# Quotas on Narwhal (*Monodon monoceros*) Hunting in East Greenland: Trends in Narwhal Killed per Hunter and Potential Impacts of Regulations on Inuit Communities

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**Abstract** This study evaluates the introduction of quotas on narwhal hunting in East Greenland with respect to effects on Inuit culture and based on trends in narwhal killed per hunter and assessment of migration patterns. Cultural aspects were assessed through group discussions and comparison between East and Northwest Greenland. Trends in narwhal killed/hunter were modeled from catch statistics using information on number of hunters and climate and ice cover data for the period 1993-2004. Results indicate negative impacts of quotas on Inuit culture; did not detect negative trends in narwhal killed/hunter; and suggest southwest-bound migration, implying potential immigration from non-hunted populations that was not considered in quota setting. The implementation of quotas without local consultations and legal basis in the relevant executive order is therefore in our opinion inappropriate. Conservation and sustainable use of narwhal stocks may be more likely to succeed if local communities are involved through comanagement agreements.

**Keywords** Small whale hunting · Hunting quotas · Traditional culture · Ice cover trends · Co-management

We hereby declare that this manuscript is our original work, that it is not being submitted elsewhere, that both authors agree with the contents and to the submission, and that all appropriate ethics were followed during the research.

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# Introduction

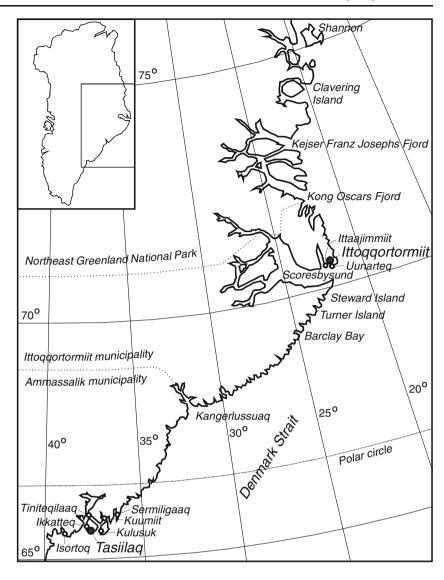
Narwhals occur in East Greenland from 64° N latitude to at least 77° N latitude (Dietz *et al.* 1994). Known summer concentrations are found mainly in Ittoqqortormiit (Scoresby Sound), Kangerlussuaq and Sermilik where harvesting takes place (Dietz *et al.* 1994; NAMMCO 1999) (see Fig. 1). South of Scoresby Sound narwhals are observed along Blosseville coast and particularly at Steward and Turner Island and in Barclay Bay (Aastrup *et al.* 2005). Winter locations are poorly known (Born 1983) but it is assumed that narwhal landed in East Greenland are taken from a larger stock wintering in the Greenland Sea (Gjertz 1991; NAMMCO 1999). Little is known about stock delineation and migration routes (Heide-Jørgensen *et al.* 2010).

Until recently the only attempt to estimate the size of narwhal populations in East Greenland was in Scoresby Sound fjord in 1984 and 1985 (Larsen *et al.* 1994). But in the summer of 2008 two surveys were conducted. One provided an abundance estimate of 6,583 (95 % CI 2,541-17,052) narwhals south of Ittoqqortormiit (Heide-Jørgensen *et al.* 2010) whereas a survey further north generated too few observations (Boertmann *et al.* 2009). Narwhal catches in East Greenland have been increasing (JCNB/NAMMCO 2005; Heide-Jørgensen 2009) but sustainability is presumably ensured by the large area from which the whales are recruited relative to the restricted areas where hunting is conducted (NAMMCO 1999).

In 2004 the Greenland Home Rule Government strongly influenced by NAMMCO and various NGOs, introduced quotas on hunting of all West Greenland narwhal stocks, with basis in the executive order on protection and hunting of beluga and narwhal (GHRG 2004). Henceforth a license for the species and period is required in order to hunt narwhal, in addition to a hunting permit. Hunters in East



Fig. 1 Map of the study area and its location within Greenland



Greenland have contested the idea of quotas, which is seen as unfair and damaging to traditional culture, particularly under circumstances where scientific advice is limited or lacking. However, in 2008 the now Greenland Self Rule Government decided to implement quotas in East Greenland without the required legal basis in a new executive order on protection and hunting of beluga and narwhal (GHRG 2004. See section 3, subsection 4). Quotas were set at 85 whales annually based on biological advice using the 2008 estimate of abundance but without considering potential immigration from the non-hunted source population along the coast of the Northeast Greenland National Park, north of Ittoqqortormiit. The quotas were also implemented without any attempts to involve local communities through consultation or establishment of comanagement agreements.

Based on the concerns expressed by the hunters the objective of this study is to evaluate the potential cultural implications and examine the biological justification for the introduction of quotas on narwhal hunting in East Greenland.

This is done to determine whether there are clear indications that the narwhal stock is under a pressure that merits imposition of quotas apparently without consideration of local impacts and without backing in the relevant legislation. The implications of quotas and hunting regulations for local livelihoods and traditional culture are evaluated through a comparison of attitudes and opinions (no household socioeconomic data is available) between communities in East and Northwest Greenland to determine whether adverse consequences occur that should be weighed against the justification for implementing this new initiative. Trends in narwhal killed per hunter (which is the only available data) are examined as an indicator of stock trends to determine whether there is reason for concern for narwhal stocks that would justify this drastic way of implementing quotas. Migration patterns are examined (based on timing of kills for lack of other information) as indicators of stock range to assess the potential for immigration of narwhals from outside the area where harvesting takes place. Finally we briefly suggest a number of management recommendations



based on the results. This includes specific management responsibilities that could be devolved to local institutions in comanagement arrangements. We do not, however, suggest devolving quota setting or quota allocation responsibilities.

This manuscript is thus a contribution to a particular category of management literature dealing with data-poor but highly important issues, not only with respect to the stock in question but also to people's livelihoods and traditional culture. The study does not attempt to determine whether narwhal hunting in East Greenland is sustainable. This is impossible using the data available and we acknowledge that narwhal killed/hunter has its limitations as a proxy of animal abundance, the use of which is necessitated purely by lack of better information on hunting effort as well as lack of regular monitoring of stocks (cf. above), constraining the usefulness of surveys for identifying short-term population trends. However, an accurate sustainability assessment is not necessary in relation to the objective of this study. Here it suffices to show that there is no immediate reason for concern for narwhal stocks, which could justify introduction of quotas without consultations and consideration of relevant communities' livelihoods and traditional culture, and without backing in the relevant legislation. Furthermore we do not argue against the use of quotas as a wildlife management tool where appropriate. Restrictions on local and indigenous populations' use of natural resources have, however, often been implemented based on limited scientific evidence with reference to the precautionary principle (see for instance Dowsley 2009). Where locally generated data such as kills/hunter, local ecological knowledge etc. is available to assist informed management decisions, this should be used albeit acknowledging its limitations. In addition, affected communities should be involved and consulted in the process. We feel that this is an example where these basic guidelines have been ignored and that this should be brought to attention. This study should thus be seen as a small Arctic contribution to the literature on the effect of conservation initiatives on local livelihoods (i.e. Brockington and Igoe 2006; Cernea and Schmidt-Soltau 2006).

