Effects of Pink Salmon on Growth, Age, and Survival of Fraser River Sockeye Salmon and Western Alaska Chinook Salmon

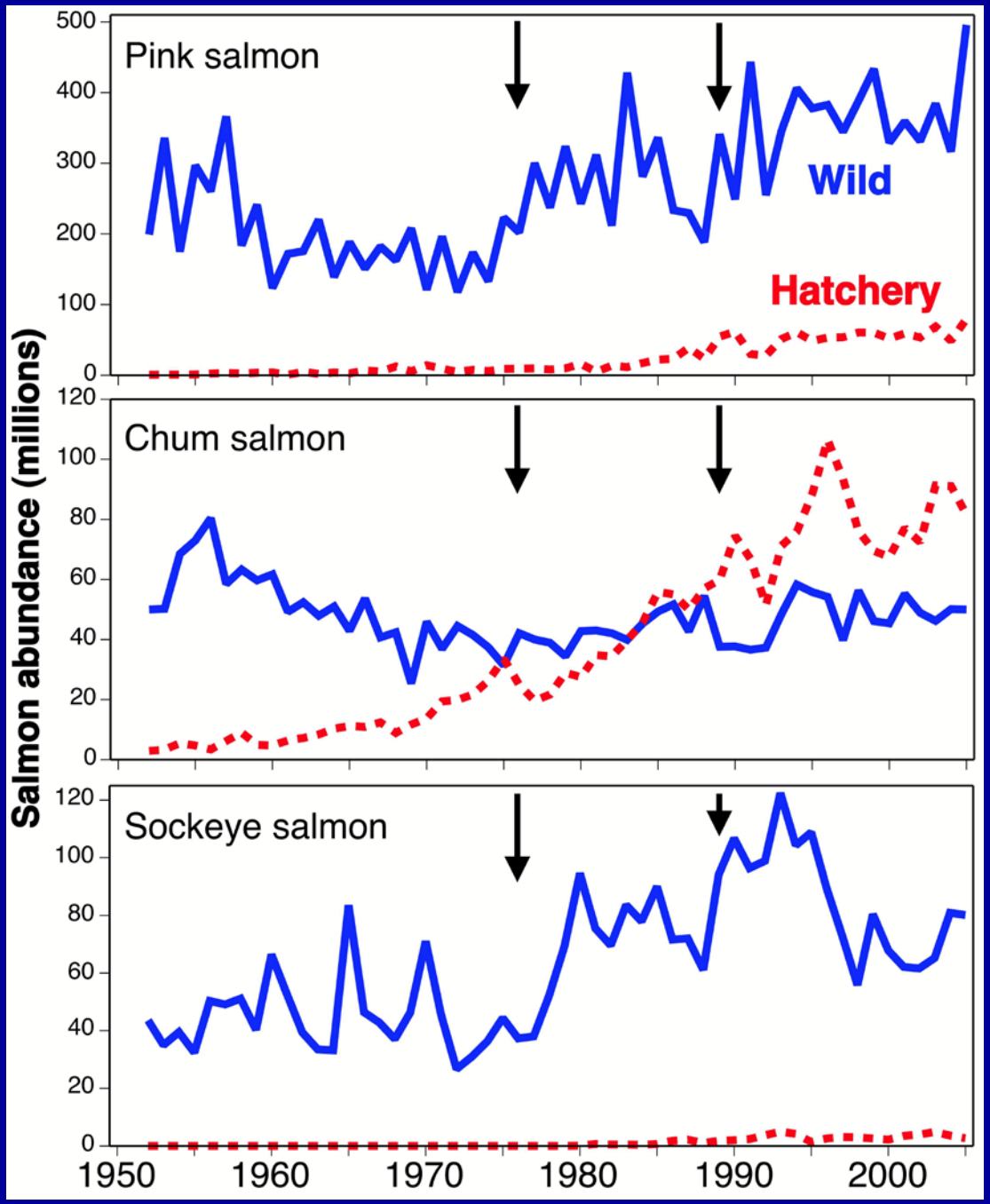
Pink Chum Workshop 2012
Juneau, AK

Greg Ruggerone (NRC)
Bev Agler (ADFG)

Support: NPRB, AKSSF

Wild and hatchery salmon trends in North Pacific Ocean

- Wild pinks 5.6x wild chum & 4.2x wild sockeye
- 1977/78 ocean regime shift

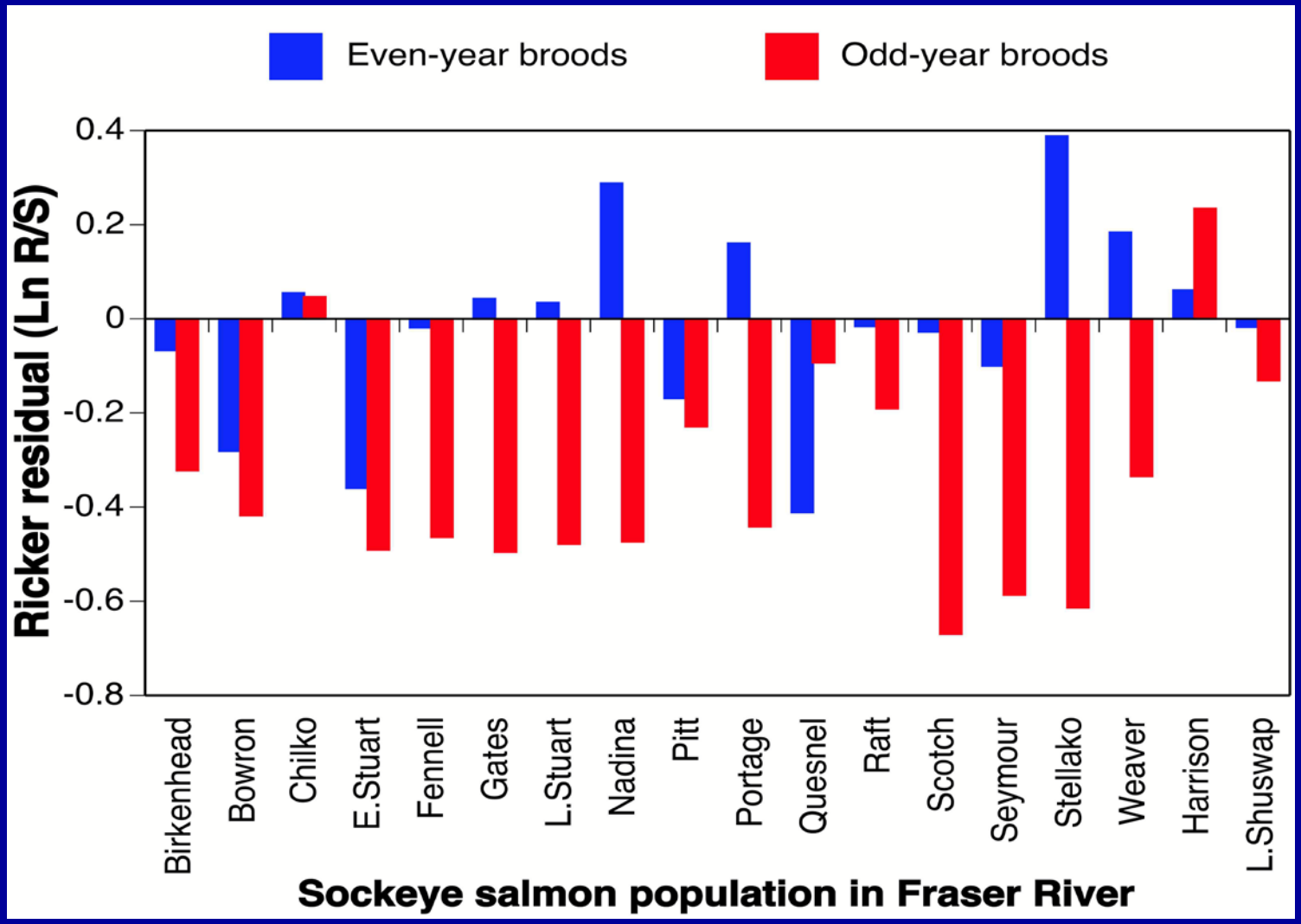


Ruggerone et al. 2010

Evidence for Pink Salmon Interactions

- Bristol Bay sockeye salmon vs. Asian pink salmon
  - Reduced adult length-at-age & growth beginning 2nd yr at sea
  - Reduced smolt-to-adult survival (26% to 46% depending on smolt age)
  - Reduced adult abundance (22% decline from even vs. odd smolts)
  - Increased ocean age (delayed maturation)
  - Increased forecast error
  - Odd-yr pinks 39x more abundant than even-yr pinks in Bering Sea
- See literature reviews
  - Ruggerone & Nielsen 2004, Ruggerone et al. 2009
- Fraser sockeye (today)
- Nushagak Chinook (today)

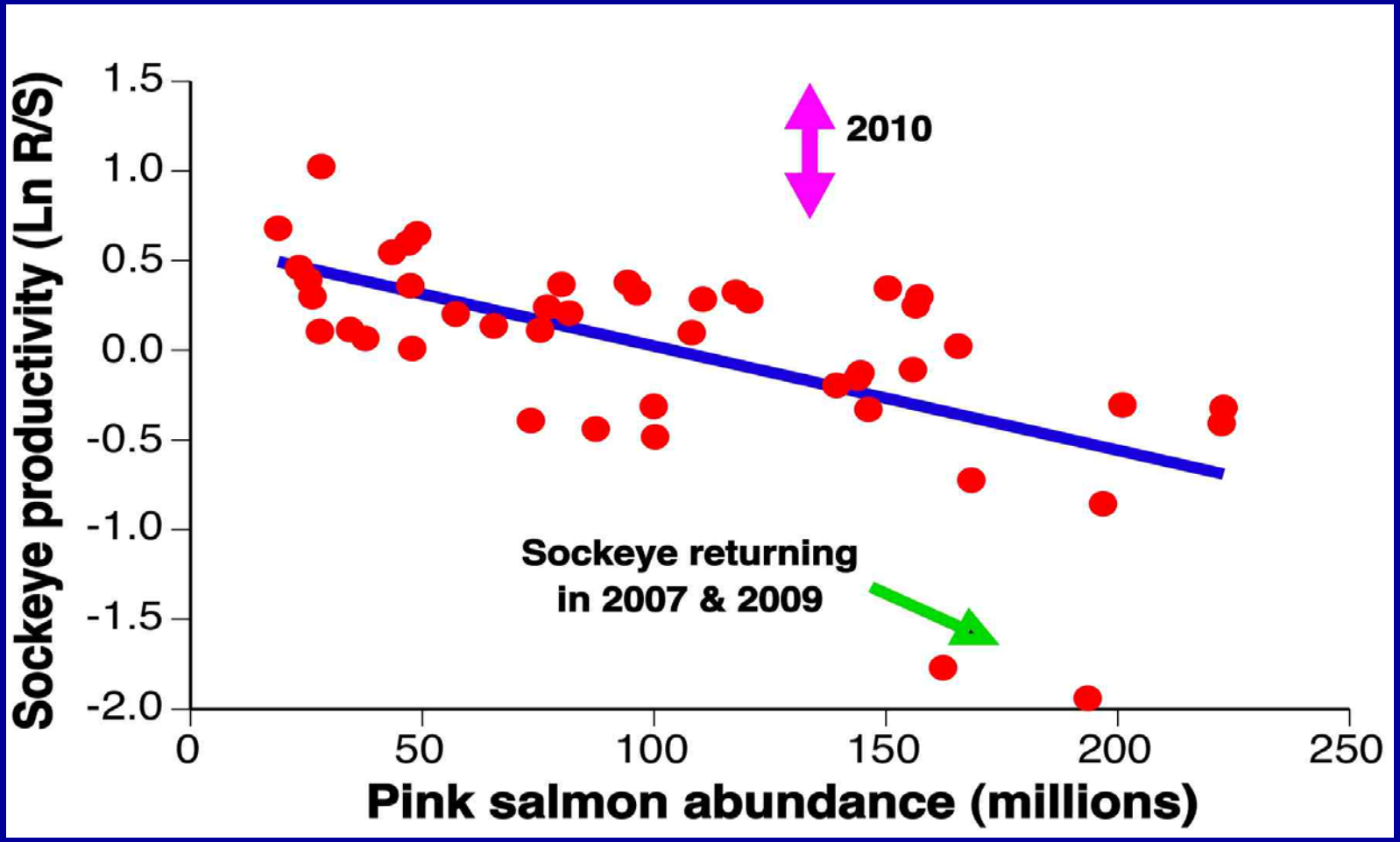
Reduced Fraser Productivity from Odd-year Broods, 1979-2005



