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Canadian Science Advisory Secretariat (CSAS)

Research Document 2013/069

Central and Arctic Region

Assessment of the winter range of Baffin Bay narwhals

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January 2014

Canada

Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

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Published by:

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200 Kent Street
Ottawa ON K1A 0E6

http://www.dfo-mpo.gc.ca/csas-sccs/
csas-sccs@dfo-mpo.gc.ca

ISSN 1919-5044

Correct citation for this publication:

Richard, P.R., Treble, M.A., and LeBlanc, B. 2014. Assessment of the winter range of Baffin Bay narwhals. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/069. iv + 9 p.

Aussi disponible en français:

Richard, P.R., Treble, M.A. et LeBlanc, B. 2014. Évaluation de l'aire d'hivernage des narvals de la baie de Baffin. Secr. can. de consult. sci. du MPO, Doc. de rech. 2013/069. iv + 10 p.

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ABSTRACT

Published tracking studies of narwhals have delimited two winter home ranges in Baffin Bay and Davis Strait for the Baffin Bay population of narwhals. One centres in northern Davis Strait and southern Baffin Bay, the “southern narwhal over-wintering area”, which is in large part within Canadian waters, and contains Canadian narwhal summering stocks from Admiralty Inlet and Eclipse Sound, and the Greenland narwhal stock from Melville Bay. New tracking data from narwhals tagged in Admiralty Inlet suggest that the narwhals that summer there use the southern wintering area annually. Animals in the southern wintering area forage at depths over 1,000 m and it appears that a large part of their diet is composed of Greenland Halibut, estimated at about 86,000 t of Greenland Halibut per annum. The second wintering area referred to as the “northern narwhal over-wintering area” is largely inside Greenlandic waters of central Baffin Bay and is used by narwhals from the Somerset Island summering stock. Animals in the northern wintering area appear to have a smaller proportion of Greenland Halibut in their diet, but the larger number of animals wintering there could still require in excess of 100,000 t of that species.

RÉSUMÉ

Des études publiées sur le suivi des narvals délimitent deux aires d'hivernage dans la baie de Baffin et le détroit de Davis pour la population de narvals de la baie de Baffin. L'une de ces aires est concentrée dans le nord du détroit de Davis et le sud de la baie de Baffin (secteur sud de l'aire d'hivernage des narvals), ce qui se trouve en grande partie en eaux canadiennes. Elle accueille des stocks canadiens de narvals estivants provenant de l'inlet de l'Amirauté et du détroit d'Eclipse, de même que le stock groenlandais de narvals provenant de la baie de Melville. De nouvelles données de suivi de narvals marqués dans l'inlet de l'Amirauté laissent entendre que les narvals qui y passent l'été utilisent tous les ans le secteur sud de l'aire d'hivernage. Les animaux dans le secteur sud de l'aire d'hivernage s'alimentent à plus de 1 000 m de profondeur, et il semble qu'une grande partie de leur régime alimentaire soit composé de flétan noir; on estime que les stocks consomment environ 86 000 t de flétan noir chaque année. L'autre aire d'hivernage (secteur nord de l'aire d'hivernage des narvals) se situe majoritairement dans les eaux du Groenland dans le centre de la baie de Baffin, et elle est utilisée par le stock estivant de narvals provenant de l'île Somerset. Les animaux dans le secteur nord de l'aire d'hivernage semblent consommer moins de flétan noir, mais les très nombreux animaux qui y passent l'hiver nécessiteront tout de même plus de 100 000 t de flétan noir.

