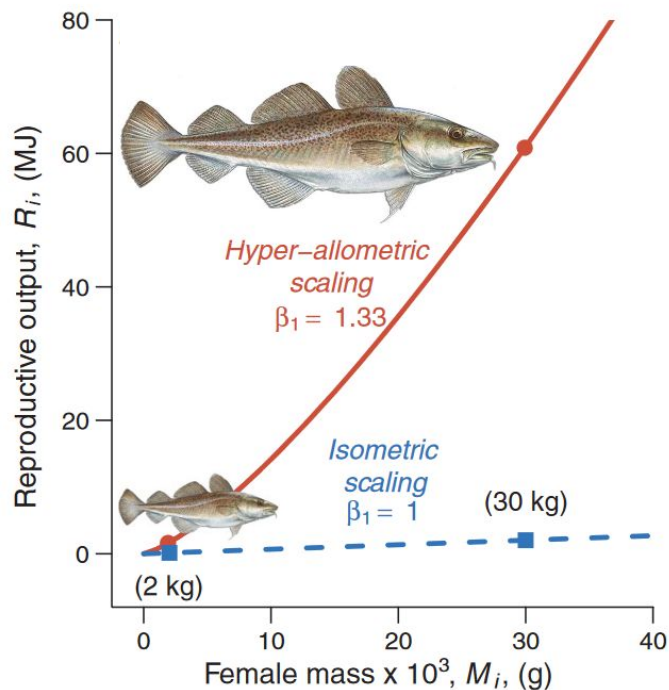




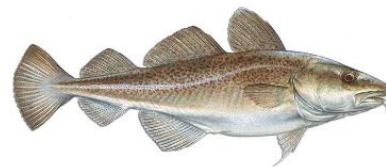
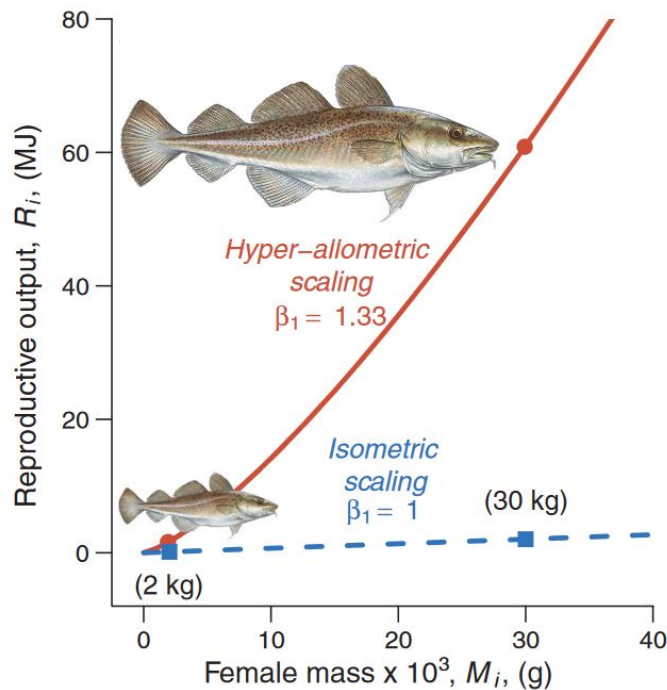
Alternative perspectives on declines in Pacific salmon body size

Cameron Freshwater
Pacific Biological Station
Fisheries and Oceans Canada

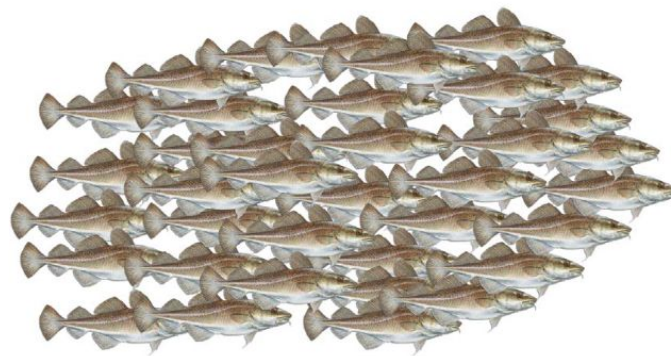
Large fish are more productive than small fish



Large fish are more productive than small fish



$$\begin{aligned} n &= 1 \\ \sum R_i &\approx 61 \text{ MJ} \\ \sum M_i &= 30 \text{ kg} \end{aligned}$$

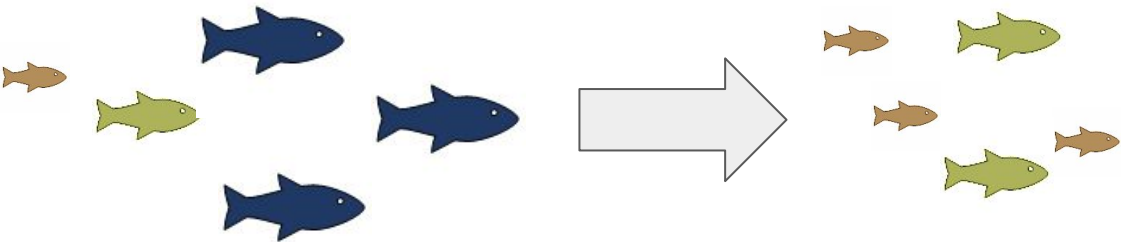


$$\begin{aligned} n &= 37 \\ \sum R_i &\approx 61 \text{ MJ} \\ \sum M_i &= 74 \text{ kg} \end{aligned}$$

Why Size Matters	Coastwide Chinook	Century of Sockeye
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More than one way to shrink a fish...

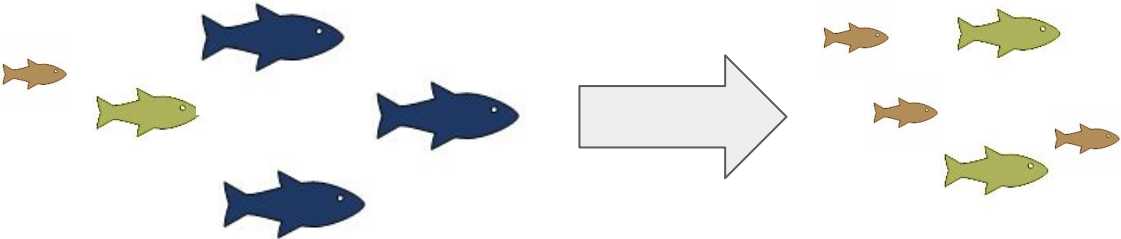
Maturation/
Recruitment
Age



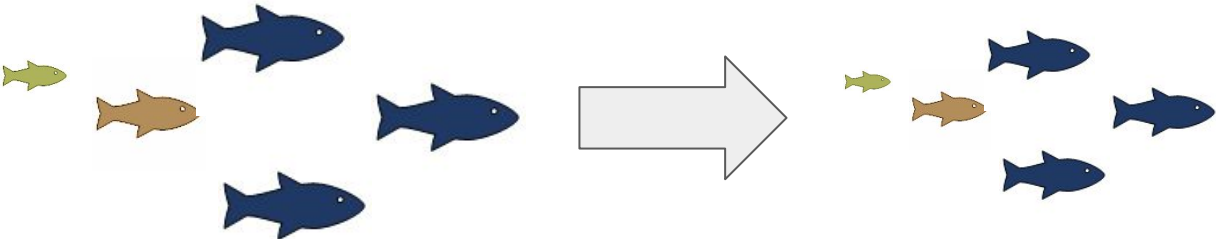
Why Size Matters	Coastwide Chinook	Century of Sockeye
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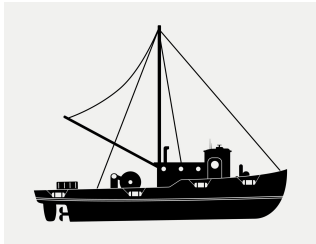
Size-at-Age



