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Alaska  
Fisheries  
Science  
Center

# Northern fur seal foraging – linking biophysical processes and fur seal behavior to demography

Alaska Ecosystems  
Program  
Plan Team  
September 14, 2016

# Management status

- Listed as depleted under the Marine Mammal Protection Act
  1. Eastern Stock population is ~ 622,908 seals (~ 1/3 of its historical peak)
  2. Well below OSP (optimum sustainable population)
  3. To be delisted, population needs to double to achieve 60% of historical K
  4. 2016 St. Paul declined ~12% and St. George Island increased ~7%
  5. Eastern Stock will likely show a ~ 5% decline (preliminary results)
- Determine factors influencing demography as outlined in the Northern Fur Seal Conservation Action Narrative in the 2007 Conservation Plan
  1. Compile and evaluate available habitat-use data
  2. Compile and evaluate existing physical environmental data
  3. Select appropriate environmental indices
  4. Quantify environmental effect on behavior and productivity
  5. Ecosystem modeling
  6. Conduct oceanographic and fishery surveys based on pelagic fur seal habitat use

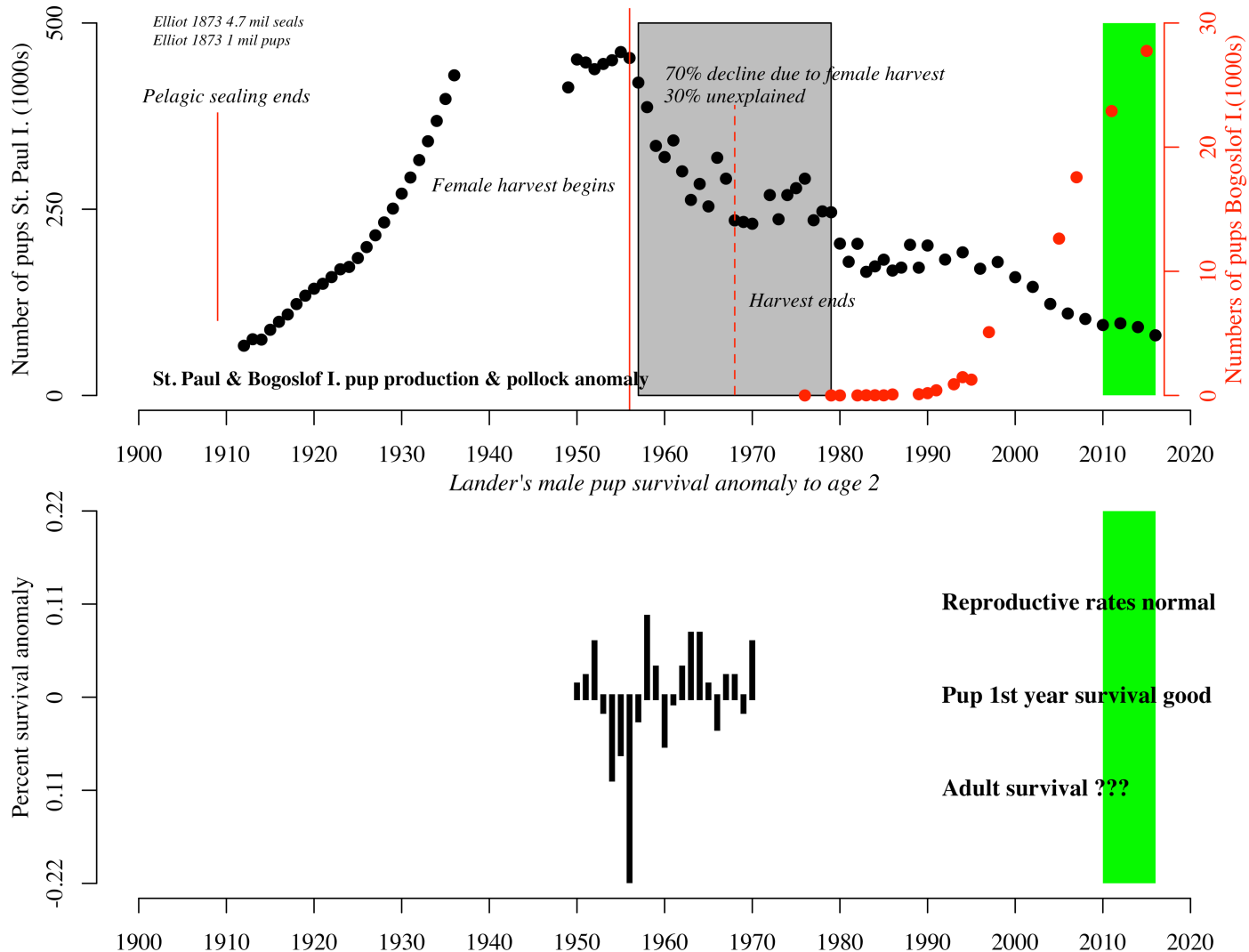
# Alaska Ecosystems Program Strategy

- Looking back to inform future study design and hypotheses (1870-2016)
  1. Data rescue
    - Roger Gentry's behavioral observation archive (1973-1992)
    - Mike Goebel's PhD thesis (1995-1996)
    - Jason Baker's Pup migration study (1996/97-1997/98)
  2. Telemetry – Alaska Ecosystem Program has satellite tagged 847 northern fur seals (1991-2016)
    - Adult males and females, juveniles, pups
    - At all Eastern Stock locations
    - Half in the winter, half in the summer
  3. Sairdrone survey of fur seal foraging hotspots in the Bering Sea
    - Autonomous oceanographic and acoustic sampling of fur seal prey fields
    - Bottom trawl, mid-water survey, and BASIS survey

# Objective

- Identify factors influencing northern fur seal demography (Eastern Stock)
  1. Pup production (~1950-2016)
  2. Lander's estimates of male pup survival to age 2 (1950-1980)
  3. Current AEP northern fur seal demography (2010-2016)
- Our hypotheses focus on bottom up processes in both summer and winter
  1. Summer foraging and pup provisioning
  2. Winter migration

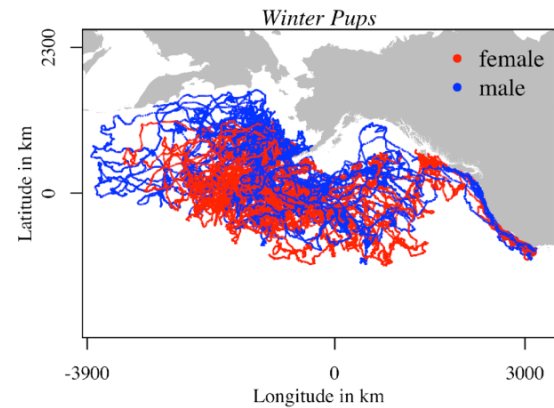
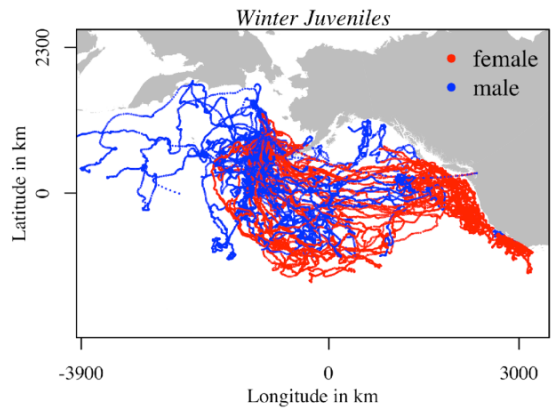
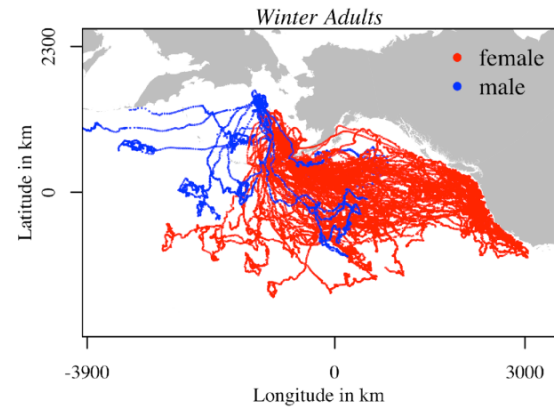
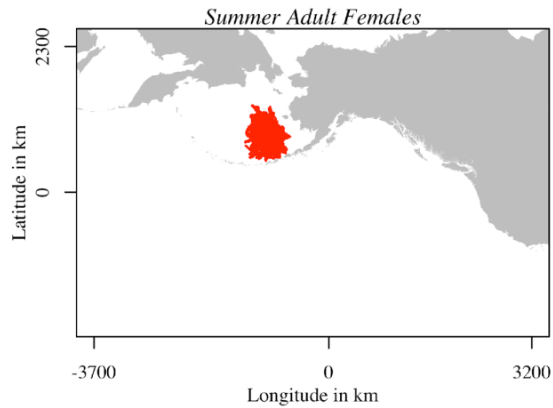
# Northern fur seal demography



