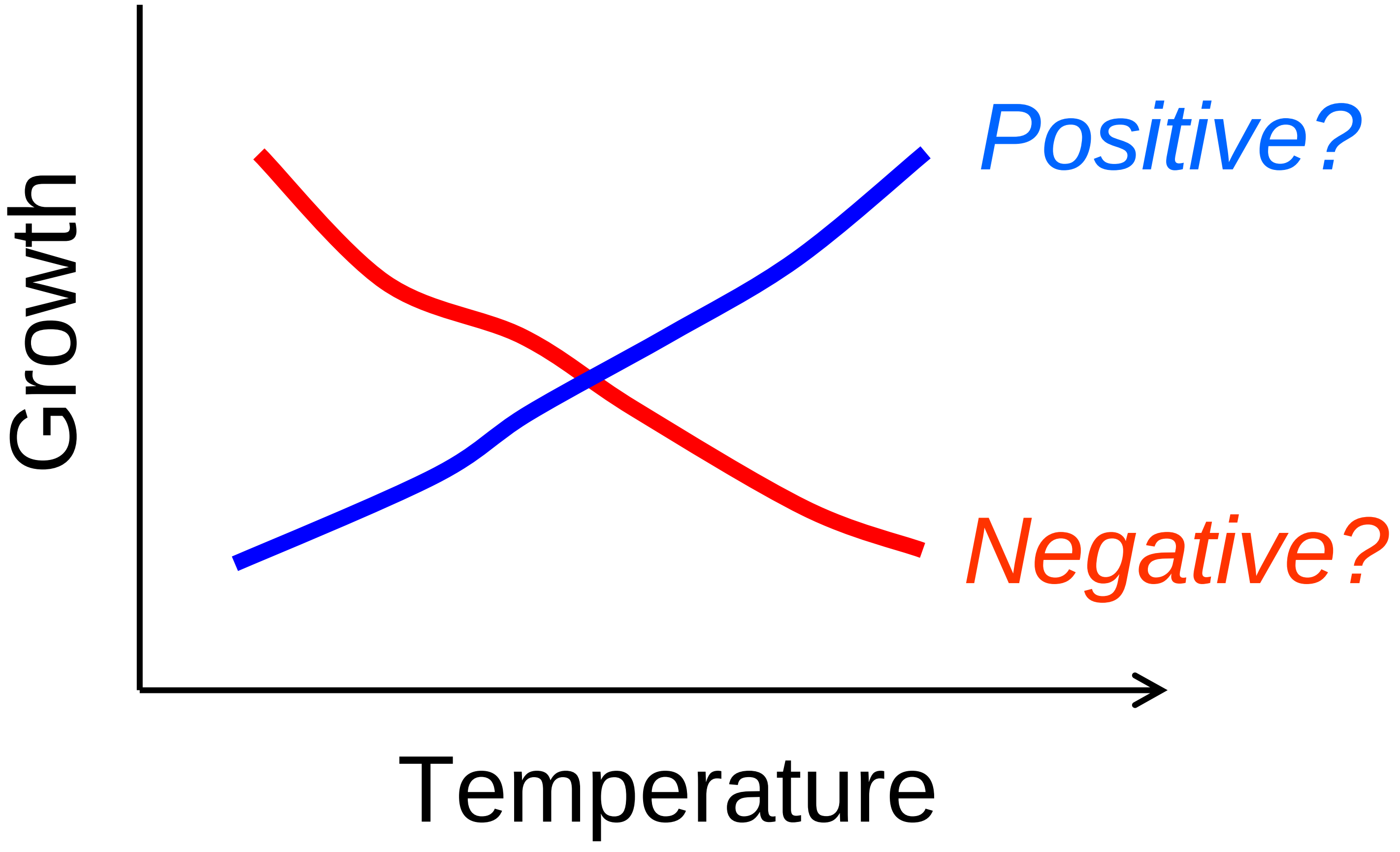
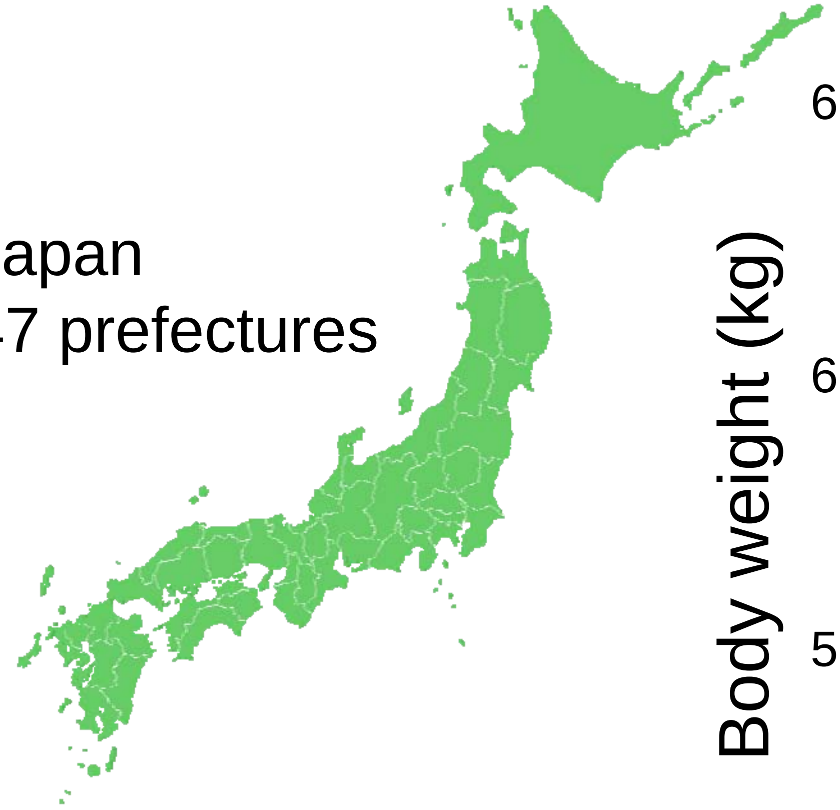
Potential effect of rising temperature on growth performance and its influence on chum salmon