INTRODUCTION

Interest in expanding the Greenland Halibut fisheries continues to increase in Arctic waters. There are environmental impacts of this fishery (e.g., marine mammal entanglement, ghost fishing, benthic impacts, and competition for important prey species) as well as those of the shrimp trawl fishery (e.g., benthic impacts) that occur in Baffin Bay and Davis Strait though the magnitude and extent of these impacts are unknown. Currently there is a fishing closure area for the Greenland Halibut fishing fleets in North Atlantic Fisheries Organization (NAFO) Division 0A meant to protect winter feeding habitat of narwhals. The area is on the slope of southern Baffin Bay, where water depths increase going north from the Davis Strait sill (~ 500 m) down to about 2,000 m (Figure 1). The slope supports an assemblage of marine fishes, with Greenland Halibut (*Reinhardtius hippoglossoides*) being dominant (Jørgensen et al. 2005), as well as a several deep-sea coral species (Gass and Willison 2005, Kenchington et al. 2010). The closure area was created to reduce fishing pressure, habitat destruction and local depletion of Greenland Halibut, narwhal's main winter prey (DFO 2007). It would also minimize gear entanglement of narwhals from both active and lost gear, protect deep-water coral and reduce gear damage to bottom fauna (DFO 2007). The fishing closure boundaries were based on the best information available in 2006. The current closure targets an area where several stocks of narwhals overlap in winter and where deep-sea corals are also found.

DFO Resource Management has asked for a review of the over-wintering information for Baffin Bay narwhals to evaluate the existing NAFO Division 0A fishing closure boundaries.

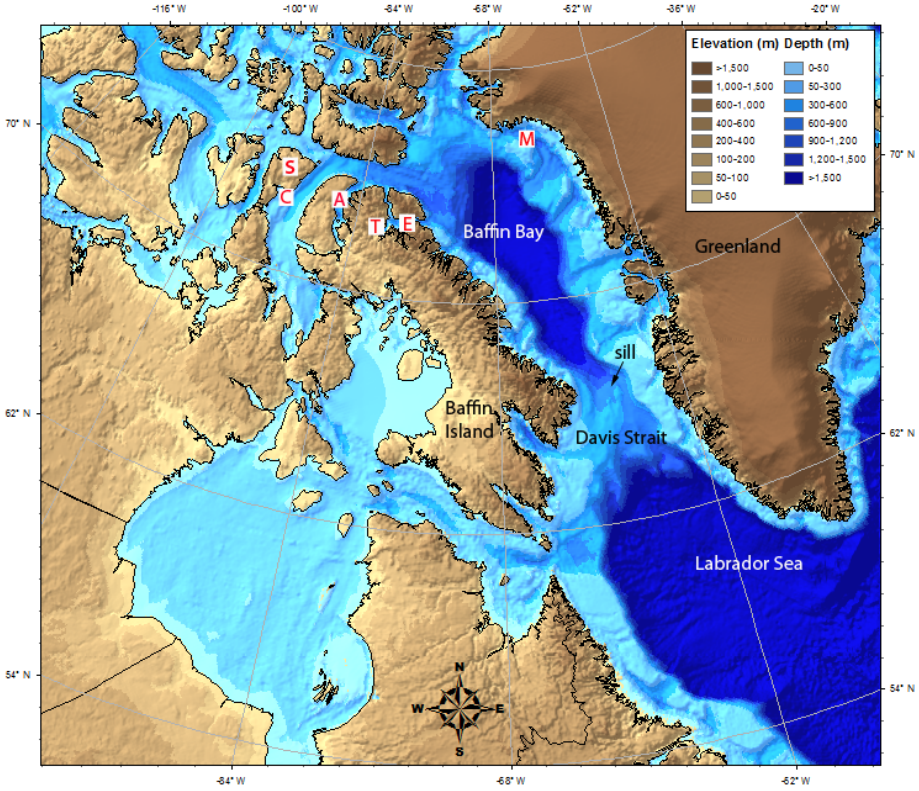

Figure 1. Map of the eastern Canadian Arctic with S – Somerset Island, C – Creswell Bay, A – Admiralty Inlet, T – Tremblay Sound, E – Eclipse Sound, and M – Melville Bay.

METHODS

A literature review was conducted to assess past tracking and biological research on narwhals. Pertinent results are summarised below.

