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# Bycatches of common guillemot (*Uria aalge*) in the Baltic Sea gillnet fishery

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## Abstract

Bycatch of common guillemots (*Uria aalge*) appears to be the single most serious threat to the population, and the proportion of recoveries of ringed birds in fishing gear, compared with other finding circumstances, has significantly increased during a 28 year period ( $P < 0.01$ ). Out of 1952 ringed common guillemots reported found between 1972 and 1999 in the Baltic Sea, 980 (50.2%) were caught in fishing gear. The bycatch in set gillnets for cod (*Gadus morhua*) constituted 22.3%, drift gillnets for salmon (*Salmo salar*) 65.5%, and other fishing gear 12.2%. The proportion of recoveries in cod gillnets has significantly increased during the study period ( $P < 0.05$ ), while no clear trend was observed in the recoveries in salmon gillnets. The Swedish fishing effort follows a similar pattern for cod but has decreased for salmon. The observed increased use of cod gillnets in the Baltic Sea may have contributed to the observed decrease in adult survival rate, and we provide two different estimates suggesting that significant proportions of the guillemot population are caught annually in the Baltic Sea gillnet fishery. We suggest several available techniques to reduce bycatch in the Baltic Sea fishery. © 2002 Elsevier Science Ltd. All rights reserved.

**Keywords:** Bycatch; Gillnet; Baltic Sea; Common guillemot; *Uria aalge*

## 1. Introduction

Marine birds all over the world drown in fishing nets (Croxall et al., 1984; Bakken and Falk, 1998). Bycatches of birds in the commercial fishery, oil pollution and depletion of available prey species by the commercial fishery are considered to be the largest human-induced factors in marine bird mortality (Furness and Ainley, 1984; Stempniewicz, 1994). In the case of the common guillemot in the Baltic Sea, Olsson et al. (2000) found that oil pollution appears to be a decreasing threat. However, this study also showed that 50.4% of all Swedish common guillemot bycatch recoveries between 1912 and 1998 were made in the commercial fishery and that adult survival has decreased from 87–90% in 1962–1989 to 78% in 1989–1997. These results were somewhat surprising and raised some concern regarding the possible effects that the Baltic Sea commercial fishery

may have on the common guillemot population. Oldén et al. (1988) studied bycatch off the Swedish west coast (in Kattegatt), where large numbers of common guillemots, mainly from the British isles, are found, and estimated that 25,000 birds drowned between the years 1982–1988. Most of these birds drowned in cod gillnets, and the common guillemot constituted >90% of the birds caught. A study made by the Swedish Salmon Research Institute found that at least 34% of all ring recoveries of the common guillemot were made in salmon gillnets (Karlsson, 1994). In the Baltic Sea, bycatch of seabirds has been recorded off the Polish (Kowalski and Manikowski, 1982; Kies and Tomek, 1990; Stempniewicz, 1994), Finnish (Harrio, 1998), Danish (Lyngs and Kampp, 1996) and Latvian coasts (Urtans and Priednieks, 1999) and in the southern part of the Baltic Sea by Christensen (1995). It has been concluded that the Baltic Sea gillnet fishery causes considerable mortality of seabirds (Anon., 2000).

The common guillemot lives in large colonies, the Baltic population consisting of 12,000–17,000 breeding

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pairs, or ca. 45,000 individuals. The largest breeding colony is on the island of Stora Karlsö off the west coast of the Swedish Island of Gotland, where 8000–10,000 pairs breed (Fig. 1). About 40,000 common guillemot chicks have been ringed in the Baltic Sea area since 1913 with metal rings containing an address to the Swedish Museum of Natural History, where ring recoveries have been recorded. The oldest bird recovered in Sweden was 29 years old (Staav, 2000).

Common guillemots are diving birds and can reach depths well over 100 m (Piatt and Nettleship, 1985; Burger and Simpson, 1986), but shallower dives are more efficient (Burger, 1991) and normal diving depths appear to be 20–50 m (Piatt and Nettleship, 1985). In the Baltic Sea the species prey mainly on sprat (*Sprattus sprattus*; Lyngs and Durinck, 1998), an important prey species also for both cod (Anon., 1997) and salmon (Karlsson et al., 1999). Cod and salmon are two commercially important species harvested with gillnets in the Baltic, hence the common guillemot feeding area overlaps with good commercial fishing areas. The Baltic fish stock is a resource shared by several countries, and according to EU legislation all fishermen in member countries are required to keep a logbook. Currently, Estonia, Latvia, Lithuania and Poland are not members of the EU.

The aim of this study was to add knowledge in order to investigate whether and by which means the Baltic Sea gillnet fishery affects the population of common guillemots. This was done by classifying all known Swedish Baltic Sea common guillemot recoveries in fishing nets between 1972 and 1999 into different net types, and by temporal and geographical distribution of the recoveries, and relating these data with relevant data for fishing effort. Further, we wanted to provide estimates of the number of birds trapped in fishing gear

annually and to make suggestions on what measures could be undertaken in order to reduce this mortality.

## 2. Methods

### 2.1. Ring recoveries

At the Bird Ringing Centre, Swedish Museum of Natural History, all records of ringed birds found are filed in a database including information about finding circumstances. All common guillemots trapped in fishing gear were extracted. They consist of birds marked in Sweden (mainly at Stora Karlsö 57°17' N, 17°58' E) and caught in the Baltic Sea (north-western boundary 55°30' N, 12°00' E). All letters with information on a recovered bird between 1972 and 1999 that contained information on common guillemots trapped in fishing gear were investigated for information on gear type and sorted into one of the following categories: (1) set gillnets for cod, (2) salmon drift gillnets, (3) other specified fishing gear and (4) unspecified fishing gear. It is a well-known fact that ringing recoveries contains several sources of biases (Perdeck, 1977) especially concerning finding circumstances, which are strongly affected by human activities. The overall proportion of recoveries caused by fishing gear found in our study may therefore not reflect actual proportions of mortality.