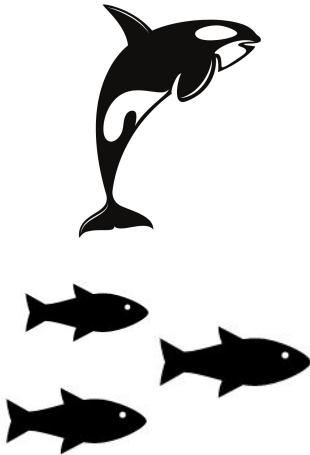
Why Size Matters	Coastwide Chinook	Century of Sockeye

Ecological-evolutionary drivers of growth and maturity

Selective Harvest



Natural Mortality



Competition



Environmental Conditions



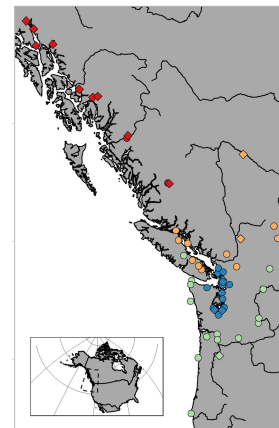
Management Practices

Qualitative Case Study 1

What ecological
traits covary with
Chinook salmon
age-at-maturity?

Nonstationary patterns in demographic traits covary with Chinook salmon marine distributions

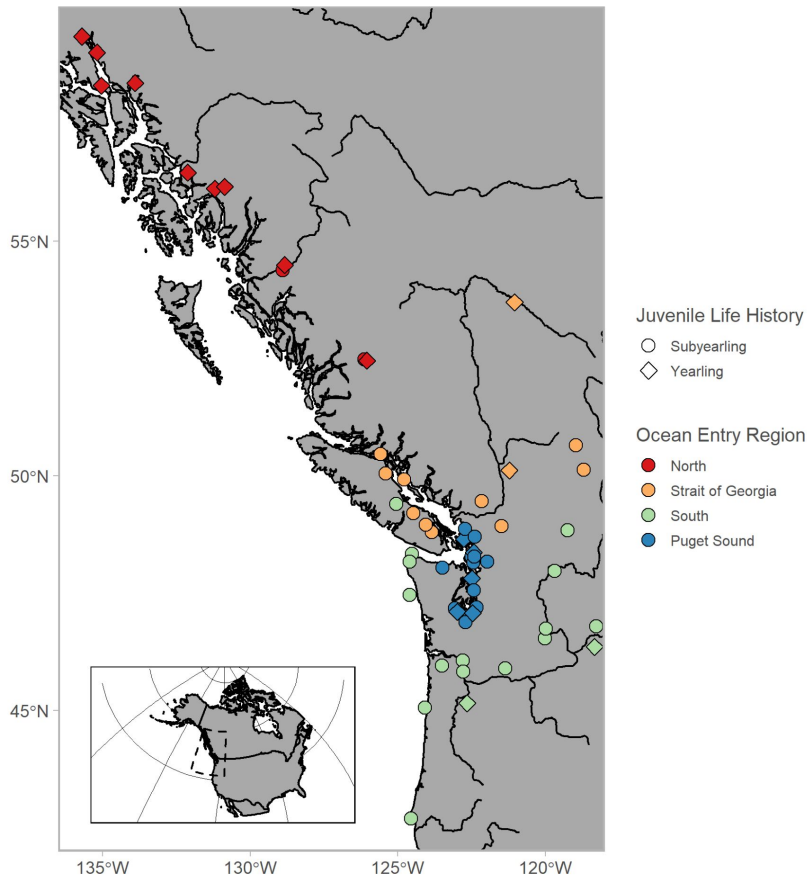
Cameron Freshwater^a, Charles K. Parken^b, Strahan Tucker^a, Antonio Velez-Espino^a, and Jackie King^a



Why Size
Matters

Coastwide
Chinook

Century of
Sockeye

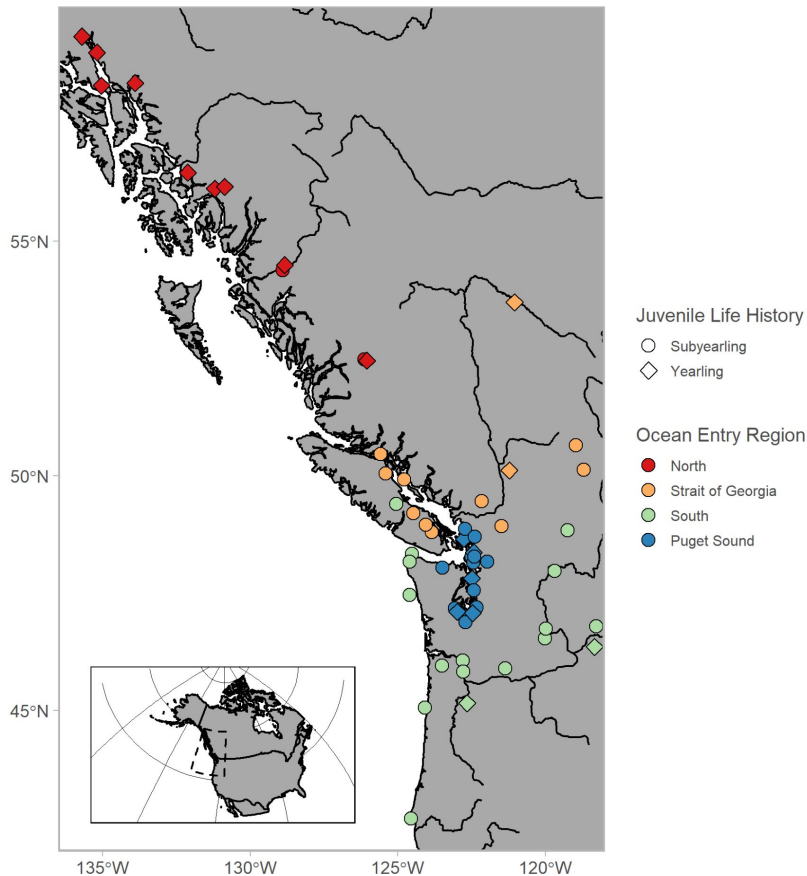


- Explored coherent patterns in mean age-at-maturity among Chinook salmon indicator stocks (1976-2015)

