Environmental determinants of spatiotemporal variability in salmon forage and its direct and indirect effects on salmon recruitment.

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Outline

- Environmental drivers of salmon forage
- Salmon condition relative to forage accessibility
- Predation on salmon
- Modeling the system to estimate salmon sensitivities and evaluate management strategies

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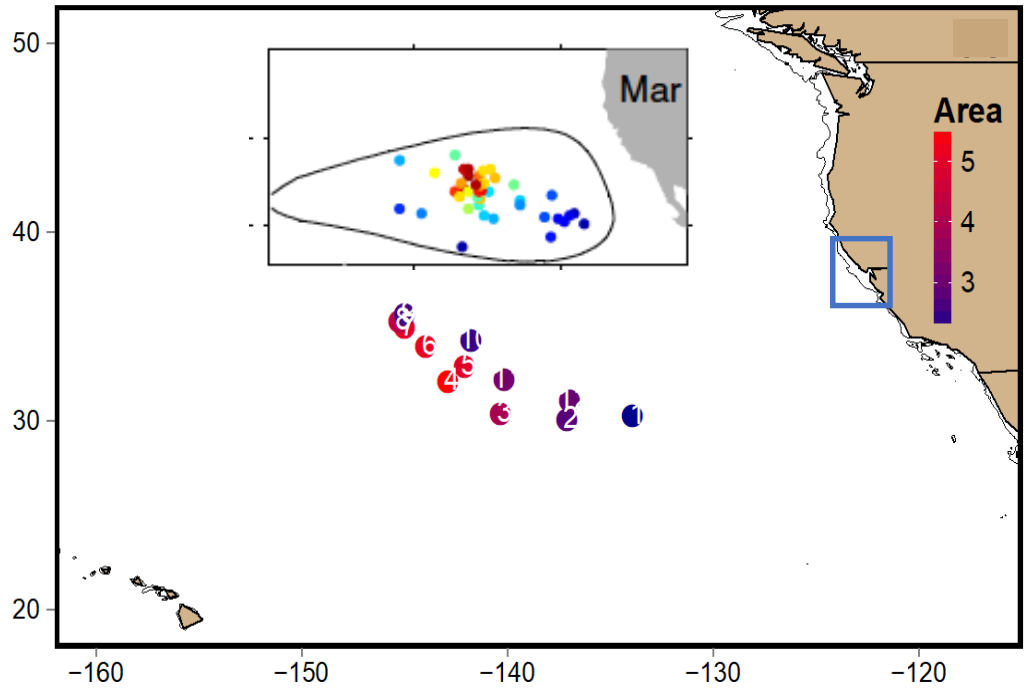
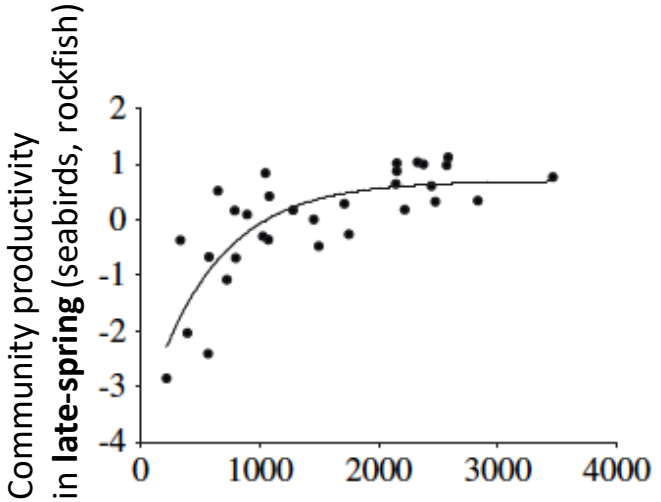
Even before salmon out-migrate, basin-scale influences precondition the system

Where, how strong, and how big the NPH is in the winter informs this year's spring conditions





Schroeder, I.D., E. Hazen, B.A. Black, S.J. Bograd, W.J. Sydeman, J. Santora, and B.K. Wells. 2013. The North Pacific High and wintertime pre-conditioning of California Current productivity. *Geophysical Research Letters.* 40:541-546

Environment

Environmental conditions associated with variability in forage assemblage

Environment

Friedman, W.R., J.A. Santora, I.D. Schroeder, D.D. Huff, R.D. Brodeur, J.C. Field, B.K. Wells. 2018. Environmental and geographic relationships among salmon forage assemblages along the continental shelf of the California Current. *Marine Ecology Progress Series*. 596:181-198.

