UNIVERSITÉ DU QUÉBEC À RIMOUSKI

COMPLÉMENTARITÉ ENTRE SAVOIR ÉCOLOGIQUE INUIT ET CONNAISSANCES SCIENTIFIQUES: LE CAS DE L'ÉCOLOGIE DU RENARD ARCTIQUE, DU RENARD ROUX ET DE LA GRANDE OIE DES NEIGES DANS LA RÉGION DE MITTIMATALIK, NUNAVUT, CANADA

MÉMOIRE PRÉSENTÉ À

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AVANT-PROPOS

Ce mémoire est présenté sous forme de trois chapitres. Le premier consiste en une introduction générale qui vise à informer le lecteur sur le contexte théorique de l'étude, de même que sur le contexte historique de l'utilisation du territoire d'étude par le peuple Inuit qui y vit. Le second, lui, est un chapitre de livre publié par C.-A. Gagnon et D. Berteaux qui décrit la situation institutionnelle et théorique faisant de l'utilisation du savoir écologique traditionnel inuit une nécessité dans la gestion des aires protégées du Nunavut. Il donne le contexte de la présente étude ainsi que quelques résultats préliminaires. Le troisième chapitre, présenté sous forme d'article scientifique à être soumis à la revue *Ecology and Society*, expose les résultats finaux du projet. Le mémoire se termine par une conclusion générale.

Il est à souligner que le travail de recherche qui est à l'origine de ce mémoire a également engendré les produits suivants, non inclus dans le mémoire faute de place. Premièrement, un compendium inclut toutes les citations extraites des transcriptions de plus de 38 heures d'entrevues. Les citations rassemblées dans ce compendium sont classées selon des sujets ayant trait à l'écologie du renard arctique, du renard roux et de la grande oie des neiges, mais abordant aussi des sujets comme les changements observés dans les écosystèmes locaux, les activités ayant eu un impact sur l'environnement, les relations écologiques entre diverses composantes des écosystèmes de la région de Mittimatalik et des concepts d'éthique environnementale inuite. Deuxièmement, toute information géographique documentée sur des cartes topographiques au cours des entrevues est intégrée dans un projet géomatique permettant de créer des cartes en lien avec un sujet et/ou un expert local particulier, tout en permettant d'accéder aux extraits d'entrevues (transcrits) durant lesquels l'information était discutée. Enfin, un DVD relate l'expérience vécue par les 18 participants au camp ainés-jeunes organisé par C.-A. Gagnon et D. Berteaux et ayant eu lieu sur l'île Bylot du 11 au 17 juin 2006. En plus d'un court film sur le camp, dont le but était de favoriser le transfert de savoir écologique traditionnel entre aînés et jeunes Inuits, le DVD comprend quatre extraits vidéos documentant quelques aspects de savoir écologique inuit mis en pratique : la préparation de la viande de phoque avant la mise en cache, le dépeçage des oies, la confection d'articles de décoration à partir d'oies et quelques extraits de légendes inuites contées par les aînés. Quiconque est intéressé par le compendium de citations, le projet géomatique ou le DVD peut contacter Catherine-A. Gagnon pour plus de détails.

Contribution des auteurs

Bien que Dominique Berteaux figure comme co-auteur du chapitre publié et de l'article à être soumis, les deux manuscrits doivent être considérés comme ayant été écrits par l'étudiante seule, constituant ainsi son mémoire de maîtrise. La contribution de Dominique Berteaux se limite au rôle normal de supervision, tant lors de l'élaboration du projet que lors de la rédaction. Catherine-Alexandra Gagnon a élaboré le projet, récolté les données, procédé aux analyses et rédigé le mémoire.

RÉSUMÉ

Dans les dernières décennies, la reconnaissance du savoir écologique traditionnel (SÉT) s'est accrue dans le milieu de la recherche et de la gestion environnementale, auxquelles il a contribué par l'apport d'information nouvelle et de perspectives locales. Au Canada, la valeur du SÉT a d'ailleurs été soulignée par l'établissement de mesures, parfois légales, exigeant la co-application du SÉT et de la science pour la gestion de certaines ressources. Or, si maints écrits ont vanté les mérites de cette co-application, peu de discussions ont eu lieu quant aux différentes méthodes pouvant maximiser le potentiel de l'intégration SÉT-connaissances scientifiques. Nous avons travaillé avec des aînés et chasseurs de la communauté de Mittimatalik (Pond Inlet), Nunavut, Canada, dont le SÉT doit maintenant être incorporé dans les mesures de gestion du Parc National du Canada Sirmilik (PNC Sirmilik). Dans ce contexte, l'objectif général de notre projet était d'analyser l'idée selon laquelle le degré de complémentarité entre SÉT et savoir scientifique dépendrait avant tout de l'échelle à laquelle chaque type de connaissance aurait été acquis. Plus précisément, nous avons testé l'hypothèse selon laquelle le SÉT devrait étendre les échelles spatiales et temporelles des connaissances scientifiques actuelles sur trois espèces importantes pour l'écosystème terrestre du PNC Sirmilik : la grande oie des neiges (*Chen caerulescens atlantica*), le renard arctique (*Alopex lagopus*) et le renard roux (*Vulpes vulpes*). Par l'entremise de 23 entrevues semi-dirigées, 3 visites sur le terrain, 4 groupes de discussion et un camp aînés-jeunes, nous avons documenté le SÉT inuit concernant des aspects de l'écologie des renards et de l'oie complémentaires aux connaissances scientifiques actuelles. Par cette approche novatrice, nous avons démontré que de manière générale, les données scientifiques locales tendent à être très spécifiques et détaillées (l'approche du 'zoom-in'), que le SÉT inuit fournit une image plus globale du système (un 'zoom-out'). De plus, nous avons démontré que le SÉT sur l'écologie des renards étendait l'échelle spatiale et/ou temporelle des connaissances scientifiques en fournissant de l'information complémentaire sur l'écologie hivernale du renard arctique, les sites de tanières du renard arctique, l'abondance du renard roux et sur les aires où les différentes phases du renard roux ont été observées. Par contre, le SÉT sur la séquence de mue de l'oie des neiges, la période de migration automnale et les changements dans l'abondance et la distribution des oies, était moins complémentaire aux connaissances scientifiques, mais plutôt comparable aux mêmes échelles régionales. Dans le cas de l'oie, les données scientifiques recueillies durant la migration et l'hiver permettaient en plus d'obtenir des connaissances à des échelles spatiales et temporelles s'étendant au-delà de l'échelle régionale couverte par le SÉT.

Ces résultats illustrent que le niveau de complémentarité entre SÉT et savoir scientifique dépend du niveau de chevauchement d'échelle entre les deux ensembles d'observations pour une espèce donnée (un faible chevauchement d'échelle entraîne une grande complémentarité, et *vice versa*). Nous défendons donc l'idée qu'il est nécessaire de comprendre les échelles respectives auxquelles le SÉT et les connaissances scientifiques opèrent si l'on veut maximiser les bénéfices de leur co-application. Aussi, nos résultats

permettent de conclure que l'intégration du SÉT et de la science par l'approche de complémentarité d'échelles est un moyen puissant et utile permettant d'obtenir une image plus claire du système socio-écologique à l'étude, et d'améliorer le niveau de communication et de collaboration entre membres des communautés locales, biologistes et gestionnaires des ressources naturelles. Enfin, le prochain pas vers une intégration et une collaboration encore plus complète entre SÉT et connaissances scientifiques pourrait être atteint en menant un projet misant *a priori* sur les forces de chaque savoir et au cours duquel SÉT et données scientifiques seraient documentés, analysés et discutés simultanément.

TABLE DES MATIÈRES

LISTE DES ABRÉVIATIONS, SIGLES ET ACRONYMES

CODE	SIGNIFICATION
ARTN	Accord sur les revendications territoriales du Nunavut
CBH	Compagnie de la Baie d'Hudson
CGRFN	Conseil de gestion des ressources fauniques du Nunavut
CWS	Canadian Wildlife Service
GRC	Gendarmerie royale du Canada
HBC	Hudson's Bay Company
HTO	Hunters and Trappers Organization
IQ	Inuit Qaujimajatuqangit
IKWG	Inuit Knowledge Working Group
JPMC	Joint Park Management Comittee
LEK	Local ecological knowledge
LEP	Loi sur les espèces en péril
NLCA	Nunavut Land Claims Agreement
NWMB	Nunavut Wildlife Management Board
RCMP	Royal Canadian Mounted Police
SÉT	Savoir écologique traditionnel
SÉL	Savoir écologique local
Sirmilik NPC	Sirmilik National Park of Canada
TEK	Traditional ecological knowledge

CHAPITRE 1

INTRODUCTION GÉNÉRALE

Cette étude tente d'approfondir les aspects du savoir écologique traditionnel (SÉT) des Inuits du nord de l'île de Baffin qui, d'une part, peuvent conduire à une plus grande compréhension de certaines composantes de l'écosystème terrestre local et, d'autre part, peuvent permettre d'améliorer l'intégration du SÉT dans la gestion d'une aire protégée. Pour mieux cerner le contexte de l'étude et présenter son approche innovatrice, la première partie de cette introduction générale définit le SÉT, présente les caractéristiques générales qui le différencient de la science, situe le contexte de l'émergence du SÉT dans la recherche et la gestion de l'environnement et énonce quelque avantages et limites de son utilisation. La deuxième partie de l'introduction générale présente le cas du SÉT des Inuits du Nunavut, dont il est question dans notre étude. Nous donnons d'abord des exemples d'études écologiques sur le SÉT inuit réalisées au Nunavut, nous présentons l'approche par laquelle ce SÉT a été intégré dans les recherches écologiques et nous décrivons le contexte faisant de l'intégration du SÉT une nécessité dans la gestion des aires protégées du territoire. Nous donnons également un bref historique de l'occupation inuite de la région de Mittimatalik afin de mieux comprendre l'échelle spatio-temporelle sur laquelle le SÉT des Inuits de cette communauté, avec laquelle nous avons travaillé, s'est construit. Nous terminons l'introduction générale du mémoire par l'énoncé de l'objectif de notre étude et la description de l'approche que nous avons employée pour remplir cet objectif.

DÉFINITIONS ET CONTEXTE GÉNÉRAL

Définition du SÉT

La première difficulté à laquelle sont confrontés les chercheurs qui tentent de comprendre et d'intégrer le savoir écologique vient d'abord du défi de le définir et de lui attribuer un nom (Gilchrist et al., 2005; Nakashima et Roué, 2002). Jusqu'à maintenant, *savoir local*, *savoir autochtone, savoir traditionnel, savoir écologique local et savoir écologique traditionnel* ont été utilisés comme synonymes (Gilchrist et al., 2005). De ces termes, savoir écologique traditionnel (SÉT) est le plus utilisé et accepté (Berkes, 1999; Huntington, 2000; Johnson, 1992; Usher, 2000). Il se définit comme « un ensemble de connaissances, de pratiques et de croyances, évoluant par processus adaptatifs et transmis de générations en générations par voies culturelles, et traitant de la relation des êtres vivants (incluant les humains) entre eux et leur environnement »[1] (Berkes, 1999, p. 8). Il représente aussi, comme l'a défini Huntington (1998), « un système de connaissances expérimentales,

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[1] Citation originale : « 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, 1999, p. 8).

acquises par observation continuelle, et transmises entre les membres d'une communauté »[2].

Le mot « traditionnel », selon ces définitions, évoque la continuité historique et culturelle (Berkes, 1999; Berkes et al., 2003; Huntington, 2001). C'est toutefois ce même mot qui, dans l'expression, peut porter à confusion et laisser croire à un savoir archaïque, ancré dans le passé, et non adapté au présent (Berkes, 1999; Nakashima et Roué, 2002; Usher, 2000). Pour cette raison, certains chercheurs (ex. Stevenson, 1996) lui préfèrent d'autres termes. Aussi, certains biologistes trouvent le terme « savoir écologique local » (SÉL) plus approprié (Gilchrist et al., 2005) car ils considèrent que le savoir écologique recueilli dans un contexte de gestion de la faune correspond souvent à un savoir actuel, recueilli par des individus au cours de leur vie (Gilchrist et al., 2005), et non pas à un savoir « traditionnel », remontant au-delà d'une génération.

Dans cette étude, nous utilisons le terme SÉT d'abord parce qu'au-delà du débat sémantique, il reste le terme le plus souvent utilisé. Aussi, le mot « écologique » le rend plus spécifique à la discipline scientifique d'intérêt et enfin, il reconnaît que des personnes non autochtones peuvent aussi détenir un SÉT (Johnson, 1992). Enfin, nous tenons à utiliser le terme SÉT plutôt que SÉL car, même si la plupart des observations rapportées dans ce mémoire ont été recueillies au cours de la vie des personnes interviewées, elles sont

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[2] Citation originale : « the system of experimental knowledge gained by continual observation and transmitted among members of a community » (Huntington, 1998).

néanmoins basées sur des pratiques et une conception du monde faisant partie d'une longue continuité historique et culturelle.

Le terme « science » lui, sera utilisé pour désigner la science occidentale moderne basée en bonne partie sur l'approche hypothético-déductive et la réfutation d'hypothèses. C'est à cette science « objectiviste » qu'appartient la discipline de l'écologie dont nous traitons ici. Cette discipline aborde en général la nature avec une attitude découlant des philosophies occidentales de René Descartes et de Francis Bacon, selon lesquelles une séparation conceptuelle entre « Humains » et « Nature » est établie (Berkes, 1999; Pierotti et Wildcat, 2000).

Si les philosophes de la science sont eux-mêmes incapables d'établir une démarcation claire entre ce qui est science et ce qui n'en est pas, Agrawal (1995) considère futile d'essayer d'opposer SÉT et science. Les différences entre ces deux types de savoirs sont effectivement difficiles à établir (Berkes, 1999). Construire les archétypes de ces deux types de savoirs peut néanmoins nous instruire sur leurs aires de complémentarité potentielles. La figure 1 présente les différences générales (et donc les aires de complémentarité) entre SÉT et science et s'inspire des travaux de Berkes (1993), Johnson (1992) et Moller et al. (2004).

Malgré les différences énoncées, SÉT et science, comme manières de savoir, sont similaires en ce qu'ils sont tous deux basés sur une accumulation d'observations (Berkes et al., 2000) et qu'ils mettent tous deux l'emphase sur la répétitivité (Huntington et al., 2004a). En effet, la science essaie de produire des résultats qui peuvent être reproduits et le

SÉT permet à ses utilisateurs de prospérer et/ou survivre en prédisant les conditions auxquelles ils devront faire face (Huntington et al., 2004a). Toutefois le SÉT, en comparaison avec la science, est généralement qualitatif, ancré dans une culture (Berkes, 1999) et reconnaît nécessairement l'Humain comme faisant partie des écosystèmes (Pierotti et Wildcat, 2000; Salmon, 2000). Le SÉT est typiquement construit à l'échelle spatiale locale (quoique « locale » puisse référer à une grande échelle, comme nous le verrons plus bas) et à une échelle temporelle

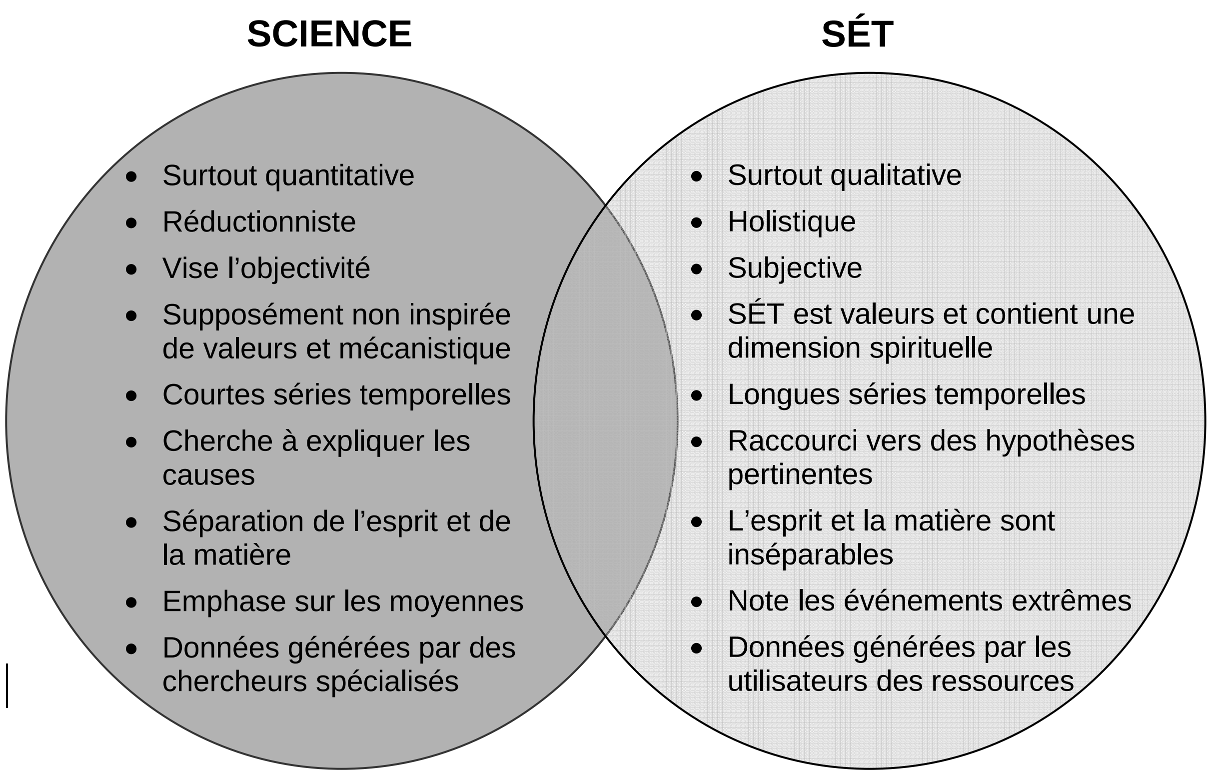

Figure 1. Différences et aires de complémentarité potentielle entre le SÉT et la science pour le suivi écologique.

couvrant facilement plusieurs décennies (Huntington et al., 2004a). La science quant à elle diffère du SÉT en ce qu'elle comprend une importante composante numérique, qu'elle exclut parfois l'humain des systèmes à l'étude (quoique plusieurs disciplines considèrent l'humain comme partie intégrante des milieux naturels) et qu'elle tente de quantifier l'incertitude associée à ses affirmations. Cette dernière caractéristique n'est d'ailleurs pas directement abordée par le SÉT (Huntington et al., 2004a). Enfin, bien que la science soit en mesure de générer des données couvrant de très longues séries temporelles (via le carottage, par exemple), la plupart des études scientifiques en écologie couvrent des séries temporelles relativement courtes (quelques décennies au plus).

Émergence du SÉT dans la recherche et la gestion de l'environnement

Depuis vingt ans environ, le SÉT de plusieurs peuples a pénétré le discours du développement durable, de la conservation de la biodiversité (Couzin, 2007; Nakashima et Roué, 2002) et de la gestion des ressources naturelles (Berkes et al., 2000; Moller et al., 2004). C'est en 1987, avec la publication de *Notre avenir à tous*, que la Commission mondiale pour l'environnement et le développement reconnaissait pour la première fois, à l'échelle mondiale, que les peuples autochtones devaient être impliqués dans la gestion des ressources naturelles (WCED (World Commission on Environment and Development), 1987). Plus tard, l'article 8(j) de la Convention sur la biodiversité (Nations Unies, 1993) contribuait aussi à cette reconnaissance en stipulant :

> Chaque Partie contractante, dans la mesure du possible et selon qu'il conviendra […] sous réserve des dispositions de sa législation nationale, respecte, préserve et maintient les connaissances, innovations et pratiques des communautés autochtones et locales qui incarnent des modes de vie traditionnels présentant un

> intérêt pour la conservation et l'utilisation durable de la diversité biologique et en favorise l'application sur une plus grande échelle, avec l'accord et la participation des dépositaires de ces connaissances […] (Nations Unies, 1993, pp. 176-177).

Au Canada, comme ailleurs dans le monde, le SÉT des peuples autochtones a gagné de la reconnaissance et son intégration dans la gestion des ressources fait maintenant partie de plusieurs législations. Si bien que selon certains, le Canada serait un des leaders mondiaux quant à ses efforts pour l'implication des connaissances des populations locales dans la gestion des ressources desquelles elles dépendent (Berkes et Henley, 1997). La Loi sur les espèces en péril du Canada (LEP) en est un des exemples les plus éloquents. En effet, selon l'article 15(2) de cette loi, le comité en charge d'évaluer et de désigner le statut des espèces doit :

> exécuter sa mission en se fondant sur la meilleure information accessible sur la situation biologique de l'espèce en question notamment les données scientifiques ainsi que les connaissances des collectivités et les connaissances traditionnelles des peuples autochtones (Sa Majesté la Reine du Chef du Canada, 2003, p. 13).

Au Nunavut, territoire de l'Arctique canadien où la population est majoritairement autochtone (inuite), l'intégration du SÉT autochtone occupe maintenant une place éminente. D'abord, le Mandat de Bathurst a fait du SÉT inuit (Inuit Qaujimajatuqangit [IQ]) un des principes directeurs du gouvernement du Nunavut (Wenzel, 2004). Aussi, selon l'Accord sur les revendications territoriales du Nunavut (ARTN; 1993), le Conseil de gestion des ressources fauniques du Nunavut (CGRFN) a dû conduire une étude sur les connaissances inuites en lien avec la baleine boréale (*Balaena mysticetus*). Par la même entente, appuyée par une entente-cadre sur les répercussions et les avantages pour les Inuits

(1999), l'agence Parcs Canada se doit d'utiliser les connaissances inuites dans la gestion de ses parcs au Nunavut.

Dans l'Arctique canadien donc, gouvernements et agences de financement demandent, et ce, de plus en plus, que le SÉT soit inclus dans la gestion de la faune (Gilchrist et al., 2005). En 2006, le CGRFN refusait d'ailleurs de financer la plupart des projets de recherche qui n'incluaient pas de composantes sur le SÉT (George, 2006). Même le programme spécial de subventions émis par le Conseil de recherches en sciences naturelles et en génie du Canada (CRSNG) dans le cadre de l'année polaire internationale 2007-2008 suggérait aux chercheurs que leurs projets incluent la participation des communautés nordiques et autochtones.

D'une part, cette appréciation croissante du SÉT a conduit à une activité scientifique bouillonnante entourant le sujet (Berkes, 1999). Ainsi, la littérature scientifique est maintenant riche d'articles discutant des mérites de son intégration dans divers aspects de la recherche et de la gestion de l'environnement tels la conservation de la biodiversité (Alcorn, 1993; Gadgil et al., 1993; Nakashima et Roué, 2002), l'acquisition de données de base sur les espèces, les processus écologiques (Drolet et al., 1987; Ferguson et Messier, 1997; Ferguson et al., 1998; Furgal et al., 2002; Mallory et al., 2001; Nakashima, 1991) et les changements environnementaux (Krupnik et Jolly, 2002; McDonald et al., 1997), les évaluations d'impacts (Nakashima, 1990; Stevenson, 1996) et la gestion des ressources (Berkes et al., 2000, 2003; Berkes et Folke, 1998; Gadgil et al., 2000; Huntington, 2000; Moller et al., 2004; Osherenko, 1988; Zamparo, 1996). D'un point de vue social, l'intégration du SÉT pourrait aussi permettre aux communautés de participer plus équitablement dans la gestion de leurs ressources (Huntington et al., 2002), leur redonnant ainsi un peu de pouvoir.

