

# Fishery selection on salmon: Are we catching the big ones and is there potential for evolutionary change?

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*Sockeye Spawning Male*



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# Humans influence life history traits of domestic and wild animals

- Domestic livestock & pets



- Wild animals



Are we catching the big ones, leaving only the small ones behind?

# Need for quantifying harvest selection

- Life history traits are changing more quickly in harvested populations than in those not harvested



Darimont et al. 2009 PNAS

- We need to evaluate the implications of selection



Carlson et al. 2007 Ecol. Letters; Olsen et al. 2004 Nature; Law 2000 ICES J. Mar. Sci.

# Fishery selection in the news— smaller Chinook salmon

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## Fishermen Say Chinook Salmon Are Smaller

FAIRBANKS, Alaska, Jan. 7, 2006

**(AP)** Tanana fisherman Charlie Campbell doesn't need scientific studies or empirical data to prove Yukon River chinook salmon \_ the mighty king of the species \_ are getting smaller. All he has to do is walk into his smokehouse.

"I'm noticing I have a lot more headroom in the smokehouse than I remember," said Campbell, a subsistence fisherman who uses a fishwheel in The Rapids area of the Yukon between Tanana and Rampart.

"Long salmon strips hang in your face and you have to duck to get underneath them. I'm 6-2, so it's an issue for me. With these shorter fish, shorter strips."

Campbell hasn't been alone in his hypothesizing. Dozens of fishermen along the middle and upper reaches of the 2,300-mile Yukon have been claiming for years that smaller kings are returning from the ocean to spawn.

A pair of U.S. Fish and Wildlife Service biologists released a study earlier this month that lends some scientific weight to that suspicion. Already there is a move under way to do something about the shrinking of the chinook \_ a worrisome evolutionary trend that has devastated other vital commercial fisheries.



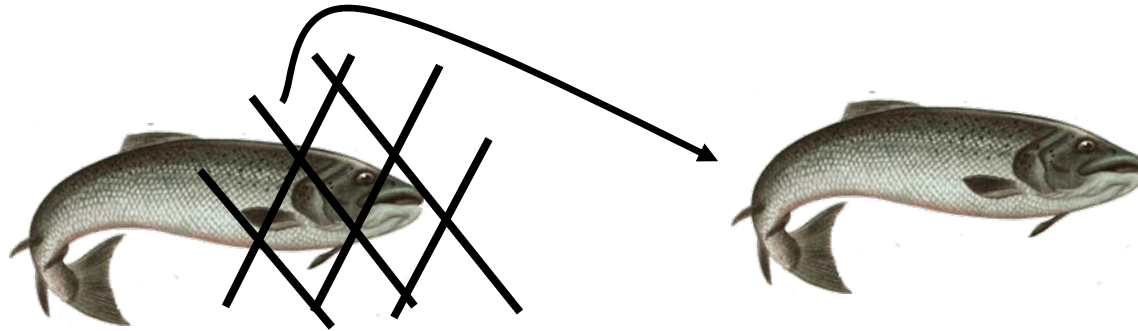
# “Fishery selection”

- Fishery gear, and specifically gillnets, catch certain sizes of fish

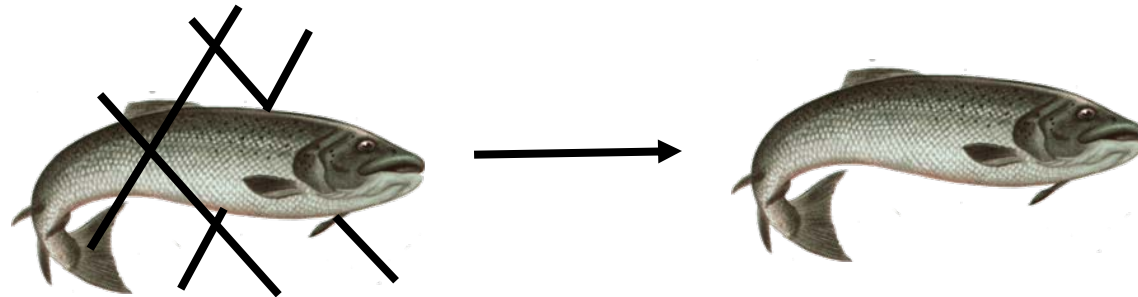


# Gillnet fisheries: mesh size selectivity

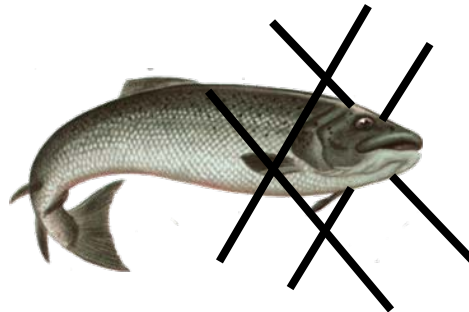
Fish too big:



Fish too small:



Fish just right:

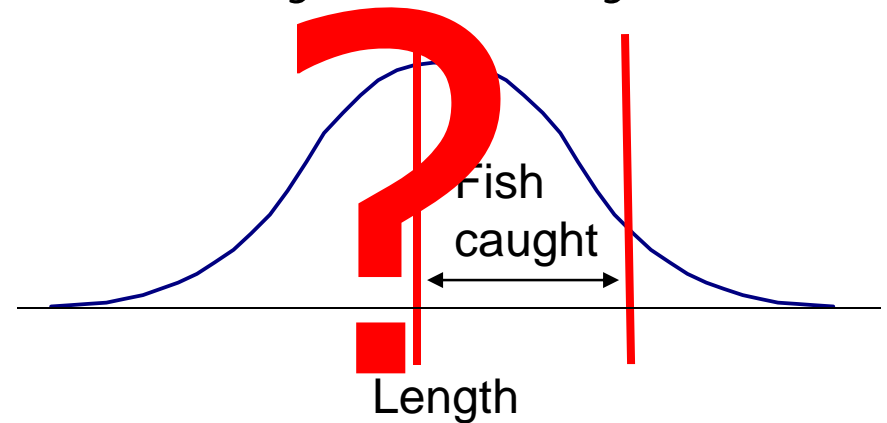


*Fish is caught!*

# Difficult to quantify fishery selection



Fishery selectivity curve





# Alaska salmon: good model to study fishery selection

- Anadromous (born and rear in freshwater, migration to ocean for 1-4 years, return to freshwater to spawn)
- Semelparous (spawn once and die)
- Length and age at maturity easy to measure
- Know population size and structure
- Long-term gillnet fisheries
- Large, long term data set





# Research questions

- Does fishery selection vary by fish length and sex?





