Fishery Selection:
Size, Age, and the Timing of Migration

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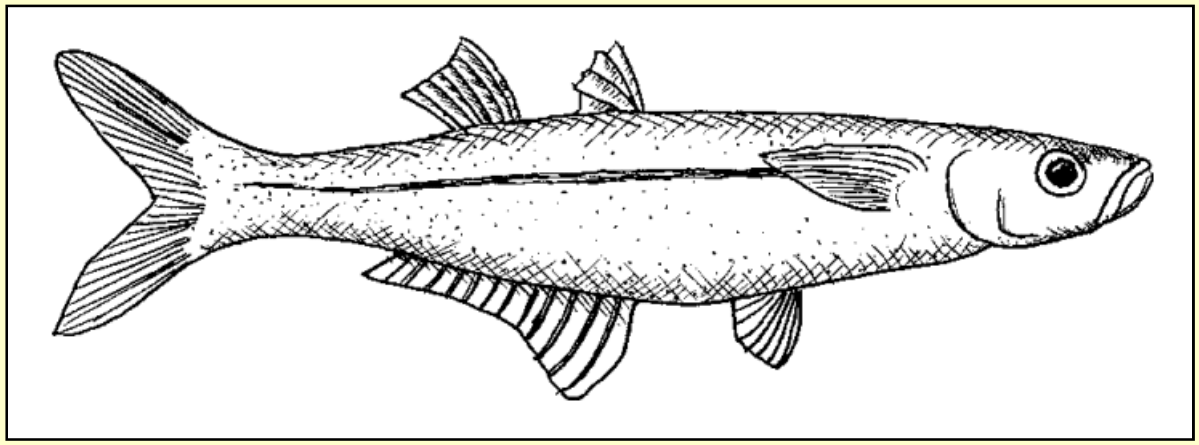
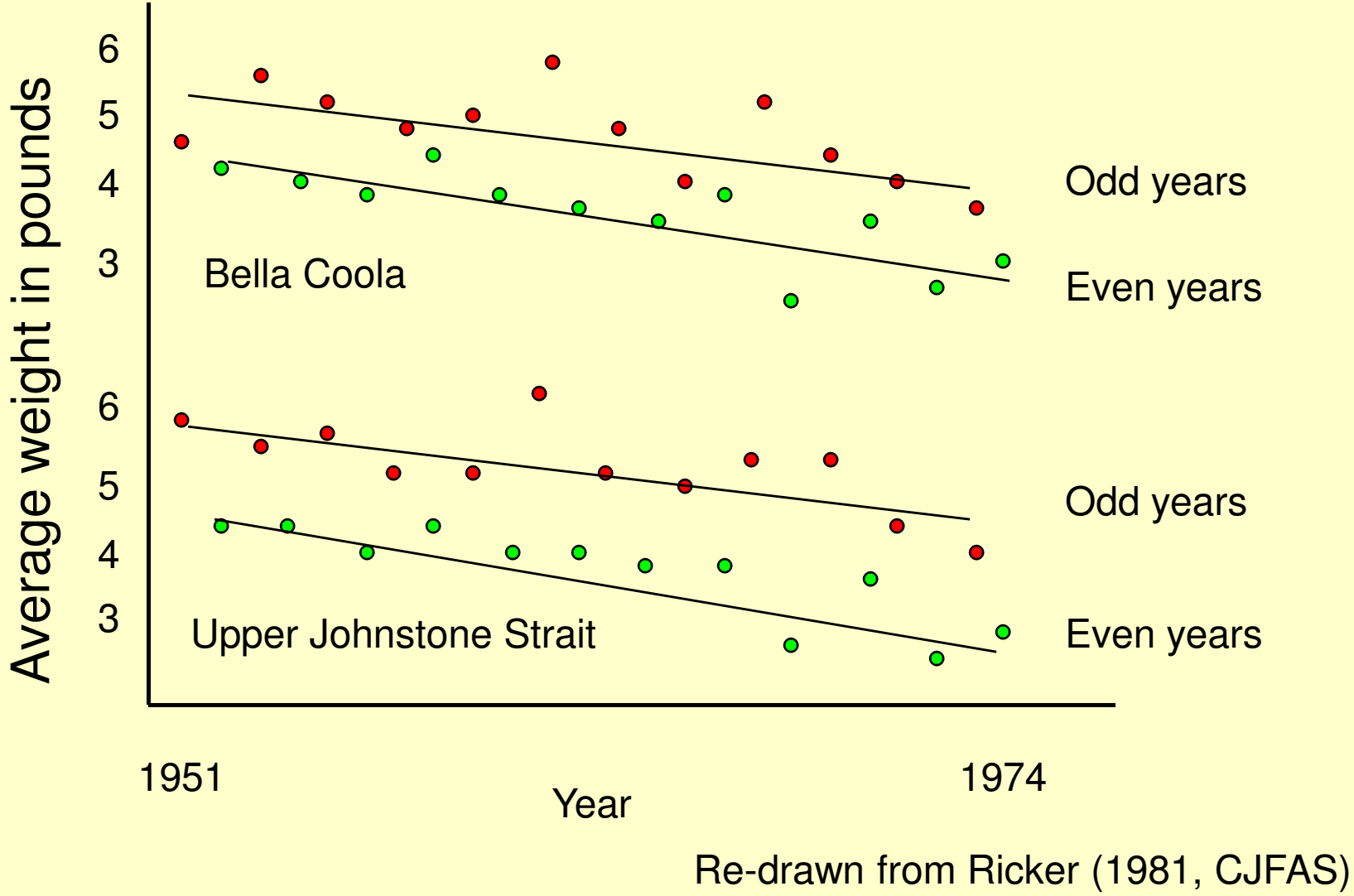
People have influenced the evolution of animals for thousands of years

In addition to domestication, harvest can also cause animal evolution



Ricker (as always, ahead of the curve) considered selection among the possible reasons for declines in body size (e.g., B. C. pink salmon)



Re-drawn from Ricker (1981, CJFAS)

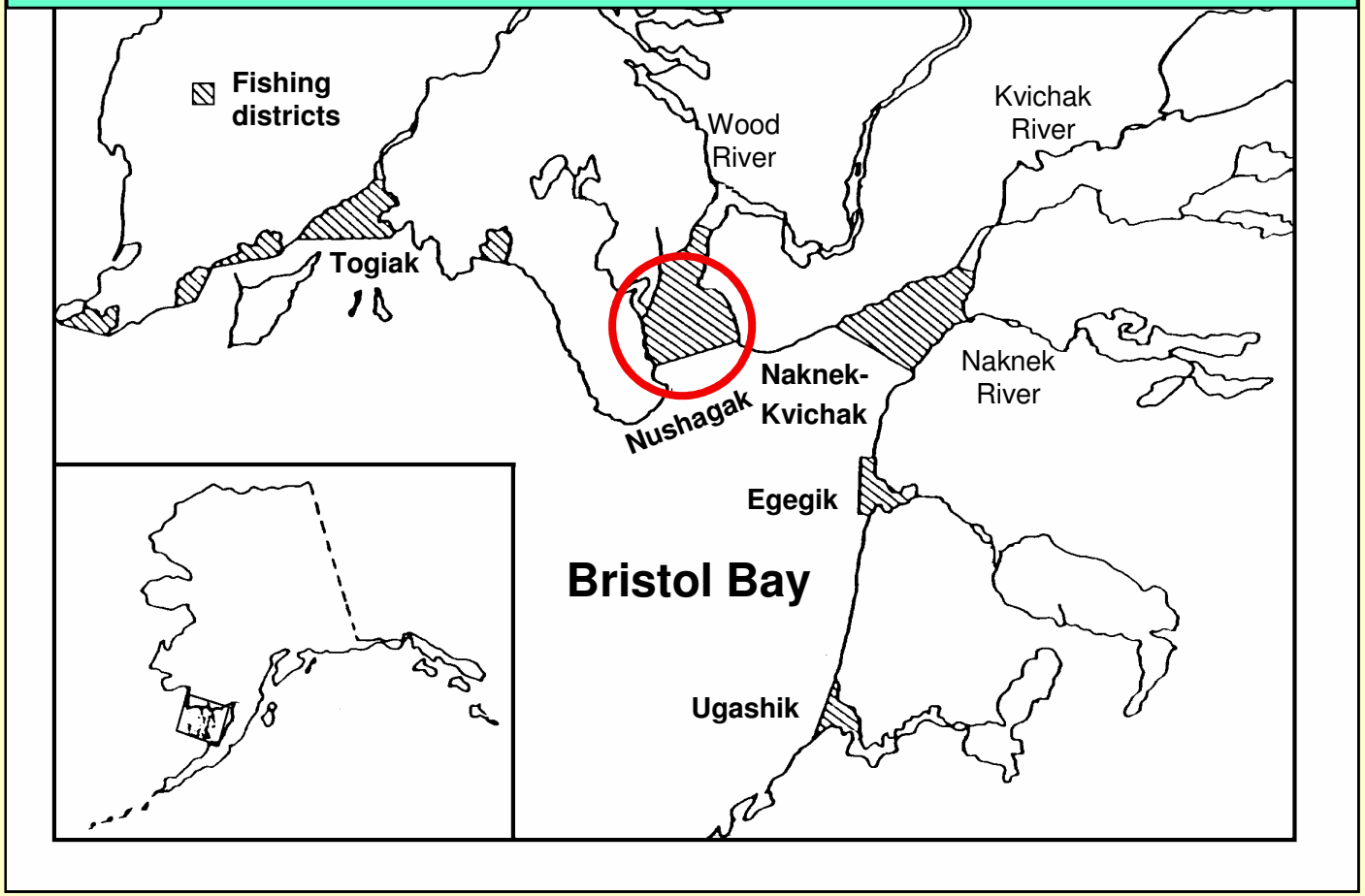
This presentation will assess:

1) Fishery selection on length & age at maturity
2) Fishery selection on timing
   a) General principles
   b) Selection among populations
   c) Selection within populations
3) Discuss possible interactions between selection on size and timing

