



Relationship between Chinook and chum salmon abundance and RKW population dynamics



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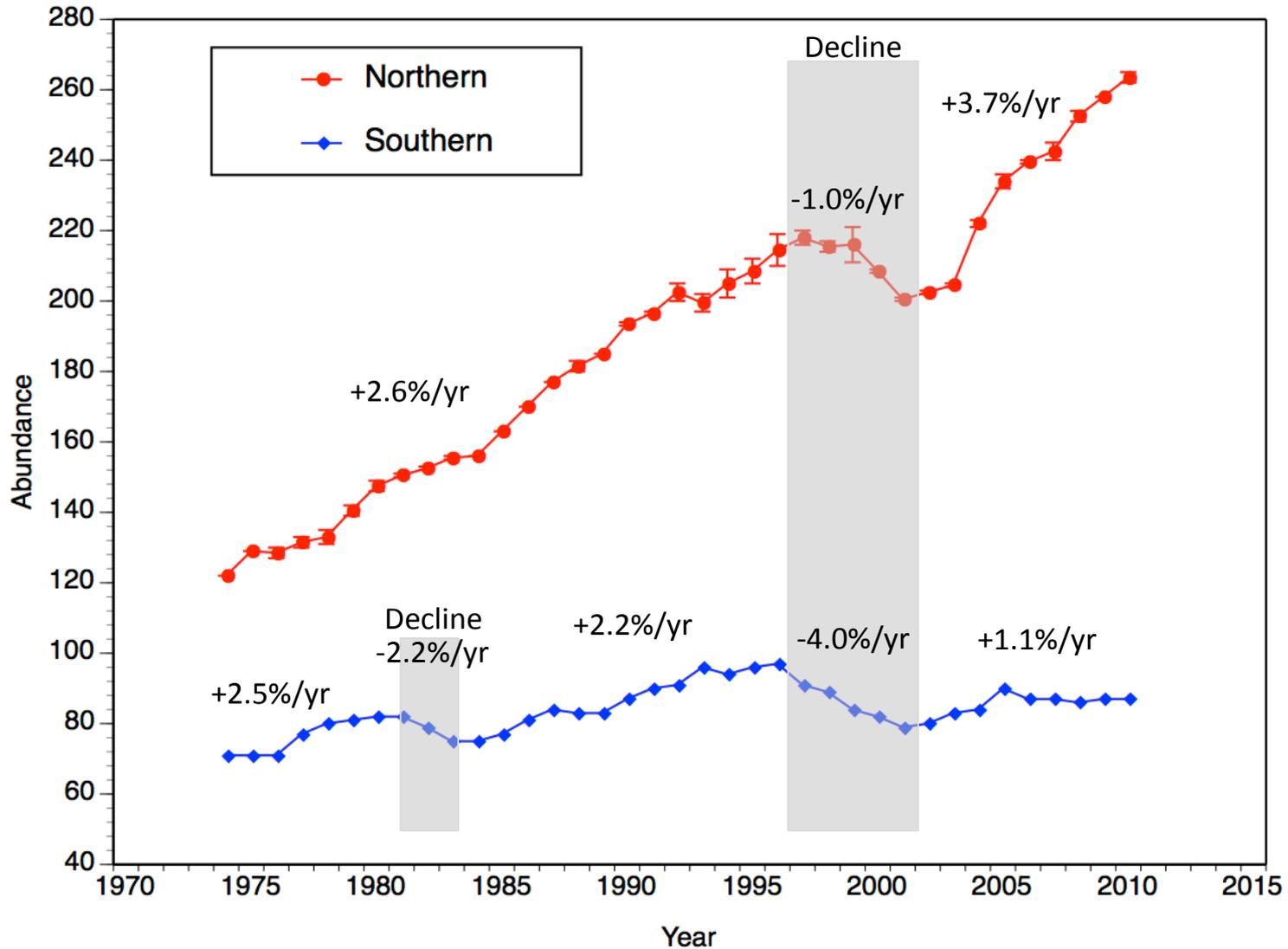
Pacific Biological Station

Fisheries and Oceans Canada

Nanaimo, British Columbia



Abundance trends in Northern & Southern Residents



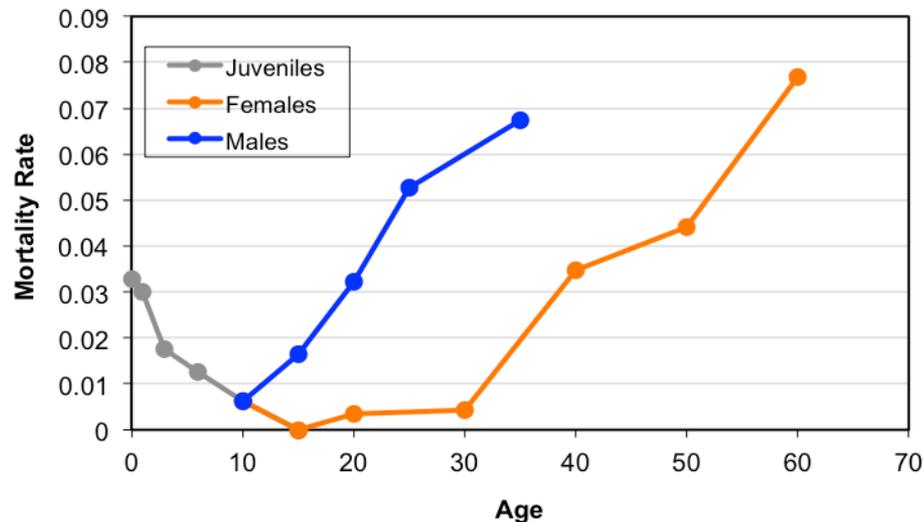
Are resident killer whale population dynamics related to prey abundance?

- Were the significant declines in the late 1990s driven by changes in survival, fecundity, or both?
- Were changes in population demographics evident across age/sex classes, social groups?
- Is there a correlation between population demographics and availability of key prey species, Chinook and chum salmon?

Assessing population dynamics...

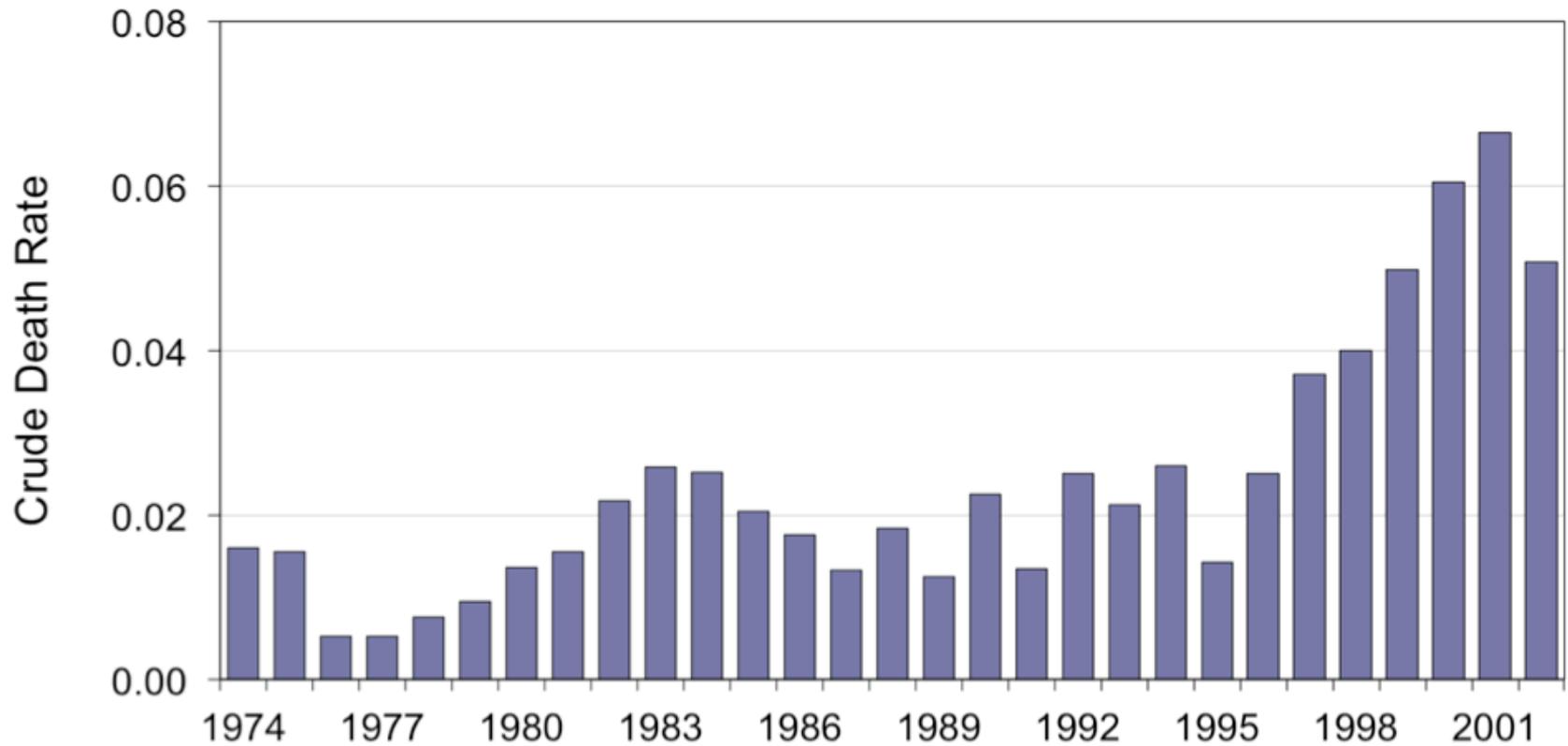
- Temporal changes examined by calculating an index based on the ratio of the number of deaths and births observed to number expected for each year
- Expected values for each year derived from sex- and age-specific mortality and fecundity schedules for period of unrestrained growth (1973-96; Olesiuk et al. 2005)
- Method explicitly takes into account age/sex structure
- Observed/expected ratios expressed as 3-year running averages

