



# Female reproductive potential of eastern Bering Sea snow crab (*Chionoecetes opilio*)

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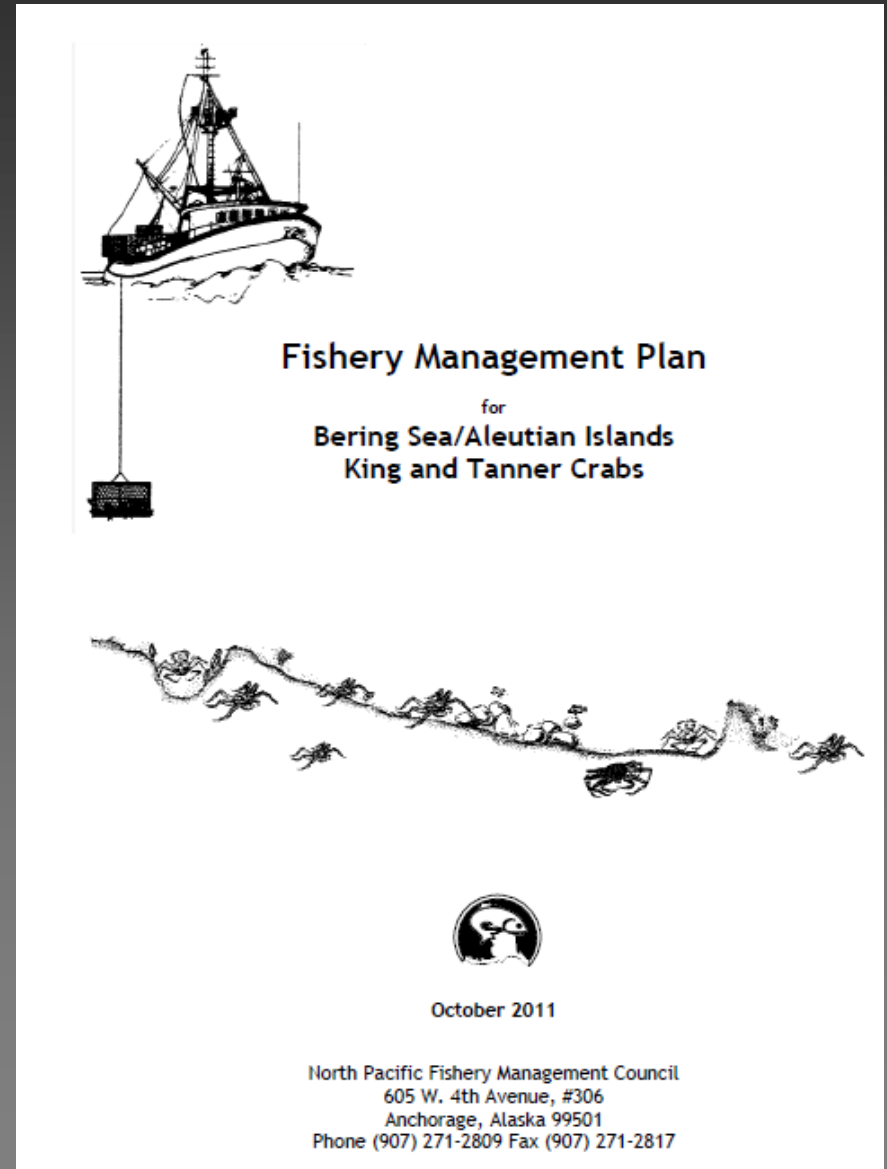
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<sup>4</sup>Department of Fisheries and Oceans, Maurice Lamontagne Institute, Mont-Joli, QC, Canada.



# Motivation

- EBS snow crab is a federally managed stock.
- FMP approved in 1989.
- The FMP establishes a State/Federal cooperative management regime that defers crab management to the State of Alaska with Federal oversight.



# Motivation

## ❖ Commercial Harvest

EBS snow crab have contributed  $\sim\frac{1}{4}$  of the biomass of crabs commercially harvested in the U.S. over the past three decades

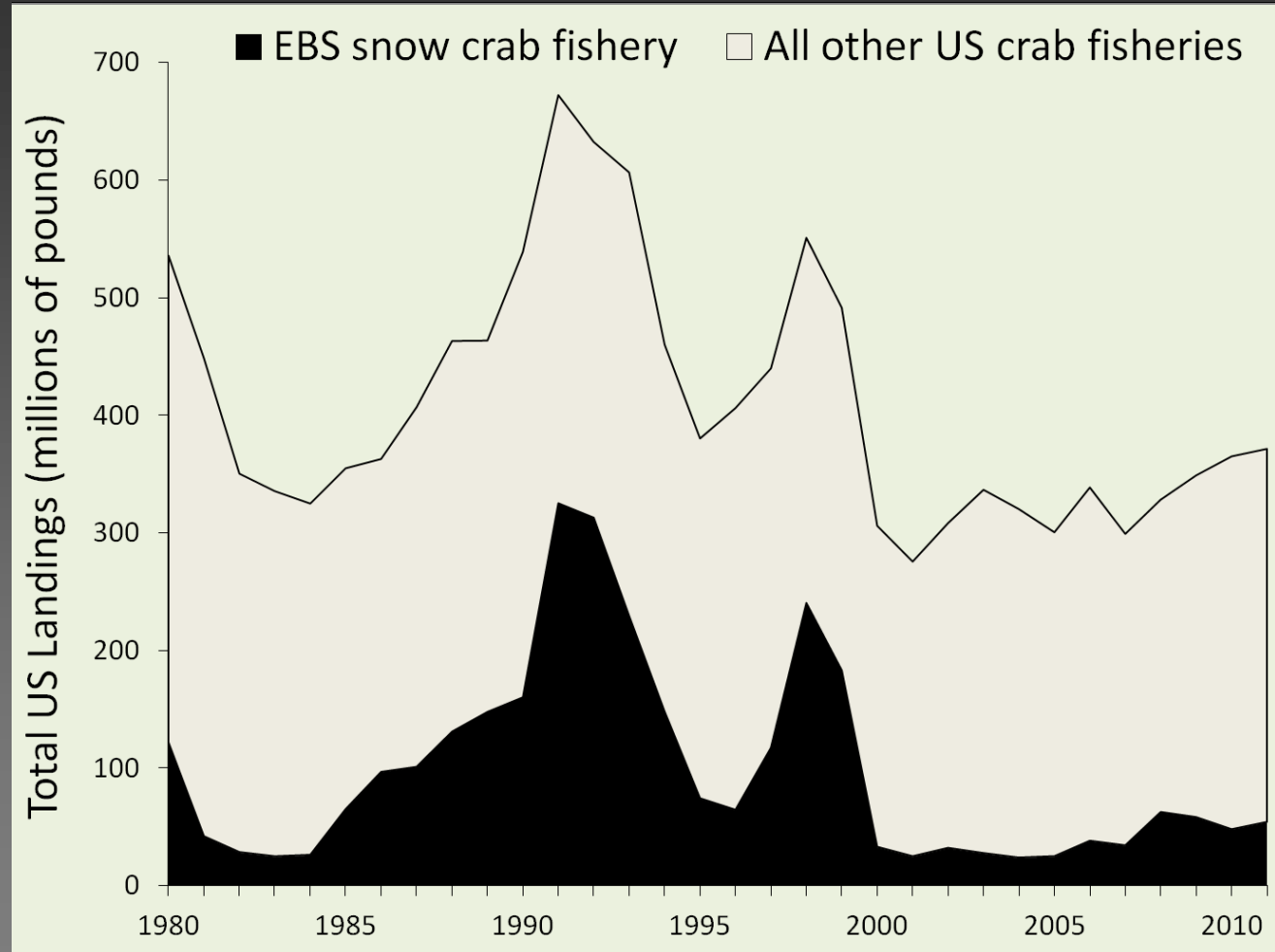


Figure modified from Pengilly et al. (2014).