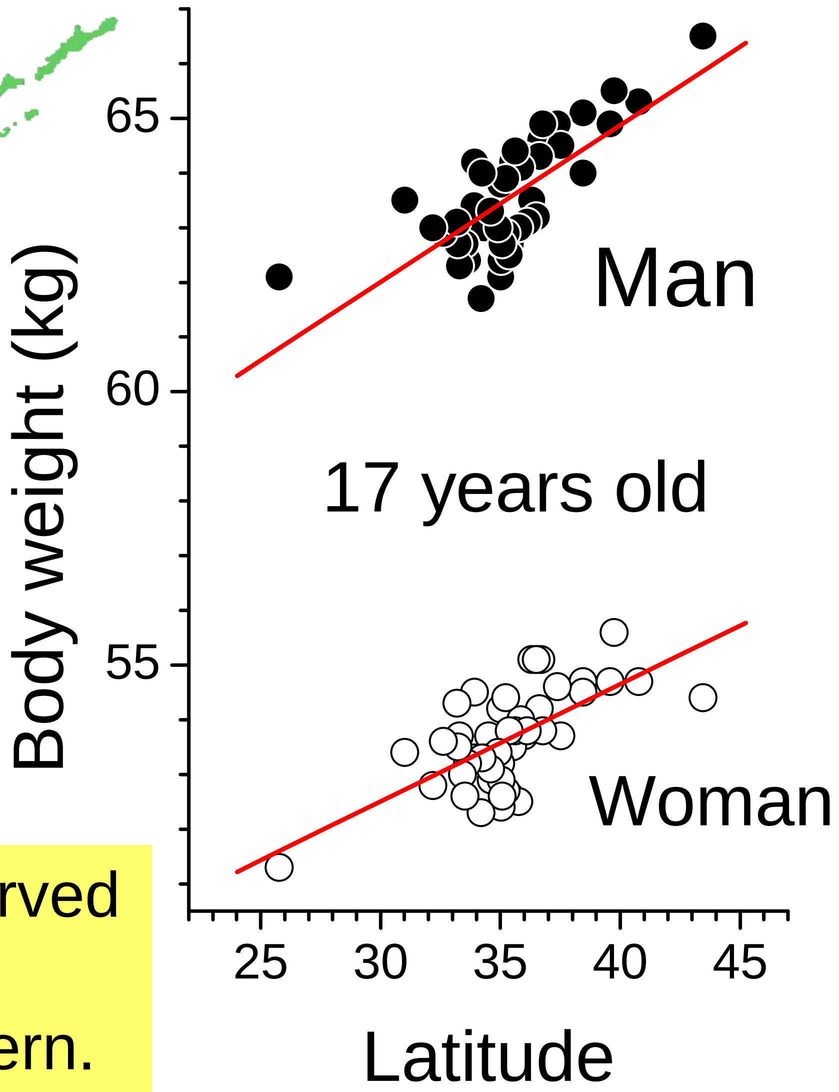
Kentaro Morita and
Masa-aki Fukuwaka
(Hokkaido National Fisheries Research Institute, Japan)

How growth respond to a rising temperature?



Bergmann’s rule

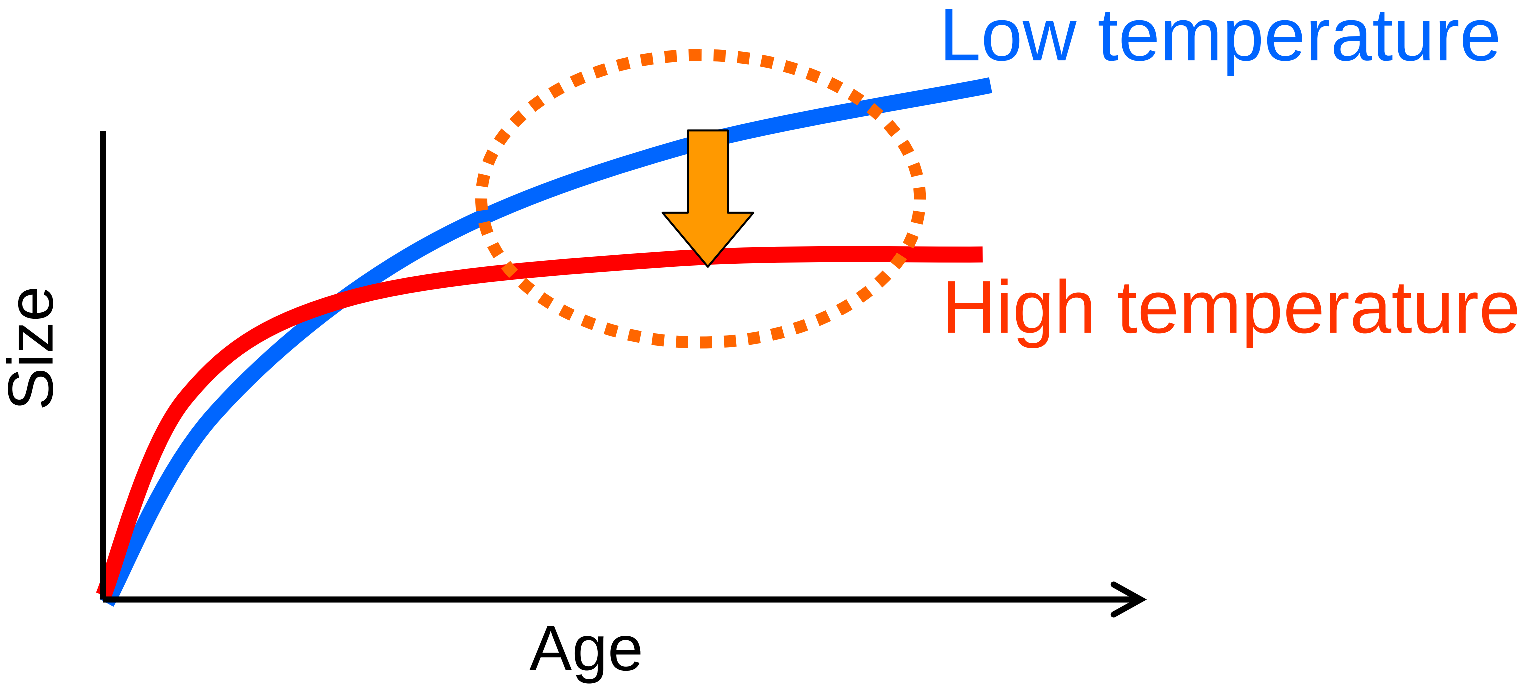




Bergmann’s rule was first observed in endotherms, but several ectotherms show a similar pattern.

