



Phenology of High Latitude Chinook Salmon

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**PICES International Symposium on Climate
Change Effects on Fish and Fisheries
W4 – Salmon workshop on climate change
Sendai, Japan April 25, 2010**

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Phenology - The relation of climate to the timing of the salmon's life cycle. In this paper it is the relation of climate to timing of migration of maturing adult chinook salmon soon after saltwater exit.

Has the warming of air temperatures that has occurred over the continent in northern Alaska and Canada changed the timing of spawning migrations?

What is the evidence for environmental control of migratory timing?

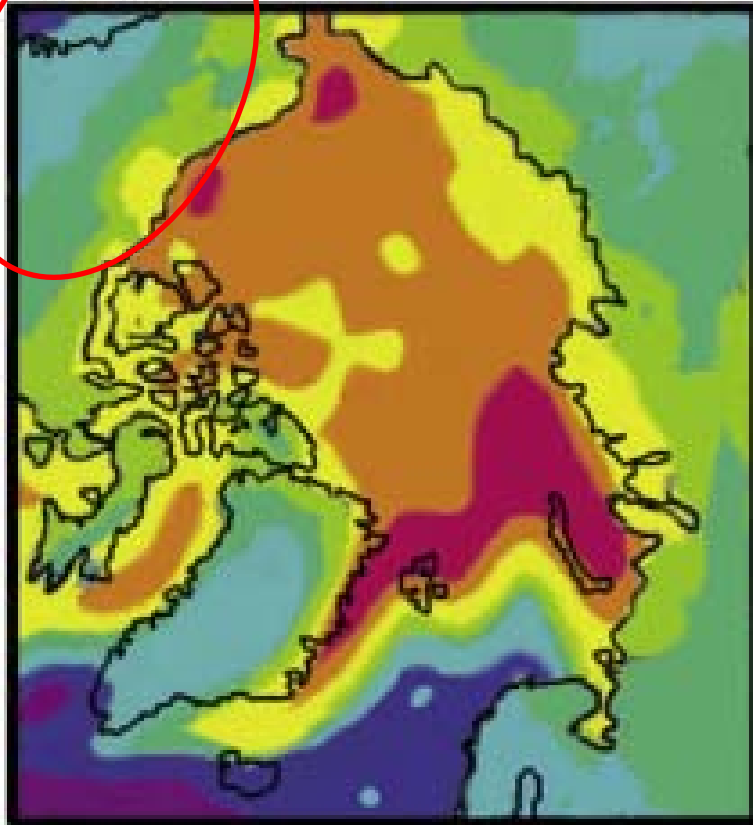
How could changing climate impact migration of maturing adult salmon?

Salmon Phenology and Climate Change

- Life cycle completion dependent on
 - Temperatures (spawning, disease, bioenergetics)
 - Phenologies of prey and predators
- Salmon distributions cover wide range of latitudes and longitudes across Pacific Rim
- Changes published for southern areas of range (Auke Creek pink salmon fry, Taylor 2008)
- Lots of salmon data – many long time series of observations throughout life cycle, but longest series are for maturing adults
- Environmental data and modeled outputs are becoming more readily available at appropriate time and space scales

Seasonal mean surface air temperature: long term increases forecast Avg(1980 – 1999) - Mod(2080 – 2099)