Why Size
Matters

Coastwide
Chinook

Century of
Sockeye

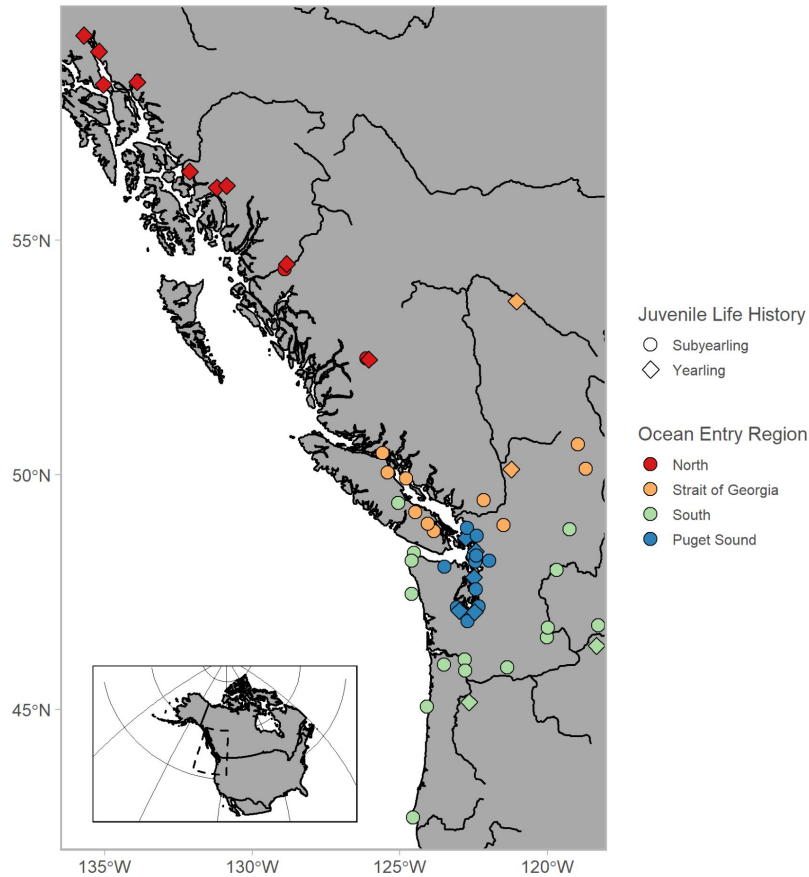


- Explored coherent patterns in mean age at maturity among Chinook salmon indicator stocks (1976-2015)
- Maturation age is an output from CTC exploitation rate analysis

Why Size
Matters

Coastwide
Chinook

Century of
Sockeye

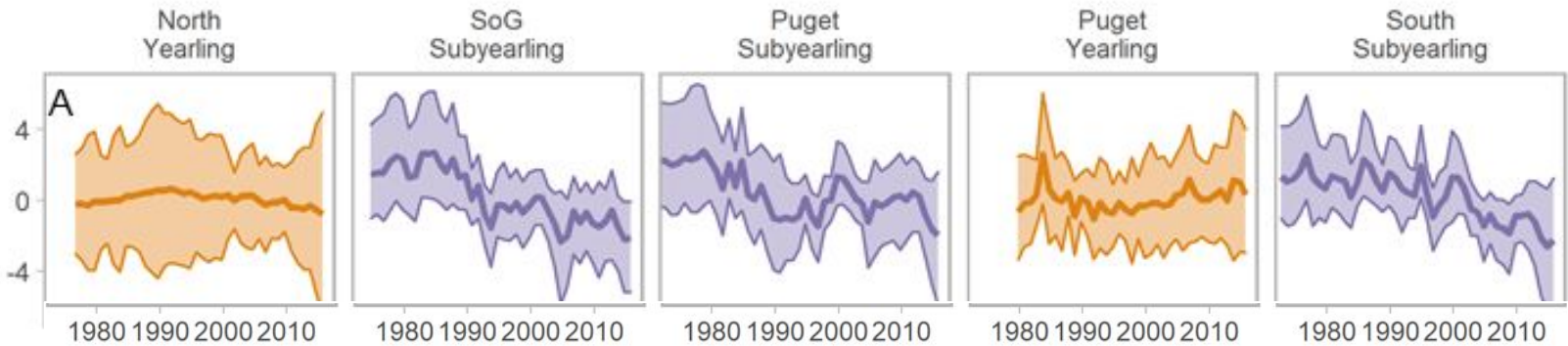


- Explored coherent patterns in mean age at maturity among Chinook salmon indicator stocks (1976-2015)
- Maturation age is an output from CTC exploitation rate analysis
- Trends covaried with juvenile life history strategy and ocean entry location, *not maturation distribution*

