



Abundance and productivity trends of Alaskan Chinook salmon stocks: gaining perspective on the magnitude of the problem

Matt Catalano
Fisheries and Allied Aquacultures, Auburn University

Joe Spaeder
AYK-SSI Research Coordinator



Analysis Background

- Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative
 - Seven hypotheses about possible causes of declines of AYK region Chinook populations
 - Thirteen member AYK SSI sponsored Expert Panel
 - Development of a “Chinook Research Action Plan” for the AYK region



Outline

- Chinook stock status, trends, evidence of declines
- Comparative analysis of productivity trends among stocks
- Evidence for density-dependent effects on productivity



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What is the pattern we seek to explain?

- Episodes of low abundance and productivity
- Failure to meet escapement goals
- Restrictions on subsistence harvest
- Infrequent directed commercial fisheries
- Changes in age/length/sex composition



What data do we have?

- 12 Chinook salmon stocks
- Escapement
 - Weirs, air surveys, counting towers, telemetry, mark-recapture
- Harvest
 - Commercial trip tickets
 - Subsistence post-season surveys
- Age/sex/length composition
- Often cannot enumerate the entire escapement



Alaska Chinook Data Sets

Stock	Region	Years
Kuskokwim	AYK	1976-2011
Yukon	AYK	1982-2010
Anchor	Cook Inlet	1977-2011
Deshka	Cook Inlet	1979-2010
Ayakulik	Kodiak Island	1976-2010
Karluk	Kodiak Island	1976-2010
Nelson	Alaska Peninsula	1976-2011
Alsek	Southeast Alaska	1976-2007
Blossom	Southeast Alaska	1975-2007
Situk	Southeast Alaska	1982-2010
Stikine	Southeast Alaska	1981-2009
Taku	Southeast Alaska	1973-2010

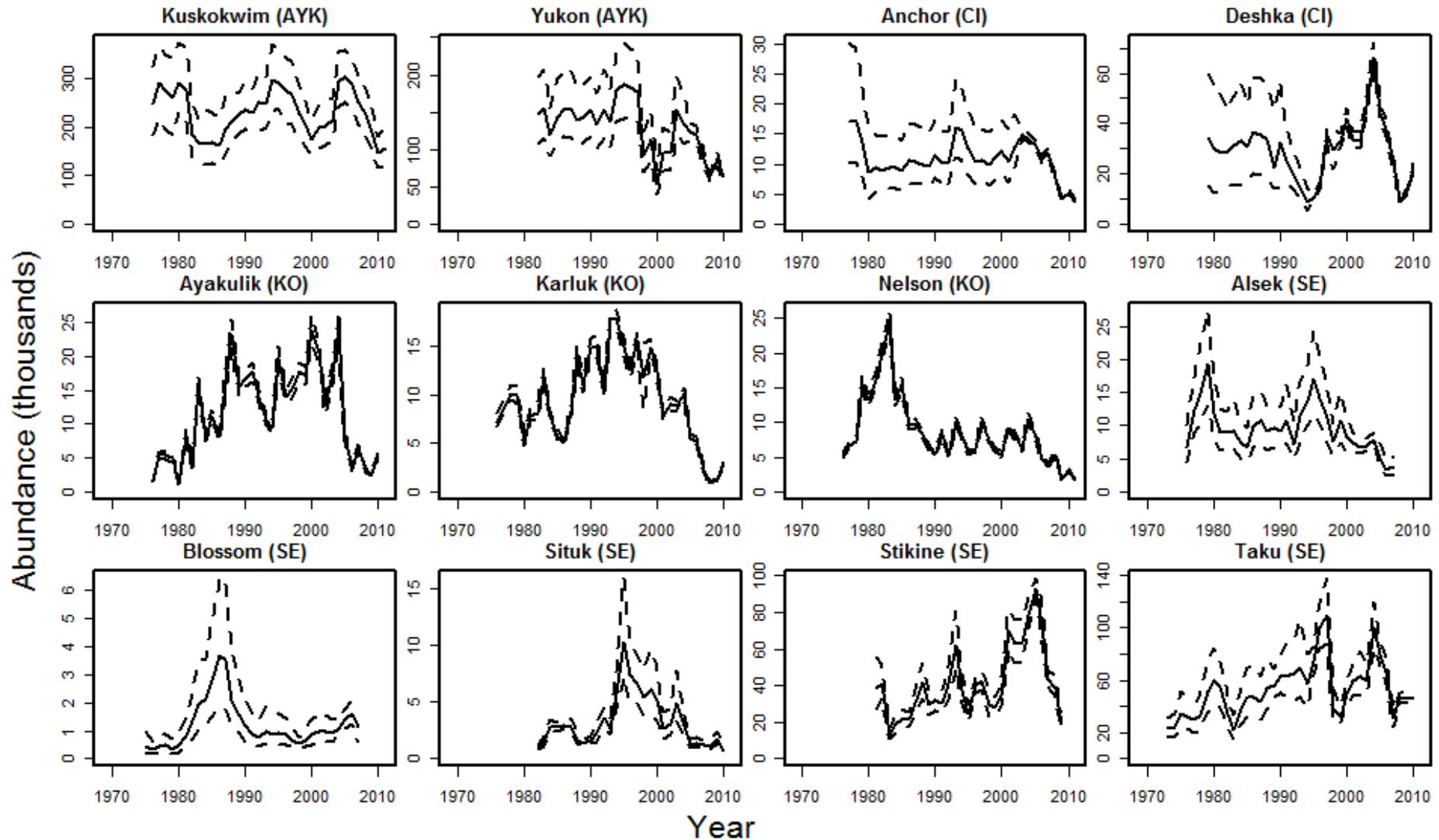


The State-Space Model

- Estimation of observation and process errors
- Age-structured: incorporates maturity variation
- Uncertainty due to missing data
- Recruitment is treated as unobserved
- Estimation of time-varying parameters
- Method of choice for ADFG

