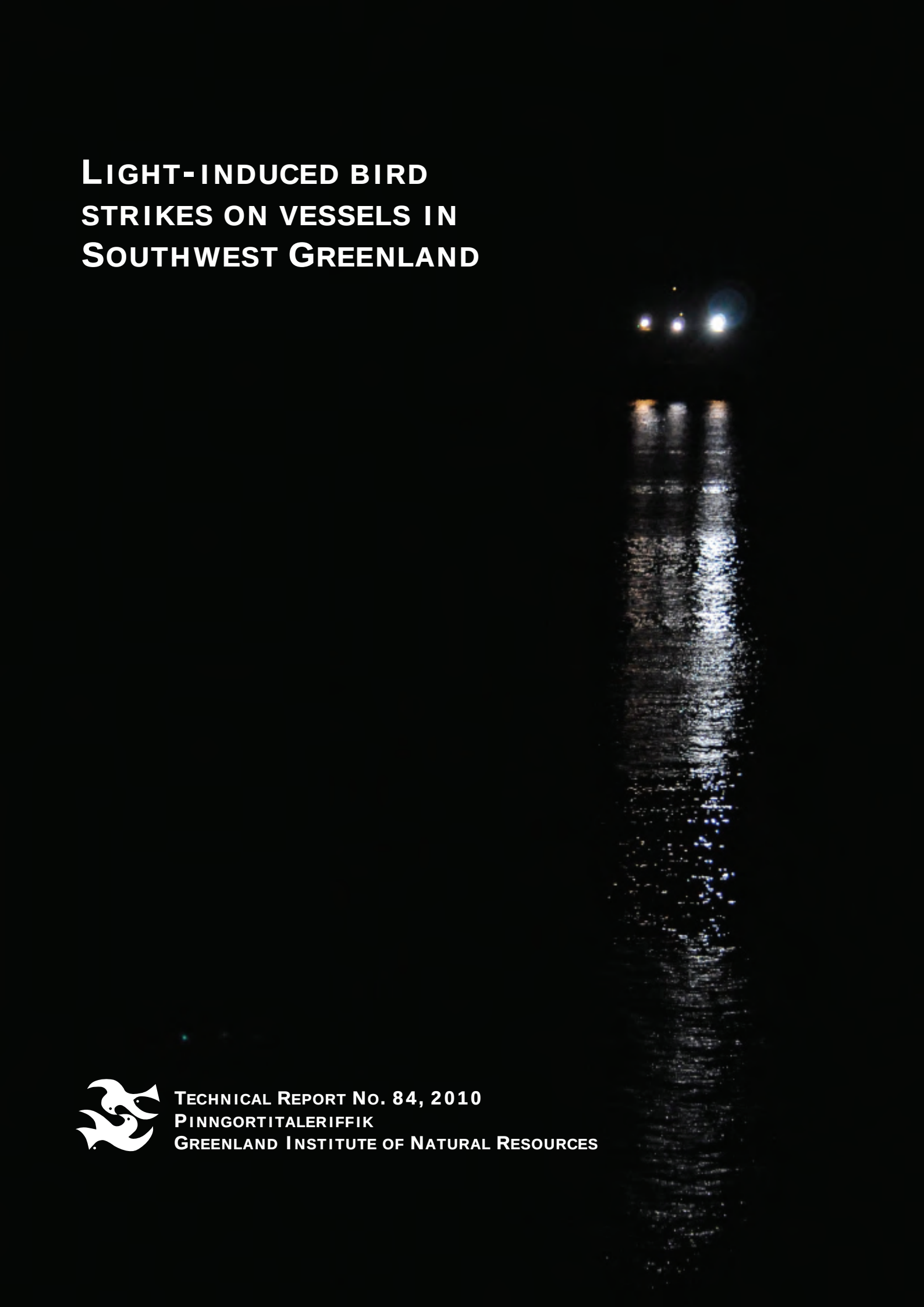
# Light-induced bird strikes on vessels in Southwest Greenland



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# Data sheet


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# Light-induced bird strikes on vessels in Southwest Greenland

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# Contents



**Greenland Institute of Natural Resources**

**Technical Report No. 84**

# Summary

Seabirds are highly visually oriented organisms and are known to become disorientated at night in the presence of artificial light, e.g., from lighthouses, oil platforms or vessels. Coastal and certain offshore waters of Southwest Greenland constitute internationally important wintering areas for seabirds and bird strikes are reported as a problem when vessels navigate in icy waters using powerful searchlight. In this study a selection of navy vessels, cargo vessels and trawlers reported on incidents of bird strikes using pre-supplied forms.

Among 19 vessels initially included in the study, 10 vessels reported a total of 41 incidents of bird strikes over a period of two winters (Oct.-Mar., 2006-08; for two vessels also the winter 08/09). Most bird strikes occurred less than 4 km from land (76% events, 93% birds), but in two cases as far offshore as 205 km and 422 km. The mean number of birds (±S.E.) reported killed was 11.5 ± 3.1 birds/incident, with 88 birds reported as the highest number. All bird strikes occurred between 4 p.m. and 5 a.m. and significantly more birds were killed when visibility was poor (snow) rather than moderate or good. The species reported were common eider (95%), king eider (3%), long-tailed duck (1%), murres (<1%) and black guillemot (<1%). In 17% of the incidents vessels reported about damaged navigation or communication equipment due to avian collisions.

Despite huge variation in the reporting of bird strikes among vessels, this study confirms that light-induced bird strike incidents occur on a regular basis in Southwest Greenland during winter, especially in coastal areas when visibility is poor. A crude estimate for the annual number of birds killed in Southwest Greenland sum up to app. 2.000 individuals; however, additional studies are needed to verify the level of this estimate. It is clear though, that common eider is the main species of concern, accounting for 95% of the birds reported.

To reduce the number of bird strike incidents I recommend vessels to avoid known high-risk areas at night when visibility is poor, to shield as much light as possible towards the sky, to switch off light when not used and I recommend studies that investigate alternative ice lookout techniques, e.g., filtering out certain wavelengths or combining modified search light with image enhancing technology.

# Sammenfatning

Havfugle orienterer sig i stor udstrækning visuelt og er kendt for ofte at miste orienteringen om natten, såfremt de udsættes for kunstig belysning fra eksempelvis fyrtårne, olie/gas platforme eller skibe. Kystnære havområder og visse udenskærsområder i Sydvestgrønland udgør et internationalt vigtigt overvintringsområde for havfugle, og kollisioner mellem skibe og havfugle rapporteres ofte som et problem, når skibene sejler om natten i isfyldt farvand og gør brug af kraftige isprojektører. I denne undersøgelse har et udvalg af inspektionskuttere, fragtskibe og trawlere rapporteret om tilfælde af kollisioner med havfugle via udleverede spørgeskemaer.

