Environmental impacts of shipping to and from Citronen Fjord

A preliminary assessment

NERI Technical Report no. 162

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David Boertmann
Department of Arctic Environment

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Data sheet

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Author:	David Boertmann
Linguistic improvement:	Mark White
Kalaallisut imaqarnersiorlugu naalisarnera:	Finn Olsen
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Contents

Summary

A large zinc mineralisation has been discovered in the Citronen Fjord area of Peary Land, North Greenland (Fig. 1), and exploration is presently being undertaken.

If it is decided that the ore will be exploited, there is only one way of transporting the zinc concentrate from the area: by ship.

Citronen Fjord and Frederick E. Hyde Fjord are covered with fast ice most of the year. Late in summer, Citronen Fjord and sometimes also Frederick E. Hyde Fjord become more or less ice free. Multi year fast ice are found off the outer coast, and multi year drift ice covers the Wandel Sea and the majority of the Greenland Sea.

Sailing in these waters will require powerful icebreaking capabilities, and icebreaking impacts the environment in different ways.

In general, it seems that noise from shipping sometimes causes short-term behavioural response and temporarily displacement of various marine mammals. Marine mammals in icecovered waters may be particularly sensitive to noise. However, the effects are usually of short duration, and there are no conclusive studies on the long-term effects and effects on population scale available.

This report identifies vulnerable bird and marine mammal populations, and as well as the habitats of these organisms.

The wildlife in the Wandel Sea and in the drift ice of the Greenland Sea is generally scarce. Furthermore, the drift ice habitat is very dynamic, and it is therefore concluded that icebreaking in these waters is likely to have only limited environmental impacts.

Open water is present along the coasts between Nordostrundingen and Hovgaard Ø June-September. This is the Northeast Water, a recurrent polynya. The Northeast Water supports large amounts of seabirds during the open water period. The largest stock of walrus in Northeast Greenland is found here and narhvals are rather common. The coasts and the ice edge zones of the Northeast Water and the shallow waters around Henrik Krøyer Holme are the most sensitive to sailing and icebreaking. Sailing and icebreaking in these areas should be avoided.

The movement of icebreakers through the fast ice of Frederick E. Hyde Fjord may alter the habitat of a population of ringed seals that inhabit the fiord.

Incidental oil spills from the ships sailing to and from Citronen Fjord poses the most serious threats to the wildlife in the area covered by this report.

Dansk resumé

baggrund

I 1993 opdagedes en stor zink forekomst ved Citronen Fjord (83° 05' N, 28° 16' W) i Peary land (Fig. 1). Hvis denne forekomst skal udnyttes må zinkkoncentratet nødvendigvis sejles ud derfra.

sejlads

Sejladsen må foretages med isbrydende skibe eller med isbryder assistance, da største delen af farvandene i området er isdækkede året rundt.

isforhold

Selve Citronen Fjord bliver som regel isfri om sommeren, men den større Frederick E. Hyde Fjord er som regel isdækket også om sommeren. Langs yderkysten fra Nordostrundingen og op mod Kap Morris Jesup ligger en kystnær bræmme af fastis, som er meget tyk. Langs ydersiden af denne dannes en sprækkezone, hvor der ofte er åbent vand om sommeren. Ellers er hele Wandel havet og store dele af Grønlandshavet dækket af mere eller mindre tæt drivis.

polynie

Ud for østkysten af Kronprins Christian Land mod syd til Hovgaard Ø dannes hver sommer et åbenvands område af varierende størrelse - et polynie, der kaldes Nordøstvandet (Schneider & Budéus 1994, Minnett et al. in press).

dyreliv

Forekomsten af fugle og havpattedyr beskrives for et område fra Kap Morris Jesup i nord til Lambert Land i syd. Oplysningerne i litteraturen er generelt sparsomme om dyrelivet i dette område, men på grund af intensiv forskning i Nordøstvandet i somrene 1992 og 1993 er specielt dette område velundersøgt.

I Wandelhavet og i de drivisdækkede dele af Grønlandshavet nær Grønland ser det ud til at der er lave tætheder af fugle og havpattedyr. Derimod kan der langs iskanten ud mod det åbne vand i Grønlandshavet forekomme store tætheder af trækfugle (søkonger og polarlomvier) og isbjørn og narhval er registreret hyppigt her.

fugle

Ved kysten ud til og langs iskanterne af Nordøstvandet er der store forekomster af havfugle. Her findes 6 kolonier af ynglende mallemukker med ialt 1500 ynglepar (Falk & Møller 1995), her er flere havternekolonier og de sjældne mågearter sabinemåge og ismåge yngler flere steder. Om foråret samles ederfugle i flokke (totalt op til 3000) før yngletiden langs kysterne. Særligt øgruppen Henrik Krøyer Holme kan huse mange fugle: Havterne, ismåge, sabinemåge og ederfugl.

ringsæl

Ringsælen er det almindeligste havpattedyr. Den er især knyttet til fastisen på fjordene, og der er en god bestand i Frederick E. Hyde Fjord.

hvalros

Bestanden af hvalros i Nordøstvandet vurderes til 200 dyr (Born et al. 1995a), og den vigtigste forekomst i hele Østgrønland af hunner med unger findes her. Nordvest for Nordostrundingen er hvalrossen sjælden.

isbjørn

Isbjørn forekommer især på fastisen nær Nordøstvandet, men generelt er tætheden lav også i polynieområdet, sammenlignet med f. eks. Svalbardområdet.

narhval

Der er en bestand af narhvaler i området. De største forekomster er flokke på op til 150 dyr.

miljøpåvirkning

Sejlads i is giver miljøpåvirkninger i form af støj, fysiske påvirkninger (påsejling, ændring af habitater) og kan ved uheld give anledning til oliespild.

Havpattedyr kan være følsomme over for støj, og det er vist at arter som narhval og hvidhval undviger skibe, der sejler i is. Imidlertid er der tale om korttidseffekter, og generelt er resultaterne af forskellige undersøgelser ikke entydige. Langtidseffekter af støj fra skibe der sejler i is er ikke kendt.

Fastisen på Frederick E. Hyde Fjord vil blive gennemsejlet, hvis der skal skibe ind til Citronen Fjord. Denne fastis er levested for ringsæler, og bestanden kan måske påvirkes af sejladsen.

oliespild

Den væsentligste trussel mod miljøet i området er oliespild i forbindelse med uheld. Olie vil samles i åbne render og langs iskanter og den kan bevares meget længe og transporteres over lange afstande på grund langsom nedbrydning i det kolde miljø. Åbne render og iskanter er ofte samlingssteder for fugle og havpattedyr, hvorfor betragtelige dele af bestandene kan blive påvirket af olieforureningen.

Havfuglebestande er særdeles følsomme over for olieforurening, mens havpattedyr generelt er mindre følsomme. Imidlertid er isbjørnen meget sårbar, fordi den under pelspleje vil sluge olie. Hvalrossen er muligvis også mere sårbar end de andre sæler på grund af dens specielle levevis.

Det vurderes, at sejlads i drivisområder ikke vil give anledning til væsentlige påvirkninger af dyrelivet, dels fordi tæthederne er lave dels fordi drivisen i sig selv er en meget dynamisk habitat.

Sejlads i Nordøstvandsområdet skal undgås på grund af de vigtige forekomster af fugle og havpattedyr. Polyniets tilstedeværelse er bl. a. betinget af to store fastisflader, henholdsvis nord og syd for det åbne vand. Det vurderes, at disse fastisområder ikke må gennemsejles (hvis det overhovedet er muligt).

Kalaallisut imaqarnersiorlugu naalisarnera

1993-mi zink-eqarfissuaq Peary land-imi Citronen Fjord-imiittumi (83 gr. 05 min. N, 28 gr. 16 min. W) nassaarineqarpoq. Aatsitassaq taanna iluaqutiginiarneqassaguni umiarsuarnik tamaanngaanniit assartorneqartariaqarpoq.

Umiarsuit assartuutit sikusiutaasariaqassapput imaluunniit sikusiutinik ikiorneqartariaqassapput, tassami tamatuma imartaasa annertunersaat sikuiuitsuugamik.

Citronen Fjord-ip kangerluttavia aasaanerani sikuikkajuppoq, kisiannili kangerluk annerusoq Frederick E. Hyde Fjord aasaagaluakkulluunniit sikuerpiarneq ajorpoq. Nordostrunding-imiit Kap Morris Jesup-ip tungaanut avammut sineriaani sinerissamut qanittumut aalaakkaasumik issoqisumik sikoqarpoq. Tamatuma killingani aasakkut imarnersaqalerajuttarpoq. Kisiannili Wandel havet Grønlandshavet-illu ilarujussua annerusumik minnerusumilluunniit eqimasunik sikorsuaqartarpoq.

Kronprins Christian Land-ip kangimut sineriaani kujammut Hovgaard Ø tikillugu aasat tamaasa imarnersaqalersarpoq angissusaa assigiinngitsuusinnaasumik - polynya, Nordøstvandet-imik (Tunup Avannaarsuata imarnersaa) taaguuserneqarsimasoq. (Schneider & Budeus 1994, Minnett et al. in press).

Avannamut Kap Morris Jesup-imiit kujammut Lambert Land-imut timmiaqassusaa immamilu miluumasoqassusaa allaaserineqarpoq. Tamaani uumasut pillugit passissutissat allattorsimasat annikipput, kisianni Nordøstvandet-ip aasaanerani 1992-mi 1993-milu annertuumik ilisimatusarfigineqarneratigut tamanna pingaartumik misissorluarneqarsimavoq.