D'autre part, l'adoption de politiques et de lois nécessitant l'intégration du SÉT dans la gestion de l'environnement (Mauro et Hardison, 2000) a pour conséquence que plusieurs scientifiques et gestionnaires de l'environnement ont maintenant l'obligation légale d'incorporer le SÉT dans leurs évaluations et décisions (Mauro et Hardison, 2000), sans toutefois connaître la méthodologie à suivre pour une telle intégration (Usher, 2000). Or, même les chercheurs les plus enclins à l'intégration du SÉT admettent que sa collecte présente plusieurs défis (Huntington, 2000; Nuttall, 1998), que ses applications générales restent souvent obscures (Huntington, 2000) et que la combinaison du SÉT et de la science n'a pas encore atteint tout son potentiel (Huntington et al., 2004a). Dans ce contexte, et face au fait que les droits autochtones seront de plus en plus considérés dans la gestion et l'établissement de politiques, les scientifiques sont appelés à suivre les développements en cours (Mauro et Hardison, 2000) et à trouver des méthodes innovatrices et concrètes d'impliquer le SÉT dans leurs recherches.

Applicabilité et limites du SÉT

Outre les impératifs légaux et les débats philosophiques, l'intégration du SÉT présente un potentiel réel (Agrawal, 1995). Le SÉT peut, par exemple, fournir de l'information détaillée et de longue durée sur certaines ressources fauniques et processus écologiques (Ferguson et al., 1998; Hay et Members of the Inuit Bowhead Knowledge

Study Committee, 2000). En région éloignée et difficile d'accès, comme dans l'Arctique, l'échelle spatiale et temporelle des données scientifiques est souvent restreinte par les contraintes logistiques et monétaires imposées aux chercheurs. Une intégration du SÉT et de la science a donc le potentiel d'y être particulièrement utile (Gilchrist et al., 2005; Hay et Members of the Inuit Bowhead Knowledge Study Committee, 2000). Elle peut entre autres permettre d'améliorer les connaissances écologiques et les plans de gestion en augmentant l'échelle spatio-temporelle des connaissances, en stimulant de nouvelles questions et hypothèses de recherche (Moller et al., 2004) et en présentant de nouvelles avenues pour l'interprétation de résultats scientifiques (Riedlinger et Berkes, 2001). Le SÉT est en quelque sorte similaire à l'opinion d'expert utilisée parfois en gestion de la faune (Gilchrist et al., 2005).

Or, la gestion des ressources naturelles requiert non seulement l'acquisition de bonnes données, mais aussi l'établissement de liens de confiance entre les gestionnaires et les populations les plus directement affectées par leurs décisions (Berkes, 1999; Huntington et al., 2002). Dans une situation où gestionnaires et populations locales proviennent de cultures différentes, comme c'est le cas dans l'Arctique canadien, cette tâche peut être particulièrement ardue. Dans cette optique, l'intégration du SÉT et de la science est une approche prometteuse pour impliquer les usagers des ressources dans la prise de décisions qui les concernent, de même que pour favoriser l'échange de perspectives entre scientifiques, gestionnaires et membres des communautés (Huntington, 2000; Huntington et al., 2002).

Si son utilité a été exposée dans plusieurs études, pourquoi le SÉT est-il donc reçu avec encore autant de scepticisme au sein de la communauté scientifique (Pierotti et Wildcat, 2000)? Plusieurs chercheurs ont offert des explications à ce sujet (Gilchrist et al., 2005; Huntington, 2000; Nakashima, 1998; Nakashima, 1991). D'abord, le SÉT peut prendre plusieurs formes selon la culture dont il provient (Gilchrist et al., 2005), ce qui le rend souvent inintelligible aux chercheurs et institutions en place. Chercheurs et institutions, en conséquence, démontrent une certaine inertie face à l'utilisation de savoirs qui les forceraient à s'adapter à de nouveaux paradigmes (Huntington, 2000). À ce sujet, Nakashima (1998) mentionne qu'il est toujours difficile de concevoir comment différentes traditions culturelles appréhendent la nature et sa gestion. Il nous rappelle toutefois que la science est une construction culturelle en soi, constat qui, selon lui, confronte scientifiques et gestionnaires des ressources naturelles (Nakashima, 1998).

Certains scientifiques sont aussi résistants face à l'utilisation du SÉT sous prétexte qu'il n'est pas un savoir fiable et que son utilisation est motivée par un désir d'être «politiquement correct », réalisé au dépend de la rigueur scientifique (Huntington, 2000). Selon Gilchrist et al. (2005), le fait que le SÉT ne se base pas sur l'approche hypothético-déductive de la méthode scientifique serait une des causes principales du scepticisme à son égard, scepticisme qui serait exacerbé par les obstacles pratiques liés à sa collecte. Parce qu'il est rarement documenté par écrit, le SÉT est effectivement, dans la plupart des cas, difficilement accessible (Huntington, 2000). Sa collecte implique habituellement un long processus, fréquemment compliqué par des considérations d'ordre linguistique et culturel (Ferguson et Messier, 1997; Usher, 2000). Ces obstacles pratiques sont aussi amplifiés par la nécessité d'utiliser des méthodes appartenant aux sciences sociales pour la collecte du SÉT (Huntington, 2000). Or, certains scientifiques ne sont pas préparés à utiliser ces méthodes, même pour acquérir des données biologiques autrement inaccessibles. Finalement, la difficulté à faire la collecte de SÉT peut aussi provenir de la réticence des détenteurs du SÉT à partager leur savoir. Cette réticence peut être basée sur des tensions sociales, sur des inquiétudes face au fait que leurs connaissances soient mal interprétées ou enfin associée à des questions de propriété intellectuelle (Huntington, 2000).

Si les raisons justifiant le scepticisme face à l'utilisation du SÉT sont discutables (Huntington, 2000), le SÉT ne doit pas pour autant être considéré comme une panacée. Comme toute autre forme de savoir, le SÉT peut être incorrect (Gilchrist et al., 2005; Huntington, 2000; Moller et al., 2004) et présenter des biais importants (Lyver, 2002). Alors, comme le mentionne Huntington (2000), « Ne pas remettre en question l'acceptation du SÉT est aussi insensé que ne pas remettre en question son exclusion »[3]. De plus, l'utilisation du SÉT n'est pas toujours désirable et l'insistance pour qu'il soit incorporé dans chaque projet de recherche ne peut servir, selon Huntington (2000) qu'à le diminuer. Le SÉT devrait donc être promu pour ses qualités et évalué avec discernement, comme le sont les autres sources d'information utilisées en recherche et en gestion (Gilchrist et al., 2005; Huntington, 2000). Enfin il devrait être utilisé dans les cas où il augmente la qualité des connaissances disponibles et améliore l'implication des utilisateurs de ressources dans les prises de décisions qui les concernent (Huntington, 2000).

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[3] Citation originale : « Unquestioning acceptance of TEK is as foolish as unquestioning its rejection » (Huntington 2000).

CAS DU SÉT DES INUITS AU NUNAVUT

Études sur le SÉT des Inuits du Nunavut

De par leur occupation et utilisation intensive du territoire, les Inuits ont développé un SÉT très riche sur l'environnement arctique. Ce savoir a été au centre de plusieurs investigations, depuis des ethnographies en lien avec la chasse jusqu'à des études écologiques très détaillées (Wenzel, 2004). Or jusqu'à récemment, les études écologiques sur le SÉT, menées au Nunavut, ont été largement orientées vers les espèces récoltées comme par exemple la baleine boréale (Hay et Members of the Inuit Bowhead Knowledge Study Committee, 2000), le caribou (*Rangifer tarandus*) (Ferguson et Messier, 1997; Ferguson et al., 1998), l'ours polaire (*Ursus maritimus*) (Van de Velde et al., 2003) et l'eider à duvet (*Somateria mollissima*) (Nakashima, 1991). Dernièrement, le Service canadien de la faune a aussi conduit une série d'études sur le SÉT en lien avec plusieurs espèces d'oiseaux marins (Gilchrist et al., 2005; Mallory et al., 2006; Mallory et al., 2001; Mallory et al., 2003). De plus, suite aux changements globaux auxquels l'Arctique est présentement soumis, on a vu surgir un intérêt pour les études sur le SÉT inuit en lien avec les changements environnementaux (Fox, 2002) et leurs impacts sur les communautés inuites (Ford et Smit, 2004).

Les résultats de ces études ont surtout été présentés sous forme de documentation du SÉT et accompagnés, dans certains cas, de réflexions sur le potentiel d'intégration du SÉT et de la science (Ford et Smit, 2004; Fox, 2002; Hay et Members of the Inuit Bowhead Knowledge Study Committee, 2000; Mallory et al., 2001; Mallory et al., 2003; Van de Velde et al., 2003). D'autres études ont aussi réussi à intégrer SÉT et connaissances scientifiques en employant une approche de comparaison entre les deux savoirs (Ferguson et Messier, 1997; Ferguson et al., 1998; Gilchrist et al., 2005). Selon l'étude, le but de l'approche comparative était de « valider » le SÉT recueilli (Gilchrist et al., 2005), d'identifier les causes de disparité entre les deux savoirs, d'augmenter le niveau de confiance des données disponibles ou de combler certains vides (Ferguson et Messier, 1997; Ferguson et al., 1998). Toutefois, si l'approche comparative entre SÉT et science présente plusieurs utilités (Gilchrist et al., 2005; Huntington et al., 2004a; Huntington et al., 2004b), une autre approche d'intégration, possiblement plus prometteuse, a été maintenant proposée et sera plus tard (voir partie «*Objectif de l'étude* ») expliquée (Huntington et al., 2004b).

Intégration du SÉT inuit dans la gestion d'aires protégées au Nunavut

Comme nous l'avons mentionné, l'Accord sur les revendications territoriales du Nunavut (ARTN; 1993), a établi le SÉT des Inuits (IQ) comme un des principes directeurs du gouvernement du Nunavut. Ce même accord requiert aussi que le SÉT des Inuits soit incorporé dans la gestion des parcs nationaux du Nunavut. Ce mandat est d'ailleurs au centre des priorités de l'Unité de gestion du Nunavut de l'agence Parcs Canada depuis quelques années (voir le Chapitre 2 pour plus de détails). Toutefois, alors que l'agence Parcs Canada doit augmenter l'importance du SÉT dans le plan de gestion de ses ressources, son but ultime est de protéger l'intégrité écologique de ses parcs (Agence Parcs Canada, 2000). L'Agence a d'ailleurs développé sa propre définition de l'intégrité écologique comme étant : « un état jugé caractéristique de sa région naturelle et susceptible de durer, qui comprend les composantes abiotiques et la composition de même que l'abondance des espèces indigènes et des communautés biologiques, les rythmes de changement et les processus qui les soutiennent » (Parcs Canada, 2004).

La mise en place de plans de gestion visant à protéger l'intégrité écologique d'un parc requiert des connaissances de base sur les écosystèmes à gérer. Or, dans le cas des parcs nationaux de l'Arctique, les connaissances scientifiques sur les écosystèmes sont souvent restreintes. Par exemple, dans le cas du parc national du Canada Sirmilik dont il est question dans cette étude, seule une petite portion du parc a été étudiée en détails par les scientifiques, avec une attention particulière sur l'écologie de la grande oie des neiges et des renards arctiques et roux (voir le Chapitre 2 pour plus de détails). Le SÉT que possèdent les membres de la communauté de Mittimatalik, qui utilisent le parc de façon régulière pour vaquer à leurs activités de subsistance, présente donc une bonne opportunité pour compléter l'étendue du savoir scientifique actuel et identifier de nouvelles pistes de recherche. D'ailleurs, le SÉT des Inuits de Mittimatalik couvre des échelles spatiales et temporelles généralement plus grandes que celles couvertes par les données scientifiques actuelles, du moins au niveau régional.

L'utilisation du territoire et des ressources par les Inuits de Mittimatalik

Le SÉT dont il est question dans cette étude est celui d'aînés et de chasseurs actifs de la communauté de Mittimatalik, située dans le nord de la Terre de Baffin (Territoire du Nunavut, Canada). Afin de bien comprendre le contexte et l'échelle spatio-temporelle sur laquelle repose le SÉT recueilli dans cette étude, il est nécessaire de jeter les bases historiques et modernes de l'utilisation du territoire et des ressources par les experts locaux reçus en entrevues, de même que par leurs parents, grands-parents et ancêtres.

Selon les évidences archéologiques, la région de Mittimatalik a été constamment habitée depuis environ 4 000 ans (Mary-Rousselière, 1984-1985). D'abord ce sont les chasseurs des cultures prédorsétienne (2000 à 500 ans av. J.-C.) et dorsétienne (500 av. J.-C. à 1500 ap. J.-C.) qui habitèrent la région. Les « Prédorsets » sont les chasseurs qui ont probablement traversé le détroit de Béring environ 2000 av. J.-C., pour ensuite peupler l'Arctique canadien et le Groenland. La culture de Dorset, descendant des « Prédorsets », était centrée sur la chasse aux mammifères marins, ses chasseurs étant capables de récolter des animaux aussi imposants que le morse (McGhee, 2006, p. 51-53). Plusieurs sites prédorsétiens et dorsétiens sont connus dans la région de Mittimatalik (Mary-Rousselière, 1987; Mary-Rousselière, 2002). Selon les légendes, les Dorsets, que les Inuits appellent « *Tunniit* » (sing. *Tuniq*) (Mary-Rousselière, 2002), étaient des gens extrêmement forts, mais gênés et facilement effrayés par les Inuits (Cornelius Nutarak, communication personnelle).

Environ 1000 ans ap. J.-C., les Inuits d'Alaska de la culture de Thulé (1000 à 1600 ap. J.-C.) ont commencé une migration vers l'est et ont tranquillement déplacé la culture de Dorset, dont aucun descendant n'a survécu jusqu'à aujourd'hui (Rigby et al., 2000). Les « Thulés » apportèrent avec eux des techniques complexes de chasse aux grands mammifères marins, telle la baleine boréale (McGhee, 2006 p.115), qui fut d'ailleurs grandement chassée dans la région de la Terre de Baffin. Aux alentours de 1600 ans ap. J.-C., la culture Thulé a commencé à être grandement bouleversée par les changements de conditions climatiques associés à la *Petite Glaciation*, de même que par les maladies introduites par les premiers explorateurs européens (McGhee, 2006, p.128-131). Néanmoins, plusieurs chasseurs Thulés se sont adaptés et ont continué à occuper l'Arctique pour devenir les ancêtres des Inuits contemporains (McGhee, 2006, p.116).

Les Inuits de la région de Mittimatalik appartiennent au groupe tribal des Inuits Iglulik, et plus précisément au sous-groupe des « Tununirmiut ». « Tununirmiut » signifie le « peuple de la place ombragée », en référence aux montagnes de la région qui cachent parfois le soleil. Traditionnellement, les « Tununirmiuit » (pluriel de Tununirmiut) étaient des chasseurs-cueilleurs vivant en petits groupes dispersés et se déplaçant au gré des saisons pour suivre les animaux. Ils utilisaient surtout les fjords du détroit d'Éclipse et le Navy Board Inlet comme territoires de chasse. Comme la majorité des Inuits, leur survie dépendait surtout des mammifères marins, notamment plusieurs espèces de phoques et le narval (Mary-Rousselière, 1984-1985). Cette diète était complétée par le caribou qui fournissait, en plus de la viande, le matériel essentiel à la fabrication de vêtements chauds (Rigby et al., 2000). Selon la saison, la diète des Tununirmiuit était aussi complétée par le poisson (surtout l'omble chevalier), les oies et les canards (de même que par leurs œufs), les lagopèdes, le lièvre et quelques baies (Rigby et al., 2000).

Les contacts plus fréquents avec les Européens, qui datent du début du 19e siècle, ont beaucoup modifié la culture matérielle et l'utilisation du territoire faite par les Tununirmiuit. D'abord, l'arrivée des baleiniers, durant la deuxième moitié du 19e siècle, a encouragé plusieurs familles à changer leurs mouvements saisonniers pour aller chasser les espèces fournissant des biens de grande valeur d'échange (l'ivoire et les fourrures) et ensuite aller les troquer contre des biens matériels provenant du Sud (Brody, 1976). Les Inuits sont rapidement devenus dépendants des avantages procurés par plusieurs de ces biens, tel le fusil. Au début du 20e siècle donc, suite au départ des baleiniers ayant dilapidé les stocks de baleines, les familles de la région se sont tournées vers la traite des pelleteries pour pourvoir à leurs besoins. Ainsi, la traite du renard arctique est rapidement devenue le centre de l'économie inuite. C'est entre 1912 et 1920 que les premiers postes de traite ont été installés dans la région de Mittimatalik, dirigés par différentes compagnies et indépendants. Ces premiers postes furent fermés suite à l'établissement du poste de la Compagnie de la Baie d'Hudson (CBH) en 1921 (Usher, 1972).

La traite de la fourrure, encore plus que les baleiniers, a encouragé les familles inuites à faire de longs voyages vers les postes de traite et à explorer des territoires de chasse lointains. En effet, les activités de la traite « impliquaient de longs voyages dans le but de faire des échanges, une vie qui amenait les familles à faire des allers-retours dans la région toute entière, entretenant ainsi l'utilisation et le savoir d'une vaste contrée »[4] (Brody, 1976, p. 154). La traite appliquait aussi des pressions contraires sur les Inuits :

> Les familles étaient d'un côté encouragées à déménager près des Blancs et de l'autre, poussées à faire la plus complète utilisation de leur territoire d'une part pour préserver leur indépendance par la distance, d'autre part pour utiliser leurs ressources de façon optimale (Brody 1976, p. 156).[5]

Suite à l'établissement du poste de la CBH en 1921, la Gendarmerie royale du Canada (GRC) installa un poste à Mittimatalik en 1922, suivie de près par les églises anglicane et catholique, en 1929 et 1930. Toutefois, malgré l'établissement de ces institutions, la plupart des familles inuites ont continué à vivre dans des camps dispersés sur toute la région (Mary-Rousselière, 1984-1985) et à poursuivre la traite des pelleteries. Ce n'est qu'au début des années 60, suite à la construction d'une petite école, que la plupart des familles se sont déplacées vers Mittimatalik. Même après cette sédentarisation, la traite de la fourrure est demeurée une activité économique importante, du moins jusqu'aux années 80 quand les revendications des groupes de défense des droits des animaux ont provoqué la chute du marché de la fourrure (Wenzel, 1991).

De nos jours, Mittimatalik dispose, comme la plupart des communautés nordiques, d'une économie mixte, basée surtout sur les emplois du gouvernement, les paiements de transfert et les activités de subsistance (voir Chapitre 2 pour plus de détails) qui amènent les

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[4] Citation originale : « involved long journeys for the purpose of trade, a life that took families back and forth across the whole region, thereby maintaining the use and knowledge of a vast area » (Brody, 1976, p. 154).

[5] Citation originale : « Families were as they were, on one hand, encouraged to move towards the Whites, but, on the other, they were pushed into making the fullest use of their lands, both to preserve independence through distance and to make best use of the resources» (Brody, 1976, p. 156).

chasseurs à utiliser un vaste territoire. La région de Mittimatalik est d'ailleurs particulière du fait que le détroit d'Éclipse, se situant entre la Terre de Baffin et l'Île Bylot forme une « autoroute de glace » sur laquelle les chasseurs peuvent circuler de façon sécuritaire d'octobre à juillet (Mary-Rousselière, 1984-1985). Aux extrémités de cette autoroute, c'est-à-dire aux limites est et ouest de l'île Bylot, se situe la limite de la banquise (floe edge) où les mammifères marins sont particulièrement accessibles (Mary-Rousselière, 1984-1985). Ces deux zones ont toujours été très prisées par les chasseurs de Mittimatalik qui, encore aujourd'hui, effectuent plusieurs heures de déplacement pour y parvenir (observations personnelles). Outre ces zones, plusieurs autres sont fréquentées pour des raisons spécifiques telles la chasse au caribou, la trappe du renard et la chasse à l'oie. Ainsi, les activités de subsistance, qui ont toujours une place importante à Mittimatalik, font en sorte que plusieurs membres de la communauté entretiennent de vastes connaissances écologiques sur leur territoire. L'aire totale du territoire de chasse couvert par la communauté était d'ailleurs estimée, en 1991, à 97 000 km^2 (Riewe, 1991). Ainsi, aujourd'hui même, le SÉT des Inuits de Mittimatalik couvre un espace plus étendu que les études scientifiques menées dans la région, s'étalant de plus sur une échelle temporelle couvrant plusieurs décennies de mémoires personnelles et collectives.

OBJECTIF DE L'ÉTUDE

Dans ce contexte, *l'objectif général* de l'étude était de faire la collecte de SÉT afin de compléter la boîte à outils utilisée par les scientifiques et gestionnaires pour gérer l'écosystème terrestre du parc national du Canada Sirmilik (voir figure 2).

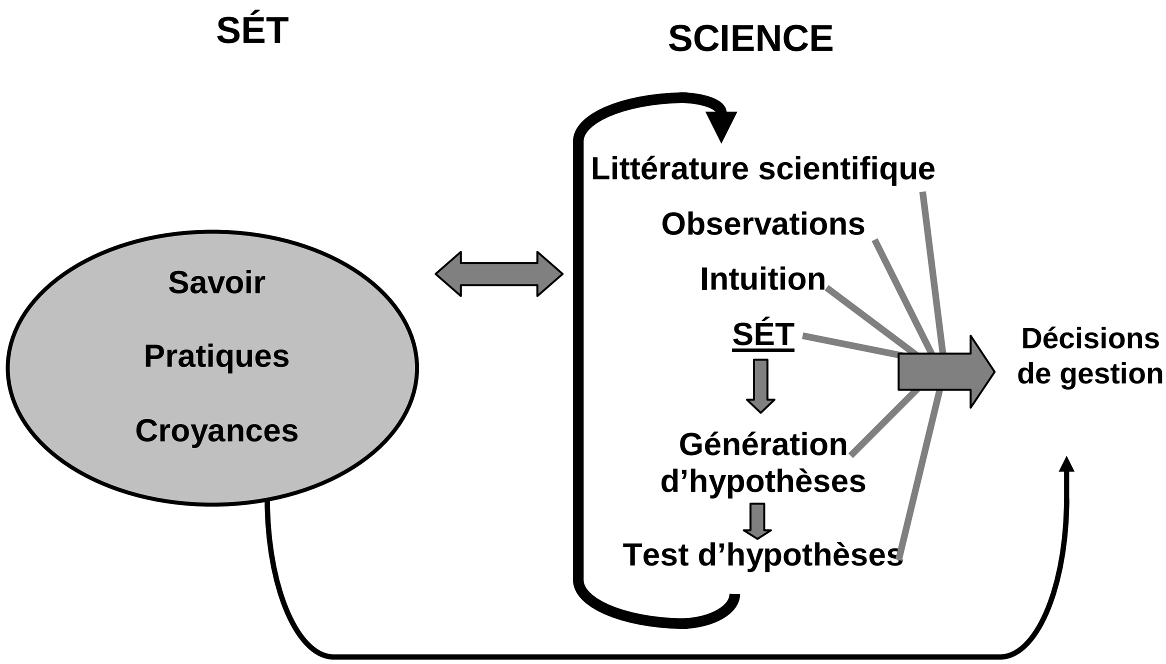

Figure 2. Organisation générale de la recherche au parc national du Canada Sirmilik, montrant comment le SÉT peut être utilisé pour améliorer la compréhension et la gestion d'un écosystème terrestre arctique

Dans le but de poursuivre cet objectif général, notre sous-objectif principal était de: *faire la collecte de savoir inuit en lien avec l'écologie et le comportement de la grande oie des neiges et des renards arctique et roux, en mettant l'emphase sur la collecte* *d'informations pouvant étendre l'échelle spatio-temporelle des connaissances scientifiques actuelles sur ces espèces.*

Le principal intérêt de ce sous-objectif était de voir si le SÉT peut fournir de nouvelles observations, idées et valeurs permettant de générer de nouvelles hypothèses de recherche et de contribuer à l'interprétation de données scientifiques disponibles. Dans ce contexte, le but du sous-objectif n'était pas de comparer le SÉT avec les données scientifiques existantes (quoiqu'en certains cas il ait été possible de le faire; voir Chapitre 3), mais bien d'explorer les aspects du SÉT qui pourraient potentiellement enrichir la base d'informations sur laquelle scientifiques et gestionnaires dépendent pour générer de nouvelles hypothèses et interpréter leurs résultats. De par le fait même, ce sous-objectif permettait d'appliquer l'approche par complémentarité entre SÉT et science, tel que suggérée par Huntington et al. (2004b), et d'en évaluer ses avantages et ses limites.