Ud af i alt 19 skibe der deltog i undersøgelsen, rapporterede 10 skibe i alt 41 tilfælde af kollisioner med havfugle over en periode på to vintre (okt. – mar., 2006-08; for to skibe også vinteren 08/09). De fleste kollisioner skete nærmere end 4 km fra land (73 % af episoderne, 93 % målt i antal fugle), men i to tilfælde så langt som 205 km og 422 km fra land. Det gennemsnitlige antal fugle (±S.E.) rapporteret dræbt ved kollisionerne var 11.5 ± 3.1 fugle/kollision, med 88 fugle som det højeste antal. Alle kollisioner skete mellem kl. 4 om eftermiddagen og kl. 5 om morgenen, og signifikant flere fugle kolliderede når sigtbarheden var dårlig (snevejr), sammenlignet med god eller moderat sigtbarhed. De rapporterede arter var almindelig ederfugl (95 %), kongeederfugl (3 %), havlit (1 %), lomvier (<1 %) og tejst (<1 %). I 17 % af tilfældene rapporterede skibene om skader på navigations- eller kommunikationsudstyr som følge af kollisionerne.

Til trods for stor variation i rapporteringsfrekvensen skibene imellem, bekræfter undersøgelsen at kollisioner med fugle, forårsaget af skibenes brug af lys om natten, sker regelmæssigt om vinteren i Sydvestgrønland, særligt i kystnære områder og i forbindelse med dårlig sigtbarhed. Et groft estimat af den samlede årlige dødelighed i Sydvestgrønland løber op i ca. 2.000 fugle, men det må dog anbefales, at gennemføre supplerende studier for at bekræfte at dette er et retvisende niveau. Det står imidlertid klart, at det specielt er almindelig ederfugl der rammes, idet hovedparten (95 %) af de rapporterede fugle var af denne art.

For at reducere antallet af kollisioner mellem skibe og havfugle i Sydvestgrønland om vinteren, anbefales det, at skibene så vidt muligt undgår færdsel i kendte risiko-områder om natten, når sigtbarheden er dårlig; at afskærme mest mulig lys, således at det ikke oplyser himlen, og at slukke projektører når de ikke er nødvendige. Desuden anbefales det, at eksperimentere med alternative overvågningsteknikker til scanning af isforhold, så som filtrering af særlige bølgelængder, eller at kombinere modificeret søgelys med egnede billedforstærknings teknikker.

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# 1 Introduction

Seabirds are highly visually oriented and it is recognized that many bird species become disorientated at night in the presence of artificial light (Bruderer *et al*. 1999). The major sources of artificial light in the marine environment include vessels, lighthouses, light-induced fisheries, and oil and gas platforms. The attraction to light and resulting risk of collisions appear to depend on the weather, season, the age of the birds and the lunar phase (see ref. in Montevecchi 2006). A few documented cases of mass collisions of hundreds or thousands of seabirds with vessels have been documented (Dick & Davidson 1978, Ryan 1991, Black 2005), but in general quantitative information about bird strikes on vessels is very limited.

The coastal and offshore waters of Southwest Greenland constitute internationally important wintering areas for seabirds. Roughly estimated, a minimum of 3.5 million seabirds use this region in winter, mainly birds from Arctic Canada, Greenland and Svalbard and smaller numbers from Alaska, Iceland, mainland Norway and Russia (Boertmann *et al*. 2004). With the relatively few hours of daylight during winter at these latitudes (60°-70°N) and with extensive shipping activities from cargo suppliers, fishing vessels and tourist operators (Fig. 1.1), the potential risk of bird strikes on vessels in Southwest Greenland is high. Occasional reports from vessels confirm that incidents of bird strikes do occur when they navigate in icy waters using powerful searchlight, but so far no attempts to quantify the magnitude of the problem has been carried out.

Here I present the results of a study conducted over three winters (2006-2009) in Southwest Greenland, for which a selection of navy vessels, cargo vessels and fishing vessels cooperated in reporting on incidents of light-induced bird strikes. I present the locations of the reported bird strikes and analyse the frequency of incidents according to time of season, time of day, visibility and distance to land. I roughly compare the traffic intensity of large fishing vessels and cargo vessels with the observed bird strikes and with water depths to identify high-risk regions for bird strikes. Finally, I make recommendations on how to reduce the number of bird strike incidents.

