The changing physical and ecological meanings of North Pacific Ocean climate indices

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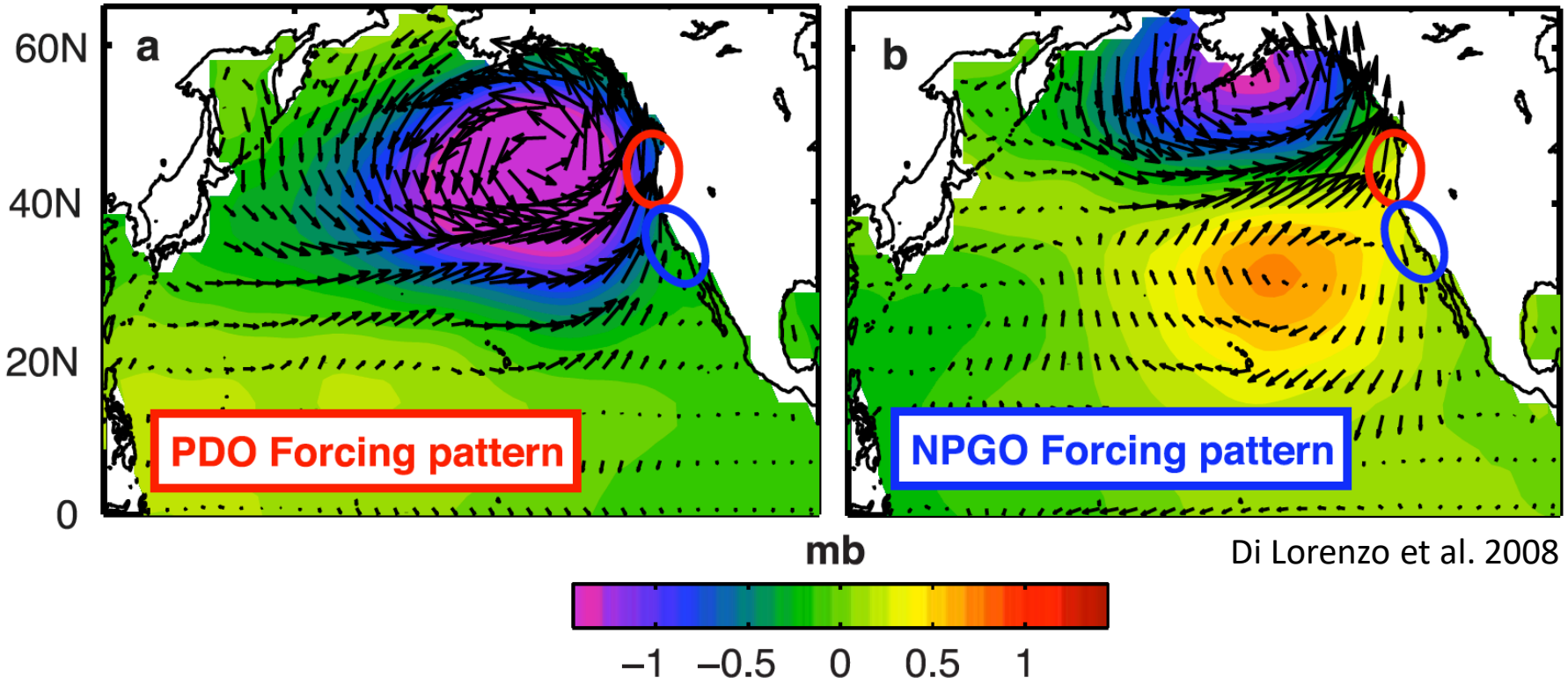
The “canonical” view: PDO & NPGO track fixed atmosphere-ocean interactions



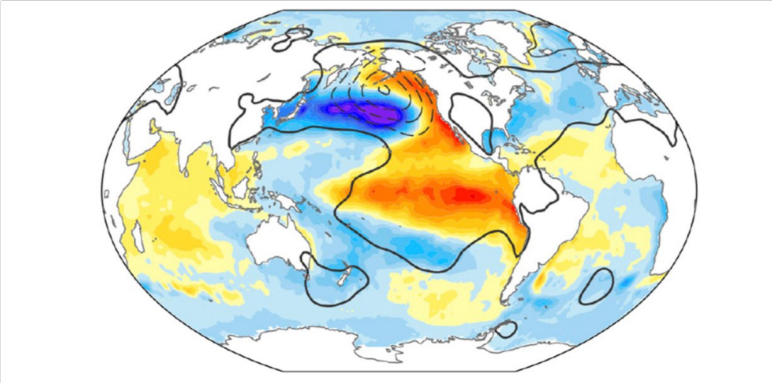
Di Lorenzo et al. 2008

Multiple Processes drive the PDO (and the NPGO)

Newman et al. 2016, J. Clim.

<u>For the PDO:</u>

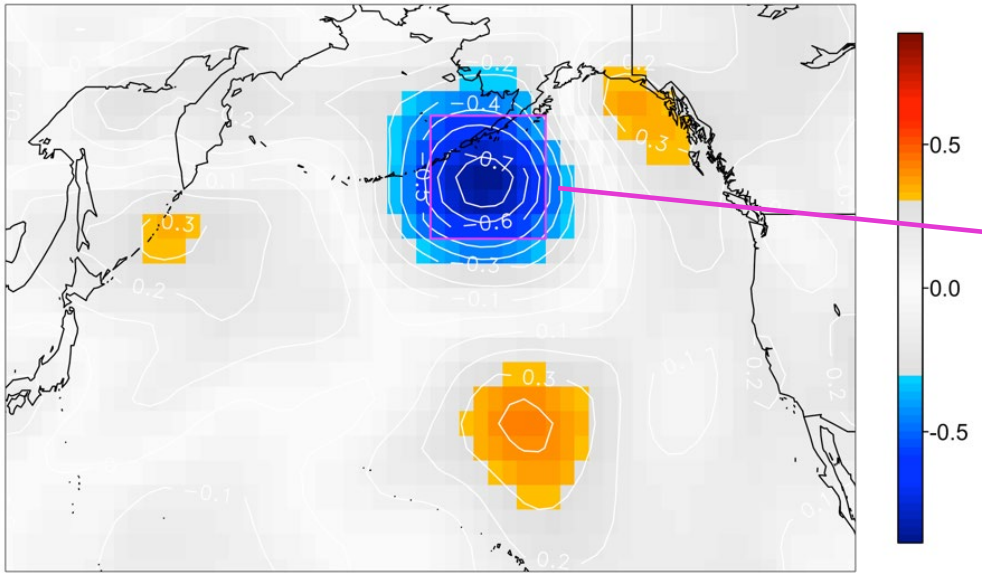
- Aleutian Low
- Teleconnections from the tropics
  - Atmospheric bridge
  - Coastally trapped waves
  - Tropical decadal variability
- Midlatitude ocean dynamics
  - Reemergence
  - Gyre dynamics
  - Air-sea feedbacks
  - Extra-tropics to tropics feedback



