NOAA FISHERIES

AFSC

Spatial and Temporal Variability of Walleye Pollock Fecundity

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Pollock stock assessment reproductive biology research need

- Theory of harvest: sustainable fisheries are those in which harvests are matched to the productive capacity of the stock
- For pollock (as with most stocks) female spawning biomass is used as a metric for reproductive output (fecundity)
- The annual quantity of eggs produced is a better measure
- Other gadids, such as Atlantic cod (Gadus morhua), fecundity is **not** time-invariant per unit of biomass
- Goal of this project: estimate variability in fecundity and examine functional relationships between fecundity and stock biomass and environmental factors so that fecundity can be treated dynamically in stock assessment

Hypotheses

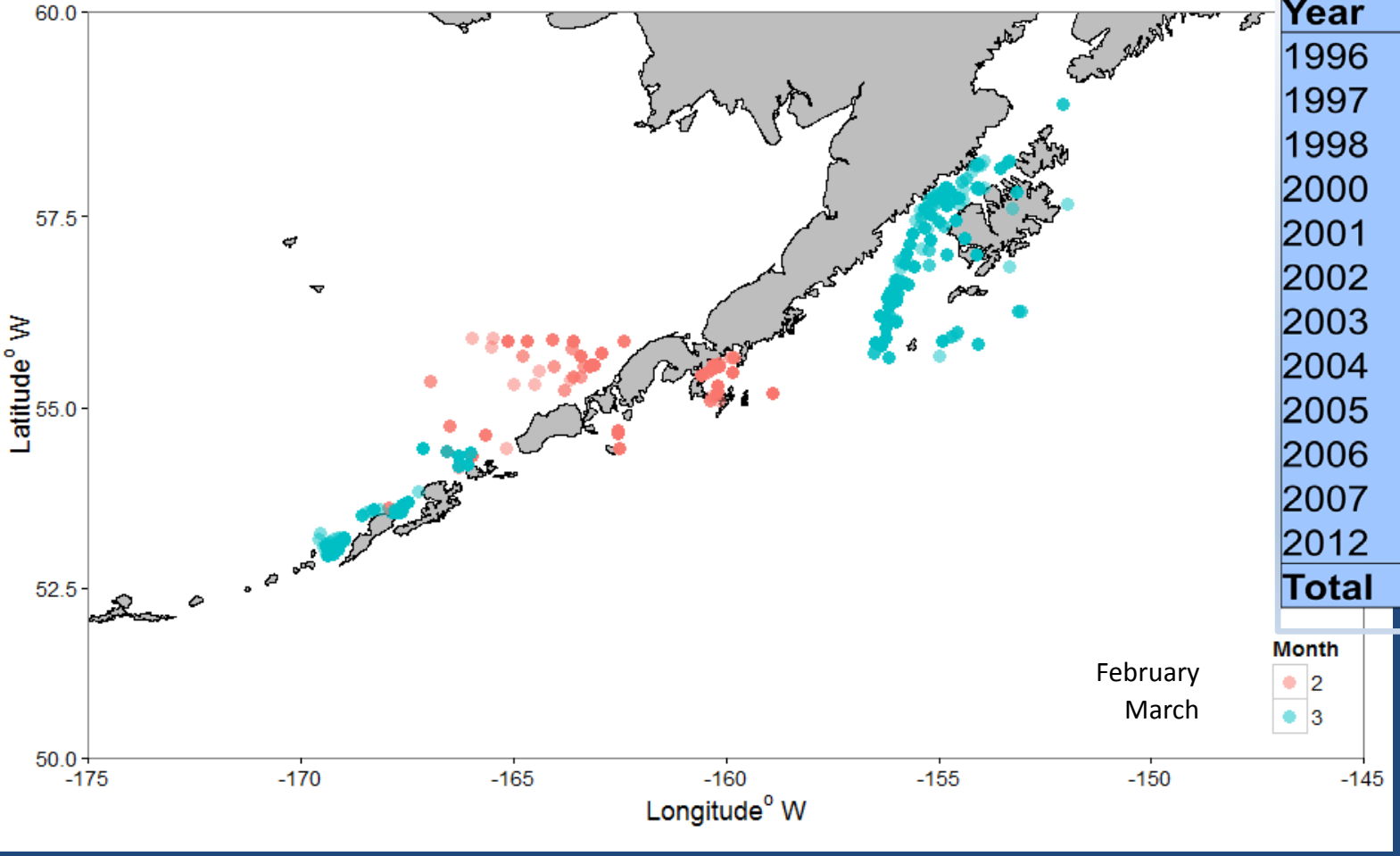
H_a Body condition and fecundity are negatively associated with pollock abundance (density dependence).

H_b Colder years during the growing season (April to October) or during the final stages of maturation (November to March) lead to reduced fecundity. Because temperature directly impacts pollock metabolism.

H_c Ocean productivity is positively associated with fecundity. Increased ocean productivity during the growing season translates into increased consumption of prey by pollock and accumulation of energy reserves for reproduction.

Study area

Pollock sample locations

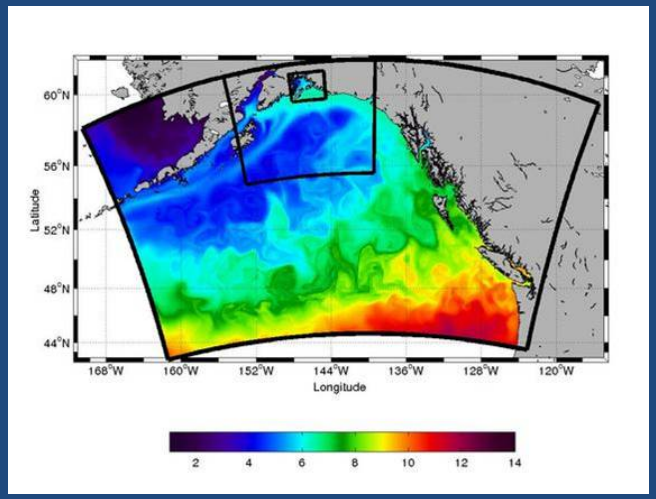


Year	Specimen
1996	126
1997	64
1998	99
2000	108
2001	131
2002	176
2003	81
2004	61
2005	5
2006	148
2007	65
2012	166
Total	**1230**

Environmental data

Satellite Remote Sensing Data

- SeaWiFS monthly averaged chlorophyll-a concentrations were downloaded from the NOAA Coastwatch Program
- Summer chlorophyll-a averaged over polygon area



