Growth of Bristol Bay & Yukon River, Alaska Chum Salmon in Response to Climatic Factors & Inter-specific Competition

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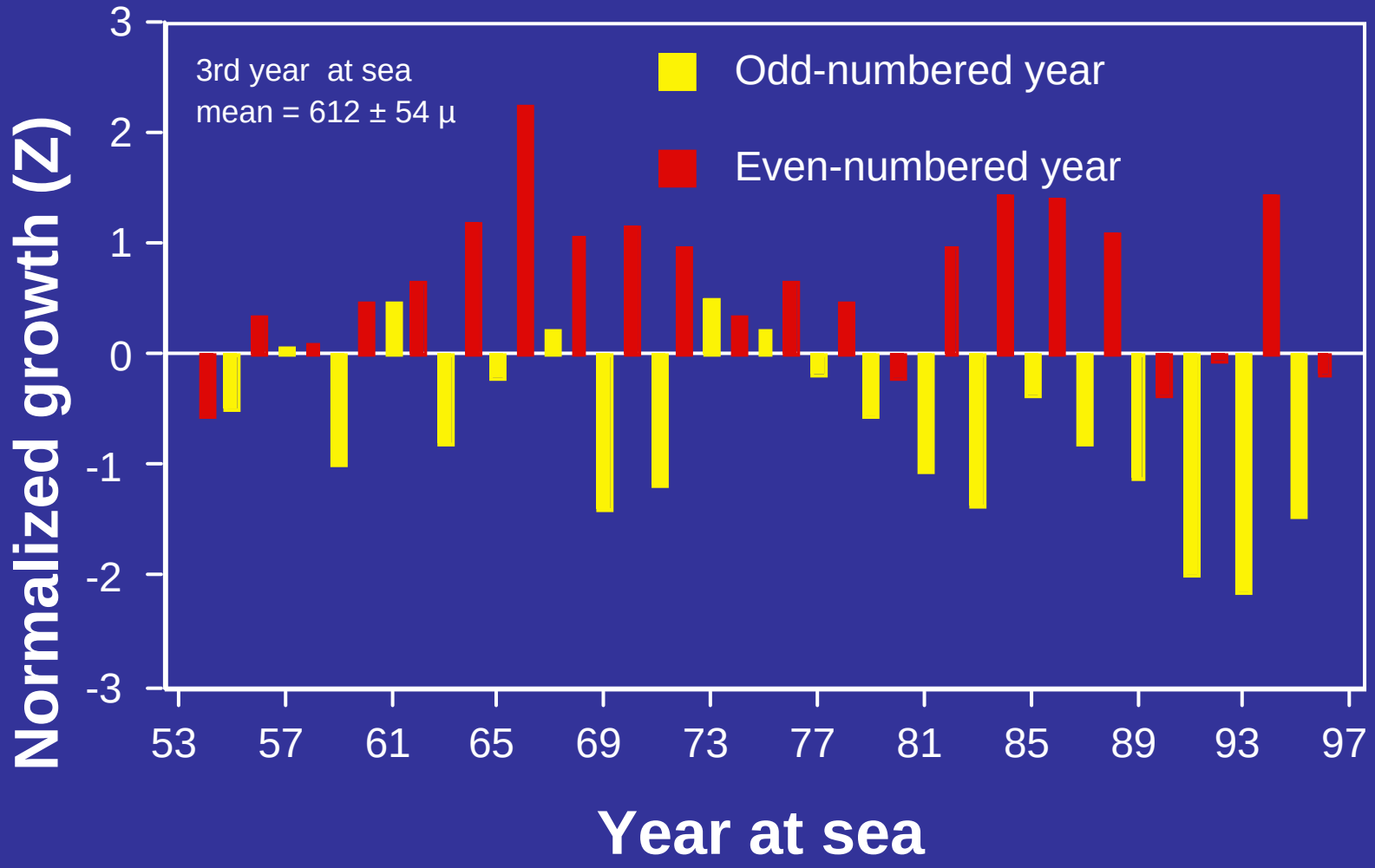
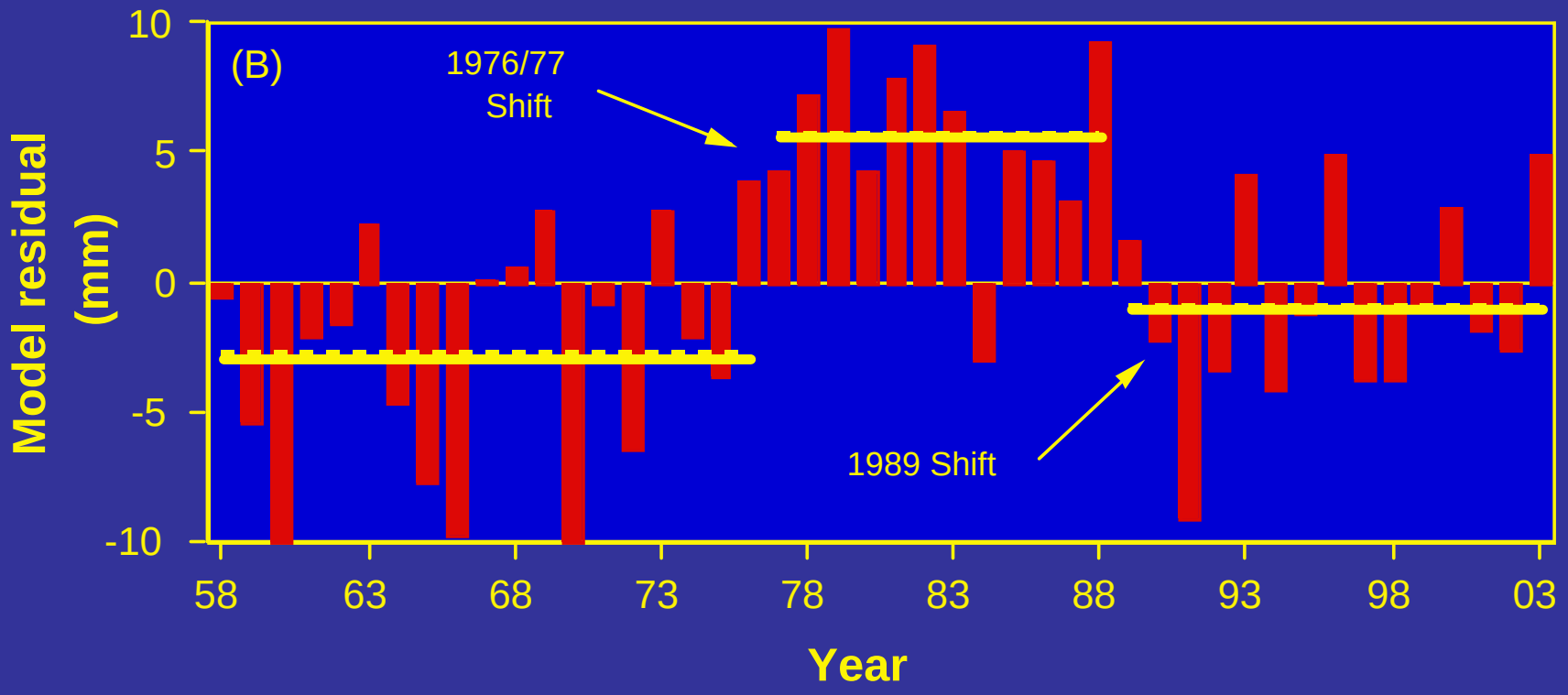
Sockeye growth reduced during odd years at sea corresponding to Asian pink salmon abundance



