Gillnet bycatch of seabirds in South-west Greenland, 2003 - 2008

TECHNICAL REPORT NO. 85, 2011
PINNGORTITALERIFFIK
GREENLAND INSTITUTE OF NATURAL RESOURCES

Data sheet

Title:	Gillnet bycatch of seabirds in Southwest Greenland, 2003 - 2008
Series title and no.:	Technical Report No. 85
Author(s):	Flemming R. Merkel
Department(s):	National Environmental Research Institute, Aarhus University Greenland Institute of Natural Resources
Publisher:	Pinngortitaleriffik, Greenland Institute of Natural Resources
Year of publication:	February 2011
Referee(s):	Morten Frederiksen, Kaj Sünksen, Rasmus Hedeholm and Jens Bagger
Financing:	Department of Domestic Affairs, Nature and Environment
Please cite as:	Merkel, F.R. 2011. Gillnet bycatch of seabirds in Southwest Greenland, 2003 - 2008. Technical Report No. 85, Pinngortitaleriffik, Greenland Institute of Natural Resources
Translation:	Søren Kristiansen
Drawings:	
Cover photos:	Bo Bergstrøm
ISBN: ISSN (electronic):	87-91214-55-6 1397-3657
Number of pages:	25
Internet version:	The report is available only in electronic format (pdf) at GINR's website http://www.natur.gl

Prints can be requested from:

Pinngortitaleriffik
Postboks 570
3900 Nuuk
Greenland

Phone. +299 36 12 00
Fax. +299 36 12 12
info@natur.gl

Gillnet bycatch of seabirds in Southwest Greenland, 2003 - 2008

Flemming Ravn Merkel
National Environmental Research Institute,
Aarhus University,
Greenland Institute of Natural Resources

Technical Report No. 85, 2011
Pinngortitaleriffik
Greenland Institute of Natural Resources

Contents

Summary 7

Sammenfatning 8

Eqikkaaneq 9

1 Introduction 11
1.1 Acknowledgements 11

2 Methods 12
2.1 Bycatch statistics and fish landings 12
2.2 Analyses 12

3 Results and discussion 13
3.1 Species and numbers reported as bycatch 13
3.2 Potential bycatch sources 16
3.3 The reported bycatch of murres 17
3.4 The bycatch of eiders 18

4 Conclusions and recommendations 21

5 References 24

6 Appendix 26
6.1 Hunting report 26

Greenland Institute of Natural Resources

Technical Report No. 85

Summary

Previous studies (2000/2001) in Southwest Greenland, limited to the Nuuk area, showed that bycatch in gillnets, especially lumpsucker (*Cyclopterus lumpus*) gillnets, was of conservation concern for the common eider (*Somateria mollissima*). From 2002 it became mandatory to report the bycatch as part of the annual hunting statistics and here I present the data reported for 2003 – 2008, with the purpose of describing the relative magnitude of the problem within Greenland. Landing statistics representing gillnet catches of lumpsucker, cod (*Gadus morhua*) and ringed seal (*Phoca hispida*) were analysed to identify sources of the bycatch.

The data show that bycatch of seabirds in Greenland is largely limited to Southwest Greenland and concerns almost exclusively the common eider and to a smaller extent also the king eider (*Somateria spectabilis*). Murres (*Uria spp.*) were also consistently reported as bycatch, 307 - 1,911 birds annually. However, these numbers appear to be strongly biased by reporting errors. No relationship was found between the various gillnet catches in Southwest Greenland and the reported bycatch, but a significant proportion (52%) of the bycatch variation was explained by the hunting records for murres, indicating that some hunters incorrectly reported hunted birds as bycatch. Probably, the true number of murres caught as bycatch in gillnets is negligible. Five other seabird species were reported as bycatch, but also in negligible numbers.

For the eiders, the data confirm that the bycatch in Southwest Greenland to a large extent is caused by the gillnetting of lumpsucker in March, April and May, and especially the regions of Nuuk and Maniitsoq appear to be high-risk areas for eider bycatch. The lumpsucker landings explained 40% of variation in eider bycatch, but also the gillnet catches of ringed seal contributed significantly to the bycatch. Combined, the two variables explained 68% of the bycatch variation. In contrast to previous observations from Nuuk, the cod fishery was not detectable as a factor influencing the level of eider bycatch, however, this may be due to the available statistics on cod landings, which does not discriminate between gillnet fishery and other fisheries. In months with no records of lumpsucker landings only the hunting records for eiders could explain a significant proportion of the eider bycatch (56%), indicating that errors due to misalignment also occur when hunted eiders are reported. The total number of eiders reported as bycatch ranged between 1,000 and 5,930 birds annually in 2003 - 2008, but an alternative estimate indicates that the actual level of eider bycatch, from lumpsucker gillnets alone, was between 6,000 and 20,000 birds.

The fastest and most effective solution to reduce the bycatch of eiders would be to manage the lumpsucker fishery according to abundance-based fishery openings, which would imply a postponement of the lumpsucker fishery until May. This may be implemented throughout Southwest Greenland, or limited to the fishing areas with the highest bycatch risk. The latter would, however, require more detailed information about the exact locations of the bycatch and the circumstances.

Sammenfatning

Tidligere undersøgelser i Sydvestgrønland (2000/2001) har vist at bifangst i fiskegarn og særligt i stenbidergarn, er et potentielt forvaltningsproblem for almindelig ederfugl (*Somateria mollissima*). Problemets omfang har dog kun været undersøgt omkring Nuuk. I 2002 blev det imidlertid lovpligtigt at indberette bifangsten som en del af jagtudbyttet og i denne rapport præsenteres disse indberetninger for årene 2003 – 2008. Dette med henblik på at beskrive den relative størrelse af bifangstproblemet i forskellige dele af Grønland. Indhandlingsstatistik der repræsenterer netfangst (i nedgarn) af stenbider (*Cyclopterus lumpus*), torsk (*Gadus morhua*) og ringsæl (*Phoca hispida*) er inkluderet og analyseret for eventuelle sammenhænge med den rapporterede bifangst af havfugle.

Tallene viser at bifangsten af havfugle i grove træk er begrænset til Sydvestgrønland og primært vedrører almindelig ederfugl og i mindre grad kongeederfugl (*Somateria spectabilis*). Lomvier (*Uria spp.*) blev også konsistent rapporteret, årligt mellem 307 og 1.911 fugle, men tilsyneladende er disse tal fejlbehæftede. Ingen sammenhæng var at finde mellem de indhandlede fisk og bifangsten af lomvier, men til gengæld kunne en signifikant andel (52%) af variation i den rapporterede bifangst forklares med indrapporteringen af skudte lomvier. Dette indikerer, at nogle af fangerne fejlagtigt registrerer oplysninger om skudte fugle som bifangst, sandsynligvis fordi tallene forskydes til den forkerte række i fangstregistreringsskemaet. Den reelle bifangst af lomvier er formentlig ubetydelig. Fem andre arter af havfugle blev registreret som bifangst, men i et ubetydeligt antal.