En effet, si les dernières années ont vu l'apparition d'un discours préconisant l'utilisation conjointe du SÉT et de la science, (Chapin III et al., 2004; Gilchrist et al., 2005; Huntington et al., 2004b), relativement peu de discussions ont eu lieu quant aux différentes manières d'intégrer ces savoirs (Huntington et al., 2004b). Comme nous l'avons vu, l'approche comparative entre SÉT et science a été jusqu'à maintenant la plus largement utilisée (Gilchrist et al., 2005; Huntington et al., 2004a; Huntington et al., 2004b). Or, Huntington et al. (2004b) ont récemment proposé d'utiliser le SÉT et la science de façon complémentaire plutôt que comparative. En identifiant les forces et limites du SÉT et des données scientifiques, cette approche par complémentarité serait selon eux plus prometteuse, car elle permettrait de maximiser l'utilisation des qualités de chacun des savoirs. Jusqu'à maintenant, très peu d'études ont misé sur cette approche (Huntington et al., 2004b). C'est donc pour son côté innovateur, de même que pour sa plus grande capacité à élargir l'étendue de nos connaissances, que nous avons décidé de favoriser cette approche dans la présente étude. Enfin, le choix de cette approche était d'autant plus justifié par le fait que le savoir des Inuits de Mittimatalik s'étend à des échelles spatiales temporelles complémentaires à celles du savoir scientifique actuellement disponible pour la région.

Finalement, la grande oie des neiges et les renards arctique et roux étaient des modèles particulièrement intéressants pour cette étude parce que : 1) ces espèces sont bien connues et récoltées par les Inuits de la communauté de Mittimatalik, 2) elles sont bien étudiées par les scientifiques, mais seulement durant le printemps et l'été et ce, dans une aire précise, 3) elles jouent un rôle clé dans l'écosystème terrestre local (voir Chapitre 2) et 4) la collecte de SÉT en lien avec ces espèces est facilitée par le fait qu'elles sont « apolitiques » (voir Chapitre 3).

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CHAPITRE 2

INTEGRATING TEK AND ENVIRONMENTAL SCIENCES INTO THE MANAGEMENT OF CANADA'S NATIONAL PARKS

Chapitre de livre publié après révision par les pairs, et dont la référence est :

Gagnon, C.-A., et D. Berteaux. 2006. « Integrating traditional and scientific knowledge: management of Canada's national parks ». Pages 209-221 *dans* R. Riewe, et J. Oakes, editeurs. **Climate change: integrating traditional and scientific knowledge.** Winnipeg : Aboriginal Issues Press. 289 p.

Le format original du chapitre a été modifié afin de satisfaire à la mise en page requise pour le mémoire.

C.-A. GAGNON ET D. BERTEAUX. Intégration de savoir écologique traditionnel et de sciences environnementales pour la gestions des parcs nationaux du Canada

Dans cette étude de cas menée au parc national du Canada Sirmilik, nous présentons le contexte d'un projet de recherche s'intéressant au Savoir Écologique Traditionnel (SÉT) en lien avec l'oie des neiges, le renard arctique et le renard roux. Nous montrons comment le SÉT partagé par plusieurs aînés et chasseurs de Mittimatalik (Pond Inlet, Nunavut) complète les données obtenues par la science occidentale et peut contribuer à la gestion du parc. Nous pensons que la collecte de SÉT est essentielle pour le développement de stratégies de gestion écosystémique qui soient sensibles aux réalités locales.

C.-A. GAGNON AND D. BERTEAUX. Integrating traditional ecological knowledge and environmental sciences into the management of Canada's national parks.

In this case study from Sirmilik Canada National Park, we present the context of a research project on Inuit Traditional Ecological Knowledge (TEK) pertaining to snow geese, arctic foxes and red foxes. We show how TEK shared by Elders and hunters from Mittimatalik (Pond Inlet, Nunavut) complements Western Science and can contribute to the management of the park. We argue that documenting TEK is essential for the development of ecosystem-based management strategies that are locally sensitive.

INTRODUCTION

Over the past 20 years, the idea of combining Traditional Ecological Knowledge (TEK) and Western Science for managing natural resources has gained a growing recognition (Berkes et al., 2000; Moller et al., 2004). In Canada, the increased appreciation of TEK, coupled with native political and cultural claims, has led to legislation and policies requiring that TEK be considered alongside Western Science in certain resource management decisions (Usher, 2000). For example, a cornerstone of the Nunavut Land Claims Agreement was the creation of a council that would ensure Inuit involvement in decisions regarding the preservation and development of land covered in the agreement (Gouvernement du Canada, 1993). Furthermore, following the creation of the territory in 1999, Inuit Traditional Knowledge (*Inuit Qaujimajatuqangit [IQ]*) has emerged as a guiding principle of the Government of Nunavut (Wenzel, 2004).

Set out in the Nunavut Land Claims Agreement (Gouvernement du Canada, 1993), and further defined in an Inuit Impact and Benefit Agreement (1999), it is also now a legislative requirement that Inuit knowledge be included in the management of Canada's National Parks in Nunavut (Nunavut Field Unit of Parks Canada, 2004). The first step in fulfilling this requirement was the creation of Joint Park Management Committees (JPMC) for each National Park in Nunavut. For Sirmilik National Park of Canada (Sirmilik NPC, Figure 1), a JPMC was created when the park was established in 2001. Since its creation, the JPMC has fulfilled its advisory role to Parks Canada, but members of the committee soon realized that true integration of Inuit knowledge wasn't being fully achieved. As a consequence, the JPMC for Sirmilik NPC set the collection and integration of Inuit TEK as the first priority for the park (Parks Canada, 2002). During the 2001 Sirmilik NPC Resource Description workshop, it was also agreed by Elders, scientists and Parks Canada that collection and integration of TEK related to birds, hunting activities, history of people in the area, and wildlife behaviour would be a priority.

Recognizing that the integration of TEK in Nunavut National Parks was not being fully addressed (Nunavut Field Unit of Parks Canada, 2004), the Nunavut Field Unit of Parks Canada launched a multi-year ″Inuit Knowledge Project″ in 2004 precisely dedicated to the incorporation of TEK in the planning and management of Nunavut parks (Parks Canada, 2005).

Here, we present an ongoing project in which interests of Mittimatalik (Pond Inlet) residents, Parks Canada staff, and academic scientists were combined to investigate Inuit TEK pertaining to greater snow geese (*Chen caerulescens atlantica*), arctic foxes (*Alopex lagopus*) and red foxes (*Vulpes vulpes*). This project is a crucial step in integrating Inuit TEK into the management of Sirmilik NPC, first because it puts in place an approach to TEK collection, and second because it gathers abundant information on species central to the local ecosystem. At the time of writing, the project reaches its final stages and this paper presents the current views of the two academic scientists most deeply involved in the study.

The project also has the potential to contribute to a broader understanding of Inuit values and activities associated with the above-mentioned wildlife species. Inuit from

Mittimatalik have traditionally hunted greater snow geese and collected their eggs (Brody, 1976; Riewe, 1992). Today, families from Mittimatalik hunt geese and gather their eggs while camping on the South plain of Bylot Island (personal observation, June, 2005), where is established the most important breeding colony of this sub-species worldwide (Reed et al., 1998). As for arctic foxes (and to a lesser extent red foxes), Inuit from the area formerly trapped them extensively. From the 1920's, when the Hudson's Bay Company established a trading post in Mittimatalik, to the mid 1970's, fox fur represented the most important asset traded by Inuit to secure cash and/or other valuable goods (Sawtell, 2005). Currently, only a few hunters still trap foxes around Mittimatalik, and trapping is no longer a major economic activity in the area. Nonetheless, foxes are highly visible and are frequently observed by local hunters traveling on the land (Panipakoocho, 2005).

Greater snow geese, arctic foxes, and red foxes, are also intensively studied by scientists at Sirmilik NPC. In the late 1960s and early 1970s Canadian authorities conducted reconnaissance surveys of breeding greater snow geese on Bylot Island (J.D. Heyland, unpublished) and instituted a standard survey in 1983, which has been repeated every five years since (Reed et al., 2002). In 1988, a permanent study site was established on the South plain of Bylot Island as a joint collaboration between Université Laval and the Canadian Wildlife Service. Major themes investigated at this site include: a) goose demographics and population dynamics (Gauthier et al., 2004; Reed et al., 2002), b) impact of goose grazing on tundra vegetation (Gauthier et al., 1995) and more recently c) trophic interactions between plants, herbivores and predators (Bêty et al., 2002; Gauthier et al., 2004). As part of this last theme, arctic and red foxes have been studied since 1993.

However, research on arctic and red foxes expanded in 2002 to include a) a study of the northern range expansion of red fox that occurred during the twentieth century (MacPherson, 1964), b) an investigation of the potential competition between arctic and red foxes (Gauthier et Sahanatien, 2005), and c) a study on the potential effects of global climate change on the ecology of these two fox species.

Thus, the idea of developing an Inuit TEK project that would focus on geese and foxes emerged from the mutual interests of local community members seeking to promote the value and application of their knowledge, and academic and government scientists seeking to expand their sources of information. Furthermore, one of the management objectives of Parks Canada is also to protect the ecological integrity of its parks. In this context, collecting Inuit TEK about geese and foxes has the potential to contribute to the monitoring of the ecological integrity of Sirmilik NPC by providing information on two important changes operating in its terrestrial ecosystems, namely the increase in numbers of greater snow geese migrating to the area, and the appearance of a new species to the area (the red fox, a potential competitor to the arctic fox).

Further stimuli for the project included the perceived need by both scientists and the local community to build partnerships and stronger human relations between academics (who usually are busy summer visitors to the Arctic who ″come and go with the birds″) and year-round resident Inuit Elders, trappers, and hunters.

METHODS

Study Area

Mittimatalik is a community of approximately 1200 inhabitants, of whom 94% are Inuit (Sawtell, 2005). Historically, people from Mittimatalik lived in outpost camps throughout Lancaster Sound, Eclipse Sound and Navy Board Inlet (Brody, 1976). The Hudson's Bay Company established a trading post in Mittimatalik during the 1920's, but it was not until the 1950's that permanent settlement started to occur, becoming prominent from 1955 to 1965 (Brody, 1976).

Today, Mittimatalikmiut (the people from Mittimatalik) have a mixed economy divided between wage salaries and land-based subsistence activities such as hunting and fishing (Indian and Northern Affairs Canada, 2004). Subsistence activities are associated with wildlife species such as ringed seal (*Phoca hispida*), bearded seal (*Erignathus barbatus*), harp seal (*Pagophilus groenlandicus*), narwhal (*Monodon monocerus*), caribou (*Rangifer tarandus*), polar bear (*Ursus maritimus*), arctic char (*Salvelinus alpinus*), greater snow goose (*Chen caerulescens atlantica*), and arctic fox (*Alopex lagopus*) (Riewe, 1992; Statistics Canada, 2004). Still today, Mittimatalikmiut perfom subsistence activities on a wide territory spreading through Eclipse Sound, Northern Baffin and Bylot Island.

Sirmilik means ″the place of glaciers″ in Inuktitut. In 2001, Sirmilik NPC was created in the area adjacent to the communities of Ikpiarjuq (Arctic Bay) and Mittimatalik (Pond Inlet). Covering an area of over 22 000 km^2, the park encompasses most of Bylot Island and most of the northern tip of Baffin Island (Figure 1). It includes territories travelled, hunted and fished for thousands of years by local Inuit and their ancestors (Brody, 1976; Mary-Rousselière, 2002).

Preliminary Consultations

Prior to the implementation of the project, we conducted general community consultations during two meetings held in Mittimatalik in February-March 2005. These meetings served to introduce the project and to invite advice and feedback. Approximately 20 local Elders, representatives from the Inuit Qikiqtani Association, and members of the JPMC attended the meetings. Consultations allowed us to evaluate concerns and the level of community support of the project. During both meetings, representatives from the community expressed their support for the project. In July 2005, a Mittimatalik Inuit Knowledge Working Group (IKWG) was created as part of the Parks Canada Inuit Knowledge Project. This working group, which overlooks the project, is composed of three Elders (two individuals elected from the Elders Committee and one individual selected by the Hunters and Trappers Organization), and a youth member. We maintain frequent contacts with the IKWG to ensure that local benefits are promoted through every step of the project.

Approach to TEK Collection

Following consultations, one of us (C.-A. Gagnon) resided in Mittimitalik from May-September 2005 and conducted the first phase of knowledge gathering upon which this project is based. Over this period, 21 local experts (6 women, 15 men; 9 Elders not-actively hunting; 5 Elders actively hunting; 7 hunters) were interviewed using the informal semi-directive interview method (Grenier, 1998). Semi-directed interviews are open and flexible, and are not as rigid as questionnaires. General themes are established in advance by the interviewer, but questions remain open-ended and leave room for new subjects to emerge (Grenier, 1998). In general, the two following themes were brought up during interviews: a) geese: cultural use and importance, hunting areas, changes in abundance and distribution, migration routes, and timing of moult; b) foxes: cultural use and importance, location of trap-lines, changes in abundance and distribution, winter feeding habits, moult, and arrival of red fox in the area. We selected local experts to be interviewed based on recommendations from Elders, members of the Mittimatalik Hunters and Trappers Organization, people from the Hamlet Office, and community members working for Parks Canada and the Nunavut Wildlife Management Board. With the consent of informants, a local student assistant audio and video recorded all interviews. Interviews were simultaneously translated into English and Inuktitut by a local translator. All audio, video and written materials produced through the interviews will be archived by Parks Canada and made accessible to the community (Nunavut Field Unit of Parks Canada, 2004).

During interviews, maps stimulated conversation and were used as a recording aid. TEK pertaining to factual data about the environment is geographically specific, so maps convey tremendous value (Usher, 2000). Maps allowed informants to draw attention to places that are important for foxes and geese, or were personally valued for other reasons. As much as possible, we conducted interviews in places where informants felt comfortable, which included personal homes, the local visitor centre, the Parks Canada office, and traditional camping and hunting sites. Interviews conducted on the land were particularly effective in stimulating conversation, bringing back memories of hunting and camping stories. They generally made the informant feel more at ease. However, due to logistical and economic constraints, we could not conduct all interviews on the land.

An important step in performing TEK studies is data validation, a technique that involves a detailed check of data accuracy, interpretation of data, and conclusions drawn from data. Data validation is performed by the informants who are given the opportunity to judge the accuracy of the accounts and the correctness of the interpretations reported by the interviewers (Creswell, 1998).

At the time of writing this paper, only a small portion of the collected information and subsequent interpretation was validated by informants. We here only present this validated fraction of the project results, and use that merely to demonstrate the type of outcomes that will emerge from the study. Research will be completed in late 2006, after complementary information will have been collected from informants and they will have validated all interpretations.

Elders and other local representatives have expressed, since the beginning of the project, their desire that their knowledge be shared with youth from the community. Considering this, we will organize an Elder-youth camp in the summer of 2006, during which the knowledge shared by the Elders and hunters will be discussed, put into practice, and communicated to the younger generation. The camp, held within Sirmilik NPC boundaries, will not only allow for meaningful educational experiences for the youth. It will also provide an opportunity for Elders, youth, scientists, and Parks Canada staff to exchange, while on the land, about common interests (e.g. wildlife, ecological relationships, conservation of resources) usually approached from different conceptual angles, and with various techniques, objectives, and cultural background. All of these human groups play a role in the current or future understanding and management of the local environment.

RESULTS AND DISCUSSION

We have recorded nearly 40 hours of interviews. While the project is still ongoing, the information shared and validated by local experts already reveals the richness of local Inuit TEK pertaining to geese and foxes.

Greater Snow Geese

Interviews provide insights on cultural importance (traditional and current) of geese to local people, on hunting techniques, and on goose ecology. Below we illustrate the information that was shared, first through an example about the past and present importance of geese to people, and then through an example related to the fall goose migration.

Goose meat and eggs have always been alternative food items for local people, both historically and in contemporary times. However, the importance of geese to informants seemed to depend on the location where they camped and hunted when they were young.

Informants who had lived closer to the goose colony were more likely to consider goose as a delicacy.

> Usually it (the importance of geese) depends on the kind of food people usually eat. People who eat quite a bit of geese, their younger generation will tend to eat the same type of food that their Elders are eating. So the geese are very important for the younger generation, to be passed on to, like food wise and to learn how to hunt… So food wise and hunting wise, I believe it's very important to give to the younger generation (Akomalik, 2005).

Traditionally, geese were used as food for immediate consumption or, when hunted in surplus, were dried or cached for later use. Goose body parts were also transformed into domestic objects such as brooms (wings), mattresses (skins with feather), down-filled garments, flutes (trachea) and small bags (skins from legs and feet). Today, geese and their eggs are considered as a delicacy, and they are eaten shortly after being hunted or collected. Down-filled garments and brooms made of goose wings are still used in some households (personal observation, June, 2005).

> Like the wings, I always collect them, I put them in bags, and all during the winter, I use them for broom … just like my late in-laws were using them in the same way … When I was young, we used to take the wind pipe of the goose and we would clean it thoroughly and when it's clean we'd dry it and then, we'd used it. We'd use it for whistles, like for children (Katsak, 2005).

To local Elders and hunters, geese also have an intrinsic value.

> It's good to hear them … it seems to make everything more peaceful and more beautiful because of the sound of the geese and other birds that are migrating up. … when they're coming back up and you can hear them … you know that spring is here (Peterloosie, 2005).

Fall goose migration has never been scientifically investigated in the area because of the huge costs involved in tracking birds over the vast expanses of the Arctic (one exception is a pilot study using satellite telemetry in 1995-96 (Blouin et al., 1999). The knowledge of local experts, on that matter, has expanded the temporal scale of scientific knowledge by providing information on migration routes, timing of fall migration and behaviour during migration. For example, goose biologists were interested in knowing whether geese gather in one large area before starting their fall migration. From a wildlife management point of view, knowing about the existence and location of areas where geese congregate would clearly have implications on future land management. On that point, the consensus among informants was that geese do not gather in a large group in any local area before the fall migration. Instead, geese leave in small groups.

> They don't gather, but whichever geese are able to fly then they start leaving, they leave one after the other in groups, but they don't gather or anything like that. They just start leaving as soon as they are able (Koonark, 2005).

> The geese that are going through there (during migration) they don't congregate all at once. … There's up there always groups of geese like one after the other. They don't seem to congregate in one group (Panipakoocho, 2005)

This example shows how TEK can offer information of high interest to scientists.

Arctic and Red Foxes

Interviews provided a wealth of information related to important trapping sites, traditional ways of trapping, uses of foxes (other than for trading), and ecology of foxes. To illustrate the potential for TEK to complement Western Science in relation to foxes, two examples are developed: one pertaining to the arctic fox winter feeding ecology, and the other about the recent invasion of red foxes in the area.

No scientific study has been done about arctic fox winter feeding in the North Baffin area. However, local trappers, who followed foxes during the winter, had considerable knowledge to share on the subject. According to them, two types of foxes, differing in their winter feeding behaviour, can be distinguished in the area. One type feeds on sea mammal carcasses in winter. This type has a thinner fur and its neck is stained by the sea mammal fat it feeds from. The other type is mainly terrestrial and has a thick and bright white fur. Local experts also mentioned that foxes, whether terrestrial or marine, move to the sea ice between late March and early April to hunt the new-born ringed seal pups.

> There's also a difference between foxes who live on the mainland and foxes who live on the sea ice… they're all white but the difference is the…foxes that live mainly on the sea ice, their fur is thinner and the foxes that live on the mainland, their fur is thicker (Peterloosie, 2005).
>
> And there's a difference too in foxes. Foxes that usually remain on the mainland have thicker fur, and the ones that are on the sea ice tend to have thinner fur (Nutarariaq, 2005).
>
> And also in spring…like at the last week of March, you find them (arctic foxes) on the sea ice, hunting for seal pups (Mucktar, 2005).
>
> From the middle of April, when seals start having their pups… you see a lot of tracks from the land going down to the ice … starting in April. … We use to see, when we'd go out seal pup hunting, we would see fox holes diggings into seal dens. … And one time, while I was seal pups hunting, I opened a seal den and inside was a fox (Kilukishak, 2005).

Interestingly, the existence of two feeding strategies in arctic foxes, one terrestrial and one marine, has been scientifically documented in Iceland, Svalbard and Greenland (Angerbjorn et al., 1994; Eide et al., 2005). But these were summer studies documenting summer behaviour. For the winter, Roth (2002) has suggested that two winter foraging options (marine and terrestrial) might be adopted by different segments of arctic fox populations. Yet, his results found no evidence of a bimodal use of resources for populations living near Cape Churchill, Manitoba. Instead, his stable isotopes analysis showed that the winter diet of the studied populations consisted of both marine and terrestrial components (Roth, 2002). The existence of two distinct winter feeding strategies was apparently not documented. The existence of variations in fur thickness, related to winter feeding behaviour, is also new information to scientists. Information provided by local experts expanded the spatial scale of knowledge on fox feeding behaviour to outside the south plain of Bylot Island, and is now the source of a new direction for scientific questioning for one of us (D. Berteaux).

An aspect of fox ecology of some concern in the Arctic is the northern expansion of red foxes (Chirkova, 1968; MacPherson, 1964), and the negative competitive effect they may have on arctic fox populations (Tannerfeldt et Angerbjorn, 1998). In the North Baffin area, the only historical information on the red fox invasion comes from the pelt records of the Hudson’s Bay Company trading post in Mittimatalik. According to these records, the arrival of the red fox is estimated to have occurred approximately in 1947 (MacPherson, 1964). In order to complement this information, the arrival of the red fox was discussed with Elders and older hunters from the area. Many of them remembered the year a red fox was first caught in one of their traps, which coincided with the Hudson’s Bay Company records. Not only did the informants reinforce historical evidence on the invasion, but existing memories of this event open the way to further collection of information about the interactions between the two species when they first entered in contact and the reactions of people to the arrival of this new species.