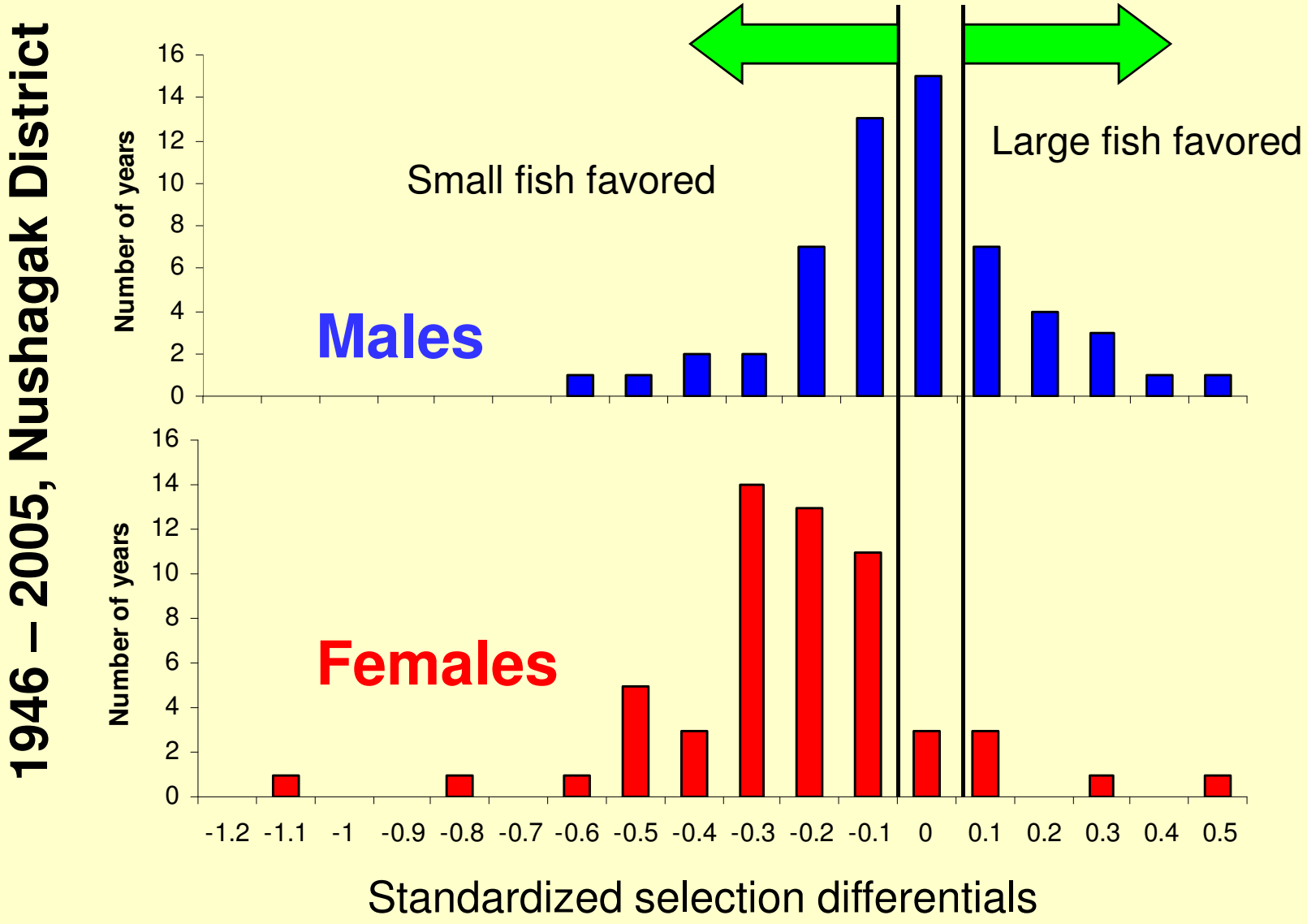
Examples: western Alaska sockeye salmon

Selection on size and age at maturity: Nushagak District, 1947 to 2006

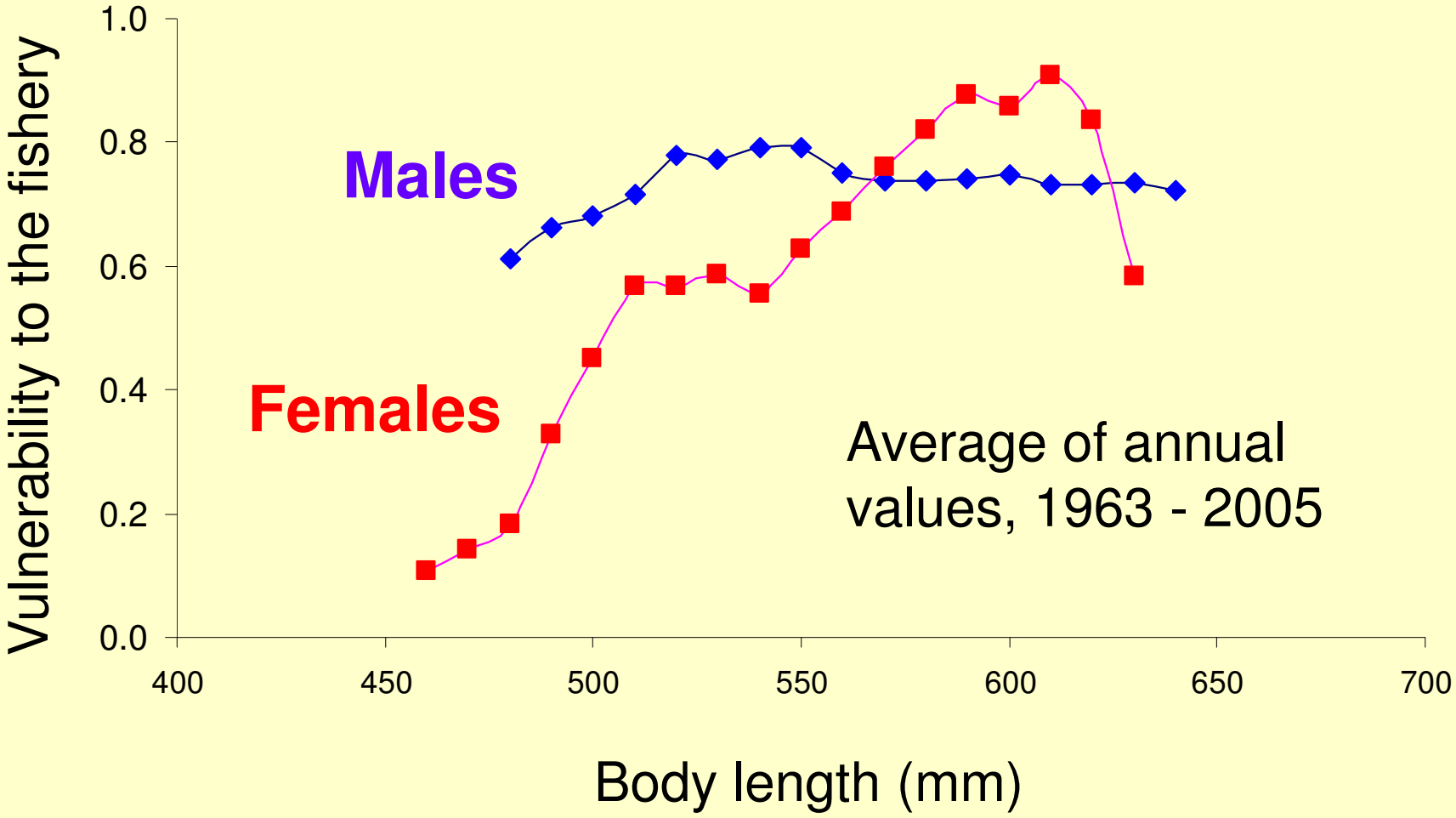
Expectation: gillnet fishery is selective against large fish



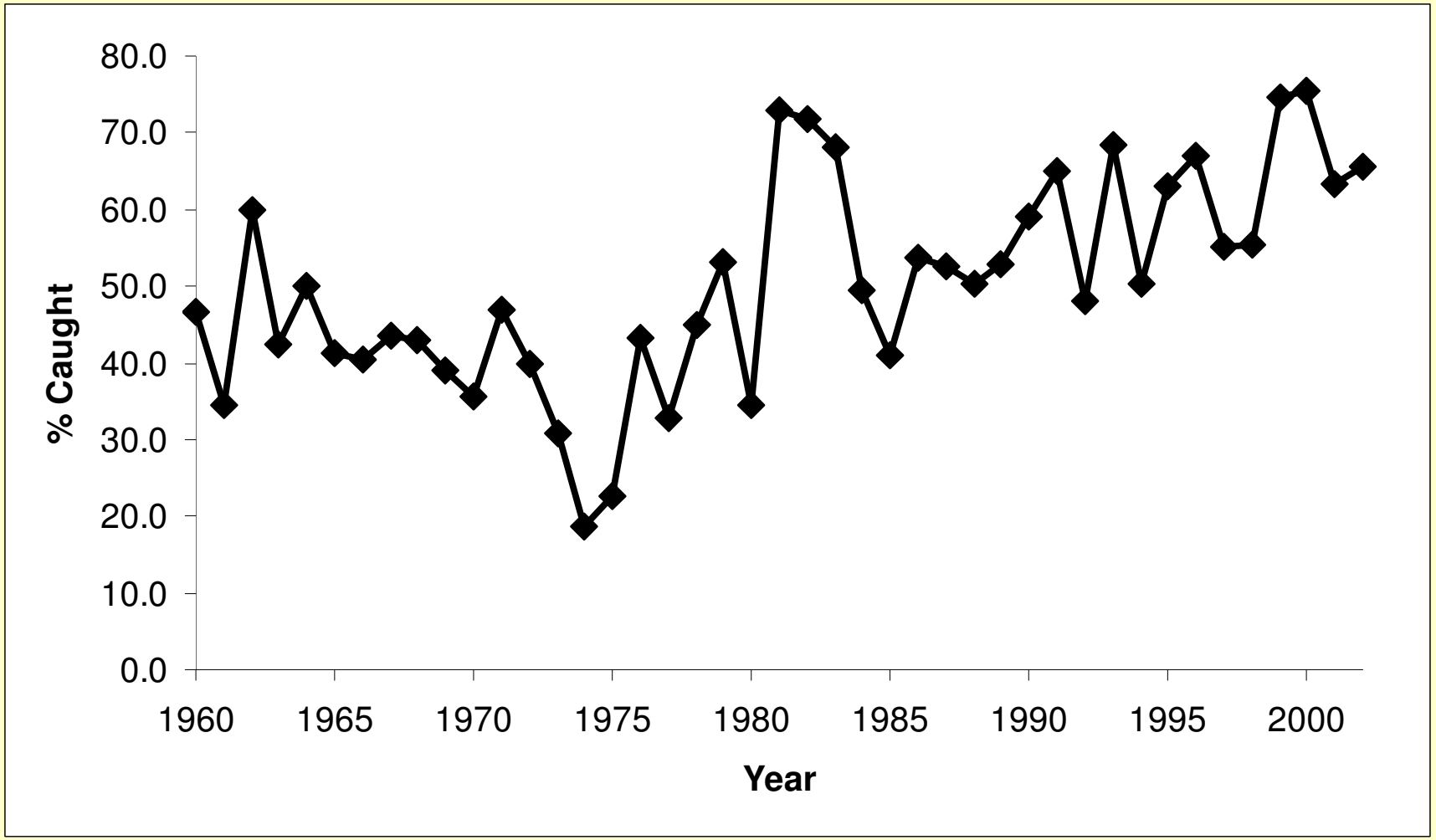
In most years, salmon in the catch were longer than those escaping to spawn, especially females