Winter



Summer

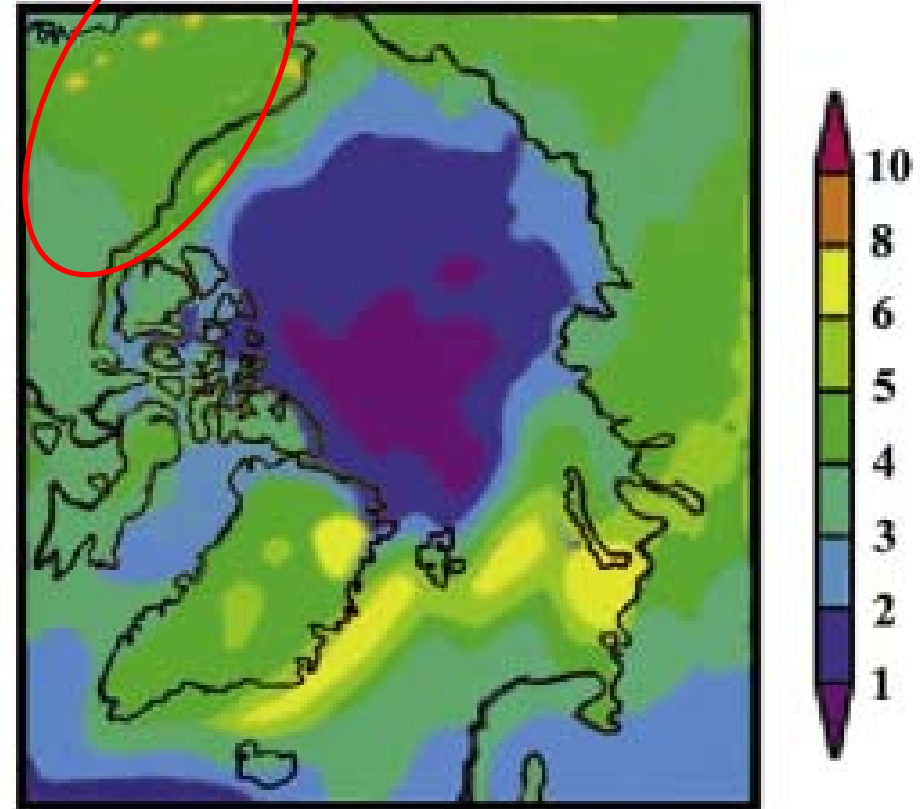
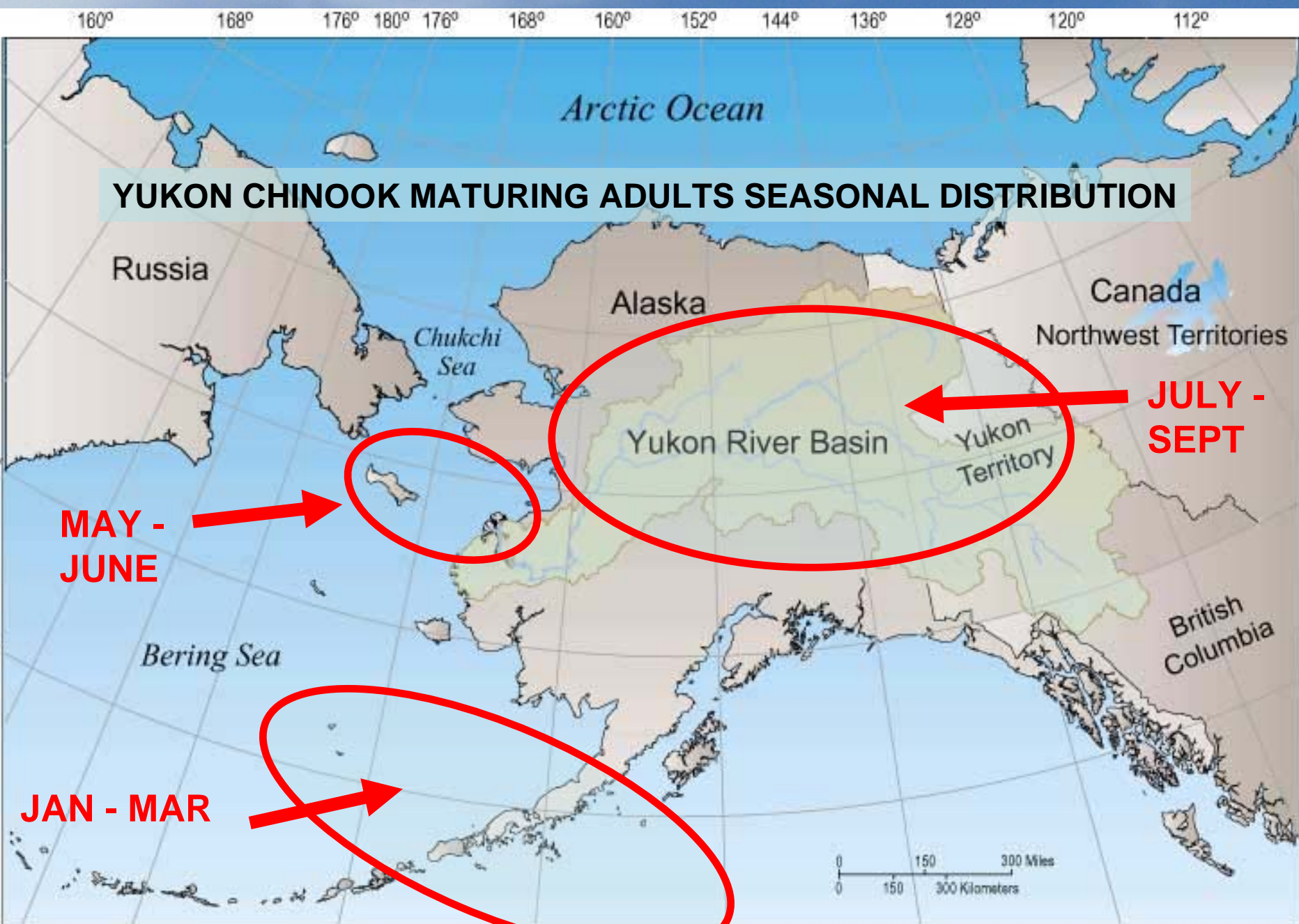