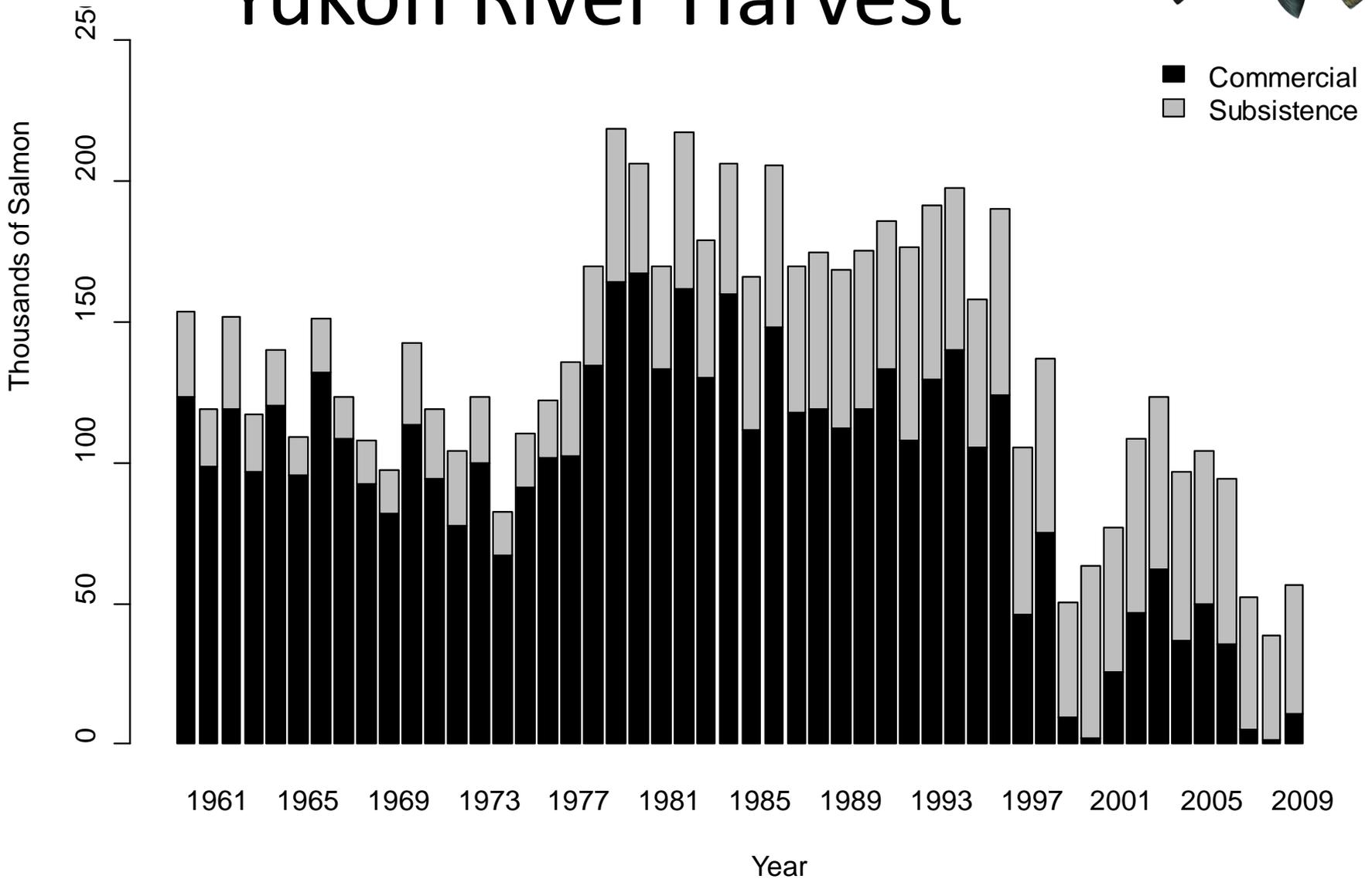


Abundance



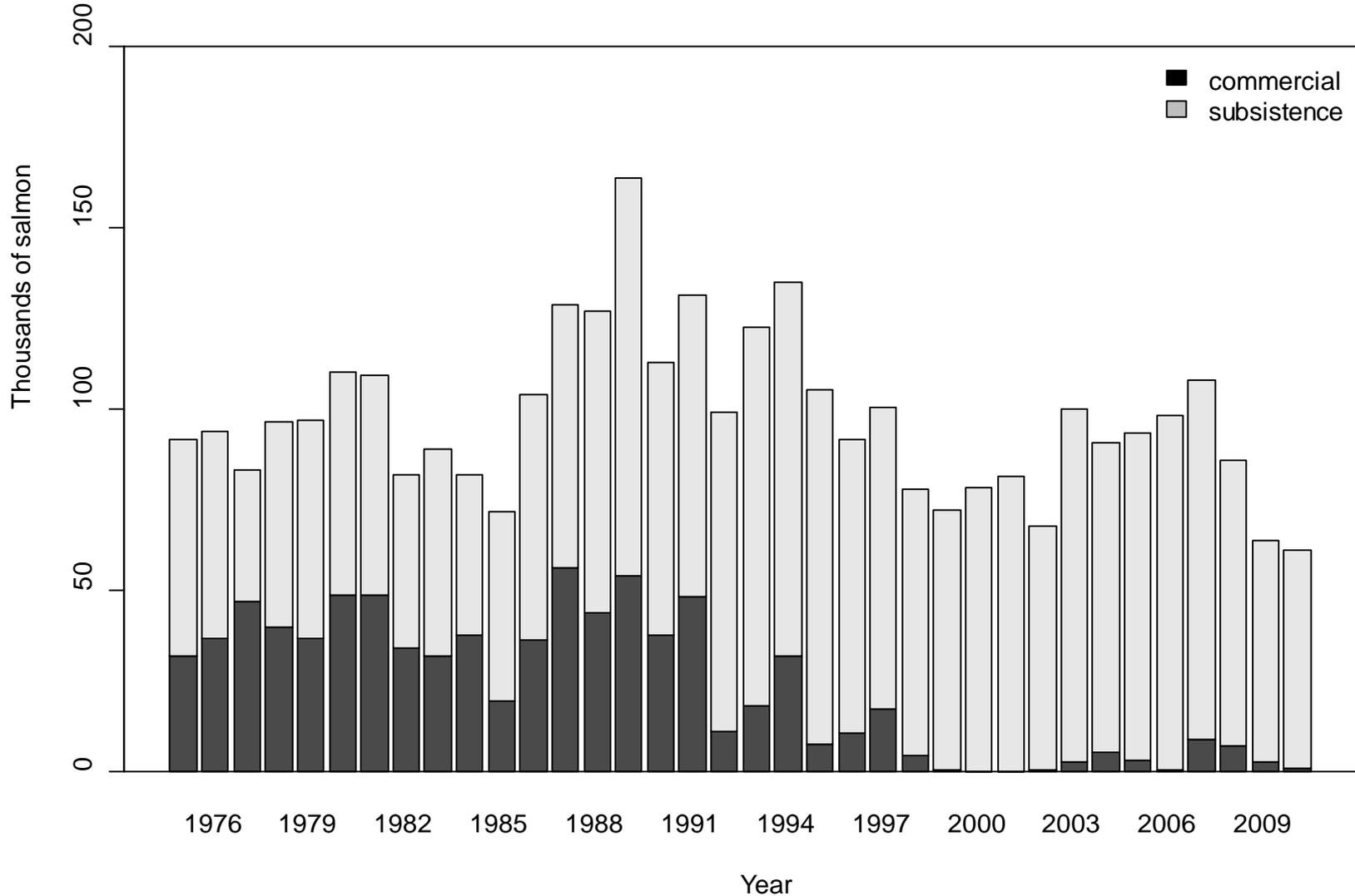


Yukon River Harvest





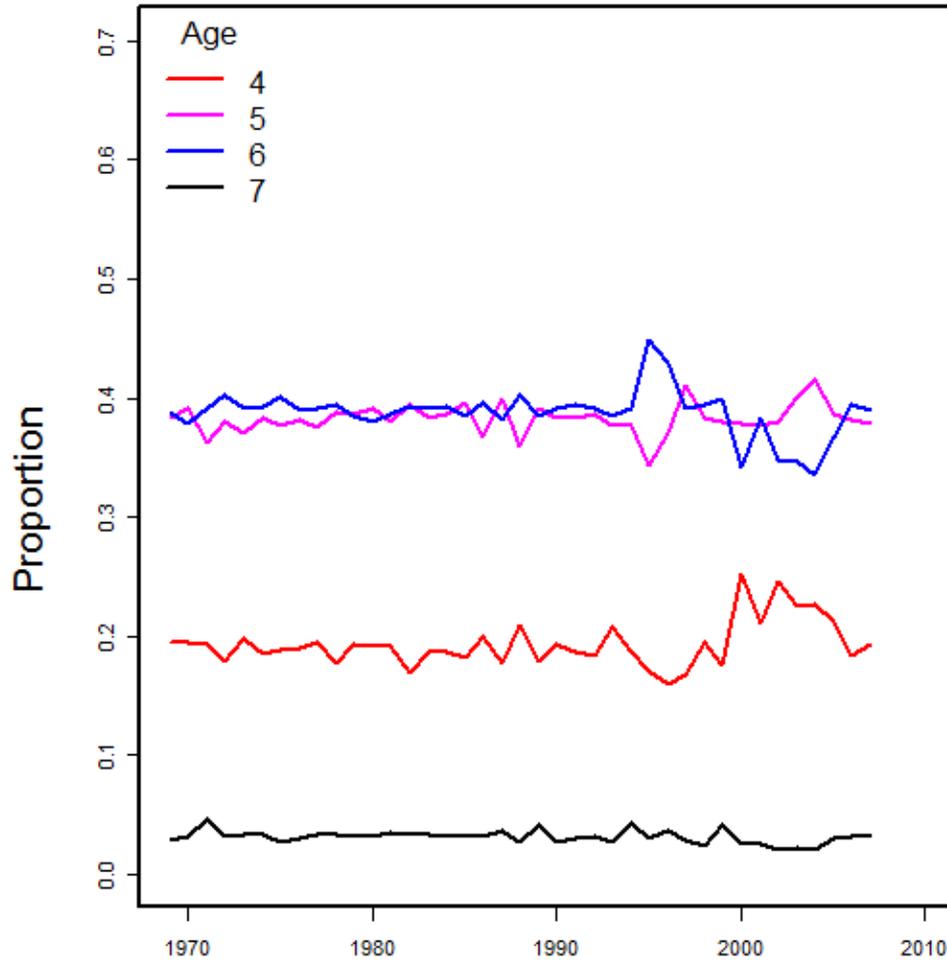
Kuskokwim River Harvest