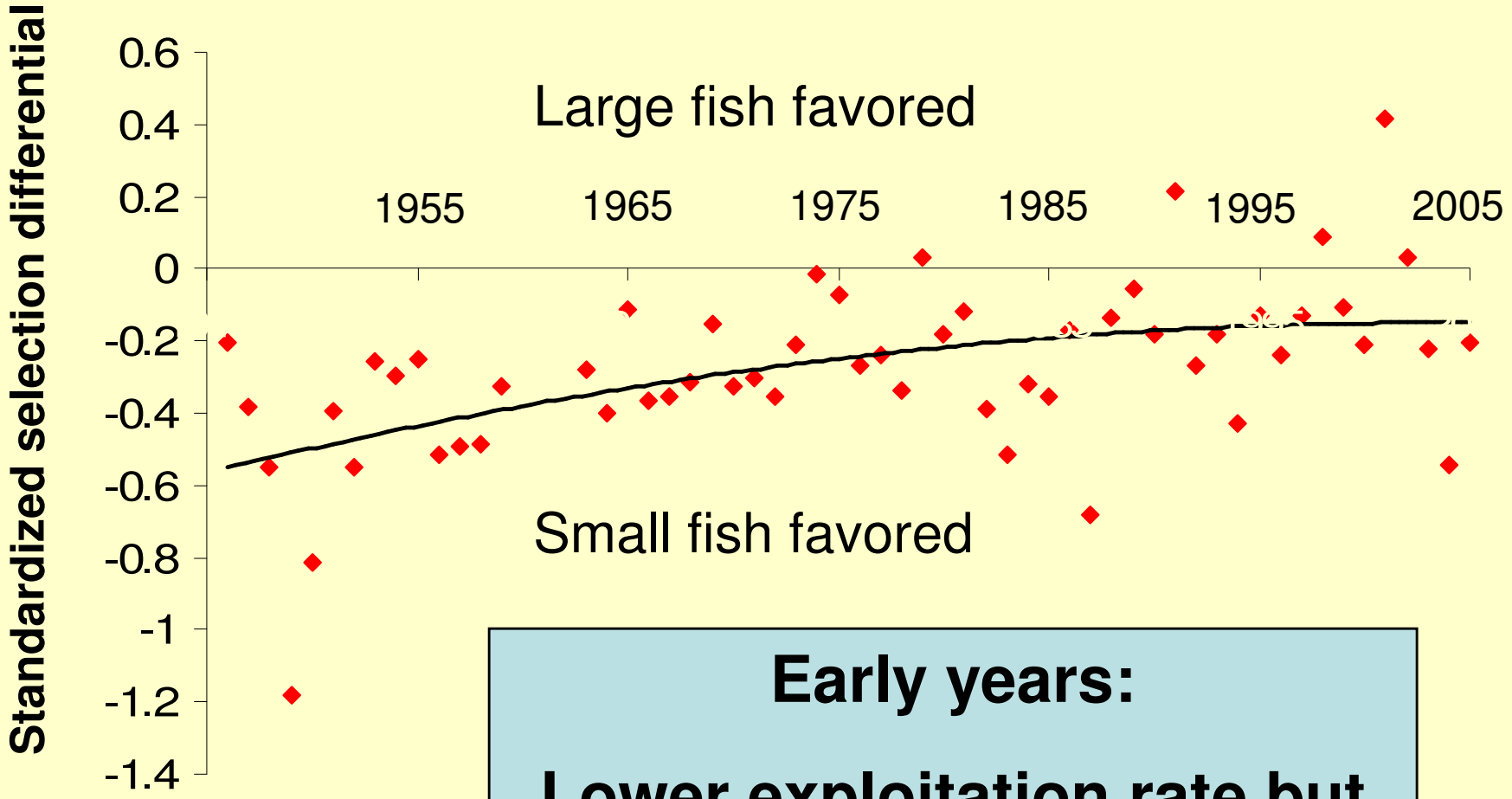
Smaller is safer, on average, but the very largest fish were not the most vulnerable



Exploitation rates have increased in the Nushagak District as runs increased



The fishery is now less size-selective than it was in the past (e.g., females)



Early years:

Lower exploitation rate but more size-selective

Differential exploitation of populations based on body size

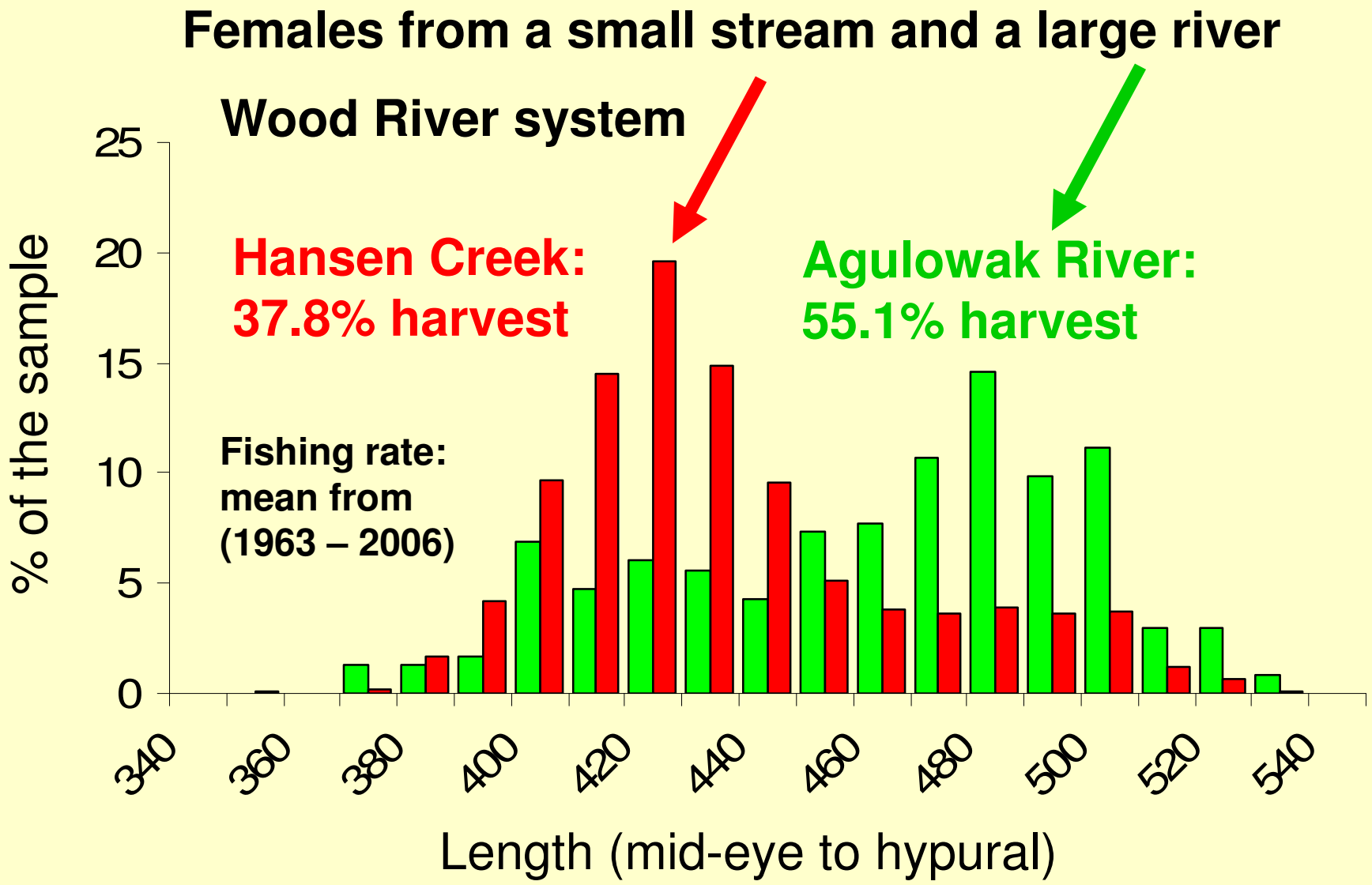
Population complex

(spawning population)

(spawning population)

$Mean_2$ $Mean_1$ $Mean_3$

Length at maturity varies among populations, so exploitation rate also differs



The evolutionary effects of fishery selection on length at age and age at maturity are mitigated by both