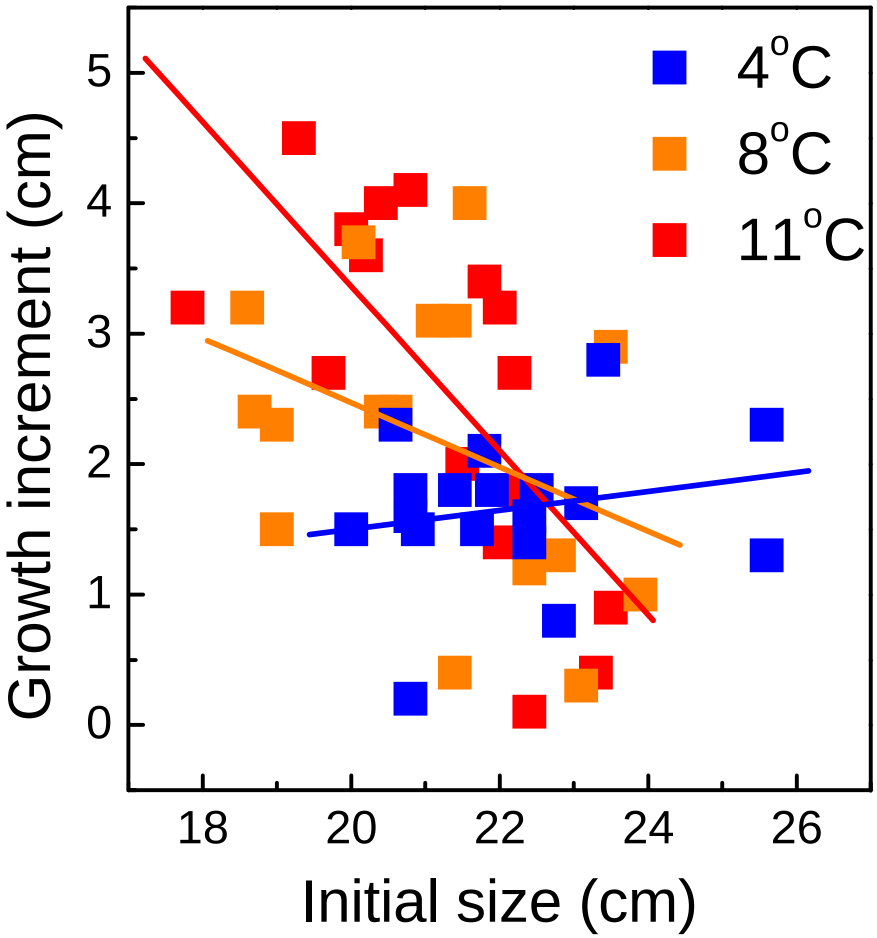
Empirical evidence I

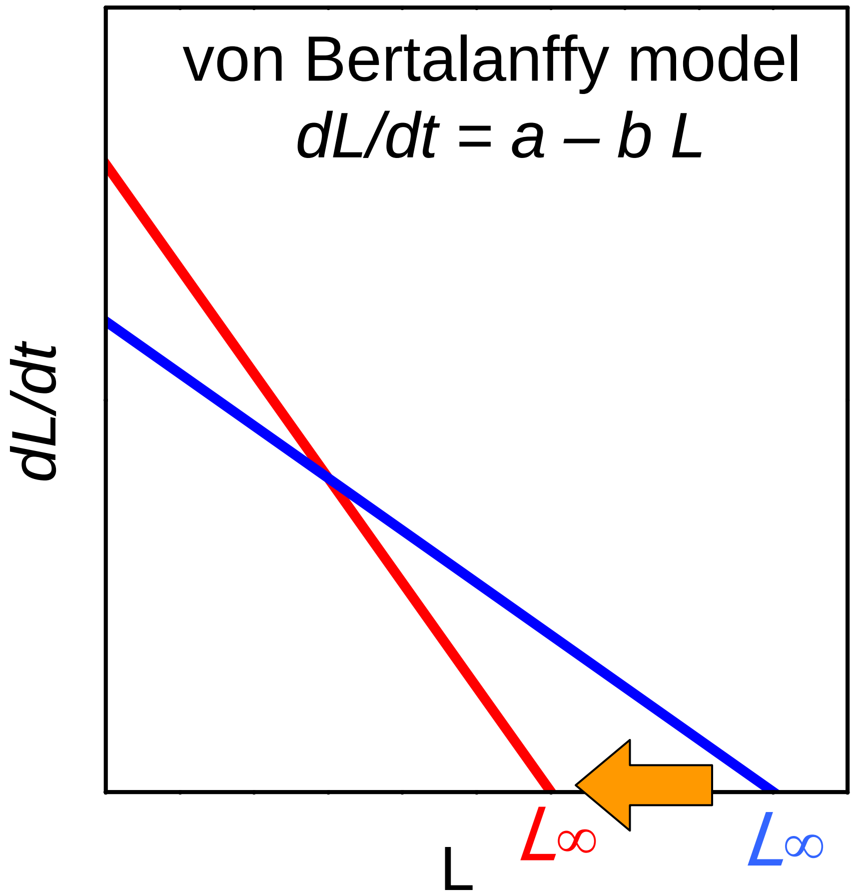
- Fish reared at lower temperatures grow to a larger final size