Aleutian Low variance *declined* in the late 1980s

Spatial Pattern

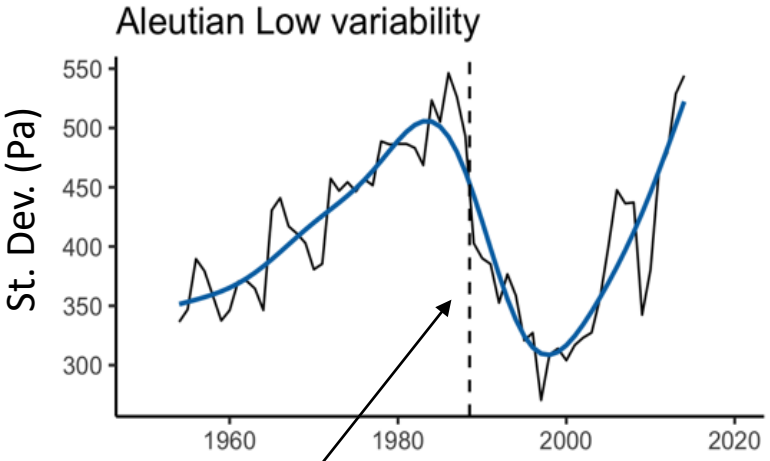
Standard deviation (hPa): (1989:2012) - (1988-1950)



NCEP/NCAR Reanalysis

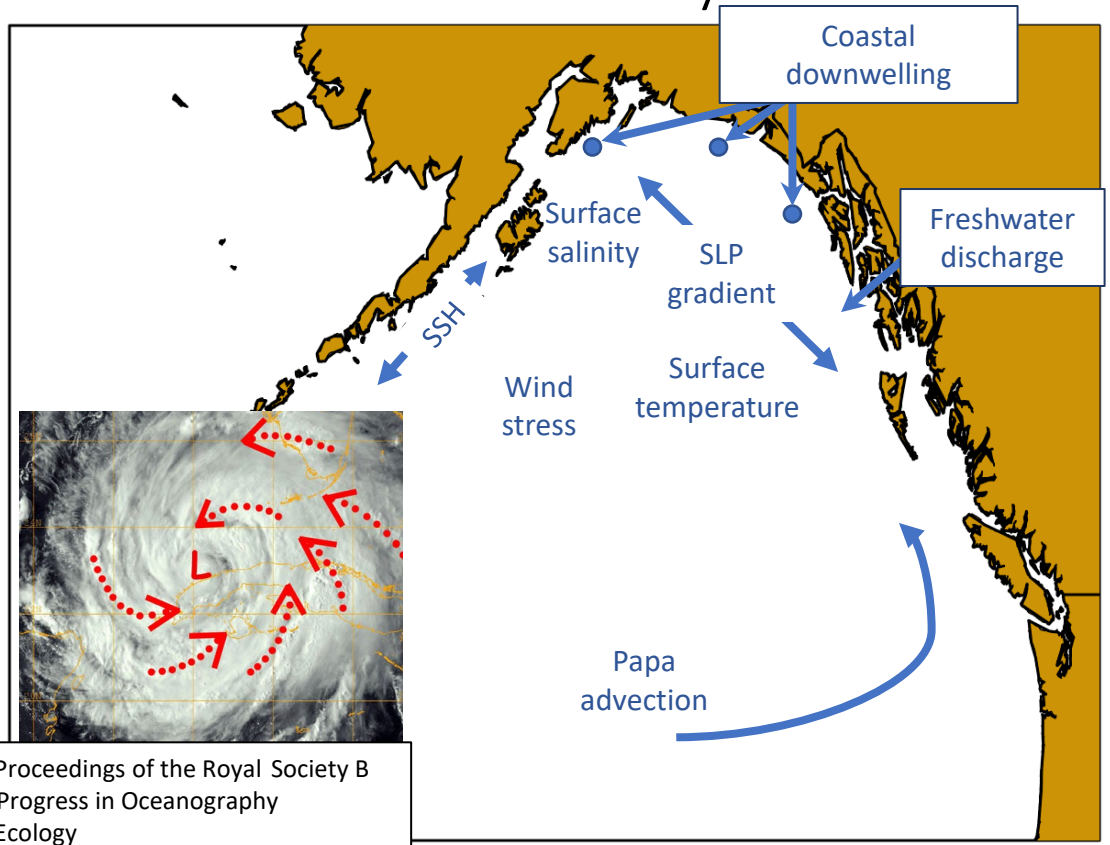
Temporal Pattern

Standard deviation:
11 year (133 month) rolling windows



Underlying SLP data smoothed

The Aleutian Low creates correlated environmental variability in the Gulf of Alaska

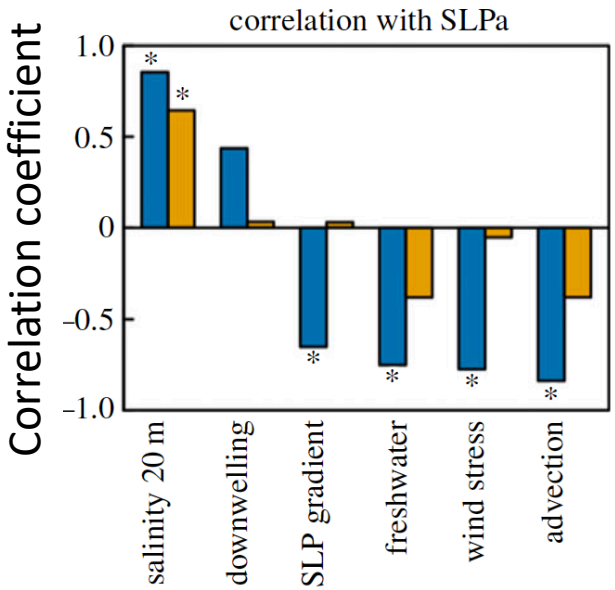


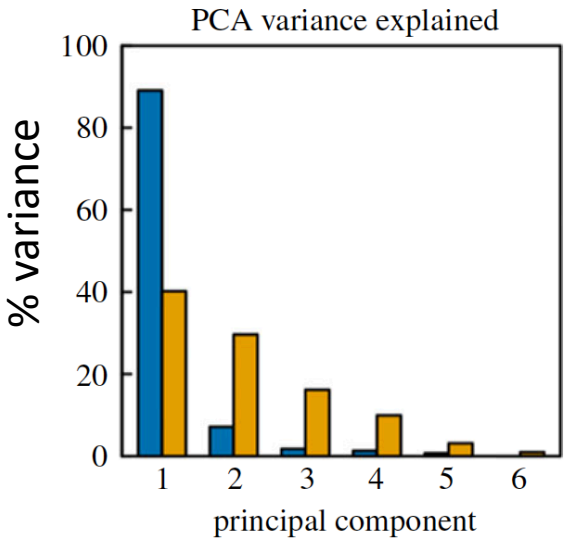
Litzow et al. 2018. Proceedings of the Royal Society B
Puerta et al. 2019. Progress in Oceanography
Litzow et al. 2019. Ecology

