

Interactions between seals and salmon fisheries in Tana River and Tanafjord, Finnmark, North Norway, and possible consequences for the harbour seal *Phoca vitulina*

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Henriksen, G. & Moen, K. 1997. Interactions between seals and salmon fisheries in Tana River and Tanafjord, Finnmark, North Norway, and possible consequences for the harbour seal *Phoca vitulina*. - Fauna norv. Ser. A 18: 21-31.

In the 1820's, a relatively large harbour seal population may have inhabited the Tana River Estuary. Due to heavy persecution, especially in the 1920's and 1930's, it was reduced dramatically, and today there are probably less than 40 individuals left. There are few interactions between harbour seals and the salmon fishery in the river, most likely because of the low population size. Only 17 % of the fishermen questioned, reported harbour seals drowned in fishing nets in the river. The salmon fishermen in Tanafjord reported more interactions, most often with the grey seal, but neither harbour nor harp seal interactions were uncommon. During an experiment using bag nets, 16 % of the salmon caught showed scarring from seal attacks.

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INTRODUCTION

Interactions between seals and fisheries is well described from several areas (see Mate 1980, Strombom 1981, Bonner 1978, 1982, 1989, 1994, Harwood 1983, Beddington et al. 1985, Riedman 1990). In Norway, particular attention has been paid to winter and spring invasions of harp seals *Phoca groenlandica* that occur occasionally along the coast of northern Norway (Haug et al. 1991, Nilssen et al. 1992, Ugland et al. 1993, Haug & Nilssen 1995). In 1902, 1903, 1987 and 1988, tens of thousands of harp seals invaded large parts of the Norwegian coast. Upon each incident, many were drowned in gill nets, destroying the nets in the process (Bolstad 1987, Wiig 1988, Eriksen 1987). Along the coast of eastern Finnmark, there have been minor invasions more or less annually since 1978 (Haug & Nilssen 1995).

Interactions between coastal seals and fisheries in Norway have received little attention. However, there is no

doubt that local fishermen regard both harbour seals *Phoca vitulina* and the grey seals *Halichoerus grypus* as competitors for fish resources in many areas (Broch 1953, Vik 1959, Øritsland 1990). Collett (1912) characterise the harbour seal as the most "noxious" animal in Norway. The Director of Fisheries in Norway wanted to eradicate the species at the turn of the century (Øynes 1964). Both harbour and grey seals can cause severe damage to fishing gear and fish farms (Altman 1991, Henriksen et al. 1993). They do sometimes prey on commercial fish (Bonner 1982), and both species are final hosts for the cod worm *Pseudoterranova decipiens*, which can affect fisheries such as that for cod *Gadus morhua* (Bonner 1982, 1989, Anon 1990, Haug et al. 1991, Andersen et al. 1995, Hauksson & Ólafsdóttir 1995).

Interactions between seals and river fisheries, are probably more uncommon than between seals and fisheries in the sea, but nevertheless problematic. Several species of marine mammals can enter fresh water, and the

harbour seal is known to swim up several rivers in Europe (King 1983). In Finnmark, ringed seals *Phoca hispida*, harp seals and bearded seals *Erignathus barbatus* are occasionally seen on ice in river estuaries (pers. obs.). During summer it is mainly harbour and grey seals that are observed in fresh water in this area. Grey seals are usually observed in the lowest part of the river, whereas the harbour seals may travel considerable distances upstream. Collett (1912) mentioned harbour seal observations as far as 250 km up the Tana River in Finnmark, and catches of harbour seals are described several km upstream of the mouth of the river (Helland 1905, Collett 1912).

In the Tana River, there are extensive salmon *Salmo salar* fisheries which use a variety of different gear during summer. This creates a potential for interactions between seals and salmon fisheries. The Tana River Estuary is in the interior of the Tanafjord, which is rich in salmon and supports an intensive fishery. Also, several seal species are found, annually or at least occasionally, in the fjord. In this study, our aim was to document the magnitude of the interactions between seals and salmon fisheries in the Tana River and Tanafjord, and to evaluate the consequences for seals, in particular the harbour seal.