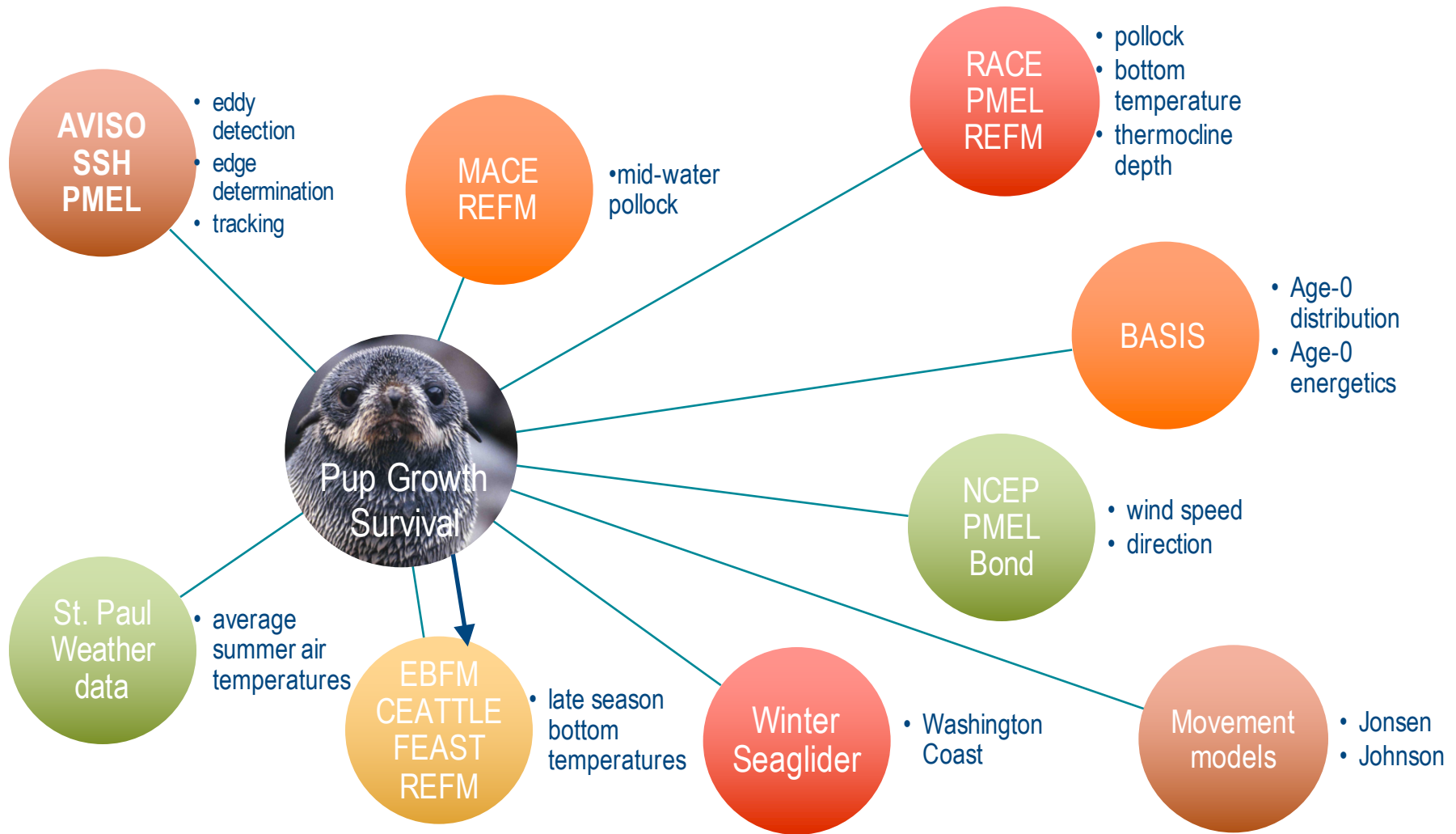
# Objective

- Identify factors influencing northern fur seal demography
  1. Pup production (~1950-2014)
  2. Lander's estimates of male pup survival to age 2 (1950-1970)
  3. Current AEP northern fur seal demography (2010-2015)
- Our hypotheses focus on bottom up processes in both summer and winter
  1. Summer foraging and pup provisioning
  2. Winter migration

# Annual Cycle



# Ecosystem Data





# Objective – Align with Ecosystem Models



## Alaska CLIMATE Project

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 Al Hermann (UW JISAO/PMEL)  
 Wei Cheng (UW JISAO/PMEL)  
 André Punt (UW SAFS)

**FATE: Fisheries & the Environment**  
**SAAM: Stock Assessment Analytical Methods**  
**S&T: Climate Regimes & Ecosystem Productivity**



### IPCC Scenarios (x3)

AR4 A1B  
 AR5 RCP 4.5  
 AR5 RCP 8.5

### Global Climate Models (x 11)

ECHO-G (AR4 A1B)  
 MIROC3.2 med res. (AR4 A1B)  
 CGCM3-t47 (AR4 A1B)  
 CCSM4-NCAR-PO (AR5 RCP 4.5 & 8.5)  
 MIROCESM-C-PO (AR5 RCP 4.5 & 8.5)  
 GFDL-ESM2M\*-PO (AR5 RCP 4.5 & 8.5)  
 GFDL-ESM2M\*-PON (AR5 RCP 4.5 & 8.5)

