Impact of climate variability and change on winter survival of Bristol Bay sockeye salmon

NOAA FISHERIES

- Alaska Fisheries Science Center

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PICES - NPAFC Workshop W2

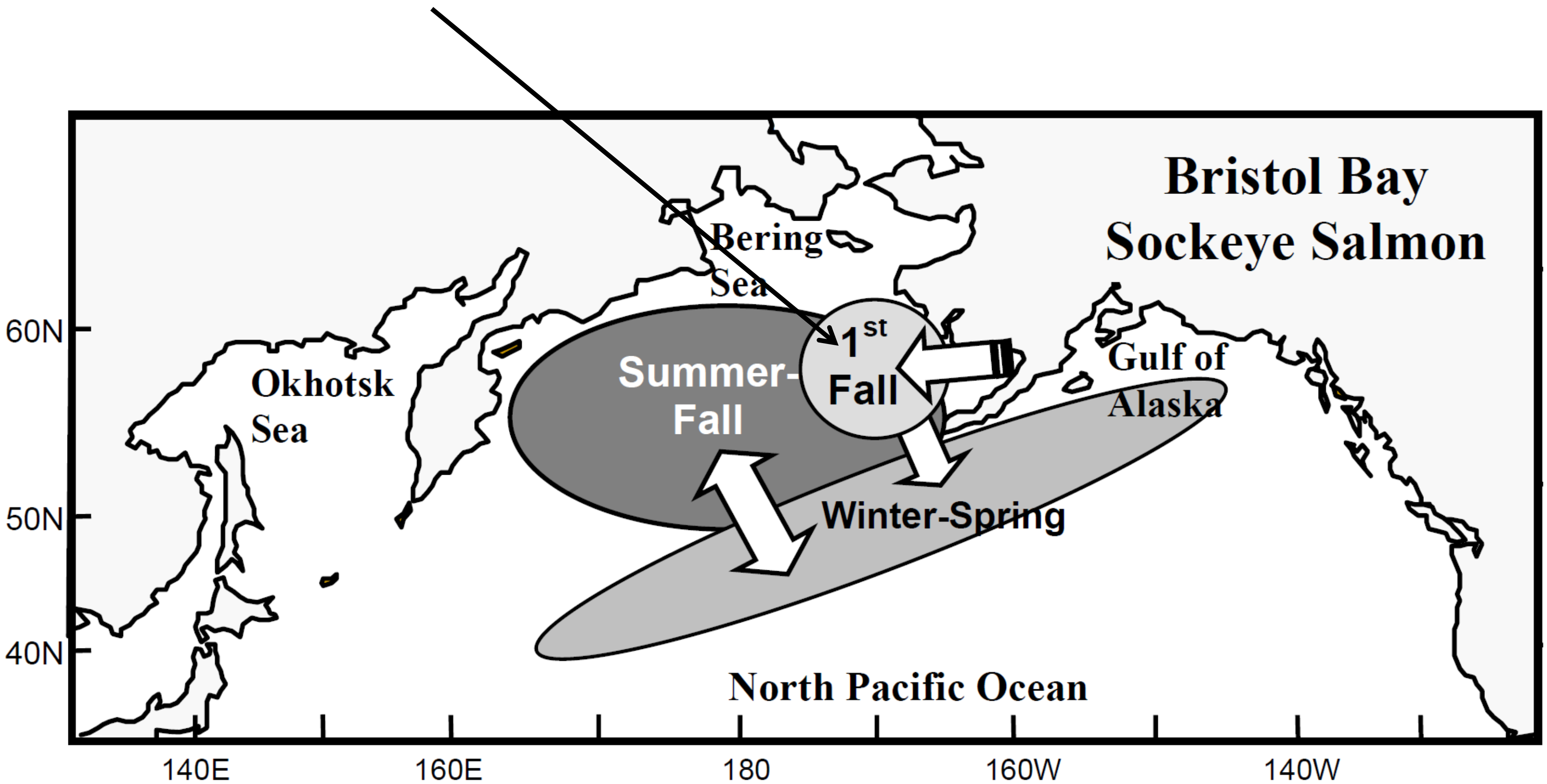
Linkages between the winter distribution of Pacific salmon and their marine ecosystems and how this might be altered with climate change

October 17, 12:10 (W2-9583)

PICES 2014 Annual Meeting Yeosu, Korea

Ocean distribution

Period when juvenile sockeye salmon need to grow and put on lipid



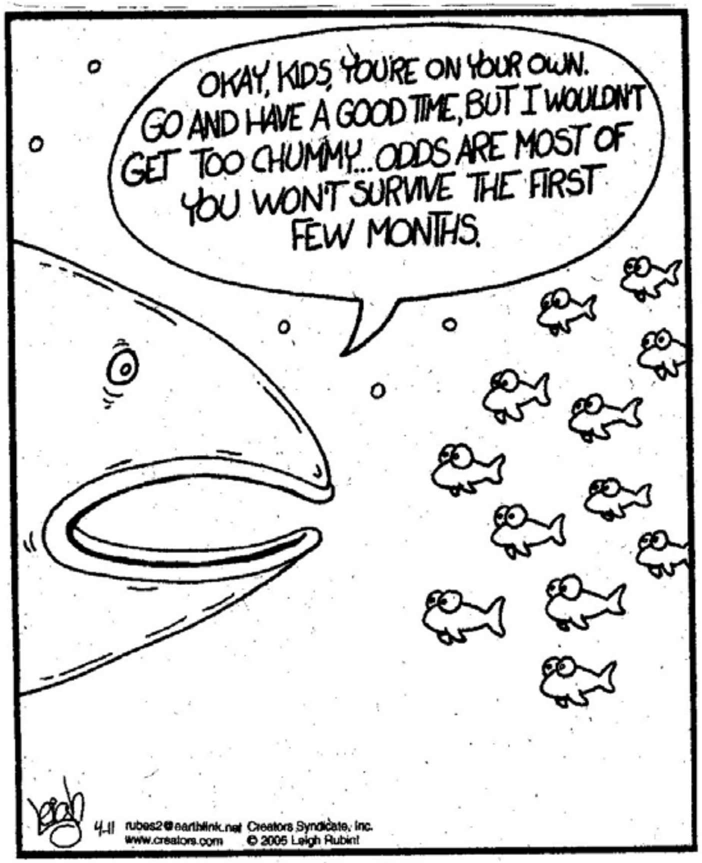
Myers et al. North Pacific Anadromous Fish Commission Bulletin 4; 2007

A Series of Related Concepts

1. **Climate states** can impact prey quality and quantity on the eastern Bering Sea shelf
2. **Prey quality and quantity** during their first summer at sea determines size and fitness of juvenile (marine Age-0) salmon
3. **Size and fitness of juvenile salmon** drives size-selective mortality, SSM, during winter.
4. **Winter size-selective mortality** occurs because smaller, less fit fish must feed during winter to maintain protein levels, which may lead to higher risk of predation; whereas larger fish are able to burn more lipid to reduce predation risk.
5. **Other winter mortality factors** may operate, such as pinks “predator-buffering” sockeye salmon during winter. Recent data on competition support a positive relationship between Asian pink salmon abundance and Bristol Bay sockeye salmon survival and abundance.

