NOBANIS - Invasive Alien Species Fact Sheet

Paralithodes camtschaticus

Author of this fact sheet: Lis Lindal Jørgensen, Institute of Marine Research, Sykehusveien 23. P.O.Box 6404. V-9294 Tromsø, Norway. +47 77 60 97 58; lis.lindal.joergensen@imr.no

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Species description

Scientific names: *Paralithodes camtschaticus* (Tilesius, 1815).
Synonyms: *Paralithodes camtschatica* (Tilesius, 1815) (Reptantia, Lithodidae).
Common names: The red king crab (GB), krab kamčatský (CZ), Königskrabbe, Kamtschatkakrabbe (DE), kongekrabbe, kamchatkakrabbe (DK), Kamtšatka ebakrabi (EE), kuningasrapu (FI), rød kongekrabbe, kamtsjatkakrabbe (NO), Kamtschatca crab (RU).

Fig. 1. The red king crab, *Paralithodes camtschatica*, photo by Lis Lindal Jørgensen.

Species identification
Paralithodes camtschaticus, which is among the world's largest arthropods (weighing over 10 kg and 22 cm in carapace length, Powell and Nickerson 1965) has a crab-like morphology and a strong calcified exoskeleton with spines (Cunningham *et al.* 1992). It has a fused head and thorax, a fan shaped tail, 5 sets of appendages, the first two are pincers, the right is usually larger than the left, and three pairs of walking legs. In the front, the crab has an array of antennae and mouth parts (mandibles, maxillae and maxillipeds). The body is red/ brownish but has also been found blue. The characteristics distinguishing the red king crab includes the number of spines. The carapace is split into four regions: two lateral regions with 9 spines each, the front area with 9 spines, and the upper posterior region with 6 spines.

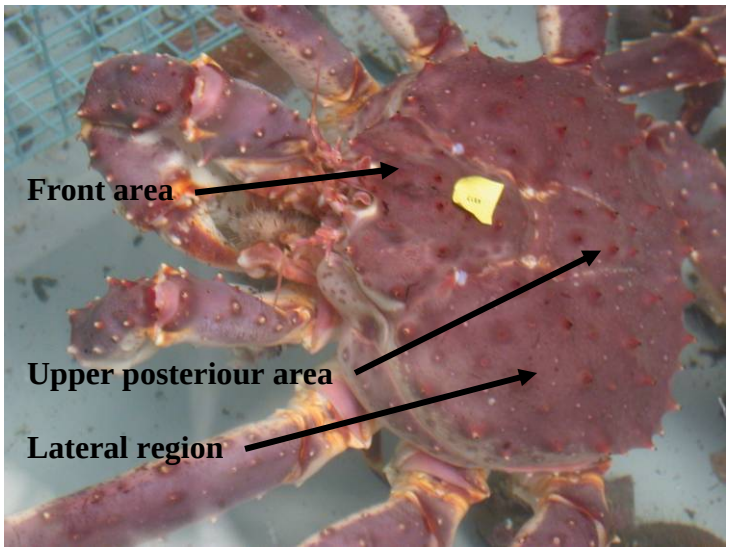

Fig. 2. Carapax regions of the red king crab, photo by Lis Lindal Jørgensen.

Native range
Paralithodes camtschaticus is native to the Okhotsk and Japan Sea, Bering Sea and Northern Pacific Ocean. On the Asian side of the Pacific, crabs are found from Korea, along the eastern coast of Siberia and the coasts of the Kamchatka peninsula. In the Northeast Pacific and Bering Sea the red king crab are distributed throughout the Aleutian Island chain, north to Norton Sound, Alaska, and southeast to Great Bay in Vancouver Island, Canada (Figure 3).

