Intra-guild predation among early benthic phase red and blue king crabs: evidence for a habitat-mediated competitive advantage

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Introduction

The Pribilof Islands, Alaska, USA is one of the few areas worldwide where the spatial distributions of red (*Paralithodes camtschaticus,* RKC) and blue (*P. platypus*, BKC) king crabs overlap. Blue king crab was the predominant king crab species until a population decline in the mid-1980s, which was followed by an increase in the red king crab population. Despite fishery closures, Pribilof Islands blue king crab abundance has not recovered to levels observed prior to the decline in the mid-1980s.

Intra-guild predation between species has been suggested as a mechanism limiting the recovery of the Pribilof Islands blue king crab stock. Field studies suggest interactions between species may be important for recently-settled individuals; however, whether red king crabs preferentially consume blue king crabs is unknown. Differences in habitat preference (RKC: cobble, BKC: shell) and morphology (Fig. 1) suggests differing strategies for minimizing predation, which may lead to advantages in certain habitats.

Fig. 1. Morphological differences between RKC (left) and BKC (right) occur in the early benthic phase (year 0-2), including the larger size, more pronounced spines, and monochromatic coloration of red king crabs.

Objectives

- Examine the foraging behavior of year-1 red king crab predators preying on year-0 red and blue king crabs in various habitats.
- Compare predation rates, crypsis, and feeding efficiency in cobble and shell habitats.

Hypotheses

1. Year-1 red king crabs preferentially consume year-0 blue king crabs, and predator preference varies with habitat type.
2. Predation rates vary with habitat type.
3. Prey crypsis (i.e., use of physical structure) varies between species and between habitat types.

Methods

- ***Prey***: Year-0 juvenile RKC (4-10 mm carapace width) and BKC (2.5-4.5 mm carapace width).
- ***Predators***: Year-1 juvenile RKC (16 - 23 mm carapace length).
- ***Habitat***: cobble, shell
- ***BKC:RKC prey ratio***: 1:9, 3:7, 5:5, 7:3, 9:1.

Methods

- Predators foraged for 48 h, survival was calculated at end of trial.
- Crypsis was measured as proportion of live crabs hiding.
- Controls (no predators) were conducted for all treatments.

Fig. 2. Experimental mesocosms with either cobble or shell as habitat. Prey ratios were randomly assigned to each mesocosm.

Prey preference was modeled as in Murdoch (1969):

$$D_M = \frac{cA_M}{1 - A_M + cA_M}$$

- c is proportionality constant indicating predator preference, where $c > 1$ indicates preference for blue king crabs, and $c < 1$indicates preference for red king crabs.
- D_M is the proportion of blue king crabs in the diet.
- A_M is the proportion of blue king crabs available.

We fit the number of blue king crabs eaten to a series of models: 1) No preference, 2) Simple preference, 3) Prey switching, 4) Preference differs between habitats, and 5) Preference in shell, but not cobble.

Results

- Predators preferred red king crabs in shell habitat (model 5), but had no preference in cobble habitat (model 1).

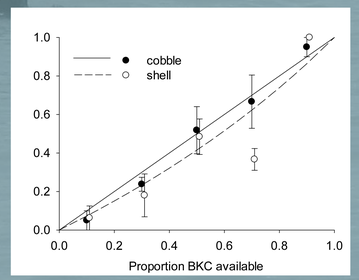

Fig. 3. Proportion (average ± SE) of blue king crabs eaten by predators at each prey ratio. Lines represent the maximum likelihood estimates for the predator preference model in cobble (model 1, solid line) and shell (model 5, dashed line). The maximum likelihood estimate for *c*, the predator preference parameter, is 0.71 in shell and 1.00 (i.e., no preference) in cobble.

Model No.	Model	K	AIC_c	ΔAIC_c	Likelihood	AIC_c Weights
1	No Preference	0	116.81	0.00	1.00	0.34
2	Preference	1	118.48	1.67	0.43	0.15
3	Switching	2	120.15	3.34	0.19	0.06
4	Preference(H)	2	118.89	2.08	0.35	0.12
5	Preference shell	1	116.95	0.14	0.93	0.32

Table 1. AIC_c for prey-preference models for blue and red king crabs. Model indicates the model fit. H indicates that preference differed between the habitats.

Results

- Blue king crab crypsis was high in both habitats, and did not vary with the presence/absence of predators.
- Red king crab crypsis was higher in shell than cobble, and higher in the presence of a predator.

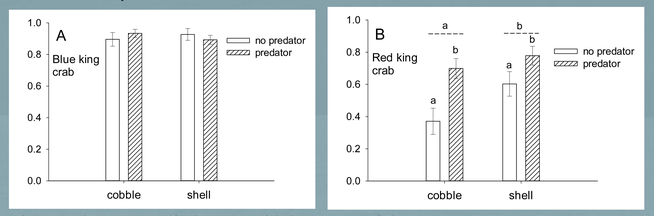

Fig. 4. Crypsis (average ± SE) index of (A) blue and (B) red king crabs with and without predators in cobble and shell habitat. Different letters indicate statistical significance (ANOVA Tukey's HSD, $p \leq 0.05$).

- The number of crabs eaten varied with habitat for blue king crabs, but not for red king crabs.

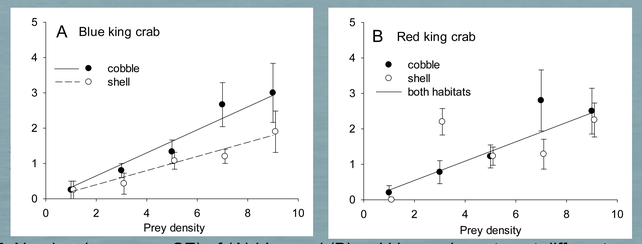

Fig. 5. Number (average ± SE) of (A) blue and (B) red king crabs eaten at different densities in cobble and shell habitat.

Discussion and Conclusions

- Shell microhabitats mediate predation vulnerability and may provide some degree of competitive advantage to blue king crabs. The apparent specialization juvenile blue king crabs have for shell habitat implies that the availability of such benthic material may dampen intra-guild competition through selective predation on red king crabs.
- The extent of shell habitat may be an important factor regulating blue king crab distribution or the recovery of depleted populations around the Pribilof Islands.
- Future research should assess the current status of habitat composition and associated benthic species assemblages around the Pribilof Islands to better understand ecosystem-level processes and identify population bottlenecks.

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