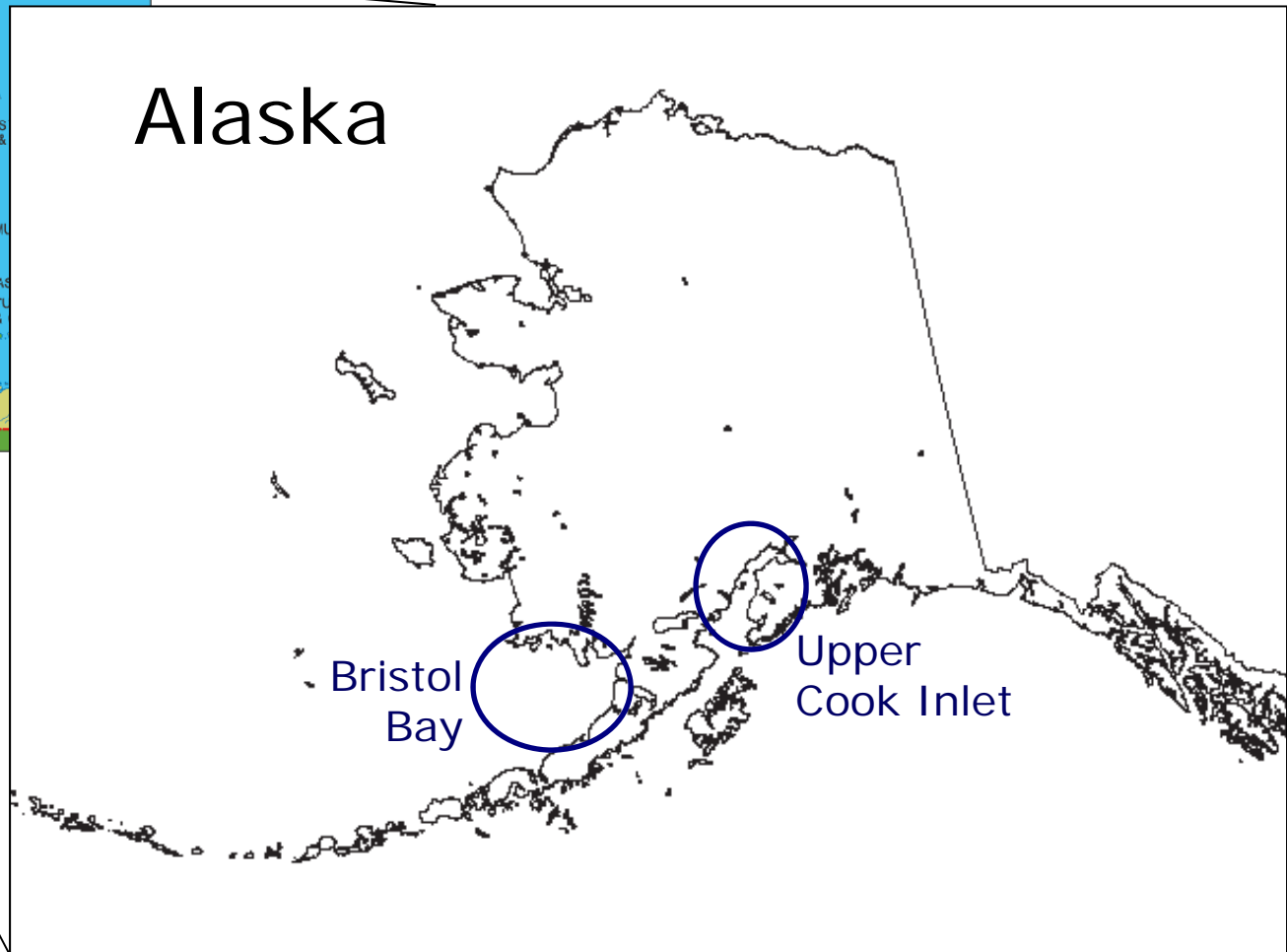
# Research questions

- Does fishery selection vary by fish length and sex?
- Are long term changes in fish length correlated with fishery selection?





# Alaska sockeye salmon fisheries



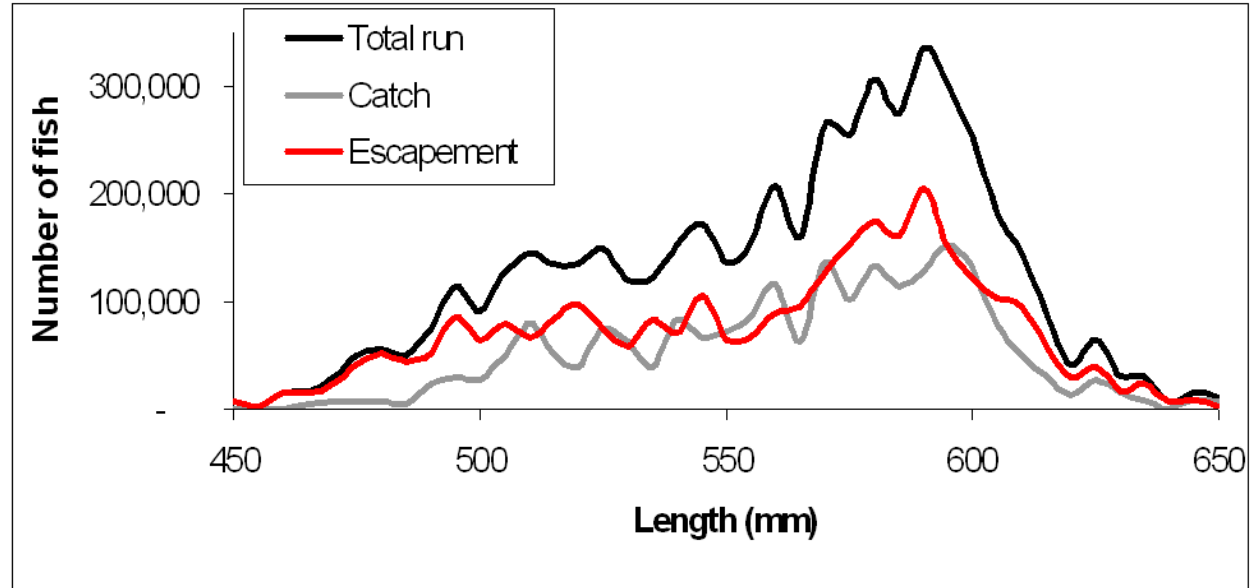


# Methods

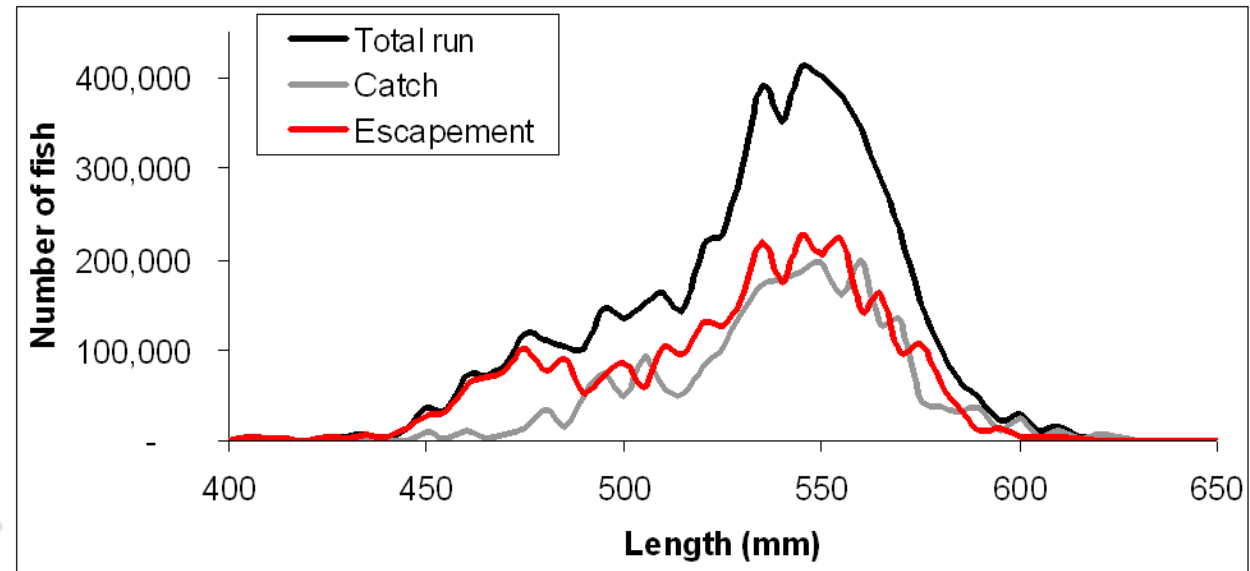
- Yearly historical fishery reconstruction to characterize annual length distributions in catch, escapement (not caught), and total run
- Estimate selection metrics:
  - 1) Length-specific vulnerability
  - 2) Selection differentials

