4 Biological environment

The arctic sea off West Greenland is compared to temperate latitudes characterised by a relatively low number of species which however often occur in very high numbers and densities. This means that the food web is less complex than food webs at lower latitudes. The primary production is high and comparable to or even higher than the production at much lower latitudes, but due to the presence of winter ice and the marked variation in solar radiation is it highly seasonal with an intensive phytoplankton spring bloom (Söderkvist et al. 2006).

The following description is divided in sections which cover important ecological components of the biosphere in the assessment area.

4.1 Primary production

The development of the phytoplankton (microscopic algae) spring bloom gives a peak in the primary production in the water column, and it is the single most important event determining the production capacity of arctic marine food webs (Söderkvist et al. 2006). The onset of the bloom varies between years depending on duration of the winter ice cover, oceanography and meteorological conditions. But when the water column is stabilised and stratified, the spring diatom bloom develops exponentially and quickly depletes the surface layers (the euphotic zone) for nutrients. It usually starts in late April and develops through May (Figure 10). A review of the existing data and literature clearly illustrates that the surface distribution of phytoplankton and the occurrence of *Calanus* copepods (a key player in arctic marine food webs) can be used as proxy for high biological activity of the higher trophic levels as well (Söderkvist et al. 2006).

The primary production is initiated by sunlight and a stratified water column in spring, and the production usually depletes the water from nutrients thereby inhibiting the production over some time. At ice edges the spring bloom is often earlier than in ice-free waters due to the stabilising effect of the ice on the water column. However, at sites where nutrients continuously are brought to the uppermost water layers, for example by hydrodynamic discontinuities such as upwelling or fronts, primary production hot spots may occur throughout the summer. Other examples are glacier fronts where the freshwater plume stabilises the water column and brings nutrients to the active layers. Upwelling areas are for example found at the northeastern corner of Store Hellefiskebanke, in outer Disko Bay and around Hareø, and off the most significant glacier front situated in Jakobshavn Isfjord in interior Disko Bay. Seabirds and marine mammals often occur and congregate along ice edges and in the marginal ice zones. Ice edges are not stable in time, and their distribution varies according to oceanographic and climatic conditions. Upwelling areas may, besides enhanced production, also retain copepods which again are utilised by fish larvae (Simonsen et al. 2006). Upwelling events can be predictable in time and persistent over long periods, although those driven by the tidal currents vary with the tidal cycle, and others are wind driven and vary with the wind conditions. Fronts are often short-term phenomena and less predictable in time and space, but are extensively utilised by seabirds, which are able to search large areas and locate such phenomena (Söderkvist et al. 200&).

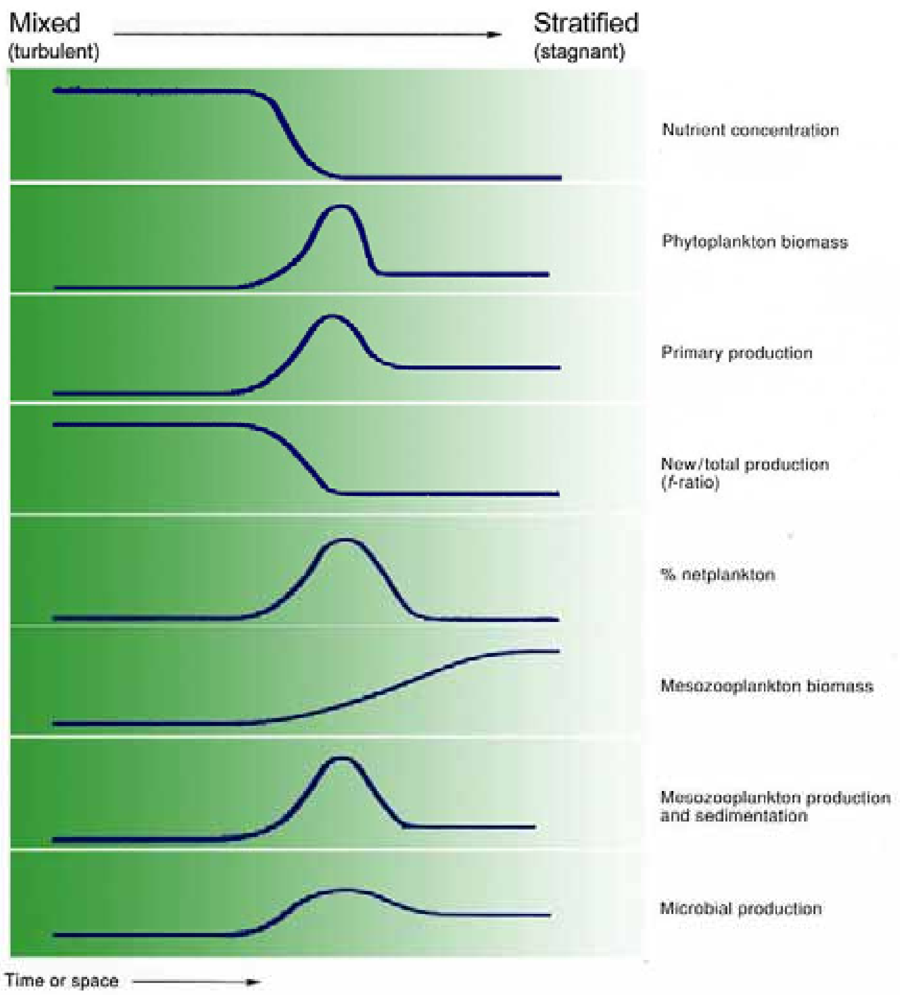


Figure 10. Hydrographical discontinuities are often sites of enhanced biological activity. This can be defined in time, e.g. the shift from mixed water in the winter to stratified water in the spring or in space when two water masses meet or at the marginal ice zone where the frontal zone will provide better growth conditions for plankton and the succeeding links in the food web (Legendre & Demers 1984).

The underside of the sea ice has it own special biological community with algae, invertebrates and fish. In spring when the light increases, this community can be very productive. There is no knowledge on this environmental component for the assessment area.

4.1.1 Polynyas, shear zones and marginal ice zone

Polynyas are predictable open-water areas in otherwise ice-covered waters in winter and spring. In polynyas the primary production starts much earlier than in ice-covered areas; they are often therefore preferred feeding areas for marine mammals and seabirds. However, also the mere presence of open water makes polynyas attractive for resting seabirds and for mammals which are dependent on open waters for breathing. Many migrating seabirds also use polynyas as staging grounds on their way to the breeding grounds further north.

Shear zones are where the solid coastal ice meets the dynamic drift ice. Cracks and leads with open waters are frequent in such areas and may attract marine mammals and seabirds. When the West ice reaches the coasts of the assessment area a shear zone and polynyas (e.g. in the mouth of Vaigat) are usually present.

At the marginal zone of the West Ice, primary production during the spring bloom is very intense and this attracts species higher in the food web including seabirds and marine mammals.

In the spring, April-May 2006, a multidisciplinary ecological survey was conducted in the assessment area with focus on the marginal ice zone. The programme included aerial surveys of seabirds and mammals covering the entire region (Figure 11); ship-based surveys including counts of marine mammals and seabirds alongside biological oceanographic sampling on transects from open water and into the drift ice at the marginal ice zone; and satellite data on primary production obtained from the same period. The research vessel did not have ice-breaking capabilities and generally ship transects did not proceed when ice cover was above 8/10. However, in some situations, when ice thickness and size of floes were manageable for the vessel, samples were taken at locations with ice concentration higher than 8/10. The vessel survey covered Disko Bay, Vaigat, and areas west of Disko and south of Disko including the northern half of Store Hellefiskebanke (Figure 12). From the vessel, oceanographic profiling of the water column and biological sampling were conducted at 116 sampling stations. Sampling included CTD measurements, i.e. depth distribution of salinity and temperature, flourometer measurements i.e. indicating depth distribution of chlorophyll a fluorescence, and water samples for nutrients and chlorophyll as well as net hauls for zooplankton composition and biomass. All these data are in the process of being analysed; however, preliminary results are presented here in the Figures 13 - 15.

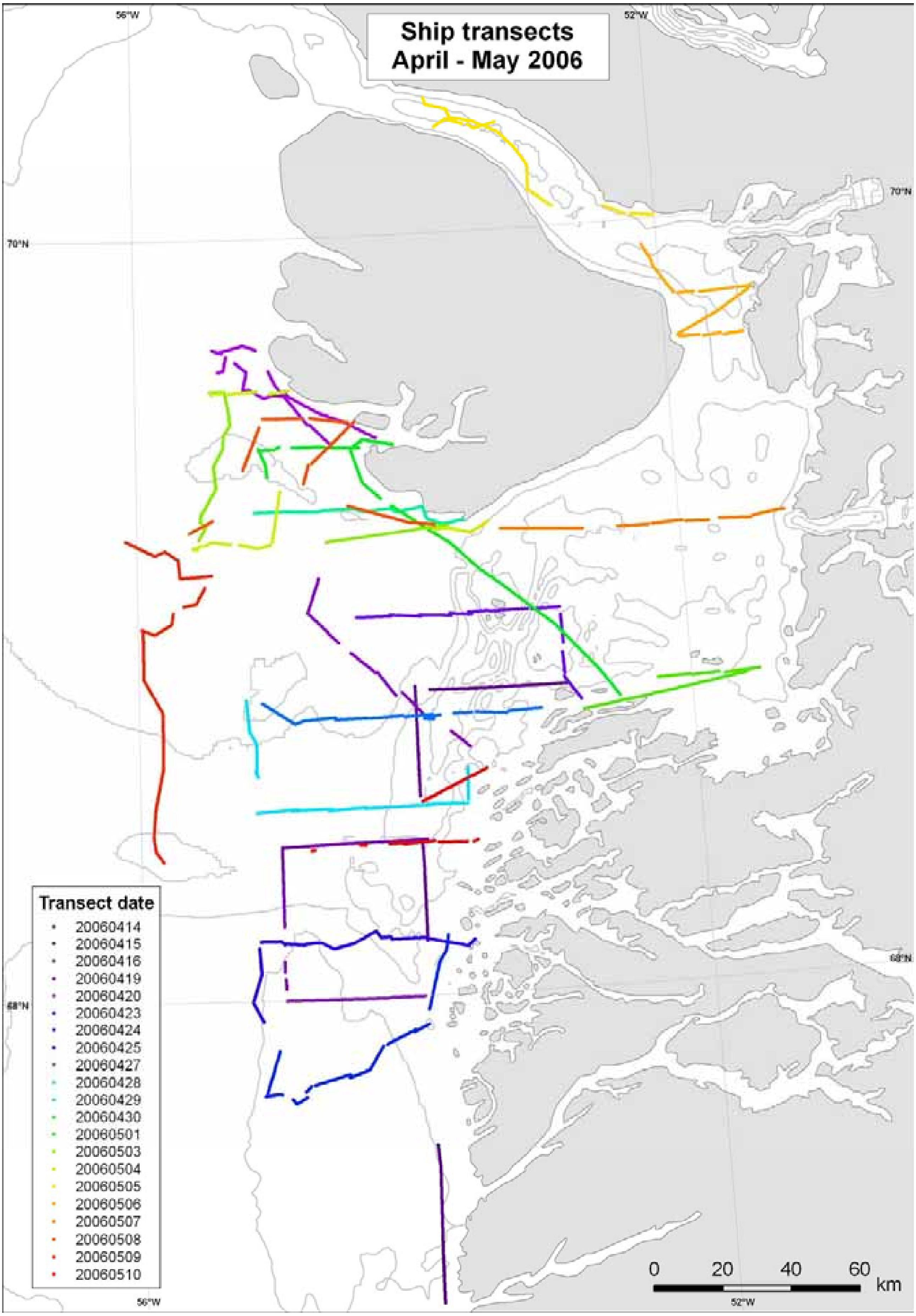


Figure 11. The ship based transects, sailed during the marginal ice zone project in April and May 2006.

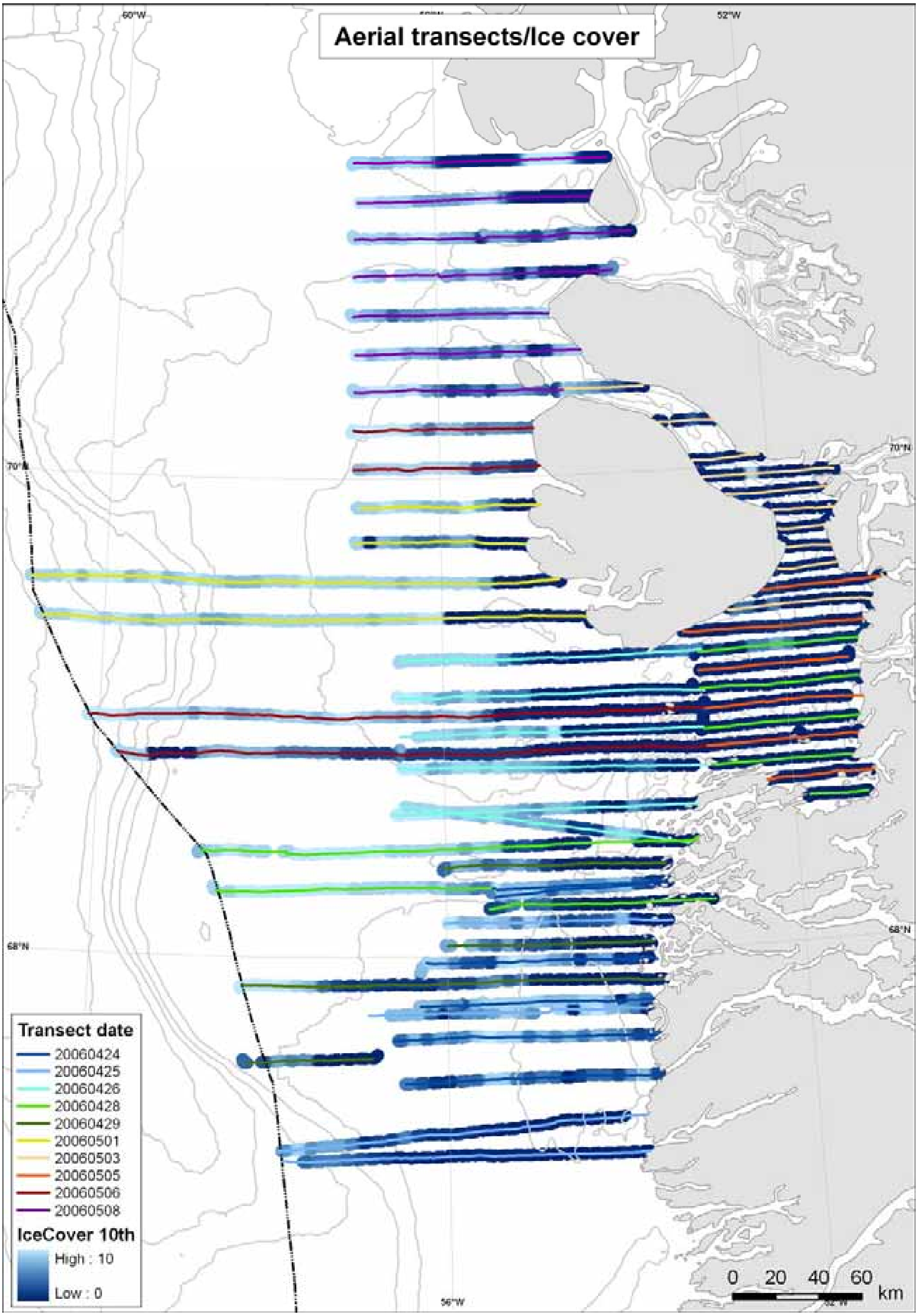


Figure 12. The aerial transects flown during the marginal ice zone project in April and May 2006. Ice cover recorded along the transects indicated.

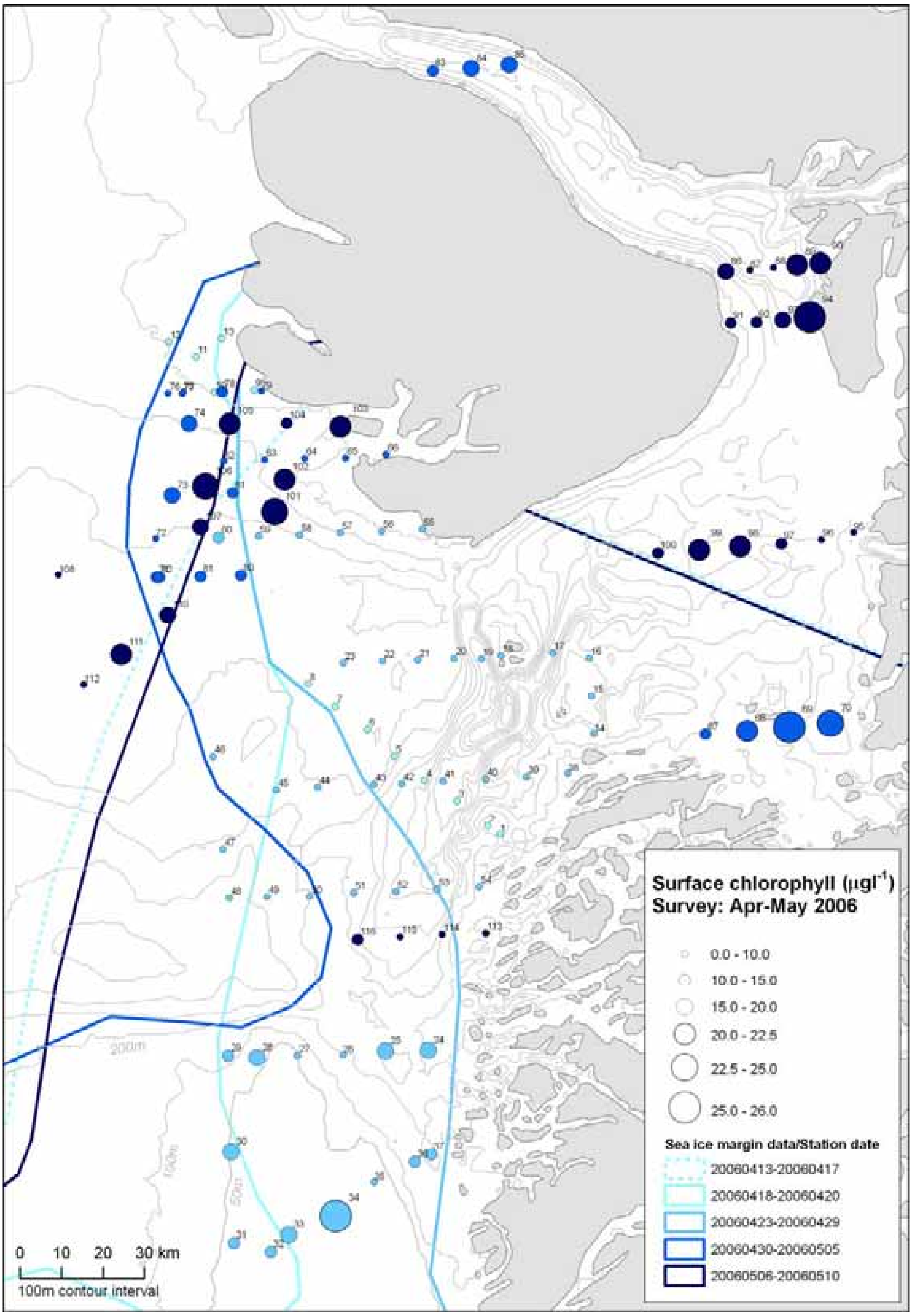


Figure 13. Surface concentration of chlorophyll (mg m^{-3}) at each station, which is at about 1 m. depth. The number associated to each circle represents the station number; the size of the circle corresponds to a certain concentration interval, given by the legend in the lower right corner, and the colour of the filled circles give time period when the observation was collected. The lines indicate the location of the ice edge for different time periods, and the colour for each particular line corresponds to a certain time interval, given by the legend in the lower right corner. For guidance; the typical winter concentration in the region 0.05 mg m^{-3}, and 2 mg m^{-3} during the early stages of plankton bloom. The observations are collected during a time period when the bloom goes from an early stage to large plankton bloom. In late April high values are observed on the Store Hellefiskebanke. In May there are relatively high levels in the central and southern parts of Disko Bay as well as west of southern Disko (west of Disko Fjord). Chlorophyll levels were relatively low at the Disko Bay entrance (Aaasiaat -Qeqertarsuaq) (not shown), and west of the entrance.

