Effects of oil spills and shooting on Great Northern Divers which winter in Scotland

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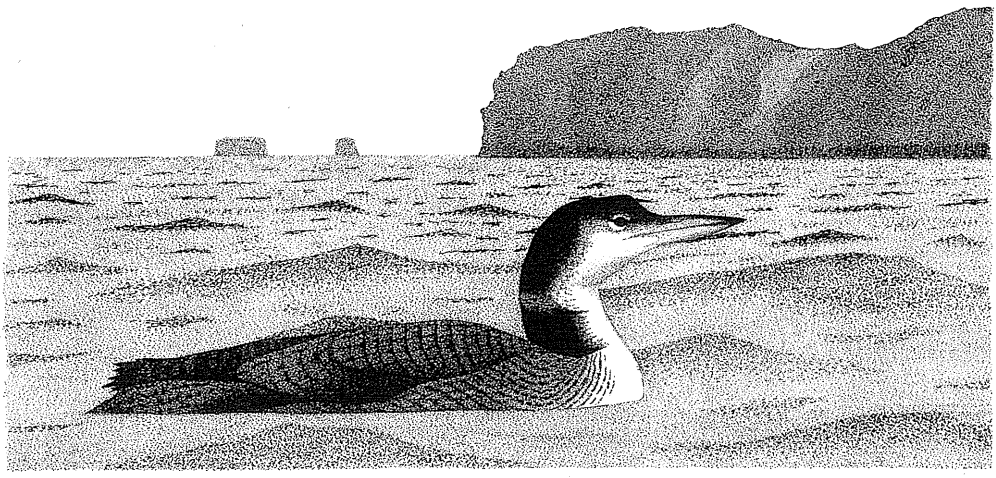

(Med et dansk resumé: Overvintrende Islommer ved Skotland: oprindelse og betydning af olieforurening og beskydning)

Introduction

The National Museums of Scotland (NMS) has a large collection of Great Northern Divers *Gavia immer* from Scotland. Most were killed by major oil spills in Shetland in 1979 and 1993; Shetland is a main site for the landing, loading and transit of North Sea oil. About 6000 Great Northern Divers winter in Europe, with about a quarter of them in Scottish waters, especially in Shetland (Heubeck et al. 1993). Age, sex, possible origins and other aspects of biology were investigated for 68 NMS specimens from the Shetland oil spills in 1979 (Richardson et al. undated, Heubeck et al. 1993).

We examined, or re-examined, a Scottish sample of 103 from the NMS. Compared with the earlier studies (above), we a) refined assessment of origin, b) assessed impacts of oil spills in a sample from several years, instead of only one, and c) improved assessment of the incidence of gunshot injuries. The Nordic interest was that most of the birds in this sample appeared to be from Iceland and Greenland, and that shooting took place there.

Materials and methods

There were 114 Great Northern Divers in the NMS in January 1995. We excluded 11 from examination, because they were not from Scotland, or they lacked data, or were mounted specimens on exhibition. Most of those examined were study skins plus partial skeletons, or complete skeletons plus feathered left wings. A few were either study skins or skeletons alone. Nearly all were collected in October-April, between 1880 and 1994.

Methods of ageing and measurements were already described (Richardson et al. undated, Heubeck et al. 1993). As in those studies, we assessed possible origin by comparing the multimodal frequency distribution of wing lengths with data for summer adult specimens from many breeding areas. None of the birds had been ringed and the earlier studies found that wing length was the most useful comparative measurement. There were three difficulties in the comparisons of these data. Firstly, wing lengths of specimens shrank by 1.5% in the first five years after preparation, and by 2-6% in 20-60 years (Heubeck et al. 1993). We

used measurements taken at least five years after preparation, except for 12 specimens from 1993. For these we subtracted 2.5% from fresh wing length. Secondly, the comparative data were contributed by a number of institutions (see Heubeck et al. 1993) and we could not take account of slight differences in measuring techniques between individual workers (Heubeck et al. 1993). Thirdly most NMS specimens were collected soon before wing moult, whereas all the comparative specimens had fresher primaries, which would be less worn at the tips. We could not fully allow for this, so omitted a very few NMS specimens in which wingtip abrasion clearly was substantial. There also was a statistical problem, in that some single-sex samples in NMS or comparative data had wing length measurements which were not normally distributed, or were only assumed to be so (Heubeck et al. 1993, this study). We therefore compared combined-sex samples to assess origins. Sex ratio did not differ significantly from unity in any sample and the Central Limit Theorem indicated that most combined-sex samples were large enough for frequency distribution to approach normality.