## Future Climate Scenarios



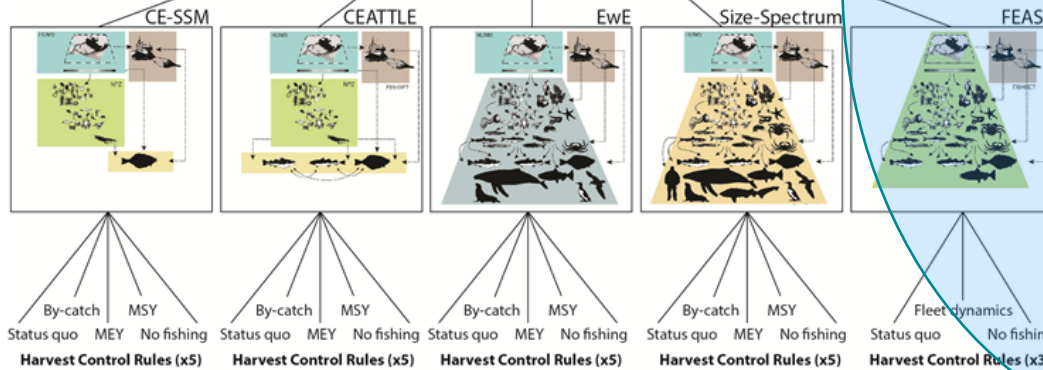
## Climate-enhanced Biological Models



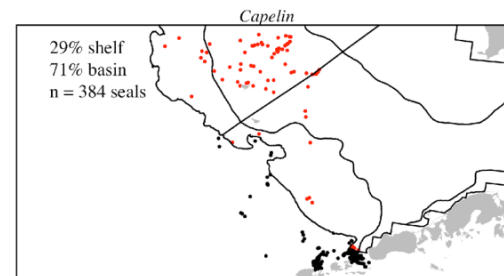
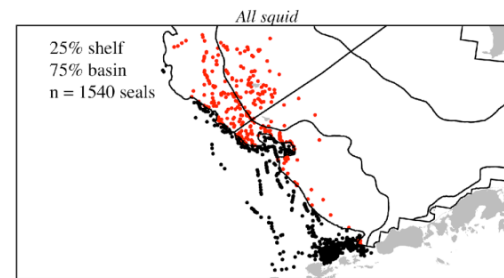
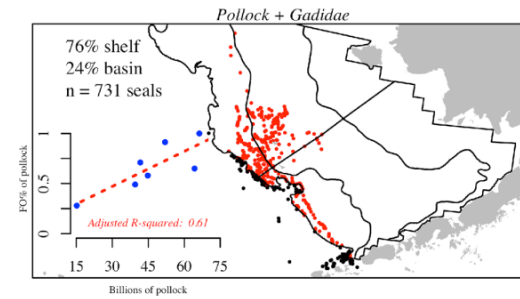
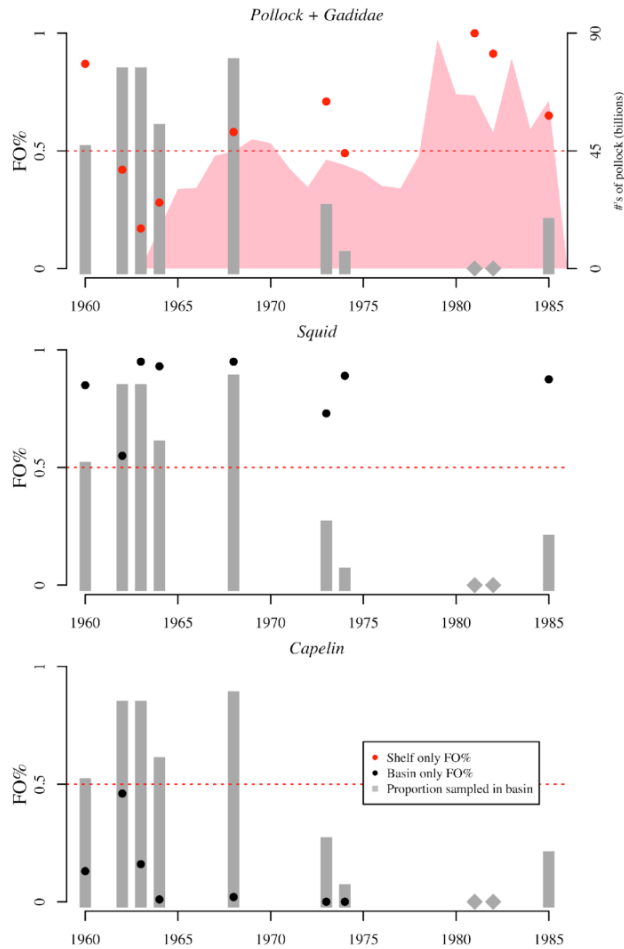
## Fishing Scenarios