BB Sockeye Length & Climate Change

L = 550.9 - .178(sockeye) - .144(pinks), r2 = .40



Chum Salmon

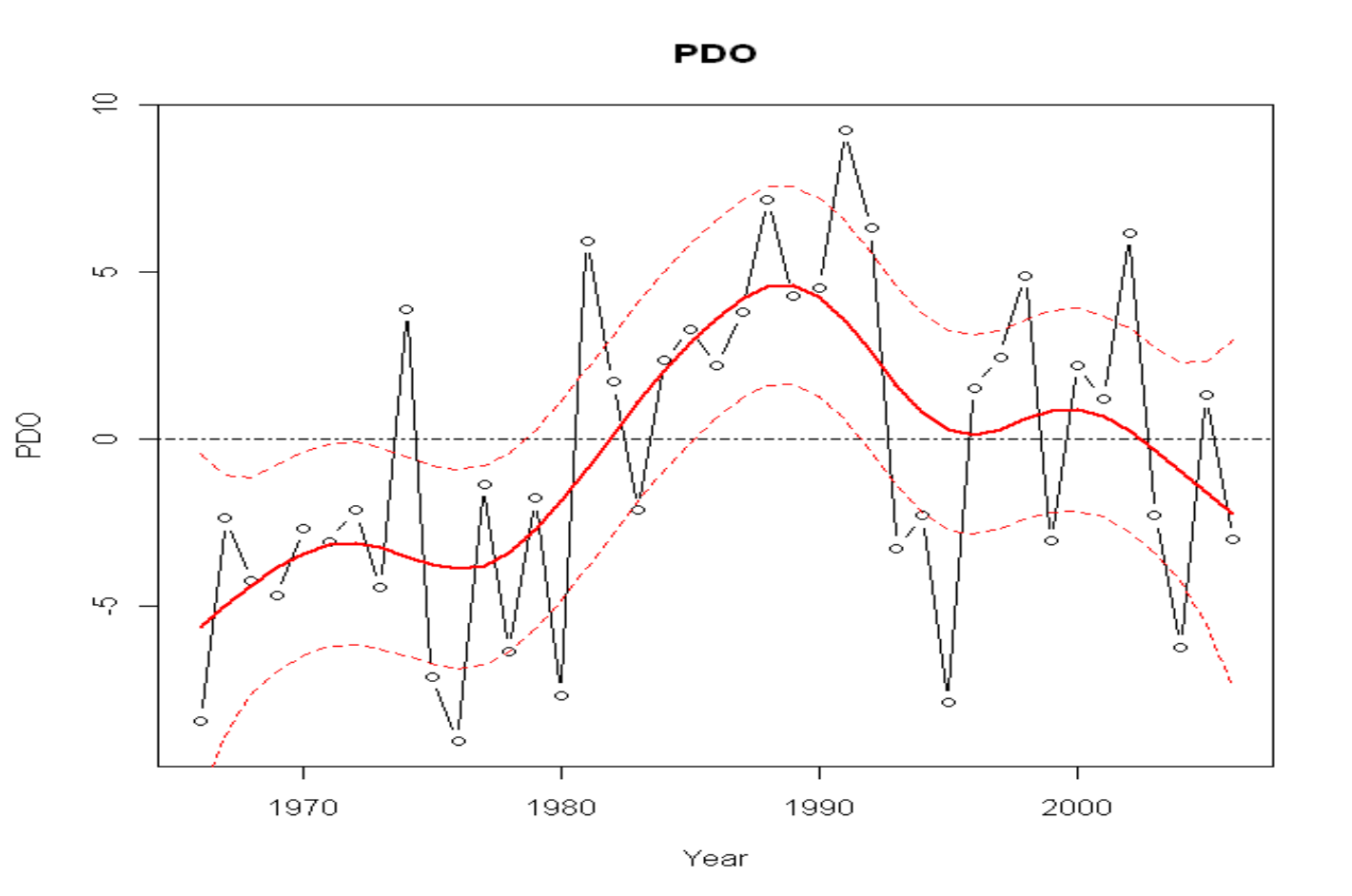
- Are there climatic factors that affect growth of Bristol Bay & Yukon River, Alaska chum salmon?
  - Used several environmental variables for comparisons
- Does Asian pink salmon abundance affect growth of Alaska chum salmon?
- Does Asian chum salmon abundance affect growth of Alaska chum salmon?

Environmental Variables

- North Pacific Index (NPI)
- Aleutian Low Pressure Index (ALPI)
- Arctic Oscillation Index
- El Nino Index
- Annual Sea Surface Temperature (SST)
- Ice Cover
- Mean May SST
- 2 mixing indices
- Bering Sea Level Pressure (winter & spring)
- Air Temp (local by fish system)
- Pacific Decadal Oscillation Index
  - Winter index – November – March

Explanatory Variables

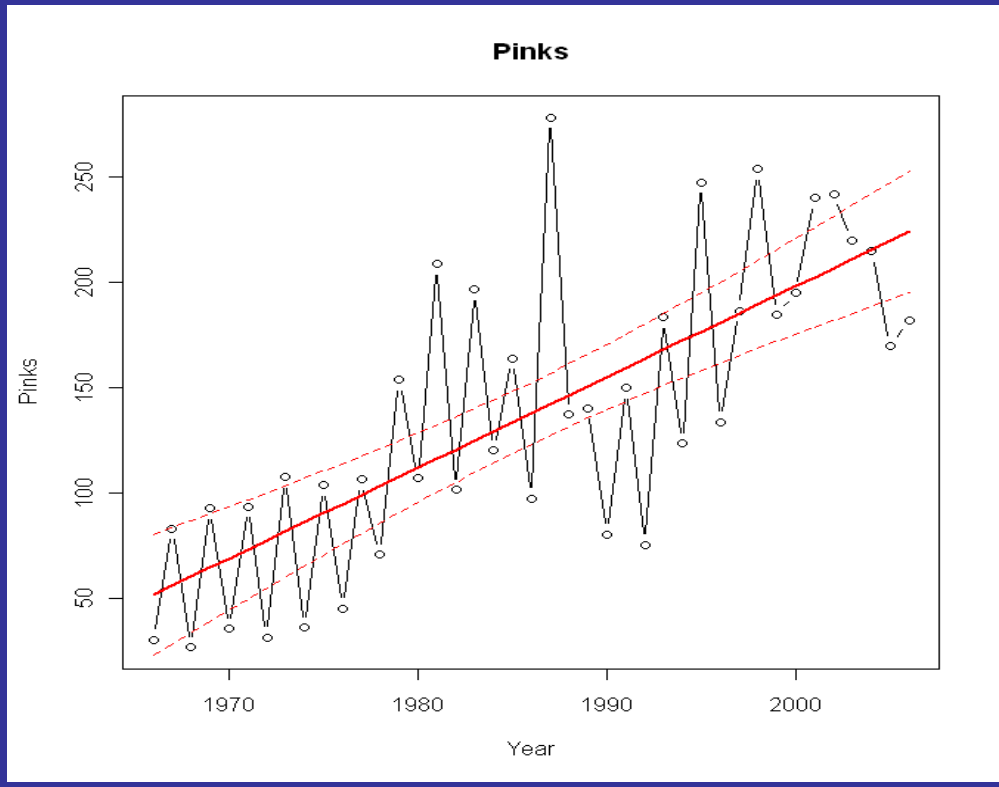
- Pacific Decadal Oscillation (PDO)
  - Used Winter Index, November – March



Mantua et al.