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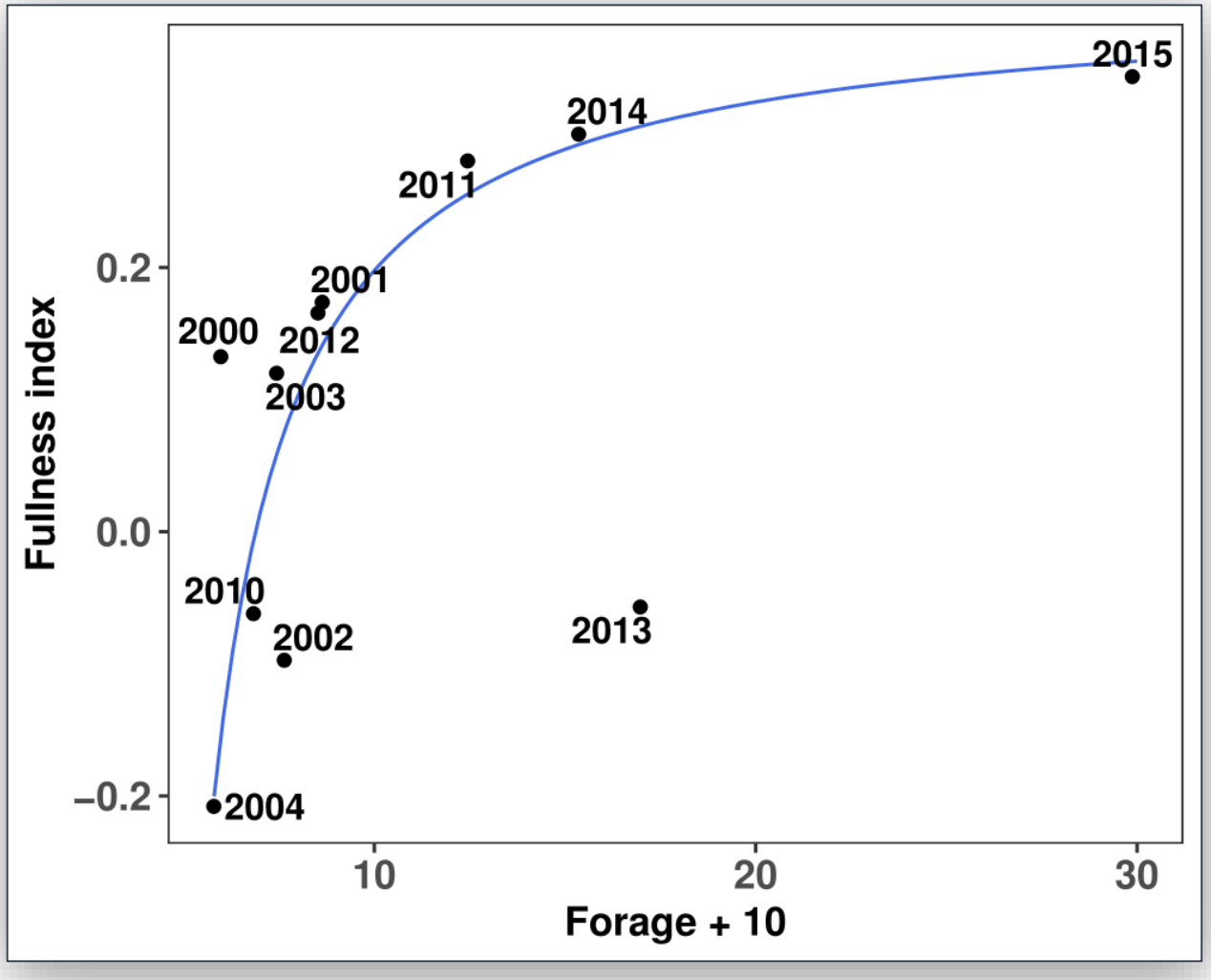
Salmon fullness is directly related to the over all abundance of prey