Wandelhavet-imi kiisalu Grønlandshavet-ip nunatsinnut qanittuani sikorsuaqarfiusumi timmissat immamilu miluumasut akuttorpasipput. Tamatuma akerlianik Grønlandshavet-imi immap ammaannartup tungaanut sikup killinga timmissat aallartartut (appaliarsuit appallu) annertuumik ornigarsinnaasarpaat. Nannut qilalukkallu aamma taamaani akuttunngitsunik nalunaarsorneqartarsimapput.

timmissat

Sinerissamiit sikup killinga tikillugu Nord stvandet malillugu imarmiunik timmiarpassuaqarpoq kisalu immami miluumasorpassuaqarluni. Tamaani arfinilinnik timmiaqarfissuaqarpoq qaqullunnik piaqqiorfigineqartoq, qaqulluillu piaqqiortut aappariit katillugit 1500-upput (Falk & Møller 1995). Tamaani imeqqutaalaqarfiit arlaliupput kiisalu naajat qaqutigoortut taateraarnaq naajavaarsullu tamaani sumiiffinni arlalinni piaqiortarlutik. Upernaakkut meqqit piaqqiulinnginnerminni sineriammi katersuuttarput amerlasoorsuanngorlutik (3000-it tikillugit). Ingammi qeqertaarartpaat Henrik Krøyer Holme timmiarpassuaqarsinnaasarput: Imeqqutaallat, naajarluit, taateraarnat meqqillu.

natseq

Natseq immami miluumasuni naliginnaanersaavoq. Kangerlunni sikumi aalaakkaasumiikkajunneruvoq. Frederick E. Hyde Fjord-imi natseqarluarpoq.

aaveq

Nordøstvandet-imi aarrit nalilerneqarput 200-nissaat (Born et al. 1995a), Tunumilu arnavissat piarallit pingaarnersaat tamaaniippoq. Nordostrundingen-ip avannamut kitaani aarrit akuttoqaat.

nanoq

Nannut pingaarnerusumik Nordøstvandet-ip qanittuani sikumi aalaakkasumiinnerupput, kisianni naliginnaasumik tamaani imarnersaqarfiusup qanigisaani akuttusuujupput soorlu Svalbard-ip eqqaanut naleqqiullugu.

qilalugaq

Taamaani ikigisassaanngitsunik qilalugaqarpoq.

avatangiisinik sunniineq

Sikusiorluni angalaneq avatangiisinut sunniuteqartarpoq nipiliornikkut, pinngortitanillu sunniinikkut (kalluaaneq, najugaqarfiusunik allannguineq) ajutoornikkullu uuliakoornermik kinguneqarsinnaalluni.

Immami milumaasut nipiliornernut sunnertiasinnaasarput, ilisimaneqareerporlu qilalukkat qernertat qaqortallu umiarsuarnut sikusiortunit qimagusimaniartartut. Kisianni matumuuna sivikitsumik sunniutaasarput, naliginnaasumillu misissuinerit assigiinngitsut inerneri ataasiinnaaneq ajorput. Umiarsuit sikusiorlutik nipiliortut sivisunerusoq eqqarsaatigalugu sunnittarneri ilisimaneqanngillat.

Frederick E. Hyde Fjord-imi siku aalaakkaasoq aserorterneqartartussaavoq umiarsuit Citronen Fjord-imut pulasassappata. Siku tamanna natseqarfiuvoq, natserillu tamaaniittut umiarsuarnik aserorterutinik sunnerneqaratarsinnaapput.

uuliakoorneq

Tamaani avatangiisinuk navianartorsiortitsisinnaasut annersaraat ajutoornikkut uuliakoorsinnaaneq. Uulia quppani sikullu killingini takissuuni katersuuttussaavoq sivisuumillu atasinnaalluni ungasissorsuarmullu ingerlanneqarsinnaalluni avatangiisini isittuni arriitsumik nungujartuaarusaarnissani pissutigalugu. Quppat ammasut sikullu killigi timmissanut immamilu miluumasunut katersuuffiukkajuttarppoq, taamaattumillu uumasut ilarparujussui uuliaarluersinaallutik.

Timmissat uuliakoornernut sunnertiasoorujussuupput, aappaatigulli immami miluumasut sunnertiannginnerullutik. Tamakku akornanni nanoq sunnertianersaavoq meqqulerinermigut uuliamik iioraasussaagami.

Sikorsuaqarfikkut umiarsuarnik angalasarneq nalilerneqarpoq annertunerusumik uumasunik sunniuteqassanngitsoq, ilaatigut uumasut akutsummata ilaatigullu sikorsuit najugaqarfiummata namminerisaminnik allanngorartuartut.

Nordøstvandet-ip eqqaani umiarsuarnik angalanissaq pinngitsoorneqartariaqarpoq timmissanik immamilu miluumasunik pingaarutilinnik peqarmat. Imarnersaqarfiup tamaaninnerata tunngavigai sikumik aalaakkaasoqarfiit marlussuit, imarnersap avannaani kujataanilu. Nalilerneqarporlu taakku sikunik aserorterutinik angallavigineqassanngitsut (tassami taamaatsoqarsinnaassappat).

1. Introduction

zinc

In the spring of 1993, Platinova A/S discovered a large zinc mineralisation in the Citronen Fjord area of Peary Land in North Greenland. The preliminary results of the exploration in 1993 were encouraging and extensive exploration drilling were carried out in the following years.

If the zinc mineralisation proves to be profitable for exploration is it likely that the zinc ore will be concentrated on site and shipped from the area. However, the zinc concentrate will have to be carried by icebreaking vessels or with assistance with icebreakers, through extensive drift ice areas as well through fast ice in the fiords and off the Greenland coast.

Sailing in icecovered waters implies impacts on the environment, and this report identifies the species and areas that could be impacted. In addition the knowledge about the the major impacts from sailing in ice is summarised.

1.1 Geography

Citronen Fjord

Citronen Fjord (83° 05′ N, 28° 16′ W) is a small branch of the Frederick E. Hyde Fjord, which cuts 180 km into Peary Land from the east. Fig. 1 shows the area with the most important site names indicated. A general description of the Citronen Fjord area is given by Glahder & Langager (1993).

This report covers the waters off eastern North Greenland from Kap Morris Jesup (83° 40′ N) and southwards to Lambert Land (79° N), including the Wandel Sea and the western part of the Greenland Sea.

1.2 Ice conditions

icecover

The fast ice in Citronen Fjord usually thaw during August. However, the fiord may be icecovered even in August, as was the case in 1995. On the contrary, the fast ice on Frederick E. Hyde Fjord does not usually thaw and the fiord remain icecovered throughout the year. There are ice free parts at river outlets, at the head of the fiord and along the shore. Cracks and leads may also develop during the summer (Håkansson et al. 1981). Yet, in August 1993 was almost the entire fiord ice free.

shear zone

Off the coast of Peary Land, a long and wide coastal lead usually develops in the shear zone between the shore fast ice and the drift ice. This lead stretches from Nordostrundingen of Kronprins Christian Land northwestwards at least as far as Kap Morris Jesup. To the northeast of this lead, multi year polar drift ice covers the ocean. Between the lead and land is multi year fast ice (Fig. 2), which probably is the thickest fast ice (up to 6 m) in the polar basin (P. Gudmandsen pers. comm.). This fast ice belt only breaks up occasionally, and usually blocks the mouth of Frederick E. Hyde Fjord throughout the summer.

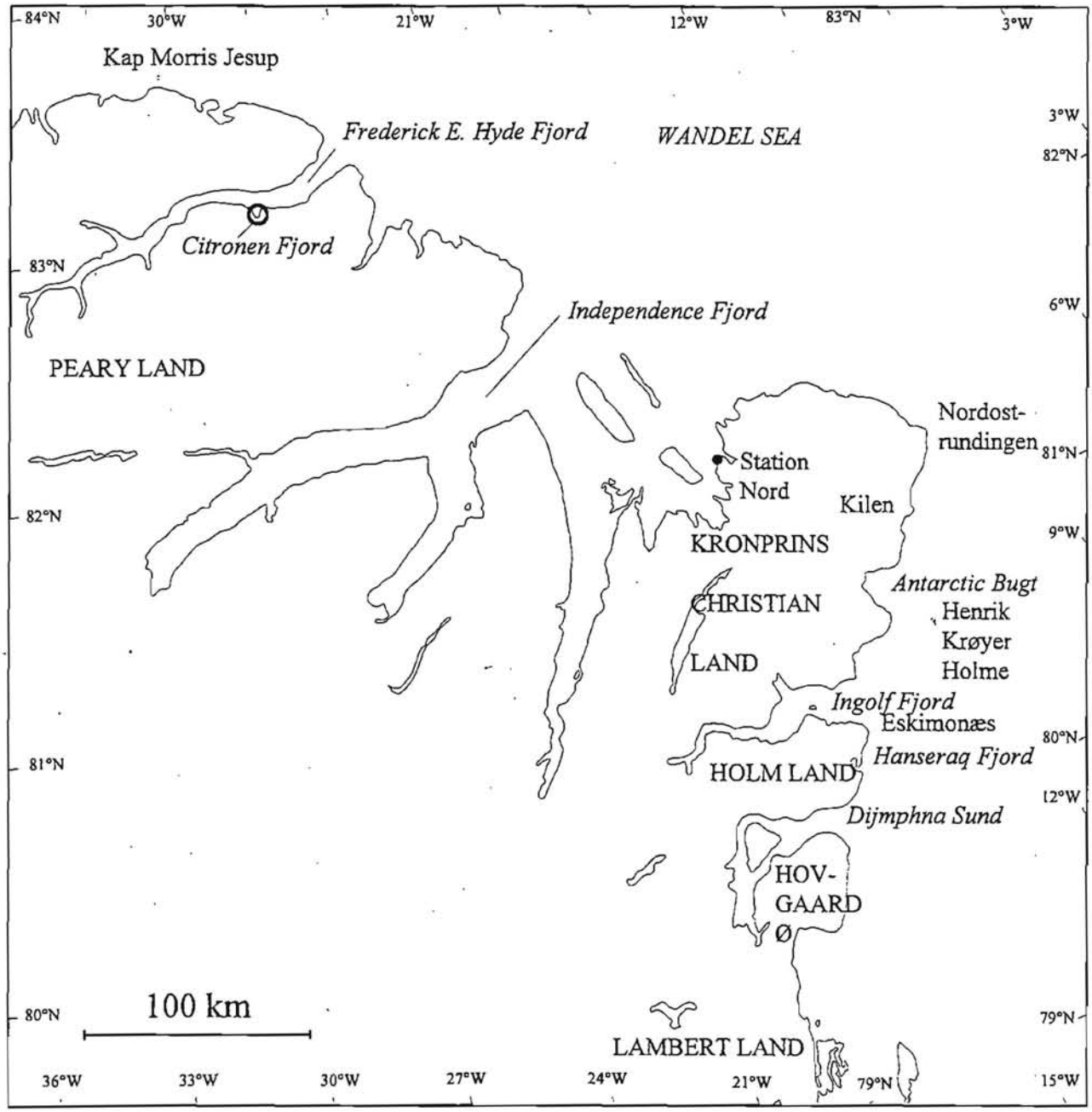

Fig. 1. The area described in this report, with the most important locations indicated.

