Red king crab lifespan

Skip Nav Destination Red King Crab (Paralithodes camtschaticus) is native to the Bering Sea, but was deliberately delivered to the Barents Sea during the 1960s. Since then, the red king crabs have spread to Norwegian waters, and the density of crabs has increased sufficiently to support coastal fishing. There is a lack of information on full and natural mortality, which is important for proper management. Estimates of annual total mortality (Z) were calculated using the catch curves converted by length for three periods of different levels of use. Separate analyses of trap and trawl data, as well as initial and effort-adjusted data, were carried out. Natural mortality was assessed using linear regression of the total mortality and exploitation level and indirect methods based on life history parameters. During both sex periods, Z increased significantly in a row. The increase in the level of male exploitation coincided with an increase in the level of exploitation. The increase in female mortality, which has not been explained by the level of exploitation, is probably the effect of an increase in male mortality. The natural mortality rate (M) calculated using indirect methods was on average 0.23 for both sexes. The estimated M using linear regression was 0.37/0.44, which may be overestimated. The Red King crab (Paralithodes camtschaticus) is native to the Bering Sea, but in the 1960's USSR scientists deliberately introduced the Barents Sea (Orlov and Ivanov, 1978). This species is a valuable commercial resource in the Bering Sea, and the purpose of the introduction was to benefit local fisheries. Since its introduction, red king crabs have spread to Norwegian waters and the density has increased sufficiently to support coastal fishing, with recent annual landings of >2000 t (Hvingel et al., 2012). Commercial fishing started in 2002 and since 2004 the population of legal men has steadily decreased [karaace length (CL) ≥130 mm]. In 2012, the stock pile was considered relatively low (Anon., 2013a). In order to ensure proper management of resources, information on instantaneous total mortality (Z) and natural mortality (M) is needed. The catch curve analysis can be used to estimate overall mortality by monitoring the regular decrease in the number of cohort individuals (Pauly, 1983, 1990). The age determination of crustaceans is difficult because hard parts are lost after ecstasy, so mortality assessments must depend on long-term methods. Using the age and length key, age can be assigned to a observed length in the so-called length converted catch curve (LCC) analysis. The slope of the catch curve with the changed mark is measure Z of the resources in service and measure M when operation is negligible. This method requires that the growth function used to convert length into age is the entire sampling period. Cross-sectional analysis using data over several years also assumes that the data reflect a stable age distribution, i.e. the samples used to create a catch curve should reflect the average conditions under which recruitment varied slightly or randomly (Pauly, 1987). Violations of this assumption can lead to catch curves that are not linear in the descending right limb. The calculation of M may allow the use of total mortality and average fishing effort for the exploited stock over the same period. However, M is a complex parameter that needs to be evaluated and is often puzzled by other parameters, such as accessibility, fishing mortality and recruitment (Schnute and Richards, 1995; Frusher and Hoenig, 2001). Despite the opposite evidence, it is often assumed that natural mortality over time and with gender and body size is constant (Kremers, 1988). Several fish studies have shown that natural mortality is usually particularly high in the stages of larvae and juveniles due to predator, decreases during maturity and increases again when fish are approaching the maximum age due to sensuality (Vetter, 1988). Studies of many exploited crustacean species have shown that natural mortality can vary according to gender and age and over time (Fu and Quinn, 2000; Xiao and McShane, 2000). Zheng et al. (1995a,b) included this pelvic function M in an attempt to model the level of abundance of red king crabs in the Bering Sea. They found that not only did natural mortality fluctuated over time, but were also higher in females and juveniles than in males and old specimens. Siddeek et al. (2002) attempted to assess the natural mortality of several species of king crabs in local areas from significant restoration data. Estimates of red king crabs ranged from 0.02 to 1.62 years-1 and were thought to be too high, taking into account the estimated life span of 20 years (Matsuura and Takeshita, 1989). There is a lack of knowledge of the complete