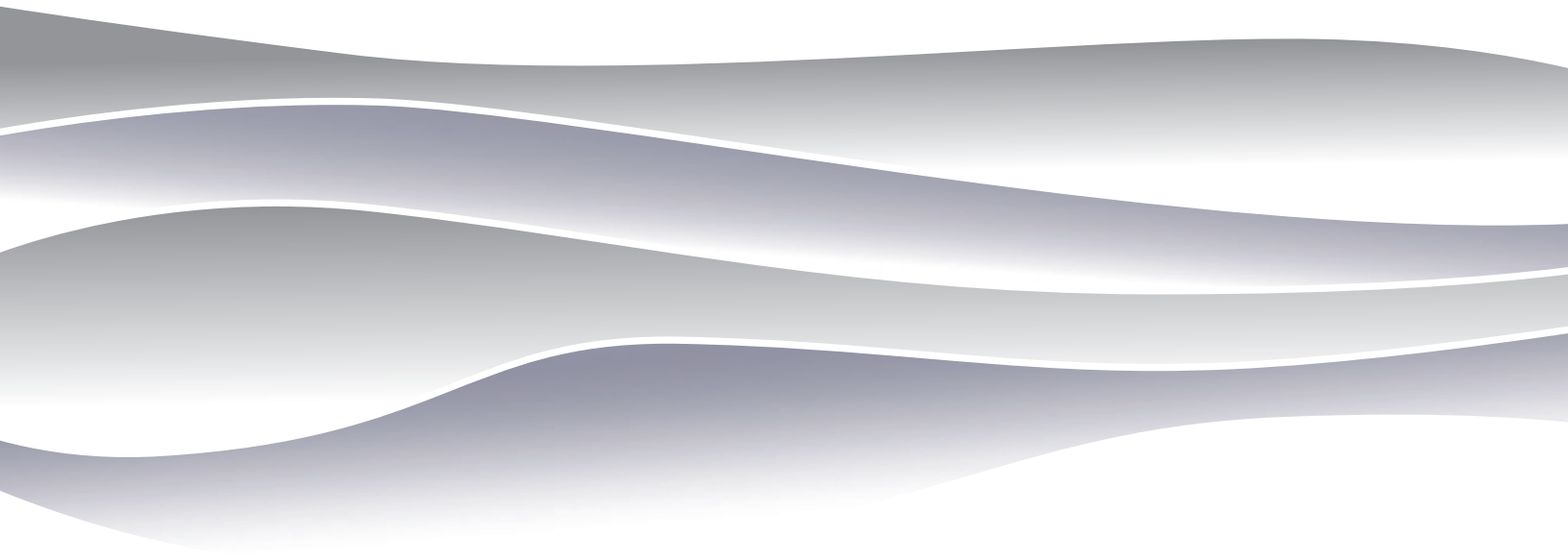
Conduct of Traditional Knowledge Research—

A REFERENCE GUIDE



Wildlife Management Advisory Council North Slope

Peter Armitage
and
Stephen Kilburn

Conduct of Traditional Knowledge Research—A Reference Guide

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Contents

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Any errors of omission, misunderstanding, and misinterpretation are, of course, entirely our responsibility.

Foreward

Let us be clear from the outset that with traditional knowledge "the knowing is in the doing." This is the essential character of aboriginal traditional knowledge. A reference guide on the conduct of research into traditional knowledge is at the same time a guide on the conduct of research into traditional land and resource use by aboriginal people.

Understood in this way, traditional knowledge studies in the Inuvialuit Settlement Region are not new. Indeed, this research could be viewed in modern terms as supporting the 1977 Inuvialuit land claim proposal – Inuvialuit Nunangat - that ultimately evolved into the 1984 Inuvialuit Final Agreement. For many years since, traditional knowledge studies have been conducted for a variety of purposes by governments, aboriginal authorities, wildlife management organizations and by industry and academic institutions. These studies are driven by legal requirements and policy and planning objectives to give full consideration and weight to Inuvialuit knowledge in wildlife conservation management, harvest management, environmental impact assessment, and land and resource management decisions.

In some cases, they have been informed by a growing literature on how to conduct traditional knowledge studies. Terry Tobias's Living Proof: The Essential Data-Collection Guide for Indigenous Use-And- Occupancy Map Surveys is clearly a seminal work in this regard.

The Environmental Studies Revolving Fund in 2008 published two reports: the first reviewing and evaluating requirements for traditional knowledge across northern Canada, and, the second, general guidelines for the use of traditional knowledge in environmental impact assessment and application in the Inuvialuit Settlement Region.

This report is different and much needed. As a reference document, it provides detailed technical guidance and, importantly, supporting rationale for best practices that should be fully considered by anyone contemplating, undertaking and applying traditional knowledge research on the Yukon North Slope. Its intended audience is traditional knowledge researchers and those organizations – government agencies, co-management bodies, environmental assessment boards, aboriginal authorities and industry – that require and work with traditional knowledge.

Peter Armitage and Stephen Kilburn are practicing social scientists – a somewhat neglected group of scientists – in the area of traditional knowledge research in Canada. They are researchers who care passionately about the quality of the methods they and others employ in the documentation and study of indigenous traditional knowledge.

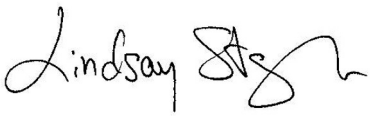
The Wildlife Management Advisory Council (North Slope) had the good fortune to work with Peter and Stephen in the preparation of a major report documenting Inuvialuit traditional knowledge about nanuq - polar bears. It was published earlier this year. Over the course of this project, the Council learned a great deal about what makes for sound design, conduct and documentation in traditional knowledge research. At the conclusion of the project, the Council asked Peter and Stephen to provide their views on these matters. This report is the result of that request.

There is much in this report to think about, especially since it also benefits from the contributions of other social scientists working in the area of applied traditional knowledge research.

This report is timely. As traditional knowledge research has become more broadly accepted and conducted, the quality of the research has often been wanting. For holders of traditional knowledge who have participated in good faith in these projects, flawed and unsound methods amount to a breach of trust. They can also be expensive mistakes, especially when their findings are easily challenged and dismissed.

Traditional knowledge research is coming under greater scrutiny by traditional knowledge holders and by any institution or group that seriously evaluates and tests the body of information and evidence that it works with. When the findings of biological, ecological and climate change research, for example, don't agree with those of traditional knowledge research, it is reasonable to expect that the transparency, rigor and integrity of the research methods are an area of immediate interest and concern. Traditional knowledge research, like other fields of research, should not enjoy a "free ride" when it comes to soundness of its methods and practices.

This reference guide to the conduct of traditional knowledge research addresses this challenge. For those who are seriously committed to evolving best practices in traditional knowledge research, it is essential reading.



Lindsay Staples
Chair
Wildlife Management Advisory Council (North Slope)

Terms and Abbreviations

base data	Geospatial datasets that contain topographic information (e.g., water bodies, water lines, contours) and built environment information generally used to orient map readers (e.g., roads, utility lines, communities)
CPM	Conventional paper mapping—an approach to recording spatial TK knowledge using paper maps
DCM	Data collection manual
DTD	Direct-to-digital—an approach for recording spatial TK knowledge in digital format without use of paper maps
georeference	Associate a paper map or image of a map with spatial locations
GIS	Geographic Information System—a computer system that stores, manages, manipulates, analyzes, and displays spatial information
GPS	Global Positioning System—GPS devices determine their locations with reference to satellites
HTC	Hunters and Trappers Committee
IGC	Inuvialuit Game Council
information product	Summary research output produced from raw spatial data (e.g., whole community map, thematic map, spatial analysis, tabular or statistical report, etc.)
ISR	Inuvialuit Settlement Region
JS	Joint Secretariat
OPTs	Observations, propositions, and theories: the bundle of elements that contribute to and constitute TK
PI	Principal Investigator
rubbersheeting	A process of stretching and shrinking a map image between known locations to fit it to geographic space
TEK	Traditional Ecological Knowledge
THROT	Two-Hour Rule Of Thumb—guideline stipulating that a map biography interview should not exceed two hours of recorded interviewing time
TK	Traditional Knowledge
TKH	Traditional Knowledge Holder
WMAC(NS)	Wildlife Management Advisory Council (North Slope)
WMAC (NWT)	Wildlife Management Advisory Council (Northwest Territories)

Introduction

The preferred term among the Inuvialuit for land-based,[1] embodied, practical knowledge about the land, animals, plants and other living things is traditional knowledge (abbreviated "TK").

> [Traditional Knowledge] is a cumulative body of knowledge, know-how, practices and presentations maintained and developed by the peoples over a long period of time. This encompasses spiritual relationships, historical and present relationships with the natural environment, and the use of natural resources. It is generally expressed in oral form, and passed on from generation to generation by storytelling and practical teaching. (Smith 2006, i)

In other regions, TK goes by other names as well, including Inuit Qaujimajatuqangit (IQ), Traditional Ecological Knowledge (TEK), Local Ecological Knowledge (LEK), Customary Ecological Knowledge (CEK), and Aboriginal Traditional Knowledge (ATK). All of these are labels of convenience for practical craft knowledge acquired through direct experience and by watching, listening to, travelling, and harvesting with more experienced people on the land, ice, and water (Joint Secretariat 2014).[2]

The objective of this document is to provide background information and practical guidance for principal investigators (research directors) and other researchers planning to conduct Traditional Knowledge research on the Yukon North Slope (YNS). In reviewing past research in the ISR and other parts of Canada, the authors have observed that: (1) current research standards across northern Canada vary greatly from one project to the next; (2) a significant amount of the TK research does not meet minimal data quality standards; and, (3) TK research and studies are falling under increasing critical scrutiny, especially where documented TK is at odds with science-based knowledge.[3]

Well-documented and defensible TK research is important when preparing data/evidence in support of environmental assessment, land and water management, wildlife management, conservation planning, aboriginal self-government decision making, land claims negotiations, and other applied purposes.

These guidelines are an attempt to push standards in the direction of best practices. Researchers should strive for the best possible design and conduct within the constraints imposed by budgets, time, and logistics. In research, there is always a direct relationship between cost and time, on the one hand, and accuracy, precision,

1 As with the term "land use," "land-based" is shorthand for travel, harvesting, dwelling/living upon and other activities conducted on land, water, snow and ice.

2 Additional definitions and descriptions of TK are provided in Appendix A.

3 See Usher (2000, 188–189); see also Gilchrist and Mallory (2007), Gilchrist et al. (2005), Houde (2007), and Peters (2003). In recognizing the rich diversity of TK studies, Huntington (2005) argues that they should be judged on their own merits depending on their distinct objectives, approach and conception, and that it is misleading to evaluate a particular study in relation to others for which the objectives and associated methods, style of interpretation and presentation are different. While we agree with the caution not to compare apples and oranges with respect to objectives and associated methods, this cannot mean that quality research standards should not apply. Whether the TK research focuses on "culture and cultural views as embodied in traditional knowledge…. information about the surrounding environment, with or without reference to the role of humans in using and shaping that environment…. [or] the structure of knowledge and how it is accumulated, transmitted, and used by individuals and within a group" (Huntington 2005, 31), no research should be exempt from critical evaluation, and some notion of what constitutes quality research should apply in all cases.

and data richness (completeness, depth, and thoroughness) on the other; this is why the degree of accuracy, precision, and data richness must be carefully assessed in relation to research objectives.[4]

Murray et al. (2008, 102) summarize well a critical shortcoming with the current literature in the field:

> While many authors have suggested that LEK [Local Ecological Knowledge] can provide a powerful addition to science and management, few have explicitly described how this data might be collected in a rigorous, efficient manner that is sensitive to the epistemological characteristics of this knowledge system – hence the 'black box' metaphor.[5]

A number of documents review or summarize TK literature, and a scattered few offer guiding principles for the conduct of TK research (e.g., Burgess 1999; Fedirechuk, Labour, and Niholls 2008b; Government of Canada 2012; GNWT n.d.).[6] Rarely do TK research publications offer good methodological guidance for those wishing to design and conduct TK research (see Davis and Ruddle 2010; Davis and Wagner 2003; Huntington 1998; Tobias 2009; Tobias 2000). Moreover, rarely do such publications contain descriptions of methods that allow readers to understand clearly how the research was undertaken, and to evaluate the quality of its conduct, data, and analyses.[7]

The guidelines put forward in this document are based upon an incomplete survey of the considerable literature concerning TK that has been documented for Aboriginal, hunter-gatherer, pastoral, fisher, horticultural, and other peoples around the world. They do not cover all approaches found in TK research contexts such as environmental assessment, resource management, cultural heritage protection, and academic research. As a result, this document is not intended as a detailed and comprehensive methods prescription, but rather to provide advice on critical matters that, in the authors' experience, are too regularly neglected to the detriment of research product. The authors recognize that flexibility is required in research design to account for subject

4 Jennifer Carpenter (personal communication, 8 August 2014) notes that "adjusting research design to budget and time constraints has led to compromised and watered down methodologies that lead to results of questionable use and interpretation. This happens when an overly ambitious research design is attempted with limited time and resources, as can happen when government and outside agencies set the rules and expectations. Research design should be adjusted to the intended application of the research results and not try to do more with less. Be realistic. Focus."

5 The lack of transparency in TK methods reporting is part of a larger problem typical of qualitative research in general. Miles (1984, 16) notes, for example, that "analysis methods are rarely reported in detail in published case studies or in cross-site synthesis reports. One cannot ordinarily follow how a researcher got from 3600 pages of field notes to the final conclusions, sprinkled with vivid quotes though they may be."

6 Hart's (1995) oral traditions research manual is useful. TK can be documented using oral traditions research methods, and useful TK with great historical depth can be gleaned from oral traditions sources. For example, Hart and Amos (2004) extracted historical (living memory) TK and other information from previously documented Inuvialuit knowledge related to marine resources and their use at the request of the Working Group of the Beaufort Sea Integrated Management Planning Initiative.

7 This point is made by Davis and Wagner (2003, 468), who surveyed 65 articles on the subject and found that only 22 had a case study or methodological focus, and concluded: "Social researchers are focusing far less on 'method' than on the many epistemological, ethical, and property rights issues associated with the study of local knowledge systems."

matter, location, research objectives, Traditional Knowledge Holder (TKH)[8] sample, budgets, time and other factors, and that research methodologies can evolve. At the same time, some matters, that if neglected, severely affect the value of research products, primarily require extra awareness and attention from the research team rather than a great deal of time or money.

From both ethical and professional perspectives, research methods and results must be credible and trustworthy.[9] Whether the TK research will be subject to rigorous public inspection or not, researchers and the entities that sponsor them have an ethical responsibility to do everything in their power to bequeath quality TK to future generations, and where relevant, ensure that the research is of pragmatic benefit to TKHs and their communities. TK documentation may be the only record available to future generations because TK is being lost as a result of a breakdown in the intergenerational transmission of such knowledge (see Collignon 2006, 193–201) and/or external influences that displace Aboriginal peoples from traditional territories, or extirpate important local species that they depended on for subsistence (e.g., sturgeon, woodland caribou). Furthermore, TK research and resultant data have important uses in a variety of wildlife management and aboriginal self-government decision making, and in environmental assessment, effects mitigation, and monitoring.

Five essential ingredients for the conduct of quality TK research are discussed in these guidelines:

1. **Solid Foundations**, including putting together a good inter-disciplinary research team, matching research to objectives, using systematic research designs, and selecting appropriate samples;
2. **Basics**, such as choosing appropriate methods, understanding the nature of TK, and paying careful attention to language and Aboriginal (local) worldview;
3. **Study Execution**, including practical matters such as interview timing, space, equipment, matters to attend to during interviewing, and managing interview products in the field;
4. **Spatial Knowledge Documentation**, such as creating base maps, choosing appropriate software, creating and verifying data; and,
5. **Post-Study Data Management**, including practical considerations for long-term research product and data management.

Ethics protocols are not reviewed in this document, apart from a brief discussion related to community engagement and protecting a community's culture of research. Regarding research planned for the YNS, guidance with respect to ethics should be obtained through The Aurora Research Institute, the Tri-Council Policy

8 *Informant* and *respondent* are standard social science terms for research subjects who are interviewed or encountered during ethnographic inquiry. Respondent is used for the subject interviewed using a survey methodology for which there is a scientific sample. Informant is used in all other cases. Synonyms for these terms in popular usage include *participant*, *interviewee*, and *Traditional Knowledge Holder* (TKH). TKH is used throughout these guidelines.

9 Criteria used to evaluate the trustworthiness and credibility of TK research products in general and a TKH's observations, propositions and theories (OPTs) in particular could well differ between those of the community (including the TKH's peers) and those of external governments, wildlife biologists, industry, and other entities engaged in resource development, land, water, and wildlife management, environmental assessment, or litigation. TK research must be designed with such end-users and potential critics in mind.

Statement (Canadian Institutes of Health Research et al. 2014), the Wildlife Management Advisory Council (North Slope) [WMAC(NS)], and Wildlife Management Advisory Council (NWT) [WMAC(NWT)].[10]

In addition to referencing the various literature cited throughout this document, the References section includes TK literature relevant to the ISR that is worthy of attention because of the quality of the methods, descriptions thereof, data, and analysis. Readers are invited to consult these references for guidance and good examples concerning how to conduct quality TK research in the YNS.

10 Aurora Research Institute http://www.nwtresearch.com/licensing-research; Tri-Council Policy Statement http://www.pre.ethics.gc.ca/pdf/eng/tcps2-2014/TCPS_2_FINAL_Web.pdf; Wildlife Management Advisory Council (NS) http://www.wmacns.ca.

Conduct of Traditional Knowledge Research—A Reference Guide

1 Solid Foundations

1.1 Research scope, constraints, goal, and objectives

Research is governed by a statement of the overall area of inquiry, or scope (what will be studied) and constraints or limitations (elements in the area of inquiry that cannot or will not be covered). Once scope has been established, research is usually guided by a single aim or goal, and a series of objectives that more specifically define how the goal is to be achieved.[11]

Research that attempts to do too much, with too little time, human and financial resources is called "shotgun research." Shotgun approaches result in poor quality data that do not satisfy the research objective or fail subsequent scrutiny.[12] Well-designed research has an appropriate research scope with methods tailored to a clear goal and objectives, in particular practical uses of the information, such as environmental monitoring, impact assessment, and other wildlife and resource management purposes.[13] Furthermore, well-designed research is fundamentally respectful of research participants (TKHs); it respects their basic limitations as human beings and capacity for prolonged intellectual labour and hence does not subject them to unnecessary response burden. Using Tobias' (2009, 127; 2000, 29–20) "two-hour rule of thumb" (THROT) is a good way to ensure the research experience for participants is respectful.[14]

To avoid shotgun research designs, researchers should pay attention to two core research qualities:

- **Clear definition of the knowledge domain**: Focus must be on a particular domain (such as the TKH's life-time knowledge regarding grizzlies, ringed seals, polar bears, wolverines, or permafrost) even though the informants know much more than any single domain. Knowledge of other domains such as ice morphology might be important to document if closely linked to the priority domain, but researchers and their sponsors must decide what the priorities are.

11 Confusingly, the meaning of terms used in texts can vary. In some, the meanings of "goal" and "objective" are reversed, with the "objective" being the primary research aim, and "goals" being more specific elements of inquiry.

12 In Huntington's (2005, 32) view, "we must plan our studies carefully, based both on what we have collectively learned about the many characteristics of traditional knowledge and the study thereof and on the specific aspects of traditional knowledge that we are focusing on. We cannot address all aspects of the study of traditional knowledge at once, and must acknowledge our limitations and also recognize that other researchers pursue different goals, and thus may not conduct their studies as we would conduct ours."

13 There are special circumstances where documenting TK in an ad hoc manner is warranted, for example, where an elder's lifespan is coming to an end, and there is no time to fund and/or complete the design of a research project. Furthermore, data collected using oral history, linguistic, use-and-occupancy, and other types of research may have valuable TK components that can be retrieved and integrated into dedicated TK research projects.

14 "The very important 'two-hour rule of thumb' (THROT) stipulates that the average map biography should involve no more than two hours of recorded interviewing time. (Because the two-hour rule of thumb excludes set-up time, coffee and bathroom breaks, interview shutdown, etc., the average time required of a respondent for a map biography, including when the recorder is turned off, is usually closer to three hours.)" (Tobias 2009, 127–128)

- **Appropriate definition of research goal and objectives:** Define the research goal and objectives with linkages to their practical uses. Consider what research results will be used for—wildlife management, environmental assessment, project effects mitigation and monitoring, harvest quotas. Methods must be carefully designed with precise objectives in mind. Objectives should be more than imprecise propositions like "facilitating integration of TK and biological science." For instance, if the research goal was to support regional conservation planning, objectives could include collecting information about habitat and migration patterns for top predators and species at risk. If it was to support land use decision-making, it could be valuable to collect information on important use areas and travel routes that might be adversely affected by development. If it was to complement scientific knowledge on impacts of climate change, it could query knowledge of changing sea ice conditions and seasonal weather patterns.

Don't ask too much! Set clear research objectives.

Restrict research topics so the work can be achieved in the time and with the resources available.

During the early stages of research scoping and design, researchers and their sponsors should consider long-term and comparative uses of the TK data and research results (for example, whether they will be used for long-term environmental monitoring purposes or comparison with TK in other geographical areas). If long-term use is contemplated, consistent approaches, methods, data collection and storage should be adopted so that the TK data are compatible with those collected over time or possibly in other geographical areas.

1.2 The research team

TK research is social science research because it involves human knowledge and practices, observing and documenting human social relations, cognitions, and behaviours. The branches of social science research best suited for TK research include anthropology, sociology, cultural geography, and linguistics. Even so, social scientists by themselves cannot be expected to know enough about the complex ecosystems, life histories, population dynamics, and other qualities

Good TK research requires expertise from a variety of fields, not just social science. A Principal Investigator (PI) should seek input from interdisciplinary experts on a variety of topics.

of the natural entities that are the subjects of research. For that reason, interdisciplinary teams are ideal when conducting TK research. [15]

The benefits of interdisciplinary collaboration are well illustrated in a story recounted by Jared Diamond, about ethnobiologist Ralph Bulmer. Bulmer worked with Kalam people of Papua New Guinea.

> One year, after Kalam people had already told Bulmer names and descriptions for over 1,400 species of animals and plants known to them, Bulmer began to quiz them about rocks as well. To his great surprise, they claimed to have just one word covering all rocks. In vain did Bulmer protest that the Kalam had until recently used stone tools, and so surely they must have names for different types of rocks to identify which ones were good for making tools. Bulmer's Kalam friends brushed aside his protests and continued to insist that they didn't classify rocks by name. The next year, Bulmer returned to the Kalam area with a geologist friend whom he introduced to his Kalam informants. Within an hour, the geologist gave Bulmer a long list of words that the informants had volunteered for different rocks.… At the point Bulmer exploded to his Kalam friends, "How could you lie to me? After all these years that I've been working with you! You kept insisting that you didn't bother to classify rocks, and now you've embarrassed me in front of my friend!" To which the Kalam replied, "When you asked us about birds and plants, we saw that you knew a lot about them, and that you could understand what we told you. When you began asking us about rocks, it was obvious you didn't know anything about them. Why should we waste our time telling you something you couldn't possibly understand? But your friend's questions showed that he does know about rocks." (Diamond 1991, 85)

Diamond also advocates interdisciplinary teams. He notes, for example:

> Informants in New Guinea and some other parts of the world know far more about local birds than do most anthropologists interviewing them. To approach the informants' knowledge takes years even for ornithologists specialising in New Guinea birds. The second-best solution to this dilemma is for ethnologists to collaborate with biologists who already have that competence. (ibid., 86)

The consequences of interviewers having inadequate biophysical knowledge can be serious, as noted by McGoodwin, Neis, and Felt (2000, 254). They report:

> Existing research suggests that the quality of data provided by informants, particularly those considered to be local experts, partly reflects their sense of the knowledgeability of the interviewers. If the interviewer is believed to be lacking knowledge regarding fisheries or fisheries

15 Inuktitut linguist Alana Johns takes this position, informed by her collaboration with Inuit experts, anthropologists, and geographers on a research project related to Inuit sea ice knowledge and terminology. In her view, "an increase in collaboration across disciplines…would be welcomed…. [I]n language documentation, specialists from different areas should be involved in close cooperation" (Johns 2010, 409). Anthropologist Daniel Clément (1990, 14), reports that he took two university botany courses in preparation for his ethnobotanical research among Mingan Innu in the early 1980s.