Data compiled from NMFS Fisheries Statistics Division:

[www.st.nmfs.noaa.gov/st1/commercial/landings/gc\\_runc.html](http://www.st.nmfs.noaa.gov/st1/commercial/landings/gc_runc.html).



# Motivation

- ❖ How does large-male exploitation influence female reproductive potential and stock productivity?



[www.lastfrontier.org](http://www.lastfrontier.org)



Ashton Photography

Mature male biomass used as an index of reproductive potential in stock assessment

# Goals

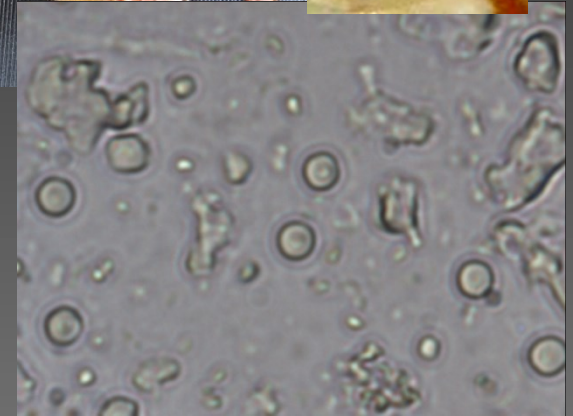
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- Develop an index of female reproductive potential that reflects stock mating dynamics
- Analyze spatiotemporal trends in female sperm reserves to inform functional relationships among female reproductive potential, maternal characteristics, and the availability of male mates
- Assess the impact of the fishery's harvest of only large males on the reproductive output by females
- Compare new indices with the biomass proxy for stock productive capacity currently used in management

# Approach

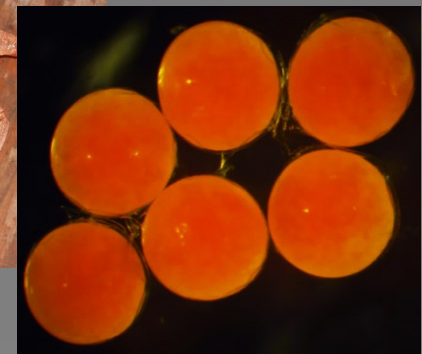
## ❖ Evaluate Fecundity

- Factors that effect variability in egg production
- Clutch fullness index over survey time series



## ❖ Evaluate Female Sperm Reserves

- Male availability for mating and direct measure of contribution to female reproductive success
- Spatiotemporal variability





# Approach

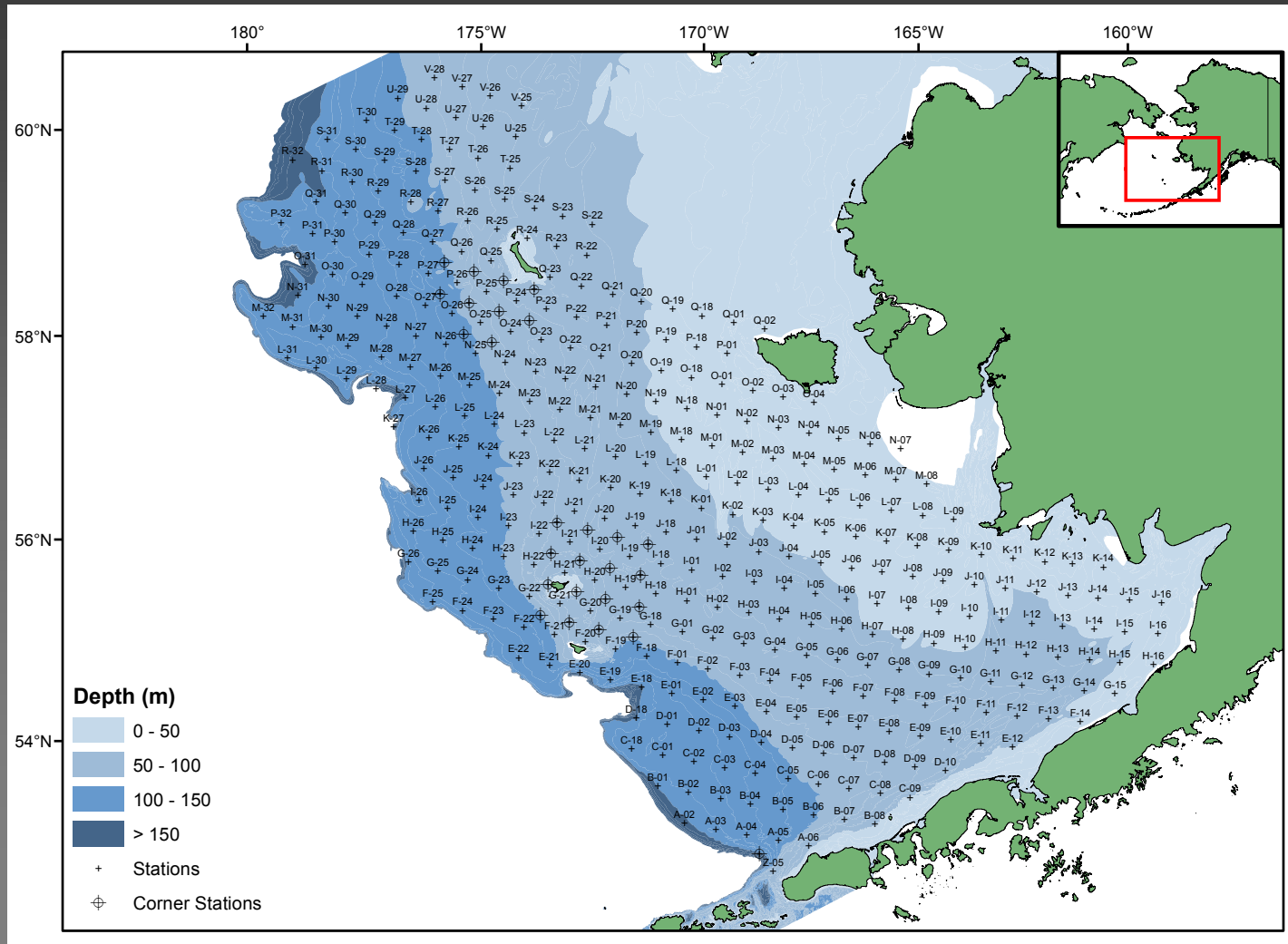
## ❖ Female Reproductive Stage

| Shell Condition                 |          | Newshell (SC2)    | Oldshell (SC3)            | Very Oldshell (SC4-5) |
|---------------------------------|----------|-------------------|---------------------------|-----------------------|
| Reproductive status             | Immature | Primiparous       | Multiparous (Primiparous) | Multiparous           |
| Approximate years post-maturity |          | $\leq \sim 1$ yr. | $\sim 2-4$ yr.            | 4+ yr.                |



