

It's about time! Natural and unnatural selection on salmon migration and spawning

Evolution, climate change, hatcheries, and fishing effects.

What more could you want in a 20-min talk?

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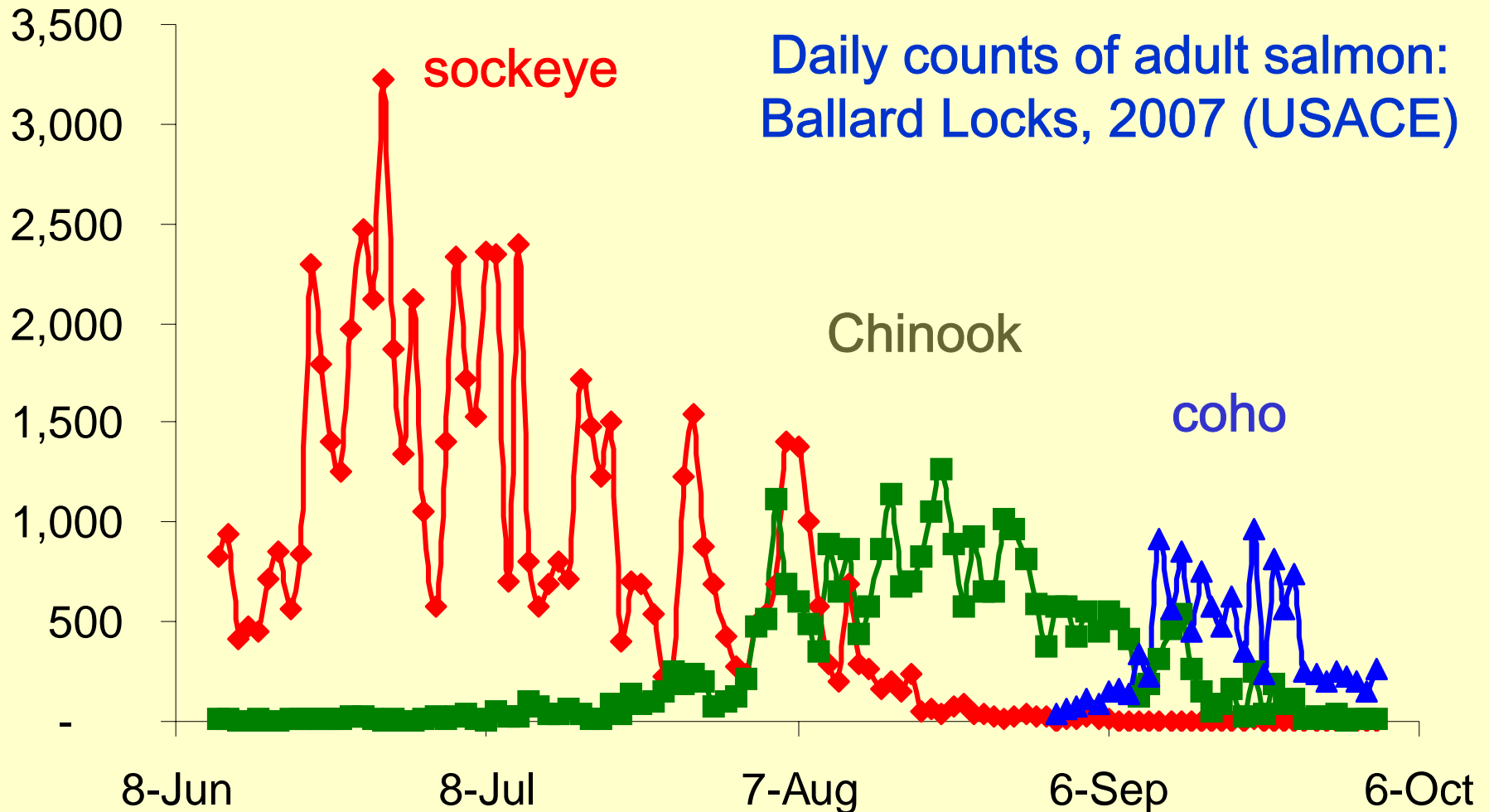


Overall themes:

- 1) Natural selection operates on the timing of migration and spawning by salmon
- 2) Salmon seem to be adapting to climate change *but*
- 3) Artificial selection from hatcheries and from
- 4) Fisheries can counter (or enhance) natural selection

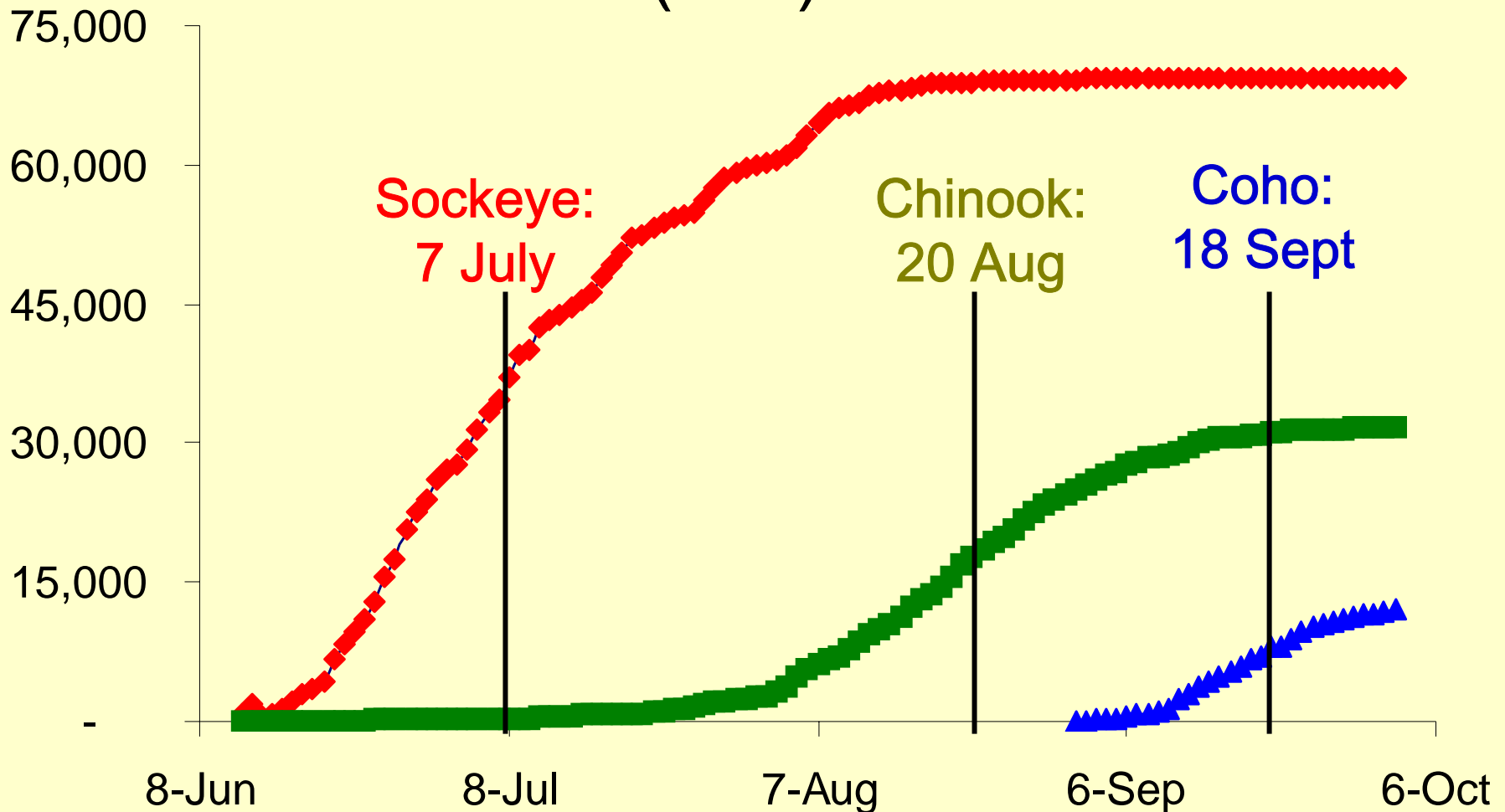


Species have distinct migration and spawning periods that are consistent among years

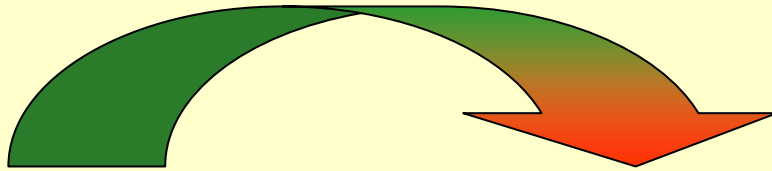


Cumulative counts of adult salmon ascending the Ballard Locks in 2007

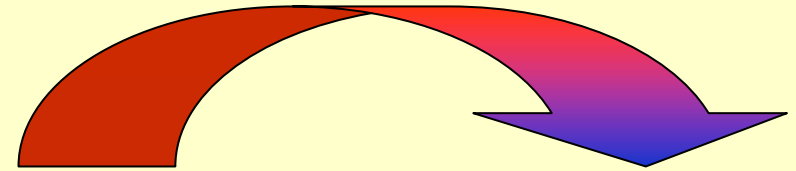
Median (50%) dates:



Temperature and flow are the primary physical factors in the evolution and ecology of timing