Critical Size and Period Hypothesis

H1: **The effects of climate and ecosystem function on fish recruitment are most evident during 2 critical periods:**



Salmon moms

Critical Periods

First Spring

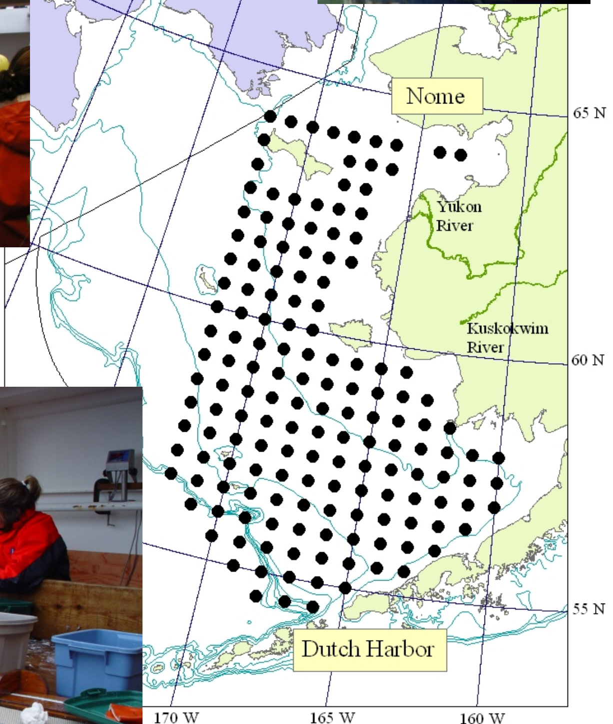
Faster growing sockeye salmon escape predation

First Winter

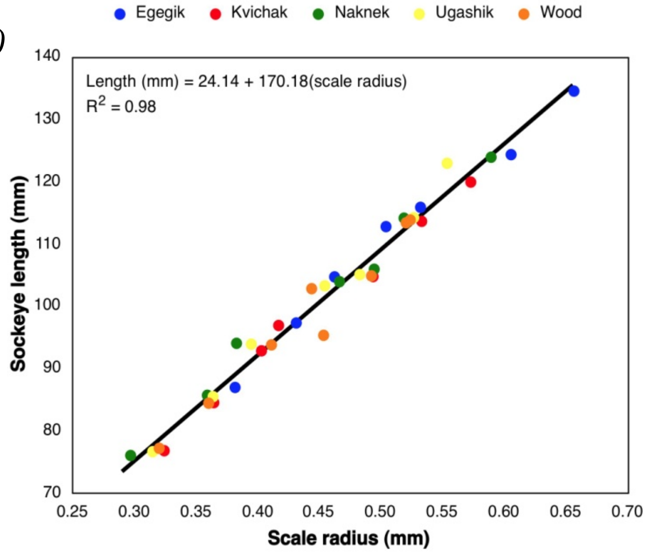
Larger and more energetic sockeye salmon survive winter

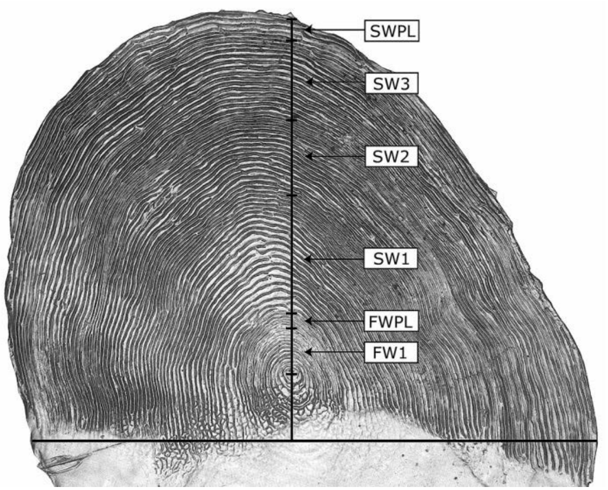
Evidence of Critical Size

Juvenile sockeye salmon surveys
(measure length/collect scales for age and growth)