The records in the database are classified according to the degree of security regarding the date when the bird has been recovered. All reports dated according to the postage stamp on the recovery letter or reports with an uncertainty between years were excluded from temporal analyses. In the analysis on a monthly basis performed later, all records with an uncertainty of more than  $\pm 14$  days were excluded. The ages of birds found were calculated only for birds marked as chicks.

In order to test if immature birds were more likely to get trapped in fishing gear than adult birds, we compared the finding circumstances between age-classes (year of life). All birds with an age of 6 years and older were pooled in age-class 6. All recoveries were divided into the categories trapped in fishing gear or other known finding circumstance according to age-class. The same method was used to compare the distribution of age-classes in different net type.

### 2.2. Net types

Several types of gillnets are used in the Baltic Sea. This study focused mainly on set gillnets for cod and salmon drift gillnets.

Set gillnets for cod are set at the bottom at varying depths, are normally set around noon and retrieved the following morning. A Swedish boat in the Southern

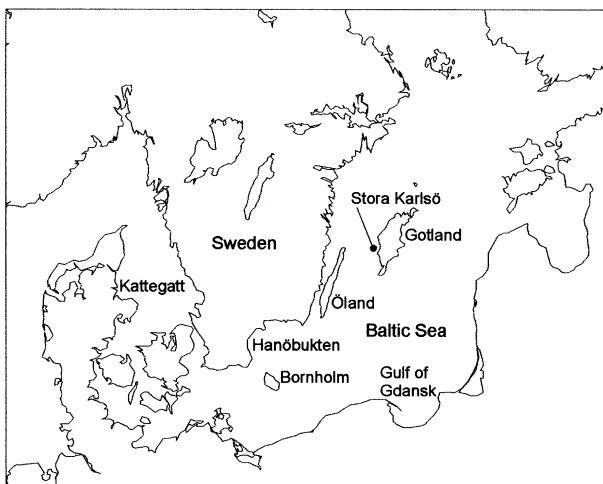


Fig. 1. Map of the southern Baltic Sea, indicating places mentioned in the text.

Baltic carries on average 57 nets (range 20–65) with an average total length of 5.8 km (range 2–12 km; Tschernij and Koppetch, 1997). The average number of wet hours are 19.5 h (range 10–24). The minimum stretched mesh size is 105 mm (Högberg, 1993).

Salmon drift gillnets are set close to the surface around dusk and retrieved around dawn (Harrio, 1998). The maximum number of nets is 600, each one being 35 m in length (Högberg, 1993) giving a total length of 21 km. The minimum stretched mesh size in drift nets is 157 mm (Högberg, 1993).

### 2.3. Logbook data on fishing effort

The recoveries in fishing gear are made by fishermen from all countries bordering the Baltic Sea but we have no information on the extent to which recoveries are reported. The data we used for fishing effort deal only with the Swedish fishing industry in the Baltic Sea (north-western boundary 55°30' N, 12°00' E). These data were obtained from logbooks kept at the National Board of Fisheries, where all fishermen with a ship permit are required to record the date, position, net type used, hours spent working, numbers of nets used and the quantity of fish caught. As it proved very difficult to analyse these data due to a large number of errors in the database, we were forced to limit the figures for fishing effort to the number of fishing trips made in a particular year. One record of a fishing trip in the logbook is regarded as one fishing day. The use of logbooks was initiated in 1978 for salmon gillnets and in 1979 for cod gillnets. Due to widespread reluctance among many fishermen to fill in logbooks, these data should be viewed as the minimum number of fishing trips made every year. This fact is particularly true for the first years the logbooks were in use (P.-O. Larsson, personal communication).

To be able to compare fishing effort for one fishing method and the proportion of recoveries made in that net type, the recoveries in cod gillnets and salmon gillnets were treated separately. The number of recoveries in cod gillnets 1 year was divided by the total number of recoveries in cod gillnets and salmon gillnets that year. This provided us with a measure of the relative number of recoveries in cod gillnets as a proportion of recoveries in cod and salmon nets pooled. We compared these proportions with information from the logbooks on the relative number of fishing days with cod nets as a proportion of fishing days with cod and salmon nets pooled. Recoveries in salmon gillnets were analysed in the same way. This method enables us to test whether a relative increase in fishing effort correlates with a relative increase in ring recoveries in the net type analysed, i.e. do more nets (measured in fishing effort according to Swedish logbooks) catch proportionally more birds?

## 3. Results

### 3.1. Finding circumstance

Between 1972 and 1999 31,212 common guillemots were marked in the Baltic Sea area with Swedish rings. During this period there were 1952 recoveries in the Baltic Sea Area (a recovery rate of 6.3%), out of which 980 (50.2%) were reported caught in fishing gear. Only 44.4% of all ringed birds caught in fishing gear included details on type of gear. Of the reports where net type was specified, 22.3% ( $n=97$ ) were for cod gillnets, 65.5% ( $n=285$ ) for salmon gillnets and 12.2% ( $n=53$ ) for other fishing gear such as set gillnets for herring (*Clupea harengus*), flatfishes Pleuronectoidei, pike (*Esox lucius*), perch (*Perca fluviatilis*) or whitefish (*Coregonus* spp.), stationary poundnets for salmon, fyke nets for salmon, eel (*Anguilla anguilla*) pots, hook or trawl. Some birds were found in ghost nets, i.e. nets that had broken loose due to strong wind or other factors. An additional 55.6% ( $n=545$ ) of the bycatch was made in unspecified fishing gear, and it was unknown whether the same distribution between net types was valid for the bycatch in unknown net types.