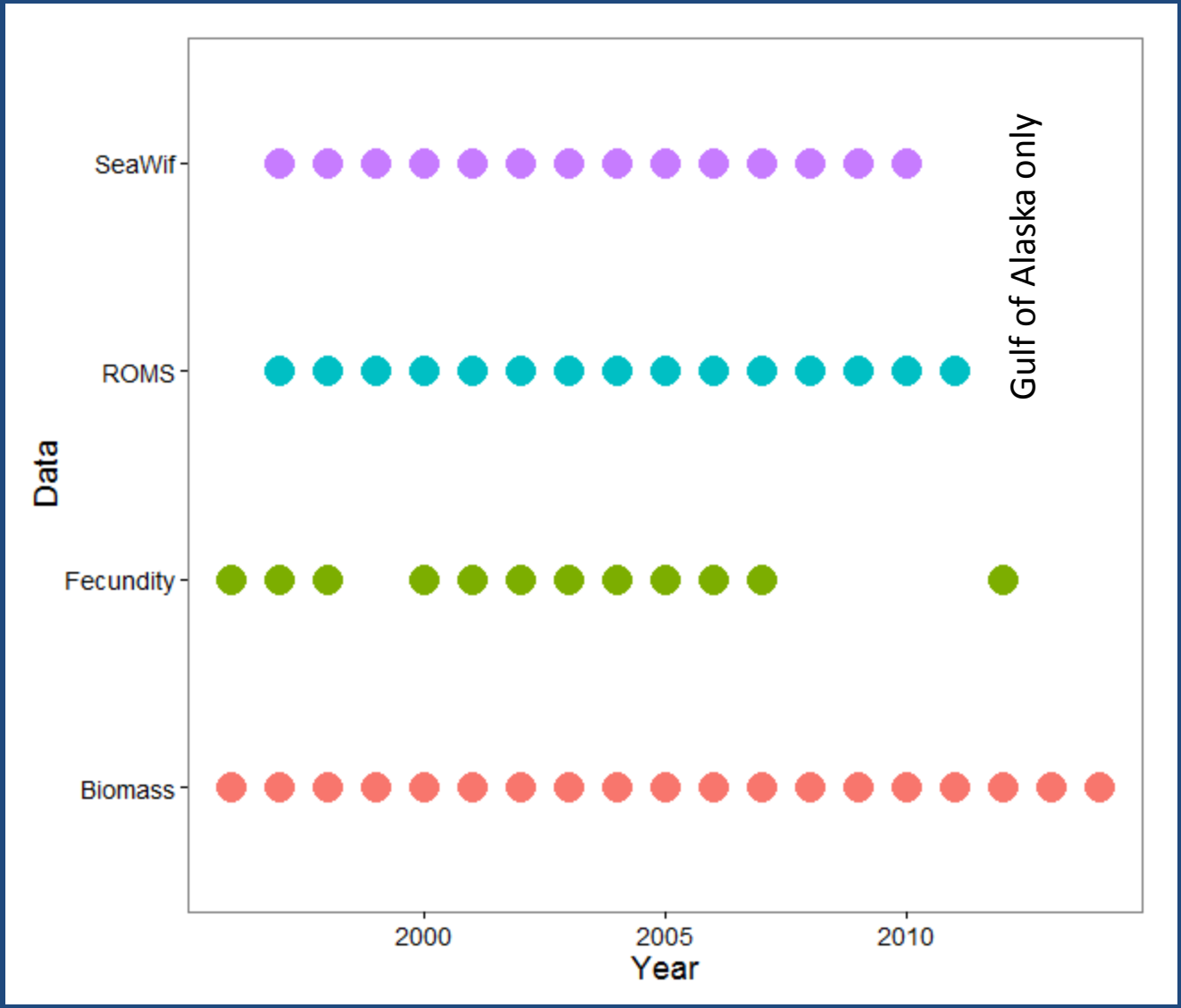
Environmental data

Model (ROMS) Output

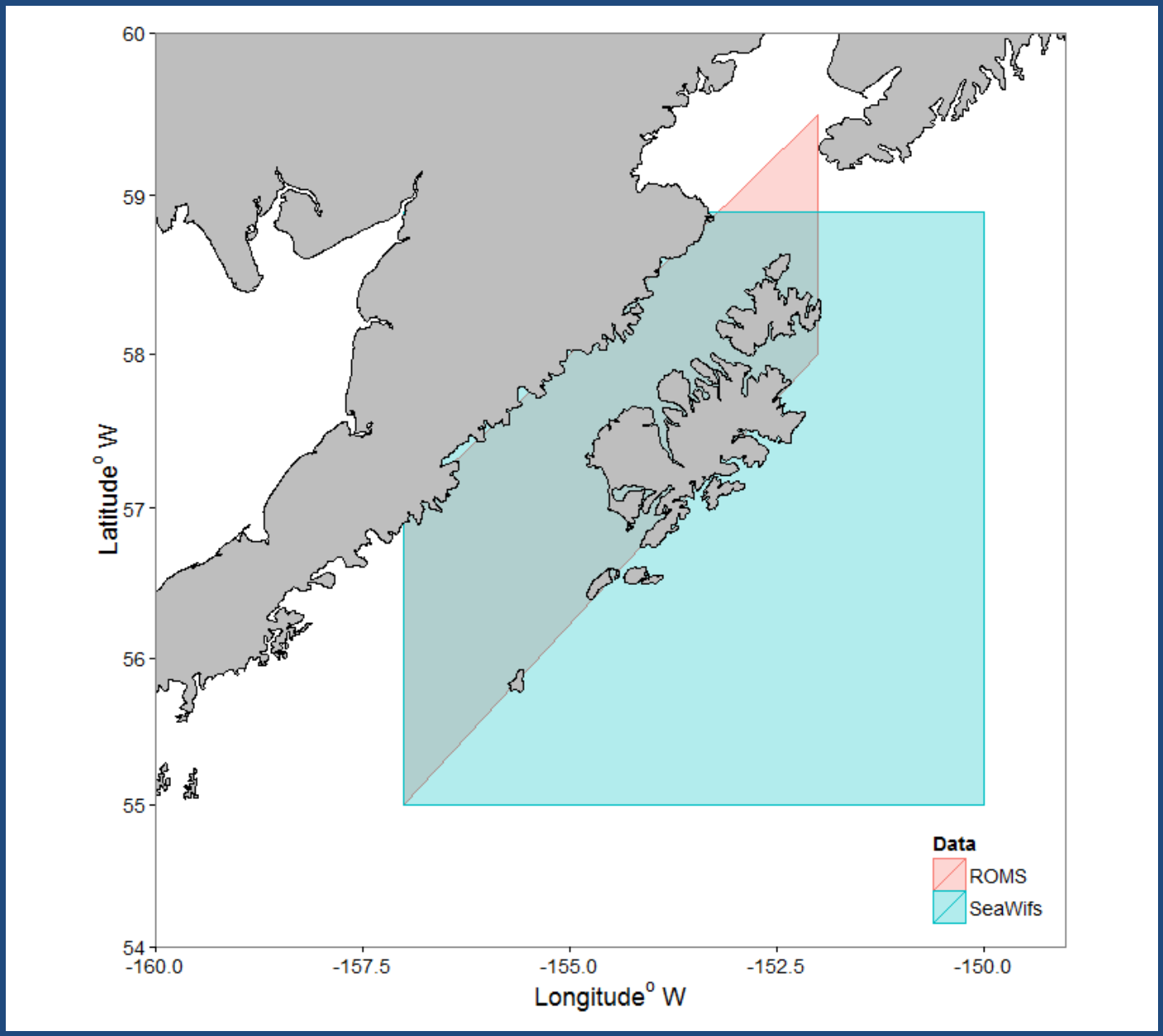
Ocean Circulation

- ROMS is a hydrostatic, primitive equation, generalized sigma-coordinate model
- Driven by historical surface forcing and integrated forward in time
- Model simulation covers years 1997-2007
- Winter and summer water column temperature (average surface to 250 m)
- Weekly averages of ocean temperature (T), salinity (S) from surface to 75-meter depth to develop an ocean stratification index

