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# A Synthesis and Critical Review of the Traditional Ecological Knowledge Literature on Narwhal (*Monodon monoceros*) in the Eastern Canadian Arctic

# Synthèse et revue critique de la littérature sur le savoir écologique traditionnel (SET) relative au narval (*Monodon monoceros*) dans l'est de l'Arctique canadien

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## ABSTRACT

This paper synthesizes and reviews the documented Inuit Knowledge (referred to here and in the literature generally as Traditional Ecological Knowledge, or TEK) available on narwhal (*Monodon monoceros*) in the Canadian Arctic. It has identified a number of significant contributions from Inuit Knowledge holders evident in the reports of interest for species management including the identification of critical habitat, a potential challenge to the understanding of summer site fidelity in the species, the existence of two colour and size morphs among the species, and trends in stock numbers. In comparing the science and TEK on this species at the stock and population levels, opportunities for complementary use of the datasets are evident. The TEK has the potential to enhance understanding of the species' ecology in a number of areas. Contradictions that may exist between the two datasets or knowledge systems, may originate from differences in the temporal, spatial or phenomenological scale at which observations are gathered and knowledge is generated. A review of the methods used in the collection, treatment, analysis and reporting of the TEK identified a number limitations in the research conducted to date. Currently the lack of attention to detail in social research methods and processes to ensure reliability and validity in the collection and analysis of the TEK, or the communication of this information in the reports, raises questions with regards whether or not the full contribution from this knowledge is accurately represented. It is recommended that a comprehensive, integrated science and TEK mixed methods study be considered to gain a more comprehensive understanding of narwhal biology and ecology, on which management decisions could be based. Such cooperative inquiry would allow for a valuable, robust, transparent, and defensible dataset to be created that considers all knowledge holders and sources involved.

## RÉSUMÉ

Ce document résume et examine le savoir inuit documenté (appelé ci-après, et dans la littérature de façon générale, le savoir écologique traditionnel, ou SET) disponible sur le narval (*Monodon monoceros*) dans l'Arctique canadien. On y indique l'apport d'un certain nombre d'éléments importants attribuables à des personnes ayant des connaissances des Inuits; ces éléments ressortent dans les rapports d'intérêt pour la gestion de l'espèce, y compris l'identification de l'habitat essentiel, le possible défi de la compréhension de la fidélité aux sites d'été de l'espèce, l'existence de deux couleurs et morphologies parmi l'espèce, ainsi que les tendances quant au nombre d'individus. En comparant les données scientifiques et le SET relatifs à cette espèce au niveau des stocks et de la population, il y a des occasions évidentes d'utilisation complémentaire des ensembles de données. Le SET a le potentiel d'accroître la compréhension de l'écologie de l'espèce pour un certain nombre de domaines. Les éventuelles contradictions entre les deux ensembles de données ou systèmes de connaissances peuvent être dues aux différences quant à l'échelle temporelle, spatiale ou phénoménologique à laquelle les observations sont recueillies et à laquelle les connaissances sont obtenues. Un examen des méthodes utilisées pour la collecte, le traitement, l'analyse et les rapports du SET a indiqué un certain nombre de limitations relativement à la recherche effectuée jusqu'à maintenant. À l'heure actuelle, le manque d'attention accordé au détail dans les méthodes de recherche sociale et les processus en vue d'assurer la fiabilité et la validité de la collecte et de l'analyse du SET, ou la communication de cette information dans les rapports, soulèvent des questions à savoir si la totalité de l'apport attribuable à ce savoir est représentée de façon exacte ou non. Il est recommandé de songer à réaliser une étude exhaustive et intégrée de la science et des méthodes mixtes de SET afin d'obtenir une compréhension plus approfondie de la biologie et de l'écologie du narval, étude sur laquelle reposeraient les décisions de gestion. Une telle enquête en coopération permettrait de créer un ensemble de données précieux, solide, transparent et justifiable tenant compte de toutes les personnes détentrices du savoir et des sources concernées.

## BACKGROUND AND PURPOSE OF THIS REPORT

Narwhal (*Monodon monoceros*) is listed on Appendix II of the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES). The Scientific Authority at Fisheries and Oceans Canada (DFO) must issue a CITES non-detriment finding (NDF) for narwhal if products (e.g. tusks, carvings) are to be exported. An NDF is an assessment of whether harvests and trade are detrimental to the survival of the species in the wild. To ensure that the issuance of narwhal NDFs are based on the best available information, DFO requires a report that: i) summarises existing published Inuit traditional knowledge* relevant to Canadian narwhal abundance and seasonal distribution/movements; ii) identifies where similarities and differences exist between traditional knowledge and current scientific advice related to narwhals; and iii) provides suggestions for reconciliation and a path forward.

Therefore, the objectives of this report are to:

- Gather, review, synthesize and critique/analyse the TEK* documentation and research (methods and approach) previously conducted on narwhal (*Monodon monoceros*) in the Canadian Arctic.

- Synthesize existing science for commonly available parameters related to population dynamics and management of the species also represented in the TEK literature.

- Provide a parallel presentation of the science and TEK* in tabular form. Provide possible recommendations for future research and documentation based on the critical review and analysis presented.

*In the context of this study previous documentation may refer to or characterize TEK held by Inuit on narwhal as Inuit Qaujimajatuqangit or Inuit Knowledge.

## INTRODUCTION

The narwhal (*Monodon monoceros*) is an Arctic cetacean divided into three distinct populations worldwide. These include the Baffin Bay (BB) and Northern Hudson Bay (NHB) populations existing in Canadian waters and the East Greenland population (COSEWIC, 2004). The Baffin Bay population is estimated to be ~80,000 animals by Fisheries and Oceans Canada (DFO, 2010), with COSEWIC (2004) estimating the population to be between 45,000 and 50,000 animals. The NHB population has been estimated to include 5,053 animals by DFO (DFO, 2008), and a smaller 1,778 animals by Bourassa (2002). Male narwhal can grow up to 5.4 m in length with a weight of 1900 kg, while females can reach 4.9 m in length and a slightly smaller 1500 kg in weight (COSEWIC, 2004). The left incisor tooth of male narwhals typically protrudes to form a tusk, while the remaining incisor stays embedded in the jaw. It is rare for males to not have a tusk and similarly rare for females to have a tusk or for either genders to produce two visible protruding tusks (Reeves and Mitchell, 1981). Narwhal are gregarious animals, separating into smaller sexually segregated groups of males and females, and larger mixed groups, similar to beluga whales (*Delphinapterus leucas*) (Marcoux et al., 2009). Females have a gestational period lasting 15 months and typically only give birth to one calf per pregnancy. Birthing is reported to commonly occur in inlets, bays, and fjords during the summer months (Hay, 1984).

The critical habitat for narwhal varies during the seasons, but is influenced by ice cover, water depth, and areas of ocean upwelling (Laidre et al. 2008; Laidre and Heide-Jørgensen, 2004; Heide-Jørgensen *et al.*, 2003). Narwhal are deep divers and feed at the bottom of deep bays (Laidre and Heide-Jørgensen, 2004). Their diet varies from season to season, but consists primarily of cod (*Arctogadus glacialis, Boreogadus saida*), squid (*Gonatus spp.*), and halibut (*Reinhardtius hippoglossoides*) species (Laidre *et al.*, 2008). It is assumed that narwhal return to the same locations every year (Laidre and Heide-Jørgensen, 2004), but there is limited science on the home range of these animals in this regard to date (DFO, 2010b; Heide-Jørgensen *et al.*, 2003). Due to the limited knowledge of home range, the feeding strategy and strong association with ice that these animals have, they are likely highly sensitive to climate change and variability (Laidre *et al.*, 2008).

The narwhal is an important species to northern communities for a variety of reasons including food, culture, and economy. Narwhal are the source of many legends in Inuit culture (Spalding, 1979; www.narwhal.org) and are an integral part of many communities' local economy through the sale of ivory tusks or their transformation and sale in the Inuit arts and crafts industry. They are also important to community social cohesion through their focus in collective management and hunting activities, and in community health through the consumption of maqtaq and meat by Inuit throughout the range of the species (Armitage, 2005).

Narwhal are hunted throughout the Arctic and are primarily valued today for food (maqtaq and meat) and the economic value of their tusk (Stewart *et al.*, 1995). The hunting and sharing of narwhal is highly valued and demand usually exceeds supply for maqtaq in communities (COSEWIC, 2004). A narwhal tusk has high market value and can be sold for an estimated $80-$150/ft (Armitage, 2005).

Narwhal are currently managed by the federal *Marine Mammal Regulations and the Fisheries Act*, in conjunction with Article 5 of the *Nunavut Land Claims Agreement* (NLCA). The population is managed through a co-management structure and the local Hunters and Trappers Organizations (HTOs) are responsible for tracking harvest data and regulating community hunts (DFO, 2010a). DFO produces recommended *Total Allowable Landed Catch* (TALC), but currently all quotas are set by the *Nunavut Wildlife Management Board* (NWMB) based on historical hunt levels and communities' needs (Armitage, 2005), and some have since been revised based on the process outlined in the NLCA. Table 1 presents a listing of Canadian Arctic narwhal stocks, communities within their management area and associated quota and catch levels. DFO's stock hypothesis and TALC is now being evaluated and considered by the NWMB. Although there have been a limited number of studies conducted to date, there exists a significant body of Traditional Ecological Knowledge (TEK) on this species in written form for many of the same aspects of its' ecology as discussed above. A synthesis, review, and critique of this literature, and the methods used to gather and present it are the focus of this report.