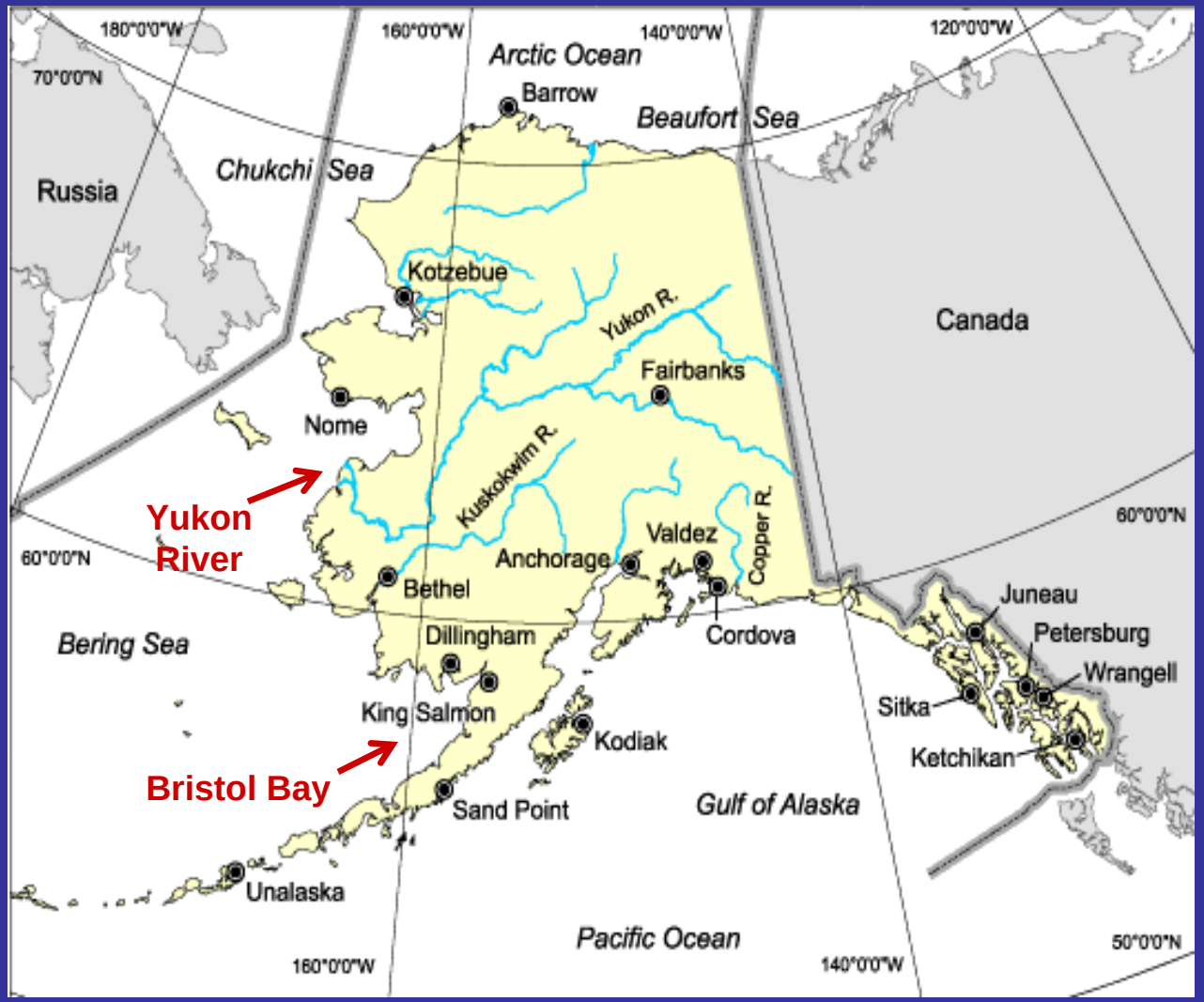
Abundance Data Available

- Pink Salmon Abundance
  - Total catch and escapement from Russia



- Asian Chum Salmon Abundance
  - Catch and escapement data in millions of fish from Japan and Russia
  - Used a 4-year moving average

Areas Sampled



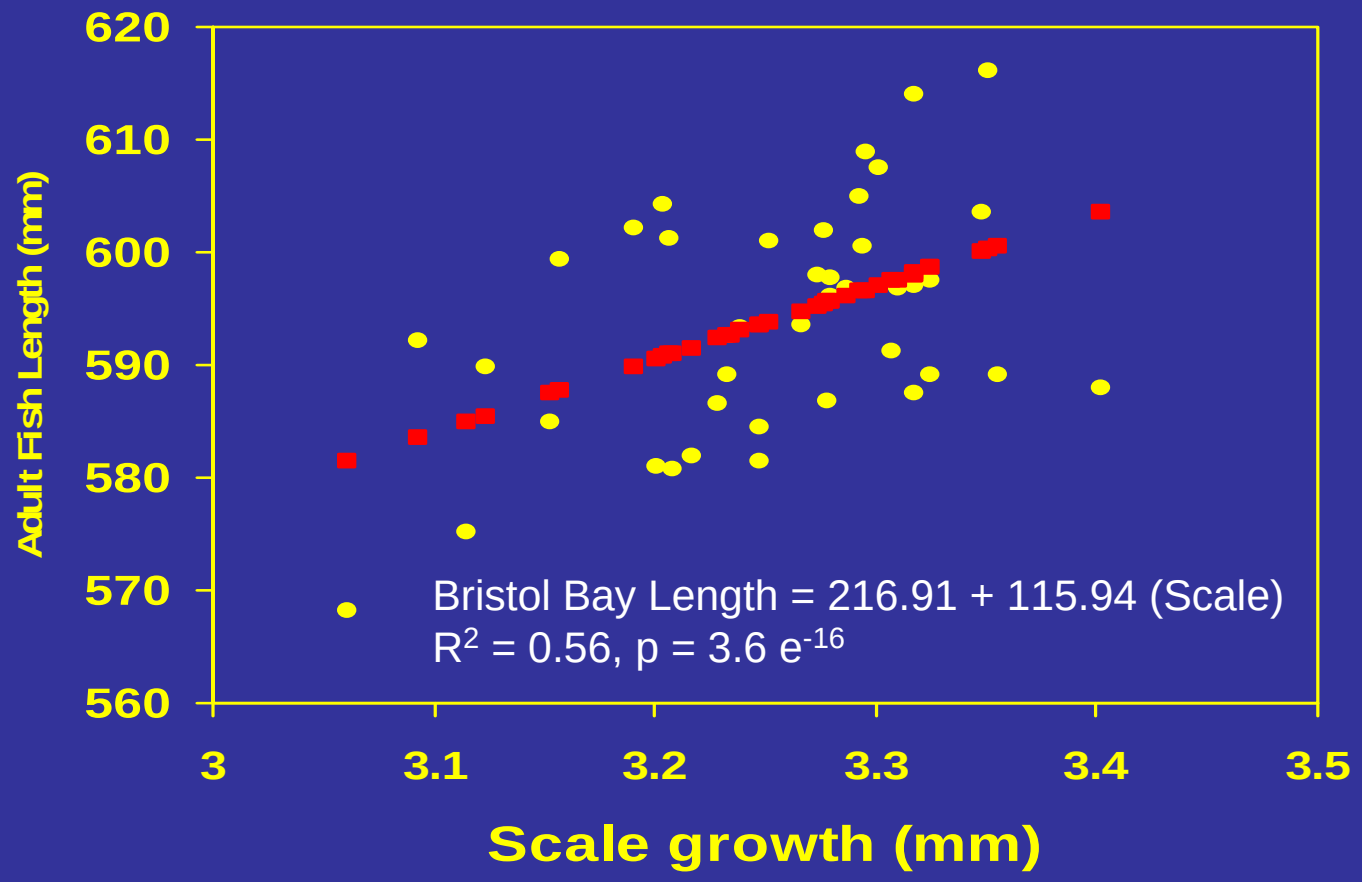
Scale Samples from 2 regions:

- Yukon River – Big Eddy (near mouth)