Why Size
Matters

Coastwide
Chinook

Century of
Sockeye

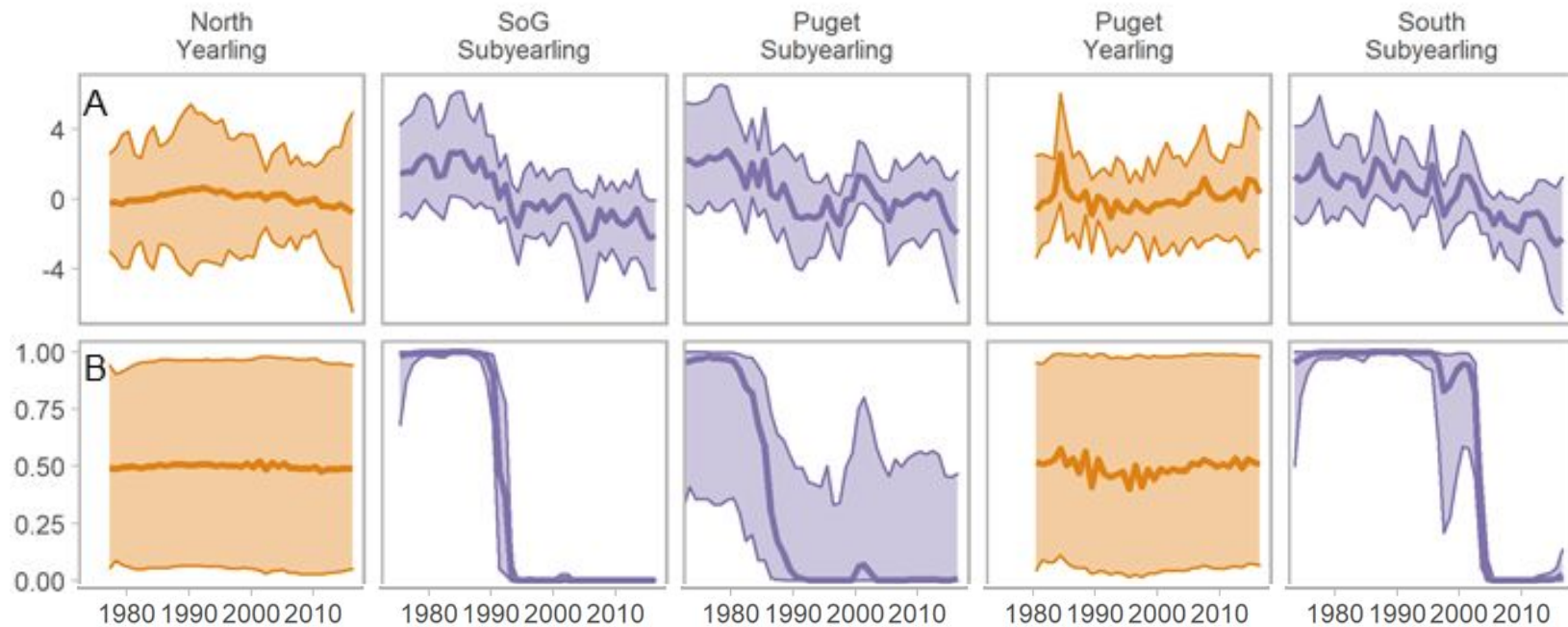


Shared trends differed among yearling and subyearling life history strategies

Why Size
Matters

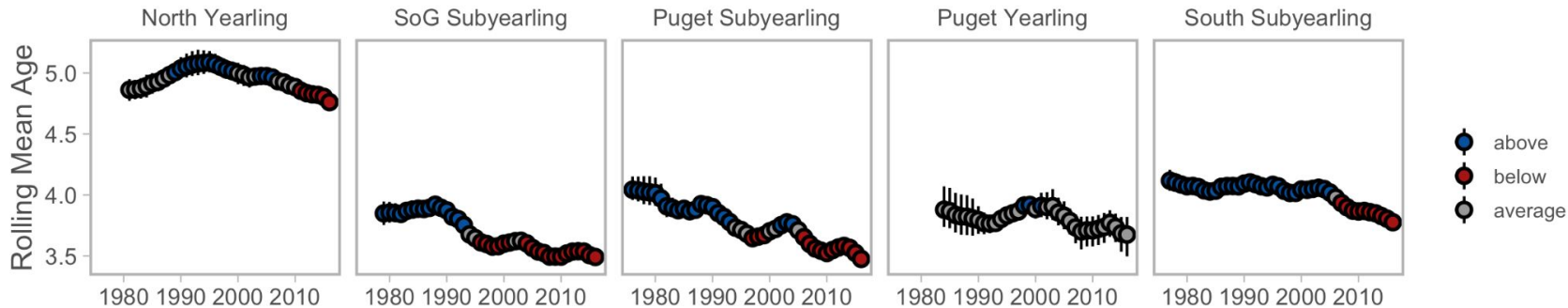
Coastwide
Chinook

Century of
Sockeye



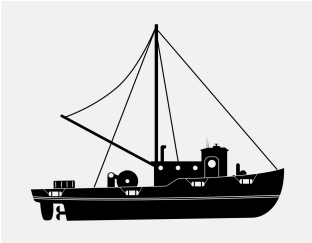
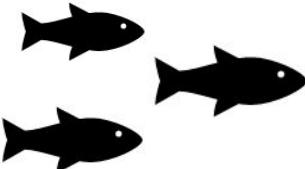
Magnitude of declines and probability of regime shift greatest for subyearling life history types; timing of declines was variable

Why Size Matters	Coastwide Chinook	Century of Sockeye



Four of five stock groups have below average age-at-maturity in recent years

Declines in BC/WA/OR stocks greater than previously considered likely due to changes in hatchery releases, sampling and harvest rates

Why Size Matters	Declining harvest rates 		
Coastwide Chinook	Increasing marine mammal abundance 		  Difficult to assess
Century of Sockeye	Minimal overlap with abundant species 		  Size at release stable

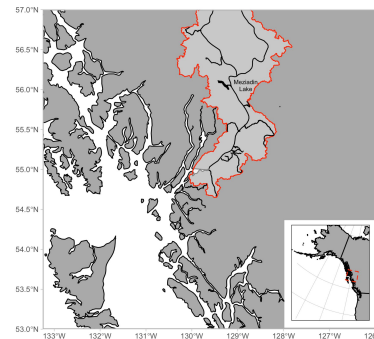
Qualitative Case Study 2

Do long time series
change our
perception of trends
in sockeye salmon
size-at-age?

A century-long time series reveals large declines and greater synchrony in Nass River sockeye salmon size-at-age

Cameron Freshwater¹, Will Duguid², Francis Juanes², and Skip McKinnell²

¹Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, BC, Canada; ²Department of Biology, University of Victoria, Victoria, BC, Canada

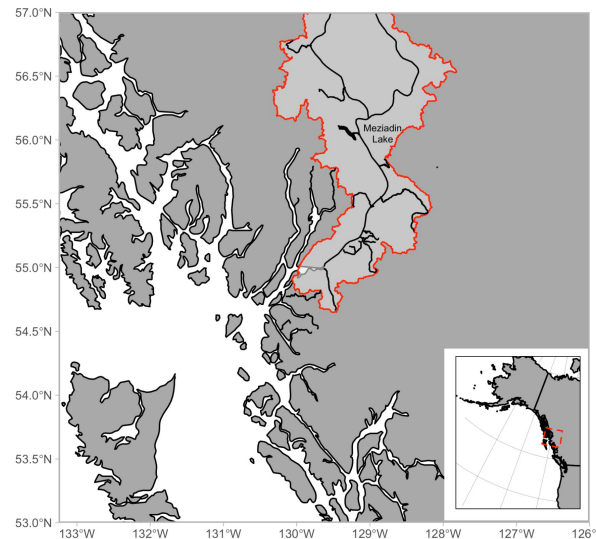


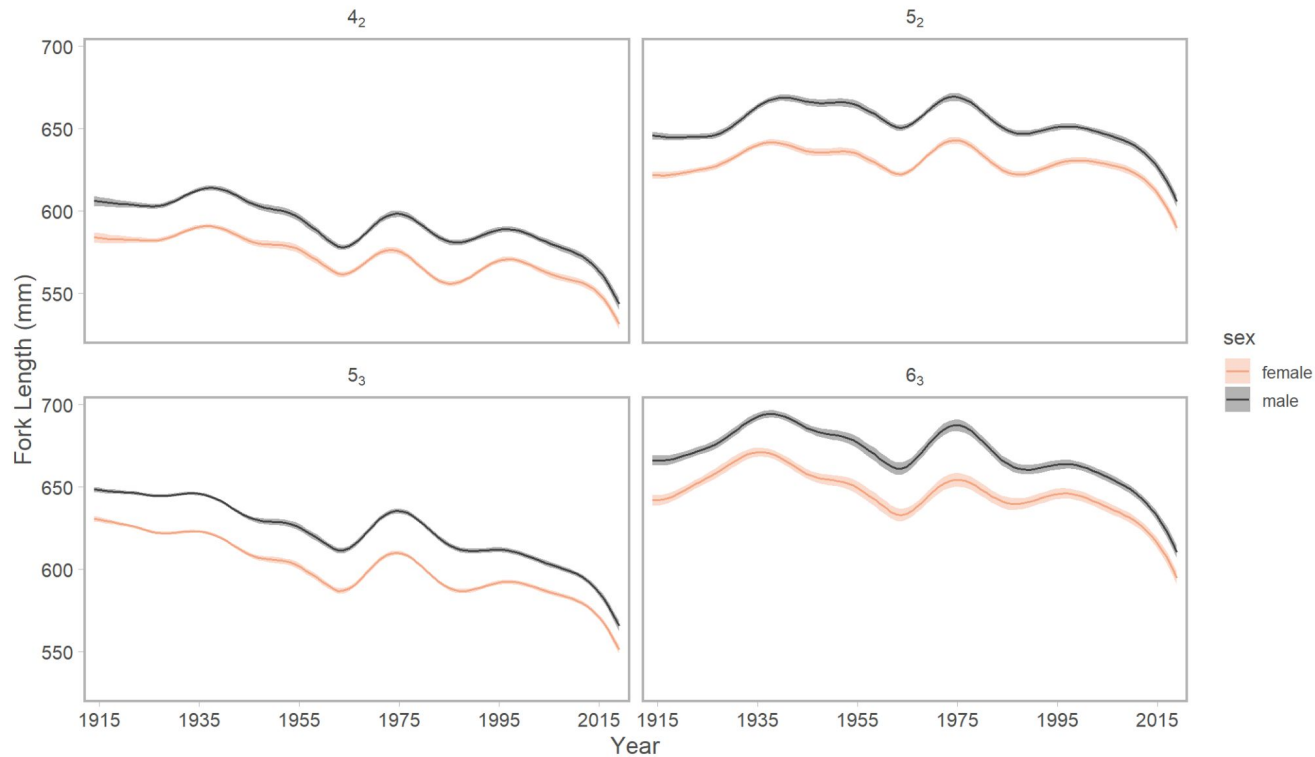
Why Size
Matters

Coastwide
Chinook

Century of
Sockeye

- Historical samples recovered by Skip McKinnell, combined with contemporary samples
- Charles Gilbert began sockeye salmon sampling program in 1915
- Spans periods with extensive exploitation and multiple environmental regimes
- Analysis accounted for gappy time series and changes in the timing/selectivity of sampling