polynya

The Northeast Water (NEW) is situated between Nordostrundingen and Hovgaard Ø (Schneider & Budéus 1994, Minnett et al. in press). This is a recurrent polynya, open from May-June through September, although open water also occurs to a much lesser extent during the winter. The polynya is bordered to the south by a large fast ice shelf, which is anchored on the Belgica Bank, and which prevents drift ice carried by the northern current along the shore, from entering the polynya (Fig. 2). Along the northern side of the polynya there is another fast ice shelf stretching from Nordostrundingen onto the Ob Bank. This shelf also creates a barrier to the drift ice coming from the north. The existence of the polynya largely depend on these two ice shelfs. The extension of the summer polynya varies greatly between years. The polynya very rarely opens into the Fram Strait. In other years is it almost filled with drift ice, as was the case in 1993 when the southern barrier broke off.

The amount of ice drifting from the polar basin with the East Greenland Current (Fig. 2) along the coast shows large inter annual variability.

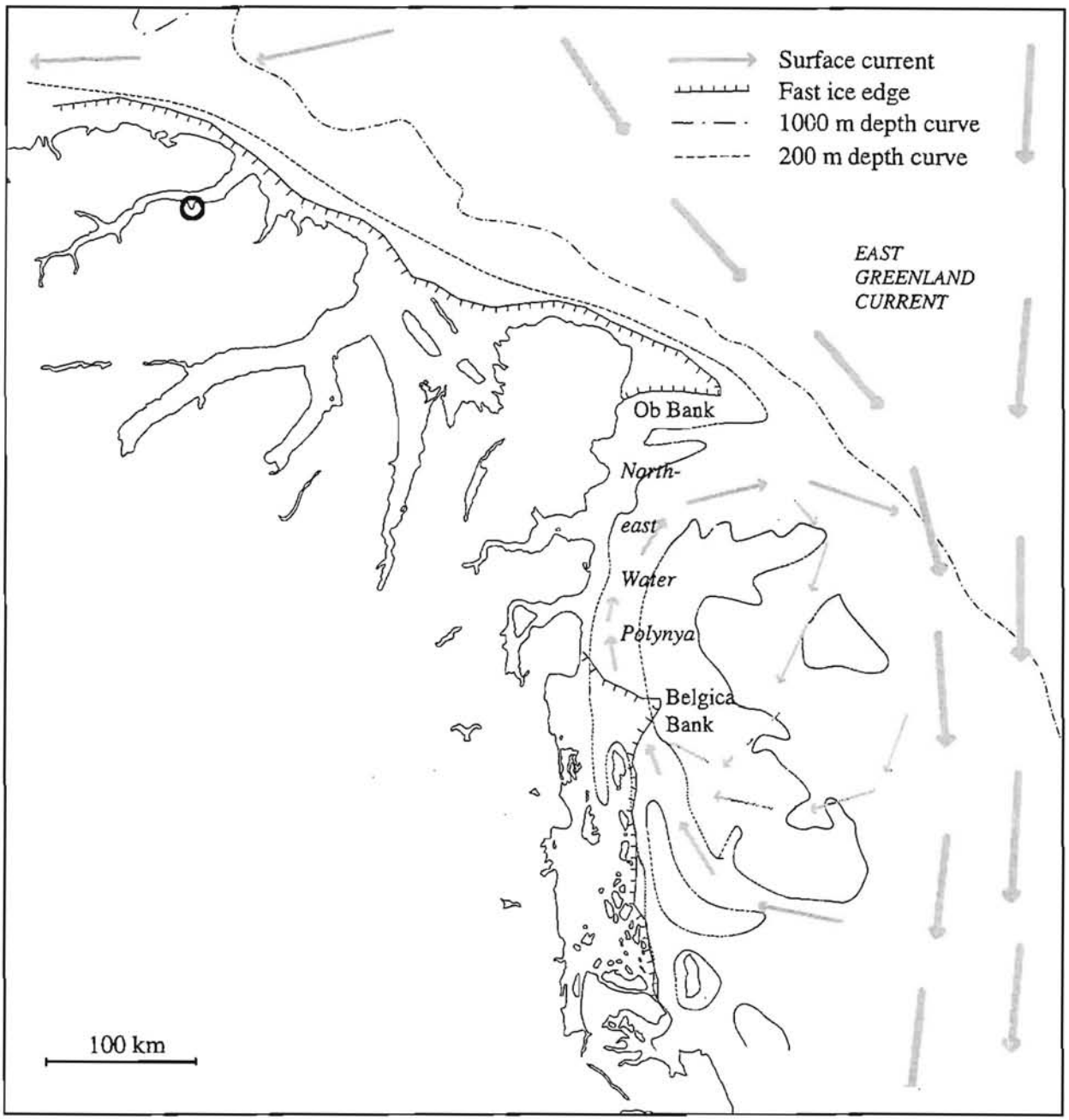

Fig. 2. Surface currents, depths and major fast ice edges. Currents after Mehlum (1989), Buch (1990) and Ashijian et al. (1995). Bold circle indicates the position of Citronen Fjord.

2 Research in the area

before 1984

A review of bird and mammal observations made during various expeditions, research etc. in North and Northeast Greenland before 1984 is given by Dietz & Andersen (1984) and Dietz et al. (1985).

since 1984, NEW

Since 1984 several expeditions have visited the study region, particularly during the large scale NEW-operations in 1992 and 1993, which involved two research vessels (Polarstern and Polar Sea) as well as land based studies. During these operations, pelagic seabirds and mammals were surveyed in the waters to the east of Kronprins Christian Land (Kristensen & Kristensen 1993, Joiris & Helsen 1994, Tahon & Vens 1994, Falk et al. in press, Joiris et al. 1995). However, these data have not yet been published in detailed form. The quoted references are mainly abstracts from a symposium held in Denmark (Northeast Water Polynya Symposium 1-5 May 1995, Helsingør, Denmark). Born et al. (1995a, in press) have published accounts of polar bear and walrus studies in the NEW-area, and a some data on other marine mammals are found in the ornithological accounts mentioned above. The ornithological part of the land based activities included research on northern fulmar and kittiwake colonies along the NEW coast (Falk 1993, Falk & Møller 1995a, b).

Several bird surveys have been carried out in the northern Greenland Sea: Brown (1984) has published observations from March 1982 outside the drift ice. Joiris (1992) and Joiris & Tahon (1992) joined the R/V Polarstern cruises to the Greenland Sea in 1988 and Mehlum (1989) has summarised the observations from research cruises during the summers of 1980-1984. At least one of these included transects in the Wandel Sea as far as c. 18° W. Hjort (1976) describes some remarkable observations of ivory gulls made during the Swedish icebreaker cruise to the North Pole in 1975.

In the summers of 1991, 1994 and 1995 the KANUMAS (Kalaallit Nunaat Marine Seismic Programme) project carried out seismic surveys in the waters off Northeast Greenland as far north as 78° 30′ N. Seabirds and marine mammals were counted during these surveys. However only the data from 1991 have been provisionally processed (Søder 1991).

In relation to the terrestrial environment, geological surveys have been carried out in the region, and some of the geologists have published ornithological reports with notes on seabirds (Hjort 1980, Håkansson et al. 1981, Hjort et al. 1983).

It must be stressed that research in region outside the NEW-area, is incomplete and generally lacking for the marine environment.

Information in relation to impacts of sailing in ice/icebreaking on marine mammals is derived from Dietz (1992).

3 Species account

3.1 Marine mammals

seals

Ringed seal *Phoca hispida*

The ringed seal is the most abundant and widespread marine mammal in the area. It occurs both in the fiords and in the drift ice off the coast (Dietz & Andersen 1984, Dietz et al. 1985). It was described as numerous in the drift ice surrounding the NEW by Kristensen & Kristensen (1993) during their cruise with R/V Polar Sea in July-August 1992. However, the general impression conveyed by the reports from the 1994 R/V Polarstern cruise, is that ringed seals were rather scarce (Joiris & Helsen 1994, Tahon & Vens 1994, Born & Thomassen 1994). 139 ringed seals were recorded during 1500 nautical miles (nm) ship borne transects in the NEW-area in June-July 1993 (Joiris & Helsen 1994). Born et al. (in press) report that they observed 12 ringed seals in the offshore drift ice and 149 on landfast ice during helicopter surveys (abundance index: 0.01 seal/minute search on drift ice, and 0.16 seal/minute search on landfast ice). This indicates that the seals are more abundant on the landfast ice, which is also the preferred habitat in other parts of the Arctic.

Ringed seals are common in Frederick E. Hyde Fjord. 50 seals were counted close to coastal leads in one occasion in 1969 (Dietz & Andersen 1984).