ANOVA, $P < 0.001$

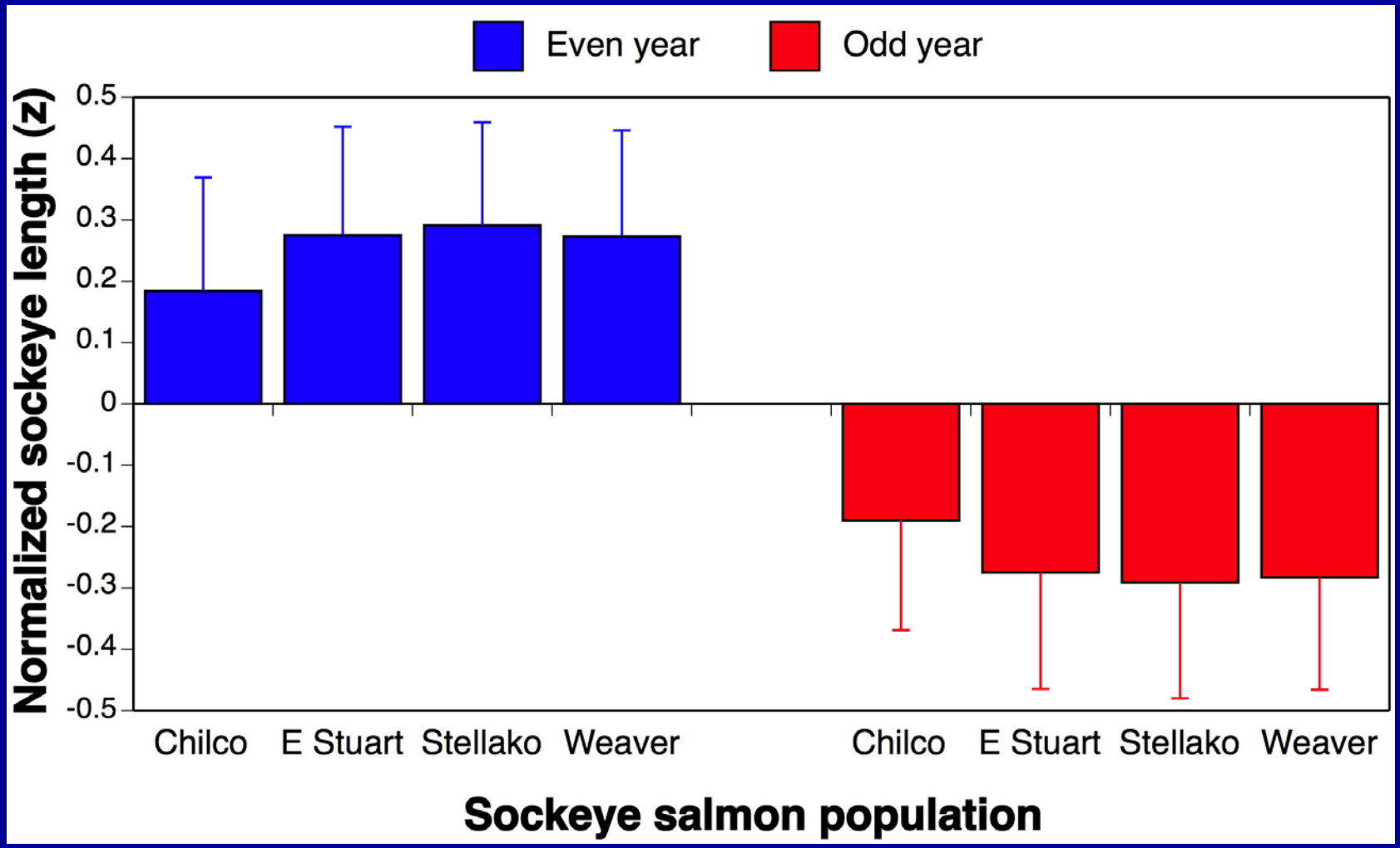
Fraser Sockeye Productivity vs. North American Pink Abundance

(Ricker residuals)



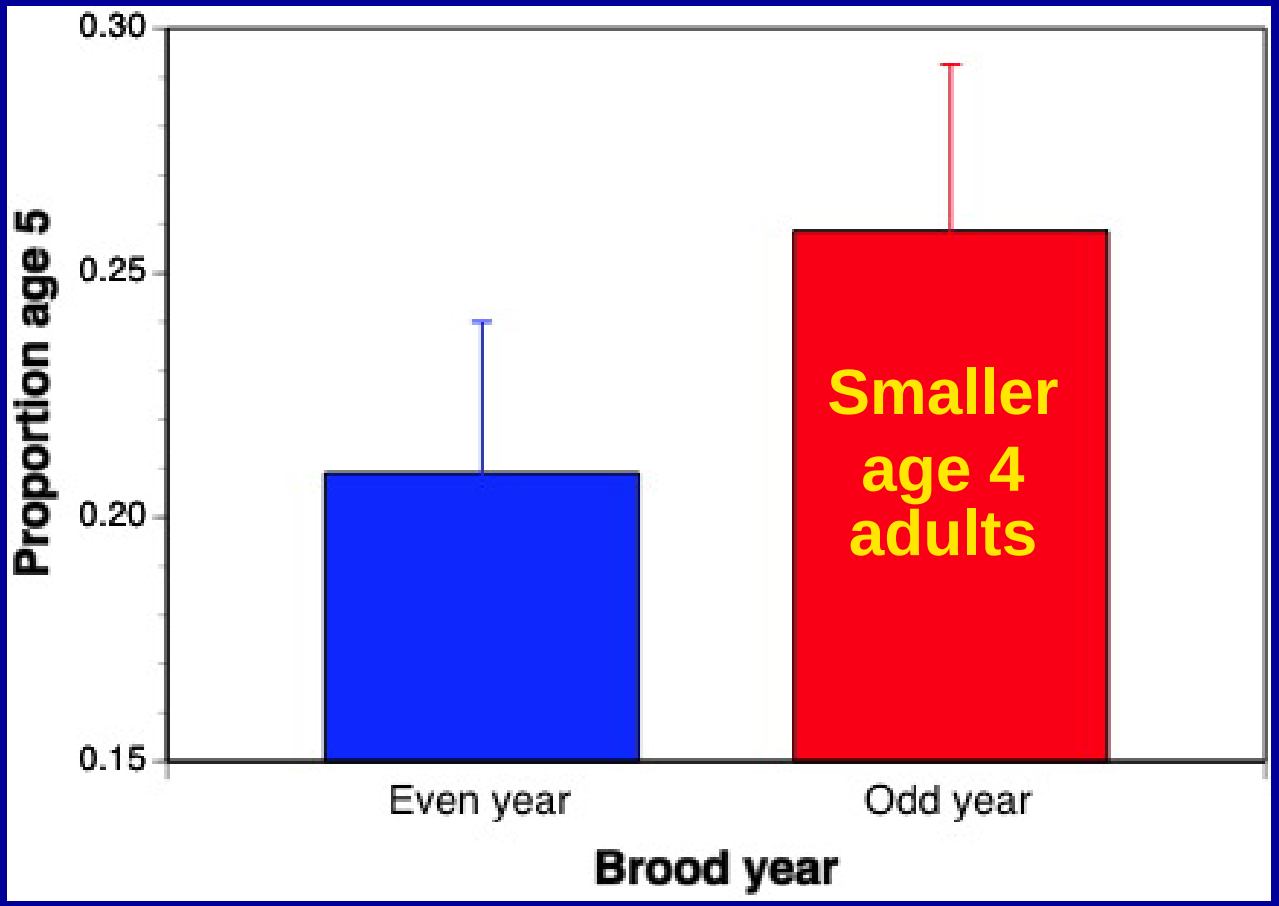
16 sockeye stocks (excl. Harrison & Shuswap) BY 1961-2005

Fraser Sockeye Length (age 1.2)



