

Seasonal and geographical variation in net-entrapment of Danish Great Cormorants *Phalacrocorax carbo sinensis*

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(Med et dansk resumé: Hvor og hvornår på året drukner danske Skarver i fiskeredskaber?)

Introduction

Cormorants (Phalacrocoracidae) are diving birds that sometimes forage in and around various types of fishing nets (Craven & Lev 1987, Bildsøe et al. 1998, Buch 1998, Engström 1998). They prey on and injure fish trapped in the pot of pound nets, and sometimes they also damage fishing gear and reduce the catch when becoming trapped in fykes or entangled in gill nets (Craven & Lev 1987, Bildsøe & Jensen 1997, Buch 1998, Engström 1998, H. Bruun, T. Nielsen & J. Rieber pers. comm.). It is also claimed that cormorants can scare away fish from the nets and significantly reduce the stocks of commercially important fishes (A. Buch pers. comm.). Consequently, cormorants are in conflict with net fisheries in many parts of the world.

Information about seasonal and geographical variation in cormorant foraging at nets is relevant for evaluating options for managing conflicts between net fishing and cormorants. Population control of local colonies may not be a feasible option if conflicts are most intense during the post-breeding season and in areas used by birds from many colonies. By use of video recording, Bildsøe & Jensen (1997) found large geographical variation in the occurrence of Great Cormorants *Phalacrocorax carbo* at pound nets at the Danish coast: some nets were hardly ever visited, whereas others were visited by up to 700 individuals in a single day. Video recording or direct observation are costly methods to study feeding activity at nets on a large geographical scale. Hence, it is relevant to test the applicability of other, indirect methods to quantify the temporal and geographical variation in cormorant feeding activity at nets.

Some cormorants eventually get trapped and drown when foraging at nets (P.C. Rasmussen unpubl. data, Hald-Mortensen 1994, Engström 1998) and recordings of cormorants drowned may be a useful source of information about seasonal and geographical variation in cormorant foraging

at nets. In a part of Randers Fjord, NE Jutland where net fishing was fairly constant between April and October, almost all cormorants drowned between July and September, which coincided with the time of the year when fishermen recorded frequent incidents of predation and injuries of fish caught in pound nets (P.C. Rasmussen pers. comm.). Engström (1998) recorded geographical variation in the occurrence of drowning of Great Cormorants among five areas in South Sweden and found that an average of 0.04 to 0.31 cormorants per day drowned in each net.

In this paper, I use about 3000 recoveries of Great Cormorants *P. c. sinensis* of Danish origin (hereafter referred to as Cormorants) to describe seasonal and geographical variation in net-entrapment on a large geographical scale. I identify the season, and locate the areas, where pronounced conflicts between net fishing and Cormorants can be expected.

Study area

The present study focuses on the region where most Danish Cormorants forage during the breeding and post-breeding seasons. This area includes coastal and freshwater areas in Denmark, South Sweden and NE Germany (see Bregnballe & Rasmussen in press).

Types of nets. When relevant I distinguish between pound nets, fyke nets and gill nets. However, the vast majority of drowned Cormorants in the main study area are recovered in pound nets and therefore I also use the term pound nets in contexts where a few Cormorants may have drowned in fyke nets or gill nets. A pound net is here defined as a net consisting of a long lead net that directs the fish into a hook net, then on into a pre-pot net and finally into a pot, which is in most cases connected to a fyke (some pound nets do not have a hook net and a pre-pot net). The pot is the net circle in which

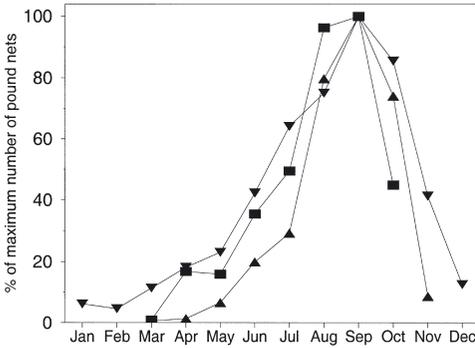


Fig. 1. Seasonal variation in the number of pound nets in Ringkøbing Fjord (▼, n=501, Jan.-Dec. 1994), Randers Fjord (■, n=107, Mar.-Nov. 1991) and Limfjorden (▲, n=532, Mar.-Oct. 1997). Data from Rasmussen (1992), Dieperink (1995) and Rasmussen (1998). Actual numbers were converted to the percentage of the maximum number of pound nets in use.