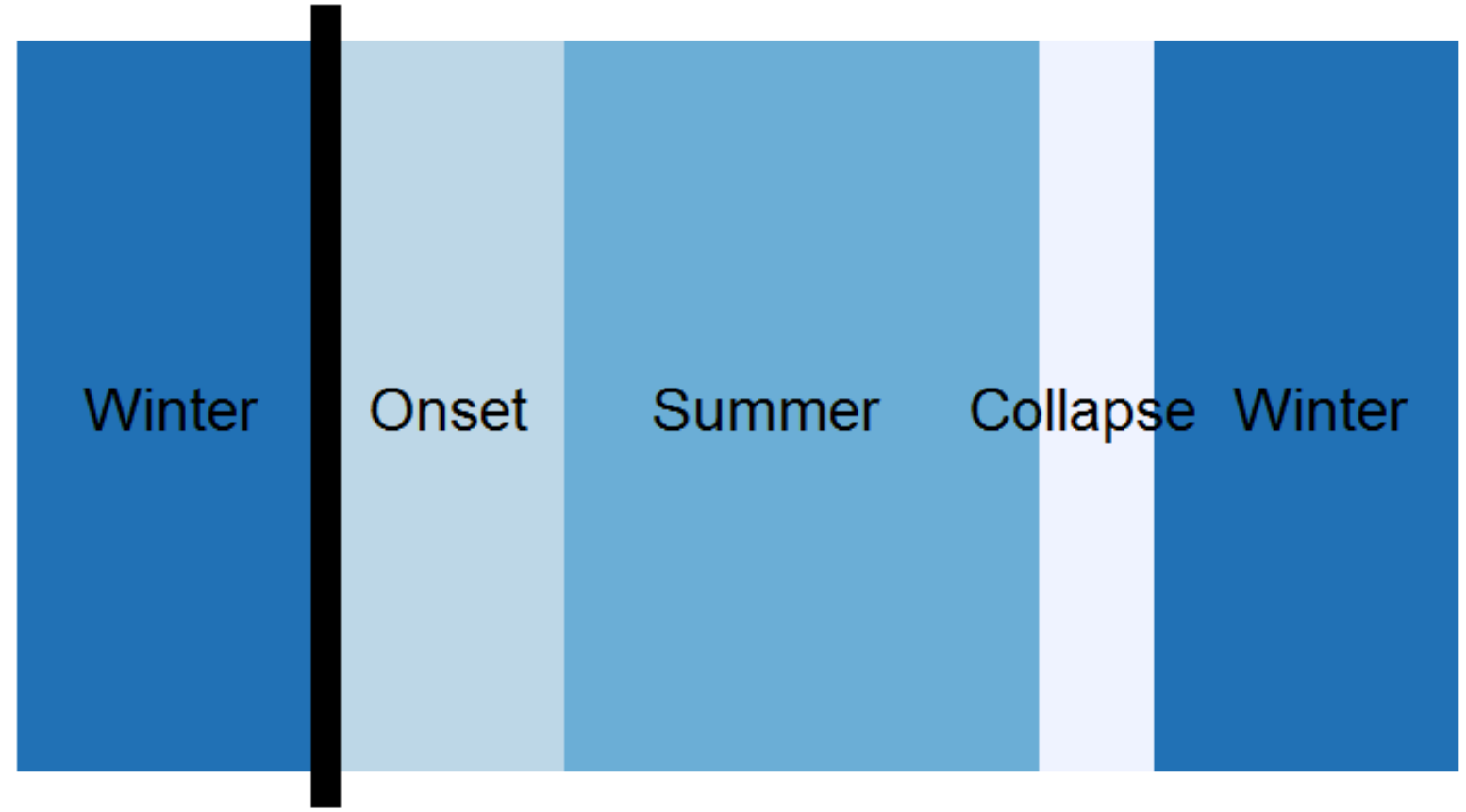
Data


SeaWif
ROMS
Fecundity
Biomass
Data
Gulf of Alaska only
2000
2005
2010
Year

Environmental data



Seasons defined by stratification

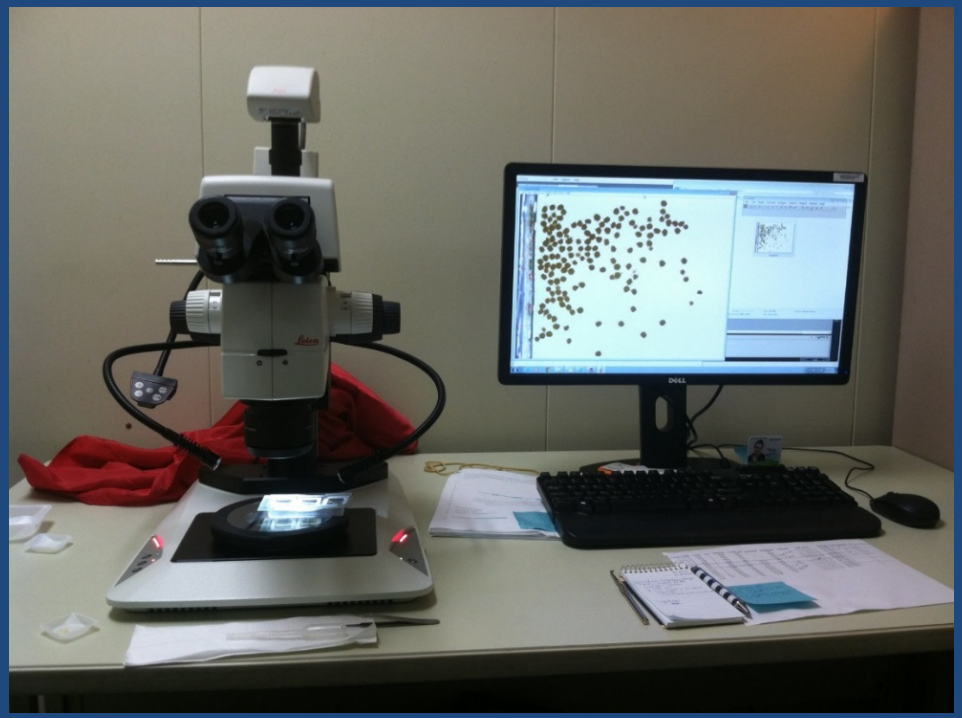


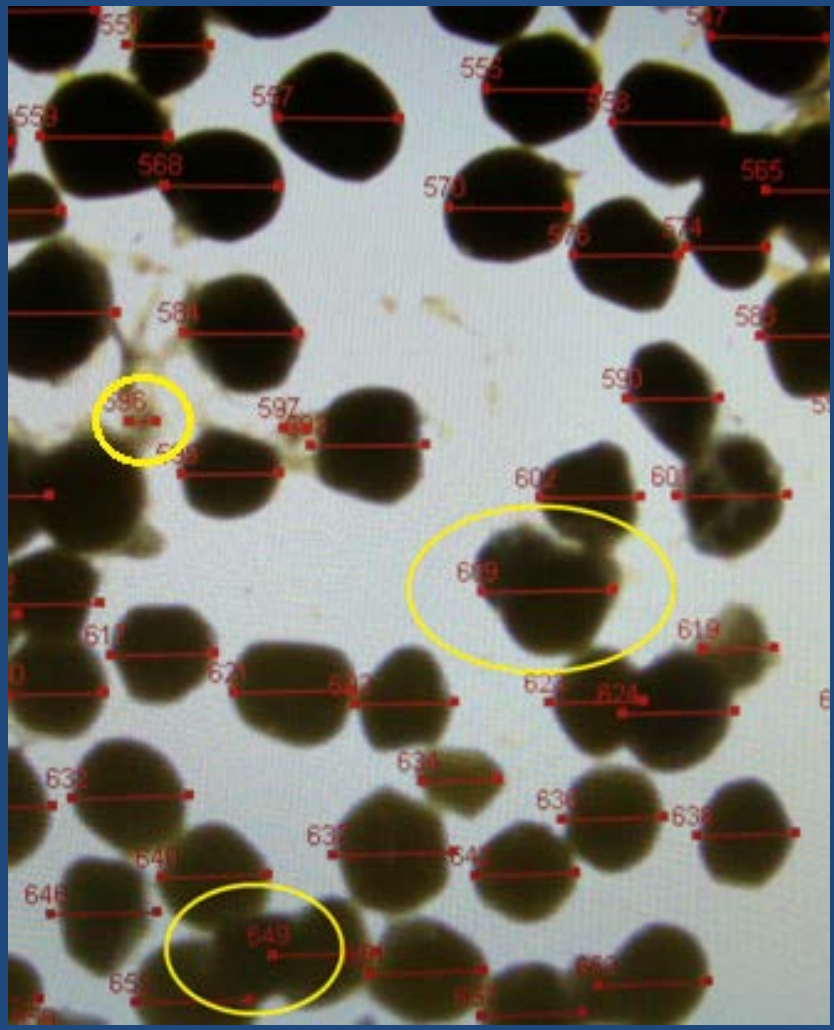
Gravimetric method:

Sample oocyte count/ sample weight * whole ovary weight

Specimen Processing:

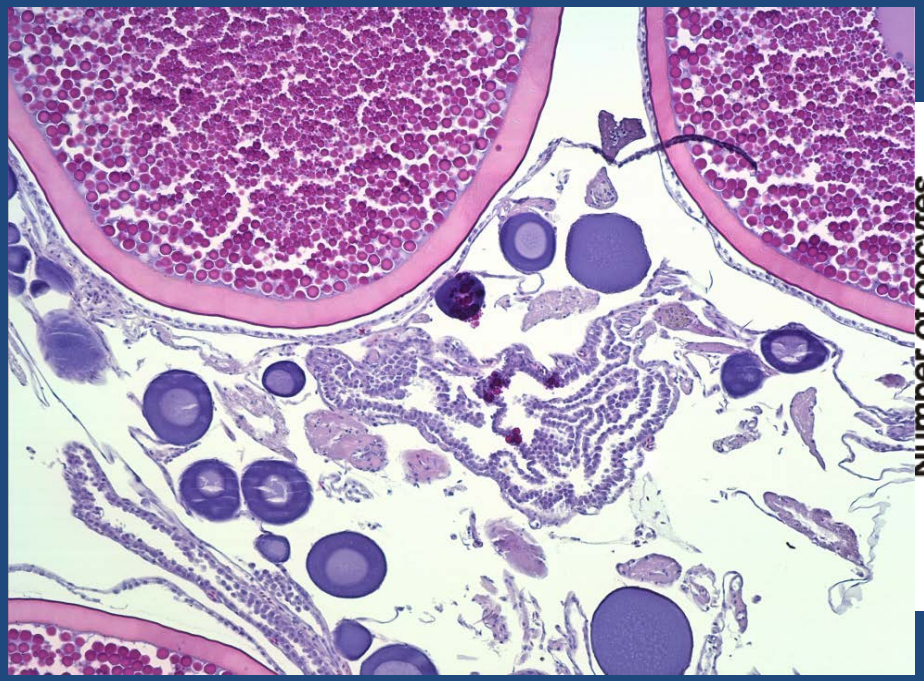
- Image J freeware digitizes image
  - Individual oocytes counted

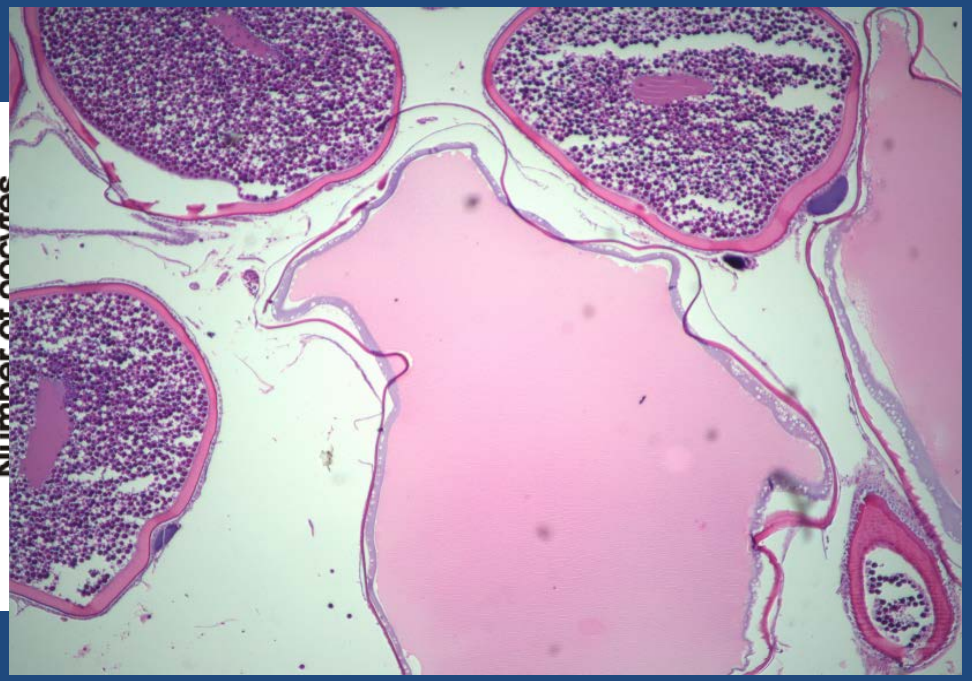




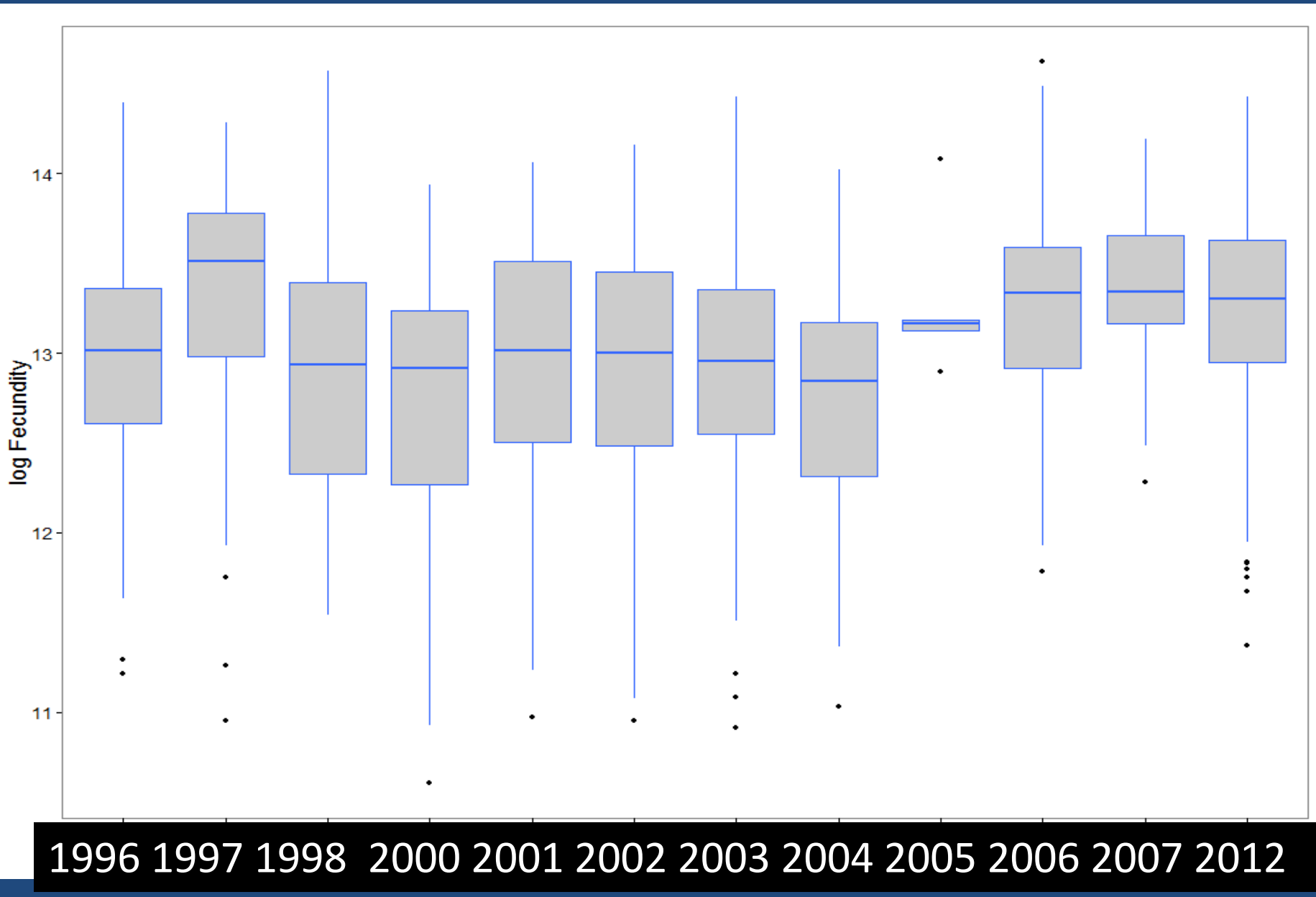
Specimen Processing

- Histological processing
  - Homogenous distribution of oocyte sizes
  - Determinant spawner with a hiatus between oocyte stages
  - Histological analysis to check for POF/ hydration