### Methods

Interviews and Group Discussions

To assess the implication of quotas, regulations and management procedures, semi-structured (or guided) focus group discussions were conducted with the board and members of local occupational hunter's organizations (KNAPK), part-time hunters organizations (TPAK), municipal councils or village boards (depending on the nature of the location) and at public meetings in selected communities in East and Northwest Greenland. In addition semi-structured interviews

were conducted with individual hunters. Communities in Northwest Greenland were selected to be comparable to East Greenland communities by primarily being small and remote communities with high narwhal catch and few sources of formal employment (i.e. no fishing industry and limited tourism). Focus group discussions, meetings and interviews were conducted first in Northwest Greenland in Siorapaluk, Qaanaaq, Upernavik and Kullorsuaq between 30 November and 11 December 2006 (as fieldwork was conducted before the recent municipal restructuring (in 2009) we use the original names of the municipalities). Similar meetings were conducted in East Greenland in Ittoqqortormiit, Sermiligaaq and Tasiilaq between 6 and 21 May 2007 (i.e. before quotas were implemented). The number of people participating in the various meetings depended on the type of the relevant organization and corresponded roughly to the size of the community (see Table 1). Semi-structured interviews were conducted with two individual hunters in each community except Siorapaluk and Sermiligaaq, because the small size of these communities meant that group discussions and public meetings included most hunters in the communities. The interviewees were selected from the national catch database based on their catch so that one primarily caught larger species, such as narwhal, beluga, polar bear and walrus, while the other focused on seals and birds. This research design was selected to enable collection of information from all relevant stakeholders, including individual hunters of various types, local hunter organizations, local authorities and the greater public. In all meetings and interviews the discussion focused on hunting of narwhal and on attitudes towards quotas and hunting regulations. Probing questions were asked to reveal problems perceived in relation to: distribution of quotas between various municipalities and their respective communities, distribution of licenses between occupational and part-time hunters, required preconditions for access to occupational hunter's permits and licenses to species under quotas, and the pros and cons of various hunting restrictions and regulations. Semistructured group discussions and individual interviews were selected as a research approach over more open-ended or structured methods to ensure that the required information was collected while also enabling a measure of flexibility (Bryman 2004, Lloyd-Evans 2006) and the individual interviews were included to obtain information that individuals might otherwise refrain from mentioning during group discussion. Key points raised were reviewed with the local interpreter immediately after focus group discussions for verification and validation.

Hence, with the exception of the interviews with individual hunters, the data was based on translations from often very lively and sometimes heated discussions in Greenlandic (a highly descriptive 'polysynthetic' language of the Inuit-Aleut family) to Danish. Due to the inherent problems in accurate translation under these circumstances and between



**Table 1** Number of participants in meetings with KNAPK, TPAK, municipal councils or village boards and public meetings and the number of individual hunters interviewed in Northwest and East Greenland. The last two columns show the number of occupational and part-time hunters permits issued and the total number of

inhabitants in the towns/villages. Only Upernavik had a local branch of TPAK and no meeting was conducted with KNAPK in Tasilaq as it had been dissolved. No meeting was conducted with the municipal council and only one individual hunter was interviewed in Upernavik as the team stranded 16 days in Kullorsuaq due to bad weather

|                    | KNAPK       | TPAK | Individual interviews | Municipal / village authorities | Public meetings | Total hunters<br>(Occupational /<br>part time) | Total population |
|--------------------|-------------|------|-----------------------|---------------------------------|-----------------|--|------------------|
| Qaanaaq municipa   | ality       |      |                       |                                 |                 |  | _                |
| Qaanaaq            | 4           | ÷    | 2                     | 4                               | 19–21           | 31/78  | 640              |
| Siorapaluk         | 12          | ÷    | 0                     | 4                               | *               | 16/7   | 60               |
| Upernavik munici   | pality      |      |                       |                                 |                 |  |                  |
| Upernavik          | 8           | 6    | 1                     | ÷                               | ÷               | 95/165   | 1144             |
| Kullorsuaq         | 4           | ÷    | 2                     | 4                               | 16              | 68/19  | 415              |
| Ittoqqortormiit mu | inicipality |      |                       |                                 |                 |  |                  |
| Ittoqqortormiit    | 3           | ÷    | 2                     | 4                               | 18              | 19/107   | 537              |
| Ammassalik muni    | cipality    |      |                       |                                 |                 |  |                  |
| Tasiilaq           | ÷           | ÷    | 2                     | 8                               | 14              | 33/110   | 1883             |
| Sermiligaaq        | 3           | ÷    | 0                     | 3                               | 14              | 21/17  | 220              |

<sup>\*</sup>The public meeting and the meeting with KNAPK was combined due to the low number of inhabitants in the community and because most people are occupational hunters

these two very different languages and worldviews, data consists of extensive field notes (Patton 2003; Emerson et al. 2011) rather than transcripts. Therefore, in order not to overextend our analysis by attempting an in-depth qualitative analysis we rely on comparing presence-absence of particular opinions and attitudes towards specific management procedures (e.g. was a particular regulation aspect of concern or not?). Analysis involved categorizing, collating and filtering the data in order to identify and extract themes as identified both in questions asked and responses provided. Only where we are certain that the translation was exact and captured all aspects of the statement (i.e. primarily in individual interviews) do we use quotation to support our argumentation. Furthermore, as the data is mainly based on focus group discussions and conducted in only three and four locations in East and Northwest Greenland (Table 1), respectively, there is no scope for a formal statistical comparison.

### Catch Statistics

To evaluate whether there is immediate cause for concern for narwhal stocks in East Greenland, catch statistics were extracted from the national catch database, Piniarneq, for the period 1993–2004 for all towns and settlements along the east coast of Greenland. All hunters record catches monthly and annually report it to the DFFL that manages the database. A number of records (12 out of 19,584 monthly observations (0.06 %) for 136 hunters that had caught narwhal in 1993–2004) of excessive catch, were initially excluded from the data as a precautionary measure (i.e. to

avoid inflating narwhal kills/hunter). These include 20 narwhals allegedly caught by one hunter in January 1999 and 26 by another in January 2001, both outside the narwhal hunting season. A sensitivity test was conducted to determine the implications of this exclusion. Information on number of hunters was extracted from the national hunting license register. Narwhal kills/hunter was modeled with both occupational and part-time hunters. Status as occupational hunter provides access to licenses for species under quotas, higher prices for seal skin and to financial support from the Self Rule Government for development of the hunting sector, but requires that the hunter can document that at least 50 % of his income originates from hunting and fishing. The individual hunter is thus the basic sampling unit. Prior to 1993 the catch data was not sufficiently detailed for the analysis. Furthermore, no information is available on the location of the catch, type of transportation, size of vessels or hunting methods used prior to 2003, which necessitates the use of kills per hunter as a proxy of effort. Data was therefore pooled at the municipality level.