Traditional Knowledge (TK) is synonymous with oral tradition, Indigenous Knowledge, local or community knowledge, or Local Ecological Knowledge (Johannes et al., 2000). TEK is a subset of TK, focused on the environment inclusive of the role of and relationship with humans. The most widely referred to definition of TEK appearing in the academic literature is *"a cumulative body of knowledge, practice and belief evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment"* (Berkes et al., 2000). In Nunavut, the term and concept of *Inuit Quajimajatuqangit* (IQ) is now used, which encompasses all aspects of traditional Inuit culture including values, world-view, language, social organization, knowledge, life skills, perceptions, and expectations (Wenzel, 2004). Only because of the preponderance of previous use of the term TEK in the literature reviewed for this report on narwhal do we use the term TEK here. We use it to refer to all Inuit hunter and Elder knowledge

and local observations contained in the reports provided by the contracting agent. In some instances this may include what is currently referred to as IQ in Nunavut.

*Table 1. Listing of identified narwhal stocks, associated communities that hunt them, Nunavut Wildlife Management Board (NWMB) identified quotas, and Fisheries and Oceans Canada (DFO) recommended Total Allowable landed Catch TALC).*

| DFO Defined Summer Aggregation (Proposed Stock) | Community | NWMB 2010 Quota | NWMB 2010 Total For DFO Defined Summer Aggregation (Proposed Stock) | DFO TALC |
|---|---|---|---|---|
| **BAFFIN ISLAND POPULATION** | | | | |
| Somerset Island | Resolute Bay | 32 | 102 | 532 |
| | Gjoa Haven | 10 | | |
| | Taloyoak | 10 | | |
| | Kugaaruk | 25 | | |
| | Igloolik | 25 | | |
| Admiralty Inlet | Arctic Bay | 130 | 130 | 28 |
| Eclipse Sound | Pond Inlet | 130 | 130 | 236 |
| East Baffin | Qikiqtarjuaq | 90 | 140 | 122 |
| | Clyde River | 50 | | |
| **TOTAL** | | | **502** | **918** |
| **NORTH HUDSON BAY POPULATION** | | | | |
| Northern Hudson Bay | Repulse Bay | 72 | 122 | 57 |
| | Chesterfield Inlet | 5 | | |
| | Kimmirut | 10 | | |
| | Cape Dorset | 10 | | |
| | Coral Harbour | 10 | | |
| | Whale Cove | 5 | | |
| | Rankin Inlet | 10 | | |
| | Arviat | ? | | |
| **TOTAL** | | | **122** | **57** |
| **OTHER** | | | | |
| Other | Iqaluit | 10 | 80 | |
| | Pangnirtung | 40 | | |
| | Grise Fjord | 20 | | |
| | Hall Beach | 10 | | |
| **TOTAL** | | | | |
| **NARWHAL TOTAL** | | | **704** | **975** |

CITES, of which Canada is a signatory, requires an assessment of whether the harvest and trade of narwhals will be detrimental to the survival of the species in the wild (i.e. a non-detriment finding) before wildlife products such as tusks and carvings can be exported. The current review is being conducted at the request of DFO to gather, review, synthesize, and critique the existing TEK literature on narwhal to inform a NDF for this species. We present such a review and critique and also present, in parallel, a synthesis of the natural science and management literature currently available, referred to here as the science data. This is done to identify common patterns as to where the TEK and science converge, diverge, or corroborate

and support one another. Patterns in this regard are presented and discussed in the interest of providing some foundation upon which to move the science-TEK discussion forward in the context of narwhal management in Canada. Finally, recommendations are provided to address identified issues raised in this review and analysis.

## METHODS

The core documentation used in this review was provided by the contracting agency, Fisheries and Oceans Canada - Ecosystem Science Directorate. TEK reports on narwhal in the Canadian Arctic were provided, along with scientific documentation on narwhal stock assessment, delineation, and management. The supporting scientific documentation was provided at the contractors' request to better understand the context and view of the issue from both TEK and science perspectives.

To provide a synthesis and parallel presentation of the TEK and science on narwhal in the Canadian Arctic it was necessary to identify and review the variables typically used in the science management for narwhal in Canada and cetaceans in general. A review and identification of critical parameters for understanding and managing marine mammal and specifically, cetacean populations (with an emphasis on narwhal), was therefore conducted. These parameters (see Table 2) were gleaned from the literature provided by DFO-Ecosystem Science Directorate, as well as a review of available scientific literature on the topic gathered through an online search of bibliographic databases (ie. ISI Web of Science, ASTIS, etc). It is important to note that a review of this documentation identified that the life history characteristics of the species are involved in DFO management calculations via the use of the equation presented in Wade (1998) and that the NWMB uses historical hunting levels based on communities' needs in their development of quotas for individual communities. As such, some specific information on life history characteristics of this species are not directly used or presented in DFO management reports reviewed for this project. Further, some terminology had to be clarified and some standardized definitions accepted in the process of developing the evaluative framework for this project as follows:

Stock: A resource unit: a group of animals subjected to hunting. Stocks may or may not be populations (DFO, 2010b).

Stock Identification: Individual narwhal stocks were identified by DFO using the following (DFO, 2010b):

- Studies of the seasonal range of the species in Nunavut and adjacent waters by documenting local and written reports of their occurrence;
- Appearance and behavioural differences of animals from different areas of Nunavut and adjacent waters;
- Studies of genetic and contaminant differences among animals from different parts of Nunavut and adjacent waters, and
- Tracking animals, using satellite-linked transmitters, to estimate their seasonal range and delimit areas of aggregations.

Population: A reproductively isolated group of animals (DFO, 2010b).

*Table 2. Relevance of narwhal characteristics to DFO management and general marine management decision processes.*

| Characteristics of Narwhal stock/population | Significance in DFO Management decisions | DFO Reference | Marine Mammal Management Reference |
|---|---|---|---|
| Population number | Estimated from aerial surveys conducted in different years for stock areas, but same population;<br><br>Basis of calculations of Total Allowable Catch (TALC) | Richard et al., 2010 (Baffin Bay); DFO, 2010c (NHB);<br><br>Richard, 2008; DFO, 2008 | Marine Mammal Protection Act, 2005; Lonergan, 2011; Marcoux et al., 2009<br><br>MMPA, 2007; Lonergan, 2011 |
| **Spatial Characteristics** | | | |
| Seasonal and Annual Location | Determines which stock the animal belongs to (changes through migration) | DFO, 2010c; Richard, 2010 | Lonergan, 2011; Grech et al., 2011; Angliss & Allen, 2009 |
| Distribution / Extent of Distribution | Two separate populations, but currently only managed based on quotas for individual communities within 5 stocks (possibly 3 other stocks);<br><br>NWMB has yet to finalize how they should be best managed | DFO, 2010c; Richard, 2010;<br><br>CBM report, 2008 | Grech et al., 2011; Caretta et al., 2009 |
| Breeding area / Critical Habitat | None | | Robards et al., 2009; Friday et al., 2008 |
| Foraging Area | None | | Laidre & Heide-Jørgensen, 2005; Robards et al., 2009 |
| **Life History Characteristics** | | | |
| Birth rate | None, use R of 0.04 for cetaceans | Richard, 2008; DFO, 2008 | Pitcher et al., 2007; Wade, 1998; Barlow and Clapham, 1997 |
| Mortality | None, use R of 0.04 for cetaceans | Richard, 2008; DFO, 2008 | Wiley et al., 1995 |
| Growth rate | None, use R of 0.04 for cetaceans | Richard, 2008; DFO, 2008 | Pitcher et al., 2007; Wade, 1998; Barlow and Clapham, 1997 |
| Age of maturity | None, use R of 0.04 for cetaceans | Richard, 2008; DFO, 2008 | Wade, 1998 |

| Characteristics of Narwhal stock/population | Significance in DFO Management decisions | DFO Reference | Marine Mammal Management Reference |
|---|---|---|---|
| Number of offspring /mother | None (maybe in hunting rules) | Richard, 2008;<br>DFO, 2008 | Wade, 1998 |
| Frequency of birthing | None, use R of 0.04 | Richard, 2008;<br>DFO, 2008 | Wade, 1998;<br>Barlow and Clapham, 1997 |
| Gender ratio | None, use R of 0.04 for cetaceans | Richard, 2008;<br>DFO, 2008 | Wade, 1998;<br>Pitcher et al., 2007 |
| Age Structure | None, use R of 0.04 for cetaceans | Richard, 2008;<br>DFO, 2008 | Wade, 1998;<br>Pitcher et al., 2007 |
| **Hunting/Predation** | | | |
| Quota | Set per community, but tags are shared between communities and tag carry-over from previous years | Richard, 2008;<br>DFO, 2008 | Lonergan, 2011; Wade, 1998;<br>Robards et al., 2009 |
| Number hunted | Based per community, but allow tag sharing… | CBM report, 2008 | Lonergan 2011; Robards et al. 2009 |
| Hunting Loss rate | Estimated based on CBM reports | CBM report, 2008<br><br>Richard, 2008;<br>DFO, 2008 | Robards et al., 2009;<br>Mcniven & Bedingfield, 2008 |
| Number preyed upon | Acknowledgement of injury and death by killer whales, but not present in management decisions | Westdal, 2008 | Laidre et al., 2006; Wade, 1998; Wiley et al., 1995 |

In order to develop a framework and criteria through which to review and critique the TEK reports (content and methods) available on narwhal in the Canadian Arctic, a review of TEK and TK documentation methods and TEK-science integration methods appearing in the peer-reviewed literature was conducted. Steps in the research approach, methods, and reporting processes commonly appearing in this literature were identified. As TEK documentation and reporting is a form of social research, it can be expected to follow the same standards as other high quality social and qualitative research that uses recognized and validated methods (e.g. Denzin and Lincoln, 2011). Therefore, a review of the social, qualitative, and mixed-methods research literature was also conducted in the identification and selection of evaluative criteria. This literature was gathered through an online search of bibliographic databases of peer-reviewed publications (e.g. ISI Web of Science, EBSCO, ASTIS, etc). Table 3 presents a listing of these criteria, their importance in qualitative research/TEK documentation and their source. All literature, gathered or previously provided by the contracting agency used in this report is presented by topical category in Appendix 1.