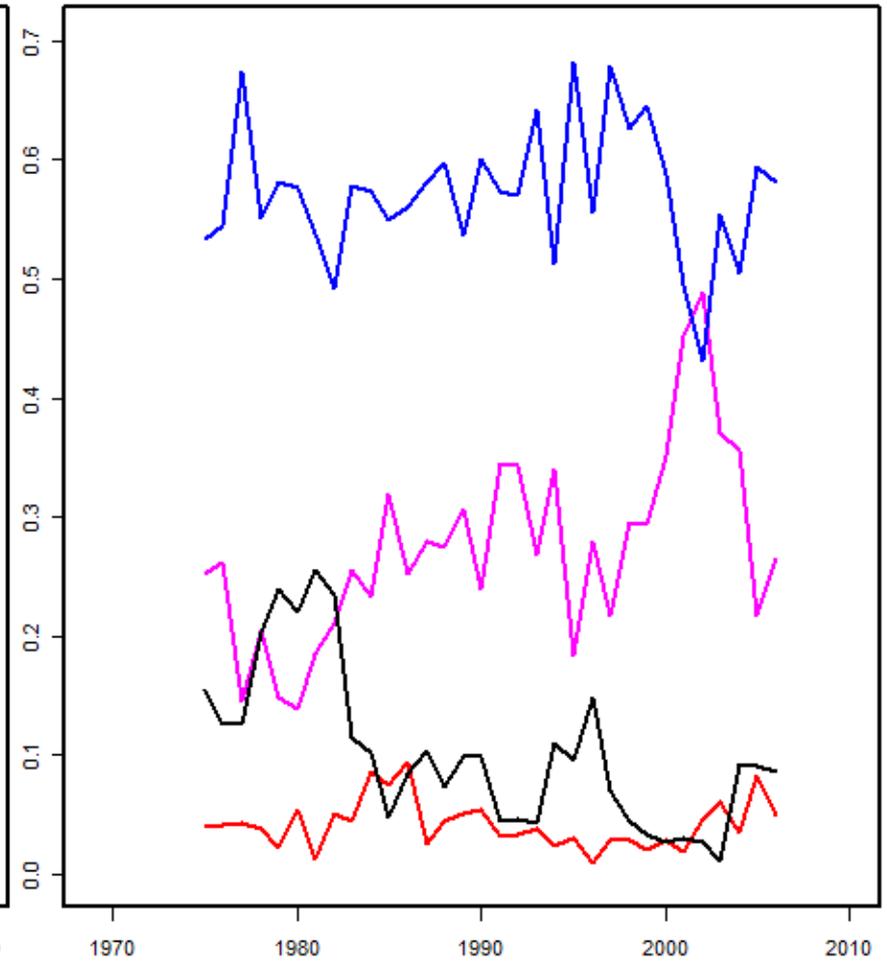


Maturity

Kuskokwim



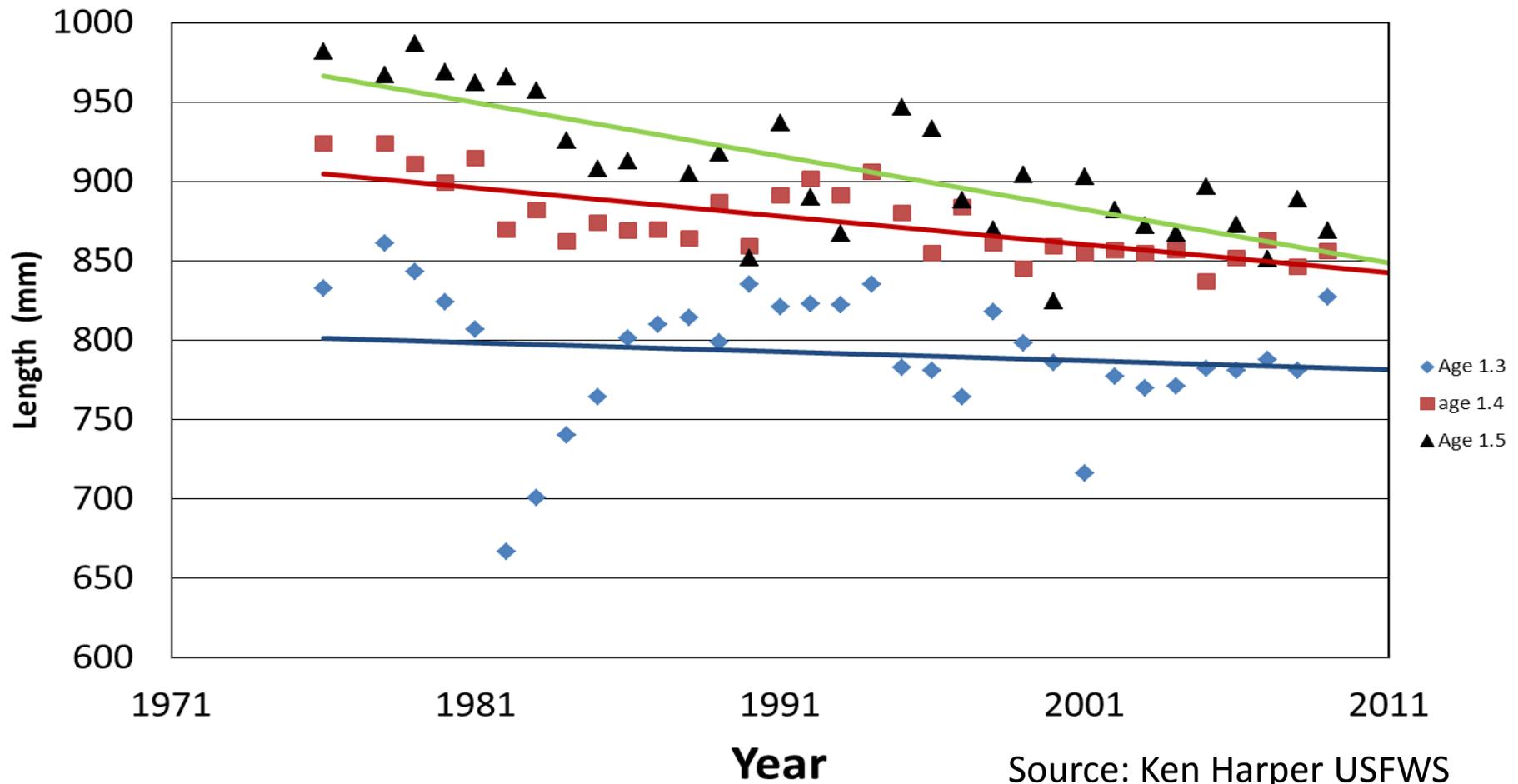
Yukon



Brood Year



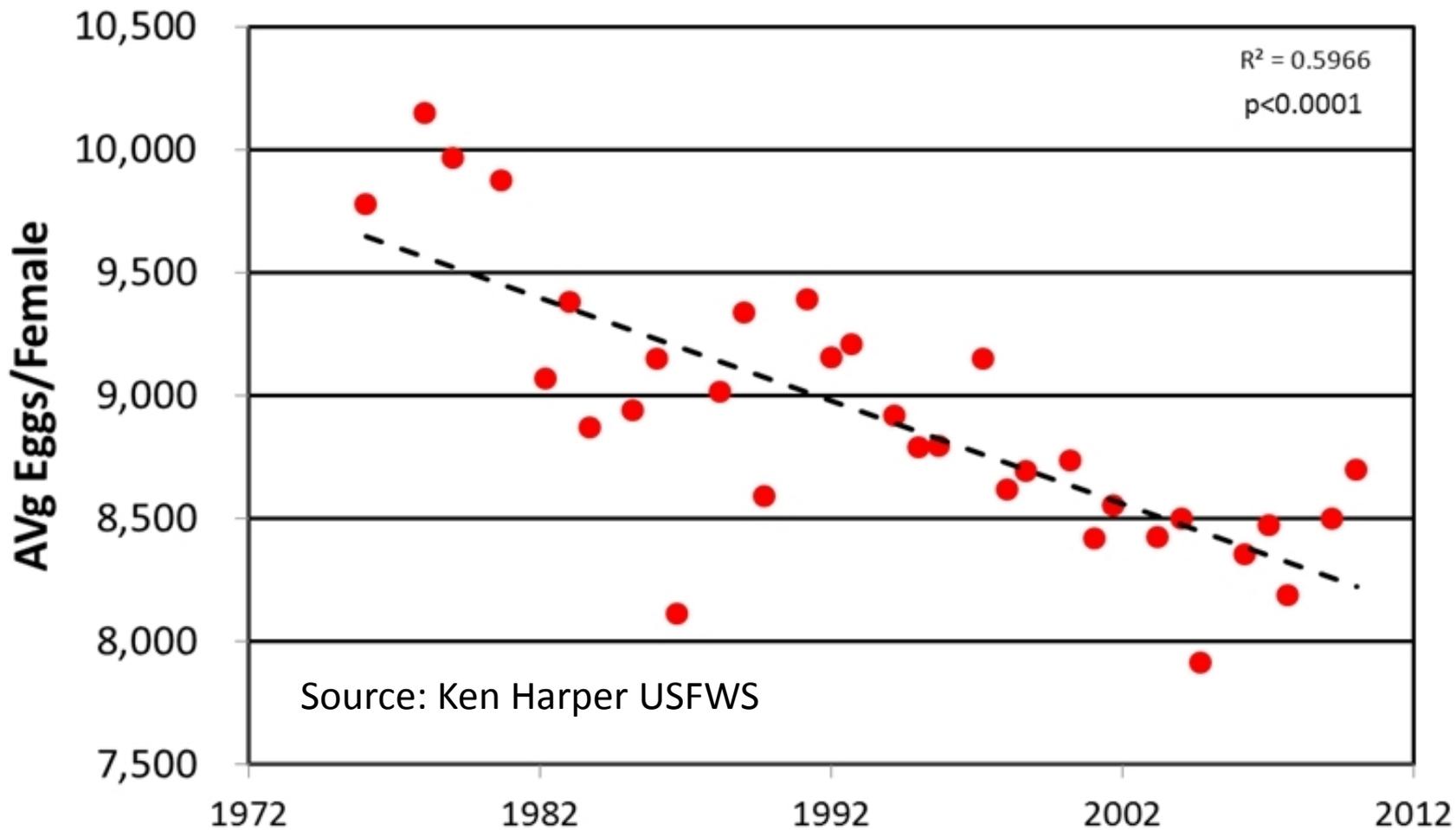
Kogrukluk Females Average size at Age