Hunting activity and accessibility of narwhals were expected to depend on weather and ice conditions (Nielsen 2009). For this reason weather and ice conditions were taken into consideration. Available data on monthly mean temperature, precipitation and wind speed for the period was obtained from the Danish Meteorological Institute's (DMI) weather stations 4360 (Tasiilaq) and 4339 (Scoresbysund). Data on wave height was not available. Ice cover data was obtained from NASA microwave radiometers measuring radiation intensities in the microwave band (19–37 GHz)



(SMMR and SSM/I) (Maslanik and Stroeve 2008; Gloerson *et al.* 1990). Ice cover was calculated by DMI using methods described by Toudal (1999) The variation of ice cover was modelled using generalised linear models. Ice cover varies within the range [0; 1]. Thus to make sure that the normality assumption was met, ice cover was transformed using the modified logit function:

$$g(C_{it}) = \ln(\left[C_{it} - \overline{c}\right]/\left[1 - \left(C_{it} - \overline{c}\right)\right]) \tag{1}$$

where  $C_{it}$  is the ice cover in region i at time t and  $\overline{c} = \overline{C} - 0.5$  is an adjustment for the overall average ice cover in region,  $\overline{C}$ . The basic models were expressed as:

$$g(C_{it}) = \alpha + R_i + M_j + RM_{ij} + \beta_0 Y_t + \beta_1 T_{it} + \beta_2 P_{it} + \beta_3 W_{it} + \beta_4 g(C_{it-1}) + \varepsilon_{it},$$
(2)

where  $\alpha$  is the intercept,  $R_i$  is region,  $M_j$  is month,  $Y_t$  is year,  $T_{it}$  is monthly mean temperature,  $P_{it}$  is monthly precipitation, and  $W_{it}$  is monthly mean wind speed,  $\beta_0 \dots \beta_4$  are coefficients to be estimated and the  $\varepsilon_{it}$  s are normally, independently and identically distributed random errors. The parameters of the models were estimated using the GLM procedure of the SAS software package (v. 9.1).

Narwhal kills per hunter was modelled by Poisson regression, as a proxy of Catch Per Unit Effort (CPUE). Thus it was assumed that the number of narwhals caught per individual was Poisson distributed and that the expected catch per hunter ( $\mu_{catch,ijkt}$ ) in region/municipality i was related to region ( $R_i$ ), year ( $Y_t$ ), month or quarter of the year ( $M_j$ ), temperature ( $T_{it}$ ), wind ( $W_{it}$ ), ice cover ( $C_{it}$ ), hunter status ( $S_k$ ) as either occupational or part-time hunter, and number of active hunters in the region ( $N_{it}$ ) as:

$$\ln(\mu_{catch,ijkt}) = \alpha + R_i + M_j + RM_{ij} + S_k + (\beta_0 + \beta_{1i}) Y_t 
+ \beta_1 T_{it} + \beta_2 P_{it} + \beta_3 W_{it} + \beta_4 f(C_{it}) + \beta_5 N_{it},$$
(3)

where  $\alpha$  is the intercept,  $RM_{ij}$  are interaction effects between region and month,  $f(C_{it})$  is a non-linear transformation of ice cover, and  $\beta_0 \dots \beta_5$  are coefficients to be estimated. The model parameters were estimated using the GENMOD procedure of the SAS software package (v. 9.1).

Applying narwhal kills/hunter, as well as CPUE, as an indication of population trends involves a number of assumptions, including constant hunting efficiency, that may be invalid due to introduction of new technology as well as climate change (Harley *et al.* 2001; Moller *et al.* 2004; Milner-Gulland and Rowcliffe 2007). By controlling for regional weather and ice cover, most consequences of climate change are taken into account, but limited information is available to allow us to control for effects of changes in technology. Applying narwhal kills/hunter is thus only justified in consideration of the absence of more appropriate

information and because a considerable time may pass before population survey data will be available as a basis for evaluating trends in abundance. The validity of the assumptions will be further considered in the discussion.

To assess the potential for immigration of narwhals from outside the area where harvesting takes place and hence the justification for the quota allocation, migration patterns of narwhals were examined based on the available data through correlation tests between the catch in one municipality in a given month and the catch in the other municipality in the previous 3 months.

#### **Results**

#### Interviews and Group Discussions

In general there was a high degree of agreement within groups and often responses to questions were consensus statements. With few exceptions there was also a high accordance within communities and between communities in East and Northwest Greenland respectively. A comparison of prevailing attitudes and opinions towards various management practices and changes of these are summarized in Table 2. The necessity of quotas on narwhal hunting in East Greenland was contested by individual hunters, occupational hunters' organisations (i.e. local branches of KNAPK), municipal councils and village boards alike and people argued heatedly against it (field notes from Ittoggortormiit, Sermiligaaq and Tasiilaq). Arguments included that the weather protects narwhal stocks by making them difficult to find and catch and that the coastline is vast compared to the approximately 3,500 people living in East Greenland (field notes from Ittoggortormiit, Sermiligaaq and Tasiilaq). Furthermore, narwhal hunting is prohibited in the National Park that covers more than 1,400 km of the coastline. The hunters pointed out that this promotes sustainability by effectively creating a potentially very large source population for the sink created by hunting in Ittoggortormiit and Ammassalik municipalities (authors' formulation based on field notes from meetings with KNAPK and public meetings in Ittoggortormiit, Sermiligaaq and Tasiilaq).

Interviews and focus group discussions with hunters, occupational hunters' organisations and authorities in Qaanaaq and Upernavik municipalities in Northwest Greenland revealed that in their opinion the introduction of quotas has had severe negative impacts on livelihoods, traditional culture as well as narwhal stocks (field notes from Siorapaluk, Qaanaaq, Kullorsuaq and Upernavik). According to the hunters, introduction of quotas has meant that the status of narwhal has changed into a limited resource, which has increased demand, attracted inexperienced hunters and created a race to catch the quota (authors' formulation based on field notes from meetings with KNAPK and public meetings in Siorapaluk, Qaanaaq,



Table 2 Summary of prevailing attitudes and opinions (not considering the part-time hunter's organization/TPAK) towards various management practices and potential changes of these in East and Northwest Greenland

| Regulation aspect  | East Greenland   | Northwest Greenland   |
|--|--|---|
| Closed season for polar bear hunting.  | Problematic because the meat is considered necessary for subsistence and informal trade.   | Accepted because the skin has no commercial value in the relevant period due to shedding of fur/hair  |
| Restrictions on which species part-time hunters has access to.   | Unacceptable due to low availability of full<br>time formal occupation. Also in conflict<br>with traditional sharing practices where the<br>one who spots the animal receives a particular<br>cut irrespectively of hunting abilities, hunting<br>permit, license etc. | Generally applauded by occupational hunters.<br>However, municipal council's opposed in<br>consideration of larger numbers of part-time<br>hunters (voters).  |
| Further restrictions on proportion<br>of quotas available for part-time<br>hunters (beluga and narwhal).                   | Unnecessary as occupational hunters are not able to catch all animals and there is perceived no reason to reduce the catch.  | Generally in favor of further exclusion of part-time hunters.   |
| 50 % of income from hunting and fishing required in order to uphold occupational hunting permit.                           | Unacceptable due to very limited number of full time jobs requiring all to hunt.   | Necessary in order to ensure fair distribution of benefits and exclude people with other sources of income from access to quotas and subsidies.   |
| Requirement of documented experience and ownership of necessary equipment in order to gain access to licenses.             | Unnecessary as everybody is a hunter.  | Applauded because it would exclude people that are not able to bring down the animals themselves and therefore often only use allocated licenses in cooperation with an active occupational hunter, thereby diminishing occupational hunters profits. |
| Increase the minimum age for occupational hunters. <sup>a</sup>  | Considered problematic because hunting often is the only occupational option after school.   | Good as it would hinder households from registering children as occupational hunters in order to increase the probability of the household getting licenses in draws when the municipal quota is distributed.   |
| People over the retirement age and people receiving invalidity pension excluded from holding occupational hunting permits. | Considered disrespectful and unacceptable as elderly people have an invaluable function in handing down their experience and skills.   | Applauded due to these groups alternative source of income from pension (except by a few individuals fitting this description).   |

<sup>&</sup>lt;sup>a</sup> currently no legal minimum age for holders of occupational hunting permits. A minimum age of 16 is, however, required to obtain license for muskoxen and reindeer

Kullorsuag and Upernavik). This has led to increased struck and loss that is often not reported and to changes in customs regarding sharing of the catch with implications of conflict and loss of traditional culture (authors' formulation based on field notes from meetings with KNAPK and public meetings in Siorapaluk, Kullorsuaq and Qaanaaq). In the words of one hunter from Kullorsuaq "it is good and fine to maintain stocks for future use but if we are not allowed to catch them now, future generations will not know how", referring to loss of knowledge about hunting practices and all the associated traditions (field notes from an individual interview in Kullorsuaq). Furthermore, according to hunters and village board in Kullorsuaq alike, the race to catch the quota has meant that traditional narwhal hunters using kayak, are increasingly competing with people from larger towns, with access to better hunting technology such as powerful motorboats, with negative effects on their subsistence and income (authors' formulation based on field notes from Kullorsuaq). By this they to some extent referred to part-time hunters from Upernavik who

were less dependent on narwhal hunting as a source of subsistence or cash income (field notes from meeting with local branch of TPAK in Upernavik).

