



Do Asian Pink Salmon Affect Survival of Bristol Bay Sockeye?

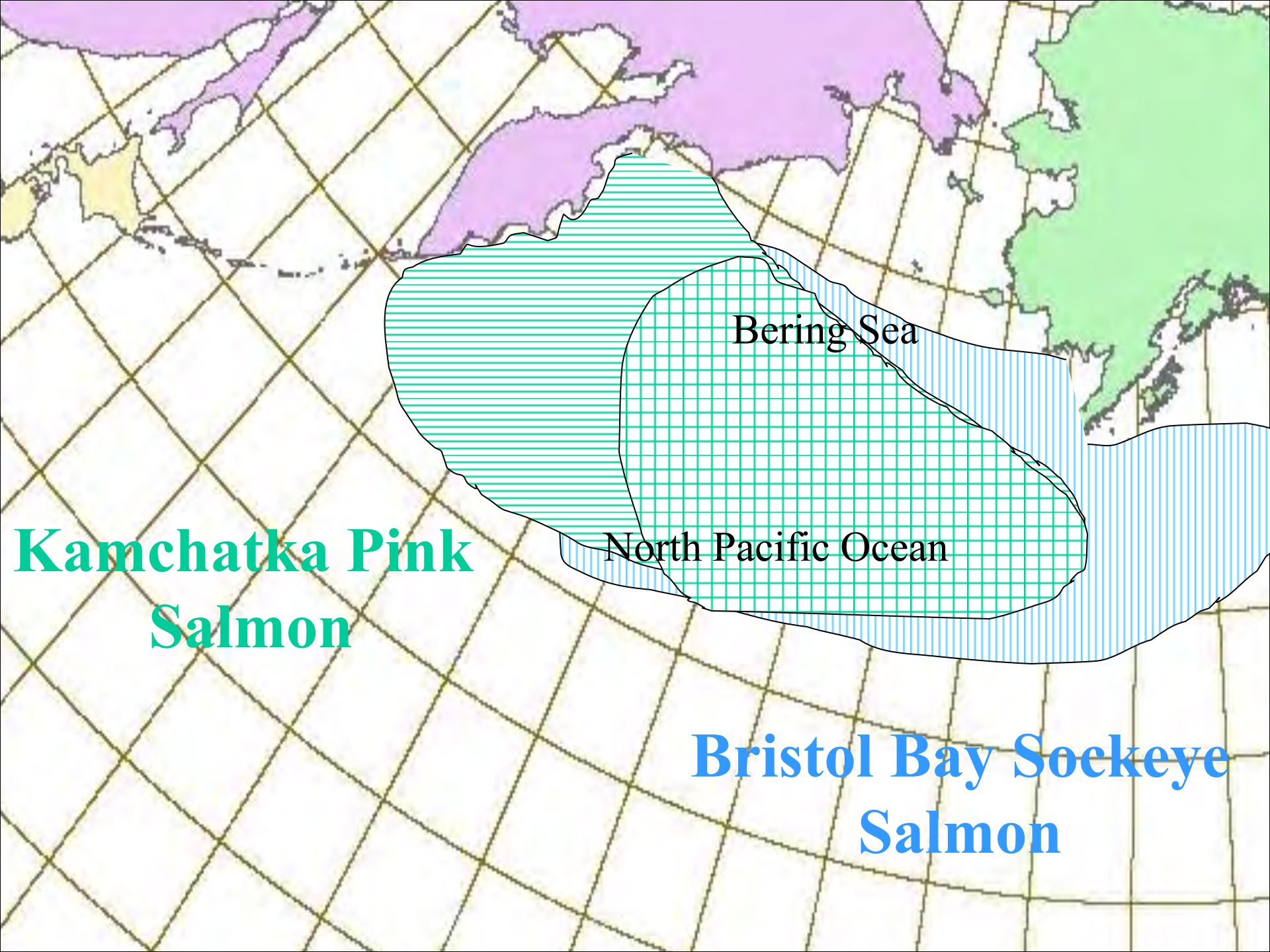
Alex C. Wertheimer
Fishheads Technical Services
And

Edward V. Farley Jr.
NOAA National Marine Fisheries Service

Ruggerone et al. (2003)

Fisheries Oceanography 12(3):

- Asian pink salmon abundance effects ocean growth of Bristol Bay sockeye salmon.
- Odd/even year differences in average Asian pink salmon abundance, Bristol Bay sockeye returns, and smolt-to-adult survival of three major sockeye salmon stocks: Kvichak, Egegik, and Ugashik.
- Density dependent interaction of sockeye salmon in their first year at sea and Asian pink salmon reduces survival of Bristol Bay sockeye salmon.