The survival rate for birds caught in salmon gillnets (20.3%,  $n=261$ ) was much better than for birds caught in cod gillnets (0%,  $n=96$ ) or for other specified net types (4.2%,  $n=47$ ) or unspecified nets (2.7%,  $n=488$ ). Injured birds that were released alive were included in the number of surviving birds. The mean setting depth of a cod gillnet with at least one recovered bird was 47.2 m ( $\pm 3.1$  S.E.,  $n=58$ ).

### 3.2. Temporal distribution of recoveries

In order to investigate if fishing nets are an increasing threat to common guillemots as opposed to other finding circumstances, the recoveries in all fishing gear as a proportion of all recoveries (controls of breeding birds excluded) were compared. There was a positive correlation during the time period ( $r=0.56$ ,  $P<0.01$ ,  $n=28$ , Fig. 2). The proportion of recoveries in fishing gear has increased during the study period.

In order to investigate how the recoveries were distributed over time the recoveries in cod gillnets and salmon gillnets were calculated as proportions of the number of recoveries from birds found by other circumstances and analysed in 4-year periods. There was a positive correlation between the proportion of recoveries in cod gillnets and time ( $r=0.96$ ,  $P<0.001$ ,  $n=7$ , Fig. 3a) but no trend between the proportion of recoveries in salmon gillnets and time ( $r=0.21$ , n.s.,  $n=7$ , Fig. 3b). Hence an increasing proportion of birds get entangled in cod gillnets every year. The proportion of recoveries in other fishing activities had not changed significantly during the same period ( $r=-0.11$ , n.s.,

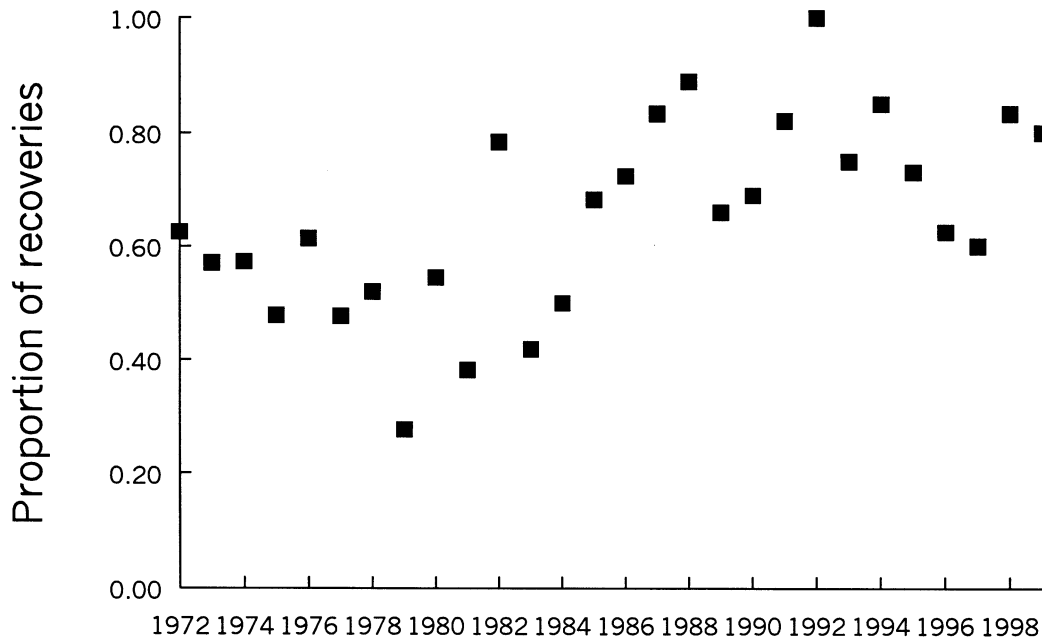


Fig. 2. The proportion of ringed common guillemot reported as entangled in fishing gear between the years 1972 and 1999. The total number of reported birds is 1306, out of which 784 birds were caught in fishing gear and 522 were reported found dead, found oiled or with another finding circumstance. Controls of breeding birds are not included in the calculated proportion.

$n=7$ ) and there was a significant positive correlation between the proportion of recoveries in unspecified fishing and time ( $r=0.89$ ,  $P<0.01$ ,  $n=7$ ).

The number of Swedish fishing days with cod gillnets increased between 1979 and 1999 (Fig. 4), while the number with salmon gillnets decreased between 1978 and 1999 (Fig. 4).

There was a significant positive relationship between the relative use of cod gillnets and the relative proportion of recoveries in that net type ( $r^2=0.20$ ,  $P<0.05$ ,  $n=21$ , simple linear regression). Correspondingly, there was a significant positive relationship between the relative use of salmon gillnets and the relative proportion of recoveries in that net type ( $r^2=0.20$ ,  $P<0.05$ ,  $n=21$ , simple linear regression). These results suggest that more use of one net type results in more recoveries in that net type. Hence, with the current development of the Swedish fishing effort, cod gillnets are an increasing threat for common guillemots and salmon gillnets are a decreasing threat for common guillemots.

The recoveries in salmon gillnets and cod gillnets varied between months (Fig. 5). In general, the recoveries in both net types followed the fishing season, with more birds caught in nets when the fishing was intense (i.e. many recoveries in the fall in drift gillnets and many recoveries in the spring in cod gillnets). The recoveries in unspecified fishing gear appear to follow the temporal trends for both cod gillnets nets and salmon gillnets, suggesting that the unspecified nets are actually either one of these two categories.