Harbour seals in the Tana River were once exploited as a resource, both for their meat and pelts. However, during the 1970's, it seems that the seals changed status from a resource to being regarded as a competitor. This may be due to several reasons which will be discussed while also addressing the question why the Tana harbour seal population neither seems to go extinct nor increase in numbers.

The study area and salmon fisheries

The Tana River flows from south to north along the border between Norway and Finland. The last 77 km of the river are located in Norway, prior to its entry into Tanafjord (Figure 1). The last 37 km of the river fall by 0.23 m/km, and 12-15 km is influenced by tidal water (Huru 1990). Traditional net fisheries for salmon are permitted in the river. There are regulations aimed at preventing overexploitation of the stock. Weir is the net most easily observed from the shore, but gill nets,

drift nets and seines are also permitted. In 1975, 250 tons of salmon were caught in the Tana water course. In the last 10 years the mean has been 130 tons per year. The salmon catch in the Tana River represents about 1/3 of the entire salmon catch in Norwegian rivers. This makes the Tana the most important salmon river in Europe.

The Tanafjord is a north/south fjord in Finnmark. It is 65 km long and between 8 and 12 km wide. It has several fingers, and very dispersed human settlements. There are close to 300 registered sites for salmon fishing in the fjord, and bag nets and hook nets are the most common legally applied fishing gear between 15 May and 4 August. The Tanafjord catch is approximately 15 % of the total catch of salmon in the sea in Finnmark (Kjell Moen, unpublished data).

MATERIAL AND METHODS

Harbour seals were counted in the Tana River Estuary by the same personnel one or several times in the period 3 July-15 October in the years 1988-91 and 1995. Both the total number of animals and the number of pups were recorded. In cases where the seals were counted several times in one day, the highest number was used as a minimum number. Counts on days where no animals were seen, are not included in the material. Harbour seals usually haul-out at low tide (Venables & Venables 1960), and the seals were, therefore, counted from the shore at low tide by use of binoculars and telescopes. Data on number of seals in the Tana River and the Tanafjord before 1988 are compiled from older literature, personal communications and our own unpublished materials.

Sixty eight salmon fishermen from the lower part of the Tana River that fish using drift nets, weirs and gill nets, received a questionnaire on 10 January 1995. A similar questionnaire was sent to an additional 59 salmon fishermen that use 116 locations in the Tanafjord on 7 September 1995 (Table 1). The questionnaire consisted of 14 questions divided into two parts. In the first part the fishermen were asked about their own experiences with seal interactions, and in the second part we asked about their opinions about several seal - fishery interactions/concerns. In questions where fishermen were

Figure 1. The Tana River estuary in the Tanafjord. ■ = Bag net test fishing stations, — = Area where the questionnaires were carried out.