Rising temperature reduce growth of large fish

Pink salmon experiment

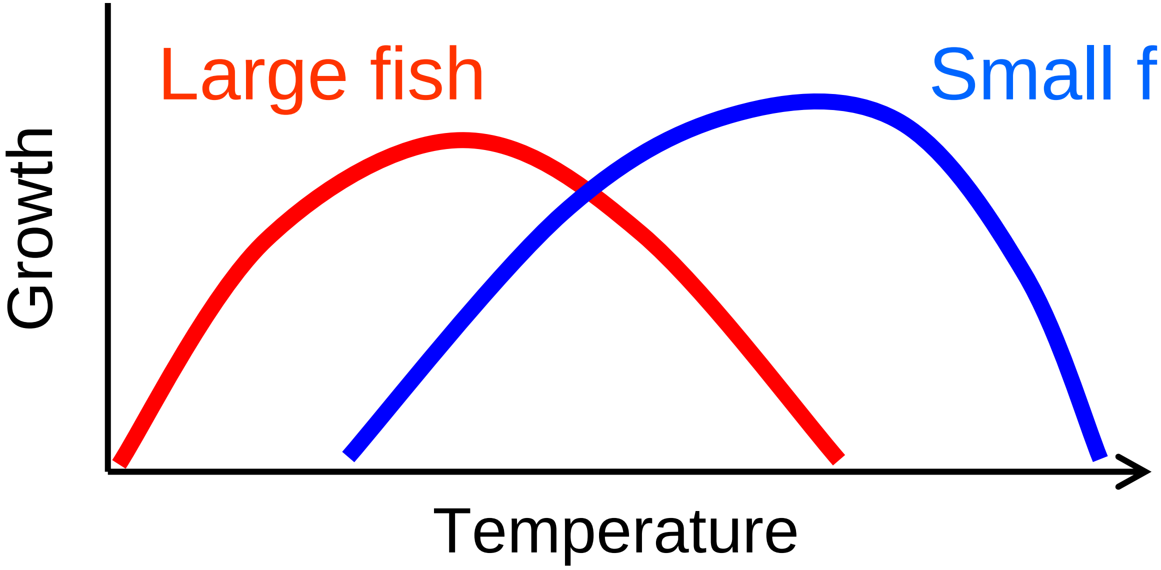




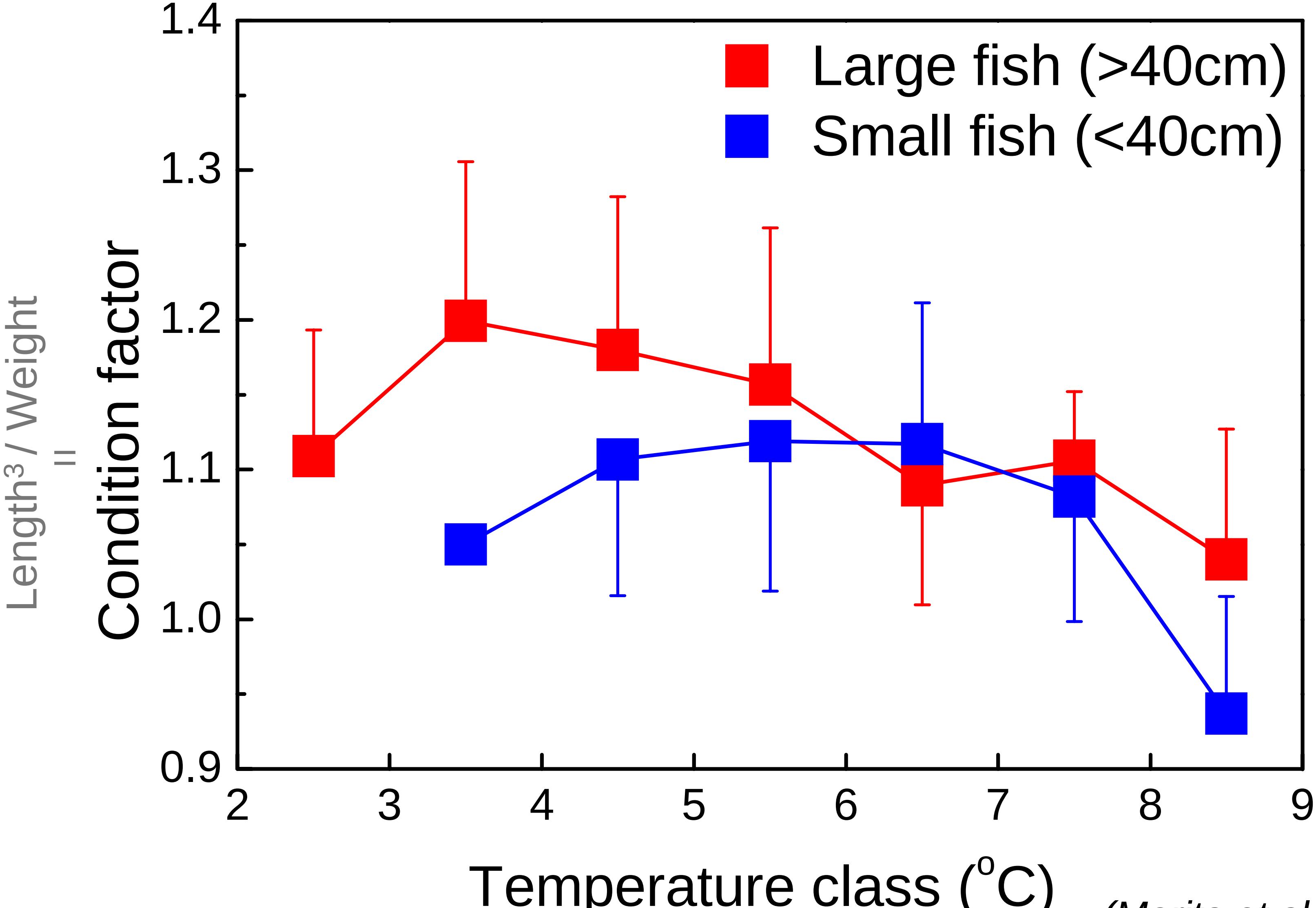
(Morita et al. submitted)

Empirical evidence II

- Optimal temperature for growth of fish decreases with increasing body size



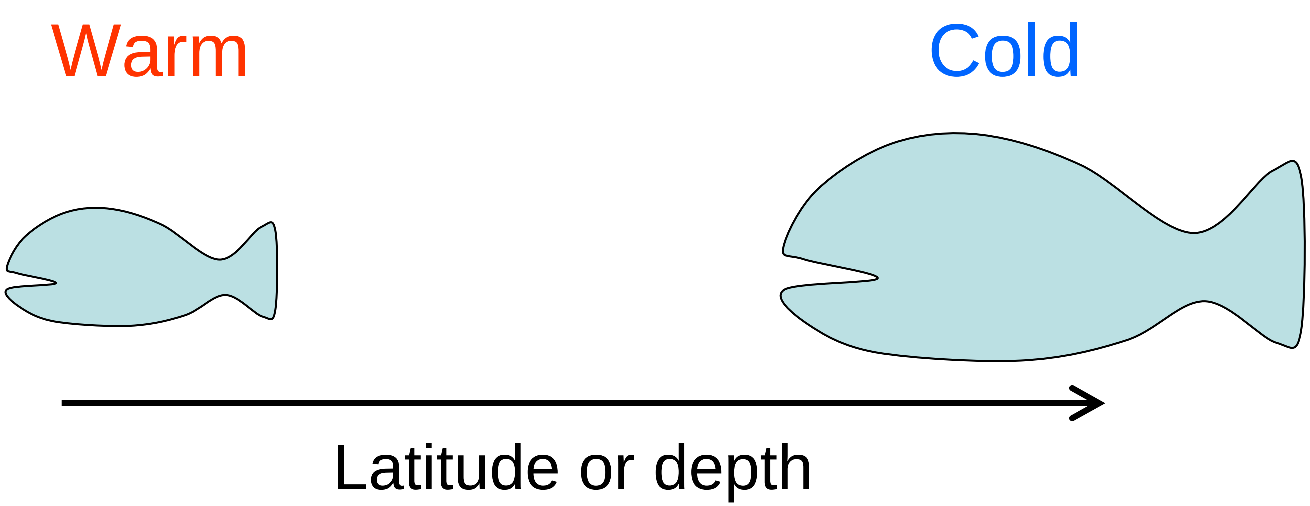
Chum salmon in the North Pacific



(Morita et al. submitted)