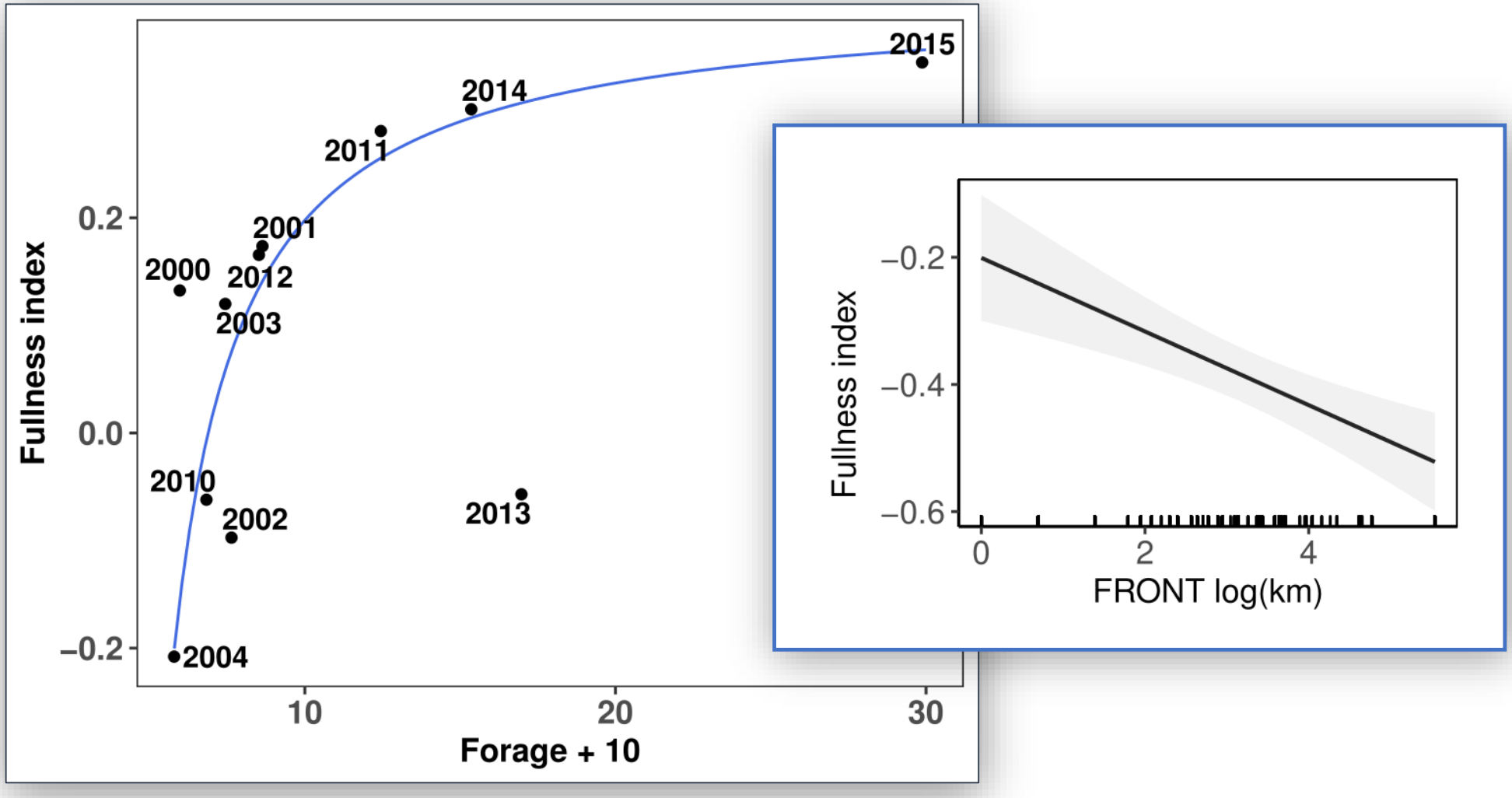
Salmon condition



Sabal, M, E.L. Hazen, S. J. Bograd, R. B. MacFarlane, I.D. Schroeder, S.A. Hayes, J.A. Harding, K.L. Scales, P.I. Miller, A.J. Ammann, and B.K. Wells. *In review*. The California Current seascape influences juvenile salmon foraging ecology at multiple scales. *Marine Ecology Progress Series*