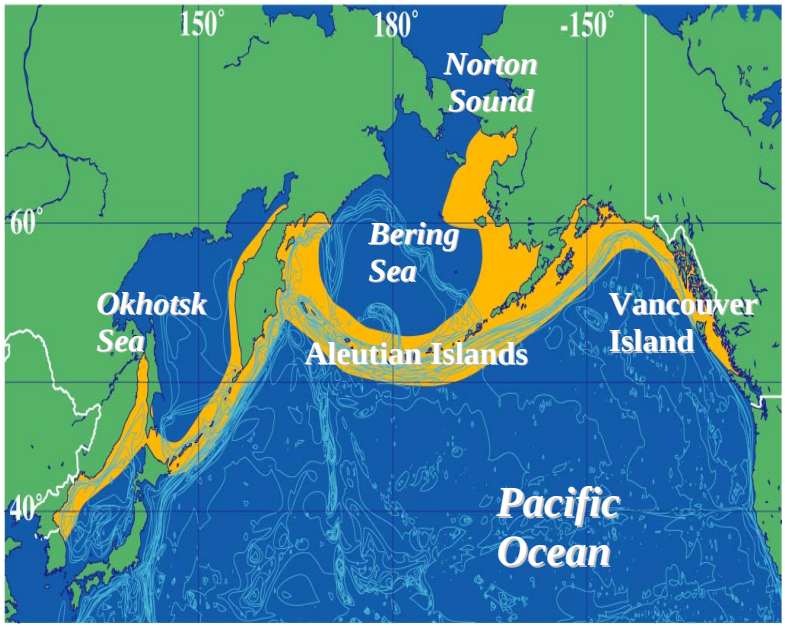

Fig. 3. The native distribution of the red king crab (yellow shading) along the coasts of Korea, Japan, Russia, Alaska, and Canada.

Alien distribution

History of introduction and geographical spread

During the period 1961-1969, 1.5 million zoea I larvae, 10,000 1-3 year old juveniles (50% females and 50% males) and 2,609 5-15 year old adult (1,655=females, 954=males) *P. camtschaticus* from West Kamchatka, was intentionally released by Russian scientists in the Kolafjord in the east Barents Sea (Russia) to create a new and valuable fishing resource in the region (Orlov and Karpevich, 1965; Orlov and Ivanov, 1978). Since then, the crab has spread both east along the Kola Peninsula, and westwards into the Norwegian zone (Figure 4).

Fig. 4. The distribution of the red king crab (yellow shading) in the native northern Pacific, Otkhotsk and Bering Sea and the non-native distribution in the Russian and Norwegian southern Barents Sea.

In the Russian part of the Barents Sea the highest densities were observed on both sides of the Rybachi Island during late 1980s and early 1990s. During the late 1990s, crabs became abundant on the eastern part of the Peninsula. The range up to 2002 included Cape Kanin and the entrance of the White Sea to the east. Further northwards the crab was found on the Kanin Bank and at the Goose Bank. Russian scientists believe that the red king crab in the Barents Sea has reached the limits of its eastern distribution (probably due to salinity and temperature).

It was not until 1992 that the crab became abundant in Norwegian waters, first occurring in the southern areas of Varangerfjord. The general rate of spread of the distribution along the coast of Northern Norway is shown in Figure 5. By 1994 *P. camtschaticus* had spread to the northern side of the fjord, and it was caught in Tanafjord for the first time in 1995. At that time it had almost certainly established breeding populations in the coastal waters between Vardø and Tana. Further range extensions were noted in Laksefjord and Porsangerfjord in 2000, and by 2001 fishermen had caught several adult crabs west of Sørøya, west of the North Cape (Figure 5). In 2002 crabs were captured close to Hammerfest and three crabs were caught by a longliner at about 120 nautical miles off the North Cape. In 2003 the crab was estimated to 2.9 million in 2001 and 3.5 million crabs in 2003 along the coast of northern Norway (Hjelset et al. 2003). Since then, the estimated total stick indexes have declined and are now estimated to be approximately 3 million specimens

(Sundet et al 2012). The term “total stock” is biased due to the fact that only individuals with a carapace length larger that 70mm and caught deeper than 100 meters are included in these estimates. If juveniles and adults in shallow waters were included, the number is expected to increase.
Recently, several specimens of ripe female king crabs are caught in the vicinity of Tromsø; far west of the quota regulated area in eastern Finnmark.
Amazingly, a single red king crab male was recorded in the Mediterranean Sea, though no explanation is given of its mode of introduction and survival so far south (Faccia et al. 2009).