# Length frequency histogram example

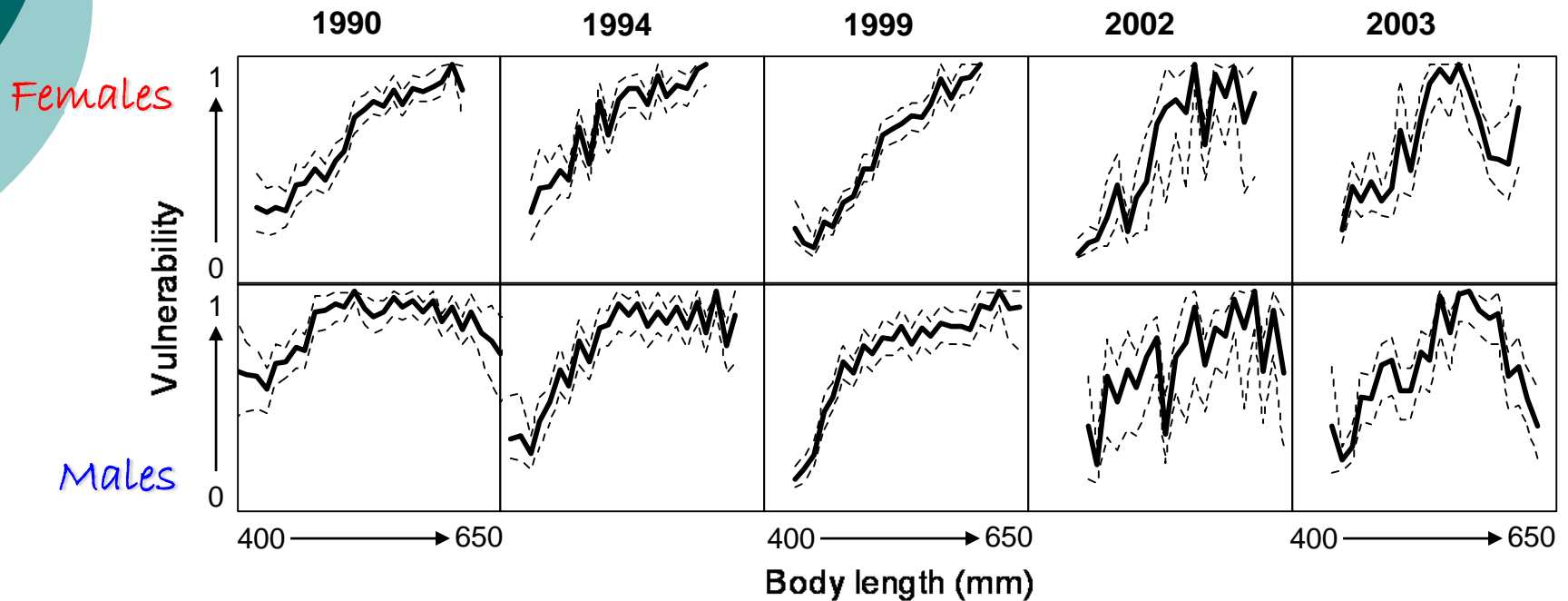
Males



Females



# Vulnerability profiles by length



- Longer fish more vulnerable to being caught
- Largest females most vulnerable
- Larger, but not largest, males most vulnerable
- Vulnerability varies over time

# Selection on length: SSDs

Standardized selection differential =

$$\frac{\overline{\text{length}}_{\text{escapement}} - \overline{\text{length}}_{\text{total run}}}{\text{std. deviation of length}_{\text{total run}}}$$



Smaller fish are  
escaping to spawn than  
are getting caught



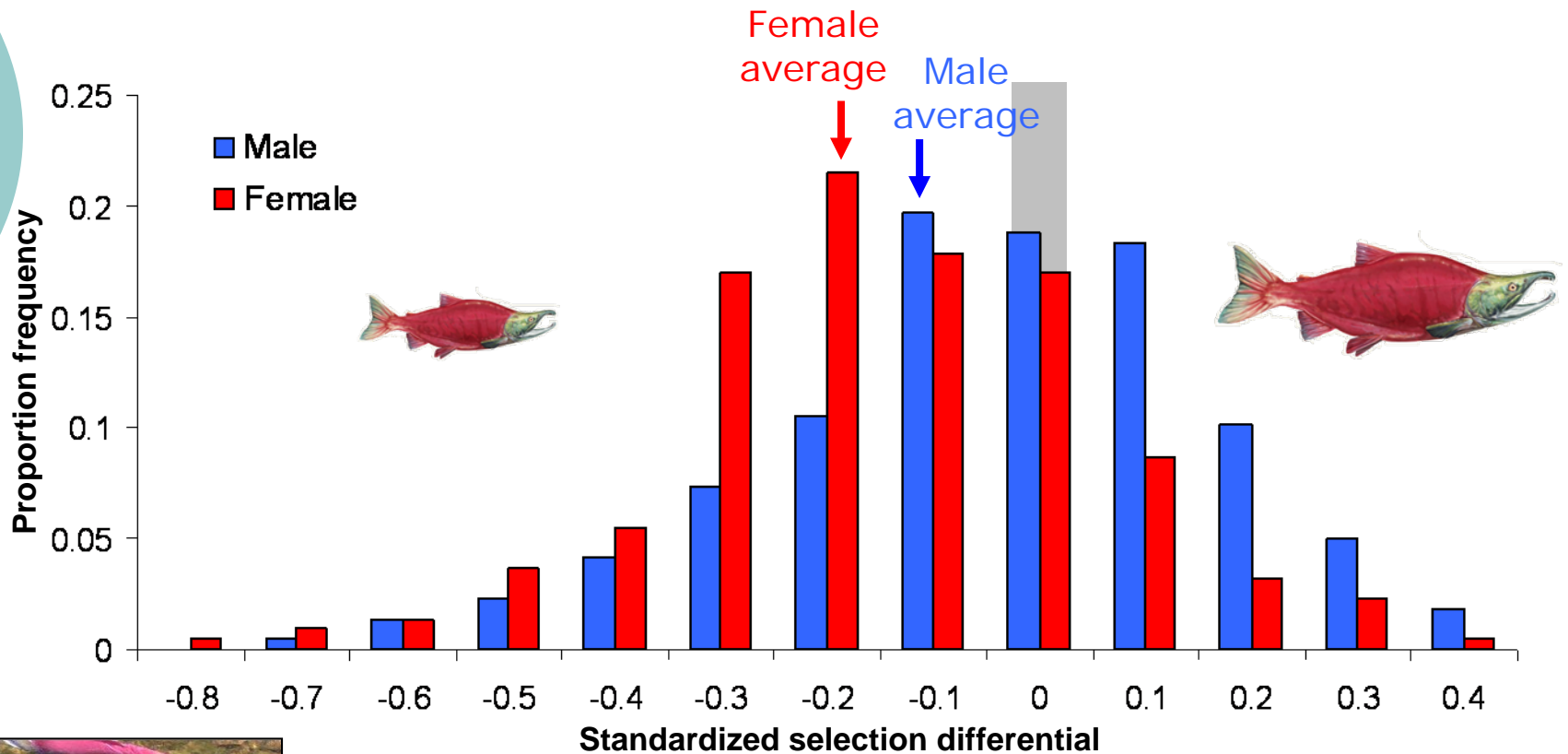
Larger fish are  
escaping to spawn than  
are getting caught