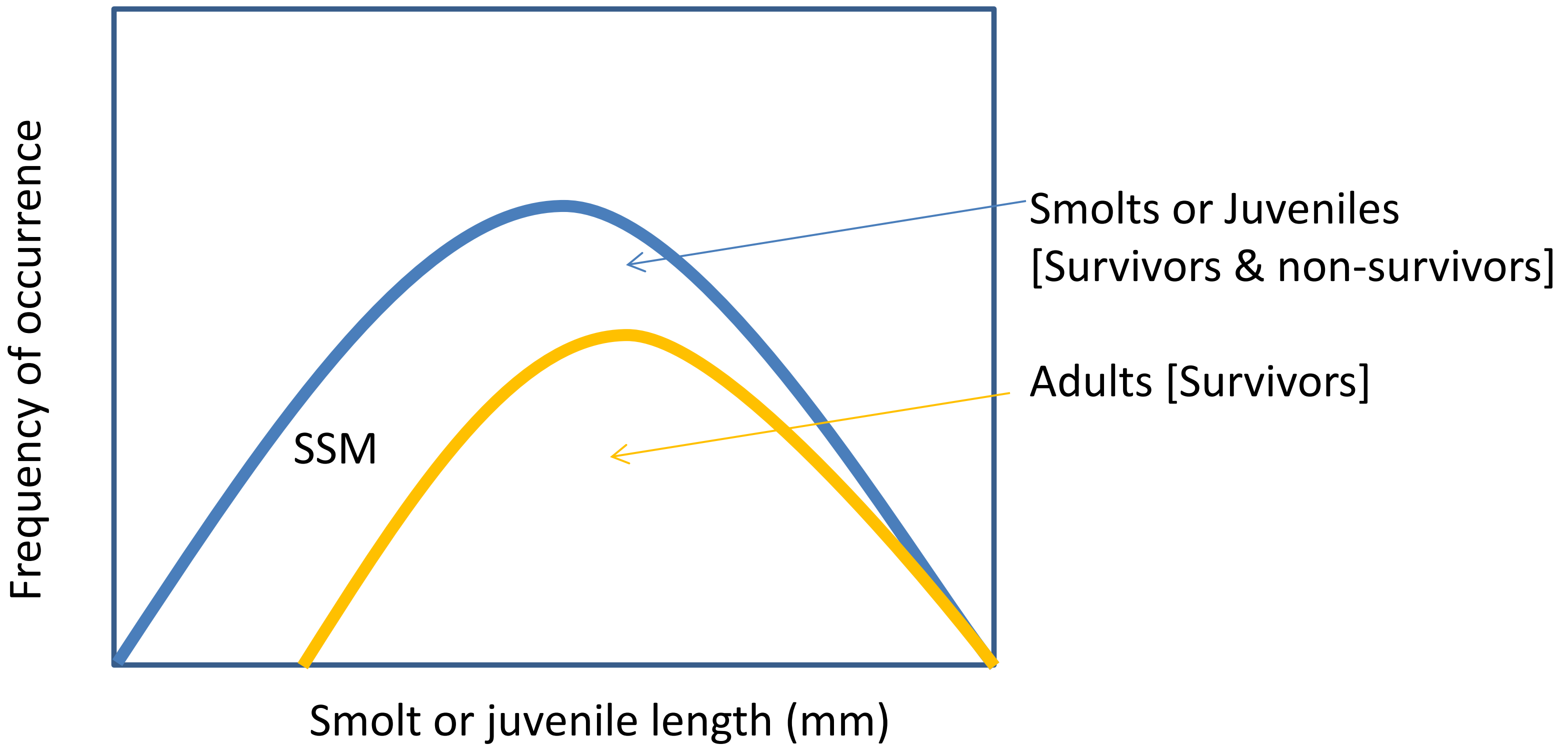
Adult scales to back-calculate length of Juvenile sockeye salmon



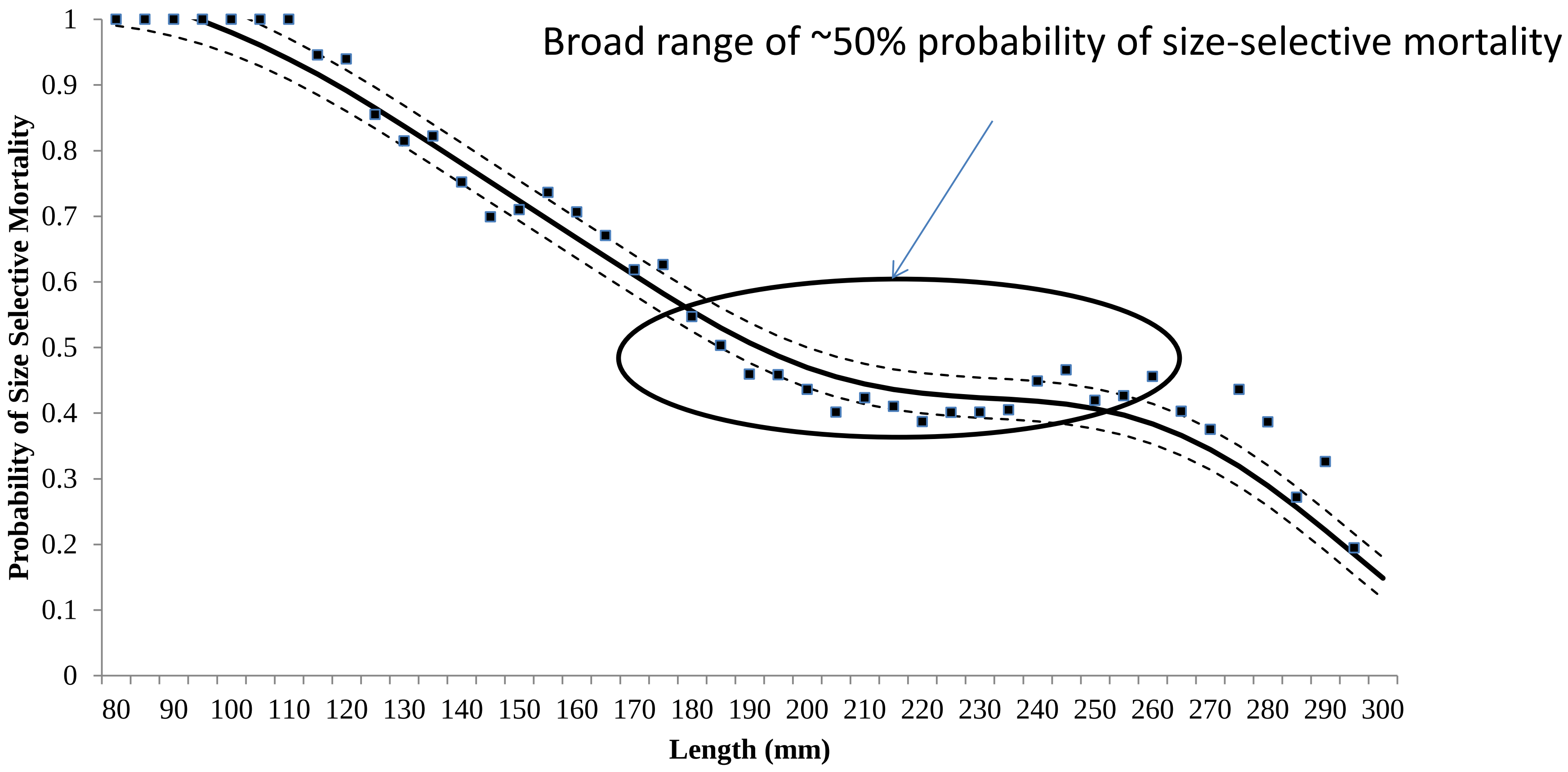


Tracking length-frequency distributions in natural populations.