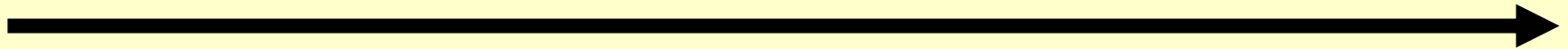


Optimal date for
adult migration

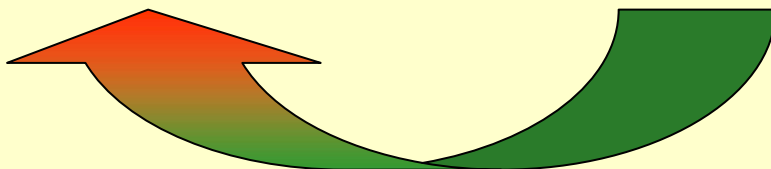


Optimal date for
spawning

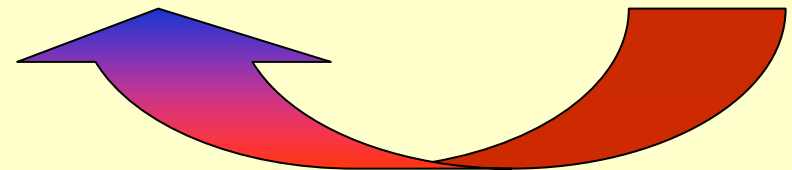
Optimal date for
fry emergence



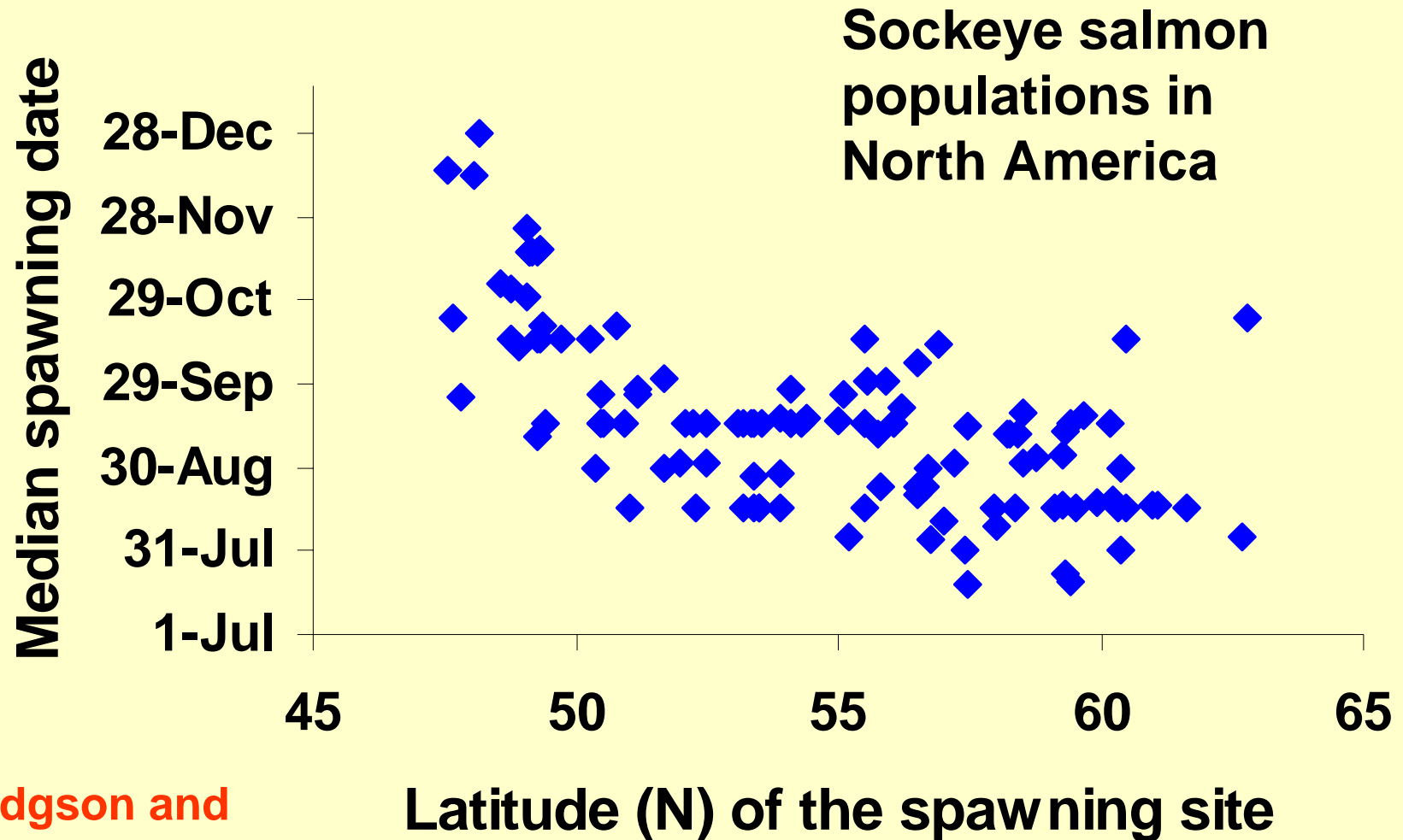
Flow must be adequate for
migration, temperature
cool enough for holding