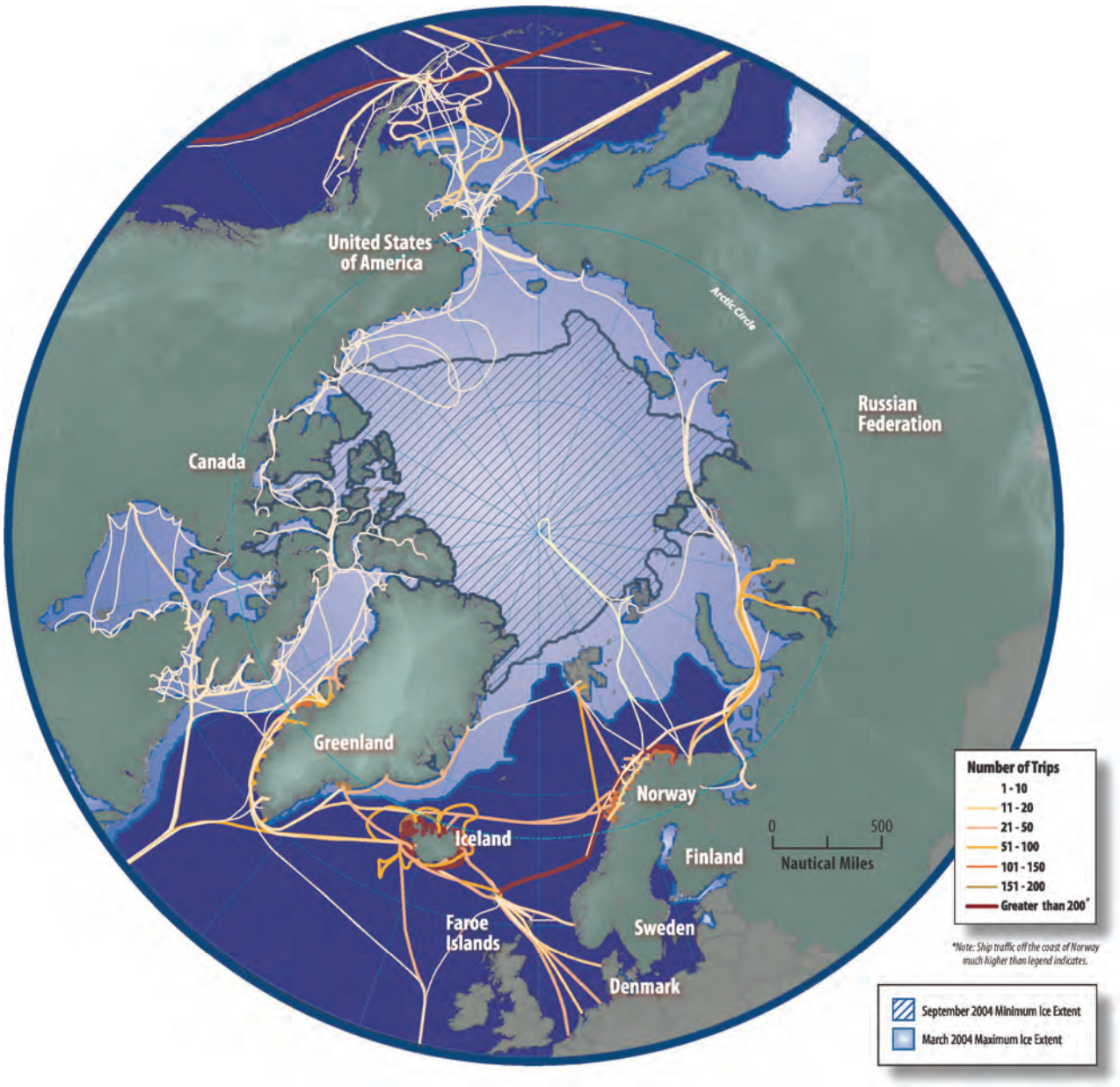



**Fig. 1.1.** Shipping traffic in the Arctic marine area in 2004 (PAME 2009). The AMSA database identified four types of vessel activities as most significant in the Arctic in 2004: Community re-supply, bulk cargo of commodities such as oil and gas, tourism and fishing activity operations (not shown).

## 1.1 Acknowledgements

I wish to thank Ivalo Egede (Royal Arctic Line), Lene K. Nielsen (Royal Greenland), Søren Bjerregaard (KNI-Pilersuisoq), Rasmus Krog, Tom Grastrup Jensen, Niels Vestergaard and Sigrid Hansen (The Danish Navy, Command Grønnedal) for organizing the data collection of bird strike incidents on various vessels. Also thanks to Mads Rossing Lund (Greenland Fisheries Licence Control Authority) and Allan Idd Jensen (Royal Arctic Line) for making the data on daily movements of vessels available. Finally, thanks to Kasper Johansen for conducting GIS analyses. The Ministry of Domestic Affairs, Nature and Environment funded the study.

# 2 Methods

## 2.1 Data collection

Prior to the winter of 2006/2007 arrangements were made with The Danish Navy (2 coastguard vessel from Command Grønnedal), Royal Arctic Line (transatlantic cargo shipping, 6 vessels), KNI-Pilersuisoq (local cargo shipping, 5 vessels) and Royal Greenland (fishery, 6 trawlers) to report on incidents of bird strikes on vessels. Forms were sent or handed out to the vessels and for each bird strike events the crew were asked to fill in information about vessel ID, date, time, GPS position, wind speed, wind direction, visibility and precipitation. They were also asked to count the number of birds found dead or injured on the deck of the vessel and to assess whether injured birds also fell into the water. The Danish Navy provided information in three consecutive winters (2006-2009, Oct. 1 – Mar. 31), while the other vessels contributed to the survey only during the first two winters. One of the Navy vessels (Agpa) was replaced by a larger vessel (Knud Rasmussen) during the third winter. Additional information (one bird strike incident) was received from a tourist boat from Nuuk, since one of the passengers knew about the bird strike survey.

Information on daily movements of fishing vessels in Southwest Greenland was obtained from the Greenland Fisheries Licence Control Authority for the winter 2006-07 and 2007-08 (Mads Rossing Lund, pers. comm.). The data include positions from all vessels >90 BT (~130 vessels), witch by law are required to have a GPS-transmitter installed. This regulation does not apply to vessels <90 BT. For the same periods Royal Arctic Line provided a similar dataset on the daily movements of their 6 transatlantic cargo ships (Allan Idd Jensen, pers. comm.).

## 2.2 Analyses

This study deals only with the positive records of bird strike incidents and as such does not reveal facts about the external environment at periods when bird strikes did not occur. Instead, the importance of such factors (visibility, distance to land, etc.) was analysed by correlating these to the number of birds involved in the bird strike incidents. The assumption of normality (Andersen–Darling test) and homogeneity among variances (Bartlett's test) did not apply to the count data on number of injured or killed birds (neither raw nor log-transformed data) and therefore differences among the occurrences of bird strike incidents were tested using the non-parametric Kruskal-Wallis procedure.


**Fig. 2.1.** Tulugaq, one of the coast-guard vessels (identical to Agpa). Photo: The Danish Navy


**Fig. 2.2.** Knud Rasmussen, a larger coastguard vessel. Photo: The Danish Navy


**Fig. 2.3.** Akamalik, one of the large fishing vessels of Royal Greenland. Photo: Wikimedia


**Fig. 2.4.** Arina Arctica, one of the Royal Arctic Line cargo vessels. Photo: Carsten Egevang

The traffic intensity of fishing vessels in Southwest Greenland was calculated in the following manner: From the complete dataset of ship positions from the winter 2006-07 and the winter 2007-08, all positions transmitted between one hour after sunset and one hour before sunrise were selected (positions after dark). Monthly mean sunset and sunrise times were used. On the basis of these positions, the route taken by each ship each night was defined as a polyline.

The area between 59-70 ˚N and 40-61 ˚W was gridded into 2.5 x 2.5 km cells, and for each cell the traffic intensity was calculated as the sum of the lengths of polylines (in km) within a 10 km circular neighbourhood around the cell centre, divided by the area of this neighbourhood (3.14 x 25 $km^2$). As some neighbourhoods overlap land, the traffic intensity index was adjusted by dividing with the fraction of sea within the neighbourhood. Further, as the dataset includes 2 winters, the index was divided by 2 to arrive at a traffic intensity per winter. Finally, all cells with a centre falling on land were excluded. The traffic intensity of Royal Arctic Line cargo ships was calculated in the same way as with the fishing vessels. However, deviation in shipping routes between day and night was not expected and therefore all positions from the two winters in question were included, not only night positions.

# 3 Results and discussion

## 3.1 Frequency, timing and locations of bird strikes

A total of 42 incidents of light-induced bird strikes were reported over the three winters 2006/07, 2007/08 and 2008/09, within the period October 1 – March 31. Incidents were reported throughout Southwest Greenland, but only rarely north of Maniitsoq (Fig. 3.1). In the northern part of Julianehåbsbugten in South Greenland the reported number of bird strike incidents was much higher that elsewhere in Southwest Greenland and probably relates to the fact that the Narsarsuaq International Airport is located at the eastern end of Bredefjord. Command Grønnedal (The Danish Navy), which is stationed at Ivittuut in Arsuk Fjord, often travels forth and back to Narsarsuaq Airport when relieving navy crews. In general, the Navy coastguard vessels accounted for a large proportion of the bird strike reports (71%), either because these vessels only patrolled the coastal areas (< 10 nautical miles from the coast, N. Vestergaard, pers. comm.) and/or because the Navy reported the bird strikes more consistently. Royal Arctic Line reported 20% of the bird strike incidents, Royal Greenland 7% and KNI-Pilersuisoq 2% (not including the tourist boat). Approximately half of the vessels (9 of 19) that initially agreed to report on bird strikes did not report any incidents. See section 3.4 for a description of the typical routes undertaken by these vessels.

