Supplementary material

Survey questionnaire translated from Norwegian

Survey on risk from the spread of the red king crab (RKC) in the Barents Sea

The Barents Sea provides several goods and services benefiting human beings. Among these are fish, both for commercial and recreational fishing; kelp forests both used as food ingredients for humans and providing habitat for fish; and seabed organisms serving as nutrients to a wide variety of benthic organisms, as well as serving as habitat. The Barents Sea is home to the northeast Atlantic cod, a stock which is well managed and provides large income to several countries with fishing rights in the sea.

The red king crab (RKC) is a species not originally inhabiting the Barents Sea, but has been transferred by humans into the area. While this species has laid the foundation for a profitable fishery, it is also impacting existing organisms in the area.

The scientific knowledge on the likelihood for the RKC to move further west along the Norwegian coastline and on potential impacts this may have on existing marine life is uncertain and insufficient. Hence, this survey aims to ask various stakeholder groups, like commercial fishers, marine fishing tourism companies, scientific experts, and the general public inhabiting the coast of Finnmark and northern Troms (according to the old county definition) about their assessments of probability for the red king crab to move further into western parts of the Barents Sea and impacts this may pose to existing marine life and human activities.

The survey is part of a larger research project, PICO, aiming to provide knowledge for decision makers regarding the management of the red king crab in the Barents sea in general, and in Norwegian coastal waters west of North cape, in particular.

This survey encompasses 4 parts: 1) personal and professional knowledge of and interest in the crabs, 2) assessment of future distribution of the red king crab, 3) assessment of impacts on ecosystem services, 4) personal information.

1 Interest in and knowledge of the red king crab

1.1. Which interest(s) do you have in the red king crab? (tick off all answers that apply)

□ Professional, academic
□ Professional, commercial/industrial
□ Professional, regulatory/management
□ Private, recreational (interested in harvesting the red king crab)
□ Private, other interests in the red king crab
□ None

1.2. How would you characterize your knowledge of the red king crab?

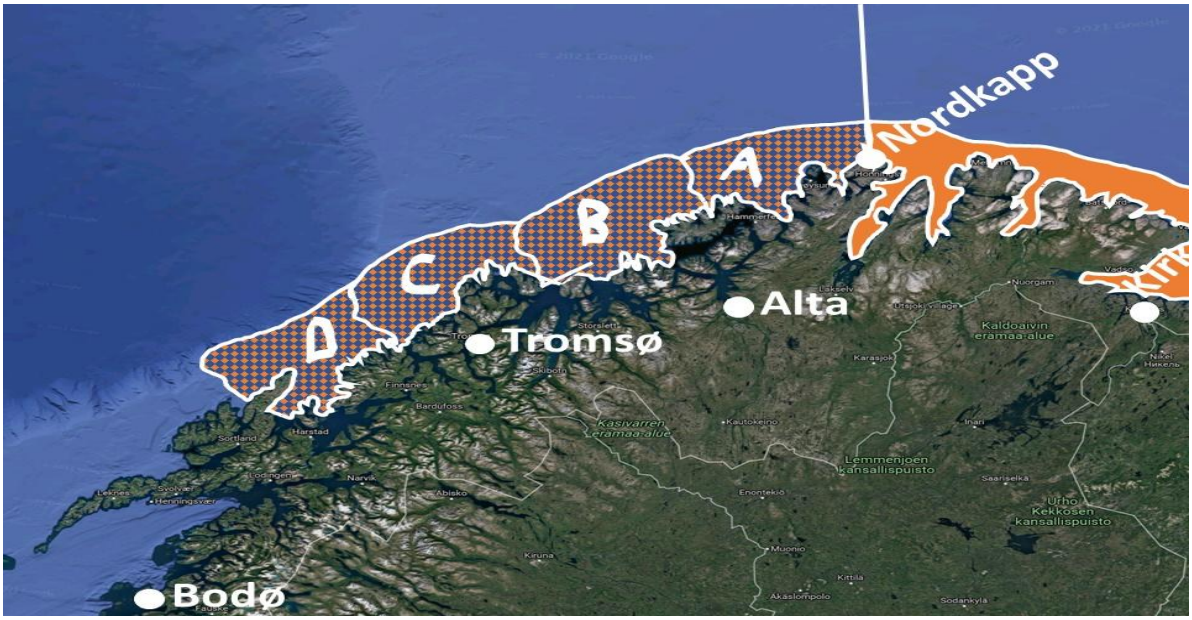
Knowledge level/	Expert	Knowledgeable	Some knowledge	Little knowledge	No knowledge

