Assessing the Relative Importance of Local and Regional Processes on the Survival of a Threatened Salmon Population

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Snake River Spring/Summer Chinook Salmon

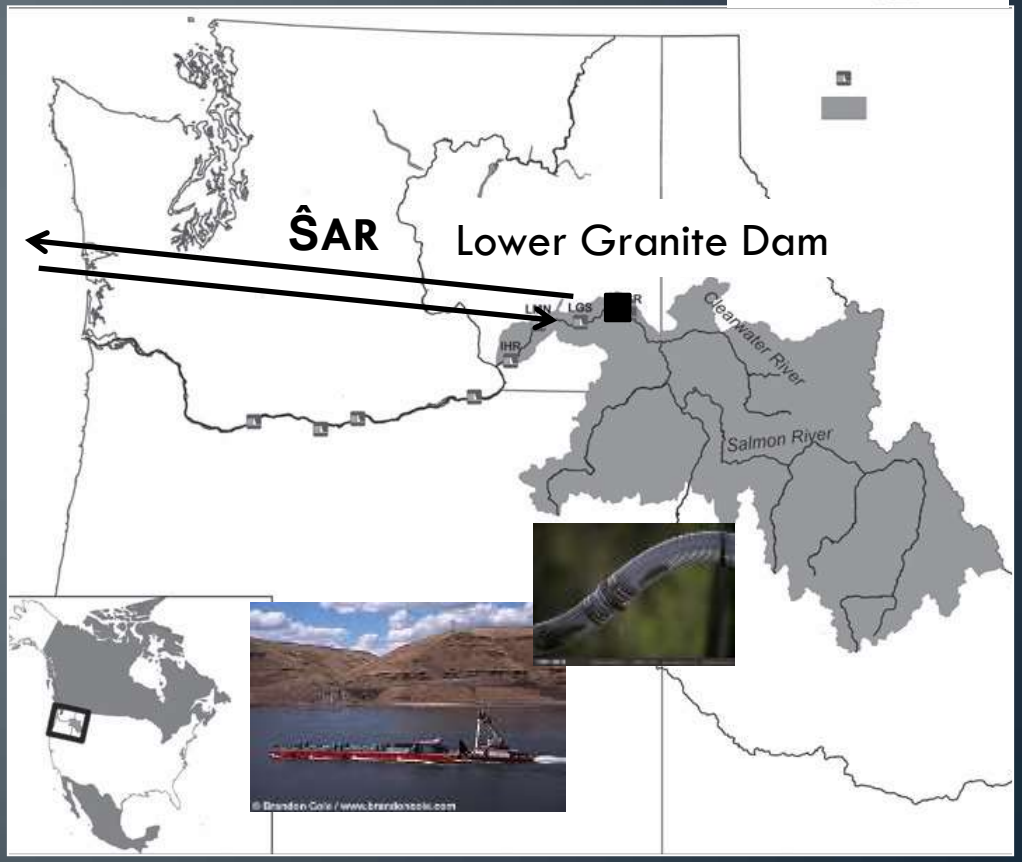
ESA: Threatened (1992)

Smolt-to-Adult (SAR) return
1998 to 2008

ŜAR: 0.22 – 3.7%

Higher river flow
Cooler water temps
Upwelling intensity

FW vs. Marine?
Mechanisms?