Sæsonmæssig ændring i antallet af bundgarn i Ringkøbing Fjord (▼), Randers Fjord (■) og Limfjorden (▲) vist som andel af det maksimale antal bundgarn i brug i hvert område.

the fish swim before entering the fyke. The fyke is a cone-shaped net where the fish get trapped on entering. The vast majority of pound nets have one or two fykes attached to the pot, but many of the pound nets used in spring have no fykes. I define fyke nets as cone-shaped net traps that are connected only to a lead net and have no pot. I define gill nets as thin nets hanging vertically in the water column, not held in position by wooden poles or connected to a pot or a fyke.

Why do Cormorants drown in nets? Most Cormorants drowning in pound nets or fyke nets are found lying unentangled in the fyke, probably because they chase the fish towards the end of the fyke where they get trapped (A. Buch, T. Nielsen, O. Petersen, P.C. Rasmussen & J. Rieber pers. comm.). Entanglement apparently occurs when Cormorants attempt to fish in pots covered with floating nets (A. Buch & J. Rieber pers. comm.), when they attempt to enter fykes having stop nets (T. Hansen pers. comm.), and on rare occasions when hunting towards or along the sides of gill nets.

The probability of net-entrapment is likely to depend on factors associated with the design of nets and fykes, on environmental factors (turbidity of the water (Engström 1998), light intensity and human disturbance (P. C. Rasmussen unpubl. data)), and on the behaviour of the birds.

Net fishing in Denmark. Fishing with nets, especially pound nets and fyke nets, but also gill nets,

occurs in coastal waters and lakes within most parts of the region Denmark, South Sweden and NE Germany. The following description of pound net fishing in Danish coastal waters mainly concerns the commercial fishery in 1994 and 1997 (data presented in Koed & Pedersen 1996, Anon. 1998). Approximately 80% of all pound net sites registered in 1994 were located along the south-east coast of Jutland and around Funen, Zealand and nearby islands. Fishing during spring (2106 registered net sites) was concentrated to Little Belt and Great Belt, whereas autumn fishing (5109 sites) was more widespread and also occurred in many fjords. A study in 1997 included at least 80% of the commercial pound net fishermen in Denmark. It was found that 255 pound nets were in use by 41 fishermen in spring, and 952 nets (103 fishermen) in autumn; most nets were used in SE Denmark. In 1994, the vast majority of pound nets (83% in both spring and autumn) stood at water depths of 1.5-5 m; big pound nets at 10-16 m depth were only used in a few areas.

The seasonal variation in pound net fishing is illustrated in Fig. 1 for three fjords in Denmark. In spring, fishery in the fjords is primarily aimed at eel *Anguilla anguilla*, whereas fishery at more open coasts is aimed at migrating fish ready to spawn, such as herring *Clupea harengus*, cod *Gadus morhua*, and garfish *Belone belone*. In autumn, most pound nets and almost all fyke nets are set for migrating silver eel.

Material and methods

The presented analyses are based on 2977 recoveries from 23 844 Cormorants ringed as chicks 1972-1998 in 14 Danish breeding colonies (see Bregnballe et al. 1995). All recoveries reported before 1 September 1998 were included, except those where only the ring was found or the bird was found inside a colony. I further excluded recoveries of birds where the date of recovery was reported with a precision of less than one month.

A distinction was made between the "main post-breeding area" and staging and wintering areas south of the main post-breeding area. The main post-breeding area refers to Denmark (thus including the breeding area), Sweden south of Uppsala, Västmanland and Värmland, NE Germany (EURING provinces Schleswig-Holstein, Rostock, Schwerin, Neubrandenburg), and NW Poland (EURING province Szczecin). The main post-breeding area was divided into 19 sub-areas mainly to localise the areas where a large propor-

Tab. 1. The percentage of Cormorants recovered drowned in their first year of life or as older birds in the main post-breeding area and in the staging and wintering areas farther south; n denotes the number of recoveries. *Procenten af Skarver genfundet druknet i fiskeredskaber i første leveår hhv. som voksne i Danmark, Sverige og NØ Tyskland og i sydligere raste- og overvintringsområder; n angiver antallet af genfund.*

