Climate change impacts on predator-prey dynamics in the Bering Sea:

changes to foraging rate and prey demand of walleye pollock, Pacific cod, and arrowtooth flounder

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INTRODUCTION

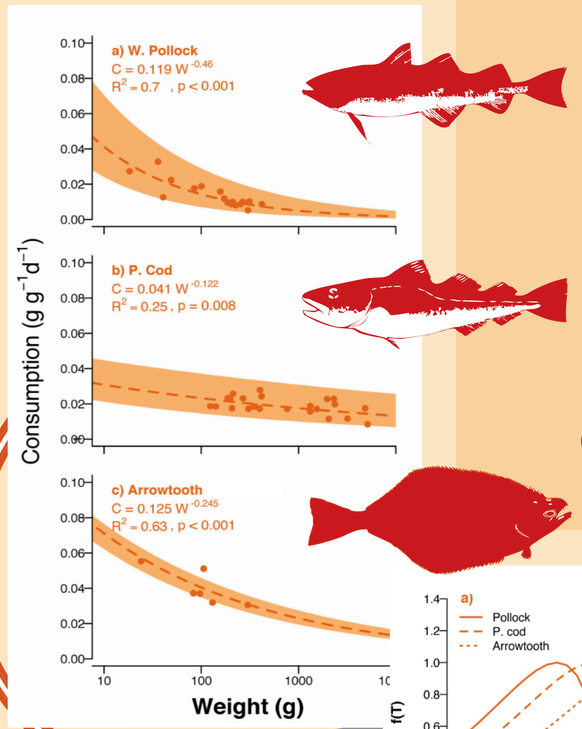
Climate change has already affected marine species and attendant fisheries worldwide, with future projected changes over the next 100 years postulated to be largest for arctic and sub-arctic ecosystems. Trophodynamic processes are likely to be directly affected, as changes in water temperature may increase metabolic costs and shift the spatial distribution of top consumers, while environmental changes will alter primary and secondary production.

OBJECTIVE

Evaluate climate effects on temporal, regional, and ontogenetic patterns in foraging rates of AK groundfish predator species.

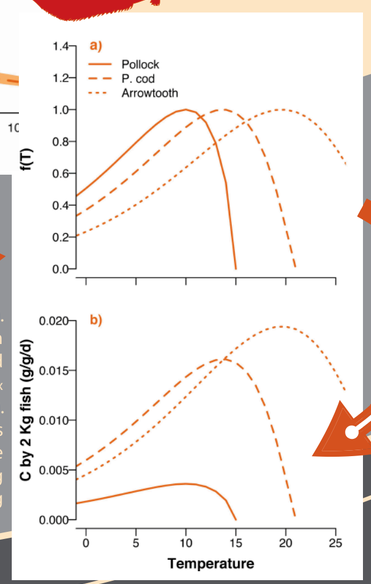
METHODS

1. Calculate consumption as a function of fish weight (W).
2. Determine the temperature (T) scaling algorithm for each species.
3. Multiply W x T to get C_{max} (maximum consumption).
4. Compare C_{max} to consumption rates from NOAA fishery observer and groundfish survey data (C_{obs}) to derive relative foraging rates (RFR).
5. Fit GAMS to RFR and ration to determine residual effect of weight and water temperature on foraging rates.