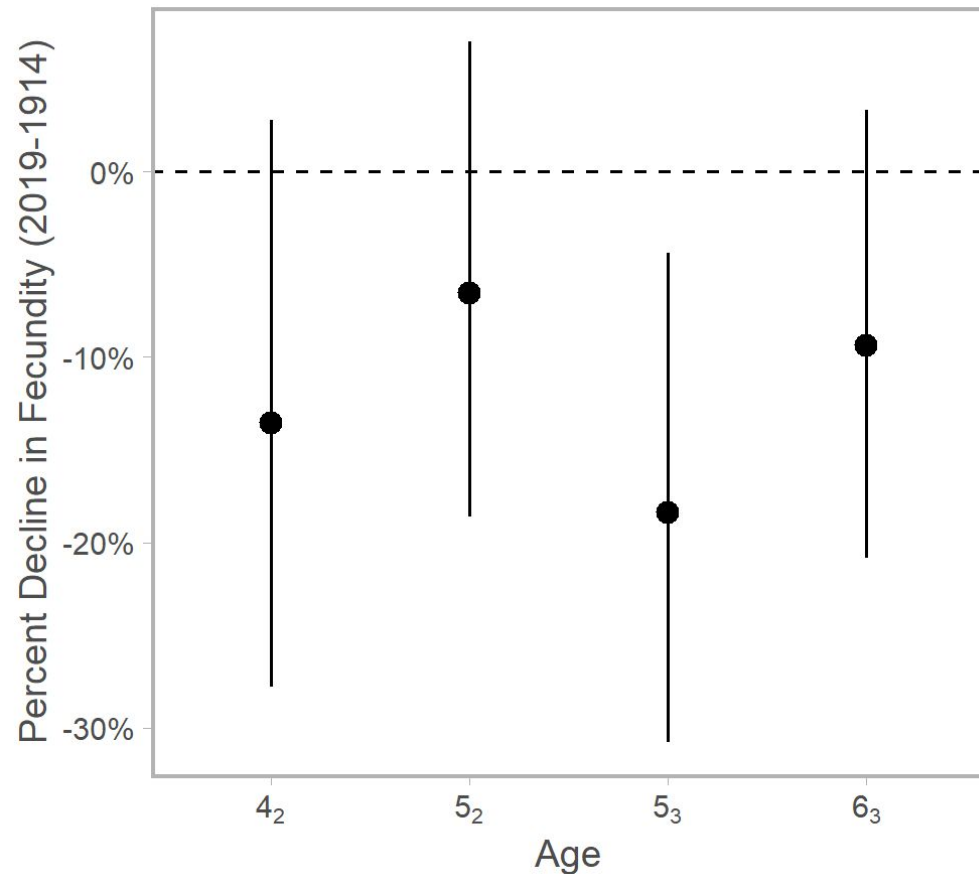




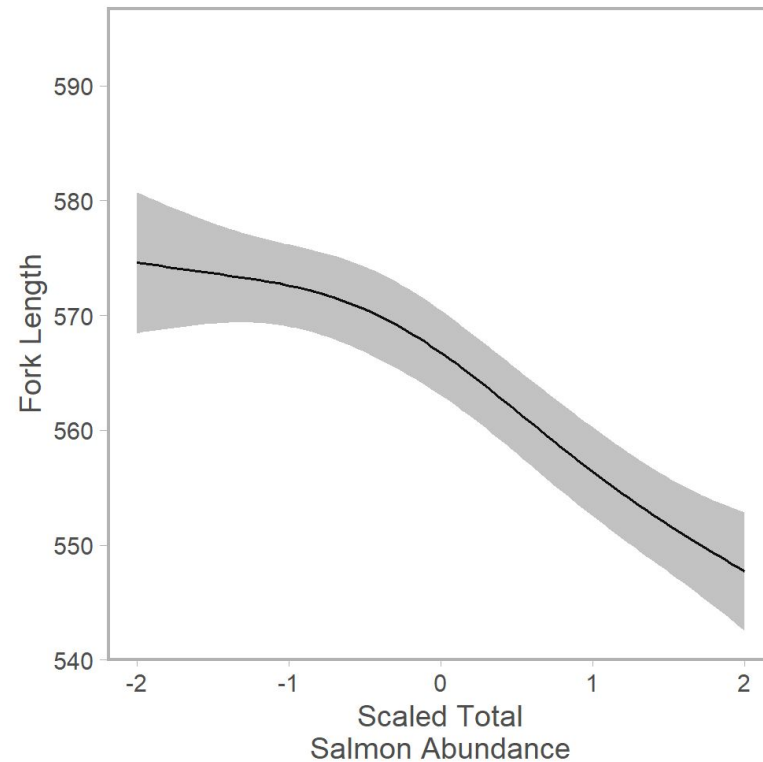
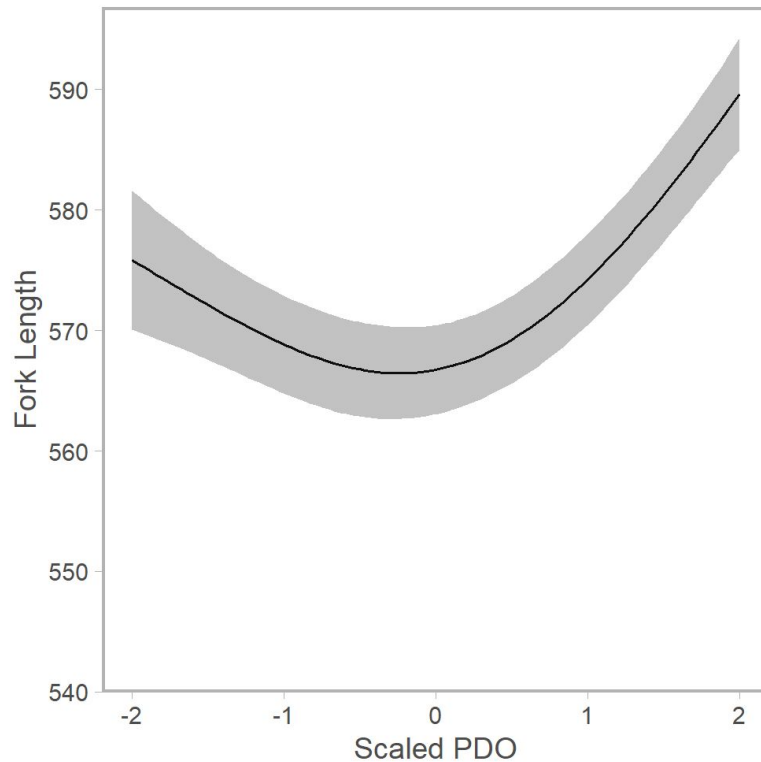
- Divergent patterns among ocean age classes disappear early in time series
- Multiple stanzas of decline that have accelerated since ~2000

Why Size Matters	
Coastwide Chinook	
Century of Sockeye	

- Declines in size have likely resulted in impacts to fecundity
- Underestimates total impact on productivity because egg mass effects excluded
- Consequences for escapement goals