### 3.3. Estimates of birds entangled in fishing gear

The number of birds entangled in fishing gear annually can be estimated by using ring recoveries in relation to the proportion of birds ringed in the population. At Stora Karlsö where 2/3 of the Baltic population breeds, three out of 124 adult breeding birds trapped in the colony in 1997 were previously ringed (2.4%) (Olsson unpublished). This figure can be used as a rough estimate of the overall proportion of ringed birds in the population. Each year on average  $35 (\pm 3.8 \text{ S.E.})$  ringed Swedish birds are reported recovered in fishing nets in the Baltic Sea. Thus, by dividing the number of recovered birds with the proportion of ringed birds the total number of entangled birds can be estimated at about 1500 annually, assuming that all recoveries are reported.

### 3.4. Age of recovered birds

Immature birds were more likely to get trapped in fishing gear than adult birds ( $\chi^2=25.5$ , d.f.=5,  $P<0.01$ ), suggesting that young birds are relatively more likely to get trapped in fishing gear (Fig. 6a). However, there was a significant difference between the distribution of all age-classes in the two net types, cod gillnets and salmon gillnets ( $\chi^2=8.6$ , d.f.=3,  $P<0.05$ ). It appears as if a larger proportion of adult birds is trapped in cod gillnets than in salmon gillnets (Fig. 6b).

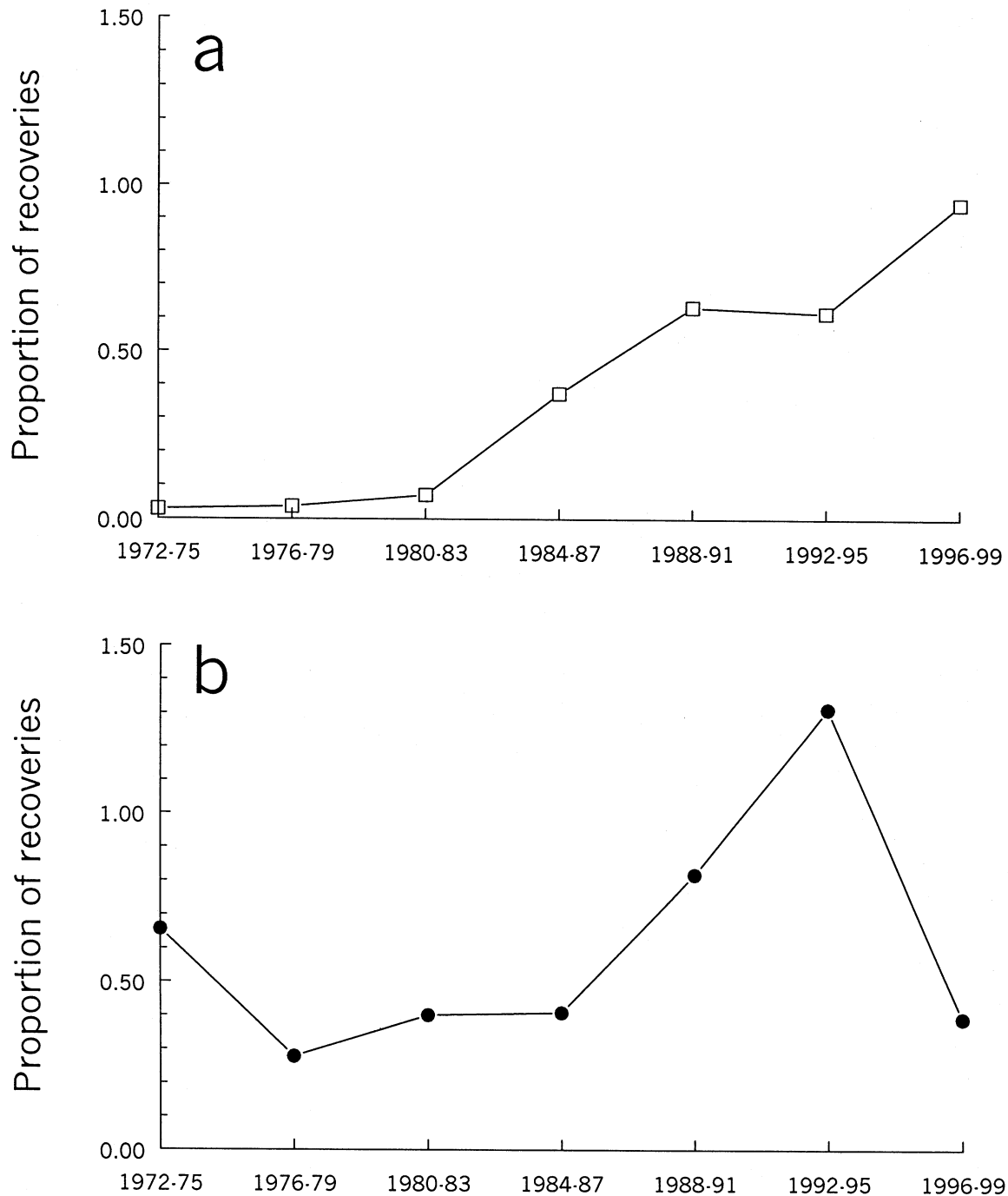


Fig. 3. Common guillemots reported as entangled in (a) salmon gillnets (●, 249 recoveries) and (b) cod gillnets (□, 87 recoveries) as a proportion of the number of birds found by other circumstances between the years 1972 and 1999.

### 3.5. Geographical distribution of recoveries

The bycatch in cod gillnets is concentrated in Hanöbukten and in the area around the northern tip of Öland (Fig. 7). The bycatch in salmon gillnets is concentrated around the fishing banks south and east of Gotland, in Hanöbukten and the northern tip of Öland (Fig. 7). These are the areas where the fishing is most

intense for the two net types, respectively, according to the Swedish logbooks. The bycatch in unspecified fishing gear is in part concentrated in the same areas as the catch in cod gillnets and salmon gillnets, but more importantly in the Gulf of Gdansk area where 343 unspecified recoveries were made. This is 62.9% of all unspecified recoveries or 35.0% of all recoveries made in fishing gear.

