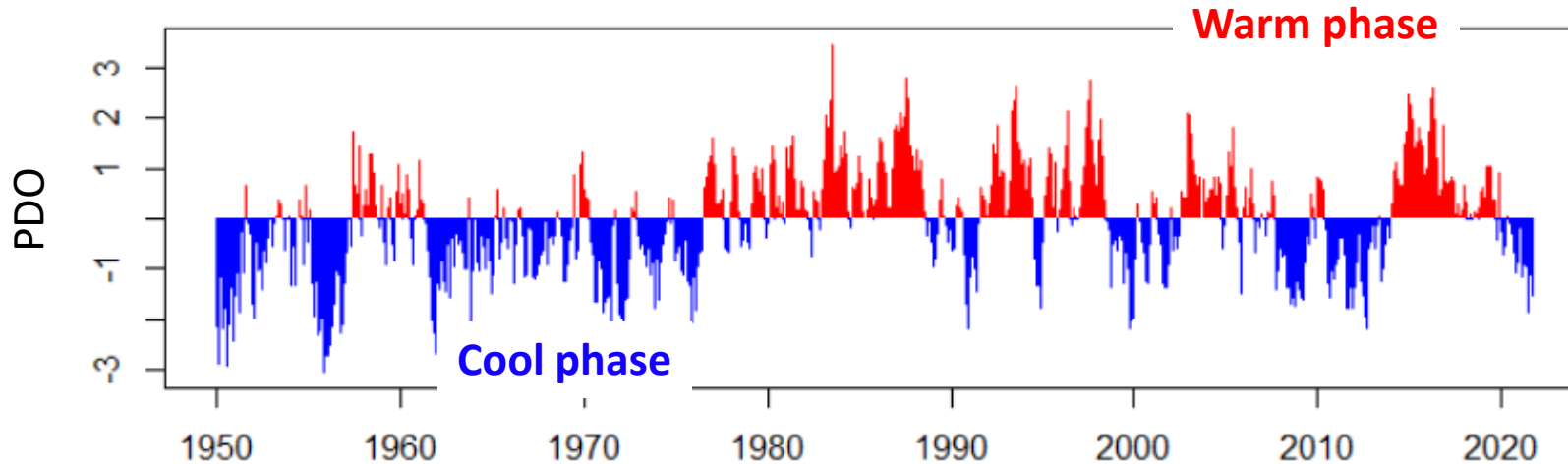


Are current hatchery strategies designed to engage with future ocean variation?

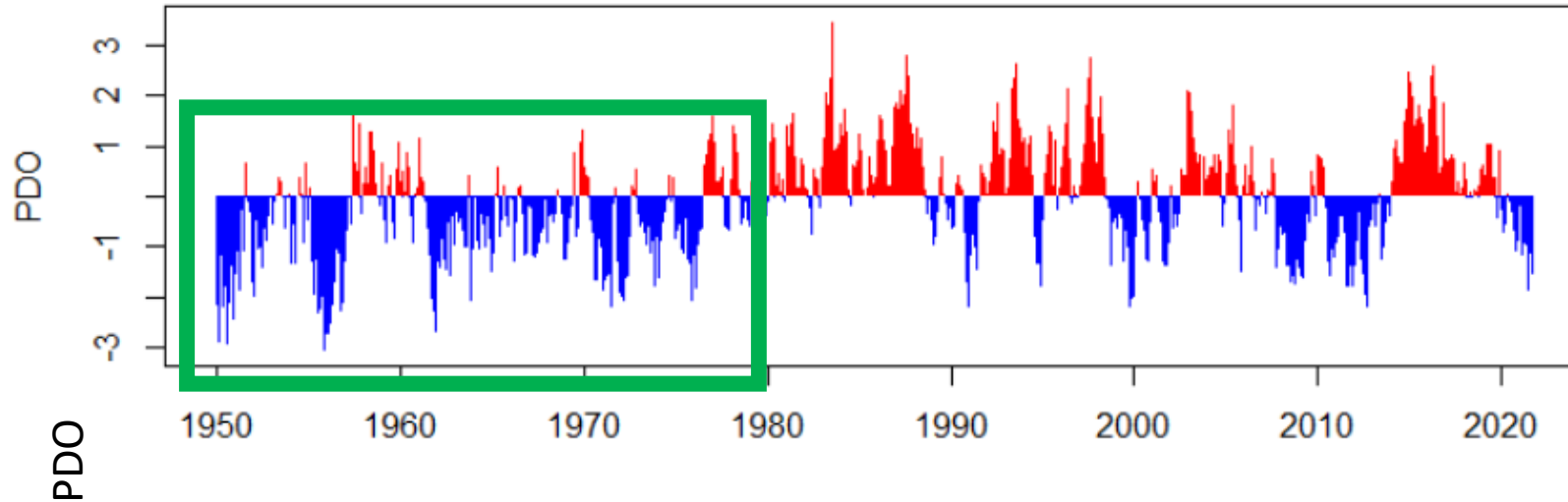
(this will be very Chinook salmon-centric)

**Brian Beckman
NWFSC, NMFS, Seattle**

**The ocean has been variable and unpredictable
but “stable” flipping between two states**



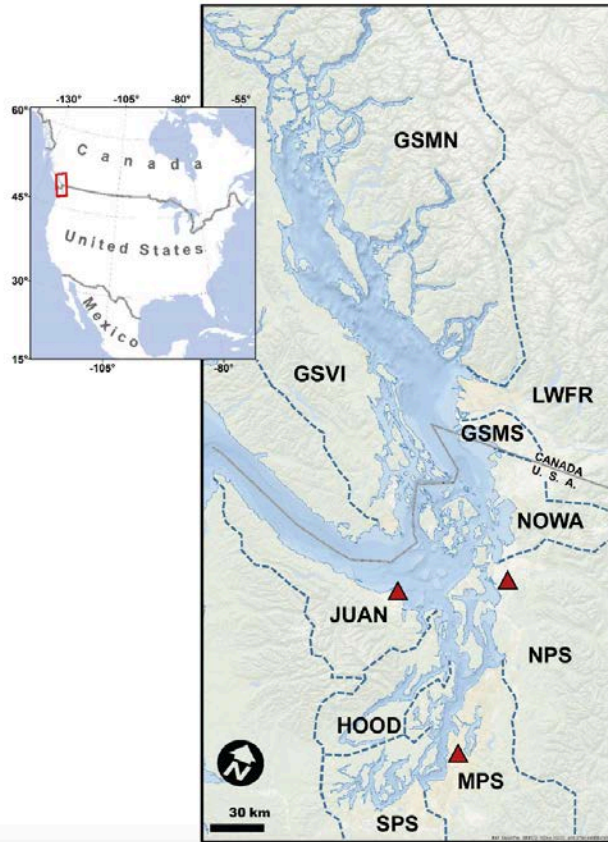
Hatchery production strategies were developed during a period of predictably "good" ocean conditions