Probability of survival = $\frac{\text{AUC back-calculated juvenile length}}{\text{AUC observed juvenile length}}$

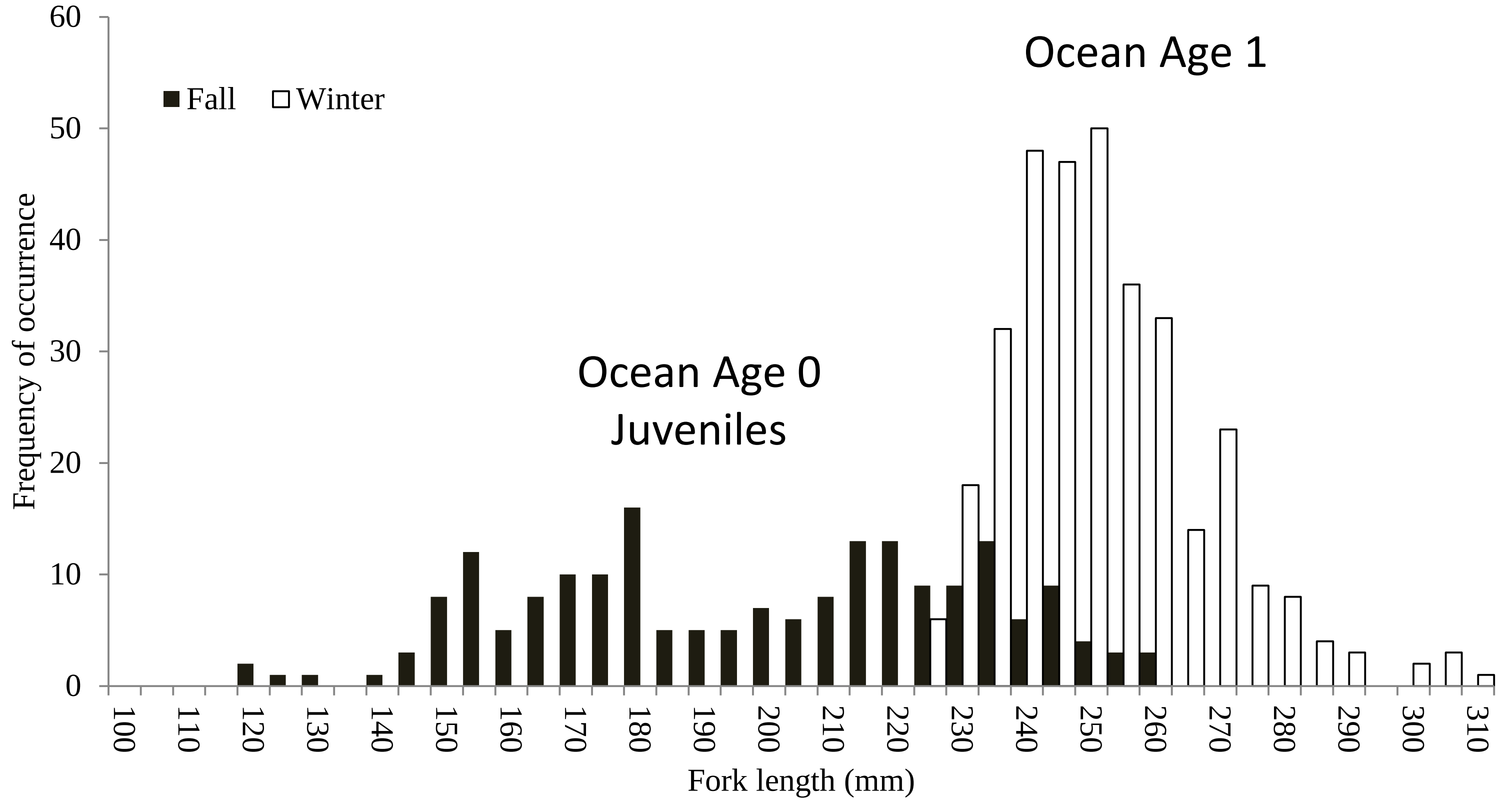


Probability of Size Selective Mortality

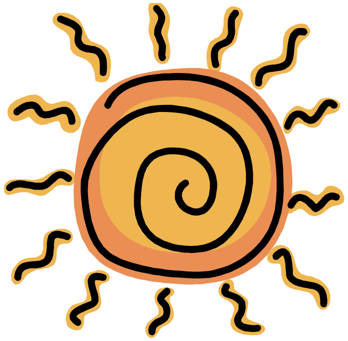


Evidence of Winter Mortality

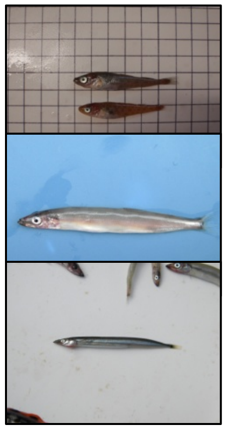
Juvenile Sockeye salmon < 220 mm before winter not likely to survive



Farley et al. – ICES Journal of Marine Science, 68: 1138–1146.