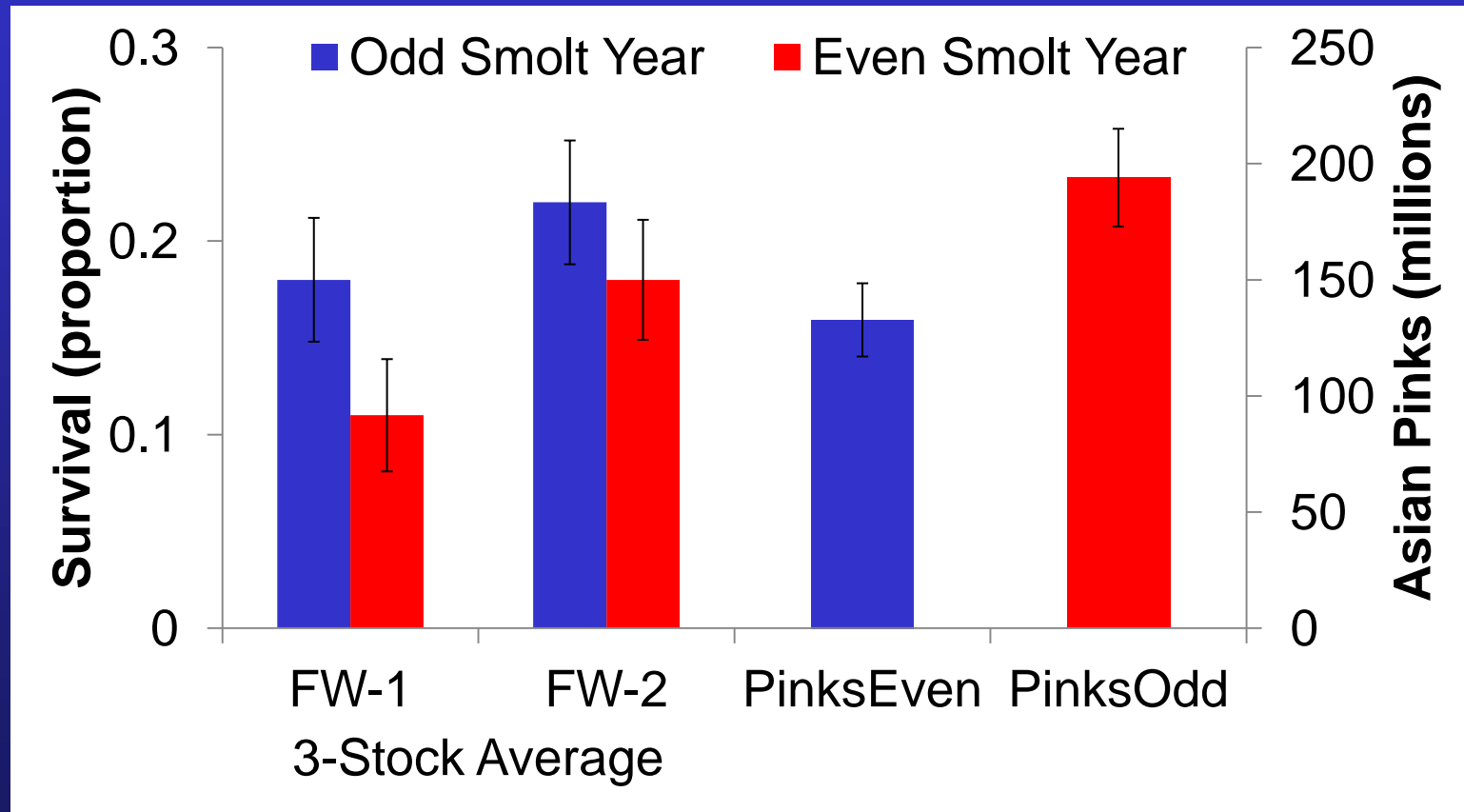
**Kamchatka Pink
Salmon**

Bering Sea

North Pacific Ocean

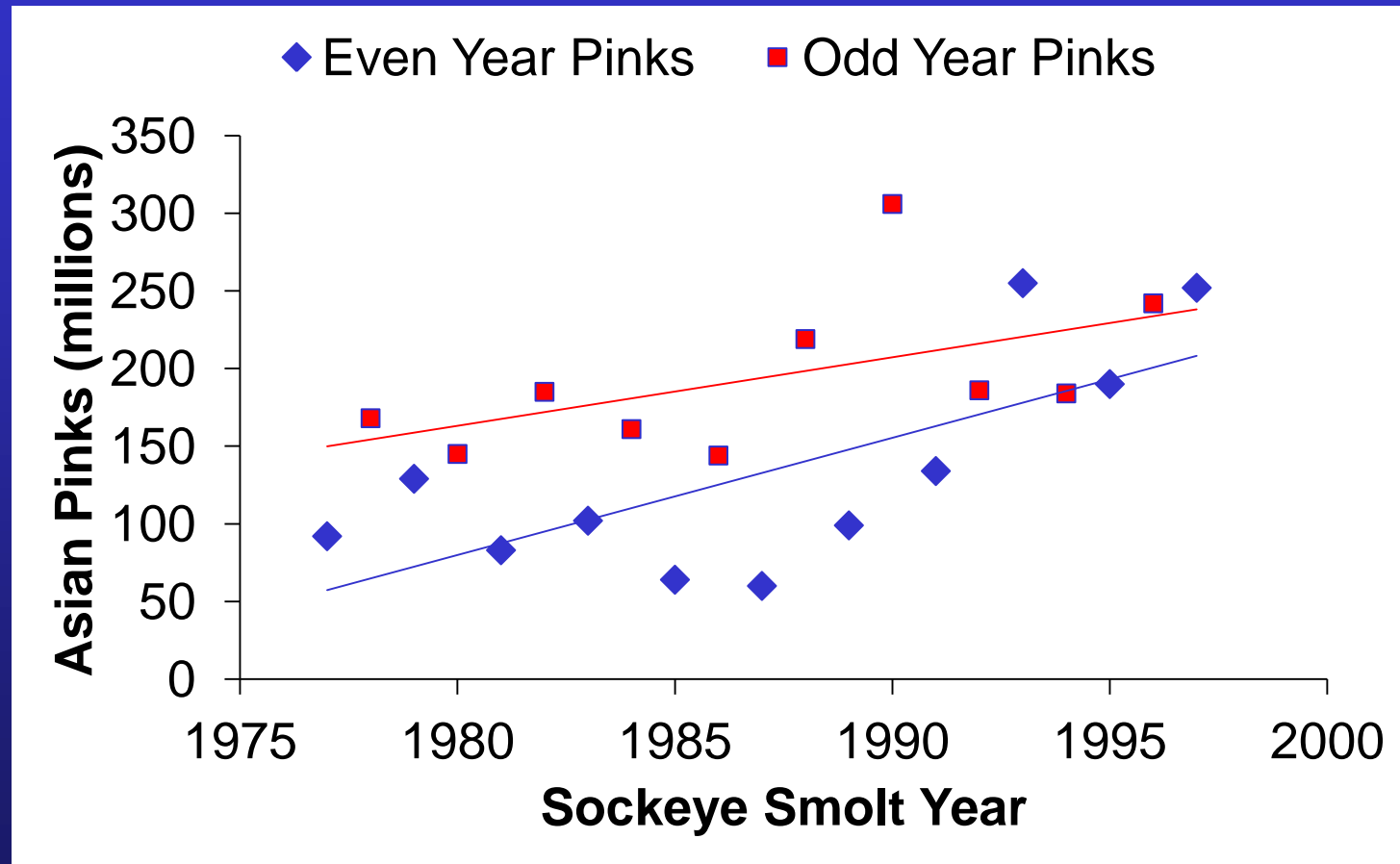
**Bristol Bay Sockeye
Salmon**

3-Stock Average Bristol Bay Sockeye Smolt Survival and Asian Pink Salmon Abundance 1977-1997



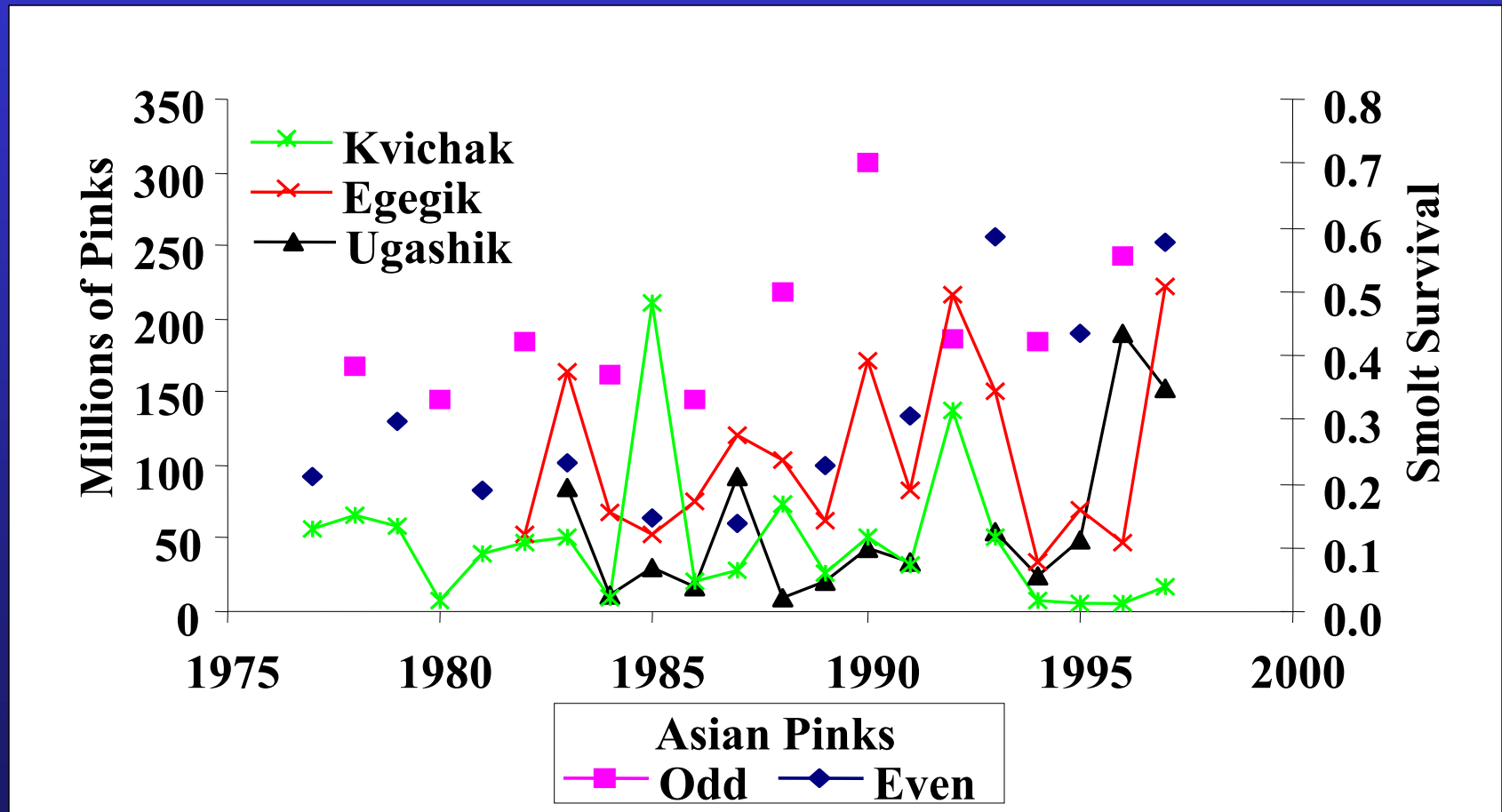
From Ruggerone et al. (2003), Rogers (2001)

Trends in Asian Pink Salmon Abundance 1977-1997



From Rogers (2001)

Bristol Bay Smolt Survival: Time Series By Stock



From ADFG (2003)

Cross-correlation Matrix

Sockeye Survival and Pink Abundance 1977-1997 Data

	Year	Kvichak	Egegik	Ugashik	
Kvichak		-.187			
Egegik		.221	.166		
Ugashik		.511*	-.249	.340	
Pinks		.571**	-.233	.344	.269

* $P = 0.06$

** $P < 0.01$

Objectives Of This Presentation

- Use regression and time-series models to examine the relationship between the abundance of Asian pink salmon and marine survival of 3 major Bristol Bay sockeye salmon stocks :
 - Kvichak 1977-1997
 - Egegik 1982-1997
 - Ugashik 1983-1997
- Use BASIS index of juvenile Bristol Bay sockeye salmon (2002-2007) in the Bering Sea to examine relationship of subsequent survival and returns to the abundance of Asian pink salmon.