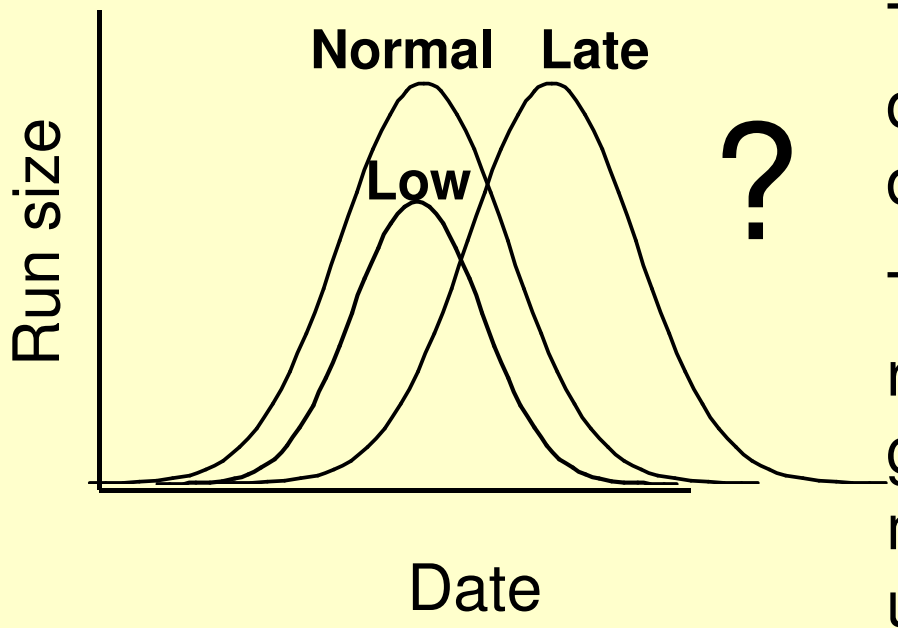
1) Opposing natural selection, and

2) Strong environmental influences

But,

Fishing is also often selective for migration timing, and this trait is under strong genetic control

Fisheries can be selective with respect to timing, as a by-product of conservation efforts

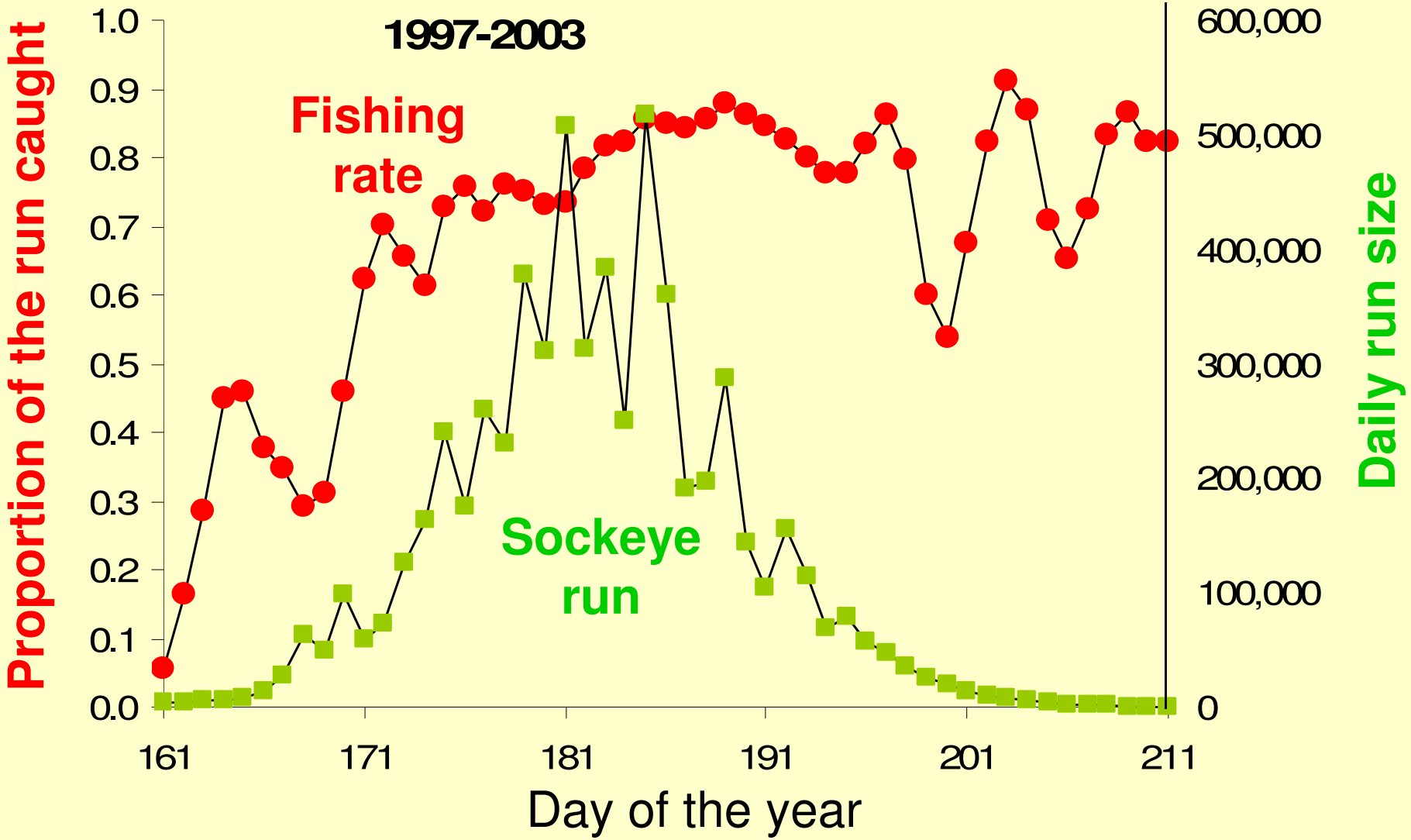


The manager expects a normal distribution, beginning at some date, based on previous runs.

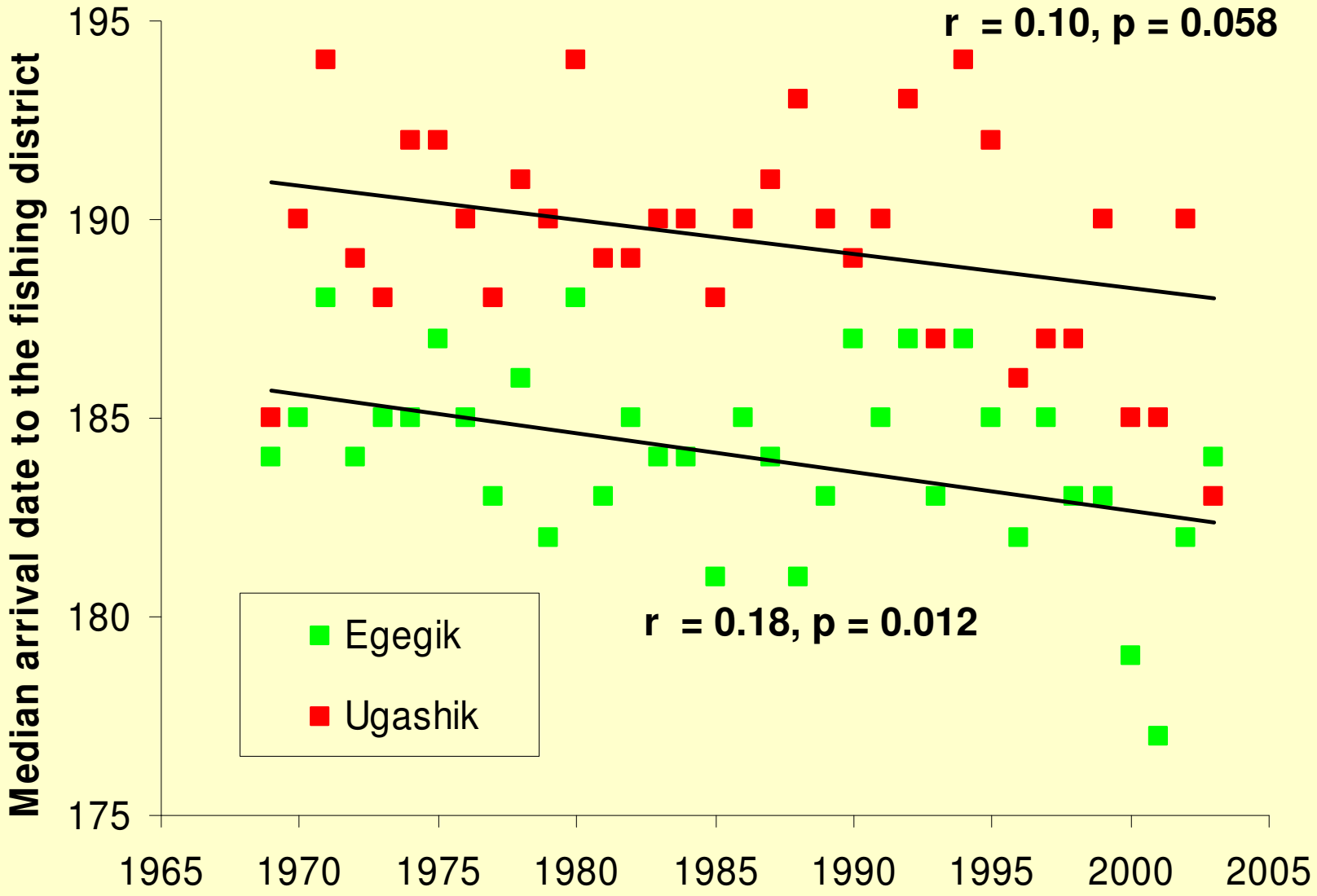
There is uncertainty about the run size, and if an escapement goal is to be met, the prudent manager allows limited fishing until the run shows its true size.

Once it is clear that the goal will be met, increased fishing may be permitted on the late part of the run.