Recovery region <i>Genfundsområde</i>	First-year birds <i>Unge Skarver</i>		Older birds <i>Voksne Skarver</i>	
	%	n	%	n
Main post-breeding area				
<i>Danmark, Sverige og NØ Tyskland</i>	56.1	1091	30.8	643
Denmark	51.7	721	25.8	472
NE Germany <i>NØ Tyskland</i>	65.8	243	38.9	126
South Sweden <i>S Sverige</i>	59.8	97	37.9	29
Staging and wintering areas				
<i>Raste- og overvintringsområder</i>	16.5	601	14.3	642

tion of Cormorants were likely to drown; these sub-areas are defined in Bregnballe & Rasmussen (in press). The staging and wintering areas south of the main post-breeding area were divided into ten areas, corresponding to areas IV-XIII in Bregnballe et al. (1997).

In all comparisons, except for the comparison of staging and wintering areas, significant differences were observed in the proportion of birds drowned and recovered in their first year of life (recovered before 31 May in the year after ringing; referred to as first-year birds) and birds recovered when older than one year (referred to as older birds). I therefore treated these two age groups separately.

To ensure that the proportion drowned was calculated from at least 20 recoveries, I pooled data from adjacent months or sub-areas where necessary. I began with January and lumped data from January with those from February etc. until the sample size reached at least 20 recoveries. I pooled data from different sub-areas if these were adjacent and fairly similar in type of habitat where most Cormorants had been recovered.

Results

The overall proportion of Danish-ringed Cormorants recovered dead and reported drowned was higher among first-year birds than among older birds (42.0% vs 22.6%, n=1692 and n=1285, respectively). Other important causes of mortality were "shot" (15.2% for first-year birds and 20.9% for older birds) and "found dead" (38.0% and

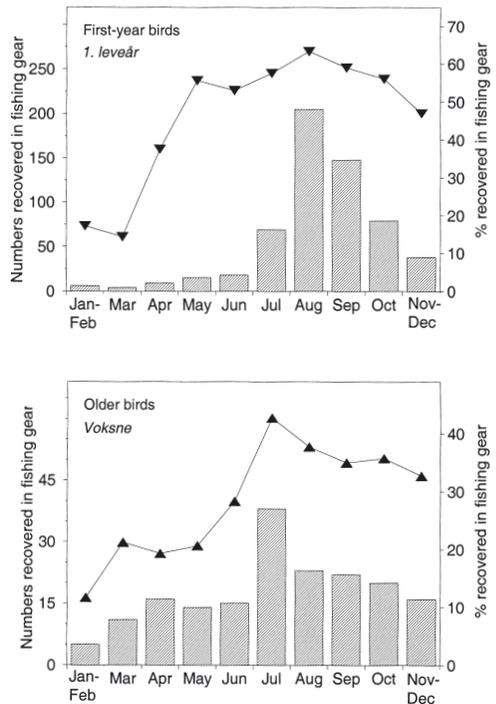


Fig. 2. Seasonal variation in the occurrence of drowning in fishing gear of first-year and older Cormorants ringed in Denmark and recovered in the main post-breeding area including Denmark, South Sweden and NE Germany. Lines (right axis) show the proportion drowned of those recovered; bars show numbers recovered drowned. *Sæsonmæssig variation i forekomsten af Skarver gemeldt som druknede i fiskeredskaber i første leveår hhv. som voksne i Danmark, Sverige og NØ Tyskland. Linierne viser procenten druknet af de, som blev gemeldt, og søjlerne viser antallet gemeldt druknet.*

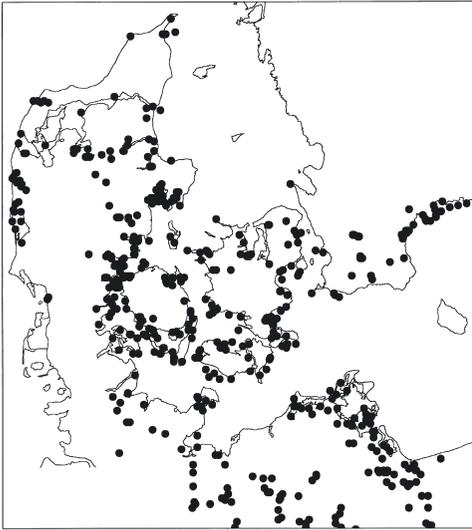


Fig. 3. Sites within the main post-breeding area where Danish-ringed Cormorants were reported drowned in fishing gear.