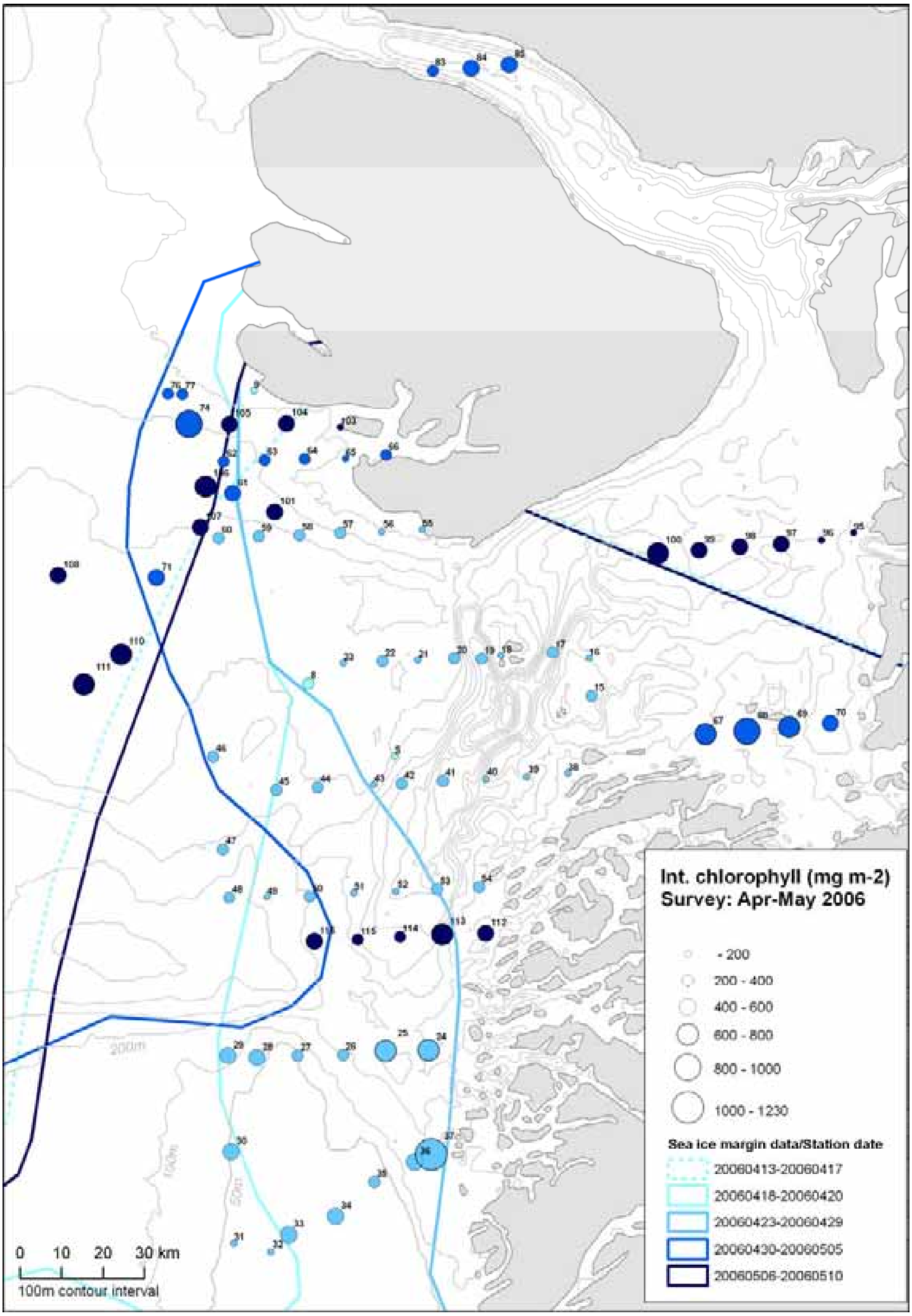


Figure 14. Vertical integration of chlorophyll from surface to max sampling depth (mg m^{-2}) measured during the survey in April and May 2006. The number associated to each circle represents the station number; the size of the circle corresponds to a certain concentration interval, given by the legend in the lower right corner, and the colour of the filled circles give time period when the observation was collected. The lines indicate the location of the ice edge for different time periods, and the colour for each particular line corresponds to a certain time interval, given by the legend in the lower right corner. In general, the integrated chlorophyll shows a similar pattern as the surface values of chlorophyll. Differences between surface and integrated chlorophyll are found in the deep water "wedge" between the bank and the coast east and northeast of Store Hellefiskebanke there was a tendency to higher levels in the deep water layers (integrated chlorophyll) compared to the surface chlorophyll. The low values observed at westernmost stations located within the ice (stations 11-13, 72, 75, 76, and 108) may be due to high ice concentration.

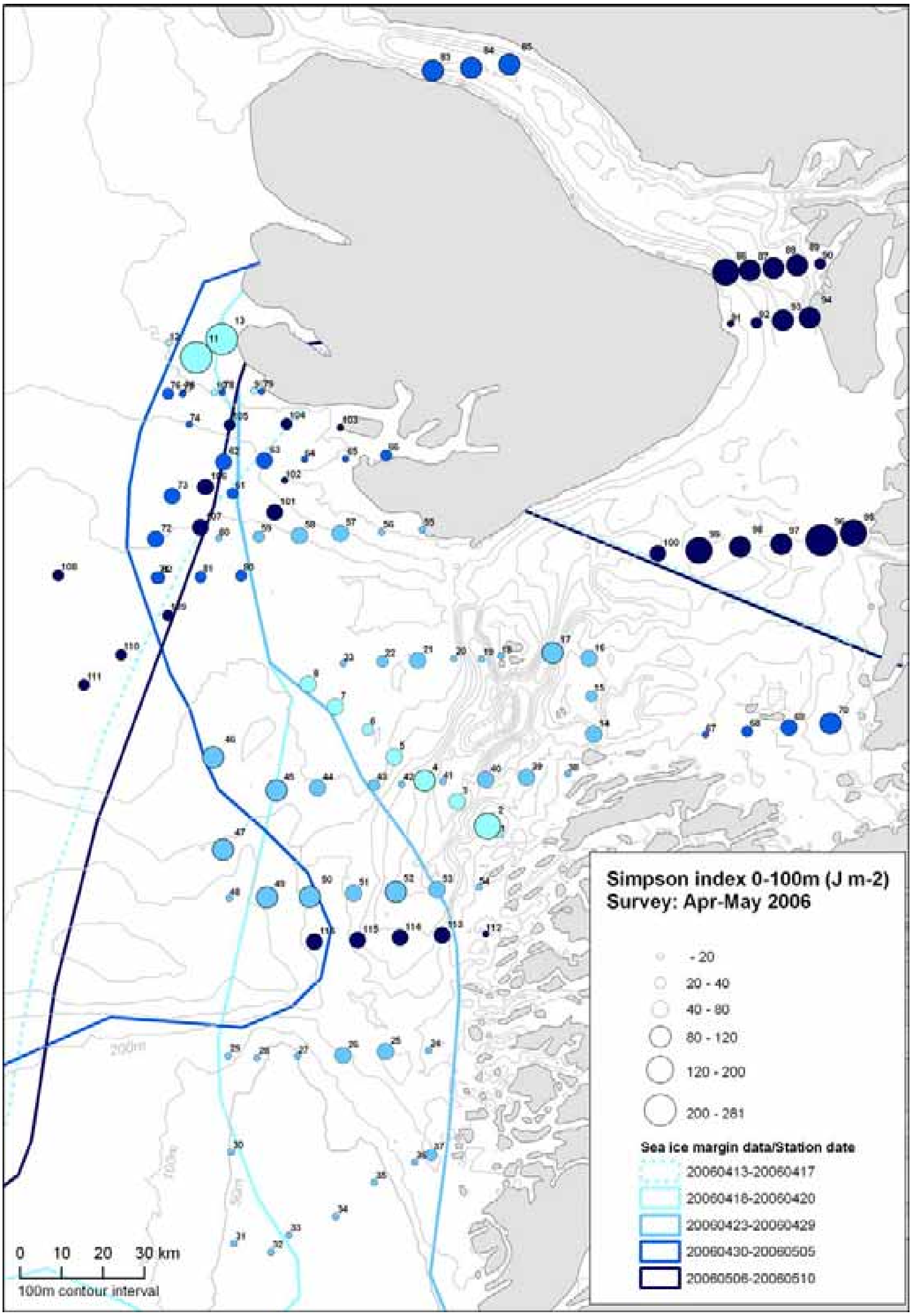


Figure 15. Simpson index, which is a measure of the strength of the vertical stratification, measured during the survey in April and May 2006. The number associated to each circle represents the station number; the size of the circle corresponds to a certain interval, given by the legend in the lower right corner, and the colour of each filled circle give time period when the observation was collected. The lines indicate the location of the ice edge for different time periods, and the colour for each particular line corresponds to a certain time interval, given by the legend in the lower right corner. A high value of the Simpson index means that the upper water column is well stratified and that it takes more energy to mix the upper waters, compared to locations with low Simpson index value. A low Simpson value may be explained by strong vertical mixing or low fluxes of heat and salt. In regions with high Simpson index the primary produces will remain near the surface where there are sufficient light to grow, while in regions with low Simpson index the primary producers are easily mixed down to greater depths with no or very weak sun light. The highest values of the observed Simpson index are found in Disko Bay and at the northernmost stations west of Disko Island. Low values of the Simpson index are found at Store Hellefiskebanke, west of Disko Island, and at the entrance of Disko Bay.

4.1.2 Primary production in 2006

The studies carried out in 2006 confirm that there is large spatial and temporal variability in the chlorophyll levels and there are high chlorophyll levels (spring bloom) distributed over large areas in the region. This means that the areas of highest importance for the primary production in the region will vary within season and between seasons, depending for example on ice conditions.

The overall distribution of surface chlorophyll (1 m) as well as integrated chlorophyll (from surface to max. sampling depth) from the stations shows relatively high concentrations in central and southern Disko Bay as well as west of southern Disko (west of Disko Fjord) (Figures 13 and 14). On the northern part of Store Hellefiskebanke chlorophyll levels were also high. In the deepwater 'wedge', with high turbulence between the bank and the coast east and northeast of Store Hellefiskebanke (Figure 15), there was a tendency to higher levels in the deepwater layers (integrated chlorophyll) compared with the surface chlorophyll. Chlorophyll levels were relatively low at the Disko Bay entrance (Aaasiaat-Qeqertarsuaq) and west of the entrance.

Surface chlorophyll measured from satellite (MODIS and SeaWiFS data) shows a clear increase in surface chlorophyll levels from the first week of the survey (15-22 April 2006) to the last week (9-16 May 2006) (Figures 16 and 17). In approx. half of the area a ten-time increase in chlorophyll levels was apparent. Maximum levels were in the central Disko Bay, at the northern Store Hellefiskebanke and west of southern Disko, corresponding to the vessel data, but the satellite data also showed high levels west of the Disko Bay entrance in the final week. In nearly all areas the highest chlorophyll levels were found close to an ice edge. (The red squares next to the white areas on the map. White areas on the map are caused by lack of satellite data generally due to dense ice or clouds). The resolution (in time and space) of the satellite data does not allow detailed resolution of the chlorophyll a, so small bloom areas in connection with oceanographic discontinuities, e.g. the meltwater from the glacier or in connection with upwelling along the banks, cannot be identified and followed over time.

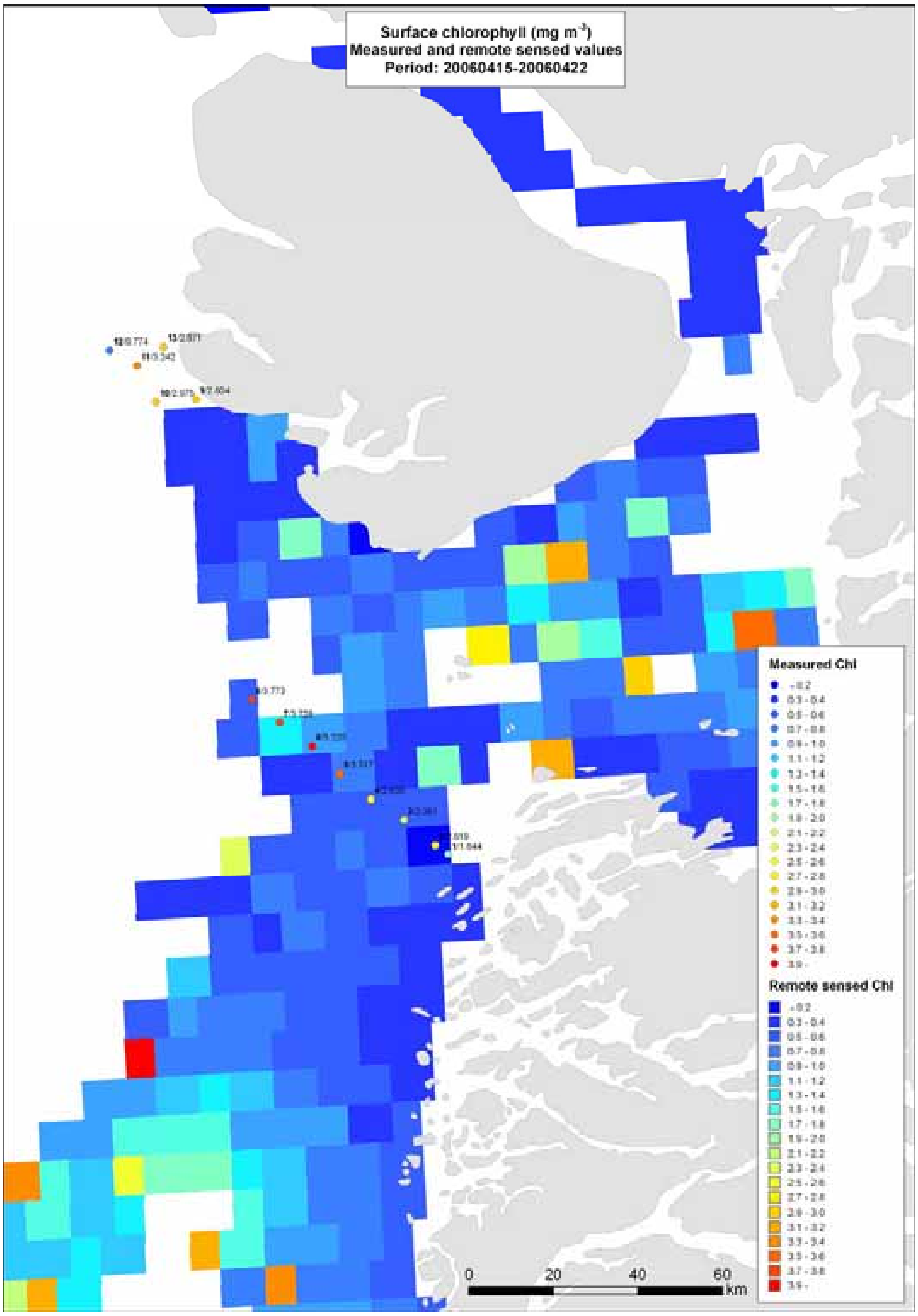


Figure 16. Surface concentration of chlorophyll (mg m-3) for the time period April 15 to April 22 2006. The colours show the concentrations when using sensing data together with a standard algorithm. The coloured dots give the in situ concentration at 1 m. depth. The numbers right next to the coloured dot indicate the station number and the absolute value of the concentration. Note that the colours corresponding to the remote sense data and in situ observation have the same scale. Along the transect located southwest of Disko Bay entrance (stations 1-8) the concentration at the first station near the coast is just below 2 mg m-3 (sampled April 18), and between 2 and 5.2 mg m-3 at stations 2-9 (sampled April 19). It seems thus that the primary production is in the early stage of a plankton bloom in this region. Note that the in situ values are much higher than the remote sense data. The algorithm to compute the chlorophyll concentration from remote sense data underestimate the surface concentration, and one should be careful when interpreting the remote sense data. Here we use the relative distribution of chlorophyll to identify high productive regions, but more analysis is needed to make any conclusions when interpreting the satellite observations. However, the preliminary results suggests that the 8 day mean value of the remote sensing data for surface chlorophyll (mg m-3) for the period April 15-April 22 shows relatively high values of chlorophyll at Store Hellefiskebanke, and lower concentration in Disko Bay and westwards towards the ice edge. Some local areas with high chlorophyll concentration are also observed at the entrance to Disko Bay and the central parts of Disko Bay. The areas with relative large concentration of chlorophyll indicate that the plankton bloom have already started before April 15, or is just about to start.

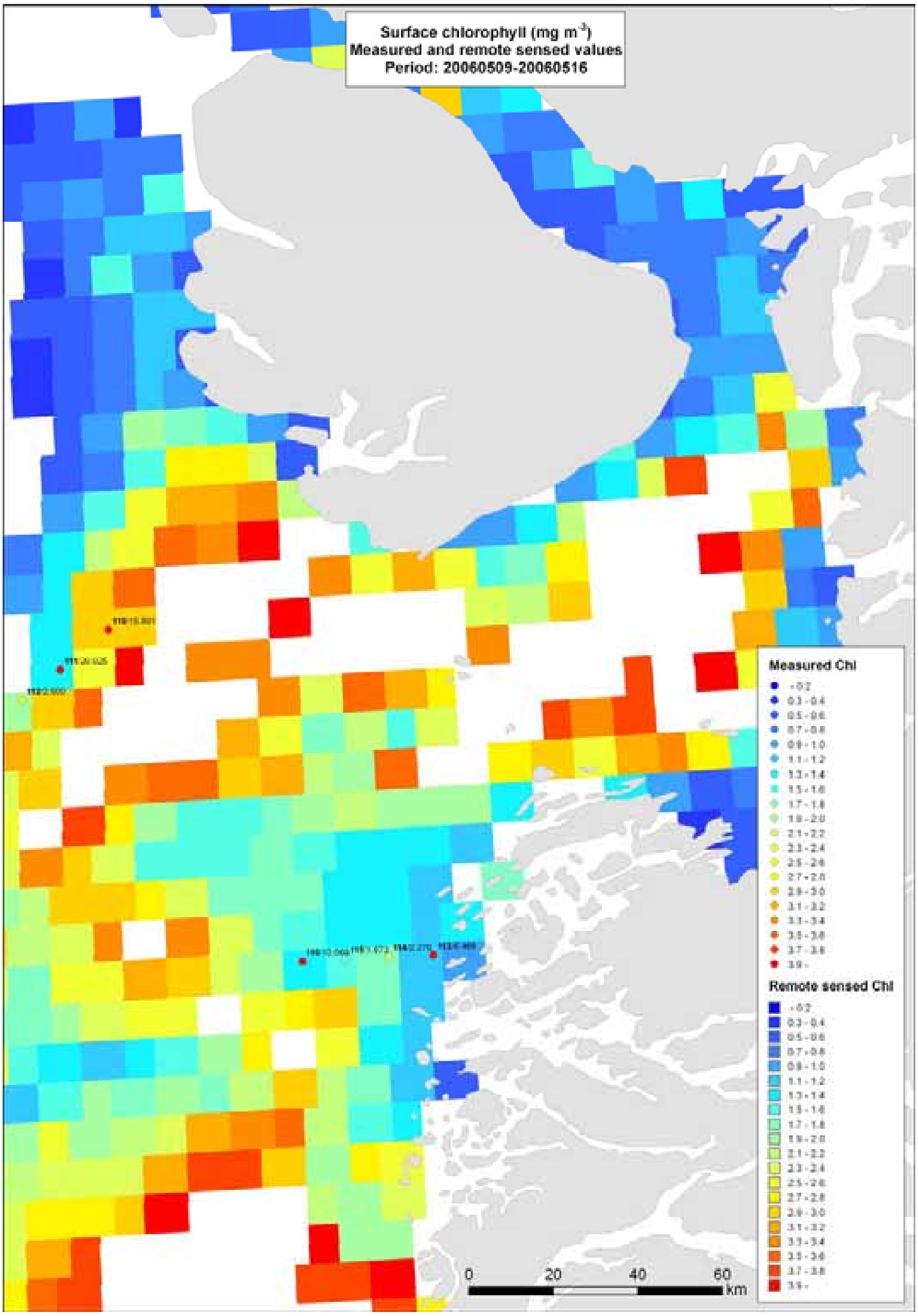
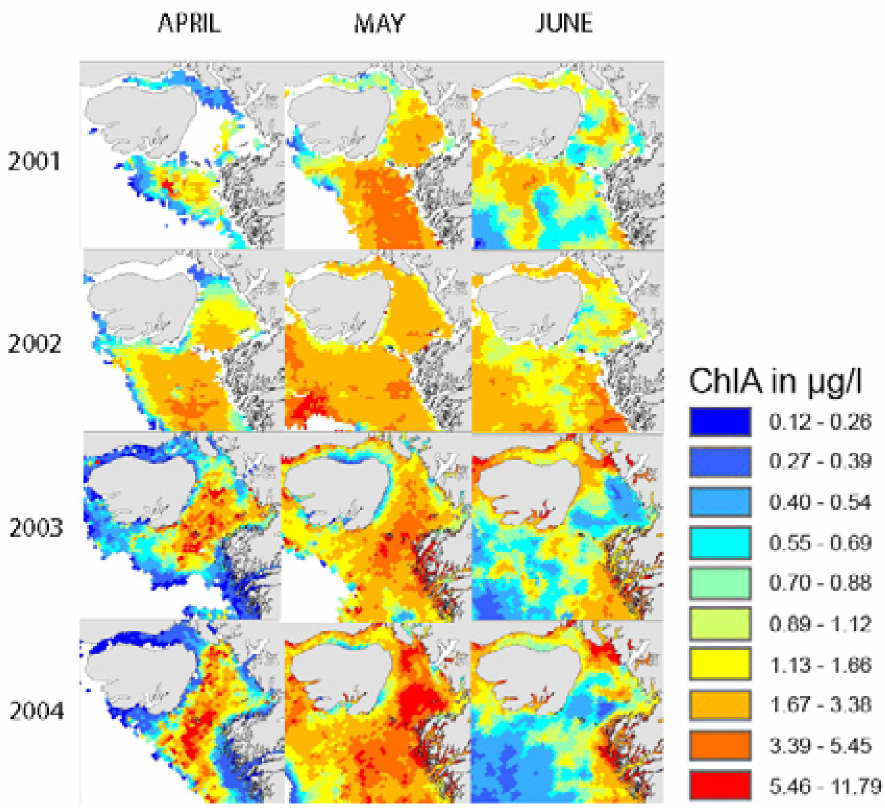


Figure 17. Surface concentration of chlorophyll (mg m-3) for the time period May 9 to May 16 2006. The colour map shows the concentrations when using sensing data together with a standard algorithm. The coloured dots give the in situ concentration at 1 m. depth. The numbers right next to the coloured dot indicate the station number and the absolute value of the concentration. Note that the colours corresponding to the remote sense data and in situ observation have the same scale. During the period 20060509-20060516 the in situ observations at the ice edge located west of Disko Bay was typically 15-20 mg m-3, and around 2 mg m-3 somewhat more to the west, which is a region where the ice concentration was higher (not shown). The observed concentration of chlorophyll North West of Store Hellefiskebanke varied between 1.6 and 10 mg m-3. The algorithm to compute the chlorophyll concentration from remote sense data underestimate the surface concentration, and one should be careful when interpreting the remote sense data. Here we use the relative distribution of chlorophyll to identify high productive regions, but more analysis is needed to make any conclusions when interpreting the satellite observations. However, the preliminary results suggests that the chlorophyll concentrations using remote sensing data were high at the Store Hellefiskebanke, central part of Disko Bay and outside Disko Bay. Low values were observed south west of Disko Bay, west of Disko Island, and in the northern channel connecting the eastern part of Disko Bay with Baffin Bay (the Vaigat).

The chlorophyll distribution measured from the vessel compared with the surface chlorophyll obtained from remote-sensing data shows that the in situ measurements from the vessel generally have higher values and with less temporal progression. This could be because the satellite sampling is more sensitive to the vertical distribution of the phytoplankton. And moreover, there seems to be a lack of proper calibration of the values derived from the satellite (with the widely used standard data processing we have used so far) and measurement of the water samples.