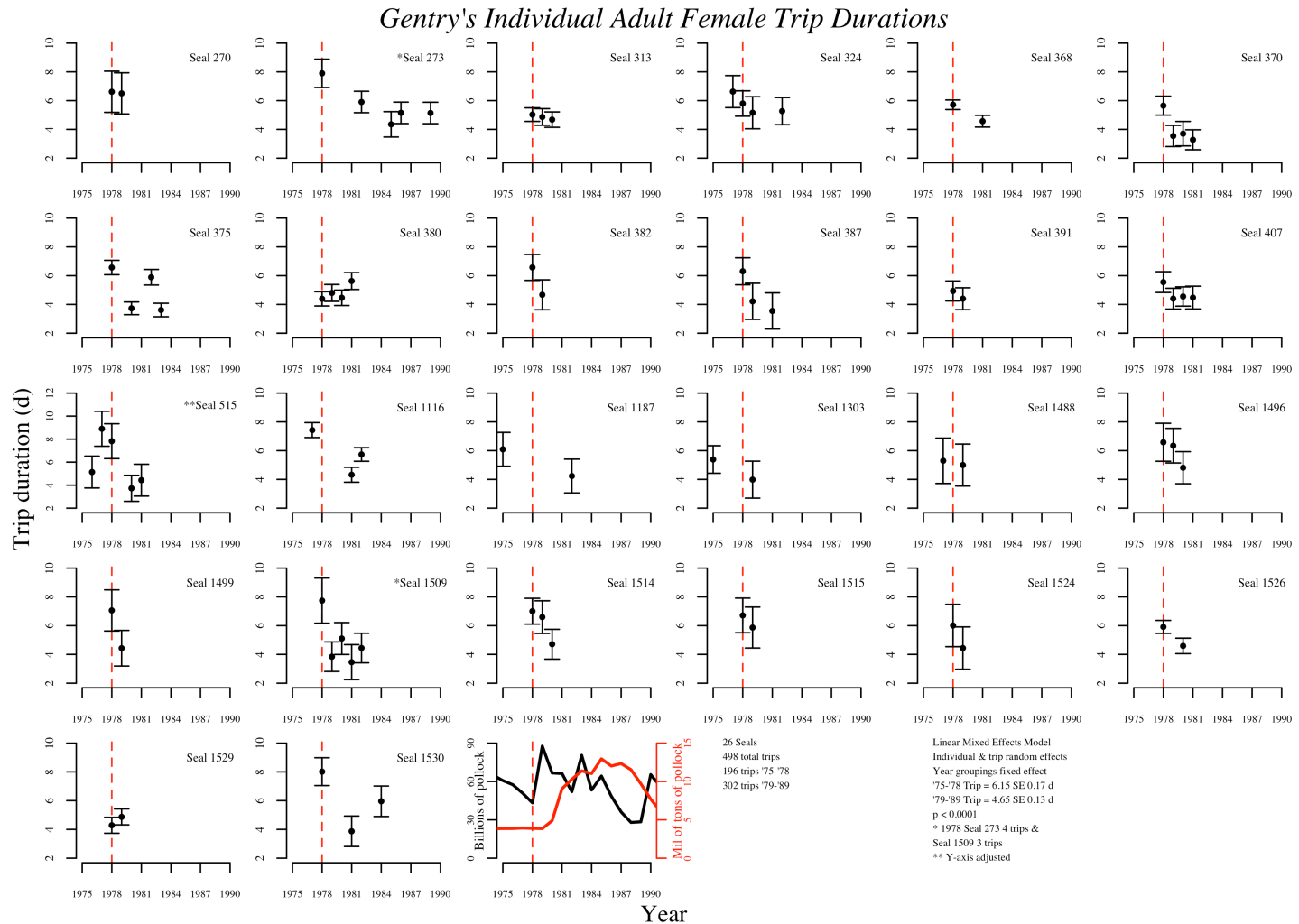
### Bering Sea Models



# Diet – spatial

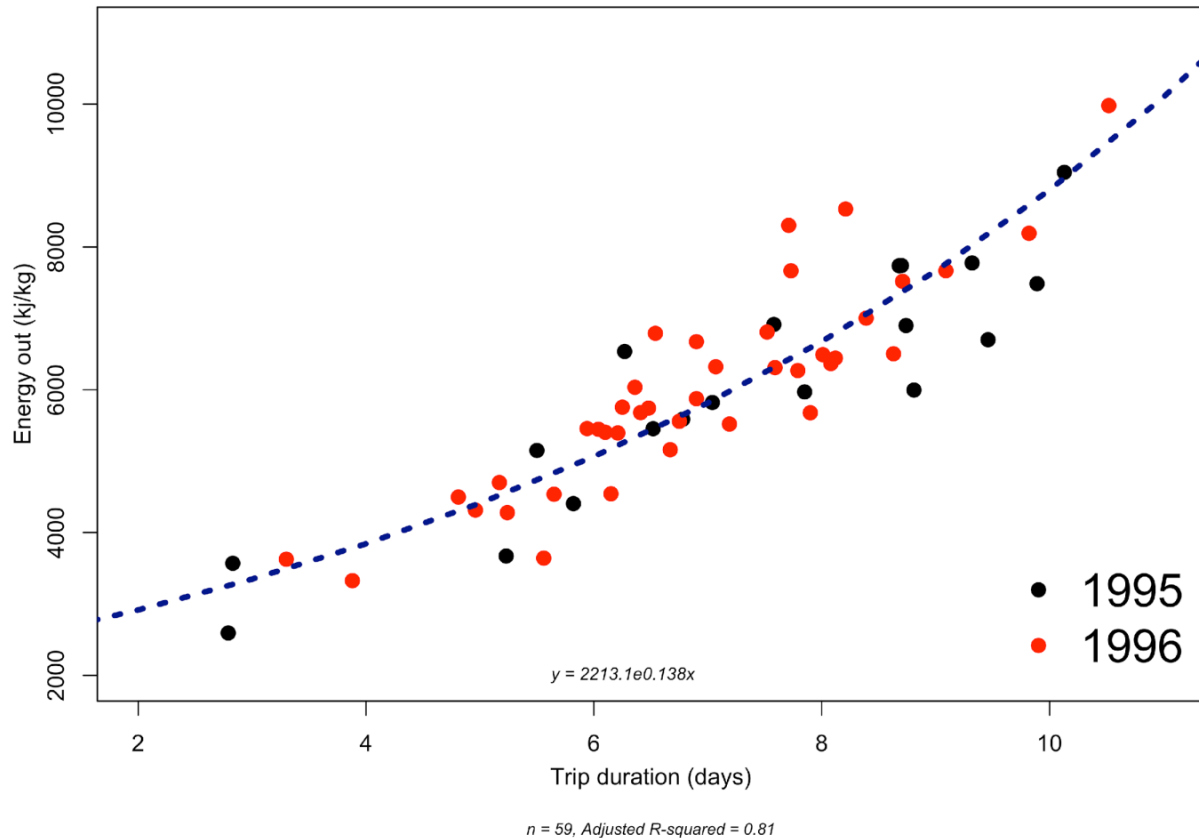


# Gentry's Trip Durations



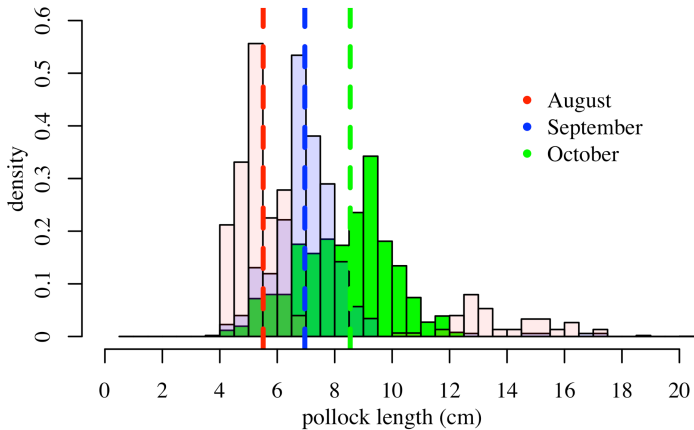
# FEAST – unpublished fur seal energetics data

Adult female energetics

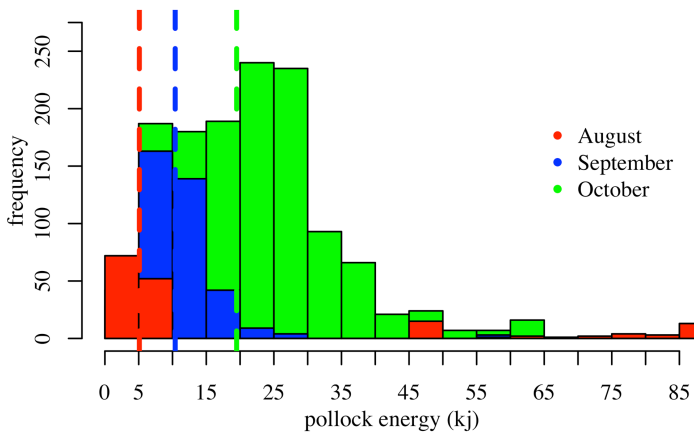


# Fur Seal Diet – Energetics

August, September, October pollock length frequencies



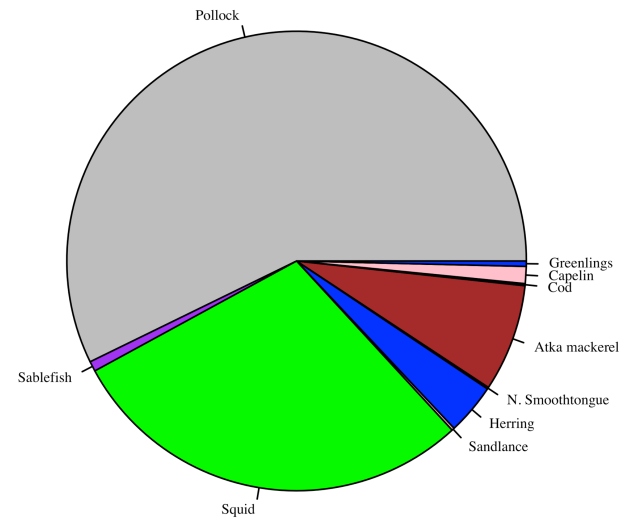
August, September, October pollock energy in kilojoules



## 1996 Enema Results

*n* = 65 seals and 1,986 fish & 313 squid

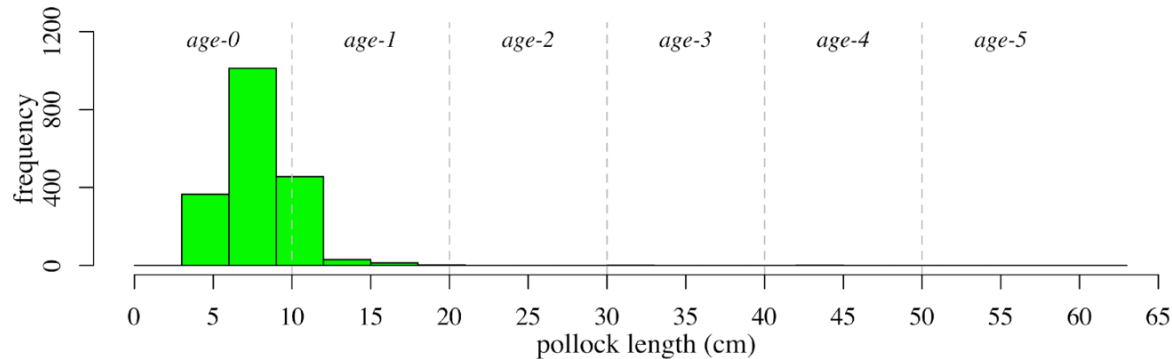
Enema prey energy content - Total = 70,689 kj



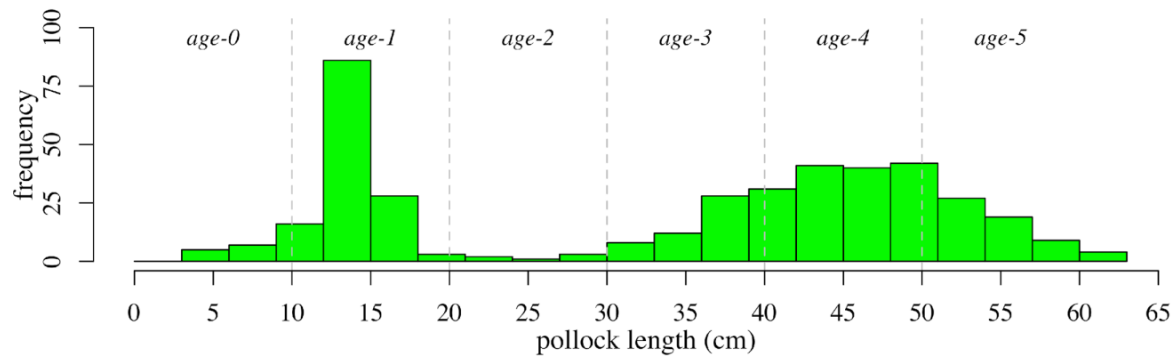
# Diet – pollock age structure by sample type