A good example of an interdisciplinary approach to TK is a sea ice knowledge project, the Wales Inupiaq Sea Ice Dictionary (2012), authored by local Inupiaq researcher Winton Weyapuk Jr. (who holds degrees in land use planning and Inupiaq language) and outside researchers Matthew Druckenmiller (geophysicist), Igor Krupnik (anthropologist), Hajo Eicken (geophysicist), Lawrence Kaplan (linguist), and others.

ecology, respondents will tend to be less willing to participate and will tend to provide poorer information. Uninformed interviewers will be less likely to distinguish effectively information that is new and information that is partial, making them less likely to follow up important leads.

In an ideal world,[16] a TK research project would have contributions of expertise from a well-resourced, interdisciplinary team, including:

- indigenous/local experts;
- anthropologist, sociologist, cultural geographer;
- linguist, local language expert;[17]
- natural/bio/physical/medical scientist (e.g., biologist, ecologist, physical geographer, geomorphologist, climatologist, nutritionist, pharmacologist, veterinarian, etc.);
- spatial information expert (who is more than a GIS technician); and,
- peer reviewers for draft methods and reports.

If the TK research involves local classifications, taxonomies, species lists, anatomical descriptors, place-names, etc., and the starting point is the local view of the world, not one imposed from the outside, a language expert is indispensible to the team. Linguists help with these details and the nuances of language and translation in general.[18]

When the research products include spatial information (see section 2.2), it is important to involve a spatial information expert before the research instrument is designed. Some of the reasons for this are detailed in chapter 4.

The PI and sponsors should be careful to select peer reviewers who have expertise in the relevant TK research domain. There have been many examples of peer review where the reviewers lacked experience with TK

16 Of course, we do not live in an ideal world. However, even if a researcher responsible for all aspects of a project is aware of the various lenses through which the research can be viewed, he or she should seek advice and input when making decisions outside his or her core knowledge areas.

17 Ideally a local Aboriginal language expert should have a rich vocabulary of "elder" terms related to animals, plants, weather, land, water and ice forms, and traditional methods of harvesting, travelling, erecting dwellings, preparing food and animal skins, craft making, etc. She or he should also have a good command of English (in the ISR) and understand the complexities of translations between the Inuvialuktun dialects and English. Note Johns' (2010, 409) caution that "as in all languages, speakers of a language are not naturally able to provide principled analyses of morphemes without training, special skills, or experience. Many Inuktitut speakers do not perceive the individual pieces within the word, even as they use them with great expertise." See Riseth et al. (2011, 214) re. the benefits of bi-cultural and linguistic competence on a TK research team.

18 Riseth et al. (2011, 203) note that "linguistic methods can be used to secure more detailed information on the ecological adaptation and overall management of reindeer herding, especially when the approach is emic, that is taking place from within a culture. Languages, such as Sámi, contain systems of culture-based classifications…and provide information on ecological and climate-related conditioning of the adaptation strategies in reindeer herding."

among Aboriginal peoples and social science research, and in various other ways were not properly qualified to act as peer reviewers.

While interdisciplinary collaboration on TK research is highly advised, such collaboration can be problematic. Differences in the intellectual cultures of individual disciplines can cause serious misunderstandings among researchers, especially when bridging the divide between the social and the physical or natural sciences. Archaeologist John Terrell touches on this problem in his discussion of defects in the science journal *Nature*'s peer review process.

> If the hypothesis is correct that different scientific communities favour different root metaphors and key scenarios, then knowing what these metaphors and scenarios are is crucial if experts in different fields want to work together.... Knowledge of how experts with different backgrounds, training, and ideas look on the world around us and are prepared to understand the events of yesterday, today, and tomorrow is not trivial knowledge. (Terrell 2000, 814)

1.2.1 Role of the PI

The PI (principal investigator, i.e., research director) has a special role to play in the design and execution of a TK research project, particularly if the PI is also responsible for data processing and report writing. The PI needs to have a good understanding of the history and culture of the people whose TK is being studied. This usually requires a substantial amount of background reading.

The PI should understand the history and culture of the people whose TK is being studied.

To achieve a richer understanding of the context of the research, the PI should embed him- or herself in the community, an experience usually described as "ethnographic." When the interview schedule is tight, PIs usually don't have time for ethnography (participant observation), so it is difficult for them to participate in community life in a way that nourishes their understandings of the research context. The inclusion of "ethnographic time" is merited for the PI and researchers with limited experience of the community where the TK research is being conducted. Ethnographic time promotes a greater sensitivity to local perspectives, worldview, and way of classifying, interpreting, and constructing reality. It is a good way to document two important TK components identified by Usher (2000): values about the environment (e.g., ethical respect for animals) and the foundation of the knowledge system (e.g., cosmology).[19] The PI spends time with people, gets to known them, how they think, how they talk and act, and is able to compare what people say with what they do. Ethnographic time also contributes to a more nuanced understanding of community politics, and interpersonal dynamics, that may affect the conduct of the research.

Ethnographic time promotes a greater sensitivity to local perspectives, worldview, way of classifying, interpreting, and constructing reality.

19 Documenting values about the environment and foundational aspects of the knowledge system also can be undertaken using oral traditions research methods (see Hart 1995). The deep cultural understandings that are facilitated by ethnographic and oral traditions research are important when it comes to framing, contextualizing or re-contextualizing TK information in reports, environmental assessment hearings, and other media or venues.

Collignon (2006, 272) discusses the advantages of an ethnographic approach to her Inuinnait research:[20]

> In my research, I found participant observation useful for collecting information in context for all the areas I was interested in, and particularly for grasping how Inuinnait perceive space and how they relate to the land. This was especially important because of how the Inuinnait personalize their knowledge. It comes across in casual conversation, in reminiscences about life on the land, stories of personal experiences. There are often intimate feelings involved, not just thoughts. It would have been impossible to uncover these aspects of geographic knowledge by staging meetings in a formal interview situation, with me sitting behind a desk with a tape-recorder, an interpreter by my side, and the interviewee opposite us.

1.2.2 Training and supervising community co-researchers

Community co-researchers must be well trained and supervised.

For community co-researchers, it is important to remember there is more to doing interviews than meets the eye. Most community co-researchers who lack formal social science training or interview experience are able to administer structured interview questionnaires. However, they often have trouble with semi-structured or semi-directive methods. These require considerable flexibility and innovation, and perhaps even the disposition to push the boundaries of polite behaviour in cultures where people, especially elders, should not be interrogated. Thus, local co-researchers usually require training in social science methods, and in particular those related to interviewing and data management. The quality and utility of any study depends on the training and experience of the research team, and it is a false economy to cut corners with respect to it. What sponsors save in training expenses they lose down the road in data quality compromised by undertrained researchers. If interviews are to be conducted exclusively by local co-researchers, the co-researchers must be well-trained and supervised, with frequent reviews of their interview data to check for errors.

1.3 Systematic research designs and practices

Use systematic, formal social science research designs.

Systematic research designs and best practice are important for doing good social science research (see Babbie 1992). Researchers must be properly trained in and use standard social science research methods.

A good research design will include:

- a definition of the population from which informants or respondents are taken;
- a description of how the sample of informants or respondents (TKHs) was chosen;
- a manageable toolkit;

20 The Inuinnait are an Inuit group based in the Victoria Island portion of the central-western Arctic. They include the people of Ulukhaktok, one of six Inuvialuit communities in the ISR.

- a manageable number of questions in questionnaires;
- questions that are intelligible to informants;
- no leading questions;[21]
- provision for quality Inuvialuktun-English interpretation during interviews when required;
- procedures that limit response burden, which is the perception by TKHs that the interview (and research) is tedious, tiring, boring, a waste of time, unimportant, or otherwise onerous;[22]
- pre-testing and validation of the survey questionnaire; and,
- quality base maps for map biographies (see section 4.2).

1.4 Access to good background materials

Conducting quality TK research is made a lot easier if pre-existing background materials are available, including:

- dictionaries, grammars, orthographies of Aboriginal languages;
- technical vocabulary lists;
- information related to anatomical, habitat, and geographical concepts and vocabulary, and worldview/ontological orientation;
- taxonomies (classifications of organisms); and,
- toponymy (place-names).

When possible, access background materials such as dictionaries, literature, vocabulary lists, taxonomies and the like while designing research.

People embarking on new TK research projects need to familiarize themselves with these materials at the planning stage. Furthermore, depending on the TK research in question, the logical starting point for research is collating existing literature and data, an assessment of its quality, and determining whether it can be integrated with the planned research.

21 "Leading questions have been shown to produce less reliable responses in some research on Aboriginal users' ecological knowledge….A full analysis of data collected in interviews should include an examination of both questions and answers, and consideration should be given to the exclusion from the analysis of answers to leading questions" (McGoodwin et al. 2000, 257). See also Ferguson and Messier (1997, 24).

22 See Usher and Wenzel's (1987, 154) discussion of the causes of response bias including "poor questionnaire design (for example, leading questions, unclearly or ambiguously worded and thus misleading questions, excessive burden on the respondent due to length or complexity of questionnaire)."

Existing datasets may be managed by different agencies. Accessing them may require separate data-access and confidentiality agreements with each agency. With respect to TK research in the ISR, primary agencies holding relevant data include the Joint Secretariat, WMAC(NS) and WMAC(NWT), the Inuvialuit Cultural Resource Centre, individual Hunters and Trappers Committees, Environment Canada, Parks Canada, Government of the Northwest Territories, and Yukon Government.[23] As well, individual university researchers and private consultants who have worked in the ISR may have relevant datasets.

Researchers are part of a research community including people with expertise, experience, and resources that can be called upon in designing and conducting new TK research. For example, researchers requiring technical advice related to language should contact linguists and local language experts rather than grapple with thorny linguistic matters entirely by themselves. Part of the work in designing new research, and in assessing existing datasets, includes identifying the "who's who" in the research community and reaching out for collegial assistance when required.

Research design also requires a thorough review of the existing literature (published and grey) in the field of study and not just that directly related to the research locale. As noted by Anthony Davis (personal communication, 23 September 2014), "it is important not to waste time and resources 'reinventing wheels', especially around research designs and methodologies. Learn from and build on the work of others, including correcting their shortcomings, limitations, and errors. Also, the prospect of situating outcomes comparatively only strengthens research results and analyses."

1.5 Commitment to data quality standards

While recognizing that budget, time and logistical constraints have a bearing on research methods and their implementation, researchers should commit to high data quality standards. This commitment must include documenting any failure to achieve those standards, so that the research limitations are clear to future data users.

> Commit to high data quality standards. Document known shortcomings or data limitations in research products.

Tobias' (2009) discussion of data quality standards is a good reference. He lists seven criteria that should be used to evaluate data quality and the methods used to generate them:

- objectivity (data documentation and analysis are independent of the personal feelings and opinions of researchers);[24]

23 The Inuvialuit Cultural Resource Centre (ICRC) has sponsored or supported various TK research projects of relevance to "resource" co-management and land use planning (e.g., Bandringa and Inuvialuit Elders 2010; Hart 2011). Cooperation between the ICRC and wildlife and fisheries co-management bodies in future TK research initiatives in the ISR is advised.

24 True "objectivity" is not possible. Babbie (1992, G4) prefers the term "intersubjectivity" meaning that "quality of science…whereby two different researchers, studying the same problem, arrive at the same conclusion. Ultimately, this is the practical criterion for what is called objectivity."

- reliability (data-collection methods are applied consistently from one interview to the next so that other researchers would obtain similar results if the methodology were repeated);
- validity (whether data and findings reflect the truths claimed) (see Whittemore, Chase, and Mandle 2001);
- accuracy/precision[25] regarding spatial, temporal, descriptive data;
- integrity (traceability of data back to sources);[26]
- auditability (research is transparent and accountable);[27] and,
- representativeness (extent to which research findings represent the knowledge of the study population not just the knowledge of the people sampled).

Davis and Ruddle advocate the same rigorous research orientation, although some argue that such rigour is only required where data and results will be reviewed or used in adversarial contexts such as environmental assessment hearings or litigation.

> The results of any field research must be robust enough to withstand severe criticism from the general public, as well as from such specialized sectors as financial backers, vested interests, disappointed people left out of a potential project by the results of the research, one's research peers, and 'others', including 'elders' and 'traditional elites'. (Davis and Ruddle 2010, 890)

A rigorous research orientation is the best way to produce a research product that is credible, trustworthy and of maximum value in co-management contexts as well as to future generations of Inuvialuit.

25 Accuracy refers to the "measure of the closeness of fit between the locations of features as marked on a map and the real positions of the sites on the ground" (Tobias 2009, 143). "A measure of positional precision indicates the degree of fineness with which features are marked on maps during data collection. A measure of descriptive precision indicates the level of detail with which mapped features are described on audio recordings. Both positional precision and descriptive precision are indicators of the level of technical refinement of measurement" (ibid., 442).

26 Enables one to track data back to original sources who can be consulted for additional information, land use management decisions, etc.

27 This refers to the need for full methods descriptions to allow others to assess credibility. As noted by Jennifer Carpenter (personal communication, 8 August 2014), a "methodology report should start by articulating the assumptions and rationale behind the methodology chosen relative to the purpose, focus, and intended application of research results, and include a critique of findings, including what worked and what did not work in implementing same." See also Candler et al. (2006): "Successful PGIS [Participatory GIS] must deliver high quality products through following a consistent and documented set of methods. It must be based on good quality research that leaves a clear paper trail."

1.6 Community engagement and culture of research

The foundation of any TK research involving the Inuvialuit and their territory is good community understanding of, support for, and involvement in the research, which is normally referred to as "community engagement."[28] There are numerous elements that contribute to this:

Take active steps to support community members' willingness to participate in research. The rock-solid foundation of any TK research involving the Inuvialuit and their territory is good community understanding of, support for, and involvement in the research.

- Research must be designed with the communities and/or their representatives from the ground up. Preferably, research should be formulated in consideration of expressed community needs rather than presented to the community as well-packaged proposals that have already cleared institutional ethics and funding reviews, with little if any community involvement to that point in time.[29]
- Depending on the nature of the research, entities in the ISR requiring direct involvement throughout the life of a TK research project may include community Hunters and Trappers Committees (HTCs), the Inuvialuit Game Council (IGC), the Fisheries Joint Management Committee, and the Joint Secretariat, WMAC(NS), and WMAC(NWT). Establishing contact and building relationships with local people (e.g., chairs of HTCs, HTC staff person) is essential at the outset.[30]
- Research proposals involving research in the NWT portion of the ISR must be submitted to the Aurora Research Institute for ethics clearance and a research licence. (See http://www.nwtresearch.com/licensing-research.)
- Researchers have a duty to ensure that all data and other research products are returned to the appropriate bodies, which may be data warehousing entities such as the Joint Secretariat (more on this below). Researchers may be expected to sign agreements related to returning research products to communities, the Joint Secretariat, or other entities.[31]

28 The Inuit Tapiriit Kanatami (ITK) and Nunavut Research Institute (NRI) document *Negotiating Research Relationships with Inuit Communities: A Guide for Researchers* (2007) is a useful reference when formulating possible research among the Inuvialuit. We note that some environmental review processes reference documents (e.g., Ehrlich et al. 2011; Schuh 2005) provide guidance for, or describe, the incorporation of TK into their processes. However, we have not undertaken a systematic evaluation of these documents.

29 Presumably, ethics and funding reviews require a demonstration of community engagement in setting research objectives and design, etc.

30 See http://www.accessnwt.ca/for-researchers

31 Tobias (2009, 131) talks of a "posterity principle": "Research designers have an ethical obligation to increase the chance that the products of their surveys will be available and useful long into the future."

- Researchers may also be required to sign Intellectual Property (IP) rights agreements with the Joint Secretariat or other entities that define the use, ownership, and future disposition of data collected from Inuvialuit community members.[32]

- A standard ethics protocol is that all individual research subjects provide their informed consent prior to the commencement of interviews. Therefore, toolkits must include brief, plain English and Aboriginal language descriptions of the research, its objectives, the future disposition of data, informant/respondent rights to confidentiality, and notice of support for the research by responsible community or regional organizations. The toolkit must also include a form to be signed by the informant/respondent, in which he/she agrees to participate in the research. The form should stipulate any restrictions related to disclosure of data and identity (confidentiality requirements).

- In proposing TK research or responding to research initiatives from the Inuvialuit and their co-management institutions, researchers must be mindful of the total research burden to which community members are subject from all sources, be they related to wildlife, climate change, health, education, employment, language protection, environmental assessment, etc. Clearly, there is a limit to how much research a community can tolerate, which means that researchers should organize their research with full knowledge of other research projects and the total research burden over time.

- All communities have a "culture of research." This refers to attitudes held by community members to past, present and future research (see Tobias 2009, 164). A healthy culture of research is one in which members understand the purpose of research and view it as: (1) having practical benefits for them; and (2) worthy of their time and energy.[33] Signs of an unhealthy culture of research include high levels of cynicism towards the research, distrust of researchers and their sponsors, and in some cases demands for relatively high payments for participating in research.[34] All researchers have a responsibility to protect the community's culture of research. Furthermore, "it is in the best interests of any First Nation or Aboriginal government to encourage a culture of research that is favourable to future initiatives. Effective governance requires that constituents be willing to provide good data and information when called upon" (Tobias 2009, 164).

32 For an example of a comprehensive IP and data-sharing agreement, see "Final Research Agreement for a Project on Iiyiyiu Anti-diabetic Plant Medicines" (2003).

33 Note the Tri-Council Policy Statement, second edition (TCPS2 2014) guidelines: "Where the form of community engagement and the nature of the research make it possible, research should be relevant to community needs and priorities. The research should benefit the participating community (e.g., training, local hiring, recognition of contributors, return of results), as well as extend the boundaries of knowledge.…To benefit the participating community, a research project should be relevant to community priorities and have the potential to produce valued outcomes from the perspective of the community and its members" (Canadian Institutes of Health Research et al. 2014, 128).

34 Requests for high levels of remuneration may suggest that community members participate in the research only because it is a source of income, not because they view it as having intrinsic value or benefit to them and their community as a whole. However, these requirements may also be regarded as fair exchange for the knowledge, experience and time provided by local experts who should be compensated appropriately. Also, research design and scheduling should consider TKH obligations and priorities such as wage employment or harvesting.

- Research product should be returned to individual informants/respondents, e.g., copies of audio or video recordings, transcripts, individual TK maps, and final reports.
- Researchers should submit draft copies of reports to relevant HTCs, the Joint Secretariat and/or other bodies as determined in their research permits, agreements or contracts, and by other obligations negotiated in the early stages of research design.
- Researchers must abide by any restrictions on publication (scientific or otherwise) negotiated during the initial community engagement phase. This may include embargoes on results or the non-publication of some or all results.
- Researchers should provide plain language summaries of the research that are accessible to community members. Other plain language products should be generated if possible in order to facilitate communication with research participants and other community members.
- Users of the research products should strive to communicate to community members that the products are being used and how they are being used.

In addition to the above recommendations, it is critically important that a thorough and credible confirmation/validation process be included in the community engagement strategy. The manner in which this was done in the ISR in the context of an Inuvialuit Polar Bear Traditional Knowledge (PBTK) study (Joint Secretariat 2015) has many good characteristics that are worthy of emulation. Here, transcripts, and copies of audio and/or video recordings of interviews with TKHs (interviewees) were sent back to the TKHs for their review.[35] Once the draft report and associated thematic TK maps (if any) had been completed, a series of workshops and public meetings was held in the six ISR communities in which the TK research was conducted.[36] The workshops were 1–2 daylong events (2–3 sessions) and were restricted to interviewed TKHs and co-researchers. Detailed summary information concerning the results of the research including summaries of the OPTs provided by the TKHs and thematic maps (e.g., polar bear maternity den locations) were reviewed with the workshop

35 The process of seeking verification through the return of transcripts to interviewees has some flaws because transcripts are usually in English, and in the case of Inuvialuktun speakers, are based on the English-language interpretation of what they said in their mother tongue during the interviews. In general, financial resources are not provided for bilingual co-researchers to review carefully the English language transcripts with interviewees who are either illiterate, semi-literate, or who cannot read English. A failure on the part of TKHs to provide feedback on their transcripts may mean that (1) they reviewed their transcripts and were satisfied with the textual record of the interview but chose not to respond, (2) they reviewed their transcripts and were unsatisfied with the textual record of the interview but chose not to respond, or (3) could not, or chose not to, read the transcript and did not respond.

36 With respect to verification of use and occupancy (UO) data derived from map biography interviews, including draft thematic maps, Tobias (2009, 318–321) states that large group meetings alone are not the best way to verify UO data and research results with community members. Public meetings in combination with feedback from smaller groups of people are preferred by many researchers. Tobias' preference is for small-group meetings of 3–4 respondents who are closely related by kinship and who therefore know and trust one another well enough to discuss their land use and its documentation openly (ibid., 320).

participants. A public meeting where briefer summaries were provided to the general public, and where community members were invited to review the draft thematic maps, complemented each workshop.[37]

These workshops and public meetings helped the PI reflect critically on the draft results and conclusions of the study and correct errors of fact, omission and interpretation. TKHs involved in the research and the HTCs that represent them were provided one final chance to "sign off" on the study report by reviewing the next-to-final draft. The Inuvialuit Game Council and Wildlife Management Advisory Councils (co-management bodies) also reviewed the draft reports and an Inuvialuit representative was a member of the steering committee for the study.

These confirmation/validation steps and other mechanisms for direct Aboriginal involvement in research planning and data review are respectful of TKHs and community members and satisfy ethical and community engagement commitments. They also demonstrate that the TK documented and research results are trustworthy and credible in the eyes of community members and their representatives, and are ready for disclosure to third parties or the general public. However, these processes have associated costs that contribute significantly to TK research budgets and must therefore be anticipated in the earliest stages of research planning.

The ISR has a long established culture of research. This is hardly surprising given the culture of well-established norms, protocols and regulations that apply to research over the last 60 years. It is also a culture that is evolving in response to changes in research itself, and new developments in ethics and Intellectual Property (IP) rights. Like all research cultures, it is infused with ethical considerations, many of which are addressed explicitly in the Tri-Council Policy Statement (TCPS2 2014) (Canadian Institutes of Health Research et al. 2014).[38] While the TCPS 2 is intended to guide the conduct of academic research across Canada, its principles and guidelines should be taken seriously whether the research is academic or not.

Much of the above has to do with respect for the research subjects as individuals, as well as their history, culture and knowledge. Respect is an intrinsic value and "an absolute prerequisite" for successful research, as noted by Tobias (2009, 126). "Respect is the bedrock of human decency…. A single incident of disrespect on the part of an interviewer, especially if an elder is involved, will quickly make the rounds in a small community, breaking trust between project personnel and respondents."

37 These processes may fail as valid confirmation/verification processes if low numbers of interviewees participate in the workshops and few community members participate in the public meetings. High participation rates in the workshops can be achieved through the remuneration of the interviewees (TKHs) and through good timing and promotion of workshops and public meetings in close collaboration with local HTCs.

38 The TCPS notes for example, that "researchers have an obligation to become informed about, and to respect, the relevant customs and codes of research practice that apply in the particular community or communities affected by their research" (Canadian Institutes of Health Research et al. 2014, 122). See Wenzel's (1999, 118–121) discussion of research ethics and IP among Nunavut Inuit.

2 Basics

2.1 Choosing appropriate research methods

Six types of research methods (protocols) are available to the TK researcher, four of which involve interviewing:

- structured interviews;
- semi-structured interviews, including the map biography survey method;
- semi-directive interviews;
- opinion surveys;[39]
- focus groups; and,
- ethnography, including participant observation.

Choose social science research methods most appropriate to meet the research objectives.

Content analysis, which is not a data-collection method, often is conducted while processing TKH narratives generated in the context of interviews or ethnography; this may involve the use of qualitative software such as Atlas-ti, HyperRESEARCH and NVivo.[40]

All of these methods have their strengths and weaknesses, and there is a vast social science literature dealing with all of them.[41] The authors of these guidelines assume that researchers embarking upon new TK research in the ISR have an acceptable level of social science training in these methods, and for that reason there is no need to explain them here. Nonetheless, a number of comments are in order.

2.1.1 Strengths and weaknesses of structured, semi-structured, and semi-directive interviews

Having conducted research on Inuinnait[42] landscapes, environment, and toponymy (place-names), Collignon (2006, 275) critiqued the use of formal interviews as the basis for arriving at a detailed, nuanced understanding of the geographic knowledge component of TK. "Questionnaires and formal interviews are poorly suited

39 For an example of an opinion survey approach to TK research, see Kotierk (2010).

40 Some types of content analysis are based on inferences resulting from the systematic quantitative analysis of themes, sources, lexical items and other semantic elements across a corpus of texts or narratives (see Bardin 1977; Miles 1984).