Salmon fullness is directly related to the over all abundance of prey *and* distribution

Salmon condition



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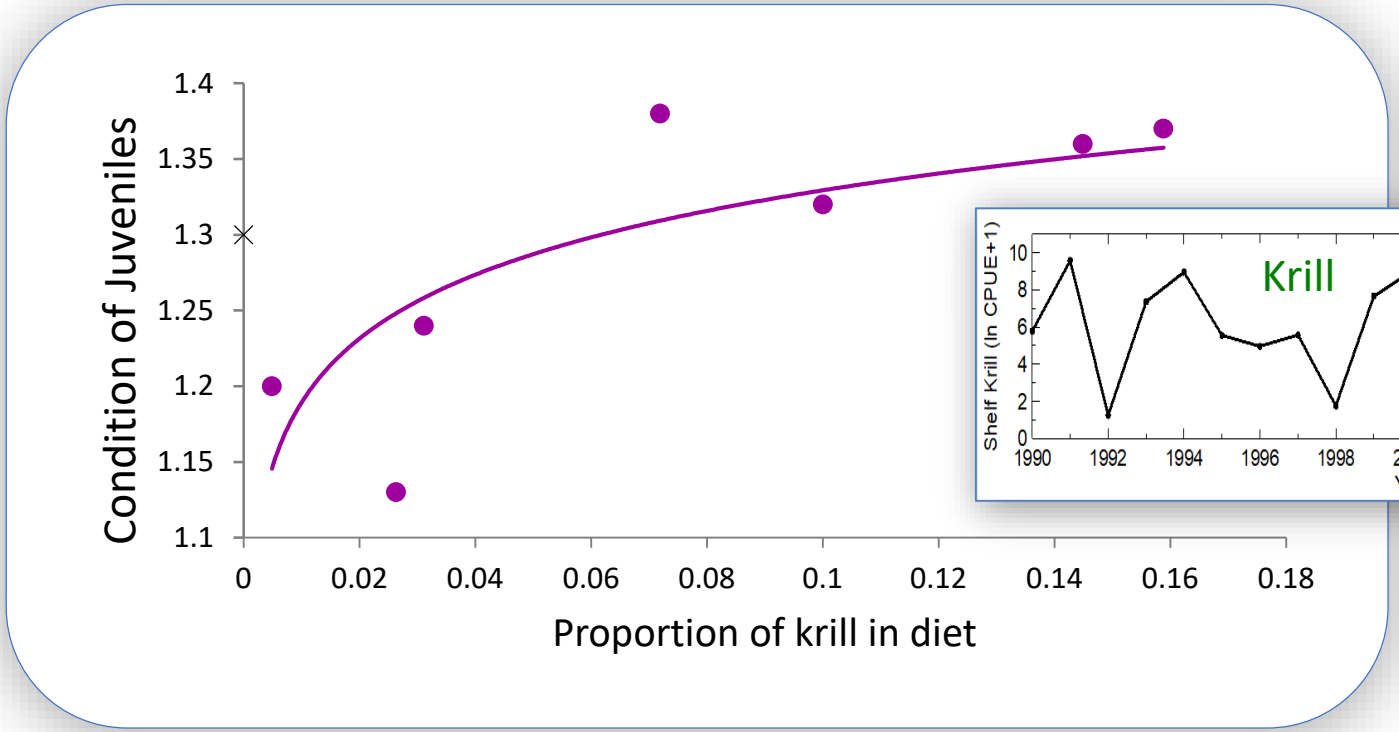
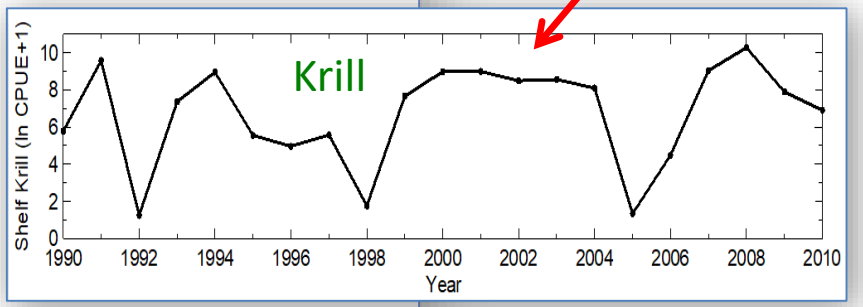
Example of relationship of salmon condition to krill