Time Series Analysis

Model 1: Regression Model
(no trend to survival)

Model 2: AR(1) Model
(annual trend to survival)

Model 3: AR(2) Model
(biennial trend to survival)

Model 4: AR(1,2) Model
(annual and biennial trends to survival)

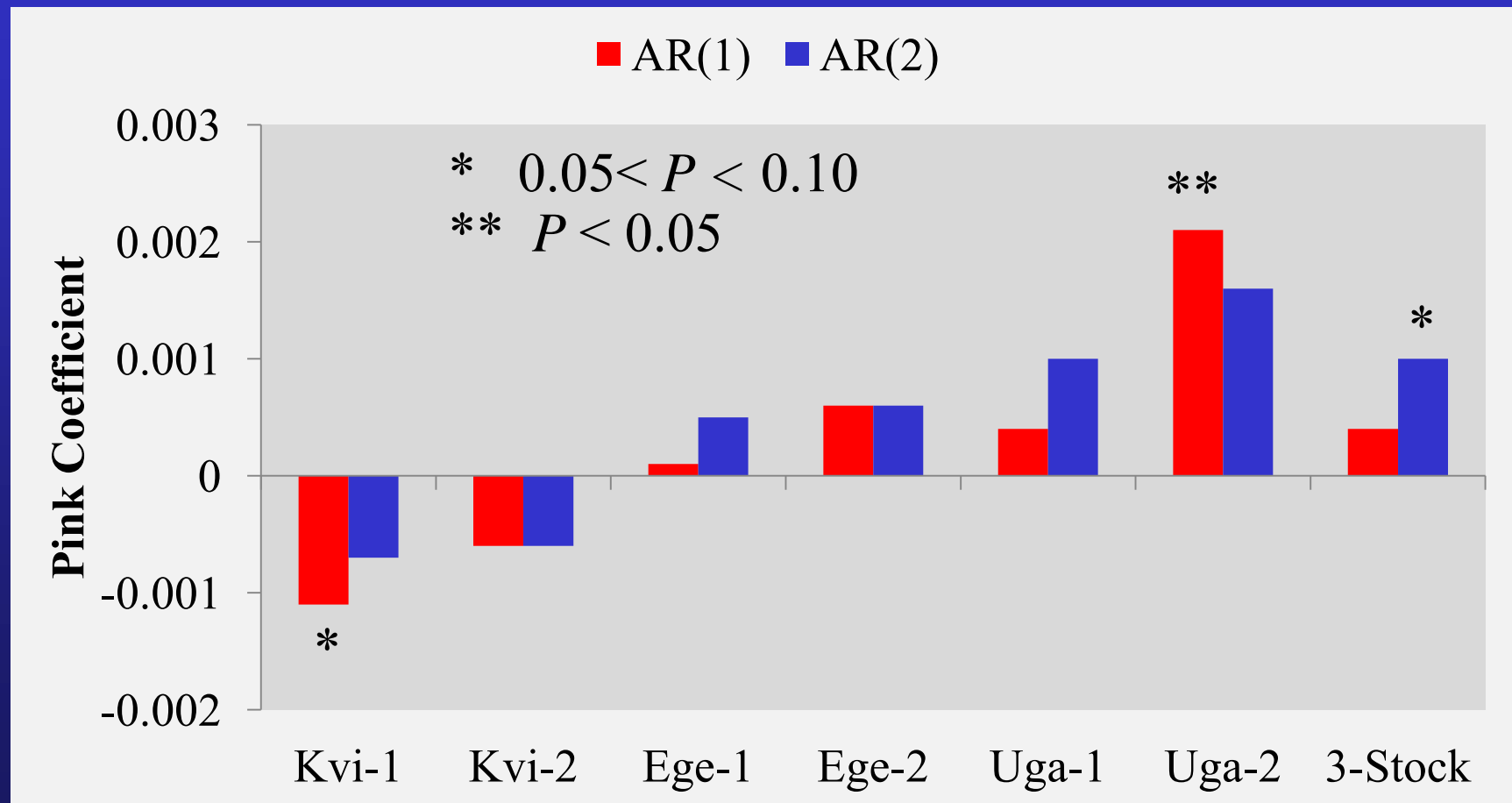
Time Series Models: Akaike Information Criterion (AIC_c) Values

Stock/Age	Model 1 Regression	Model 2 AR(1)	Model 3 AR(2)	Model 4 AR(1,2)
Kvichak-1	-10.39	-32.51	-32.13	-29.06
Kvichak-2	-11.26	-32.28	-32.29	-29.21
Egegik-1	-1.18	-26.09	-29.52	-27.77
Egegik-2	-0.67	-35.10	-35.28	-32.85
Ugashik-1	-8.04	-27.09	-27.00	-23.55
Ugashik-2	-4.69	-27.56	-26.79	-24.29
3-Stock Avg.	-32.55	-44.95	-44.63	-44.48

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“Best” Time Series Models: Pink Coefficients for AR(1), AR(2)



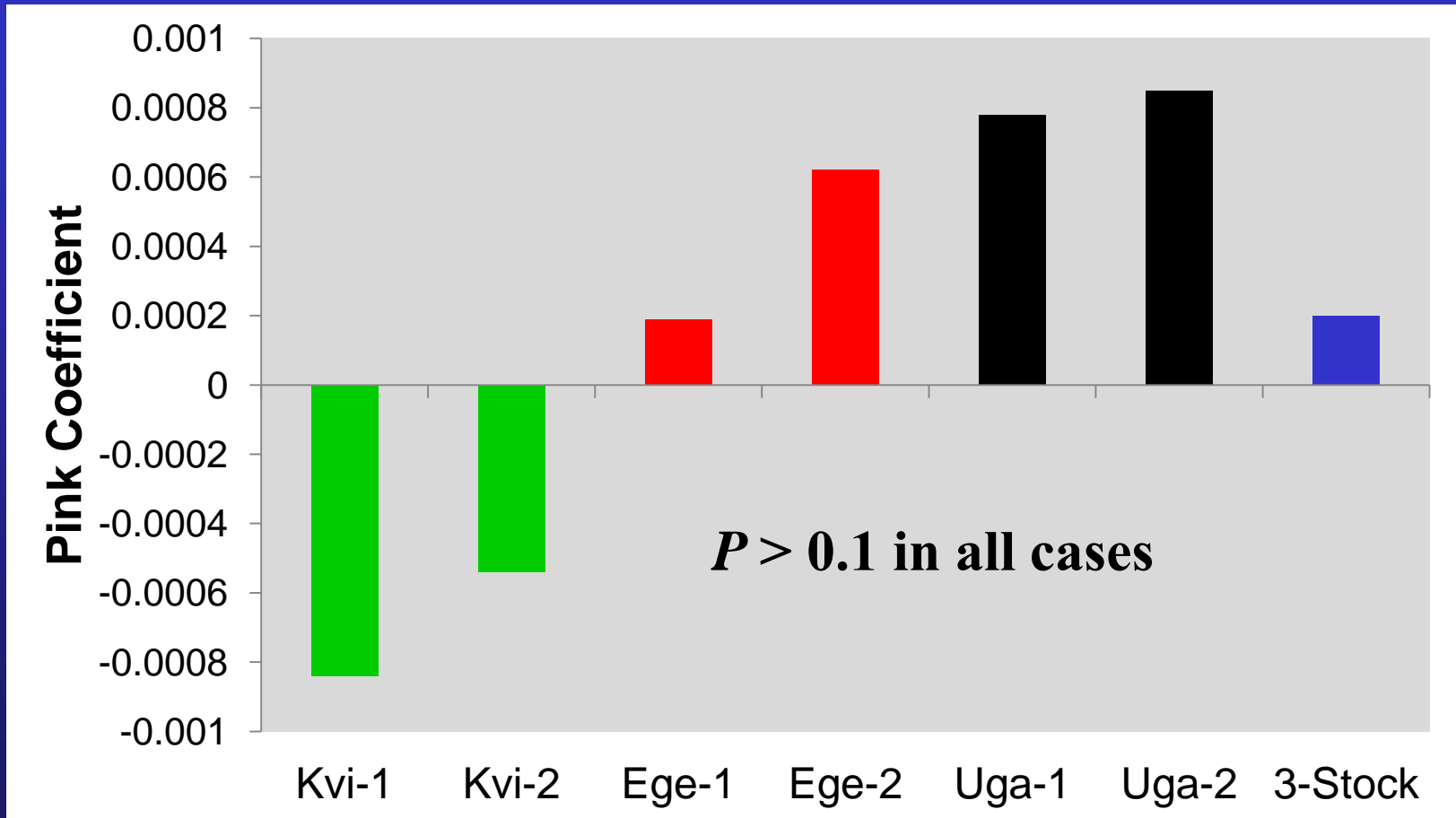
Significance of Autoregressive Parameters for Smolt Survival

Stock/Age	Model 2 : AR(1)		Model 3: AR(2)	
	Coefficient	<i>P</i> -value	Coefficient	<i>P</i> -value
Kvichak-1	-0.267	0.231	0.131	0.596
Kvichak-2	0.102	0.665	-0.249	0.303
Egegik-1	-0.354	0.185	0.153	0.545
Egegik-2	-0.064	0.821	-0.267	0.367
Ugashik-1	0.149	0.632	0.247	0.625
Ugashik-2	-0.476	0.113	0.294	0.460
3-Stock Avg.	-0.421	0.115	0.472	0.098