# Approach

## Study Area: Annual NOAA AFSC EBS shelf trawl survey





# Approach

## Sample Processing: Dissect Crabs

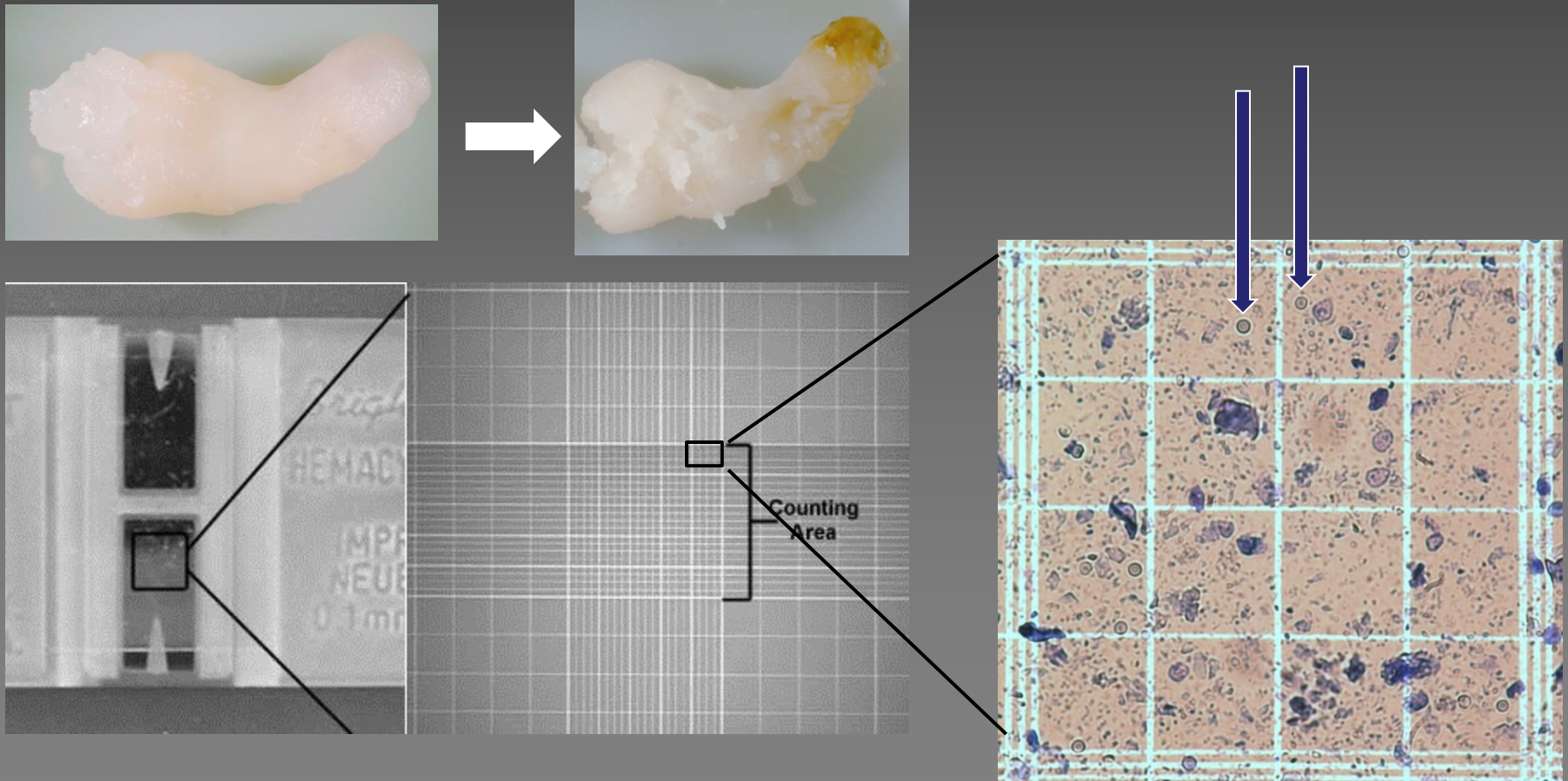


- Sperm
- Eggs
- Maternal characteristics and condition

# Approach

## Sample Processing: Sperm Storage

- Wet weight and counts



# Results

In Press. Canadian Journal of Fisheries and Aquatic Sciences.



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ARTICLE

## The contribution of fecundity and embryo quality to reproductive potential of eastern Bering Sea snow crab (*Chionoecetes opilio*)

Joel B. Webb, Laura M. Slater, Ginny L. Eckert, and Gordon H. Kruse

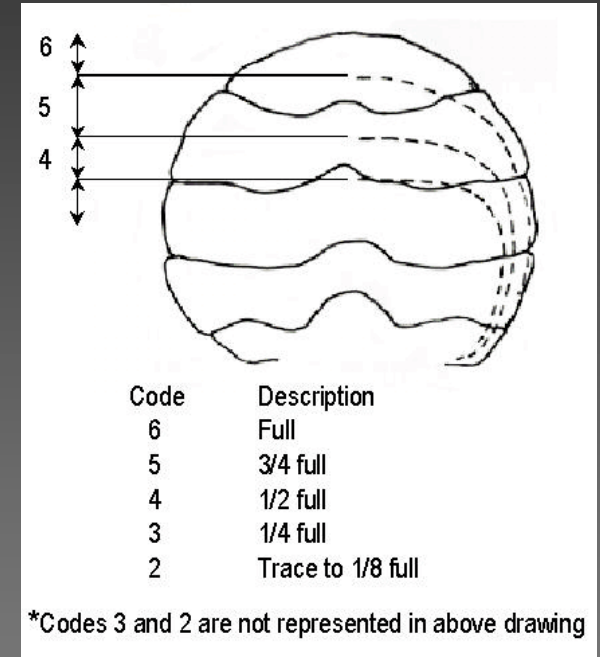
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**Abstract:** Development of refined indices of female reproductive potential is needed for estimation of alternative biological reference points for the eastern Bering Sea (EBS) snow crab (*Chionoecetes opilio*) fishery, which is managed with large male-only harvest regulations. Females were collected from 2007 to 2009 to investigate seasonal and interannual variation in fecundity with maternal size, shell condition (a proxy for age after maturity), and recent mating and again in 2010 to examine biochemical measures (carbon, hydrogen, and nitrogen) of embryo quality. Mean model-adjusted fecundity was highest for primiparous and young multiparous females and declined with advancing shell condition, presumably from senescence. This pattern was also found for clutch fullness indices evaluated from 20 years of stock assessment survey data. Indicators of low female sperm reserves were associated with decreased (~10%) fecundity for multiparous females. Seasonal comparison of size–fecundity relationships suggested that embryo loss during brooding was minimal, and embryo quality analyses suggested that strong variation with maternal characteristics was unlikely. Finally, fecundity-at-size of EBS females may be lower than that of conspecifics in Japan and eastern Canada.



