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THE REINTRODUCTION OF GREY SEAL HUNTING IN SWEDEN – A REVIEW OF HUNTING AND SEAL POPULATION DATA (2001-2024)

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ABSTRACT

This study reviews the reintroduction and transformation of the grey seal (*Halichoerus grypus*) hunting in Sweden from 2001 to 2024, together with regional grey seal population trends. Implementation of the hunting as well as implications for management and ecosystem dynamics have been examined. The results provide an overview of protective and licensed hunting as potential management tools to reduce conflicts between grey seals and coastal fisheries, while considering implications for ecosystem-based management and conservation.

Data were compiled from national management documents, records submitted by hunters and national environmental monitoring programmes. Spatial and temporal patterns of hunting, quota allocations, retrieval rates and grey seal population trends were examined. Results show that hunting began as protective hunting in the northern counties and progressively expanded southwards, becoming nationwide along the Baltic coast by 2014. Seasonal timing of the hunting bag shifted from spring and autumn to late summer, and quota systems changed from county-specific limits to nation-wide licensed hunting. Despite increased quotas and relaxed restrictions since 2020, the hunting bag did not increase, and the national quota was only fully utilised in 2024 when it was significantly reduced. Retrieval rates declined from 89 % (2002–2013) to 57 % (2014–2024), raising concerns about hunting efficiency and animal welfare. High regional hunting pressure relative to seal abundance was noted in several counties, with unclear implications for local population trends. Scientific support of grey seal hunting as an effective management measure to reduce seal-induced damage to fishing gear and catches is weak, and scientific evidence of positive impacts on fish stocks is lacking.

The findings suggest that although grey seal hunting has been widely implemented, its demographic and ecological consequences remain uncertain. Key knowledge gaps persist regarding seal population dynamics, age and sex composition of hunted individuals, and broader ecosystem effects. As grey seals are constrained to producing a single pup per year and face multiple anthropogenic threats, sustainable management requires improved data collection, spatially explicit ecological modelling, and an ecosystem-based approach. Continued monitoring and research are essential to evaluate long-term impacts of hunting and inform adaptive management strategies.

Keywords: Grey seal (Halichoerus grypus), Baltic Sea, Wildlife management, Seal hunting, Population monitoring, Human-wildlife conflict.

INTRODUCTION

Marine mammals, including seals, are ecologically important top predators (Aarts et al., 2019; Bowen, 1997; Buren et al., 2014; Estes et al., 2016; Heithaus et al., 2008; Rosenblatt et al., 2013). Their prey choice may overlap with human fishing activities and lead to conflicts in the form of damage to fishing gear and catches, by-catches and potential resource competition. Characterised by late onset of breeding and low fecundity, marine mammals are sensitive to top-down pressures, e.g., from hunting (Carroll et al., 2024; Halley et al., 2018; Silva et al., 2021). Previous overexploitation of marine mammals, resulting from conflicts with humans has resulted in extensive reductions in population size and distribution, globally (Boehme et al., 2012; Estes et al., 2009; Lotze et al., 2006; Magera et al., 2013; Ripple et al., 2014; Schipper et al., 2008; Thomas et al., 2019) and in the Baltic Sea (Carroll et al., 2024; Durant & Harwood, 1986; Hårding & Härkönen, 1999; Kokko et al., 1999). As a result of conservation efforts, many marine mammal populations have since increased in numbers and expanded geographically (Cammen et al., 2019; Harding et al., 2007; Havs- och vattenmyndigheten, 2025; HELCOM, 2023b).

Grey seal in the Baltic Sea

The grey seal (*Halichoerus grypus*) is divided into three main sub-populations: the Western Atlantic population, the Eastern Atlantic population and the Baltic population. The Baltic population is genetically distinct and classified as a subspecies (*Halichoerus grypus grypus*) (Fietz et al., 2016; Olsen et al., 2016). Grey seals occur throughout the Baltic Sea (Figure 1) and are the most numerous and largest seal species in the area, coexisting with ringed seals (*Pusa hispida*) and harbour seals (*Phoca vitulina*).

The grey seal population in the Baltic Sea is monitored during the moulting period in May-June, when the seals spend much

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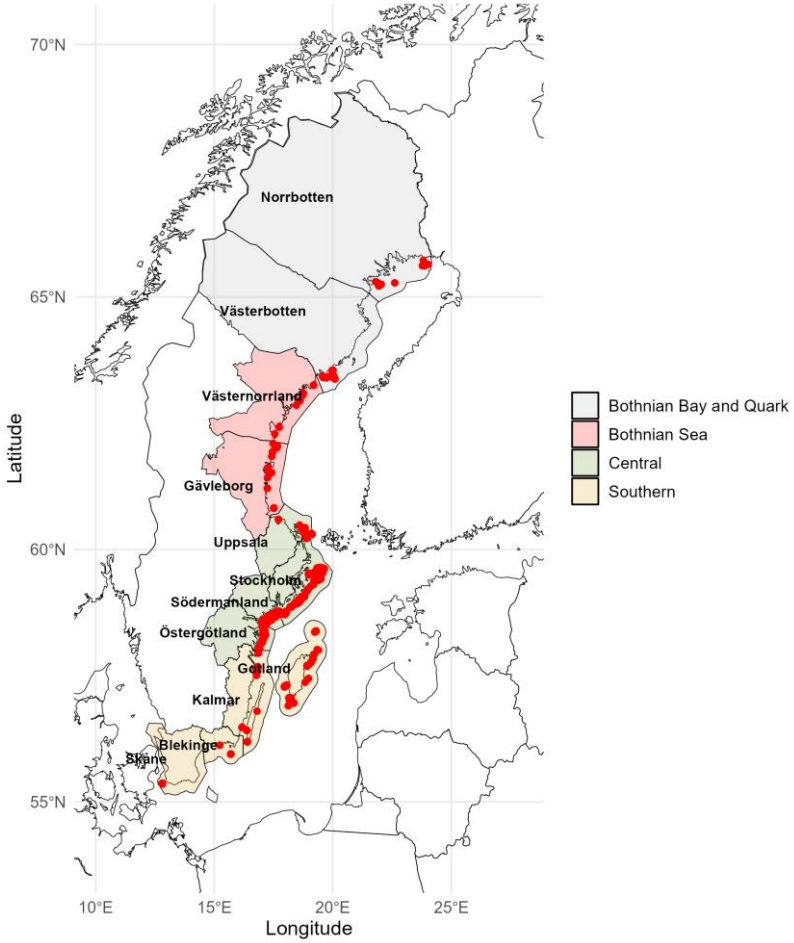