In Figure 18 satellite chlorophyll measurements from the Disko Bay area are shown for spring in 2001 to 2004. These maps show great variability in location and extent in the productive areas between years.

Figure 18. Monthly progression of chlorophyll a production in Disko Bay, West Greenland between 2001 and 2004. Data are presented as monthly averages from MODIS level 3 Terra (2001 and 2002) and level 3 Aqua (2003 and 2004) with adjustment of the Terra data to ensure compatibility. White areas are ice covered and grey is land. Blue is very low chlorophyll a concentrations and red is high (Figure from Heide-Jørgensen & Laidre 2006).



The marginal ice zone is an important feature in the assessment area. From other Arctic areas it is known that this zone can have high productivity in spring because meltwater stabilises the water column, and there is also a specialised (epontic) community including algae and grazers on the underside of the ice. In the assessment area there is only first-year ice which is known to have less developed epontic communities compared with multi-year ice. However, very little is known of the relative importance of the marginal ice zone in the assessment area, and further studies of the biology and oceanography have been conducted in 2006 as part of the background study programme.

4.2 Zooplankton

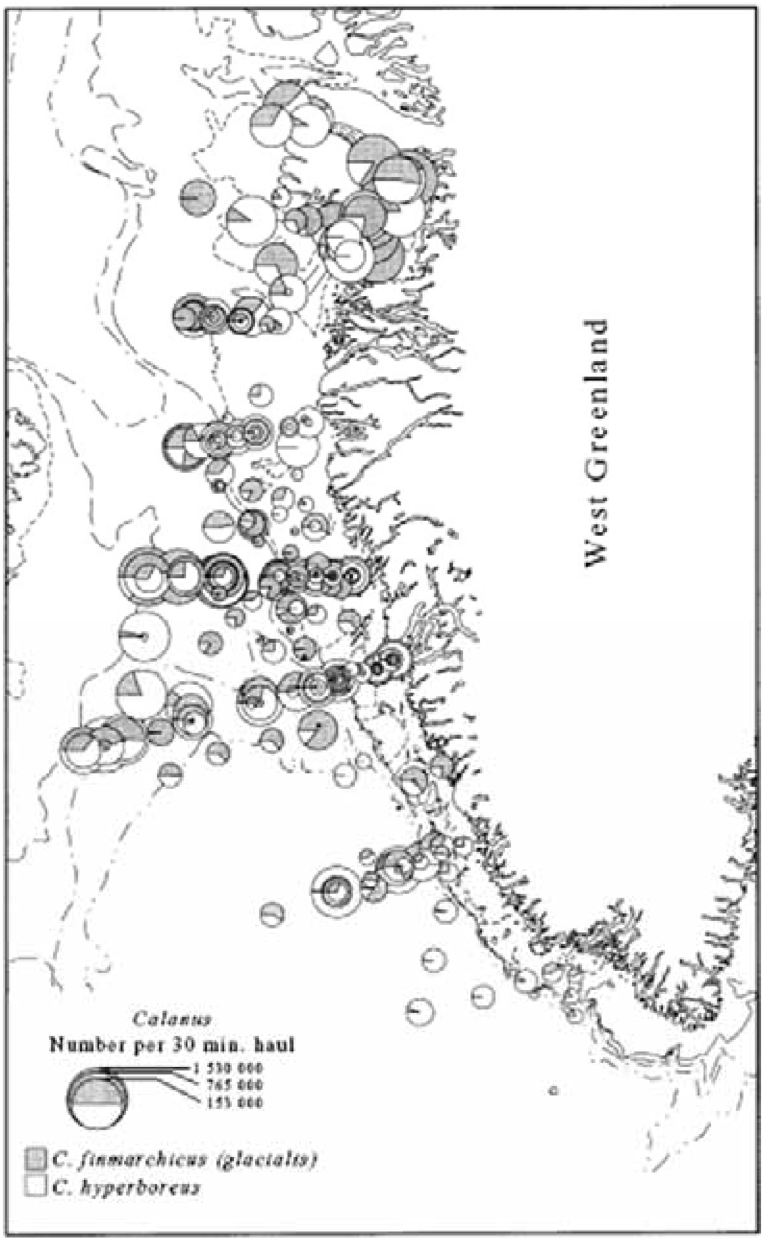
The mesoplankton communities in the waters off West Greenland are dominated by the large copepods of the genus *Calanus* (incl. their larval stages) (Pedersen et al. 2005). They are significant grazers on the primary production and constitute an important prey for fish and their larvae, whales (primarily bowhead whales) and seabirds (the little auk is a specialised *Calanus* feeder). Most of the higher trophic levels in the Arctic marine ecosystem rely on the lipid that is accumulated in *Calanus*. Consequently, a great deal of the biological activity e.g. spawning and growth of fish is synchronised with the life cycle of *Calanus*. The *Calanus* copepods also play an ecological key role in supplying the benthic communities with high quality food by their large and fast sinking faecal pellets (Söderkvist et al. 2006).

The investigation in the Disko Bay clearly corroborates the hypothesis that most of the biological activity in the surface layer is present in the spring and early summer in association with the spring bloom and the appearance of the *Calanus* populations. The peak abundance of shrimp and fish larvae is also observed in the early summer in association with the peak abundance of their plankton prey. *Calanus* occur widespread in the West Greenland waters where high numbers have been recorded in Disko Bay and both on the banks and west of the banks in deep waters (Figure 19).

The only locality along western Greenland where the annual dynamics of the plankton community have been investigated at high temporal resolution is in Disko Bay off Qeqertarsuaq.

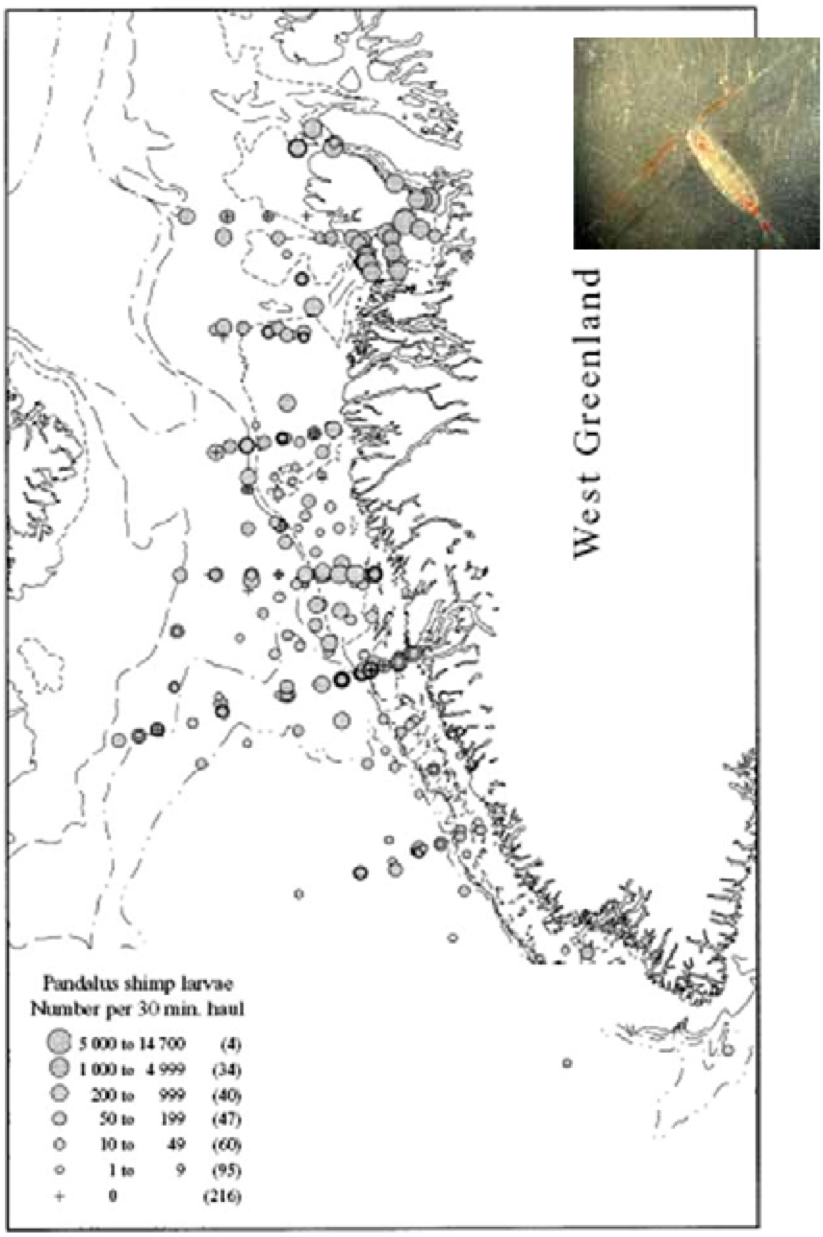
Larvae of fish and shrimp are important components of the plankton, and movements and behaviour have been studied for some of the commercially utilised species. Pedersen & Smidt (2000) analysed shrimp and fish larvae data sampled along three transects during summer in West Greenland waters over 34 years. Recently, several surveys have investigated the horizontal distribution of shrimp larvae (Pedersen et al. 2002, Storm & Pedersen 2003) and fish larvae (Munk 2002, Simonsen et al. 2006) in relation to oceanography and their potential prey along West Greenland. An integrated part of these investigations was the development of a particle-tracking model. To simulate larval drift, particles (larvae) were released in four areas along the southwest Greenland coast assuming a pelagic life of 100 day’s duration (Ribergaard et al. 2004). The model illustrates how the fish larvae are concentrated over the fishing banks. The residence times were significantly longer on the banks indicating that they act as retention areas. Despite pronounced difference in the year class strength, the simulations of shrimp larval drift for 1999 and 2000 were almost identical. The model results are corroborated by results of sampling programmes conducted along the coast. The cruises cover the main part of the productive season (May to July). They document that the important sites for the development of shrimp and fish larvae are the slopes of the banks and the shelf break, and in Disko Bay where the highest biomass of their copepod prey is also located (Simonsen et al. 2006).

Figure 19. Distribution of two species of Calanus. Numbers per 30 min hauls summarised over all sampling in June-July 1956-1983, with frequency of occurrence in parentheses (From Pedersen & Smidt 2000).



Shrimp larvae are widely distributed with high numbers both on the banks, west of the banks and in the assessment area (Figure 20). Shrimp larvae are estimated to travel up to 500 km from their release site before they settle, and simulations indicate that there are several such release sites on the banks south of Disko Bay. An analysis of many years' sampling in the West Greenland waters showed that shrimp larvae were generally more abundant in waters less than 200 m deep and showed high abundance mainly over the West Greenland shelf and in the Disko Bay area, and also that shrimp larvae abundance correlated most highly with copepods and Greenland halibut larvae (Pedersen & Smidt 2000). Shrimp larvae are usually released from the females at rather shallow water depths (< 150 m), shallower than where the fishery usually occurs (100-600 m). Larvae are released in May off Nuuk and Maniitsoq and possibly later in August in Disko Bay (S.A. Pedersen ICES pers. comm.). Larvae in some areas may be more important for recruitment than others because of a good match with food resources resulting in rapid growth and high survival. This may occur in the retention areas created by currents on some of the banks areas.

Figure 20. Distribution of shrimp larvae. Numbers of larvae per 30 min hauls, summarised over all sampling in June-July 1956-1982, with frequency of occurrence in parentheses (From Pedersen & Smidt 2000).



It is not clear whether shrimp stocks in Disko Bay are self recruiting or to what degree influx of larvae from the southern shrimp areas contributes to the stock (S.A. Pedersen ICES pers. comm.). Shrimps in waters north of Disko Bay are probably recruited from Disko Bay (S.A. Pedersen ICES pers. comm.). Within the assessment area high numbers of shrimp larvae were found on the northern edge of Store Hellefiskebanke, in Disko Bay and in the waters around Hareø (Figure 20).

Greenland halibut larvae concentrations in the upper water column are relatively high south of 68° N, while within the major part of the assessment area they are low in June-July, based on Figure 21.

Other fish larvae which have been studied include sandeel (*Ammodytes spp*.), which were very numerous particularly in Disko Bay and on some of the banks (Figure 22), and redfish (*Sebastes spp*.), which were very numerous south of 62° N and almost absent from the waters of the assessment area (Pedersen & Smidt 2000).

Figure 21. Number of Greenland halibut larvae per 30 min haul. All samples in June-July 1950-1984, frequency of occurrence in parentheses. From Pedersen & Smidt 2000.

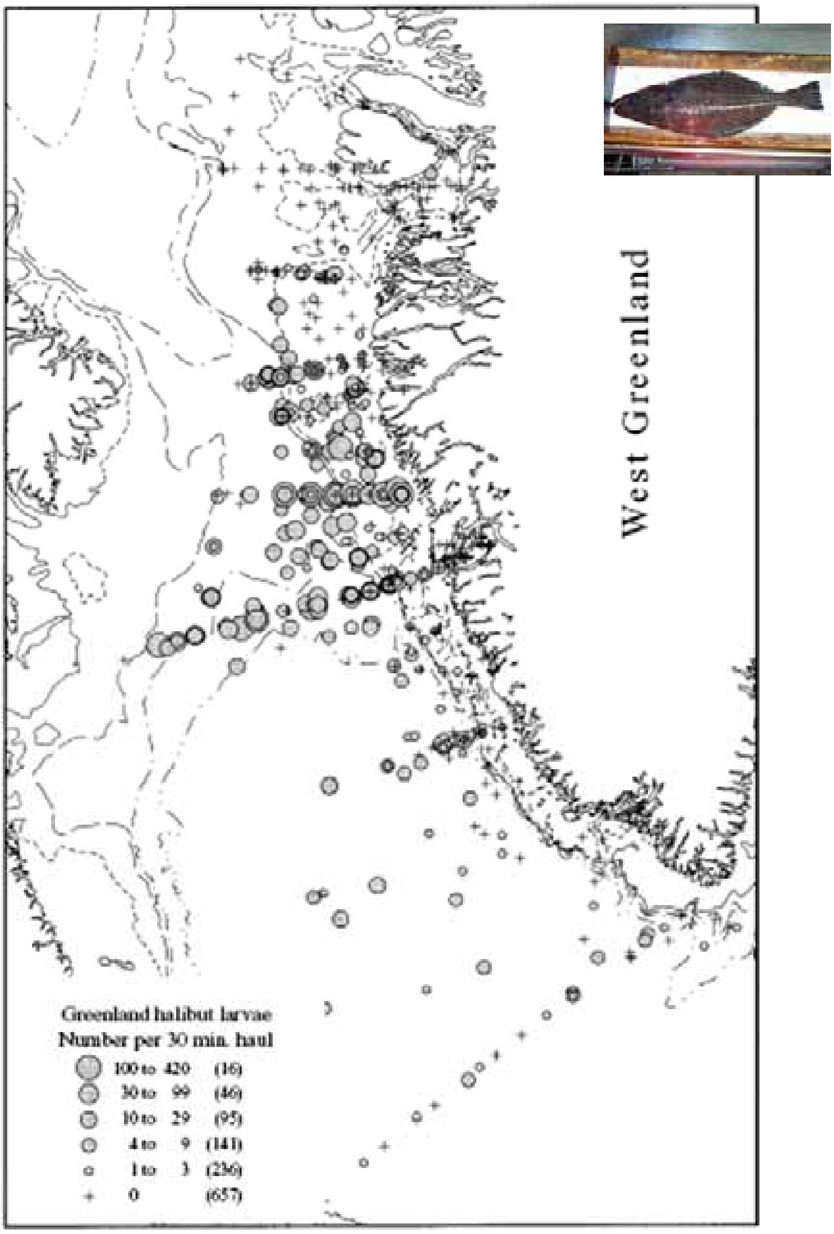
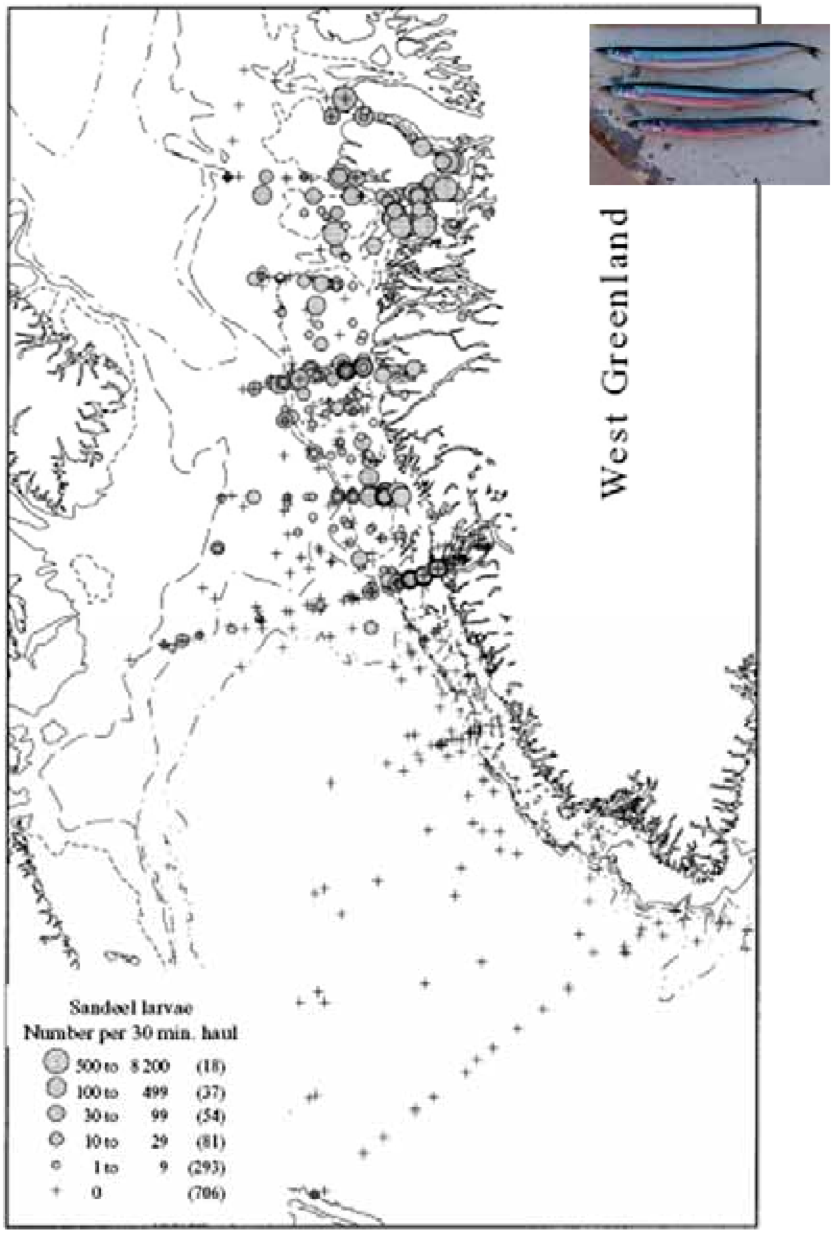


Figure 22. Number of sandeel larvae per 30 min haul. All samples in June-July 1950-1984, frequency of occurrence in parentheses. From Pedersen & Smidt 2000.



New studies of fish larvae in the West Greenland waters have been carried out in the years 1996-2000 (Munk et al. 2000, 2003, Munk pers. comm., and REKPRO-data from C. Simonsen and S.A. Pedersen pers. comm.). These studies did not find the sand eel larvae concentrations as reported by Pedersen & Smidt (2000) (Figure 23). They found a large interannual variation in abundance of polar cod larvae in Disko Bay (Figure 24) and confirmed the distribution of Greenland halibut larvae as reported by Pedersen & Smidt (2000) (Figure 25). Recurrent concentrations areas of fish larva were not located, and generally there seems to be large variation in distribution and abundance of fish larvae between years.

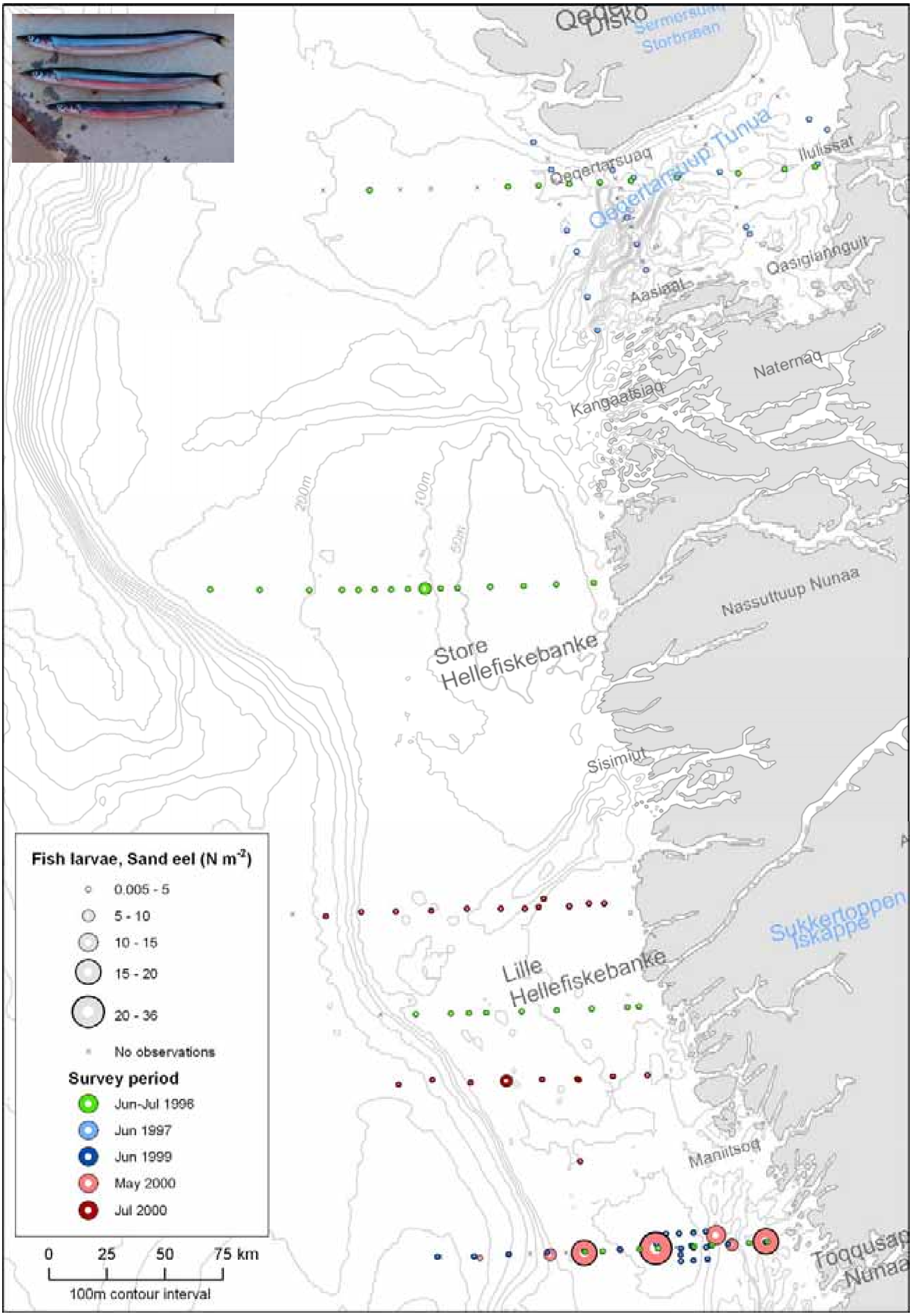


Figure 23. Distribution of sand eel larvae recorded during surveys in May-July 1996-2000. (Munk et al. 2000, 2003, Munk pers. comm. and REKPRO-data from C. Simonsen and S.A. Pedersen pers. comm.).