Adult ringed seals are usually stationary, while immatures may undertake considerable movements (Smith 1987).

The pups are born in snow covered liars on the ice during March-May and stay within these liars for 6-8 weeks.

Bearded seal *Erignathus barbatus*

The bearded seal occurs mainly south of Nordostrundingen. However, a few stragglers have been seen as far north as Kap Morris Jesup (Dietz & Andersen 1984, Dietz et al. 1985). It is generally much less abundant than the ringed seal. Kristensen & Kristensen (1993) state that bearded seals were numerous in the drift ice surrounding the NEW during the R/V Polar Sea cruise in July-August 1992, and Tahon & Vens (1994) report it as the most abundant seal during the ARK IX/3 leg of the R/V Polarstern cruise in July 1993. 19 bearded seals were recorded during 1500 nm of ship borne survey in the NEW-area in June-July 1993 (Joiris & Helsen 1994).

The bearded seal is usually stationary, although it will leave areas where the winter ice exceed a thickness of 20-30 cm (Vibe 1981, Dietz & Andersen 1984). This is probably the case in most of the study region except the NEW, where open water or areas with thin ice occur through the winter

Hooded seal *Cystophora cristata*

The hooded seal is a straggler to the region, and only low numbers have been recorded during the summer (Dietz & Andersen 1984, Dietz et al. 1985). During the NEW-operations only a few were reported (Tahon & Vens 1994), although without exact location. It is possible that these seals were observed south of the region covered by this report.

Harp seal *Phoca groenlandica*

The harp seal is an irregular and rare visitor to the region. Dietz et al. (1985) report a few sightings as far north as Station Nord, and propose that harp seals may occur in the area in years with very little drift ice. Tahon & Vens (1994) write that harp seals were present in low numbers. However without indicating the exact location, and they were probably observed outside the region covered by this report.

Walrus *Odobenus rosmarus*

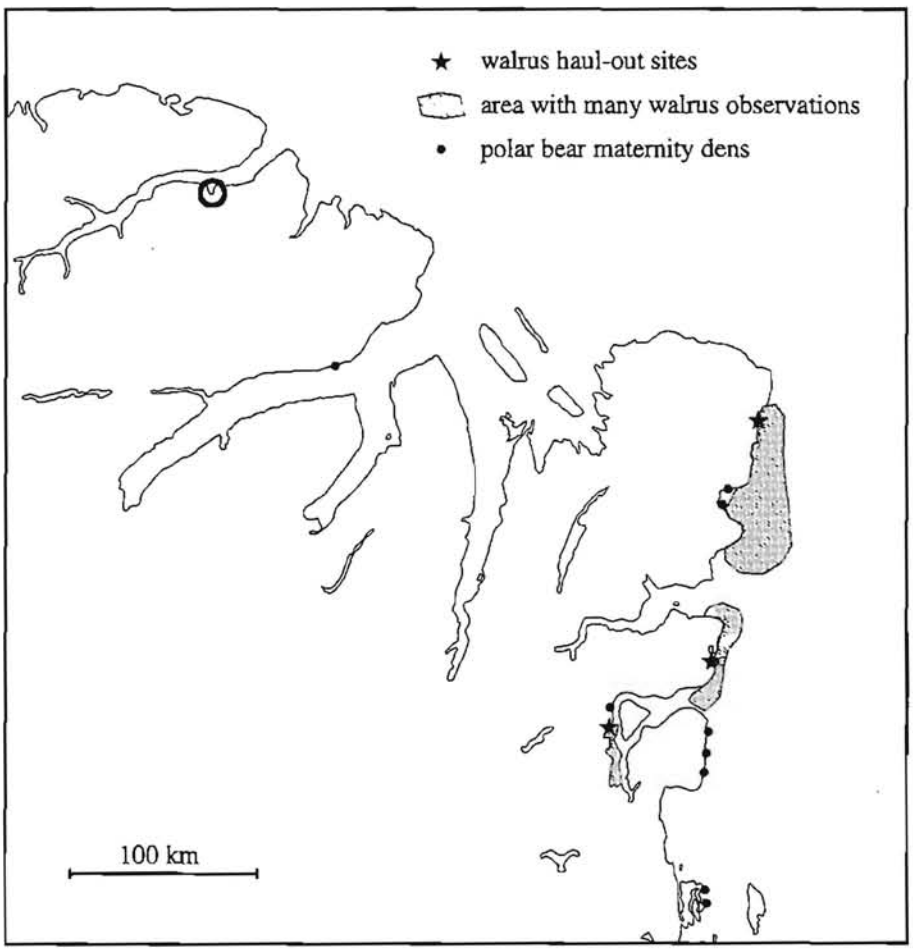

Fig. 3. Main occurrence of walrus and position of polar bear maternity dens (based on Dietz et al. 1985, Born et al. 1995a, in press). Bold circle indicates the position of Citronen Fjord.

The walrus occurs within the study region mainly in the NEW-area. Born et al. (1995a) estimated that about 200 individuals were present in the NEW-area during the summer of 1993. The majority were found between Henrik Krøyer Holme and Kilen (Fig. 3), and most of these were females, calves and subadults. Males seem to leave the NEW-area in the summer, and migrate southward to haul-out sites further south along the East Greenland coast (Born et al. 1995b).

The NEW-area is the only area in East Greenland where walrus females with calves are seen in fair numbers. The NEW must be categorised as extremely important to the East Greenland walrus stock.

Terrestrial haul-out sites have been recorded at Kilen, in Antarctic Bugt and in the head of Dijmphna Sund (Born et al. 1995a)(Fig. 3).

Walruses equipped with satellite transmitters have stayed within the NEW-area throughout the winter period (Fig. 4), indicating that at least a segment of the population stays in the area year round (Born & Knutsen 1992).

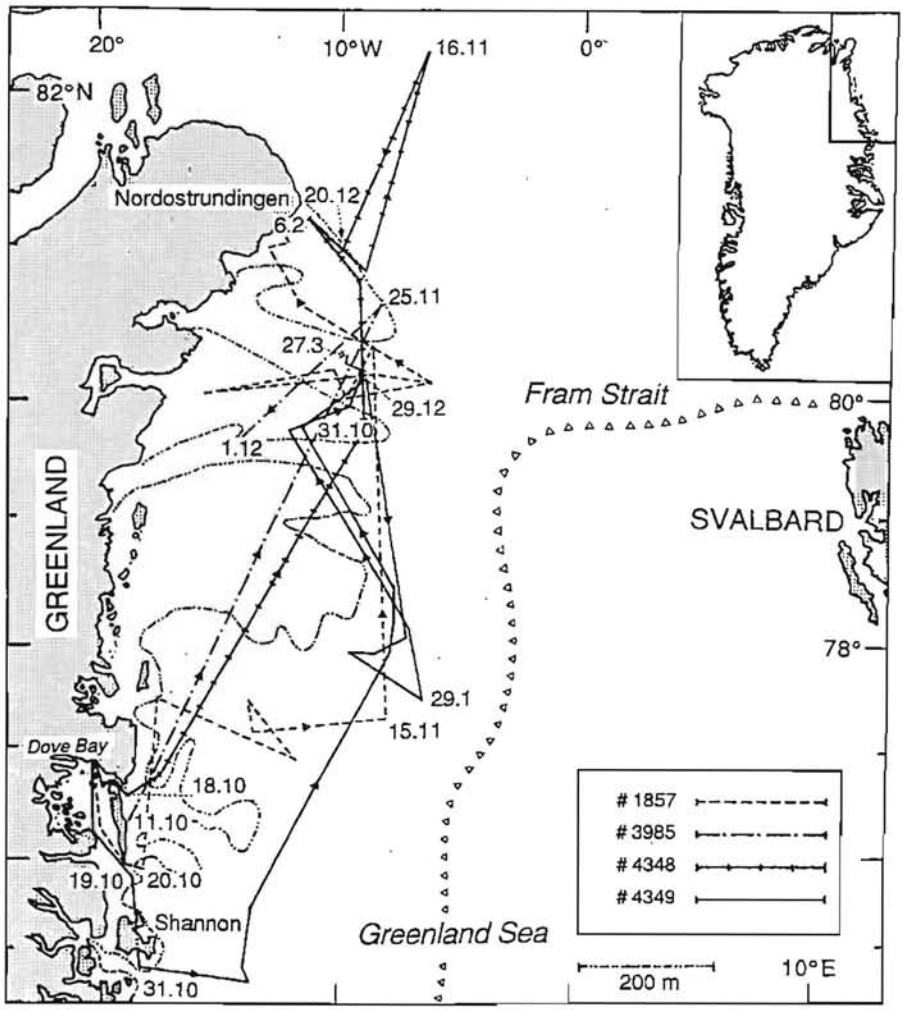

Fig. 4. Movements during winter 1990/91 in the Greenland Sea of four walruses equipped with satellite transmitters in Dove Bugt. Drift ice edge in March 1991 indicated with row of triangles. From Born & Knutsen (1992).

Walruses may occur anywhere in the waters between NEW and Svalbard. The populations are probably connected, as exemplified by a walrus tagged in Northeast Greenland in 1989 and resighted in Svalbard in 1992.(Born & Gjertz 1993).

There are no walrus observations along the Greenland coast to the northwest of Nordostrundingen (Dietz & Andersen 1984).

whales

Narwhal *Monodon monoceros*

Dietz et al. (1994) summarise the coastal observations of narwhals in the region (Fig. 5). Narwhals have been recorded from late May to July and flocks up to 150 have been reported. Narwhals also occur further offshore in the drift ice and along the ice edge zone in the Greenland Sea, and at least as far north as 83° N (Dietz et al. 1994).