Figure 1. Map showing the Baltic Sea, the different Swedish counties along the coast (counties bordering the Bothnian Bay and the North Quark in grey, counties bordering the Bothnian Sea in red, central counties in green and southern counties in yellow) and grey seal haul-out sites in Sweden (red dots based on moult count data 2003-2023). County borders also include sea areas within 12 nautical miles from the coastline.

time on land and aggregate in larger groups. Grey seals show strong site fidelity during moulting and breeding, but the moulting and breeding sites can differ (Karlsson et al., 2005; Pomeroy et al., 2000; Russell et al., 2013; Twiss et al., 1994).

Outside the moulting and breeding seasons (July-January), grey seals spend most of their time in the water foraging to replenish energy lost during reproduction and moulting and to build up new energy reserves. During this period some individuals undertake long distance movements between Baltic Sea basins (Dietz et al., 2003; van Beest et al., 2019), while other individuals stay in the local area (Oksanen et al., 2014; Sjöberg & Ball, 2000).

During the first half of the 20th century, the Baltic grey seal population declined dramatically due to intensive hunting (Hårding & Härkönen, 1999; Kokko et al., 1999). This decline was exacerbated by the effects of environmental contaminants that reduced the reproductive capacity of grey seals, resulting in a population of only a few thousand individuals in the 1970s (Bergman, 1999; Nyman et al., 2003; Olsson et al., 1994). Successful conservation measures, such as hunting bans, seal sanctuaries and an overall improvement of the marine environment, allowed the grey seal population in the Baltic Sea to recover since the 1980s, with an observed improvement of both seal health and population size. In 2023, approximately 46,000 grey seals were counted in the entire Baltic Sea, which is assumed to correspond to 60-80 % of the estimated total population (Hiby et al., 2007; ICES, 2024). Approximately 17,000 grey seals were counted in Swedish waters in 2023 (Figure 2). Although the grey seal population in the Baltic Sea has increased in size and distribution since the 1970s, it is still at a lower level compared to the estimated number of seals in the early 20th century (Fietz et al., 2016; Hårding & Härkönen, 1999; Härkönen et al., 2007; Kokko et al., 1999).

Conflicts between grey seals and fisheries in the Baltic Sea

Damage to fisheries

As a result of the grey seal population increasing in size and distribution, conflicts with fisheries have intensified (Suuronen et al., 2023; Svels et al., 2019; Waldo et al., 2020). The seals can cause damage to fishing gear and catches, leading to reduced catches and economic losses (Blomquist & Waldo, 2021; Waldo et al., 2019). Seal-induced damage has been reported from different types of fishing gear in the Baltic Sea, targeting

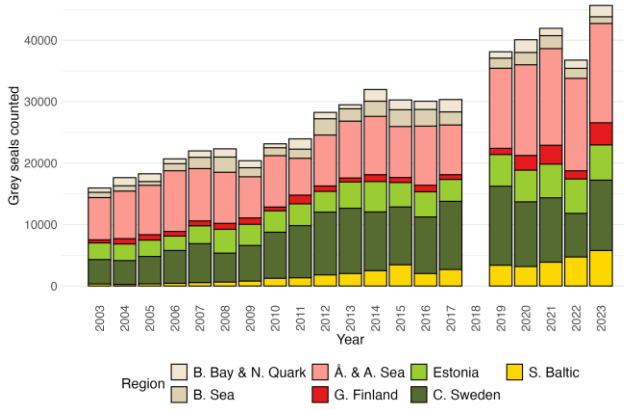

Figure 2. The number of grey seals counted during the annual moult surveys in different areas in the Baltic Sea 2003-2023. Data for 2018 are not presented since no inventory was carried out in Finland. Data from HELCOM. The areas, from north to south are: Bothnian Bay and Northern Quark, Bothnian Sea, Åland Sea and Archipelago Sea, Gulf of Finland, Estonia (Gulf of Riga), central Sweden and southern Baltic. Sea.

different fish species such as salmon (*Salmo salar*), whitefish (*Coregonus lavaretus*), herring (*Clupea harengus*) and cod (*Gadus morhua*) (Fjälling, 2005; Glemarec et al., 2024; Kindt-Larsen et al., 2023; Königson et al., 2013; Königson et al., 2007; Lunneryd et al., 2003). From the 1980s until today, national authorities (the Swedish Board of Fisheries (Fiskeriverket), the Swedish Agency for Marine and Water Management (Havs- och vattenmyndigheten), the Swedish Board of Agriculture (Jordbruksverket), the County Administrative Boards (Länsstyrelsen) and the Swedish Environmental Protection Agency (Naturvårdsverket) have compensated commercial fishermen financially for damage caused by seals (Havs- och vattenmyndigheten, 2014; Naturvårdsverket, 2006; Westerberg, 2010; Westerberg et al., 2000). Compensation has been paid both for direct damage to the gear and as a grant to develop seal-safe fishing gear. The efforts to develop seal-safe fishing gear, e.g., by altering design and materials, began in the 1990s (Bruckmeier et al., 2013; Westerberg et al., 2006). Seal-resistant fishing gear and acoustic harassment devices have been implemented in various fisheries, targeting primarily salmon, whitefish and cod, with generally positive results as regards reduction in seal-induced damage (Fjälling et al., 2006; Kindt-Larsen et al., 2023; Königson et al., 2015; Lehtonen et al., 2022; Lehtonen & Suuronen, 2004; Lunneryd et al., 2003; Vetemaa et al., 2021).