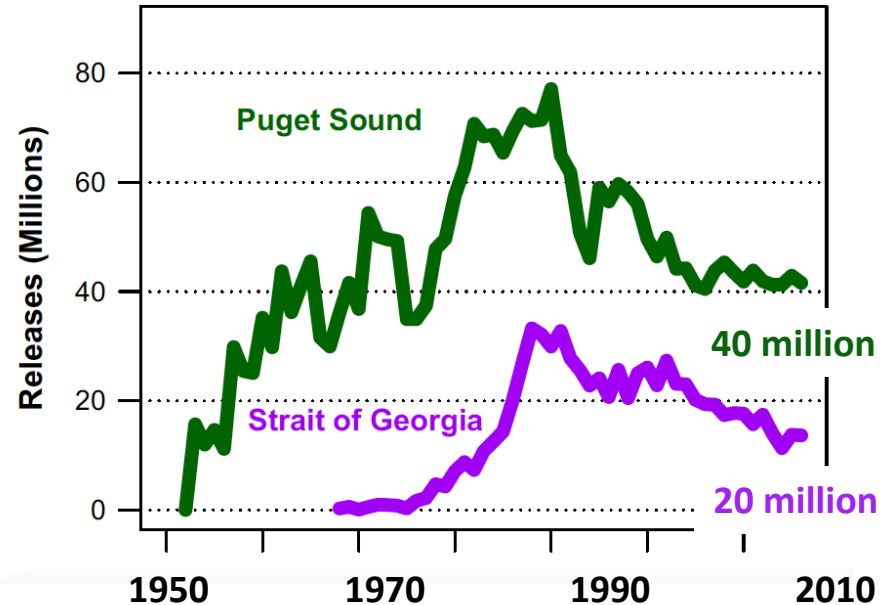
Trajectory of hatchery production strategies in the Puget Sound

Ecological implications of changing hatchery practices for Chinook salmon in the Salish Sea

BENJAMIN W. NELSON^{ID, 1,2,†} ANDREW O. SHELTON,³ JOSEPH H. ANDERSON,⁴
MICHAEL J. FORD,³ AND ERIC J. WARD³



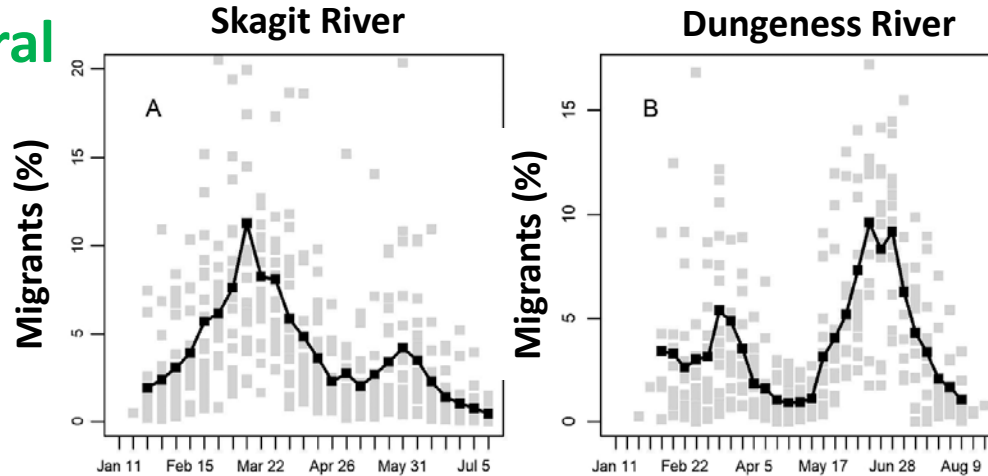
Chinook Salmon Hatchery Releases (millions)



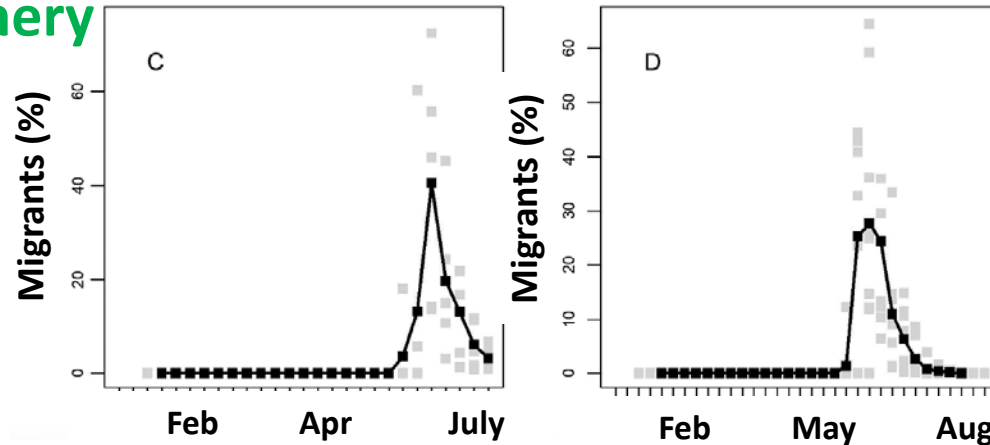
Current natural fish migration timing is variable and extended (6 months)

Current hatchery fish timing is unimodal and short (6 weeks)

Natural

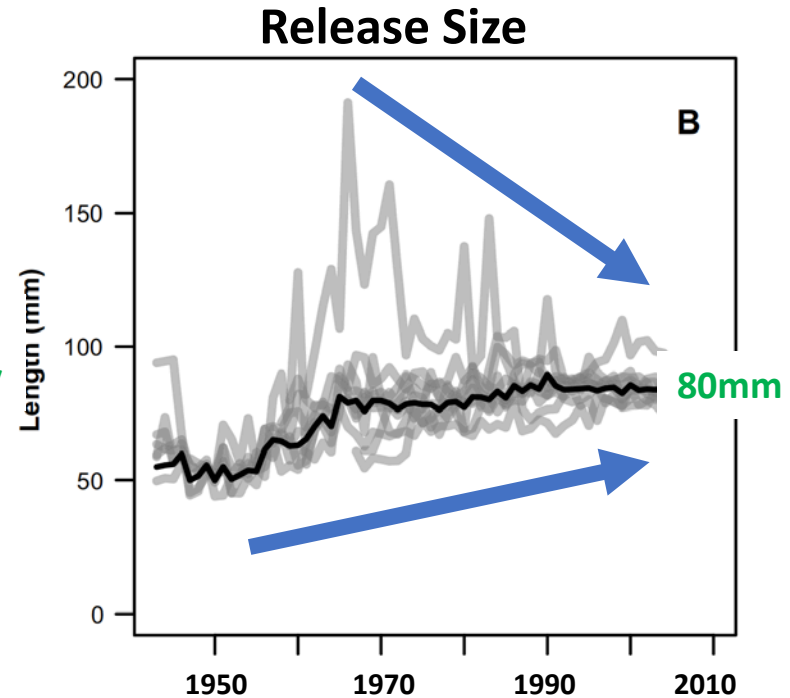
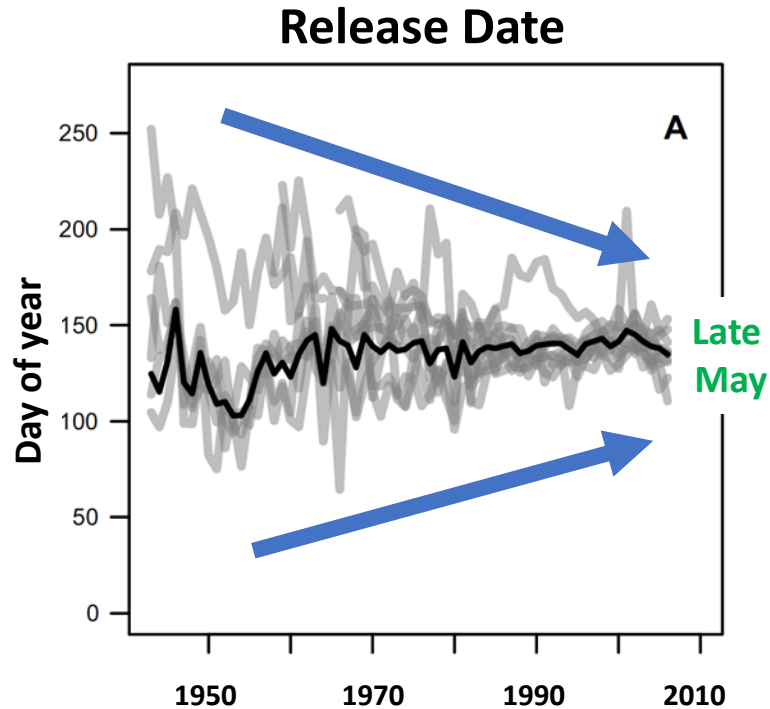


