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Age, sex and body condition of Baltic grey seals: Are problem seals a random sample of the population?

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The increasing Baltic grey seal (*Halichoerus grypus*) population causes considerable damage to coastal fisheries. The aim of the present study was to compare the age, sex and blubber thickness of seals that cause problems to coastal fisheries (i.e. by-catch seals and those shot near the fishing gear) with those killed during regular hunting. This knowledge is essential for population management. We collected seal samples from hunters and fishermen from Finland, Sweden and Estonia in 2011–2013. Hunted seals included individuals of all age classes, whereas most by-catch seals were small pups (in spring) or sub-adult and adult males (in autumn). By-catch seals had a thinner blubber layer than hunted seals. Most seals shot near the fishing gear were adult males in good condition. The 'problem seals' were thus not a random sample of the population. We suggest that hunting should be targeted especially at males to mitigate the damage to fisheries without threatening the population.

Introduction

The Baltic grey seal (*Halichoerus grypus*) population has increased since 1990 at an annual rate of 5.8%–8.5% (Harding *et al*. 2007, Ahola & Kauhala 2015), and the number of counted grey seals during aerial surveys exceeded 32 000 in 2014 (Ahola & Kauhala 2015). The increasing Baltic grey seal population has caused problems to coastal fisheries during recent decades. Seals destroy fishing gear and rob fish from gill and trap nets. The damage caused by seals to fisheries may be considerable, including both visible catch losses such as partly eaten fish and hidden losses when fish are scared away or removed entirely without leaving any visible fish remains in the net (Jounela *et al*. 2006, Königson *et al*. 2007, Bruckmeier & Larsen 2008). Hidden losses can account for about one third of the potential total catch as estimated for the inshore gillnet fishery in the central Baltic Sea (Königson *et al*. 2007).

After a period of protection, Baltic grey seals have been hunted in Finland since 1998 and in Sweden since 2001. The annual hunting quota in Finland (including the Åland islands) is 1500 individuals, and the annual catch has increased from some tens in 2000 to 260–620 in recent years (Finnish Wildlife Agency 2013, Ålands landskapsregering 2013). In Sweden, the annual quota is about 200, and the catch has been > 100 grey seals per year since 2009 (Bäcklin & Moraeus 2013). Seals are not hunted in Estonia.

Hunting usually takes place in the latter half of April and May from the ice, or in late summer and autumn in the outer archipelago or around fishing gear near the coast. One aim of the hunt is to diminish the damage seals cause to coastal fisheries. Furthermore, keeping ancient seal hunting traditions alive and making use of seals as a resource are considered important by some seal hunters. To plan how to mitigate seal-induced damage to coastal fisheries (e.g. to optimize hunting) it is essential to identify the age and sex of seals that cause most of the problems in each season (Linnell *et al.* 1999). Knowledge of their body condition is also important: whether they are in normal or poor condition. Hunger may drive seals in poor condition to rob fish from fishing gear. Furthermore, trap nets are located at sites known to be favoured by fish, and the leading nets of a trap net gather fish from a wide area, further increasing fish density near the entrance of the gear: this obviously attracts seals to forage there.

On the other hand, unknown numbers of seals drown as by-catch in the fishing gear each year (e.g. Read *et al.* 2006, Harding *et al.* 2007, McClellan *et al.* 2009), and conservation of the seal population requires accurate information about human-induced mortality (both hunting and by-catch) on seal populations. Earlier studies suggested that the number of by-catch seals in the Baltic Sea might exceed 1000 per year (Lunneryd & Westerberg 1997, Harding *et al.* 2007). A recent estimate is about 2000 per year (Vanhatalo *et al.* 2014), which points to the conclusion that drowning in fishing gear is the most common human-induced mortality factor for grey seals, especially for pups during their first months of life (Bjørge *et al.* 2002). Knowledge on the demographic structure and body condition of hunted and by-catch seals is essential when estimating the impact of human-induced mortality on the seal population because the impact depends on the quality, not only the quantity, of the catch.

The aim of the present study was to compare the sex ratio, age distribution, body condition and size of grey seals hunted during regular hunting, which mainly takes place in the outer archipelago (from ice in spring or small islets in autumn), shot in the vicinity of fishing gear, and by-catch in the fishing gear (usually trap nets) near the coast. As indicated by earlier studies, we predicted that (1) by-catch grey seals tend to be pups, especially in spring after weaning (e.g. Bjørge *et al.* 2002, Bäcklin *et al.* 2011), (2) most 'problem seals', i.e. those shot near the fishing gear or by-catch in the fishing gear, are males (Bäcklin *et al.* 2011); and (3) by-catch seals are in poorer condition than hunted seals mainly hunted in the outer archipelago (Bäcklin *et al.* 2011). Our purpose was thus to identify seals that cause most of the conflicts with coastal fisheries, because this information is essential for seal population management, i.e. diminishing the damage to coastal fisheries without threatening seal populations.