By-catch

By-catch of seals in fishing gear is another conflict between seals and fisheries. However, there is a lack of up-to-date information on the extent of by-catch of different seal species in Swedish fisheries (Lunneryd et al., 2005; Lunneryd et al., 2004; Lunneryd & Westerberg, 1997; Vanhatalo et al., 2014). In combination with mortality from hunting, total anthropogenic removals of grey seals from the Baltic Sea can be assumed to be substantial (Carroll et al., 2024; HELCOM, 2023a).

Resource competition

Grey seals are fish-eating predators, feeding on a range of fish species in the Baltic Sea, but with distinct geographical differences in prey choice (Lundström et al., 2010; Scharff-Olsen et al., 2018; Suuronen & Lehtonen, 2012; Tverin et al., 2019). As the number of grey seals in the Baltic Sea have increased, the number of fish that the seal population requires to meet its energy needs has also increased. This has raised concerns about competition with fisheries. While the conflict previously focused mainly on damage to fishing gear and catches, discussions have shifted towards a focus on possible competition for fish and seals having direct negative impacts on fish stocks. Research suggests that while grey seals in the Baltic Sea can remove large quantities of specific fish species, their overall fish consumption remains minor (14 %) compared to human fishing activities (Hansson et al., 2017). At the same time, fisheries together with environmental factors seem to have a greater impact on fish populations in the Baltic Sea than seal predation (Bauer et al., 2019; Costalago et al., 2019; Lundström et al., 2025; MacKenzie et al., 2011; Tomczak et al., 2012). Some studies present indications that predation from grey seals may have a negative impact on specific populations of pike (*Esox lucius*) and perch (*Perca fluviatilis*) in coastal ecosystems of the Baltic Sea, but the causal relationships and the relative impact of grey seals compared to other ecological influencing factors remain unclear (Bergström, Berkström, et al., 2022; Bergström, Larsson, et al., 2022; Olin et al., 2024).

Aim and objective

The reintroduced hunting of grey seals has been ongoing in Sweden for over two decades. However, there is still a paucity of detailed collated information on the extent and distribution of hunting in time and space along the Swedish Baltic Sea coast, in spite of previous assessments of the hunt (Galatius et al., 2021; Harding et al., 2007; Härkönen et al., 2023; ICES, 2023, 2024; Kauhala et al., 2016; Kauhala et al., 2012; Kauhala et al., 2015; Kiełpińska & Kowalski, 2021). Additionally, monitoring results indicate that the geographical distribution of grey seals during the moult has changed in recent years. The reasons for this are unknown, but disturbances from hunting could be an influencing factor (Havs- och vattenmyndigheten, 2025; ICES, 2024).

The aim of this study is to provide a historical overview of seal hunting and present statistics from the Swedish Baltic Sea coast since hunting was resumed in 2001. The geographical distribution and transformation of the grey seal hunting over time are presented together with the trends for the grey seal population in corresponding geographical areas. The aim does not include an evaluation of the effects of the hunting in relation to fishing gear, fish catches, fish stocks and/or the grey seal population.

MATERIALS AND METHODS

Hunting data

Information on the grey seal hunting bag, i.e., the number of shot seals, in different regions of Sweden has been obtained from the Swedish Environmental Protection Agency. The statistics are based on the reports submitted by active hunters. Reports include data on location, date, type of weapon and whether the seal could be retrieved or not. The hunters are also asked to report information on sex and size (length and estimated weight) of each retrieved seal. Tissue samples are collected from a subsample of the retrieved seals to determine age and monitor health as part of the Swedish national environmental monitoring programme; this work is coordinated by the Swedish Museum of Natural History (Naturhistoriska riksmuseet).

Seal count data

Grey seals along the Swedish Baltic Sea coast are monitored annually during a two-week period in their peak moulting time in late May-early June. The monitoring is part of the Swedish national environmental monitoring programme and is carried out by the Swedish Museum of Natural History, on behalf of the Swedish Agency for Marine and Water Management. Monitoring follows HELCOM guidelines and is coordinated internationally since 2000 (HELCOM, 2018). The purpose of the monitoring is to obtain an index of abundance to follow population trends over time as well as data on distribution during the moulting period. The monitoring is not designed to provide the total abundance of seals. The coast from southern Västerbotten County (Umeå) to southern Östergötland County (Gryt), i.e., the core area of the grey seal population along the Swedish coast, has been monitored using helicopter since 2006. In 2021, the helicopter route was extended south to include the northern Kalmar County (Oskarshamn). Each moulting site is monitored three times during the survey period, if weather allows, and seals are counted from photographs collected during the survey.

The areas north and south of the helicopter route have been counted either by volunteers (from land or by boat), through collaboration with the Swedish Coast Guard (air) or by international partners (air). The timing of these counts can vary between locations and can occasionally occur outside of the survey period and may not have repeated counts. As a result, the data from the counties of Norrbotten, Gotland, Blekinge, central-southern Kalmar and Skåne may be of lower quality and have more inter-annual variation compared to the more coordinated helicopter survey in the core-area. At the same time, these areas represent a relatively small proportion of the total population in the Baltic Sea. To follow trendlines of the entire total population of grey seals in the Baltic Sea, the maximum number of seals counted within each survey area has been used (HELCOM, 2018). For abundance and trends of grey seals within each county in this study, the survey maximum of seals counted within each county was used. The counts indicate the distribution and abundance during the moulting period, but do not necessarily reflect the situation year around.

