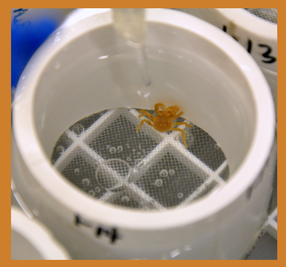

Upper thermal tolerances for red and blue king crabs

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Introduction

Red and blue king crabs (*Paralithodes camtschaticus* and *P. platypus*) are commercially important in Alaskan waters and have generally disjunct spatial distributions. Thermal tolerance is likely important for many aspects of their life history, including growth and survival, and may explain distributional differences between the two species. With expected increasing global temperatures , understanding the thermal tolerance of crabs will help predict how populations may respond to a changing climate.

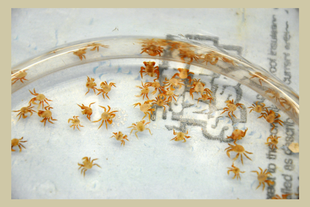
Red king crabs

- Important fishery species in Bering Sea and the Gulf of Alaska
- Juveniles generally found in structurally complex, near-shore habitats
- Distributed in slightly warmer waters than blue king crabs

Blue king crabs

- Important fishery species in Bering Sea
- Juveniles generally found in structurally complex, near-shore habitats
- Distributed in slightly cooler waters than red king crab

Study objectives



- Determine the how temperature affects red and blue king crabs
  - Acute upper thermal tolerance
  - Behavior
  - Feeding ration
  - Molting and growth

Methods

Animals

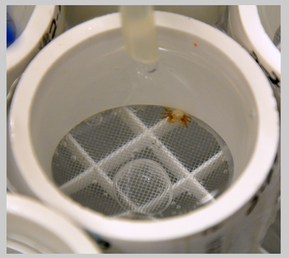
- Hatchery/laboratory reared
- Year-0 and year-1 juveniles
  - Blue king crab 3-10 mm carapace width
  - Red king crab 4-8 mm carapace width

- Held in tanks with flowing, unfiltered seawater at ambient temperature and salinity (32 psu)

Experimental setup

- Crabs held in individual containers
- Tubs received flowing filtered ambient seawater
- Water flow was provided to each crab
- Temperatures maintained within 0.5 °C of set point
  - Submersible heaters
  - Flow-through chiller/heaters

Experimental 1: Acute upper thermal tolerance and behavior



- 14 crabs/species/temperature
- Temperatures tested:
  - Red king crab- 14, 16, 18, 20, 22, 24, 25, 26 °C
  - Blue king crab- 14, 16, 18, 20, 21, 22, 24, 26 °C
- Temperatures changed from ambient , ~ 8 °C, over 4 h
- Assessed for:
  - Survival: LT_{50}
  - Ability to right after being flipped: FT_{50}

Experimental 2: Feeding ration

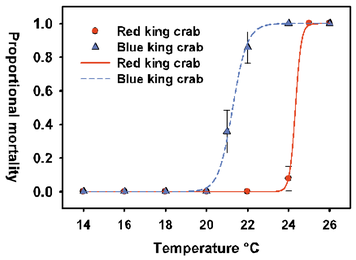
- 5-7 crabs/species/temperature
- Starved 24 h before trials
- Temperatures tested:
  - Red king crab- 10, 12, 15, 17, 20, 23 °C
  - Blue king crab- 2, 5, 8, 10, 12, 15, 17, 20 °C
- Temperatures changed from ambient (~7 °C) over 4 h
- Allowed to feed on chopped squid for 24 h
- Food consumed normalized to crab mass

Experimental 3: Growth and survival

- 12 crabs/species/temperature
- Temperatures tested:
  - Red king crab- 12, 15, 20 °C
  - Blue king crab- 12, 15, 17 °C
- Held for 45 days
- Fed 3x per week to satiation
- Checked daily for molting and mortality

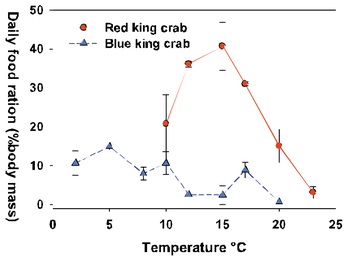
Results

Experiment 1: Acute upper thermal tolerance and behavior



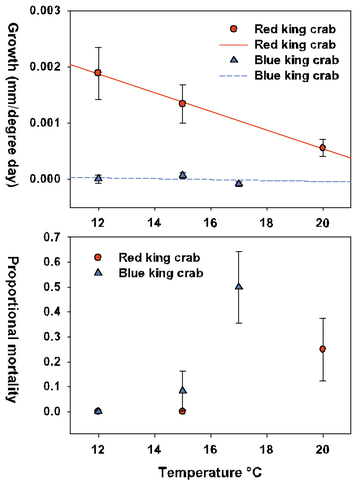
- LT_{50} ± SE (temperature at which 50% died)
  - Red king crab- 24.3 ± 1.6 °C
  - Blue king crab- 21.3 ± 1.6 °C
- FT_{50} ± SE (Not graphed)
  - Red king crab- 24.3 ± 1.6 °C
  - Blue king crab- 21.0 ± 1.4 °C
  - Almost identical to LT_{50}s

Experiment 2: Feeding ration



- Red king crab feeding peaks around 12-17 °C
- Blue king crab feeding peaks around 5-10 °C
- Reds have a higher food ration than blues at all comparable temperatures.

Experiment 3: Growth and survival



- Red king crab
  - Individual growth decreases with temperature (p = 0.018)
  - No significant morality until 20 C °C
- Blue king crab
  - Low individual growth at all temperatures
  - Negative individual growth at 17 °C
  - Mortality increases above 15 °C
- Many mortality events in both species associated with molting

Conclusions

- Upper thermal limit of red king crabs is ~3 °C higher than blue king crab for responses measured
- Temperature may partially mediate range overlap between the species
- Low feeding rations at higher temperatures may lead to low growth and high mortalities.
- In Bering Sea, both species may tolerate some warming without strong negative effects
- Other life history stages (e.g., embryonic, larval, and adult) should also be assessed

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