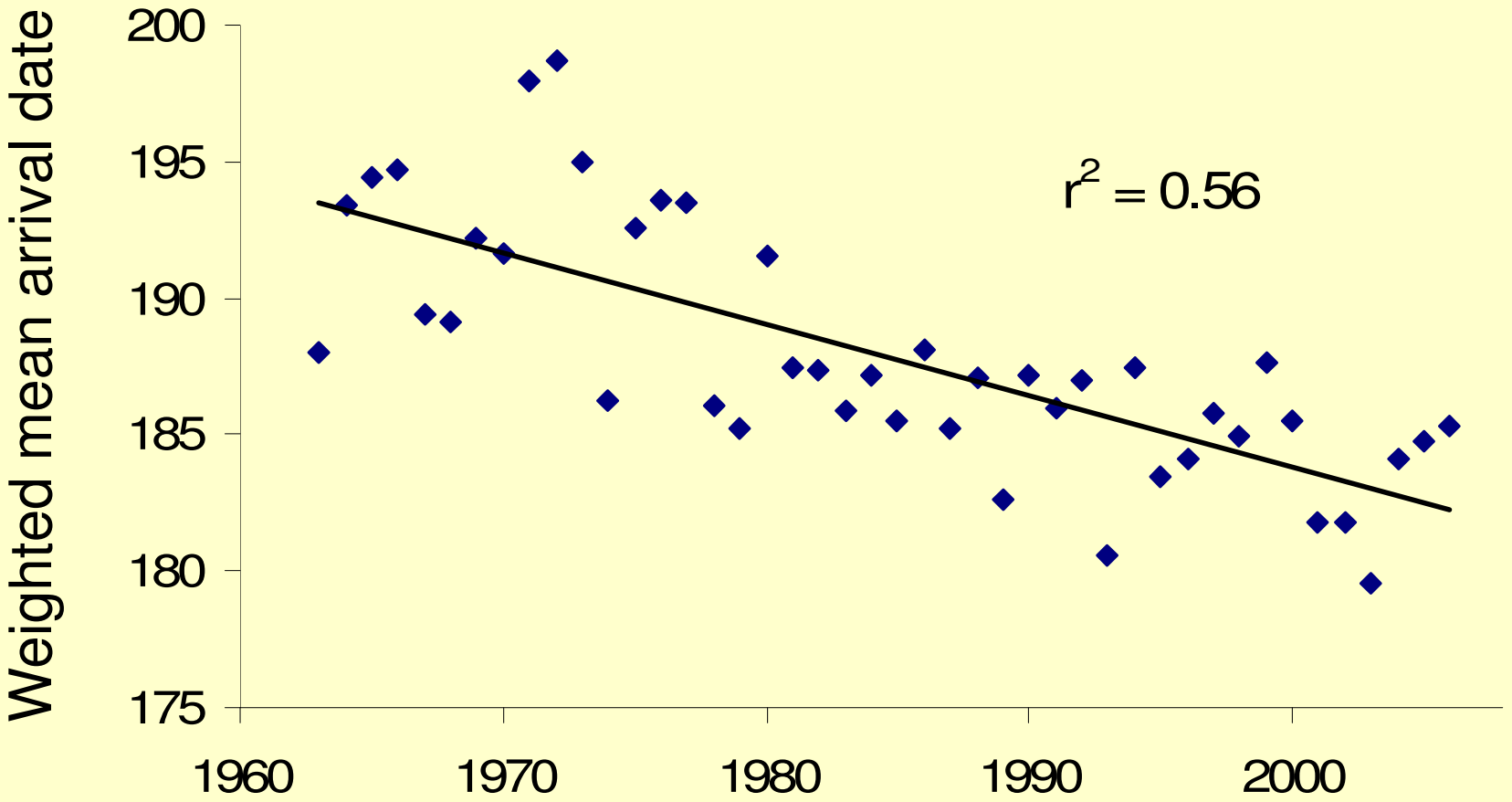
Increased fishing rate during the season: Egegik District of Bristol Bay



The salmon seem to be shifting their migration timing, as predicted from the selective fishing



The Nushagak River run is also arriving earlier than in the past, consistent with selection



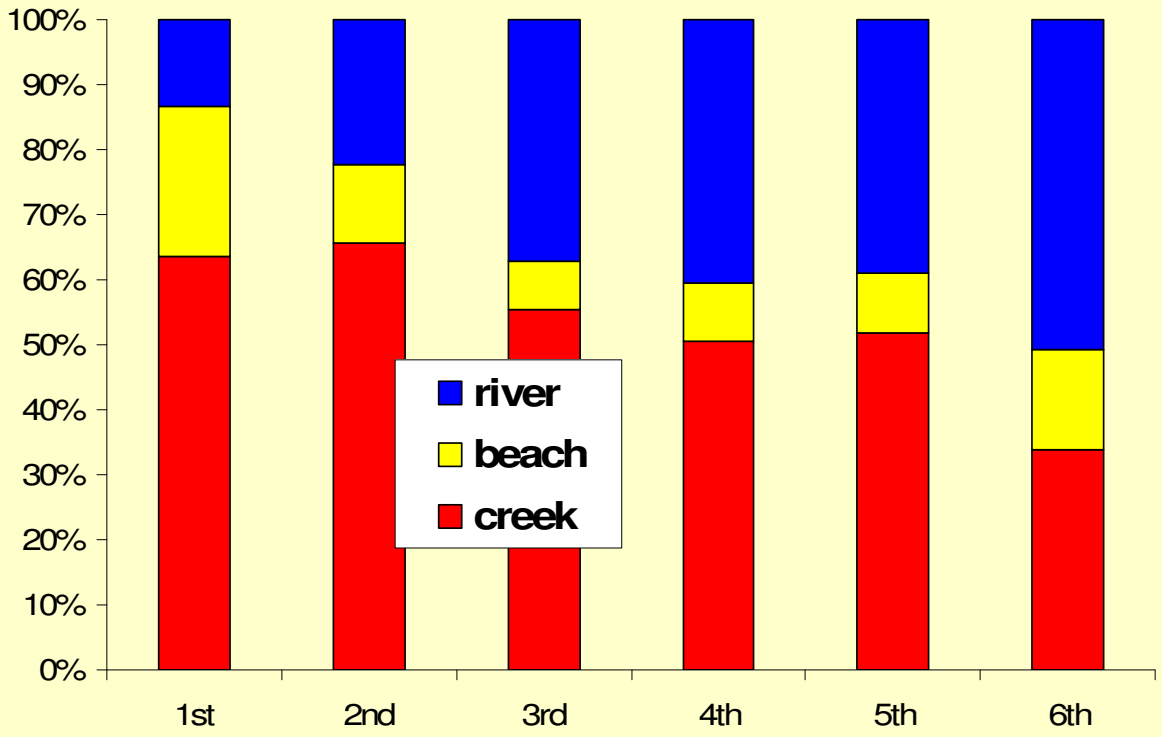
Possible mechanisms for selective change in migration timing

1) Higher exploitation at the end of the run reduces populations that migrate late

2) Late-migrating individuals are selectively removed from each population

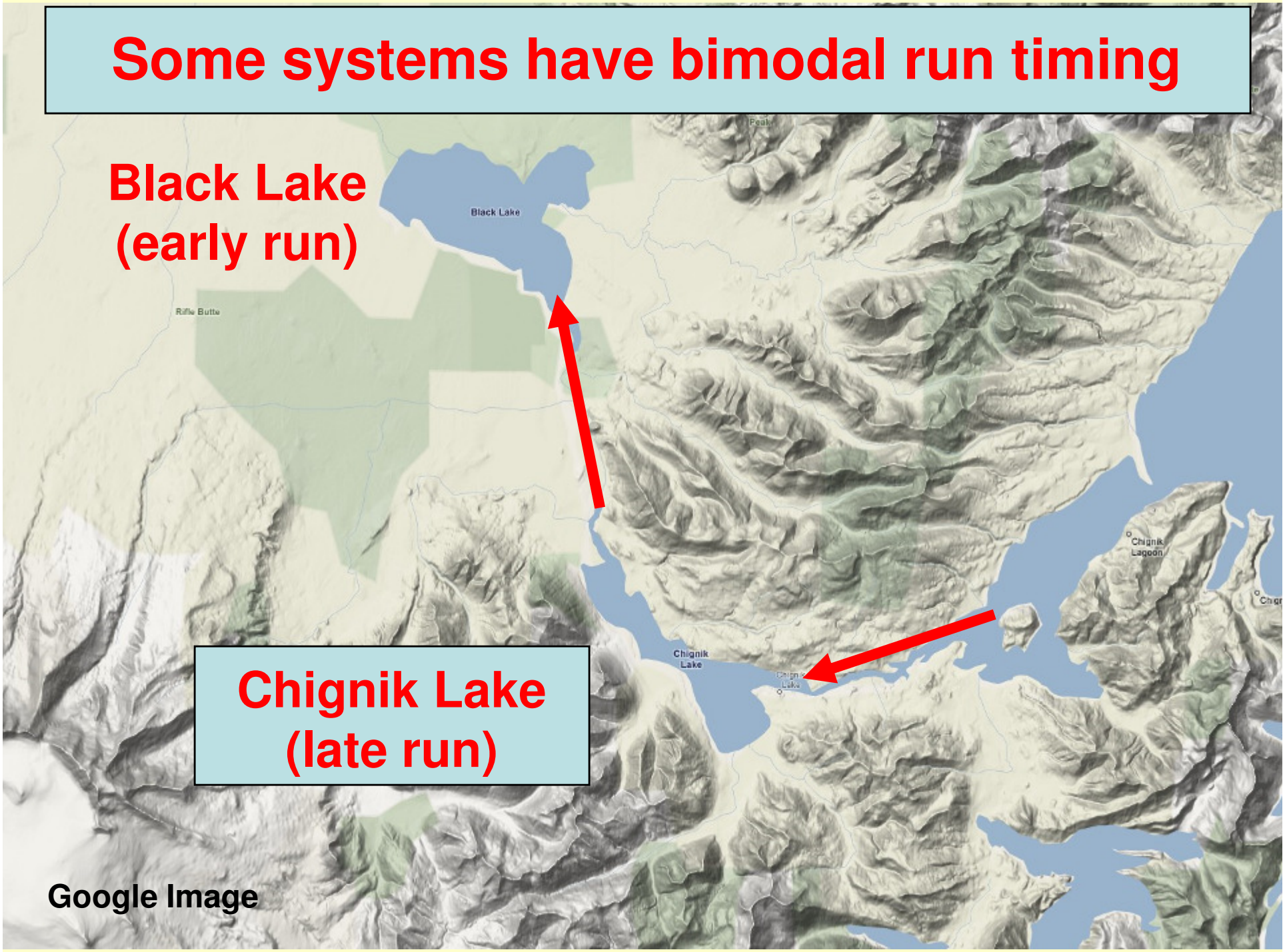
Bristol Bay sockeye salmon are known for their compressed, unimodal run timing. However…

Early migrants up the Wood River tended to spawn in small streams; later migrants tended to spawn in large rivers.