Temperature determines
incubation rate, flow can
affect survival

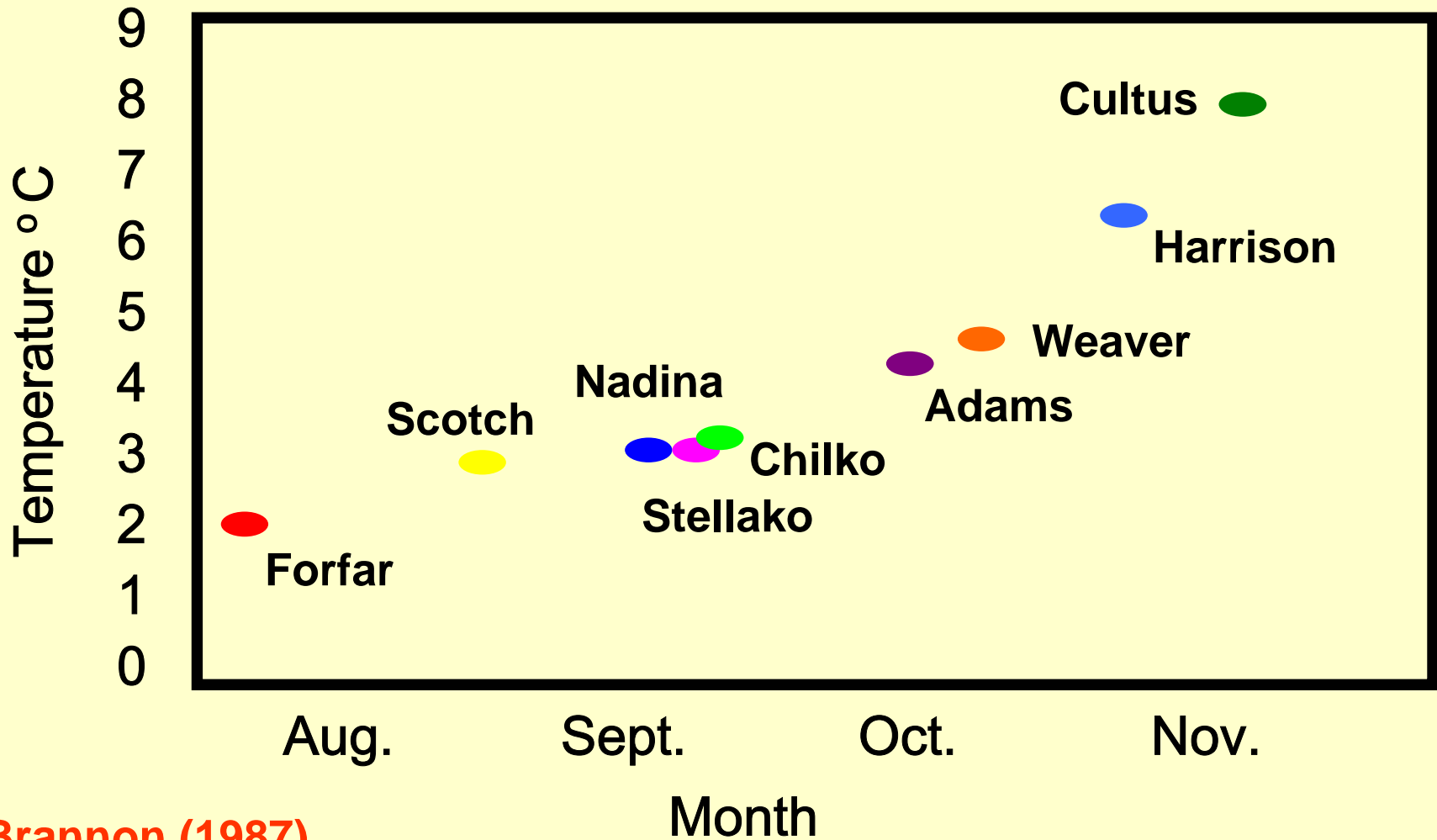


Spawning varies with latitude, a surrogate for thermal conditions

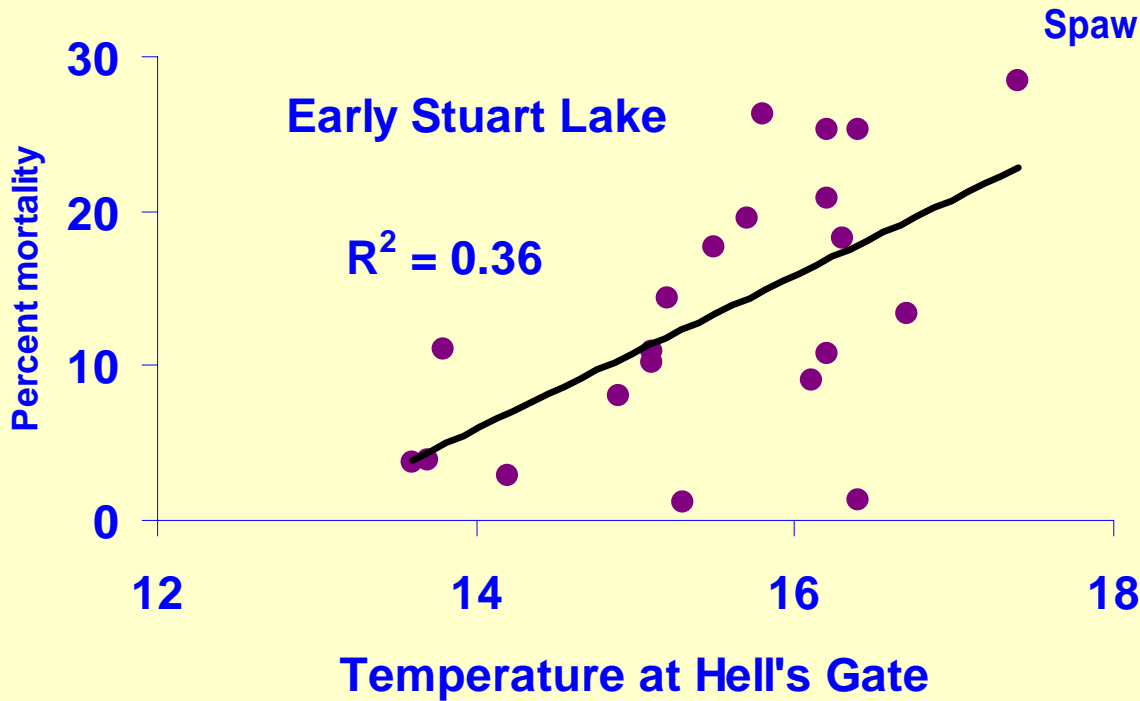
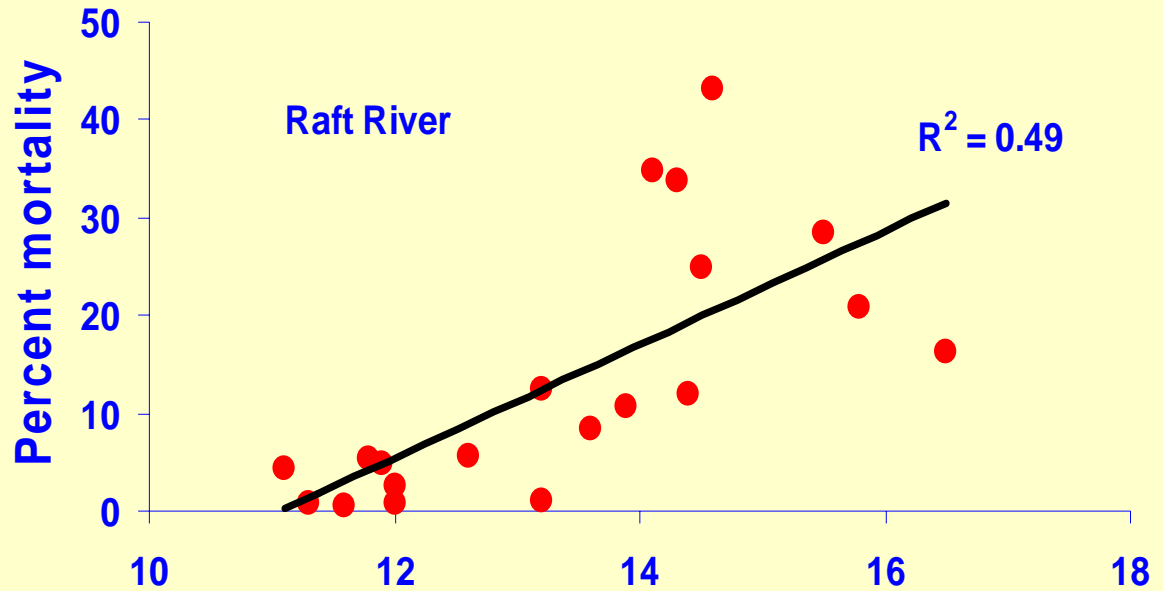


Hodgson and
Quinn (2002)

Salmon spawn earlier where incubation temperatures are colder: Fraser River sockeye salmon populations