Significance of Autoregressive Parameters for Smolt Survival

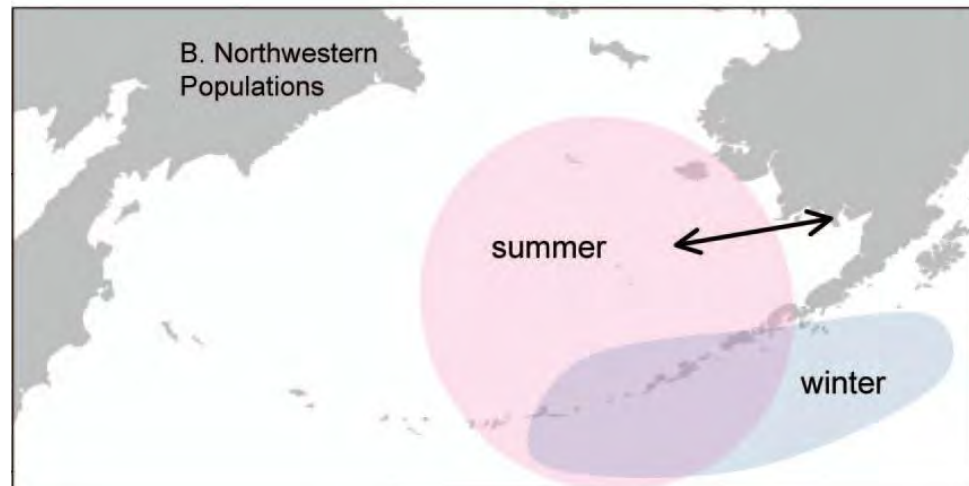
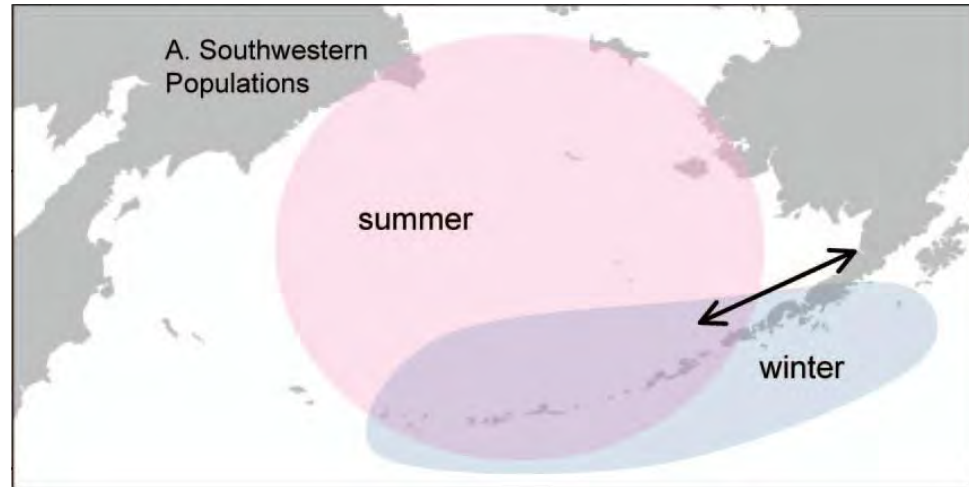
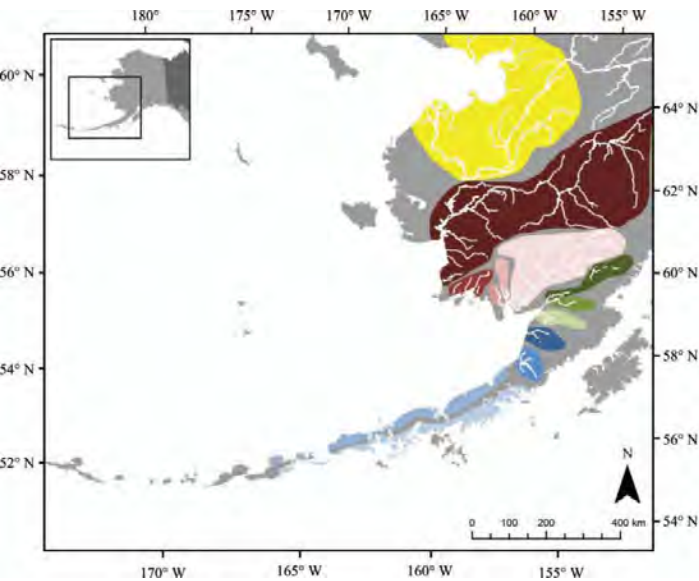
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Regression of Smolt Survival by Stock/Age with Pink Abundance