Source: Ken Harper USFWS

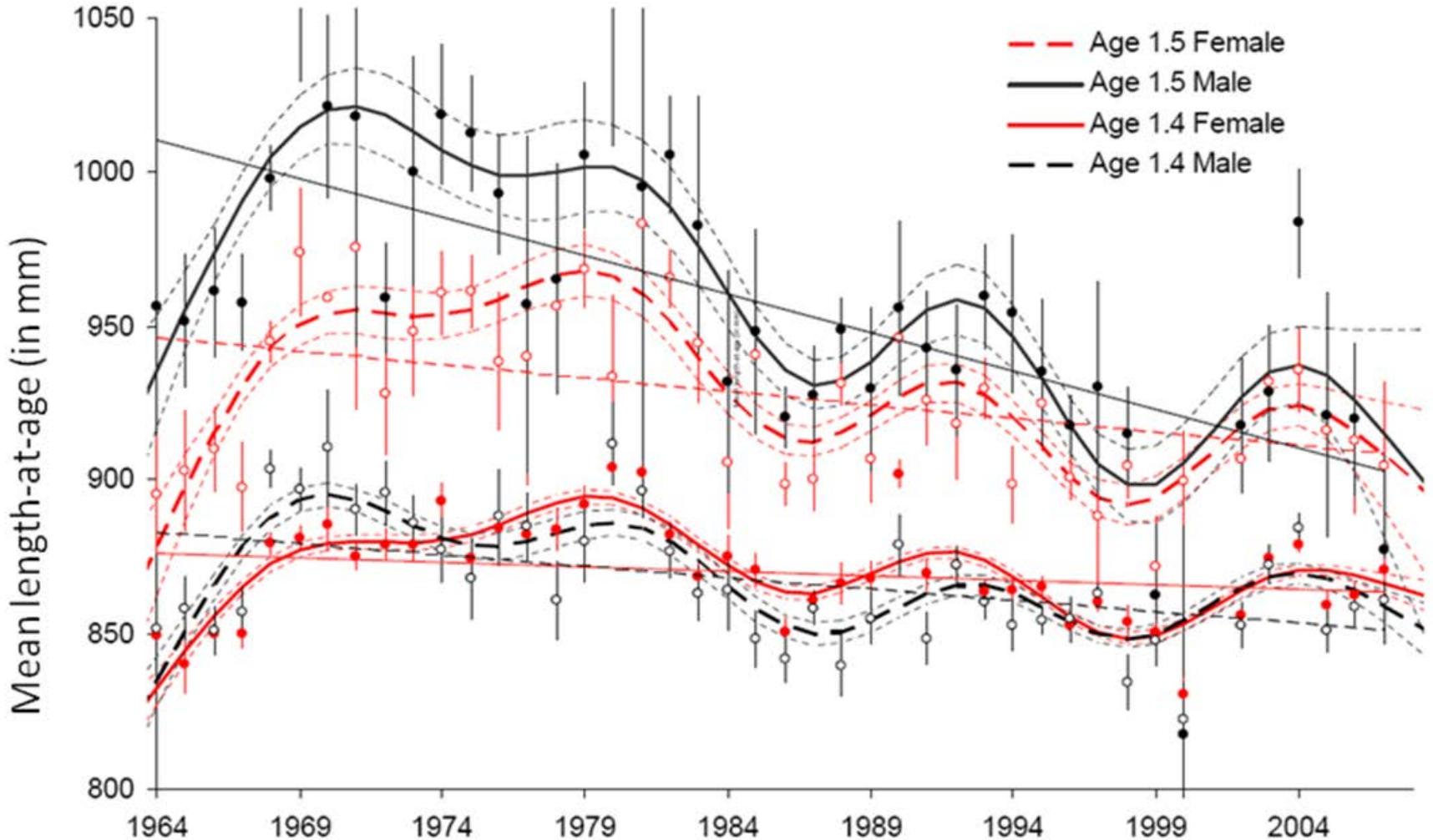


Average Eggs/Female Spawner ~16% drop in 35 years





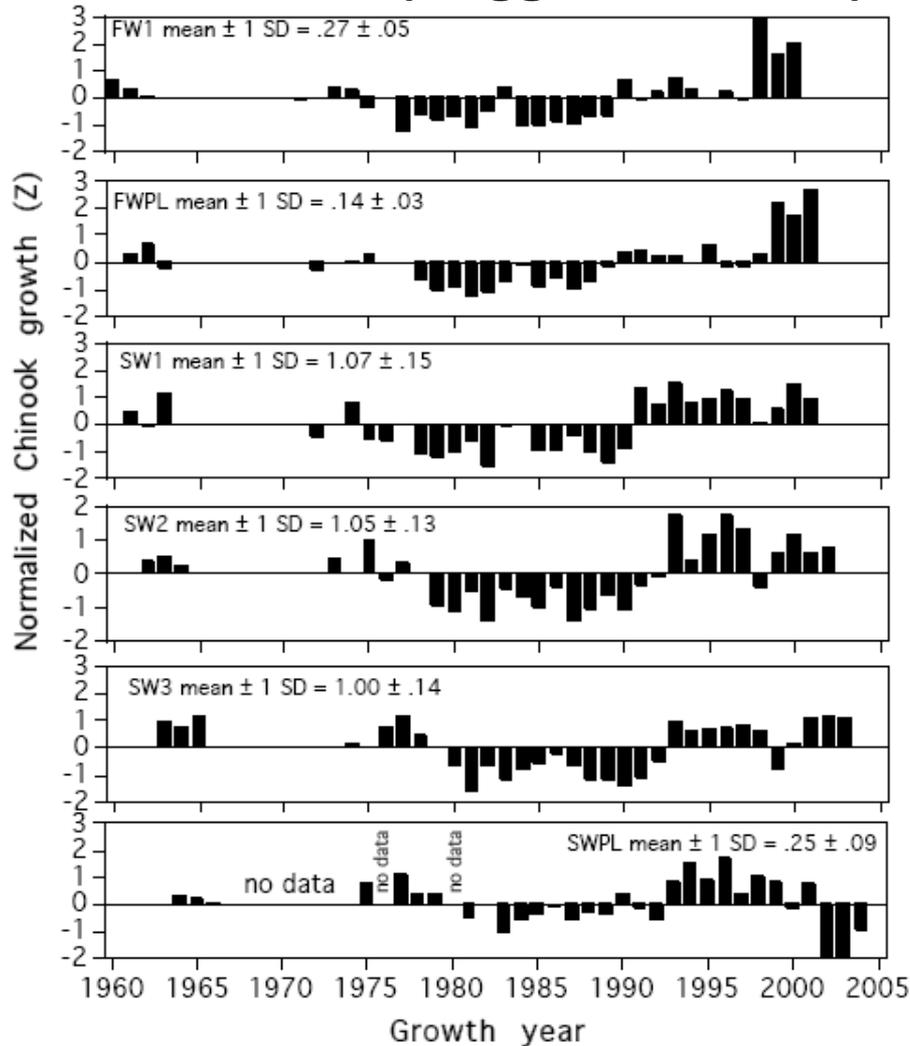
Yukon Length-At-Age (Hamazaki 2009)