# RESULTS

## SYNTHESIS OF PARALLEL PRESENTATION OF TEK AND SCIENCE ON CRITICAL NARWHAL CHARACTERISTICS

Tables 4.1 – 4.5 present syntheses of both the TEK and DFO science on five of the six identified Canadian Arctic stocks of narwhal. The estimated populations are 5,362, 10,073, 20,225, 45,358, and 5,053 for Admiralty Inlet, East Baffin Island, Eclipse Sound, Somerset Island, and North Hudson Bay (NHB) stocks, respectively (DFO, 2010a). An abundance estimate for the putative stocks of Parry Channel, Jones Sound, and Smith Sound is not available. These population estimates come from aerial surveys in different years (DFO, 2008), and due to a limited time series of data, are unable to indicate whether population numbers for individual stocks are increasing or decreasing. However, the TEK gathered to date reports trends in stocks based on local observations. The TEK reports that the East Baffin stock is increasing in number (Table 4.2), the NHB stock (Table 4.5) and Eclipse stocks are potentially decreasing (Table 4.3), and that there is no observed change in the population level of the Admiralty (Table 4.1) and Somerset stocks (Table 4.4). The TEK suggests that the changes in population numbers are due to changes in sea ice conditions and increased shipping traffic in other areas (Stewart et al., 1995; Remnant and Thomas, 1992). There is information available for TEK on narwhal in Grise Fjord, which is located within the putative stocks (Stewart el al., 1995; Remnant and Thomas, 1992), but there is no comparable DFO science and population estimates presented at this spatial scale (DFO, 2010b,c).

*Table 3. Standard social research method components for a TEK study, and corresponding rationale for their inclusion.*

| Description | Rational | Reference |
|---|---|---|
| Definition of TEK, IK or IQ | Influences the content focus of data collection (defines what constitutes 'data' for the study); influences decision of who is involved, and what is presented as final data | Berkes et al., 2000; Inglis, 1993; Pierotti and Wildcat, 2000; Wenzel, 1999; 2004 |
| Reason for the study / Research Question / Objective(s) | Influences selection of study design, approach and methods | Creswell, 2009; Crawford, 2009; Furgal et al., 2006 |
| Framing of study/approach to community | Influences interpretation by community of study objectives / goals; can influence respondent bias | Creswell. 2009, Denzin and Lincoln, 2011 |
| Choice of approach (Qual, Quant, mixed-methods) | Approach determines appropriateness to data available and influences content gathered; each has strengths / limitations | Creswell, 2007; 2009; Charmaz, 2006; Johnson and Onwuegbuzie. 2004 |
| Criteria for selection of participants | Influences reliability of data, credibility of respondents and validity of data interpretation | Davis and Wagner, 2003 |
| Criteria for selection of community | Influences reliability of data and validity of data interpretation | Davis and Wagner, 2003; Gagnon and Berteaux, 2009 |
| Ethics/cultural ethics of process | Ensures appropriate 'environment' in which data collection takes place and therefore influences reliability of data provided by respondents | Creswell, 2009; Huntington, 2006; Nadasdy, 1999; Svalastog,A.L. and Eriksson, S.,2010 |
| Method of data collection (semi-directive interviews, life histories, questionnaire, focus groups, community workshops, etc) | Influences validity of data interpretation and conclusions drawn from study | Berkes, 2009; Butler, 2004; Huntington, 1998; Denzin and Lincoln, 2011, Trochim, 2006 |
| Tools of data collection (audio, video, mapping, etc) | Influences reliability and accuracy of data collection and presentation | Huntington, 1998; Seidman, 2006; Denzin and Lincoln, 2011 |
| Selection and description of methods of analysis | Influences validity and transparency (credibility) of interpretation and conclusions drawn | Creswell, 2009; Charmaz, 2006; Denzin and Lincoln, 2011, Trochim, 2006 |
| Verification and validation of data collection and analysis | Influences reliability and validity of qualitative data and its' interpretation by the researcher | Creswell, 2009, Cruikshank, 1981; Charmaz, 2006; Denzin and Lincoln, 2011; Trochim, 2006 |
| Copy of interview guide | Transparency of methods adds to credibility/rigour of study | Denzin and Lincoln, 2011; Seidman, 2006 |
| Return of results to community | Influences history of trust in TEK research and therefore reliability of future research studies; Provides opportunity to validation of interpretation | Creswell, 2009 |

*Table 4.1. Synthesis of Traditional Ecological Knowledge (TEK) and Science knowledge on narwhal (Admiralty Inlet Stock).*

| Characteristics of Narwhal stock/population | TEK | Science | |
|---|---|---|---|
| | | Stock Specific | Population Specific |
| Population number | Fewer narwhal are present in Arctic Bay (pp. 20, Remnant & Thomas, 1992)<br><br>No population change trends were present (pp. 21, Remnant & Thomas, 1992)<br><br>Two forms of narwhal; a large and small form (9/10) (pp. 21, Remnant & Thomas, 1992) | 5,362 (DFO, 2008) | |
| **Spatial Characteristics** | | | |
| Seasonal and Annual Location | Migrate into Admiralty Inlet during summer (n=9/10) (pp. 20, Remnant & Thomas, 1992; pp. 29, Stewart et al., 1995)<br><br>Ship traffic is scaring narwhals away (pp. 33, Stewart et al., 1995) | | Baffin Bay Narwhal Population (DFO, 2008; DFO, 2010a; Richard et al., 2010) |
| Distribution / Extent of Distribution | Suggested narwhal move out to water between Newfoundland and Greenland during winter (n=1/10) (pp. 20, Remnant & Thomas, 1992) | | Baffin Bay Narwhal Population (DFO, 2008; DFO, 2010a; Richard et al., 2010) |
| Breeding area / Critical Habitat | Feeding and mating take place in Admiralty Inlet (pp. 20, Remnant & Thomas, 1992)<br><br>Majority of hunters said mating took place anytime (n=5/10) (pp. 21, Remnant & Thomas, 1992)<br><br>Mating takes place at the floe edge and birthing areas are distributed within Admiralty Inlet (pp. 33, Stewart et al., 1995) | | |
| Foraging Area | Feeding takes place within Admiralty Inlet and along the floe edge (n=7/10) (pp. 20, Remnant & Thomas, 1992) | | |
| Prey | Narwhal feed on cod, halibut, shrimp and plankton (pp. 21, Remnant & Thomas, 1992)<br><br>Fish, mostly cod (pp. 33, Stewart et al., 1995) | | |

| Characteristics of Narwhal stock/population | TEK | Science | |
|---|---|---|---|
| | | Stock Specific | Population Specific |
| **Life History Characteristics** | | | |
| Birth rate | | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Mortality | | None | |
| Growth rate | | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Age of maturity | | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Number of offspring /mother | One calf per pregnancy (n=8/10) (pp. 21, Remnant & Thomas, 1992)<br><br>Narwhals calve either every year (n=7/10), or every 2 years (3/10) (pp. 21, Remnant & Thomas, 1992; pp. 33, Stewart et al., 1995) | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Gestation | Gestation is thought to be less than a year (n=4/10)<br>Calving takes place at any time of the year (n=7/10)<br>(pp. 21, Remnant & Thomas, 1992; pp. 33, Stewart et al., 1995) | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Gender ratio | Males are generally larger, breathe stronger and have more tusks (pp. 35, Stewart et al., 1995) | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Age Structure | | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| **Hunting/Predation** | | | |
| Quota | | 28<br>(DFO, 2008) | |
| Number hunted | 7 (pp. 35, Stewart et al., 1995) | | |
| Hunting Loss rate | Healed scars from bullets and harpoons have been observed (pp. 33, Stewart et al., 1995) | | |
| Number preyed upon | Killer whales prey successfully on narwhal (pp. 33, Stewart et al., 1995)<br><br>2 hunters indicated sharks attacked narwhal (pp. 33, Stewart et al., 1995) | | |
| **Behaviour** | | | |
| Disturbance | | | |
| Grouping | | | |
| Diving | | | |
| Influences of tide | | | |