Sex and Age Specific Mortality Rates - Northern Residents



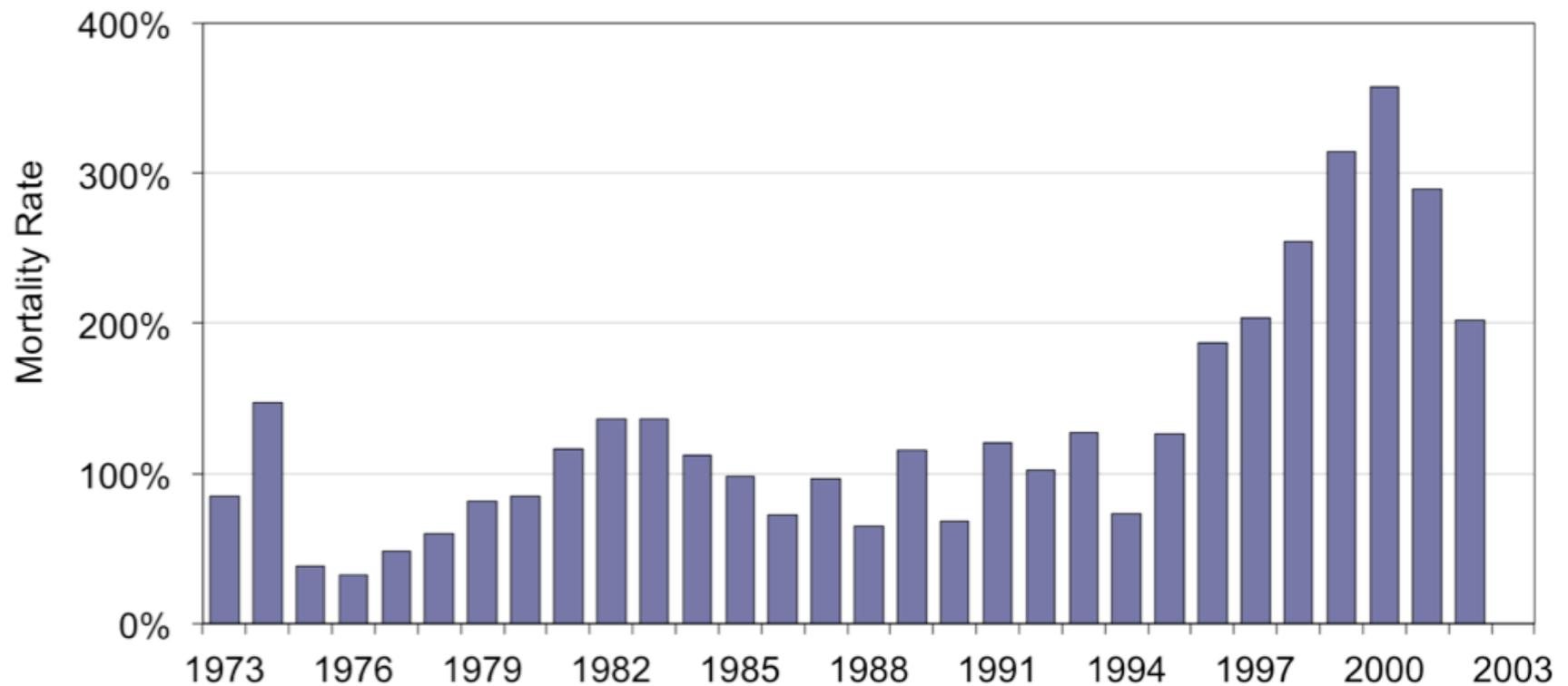
Crude Death Rate

Northern Residents



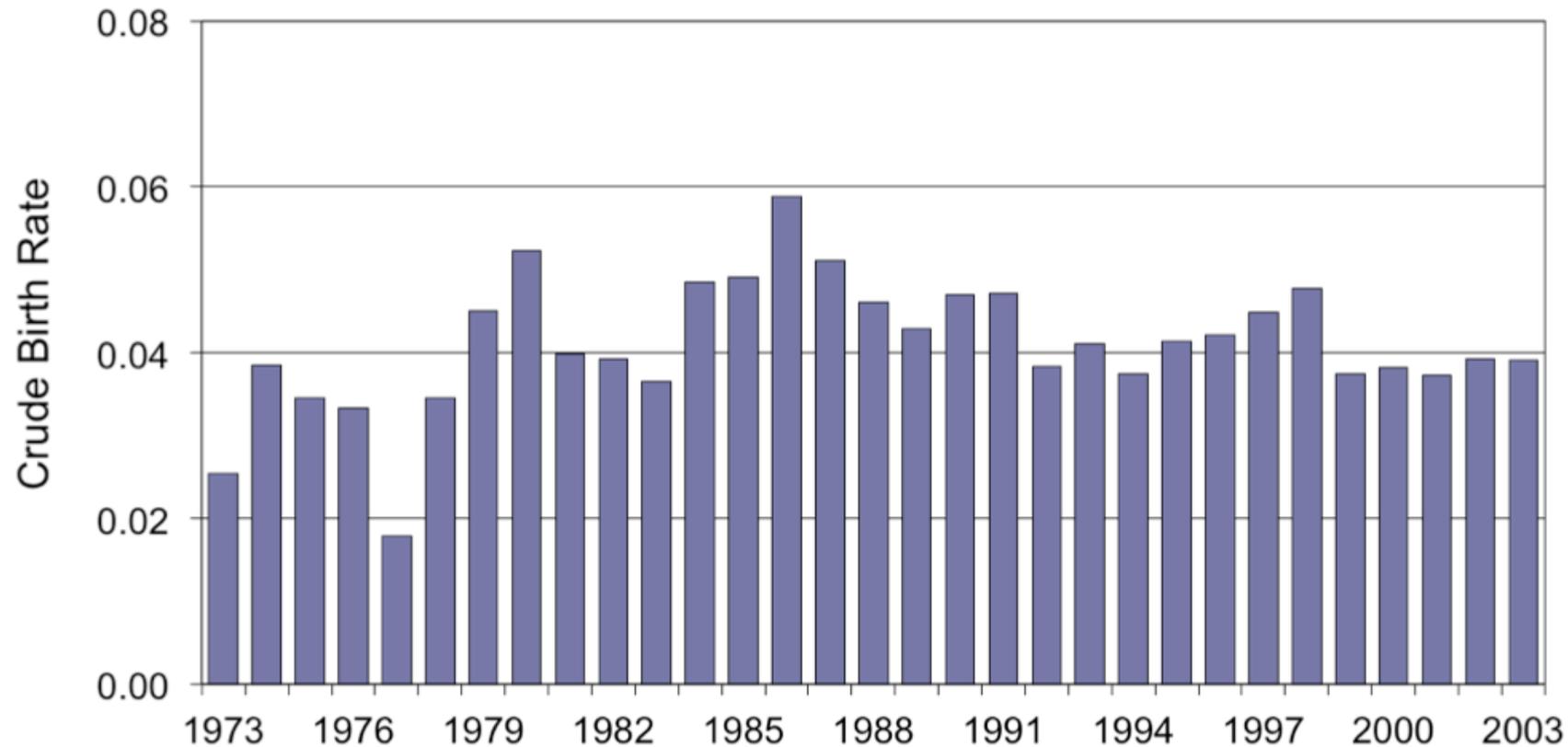
Deviations in Mortality Rate

Northern Residents



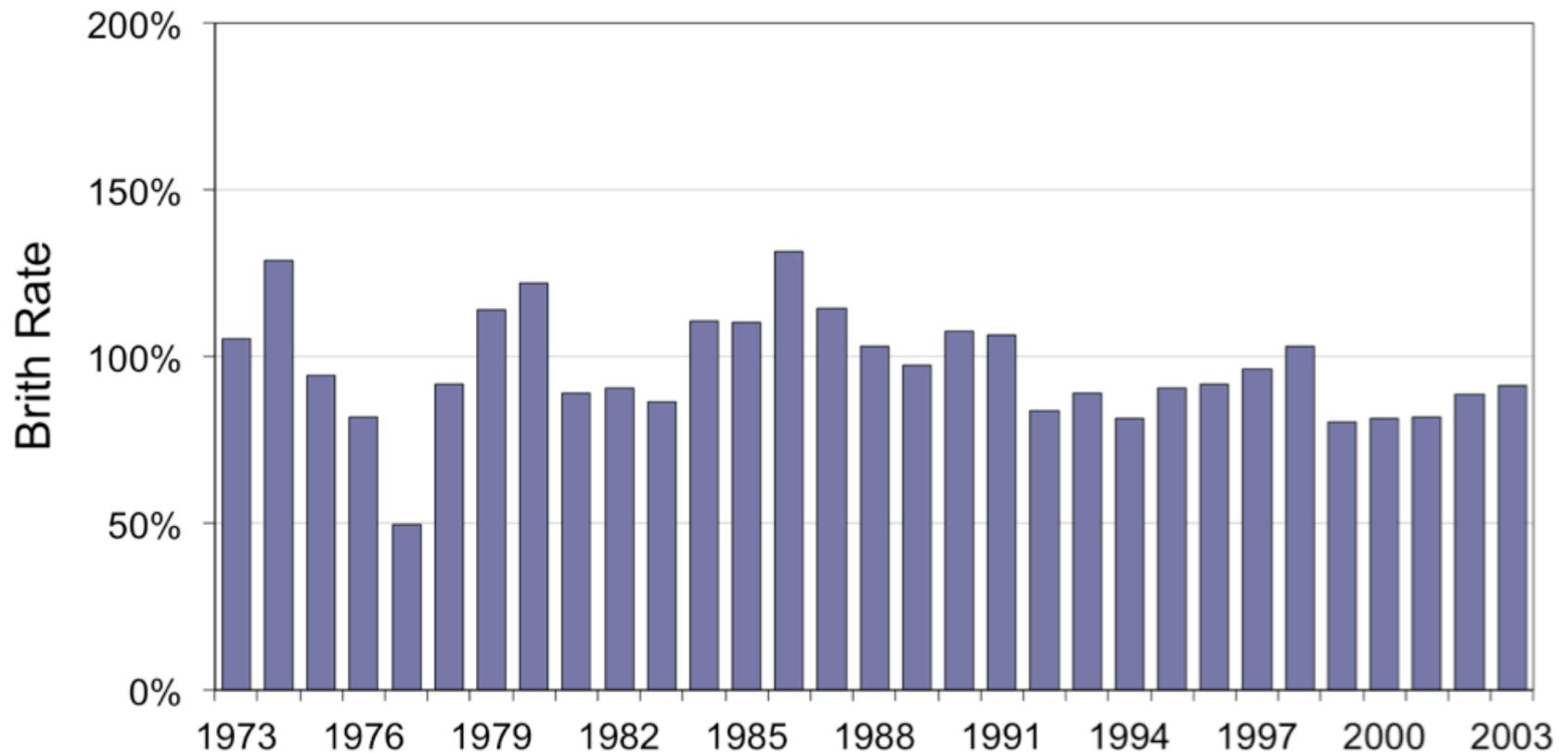
Crude Birth Rate