More krill = more in the diet = fatter fish = better survival





Salmon condition

Wells, B.K., J.A. Santora, J.C. Field, R.B. MacFarlane, B.B. Marinovic, and W.J. Sydeman. 2012. Population dynamics of Chinook salmon (*Oncorhynchus tshawytscha*) relative to prey availability in the central California coastal region. *Marine Ecology Progress Series*. 457:125-137

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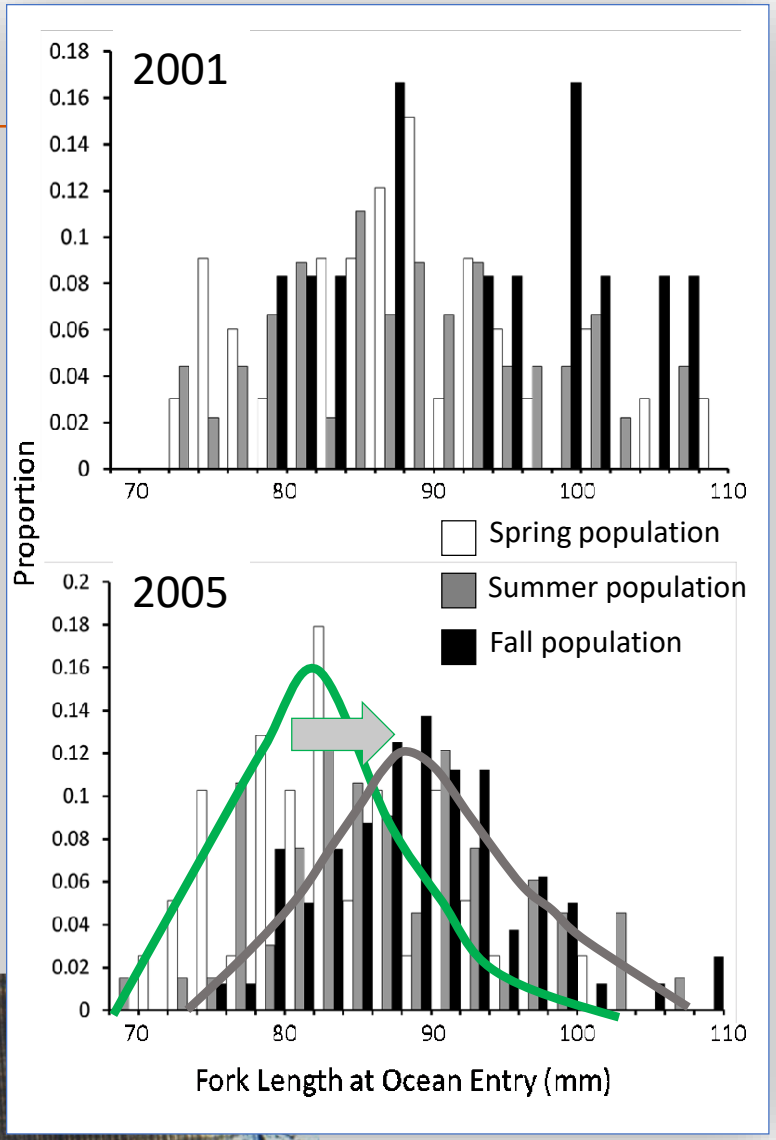
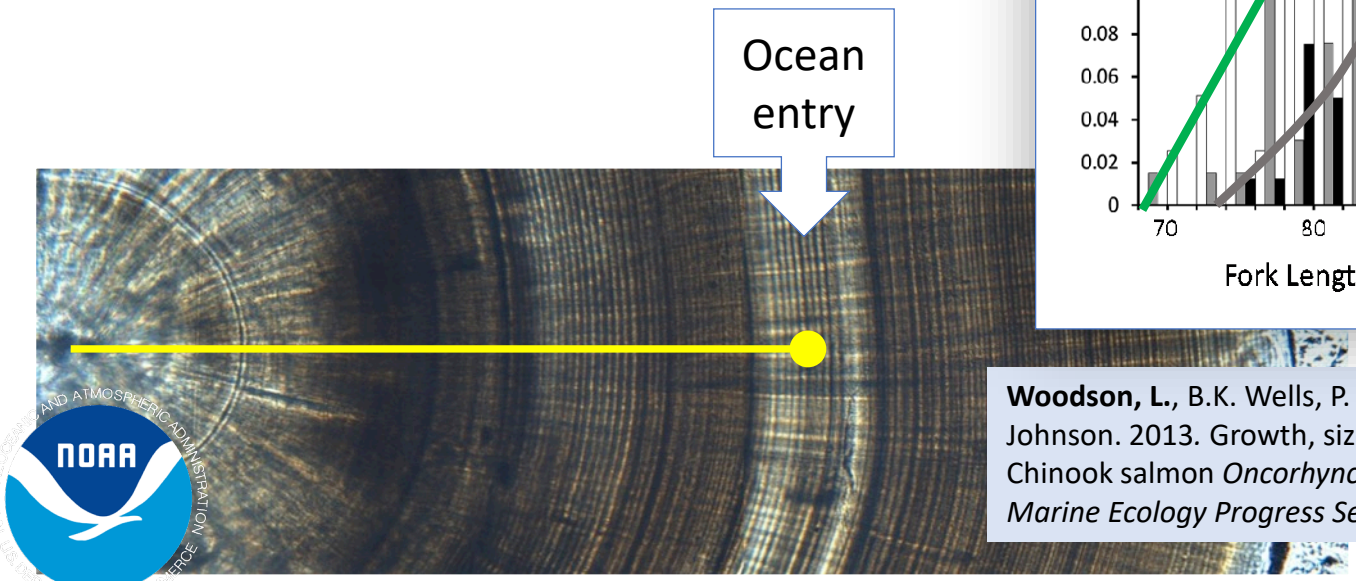
Predation