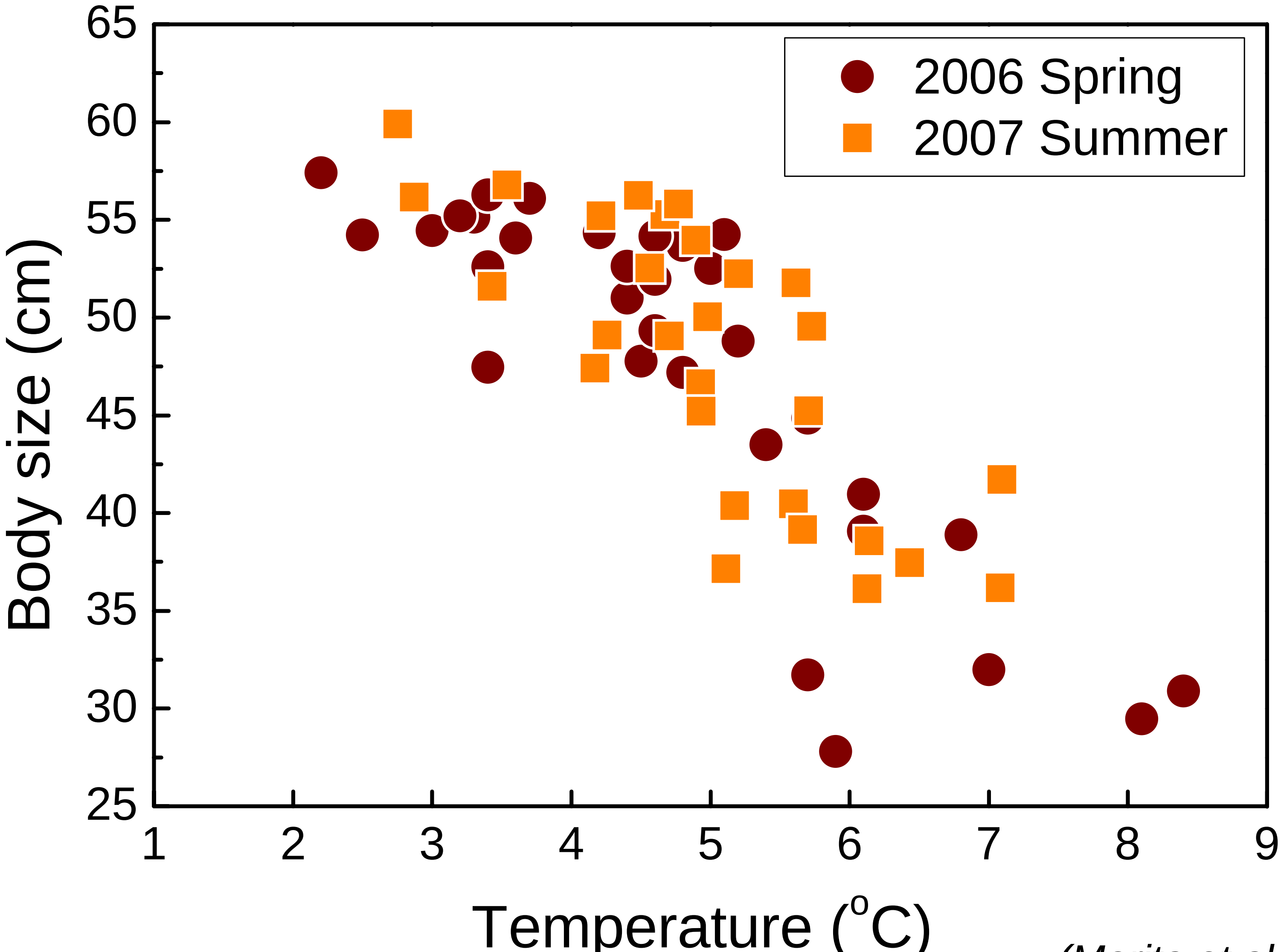
Empirical evidence III

- Larger fish often inhabit deeper depths, higher latitudes, or colder waters than small fish



Rising temperature may reduce habitat of large fish

Chum salmon in the North Pacific



(Morita et al. submitted)