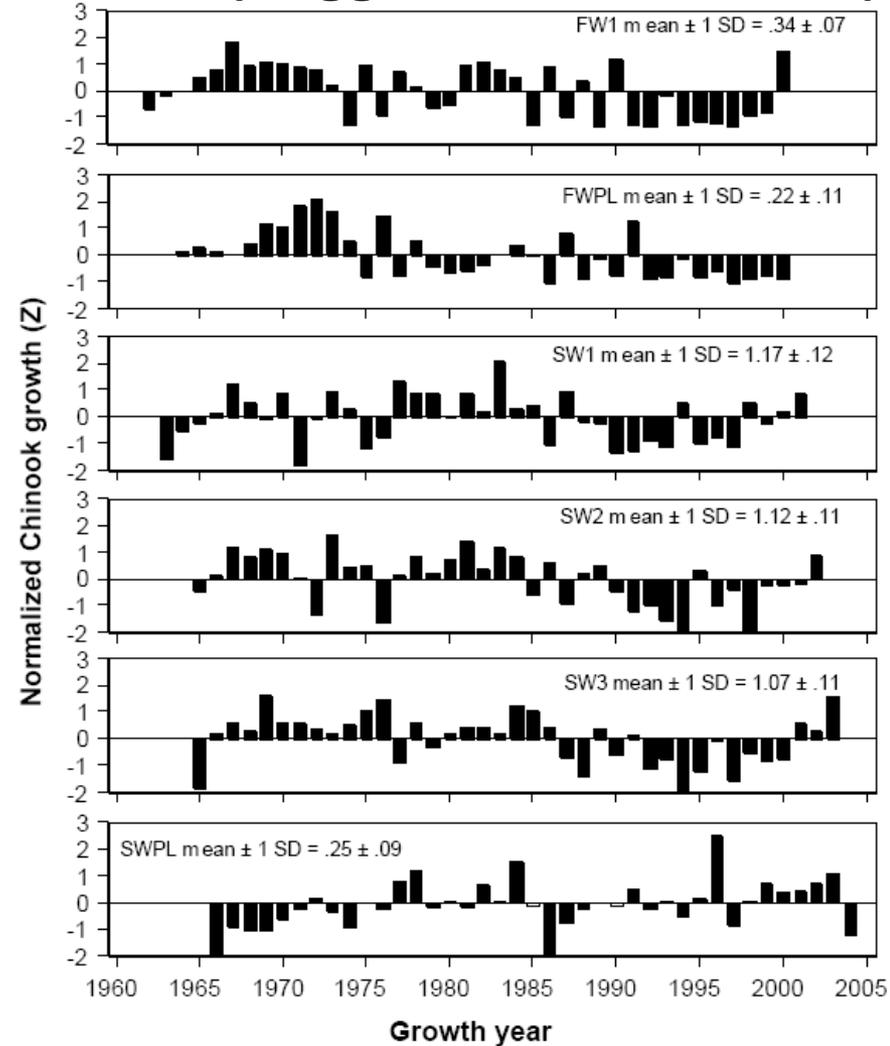


Growth: Scale Pattern Analysis

Kuskokwim (Ruggerone 2007)



Yukon (Ruggerone et al. 2009)





Summary: Stock Status and Trends

- Nearly all stocks currently experiencing low returns
- The returns are the lowest on record for half of stocks
- Decrease in mean length-at-age (Kusko and Yukon)
- Decrease in eggs per female (Kusko and Yukon)
- Differential growth patterns (Kusko and Yukon)



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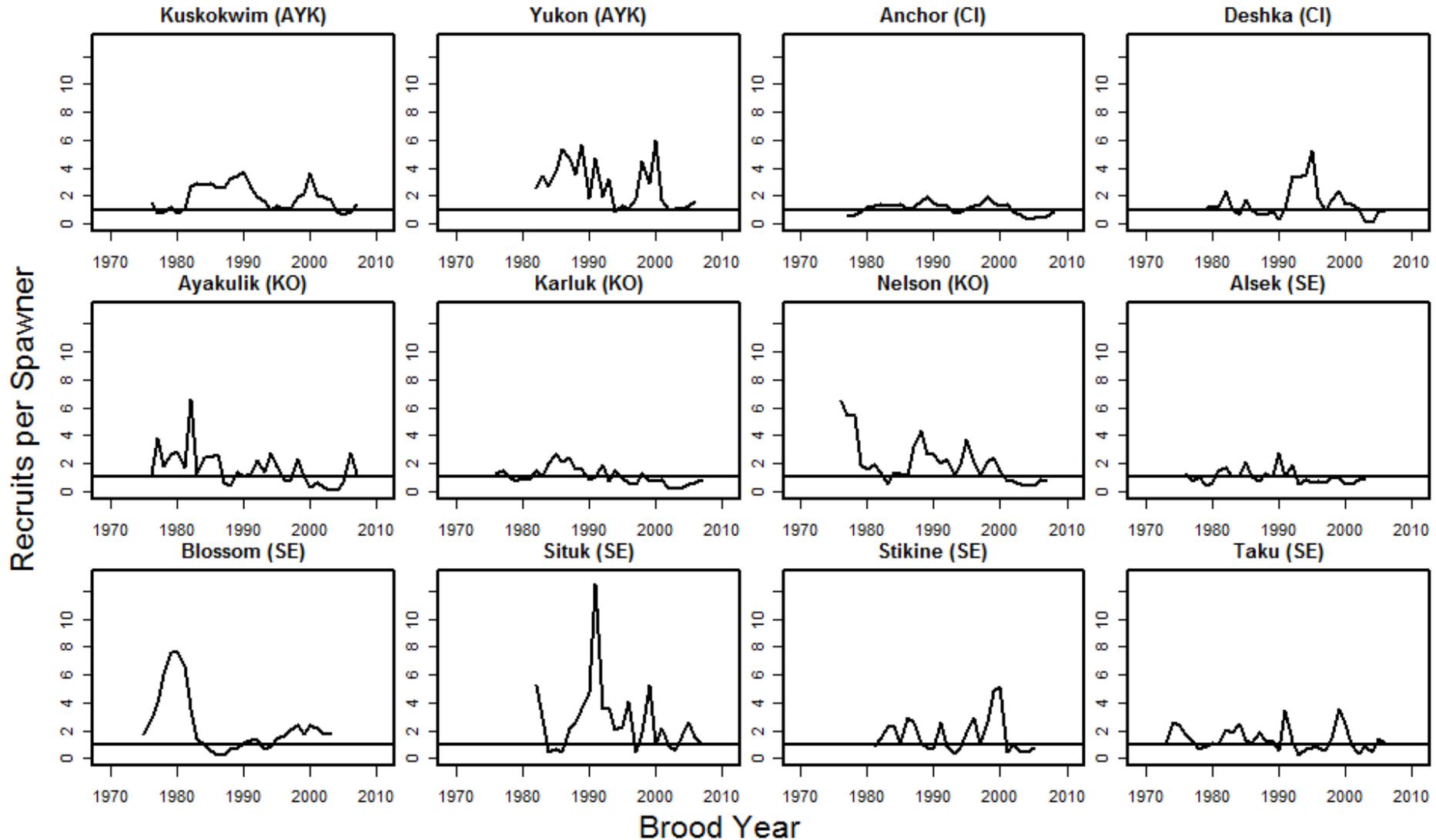


Measures of “Productivity”

1. Recruits per spawner
 - Does not account for density dependence effects
2. Recruits per spawner residuals
 - Removes density dependence effects on productivity
3. Time varying alpha parameter from SR model
 - “filters” out white noise to “uncover” underlying productivity trends