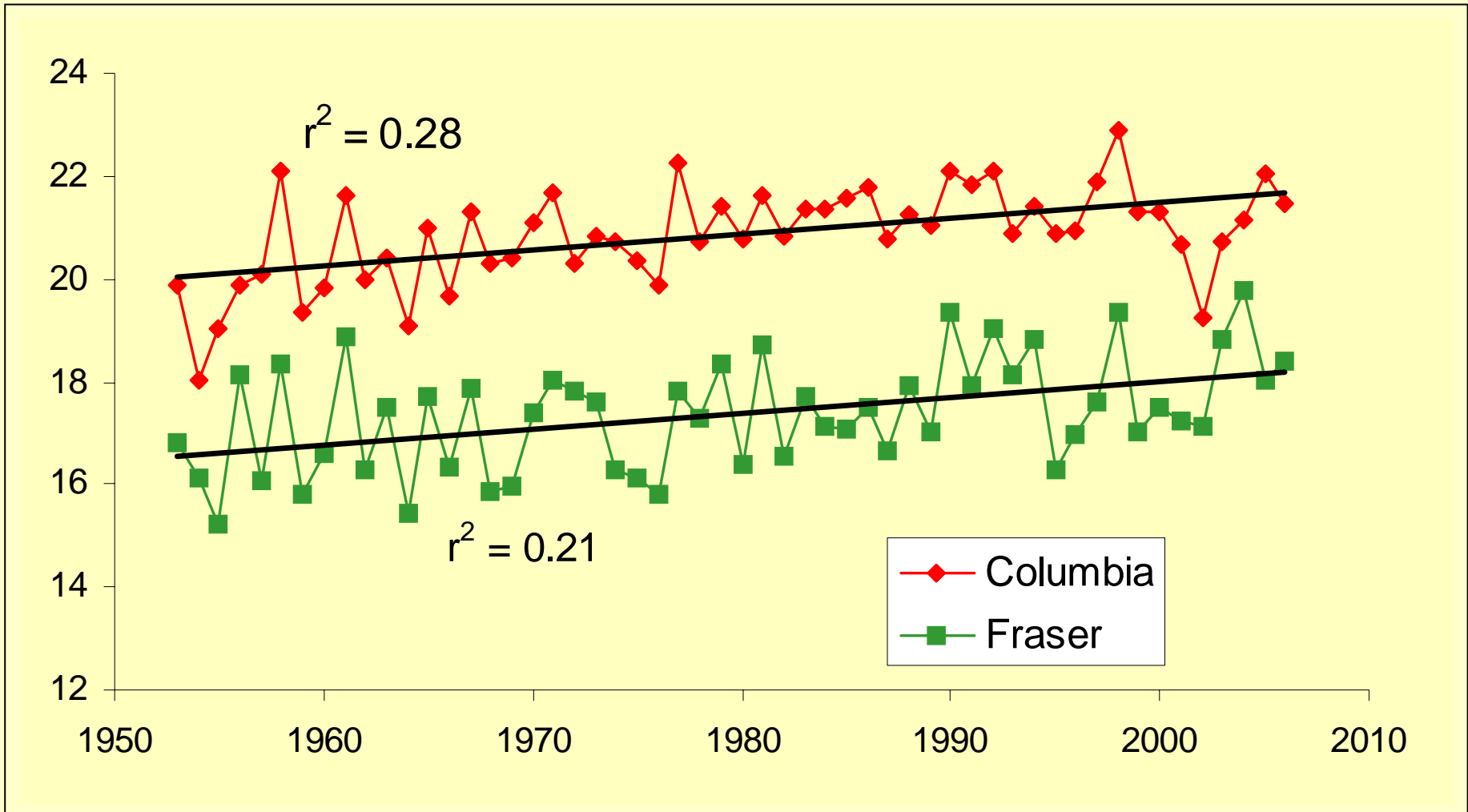


Mortality of Fraser River sockeye salmon increases with temperature

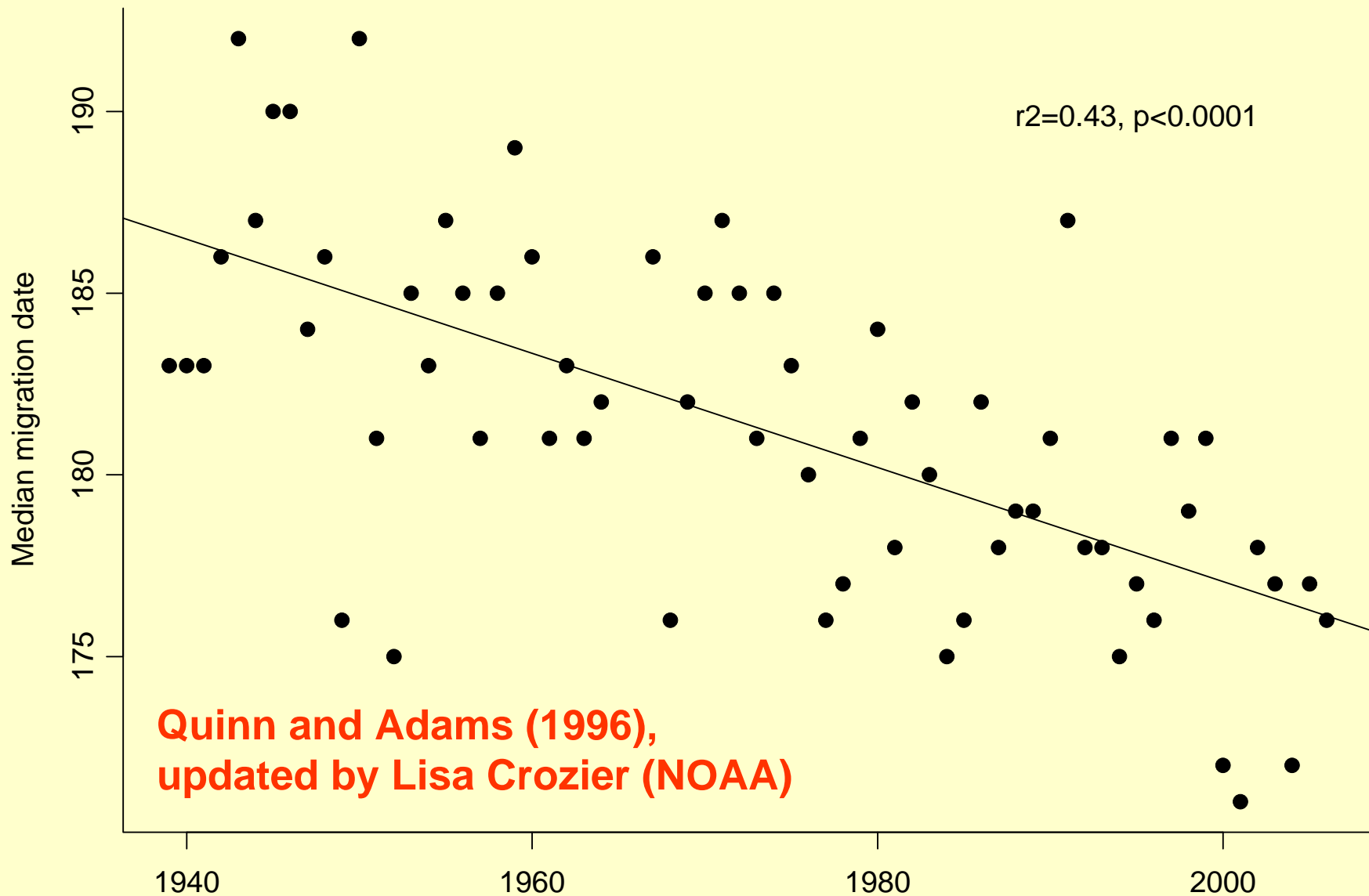


(Gilhousen 1990)

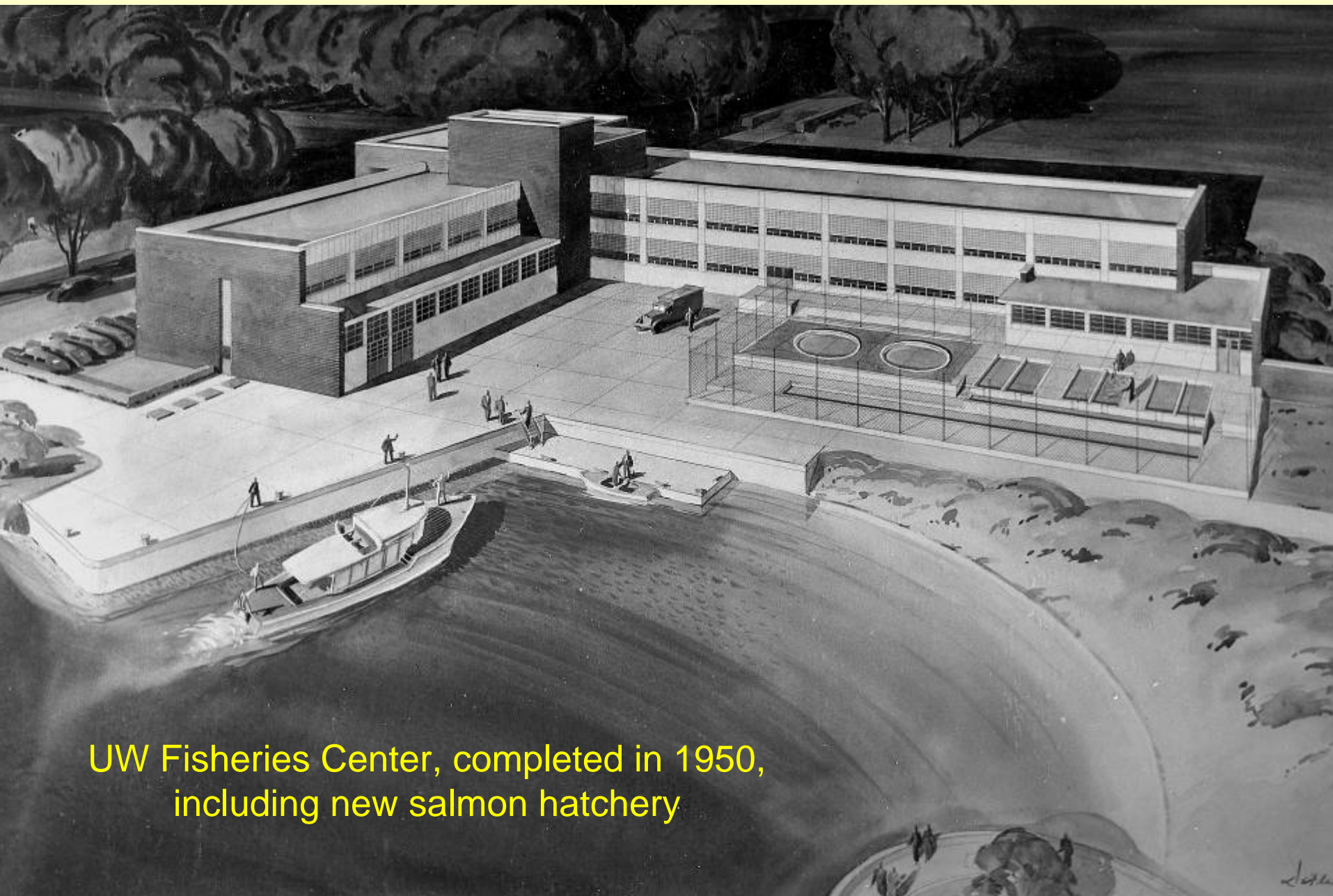
Water temperatures (e.g., August means) have been getting warmer...