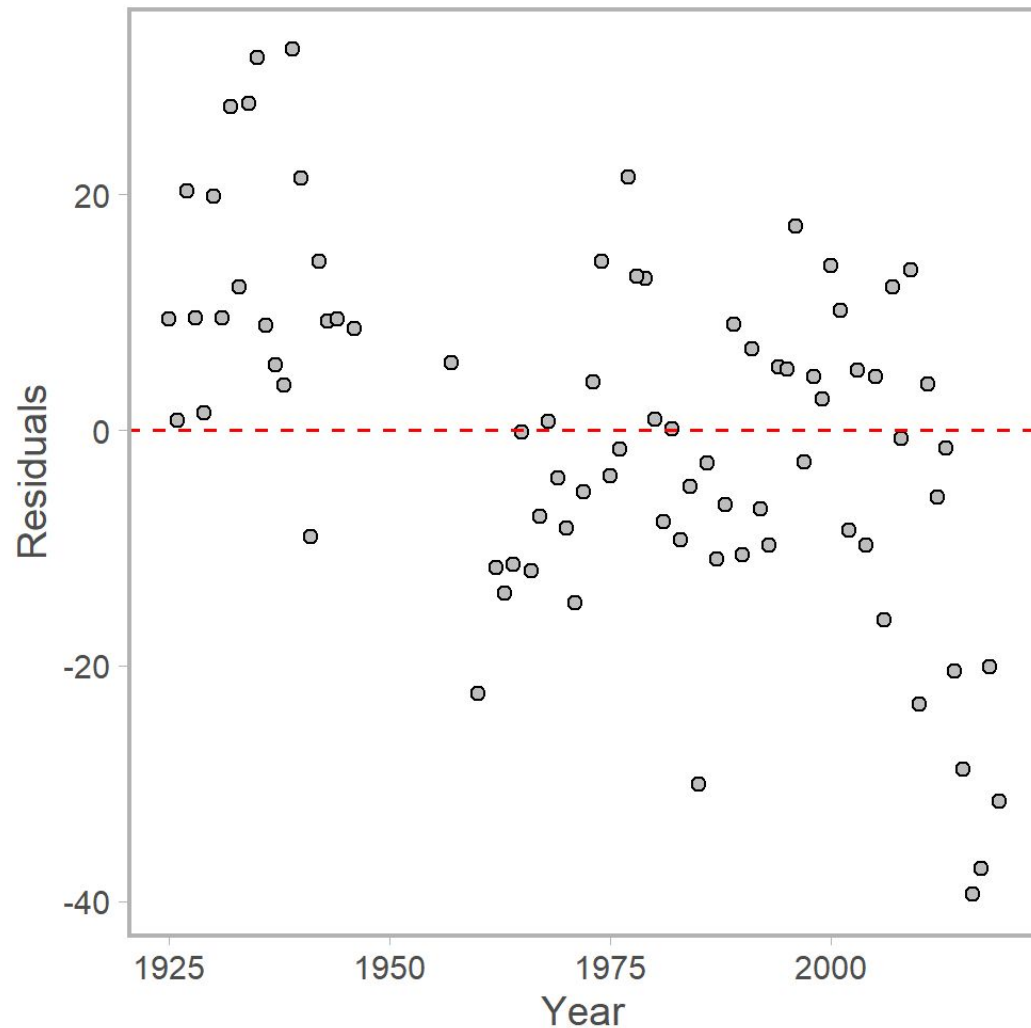


Why Size Matters
Coastwide Chinook
Century of Sockeye

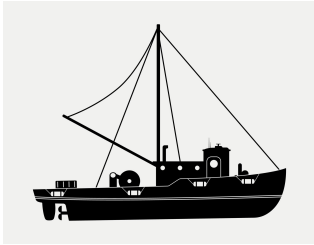
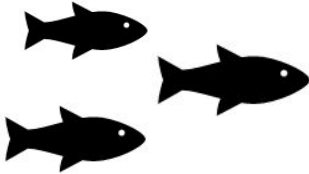


- Limited number of covariate time series available
- Significant PDO and density dependent effects

Why Size Matters
Coastwide Chinook
Century of Sockeye



However considerable
residual variability
emphasizes modest
predictive power of these
covariates

Why Size Matters	High exploitation historically, recently low	?				
Coastwide Chinook	Predation rates unquantified	?			?	Difficult to assess
Century of Sockeye	Declines preceded large increases in abundance	?			?	Improved fish passage & capacity

Can late stage marine mortality explain observed shifts in age structure of Chinook salmon?

Kaitlyn A. Manishin, Curry J. Cunningham



ARTICLE

Incorporating demographic information into spawner–recruit analyses alters biological reference point estimates for a western Alaska salmon population

Benjamin A. Staton, Matthew J. Catalano, S

RESEARCH ARTICLE | BIOLOGICAL SCIENCES | 8



Resurgence of an apex marine predator and the decline in prey body size

Jan Ohlberger , Daniel E. Schindler, Eric J. Ward , +1, and Timothy E. Essington [Authors Info & Affiliations](#)

Edited by James A. Estes, University of Ca

December 16, 2019 | 116 (52) 266

PRIMARY RESEARCH ARTICLE

WILEY Global Change Biology

Signals of large scale climate drivers, hatchery enhancement, and marine factors in Yukon River Chinook salmon survival revealed with a Bayesian life history model

Curry J. Cunningham



RAPID COMMUNICATION

Climate and competition influence sockeye salmon population dynamics across the Northeast Pacific Ocean

Brendan Connors, Michael J. Malick, Gregory T. Ruggerone, Pete Rand, Milo Adkison, James R. Irvine, Robert Campbell, and Kristen Gorman

Can late stage marine mortality explain observed shifts in age structure of Chinook salmon?

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1755



ARTICLE

Incorporating demographic information into spawner–recruit analyses alters biological reference point estimates for a

Tidal wave of fantastic quantitative papers on salmon dynamics → challenge is weighting relative importance of different drivers

Signals of large scale climate drivers, hatchery enhancement, and marine factors in Yukon River Chinook salmon survival revealed with a Bayesian life history model

Curry J. Cunningham



Peter A. H. Westley | Milo D. Adkison

943

RAPID COMMUNICATION

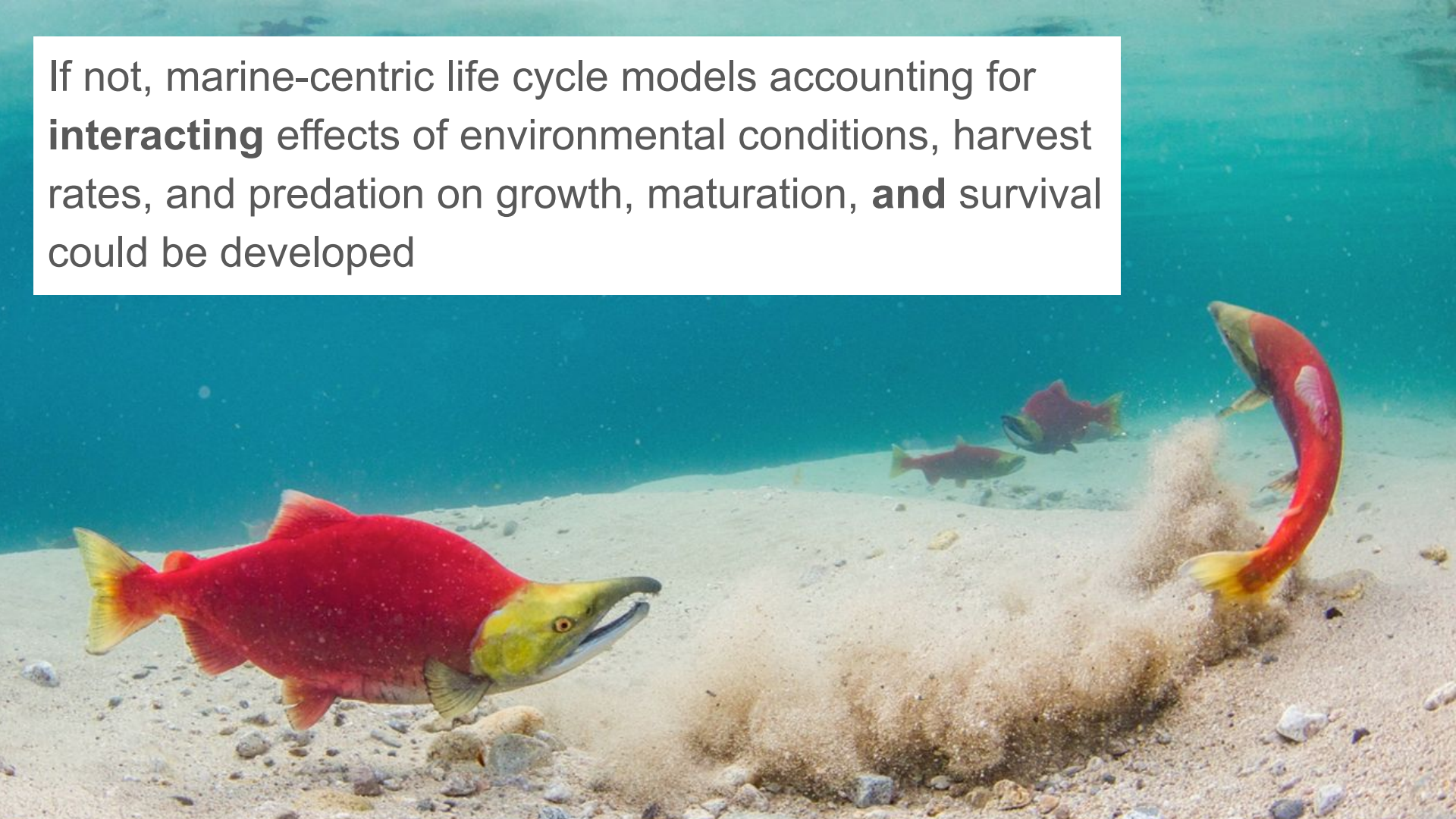
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Brendan Connors, Michael J. Malick, Gregory T. Ruggerone, Pete Rand, Milo Adkison, James R. Irvine, Robert Campbell, and Kristen Gorman