RESULTS AND DISCUSSION

Historical grey seal hunting in the Baltic Sea

Seal hunting in the Baltic Sea has been going on for thousands of years and dates back to the Mesolithic period (Ahlgren et al., 2022; Apel & Storå, 2020; Kvist, 1991; Storå, 2002). Initially, seals were hunted as a subsistence resource providing meat, fur, blubber and bone. At the start of the 19th century, the resource value and economic value of seals decreased, which reduced hunting and resulted in an increasing population size of grey seals. Consequently, conflicts between human activities and seals were heightened due to increasing seal-induced damage to fishing gear and catches. These conflicts coupled with pressure from the fishing industry led to the initiation of a state-subsidised bounty hunting programme in the early 20th century, which aimed to reduce problems for fishermen whilst simultaneously providing an important source of income for hunters. The hunting programme drastically reduced all seal populations in the Baltic Sea for decades (Hårding & Härkönen, 1999; Olsen et al., 2018).

The bounty hunting in Sweden was abolished in 1967 and general hunting was banned in 1975, after which only protective hunting was allowed (Havs- och vattenmyndigheten, 2019). In 1988, HELCOM issued a recommendation to ban seal hunting in all member states and protective hunting was stopped in Sweden the same year (HELCOM, 1988).

Reintroduction of grey seal hunting

As seal-induced damage to catches and gear increased in commercial fishing while the number of grey seals increased during the 1990s, the fishing industries in Sweden and Finland urged the governments to take action, which led to the reintroduction of seal hunting as a management measure (Räsänen, 2025). In 1995, derogations were made from the HELCOM recommendation on the ban on hunting seals in the Baltic Sea (HELCOM, 1988) allowing hunting for scientific purposes of seals that caused damage to the fishing industry (Havs- och vattenmyndigheten, 2019; HELCOM, 1995a, 1995b). This resulted in an experiment with research hunting of grey seals in Sweden in 1997 with no observations of reduced damage to fishing gear (Westerberg et al., 2006).

In 2001, protective hunting of grey seals was reintroduced in Sweden as a management measure to limit seal-induced damage to catches and fishing gear under the national management plan for grey seals in the Baltic Sea (Naturvårdsverket, 2001). However, the link between the hunting and specific fisheries has varied in the annual decisions on the protective hunting, from being allowed only in defined “damage areas” and in the vicinity of fishing gear to no connection at all to fishery activities (Figure 3). Initially, 2001-

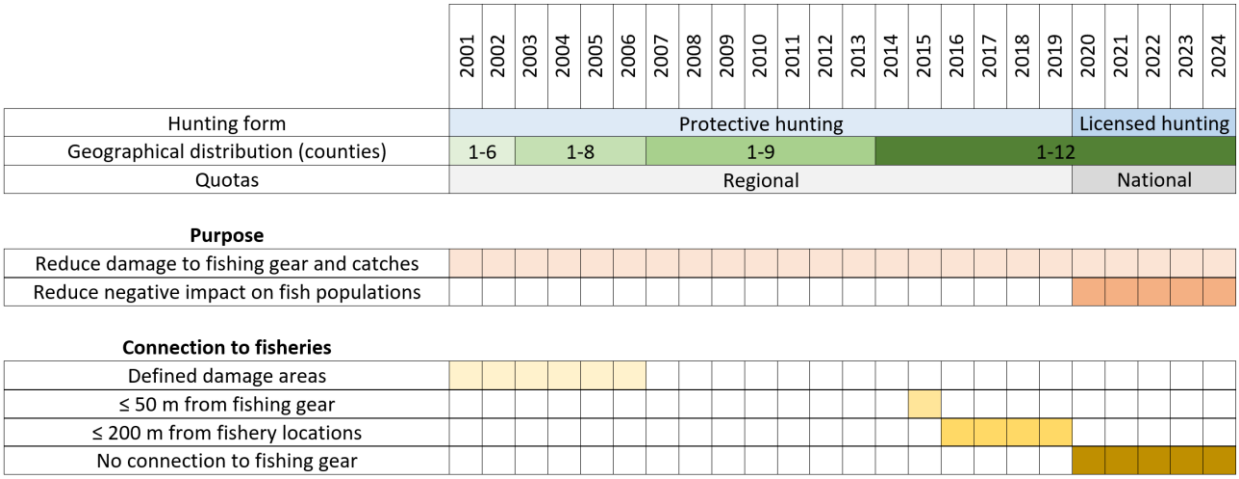

Figure 3. Schematic timeline of the grey seal hunting in Sweden 2001-2024. Counties, from north to south (Figure 1): Norrbotten (1), Västerbotten (2), Västernorrland (3), Gävleborg (4), Uppsala (5), Stockholm (6), Södermanland (7), Östergötland (8), Kalmar (9), Gotland (10), Blekinge (11), and Skåne (12). See Table A1 in appendix for more details (Supplementary file 1).

2014, the protective hunt took place in specific areas prone to seal damage, but not necessarily in the vicinity of fishing gear. The areas were defined by the regional County Administrative Boards, the fishing industry and the Swedish Environmental Protection Agency. Between 2015 and 2019, the protective hunting was more focused on reducing seal-induced damage where damage took place, i.e, in the vicinity of fishing gear. In the hunting decision from 2015, the hunt should, "as far as possible", target the seals causing damage to fishing gear and be carried out within 50 metres of that gear. In the hunting decisions from 2016 to 2019, the requirement was that the hunt for seals should be conducted within 200 metres of a fishing spot where seals have caused damage to fishing gear or catches. Other aspects regulating the hunt that have changed over the years were if the hunt was allowed from a boat in the water and whether the quota was given by region (county) or as one nationwide quota. Regional quotas ended with the shift from protective hunting to licensed hunting in 2020 (Figure 3; Supplementary Information 1).