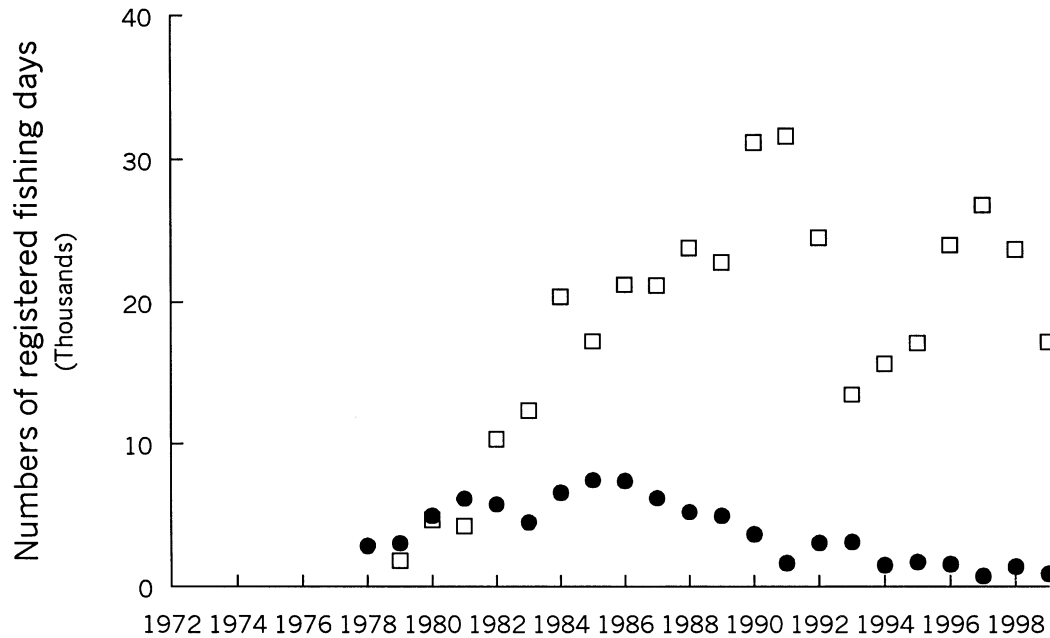


Fig. 4. The registered number of fishing days with salmon gillnets (●) between the years 1978 and 1999 and cod gillnets (□) between the years 1979 and 1999. The total allowable catch for cod was severely restricted in 1993 due to low population levels (Hjerne, 2000; Hjerne and Hansson, 2000).

#### 4. Discussion

The logbook data from the Swedish National Board of Fishery show that the Swedish fishing effort with cod gillnets has increased dramatically and the use of drift gillnets has decreased. The proportion of recoveries in fishing gear as a proportion of all recoveries has increased during the same time period (but see later), suggesting that the increased fishing effort with cod gillnets has caused this increase. When analysing data on bycatches of birds in fishing gear there are two main factors that need to be considered: (1) the large proportion of recoveries in unspecified fishing gear, and (2) the reporting rate of ringed birds trapped in fishing gear; it is very unlikely that all recovered birds are reported.

##### 4.1. Net types involved

According to the ring recoveries, there was no net type other than cod gillnets and salmon gillnets that caused large bycatches of common guillemots. A common guillemot head measures 35 mm in diameter (Oldén et al., 1988) and Stempniewicz (1994) concluded that nets with a mesh size >35 mm (70 mm stretched mesh size) were most dangerous for diving birds. In the Swedish fishery this means that salmon gillnets, cod gillnets and set gillnets for flounder (*Platichthus flesus*) and turbot (*Psetta maxima*; Högberg, 1993) are potential major threats.

The bycatch in the unspecified net types follow the seasonal pattern for both cod gillnets and salmon gillnets. More than half of the recoveries in unspecified fishing gear is made in the Gulf of Gdansk area. Information on fishing methods from bycatch studies in Puck Bay, western Gulf of Gdansk (Kies and Tomek, 1990) and the central Gulf of Gdansk (Stempniewicz, 1994), together with the seasonal distribution (this study), suggests that a large proportion of the unspecified bycatch in this area is actually either in gillnets for cod or salmon.

The logbook data from the Swedish National Board of Fisheries show that an increased use of cod gillnets also leads to an increase of ringed birds found in this net type. During the same time period there has been a decrease in the use of salmon gillnets (according to the logbook data) but without showing any clear trend in the proportion of recoveries in this net type.

An increase in fishing effort off Newfoundland, Canada, between the 1950s and 1970s led to a similar response (Piatt et al., 1984). However, between 1977 and 1988, the fishing effort continued to increase without a corresponding increase in bycatch. Instead, bycatch rates decreased as a result of less available biomass of capelin (*Mallotus villosus*), which is the main summer food item for common guillemots in this area (Piatt et al., 1984). Similarly an increase in herring and sprat stock led to an increase in the number of recoveries of British-ringed common guillemots in Danish waters (Lyngs and Kampp, 1996).