Apart from a common concern in relation to the effects of quotas, considerable difference was observed between the attitudes and priorities of hunters in East and Northwest Greenland (see Table 2). The hunters in Northwest Greenland generally had more positive attitudes towards regulations that favour exclusion by increased differentiation between hunters. This included having positive attitudes towards restricting allocation of quotas and licenses to part-time hunters and not issuing hunting permits to young and inexperienced or retired people and to people that were not in possession of appropriate hunting equipment (field notes from Siorapaluk, Qaanaaq, Kullorsuaq, and Upernavik) (see Table 2). By contrast hunters in East Greenland generally favoured maintaining traditional sharing practices and community cohesion, emphasized handing over of elder's traditional ecological knowledge and considered the above



changes unacceptable (field notes from Ittoqqortormiit, Sermiligaaq and Tasiilaq) (see Table 2). In Northwest Greenland there were also several examples of people using various strategies to exploit loopholes in the regulations in order to increase their likelihood of obtaining licenses. In the discussion we consider the explanations for these differences and further cultural implications of introduction of quotas and related management interventions.

#### Ice Cover

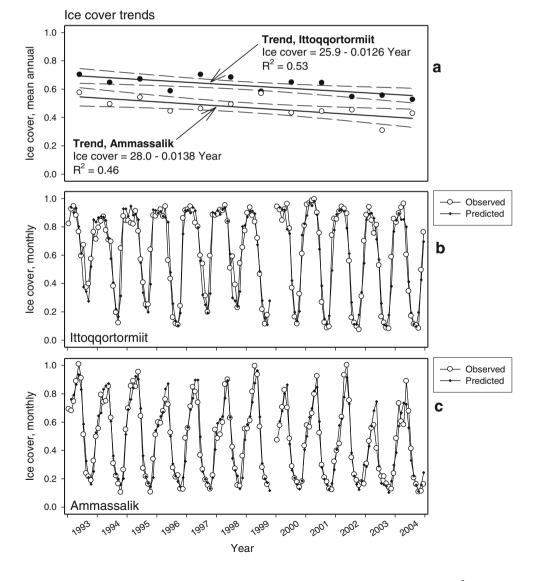
The initial results indicate that ice cover exhibited a parallel and declining trend across the observation period as illustrated for each municipality in Fig. 2a. Models of monthly ice cover were constructed by starting out with a basic model and gradually including additional explanatory variables. The initial model included municipality, month and year only. Subsequently, models including temperature, precipitation, wind speed and ice cover were tested. In the final model these

Fig. 2 a Variation of mean annual ice cover in Ittoqqortormiit (filled circles) and Ammassalik (open circles) and linear regressions with 95 % confidence intervals (dashed) of the expected value. b and c: Observed and predicted monthly ice cover for Ittoqqortormiit (B) and Ammassalik (C) municipalities (model in Table 3)

parameters were combined with the ice cover of the previous month, thereby accounting for the inherent inertia in the system caused by ice growth and melting delays. That is, it was expected that, in addition to location, month, year, temperature and wind speed, the ice cover in the current month was determined by the ice cover at the beginning of the month. Among all of the models tested the final model:

$$g(C_{it}) = RM_{ij} + \beta_0 Y_t + \beta_1 T_{it} + \beta_3 W_{it} + \beta_4 g(C_{it-1}) + \varepsilon_{it}$$

had the best fit with R<sup>2</sup>=0.89 and RMSE=0.52. In addition, with a Durbin-Watson test statistic of 1.91 the model has no appreciable autocorrelation and based on visual inspection of correlograms, scatter plots and Q-Q plots the residuals are nicely distributed. In combination with the statistical significance of coefficients and the high R<sup>2</sup> the model is deemed robust. The regression coefficients of the model are presented in Table 3 and illustrations of observed versus predicted ice cover is shown for each of the two municipalities in Fig. 2b and c.



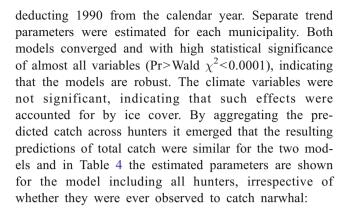


**Table 3** Regression coefficients with standard errors in brackets of the model (see text) describing the variation in ice cover including trend and lag effect. The overall average ice cover,  $\overline{C}=0.54636.$  \*, \*\* and \*\*\* signify statistical significance at 0.05, 0.01 and 0.001 levels, respectively

| Variable                                 | Statistics       |  |  |
|--|------------------|--|--|
| Ittoqqortormiit×January                  | 60.69 (20.36)**  |  |  |
| Ittoqqortormiit×February                 | 60.82 (20.36) ** |  |  |
| Ittoqqortormiit×March                    | 60.59 (20.36) ** |  |  |
| $Ittoqqortormiit \times April \\$        | 60.77 (20.32) ** |  |  |
| $Ittoqqortormiit \times May \\$          | 60.28 (20.29) ** |  |  |
| Ittoqqortormiit×June                     | 59.77 (20.25) ** |  |  |
| $Ittoqqortormiit \times July \\$         | 59.32 (20.22) ** |  |  |
| $It to qq or tormiit \times August \\$   | 59.04 (20.20) ** |  |  |
| $It toqqortormiit \times September \\$   | 59.04 (20.21) ** |  |  |
| Ittoqqortormiit×October                  | 59.98 (20.24) ** |  |  |
| $It to qq or tormiit \times November \\$ | 61.34 (20.28) ** |  |  |
| $It to qq or tormiit \times December \\$ | 60.65 (20.33) ** |  |  |
| Ammassalik×January                       | 60.06 (20.28)**  |  |  |
| Ammassalik×February                      | 60.32 (20.28)**  |  |  |
| Ammassalik×March                         | 60.42 (20.29)**  |  |  |
| Ammassalik×April                         | 60.89 (20.27)**  |  |  |
| $Ammassalik \times May$                  | 61.05 (20.26)**  |  |  |
| Ammassalik×June                          | 59.61 (20.25)**  |  |  |
| Ammassalik×July                          | 59.30 (20.21)**  |  |  |
| Ammassalik×August                        | 59.29 (20.19)**  |  |  |
| Ammassalik×September                     | 59.21 (20.20)**  |  |  |
| Ammassalik×October                       | 58.71 (20.21)**  |  |  |
| $Ammassalik \times November \\$          | 59.58 (20.22)**  |  |  |
| Ammassalik×December                      | 60.15 (20.24)**  |  |  |
| Year                                     | -0.03 (0.01)**   |  |  |
| Average temperature                      | -0.05 (0.02)*    |  |  |
| Average wind speed                       | -0.11 (0.04)**   |  |  |
| Ice cover (month-1)                      | 0.52 (0.05)****  |  |  |
| N  | 278              |  |  |
| R-square                                 | 0.89             |  |  |
| Root MSE                                 | 0.526            |  |  |