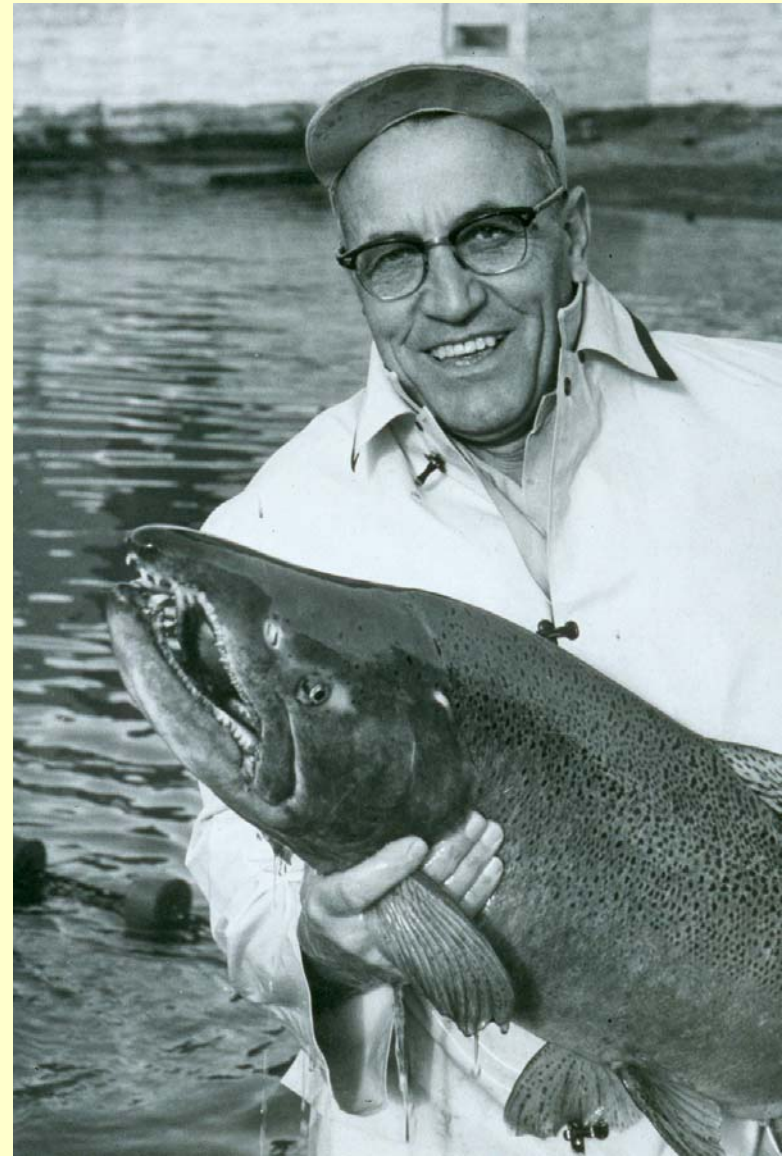
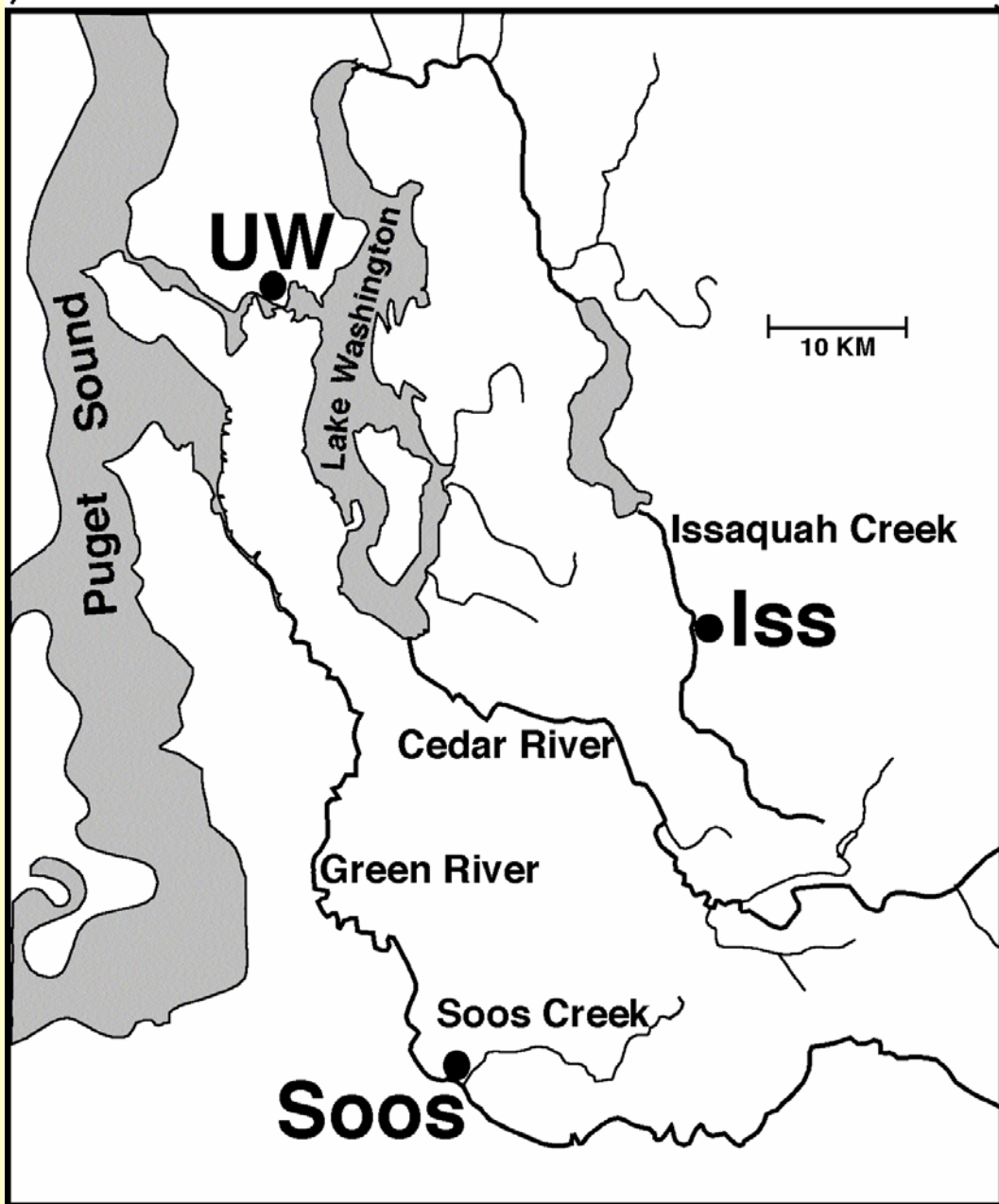
Columbia River sockeye are migrating earlier than in the past, presumably to avoid the warmer water



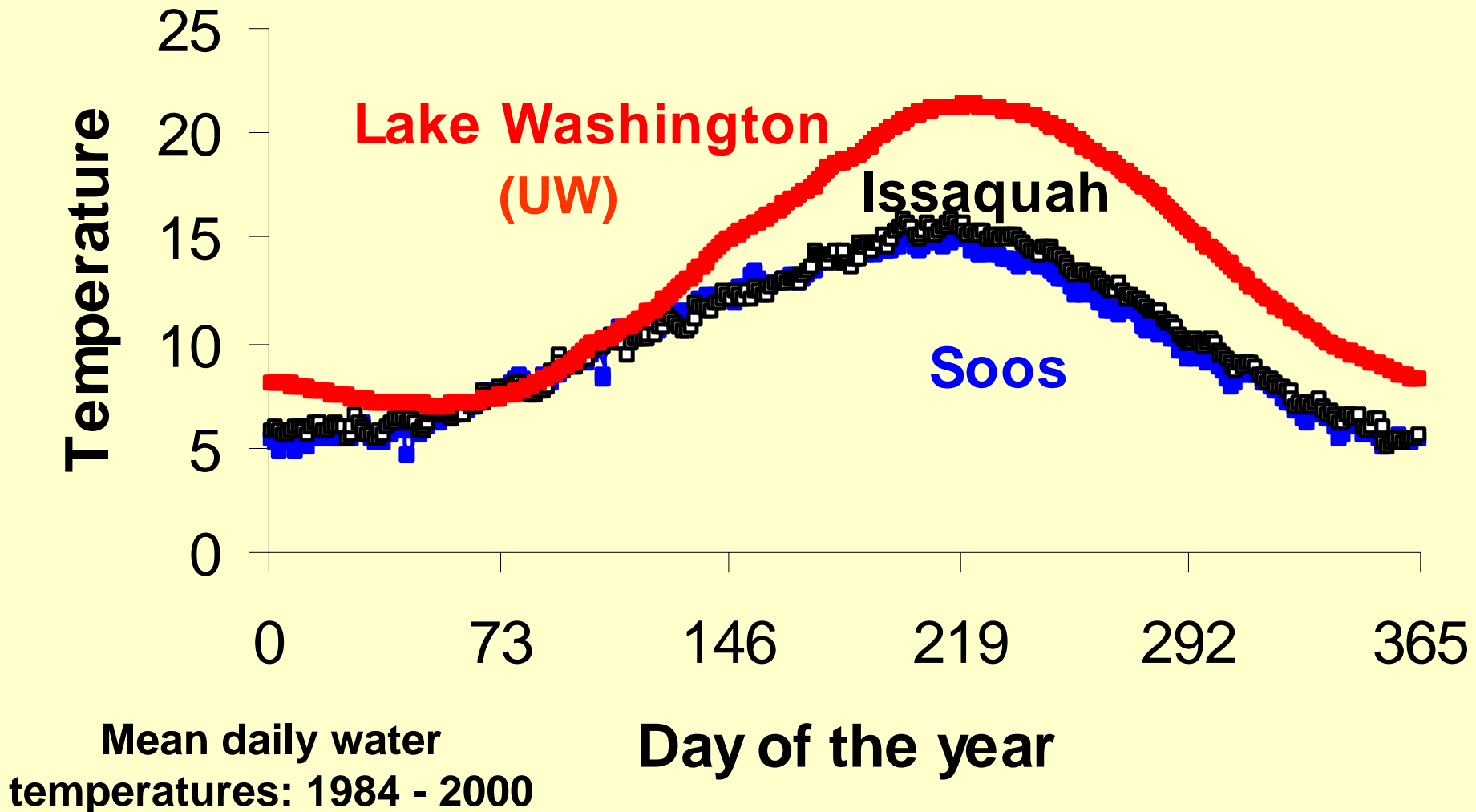
Salmon in hatcheries also experience selection on timing