and natural mortality of red king crabs in Norwegian waters. In this document, using an analysis of the catch curve, i aim to assess the overall mortality of red crab males and females in Norwegian waters. I have examined three separate periods of different operating regimes to assess the impact of different levels of exploitation. The second method of assessment of M is based on the observation that M often correlates with different parameters of life history, such as life expectancy, age at maturity and growth rate (Vetter, 1988). I compare the results of the LCC analysis with M estimates using indirect methods based on life history parameters. Materials and methods The sampling zone and data processing The sampling zone consisted of four large fjords and open water off the northern coast of Norway (Figure 1). The stations were selected to cover all areas and Data from the whole field of investigation were pooled. For more information on Hvingel et al. (2012). A total of 64,535 red king crabs (30,323 females and 34,212 males) with a karaace length (CL) range of 8 to 210 mm were caught during annual scientific cruises on the northern Norwegian coast between August and November 1994. Crabs were collected using a large Agassiz trawl (n = 26,634) and bait traps (n = 37,902). Cl was measured to the nearest millimetre of all persons and gender was recorded. In 1994, varangerfjorden lived the largest population. During the sampling period, the distribution of red king crabs expanded to include Tanafjorden, Laksefjorden and Porsangerfjorden (Figure 1). Open in a new tabCreate slide Survey area map and sampling points (a) trawl sampling and (b) trap sampling in period I (black squares), period II (white circles) and period III (black circles). I separated the data by sex and tools (agazziz trawl or trap), then divided it into 5 mm carapax length intervals. King crabs grow step by step through frames at certain periods of the year. The main periods of male moulting are January-April, and for women april-May (Wallace et al., 1949; Powell, 1967). It seems that the periods of the red king crabs in the southern Barents Sea are the same as in the Irring Sea (Nilssen and Sundet, 2006). The sampling period for the full year took place from August to November, when the length did not work. Therefore, monthly samples were pooled. The management of the red king crabs changed between 1995 and 2012, and the sexes were also exploited differently. I therefore divided the individual analyses and datasets for men and women into three periods: (i) 1995-2001 (period I, scientific fishing), (ii) 2002-2007 (period II, period of early commercial fishing) and (iii) 2008-2012 (period III, late commercial fishing). During the period I, there was no commercial fishing, either on grounds of sex, nor only a small scientific quota for men (Table 1). During the II period, in addition to the scientific quota, a commercial quota was established for men (allocated to the number of animals). During the III period, the male quota increased significantly and quotas for women were introduced. In addition, quotas were presented in tonnes rather than in the number of animals. For the purposes of this investigation, the quotas for the period III were converted into figures, divided by the average individual weight. No data were provided in 1994 due to a lack of precise data on efforts. Table 1: Total allowable catches for the years 1994 to 2007 (figures) and 2008/2012 (tonnes) and [% of legal males (CL > 137)] in scientific and commercial fisheries and cpue scientific fishing for red king crabs in Norwegian waters for the years 1994 to 2012. TAC (t) . TAC (1000) . Harvest rate . Cpue . Men. Women. Malesa . Trapb . Trawl 925 235 450 679/110b 85 24.987/21.435 0.136/0.116 2009 1 075 106 110 1 474/50b 95 17.190/14.403 0.626/0.548 2010 825 50 75 – 90 15.857/13.1 427 0.669/0.598 2011 1 100 50 100 – 76 11.397/9.899 0.587/0.483 20 12 800 50 100 – 48 11.605/9.458 0.564/0.741 I included total annual mortality (Z) using LCC FISAT II software (Gayanilo et al., 2002). Age is attributed to the observed length according to this von Bertalanffy age and length key: where tL is age t, t0 is an age of = 0, k is a constant of speed, and L∞ is asymptomatic. L∞ (192.5 and 158.6 men and women respectively) and k (0.2556 and 0.2352 for men and women respectively) were reported by Windsland et al. (2013). 