All birds with oiled plumage were regarded as oil spill casualties and gross pathological examinations supported this. We examined most birds for non-fatal gunshot injuries, by a combination of radiography, visual examination during skinning or skeletonizing, and examination of skeletons. Injury sometimes was detected by only one of the three methods and all three methods could not be used for every specimen. Thus our results for incidence of injury were minima and this applied even more to the earlier studies (above), in which skeletons were not examined.

Results

Age and sex

Of 14 birds which were from Shetland to southern Scotland in 1880-1941, six (43%) were adult, i.e., third year or older, compared with 87 of 89 (98%) which were from Shetland (84) or northern Scotland (5) in 1978-94. The difference was significant ($\chi^2_1 = 40.17$, $P<0.001$). Young birds tended to be collected early in winter, or in southern Scotland, whereas Shetland oil spills were in mid or late winter. It appears that young birds moved south as winter progressed.

Overall sex ratio was 36 males: 49 females. In those from the 1979 and 1993 Shetland oil spills, it was 28 males: 40 females, but even this subsample did not diverge significantly from unity ($\chi^2_1 = 2.12$, n.s.).

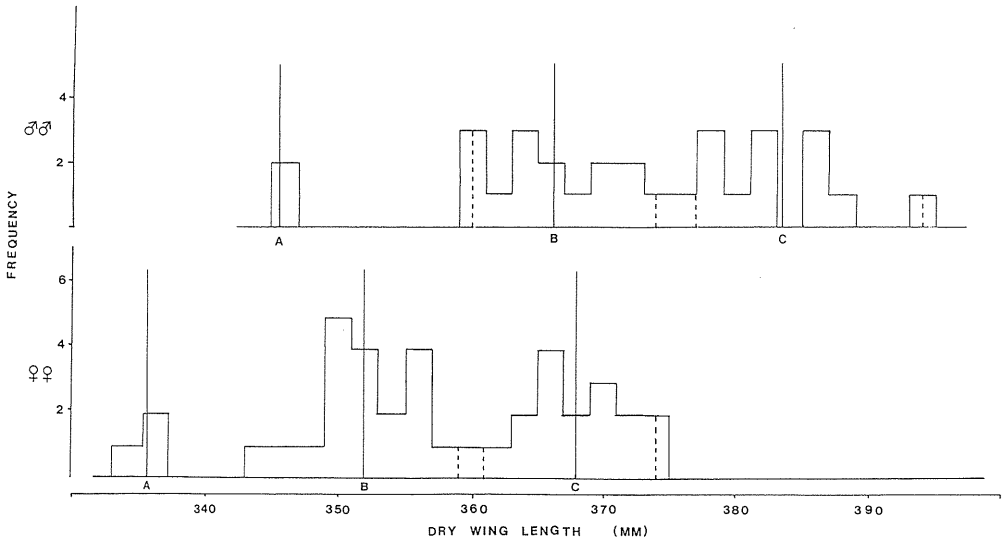

Fig. 1. Frequency distributions of the dry wing lengths of male and female Great Northern Divers from Scotland. Means of the three groups (A, B and C) are marked by vertical lines. The vertical dashed lines show the limits of the ranges between birds assigned to groups B and C.
Vingelængder (skrumpede efter tørring) af Islommer fra Skotland. Fuglene vurderes at tilhøre tre grupper, angivet med A, B og C. Middelværdierne for disse grupper markeres med lodrette linier, mens de stiplede linier viser variationsbredden for de fugle, der henføres til henholdsvis gruppe B og C.

Possible origins

Frequency distributions were shown for 30 adult male and 39 adult female wing lengths (Fig. 1). Frequency distributions were tri-modal for both sexes, most distinctly in females. Groups of measurements were A, B and C, in order of increasing wing length. Coefficients of variation were low for both sexes in groups B and C, but higher in the much smaller group A samples. In all three groups, mean wing lengths of females were 96-97% of corresponding male means. The proportion of males to females was similar in all three groups. Groups tended to be consistent in these respects and were distinct, but four birds were assigned to either group B or group C, although their measurements were in areas of overlap. These assignments may have slightly exaggerated the difference between groups B and C. Wing length means, standard errors and ranges for all three groups are shown in Tab. 1.

We compared the combined-sex means of groups A, B and C with those of summer adults from breeding areas (Fig. 2). From t-tests, two-tailed at $P<0.01$, the Group A mean differs significantly from all but those from Ontario and NE Canada, Group B from all but Baffin I. and Greenland and Group C from all but Iceland. However, we stress caution in accepting these correspondences, given the problems of comparability (see Methods). The overlap in Baffin I., Greenland and Iceland measurements in Fig. 2 corresponded to incomplete separation of groups B and C in Fig. 1 (above).