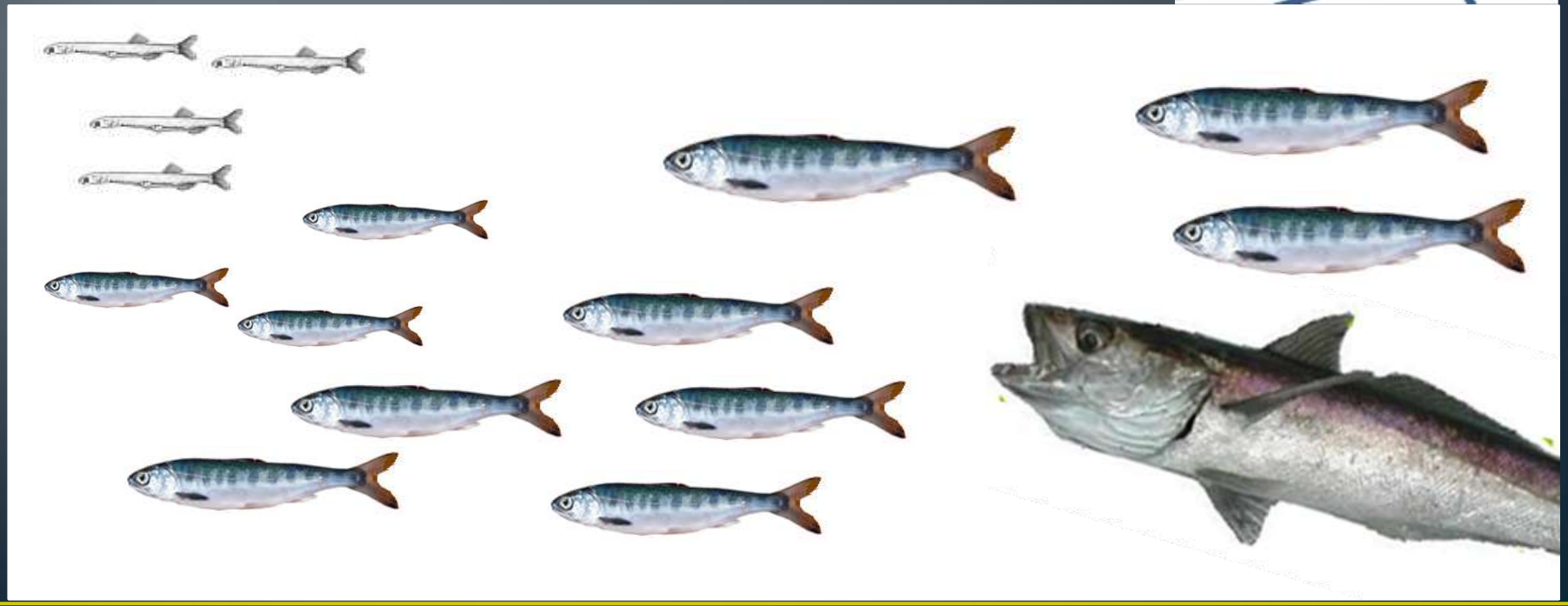


Modified from Petrosky & Schaller 2010

Objectives

- Characterize juvenile emigration
  & early marine residence

- Evaluate Growth-Mortality and Match-Mismatch Ho

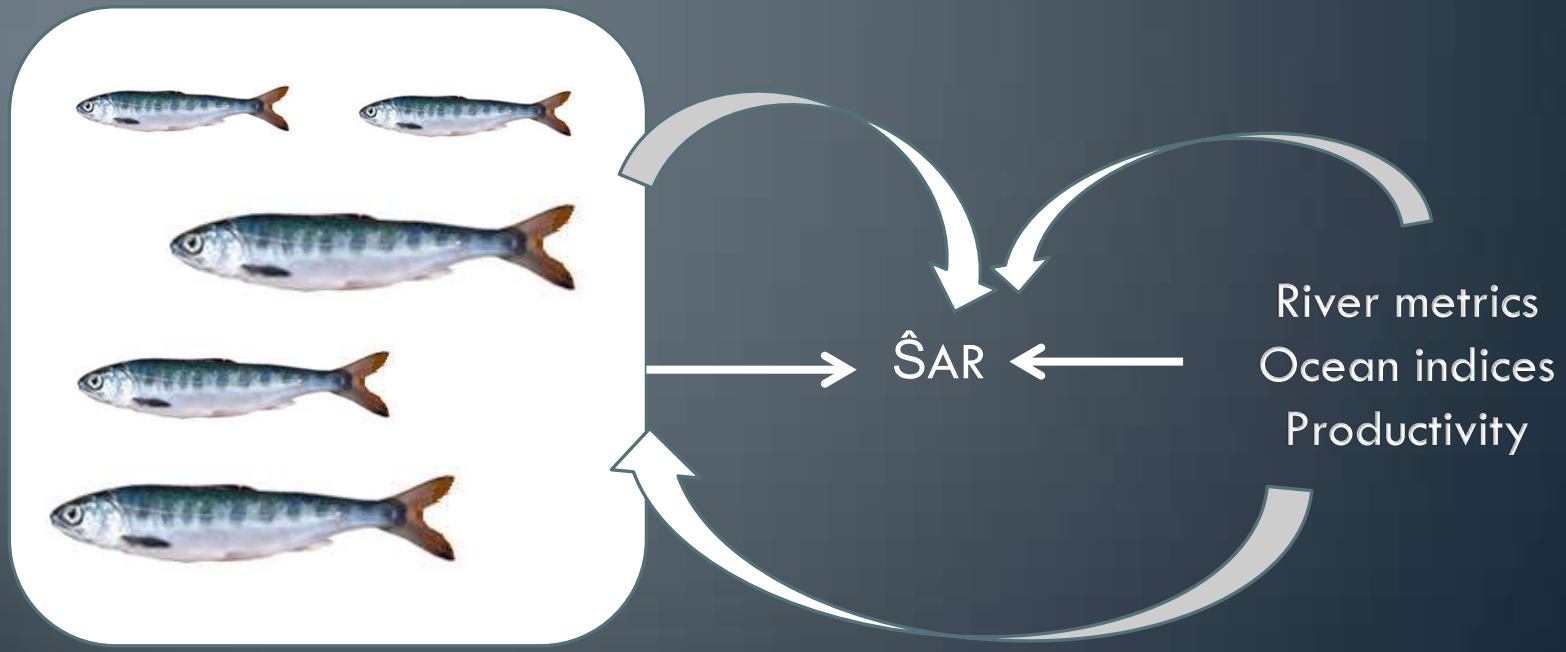


Questions

Are juvenile attributes during early marine residence related to survival?

If so, what physical or biological variables are related to those attributes?

Insights into mechanisms of survival?



Approach: Genetic Stock ID & Otolith Chemistry/Structure

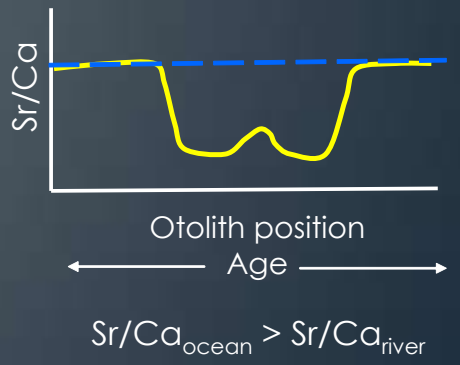
Genetic Analysis of Pacific Salmon (GAPS)

Seeb et al. 2007 - microsatellite DNA baseline

Stock-Specific

Size at and timing of marine entry

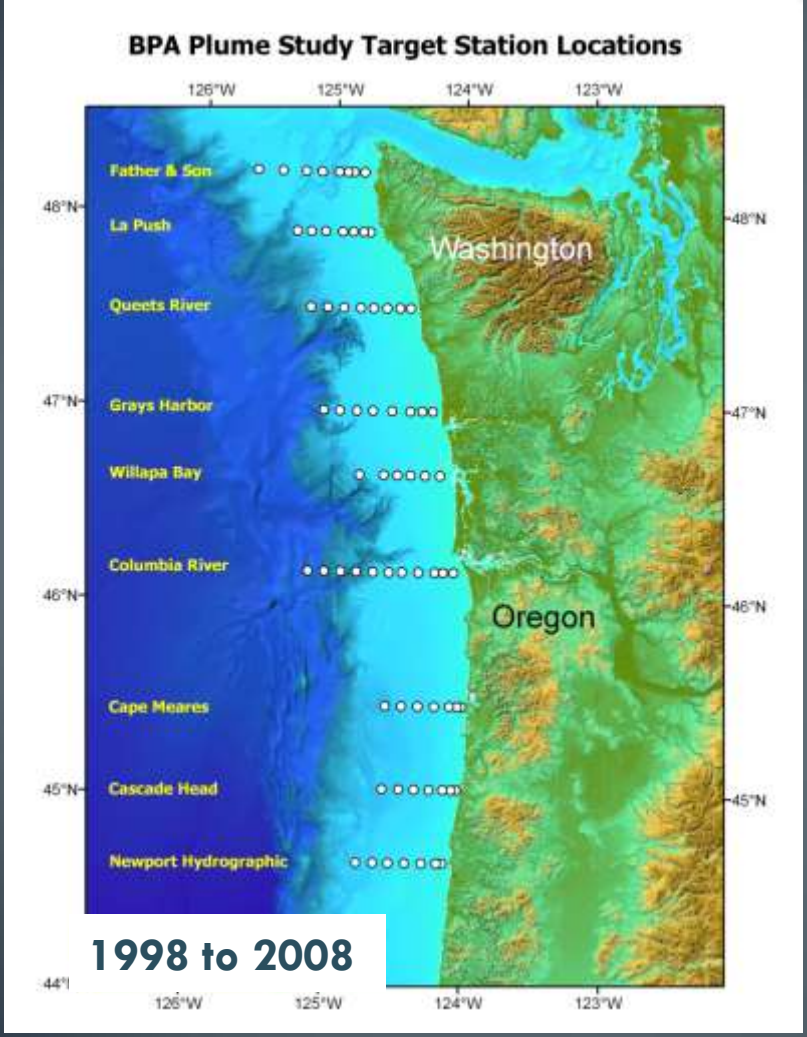
Marine growth rate



$Sr/Ca_{ocean} > Sr/Ca_{river}$

Tomaro et al. 2012: Mid-upper Columbia River spring Chinook

Ocean Collections



NOAA NWFSC. BPA

Snake River Sp/Su Chinook
22% of all yearlings collected

May and June
1999-2000, 2002-2004, 2006-2008
(very low catch in 1998, 2001 & 2005)