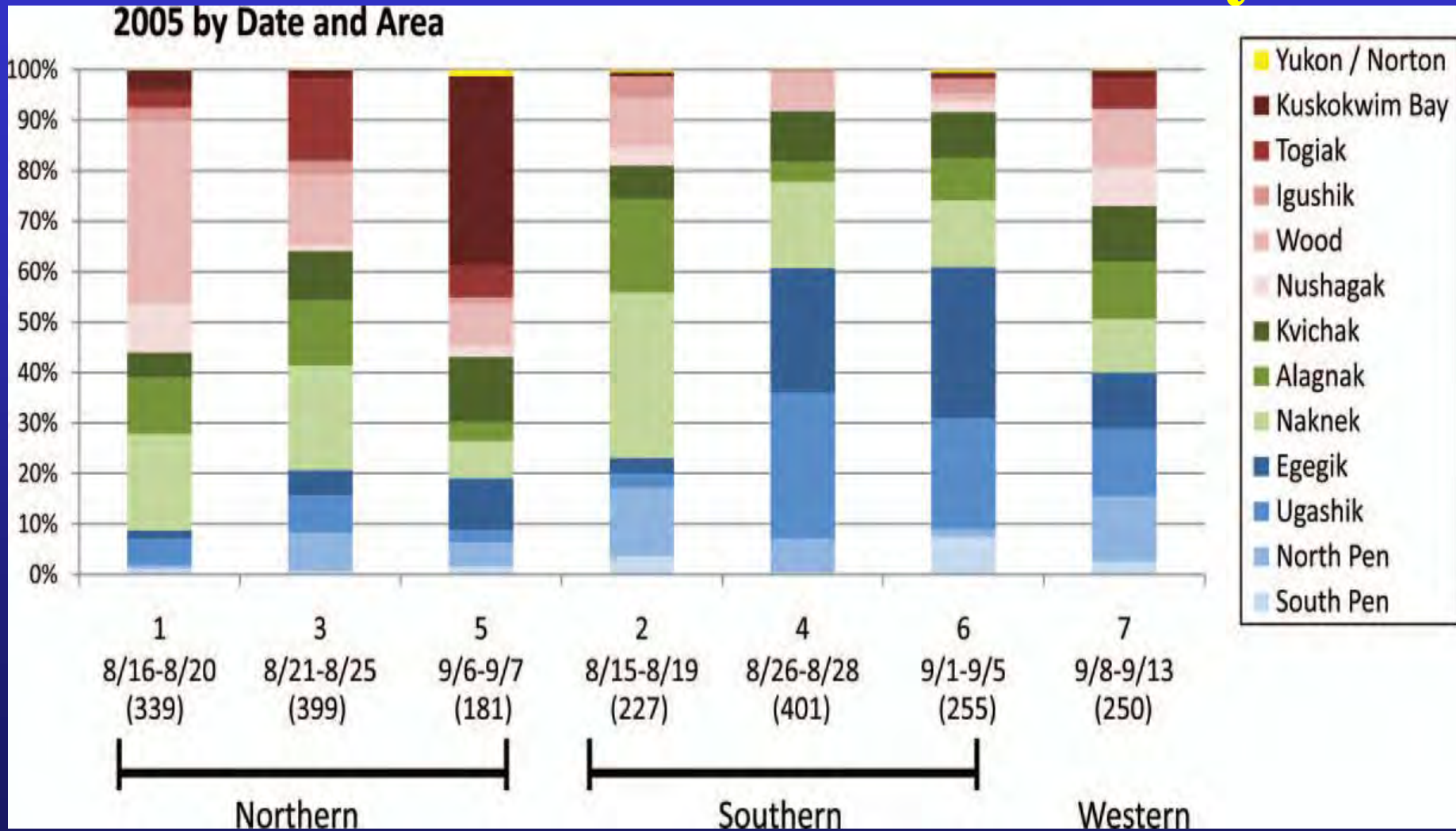




Bristol Bay Sockeye Salmon Seasonal Migration



Stock-specific Distribution First Ocean Year BB Sockeye

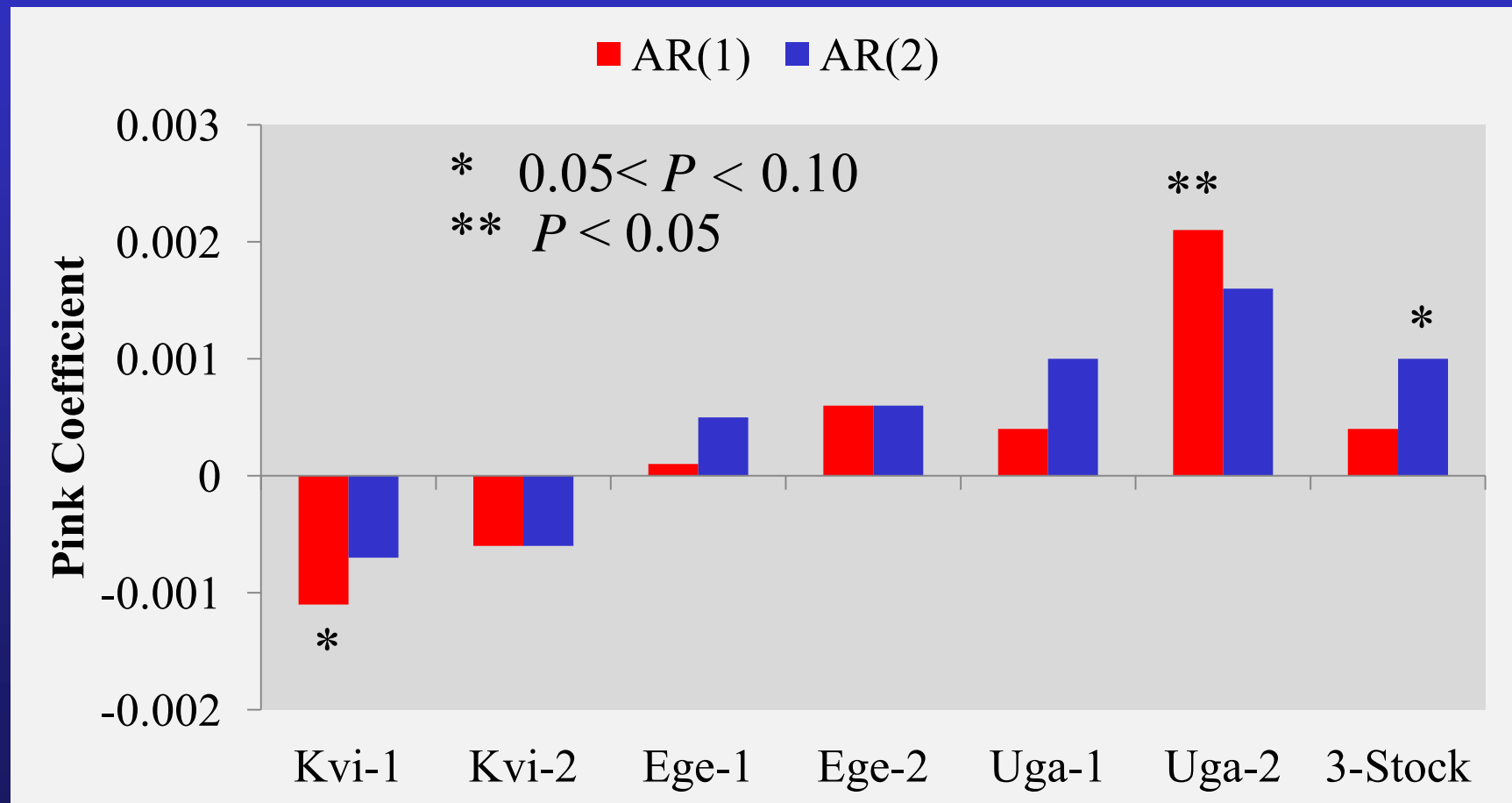


From Seeb et al. (2011)

Conclusions: 1977-1997 Smolt Years

- Tendency for odd/even differences in smolt survivals from 3 major Bristol Bay sockeye salmon stocks
- No consistency among stocks in survival response over time or in relation to pink salmon abundance
- **COMPLEX:** Density interactions with Asian pinks are stock specific and compensatory (competition vs. predator sheltering)

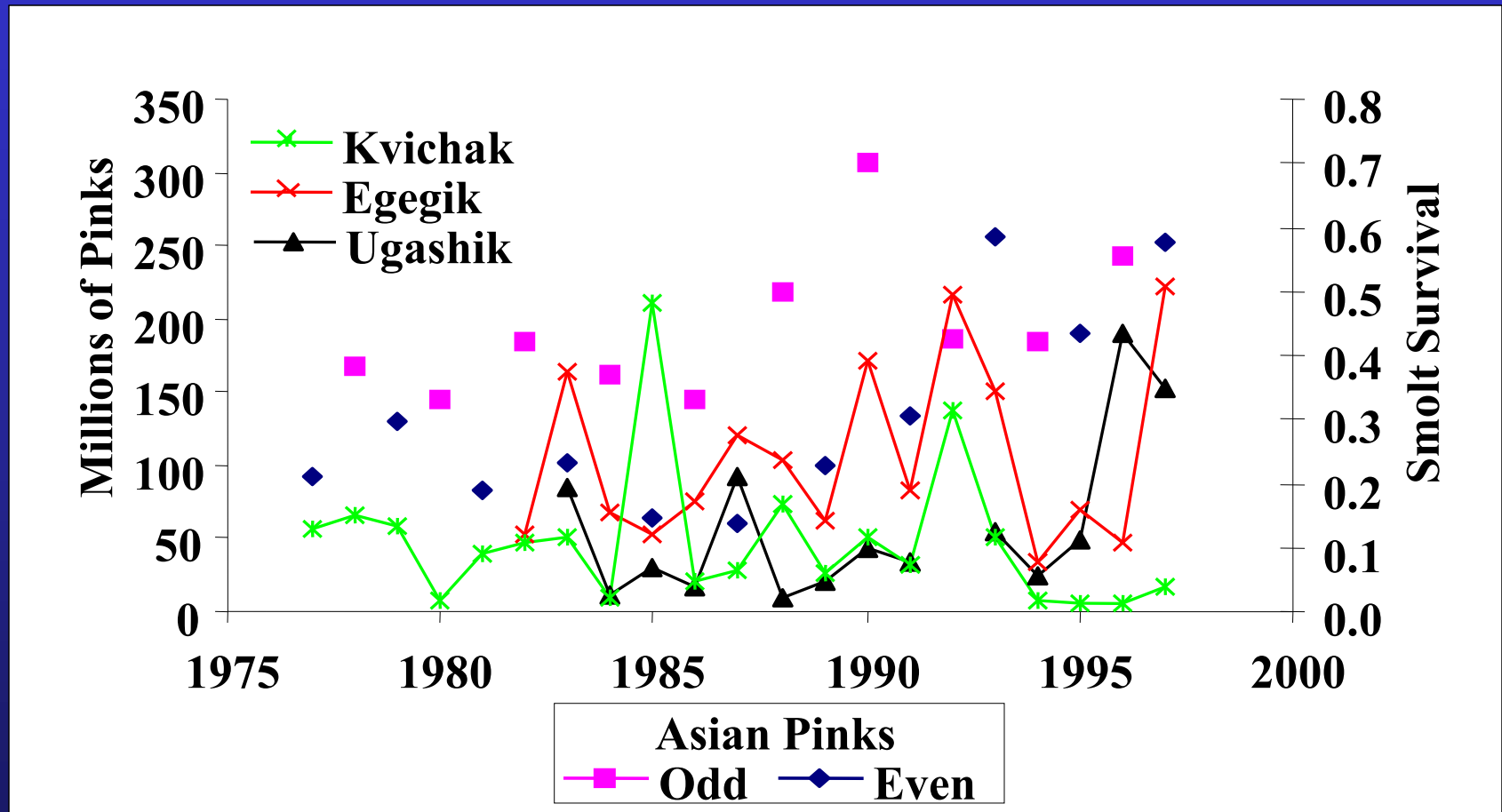
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- **SIMPLE:** Relationships between smolt survival and Asian pinks are artifacts of increasing pink abundance and stock-specific patterns in sockeye smolt survivals

Bristol Bay Smolt Survival: Time Series By Stock



From ADFG (2003)

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- SIMPLE: Relationships between smolt survival and Asian pinks are artifacts of increasing pink abundance and stock-specific patterns in sockeye smolt survivals
- Regardless of mechanism, no net reduction in BB smolt survival in relation to Asian pink salmon abundance