Years: 1953-2009

Fraser Sockeye Age at Maturation

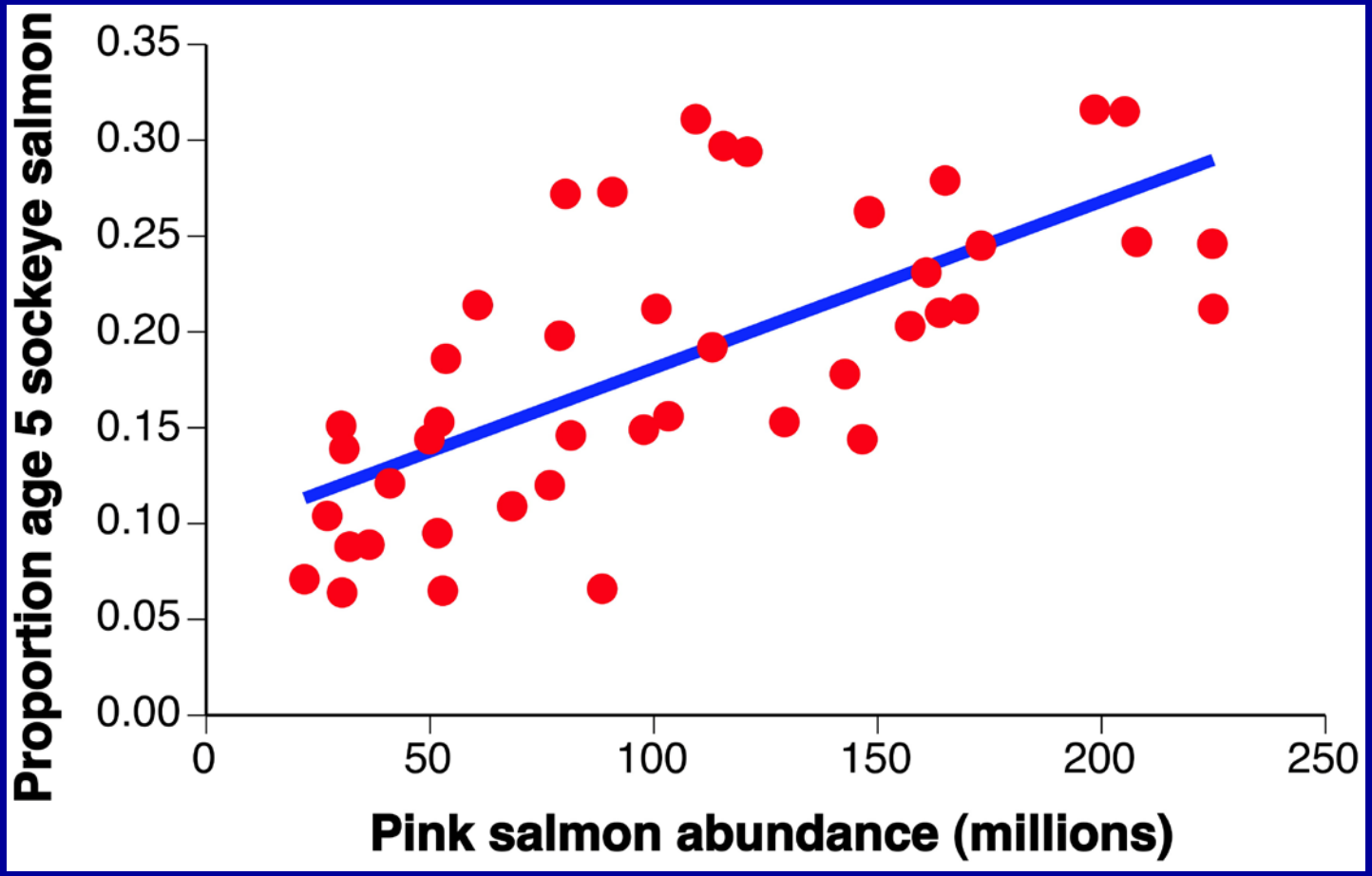


Odd-year broods: lower productivity, reduced growth, delayed maturation

Same pattern in Bristol Bay

1979-2004
All Fraser stocks

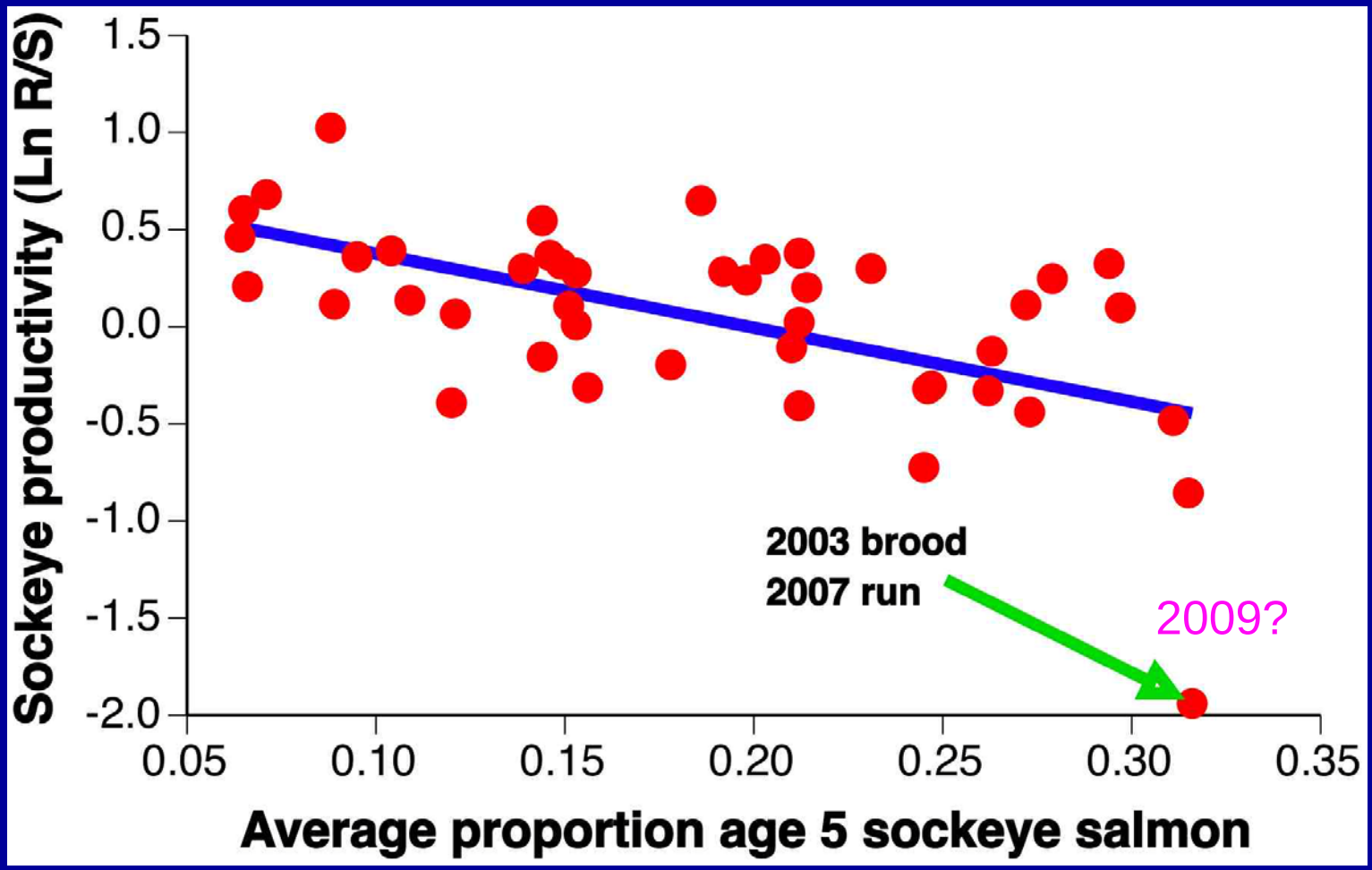
Age at Maturation Increases with Pink Salmon Abundance



Mean of 16 sockeye stocks
BY 1961-2004

Same pattern in Bristol Bay

Fraser Sockeye Productivity Declines with Age



Same pattern in Bristol Bay

Predicted Effect of Pink Salmon on Fraser Sockeye

Based on previous regression & assumed 1 million spawners

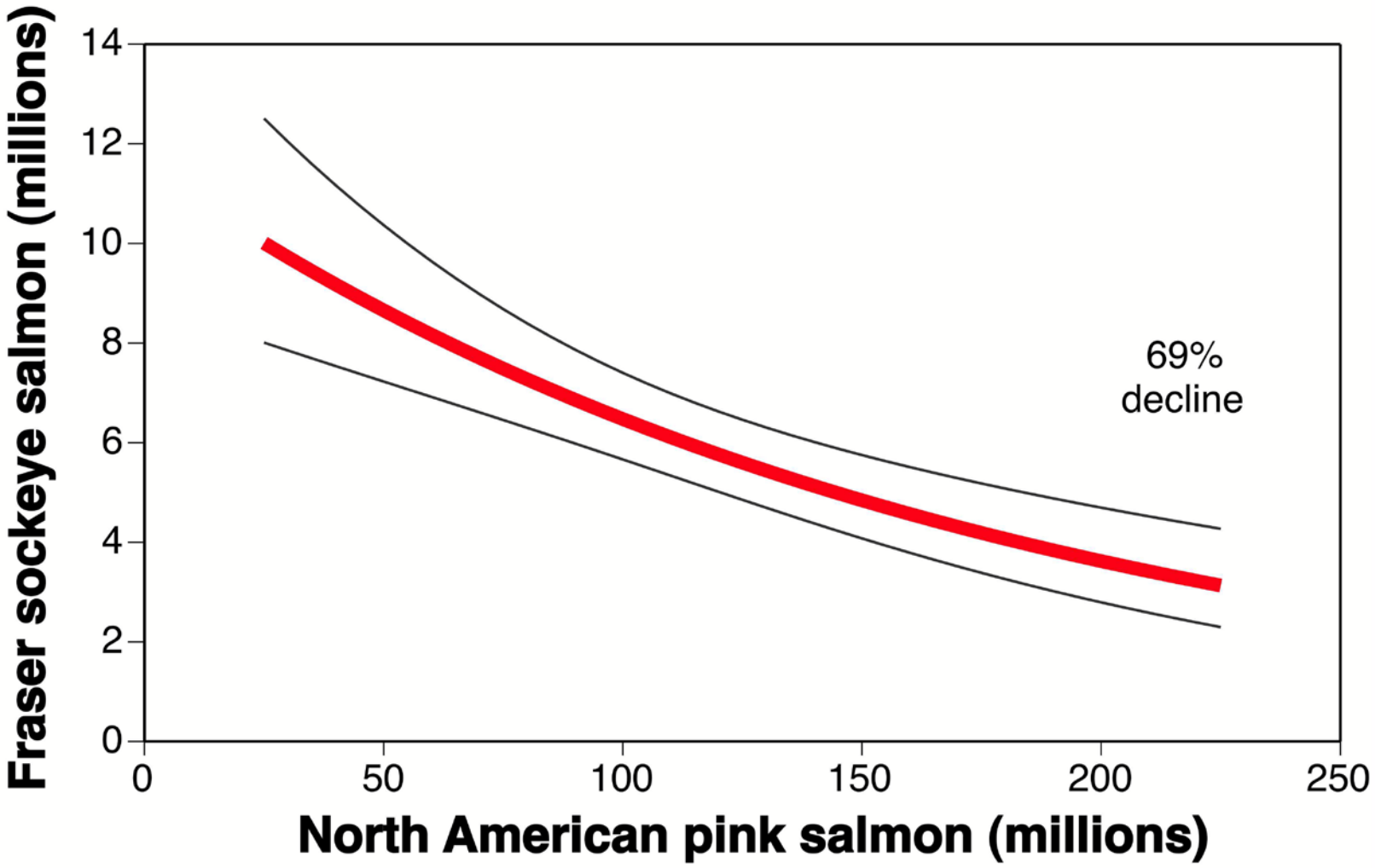
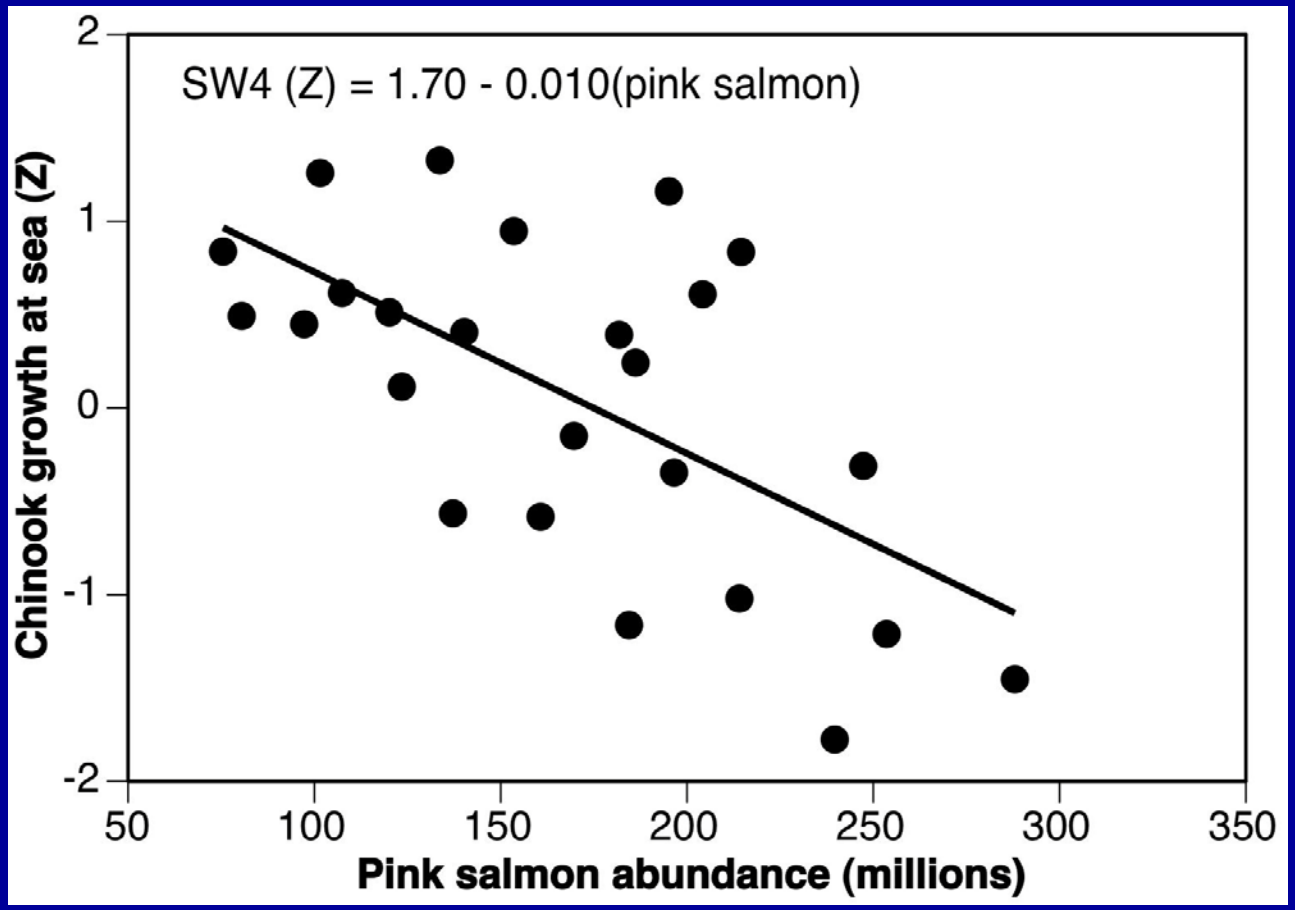