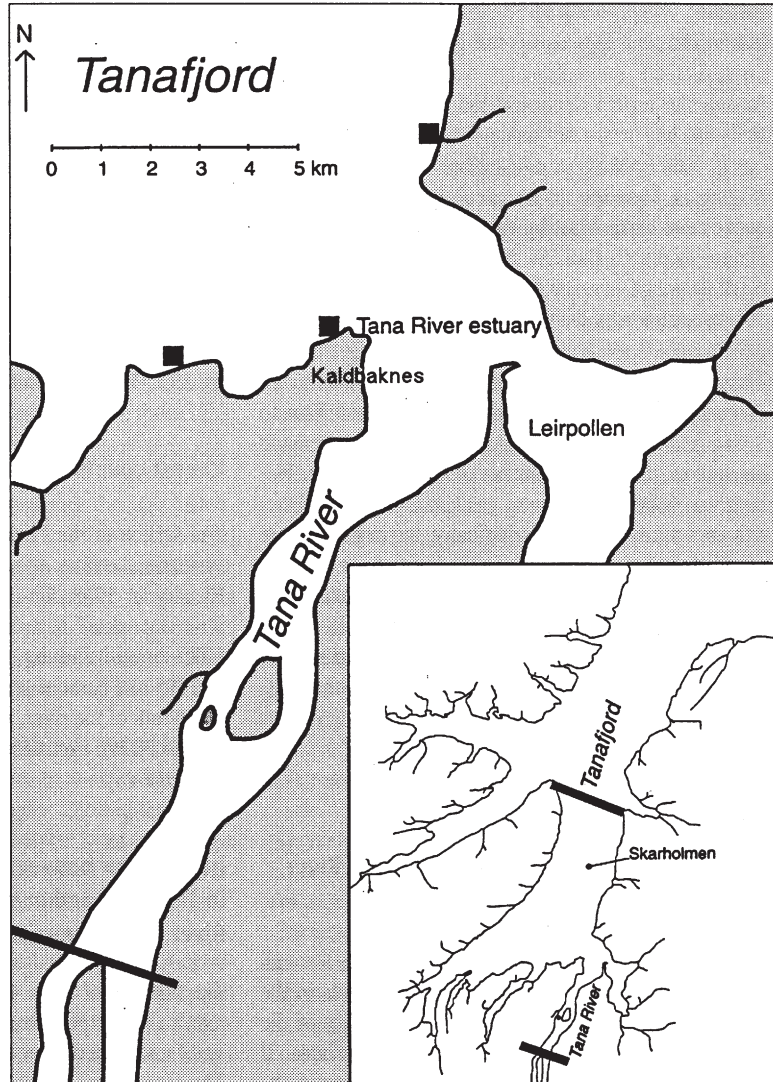


Table 1. Number of river- and fjord salmon fishermen who participated in the questionnaire.

	River fishermen	Fjord fishermen	River and fjord fishermen
Number asked	68	59*	127
Number of replies	46	46	92
In percent (%)	68	79	72

*59 fishermen that use a total of 116 locations

asked to compare a present situation with a situation before, the time span equals one generation.

In order to further document the interactions between seals and bag nets, a test fishing experiment was carried out in Tanafjord at locations close to the river mouth (Figure 1). The experiment was a secondary study in an experiment carried out by the Norwegian Institute for Nature Research (NINA) and the Office of the Finnmark County Governor designed to study migration of Atlantic salmon by use of radiotransmitters.

The test fishing was conducted from 21 June to 12 August during the 1995 salmon fishing season. One to 3 bag nets with mesh sizes of 40-45 mm were used throughout the whole duration of the experiment. Fishing was conducted even on weekends when the fisheries are usually banned. Periodically, the bag nets were guarded, and seals occurring in the bag nets or close by were shot at to keep them away. To prevent seals from taking too many salmon, the nets were controlled periodically 4-6 times per day and night. We noted salmon caught by seals and which parts of the fishes the seals had eaten.

RESULTS

The harbour seal population in the Tana River Estuary 1820-90

Table 2 summarises information that provides a rough estimate of the population size of harbour seals in the mouth of the Tana River. Although the quality of the information for different time periods is variable, it seems likely that the population was numerous in the 1820's. Relatively intensive hunting pressure occurred during the following decades, and in 1926 130 animals were reported caught during one day. A similar incident occurred in the 1930's (Table 2). Broch (1953) referred to a questionnaire in the early 1950's, where several people along the coast of Finnmark were asked about the abundance of grey and harbour seals. Nobody had seen harbour seals after the Second World War, and one person, who had spend his entire life hunting and fishing in Tanafjord and adjacent areas, assumed that the harbour seal population in eastern Finnmark was extinct (Broch 1953). However, people report cat-

ching of pups on the river mouth sandbanks in the 1960's when the population may have been at a low level. In July 1963, less than 40 animals were observed on the sandbanks (Table 2). Øynes (1964) described the decrease in the harbour seal population in Tana as very dramatic. In the early 1980's, 100-125 harbour seals seem to have had some relation to the Tana River Estuary. Females, males, pups and juveniles were reported to occur at this time. Henriksen & Haug (1994) interviewed harbour seal hunters, and estimated that an average of 14 animals may have been shot each year in the period 1980-85. The corresponding number for 1985-90 was 4 animals per year.