> It was probably in the … early 50's, when we had a camp at Nunatsiaq. Somebody caught a red fox and it was very unusual to see a fox like that. We were quite amazed to see the red fox. It was something different and it was a big thing for us. We had a camp at Nunatsiaq and the hunters in Nadluat used to set their traps along this shore here (pointing on the map). It was one of the hunters who lived in Nadluat that caught a red fox and on his way back he stopped at our camp (Sangoya, 2005).

CONCLUSION

Preliminary results from the interviews conducted on Inuit TEK have clearly revealed insights on the uses and importance of geese and foxes to Mittimitalikmiut. Results also brought important ecological information complementary to western scientific data. This shows how Inuit TEK can be integrated into the management of the ecological integrity of Sirmilik NPC by a) contributing to the acquisition of baseline data on components of the terrestrial ecosystems and changes observed within the systems and b) providing a greater understanding of the relationship between Inuit and their environment. At a time when the Arctic is experiencing deep social and ecological changes, efforts to integrate Inuit TEK and Western Science are essential if we hope to develop locally sensitive ecosystem-based management strategies.

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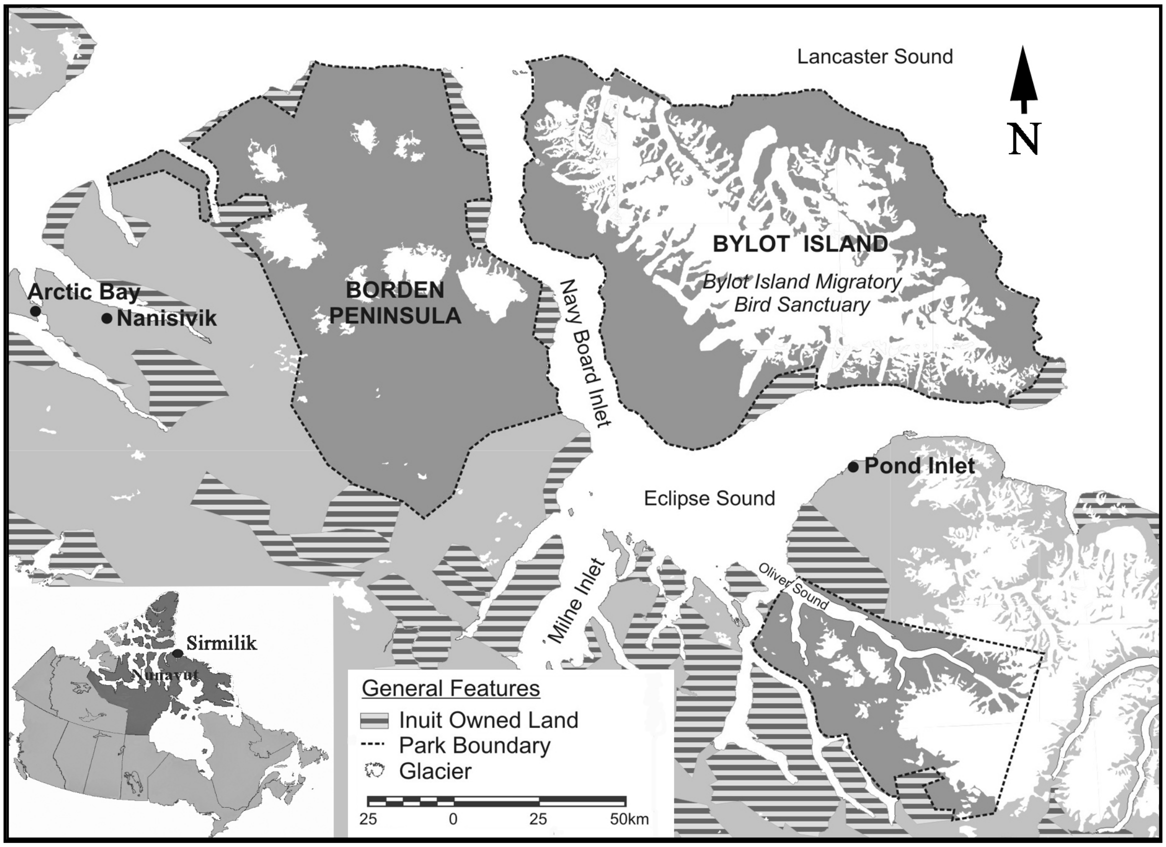

Figure 1. Sirmilik National Park of Canada and its surrounding areas, northern Baffin Island. Copyright 2004 by the Nunavut Field Unit of Parks Canada. Adapted with permission

CHAPITRE 3

INTEGRATING TRADITIONAL ECOLOGICAL KNOWLEDGE AND ECOLOGICAL SCIENCE: A QUESTION OF SCALE

Manuscrit en préparation pour une publication

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C.-A. GAGNON ET D. BERTEAUX. Intégration du savoir écologique traditionnel et de la science de l'écologie : une question d'échelle

Malgré plusieurs années de rhétorique prônant l'intégration du savoir écologique traditionnel (SÉT) et des sciences écologiques, peu d'approches novatrices ont été suggérées afin d'optimiser les bénéfices tangibles de cette co-application. Nous avons travaillé avec la communauté inuite de Mittimatalik, Nunavut, Canada, afin d'explorer le concept selon lequelle le degré de complémentarité entre le SÉT et le savoir scientifique, en termes de données écologiques, dépendrait surtout des échelles spatiales et temporelles sur lesquelles chaque type de connaissance a été construit. Plus précisément, nous avons vérifié l'idée selon laquelle le SÉT devrait étendre les échelles spatiales et temporelles des connaissances scientifiques actuelles sur deux espèces (le renard arctique *Alopex lagopus* et la grande oie des neiges *Chen caerulescens atlantica*) importantes au fonctionnement de l'écosystème d'une aire protégée (le Parc National du Canada Sirmilik, Nunavut). Ces espèces sont étudiées intensivement par des scientifiques dans la région, et des représentants locaux ont exprimé leur désir de partager leurs connaissances en lien avec ces espèces. En utilisant une série d'approches participatives, nous avons documenté du SÉT sur l'écologie des renards et des oies en mettant l'accent sur des aspects le plus possible complémentaires aux connaissances scientifiques. Nous avons démontré que le SÉT sur l'écologie du renard arctique étendait l'échelle spatiale et/ou temporelle des connaissances scientifiques en fournissant de l'information complémentaire sur l'écologie hivernale et les sites de tanières du renard arctique, l'abondance du renard roux et les aires où les différentes phases du renard roux ont été observées. Alors que les données scientifiques acquises sur les renards de la région tendaient à être très spécifiques et détaillées (l'approche du « zoom-in »), le SÉT inuit fournissait une image plus globale du système (un « zoom-out »). Par contre, le SÉT sur la séquence de mue de l'oie des neiges, la période de migration automnale et les changements dans l'abondance et la distribution des oies était moins complémentaire aux connaissances scientifiques car les deux types de connaissances étaient basés sur des observations effectuées approximativement aux mêmes échelles régionales. Dans le cas de l'oie, les données scientifiques recueillies durant la migration et l'hiver permettaient en plus d'obtenir des connaissances à des échelles spatiales et temporelles s'étendant au-delà de l'échelle régionale couverte par le SÉT. Suite à cette étude de cas, nous suggérons que l'analyse des échelles spatiales et temporelles des observations formant la base du SÉT et des connaissances scientifiques est un pas nécessaire pour mieux anticiper les bénéfices de la co-application du SÉT et de la science. L'intégration du SÉT et des connaissances scientifiques par une approche mettant l'emphase sur la complémentarité d'échelles est un outil puissant permettant d'obtenir une image plus claire du système socio-écologique à l'étude, et de nourrir l'apprentissage mutuel et la collaboration entre communautés locales, scientifiques et gestionnaires de ressources.

C.-A. GAGNON AND D. BERTEAUX. Integrating traditional ecological knowledge and ecological science : a question of scale

Despite years of rhetoric praising for the integration of TEK and ecological sciences, few new approaches have been put forward to optimize the tangible benefits of this co-application. We worked with the Inuit community of Mittimatalik, Nunavut, Canada, to explore the concept that the degree of complementarity between TEK and scientific knowledge mostly depends on the time and space scales of the observations from which each type of knowledge is derived. More specifically, we verified our expectations that TEK would expand the spatial and temporal scales of current scientific knowledge available on two species (the Arctic fox *Alopex lagopus* and the greater snow goose *Chen caerulescens atlantica*) important to the ecosystem functioning of a protected area (Sirmilik National Park of Canada, Nunavut). These species are extensively studied by scientists in the area and local representatives expressed the desire to share their knowledge about them. Using a variety of participatory approaches, we documented TEK on the ecology of fox and geese, focusing on aspects as complementary as possible to known scientific knowledge. We found that TEK on arctic fox ecology expanded the spatial and temporal scales of current scientific knowledge by providing complementary information about the arctic fox winter ecology and denning locations, red fox abundance, and areas where various color phases of red fox have been sighted. While scientific data collected locally on foxes tended to be very specific and detailed (the ″zoom in″ approach), Inuit TEK provided a broader picture (a ″zoom out″) of the system. On the other hand, TEK about the timing of goose molt, the timing on goose autumnal migration, and changes in goose abundance and

distribution was less complementary to scientific knowledge because the two types of knowledge were based on observations performed at roughly similar regional scales. In the case of the snow goose, scientific data collected during the migration and winter also covered spatial and temporal scales that spanned outside the regional scales comprised by TEK. From this case study, we suggest that analyzing the spatial and temporal scales of observations forming the basis for TEK and scientific knowledge is a key step to anticipate the benefits of the co-application of TEK and science. Integrating TEK and scientific knowledge through an approach that focuses on complementarities across scales can be a powerful tool to get a clearer picture of a given social-ecological system, and to foster mutual learning and collaboration between local populations, scientists and resources managers.

INTRODUCTION

Traditional ecological knowledge (TEK; see definition in Berkes 1999, p. 8) encompasses i) factual knowledge about ecological components and processes, ii) knowledge put into practices of environmental use, and iii) cultural values, ethics, and philosophies defining human relationships with the natural world (Stevenson 1996; Usher 2000). All the above TEK ″categories″ have contributed to environmental research and management, through improvement of baseline data on species and ecological processes (Drolet et al. 1987; Ferguson et al. 1998; Furgal et al. 2002; Mallory et al. 2001; Mallory et al. 2003; Nakashima 1991), by providing insights to develop alternative resources management systems (Berkes 1999, p. 52; Berkes and Folke 1998; Turner et al. 2000), or by renewing conservation ethics (Berkes 1999, p. 182).

There are now, at the policy level, structures that encourage, or even require, the co-application of TEK and science in natural resources management (Mauro and Hardison 2000; Usher 2000). Yet, despite decades of theorization about the merits (Berkes 1999; Huntington 2000) and difficulties (Agrawal 1995; Nadasdy 2003) of this co-application, few methodological innovations have been proposed to facilitate the articulation of traditional and scientific knowledge (Bart 2006; Huntington et al. 2004b). Moreover, how much of what has been suggested applies to the real world remains unclear (Gilchrist et al. 2005; Huntington et al. 2004a).

Up to now, the most common approach taken to integrate TEK and science has been to compare observations derived at similar temporal and spatial scales from both types of knowledge (Ferguson et al. 1998; Gilchrist et al. 2005; Huntington et al. 2004a). Although criticized (Brook and McLachlan 2005), this approach helps recognizing the strengths and weaknesses of information derived from both TEK and science, identifying gaps in overall knowledge, and exposing new research needs (Gilchrist et al. 2005; Huntington et al. 2004a; Huntington et al. 2004b). However, Huntington (2004b) suggests that ″another, and perhaps a more powerful, approach is to recognize the strengths of each system and to use them to complement one another″.

There are several axes on which TEK and science can best complement one another, but when investigating factual ecological knowledge, the scale at which field observations are performed is perhaps one of the most promising directions offering potential for complementarities (Huntington et al. 2004b). It is well known that ecological systems operate on a multitude of space and time scales (Levin 1992; Wiens 1989). A given observer can only specialize on a subset of these scales, due to the nature of its economic incentives, time and logistical constraints, or simply personal and cultural interests. In particular, scientists and members of local communities usually operate with very different motives and have access to different equipment to observe the natural world. The general objective of this paper is therefore to explore the idea that, considering factual ecological insights, the degree of complementarity between TEK and ecological science is largely a matter of space and time scales.

We worked with the Inuit community of Mittimatalik (Nunavut, Canada), which is both the main user and a co-manager of Sirmilik National Park of Canada (henceforth

Sirmilik NPC). We have explained elsewhere (Gagnon and Berteaux 2006) in details the political and scientific context of this study. In short, Parks Canada has the mandate to assess and protect the ecological integrity of its parks (Agence Parcs Canada 2000). However, due to logistical constraints and a short history, baseline ecological data is often lacking in northern Canadian parks. Conversely, the local community of Mittimatalik has had a long history of land use in the area of Sirmilik NPC and conveyed the desire to share their knowledge. All these factors provided a favorable setting for us to conduct this research project.

We concentrated our study on knowledge about arctic fox (*Alopex lagopus*) and greater snow geese (*Chen caerulescens atlantica*). Both species are important components of the local terrestrial ecosystem (Bêty et al. 2002; Gauthier et al. 1996), and people from Mittimatalik expressed their desire to contribute knowledge about them. Also, arctic fox and greater snow geese have been extensively studied by scientists in the area, thus allowing for knowledge integration at the same population level. These two species were an ideal focus for our case study about integration of TEK and science, because they are of interest to both the local population and scientists, but without being strongly politically charged (Fig. 1).

Our expectation was that TEK should expand the spatial and temporal scales of current scientific knowledge about the species, providing a broader regional picture (a regional ″zoom out″) of the system. TEK is generally recognized as differing from science in being based on information acquired through longer time series, but over smaller and more specific localities (Berkes 1993; Johnson 1992; Moller et al. 2004). Therefore, TEK usually provides a temporal ″zoom out″, but a spatial ″zoom in″ on the system being studied, although this may not always be the case (Table 1). In the Mittimatalik area for example, due to the harsh climate encountered during the arctic winter as well as the migrating patterns of geese, scientific research has been performed during the spring and summer seasons exclusively. Costs of travel in the Arctic have also restrained the studies to more or less one site: the south plain of Bylot Island (Fig. 2). Scientific projects in the area became intensive about 20 years ago. Therefore, while scientific data collected locally tend to be very specific and detailed (the ″zoom in″ approach), we expect that Inuit TEK from the area should expand the scales (both spatial and temporal) of knowledge about arctic foxes and greater snow geese.

In order to compare how the reality fitted our expectation, TEK was collected that focused on information as complementary as possible to scientific knowledge. In other words, we used our knowledge of the scientific literature and of the local use of natural resources to investigate areas of TEK that were the most likely to generate information unknown to scientists. To illustrate if and how TEK expanded the current scales of scientific knowledge, results of our case study are organized as a series of biological topics pertaining to fox and goose ecology. For each topic, we first summarize collected TEK, we then briefly review available scientific knowledge, and we finally describe how complementary are TEK and scientific knowledge. Throughout the paper, we strive not to compare TEK with existing scientific knowledge (nor to test the validity of one or the other form of knowledge), but rather to expose areas of complementarity across scales.

METHODS

Study area and people

We worked with Inuit elders and hunters from Mittimatalik ($72^{o}40'$ N, $77^{o}58'$W; also known as Pond Inlet), a community of 1,200 inhabitants located on north Baffin Island, Nunavut, Canada (Fig. 2). Northern Baffin Island and adjacent Bylot Island are characterized by mountainous and glaciated terrains, deep fjords and inlets, and a fauna and flora typical of the Arctic Cordillera and Northern Arctic ecozones (Environment Canada 2005). Bylot Island is the most important breeding site for greater snow geese worldwide (Reed et al. 1998). The main terrestrial predator of the area is the arctic fox.

According to archaeological evidence, modern Inuit and their ancestors have lived in the Mittimatalik area for 4,000 years (Mary-Rousselière 1984-1985). Prior to contact with Europeans (mid 19th century), the region was inhabited by nomadic hunters who used the fjords of Eclipse Sound and the west side of Navy Board Inlet as main hunting grounds (Brody, 1976, p.153). In the mid 19th century, the arrival of whaling crews modified Inuit land use. Families then made long journeys towards the whaling stations to trade. This trend was exacerbated by the arrival of fur traders at the beginning of the 20th century. The trade of arctic fox furs then became the main economical staple of Inuit. For Inuit families, trading activities ″involved long journeys for the purpose of trade (…), thereby maintaining the use and knowledge of a vast area″ (Brody, 1976, p. 154), but trade also put contradictory forces on Inuit families as they were ″on one hand, encouraged to move towards the Whites, but, on the other, were pushed into making the fullest use of their lands, both to preserve independence through distance and to make best use of the resources″ (Brody, 1976, p.156).

In Mittimatalik, the Hudson's Bay Company established a trading post in 1921, quickly followed by the Royal Canadian Mountain Police (R.C.M.P.) detachment (1922), and Anglican and Catholic Churches (1929 and 1930). However, the majority of Inuit families only settled in the community in the decade following the establishment of the federal school in 1959. After settlement, fur trading remained an important economic activity, until the collapse of the fur trade market in the 1980s (Robinson 2005).

Mittimatalik has now a mixed economy divided between wage salaries, transfer payments and land-based subsistence activities. The latter are associated with species like ringed seal (*Phoca hispida*), bearded seal (*Erignathus barbatus*), harp seal (*Pagophilus groenlandicus*), narwhal (*Monodon monocerus*), caribou (*Rangifer tarandus*), polar bear (*Ursus maritimus*), arctic char (*Salvelinus alpinus*), greater snow goose, and arctic fox (Riewe 1992; Statistics Canada 2004). Families from Mittimatalik make frequent trips to hunting grounds and traditional campsites, an activity that plays a central role in the generation and transfer of knowledge about the land. The main spoken language is Inuktitut, although English is known by a large portion of the population.

Context of biological researches on fox and geese

Following a few reconnaissance surveys of greater snow geese in the area (see Reed et al. 1998), Canadian authorities have instituted in 1983 a standard survey of breeding snow geese that covers the 1,600 km^2 south plain of Bylot Island, and which has since been repeated at five years intervals (Reed et al. 2002). In 1989, university researchers and the Canadian Wildlife Service established a research camp on Bylot Island, where various aspects of the ecology of breeding geese have since been investigated (Gagnon and Berteaux 2006). From 1993 to 2002, the breeding activities of arctic and red fox have also been surveyed in areas adjacent to the goose research camp. In 2002, the fox studies expanded to include surveys of fox breeding activities over 425 km^2 of Bylot Island and several aspects of the ecology of arctic fox (see Gagnon and Berteaux 2006). In the *Results* section of this paper, information classified as scientific knowledge gathers both published quantitative data and unpublished quantitative and qualitative data gathered by the authors and their colleagues working on Bylot Island.

Establishment of a protected area and ensuing co-management

In 2001, Sirmilik NPC (Fig. 2), which means ″the place of glaciers″ in Inuktitut, was created in areas adjacent to Mittimatalik, encompassing most of Bylot Island and the northern tip of Baffin Island. Through legislative agreements and recommendations made by co-management bodies, it became a requirement and priority that Inuit knowledge be included in the management of Canada's National Parks in Nunavut (Gagnon and Berteaux 2006). In accordance, the Nunavut Field Unit of Parks Canada launched an Inuit knowledge Project in 2004, as a prototype to increase the involvement of Inuit TEK into the understanding and management of its parks in Nunavut (Parks Canada 2005). Our study was conducted in collaboration with this larger project (Gagnon and Berteaux 2006).

Collection of Inuit traditional ecological knowledge (TEK)

In February-March 2005, we held two consultation meetings to present the project and invite the community to express ideas, concerns and advices. From February 2005-July 2006, we collected TEK using several qualitative research approaches such as workshops, semi-directive interviews, focus groups and participatory observations. These were spread over four visits to Mittimatalik.

Upon approval from the community, we started the first phase of TEK collection using semi-directive interviews (Grenier 1998; Huntington 1998), a methodology that allows unanticipated information to emerge (Ferguson and Messier 1997; Huntington 1998). Between May and September 2005, we interviewed 21 local experts on geese, foxes, and the land. We selected informants based on the number of times their names had been recommended by elders, members of the Mittimatalik Hunters and Trappers Organization (hereafter HTO), and community members working for Parks Canada, the Hamlet Office, and the Nunavut Wildlife Management Board. Using multiple recommendations decreased biases in the selection of informants.

Each interview lasted between one and a half and four hours, for a total of 38 hours recorded. Interviews started with questions about the informants' birth location and most known hunting and travelling areas (according to seasons), providing a temporal and spatial context for the information later collected. Information collected then covered topics regarding the ecology of foxes and geese (see appendix I).

The autoecology of a species can be decomposed into a large number of themes and sub-themes, and how these categories are defined is largely subjective. In our results, we present three categories of information for each species (arctic fox: winter feeding, arrival of red fox (*Vulpes vulpes*) in the area, denning areas; geese: molting cycle, fall migration, trends in numbers and distribution). These categories were chosen because they represent important components of each species' local ecology, as well as areas of interest to both scientists and local experts, that could potentially provide large amounts of complementary information. These categories were thus excellent candidates to test and discuss our hypothesis. TEK regarding the fox molting cycle, fox numbers, fox cultural importance, goose nesting locations, and other various topics was also documented (appendix I). We do not present this TEK here, but it is also available to the community and for analysis and integration with scientific knowledge.

Throughout interviews, we used 1:250,000 topographic maps to stimulate conversation and record geographical information (Huntington 1998). With the assistance of a professional interpreter, we conducted the interviews in both English and Inuktitut. Being born and raised in Mittimatalik, the interpreter helped identifying exact geographical locations and associated place names, stimulated conversations, and minimized the likelihood of translating errors due to differences in local dialects. Upon consent, an assistant from Mittimatalik audio and video recorded all interviews. Materials collected and produced during the research, including the video tapes and maps, remain the property of the community and are archived and made accessible by Parks Canada.

When possible, we conducted interviews in places where local experts felt at ease (Ferguson and Messier 1997). These included the local Parks Canada office (n = 6) and visitor centre (where elders have weekly gatherings; n = 10), houses of informants (n = 3) as well as traditional campsites (n = 2). Conducting interviews on the land was very effective in stimulating thought and old memories, but was logistically constrained.

Management, analysis, and verification of data

We transcribed and imported the English portions of all audio recordings into the NVIVO software version 2.0 (QSR International Pty. Ltd. 2002). We then codified segments of the transcripts according to the topic(s) they covered, using both deductive (predefined) and inductive (defined a posteriori) coding (Miles and Huberman 2003, p. 114-118). Using the ArcView software versions 9.1 (ESRI 2005), we digitized and georeferenced all the spatial information in order to produce comprehensive maps.