*Table 4.2. Synthesis of Traditional Ecological Knowledge (TEK) and Science knowledge on narwhal (East Baffin Stock).*

| Characteristics of Narwhal stock/population | TEK | Science | |
|---|---|---|---|
| | | **Stock Specific** | **Population Specific** |
| Population number | Majority (n=18/23) of hunters believe the population to be increasing since the 1960s and 1970s (pp. 7, Remnant & Thomas, 1992)<br><br>Majority of hunters (n=13/19) believe the population has been increasing over the last 20-30 years. Increasing because of increased shipping in other areas and changing sea ice conditions (pp. 11, Remnant & Thomas, 1992)<br><br>Some (n=2/19) believe there is an increase in narwhal because of improved management and treatment of the animal (pp. 11, Remnant & Thomas, 1992) | 10,073<br>(DFO, 2008) | |
| **Spatial Characteristics** | | | |
| Seasonal and Annual Location | Waiting for ice to break-up in spring to move into fjords<br>Usually not present during the winter (pp. 5-6, Remnant & Thomas, 1992)<br><br>Showing up earlier every year because of earlier ice break-up (pp. 9-10, Remnant & Thomas, 1992) | | Baffin Bay Narwhal Population<br>(DFO, 2008; DFO, 2010a; Richard et al., 2010) |
| Distribution / Extent of Distribution | (pp. 5-6, Remnant & Thomas, 1992)<br><br>(pp. 9-10, Remnant & Thomas, 1992)<br><br>Most hunters (n=13/19) believe there are two types of narwhal: a larger, darker form that feeds in northern fjords and a smaller lighter form. Sometimes they mix together (pp. 8, 11, Remnant & Thomas, 1992) | | Baffin Bay Narwhal Population<br>(DFO, 2008; DFO, 2010a; Richard et al., 2010) |
| Breeding area / Critical Habitat | (pp. 6-7, Remnant & Thomas, 1992)<br><br>Thought to mate throughout the year (n=7.5/19)<br>(pp. 10, Remnant & Thomas, 1992)<br><br>Give birth during spring/summer (n=17/23) (pp. 7, Remnant & Thomas, 1992)<br><br>Give birth in Fjords where the water was warm and silty (pp. 10, Remnant & Thomas, 1992) | | |
| Foraging Area | (pp. 6-7, 10 Remnant & Thomas, 1992) | | |

| Characteristics of Narwhal stock/population | TEK | Science | |
|---|---|---|---|
| | | Stock Specific | Population Specific |
| | Some hunters believe feeding takes place in winter has they are thinner in the summer. Winter feeding areas are at the floe edge. Fjords are summer feeding grounds (pp. 7, Remnant & Thomas, 1992) | | |
| Prey | Narwhal diet consists of codfish, halibut, shrimp, herring arctic charr and sculpin (pp. 7, Remnant & Thomas, 1992)<br><br>Narwhal diet consists of arctic charr, cod, shrimp, turbot sculpin, krill and squid throughout the year (pp. 11, Remnant & Thomas, 1992) | | |
| **Life History Characteristics** | | | |
| Birth rate | | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Mortality | | None | |
| Growth rate | | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Age of maturity | | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Number of offspring /mother | One per year, but may have two calves from different years (n=16/19) (pp. 7, 11, Remnant & Thomas, 1992) | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Gestation | Mostly unknown (n=15/19), some say less than a year (4/19) (pp. 7, 10, Remnant & Thomas, 1992)<br><br>Give birth annually (n=17.5/23)<br>(pp. 7, Remnant & Thomas, 1992)<br><br>May skip a year of pregnancy while nursing young (pp. 11, Remnant & Thomas, 1992) | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Gender ratio | | Use 0.04 for cetaceans | |

| Characteristics of Narwhal stock/population | TEK | Science | |
|---|---|---|---|
| | | **Stock Specific** | **Population Specific** |
| | | (DFO, 2008; Wade 1998) | |
| Age Structure | | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| **Hunting/Predation** | | | |
| Quota | | | |
| Number hunted | | | |
| Hunting Loss rate | | | |
| Number preyed upon | | | |
| **Behaviour** | | | |
| Disturbance | Very sensitive to noise (pp. 11, Remnant & Thomas, 1992) | | |
| Grouping | | | |
| Diving | | | |
| Influences of tide | | | |

*Table 4.3. Synthesis of Traditional Ecological Knowledge (TEK) and Science knowledge on narwhal (Eclipse Sound Stock).*

| Characteristics of Narwhal stock/population | TEK | Science | |
|---|---|---|---|
| | | Stock Specific | Population Specific |
| Population number | Narwhal are less common than they were in the 1960s. Suggested because of increased hunting pressure, increased noise from boats and snowmobiles (pp. 14, Remnant & Thomas, 1992)<br><br>Increase around Igloolik (n=5/35), which may be the decrease in animals in Pond Inlet (pp. 15, Remnant & Thomas, 1992)<br><br>Some hunters (n=21/35) feel the population of narwhal have not changed (pp. 16, Remnant & Thomas, 1992) | 20,225<br>(DFO, 2008) | |
| **Spatial Characteristics** | | | |
| Seasonal and Annual Location | Wait near Pond Inlet for ice to break and summer in area around Eclipse sound (n=24/35)<br>(pp 13-14, Remnant & Thomas, 1992)<br><br>Young whales tend to stay in inlets, where older ones will travel between inlets (n=1/35)<br>(pp. 14, Remnant & Thomas, 1992)<br><br>Leave inlets before ice forms in fall (n=32/35)<br>(pp. 14, Remnant & Thomas, 1992) | | Baffin Bay Narwhal Population<br>(DFO, 2008; DFO, 2010a; Richard et al., 2010) |
| Distribution / Extent of Distribution | Possibly migrate to between Newfoundland and Greenland during winter (n=3/35)<br>(pp. 13, 14, Remnant & Thomas, 1992) | | Baffin Bay Narwhal Population<br>(DFO, 2008; DFO, 2010a; Richard et al., 2010) |
| Breeding area / Critical Habitat | Unknown when narwhal mate (50%), but suggested that they mate any time of the year and most hunters do not know where they mate (pp. 15, Remnant & Thomas, 1992)<br><br>Calving takes place during summer anywhere narwhal feed and can take place over days (n=11/35)<br>(pp. 15, Remnant & Thomas, 1992) | | |
| Foraging Area | Narwhal feed actively prior to fall migration<br>(pp. 14, Remnant & Thomas, 1992)<br><br>Milne Inlet, Eclipse Sound and Koluktoo Bay contain rich food supplies | | |

| Characteristics of Narwhal stock/population | TEK | Science | |
|---|---|---|---|
| | | Stock Specific | Population Specific |
| | (n=2/35) (pp. 16, Remnant & Thomas, 1992) | | |
| Prey | Narwhal feed all year long, but increase consumption prior to their fall migration (pp. 15, Remnant & Thomas, 1992)<br>Narwhal feed on cod, Arctic char, halibut and shrimp (pp. 16, Remnant & Thomas, 1992) | | |
| **Life History Characteristics** | | | |
| Birth rate | | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Mortality | | None | |
| Growth rate | | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Age of maturity | | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Number of offspring /mother | Majority of hunters (n=27/35) stated there was only one calf per pregnancy (pp. 15, Remnant & Thomas, 1992) | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Gestation | Gestation has been suggested at less than one year (n=12.5/35) (pp. 15, Remnant & Thomas, 1992)<br><br>Many respondents said narwhal have a calf every two years (n=16/35) (pp. 15, Remnant & Thomas, 1992) | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Gender ratio | | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Age Structure | | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |

| Characteristics of Narwhal stock/population | TEK | Science | |
|---|---|---|---|
| | | Stock Specific | Population Specific |
| **Hunting/Predation** | | | |
| Quota | | | |
| Number hunted | | | |
| Hunting Loss rate | | | |
| Number preyed upon | Narwhal will wait in inlets if killer whales are present (n=1/35) (pp. 14, Remnant & Thomas, 1992) | | |
| **Behaviour** | | | |
| Disturbance | | | |
| Grouping | | | |
| Diving | | | |
| Influences of tide | | | |

*Table 4.4. Synthesis of Traditional Ecological Knowledge (TEK) and Science knowledge on narwhal (Somerset Island Stock).*

| Characteristics of Narwhal stock/population | TEK | Science | |
|---|---|---|---|
| | | Stock Specific | Population Specific |
| Population number | Little change in the number of narwhal (n=10/10) (pp. 23, 25, Remnant & Thomas, 1992; pp. 35, Stewart et al., 1995)<br><br>Two types of narwhal; larger darker and smaller lighter (n=3/10) (pp. 25, Remnant & Thomas, 1992) | 45,358 (DFO, 2008) | |
| **Spatial Characteristics** | | | |
| Seasonal and Annual Location | Move into Resolute Bay during summer (pp. 23, Remnant & Thomas, 1992)<br><br>Migrate in during Spring and out during Fall (pp. 23, Remnant & Thomas, 1992; pp. 35, Stewart et al., 1995) | | Baffin Bay Narwhal Population (DFO, 2008; DFO, 2010a; Richard et al., 2010) |
| Distribution / Extent of Distribution | | | Baffin Bay Narwhal Population (DFO, 2008; DFO, 2010a; Richard et al., 2010) |
| Breeding area / Critical Habitat | Mating and calving areas within Resolute Bay (pp. 24, Remnant & Thomas, 1992) | | |
| Foraging Area | Feeding towards Austin Channel (n=4/10) (pp. 23, Remnant & Thomas, 1992)<br><br>West of community of Resolute Bay and the southwest coast of Devon Island (n=2/10) (pp. 24, Remnant & Thomas, 1992) | | |
| Prey | Feed all year long (n=10/10) (pp. 24, Remnant & Thomas, 1992)<br><br>Feed on cod and other species of fish (pp. 24, Remnant & Thomas, 1992)<br><br>Shrimp, Arctic cod, and unidentified fish (pp. 39, Stewart et al., 1995) | | |

| Characteristics of Narwhal stock/population | TEK | Science | |
|---|---|---|---|
| | | Stock Specific | Population Specific |
| **Life History Characteristics** | | | |
| Birth rate | | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Mortality | | None | |
| Growth rate | | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Age of maturity | | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Number of offspring /mother | One calf per year (n=6/10) and there was no consensus on how often mothers have calves (pp. 24, Remnant & Thomas, 1992) | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Gestation | Gestation period is unknown as is calving time (pp. 24, Remnant & Thomas, 1992) | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Gender ratio | Males and females form separate groups (pp. 39, Stewart et al., 1995) | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Age Structure | | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| **Hunting/Predation** | | | |
| Quota | | | |
| Number hunted | | | |
| Hunting Loss rate | Narwhals observed with scars and healed bullet wounds (pp. 39, Stewart et al., 1995) | | |
| Number preyed upon | | | |
| **Behaviour** | | | |
| Disturbance | | | |
| Grouping | | | |
| Diving | | | |
| Influences of tide | | | |