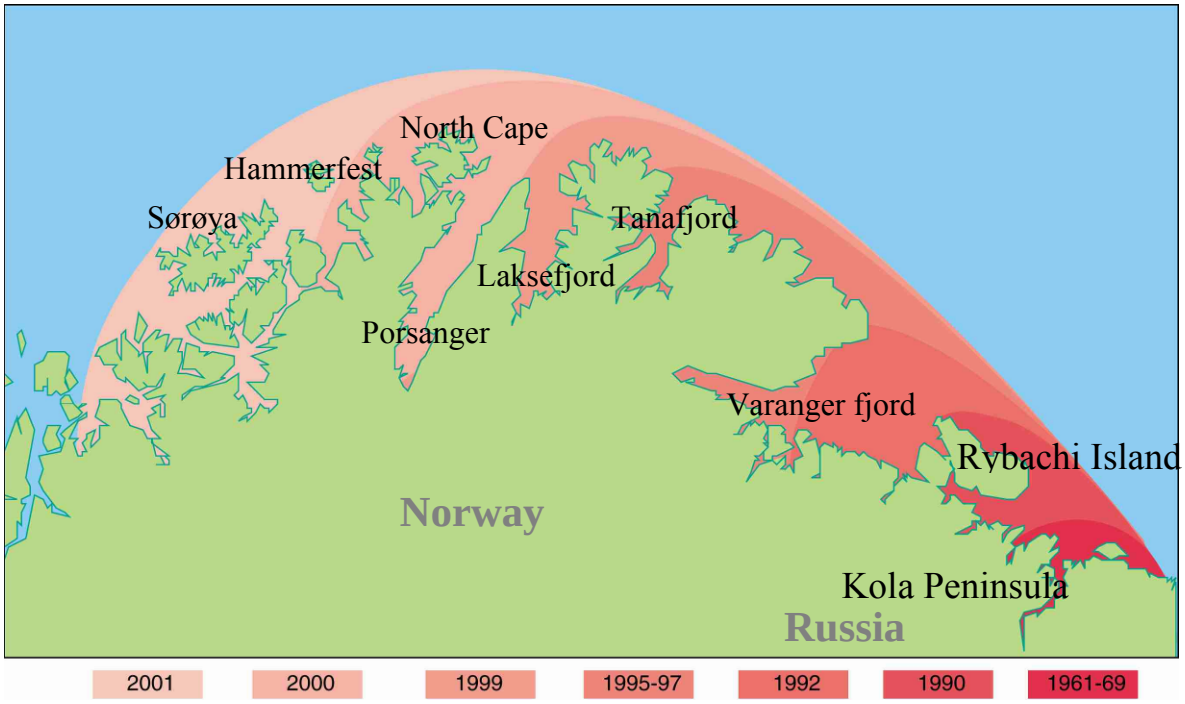

Fig. 5. Generalised distribution and spread of the red king crab from its release region in the Barents Sea. Illustration made by Jan Sundet.

Pathways of introduction
In the Barents Sea the species is spreading from the coastline and offshore in a north - and westward direction in Norwegian waters, and in an eastern and northward direction in Russian waters.

Country	Not found	Not established	Rare	Local	Common	Very common	Not known
Austria	X						
Belgium	X						
Czech republic	X						
Denmark	X						
Estonia	X						
European part of Russia						X	
Finland	X						
Faroe Islands	X						
Germany	X						
Greenland	X						
Iceland	X						
Ireland	X						
Latvia	X						
Lithuania	X						
Netherlands	X						
Norway						X	
Poland	X						
Slovakia	X						
Sweden	X						

Table 1. The frequency and establishment of *Paralithodes camtschaticus* in the coastal marine environment, please refer also to the information provided for this species at www.nobanis.org/search.asp. Legend for this table: **Not found** –The species is not found in the country; **Not established** - The species has not formed self-reproducing populations (but is found as a casual or incidental species); **Rare** - Few sites where it is found in the country; **Local** - Locally abundant, many individuals in some areas of the country; **Common** - Many sites in the country; **Very common** - Many sites and many individuals; **Not known** – No information was available; **Native** – when a species is native in a country this is indicated in the table under the relevant frequency category.