Hatchery



Abundance
of migrating
Chinook salmon smolts
at weirs/traps

Variation in hatchery release time and release size of Chinook salmon in Salish Sea has decreased and become unimodal



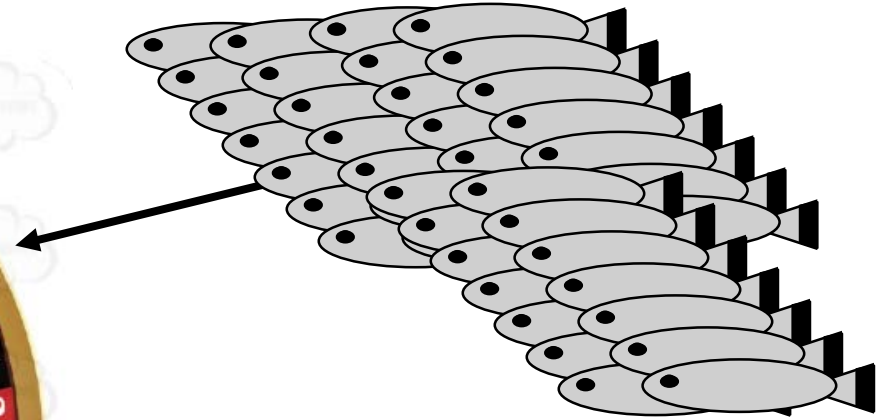
from CWT records

Nelson et al. 2019

**Puget Sound strategy: release of
a uniform group of smolts in the early summer
(the big bet)**



**Forty million on:
5 June at 40 fpp**

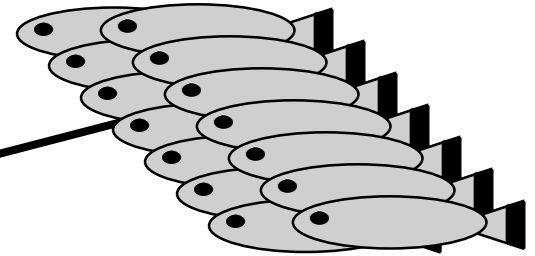


Based on:
A history of success
Size/time release studies

**A common Col R strategy is a single release of
yearlings in the spring**



**One million on:
5 April at 18 fpp**

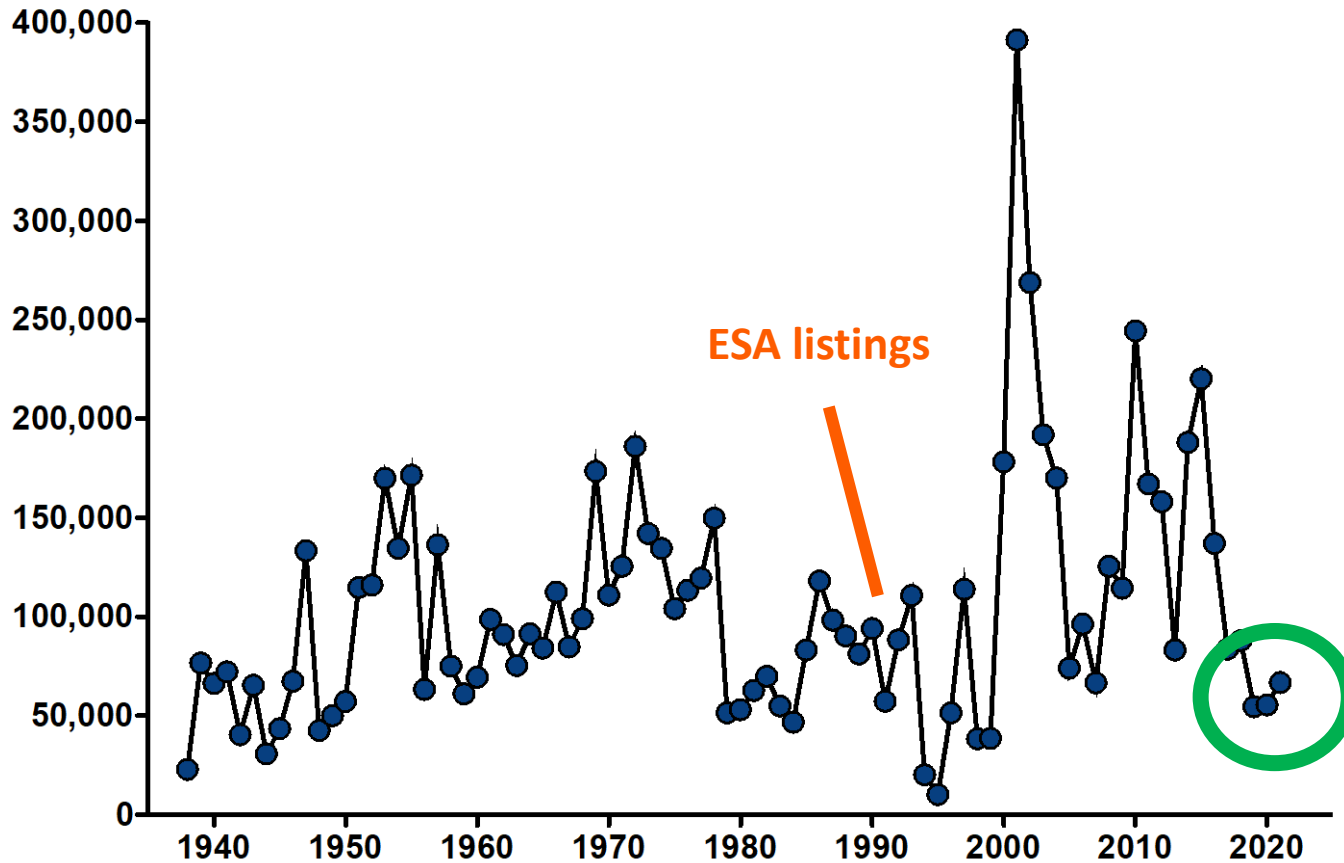