41 E.g., Babbie 1992; Berg 2001; Emerson, et al 1995; Faubion and Marcus 2009; LeCompte and Schensul 2010; Miles 1984; Salant and Dillman 1994; Schensul and LeCompte 2013). "Participatory action research" and "community participatory research" are "frameworks for the conduct of research", not research per se (Miraglia 1998, 20–25). While they are not discussed directly in these guidelines, important elements of them are covered in section 1.6 dealing with community engagement.

42 The Inuinnait are an Inuit group based in the Victoria Island portion of the central-western Arctic. They include the people of Ulukhaktok, one of six Inuvialuit communities in the ISR.

to any study of vernacular knowledge," she argued, because they are framed in an non-Inuit way and "lock participants into a way of thinking that is not theirs, but the researcher's." Moreover:

- Reducing land use-and-occupancy to a small number of questions generates superficial information not a good "understanding of how people truly perceive space and landscapes." (ibid., 274)
- "During formal interviews, the answers that are usually given are typically short and vague. It is very rare to obtain, out of context, precise answers to specific questions, no matter what the subject." (ibid., 275)
- "Inuit tire very quickly during this form of exchange, because for them it is not an exchange; it is a one-way set of questions that give them no chance to express the connections that come to their mind." (ibid., 275)
- The Inuit she worked with did not like questionnaires. "It is up to the researcher to communicate in a way that respects the standards of the Inuit, not the other way round." (ibid., 275)

While her critique is focused primarily on methodologies that involve interviewing older Inuit with limited if any command of English, she did use semi-informal interview methods for a toponymic survey. The strengths of the ethnographic, participant observation approach she advocates are discussed at greater length below. However, they are not always practical given the budgetary and time constraints faced by many research sponsors. Furthermore, people trained in ethnographic methods may not be available to participate in co-management, environmental impact assessment, and other forms of applied research. Efficient, "sociological" methods involving some type of formal interviewing—structured or semi-structured—may be necessary despite their limitations in terms of the depth of cultural understanding they can achieve.[43] Formal interview methods are best deployed where researchers already have a good grounding in the culture of the TKHs and know well how to craft meaningful questions.

In the case of semi-structured interviews,[44] researchers must remember that the addition of supplementary questions can result in overly long interviews, response burden, failure to address all the questions in the questionnaire, and superficial treatment of many of the topics covered in the questionnaire.

In semi-directed interviews,

> the participant or participants are guided in the discussions by the interviewer, but the direction and scope of the interview are allowed to follow the associations identified by the participant. There is no fixed questionnaire, nor is there a pre-set limit on the time for discussions,

43 The ethnographic method is the hallmark of traditional anthropology. In discussing anthropology's role in the contemporary research context in an interview with Marie-France Bazzo, Bernard Arcand explained that "anthropology is slow. We work slowly. This slowness is very poorly adapted to the rhythm of our society which wants immediate answers….Where I have a quarrel is with certain efforts to transform anthropology into a rapid discipline, efficient, that will provide quick results" ("Bernard Arcand" 2001, our translation).

44 In semi-structured interviews, the "interviewer is prepared with a list of questions and topics to be discussed. However, the order of the questions and topics is undefined. It depends on the flow of the discussion" (Hardon, Hodgkin, and Fresle 2004, 24).

> although a list of topics may be a useful reference, helping the interviewer cover important areas while allowing the participants to add or skip topics depending on their interest and expertise. (Huntington 1998, 238)

One limitation of this interview method is that it cannot be used where quantitative or comparative TK data are required, for example, where a scientific sample of respondents is required, to whom the same questions must be asked in the same manner, or where "formal eliciting procedures" are used, such as in studies of taxonomy and other TK components where careful control over questions is important (see Black 1967; Black and Metzger 1969).

Field trips of variable duration involving the participation of TKHs are often used in TK research approaches that require rich contextual or ecological information. The semi-directive interviewing method may be employed in such cases. Examples of research where field trips are invaluable include the documentation of climate change effects on local land forms or, in the case of ethnobotanical and ethnozoological research, the in-situ identification of plant, bird and other species using voucher specimens, visual, auditory, and other means (see Andre and Fehr 2010; Clément 1990; Davidson-Hunt et al. 2005; Diamond 1991).

2.1.2 Concerns about quantitative analysis of TK data

Consideration must be given at the outset to the question of whether TK research is suited to any kind of quantitative data collection and analysis. For example, some researchers may wish to use a structured questionnaire with a scientifically designed sample in order to document quantitative TK data related to changes in an animal's abundance and distribution. Even if the challenges of securing a scientific sample can be met, what is likely to pass as quantitative data often amounts to a tabulation of how many TKHs supported particular observations, propositions and theories (OPTs),[45] and the geographic distribution of their OPTs from one community to the next. The quantification of the degree of consistency in responses to particular questions may be useful, especially if it encourages a search for reasons for inconsistency.[46] However, majority support for a particular OPT does not demonstrate its validity; an "outlier" OPT may be more valid depending on the context and the criteria of validity used.[47] We return to this issue of consistency in responses when discussing sampling (in section 2.5) because it relates to representativeness and the relationship between individual OPTs and shared community TK or local knowledge "systems."

45 "Observations, propositions and theories" (OPTs) refers to the bundle of elements that contribute to and constitute TK, as opposed to "ideas," "notions," etc.

46 In Kim Heinemeyer's view, "if one assumes that the study is well-designed and OPTs from different time periods or areas of the study are controlled for, looking for consistency across compatible OPTs provides an important metric. Both the consistency and the lack of consistency are key characteristics to recognize when trying to interpret TK in research efforts….and, as with any data, very thoughtful, careful review and consideration should be given before including or excluding outlier information." (personal communication, 7 October 2014)

47 In many wildlife co-management contexts, external criteria of validity (e.g., methods of inferring from samples to larger populations) derived from bio-science are used to evaluate the validity of TKH OPTs. This positions bio-science as the arbiter of truth, something that many TKHs contest. Paradoxically perhaps, social scientists also impose external standards of truth assessment in their push for robust research methodologies that will produce credible TK data for use in these same co-management contexts.

When resource users and scientists disagree over their determinations concerning the abundance of a given species (e.g., caribou, polar bears, fish, migratory waterfowl), the root of their disagreements can be traced to the differences underlying their respective knowledge cultures. Biologists use statistics-based modelling and inferential logic based on range-scale (if possible) transect surveys, mark-recapture, acoustic biomass surveys, analyses of catch rates and harvester logbooks,[48] and other methods in order to track changes in population numbers. Alternative, TK-based approaches often are understood by the scientific community as inherently less exacting and verifiable.[49] TKHs, on the other hand, base their assessments of species abundance on eye-witness observations and their harvest successes across local-level harvest areas, and in some cases over long periods of time across larger geographic areas through the communication of observations among TKHs occupying different parts of a traditional use territory.[50] These resource users are frequently sceptical about abundance estimates scientific methods produce.

TK researchers should be cautious when trying to derive quantitative population estimates (i.e., estimates of "all organisms" in a defined area, at a given point in time) from TK. The quantification of responses, especially to change-related questions, may over-simplify complex and nuanced observations and thinking about change. As well, the small sample sizes used in many TK studies can mean that quantitative differences have no statistical significance. For instance, *Inuvialuit and Nanuk* highlights difficulties numerically analyzing TK in two polar bear traditional knowledge studies (see Joint Secretariat 2015, 174). In these, researchers quantified differences in OPTs among Inuit informants. Presumably, an intention was to provide a sense of what a majority and minority of research participants held true, the degree of consistency and inconsistency in responses, whether there was a consensus, etc. As well, the researchers wanted to explore possible regional variations in responses resulting from differing local ecology, ice conditions, and other matters relevant to polar bear numbers and condition. In Born et al. (2011, 125), of 16 responses to the question, "Have you observed changes to the occurrence of polar bears?":

> 13 (ca. 81%) said 'yes', 1 (6%) said 'no' and two others had no opinion on this subject. Several of the responses were statements that indicated the bears have come closer to the coast, but several implied that there are more bears now. Some of the responses were a combination of these two statements.

Examples of these statements are also provided to help readers understand the rationale and nuance behind the responses. However, the report notes (2011, 203), "These kind of qualitative data are not easy to summarize. It is particularly problematic to weigh statements when they are contradictory in nature (e.g., some

48 Harvester logbooks and diaries are not TK; they are social science survey instruments that oblige harvesters to systematically record harvest numbers, a method which is foreign to the epistemology of TKHs.

49 Gilchrist et al. (2005) argue that "most LEK is inherently qualitative and difficult to validate. Therefore it could help to identify coarse (and necessarily large) changes in population size or distribution (e.g., declines of eiders and gulls), but our experience suggests that scientific surveys will almost always be required to verify and measure population changes at the levels necessary for wildlife management." Dawe and Schneider (2014) assert that "while LEK can be gathered and assembled, it does not lend itself to inclusion in a science based and quantitative setting via numerical weighting." See also Peters (2003, 54) Table 3 and Nadasdy (2003, 370).

50 According to Neis et al. (1999b, 1999), "resource users develop a detailed, small-scale understanding of population complexes, while scientific management typically aims at a larger scale. This mismatch in spatial scale can lead to different assessments of stock status and apparent disagreements where none may exist."

informants thought polar bears are thinner, others that they are unchanged, and a few that thought they are fatter or had changed colour)."

The problems of quantification, generalization, and interpretation of TKH statements about "natural" phenomena are compounded when one considers the indeterminacy and indirection that are characteristic of traditionally-minded Aboriginal peoples in the Arctic. For instance, for the Alaskan Yupik:

> There is no privileged point of view: the individuality and multiplicity of human experience and perception make definitively collective statements about the world impossible. Consequently, any attempt to combine descriptions from several sources results in interpretive errors vis-à-vis an anthropological fiction of 'the' emic [i.e., perception and understanding within the culture] description. It is preferable to present multiple accounts rather than to try to reduce them to common elements. (Morrow 1990, 153)

TK researchers must be mindful, therefore, of their own philosophical and disciplinary orientations. Note in particular that the quest for consensus, relatively simple "truths", specificity, and elimination of confusion or contradiction is a scientific preoccupation, not necessarily that of TKHs. The latter may be extremely tolerant of ambiguity, diverse interpretations, and differences of opinion with respect to the "facts".[51]

Despite the above concerns about inappropriate quantification, GIS modeling and other analytical approaches are appropriate when undertaken in a rigorous manner.[52]

2.1.3 Strengths and weaknesses of focus groups

A focus group or group interview is typically a meeting of three to a dozen or more people for the purpose of participating in a guided discussion on a given subject. In TK studies these are usually highly knowledgeable and experienced TKHs. Hence, they are a grouping of key informants carefully selected from a larger sample of community members.

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51 Jean Briggs made this point in the Aboriginal Studies Lecture Series at Memorial University, St. John's, Newfoundland during her 17 March 2011 lecture entitled "Fieldwork as a Kaleidoscope: Creating Truth Through Experience" (audio recording, P. Armitage files).

52 There are few publications describing such approaches and demonstrating how they have been used. However, some do exist:

In their work with Taku River Tlingit First Nation, Round River Conservation Studies researchers interviewed Tlingit TKHs concerning the past and present distribution of focal species and their seasonal habitat use patterns. Informant descriptions of habitat use and map biography data on key species areas and distributions "provided the foundation for the development of habitat suitability models" (Heinemeyer, Lind, and Tingey 2003, 63).

Attempts have been made to classify local knowledge responses quantitatively as a complement to incomplete scientific knowledge of species behaviour. Mackinson (2000 and 2001) used a fuzzy logic expert system to combine scientific information and knowledge of fishers about herring shoal structure, dynamics and distribution. Leduc et al. (2005) used a TK ranking system, along with correspondence and clustering analyses, to understand medicinal plant species used by the James Bay Cree.

For an interesting example of innovative use of TK research, see Kowalchuk and Kuhn (2012), in which the authors report on research related to the quantification of spatial Inuit harvest data for possible application in the COSEWIC risk assessment process.

Focus group interviews are popular with industry-sponsored consultants because they are cost-effective and save time, and they allow proponents to claim that they have engaged in meaningful Aboriginal consultation. However, focus group research is not conducive to the systematic documentation of detailed TK. Moreover, focus groups are difficult to facilitate and often suffer from the problem of "opinion leadership", where particularly knowledgeable or vocal participants suppress the expression of TK by others. Some participants may hold valuable OPTs but refuse to share them in a focus group setting because of its lack of confidentiality, especially in cases where their views run counter to an apparent group or community majority opinion or that of the community's political leadership. Individual or paired interviews allow participants greater freedom of expression, permit researchers to compare OPTs across age, gender, ethnic, and other community divisions, and assess consistencies and inconsistencies in OPTs across the sample.[53] In any event, focus groups should be used judiciously and with very clear linkages to research objectives, in particular, the depth or richness of the TK that researchers wish to elicit. Small group sessions (focus groups) are useful in confirmation/validation contexts when reporting draft TK research results to TKHs.[54]

2.1.4 Formal eliciting procedures

Formal eliciting procedures and other methods developed by ethnoscience and ethnolinguistic researchers in the post-WWII period are useful for certain types of TK research. Such procedures entail a systematic, controlled question-response method in which questions are formulated in the informant's language in order to elicit his/her semantic categories, and to avoid ethnocentric imposition of outsider (etic) ones. Formal eliciting procedures can be a useful addition to the TK researcher's toolkit, especially where a major objective of the research is to document animal and "plant" taxonomies, traditional concepts and vocabulary related to landscape features, anatomy, behaviour, reproduction, alimentation, etc. (see Armitage 2007; Black 1967; Clément 1995; Clément 1990; Mailhot 1993).[55] But the researcher needs to understand exactly what question an informant is responding to; this is why the question has to be formulated properly in the first place. Learning how to ask the right question in the TKH's language is the starting point in this method, and it is here that bilingual co-researchers can be of immense help to an outside researcher (Black and Metzger 1969; Clément 1990, 14).

53 Gilchrist et al. (2005) advise "interviews of several individuals separately to quantify variability among interviewees, as well as questions to assess each individual's (and community's) familiarity and experience with the habitat and species in question (i.e., their level of expertise). Depending on the time and financial constraints of the study, a targeted (nonrandom) a priori selection of the individuals most knowledgeable about the species in question is also advisable."

54 Alain Cuerrier (personal communication, 2 October 2014) says he prefers to use focus groups to report research results back to community members.

55 Ethnoscience was subjected to a withering critique four decades ago, and has been out of fashion in academic circles ever since (see Keesing 1972). However, the caution to clearly state questions to informants in ways that are intelligible to them is extremely important (see Clément 1990, 14). Too many researchers are sloppy about the manner in which they pose questions, or pay little attention to whether they are properly understood by informants.

2.2 Spatial and non-spatial aspects of TK

TK research involves much information that is not spatial, but many aspects are spatial or have a spatial component.

Most aspects of TK are not spatial in nature or at least are not explicit as to location. Examples include observations of: animal behaviour, morphology, anatomy, reproduction, seasonal cycles, and alimentation; predator-prey relations; plant morphology; animal and plant nomenclature and taxonomy; OPTs related to changes in distribution and abundance; OPTs related to the effects of human disturbance and disrespect (e.g., industrial activities, linear transportation corridors, low-flying aviation, contaminants, disrespectful treatment of animals or their remains, etc.); and the "cosmological" or "spiritual" component in human-animal-plant relationships.[56]

On the other hand, many aspects of TK are spatial, or include reference to locations. Some examples include:

- waterfowl nesting, moulting and staging areas;
- raptor nests, heron rookeries;
- caribou calving grounds, river crossings and other migration routes;
- polar bear denning locations and migration routes;
- fish spawning locations;
- beaver lodge locations;
- Dall's sheep lambing, rutting, winter range and migration corridors;
- locations where specific species are found in abundance at certain times of the year;
- specific vegetation and rare plant locations;
- land form descriptions; and,
- locations where bank erosion, creek siltation, coastal flooding, permafrost melts, and other environmental changes have been observed.

When we consider TK, which is firmly rooted in hunting, trapping, fishing, gathering, and other harvesting activities, as well as the associated forms of use-and-occupancy, it becomes clear that the spatial and non-spatial components of TK are conjoined. TK is required for safe and successful harvesting activities, and is learned and updated by way of them. TKHs know what they know because they learned it first hand and from more experienced people. The documentation of harvesting and travelling activities recognizes the integrated

56 Depending on the culture in question, animals, plants and inanimate entities are ensouled and considered sentient, mindful beings who to varying degrees understand human language and intentions. Humans enter into social relations of reciprocity with these beings, the most important element of which is the need on the part of humans to show them respect.

social-ecological nature of TK (Lutz and Neis 2008, 8; Pinkerton 2009); map biography interviews bring in the spatial components of this integrated knowledge.[57] However, one TK research project cannot do everything; research designs that attempt to document harvesting, use-and-occupancy, and "ecosystem components", will almost certainly result in a shotgun approach with all of its defects (see Tobias 2009, 58; and section 1.1).

2.3 Assumptions concerning spatial knowledge

Ensure that your methodologies are informed by a good understanding of the knowledge you are documenting and reshaping.

The primary method used to document Aboriginal spatial knowledge in TK studies and use-and-occupancy surveys is the map biography method. This is a survey technique in which a sample of TKHs in a given population is interviewed concerning their use-and-occupancy in a given geographic area or their observations of animals, plants, and other entities there. Depending on research objectives, TKHs are asked to recall locations where they have traveled across the land or water, hunted, trapped, fished, gathered wild fruits, cut firewood, and where dwelling places, burial sites, mythical, spiritual, death and birth places, and place-names are located. When the research concerns the ecology of caribou, polar bears, fish or some other species, they are asked to identify locations where these entities are found in abundance, where they reproduce, feed, travel, etc. Likewise, when it concerns entities that grow in the earth (e.g., trees, shrubs, herbaceous plants, lichens, flowers, etc.), they are asked to identify locations within their traditional use territory where they have observed and/or harvested such entities. Their memories of these locations are then inscribed on base maps in the form of point, line and polygon features, and the inscribed map is referred to as a "map biography."

Map use by Aboriginal people is widespread nowadays. Nonetheless, an important issue at the outset of any "cross-cultural map-making episode" (Bravo 1996, 3) is the way in which TKHs conceptualize and use space and then translate this into the two-dimensional medium of the paper or digital map biography base map. We suspect that few TK researchers give proper consideration to this issue. Instead, researchers assume, perhaps erroneously, that the spatial constructs of TKHs are universally-held ones, and that they can be represented easily on a map. The difficulty is aggravated when the TKH and the researcher do not share the same language, and require an interpreter to translate complex spatial knowledge into cartographic inscriptions. In such cases, the researcher remains ignorant about the complex transaction between informant and interpreter, and

57 Usher's definition/description of TK (Appendix A) includes "knowledge about the use of the environment." See also Houde (2007).

may not realize that it is the interpreter, not the informant, who is doing the map reading required for inscription.[58] For a description of how TKHs use maps in interview settings, see Appendix B.

Until relatively recently, researchers studying spatial cognition and representation believed that people hold "cognitive maps" in their heads.[59] With this understanding, it follows that TKHs must use these same cognitive maps and represent them cartographically when they participate in map biography interviews. However, the cognitive or mental map metaphor has been convincingly critiqued and replaced with more nuanced understandings of how TKHs use and think about the world around them, such as wayfinding[60] (see Aporta 2003; Bravo 1996; Ingold 2000; Lynch 1960; Tversky 1993).

What a TKH brings to a map biography interview is not a "mental map" of his/her territory that can be transposed simply onto a National Topographic System map with its UTM grid, calibrated scale, and other cartographic conventions. The social-spatial-cognitions are much more complex, and must be understood in terms of how TKHs perceive their environment and how they travel through it. Aporta's (2003) discussion of the way in which Igloolik Inuit employ a variety of spatial frameworks when travelling throughout their territory is a useful point of departure for TK researchers who intend to use a map biography methodology. These spatial frameworks include wayfinding in reference to "mainland" landscapes, highly dynamic seascapes with their myriad ice features depending on the season (polynyas, floe-edge, ice cracks, open leads, currents, etc.), and coastal features (cliffs, fjords, bays, raised beaches, etc.). Wayfinding and spatial orientation are facilitated by

58 Some TKHs lack functional cartographic literacy even though maps are ubiquitous in Aboriginal communities and widely used by many land users. However, their illiteracy may be hidden from the researcher by sophisticated interpreters who process verbal descriptions of land use (using Aboriginal-language geographic terminology, place-names, travel narratives and gestures) and translate these into points, lines and polygons using elevation contours, linear hydrological features and other map symbology. The researcher erroneously believes that the informant is "reading" the base map during the interview when in fact it is the interpreter who is doing the "reading." Although conceived in terms of the "mental map" metaphor, Nuttall had some useful observations with respect to the way in which Greenlandic Inuit used maps. One of Nuttall's key informants "enjoyed reading maps. It was like looking back over a lifetime, with each experience and every hunting trip made familiar. But maps, as Josepi showed me, are profoundly inaccurate compared with a hunter's memory of the places they chart. Most older hunters I interviewed had difficulty relating to sheet maps. Placenames are often wrong and informants tend to understand oblique aerial photographs far better. I found that sheet maps were useful as a reference to which a hunter could 'add his own layers of detailed information.' " (Nuttall 1997, 48–49).

59 Ingold (2000, 220) calls this a "complex-structure metaphor."

60 Wayfinding better describes the complex manner in which Inuvialuit/Inuit travel across ice and tundra. Their manner surely is not navigation if the term means that "one must possess some representation of space—a map—whether internal or external, inscribed in the mind or on a sheet of paper, within which every object or feature in one's environment is assigned a determinate location" (Ingold 2000, 235). In contrast, wayfinding describes a process whereby "one knows the way in terms of the specific order in which the surfaces of the environment come into or pass out of sight as one proceeds along a path.…Thus to travel from place to place involves the opening up and closing off of vistas, in a particular order, through a continuous series of reversible transitions" (ibid., 238). An Inuvialuit polar bear or seal hunter is much like a Micronesian seafarer who "feels his way towards his destination by continually adjusting his movements in relation to the flow of the waves, wind, current and stars" (ibid., 239). And, to this observational, sensory repertoire, we can add reading the patterns of drifting snow and other skills adapted to the Arctic environment (Joint Secretariat 2015). See also Tversky's (1993) concept of "cognitive collage."

the use of place-names, observing the position of the sun, moon and stars, noting wind directions, and other means (Aporta 2003).[61]

Thus, the TK map biography method suffers from the same paradox as all other methods of TK representation: they reshape the knowledge in the process of documentation (Duerden and Kuhn 1998, 33).[62] However, what is the alternative, given that a knowledge product must be created for use in wildlife management, environmental assessment and other practical applications, by people who cannot live the lives of the TKHs and experience the world exactly as they do? The data obtained through map biography and other methods, therefore, must serve as a proxy for the experiential knowledge of the TKH.[63] As is the case with all social science research, the best we can do is to ensure that our methodologies are informed by a good understanding of the knowledge we are reshaping, and continue to caution end-users of the data that what they are using is an approximation, a proxy for a knowledge form that we cannot replicate with total accuracy or completeness.

2.4 Language and worldview

Do speakers of the three Inuvialuktun dialects—Uummariutun, Siglitun and Kangiryuarmiutun—classify landscape features differently than non-Aboriginal Canadians and scientists? To what English- language terms, if any, do their classifications and related terminology correspond? What are the Inuvialuktun equivalents or translations of "population" or "subpopulation" (as in a subpopulation of polar bears)? Do traditionally-minded Inuvialuit divide animal populations into "populations", "herds", "stocks" and other groupings identified by biologists? If so, what are the concepts and

Make certain always to consider nuances in concepts, understandings, and language while designing and executing research and using translation.