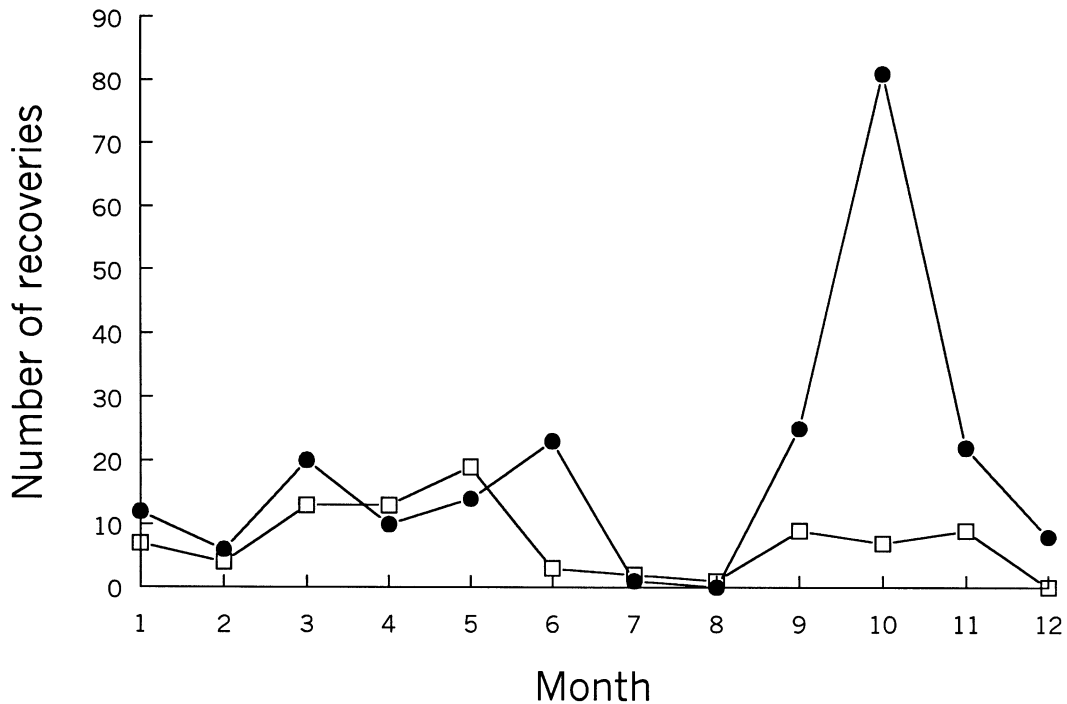


Fig. 5. The number of recoveries every months in salmon gillnets (●, 222 recoveries) and cod gillnets (□, 87 recoveries) between 1972 and 1999.

#### 4.2. Estimates of birds entangled in fishing gear and reporting rate

There are two different ways to estimate the number of birds killed in fishing gear. One is to use ring recoveries and another is to use measurements of observed bycatch rates. The estimated number of birds trapped in fishing gear annually in this study is exclusively dependent on reporting rate. Anecdotal evidence suggests that only a small proportion of all recovered ringed birds is reported and the number of 1500 trapped birds annually is therefore to be considered as a minimum estimate. If, for example, one out of three is reported the number entangled would be 4500. Thus, assuming the Baltic population of common guillemots are 45,000 individuals, our estimates of birds trapped each year range between 3 and 10%.

An estimate of the total bycatch in salmon gillnets can be made by using data from an observer programme performed by Christensen (1995) in the Baltic Sea. The estimated average bycatch of common guillemot was 0.0047 individuals per net day. The registered total of the Swedish fishing effort between the years 1978–1999 with salmon gillnets was, according to the logbooks, 84,031 fishing days, with an average of 450 nets per fishing day. This is equal to a fishing effort of 37,813,950 net days. The calculated bycatch in salmon gillnets during the same period, multiplying the fishing effort with the bycatch rate of 0.0047 per net day, results in 177,726 guillemots in total between 1978 and 1999, or 8078

guillemots trapped in salmon gillnets every year. If 62.5% of all guillemots are released alive, as indicated by the observer programme, this suggests that 3029 birds are killed every year on average, in the Swedish salmon gillnet fishery alone. The Swedish salmon gillnet fishery 1995–1997 constituted around 1/3 of the total Baltic Sea salmon gillnet fishery (Wramner and Andreasson, 1998). If this has been the case throughout the whole study period, the estimated number of killed guillemots in salmon gillnets in the Baltic Sea has exceeded 9000 annually. This constitutes a large part of the estimated yearly reproduction for guillemots (based on the total population of birds and estimated yearly reproduction). The bycatch rate for cod gillnets is not known and clearly more studies in the field are needed to obtain accurate measurements on bycatch rates in all gillnet fisheries in the Baltic Sea. Preliminary results from an observer programme performed by the National Board of Fisheries show only small number of bycatches in the Swedish cod gillnet fishery between 1995 and 2000 (Y. Walther, personal communication).

Bycatch of seabirds in the Baltic Sea is not a problem exclusively for guillemots. In Finland, bycatch mortality is probably one of the most important population-regulating factors for the razorbill (*Alca torda*; Harrio, 1998). The long-tailed duck (*Clangula hyemalis*) is the most common species trapped in fishing gear in the Gdansk Bay and along the Latvian coast and several other diving species are affected (Kies and Tomek, 1990; Stempniewicz, 1994; Urtans and Priednieks, 1999). It