**Based on:
A history of success
Size/time release studies**

**Are current hatchery strategies always successful?
Or, is there a consistent return of fish?**

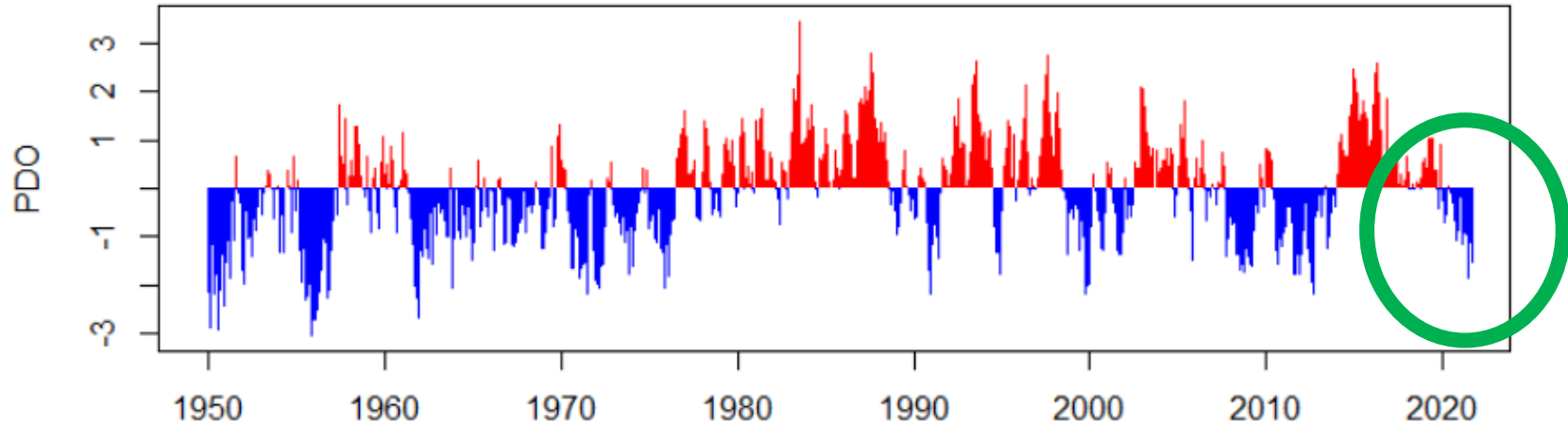
Spring Chinook salmon count at Bonneville, 2019 – 2021

Do we have a problem?



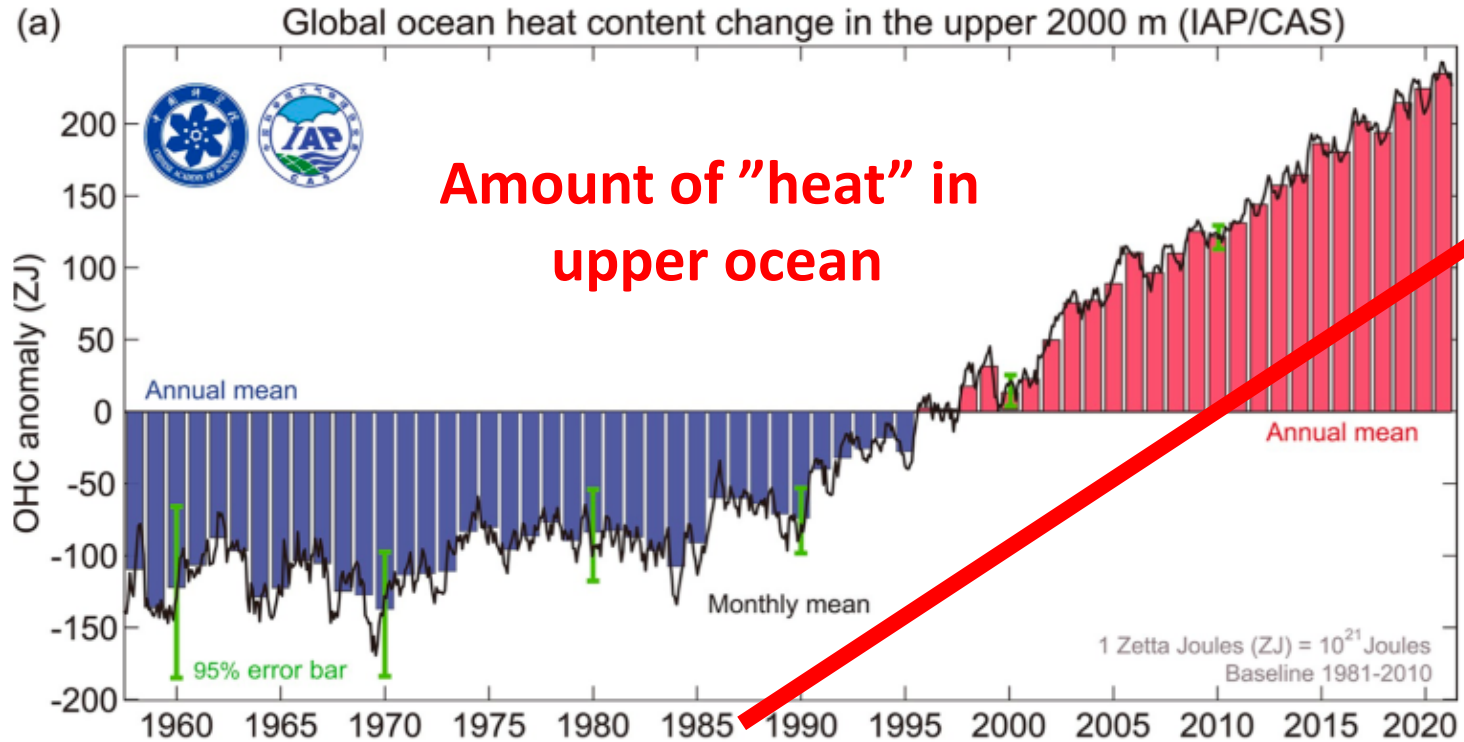
**Current hatchery strategies may result in poor returns but
stability of ocean ecosystem has ensured success
when ocean conditions
return to a cool and productive regime
2020??**

=> Maintain current strategies based expectations of a stable ocean?



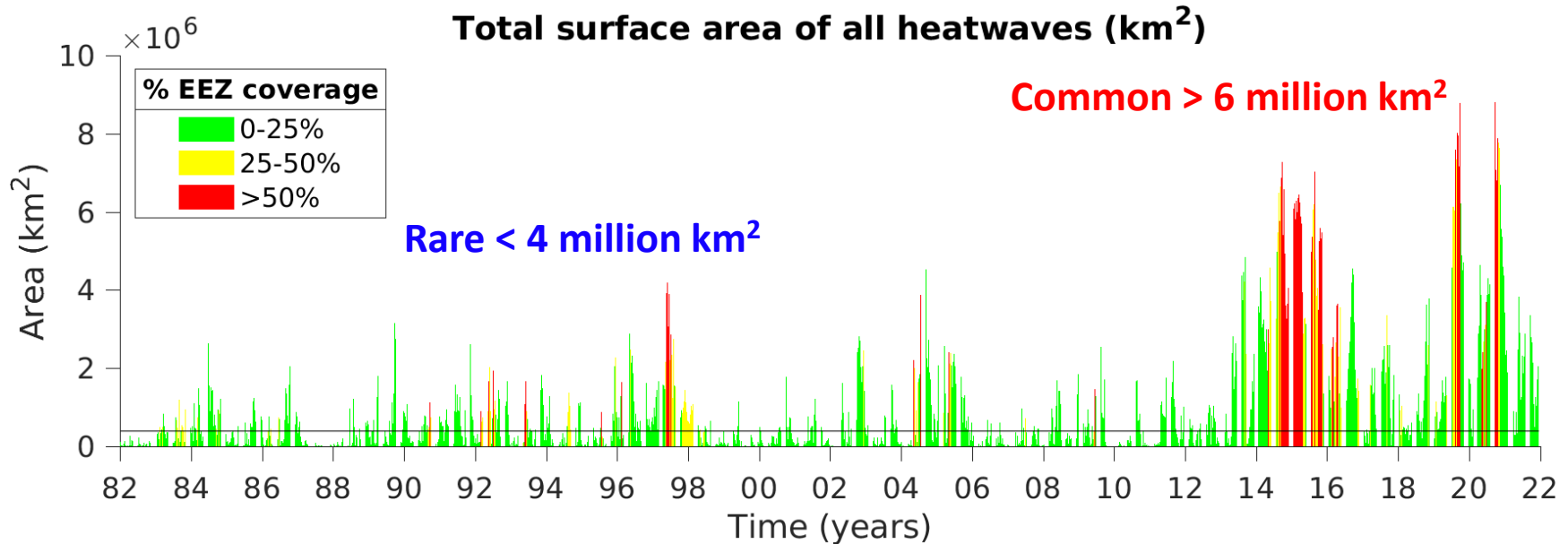
Patterns of ocean variation are changing

CHENG ET AL.