81% >75%
posterior probability of genetic assignment

Biological & Physical Metrics

Juvenile Salmon

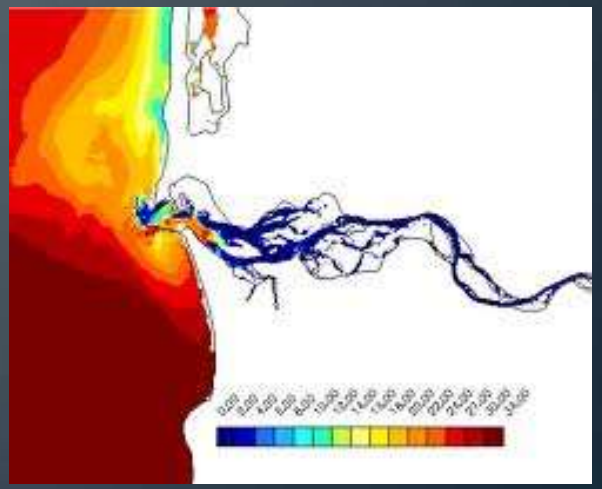
- Size at and timing of emigration
- Marine growth rate (% d^{-1}, mm)
- Size at capture
- May & June CPUE (yearlings km^{-1})

Productivity

- Copepod Community Index (CCI)
- Biological spring transition = seasonal shift in CCI

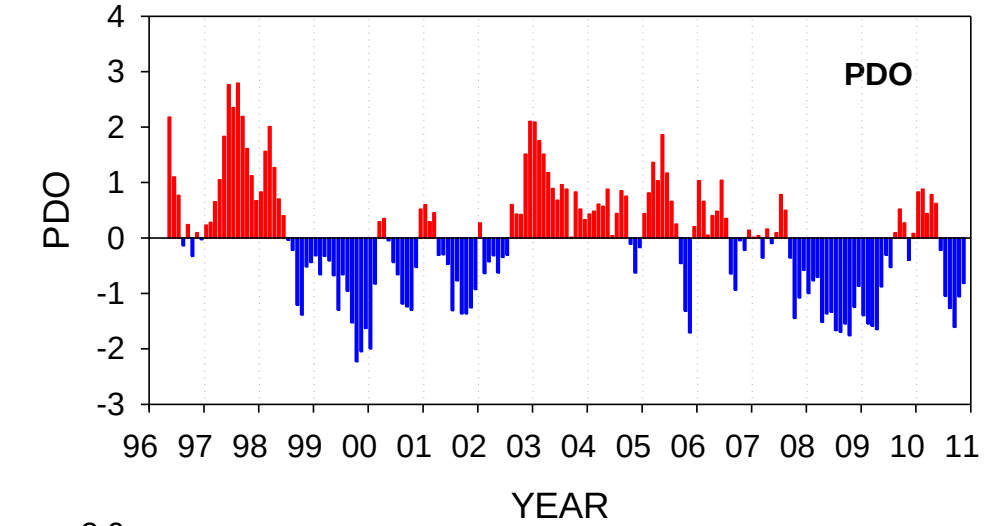
Physical Metrics

- Columbia River flow
- Plume metrics (volume, area, position)
- PDO, NPGO
- Physical spring transition



Multi-model inference: AIC
$r < 0.50$

Biological Indicators: Copepod Community Index (CCI)



Ordination of copepod community

← Warm-water, lipid-poor community

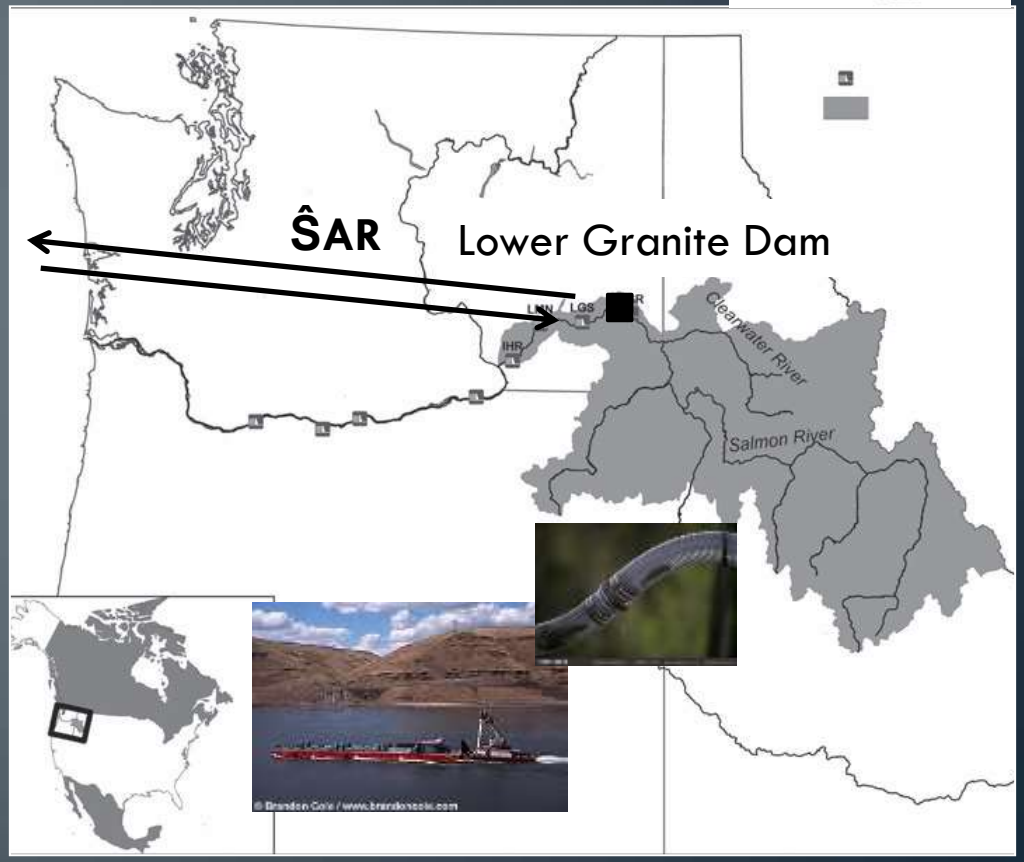
← Cold-water, lipid-rich community

Snake River Spring/Summer Chinook Salmon

Smolt-to-adult return

Lower Granite Dam – Lower Granite Dam

Fish Passage Center (http://www.fpc.org)