New tracking data of Admiralty Inlet narwhals tagged in August 2009 was examined to determine at what dates animals became more sedentary in late fall and when they started moving again in spring. Latitude and longitudes were plotted over time to determine dates when movements became reduced in late fall and when they increased again in spring. The 12 Nov 2009 (Julian day 315) was selected as the date of the start of over-wintering and the 28 March 2010 (Julian day 86, shown as 451, or 86 + 365) as the end date (Figure 2).

Estimated locations were obtained from the tracking data using a Bayesian switching state-space model (Jonsen et al. 2005, 2007, Luque 2008) which estimates locations at regular intervals from the irregular data of all ARGOS location classes, except Z. The tags were duty-cycled to transmit all day every fourth day so an interval of 4 days was used to estimate each location. Fixed kernel probability polygons (50 percentile (pc), 75 pc and 95 pc) (Worton 1989, 1995, Hooge and Eichenlaub 1997, Hooge et al. 1999) were obtained from the estimated locations. Table 1 lists the tags used in the analyses.

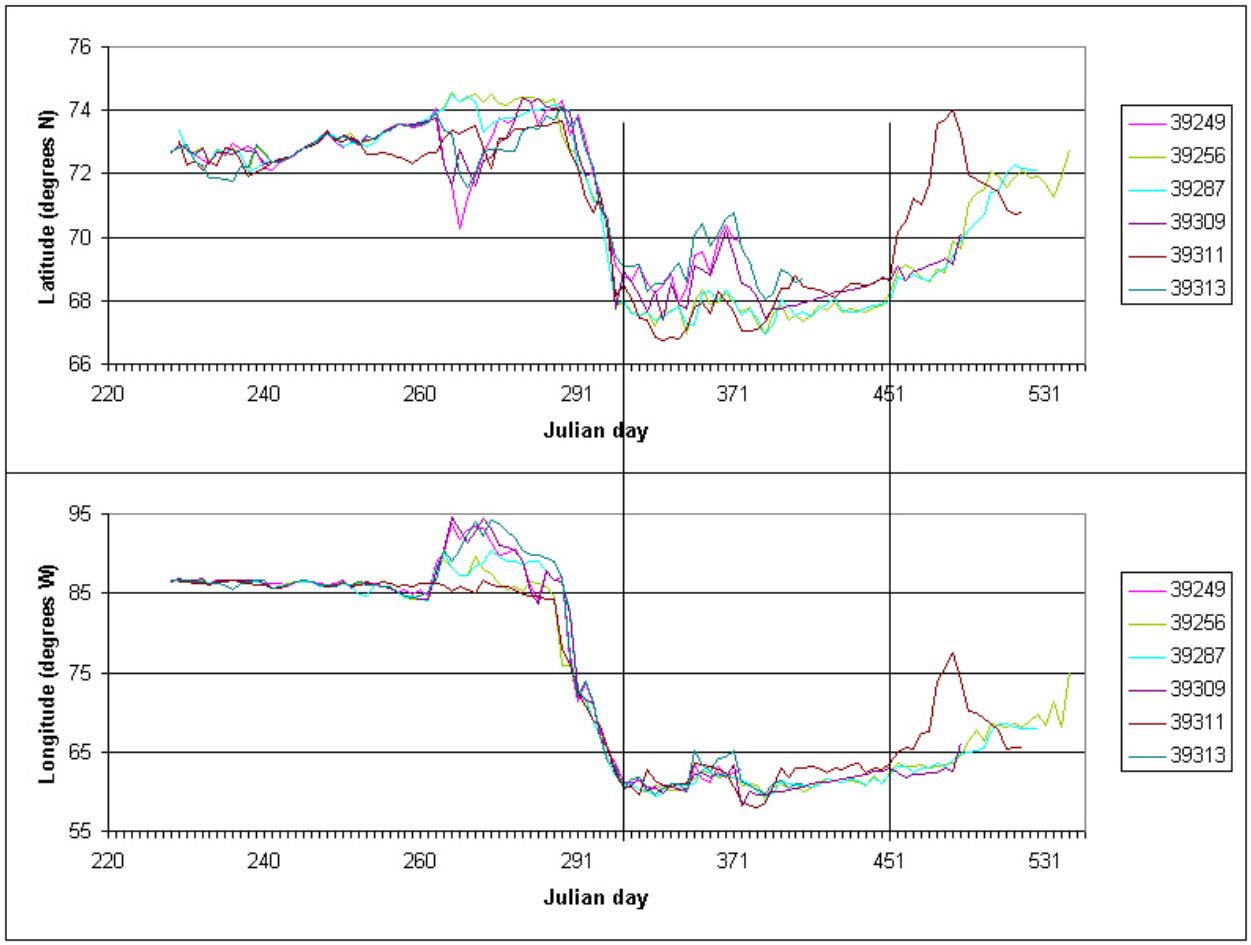

Figure 2. Latitude and longitude of tracked 2009 Admiralty Inlet narwhals over Julian day. The vertical lines represent the cut-off dates used for the winter home range estimation.

Table 1. Tracked 2009-2010 Admiralty Inlet narwhals. The IDs with an asterisk are tags that lasted long enough (see Figure 2) to be used for the winter home range estimation.

Tag ID	Sex	Length (cm)	Start date (mm-dd-yy)	End date (mm-dd-yy)	Tag duration (days)
39249	F	386	08-19-09	01-10-10	145
39256*	M	450	08-19-09	07-05-10	321
39287*	M	439	08-17-09	06-11-10	299
39290	F	374	08-15-09	02-23-10	193
39309*	M	377	08-16-09	04-28-10	260
39311*	M	307	08-17-09	06-03-10	291
39313	F	391	08-16-09	02-11-10	180

RESULTS AND DISCUSSION