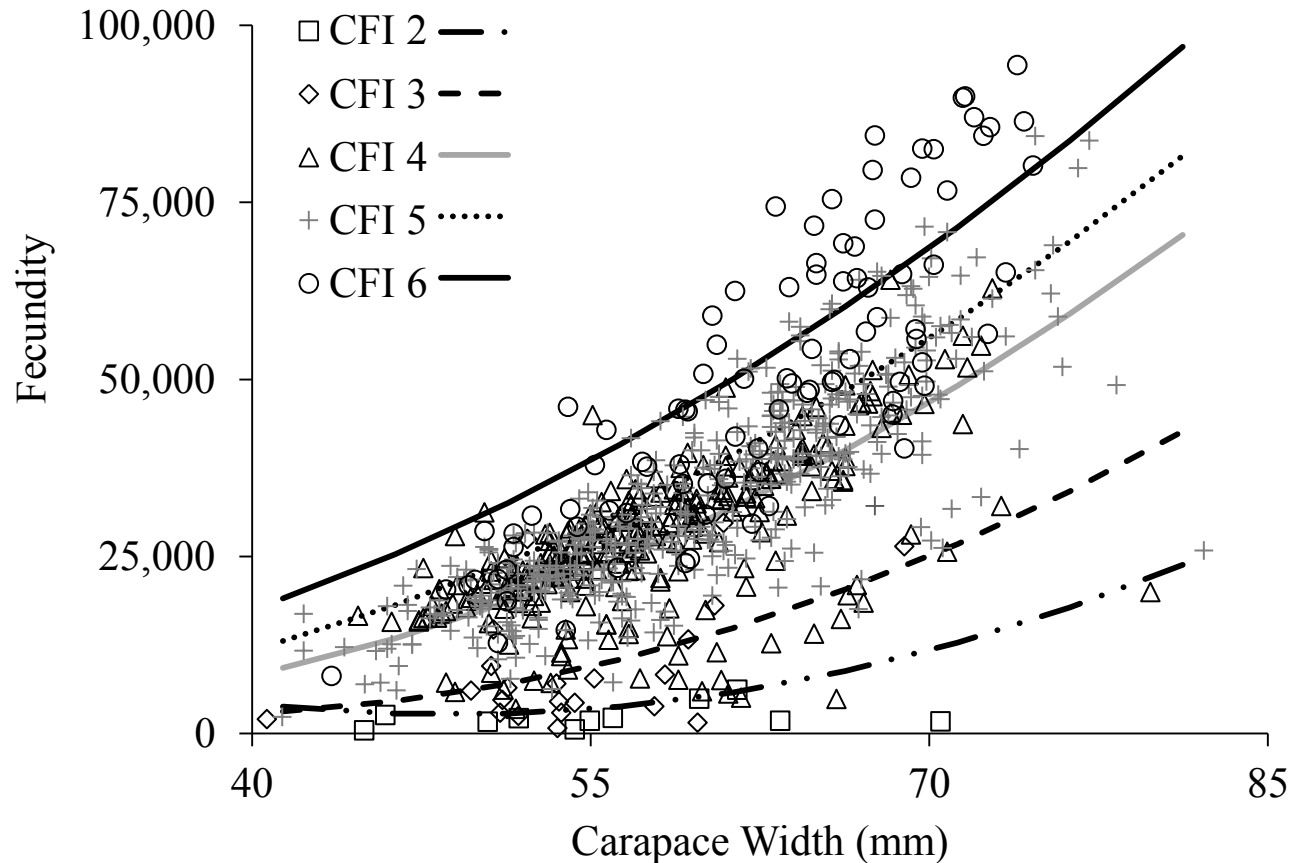
# Results

## Clutch Fullness Index



# Results

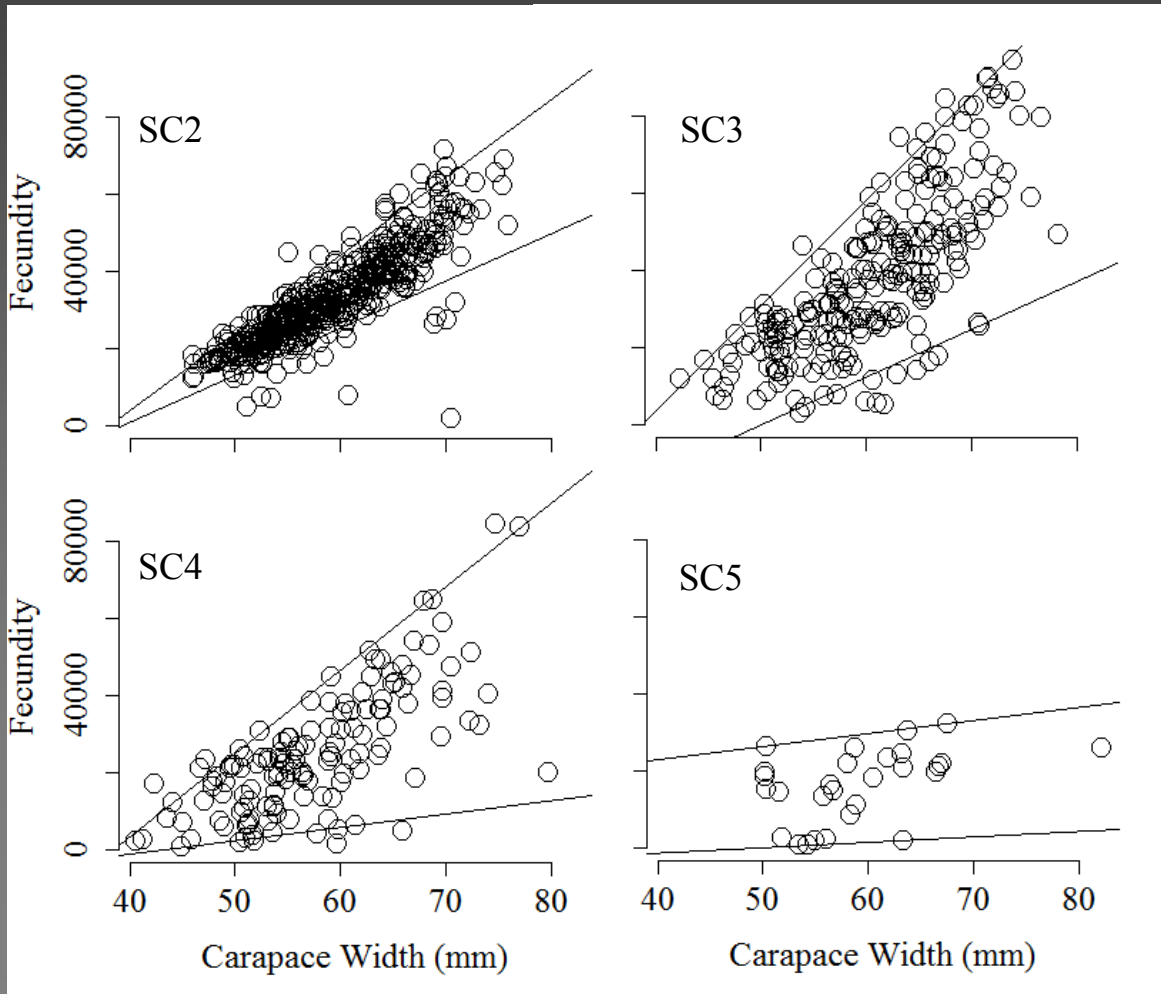
## Robust size-fecundity relationship by clutch fullness



Linear mixed model,  $R^2=0.80$

# Results

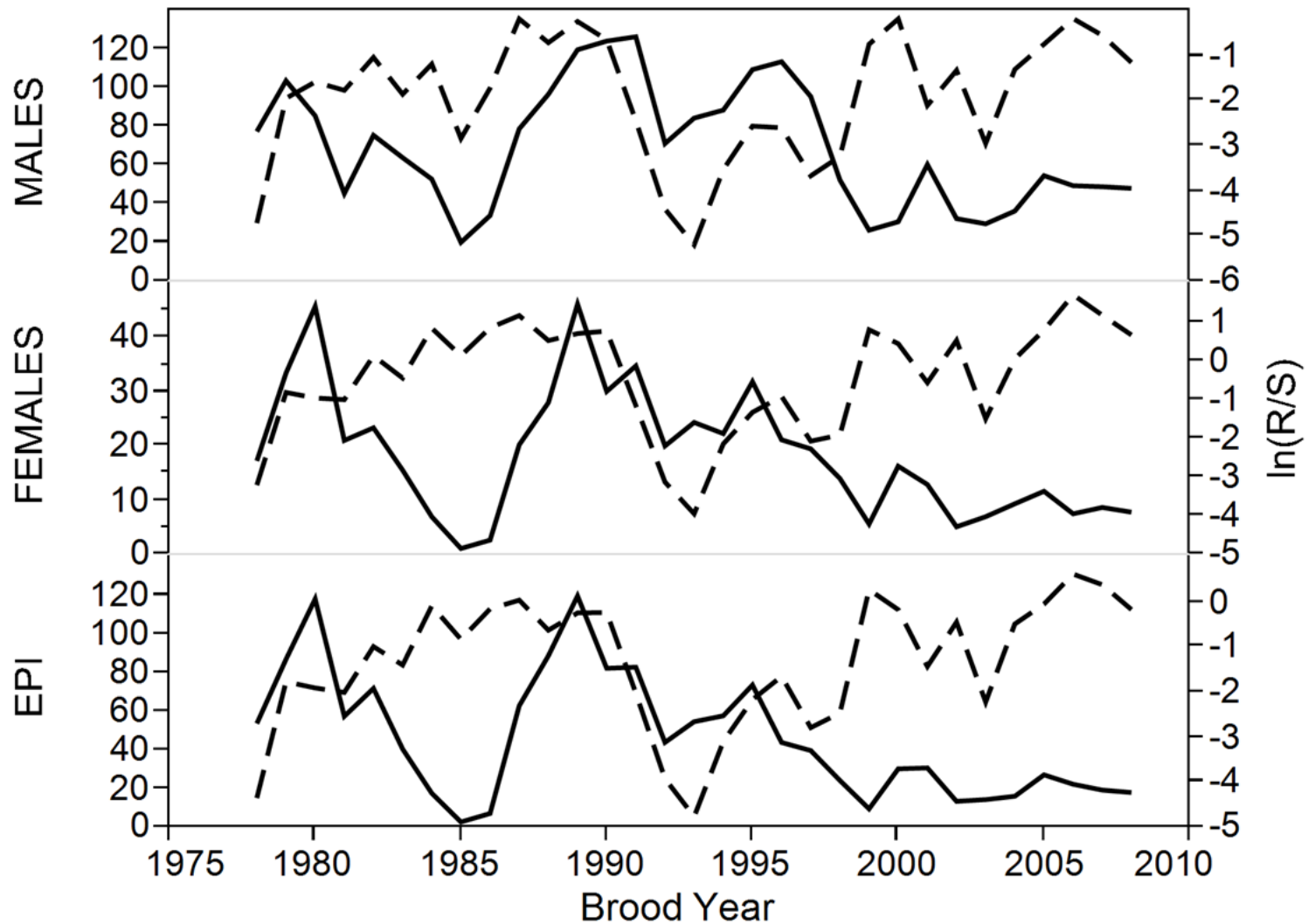
Increased variability and decreased output over reproductive stage (age)