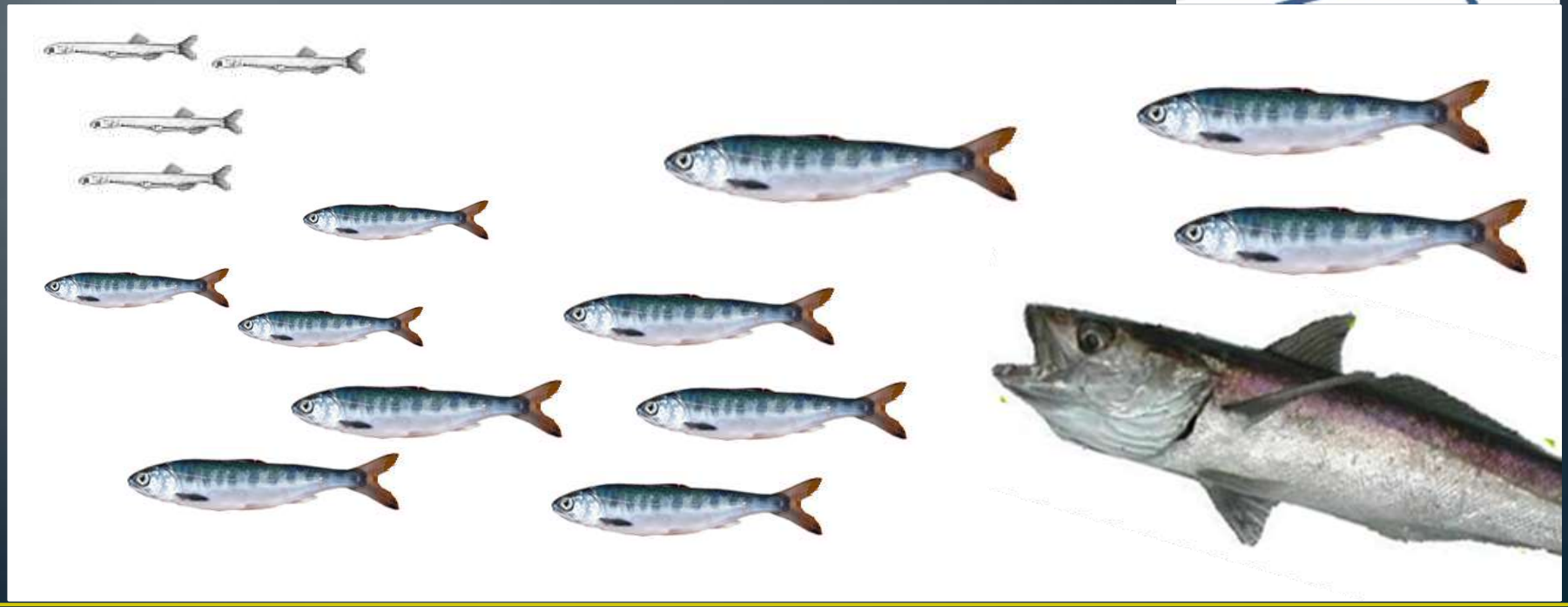


Modified from Petrosky & Schaller 2010

Results

Match-Mismatch Ho

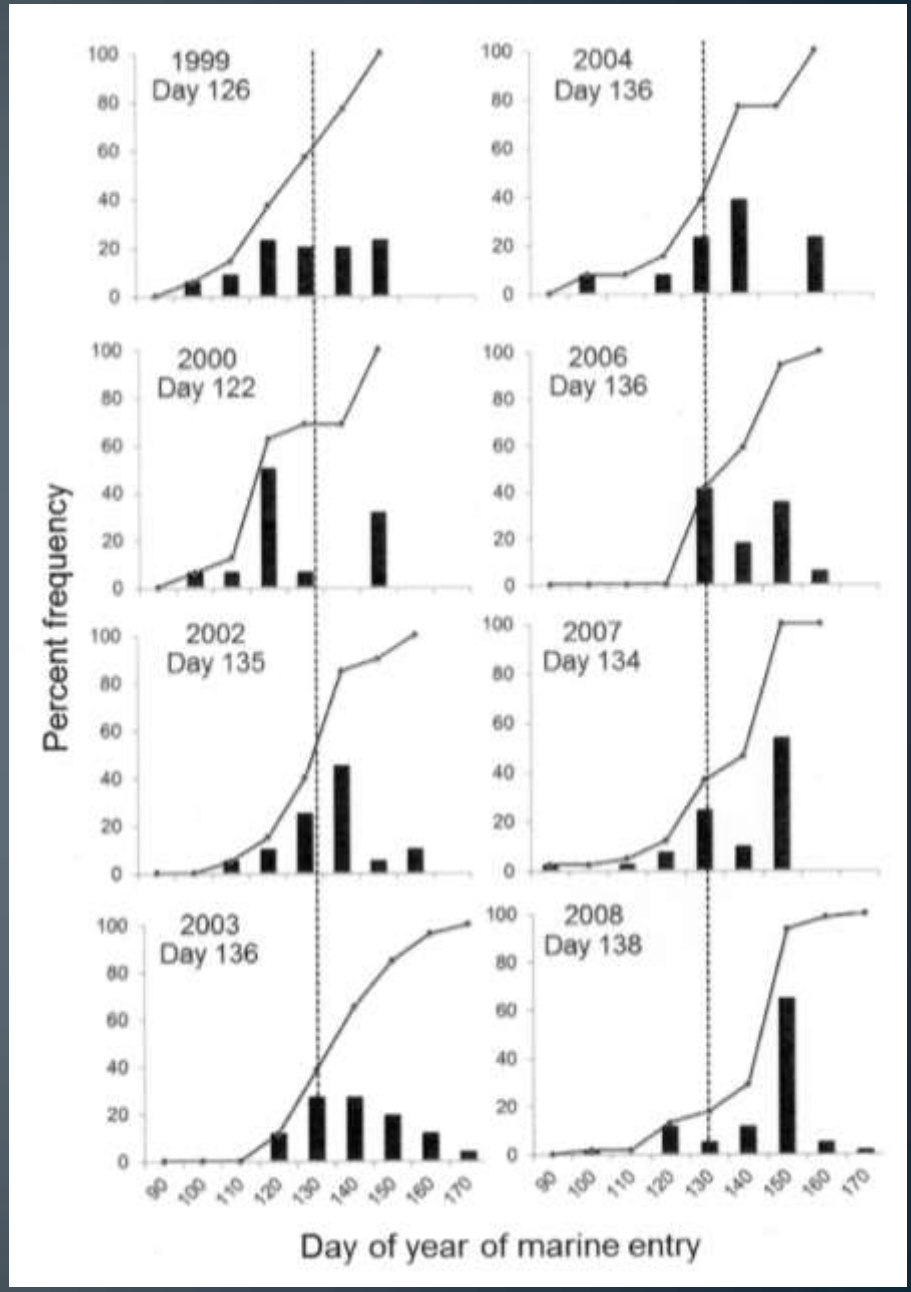
- timing of juvenile emigration
- interannual variation?
- relationship with survival?