Published tracking research on Baffin Bay narwhals has been conducted since 1997 with projects conducted in Tremblay Sound, Baffin Island, in 1998 and 1999; Creswell Bay, Somerset Island, in 2000 and 2001; and in Admiralty Inlet, Baffin Island, in 2003 and 2004 (Dietz et al. 2008). It was observed that narwhals from Admiralty Inlet as well as from Melville Bay and Tremblay Sound over-winter in northern Davis Strait and southern Baffin Bay, identified as the “southern narwhal over-wintering area” (Dietz et al. 2001, Heide-Jørgensen et al. 2002) but narwhals from Somerset Island (Creswell Bay) over-wintered further north in central Baffin Bay, identified as the “northern narwhal over-wintering area” (Heide-Jørgensen et al. 2003). The northern over-wintering area lies largely within Greenland waters, while the southern area lies primarily within Canadian waters (Figure 3).

An examination of dive behaviour data showed that the number of surface dives (0 to 50 m) and time at the surface declined between summer and winter and clear differences were noted between the two over-wintering areas (Laidre et al. 2003). In the northern over-wintering area, narwhals spent most of their time diving to depths between 200 and 400 m while narwhals in the southern over-wintering area spent less time at shallow depths and most of their time diving to 800 m or deeper, spending over three hours at these depths per day and traveling 13 minutes per round trip to reach these depths (Laidre et al. 2003).

Stomach contents of narwhals harvested in eastern Canadian high Arctic and West Greenland were examined to assess feeding activity and prey selection (Laidre et al. 2004a, Laidre and Heide-Jørgensen 2005). Stomachs collected from summer harvests contained Arctic Cod, Polar Cod and squid but most were found to be empty. In winter, Greenland Halibut, squid and shrimp were most common with Greenland Halibut constituting a significant resource, observed in 51% of 49 stomachs and often the only prey species identified in completely full stomachs (Laidre and Heide-Jørgensen 2005).