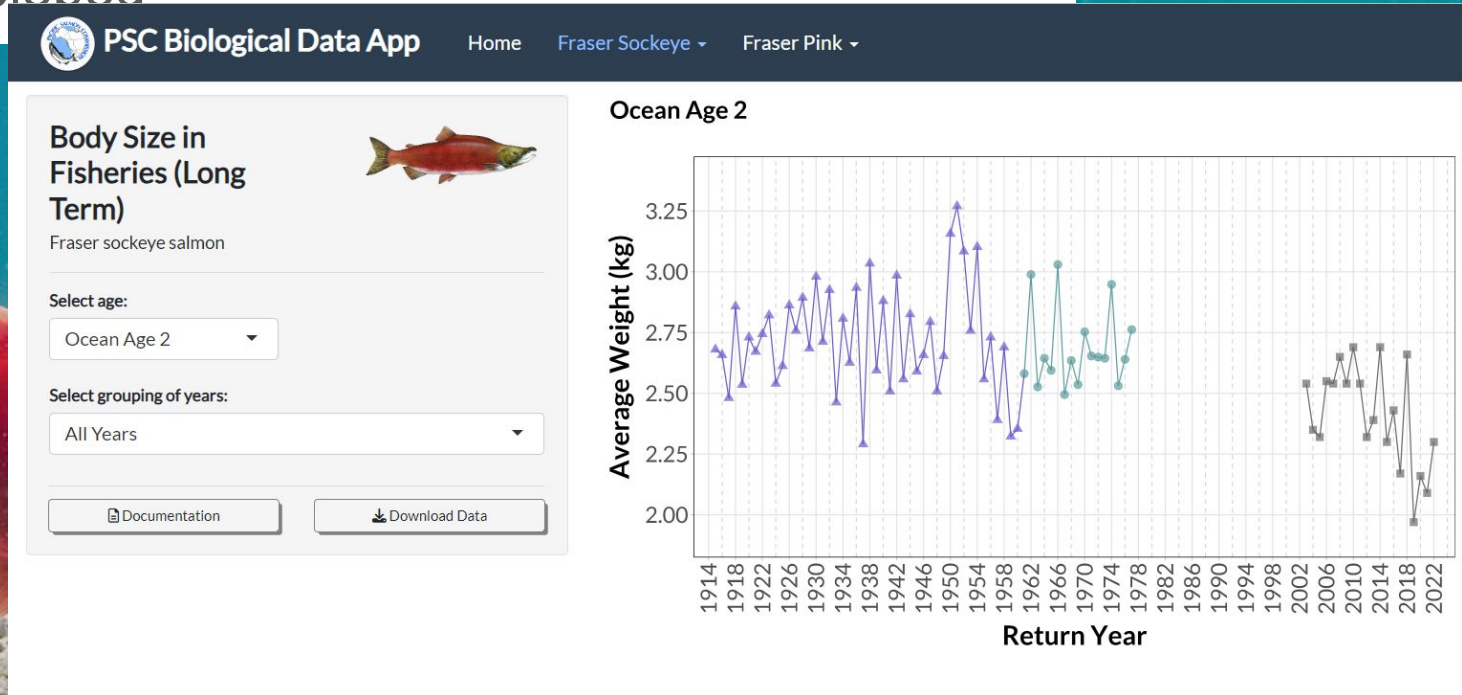


Are current analytical frameworks sufficient for management needs?

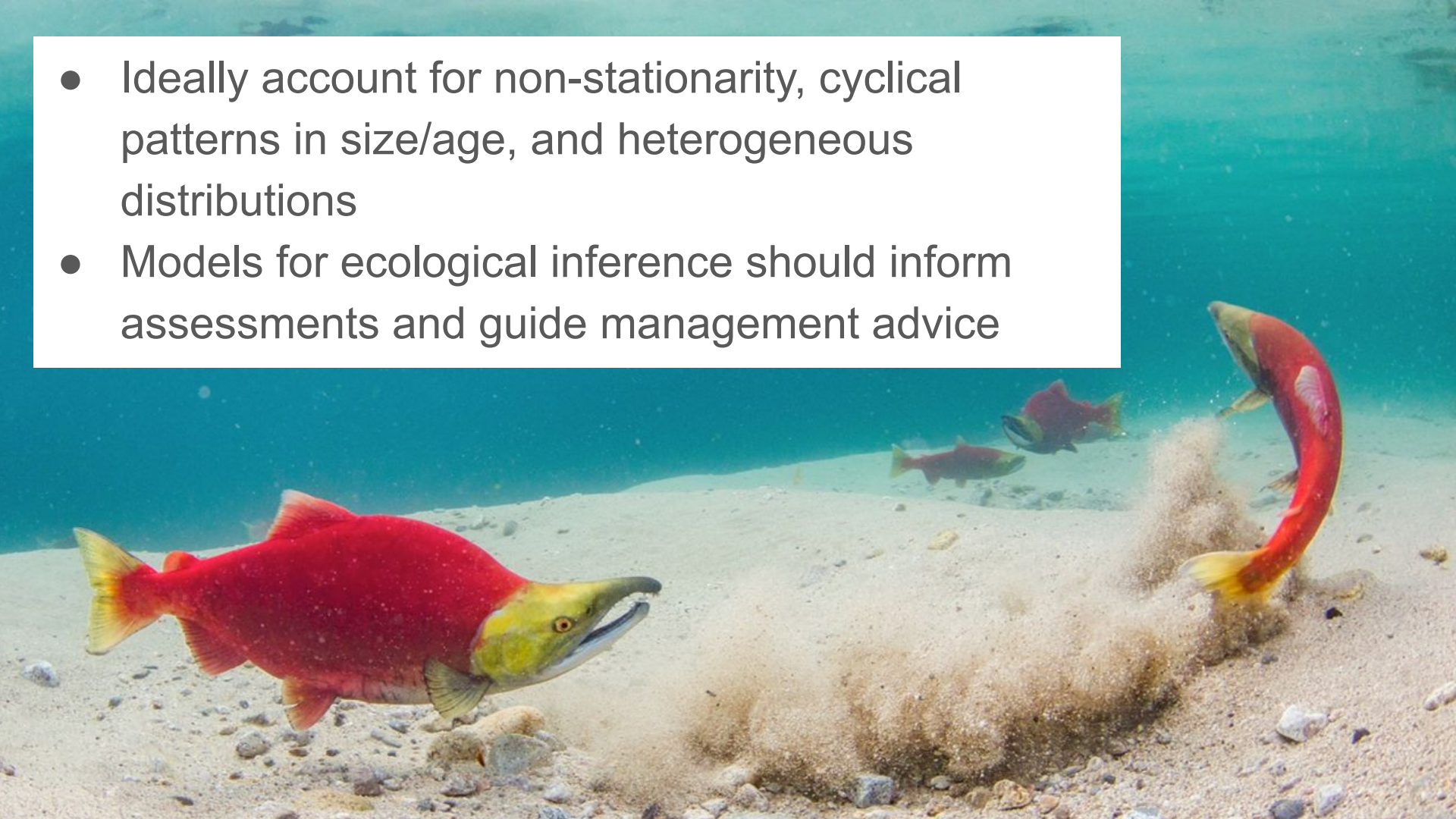
If not, marine-centric life cycle models accounting for **interacting** effects of environmental conditions, harvest rates, and predation on growth, maturation, **and** survival could be developed