Photo by A. Solonsky

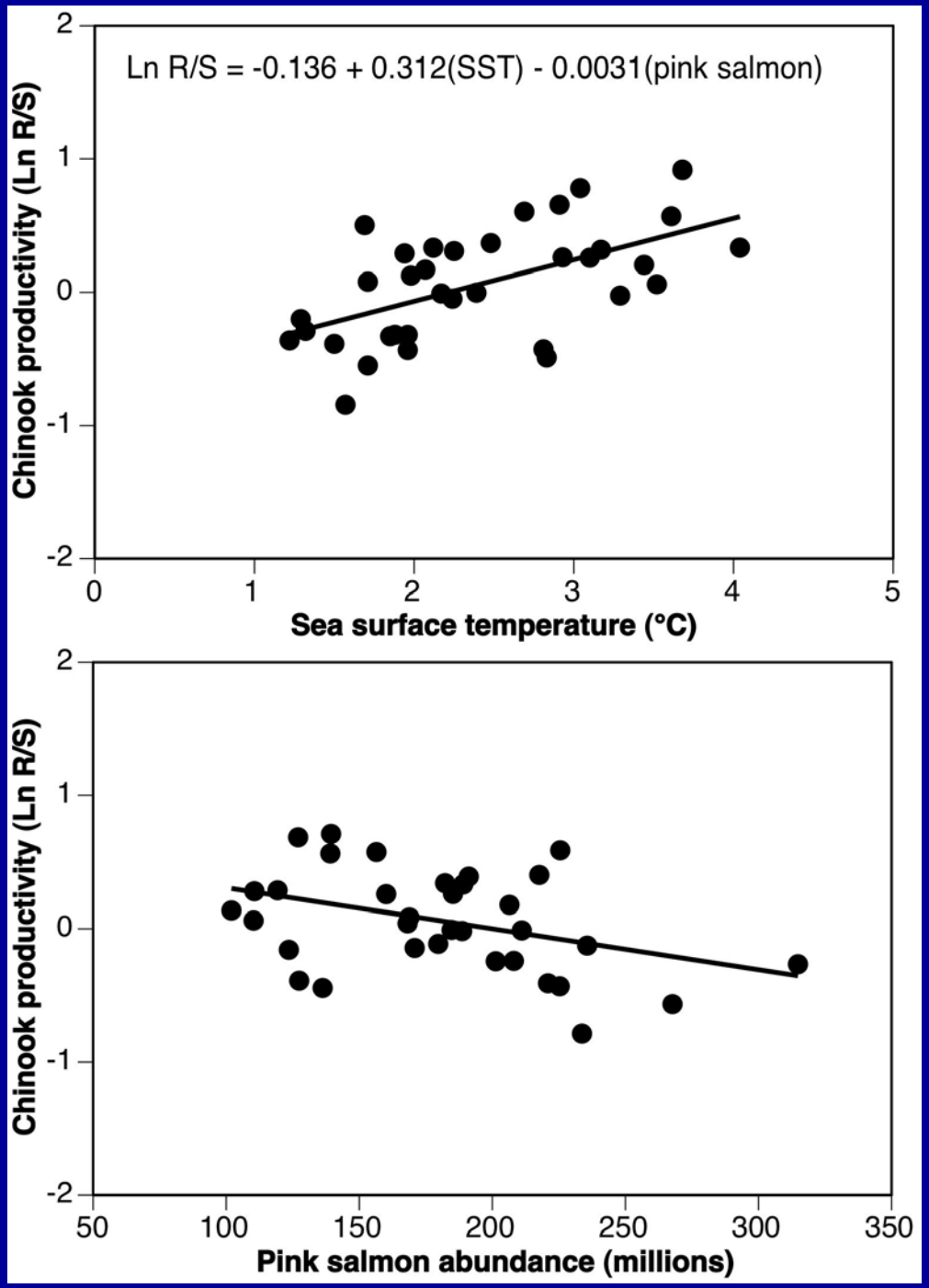
Nushagak Chinook Interactions with Russian Pink Salmon

Salmon Comparisons Across Large Ecosystems (SCALE)

Chinook Growth vs. Pink Salmon Abundance



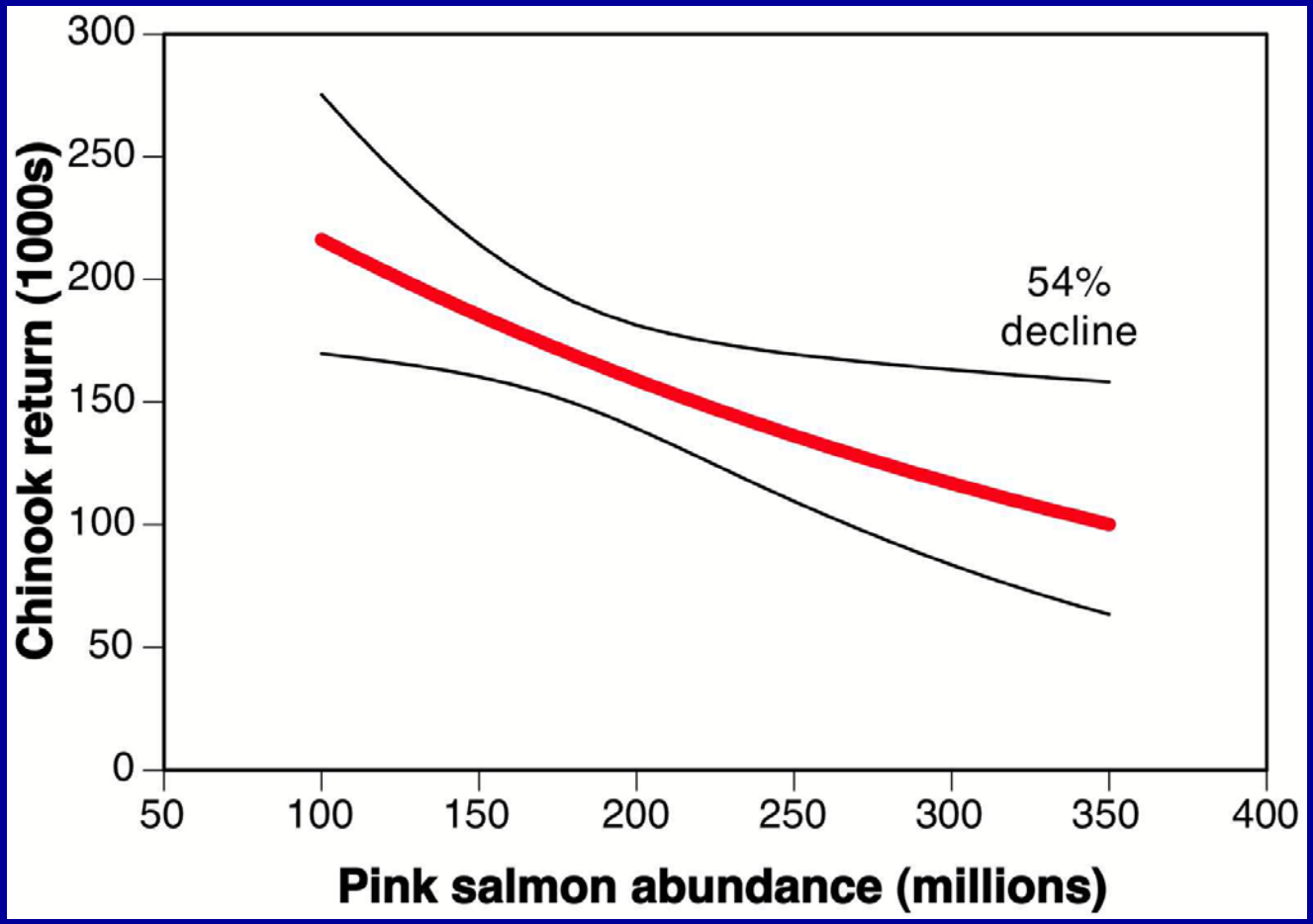
4th yr at sea (1975-2006): r = -0.56 3rd year: r = -0.56
Adult length-at-age: r = -0.42



Chinook Productivity vs. SST and Pink Salmon Abundance

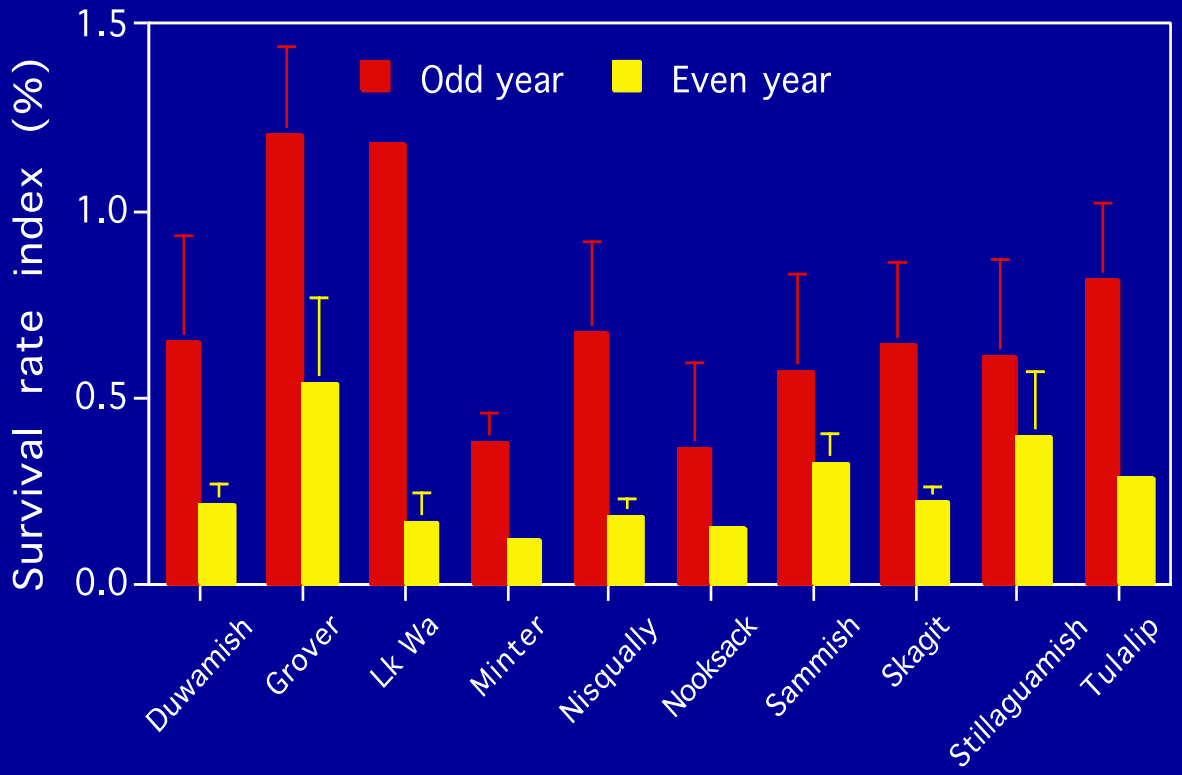
Productivity is the residual from Ricker curve, BY 1970-2004