Material and methods

Data collection and sampling procedure

We collected samples of grey seals (total n = 285) from hunters and fishermen from Finland (n = 180), Sweden (n = 72) and Estonia (n = 33) in 2011–2013 (Fig. 1, Table 1, Appendix). The seals sampled during regular hunting (from ice in spring or usually from small islets in autumn), are hereafter called 'hunted' (n = 141) to separate them from seals shot in the vicinity of fishing gear, mainly trap nets used in coastal fisheries ('shot', n = 26). These seals were seen repeatedly swimming around the trap nets, and fishermen considered that they caused problems by stealing fish, destroying the gear and scaring fish away from the gear. We thus asked the hunters to report on where the seal was killed, i.e. was it 'hunted' or 'shot'. The third group consisted of seal by-catch in the fishing gear (n = 118, 86% of them drowned in trap nets, the rest in gill nets).

The hunting season in Finland and Sweden lasts from 16 April to 31 December, except on the island of Åland where it continues until 31 January. Seals are not hunted in Estonia. Therefore, we only received by-catch seals from region ICES SD 28 (Fig. 1).

The samples of seals from Finland and Estonia and those of hunted seals from Sweden included the lower jaw and reproductive organs. Samples of by-catch seals from Sweden were collected during full necropsies at the Swedish Museum of Natural History (SMNH). We used the lower jaw to verify the seal species. The age of seals was determined from histological sections of lower canine teeth (e.g. Mansfield 1991). Sex was verified from reproductive organs. Hunters and fishermen or SMNH staff also measured the length of the seals (to the nearest cm) from the tip of the nose to the tip of the tail. The thickness of the subcutaneous blubber layer from the posterior end of sternum was also measured (to the nearest mm) by hunters and fishermen or by the researchers (depending on whether we received samples of the seals or the whole seal). An earlier study (Bäcklin *et al.* 2011) showed no significant difference in the measurements of blubber thickness taken by hunters and personnel in the laboratory.

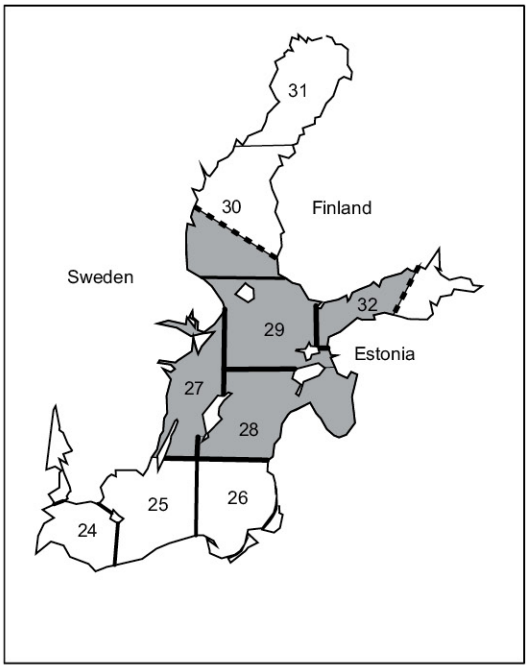

Fig. 1. Samples of grey seals were collected from ICES SD areas 27–29, 32 and southern part of SD 30.

Statistical analyses

Differences in sex ratios and age structures were analysed with the χ^2-test (cross tabulations). Demographic structures of the samples were studied separately for spring (April–June) and autumn (July–December), because the behaviour of seals differs greatly between seasons.

In the Baltic Sea, grey seals give birth, mainly on drift ice, in February or March (Jüssi *et al.* 2008). In April pups have been weaned and start their independent life. Grey seals moult in late May–early June in the outer archipelago (Hiby *et al.* 2007). In late summer and autumn they move longer distances when foraging and gather fat reserves (Karlsson *et al.* 2005).

When we compared the age structures of different seal groups (hunted, shot, by-catch) in spring and autumn samples, we used three age groups: pups (< 1 year old), subadults (1–4 years old) and adults (≥ 5 years old). The mean killing date of hunted seals in spring was 7 May, that of by-catch seals 28 April and that of seals shot near fishing gear 22 May. The corresponding values for autumn samples were 10 October for hunted, 16 October for by-catch, and 23 October for shot seals.

The factors affecting blubber thickness and body length were analysed with ANOVA. The

Table 1. Samples of Baltic grey seals obtained from hunters and fishermen from different areas (ICES SD) in 2011–2013. We classified the samples into three groups: seals hunted during normal hunting mainly from the outer archipelago ('hunted'), those shot near the fishing gear ('shot') and by-catch in the fishing gear usually near the coast.