knowledge area					
Biology					
Ecosystem interaction					
Commercial importance					
Market opportunities					
Regulations					

2 *Assessment of future distribution of the red king crab*

Currently, we find the red king crab along the coast of Finnmark and Troms. While east of North Cape (26 degrees east) there is a regulated commercial fishery based on the crab which is managed in order to maximize profit, west of this line there is an open access fishery. The management of the crab west of North cape aims at limiting it from spreading further west and south.

A stock is considered established in an area if it, under normal circumstances, is able to maintain itself. How likely do you think it is that, within the next 15 years, the red king crab becomes established in the different areas coloured on the map below?



Probability	Small (0-25%)	Moderate (26-50%)	Large (51-75%)	Very large (76-100%)
Area A: 0-100 km				
Area B: 100 - 200 km				
Area C: 200 - 300 km				
Area D: 300 – 400 km				

3 Assessment of impacts on ecosystem services

Currently, there is little scientific knowledge of how ecosystem services will be affected if the red king crab establishes in new areas west of North Cape. We are interested in having your opinions about what to expect.

Suppose the red king crab establishes a sustainable stock in the area between Senja and where it is currently established. In this case, how large do you think the probability is that the following threats are realized?

	Very large	large	Moderate	small	Very small	None	I don't think this effect is negative, but rather positive	Don't know
Reduced biodiversity on the seabed								
Local stocks of cod is reduced								
Stocks of haddock is reduced								
Stocks of flounder is reduced								
The capelin stock is reduced								
The stock of cleanerfish is reduced								
The stock of sea urchin is reduced								
Poorer environmental conditions at the seabed due to reduced oxygen transportation								

Suppose the red king crab establishes a sustainable stock in the area between Senja and where it is currently established. In this case, how large do you think the probability is that the following benefits are realized?

	Very large	large	Moderate	small	Very small	None	I don't think this effect is negative, but rather positive	Don't know
Stocks of wolfish will increase								
The kelp forest will grow larger								
Commercial crab fisheries will increase the activity in coastal communities								
Tourism based on the RKC will increase the								

profitability of the whole tourism sector								
Local inhabitants can fish recreationally for RKC								

4 Personal assessments

Please indicate to what degree you agree or disagree with the statements in the table below

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Don't know
1. We are approaching the limit of the number of people the Earth can support.						
2.Humans have the right to modify the natural environment to suit their needs.						
3.When humans interfere with nature it often produces disastrous consequences						
4.Human ingenuity will ensure that we do not make the Earth un-liveable						
5.Humans are seriously abusing the environment.						
6.The Earth has plenty of natural resources if we just learn how to develop them						
7.Plants and animals have as much right as humans to exist						
8.The balance of nature is strong enough to cope with the impacts of modern industrial nations						
9.Despite our special abilities, humans are still subject to the laws of nature						
10.The so-called "ecological crisis" facing humankind has been greatly exaggerated						
11.The Earth is like a spaceship with very limited room and resources						
12.Humans were meant to rule over the rest of nature						
13.The balance of nature is very delicate and easily upset						
14.Humans will eventually learn enough about how nature works to be able to control it						
15. If things continue on their present course, we will soon experience a major ecological catastrophe						

Ethical approval

The above questionnaire was approved for distribution and collection of data by SIKT - Norwegian Agency for shared services in education and research, under reference number 957493.