For ederfuglene bekræfter resultaterne, at bifangsten i Sydvestgrønland i stor udstrækning forårsages af stenbiderfiskeri i marts, april og maj måned. Særligt området omkring Nuuk og Maniitsoq ser ud til at være belastet af bifangst. Indhandlingen af stenbider kunne forklare 40% af variationen i den rapporterede bifangst, men også netfangst af ringsæl bidragede signifikant. Tilsammen forklarede de to variable 68% af variationen i bifangst. I modstrid til tidligere observationer ved Nuuk kunne torskefangsten ikke detekteres som en betydende faktor for bifangsten af ederfugle. Dette skal sandsynligvis ses i sammenhæng med, at den tilgængelige indhandlingsstatistik for torsk ikke skelnede mellem nedgarnsfiskeri og andet fiskeri. I måneder uden indhandling af stenbider var det kun antallet af skudte ederfugle, som kunne forklare en signifikant andel (56%) af variationen i bifangst, hvilket indikerer, at der også her sker en betydelig fejlregistrering af skudte fugle. I alt blev der årligt i perioden 2003 - 2008 rapporteret mellem 1.000 og 5.930 ederfugle som bifangst, men et alternativt estimat indikerer, at den reelle bifangst, alene fra stenbiderfiskeriet, måske snarere varierede mellem 6.000 og 20.000 ederfugle.

Den hurtigste og mest effektive måde at reducere bifangsten af ederfugle, vil være at forvalte stenbiderfiskeriet efter såkaldte "abundance-based fishery openings", hvilket vil indebære at starten på stenbiderfiskeriet udskydes til maj måned. Dette kunne implementeres for hele Sydvestgrønland, eller alternativt kun de steder hvor bifangsten er størst. Sidstnævnte vil imidlertid kræve yderligere undersøgelser.

Eqikkaaneq

Kitaata kujataani siusinnerusukkut (2000/2001) misissuinerit takutippaat qassutinik aalisagarniutinik, ingammik nipisanniutinik, miternik siorartuunik (Somateria mollissima) pisarisuukkat miternik tamakkuninnga aqutsinermut ajornartorsiutaasinnaasut. Nuulli eqqaani annertunerusumik tamanna ajornartorsiutigineqarsimavoq. 2002-mili piniarnermut nalunaarsuiffimmut pisarisuukkat pisat ilaattut nalunaarutigineqartarnissaat inatsisitigut piumasaqaataalerpoq, nalunaarusiamilu matumani 2003 – 2008-mi pisatut nalunaarutigineqarsimasut takutinneqarput. Tamatumani kalaallit Nunaata ilaani sumiiffinni assigiinngitsuni pisarisuukkanik ajornartorsiuterpassuit allaaserineqarnissaat siunertarineqarluni. Qassutinik kivisittakkanik nipisanik (Cyclopterus lumpus), saarullinnik (Gadus morhua) aamma natsernik (Phoca hispida) tunisinerni kisitsisit ilanngunneqarput timmissanillu imarmiunik pisarisuukkatut nalunaarsorneqarsimasunut ataqatigiittoqarsinnaanera misissoqqissaarneqarluni.

Kisitsisit takutippaat timmissanik imarmiunik pisarisuukkat Kitaata kujtaaniunerusoq pisarisoorneqartartut tamakkulu nalinginnaasumik tassaanerullutik meqqit siorartuut ikinnerusullu meqqit siorakitsut (Somateria spectabilis). Appat (Uria spp.) pisarisuukkat nalunaarsorneqartunut aamma naapertuupput , ukiumut timmissat 307 1.911-it akornanni, kisitsisilli tamakku kukkunertaqarsinnaapput. Aalisakkat tunineqarsimasut appallu pisarisuukkat ataqatigiinnerat takuneqarsinnaanngilaq akerlianilli pisarisuukkatut nalunaaru-tigineqarsimasut (52%) appatut aallaasatut nalunaarsorneqarsimasutut nassuiarneqarsinnaapput. Taamaalilluni piniartut ilaasa kukkullutik timmissat aallaasatik pisarisuukkatut nalunaarsortarsimassagaat ilimanaateqalerpoq, imaassinnaavoq pisanik nalunaarsuiffimmut kukkusumik tulleriiaarneqartarsimanerannik pissuteqartumik. Appanilli pisarisuugaviit amerlavallaarsimagunanngillat. Timmiaqatigiit imarmiut allat pisarisuukkatut aamma nalunaarsorneqartarsimapput, tamakkuli amerlanngillat.

Miternut tunngatillugu angusat uppernarsisippaat Kitaata kujataani marsimi, apriilimi maajimilu nipisanniarnerni pisarisuukkat amerlanerpaajusut. Ingammik Nuup Maniitsullu eqqaanni pisarisuukkat amerlasoorpassoorpasipput. Nipisanik tunisinerni 40 %-nik nikingassut pisarisuukkat allanngorarnerannik nassuiarneqarsinnaagunarpoq, aammali natsiit qassutinik kivisittakkanik pisarisuukkat amerlangaatsiartoorpasipput. Taakku katinnerat 68 %-inik pisarisuukkani allanngorarnernut marluusunut taakkununnga nassuiaataapput. Nuup eqqaani siusinnerusukkut takusanut akerliusumik saarullinniarnermi miternik pisarisuukkat amerlasoorsuartut oqaatigineqarsinnaanngillat. Tamanna saarullinnik tunisinerni kisitsisini qassutinik kivisittakkanik allatullu saarullinniarnerni pisat immikkoortinneqarneq ajornerannik pissuteqarunarpoq. Qaammatini nipisat suaannik tunisiffiunngitsuni mitit aallaallugit pisat pisarisuukkat allanngorarnerannut (56 %) pissutaapput, tamatuma ilimanarsisippaa timmissat aallaallugit pisarineqartartorpassuit kukkusumik nalunaarsorneqartarsimasut. 2003 – 2008-mi meqqit ukiumut katillugit 1.000 aamma 5.930-it pisarisuukkatut nalunaarutigineqarsimapput, allatulli missingiinerit ilisimanarsisippaat

mitit pisarisuugaviit, nipisanniarnerinnarmi, 6.000 aamma 20.000-it akornanni nikerarsinnaasut.

Miternik pisarisuukkanik sukkanerpaamik sunniuteqarluarnerpaamillu ikilisitsineq tassaasinnaavoq nipisanniarnerup "abundance-based fishery openings"-mik taaneqartartoq malillugu aqunneqarnissaa, tamatuma kingunerisaanik nipisanniarneq maajip qaammataani aatsaat aallartinneqartassaaq. Tamanna Kitaata kujataani tamarmi atuuttussanngortinneqarsinnaavoq allatulluunniit periaaseqarluni sumiiffinni allani pisarisuukkat amerlanerpaaffiani taamaallaat atuuttussanngortinneqarluni. Kingullerli taaneqartoq atussagaanni annertunerusumik misissuisoqartoqarpoq.

1 Introduction

Incidental capture of non-target species in fishing gear (bycatch) is known as a conservation issue for several seabirds, sea turtles and marine mammals (Tasker *et al*. 2000, Lewison *et al*. 2004). The bycatch of birds reported from southern areas often involves long-lines, such as the familiar cases of albatross long-lining mortality in the Southern Ocean (e.g., Weimerskirch *et al*. 1997), while bycatch concern in northern areas generally concerns mortality related to gillnet fisheries (Bakken & Falk 1998). Previously, gillnet bycatch has received little attention, but recent concern has been expressed for Greenland, Norway and the Baltic region, involving large bycatches of auks, cormorants and seaducks, and mainly gillnets used for cod (*Gadus morhua*) and lumpsuckers (*Cyclopterus lumpus*) (Merkel 2004, Christensen-Dalsgaard *et al*. 2008, Žydelis *et al*. 2009).