If not, marine-centric life cycle models accounting for **interacting** effects of environmental conditions, harvest rates, and predation on growth, maturation, **and** survival could be developed



- Ideally account for non-stationarity, cyclical patterns in size/age, and heterogeneous distributions
- Models for ecological inference should inform assessments and guide management advice



Thanks to:

- Decades of field technicians and biologists
- Jackie King, Strahan Tucker, Chuck Parken, Antonio Velez-Aspino (DFO)
- Skip McKinnell, Will Duguid, Francis Juanes (UVic)
- DFO North Coast Staff, Nisga'a Fish and Game, and LGL Consultants



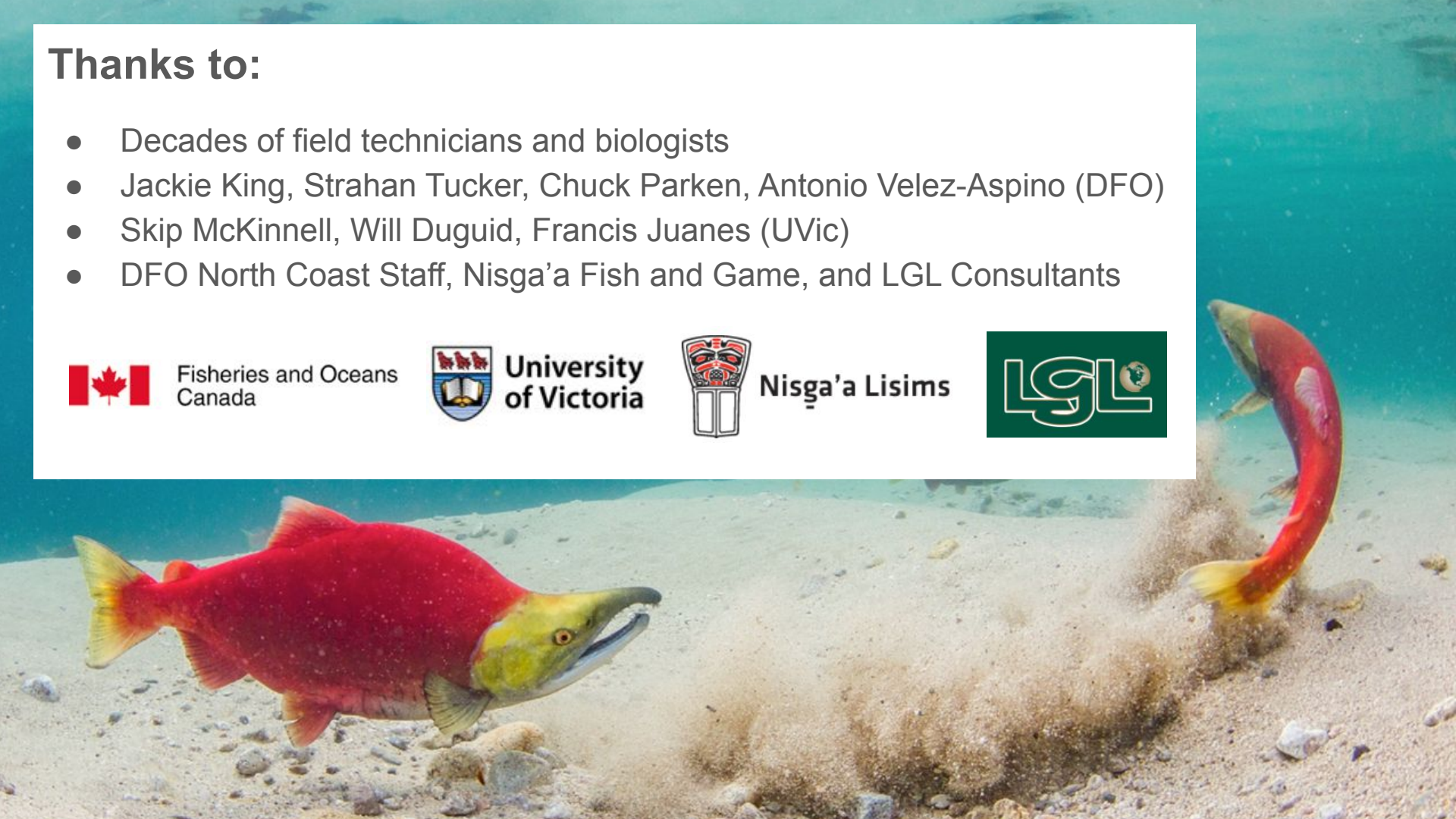
Fisheries and Oceans
Canada



University
of Victoria



Nisga'a Lisims



Rolling Mean Survival

North Yearling

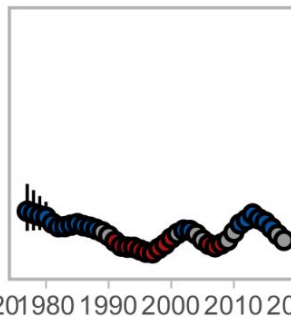
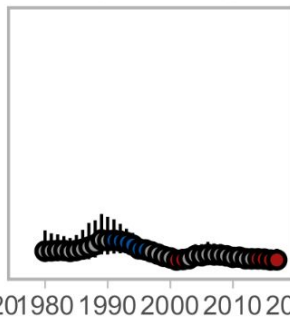
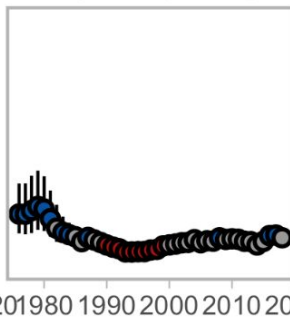
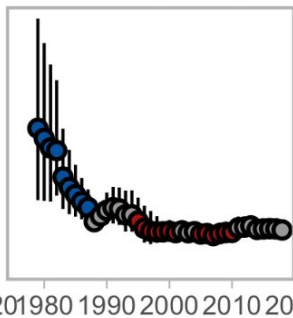
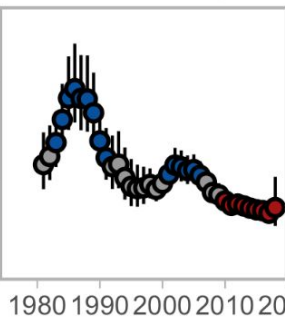
SoG Subyearling

Puget Subyearling

Puget Yearling

South Subyearling

above
below
average



year