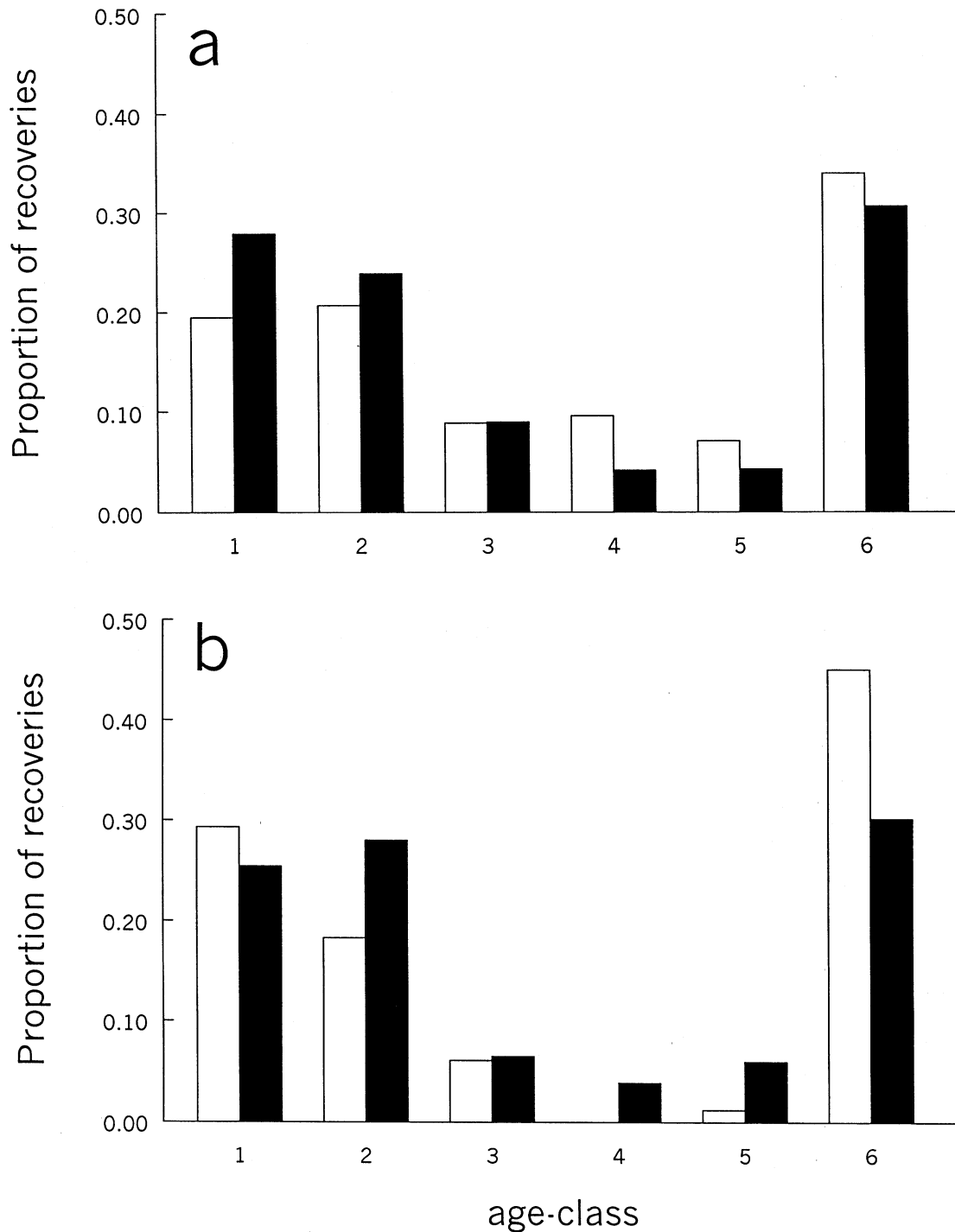


Fig. 6. Common guillemots found according to age-class (year of life), as a proportion of all birds caught in (a) fishing gear (black, 765 recoveries) and found by other finding circumstance (white, 426 recoveries) and (b) bycatch in salmon gillnets (black, 232 recoveries) and cod gillnets (white, 82 recoveries). Only birds ringed as chicks are included in the sample. All birds with an age of at least 6 years are pooled in age-class 6.

has been estimated that 17,500 birds die annually in the Gulf of Gdansk (Stempniewicz, 1994). These results, together with the findings in this study provide evidence that there is need for action from involved authority and the fishery in order to reduce seabird mortality in fishing gear and thereby address an important factor in Baltic Sea seabird conservation.

#### 4.3. Bycatch and population impact

All data available suggests that the Baltic population of common guillemot has increased throughout the last century (Nettleship and Evans, 1985). However, there are several aspects that makes the species more vulnerable than population data suggests. The common guillemot