Alien status in region

The species is found naturalised in the southern part of the Barents Sea in Russian and Norwegian areas. *P. camtschaticus* has not yet reached Jan Mayen and Svalbard in the north, nor Sweden and Denmark in the south (see table 1).

Ecology

Habitat description

Settlement of larvae is found to be in shallow waters (<20 m) (Marukawa 1933). Successful recruitment of the juvenile crab will depend on a well-developed animal bottom-community to support a massive settlement of larvae. The habitat must be temporally synchronised with the spring phyto- and zooplankton peaks and in the upper 15 m of the water column (Shirley and Shirley 1989). The survival in one-year-old red king crab is directly related to availability of cover, while dependence on the epifaunal community apparently decreases, as crabs grow older (~2 years). *P. camtschaticus* specimens smaller than 20 mm carapace length (CL) have no podding behaviour and

remain solitary the first year as cryptically living beneath rocks and stones and in crevices. In the second year (20-25 mm CL) podding behaviour is seen (Dew 1990). After the first two years they migrate to deeper water (20-50 m depth) where they congregate in large, tightly packed groups, often referred to as pods (Powel 1974).

Adults occur on sand and mud substrata (Vinogradov 1969, Fukuhara 1985) and aggregate according to size, life history group or sex. Extensive aggregations, where both sexes occur, are made during the spring spawning season. After this period, the sexes form separate aggregations for the remainder of the year (Fukuhara 1985). The regions where these spawning aggregations occur can also be found in shallow water where kelp occurs (Powel and Nickerson 1965). The kelp may provide them with some protection for the females following moulting ecdysis and make them less vulnerable during mating (Jewett and Onuf 1988).

Reproduction and life cycle

The adult crab has two migrations, a mating-molting and a feeding migration (Figure 6). It is known from the crab's native area that the adult part of the stock migrates to shallow waters in spring in connection with hatching, mating and spawning. During summer and autumn it moves to deeper waters, and over-wintering takes place at depths below 200 m. Observations in Norwegian waters show approximately the same pattern, but findings of a few adult crab in shallow waters during the whole year indicate differences from the area of origin (Sundet *et al.* 2000 a).
Female *P. camtschaticus* brood eggs underneath their tail flap for about 11 months. Fecundity varies between 15 000 to nearly 500 000 eggs, depending on area (Jewett and Onuf 1988). The crab larvae develop in the coastal zone. After hatching into a brief (couple of minutes) prozoea stage, the larvae pass through four pelagic stages, followed by a settling stage (megalopa), in about two months (Rodin 1989). The larvae may be transported considerable distances by currents. For survival of the young, the larvae must be transported to favourable habitats.

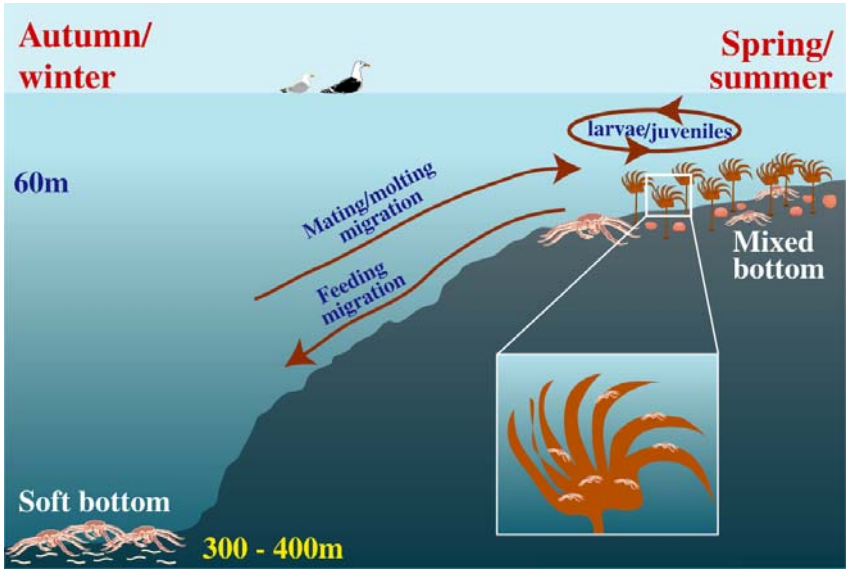

Fig. 6. Seasonal migration of *Paralithodes camtschaticus*: the mating-molting migration in the spring/summer period to various substrates with benthic communities principally composed of calcified prey organisms, and a subsequent feeding migration in winter/autumn to soft substrate where annelids occur (enlarged picture: juvenile red king crabs associated with kelp).