# Results

## ❖ Indices of Reproductive Potential



# Conclusions

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## ❖ Egg Production

- clutch fullness index is a robust index of egg production
- Demography (age & proportion abundance by age) impacts population egg output
- Egg production index is proportional to mature female abundance
- Proportion of population on biennial cycle important but difficult to estimate

# Results

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## 2010. Biology and Management of Exploited Crab Populations under Climate Change.

### **Preliminary Analysis of Spermathecal Load of Primiparous Snow Crab (*Chionoecetes opilio*) from the Eastern Bering Sea, 2005-2008**

**Laura M. Slater, Kirsten A. MacTavish,<sup>1</sup> and Douglas Pengilly**  
*Alaska Department of Fish and Game, Commercial Fisheries Division, Kodiak, Alaska, U.S.A.*

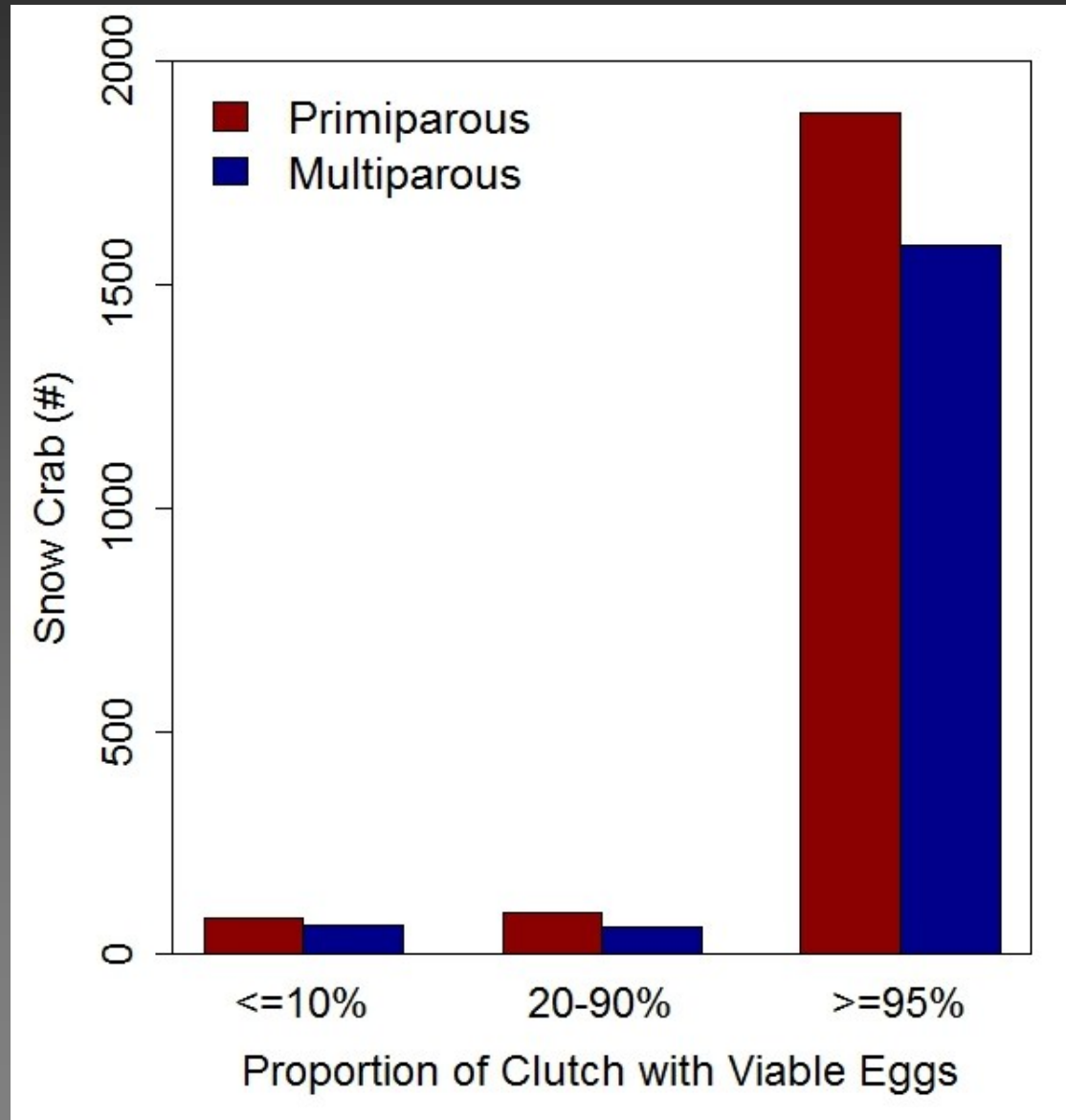
#### **Abstract**

Male snow crab (*Chionoecetes opilio*) are harvested commercially in the eastern Bering Sea. Female snow crab possess sperm storage organs and can store sperm for successive clutch fertilization, a feature that could buffer the stock from recruitment overfishing by the males-only fishery. To better understand factors affecting reproductive potential of eastern Bering Sea snow crab, sperm reserves were assessed for primiparous crab in 2005, 2007, and 2008 through measurements of spermathecal load (SL). Area of collection and female size had significant effects on SL, and interactions existed between SL, area of collection, female size, and year. Patterns of female sperm reserves in the eastern Bering Sea underscore the importance of understanding the effects of spatial processes on the eastern Bering Sea snow crab stock.



# Results

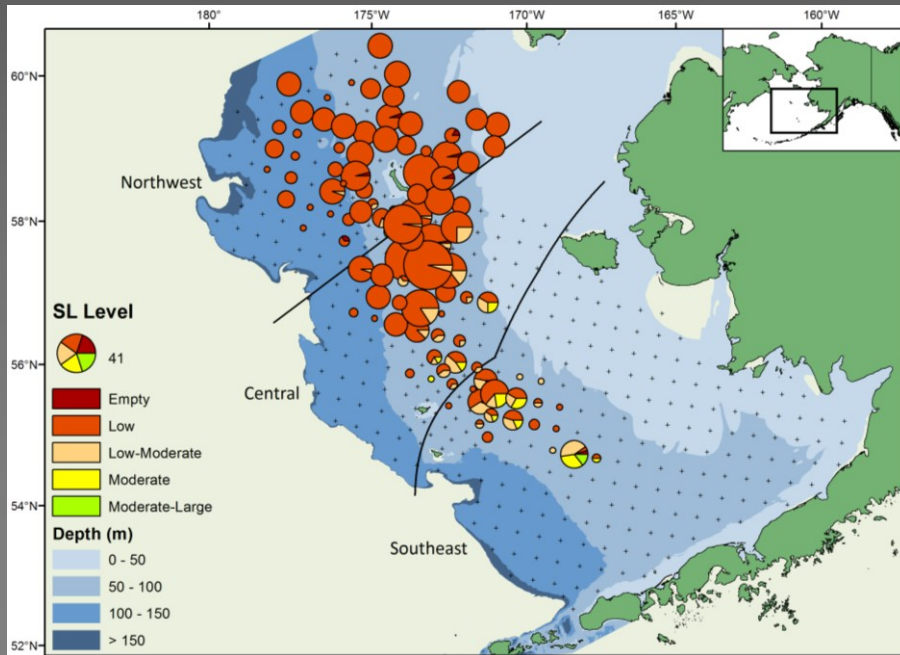
- Most (92% of 3,781) snow crab examined had clutches with mostly viable eggs
- Restricted to eggs with noticeable embryonic development