61 Collignon (2006, 96–98; Appendix B of this document) uses a mental map ("complex-structure") metaphor. Compare her discussion of Inuinnait perception of space and map usage with Aporta's discussion regarding Igloolik Inuit (2003). Compare both descriptions with the theoretical orientation proposed by Ingold (2000, 219–242). For example, Collignon (2006, 97) argues that "for the hunter, land is both a network of axes and a set of surfaces over which game is distributed. Three types of surfaces are distinctly defined: *nuna* ('the land'); *hiku* ('the ice cover,' 'the ice-sheet'); and, *tariuq* ('the salt,' 'the sea')." In contrast, Ingold (2000, 240–241) argues that "the world has no surface…. [T]he world can only be perceived to have an exterior surface by a mind that is situated above and beyond it. In ordinary wayfinding however, whether on land or at sea, the world is apprehended from within. One makes one's way through it, not over or across it. Of course the traveller encounters surfaces of diverse kinds – of solid ground, water, vegetation, buildings, and so on – and it is largely thanks to the responses of these surfaces to light, sound and the pressure of touch that he perceives the environment in the way he does….These are surfaces, however, in the world, not of the world."

62 As noted by Jennifer Carpenter (personal communication, 8 August 2014) the map biography methodology is not well suited to documenting indigenous values, associated social customs, and non-spatial knowledge of landscapes, plants and fauna.

63 Arn Keeling (personal communication, 2 September 2014) argues that the data generated in TK research is really a "co-production of knowledge rather than its more-or-less accurate transposition from one person/context to another. The [information] itself–whether generated with a map, a recorder, or in the bush–is a unique production of that research encounter, and so is relational, inherently not replicable and to some extent indeterminate (although no less valid and useful for that)."

the terms that express these geographically and/or genetically delimited groupings of animals found within the ISR? The authors of these guidelines know of no research that addresses these questions definitively. They are subtle but important matters that should be considered during research design and execution.

Sensitivity to all the nuances of language is extremely important even when working in English, because one is likely to be working with regional dialects of English with their own vocabularies and meanings. One must be confident that the concepts/entities communicated by TKHs are what one thinks they are. McGoodwin, Neis, and Felt (2000, 256–257) make this point in relation to research with fishers who speak non-standard, regional dialects of English.

> Another methodological issue associated with LEK [TK] research…relates to the challenge of accessing and correctly understanding local terms and the underlying taxonomic systems (where these exist), spatial constructions, and designations (toponyms) and the logic that informs the thinking of resource users…. Some of the pitfalls associated with this type of [ethnozoological] research include premature assumption of equivalence between folk and scientific taxa and a failure to recognize that the same words can mean different things in different contexts.

Research tasks as seemingly simple as eliciting local names for animals, fish, plants, land and ice forms, and other features of the "natural environment" can lead to difficulties.[64] Laidler (2007, 369) notes, for example:

> It can be difficult to link English and Inuktitut sea ice terminology due to the nuances of localized terminology referring to practical uses, or specific ice conditions only observed up close. There is also the added complexity of contextual references whereby different variations of a term will be used depending on whether a person is describing a condition to you from a distance, while on the ice, or while the process is actually occurring.

Local names for animals and plants are often different than the common ones known to western science; this can lead to identification problems such as those noted by Hartwig, who sought clarity concerning equivalent common/scientific names for a number of fish species referenced by the Inuvialuit (broad back, flat fin fish, cod herring).[65]

> Two species identified by community members were not identified in the Inuvialuit Harvest Study (Joint Secretariat 2003), which collected monthly harvest information from Inuvialuit subsistence harvesters. The species' names were changed according to what fisheries biologists believed they were in reference to (pers. comm. S. Stephenson, DFO 2009). Broadback

64 In 2008, Armitage undertook a verification process with three La Romaine Innu elders in the context of collaborative work on a pan-Innu dictionary. In reviewing various wildlife-related lexemes, he noted a diversity of opinions concerning the identities (derived from photographs in natural history field guides) of many living entities particularly insects, small birds, and seals which are not harvested by the Innu. Lexemes for a variety of these entities exist, but they could not be linked definitively to species photographs in a field guide.

65 Likewise, Mackinson (2001, 535) notes with respect to TK research focused upon herring fishers that "terms used by interviewees to describe shoals were frequently different than those used in scientific literature and, accordingly, some interpretation was necessary on my behalf." Kim Heinemeyer (personal communication, 7 October 2014) notes that in some places "common names used locally are actually common names for an entirely different species elsewhere. For example, what 'we' call ground squirrels are locally called gophers in the north. Gophers are entirely different creature."

> was assumed to be Broad Whitefish (*Coregonus nasus*) and Flat Fin Fish was changed to Flat Fish (although the species of Flounders remains unknown). In many cases however, a single name such as cod or herring was used to identify a species and it was not possible to determine exactly what species the respondent was referring to. Similar issues were noted in the Inuvialuit Harvest Study (Joint Secretariat 2003) and by Stephenson (2004). Although there may be some discrepancy in the species' names, this information is still useful for identifying ecologically and biologically important areas. Participants used local names in many instances so that Northern Pike (*Esox lucius*) were simply referred to as Jackfish, Burbot (*Lota lota*) as loche and Pacific Herring (*Clupea pallasii*) as Blue Herring or sometimes just herring. It is possible that 'herring' may have also referred to some species of Coregonid such as the Arctic Cisco (*Coregonus autumnalis*). (Hartwig 2009, 4)

Hartwig's account serves as a useful caution with respect to the choice of feature categories used in TK survey methodologies, including map biographies.

One possible solution to this identification problem is to ask informants to identify animals and plants with the researcher present during harvesting activities and/or using quality photographs and diagrams during interviews.[66] However, these methods may cause problems related to the separation of a species from its defining, contextual habitat (required for proper identification), worldview and the way that perception works among traditionally-minded Aboriginal people. Diamond speaks to this problem in relation to his own research experience in New Guinea.

> The basic problem with trying to elicit bird names by pictures or specimens is that these methods fail to present birds in the way that New Guinea hunters normally perceive them. To elicit names under natural circumstances, I routinely have one or two local hunters accompany me through the jungle whenever I am bird-watching in New Guinea…. To elicit names successfully, one must learn how local hunters perceive each bird species. (Diamond 1991, 85)

2.4.1 Interpretation and translation

When interpretation is required during interviews, English-language questionnaires should be carefully tested using a "back-translation" methodology. For example, during the methodology pre-testing phase of the research, the interpreter's questions, and TKH responses, would be transcribed in Inuvialuktun and closely translated back into English. The translated discourse would then be compared to the original English questionnaire. The principal investigator (PI) would then adjust the questionnaire in close cooperation with the interpreter to ensure that questions are asked clearly and consistently in all subsequent interviews and are intelligible to TKHs.

Once interviews are completed, audio recordings are often sent to consultants who are not speakers of Aboriginal languages. The English-language parts of the audio recordings are transcribed, but not the Aboriginal

66 To the greatest extent possible, species identification, folk taxonomy and terminology, geographical concepts, toponymy and other matters should be worked out during community research planning meetings in advance of the pretest (pilot) interviews. Quality photographs and diagrams from natural history field guides, maps and other reference materials can assist in clarifying species identifications and sorting out a range of ambiguities and potential problems that might compromise the quality of the data obtained during interviews (Terry Tobias, personal communication, 21 July 2014).

ones, meaning that researchers are entirely dependent on the transcriptions of the translations provided during the interviews for subsequent data processing and analysis. In addition, while technical Aboriginal language vocabulary embedded in primarily English narratives may be transcribed, the spellings are usually quite approximate and require validation by Aboriginal language experts.

As explained by Murielle Nagy (2006, 71), a total dependence on English-language narratives comes with a price:

> Since oral narratives are often the major sources of information with which anthropologists will work, the recorded interviews need to be transcribed and translated. However, translations are not perfect duplicates of the original narratives; they are only equivalents.… Although translators do their best to transfer into another language what the narrators have said, there are times when the original meaning of words and expressions is distorted, if not lost, during the translation process. Furthermore, once anthropologists interpret translated narratives, there is another level of translation going on, and if the translations do not represent the intention of the narrator, elements of the narratives may be misinterpreted.

Nagy notes in reference to the Inuvialuit texts she worked with that Inuvialuit translators and bilingual interviewees frequently use the present tense when talking about past events:

> One issue that particularly interested me in the English translations I worked with was the pervasive use of the present tense. Although these dialects all have a 'present declarative' form that can be used in some contexts to refer to an event that is past…the English translators often chose to use the present tense in English. (Nagy 2006, 75)

Nagy provided the following reasons for the extensive use of the present tense in translation to English:

- "once the speaker makes it clear that he or she is going to talk about past events…there is no need to emphasize that the story is happening in the past; hence the use of narrative present" (ibid.);
- "use of the narrative present also indicates that telling a story means to re-enact particular experiences and to perform it" (ibid.); and,
- when narrators talked about the past, "they did not seem to go back into time but rather into the places where events happened" (space and time merged linguistically) (ibid.).

The sensitivity to language and translation discussed by Nagy is required in many other ways when conducting TK research. Most importantly, researchers must pay careful attention to the ways in which OPTs are expressed in Aboriginal languages with respect to cause-effect statements related to environmental change (e.g., climate, animal abundance and distribution, etc.). What may appear as definitive statements of fact may in reality be much more nuanced, speculative, hypothetical, or predictive discourses (see Armitage 2007, 68–75).[67]

67 Note Morrow's (1990, 144) point about a common translation problem from Yupik to English, "which, if anything, would tend to make Yupik speech look more specific than it actually is. This is the common omission, in translation, of pervasively-used qualifiers. These are often left out because they tend to make the English seem too vague."

Maintaining a cautious stance vis-à-vis translations is important because some interpreters infer the intentions of the people they translate for, what they think speakers intend to say versus what they actually say, thereby over-translating the narratives and reading more into them than had actually been stated (ibid.). In addition, unbeknownst to the outside researcher, some interpreters insert their own OPTs into the translation. Thus, good translation and interpretation is essential for the production of quality, credible, trustworthy data (Collignon 2006, 277; Laidler 2007, 367). Research budgets should include funds for close translation, and linguistic/grammatical analysis where required.

Understanding the worldview of the Aboriginal informants whose TK is being documented is crucial if we are to avoid the problem of forcing the square pegs of this knowledge into western scientific round holes.[68] In designing TK research in the ISR, an important starting point is how the Inuvialuit perceive the world; we need to understand the categories that they use to make sense of the world around them rather than impose outsider ones that distort their knowledge in the process. Researcher terms and the concepts they label—such as "population", "morphology", "habitat", "herd", "stock", "shoal", "ecosystem", "ecological landscape unit", and "environment"—may have no direct equivalent in Inuvialuktun dialects and the thinking of traditionally-minded Inuvialuit, and even where TKHs are bilingual or unilingual English speakers, one cannot assume that local meanings are identical to those of the researchers and external audiences. Some terms, such as "genetic variation", are probably impossible to translate, and the concepts they label are probably as incomprehensible to TKHs as they are to the majority of the lay-public who lack bioscience training.

In sum, wanting to delve deeply into the understandings held by local people concerning their land, animals and other living entities, researchers should pay careful attention to the ways in which they conceptualize and express the understandings in whatever languages they use. This includes achieving a good understanding of "ontological" difference, that is, the profound differences in worldview, such as beliefs in the ensoulment of animals, trees, rocks, and other seemingly inanimate entities, and their potentially great sentience (see Houde 2007). Researchers should not lose sight of the value of indeterminacy with respect to knowledge in Aboriginal cultures, and the idea that Aboriginal peoples may not parse the world and knowledge about it into distinct categories like "environment", "religion", "nature", or "society."

68 Johns (2010, 408) notes that Inuit are unlikely to make lists of sea ice terms, and that "words are often sentences in Inuktitut so that the status of word between the two languages [English and Inuktitut] is quite different." Moreover, even disciplinary differences have effects on the way in which TK is documented. "Geographers seem to start with specific geophysical distinctions in mind (such as ice types and processes), while anthropologists collect terms in the context of hunting, fishing, and travel" (ibid.).

2.5 Sampling

Research findings may suffer from any number of biases that seriously compromise their credibility and utility if the sample is not designed well.[69] As noted by Davis and Wagner (2003, 475), "the quality and impact of data assembled during LEK [TK] research depends to a large extent on who is identified as 'knowledgeable' and whether information is gathered systematically from a large enough group of knowledgeable individuals." (See also Gilchrist, Mallory, and Merkel 2005)

Identifying the right sample of people to be interviewed or included in focus groups in TK research is very important.

Random sampling is the gold standard for large populations but may not be necessary in small populations such a community of elders. TK increases with age and land use experience, and so a small population consisting of elders can be more informative than a larger population including younger people. In the past, TK interview samples in the ISR have relied, to a major extent, on the recommendations of community Hunters and Trappers Committees (HTC), augmented to varying degrees by peer references obtained during initial interviews. Peer references are a type of "snowball sampling" approach, where initial study participants recommend other possible participants. The manner by which TKHs are chosen by their HTCs is usually opaque to PIs and other outsider researchers. The criteria for a restricted population (sample) should be stated where these are based on evaluations of the TK and land use experience of community members.

The definition of the population of TKHs should recognize that not everyone is equally knowledgeable about a given TK subject or geographical area.[70] The people who are likely to be the most knowledgeable are those with ongoing and active land, water, and ice use throughout the year involving a number of animals and other living entities. Usher (2000, 187) notes, in the context of environmental assessment research, that repeated observations of the environment over time are key to good quality TK: "The circumstances that foster [TK] are neither uniformly distributed nor permanent among Aboriginal communities. In places where, for whatever reason, few if any members of the community have recent or current experience of a particular area or phenomenon, there may not be much TEK that will be useful to environmental assessment."

69 In some contexts, political expediency or ideology can seriously compromise sample design and the quality of research. For example, researchers may be pressured to include age or gender categories in the sample even though their members lack knowledge and experience with respect to the research objectives. One result is that scarce research funds are not used productively in ways that would maximize the quality of the research and justify the often substantial financial investment in it. This problem can be acute in communities where income from interview honoraria and co-researcher salaries is a badly needed addition to household income. There are many examples across the North of people hired as co-researchers or included in research samples primarily because they needed income or because they were related to important community decision-makers, not because of their knowledge and expected contribution to an important research product.

70 See McGoodwin et al.'s (2000, 255) discussion of sampling regimes. As a result of their analysis of four LEK case studies, Gilchrist et al. (2005) noted that "the breadth and quality of LEK varied among species, and thus the relationship of the species in question to the local community must be clearly understood….the accuracy of LEK often varied among interviewees, so an adequate sample size of individuals must be questioned to increase confidence in the information provided….LEK quality was higher for species with which local peoples had greater familiarity through harvest or year-round contact or both (e.g., nonmigratory eiders). However, this may not necessarily be related to levels of harvest alone (e.g., breeding murres in Greenland)."

When determining which TKHs are best for a particular TK study, the objectives must be considered. Informants should be neither too young nor too old and sedentary to meet the objectives. Young community members may lack the experience required for richly documented TK research, while older individuals may have ceased their harvesting activities because of infirmity and may therefore lack recent knowledge of value in some TK studies. Furthermore, they may suffer from frailties, such as poor eyesight, that make it difficult to participate in studies that elicit knowledge using map biography methods. Nonetheless, in the case of species that have declined to an extent they are no longer harvested and/or observed, older TKHs may be the only people who have any knowledge. Therefore, it may be important to make every possible effort to document their knowledge if the subject of the study specifically pertains to an extirpated species or one in serious decline.

To complicate matters, map biography methods require cartographic literacy on the part of TKHs, and such literacy is often variable among community members. Where TKHs have trouble reading maps, it may be necessary to retain another cartographically literate TKH and/or interpreter to assist in georeferencing the interviewee's TK. Eliminating a TKH from a study due to map illiteracy alone is not justified because spatial TK is only one component of a given TK knowledge domain and it may not be the most important one given study objectives.

If a restricted population is chosen for sampling, the demographic characteristics of the entire community from which that population is taken should be reported where possible. Lists of Inuvialuit Final Agreement beneficiaries, community members and members of HTCs are good starting places. Data concerning names, gender, age, harvesting experience, and territorial affiliations of community members are all relevant to survey design; gaining access to these may require special agreements with local or regional administrative bodies and individual TKHs because some of this information, such as community member's ages, is confidential. Lists of interview and focus group participants from other research projects are also sources of names that can be used to make lists of potential interviewees. Where PIs work entirely with lists of TKHs provided by HTCs or through peer referrals, knowledge of the larger community from which the sampling frame is chosen will help them assess potential biases in the choice of sampling frame, and facilitate negotiations over revisions to it.[71]

In TK-related research, the sampling frame is likely to be the total list of community members 15 years and older, male and female, who have harvested, traveled and lived on the land, water, and ice and who might have TK related to the study's subject matter. It is usually impossible to interview all of these people, so a restricted population of TKHs is selected. In TK studies, these are usually the most knowledgeable and experienced members of the community, as noted above. Because the pool of knowledgeable and experienced people in a community may be vast, decisions must be made about whether to define a restricted population to sample,

71 E.g., one scenario is where the PI notes that the list of TKHs provided by an HTC does not include people with experience in particular portions of the community's traditional use territory even though the study area covers the entire territory.

relative to time and budget constraints.[72] Often, "stratified" samples are created that may have any number of characteristics depending on research objectives. Some examples include:

- In cases where TK is sought across the community's entire traditional use territory, a restricted population of TKHs is selected, those who have experience across the territory, or whose knowledge in the aggregate is well distributed across it. A sufficient number of people must be selected to achieve this distribution. This has consequences for the budget and time allocated to the research.

- Where TK is required concerning specific living entities (e.g., grizzly bears, fish, medicinal plants), TKHs must be selected from a population of individuals who have direct experience with these entities. These are usually people who have harvested and observed them over a lengthy period of time. For example, with some exceptions, one would not expect a community member who had never hunted or observed grizzly bears to be knowledgeable of the animal, and as result, s/he would not be included in the interview sample.

- In cases where it is important to obtain TK information with great time-depth, and important research questions relate to environmental changes over time (e.g., changes in species abundance and distribution), older TKHs must be selected who have great accumulated harvesting, land, water, and ice use experience throughout the time period of interest. The restricted population must be large enough to achieve this temporal coverage. Again, this has consequences for the budget and time allocated to the research.

- Where "current" TK is required, active land users are priority informants. The inclusion of some elderly TKHs in a (restricted) population frame may not be justified if they have not harvested or spent time on the land, water, and ice in recent years. The same applies to community members who have been absent from the community and its traditional use territory for many years.

- High sampling fractions reduce uncertainty. Some examples are a sampling fraction of 100% for all of the people who have occupied cabins in the Shingle Point region during the last 10 years, or 100% of the people who currently own hunting and trapping cabins in the Mackenzie River delta, or 100% of the hunters who have received grizzly bear tags over the last five years. High sampling fractions reduce uncertainty toward zero in the case of 100%. Here again, the choice of larger population and restricted population must be directly related to research objectives with consideration given to research time and budgets.

72 Marine ecologist, David Schneider (personal communication, 18 August 2014), who has experience in team research projects related to fisheries science and local ecological knowledge, recommends the following procedure for the design of TK research samples. Firstly, from the total population of knowledge holders, define a restricted population of potential respondents (e.g., elders) on the grounds that TK is not distributed proportionately. Next, determine the number of people who can be interviewed depending on time and budget. The ratio of interviewees (respondents) to the number of people in the restricted population is the "sampling fraction." If this fraction is small (e.g., <30%), use random numbers to select the interviewees from the restricted population. Record the number of potential respondents who decline interviews. Random sampling matters less if the sampling fraction is large (e.g., >50%) because the uncertainty inherent in results derived from sampling decreases substantially as this fraction rises beyond 50%.

A note on redundant data: as interviews proceed, researchers may note emergent patterns in the TK elicited. Increasingly, interviews may generate redundant data in the sense that TKHs point to the habitat areas, behavioural or environmental change characteristics, and other TK features that were reported by other research participants. This repetition is called "data saturation" which is "the point at which the incremental addition of more respondents' data makes no difference to overall findings" (Tobias 2009, 146). This will be the case with large sampling fractions, and it is not an inherent defect of the sample design. Reinforcing TK OPTs are meaningful, but so is the "outlier" OPT of the TKH whose views diverge significantly from those of the majority. Reasons for the divergence should be explored thoroughly.

A representative sample is guaranteed by the use of random taking of samples from a population, but this is rarely possible in social science research. For Davis and Wagner, it is important to demonstrate that an individual TKH's OPTs are representative of a shared community TK, part of local knowledge "system." In their view:

> The knowledge that is unique to a single individual may be as sound empirically as knowledge that is widely shared, [but] it cannot be considered representative of the knowledge system as a whole and is not likely to inform social behaviour as it relates to resource use. Such knowledge, sound as it may be in its own right, may well be discounted as mere 'anecdotal' evidence if presented in a resource management setting where final decisions are made by external regulatory agencies. (Davis and Wagner 2003, 466)

They propose a method to establish the representativeness of a given OPT. This involves documenting a "minimum of three independent observations…respecting each particular ecological, environmental, or resource behavioural knowledge claim" (ibid., 477).[73]

In contrast to Davis and Wagner's criteria for representative samples, Wenzel (1999, 116–117) recognizes that contextualized and divergent OPTs exist making generalization difficult if not impossible:

> Because we generally assume (and are not infrequently told) that traditional ecological knowledge is a broadly held body of information, there is a tendency to ignore just how specific the source of TEK items may be…. A very real issue may be just how generalizible individual traditional knowledge is…. In fact, TEK, precisely because individuals contribute both subjectively and selectively, requires the same level of independent 'truthing' as other kinds of data, either from other community members, through participant observations, or by other means. Just how structurally embedded even the most mundane elements of TEK actually are…may be questionable precisely because this information is so contextualized in individual experience.[74]

73 See also the discussion in Neis et al. (1999b, 1961) regarding consistency with respect to Newfoundland fishers' LEK. "Reliability and internal consistency are increased by comparing results from different techniques (triangulation), by internal comparisons within and between transcripts, and with the results of feedback meetings and independent interviews and discussions with fishers…" Tanner (2015, 11) questions "the assumption than an Indigenous group has a single unifying world view and a knowledge system that is internally consistent."

74 As well, individual variations in areas used over the course of the year, overlaps in areas, and sharing of observations and thoughts among hunters mean that information and numbers provided may vary considerably from one person to another (Nadasdy 2003, 375). See also Morrow's (1990, 153) point (referenced in subsection 2.1.2) that traditionally-minded Alaskan Yupik can value indeterminacy and ambiguity, and that for these people "definitively collective statements about the world [are] impossible."

The representativeness of TK data is certainly a serious matter in TK research design. However, the reality of such research in many Aboriginal communities today is that the most knowledgeable TKHs are elderly and there are very few of them remaining. TK related to distant parts of the traditional use territory, older harvesting techniques, and environmental characteristics may reside in the minds of a handful of individuals, not large cohorts of them. Their TK may once have been part of a widely shared local knowledge "system", but nowadays this system is held by few individuals. The issue of representativeness and TK validity related to idiosyncratic TK is complex for numerous reasons, and tests for validity or confirmation must be considered carefully.[75]

The observations of TKHs can be weighted by providing summaries of their life histories (biographies) in various portions of the traditional use territory. Descriptions of their use of land, water and ice help to explain how they know what they know. However, this approach may require providing information about TKHs that makes it impossible to protect confidentiality (if required), and it requires supplementary interview time and expense, probably in addition to that required for the primary survey instrument.[76]

Where the PI needs to know more about the knowledge of TKHs prior to commencing in-depth interviews, a two-tiered sampling strategy that weights knowledge may be in order. Here, a (relatively superficial and easily administered) structured survey is administered to as many potential interviewees (members of the sampling frame) as possible within time and budget constraints.[77] The survey poses questions designed to ascertain the geographical extent, temporality, and other characteristics of respondents' TK, and the results are used to design the ultimate key informant sample. Davis and Wagner (2003, 480–481) report using a version of this method in their research among Nova Scotia lobster fishers. Their sample design started with a telephone survey based on a random sample of licensed lobster fishers stratified by the harbour they fished from. Inter alia, the survey asked respondents to identify up to three people, other than the respondent, "considered to be particularly knowledgeable about the local fisheries and fishing grounds" (ibid., 481). The researchers then tabulated respondent recommendations and created a list that "rank ordered all those mentioned in terms of the number of mentions received. This list identifies those fishermen, currently fishing or retired, who are considered within their peer reference groups to be the most knowledgeable about the local fishing grounds" (ibid., 483). Finally, the researchers identified at least five people in each community area on the basis of the "criterion of two first mentions or three total mentions" by the respondents, and these people comprised the sample for the second survey involving in-depth, face-to-face interviews (ibid.).

75 For more on the issue of TK validity, the management of response bias, the value of triangulation, validity criteria, etc., see McNabb (1990) and Whittemore et al. (2001).