Two bird strike incidents deviated significantly from the rest as they took place far offshore in the Davis Strait, 205 km and 422 km from the nearest coastline (Fig. 3.1). Both incidents happened in mid October and coincidence with the autumn migration period for seabirds. Eiders migrate from breeding areas in Canada to moulting and/or wintering areas in western Greenland and auks migrate from breeding areas in northern Baffin Bay south through the Davis Strait to wintering areas in Southwest Greenland or Southeast Canada (Lyngs 2003, Mosbech *et al*. 2006). A minimum of three birds were killed in these two offshore bird strikes, one common eider, one king eider and one thick-billed murre. Most of the other bird strikes took place in coastal areas and there was a tendency that incidents occurring very close to land also involved more birds (Kruskal-Wallis, $P < 0.05$, Fig. 3.2). Bird strikes reported by the Navy coastguard vessels occurred on average 2.2 km (n=29) from land, while the mean distance for Royal Arctic Line was 7.6 km (n=8) and 209.5 km (n=3) for Royal Greenland.

There was a gradual decrease in the number of reported bird strikes over the three winters (Fig. 3.3). The rather low number in the final winter (2008/09) was expected since only the coastguard vessels were asked to continue the reporting. However, the large decline in reports from the first to the second winter was unexpected since both seasons involved the same number of vessels. This may indicate that bird strike incidents were not equally reported in both years. Concerning weather conditions see section 3.3.

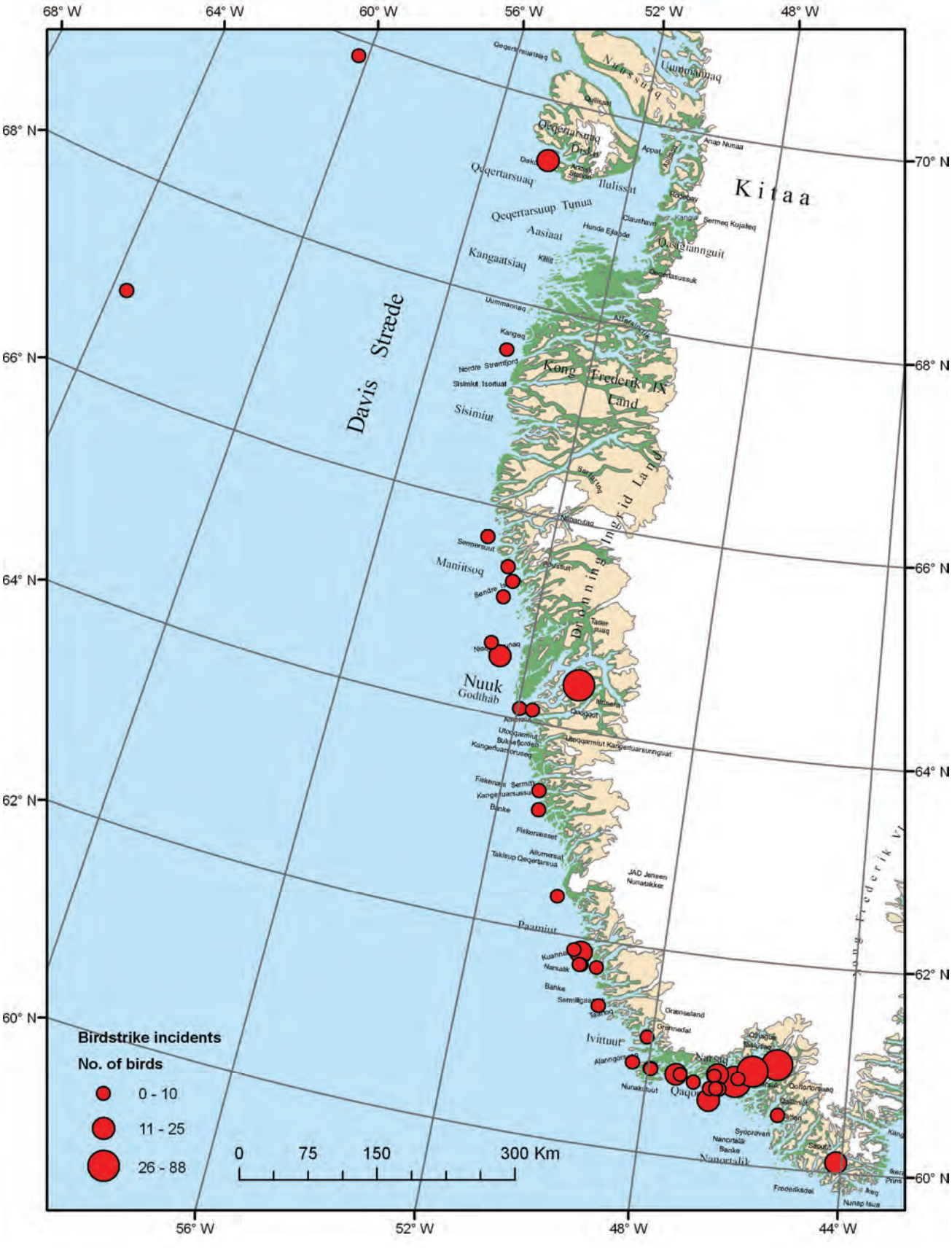



**Fig. 3.1.** Bird strike incidents reported on 10 vessels during winter (Oct. – Mar.) in 2006-2009

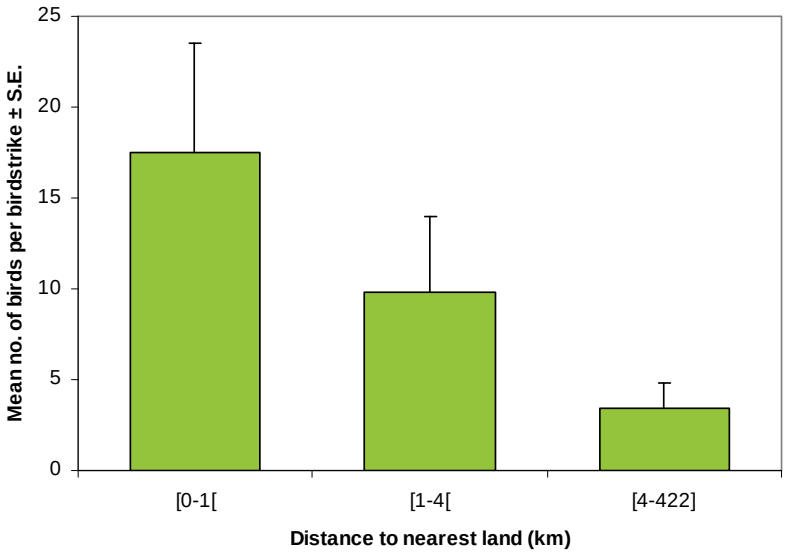



**Fig. 3.2.** The distance to land and the mean no. of birds involved in 42 bird strikes reported during winter (Oct. – Mar.) in Southwest Greenland in 2006-2009.