*Table 4.5. Synthesis of Traditional Ecological Knowledge (TEK) and Science knowledge on narwhal (North Hudson Bay Stock).*

| Characteristics of Narwhal stock/population | TEK | Science | |
|---|---|---|---|
| | | Stock Specific | Population Specific |
| Population number | "Not decreasing", "Many not counted (pp. 13, Gonzalez, 2001)<br><br>Hard to determine the number of whales present each summer, but appear to be decreasing in number (pp. 84, Westdal et al, 2010) | 5,053<br>(DFO, 2008) | |
| **Spatial Characteristics** | | | |
| Seasonal and Annual Location | Leave Repulse Bay in late August and head south-east (pp. 14, Gonzalez, 2001); "No one is sure where Narwhal winter" (pp. 17, Gonzalez, 2001)<br><br>Migrate into Repulse Bay in June and July and out in August and September (pp. 81, Westdal et al, 2010)<br><br>Spend some time in the fall in Lyon Inlet, where there is a strong current, before moving on (pp. 83, Westdal et al, 2010) | | NHB Population<br>(DFO, 2010c) |
| Distribution / Extent of Distribution | Repulse Bay, Frozen Straight, Foxe Channel, Gore Bay, Lyon Inlet (pp. 13-14, Gonzalez, 2001) | | North Hudson Bay Population<br>(DFO, 2010c) |
| Breeding area / Critical Habitat | Calves are first seen in the area around Repulse Bay. Usually takes place over one month (pp. 17, Gonzalez, 2001) | | |
| Foraging Area | In summer: Narwhal are "following fish and they travel according to the food source" (pp. 14, Gonzalez, 2001) | | |
| Prey | "uugaq" or Arctic cod and "other things including shrimp, clams and smaller fish (pp. 17, Gonzalez, 2001) | | |
| **Life History Characteristics** | | | |
| Birth rate | | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Mortality | | None | |
| Growth rate | | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |

| Characteristics of Narwhal stock/population | TEK | Science | |
|---|---|---|---|
| | | Stock Specific | Population Specific |
| Age of maturity | | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Number of offspring /mother | | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Gestation | Some hunters think gestation is less than 15 months, whereas others think this may be correct as they either find really small fetuses or almost full term fetuses (pp. 17, Gonzalez, 2001) | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Gender ratio | | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| Age Structure | "big tusks are smarter than the younger narwhal" (pp. 18, Gonzalez, 2001)<br><br>Older narwhal in middle of bays, younger/mother and calves near shore (pp. 18, Gonzalez, 2001) | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) | |
| **Hunting/Predation** | | | |
| Quota | "Arviq HTO sets their maximum allowable of landed narwhal per year to 100"<br>"DFO quota for Repulse Bay is 25"<br>"This is a significant difference that needs to be addressed"<br>(pp. 23, Gonzalez, 2001) | | |
| Number hunted | "younger hunted when breaking thin ice" (pp. 18, Gonzalez, 2001)<br>"we see the ones with big tusks and we see money because we do not have jobs" (pp. 20, Gonzalez, 2001)<br><br>Provide information to the HTO, but could not be found at the HTO office. Members thought the information was sent to DFO in Winnipeg "Although hunters dutifully collect the information it is done because it is a requirement and not because it is useful to them" (pp 21, Gonzalez, 2001)<br>"it appears that at least some information is being lost" in relation to lack of co-ordination of CBM program (pp. 21, Gonzalez, 2001) | | |
| Identifying sexes/individuals | "Male narwhal are identified by their tusks. Very rarely does a female narwhal have a tusk. On occasion a large female will be taken by mistake" (pp. 19, Gonzalez, 2001)<br><br>"There are physical differences between individual narwhal but most hunters | | |

| Characteristics of Narwhal stock/population | TEK | Science | |
|---|---|---|---|
| | | Stock Specific | Population Specific |
| | cannot recognize narwhal from year to year" (pp. 19, Gonzalez, 2001) | | |
| Hunting Loss rate | "Hunting techniques and practices to reduce loss rate should be reviewed" (pp. 22, Gonzalez, 2001) | | |
| Number preyed upon | "Narwhal summer distribution us affected by the presence of Killer whales" (pp. 14, Gonzalez, 2001)<br><br>Killer whales cause narwhal to "panic" and disregard everything around them, sometimes almost beaching themselves (pp. 18, Gonzalez, 2001)<br><br>Killer whales are of large concern (pp. 19, Gonzalez, 2001)<br><br>If killer whales are present, narwhals come close to Repulse Bay (pp. 84, Westdal et al, 2010) | | |
| **Behaviour** | | | |
| Disturbance | "Narwhal get spooked easier than other marine mammals" (pp. 18, Gonzalez, 2001)<br><br>"Silent narwhal are scared narwhal taking action" (pp. 18, Gonzalez, 2001) | | |
| Grouping | "typically tavel in groups of 10-20 animals"<br>"when frightened or in danger, narwhal group together"<br>"otherwise narwhal separate in to male and female groups. Males further divide based on age and size" (pp. 18, Gonzalez, 2001) | | |
| Diving Behaviour | "15-20 minutes" or "30 minutes if being chased, decreasing as they get tired" (pp. 17, Gonzalez, 2001) | | |
| Influences of Tide | "In extreme high tide al animals get more active including narwhal"<br>"There is also more narwhal movement with the morning tide" (pp. 18, Gonzalez, 2001) | | |

Narwhal in the Baffin Bay population, consisting of four stocks plus the putative stocks, migrate in spring from eastern Baffin Bay, through the East Baffin and Eclipse Sound stock areas and then disperse into the Admiralty Inlet, Somerset Island, and Parry Channel, Jones Sound and Smith Sound stocks (Remnant and Thomas, 1992; Figure 1). In the fall, animals return by this same route back to Baffin Bay. The narwhal in the NHB population migrate from south Baffin Bay, through Hudson Straight, and towards Repulse Bay in the spring (Westdal et al., 2010; Westdal 2008; Gonzalez, 2001). They return on this same route in the fall towards southern Baffin Bay. This pattern of migration is consistent as reported in both the DFO science and TEK documentation. The TEK for the Baffin Bay population indicates that there is movement between summer stock areas of animals whereas the DFO science reports that there is no movement.

The TEK indicates that there are two forms of narwhal; a larger, darker narwhal and a smaller, lighter narwhal (Remnant and Thomas, 1992). The larger, darker animals tend to have a longer tusk, with the smaller lighter narwhal having a shorter tusk. Also, the TEK identifies that narwhal travel in groups of 10-20 animals, congregate when threatened and separate into groups of males and females during the summer (Gonzalez, 2001). TEK documented by Gonzalez (2001) also reports that narwhal are more active at high tide, especially during the morning tidal cycle.

Critical habitat is identified in the TEK (Gonzalez, 2001; Stewart et al., 1995, Remnant and Thomas, 1992), with feeding taking place at the floe edge and in deep channels, with strong currents. The TEK identifies Arctic Cod, Arctic Char, shrimp, halibut, turbot and other smaller fish as primary prey species. Information on critical habitat was not present in the science documentation reviewed for this report.

Life history characteristics are also reported in the TEK, identifying critical parameters such as number of offspring, gestation period, number of calves/female and location of mating. Furthermore, TEK studies clearly report that narwhal are sensitive to noise and alter their behaviour in the presence of killer whales (Stewart et al., 1995).