Figure 1 from Vors and Boyce Global Change Biology (2009) 15, 2626–2633

YUKON CHINOOK MATURING ADULTS SEASONAL DISTRIBUTION



LONG TIME SERIES OF MATURING ADULT YUKON CHINOOK OBSERVATIONS

49 YRS FROM 1961
~ 3000 DAILY
OBSERVATIONS



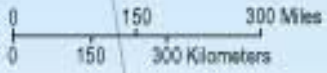
TIMING OF MATURING ADULT YUKON CHINOOK LINKED TO WEATHER AND CLIMATE

STAGING AREA

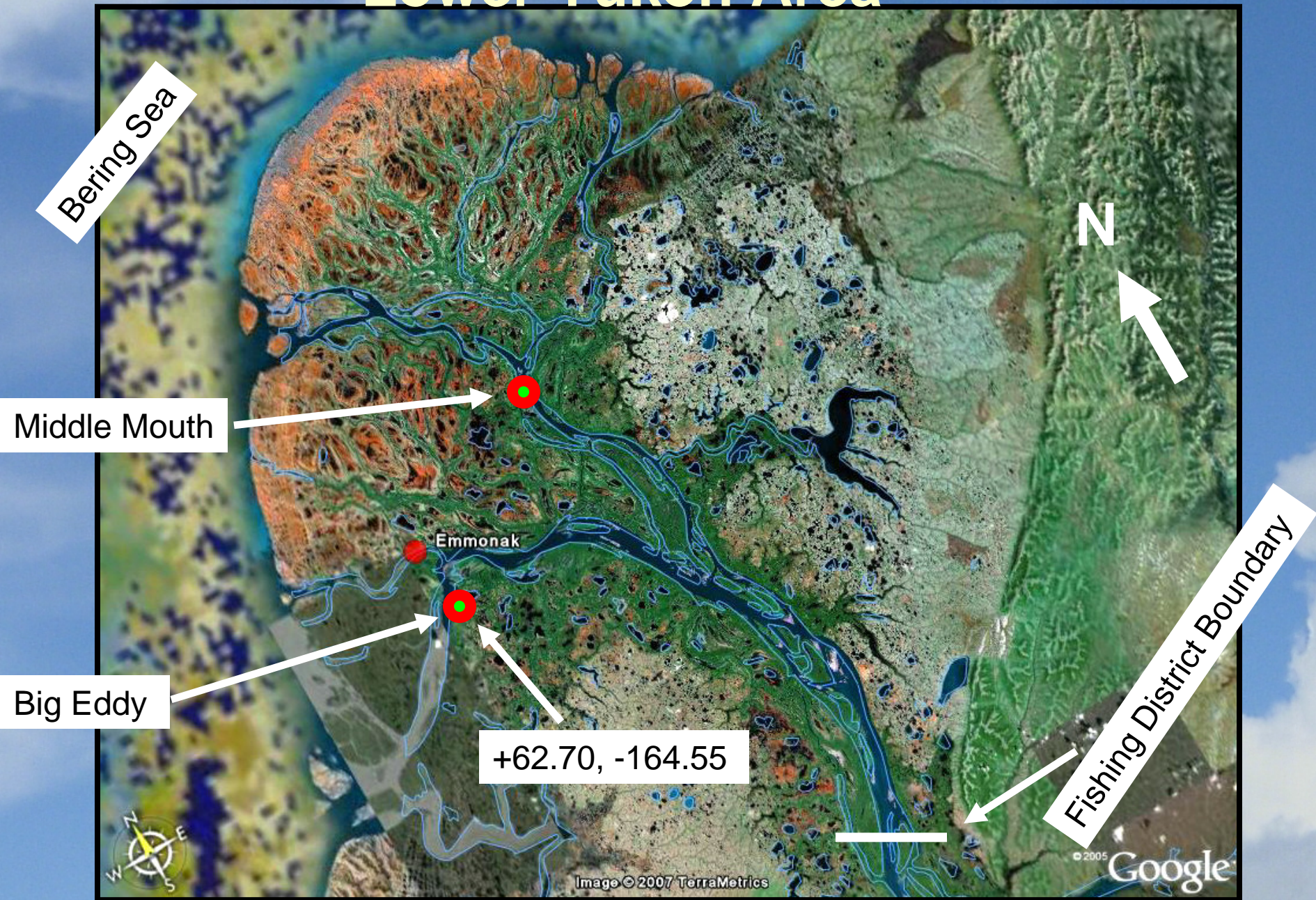
- Air Temp
- Model SST
- Ice cover



Working Hypothesis
Timing of marine exit is linked to climate and weather through effects on the location and stability of temperature-salinity fronts at river's mouth.