From May-July 2006, we worked in Mittimatalik with a local research assistant to shed light on confusing segments of interviews and discuss interpretations, thus entering in the validation phase of the project (Creswell 1998, p. 210-211). Upon need, we contacted the interviewees, conducted more interviews, and consulted elders. Four verification workshops were organized (20-22 June), each with 4 selected experts, to confirm and discuss our findings. From 11-17 June 2006, the two of us also participated in an elder-youth camp we had organized in collaboration with the local elders' committee. While the main purpose of the camp was to create an opportunity for transfer of knowledge among generations, it also provided us with the opportunity to see *in situ* demonstrations of the knowledge shared by local experts during interviews, and to have numerous informal discussions. Focus groups and informal discussions allowed us to compare the congruence of information gathered using different approaches (Creswell 1998, p. 210-211).

If not mentioned otherwise, we report results based on firsthand observations provided by the informants. Because we used semi-directive interviews, answers from local experts did not always address every topic we had intended to cover. We thus present some of the results as frequencies of informants' observations about a topic, in the form of ″number of informants who made a particular observation/number of informants who did discuss the topic pertaining to the observation″. Such frequencies provide relative indices about the 'importance' of certain observations. We excluded from the analysis observations made by informants who had explicitly mentioned their lack of knowledge regarding the covered topic.

RESULTS

Biographical information and land use patterns

The 21 local experts interviewed included six women and 15 men. Nine were elders no longer hunting actively, five were elders actively hunting and seven were active hunters. The average age of the informants was 68 years. Two were born in the 1920s, eleven in the 1930s, five in the early 1940s, two in the early 1950s and one in 1978. All but two informants spent the major part of their active life in the Mittimatalik area. Local experts interviewed thus contributed on average 50 years of experience on the land. Eighteen informants had trapped foxes actively when they were young, but most reduced trapping activities in the mid 1960s, when settling in Mittimatalik, or in the early 1980s, when the fur economy collapsed. Three still trapped actively, while the others continued to trap opportunistically. Thirteen experts considered themselves geese hunters (both in the past and currently) and egg gatherers. Four stated they hunted and gathered eggs, but not as much as other hunters. Four were neither geese hunters nor egg gatherers. Geese were never a resource as important as foxes, and therefore much less energy was spent hunting geese then trapping foxes.

Areas used to trap foxes and hunt geese have contracted dramatically in the recent decades (Fig. 3). In the past (up to the late 1970s), traplines covered a large portion of the inlets and coast lines of the study area. Informants explained that traplines were located near the shorelines to facilitate transportation by dog team and to allow seal hunting while trapping. Geese hunting grounds used to be spread all around the south shore of Bylot Island, but are now more concentrated on the southern tip of the island. On Baffin Island, informants now hunt geese in areas closer to Mittimatalik. While exploitation areas associated with geese and foxes have contracted, some informants (n = 12) still hunt other species over vast areas. Two informants, for instance, spend a large portion of each year living and hunting 120 km west of Mittimatalik, and many outposts camps are still active throughout the area (Fig. 3). From sea ice freezing in October to sea ice break up in July, the two floe edges and Eclipse Sound (Fig. 2) are also highly exploited for narwhal, polar bear and seal hunting. Inland areas on Baffin Island are also used for caribou hunting.

Through the use of SBX radios, there is now much communication between the camps and exchanges of information over large areas.

Ecology of the arctic fox

Winter feeding ecology and distribution

<u>TEK</u>

Informants' description of artic fox winter distribution varied. Of the 18 informants providing comments, 8/18 stated they observed arctic foxes mostly on the land, while 3/18 mentioned seeing them mostly on the shorelines, 3/18 either on the land or the ice, 2/18 on the sea ice, 1/18 at the floe edge and 1/18 at the floe edge and on the mainland. Of the informants stating that foxes were seen mostly on the land (8) and on the sea ice (2), 4/8 added that they also, to a lesser extent, saw them on the sea ice (4/8) and on the land (1/2), respectively.

According to local experts, the winter diet of the arctic fox consisted of various items; the most often cited being the carcasses of sea mammal (12/16) and lemmings (11/16). Two informants explicitly commented that lemmings were the main winter food item for foxes. While 12 informants mentioned the carcasses of sea mammals, some specified that these carcasses came from beached animals (7/12) or were left on the ice by polar bears (5/12) or hunters (3/12). Other items cited as part of the arctic fox winter food were caribou meat (2/16), arctic hares (1/16), birds (most likely ptarmigans; 1/16), and food caches prepared by hunters (1/16). Other knowledge holders more generally stated that foxes are scavengers (3/16) and eat anything they can find (1/16).

Unexpectedly, 11 informants reported the existence of two different over wintering strategies for the arctic fox: one mostly remaining on the land and the other remaining on the sea ice. This was confirmed during verification workshops. The ″land fox″ was reported as having a thicker fur (8/11), a whiter fur (4/11) and a larger size (2/11). Other informants mentioned that ″land″ foxes have a harder and less oily fat (1/11), longer fur (1/11), thinner skin (1/11), are better to eat (1/11) and turn white earlier in the winter (1/11; the inner fur of the ″sea″ fox turning completely white only in spring). Seven informants speculated on the reasons explaining these physical variations, six of whom mentioned differences in food sources as the main reason. One informant also stated that due to its proximity to open water, the floe edge is always warmer in winter. Thus the temperature gradient between the floe edge and the land could explain the difference in thickness between the furs of the ″land″ fox versus that of the ″sea″ fox. Two informants further stated that younger foxes were on the sea ice (at the floe edge) and adult ones were inland. While discussing the ″land″ and ″sea″ fox distribution during a workshop, it emerged that ″land″ foxes were mostly trapped on the mainland and at the end of the inlets to the south of Eclipse Sound, while ″sea″ foxes were trapped at the floe edges (Fig. 4). One local expert, however, specified that foxes were not limited to these distributions and that it was possible to catch some foxes with thicker fur near the coast. Finally, 17 out of 21 informants reported a massive spring (March-April) migration, during which foxes move towards the sea ice to feed on newborn ringed seal pups.

Scientific knowledge

The arctic fox is considered an opportunistic omnivore, exploiting both the terrestrial and marine environments (Angerbjorn et al. 1994; Chesemore 1968b; Eide et al. 2005; Fay and Stephenson 1989; Frafjord 1993; Macpherson 1964; Roth 2002). The winter diet of arctic foxes, however, has seldom been quantified (Roth 2003) and there is currently no scientific information regarding the winter feeding habits of arctic foxes from the Mittimatalik area.

Lemmings (*Dicrostonyx* and *Lemmus* spp.) and voles (*Microtus*), where they exist, are the primary preys of arctic foxes occupying inland habitats during the winter (Angerbjörn et al. 1999; Elmhagen et al. 2000; Macpherson 1964). In years of low small mammal abundance, or where rodents are mostly inexistent (e.g. Svalbard), arctic foxes may otherwise feed on caribou carrion, arctic hares, ptarmigans, stored eggs (Chesemore 1968a; Eide et al. 2005; Fay and Stephenson 1989; Macpherson 1964) or increase their consumption of marine food sources (Roth 2002). In areas close to human settlements, arctic foxes may also feed on garbage and sheep to complement their winter diet (Kapel 1999).

In coastal areas, the winter diet of arctic foxes consists mostly of items provided by the marine ecosystem such as sea mammal carrion, invertebrates, seaweed, shellfish and fish (Fay and Stephenson 1989; Garrott and Eberhardt 1987; Kapel 1999). Where bird colonies are found, arctic foxes may also feed on birds and eggs cached during summer (Bantle and Alisauskas 1998; Fay and Stephenson 1989; Sklepkovych and Montevecchi

1996). Arctic foxes can follow polar bears on the sea ice to scavenge on the remains of kills (Hiruki and Stirling 1989; Roth 2002) and, in late winter and spring, prey on ringed seal pups by entering their subnivean birth lairs (Smith 1976), a behaviour that has been observed in various sites across the Canadian Arctic (Furgal et al. 1996; Hammill and Smith 1991; Smith 1976), Alaska (Burns and Frost 1988, cited in Hammill and Smith 1991) and Spitzbergen (Lydersen and Gjertz 1987). Seal pups may therefore constitute an important food source for arctic foxes (Hiruki and Stirling 1989; Smith 1976), although predation rates vary on both an annual and regional basis (Furgal et al. 1996). In a study performed in the Admiralty Inlet, around 250 km west of Mittimatalik, Furgal et al. (1996) recorded that arctic foxes were responsible for less than 1 % of all seal pup kills in the only year (over three) they recorded successful predation by arctic foxes.

Differences in the ecology of arctic foxes residing in coastal versus inland areas have been documented in Alaska, Svalbard, Iceland and Greeland (Angerbjorn et al. 1994; Chesemore 1967; Eide et al. 2005; Fay and Stephenson 1989). In Greenland, Baestrup (1941) suggested that fox populations be divided into the non-rodent eating foxes, mainly of the blue color phase and found in coastal areas, and the rodent eating foxes, more frequently of the white phase and inhabiting inland areas. On a large scale (i.e. comparing population across countries), differences in feeding habits have been measured (Angerbjorn et al. 1994) between inland and coastal foxes. At a smaller scale, two distinctive summer feeding strategies have been documented in areas where arctic foxes occupying coastal areas have access to seabird cliffs (Angerbjorn et al. 1994; Eide et al. 2005; Fay and Stephenson 1989). It has been suggested that the two foraging options, one terrestrial and one marine, may also be adopted by different segments of local arctic foxes population during the winter (Roth 2002), although this was not demonstrated.

Winter food may be a limiting factor for arctic foxes (Eide et al. 2005); it may regulate reproductive output (Angerbjörn et al. 1991; Elmhagen et al. 2000) and winter starvation can cause mortality (Macpherson 1964). In coastal areas, arctic foxes may therefore remain in productive shorelines throughout the year (West and Rudd 1983, cited in Garrot and Eberhardty 1987). In Alaska, foxes occupying inland areas have been observed to move towards the coast and sea ice during the fall, returning to inland denning sites in spring; however, in some inland areas arctic foxes may remain in their summer range throughout the winter (Eberhardt et al. 1983). Winter food shortages associated with severe rodent declines are also believed to stimulate fox migrations or dispersal (Chesemore 1968a; Eberhardt 1978; Wrigley and Hatch 1976), some of which may be extensive as arctic foxes have been documented to have traveled hundreds to thousands of kilometers (Chesemore 1968a; Eberhardt 1978; Wrigley and Hatch 1976).

Complementarities between TEK and scientific knowledge

TEK pertaining to the winter feeding ecology of arctic foxes expanded current scientific knowledge at both spatial (covering an area beyond the south plain of Bylot Island) and temporal (beyond the summer) scales. Scientific information is currently lacking regarding the winter diet of regional fox populations and the fact that arctic foxes are opportunistic omnivores that occupy various habitats makes it hard to generalize the few existing winter dietary data (Angerbjorn et al. 1994; Eide et al. 2005; Fay and

Stephenson 1989) across populations. On a spatio-temporal scale, observations from TEK holders provided evidence that arctic foxes from the Mittimatalik area use a variety of habitats during winter (from land to sea ice). On a temporal scale also, TEK provided an overview of the items eaten by local arctic foxes during the winter and pointed to the potential importance of seal pup consumption for arctic foxes in early spring in the Mittimatalik area.

Inuit TEK about the existence of two distinct uses of resources, one marine and one terrestrial, among the arctic fox population of the Mittimatalik also expanded the spatio-temporal scale of current regional knowledge. The existence of two fox ″ecotypes″ has only been documented by scientists outside of the study region for summer diet, in areas where foxes have access to large bird colonies (Eide et al. 2005; Fay and Stephenson 1989), or at a pan-arctic scale across fox populations evolving in very different habitats (Angerbjorn et al. 1994). TEK about the differences in fur characteristics between the two ″ecotypes″ is also an aspect of the arctic fox natural history apparently not documented through scientific means. On the other hand, international scientific investigations have provided causal evidence of the impact of winter food shortages on arctic foxes. They have also provided information about extensive fox migrations, by following single individuals, over areas extending beyond the regional settings.

Arrival of the red fox in the area

TEK

At a larger temporal scale, informants were asked to comment on the arrival of the red fox in the area. Of 17 informants who provided comments, 3/17 mentioned having always seen an occasional red fox while one informant believed, based on information from his parents, that red foxes had always been around. The remaining 13 informants remembered the first time they had seen a red fox in their hunting areas. 1/17 stated having seen one for the first time in 1943 when he was living in Igloolik and 2/17 stated having seen one in 1947-1948 in the Mittimatalik area. Of the remaining informants, 8/17 stated that first sightings occurred in the 1950s and 2/17 stated the 1960s. Nine informants also commented that since its arrival, the red fox has increased in numbers, a comment that was reiterated by two local experts during verification workshops.

According to knowledge holders, not only the red fox, but also its silver and cross colour morphs have been sighted in the area. Informants identified some of the locations where they have seen the two morphs (Fig. 4). Two informants commented on the red fox being more often seen on the mainland but barely at the floe edge to the east of Bylot Island.

Scientific knowledge

Over the last century, a northward expansion in the distribution of the red fox has been observed in North America, Europe and Eurasia (Chirkova 1968; Macpherson 1964). Coinciding with this northward spread of the red fox, the arctic fox has shown a reduction in abundance and distribution throughout its circumpolar range (Angerbjorn et al. 1994; Chirkova 1968), and there is now an extensive zone of overlap in the distribution of both species (Angerbjorn et al. 1994). Due to their larger size and aggressivity, the red fox tends to be a superior competitor than the arctic fox (Korhonen et al. 1997; Rudzinski et al. 1982) and can even be its predator (Hersteinsson et al. 1989). Red foxes may also exclude arctic foxes from the most productive feeding habitats (Elmhagen et al. 2002). When selecting denning sites, arctic foxes tend to avoid areas occupied by red foxes (Tannerfeldt and Angerbjorn 1998). It has been suggested that red foxes may gradually limit the southern distribution of the arctic fox (Angerbjorn et al. 1994). So far in North America, the impacts that the northward expansion of the red fox may have on arctic fox populations have not been studied (Szor 2006).

Pelt records are the only published information available regarding the timing of the colonisation of Baffin Island by red foxes (Macpherson 1964). According to these records (considered approximate), red foxes were observed for the first time on south Baffin Island in 1918, and then continued their expansion northward to reach Mittimatalik and Arctic Bay in 1947 and 1948, respectively (Macpherson 1964). The first scientific mention of a red fox on Bylot Island dates from 1977 (Kempf et al. 1978).

Complementarities between TEK and scientific knowledge

TEK regarding the arrival of the red fox and sightings of various of its color phases partially complemented scientific knowledge across scales. On one hand, TEK about the increase in abundance of red foxes since its arrival in the area expanded the temporal scale of scientific knowledge by providing a historical overview of red fox abundance over several decades. TEK about the locations where various color phases of red foxes have been sighted also expanded the spatial scale of scientific observations beyond Bylot Island. Regarding the arrival of the red fox in the area however, TEK overlapped with scientific information concerning the first red fox traded in Mittimatalik (Macpherson 1964). International scientific investigations then complemented TEK in providing detailed information on the nature of interactions between arctic and red foxes outside of the Mittimatalik region.

Locations and characteristics of denning areas

TEK

Denning locations reported by the local experts are summarized in Figure 5. These included pinpointed locations as well as general areas for both arctic fox and red fox dens. When asked about the characteristics defining good denning habitats, the majority of experts providing observations (i.e. 17) mentioned the presence of a sandy soil or sandy area (13/17). In addition, the presence of fish (2/17), places with soil (1/17), low lying areas (1/17) and little hills where foxes can dig (1/17) where mentioned as other positive variables.

Scientific knowledge

Detailed research on the location and characteristics of fox dens has been done on a 425 km^2 study area of Bylot Island (Szor et al. in press). Analyses of the environment and characteristics of the 83 studied dens revealed that dens were preferably excavated on mounds or steep slopes, most often southerly exposed, in the proximity of streams and on a sandy substrate (Szor et al. submitted). Dens were also preferentially located at sites with high ground temperature, high depth to permafrost and low snow cover in spring. Of the 83 dens identified, 27 have been used at least once for reproduction between 2003 and 2005. Resource selection analysis applied to the reproductive dens revealed that while food resources influenced positively the selection of reproductive dens, proximity to other dens seemed avoided (Szor et al. submitted). Characteristics of arctic fox dens have also been investigated in other arctic regions and concord with the findings of Szor et al. (submitted).

Complementarities between TEK and scientific knowledge

TEK partially complemented current scientific knowledge by extending known denning locations, for both red and arctic foxes, to an area greater than the south plain of Bylot Island. When looking at denning locations from Bylot Island however, TEK and results from scientific studies were comparable at similar scales, and revealed that scientific investigations located dens more systematically. There was also an overlap between TEK and scientific information regarding the factors that favor den establishment. Both TEK and science were congruent in identifying sandy substrate as a characteristic positively influencing the establishment of dens, but scientific studies identified multiple other important variables through precise quantitative measures (e.g. depth to permafrost, snow cover in spring, distance to other dens; Szor et al. submitted).

Ecology of greater snow geese

Molting cycle

TEK

Of 14 informants commenting about the molting cycle of geese, 12 mentioned that non-nesting geese molt earlier than nesting ones, and two did not comment on that topic. When commenting on the exact timing of the molt, six informants mentioned that non-nesting geese start their molt at the end of June, while one informant said they start in the middle of July. Nine informants more generally agreed that non-nesting geese molt through the month of July. Two informants interviewed on 5 August and 9 August mentioned that at that time non-reproductive geese were just completing their molt while nesting geese were molting. For nesting geese, 10/14 informants stated more generally that they molt when their goslings have hatched and have grown bigger. One informant mentioned that they start in the middle of July while another, interviewed on 26 July, mentioned nesting geese would molt later on. Another informant, interviewed on 27 July mentioned nesting geese were probably molting at that time.

Local experts' observations regarding molting locations for nesting and non-nesting geese were variable (Fig. 6). Of 14 informants making comments, four indicated not knowing if non-nesting geese went to a particular place to molt, but four stated that nesting and non-nesting geese never molt together and one stated that nesting and non-nesting geese both molt on Bylot Island. Another informant mentioned not knowing whether nesting and non-nesting geese molted together. Other experts commented about nesting geese gathering around ponds (2/14) and non-nesting geese molting in higher grounds than nesting ones (3/14), although one informant commented seeing nesting geese molting in higher grounds at a specific location. When asked if there have been any changes in the molting locations used by geese since they were younger, 4/7 informants mentioned there has been no change while 3/7 said they did not know or could not tell because they hadn't been to their old goose hunting grounds lately.

Scientific knowledge

There is no published quantitative data regarding molt timing of breeding and non / failed breeding snow geese studied on Bylot Island. Based on unpublished observations and studies performed elsewhere, nesting geese start to molt two to three weeks after goslings have hatched (Gauthier, G. pers. comm.; Mowbray et al. 2000) and last for about three weeks (Mowbray et al. 2000). Since the average hatching date is 9 July on Bylot Island (Gagnon et al. 2004), breeding geese should start to molt around 31 July, regaining their flying capacities around 20 August. However, this depends on the timing of reproduction which varies annually (Bêty et al. 2003). Data are available that could allow quantifying the molt timing of adult geese breeding on Bylot Island more precisely. Indeed, measures of the 9th primary feathers taken while banding geese each August, combined with information on feather growth, could allow to quantifying when feather growth was initiated and when it would cease; but deriving this information would take time and has not yet been performed (G. Gauthier, pers. comm.).

As for non-breeding geese, data on radio-collared female geese revealed that around 90% of tracked non-breeding and failed nesting female snow geese departed Bylot Island between the end of June and the middle of July to molt away from the island (Reed et al. 2003). There are few large water bodies providing protection against predators on Bylot Island (Reed et al. 2003). Large concentrations of molting geese (most of which were non-breeders or failed nesters) were observed in 1993 and 2006 in an area located around 200 km south of Bylot Island, encompassing several large lakes (A. Reed and M. Evans, pers. comm.). Yet, it remains unclear whether geese observed during these surveys came from Bylot or not (G. Gauthier, pers. comm.), although this area is along the spring migratory path of geese nesting on Bylot island (see below).

Although most non-breeding and failed nesting females left Bylot Island to molt elsewhere, Reed et al. (2003) have observed around 700 non-breeding geese molting on Bylot Island on 15 July 1999. No breeding female had started to molt at that time. The authors also suggest that 5 non-breeding females that were tracked and molted on Bylot Island had completed their molt between July 31 and 8 august. This pattern of non-breeding geese molting earlier than the breeders has been mentioned elsewhere in the literature (Mowbray et al. 2000).

Complementarities between TEK and scientific knowledge

TEK about the molting ecology of geese provided observations that either complemented scientific information across scales or that overlapped with scientific observations at similar scales. TEK about the molting locations extended current spatial information by identifying areas where geese have been observed molting outside of Bylot Island. Yet, scientific observations also complemented TEK by providing information on major molting locations for non-reproductive geese (A. Reed and M. Evans, person. comm.) that extended beyond the spatial scale of documented TEK. These molting locations, located on Baffin Island around 200-250 km south of Bylot Island and identified through scientific surveys (Reed et al. 2003) fall outside of the area used by local experts interviewed, thus exposing one geographical limit of the spatial extent of regional TEK. About the molting cycle of reproductive and non-reproductive geese, TEK overlapped with scientific observations at the temporal scale.

Migration: timing of fall migration, routes, and stopovers

TEK

Of 16/21 informants familiar with goose migration, most provided consistent periods during which geese leave for the fall migration. The most prominent observations were that geese start to leave at the end of August to September (13/16), or as soon as they are able to fly (after molting) (3/16). They also do not leave simultaneously (15/16), but rather in small groups, although three informants stated they believe geese may be gathering in larger groups as they go south. Informants reported observed spring and fall migrating routes, as well as stopovers (Fig. 7). According to informants, geese follow similar paths during the fall and spring migrations, flying over a north-south axis that goes over the fjords and inlets of North Baffin Island. Several stopovers have been identified on the lowlands located at the end of the fjords of North Baffin, where geese gather and feed before resuming their fall migration.

Scientific knowledge

For geese nesting in the High Arctic, the only scientific information available regarding the timing of the fall migration and migrating routes is based on five reproductive geese tracked by satellite telemetry from their breeding ground on Bylot Island to their wintering grounds on the Atlantic coast (G. Gauthier, pers. comm.). The tracked birds left Bylot Island between 28 August and 3 September and spent few days on the north coast of Baffin Island (nearby Milne Inlet) (Blouin 1996). From there, geese seem to have made a direct flight across the Foxe Basin until they reached the Ungava Peninsula where they spent close to a month; then, they flew inland over the boreal forest to reach their staging area in the St-Lawrence estuary around beginning to mid October and from there left for their wintering grounds in New Jersey and Delaware (Mowbray et al. 2000). Besides this information, surveys performed in the North Baffin area in summer 2006 also suggest that during the spring migrations, the area of Steen Bay, along north Foxe Basin (around 250 km south of Bylot Island), may be an important stopover for geese migrating to Bylot Island (M. Evans, pers. comm.).

