RED KING CRAB

Stock name: Red king crab
Latin name: *Paralithodes camtschaticus*
Geographical area: Barents Sea (ICES subarea 1)
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Stock Sensitivity Attributes

HABITAT SPECIFICITY: Adult (mature) red king crabs (*Paralithodes camtschaticus*, Lithodidae) migrate late autumn (large males) or early winter (females) from deep areas (>150 m) with commonly soft sediments, to shallow waters usually with hard substrate to hatch eggs, molt and mate. After spawning and mating in spring, the crabs move to deeper areas during summer and autumn to feed (Sundet & Hjelset, 2010). Juvenile red king crabs (CL< ~ 50 mm) settle at rough bottom sediments in very shallow waters (< 20 m) and stay there for one to two years before they start their descents to deeper waters (Stevens, 2014b).

PREY SPECIFICITY: The red king crab exploit a wide range of organisms including algae. The occurrence of prey in the stomachs seem to mirror the abundance of available food, indicating an opportunistic foraging behaviour (Feder & Paul, 1980). The most frequent prey groups found both in the Bering and the Barents Sea are Polychaeta and bivalves (Cunningham, 1969; Sundet et al., 2000).

SPECIES INTERACTION: The red king crab seems to have only minor competition for food in the southern Barents Sea. The crab feeds on a wide range of prey, including scavenging. It is reasonable to believe that there might be some competition for food with bottom feeding fishes. Russian scientists from VNIRO-PINRO, Murmansk have estimated the effect of red king crab foraging on haddock and found minimal effects (Anisimova, unpublished). Red king crabs are covered with a spiny exoskeleton that provides protection from potential predators. In different stages of its lifecycle, the species is preyed upon by fishes, octopuses, and some marine mammals. Red king crabs are also known to be occasionally cannibalistic. From the Bering Sea, it is known that the Pacific cod (*Gadus macrocephalus*, Gadidae) can be an important predator on soft-shelled females (Blau, 1986; Otto, 1986).

ADULT MOBILITY: Tag and recapture experiments in Norwegian waters have revealed that the red king crab seem to have a high site fidelity (Windsland et al., 2014). However, both adult males and females have been observed to move long distances during a year in the process of dispersal of the crab in Norwegian waters since the first appearance in 1977.

DISPERSAL OF EARLY LIFE STAGES: The development of the red king crab larvae from hatching to settlement takes approximately 460 day×degrees (Kurata, 1960). With an average temperature of 4 °C the whole planktonic phase is approximately 2.5 months. This entails that the planktonic larvae could be dispersed over large distances along the Norwegian coast, with currents (Pedersen et al., 2006).

EARLY LIFE HISTORY SURVIVAL AND SETTLEMENT REQUIREMENTS: Red king crab larvae undergo 4 zoea stages as a pelagic larva before it moults to a glaucothoe stage which settles on substrate (Stevens, 2014a). There is an ontogenetic change with age (stage) of the larvae; with highest temperature and salinity tolerance of the first (zoea I) stage (Shirley & Shirley, 1989). In general, the larvae have thrive at temperature between 3 and 9 °C and salinities between 20 and 30 ppt (Shirley & Shirley, 1989). Early benthic stages of red king crab are restricted to areas with adequate cover (stones and crevices) and food (hydroids, bryozoans and polychetes) (Sundberg & Clausen, 1979). Juvenile crabs are common in shallow areas with a coarse substrate with abundant epifauna (Tsalkina, 1969). Newly settled glaucothoe and young-of-the year juvenile crabs are cryptic and hide under stones and epifauna.

COMPLEXITY IN REPRODUCTIVE STRATEGY: Adult (mature) male red king crabs start migrating to shallow water as early as in November, while females move to shallow areas (10-20 m) in January/February to reproduce. In shallow waters the females hatch eggs that have been attached to the pleopods for about 11 months, before they start the new reproduction process with moulting, spawning and copulation (Powell & Nickerson, 1965). The period of red king crab reproduction in Norwegian waters may last from February until June with a peak in March/April dependent on temperature. The red king crab performs a precopulatory mate-guarding where the male crab grasps females almost ready to moult and spawn for 3-7 days (Powell & Nickerson, 1965). Following the female moulting, the male grasps the soft-shelled female. Spawning and copulation occurs shortly after the female moulted. Fertilization must occur at spawning since female red king crab are not able to store sperm.