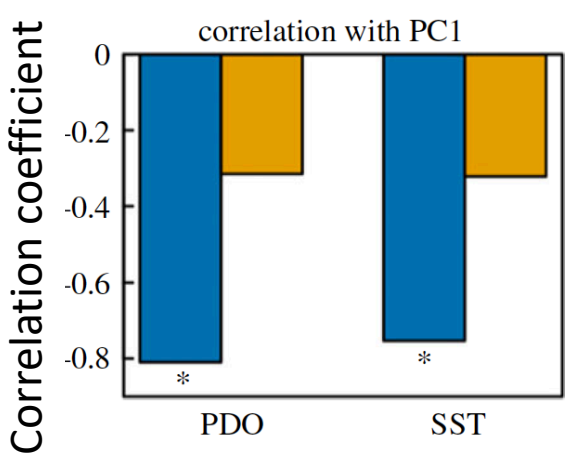
Changes in Aleutian Low variance change relationships among Gulf of Alaska climate variables

1950–1988 (high variance)

1989–2012 (low variance)

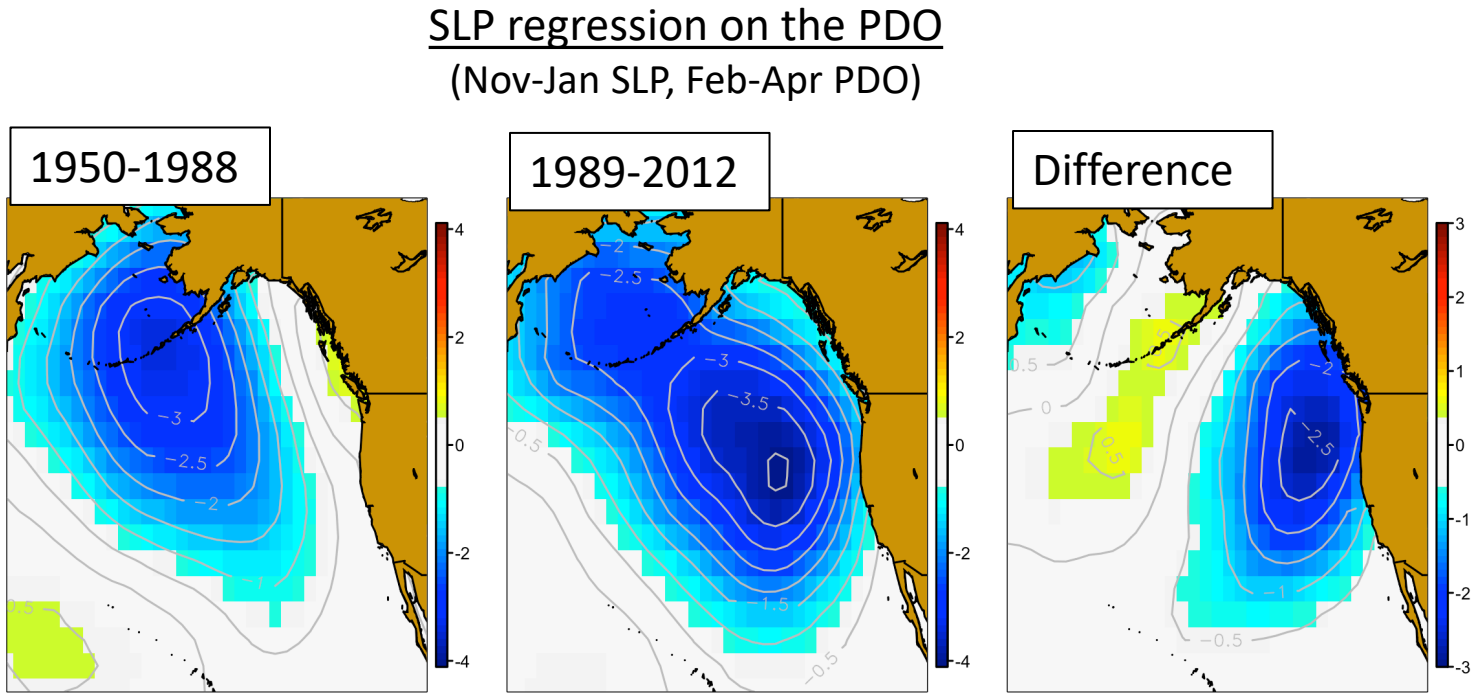






Litzow, M. A., L. Ciannelli, P. Puerta, J. J. Wettstein, R. R. Rykaczewski, and M. Opiekun. 2018. Non-stationary climate–salmon relationships in the Gulf of Alaska. Proceedings of the Royal Society B: Biological Sciences

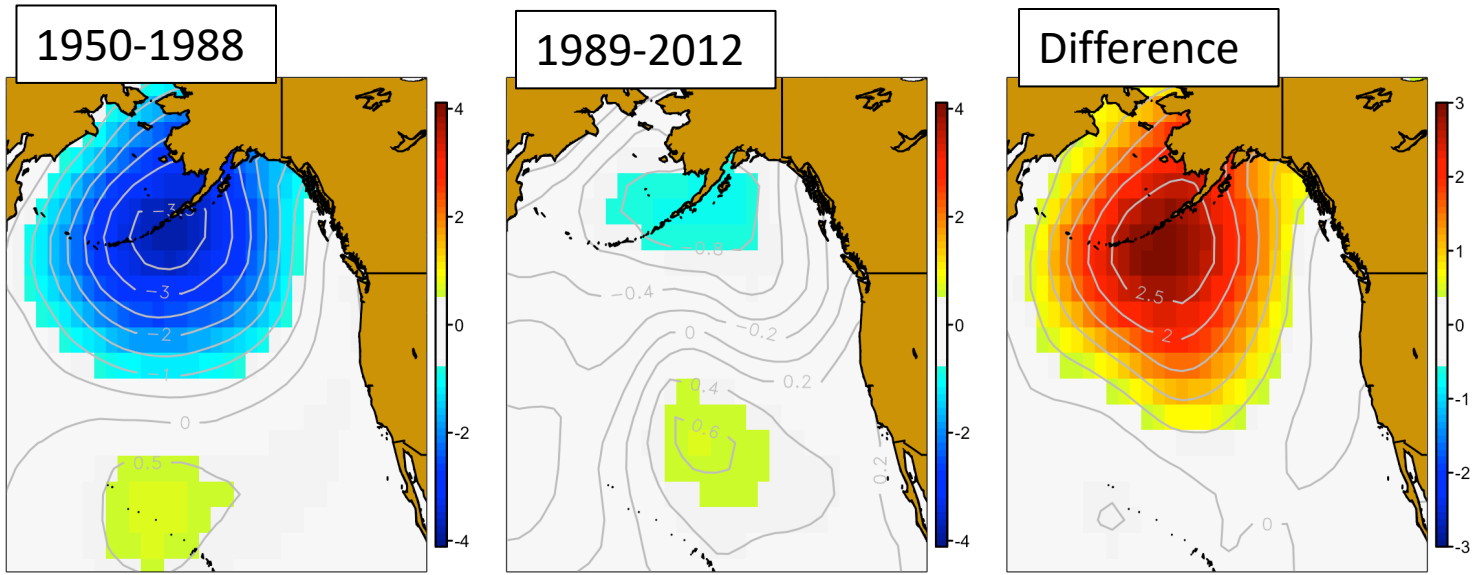
Forcing of the PDO became *less associated* with the Aleutian Low