Bristol Bay – Nushagak River

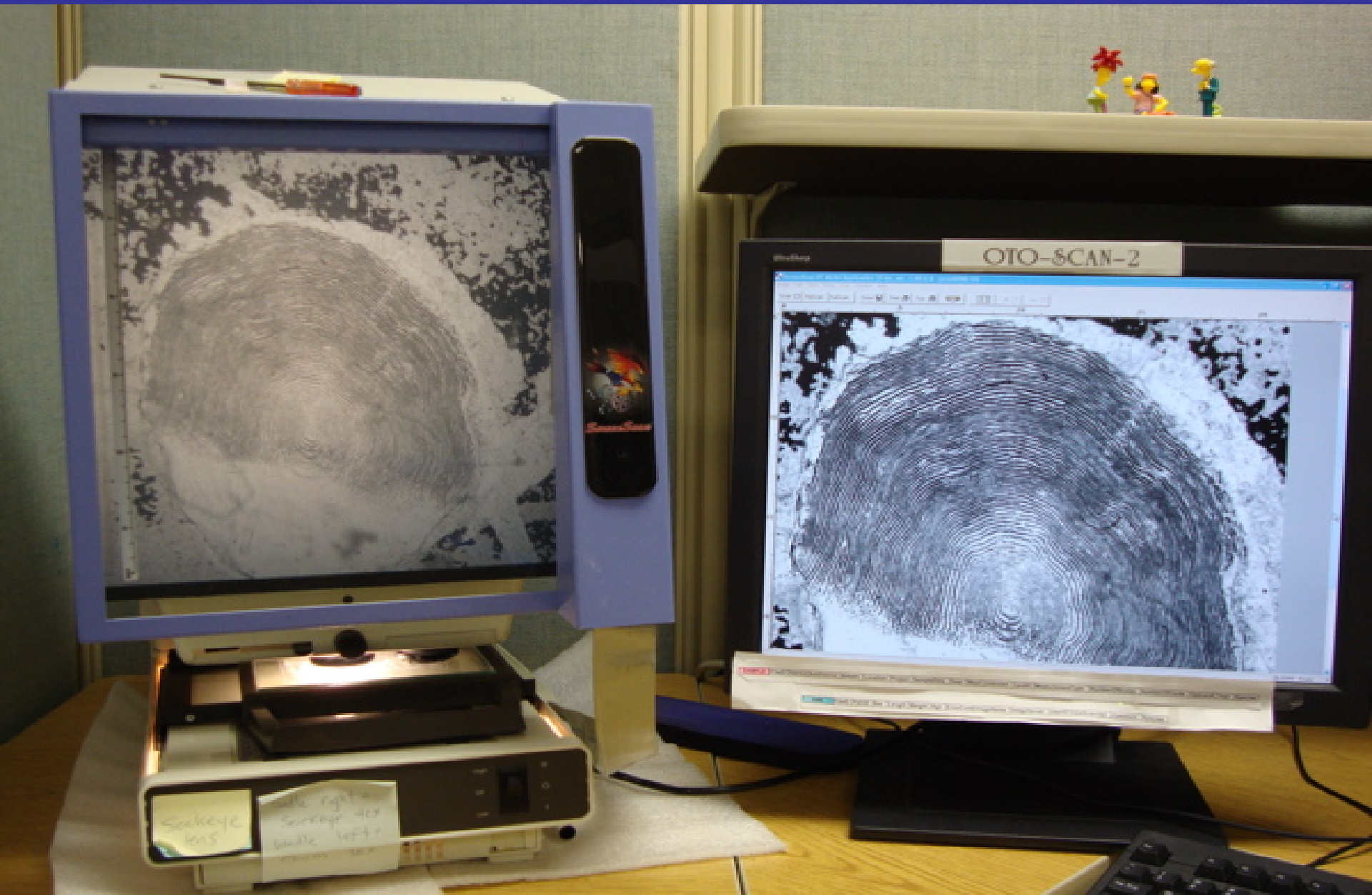
Collected 1965-2006

Scale growth - proxy for overall growth

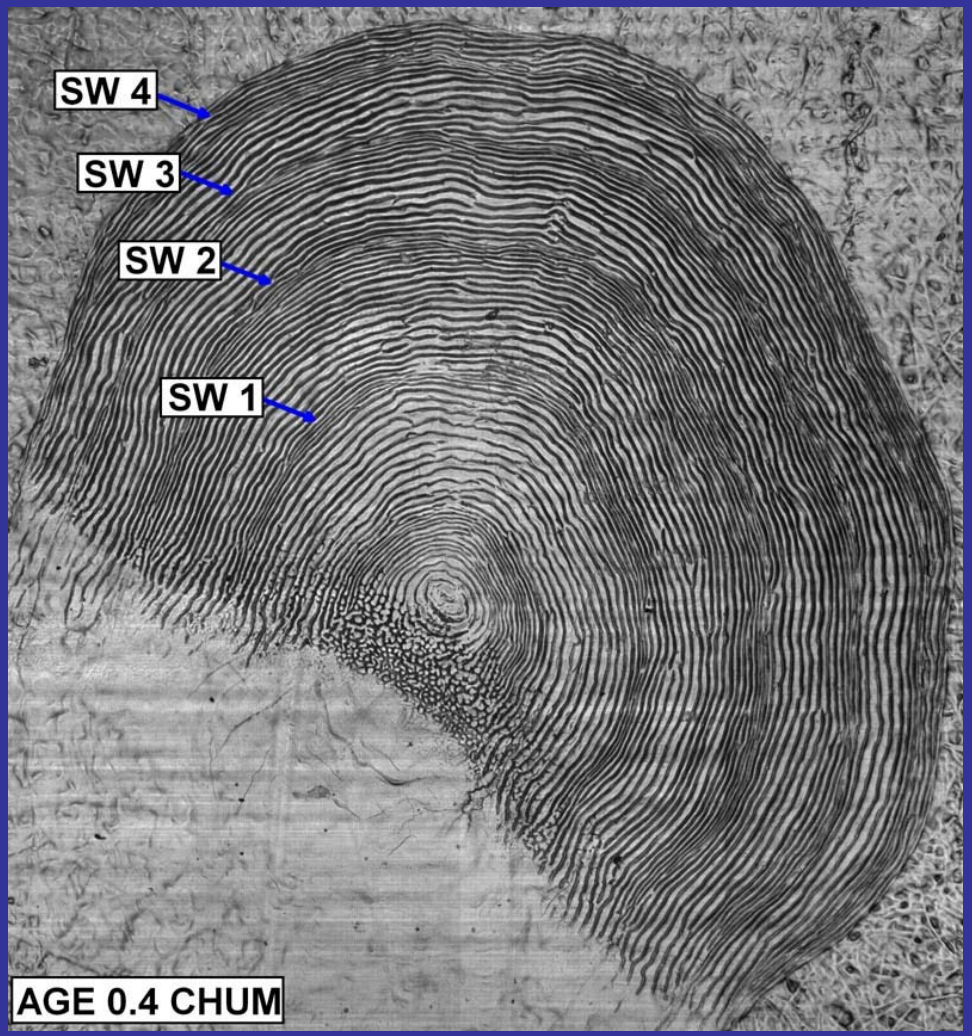


Yukon Length = 236.69 + 115.15 (Scale growth) $R^2 = 0.52$, $p = 9.4\ e^{-08}$

Scale Digitizing Equipment



Annuli & Circuli Measurements



Chum Salmon scale

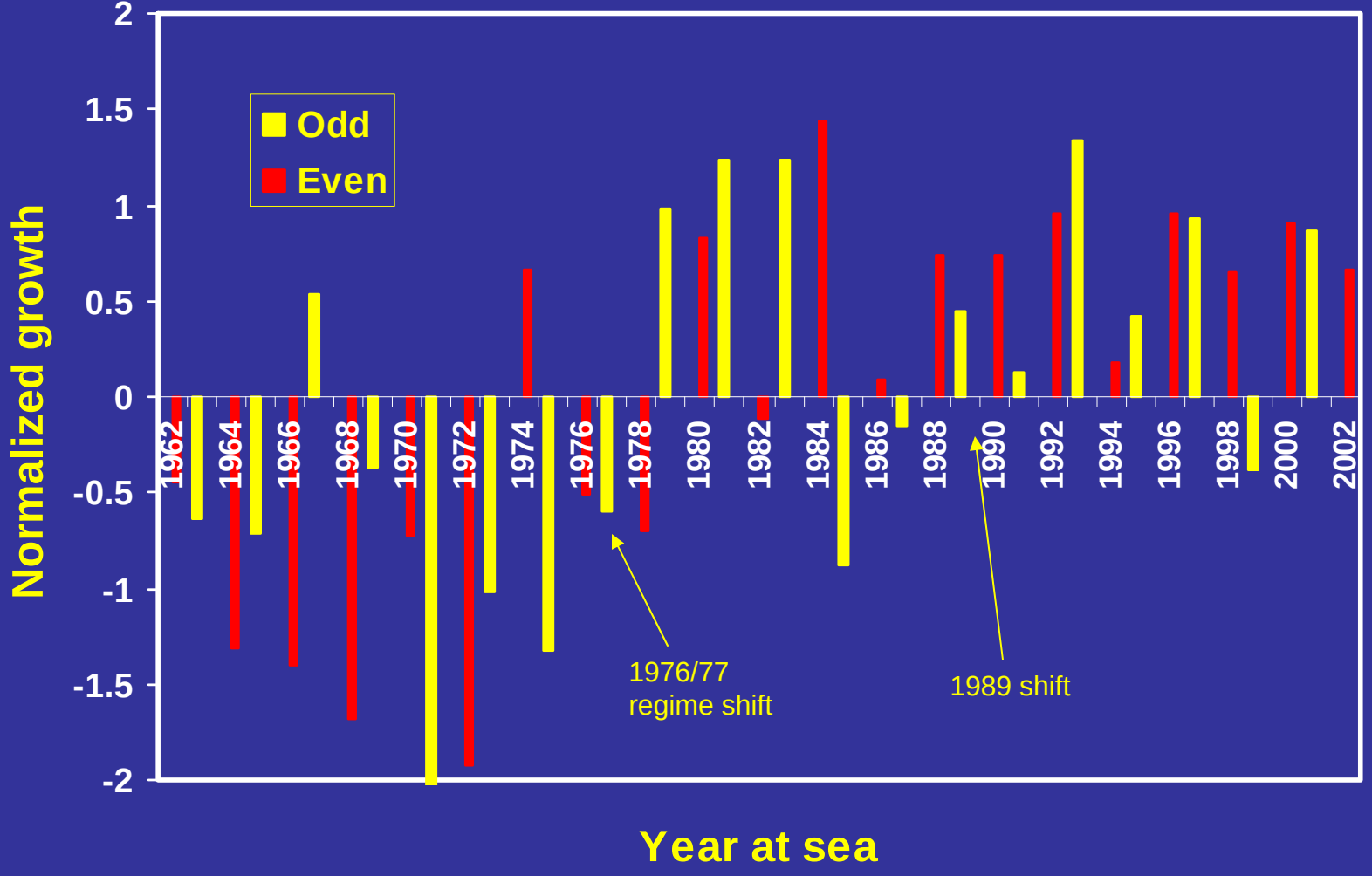
- Use average size of growth zone by year.