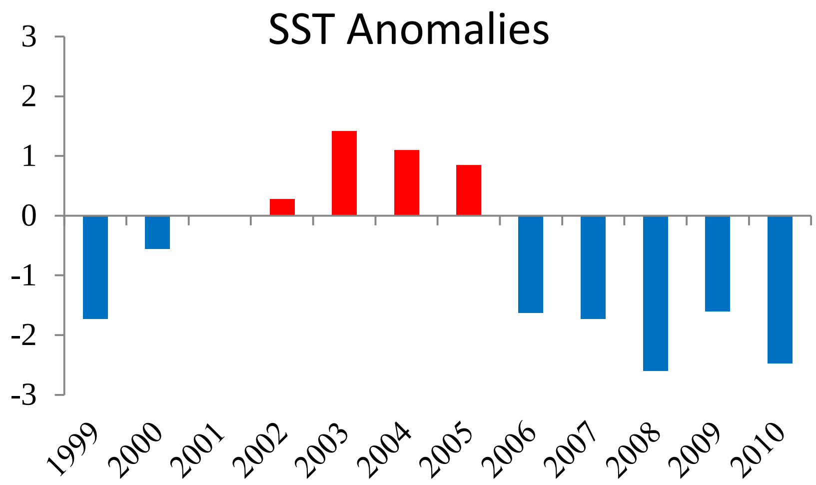
Climate

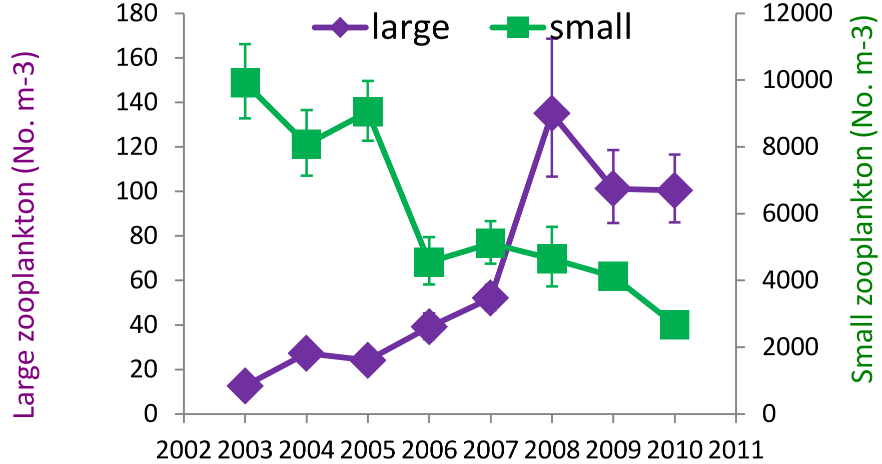


Prey Quality and Quantity

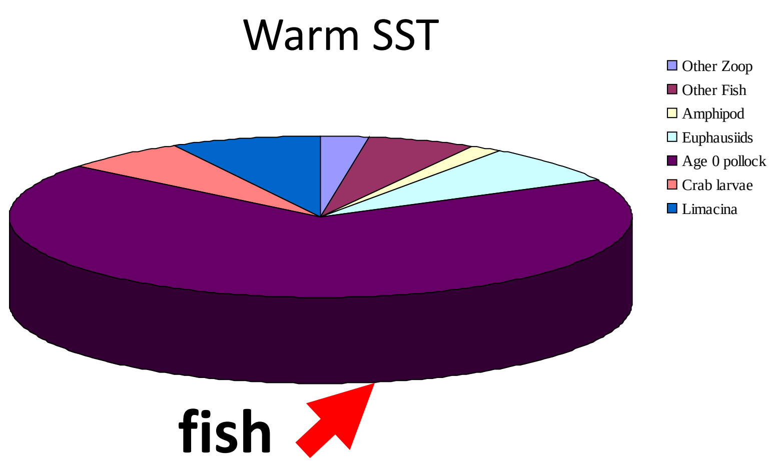
Fish Size and Fitness

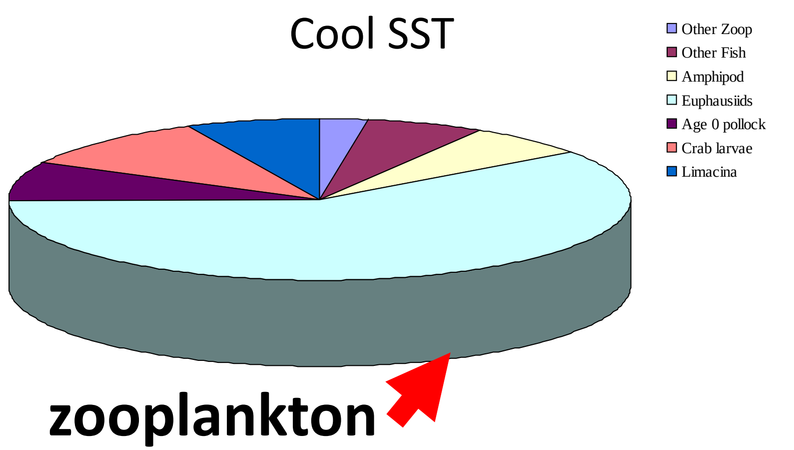
e.g. Bering Sea Climate States and Ecosystem Response