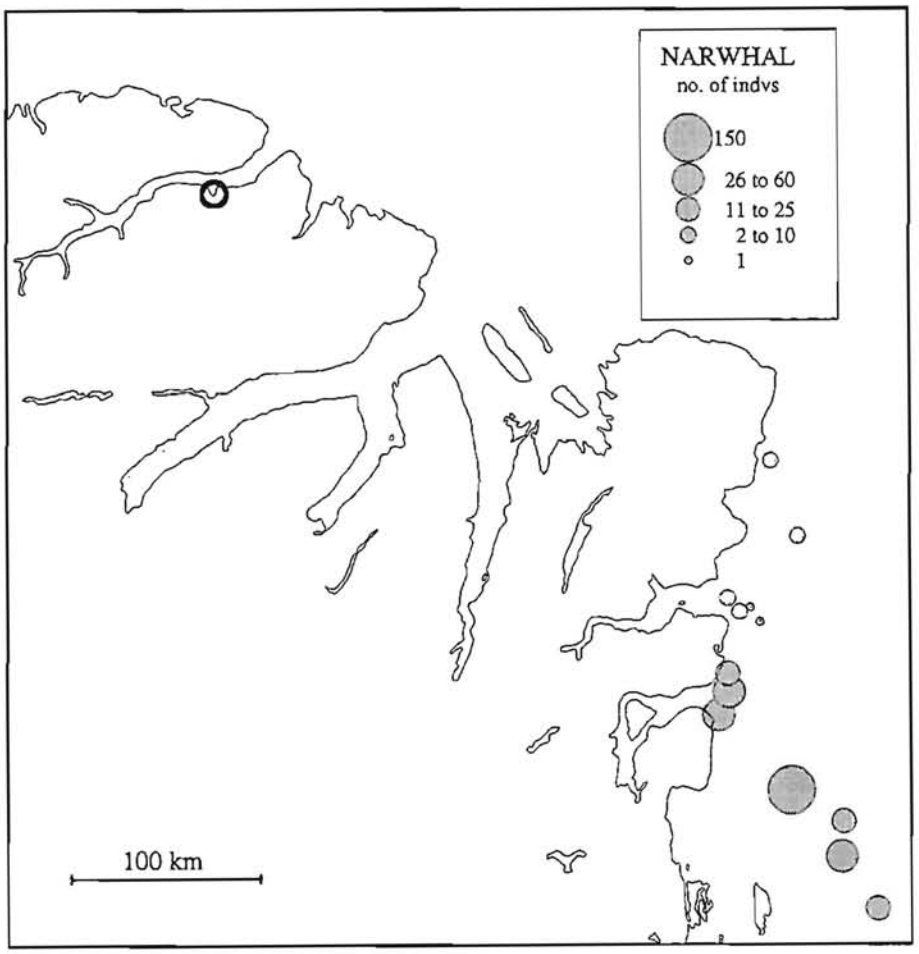

Fig. 5. Coastal observations of narwhals since 1984. Based on Dietz et al. (1994). Bold circle indicates the position of Citronen Fjord.

Killer whale *Orcinus orca*

A single killer whale observation was recorded during the NEW-operations in 1992: Three individuals were seen at 80° 30' N, 14° 31'W on July 23 (Kristensen & Kristensen 1993). Heide-Jørgensen (1988), in a review of the occurrence of the killer whale in Greenland waters, mentions only a few observations from the Greenland Sea,

but states that this fact probably reflects the low level of human activity in this area.

Bowhead whale *Balaena mysticetus*

The bowhead whale is extremely rare to day along the coast of Northeast Greenland, and sightings are not annual. During the NEW-operations only one record has been reported, on June 29, 1993 (Tahon & Vens 1994). It was however seen to the south of the region covered by this report. Moore & Reeves (1993) refer to three records in July 1984 along the Greenland coast between 79° and 81° N.

Bowheads occurring along the Northeast Greenland coast belong to the "Spitsbergen Stock", which was nearly exterminated as a result of three centuries of whaling (app. 1600 - 1900). During this period, bowheads were mainly caught in the inshore waters of Spitsbergen and along the drift ice edge between Spitsbergen and Greenland.

polar bear

Polar bear *Ursus maritimus*

Polar bears may occur anywhere in the region described in this report. However, they are rare north of Nordostrundingen (Dietz & Andersen 1984, Born et al. in press.). The NEW-area provides suitable polar bear habitats, as the bears prefer the fast ice and the drift ice over the continental shelf. During 40.5 hours helicopter surveys Born et al. (in press.) observed 0.85 bears/hour on shore fast ice and 0.44 bears/hour on the offshore drift ice in the NEW-area. Females with youngs were mainly observed on shore-fast ice in fjords. Compared with other areas with polar bear populations such as Svalbard, the density of bears is generally low in the Northeast Greenland area, particularly in offshore areas (Born et al. in press.).

Females in maternity dens (October through April) are particularly vulnerable to disturbance. Maternity dens have been located on the coast along the western side of NEW and in Independence Fjord north of the NEW-area (Born et al. in press.). See Fig. 3.

Polar bears tagged with satellite transmitters in the NEW-area generally show fidelity to the area. They move around to some extend in the drift ice to the east and north of the polynya, but seem to return for periods of time, particularly during spring perhaps in search of seals and their pups on the fast ice of the fiords (Born et al. in press.).

Polar bears are distributed throughout the drift ice between Svalbard and Greenland, and there are numerous summer observations along the drift ice edge in the Greenland Sea (Dietz et al. 1985).

3.2 Birds

Northern fulmar *Fulmarus glacialis*

Six breeding colonies are found along the coast of the NEW (Fig. 6). The colonies have recently been surveyed, and the total population was estimated at about 1500 breeding pairs (Falk & Møller 1995a).

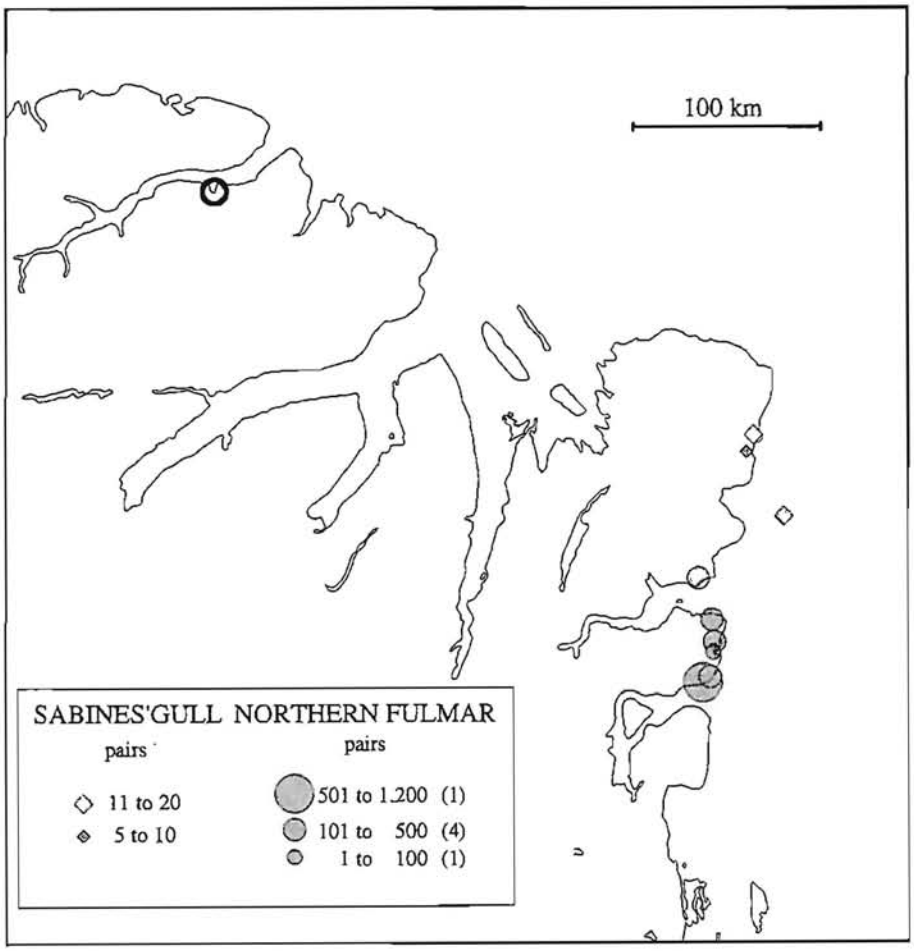

Fig. 6. Distribution and numbers of breeding northern fulmars and sabine's gulls. All colonies are on the coast of the Northeast Water Polynya. Based on information in Hjort et al. (1983), Kristensen & Kristensen 1993 and Falk & Møller (1995a). Bold circle indicates the position of Citronen Fjord.

Fulmars occur throughout the drift ice, where open water is present, and is probably the most widespread and numerous bird species in the drift ice (Joiris, 1992, Joiris & Tahon 1992). It is the most common bird species in the NEW (Falk et al. in press). Concentrations may be found in suitable feeding grounds, which are more or less unpredictable in time and location. Joiris & Helsen (1994) counted 939 fulmars along 1500 nm of ship transects in June 1993. Brown (1984) observed 0.1 fulmars/km in the Fram Strait during March 1982, and found that they were mainly concentrated along the drift ice edge. Viewed on a broader scale, it seems that the fulmar are less abundant off Northeast Greenland than further east in the Greenland Sea and Barents Sea (Mehlum 1989).

Common Eider *Somateria mollissima*

Common eiders were first reported in the region by Hjort et al. (1983), who found eiders rather common along the coast of NEW, both as breeders and in post breeding flocks. A breeding colony has been found on Henrik Krøyer Holme (Hjort et al. 1983, Kristensen & Kristensen 1993), although only empty nests cups have been seen. Nests have also been recorded on the coastal lowlands between Hanseraq Fjord and Amdrup Land (Falk et al. in press). Females with chicks have been seen at several sites elsewhere along the NEW coast. Tahon & Vens (1994) saw 168 males and 149 females/families during helicopter transects along the shore between Nordostrundingen and Eskimonæs on 25 July 1993.