*All spew samples vs 1995 & 1996 enema samples*

*Enema pollock length frequency*



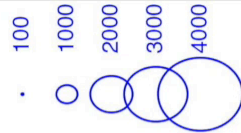
*Spew pollock length frequency*



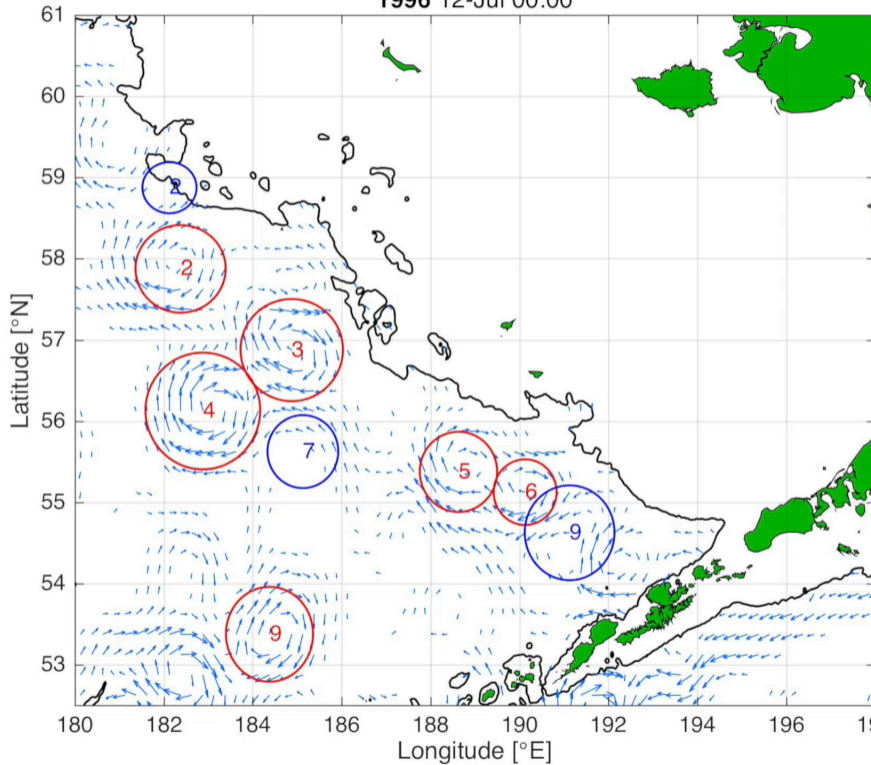
# Pup provisioning – 2 Studies (Goebel & COFFS)

St. George NORTH  
 St. George SOUTH  
 St. Paul NORTHEAST  
 St. Paul SOUTHWEST

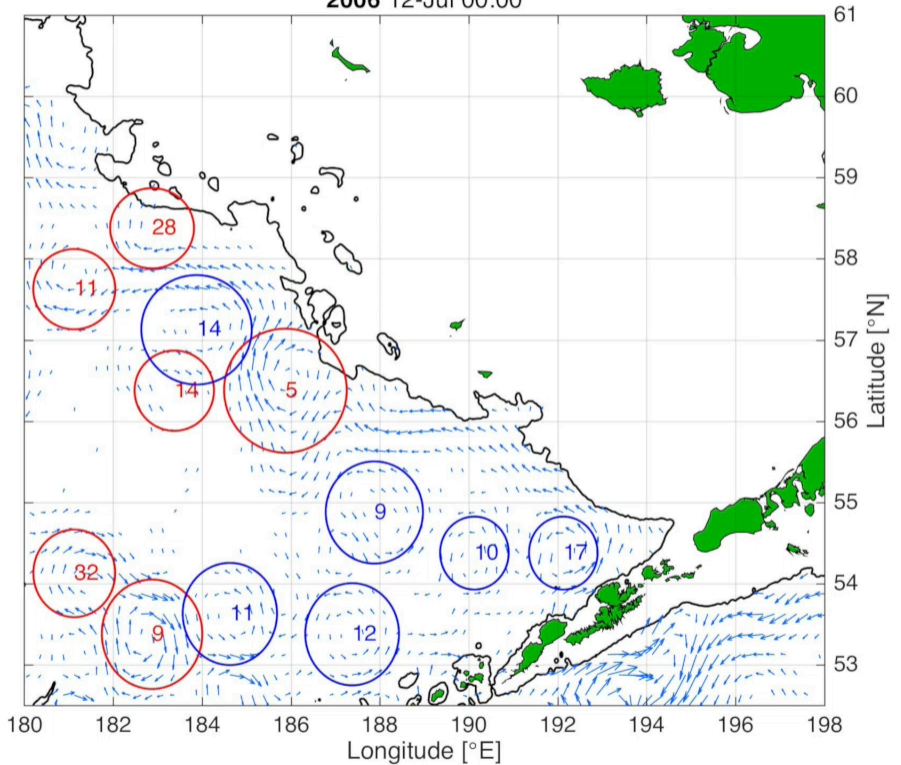
Vert Dist  
 [m hr<sup>-1</sup>]