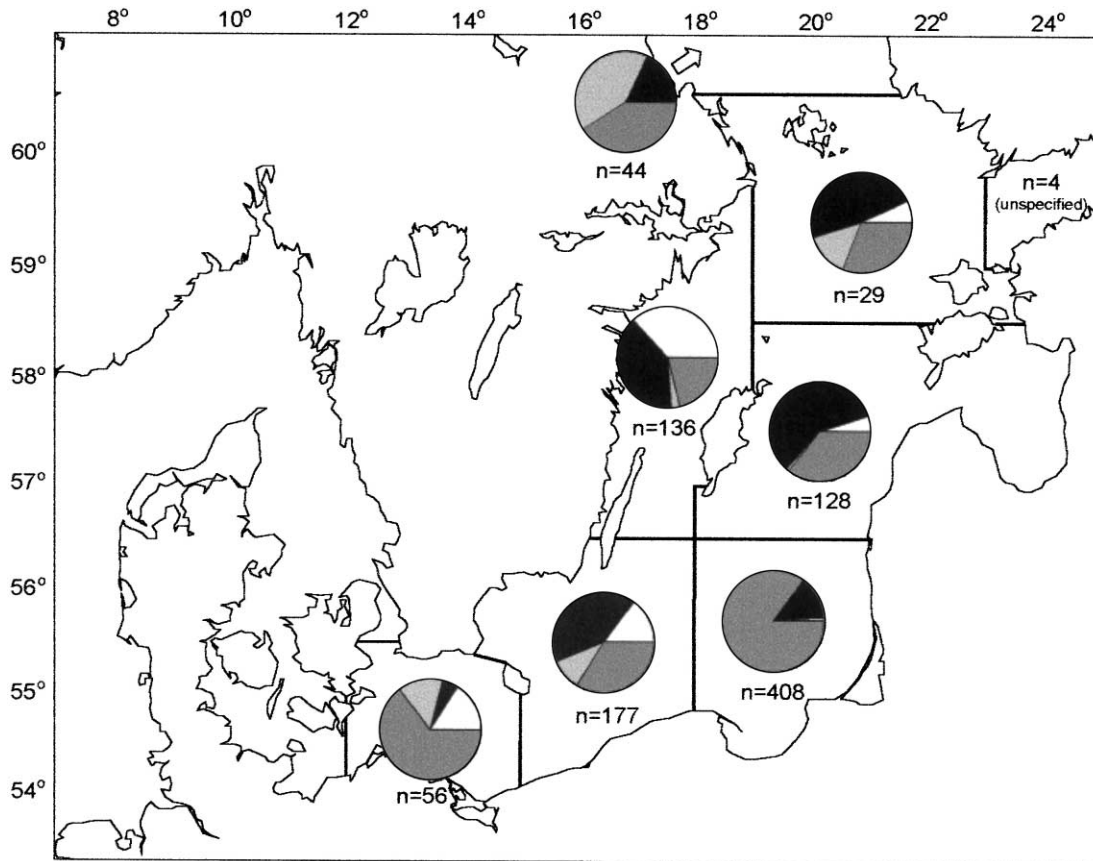


Fig. 7. The geographical distribution of all ring recoveries of common guillemot in the Baltic Sea reported as recovered between 1972 and 1999 ( $n=980$ ). Birds recovered in black = salmon gillnets, white = cod gillnets, dark grey = unspecified net type and light grey = other specified net type. The division of the Baltic Sea into sub-areas is made as far as the data set permits according to ICES (International Council for the Exploration of the Sea) subdivisions.

has a natural high adult survivorship and lives to an old age, but birds mature slowly and have a low reproduction rate because they raise at the most one chick every year. This implies that an increased mortality among adult birds affects the population development significantly. An 80–90% decrease of the total Norwegian breeding common guillemot population (excluding Björnöya, where a 75% decrease was observed between 1986 and 1987) has been observed between 1965 and 1989 (Vader, 1990). The decrease is thought to be a result of bycatch (mainly in salmon gillnets west of the North Cape, salmon pound-nets and cod gillnets in north Norway) and food-shortage (due to population crashes of atlanto-Scandic herring in 1969–1970 and Barents Sea capelin in 1986–1987; Vader, 1990). A similar decline has been observed in central California, USA, where the population declined 52.6% in only 4–6 years (1980–1986) caused by a combination of an intense gillnet fishery, oil spills and effects from El Niño events (Takekawa et al., 1990). Individual colonies in that area declined 45.8–100% where the most severe declines were observed in areas with highest mortality in gillnet fishery (Takekawa et al., 1990).

The first two age-classes are more likely to get entangled in fishing gear than adult birds, suggesting that adult birds are better at avoiding gillnets. A similar trend has been observed for common guillemots in Denmark (Lyngs and Kampp, 1996) and at the West Coast of Sweden (Oldén et al., 1988). Olsson et al. (2000) found a significant difference between the distribution of the first two age-classes and older birds. However, this was due to the fact that younger birds are more likely to winter further away from the colony, a few birds even outside the Baltic Sea. Within the Baltic Sea there was a strong overlap of the recoveries for different age-classes, but older birds were more concentrated in the areas where fishing is most intense. Still, younger birds are over represented among birds entangled in fishing gear. However, there is a difference between the distribution of age-classes in salmon gillnets and cod gillnets. It appears as if a larger proportion of adult birds (> 5 years) are entangled in cod gillnets than in salmon gillnets which might indicate that cod gillnets are more difficult to avoid even for experienced birds. An increased use of cod gillnets can therefore be responsible for the observed lower adult survival, which was observed by Olsson et al. (2000).

The study by Olsson et al. (2000) suggested that the use of salmon gillnets had caused the decrease in adult survival, which in the light of the new data presented in this study might not be a correct assumption. Even though salmon gillnets appear to pose a decreasing threat to common guillemots it is still a major threat.

#### 4.4. Techniques for reducing bycatches

Several techniques for reducing bycatch in gillnets are available (Melvin et al., 1999). One would be to designate protected areas on a seasonal scale and/or on a diurnal scale, since the feeding habitats for common guillemots vary geographically on a seasonal scale and seabird bycatch is rare during the night (Melvin et al., 1999). Concentrating salmon fisheries when salmon densities are high could improve fishing efficiency and catch/bycatch ratios (Melvin et al., 1999).

Some fishermen who previously harvested cod with set gillnets in the Baltic Sea have recently switched to hook and line fishery for cod (P.-O. Larsson, personal communication). The effects on the common guillemot population from an intensified long-line fishery in the Baltic Sea are unknown. In general, a switch from one type of fishery to another, or a relocation of a fishery from one place to another may solve the bycatch problem for one non-target species, but it may also initiate a bycatch problem for a different species.

Use of an alternative fishing method, such as the cod pot developed by the institute of Marine Research in Bergen, Norway (Furevik, 1997) could possibly reduce seabird mortality.

A different solution to the bycatch problem is gear modification. The materials used in the nets are an important factor regulating bycatch. The introduction of inconspicuous monofilament nylon nets for salmon has markedly increased seabird mortality (Evans and Nettleship, 1985). This is perhaps due to the assumed fact that seabirds of the alcid family are visual predators (Gaston and Jones, 1998). Successful attempts in Puget Sound, USA, have been made with modified salmon drift gillnets. Salmon gillnets that were made more conspicuous reduced bycatch of common guillemots by 45% (Melvin et al., 1999) and a salmon gillnet modified with sound omitting Pingers reduced bycatch of common guillemots by 50%, both methods without negatively affecting the salmon catch. Melvin et al. (1999) concluded that bycatch of seabirds in the Puget Sound area can be reduced by 70–75% by several complementary tools such as gear modification, abundance-based fishery openings and time-of-day restrictions.

Except for the event of an oil spillage (Olsson et al., 1999) there are currently no known factors other than gillnet mortality that can pose a serious threat to the common guillemot population in the Baltic Sea.

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