The NEW is also a pre-breeding congregation area: up to 2500 common eiders have been recorded off southern Kilen in May during the NEW-operations in 1993 (Falk et al. in press).

The eiders breeding in the region most likely migrate to and from the area along the East Greenland coast.

King eider *Somateria spectabilis*

The king eider usually breeds inland at lakes and ponds. However, during spring pre-breeding flocks assemble in coastal areas with open water. An estimated 1000 king eiders congregated in the NEW-area off southern Kilen during May in 1993, before dispersing to breeding grounds (Falk et al. in press). The were observed mixed with flocks of common eider, in the coastal part of Ob Bank, which seems to be the only extensive areas potentially avialable to eiders during early summer (Falk et al. in press).

Spring and autumn migration probably takes place along the coast of Northeast Greenland.

Grey phalarope (red phalarope) *Phalaropus fulicarius*

The grey phalarope is usually considered to be a scarce, but probably annual visitor to North Greenland. However, observations of flocks in recent years in the NEW indicate that this area may serve as staging area for migrants (Hjort et al. 1988, Falk et al. in press). Moreover, the species probably bred on Henrik Krøyer Holme in 1992 and 1993 (Falk et al. in press).

Glaucous gull *Larus hyperboreus*

This is a fairly common breeder along the coasts of the NEW (Hjort et al. 1983, Falk & Møller 1995a, Falk et al. in press) (Fig. 7). Falk & Møller (1995a) counted 16 pairs in the fulmar colonies at the NEW. Elsewhere is it, a rather scattered breeder, and according to Håkansson et al. (1981), it occurs mainly at lakes, large rivers and at fiords which become icefree during the summer.

During the shipboard transects in the NEW-area, 307 glaucous gulls

were counted on 1500 nm (Joiris & Helsen 1994). Brown (1984) states that it was seen fairly often in small numbers in the Greenland Sea in March 1982, while Mehlum (1989) remarks that it was almost absent from the waters off Northeast Greenland during the surveys in 1980-1984.

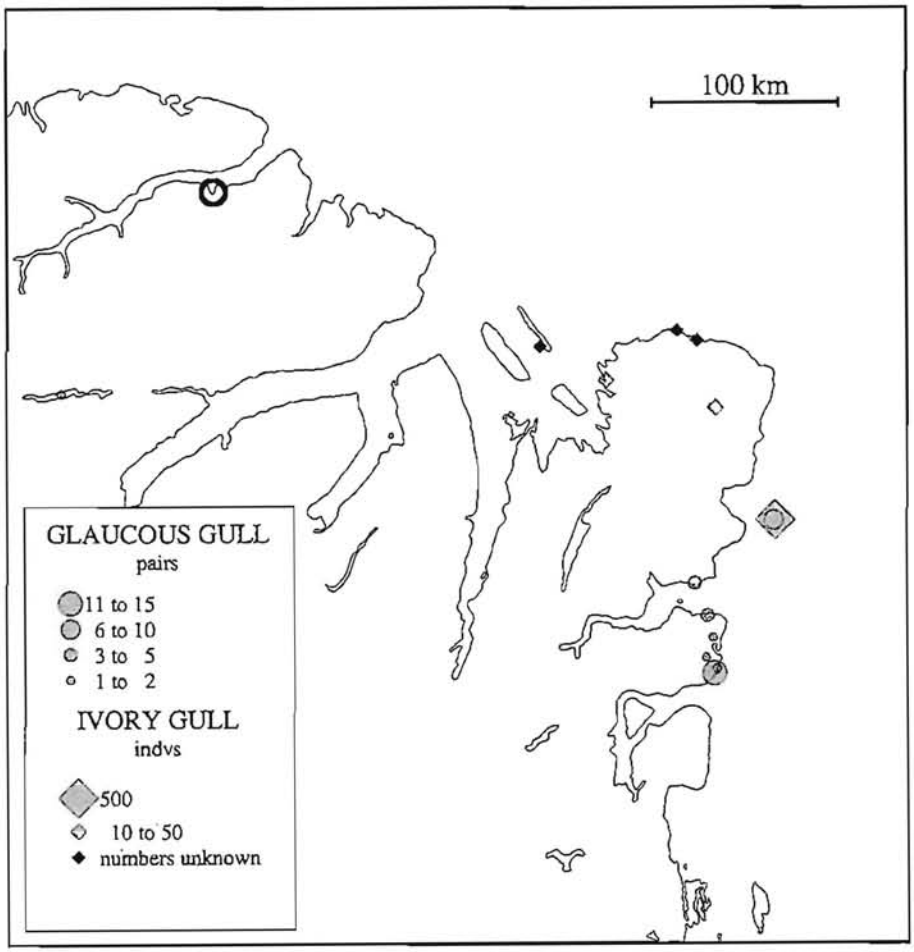

Fig. 7. Colonies of breeding glaucous gulls and ivory gulls. There are probably many more small glaucous gull colonies in the area. Based on Håkansson et al. (1981), Hjort et al. (1985), Falk & Møller (1995a) and Falk et al. (in press). Bold circle indicates the position of Citronen Fjord.

Kittiwake *Rissa tridactyla*

There is only one breeding colony in the region. It is situated on Mallemukfjeldet, close to the NEW (Fig. 8). Falk & Møller (1995a) reported 873 occupied nest sites in 1993. In certain years, the kittiwakes may not breed due to bad weather or unfavourable ice conditions, as was the case in 1980, when no kittiwakes were seen at the colony (Hjort et al. 1983).

Kittiwakes were observed in most parts of the NEW polynya in 1993, although in small numbres (Falk et al. in press), and 351 kittiwakes were counted on 1500 nm transects in the NEW-area in June 1993 (Joiris & Helsen 1994). Seen on a broader scale kittiwakes generally occur in much lower numbers in the northwestern part of the Greenland Sea than in the eastern part (Mehlum 1989).

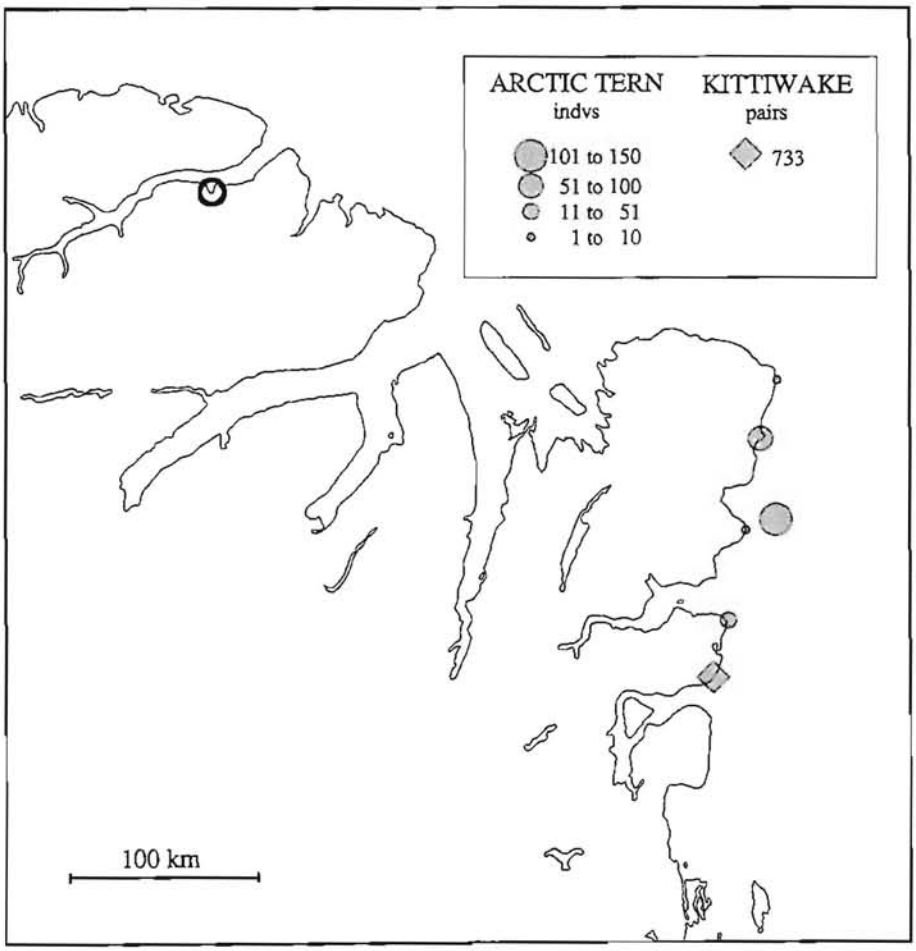

Fig. 8. Distribution and size of kittiwake and arctic tern colonies. Based on Falk & Møller (1995a) and Tahon & Vens (1995). There are probably more arctic tern colonies in the area. Bold circle indicates the position of Citronen Fjord.

Ivory gull *Pagophila eburnea*

The ivory gull is a character species in the study region. Several colonies are found along the coast of Kronprins Christian Land, on Kilen (Håkansson et al. 1981, Hjort et al. 1983, 1988) and on Henrik Krøyer Holme (Fig. 7). The last mentioned colony is the largest colony recorded in Greenland and one of the largests in the world, with about 500 individuals and 125 broods recorded in 1993 (Falk et al. in press). The entire NEW-area is estimated to hold about 400-500 pairs (Falk et al. in press) of this rare and little known bird, and this segment comprises one of the largest populations known.