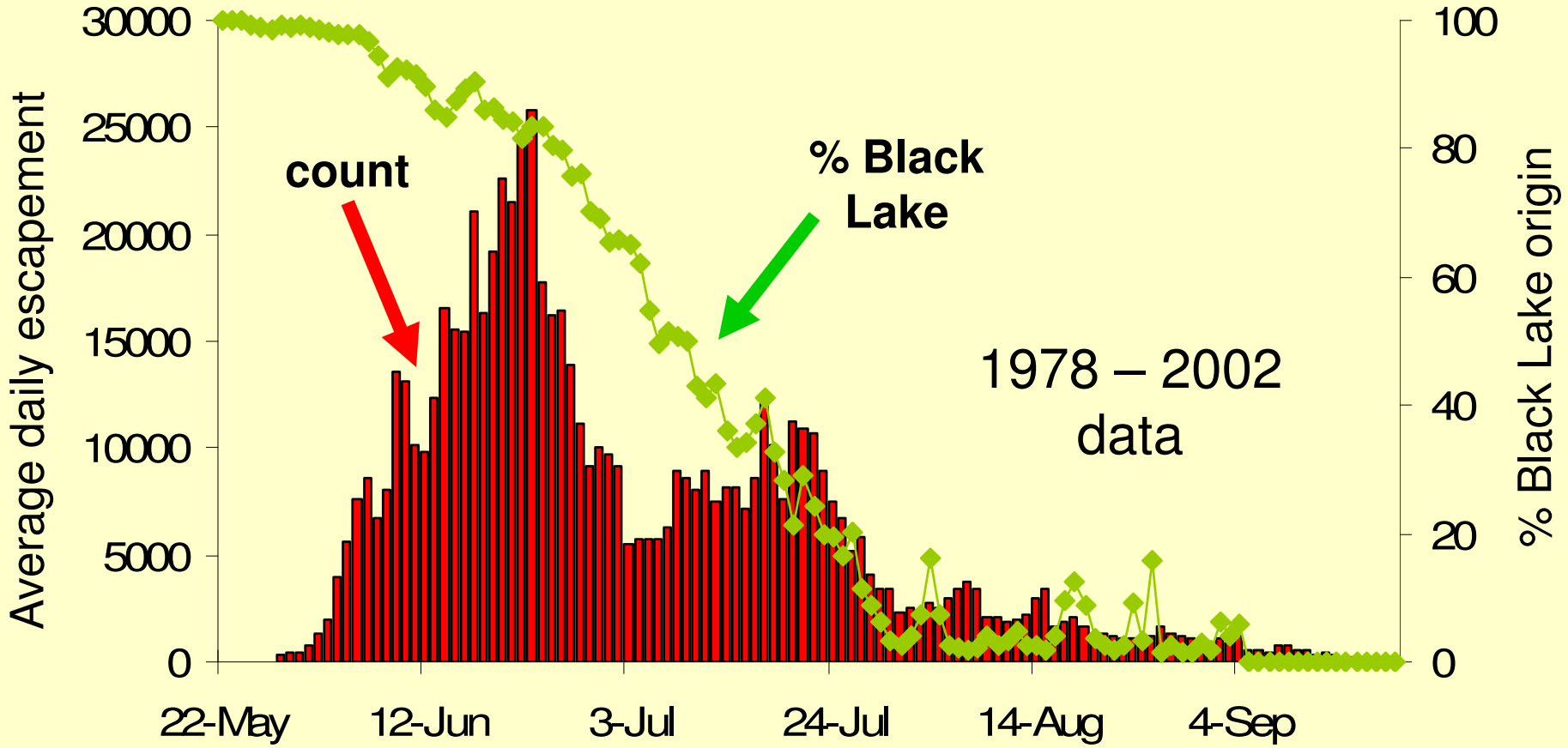


Sequential tagging periods

Some systems have bimodal run timing

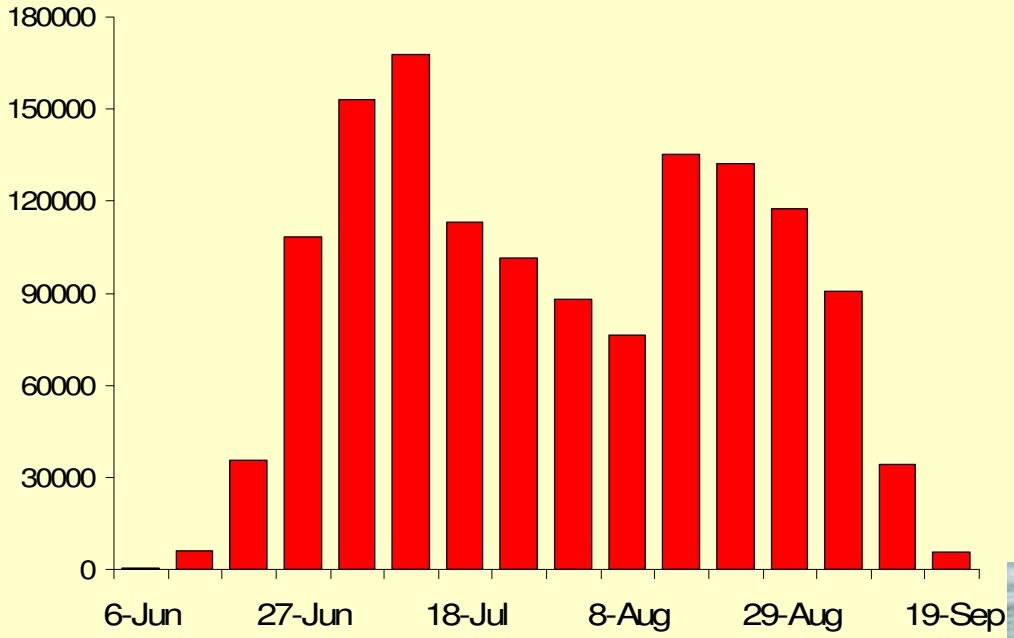


Bimodal migrations can reflect two populations but the runs may overlap considerably



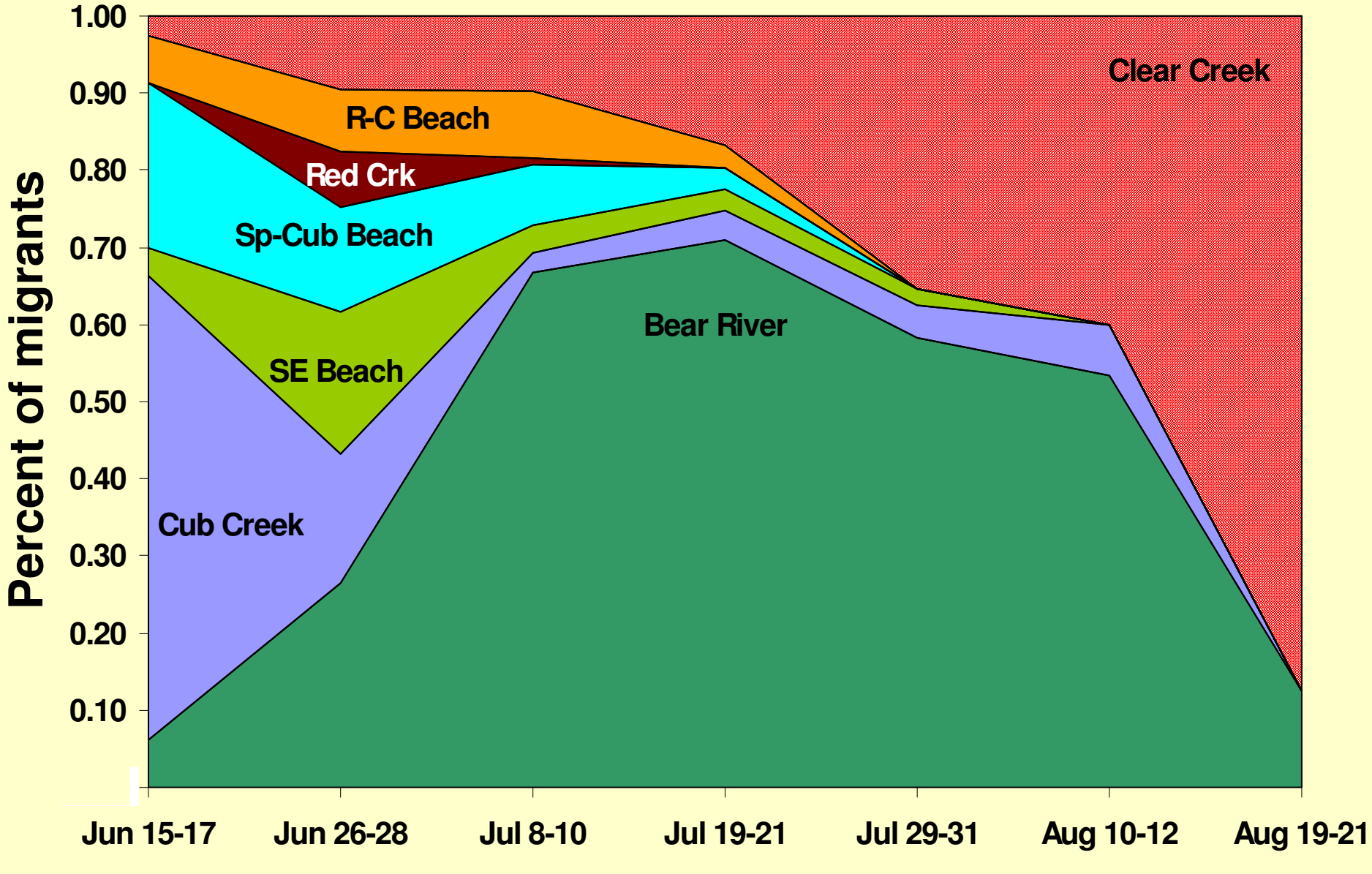
Sometimes, bimodal run timing does not reflect a simple 2-population system