ICES SD	Hunted	Shot	By-catch	Total
27	15	2	26	43
28	0	0	28	28
29	35	7	11	53
30	47	12	17	76
32	44	5	36	85
Total	141	26	118	285

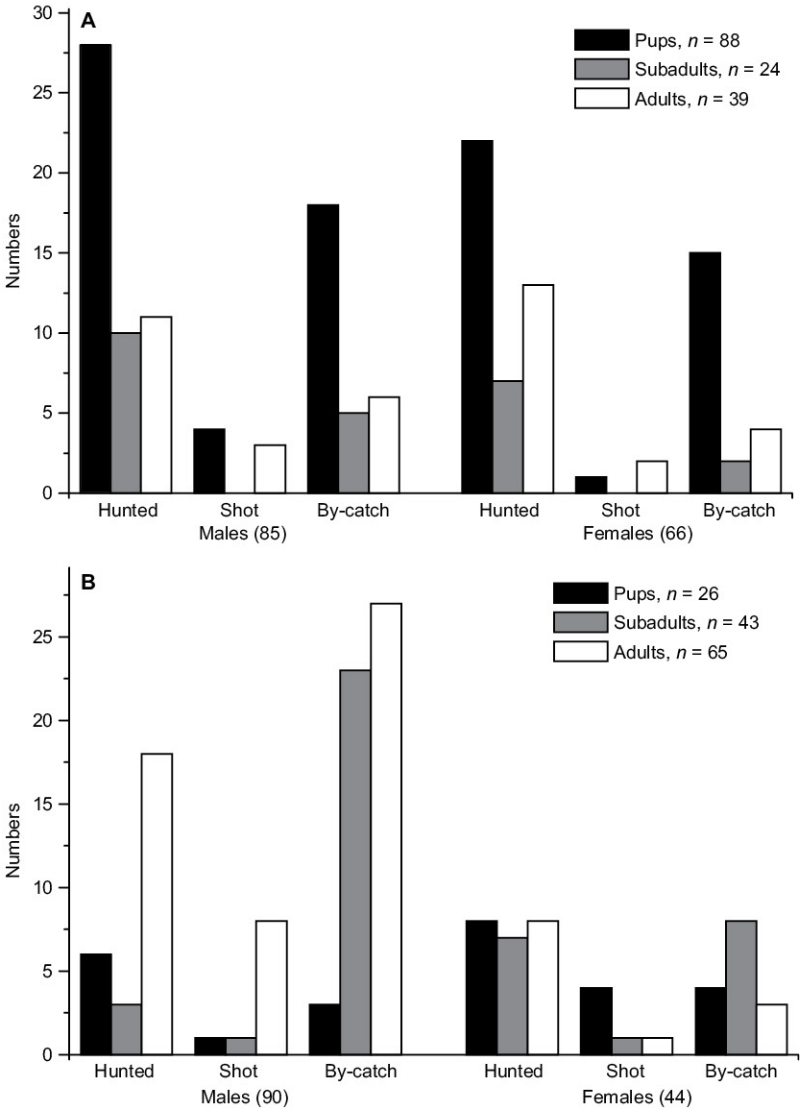

Fig. 2. Numbers of Baltic grey seals of different age-groups killed during regular hunting, shot near fishing gear and by-catch in fishing gear in (**A**) spring (April–June, n = 151) and (**B**) autumn (July–December, n = 134).

independent variables included were seal group (hunted, shot, by-catch), age group (pup, subadult, adult), sex (male, female), and month. Because the main interest was in the differences between the seal groups (hunted, shot, by-catch) within age groups (especially pups in spring and adult males in autumn, *see* Fig. 2) pre-specified contrasts (t-test) were performed without adjustment. We excluded samples from ICES SD 28 from these analyses (comparison between the seal groups) because we received only by-catch seals from the area (Estonia). Assumptions of normal distribution were checked from residuals after the analysis of variance with a Kolmogorov-Smirnov test. Statistical analyses were conducted with SYSTAT 13 (Systat software, Inc., Chicago, IL, USA).

Results

Demographic structure of the samples

In the whole data set (n = 285) there were more males than females: sex ratio (males/females) was 1.59 (Table 2). The sex ratio dif-

fered between seal groups being highest (most male biased) in the sample of by-catch seals, and higher among by-catch seals drowned in autumn than among those drowned in spring. The sex ratio of other seals did not differ between seasons. The sex ratio was thus lowest in the sample of hunted seals and highest in the sample of by-catch seals in autumn (Table 2).

In the whole data set, age structures differed significantly between hunted, shot and by-catch seals (χ^2 = 73.5, df = 54, p = 0.040; Fig. 2, Appendix). The proportions of pups, subadults and adults did not differ significantly in spring (April–June; χ^2 = 5.9, df = 4, p = 0.208; Fig. 2A) but they differed in autumn (July–December; χ^2 = 14.6, df = 4, p = 0.006; Fig. 2B). The difference was, however, significant only for males (males: χ^2 = 13.7, df = 4, p = 0.008; females: p = 0.289). Most hunted and shot males in autumn were adults, whereas among by-catch males there were both subadults and adults. Consequently, the age structure of the seals (pooled for both sexes) differed between seasons (χ^2 = 44.8, df = 2, p < 0.001). The proportion of adults (49%) and subadults (32%) was greater in autumn, whereas the proportion of pups (58%) was greater in spring.