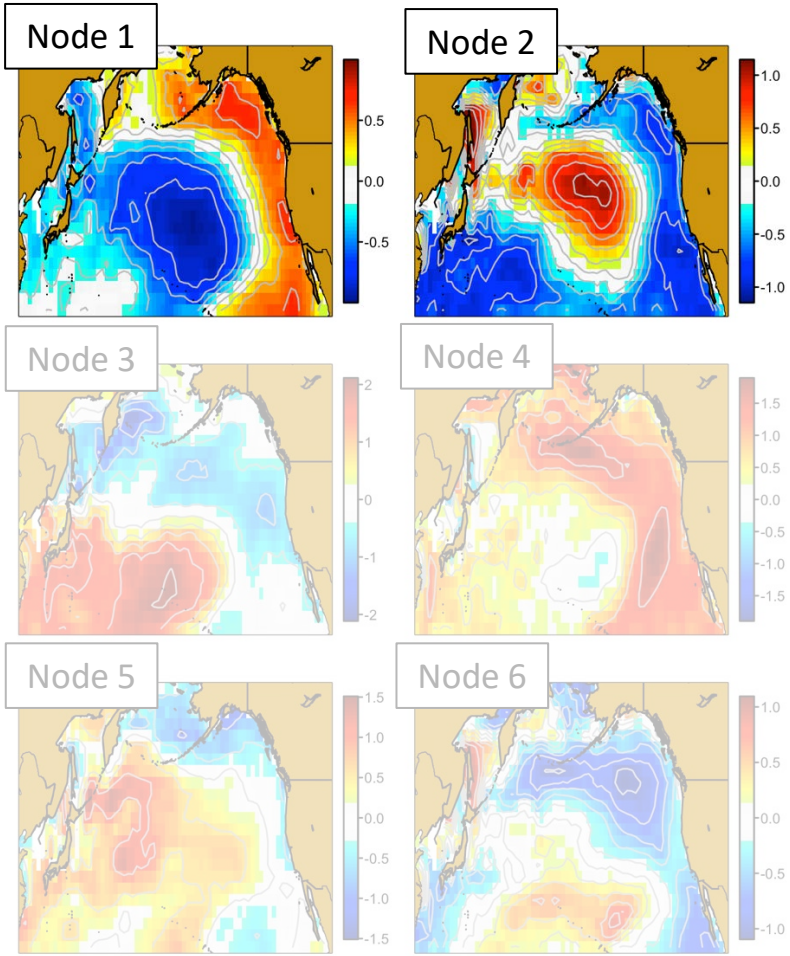
Forcing of the NPGO *weakened*

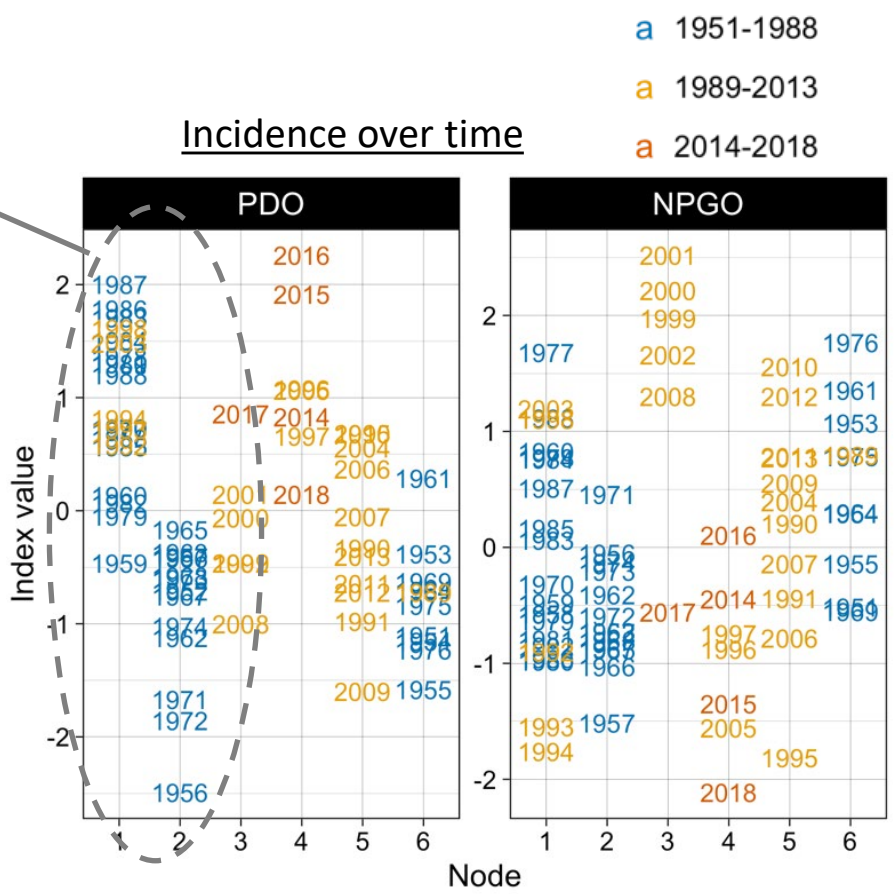
<u>SLP regression on the NPGO</u>

(Nov-Jan SLP, Feb-Apr NPGO)



Spatial expression of PDO/NPGO has changed: Self-organizing maps of *non-detrended* SSTa