2002 In the procedure described in Gayanilo et al. (2002), I used scientific cruise effort data to determine the catch per effort unit (trawl hour/trap days) (C/f): where Nold is the number of animals in the sample and Nnew is the number of animals after the sample has been raised in order to catch the unit (cpue). I also ran an analysis without correcting cpue. Instead, I transform the sample to represent the percentage of the whole sample (not corrected). I assessed Z from each age group the number of animals in the natural log has the least square regression: here Nnewi is the number of class I animals, Δti is the time needed for the animal to grow through the length of the class, ti is the relative age corresponding to the middle length of class I, and b (when the sign changes) is the Z estimate. I used the same procedure to calculate Z's original sample data (Nold). The calculation of total mortality In women (trap and trawl data) and male length distribution in trap data was bell-shaped. Data from male trawls showed signs of bimodalm (Figure 2) indicating the presence of a strong class of the year. To take into account the progressive curve of selectivity of red king crabs, I used the peak criterion, i.e. the first length group was a group near the maximum abundance length (Smith et al., 2012). The maximum abundance of trawl data was observed when the mean CL for male and females is 92 and 97 mm respectively (Figure 2). The maximum abundance of trap data was observed at an average of 112 mm CL for both sexes. The corresponding relative age length groups of one greater than the length of the peak abundance were 2.7 and 4.4 years for men and women, respectively, using the Agazziz trawl, and 3.7 and 5.7 years using traps. It is estimated that the size of the female red king crabs during maturity is 110 mm (Hjelset et al., 2009), and males are considered to be mature of the same size. Thus, the age of full recruitment is found at the relevant deadline and slightly before maturity in the catch and trawls caught in the trap. To my knowledge, there is no data on Age. Therefore, at an older age, I thought that trawl and traps are completely selective. Open a new tabDownload slideLength Distribution (mm) for male and female red king crabs caught in Agassiz trawl and traps in Norwegian waters from 1994 to 2012.The data used in this study was collected in August-October, when growth was taking place. Therefore, I chose not to download for seasonality. The decision to include or exclude the last data point (Plast) was based on the projection of Pauly (1990), who suggested that the last data point should be included in the regression only if it is below the projection of the original regression line, which did not include the last point. Natural mortality According to Jennings et al. (2001), natural mortality (M) is equivalent to total mortality (Z) in unused populations, given that sampling of animals does not significantly increase mortality. Norway's red king crab population has seen little or no exploitation for a long time. However, by-catches of red king crabs in cod (Gadus morhua) and lumpsucker (Cyclopterus lumpus) fishing was a big problem. Research on the Bering Sea shows that the mortality rate of red king crabs may be high depending on the fishing gear used (Anon., 2010). Mortality ranged from 0 (pots) to 80% (trawls). In Norwegian waters, most of the by-catches are caught in gills that have not been tested, but therefore we cannot assume that the mortality rate is negligible. For this reason, it is likely that Z will be slightly higher than M, even if there is no target fishing. Therefore, I use the data on the level of operation to estimate M from Z.M was considered to be taking over the linear regression of Z as a function of total allowable catches (TACs). In a study on the size and yield of red king crabs related to fishing, Hjelset et al. (2012) indicated that the survival of women can be influenced by the abundance of large men, since women depend on men during their period of contact. As a result, female mortality is influenced by the level of exploitation of both women and men. For this reason, I did not run a linear regression on women. Indirect M rating relates to other parameters of the M life story. Many methods have been developed, especially those used for fish, but these methods have also been used for various crab species (Jensen, 1996; Zheng, 2005; Hewitt et al., 2007). I use five published methods based on the parameters of life history to calculate indirect M estimates for male and female red king crabs. Results Overall mortality In period I, male mortality estimates vary significantly, with an estimate of 0.22 to 0.55 years-1. Female mortality estimates were more consistent, but the estimate using irreparable trap data was lower than the other three estimates. Estimates of the total During the II period ranged from 0.57 to 0.65 years to 1 for different sexes, gear types and data processing (Figure 3). During the III period, male mortality estimates were very similar, ranging from 0.99 to 1.10 years-1, while female mortality estimates varied according to gear types. Some catch curves (period I data on male trawls and both sets of period