Introduction of licensed hunting

In 2013, the Swedish Environmental Protection Agency stated in a commission from the government on the conditions for licensed hunting of seals that it was possible to introduce licensed hunting (Naturvårdsverket, 2013).

In April 2019, the Swedish Parliament supported a proposition from the Committee on Environment and Agriculture (Miljö- och jordbruksutskottet) to introduce population-regulating licensed hunting of grey seals. The Swedish government was urged to introduce licensed hunting of seals because "the seal population is increasing and is threatening fish stocks and coastal fishing in the Baltic Sea" (Swedish Parliament, 2019b, 2019c).

In July 2019, the Swedish government amended the Hunting Ordinance (Jaktförordningen 1987:905) enabling the Swedish Environmental Protection Agency, after consultation with the Swedish Agency for Marine and Water Management, to decide on licensed hunting of seals (Swedish Parliament, 2019a). The licensed hunting is considered an important component of Swedish wildlife management. The purpose of licensed hunting of grey seals is to reduce conflicts between seals and humans in regions with high seal abundance. In the latest national management plan for grey seals in Sweden, licensed hunting is included as a tool for managing the species (Havs- och vattenmyndigheten, 2019). The prerequisites for licensed hunting are that *a*) the hunting is included as a tool in the management plan; *b*) the hunting is scientifically justified from an ecosystem perspective; *c*) the management is adaptive; *d*) the hunting complies with international commitments for the grey seal population in the Baltic Sea.

The licensed hunting of grey seals in Sweden began on 20th of April 2020 and ended on 31st of December 2021 as the regulations no longer applied after 1st of January 2022. The hunting of grey seals in January 2022 was therefore conducted as a protective hunting. A new decision on licensed hunting of grey seals was taken on 13th of April 2022 and the hunt has since then been conducted as a licensed hunting (2022-2024).

Figure 3 and table A1 (Supplementary Information 1) present a timeline of the grey seal hunting in Sweden, showing the restrictions through time. Hunting of Baltic Sea grey seals has been reintroduced in other countries as well. In Finland and Åland, hunting was resumed in the late 1990s and early 2000s, respectively (Ministry of Agriculture and Forestry, 2007; Räsänen, 2025; Ålands Landskapsregering, 2007), with a joint quota of approximately 1,500 seals (ICES, 2023). In Estonia and Denmark, hunting of grey seals has been allowed during the last 10 years but to a very limited extent with less than 30 seals reported per year (ICES, 2023).

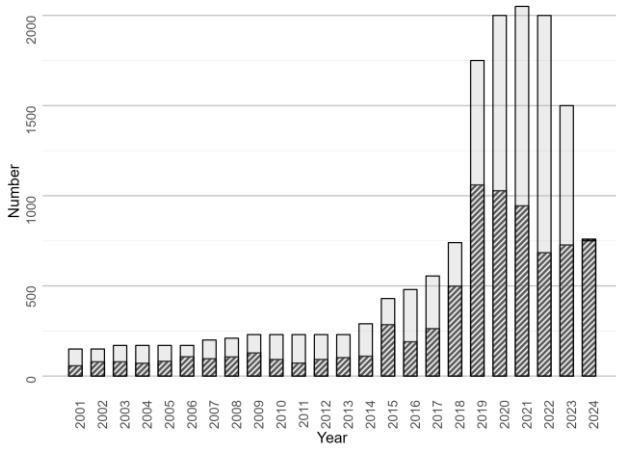

Figure 4. Grey seal hunting bag, i.e., the number of reported seals shot (bars with oblique line pattern) relative to the total quota (grey bars) in the Swedish Baltic Sea region from 2001 to 2024. The years 2019-2024 also includes January the following year (2020-2025). The hunting bag includes all reported seals shot, i.e., also regional additional quotas (Supplementary file 1).

Hunting pressure in different areas and variations between years and seasons

The first two years (2001 and 2002), protective hunting was allowed in the northern part of the Baltic Sea, from Stockholm County and northwards (Stockholm, Uppsala, Gävleborg, Västernorrland, Västerbotten and Norrbotten). From 2003 onwards, protective hunting was also allowed in the counties of Södermanland and Östergötland. In 2007, hunting was expanded southwards to Kalmar County. Since 2014 the counties of Gotland, Blekinge and Skåne were also included in the hunt, as such, hunting is today permitted along the entire Swedish Baltic Sea coast. Hunting has not been allowed in specific protected subareas, e.g., bird-/seal sanctuaries and Natura 2000 areas. In addition, no hunting has been allowed in specific areas with grey seal haul-outs that are important for the national monitoring of the grey seal population: year-round 2001-2014; before 16th of June, 2015-2021 and 2023; between 21st of May and 5th of June, 2022 and 2024.

During the first two years the protective hunting started in September (2001) and May (2002) and lasted until the end of the year. Thereafter, the hunting started in mid/late April and continued throughout the year. Since 2019, the hunting has extended into January the following year (2020-2025). During the years 2003-2013, it was allowed to shoot half of the maximum quota in each county before June (2003-2009) or July (2010-2013). After 2013, hunting has not been limited in time during the hunting season (Supplementary Information 1).