76 This approach was used by Armitage (2007) in relation to the documentation of Innu TK along Mishta-shipu (Churchill River) in Labrador.

77 Jennifer Carpenter (personal communication, 8 August 2014) notes that "a survey questionnaire could be used to find out who knows about what in a knowledge community to short-list potential participants."

2.6 The data collection manual

A key resource for systematically designed, structured and semi-structured interviews is a well-conceived research methods protocol, which is documented in a data collection manual (DCM).

If using structured or semi-structured interviews, create a data collection manual that documents the questionnaire and data recording conventions.

The DCM has been termed "the interviewer's bible" (Tobias 2009, 278). It distils, into one place, the decisions made during research design and scoping. It includes a complete, detailed questionnaire, as well as instructions on how information is to be recorded. Furthermore, for research using the map biography method, it includes descriptions of all conventions and procedures established for recording information on maps (ibid.). The DCM is also a useful metadata document that enables data users to understand clearly the data collection methodology.

A good DCM will include stepwise instructions for the whole interview process, for instance: how confidentiality is to be handled; when the TKH is to be offered the consent form (at the beginning of the interview); how audio recording equipment is to be set up; how the questions are to be phrased and ordered; and how study materials are to be labelled and stored once the interview is complete.

The DCM serves two purposes:

- **For interviewers and co-interviewers**, it takes away much of the need to memorize conventions, and the associated potential of forgetting or changing them in the thick of interviewing. It helps them apply the methodology consistently. Over time, an interviewer will become familiar with the content and need to refer to the DCM less and less. However, it will always be available if any question arises (Tobias 2009, 279).
- **For others involved in using the research products**, the DCM provides clarity about how the research was conducted and information recorded, without requiring contact with the original researcher. Many TK research practitioners, including the authors of this document, can recount stories of encountering previous research where the original researcher had passed away or cannot be contacted, and going through frustrating and time-consuming exercises trying to fathom what was recorded on maps and forms. It is disheartening, knowing that valuable information, perhaps from elder members of a community who have passed on, is recorded but is inaccessible due to inadequate or missing metadata.

2.7 Methodology pre-testing

No matter how well research design has been done, base maps prepared, and the DCM written, it is critical to test these materials in a controlled environment, and tweak them where necessary before interviewing.

Always allow time and budget for pre-testing the research design and materials, and revising them if necessary.

A successful TK research design incorporates many conceptions of how the TKHs understand the research topics, locate themselves on map biography base maps, and the like. Regardless of how much background material is consulted, how familiar the PI is with the community and its people, and how carefully community contacts are consulted, it is likely that there will still be areas of ambiguity in the research materials that will not be discovered until real interviews are conducted.

For instance, in one study of communities in the far north, it was discovered during the pre-test that most harvesters did not differentiate between snowshoe hare and Arctic hare when asked about harvesting, so two questionnaire categories had to be combined into a generic "rabbit" category. It might be discovered that people use a local name for a hunted species, or that the phrasing of a question is confusing to the people (though perfectly clear to the PI), or that a question is considered disrespectful and will not be answered.

It is important to pre-test interview base maps for map biography interviews because they may lack critical information that TKHs use to orient themselves (see also section 2.3 above).[78] For instance, the authors have been involved in a study where harvesters wanted near shore depth soundings (bathymetry) on the maps, because they were used to travelling by boat at certain times of the year and were familiar with these, and another where the pre-test maps were understood as inadequate because seismic cut lines widely used for travel were not marked.

Pre-testing also allows research team members to become familiar with the DCM and research procedures in a controlled way. No amount of reading or role play can substitute for the experience of observing and/or participating in real interviewing. Like any new activity, people begin hesitantly, make mistakes, but improve with practice and repetition.[79]

78 Research PIs and co-researchers must have a good grasp of the geography and place-names (toponyms) of the study area especially if they are participating in research planning meetings, methods pre-tests, or interviews, otherwise valuable time may be wasted while researchers search for geographic features referenced by TKHs. Lack of familiarity with the geography and toponyms suggests researcher incompetence and may contribute to response burden on the part of interviewees (Patt Larcombe, personal communication, 28 July 2014).

79 See Tobias 2009, 296–301 for a detailed discussion of methodology testing.

3 Study Execution

3.1 Interview timing

The cardinal rule in doing community research is *nothing ever goes in a straight line*. People who are not patient and flexible should not do research in Aboriginal communities. There are many words of advice that seasoned researchers can pass on to neophytes, and they would fill many pages of a methods textbook (such as Tobias 2009). Here, we list some essentials:

Always allow sufficient time for interviews and associated activities, as well as extra time for unanticipated problems.

- In planning and conducting the interview phase of the research, allow time for inevitable hiccoughs (bad weather, informants/respondents who fail to show up for their interviews, materials and honoraria cheques not arriving, etc.).
- Ensure that appropriate lead time is provided so that map biography base maps and other bulkier materials and equipment can be shipped to communities in time for commencing research.
- Allow sufficient time for interviews, and be prepared to extend interviews to two sessions. Follow the "two-hour rule of thumb" (THROT) emphasized by Tobias (see section 1.1). Normally a single session lasts 2–3 hours including the time it takes to review permission forms, and other details. We italicize "normally" because interview time required to conduct a complete interview can vary greatly. Take care to be sensitive to a participant's energy and patience, and always remember that the longer the interview, the greater the risk of excessive response burden for interviewees.
- TKHs who have a limited or no command of English require interpretation (see Collignon 2006, 277–278). For these individuals, completing a questionnaire-driven interview requires far greater time than interviews conducted in fluent English. Questionnaires and other survey instruments must be well pilot-tested with this in mind.
- There are many ways that an interviewer can get bogged down during an interview, resulting in an incomplete response to a survey questionnaire, and/or important topics not addressed or superficially addressed. Time management during the interview is crucial, and researchers experienced in social science interviewing know how to pace themselves and their questions in relation to the total time available. Nonetheless, subtly steering TKHs away from tangents and excessive detail on a given topic can be very tricky, especially when the cultural norm is not to interrupt speakers,

elders in particular.[80] One of the purposes of piloting questionnaires and other survey instruments is to determine whether they can be administered well, allowing time for TKHs to provide sufficient detail, in the 2–3 hour time period that should typify a single interview session.

- Allow sufficient time in the day to prepare for interviews (e.g., set up map biography base maps) and process those already conducted. Map biographies must be checked for errors, catalogued (along with data recording forms), and notes taken on the conduct of the interview, etc. Subsequent interviews must be lined up as well. All of this amounts to a great deal of work, meaning that it is unlikely a researcher will be able to complete more than two interviews per day.
- Some TK research designs require use of the ethnographic method. This entails researchers passing many hours socializing with community members and spending time with them on the land, water, and ice, participating actively in and observing harvesting activities in which TK is put to use. For this kind of research, TK is documented through participant observation and informal conversation with TKHs. The diary is the major data-recording medium. This is an extremely time-consuming methodology that research sponsors can rarely afford, especially if the research is conducted by consultants. Its primary benefit is that it provides PIs with a better understanding of the context in which TK is generated (e.g., the socio-economic and political aspects of community life that affect TK), and promotes a potentially more nuanced and sophisticated interpretation/analysis of the data. To respect time and budget constraints, survey methods involving interviews and questionnaires may be blended with ethnography so that PIs are directly exposed to TK through "country-living" experiences on weekends and other occasions when interviews are not being conducted.

80 As noted by Huntington (2000, 1271) with respect to the relationship between beluga whales and beavers, exploring tangents may be highly productive. "Discussions in one group interview suddenly turned to the increasing population of beaver in the region. I was caught off guard, and as I listened to the conversation, I wondered whether it was time to exercise the 'directive' part of the method. Seeing my confusion, one of the elders then explained why beaver were relevant to beluga: the beaver dam streams where some salmon spawn, reducing salmon habitat, and thus potentially affecting the abundance and distribution of the salmon on which beluga feed." Semi-directive interview methods are well suited for exploring tangents (Huntington 1998).

3.2 Interview space

Many researchers continue to conduct in-depth interviews with TKHs in their homes despite numerous problems with this practice.[81] Home interviews should be avoided wherever possible for the following reasons:

Arrange for adequate interview space (adequate space, lockable door, quiet, secure, etc.). Avoid home interviews.

- Family members or friends may be present who distract the TKH.
- Background noise from televisions, radios, phones, visitors, and pets may negatively affect audio recordings of the interview, complicating the work of transcribers and even rendering portions of the recordings inaudible.
- Households usually lack wall or table space required for map biography interviews.
- Interviewers have enough to manage during an interview without having to worry about the household environment and its potential contributions.
- The confidentiality of a TKH's interview cannot be protected if family members and friends are able to listen to the discussion.
- Some TKHs may be reluctant to discuss certain topics or share concerns with interviews with other people listening.

For researchers and TKHs to focus clearly on the subject manner, and to maximize the intellectual productivity of their time together, they need a comfortable, quiet interview space. Qualities of a good research space include:

- adequate wall and table space to use map biography base maps (if maps are being used);
- good lighting, preferably daylight for daytime interviews, and not fluorescent lights;
- a lockable door to prevent unwanted visitors;
- a quiet room, so that researchers and interviewees can understand one another and so that interviewers can record audio well;
- good security, because valuable research equipment (e.g., digital recorders) and data will be kept there for the duration of the interviews; and,
- easy access to washroom facilities.

81 We have a difference of opinion with some researchers on this point. They argue that interviews should be conducted in the spaces that offer TKHs the highest level of personal comfort, and that the unavoidable presence of others should be welcomed and accommodated. Requesting that TKHs conduct their interviews outside of their homes may well impose artificial research conditions but the entire research enterprise is an imposition at many levels. Household visits by researchers may function well for certain TK research methodologies (e.g., short structured questionnaires and some kinds of semi-directive interviews depending on the research topic).

3.3 Interview equipment and considerations

3.3.1 Writing implements

Having an adequate supply of appropriate pens and pencils is important, especially using the map biography method with conventional paper maps. There are several specific attributes for good community research writing implements. Key considerations include:

- For map biography method interviews, pens should be permanent ink, fine tipped markers (e.g., Staedtler Lumocolor permanent, 0.6mm line width), ideally in a selection of four colours (black, red, green, blue). Markers are easy to use and reduce risk of scoring or damaging paper in comparison to ballpoint pens. (See Tobias 2009, 215–216 and 400 for detailed discussion.)
- It is advisable to carry ballpoint pens and mechanical pencils as a backup, and to allow TKHs to indicate where to mark information on a map, should they wish to.[82]

3.3.2 Audio recording

Quality interview equipment is essential for any in-depth interviewing methodology.[83] Good equipment will provide crisp, clear recordings of even soft-spoken informants/respondents.[84] Quality, fully audible and intelligible recordings make it possible for transcribers to do their job properly, and some types of careful linguistic analysis of TK discourses demand quality recordings. Furthermore, quality recordings satisfy the "posterity principle" (see section 1.6) because they can be archived for the long term (depending on storage media) and easily edited for educational and other products.

Understand the attributes of digital recordings and how to decide on them.

Practice using digital recorders.

Make backups of digital files during data collection.

With the advent of digital recordings, the potential for data loss has become both greater and lesser than with analogue recording. On one hand, analogue cassette tapes were easy to label and safeguard in boxes, harder to misplace because of their relative size, and not particularly subject to complete loss of information. Digital data are somewhat trickier: storage devices are generally small, hard to label, and easier to lose track of; as well, data corruption or accidental overwriting can permanently delete digital recordings in an instant. On the other hand, digital media allow easy duplication of recordings, a difficult and time-consuming task with analogue recordings. To help avoid loss of digital information, redundant data storage should be

82 TKHs can hold pencils and use these to point to TK features. They should not hold any permanent markers or pens.

83 Informed consent methods (using consent forms or recordings) must clearly register an interviewee's consent to use a particular recording technology/method be it audio, video, interviewer note-taking, map biography, etc.

84 Examples include the Zoom H4n Handy Recorder or Tascam DR–08. Patt Larcombe (personal communication, 28 July 2014) recommends the use of clip-on microphones, one on the interviewer and one on the interviewee.

available in the data collection setting itself. The research methodology must include a protocol ensuring that digital recordings are backed up with great frequency, preferably after every interview.

For digital recording technology to work as intended, researchers and co-researchers should be properly trained and practiced in its use, and properly equipped with relevant computers and backup devices. Digital data concerning Inuvialuit TK should be archived immediately with the Joint Secretariat or some other co-management or Inuvialuit entity to create another level of data redundancy.

Lastly, PIs should understand differences in audio fidelity (which is a type of data resolution), digital file formats and file sizes so that they can make educated decisions about the formats and recording quality required for their research.[85]

3.4 Interview execution specifics

Research, interviewing and fieldwork constitute a craft with numerous elements, many of which are discussed by Tobias (2009), especially those related to documenting spatial knowledge using the map biography method. Some of these craft details include:

Interviewing is a craft that requires attention to numerous details, some technical, some interpersonal.

- Interviewers must know how to put TKHs at ease at the beginning and during an interview. Doing so includes not distracting TKHs with irritating interruptions, technologies, or an excessive number or research assistants and observers. (Using computer technologies during interviews is a particular concern in this regard—see section 4.6.)
- Researchers, not TKHs, hold the pen and mark features when documenting points, lines, polygons and alphanumeric codes on map biographies. (If a TKH wishes to indicate or mark a specific location on the map, s/he can be given a pencil, and then the feature marked in pen by the interviewer.)
- Pens used in recording TK features on map biographies should be carefully selected (see subsection 3.3.1).
- Colour ideally should not be used to record any information attribute in map biographies. It should only be used to help make recorded information more discernible (e.g., using different colours for points that are close together or overlapping areas).[86]

85 For most research purposes the popular mp3 file format, mono, 256kbps will provide sufficient audio recording quality while saving computer hard drive space. However, with digital memory capacity constantly becoming greater and less expensive, file size is likely to become less and less a consideration meriting attention.

86 This is advisable for several reasons: During interviewing switching pens can distract from the all important focus on the TKH. It is too easy for an interviewer to forget to switch pens, and difficult to spot or correct erroneous use of colours after information is marked. Colour blindness affects a large enough percentage of the population that it is quite possible that someone involved in the research may find distinguishing between and using colours problematic. As well, over the long-term ink colours can degrade, making it difficult to distinguish between them.

- All interviews should be audio-recorded using quality digital recording equipment (see subsection 3.3.2).[87]
- TKHs should be treated with respect at all times.

3.5 Managing interview products during fieldwork

Follow data management protocols scrupulously.

Data and other interview products, in the form of audio recordings, permission forms, post-interview reports, and map biographies will accumulate rapidly as community interviews proceed. Unless researchers are well organized, the collection of research products will degenerate into a disorganized mess that will complicate upcoming interviews and risk the loss of valuable data. Good organization is a sign of good research practices and experienced researchers.

In order to manage data and other research products, the PI must generate protocols. This should include standards for processing and archiving materials, including hard copy documents such as maps and permission forms, and digital data such as digital audio recordings, photographs, etc. (Digital data might be in the form of physical memory cards or stored data files.) Some researchers use custom-built map caddies to store base maps and map biographies during the community interview phase in addition to standard legal-size file cabinets.

An important feature of organized fieldwork is the creation of metadata, which are data about data. They include indexes to and descriptions of the data that make it possible for the PI and other researchers to organize, retrieve and analyze data. Typical metadata types include the TKH names, dates of birth, date and time of interviews, length of interviews, names of researchers and observers, locations of interviews, whether there were any deviations from the questionnaire or methodology, obvious errors in data recording during the interviews, and temporary locations of data (e.g., storage on a named external hard drive). Metadata also record ownership of the data, for example, a copyright symbol to the entity sponsoring the research (e.g., ©Joint Secretariat, 2015).[88]

87 Occasionally, interviewees are uncomfortable being recorded or even refuse the recording of their interview. Hopefully, public communications concerning the research, its public endorsement by community leaders, and explicit statements regarding confidentiality in the permission forms and other documents will have increased trust and comfort levels to the point where interviews can be recorded. Knowledge that copies of audio or video recordings will be provided to interviewees may encourage consent for recording. However, in cases where interviewees will not consent to recording (a situation likely to arise immediately prior to the commencement of the interview), interviewers should be prepared to take written or typed notes (e.g., in a research notebook). This amounts to multi-tasking for the interviewer and greatly increases his/her work load. It also has consequences for data quality such as the detail with which TK can be documented, whether accurate attribute data can be provided for spatial TK recorded on map biographies, etc. A worst-case scenario where large numbers of people refuse recording may indicate a serious distrust of the researcher, his/her sponsors, and even the community leadership that endorses the research. Moreover, distrust of the research invites strategic response bias, elevated response burden, and other problems. Research subject to such problems should not proceed.

88 Metadata should be linked explicitly to research and long-term data management protocols that relate to confidentiality, Intellectual Property and data ownership, third party access to data, etc.

3.6 Qualitative attributes of mapped information

To document spatial information using the map biography methodology (see section 2.3), TK features are marked on maps using points, lines, polygons (areas), and identifying alphanumeric codes. Features can have considerable qualitative descriptive information associated with them. For instance, marking a cabin might elicit a story of how it was built, with whom, its history, and when it has been used. Separated from the contextual, descriptive information, the location and feature code are worth much less.

Remember the importance of contextual, descriptive information provided when collecting map biography information, and transcribe it if budgets permit.

This information should be recorded using an audio-recording device.[89] Depending on research objectives, the audio recording may be used for a complete transcription of the dialogue between interviewers and TKHs, in which case the transcription comprises a major part of the research database and product.

Properly qualified people should be retained to transcribe audio recordings. These are usually people with specialized computer software, good typing skills, and the kind of research discipline required for endless hours of focused computer screen-time. Where TK research projects rely heavily on Aboriginal languages and where in-depth analysis and understanding of these languages is an important objective, Aboriginal and English-language portions of audio recordings will be transcribed. Clearly Aboriginal language experts are required for the Aboriginal component. Aboriginal language transcribers must know how to write in their own language and have experience with transcription and translation work. In general, they create both a word-for-word transcription of mother tongue narratives ("verbatim") and a "close" translation in English. This enables the PI and co-researchers to examine transcripts for terms, phrases, sentences and concepts that address specific TK research questions. However, this kind of in-depth language work can be extremely time-consuming and expensive, and must be planned carefully with budgetary and time constraints in mind.

89 Some researchers swear by video recording in addition to, or instead of, audio recording. The Inuvialuit Polar Bear Traditional Knowledge study (Joint Secretariat 2015) employed both audio and video recording technologies. While the video recordings assisted with the "posterity principle," and copies were returned to TKHs for their personal use, virtually none of them were used in data processing. (However, the PI responsible for data processing and report preparation did use a portion of one video recording to examine the cartographic literacy of one of the TKHs.) Transcribers generally do not work with video because transcription software is computer and audio based. Digital video also complicates data warehousing, due to the size of the storage media required, and because video formats seem to change relatively quickly. Furthermore, having to operate both audio and video recorders during an interview greatly increases the workload for interview personnel, thereby increasing the risk of technology failure, error, data loss, and the inhibiting of rapport. Finally, some argue that video recording is obtrusive and distracting to many TKHs, making the interviews proceed less naturally.

3.7 Method of remuneration

Tensions can arise in some communities with respect to the amount of money informants/respondents should be paid for interview honoraria and co-researcher wages. Furthermore, unbeknownst to the PI, resentments related to money may develop toward him or her, especially if the PI is viewed as controlling access to honoraria and wages, a scarce resource in many communities. Therefore, sponsoring research entities or community organizations that are supporting or collaborating in the research should assume responsibility for setting honoraria and co-researcher rates. Where possible, someone other than the PI should be assigned the task of paying research participants and co-researchers.[90]

> The PI should not be responsible for setting honoraria and wages, or paying research participants and co-researchers.

90 In general, university-based researchers manage their own project finances and must negotiate compensation directly with interviewees and co-researchers. Wherever possible, university researchers should transfer research funds to community partners (if they exist) for allocation, and seek their recommendations with respect to compensation levels. Obtaining information about compensation levels is a normal part of research budgeting.

4 Spatial Knowledge Documentation

While not all TK studies involve spatial data, many do (see section 2.2). When studies elicit spatial knowledge, several linked topics must be considered, including the way that spatial knowledge is culturally constituted by TKHs (see section 2.3), cartographic issues, choice of software, geospatial database design, and how to create desired information products (maps, reports, tables). If research seeking to document spatial information is designed by people who lack sufficient knowledge of these considerations, it is likely to produce mediocre results. Even the apparently simple task of choosing or creating base maps involves technical decisions that PIs without such knowledge may not realize they are making. Maps are so commonplace and apparently simple that it is easy for a neophyte to believe that knowing how to use a map to find a route or place means that it is easy to make one.

Currently, there are two general approaches to documenting TK spatial knowledge. The first, well-established conventional approach is to use paper maps to record information, then convert the information to digital format for mapping, analysis, and reporting. A second approach, with which some practitioners have been experimenting in the past few years, is to record information directly into computer datasets, either by collecting locations in the field using GPS units, or through direct-to-digital (DTD) methods, where mapping software and computers are used to record information during interview sessions.[91]

In this chapter, we focus first on conventional paper mapping (CPM) approaches. However, many of the basic concepts and considerations described are also pertinent to DTD, so readers are advised to review them even if they expect their projects will use DTD. Though we cover issues specific to DTD, we do not provide a thoroughgoing discussion of all considerations. We consider current DTD methods to be in the early stages of development. Current approaches have practical limitations that compromise good interviewing practices. DTD also introduces a host of technical considerations that can compromise information integrity if not handled very carefully. In our view, the costs of using DTD usually outweigh possible benefits. GPS can be useful if research can be structured to allow TKHs to record locations on the ground, but this is difficult or unfeasible for much TK research.

The authors recognize that some of the discussion in this chapter will make sense only to those with knowledge of mapping and geomatics. We hope that exposure to important considerations will help readers to know when to seek out expert advice and be able to ask the right questions if they are venturing into realms beyond their technical expertise.

91 In an earlier generation of studies, sometimes as an alternative to recording information directly on paper maps, clear plastic sheets ("overlays") were placed on top of paper maps, and spatial data were written on the overlays. All considerations that apply to paper mapping apply when using overlays. As well, special care needs to be taken to secure overlays on top of maps during interviews, and to record known locations on the overlays that can be used for georeferencing. This method is not discussed any further in this reference guide, as it is almost never used in current research.

4.1 Linking studies, spatial data creation, and outputs

A key first consideration when designing research that involves mapping spatial knowledge is always to plan for the entire process of converting the information collected into geospatial data and information products (composite community maps, thematic maps, spatial analyses, reports). For lack of budget or technical staff, projects will sometimes proceed with research involving maps without giving adequate thought to spatial data processing and other tasks required in later stages of the research.

> Always involve a geomatics specialist during design of research that includes mapping and management of spatial data.

Treating spatial data collection and processing as separate components is a poor decision. Research decisions as simple as establishing marking or coding conventions for paper maps can greatly affect the design of databases and the process of digitizing information (creating spatial data), and the associated effort and cost of executing these tasks. Often, a very small amount of input from a geomatics specialist to a PI during research design can circumvent such problems. If particular information products would be useful for meeting a project's objectives, the research design can be tweaked to support producing those products. At the same time, the PI's input on the objectives might help the geomatics specialist understand what is desired, and suggest other possibilities.

When using conventional paper mapping, another reason to integrate planning of spatial data collection and spatial data processing is that linking the two can improve both the research process and the digital dataset that is created:

- The research process can be improved because the process of digitizing effectively puts every feature on every map under a magnifying glass. If an interviewer is misinterpreting or deviating from the DCM, this will often be spotted during digitizing. For instance, a properly designed geospatial database will include rules that restrict how features can be coded. If a DCM specifies that a polar bear harvest site can only be recorded as a point, and an interviewer records it as an area, the GIS software will refuse to accept the marked coding. A PI informed of such an issue can speak to the interviewer and clarify how information is to be marked in future interviews.
- The digital dataset is improved because any ambiguities (to the digitizer) in data marked on maps can be referred to the interviewers for clarification. The interviewers are the front line staff, in the best position to understand what was meant when information was mapped. Conversely, the person digitizing is removed from interviewing, so interpretations or decisions regarding ambiguities are less likely to be correct than the original interviewer's.
- Communication between the PI, researchers, and technical team members helps to minimize the possibility of knowledge loss as information moves from the interview to digital formats and to information products such as maps, charts, tables, and reports.

