Climate Forcing and Regime Dynamics in the Ocean

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The Regime Concept in Pacific Salmon Production

The Pacific Decadal Oscillation and Salmon Production Regimes

Hare and Francis 1995; Mantua et al., 1997; Hare et al. 1999
Two regimes in the North Pacific?

Beamish and collaborators, late 1990s NPAFC reports: No – there are multiple and different kinds of states
The North Pacific Gyre Oscillation and West Coast Coho and Chinook salmon SARs

D. Patrick Kilduff et al. PNAS 2015;112:35:10962-10966
The two leading patterns of Northeast Pacific SST variations account for most of the year-to-year variability. These variations aren’t limited to 20-30 year regimes.

- non-stationary relationships between Gulf of Alaska salmon catch and SST (PDO too)
- NPGO pattern has had increasing variance since the 1990s
More variance in shorter (~4 to 8 year) “regimes” in the North Pacific since the 1990s, including multiyear marine heat waves

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New Marine Heatwave Emerges off West Coast, Resembles "the Blob"

September 05, 2019

Researchers are monitoring a new marine heatwave off the West Coast for effects on the marine ecosystem.


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Bottom-up forcing impacts on salmon

Gyre and current strength, transport of subarctic vs. subtropical water masses, stratification and upwelling of nutrients

sub-tropical water, warm stratified ocean, few nutrients, weak upwelling and low production of low lipid food-web

Thysanoessa spinifera
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Bottom-up driven prey-switching impacting (top-down) predation on juvenile salmon

Optimal upwelling
- Murre predation dispersed

Suboptimal upwelling
- Murre forage inshore
- Increased predation on anchovy and out-migrating salmon

Peak warm SST years in the CCS had large numbers of California sea lions in the lower Columbia River.
Declining portfolio effects

Increased synchrony in Chinook salmon population dynamics among stocks has been noted for West Coast basins (Moore et al. 2010; Carlson and Satterthwaite 2011; Griffiths et al. 2014)

California Chinook hatchery rearing and release practices are likely contributing to these declines – more eggs are going into fewer and fewer baskets (Huber and Carlson 2015; Satterthwaite and Carlson 2015; Willmes et al. 2018)
Central Valley hatchery Fall Chinook salmon release and ocean entry timing have narrowed dramatically since the 1970s-80s.
wild Central Valley Spring Chinook outmigrant trap data

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Salmon conservation in an era of a rapidly changing ocean

Promote diversity in salmon populations by increasing the complexity of salmon watersheds

Increase the odds for success when juveniles go to sea

Enable adaptation by maintaining or restoring diversity in genetics, life-histories, and high-quality habitat options

McElhany et al. 2000; modified by T. Williams, NMFS/SWFSC
Climate Insurance requires actions that promote resilience

Protect intact salmon habitat and viable populations

Reduce existing stressors to make space for climate change before it is too late

• This means undoing the 4-H’s that have put many salmon populations on the brink without climate change
Questions?