- Age 03 or 4-year old fish &
- Age 04 or 5-year old fish

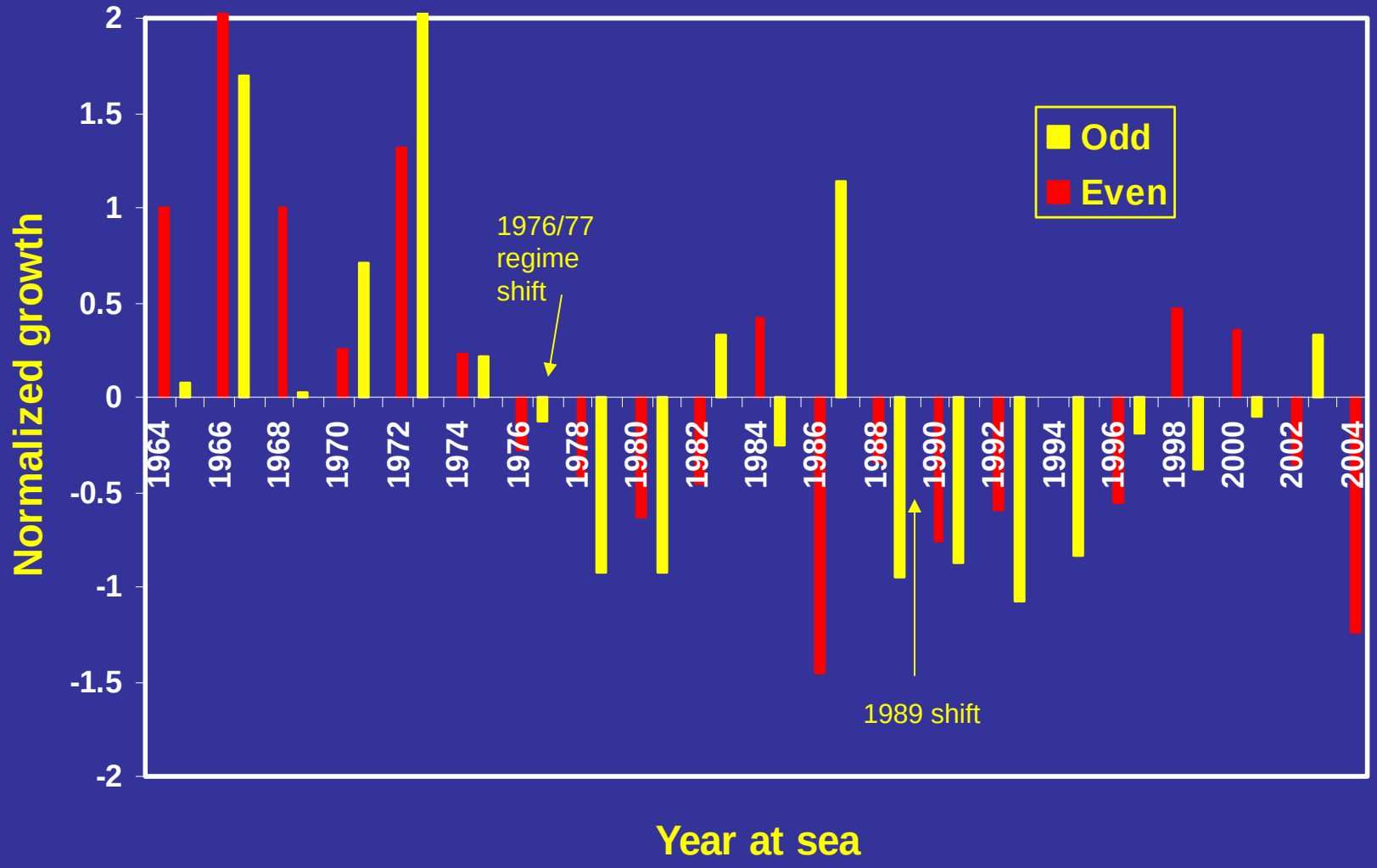
- Examined 2 growth zones:
  - SW1: Critical period – Critical size hypothesis

  - SW3: Time when fish "choose" to stay in marine waters or return to spawn.

BB Chum SW1 Growth During Even vs. Odd Years at Sea



BB Chum SW3 Growth During Even vs. Odd Years at Sea



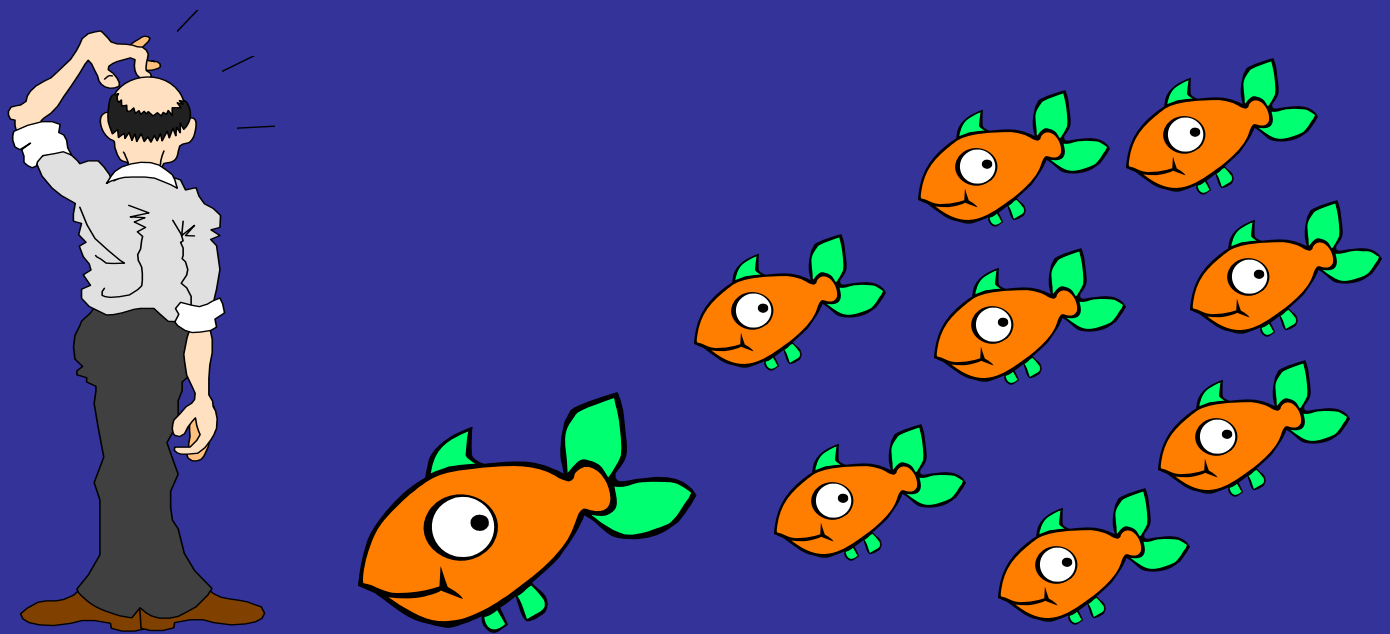
Methods

Correlations

Compared salmon growth with environmental variables using correlation analysis

Used data re: significant p values to determine what to use in multiple regression models

Generalized additive models (GAMS) to explore data



Generalized Linear Models (GLMs)

- Linear model
- Why “generalized?”
  - Accommodates non-normal distribution
  - Allows violation of homogeneity
- “Ordinary” linear models are a special case of GLM
- Fits model using iterative algorithm (No closed-form solution as in linear model)
- Maximize likelihood OR, equivalently, minimize deviance

More difficult to fit, may not always work!