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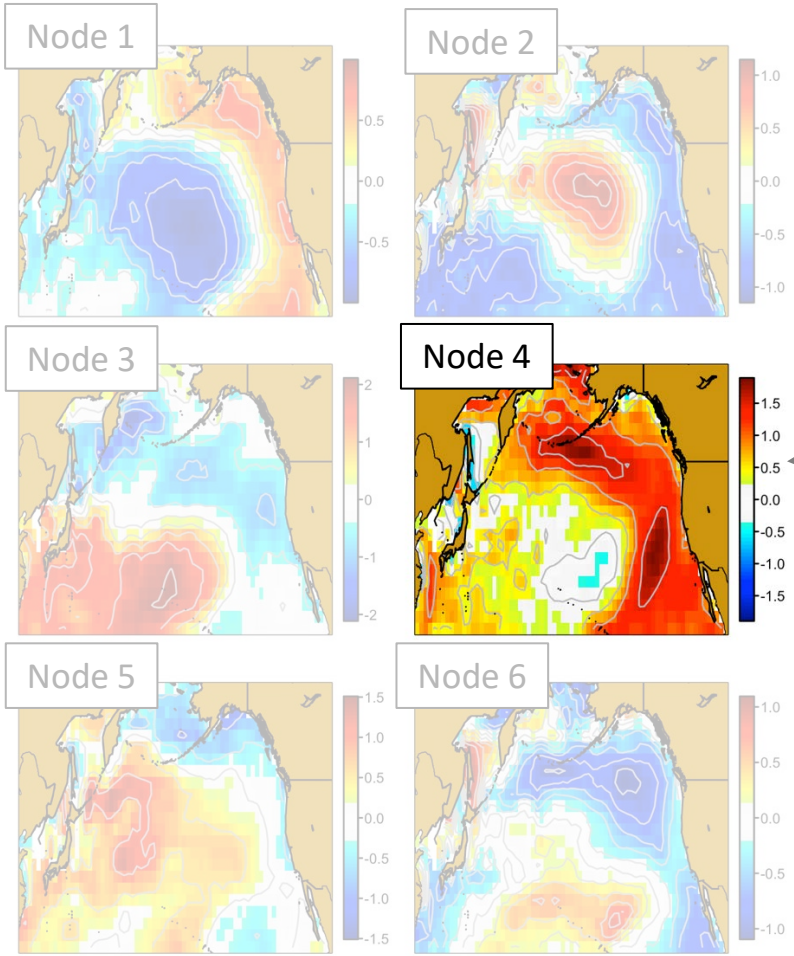
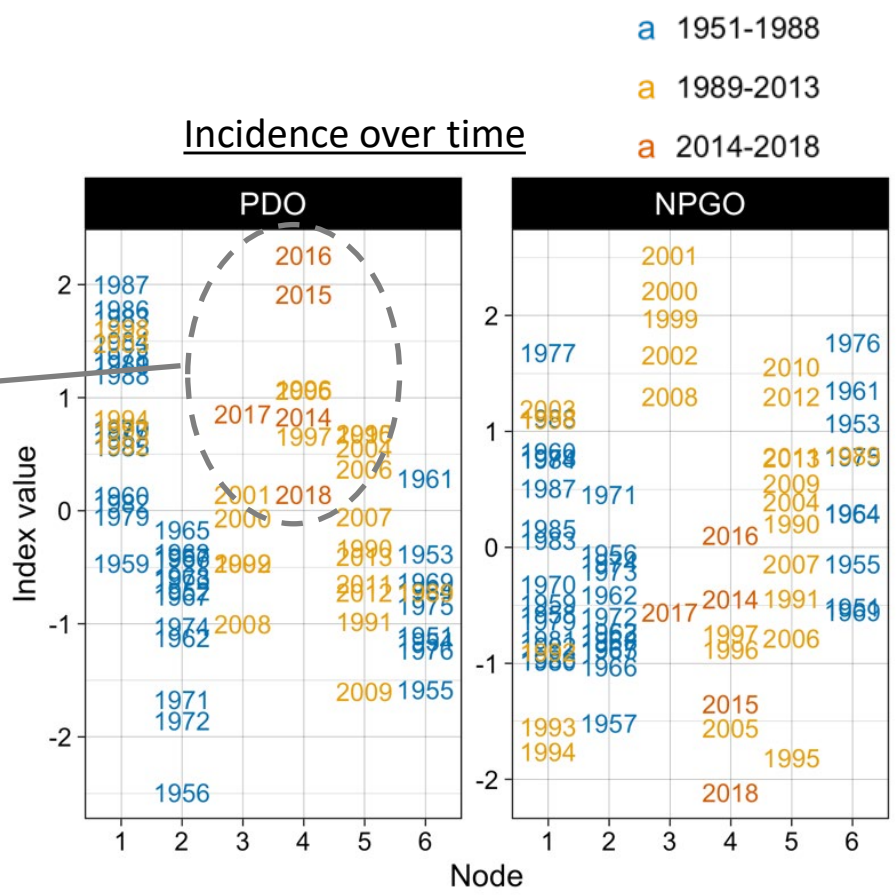
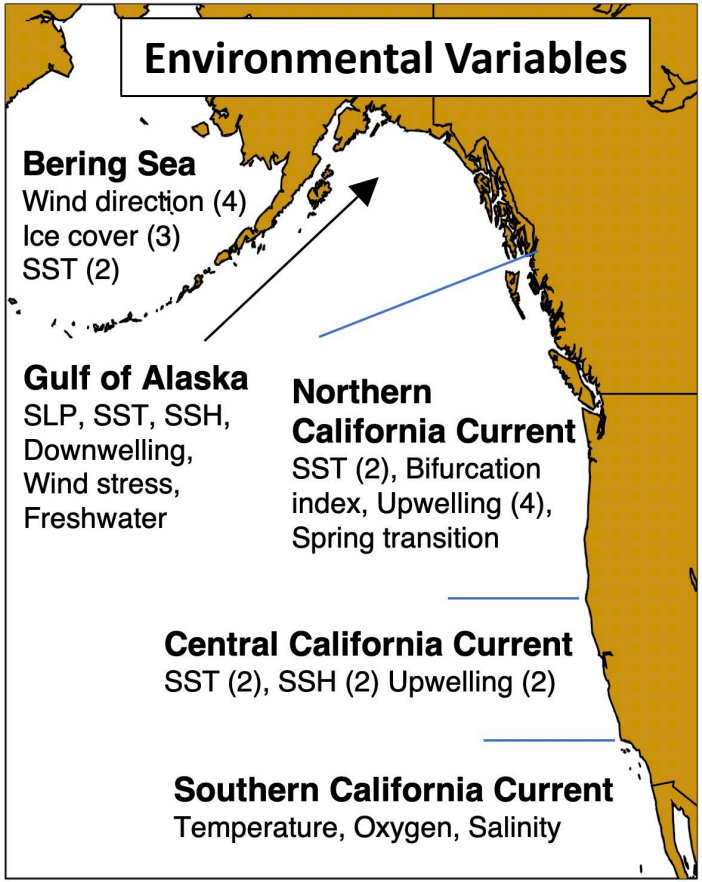
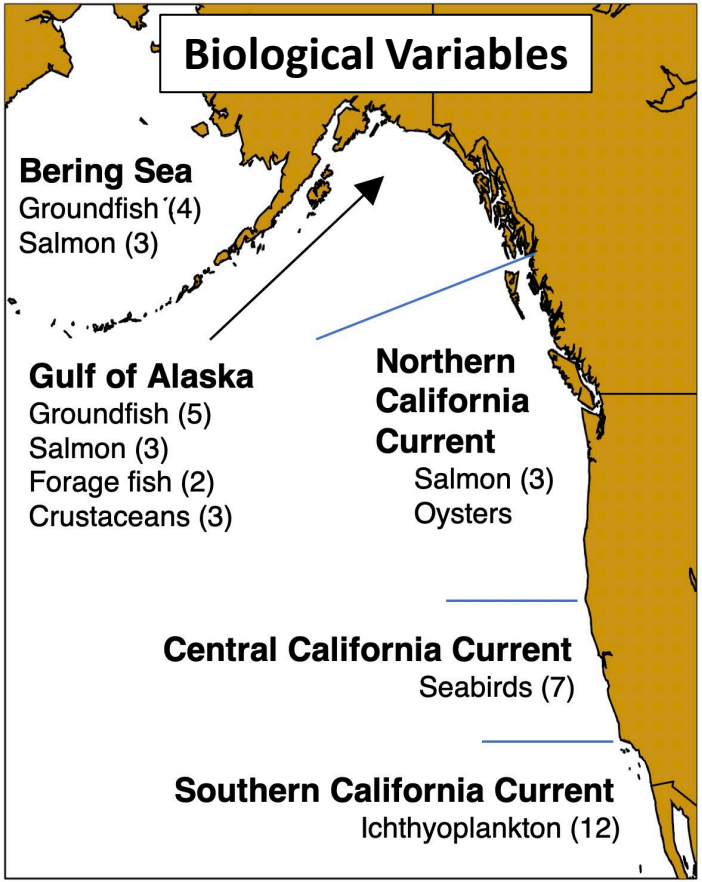