Studies conducted in Greenland in 2000 and 2001 showed that bycatch of king eiders (*Somateria spectabilis*) and common eiders (*S. mollissima*) in lumpsucker gillnets was a conservation issue in wintering areas around Nuuk, Southwest Greenland. Bycatch in gillnets accounted for as much as 52% of the eiders brought to the local market in Nuuk in March and April and in some areas the bycatch included a very high proportion of adult common eiders. In March and April the bycatch mortality was of the same order of magnitude as hunting, and 1,500 – 2,000 birds were estimated to drown annually in the Nuuk area alone (Merkel 2004). From 2002 the fishermen were no longer allowed to sell the bycatch at the local market and it became mandatory to report bycatch as part of the annual hunting statistics.

In this report, I analyse the statistics reported on bycatch since 2002 with the purpose of describing the relative magnitude of the problem in Greenland, acknowledging that the bycatch probably is markedly underreported, but assuming that the relative numbers reported for subregions are comparable. Landing statistics representing gillnet catches of lumpsucker, cod and ringed seals (*Phoca hispida*) were analysed to identify sources of bycatch. Future studies and mitigation measures are suggested.

1.1 Acknowledgements

I wish to thank Kaare Winter Hansen, Department of Fisheries, Hunting and Agriculture, for making the harvest statistics available. The Department of Domestic Affairs, Nature and Environment funded the study.

2 Methods

2.1 Bycatch statistics and fish landings

Statistics on bycatch and hunting were made available by the Greenland Government Department of Fisheries, Hunting and Agriculture. Since 1993, this department has collected harvest statistics on a national scale, referred to as Piniarneq. The statistics include all hunting in Greenland, but also egg collection, gillnet harvest of ringed seals and from 2002 also bycatch of murres (*Uria spp.*), common eiders and king eiders. The hunters or fishermen report once a year on monthly bag numbers and failure to do so implies that the hunting license is not automatically renewed. In most cases below, the statistics on common eiders and king eiders were lumped, due to previous studies showing that a large proportion of the king eiders are reported as common eiders (Frich & Falk 1997, Merkel 2004)

Fisheries statistics on lumpsucker and cod were obtained from Statistics Greenland (www.stat.gl) and represent the registered landings in 1997-2008.

2.2 Analyses

To identify sources of seabird bycatch, stepwise backwards multiple regression was applied using the number of birds reported as bycatch as the dependent variable (bycatch per month for all Greenland, 2003 – 2008), and a combination of independent variables representing gillnet fisheries that previously were identified as causing seabird bycatch in Greenland, i.e., the gillnetting of lumpsucker, ringed seal and cod (Merkel 2004). In addition, statistics on the number of hunted birds was included as an independent variable for seabird bycatch due to indications that hunters sometimes report hunted birds incorrectly as bycatch.

At each step in the multiple regression the variable with the highest P-value (> 0.1) was removed from the analysis until only those variables that contributed significantly to the variation in the dependent variable remained ($P < 0.05$). The independent variables initially included in the regression analyses were those having a significant positive correlation with the dependent variable (Pearson correlation, $P < 0.05$), excluding inter-correlated variables. Regression analyses were applied to log-transformed data. The dependent variable and the regression model residuals were tested for normality using the Andersen-Darling Normality Test ($P < 0.05$).

Previous bycatch estimates from Nuuk and the relative distribution of lumpsucker landings in Greenland were used to construct a crude estimate of the total bycatch of eiders in Southwest Greenland (Qeqertarsuaq – Nanortalik). Among two bycatch estimates available for eiders in Nuuk, the highest one was used (1711 eiders in 2001, March – May) based on the assumption that they were both minimum estimates (Merkel 2004).

3 Results and discussion

3.1 Species and numbers reported as bycatch

As a general remark, it should be noted that harvest statistics derived from bag reports, like the Piniarneq system in Greenland, normally are suspected to underestimate the actual take because they rely on a large number of persons being active and willing to submit annual reports on harvest. Previous studies of the trade of birds at the local market in Nuuk indicate that underestimation of hunting levels is, or at least has been, an issue for both eiders and murres in Greenland (Falk & Durinck 1992, Frich & Falk 1997). Concerning the bycatch, no previous studies have dealt with the reliability of the harvest statistics; however, underestimation could be expected for at least two reasons: a) the obligation to report bycatch is a relatively new practice and probably requires some time to be fully acknowledged, b) the possibility for commercial hunters/fishermen to sell bycatch at the local market was discontinued in 2002 and to some extent changed the financial situation for some of the fishermen. The latter might have influenced their willingness to report the bycatch. However, as this report shows, underestimation is not always the case. Circumstances may cause low harvest levels to be overestimated (section 3.3).

Since the bycatch of murres and eiders became part of the Greenland hunting statistics in 2002, there has been a gradual increase of reported bycatch of eiders (Fig. 1). As earlier mentioned, king eiders are often reported as common eiders, making it necessary to lump the two species. Murres were also consistently reported as bycatch since 2003, usually in small numbers, but with some variation (Fig. 1). Other reports on bycatch in the period 2002 – 2008 include six incidents (17 birds) of cormorant (*Phalacrocorax carbo*), seven incidents (163 birds) of little auk (*Alle alle*), three incidents (62 birds) of black guillemot (*Cepphus grylle*), two incidents (5 birds) of great northern diver (*Gavia immer*) and two incidents (11 birds) of black-legged kittiwakes (*Rissa tridactyla*). Due to the low numbers of these latter species, only murres and eiders will be subject to further discussion in this report.

Except for some reports of eider bycatch from the Upernavik area, nearly all the bycatch was reported in Southwest Greenland, especially the area from Sisimiut to Nanortalik (Fig. 2) and especially during March, April and May (Fig. 3). Most birds were reported from the Maniitsoq area with an average of ca. 900 birds per year. The area from Sisimiut to Nanortalik was also the main bycatch area for murres, although with much smaller numbers reported (Fig. 2). On average, 3,260 ± 725 (S.E.) eiders were reported as bycatch in 2003 – 2008 and 769 ± 264 murres. The maximum number reported in a single year was 5.930 eiders (2008) and 1,911 murres (2004).

Fig. 1. The bycatch of murres and eiders in Greenland from 2002 to 2008, based on the Greenland hunting statistics (Piniarneq).

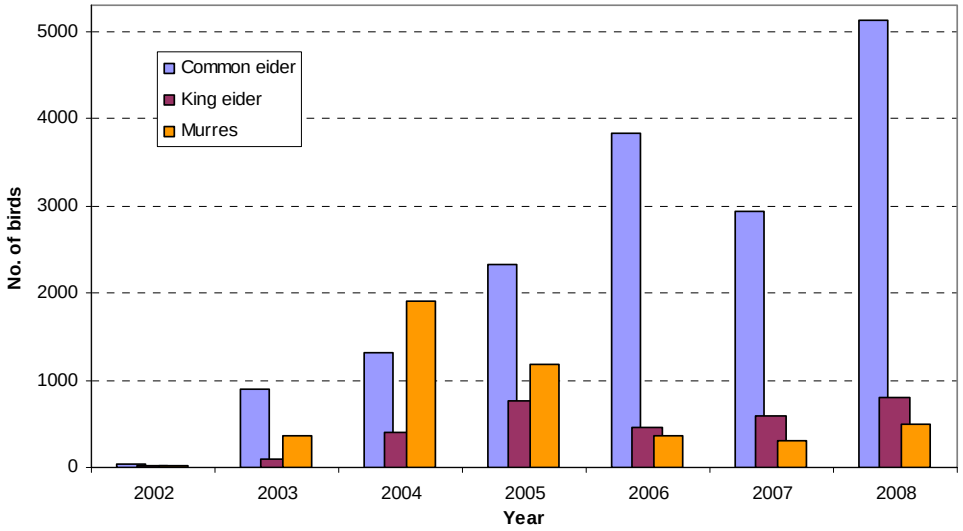


Fig. 2. The annual mean no. of eiders and murres caught as bycatch in various districts of Greenland (Piniarneq, 2003 – 2008). Districts in West Greenland (Qaanaaq - Nanortalik) are arranged from north to south.