4.2 Base mapping and base data

Data collection base maps must be chosen or created for TK research using the map biography method or related approaches that require mapping. Numerous matters come into play. The sections below are not exhaustive, but lay out some important elements.

4.2.1 Choice of map scale for research

Choice of an appropriate map scale or scales involves several key considerations. Careful thought must be given to the nature of the information being researched, appropriate map scales for collecting it, how map scale will affect interview demands both on TKHs and interviewers, and limitations imposed by a project's budget. Finding a scale that is both reasonable to elicit the desired information and reasonable in the amount of time and budget required for its use can be challenging.

Choose a map scale appropriate to the research objectives while balancing other considerations.

First, a review of basic terminology. Map scale refers to the relationship between a distance on a map page and the corresponding distance on the Earth's surface. This often is expressed as a ratio. For instance, if a map has a scale of 1:50,000, one centimetre on the page represents 50,000 centimetres (i.e., 50 metres) on the ground. The ratio can also be understood as a fraction; in this example, the map shows the Earth's surface scaled to one fifty-thousandth of its real size. Maps on which a distance on the map page represents a relatively large distance on the ground are referred to as small scale while those on which a unit represents a relatively small distance are referred to as large scale.[92] Small-scale maps show less detail than large-scale maps.

There are several key considerations when choosing map scale that relate to one another other.

- **Anticipated use of the information:** If information is to be used as part of a regional resource management and planning process, smaller scale maps where locations are accurate within a couple kilometres or more may be appropriate. On the other hand, if information is to be used for operational planning such as considering possible impacts of a proposed mine site, large scale maps where locations are accurate within 250 metres may be of greater value.
- **Nature of the information being documented:** If the research is seeking to explore broad, regional level patterns, such as caribou migration or changes in ice floes and leads, small-scale maps may be appropriate. If the research seeks to document specific locations, such as cabin locations or Arctic char spawning beds, larger scale maps may be a good choice.

92 This terminology is used because the scale, expressed as a fractional number, is smaller when a large distance is represented by a distance on a map, and larger when a small distance is represented. For instance, on a 1:20,000 scale map, a feature is represented as one twenty-thousandth (1/20,000) as big as it is in reality, while on a 1:1,000,000 scale map, a feature is represented as one one-millionth (1/1,000,000) as big; 1/20,000 is a larger number than 1/1,000,000.

- **Utility of maps for TKHs:** Smaller scale maps by their nature omit details about the landscape. If TKHs regularly use omitted details to orient themselves, they will have a hard time locating places.[93]
- **Response burden for TKHs:** A general principle of map-based research is larger scales = more maps = longer interviews. Longer interviews increase the response burden for TKHs, which must be kept reasonable (see section 1.3).
- **Availability of appropriate maps or base data:** Government issued base maps are available at standard scales, and may be outdated or lacking information TKHs require. Base datasets[94] of appropriate accuracy for a desired scale may be difficult to obtain (see subsection 4.2.5).
- **Research budget:** Choice of map scale must also respect the research budget. Larger map scales result in a cascading increase in this budget. Longer interviews will increase the cost of fieldwork unless sample size is reduced. Larger map scales mean that a given map covers less geographic area, so more maps will be required to cover a study area. In turn, this will mean that each interview is likely to produce more maps, which in turn will require more processing time and effort.

4.2.2 Mixed map scales

It may be appropriate to mix maps of different scales in a single study if the nature of the spatial knowledge and its anticipated uses vary. For instance, if a regional study of polar bears is conducted, smaller scale maps may be reasonable for capturing seasonal movement patterns, habitat and the like, while larger scale maps may be better for locations of maternity dens and other specific sites. In this example, mixing maps of two scales could reduce the amount of interview time required (reducing interviewer time during community research and response burden for TKHs), along with the time and financial budgets for map printing and data processing. Furthermore, differences in landscape characteristics across a study area may justify mixing map scales. For instance, one study (Joint Secretariat 2003, 11) noted that Inuvialuit had a hard time locating places on small scale (1:250,000) maps of the Mackenzie Delta because of the complexity of the islands and river channels, but that they were more comfortable using small scale maps along the coast and in the inland areas away from the Delta.

Mixing map scales creates its own set of problems that should be considered when deciding whether it is an appropriate approach:

93 While no research has methodically demonstrated the effects of map scale on the thoroughness of map-based TK research, there is general agreement among practitioners that in comparison to less detailed mapping, more detailed mapping prompts respondents to recall more features and allows them to locate them more accurately.

94 These are geospatial datasets that contain topographic information (e.g., water bodies, water lines, contours) and built environment information (e.g., roads, utility lines, communities) generally used to orient map readers.

- **Differing accuracy of mapping information:** When TK features are marked on maps at different scales, differences in the accuracy of their georeferencing are likely to vary more than when they are marked at the same scale.[95] As well, the increased level of detail on larger scale maps may cue TKHs differently than that on smaller scale maps, effectively contributing to differing responses even if questions are phrased identically. These issues of accuracy and consistency need to be documented and considered when data are put to use.
- **Practical challenges when interviewing:** In most studies, more than a single map will be required to cover the whole study area. When paper maps are of a single scale, the edges can be folded and lined up to create a continual map. When scales are mixed, this is unfeasible.

4.2.3 Projection and datum

One of the most basic decisions a cartographer makes when designing a map is what the map's projection should be. A map projection, technically, is the mathematical means through which locations on the Earth's surface (a flattened sphere, or spheroid) are transformed onto a two-dimensional plane (paper page or computer screen).[96]

Choose an appropriate map projection and datum for your research.

To generalize, map projections always involve some sort of distortion in one or more of three basic qualities–distance, direction, or area. Choice of projection is influenced by the size of the area to be mapped, and the importance of distance, direction, and area to intended map uses. As well, the most common projection used for existing data from government and other sources is often chosen to avoid having to convert data, and to make new data most readily compatible with existing data. For TK research, it is also important to consider the map projections most familiar to the study participants.

The most commonly used projection and datum in the ISR is Yukon Albers, NAD83.

A map projection must be chosen in conjunction with a datum. A datum is a set of known locations used to represent the Earth's spheroid or a part of it (i.e., the datum defines the shape of the "from" [Earth's surface], and the projection defines how to get from the "from" to the "to" [the flat page]). In North American mapping, the standard datum used earlier in the last century is North American Datum 1927 (or NAD27 for short). This was replaced by a revised, more accurate version in 1983 (NAD83). With advances in satellite positional measurement and other technologies, more precise variations on NAD83 are now available.[97]

95 In an ideal sense, positional accuracy of locations marked on maps with identical scales should be identical. However, TK research is unlikely to approach this ideal. Although, to the knowledge of the authors, no research methodically examining the subject has been published on the subject, accuracy in map-based TK research is almost certain to vary between different TKHs (and interviewers) because of factors such as the TKH's eyesight, map reading skill, memory, and personal attention to detail.

96 You can imagine this process as like taking a large piece of orange peel and trying to flatten it.

97 The current Canadian standard used for mapping is NAD83(CSRS) ("Canadian Spatial Reference System"). This provides accuracy likely much higher than will ever be required for TK research. We mention datum because a project that compares current information with historic information might involve historic maps in NAD27.

The projection and datum most commonly used for research in the ISR are Yukon Albers, NAD83. These are appropriate choices for most TK research.[98]

4.2.4 Map series and coverage of study area

Unless the study area or map scale are very small, a study will require multiple maps to cover the study area. All the individual maps that together cover a study area are called a *map series*. There are several attributes of a good map series for TK research, including:

Define the map series to cover the whole study area.

Avoid ad hoc mapping.

- Maps in a series should never be created on an ad hoc basis. If a map series is not defined methodically, the research risks having maps overlap, or leaving unintended gaps in coverage of the study area. Overlapping maps are difficult to align during interviewing; problems with alignment can result in errors in information recording.[99]
- It is best to consider, during study design, not only the whole area for the current study, but the possibility of similar or follow-up future research outside this area. With this in mind, a grid of maps should be defined to cover the whole potential future study area seamlessly.
- As much as possible (in light of anticipated map scale and paper map size), the series grid lines should be placed so that areas likely to have much information recorded are not broken into multiple maps. This spares the research team extra work aligning abutting maps during interviews.)

4.2.5 Base features

While it is universal to map water lines and water bodies, other base features may be required for TKHs to find locations. The base features required will vary depending on the particular research topic. For instance, research on particular species might require vegetation or topographic information that relate to habitat. The choice of what contour interval to use on the base maps may be a function of the research subject. For example, trail mapping may require inland contours at a particular interval, while coastal mapping of polar bear sites might more appropriately use a smaller contour interval close to sea level and a larger one inland. (This would give a fine sense of detail at the coast, but only a coarse sense of larger hills and mountains inland.)

Choose base features in consultation with knowledgeable community members, and pretest maps to make certain content allows TKHs find locations related to the research topic.

98 It should be noted that mapping software often defaults to using the projection of the first dataset added to a map, or to a numeric grid of latitude and longitude values. **The latter is a particularly bad choice for northern regions like the ISR**, and will result in distorted maps.

99 One previous study in the ISR that the authors reviewed used this approach. It resulted in gaps between maps and problems in information recording where maps were not aligned properly during an interview.

Ideally, knowledgeable individuals who understand features that community members use for orienting themselves and wayfinding should be shown draft base maps so they can suggest additional base features. Logging roads, seismic cut-lines, and groomed snowmobile trails are examples of recent base features that could be added to base maps in order to facilitate the accurate identification of TK and use-and-occupancy features by TKHs. As well, maps should be tested during methodology pre-testing (see section 2.6) and revised as required.[100] This pre-testing phase also allows the research team to identify extraneous information or clutter that is likely to frustrate base map reading so it can be removed before the main data-collection phase commences.

Spatial accuracy of base features from government datasets is often provided as a series of metadata elements stating how far locations may vary from their true positions. (It is also fairly commonplace for data suppliers to provide a nominal indication of accuracy as a simple original map scale value—for example, "Original data collection scale 1:50,000"—to indicate that the data can be used at this scale without noticeable accuracy problems, although this is only an implied statement of accuracy.) Accuracy of base features should always be reasonably matched to the chosen map scale.[101]

4.2.6 Registration points

The first step in creating digital data from maps is to "georeference" them.[102] Georeferencing a map involves establishing an association between locations on the map and geographic space. To georeference a map, point locations on the map with known locations on the ground are entered into the software (see subsection 4.4.4).

Include enough known spatial reference points ("tics") on base maps to permit georeferencing and resolve image distortion.

Some previous studies the authors have reviewed, both in the ISR and elsewhere, have been problematic because the technical need for georeferencing was not adequately considered when base maps were being designed.

To facilitate georeferencing, a suitable number of known reference points ("tics") should be included on base maps so maps can be easily georeferenced. In general, including a large number of points spread across the map provides technical staff greatest flexibility to deal with issues that can arise (damage to the map, image distortion, etc.) A grid of small cross marks at around every 10 centimetres of map page distance is ideal.

100 Of course, base features that can be provided are a function of base data availability. Desired features may not always be available.

101 In general, the nominally accurate scale for base data should be equal to or greater than the base map scale. For instance, it is reasonable to use data nominally accurate at 1:50,000 scale in 1:100,000 maps, but not appropriate to use data nominally accurate at 1:250,000 scale in 1:100,000 scale maps. However, caution also should be exercised if a map of a particular scale is to incorporate base data with a much higher nominally accurate scale. It may be necessary to generalize the accurate data (i.e., remove fine detail) to make them legible on the map.

102 Formerly, physical maps or overlays were georeferenced by attaching them to an electronic table called a "digitizing tablet", but modern georeferencing almost always involves creating a raster image of a map and then georeferencing the image (i.e., "heads-up" or automated digitizing). In this subsection, "maps" means both physical maps and map images.

4.2.7 Place-names (toponyms)

Place-names (or "toponyms") aid TKHs in translating their land use experience into the two-dimensional world of the map. They help TKHs orient themselves on the base maps in relation to hydrological and landform features and zero in on specific locations, making it faster and easier for them during interviews.

Provide enough place names on maps to make it easy for TKHs to find locations.

Toponyms appropriate to the study's subject matter should be included on the map. These should include not only official names, but also unofficial, commonly used ones and Inuvialuktun names. If useful for study participants, toponyms should be multilingual.

4.2.8 Metadata

Every map should include information on a number of attributes, some of which have been documented in this section. The map should include text with the following information:

Include metadata such as map projection, scale, and data sources on each map, and space for information about the interview in which the map is used.

- map projection and datum;
- scale (both as a representative fraction and as a scale bar);
- north arrow;
- legend; and,
- data sources and dates.

As well, include labelled spaces where information about the interview in which the map is used can be written:

- participant (TKH) identification number;
- participant name and signature;
- map number;
- total number of maps upon which data were recorded;
- interviewer;
- interview date(s); and,
- inventory control number.[103]

103 This is a unique alphanumeric code assigned to each completed biomap to allow it to be identified quickly. It aids tracking research materials (see subsection 5.1.1).

4.2.9 Printing maps

Base maps are printed on large format plotters. For these, there are two paper types: bond and coated. Coated paper (called "glossy" paper) has a clay-based coating applied to the surface. It is generally more expensive than bond (uncoated) paper. Coated paper should not be used for research base maps. The coating resists marking from permanent markers and can seriously impede data collection.

Do not print base maps on coated paper.

Care should also be taken to test the paper to make certain it will work well with the pens chosen for data collection (see subsection 3.3.1). For instance, some paper grades, especially those of lower weight, can absorb too much ink and "bleed", making it more difficult to read what was marked.

4.3 Data-marking conventions

In general, TK features are mapped using points, lines, and areas (which are also commonly referred to as "polygons"). Which of these should be used depends upon the nature of the information,[104] research objectives, and future uses of the data. Points and lines generally provide the greatest degree of accuracy and precision and may be used to document the location of raptor nests, polar bear maternity dens, otter slides, fish spawning locations, salt licks, river crossings for migratory caribou, fresh water mussel beds, and other discrete features. Using polygons, especially large "sausage and blob" ones, to document TK features is somewhat problematic; concerns have been expressed about their credibility and validity (Tobias 2009, 384–385).[105] Nonetheless, when used properly, they are useful for certain types of TK research. For example, they have been used when research objectives required mapping of waterfowl staging areas, moose wintering yards, caribou calving grounds, large rookeries, concentrated plant communities, and other large feature habitat and ecological features. Moreover, certain types of analysis such as those undertaken by conservation biologists when modeling habitat suitability can make good use of large polygons even when inscribed on relatively small-scale maps (e.g., 1:250,000).

Use methodical, consistent, and well-documented standards for marking TK information on maps.

104 For instance, indications of direction and travel routes are most often represented using lines; features that cover a relatively small, discrete location on a map using points; features that cover relatively large areas of a map using polygons. As well, a particular information category can be amenable to more than one type of representation.

105 In the pioneering days of use-and-occupancy research in Canada, large and smoothly-edged polygons often were used to document harvest locations. However, as the map biography method progressed in the context of land claims negotiations and land rights litigation, the use of large polygons was discouraged because of concerns about their credibility and validity (Tobias 2009, 384–385). They remain in use in Alaska, where land rights issues largely have been resolved through the Alaska Native Claims Settlement Act. There, they are primarily used in the context of mapping community subsistence harvest areas for harvest level monitoring and environmental impact assessment (see Fall 1990; Stephen R. Braund & Associates 2010).

Spatial components of TK should be marked on paper base maps using a methodical, consistent, and well-documented set of standards. A well-considered approach is described by Tobias (2009, 226–255). In general, standards need to be straightforward and easy to use in the field, minimize the amount of time required to record information, avoid the possibility of ambiguity, and anchor mapped information to interview transcripts and other interview records.[106]

4.4 Creating geospatial data from paper maps

Creating a geospatial dataset and using it involves a number of steps and associated decisions, including: choosing mapping software; designing a database; converting paper map biographies to digital imagery; georeferencing the images; digitizing information; and checking data quality. This section discusses some considerations for each step.

4.4.1 Choosing mapping software

There are many mapping software options available for creating maps and processing spatial data.[107] Software packages have greatly differing capabilities and costs.

Choosing software for a research project is often a matter of defaulting to software that is already familiar or available to the research team or study sponsor. If this is not the case, a research team is likely to focus on the immediate needs of the study and the software

Choose mapping software that is compatible with existing datasets, supports widely used data standards, and is likely to have longevity.

106 When research objectives require the use of large polygons, we recommend that these polygons be drawn as small as possible using the method recommended by Tobias (2009, 245–247) with respect to marking trapping areas. Here, a TKH is asked a series of questions to identify carefully where he has seen evidence of a given species (eye-witness observation of the live animal or plant, tracks, scat, seed, etc.). Using a pencil, the interviewer inscribes a check mark √ on the map biography base map at each location where the species was observed. If the species was not observed at a particular location, the interviewer inscribes an 'x' at that location. The TKH is asked repeatedly about locations on the map where he has seen the species until the interviewer senses that the pattern of check marks √ and 'x's on the map delimits the geographical extent of the area where the species was observed. When the interviewer is satisfied that this area has been fully delimited, a marker line is drawn enclosing the check marks and excluding the 'x's to form a polygon. This polygon is coded with an alphanumeric code (subsequently linked to attribute information) and taken to represent the observed habitat of the species of interest.

107 The software discussed here is commonly referred to as *GIS (Geographic Information Systems) software* or *mapping software*. GIS are computer systems that store, manage, manipulate, analyze, and map spatial data. Mapping software provides a more limited capability to perform some of these tasks, and usually no analytical functions. Hence all GIS software is mapping software, but not all mapping software is GIS software. (Examples—GIS: ArcGIS, IDRISI, Manifold, QGIS; mapping software: ArcExplorer, Google Earth, Google Maps.) While we use the terms somewhat interchangeably in this document, and recognize that it is possible to use mapping software such as Google Earth for data collection and then transfer data to GIS for analysis and cartography, it is unlikely that a TK research project that collects spatial data can succeed without using GIS.

See GeoConnections (2010, 20–21) for a more detailed overview of considerations for choosing GIS software.

capabilities needed to satisfy them, and on software cost. While these approaches can result in good choices, they can also lead to longer-term problems.

Aside from the immediate functional needs of the research, three critical interrelated elements must be considered when choosing mapping software:

- **Compatibility with existing datasets:** The spatial data produced by the research must be understood to be a contribution to a larger and growing body of data in the ISR. If the chosen software produces a dataset incompatible with other datasets, this will hinder future use of the dataset.
- **Support of data standards:** The software must support common data standards used by government and other data providers. This will allow easy acquisition and use of base data.[108]
- **Longevity:** The software and the data standards it uses should be time tested, and likely to continue to be produced and supported in the future. In general, this principle points to well established and widely used software.

4.4.2 Spatial database design

Designing a spatial database is a technical exercise, but one that involves more subtle decisions than are apparent to a casual or occasional GIS user. Following a few general principles will help to avoid some of the common pitfalls:

- **Start with the end in mind:** A primary principle—and a good principle for all elements of research design—is to anticipate end use of TK information in the long term and design your database for it. Neophyte GIS users often focus on capturing what was marked on the maps, and perhaps on immediate reporting needs for the study. This can result in databases that are difficult to use.[109] As well, some consideration needs to be given to long-term use and how to support it.[110]
- **Embed metadata in the database:** It is good practice to include metadata (information about information) in the database.[111] For instance, if two-letter feature codes are used for recording information, while it might be clear to the research team what they mean, a later data user who was

108 The most universal data standard for GIS is shapefile. Shapefile was originally developed by ESRI, a major GIS software producer, but it is widely supported by other software. A second standard, ESRI geodatabase, is being used increasingly by government to distribute large datasets.

109 For instance, if a convention of feature code + sequence number is used for coding data, and this information is entered into a single database field, creating a simple query to select items with a list of codes involves a great deal more typing than if the feature code is stored separately from the sequence number. A study might use the code TN for tents, TF for tent-frames, and CB for cabins, resulting in a series of maps with alphanumeric codes such as TN14, TF18, CB209, etc. If these are recorded with the codes in column FCODE, a query to select them in ArcGIS would read "[FCODE] in ('TN', 'TF', 'CB')". If they are recorded in a column CODESEQ, a similar query would read "LEFT([FCODE],2)='TN' OR LEFT([FCODE],2)='TF' OR LEFT([FCODE],2)='CB'".

110 For instance, providing a place for additional attribute information that can be entered from interview transcripts later to facilitate searching, if this is anticipated to support a longer term research need.

111 Formal standards for geographic information metadata have been established by the International Organization for Standardization (see International Organization for Standardization 2014).

not involved in the original research may have to resort to looking their meanings up in a report, or worse, might mistake one for another and misinterpret the data. More recent database standards support embedding information of this nature in the database.[112] Metadata can also include summary text describing the project's goals, sampling, interviewing methods, and the like.[113]

- **Use database restrictions to avoid data errors:** Modern databases offer means of restricting valid values for fields. When these are used, it is easier to avoid data entry errors, for instance typos in codes.
- **Consider use with other datasets:** Unless the study stands alone and will never be used in combination with any other information, the design should take into account standards used in previous work. This should be understood both in technical terms[114] and more practical research design terms.[115]

4.4.3 Creating map images ("scanning")

While in the past digitizing involved carefully taping maps or overlays to a special electronic digitizing table, current practice almost always involves creating digital images of maps. The process of creating these images is called scanning.

112 The structures used are referred to as *domains*. A domain might record that the code "DE" has the meaning "denning area."

113 Even if older database formats are used, additional database columns can be provided to clarify meanings. For instance, a "Code Description" column might be added that gives a text description of a two letter code, e.g., "caribou" for "CB". While this approach violates an ideal principle of pure database design (normalization), it serves casual end users much better than entity relationship models.

114 For example, database formats should be compatible, and shared database columns should be defined identically [e.g., if a participant number is defined in previous datasets as a 4-digit number, it should not be defined in the new dataset as a 4-character text field].

115 E.g., it is good practice to reuse the same participant numbers used in previous studies rather than assigning new numbers: this means that when selecting information for a particular participant, there is no need to cross-reference his participant numbers for different studies.

Large format scanning hardware is specialized equipment, both expensive to purchase and expensive to maintain. Unless the study proponent has access to a large format scanner and staff to run it, the research budget should include funds for scanning maps by an outside graphic services provider.[116]

4.4.4 Georeferencing

Before data from a map image can be digitized, the image must be positioned in geographic space using the GIS software.

Check image georeferencing by visually checking georeferenced images against original base data layers.

Georeferencing a scanned image involves entering a series of locations (registration points, or "tics") on the map image for which the geographic coordinates are known. The software uses these tics to place the map image in geographic space, interpolating locations between them. If images are distorted in some way (for instance, if the map was wrinkled), the GIS software also can stretch or compress the image between tics in a process called *rubbersheeting*.

The goal of georeferencing is to locate the image in geographic space accurately (relative to the original map scale). The best approach for checking accurate registration is to draw original base data layers on top of the registered image—most often water lines and water bodies are used—and visually check how they match the corresponding data on the map image. This should be done by viewing the image at the original map scale or larger.

116 A digital image is created by dividing the original image into a grid of rows and columns. Each cell in this grid is called a pixel. Scanning involves sampling the colour and saturation of each pixel. Digital images have two basic quality attributes—resolution and colour depth.

Resolution refers to how finely the grid is spaced, and is usually provided in dots per inch (dpi) or pixels per inch (ppi), which can be understood as meaning the same thing. 300dpi or greater is usually understood to be close to original quality, while smaller values result in loss of quality.

Colour depth refers to how much storage is allocated to record the colour and saturation of each pixel; this is measured in bits.

The higher the resolution and colour depth, the higher the quality of the image, but the bigger it is. wImages are usually compressed to save disk space. One kind of compression ("lossy") saves a great deal of space, but at the cost of reducing the quality of the uncompressed image. Another ("non-lossy") saves some space—though less than lossy—but does not reduce the original quality.

It is better to scan maps using high resolution values (300dpi, 24-bit colour) and receive images in formats that use non-lossy compression (e.g., TIFF, PNG) rather than lossy compression formats (JPG). High resolution images can be used as an archival backup for the original maps. Sometimes, these will be too large to be used easily in GIS software. In this case, smaller files or lower resolutions can be created from high resolution images.

4.4.5 Digitizing and checking quality

The actual process of digitizing mapped TK data is often understood as a straightforward exercise, but paying attention to a number of rules will make it more effective for supporting the overall research project and producing the best dataset. (Some of these rules overlap with and relate to database design.)

Establish and follow standards for good digitizing practices.

Link digitizing to the research.