Lower Yukon Area



Test Fisheries:

Big Eddy

Middle Mouth

**Observations daily
throughout
migration June,
July, August**

1979 - present

Set Gillnet



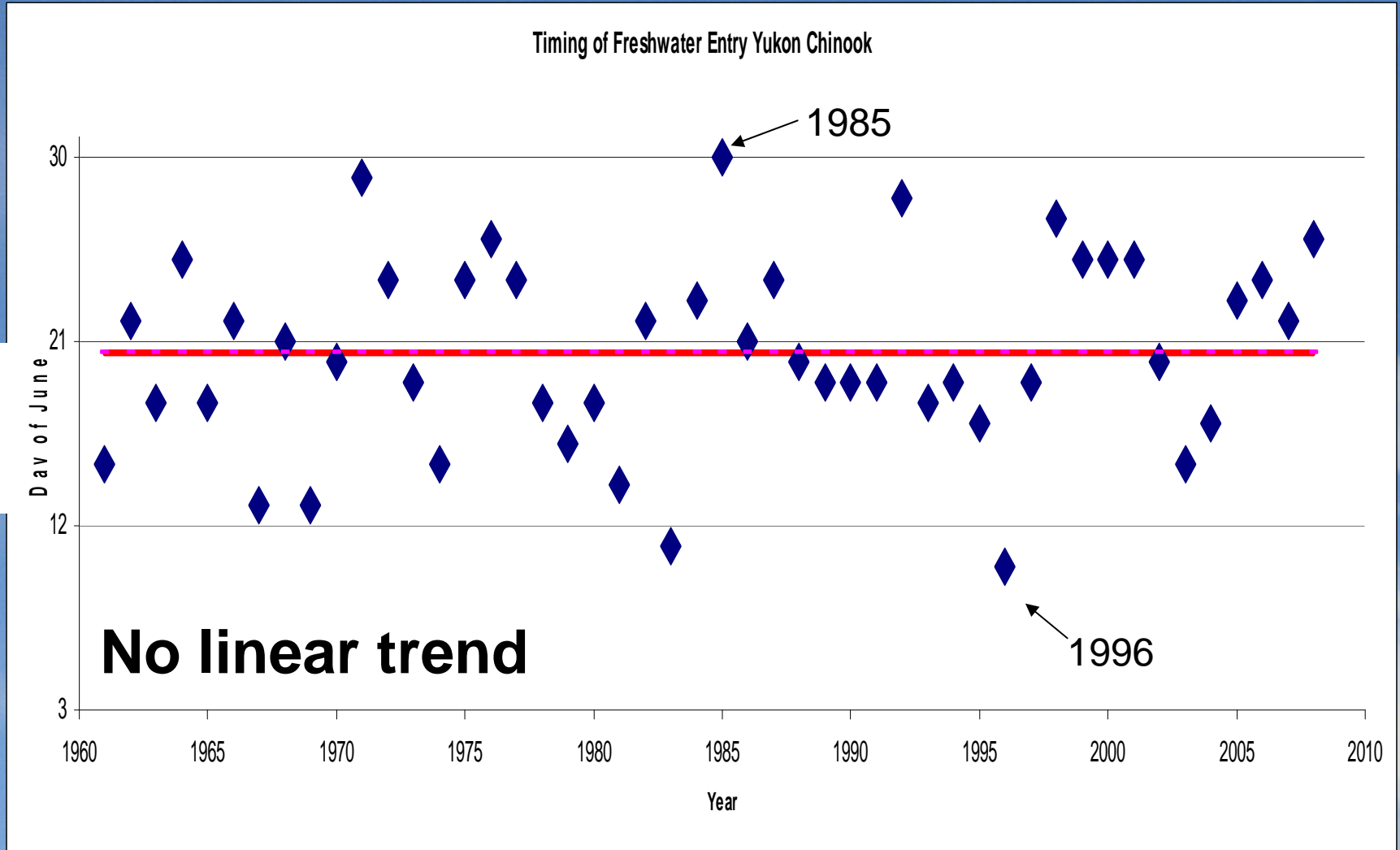
Biological Sampling, ASL



Drift Gillnet

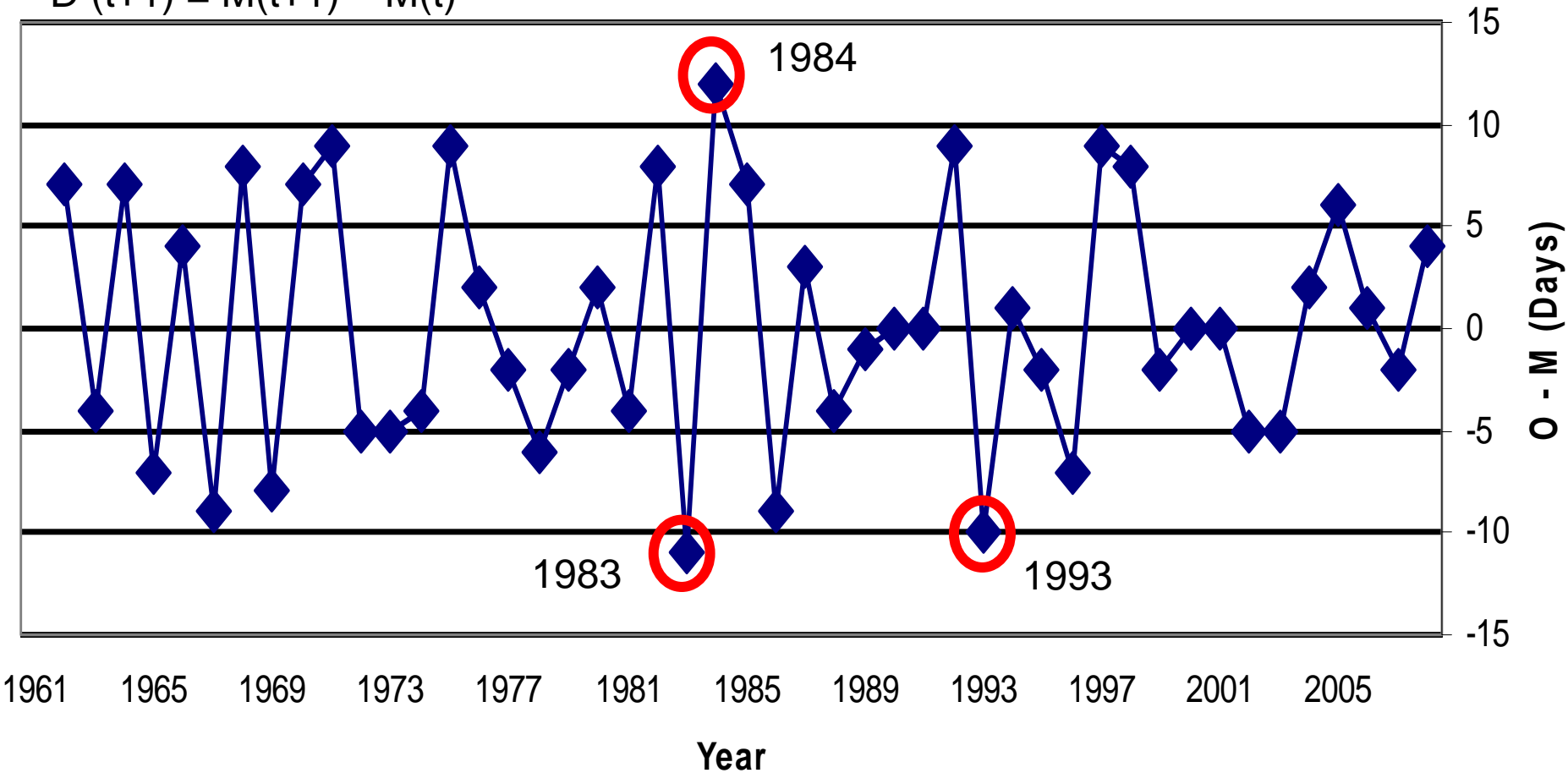
Median Date Freshwater Entry Yukon R Delta 1961 - 2008