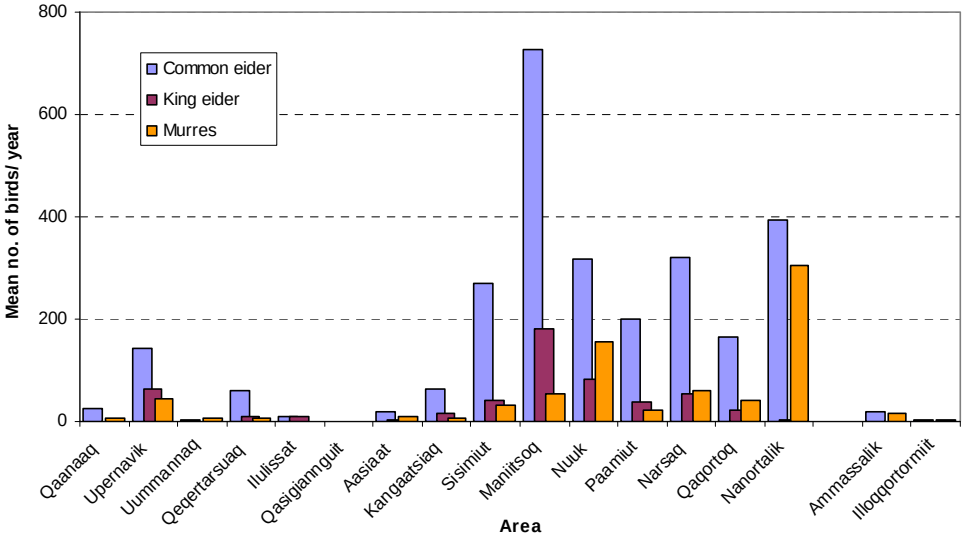


Fig. 3. The bycatch of murres and eiders in Greenland calculated as monthly means (± SE) for the period 2003 – 2008. King eiders and common eiders are combined

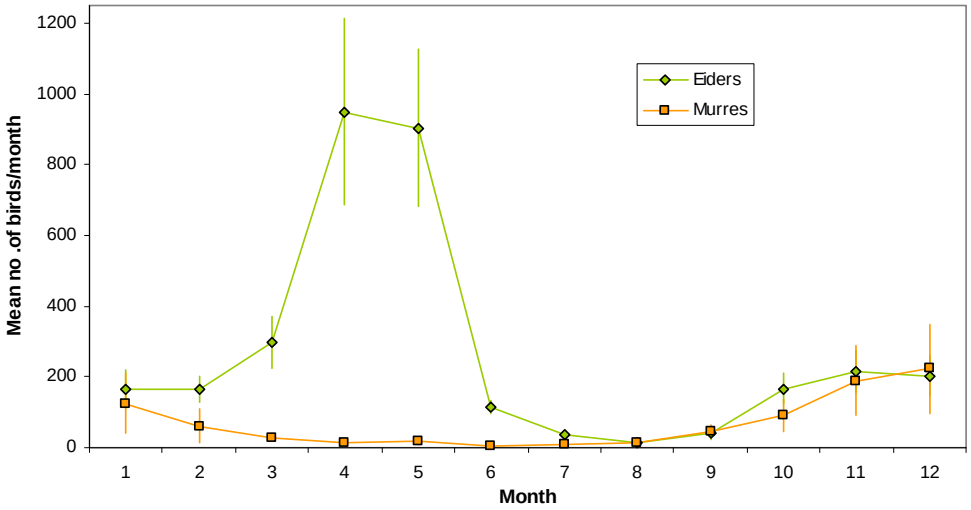


Fig. 4. Annual landings (tons or no.) of lumpsucker, cod and ringed seal (hunting not included) in Greenland according to data from Greenland Statistics and Piniarneq.

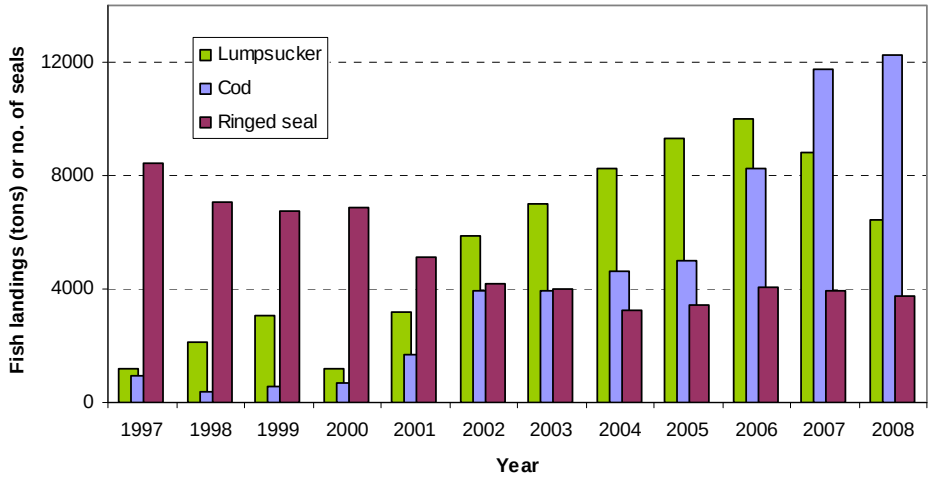


Fig. 5. Mean monthly landings (tons or no.) of lumpsucker, cod and ringed seal in Greenland (2003-2008) according to data from Greenland Statistics and Piniarneq. Only data from Southwest Greenland is shown for ringed seal.

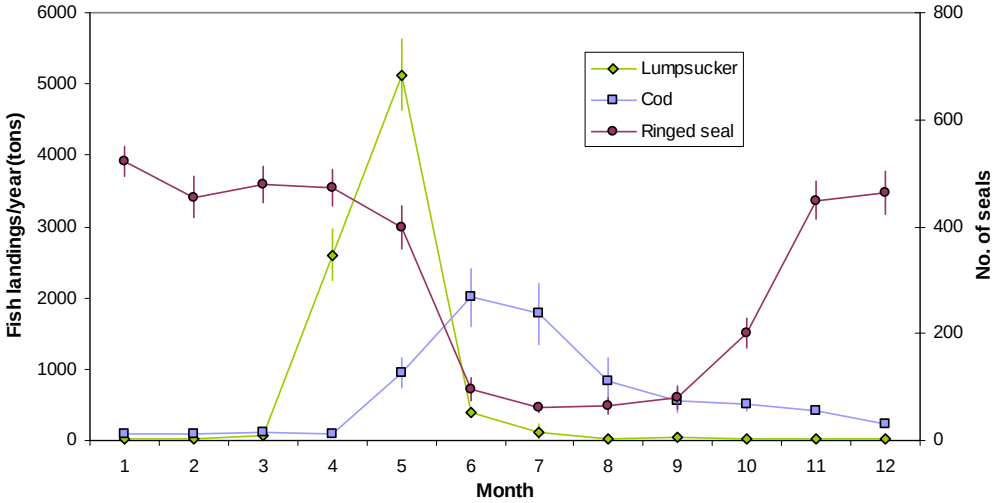
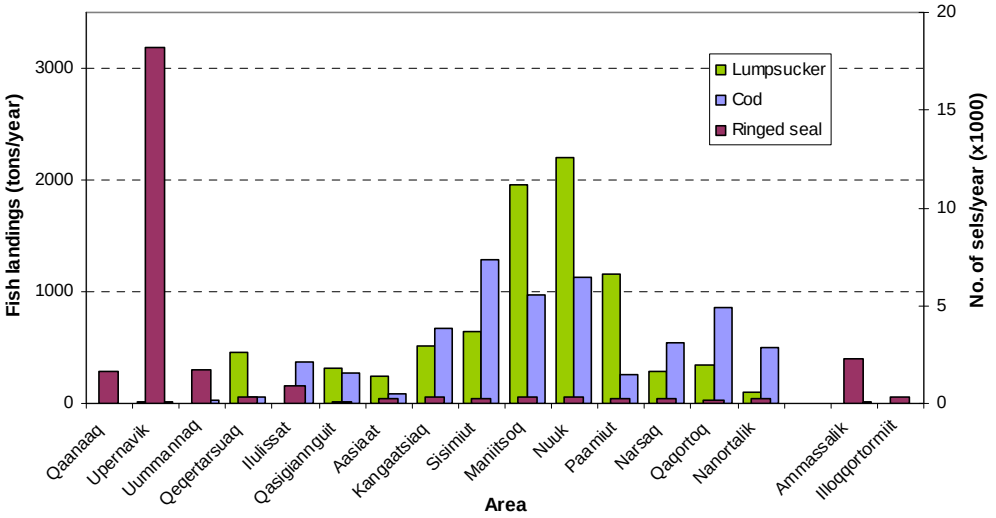