-

SSD

+

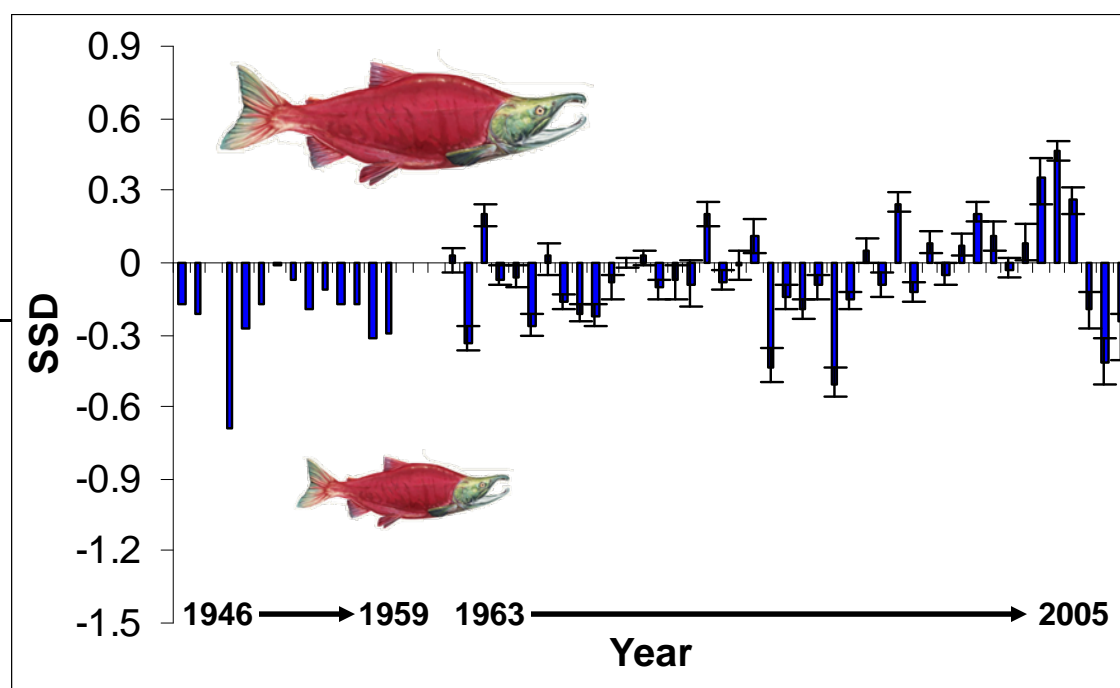
# Female SSDs more consistently negative than male SSDs



- In most years, longer than average fish caught, shorter fish escape to spawn
- Greater effect on females than males
- Variation over time

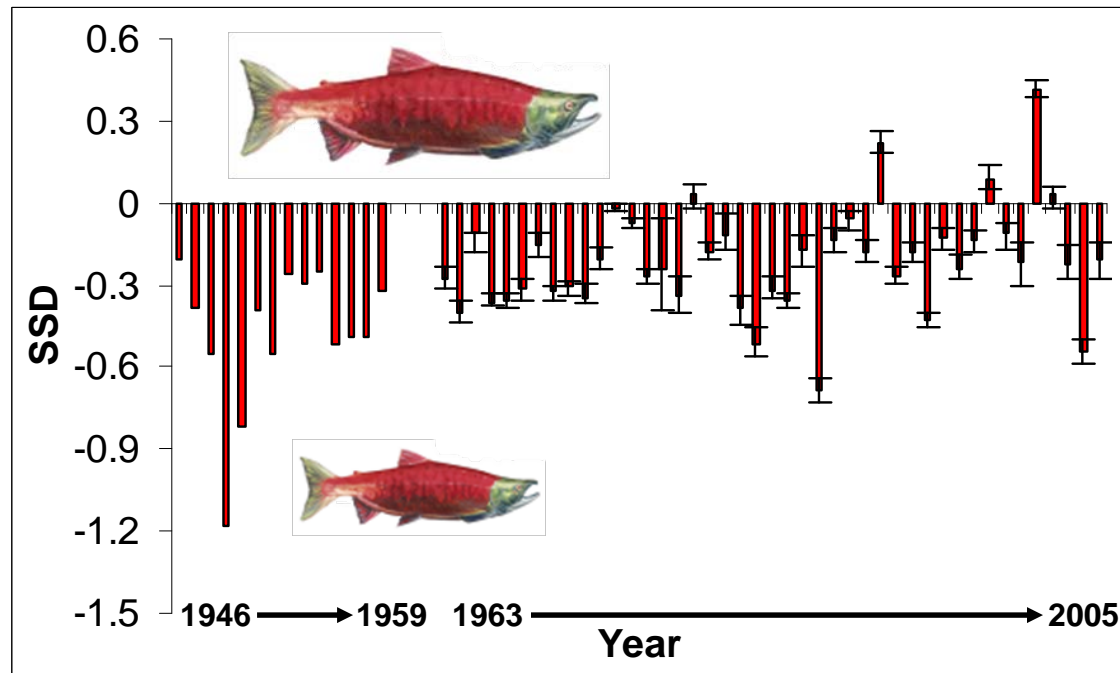
# SSDs have varied over time

Males



- Differences among sexes
- Variation over time (less selection recently)