- **Establish and follow standards:** Similar to drafting a good data collection manual, one of the best means of producing a consistent, high quality dataset is to establish a set of steps to be followed and quality standards.[117]
- **Do not degrade data quality:** Mapped data has a nominal accuracy that is sometimes referred to as the minimum mapping unit (MMU).[118] MMU recognizes that for any map, there is an intrinsic maximum positional accuracy.
- **Maintain links back to original data source:** No matter how perfect a data creation process and quality checking process, any large dataset might contain errors. If questions arise about any particular data element, it is very useful to have an attached reference to the original source that can expedite checking.
- **Be efficient:** Modern mapping software can automate mechanical data creation tasks, saving time, and helping to keep errors from creeping in. Learn to use such software functions.
- **Use formal quality assurance procedures:** Digitizing is a mechanical and repetitive task, and even the most attentive technician is likely to make an occasional error. A formal quality checking process should be followed to catch and correct any mistakes.
- **As much as possible, do not interpret information:** It is the job of the digitizing technician to, as much as possible, capture everything as originally marked on the maps. Where ambiguities are present or the interviewer apparently has departed from the DCM, the issues should be brought to the attention of the interviewer and PI so that decisions can be made. The technician should not infer what was intended.
- **Understand digitizing as part of the research effort:** By forcing close examination of the contents of each map, digitizing can aid in spotting inconsistencies between the directions in the DCM and information marked on maps. This can help the PI improve interviewing practices.

117 Furthermore, you must adhere scrupulously to your methodology and standards. The temptation to relax standards can be strong, especially when time is tight. If this occurs, data quality can be compromised. Documentation must mention that protocols were not always followed if this is the case.

118 For a discussion of MMU, see Nate Herold (2011).

4.5 Creating TK spatial data using GPS

In earlier sections, we discuss one approach for recording spatial TK locations that involves marking information on paper base maps and then scanning and digitizing the information. A second approach is to use global positioning system (GPS) units to record locations.

Use GPS for ground-truthing sites of very high value and priority or as one part of long term research programs.

GPS can provide information of far greater accuracy than any imaginable mapping approach. However, for most management and planning purposes, and even for most operational ones, the very high accuracy provided by GPS is much greater than will be required.

As well, GPS use requires that TKHs travel to each location so its coordinates can be recorded. If the TKH travels with a researcher, it will be prohibitively expensive because of travel time and costs except if the study area is very small. Because of the expense of using this approach, it should be reserved for "ground-truthing"[119] only sites of very high value and priority.

Another approach to using GPS for documenting TK locations is to use research protocols that allow TKHs to record locations while on the land or ice and then upload the information for mapping and analysis later. This has been used successfully for long-term programs where community monitors use GPS units with photographic and other recording capabilities to document observations. While some costs may be incurred for GPS units, training, and quality control, this approach can enhance community involvement in data collection.

It should be noted that since this approach relies on individual TKHs recording data during land-based activities, data are likely to be biased in favour of some areas and against others by numerous factors (e.g., weather and sea ice restrictions on travel, distances, terrain, fuel costs, personal motivations to travel to some locations, etc.). This must be taken into account in study design and reporting. As well, this approach is best suited to research that can be conducted over a considerable period of time, likely multiple years. However, it might be a valuable adjunct to other TK research approaches as part of an overall study design.

4.6 Using direct-to-digital methods for recording spatial TK

Recently, some practitioners have begun to experiment with entering information directly into spatial datasets, either using dedicated GIS software and computers in the interview room, or using online mapping software such as Google Earth.[120] This is seen as attractive because it might speed up how quickly data are ready once interviews are completed, and reduce some costs. As well, it is understood to have benefits such as avoiding the need to align map edges using conventional mapping, automating data coding, allowing base features or

119 I.e., verifying the exact location of a feature marked more approximately on a map or mentioned in an interview.

120 See subsection 4.4.1 for discussion differentiating GIS software and mapping software.

imagery to be turned on and off, and permitting fast and easy changes to the area being viewed on screen using panning and zooming.[121]

This section discusses some specific considerations introduced when using direct-to-digital (DTD) methods for recording spatial TK. While some of the preceding matters that apply to conventional paper mapping, such as providing registration points and attending to particular printing characteristics, are irrelevant when using DTD, many are still important. As well, DTD introduces a number of additional issues that do not come into play when using conventional mapping.

4.6.1 Preventing the technology from dictating the study methods

Because using direct-to-digital methods in a TK study involves entering information into a spatial database using some form of on-screen mapping, a spatial database must be put in place as a matter of course, and there must be some consideration of base data and associated matters discussed in section 4.2. However, mere design of a database that can support data collection will not necessarily result in one that will support preparing desired information products. Just as a PI using conventional paper maps should think about how the mapped information will become spatial data that support the research goals, a PI using DTD-based research should consider how the database will support the study objectives.

> Focus on the research goals when establishing DTD data collection protocols, not on what the software can do most easily.

Particular care must be taken to have the spatial database and DTD data collection protocols serve the research, and not to have the PI build the research instrument on the basis of what is most straightforward to implement using the computer software. Any recording medium imposes its own limitations on what can be recorded and what is easy to record, while providing its own set of benefits.

For instance:

- **Using a paper map:** *it is quick and easy* to draw a line on the map and label it with several attributes (e.g., caribou fall migration route; 1990–2000; mentioned by TKHs 14 and 15). However, *it is more difficult and time consuming* for an interviewer if that line crosses the edge of the map onto another, because the edges must be folded or trimmed and the maps lined up (taking time). Furthermore, *it is impossible* to have the map provide extra base data (e.g., if a TKH mentions a narrows where caribou cross that is too small to be shown at the map scale).
- **Using GIS:** *it will be slower or less accurate than pen and paper* to enter a line into the computer, and coding several attributes (caribou fall migration route; 1990–2000; TKHs 14 and 15) *is likely to be slower than pen and paper*. In addition, it may require a second researcher to handle data entry. On the other hand, *it is quick and easy* to pan the on-screen map if the line reaches the

121 One reviewer brought to our attention a hybrid approach using a digital paper and pen technology developed by the Swedish company Anoto Group AB. In this approach, information is marked on specially printed paper maps using a combined pen and digital camera. We expect this approach would be subject to some of the considerations specific to conventional mapping and others specific to DTD.

edge of the screen; and *it is possible* (if more detailed base data are available) to zoom the map to display landscape features in more detail.

Practically, a balance must be struck. While clever use of software can sometimes address limitations or difficulties using DTD, this approach will have costs as well as benefits. The PI should weigh these and decide whether the trade-offs are acceptable in light of the research goals.

4.6.2 Map scale considerations

One matter that needs to be given careful consideration when using direct-to-digital methods is the implications of the easy potential for recording information at mixed map scales. One of the attractions of using DTD is the ready ability of GIS and online mapping software to zoom to different scale levels, making it easier for TKHs to find locations. However, along with this comes an equally ready ability to record locations at different scale levels. Unless the software is forced to display base mapping at a single scale when information is entered, or great care is taken in using a single scale, accuracy of any spatial information can vary because the data collection scale is not fixed (see subsection 4.2.2).[122]

When using DTD, take care to consider implications of map scale.

Establish scale standards for recording TK information.

Paper maps by nature fix the map scale at one value. In contrast, mapping software (by default) does not restrict the scales at which any data can be displayed. It also does not take into account original base feature accuracy. This characteristic of DTD can easily lead to data being collected at a variety of scales, some inappropriate vis-à-vis the accuracy of the base data used.[123]

A community dataset where information has been collected using on screen mapping zoomed to a variety of different scales will have heterogeneous accuracy that must be documented and taken into account when it is used.[124]

Because of the foregoing, when DTD methods are used, it is best to establish explicit screen display scale limits for recording information. This can be as simple as a directive that location information will not be recorded at a scale smaller than a given value. Other solutions are possible. Some GIS software will permit setting up one

122 It should never be forgotten that any piece of spatial information has an associated level of accuracy. For both paper and on-screen maps, information displayed at a smaller scale is intrinsically less accurate than information displayed at a larger one. For instance, a 0.5 millimetre dot on a paper map or screen showing base data at 1:1,000,000 scale covers an area 500 metres in diameter, while the same dot shown at 1:50,000 scale covers an area 25 metres in diameter.

123 For instance, if a DTD-based research project sets up base information using data nominally accurate at 1:250,000 scale, GIS and online mapping software will readily display it at 1:25,000 scale or 1:2,500 scale without warning, even though this is well beyond its accuracy. Any TK information recorded with reference to it could not be considered as accurate as the display scale.

This is similar to photo-enlarging 1:250,000 paper maps to twice the size of the originals and recording information on it. The new maps will have no more accuracy than the originals, even though the map scale is now 1:125,000.

124 This is in addition to any variation in accuracy resulting from differences in TKHs' eyesight, map reading ability, and the like.

map view window that displays information at a fixed scale, and a second that permits the scale to be varied so that a map can be zoomed to allow navigation around a study area. It may also be possible to have the software record the scale at which each TK location was digitized.[125]

4.6.3 Image quality considerations and cartographic symbolization

When using DTD, symbolize base features to take into account limitations of computer screens.

The image quality of printed maps far exceeds the image quality any standard computer screen or projector can display. A single pixel, or dot, on an average computer screen is around three times larger than a dot printed at standard printer resolution (300dpi). This means an area on a printed map will have over nine times the number of dots as an area of the same size on a screen will have pixels. As well, the nature of screen display technologies makes them less capable of rendering colours and colour saturation as subtly as printers can, using ink. In short, when compared to printed maps, maps displayed on screen are almost certain to be relatively blurry and imprecise.

The differences in image quality must be taken into account when designing data collection maps for on-screen display. In general, symbols must rely on more dramatic differences in sizes than those used for paper maps, and sizes should be chosen that respect the capabilities and limitations of the screen.[126] Additionally, colours[127] should be chosen that contrast well on a display. It may also be necessary to limit the number of base feature types (see subsections 4.2.5 and 4.6.5) more than if paper maps were being used to make the map easy to read for TKHs.

4.6.4 Projection and datum considerations

As with conventional paper maps, care should be taken to choose an appropriate projection and datum for DTD on screen map images. All full-featured GIS software should support almost any imaginable projection and datum desired. Considerations are similar to those discussed earlier (see subsection 4.2.3). Software

125 It should be noted that scale is a particular problem if using Google Earth. Google Earth does not provide a scale value, but rather an "eye altitude" value, which is represented as the number of metres above the ground the viewer's eyes are. This can be converted to a scale ratio, but the calculation involves taking into account screen size, the number of pixels being displayed, and the distance above sea level for the location (because the eye altitude value is with reference to sea level, not ground). Additionally, if the display is set to "tilt", the nominal scale will vary from the top of the screen to the bottom. As well, the projection used in Google Earth results in accuracy at larger eye altitude values (i.e., further above the surface) varying between the centre of the screen and the edges. (See subsection 4.6.3.)

126 For instance, the published standards for contours on Canadian National Topographic Series 1:50,000 maps specify that index contours should be symbolized with 0.18mm lines, and intermediate contours with 0.10mm lines, both with a minimum distance of 0.20mm between contours (see Charbonneau et. al 2014). However, a single dot on even a small, high resolution screen (1920x1080 pixels, 15 inches diagonal) is 0.17mm, and one on a larger screen (1920x1080 pixels, 22 inches diagonal) is over 0.25mm. (That is, a single screen pixel has a much larger diameter than the specified line width for an intermediate contour.) Neither screen could display lines symbolized following the specifications to allow one to be differentiated from the other.

127 I.e., combinations of hue (the wavelength), saturation (intensity), and value (lightness).

often defaults to using the projection of the first data added, or to using grid latitude and longitude. Care should be taken to make an explicit and well-considered choice.

Projection and datum are more problematic when using online mapping software such as Google Maps or Google Earth. Google Maps apparently uses Mercator projection, which has considerable distortion approaching the poles, and is inappropriate for use in the ISR. Projection is a particular problem if using Google Earth. To our knowledge, the details of the Google Earth projection have not been published, though there is online discussion and speculation on its characteristics.[128]

4.6.5 Base feature considerations

As discussed previously (see subsection 4.6.2), DTD allows mapped information from TKHs to be input at a variety of scales. With this capability comes the need to provide base features accurate at the scale ranges the research intends to use. This might involve securing base datasets at more than one level of accuracy, or generalizing more accurate datasets for use at smaller scales.

Special care should be taken when using satellite imagery or aerial photographs (which we will refer to here generically as "imagery"):[129]

- Some researchers naively believe that imagery provides a sort of objectively true view of the Earth's surface. However, imagery is often subject to digital enhancement that emphasizes some landscape features over others. As well, un-interpreted imagery will, by its very nature, make some features more visible than others.
- Imagery is a snapshot of a location at a particular moment in time. Obviously, landscape changes after the image was created will not be present.
- Imagery may bias the responses of TKHs to questions. For instance, if questions are asked about habitat and activities in an area where a resource extraction project has altered lake and stream features, TKHs may have difficulty locating fish harvest sites that pre-date the project because imagery does not show the former lakes and streams. Alternatively, if the community has expressed concerns about project impacts on fish habitat, study critics may discount the validity of TKH information on the basis that the visibility of the project site in imagery focuses attention on the site and biases responses.

128 Google states that Google Earth uses Simple Cylindrical (Plate Carree) projection with a WGS84 datum for its imagery base ("Google Earth Projection" n.d.), but this is not what is used on screen. It apparently uses a general perspective azimuthal projection with an unknown projection centrum ("Map Projections: Azimuthal Projections" n.d.; "projection for google earth" n.d.). In light of this lack of concrete information, care should be taken to take into account possible inaccuracy when using locations recorded with this software.

129 Imagery is a particular concern using Google Maps and Google Earth. These stitch together a wide variety of images from a multitude of sources, with varying degrees of accuracy, created at various times. Image quality in remote, sparsely populated areas such as ISR generally is worse than in densely populated urban areas. As well, since images are being updated regularly, there is no guarantee that after the study TK locations will be viewable against the image the TKH saw during the interview.

4.6.6 Data recording and quality control

Recording information using DTD has the potential both to reduce the potential for errors and to increase it:

When using DTD, build rules and functionality into databases and data entry forms to help reduce interviewer errors.

- It is straightforward for an interviewer to write ad hoc explanatory notes about particular features directly onto paper maps to provide clarification or additional information. This is generally more difficult using DTD, and usually requires that special provision be made while writing the data recording methodology and designing the database.
- Paper mapping provides a concrete, permanent way to record information. In some respects, it is easier to spot errors and understand how they occurred than when using DTD.[130]
- DTD data recording can be set up to include rules to reduce the chance of errors being made.[131] In contract, it is more difficult to establish similar rules or guidelines using paper maps.
- DTD data entry forms can be set up to provide cues that help interviewers enter information correctly. There is far less potential for providing similar interviewer assistance using paper maps and interview guides.[132]
- DTD can be set up to record additional information such as timestamps (the exact date and time the feature was entered). This has the potential of allowing more precise linking of mapped TK features to interview records such as audio recordings and time-coded transcripts.

No matter what the choice of mapping software, it is unlikely to provide most of the ways of reducing errors described above without some customization. It will require careful thought and some programming effort to build data recording rules and forms that maximize data quality when using DTD.

130 For instance, a code might be handwritten sloppily so that it appears to read "CD" instead of "CP". If no "CD" code is defined in the study methodology it should be flagged as an issue. The original map or digital image might provide evidence for what was intended—apparent sloppiness in the handwriting, colour of ink compared to proximate features coded "CP", feature number if part of a sequence of numbers where codes are "CP". In contrast, if using DTD a code is typed or selected as "CO" instead of "CP", there will be no such evidence.

131 Continuing with the previous example, if a data entry form is set up to allow only valid codes to be selected, there will be less chance of an erroneous "CD" code being entered. See also subsection 4.4.2 on database domains and metadata.

132 For instance, more intuitive descriptions can be included on a form (e.g., "CA-caribou harvest site"), along with icons depicting the information category (e.g., a caribou symbol), reducing the chance that an interviewer mistakenly uses the wrong code.

4.6.7 Metadata

Record metadata in DTD databases and associated documentation.

As discussed in subsection 4.2.8, it is good practice to include information about a number of attributes on paper maps, including map projection and datum, scale, legend, and data sources, and to provide space to record other information such as the TKH's identification number and name, and interview date. Including these metadata gives future users of the information easy access to them so it will not be necessary to look them up in a separate report. Subsection 4.4.2 mentions that modern geospatial databases provide locations in which metadata can be recorded.

For the same reasons as when using paper maps, metadata should be recorded in DTD databases—as much as the database used supports this—and in other documentation bundled with the databases.[133] This is all the more important using DTD because future data users do not have recourse to original study maps that could help clarify these details.

4.6.8 Protecting information and creating an enduring record

Digital datasets are simultaneously less and more subject to degradation and loss than paper records. This arises from the fundamental nature of each medium. Digital data can be replicated, and copies can be transmitted to various physical locations very quickly and easily. If one copy is damaged, others can be used. At the same time, when digital storage devices are damaged or malfunction, data most often are completely and irretrievably lost. In contrast, it requires time, effort and cost to replicate paper records, and transporting and storing them at different locations also is costly. At the same time, most types of damage other than catastrophic loss by fire, flood, or accidental destruction, will result in little or partial information loss.[134]

When using DTD, take care to protect equipment and save regularly while interviewing.

Copy digital media regularly and methodically while interviews are being conducted.

- While community interviews are being conducted, data recorded on digital media are much more subject to loss—as a result of technology failure or human error—than information recorded on paper maps. To avoid this, when using DTD special care should be taken to save data regularly during interviews, to back up and protect media regularly during the study, to use electrical power protection, and to take care to protect equipment. Of course, care must be taken to protect maps and other physical records during conventional mapping, but good practices should be more intuitively obvious and easy to follow than with digital media.

133 This is easy to forget, and not likely to be noticed by study team members responsible for producing information products, for whom these details most likely will be known.

134 For instance, a cup of coffee spilled on a map will result in a coffee stain that might make information difficult to read, while a cup of coffee spilled on a computer could result in a completely non-functional computer, with all data recorded from the last save operation lost, or worse.

- Once interviews are completed, datasets should be copied, and duplicates stored at different physical locations or in secured data storage facilities such as cloud storage (see subsection 5.3.4).

- Paper maps retain the relationship between base data that TKHs use to orient themselves (e.g., roads, water bodies, etc.) and the TK locations they provide. In contrast, DTD base features are logically separated from recorded TK locations, making it more likely that the link between them will be broken later on. To help avoid this, at the conclusion of an interview it is a good practice to create a PDF or image file containing the information provided by each TKH. For instance, digital TK locations can be overlaid on base data along with attribute codes to create a PDF map document. This provides a snapshot of the recorded information that can complement the dataset. If a physical record of the interview is desirable, this may be printed and signed by the TKH and interviewer.

When using DTD, create digital snapshots of TK information documented during each interview.

- Paper mapping is relatively durable and robust. If it degrades (through paper yellowing, ink fading, etc.), losses of information are normally gradual. This makes it amenable for long-term storage as a part of a community's historical record. In contrast, digital data standards are subject to evolution and obsolescence (see subsection 5.3.5). Software and hardware standards change over time. Support of and compatibility with aging standards is not guaranteed. To preclude information loss of this nature, it is good to keep data in use and to create replicated versions using dominant and widely supported standards.[135]

4.6.9 Facilitating good interview rapport

One concern with using computer technologies during interviewing is that it can interfere with establishing rapport and putting TKHs at ease (see section 3.4).

Make certain that DTD information recording does not distract from good rapport between interviewers and TKHs.

- A researcher's focus on the TKH can be reduced considerably when conducting an interview while also operating a computer (compared to using pens and paper maps) unless the computer data entry methods are carefully designed.

- When using computer screens or projectors, interviewers and TKHs may reduce face-to-face interaction in favour of focusing on the computer screen. Reduced face-to-face interaction decreases opportunities for making eye contact, paying attention to non-verbal communication, and other interviewing practices that facilitate conversation that is so critical to a successful and fruitful interview.

- If a second researcher is tasked with computer data entry and other computer tasks, the TKH may be distracted by the associated keyboard, mouse and other activities.

135 This applies particularly if using non-commercial open source software.

- Unless the computer data entry procedure is highly streamlined, DTD can slow the recording of each TK observation.[136]

Care should be taken to ensure that DTD information recording procedures are designed to minimize their obtrusiveness in the interview.

136 DTD projects we have reviewed sometimes require several steps to record a location, e.g., choose observation type; click mouse at location; right-click to open data entry form; tab through several data entry items selecting attributes or typing information; press OK button to complete record. If the TKH must wait 30 seconds or more after indicating where a site is so a researcher can record it using a computer, and only a few seconds during a paper map based interview, it is clear that amount of information that can be recorded using the computer in an interview timeslot may be substantially less than using a paper map.

5 Post-Study Data Management

TK research products—permission forms, field reports, maps, audio and video tapes or digital memory sticks, computer storage devices and the like—are valuable assets for the community. There are several reasons they should be safeguarded:

- The research was done at a cost in time and money to pay researchers, TKHs, and administrators.
- The research products were created using the valuable time of the community members who provided their knowledge of the land, water and ice and their activities there. It would be disrespectful not to store them carefully.
- The research products are part of the historic community record.
- If questions arise about transcripts, digital data, and other research products, it might become valuable to review the originals.
- If the information ever is used in court, it might be necessary to enter original maps and other items into evidence.

Research proponents and researchers most often do not consider how research products and data will be stored and managed once the research is completed. This is easy to understand. The focus of the project is on getting the research done and the knowledge products finished so the research objectives can be met.

However, without a plan, when boxes of maps and other items arrive in the mail, they might end up at the back of a storage room, stacked in a corner, or beside a furnace or water heater. This can lead to damage. It can also lead to accidental loss by staff who discard the boxes without knowing of their contents and value.

It is important to put a plan in place for how research materials and products will be stored, managed, and tracked. This does not have to be costly or complicated, but it should be known by anyone who might come into contact with the maps and items.

5.1 Management protocols and procedures

5.1.1 Material tracking

In some organizations, maps and other research products have a tendency to go missing. For instance, an enthusiastic community leader might pull out maps to show colleagues at a meeting, and then forget to return them. Or someone might walk into a storage area, see a portable hard disk, and take it to use for a task, not knowing that it contains distilled research product from a $250,000 project.

This sort of problem is easy to avoid if three simple practices are followed:

1. A staff member of the responsible sponsor organization must be formally assigned responsibility for the research materials.[137]
2. Before any map or item is moved out of storage, the person responsible for managing these must be contacted.
3. If any map or other item is moved out of storage, it should be signed out on paper. It should be signed back in when it is returned.[138]

ASSIGN RESPONSIBILITY FOR RESEARCH MATERIALS TO SOMEONE, AND INSIST ON A SYSTEM OF TRACKING WHENEVER ANYTHING IS REMOVED FROM STORAGE UNTIL IT IS RETURNED.

5.1.2 Confidentiality

A second challenge some organizations face is keeping information appropriately confidential. Almost all TK research is conducted under the umbrella of a confidentiality resolution or assurance that specifies who will have access to information and for what purposes, and a consent form signed by the TKH agreeing to release of her/his information as specified in the confidentiality resolution (see Tobias 2009, 152).

CONFIDENTIALITY SHOULD BE MAINTAINED BY INSISTING ON WRITTEN AGREEMENTS AFFIRMING IT.

INFORMATION SHOULD BE STORED ON SECURE, PASSWORD PROTECTED COMPUTERS.

As we all know, digital data is very easy to copy and share. The authors are aware of organizations where confidentiality has been violated. While most of the time this has caused little damage to the study participants, every breach is very important because it can damage the credibility of the organization and the culture of research of the community.

The following steps should be taken to avoid this situation:

1. Anyone who works with the TK data should sign a written agreement affirming that he or she understands the confidential nature of the information and will not release it in any form to unauthorized parties.
2. Information should be stored on secure computers/devices (password protected, and not publicly accessible).

137 This responsibility must be passed to successors, which can be a challenge when there is high staff turnover.

138 These are standard, well-accepted library/archive practices.

5.2 Storage and handling of research materials

Research materials are important community assets. They should be stored carefully so they are not damaged.

5.2.1 Paper documents

Storing paper documents created during research involves following a few straightforward rules:

- Store the documents flat, away from light sources and sources of moisture.
- Assure that temperature and humidity in the document storage area are moderate and do not vary greatly.
- Do not use rubber bands or metal paper clips to hold pages together. Instead, use file folders or sleeves.
- Wash your hands before you handle the documents.
- Handle the documents as little as possible.