Dispersal and spread

Results from tag-recapture experiments carried out in the Varangerfjord, Northern Norway, reveal that adult crabs here move only short distances (2-15 nautical mile) over a three-year period. The

experiments also indicate that when local stocks reach a certain density, significant migration over longer distances is observed (Sundet *et al.* 2000 a). Tagged individuals have been found to move over significant distances over short periods of time. Further knowledge about seasonal migration patterns and density dependent emigration is necessary to understand the crab's dispersal potential to new areas (J.H. Sundet, pers. com.).

Norwegian laboratory studies have shown indications of better larvae survival at 6 ºC compared to 1-3 ºC (Larsen 1996). This counts in favour for *P. camtschaticus* being a successful invader of Norwegian waters. In Norway immature and mature crabs migrate generally westward. Large egg-carrying females are often the first individuals to be caught in new areas (J. H. Sundet, pers. comm.). The release of brood by these females may greatly enhance their rate of spread.

It has been questioned how far south along the east Atlantic coast the crab will spread. In the Okhotsk Sea, the bottom temperature at 100-300 m is ~0 ºC. In the Barents Sea and northern part of the Norwegian Sea at 100 m depth the temperature varies from 0 to ~+6 ºC in winter. The temperature increases with a southward progression along the coast of Norway. However, temperatures remain low around Svalbard and in the Northern Barents Sea. Laboratory studies have shown a temperature preference in immature *P. camtschaticus* to temperatures below 4-6 ºC (Hansen 2002). Hansen (2002) speculated that the crab will spread to elsewhere in northern Norway and may extend further south as the uppermost temperatures are likely to be limiting but remain unknown. He also indicated a northward spread to Svalbard.

The availability of food for the crab would likely appear to be the most important factor in limiting its distribution in its new environment (Gerasimova 1997).

Impact

Affected habitats and indigenous organisms
The nature of the food consumed varies according to the life history. The pelagic larvae consume both phytoplankton and zooplankton (Bright 1967) and once settled feed on the dominant epifaunal component of the refuge substrate (Tsalkina 1969). Dew (1990) reported that small crabs feed on sea stars, kelp, molted king crab exuvia, clams, mussels, nudibranch egg masses, and barnacles.

Adults are opportunistic, omnivorous feeders according to what is most readily available in the benthos (Cunningham, 1969). They normally use the most abundant benthic organisms as food, and usually one food group/or species is dominant and varies according to region (Kun and Mikulich 1954, Kulikova 1955, Jewett *et al.* 1989).

P. camtschaticus have two distinct methods of feeding: 1) grasping and tearing apart larger invertebrates, and 2) sieving organisms using the third maxillipeds following the scooping-up of sediment by the lesser chela.

Adult crabs are active and consequently, where there are low densities of available food, they may swiftly migrate, by walking rapidly on the long legs, to a different and less exploited region where food is more abundant (Somerton 1981). This enable the adult crabs to exploit considerable areas of sea bottom (Cunningham 1969).

Molluscs and echinoderms mostly make up the crab diet in areas of the Barents Sea recently invaded by the crab (Sundet *et al.* 2000 b). But as the crab abundance increase, the echinoderms in the diet decrease while polychaets become more important (Jørgensen *et al.* 2005).

Laboratory results have shown that the susceptibility of native, shallow water, epibenthic communities to red king crab predation, must be considered significant when foraging rates are contrasted with observed natural scallop biomass (Jørgensen 2005).

Genetic effects
None.

Human health effects
None.