Slower growers are more likely to die

A shift in the mean and distribution of retrospective sizes at ocean entry informed us about the level of selective mortality during good and bad years.

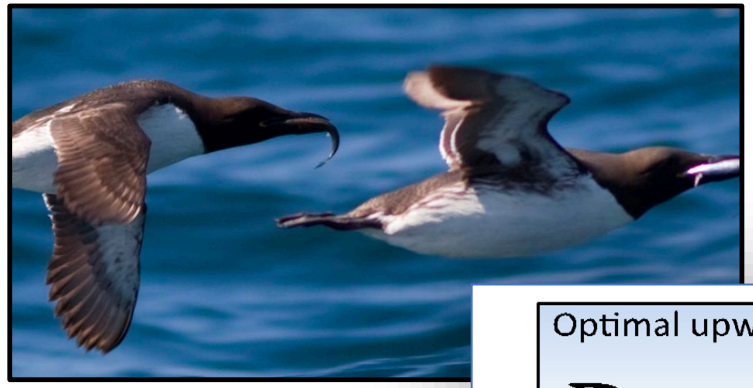


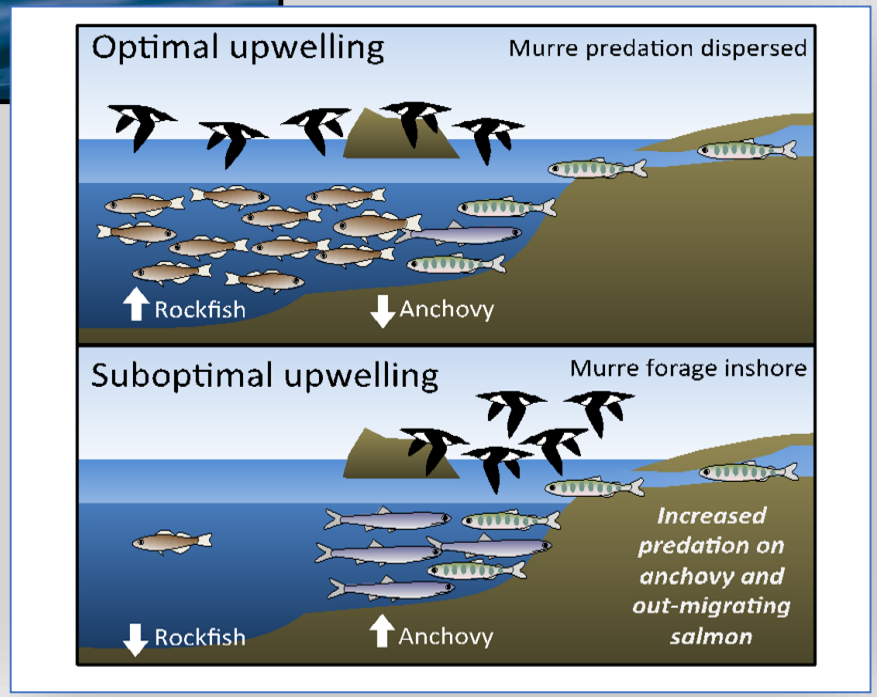


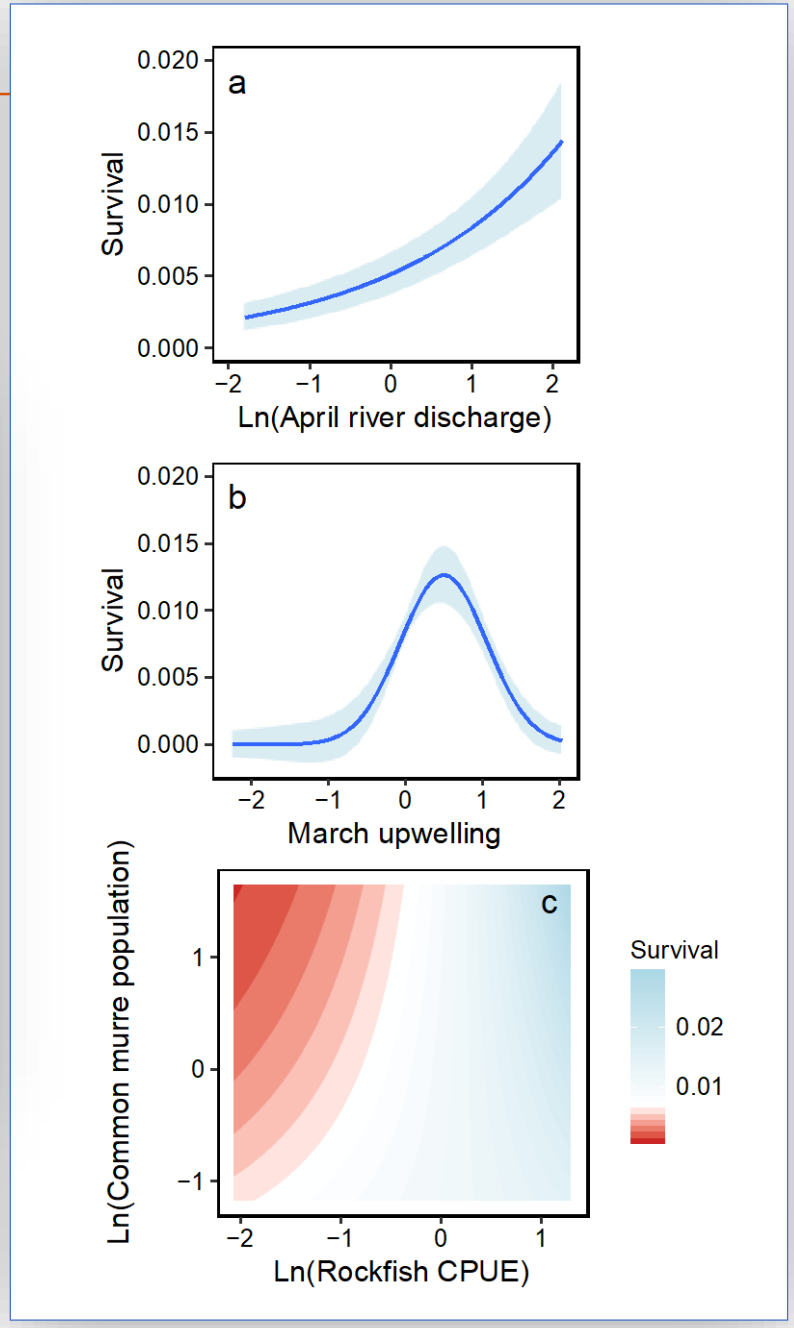
Woodson, L., B.K. Wells, P. Weber, R.B. MacFarlane, G Whitman, and R. C. Johnson. 2013. Growth, size, and origin-dependent mortality of juvenile Chinook salmon *Oncorhynchus tshawytscha* during early ocean residence. *Marine Ecology Progress Series*. 487:163-175.