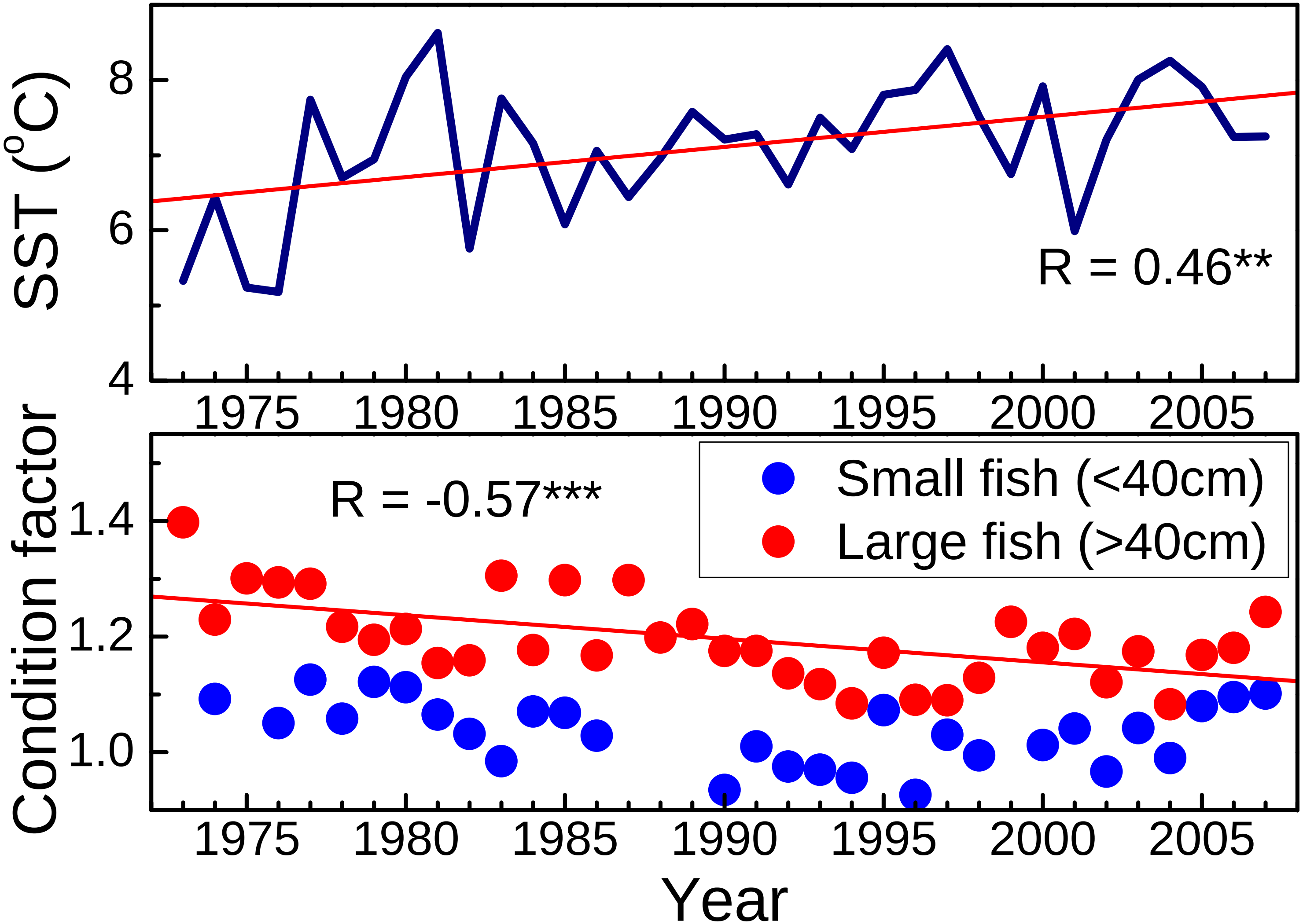
Consequence of rising temperature

- Rising temperature may reduce
  - available thermal habitat of **LARGE** fish
  - growth performance of **LARGE** fish
  - maximum size $\boldsymbol{L_\infty}$ of growth curve

➢ Examine trends in SST and condition factor in the Bering Sea 1973-2007

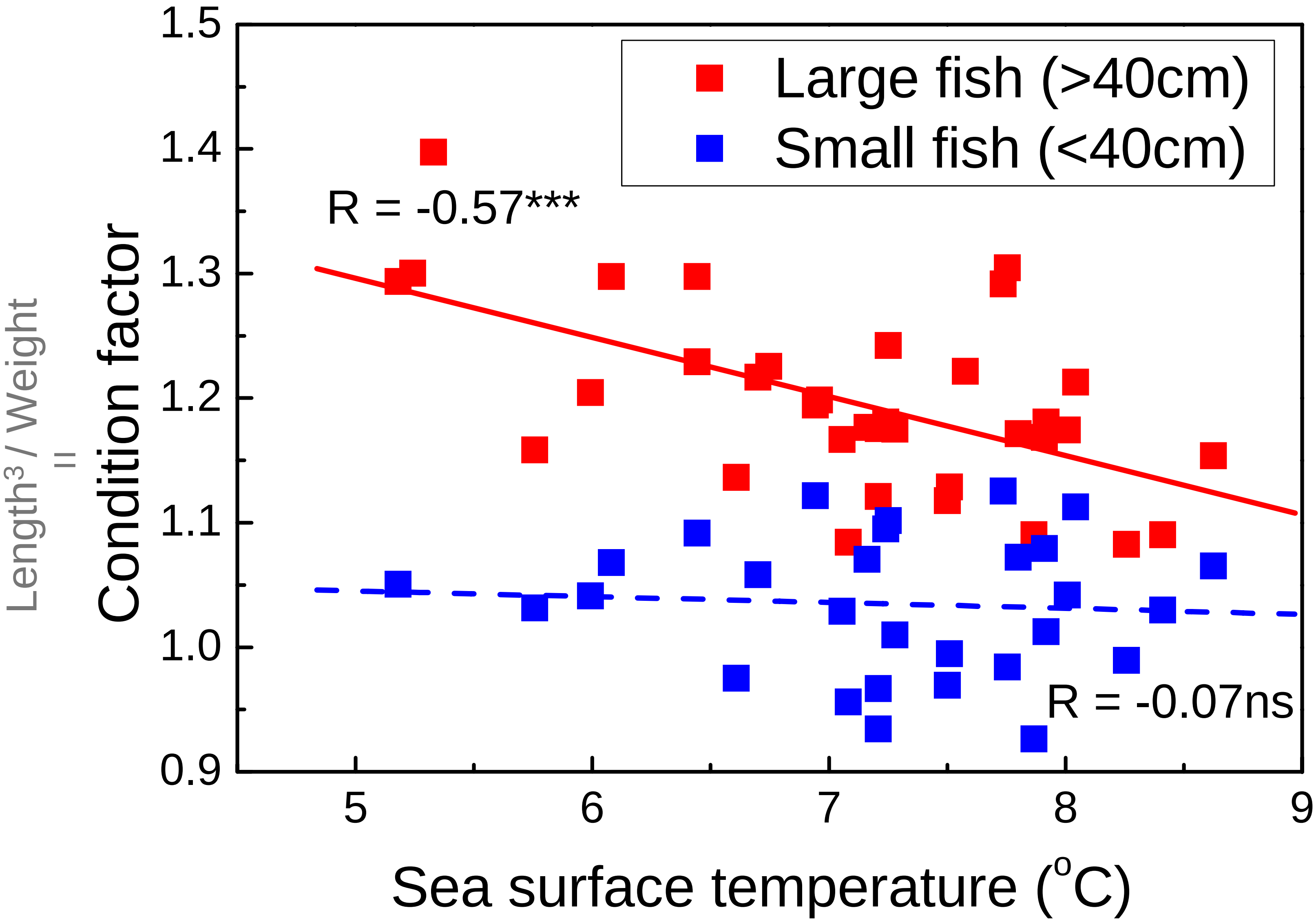
➢ Simulate the potential influence of decreasing maximum size