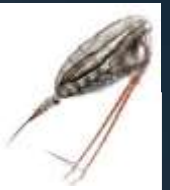
Emigration Timing

- April 20 to June 19
- Mean = May 6 to May 18
- 20 d in marine waters prior to capture (15 to 26 d)
- 146 – 169 mm FL at capture

34% emigrated <3 d prior to capture

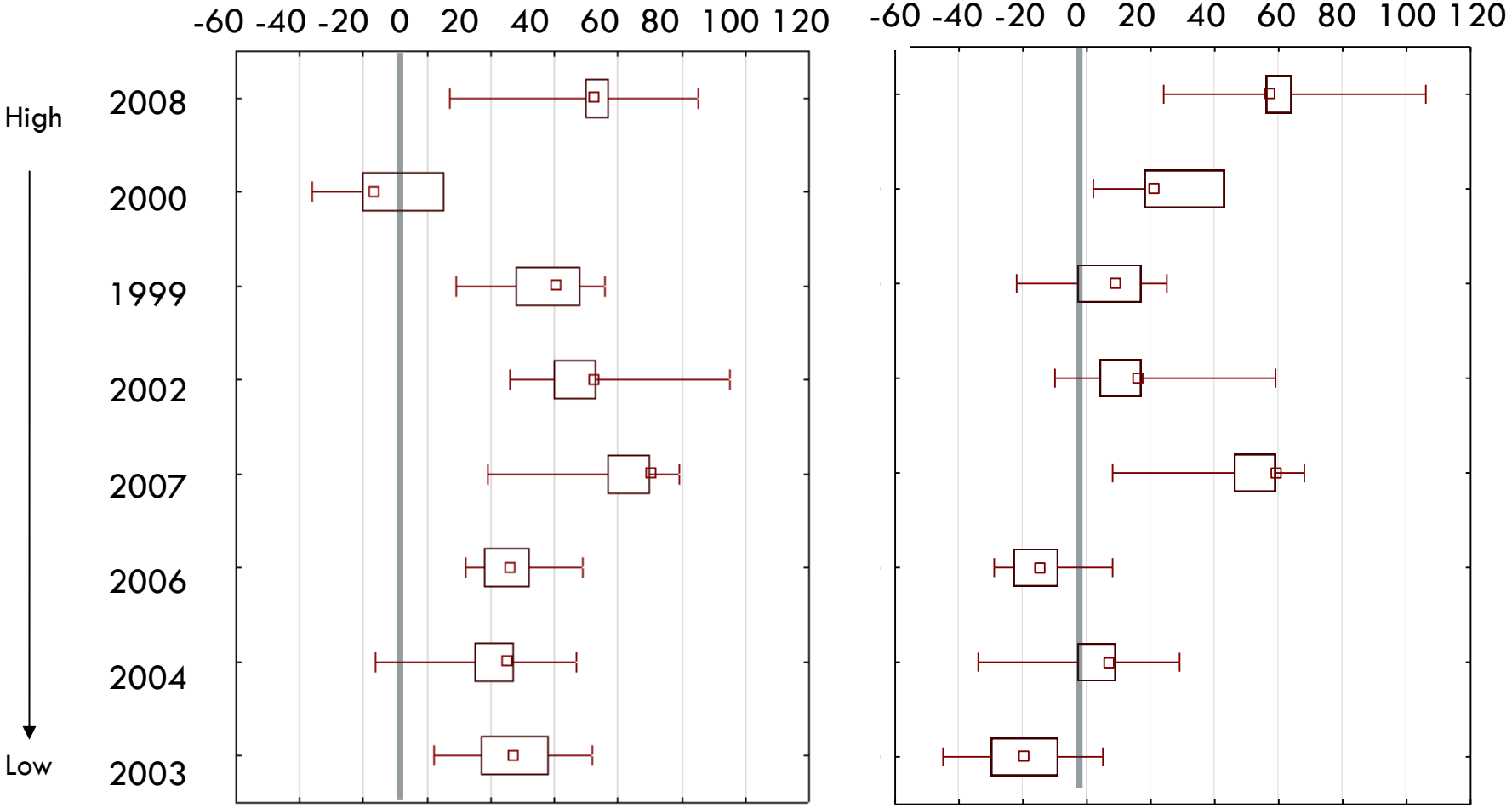


Juvenile emigration timing in relation to survival



Physical Transition (r = -0.090)

