Ocean Model – ROMS
   - IBM – POPCYCLE
3. Results
   - Seasonal & Longer Trends
   - Links to Higher Trophic Levels
4. Concluding Thoughts

Modeled Krill Distribution in the California Current, 1991-2008

Overview of the Study Area



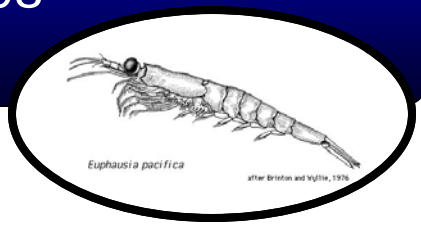




(Field JC et al., Prog Ocean, 2006 68:238-270)

Modeled Krill Distribution in the California Current, 1991-2008

Questions



Physical Forcing

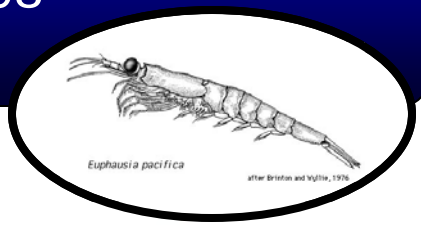
How do seasonal conditions impact krill abundance (mortality, advection) condition, and spatial distribution of krill respond to seasonal and long time scale forcing (i.e. Pacific Decadal Oscillation)?

Higher Trophic Level Connections

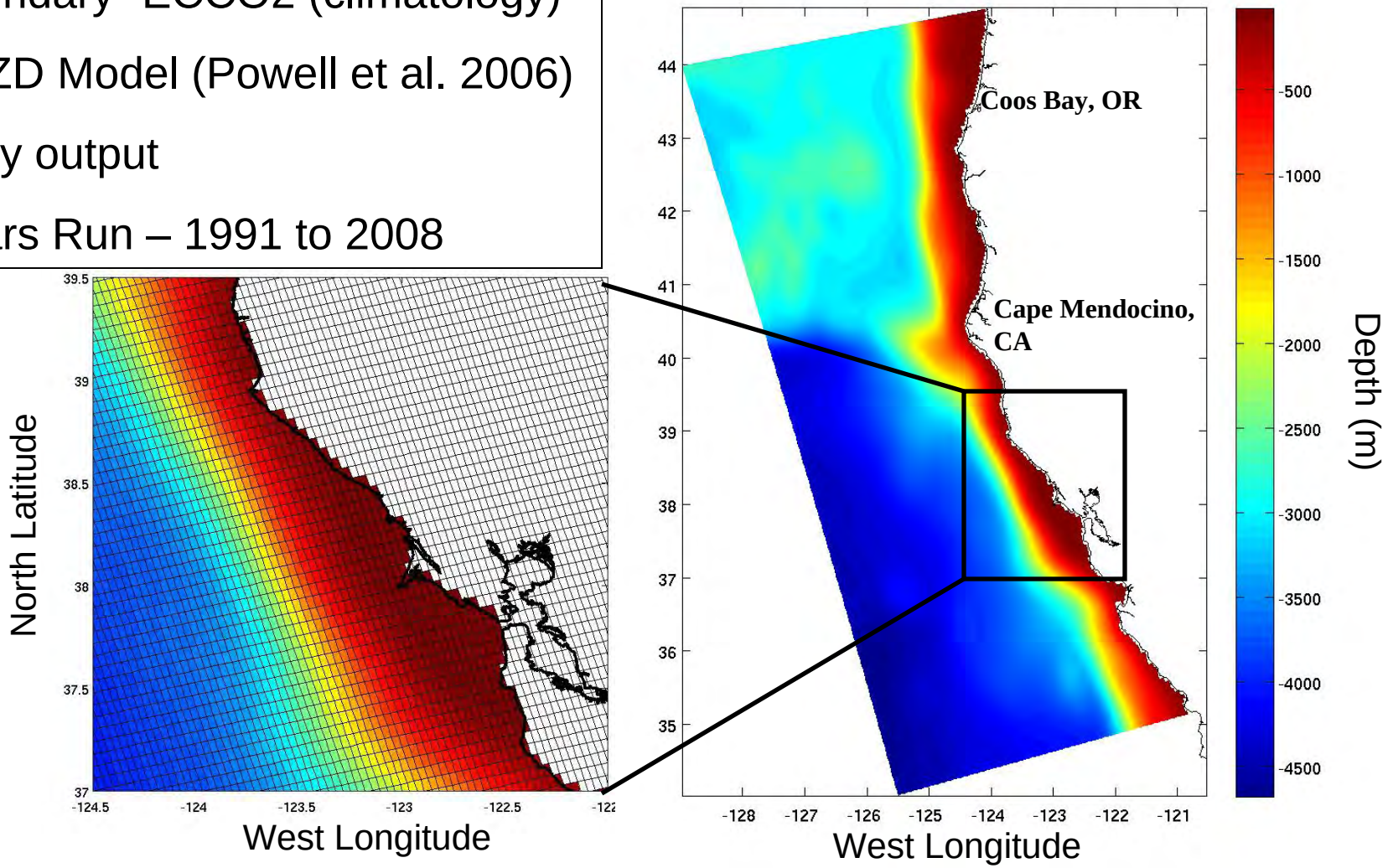
How does modeled krill correlate with higher trophic level indices (auklets and salmon)?

Modeled Krill Distribution in the California Current, 1991-2008

Methods – Regional Ocean Modeling System (ROMS)

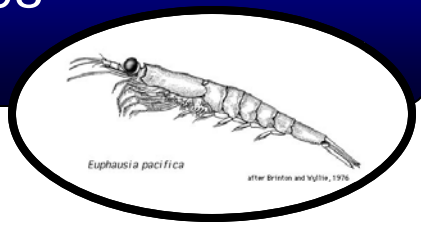


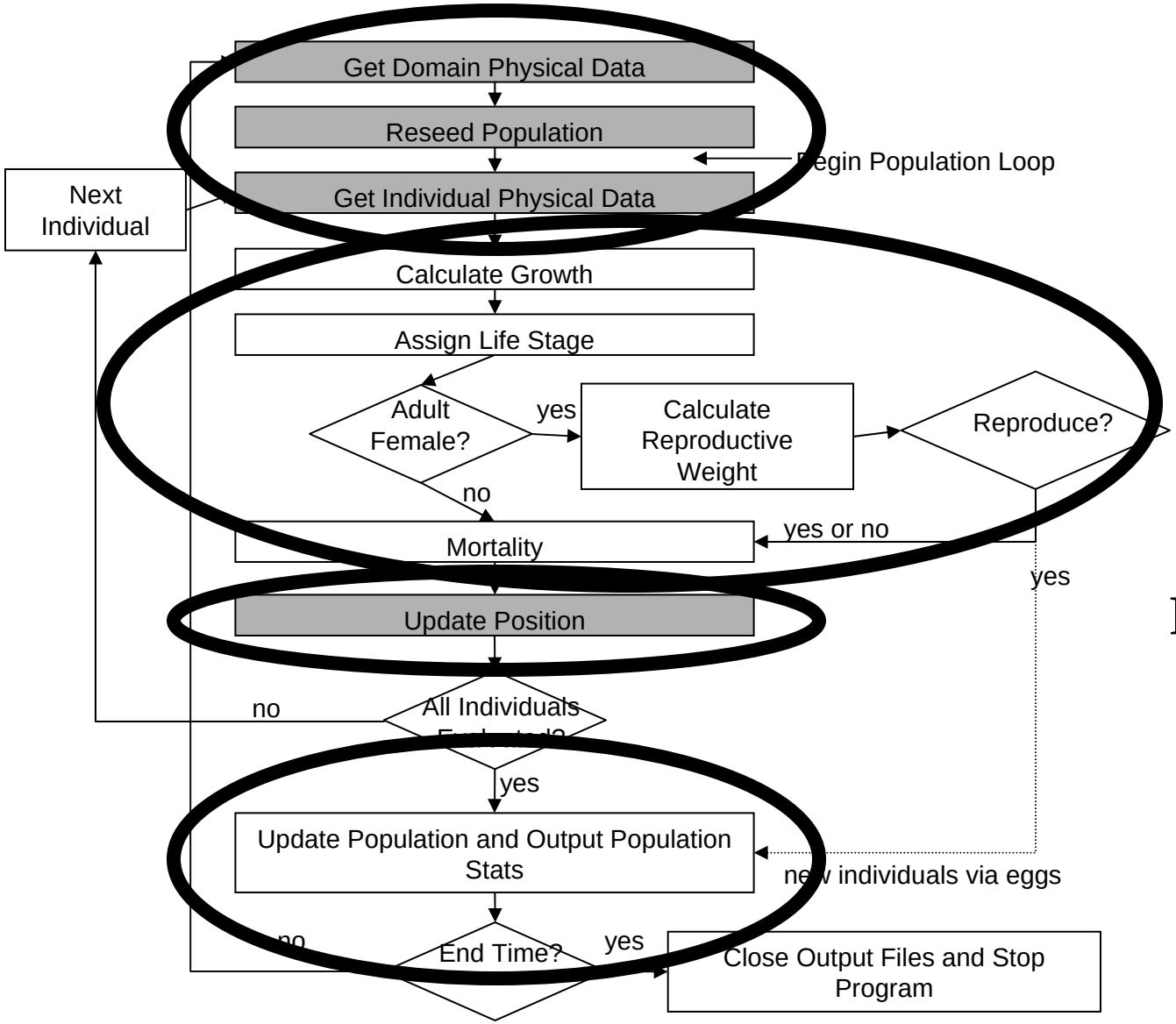
- -Forcing- NCEP-NARR (3hr)
- -Boundary -ECCO2 (climatology)
- -NPZD Model (Powell et al. 2006)
- -Daily output
- -Years Run – 1991 to 2008