Complementarities between TEK and scientific knowledge

TEK and scientific observations regarding the autumnal migration of geese mostly overlapped at similar scales. TEK about geese starting to leave at the end of August /

beginning of September, or after they have molt, strongly corresponded with information from the few individual geese tracked with satellite collars in the mid 1990s.

While both local experts and scientific information identified Milne Inlet as a short stopover for geese during migration, TEK slightly extended the regional spatial scale of scientific information by locating other stopovers. On the other hand, scientific observations extended the spatial scale of TEK observations at a more global level by identifying a potentially important stopover located 200-250 km south of Bylot Island that was identified through scientific surveys (M. Evans, pers. comm.). Through satellite tracking, science also provided information on the migrating routes of a few individual geese over a spatial scale that spans well beyond the geographical extent of regional TEK (Blouin 1996).

Trends in population numbers and distribution

TEK

Comments on the size of the local goose population were not unanimous among informants. Over 13 local experts, 4/13 stated the number didn't change over the past decades, 2/13 mentioned an overall increasing trend, 2/13 mentioned a decline while 5/13 indicated not knowing or not being able to comment on the overall trend (Table 2). Four of the informants further commented that the goose population observed in the areas varies between years (Table 2).

More specifically, 12/15 informants indicated that geese are more scattered now than they used to be in the past, and that geese are no longer concentrated on Bylot Island, but have relocated to other areas (3/15; Table 2). Only one local expert stated not observing any changes in distribution (Table 2).

Many individual comments about goose distribution referred to Bylot Island, as 8/15 stated a decline in goose abundance on the island, four of whom stating that geese use to be all around the south plain of the island but are no longer. Other informants commented that geese have moved towards the western part (5/15) and higher grounds (4/15) of the island (Fig. 8). Increasing and decreasing trends have been recorded for various specific locations (Fig. 8, Table 2). Descriptions of groups of geese that were so numerous on the island in the past that they looked like snow patches were often recalled to illustrate declines in goose abundance in certain areas (6/15 informants commented). Comments were also made about geese being more abundant nearby the arctic communities of Igloolik and Arctic Bay nowadays.

10 informants provided a timeline for when they started observing changes in goose distribution and/or abundance. The most frequent statement was that changes were observed since biologists started the geese surveys in the region (3/10) which corresponds to the early 1980s. Others noticed changes since the 1990s (2/10), in recent years (2/10) or in the 1970s, since rifles and snowmobiles were used more extensively (1/10). Two informants noticed a change in goose abundance since their childhood (which occurred in

the 1940s and the 1950s), the former mentioning an increase in abundance while the latter noticed a decline.

As for the reasons explaining those changes, most informants providing comments perceived they were due to the biologists doing their research (11/14) and the associated use of helicopters (9/14), as well as to the increase in hunting pressure (4/14) and the use of new hunting equipments such as rifles and snowmobiles (6/14). Informants also stated that changes might be due to the increased aerial traffic in Mittimatalik (2/14), to the fact that geese are hiding away (2/14) or to a potential increase in fox abundance since the collapse of the trapping economy (2/14).

When doing verification workshops to clarify information about changes in goose abundance, the consensus was that overall, geese may not be less, but are more dispersed than they used to.

Scientific knowledge

Spring surveys conducted at staging areas in the St-Lawrence estuary (Québec, Canada) show a pronounced increased in the total greater snow goose population (Reed et al. 1998). From < 40,000 birds in the mid 1960s, the population has grown to ca. 700,000 birds in 1997 (Reed et al. 1998), mostly due to extensive use of agricultural food resources during the winter (Gauthier et al. 2005).

Surveys performed at five-year intervals since 1983, during the brood-rearing period (late July), also revealed an increase in the number of adults geese present on Bylot Island.

From 25,500 in 1983 the number of adult geese increased to 69,500 in 1993, a year of exceptional reproductive success, and then declined to 60,700 in 1998 (Reed et al. 2002) and 47,800 in 2003 (J. Lefebvre, CWS, unpubl. data). The same tendency has been observed for goslings. Their number increased from 26,500 to 86,500 from 1983-1993 and then decreased to 59,100 and 58,000 in 1998 and 2003, respectively (Reed et al. 2002; J. Lefebvre, CWS, unpubl. data). According to Reed et al. (2003), failed/non-nesting geese leave Bylot Island to molt and spend the summer elsewhere. Thus, variations in the number of geese spending the summer on Bylot Island is influenced by their breeding success, which in turn is dictated by spring climatic conditions (Reed et al. 2004) and predator pressure (Bêty et al. 2002).

As the population increased on Bylot, brood densities and distribution of snow geese varied on the island. From an average brood density of 5 brood/km^2 in 1983, brood densities increased three fold to reach 17 broods/km^2 in 1993 and decline to 12 brood/km^2 in 1998 and 2003. At low breeding numbers (1983 and 1988), the broods distribution was concentrated in few areas of high and moderate brood densities and one large area of low density (Reed et al. 2002). As the number of geese increased, areas of high to moderate densities expanded, increasing brood densities in the low quality habitats (mostly located on upland sites) (Reed et al. 2002).

During the last 20 years of extensive scientific research performed on Bylot island, there has been no evidence of consistent changes in the location of nesting sites utilized by greater snow geese (G. Gauthier, pers. comm.). Although it was observed that in some years the nesting distribution of geese was different, this was related to specific causes, such as a very late spring snow melt or the nesting of many snow owls with whom geese nest in association in peak lemming years. These changes in distribution were always short-lived (one year) and geese resumed their normal nesting pattern in the following year. However some unpublished information dating back almost 40 years is presently being re-analyzed, and may show some changes over this longer period (A. Reed, pers. comm.). Finally, due to the high cost of travel in the arctic, there is no information available regarding changes in numbers and distribution of greater snow geese elsewhere in the Arctic.

Complementarities between TEK and scientific knowledge

Complementarities between TEK and scientific observations regarding changes in goose abundance and distribution were harder to identify because comments varied extensively between informants. For the most part however, there was a large degree of overlap between the temporal and spatial scales (at least regionally) of TEK and scientific observations concerning goose abundance and distribution.

In the case of goose distribution, TEK was nevertheless complementary to scientific observation and extended the spatial scale of knowledge by providing information on sites outside of Bylot Island as well as comments on localities beyond the region where people have observed increases in goose populations. Certain TEK observations also provided a historical perspective on goose abundance extending beyond the range of scientific observations. On the other hand, when looking at goose abundance and distribution on

Bylot Island, TEK provided small scale details on changes in goose distribution at specific sites, while detailed scientific surveys were performed systematically over the entire south plain of the island. Through population surveys performed at staging areas during spring, scientific investigations also provided information on the overall greater snow goose population, covering an area and time scale extending beyond regional and seasonal TEK.

DISCUSSION

Despite the growing appreciation that TEK has a great deal to contribute to environmental sciences and management, few methodological innovations have been proposed as to how the co-application of TEK and science could reach a greater potential (Bart 2006; Huntington et al. 2004b; Turner et al. 2000). One recent suggestion has been to approach the integration of both knowledge types by focusing on complementarities across scales rather than by looking at concordance at similar scales (e.g. Huntington et al. 2004b). Here we investigated the idea that the level of complementarity between TEK and science is indeed mostly a question of scales. More specifically, we looked for complementarities between TEK and science regarding the ecology of two tundra species, and evaluated whether the presence or lack of complementarity reflected differences in the time and space scales at which observations had been performed.

The question of scales in ecological studies has been a recurring source of discussion over the last decades (Levin 1992, 2000; Wiens 1989), as ecologists realized that patterns and processes observable at one scale could not always be generalized to other scales

(Wiens 1989). In the Arctic, the scale of observations is often imposed on researchers by logistical constraints such as lack of infrastructures for transportation, extreme weather seasonality, or high costs of field work. Because they are year-round Arctic residents with considerable cultural and economic interest in natural resources, local experts have sometimes built an ecological knowledge over spatial and temporal scales not well covered scientifically. Below we first address how our results satisfied or not our expectation that TEK would expand the spatial and temporal scales of current scientific knowledge about arctic fox and snow geese in the Mittimatalik area. In particular, we discuss the various factors that can explain why TEK was more complementary to science for some topics than for others, comparing results between our two focus species, the arctic fox and the greater snow goose. We then address three questions that follow from our results: 1- How good was the fit between TEK and scientific knowledge when both were available at the same scale? 2- What was the level of precision (that is, lack of variability) in the information collected from local experts? 3- What are the implications of the study for future ecological research and management in the area?

How did TEK expand the spatial and temporal scales of current scientific knowledge? From a zoom-in to a zoom-out

Our results give several examples of TEK broadening current scales of scientific knowledge. At the regional spatial scale, TEK about areas where various color phases of the red fox were observed, and to a lesser extent fox denning locations, goose molting locations, migrating stopovers and goose distribution all covered areas (40,000-42,000 km^2

in size) that expanded beyond the scientifically investigated south plain of Bylot Island (ca. 1,600 km^2). At the temporal and spatio-temporal scales, TEK about the increase in the red fox population (several decades) and the winter and spring ecology of arctic fox (several seasons) also enlarged the realm of regional scientific data (several years, summer only).

Interestingly, many studies that have integrated TEK and scientific knowledge found that while TEK operated on long time series, it generally provided information at a smaller spatial scale than that provided by science (Table 1). On the contrary, the study of Ferguson and Messier (1997) (Table 1) and ours (in the case of the arctic fox), both performed with Inuit experts from Baffin Island, found that TEK could provide a broader spatial context than scientific data. Inuit from North Baffin Island have traditionally lived in camps spread out over vast territories (Brody 1976; Mary-Rousselière 1984-1985; Treude 1977). Since settlement, they have modified their land use patterns, but have nevertheless continued to hunt over large areas (Pers. observ.; Riewe 1992). The use and knowledge of such vast areas (the people of Mittimatalik hunted over ca. 96,200 km^2 in 1991 (Riewe 1991)) has been encouraged by a number of factors including the large spatial extent over which exploited animal populations were located (Brody 1976), the presence of sea ice which facilitates travel by dog teams or snowmobiles, and the absence of nearby villages. In addition, the fur trading activities have, within living memories, encouraged families to spread over the landscape and make long journeys to trading posts (Brody 1976).

The contrast between our study and most other ones regarding the way in which TEK complements scientific knowledge reminds us of the influence that cultural and biogeographical contexts have in delimiting the scales covered by the TEK of a particular group. Eminently, every cultural group has had a specific pattern of land use, stressing the fact that Aboriginal people (and their TEK) cannot be looked at as a single entity (Turner et al. 2000). Understanding the land use pattern of a cultural group is therefore necessary for both guiding research on TEK and interpreting the obtained results.

While scientific data collected locally tended to be very specific and focused (the ″zoom in″ approach), TEK provided a broader picture (a ″zoom out″) of the ecological system, allowing local experts to identify regional patterns (e.g. two over wintering strategies of arctic fox) that could have gone unnoticed at the smaller observational scale used by scientists. The ″zoom out″ provided by TEK can now be used by scientists to test new hypotheses using a ″zoom-in″ approach. This complementarity between different approaches used at different scales echoes the ″Strategic Cyclical Scaling″ described by Root and Schneider (1995; 2003) in another context. Therefore, our results not only confirm the hypothesis that TEK can expand the spatial and temporal scales of knowledge about arctic species from the Mittimatalik area, they also bear evidence of the great potential of integrating TEK and scientific knowledge as complementary approaches providing information at various scales (Huntington et al. 2004b).

Collecting TEK by consciously focusing on information complementary to scientific observations helped identifying several areas of convergence between TEK and science (Riedlinger and Berkes 2001). First, it provided a historical perspective (e.g. on red fox abundance) that scientific observations simply lacked. Second, it provided several new insights for current and future ecological understanding and research (see above). Had we collected TEK about foxes with the sole intent of comparing it with scientific observation at a similar scale (i.e. the summer season), these new insights would have remained unnoticed to ecological scientists.

Highlighted by the above discussion is also the salient difference in the level of spatio-temporal complementarities between TEK and science when investigating the ecology of arctic foxes versus that of greater snow geese, which again, can be explained by a question of scales. In the case of arctic foxes, detailed scientific studies have been conducted since a relatively short period of time (i.e. less than 10 years), on a restrained geographical scale (i.e. the south plain of Bylot island) and for rather few topics in the summer time. On the other hand, local people have had a very high level of familiarity with the species through the very extensive trapping era that lasted until the 1980s and through year-round contact with the species. For arctic foxes then, the degree of overlap between TEK and science was not very wide, thus allowing much opportunity for complementarities. As time passes and scientific studies progress though, the degree of overlap between TEK and regional sciences is likely to increase, diminishing the potential of scale complementarities. For example, satellite transmitters that have been fitted on arctic foxes will, in the next few years, bring scientific information on the winter ecology of the species and beyond Bylot Island (D. Berteaux, unpublished).

In the case of the snow goose, the first scientific research was conducted prior to the 1980s and, since 1989, research has covered a large variety of ecological topics regarding its ecology. Scientific investigations, although centered on Bylot Island, have also included exploratory studies outside of Bylot Island through helicopter surveys and satellite transmitters. Also, local people seemed to have a lesser degree of familiarity with greater snow geese than with arctic foxes since greater snow geese, although appreciated, have never been a critical source of food or income for Inuit families living in the Mittimatalik area. Being a migratory species, geese are only available for observation in the Arctic during the summer months, when scientists are active in the area. Thus, both spatial and temporal zones of overlap between TEK and science regarding greater snow geese were high, allowing for less complementarity and more comparisons. Moreover, studies performed by scientists during the goose migration (via satellite telemetry) and in southern latitudes during the winter cover spatial and temporal scales that extend beyond what is possibly covered by TEK. Such may be the case for most large migratory bird species.

When TEK and science overlap across scales

Although we have strived not to compare TEK and scientific observations, both sets of knowledge did sometimes overlap, at similar scales. Such was the case for information regarding the arrival of the red fox, the timing of goose molt and migration, and changes in goose abundance. Congruence was found between TEK and scientific knowledge concerning the arrival of the red fox around Mittimatalik and the timing of goose molt and migration. On the arrival of the red fox, the earliest sighting reported by informants dated back to 1947-48 and coincided exactly with the year the first red fox pelt was traded by the HBC in Mittimatalik (Macpherson 1964). In this case however, there was some disparity in the accounts of informants, the majority mentioning their first sight in the 1950s, two stating the 1960s, and three saying that red foxes were always seen and one believing red foxes have always been around. This issue of variability will later be discussed.

On the topic of goose molt, both TEK and science were also congruent in stating that non-reproductive geese molt earlier than nesting ones. Although less quantitatively stipulated, local experts mentioning that nesting geese molt after their gosling have hatched and grown bigger was consistent with scientists mentioning that nesting geese molt around three weeks after goslings have hatched. Similarly, TEK about the period when non-reproductive geese molt and the preference of molting geese for lakes and pond was consistent with scientific reports (Hughes et al. 1994; Reed et al. 2003), but more generally expressed.

In the case of goose abundance however, there was high variability between the comments of informants as well as similarities and apparent discrepancy between TEK and scientific observations. If we compare TEK with scientific data obtained through the surveys performed on Bylot Island, there is some disagreement in that scientific surveys have noticed more than a three-fold increase in the geese population from 1983 to 1993 (Reed et al. 2002), whereas 8/15 informants stated a decline of goose abundance over the island. Yet, scientific surveys have also noticed a slight decrease in abundance since the peak of 1993. Is the perceived decrease in abundance by informants since the 1990s then based on comparison with the 1993 benchmark? This explanation does not entirely resolve the apparent discrepancy between TEK and scientific observations however. Indeed, of those eight informants who noticed a decline on the island (geese that redistributed), three noticed this change since the biologists started their surveys in the area, two noticed the change in recent years, one since Inuit started to use riffles extensively (the 1970s) and one compared to his childhood (the 1950s). The eighth informant did not provide a timescale for observed changes From the scientific point of view, the perception is that the distribution of nesting geese has not changed overall since the 1980s, but that the distribution of goose families, during the brood-rearing period, has presented slight changes over specific areas (Reed et al. 2002). Besides these long term tendencies, scientists, in accordance with TEK experts, have also noticed an inter-annual variability, sometimes strong, in the abundance and distribution of goose nests. Because geese are gregarious birds, these short term changes (not to be confounded with long term tendencies) are probably highly perceptible in certain sites. It may be that in the case of geese, perceptions of population abundance by local experts are based on observation of abundances at very specific sites. Therefore, high inter annual variation at specific sites could contribute to explain variability in the answers of local experts. In that case, and even if validation workshops have been performed to shed light on the question, there is still need for further TEK explorations to understand more clearly the perception of local experts on changes in goose abundance and distribution in the area as well as to clarify whether these changes have been observed for nesting or brood-rearing geese, which seem to vary differently. It would also be interesting to investigate the potential biases that a local distrust in goose biologists may have generated. Indeed, while we had thought geese were a species not subject to tensions, documentation of TEK regarding goose abundance and distribution revealed a distrust of goose biologists, based in a large part on the marking of geese with collars and the use of helicopter. For cultural reasons, these activities are not well perceived by several members of the community who consider them as disrespectful and disturbing for the animals. Therefore, if the question of goose abundance and distribution needs further clarifications, our results at least highlighted the need for further communication and exchange between TEK holders and scientists to try to resolve apparent tension.

Overall, the comparison of TEK with scientific information at similar scales provided information that led to better confidence in our understanding of certain aspects of the ecology of foxes (timing of the arrival of the red fox) and geese (molt and migration). Comparison also pointed to the need for further investigations on the topic of goose abundance over Bylot Island as well as communication between scientists and the local population. We believe the comparative approach is a very important step to ″increase confidence and depth of knowledge″ (Huntington et al. 2004a). In that sense, more data need to be produced (or made available) that are comparable at similar scales, from both the TEK and scientific sides (Huntington et al. 2004a).

Variability in the information provided by local experts

Difficulties in accessing and integrating TEK, and the associated issues of heterogeneity and reliability of observations, have been largely discussed (Ferguson and Messier 1997; Huntington 2000). Errors of interpretation, poor translation, errors on (or lack of) recall of specific facts, informants reliability, context of the interview and reluctance in revealing sensitive knowledge have all been raised as factors that can influence the accuracy of TEK (Cutler III 1970; Ferguson and Messier 1997; Huntington 2000). The question of credibility has been similarly addressed for scientific information (Huntington et al. 2004a). In that case, peer review insures a ″standard of credibility″ (Huntington et al. 2004a), although it is not infallible.

Throughout this study, we took several measures to minimize the sources of error while documenting TEK, ranging from the selection of participants and interpreter to the data validation and verification (the latter being analogous to the scientific peer review (Huntington et al. 2004a)). Despite these measures, variability remained in the comments of informants regarding certain topics of our study (e.g. the arrival of the arctic fox and changes in the abundance of geese). We don't know the reasons for this variability. As mentioned, perception of goose abundance and distribution may have been influenced by high inter annual variation in goose abundance at specific sites, generally a consequence of spring meteorological conditions (Reed et al. 2004). In that sense, although local experts covered a large area collectively, it is possible to think that each person has had an intimated knowledge of a smaller area, where conditions may have varied differently than in other sites. This may be especially true for species such as geese that are unevenly spread over the territory (i.e. hunted in restrained sites) and that have high dispersal capacities. In other instances, variability also seemed clearly associated with the biographical context of informants (rather than to their credibility) and the nature of the question addressed. For example, in the case of the arrival of the red fox, most inuit families lived in camps spread over a large area in the 1950s and 60s. Therefore, it is plausible that while one red fox was sighted and caught in 1947, it took several years for the area to be colonised by the species.

Four informants have always seen a red fox or believe they have always been around. Two were born in the 1940s and it is likely that by the time they started to trap themselves, red foxes had indeed colonised the area. The third one was the informant for whom we evaluated the birth date as 1935. His answer is harder to explain because we are unsure of his exact age. The fourth informant, born in 1924, believed red foxes were always around because his father talked about the red fox when he was young. This informant was originally from Clyde River, several hundred kilometres south on Baffin Island, and his father was working for the trading post and whaling crews. It is possible that his father had heard from the red fox long before they had colonized the Mittimatalik area. Finally, one expert stated having seen a red fox for the first time in 1943 in Igloolik, which does not correspond with the first trading records of 1950 and 1951 reported by MacPherson (1964). In that case, discrepancy between TEK and science could be explained by either the inaccurate memory of the informant or by the fact that due to low prices, red fox pelts were not always traded (Macpherson 1964).

Implications for future research and management: cross-level linkages and communication among stakeholders

Arctic foxes and geese are not currently subject to active wildlife management in the Mittimatalik region. Therefore, no immediate action is needed in which both TEK and scientific knowledge could be applied together for managing these resources. However, given the ecological importance of these two species in the recently created Sirmilik National Park of Canada, the early articulation of TEK and scientific knowledge will no doubt smooth the integration process in the case decisions need to be taken.

Here we have looked at the contribution of combining indigenous and scientific knowledge from a strict ecological research standpoint. However, as mentioned earlier, TEK not only provides factual ecological information. It is made of values, ethics and cultural knowledge that also contribute to the management of natural resources (Usher 2000). Although not analyzed in this paper, we did document TEK that pertained to cultural values associated with foxes, geese, and the environment. Hence, in addition to providing useful ecological insights, the research process has increased mutual understanding between local populations, scientists, and the Parks Canada Agency, building up linkages between the three main players of management of local natural resources.

CONCLUSION

In this case study, the degree of complementarity between TEK and ecological science largely depended on the spatial and temporal scales from which each type of knowledge was derived. More specifically, complementarity was greater in the case of arctic fox ecology (highly complementary data were obtained on two out of three variables) than in that of greater snow goose ecology (data were at best moderately complementary). This difference between the two species was clearly generated by three factors that influenced the degree of congruence between the spatial and temporal scales of observations forming the basis of TEK versus scientific knowledge. These three factors are the history of local scientific investigations, the way local experts interacted with the two species, and some characteristics of the natural history of the species. First, ecological research in the Sirmilik area had been conducted for a longer time period on geese than on foxes, offering less room for TEK to provide information spatially and temporally complementary to scientific investigations, at least in terms of strict ecological facts. Second, because arctic fox have been the main staple of Inuit for many decades, local experts had developed an intimate knowledge of arctic fox, which they followed every winter and over large areas. In comparison, geese had been at the most hunted as a delicacy over a short period of the year and in specific sites. Third, because the arctic fox is a resident species that uses a great variety of habitats, including the sea ice, it allowed local experts to make year round, sometimes random, observations in different locations. On the other hand, because the snow goose is a migratory and gregarious species that uses more restrained habitats (i.e. mostly arctic wetlands), it only allowed local experts to make spring and summer observations in restrained sites.

Thus the argument for an early integration of TEK and science that, one side, can improve involvement, communication and trust between scientists and local populations from the onset of a research project and, on the other side, present more opportunities for contributing new ecological information. Comparing observations at similar scales, as we have seen, is nevertheless important and necessary to get better confidence in obtained conclusions as well as to determine research and communication needs. In a sense, this approach also largely depends on a question of scales for reliable comparisons necessitate TEK and scientific observations that present a large temporal and/or spatial overlap. Based on our study however, we maintain that integrating TEK and scientific knowledge by combining information complementary across scales is an approach that can be more powerful for generating new ecological insights and hypotheses, as well as to get a clearer picture of the social-ecological systems under study. At times when the needs in TEK research are towards the identification of concrete approaches for its integration within ecological science, we suggest that understanding the scales of TEK and scientific observations is a necessity and that it presents a good standpoint to look out from to obtain the greatest benefits out of the articulation of TEK and science.