In an earlier study the age structure of the Baltic grey seal population was estimated using a life-table analysis based on seal samples (mainly hunted) from the Finnish sea area in 2005–2009 (Kauhala *et al*. 2012). A comparison between the age structures of samples in the present study and the age structure of the population according to the previous study indicated that pups were overrepresented, especially in the samples of females and hunted males, whereas subadults were underrepresented in the samples of hunted and shot seals (Fig. 3). Adult females were underrepresented in all samples (Fig. 3A) whereas the proportion of adult males shot near fishing gear was higher than the proportion of adult males in the population (Fig. 3B).

Body condition and size

The mean subcutaneous blubber thickness in the total data was 38.6 mm (SD = 12.92, n = 273). Blubber thickness was lowest in June and thickest in November (t-test, all seals: t_{59} = 5.7, p < 0.001; adults: t_{26} = 4.7, p < 0.001; Fig. 4). The mean and median values of blubber thickness and body length for the samples of different seal and age groups are given in Table 3.

Results of ANOVA indicated that seal group, month, the interaction between month and age group, and that between sex and age group significantly affected blubber thickness (Table 4). Age group and the interaction between sex and age group affected the body length of seals (Table 4). Because most 'problem seals' (by-catch or shot) were either pups or adult males (Fig. 2), we examined especially the blubber thickness and body length of these two groups.

The blubber layer of by-catch and shot pups was thinner than that of hunted pups (Figs. 5 and 6, Table 5) and by-catch pups had less blubber than those shot near the fishing gear. By-catch pups were also shorter than hunted or shot pups (Table 5). By-catch adult males had less blubber than hunted or shot ones (Figs. 5 and 6, Table 5). Hunted adult males were the longest, whereas those shot near the fishing gear were shorter than other adult males (Table 5). Therefore, we examined the age distribution of adult males belonging to different groups: hunted adult males were older (median 10.0 years, mean ± SD = 11.3 ± 4.90, range 5–26) than shot (median 6.0 years,

Table 2. Sex ratio (males/females) in samples of Baltic grey seals of different groups in spring (April–June) and autumn (July–December). Sample sizes are given in parentheses.

	Hunted	Shot near fishing gear	By-catch	Total
Spring	1.17 (91)	2.33 (10)	1.38 (50)	1.29 (151)
Autumn	1.17 (50)	1.67 (16)	3.53 (68)	2.04 (134)
Between seasons		p = 0.696	χ^2 = 5.4, df = 1, p = 0.020	χ^2 = 3.5, df = 1, p = 0.060
Total	1.17 (141)	1.89 (26)	2.28 (118)	1.59 (285)
				Between seal groups: χ^2 = 6.8, df = 2, p = 0.034

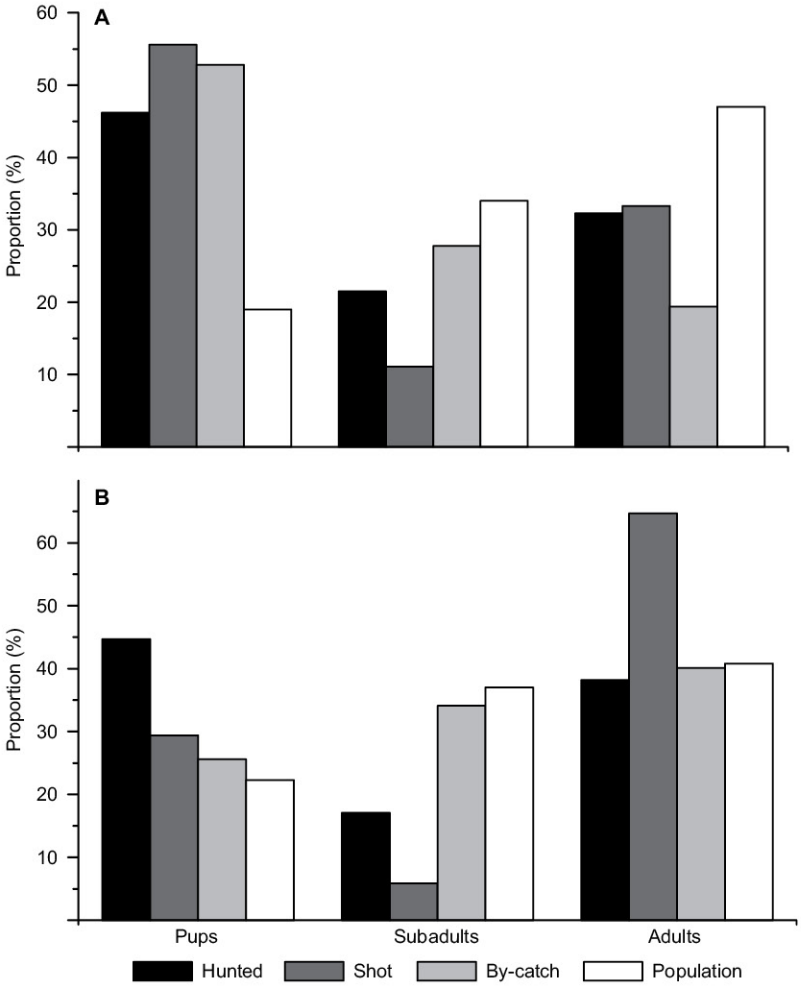

Fig. 3. Comparison between the age structures of (**A**) female and (**B**) male grey seals that died of different causes in the present study and the age structure of the population estimated in a previous study (Kauhala *et al.* 2012).