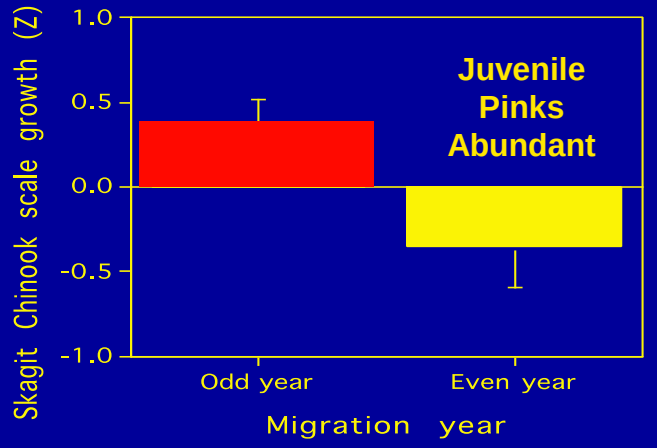
Pink Salmon Effect on Nushagak Chinook Returns



Based on multi-variate model; SST held at mean

Puget Sound Chinook Survival 62% Lower when Migrating in Even Years w/ Pinks 1984-1997



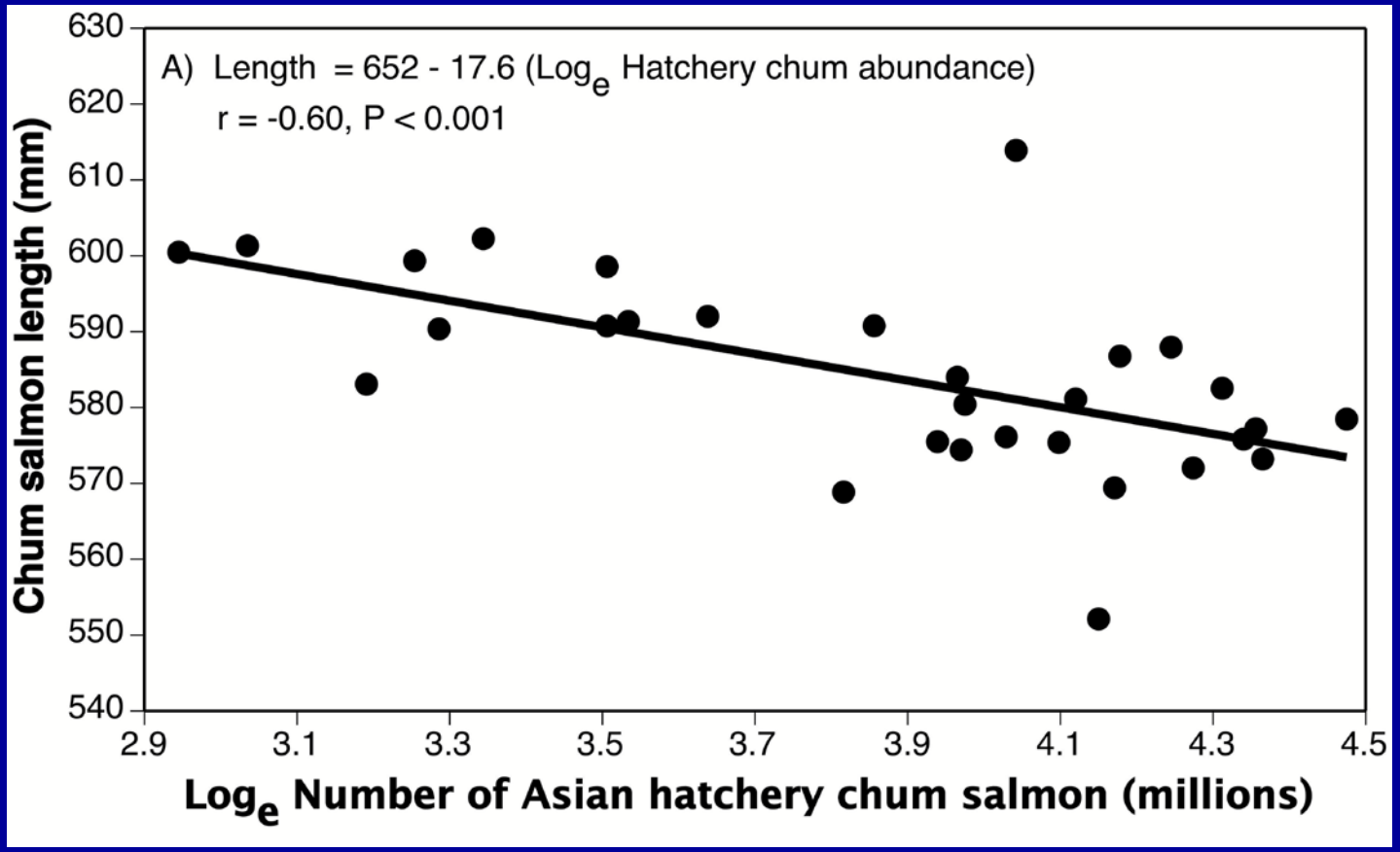


Ruggerone and Goetz 2004; survival based on recoveries of code-wire-tags

END

(supplemental slides follow)

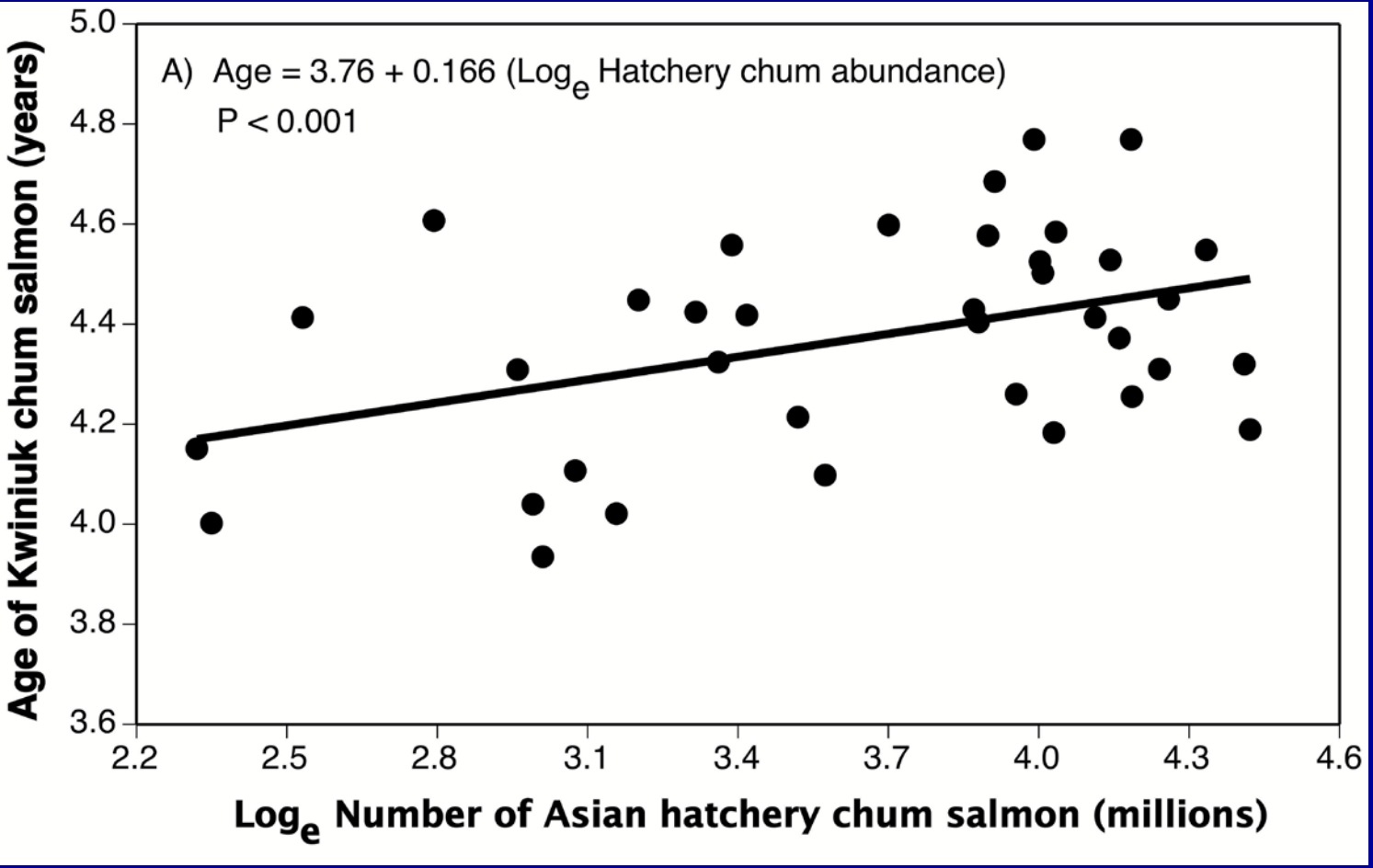
Norton Sound Chum Length-at-age declined with greater Asian Hatchery Chum Abundance, 1974-2005



Length is mean of age 0.3 & 0.4 chum salmon

Ruggerone et al. 2011 (Env. Biol. Fishes online)