Strange patters also appeared when looking at the frequency of reports for individual vessels. For instance, one coastguard vessel reported approximately equal numbers of incidents in the first two winters, while an identical vessel reported zero incidents in the same period. According to navy officer N. Vestergaard (pers. comm.) both vessels patrolled the same area (between Kap Farvel and Aasiaat) in a similar way (< 10 nm from the coast) in both winters and the contrasting numbers should probably be ascribed to contrasting awareness/priority among the vessel crews.

All reported bird strikes occurred during night or in twilight periods between 4 p.m. and 5 a.m. with no clear pattern of occurrence within this period (Fig. 3.4). However, when grouped according to month the data suggest that a higher frequency of bird strikes occurred during November, December and January, coinciding with the extended darkness in the mid-winter period (Fig. 3.5).

## 3.2 Numbers and species involved in bird strikes

A total of five species and 480 individuals killed or injured were involved in the 42 reported bird strike incidents. The vast majority of the birds were common eiders, accounting for 95% of the individuals, while king eider (3%), long-tailed duck (1%), black guillemot (1%) and thick-billed murre (<1%) occurred in small numbers. According to previous aerial surveys common eider is by far the most common seabird species in the coastal areas of Southwest Greenland (Merkel *et al*. 2002) and this alone explain why this species is relatively numerous in bird strike events on vessels. The fact that common eiders always fly low over the water and hardly ever cross land, probably makes it more susceptible to collision with vessels.

**Fig. 3.3.** Reported incidents of bird strikes per winter season (Oct. – Mar.) in Southwest Greenland reported by 10 vessels (N = 20 vessels in 2006-08, N = 2 vessels in 2008-09).

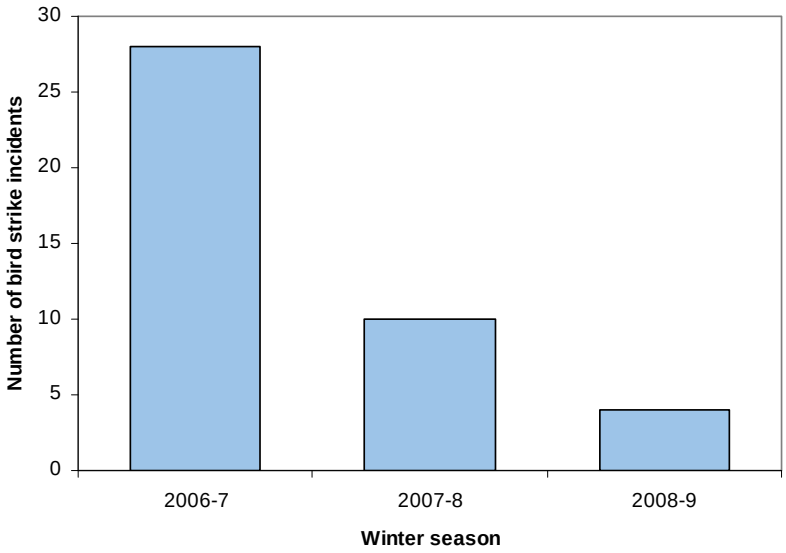



**Fig. 3.4.** Number of reported bird strike incidents grouped according to time of day and summarized for all winter seasons.

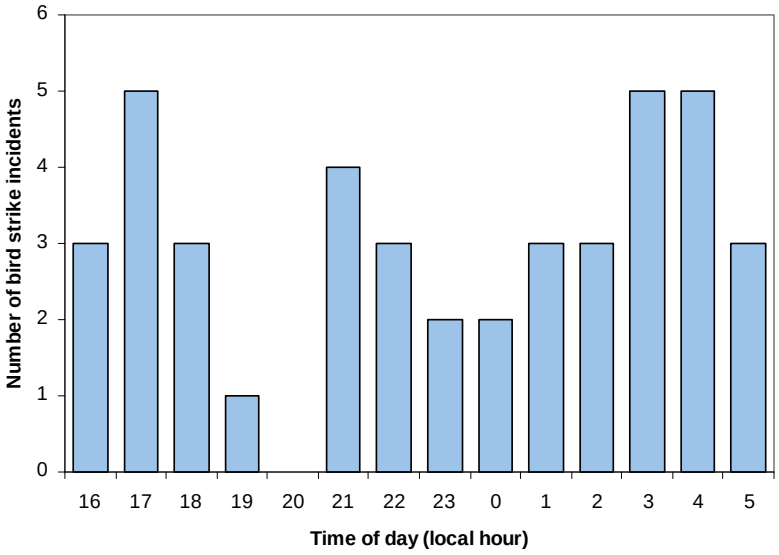
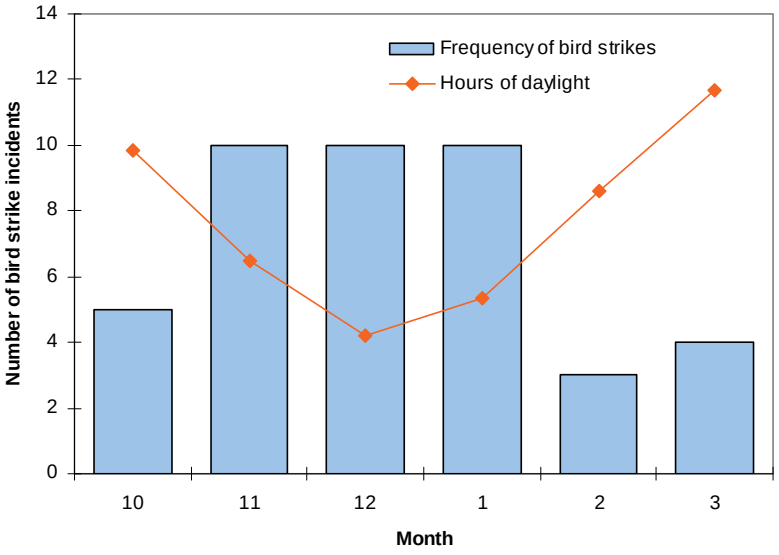



**Fig. 3.5.** No. of bird strike incidents per month as summarized for three winter seasons and the median number of daylight hours in Nuuk (app. centre of Southwest Greenland).



The maximum number of birds reported killed or injured in a single bird strike incident was 88 birds. Among the incidents that involved the largest number of birds, the top seven cases (>17 birds) all took place in fjord areas and involved only common eiders. This is probably no coincidence since fjord habitats in Southwest Greenland are known as important wintering areas for common eiders and compared to coastal areas the eiders often aggregate in larger flocks in the fjords (Merkel *et al*. 2002). It is also known that common eiders in the fjord are more active during nights as they feed mainly during darkness, while coastal birds predominately feed during daytime (Merkel & Mosbech 2008).