mean ± SD = 8.8 ± 6.27, range 5–25) or by-catch adult males (median 6.0 years, mean ± SD = 9.6 ± 6.10, range 5–34; Kruskal-Wallis analysis of variance, $p = 0.040$).

Discussion

Demographic structure and blubber thickness of problem seals

As predicted, most 'problem seals' were by-catch pups in spring, and subadult and adult males in autumn, and by-catch seals had a thinner blubber layer than other seals.

In spring, pups are inexperienced and just learning to catch fish, and hence move a lot and get easily caught in fishing gear (Bjørge *et al.* 2002). By-catch grey seal pups had less blubber and were smaller in size (in spring) than hunted pups. We suggest that the leanest and smallest pups are most often caught in fishing gear, probably because they are driven to search for food in fishing gear due to hunger, i.e. animals with smaller energy stores are more prone to take risks when foraging than animals of normal body condition. Risk-prone foraging behaviour of animals with smaller body reserves has also been observed in other species (e.g. Damsgird & Dill 1998).

There were more males than females among the by-catch seals, especially among subadults and adults (Fig. 2). This is a common feature of many mammals: the mortality rate of males is often higher than that of females (e.g. Clutton-

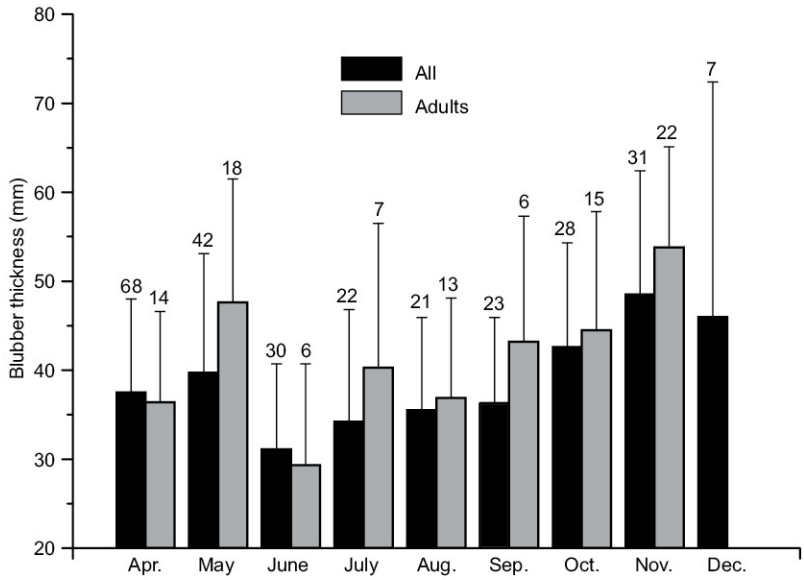

Fig. 4. Seasonal variation in the measured values of the subcutaneous blubber layer of Baltic grey seals (mean ± SD, n = 272). Sample sizes are given above the line segments. Data for both sexes and different age groups were pooled.

Table 3. Blubber thickness (mm) and body length (cm) in the samples of Baltic grey seal pups, subadults and adults killed during regular hunting, shot near the fishing gear or by-catch in the fishing gear in spring (April–June) and autumn (July–December). Seals from ICES SD 28 were excluded because only by-catch seals were received from the area. Data for subadults shot near fishing gear and by-catch in spring were excluded due to a small number of samples ($n < 4$).

	Blubber thickness				Body length			
	Mean ± SD	Median	Range	*n*	Mean ± SD	Median	Range	*n*
Pups								
Hunted								
spring	37.5 ± 9.5	40	10–60	42	115 ± 13.3	114	91–146	37
autumn	34.7 ± 10.8	35	8–50	14	124 ± 7.5	125	107–131	13
Shot								
spring	29.6 ± 6.1	30	20–37	5	116 ± 11.8	120	104–132	5
autumn	33.4 ± 4.2	32	30–40	5	124 ± 10.9	123	108–136	5
By-catch								
spring	24.8 ± 7.3	25	14–40	12	107 ± 12.0	108	85–126	13
autumn	30.2 ± 3.3	30	25–35	6	124 ± 3.2	123	120–129	7
Subadults								
Hunted								
spring	36.2 ± 11.0	40	15–50	17	149 ± 14.7	150	110–171	17
autumn	45.5 ± 12.8	45	30–70	10	149 ± 14.2	152	119–167	10
By-catch								
autumn	33.6 ± 8.5	31	20–60	30	156 ± 13.1	154	129–194	30
Adults								
Hunted								
spring	46.5 ± 12.4	45	30–70	24	181 ± 22.4	186	120–210	24
autumn	51.1 ± 14.7	50	28–80	26	186 ± 27.1	190	78–233	26
Shot								
spring	32.5 ± 6.5	33	25–40	4	179 ± 35.1	170	148–232	5
autumn	56.8 ± 17.2	54	35–95	8	176 ± 11.5	180	160–196	9
By-catch								
spring	28.0 ± 13.7	29	12–50	7	184 ± 19.5	190	150–198	5
autumn	39.5 ± 11.8	39	17–60	30	186 ± 17.1	187	142–230	29