Cheng et al. 2022

Marine heat waves are increasing in frequency and magnitude

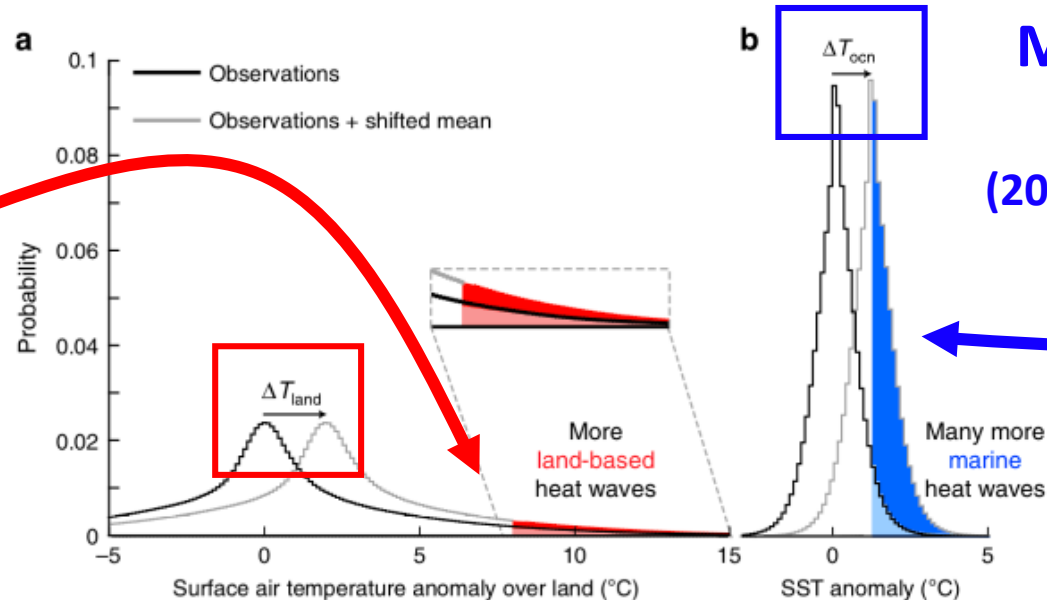


Emerging risks from marine heat waves

Thomas L. Frölicher^{1,2} & Charlotte Laufkötter^{1,2}

The forecast is for even more marine heat waves w/ warming

Land-based heat waves
(June 21)



Marine-based heat waves
(2014-16, 2018, 2019)

Fig. 2 The effect of a simple shift towards a warmer climate on the probability of land-based and marine heat waves. **a** shows the observed distribution of the linearly detrended and deseasonalized local daily surface air temperature anomalies over land using the CRU-NCEP-v8 data set^{21,22}; **b** as for **a** but for local daily sea surface temperature anomalies using NOAA's daily Optimum Interpolation sea surface temperature data set¹¹. Solid black lines show the distributions over the 1982–2016 period and solid gray lines indicate the same shape of the distributions, but the land is shifted by $\Delta T_{\text{land}} = 2^\circ\text{C}$ and the ocean by $\Delta T_{\text{ocn}} = 1.33^\circ\text{C}$. Here we assume $\Delta T_{\text{land}}/\Delta T_{\text{ocn}} = 1.5^{20}$. A heat wave is defined as temperature exceeds the 95th percentile (red and blue shaded areas). The inset highlights the changes in land-based heat waves

There is an increasing trend in marine heat

Variability is increasing

The variation is becoming more intense

The ocean is becoming more unpredictable

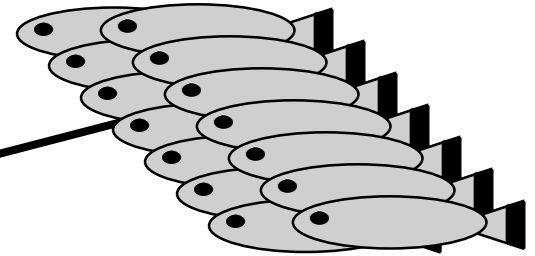
Marine conditions are exceeding historic norms

Might the PDO “flip” become unstable?

Do we want to continue with the current strategy (**the big bet**) or perhaps consider some alternatives?



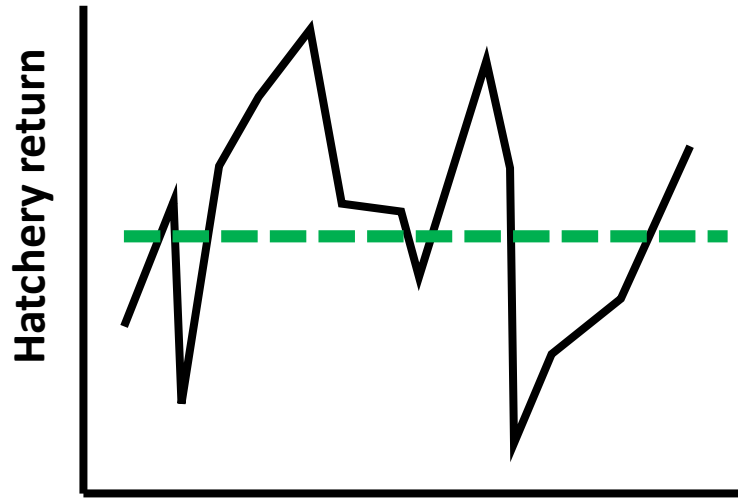
**One million on:
15 April at 18 fpp**



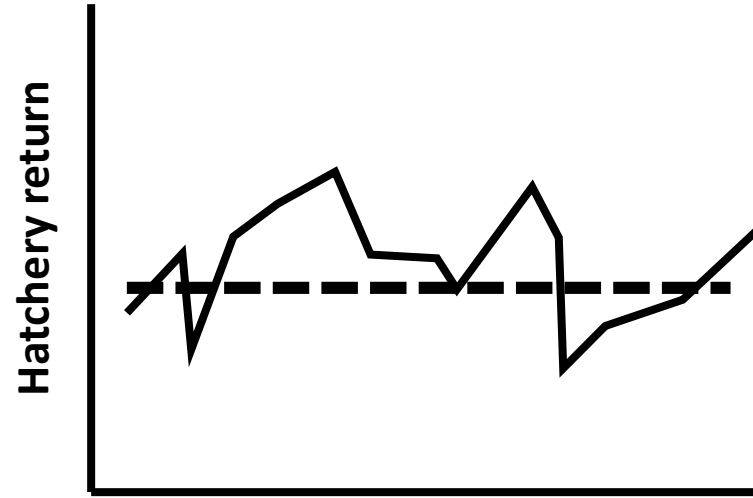
**Based on:
A history of success
Size/time release studies**