Ivory gulls are numerous in the offshore drift ice of the NEW-area. Joiris & Helsen (1994) observed 707 during 1500 nm ship transects. In general, this species is widely dispersed in the drift ice of the Greenland Sea during spring and summer (Brown 1984, Mehlum 1989, Joiris & Tahon 1992, Joiris 1992), and according to Mehlum (1989), is it the most abundant species in the waters off Northeast Greenland.

Autumn migration has been described by Hjort (1976), who observed what he believed to be concentrated southward movements in the drift ice off central Northeast Greenland in early September 1975.

Sabine's gull *Larus sabini*

This small gull breeds at least three sites on the coasts of NEW (Fig. 6), on Kilen where Hjort et al. (1988) found 20-30 pairs in two colonies in 1985, and on Henrik Krøyer Holme where at least 200-300 adults were observed in 1992 (Kristensen & Kristensen 1993) and at least 50 pairs were estinmated to breed in 1993 (Falk et al. in press).

There are a few records of stragglers as far north as Peary Land (Håkansson et al. 1981, Boertmann 1994).

This gull is a coastal forager during the breeding time, and it is generally rare in offshore waters (Mehlum 1989, Joiris 1992, Joiris & Tahon 1992).

Ross's gull *Rhodostethia rosea*

Ross's gull only occasionally breeds in the area (Hjort 1980, Falk et al. in press), the main breeding area is in northeastern Siberia. In late summer (July, August and early September) non-breeding adults and immatures occur in the drift ice around and north and east of the NEW in fluctuating numbres form year to year (Meltofte et al. 1981, Hjort et al. 1983, Mehlum 1989, Falk et al. in press). Tahon & Vens (1994) state that Ross's gull sometimes in 1993 was the most common of the gulls.

Arctic tern *Sterna paradisaea*

The arctic tern breeds in small colonies or solitary pairs along the coast of the entire study region. An estimated 500 - 1000 individuals breed in the NEW-area (Fig. 8), with colonies on Nordostrundingen, Kilen , between Kilen and Antarctic Bugt, Sophus Møller Næs, Kap Jungersen, Eskimonæs and on Henrik Krøyer Holme (Hjort et al. 1988, Tahon & Vens 1994, Falk et. al. 1995). Elsewhere, it is dispersed and breeds in low numbers (Håkansson et al. 1981). According to Mehlum (1989) the terns are mainly found in inshore waters during summer. However, some are also found offshore in the marginal ice zone in the Greenland Sea.

Brünnich's guillemot (Thick-billed Murre) *Uria lomvia*

The Brünnich's guillemot does not breed in the study-region. The nearest breeding places are in Svalbard and around the mouth of Scoresby Sund. It is a scarce summer visitor in the study area (Mehlum 1989, Joiris & Tahon 1992, Joiris & Helsen 1994). An unknown, but probably significant segment of the Svalbard population migrate during spring and/or autumn along the drift ice edge in the Greenland sea. Brown (1984) surveyed the northern Greenland Sea in March 1982, and only saw guillemots in the vicinity of the Svalbard coast.

Black guillemot *Cepphus grylle*

The black guillemot is the only auk breeding in the study-region. A small colony with c. 20 individuals was found on Mallemukfjeldet (Falk 1993). A few individuals have been seen along the coasts of the NEW in Hanseraq Fjord, Dværgfjorden and at Henrik Krøyer Holme in 1993 (Falk et al. in press).

There are very few records from the offshore areas of the study-region (Mehlum 1989, Hjort et al. 1988).

In March 1982, Brown (1984) saw 25 black guillemots along the drift ice edge in the northern Greenland Sea. These were probably spring migrants on their way to Svalbard breeding sites.

Little Auk (Dovekie) *Alle alle*

This species does not breed within the study-area. The nearest breeding sites are in Svalbard and around the mouth of Scoresby Sund. However, a small colony was recently found on Hvalros Ø on the Northeast Greenland coast (Stemmerik 1990). It is an uncommon visitor to the study area during summer. Mehlum (1989), Joiris & Tahon (1992) and Joiris & Helsen (1994) only observed 35 little auks during the NEW-operations in June 1993.

Little auks are much more abundant in waters closer to the Svalbard coast where huge breeding colonies are found (Mehlum 1989). In March 1982, Brown (1984) observed large numbers of little auks in the northern Greenland Sea.

Large numbers of little auks migrate from Svalbard to West Greenland waters during the autumn (Salomonsen 1967, Norderhaug 1989), presumably along the drift ice edge in the Greenland Sea.

Other bird species

Four species of skua (jeagers) have been recorded in the region. Long-tailed skua is the only skua that breed in the area and it is at leaast in the NEW area fairly common (Falk et al. in press). The other three species (arctic, pomarine and great skua) are infrequent summer visitors (Falk et al. in press).

fish

3.3 Fish

Very little is known about the fish and their biology in the study region. Some studies were performed during the NEW-operations.

Polar cod *Boreogadus saida* and arctic cod *Arctogadus glacialis*

Both species occur in the area (Nielsen et al. 1992). However, almost nothing is known about their abundance, distribution, biology etc. in the region. These two fish are considered as ecological key species in the arctic food webs, as they are important prey to marine mammals and seabirds.

Some studies were carried out during the NEW-operations. Michaud et al. (1995) showed that the higher temperatures of icefree waters were important to the feeding of cod larvae, and that early opening of the NEW is to the benefit of the larvae hatched the same year. Polar cod caught in the NEW-area were analysed for stomach contents, and the result showed that arctic cod feed exclusively on pelagical organisms (Süfke 1995).

3.4 Invertebrates

macrozooplankton

It has been reported that the macrozooplankton communities in the NEW-area are weakly developed, with the lowest biomass values ever reported from polar oceans (Hagen et al. 1995).

benthic fauna

The banks of NEW are very rich in benthic fauna. 200 different species were found during cruises in 1985, 1990 and 1993 with brittle stars and sea urchins predominating (Piebenburg 1995).

Mussels and other molluscs are important food for walruses and bearded seals.

4 Impacts of icebreaking

The major impacts of icebreaking or sailing in more or less icecovered waters are physical effects and noise (Dietz 1992, Richardson et al 1995). Incidental oil spills also have to be considered as impacts from oil spills in icecovered waters are potentially very harmful.

4.1 Physical effects

Dietz (1992) lists three direct physical effects of icebreaking on marine mammals:
-alteration of ice habitats
-crushing of animals
-entrapment of whales in leads formed by icebreakers

alteration of icehabitats

Icebreaking in fast ice creates a narrow open zone, slightly wider than the ship, where the ice is broken up to small pans, floes and brash ice. This zone freezes quickly when ambient temperatures are well below zero. This form of habitat change is temporary and localised. However, when the temperature is above freezing point a track in fast ice may remain open for long periods, and may cause premature break up of ice in the early summer. The fast ice of the Frederick E. Hyde Fjord is an important ringed seal habitat.

The fast ice barrier southeast of Hovgaard Ø occasionally breaks off, as was the case in 1993, and the NEW is subsequently filled with drift ice. Icebreaking in this fast ice barrier and in the fast ice off Nordostrundingen (if possible at all) should be prevented as such activities may cause break off of large parts of the fastice, with consequences for the ice regime of the polynya.

collision

Marine mammals resting on the ice may be hit by an icebreaking vessel, although direct collisions with marine mammals during icebreaking has never been described (Dietz 1992). Adult individuals are usually able to avoid an icebreaker and are often scared off at considerable distance. Only seal pups laying in liars on the ice are likely to be hit. The density of pups is usually low and only few may actually be hit. Another effect of icebreaking in fast ice could be exposure of seal pups to predators such as polar bears or arctic foxes, due to disruption of their snow covered liars.

entrapment

The only whale which occurs regularly in the area is the narwhal. Flocks of narwhals occasionally become entrapped in fast ice (sassat) and may succumb if ice conditions do not improve. But it is not likely that narwhals will follow an icebreaker track into the fast ice of Frederick E. Hyde Fjord, as they usually avoid the noise produced by icebreakers (Dietz 1992).

The physical impacts on the wildlife of icebreaking in the drift ice areas are probably negligible, as this habitat is constantly changing due to moving ice. Icebreaking in the fast ice of Frederick E. Hyde Fjord may create an open lead along the fiord and may change the break up pattern of the ice and thus an increased mortality of ringed seal pups if icebreaking takes place when the pups are still in their liars.

Birds are able to avoid the ships and to escape from entrapment by flying, and for this reason only alteration of habitats may apply to them. Birds are often attracted to icebreakers because icebreaking creates open turbulent water where food items are exposed and easily caught.

4.2 Noise

Sailing in ice and icebreaking produce stronger and more variable sounds than would normally be produced by ships of similar size and power (Richardson et al. 1995). The increased noise is due mainly to the propellers (Richardson et al. 1995). Particularly in areas with stable fast ice can the ambient sound levels be low and icebreaking can increase the noise level dramatically (Richardson et al. 1995). One effect of the noise is masking of the communication calls of marine mammals in the water, another effect is stress and changes in behavioural responses. However, there are very little information available concerning acoustic effects of icebreaking ships on marine mammals (Dietz 1992).

The noise can mask the communication calls of marine mammals in the water.

Marine mammals may respond to the noise from icebreakers and ships. Walruses hauled out on the ice may wake up, raise their heads or enter the water when a ship are detected. Females with cubs seem to be more sensitive than lone animals or males in flocks (Fay et al. 1986). However, it seems that in areas where they are not hunted hauled out walruses are not particularly disturbed by small boats. Fay et al. (1986) describe how walruses on ice reacted to operating

icebreakers. The walruses became alert when the icebreaker was at least 2 km away and entered the water and swam away when the ship was 0.1-1 km away. Another study (Brueggeman et al. 1990), suggested that walruses hauled-out on icefloes tended to avoid the area within 10-15 km of the icebreaker (quoted from Richardson et al. 1995).

Walruses, ringed seals and bearded seals may also scramble onto the ice when an icebreaker heads towards them (Fay et al. 1986).