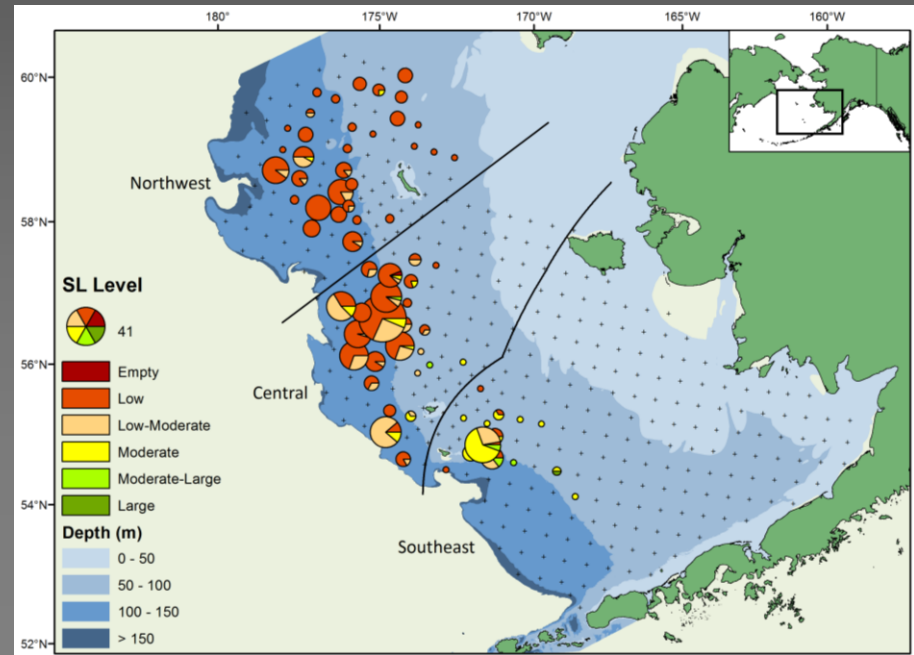
# Results

- Scale established for Atlantic Ocean snow crab
- Low SL where most of population is distributed
- Similar trends by reproductive stage