Economic and societal effects (positive/negative)
The economic value to the fishermen of the red king crab fishery (first hand price) has increased from 1.3 million Nkr in 1994 to 75 million Nkr in 2004. But the concurrent increase in the red king crab stock in recent years has also resulted in by-catch problems, particularly in the gillnet fishery. The crabs impact the longline fishery by removing bait from hooks, thereby reducing catches of targeted fish (Sundet and Hjelset 2002). The by-catch of crabs increased steadily from 1997 to 1999, but in 2000-2002 the by-catch rate decreased, and the estimated number in 2002 was only 30% of that in 1999. This is probably due to a reduction in the cod gillnet fishery.

In order to compensate for the loss of fishery and equipment (trawl-, net, and long-line fishing) caused by the invasion of the red king crab, the criterions for participation in the annual crab fishery are set in favor of the local small-scale fishermen. This is generally acknowledged by fishermen from other parts of Norway, since the presence of the crab directly influence the conditions of the local fishermen.

Management approaches

Prevention methods
Due to the fact that *P. camtschaticus* is well established in the Barents Sea over a period of about 40 years, it is postulated, that it is unrealistic to believe that it could be eradicated. Management options for the crab has been decided by Norwegian and Russian Fishery Commissions and these includes the continuation of today's management regime where the crab is managed as a valuable fish stock, and the annual TAC (total allowable catch) is set to ensure a long term sustainable harvesting. Another option is to keep the crab stock at the lowest possible level through deliberate actions. A non-regulated fishery has been proposed to reduce the crab stock in Norwegian waters. The Norwegian Fishery commissions are however, reluctant to adopt such a method due to the fact that it is only large males that are of any commercial value. It therefore seems necessary to introduce economical incentives such as a reward system to keep the crab stock at a lowest possible level.

Eradication, control and monitoring efforts
The red king crab in the Barents Sea is managed as a joint stock between Norway and Russia, and the main body deciding upon management actions is the Russian-Norwegian Fishery Commission (Kuzmin and Sundet 2000). Therefore, all research on this species is performed in cooperation between scientists of the two nations. The Commission sets a common TAC, which is divided between the two nations dependent on the standing stock in each economic zone. Until now, the

main goal of the crab management has been to perform a long-term sustainable harvest of the stock, and this has in many ways influenced the research undertaken.

The Norwegian Ministry of Fisheries started a non-legislated fishery for *P. camtschaticus* west of Nordkapp (26° E), northern Norway from summer 2004. The intension is to stop the migration of the crab west- and southward along the coast. But the fishing has not limited the spread of *P. camtschaticus* efficiently.

Information and awareness
None

Knowledge and research
The Norwegian Ministry of Fisheries decided to launch a comprehensive research and surveillance program on the ecological impacts of *P. camtschaticus* in Norwegian waters in 2003. The research is carried out at the Institute of Marine Research in cooperation with other research institutions in Norway. The program is planned to last for at least ten years. All planned research is closely cooperated with Russian research activities in the same field. The research program includes research on the king crab basic biology, distribution and spreading, direct and indirect effects on habitats, interaction with other (native) species, qualitative and quantitative effects of food competition, genetic studies, observational methodology and data analysis, diseases, parasites, and translation of Russian literature relevant for the crab as an introduced species

Recommendations or comments from experts and local communities
Concise scientific answers cannot be given to questions about the future impacts of *P. camtschaticus* in the Southern Barents Sea. So far, indications point in the direction of continuous migration both further north in the Barents Sea, as well as a southwards spreading along the coast of Norway. Due to the pelagic phase of the crab larvae, the possibility of ballast water being a vector of spreading is possible. The fact that ship traffic (oil- and gas transportation) both in the Barents Sea and in the Northern Norway is likely to increase in the near future, emphasize the possibility of ballast water spreading of the species to other areas in the Atlantic Ocean (*e.g.* American east coast).

References and other resources

Contact persons
Jan Sundet (NO). Institute of Marine Research, Sykehusveien 23. P.O.Box 6404. V-9294 Tromsø, Norway. Tel +47 77609740, E-mail jan.sundet@imr.no

Boris Berenboim (RU) Knipovich Polar Research Institute of Marine Fisheries and Oceanography, (PINRO), 183763, Knipovich Street, 6, Murmansk, Russia, Phone: ++ 815-7-25-32, E-mail borisber@pinro.ru

Links
Institute of Marine Research – fact sheet on *Paralithodes camtschaticus*

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