Common Murre are a typical predator in the area

Predation







Wells, B.K, J.A. Santora, M.J. Henderson, P. Warzybok, J. Jahncke, R. W. Bradley, D. D. Huff, I.D. Schroeder, P. Nelson, J.C. Field, D.G. Ainley 2017. Environmental conditions and prey-switching by a seabird predator impacts juvenile salmon survival. *Journal of Marine Systems*

Outline

- Environmental drivers of salmon forage
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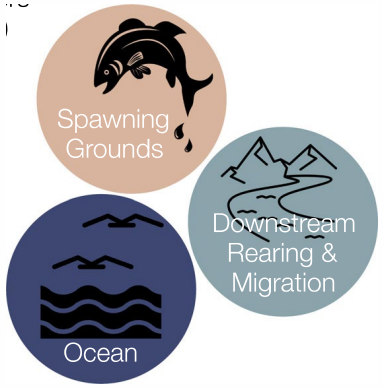
- **Modeling the system to estimate salmon sensitivities and evaluate management strategies**

A full life-cycle model can be used to estimate sensitivity to predation and ultimately estimate recruitment

Life-cycle model



Friedman, W.R., B.T. Martin, B.K. Wells, C. Michel, P. Warzybok, E.M. Danner, and S.T. Lindley. 2019. Composite effects of marine and freshwater processes on salmon population dynamics. *Ecosphere*

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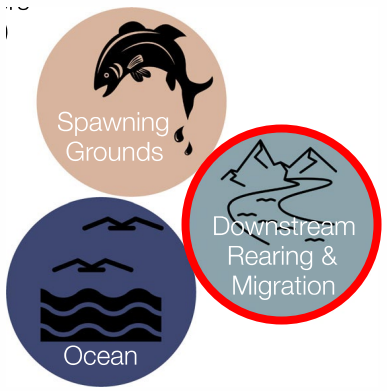

Carry-over effects such as size at emigration. Freshwater trends could have implications on ocean survival. *We may be able to manage this.*

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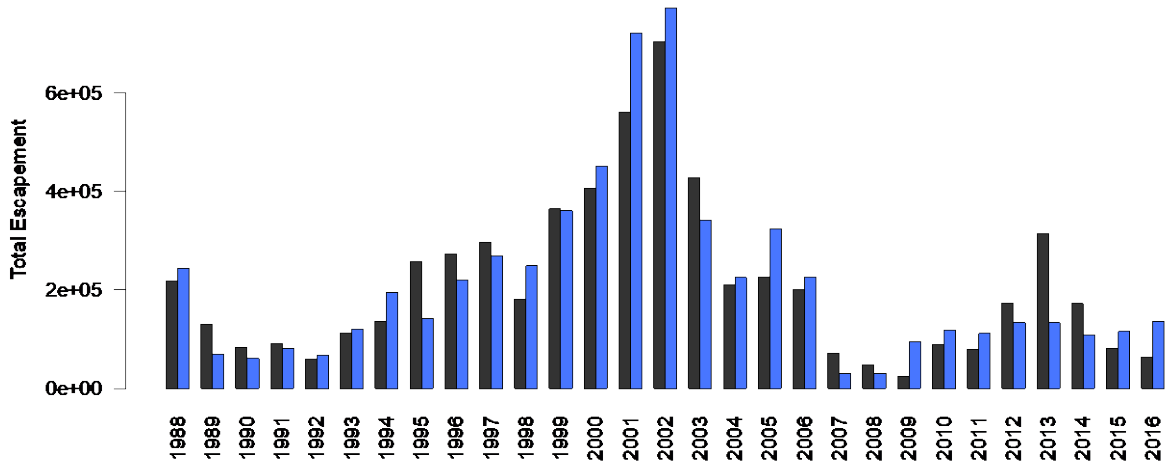

