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The red king crab, Paralithodes camatschaticus in the Barents Sea.

Introduction

Red king crab, *Paralithodes camtschaticus*is a real giant of the crustaceans having a possible leg span over 1,8 m. Its name is originating from the colour it gets when it is cooked, rather from its living appearance.[1] It is partly known for its valuable meat and that is also the reason why it was translocate from its native area. Later it has also become famous for its increasing population which has become a potential threat to the biodiversity in the Barents Sea.

The giant red king crab is native in the North pacific Alaskan water. During the 1960s and 70s Russian scientists introduced it to the Murmansk fjord of the Barents Sea. The purpose of translocation was to increase fishing profits for the fishing industry, since the king crabs meat is thought of as a delicacy and is expensive. What they didn't expect was the possible impact on the ecosystem that the giant crab could cause.The stock is growing fast and possible negative effects on the bottom fauna and spreading of various parasites needs further investigation.

Since the introduction in the 1960s, the stock has grown rapid and was in 1995 estimated to at least 500 000 crabs and has now become a self-sustaining population.[2] It is now present in areas from the Cape Kanin in east to the northern Troms in west, and spreading is still going on. There are research going on about the possible damage and consequences caused by the crabs in their new environment and these are still not fully understood. Due to its rapid spreading and destructive way of living by causing damage to gear and catches as well as to the habitat of the native species, fishing industry as well as environmentalists are concerned about controlling the crab.

Despite its destructive properties it is also protected between Norway and Russia within areas due to its commercial and economic value. Bilateral fishing quotas exist between the two countries to control the crab population. Outside of the protected areas the stock is kept at minimum levels by free fishing to keep the impact on the ecosystem as low as

1Paralithodes camtschaticus in Wikipedia
http://en.wikipedia.org/wiki/Paralithodes_camtschaticus

2Malovic, I. Hemmingsen, W. McKenzie, K. (2010)*Trypanosoma infections of marine fish in the southern Barents Sea and the invasive red king crab Paralithodes camtschaticus.*Marine pollution bulletin 60 (2010) 2257-2262.

possible.[3]

Our aim was to investigate the impact on the ecosystem in the Barents Sea caused by translocation and implantation of the red king crab. However it turned out to be hard to find scientific research about this subject in general and we decided to focus our essay to some more specific topics concerning this problem. We have chosen to study the possible interaction between king crabs as an indirect cause for increasing *Trypanosomamurmanske* infection in cods, and also the interaction between the red king crabs and amphipod *Ischyrocerus*.

The theory behind this is a suspicion of a possible correlation between an increase in Trypanosoma infection in cods and increasing density of red king crab population. The red king crab is a host for the leech *Johanssoniaarctica*, which in turn is a vector for Trypanosoma species, which infects marine fishes. In this case the red king crab would be an indirect cause of increasing the infection.

The other part of our essay aims to investigate the interactions between the red king crab as a host for amphipods of *Ischyrocerus* species and also the possible negative effects this could have on the red king crabs or its eggs in the Barents Sea.

Red king crab as an indirect reason for increasing trypanosome infection in cods?

Interfering within ecosystem by means of translocation of different species has been described as one of the greatest threats against biodiversity. The result of translocation is often not seen immediately but can later shown to be devastating.

When the red king crab *Paralithodes camtschaticus*was taken from its original area in the North pacific and was introduced to the Barents Sea by Russian scientist in the 1960s, there were no concerns about the possible impact on the marine ecosystem in their new area, except for possible low economic value[4]. The red king crab however adapted to its new environment and the stock increased heavily from the time of implantation until present, and is now common in the coastal area from Cape Kanin in east, to the northern Troms in the west.[5]

The increased density of the red king crabs was first denoted during increasing by-catches of the crab. The full impact on the ecosystem of the rapid increase in the population is under investigation and has now become object for a 10 year long research and surveillance project on the behalf of the Norwegian Ministry of Fisheries, to explore the possible ecological impact by the red king crabs.[1]

One of the concerns about the increasing population of red king crabs in the Barents Sea is its possible indirect correlation with increasing infection of Trypanosoma in cods.