1. Productivity: Recruits Per Spawner



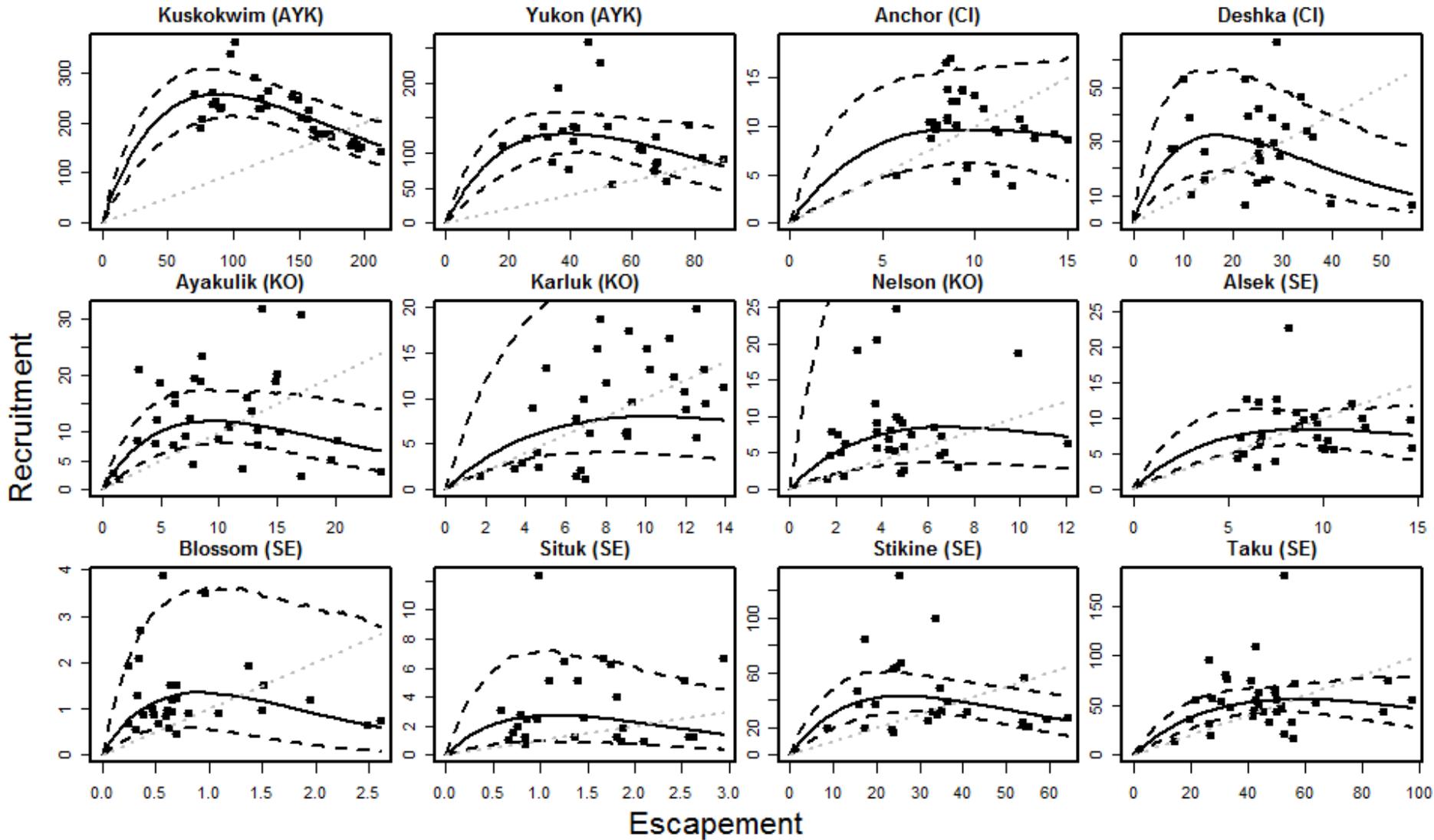


2. Productivity: Recruits Per Spawner Residuals

- How do we obtain the residuals?
 - Fit Ricker stock-recruitment models
 - $\ln R_y = \ln(\alpha) + \ln(S_y) - \beta * S_y + \varphi * v_{y-1} + \varepsilon_y$
 - Differences between observed and model-predicted recruitment

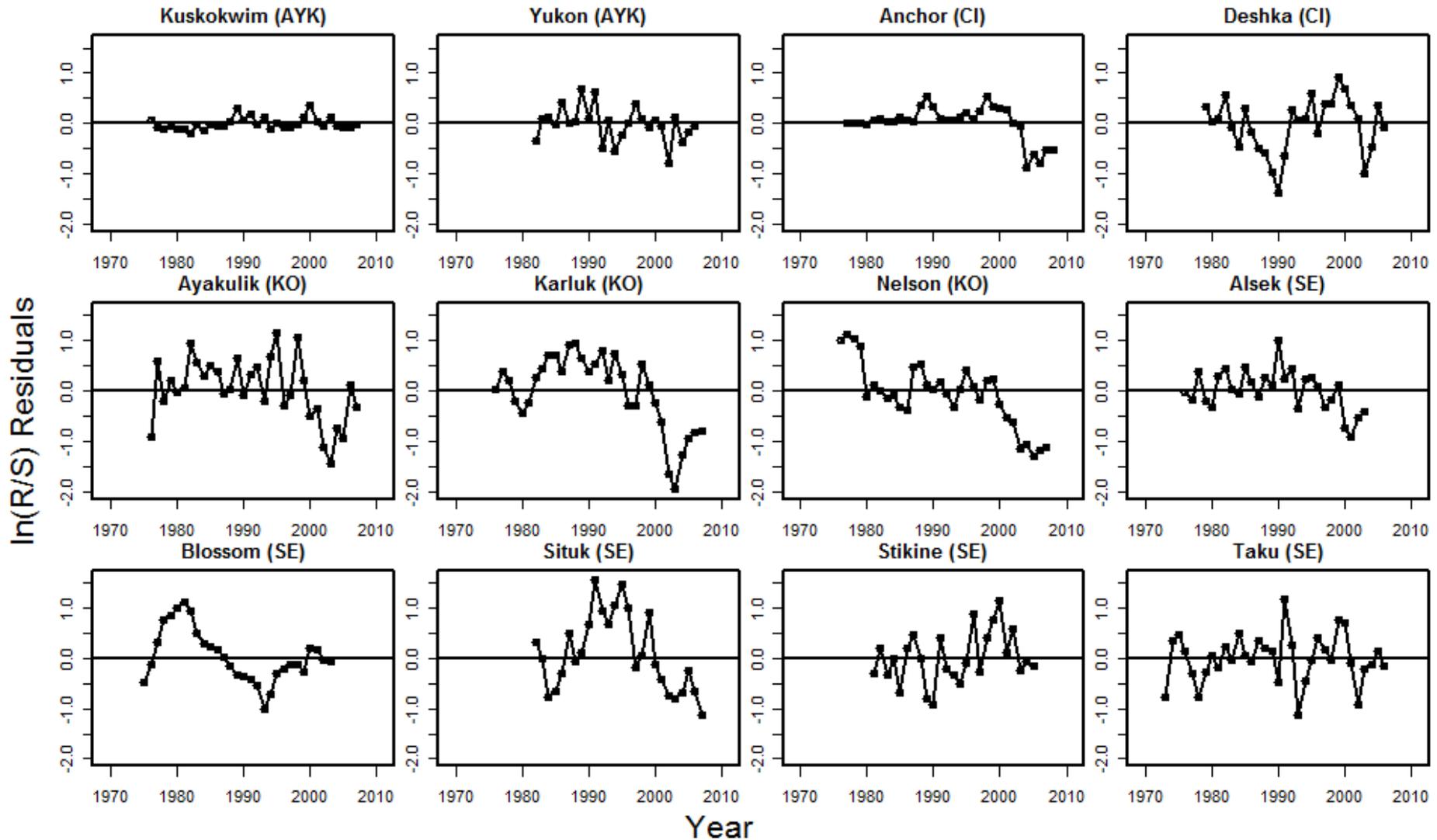


Stock Recruit Models





Recruits Per Spawner Residuals





Correlations: In(R/S) Residuals

	AYK		Cook Inlet		Kodiak Island			Southeast				
	Kusko	Yukon	Anchor	Deshka	Ayakulik	Karluk	Nelson	Alsek	Blossom	Situk	Stikine	Taku
Kusko												
Yukon	●											
Anchor	●	●										
Deshka	●	●	●									
Ayakulik	●	●	●	●				0.67 – 1.00	●	●		
Karluk	●	●	●	●	●			0.33 – 0.67	●	●		
Nelson	●	●	●	●	●	●		0.00 – 0.33	●	●		
Alsek	●	●	●	●	●	●	●					
Blossom	●	●	●	●	●	●	●	●				
Situk	●	●	●	●	●	●	●	●	●			
Stikine	●	●	●	●	●	●	●	●	●	●		
Taku	●	●	●	●	●	●	●	●	●	●	●	