On average, half of the allocated quota has been used. At its lowest, 31 % was utilised (in 2011), and the quota was only filled in 2024, when it was markedly decreased from previous years. Even though the constraints for hunting have been relaxed since 2020 with the introduction of licensed hunting and a higher quota, the number of seals shot has not increased. In 2019, the last year of protective hunting, there was a marked increase in both quota and the number of seals shot compared to previous years (Figure 4).

During the period with county-specific quotas (2001-2019) that specified the maximum number of grey seals that could be shot in each county, the quota was not consistently limiting, in that when the original quota was filled, an additional quota was allocated. This occurred in 2015, 2017, 2018 and 2019 when the national quota was increased by 23 %, 6 %, 23 % and 59 %,

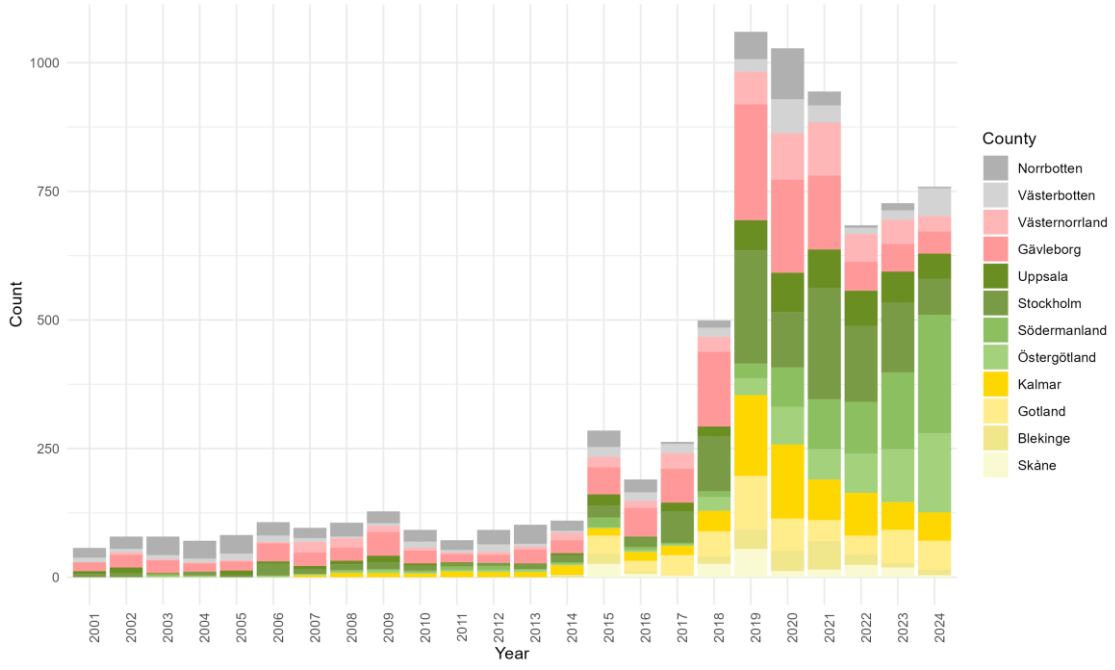

Figure 5. Geographical distribution of the grey seal hunting bag over time.

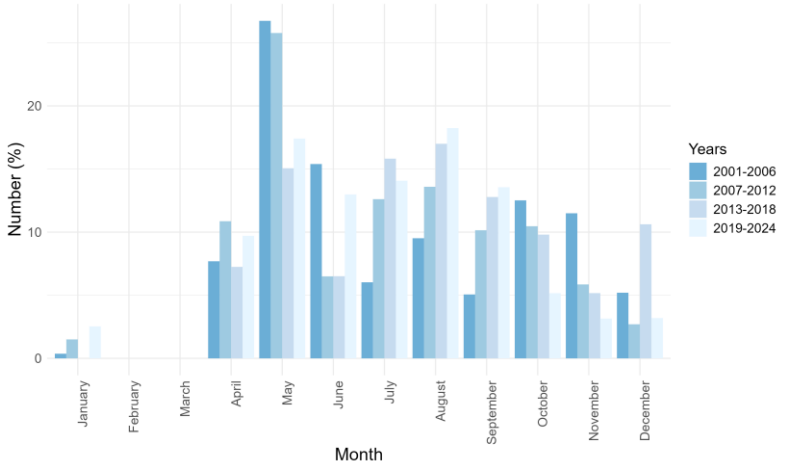

Figure 6. Seasonal distribution and long-term trends in the grey seal hunting bag in the Swedish Baltic Sea.

respectively (Supplementary Information 1). In some counties, the additional quota was higher than the original quota.

To begin with (2001-2014) the hunt was mainly conducted in the northern parts of the Baltic Sea. From 2015, the hunting bag increased markedly, and the geographical distribution of the hunting changed, with a larger proportion in the southern and central Baltic Sea (Figure 5).

Seasonally, the hunting bag seems to have shifted from spring (May) and autumn (Oct-Nov) to late summer (Aug-Sep; Figure 6).

Based on the data reported from hunters for the period 2001-2024, an average of 73 % of the shot seals were retrieved. The proportion of retrieved seals was 89 % in the period 2002-2013 but has since decreased to 57 % in 2014-2024 (Figure 7). The data on seal retrieval contains uncertainties, e.g., it may be unclear whether seals were hit by the bullet or not when seals disappear below the surface. The extent of accidental shootings in the hunt for grey seals in Sweden is unknown, but there is a risk that seals hunted in open water in particular are harmed (EFSA, 2007; NAMMCO, 2006, 2009). In addition, the actual hunting pressure in different areas is not monitored. Hunting pressure may have a bigger impact on seal behaviour compared to the actual number of seals shot.