3http://www.fisheries.no/ecosystems-and-stocks/marine_stocks/shellfish/red_king_crab/

4 Hemmingsen W., Jansen P., MacKenzie K. (2004). *Crabs, leeches and trypanosomes:an unholy trinity?* Marine Pollution Bulletin 50 (2005) 336-339

5 http://www.fisheries.no/ecosystems-and-stocks/marine_stocks/shellfish/red_king_crab/

The circumpolar piscine leech *Johanssoniaarctica*is a vector for the parasite *Trypanosomamurmanske*, which is a blood parasite of marine fish, and was first described from cod, *Gadusmorhua* in the Barents Sea by Nikitin (1927). *J. arctica* is a piscine leech, which has a circumpolar arctic distribution. During one stage of its life cycle it needs to lay its egg (cocoons) on a hard surface and use the shell of the king crabs and other crabs too for this. It can also use the carapace of the crabs as attachment after blood meal.The theory suggests that the king crabs indirectly can be held responsible for an increase in Trypansoma infection in cods and other fishes since they are beneficial transport hosts for their vector, and there have been surveys to search for evidences.[6]

The aim of these investigations was to search for a correlation between red king crab population densities and trypanosome infection of cods in the North Norwegian waters. At least two surveys have been performed, the 1st was running between 1999-2001 by Hemmingsen et al, and the 2nd was performed 2002 by almost the same team.

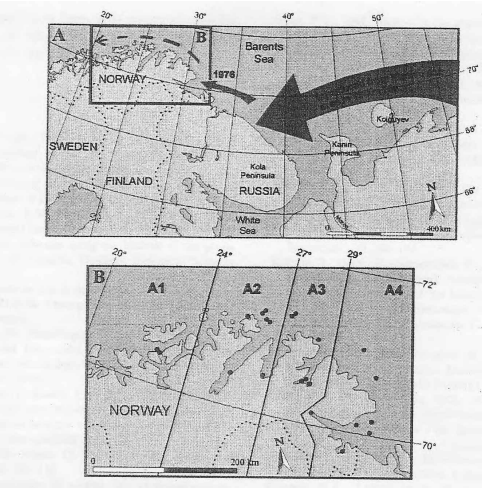
During the survey by Hemmingsen et al, three annual trips were done to catch and examine cods for Trypanosoma infection. The covered area was divided into 4 zones, A1-A4 from west to east respectively and covered the coast ofFinnmark from Troms to Varangerfjord at the border to Russia, where the crabs are most abundant. A total of 1254 cods were caught at 28 different stations during the years by means of a bottom trawl.
Hemmingsen et al. only examined the *Trypanosomamurmanske*infection only in cods, while the second team described many different speciest of trypanosome and also caught 11 different fish species to search for a correlation.

Blood was taken directly from the caught fishes from their heart and was used to prepare slides, fixed in methanol, stained with Giemsa and then were examined in microscopes. All trypomastigotes in a fixed area of the coverslip were counted. Then both prevalence of infection and relative density of Trypanosoma were calculated. The result of showed that both the occurrence of Trypanosoma infection and the relative density was always at highest in the Varangerfjord area.[1] This result suggests that the increasing population of king crabs, which are high at this area, can be indirectly the reason for transmission of trypanosome to cods and so have a negative effect on the native cod population.

The second team continued to examine this correlation in October 2002 by extending their research to 11 fish species and more trypanosome species. They also used a bottom trawl, and caught at total 681 fishes from 22 different stations using the same 4 geographical areas as in the previous study. The same method with blood sampling, fixing and staining was used to check the trypomastigotes. Measures of infection was performed as defined by Bush et al by checking prevalence, intensity of infection, mean intensity, abundance and mean abundance of Trypansoma.