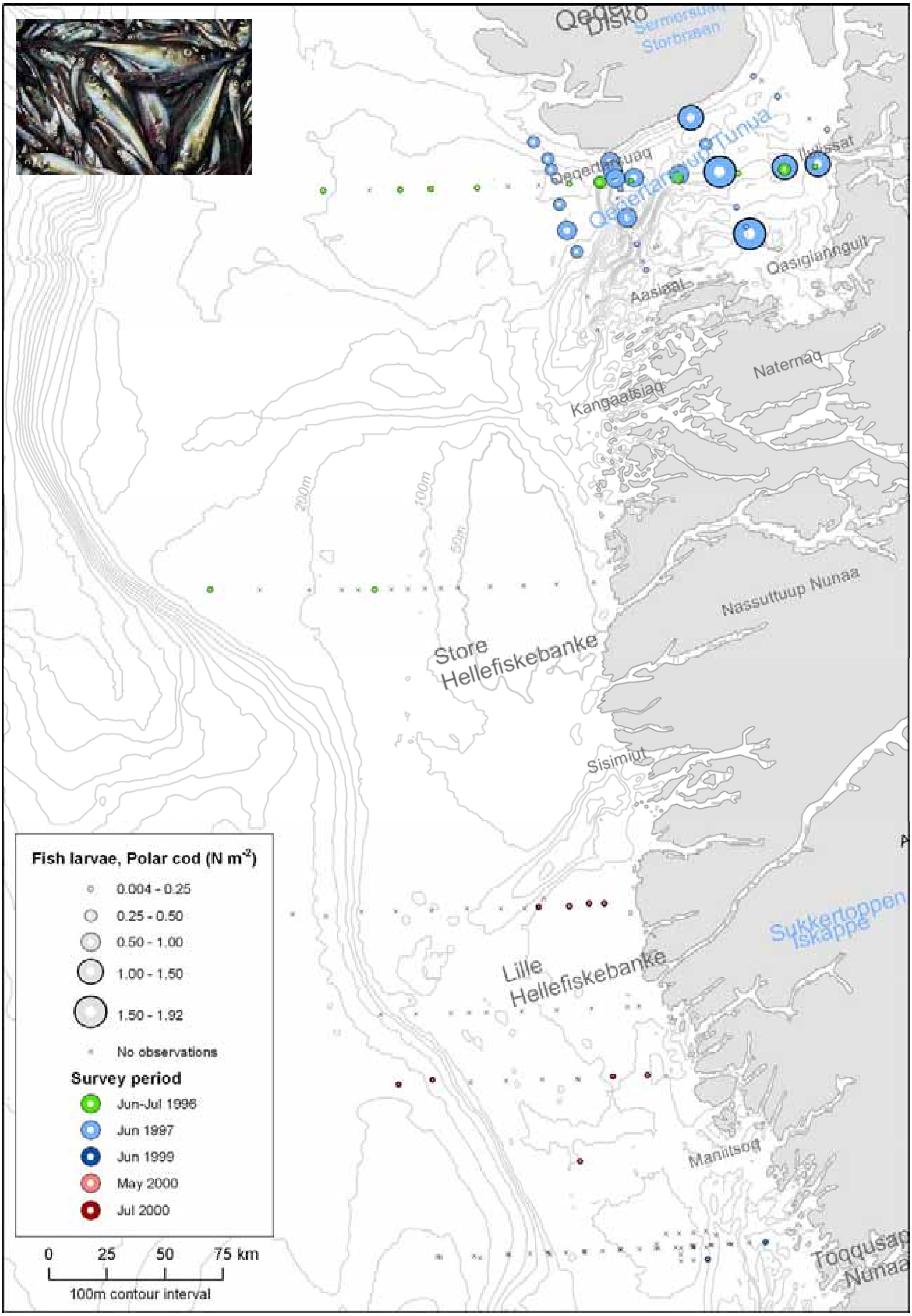


Figure 24. Distribution of polar cod larvae recorded during surveys in May-July 1996-2000. (Munk et al. 2000, 2003, Munk pers. comm. and REKPRO-data from C. Simonsen and S.A. Pedersen pers. comm.).

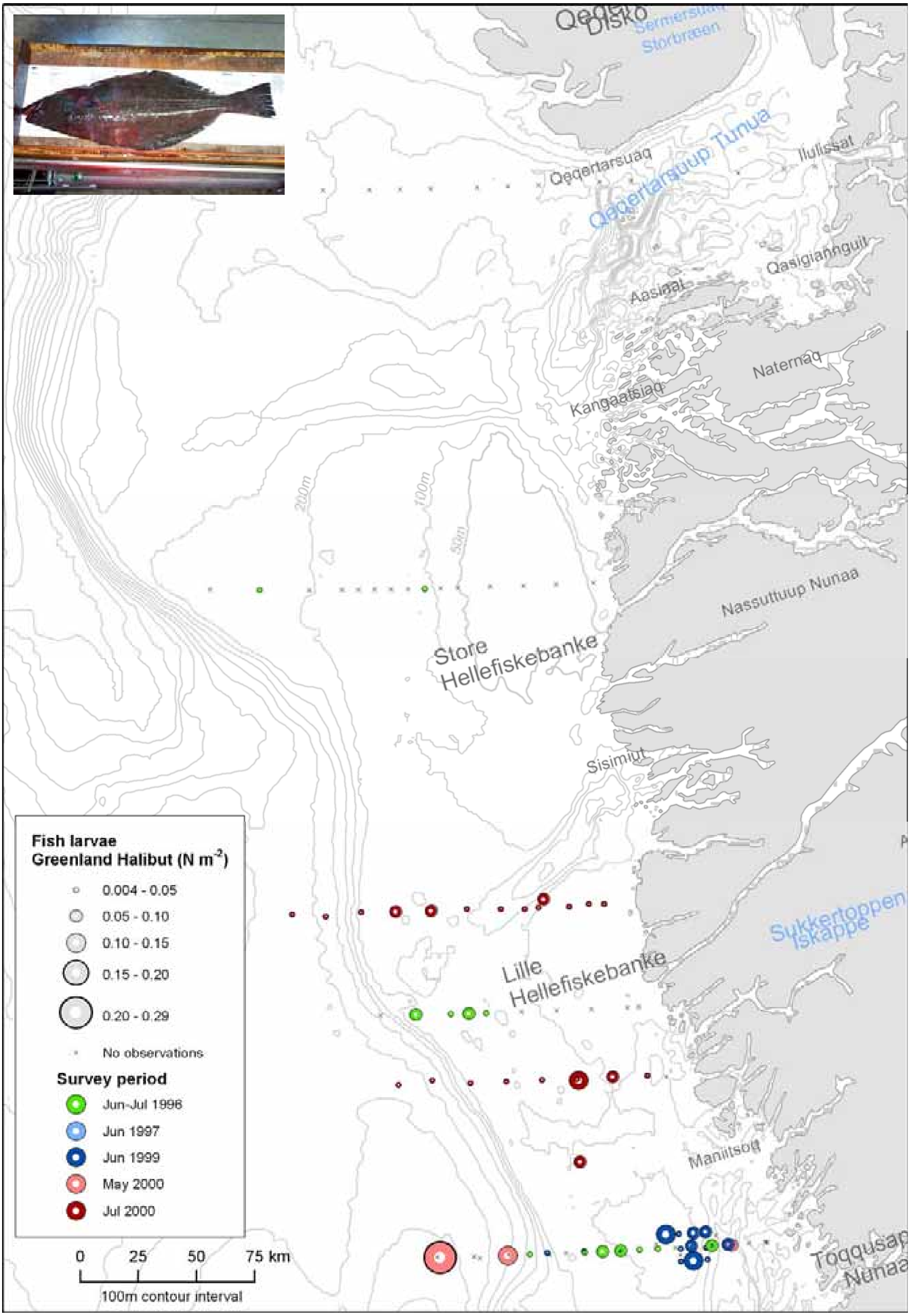


Figure 25. Distribution of Greenland halibut larvae recorded during surveys in May-July 1996-2000. (Munk et al. 2000, 2003, Munk pers. comm. and REKPRO-data from C. Simonsen and S.A. Pedersen pers. comm.).

Although planktonic organisms are supposed to move with the currents there seem to be retention areas over the banks, where plankton is concentrated and entrapped for periods (Pedersen et al. 2005).

The zooplankton sampled in April and May 2006 is still under analysis, and the assessment will be updated when results are available.

4.3 Benthic flora and fauna

The shallow coastal areas of the arctic seas can be highly productive and very important to the marine food web. The benthos in general and bivalves in particular constitute an important food source for fish, birds and marine mammals (Born et al. 2003, Merkel et al. 2007). Here often a high biomass of benthic algae, particularly brown algae, is found in the intertidal and subtidal zone down to about 50 metres of water depth. Common species in the assessment area include *Fucus vesiculosus*, *Fucus distichus*, *Ascophyllum nodusum*, *Agarum cibrosum* and several *Laminaria* species (Christensen 1981).

In coastal areas, species composition and diversity differ a great deal according to coastal type and exposure to wave action and ice (Anonymous 1979). In some coastal areas the benthic fauna can be characterised by high diversity and biomass combined with an abundance of very old individuals (Sejr & Christensen in press). In the assessment area important species include the bivalves *Mytilus edulis*, *Hiatella bysifera*, *Serripes groenlandicus* and *Mya truncata* (Theisen 1973, Anonymous 1979, Petersen & Smidt 1981, Mosbech et al. 1998). But also many species of polychaetes, echinoderms, amphipods and gastropods are found. The long lifetime of several arctic species and their slow growth makes the benthic community particularly vulnerable to disturbance. The benthic communities in intertidal and shallow areas are more exposed to effects from oil spills, both short- and long-term effects, than communities in deeper water.

On the banks (50-100 metres of water depth) polychaetes are the most numerous infaunal species, whereas the epifauna also hosts crustacea (e.g. *Hyas*, *Caprella* and shrimp species), important as fish food, and many other taxae, including bryozoa and echinoderms (Petersen & Smidt 1981, Anonymous 1978). At the slopes of the Store Hellefiskebanke the benthic fauna is richer than on the top of the banks (Anonymous 1978).

In deeper waters the bottom is often soft and silty. Here a diverse in- and epifauna is found, including crustacea, bivalves, ehcinoderms and polychates (Petersen and Smidt 1981, Anonymous 1978). This habitat is important to the fishery for deep-sea shrimp (*Pandalus borealis*) and also for snow crab (*Chionoecetes opilio*). Deep-sea shrimp occur in waters 100-600 m deep, mainly on the outer slope of the fishing banks and in Disko Bay. During the dark hours of the day shrimps can forage widely distributed in the water column and can even occur near the surface during night. They carry their eggs until they hatch and the larvae are released during spring and summer (Horsted & Smidt 1956, Carlsson & Smidt 1978). In Disko Bay the release probably occurs as late as August (S.A. Pedersen pers. comm.). The larvae then move passively with the water currents (see plankton section). Snow crab and Iceland scallop also have planktonic larvae which move passively with the water currents (Pedersen 1988, Andersen 1993). Few other species of the benthos have larvae with a planktonic life stage (Anonymous 1978).

In other oil exploration areas in the north Atlantic, consideration has been given to deep-sea coral reefs as especially vulnerable ecological components, e.g. in Norway and the Faroe Islands. Such reefs have not been reported from survey trawling in the assessment area (Ole Jørgensen pers. comm.) and apparently do not occur within the assessment area (O. Tendal pers. comm.)

4.4 Fish

Many different fish species occur in the waters of the assessment area. Most are demersal i.e. living near the seabed. Knowledge on the non-utilised species is generally poor (Pedersen & Kanneworf 1995). Only very few species are caught in the commercial fishery in Greenland: Greenland halibut (*Reinhardtius hippolglossoides*) and lumpsucker (*Cyclopterus lumpus*) are the most important seen from an economic point of view. Several other species are caught in local subsistence fishery including capelin (*Mallotus villosus*), arctic char (*Salvelinus alpinus*) redfish (*Sebastes spp.*), spotted wolffish (*Anarchchias minor*) and Atlantic halibut (*Hippoglossus hippoglossus*) (Mosbech et al. 1998). See also Table 1.

Previously, until the late 1980s, Atlantic cod (*Gadus morhua*) was numerous on the banks (in the assessment area mainly in the southern part) and it was fished intensively. But the offshore stock crashed and Atlantic cod only occur today in low numbers in inshore waters (local stocks) (Hovgaard & Christensen 1990, Horsted 2000). A recovery of the offshore Atlantic cod stocks is expected due to the increasing water temperatures recorded in recent years. Another cod species is common – the Greenland cod (*Gadus oqac*) – but it is considered as inferior in the commercial fisheries compared with the Atlantic cod, though it has some subsistence importance (Mosbech et al. 1998).

Greenland halibut (*Reinhardtius hippoglossoides*) live in deep waters at the seafloor, usually at depths below 200 m. Spawning takes place at depths >1000 m and south of 67° N. Eggs and larvae drift northwards with the current, later to settle in the shallower waters of the banks. Particularly the northern part of Store Hellefiskebanke and Disko Bay are important nursery areas for 1-2-year old Greenland halibut (O. Jørgensen GINR pers. comm.). Young fish subsequently, as they grow larger, seek towards deeper waters. This means that the Greenland halibut fished within the assessment area are recruited from spawning areas further south (Riget & Boye 1989, Pedersen & Riget 1993).

Lumpsucker spend most of the year in deep offshore waters, but in spring and early summer they seek shallow coastal waters to spawn. Here they are fished for their roe in an increasingly important gill net fishery from small boats (Mosbech et al. 1998, Olsvig & Mosbech 2003).

Table 1. Overview of selected species of invertebrates and fish from the assessment area.

Species	Main habitat	Spawning area	Spawning period	Exploitation	Importance of assessment area to population
Blue mussel	subtidal, rocky coast	subtidal, rocky coast		local	low
Iceland scallop	inshore and on the banks with high current velocity, at 20 -60 m depth	same as main habitat		commercial and local	medium
Deep sea shrimp	mainly offshore, at 100-600 m depth	larvae released at relatively shallow depth (100-200 m)	March-May in southern part, August in northern	commercial and very important	high
Snow crab	coastal and fjords, at 180-400 depth	same as main habitat	April-May	commercial	medium
Atlantic cod	banks south of 64 ° N	pelagic eggs and larvae in upper water column	March-April	local	low*
Greenland cod	inshore/fjords	inshore/fjords, demersal eggs, pelagic larvae	February-March	commercial and local	medium
Arctic cod	Pelagic	mainly N of 68° N	-	-	medium
Sand eel	on the banks at depths between 10 and 80 m	on the banks, demersal eggs, pelagic larvae	July-August	important prey item	medium
Spotted wolffish	inshore and offshore	hard bottom, demersal eggs	peaks in September	local	medium
Arctic char	coastal waters, fjords	Freshwater rivers	in autumn	local	medium
Capelin	Coastal	beach, demersal eggs	April-June	local, important prey item	medium
Atlantic halibut	offshore and inshore, deep water,	pelagic eggs and larvae, deep water	spring	and local	low
Greenland halibut	deep water, in fjords and offshore	deep water, pelagic eggs and larvae	winter	important, both local and commercial	high
Redfish	offshore and in fjords, 150-600 m depth	spawn outside area	-	local	medium
Lumpsucker	Pelagic	coastal, demersal eggs	May-June	commercial and local	medium

*may change if offshore stock is re-established. Importance of study area to population (conservation value) indicates the significance of the population occurring within the assessment area in a national and international context as defined by Anker-Nilssen (1987).

The schooling capelin (*Mallotus villosus*) spawns in huge numbers in spring in the subtidal zone along beaches and low rocky coasts (Kanneworf 1968, Sørensen 1985, Sørensen & Simonsen 1988). The capelin is an ecological key species because it is an important food resource for larger fish, seabirds and marine mammals. Capelin and lumpsucker spawning areas have been mapped in the assessment area using local knowledge from fishermen and others (see Figure 45). They spawn along extensive coastlines in the assessment area. In 2005 GINR surveyed offshore capelin in the assessment area, and found only significant occurrences in the mouth of Vaigat and in southeastern Disko Bay (GINR unpubl.).

Two other fish species are also potential key species in the marine food web, sandeel (*Ammodytes spp.*) and polar cod (*Boreogadus saida*). Both are often important food sources for seabirds and marine mammals. Sandeel live on the banks, where they often are buried in the sand, and they are one of the few fish species which spawn during the summer (Kapel 1979, Larsen & Kapel 1982, Andersen 1985). Polar cod is pelagic and often closely associated with ice, and play an important role in the food web

(Angantyr & Kapel 1990, Mosbech et al. 2003). Polar cod spawns in late winter and the eggs float and assemble under the ice. The larvae hatch in spring when the ice melts. However, knowledge on the ecology and abundance of polar cod in the assessment area is poor.

Arctic char spend the winter in rivers where they also spawn. In spring they move into the coastal waters near the river outlets, and here they feed until they move back into the river in summer and autumn. Arctic char rivers have been mapped in the assessment area using local knowledge from fishermen and others (Olsvig & Mosbech 2003, Mosbech et al. 2004).

4.5 Seabirds

Seabirds are an important component in the marine ecosystem of the assessment area. Many species are primarily fish consumers living from schooling species (capelin, sandeel, polar cod). Some species live on or supplementing their fish diet with large zooplankton (copepods, krill), and others feed primarily on benthic invertebrates (e.g. mussels) (Falk & Durinck 1993, Merkel et al. 2007). The species utilise the common resources by means of different feeding methods, for example, some species are deep-diving foragers while others take their food on the surface. Many seabird species tend to aggregate at breeding or foraging sites, and extremely high concentrations may occur. A single flock of king eiders was estimated to hold up to 30,000 birds, which may constitute as many as 6% of the total population, and some breeding colonies hold between 50,000 and 100,000 individuals. An overview of the species is given in Table 2.

Most seabirds are colonial breeders and numerous seabird breeding colonies are found dispersed along the coast of the assessment area (Figure 26). Colonies vary in size (from a few pairs to more than 50,000 individuals) and in species composition, from holding only a single species up to 10 different species. The breeding seabirds utilise the waters near the breeding site; thick-billed murres (*Uria lomvia*) may fly more than 100 km to find their food, but most feed within a much smaller range (Falk et al. 2000, NERI unpublished). However, numerous seabirds also utilise the waters much further away from the coasts and these comprise non-breeding individuals from breeding populations all over the North Atlantic – mainly black-legged kittiwakes (*Rissa tridactyla*) and northern fulmars (*Fulmarus glacialis*), which spend the summer in the food rich waters off West Greenland (Mosbech et al. 1998). Great shearwaters (*Puffinus gravis*), breeding in the southern hemisphere, also summer in the offshore seas of the region. Another non-breeding seabird segment utilises the region in summer: seaducks arrive form breeding sites in Canada and inland Greenland and assemble to moult in remote and peaceful bays and fjords (Figure 27). King eiders (*Somateria spectabilis*) are numerous in the fjords of Disko Island, harlequin ducks (*Histrionicus histrionicus*) stay at remote rocky islands, and long-tailed ducks (*Clangula hyemalis*), and red-breasted mergansers (*Mergus serrator*) in shallow fjords and bays (Frimer 1993, (Mosbech & Boertmann 1999, Boertmann & Mosbech 2002). A few species occur only as migrant visitors during spring and autumn, e.g. two species of phalaropes, Sabines gull (*Larus* *sabini*) and the rare and threatened ivory gull (*Pagophila eburnea*) (Boertmann 1994).

Table 2. Overview of selected species of birds from the assessment area. Red-list status is provisional, as the list has not yet been published. b = breeding, s = summering, w = wintering, mi = migrant visitor, c = coastal, o = offshore. Importance of study area to population (conservation value) indicates the significance of the population occurring within the assessment area in a national and international context as defined by Anker-Nilssen (1987).