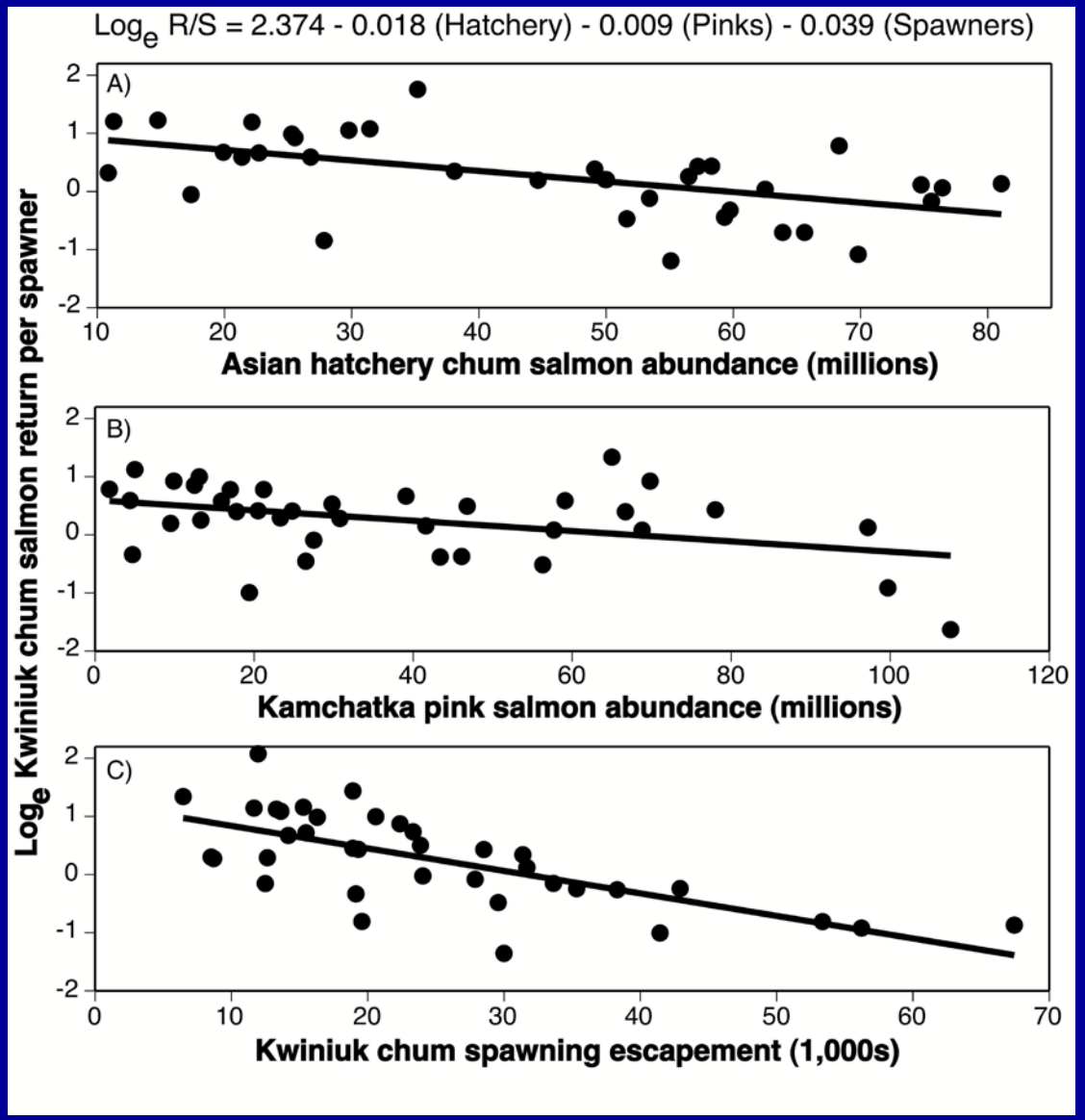
Norton Sound Chum Age Increased with Greater Asian Hatchery Chum Abundance



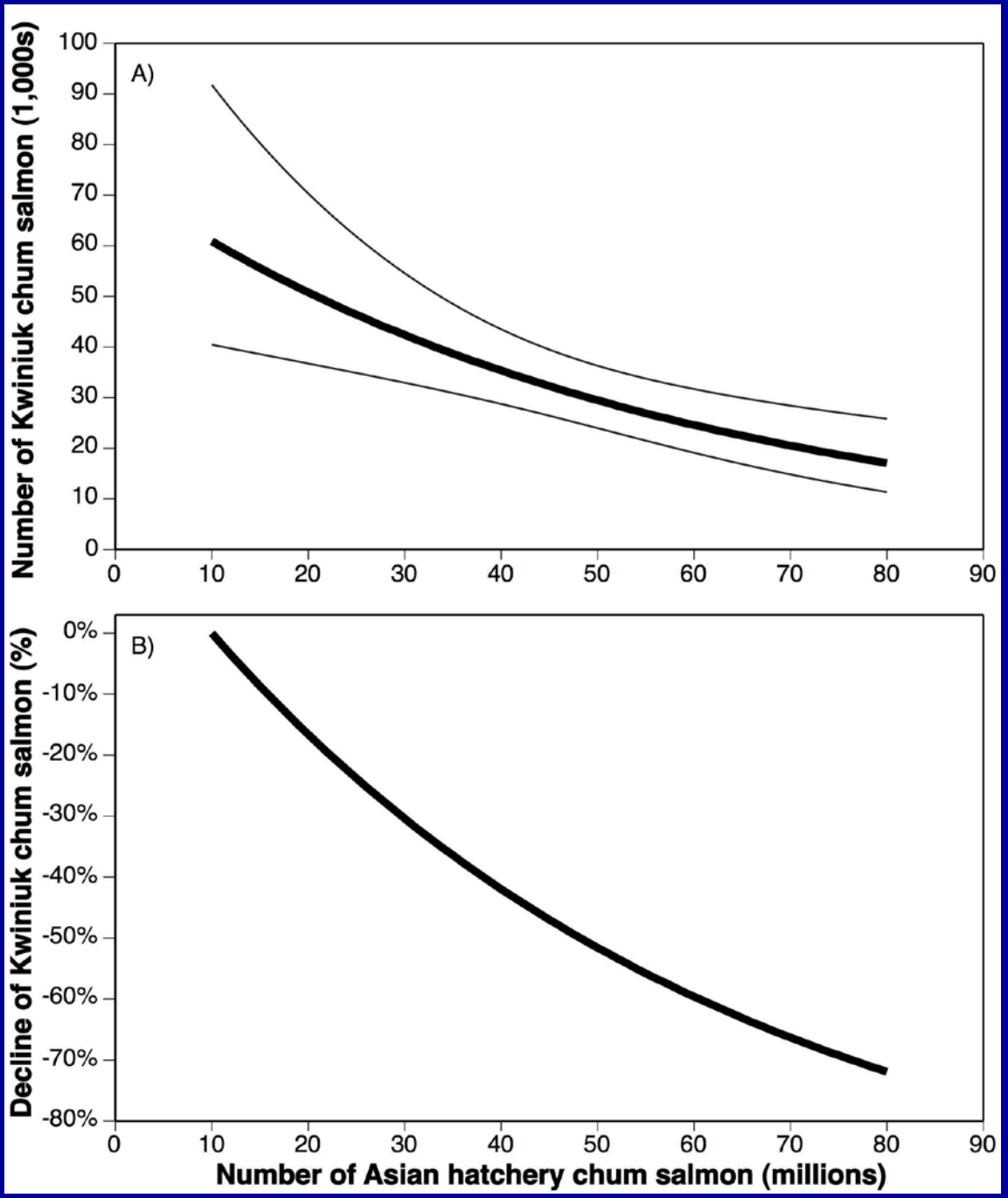
Similar relationship with hatchery and wild chum

Ruggerone et al. 2011 (EBF online)

Norton Sound Chum R/S vs. Asian Chum & Asian Pink Salmon Abundance, brood years 1965-2001



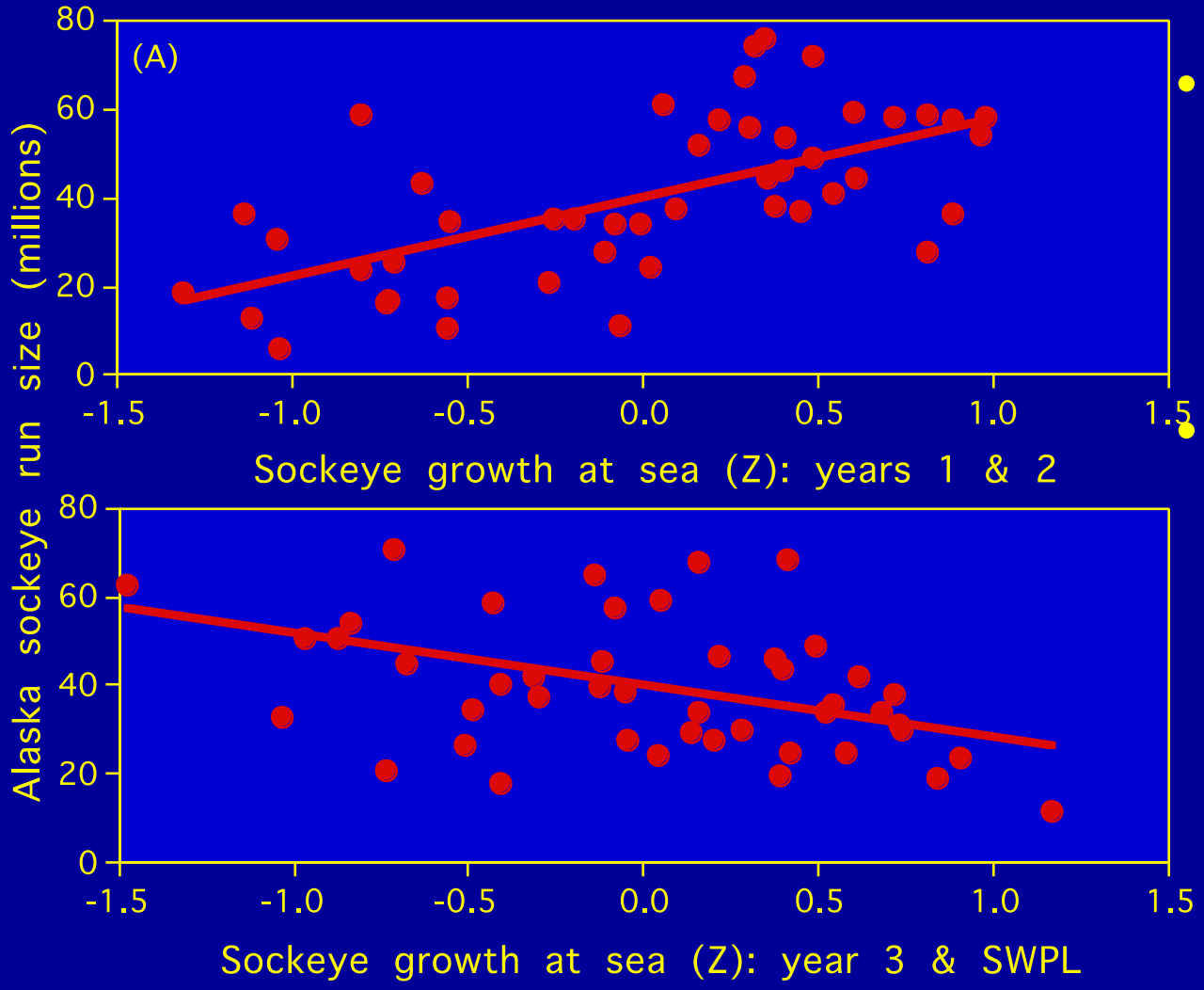
Ruggerone et al. 2011 (EBF online)



Effect of Asian hatchery chum salmon on abundance of Kwiniuk chum salmon abundance (Norton Sound).