Obviously, the reported numbers on killed or injured birds are conservative figures since some injured birds probably escaped the vessel shortly after the collision. Further, in 27 of 42 cases vessels reported that some birds ended up in the water rather than on the deck of the vessel. In 10 cases the crews were uncertain if birds also fell into the water and only in five cases they positively reported that no birds fell into the water.

The total number of birds killed in Southwest Greenland annually as a consequence of bird strike incidences on vessels is difficult to estimate from this study due to a number of uncertain or unknown variables. However, a very crude estimate indicates that the total number of casualties could add up to a substantial number: Assuming a mean number of 11.4 birds (480 birds/42 incidents) killed per bird strike incident, a mean bird strike frequency of 1.0 incidents/vessel/year (38 /19 /2) and a total number of 180 vessels roughly estimated to operate in Southwest Greenland over the winter, the total number of casualties add up to ~2,050 birds/year, of which the major part would be common eiders. The 180 vessels is estimated as ~130 fishing vessel >90 BT (see section 2.1) plus additional ~50 vessels accounting for fishing vessels of 50-90 BT, cargo supply vessels, research vessels and navy vessels. The mean number of 11.4 birds/incident may be overestimated due to the influence of the coastguard vessels (operating more coastal than most other vessels), but on the other hand, the total estimate of ~2,050 birds/year does not account for birds that went overboard and for unreported bird strike incidents.

## 3.3 Bird strike incidents and weather conditions

In 26 of 42 cases of bird strike incidents the visibility was reduced (poor or moderate) due to snow, in one case due to rain and in one case due to unspecified reasons. Bird strikes were reported in 14 cases despite of good visibility; however, the number of birds involved in these bird strikes was significantly smaller compared to incidents that occurred when visibility was poor (Kruskal-Wallis, $P < 0.05$, Fig. 3.6).

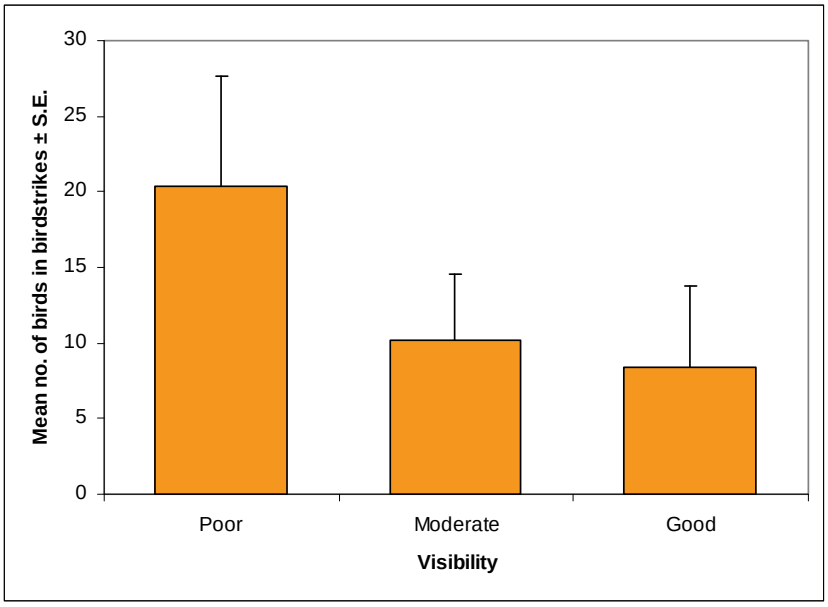



**Fig. 3.6.** The mean number of birds killed or injured in bird strikes with vessels in South-west Greenland, grouped according to the visibility from the ship (Oct. – Mar., 2006-2009).

Thus, a high correlation between the number of bird casualties from bird strikes and the amount of precipitation during winter should be expected. However, the large decline in the number of reported bird strike incidents from 2006/07 to 2007/08 (Fig. 3.3) does not correspond to more precipitation in 2007/08, at least not in Nuuk and Qaqortoq. From October until March Nuuk got 329 mm of precipitation in 59 days in 2006/07, but 377 mm in 81 days in 2007/08. For Qaqortoq the figures were 260 mm in 36 days in 2006/07 and 340 mm in 47 days in 2007/08 (www.dmi.dk/dmi/vejrarkiv). More likely, the reporting was less consistent in 2007/08 (see section 3.1).

## 3.4 Vessel routes and bird strike risks

Detailed information about the movements of the Navy coastguard vessels was not possible to get. However, we know that that they patrol the coastal area between Kap Farvel and Aasiaat and only rarely go beyond 10 nautical miles (~18.5 km) from the coastline (N. Vestergaard, pers. comm.). The mean distance to land (2.2 km) of the bird strike incidents reported by the coastguard vessels indicate that these ships operate closer to land than the vessels engaged in cargo shipping and fishery (see sec. 3.1).

For the fishing vessels, which represent the majority of the shipping activity in Greenland, detailed GPS-logs were made available by GFLK for the larger vessels (>90 BT, Fig. 3.7). The data clearly identifies the important offshore fishing grounds for halibuts and shrimps, but the highest traffic intensity appears to relate to fishing grounds closer to the coastline (e.g., shrimps, crabs and cod). In combination with the commuting between fishing grounds, landing locations and home towns the larger fishing vessels formed an ocean highway along Southwest Greenland roughly centred 10-15 km from the coastline (Fig. 3.8).