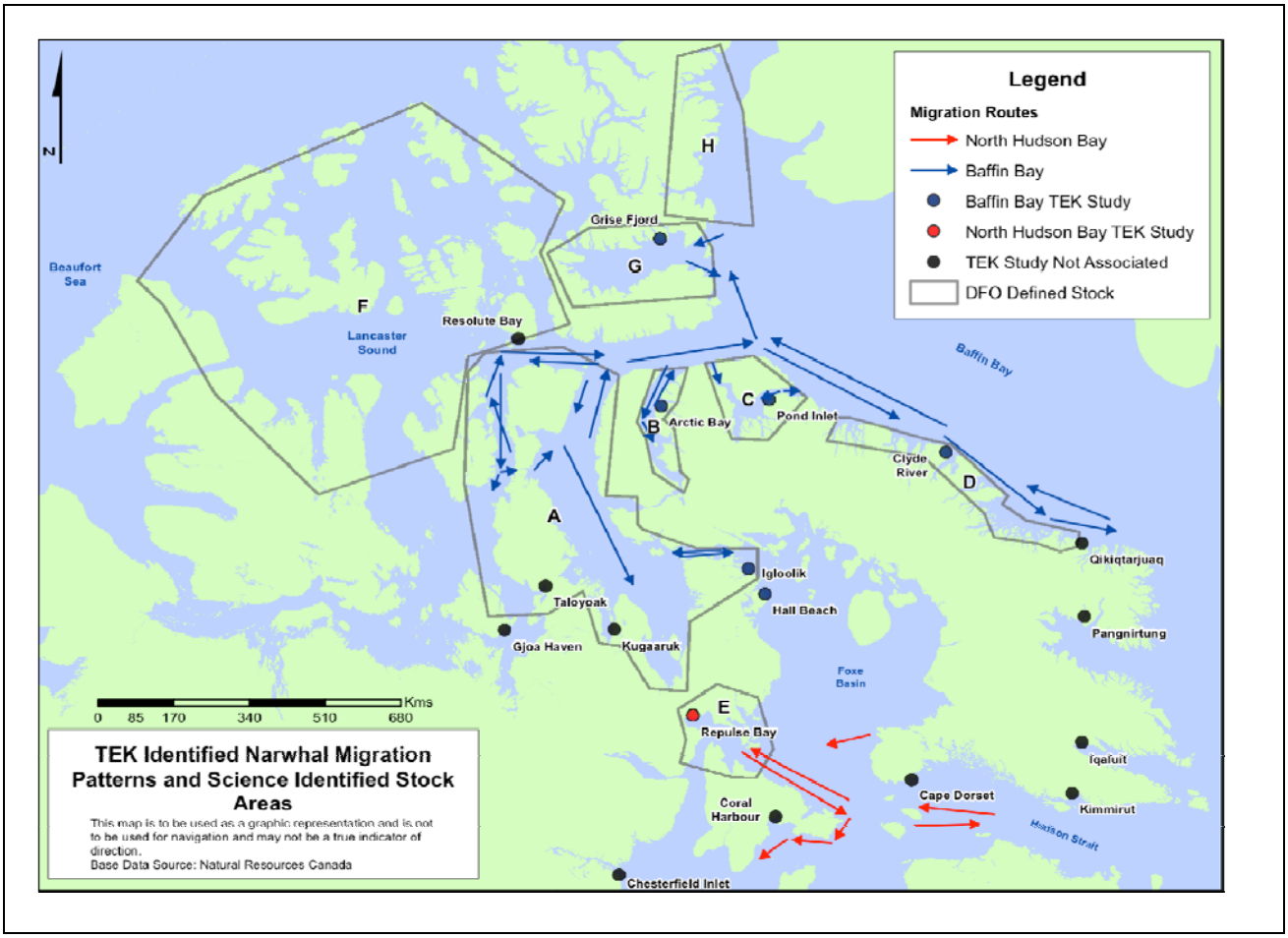


*Figure 1. Narwhal migration patterns identified through Traditional Ecological Knowledge (TEK) and narwhal summering aggregations based on scientific research surveys, tracking programs, and genetics.*

## CRITIQUE OF TEK CONDUCTED TO DATE FROM THE PERSPECTIVE OF SOCIAL RESEARCH DESIGN AND METHODS

A total of five TEK reports were identified for review in this paper. They span the years 1992 to 2010 and collectively have gathered knowledge from nine different communities and 140 individuals during this time period. A synthesis of knowledge gathered from Inuit hunters and Elders on critical management parameters is presented by stock in Tables 4.1 – 4.5 and is summarized by population in Tables 5 and 6. A rich dataset of Inuit knowledge exists among the five reports. The knowledge represented in the reports contains information on all management parameters with the exception of population gender ratios, age structure and age of maturity. In some instances, information exists within the TEK reports for which there was not science data reported on these stocks in the literature reviewed for this study (Table 5 and 6).

*Table 5. Summary of Traditional Ecological Knowledge (TEK) and Science knowledge on the Baffin Bay narwhal population.*

| Characteristics of Baffin Bay Narwhal population | TEK | DFO Science |
|---|---|---|
| Population Number | Varies between communities and years, but relatively constant (Stewart et al., 1995; Remnant & Thomas, 1992) | Summary of 4 stocks surveyed over many years: 81,018 (DFO, 2010a) |
| Seasonal and Annual Location | Overwinter in Baffin Bay, move to areas along Baffin, Devon, and Ellesmere Islands and throughout the Northwest Passage in the summer. Move between areas (DFO Stocks) from year to year (Stewart et al., 1995; Remnant & Thomas, 1992) | Overwinter in Baffin Bay as a population. Individual whales have site fidelity, returning to the same stock area year to year |
| Distribution | Extend west of Resolute Bay, North to Grise Fjord, South to Hall Beach and East to Qikiqtarjuaq. Move into inlets and bays in summer (Stewart et al., 1995; Remnant & Thomas, 1992)<br><br>Separate into groups of males, females and juveniles during summer (Stewart et al., 1995; Remnant & Thomas, 1992)<br><br>Two types of narwhal; Large, dark coloured and small, light coloured (Stewart et al., 1995; Remnant & Thomas, 1992) | Four known stocks:<br>Admiralty, Somerset, Eclipse and East Baffin (DFO, 2010a)<br>5th putative stock acknowledged |
| Critical Habitat | Mating, calving and feeding areas defined throughout their range (Stewart et al., 1995; Remnant & Thomas, 1992) | None identified |
| Birth Rate | One calf per female (Stewart et al., 1995), suggested to calve every two years , but mostly unknown (Remnant & Thomas, 1992) | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) |
| Age of maturity | None | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) |
| Gestation | Greater than a year (Stewart et al., 1995; Remnant & Thomas, 1992) | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) |
| Gender ratio | None | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) |
| Age Structure | None | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) |

*Table 6. Summary of Traditional Ecological Knowledge ( TEK) and Science on Northern Hudson Bay narwhal population.*

| Characteristics of North Hudson Bay Narwhal population | TEK | DFO Science |
|---|---|---|
| Population Number | Consistent (Gonzalez, 2001) or appear to be decreasing (Westdal, 2008) | 5,053 (DFO, 2008) |
| Seasonal and Annual Location | Overwinter in southern Baffin Bay, move through Hudson Straight to areas along Foxe Basin, Repulse Bay and North Hudson Bay in the summer. | Overwinter in Baffin Bay as a population. Individual whales have site fidelity, returning to the same area year to year |
| Distribution | Repulse Bay, Frozen Straight, Foxe Channel, Gore Bay and Lyon Inlet in summer (Gonzalez, 2001)<br><br>Separate into groups of males, females and juveniles during summer (Gonzalez, 2001)<br><br>Most hunters are unable to recognize individual narwhal from year to year (Gonzalez, 2001) | North Hudson Bay Stock (DFO, 2010c) |
| Critical Habitat | Mating, calving and feeding areas are suggested (Westdal, 2008; Gonzalez, 2001) | None identified |
| Birth Rate | None | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) |
| Age of maturity | None | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) |
| Gestation | Suggested by some to be 15 months based on fetuses observed (Gonzalez, 2001) | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) |
| Gender ratio | None | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) |
| Age Structure | None | Use 0.04 for cetaceans (DFO, 2008; Wade 1998) |

While the TEK reports provide evidence of valuable, rich, local-scale knowledge and observational data on the species, when reviewed them using standard criteria for social research methods, a number of limitations or challenges are identified (Table 7). As the data gathered through these studies are observations and knowledge of the local environment by individuals, gathered, interpreted and reported through the social research processes of interviewing and mapping it is valid to scrutinize and critique the methods used. These critiques are not, and should not be, brought to bare on the knowledge system on which these reports are based but rather on the strengths and limitations of the methods used in this social research process.

While all papers define what they refer to as TEK, definitions used vary considerably from what can be termed local ecological knowledge and expert observation to what constitutes and is referred to as IQ in Nunavut today. Three of the five TEK studies reviewed have taken a structured quantitative approach to representing the responses to questions included in knowledge interviews. Only Westdal et al. (2010) and Westdal (2008) adopt a mixed methods approach to the gathering and representation of TEK. What impact the framing of the issue had on interview responses, or how the potentially political nature of the study focus was managed to ensure good quality responses in data collection was rarely discussed by the reports. No studies discuss the positionality of the researcher, their relationship or role in the community or potential biases they bring to this social research process. Further, most studies used a referral process for participant selection and did not identify explicitly the criteria used to identify a knowledge holder or expert to be interviewed as considered by Davis and Wagner (2003). Justification of community selection for interviews similarly was not explicitly rationalized and described in the studies beyond basing selection on previous harvesting levels; Gonzalez (2001) and Westdal et al. (2010) and Westdal (2008) are exceptions in this regard. None of the studies provide details with regards to the rationale for the sample size of participants presented or how much of the active hunting population in a community their sample represents. As a result it is difficult to know how representative the knowledge is of all hunters in the community or among all observers in that local area if that was the intent of the sampling strategy. Rationale typically used in qualitative studies, such as seeking a point of 'saturation' in the data, was not presented.