Relationships based on multivariate model shown previously (other variables held constant at mean value). Ruggerone et al. 2011 (EBF online)

Alaska Sockeye Run Size v. Growth at Sea, 1955-2001



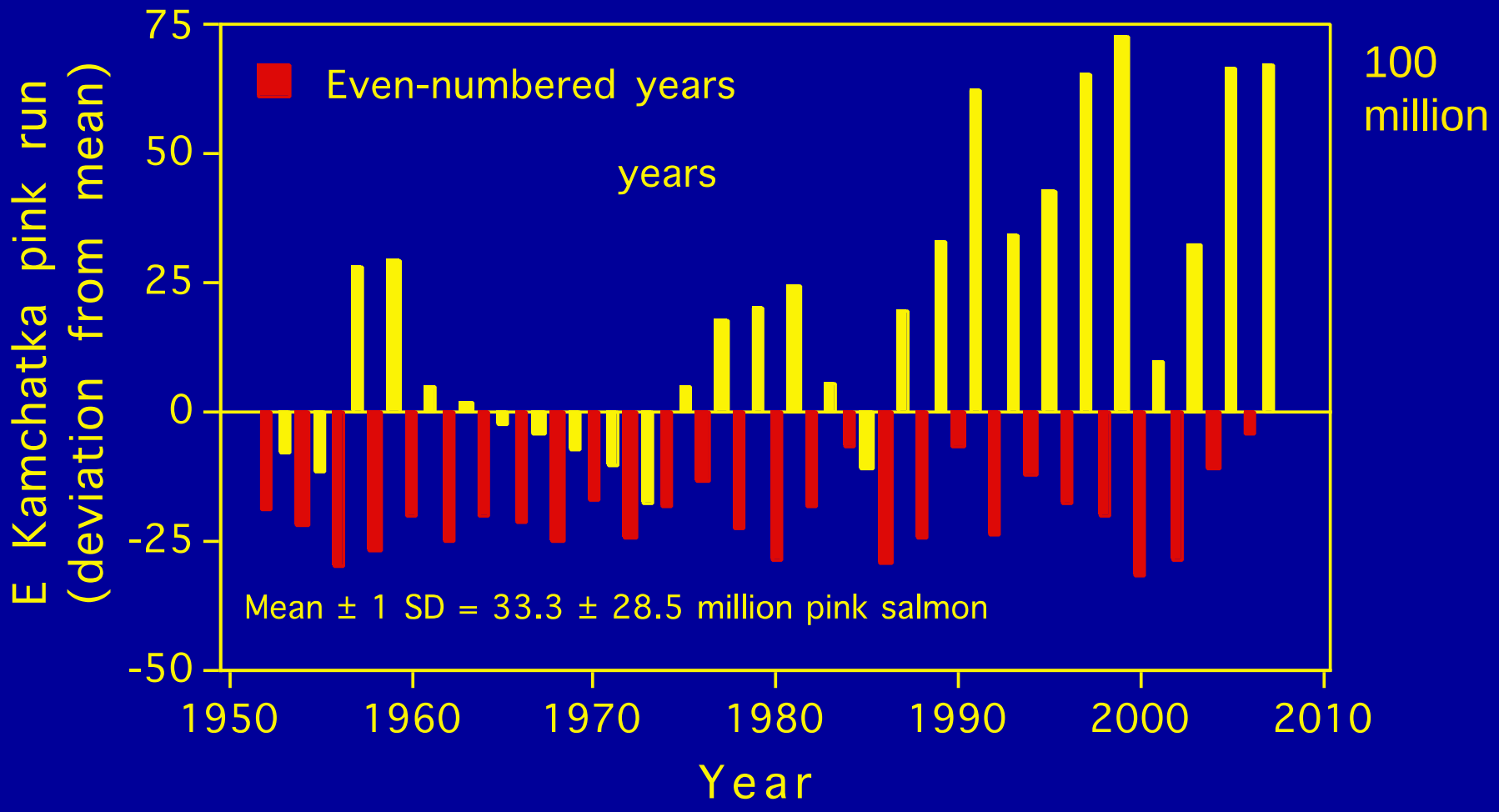
- Early marine growth was most important to survival (R/S).
- Density-dependence more apparent late life.

$y = 2.46 + 17.88(SW1\&2) - 11.78(SW3\&SWPL) - 13.91(pink\ index) + 12.18(SST)$, $R^2 = 0.56$

Ruggerone et al. 2007

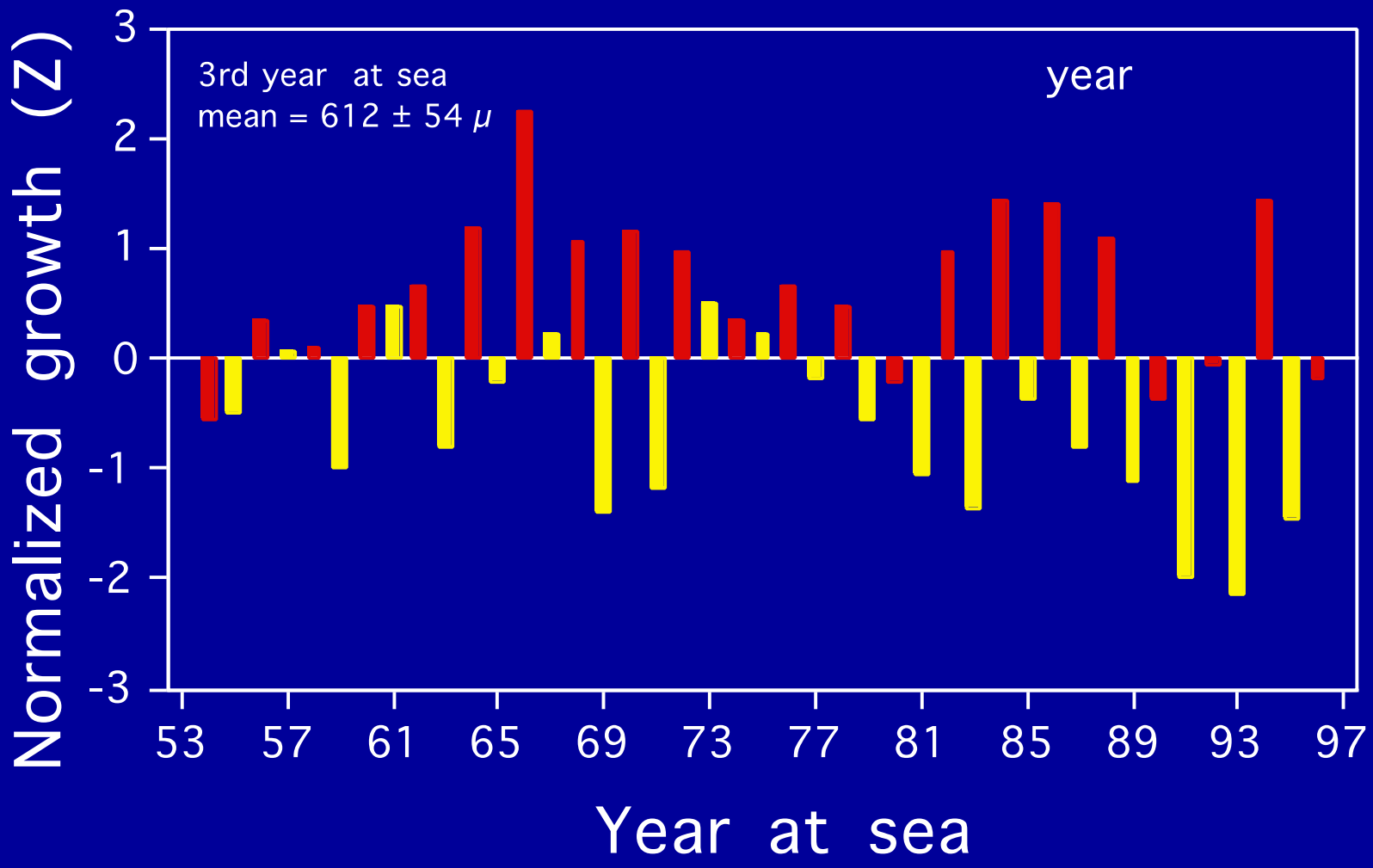
Eastern Kamchatka Pink Salmon Runs, 1952-2007

Natural Experimental Control



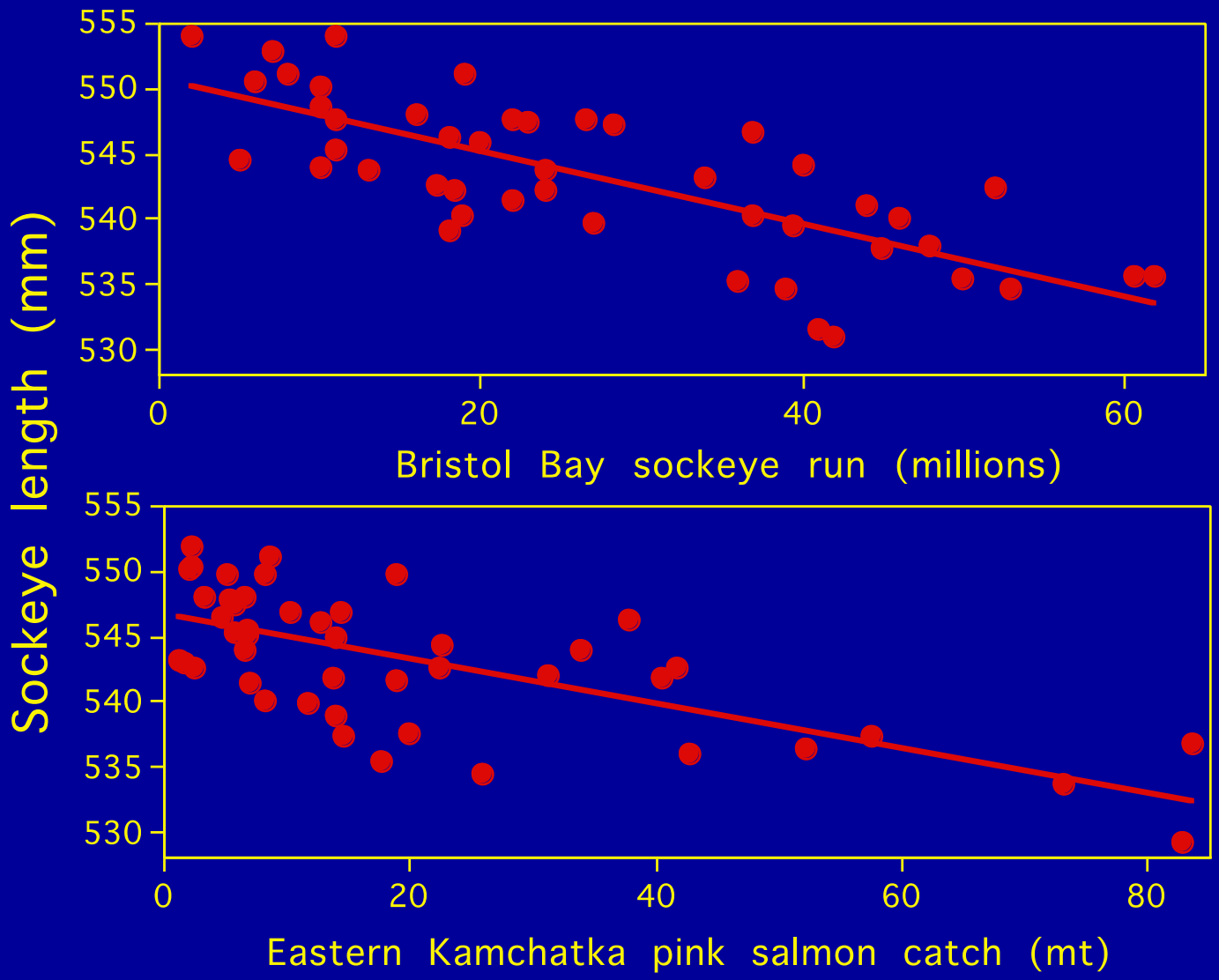
Odd-year pink salmon 39x more abundant in central Bering Sea (Davis et al. 2005)

Sockeye growth reduced during odd years at sea (2nd & 3rd yrs)