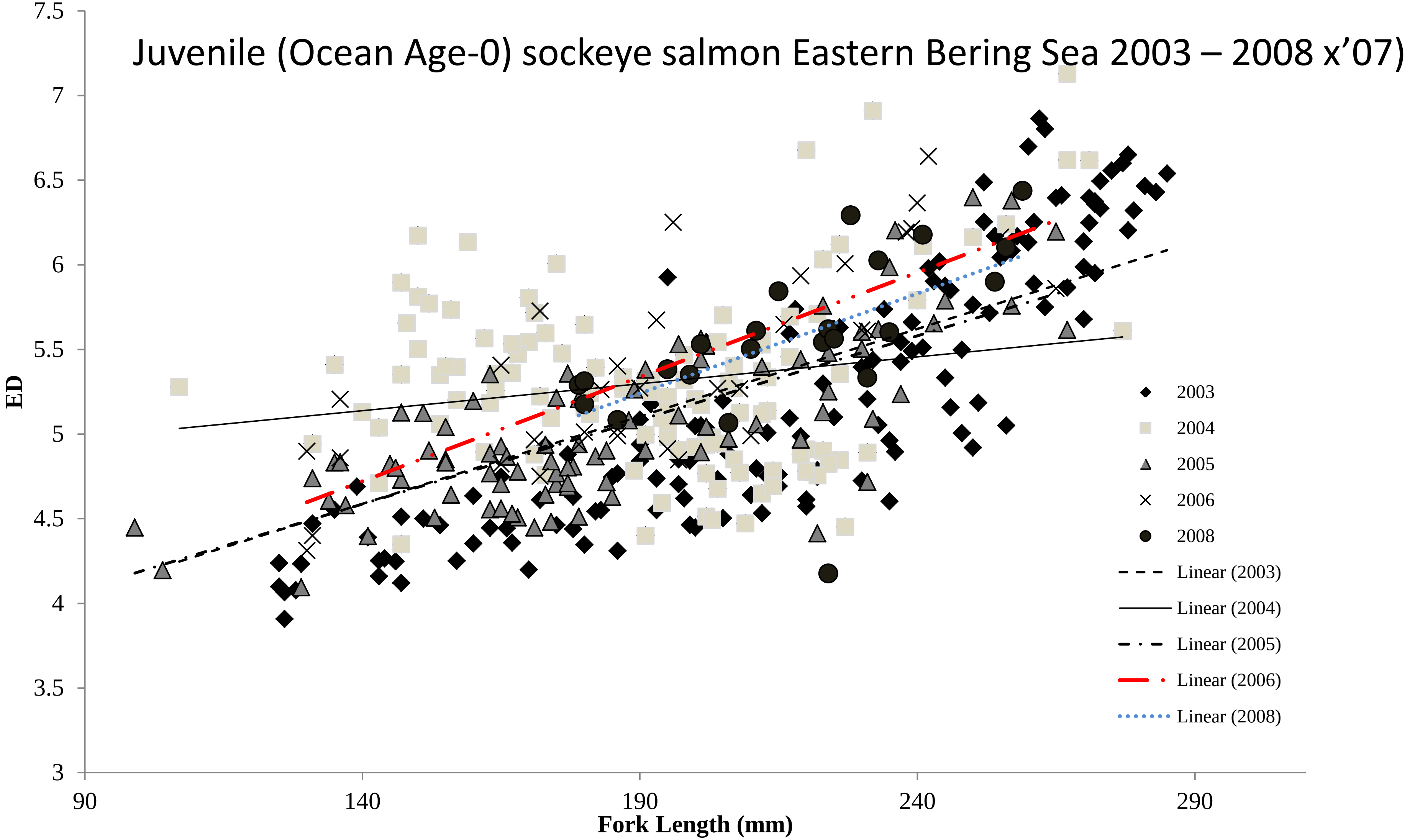


Juvenile Sockeye Salmon Diets

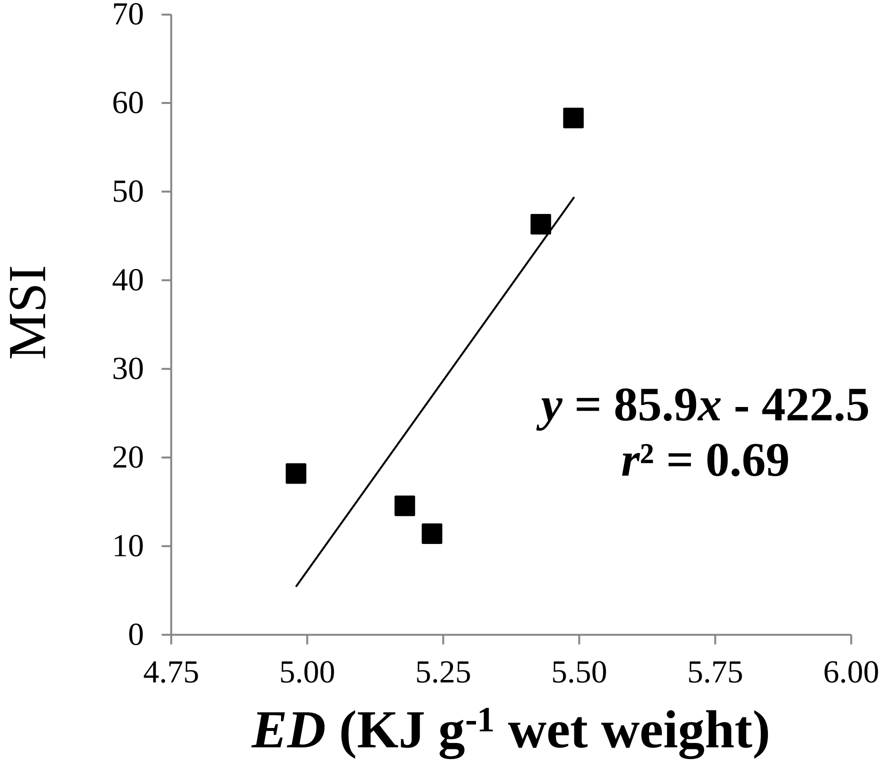




Climate and Fitness



Fitness Related to Marine Survival Index for Sockeye Juveniles (Ocean Age-0) 2003 – 2007 Using Adult Returns 2005 - 2010



Farley et al. 2011

Starvation

Three phases: **GLUCOSE, LIPIDS, PROTEIN**

Phase 1: Animals burn glucose and begin to mobilize stored lipids

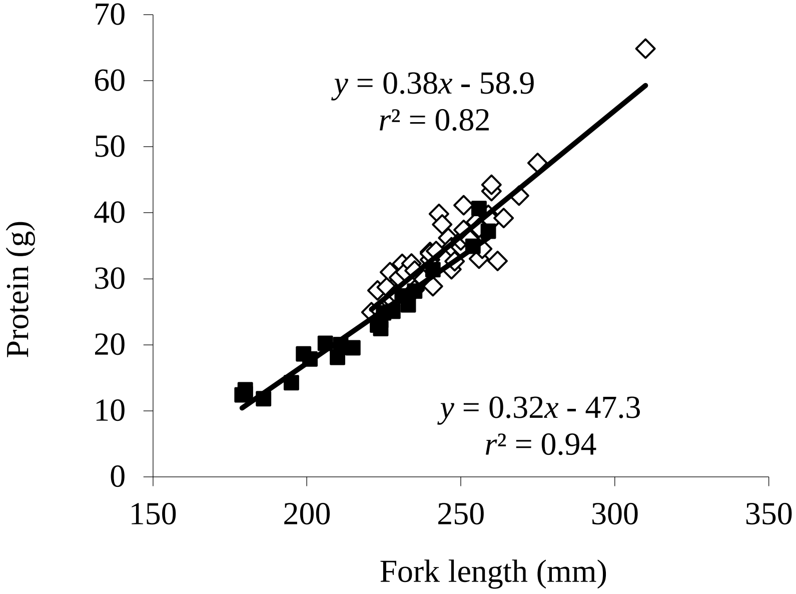
Phase 2: Increased oxidation of lipids and partial sparing of protein. (*animals in this phase are still considered fit enough to survive once prey items are restored*)

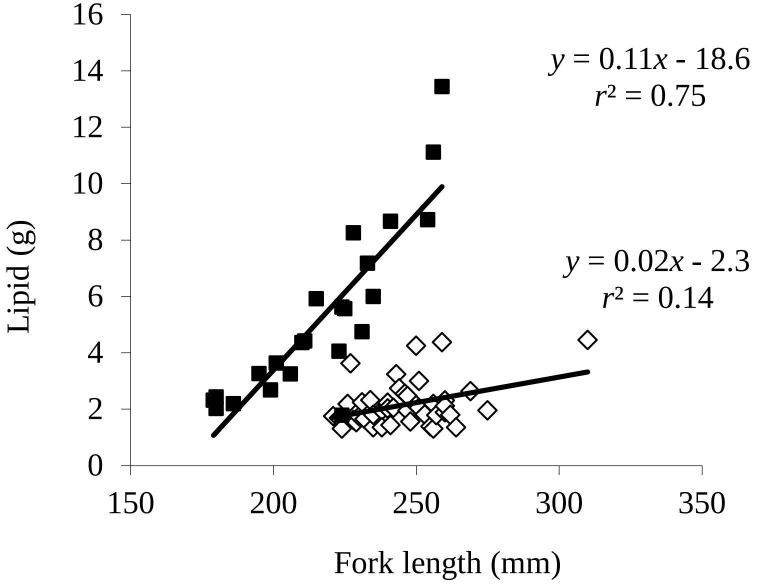
Phase 3: Terminal starvation when 30-50% of the body protein has been used. (***cardiac muscle is one of the first sources of protein utilized and other organs compromised too)***

Castellini and Rea 1992

Sockeye Salmon
Protein and Lipid

Black boxes = juveniles
Clear diamonds = ocean age 1





No evidence of starvation

Farley et al. 2011

COMPETITION

Too Many Salmon in the Sea, Pacific Study Hints

Burgeoning numbers of pink salmon may threaten the food supply of young seabirds.