3. Productivity: Time-Varying Alpha

- Fit Bayesian state-space Ricker models
- The productivity parameter, α , allowed to vary over time via random walk process:

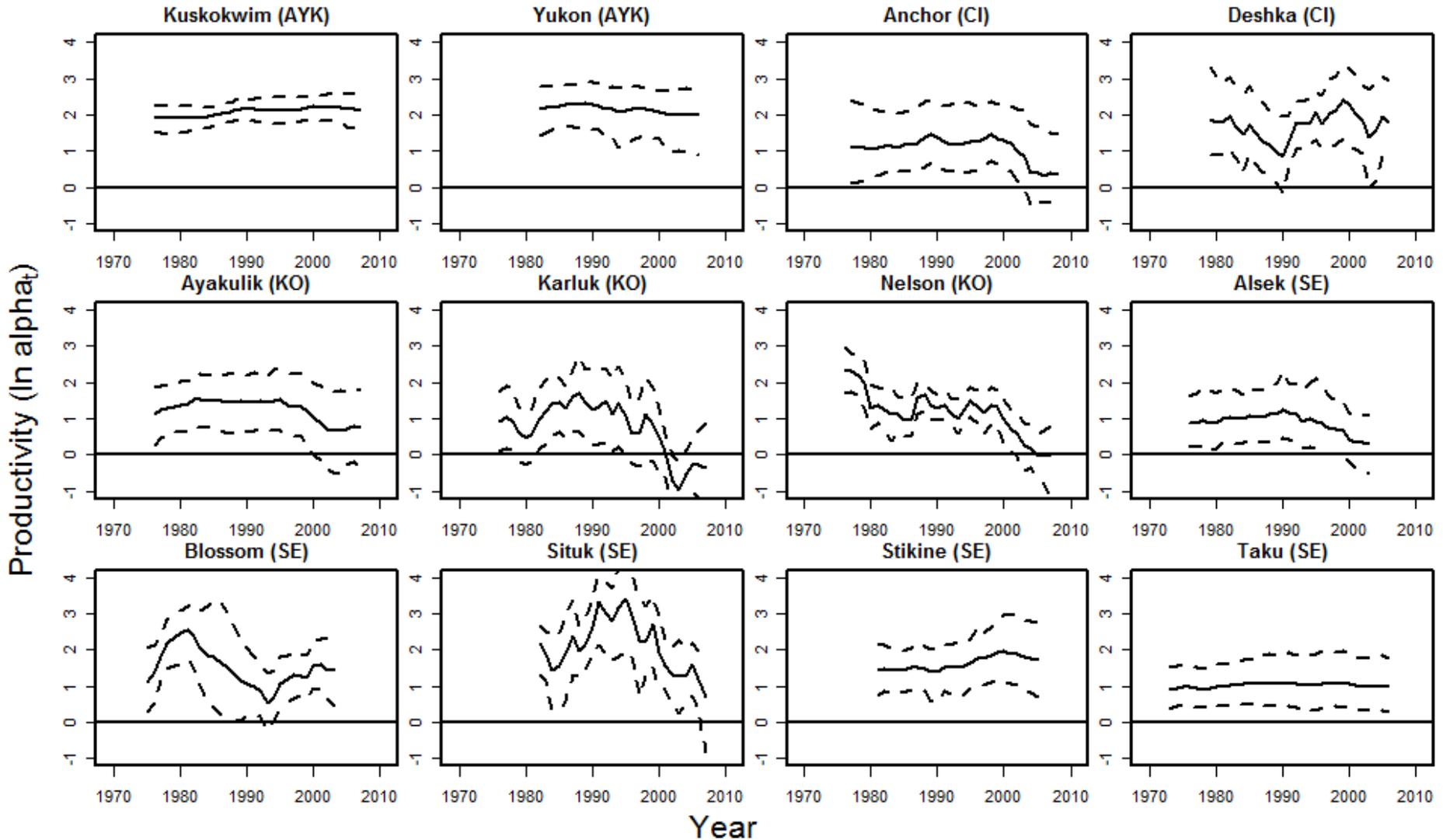
$$\ln R_y = \ln(\alpha_y) + \ln(S_y) - \beta * S_y + \varepsilon_y$$

$$\ln(\alpha_y) = \ln(\alpha_{y-1}) + w_y$$

- Similar results to Kalman Filter estimates

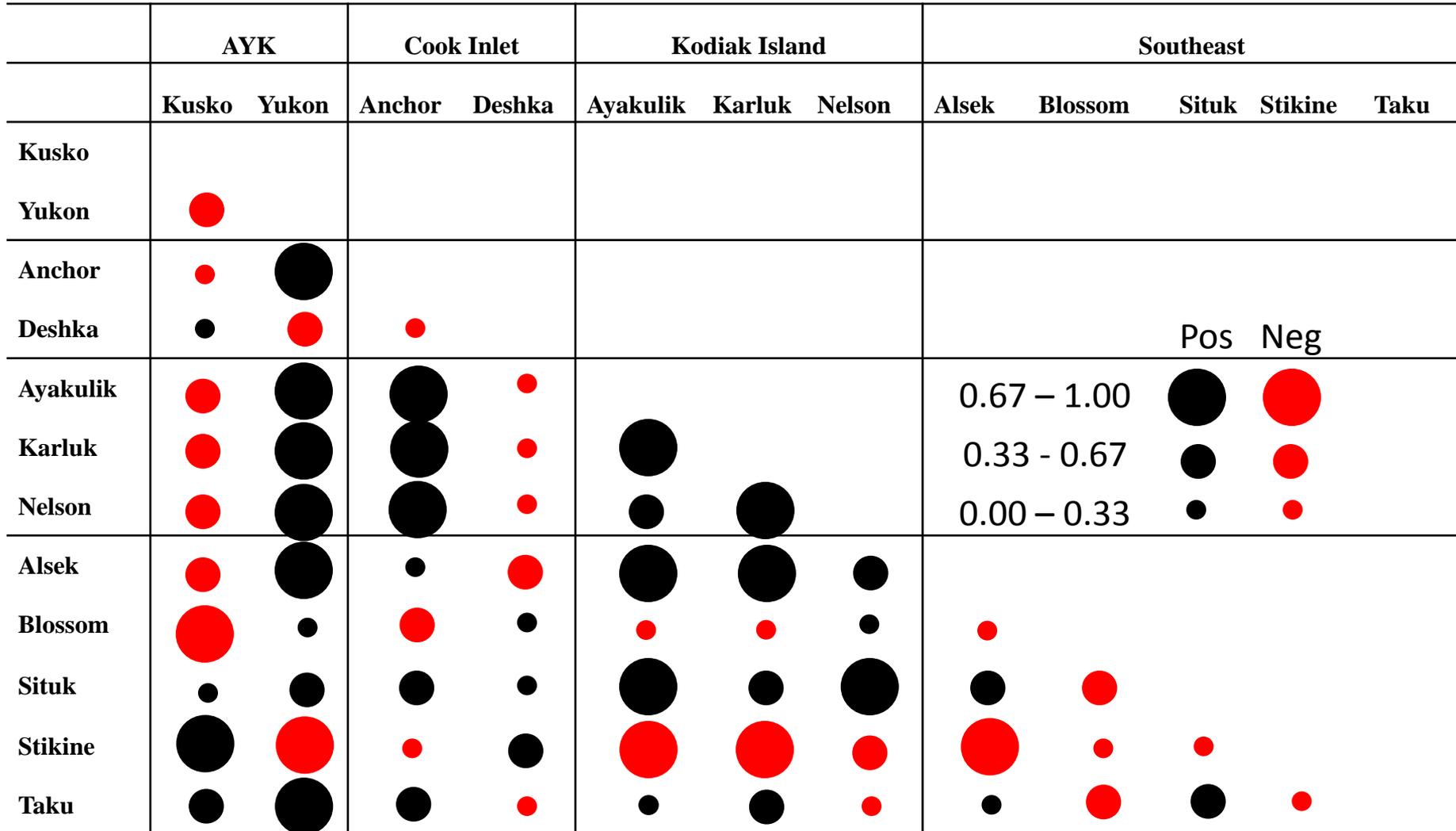


Time-Varying Alpha





Correlations: Time-Varying Alpha





Summary: Comparative Productivity Analysis

- Moderate positive residual correlation between Yukon and Kuskokwim
- Positive correlations among Yukon CA, Anchor and Kodiak stocks
- No obvious correlation patterns with/among southeast AK stocks



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Questions

- How much of the temporal pattern in productivity is attributable to density dependence?
- How much evidence is there for over-compensatory density dependence?