Recent counts of estuary seals

The Office of the Finnmark County Governor started systematic counts of harbour seals in the Tana River Estuary in 1988. Until 1991, the number of animals observed varied between 1 and 31. Similar counts in 1995 showed a minimum of 39 harbour seals (Table 3). In 1995 one harbour seal was shot in a bag net close to the mouth of the river, and two more where found dead 30 and 20 km upstream, respectively (K. Moen, unpublished data).

Interactions between seals and salmon fisheries in Tanafjord and in the lower part of the Tana River - questionnaire results.

The first part of Table 4, summarises the salmon fishermen's own experience with the interactions between seals and fisheries in the Tana River and Tanafjord. The second part of Table 4, shows the fishermen's opinions about several aspects of the problem in question.

It revealed that a majority of the fishermen had experienced that seals had been trapped in nets in the fjord, and that most of them were grey seals.

Test fishing with bag nets

During the test fishing with bag nets, interactions with seals were evident, and the results are shown in table 5. The head and fractions of the body were taken on 23 of

Table 2. Known numbers of harbour seals observed or shot in the Tana River Estuary during the last 175 years, based on written sources and personal communications.

Year	Number of shot, caught or observed seals	Source
ca. 1825	15 families shot 240 seals in 8 days	Helland 1905
1820-32	Caught seals in the river with nets, 120 seals in one catch	Fellmann 1906
1820-1910	50-100 seals shot per year by some hunters	Collett 1912
1916	The river was closed, but the catch was unsuccessful and gave only 10-15 harbour seals	Frantzen 1983
1926	126-130 seals caught in one day	Frantzen 1983
1927	40-50 seals caught	Frantzen 1983
1927	Several hundred seals killed	Øynes 1964
1930-ies	126 seals caught in one net	Olsen 1979
1949-53	A hunter in Tanafjord believes that the harbour seal is extinct in East-Finmark	Broch 1954
1960-ies	Caught several pups on the sandbanks	B.Johansen pers. comm
1963	30-40 harbour seals observed, 18 individuals on 17 July	Øynes 1964
1963	8 harbour seals shot at Lavonjarg (North of Leirpollen)	Øynes 1964
1977-89	30 harbour seals on the sandbanks	Bjørge 1993
1981	5 harbour seals observed on the 5 July	Bjørge et al. 1982
1981	8 harbour seals observed 28-29 October	Bjørge et al. 1982
1983	Almost 100 harbour seals in fall	Frantzen 1983
1984	Several harbour seals in the sea 9 March, impossible to count.	A. Ørjebu, pers. comm
1984	0 harbour seals found 10 April (aerial survey)	Øien 1984
1984	125 harbour seals observed in late October	S. Pavel pers. comm.
1984	120 harbour seals counted in November	A. Ørjebu, pers. comm
1984	10 - 15 harbour seals counted 15 December	A. Ørjebu, pers. comm
1986	100 harbour seals on the sandbanks	Bjørge 1986
1987	17 harbour seals observed the end of July	A. Ørjebu, pers. comm

Table 3. Number of harbour seals in the Tana River Estuary in 1988-91 and 1995. Number of pups in brackets.

Date	Jun		Jul						Aug			Sep		Oct		
	30	3	11	12	20	23	24	27	1	6	8	4	8	6	9	15
1988		11(4)	11(3)										21			
1989						13			12			7		16		
1990		2(1)			15(2)		15(3)									
1991		1	1	1	1	1									31	4
1995	18							35(1)		6	39					

Table 4. Results from the questionnaires among salmon fishermen in the Tana River and Tanafjord in Finnmark.