Pink salmon (shown above spawning in Alaska) have increased since the 1970s, with an estimated 640 million returning to their breeding rivers in Asia and North America in 2009 alone.

PHOTOGRAPH BY PAUL SOUDERS, CORBIS

Springer et al. PNAS

By James Owen
for National Geographic

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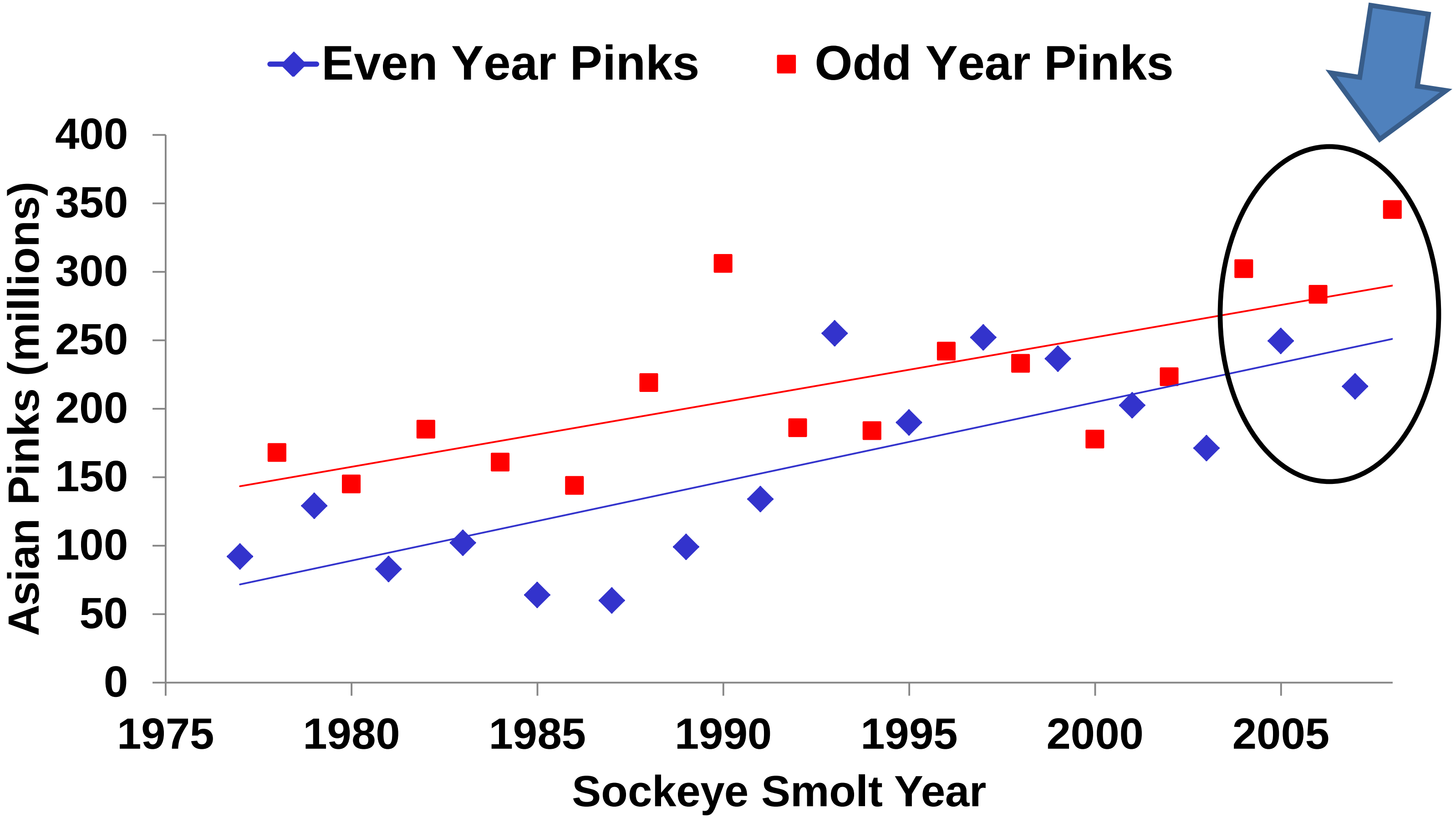
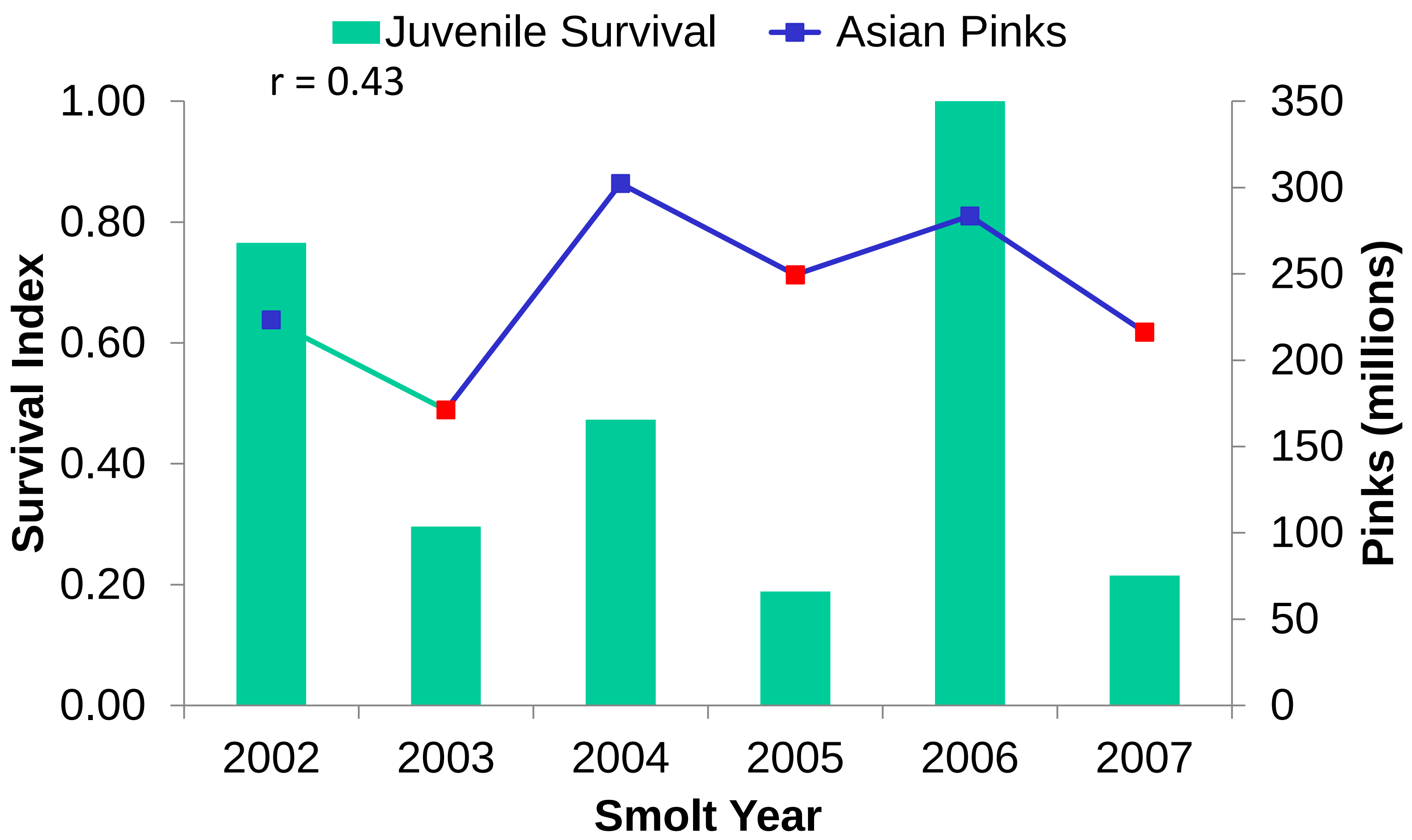
Trends in Asian Pink Salmon Abundance 1977-2008