II trawls) have different degrees of non-application (Figures 4 and 5), indicating the influence of a strong year class (Ogle, 2011). Natural mortality The previous chapter discussed the possibility that trawl data on men would be affected by a strong class I period of the year. Therefore, with the data of the trawl, I ran only from the last two periods. It is estimated that male M from linear Z regression and exploitation level was 0.37-1 using trap data and 0.44 years-1 using trawl data (Figure 6). Open a new tabDown slide red king crab trap (1995-2011) and trawl (2002-2011) total mortality (Z) linear regression data as a function of the level of use (% of legal male resources). Regression is an estimate of natural mortality (M). Indirect estimates of M in women ranged from 0.14 to 0.35 and mean 0.23 years-1 (Table 2). Male M estimates ranged from 0.13 to 0.38 years-1, with an average of 0.23 years-1. Table 2 Indirect assessment methods used to assess natural mortality rates (M) for male (m) and female (f) red king crabs based on different parameters of life history. Empirical model M . Input parameter ratings . M. Source. Women. Men. M = exp[1.44–0.982 × ln(Tmax)] Tmax = 20 0.223 0.223 Hoenig (1983) M = −ln(p)/Tmax p = 0.01, Tmax = 20 0.230 0.230 Quinn and Deriso (1999) M = 3k/exp(0.38kTmax−1) f: k = 0.2352, Tmax = 20 0.142 0.128 Alverson and Carney (1975) m: k = 0.2556, Tmax = 20 M/k = 1.5 f: k = 0.2352 0.353 0.338 Jensen (1996) m: k = 0.2556 M = 4.22/Tmax Tmax = 20 0.211 0.211 Hewitt and Hoenig (2005) ln(M) = −0.0066–0.279 × ln(L∞) + 0.6543 × ln(k) + 0.463 ln(T) f: L∞ = 158.6, k = 0.2352, T = 5 0.198 0.198 Pauly (1980) m: L∞ = 192.5, k = 0.2556, T = 5 Discussion The length frequencies used in this study were converted to age frequencies using the parameters of the von Bertalanffy growth function estimated by Windsland et al. (2013). I thought that the growth function developed by Windsland et al. (2013) could characterise growth throughout the sampling period, i.e. growth is constant throughout the sampling period, which may not be true. The growth function used was based on the years 1994-2008, i.e. periods I and II. The difference in growth of the III period cannot be excluded and the interpretation of the results should therefore be carried out in this context. Exposure to different growth parameter values Z revealed higher fluctuations in male z than females (Table 3). This is due to the greater difference in the growth parameters calculated by men. Depending on the range of growth parameter values used (upper and lower 95 % CI limit), the changes in estimated Z were not significant. Table 3: The analysis of the calculated Z uncertainty in relation to L∞ and k [mean value, lower and higher PI limit (Windsland et al., 2013)] operates on traps adjusted for period III traps. Sex. L∞ . Q. Estimated Z (95 % CI). Male 192.5 0.2232 0.93 (0.82–1.03) 192.5 0.2556 1.06 (0.94–1.18) 192.5 0.294 1.22 (1.08–1.36) 185.4 0.2556 0.96 (0.88–1.03) 192.5 0.2556 1.06 (0.94–1.18) 200.4 0.2556 1.31 (1.17–1.45) Female 158.6 0.2100 0.65 (0.50–0.81) 158.6 0.2353 0.73 (0.56–0.90) 158.6 0.2616 0.81 (0.62–1.01) 154.6 0.2352 0.77 (0.63–0.91) 158.8 0.2352 0.73 (0.56–0.90) 162.8 0.2352 0.68 (0.50–0.87) For cross-sectional analysis , the data used to assess Z shall correspond to a stable age distribution, i.e. the samples used to create the catch curve should reflect the average conditions under which recruitment fluctuated slightly or at random (Pauly, 1987). Violations of this assumption can lead to catch curves that are not linear in the descending right limb. In this study, I used data from periods each with at least 5 years, increasing the likelihood that the samples were representative for a stable distribution. The data on the period I clearly represent the uneven trend of men (Figure 4). It seems that the data set may have been distorted by the influence of strong year-on-year classes. However, any such effect is less visible on the female trawl or in any set of trap data, which is a noticeable difference. This may be due to the difference in life expectancy, trap behaviour or gear selectivity. In accordance with the overall methodology for the analysis of the catch curve, I thought the population was closed. The red king crab has a high dispersion (Windsland et al., 2014), but the samples were concentrated over a very large area (Figure 1), and any error due to dispersion should not exceed acceptable limits. I assumed complete selectivity at an older age for both types of gear used in this study. If this assumption is not met, Z may be overestimated. As expected, male mortality coincided with the level of exploitation. However, the mortality rate among women increased from the period I to II, although the level of exploitation remained the same. Interestingly, there