Did expression of the PDO & NPGO change in other regions in the late 1980s?

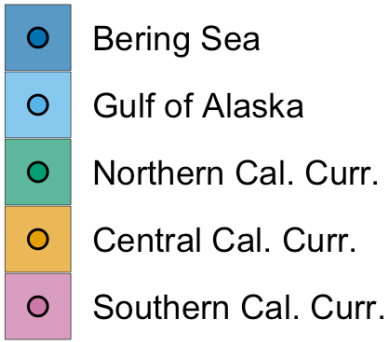


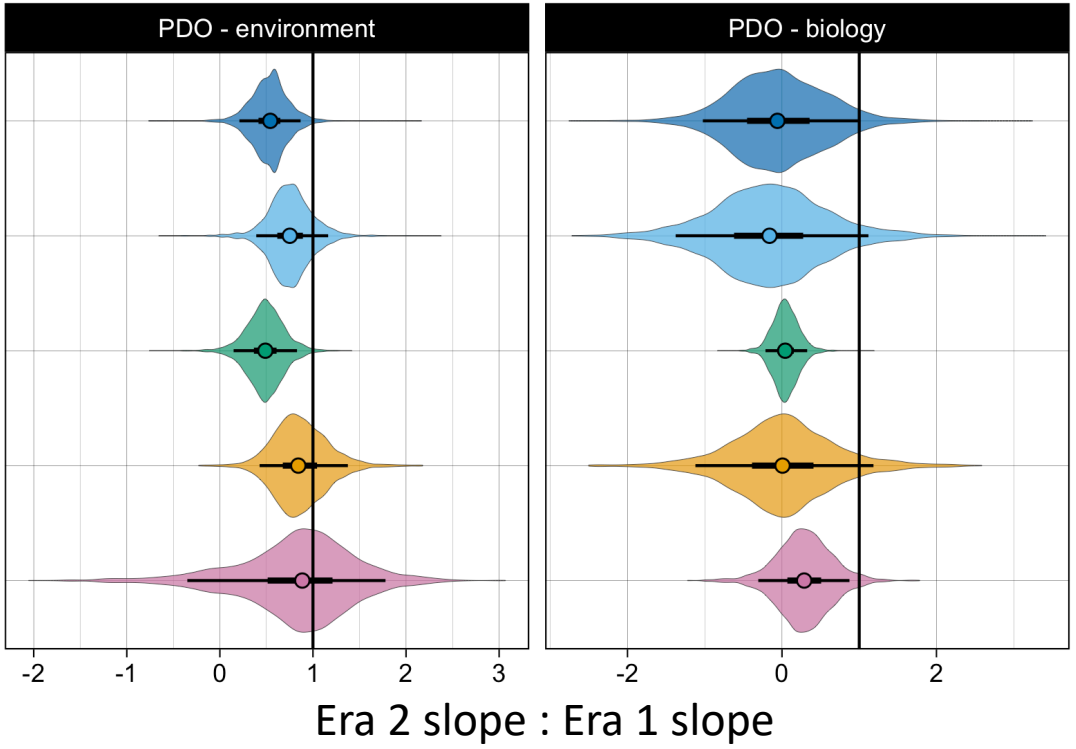


PDO effects *weakened* after 1988/89

Bayesian regression - ratio of slopes
After 1988/89 : Before 1988/89

Result	Interpretation
1	No change
0	Effect decays
negative	Sign switches
>>1	Effect strengthens