Deaths and injuries

Most of the 14 birds from 1880-1941 had been shot to provide museum specimens. Of the 89 from 1978-94, 86 (97%) had oiled plumage and pathology confirmed that oil at least contributed to almost all deaths (Heubeck et al. 1993, this study). These data in part just reflect the sources from which a national museum, subject to UK and EU laws, then and now is likely to receive specimens. However, they also represent about 0.2 specimens/year from traditional collecting, compared with about 4.9 from recent oil spills.

We examined 81 adults and three immatures, from 1978-94, for gunshot injuries. Four from Shetland, all of them heavily oiled, had been freshly killed by shooting. We assumed that this represented humane destruction and excluded these four. In the other 80, we found non-fatal, often healed, gunshot injuries in 27 (34%), from shotgun pellets in 22 (28%) and .22 rifle bullets in five

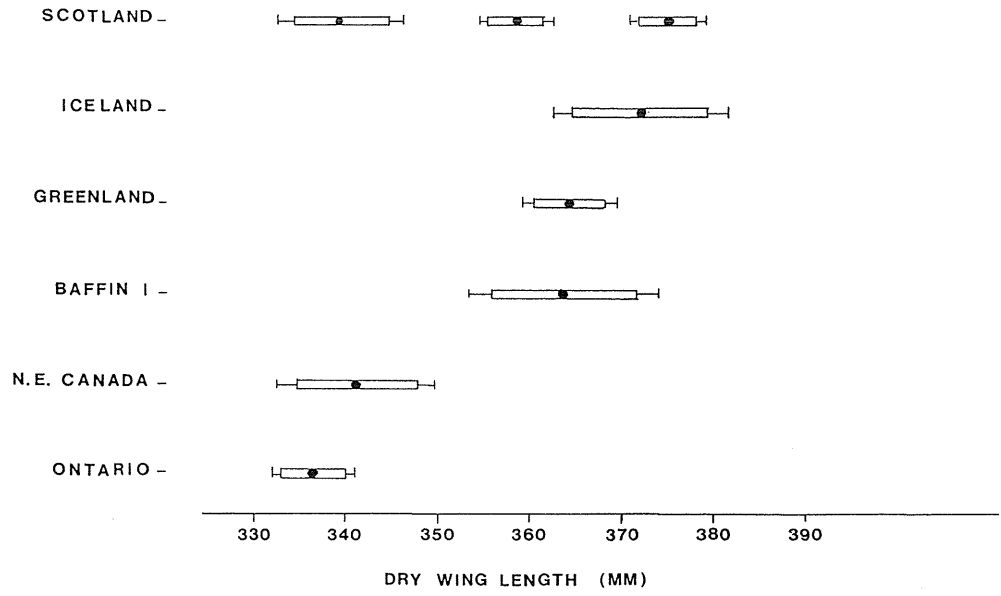

Fig. 2. A comparison of the mean dry wing lengths of the three groups of Great Northern Divers from Scotland with those from known breeding ranges (cf. Heubeck et al. 1993). The bars show 95% and 99% confidence limits of the means.

Vingelængder (udtørrede skind) for de tre grupper Islommer fra Skotland (jf. Fig. 1) sammenlignet med Islommer af kendt oprindelse (begge køn under ét). Bjælker og linier angiver 95% og 99% konfidensgrænser for middelværdierne.

Tab. 1. Wing length means (mm), standard errors and ranges of three groups of Great Northern Divers from Scotland.
Vingelængder (mm) for tre grupper af Islommer fra Skotland (jf. Fig. 1).

Group	$\bar{x}$	s.e.	Range	n
A ♂	345.5	0.50	345-346	2
B ♂	366.5	1.21	360-374	15
C ♂	383.3	1.35	377-394	13
A ♀	335.3	1.20	333-337	3
B ♀	352.2	0.92	343-359	19
C ♀	368.3	0.83	361-375	17

(6%). Presence of injury was not associated with reduced fat deposits and re-growth of bone was usual.

Of the 27 injured, two were in wing moult and could not be assigned to a group. All of the five birds injured by .22 bullets were from Groups A or B (total n=13); none were from Group C (n=12).

Discussion

Assignments to possible origins from wing lengths alone were no more than the best indications which could be made from the material, but assessments of similar origins for Great Northern Divers wintering in Europe were independently made by other workers, i.e. Storer (1988). Our analysis very strongly suggested that some birds were from mainland Canada, which was only weakly suggested in Heubeck et al. (1993). We suspect a Baffin I.-Greenland-Iceland cline in wing length, with eastern and western peaks, rather than three substantially discrete populations, partly from the spread of measurements in NMS and comparative data, and partly from the unexpectedly high incidence of gunshot injury in 'Iceland' birds (below).