Table S1 Sample characteristics of public sample

*Table S1 Socio-demographic characteristics of the "general public" sample, N=56, and the characteristics of the regional population**

	Local inhabitants	Population*
Gender; % female	48%	49%
Age, mean	51.5	41.8
Income** -median income	Group 5 (400,000-500,000)	396,000***
Education (% with university degree)	63%	26.5%
Household size	2.20	2.06
Living in Finnmark	16 (28%)	75856 (31%)
Living in Troms	39 (68%)	167202 (69%)

*includes all municipalities in Finnmark county and 5 municipalities in Troms county
**Income groups: 1= below 100,000 NOK/year, 5= 400,000 – 500,000, 10=above 1 million NOK/year
*** this is the median income for single-person households

Table S2 Stakeholder score for knowledge

Table S2 Stakeholder group score for self-reported knowledge. Self-reported knowledge runs from 1 (expert) to 5 (no knowledge).

	Scientists	Fishers	The public
Knowledge biology	2.50	3.05	4.22
Knowledge ecology	2.61	3.11	3.84
Knowledge commercial activities (fisheries & tourism)	2.53	2.65	3.70
Knowledge market	3.00	3.24	3.70
Knowledge management	2.06	3.09	4.11

Table S3 Spread of the red king crab to the west and south over the next 15 years

Table S3 Test statistic, p-value and Holm-adjusted p-value for Person's chi-square test for count data, Cramer's V, and p-value for Fisher's exact test for count data. The test statistics and p-values relate to pairwise comparisons across stakeholder groups, the adjusted p-values take into account multiple comparisons by using the family-wise error rate (FWER) and the Holm-adjustment, and Cramer's V indicates the strength of the association between the compared variables. The null hypothesis assumes independence of frequencies of answers across stakeholder groups. The following "Don't know" answers for fishers are excluded: 5 (area B), 1 (area C), 2 (area D). Scientists and the public had no "Don't know" answers. Neither of the groups had any missing values (NA).

Panel A: Excluding "Don't know" answers and NA

	Scientists – fishers				Fishers - Public				Scientists-public			
	Pearson			Fisher p-value	Pearson			Fisher p-value	Pearson			Fisher p-value
	Test-stat	p-value/Holm adjusted	Cramer's V		Test-stat	p-value/Holm adjusted	Cramer's V		Test-stat	p-value/Holm adjusted	Cramer's V	
Area A	2.05	0.73/0.73	0.32	0.85	10.08	0.018/0.054	0.50	0.028	8.02	0.045/0.09	0.33	0.07
Area B	10.38	0.035/0.07	0.76	0.03	28.38	0.00/0.00	0.88	0.046	5.86	0.12/0.12	0.28	0.12
Area C	7.77	0.10/0.20	0.62	0.08	15.60	0.004/0.012	0.63	0.003	4.55	0.13/0.20	0.25	0.24
Area D	1.40	0.71/0.71	0.27	0.75	10.23	0.037/0.11	0.515	0.046	5.67	0.13/0.26	0.28	0.15

Panel B: Including "Don't know" answers and NA

	Scientists – fishers				Fishers - Public				Scientists-public			
	Pearson			Fisher	Pearson			Fisher p-value	Pearson			Fisher p-value
	Test-stat	p-value/ Holm-adjusted p-value	Cramer's V	p-value	Test-stat	p-value/ Holm-adjusted p-value	Cramer's V		Test-stat	p-value/ Holm-adjusted p-value	Cramer's V	
Area A	0.8	0.85/0.85	0.14	0.88	10.65	0.014/0.042	0.37	0.025	8.02	0.045/0.09	0.33	0.073
Area B	12.57	0.014/0.03	0.55	0.011	26.48	0.00/0.00	0.58	0.00	5.86	0.12/0.12	0.28	0.12
Area C	8.60	0.07/0.14	0.46	0.06	16.90	0.002/0.006	0.46	0.001	4.55	0.21/0.21	0.25	0.24
Area D	2.86	0.41/0.41	0.26	0.57	11.31	0.02/0.06	0.38	0.03	5.67	0.13/0.26	0.28	0.15