Species	**Occurrence**		**Distribution**	**Red-list status in Greenland**	**Importance of study area to population**
Fulmar	b/s/w	year-round	c & o	least concern (LC)	high
Great shearwater	S	July-October	o	least concern (LC)	low
Great cormorant	b/s/w	year-round	c	least concern (LC)	high
White-fronted goose	B	May-September	c	endangered (EN)	high
Brent goose	Mi	spring and autumn	c	least concern (LC)	medium
Common eider	b/s/m/w	year-round	c	vulnerable (VU)	high
King eider	m w	Aug.-Sept. Oct.-May	c c & banks	not evaluated	high
Long-tailed duck	b/m/w	year-round	c	least concern (LC)	medium
Red-breasted merganser	b/m/w	year-round	c	least concern (LC)	medium
Harlequin duck	M	July-August	c (rocky shores)	near threatened (NT)	medium
Red-necked phalarope	mi, (b)	spring and autumn	o	least concern (LC)	low
Grey phalarope	mi, (b)	spring and autumn	o	least concern (LC)	low
Arctic skua	B	summer	c	least concern (LC)	low
Black-legged kittiwake	b/s	year-round	c & o	endangered (EN)	high
Glaucous gull	b/s/w	year-round	c & o	least concern (LC)	medium
Iceland gull	b/s/w	year-round	c & o	least concern (LC)	medium
Great black-backed gull	b/s/w	year-round	c & o	least concern (LC)	medium
Sabines gull	Mi	August and May/June	o	near threatened (NT)	low
Ross' gull	B	summer, very localised	c	vulnerable (VU)	low
Ivory gull	w, mi	November - May	o	vulnerable (VU)	medium
Arctic tern	B	May - September	c	near threatened (NT)	high
Thick-billed. murre	b/s/w	year-round	c & o	vulnerable (VU)	high
Razorbill	b/w	year-round	c & o	least concern (LC)	high
Atlantic puffin	b/w	year-round	c & o	neat threatened (NT)	high
Black guillemot	b/w	summer winter	c c & o	least concern (LC)	high
Little auk	b w	May - August September - May	c & o o	least concern (LC)	high
White-tailed eagle	b/w	year-round	c, rare in southern part	vulnerable (VU)	low

Figure 26. Distribution of seabird breeding colonies in the study area. Colonies with less than 200 individuals not shown (NERI, Map based on data from NERI and GINR, Greenland Seabird Colony Database).

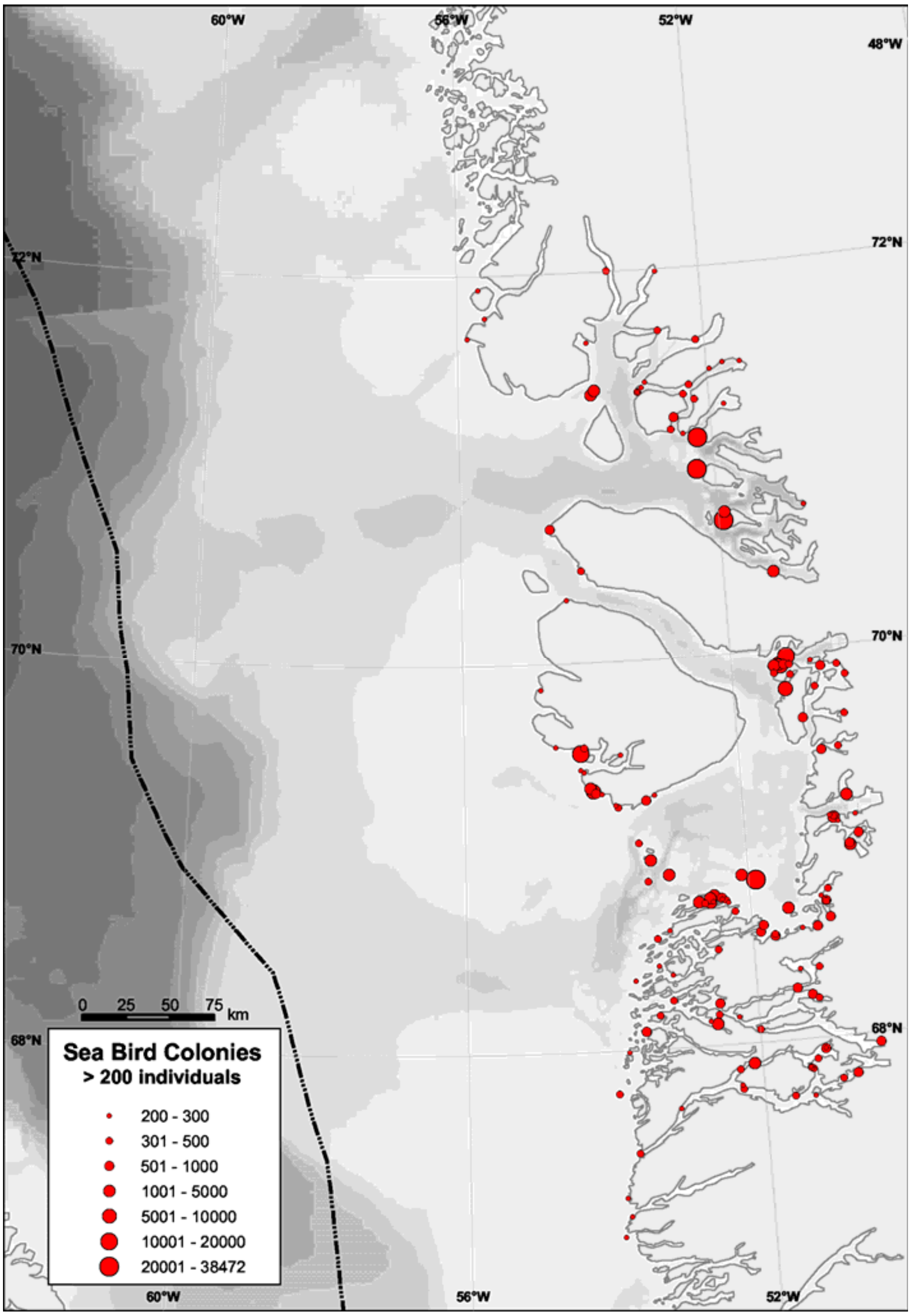
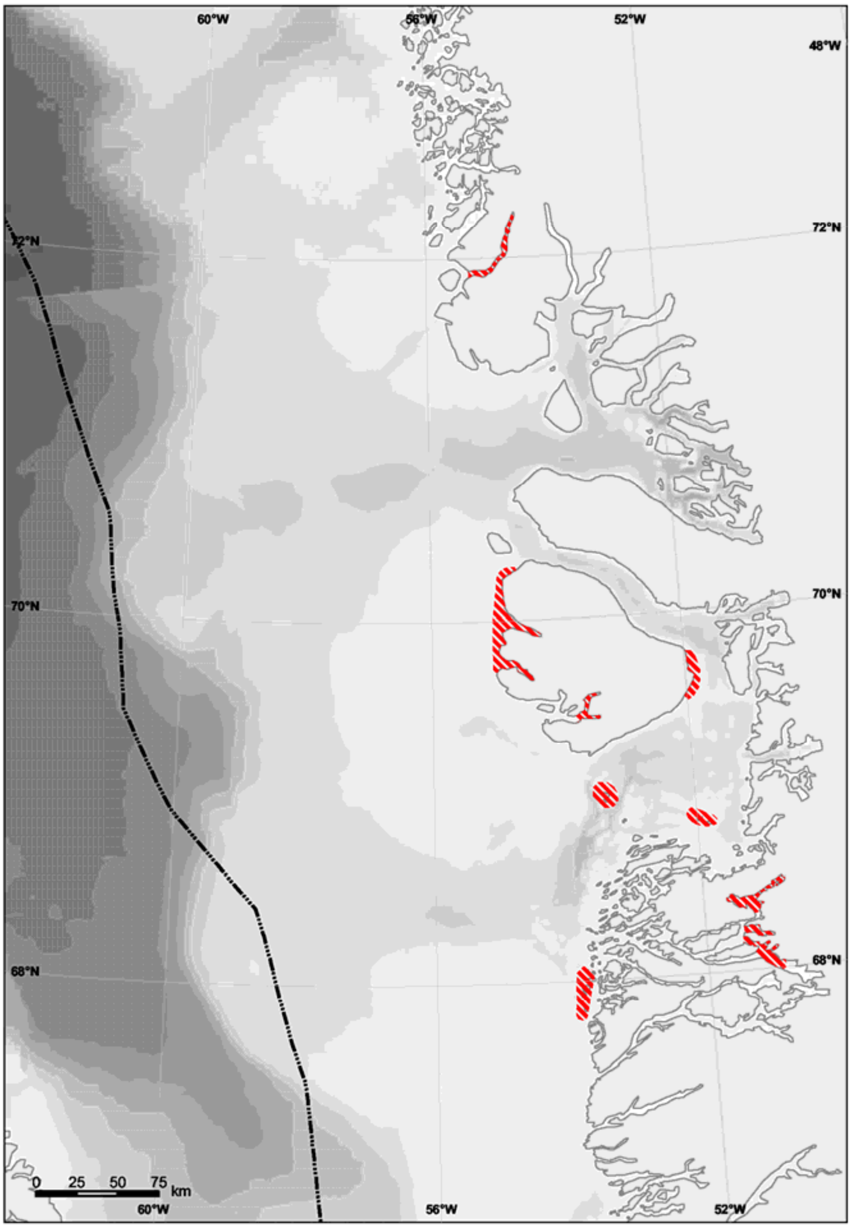


Figure 27. Important areas for moulting seaducks. These are mainly king eiders, but also common eiders, harlequin ducks and red-breasted merganser are among the moulting ducks. The moulting period is July to September. (NERI, Map based on Mosbech & Boertmann (1999) and Bortmann & Mosbech 2001, 2002).



There are 14 breeding seabird species in the assessment area (Boertmann et al. 1996). The most widespread is the black guillemot (*Cepphus grylle*), breeding along almost all rocky coasts. Northern fulmar is found in immense numbers in a few breeding colonies in Disko Bay and Uummannaq Fjord. Several of the breeding seabird species are decreasing in numbers, mainly caused by unsustainable exploitation, an issue recently addressed by the Greenland Homerule by reducing the hunting season for seabirds. The most prominent of these are thick-billed murre (one colony in the region), black-legged kittiwake (several colonies), common eider (*Somateria mollissima*) (several colonies) and Arctic tern (*Sterna paradisaea*) (several colonies). Scarcer breeding species include Atlantic puffin (*Fratercula arctica*) and little auk (*Alle alle*), and a very rare species occurring in the region is Ross's gull (*Rhodostethia rosea*) (Boertmann 1994).

During autumn large numbers of seabirds begin to assemble in the waters off the West Greenland coast. Some are under way to wintering sites outside Greenland waters, but many and probably the major part will stay throughout the winter (Boertmann et al. 2006). However, the winter ice will exclude seabirds from large parts of the assessment area, except in the southern part where open waters occur along the coast and the drift ice often is rather loose. Here, extremely high numbers of wintering seabirds often are found. These are not only of local origin, but arrive from breeding sites in Canada, Iceland and Svalbard, making the Greenland wintering sites of high international concern as regards nature conservation. The most numerous species in winter are common eider, king eider, thick-billed murre and the large gull species. The distribution of the wintering seabirds has been surveyed in the coastal area of West Greenland (Merkel et al. 2002, Boertmann et al. 2004). It is estimated that more than 3.5 million birds winter along the entire coast of Southwest Greenland. To this figure an unknown but probably very high number (several million) of little auks should be added (Boertmann et al. 2006). They occur mainly in offshore waters, where they are difficult to survey. Also large numbers of thick-billed murres occur in the offshore area in spring and autumn. The knowledge of the habitat use of the wintering seabirds and the factors governing their distribution is generally poor. Despite the unknowns it is evident that, seen in a North Atlantic perspective, the waters of West Greenland are very important for seabirds (Barret et al. 2006).

The assessment area is very important for the king eider population breeding in eastern Arctic Canada and a number of studies have been conducted in recent years (Figures 28, 29 and 30). Thirty-six king eiders were tracked from the breeding and moulting sites by means of satellite transmitters on their migration to the wintering grounds on the fishing banks off West Greenland (Mosbech et al. 2004, Mosbech et al. 2006). A single bird was followed for two years (Figure 29). Regardless of the locality where the birds were caught and implanted with a transmitter (Canada and West Greenland), almost half of the tracked birds wintered at Store Hellefiskebanke and the adjacent coast.

On Store Hellefiskebanke most birds were found in an area with water depths less than 50 m and up to 70 km from the coast (Figure 29). Surveys have shown that there can be up to in the region of 300,000 king eiders wintering in the ice in the area in March (Mosbech & Johnson 1999) and, based on the aerial survey conducted as part of the marginal ice zone project in late April 2006, it is estimated that there were about 400,000 king eiders (75% confidence intervals: 227,000 – 709,000) staging at Store Hellefiskebanke at depths less than 50 m, while outside this area king eiders were only observed sporadically.

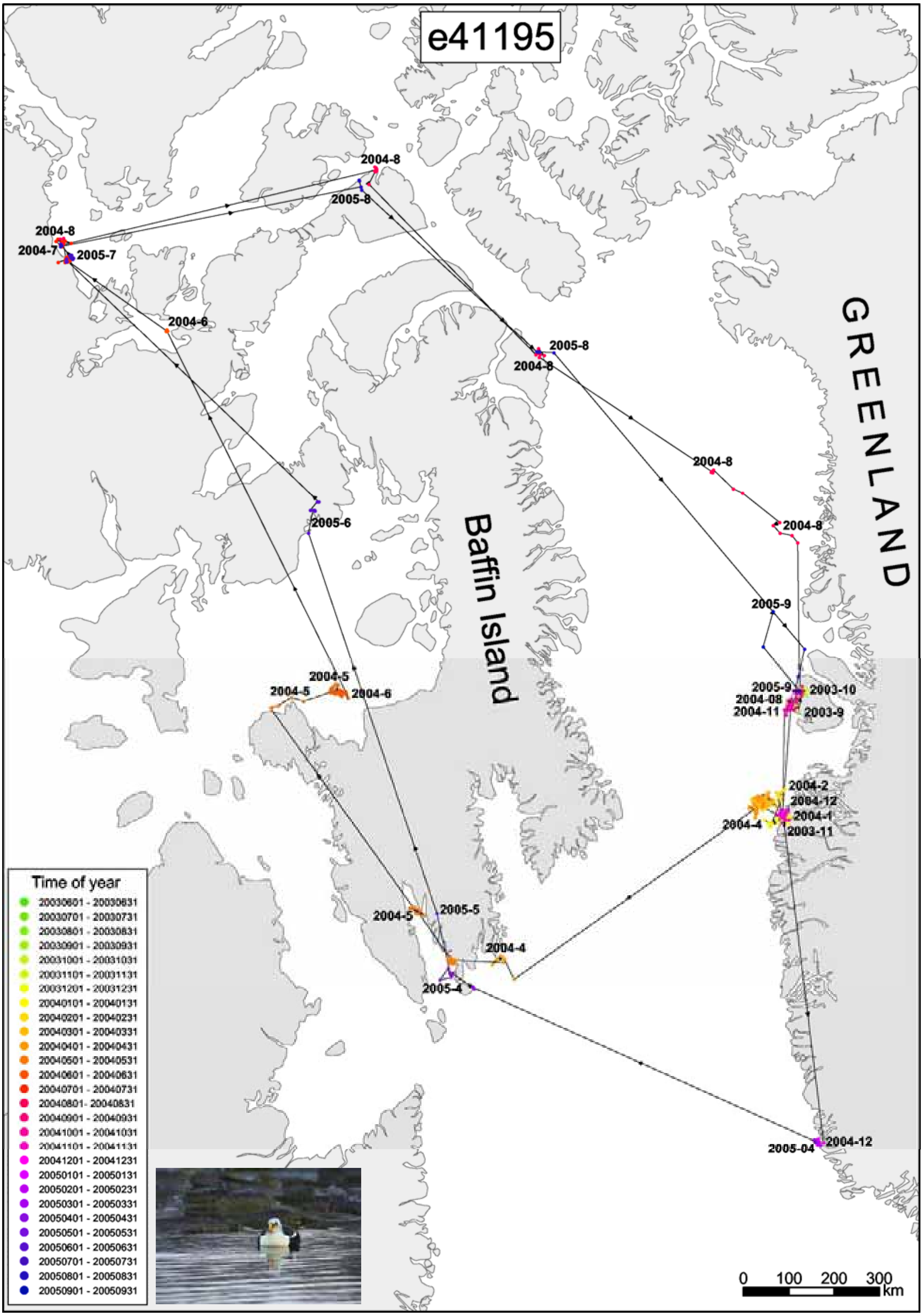


Figure 28. A King eider (No. e41195) tracked with satellite transmitter from the moulting area at Disko Island in September 2003 and the following two years through two full migration cycles to the breeding grounds in Arctic Canada. Two sites in the assessment areas were of particular importance to this bird: The waters west of Disko Island and the shallow part of Store Hellefiskebanke. Based on NERI/GINR data, Mosbech et al. (in prep.).

Figure 29. King eider satellite tracking locations from year round tracking of birds implanted at moulting localities in Umiarfik and the fjords at the west coast of Disko and at a breeding locality in Arctic Canada outside the map. The scattered dots in the central Baffin Bay and on Baffin Island are from bird migrating to and from breeding localities in Arctic Canada west of the map border. See fig 5.5.3 for an example of a full migration route. Observations from two ship based surveys are also indicated on the map. The importance of the waters west of Disko Island and on Store Hellefiskebanke (at c. 68° N) is apparent. Based on NERI/GINR data, Mosbech et al. (2006).

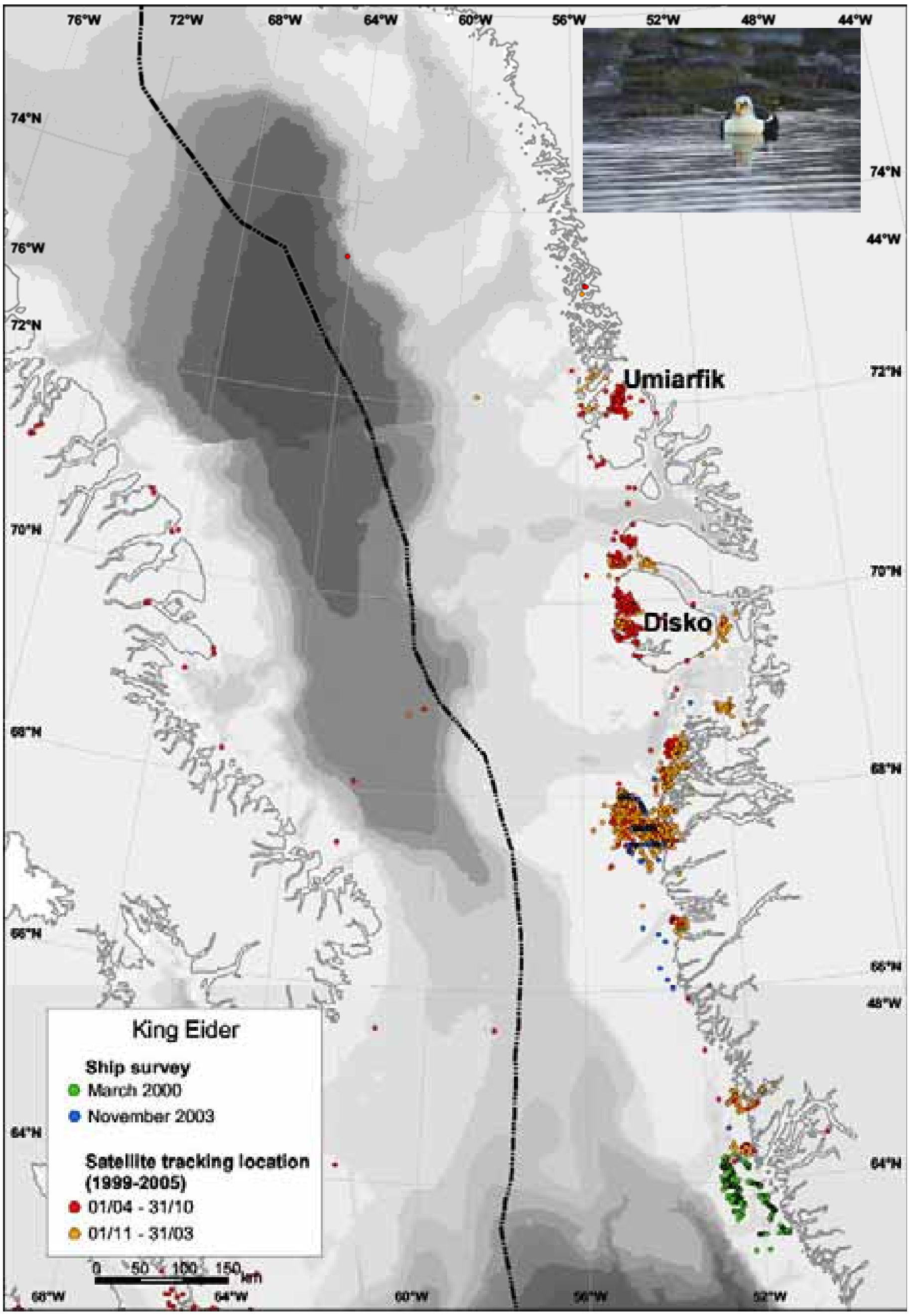
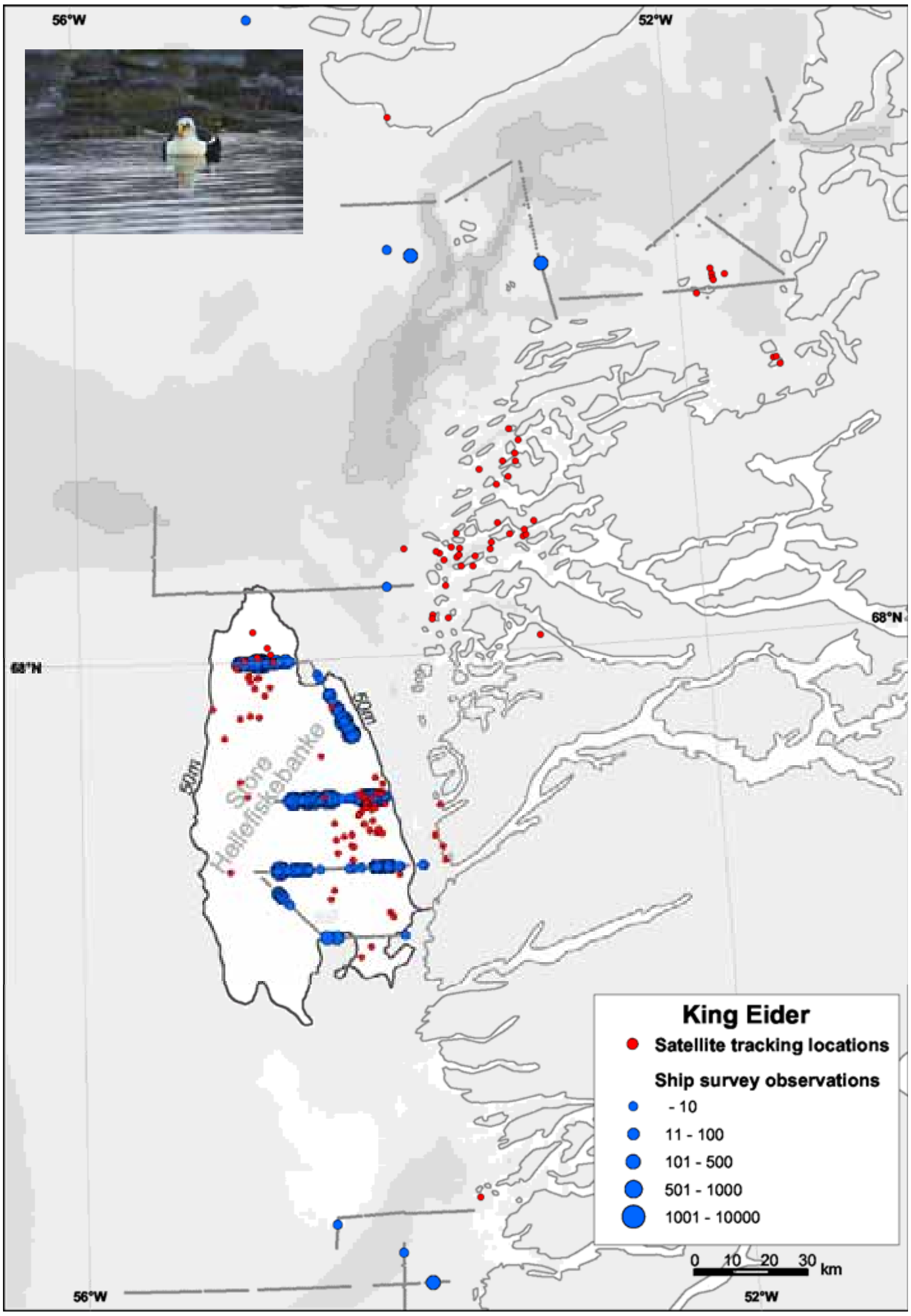


Figure 30. Locations of satellite tracked king eiders in November 2003 and observations of king eiders from a ship based survey in November 2003 (grey lines). Based on the limited number of transect lines an estimated 500,000 king eiders (75% confidence interval: 529,000-1,083,000) where present within the 50 m depth contour at Store Hellefiskebanke (excluding the not surveyed southwestern part). Based on NERI data, Mosbech et al. (2006).