Modeled Krill Distribution in the California Current, 1991-2008

Methods – Individual Based Model (POPCYCLE)





Get ROMS Data

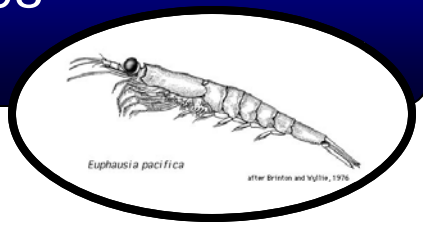
Bioenergetics

Particle Tracking

Output Data

Modeled Krill Distribution in the California Current, 1991-2008

Methods - Individual Based Model (POPCYCLE)



Bioenergetics

Egg Development
- Temperature Dependent

Growth
- Food & Temp. Dependent

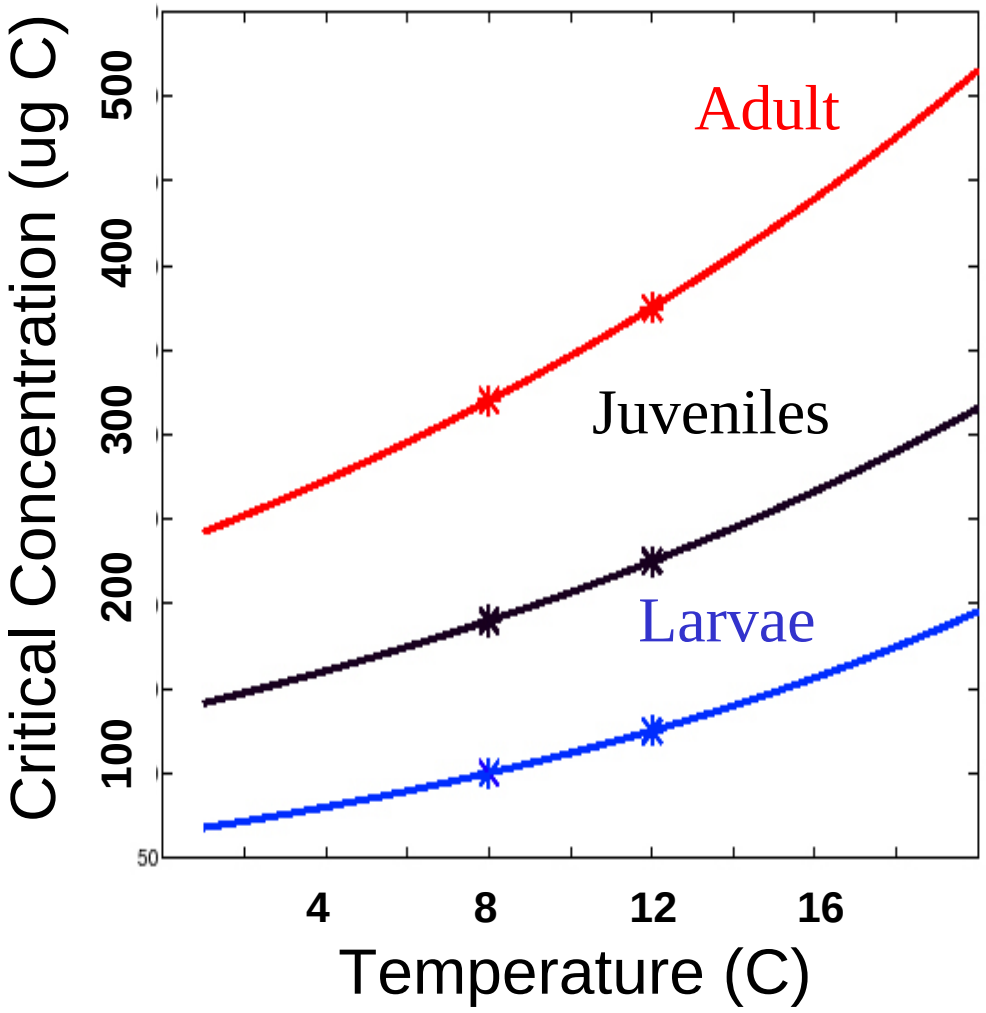
Reproduction
- Life Stage Dependent
- Growth & Time Dependent