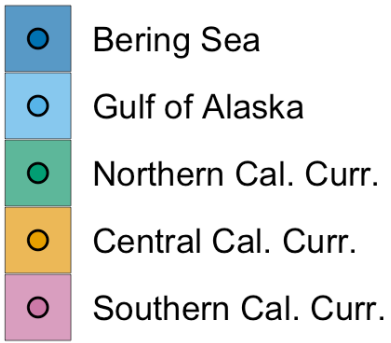


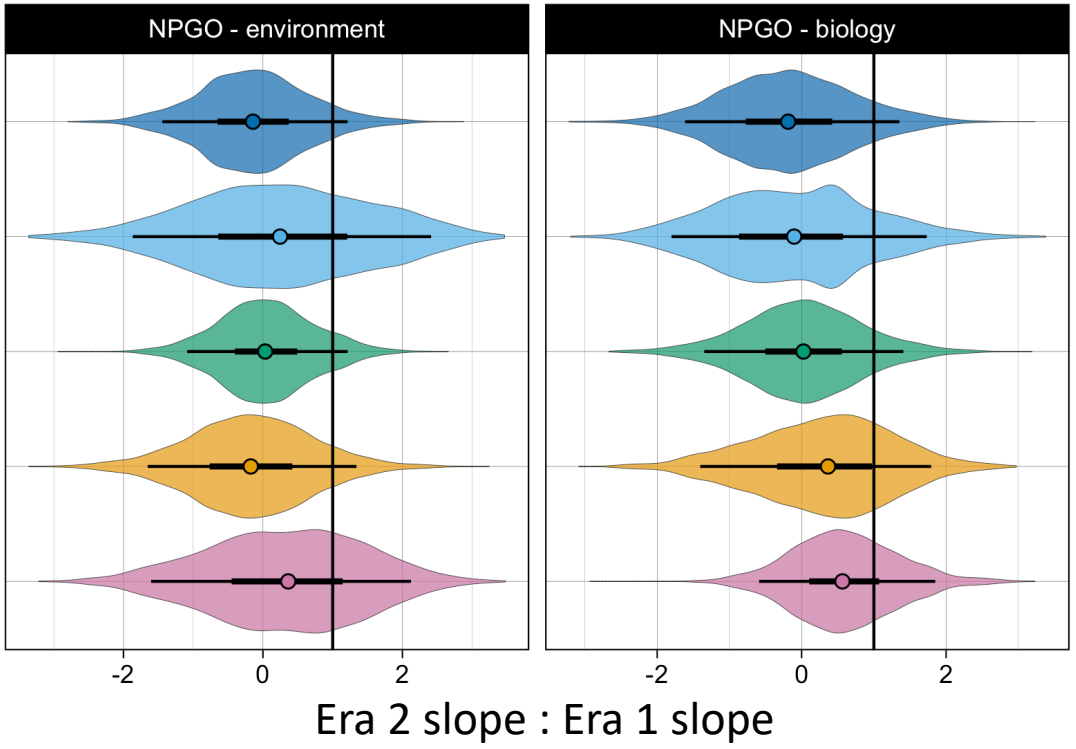


NPGO effects *weakened* after 1988/89

Bayesian regression - ratio of slopes
After 1988/89 : Before 1988/89

Result	Interpretation
1	No change
0	Effect decays
negative	Sign switches
>>1	Effect strengthens