Icebreaking in fast ice of the Beaufort Sea during winter had no effects on ringed seals numbers the following spring (Alliston 1980, 1981).

The white whale (*Delphinapterus leucas*) is rather well studied in relation to reactions to disturbance by vessels. White whales do not occur in the study region, but they are closely related to narwhals and may respond to disturbance and noise in a similar fashion. The sensitivity to noise of white whales shows a considerable variation depending on the habitat, the activities of the whale, the experience of the whale and on the type of boat (Dietz 1992). White whales and narwhals seem to be particularly sensitive to shipping in icecovered waters (Finley et al. 1986, Finley & Davis 1986, LGL & Greeneridge 1986, Barber & Hochheim 1986, Cosens & Dueck 1988). The whales reacted to ships that were more than 100 km away, and they began to move away when approaching ships were 35-40 km away (white whale) and 18 km away (narwhal).

Bowhead whales usually react strongly and rather consistently to approaching vessels. They interrupt their normal behaviour and try to avoid vessels by swimming rapidly away. These escape responses often subside when the vessel has moved a few km away. Bowheads performing social behaviour, often tolerate slowly moving boats at much closer distance than usual. (Richardson et al. 1985 a,b, Koski & Johnson 1987, Wartzok et al. 1989).

Noise from shipping often causes short-term behavioural reactions and temporarily displacement of various marine mammals, and marine mammals in icecovered waters seem to be particularly sensitive to noise. However, the effects are usually of short duration and there are no conclusive studies dealing with long-term effects and effects on population scale available.

4.3 Oil spills

Oil (bunker oil for the ships and diesel for the landbased operation) from ruptured ship tanks may pose a serious threat to the animals living within the icecovered waters adjacent to the sailing routes to and from Citronen Fjord. Due to low ambient temperatures will the oil be preserved for a long time, and may accumulate along ice edges or in leads or may be transported over long distances. Birds and marine mammals often concentrate along ice edges and in leads, thus significant parts of the populations may be exposed to oil spills.

Whales and seals seem to be rather insensitive to fouling with oil, yet seal pups which are dependent of the fur for insulation during the

first month of their life are much more sensitive (Dietz 1992). If seals or whales are trapped in areas where oil has accumulated, they might experience harmful effects from inhalation of evaporated hydrocarbons, as seen in harbour seals (Frost & Lowry 1993).

Born et al. (1995b) believe that walruses may be more sensitive to oil spills tan many other marine mammals.

Polar bears are more sensitive to oil than whales and seals, as they swallow oil that they groom from their fur, and this habit may lead to the death of the bear (Øritsland et al. 1981, Hurst & Øritsland 1982, Hurst et al. 1982). Moreover are polar bears more dependent on their fur for insulation than seals, and oil fouled fur increases heatloss and which in turn gives rise to elevated metabolic rate.

Seabirds are the most oil spill sensitive group of vertebrates. Oil spills have the potential of significantly reducing populations size.

Birds which accumulate in large flocks on the water, during different stages of their life cycle, are particularly susceptible to oil spills. Some of the seabird species in the study region breed in colonies along the coasts of the NEW: northern fulmar, arctic tern, glaucous gulls, ivory gull, sabine's gulls and black guillemot. Furthermore there are colonies of ivory gulls on the shore along the coastal lead stretching from the NEW towards the northwest. During spring, eiders of both species accumulate along the coasts of the NEW, and later common eider females with chicks form flocks along the coast near the breeding colonies.

4.4. Zinc concentrate in the marine environment

Ships with a cargo of zinc concentrate may get lost and the zinc concentrate become exposed to the seawater with dissolving of metals as a result. The Citronen Fjord ore contain besides zinc low concentrations of lead, copper and cadmium.

In August 1991 a zinc concentrate carrier "Finn Polaris" sank off Upernavik with 12000 t zinc concentrate from the Nanisivik mine in Arctic Canada. It was concluded then that zinc was the only metal that could create a significant environmental effect in a worst case scenario, and that there would be no human health risk related to consumption of sea food from the affected area (Asmund 1992).

One of the rivers in the Citronen Fjord area cross the zinc ore and wash considerable amounts of zinc, lead, cadmium and copper out into the marine environment (Glahder & Asmund 1995), perhaps creating a "natural pollution" much more severe than the heavy metal pollution from a wrecked carrier ship.

5 Conclusions

It should be stressed that there is a general lack of biological information in relation to the marine environment of the region to the west of Nordostrundingen. Only the NEW-area has been well studied. This fact makes it difficult to assess environmental impacts in the area as a whole, and the present conclusions are therefore preliminary.

However, it seems clear that marine wildlife is most abundant in the area around the NEW, particularly at the coasts and in the ice edge zone. Elsewhere in the region - in the drift ice and along the coasts of North Greenland - wildlife is scarce and dispersed when compared to the Svalbard-region and the Barent's Sea for example.

The NEW is the most important walrus area in the entire East Greenland area. There are at least three haul out sites on the coast and significant numbers of females with calves occur in the region, particularly around Henrik Krøyer Holme.

Narwhals occur in fair numbers in the NEW-area.

The NEW-area is important to polar bears, although the density of bears is rather low.

Seabird colonies are mainly found on the coast of the NEW, although ivory gulls also breed along the coastal lead zone to the northwest of the NEW. The most numerous breeding seabirds are northern fulmar, common eider, kittiwake and arctic tern. Sabine's gull and ivory gull, which are both rare species with low population numbers are also found in significant numbers in the area. Other seabird concentrations in the NEW are the pre-breeding aggregations of common eider and king eider as well, as post-breeding aggregations of common eider. Outside the NEW-area, large concentrations of migrating Brünnich's guillemots and little auks from the Svalbard breeding area are supposed to occur in the ice edge zone of the Greenland Sea during autumn and possibly also in spring.

The ivory gull population in the region is of particular concern, because it forms a large proportion of the known total breeding population.

Concentrations of seabirds and mammals may occur in the drift ice where there are temporarily good feeding opportunities. However, they are more or less unpredictable and cannot be mapped in this context.

The most vulnerable areas in relation to ship transport/icebreaking are the Henrik Krøyer Holme and the surrounding shallow waters as well as the coastal areas of the NEW.

The Citronen Fjord zinc project is still in the exploratory phase, and there are no immediate plans for exploitation. Consequently, the size and type of ships to be utilised is not known, nor the number of ship calls at Citronen Fjord.

Sailing to and from Citronen Fjord will require powerful icebreakers, as immense areas with drift ice and fast ice will have to be traversed. Sailing is probably only possible during July, August and early September. The most likely route to Citronen Fjord will be from the open water of the Greenland Sea, through the most narrow drift ice belt.

Icebreaking in the drift ice will probably not have significant impacts on the environment, as this habitat is under constant change and the ice conditions are more or less unpredictable.

Icebreaking in the fast ice of Frederick E. Hyde Fjord will create open leads which may be open for longer periods, depending on the temperature and the number of ships sailing through the lead. This might have an effect on the ice regime of the fjord. Icebreaking in this fiord may have impacts on biota dependent on the fast ice such as the population of ringed seals. However, seals and their liar on the ice are generally so dispersed that icebreaking and sailing along the same route will have very little effect on the population.

Icebreaking through the fast ice barriers (if possible at all) south and north of the NEW should be avoided, as these fast ice barriers are very important for the formation and maintenance of the NEW polynya.

Zinc concentrate released in the sea from loss of carrier ships may cause elevated concentrations of zinc in the environment. The ore hold low concentrations of other metals as lead, cadmium and copper. It is too early to draw any conclusions on the effects of these metals if zinc concentrate is released in the sea. However, it was estimated that the effects of a wrecked zinc ore carrier in 1991 off West Greenland was negligible.

Incidental oil spills caused by ruptured tanks probably pose the most serious threat to the environment along the sailing routes to Citronen Fjord.

As the NEW-area appears to be the most important area to marine life that could potentially be affected by shipping , sailing (incl. icebreaking) in this areas should be avoided.

It is recommended that the fauna dependent of the fast ice of Frederick E. Hyde Fjord should be studied before icebreaking starts. The ringed seal is an ecological key species in this habitat, and there seems to be a large population present in the fiord. It is therefore obvious to carry out studies on this species, beginning with a population survey and later, if mining is to take place studies of responses to icebreaking and impacts of this activity on the population.

The sailing conditions and the related environmental impacts may be compareable to the conditions off the zinc mine Nanisivik in Strathcona Sound in high arctic Canada. However, the sailing routes to this mine are icefree in late summer and autumn, and there is is no multi year ice (Dickins et al. 1990, Kemper et al. 1976).

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National Environmental Research Institute

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Addresses:

National Environmental Research Institute
Frederiksborgvej 399
P.O.Box 358
DK-4000 Roskilde
Denmark

Tel: +45 46 30 12 00
Fax: +45 46 30 11 14

Management
Personnel and Economy Secretariat
Research and Development Secretariat
Department of Atmospheric Environment
Department Environmental Chemistry
Department Policy Analysis
Department of Marine Ecology and Microbiology

National Environmental Research Institute
Vejlsøvej 25
P.O.Box 413
DK-8600 Silkeborg
Denmark

Tel: +45 89 20 14 00
Fax: +45 89 20 14 14

Department of Lake and Estuarine Ecology
Department of Streams and Riparian Areas
Department of Terrestrial Ecology

National Environmental Research Institute
Grenåvej 12, Kalø
DK-8410 Rønde
Denmark

Tel: +45 89 20 14 00
Fax: +45 89 20 15 14

Department of Coastal Zone Ecology
Department of Landscape Ecology

National Environmental Research Institute
Tagensvej 135, 4th floor
DK-2200 København N
Denmark

Tel: +45 32 82 14 15
Fax: +45 32 82 14 20

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