

## Change in maximum body size for male and female red king crab in Norwegian waters

*Ann Merete Hjelset*(1), *Jan H. Sundet*(1) and *Einar M. Nilssen*(2)

(1)Institute of Marine Research, Tromsø, Norway; (2) The Arctic University of Norway, Tromsø, Norway.

Presenter contact details: [ann.merete.hjelset@imr.no](mailto:ann.merete.hjelset@imr.no), Phone +47 99 50 62 29

### Summary

The harvest of the introduced and now commercially valuable red king crab (*Paralithodes camtschaticus*) in northern Norway has a fishery history going back to 1994. The fishery management has undergone several changes, harvest rate being very low and increasing to very high in the recent 5-10 years. A male-only fishery went on for the first 14 years and since 2008 an additional small quota on female crabs has been given, with the same minimum legal size for both sexes. In this study we investigate effects of increasing harvest rate on the maximum size of both male and female crabs and discuss possible ecological consequences. Varangerfjorden was chosen as a main study area since this is the area of longest fishery history in Norwegian waters, and has been through all stages of the management of the crab fishery. Both the mature male and the ovigerous female part of the stock displayed a reduced maximum size around 1999-2000. A new and significant reduction in maximum size occurs in accordance with the onset of a fishery quota on females in 2008. Recently maximum body size for both male and female crabs seems to have stabilized and adjusted in accordance with the present harvest rate.

### Introduction

The red king crab was introduced to the Barents Sea in the period 1961-1969 by the Soviet authorities (Orlov and Ivanov 1978) and the first red king crab was caught in Varangerfjorden January 1977. After the release of the red king crab in the Barents Sea with the purpose to establish a valuable coastal fishery, Russian and Norwegian authorities agreed to protect the red king crab against harvest and let the stock develop and grow for several years. During the early 1980's it started to be abundant in Norwegian waters close to the Russian border. At the same time local fishermen experienced heavy bycatch of the crab in gillnet fishery. The regulated fishery for red king crab (*Paralithodes camtschaticus*) goes back 20 years. During this time period the fishery has been through several phases. It started out as a small research fishery with a small quota in 1994 and until 2003 the quota increased steadily. When the fishery converted to a commercial fishery in 2003, the annual quotas increased markedly and reached a maximum level in 2008. The last years there have been a significant decrease in both quota and landings in the regulated fishery. The commercial stock was managed according to the 3S regime (sex, size and season) and only males with a carapace length (CL) larger than 137 mm could be landed during the fishery after the Alaskan model (Kruse 1993). From 2008 also females larger than 137 mm CL could be landed in the legal catches. From 2011 also the legal size for both males and females was reduced to 130 mm CL.

### Material and methods

Data for the current study was collected in Varangerfjorden during annual scientific cruises in the period 1994 to 2013. Varangerfjorden is the most eastern fjord in Norwegian waters, close to the release site. The red king crab is well established in Varangerfjorden and Norwegian fishery started here in 1994. The 95<sup>th</sup> percentile values of CL's were calculated annually for male crabs  $\geq 110$  mm CL and for the 95<sup>th</sup> percentile values of all females CL with roe. The advantage of choosing the 95<sup>th</sup> percentile value of CL is to avoid the maximum sizes of catches which can represent outliers in the material. The harvest rate used is the relationship between the quota and the estimated indices for the legal males.

## Results and Discussion

The upper 95<sup>th</sup> percentile CL value for males and ovigerous females based on pooled data from Varangerfjorden increased from 1994-1999 for males, and from 1995-2001 for ovigerous females. After 2000 and 2002, for males and ovigerous females respectively, a decrease in the 95<sup>th</sup> percentile CL size until 2013 can be observed. The harvest rate set for legal males was kept low at the start of the fishery, below 22% for the first eight years and on average 15%. In the middle period it was raised and ranged from 12-33 % and was on average 25%. In the last period it peaked further and was more than 72% from 2008-2013 with a maximum value of 95% in 2009.

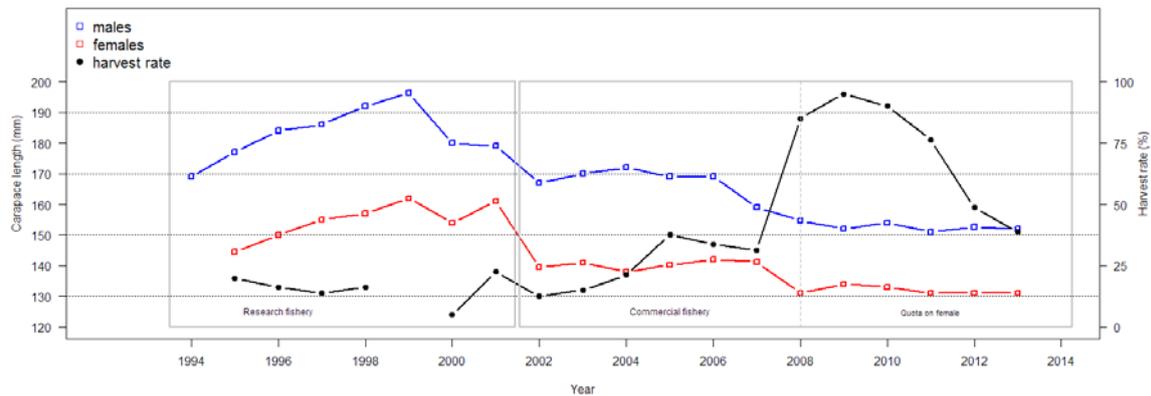


Figure 1. Development of the maximum body size for males and females in Varangerfjorden in the period 1994-2013.

It is well known and seen in a number of studies that size-selective harvesting has a negative effect on the demography in several populations. The observed reduction in size range of males in the period 2000 until present is a primary effect of the size-selective harvesting strategy in the fishery. In addition, there is observed a reduction in size range of females during the study period and it took place before the onset of fishing for females, and fell further when the quota for females was implemented. The reduction of large sized males seems to have had an impact on the survival of the females. Availability of large males during the mating event is important for females. The female red king crab always moults prior to spawning, and this is a vulnerable stage. The large male's protects the females during the moult and is present during the egg extrusion event to fertilize the eggs. A study by Hjelset *et al.* 2012 showed that the size specific fecundity in female red king crab decreased during a period of eight years. Temporal and spatial changes in individual egg weight were found. The high fishing pressure on large male can be one explanation on the reduction seen. The reduced individual fecundity, reduced size range of both males and females can lead to reduced reproductive potential for the stock and jeopardize a stable long-term fishery. We have thus showed that the size selective harvesting has an effect on the demography for both males and females. And this has to be taken into account in the future management of the stock.

## References

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