SW1 – Bristol Bay

Full model

SW1 ~ Pinks + Chums + Local annual SST + May mixing + Local air temp

Reduced model

Age 03 fish

SW1 growth ~ Chums + Local annual SST

Age 04 fish

SW1 growth ~ Chums + Local annual SST + May Mixing

SW1 – Yukon River

Full model – Age 03

SW1 ~ ALPI + Local Annual SST + May Mixing + Nome Annual Temperature

Reduced model

SW1 growth ~ May Mixing + Nome Annual Temperature

Full model – Age 04

SW1 ~ ALPI + Local Annual SST + NPI +Nome Annual Temperature

Reduced model

SW1 ~ ALPI + Local Annual SST

SW3 – Bristol Bay

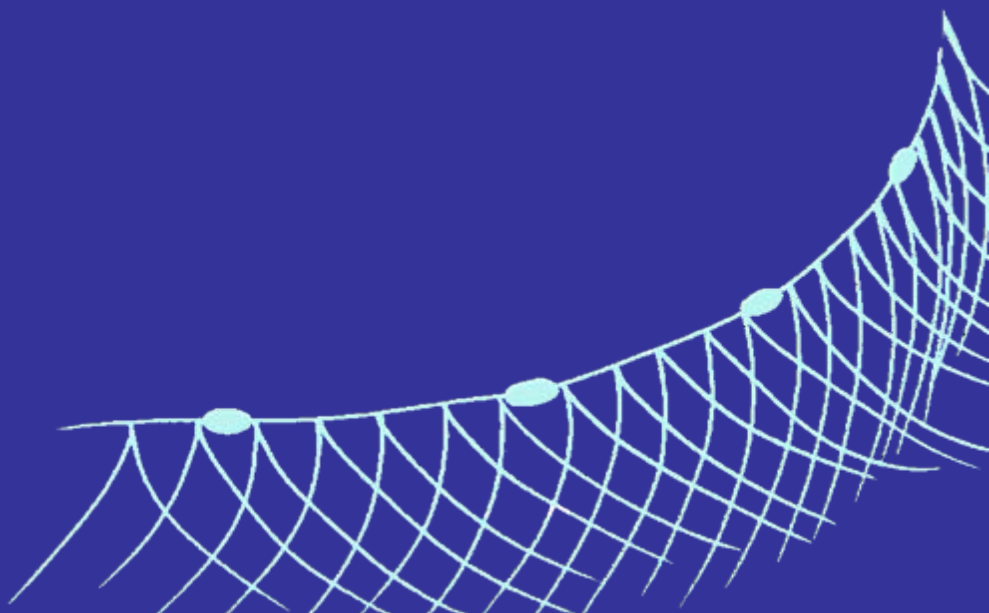
Full model

SW3 ~ Pinks + Chum + GOA Annual SST + ALPI + Gender +Pinks:Chum

Reduced model

Age 03 and 04 fish

SW3 ~ Pinks + Chum + GOA Annual SST + Gender + Pinks:Chum



SW3 – Yukon River

Full model

SW3 ~ Pinks + Chum + GOA Annual SST + NPI + Gender +Pinks:Chum

Reduced model

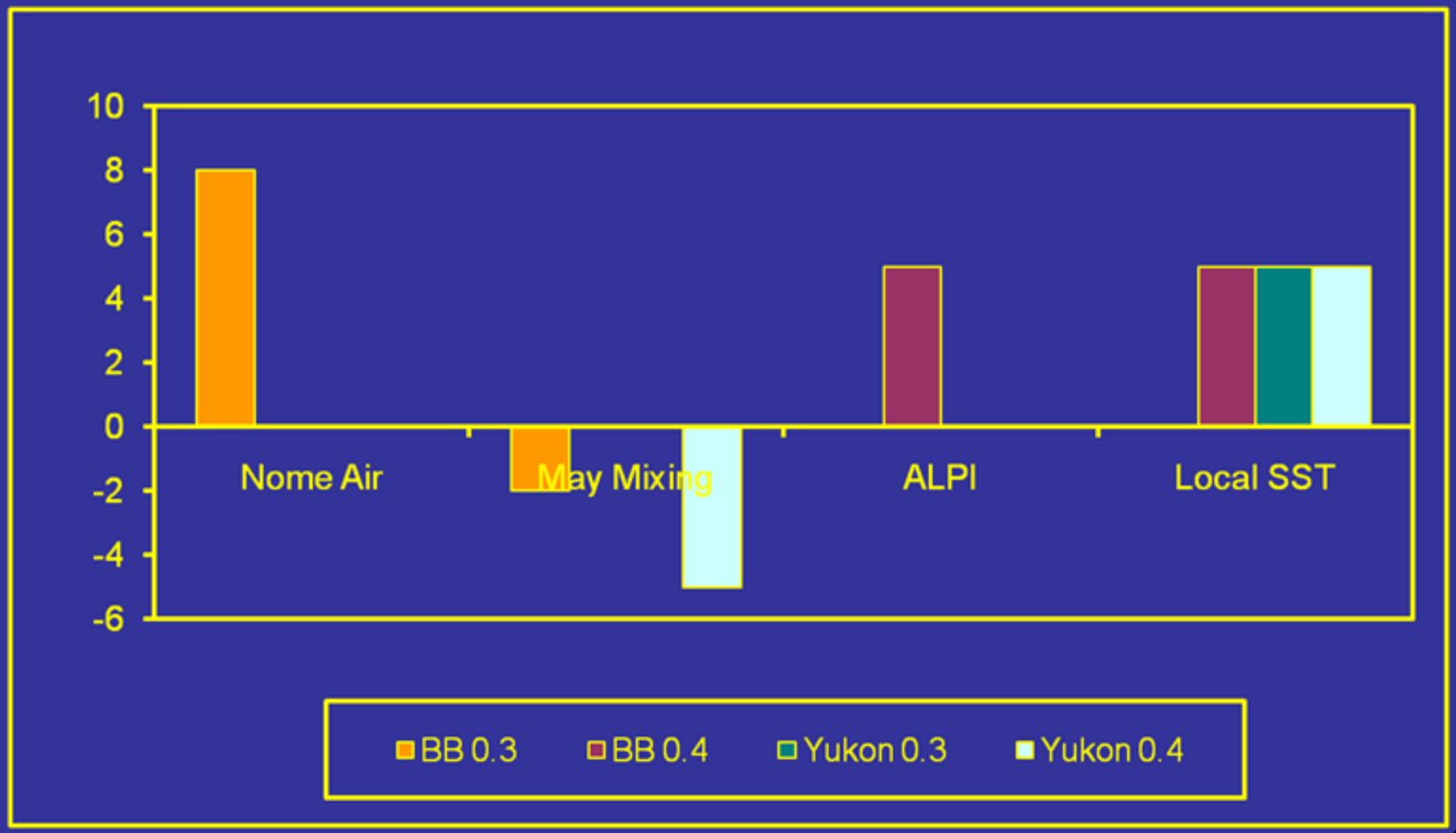
Age 03 and 04 fish

SW3 ~ Pinks + Chum + GOA Annual SST + Gender + Pinks:Chum

Original Questions

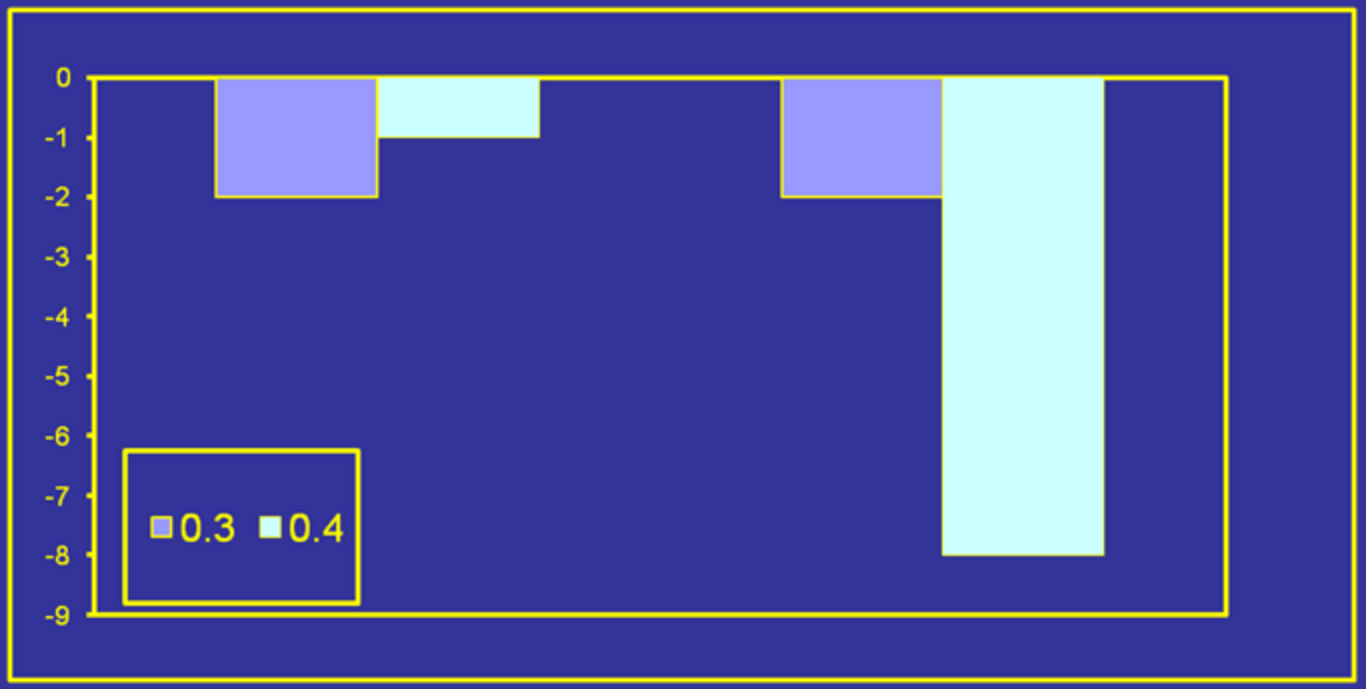
Are there climatic factors that affect growth of Bristol Bay & Yukon River, Alaska chum salmon?