# Narwhal Kills per Hunter

An average of 20.3 (95 % CI 20.3±8.2) narwhals were caught per year in Ittoqqortormiit and 42.7 (95 % CI 42.7±17.3) in Ammassalik municipality between 1993 and 2004. Models of narwhal kills/hunter considering trends in climate and ice cover parameters were constructed for narwhal hunters separately and for all hunters combined. Catch was pooled in quarters due to low monthly catch and, acknowledging that catch may not be impeded by a partial ice cover, a range of non-linear transformations of ice cover were tested. The best performance was obtained for a cubic transformation. Due to convergence problems the year was furthermore rescaled by



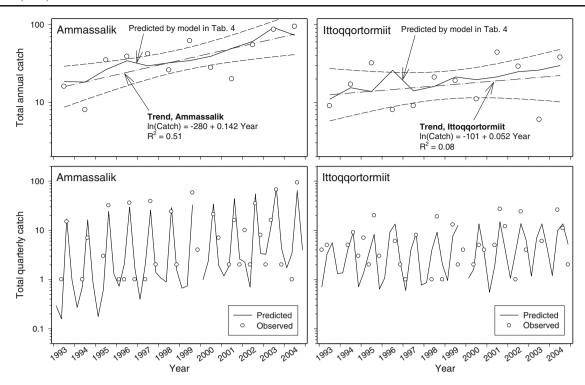
$$ln(\mu_{catch,iikt}) = RM_{ii} + S_k + \beta_{1i} Y_t + \beta_4 C_{it}^3 + \beta_5 N_{it}$$

Illustrations of the development of observed total and aggregated predicted catch over time are shown in Fig. 3. In the upper part of Fig. 3 trends in annual catch are illustrated separately for each municipality. In the lower part of Fig. 3 predicted total quarterly catch is shown for all hunters taken together. For quarterly catch the estimated trend parameters (Table 4) were positive and significant in

**Table 4** Poisson regression model (see text) describing the variation of quarterly narwhal kills per hunter as a function of municipality, quarter of the year, hunter status (occupational, part time or inactive), year, ice cover and number of active hunters (occupational and part time altogether). Regression coefficients with standard errors in brackets. \*, \*\* and \*\*\* signify statistical significance at 0.05, 0.01 and 0.001 levels, respectively; NS=not significant

| Variable                                     | Statistics              |  |  |
|--|-------------------------|--|--|
| Ittoqqortormiit×1st.quarter                  | -9.05 (1.17)***         |  |  |
| $It to qq or tormiit \times 2nd. quarter$    | -8.74 (1.06) ***        |  |  |
| $It to qq or tormiit \times 3rd. quarter \\$ | -9.47 (1.02) ***        |  |  |
| Ittoqqortormiit×4th.quarter                  | -10.07 (1.05) ***       |  |  |
| $Ammassalik \times 1 st. quarter$            | -13.61 (1.16)***        |  |  |
| $Ammassalik \times 2nd. quarter$             | -12.33 (1.15)***        |  |  |
| Ammassalik×3rd.quarter                       | -10.84 (1.12)***        |  |  |
| Ammassalik×4th.quarter                       | -13.67 (1.14)***        |  |  |
| Part time hunters                            | 6.23 (1.00)***          |  |  |
| Occupational hunters                         | 7.74 (1.00)***          |  |  |
| Inactive hunters                             | 0.00 (0.00)             |  |  |
| (Year-1990)×Ittoqqortormiit                  | 0.041 (0.02)*           |  |  |
| (Year-1990)×Ammassalik                       | 0.165 (0.02)***         |  |  |
| (Ice cover) <sup>3</sup>                     | -4.09 (0.67)***         |  |  |
| Number of active hunters                     | $-0.0008 (0.0008)^{NS}$ |  |  |
| N  | 69184                   |  |  |
| Deviance                                     | 5627.75                 |  |  |
| Scaled deviance                              | 5627.75                 |  |  |
| Pearson Chi-squared                          | 86305.81                |  |  |
| Scaled Pearson X <sup>2</sup>                | 86305.81                |  |  |
| Log likelihood                               | -2645.87                |  |  |

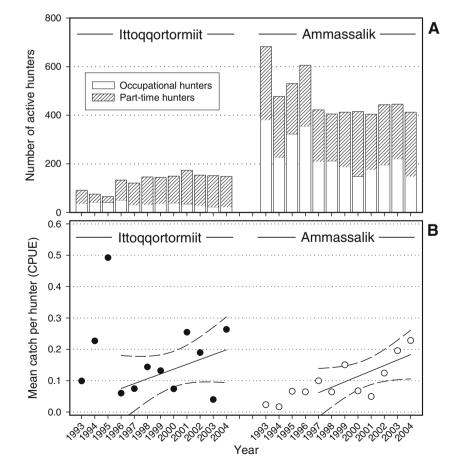




**Fig. 3** *Top*: Development in total annual catch, 1993–2004 in Ammassalik (*left*) and Ittoqqortormiit (*right*). *Solid lines* are predictions based on the model in Table 4. Broken lines (*dash-dot-dash*) are trend curves and dashed lines 95 % confidence intervals for the predicted trend. The

slope parameters of the trend regressions indicate annual growth rates. *Bottom*: Observed (*open circles*) and predicted (*solid lines*) quarterly catch based on the model in Table 4. NB: logarithmic scale on ordinate axes

Fig. 4 a Variation in the number of hunters in Ittoqqortormiit and Ammassalik municipalities. b Variation in narwhal kills per hunter across the period. *Trend lines* exclude years with large fluctuations in number of hunters. *Dashed lines* are 95 % confidence intervals for the *trend lines* 





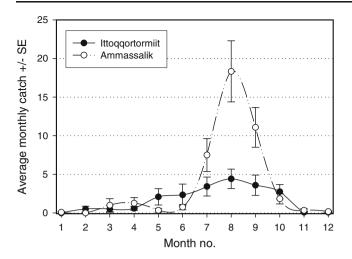


Fig. 5 Mean catch per month and associated standard errors for Ittoqqortormiit (*filled symbols*) and Ammassalik (*open symbols*) municipalities in the period 1993–2004

both municipalities. In spite of the fact that the number of active hunters changed considerably from 1993 to 2004 in both municipalities (-40 % in Ammassalik, +60 % in Ittoqqortormiit) (see Fig. 4a), the number of active hunters was not observed to have any significant effect on narwhal kills/hunter, the implications of which we will considered further in the discussion. With an annual increase in catch of 14 % in Ammassalik and 5 % in Ittoqqortormiit it appears that the recently established quota of 85 whales per year will soon be a constraint. However, as revealed above and discussed further below it was not so much the limit of 85 whales as the implication of quotas for traditional practices that people were objecting against.