SST and condition factor of chum salmon in the Bering Sea 1973-2007

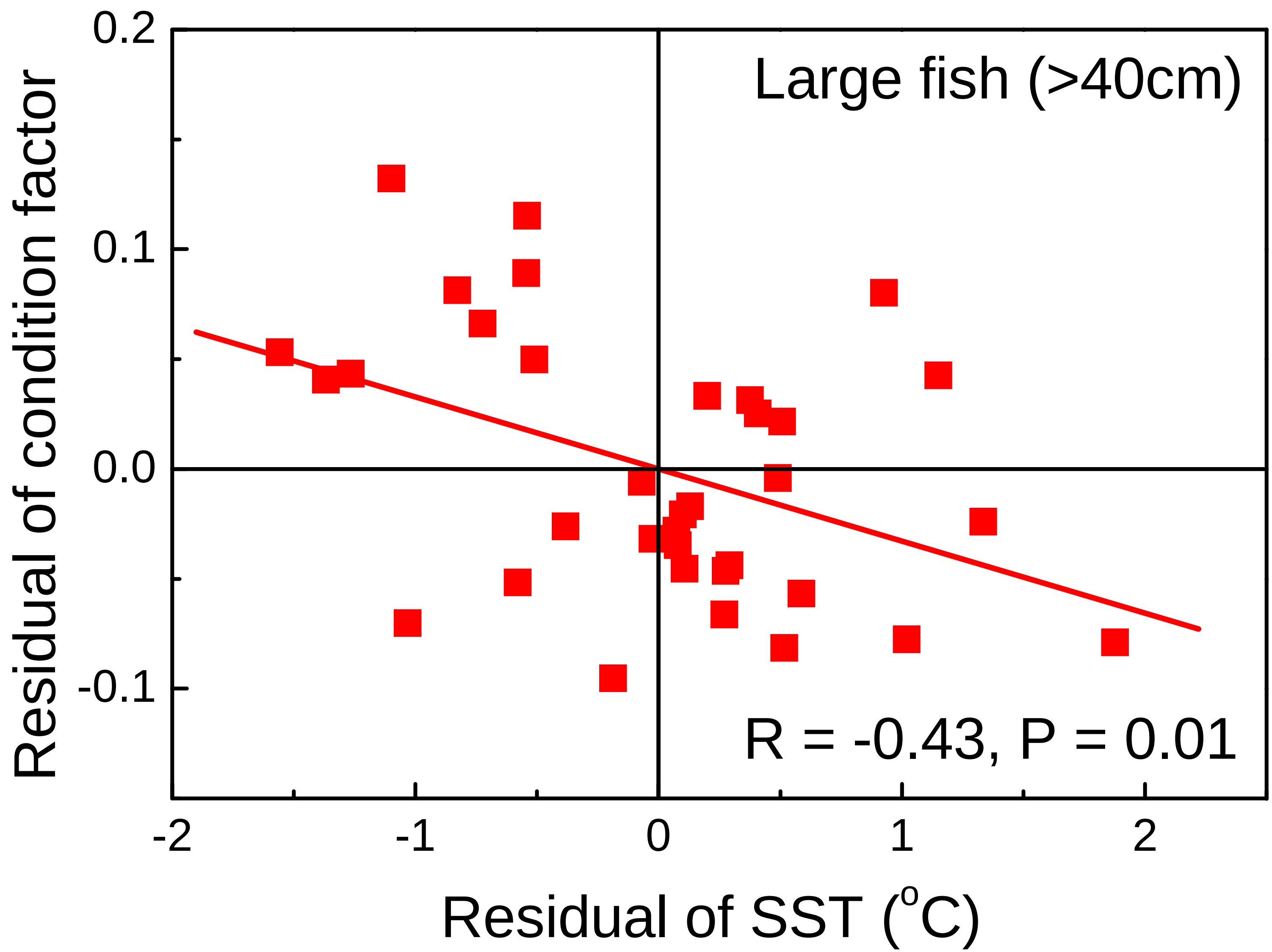


(Morita et al. submitted)

SST vs. condition factor 1973-2007



Detrended data



How populations respond?

- Simulate the potential modification of age and size at maturity, spawning stock biomass in response to reducing maximum size.
- Size-structured model with age- and size-specific maturation rates $\mathbf{P}$ (Morita et al. 2005 CJAFS).

$$\mathbf{N}_{t+1} = e^{-M}\underline{\mathbf{G}}(\mathbf{N}_t - \mathbf{P}\mathbf{N}_t)$$

Transition matrix = $f(L\infty)$

Simulation results

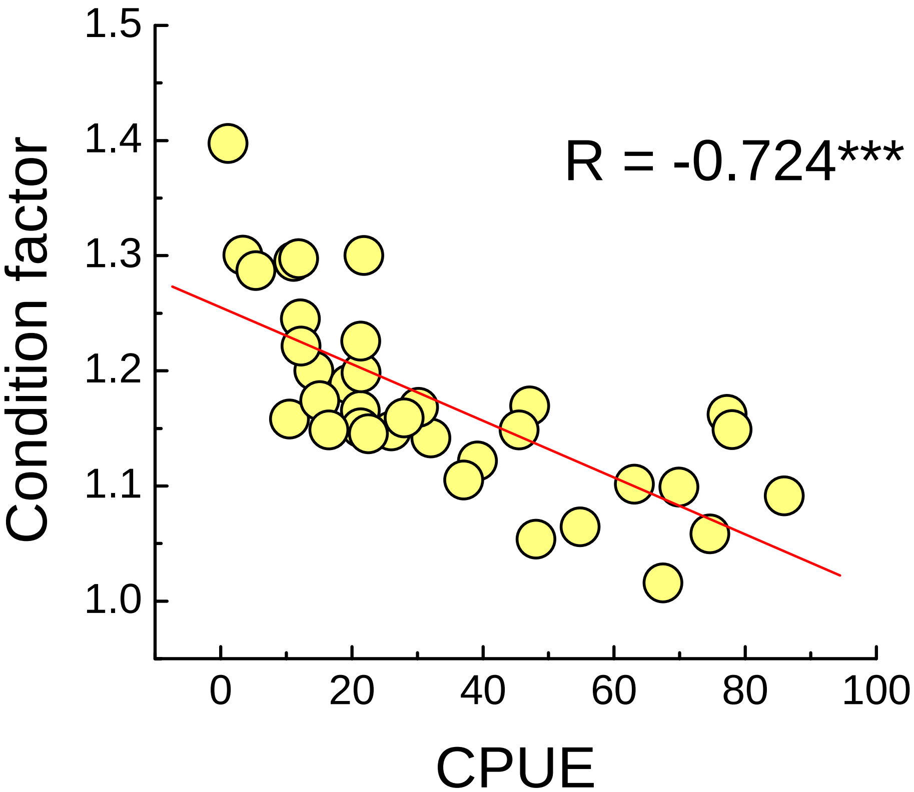
Change in L_∞	Basic value = 85 cm	-5%	-10%
Age at maturity	4.0yr	4.2yr	4.5yr
Size at maturity	68cm	65cm	62cm
Spawning stock biomass	100%	85%	72%