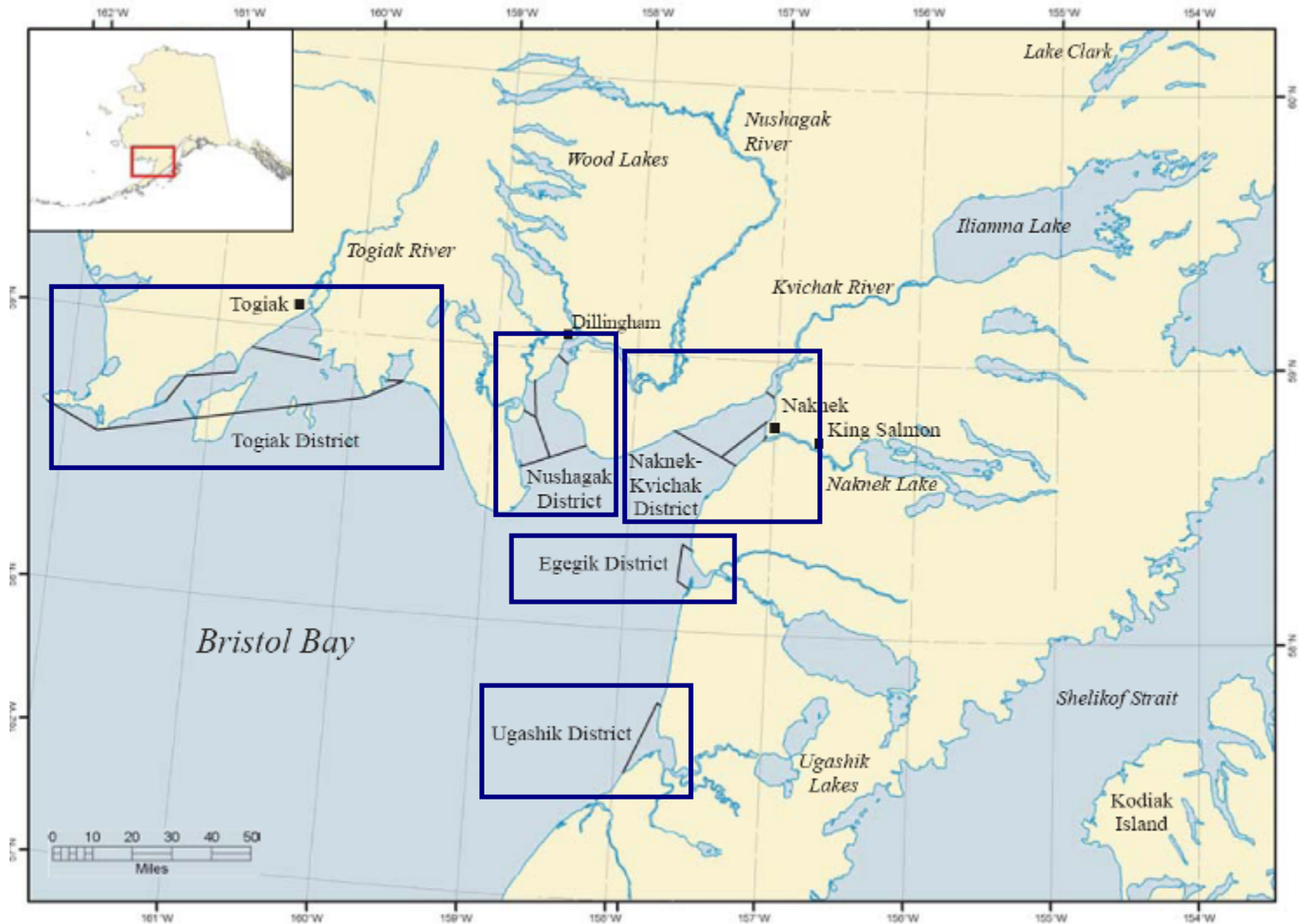
Females



# Fishery selection on Bristol Bay sockeye salmon and long term changes in length

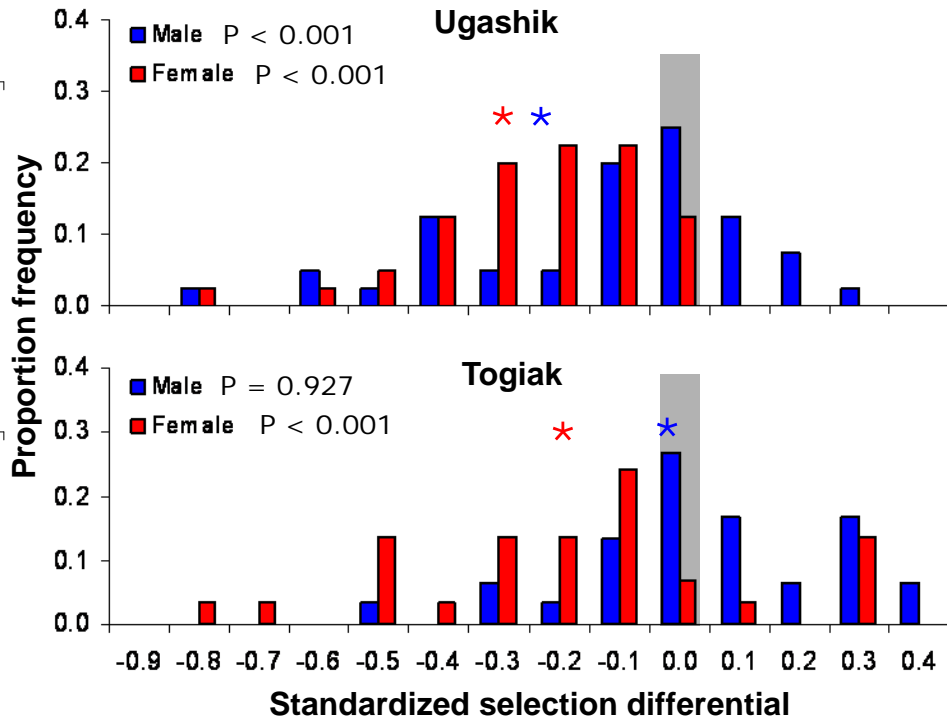
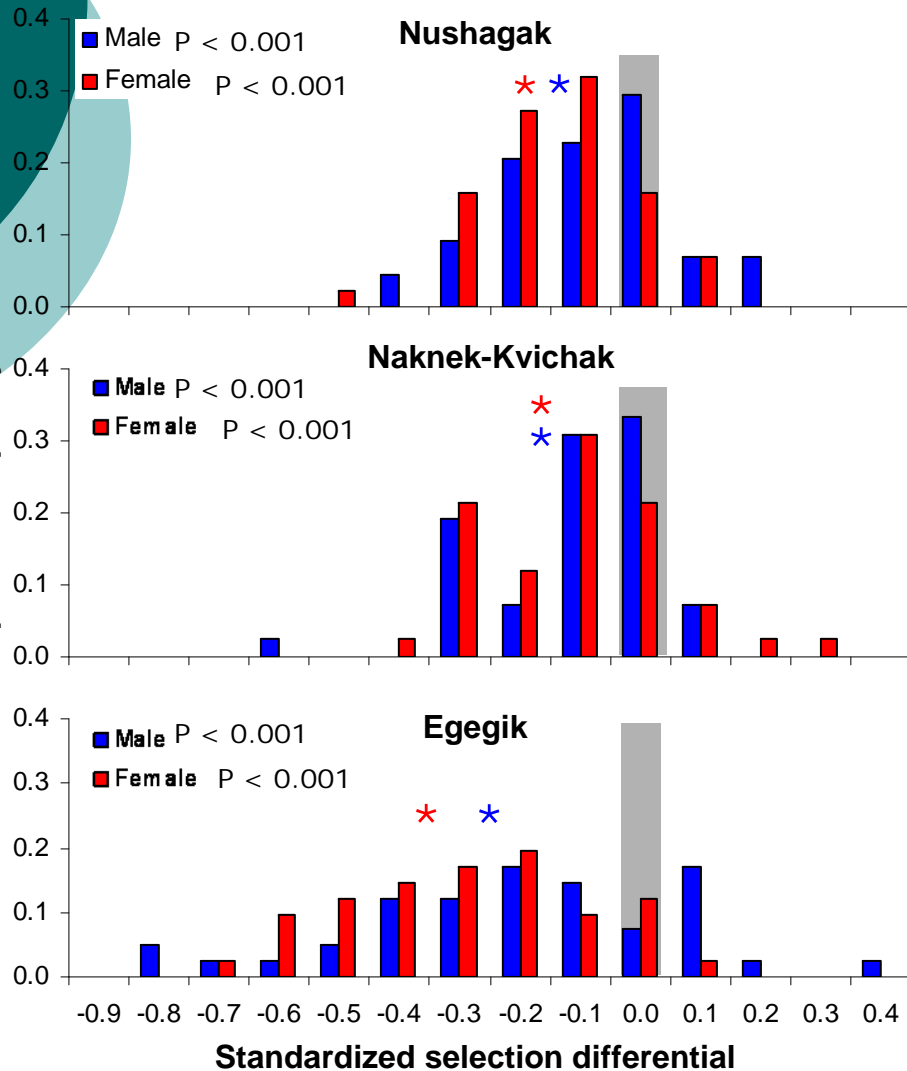