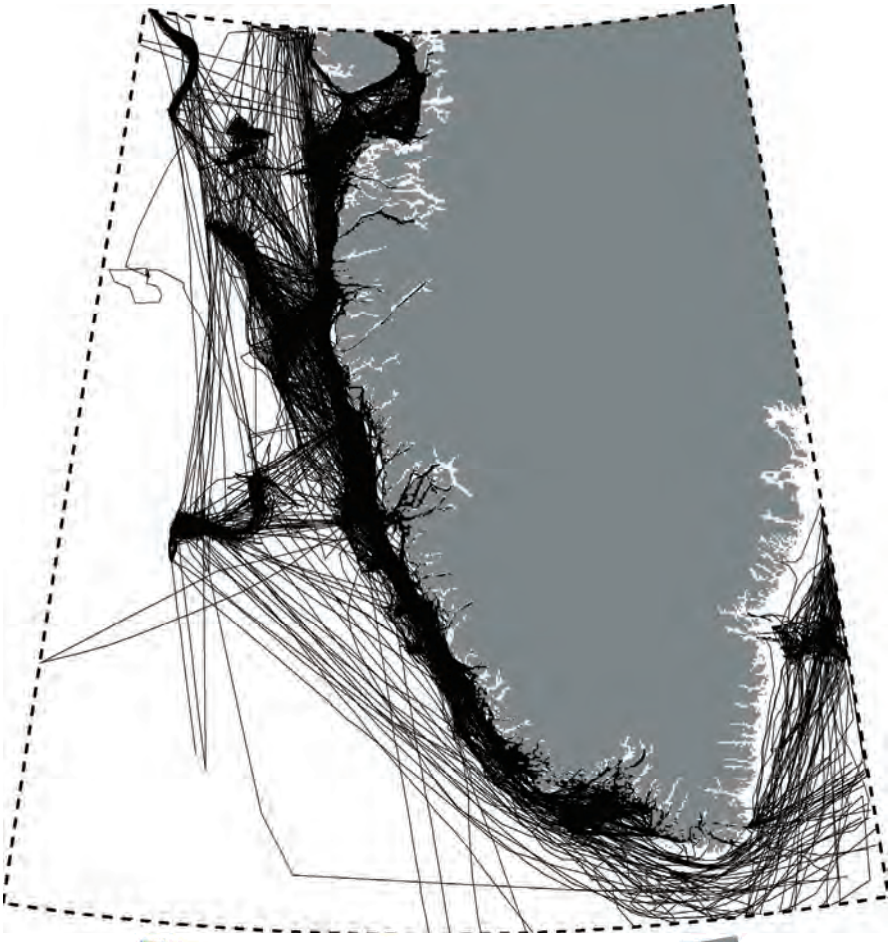


**Fig. 3.7.** Tracks of fishing vessels (>90 BT, N ≈ 130) in Southwest and Southeast Greenland during the winter (Oct.-Mar.) of 2006-2007 and 2007-2008. Data from GFLK.

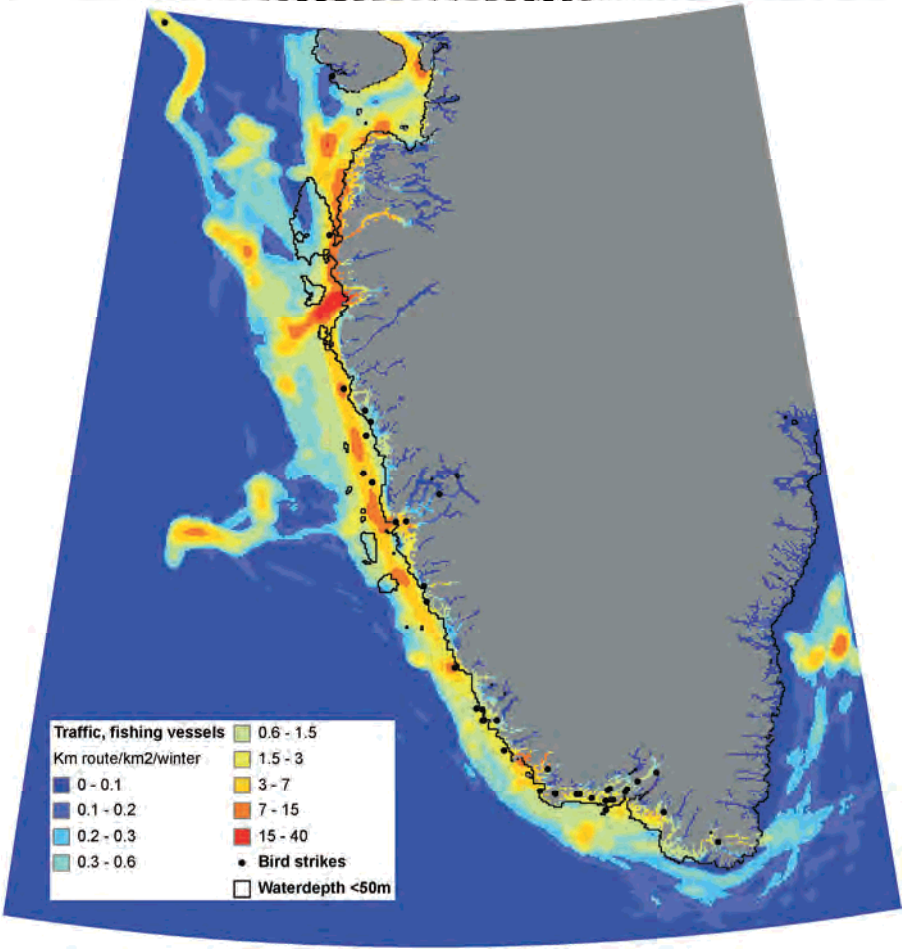



**Fig. 3.8.** Traffic intensity of fishing vessels (>90 BT, N ≈ 130) in Southwest and Southeast Greenland during the winter (Oct.-Mar.) of 2006-2007 and 2007-2008. Calculations based on the data shown in Fig. 3.7, however, excluding data from daylight periods. Data from GFLK.

The transatlantic cargo vessels from Royal Arctic Line use the same ocean highway when supplying the cities in Southwest Greenland. Since they go to fixed destinations by a fixed timetable the shipping routes vary only little in time and space. When the ships arrive in South Greenland from transatlantic locations they tend to go farther offshore compared to the fishing vessels.

Approximately half (46%) of the reported bird strike incidents took place on the ocean highway identified for the fishing industry. Ironically, none of these bird strikes were reported by fishing vessels (Royal Greenland), but instead by the coastguard (12 of 29 cases) and cargo vessels (7 of 9). Whether this is a coincidence or a matter of insufficient reporting from Royal Greenland vessels, is unknown.

The highest risk of bird strike incidents along the ocean highway should be expected where this overlap with shallow waters (< 50m). According to Fig. 3.8 this is especially the case in South Greenland and north of Sisimiut. The 42 reports on bird strikes confirm that South Greenland is a high-risk area for bird strikes on vessels, whereas hardly any reports were received for the shallow waters north of Sisimiut. This may, however, be strongly biased by uneven "survey efforts" and response rates among the vessels included. A total of 66% of the reported bird strike incidents took place at shallow waters (< 50m), and 17% occurred where shallow waters overlapped with the identified ocean highway.