Lokaliteter i Danmark, Sverige og NØ-tyskland, hvor danskmærkede Skarver er rapporteret druknet i fiskeredskaber.

50.5%, respectively). The "found dead" category is a heterogeneous group and undoubtedly includes some birds that actually drowned.

The main post-breeding area. The proportion of first-year Cormorants reported drowned in fishing gear was high in Denmark, NE Germany and South Sweden (Tab. 1), being highest (53-63%) from late spring to early winter (Fig. 2). Among older birds, the proportion drowned increased from 12% in late winter to a maximum of 43% in July and remained high until early winter (Fig. 2). The proportion drowned was very low in February both among first-year birds (6%, n=17) and older birds (6%, n=32).

Cormorants were recovered drowned in fishing gear in lakes as well as along coasts in most parts of Denmark, NE Germany and South Sweden, though not in the Wadden Sea area and only at a few localities in interior Sweden (Fig. 3).

The percentage drowned varied from 15% to 85% among sub-areas in the main post-breeding area (Fig. 4). Among first-year birds, drowning was particularly frequent (>50%) in interior Scania, West Jutland, North Zealand, Great Belt, Neubrandenburg, Rostock, Schwerin, and NW Poland (Fig. 4). The geographical variation among older birds differed from that of first-year birds, mainly in a low percentage drowned in Great Belt

(Fig. 4).

The staging and wintering areas. The overall proportion of Cormorants reported drowned in fishing gear in the staging and wintering areas was almost equal for the two age-groups and markedly lower than in the main post-breeding area (Tab. 1). The monthly percentage of first-year birds recovered drowned was lowest between November and March (11-14%) and highest between April and October (24-40%). Among older birds the percentage ranged from 10% to 21%, being highest during July-September. The staging and wintering areas with the highest proportion of drowned birds among those recovered were the Netherlands (29%, n=172), Germany (20%, n=95), and Switzerland (24%, n=123) (Fig. 5).

Discussion

The proportion recovered drowned

This study documents that drowning in fishing gear is a frequent cause of mortality among

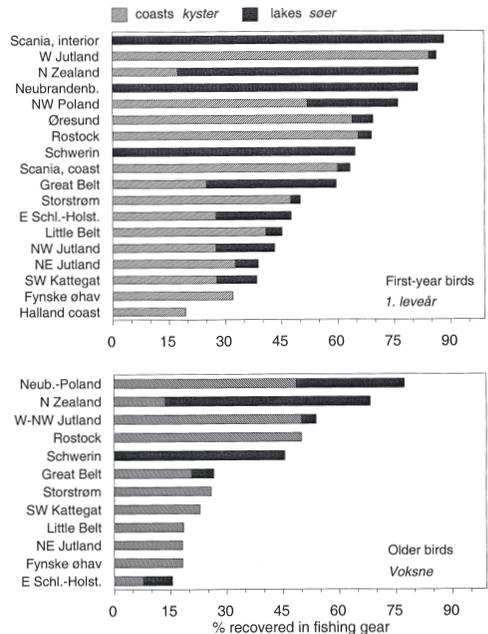


Fig. 4. Percentage of Danish-ringed Cormorants reported drowned in fishing nets of those recovered within sub-areas of the main post-breeding area. See Bregnballe & Rasmussen (in press) for definition of sub-areas. First-year birds: n=24-189; older birds: n=21-198.

Procenten af genfundne danske Skarver rapporteret druknet i fiskeredskaber inden for delområder i Danmark, Sverige og NØ Tyskland. Delområdernes afgrænsning er vist på kort i Bregnballe & Rasmussen (in press).

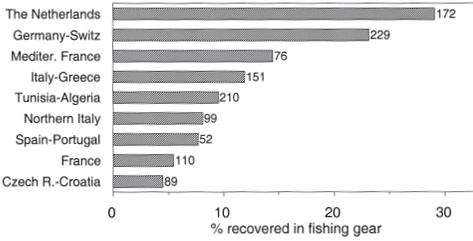


Fig. 5. Percentage of Danish-ringed Cormorants reported drowned in fishing nets in staging and wintering areas in Europe south of the main post-breeding area. Numbers denote total numbers recovered. First-year birds and older birds are combined because no age-related differences were found. See Bregnballe et al. (1997) for definition of areas.