Fig. 6. Mean annual landings (tons or no.) of lumpsucker, cod and ringed seal (hunting not included) in various districts of Greenland. Based on 2003 – 2008 data from Greenland Statistics and Piniarneq. Districts in West Greenland (Qaanaaq - Nanortalik) are arranged from north to south.



3.2 Potential bycatch sources

Figure 4, 5 and 6 shows the annual, seasonal and regional catch distribution for three previously identified sources of seabird bycatch in Greenland; the lumpsucker and cod fishery and the netting of ringed seals (Merkel 2004).

The lumpsucker and the cod landings appear to have increased considerably since the late 1990s and early 2000s, and at least for the lumpsucker there was a distinct seasonal overlap between the bycatch of eiders and the lumpsucker landings. Lumpsuckers are caught mainly due to the highly valued and remunerative roe production, with the spawning season starting in April in shallow bays along the outer coastline or in the fjords (Nielsen *et al*. 2000). These spawning areas often overlap with the foraging areas of the eiders and occasionally the birds feed directly on the eggs (Bustnes & Erikstad 1988, Merkel *et al*. 2007).

The cod fishery in May and June may also add to the bycatch of eiders (Fig. 3 and 5) because gillnets are used to some extent in the cod fishery. However, approximately 70-80% of the annual catches are caught using pound-nets, which are not likely to cause bycatch of eiders (Anja Retzel, pers. com. 2010). Another reason not to expect a meaningful correlation between cod landings and the eiders bycatch is the fact that the available landing statistics from Statistics Greenland were also mixed with offshore catches of cod.

The bycatch of murres was reported almost exclusively during winter (Fig. 3). The highest numbers were reported in November, December and January, along with similar numbers for eiders. This winter bycatch appears only to overlap with the gillnet catches of ringed seal (Fig. 5). For the eiders, the seal gillnets are known to cause some bycatch, at least in the Nuuk area (Merkel 2004), however, for the murres no such bycatch has been described and should perhaps not be expected. In general, wintering murres in Southwest Greenland are distributed farther offshore than the eiders (Merkel *et al*. 2002) and only sporadically overlap with the gillnetting of seals, which usually takes place in coastal bay areas or in the fjords (Merkel 2004; Aqqalu Rosing-Asvid and Bjørn Rossing, pers. com. 2010).

Previously, a large commercial offshore salmon (*Salmo salar*) fishery took place in West Greenland and was known to cause large bycatches of murres in offshore driftnets during the autumn. Studies indicated that up to half a million birds were killed annually when the salmon catches peaked in the early 1970s (Tull *et al*. 1972, Christensen & Lear 1977, Falk 1998). However, since then the salmon catches gradually decreased and went from more than 2000 tons a year in the early 1970s to a reported 9 tons in 2003 (Jensen 1990, Rasmus Nygaard, pers. com. 2010). From around the late 1980s, the salmon fishery was no longer considered a significant bycatch issue in Greenland due to fact that the movements of the murres and the salmon fishery became separated in time and space (Kampp *et al*. 1994).

3.3 The reported bycatch of murres

Only for ringed seals a positive significant correlation was found between current gillnet fisheries in Greenland and the reported bycatch of murres ($r = 0.47$, $P < 0.001$, $n = 58$). However, this correlation did not exist when excluding the large bulk of ringed seals reported from Uummannaq, Upernavik, Qaanaaq and Ammassalik (Fig. 6, $r = 0.25$, $P = 0.06$).

Individual bag reports indicate that perhaps the reported bycatch represents errors. Occasionally, hunters apparently fill in the space for bycatch instead of that for hunted birds. The two spaces are located next to each other in a rather large sheet containing many rows and columns (App. 1). A suspiciously large number of blanks exist for hunted birds at months where bycatch of birds were reported. During the murre hunting seasons (September – March) in 2003 – 2008, bycatch of murres were reported in 130 months (65 hunters, 1 – 7 reports), but only in 28 cases (22%) did these hunters also report shot birds in the same month. This is an unusual low proportion given the high frequency of bag records normally reported for shot birds in the September – March period: 14,670 monthly reports in 2003 - 2008 (2669 hunters).

A correlation analysis confirmed that there was a positive and significant relationship between the reported number of shot murres and the reported number of birds caught as bycatch ($r = 0.65$, $P < 0.001$). An even stronger correlation was found when analysing the number of reports ($r = 0.72$, $P < 0.001$), instead of number of individuals, indicating that the risk of misalignment of bag records increased as the total number of reports went up, as one should expect if this was caused by random errors.

A regression analysis showed that the monthly reports of shot murres explained a large and significant proportion (52%) of the variation in monthly reports of murre bycatch ($t = 7.78$, $P < 0.001$, $n = 58$). Adding gillnet catches of ringed seals as a factor for the bycatch did not add any explanation to the bycatch variation, as monthly reports of shot murres were inter-correlated with gillnet catches of ringed seal. Probably this inter-correlation was an artefact caused by coinciding seasonal patterns in the catch/hunting rates. In reality, there is a spatial segregation between the seal catches and the murre hunting in most cases (section 3.2).

The problem of misplacement, and in particular misalignment, of bag records when reporting to Piniarneq is known for other species, especially those that normally are reported in small numbers, such as large marine mammals. For such species a single misplaced figure can make a huge difference for the annual total and this is how the Department of Fisheries, Hunting and Agriculture became aware of this problem (Kaare Winter Hansen, pers. com. 2010). To reduce the number of errors, the Department has redesigned the report form a number of times over the years. Apparently, this was not sufficient. In fact, the risk of making errors occurs twice since the reporting is a two-step procedure. First, the hunters fill in a day-log form and at the end of the hunting year these figures are copied to a final submission form that summarizes monthly totals (App. 6.1). Finally, mistakes can also occur when the figures are entered into the Greenland Government database. Ideally, this three-step procedure should be reduced to a single entry procedure, which could be achieved by an internet solution were hunters/fishermen report di-

rectly to the Greenland Government database. Confirmation procedures related to species, harvest methods and dates would be an integrated part of such a system. This would of course have to be introduced gradually and on a voluntarily basis to account for the fact that some have limited access to the internet or will be reluctant to use such a system.