Panel A: Using the Holm adjusted p-values, taking into account that multiple pairwise tests are run on the same sample, leads to only minor changes. The difference between fishers and the public in area D is no longer significant, and the difference between fishers and the scientists in area C, which was significant at 10%-level (p=0.1) is not longer significant. Some differences that were significant at 5%-level are now significant only at 10%-level (fishers vs public and scientists vs public in area A, and scientists vs fishers in area B).

Panel B: Using the Holm adjusted p-values, taking into account that multiple pairwise tests are run on the same sample, leads to only minor changes. The difference between scientists and fishers in area

C, which was originally significant at 10% level, is no longer significant, and the difference between scientists and the public in area A, which was originally significant at 5% level, is now significant only at 10% level.

Including "Don't know" answers and NA in the comparisons of distribution of answers between the three stakeholder groups leads to one change when using the Holm-corrected p-values. The difference between fishers and the public becomes significant (at 5%-level) also for area D.

Table S4 Threats from the red king crab to native ecosystems

Table S4 Test statistic, p-value and Holm-adjusted p-value for Person's chi-square test for count data, Cramer's V, and p-value for Fisher's exact test for count data. The test statistics and p-values relate to pairwise comparisons across stakeholder groups, the adjusted p-values take into account multiple comparisons by using the family-wise error rate (FWER) and the Holm-adjustment, and Cramer's V indicates the strength of the association between the compared variables. The null hypothesis assumes independence of frequencies of answers across stakeholder groups. The following "Don't know" answers are excluded: Fishers: 2 (oxygen), and Scientists: 1 (capelin). In addition, the following NA are excluded: Fishers: 1 (capelin), Scientists: 1 (cod, haddock, flounder, sea urchin, oxygen) and 4 (cleanerfish). For the public we could not distinguish between "Don't know" and NA, and the following are missing from the distribution: Public: 3 (seabed, cod), 6 (flounder, sea urchin), 7 (oxygen), 8 (haddock), 13 (cleanerfish), 14 (capelin).

Panel A: Excluding "Don't know" answers and NA

	Scientists - fishers				Fishers - Public				Scientists-public			
	Pearson			Fisher p-value	Pearson			Fisher p-value	Pearson			Fisher p-value
	Test-stat	p-value/Holm adjusted	Cramer's V		Test-stat	p-value/Holm adjusted	Cramer's V		Test-stat	p-value/Holm adjusted	Cramer's V	
Seabed	3.17	0.53/1.0	0.278	0.61	6.08	0.30/0.9	0.282	0.24	1.54	0.91/1.0	0.147	0.95
Cod	5.39	0.49/0.49	0.367	0.55	8.18	0.15/0.30	0.33	0.18	14.16	0.03/0.09	0.45	0.02
Haddock	4.27	0.37/0.40	0.327	0.36	7.32	0.20/0.40	0.323	0.18	13.48	0.019/0.057	0.455	0.011
Flounder	7.19	0.21/0.42	0.42	0.20	6.91	0.33/0.42	0.31	0.37	13.86	0.03/0.09	0.454	0.023
Capelin	6.96	0.22/0.44	0.417	0.22	6.67	0.25/0.44	0.325	0.32	12.27	0.031/0.093	0.46	0.046
Cleanerfish	1.54	0.82/0.82	0.204	0.82	7.01	0.22/0.44	0.336	0.205	8.57	0.13/0.39	0.387	0.12
Sea urchin	5.28	0.38/1.00	0.363	0.47	1.38	0.93/1.00	0.138	0.96	5.14	0.40/1.00	0.277	0.47
Oxygen	7.13	0.31/0.93	0.433	0.35	6.34	0.39/0.93	0.30	0.38	3.81	0.58/0.93	0.24	0.67