This survey could not show any significant difference in neither prevalence nor intensity between the different areas of sampling contradicted to the first studies. However there

6Malovic I., Hemmingsen W., MacKenzie K. (2010) *Trypanosome infections of marine fish in the southern Barents Sea and the invasive red king crab Paralithodes camtschaticus.*Marine Pollution Bulletin 60 (2010) 2257-2262



was a higher prevalence of infection in the A2 area compared to the previous study and also an increased number of king crabs were caught in this area some years earlier. The study could not further prove that the theory of the red king crab as an indirect reason for increasing trypanosome to marine fishes in the Barents Sea. However this couldbe an effect of using more than one species of Trypanosoma in the trial. The situation is also complicated since there is no historical data of this issue to compare with[3].

Picture:
Above: Showing migratory path of the red king crabs since their introduction to the Barents Sea in the 1960s.
Below: The defined areas defined and used in the studies.

Amphipod Ischyrocerus interactions with the red king crab Paralithodes camtschaticus.

Two different studies have been made by Alexander G. Dvoretsky and Vladimir G. Dvoretsky concerning the relationship between the red king crab *Paralithodes camtschaticus*and the amphipods Ischyrocerus. In the first study the possible interactions between Ischyrocerus species with the red king crabs was examined in the Barents Sea. In the second study the aim was to find out if the amphipod *Ischyroceruscommensalis* is an egg predator of the red king crab or only a scavenger.

Interactions between species occur in all types of different ecosystems including the marine ecosystem. Tree different types of interactions can be differentiated:

1. Commensalism (only one partner benefits)
2. Mutualism (both partner benefits)
3. Parasitism (one partner benefits, the other is harmed).

The host-symbiont relationship between the red king crabs and Ischyrocerus species is the main focus of the two studies made by Alexander and Vladimir G. Dvoretsky to find out whether their relationship is commensalism or parasitism.

Both genders of red king crabs were collected in Dalanezelenetskaya bay (DZB) and Dolgaya bay (DLB) area of the Barents Sea and the distribution of Ischyrocerus was investigated.

Examination of prevalence and intensity of symbionts were made during a period of August-September. The specific period was chosen since this is the reproduction time of the Ischyrocerus species. Crabs were collected by SCUBA diving. Size and number of amphipods was recorded on each crab. Each crab was also inspected for local damages which might be caused by the amphipods.

In area number one (DZB) *Ischyroceruscommensalis* was found in 30,5 % of the investigated crabs with a mean number of 55,1 per crab. In area number two (DLB) 28,6 % of the investigated crabs carried I. commensalis with mean number of 19,3. The other genus of Ischyrocerus investigated was Ischyrocerusanguipes found in 13,5 %, mean number 7,3 (DZB) compared to 1,3 % with a mean number of 1,5 in (DLB).

No difference in proportion between male and female red king crabs infected by *Ischyrocerus* in the two examined areas was noticed. *I commensalis* was found mostly on the gills of the red king crabs were it builds tubes, followed by mouth parts and then limbs while I. anguipes was mostly found on the carapace and limbs of the crabs.

Occurrence of both *I. commensalis* and *I. anguipes*amphipodes were commonly observed during the study. *I. anguipes* have been found on the red king crabs just recently and was therefore only found in low numbers during the study while *I. commensalis* was found in higher number since it has been present for longer time.

With increasing size of the crabs the number of *I. commensalis* and their empty tubes increase. The study showed densities of *I. commensalis* as high as 200 living amphipods in the gills of collected crabs or up to 350 amphipods plus empty tubes per crab. This large amount of infestation may have a negative impact on the red king crabs in at least two different ways. It may impair the respiration of the host or it might have negative energetic coasts of the host, which have to increase the activity of the 5th pair of rudimentary legs to clean the gills. If this is the case then crab-amphipods relationship may be classified as negative for the red king crabs but this could not be proven by the research.
The research showed a strong symbiotic relationship between the *I. commensalis*and the red king crabs. The symbiosis was indicated by the large amount of colonized crabs, high symbionts densities, evidence of symbionts reproduction on the crabs and location to different body parts. The location and the lower number of *I. anguipes* found on the red king crabs makes it a less specific symbiont.