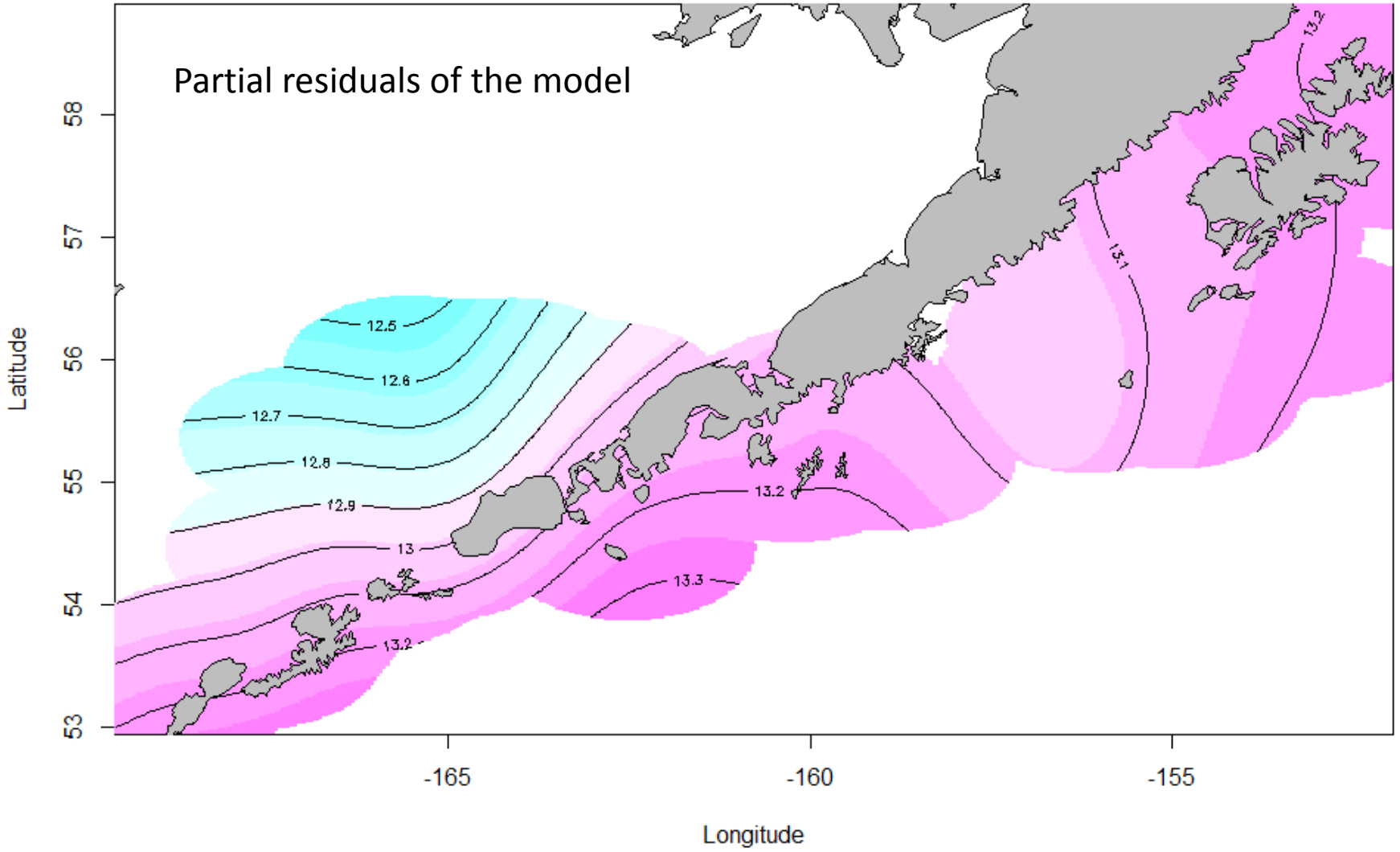


Fecundity and variability

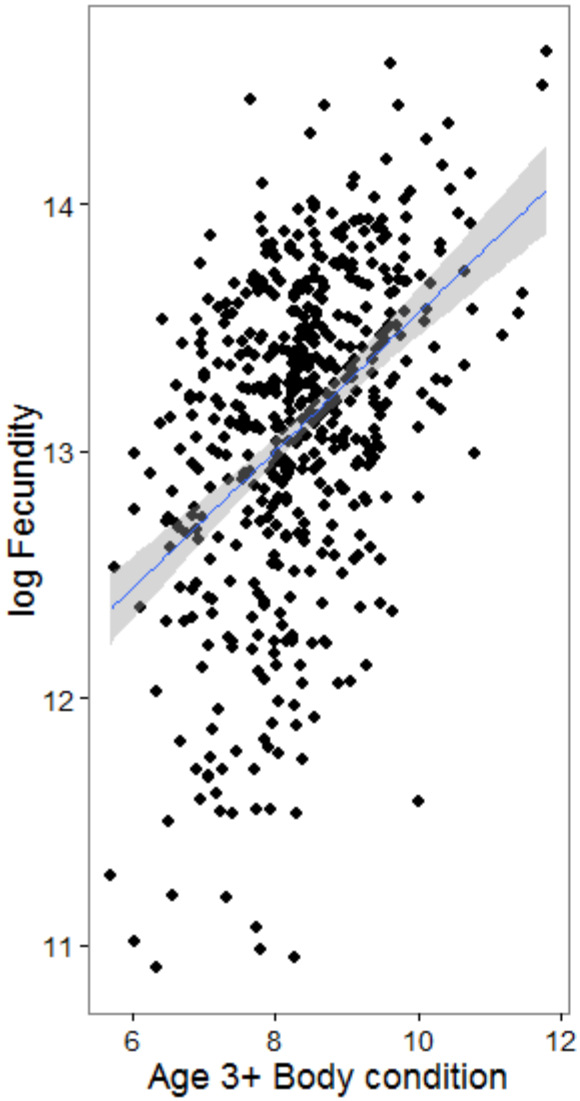


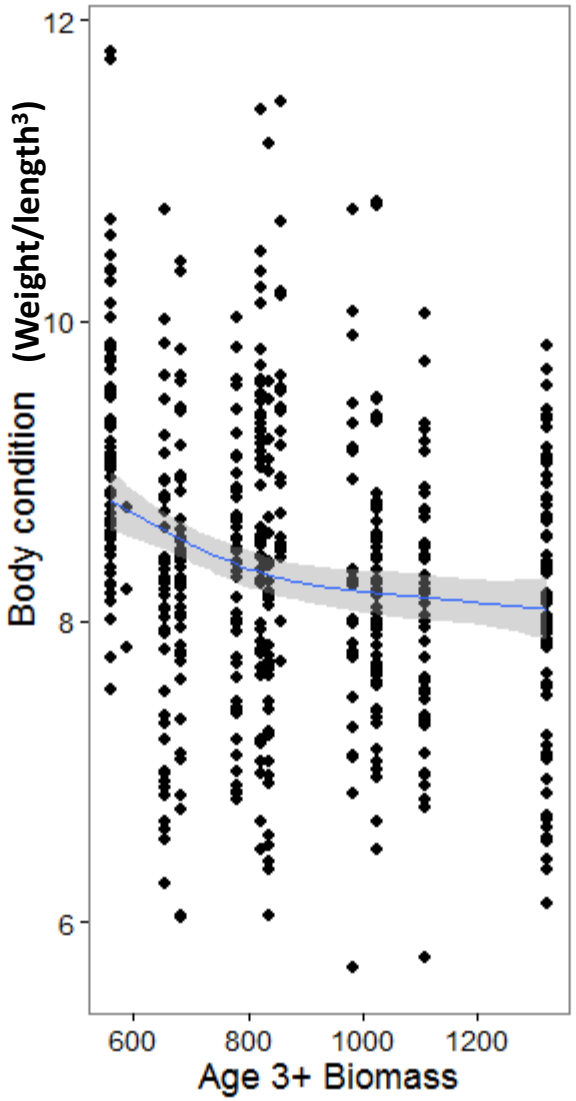
Spatial trends in fecundity

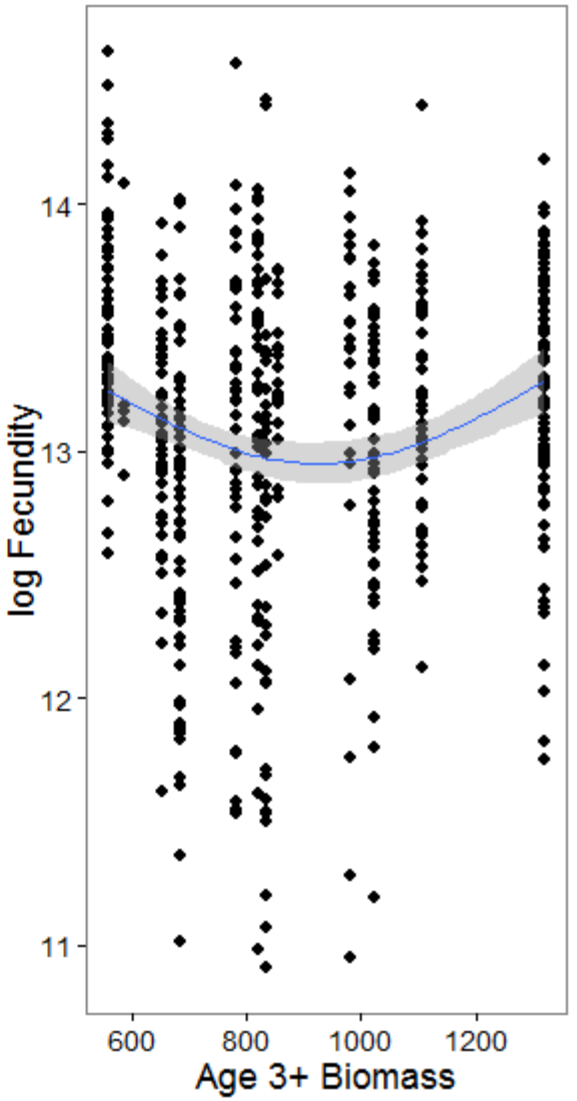
E (fec) = s(long,lat) + s(fish weight) + s(year) + s(diam) + s(atresia) +s(ID)