Based on a ship survey in 2003 it was estimated that there were more than 500,000 king eiders (75% confidence intervals: 529,000 – 1,083,000) on Store Hellefiskebanke in November (Figure 30) (Mosbech et al. 2006). This probably approaches the entire population of king eiders wintering in West Greenland, which makes this shallow part of Store Hellefiskebanke extremely sensitive to oil spills. A tracked king eider equipped with a depth transducer recorded 43 m as maximum dive depth and it showed a diurnal diving pattern of diving preferentially during daylight, even in midwinter when there are only a few hours of twilight (Mosbech et al. in 2006). So, these few hours of foraging appears to be very important. It also indicates that there are plenty of benthic mussels at the site, since the birds are able to find sufficient food during these few hours.

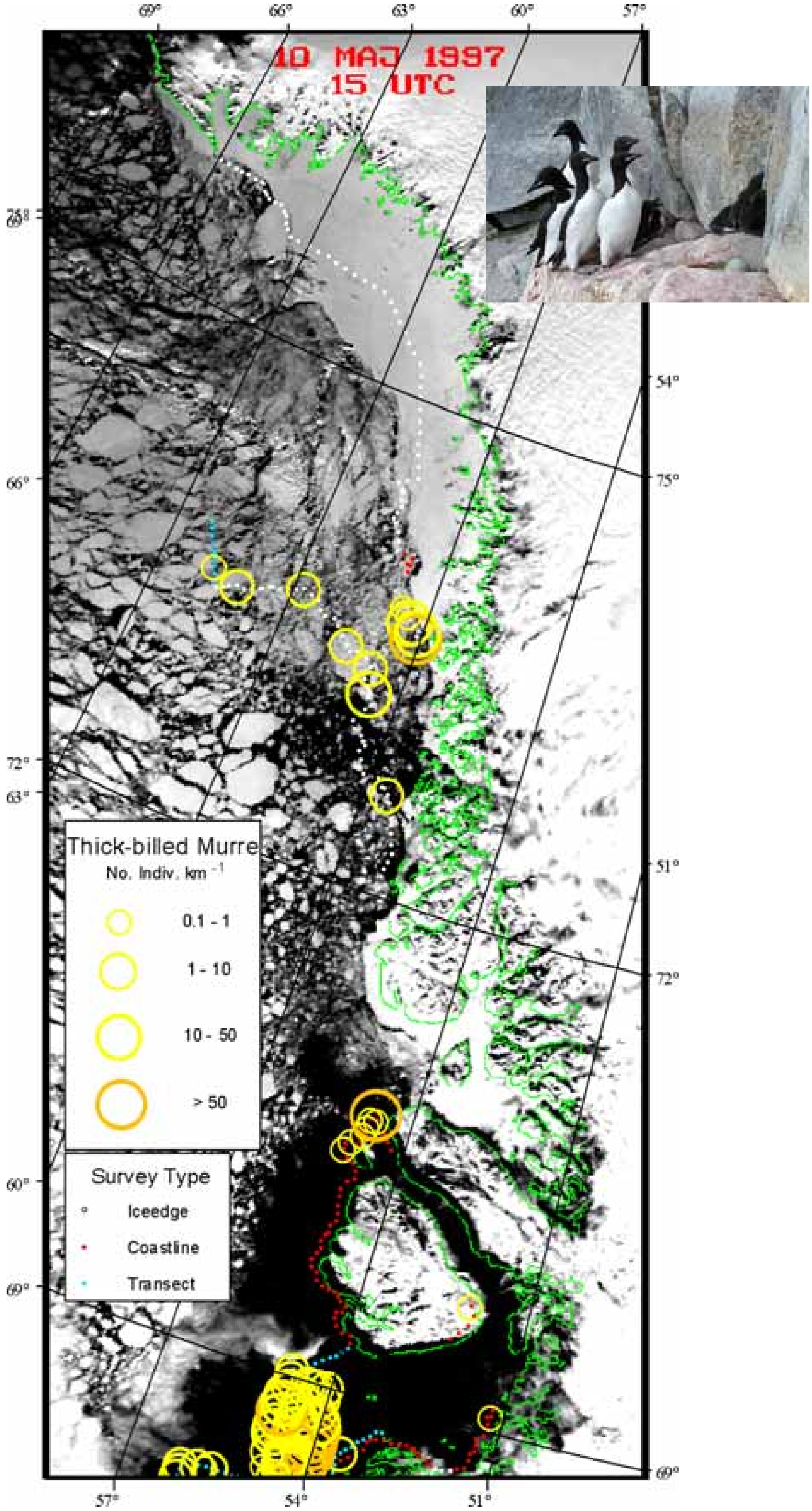
Thick-billed murre abundance and distribution have been surveyed from aircraft in spring, and some significant concentrations were observed in the assessment area (Figure 31) (Merkel et al. 2002). Another study initiated in 2005 focused on the post-breeding migration of the thick-billed murres from the breeding colony in Disko Bay. The three-week old chicks leave the colony and initiate a swimming migration together with one of the parent birds which then moult flight feathers and become unable to fly for a three-week period. The temporal and spatial distribution of this swimming migration was unknown until 2005, when ten birds were satellite tracked. This study was followed up in 2006 by tracking an additional 17 birds (NERI unpublished). The birds moved both to the south of Disko island and to the north through Vaigat, and dispersed in the waters west of Disko (Figure 33).

The marginal ice zone project in April and May 2006 revealed large concentrations of thick-billed murres present in the assessment area and confirmed earlier studies (Figure 31), although the murres were much more widespread in the area and many were found even in dense drift ice near the Canadian border (Figure 32). In total about 400,000 thick-billed murres were estimated to be present in the assessment area during the survey, and significant concentration areas were located (Figure 32).

Although not seabirds, geese should also be mentioned in this context, because they often utilise saltmarshes within the assessment area. These saltmarshes are very low and become inundated at high water levels. Particularly the Greenland white-fronted goose (*Anser albifrons flavirostris*) is vulnerable, because the population is seriously decreasing. Brent geese (*Branta bernicla*) on migration between breeding sites in Arctic Canada and wintering grounds in northwest Europe also utilise these salt marshes during stopovers (Boertmann et al. 1997, Boertmann & Egevang 2001).

The overall and general knowledge of seabirds in the assessment area is fairly good. However, many specific questions remain to be solved in order to conduct specific EIAs.

Figure 31. Distribution of thick-billed murres in May 1997 transposed on a synoptic image of the ice distribution. A large concentration is seen in the mouth of Disko Bay (NERI).



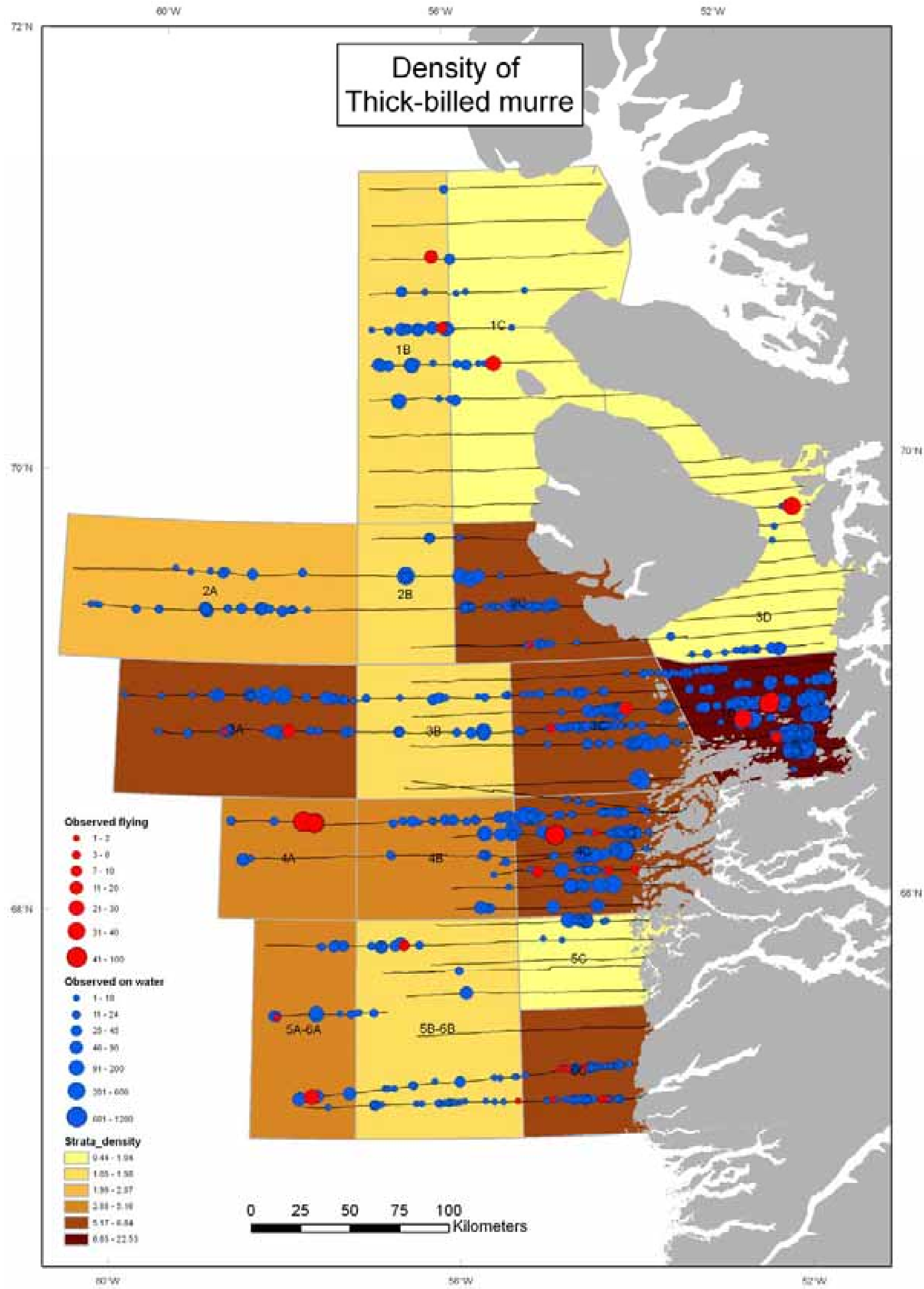


Figure 32. Densities of thick-billed murres in the spring 2006 survey area. Based on a preliminary estimate of the number observed from aircraft during the marginal ice zone project in April and May 2006. In total about 430,000 (CV 11%) thick-billed murres were estimated to reside in the area and especially high concentrations were found in southern Disko Bay (ice free) and relatively high concentrations were found northwest, west and southwest of the entrance to the bay in areas with both open water and quite dense ice cover. Surprisingly high concentrations were found far offshore near the Canadian border in areas with dense ice cover. This is presumably birds crossing directly over the central Davis Strait and Baffin Bay on their way to the large breeding colonies in Arctic Canada.

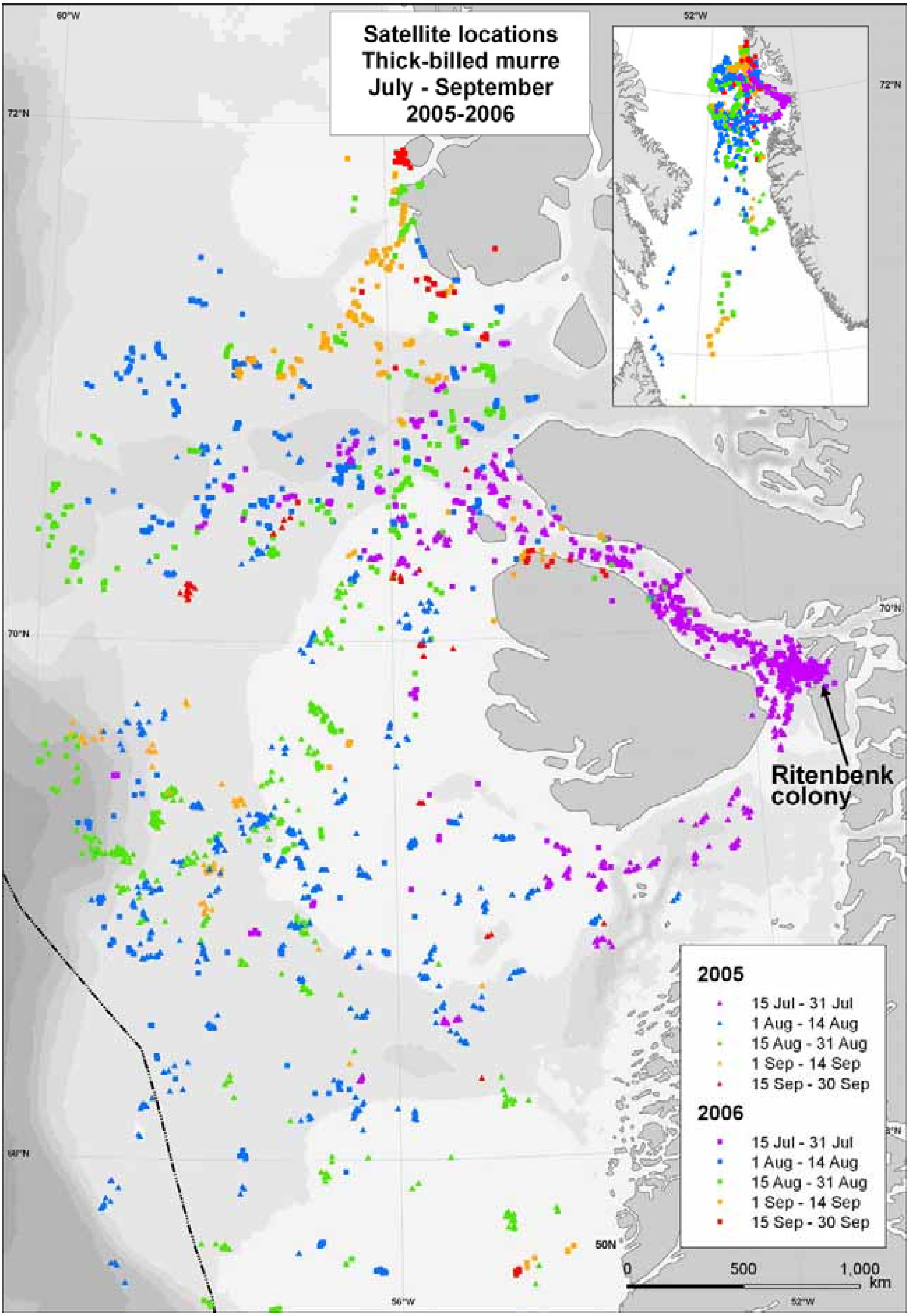


Figure 33. Locations of thick-billed murres equipped with satellite transmitters in July 2005 (n = 10) and 2006 (n = 17) on the breeding site (Ritenbenk colony).

4.6 Marine mammals

The marine mammals of the assessment area comprise 5 species of seals, walrus, 13 species of whales and polar bear (*Ursus maritimus*) (Table 3).

Table 3. Overview of selected marine mammals occurring in the assessment area. Red-list status is provisional, as the list has not yet been published. Importance of study area to population (Conservation value) indicates the significance of the population occurring within the assessment area in a national and international context as defined by Anker-Nilssen (1987).

Species	Period of occurrence	Main habitat	Stock size or abundance	Protection/ exploitation	Greenland red-list status	Importance of assessment area to population
Bowhead whale	February-June	Pack ice/ marginal ice zone	some hundreds	Protected (since 1932)	near threatened (NT)	high
Minke whale	April-November	Coastal waters and banks	4000	Hunting regulated	least concern (LC)	medium
Humpback whale	June-November	Edge of banks, coastal waters	1000	Protected (1986)	least concern (LC)	medium
Fin whale	June-October	Edge of banks, coastal waters	2000	Hunting regulated	least concern (LC)	medium
Blue whale	July-October	Edge of banks	few	Protected (1966)	data deficient (DD)	low
Harbour porpoise	April-November	Whole area	common	Hunting unregulated	data deficient (DD)	medium
Bottlenose whale	(June-August)	Deep water	infrequent	Hunting unregulated	not applicable (NA)	low
Pilot whale	June-October	?	occasionally	Hunting unregulated	least concern (LC)	low
Killer whale	June-August	Whole area	rare but regular	Hunting unregulated	not applicable (NA)	low
White whale	November-May	Banks	8000	Hunting regulated	critical endangered (CR)	high
Narwhal	November-May	Edge of banks, deep waters	3000	Hunting regulated	critical endangered (CR)	high
Sperm whale	May-November	Deep waters	rare but regular	Protected (1985)	not applicable (NA)	low
Harp seal	June-October	Whole area	5.4 millions.	Hunting unregulated	least concern (LC)	medium
Hooded seal	March-October	Whole area	unknown, but many	Hunting unregulated	least concern (LC)	medium
Ringed seal	Whole year	Whole area, usually in ice	common	Hunting unregulated	least concern (LC)	medium
Harbour seal	Whole year	Coastal waters	very rare	Hunting regulated	critical endangered (CR)	high
Bearded seal	Mainly winter	Drift ice on the banks	common	Hunting unregulated	data deficient (DD)	medium
Walrus	Winter	Drift ice on the banks	3000	Hunting regulated	endangered (EN)	high
Polar bear	Mainly winter	Drift ice and ice edges	4000	Hunting regulated	vulnerable (VU)	medium

Seals

The most numerous seals in the assessment area are the ringed seal (*Phoca hispida*), hooded seal (*Cystophora cristata*) and harp seal (*Phoca groenlandica*). Ringed seals occur mainly in ice-covered waters and they whelp on the fast ice of the fjords. They live on fish and crustaceans (Siegstad et al. 1998). Harp and hooded seals are migrant seals occurring mainly in the summer and they whelp outside the assessment area; both are mainly fish eaters and hooded seals are known to dive to considerable depth (1000 m) (Kapel 1995, 1996, Kapel & Rosing-Asvid 1996, Folkov & Blix 1999). Bearded seals are a winter visitor, occurring in the drift ice, where they mate and whelp in the early spring (Kapel unpublished). Harbour seals are today very rare or absent from the assessment area. The nearest known site with regular occurrence is the fjord Kangerlussuaq just south of the assessment area (Teilmann & Dietz 1994, Lisborg & Teilmann 1999, NERI unpublished).

Walrus

Walruses occur in the period February to May on the relatively shallow bank areas (water less than 100 m deep) where they can dive to the seafloor and feed on bivalves (e.g. Born 2005). The population is declining due to unsustainable harvest. Based on an aerial survey conducted by GINR in March 2006 the population between the entrance to Nassuttoq and Vaigat was estimated to 3,085 individuals (90% confidence interval 1239-7681 animals). Their exact summer habitats are unknown, and a relationship with southeast Baffin Island in Canada and the Qaanaaq area has been speculated (Born et al. 1994). Not until 2005 was direct evidence for the connection to southeast Baffin Island established, when a single female was tracked (by means of satellite) across the northern Davis Strait to Baffin Island (Figure 34) (NERI & GINR unpublished data). Additionally, seven walruses were equipped with satellite transmitters in March 2005 and 2006 to follow their movements on and away from the West Greenland wintering grounds (NERI & GINR unpublished data). The tagging also showed that an animal moved northwards indicating a link between Store Hellefiskebanke and the banks west of Disko Island (Dietz et al. in prep.).

Walruses were surveyed from aircraft during the NERI marginal ice zone project for the present assessment in April and May 2006. In total, 415 walruses were estimated, located in two separate areas, one off northwest Disko Island and one on Store Hellefiskebanke. In the first area, 46 individuals were estimated and in the second 370 (figures not yet corrected for submerged animals, a correction which will increase the estimate). Particularly on Store Hellefiskebanke the walruses were confined to a very distinct area similar to the home range calculated from the satellite tacked animals in 2005 and 2006 (Figure 35).

The walruses occurring in West Greenland are confined to a restricted habitat, where they concentrate for feeding and mating. This habitat is found entirely within the assessment area, and no alternative habitats are known in West Greenland.