**Are hatchery goals 1) maximizing return every year or
2) minimizing variance in return between years?**

Are there alternative production strategies that might produce different patterns of variance?



the big bet

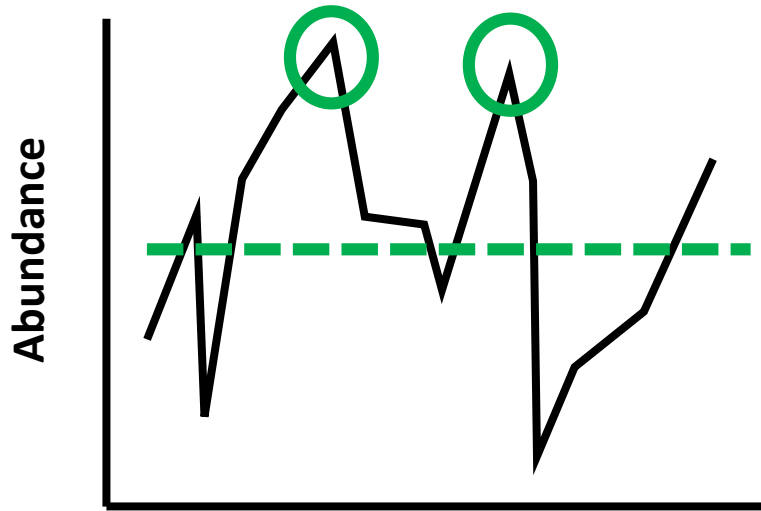


something else

Year

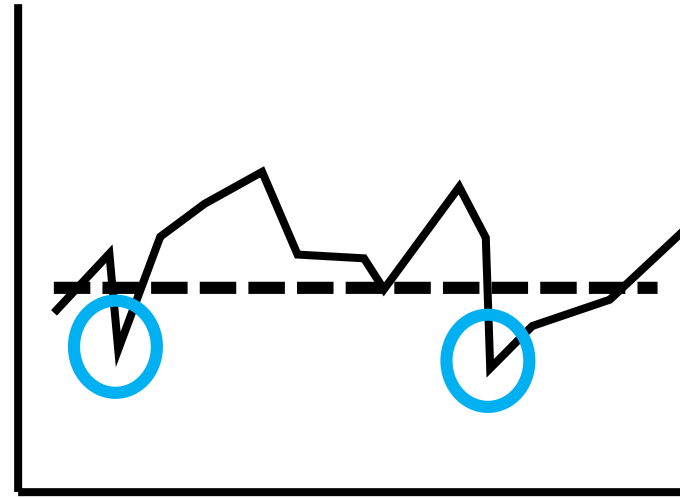
Are there alternative production strategies that might produce different patterns of variance?

Annual mean is higher
Max annual catch is higher



the big bet

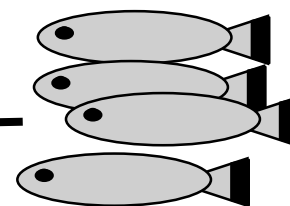
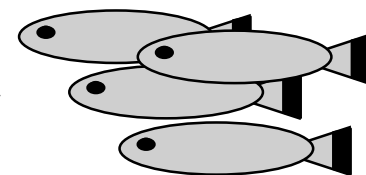
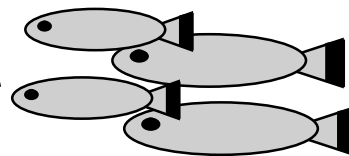
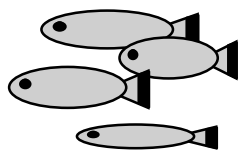
Minimum annual catch is higher
Variance is lower



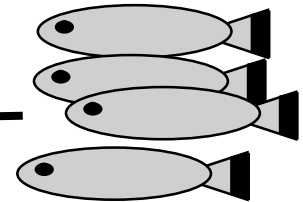
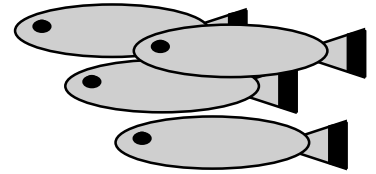
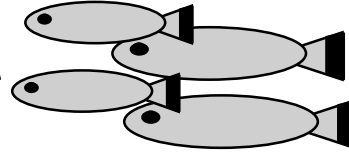
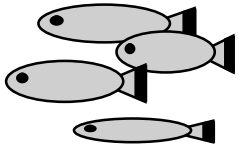
something else

Year

250k each on: ???? at ?????



250k each on: ???? at ?????



**Bet small – win small
but don't bust**

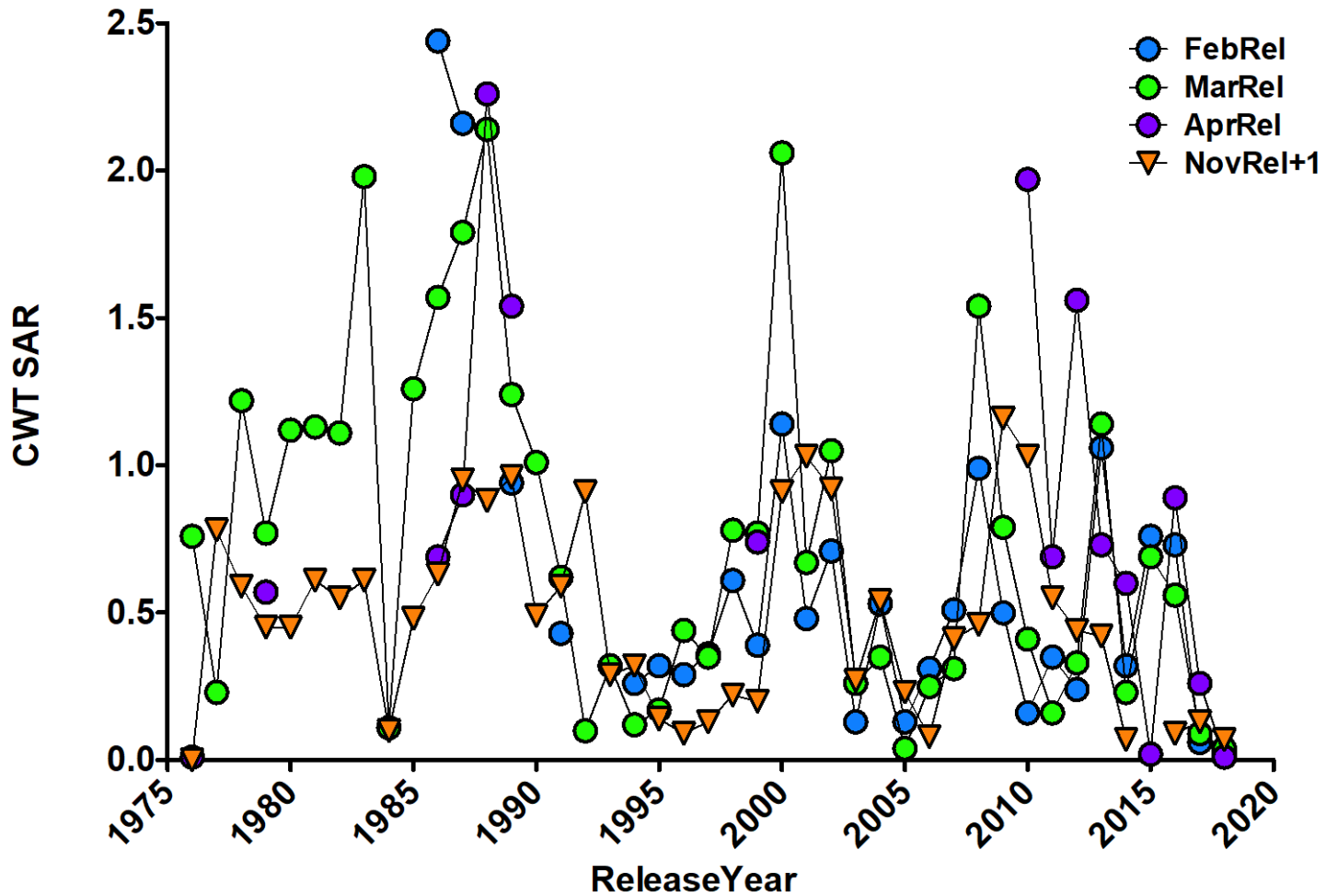


What data do we have on "small bets"?