Sockeye enter from the Bering Sea

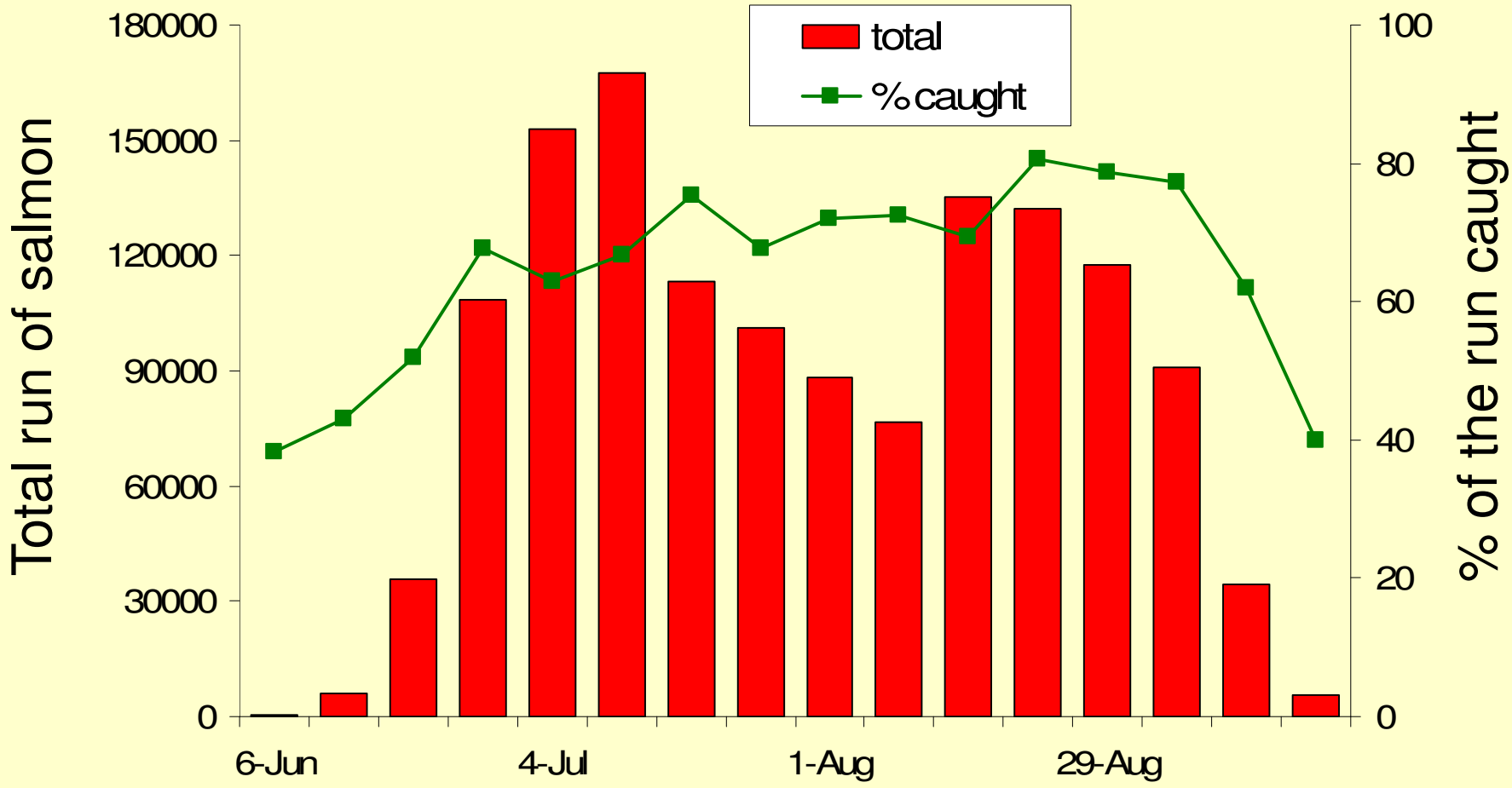


A tagging study was conducted to determine where the early and late migrating sockeye salmon spawned

Tagging showed early, middle and late spawning populations within the lake system



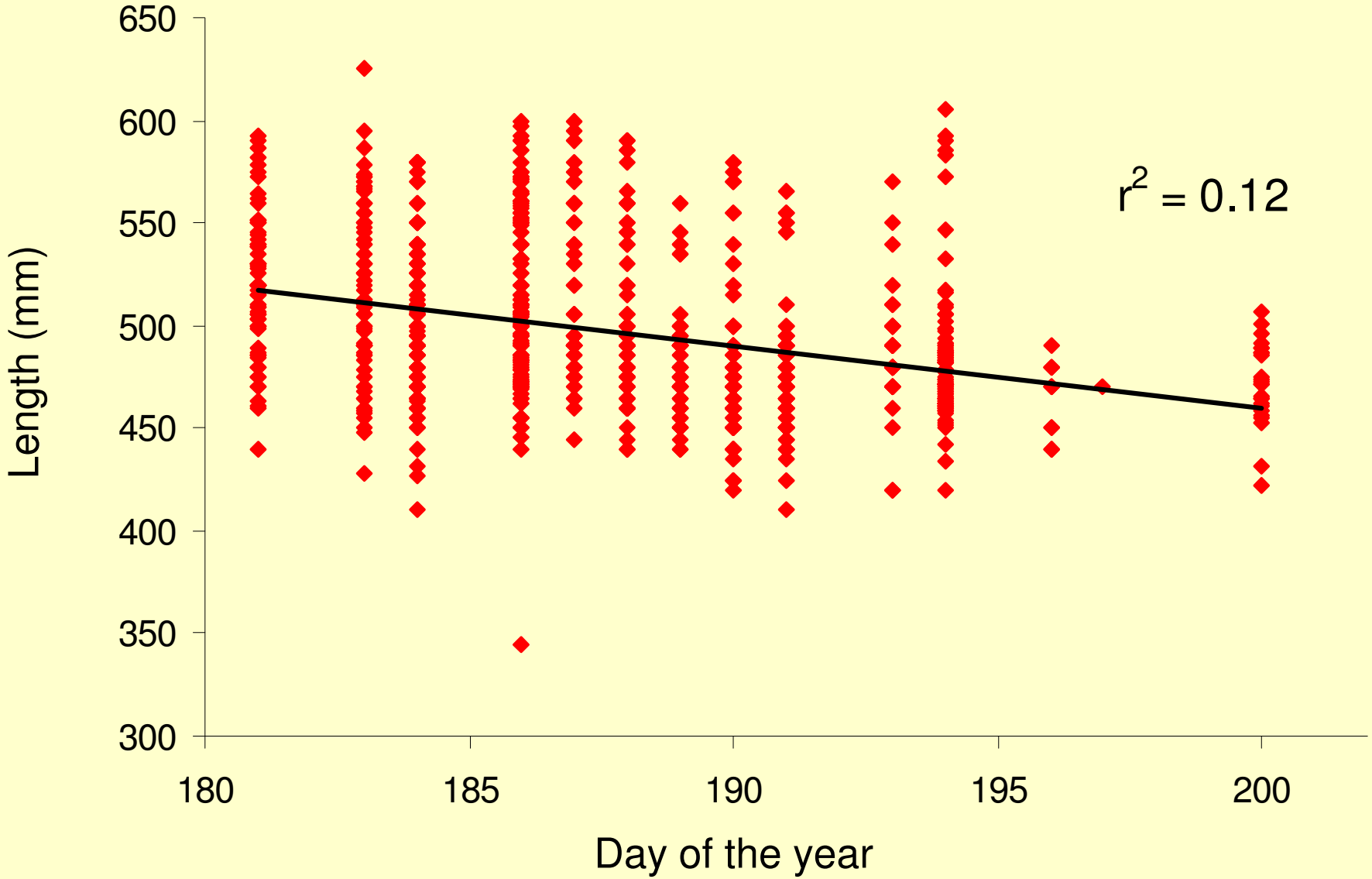
Fishing was lighter on the earliest and latest fish, but the middle (Bear River) run was fished heavily, exaggerating the bimodal run timing