JUNE

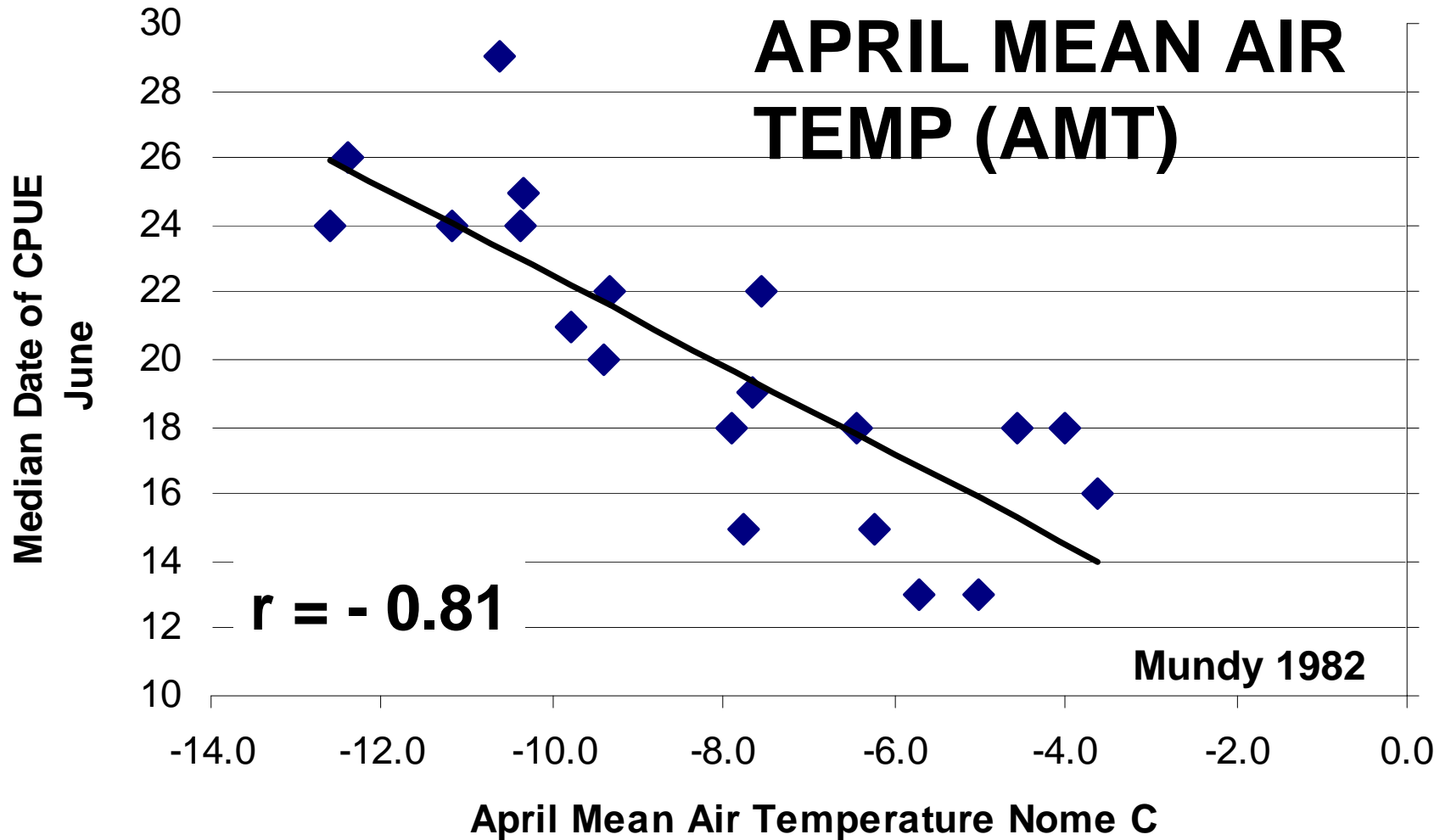


Yukon chinook timing interannual difference in medians

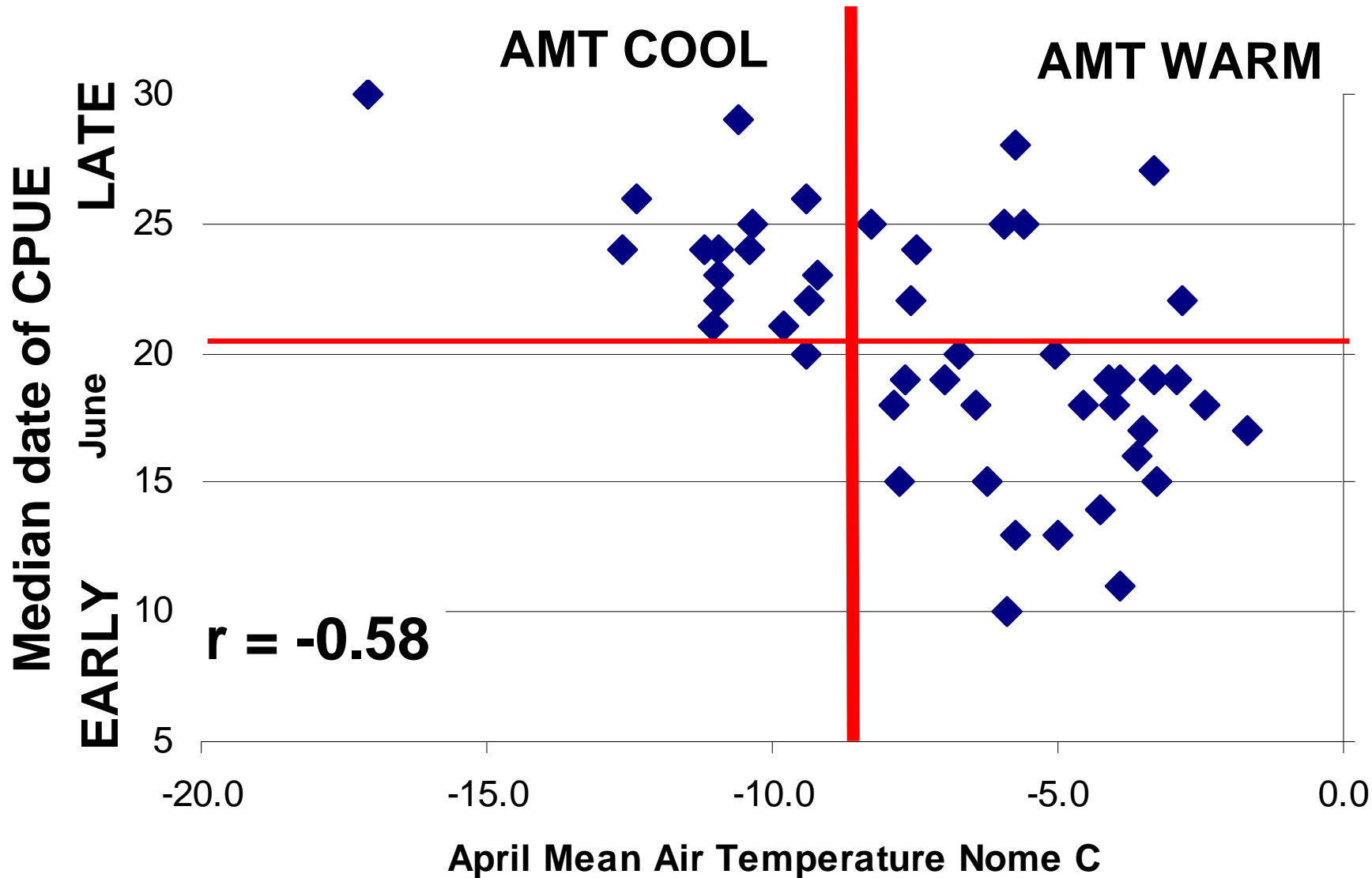
$$D(t+1) = M(t+1) - M(t)$$



Environmental Mediation of Timing 1961 - 1980

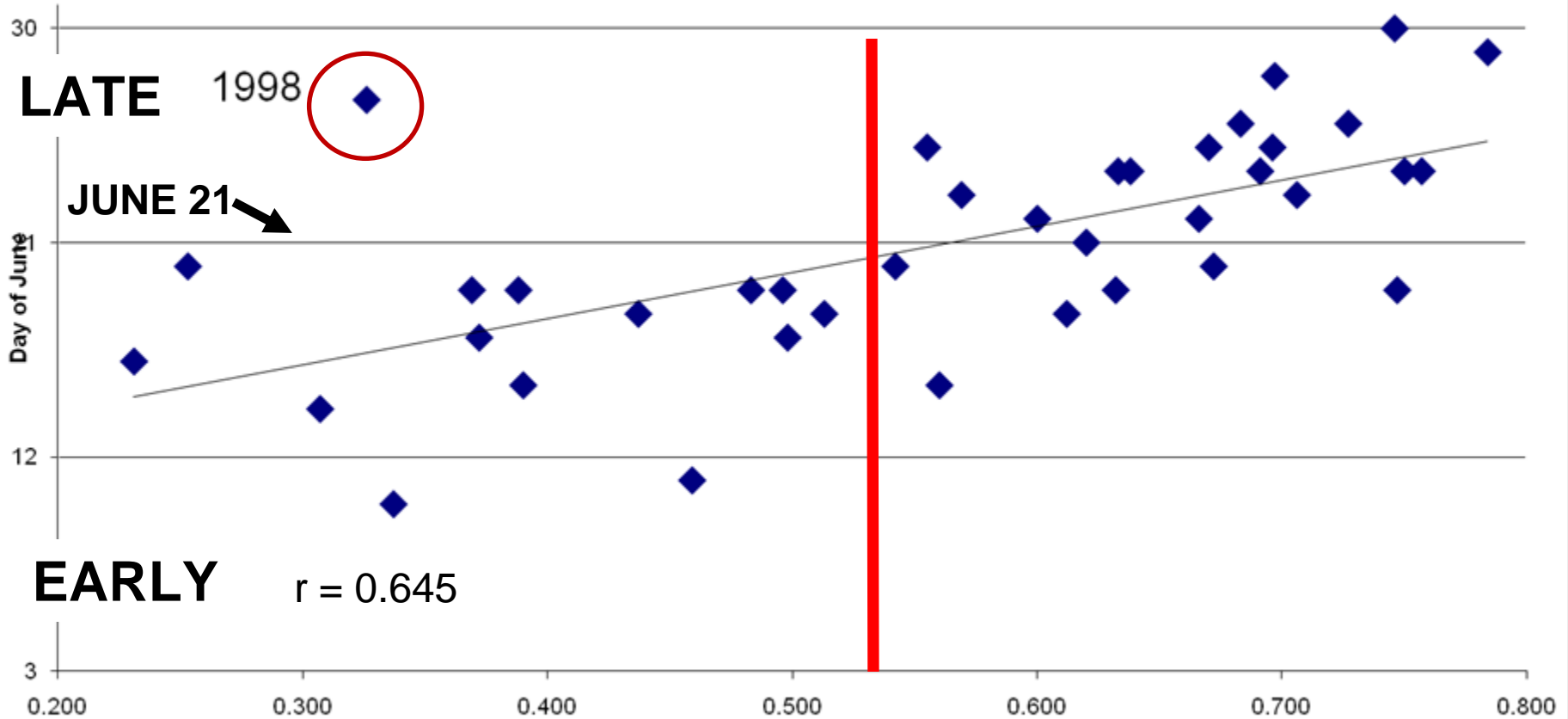


Environmental Mediation of Timing 1961 - 2008



Yukon Chinook Timing v Early Spring Ice Cover 1970 - 2008

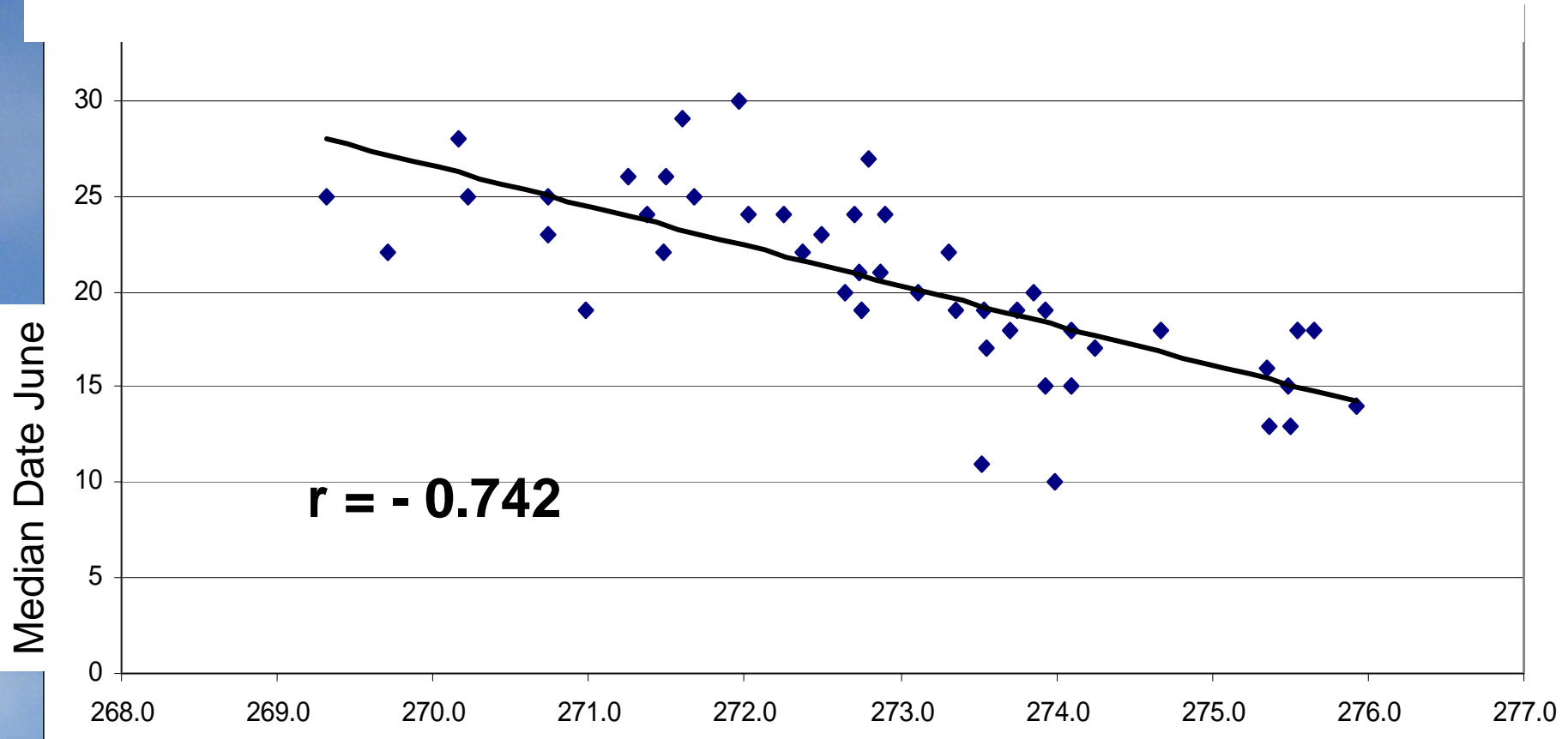
SPRING ICE COVER



Ice Cover 166W - 169W, 62N - 63N March 20 - June 1

Jinlun Zhang

Modeled May SST (K) v Yukon Chinook Timing 1961 - 2008



SST 63.1N 165.5W Modeled output from NCEP Reanalysis
surface skin temperatures by Nick Bond Degrees K

CONCLUSIONS

- No evidence of effects of warming continental air temperatures on migratory timing 1961 - 2008
- Timing is highly likely to be late following a cool spring
- Timing is likely to be early following a warm spring, but timing becomes less predictable as springs become warmer
- Temperature is related to timing through its relation to stability of the water column in the marine staging areas, so temperature is limited in its utility as a stand alone predictor of timing



More Conclusions

- Retain hypothesis: Timing of marine exit is linked to climate and weather through effects on the location and stability of temperature-salinity fronts at river's mouth.
- Timing of spawning migrations of high latitude chinook will become more highly variable as climate warms
- Warming climate does not necessarily produce earlier spawning migrations as timing becomes less critical to spawning success in milder climates.