3.4 The bycatch of eiders

Lumpsucker and cod gillnets have been identified as key sources for bycatch of eiders in several countries, including Greenland (Falk 1998, Merkel 2004, Christensen-Dalsgaard *et al*. 2008, Žydelis *et al*. 2009). In Nuuk, lumpsucker gillnets accounted for 86% of the bycatch brought to local market in 2000 and 2001, cod gillnets for 11% and seal gillnets, as a third source, accounted for 3% of the bycatch (Merkel 2004).

In this study the analyses of harvest statistics indicated that both the lumpsucker fishery and the gillnet catches of ringed seals contributed to the bycatch of eiders, but as with the murres, misplacement errors when reporting also appeared to influence the bycatch statistics (see below). In contrast to Merkel (2004), the cod fishery could not be identified as a contributing factor to the bycatch of eiders ($r < 0$, $P > 0.05$); however, keeping in mind the limitations of the available statistics on cod landings mentioned earlier (section 3.2).

The relative importance of the lumpsucker landings, the ringed seal catches and the misplacement errors varied between seasons. When analysing only the months with positive records of lumpsucker landings (mainly April – June, n = 35), both lumpsucker landings and ringed seal catches were significantly correlated with the bycatch of eiders ($r = 0.64$, $P < 0.001$; $r = 0.48$, $P < 0.01$; respectively), while the reported number of shot eiders was not ($r = 0.14$, $P = 0.40$). According to a regression analysis lumpsucker landings explained 40% of the variation in the reported bycatch of eiders and combined with a ringed seal variable the model explained 68% of the bycatch variation (Lumpsucker: $t = 6.62$, $P < 0.001$; Seals: $t = 5.19$, $P < 0.001$). The lack of a significant misplacement factor does not rule out the possibility that errors were made when reporting shot eiders during the lumpsucker season, only that the amount of errors were insignificant compared to the influence of the lumpsucker fishery.

When analysing months with no records of lumpsucker landings (n = 37), the number of shot eiders and the catches of ringed seal were both significantly correlated with the bycatch of eiders ($r = 0.75$, $P < 0.001$; $r = 0.66$, $P < 0.001$; respectively). However, as in the murre case, these two variables were inter-correlated ($r = 0.84$, $P < 0.001$), and only shot birds contributed significantly to the variation of eider bycatch (56%, $t = 6.72$, $P < 0.001$). As known from the Nuuk study the distribution of eiders and the gillnetting of seals are not necessarily spatially segregated, but it appears that any potential bycatch was insignificant compared to the errors in reporting.

The previous studies from Nuuk strongly suggested that the bycatch of eiders was heavily underreported in Piniarneq. Summarized for March, April and May between 65 - 376 eiders were reported as bycatch in Nuuk

in the years 2003 – 2008, while Merkel (2004) estimated that a minimum of 1576 – 1989 birds were caught during these months in 2000 and 2001. Local fishermen recently pointed out that bycatch of eiders is a severe problem in the district of Nanortalik, and they believe that up to 2,000 eiders can be caught in lumpsucker gillnets on a single day (Bent Bredde Olesen, Nanortalik, pers. com.). On a normal day in Nanortalik the bycatch is probably far below this level, but the information is indeed highly contrasting to the numbers reported to Piniarneq, which were between 65 – 1137 birds in Nanortalik during March, April and May, 2003 – 2008.

Based on the 2001 bycatch estimates from Nuuk (Merkel 2004) and the relative distribution of lumpsucker landings in Greenland (2001 – 2008), it was estimated that roughly 6,000 eiders was caught as bycatch during March, April and May in 2001 in Southwest Greenland (Qeqertarsuaq – Nanortalik, which account for 99% of the lumpsucker landings). This is based on the calculation that Nuuk accounted for 28% of the lumpsucker landings and the assumption that the 2001 bycatch rate calculated for Nuuk (1.8 eiders/ton of lumpsucker) was representative for the remaining Southwest Greenland. The last assumption is probably not true; however, information was only available for Nuuk. An even more critical question is whether the statistics on lumpsucker landings, showing a factor 3.34 increase from 2001 to 2006, are reliable (Fig. 4). If this is true, the total bycatch of eiders may have been as high as 20,000 eiders in 2006 (when lumpsucker landings peaked). And this does not include the potential bycatch in the gillnets used for ringed seal and cod, which in the Nuuk case accounted for additional 14% (Merkel 2004).

Fig. 7. Bycatch of common eiders in seal gillnets. Photo: Bo Bergstrøm, Nuuk Fjord, March 2006.

4 Conclusions and recommendations

The bycatch of seabirds in Greenland is largely limited to Southwest Greenland and concerns almost exclusively eiders - primarily the common eider and to a small extent also the king eider. The bycatch can be characterized as a typical gillnet bycatch phenomenon, caused by one or more coastal gillnet fisheries involving a diverse fleet of numerous small boats that usually are difficult to monitor (Žydelis *et al*. 2009). Bycatch of eiders due to commercial netting in the littoral zone is also known from coastal Newfoundland, Iceland, Norway, Germany, and the Baltic Sea (Kies & Tomek 1990, Follestad & Runde 1995, Henriksen 1997, Bakken & Falk 1998, Kirchhoff (1982) in Tasker *et al*. 2000). See additional references for Sweden and Germany in Žydelis *et al*. (2009).

Based on the analyses of various Greenlandic harvest statistics this report support previous findings from Nuuk (Merkel 2004), that the bycatch of eiders in Southwest Greenland to a very large extent is caused by the gillnetting of lumpsucker in March, April and May. Especially shallow waters in the area of Nuuk and Maniitsoq can be categorized as high-risk areas for eider bycatch due to large amounts of lumpsucker landings (50% of total), however, lumpsucker fisheries occur throughout Southwest Greenland (Fig. 6). The analyses also confirm that the gillnet catches of ringed seal contribute to the bycatch of eiders at certain periods. However, the cod fishery was not detectable as a factor influencing the level of bycatch, in contrast to what was previously observed in Nuuk (Merkel 2004).

The report emphasizes that harvest statistics based on hunting reports or fish landings are fraught with various uncertainties, and underline the need to interpret these with great caution. The landing statistics of cod was a mixture of information from three types of fisheries, involving diverging fishing techniques and catch areas, making it highly unlikely to detect any possible minor link to the bycatch of eiders. Based on what was previously known about bycatch levels of eiders in Southwest Greenland, it is safe to conclude that the total amount of bycatch reported by hunters/fishermen constitute a substantial underestimate. Between 1,000 and 5,930 eiders were reported to Piniarneq as bycatch annually in 2003 - 2008, but according to a bycatch rate calculated for Nuuk and the relative distribution of lumpsucker landings in Greenland, this report suggests that the true number of eiders caught as bycatch in lumpsucker gillnets in Southwest Greenland ranged between 6,000 and 20,000 birds per year. It should be emphasized that this is a very crude estimate; partly because it relies on a simplified and single bycatch rate calculation for the Nuuk area. This figure (1.8 eiders/ton of lumpsucker) may indeed not be representative across years and areas. Comparison with bycatch rates from the literature is not really possible, because these represent other species and areas and usually are reported as birds/net-length/day (Žydelis *et al*. 2009).