1996 12-Jul 00:00

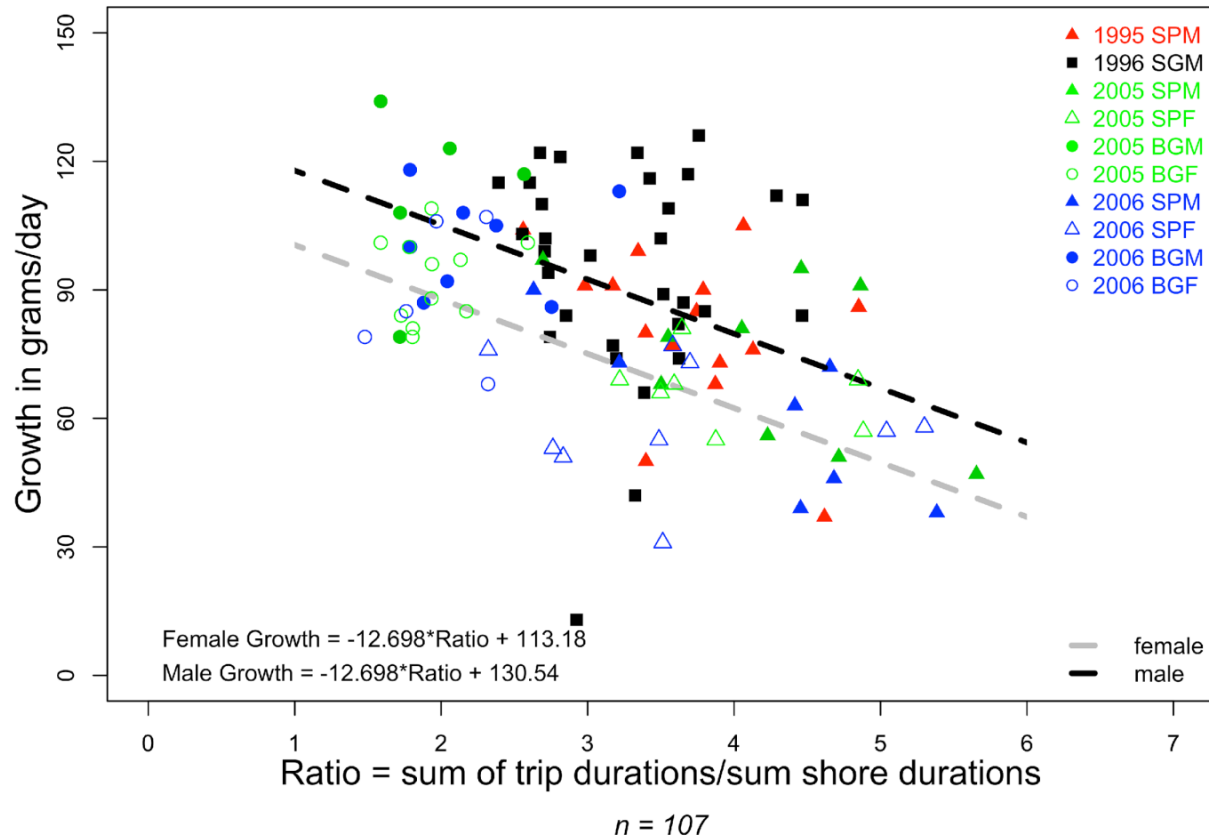


2006 12-Jul 00:00



# Mom behavior and pup growth

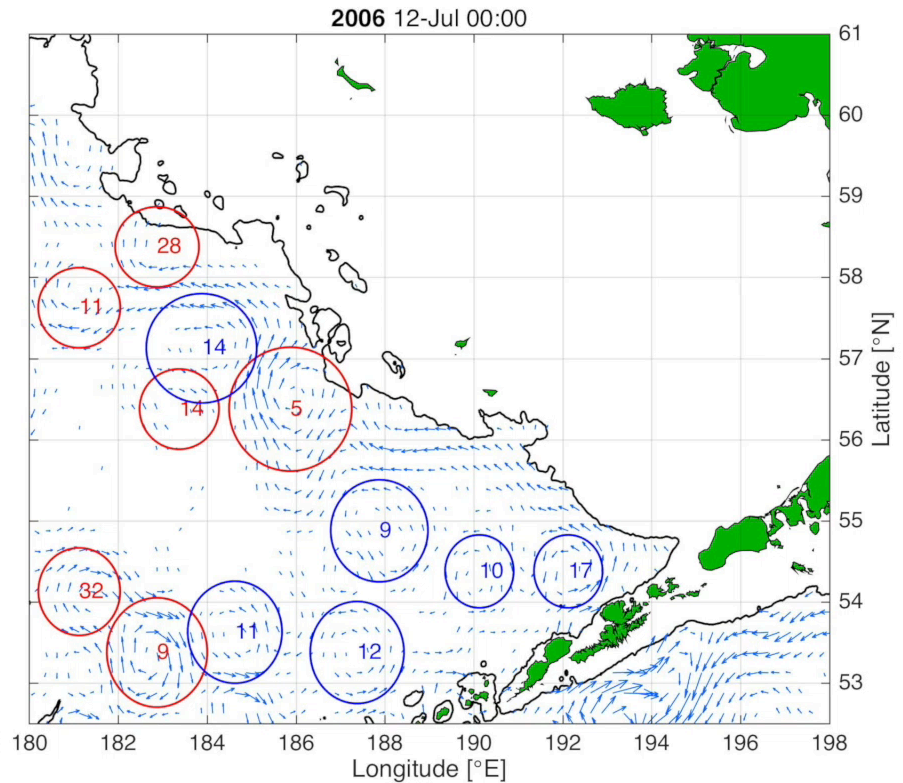
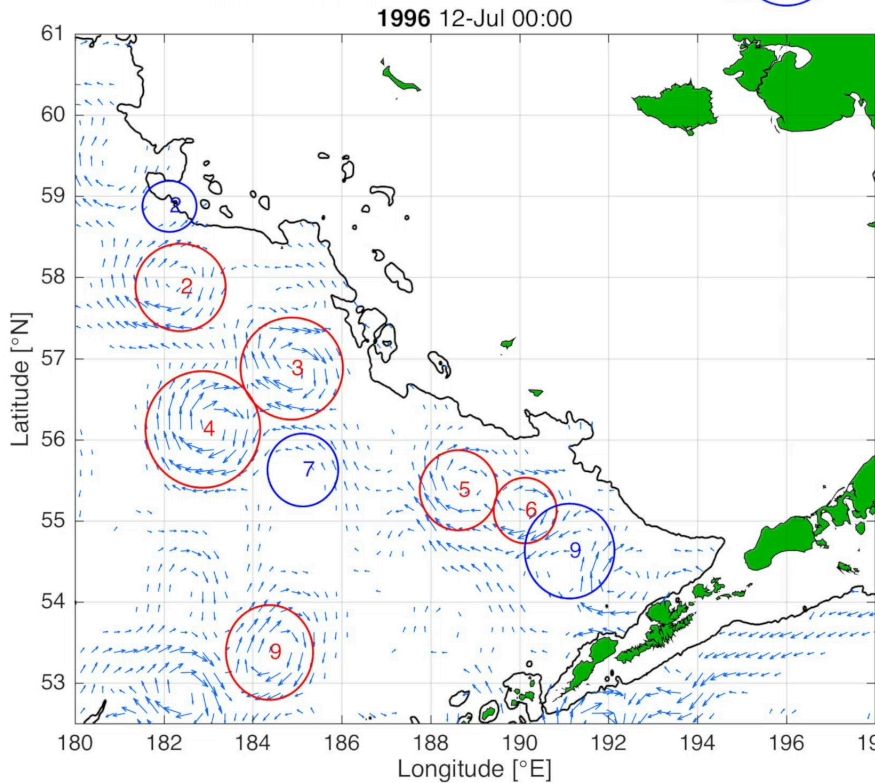
Male & Female Pup Growth