### Monthly Distribution of Catch

Plotting the total catch for each month provides some insight in narwhal migration routes along the coast, assuming that the hunt starts immediately upon arrival of pods from wintering grounds. The results suggested that narwhals arrive in Ittoqqortormiit in April or May and in Ammassalik in June with catch increasing to a maximum at both locations in August (see Fig. 5). Thereafter the catch of narwhals declines and levels

off in October. Correlation analysis reveals that the catch in Ammassalik municipality was positively correlated with the catch in Ittoqqortormiit in the previous 1–3 months, whereas there was no positive correlation between the catch in Ittoqqortormiit and the catch in Ammassalik in previous months (Table 5). Due to increasing effect of seasonality this analysis could not be extended beyond a time horizon of 3 months.

#### Discussion

# Effects of Management Interventions

Concerns similar to those raised by East Greenland hunters in relation to the introduction of narwhal quotas have been raised in many other locations in the Arctic. As discussed below, management interventions and their consequences, despite regional variations, can have negative consequences for Inuit communities and sometimes without creating any major improvements in the status of wildlife stocks in the short to medium term (Sejersen 2001; Fernandez-Gimenez et al. 2006; Tyrrell 2006). Wildlife management plans, formalized rules, regulations and quotas, are therefore often met with scepticism (Richard and Pikes 1993; Caulfield 1993 and 1997; Clever 2000; Sejersen 2003; Armitage 2005; Stevenson 2006; Tyrrell 2007; Fernandez-Gimenez et al. 2008).

Numerous examples occur in arctic wildlife management of differing scientific and indigenous perceptions of the status of animal populations, hence leading to conflict over management of species (Davis *et al.* 1985; Freeman 1989; Richard and Pike 1993; Sejersen 2001 and 2003; Armitage 2005; Tyrrell 2006; Dowsley and Wenzel 2008; Dowsley 2009; Dale and Armitage 2011). Hunters' perceptions of trends in narwhal stocks in West Greenland for instance differed markedly from the scientifically observed decline (Heide-Jørgensen *et al.* 2002; Heide-Jørgensen and Acquarone 2002; Heide-Jørgensen 2004; JCNB/NAMMCO 2004), which they largely attributed to scientists' lack of local knowledge. Science is furthermore often seen as a means of state control (Fernandez-Gimenez *et al.* 2006) and local responses range from concern to utter mistrust (Usher 1993; Sejersen

**Table 5** Coefficients of correlation between catch in a given month in one of the municipalities and catch in the other municipality up to 3 months previously. \*, \*\* and \*\*\* signify statistical significance at 0.1, 0.05 and 0.01 levels, respectively

|                              | Months previously in other municipality              |   |   |  |  |  |
|------------------------------|--|---|---|--|--|--|
|                              | 0  | 1   | 2   | 3  |  |  |
| Ammassalik<br>Ittoqqortormit | 0.23*** ( <i>n</i> =144)<br>0.23*** ( <i>n</i> =144) | 0.22** ( <i>n</i> =144)<br>0.14* ( <i>n</i> =143) | 0.22*** ( <i>n</i> =143)<br>0.04 ( <i>n</i> =142) | 0.18** ( <i>n</i> =141)<br>-0.16* ( <i>n</i> =141) |  |  |



2001). In East Greenland polar bear and walrus quotas were introduced in 2006 before scientific recommendations became available and people considered this particularly unfair and damaging to traditional hunting and sharing practices (see also Ikkidluak *et al.* 1991, referenced in Richard and Pike 1993).

Sharing practices, cooperative hunting activities, common user rights and intimate knowledge of the social and physical landscape has been outlined as central to Arctic community life (Wenzel 1991; Freeman 1993; Condon et al. 1995; Bodenhorn 2000; Sejersen 2001; Furgal et al. 2002; Hovelsrud et al. 2008). In addition, hunting of beluga and narwhal is still an activity of great socio-cultural and economic significance in present-day Greenland (Dahl 1989; Sejersen 1998). Whaling entails high uncertainty and risk of loss, but the profit when successful creates multiple possibilities that are important in sustaining the social and economic livelihood of the household (Wenzel 1991; Caulfield 1993; Sejersen 2001; Nuttal et al. 2005; Hovelsrud et al. 2008). A socioeconomic survey in this respect considered 10 % of the occupational hunters in Greenland poor in an international context (Rasmussen 2005). The distribution of occupational hunters in the poor category was highly skewed towards a concentration in East and Northwest Greenland where narwhal hunting is an important activity (Rasmussen 2005). Whaling also plays a key role in transmission of knowledge and skills and in sustaining social relationships (Berkes and Jolly 2001; Tyrrell 2007; Hovelsrud et al. 2008). The introduction of hunting regulations and quotas may therefore have a large effect on individual hunters' livelihoods as well as traditional culture (Richard and Pike 1993; Ford et al. 2006). A ban on hunting beluga and narwhals by encirclement introduced by the Greenland Home Rule Government in 1995 is for instance considered to have eroded the collective organization of beluga whaling in West Greenland (Albrechtsen 2001).

Rules and regulations introduced by the Home Rule Government and maintained by the Self Rule Government create a division between hunter groups that is not readily acceptable to all. Regulations on size of vessels that can be used for beluga and narwhal hunting have been introduced with the intention of favouring certain socioeconomic groups that depend on hunting while decreasing the total catch in West Greenland in accordance with biological advice (Sejersen 2001). Requiring that more than 50 % of the annual income is earned from hunting and fishing in order to uphold occupational hunting permit and restricting part-time hunter's access to species under quotas are other types of regulations introduced by the Home Rule Government with socio-economic and cultural implications. Such regulations on access promote occupational specialization, and have created an increasing socio-economic division and segregation of the hunters in West Greenland that run contrary to traditional management systems where everyone can hunt

all species (Caulfield 1993: Seiersen 2001: Ford et al. 2006). In this context it is noteworthy that occupational hunters in Northwest Greenland often applauded increased control with allocation of occupational hunters' permits, exclusion of people without appropriate equipment and experience, and further restrictions on part-time hunters' access to quotas and their share of the quota (see Table 2). By contrast, hunters in East Greenland generally opposed any distinction between occupational and part-time hunters. Although restrictive quotas had recently been introduced on polar bear and walrus, hunters in East Greenland felt that all should be allowed to hunt these species. Hunters in Northwest Greenland in addition held the opinion that people above the official retirement age and people receiving disability retirement benefits should not be able to hold an occupational hunting license although board members of at least one local KNAPK branch opposed this idea, likely because several of them were retired and/or disabled. In East Greenland on the other hand, it was generally thought that elder hunters had an important function in handing down experience and the suggestion was therefore considered unacceptable. These striking differences between East and Northwest Greenland are likely connected to the increased competition for limited resources in Northwest Greenland even though access to alternative income generating opportunities appears to be more restricted in East than in Northwest Greenland (see Table 2). And in this respect there was indication that people in Northwest Greenland attempt to circumvent and exploit loopholes in the regulations.