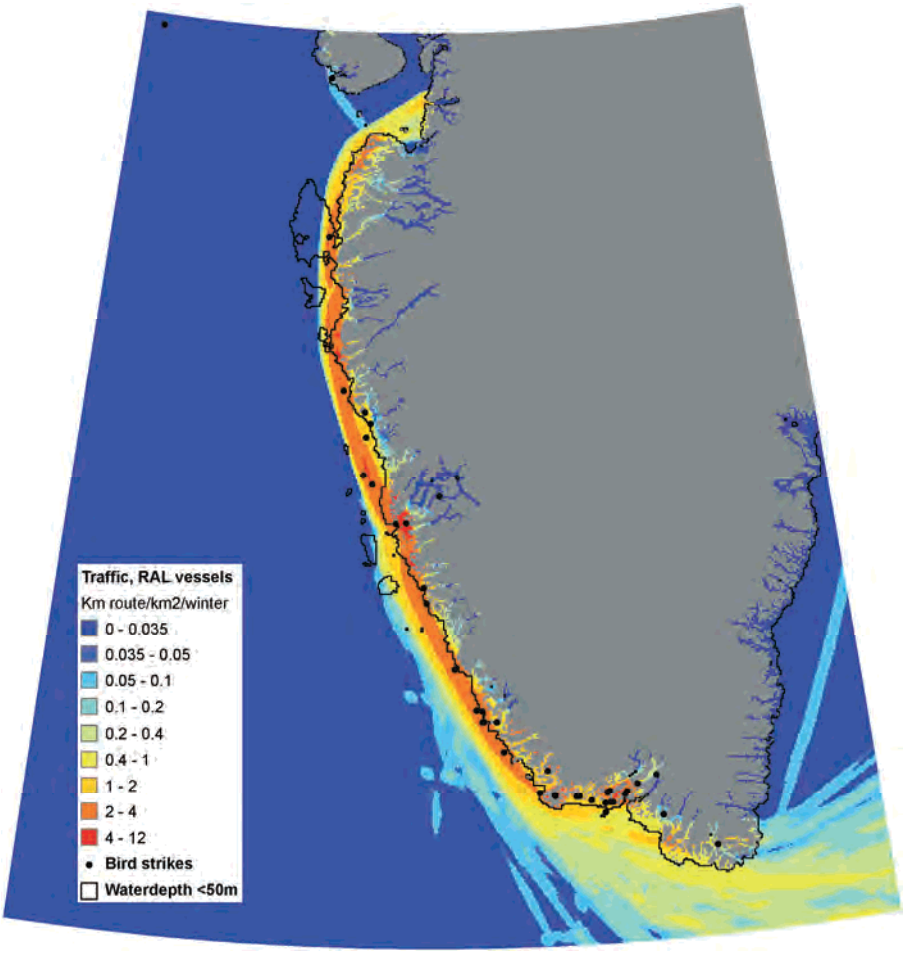



**Fig. 3.9.** Traffic intensity of transatlantic cargo vessels (N=6) from Royal Arctic Line in Southwest and Southeast Greenland during the winter (Oct.-Mar.) of 2006-2007 and 2007-2008. Data from Royal Arctic Line.

## 3.5 Light specifications and damages to vessels

The use of light on vessels can serve multiple purposes and the quantity used depends on the type and the size of the vessel. In addition, ship construction varies quite a bit depending on the type of vessel (e.g., fig. 2.2 vs. fig. 2.4) and consequently the number of obstacles with which birds can collide varies considerably between vessels. Often spotlights are mounted above the bridge to illuminate the foredeck during factory operations. Such illumination should be shielded towards the sky, because birds are attracted primarily to light sources rather than the areas they illuminate (Reed *et al*. 1985). Further, the light disturbance could be much reduced if lights are turned off when foredeck activities are finished, especially when this coincide with poor visibility (fog or snow).

The use of powerful search lights is essential, and for vessels >150 BT also required by regulation (Anon 2009), for the safe navigation of vessels in icy waters. The light occurs at intense source points and can attract marine birds from a large catchment area, and currently alternative lookout techniques appear to be limited. Large icebergs can safely be detected on radar images, but small ones can easily go undetected or be mistaken for radar noise at the sea level. Based on a number of major bird strike events in the Southern Ocean, the Government of South Georgia and the South Sandwich Islands have been investigating the use of image enhancing technology to enable a lookout to be kept with limited use of lights (Black 2005). The status of this work is however unknown. Elsewhere experiments using red filters in front of floodlights on tall constructions have been shown capable of reducing avian casualties up to 80% (see ref. in Wiese *et al*. 2001). In the North Sea similar good results have been achieved by replacing traditional white light sources with bird-friendly green lamps (low in red) on an offshore gas-production platform (Poot *et al*. 2008). To my knowledge similar experiments have not been conducted with search lights on vessels.

Attempts to reduce the amount of light used on vessels can reduce not only the number of bird casualties, but also the cost of replacing damaged ship equipments. In 17% of the bird strike incidents vessels reported about damaged equipment due to avian collisions. The damages were mainly navigation or communication equipment mounted high at the bridge, including searchlights, lanterns, antennas and radars.

# 4 Conclusions and recommendations

This study confirms that light-induced bird strike incidents occur on a regular basis on vessels that operate in Southwest Greenland during winter, especially in coastal areas (< 4 km offshore) when visibility is poor. However, there was a huge variation in the frequency of bird strikes reported among vessels and years, which may be due to variation in the distance covered, geographic area of operation, vessels specifications (incl. size and search light specifications) and inconsistency in reporting.

The fishing vessels, which represent the majority of the shipping activity in Greenland, form an ocean highway along Southwest Greenland roughly centred 10-15 km from the coastline and the highest risk of bird strikes is expected where this overlap with shallow waters (app. < 50m). This is especially the case in South Greenland and north of Sisimiut. Our study confirms that South Greenland is a high-risk area for bird strikes, but not the shallow waters north of Sisimiut. However, this could be strongly biased by uneven "survey efforts" and response rates among the vessels included.

A total estimate of the annual number of birds killed or injured in Southwest Greenland sum up to around 2,000 individuals. However, it is important to emphasize that this is a crude estimate and additional studies are recommended to verify the level of this estimate. It is clear though, that common eider is the main species of concern, accounting for 95% of the birds reported. By way of comparison it can be mentioned that the total number of common eiders shot by hunting in Greenland ranged between 20,000 – 25,000 birds/year in the period 2003 - 2008 (Piniarneq 2010).

The following steps should be taken to reduce seabird mortality caused by light-induced bird strikes on vessels in Southwest Greenland (some recommendations modified from Ryan 1991). This can reduce not only the number of avian casualties, but also the cost of replacing navigation and communication equipment damaged by the collisions.

- The captains and crews of fishing vessels or other vessels need to be made aware of the necessity to reduce and/or cover light sources on dark nights, especially when visibility is reduced due to fog or snow.

- Experienced captains will know at least some of the high-risk areas for bird strikes in Southwest Greenland and should whenever possible avoid going there on nights with poor visibility.

- The use of powerful search lights are essential for the safe operation of vessels in icy waters and for larger vessels (>150 BT) also required by regulation. However, priority should be given to investigate alternative green light sources (low in red), perhaps combined with image enhancing ice lookout techniques.

- The use of spotlights mounted above the bridge to illuminate the foredeck during factory operations should be shielded towards the sky, replaced with smaller lights mounted lower and closer to specific working areas on the foredeck or replaced with more bird-friendly green light sources. Further, much light disturbance could be avoided by switching off the lights at periods with no activity at the foredeck.

- The construction/organisation of the foredeck should be as simple as possible; minimizing the number of vertical object (wires, working tools, etc.) that could increase the collision risk of seabirds. Where possible, crevices where birds become lodged should be covered over.

- Crew members should be encouraged to search the vessel after a bird strike event, to release birds found still alive and to keep records of all bird strike events (incl. number of birds, location and weather conditions).

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