# Bristol Bay, Alaska fishing districts



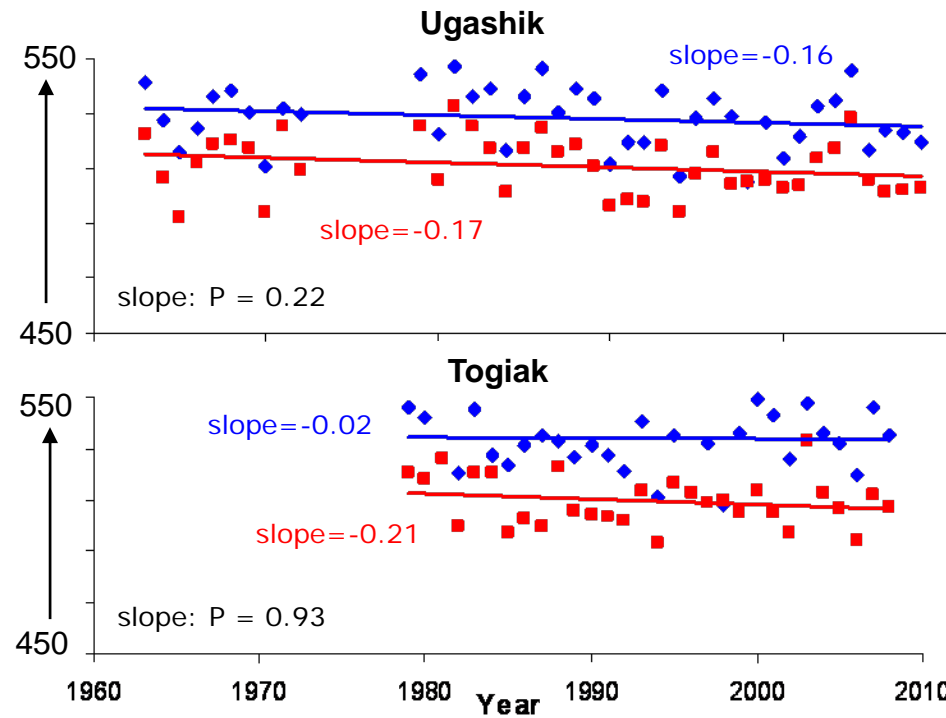
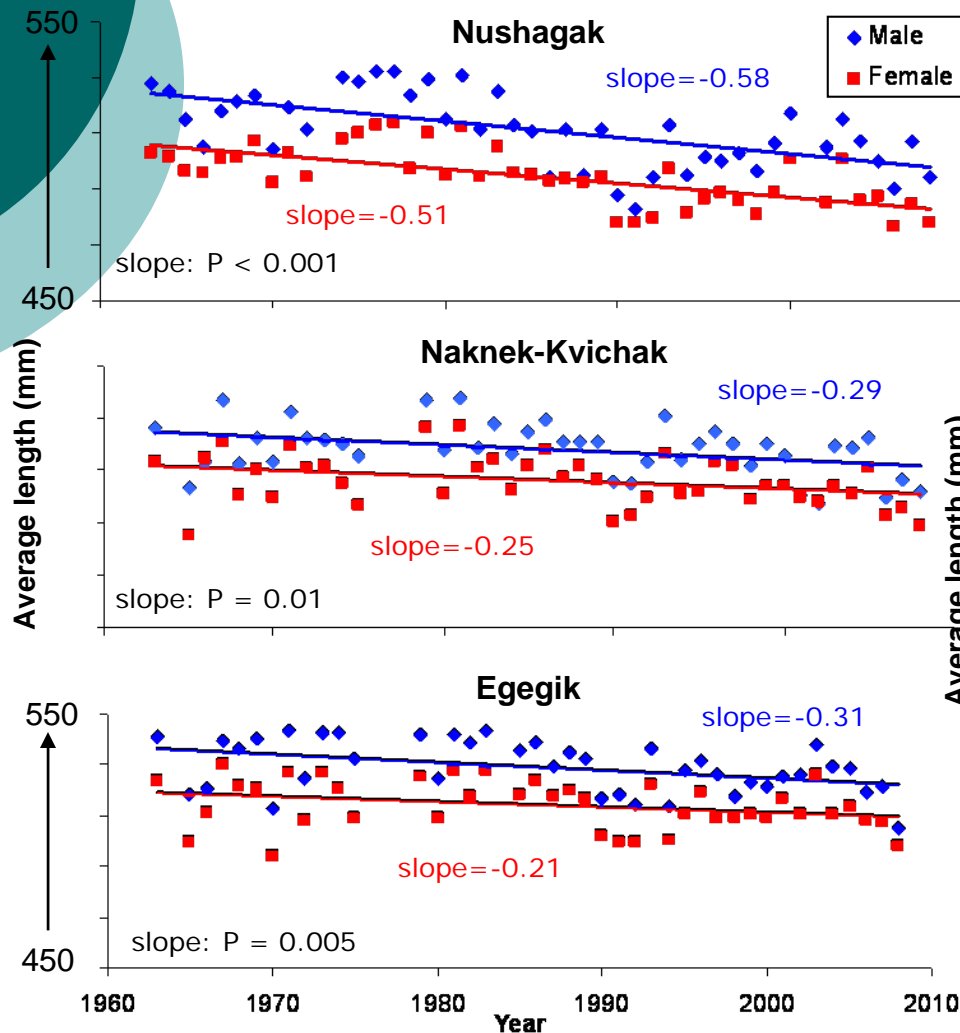
# Differential fishery selection on ocean age 2 fish

- In most districts, **larger** than average fish caught
- Differences in selection among districts



# Average lengths of ocean age 2 fish have decreased over time

- In most districts, fish getting smaller over time
- Differences in size decline among districts





# Why different selection among fishing districts and over time?

- Run sizes/harvest rates vary
- Average fish sizes vary
- Fishing regulations (mesh size, timing, breaks between fishing periods) vary

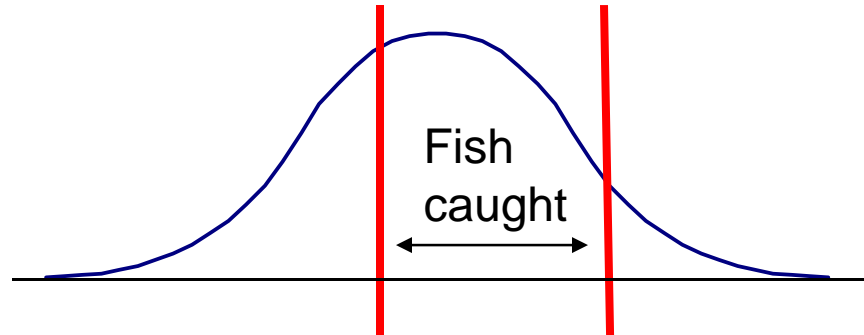




# Conclusions

- Are longer than average fish more vulnerable to being caught?