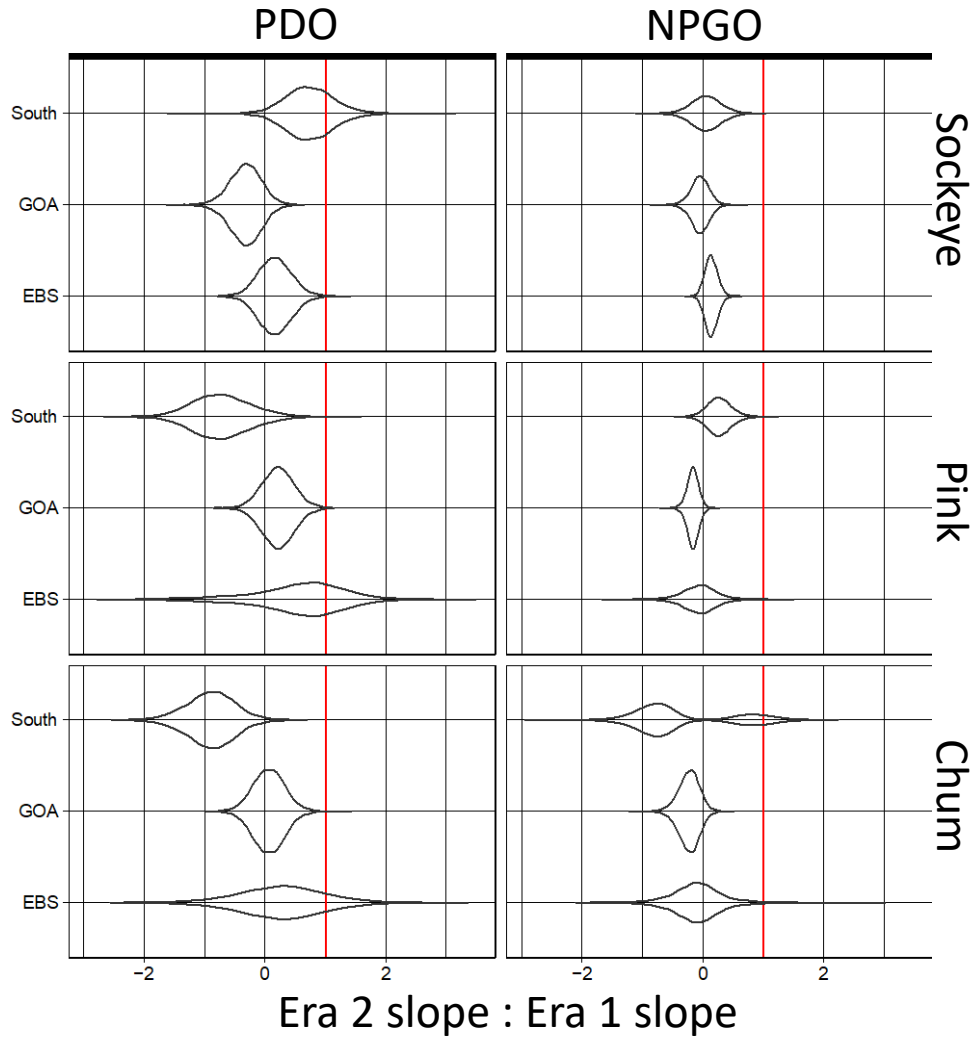




Effects on salmon *weakened* (or changed sign) after 1988/89

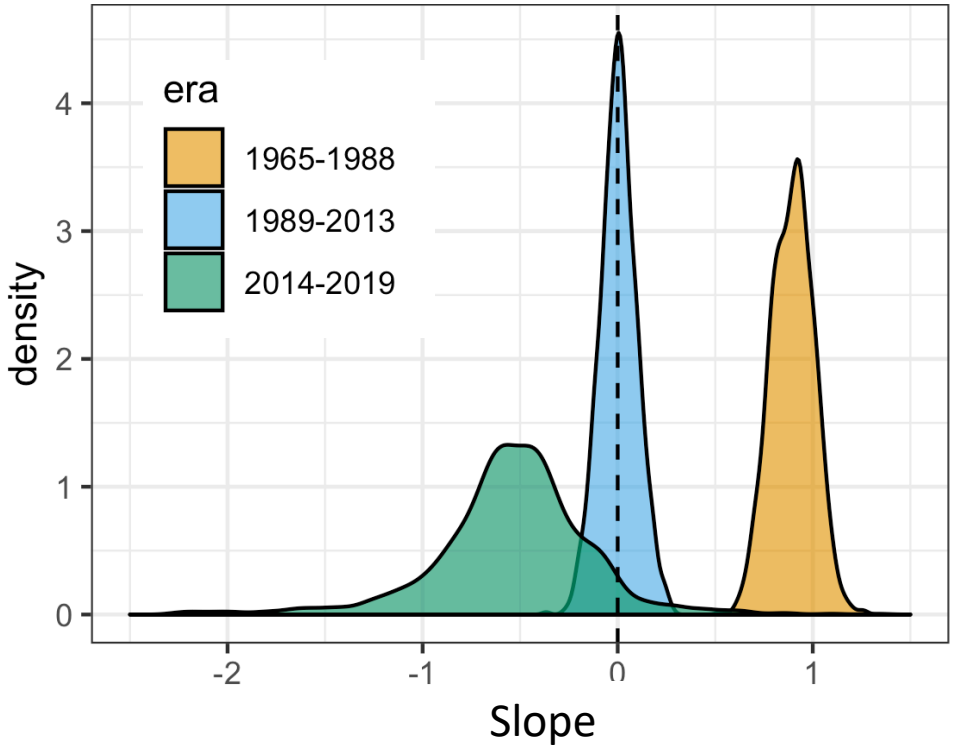
Bayesian regression - ratio of slopes
After 1988/89 : Before 1988/89

Result	Interpretation
1	No change
0	Effect decays
negative	Sign switches
>>1	Effect strengthens

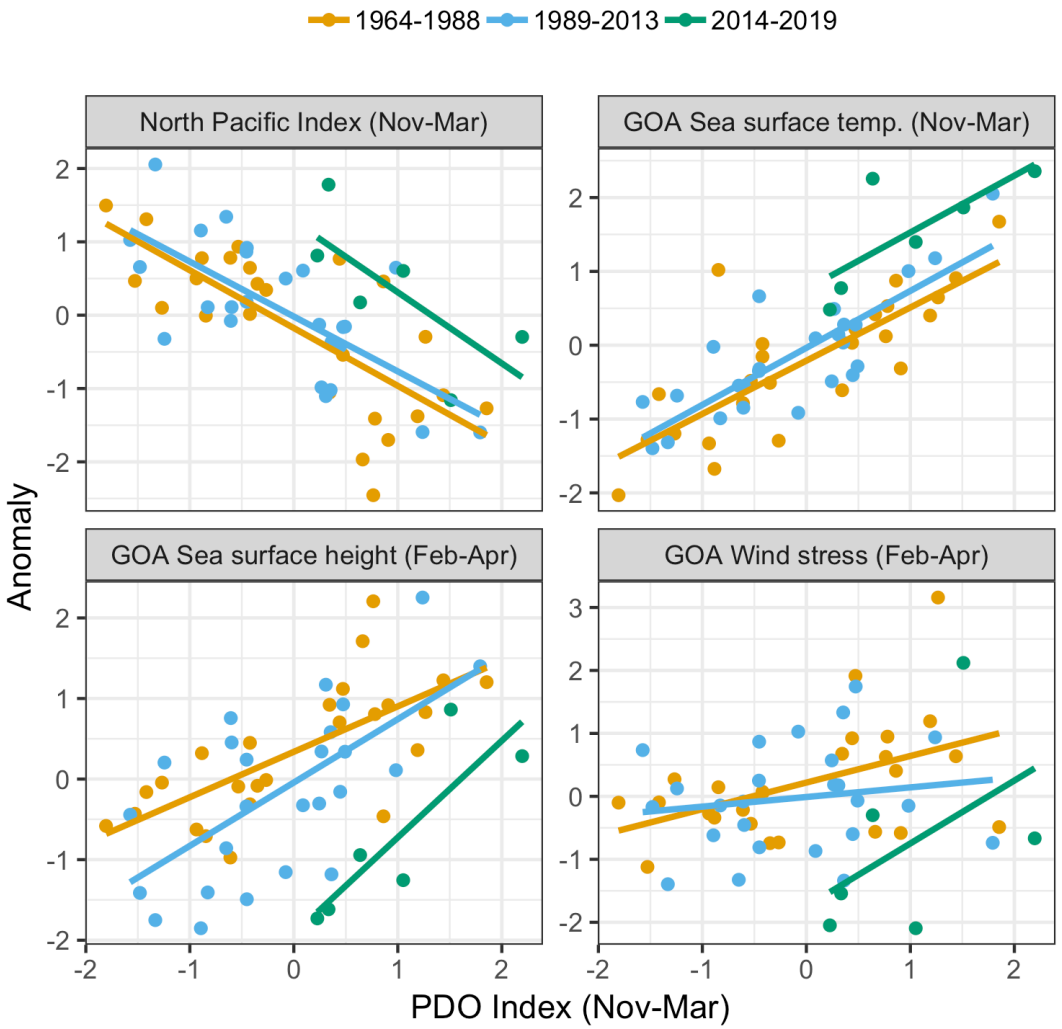


PDO expression may be changing again since 2014

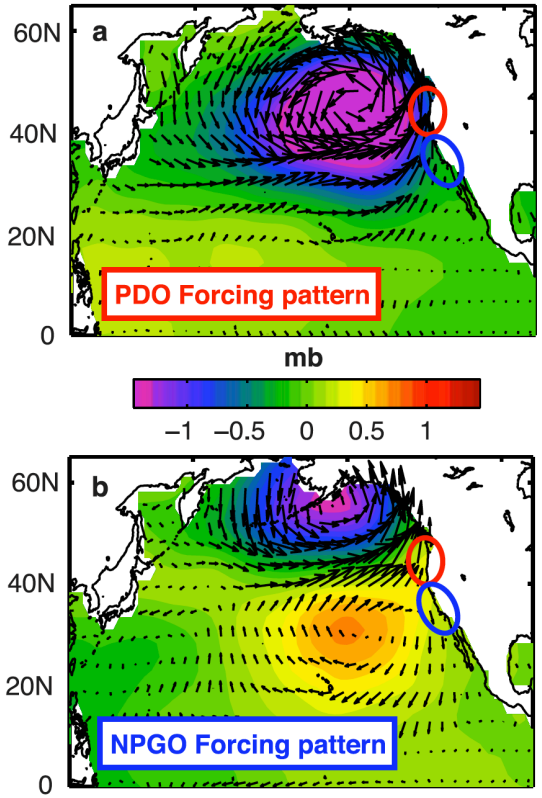
Gulf of Alaska sockeye salmon catches regressed on the PDO: posterior distribution of slopes



PDO expression may be changing again since 2014



Implications



- Suggests caution in use of PDO/NPGO as climate indices over multidecadal time scales
- Novel ‘packets’ of climate are associated with the PDO/NPGO over time
- Need to understand basin-scale -> regional linkages driving nonstationarities

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