Question	Answer	River		Fjord		All	
		n	%	n	%	n	%
First part:							
Have you experienced seals trapped in your nets?	yes	8	17	36	78	44	48
	no	38	83	10	22	48	52
If yes, what species?	harbour seal	8	100	13	23	21	
	grey seal	0	0	24	43	24	
	harp seal			13	23		
	don't know	0	0	6	11	6	
Did the seal survive?	yes	8	17	5	14	13	16
	no	38	83	32	86	70	84
How often has this happened in the last 10 years?	once	5	63	5	14	10	23
	twice	3	38	13	35	16	36
	several times	0	0	18	50	18	41
Was there damage to the nets?	yes	5	63	29	78	34	76
	no	3	38	8	22	11	24
Have you experienced that seals have eaten fish already captured in the nets?	yes	24	52	42	93	66	73
	no	22	48	3	7	25	27
If yes, how often has it happened during the last 10 years?	once	3	13	2	4	5	8
	twice	13	54	14	31	27	41
	several times	8	33	26	58	34	52
Have you experienced that seals have made holes in the nets?	no			3	7		
	once			2	4		
	some times			14	31		
	many times			26	58		
Second part:							
Do you believe that seals scare salmon from entering the river?	yes	30	65	31	67	61	66
	no	7	15	2	4	9	10
	do not know	9	20	13	28	22	24
Do you believe that seals are a threat against the salmon stock?	yes	20	43	40	87	60	65
	no	12	26	2	4	14	15
	do not know	14	30	4	9	18	20
Do you have the impression that there were more seals before?	yes	18	39	12	27	30	33
	no	15	33	31	67	46	50
	do not know	13	28	3	7	16	17
Do you have the impression that the interactions between seals and fishery were bigger before?	yes	11	24	4	9	15	16
	no	21	46	36	80	57	63
	do not know	14	30	5	11	19	21
Do you believe that there is more human traffic in the area now than before?	no	6	13	15	33	21	23
	some	17	37	14	30	31	34
	much/very much	14	30	14	30	28	30
	do not know	9	20	3	7	12	13
Do you want to save or to eradicate the seals in the area?	save	21	46	14	30	35	38
	eradicate	12	26	27	59	39	42
	do not know	13	28	5	11	18	20

Table 5. Number of salmon caught, and number of trapped salmon partially eaten by seals in a test fishery with bag nets in Tanafjord in 1995.

Number of salmon	Salmon less than 3 kg	Salmon more than 3 kg	Sum
Captured	203	16	219
Partially eaten on by seals	31	4	35
In percent (%)	15	25	16

the 35 damaged salmon. Both harbour and grey seals were observed close to and inside the nets. Grey seals were observed most often, and they were also observed with salmon in their mouths at other locations in the area.

DISCUSSION

Harbour seals in Tana

Hunting of harbour seals prior to the 1960's may have reduced the breeding population in the Tana River Estuary (see Øynes 1964). Less than 40 individuals were counted from 1963-84. The low number of pups observed also suggest a small population size. The harbour seal counts conducted during this study from 1988-91 and in 1995 provide only minimum numbers. An unknown proportion of the seal population will always be in the water (Terhune & Almon 1983). Repeated counts are believed to improve the accuracy of the results. Counts in the moulting period are thought to give the most correct estimate of population size (Thompson & Harwood 1990). But such counts do not provide information about pup production due to difficulties in distinguishing pups and adults in the field at this time. Our results indicate that there are approximately 40 harbour seals in the Tana River Estuary.

When animal populations decrease, they may become fragmented and the risk for extinction will increase (Pimm 1991, Meffe & Carroll 1994). Small populations will be threatened by demographic and environmental stochasticity; the population will be reduced in size which will make it even more vulnerable to extinction. Genetic stochasticity may also play a part. Inbreeding reduces the genetic variation in the population, which makes it less able to meet unforeseen events.

Finally, environmental stochasticity may further reduce the population or make it go extinct (see Pimm 1991). Movements among fragments will reduce the risk for extinction and perhaps allow recovery of an isolated or endangered population.

What are the chances for the harbour seal population in the Tana River Estuary to survive? Bjørge et al. (1993) investigated this question by using theoretic probability models. These models assume that there will be no immigration to the colony. Bjørge et al. (1993) suggest that a theoretically stable population must consist of at least 50 individuals (25 females) if the population shall have 95 % probability to survive for 100 years. If this is correct, the harbour seal population in the Tana River estuary with its approximately 40 individuals (Table 3) will probably go extinct, if there is a 50:50 sex ratio and if there are no sources of immigration to the colony.