YES

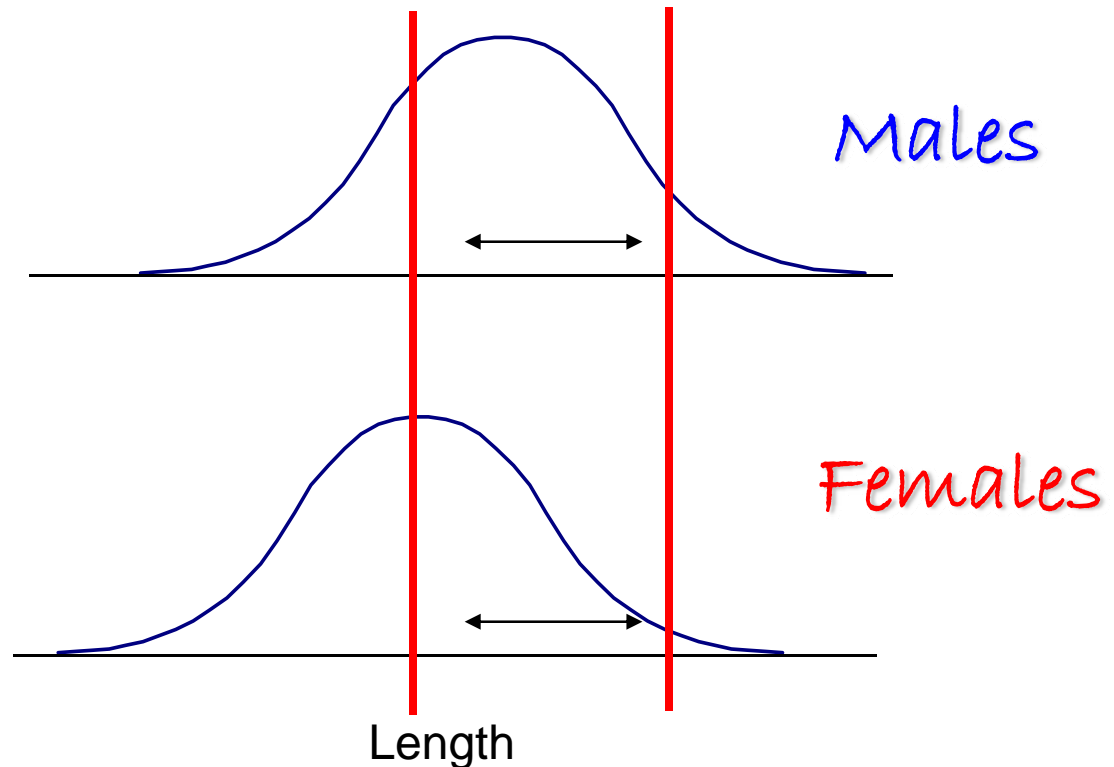




# Conclusions

- Does the fishery harvest different lengths of males than females?

YES





# Conclusions

- Are fish length at age changes over time correlated with fishery selection?

Yes, but...

*Other factors, such as ocean temperature and competition, affect growth*



# Relevance to Puget Sound

- Gillnets, purse seines, and trolling used in the Sound
- All will have different patterns of selection
- Lessons and analytical tools learned in Alaska can be applied here