Stage Progression
- Weight Dependent

Mortality

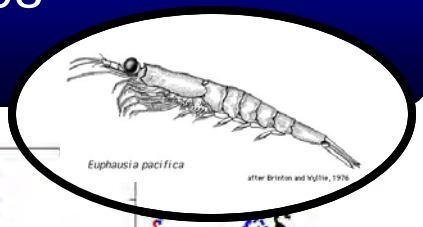
Predation

Starvation



Modeled Krill Distribution in the California Current, 1991-2008

Methods – POPCYCLE Initial Conditions



Initial Conditions

~ 10,500 particles
All Same Weight

Day 0

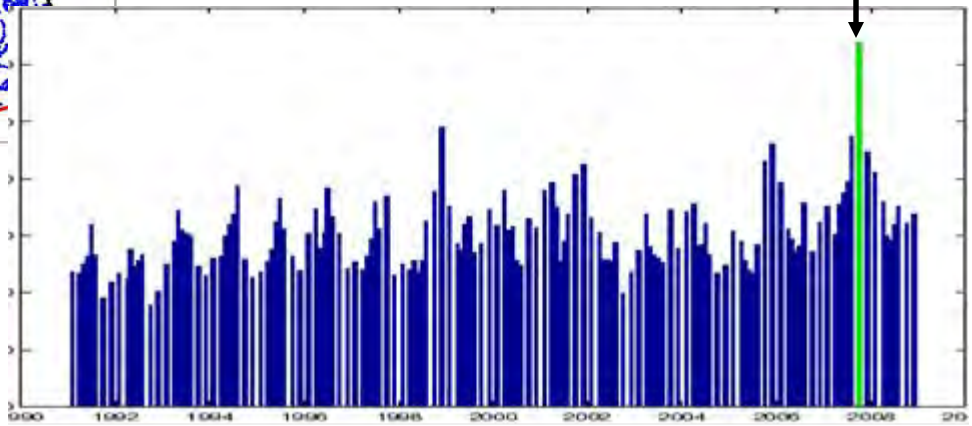
Day 25

Day 50

Day 75

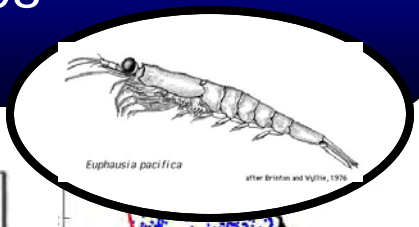
Day 100

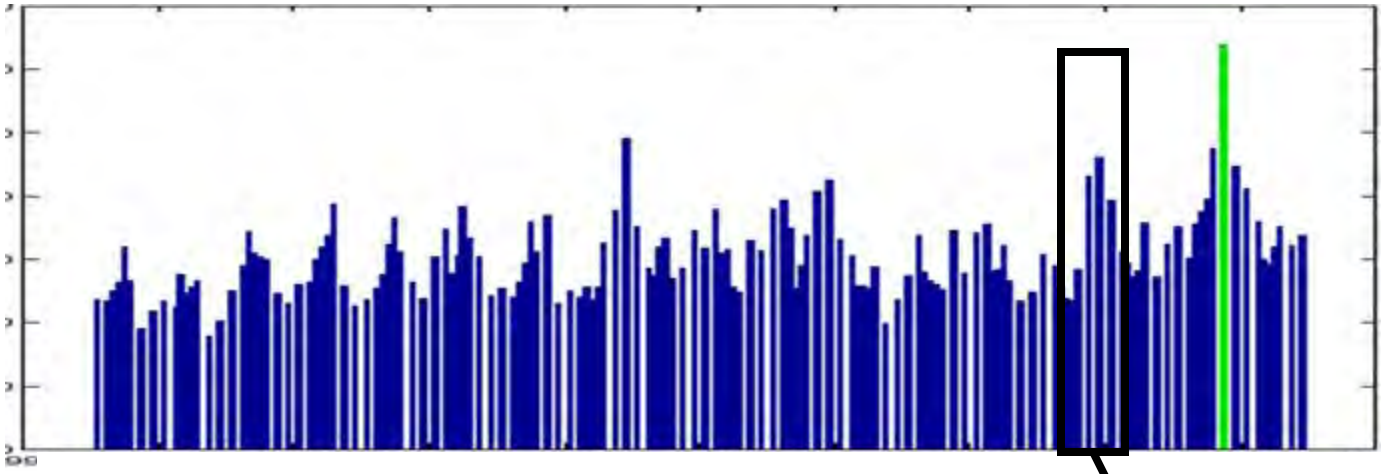
Day 180



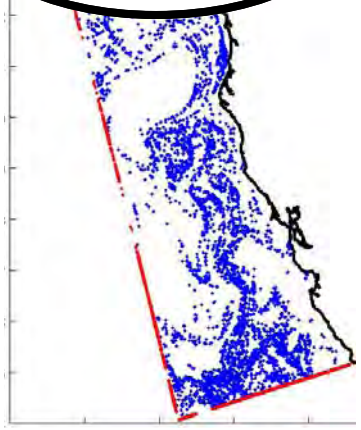
Modeled Krill Distribution in the California Current, 1991-2008

Methods – POPCYCLE Initial Conditions

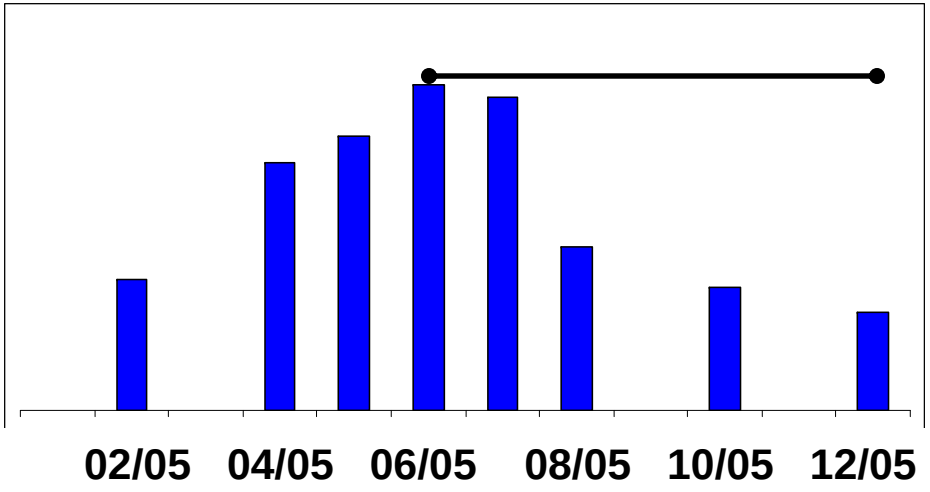




1991 2000 2008



Years Modeled: 1991 – 2008
Runs Per Year : 8
Initial Weight: Eggs or Adults

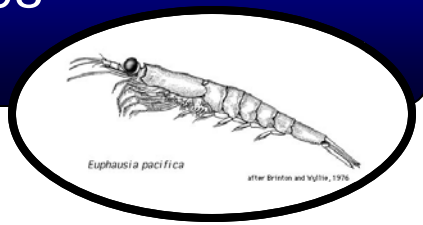


Data Products:

- Mean Particle Weight
- Mortality Numbers
- Number Advected

Modeled Krill Distribution in the California Current, 1991-2008

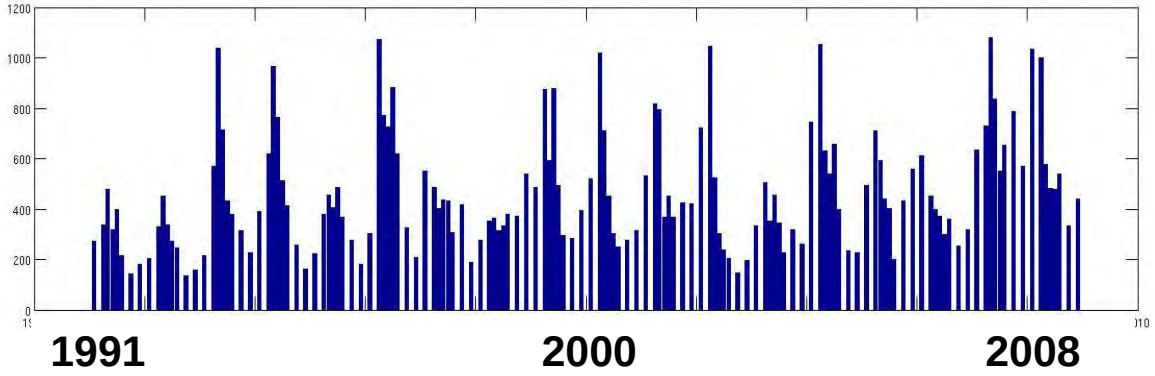
Results – Seasonal Trends



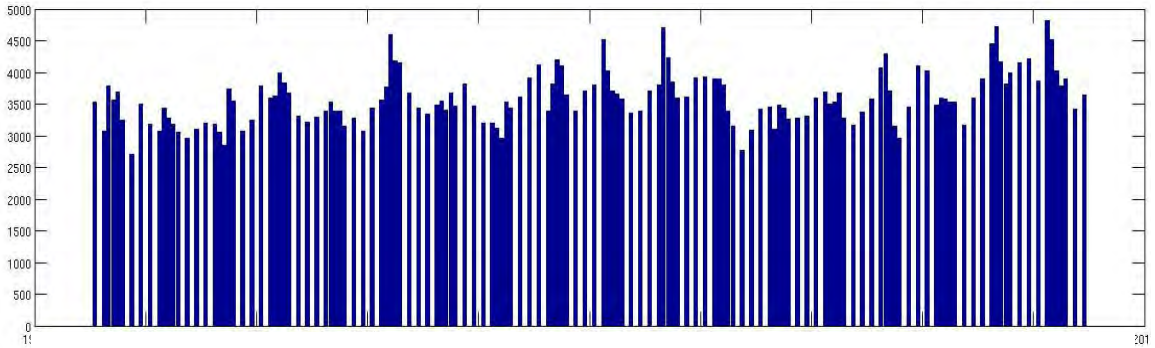
Seasonal Response

Growth

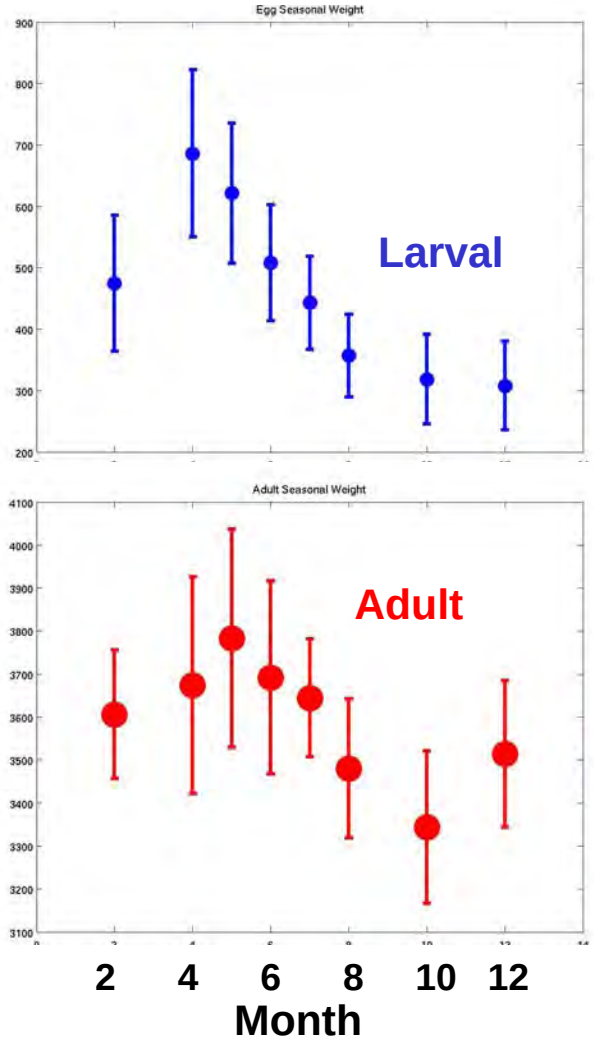
Larval Population Growth



Adult Population Growth

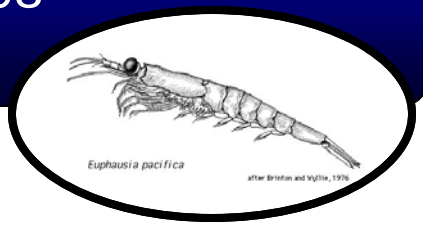


Monthly Mean Growth



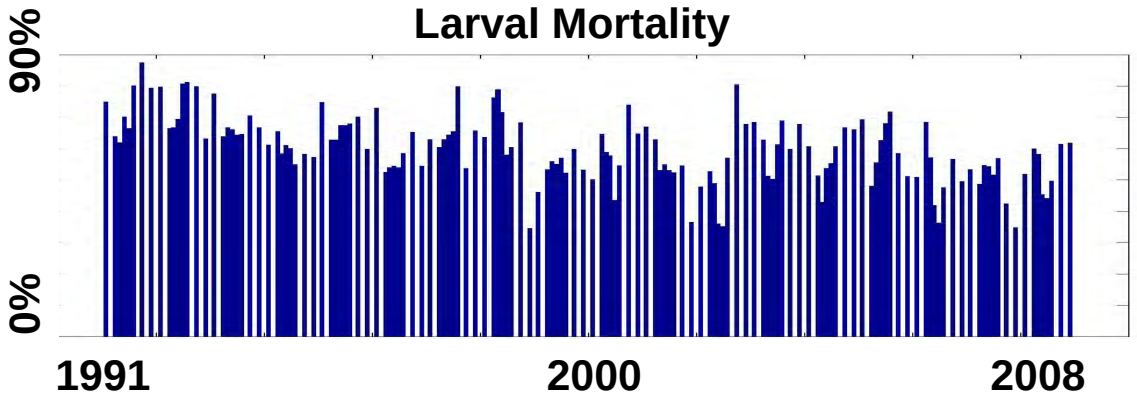
Modeled Krill Distribution in the California Current, 1991-2008

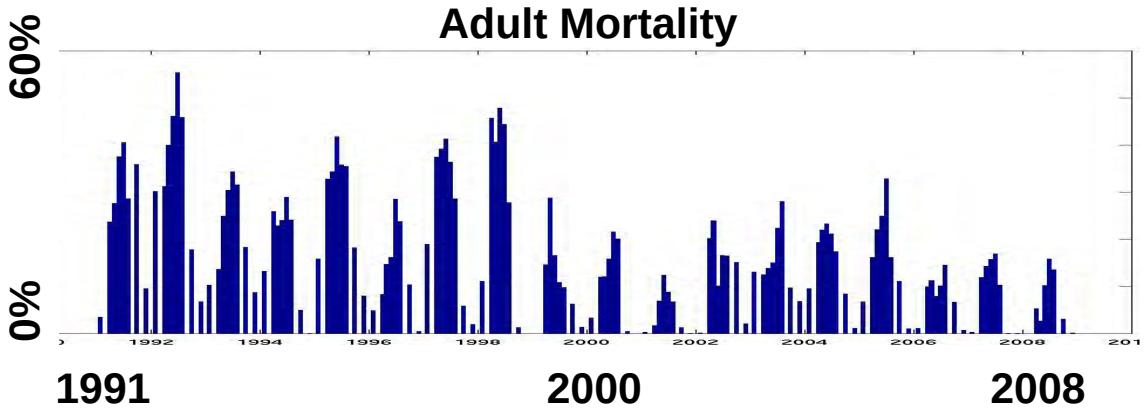
Results – Seasonal Trends

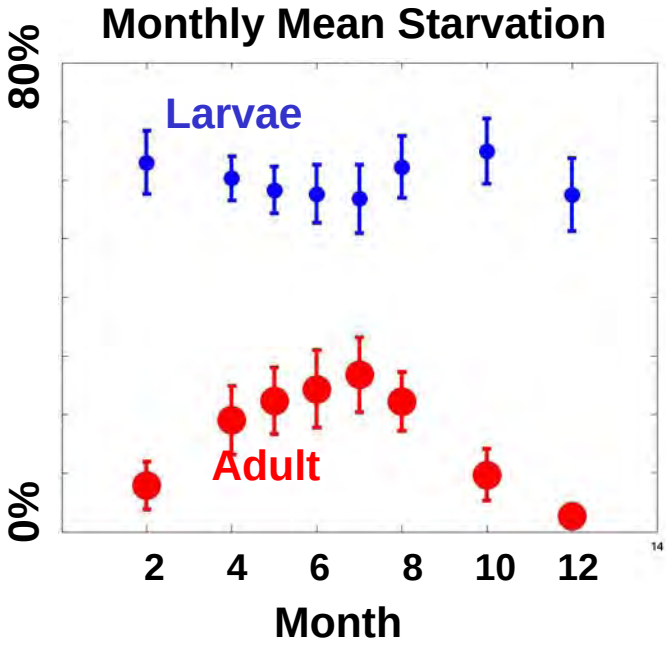


Seasonal Response

Mortality

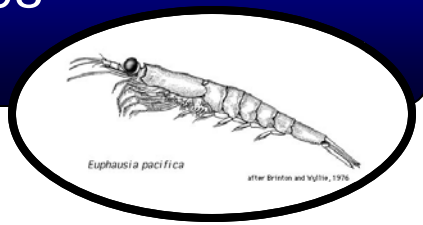


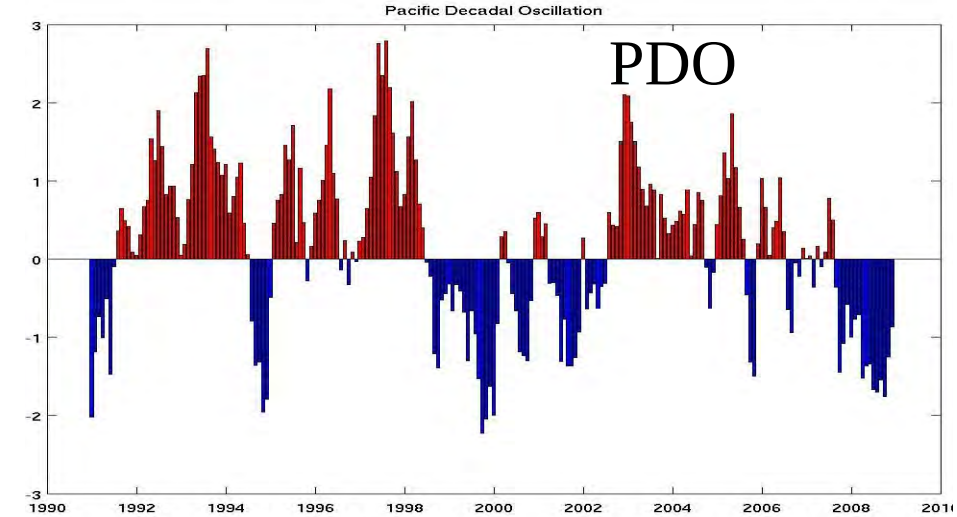




Modeled Krill Distribution in the California Current, 1991-2008

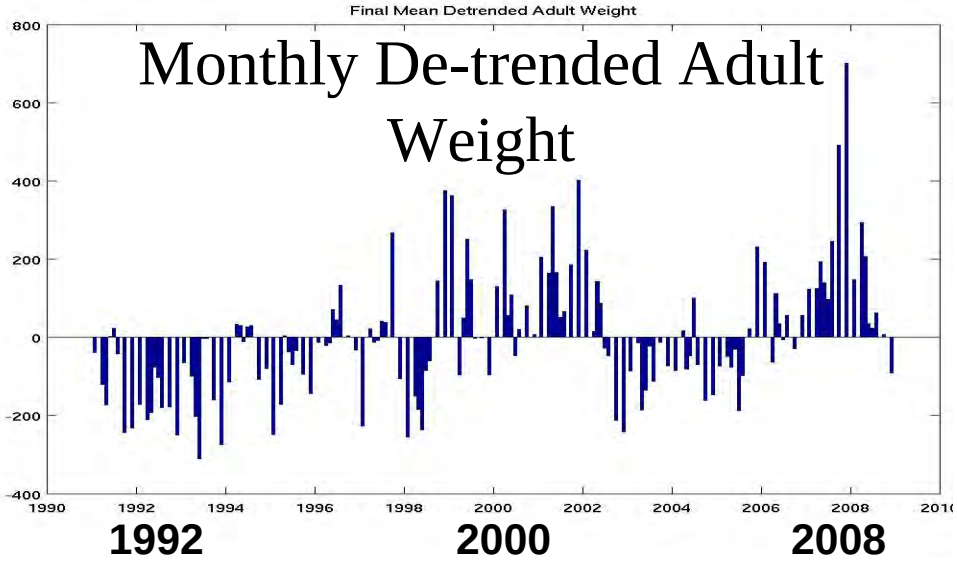
Results – Long Time Scale Trends (PDO)