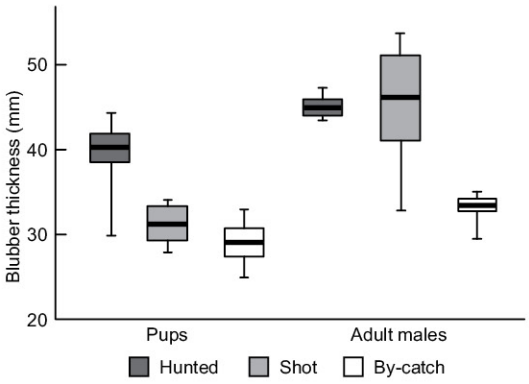

Fig. 5. Model-predicted values of the blubber thickness of pups and adult males of different seal groups. Means, 95% confidence limits (box) and ranges are shown.

Brock *et al.* 1982, Hall *et al.* 2001, 2002). The higher mortality rate of males in Baltic grey seals was shown also by life tables in an earlier study (Kauhala *et al.* 2012). The grey seal is a sexually dimorphic species, with males larger than females, which might lead to an increased energy demand for males: they need more food than females and thus in bad times may suffer more than females from scarcity of food (Clutton-Brock *et al.* 1982). Males therefore might have more to gain using a more profitable, albeit dangerous, foraging strategy. Females are generally more cautious than males, and especially adult females were underrepresented in our samples compared with the population.

In autumn, most by-catch seals were subadult and adult males, which were in poor condition as compared with other adult males. Reasons for the thin blubber layer of by-catch adult males are not clear but may include different long-term diets between male groups. It is known that intraspecific variation in the foraging behaviour and diet does occur in grey seals (Beck *et al.* 2007). Preliminary results based on fatty acid composition of Baltic grey seals suggest that the proportion of herring (*Clupea harengus*) in the diet of by-catch adult males is greater than that in the diet of other adult males (R. Käkelä & K. Lundström unpubl. data). Small fish are perhaps not a good energy source for large seals: seals have to spend much time and energy on foraging to catch enough small fish to fulfill their energy requirements. Perhaps these thin males are subordinate individuals that do not have access to the best foraging areas with larger fish. The hungry seals in poor condition may become reckless and enter the traps easier than seals in good condition. Furthermore, since many fish traps used in the Baltic Sea have gates or physical barriers to prevent seals from entering the trap in order to reduce seal induced damage, seals in good condition (larger girth) may have difficulty entering the traps.

Most seals shot near fishing gear were adult males, which were overrepresented in our samples as compared with the population. These males may be more cautious and experienced than the by-catch in the trap nets (many of the by-catch males in autumn were indeed subadults which may be less experienced than adult males). Some adult males may have specialized in catching fish from fishing gear and have learnt how to avoid being trapped. Adult males are also

Table 4. The effects of different variables and their interactions on blubber thickness and body length of Baltic grey seals (ANOVA). Seal group: hunted during regular hunting, shot near fishing gear or by-catch in fishing gear. Age group: pups (< 1 year old), subadults (1–4 years old) and adults (> 4 years old). Significant differences are indicated with boldface.

Effect	df	*F*	*p*
BLUBBER THICKNESS			
Seal group	**2, 225**	**5.5**	**0.005**
Age group	2, 225	2.1	0.119
Month	**1, 225**	**23.2**	**< 0.001**
Sex	1, 225	0.04	0.840
Seal group × age group	4, 225	0.2	0.930
Seal group × month	2, 225	2.3	0.106
Sex × seal group	2, 225	0.7	0.506
Age group × month	**2, 225**	**7.8**	**0.001**
Sex × age group	**2, 225**	**5.0**	**0.007**
Sex × month	1, 225	0.2	0.662
BODY LENGTH			
Seal group	2, 219	0.5	0.618
Age group	**2, 219**	**34.3**	**< 0.001**
Month	1, 219	2.0	0.154
Sex	1, 219	2.7	0.105
Age group × seal group	4, 219	0.8	0.504
Seal group × month	2, 219	0.7	0.510
Sex × seal group	2, 219	0.1	0.865
Age group × month	2, 219	2.9	0.058
Sex × age group	**2, 219**	**7.0**	**0.001**
Sex × month	1, 219	0.1	0.738