# Acknowledgements

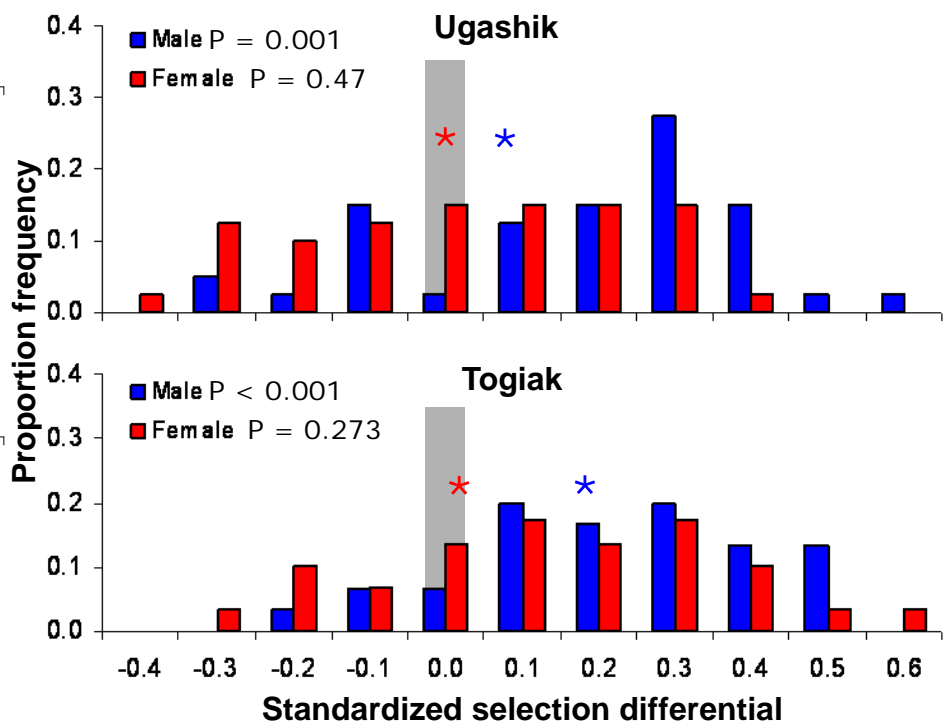
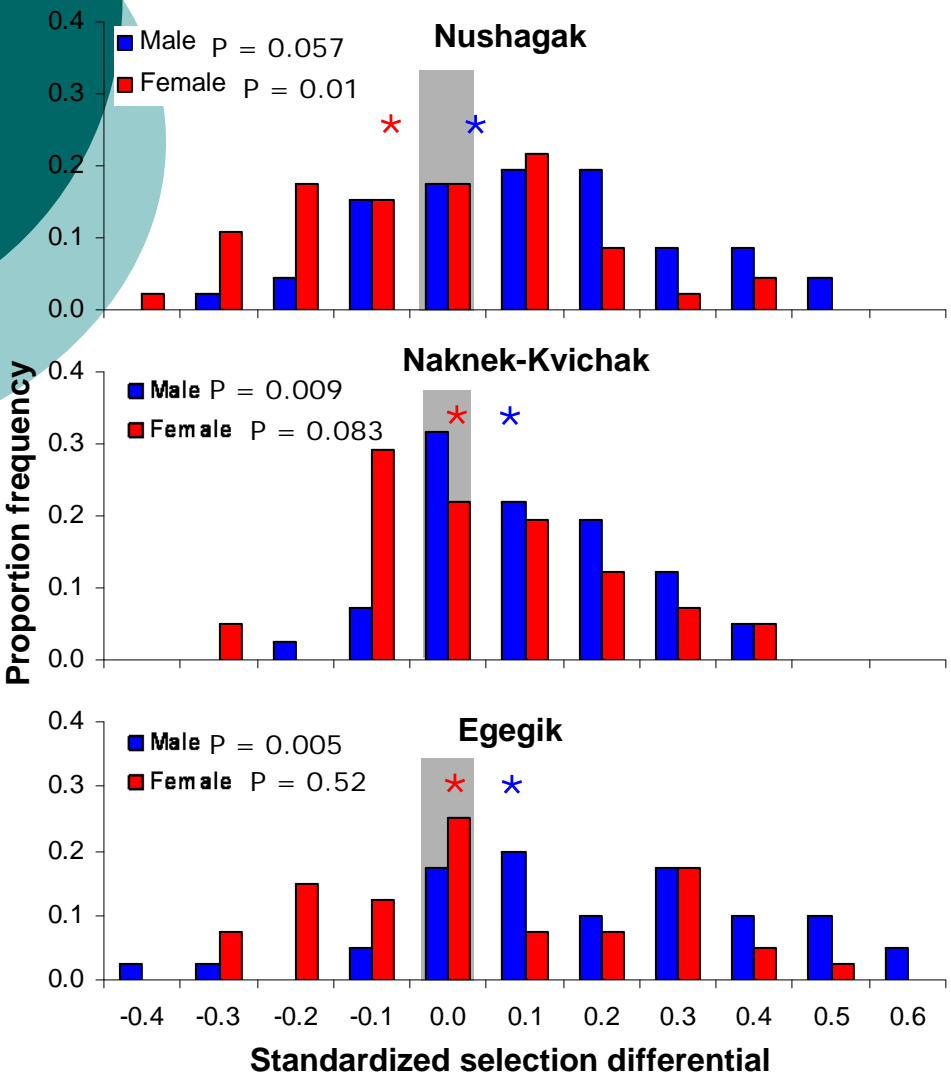
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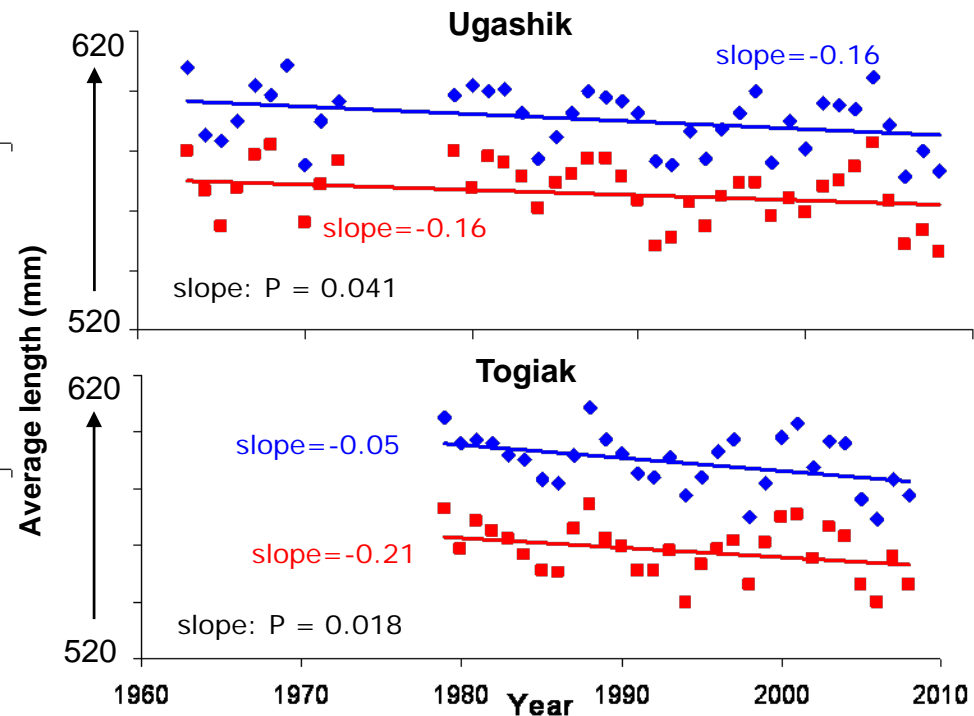
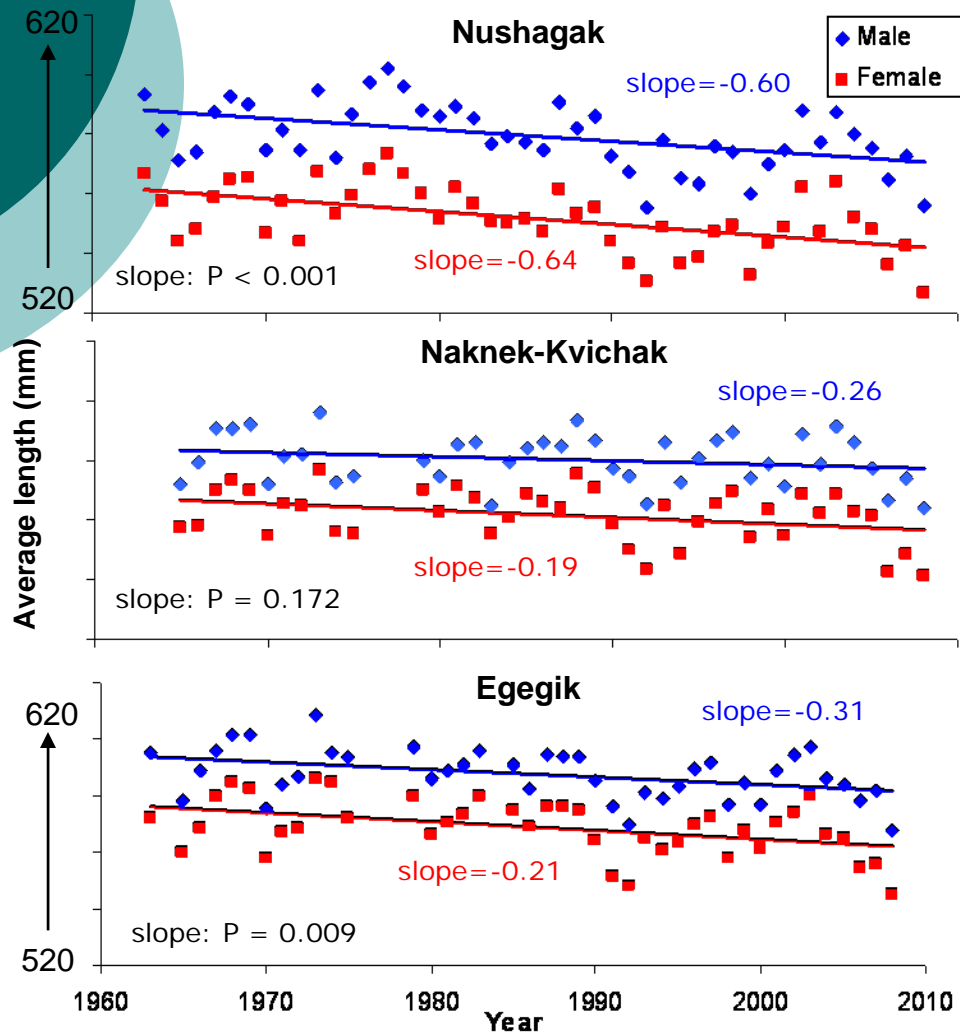
# Differential fishery selection on ocean age 3 fish

- In most districts, **smaller** than average male fish caught, average female
- Differences in selection among districts



# Average length of ocean age 3 fish has decreased over time

- In most districts, fish getting **smaller** over time
- Differences in size decline among districts





# Conclusions

- Potential for evolutionary changes?

??

*Still working on this...*

*Both genetic and  
environmental influences  
may be important*



# What can fishery managers do?