UW Fisheries Center, completed in 1950,
including new salmon hatchery



The water supplies for the hatcheries vary in thermal regimes

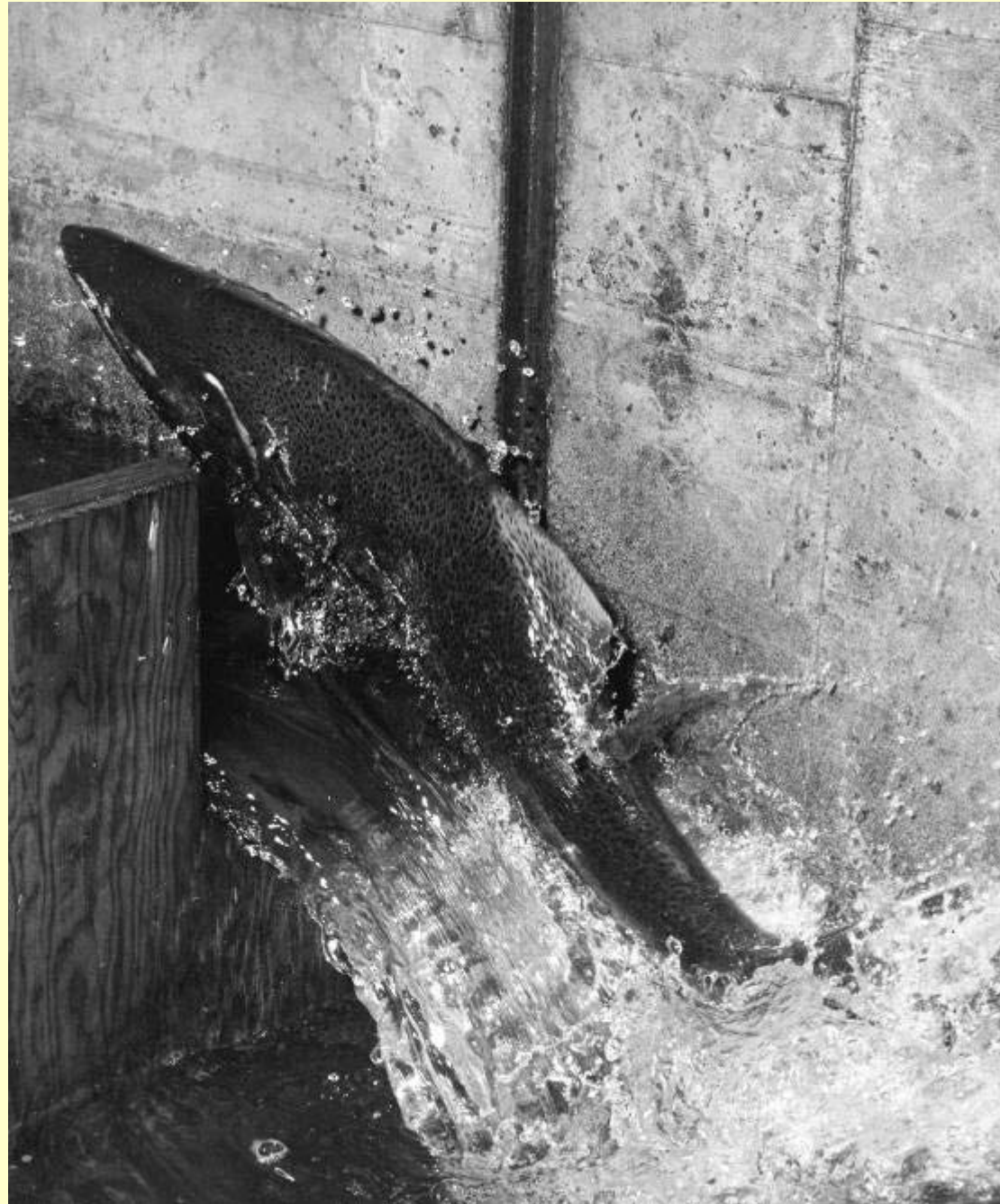


Variation in spawning date among the three populations follows the general “colder = earlier” pattern

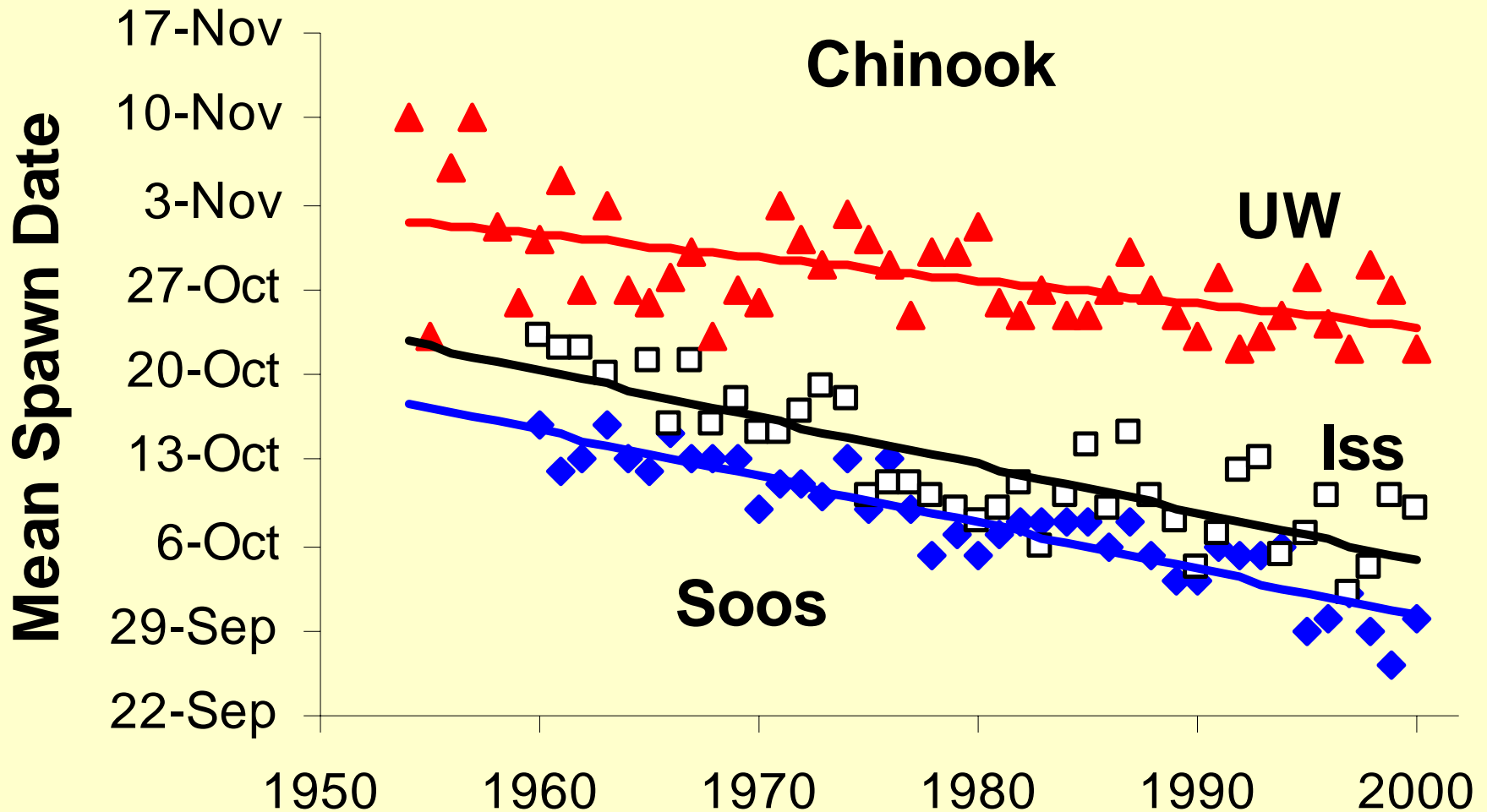
Hatchery	Mean Sept. temp.	Mean spawning date
Soos Creek	12.0	7 October
Issaquah Creek	12.9	12 October
Univ. of Wash.	19.0	27 October

Moreover, the manager is unsure how many fish will return. So, fish are spawned as they arrive until the capacity is reached. Late fish may be killed but not spawned.

Thus selection often favors early fish.



Mean spawning dates have been getting earlier over the years



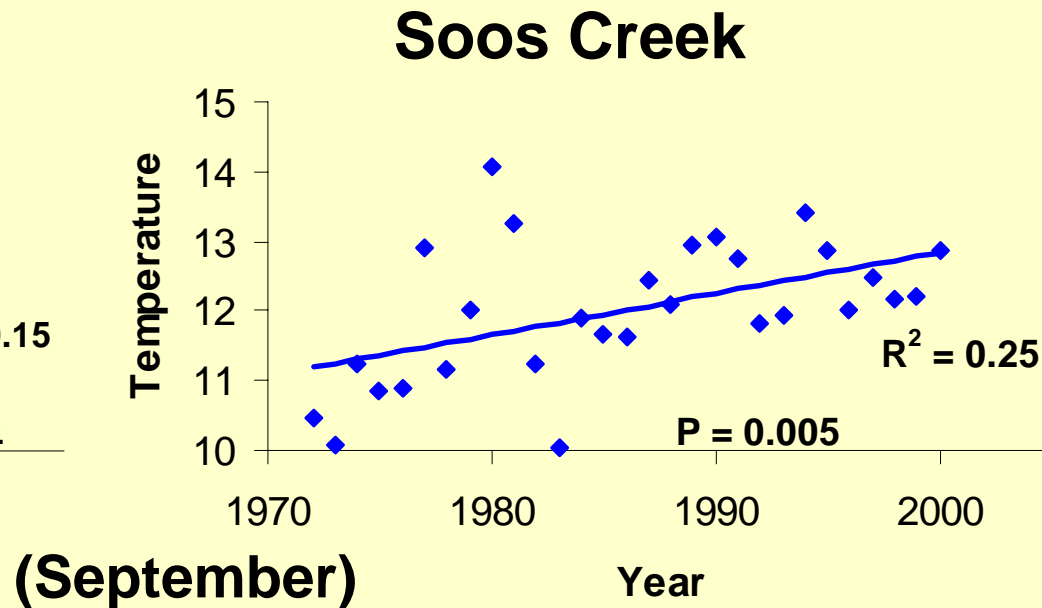
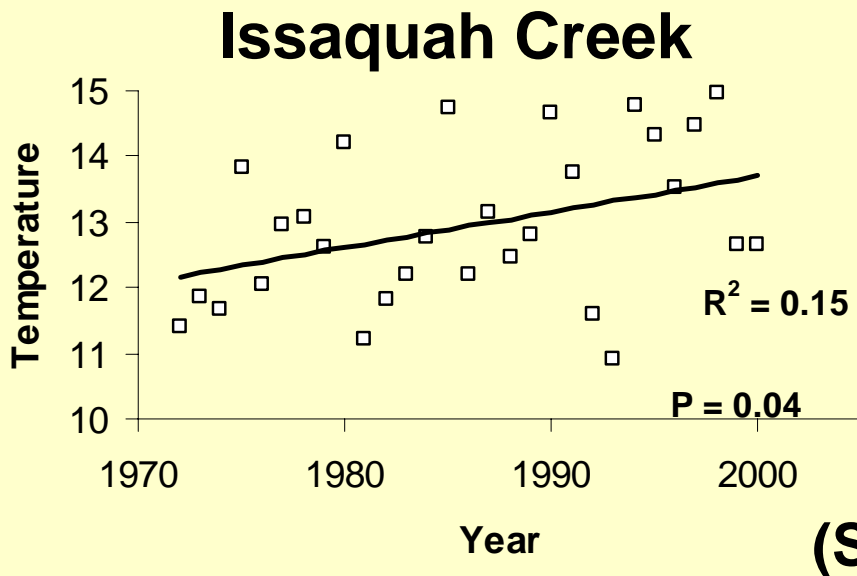
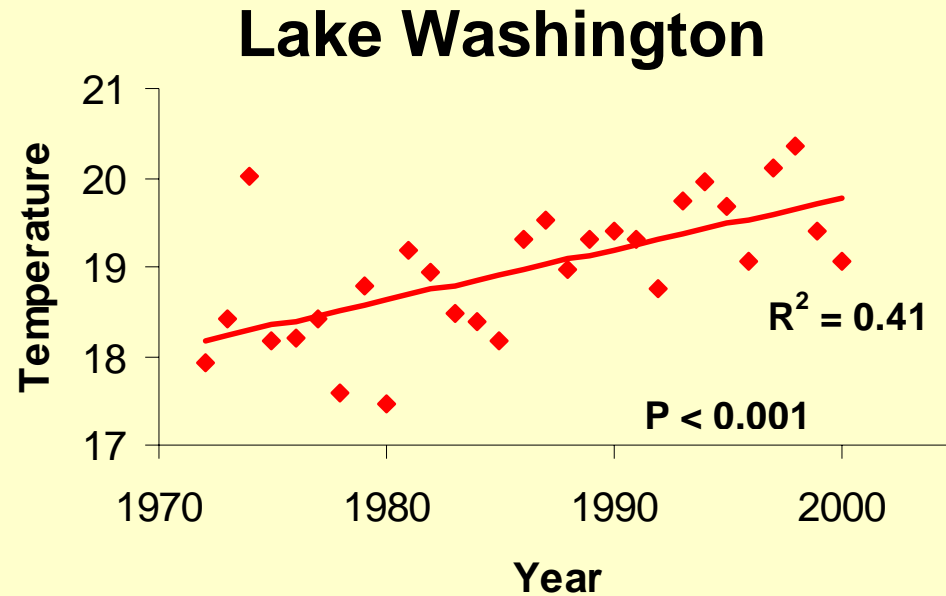
Trends in spawning date