If, on the other hand, we suppose that there is immigration from other colonies in Finnmark (see Henriksen & Haug 1994) or from other more distant areas, why does the population not increase in numbers? Seventeen percent of the fishermen in the river had experienced harbour seals drowned in the nets, and, though the interactions between seals and salmon fishery in the fjord was bigger, only one of four seals drowned was a harbour seal (23 %). The number of seals hunted in the period 1980-85 and 1985-90 is estimated to be 70 and 20 individuals respectively (Henriksen & Haug 1994). This is a substantial take from such a small population and it is probable that it might have caused extinction if immigration had not been taking place.

In 1991, a nature reserve was established in the Tana River Estuary (Henriksen 1995), but we do not know yet if this will have any effect on the harbour seal

population in the area. Most fishermen believe that human traffic and disturbances have increased, both in the river and in the fjord. If the harbour seal stock in Tana is balanced by immigration from other colonies, it is evident that it must be vulnerable to any changes in environmental conditions (or hunting pressure in neighbouring recruitment areas) since it exists on the edge of extinction. In October 1994, an oilspill from a ship in Leirpollen (Figure 1), within the border of the protected area, polluted at least 6 km of the shoreline. We do not know how this affected the local harbour seals.

Interactions between seals and salmon fisheries

From the questionnaires, it appears that there are few interactions between seals and salmon net fisheries in the Tana River today, possibly because the number of seals are so low. Upstream, for instance near Storfossen 70 km from the outlet, some interactions are reported between seals and anglers. Local inhabitants (E. Mathisen and A. Pavel pers. comm.) describe incidents where harbour seals have taken hooked sea trout (*Salmon trutta*) during angling in the river near the estuary. Although many of the fishermen have the opinion that seals scare the salmon from entering the river and may be a threat to the entire salmon stock, there are still some support for protecting the harbour seal in the Tana River Estuary among fishermen.

Interactions between seals and salmon fisheries in the fjord seems to be a larger problem than in the river. A majority of the fishermen questioned had experienced seals trapped in the nets several times and reported that they had damaged the nets severely. The grey seal is the most common species caught in nets, and the destruction of nets by this species in its attempts to eat trapped fish or in trying to escape from entanglement is well documented (Rae 1960, Rae & Shearer 1965, Mansfield & Beck 1977, Bonner 1982). Results from a study in Central Norway, suggest that the grey seal causes more damage to fishing nets than the harbour seal (Korsen 1983).

Several seal species, including harbour and grey seals, may learn to steal fish from fishing nets (Bonner 1982). Harbour seals are known to steal salmon from nets both

in the North Pacific (Imler & Sarber 1947, Fisher 1952) and on both sides of the West Atlantic (Bonner 1982).

Almost all fishermen in the Tanafjord claimed that seals quite commonly prey on salmon already trapped in the nets or they make holes in the nets. The results from the test fishing with bag nets confirms the answers from the questionnaire. Holes were made in these nets due to seal attacks. Therefore, the number of damaged salmon counted in this study, is a minimum number, since salmon taken by seals outside the nets, or being carried away from the nets, were not registered.

Seal damage to salmon fisheries is also observed in other areas. In Central Norway 29,1 % of all salmon caught have marks indicating seal attacks (Korsen 1983). Fossum (1986), on the basis of interviews with salmon fishermen in Central Norway, estimated that approximately 4 % of all salmon caught were damaged by harbour seals. Harbour and grey seals are also reported to consume large amounts of commercial fish including salmon, which are often observed to have marks from seal attacks in Scottish waters (Rae 1960, Rae & Shearer 1965, Parrish & Shearer 1977, Potter & Swain 1979).

The grey seal population in Finnmark is viable, and immigration of animals from big colonies along the Murman coast in Russia are known to take place (Haug et al. 1994, Henriksen et al. 1996). The few individuals killed in salmon fisheries in Tanafjord are therefore unlikely to influence the size of the total grey seal population in the area. However, there are indications that the local breeding colony on Skarholmen in Tanafjord (Figure 1) may have disappeared (see Henriksen et al. 1993). This may be due to drowning in fishing nets, although disturbances caused by increased human traffic in the fjord may have an additional effect. According to Øritsland (1990), approximately 6 % of grey seal pup mortality may be due to drowning in fishing nets. Grey seals migrate a lot during the summer months (Henriksen 1995, Henriksen et al. 1996), and most of the grey seals in Tanafjord probably have their breeding and moulting sites in other areas (Haug et al. 1994).