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FIGURES AND TABLES

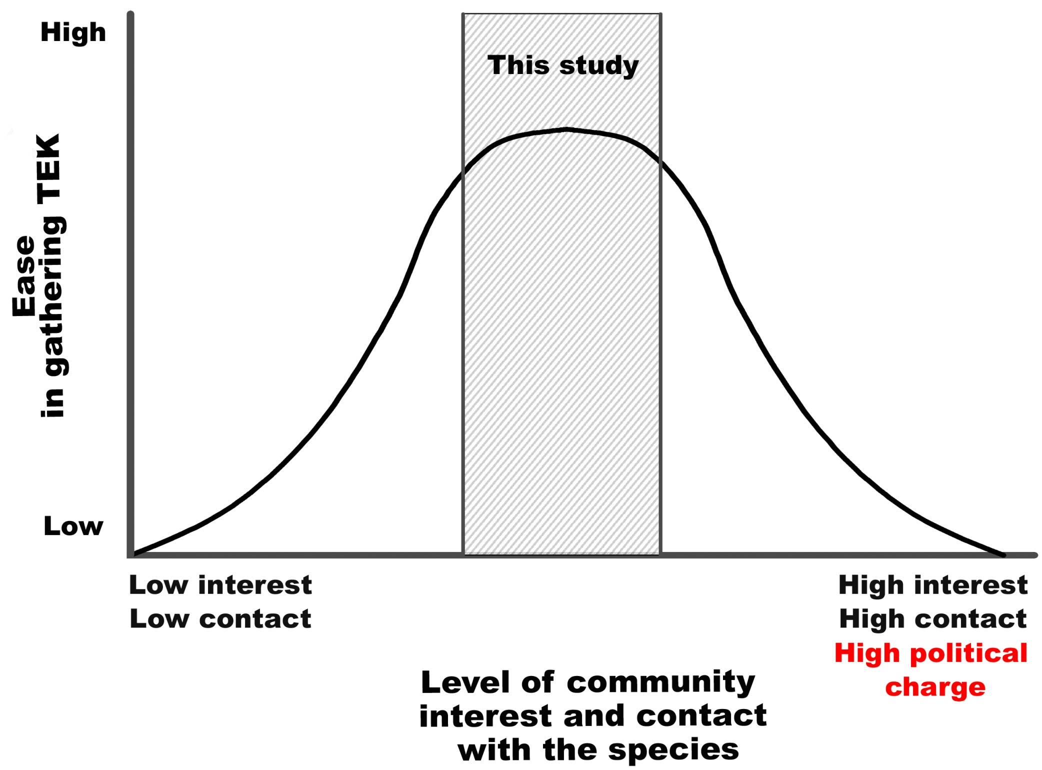


Figure 1. A conceptual model showing how the level of interest and contact of a local community with a given species influences the difficulty in gathering traditional ecological knowledge (TEK) about this species. When a community has little interest in or is in little contact with a given species (e.g. some cryptic insects), TEK is low and therefore cannot be gathered productively (left side of the curve). Conversely, when a species raises so much interest that issues surrounding this species are locally strongly politically charged (e.g. polar bears in some communities), TEK can become difficult to access without bias (right side of the curve), although it can be broad and diverse. The arctic fox and greater snow geese studied here provided an ideal context to collect TEK (center of the graph), since both species are visible and harvested, but not strongly charged politically.

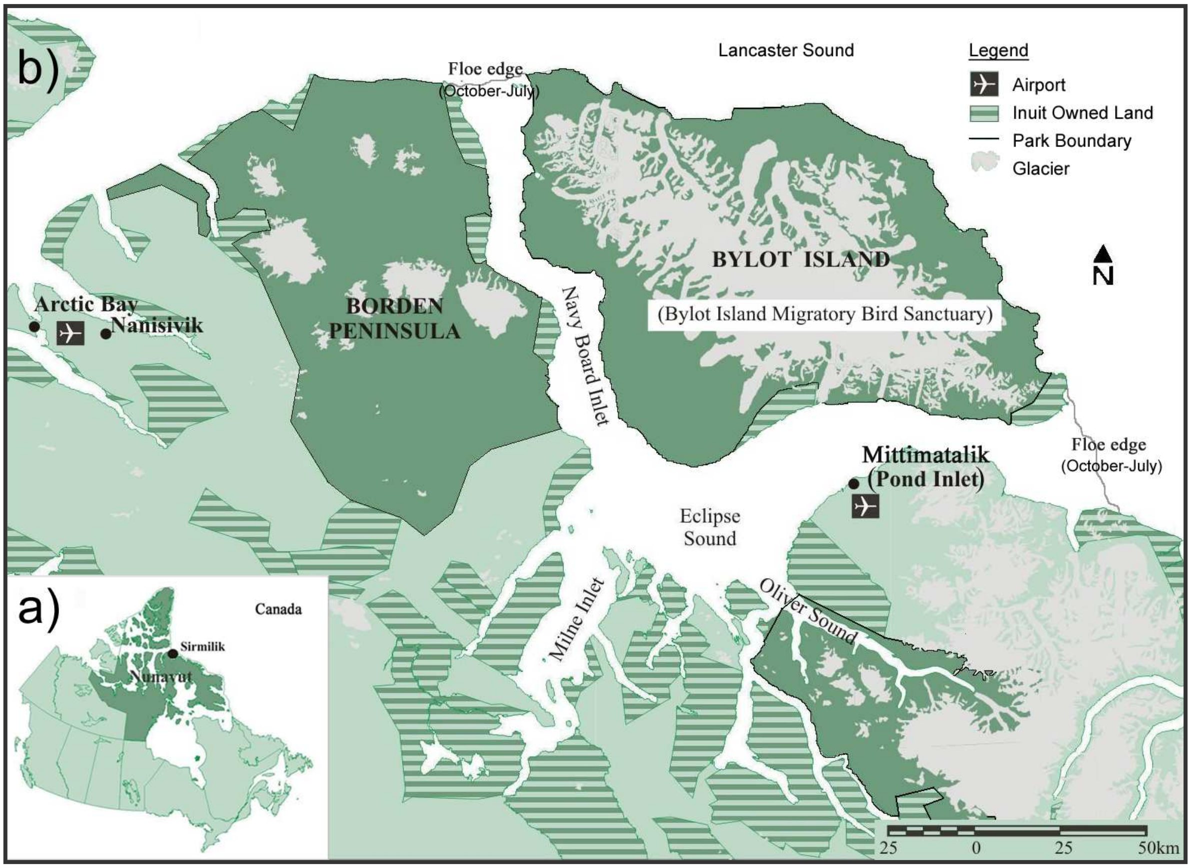
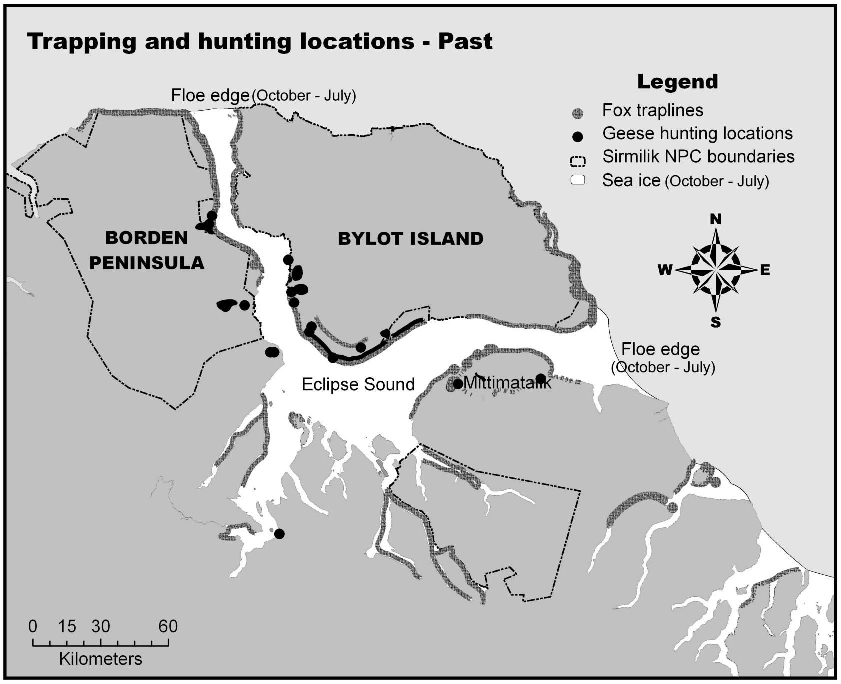


Figure 2. Study area. a) Location of the Nunavut territory (darker) and Sirmilik National Park of Canada. b) Area of Northern Baffin Island and Bylot Island, Nunavut, Canada. The community of Mittimatalik is located at the doorway of Sirmilik National Park of Canada, which is indicated by the darker green colour. Copyright 2004 by the Nunavut Field Unit of Parks Canada. Adapted with permission.



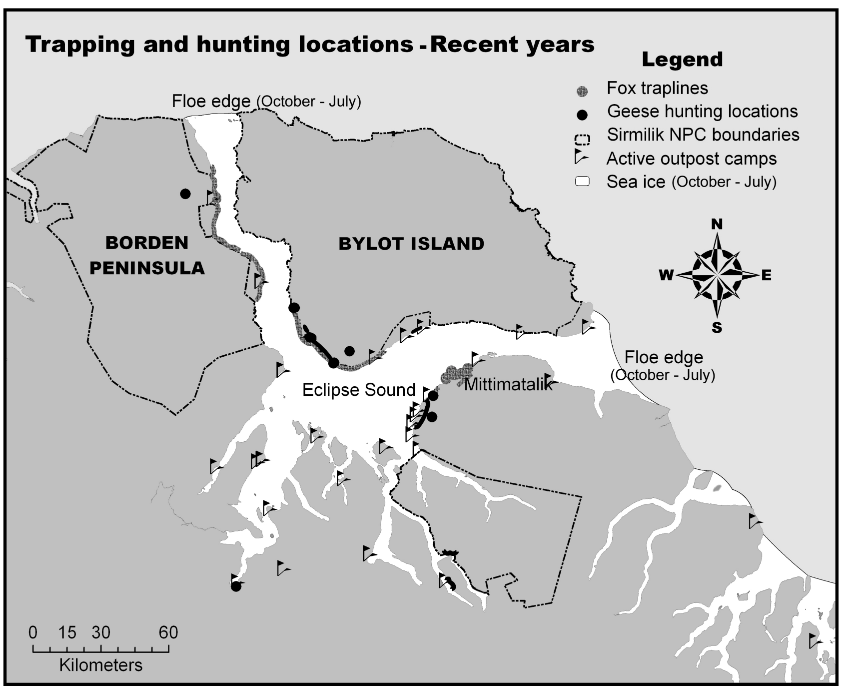


Figure 3. Past (up to the late 1970s) and recent (1980s and after) areas used for fox trapping and goose hunting by the local experts from Mittimatalik (Nunavut, Canada) interviewed in this study. Flags represent the locations of outpost camps currently actively used to hunt or fish species such as caribou, ringed seals, narwhals, and arctic char.

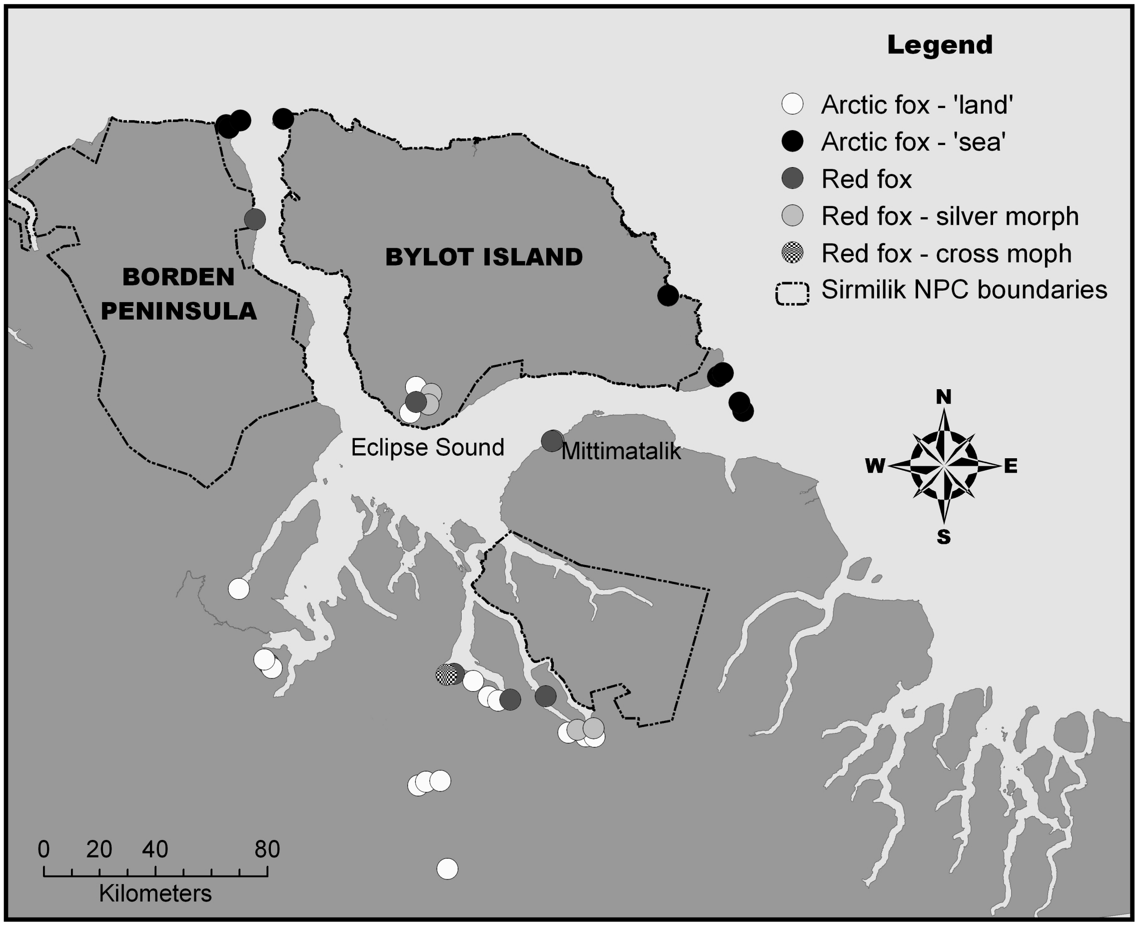


Figure 4. General spatial distribution of ″land″ and ″sea″ arctic fox and locations where the various color morphs of arctic and red fox have been sighted, according to the traditional ecological knowledge (TEK) reported by local experts from Mittimatalik, Nunavut, Canada.

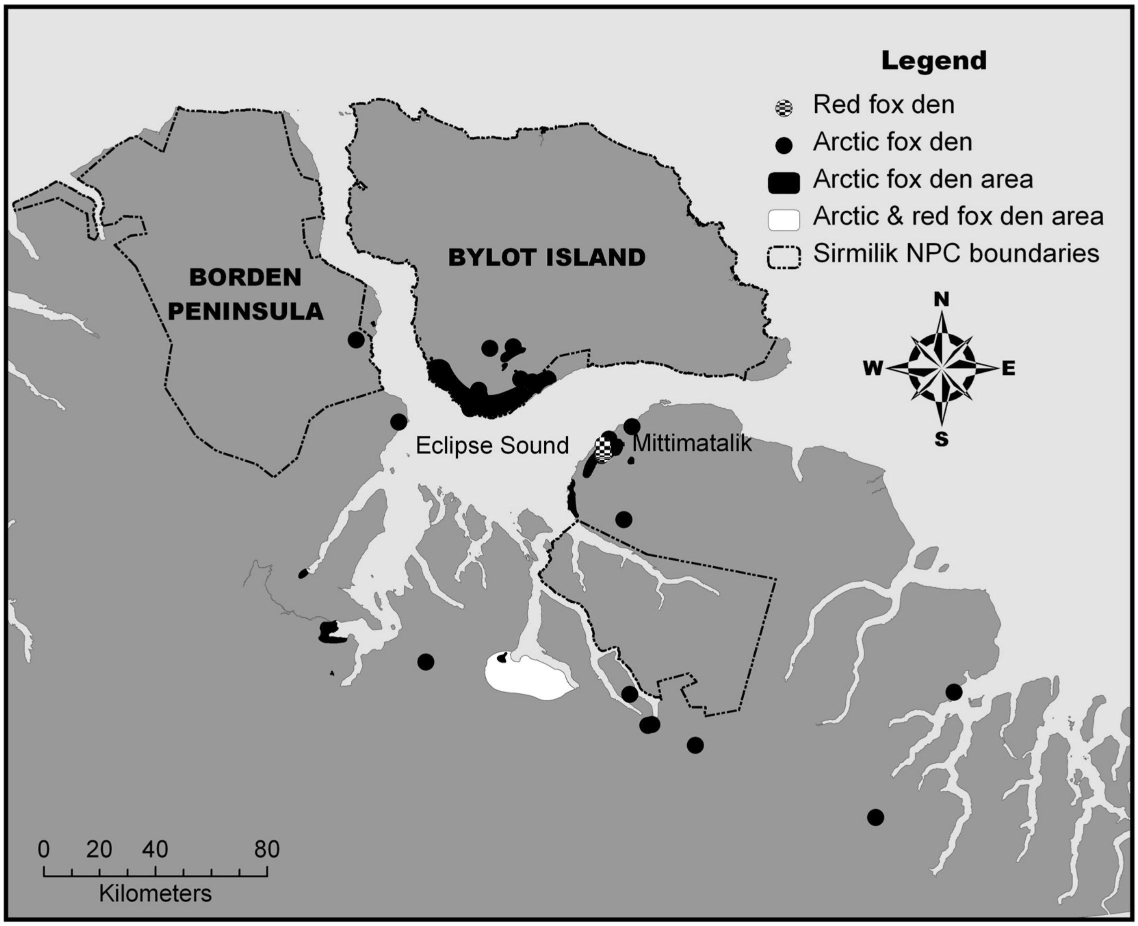


Figure 5. Locations of arctic and red fox dens and denning areas, as reported by local experts from Mittimatalik (Nunavut, Canada) interviewed in this study.

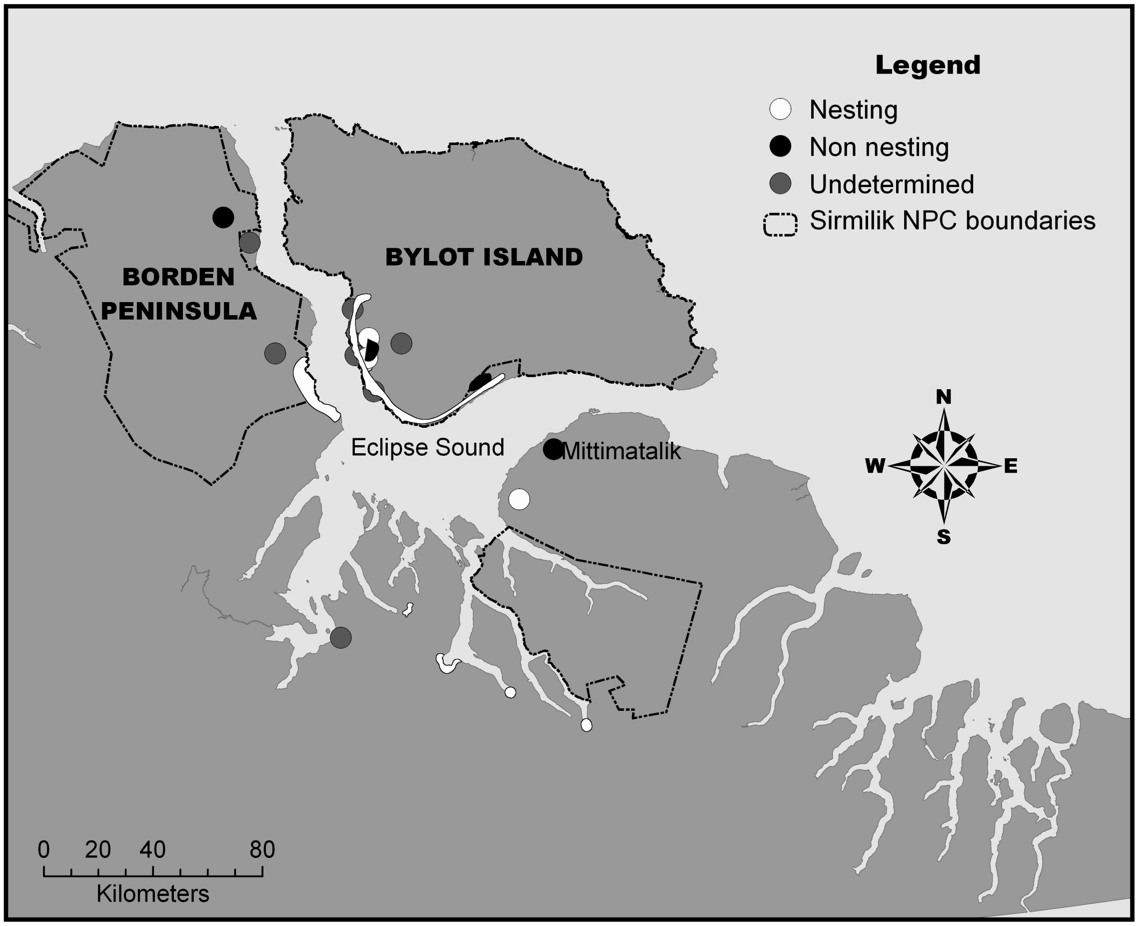


Figure 6. Molting locations for nesting and non nesting greater snow geese, as reported by local experts from Mittimatalik (Nunavut, Canada) interviewed in this study. Informants did not specify the breeding status (nesting, non nesting or both) of molting geese encountered on locations marked as 'undetermined'.