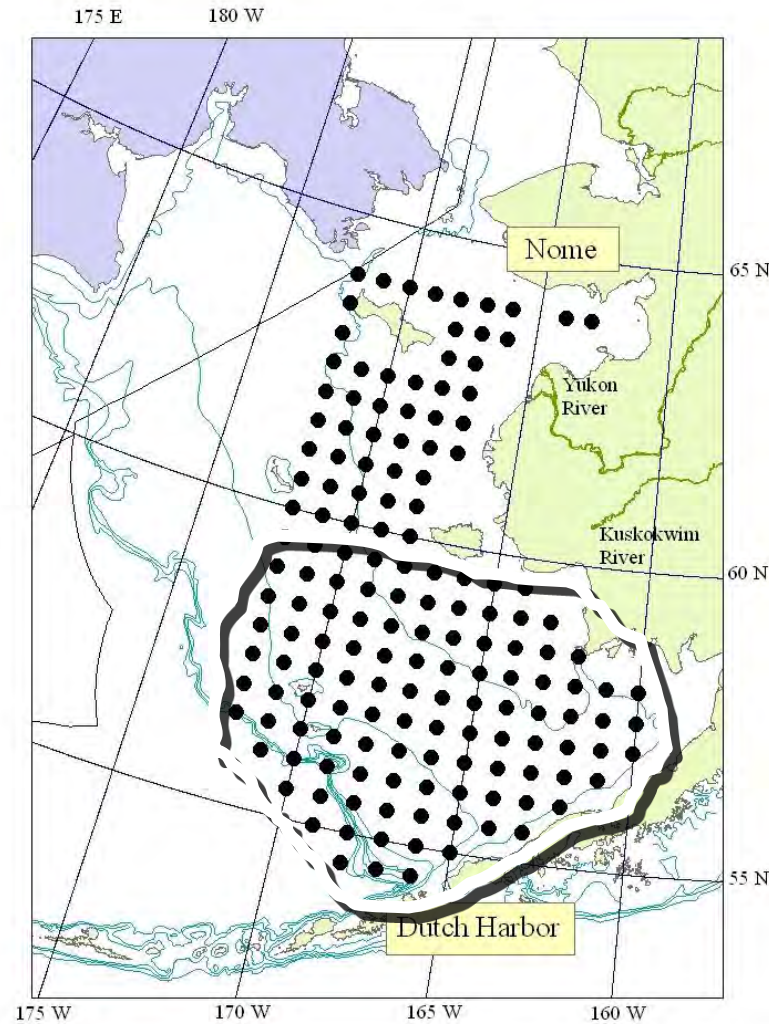
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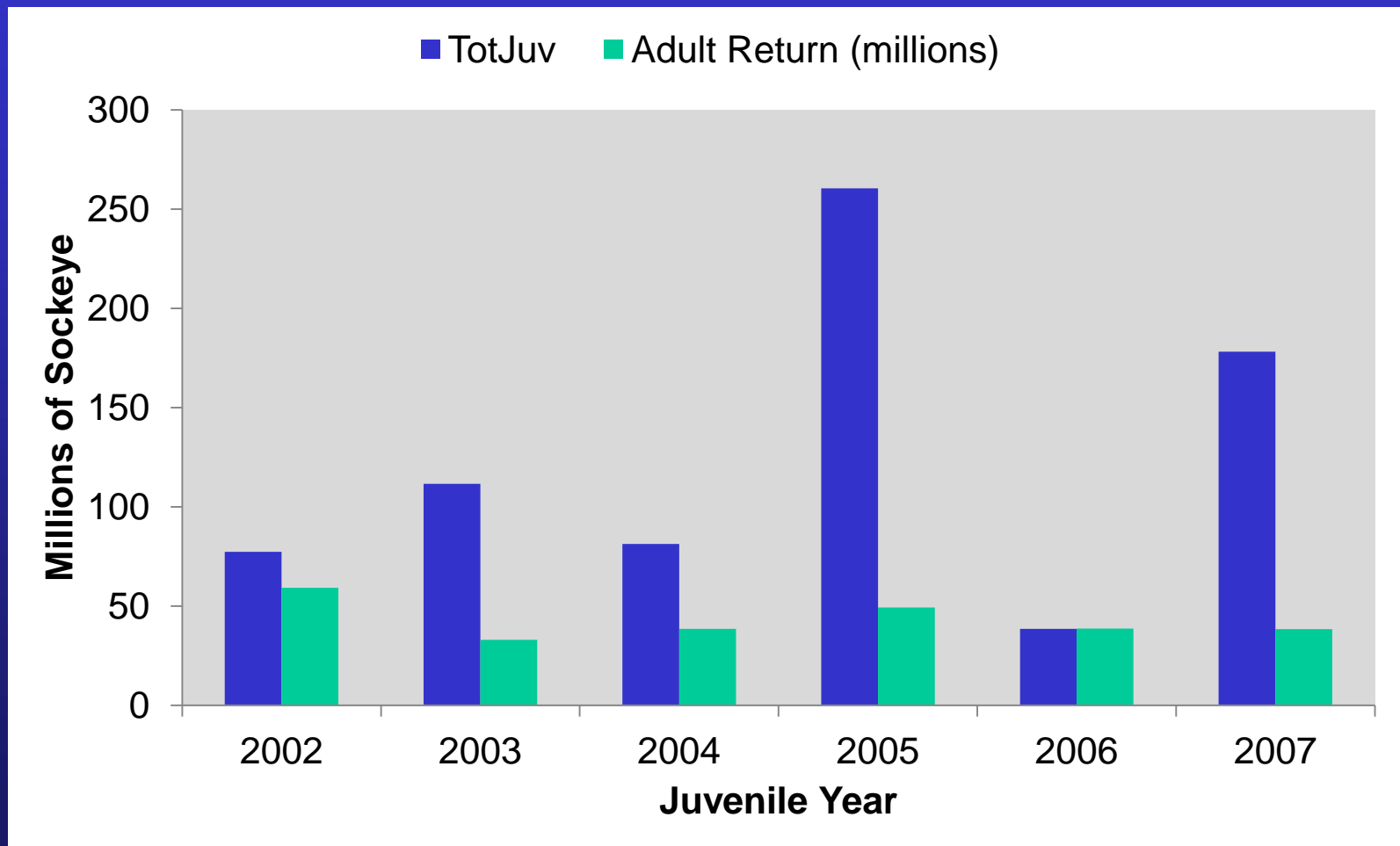