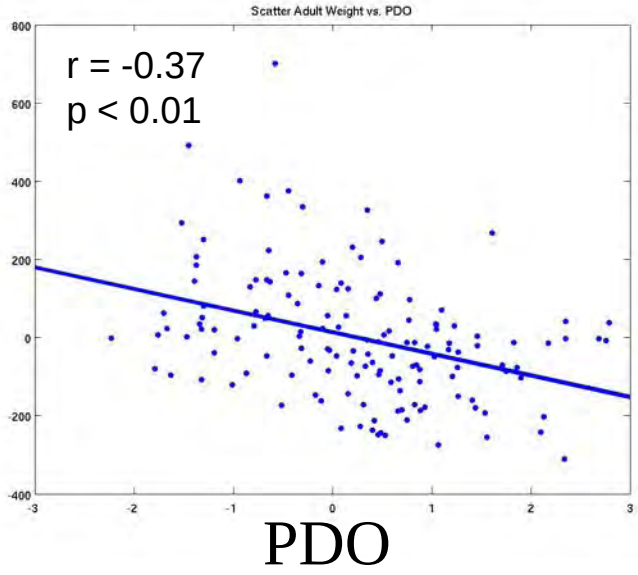




Long Time-Scale Response

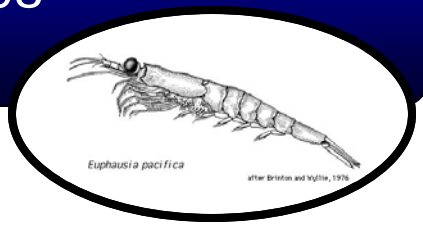
Growth

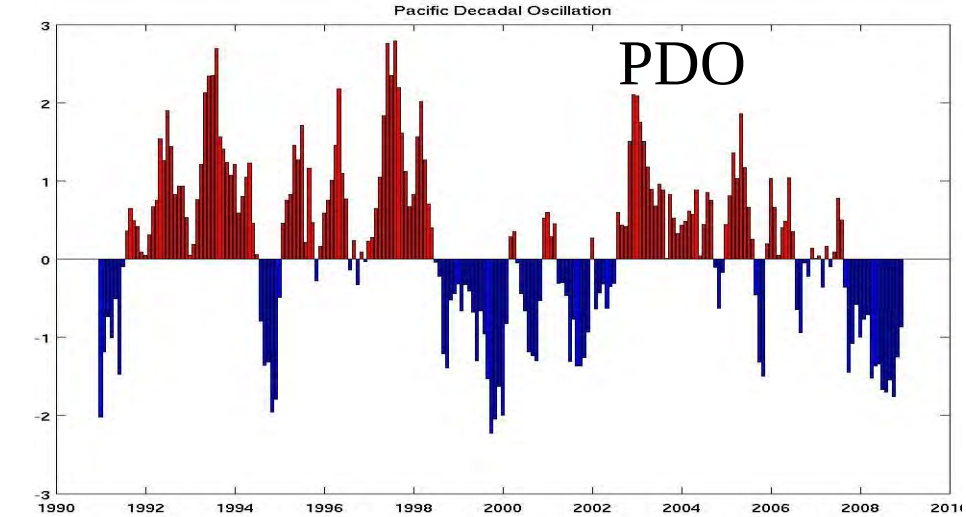




Modeled Krill Distribution in the California Current, 1991-2008

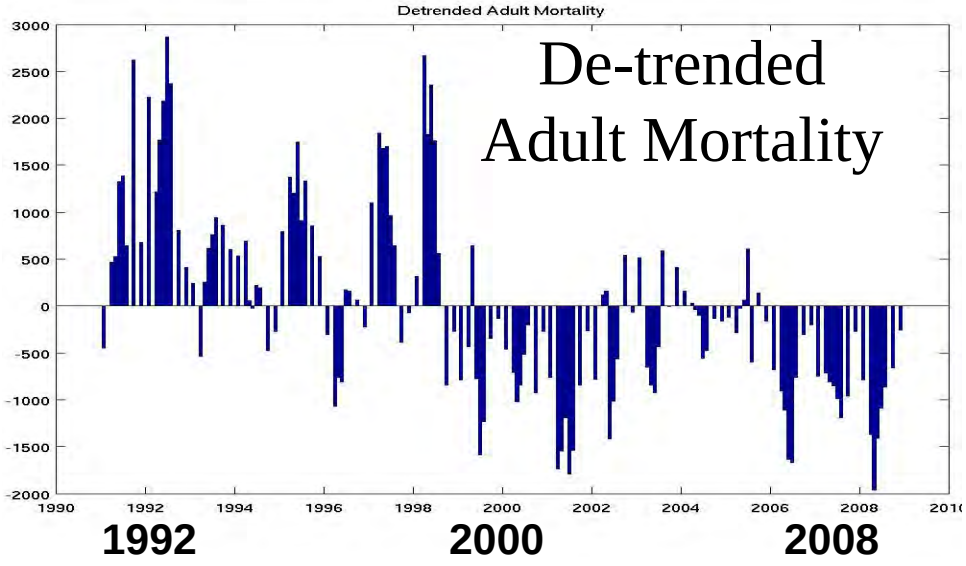
Results – Long Time Scale Trends (PDO)