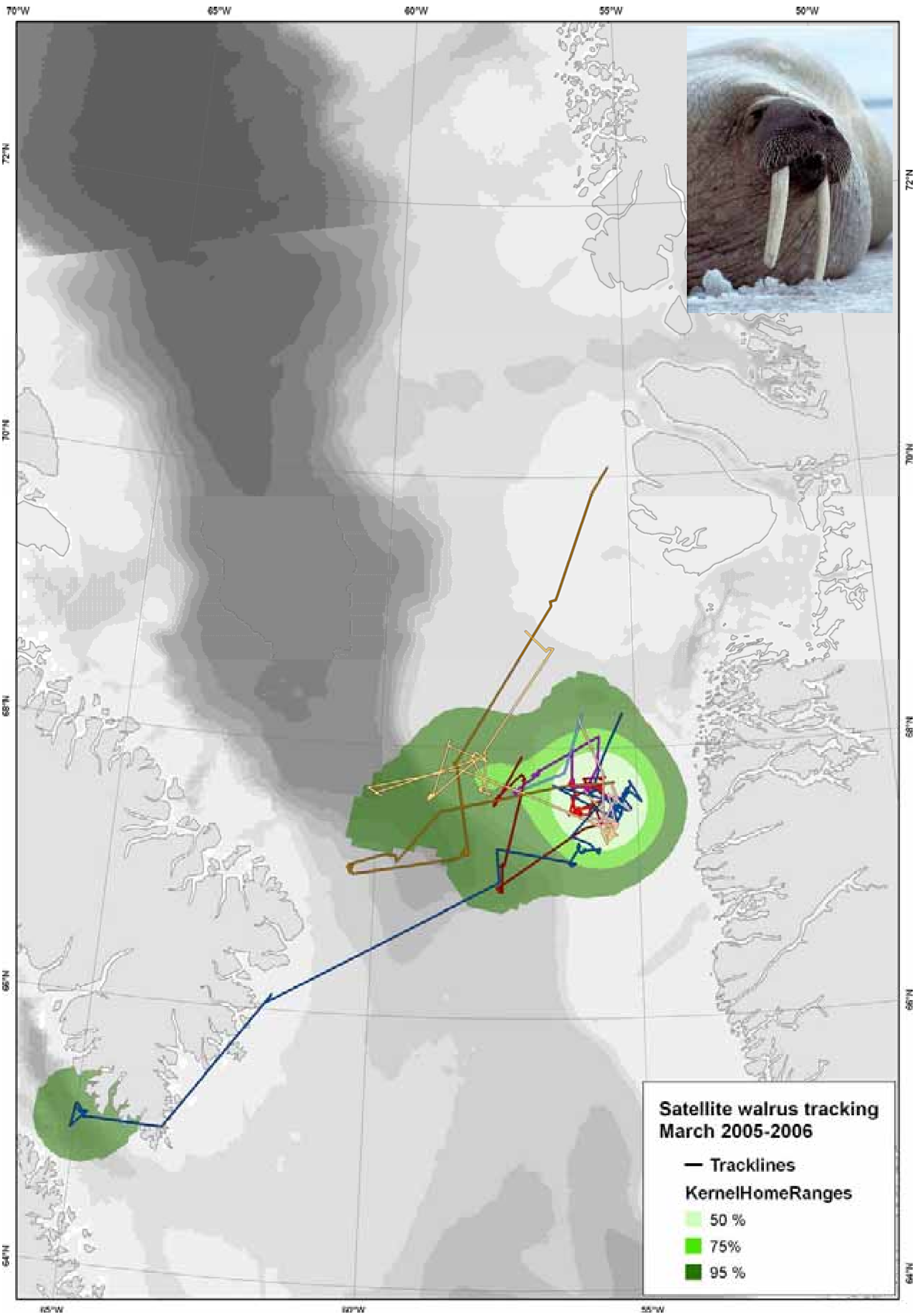


Figure 34. Track lines from eight walruses tagged with satellite transmitters during March 2005 and 2006 off West Greenland. One transmitter (in 2005) lasted long enough to show the migration route across the northern Davis Strait to the Canadian summering grounds of South East Baffin Island and additional two (in 2006) entered Canadian waters during dense ice conditions trying to access the Canadian coast. Pale green colour indicates the home range with 50%, bright green with 75% and dark green with 95% probability.

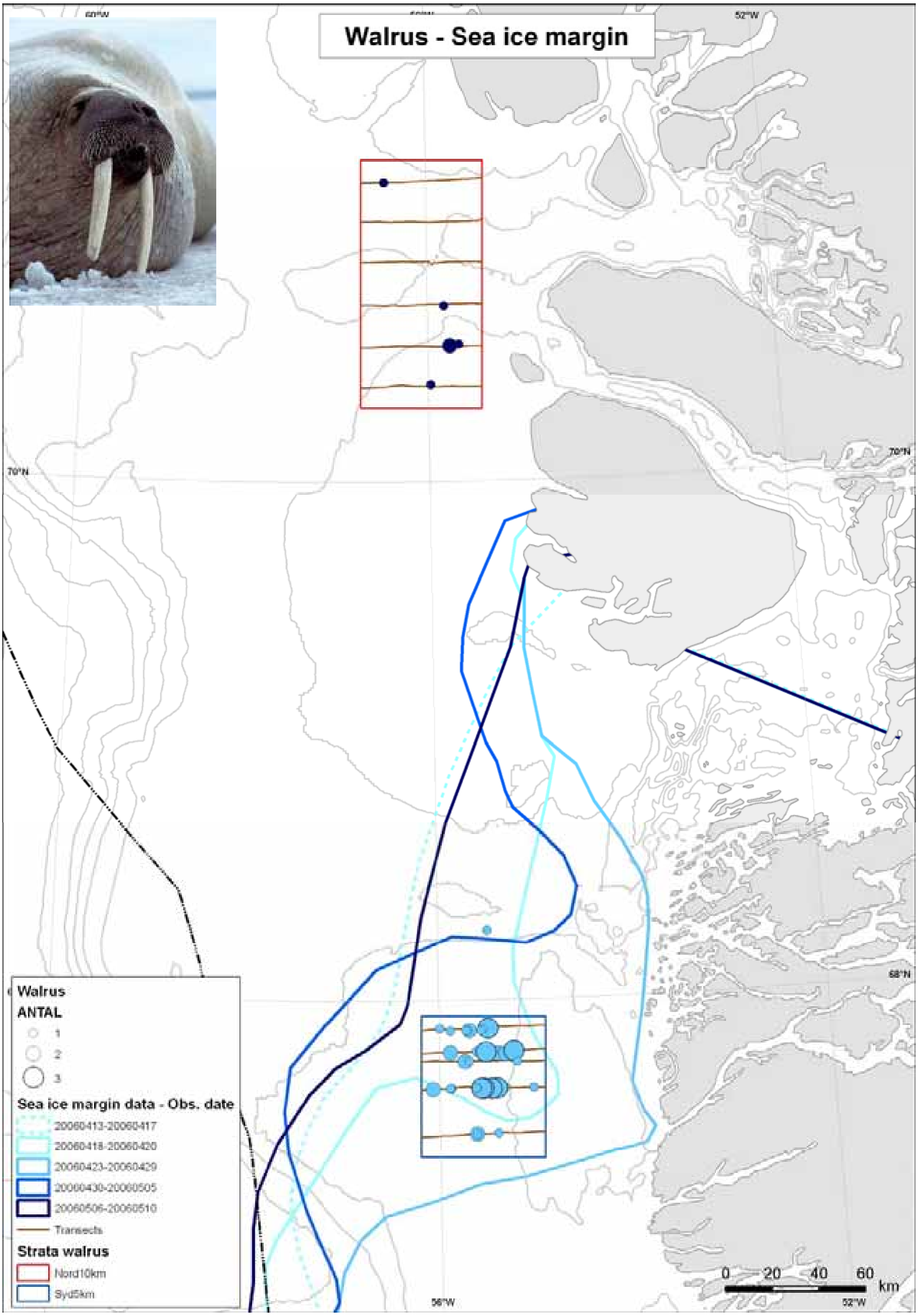


Figure 35. Walrus observations during the NERI-survey in April and May 2006. The ice edge at different dates is indicated by coloured lines. Dots represent individual observations of walruses. In the southern block (stratum) 370 walruses were estimated and in the northern block 46.

Whales

Bowhead whale (*Balaenena mysticetus*), narwhal (*Monodon monoceros*) and white whale (*Delphinapterus laucas*) utilise the assessment area during autumn, winter and spring. They rely heavily on the production and foraging opportunities provided in the open water along West Greenland in winter. Other whale species like harbour porpoise (*Phocoena phocoena*), minke whale (*Balaenoptera acutorostrata*), fin whale (*Balaenoptera physalus*) and humpback whale (*Megaptera novaeangliae*) migrate from more southern wintering grounds to the assessment area where they are abundant visitors and predators during summer and autumn. Less common but regular visitors to the area are killer whales (*Orcinus orca*), pilot whales (*Globicephala melas*), sperm whales and blue whales (*Balaenoptera musculus*).

Narwhal

Narwhals are abundant in the deeper basins of the assessment area during November through May. Narwhals winter in the dense pack ice in Baffin Bay as well as in the coastal areas close to the southern entrance to Disko Bay and in the outer parts Uummannaq Fjord. Satellite tracking studies have shown that narwhals from Melville Bay winter in the assessment area together with narwhals from the Eclipse Sound population in Canada (Figure 36) (Dietz & Heide-Jørgensen 1995, Dietz et al. 2001, Heide-Jørgensen et al. 2002, 2003). Large numbers of narwhals visit Uummannaq in November and later, narwhals arrive in Disko Bay. Narwhals from Melville Bay also enter Disko Bay in winter but it is presumed that other narwhal stocks also contribute to the winter occurrence of narwhals in Disko Bay. This is in agreement with genetic studies that suggest that a mix of narwhals from different populations contributes to the harvest in Disko Bay (Riget et al. 2002).

White whale

White whales (*Delphinapterus leucas*) are abundant on the banks of the assessment area from November through May. They arrive from the Canadian summer grounds to the assessment area in November and stay until May. They usually occur in shallower waters and closer to the coast than narwhals and mainly in the waters between the drift ice and the coast (Figure 37). The population is decreasing seriously due to excessive hunting (Heide-Jørgensen & Reeves 1995, Alvarez-Flores & Heide-Jørgensen 2004).

Only two individual have been tracked from the Canadian summer grounds to the wintering aeas in West Greenland (Heide-Jørgensen et al. 2003b), and the knowledge on the migrations of white whales in West Greenland is limited compared with that for narwhals. Just as for narwhals, belugas are expected to acquire the major part of their annual food intake in West Greenland in winter.

Figure 36. Track lines (upper map) and 95% kernel home range polygons (lower map) for the narwhals tagged in 2003 and 2004 in Admiralty Inlet compared with previous tagging published by Dietz & Heide-Jørgensen (1995), Dietz et al. (2001) and Heide-Jørgensen et al. (2002, 2003). Dark green = narwhals tagged in Admiralty Inlet, yellow = tagged at Somerset Island, pale green = tagged in Eclipse Sound and red = tagged in Melville Bay (Figure from Dietz et al. submitted). The winter areas are the home ranges in Baffin Bay and Davis Strait. Note particularly the restricted winter area (red) of the Melville Bay narwhals.

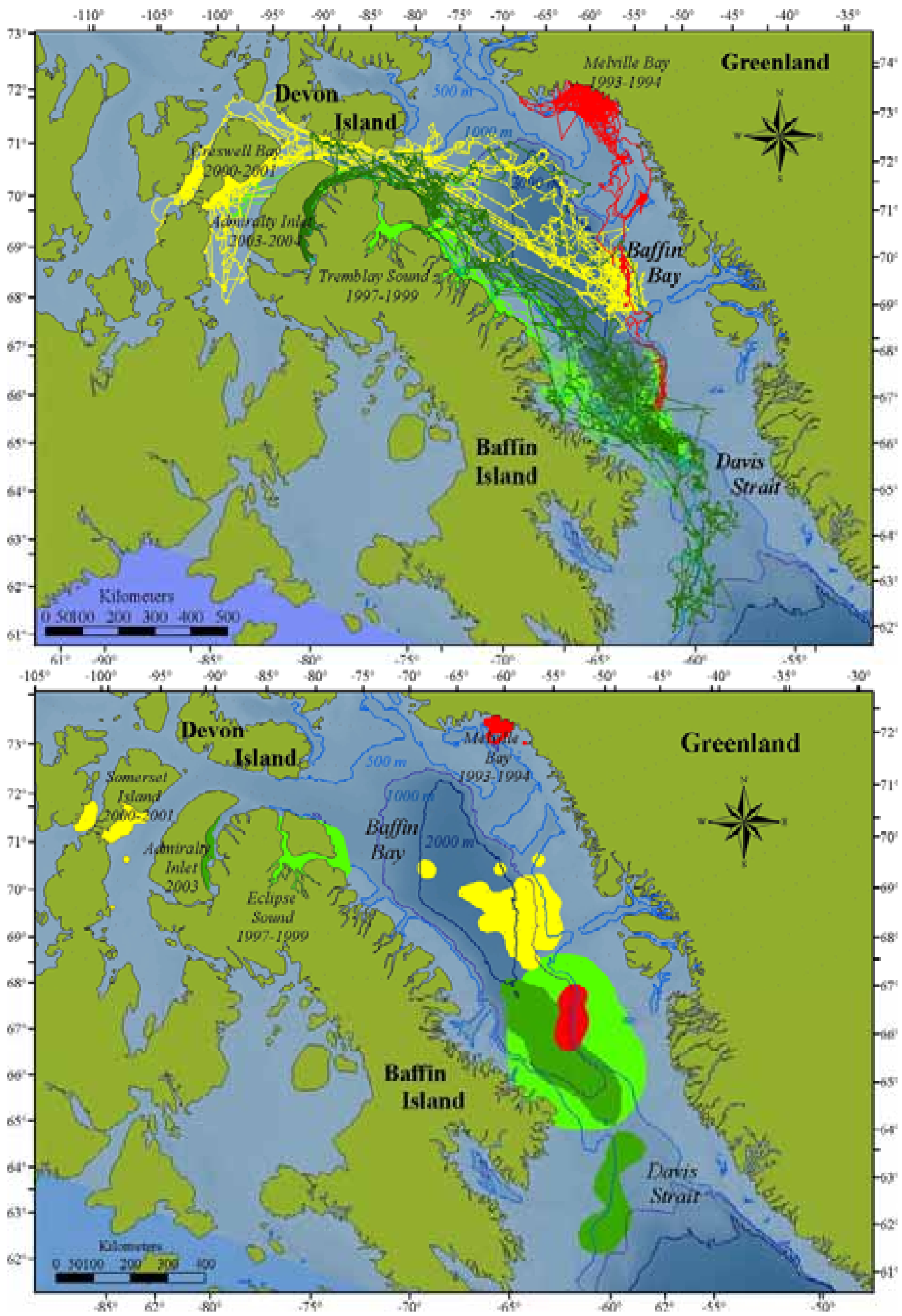
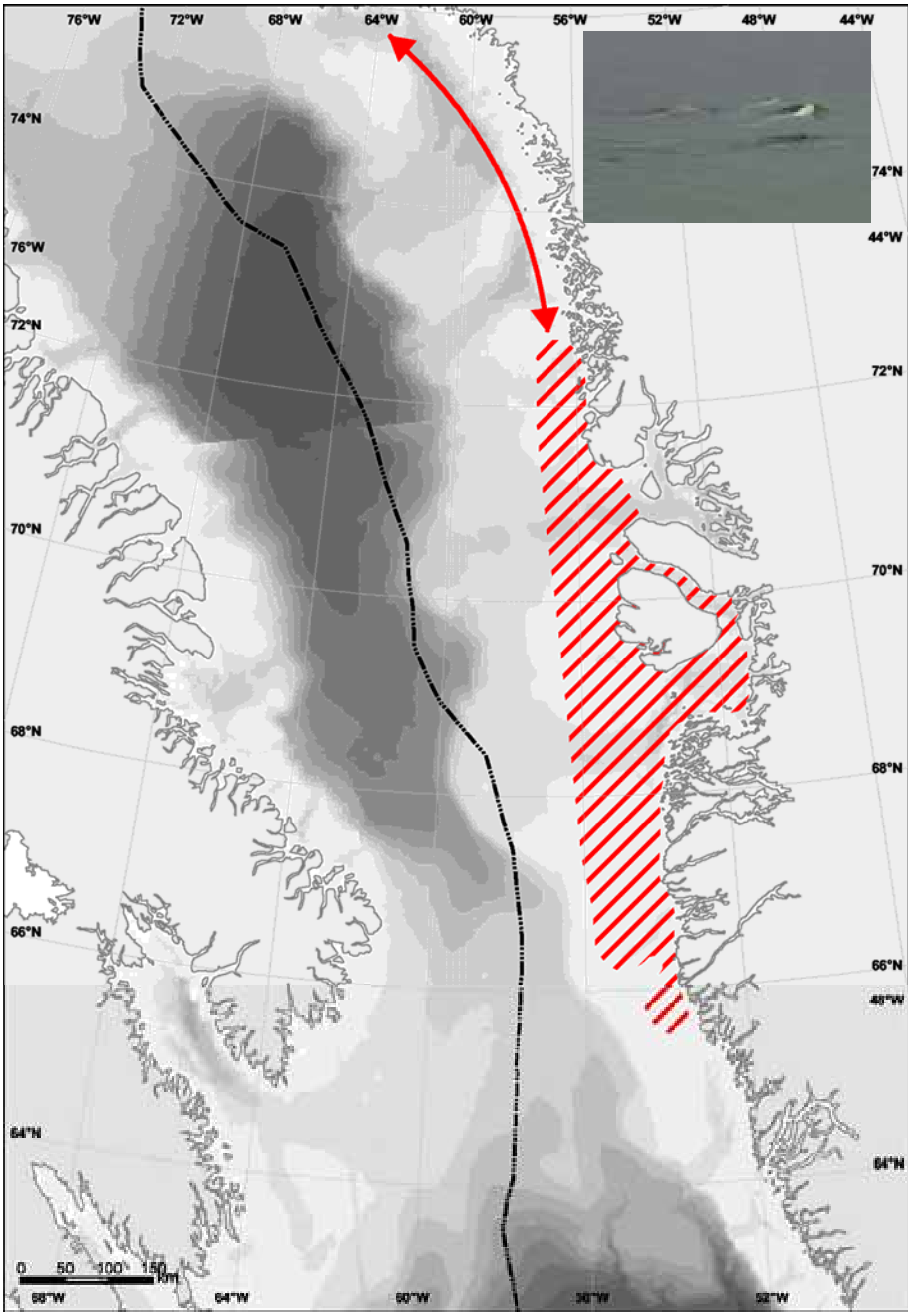


Figure 37. Distribution and migration routes of wintering white whales in West Greenland. The whales are present in October through May. During summer the white whales are in high Arctic Canada (Based on Heide-Jørgensen et al. 2003).



Bowhead whale

Bowhead whales are winter and spring migrant visitors in the assessment area, occurring from February (probably earlier in the southern parts) until late May/early June. Departure from the area initiates in mid-May. The whales stay mainly in the marginal zone of the West Ice and in the waters south of Disko Island. Recent satellite tracking has shown that they move from West Greenland across the Baffin Bay to the waters of the high Arctic Canadian archipelago, and from there along Baffin Island to winter quarters in the Hudson Strait (Heide-Jørgensen & Laidre in prep.). Bowhead whales were heavily exploited by European and North American whalers until 1932 when the whales became protected. At this time the stock was very small, and it still is, although there are now signs of a slow recovery. The bowhead whale is globally red-listed as conservation dependent and regionally listed as 'endangered' in Canada and as 'near threatened (NT)' in Greenland. The total Baffin Bay/Davis Strait population numbers probably a few thousands individuals, of which perhaps a thousand occur in Greenland waters.

Bowhead whales are specialised copepod feeders and, in the assessment area, exploit dense concentrations of *Calanus* near the seabed. Tagging has shown that dive depths range from 12 m to 487 m for individual whales in the assessment area (Heide-Jørgensen & Laidre in prep.). Thirty whales have been equipped with satellite tracking instruments in the period 2001-2006, and their movements within the assessment area are shown in Figure 38. These trackings also make it possible to calculate the area usage for different periods, which reveals an area of concentration off south Disko Island (Figure 39). It is of special concern that 85% of the whales (n=93) that have been sex determined are females and all of mature length but usually without calves. It is suspected that the assessment area is a major foraging ground for pregnant or resting females from the entire Canada-Greenland population of bowhead whales.