## Primiparous

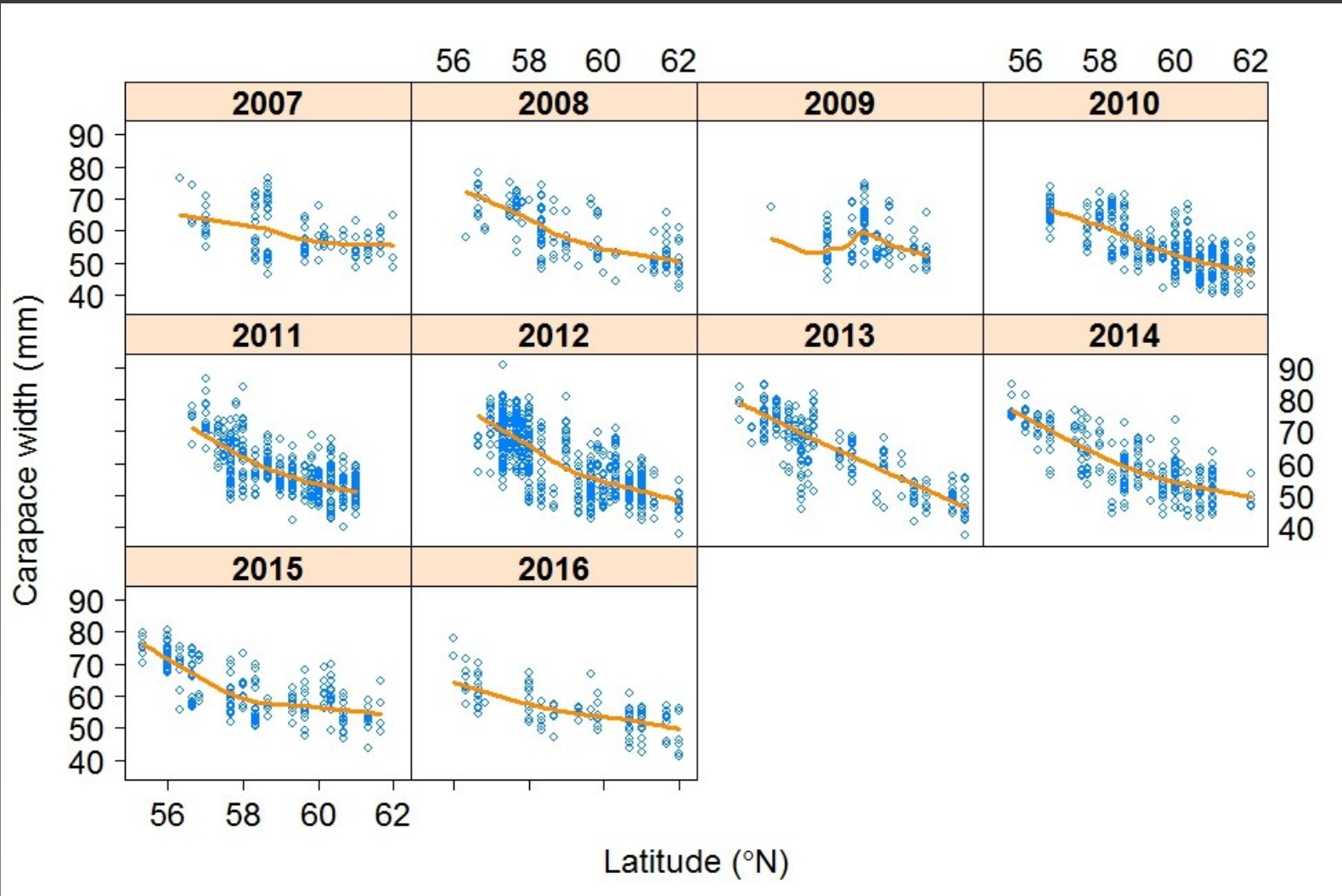


## Multiparous



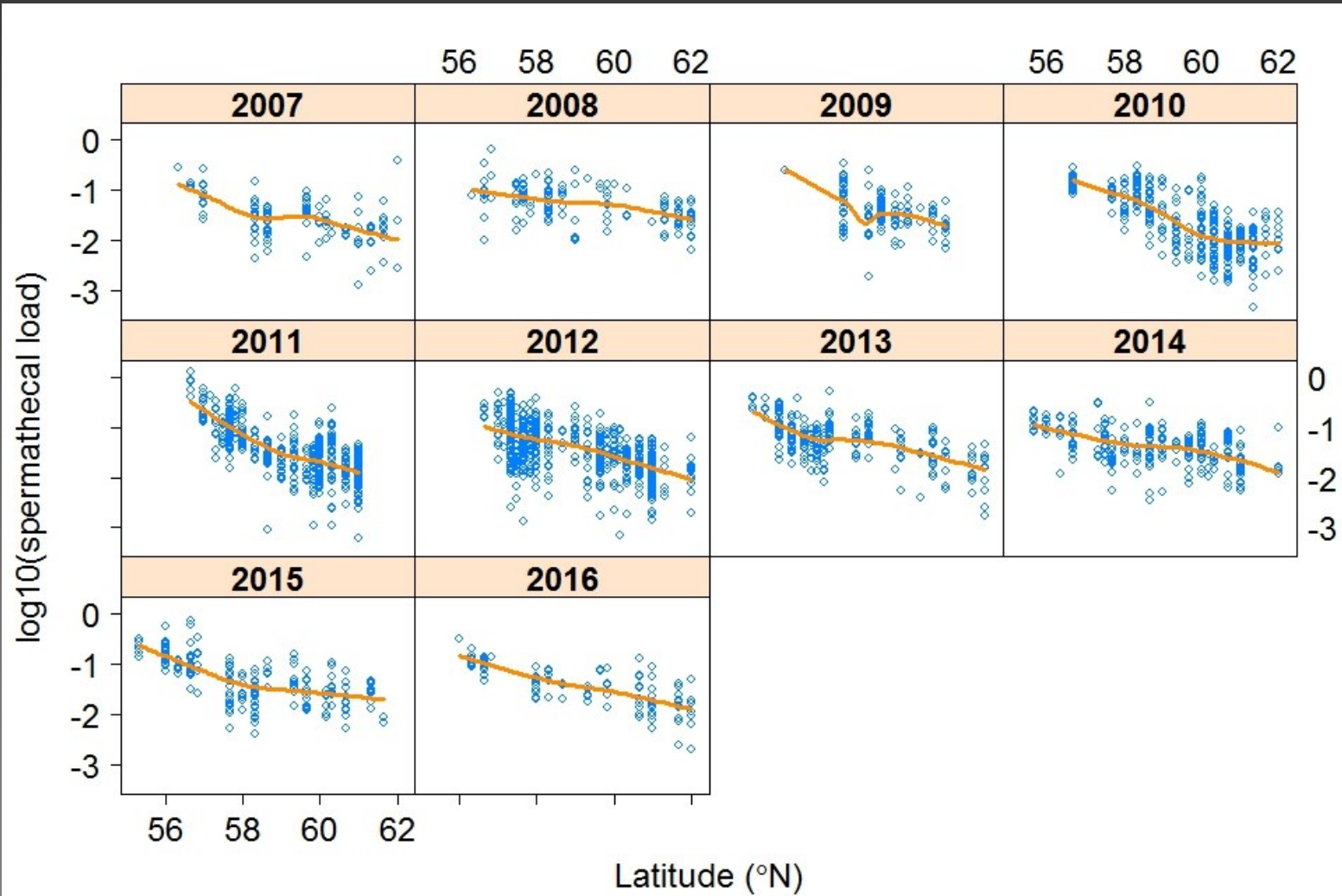
# Results

Size declines with latitude across all years



# Results

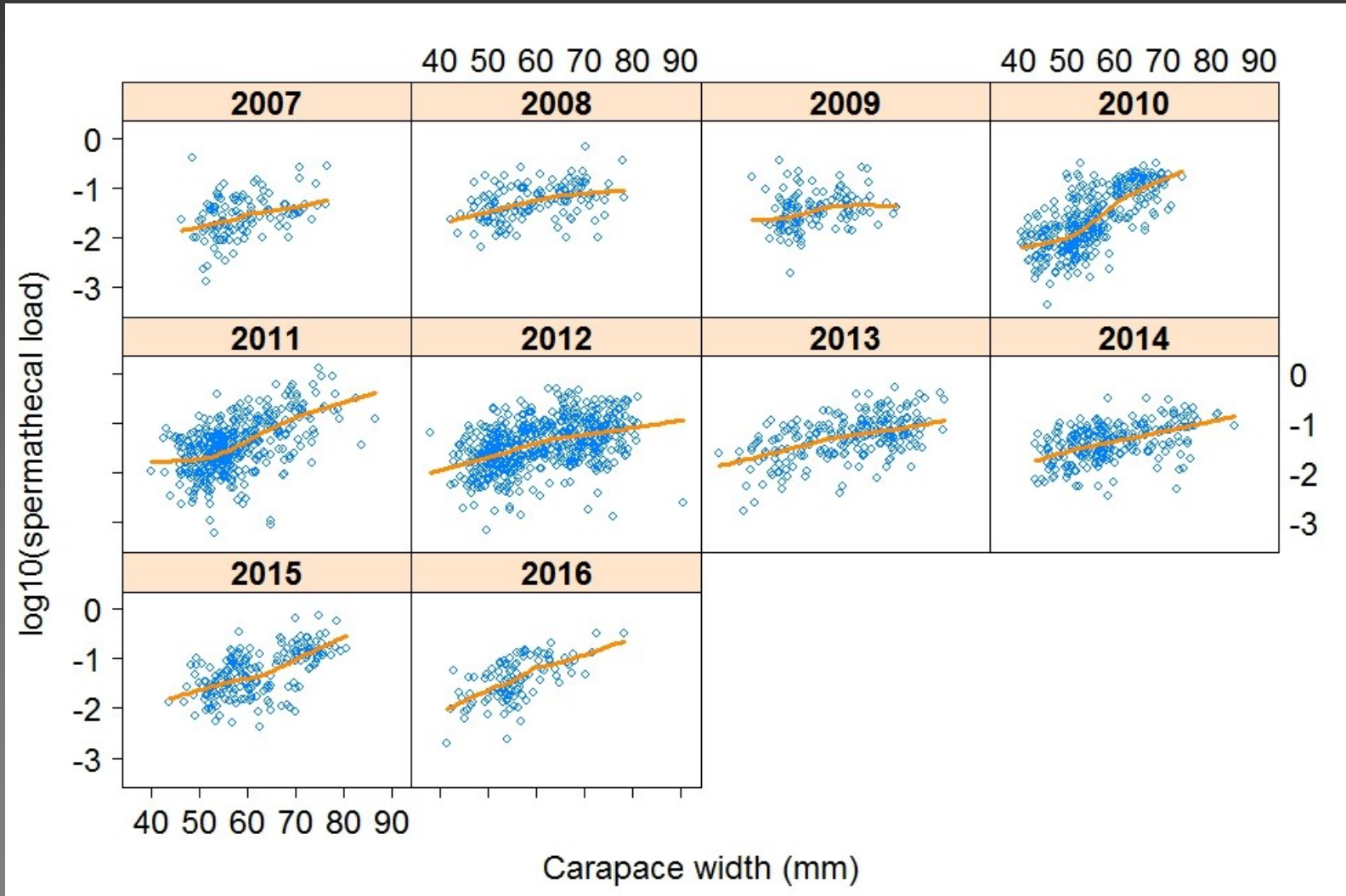
SL also declines with latitude across all years