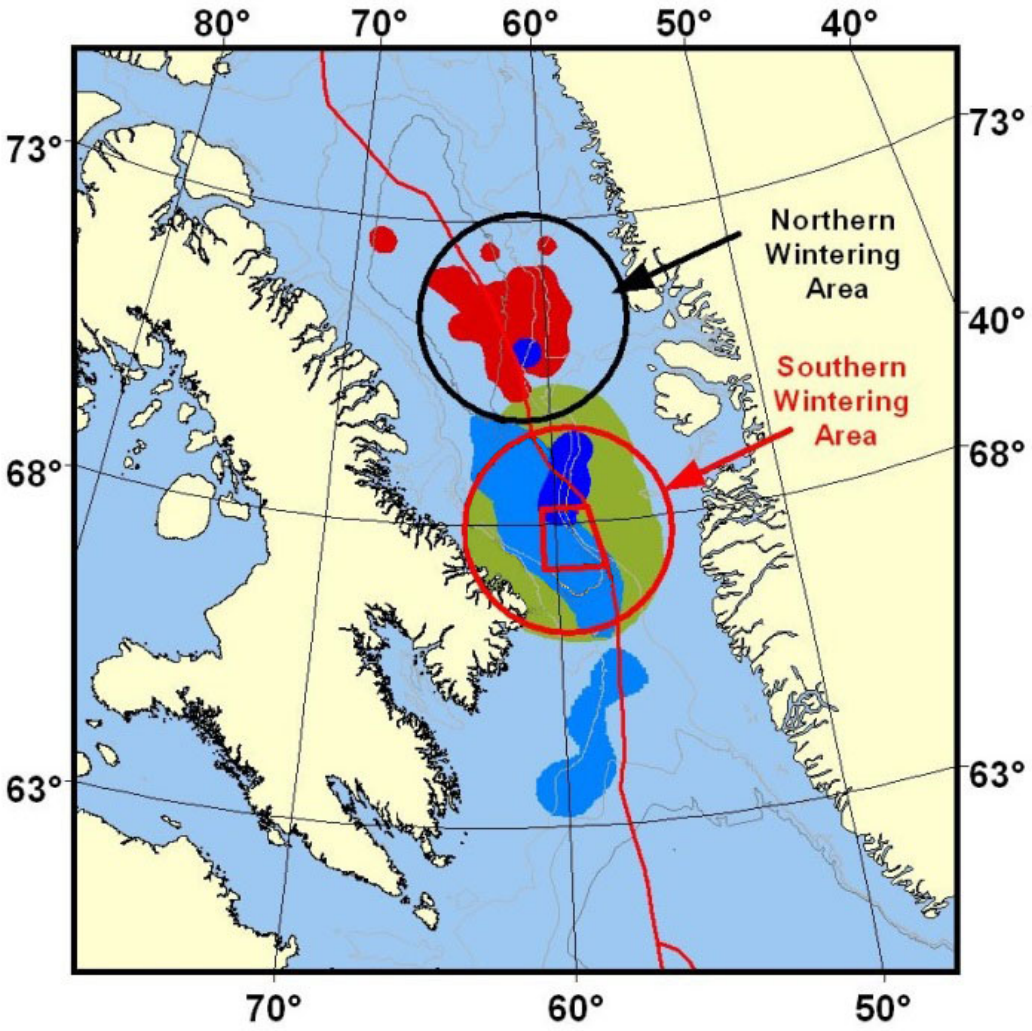

Figure 3. Published winter home ranges of tracked Baffin Bay narwhals (reproduced from Dietz et al. 2008). Filled coloured polygons represent the estimated 95 percentile kernel home range of different summering stocks: Somerset Island (red), Admiralty Inlet (light blue), Eclipse Sound (green), Melville Bay (dark blue). The Somerset Island narwhals are in what has been referred to as the "northern narwhal over-wintering area" and the other stocks are in the "southern narwhal over-wintering Area". The thick red polygon represents the area closed to Greenland Halibut fishing in NAFO Division 0A. Bathymetric contours are indicated (500, 1000, 2000 m).