Regional hunting pressure in relation to monitoring data for grey seals

The geographical distribution of the hunting bag has not been proportional to the distribution of the seal population, based on the number of counted seals (Figure 8; Supplementary Information 1). The hunting bag in relation to the number of seals counted has been remarkably high in the counties of Norrbotten, Västernorrland, Gävleborg, Kalmar, Gotland and Blekinge (Figure 8). It is however unclear how the results from the annual count during the moult represent the number of seals in the different areas of the Baltic Sea year around. Indication of a decrease in the number of seals counted can be seen in the counties of Västerbotten, Gävleborg, Uppsala, Stockholm and Blekinge (Figure 8). In the hunting decisions from the Swedish Environmental Protection Agency, it is unclear how the hunting quotas in the different counties

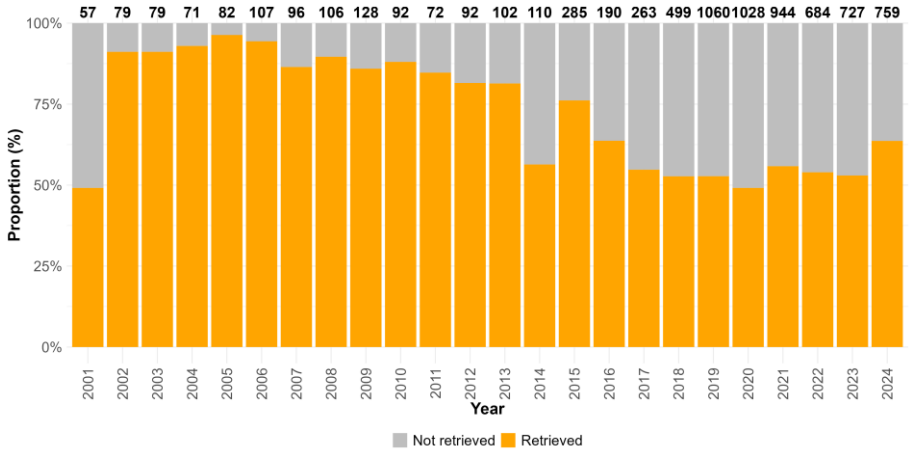

Figure 7. Proportion of retrieved (orange) and non-retrieved (blue) grey seals out of the hunting bag. The total number of reported hunted grey seals for each year is displayed on top of the bars.