The bycatch estimate of ~20,000 eiders when lumpsucker landings are as high as in 2006, suggests that bycatch from the lumpsucker fishery may be similar in magnitude to hunting. Between 24,130 and 31,722 eiders (both species combined) were reported shot annually in Greenland from 2003 to 2008 (Piniarneq 2010). Bearing in mind that the bycatch has been

shown to target an older segment of the population than hunting (Merkel 2004), the bycatch caused by lumpsucker gillnets is indeed of conservation concern. Perhaps this is not a huge concern for Greenland as long as the breeding population of common eider increases as fast as recently documented in Northwest Greenland - however, high growth rates like this are usually something that are observed during a recovery phase or periods with particular favourable breeding conditions and not something that can be expected to continue for several decades (Merkel 2010).

In contrast to the eiders, the results indicate that the number of murres reported as bycatch is strongly biased in the opposite direction due to errors made when filling out the harvest reports. Occasionally hunters report hunted birds incorrectly as bycatch, most likely due to misalignment of the bag records. Most likely, the true number of murres caught as bycatch in gillnets in Southwest Greenland is negligible. The problem of misalignment of bag records in Piniarneq was also detectable for eiders outside the lumpsucker season, when the bycatch of eiders was low and the hunting level was high. To some extent the misalignment of bag records probably occurs between all neighbouring rows in the report sheet, and for species otherwise reported in low numbers this potential bias may represent a significant error.

In terms of mitigation measures to reduce the bycatch in gillnets, Žydelis *et al* (2009) emphasized that the key to the solution of the problem is the willingness of fishermen and authorities to take action and to promote the co-existence of fisheries and bird populations. In Greenland a ban on local trade of seabird bycatch was introduced in 2002, but otherwise no actions have been taken to reduce the bycatch. In the meantime the problem probably increased considerably, at least based on the recent development in lumpsucker landings (Fig 4).

Few methods have been developed for seabird bycatch reduction in gillnets, however, among three general toolboxes used in the mitigation of gillnet bycatch, i.e., gear modification, time-of-day restrictions and abundance-based fishery openings (Melvin *et al*. 1999, Bull 2007), Merkel (2004) concluded that abundance-based fishery openings probably is the fastest and most effective solution to the problem of eider bycatch in Southwest Greenland. This represents the idea of allowing target fishery only in periods when catch per unit effort is very high. The total fish catch can be secured by only a small increase in effort at such times, and bycatch will be reduced because total fishing effort is reduced. By postponing lumpsucker fisheries in Southwest Greenland until May (when many eiders have left the wintering area) a large proportion of eider bycatch could be avoided. Perhaps the fishermen will have the opportunity to compensate for lost income in April by increasing fishing effort in May. A comparison of the eider bycatch and lumpsucker landings in April and May (Fig. 3 and 5), suggests that the bycatch rate in May was only half of the level in April. It should be emphasized that the total gillnet effort for lumpsucker is not known, only the catches.

A softer version of the abundance-based fishery option would be to restrict the lumpsucker fishery in only some fishing areas – those with the highest bycatch risk. However, this would require more detailed information about the exact locations of the bycatch and the circumstances.

There are several ways of pursuing this and below three possibilities are mentioned, of which the third may also improve the possibility to quantify the magnitude of the bycatch problem by generating bycatch rates per catch unit or fishing effort.

- Pursue the possibility that hunting wardens conduct regular surveys of known lumpsucker fishing areas (e.g., Nielsen *et al*. 2000). Ideally they should mark a GPS position and collect information about number of nets, numbers of birds, bird species and approximate age.
- Complete a semi-quantitative questionnaire survey asking all the registered lumpsucker fishermen to grade used fishing sites according to a simplified scale of bycatch risk. The survey may cover a single fishing season or multiple seasons.
- Complete a quantitative questionnaire survey asking a selected group of lumpsucker fishermen to fill in a questionnaire for each fishing trip. In addition to the bycatch details, they should fill in information about the nets, fishing time and lumpsucker catches. This would allow the calculation of bycatch rates both as birds/net-length/day and as birds/lumpsucker catch unit.

Fig. 8. Bycatch of common eider in lumpsucker gillnets. Photo: Lars Maltha Rasmussen, Nepisat Sund, Nuuk, April 2009.

5 References

Bakken, V. and Falk, K. 1998. Incidental take of seabirds in commercial fisheries in the Arctic countries. Circumpolar Seabird Working Group (CSWG), Akureyri, Iceland, CAFF Technical Report No. 1. 50 pp.

Bull, L.S. 2007. Reducing seabird bycatch in longline, trawl and gillnet fisheries. Fish and Fisheries 8: 31-56.

Bustnes, J.O. & Erikstad, K.E. 1988. The diets of sympatric wintering populations of Common Eider *Somateria mollissima* and King Eider *S. spectabilis* in Northern Norway. Ornis Fennica 65: 163-168.

Christensen, O. & Lear, W.H. 1977. Bycatches in salmon driftnets at West Greenland in 1972. Meddelelser om Grønland, Bioscience 205: 1-38.

Christensen-Dalsgaard, S., Fangel, K., Dervo, B.K., and Anker-Nilssen, T. 2008. Bifangst av sjøfugl i norske fiskerier - eksisterende kunnskab og forslag til kartleggingsprosjekt. Norsk Institutt for Naturforskning, Trondheim, NINA Rapport 382. 62 pp.

Falk, K. 1998. Review of seabird bycatch in Greenland. In: Bakken V. & Falk K. (eds), Incidental take of seabirds in commercial fisheries in the Arctic countries, pp. 18-23. Circumpolar Seabird Working Group (CSWG), Akureyri, Iceland.

Falk, K. & Durinck, J. 1992. Thick-billed Murre hunting in West Greenland. Arctic 45: 167-178.

Follestad, A. and Runde, O. 1995. Sjofugl og fiskeredskaper: gjenfunn av ringmerkede fugler. NINA, Norway, Oppdragsmelding 350. 26 pp.

Frich, A.S. and Falk, K. 1997. Jagtindsats og ederfuglefangst ved Nuuk. Greenland Institute of Natural Resources, Nuuk, Greenland, Technical Report No. 5. 33 pp.

Henriksen, G. 1997. Effects of Lumpsucker *Cyclopterus lumpus* fishing on Steller's Eider in Northern Norway, legislation and management. Wetland International Seaduck Specialist Group Bulletin 7: 42-44.

Jensen, J.M. 1990. Atlantic salmon at Greenland. Fisheries Research 10: 29-52.

Kampp, K., Nettleship, D.N. & Evans, P.G.H. 1994. Thick-billed Murres of Greenland: Status and prospects. In: Nettleship D.N., Burger J. & Gochfeld M. (eds), Seabirds on Islands, Threats, case-studies and action plans, pp. 133-154. Birdlife International, Cambridge.

Kies, B. & Tomek, T. 1990. Bird mortality in fishing nets in the Gulf of Gdansk, Polish Baltic Coast. Pelagicus 5: 23-27.

Lewison, R.L., Crowder, L.B., Read, A.J. & Freeman, S.A. 2004. Understanding impacts of fisheries bycatch on marine megafauna. Trends in Ecology & Evolution 19: 598-604.

Melvin, E.F., Parrish, J.K. & Conquest, L.L. 1999. Novel tools to reduce seabird bycatch in coastal gillnet fisheries. Conservation Biology 13: 1386-1397.

Merkel, F.R. 2004. Impact of hunting and gillnet fishery on wintering eiders in Nuuk, Southwest Greenland. Waterbirds 27: 469-479.

Merkel, F.R. 2010. Evidence of recent population recovery in common eiders breeding in western Greenland. Journal of Wildlife Management 74: 1869-1874.

Merkel, F.R., Jamieson, S.E., Falk, K. & Mosbech, A. 2007. The diet of Common Eiders wintering in Nuuk, Southwest Greenland. Polar Biology 30: 227-234.