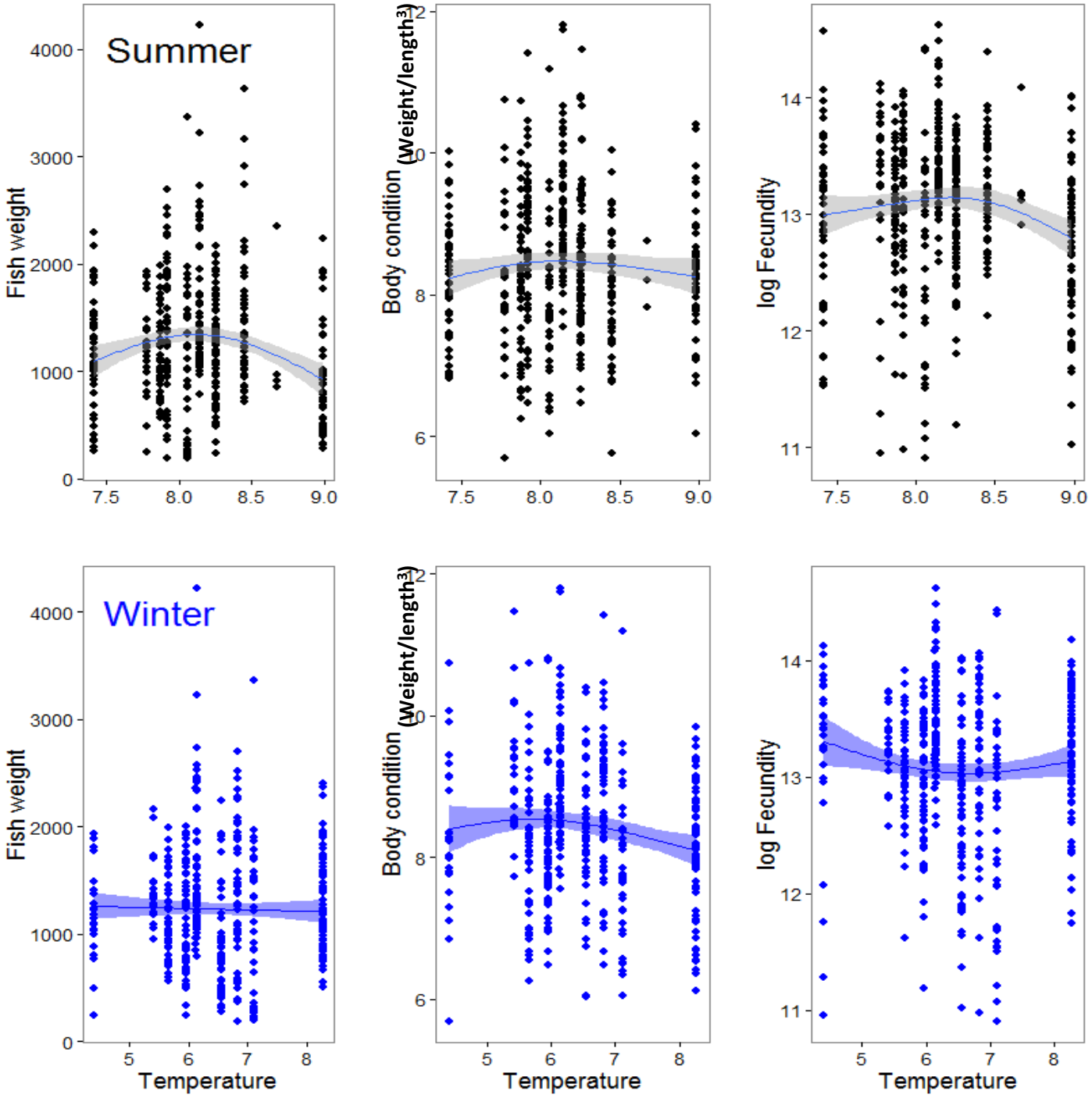
Density-dependence



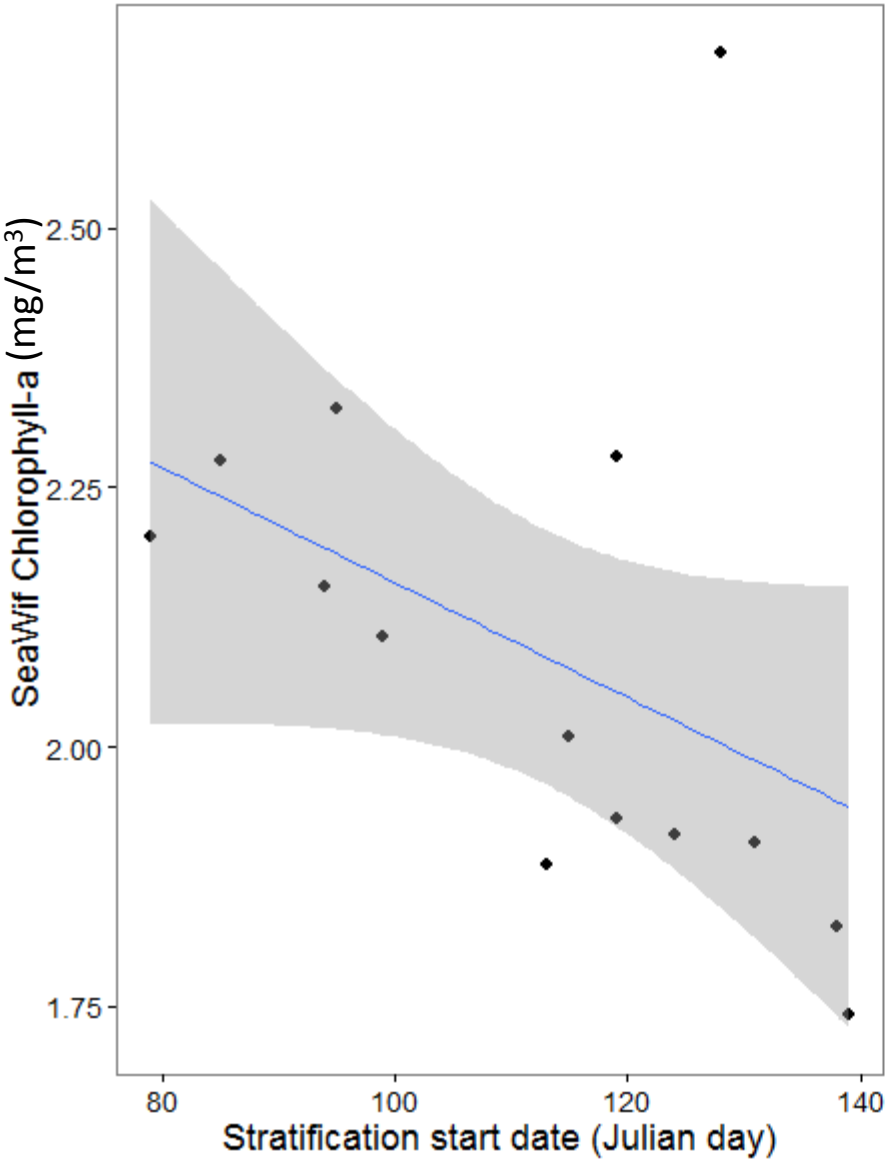


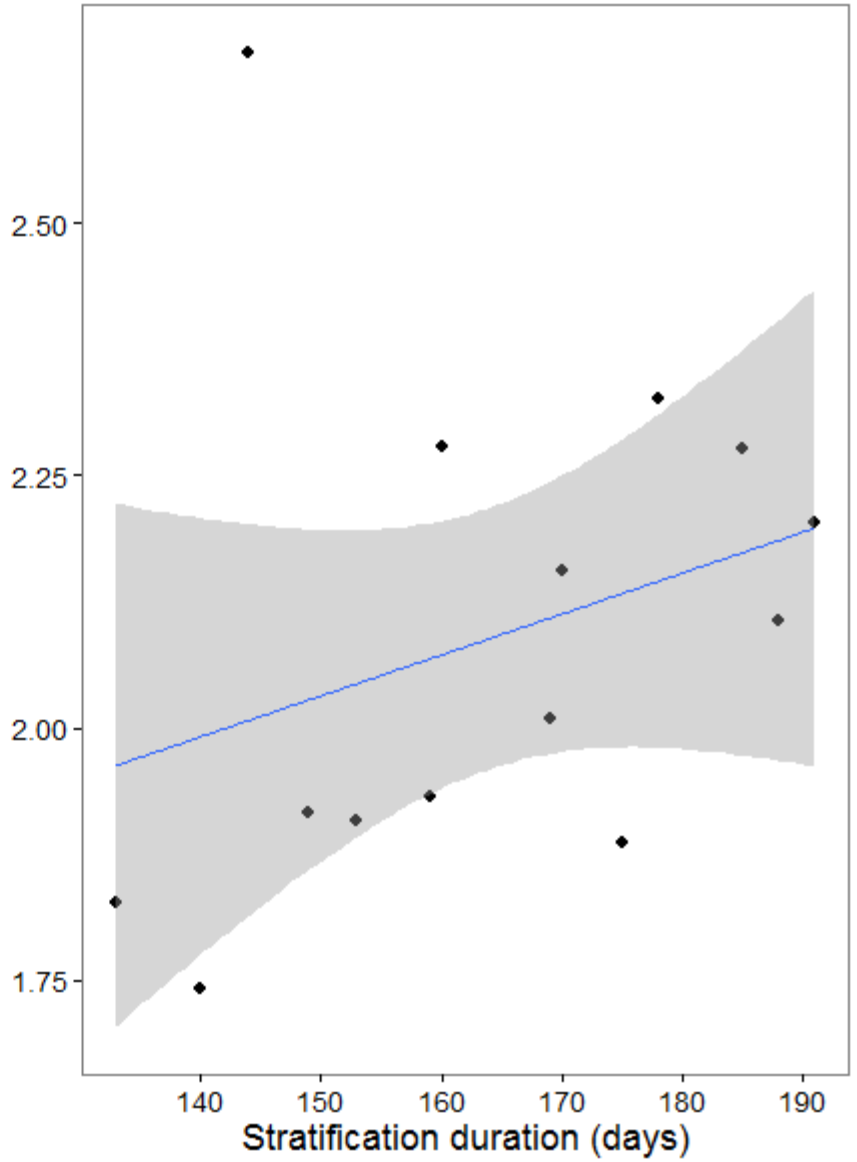


Temperature

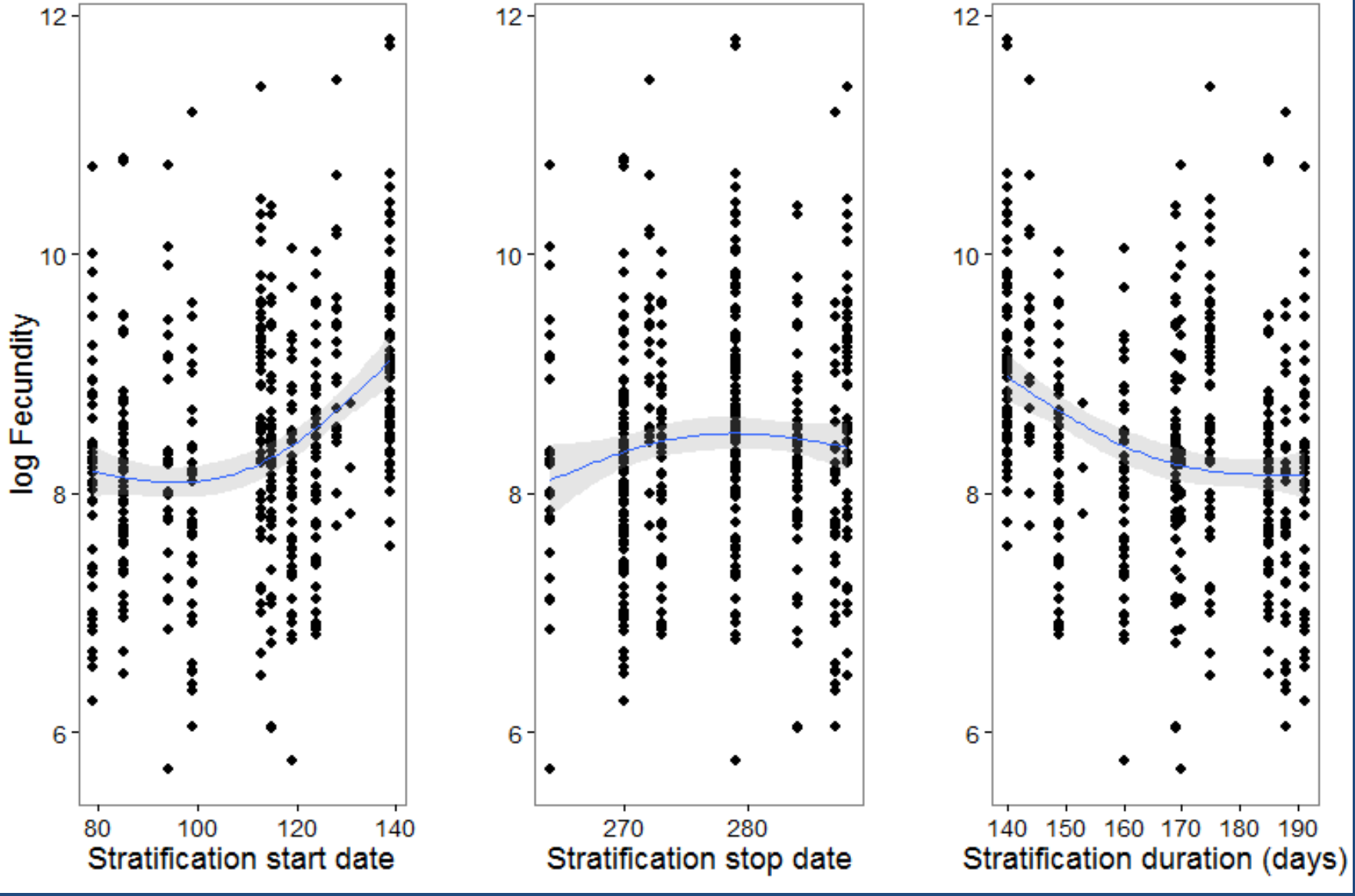


Stratification and chlorophyll-a

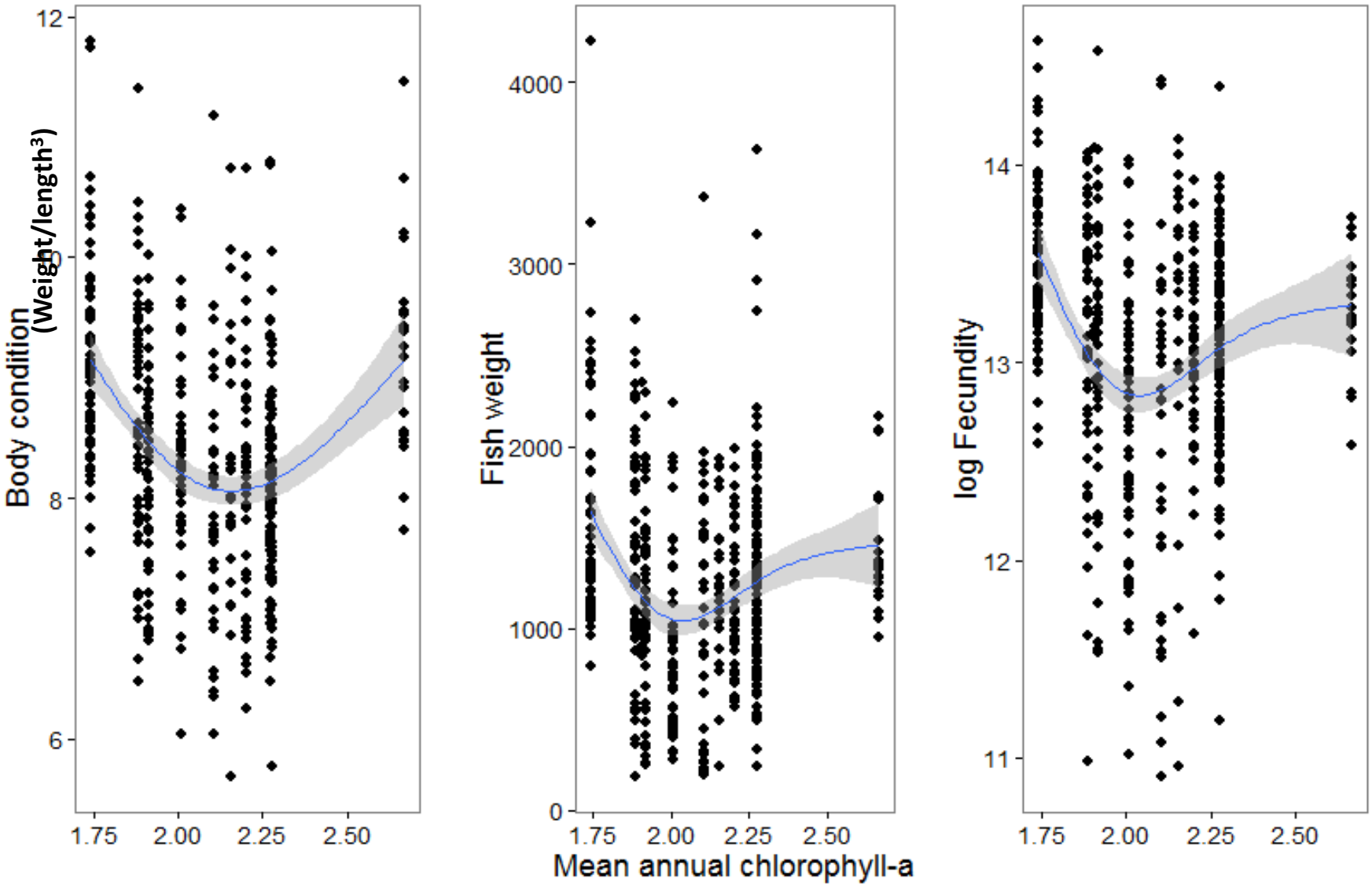




Stratification timing



Chl-a and fecundity



Summary

- Spatial trend in fecundity
- Interannual variability in pollock fecundity
- No clear density-dependent trend in fecundity
- Weak relationship between temperature and fish weight in summer
- No clear relationship between temperature and fecundity in winter or summer
- Increased fecundity with later stratification onset
- Decrease in fecundity with chlorophyll-a biomass and then an increase at higher levels

Application to pollock stock assessment

- Primary analysis: evaluate implications of alternative metrics of reproductive output on status determination and stock productivity, and include in base assessment model as required:
  - Spawning biomass with year-invariant maturity
  - Spawning biomass with annual variation in maturity
  - Egg production with year-invariant fecundity
  - Egg production with annual variation in fecundity

Application to pollock stock assessment

- Environmental relationships (if they can be shown to be robust, or at least the uncertainty adequately characterized) allow for extension to years without fecundity data:
  - Retrospective analysis of historical patterns
  - MSE of current and/or alternative harvest policies
  - Evaluation of climate change scenarios (with necessary caveats)

Acknowledgements

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- NOAA Fisheries and the Environment

Future work

- Further examine relationships between temperature, chlorophyll-a and fecundity
- Is chl-a biomass inversely related to zooplankton production?
- Explore the possibility of relating body condition and fecundity to zooplankton species abundance and/or size
- Explore relationship between stratification timing and zooplankton production and species composition

Fecundity

gravimetric method:

sample count/ sample weight * whole ovary weight