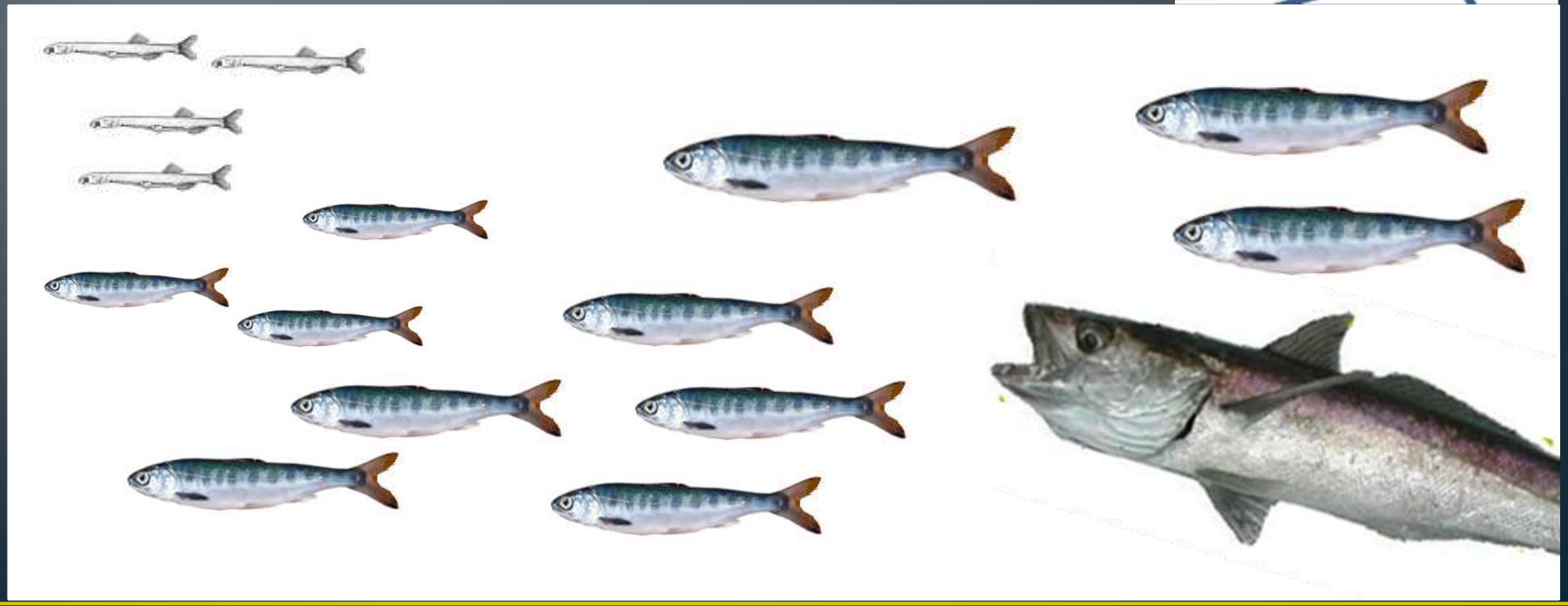
Biological Transition (r = 0.639)



Results

Growth-Mortality Ho

- Is early marine growth related to survival?



Growth-Mortality Ho

Size at freshwater emigration (n = 151)

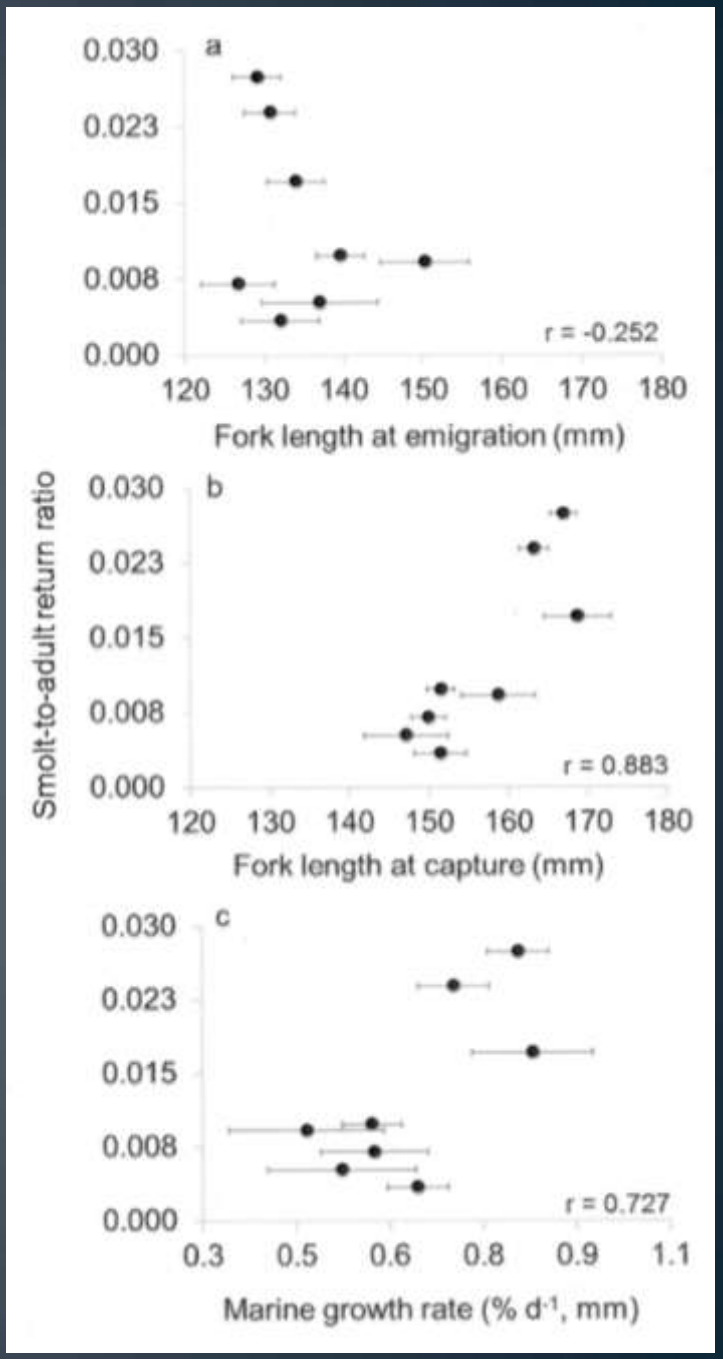
r = -0.252

Size at capture (n = 731)

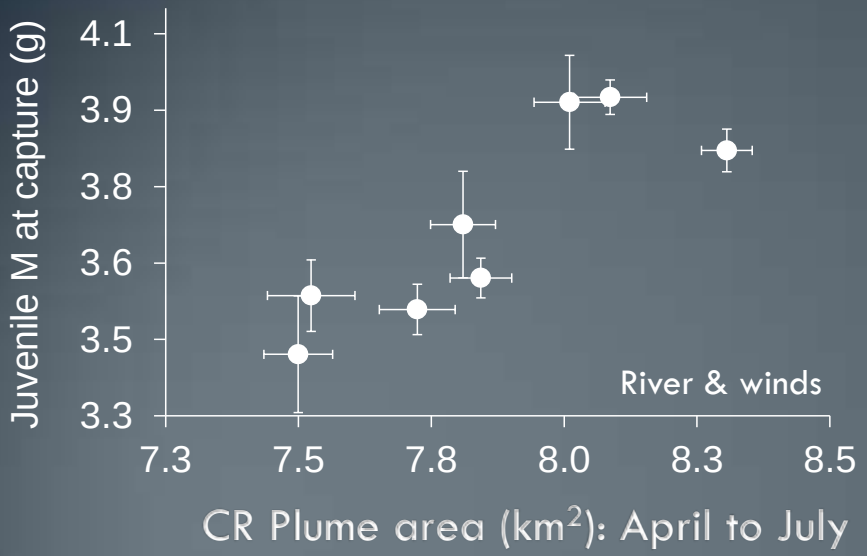
r = 0.833

Marine growth (n = 151)

r = 0.727



Indicators of juvenile size at capture (20 d at sea)