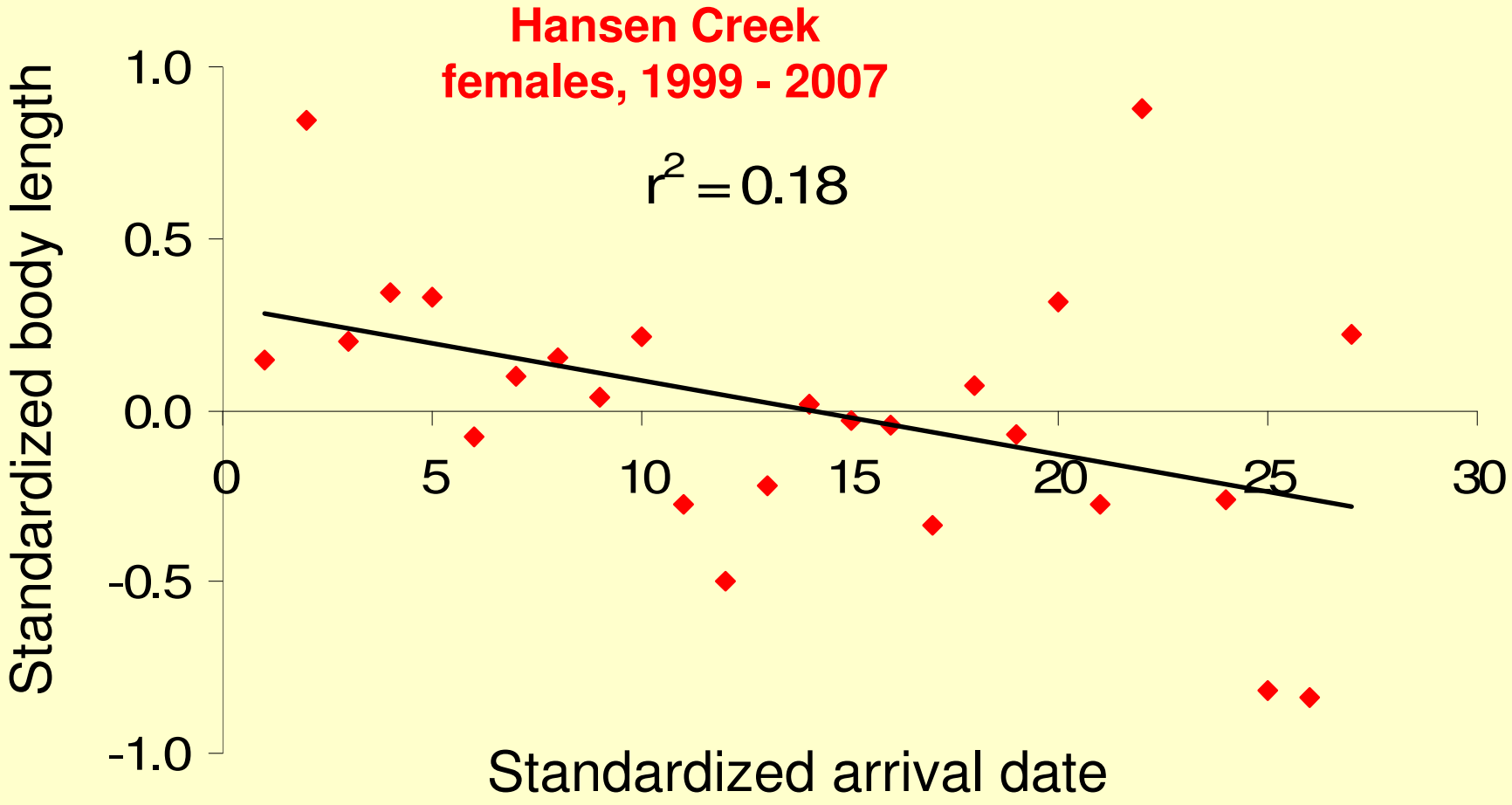
Selection on timing can also affect patterns within populations

Early migrants tend to be older and larger than later ones, tend to spawn earlier, and may use different parts of the stream, further complicating the effects of fishing.

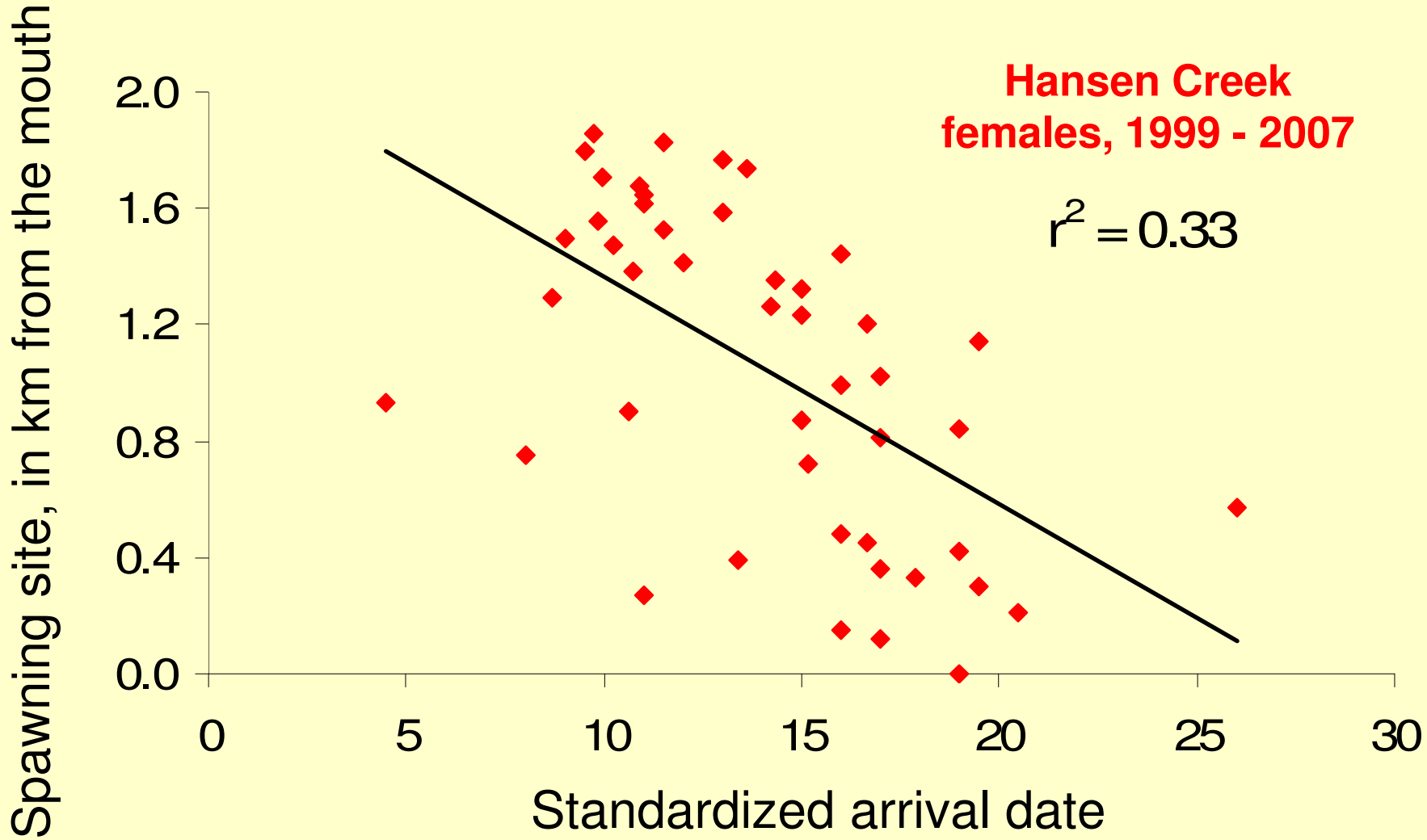
Larger salmon migrate earlier than smaller ones (e.g., Wood River females in 1999)

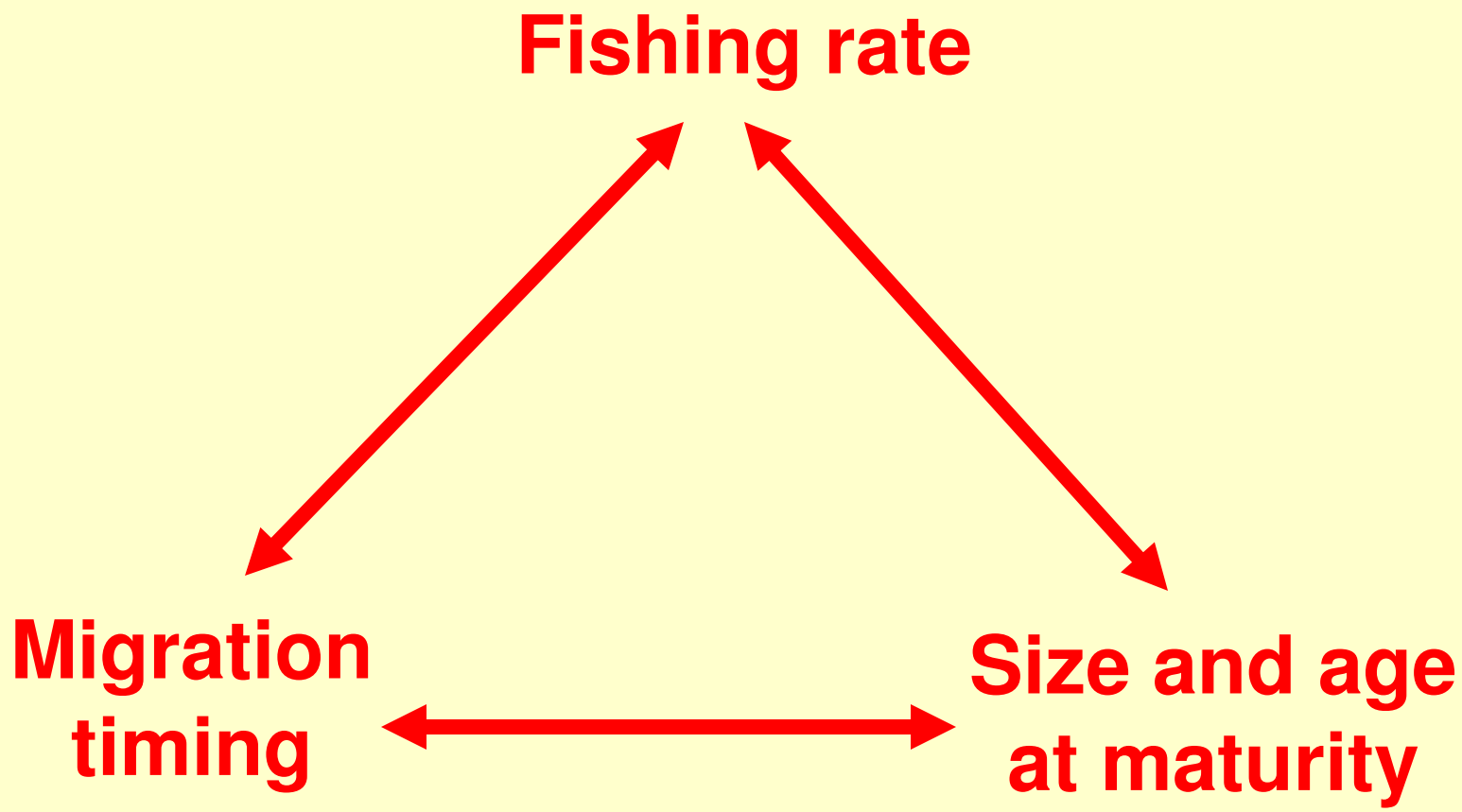


Larger fish may enter the spawning grounds earlier than smaller ones



Fish arriving early may occupy different parts of the stream than later arrivals





Most salmon fisheries are selective with respect to timing, by design of otherwise.

Given the interactions between size and timing, what are the evolutionary effects of fisheries on salmon?

Conclusion

Selective fishing on timing is wide-spread and poses challenges for management. This may be at least as important as selection on size and age.

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