Even though 23 % of all the seals reported drowned in nets in Tanafjord are harp seals, this probably means

little for the total population of this species which must be regarded as numerous whether they belong to the Greenland Sea (West Ice) or the Barents Sea (East Ice) population (Haug & Nilssen 1995).

Apparently, the salmon fisheries in Tanafjord have the most severe effect on the harbour seals, in particular the local colony in the river outlet. Twenty-three percent of the seals that drowned during salmon fisheries in the fjord were harbour seals, and adding other factors such as drowning in nets in the river, disturbances and hunting, an extinction of the local breeding population in the Tana River Estuary may be inevitable unless changes occur in the near future.

Interactions between seals and salmon fisheries in the sea, are not unique to Tanafjord. In a questionnaire of salmon fishermen along the coast of Finnmark in 1981, 57 % said that grey seals were a big, or very big problem for salmon fisheries (Rikstad & Ørjebu 1982). During a test fishing experiment with bag nets in 1995 in a fjord to the west of Tanafjord (Laksefjord), the net was visited by seals daily after 5 June (Hansen 1996). Salmon remains were found in the net mesh, and damaged nets (with holes 1 metre across) were observed. Alderdice et al. (1954) observed that parts of marine-mammal skins, particularly from harbour seals and sea lions, released alarm reactions in Pacific salmon, and Bonner (1989) believes that dead seals, or even the smell of seals, in a net, may prevent salmon from entering the net. Interactions with seals are primarily an economical loss for the fishermen (e.g. Bonner 1982, Korsen 1983), but they also represent a logistic problem. The fact that seals are frequently trapped in nets, damage nets or eat the salmon already caught, are most likely the main reason why a majority of the fishermen in the Tanafjord want to eradicate the seals.

We do not know of any successful attempt to reduce interactions between seals and salmon fisheries. Hall (1995) discussed the possibility of reducing fishing intensity in order to reduce bycatches. Hansen (1996) claimed that he got rid of the problem with seals by scaring them using sounds of high intensity. However, seal scaring sounds have proved to be ineffective for several reasons; seals habituate to the sounds and individual animals exhibit different tolerance for the sounds or the intensity is not strong enough to scare the

seals away (Geiger 1985, Anderson & Hawkins 1978). Scaring seals by sound has also been attempted with variable success close to sea farms (Altman 1991). Sounds from killer whales *Orcinus orca* have failed to scare seals away permanently in river outlets (Andersen & Hawkins 1978) or at sea (Riedman 1990). Killing seals in the net or close to the net may have an effect in the short run (Bonner 1994), but with the present size of the grey seal population, this will not solve the problem in the long run. Scaring seals with shots may help, but experiences from sea farms show that the seals quickly habituate to the noise.

ACKNOWLEDGEMENTS

We thank Kit Kovacs, Arne Bjørge and Tore Haug for valuable comments on the manuscript.

SAMMENDRAG

Konflikter mellom sel og laksefiske i Tanaelva og Tanafjorden og konsekvenser for den lokale steinkobbebestanden

I begynnelsen på 1800-tallet, var det en relativt stor bestand av steinkobbe i munningen av Tanaelva i Finnmark. Bestanden ble redusert dramatisk etter hard beskatning, både i 1920- og 1930-åra, og i dag er det sannsynligvis mindre enn 40 individer tilbake. Det er få konflikter mellom steinkobbe og laksefiske i elva, sannsynligvis p.g.a. liten bestand av steinkobbe. Kun 17 % av fiskerne hadde opplevd at steinkobbe hadde druknet i garn i elva. Fjordfiskerne opplevde størst konflikter med havert, men steinkobbe og grønlandssel var også vanlig å finne i garn. Under et forsøksfiske med kilenøter, hadde 16 % av laksen merker etter angrep fra sel.

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