Ruggerone et al. 2003

Sockeye Length vs. Sockeye & Pink Abundance, 1958-2003

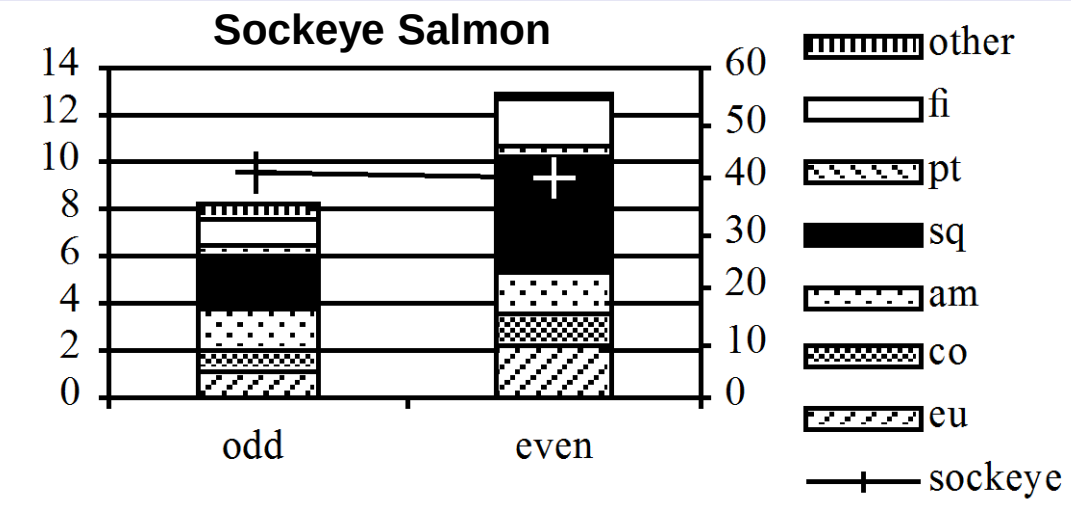


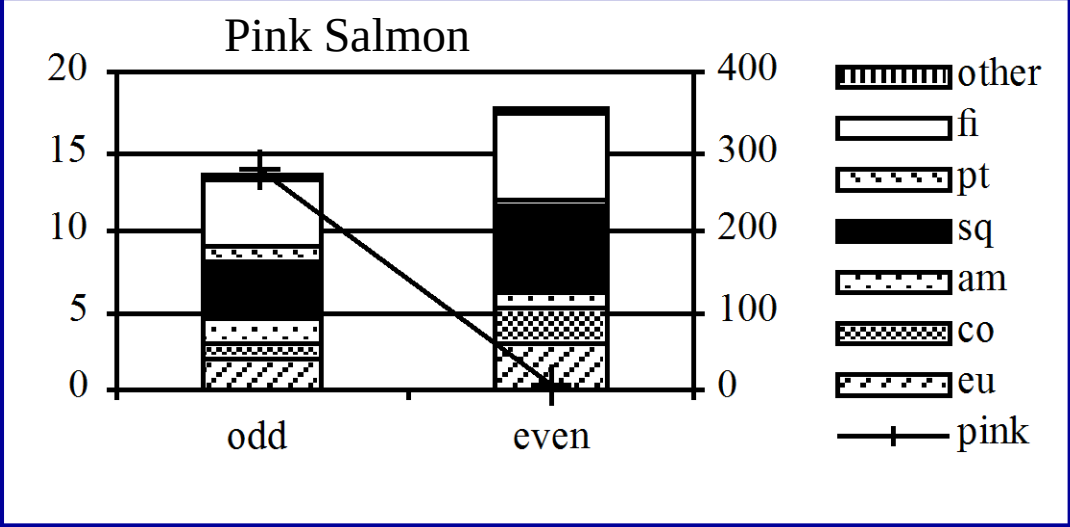
L (mm) = 550.0 - .275(sockeye) - .170(pink) + 10.3(period: 77-88) + 4.4(period: 89-03)

Ruggerone et al. 2007

Sockeye & Pink Salmon Diet in Bering Sea, 1991-2000

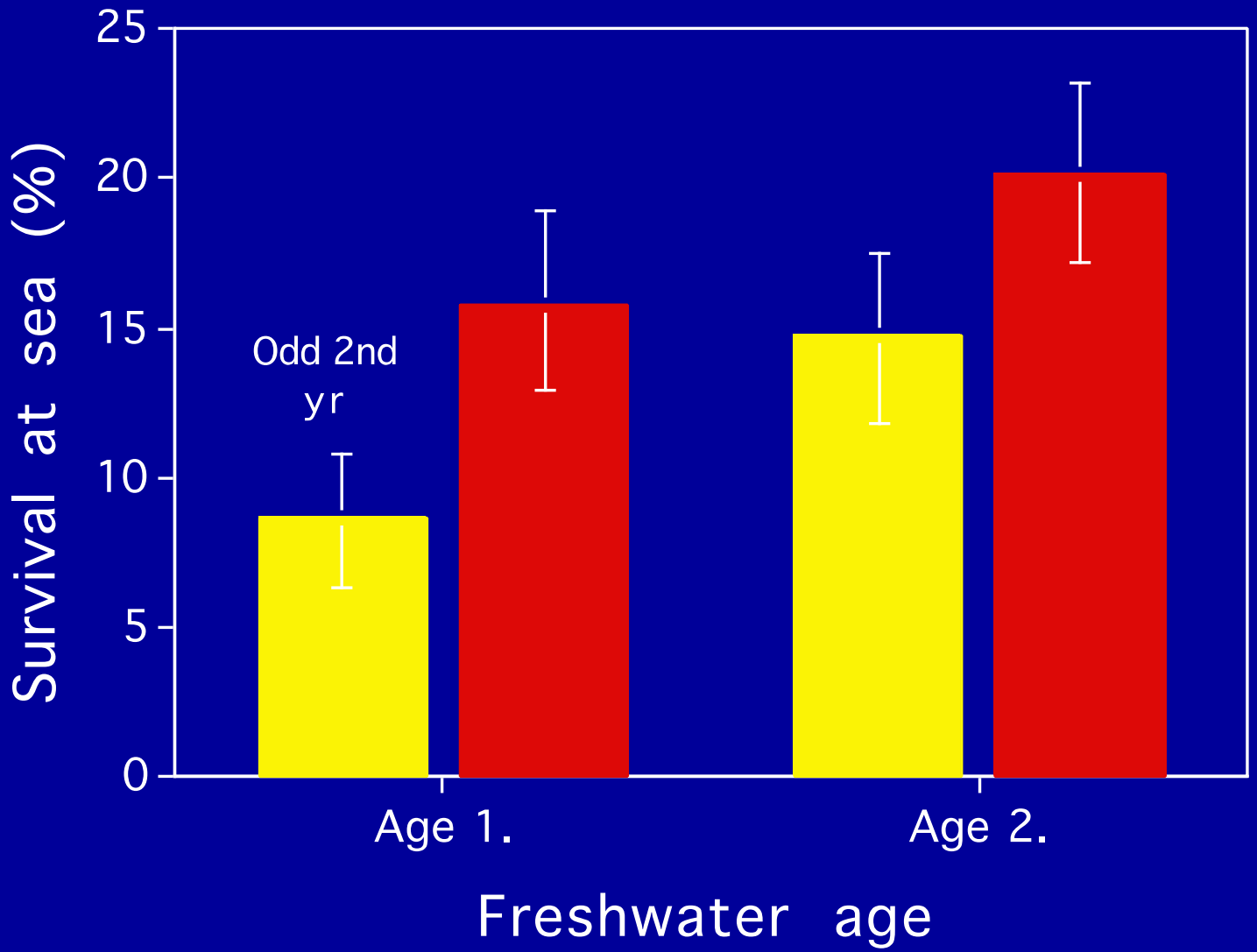
(Davis et al. 2005)





- Stomach content of sockeye & pink salmon declined 36% & 24%, respectively, in odd-years.
- Key prey (squid & fish) declined 27% in sockeye, 7% in pinks.
- Pink CPUE was 580% > than sockeye.

Sockeye Smolt to Adult Survival, 1977-1997

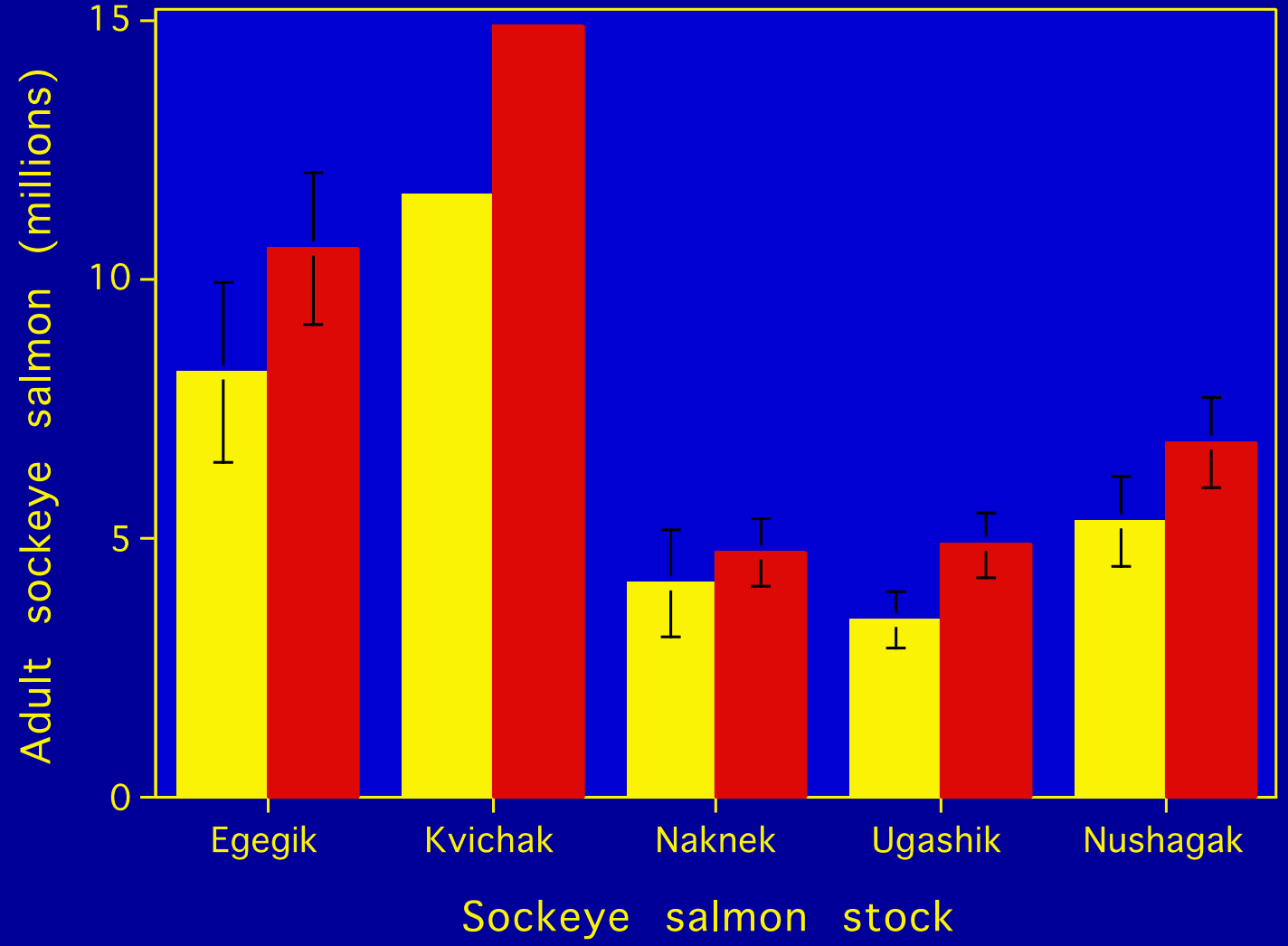


Age-1: -45% when pinks

Age-2: -26% when pinks

Ruggerone et al. 2003

91 Million Fewer BB Sockeye, 1977-1997 ($482 million loss)



22% loss

Ruggerone and Nielsen 2004