Project information

Keywords
Red king crab, crustacean, age, gastric mill, growth curve, stock management

Project title
Are growth bands key to determining age in large crustaceans?

Year
2016

Project leader
Bodil Bluhm

Geographical localization of the research project in decimal degrees (max 5 per project, ex. 70,662°N and 23,707°E)
Porsangerfjord, 70.59 deg N, 25.59 deg E

Participants

Bodil Bluhm (UiT The Arctic University of Norway), William G. Ambrose Jr. (Bates College, USA/ Akvaplan-NIVA (APN)), Raouf Kilada (University of New Brunswick St. John (UNB), Canada), Paul Renaud (Akvaplan-NIVA and University Studies in Svalbard)

Flagship
Fjord and Coast

Funding Source

Fjord and Coast Flagship, UiT The Arctic University of Norway, in kind participating institutions

Summary of Results

Brief objectives and methods. Red king crab is a large omnivorous, predatory crab that was intentionally introduced to the Barents Sea and adjacent fjords in the 1960s. Its establishment has given rise to both a high-value fishery, currently of males and females ≥130 mm carapace length, and to destructive effects on habitat and native benthic communities. Accurate information on growth and age span is needed to improve management and mitigation strategies, but is difficult to obtain in crustaceans. This study applied a relatively new direct aging method to red king crab through growth band features in ptero-cardiac and zygo-cardiac ossicles of the gastric mill in order to improve the understanding of growth and longevity in red king crab from Porsanger Fjord in northern Norway. Specifically, our study objectives were (1) to find out if red kind crab from northern Norway had growth bands in the endocuticle layer of gastric mill ossicles, (2) To validate the annual deposition of these growth bands, and (3) to produce the size-at-age relationship of the species using band counts.

Red king crabs were collected in Porsangerfjord in the fall of 2014 and 2015. A sub-set was stained with a fluorescent calcium carbonate marker and subsequently held in captivity for several months to just over a year to validate annual periodicity of the growth bands. Gastric mills of stained and unstained crabs were dissected, embedded in resin, longitudinally sectioned, and viewed and imaged under a compound microscope. Growth bands recognized as paired light and dark zones in the endocuticle were counted from the basal to the distal region, with a sub-set of growth bands read by two independent readers to assess precision of the readings. Sections of stained crabs were imaged using a laser-scanning confocal microscope to evaluate the mark resulting from the staining. Based on the below reported findings, growth bands were interpreted as annual age bands. The size-at-age relationship was examined and a von Bertalanffy Growth Function generated for male crabs for which the sample size was sufficiently large.

Summary of results

In crabs sacrified just after staining, the calcein mark was visible at the growing edge of thin sections in the ptero-cardiac of all individuals. In individuals sacrificed after just over a year, we were able to

identify the calcein mark followed by a new growth band which was deposited outside the calcein stain mark, near the growing edge (Figure 1). The presence of a complete, newly deposited growth band suggests the annual deposition of a single band in the calcified structure and therefore, band counts may be considered as an age indicator.

Sections from 96 red king crabs (34 females, 62 males) ranging in size between 37.6 mm and 180.0 mm were of sufficient quality to result in useful band reads. The band count ranged from 2 to 13 bands, interpreted as age bands. The precision of the readers was high with a coefficient of variation = 6.8 %. Norwegian red crab exhibited a significant relationship between age and carapace length, though with substantial variability. For males, the von Bertalanffy growth model that was used to describe the size-at-age relationship estimated L_{∞} = 187.7 mm, k = 0.2 mm y^{-1} and t_0 = 1.4 y (Figure 2) with k being a growth coefficient, L_{∞} being the asymptotic length and t_o being the theoretical age at 0 length. Variation within the growth metrics was large because similar-sized crabs spanned up to 5 years in age in both males and females. Also, within a single year class, crab size varied by up to 7 cm CL in males and 4 cm CL in females. Male king crab reached an age of at least 13 years based on the assumption that band counts represent annual growth bands while the oldest female in the sample was 9 years old. Male crabs above harvest size were 6 years or older, and females were 5 years or older.

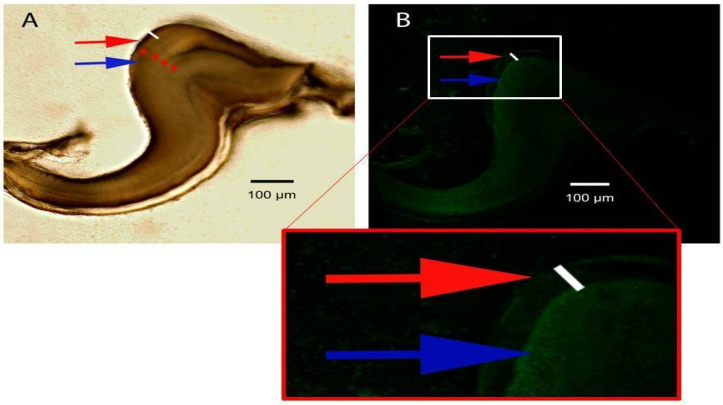
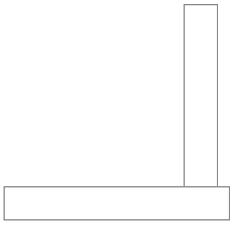


Figure 1. Image of thin section (180 µm) in the zygo-cardiac of red king crab using bright field light (A) and fluorescent light (B). Red dots in (A) indicate the growth bands. In crab sacrificed one year after staining, the calcein mark (blue arrow) is visible on the fourth band while the new growth band (marked white between calein mark shown with blue arrow and growing edge shown with red arrow) is not stained. The width of the new growth band is similar to that of the previous one giving support to the notion of annual growth band deposition.