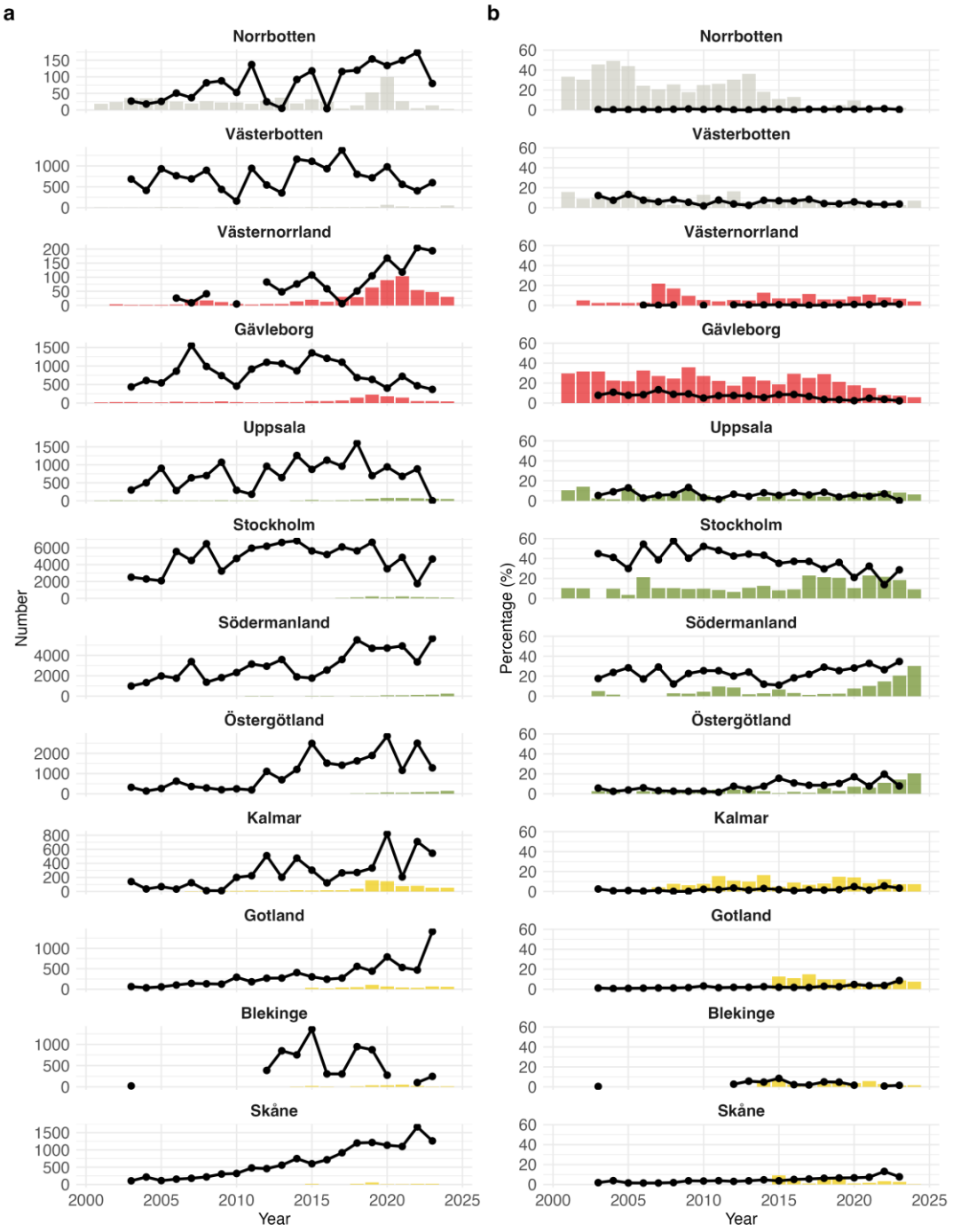

Figure 8. Trends in grey seal hunting and counted seals across Swedish counties. (a) The total number of reported grey seals hunted per year (coloured bars) in each county, overlaid with the grey seal count (black line and points). (b) The proportion of total reported hunted seals per county per year (coloured bars), overlaid with the proportion of the county's share of the total Swedish seal count (black line and points). Swedish counties are arranged from north to south with Bothnian Bay and Quark counties in grey, Bothnian Sea counties in red, central counties in green and southern counties in yellow.

were set, e.g., in relation to the spatial distribution of the grey seal population.

Seal populations are limited to having a single pup per sexually mature female each year and are therefore more vulnerable to hunting than species with higher reproductive capacity. Historically, excessive hunting has resulted in severe declines of seal populations (Hårding & Härkönen, 1999; Reijnders et al., 1993) or local extinctions (Gill, 1978; Hårding & Härkönen, 1999; Härkönen et al., 2007; McClenachan & Cooper, 2008). Even relatively large and seemingly stable seal populations can be highly sensitive to increased mortality due to hunting (Carroll et al., 2024; Silva et al., 2021). It is important to monitor also the age and sex of the seals that are shot, as hunting sexually

mature females has a greater negative impact on the seal population compared to hunting males and sexually non-mature individuals (Harding et al., 2007; Havs- och vattenmyndigheten, 2019; Härkönen et al., 2023). In addition to the impact of hunting, including illegal hunting, other factors may threaten the grey seal population, including by-catches of seals in fisheries, human disturbances, contaminants, climate change and the availability and quality of food.

Ecosystem perspective

Although the Baltic Sea ecosystem is relatively simple and well-studied (Bauer et al., 2019; Costalago et al., 2019; Elmgren, 1989; Gårdmark et al., 2012; Hansson et al., 2007; Karlson et al., 2020; Kauhala et al., 2017; Olin et al., 2024; Tomczak et al., 2022; Österblom et al., 2007), the dynamics are complicated and the state of knowledge is still limited. What ecological effects the increasing grey seal population has and how a possible population-reducing hunt will affect both the seal population and fish stocks are unknown.

There has been no evaluation of how licensed hunting of grey seals affects fish populations and ecosystems and evidence of positive impacts on fish stocks is non-existent. With the relatively limited knowledge of seal ecology and how ecosystems and fish stocks are affected by seals, and *vice versa*, it is necessary to produce relevant information to support ecosystem-based management. A better understanding of the extent to which seals contribute to the natural mortality of fish stocks, and how this varies between areas, fish stocks, seasons and years are therefore necessary both for increased knowledge of what affects a fish stock but also to be able to predict the effects of reduced predation, e.g., through hunting.

A reliable knowledge base, built on the best available scientific knowledge, and associated ecosystem-based assessments are required to be able to better inform the management. The United Nations Environment Programme (UNEP) has developed a protocol for the scientific evaluation of proposals for population-regulating hunting of seals and other marine mammals (UNEP, 1999). The protocol outlines necessary data requirements and evaluation procedures to assess different hunting proposals. One of the aims is to be able to assess the potential of the proposed hunting as a management measure. The protocol proposes the development of ecological models to describe the ecosystem in question and to be able to test the results of alternative management scenarios and evaluate the plausibility of various proposals for population-regulating hunting. Such models are currently not available to evaluate the impact of the Swedish hunt on grey seals.

CONCLUSIONS

Scientific support of hunting as an effective management measure to improve conditions for fish stocks in the Baltic Sea is lacking. In addition, the geographical distribution of the hunt has been unbalanced in relation to the distribution of the seal population. While hunting of grey seals has been going on for decades, the ecological consequences of the hunt remain unknown. The management thus needs to critically examine not only the effects but also the scientific support and actual need of seal hunting as a management measure.

To evaluate management measures aimed at reducing seal predation with the expectation that fish population status will improve, a strong and multidisciplinary scientific basis is essential. Long-term monitoring is needed to obtain time- and space-relevant information not only about the seal population (diet, consumption, distribution, movement patterns, size, population structure, etc.) but also about the prey species (population structure, distribution, migrations, length/weight distribution, stock status, etc.), fishery catches and other potential key impact factors in the ecosystem (other predators, habitat changes and environmental variables) (Lundström et al., 2025; UNEP, 1999). With the help of such information, it is possible to indirectly produce data on where, when and how the seal-fish interactions are most evident (Matthiopoulos et al., 2008; Williams et al., 2004). An adequate scientific expertise, connecting seal biology with fish biology and ecosystem dynamics, is necessary and needs to be involved throughout the process, from the design to the implementation and evaluation of management measures, to avoid actions that lack scientific support and unintended ecological consequences.

ADHERENCE TO ANIMAL WELFARE PROTOCOLS

The research presented in this article has been done in accordance with the institutional and national laws and protocols for animal welfare that are applicable in the jurisdictions where the work was conducted.

AUTHOR CONTRIBUTION STATEMENT

KL: Conceptualisation, data curation, formal analysis, investigation, project administration, methodology, data validation, analysis and visualisation, writing original draft, review and editing; **AMC** and **MPA:** Conceptualisation, data curation, investigation, methodology, project administration, validation, writing, review and editing; **MK:** Writing, review and editing; **MM:** Data visualisation, writing, review and editing; **PE:** data curation, validation and review.

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