Regulations and quotas have thus caught the individual hunter in Northwest Greenland in a moral dilemma between the socio-cultural norms regarding sharing and cooperative hunting on one side and personal economic requirements on the other (Sejersen 2001; Armitage 2005). Restrictions are seen to commoditize the resource and create a sense of excitement about the hunt (Richard and Pike, 1993; Ford et al. 2006; Tyrrell 2006) that is considered disrespectful towards animals (Berkes et al. 2007). Tyrell et al. (2006) for instance mention that when a law prohibiting people from shooting polar bears came into effect in Hudson Bay in Canada everyone wanted to do it. As pointed out by hunters in Northwest Greenland this means that the limited quota is divided between more people than would otherwise hunt narwhal (i.e. creating the race to catch the quota). Quotas and regulations have also changed the way hunting is conducted in the southern part of the Canadian Baffin Bay and, similarly to Northwest Greenland, hunters here complain that a sense of urgency and rush has caused ineffective and dangerous hunting practices (Kilabuk 1998). In Ariviat hunters argue that this may also occur through hunting regulations' insistence on the inclusion of people who would not normally hunt (Tyrrell 2006). In Alaska and Northwest Greenland hunters, using faster boats and high-



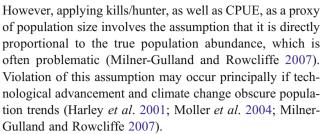
powered rifles, have introduced a highly competitive hunting practice that has undermined the local hunt (Morseth 1997; Sejersen 2001). With these changes the pace of evolution of traditions concerning allocation of access rights and division of the catch has increased and adjustments are taking place continuously (Sejersen 2001; Armitage 2005; Berkes and Jolly 2001). Sejersen (2001) showed that this means that the rules of division in West Greenland now alter from time to time, according to the persons negotiating the division rules.

National regulations have furthermore eroded communities' social control of local hunting territories (Caulfield 1993; Dahl 2000). The Home Rule government has taken over and monopolized allocation of user access and disposition rights and simultaneously turned Greenland into a single hunting territory (Dahl 1989; Sejersen 2001). This is based on a broadly unifying national agenda that has been considered discriminatory towards local practices for managing the hunt (Sejersen 2001). Instead of community control, one hunting officer has been appointed for each of nine of 18 municipalities (i.e. before the municipal reform). Thus, local control has been replaced by weak or nonexisting government control (Sejersen 2001). The loss of local control is illustrated by an increasing number of larger vessels coming from outside beluga ranges to hunt in hunting territories that were previously locally managed (Sejersen 2001). Some communities have responded by introducing bylaws that for instance make the use of kayaks mandatory for hunting beluga and narwhals in order to prevent outside participation (Sejersen 2001).

Prohibition of encirclement, restrictions on vessel size and requirements in relation to type of hunting license has thus changed narwhal and beluga hunting in West Greenland from an organised community effort to an unorganized individual hunt (Sejersen 2001). Cooperative hunting, common access and community property rights have been turned into individual hunting, limited access and individual property rights (Morseth 1997) and specific hunter groups have been limited in what they consider their cultural and economic rights (Sejersen 2001). Occupational hunters in Northwest Greenland furthermore appear to remain economically marginalised (Rasmussen 2005) despite the intentions to favour this group. The concern expressed by hunters in East Greenland thus appears to be justified.

# State of Stocks

The available evidence does not indicate declining trends in narwhal kills/hunter in East Greenland during the past 12 years. Even when taking changes in ice cover and variation in number of active hunters into account, kills/hunter was observed to increase over time in both municipalities.



The problem of ensuring that harvesting efficiency does not increase over time may be avoided by restricting the period of analysis (Milner-Gulland and Rowcliffe 2007). Although the analysis in this case is restricted to 12 years and it is unlikely that major changes have occurred in hunting technology, limited information is available to confirm this assumption. All vessels used by occupational hunters must be registered in the Greenland vessel register managed by the Greenland Fisheries License Office (GFLK). The register contains five reports from Ammassalik municipality but none from Ittoggortormiit. The reports mention 16 vessels in 1995, 31 in 1999 and 14 in 2006 and 2007 within the restrictions on BRT/BT allowed in relation to hunting narwhal. No information is available on vessels' ranges or speed. Hunters in Ittoggortormiit mentioned that it had become feasible to hunt narwhal in all parts of Scoresby Sound fjord with the introduction of faster motorboats, thereby depriving the stock of protection from hunting in the inner fjords during summer. However, the introduction of powerful outboard engines was described to have started considerably before 1993 and the limited information available on number of boats indicates fluctuation rather than a clear trend. A proportion of the catch is furthermore shot from kayaks and from the ice edge.

Results also indicate a declining trend in ice cover that was taken into account in the model. Climate changes are predicted to be experienced earlier and more acutely in the Arctic (Holland and Blitz 2003; Kattsov and Kallen 2005; Walsh 2008). Hunters in Ittoggortormiit report that major changes in sea ice cover have taken place, some claim since 1995. According to the hunters, freeze over previously occurred in September in Scoresby Sound fjord but is now delayed until November or December and breaking of the sea ice has advanced from July to June. This is in agreement with the pattern observed in Fig. 2b. In the 1990s ice cover in Ittoqqortormiit was large except for 2-3 months every summer but since 1999 the sea has been almost ice free for 3-4 months a year. These changes also correspond to changes observed by Inuit (see review in Laidler 2006) and scientifically documented in other parts of the Arctic (see review in Walsh 2008). Decreasing ice cover can increase hunter's ability to travel by boat and improve their access to whales (Nielsen 2009) thereby increasing narwhal kills/hunter. However, the hunters also report that the



amount of drift ice during the summer has decreased and become highly variable, with adverse consequences for hunting (i.e. lower kills/hunter). A particularly low catch of three narwhal in Ittoggortormiit in 2003 was for instance attributed to lack of drift ice during the summer resulting in higher waves and more difficult hunting conditions. Hunters in other locations report similar problems (Metcalf and Robards 2008). Both ice cover, temperature and wind speed were taken into consideration when preparing the quarterly narwhal kills/hunter model in Table 4 and the remaining effect of year must therefore be explained by other factors. It could be argued that making conclusions about trends on the basis of kills/hunter as a proxy of CPUE requires that the effort of hunters remains stable over time, but catching narwhal is a rare event so most of the effort is actually the basic vigilance of the hunters, always observing ice and wind conditions and watching out for narwhal whenever conditions are right. Considering the high cultural and economic value of narwhal as a catch we assume that hunters remain equally alert year after year. We therefore do not think that the observed trend is caused by a change in alertness.

A more pervasive problem which could not be evaluated is the inherent assumption that all catch is reported to DFFL. It is considered unlikely that a major proportion of the catch goes unreported in the small communities where everybody is living adjacent to the local government office. Furthermore, an incentive to underreport the catch of narwhals did not exist until after the implementation of quotas in 2008, and since the last year of the dataset is 2004 underreporting would not be expected to influence our analysis. However, in August 2008 a cruise ship discovered the partially butchered carcasses of 48 narwhals left floating at Qalaatsivik approximately 100 km south of Ittoggortormiit by hunters surprised by bad weather (KNR 2008). But according to DFFL the total reported catch in Ittoggortormiit in 2008 was only 39 narwhals, giving some reason for scepticism about the hunters' credibility. As of January 8th 2012 results of the police investigation of the matter are still pending. Finally the number of active hunters is a very rough measure of total hunting effort and in both municipalities considerable fluctuations with regard to number of hunters were observed in the first years of the period (see Fig. 4a). This may influence the parameter estimates of the quarterly kills/hunter model and it was therefore decided to recalibrate the model on a reduced dataset, excluding the years 1993-1995 in Ittoqqortormiit and 1993-1996 in Ammassalik (all years inclusive). The results revealed that in the reduced dataset there was a positive effect of number of hunters (coefficient=0.0061) which was significant at the 5 % level, implying that the expected catch of the individual hunter appeared to increase slightly with increasing number of hunters. Hence, there is no indication of a negative competition effect on narwhal kills/hunter. If anything, the result suggests a weak collaboration effect of increased number of hunters, hence supporting the previous results and arguments (see Fig. 4b). We also tested the consequence of including the 12 problematic observations of excessive off-season catch that had been omitted. This did not lead to changes in the structure of the model but in this case the effect of number of hunters was significant (coefficient= -0.0033) indicating a small negative effect of competition between hunters on narwhal kills/hunter.