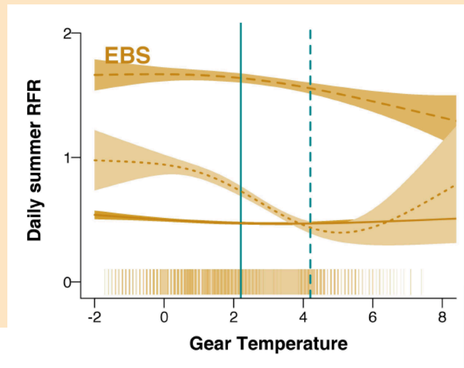


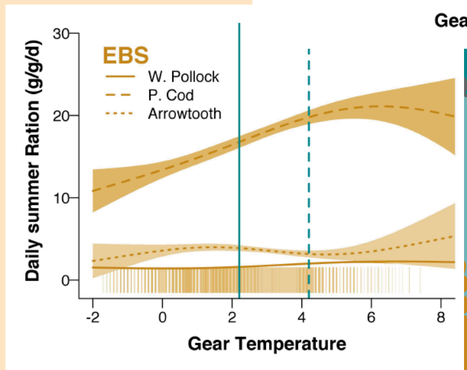
$$C_{max} = f(T) \times f(W)$$

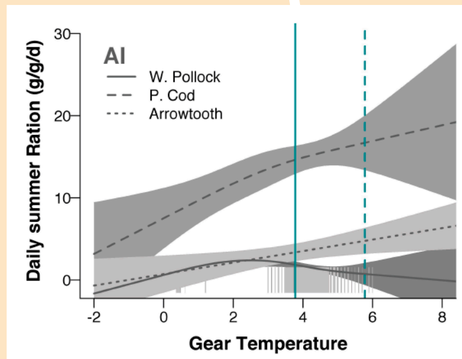
$$RFR = C_{obs}/C_{max}$$

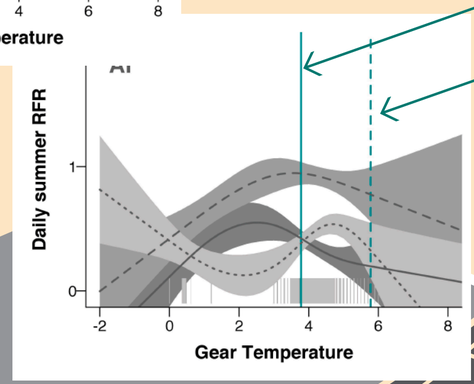


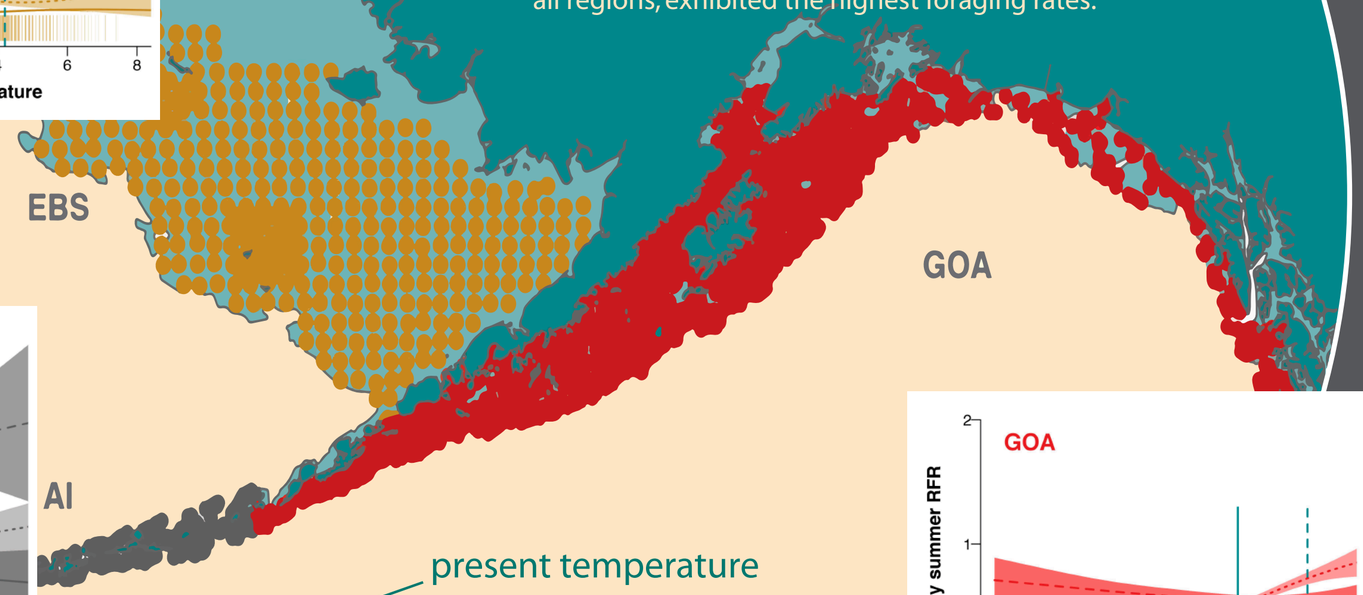
(TOP) Specific consumption rate as a function of fish body weight (g). Laboratory observations of consumption corrected for temperature (points) were used to derive the allometric relationship for C_{max} at the thermal optimum (dashed line). Shading represents 95% confidence intervals around the C_{max} estimate. Note the log scale on the x-axis. (RIGHT) Temperature scaling functions ($f(T)$) for C_{max} (a) and C_{max} of a 2 Kg fish of each species (b).





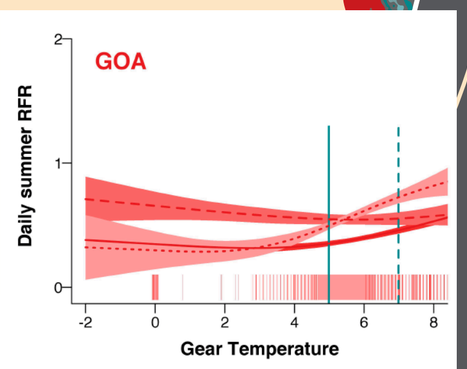


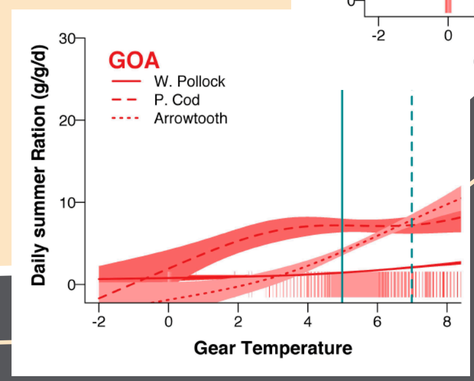




RESULTS

- Climate change (+ 2 deg C) could increase prey demand 18-25% for EBS Pacific cod and pollock, respectively; we predict an 18% decline in the daily rations of EBS arrowtooth.
- GOA pollock and arrowtooth rations and RFR might increase markedly (45% and 100%, respectively) relative to marginal increases in Pacific cod rations (~5%).
- Juveniles and adults eat 0.9–5.8 and 0.48-5.1 times their body weight per yr, respectively.
- Juvenile arrowtooth from AI and EBS, and adult Pacific cod from all regions, exhibited the highest foraging rates.





GAM estimates of daily summer C_{obs} (i.e., Daily Ration) and summer (Jun-Aug) relative foraging rate (RFR) as a function of temperature for each predator species. Results are regional averages across stations and years (1981 - 2011). Shaded regions represent 95% confidence intervals around model estimates.

IMPLICATIONS

The 2-4 deg C increase in SST projected for Alaska marine systems is likely to increase predator demand in the EBS and AI regions. This includes a potential increase of pollock predation, as young of the year pollock are important prey species for groundfish predators. Thus, we find evidence for increased consumer demand under climate change that may intensify density dependent mechanisms (i.e., cannibalism) for pollock. These results portend substantial shifts in trophic dynamics in Alaskan marine ecosystems associated with climate change. Future work will incorporate bottom up effects (e.g., zooplankton production) on species production and mortality.

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