Conclusions

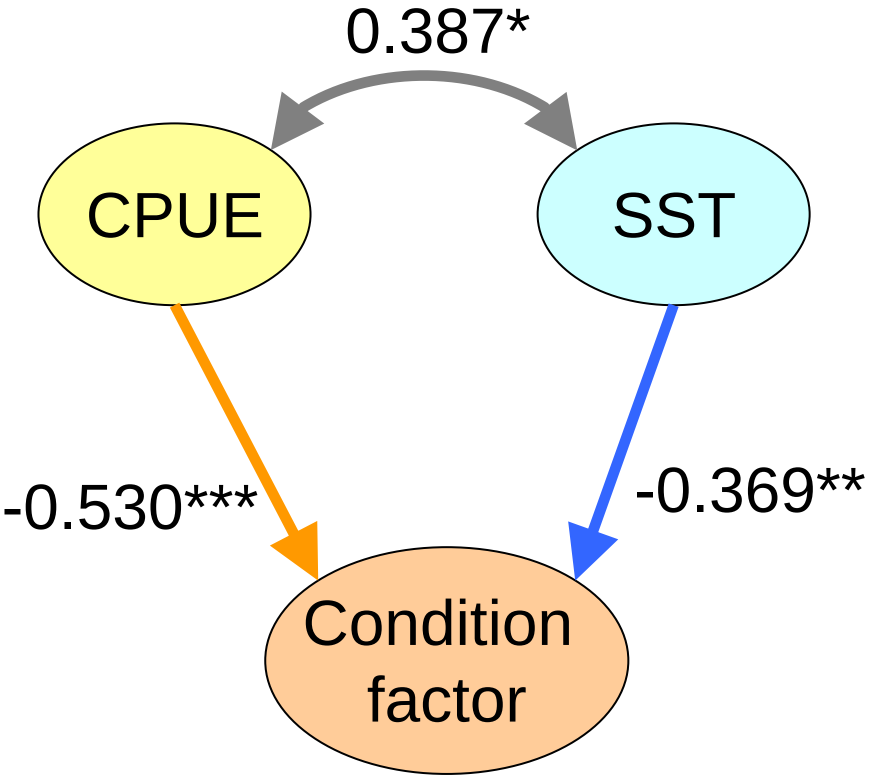
- Rising temperature reduce growth performance of LARGE fish.
- Rising temperature could decrease maximum size L_∞ (cf. Bergmann's rule).
- Decreasing L_∞ led to a decrease in size at maturity, increase in age at maturity, and decrease in SSB.


We hope cold years...

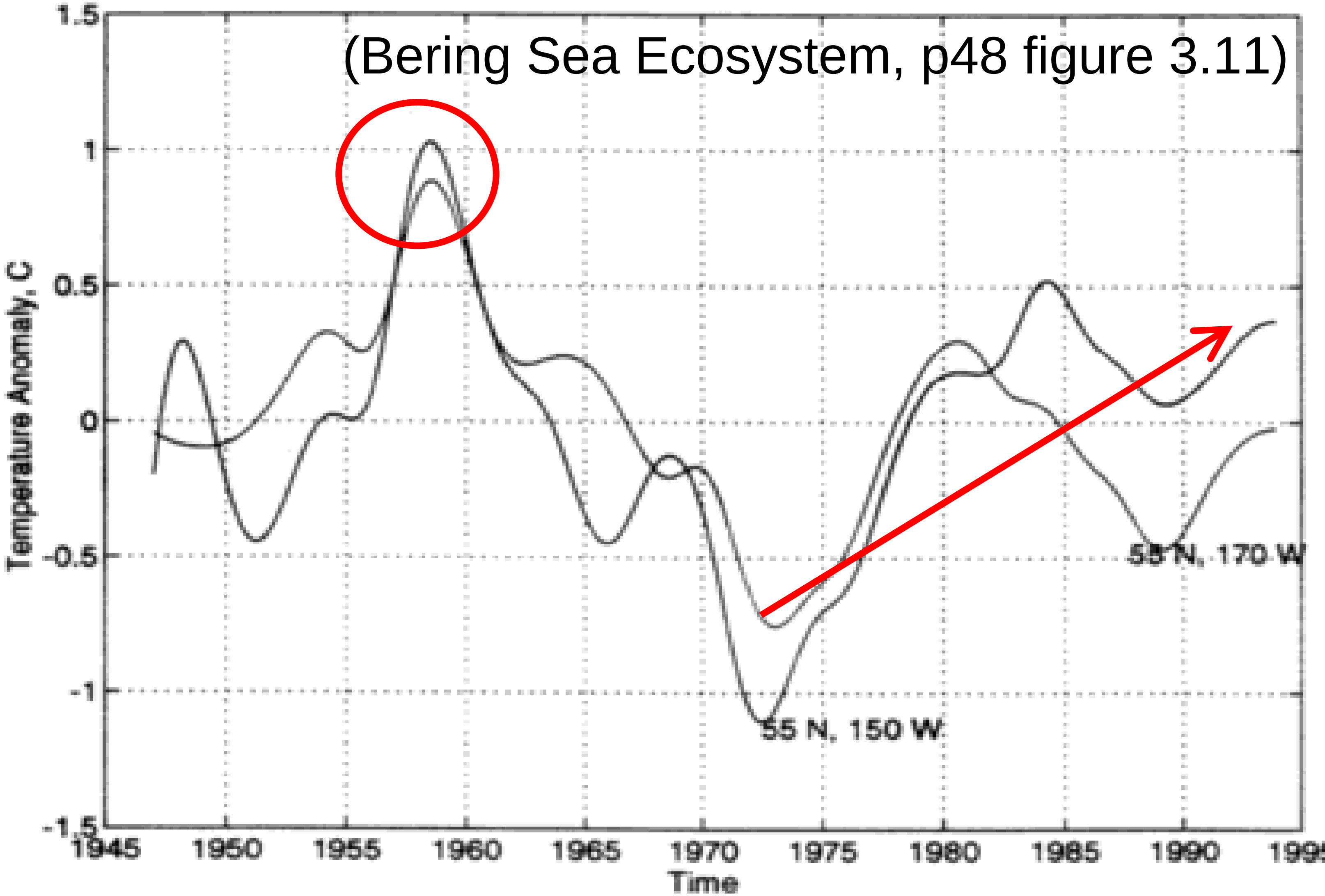
CPUE, SST, and condition factor



Path analysis



Bering Sea temperature



Temperature vs. L_∞

(Data from Jennings and Beverton 1991)