Basic steps typically used in qualitative studies to ensure reliability of data collection and transcription, and validity in terms of analysis and interpretation are not present in all of the reports reviewed for this paper (Creswell, 2009). Only Westdal et al. (2010) and Gonzalez (2001) describe processes of verification of data with community participants. This lack of attention to detail either in the conduct or simply the reporting of methods used in some studies raises questions as to the reliability of reporting of the knowledge.

While the mapping conducted by Stewart et al. (1995) and Remnant and Thomas (1992) is a valuable representation of the knowledge gathered in conjunction with the questionnaire used, no studies truly analyse the data collected from Inuit knowledge holders in the 5 reports. A descriptive representation of responses is provided with no interpretation for the reader as to the quality or limitations of data or potential reasoning for patterns observed. Finally, no data is provided to describe the quality or quantity of participants' experience and variability in observations over time. This significantly limits the opportunity for analysis of the data beyond the descriptive reporting conducted to date. However it may be valuable in providing insight into such things as atypical observations and reports of narwhal gathered in proximity to any one community. In general, the studies conducted to date provide evidence for a rich, detailed and very valuable knowledge base on narwhal in the Canadian Arctic. However it can be argued that the quality of the social research conducted has not truly represented the extent and variability in the knowledge base well.

*Table 7. Summary and review of Traditional Ecological Knowledge (TEK) papers and reports on narwhal in the Canadian Arctic (criteria drawn from Table 3).*

| Study | Gonzalez, 2001 | Remnant & Thomas, 1992 | Stewart et al., 1995 | Westdal et al., 2010 | Westdal, 2008 |
|---|---|---|---|---|---|
| **Definition of TEK** | Knowledge passed down; Learned knowledge | Holistic in nature; Knowledge that is derived/rooted in the traditional way of life of Aboriginal people | Qualitative, long term observations; Discuss opinion vs knowledge in Appendix 1 | "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings, including humans, with one another and with their environment." | Provides a historical perspective and long term understanding of a species or ecosystem |
| **Reason for the study** | To gain a more complete understanding of narwhal (when used with science) | TEK could be recorded, passed on and fill any missing gaps in the science of narwhal and beluga | Seek to integrate local knowledge with science for better management decisions; Document Inuit knowledge of beluga and narwhal | To gain a more complete understanding of the NHB narwhal population, integrating science and TEK | To improve population estimates of narwhals summering near Repulse Bay, to determine if this population is geographically separate from other narwhal populations, to identify summer movement in the Repulse Bay area and to add to written documentation of local knowledge of the species, held only by community members, that may provide insight related to these issues |
| **Choice of approach** | Quant | Quant | Quant | Mixed | Mixed |
| **Framing to the community** | Improve management decisions of narwhal | Enable the IJC, NWMAB, HTAs and DFO to work cooperatively to make management decisions | Gain information to be used in resource management strategies and scientific research | Discussion with Elders and hunters about narwhal prior to any other research taking place | Incorporating traditional knowledge can assist in improving sustainability and understanding of a species |
| **Criteria for selection of community** | Primary community that hunts NHB narwhal | Traditional narwhal and beluga hunting communities | | | Primary community that hunts NHB narwhal |

| Study | Gonzalez, 2001 | | Remnant & Thomas, 1992 | | Stewart et al., 1995 | | Westdal et al., 2010 | | Westdal, 2008 | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Communities and Sample Size** | Repulse Bay | 8 | Broughton Island | 23 | Igoolik-Hall Beach | 5 | Repulse Bay | 17 | Repulse Bay | 17 |
| | | | Clyde River | 19 | | | | | | |
| | | | Pond Inlet | 35 | Arctic Bay | 6 | | | | |
| | | | Arctic Bay | 10 | | | | | | |
| | | | Resolute Bay | 10 | Grise Fjord | 3 | | | | |
| | | | Grise Fjord | 4 | Pang. | NR | | | | |
| | | | Pang. | NR | | | | | | |
| **Criteria for selection of participants** | Nominated by the HTOs and Kivalliq Wildlife Federation | | HTA recommended an interviewer for each community. The interviewer selected most "knowledgeable participants" | | Reputational sampling method (Roberts 1993)<br><br>Local HTA identified most knowledgeable of belugas/narwhals<br><br>Interviewed by a local resident, identified by the HTA | | Drawn from a list put together by HTA and interpreter | | Drawn from a list put together by HTA and interpreter | |
| **Ethics** | | | | | (in a separate document) | | | | Consent Form, Appendix I | |
| **Data collection method** | Workshop<br><br>Mapping and Questionnaire | | Local Interviewers<br><br>Mapping and Questionnaire | | Local Interviewers<br><br>Mapping and Questionnaire (Based on Remnant & Thomas, 1992, but with alterations) | | Semi-structured Interviews | | Semi-structured Interviews | |

| Study | Gonzalez, 2001 | Remnant & Thomas, 1992 | Stewart et al., 1995 | Westdal et al., 2010 | Westdal, 2008 |
|---|---|---|---|---|---|
| **Process of data collection** | Audio recording, pen and paper;<br><br>Conducted in Inuktitut with translator | Pen and paper;<br><br>Inuktitut version of questionnaire was available | Pen and paper;<br><br>Inuktitut version of questionnaire was available | Pen and paper;<br><br>Translator was available if needed or requested | Pen and paper;<br><br>Translator was available if needed or requested |
| **Copy of interview guide** | Built into report layout | Appendix 1<br>pp. 70-74 | Appendix 2 (but not in document available) | | Interview themes, Appendix III |
| **Analysis and description of data** | Some interpretation of responses; Maps pooled for hunting areas; Provide recommendations based on responses | Quantitative identification of common responses; Maps pooled for communities | Organized by topics, descriptive with limited analysis; Maps pooled for communities | Interpretive approach that aims to connect ideas and categorize results (Kitchin & Tate, 2000) | Interpretive approach that aims to connect ideas and categorize results |
| **Verification and validation of data** | All participants reviewed draft report before the final report was written | | | | Return to community before producing final report (consent form) |
| **Return of results to community** | Mention results should be available to HTO | Mention results will be made available to all parties involved | | | |

## DISCUSSION

As documented and shown in this review, both the science and TEK data presented on narwhal in the Canadian Arctic has strengths and limitations in terms of their contribution to our understanding of the species for the purposes of management. The science data on narwhal in the Canadian Arctic has generated population estimates (DFO, 2008; DFO, 2010a,c), home ranges (DFO, 2010a,b,c; Westdal 2008; Westdal et al., 2010) and provided data upon which recommended TALC (DFO, 2008) have been established for both the Baffin Bay and North Hudson Bay populations. The estimated populations are based on aerial surveys. The Baffin Island aerial surveys were based on the DFO defined stock areas that make up this population (Figure 1), with surveys taking place in different years. Both the science and TEK identify that narwhal travel through other areas (DFO stocks) to reach their typical summer range (Remnant & Thomas, 1992; Heide-Jørgensen et al., 2003) and the timing of this migration may vary between years. These factors may result in the same animal being counted more than once for the same population estimate, despite the fact that narwhal have been shown to have strong site fidelity (Heide-Jørgensen et al., 2003). Currently, life history characteristics are accounted for by DFO in the recommended TALC (DFO, 2008) by using 0.04 as the maximum rate of increase for cetaceans (Wade, 1998) and a recovery factor ($F_R$) of 1 for all stocks, with the exception of 0.5 for the Admiralty Inlet stock. However, as Wade and Angliss (1997: pg 62) state, "the default $F_R$ for depleted and threatened stocks and stocks of unknown status should be 0.5." This may mean that the currently recommended TALC for narwhal may be an overestimate.

The available TEK identifies year-to-year changes in the number of narwhal near individual communities (Gonzalez, 2001; Stewart et al., 1995; Remnant and Thomas, 1992). Communities identify "more" or "less" narwhal than previously observed, but do not establish specific population numbers. Local migration patterns are well identified for narwhal near communities included in TEK documentation studies (Figure 1), as are critical habitat areas at the population level, including feeding, breeding and calving areas (Gonzalez 2001; Stewart et al., 1995; Remnant and Thomas, 1992). This knowledge, combined with the existing knowledge of life history characteristics, allows for a diverse and in-depth understanding of narwhal behaviour and ecology that could be useful in management deliberations. For example, it is reported that in summer, narwhal move into separate groups of males, females and juveniles (Stewart et al., 1995; Remnant and Thomas, 1992). It is important to consider this knowledge in harvest management, as certain communities may be hunting groups of mostly males or females, for which some evidence exists in community harvest reports. Furthermore, the TEK identifies two different morphs of narwhal. If these are visually distinct there may be preferential hunting for the larger, longer tusked animals. Currently no analysis has been done of the TEK and hunting data to look at patterns in harvest of particular animals and the implications of this for population structure and trends.

The migration of the two populations of narwhal and their corresponding summer ranges are consistent between the DFO science and the documented TEK (DFO 2010a,b,c; Westdal et al., 2010; Westdal 2008; DFO 2008; Gonzalez, 2001; Stewart et al., 1995; Remnant and Thomas, 1992). However, there is not a clear understanding of the extent of the range of animals beyond the six stocks identified by DFO (Figure 1). Also, it is known that narwhal are located in the stocks of Parry Channel, Jones Sound, and Smith Sound. While, DFO has not investigated the extent of these animals, there is TEK on narwhal in the Jones Sound stock (Stewart et al., 1995; Remnant & Thomas, 1992).