Northern Residents

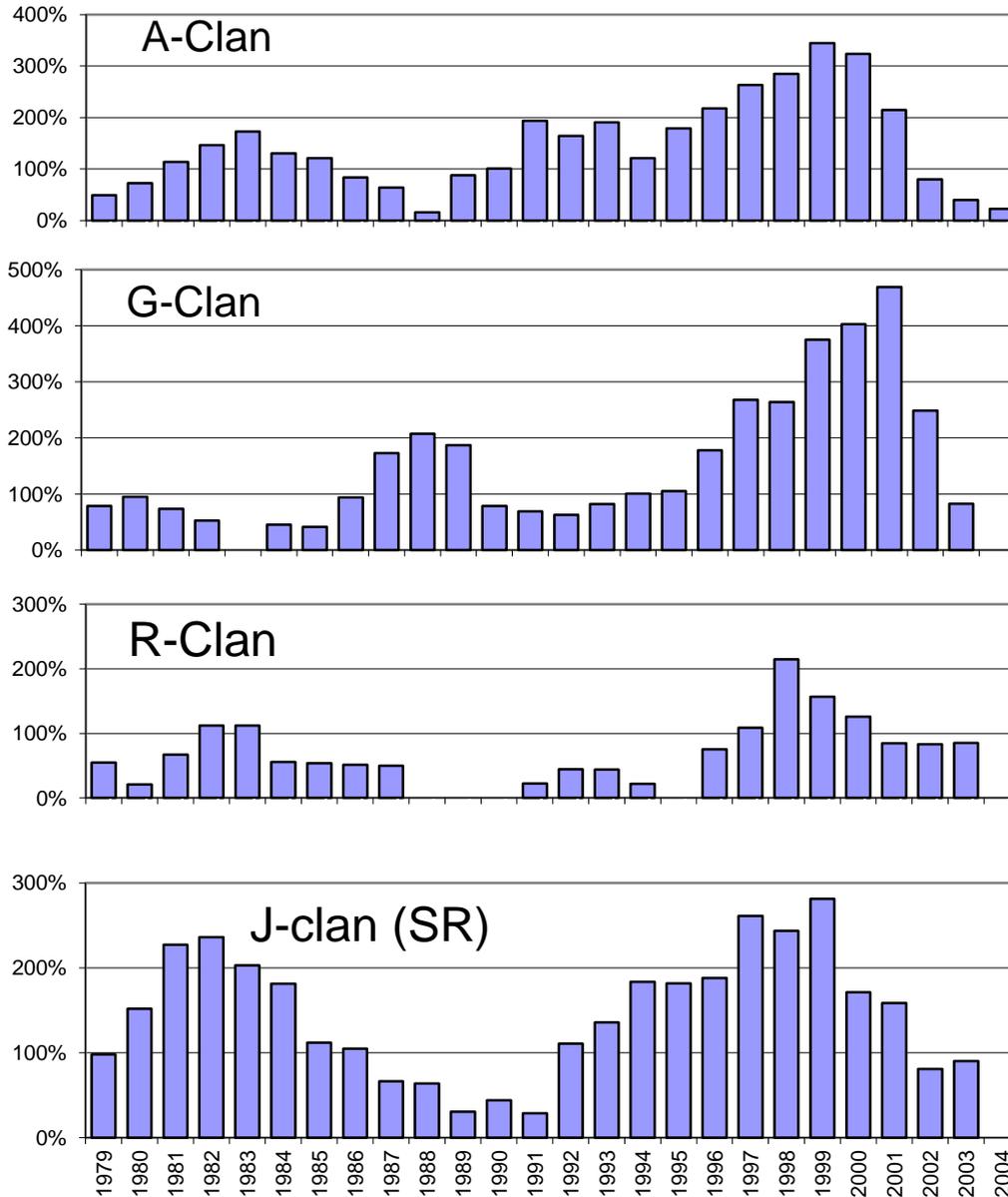


Deviations in Birth Rate

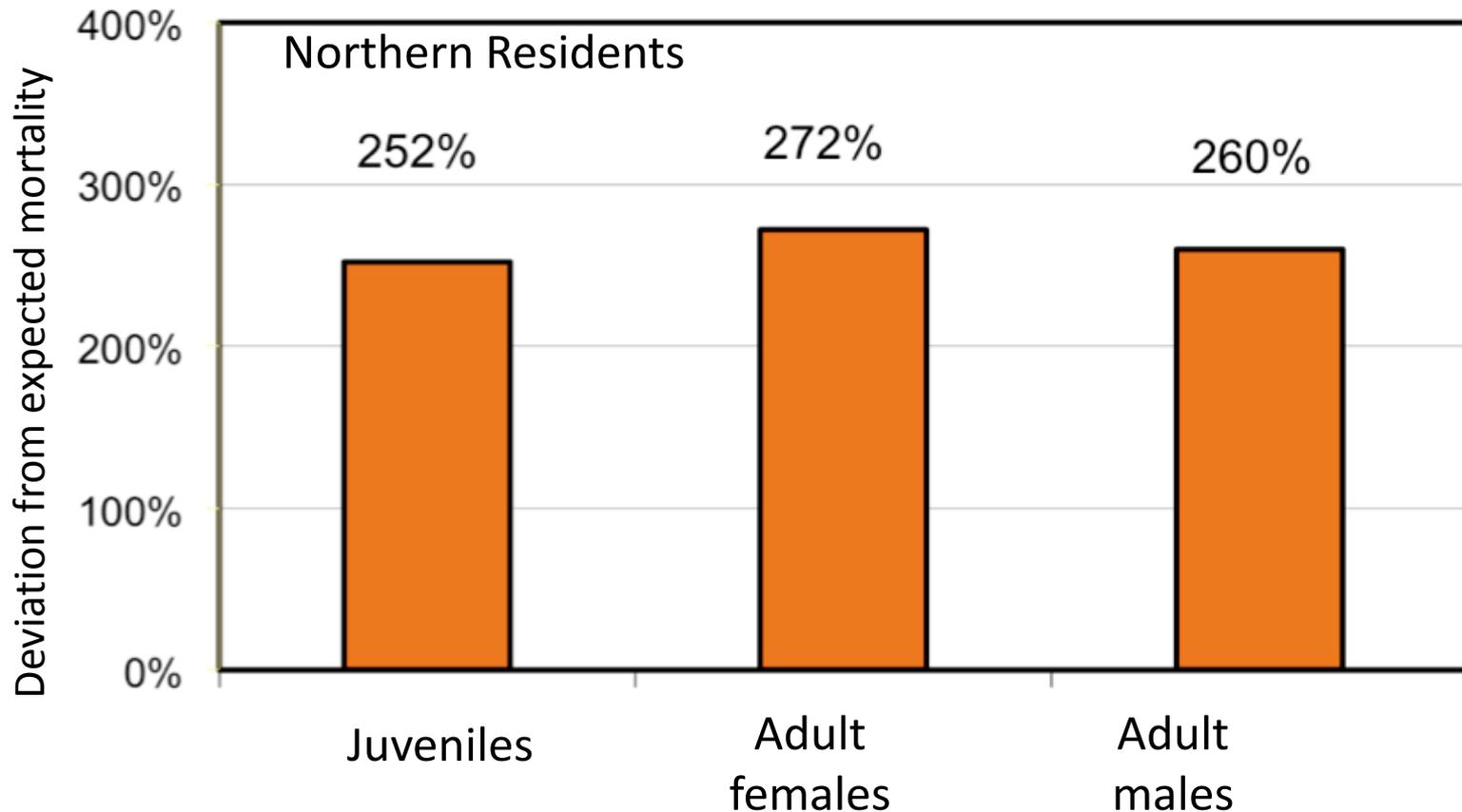
Northern Residents



Mortality rates by clan, 1979-2004

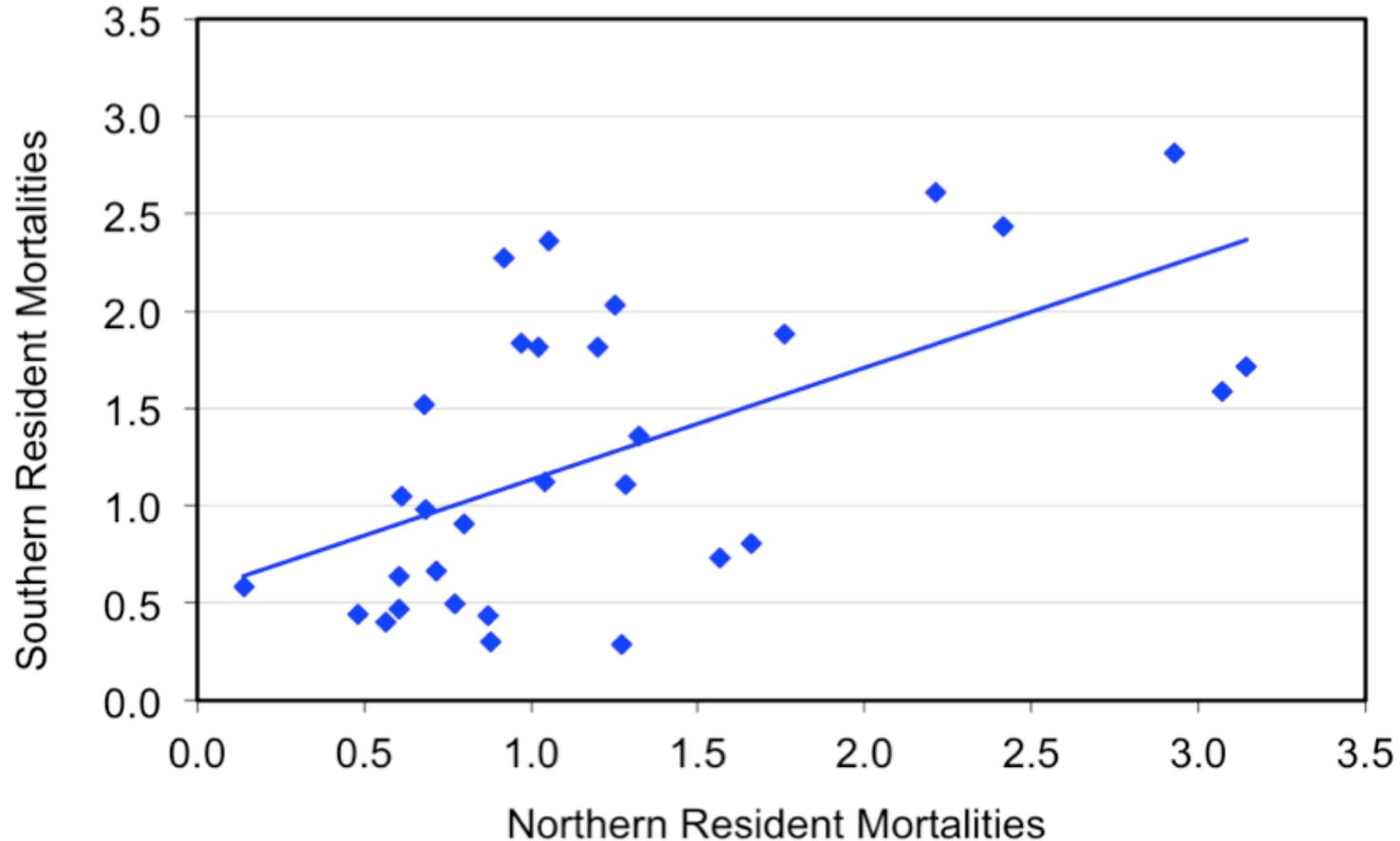


Mortalities rates by sex and age during decline, 1996-2001