Panel B: Including "Don't know" answers and NA

	Scientists – fishers		Fishers - Public		Scientists-public		
	Pearson	Fisher	Pearson	Fisher	Pearson		Fisher

				p-value				p-value				p-value
	Test-stat	p-value/Holm-adjusted p-value	Cramer V		Test-stat	p-value/Holm-adjusted p-value	Cramer V		Test-stat	p-value/Holm-adjusted p-value	Cramer V	
Seabed	3.17	0.53/1.00	0.28	0.61	7.50	0.28/0.54	0.31	0.25	1.54	0.91/1.00	0.15	0.95
Cod	6.66	0.47/0.47	0.40	0.52	8.18	0.15/0.30	0.33	0.18	14.15	0.05/0.15	0.44	0.035
Haddock	4.27	0.37/0.37	0.33	0.36	10.43	0.11/0.22	0.37	0.10	14.4	0.026/0.08	0.45	0.016
Flounder	8.44	0.21/0.39	0.45	0.18	9.89	0.195/0.39	0.35	0.22	14.68	0.04/0.12	0.445	0.035
Capelin	7.57	0.27/0.27	0.43	0.26	11.81	0.067/0.13	0.39	0.07	14.87	0.02/0.06	0.45	0.038
Cleanerfish	7.14	0.21/0.39	0.42	0.19	14.11	0.03/0.09	0.42	0.01	8.63	0.195/0.39	0.34	0.21
Sea urchin	6.55	0.36/1.00	0.40	0.41	4.11	0.66/1.00	0.23	0.67	5.71	0.46/1.00	0.28	0.56
Oxygen	7.31	0.40/1.00	0.42	0.46	6.68	0.46/1.00	0.29	0.47	4.64	0.59/1.00	0.25	0.705

Panel A: Using the Holm adjusted p-values, taking into account that multiple pairwise tests are run on the same sample, doesn't imply any changes regarding significance at 10%-level vs non-significance. Some results that were significant at 5% level, are now significant only at 10%-level. This is true for the difference between scientists and the public for cod, haddock, flounder and capelin.

Panel B: Using the Holm adjusted p-values, taking into account that multiple pairwise tests are run on the same sample, this leads to some changes. While the scientists and the public differed in their assessment of 4 out of 8 threats, they now differ for only 2 (haddock and capelin). The fishers and the public, which originally differed in the assessment of 2 threats (capelin and cleanerfish), now only differ for 1 (cleanerfish), and this difference is now only significant at 10% level (vs at 5% level without the correction).

Comparing the FWER-corrected p-values (Holm-adjusted) between the distribution of answers across the three stakeholder groups when including (panel B) and excluding (panel A) the "Don't know" answers and NA, yields three changes in results: while the difference between fishers and the public for cleanerfish becomes significant (at 10%-level), the difference between scientists and the public for cod and flounder are no longer significant (at 10%-level).

Table S5 Benefits from the red king crab to native ecosystems and society

Table S5 Test statistic, p-value and Holm-adjusted p-value for Person's chi-square test for count data, Cramer's V, and p-value for Fisher's exact test for count data. The test statistics and p-values relate to pairwise comparisons across stakeholder groups, the adjusted p-values take into account multiple comparisons by using the family-wise error rate (FWER) and the Holm-adjustment, and Cramer's V indicates the strength of the association between the compared variables. The null hypothesis assumes independence of frequencies of answers across stakeholder groups. The following "Don't know" answers are excluded: Fishers: 1 (wolfish, kelp, tourism, recreation), and 2 (fisheries). In addition, the

following NA are excluded: Fishers: 1 (wolfish, tourism, recreation) and 2 (kelp), Scientists: 1 (kelp) and 5 (wolfish). For the public, we could not distinguish between "Don't know" and NA, and the following are missing from the distribution: Public: 3 (fisheries), 5 (recreation), 7 (tourism),15 (kelp), 16 (wolfish).