BASIS Survey

Southeast
and Northeast Bering Sea
mid August – September
2003 - 2011

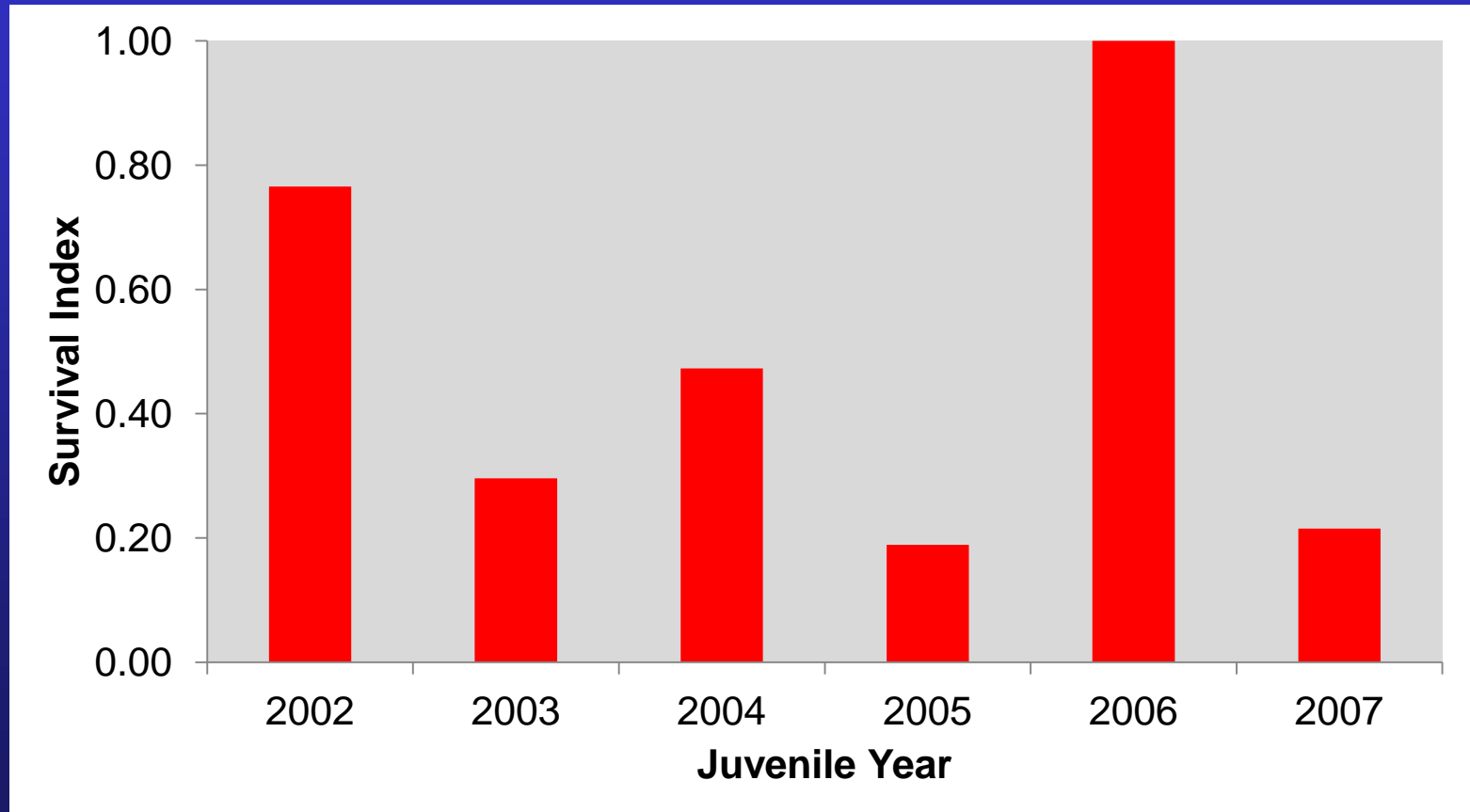


BASIS Juvenile BB Sockeye Abundance and Associated Adult Returns

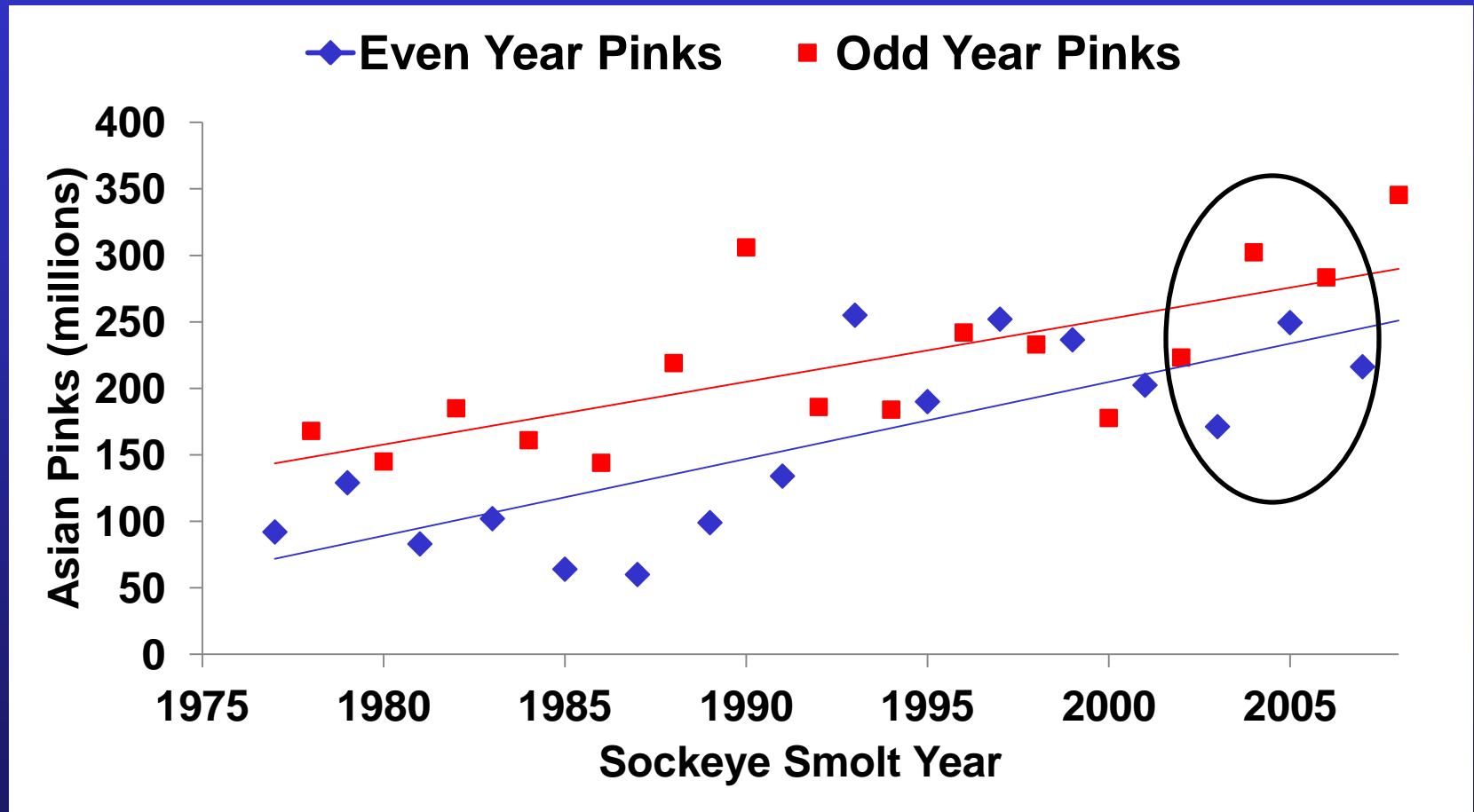


(Farley et al. 2009; ADFG 2010)

BASIS Juvenile BB Sockeye Survival Index (Adult Return/Juvenile Abundance)