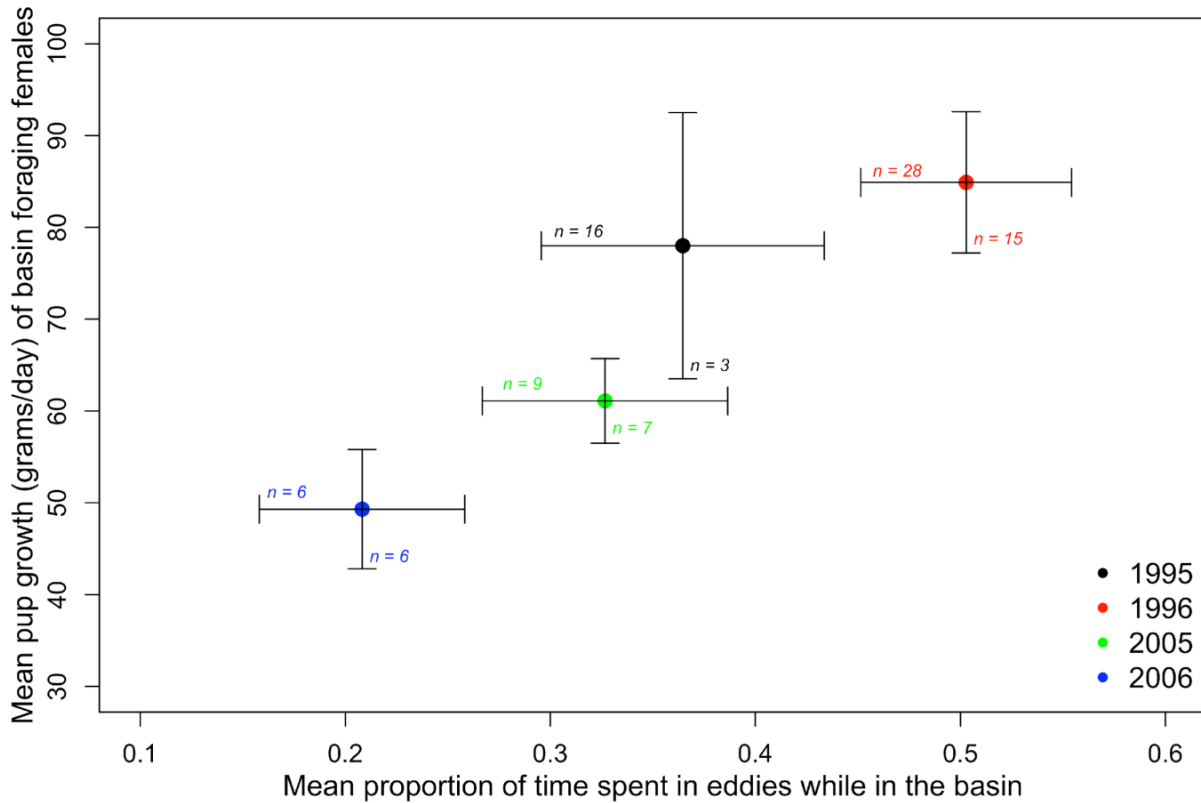
# Eddy variability

St. George NORTH  
 St. George SOUTH  
 St. Paul NORTHEAST  
 St. Paul SOUTHWEST



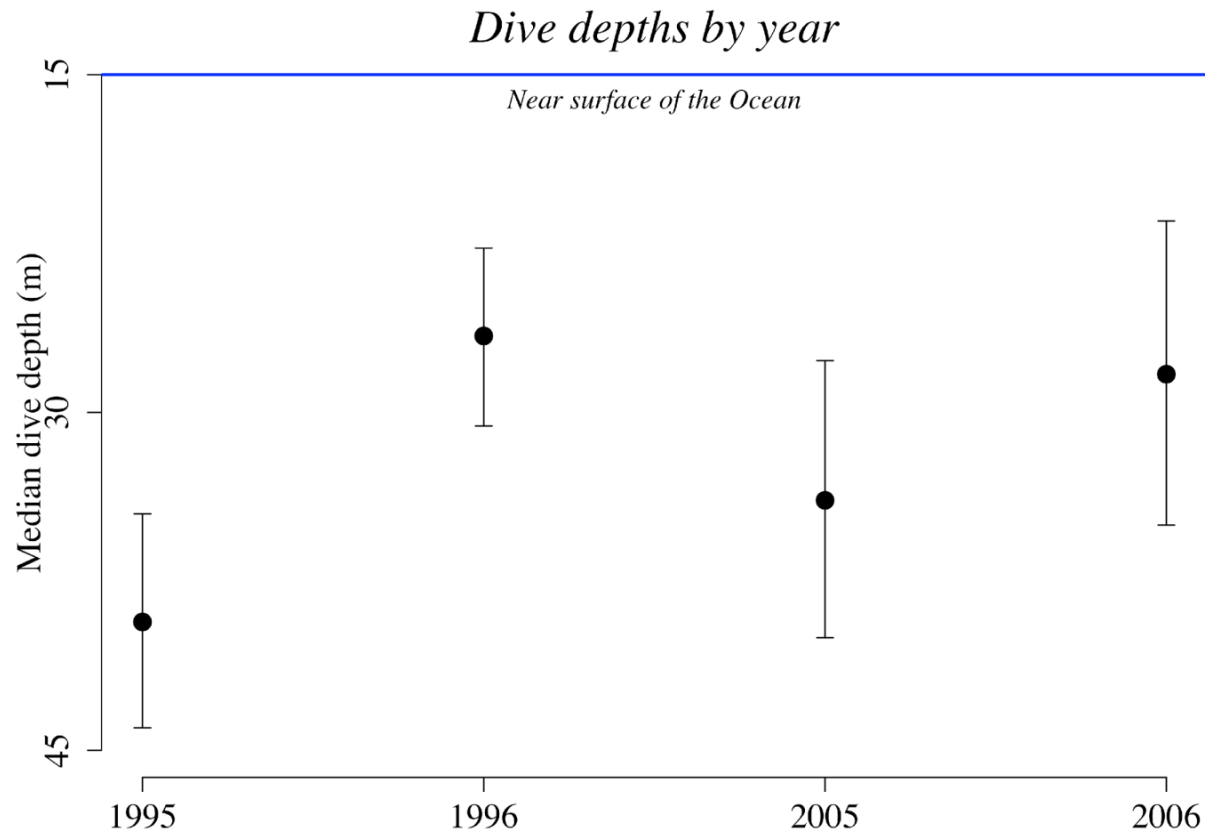
# Pup growth and time in eddies

*Proportion of basin time in eddies and pup growth*

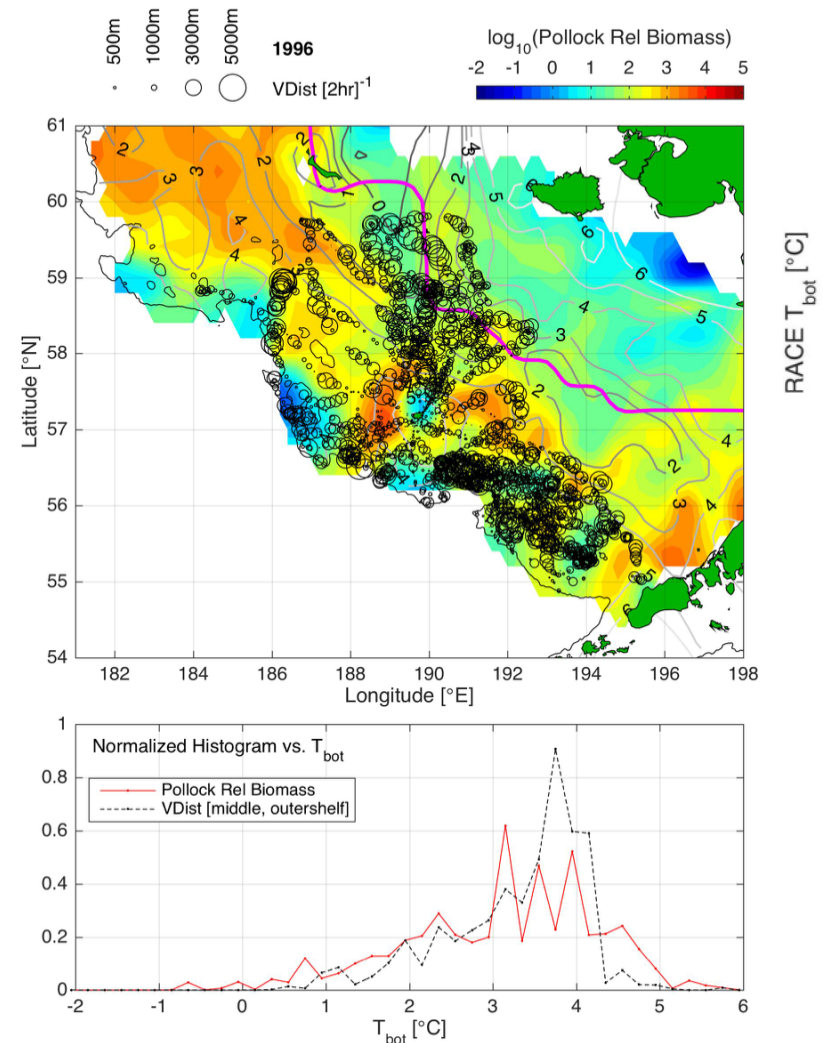
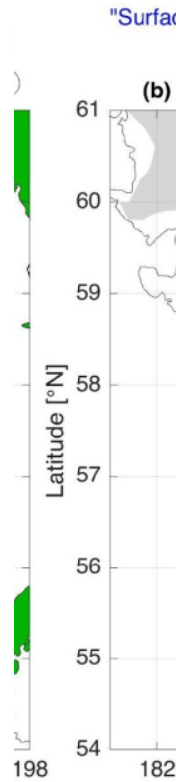
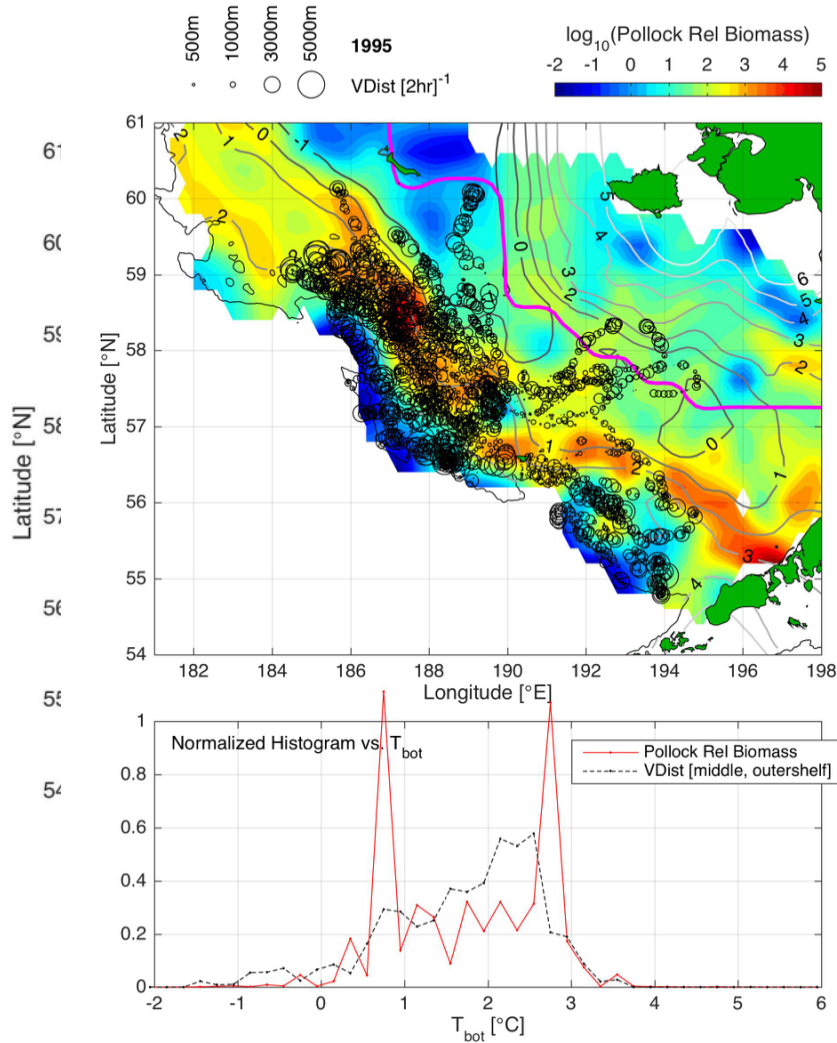