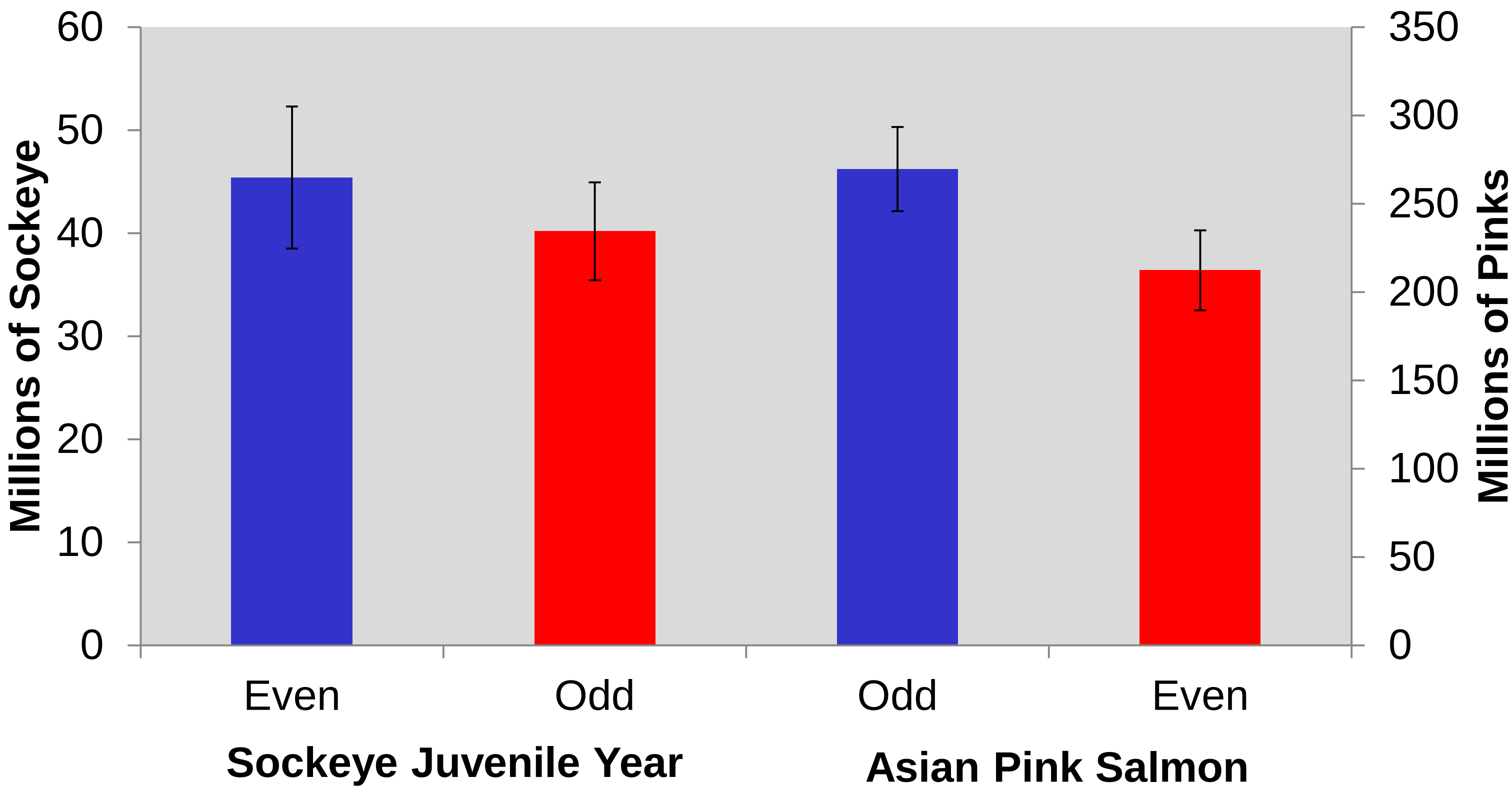


After Ruggerone et al. (2010), Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science, Number 2010:306-328. 2010. See also Rogers (2001)

Sockeye Juvenile Survival Index and Associated Asian Pink Abundance



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



Wertheimer in prep.

Conclusions

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The End

Bristol Bay Region