A bio-energetic model was used to estimate the biomass of Greenland Halibut needed to sustain the stock(s) for the five months that they spend on their winter areas (Laidre et al. 2004a). Mean densities and length distributions of Greenland Halibut inside and outside of the narwhal wintering areas were correlated with predicted whale predation levels based on diving behaviour (Laidre et al. 2004a). For the southern wintering area, which is estimated to have about 26,000 narwhals from the Admiralty and Eclipse Sound stocks (Richard et al. 2010) if the diet was comprised of 50% Greenland Halibut the stocks would require 468 t of Greenland Halibut per day with a mean consumption over five months of over 70,000 t. Adding the third stock from Melville Bay, Greenland (Heide-Jørgensen et al. 2010) to this over-winter area the revised mean estimate is 32,000 narwhals and the mean estimated daily consumption would be

approximately 576 t with a mean consumption over five months of over 86,000 t. The northern over-wintering area supports a larger number of whales (approximately 45,000 in 1996) and was estimated to require 700 t per day with a mean consumption over five months of 110,700 t. This estimate for the northern over-wintering area was greater than the abundance of Greenland Halibut estimated in a 2001 survey (36,416 t, Jørgensen 2003), suggesting that Greenland Halibut do not play the same role in the diet of narwhals in the northern area as they do in the southern area (Laidre et al. 2004a). The difference in dive behaviour between the two wintering areas also supports this conclusion.

Predators are thought to congregate at predictable sites in response to elevated availability of prey resources driven by physical oceanographic processes (Laidre et al. 2004b). Marine trophic interactions are complex and many important variables are not easily measured therefore, physical habitat features such as depth or bottom temperature are often used as proxys for the distribution of prey resources. This was examined by Laidre et al. 2004b, who noted that bottom temperature on the west side of Baffin Bay rarely exceeded 1°C while bottom temperatures were much warmer on the east side, as high as 4.0 to 4.5°C. Laidre et al. (2004b) found that bottom temperature was the strongest predictor of fall and winter movements and dive behaviour of narwhals. Laidre et al. (2004b) reported that narwhal on their wintering grounds selected the bottom temperature range and gradient that often coincided with areas of concurrent high density of Greenland Halibut.

Dietz et al. (2008) summarized the wintering home range of tracked narwhals from several Canadian and Greenlandic stocks: Somerset Island, Admiralty Inlet, Eclipse Sound and Melville Bay (Figure 3). Admiralty Inlet narwhal winter range data were obtained from more recent tracking data (2009) (Figures 4, 5). The results indicate that the winter range of Admiralty Inlet narwhals was centered roughly in the same area in the winter of 2009-2010 as in the winters of 2003-2004 and 2004-2005, and overlapped with the winter ranges of other stocks in the southern winter area. These results lend further support to the hypothesis that narwhal winter ranges in Baffin Bay are relatively consistent, even if some individuals occasionally may spread out from the main aggregation within the home range (Dietz et al. 2008).

The current area closed to Greenland Halibut fishing in NAFO Division 0A (Figures 3-5) protects a small portion of the southern narwhal wintering area and overlaps a portion of the range of several narwhal stocks.

SOURCES OF UNCERTAINTY

There are a number of sources of uncertainty about estimates of narwhal consumption of Greenland Halibut. They are based on the reasonable but untested assumption that the percentage of Greenland Halibut in the narwhal diet in the wintering areas is similar to the percentage in stomachs of narwhals caught in Disko Bay outside of the wintering areas. In addition, the estimates of narwhal numbers are mean estimates with no estimation error. The calculations are only included to emphasize the importance of Greenland Halibut in narwhal winter ecology. Note that the estimates are different from those presented in DFO (2007) or in Laidre et al. (2004a, b) because there have been new estimates of the narwhal stocks since those documents were released.

Another source of uncertainty is the small sample size of animals tracked compared to the total population size. While there is consistency between years in the wintering range of tracked animals, there were two animals from Admiralty Inlet that ranged further south than the rest. A larger sample size of tracked narwhals, including narwhals from other summering stocks, may show further departures. Tracking over a longer time period might also yield more year-to-year variation than is apparent from the new tracking data and the past tracking studies.