Procenten af genfundne unge og voksne danske Skarver rapporteret druknet i fiskeredskaber i raste- og overvintringsområder syd for Danmark, Sverige og NØ-tyskland. Tallene angiver antal genfund. Der blev ikke skelnet mellem unge og voksne Skarver.

cormorants appearing along coasts or in lakes in Denmark, NE Germany and South Sweden. The proportion recorded drowned was higher in the main post-breeding area than in the southerly staging and wintering areas, but lower than recorded in a Norwegian population of the Atlantic subspecies *P. c. carbo* (81%, Follestad & Runde 1995). However, the "found dead" proportion was very low among cormorants ringed in Norway, whereas it was high among the Danish-ringed Cormorants. Presumably, a cormorant dying at sea

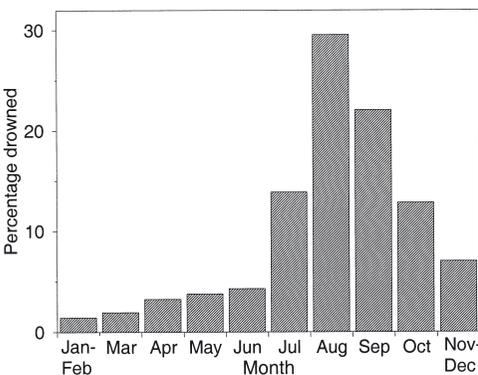


Fig. 6. Approximate seasonal variation in numbers of Cormorants drowned in fishing gear in the main post-breeding area expressed as percent drowned per month of all drowned birds (numbers for age-classes in Fig. 2 combined).

Sæsonmæssig variation i antallet af Skarver druknet i fiskeredskaber i Danmark, Sverige og NØ Tyskland (tal fra Fig. 2 omregnet til procent af det totale antal druknede Skarver).

or near the coast is more likely to be found in Denmark or NE Germany than along the coast of Norway. Drowning as a cause of mortality may therefore be just as important in Denmark, South Sweden and NE Germany as it is in Norway.

Seasonal variation

The number of Cormorants of Danish origin estimated to drown in the main post-breeding area increases markedly from June to August and then gradually declines (Fig. 6). This pattern is not surprising considering that most young birds start foraging on their own between late June and mid-July and that both young and older birds make extensive use of Denmark and NE Germany in the post-breeding season (Bregnballe & Rasmussen in press). Furthermore, foreign cormorants are present in the region in much higher numbers in late summer and autumn than in spring (own unpubl. data), and the number of pound nets in use is highest during the same months (Fig. 1). Very likely, therefore, the total number of Cormorants foraging at nets in Denmark, NE Germany and S Sweden is at its highest during July-September.

In terms of intensity of conflict, it is also relevant to estimate the number of Cormorants drowned per net. I therefore combined data from

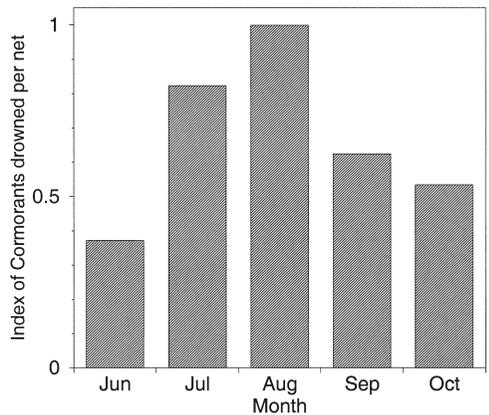


Fig. 7. Variation during June-October in the number of Cormorants drowned per pound net in fjords in West Jutland and northern Jutland. The index was calculated as the ratio between the average of the curves in Fig. 6 and Fig. 1, scaled to peak at a value of one. January-May were excluded because insufficient data were available from open coasts, where pound net fishing is more common in spring than it is in fjords.

Variation i antal Skarver druknet pr bundgarn i fjorde i Vestjylland og det nordlige Jylland fra juni til oktober. Indekset er beregnet ved at dividere den sæsonmæssige variation i "antal" druknede skarver (Fig. 6) med "antal" bundgarn (Fig. 1), og derefter skalere til en maksimumværdi på 1.