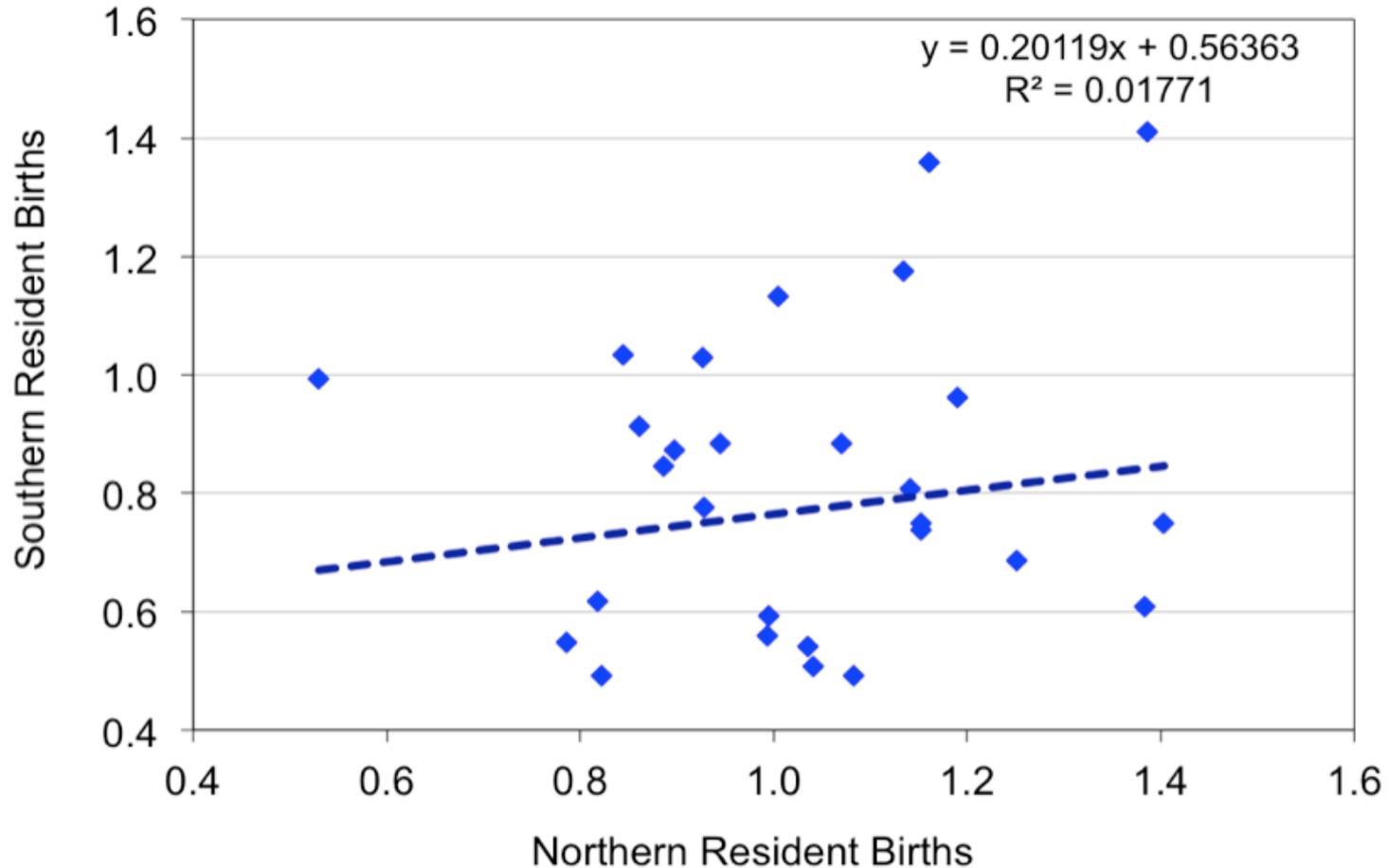


Mortalities in NR and SR resident populations are correlated

($F_{1,26} = 5.3$, $r^2 = 0.345$, $p < 0.001$)



Births in NR and SR resident populations not correlated

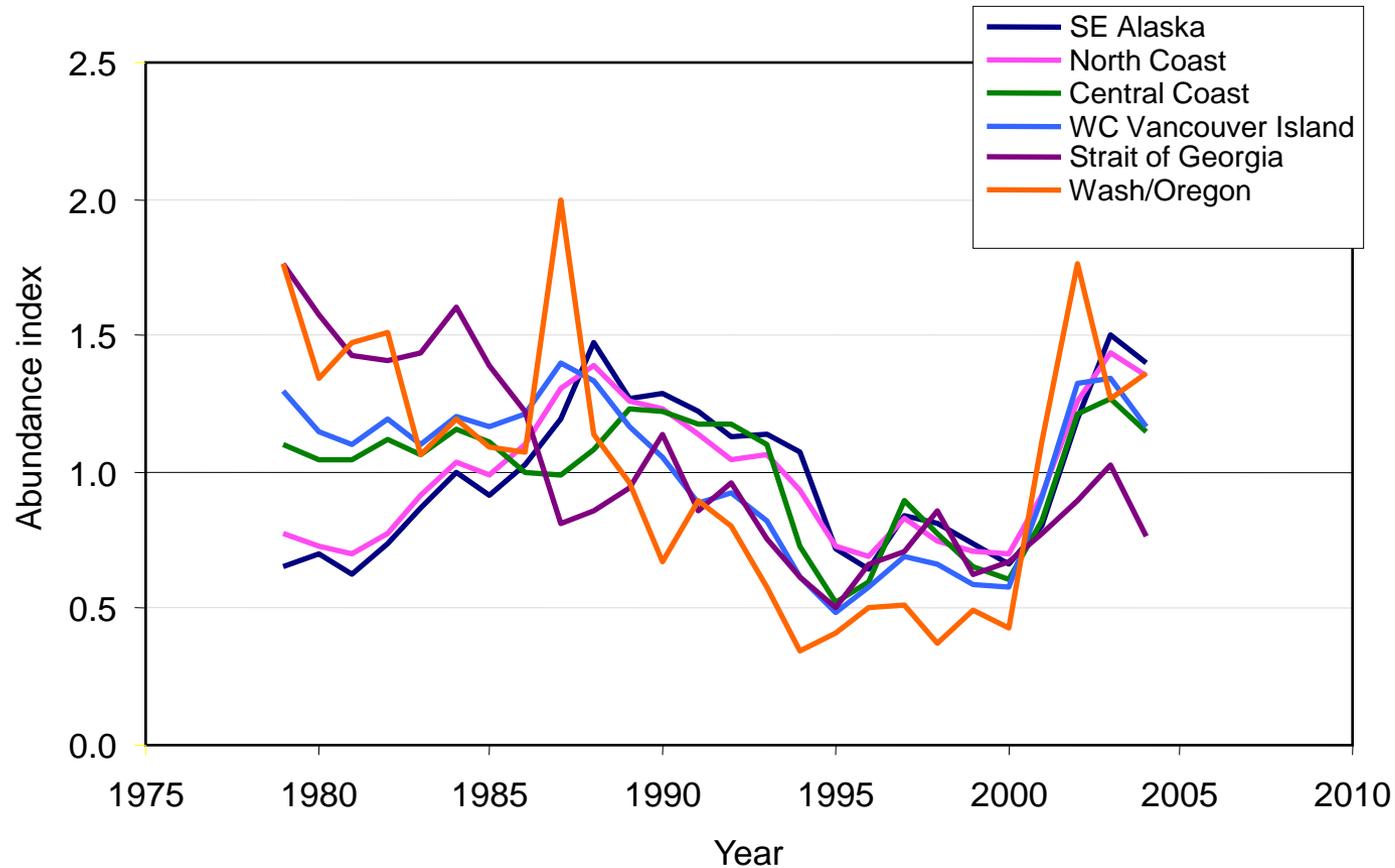


Assessing prey availability...