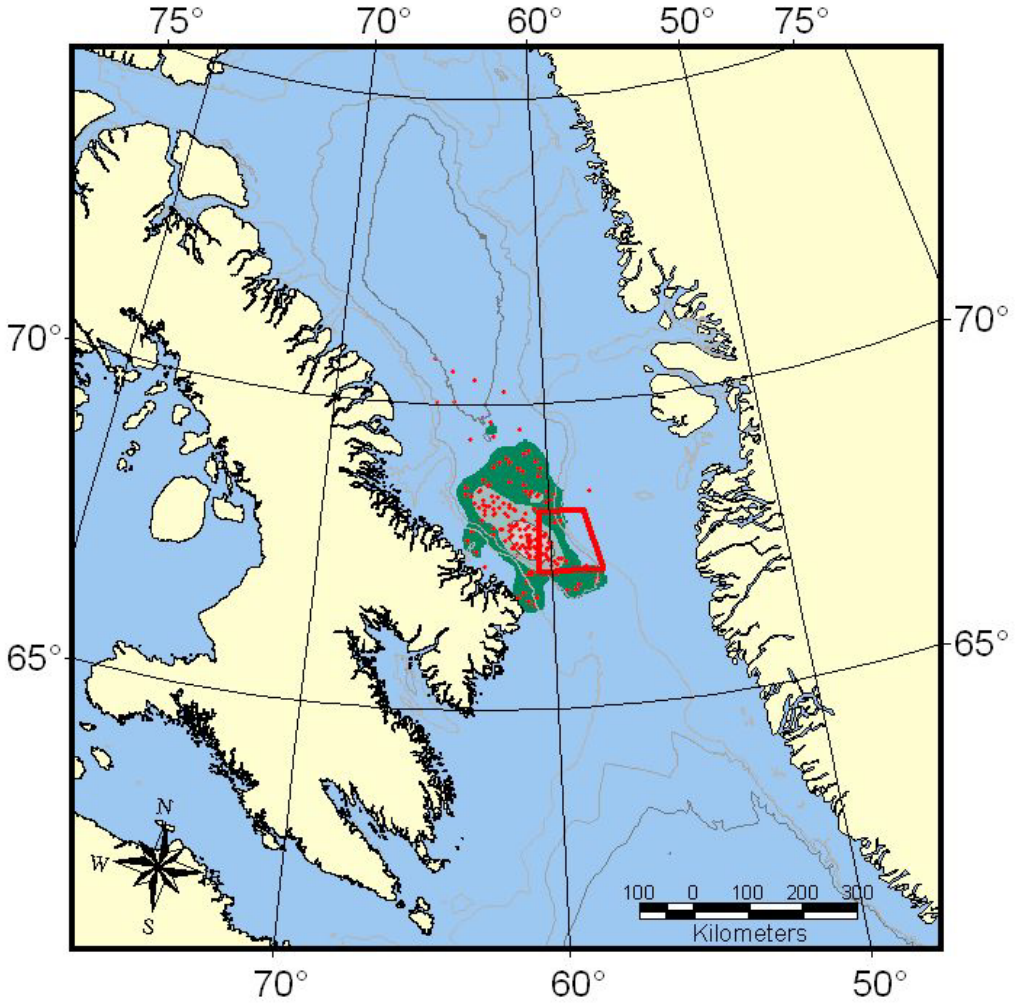

Figure 4. Admiralty Inlet 2009-2010 winter home range. Filled coloured polygons represent the 95 percentile (dark green), 75 percentile (light green) and the 50 percentile (pink). The red dots represent the locations used to estimate the kernel home range. The thick red polygon represents the area closed to Greenland Halibut fishing in NAFO Division 0A. Bathymetric contours are indicated (500, 1000, 2000 m).