Fig. 1 and Fig. 6 to obtain Fig. 7 which predicts that, overall, pound net fishermen in Denmark should find the highest number of (Danish) Cormorants drowned per net during July-August, i.e. in the first half of the main period of pound net fishing in Denmark (compare Fig. 7 with Fig. 1). This prediction is generally confirmed by information obtained from pound net fishermen.

It is noteworthy that July was the month with the highest number and highest proportion of older Cormorants recovered drowned (Fig. 2). Older birds are expected to forage more and take larger risks in June-July when they provide food for their young. This may lead to an increase in fishing activity at pound nets near the colonies. One fisherman, having pound nets 0.5-4 km from a large Cormorant colony in SE Denmark, reported injuries of fish to be at a maximum in July (T. Hansen pers. comm.).

Geographical variation in conflict

The present analysis suggests that conflicts with net fishing are likely to occur in most parts of the breeding area, throughout the main post-breeding area, and in some of the staging and wintering areas, whereas only a small proportion of the Cormorants recovered in France, Portugal, Spain, the Mediterranean and East Central Europe were reported drowned in fishing gear (Fig. 5). Since a large proportion of the Danish Cormorants winter in these areas (Bregnballe et al. 1997), I predict that there is no or little conflict with net fishing in the majority of the feeding areas exploited in late autumn and winter.

It seems reasonable to suggest that areas with a high proportion of drowned Cormorants are areas where conflicts between Cormorants and net fishing are likely to exist. Conflicts should thus be found in some freshwater lakes in South Sweden, North Zealand and NE Germany (Fig. 3, 4) and along coasts and in fjords in most parts of the main post-breeding area, in particular in West Jutland and parts of NE Germany.

It is important to realise that within each of the sub-areas identified as places where conflicts are likely to exist, there will be variation in the intensity of conflict among localities and among particular pound nets. This can be illustrated by two examples. First, the present study identified interior Scania as an area with conflicts (Fig. 4), but Engström (1998) concluded that problems caused by Cormorants in fishing gear were restricted to a few localities only. Second, in Randers Fjord, NE Jutland, P. C. Rasmussen (unpubl. data) found the

number of Cormorants drowned per pound net to range from none in nets standing at a depth of 3-4 m in high-current areas with regular traffic of boats, to a maximum of 0.75 per day in the shallow parts of the fjord (data from August). These examples illustrate how the occurrence of Cormorants at nets can vary on a very local scale. This was confirmed by Bildsøe & Jensen (1997), who found the number of Cormorants visiting pound nets (placed at different sites in Little Belt) to range from an average of 28 to 99 per net and day. Bildsøe & Jensen (l.c.) showed that large nets with large numbers of fish in the pot attracted many more Cormorants than did small nets with fewer fish (the average per day ranged from 8 Cormorants per small pound net to 267 per large net). The conclusion is that the occurrence of foraging Cormorants at pound nets varies at all geographical levels.

Migration route: implication for risk of drowning

According to the present study, the probability of encountering nets depend on where Cormorants appear in late summer, autumn and winter. For example, a first-year bird that migrate to Neubrandenburg to forage in August, then to Markermeer in the Netherlands in October, and finally to Switzerland in December will visit areas where 81%, 79% and 24% of the recovered Cormorants were recorded drowned in nets (n=47, 19 and 39, respectively). A less risky route would be from the coast of SW Sweden (19% drowned, n=26), along rivers through eastern Central Europe (5% drowned, n=40) to northern Italy (12% drowned, n=59). We know that individuals differ in their tendency to forage at pound nets and that there are site-to-site variation in risks of drowning within areas, but the examples suggest that certain migration routes are likely to be "safer" than others in terms of risk of net mortality.

Acknowledgments

The analysis of recoveries would not have been possible but for the great efforts by the ringers, in particular Flemming Christensen, Jens Gregersen, Lars Abrahamsen, Max Nitschke and Kaj Halberg. I thank Hardy Bruun, Allan Buch, Tom Hansen, Tom Nielsen, Ole Petersen, Peter Clausager Rasmussen og Jørgen Rieber for valuable first-hand information about pound net fishing and net-entrapment of Cormorants. I also thank Tau Rasmussen for assisting in preparing data files and producing maps with distribution of recoveries. Thanks to Morten Frederiksen and David Carss who read and commented upon the manuscript. The ringing was financed by the National Forest and Nature Agency. I thank the Copen-



Great Cormorant. Photo: John Larsen.