- Chose two primary prey species, Chinook and chum salmon
- For Chinook, measures of abundance were derived from the Pacific Salmon Commission CTC Abundance Index, modified to reflect annual abundance relative to the average over the time series, rather than to the 1979-82 base period.
- For chum, abundance was determined from returns in the Pacific Salmon Commission's Inner South Coast Management Area, 1973-2003. This includes 400 stream and river systems, including Fraser River

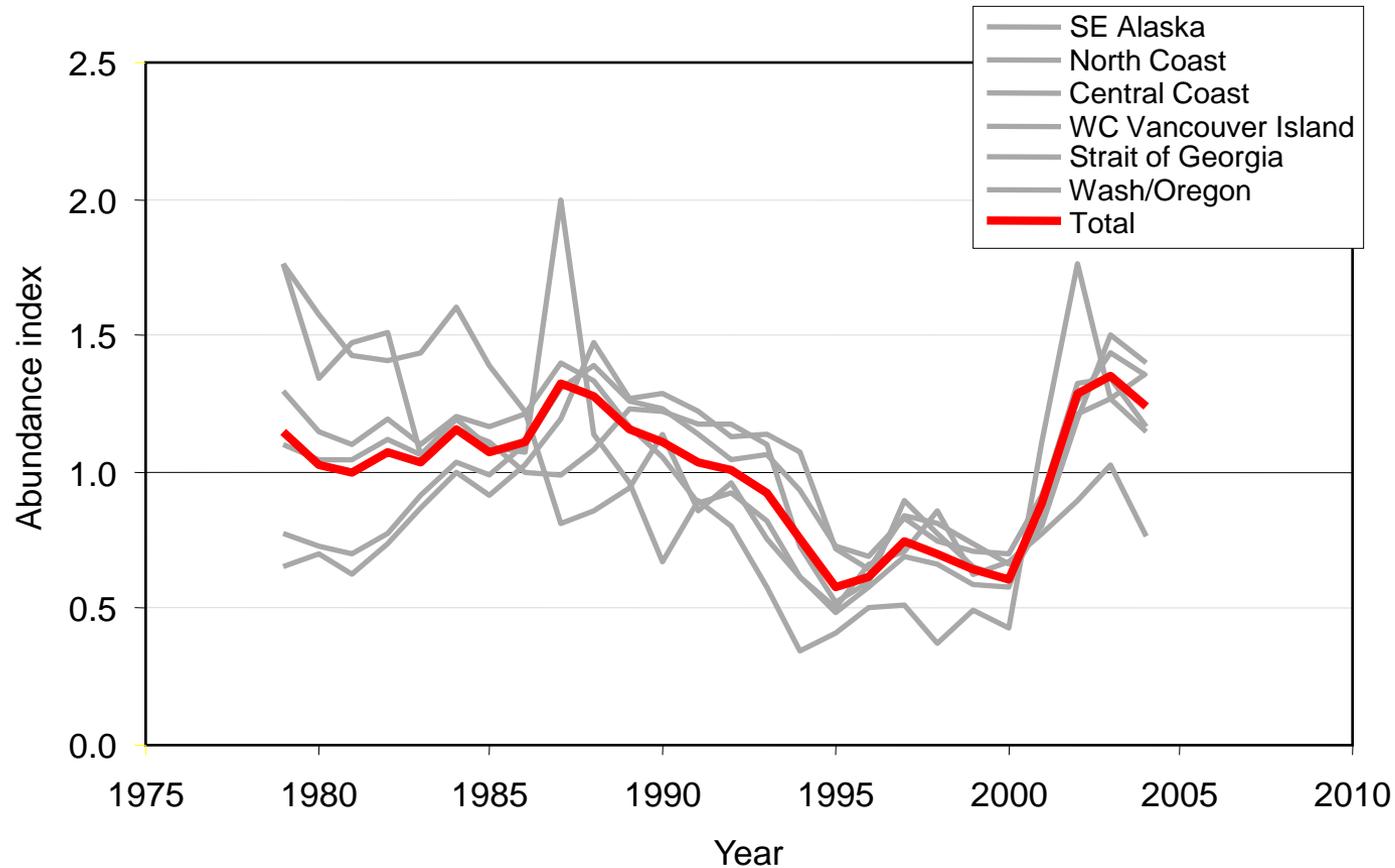
Chinook salmon abundance indices

Ratio of annual abundance over long-term average

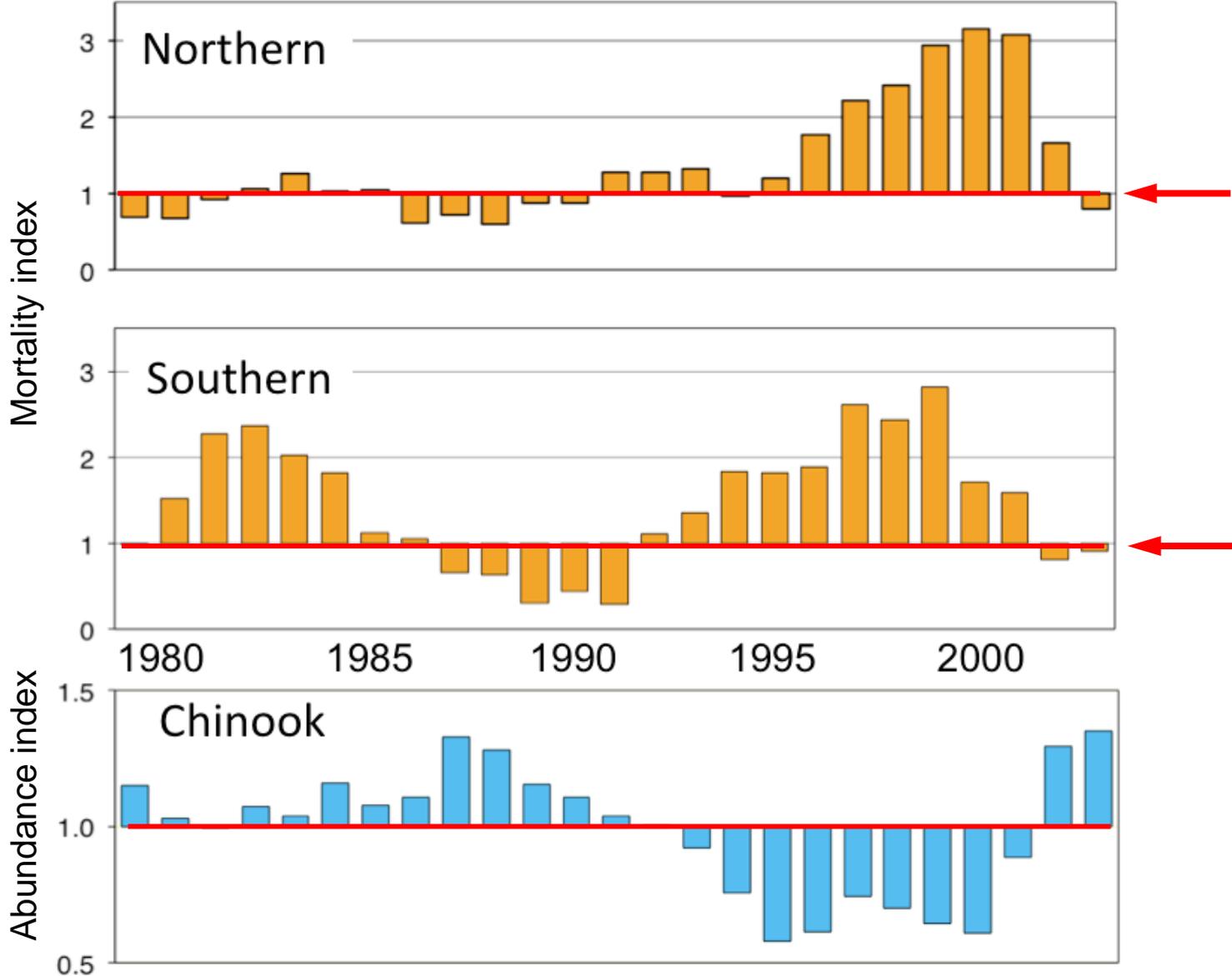


Chinook salmon abundance indices

Ratio of annual abundance over long-term average