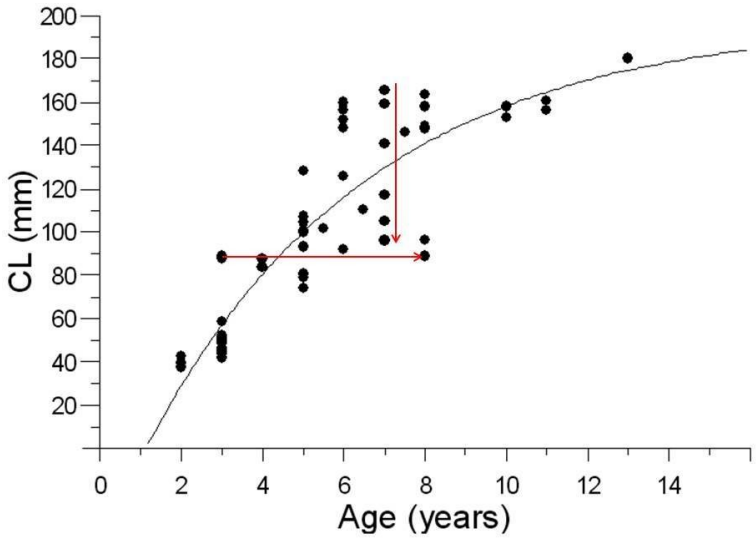


Figure 2. Size-at-age relationship for males of red king crab (n = 62). Line is the von Bertalanffy growth model (L_t = 187.7 (1–e(-0.2(t-1.4))). Red arrows mark the spread in age in same-sized crabs and that of size in same aged crabs.

Master and PhD-students involved in the project

The workshop in year 1 included a PhD candidate who subsequently explored the same aging method in a different crab species.

For the Management

Red King crab is both a valuable resource as well as a threat to habitat and food for commercial species. Age-based population assessments are critical to both sustainable fisheries management and evaluation of potential for further spreading of this invasive species. Since shells are lost during molt, standard aging techniques relying on hard parts (mollusk shells, fish otoliths, etc.) cannot be used for crustaceans. Size has been used to estimate age in lieu of direct age determination, but without the same accuracy. Here, we use and further develop a relatively new technique using growth bands in stomach ossicles. We find that male king crab live for at least 13 years, females for at least 9. Crabs spanning ~7 cm size difference can have the same age, and the same size class can include at least five year classes. This means some harvested crabs may not or barely have contributed to the reproductive success of the stock at all while others have reproduced several times before reaching harvest size. Harvesting rules may have to be modified to account for the new information that this method provides to assure sustainability of the crab stock.

Published Results/Planned Publications

Kilada R, Bluhm BA, Ambrose W, Renaud P, Locke B, Sundet J. Northern Norwegian Red King Crab: Age and Growth Estimates Based on Growth Bands in Gastric Mill Ossicles. Planned submission to PLoS ONE in December 2016

Communicated Results

Oral presentation at annual Flagship meeting in Oct 2016, Sommerøya

Skype meeting with Alaska Department of Fish & Game, Alaska, USA to compare methodological approach and results for Alaskan and Norwegian Red King Crab (Joel Webb, team lead at ADF&G's aging lab in Juneau)

In preparation: News item for Fram Center web site on primary project results

Interdisciplinary collaboration (field below is inaccessible)

The project is a collaboration between academia (project partners at UiT – The Arctic University of Norway, University of New Brunswick St. John, Canada, and Bates College, USA), a government institution (Institute of Marine Research) and a research-based company (Akvaplan-NIVA). Further knowledge exchange was established with a management agency, the Alaska Department of Fish & Game as well as (during the initial workshop) with Dr. Richard Wahle, who has a joint project with co-PIs Ambrose and Kilada.

Interdisciplinary Cooperation

Budget in accordance to results

Yes

Could results from the project be subject for any commercial utilization

Yes

If Yes

Results can be applied in stock assessment of Red King Crab and habitat conservation from crab impact.

Conclusions

This study demonstrated that features matching previous descriptions of growth bands were present in Red King Crab from Porsangerfjorden. This finding adds to the discovery of growth bands across a growing number of decapod crustacean species (e.g. Kilada et al. 2012, Kilada and Acuna, 2015). The validation experiment in this study suggests annual periodicity of the growth bands in stomach ossicles of these crabs. Evidence for this conclusion lies in the single growth band visible after a year in captivity during which large crabs in this study did not molt, and in that other species in comparable studies molted several times but still deposited one annual band (Leland et al. 2015). These observations suggest strong evidence that the growth bands are not related to molting events. Age-at-size and size-at-age was very variable in red king crab in both their native area (Stevens 1990) and in northern Norway (Windsland et al. 2013, this study). Perhaps such variation in growth and size-at-age is not surprising given documented effects of temperature on growth through variable intermolt period duration in crustaceans in general (Hartnoll 1982) and red king crab in particular (Stoner et al. 2010), the occurrence of skip-molting documented for red king crab, and the gradual decline of growth as these crabs mature (Nilssen and Sundet 2006, Stevens and Swiney 2007). Male king crab reached a higher age of at least 13 years (based on the assumption that band counts represent annual growth bands) than females which had a maximum age of 9 years in the sample. Male crabs above harvest size were 6 years or older, and females were 5 years or older.