Panel A: Excluding "Don't know" answers and NA

	Scientists - fishers				Fishers - Public				Scientists-public			
	Pearson			Fisher	Pearson			Fisher	Pearson			Fisher
	Test-stat	p-value/Holm adjusted	Cramer's V	p-value	Test-stat	p-value/Holm adjusted	Cramer's V	p-value	Test-stat	p-value/Holm adjusted	Cramer's V	p-value
Wolffish	3.05	0.69/1.00	0.30	0.84	1.58	0.90/1.00	0.16	0.91	5.58	0.35/1.00	0.324	0.36
Kelp	8.92	0.178/0.356	0.50	0.1885	3.67	0.72/0.72	0.24	0.74	11.315	0.045/0.135	0.44	0.040
Fisheries	10.33	0.035/0.07	0.515	0.031	16.36	0.012/0.036	0.47	0.007	4.27	0.64/0.64	0.245	0.82
Tourism	9.81	0.081/0.207	0.502	0.048	10.23	0.069/0.207	0.38	0.087	6.66	0.25/0.25	0.315	0.35
Recreation	9.21	0.056/0.168	0.486	0.041	9.17	0.164/0.328	0.357	0.147	5.62	0.47/0.47	0.285	0.515

Panel B: Including "Don't know" answers and NA

	Scientists - fishers				Fishers - Public				Scientists-public			
	Pearson			Fisher p-value	Pearson			Fisher p-value	Pearson			Fisher p-value
	Test-stat	p-value/Holm-adjusted p-value	Cramer V		Test-stat	p-value/Holm-adjusted p-value	Cramer V		Test-stat	p-value/Holm-adjusted p-value	Cramer V	
Wolffish	5.52	0.48/1.00	0.37	0.53	5.39	0.50/1.00	0.39	0.91	5.62	0.47/1.00	0.275	0.52
Kelp	10.34	0.17/0.34	0.50	0.18	4.63	0.705/0.705	0.24	0.70	16.36	0.012/0.036	0.47	0.01
Fisheries	11.28	0.046/0.092	0.52	0.038	16.08	0.024/0.072	0.46	0.018	5.40	0.61/0.61	0.27	0.82
Tourism	10.4	0.064/0.19	0.50	0.044	10.65	0.10/0.20	0.37	0.135	6.91	0.23/0.23	0.305	0.33
Recreation	10.94	0.053/0.159	0.52	0.037	9.19	0.24/0.48	0.34	0.23	7.62	0.37/0.48	0.32	0.43

Panel A: Using Holm-adjusted p-values, which account for multiple pairwise tests on the same sample, leads to a few changes. The differences between scientists and fishers regarding tourism and recreation are no longer significant, and the difference in assessment of benefit to fisheries is significant at 10% instead of 5%. The difference between fishers and the public regarding tourism is no longer significant, and the difference between scientists and the public regarding kelp is no longer significant.

Panel B: Using Holm-adjusted p-values, which account for multiple pairwise tests on the same sample, leads to a few changes. The differences between scientists and fishers regarding tourism and recreation are no longer significant, and the difference in assessment of benefit to fisheries is significant at 10% instead of 5%. The difference between fishers and the public regarding fisheries is

only significant at 10% level vs 5% without the Holm correction, and the difference between scientists and the public regarding kelp is no longer significant.

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Comparing the FWER-corrected p-values (Holm-adjusted) between the distribution of answers across the three stakeholder groups when including (panel B) and excluding (panel A) the “Don’t know” answers and NA, yields one change in results: the difference between scientists and the public regarding kelp becomes significant (at 5%-level) when including the “Don’t’ know” answers and NA. This difference was significant in the pair-wise tests when excluding these answers, but not when FWER-corrected.