Resident mortality indices vs Chinook salmon abundance

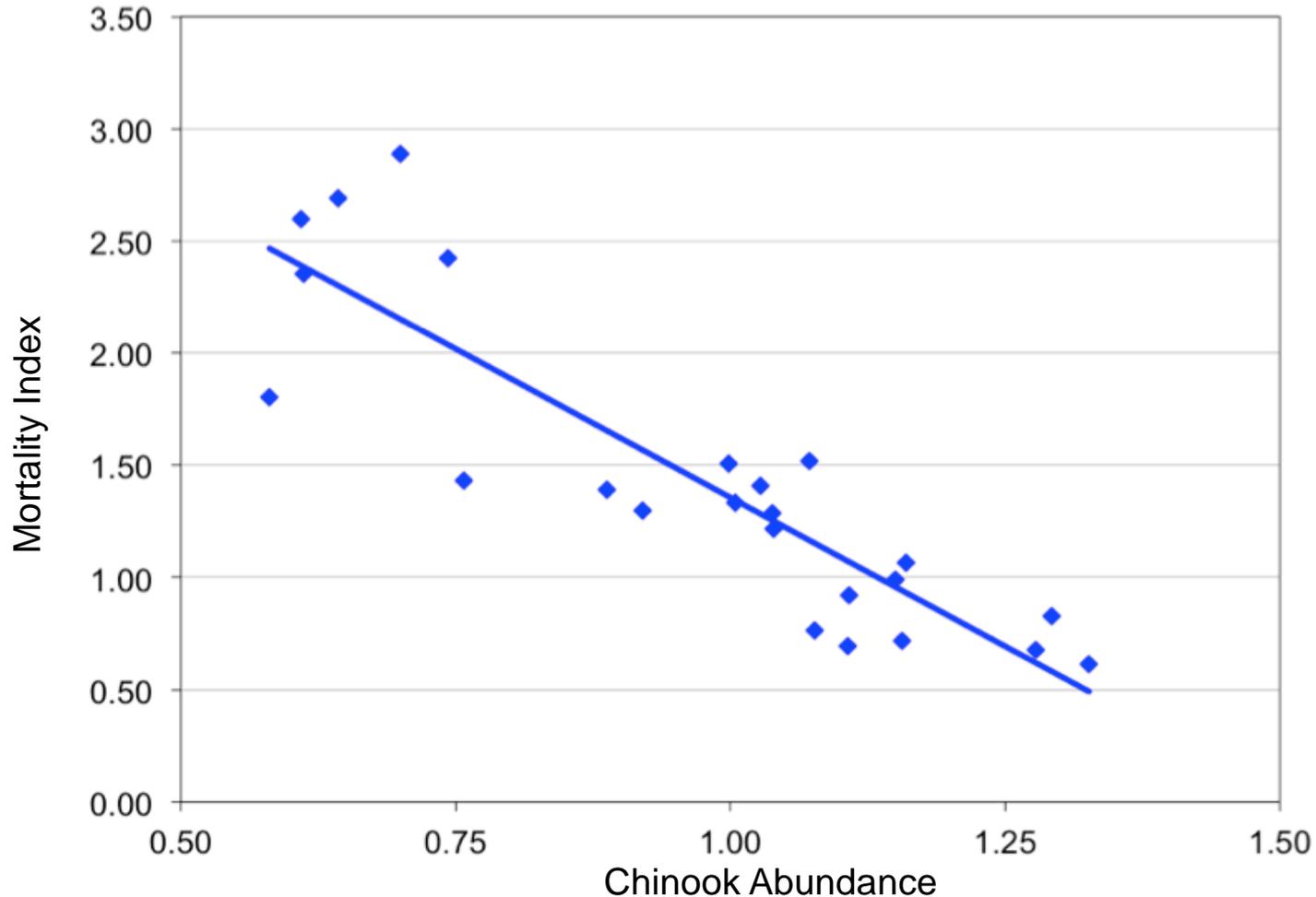


Source: Ford, Ellis & Olesiuk. 2005. CSAS Res Doc 2005/042

Resident mortality rates vs Chinook salmon abundance

Coast-wide Chinook, 1979-2004, mortality lagged one year

($F_{1,22} = 76.7$, $r^2 = 0.777$, $P < 0.001$)



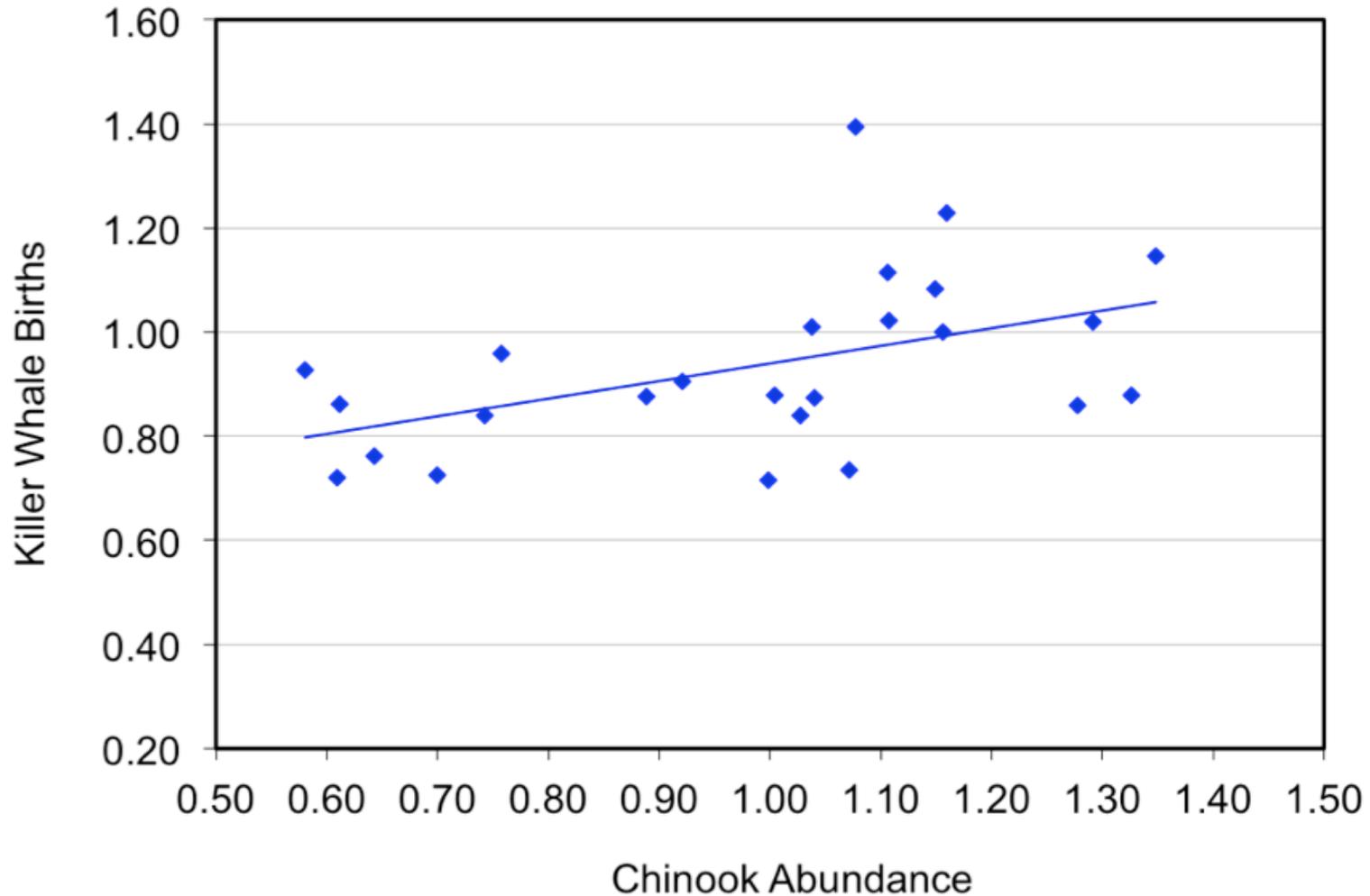
Effect of lag years on mortality vs chinook abundance correlation

Lag (yrs)	r ²	Signif.
-2	0.0183	0.510
-1	0.1552	0.046
0	0.5089	<0.0001
1	0.7772	<0.0001
2	0.5788	<0.0001
3	0.2104	0.028
4	0.0620	0.264
5	0.0494	0.333

Resident births vs chinook abundance

Percentage of expected births, coast-wide chinook

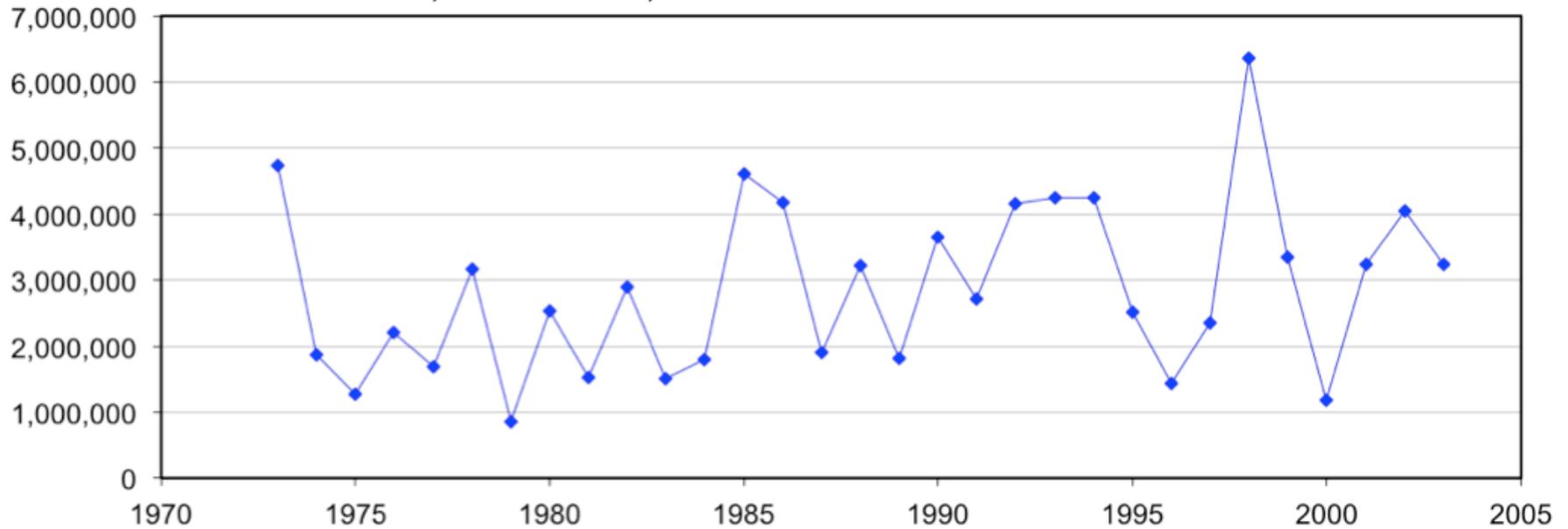
($F_{1,23} = 6.77$, $r^2 = 0.227$, $P < 0.05$)