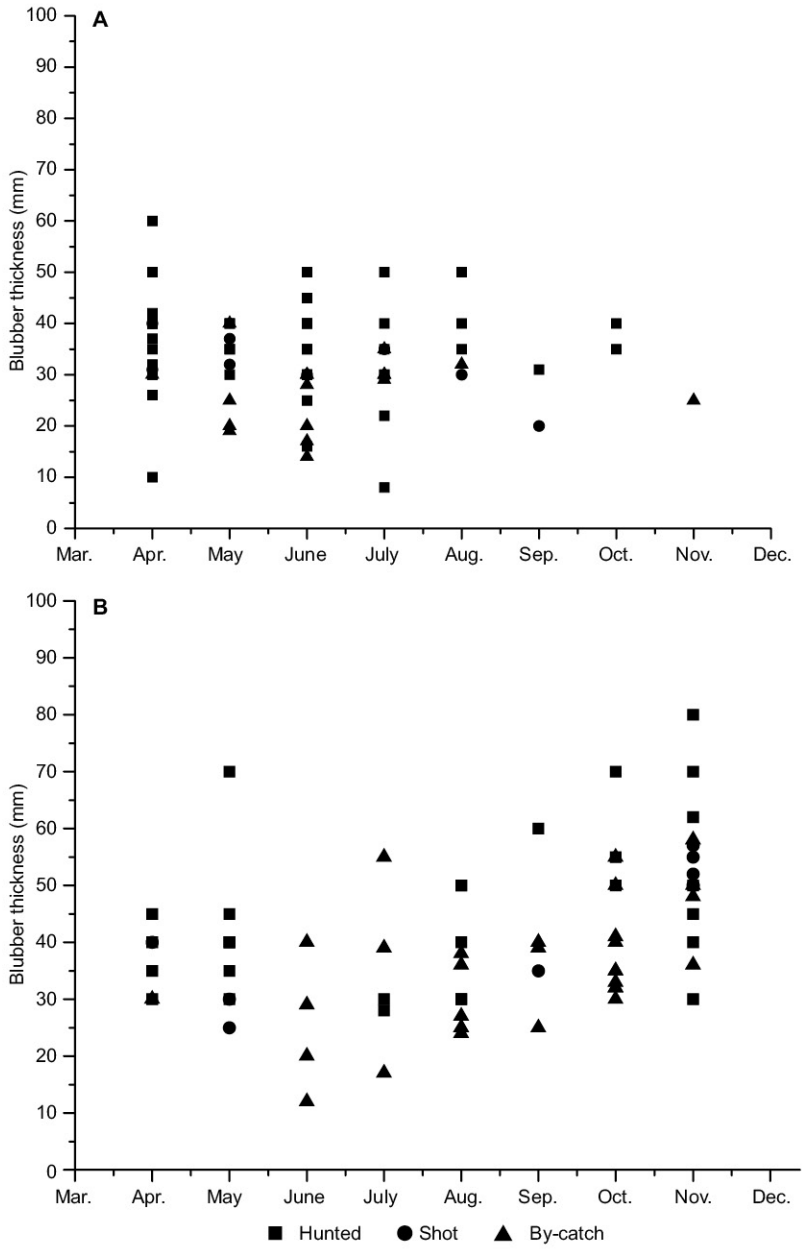

Fig. 6. Original data on the blubber thickness of (**A**) pups and (**B**) adult males.

most often involved in depredation events among other large carnivores (e.g. Linnell *et al*. 1999). In the UK, a small proportion of grey seals specialized in using rivers and had a greater impact on salmon fisheries than other seals (Graham *et al*. 2011). Königson *et al*. (2013) also found that some grey seals specialize in raiding salmon traps. Recent studies of GPS-marked grey seals in the Baltic Sea (Lehtonen *et al*. 2013) suggest that individual male grey seals concentrate on feeding around fishing gear. These seals were, however, captured in traps and therefore did not represent a random sample of the population. Our data showed that the mean age of shot adult males was lower (most were 5–7 years old) than that of other adult (mature) males, i.e. they were the youngest among mature males.

Recommendations for seal population management

The 'problem seals' were not a random sample of the population. Most were pups and subadult and adult males, and by-catch seals were in poor condition as compared with other seals. To mitigate damage to fisheries, hunting should be done more often during autumn near fishing gear to selectively remove those adult males that most often rob fish in the vicinity of the gear. More research on long-term diet and movement patterns, however, is needed to determine whether only some individual males are specializing in taking fish from the fishing gear, and how to identify these individuals. Seal-safe trap nets should be used when possible to decrease the number of by-catch seals and the harm they cause in the gear (Hemmingsson *et al.* 2008).