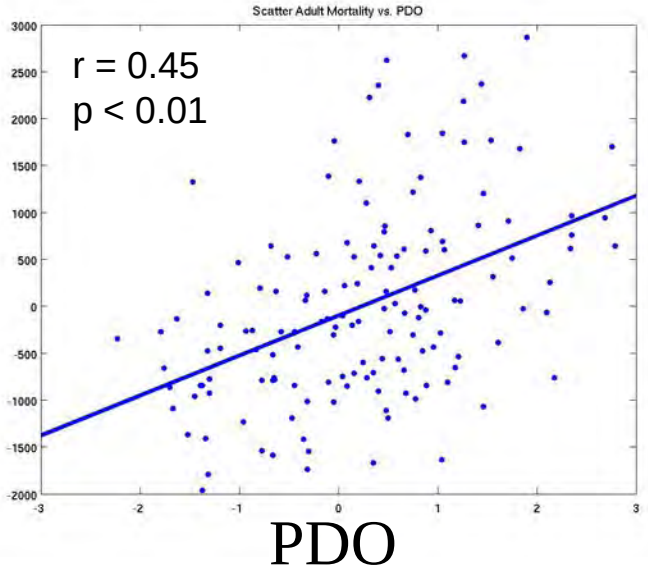




Long Time-Scale Response

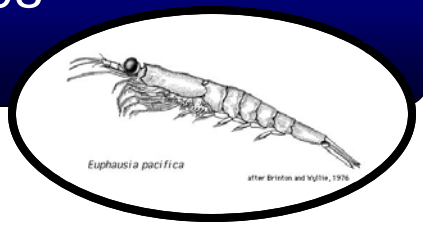
Mortality

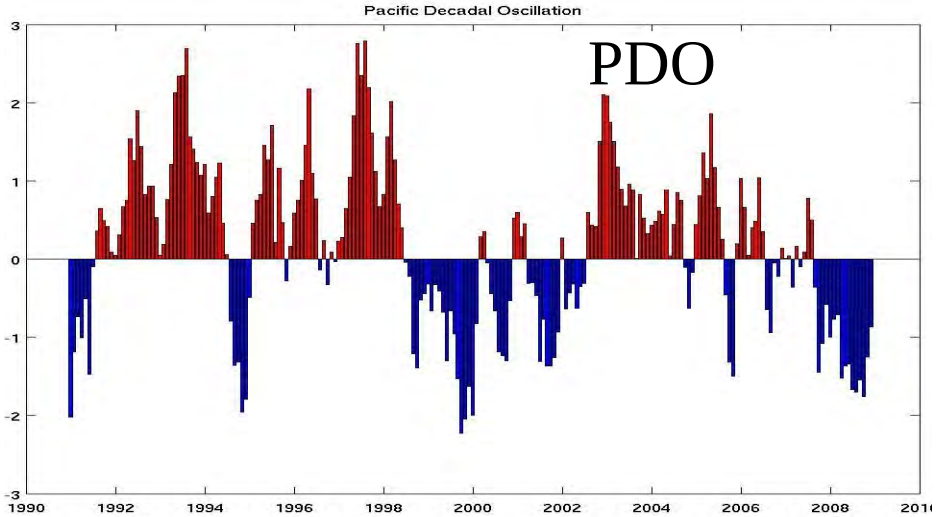




Modeled Krill Distribution in the California Current, 1991-2008

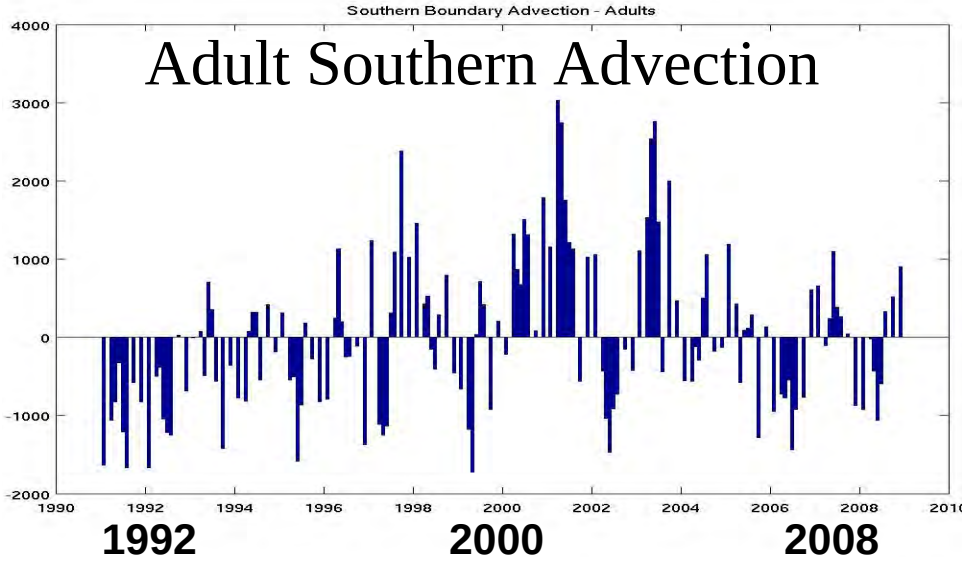
Results – Long Time Scale Trends (PDO)

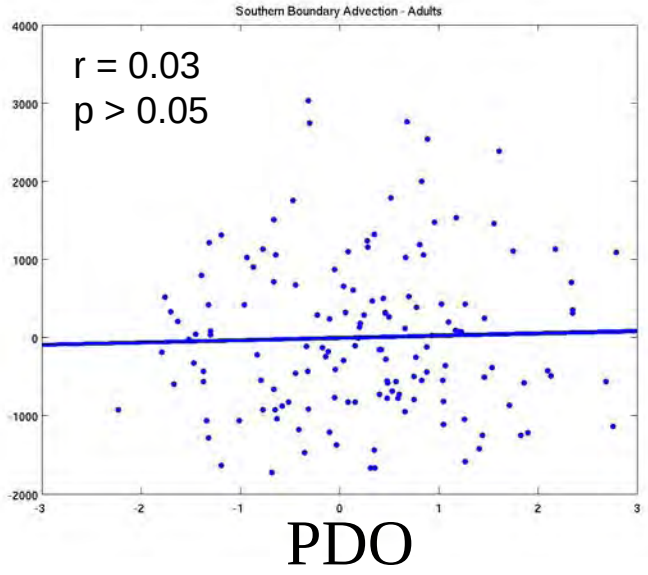




Long Time-Scale Response

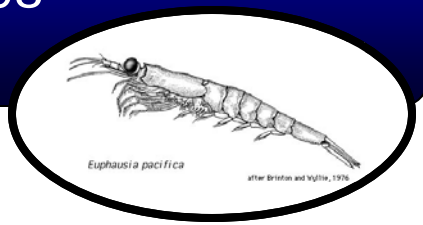
Advection





Modeled Krill Distribution in the California Current, 1991-2008

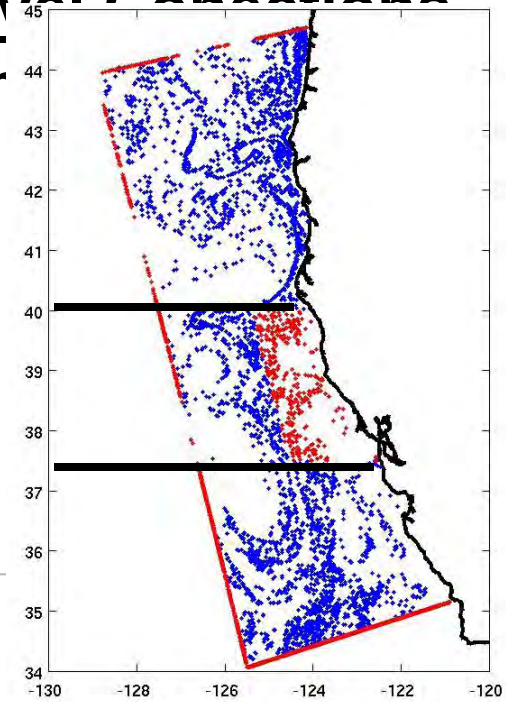
Results – Links to Northern California predators



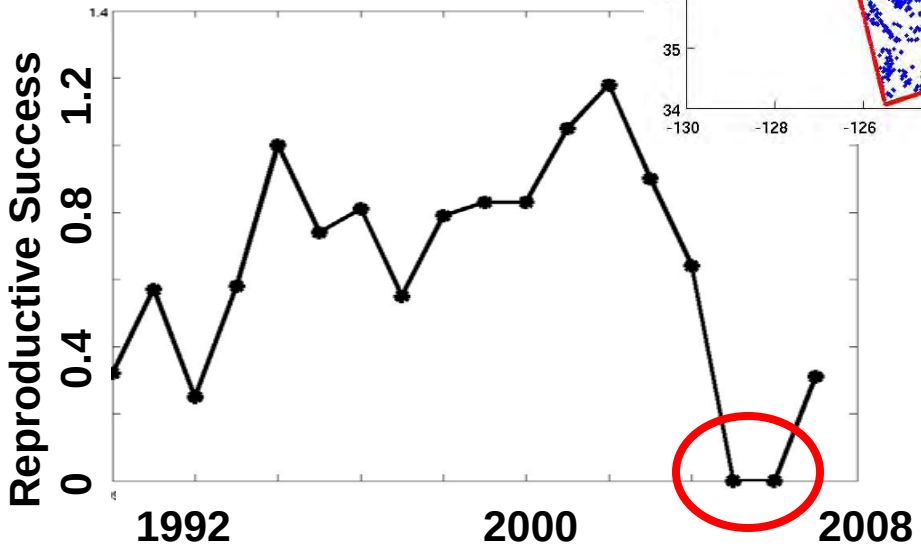
Higher Trophic Le[illegible] Connections

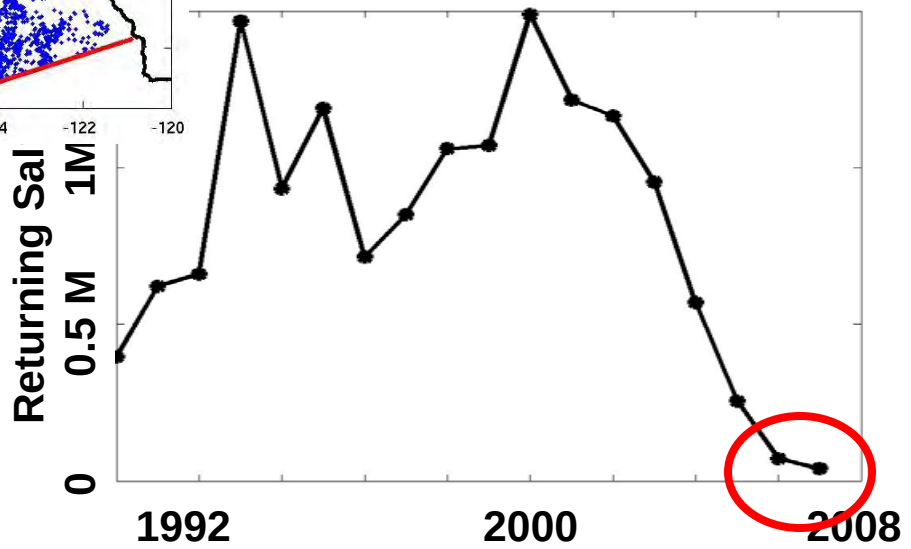
Northern Califrorr[illegible]