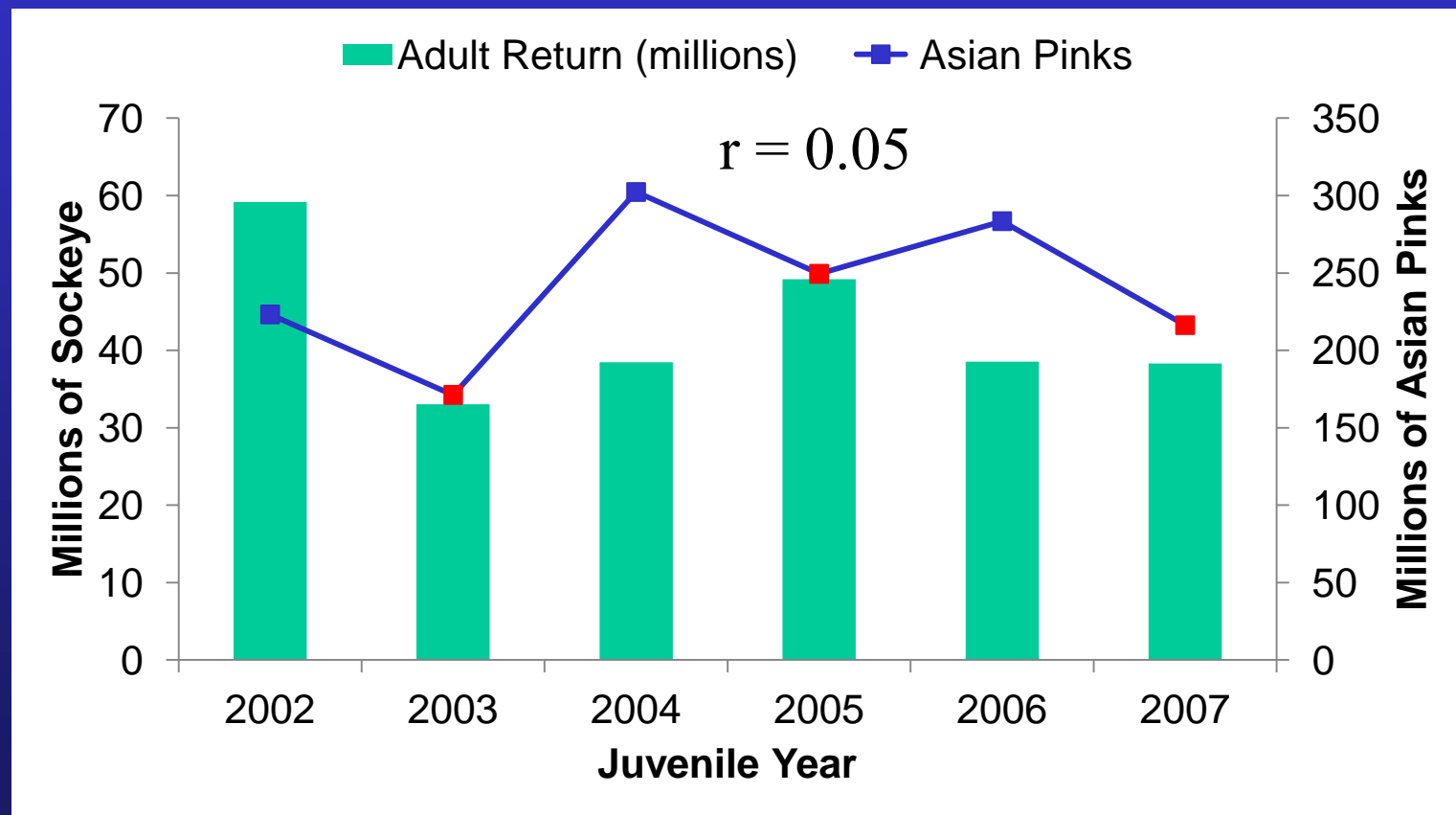


Trends in Asian Pink Salmon Abundance 1977-2008

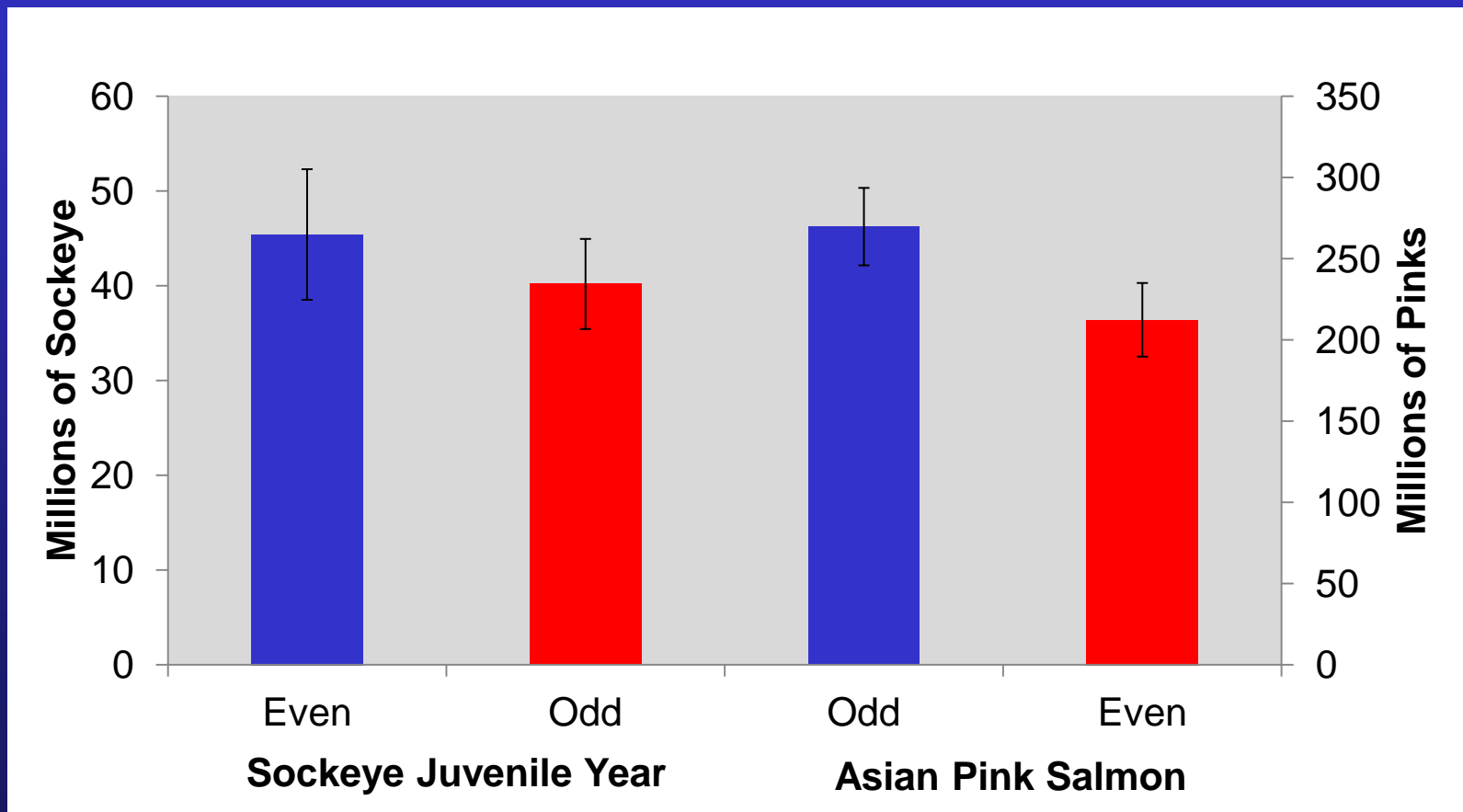


From Ruggerone et al. (2010), Rogers (2001)

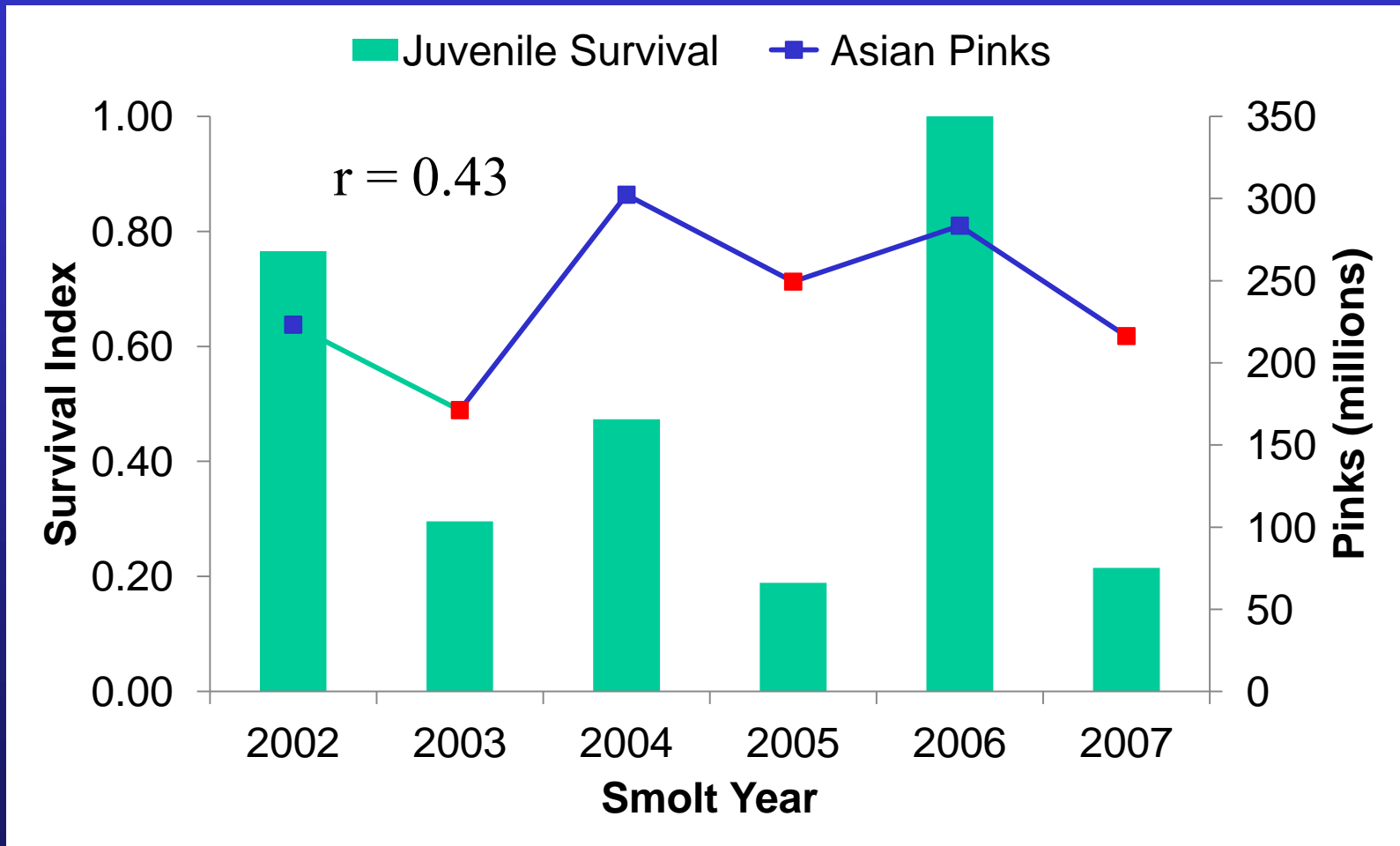
Bristol Bay Sockeye Returns and Asian Pink Salmon for 2002-7 Juvenile Years



Average Odd/Even Returns of Bristol Bay Sockeye and Asian Pink Salmon, 2002-7 Juvenile Years



Sockeye Juvenile Survival Index and Associated Asian Pink Abundance



Conclusions: 2002-2007 Juvenile Years

- **Adult returns and juvenile survival index were HIGHER for even year juveniles**
- **Juvenile survival index was positively correlated with Asian pink salmon abundance**
- **Results consistent with conclusions from Part 1 (1977-97) smolt data: no cumulative negative impact of Asian pink salmon abundance on Bristol Bay sockeye salmon survival**

Acknowledgements

- **Lowell Fair and Tim Sands, ADFG for sockeye salmon smolt and adult return data**
- **Ellen Martinson, NOAA Fisheries, for help running time series analyses**
- **Dr. Nancy Davis, Workshop Steering Committee, and NPAFC for the invitation and support to attend the Workshop**

Questions?