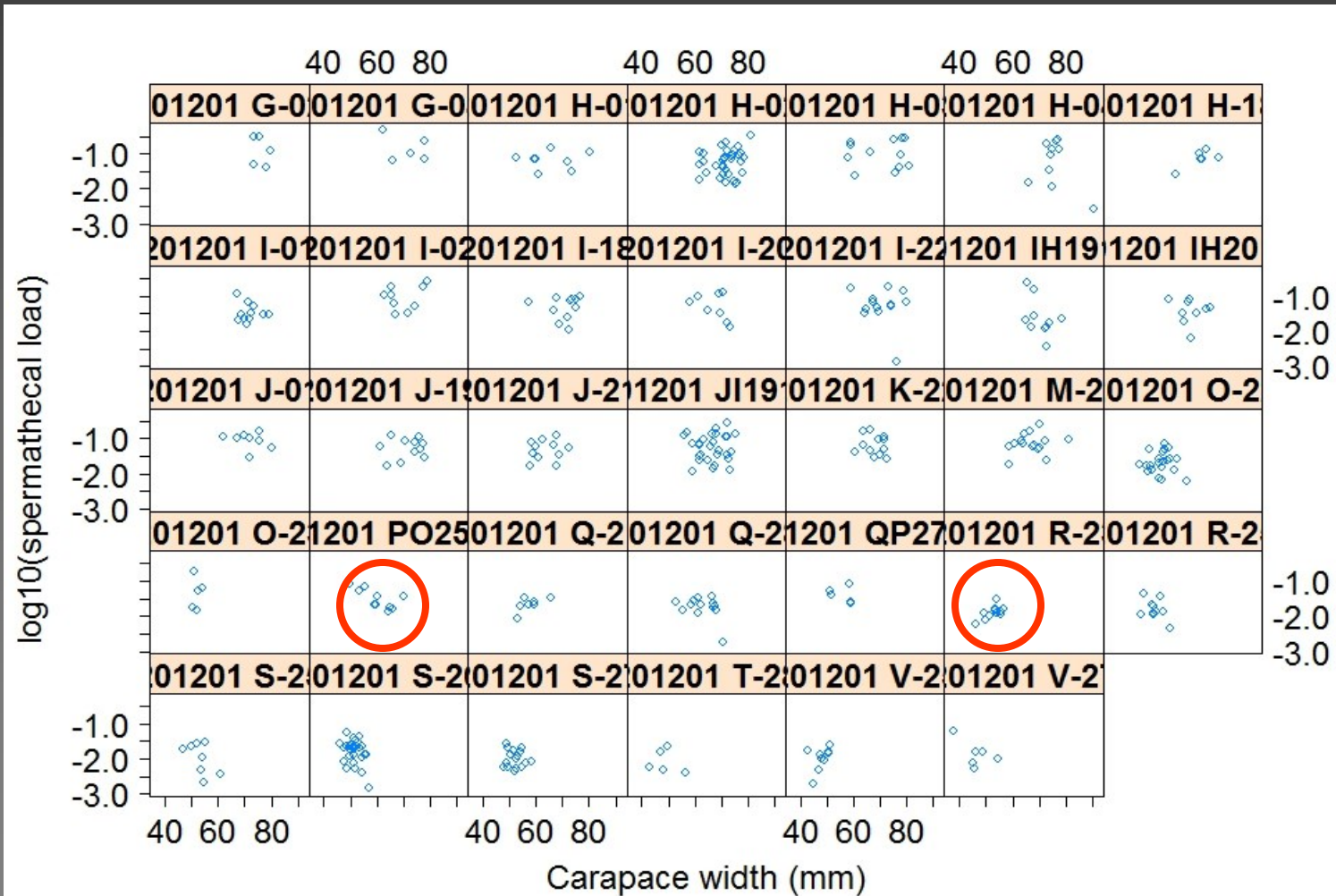
# Results

SL increases with female size



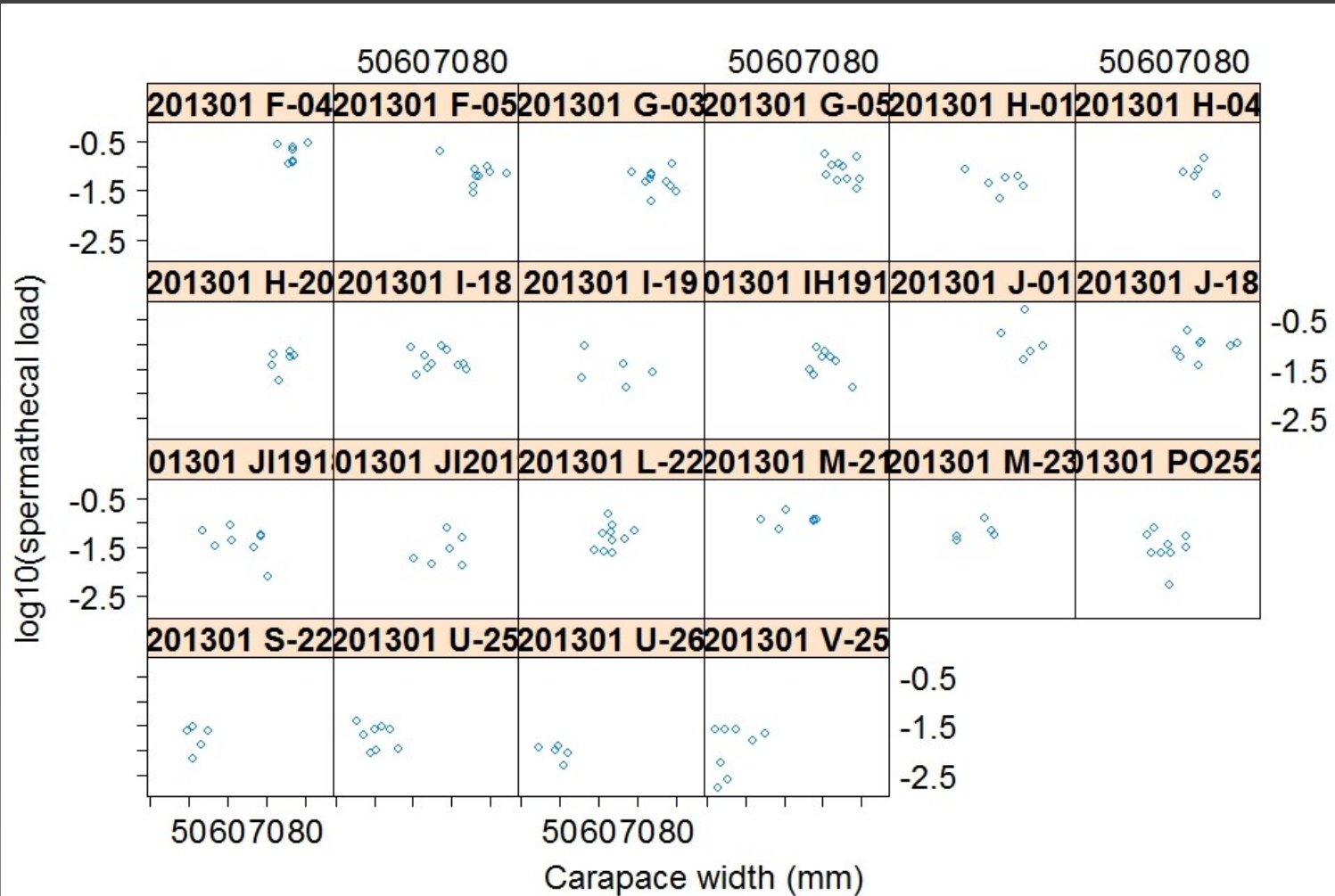
# Results

However, when examined at a station level  
2012



# Results

However, when examined at a station level  
2013



# Conclusions

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## ❖ Sperm Reserves

- no evidence of current sperm limitation
- re-mating is necessary and occurs frequently
- lack of buffer against sperm limitation
- persistent spatial trends



# Future Directions

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- ❖ Needs and New Opportunities
  - Biennial reproduction – difficult to model, paucity of empirical data
  - Relationship with sex ratio (quantity and quality of males)
  - Relationship with temperature
  - Genetics of paternity

# Many Helping Hands

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## Pilot Study

- Kirsten MacTavish (formerly ADF&G, now IPHC)

## Project Management

- ADF&G: Nat Nichols, Natura Richardson

## Sample Collection – NOAA EBS Survey

- ADF&G, NOAA, UAS survey participants, especially: Meg Inokuma, Mike Knutson, Natura Richardson

## Logistics & Sample Transport

- ADF&G Kodiak and Dutch Harbor staff, NOAA Kodiak Lab staff, UniSea

## Live Crab Stewardship & Sample Processing

- ADF&G in Kodiak and Juneau, especially: Kayla Bevaart, Jassalyn Bradbury, Leslie Curran, Tara Fritzing, Meg Inokuma, Sarah Johnson, Thomas Kinsley, Mike Knutson, Nina Leacock, Natura Richardson, Andrew Olsen

# Funding

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- ADF&G, including Bristol Bay Red King Crab Test Fishery
- National Oceanographic and Atmospheric Administration Grants
- North Pacific Research Board (Project #714)



# Any Questions?

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