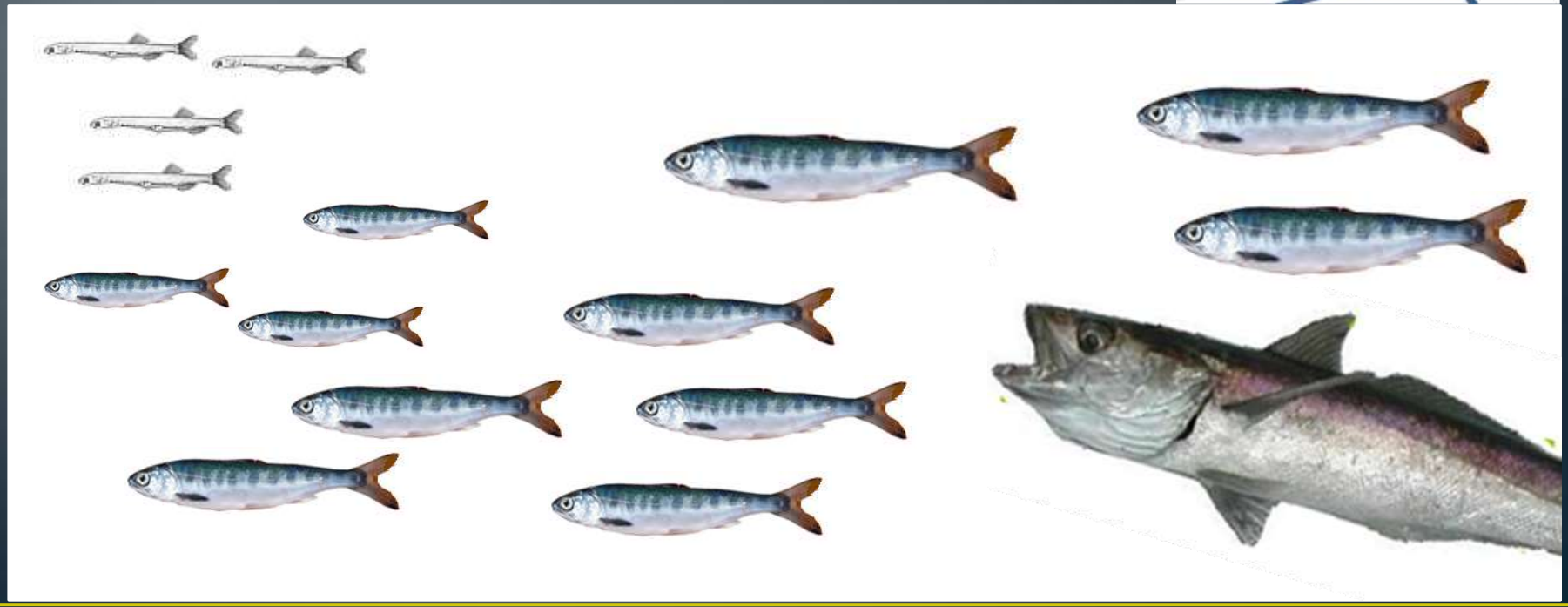


- 1999, 2000, 2002-2004, 2006-2008
- Plume area (April to July)
- NPGO (April to June)
- 15 models compared

Model	RSS	AIC_c		w_i	R^2
$PlArea_{4\_7}$	0.050	-28.67	0.000	0.398	0.812
$NPGO_{4\_6}$	0.054	-28.05	0.623	0.291	0.797
PDO_{7_9}	0.062	-26.86	1.812	0.161	0.765
CCI_6	0.069	-26.07	2.605	0.108	0.740
$CCI_6, (CCI_6)^2$	0.029	-23.59	5.083	0.031	0.890

Results

How do juvenile attributes compare with other physical and biological indices in accounting for the variation in survival?



Survival hindcast

SAR: 1998-2008

Model	AIC_c		*wi*	R^2
1. PDO_{7_9}, CCI_6	-78.15	0.000	0.430	0.830
2. PDO_{7_9}	-78.05	0.095	0.410	0.724
3. $CPUE_6$	-74.24	3.913	0.061	0.731
4. PDO_{7_9}, $(PDO_{7\_9})^2$	-73.80	4.346	0.049	0.748
5. $NPGO_{4\_6}$, $CPUE_6$	-72.16	5.985	0.022	0.707
6. $NPGO_{4\_6}$	-71.95	6.196	0.019	0.520
7. CCI_6	-69.04	9.134	0.004	0.373
8. CCI_6, $(CCI_6)^2$	-68.87	9.276	0.004	0.507
9. $CRFlow_{4\_7}$	-65.49	12.653	0.001	0.135

Parameter	Relative Importance
PDO_{7_9}	-0.692
CCI_6	-0.115
$CPUE_6$	0.059
$NPGO_{4\_6}$	0.023