SPAWNING CYCLE: The adult red king crab undertakes a spring migration to shallow water areas to mate and breed once a year (Marukawa, 1933; Powell & Nickerson, 1965). The spawning event requires specific environmental conditions as depth, temperature and light conditions. The spawning season for a population usually lasts for several months during spring.

SENSITIVITY TO TEMPERATURE: The red king crab seems to prefer low temperatures (< 4 °C) (Christiansen et al., 2015), but may inhabit environments with a wide range of temperatures (0-12 °C) (Stevens & Jewett, 2014).

SENSITIVITY TO OCEAN ACIDIFICATION: The effects of the decline in ocean pH on marine species are not well understood. Although ocean acidification (OA) may reduce larval size and calcium content, the implications are unclear but decreased survival is likely to harm red king crab populations. Experiments showed that OA affects red king crab embryos and larvae decreasing the overall larval fitness, under starvation conditions (Long et al., 2013). Additionally, OA appeared to interfere with the moulting process in adult females where 75% failed to moult successfully (Long et al., 2013). These results indicate that red king crab populations could be significantly affected by OA within a century if atmospheric CO_2 levels continue to rise as predicted.

POPULATION GROWTH RATE: The table to be consulted contains metrics considered irrelevant for red king crab.

STOCK SIZE/STATUS: The size of the Norwegian red king crab stock is estimated to be at or close to the biomass (B) maximum sustainable yield (MSY). The crab stock experiences a high fishing mortality F (F consistent with achieving MSY (F_{msy}) < F < limit reference point for F (F_{lim})), and the risk for exceeding F_{lim} is estimated to be less than 35 %. The stock appears to have reached its maximum distribution in the quota regulated area (QRA) and is close to its maximum annual production (IMR, red king crab stock assessment 2019). $B/B_{MSY2020}$ =0.66 – 0.88.

OTHER STRESSORS: In addition to fishing, the red king crab stock is a significant bycatch in other fisheries such as gillnet fishery for cod and lumpsucker, and the longline fishery (Sundet & Hjelset, 2010). In addition, there is a suspected notably mortality of soft-shell crabs during the crab fishery during the moulting period.

Scoring of the considered sensitivity attributes

Sensitivity attributes, climate exposure based on climate projections allowing the evaluations of impacts of climate change, and accumulated directional effect scoring for Red king crab (*Paralithodes camtschaticus*) in ICES subarea 1. L: low; M: moderate; H: high; VH: very high, $Mean_w$: weighted mean; N/A: not applicable. Usage: this column was used to make ad hoc notes, including considerations about the amount of relevant data available: 1 = low, 2 = moderate; 3 = high. N/A = not applicable.

Red king crab (*Paralithodes camtschaticus*) in ICES subarea 1

SENSITIVITY ATTRIBUTES	L	M	H	VH	$Mean_w$	Usage	Remark
Habitat Specificity	3	2	0	0	**1.4**		
Prey Specificity	5	0	0	0	**1.0**		
Species Interaction	5	0	0	0	**1.0**		
Adult Mobility	5	0	0	0	**1.0**		
Dispersal of Early Life Stages	5	0	0	0	**1.0**		
ELH Survival and Settlement Requirements	0	0	3	2	**3.4**		
Complexity in Reproductive Strategy	0	1	2	2	**3.2**		
Spawning Cycle	0	0	2	3	**3.6**		
Sensitivity to Temperature	0	1	4	0	**2.8**		
Sensitivity to Ocean Acidification	0	0	1	4	**3.8**		
Population Growth Rate	5	0	0	0	**1.0**		
Stock Size/Status	0	1	3	1	**3.0**		
Other Stressors	0	1	3	1	**3.0**		
Grand mean					**2.25**		
Grand mean SD					**1.17**		

CLIMATE EXPOSURE	L	M	H	VH	$Mean_w$	Usage	*Directional Effect*
Surface Temperature	0	0	0	0		N/A	
Temperature 100 m	0	0	0	0		N/A	
Temperature 500 m	0	0	0	0		N/A	
Bottom Temperature	1	3	1	0	**2.0**		1
O_2 (Surface)	0	0	0	0		N/A	
pH (Surface)	3	2	0	0	**1.4**		-1
Gross Primary Production	4	1	0	0	**1.2**		1
Gross Secondary Production	5	0	0	0	**1.0**		0
Sea Ice Abundance	0	0	0	0		N/A	
Grand mean					**1.40**		
Grand mean SD					**0.43**		
Accumulated Directional Effect					**–**		**1.8**

***Accumulated Directional Effect*: POSITIVE**	**1.8**

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