The impact of human-induced mortality on seal populations depends not only on the numbers but also on the quality of removed individuals, because reproductive value varies with age and sex, i.e. all individuals are not equally important in the population. By-catch mortality may not be totally additive to natural mortality, because small pups in poor condition are expected to have lower survival rates (and thus a lower reproductive value). Also, by-catch adult males were in poor condition and hence their reproductive value may be lower because the grey seal is a polygynous species with a dominance hierarchy among males (Lidgard *et al.* 2008). The growth rate of the Baltic grey seal population has been positive for almost three decades and thus by-catches at the present level do not pose a serious threat to the population. However, the drowning of several hundred up to two thousand seals in the Baltic Sea each year is a serious ethical problem.

When planning population management we must not rely entirely on population growth rate, population size and numbers of removed seals (both hunted and by-catch) but we also need to know the demographic structure and body condition of the population and that of the catch (Kokko *et al.* 1997). Forty-two percent of hunted mature seals were females (Fig. 2) which are valuable for the population as their numbers largely determine the number of pups produced. Hunted adult males were in good condition and therefore likely belonged to the reproducing part of the population. The impact of hunting on population growth rate thus partly depends on the proportion of adult seals hunted. However, younger females are also important to the population, because they are the future reproducers: population growth rate is sensitive to the survival rate of females < 10 years of age (Harding *et al.* 2007). Especially, female pups were overrepresented in our samples compared to the population (Fig. 3), which after a time-lag of a

Table 5. Estimated differences (pre-specified contrasts, *t*-test) in blubber thickness and body length between the seal groups (hunted during regular hunting, shot near fishing gear or by-catch) among pups (< 1 year old) and adult males (> 4 years old).

Age group	Sex	Seal groups	Estimated difference	*t*	df	*p*	95%CL
Blubber thickness (mm)							
Pups	Both	Hunted *vs.* shot	9.1	9.8	17.64	< 0.001	7.1–11.0
Pups	Both	Hunted *vs.* by-catch	11.6	11.2	31.22	< 0.001	9.5–13.8
Pups	Both	Shot *vs.* by-catch	2.6	2.1	26.87	0.041	0.1–5.0
Adults	Males	Hunted *vs.* shot	–0.9	–0.4	10.27	0.713	–6.2–4.4
Adults	Males	Hunted *vs.* by-catch	12.1	32.2	32.25	< 0.001	11.4–12.9
Adults	Males	Shot *vs.* by-catch	13.0	5.5	10.24	< 0.001	7.8–18.3
Body length (cm)							
Pups	Both	Hunted *vs.* shot	–2.3	–2.5	18.24	0.024	–4.2 to –0.3
Pups	Both	Hunted *vs.* by-catch	4.3	4.3	33.90	< 0.001	2.3–6.3
Pups	Both	Shot *vs.* by-catch	6.5	5.7	26.05	< 0.001	4.2–8.9
Adults	Males	Hunted *vs.* shot	13.4	6.3	10.56	< 0.001	8.7–18.1
Adults	Males	Hunted *vs.* by-catch	5.8	14.0	49.41	< 0.001	5.0–6.7
Adults	Males	Shot *vs.* by-catch	–7.6	–3.6	10.24	0.005	–12.2 to –2.9

few years may lead to a decreasing number of mature females. Hunting should thus be focused on males to prevent a population decline. Distinguishing between males and females, especially in the younger age groups, is very difficult in the field, and therefore the number of hunted seals should be kept at the present level.

Blubber thickness as an indicator of body condition

Sternum blubber thickness has been used as an indicator of body condition of grey seals by e.g. HELCOM (Bäcklin *et al*. 2013). However, blubber thickness was smaller among by-catch seals than among other seals and varied according to season, being smallest in early summer and increasing thereafter especially among adult seals. The pattern of seasonal changes in energy storage or blubber thickness is similar for all phocid seals and has been observed in both ringed seals (*Phoca hispida*; Ryg *et al*. 1990) and grey seals (Sparling *et al*. 2006, Hauksson 2007). Furthermore, differences between age groups are evident, and therefore, if blubber thickness is used as an indicator of body condition of Baltic grey seals, we suggest that age and month should be taken into account. By-catch seals and pups should be excluded. Blubber thickness of pups should not be used as an indicator because of the great variation in their predicted values.

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Appendix. Numbers of hunted, shot and by-catch Baltic grey seals of different ages.

Age (years)	Hunted	Shot	By-catch	Total
0	64	10	40	114
1	12	0	6	18
2	4	1	9	14
3	4	0	12	16
4	7	1	11	19
5	3	5	11	19
6	4	1	6	11
7	4	2	1	7
8	1	0	1	2
9	7	1	1	9
10	4	1	4	9
11	4	0	1	5
12	4	0	0	4
13	4	1	3	8
14	2	1	0	3
15	0	0	4	4
16	3	0	2	5
17	1	0	1	2
18	1	1	0	2
19	1	0	1	2
20	1	0	1	2
21	1	0	0	1
22	2	0	0	2
25	1	1	0	2
26	2	0	0	2
27	0	0	1	1
31	0	0	1	1
34	0	0	0	1
Total	141	26	118	285