Merkel, F.R., Mosbech, A., Boertmann, D. & Grøndahl, L. 2002. Winter seabird distribution and abundance off south-western Greenland, 1999. Polar Research 21: 17-36.

Nielsen, S.S., Mosbech, A., and Hinkler, J. 2000. Fiskeriressourcer på det lave vand i Vestgrønland - En interview undersøgelse om forekomsten af lodde, stenbidder og ørred (English summary: Distribution of Capelin, Lumpsucker and Arctic Char at shallow waters in western Greenland - An interview survey). National Environmental Research Institute (NERI), Roskilde, Working Report No. 118.

Piniarneq 2010. Hunting statistics for Greenland, 2003-2008. Department of Hunting, Fishing and Agriculture, Greenland Self Rule.

Tasker, M.L., Camphuysen, C.J., Cooper, J., Garthe, S., Montevecchi, W.A. & Blaber, S.J.M. 2000. The impacts of fishing on marine birds. ICES Journal of Marine Science 57: 531-547.

Tull, C.E., Germain, P. & May, A.W. 1972. Mortality of Thick-billed Murres in the West Greenland Salmon fisheries. Nature 237: 42-44.

Weimerskirch, H., Brothers, N. & Jouventin, P. 1997. Population dynamics of wandering albatross Diomedea exulans and Amsterdam albatross D. amsterdamensis in the Indian Ocean and their relationships with long-line fisheries: conservation implications. Biological Conservation 79: 257-270.

Žydelis, R., Bellebaum, J., Österblom, H., Vetemaa, M., Schirmeister, B., Stipniece, A., Dagys, M., van Eerden, M. & Garthe, S. 2009. Bycatch in gillnet fisheries - An overlooked threat to waterbird populations. Biological Conservation 142: 1269-1281.

6 Appendix

6.1 Hunting report

The collection of Greenlandic hunting statistics (Piniarneq) started in 1993, and since then the report sheets have changed several times to capture changes in the species covered and to reduce the risk of making errors when filling in the bag records. The day-log form and the submission form for 2008 are shown. At the end of the hunting year hunters copy the information from day-log forms to the submission form that summarizes monthly totals.

Piniarnermit nalunaarsuiffik **1. oktober 2007 – 30. september 2008** **Jagtjournal**

	Ulloq/ Dato	Qassit/ Antal	Ulloq/ Dato	Qassit/ Antal	Ulloq/ Dato	Qassit/ Antal	Ulloq/ Dato	Qassit/ Antal	Ulloq/ Dato	Qassit/ Antal	Ulloq/ Dato	Qassit/ Antal	Ulloq/ Dato	Qassit/ Antal	Ulloq/ Dato	Qassit/ Antal	Ulloq/ Dato	Qassit/ Antal
Tuttu / Rensdyr																		
Umimmak / Moskusokse																		
Ukaleq / Polarhare																		
Terianniaq / Polarræv																		
Niisa / Marsvin																		
Anarnaq / Døgling																		
Aarluarsuk / Hvidskæving / Hvidnæse																		
Niisarnaq / Grindehval																		
Natseq / netside (Ringsæl)																		
Natseq qasuutinik / Netside m/garn																		
Aataaq / Sortside																		
Allattooq / Blåside (Ung Grønlandssæl)																		
Natsersuaq / Klapmyds																		
Ussuk / Remmesæl																		
Taateraaq / Ride																		
Tulugaq / Ravn																		
Appa / Lomvie																		
• pisarisuugaq / bifangst																		
Aqisseq / Fjeldrype																		
Appaliarsuk / Søkonge																		
• mannii / Søkongeæg																		

Day-log form 2008

	Ulloq/ Dato	Qassit/ Antal	Ulloq/ Dato	Qassit/ Antal	Ulloq/ Dato	Qassit/ Antal	Ulloq/ Dato	Qassit/ Antal	Ulloq/ Dato	Qassit/ Antal	Ulloq/ Dato	Qassit/ Antal	Ulloq/ Dato	Qassit/ Antal	Ulloq/ Dato	Qassit/ Antal	Ulloq/ Dato	Qassit/ Antal
Serfaq / Tejst																		
Miteq siorart. / Edderfugl																		
• pisarisuugaq / bifangst																		
Alleq / Havlit																		
Miteq sioraki. / Kongeedderfugl																		
• pisarisuugaq / bifangst																		
Qeerlutooq / Gråand																		
Nerleq / Blisgås																		
Canadap nerlia / Canadagås																		
Nerleq siggukit. / Kortnæbet gås																		
Nerlernaq / Bramgås																		
Oqaatsoq / Skarv																		
Tuullik / Islom																		
Naajaannaq / Hvidvinget Måge																		
Naajarluk / Svartbag																		
• mannii / Svartbagæg																		
Naajarujussuaq / Gråmåge																		
• mannii / Gråmågeæg																		
Timmiakuluk / Mallemuk																		
• mannii / Mallemukæg																		
Nanoq / Isbjørn																		
Aaveq / Hvalros																		
Qilalugaq qernertaq / Narhval																		
Qasigiaq / Spættet sæl																		
Aarluk / Spækhugger																		
Qilalugaq qaqortoq / Hvidhval																		

Ukiumoortumik immersuiffissaq
1. oktober 2007 – 30. september 2008
Pisanik nalunaarsuiffik
Nassiunneqassaaq kingusinnerpaamik 15/10-08
Allakkatigut imaluunniit faxikkut fax-nr. 32 30 40

Årsskema
1. oktober 2007 – 30. september 2008
Fangstregistrering
Indsendes senest 15/10-08
Sendes med post eller på fax-nr. 32 30 40

Qaammat / Måned	OKT	NOV	DEC	JAN	FEB	MAR	APR	MAJ	JUNI	JULI	AUG	SEP
Tuttu / Rensdyr												
Umimmak / Moskusokse												
Ukaleq / Polarhare												
Terianniaq / Polarræv												
Niisa / Marsvin												
Anarnaq / Døgling												
Aarluarsuk / Hvidskæving / Hvidnæse												
Niisarnaq / Grindehval												
Natseq / netside (Ringsæl)												
• Natseq qassutinik / netside m/garn												
Aataaq / Sortside												
Allattooq / Blåside (ung Grønlandssæl)												
Natsersuaq / Klapmyds												
Ussuk / Remmesæl												
Taateraaq / Ride												
Tulugaq / Ravn												
Appa / Lomvie												
• pisarisuugaq / bifangst												

Submission form 2008 (total/month)

Qaammat / Måned	OKT	NOV	DEC	JAN	FEB	MAR	APR	MAJ	JUNI	JULI	AUG	SEP
Aqisseq / Fjeldrype												
Appaliarsuk / Søkonge												
• mannii / Søkongeæg												
Serfaq / Tejst												
Miteq / Alm. Edderfugl												
• pisarisuugaq / bifangst												
Alleq / Havlit												
Miteq sioraki. / Kongeedderfugl												
• pisarisuugaq / bifangst												
Qeerlutooq / Gråand												
Nerleq qinngoqatilik / Blisgås												
Canadap nerlia / Canadagås												
Nerleq siggukit. / Kortnæb. gås												
Nerlernaq / Bramgås												
Oqaatsoq / Skarv												
Tuullik / Islom												
Naajaannaq / Hvidvinget Måge												
Naajarluk / Svartbag												
• mannii / Svartbagæg												
Naajarujussuaq / Gråmåge												
• mannii / Gråmågeæg												
Timmiakuluk / Mallemuk												
• mannii / Mallemukæg												