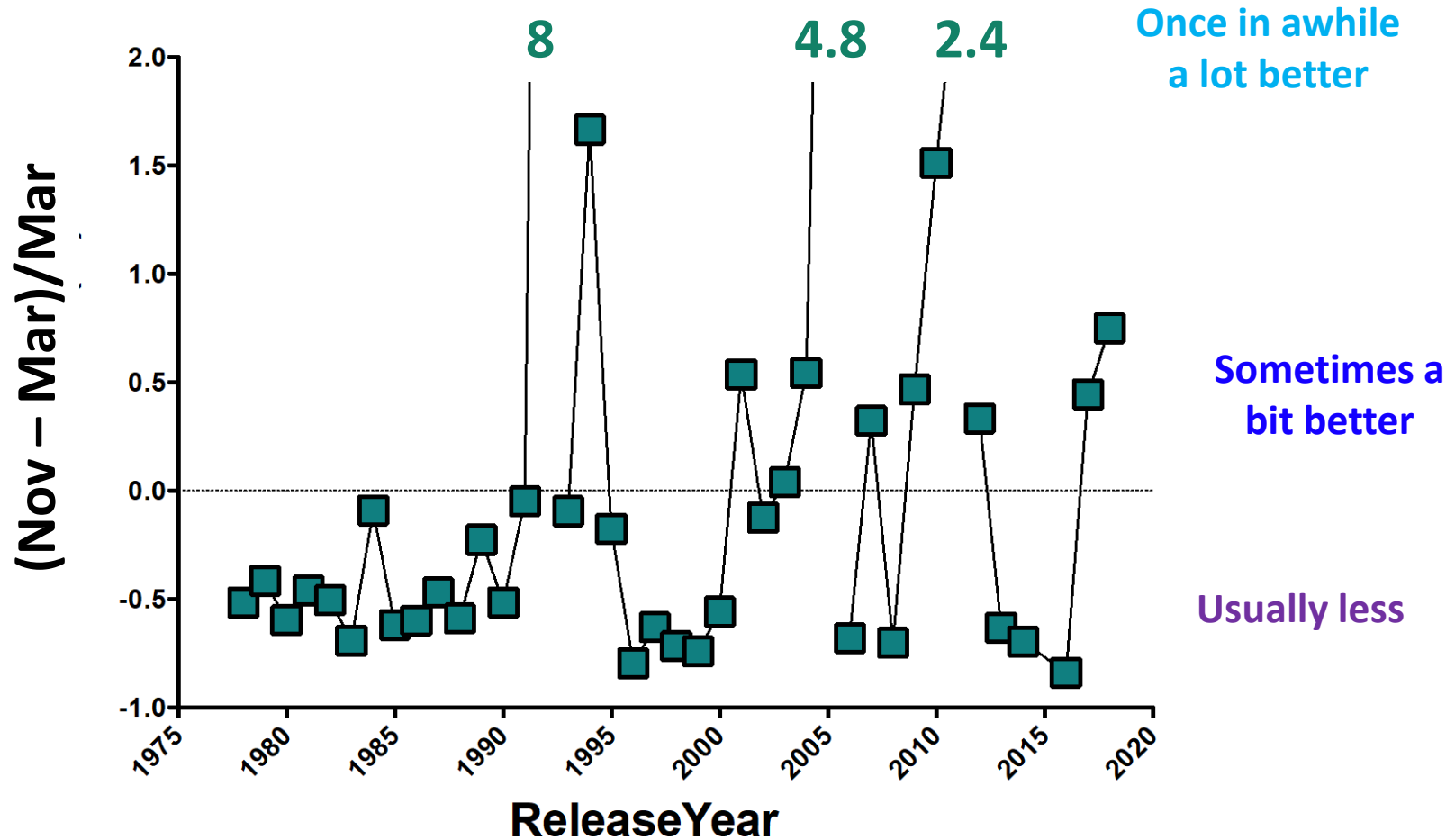
**Willamette spring Chinook salmon, ODFW
4 hatcheries, varying release dates, several decades of CWTs**