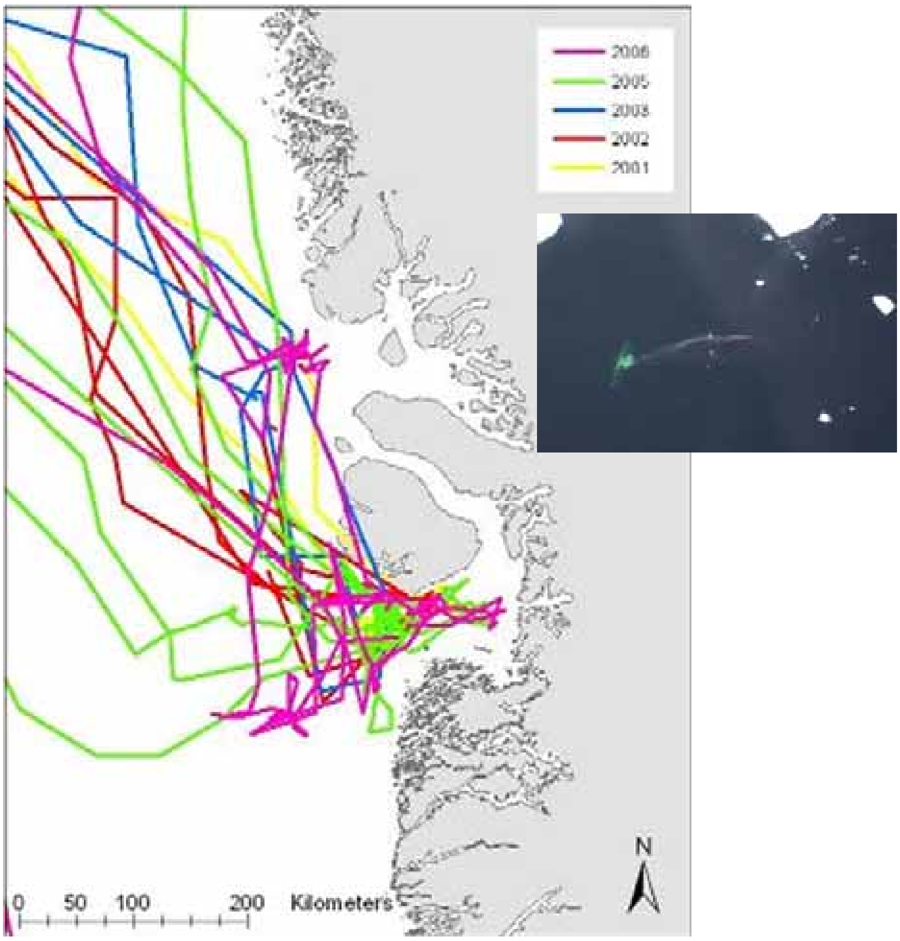
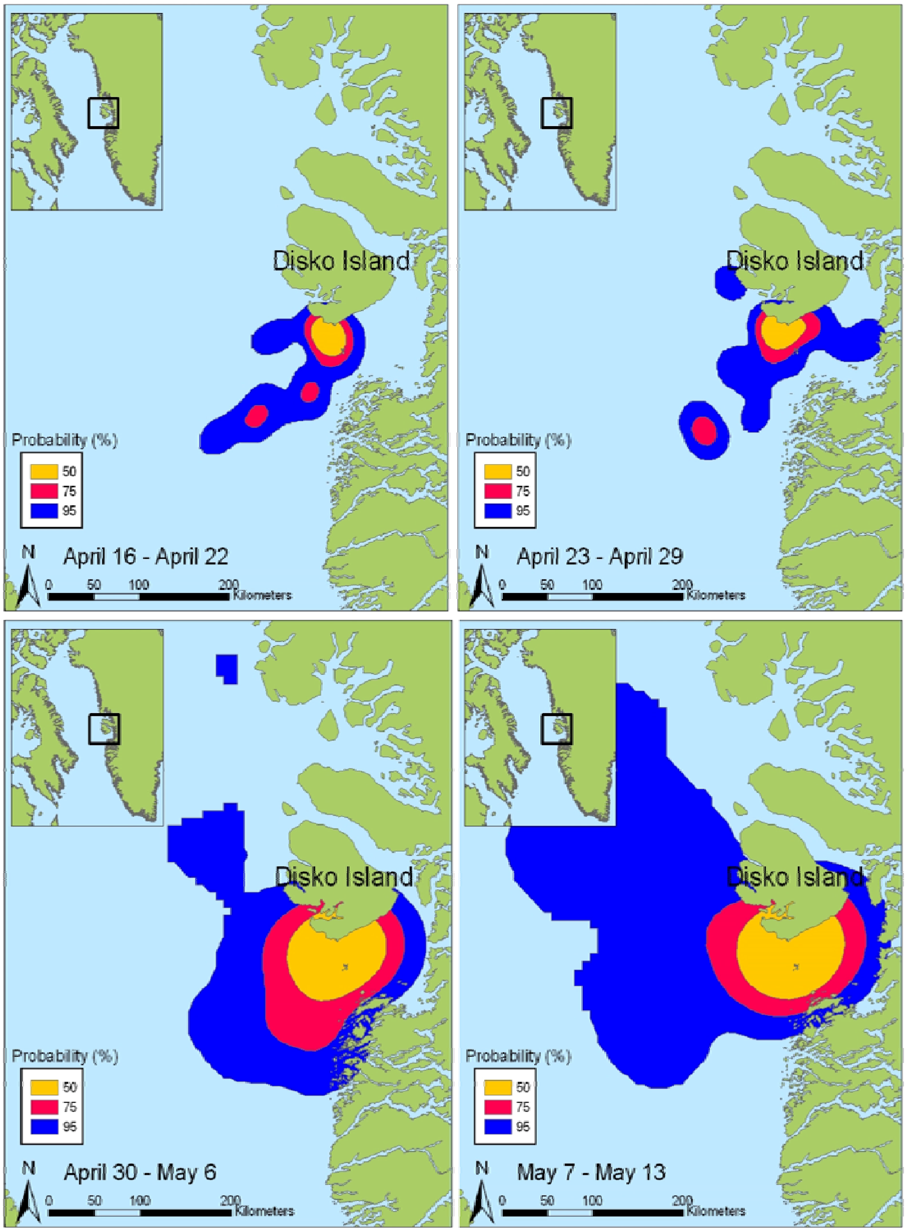


Figure 38. Tracks of bowhead whales departing Disko Bay between 2001 and 2006 in spring during their migration towards Canada in May-June (Heide-Jørgensen & Laidre 2006).

Figure 39. Area usage (kernel home ranges) mid-April to mid-May by bowhead whales tracked by satellite in 2001-2006 (n=30) (Heide-Jørgensen & Laidre in prep.). Within the yellow area there were a 50% probability of finding the whales, within the yellow and red area there were a 75% probability and within the yellow, red and blue area there were a 95% probability.



Polar bear

The polar bear (*Ursus maritimus*) occurs within the assessment area when sea ice (the West Ice) is present. These bears belong to two different populations: the Davis Strait population and the Baffin Bay population, which both are shared with Canada. Many bears follow the movements of the West Ice, bringing some into the assessment area in autumn, winter and spring (Taylor et al. 2001). The Davis Strait population was in 1996 estimated at approx. 2,000 individuals and the Baffin Bay population at 2,074 individuals (Aars et al. 2006, E.W. Born pers. comm.); it is not known how many of these bears occur on the Greenland side of the border.

Polar bears are very sensitive to oiling as they are dependant on the isolative properties of their fur and because they will ingest the toxic oil as part of their grooming behaviour (Øritsland et al 1981, Geraci & St Aubin 1990). Therefore polar bears coming into contact with oil are likely to die.

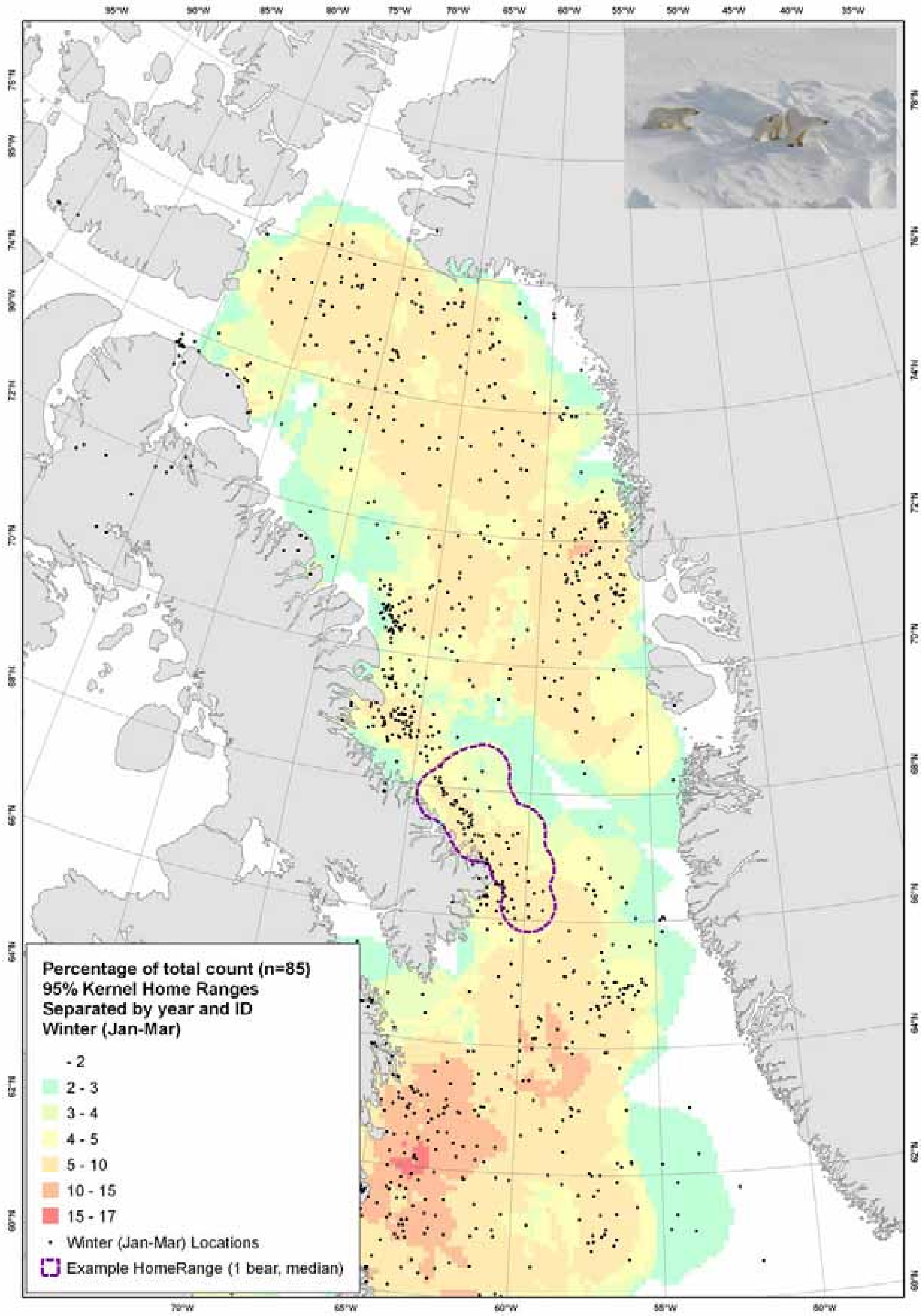


Figure 40a. Density of overlapping polar bear home ranges based on satellite tracked animals in the period 1991-2001.Colour scale indicates percentage of total number of home ranges which overlap within the single grid cells (10x10 km^2) during the season. The hatched line shows an example of a single home range. Winter situation (January– March) with 53 tracked polar bears. Black spots show locations of individual bears. Data kindly provided by Canadian Wildlife Service, Greenland Institute of Natural Resources, University of Saskatchewan, Wildlife Research Section Department of Environment (Ferguson et al. 1998, 2000; Taylor et al. 2001, 2006).

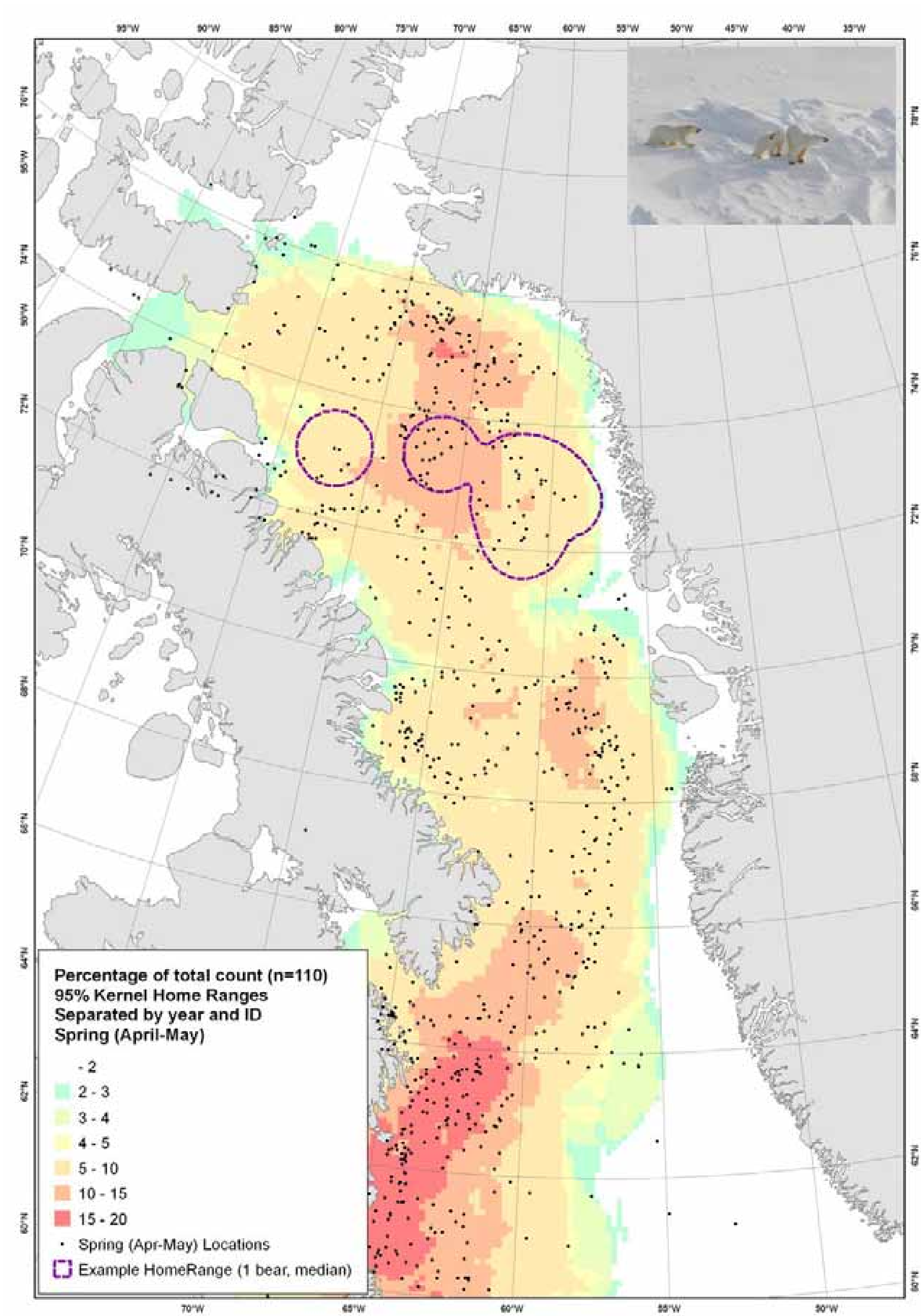


Figure 40b. Polar bear home ranges based on satellite tracked animals in the period 1991-2001. Spring (April – May) 59 tracked polar bears. See Figure 40a for explanation.

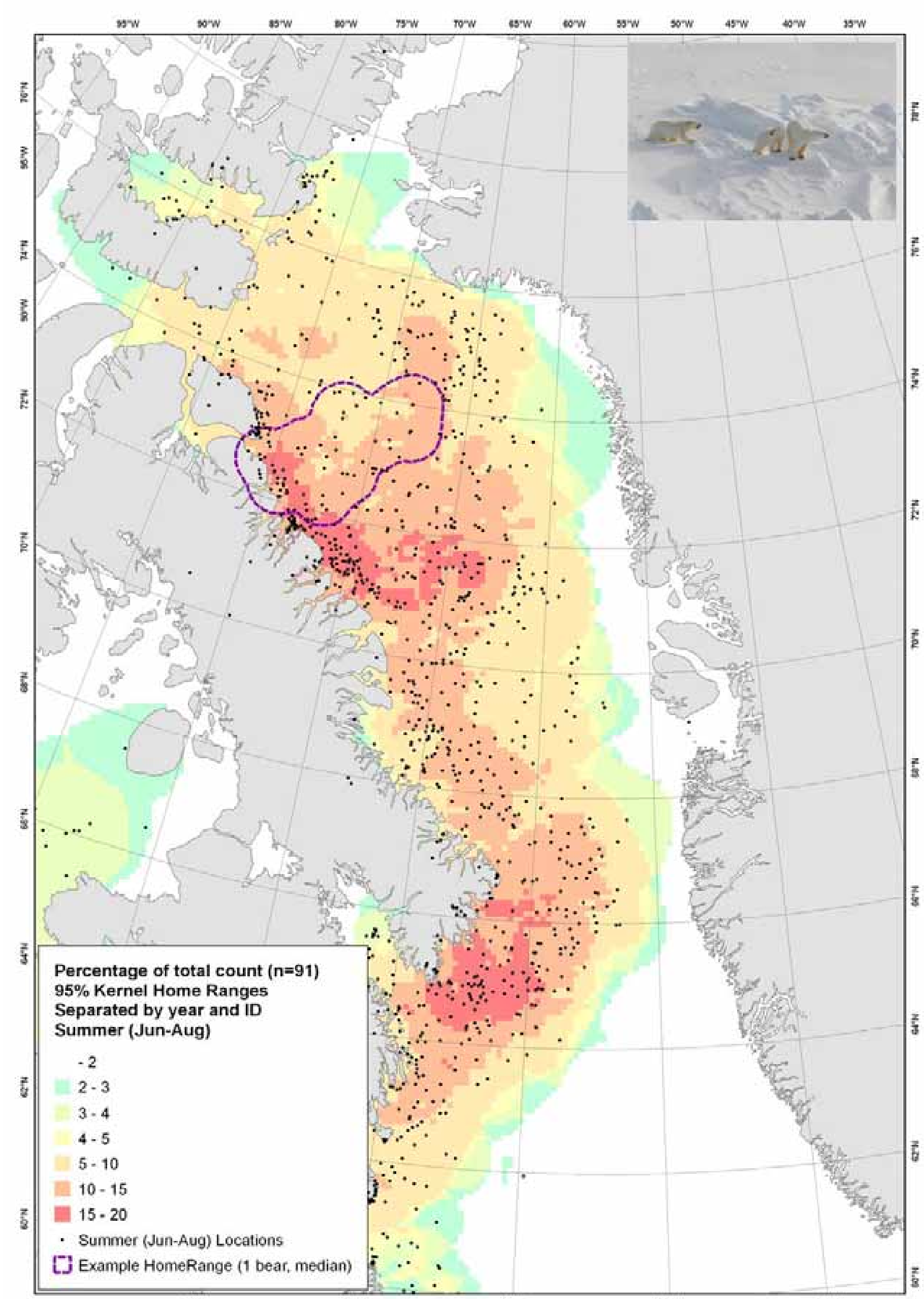


Figure 40c. Polar bear home ranges based on satellite tracked animals in the period 1991-2001. Summer (June-August) 49 tracked polar bears. See Figure 40a for explanation.

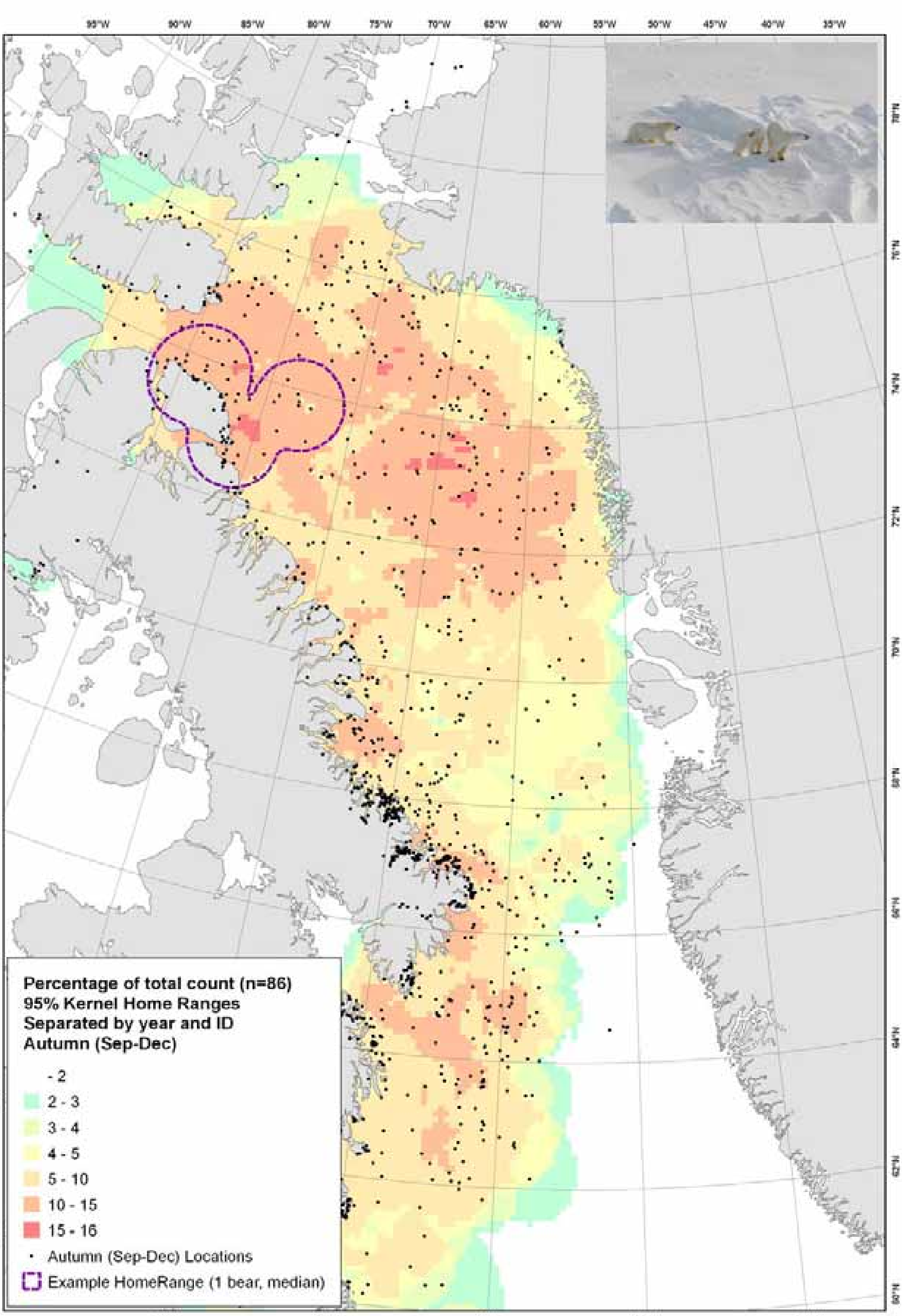


Figure 40d. Polar bear home ranges based on satellite tracked animals in the period 1991-2001. Autumn (September-December), 53 tracked polar bears. See Figure 40a for explanation.

Updated information on the occurrence and abundance of polar bears in the assessment area is not available. However, from a joint Canadian-Greenlandic population study satellite-telemetry data on polar bear movements exist for the period 1991-2001. These data allow for an estimation of the relative proportion of the Baffin Bay and Davis Strait population that may occur at various seasons inside the assessment area (Figure 40).

Recent observations and increased catches of polar bears by local hunters north of the assessment area, in Upernavik and Qaanaaq, indicate a changed distribution with higher densities near the Greenland coast (Born & Sonne 2006).