SW1



Climatic factors?

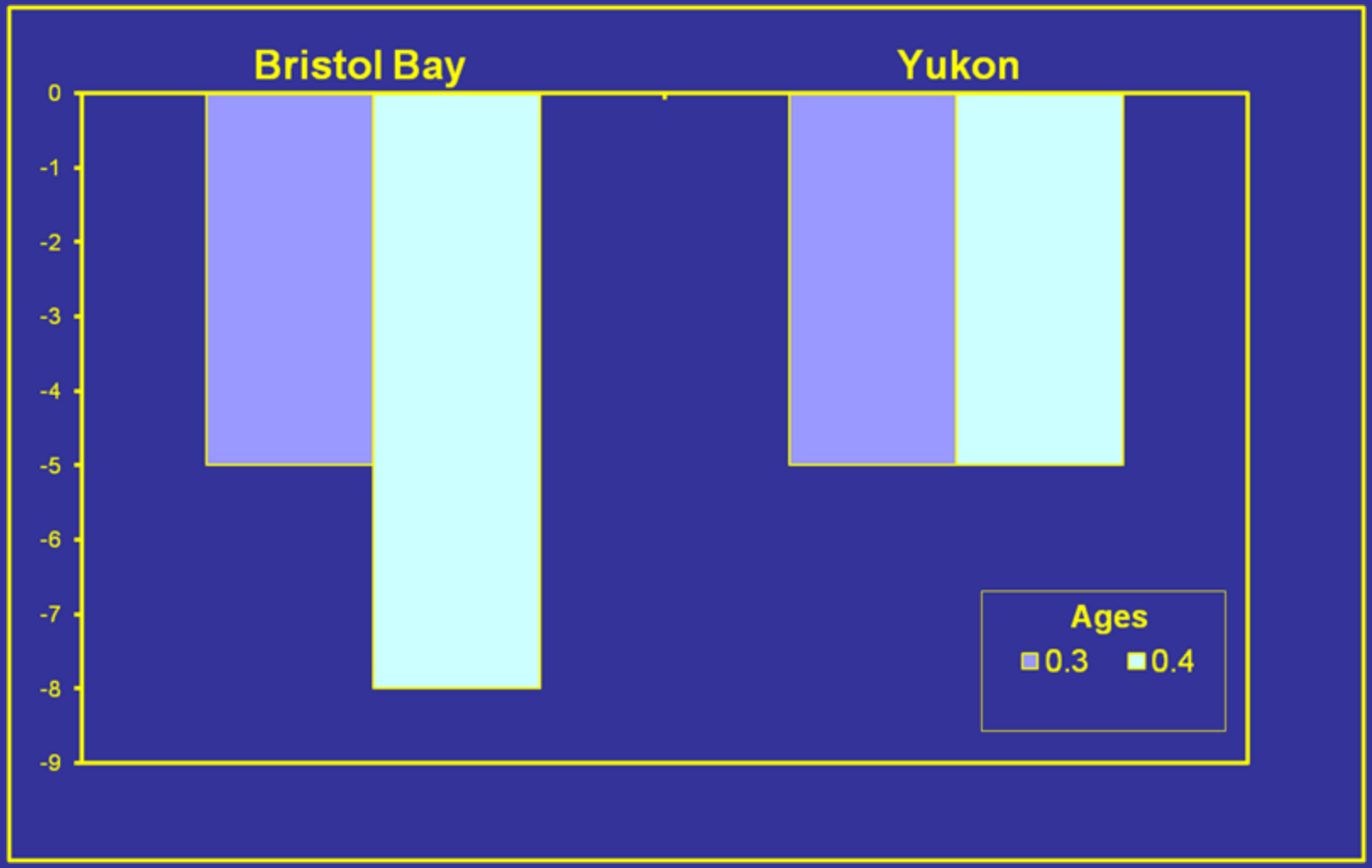
Gulf of Alaska Annual SST



SW3

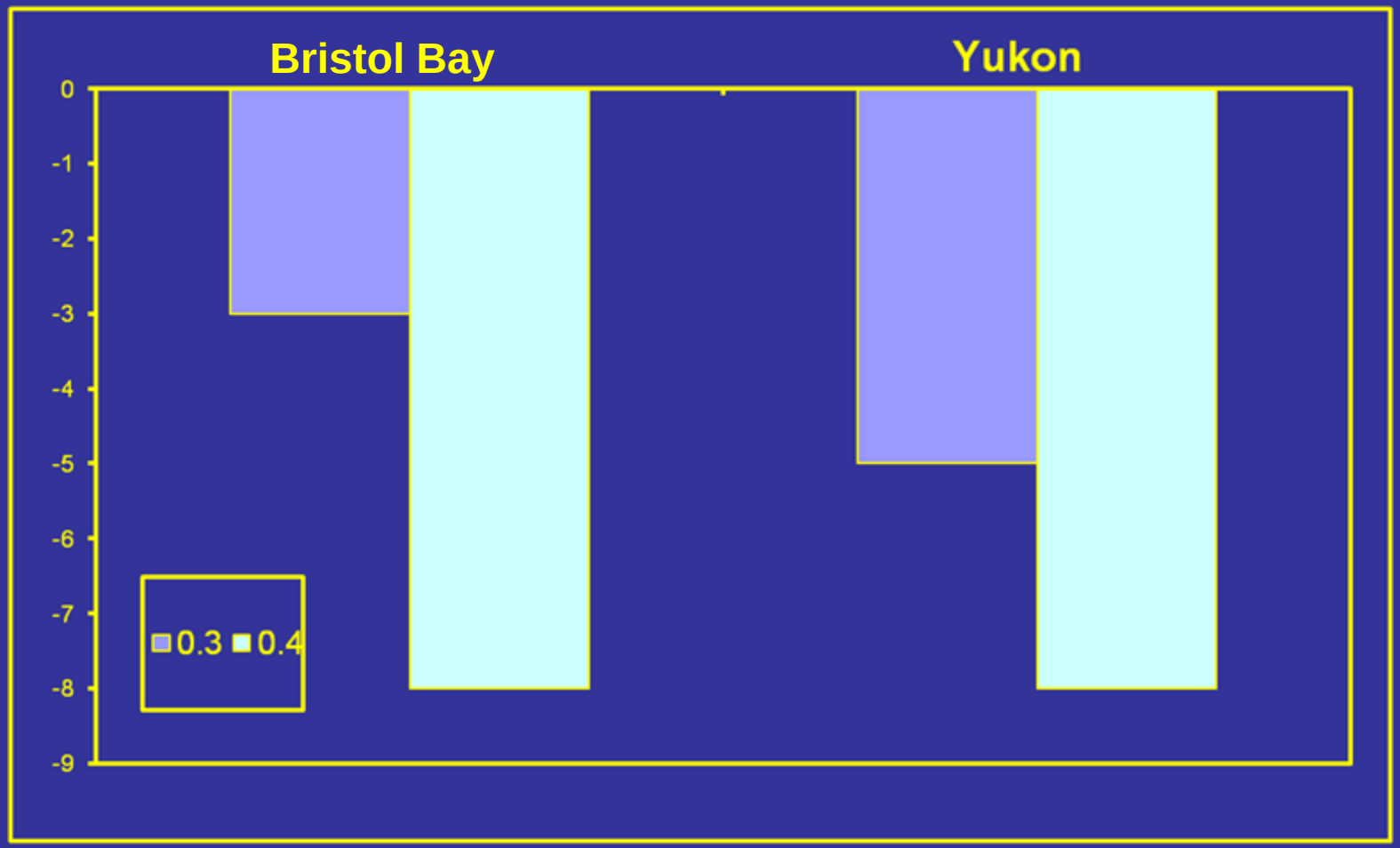
Does Asian pink salmon abundance affect growth of Bristol Bay &Yukon chum salmon?