5.2.2 Maps

Ideally, maps created during research should be stored unrolled and lying flat in dedicated and locked map cabinets. Care should be taken to follow widely published standards for archival storage of paper documents (store away from light sources, in an environment with moderate relative humidity and temperature, etc.).

However, for the maps produced during TK research, this requires large, expensive cabinets or custom built boxes that often are prohibitively expensive, or for which space is not available.

A second alternative is to store maps rolled. While this is not ideal, if necessary it can be handled in a way that causes minimal damage.

Store maps flat, or carefully rolled (if necessary) in areas where temperature and humidity can be kept moderate.

Do not hang original maps.

The main problems with storing maps rolled are:

- They curl in the direction of the roll, making handling them more difficult.
- Accessing a map or maps requires unpacking and unrolling, then re-rolling and repacking; this is hard on the maps if done frequently.
- Boxed map rolls are nondescript, and more likely to be lost or thrown out by mistake.

However, boxed rolls offer advantages:

- They are compact in comparison to flat storage.
- They are relatively easy to relocate if necessary.

- Boxed rolls provide the maps some protection from light, humidity, and temperature changes.

If you choose to store your maps rolled:

1. Make certain to label the boxes prominently with their contents and "DO NOT THROW OUT" or similar words.
2. It is useful to roll the maps face out, as it makes it easier to flatten them later when they are unrolled.
3. To keep rolls from unrolling, wrap rolls in a sheet or sheets of paper, and tape the sheets. This helps to protect the outside map of the roll. Do not use elastic bands. These break down over time and can damage the outside map edge.
4. If a box does not fit a roll tightly, add packing material. Use loosely crumpled paper, bubble wrap or the like to protect the roll ends if the box is longer than the roll.
5. Do not try to squeeze a too-big roll into a not-big-enough box.
6. It is advisable to pack the rolls in plastic so that there is some protection if the boxes get wet for some reason.

On hanging maps: Do not hang any map that cannot be reprinted later. Aside from damage caused by tacks, mounting tape and the like, hanging maps tend to wrinkle and deform over time. As well, they are subject to all the problems described above and more: careless handling, exposure to light, humidity changes, air currents, etc.

5.3 Data storage

TK research projects often produce digital data. Data files might include digital audio recordings of interviews, digital video recordings, digital photographs, scanned permission/release forms, scanned images of maps, GIS data, PDF files containing documentation, etc.

Digital data may be stored on a variety of physical media, including USB flash drives, memory cards, external hard drives, and data CDs or DVDs. These media have varying lifespans and reliability:

Be aware of the reliability and longevity of whatever physical media you choose to store project data.

5.3.1 USB flash drives / memory cards

Both media use the same storage technology: NAND flash memory chips. These are coupled with other components and a physical interface plug that allows the media to be plugged into a device (computer, camera, digital audio recorder, etc.) that can read and write data.

The memory chips are usually understood to be highly reliable. The main causes of failure are repeated rewriting or physical damage to the physical interface plug. If stored securely and not used regularly, neither of these are likely. Technological obsolescence (see subsection 5.3.5) is probably the greatest concern.

5.3.2 External hard drives

External hard drives use a hard disk drive to store data. This is coupled with a physical interface plug (usually USB) and USB controller components.

Hard disk drives use magnetic fields to store data. It is generally accepted that after very long periods of storage (decades) hard disks will lose data because magnets lose their strength over time. As well, it is possible that data might be lost if a disk is stored close to something with a strong magnetic field, e.g., a large electric motor or generator.

Mechanical failure is a concern because hard disk drives are mechanical; they use electric motors and read/write heads mounted to arms that must physically move. During storage, care should be taken that a drive is not dropped or subjected to strong vibrations.

5.3.3 Data CDs and DVDs

The longevity of recordable CDs and DVDs is uncertain, and widely variable depending on manufacturing qualities.[139]

Discs should be stored away from light sources. The temperature range should be between –10C and 23C (14F to 73F), with relative humidity between 20% and 50%.

Care should be taken to handle discs by their edges and centre hole, not the disc surface. Discs should be labelled with water-based permanent markers on the clear inner hub.

Technological obsolescence is somewhat a concern, but readers should be available for some time. A more important concern is compatibility between the writing drive and the reading drive. Drives are mechanical, with very fine tolerances. Sometimes a disc written by one drive is not readable by another.

5.3.4 Online Storage

Online (or "cloud") storage is becoming increasingly reliable and inexpensive. As well, cost and availability of network speed and bandwidth needed to access online data are gradually improving. While it would require a long discussion to review all considerations, three overriding concerns are critical:

- **Data security:** As discussed in subsection 5.1.2, much TK information has degrees of sensitivity and confidentiality. Online access has the potential to lead to release of information that violates confidentiality agreements signed with TKHs before they agreed to being interviewed. It can be very damaging to a community's ongoing engagement and culture of research (see section 1.6) if it is perceived that information given in confidence is being used by third parties without permission. While high profile malicious attacks on Internet data stores appear in the media regularly enough to be concerning, it is far more likely that information will be released mistakenly due to poor security protocols and information management.

139 See Canadian Conservation Institute (2010) for a detailed discussion of media details and storage.

- **Network bandwidth and speed requirements:** For online storage to be appropriate, the known and anticipated users of the information must have (or can be reasonably expected to have) reliable Internet connections with sufficient speed and bandwidth to make use of the data reasonably quickly and at reasonable cost.[140]

- **Necessity:** Will it serve a real need among known and anticipated users of the TK information to host or distribute it online as opposed to restricting access to a local network and distributing it on physical media on an as-required basis?

5.3.5 Technological Obsolescence

One concern with all media, especially digital media, is technological obsolescence. With rapid changes in hardware and software, a technology that is in use everywhere this year might be displaced by another in a few years or a decade.[141]

As old machines are retired and scrapped, finding a machine that can read data and turn them into usable information becomes increasingly difficult. For example, finding a reel-to-reel audio tape player to play an old tape would be challenging, as would finding a floppy disc drive or a removable ZIP drive, or a 9mm DAT backup tape reader. Cassette players are becoming increasingly rare, and CD/DVD readers are no longer being included with new computers.

Avoid losing access to data through technological obsolescence by using commonplace data formats, creating backups, and putting the study information to use. Data redundancy is good!

Technological obsolescence also applies to software, even if it seems commonplace. Software manufacturers do not always support backwards compatibility with old versions when they release new versions. Sometimes compatibility is supported, but subsequently dropped. Recovering valuable data becomes an exercise in finding someone who still has an old software version. This can be difficult and costly.

It is difficult to track hardware and software obsolescence. Each piece of hardware and software program becomes obsolete at a different speed. However, adopting a few practices will help avoid it:

1. Create backups of all digital data, preferably on a regularly used current computer system. No matter what the media, it is a good idea to create a backup or backups. At least one complete backup should be stored in a different building than the original media, preferably in a fire-safe vault. If your

140 The terms "sufficient" and "reasonable" are deliberately vague. To define them, a host of factors need to be considered, including data size, anticipated user needs, whether needs will be served by web-based applications or local software, acceptable times to users for receiving information, etc. Supporting one-time download of a relatively small dataset for use on a local computer with GIS software on an occasional basis is clearly entirely different from providing an online decision support tool that must provide quick reports responding to management needs. Network capabilities are often still very different in urban areas and small northern communities. For more complex anticipated uses, it is best to frame needs formally with a user needs assessment.

141 This section is intended more for younger readers, as older ones with experience of obsolescent technologies already have an intuitive understanding of the problem.

organization already has a backup system, the contents of the digital media can be put onto a computer and backed up from it.

2. Make copies of data in commonplace formats. For instance, convert documents into Portable Document Format (PDF), and have GIS data files delivered in shapefile.

3. Convert analogue recordings into commonplace digital formats. For instance, have audio tapes converted to WAV or MP3.

4. Put your information into use. Used information is information for which changes and incompatibilities in hardware or software will be noticed quickly, while it should be easy to find the right hardware or software to do the necessary conversion or update.[142]

5.4 Backups

Data storage devices are highly reliable, but if they fail data loss is most often absolute. Furthermore, human error can result in huge losses of data from a mistaken mouse click or two. Backups should be kept to avoid these possibilities.

Maintain backups of all study data!

The increasing availability of cheap, high-capacity storage devices and online storage has greatly reduced the effort required to maintain data backups, while increasing the number of options available. However, sadly, technical ease of use does not lead to administrative attention, oversight, and good practices.[143]

A good backup system for TK project data will have five characteristics:

1. Backups should be very simple to run, and preferably automatic.

2. The backup system should back up every file, and allow recovery of file versions at least one year old.

3. At least one current complete backup should be stored in a different building, preferably in a fire-safe vault.

4. Data should be secured so that confidential datasets cannot fall into the wrong hands.

5. The backup system should be tested regularly to ensure that files can be recovered. (GeoConnections 2010, 33–34)

142 As well, migrating data to new standards should be included in budgets and long term projections.

143 Running data backups is like regular dental flossing. We know that flossing is a good idea, but many of us fail to adopt the routine until confronted with abscessed teeth, dental implants and crowns.

6 Conclusion

A number of academic critics have observed that TK research is a distillation of knowledge embedded within complex social relations and knowledge structures. In this understanding, the representation of TK in databases, reports, scientific articles, and monographs decontextualizes, and therefore "distorts," the knowledge (Ellis 2005; Holm 2003; Nadasdy 1999, 2003; Stevenson 1996). This criticism is often made by TKHs themselves, particularly when they describe the manner in which they acquire and communicate TK, and in relation to the lack of long-term practical experience that most researchers have harvesting and travelling on the land, water, and ice. However, any act of representation is an unavoidable exercise in distillation, and we do not stop sifting through the overwhelmingly rich detail of human experience simply because it is impossible to represent its richness in entirety.[144]

Many researchers and resource managers evaluate TK only in terms of its value to science. Hutchings and Ferguson (2000, 100) argue, for example, that the "ultimate value of fishers' local knowledge to fisheries science rests on its ability to generate testable hypotheses about the behaviour and ecology of fishes (e.g., migration, reproduction, habitat associations) and on its ability to provide measurable data on stock status." Others argue for broader definitions of utility, including providing biological and ecological insights, aiding resource management with good social and cultural practices that promote conservation, offering in-depth local knowledge valuable for environmental assessment, and promoting positive social change (Inglis 1993, 5). At their foundation, these guidelines are based on the idea that no matter how they are used and in what context, the presentation of TK must be richly textured, credible, and well reported, accompanied by transparent and comprehensive methods descriptions.[145] The quality of TK and the research undertaken to document it should speak for themselves through the richness of the data and thoroughness of the reporting.

Environmental co-management, wildlife management, and environmental assessment processes have evolved and are now well established across the Canadian Arctic, and they require TK documentation as a complement to science (Gilchrist and Mallory 2007). For example, a "basic goal" of the Inuvialuit Final Agreement "is to protect and preserve the Arctic wildlife, environment and biological productivity through the application of conservation principles and practices." To achieve conservation, the "relevant knowledge and experience of both the Inuvialuit and the scientific communities should be employed."[146] Aboriginal groups negotiate hard for such provisions in their land claims agreements because they provide a level of empowerment and respect that they have been denied in previous decades. They want these provisions to work.

If they are not working as well as expected in some contexts, the reasons often have something to do with a failure to properly document TK. Future TK research must endeavour to not repeat the errors of the past, including the all-too-frequent failure to document the TK of Aboriginal guides, field assistants and

144 See Wenzel's (1999, 118–119) discussion of interpretation and "perceived reductionist methodology" in TK research. See also Laidler (2007, 377).

145 Gilchrist and Malory (2007, 1) argue that "inherent in any data collection whether LEK or empirical science, there must be a sound, defensible, and verifiable methodology in its collection and interpretation so that the information generated can be rigorously assessed, understood and applied in its proper context. This is a fundamental tenet of the western scientific method, but not necessarily of LEK studies."

146 See Inuvialuit Final Agreement, http://www.wmacns.ca/pdfs/1_IFA.pdf.

co-researchers that is shared "informally" with outside researchers.[147] This point was made by Peacock et al. (2011, 379–380), who note that,

> Informal TEK has long been acquired through consultations on research proposals and results, as well as by researchers living in communities, and working with local people during field studies. Incorporation of TEK gathered in this manner [into science and decision making] is poorly documented and therefore it is often mistakenly reported that scientists do not incorporate TEK.

While Peacock et al. recommend that "researchers better document their use of TEK in research publications and when communicating with co-management boards and communities", the recommendation falls short of what is required. Appropriate TK research methodologies must be employed from the start, and researchers must be trained in both the nuances of TK research—a subject of social science inquiry—and the subtleties of language and Aboriginal worldviews. The systematic documentation of TK is essential no matter what the research context. For this, research protocols are required that make use of best social science practices. TK research is not "common sense"; to do it properly requires training and the application of robust methods.

147 Although they are widely supported by local HTCs and community members at large because they directly involve local TKHs in data collection, community or hunter-based monitoring programmes document TK superficially and only in strict accordance with scientific categories and documentation protocols (e.g., Bell and Harwood 2012; Weaver 1991). Similarly, data documented through logbook and sentinel fishery programs are of interest to fisheries scientists studying stock abundance and distribution, but the data cannot be considered fishers' TK except in the most superficial way. (Purps et al. 2000; Zwanenburg et al. 2000)

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Appendix A: Definitions and descriptions of TK/LEK/TEK/IQ/CEK/ATK

1. **Thorpe, Natasha, Naikak Hakongak, Sandra Eyegetok, and the Kitikmeot Elders. 2001. *Thunder on the Tundra: Inuit Qaujimajatuqangit of the Bathurst Caribou*. Tuktu and Nogak Project. Vancouver: Generation Printing**

   The Inuit term qaujimajatuqangnit [cow-yee-ma-ya-tu-kang-eet] means 'things they have known for a long time'. This is "knowledge, insight, and wisdom that is gained through experience, shared through stories, and passed from one generation to the next. More than just knowledge, as commonly defined, [it]… includes a finely tuned awareness of the ever-changing relationship between Inuit and *nuna* (the land), *hila* (the weather), wildlife, and the spiritual world. (Thorpe et al. 2001, 4)

2. **Briggs, Jean. 2012. Interview with Paul Kennedy, CBC Radio *Ideas*, August 2012. Accessed 14 January 2015.** http://www.cbc.ca/ideas/episodes/2012/08/29/never-in-anger-part-1-2/

   Inuit studies scholar, Jean Briggs (personal communication, 17 April 2009), notes that the Inuit conception of "knowledge" is complex. "Facts by themselves do not constitute knowledge. Words you get out of a dictionary do not constitute knowledge. Stuff you learn in school is not knowledge. To know something, you have to live it, know how it behaves, how you have to treat it, how it fits into your life."

   "For Inuit, knowledge is an intensely personal phenomenon, intensely personal; meaningful only if you have it in some depth. For instance, one Alaskan elder said to another anthropologist, Barbara Brodenhorn, and I got it from her report from North Slope, Alaska (his name was Raymond Neakok); he said, the words in a dictionary are dead. In order to understand what cold means, you have to know that cold inland and cold on the sea are two different things. And you have to know what to do about it, how to treat it in order to know how to use the concept in your life before you can be said to understand it. Words in the dictionary don't help you. That's right, that's the way they think not only about language but about any kind of knowledge. It doesn't do to read it in a book. You have to go out and hunt to know how to hunt. You can't add it to the curriculum in a patch-work way, in a Nunavut grammar school or high school; it's not the same thing."

3. **Davis, Anthony and J. Wagner. 2003. "Who knows? On the importance of identifying 'experts' when researching local ecological knowledge." *Human Ecology*, 31(3): 463–489.**

   "Local knowledge is presumed here to constitute a 'body' and a 'system' of understandings and know-how that arise through time from a variety of individual and shared experiences and observations, mediated by culture, with regard to environmental factors, behavioural attributes, and ecological dynamics. …for it to be a 'system', LEK must be shown to reside in the heads and to arise from the experiences and observations of more than one person, including those of any one 'expert'. If left unsatisfied, this condition would reduce LEK to no more than the assemblage of an individual's or group

of individuals' experiences and observations. While interesting and possibly ethnographically compelling, such would surely not constitute the basis for developing or representing LEK effectively either as a unique knowledge system or as an alternative to existing natural resource management practices." (Davis and Wagner 2003, 477)

4. **Davis, Anthony and Kenneth Ruddle. 2010. "Constructing Confidence: Rational Skepticism and Systematic Enquiry in Local Ecological Knowledge Research." *Ecological Applications*, 20(3): 880–894.**

   Local ecological knowledge is a "dynamic phenomenon shaped in important ways through the interplay of such external factors as resource management, political processes, and the interests of socio-political-economic power with local-level experiences, interpretations, and understanding… (Davis and Ruddle 2010, 885)

5. **Berkes, Fikret. 1999. *Sacred Ecology: Traditional Ecological Knowledge and Resource Management*. Philadelphia: Taylor and Francis.**

   "Putting together the most salient attributes of traditional ecological knowledge, one may arrive at a working definition of traditional ecological knowledge as a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment." (Berkes 1999, 8)

6. **Usher, Peter. 2000. "Traditional Ecological Knowledge in Environmental Assessment and Management." *Arctic*, 53(2): 183–193.**

   TEK "refers specifically to all types of knowledge about the environment derived from the experience and traditions of a particular group of people" (p.185). He advances a useful typology of TEK that shapes the methods outlined below. In summary, Usher distinguishes four TEK categories (Usher 2000, 186):

   a) knowledge about the environment. "This includes statements of fact about such matters as weather, ice, coastal waters, currents, animal behaviour, traveling conditions…which are typically based on (a) empirical observations by individuals of specific events or phenomena; (b) generalized observations based on numerous experiences over a long time; or (c) generalized observations based on personal experience reinforced by accounts of others both living…and dead" (ibid.,186). This category of TEK "ranges from specific observations to explanatory inferences, constituting explanations of what people observe and the relations and connections among them, or more broadly, an understanding of why things are as they are." Knowledge concerning plant types and distributions and animal habitats, anatomy, behaviour, sounds, senses, and locomotion, alimentation,[148] and reproduction (e.g., Clément 1995), as well as indicators of ecosystem health (Parlee et al. 2005) fall under this category.

148 The provision of nourishment or other necessities of life.

b) knowledge about the use of the environment. This includes "factual knowledge about past and current use of the environment (e.g., patterns of land use-and-occupancy, or harvest levels), or other statements about social or historical matters that bear on the traditional use of the environment and hence the rights and interests of the local Aboriginal population in the regional environment" (Usher 2000, 186).

c) values about the environment. These are "culturally based value statements about how things should be, and what is fitting and proper to do, including moral or ethical statements about how to behave with respect to animals and the environment, and about human health and well-being in a holistic sense" (ibid.).

d) the foundation of the knowledge system. This category of TEK deals with the "culturally based cosmology—foundation of the knowledge system—by which information derived from observations, experience, and instruction is organized to provide explanations and guidance."

Usher notes that repeated observations of the environment over time are key to good quality TEK. "The circumstances that foster TEK are neither uniformly distributed nor permanent among Aboriginal communities. In places where, for whatever reason, few if any members of the community have recent or current experience of a particular area or phenomenon, there may not be much TEK that will be useful to environmental assessment" (ibid., 187).

7. Collignon, Béatrice. 2006. *Knowing Places: the Inuinnait, Landscapes, and the Environment*. Edmonton: Canadian Circumpolar Institute Press.

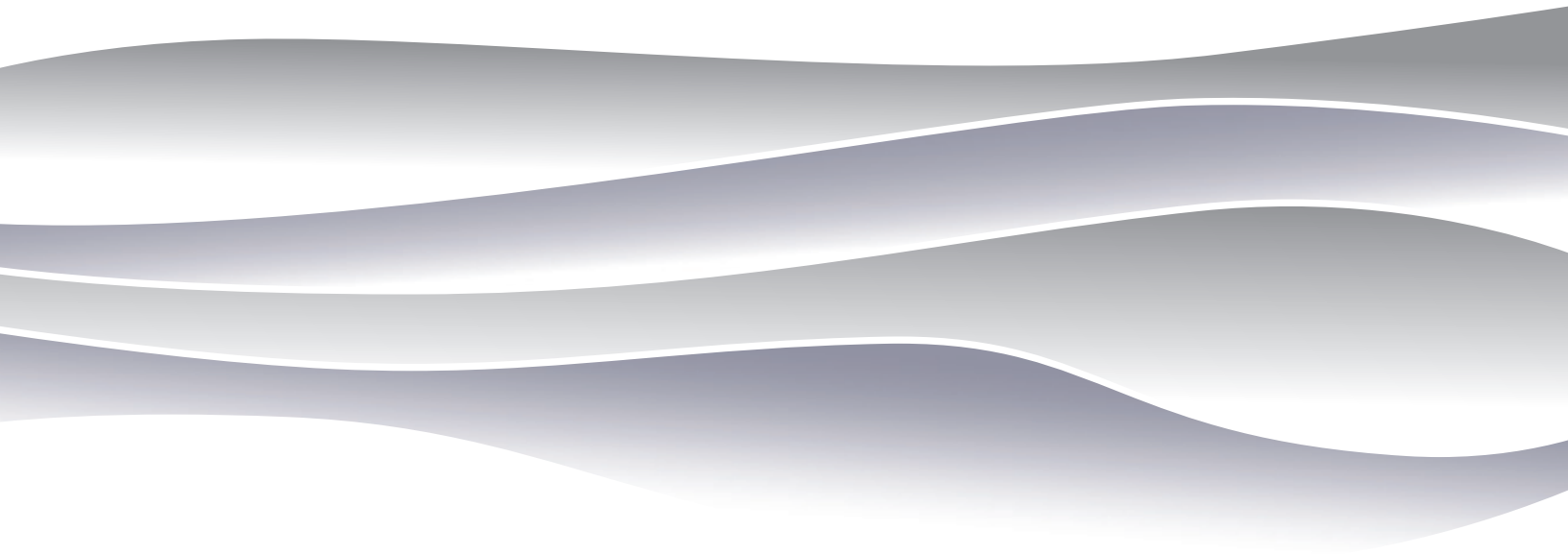
"I find the current scientific terminology quite unsatisfactory. In North America, 'traditional knowledge' and, since the early 1990s, 'traditional ecological knowledge' (TEK) are the labels most often used. Interestingly, TEK seems to apply exclusively to Aboriginal peoples. The problem with the latter is that it limits this knowledge to environmental knowledge, when in fact it covers much more than ecology. Furthermore, to most Qablunaat the word 'traditional' suggests something ancient, something that competes with modern ideas. In that context, tradition is relegated to the past, to a time before the encounter with Western science. The recognition of TEK thus goes hand-in-hand with romantic and nostalgic ideas about the past. This way of thinking ignores the fact that indigenous knowledges are constantly being re-worked and are, therefore, still operational to this day." (Collignon 2006, 263)

Appendix B: Collignon's description of Inuinnait map reading

"In my [toponymic] research I used official maps produced by the Canadian Department of Mines and Natural Resources [NTS maps]. Today, most Inuinnait are familiar with these Qablunaat maps, and hunters usually have some at home and take them with them when they travel on the land.…As they read the official map, they refer to the lines of travel that are remembered from their own experience. As the traveller's eyes move around the map, the hunter compares his mental image of the landscape to its representation on the map—its cartographic representation—by relying on his memory of the places that he knows from his own journeys. First he finds two key places on the map. Then he calls from his memory a list of places between these two more important ones, and searches the map for these smaller places on the way, using the shape of the coast-line, islands, valleys, and lakes to guide him in his reading. As a rule, he will not bother with the elevation contours that show the height of the land; he will use this detail only if there is doubt in his mind. Based on their linear perception, the Inuinnait have developed their own method of reading printed maps, on which they can orient themselves without much difficulty.

Men and women read these documents using the same method, but the women's perception of lines is more vague than the men's. They tend to 'jump' from one place to another, whereas men tend to carefully follow a mental trail that connects one place to the next.

I observed map reading techniques mainly during the place-name survey I conducted in 1991-1992, and later during the numerous times I sat down and looked at maps with one or several people while visiting in their homes or occasionally meeting in an office where it is usual to have regional 1:250,000 scale maps pinned on the wall. In 2003, I attended a meeting in Ulukhaktok where the blueprints of maps indicating the place-names we had collected twelve years earlier were reviewed for final approval.…On every occasion, the same reading technique was used, confirming my first descriptions of the process" (Collignon 2006, 94-95).



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