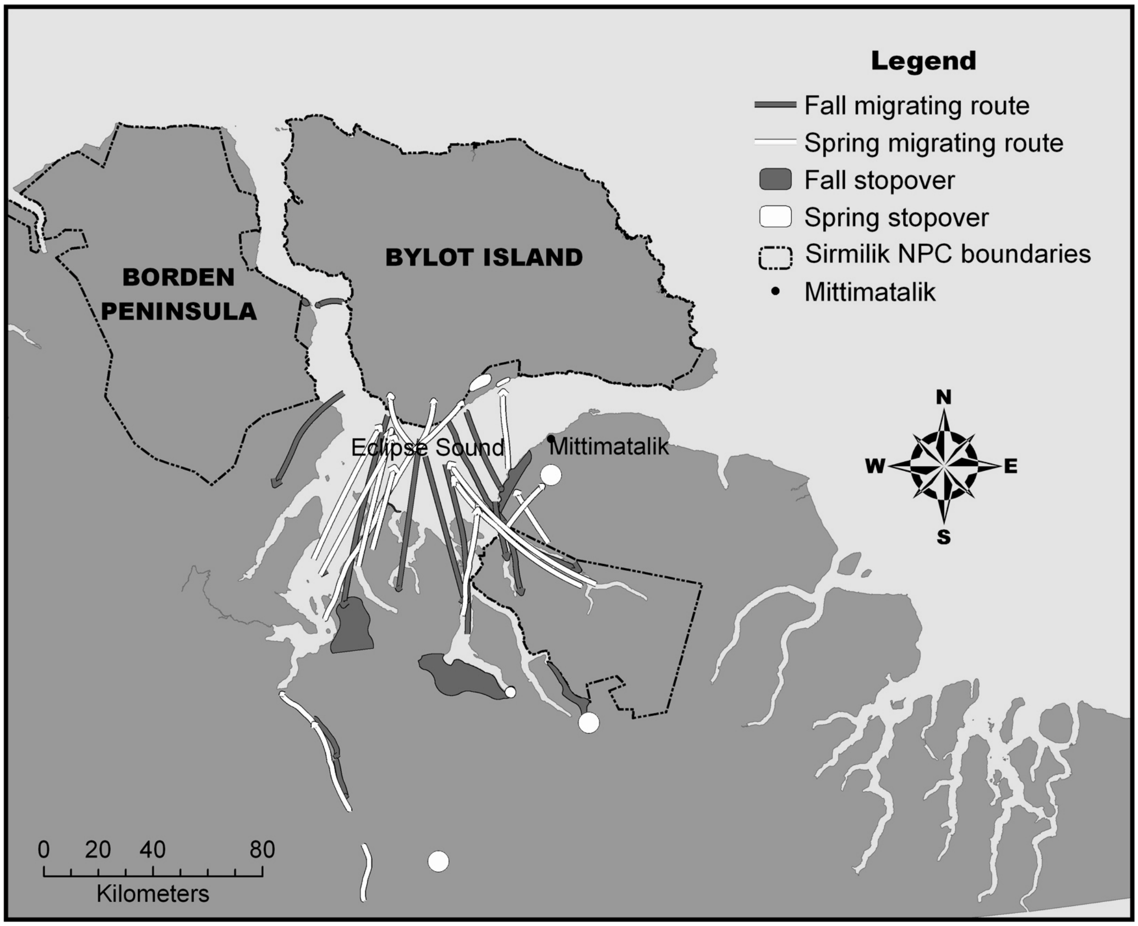


Figure 7. Fall migrating routes, spring migrating routes, and feeding stopovers of greater snow geese, as reported by local experts from Mittimatalik (Nunavut, Canada) interviewed in this study.

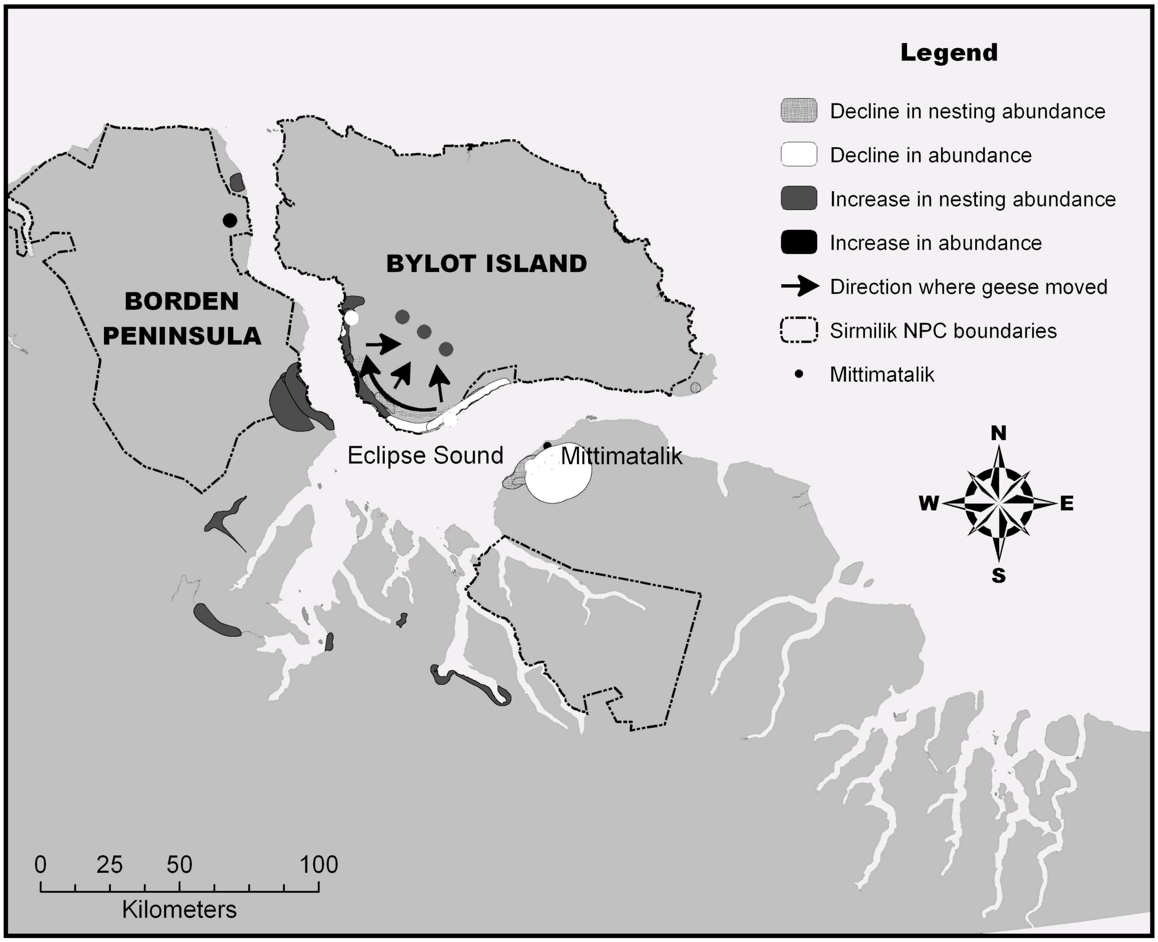


Figure 8. Changes in the abundance and distribution of greater snow geese, as reported by local experts from Mittimatalik (Nunavut, Canada) interviewed in this study. The temporal scale is "the last decades" and the spatial scale is Bylot Island and adjacent Northern Baffin Island. Arrows indicate the movements of geese toward higher grounds and the western side of the south plain of Bylot Island. Inset: enlarged view of the south plain of Bylot Island.

Table 1. Representative examples of studies combining traditional ecological knowledge (TEK) and scientific knowledge. Indications are given on how TEK provided for a more general (zoom out) or more local (zoom in) scale of spatial and temporal information compared to available scientific knowledge.

Research Subject	Study location	Spatial scale	Temporal scale	References
Winter ecology and habitat use of Common eider (*Somateria mollissima sedentaria*)	Belcher Islands, Canada	Zoom in	Zoom out	Gilchrist et al. (2005) Gilchrist et al. (2006)
Biodiversity conservation in populations of Brook charr (*Salvelinus fontinalis*)	Mistassini Lake, Canada	Zoom in	Zoom out	Fraser et al. (2006)
Ecology, behavior, harvest trends and causes of population decline of sooty shearwater (*Puffinus griseus*)	Rakiura, Poutama and Titi Islands, New Zealand	Zoom in	Zoom out	Lyver et al. (1999) Lyver (2002)
Identification of essential fish habitats for several ground fish species	Irish Sea, United Kingdom	Zoom in	--	Bergmann et al. (2004)
Flooding, ecology and environmental management history of a wetland targeted for rehabilitation	Kanyapella Basin, Australia	Zoom in	Zoom out	Robertson and McGhee (2003)
Movement and population decline of white-winged and surf scoters (*Melanitta fusca* and *M. perspicillata*)	Alaska, USA and Northwest Territories, Canada	Zoom in	--	Huntington et al. (2004)
Historical changes in distribution and abundance of a population of arctic tundra caribou (*Rangifer tarandus*)	South Baffin Island, Canada	Zoom out	Zoom out	Ferguson and Messier (1997)
Conservation of bumphead parrotfish (*Bolbometopon muricatum*)	West Solomon Islands	Zoom in	Zoom out	Aswani and Hamilton (2004)
Trends in harvest, behavior, and migrating movements of Atlantic cod and lumpfish (*Gadus morhua* and *Cyclopterus lumpus*)	Newfoundland, Canada	Zoom in	Zoom out	Neis et al. (1999)
Ecology of arctic fox and greater snow geese (*Alopex lagopus* and *Chen caerulescens atlantica*)	Northern Baffin Island, Canada	Zoom out	Zoom out	This Study

Table 2. Summary of Inuit traditional ecological knowledge pertaining to changes in the abundance and distribution of greater snow geese, as reported by 13 and 15 local experts from Mittimatalik (Nunavut, Canada) interviewed in this study, respectively. The temporal scale is ″the last decades″ and the spatial scale is Bylot Island and adjacent Northern Baffin Island. Timelines for the observations (10 experts reported), and reasons perceived to have caused the changes (14 experts reported) are summarized.

Topic	**Comment on population trend**	**Number of informants**
Overall population trend	The abundance did not change overall	4
	More geese in general	2
	Less geese in general	2
	Informant can not state whether the abundance varied overall	4
	There are inter annual variations in goose abundance	5
Variations in distribution	Geese are more scattered and have relocated	12
	Specific areas increased in goose abundance	10
	Specific areas decreased in goose abundance	9
	Less concentrated on Bylot Island	3
	Decline in numbers over Bylot Island	8
	There are no changes in goose distribution	1
	There are less non nesting geese on Bylot now	1
Timeline for the observations	Since goose biologists started their surveys on Bylot Island (early 1980s to early 1990s)	3
	Since the 1990s	2
	In recent years	2
	Since the extensive use of rifles and snowmobiles (since 1970s)	1
	In comparison with childhood (1940s)	1
	In comparison with childhood (1950s)	1
Reasons for changes	Goose biologists doing their research	11
	Use of helicopters	9
	Hunting pressure in specific areas	4
	Use of new loud hunting equipment (snowmobiles and riffles) to hunt geese	6
	All the planes coming and going from Mittimatalik	2
	Increase in fox population following the trapping decline	2
	Geese hiding away	2

APPENDIXES

Appendix I. Series of questions used as guide for the semi-directive interviews held during the first phase of the research, from May to September 2005.

Interviewee Personal Data

1. Where were you born?
2. What year where you born?
3. Have you lived in this area for a long time?
4. Did you live somewhere else and for how long?
5. Are you still going on the land for hunting and camping? If yes how often and at what time of the year?
6. If no when did you stop going on the land and for how many years did you go before you stopped?
7. Can you tell me in which area you spend the most time when you go out on the land (if applicable)? Which area do you know the most?

Snow Geese (Kanguq, Qavii, Kanguara)

<u>Hunting</u>
1. Do you harvest snow geese?
2. Can you show me on the map where? (young adult compared to now)
3. How frequently do you hunt geese? What time of the year?
4. Did you hunt geese more or less in the past?
5. Can you comment on the method you use to harvest geese?
6. Is the method similar or different than method use in the past?
7. I heard of people driving geese on the ice to kill them, have you heard of this method?
8. Have you heard of geese fences made of rocks?
9. What kind of geese are the best for hunting. Do they have young with them? What I mean is there are groups with youngs and it seems there are groups without.

<u>Eggs</u>
1. Do you gather goose eggs?
2. Can you show me on the map where? (young adult compared to now)
3. How frequently do you gather eggs, what time of the year?
4. Did you gather eggs more or less frequently in the past?

<u>Migration</u>
1. Can you show me on the map where you see geese arriving first in the spring?
2. When do you see geese leave the area?
3. What happen at that moment, do they leave all at the same time?
4. Can you show me their travel routes?

5. Do you remember times when migration was unusually early or late?

Nesting
1. Where have you seen geese nesting? Where are the large groups?
2. On you lifetime, have you seen geese nesting in the same areas or have they moved to other areas? (young adult compared to now)
3. Do you have knowledge about where your parents, grand-parents and other elders use to see large geese nesting areas?
4. Do theses areas have names?
5. I have heard of a place called Qaversisit. have you heard of this place? Can you tell me about his place? Is it a nesting place for geese.

Moulting
1. When do the geese start to molt their feathers? Do they all molt at the same time?
2. Do you know where geese go to molt their feathers?
   Those who have nest and goslings
   Those who do not have nests
3. On your lifetime, have you observed that geese (those that do not have youngs) always go to molt their feathers in the same place?
4. Do you have knowledge about where your parents, grand-parents and other elders use to see geese molting?

Numbers
1. Have you noticed any similarities or change in the number of geese you see today compared to before: (young adult compared to now)
2. Do you remember any exceptional years when you did see very many or very few geese. What was special in that/those year(s)? that could have affected the geese?

Geese Health
1. Have you noticed if geese are healthier, same or less healthy than now than they were before (young adult compared to now)
2. Do you remember anything that stands out that you have noticed concerning the health of geese?

Community use and Values
1. Can you please comment on why are geese important to you, to your culture or to your children and grand-children?
2. Do the people use geese now the same way that they use to long time ago?

Final comment about the geese
1. Do you have any other comment or old stories you would like to make regarding the geese?

Arctic and red foxes (Tiriganniaq, Qiangaqtuq, Kajuqtuq)

Hunting

1. Do you trap or hunt Arctic and/or Red Foxes?
2. IF you still hunt or trap foxes on a regular basis, How frequently do you go out to trap them?
3. If you don't trap them now, have you trap them in the past, how many years?
4. Can you show me on the map where you trap foxes? (young adult compared to now)
5. Are the areas different for the Arctic and the red foxes?
6. Do you know of other places used by trappers to get foxes?
7. Did you go out to trap foxes more or less in the past
8. What time of the year do you trap foxes (CALENDAR)?
9. Can you comment on the method you use to trap foxes?
10. Is the method similar or different than method use in the past?
11. What are the best foxes to trap?

Moulting

1. At what time of the year do you see the white fur appearing on the Arctic Foxes?
2. At what time of the year the fur of the Arctic Foxes start to be completely white?

Red Foxes

1. Have you always seen Red Foxes in the area? If not, when did you see them for the first time?
2. Did you ever hear your parents, grandparents or other Elders talking about the first time they saw the Red Foxes? When did they see them for the first time?
3. What happened after the arrival of the red fox?
4. How did people react when they did see red foxes for the first time?
5. Have you ever seen Arctic and Red Foxes at the same time? What were they doing?

Differences between arctic and red foxes

1. What are the major differences between red and arctic foxes? (behaviour, food, intelligence, relation to humans)

Reproducing Habitat

1. Can you show me on the maps areas that are good for the Foxes to reproduce, to build a den? Why are these areas good?
2. Can you show me places where you have seen fox dens. Can you show me dens that are:
    a. -old
    b. -new (last ten years)
    c. -are these dens occupied by Arctic or Red Foxes?
3. Are some areas better for the Red Foxes than the Arctic fox?
4. Do you know of dens that were abandoned, or Arctic Fox dens taken over by Red Foxes?

Feeding Habitat

1. Can you show me on the maps areas that are good for the Foxes to feed?
2. Are the good areas the same for the Arctic and Red Foxes? Why?
3. During the winter, where do you most often see the Arctic Fox? Do you see them on the land or on the ice?
4. And what about the Red Fox?
5. When you see Arctic Foxes during the winter, what are they generally doing?
6. When you see Arctic Foxes eating a carcass, the carcass of what animal do they eat more generally (seals and what kind, walruses, whales)?
7. When Arctic Foxes are eating a carcass, do they eat the fat or the meat or both?

Temporal and spatial trends in distribution and abundance

1. Do you know of any places where you used to see Arctic and/ or Red Foxes and where you do not find them anymore? Or where there are less?
2. Do the number of foxes you see today similar or different compared to when you were younger?
3. Are there places where your parents, grandparents or other Elders used to see many Arctic and Red Foxes that are different than today? Can you show me these places on the maps?
4. Consequences….

Fox Health

1. Do foxes are always the same, or have you seen changes in their health from time to time? What are the signs that tell you that their health has change?
2. Have you seen foxes that are particularly in bad health?

Threats and disturbance

1. Can you describe any threat to foxes that you know off?
2. Do you think foxes avoid places where you find humans?

Community use and Values

1. Can you please comment on why are foxes important to you, to your children and grand-children?
2. Do the people use foxes now the same way that they used to long time ago?
3. What do you use the Foxes for today?

Final comment about the foxes

1. Do you have any other comment you would like to make regarding the Foxes, any old stories or interesting thing?

CONCLUSION DU MÉMOIRE

Nous avons montré que l'articulation du SÉT inuit et des connaissances scientifiques est largement influencée par les échelles spatiales et temporelles auxquelles chaque type d'observations a été recueilli. Aussi, nos résultats illustrent que le niveau de complémentarité entre SÉT et savoir scientifique découle du niveau de chevauchement d'échelle entre les deux ensembles d'observations pour une espèce donnée (un faible chevauchement d'échelle entraîne une grande complémentarité, et *vice versa*). En misant sur cette complémentarité d'échelles, nous avons ainsi montré que l'intégration du SÉT et des connaissances scientifiques pouvait accroître l'échelle spatio-temporelle de nos connaissances sur deux composantes d'un écosystème terrestre arctique, le renard arctique et la grande oie des neiges, mais que le niveau de complémentarité pouvait varier selon le sujet d'étude (ex. renard versus oie). L'intégration de connaissances dérivées du SÉT et de la science, à des échelles complémentaires, peut ainsi fournir des pistes intéressantes pour l'interprétation de résultats scientifiques, l'élaboration de nouvelles hypothèses de recherche et pour l'amélioration de la collaboration et de la communication entre des gestionnaires de ressources naturelles et leurs partenaires locaux. Or pour certains sujets (ex. l'écologie de l'oie), la comparaison de connaissances scientifiques et traditionnelles, à des échelles similaires, est une méthode d'intégration plus appropriée, approche qui permet de mesurer le niveau de confiance en certains résultats, de mettre en lumière les sujets contentieux entre SÉT et science et d'identifier les idées demandant des investigations supplémentaires. Ces résultats fournissent un morceau de plus dans le casse-tête des réflexions actuelles sur la recherche d'innovations méthodologiques afin que la co-application du SÉT et de la science devienne plus concrète. En effet, si les dernières années ont vu une explosion de la littérature scientifique vantant les avantages de l'intégration du SÉT dans la recherche et la gestion environnementale (Berkes, 1999; Berkes et Folke, 1998; Moller et al., 2004; Nakashima, 1991; Turner et al., 2000), relativement peu de discussions ont eu lieu quant aux différentes méthodes pour articuler ces deux savoirs (Bart, 2006; Huntington et al., 2004b). De ce fait certains auteurs affirment que « l'utilisation conjointe du SÉT et de la science n'a pas réalisé son plein potentiel »[1] (Huntington et al., 2004a). Par nos résultats, nous suggérons que la notion d'échelles est un « concept clé » sur lequel il est nécessaire de se pencher si l'on souhaite faire ressortir les meilleurs aspects de l'intégration du SÉT et de la science.

Dans cette étude, le SÉT inuit a été documenté opportunément, de façon à pouvoir l'intégrer avec les observations scientifiques générées antérieurement à l'étude. Le prochain pas vers l'intégration plus systématique du SÉT et de la science pourrait être l'élaboration d'un projet de recherche misant sur les forces de chaque savoir et au cours duquel les données basées sur le SÉT et la science seraient amassées simultanément. Ainsi, une collaboration accrue entre scientifiques et experts locaux, entre science et SÉT, pourrait être établie, et ce pour toutes les étapes du projet. Par exemple, la compréhension de l'utilisation de l'espace à l'échelle régionale (quelques milliers de kilomètres carrés) par les renards

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[1] Citation originale : « the use of TEK and science together has not realized its potential » (Huntington et al. 2004).

arctiques est un sujet qui pourrait grandement profiter d'une approche où SÉT et science seraient intégrés dès la planification d'une étude.

Plus communément, le SÉT est documenté et analysé suivant des méthodes de recherches qualitatives telle l'entrevue semi-dirigée (Huntington, 2000), qui a été utilisée dans la présente étude. L'entrevue semi-dirigée présente l'avantage de préserver le contexte et la richesse du savoir documenté, d'être normalement conduite dans une atmosphère décontractée et de laisser place à l'émergence de nouveaux sujets (Grenier, 1998; Huntington, 2000). Par contre, une méthodologie qui semble n'avoir pas été mise de l'avant et qui présenterait beaucoup de potentiel serait basée sur une documentation de SÉT par l'entremise d'entrevues semi-dirigées combinées à des méthodes se prêtant plus facilement aux analyses quantitatives, tel le questionnaire. D'une part, cette méthodologie permettrait d'analyser des données dans l'intégralité de leur contexte (via l'entrevue semi-dirigée), tout en permettant d'explorer de nouvelles manières de combiner SÉT et données écologiques scientifiques, via l'entremise d'analyses basées sur les statistiques non paramétriques (permettant l'utilisation de données catégoriques) ou l'approche Bayésienne (permettant l'incorporation de l'opinion d'experts (Ellison, 2004; Wolfson et al., 1996), par exemple. Étant donné l'augmentation du nombre d'agences gouvernementales et de financement qui requièrent des chercheurs et gestionnaires qu'ils intègrent une composante de SÉT dans leurs activités (Conseil de gestion des ressources fauniques du Nunavut, 2007; Sa Majesté la Reine du Chef du Canada, 2003; Usher, 2000), la recherche de méthodes novatrices, telle celle proposée, est fortement d'actualité.

Enfin, si la question de l'articulation du SÉT et de la science est captivante d'un point de vue scientifique, elle revêt aussi une dimension humaine très importante. Il serait donc impossible de clore ce mémoire sans mentionner qu'au-delà de la cueillette d'informations écologiques, la réalisation de ce projet a mené à l'établissement de liens personnels qui ont permis l'échange sincère de perspectives entre biologistes et experts locaux qui, malgré des différences culturelles importantes et des opinions parfois divergentes, aspirent ultimement à la même cause qu'est la préservation d'un environnement sain pour les générations actuelles et celles à venir. Tout porte à croire que c'est sur l'établissement de ces liens sincères et la meilleure compréhension inter culturelle qui en découle que repose, du moins en partie, le plein potentiel de l'intégration du SÉT et de la science. Et comme le mentionnait l'ethnologue Claude Lévis-Strauss dans cette pensée éclairante tirée de son essai *La pensée sauvage* :

> […] on oublie qu'à ses propres yeux chacune des dizaines ou des centaines de milliers de sociétés qui ont coexisté sur la terre, ou qui se sont succédées depuis que l'homme y a fait son apparition, s'est prévalue d'une certitude morale – semblable à celle que nous pouvons nous-mêmes invoquer – pour proclamer qu'en elle – fût-elle réduite à une petite bande nomade ou à un hameau perdu au cœur des forêts – se condensent tout le sens et la dignité dont est susceptible la vie humaine. Mais que ce soit chez elles ou chez nous, il faut beaucoup d'égocentrisme et de naïveté pour croire que l'homme est tout entier réfugié dans un seul des modes historiques ou géographiques de son être, alors que la vérité de l'homme réside dans le système de leurs différences et de leurs communes propriétés (Lévis-Strauss, 1962, p. 296-297).

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