Mining RMIS

Willamette R spring Chinook SAR by release month



How does November compare to March? Fold-difference, Nov - March



**On average, March release SAR is higher,
~ 30% of the time November release SAR is higher**

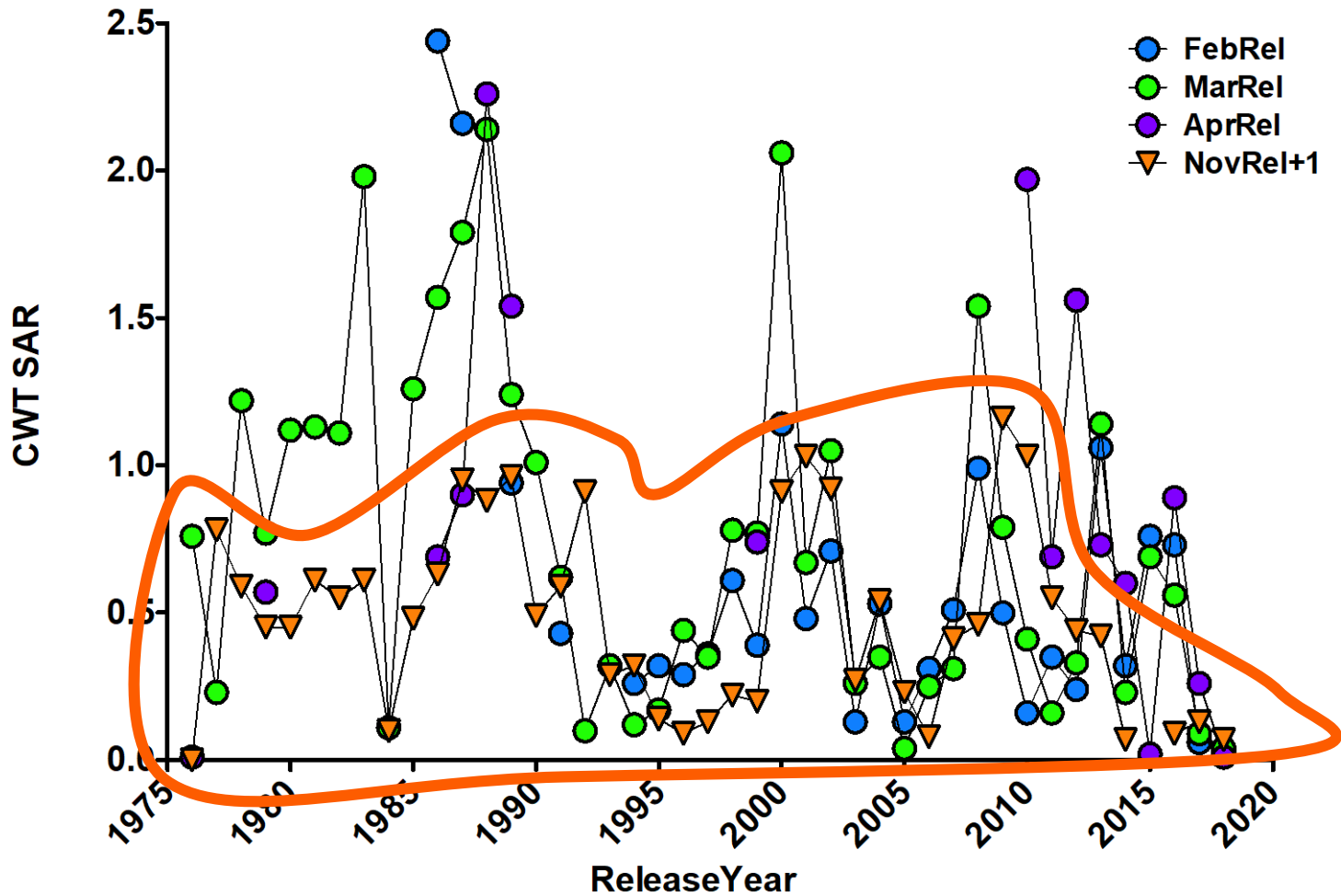
November is higher - 12

About the same - 6

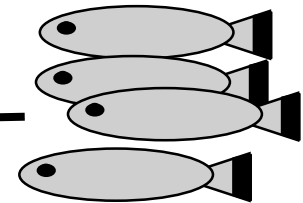
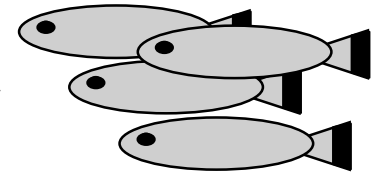
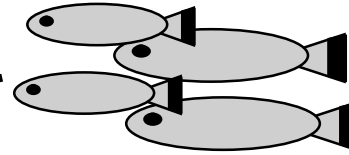
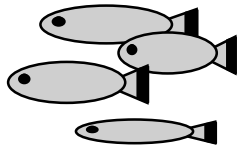
March is higher - 21

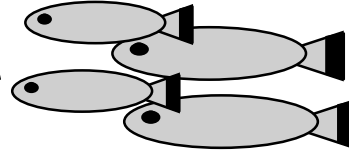
1978 – 2018, Willamette, Marion Forks, South Santiam, McKenzie
Spring Chinook salmon CWTs
lumped and averaged

November returns are never “great”

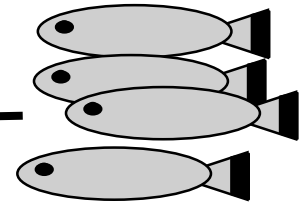
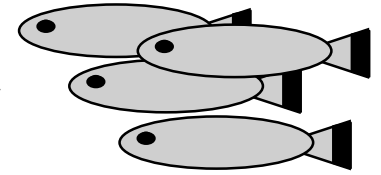


This is not a solution – it's an approach to consider

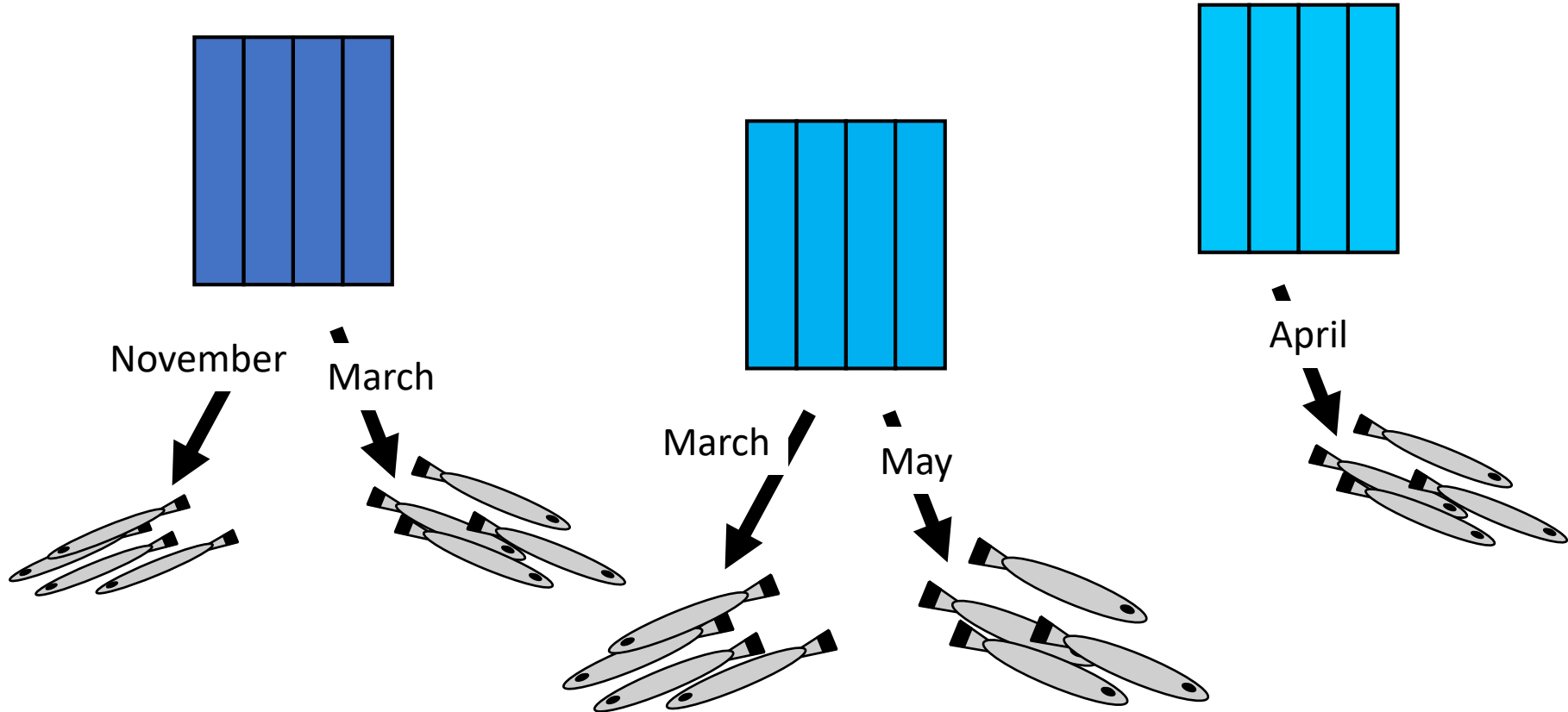




Bet small – win small but don't bust



**There are different ways to generate diversity, within a program
or within a sub-basin between programs
=> No reason any one program needs to generate all diversity**



There are opportunities to examine effects of current variation in release timing

Chinook programs with variable release timing (my knowledge):

Cowlitz, Lewis, Kalama spring Chinook salmon

Upper Columbia summer Chinook salmon

Snake River fall Chinook salmon

Klamath River spring Chinook salmon

**How do we make short-term management decisions,
within varying and unpredictable marine conditions,
while considering a long-term trend?**