has also been a significant increase in female mortality. During the III period, the women's quota was however, their level of exploitation was still very low. Mortality management could explain a certain increase in female mortality, as the increase in male quotas inevitably leads to an increase in female behaviour. Another plausible explanation is the comments of Hjelset et al. (2012), which state that women's survival can be influenced by the abundance of large men, since women depend on the protection of men during their contact. During periods I and II, numerical quotas were established which favoured larger specimens, which in turn reduced their abundance in the population. This may have led to an increase in female mortality. Natural mortality M (0.13 to 0.47 years-1) estimates appear to be low compared to other crustacean species. Hewitt et al. (2007) produced direct and indirect estimates of blue crabs (Callinectes sapidus) M from 0.7 to 1.1 year-1, while Zhang et al. (2004) estimated that the non-irrigation of male

Dungeness crab (Cancer magister) M is 0.97-year--1. Although the value of Zhang et al. (2004) seems high, given the life span of Dungeness crabs, the natural mortality of Dungeness crabs is probably higher than that of the red king crab. In the Marine Species Literature Study, Adams (1980) found that natural mortality was negatively related to body size, life expectancy and maturity, and positively correlates with growth rates. The red king crab matures at a relatively high age (Hjelset et al., 2009) and has a much longer service life (20 years; Matsuura and Takeshita, 1989) than Dungeness crabs and blue crabs; the natural mortality rate of red king crabs should therefore be lower than that of short-term species. Siddeek et al. (2002) provided estimates of M red king crabs in Bristol Bay, ranging from 0.54 to 0.70 years-1. However, the confidence interval (BP) was several times higher than the points estimates, and they concluded that the estimates, depending on the life expectancy of the species, seemed unreasonably high. Zheng et al. (1996) developed a catch-length model to assess the abundance of crab populations. The model best appeared with instant natural mortality, which was 0.4 years-1. This value is calculated in the Z centre using uncorrected and corrected trap data during a period of low or no operation and is very close to the M estimate using linear regression. According to the negative exponential survival model (Nt = N0 e-Zt), only 1% of individuals will survive up to 11 years, which is low, according to the life expectancy observed by matsuura and Takeshita (1989) for more than 20 years. According to Pauly et al. (1995), the standard LCC may overestimate Z, which in turn will lead to an overestimation of M, calculated on the basis of the Z-linear regression and the level of exploitation. Unaccounted by-catch mortality can also lead to an overestimation of M. Difference M as linear regression (0.37 to 0.44) and estimated Z (0,55, trap data) using LCC I for a period when the operating rate was low indicates high by-catch mortality. Therefore, it is not unbelievable that the estimate of approximately 0.4 years–1 is too high. The estimated M using indirect methods (0.23) is very reasonable in terms of life expectancy. Conclusion M (0.23, indirect methods; 0.44, regression) estimates range indicates that fishing mortality (F) during the III period was between 0.62 and 0.84. Since 2004, the resource population of legal men (PI ≥130 mm) has steadily declined, which appears to coincide with an increase in the level of exploitation. In 2012, the population was low (0.43Bmsy) (Anon., 2013b), indicating that the current overall mortality rate for red king crabs may be too high to achieve maximum sustainable yield. This study found a surprisingly high overall mortality rate for female red king crabs, despite low levels of exploitation. Hjelset et al. theory (2012) that women's survival depends on the survival of men may explain high mortality rates. Fishing mortality due to the recently established quotas for women will complement the mortality rate due to male shortages and by-catch mortality. Any further increase should only be allowed if this needs to be taken into account. Acknowledges I am grateful to Captain and Crew RV Johan Ruud for the help and support in collecting this dataset. Earlier versions of this document were substantially improved by the comments of Einar M. Nilssen and Torstein Pedersen. Thanks to two anonymous reviewers and Hugh M. Allen who helped improve the later versions of this document. Links. Graphical Overview of the Growth and Decomposition of Population Groups, Journal du Conseil International Pour L'Exploration de la Mer, vol. (pg. -) , . 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