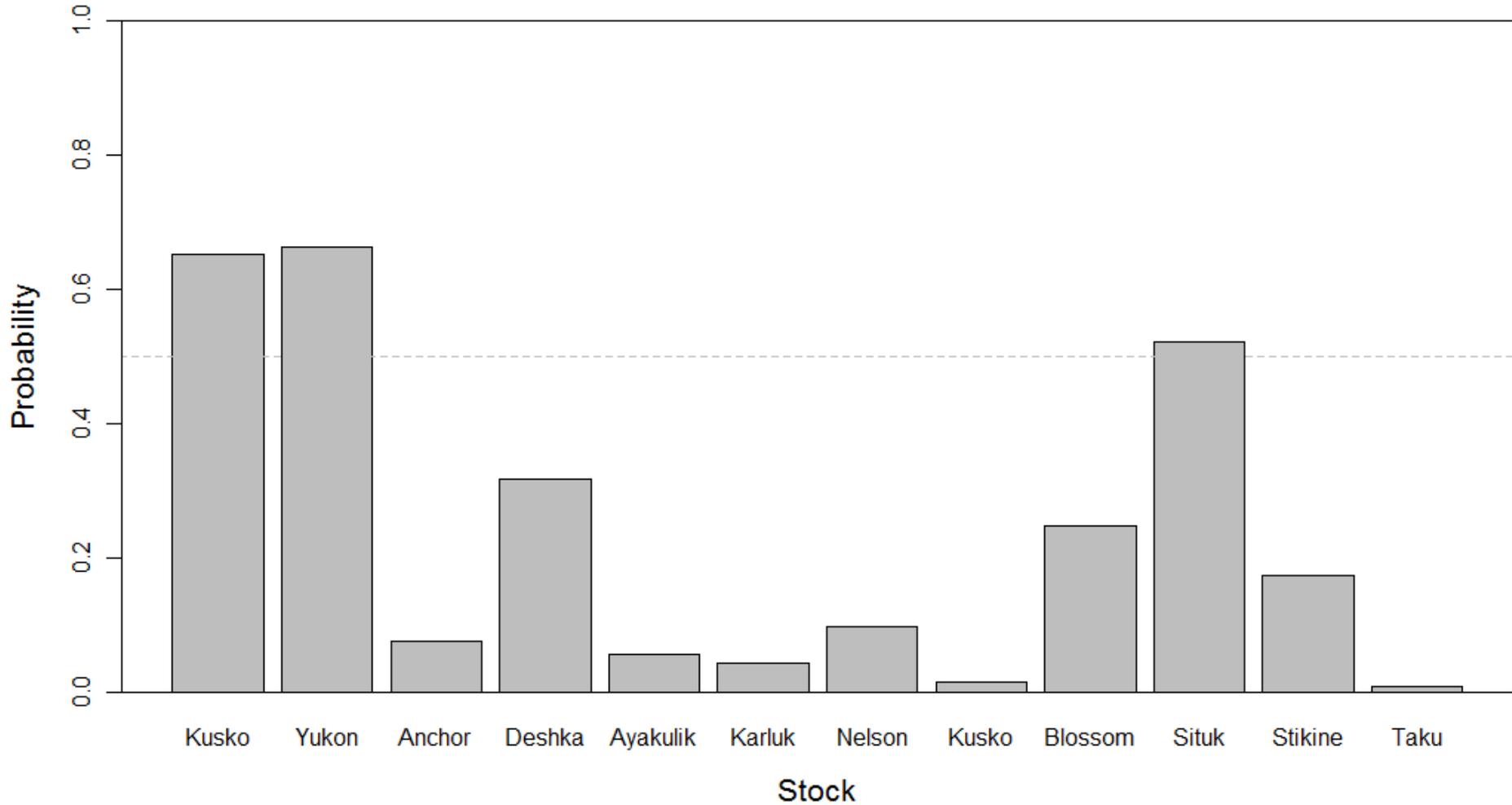


Density-Dependence: Methods

- Magnitude of alpha estimates
- Model comparison: Ricker vs. Beverton-Holt

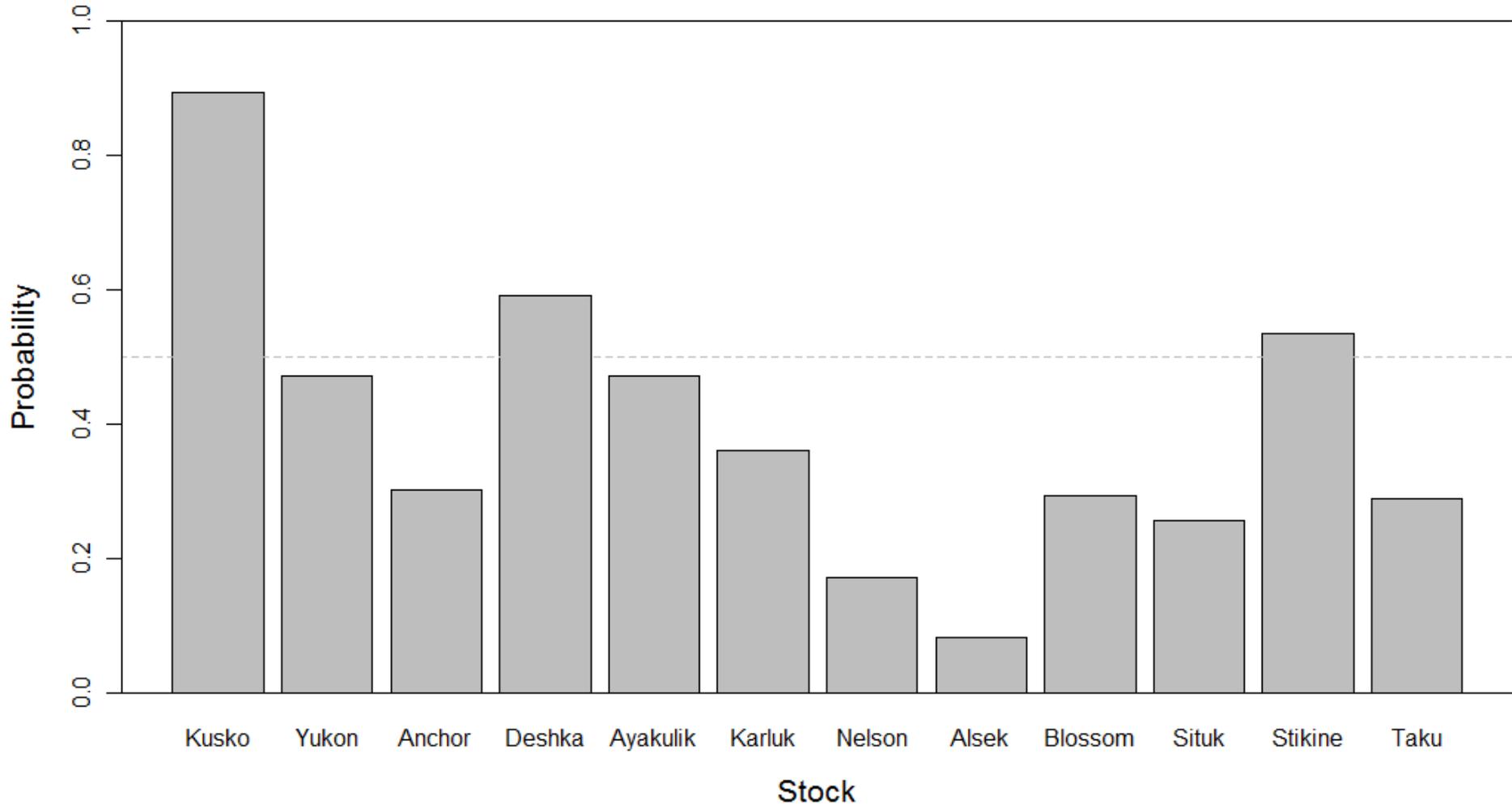


Probability($\alpha > 7.4$)





Probability(Ricker Model)





Conclusions

- Alpha was large enough to induce stable population oscillations for Kusko and Yukon
- Weak evidence for over-compensatory recruitment dynamics, except for the Kusko



Next Steps

- Additional stocks
 - Bayesian analysis of Chena/Salcha, Goodnews, Unalakleet R. stocks and possibly others
- Dec. 10-11 AYK SSI Chinook Salmon Outreach Workshop
 - New analyses
 - Management strategy evaluation workshop



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