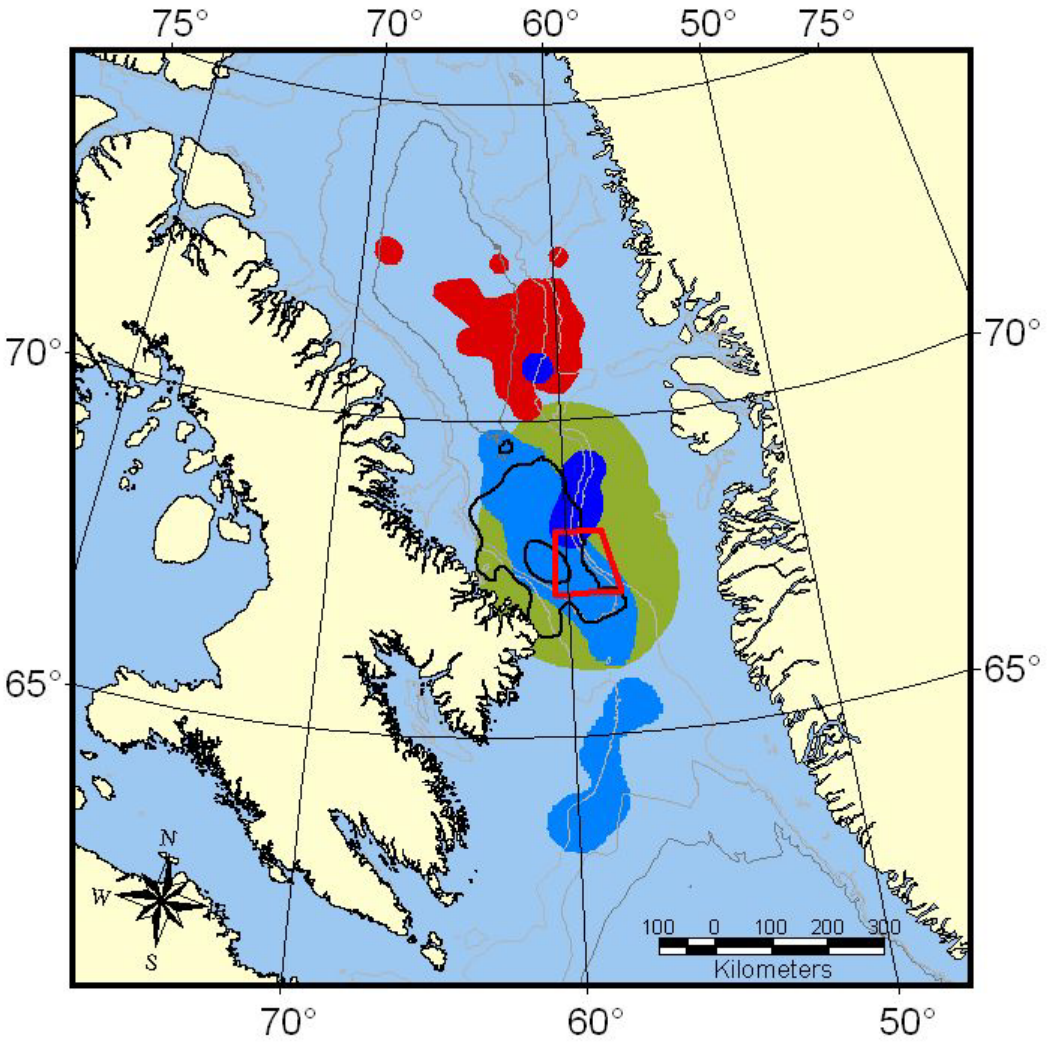

Figure 5. Admiralty Inlet 2009-2010 home range (black open shapes) superimposed on winter home ranges from Dietz et al. (2008) (Figure 3). Filled coloured polygons represent the estimated 95 percentile kernel home range of different summering stocks: Somerset Island (red), Admiralty Inlet (light blue), Eclipse Sound (green), Melville Bay (dark blue).The central black outline shows the 50 percentile and the outer outline the 95 percentile. The thick red polygon represents the area closed to Greenland Halibut fishing in NAFO Division 0A. Bathymetric contours are indicated (500, 1000, 2000 m).

ACKNOWLEDGEMENTS

Many thanks to Rune Dietz for sharing the shapefiles used in his paper. We also are indebted to Mads Peter Heide-Jørgensen and Kristin Laidre whose efforts are reflected in the shapefiles and whose studies of narwhal winter feeding have allowed the present analysis.

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