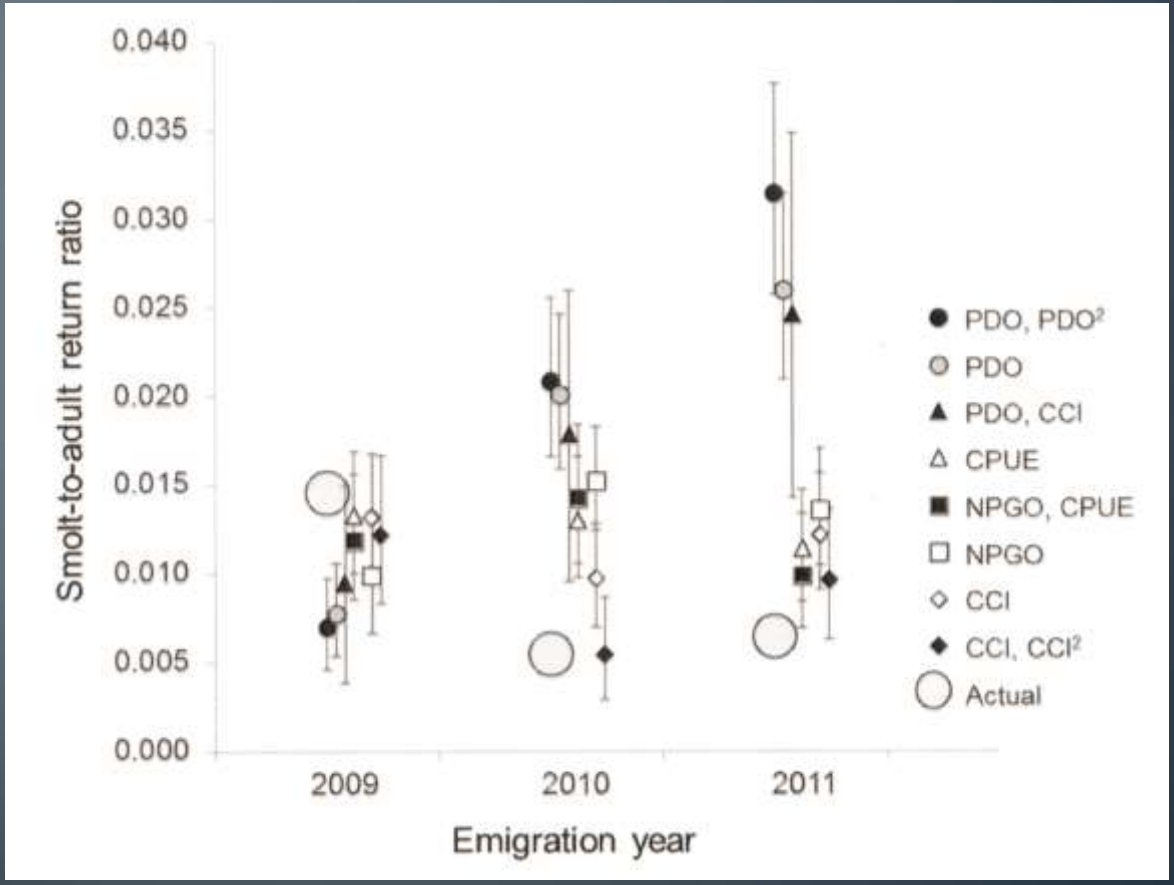
10 models compared
Only variables with cross correlations <0.5 in same model

Survival forecast

SAR: 2009-2011

PDO index remarkably informative in earlier years

Other basin-scale (NPGO) and biological indices (June CCI & CPUE) provided more accurate indications of survival in recent years.



Summary - Snake River sp/su Chinook salmon

- Limited evidence for Match-Mismatch Ho but trend towards increased survival when juveniles entered further after biological transition

- Strong evidence for Growth-Mortality Ho (similar to mid-upper CR spring Chinook)
  - Marine growth and size at capture (20 d) >> size at emigration
  - Cohort size largely established after 20 d in ocean?

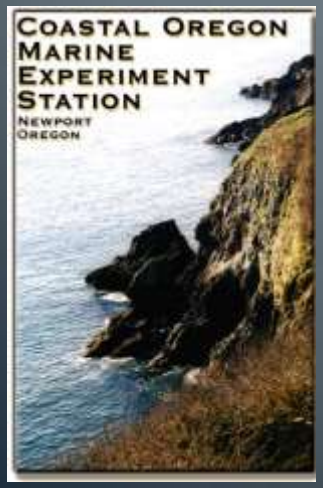
- CCI_6 and CR plume $area_{4\_7}$ best predictors of size at capture
  - *Excludes* low catch years (1998, 2001 & 2005)

- Hindcast: PDO_{7_9}, $CPUE_6$, CCI_6, and $NPGO_{4\_6}$ best predictors of SARs
  - *Includes* low catch years (1998 to 2008)

- Forecast: Basin-scale (PDO_{7_9}) poor predictor of SARs in forecast models, local, biological (CCI_6, $CPUE_6$) best

Miller et al. PLOS ONE. 2014.

Acknowledgements



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NOAA NWFSC

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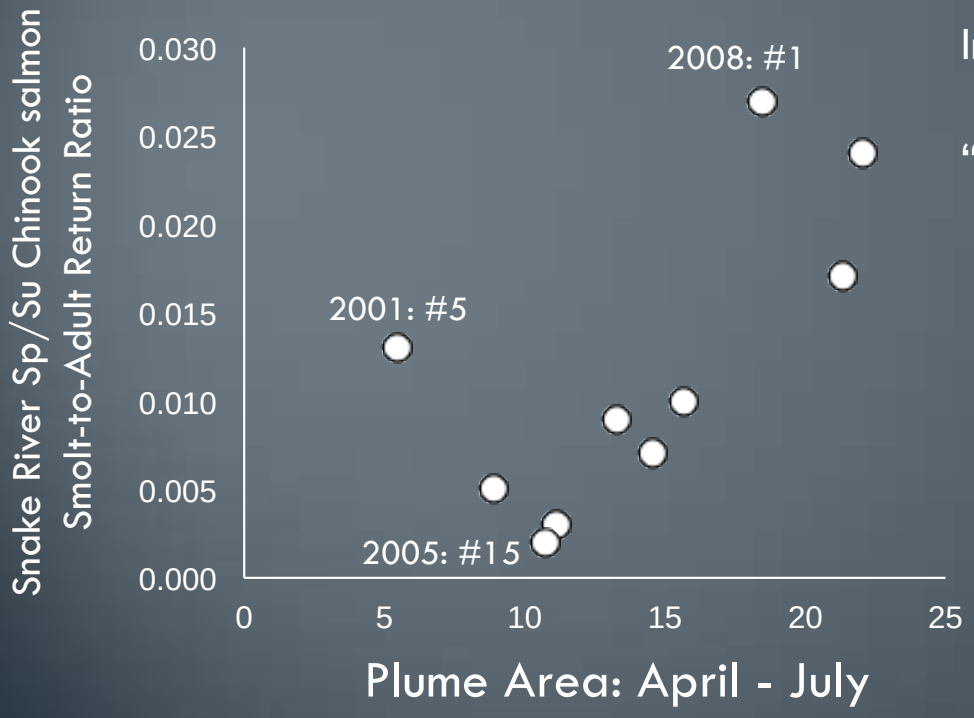
U.S. DEPARTMENT OF COMMERCE

Survival in relation to CR Plume: 1999-2008

In general, positive relationship with plume size

Salmon Ocean Indicators
(www.nwfsc.noaa.gov/research/divisions/fe/estuarine/oeip/index.cfm)



Interaction between river & coastal ocean

"good ocean" conditions compensate for "poor river/plume" conditions?

Similar pattern for Upper Col. River Su/Fa Chinook salmon & plume volume – Miller et al. 2013