Yes, SW3 only, negative correlation

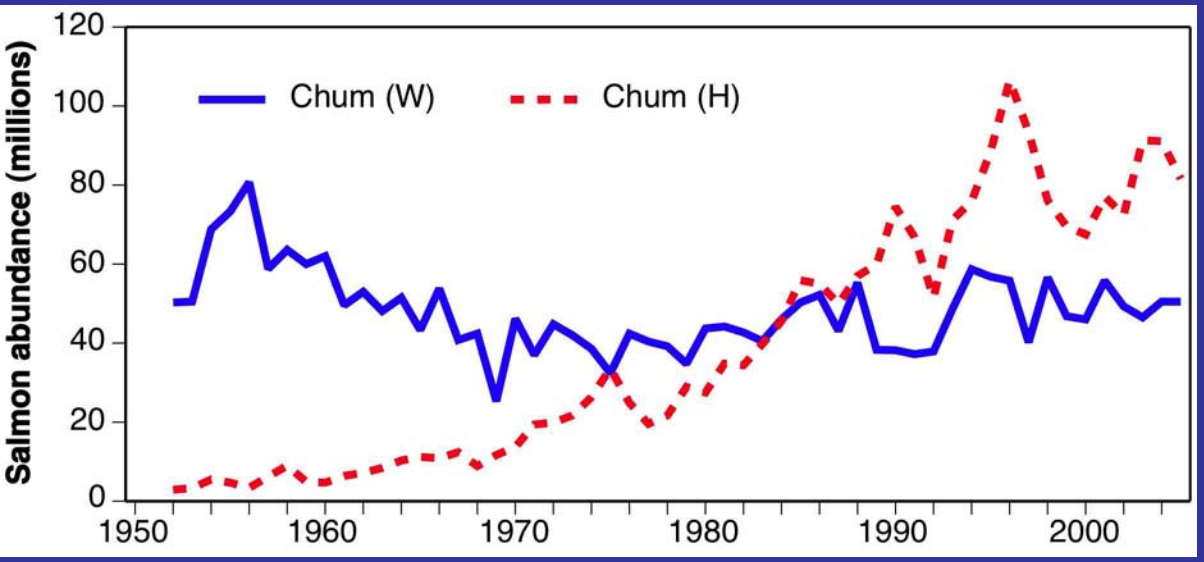


Asian chum salmon abundance & growth of Bristol Bay and Yukon chum salmon

Yes, SW3 Only, negative correlation



Do AK Chum Salmon Compete with Asian Chum & Pink Salmon?



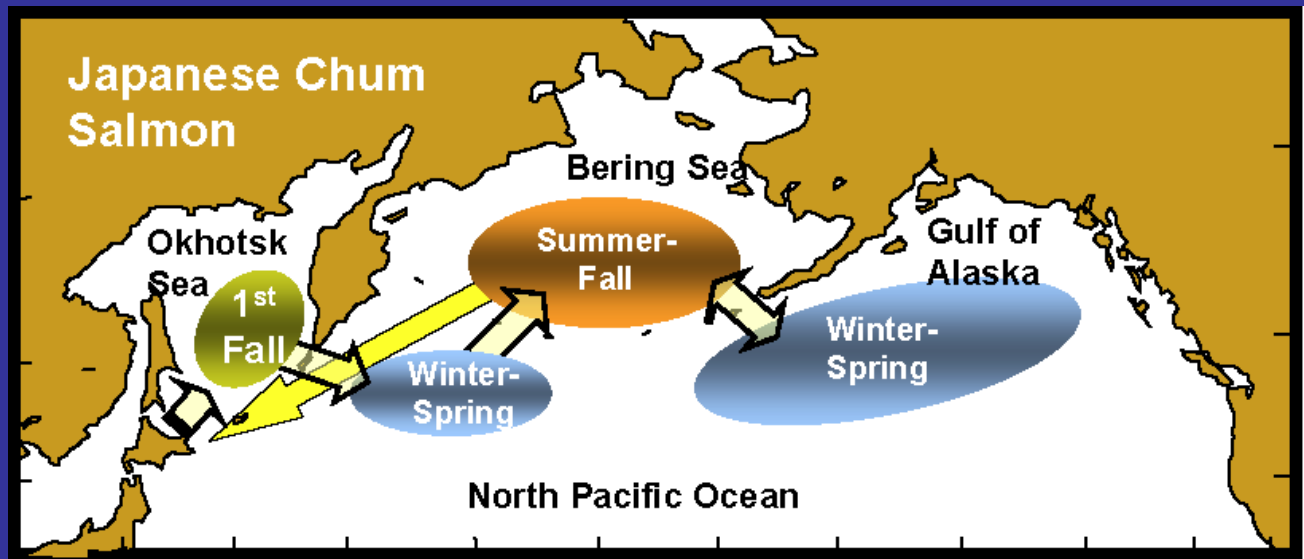
Wild chum did not increase after 1977; hatchery chum (mostly Japan)

Ruggerone et al. 2010

AYK chum overlap Japanese hatchery chum salmon

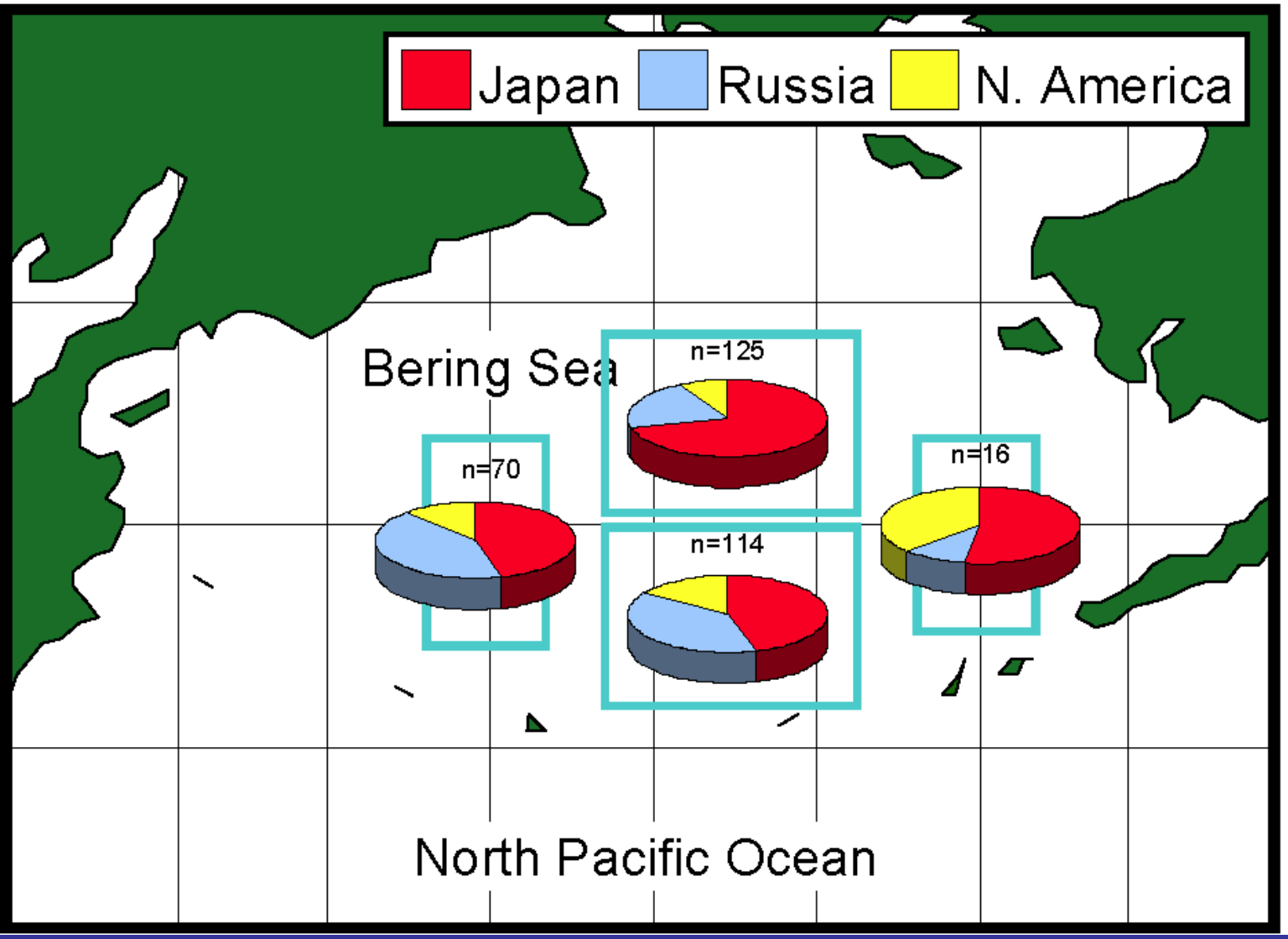
K. Myers, UW

Urawa et al. 2008



Stock Composition of Maturing Chum Salmon estimated by GSI

June/July 2003



Asian chum much more abundant than Western AK chum

Urawa et al. 2008

Where next?

- Compare with other systems
  - Norton Sound
  - Kuskokwim
  - Japan
  - Russia

  - Few issues to examine
    - Simplify models?

      Originally used on Pinks + PDO
    - Autocorrelation

Conclusions

- Environmental variables important during first year of growth.
- Appears to be density-dependent interactions among western Alaska chum salmon and Asian pink & chum salmon.
- Competition at sea can affect salmon growth & future productivity.
- Research is needed to better understand species interactions & mechanisms impacting salmon survival.