*Female pups included in 2005 & 2006 - no difference in basin M/F pup growth*

# Shelf foraging – diving

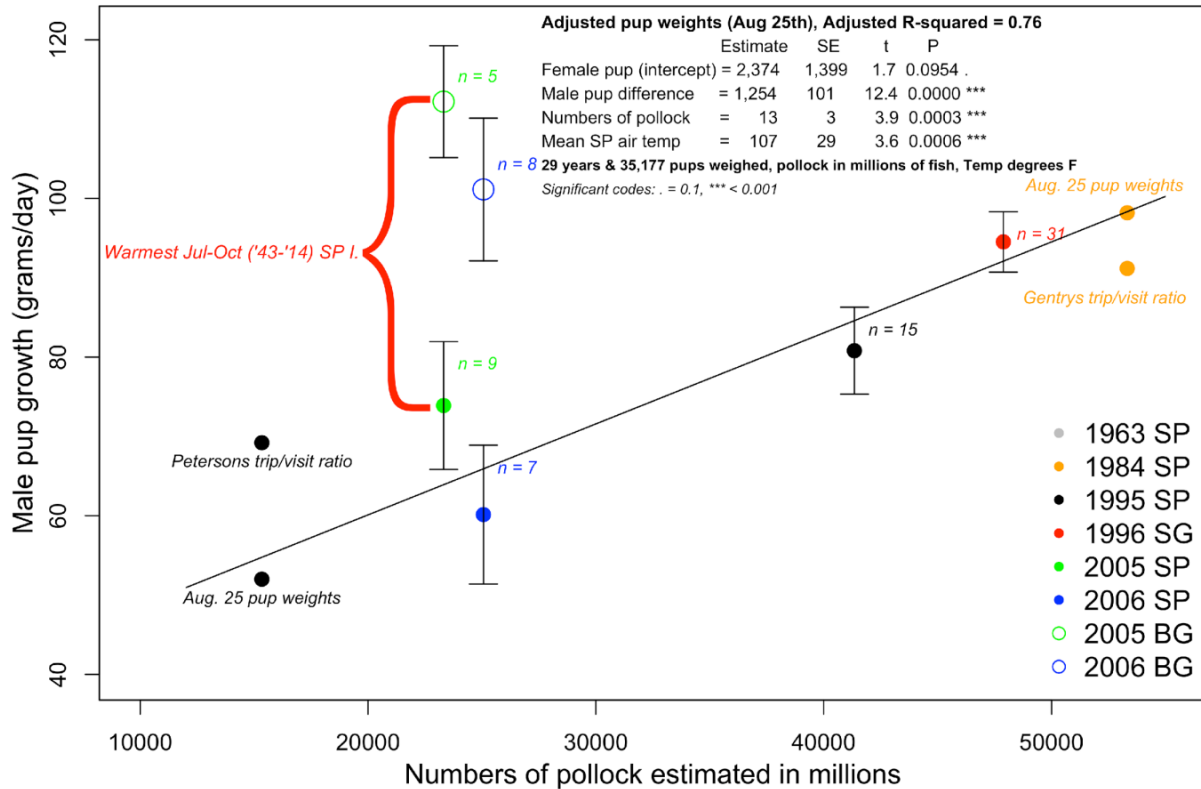


# Shelf foraging – cold vs. warm



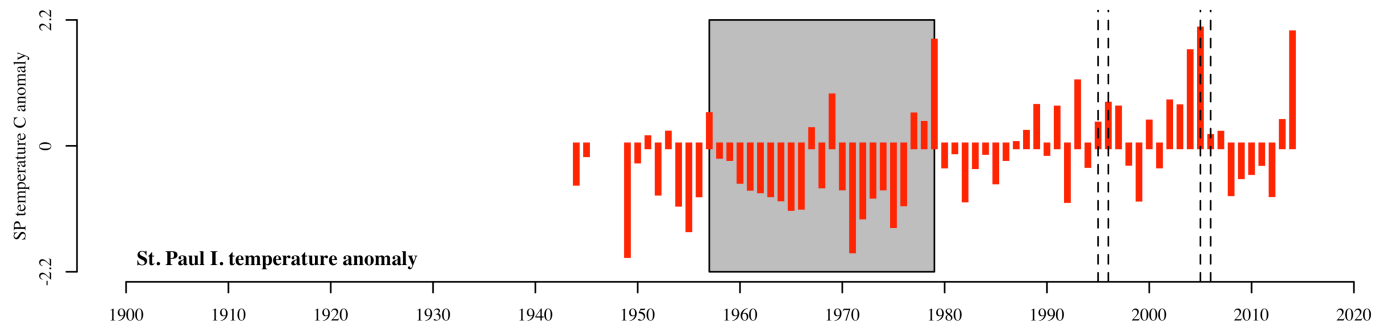
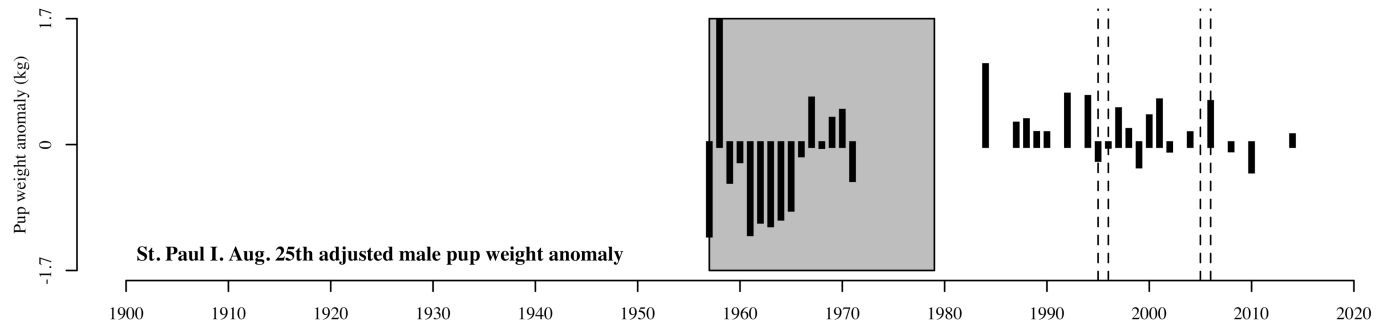
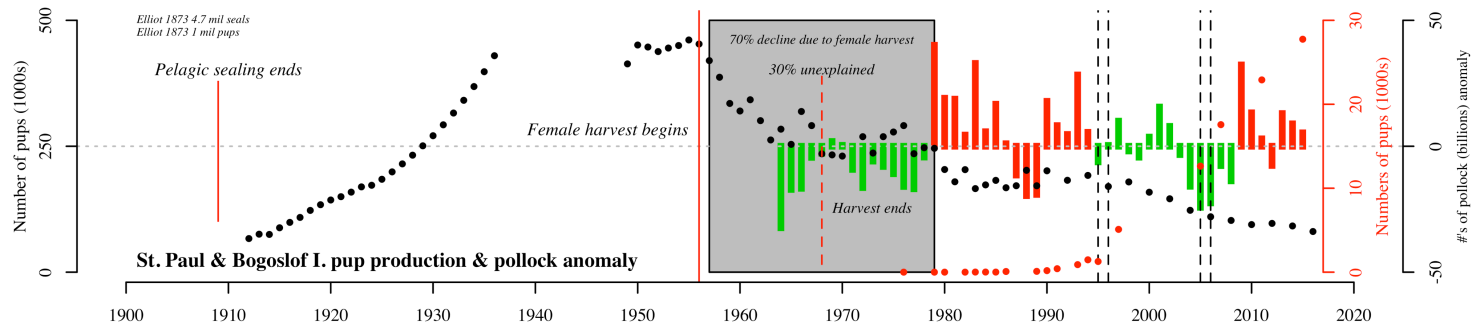
# Pup growth and linkages to pollock

Male pup growth & M/F pup weights



Linear model fitted to '63 & '84 est. growth from pup weights & '95,'96,'05,'06 Pribilof pup growth from study animals

# Potential links to productivity



# Storms

St. George NORTH  
 St. George SOUTH  
 St. Paul NORTHEAST  
 St. Paul SOUTHWEST