Thus, it cannot be excluded that improvement in technology and random events had some effect on the number of narwhal kills/hunter, not accounted for by the model. Lack of information furthermore prohibits assessment of whether narwhal tend to aggregate as depletion occurs, how depletion affects hunter's search time, whether handling or search time determines off-take and how hunters move between patches differing in narwhal abundance, which can all affect kills/hunter and mask resource depletion (Harley et al. 2001; Moller et al. 2004; Milner-Gulland and Rowcliffe 2007). The result that there appears to be no immediate reason for concern for narwhal stocks in East Greenland is, however, supported by the assessment of the abundance estimate from 2008, which considers narwhal stocks in East Greenland safely above the maximum sustainable yield (MSY) point in relation to the carrying capacity (Witting and Heide-Jørgensen 2009). But this estimate is unfortunately also subject to considerable uncertainty. Applying kills/hunter to gauge population trends is thus only justified in consideration of the absence of more reliable information and because considerable time may pass before population survey data will be available to supplement the 2008 survey (Heide-Jørgensen 2009). Kills/hunter or CPUE information cannot replace population surveys and should not be applied as the only basis for future quota allocations.

The correlations observed in Table 5 indicate that hunters in Ammassalik experience similar patterns of access to narwhals as the hunters in Ittoggortormiit, but with a delay, whereas the opposite does not occur. This suggests that at least some narwhal pods follow a south-west-bound migration route from wintering grounds in accordance with the main current along the East Greenland coast. It also indicates that Ammassalik narwhal pods migrate north to wintering grounds earlier than pods in Ittoqqortormiit and out of reach of hunters in Ittoqqortormiit. This is in agreement with local observations (Born 1983; Dietz et al. 1985; Glahder 1995). Hunters in Kangerlussuaq have observed that narwhale pods come from north in spring (Glahder 1995). Wintering areas are probably associated with the polar ice off the east coast of Greenland and it is likely that narwhals aggregate in certain areas such as opposite Scoresby Sound (Born 1983). Narwhals appear to have high site fidelity for wintering areas (Laidre and Heide-Jørgensen 2005; Heide-



Jørgensen et al. 2008) and follow very similar migration routes every year (Dietz et al. 2001; Heide-Jørgensen et al. 2003). DNA analysis furthermore indicates that there are no subpopulations in East Greenland (Palsbøll et al. 1997), suggesting only one or few common wintering areas. The likely use of common wintering grounds and predominant south-west-bound migration patterns thus suggest that spill over of narwhals from non-hunted stocks in the National Park could contribute to hunting off-take in Ittoggortormiit and Ammassalik. This was not considered in setting quotas although source sink considerations have been emphasised for sustainability in other hunting systems (Joshi and Gadgil 1991; Novaro et al. 2000, 2005; Hill and Padwe 2000; Fimbel et al. 2000). The use of catch statistics to assess migration patterns is, however, based on the assumption that potential hunting effort is equally distributed across the year in the two municipalities (see also discussion on hunter alertness above), an assumption which cannot be evaluated.

#### Options for Co-management

Greenland appears to be far behind other Arctic countries in terms of experimentation with co-management. Comanagement is generally thought of as institutional arrangements in which management responsibilities are shared between users and the government (Yandel 2003; Plummer and FitzGibbon 2004). Ideally, co-management should strive to decentralize natural resource management decisions, increase participation and democracy, and improve compliance (Noble 2000). The theoretical expectations are that increased stakeholder participation will increase the efficiency and legitimacy of decision-making as well as promote equity (Castro and Nielsen 2001; Ribot 2004). Based on the results in Table 2 devolved management responsibilities in such arrangements could include: approving applications for occupational hunter licenses; distributing licenses for quotas of relevant species between occupational, part-time and potential trophy hunters; deciding which species part-time hunters have access to; and setting minimum requirements in terms of experience and equipment etc. required in order to be eligible for licenses rather than relying on broad national regulations that are considered locally inappropriate. Co-management arrangements could also contribute to improving the currently very incomplete reporting on catch and hunting effort by constituting a local supervisory function. Finally co-management could include a jointly developed monitoring strategy (Russel et al. 2000; Huntington 2000; Harwood et al. 2002). This should, in addition to biological population counts, use the large and cost-efficient data potential in systematically recorded quantitative observations by the hunters (Johannes 1998; Kofinas et al. 2001; Moller et al. 2004; Gilchrist et al. 2005; Metcalf and Robards 2008; see also Danielsen *et al.* 2000, 2005, 2007) who regularly navigate the East Greenland coast. The latter would give hunters a valid basis for argumentation in co-management meetings and could provide an indirect measure of population trends etc. in periods between biological counts (Fernandez-Gimenez *et al.* 2006) and hence enable rapid management response to changes introduced for instance as a result of climate change (Nielsen 2009). The responsibility for quota allocation, however, should remain with the Self Rule Government due to the inherent problems in community management of migrating resources (Naughton-Treves and Sanderson 1995; Ostrom *et al.* 1999). The Self Rule Government could furthermore retain legal ability to settle disputes.

A range of studies have documented that co-management in the Arctic is not unproblematic (Richard and Pike 1993; Berkes 1994; Collings 1997; Kruse *et al.* 1998; Klein *et al.* 1999; Castro and Nielsen 2001; Nadasdy 2003,2005; Kaplan and McCay 2004; Armitage 2005; Tyrrell 2006; Fernandez-Gimenez *et al.* 2008; Dowsley and Wenzel 2008; Metcalf and Robards 2008; Dowsley 2009). Nevertheless co-management of East Greenland narwhal stocks could help to ensure the common goal of maintaining traditional culture and large viable populations in compliance with the international agreements that Greenland has adopted through locally accepted and adapted wildlife management regulations.

#### Conclusion

The information available at this point, as analyzed in this study: 1) suggests that there are high risks of negative consequences of centrally imposed regulations and quotas on traditional Inuit culture, 2) did not indicate a negative trend of the narwhal stock in East Greenland, and 3) indicates that immigration from non-hunted source populations may occur, which was not considered in the implemented quotas. Thus in our opinion, despite considerable uncertainty implied by the narwhal kills/hunter approach, there appears to be no immediate cause for concern that warrants implementing quotas without the legal basis in the relevant executive order and without consultation of users. However, this does not mean that we argue against the use of quotas as a wildlife management tool where appropriate.

Comparison between East and Northwest Greenland furthermore indicates that national unified hunting regulations are considered locally inappropriate due to large differences in context. People are generally more likely to observe and assist in enforcing rules and regulations that they have been involved in developing (Sutinen and Kuperan 1999; Gibson *et al.* 2000; Agrawal 2002; Moller *et al.* 2004). Hunters' own will to adhere to rules and regulations is particularly



important in Greenland where effective control and enforcement is practically infeasible in the huge uninhabited areas. Providing a flexible and enabling legal framework through co-management and decentralization of certain management responsibilities has furthermore been emphasised in order to facilitate Arctic indigenous people's ability to adapt to ongoing climate change (Berkes and Jolly 2001; Nuttal et al. 2005). This suggests that ensuring conservation and sustainable use of narwhal stocks as well as maintaining traditional Inuit culture and securing local livelihoods in the face of climate changes would have higher chances of success if the Self Rule Government were to devolve relevant management responsibility and decision-making power to local institutions in co-management arrangements. However, we do not suggest devolving quota setting or quota allocation responsibilities.

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