Salmon tend to spawn later where water is warm because it may be intolerable to adults, and it accelerates embryo development.

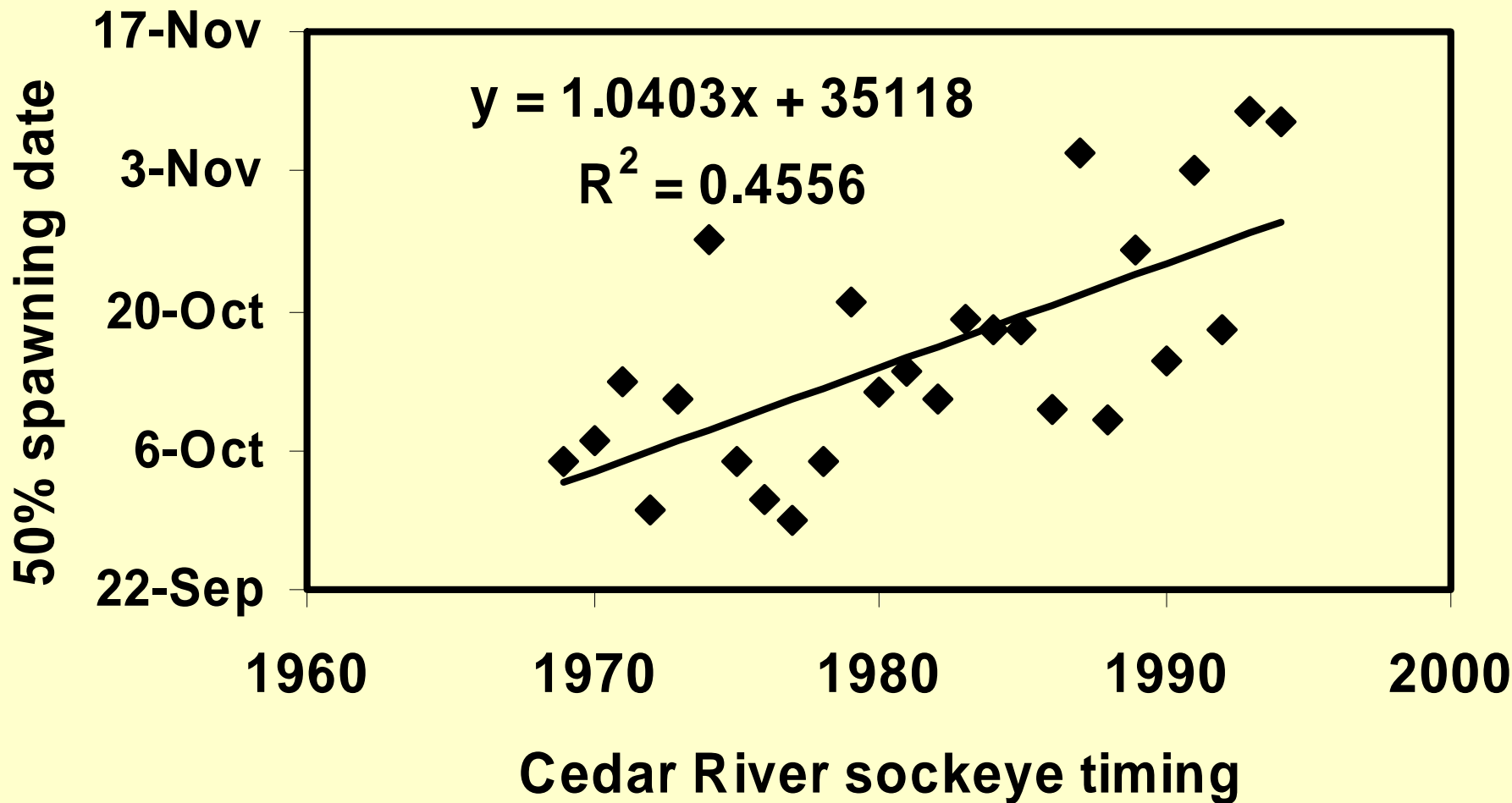
Hatcheries tend to spawn the earliest arriving salmon, so spawning becomes earlier over a period of years.

What happens when these processes oppose each other?

Water temperatures have been getting warmer, which should have resulted in later, not earlier, spawning. This suggests the role of artificial selection.



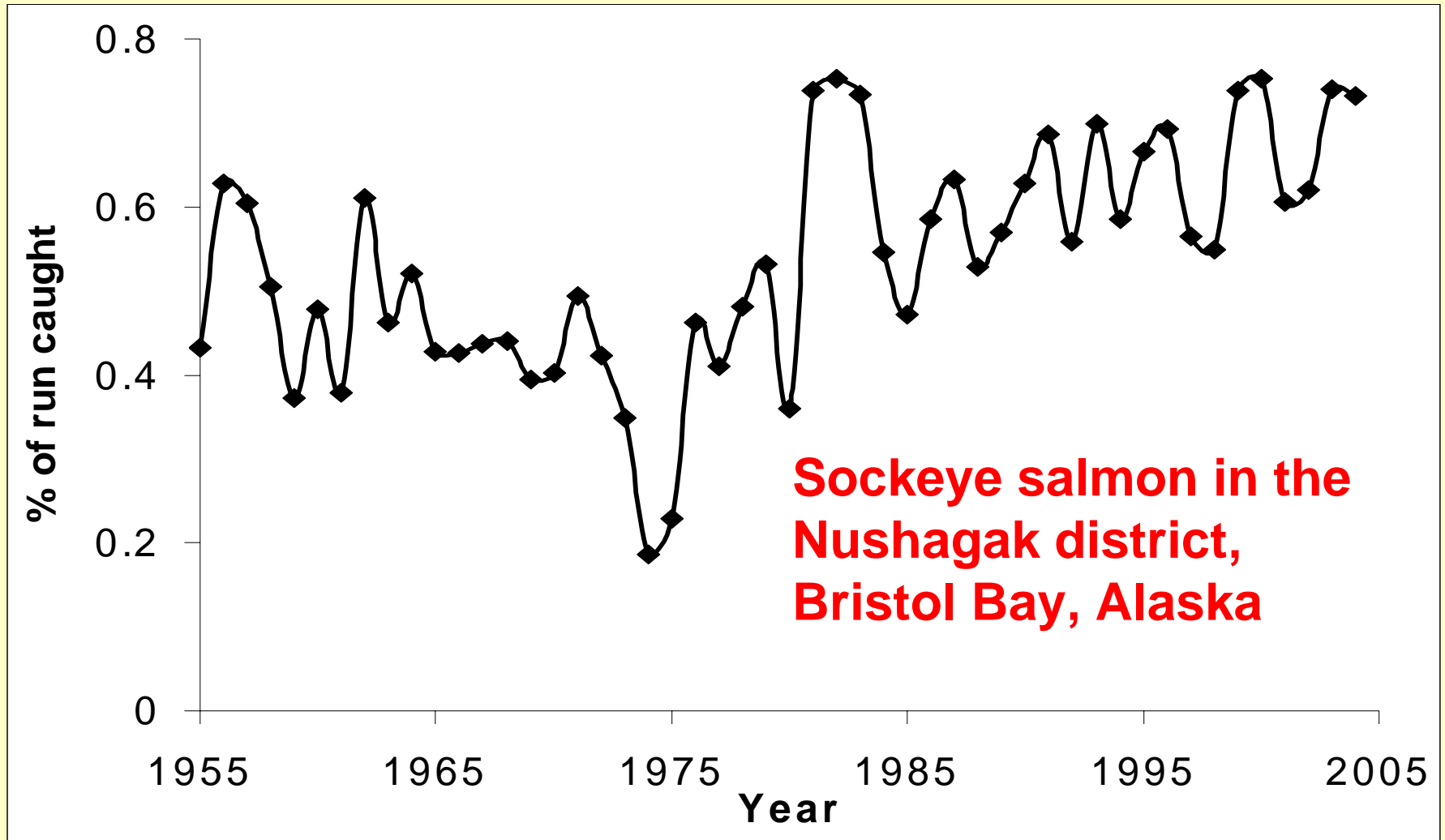
Wild sockeye salmon seem to have shifted towards later timing, consistent with adaptation to the changing conditions