After Shetland oil spills in January-April 1979, 181 dead or dying Great Northern Divers were found and 68 were examined (Heubeck et al. 1993). The sample suggested that >50 of the 181 were group C females. The estimated breeding population in Iceland was up to 500 pairs (A. Petersen, in Heubeck et al. 1993). While group C was not necessarily from Iceland alone, the 1979 spills probably killed >181 birds and represented a serious impact on easterly populations. It was exceptionally difficult to collect seabirds killed by the spill of 85 000 tonnes of oil in Shetland in 1993 (Osborn 1994). Twelve Great Northern Divers, from all three groups, were recovered so that there again was a multiple kill of divers only 14 years after the first major spills in Shetland. Protection in an important wintering area for adults clearly is not effective.

Great Northern Divers have been fully protected in the UK since 1954 and were not known to be recently shot in Shetland (MH pers. obs.). Fish-farming began there in the late 1980s (M. Richardson in litt.), whereas most divers examined were from 1979. They could not have been shot to protect fish-farms. They were fully protected and were said to be rarely shot in Iceland (A. Petersen in litt.). A few, mainly immatures, were illegally shot in the Faeroe Is. (J.-K. Jensen in litt.). By contrast, shooting for ceremonial objects, which became part of the souvenir trade, was well known in Greenland, and shooting for subsistence food was implied (Salomonsen 1967). Shooting outside the breeding season was still legal in Greenland; illegal shooting during the breeding season probably was fairly common until the late 1980s but may now have declined (K. Kampp in litt.). Casual illegal shooting in eastern Canada remained frequent (McIntyre 1988). For subsistence, the Cree and Inuit people of New Quebec annually killed by shooting ca 20% of an estimated population of 12 000 pairs (Desgranges & Laporte 1979). It was not surprising to find non-fatal gunshot injuries in about a third of adults from Greenland and Canada given that these divers are long-lived birds, so that injuries could have accumulated.

It would be surprising to find a similar incidence of gunshot injury in group C birds, if they were mainly from Iceland and were rarely shot there. Given that group C birds differed from the others in not having injuries from .22 bullets, the simplest explanation was that the extent of shooting, with shotguns, in Iceland was under-estimated. The alternative explanation, that very many group C birds were from Greenland or even Canada, did not fit the geographical peaks in wing length.

Summary

We examined 103 Great Northern Diver specimens in the National Museums of Scotland. Samples were 90% adult and 58% female, and 82% were killed by 1979 and 1993 oil spills in Shetland. Of 80 adults 34% had non-fatal gunshot injuries. Suggested origins of 69 sexed adults were Iceland ca 45%, Greenland-Baffin I. ca 45% and mainland Canada ca 10%, from mean wing lengths, but these populations overlapped. Oil spills in winter and shooting in summer are severe pressures on populations which winter in Scotland.

Acknowledgments

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Resumé

Overvintrende Islommer ved Skotland: oprindelse og betydning af olieforurening og beskydning

Omkring 25% af de 6000 Islommer, der overvintrer i Europa, træffes ved Skotland, især Shetland. Oprindelsen af disse fugle blev skønnet ved at sammenligne vingelængder fra 103 skind i *National Museums of Scotland* med vingelængder af Islommer fra forskellige yngleområder. De skotske skind synes at repræsentere tre grupper, som mht. vingelængde stemmer overens med hhv. det kontinentale Canada (10%), Baffin Island – Grønland (45%) og Island (45%). Der er korrigeret for den skrumpning, der finder sted efterhånden som skindene tørrer ud. Men der må tages et vist forbehold over for resultatet, fordi målingerne på referencematerialet er foretaget af forskellige personer. Dertil kommer den statistiske usikkerhed samt det forhold, at det var nødvendigt at kombinere de to køn ved sammenligningen.

Fordelingen mellem kønnene afveg ikke signifikant fra 1:1. Ungfugle optræder ved Shetland tidligt på vinteren, men bevæger sig i de følgende måneder mod sydligere dele af Skotland.

Af 80 Islommer fra Shetland havde 27 gamle helede skudsår. Heraf var 22 (repræsenterende alle tre grupper) ramt af hagl, mens 5 (alle fra Canada/Grønland) var skudt med kaliber .22 riffel.

Størstedelen af de 103 skotske Islommer var omkommet som følge af oliespild, i alt 86 fra årene 1978-1994. En væsentlig del var indsamlet under en alvorlig olieforurening på Shetland i 1979, hvorunder der blev fundet i alt mindst 181 Islommer. Over halvdelen stammede tilsyneladende fra Island, der har en ret lille bestand på højst 500 par. I 1993 ramte en ny oliekatastrofe Shetland, Ved den lejlighed fandtes blot 12 Islommer repræsenterende alle tre grupper; men eftersøgningen skete under meget vanskelige forhold, så antallet af ramte fugle var med al sandsynlighed væsentligt større.

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