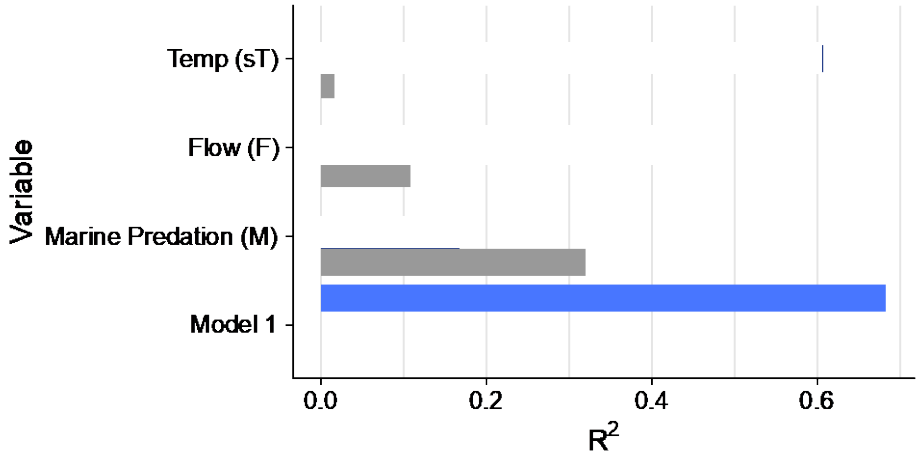

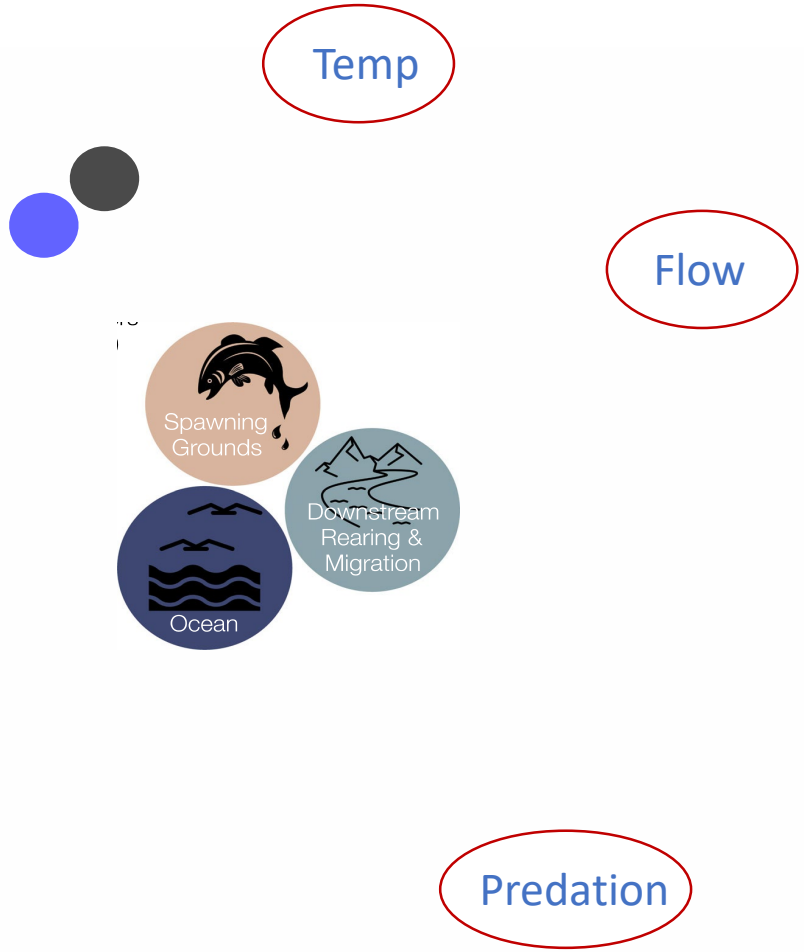

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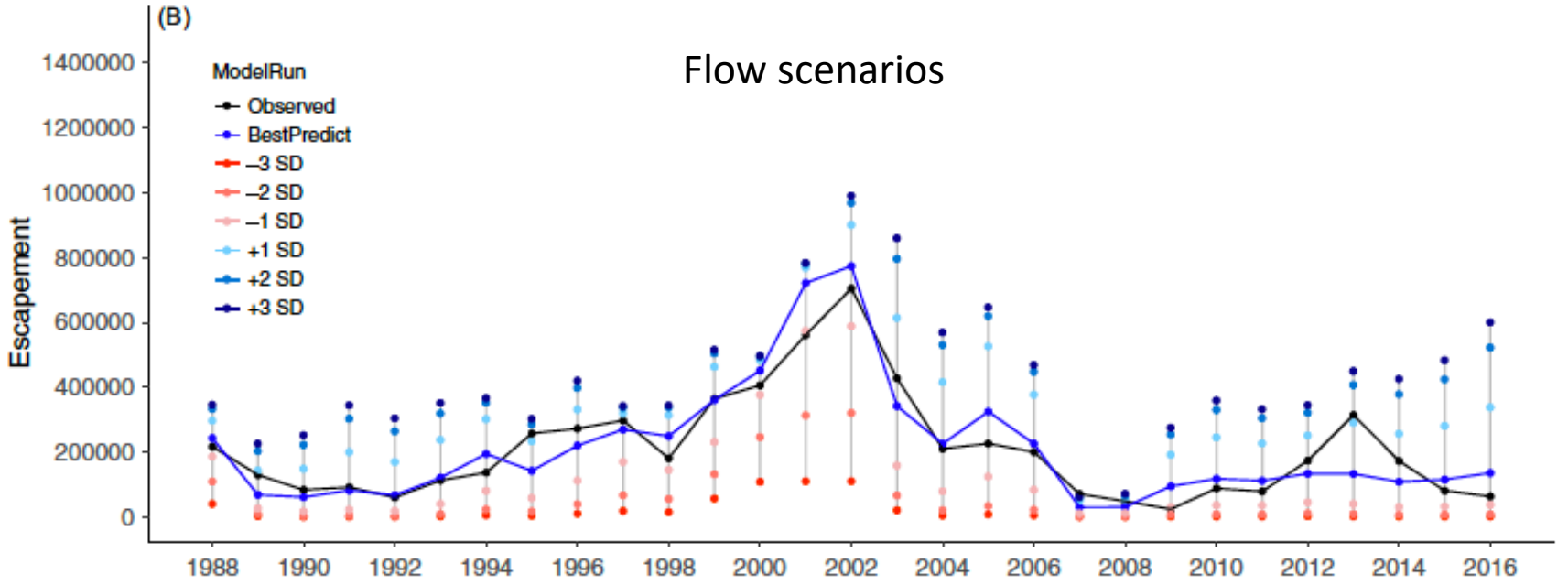
Conclusions

- Ocean conditions matter for prey abundance, availability, and salmon condition
- Smaller fish are predated on when alternate prey and feeding opportunities are unavailable for salmon and predators.
- A process-oriented life cycle model allows for estimation of climate change affects on salmon populations resulting from freshwater and oceanographic trends and variability.

Conclusions



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