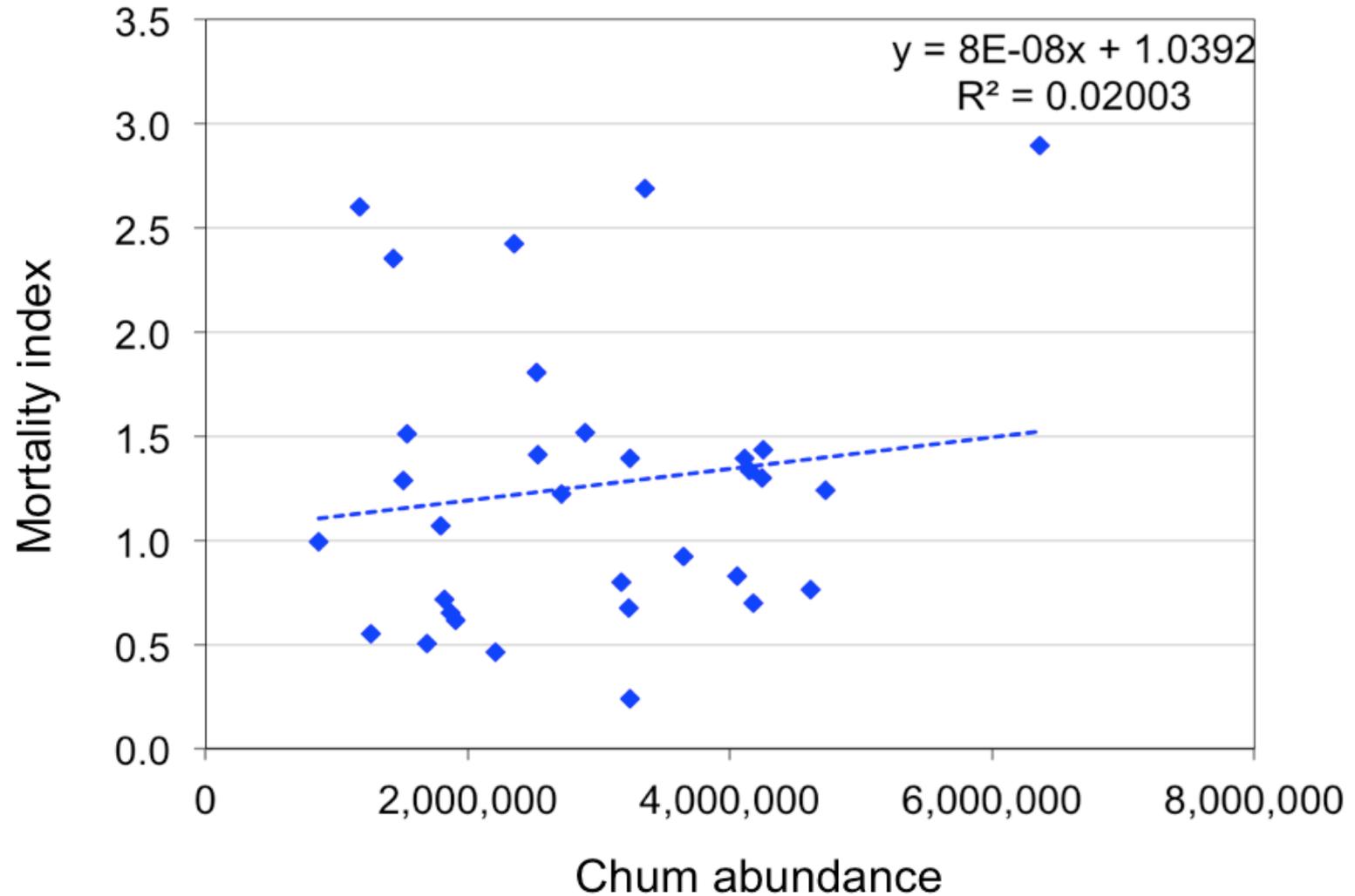
Chum abundance, BC South Coast

Chum salmon abundance

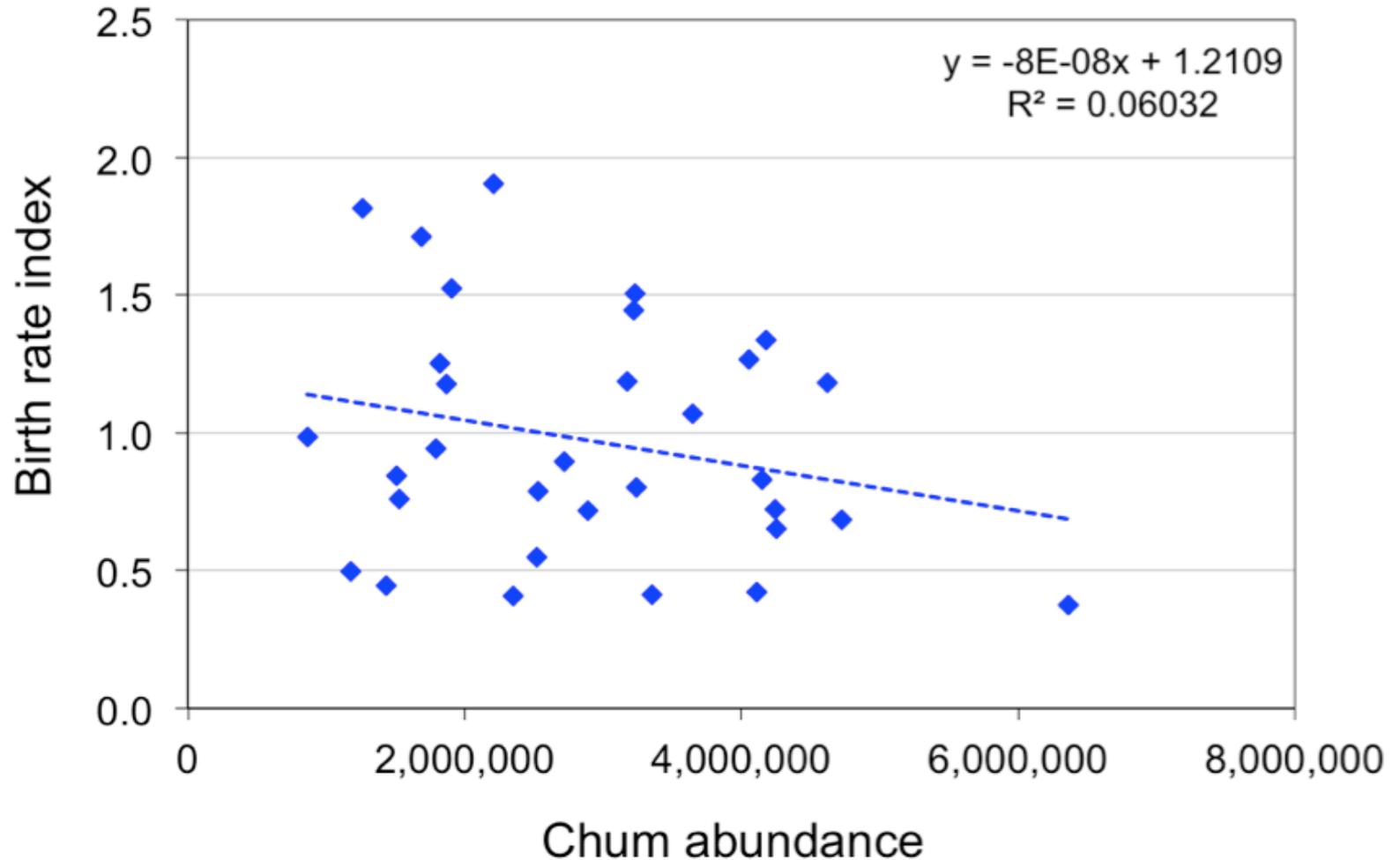
BC south coast, 1973-2003, based on 400 different stocks