Cassins's Auklet



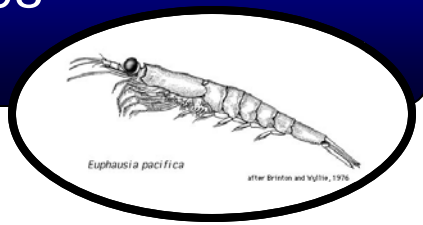
Chinook Salmon



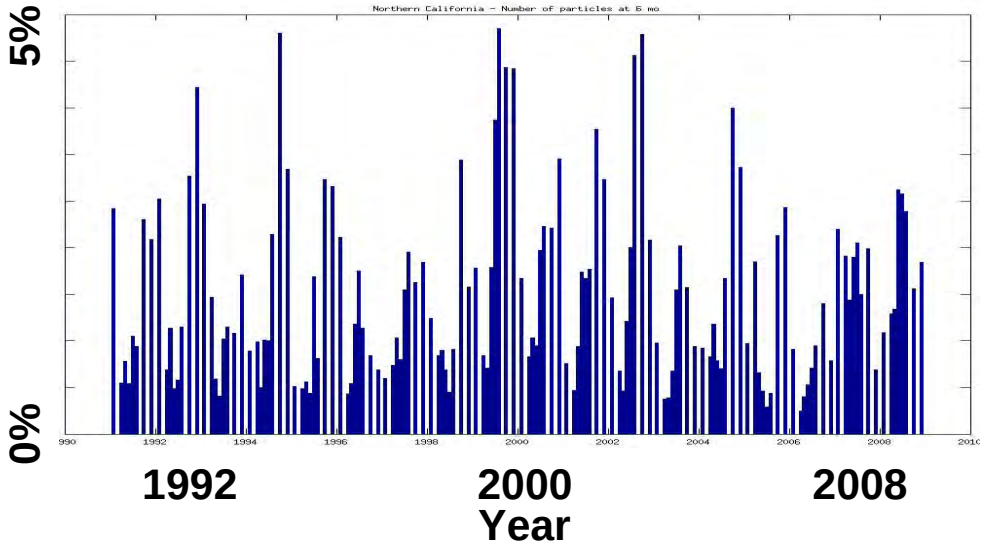


Modeled Krill Distribution in the California Current, 1991-2008

Results – Links to Northern California predators

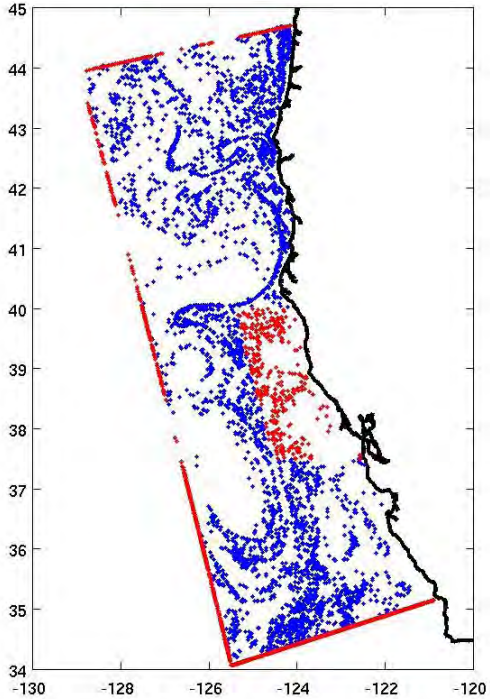


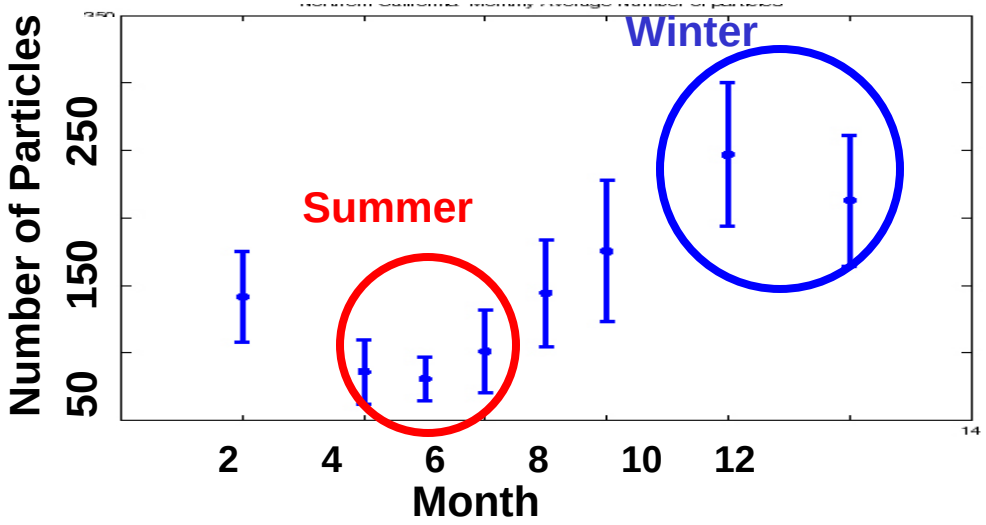
Number of Adult Particles



Northern California Region

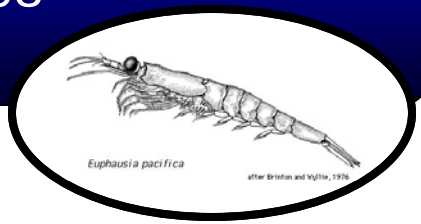
Particle Abundance





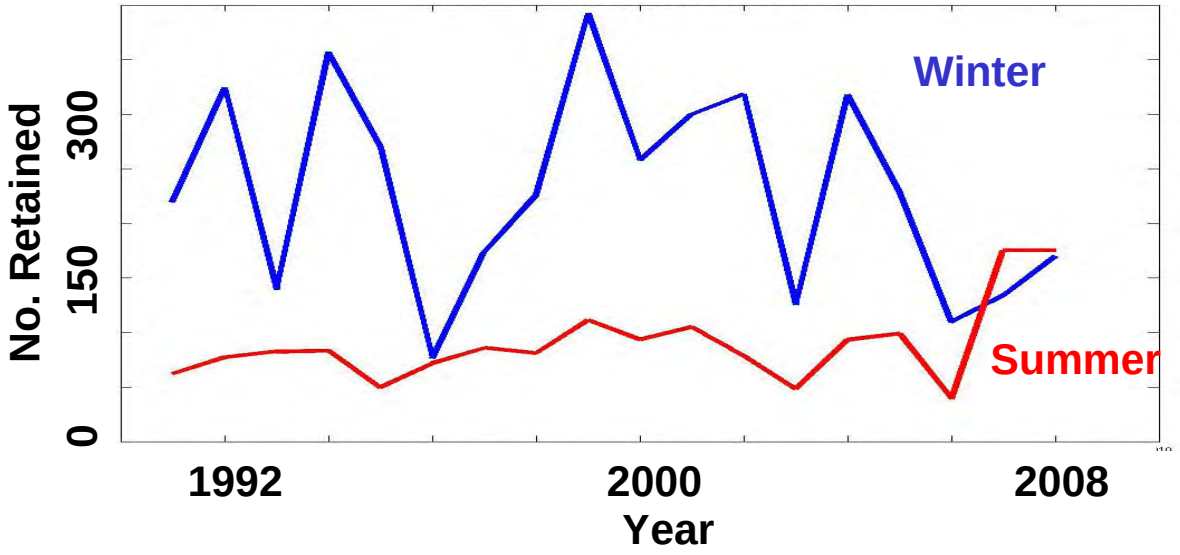
Modeled Krill Distribution in the California Current, 1991-2008

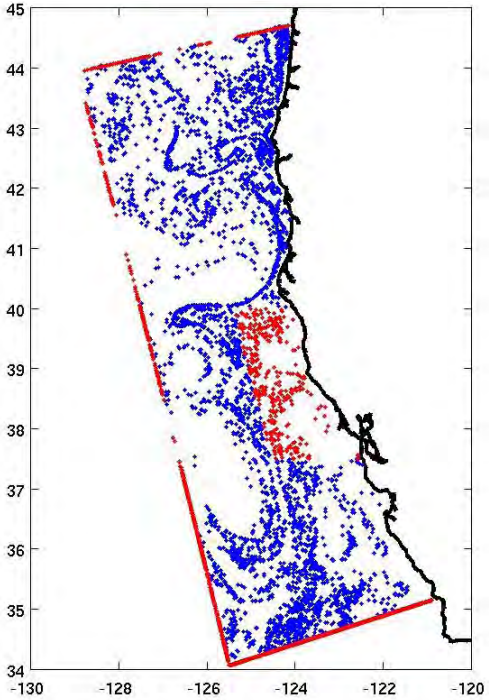
Results – Links to Northern California predators