Store mængder Skarver drukner i fiskeredskaber, når de jager fisk ved nettene eller inde i ruser.

hagen Ringing Centre for handling the recoveries and for providing data files on recoveries.

Resumé

Hvor og hvornår på året drukner danske Skarver i fiskeredskaber?

Skarvens *Phalacrocorax carbo* fødesøgning i og omkring bundgarn, nedgarn og ruser (herefter omtalt som bundgarn) har givet anledning til problemer med fiskeriet i mange områder i Europa. Problemerne med Skarverne er ikke lige store i alle områder, og i forbindelse med forvaltning er det relevant at skabe overblik over, hvor og hvornår på året Skarverne i særlig grad giver anledning til konflikter med fiskeriet. Antallet af Skarver, der søger føde i bundgarn, kan variere meget mellem de enkelte bundgarn, bl.a. afhængigt af garnenes størrelse og antallet af fisk i forgården og fanggården. Bildsøe & Jensen (1997) registrerede en variation fra i gennemsnit 8 til 267 fødesøgende Skarver pr bundgarn pr dag, og ved enkelte bundgarn registreredes besøg af op til 700 individer pr dag. Da registreringen af fødesøgende Skarver ved bundgarn er meget ressourcekrævende, er det relevant at undersøge, om der kan findes indirekte metoder til at belyse den geografiske og tidsmæssige variation i forekomsten af fødesøgende Skarver ved bundgarn.

I denne artikel bruger jeg genfund af ringmærkede danske Skarver til at belyse, hvornår på året og i hvilke områder Skarver i særlig grad drukner i fiskeredskaber. Jeg undersøger desuden, om det er muligt at udpege årstider og områder, hvor danske Skarver i særlig grad er i

konflikt med bundgarnsfiskeriet. Jeg anvendte 2977 genfund af Skarver ringmærket 1972-1998 i 14 danske kolonier og genfundet inden 1. september 1998. I analysen af den geografiske fordeling af genfund inddelte jeg Danmark, Sydsverige og NØ Tyskland i 19 delområder, og det øvrige Europa i 13 områder.

Blandt Skarverne genfundet i første leveår og som ældre blev hhv. 42% (n=1692) og 23% (n=1285) rapporteret druknet i fiskeredskaber. De øvrige vigtige dødsårsager var "fundet død" (38% og 51%) og "skudt" (15% og 21%). Andelen af Skarver rapporteret druknet var højere i Danmark, Sverige og NØ Tyskland end i det øvrige Europa (Tab. 1). I Danmark, Sverige og NØ Tyskland var procenten af druknede Skarver højest fra maj-juni til november-december (Fig. 2), hvilket i store træk også var tilfældet i det øvrige Europa. Skarver blev genfundet druknet i fiskeredskaber i de fleste egne af Danmark, Sverige og NØ Tyskland, dog ikke i Vadehavsområdet og kun få steder i Sverige (Fig. 3). Andelen rapporteret druknet oversteg 50% i Vestjylland, Storebælt, Rostock, NV Polen, Schwerin, Neubrandenburg, det indre Skåne og Nordsjælland (Fig. 4). I de fire sidstnævnte delområder blev alle eller hovedparten fundet druknet i ferskvandssøer (Fig. 4). I de sydligere områder var andelen af druknede højest i Holland (29%), Tyskland (20%) og Schweiz (24%). Se også Fig. 5.

Det estimerede antal druknede Skarver i Danmark, Sverige og NØ Tyskland (Fig. 6) steg markant fra juni til

august, hvorefter det gradvist aftog. I tre fjordområder i Danmark steg fiskeriet med bundgarn markant fra foråret til august-september (Fig. 1). Sammenholdes Fig. 1 med Fig. 6 ser det ud til, at antal druknede Skarver pr net sommer og efterår kulminerer i juli-august (Fig. 7), dvs. i begyndelsen af perioden, hvor flest bundgarn er i brug.

Samlet konkluderer jeg, at antallet af Skarver, der giver problemer med bundgarnsfiskeri i Danmark, er højest i sensommeren og først på efteråret. De danske Skarver giver tilsyneladende anledning til konflikter med net- og bundgarnsfiskeriet over det meste af Danmark og NØ Tyskland og i en række områder i Sydsverige, NV Polen, Holland, resten af Tyskland og Schweiz.

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