In general, the TEK provides long term multi-year observational data and understanding at a community level where much of the DFO science represents a smaller sample size of observational data over a larger geographic but shorter temporal period. Table 8 provides a

summary of the nature of interaction between observational data generated by the two knowledge systems. It characterizes the interaction as data that either: 1. complements one another (e.g. TEK contributions to overall understanding and identification of critical habitat), 2. corroborates each other (e.g. TEK and science data on narwhal distribution) or 3. contradicts one another (e.g. TEK and science data on population trends). In comparing and ultimately using the two sources of knowledge together for decision making it is critical to review the comparability of scales at which these observations take place (Furgal et al., 2006; Gagnon and Berteaux, 2009). It is argued that data originating from two different processes of observation may differ simply because they do not occur at the same temporal, spatial or phenomonological (conceptual) scale. Differences observed in the data presented in Tables 5 and 6 and summarized in Table 8 may be a result of differences in scale of observation and reporting rather than actual disagreements or contradictions in the datasets.

*Table 8. Summary of comparative presentation of Science and Traditional Ecological Knowledge ( TEK) on narwhal in the Canadian Arctic.*

| **Characteristics** | **North Hudson Bay** | | **Baffin Bay** | | **Nature of Science – TEK interaction** |
|---|---|---|---|---|---|
| | TEK | Science | TEK | Science | |
| Population Number | - | 5,053 | - | 81,018 | Complement |
| Population Trend | Stable or Decreasing | Uncertain | Population stable, summer stocks vary | Uncertain | Contradict / Complement |
| Known Distribution | South Baffin Bay to Repulse Bay | South Baffin Bay to Repulse Bay | North Baffin Bay to Somerset Island | North Baffin Bay to Somerset Island | Corroborate |
| Critical Habitat | Feeding, mating and calving areas | - | Feeding, mating and calving areas | - | Complement |
| Life History Characteristics | ~15 month gestation | Use 0.04 in TALC calculation | > 1 year gestation, one calf per female | Use 0.04 in TALC calculation | Complement / Corroborate |

As mentioned previously, DFO aerial surveys took place in different years, having important implications for population approximation of migrating animals. Also, depending on the year and ice conditions, the timing of the narwhal migration may be slightly different. TEK data does not exist for those exact same years from all communities. In particular there is a lack of contemporary observational information in the TEK studies, with two occurring in the early-mid 1990s, one in 2001, and then the most recent in 2008.

As the TEK identifies, narwhal numbers may fluctuate among summer stock areas between years such that these observations may challenge the reports of strict summer site fidelity for the species. This may have implications for aerial survey estimates and stock specific observations regarding population trends. The TEK reported in the five documents reviewed for this paper represent local and regional understanding and observation of the species. Currently, no data exists in the reports to better understand the extent of observational effort (areas historically and currently hunted for narwhal by each individual participant) by knowledge holders or if reports are individual observations and not representations of the collective understanding among all hunters in one community. As a result it is difficult to determine the

scale at which observations and knowledge reported in the TEK take place. Further, no integration of data has taken place among communities to assemble the dataset at a larger scale from which greater understanding may be possible. Figure 1 provides a synthesis of TEK reports on narwhal migrations from the five reports as an example.

As in all cross-cultural or multiple language research, accurate and clear terminology and translation/interpretation is critical. Questions need to be precise and constructed to prevent ambiguity in the responses of individuals. This will ensure greater chance of comparability and compatibility between community reports which may be observing and interacting with the same migratory animals at different times of the year and hence important at a larger scale. Currently very few reports and literature in this field provide the required details to the reader to understand the processes undertaken to ensure accurate and precise translation of knowledge from local experts. Work conducted by the Government of Nunavut and Nunavut Tunngavik Inc. on climate change terminology highlights the importance of this issue (GN and NTI, 2005).

The TEK reports also identify changes in hunting practices, from historical hunting at the floe edge with a harpoon to modern hunting that uses motorboats and firearms (Gonzalez, 2001). Historically, hunting required fewer resources, more patience and more effort per narwhal whereas current hunting practices allow for greater access to narwhal, more attempts at an individual whale and potentially an increased pressure to be successful as a result of a quota system, causing hunters to take animals they would not typically kill and at times or in conditions hunters would not normally hunt (Gonzalez, 2001). No influence of social, political, economic or cultural change on observational efforts, and therefore knowledge, is provided in the TEK reports. The role of contextual factors in influencing knowledge transmission and reporting has been highlighted for other issues elsewhere in the Arctic (Pearce et al., 2011) and may be relevant here.

Finally, all observational data collection and interpretation in the natural or social sciences has standardized accepted methods to ensure data quality, reliability and validity (e.g. Creswell, 2009). The social research methods used to gather and present TEK are no different. There may be critiques that pertain to the scientific methods and assumptions inherent therein for the data presented here, however the focus of this paper was on the TEK gathered on narwhal in the Canadian Arctic. Currently there exists a lack of detail in the TEK reports in either the adherence to standards of social research methods or in their presentation in the documents. The concern here is that critique of the data presented to date may be focused on the knowledge system and what it has to offer in terms of enriching our understanding of narwhal ecology. However, it is argued that such critique, if justified, should be aimed at the methods and communication of methods used in the research and not the knowledge system itself. Without attention to detail in many aspects of the methods used to ensure reliability and validity of qualitative data collection and presentation it is difficult to have significant confidence that studies are accurately and thoroughly representing the contributions that could be made from Inuit Knowledge holders on this topic. It is clearly evident that a source of significant and rich knowledge exists and likely that there is significantly more to learn from and about this knowledge on narwhal in future research.

## CONCLUSIONS

This paper synthesized and reviewed the documented TEK available on narwhal in the Canadian Arctic. It has identified a number of significant contributions from Inuit Knowledge holders evident in the reports including the identification of critical habitat, a potential challenge to the understanding of summer site fidelity in the species and the existence of two colour and size morphs of narwhal. In comparing the science and TEK on this species at the stock and

population levels opportunities for complementary use of the datasets are evident. The TEK has the potential to enhance understanding of the species' ecology in a number of areas. Contradictions that may exist between the two datasets or knowledge systems, may originate from differences in the temporal, spatial or phenomenological scale at which observations are gathered and knowledge is generated. A review of the methods used in the collection, treatment, analysis and reporting of the TEK identified a number limitations in the research conducted in this area to date. Currently the lack of attention to detail in social research methods and processes to ensure reliability and validity in the collection and analysis of the TEK, or the presentation of this information in the reports, raises questions with regards to whether or not the full contribution from this knowledge is accurately represented.

It is recommended that a comprehensive, integrated science and TEK mixed methods study be considered to gain a more comprehensive understanding of narwhal biology and ecology, on which management decisions could be based. Such cooperative inquiry would allow for a valuable, robust, transparent and defensible data set to be created that considers all knowledge holders and sources involved.

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## APPENDIX 1: LITERATURE GATHERED AND REVIEWED FOR REPORT "A SYNTHESIS AND CRITICAL REVIEW OF THE TRADITIONAL ECOLOGICAL KNOWLEDGE LITERATURE ON NARWHAL (*MONODON MONOCEROS*) IN THE EASTERN CANADIAN ARCTIC.

### NARWHAL MANAGEMENT, HARVESTING AND ECOLOGY LITERATURE (PROVIDED BY FISHERIES AND OCEANS CANADA)


DFO. 2008. Total Allowable Harvest Recommendations for Nunavut Narwhal and Beluga Populations. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2008/035.

DFO. 2010. Stock Definition of Belugas and Narwhals in Nunavut. DFO. Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/079.

DFO. 2010. Survey Index of the Northern Hudson Bay Narwhals, August 2008. DFO. Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/082.

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Richard, P.R. 2008. On determining the Total Allowable Catch for Nunavut odontocete stocks. DFO. Can. Sci. Advis. Sec. Res. Doc. 2008/022. iv + 12 p.

Richard, P.R. 2010. Stock Definition of Belugas and Narwhals in Nunavut. DFO. Can. Sci. Advis. Sec. Res. Doc. 2010/022. iv + 14 p.

Richard, P.R. 2010. Survey Index of the Northern Hudson Bay Narwhals, August 2008. DFO. Can. Sci. Advis. Sec. Res. Doc. 2010/021. iv + 17 p.

Richard, P.R., Laake, J., Hobbs, R., Heide-Jørgensen, MP., Asselin NC, and Cleator, H. 2010. Baffin Bay Narwhal Population and Numbers: Aerial Surveys in the Canadian High Arctic, 2002-04. Arctic 63(1):85-99.

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### NARWHAL TRADITIONAL ECOLOGICAL KNOWLEDGE (TEK) LITERATURE (PROVIDED BY FISHERIES AND OCEANS CANADA)


Armitage, D. R. 2005. Community-Based Narwhal Management in Nunavut, Canada: Change, Uncertainty, and Adaptation. *Geography*, Vol 18(8):715-731.

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**NARWHAL TRADITIONAL ECOLOGICAL KNOWLEDGE (TEK) – SCIENCE MIXED METHODS LITERATURE (PROVIDED BY FISHERIES AND OCEANS CANADA)**

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