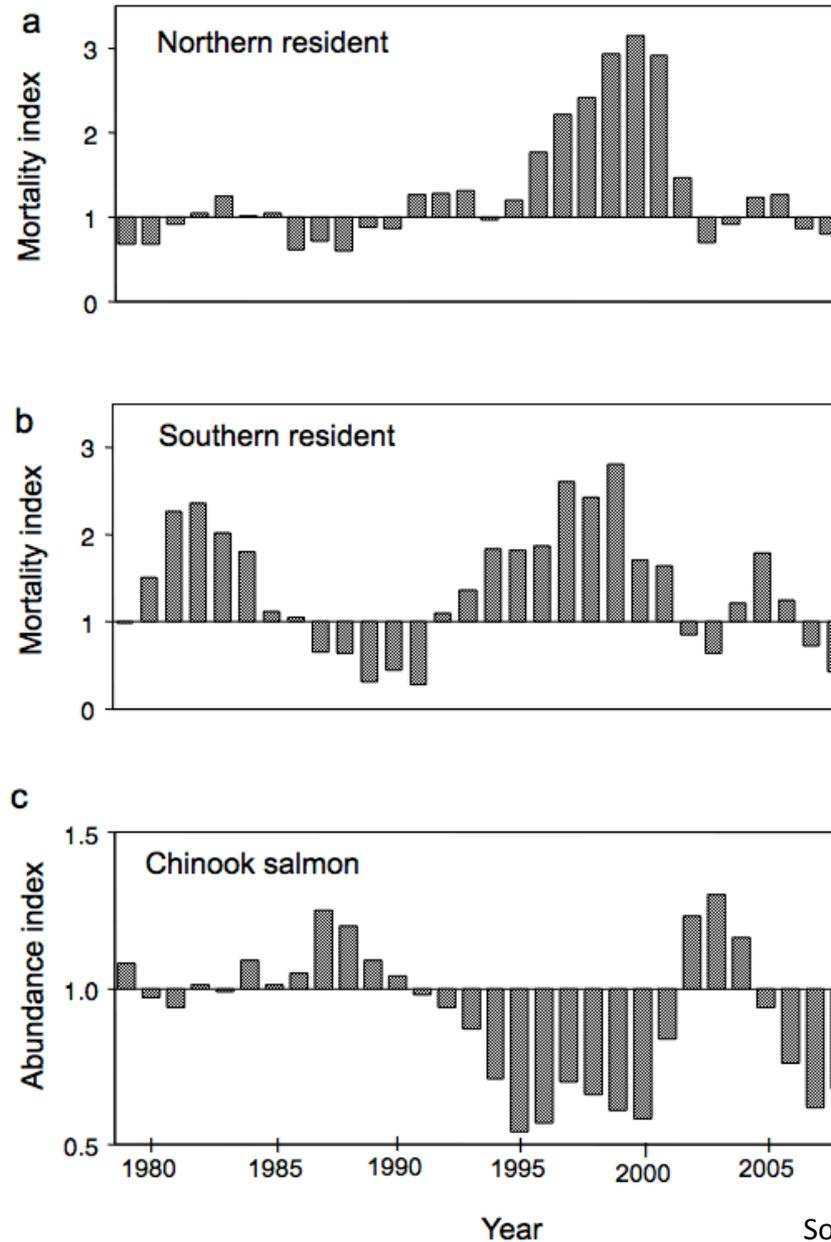
No relationship between mortalities and chum abundance



No relationship between birth rates and chum abundance

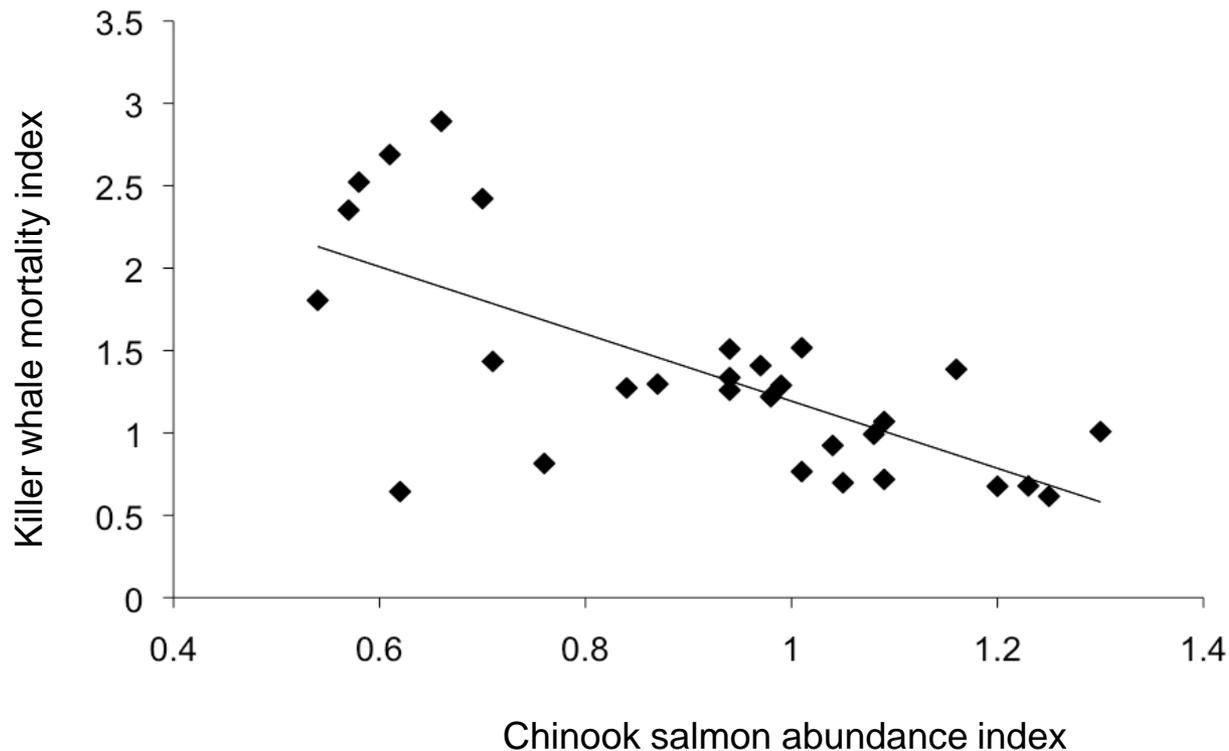


Annual indices of mortality of (a) northern and (b) southern resident killer whales and (c) abundance of Chinook salmon, 1979 – 2008.

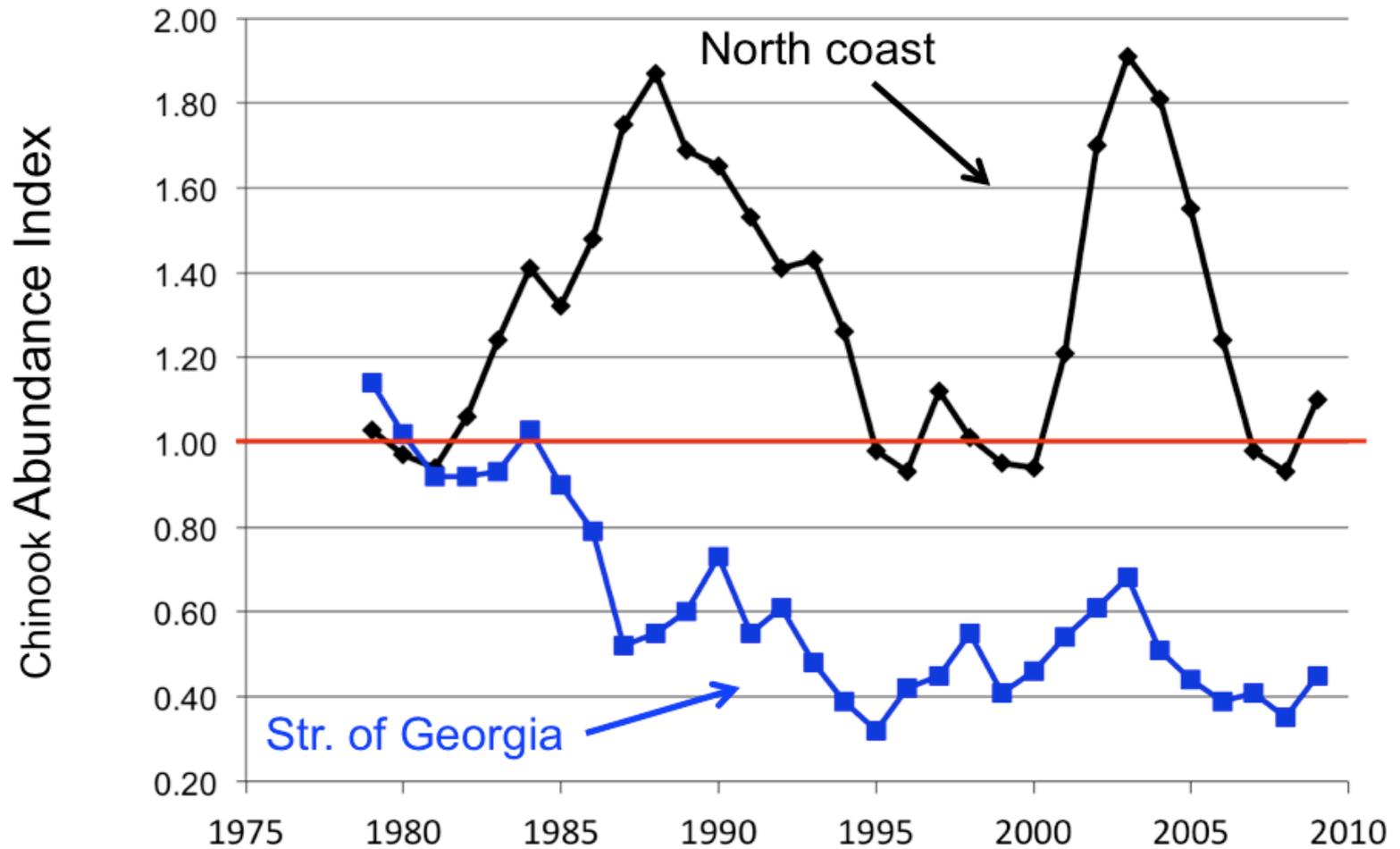


Relationship between annual indices of Chinook salmon abundance and resident killer whale mortalities, 1979-2008.

($r^2 = 0.48673$, $F_{1,27} = 25.6$, $p < 0.001$)



Changes in Chinook availability in coastal regions may affect NR and SR populations differently



Summary: population dynamics vs salmon

- Significant declines in resident populations during late 1990s driven by unusually high mortality rates
- Mortalities synchronous in both populations, and distributed among different social groups and age/sex classes
- Patterns of resident mortalities and Chinook abundance highly correlated, births also but less strongly
- Chum salmon abundance showed no correlation with resident survival or birth rates

Did prey limitation cause recent declines?

- Is there evidence of nutritional stress in population?
- Increases in neonate and juvenile mortality?
 - no, deaths spread among age/sex classes
 - stress may be spread due to food sharing and provisioning
 - high PCB levels in adults coupled with nutritional stress may increase susceptibility to disease
- Decreases in birth rate?
- Widespread synchronous mortalities in two populations difficult to explain with other known threats

Acknowledgements....

Prey sample collection

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Analysis etc.

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