No damages or scars could be found on the crabs where Ischyrocerus species were located so both *I. commensalis* and *I. anguipes* seems to be commensals but possible negative impact on the host could not be excluded or proven. [7]

In the first study only a few amphipods was found on the egg laid by red king crabs, no attaching or praying on the eggs by the symbionts could be noticed. During the second study the goal was to found out whether the amphipod *I. commensalis*is an egg predator of the red king crab or not. Since the red king crab is a highly commercial used species it is of large importance to detect potential pathogens, diseases and negative associates. Several different symbionts can occur on crab eggs most of them are thought of as predators. During the

7 Dvoretsky Alexander G., Dvoretsky Vladimir G. (2009). *Distribution of amphipods Ischyrocerus on the red king crab, Paralithoidescamtschaticus: Possible interactions with the host in the Barents Sea.* Estuarine, Coastal and Shelf Science 82 (2009) 390-396.

research *I. commensalis* was found only in low amounts on the eggs of the red king crabs and no predation could be found in field conditions of the Barents Sea. In laboratory conditions it was evaluated if the amphipods eat the eggs of crabs or not and factors affecting this process.

The experiments were carried out in 3 different steps.

1. Investigation concerning if amphipods were able to ingest the eggs of red king crabs.
2. Difference in feeding rate between different temperatures.
3. Difference in feeding rate of dead and intact eggs.

The result showed that amphipods could eat up to 10 red king crab eggs each in a 10 days period. With a body length above 7 mm of the amphipod the feeding rate was constant but amphipods less than 7 mm showed no signs of ingestion of crab eggs.

Gender of amphipods did not affect the feeding rates of eggs of red king crabs.

The feeding rate was constant in temperatures of 2, 4 and 6 °c but a significant increase in feeding rate could be noticed at 8 °c which is the summer temperature of the coastal waters of Barents Sea.

The study showed that the amphipods preferred to eat dead eggs to intact eggs and eggs in early developmental stages over older stages.

The research indicates that *I. commensalis* is not a predator of the red king crabs eggs since it prefers to eat dead eggs but rather a scavenger. The preference of dead egg to intact eggs might be due to the difference in surface condition of the eggs, which showed a lower resistance in dead eggs and could therefore be ingested more easily. [8]

Conclusion

After studying this material we have realized that the red king crab of the Barents Sea is a species of subject for a lot of research and depending on who you ask, either welcome or fought. At the same time as it causes damage to net and gears it is also providing a big income for the fishing industry of both Norway and Russia.
However we think that it is important to remember and further investigate the impact on the ecosystem, and not be completely blinded about economical aspects.

In the first part we studied a negative impact of the crabs to the native habitat by describing the theory that the red king crab provides benefits for the fish leech *Johanssoniaarctica,* which indirectly helped spreading of the parasite trypanosomaand caused infection of cods and other marine fishes.

In the other part we discussed possible negative agents acting on the red king crab by studying research of the relationship between the red king crab and the amphipod Ischyrocerus.The symbiosis between the two species seems to be of commensal nature but possible damages of the red king crabs will need further investigations as the population grows in the Barents Sea.

8 Dvoretsky Alexander G., Dvoretsky Vladimir G. (2010). *The amphipod Ischyroceruscommensalis on the eggs of the red king crab Paralithodes camtschaticus: Egg predator or scavenger?* .Aquaculture 298 (2010) 185-189.

It is hard to draw any precise conclusions of the surveys we studied, since the results of them are very vague. This is partly due to that the red king crabs are fairly new objects for the research and partly due to the lack of historical data in both of the cases.

We think that the translocation/ implantation of the red king crab is a good example of mans greed to create benefits without concerning the consequences and impact on ecosystems on a longer scale.

Sources

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