Northern California Region

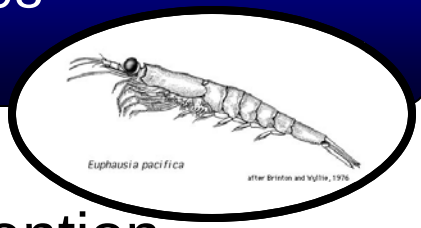
Winter Summer Number of Particles





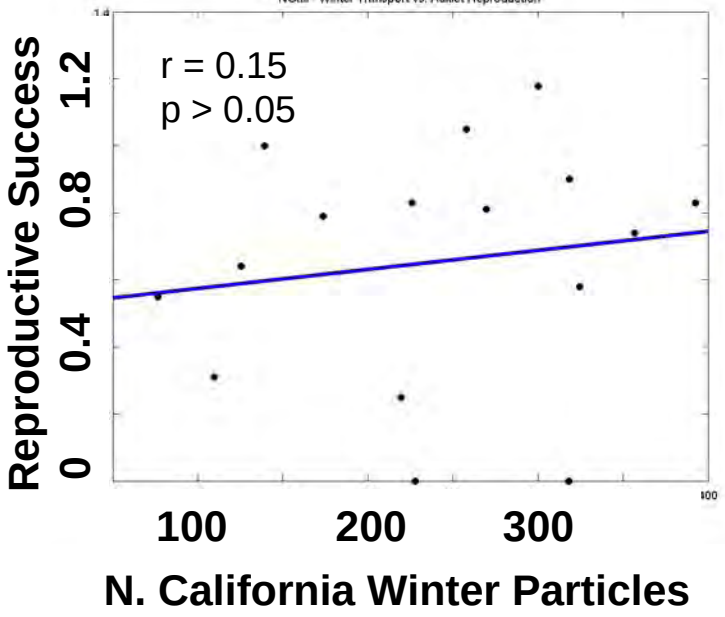
Modeled Krill Distribution in the California Current, 1991-2008

Results – Links to Northern California predators

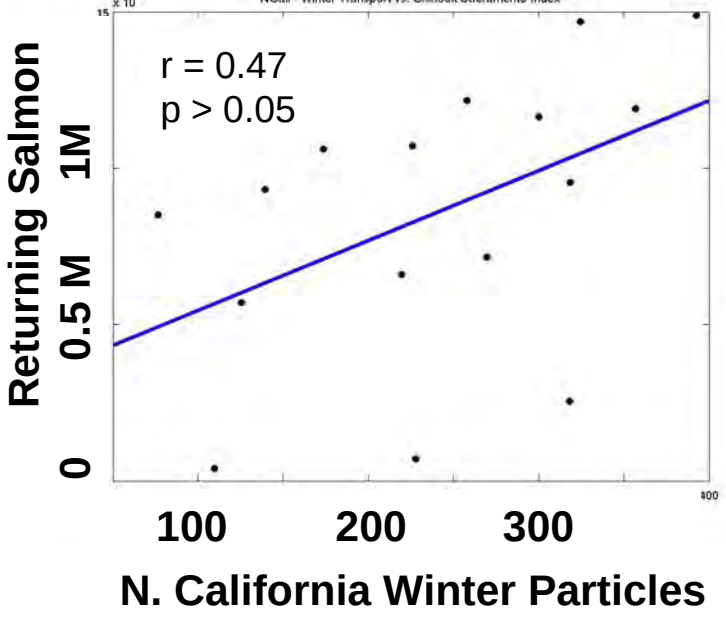


Northern California Region – Particle Retention

Cassins's Auklet

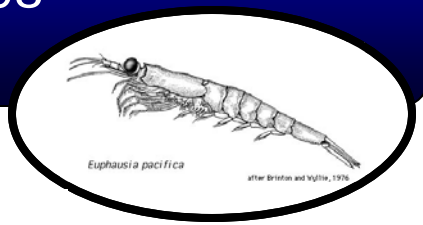


Chinook Salmon



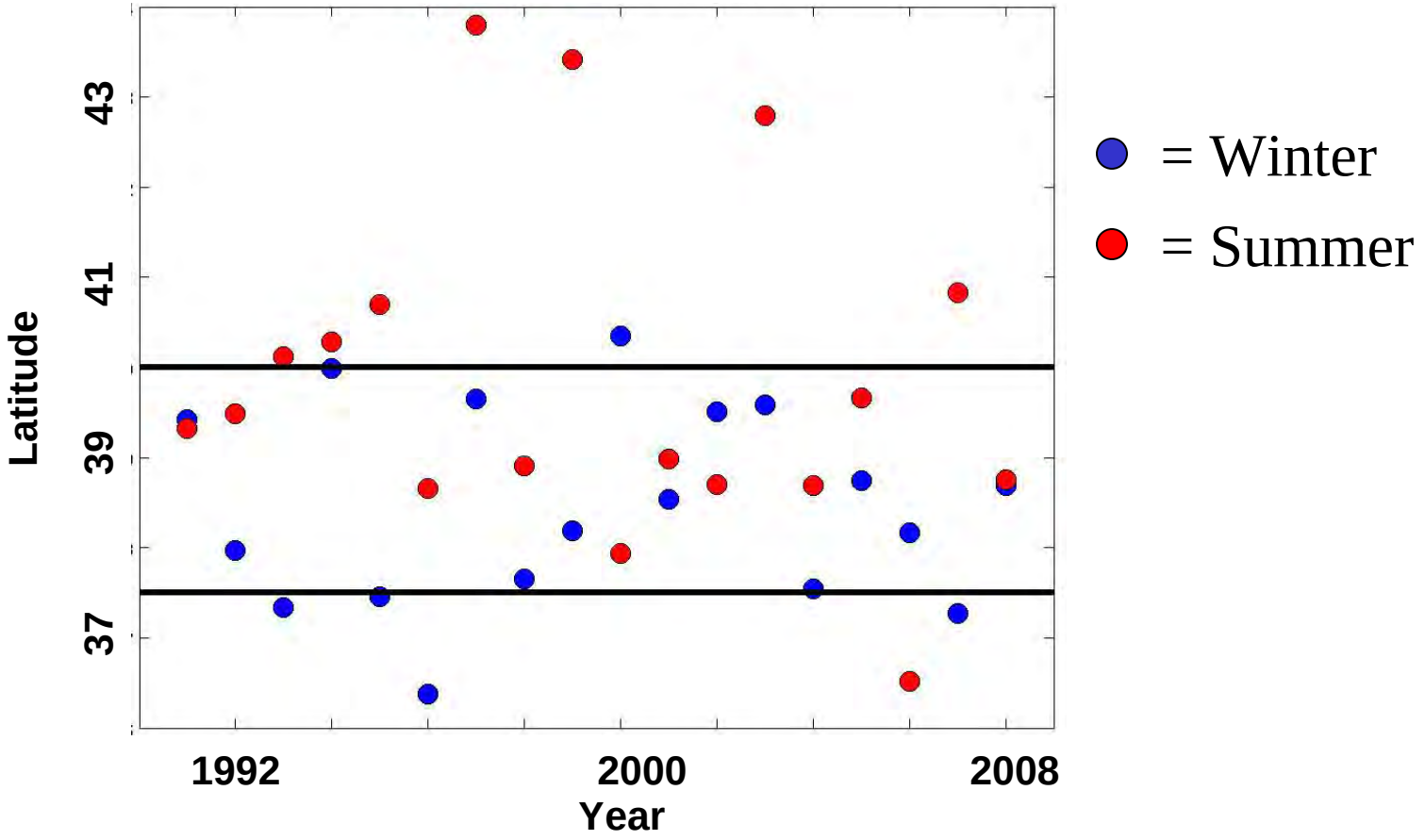
Modeled Krill Distribution in the California Current, 1991-2008

Results – Links to Northern California predators



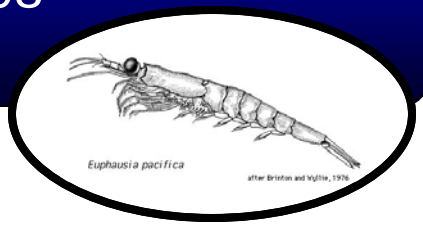
Northern California Region

Mean Start Latitude of Particles



Modeled Krill Distribution in the California Current, 1991-2008

Conclusions



! Different Responses of Adult and Egg Populations indicated the value of modeling *Euphausia pacifica* with an Individual-Based Model

Seasonal and Long-Time Scale Trends

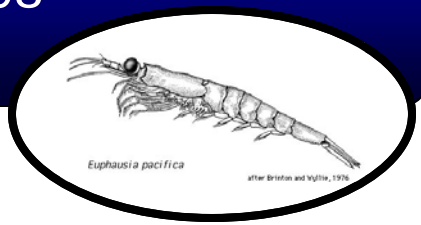
! Seasonal peaks in growth during upwelling season
! Peak adult mortality in summer due to temperature-driven higher metabolic demands offshore.
! Abundance and Condition of krill correlate with PDO. Advection does not.

Higher Trophic Levels

! Wintertime particle abundance in the Northern California Region correlates with predator success. Particles are primarily retained in the region, not advected into the region.

Modeled Krill Distribution in the California Current, 1991-2008

Acknowledgements



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Model Development

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- Hal Batchelder, Oregon State University

Data Sources

- National Centers for Environmental Prediction (NCEP)
- Estimating the Circulation and Climate of the Ocean (ECCO)
- National Aeronautics and Space Administration (NASA)
- Monterey Bay Aquarium Research Institute (MBARI)