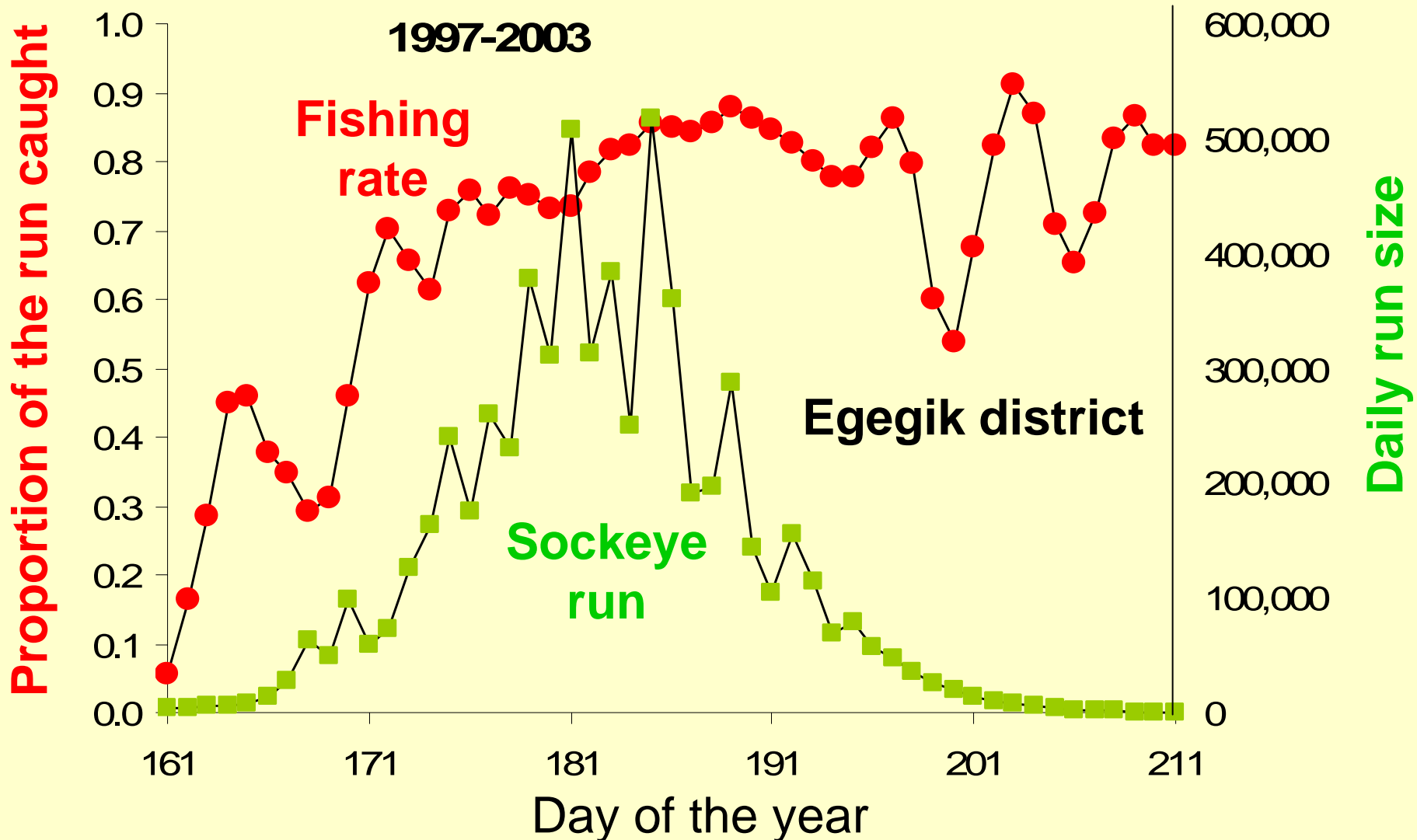
Data: WDF/Cascade Environmental Services (1995)



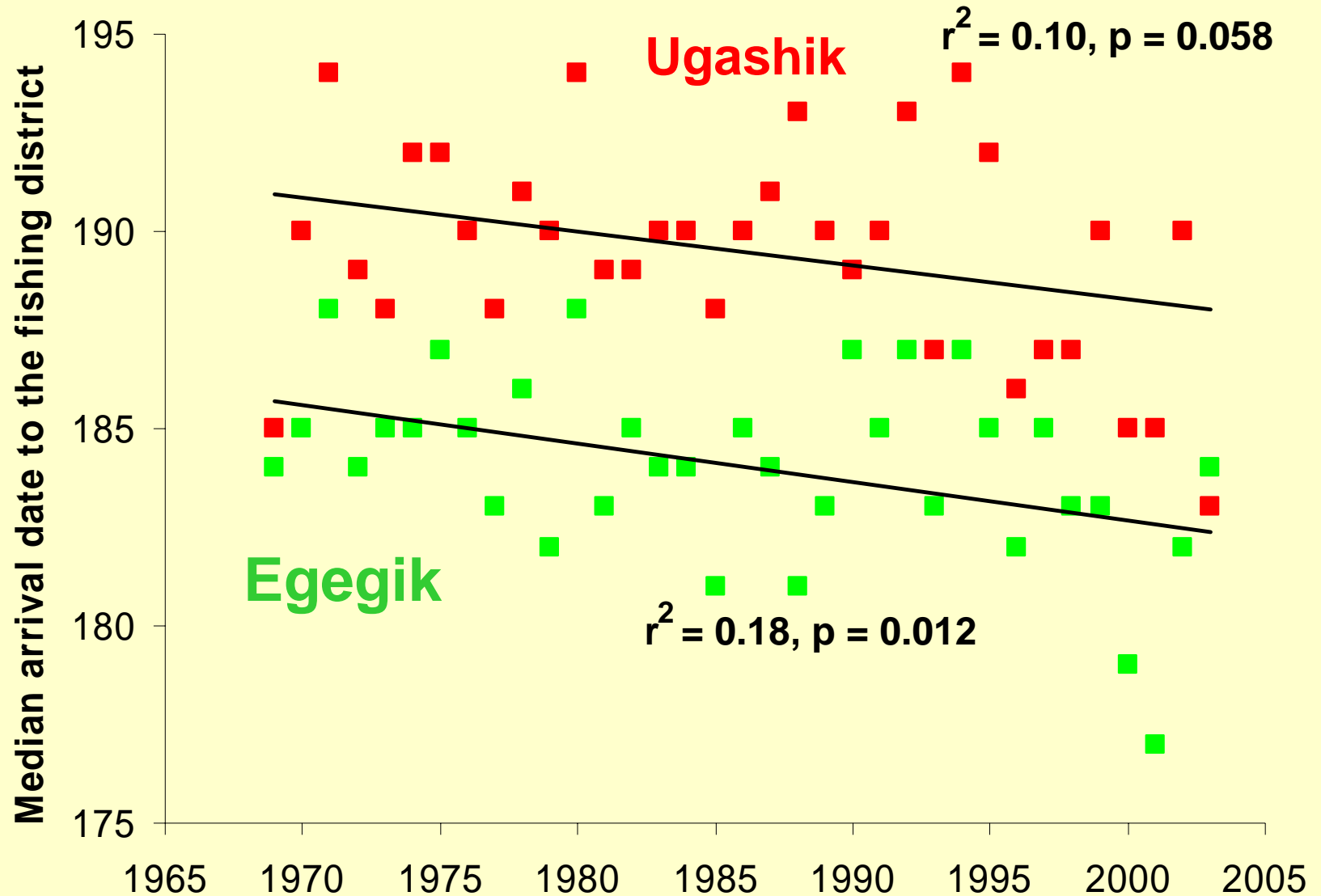
**Fisheries may take a large fraction of the run.
To protect the populations, Bristol Bay sockeye
are managed with a fixed escapement goal**



Fishing may be restricted early in the season until it is clear that the escapement goal will be met; fishing then increases.



The salmon have been migrating earlier, an effect that is not explained by climate conditions



Conclusions

- **Salmon populations have evolved to migrate and spawn at specific times of the year**
- **Climate change is altering the regime of natural selection on timing**
- **Hatchery practices and fisheries also exert powerful selection regimes**
- **Natural and “un-natural” selection regimes may augment or oppose each other, with important consequences for the salmon**



Thanks!