Local and Traditional Knowledge: Tools for Wildlife Research and Management

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Introduction

This paper will focus primarily on the body of knowledge derived from place-based experiences on local landscapes, especially as they relate to the field of ethnobiology, which will be described here. The literature pertaining to these subjects is vast and philosophical discussions regarding the similarities and incommensurabilities of knowledge systems have often been complex and sometimes contradictory. I will attempt to explore these theoretical underpinnings here in a systematic theme-based progression, especially in relation to Traditional Ecological Knowledge (TEK) and Western Science.

Terminology

It is appropriate to begin with a brief discussion of terminology since related literature employs several terms and their associated acronyms for these knowledge systems. In fact, some of the terms are distinguished merely as a matter of semantic preference among prevailing authors, yet arguments have been made for and against their adoption. Among the most common of these are Traditional Ecological Knowledge (TEK), Indigenous Knowledge (IK), Local Knowledge (LK), and Local and Traditional Knowledge (LTK) among others.

The aforementioned terms emerged within published literature to define and describe knowledge that is derived from human observations and experiences on local landscapes. Traditional Ecological Knowledge (TEK) in particular has garnered much support and is now commonplace within global dialogues pertaining to natural resource management (Nadasdy 1999). At issue with some is the tendency of the words "traditional" and "ecological" to compartmentalize the knowledge as something that is both stagnant in time and narrow in focus, ignoring the fluid, dynamic, and complex nature of its existence. In reality, this knowledge is constantly changing and conforming to the needs of those who bear it. It shifts and changes in accordance with fluctuating economic and environmental activities (Menzies 2006).

While TEK is frequently used in reference to knowledge born by indigenous peoples as is suggested by the term "traditional", this is not necessarily the case since people of all backgrounds hold intergenerational knowledge of the world. Defining the term "indigenous peoples" can also be problematic but it is frequently accepted as referring to groups of people with ancestral origins to a particular place. It is this intergenerational linkage of knowledge of place that gives rise to the body of knowledge itself. Again, this does not mean that the knowledge is incapable of change or movement in space and time.

Indigenous Knowledge (IK) is more specific than TEK in that it recognizes the distinct origins of knowledge obtained through indigenous cultural heritage, especially those that have passed from generation to generation through primarily oral traditions. It encompasses the cultural and spiritual components of this knowledge. The risk of abstracting this form of knowledge from its cultural and historical context is high and we must remember that ecological knowledge held by a group is but one aspect of their overall

culture (Berkes 1999). IK also lacks the temporal identifier, "traditional," and therefor recognizes that this knowledge is constantly changing – it is not the same now as it was in the past and will be in the future. Yet despite the benefits that IK seems to have over TEK and the baggage that the latter term carries, at their core both do largely represent the same theoretical ideas of knowledge construction.

To address the issue of TEK and IK's ambiguities pertaining to the inclusion of place-based knowledge of non-indigenous origin, some authors and institutions have employed the term Local and Traditional Knowledge (LTK), or simply Local Knowledge (LK) for a broader perspective on the topic. These recognize that place-based knowledge often transcends ethnic heritage. They also alleviate the connotation that the knowledge in questions is a relic of a past time. No matter the term(s) chosen, it is important for authors to be clear as to which body of knowledge is being documented or examined.

Background

For more than a century, Local Knowledge has been gaining popularity with natural resource research institutions and management regimes as a valid and often necessary tool for understanding animal and plant communities, as well as the habitats that support them. It has also served as a way to involve local stakeholders in the processes of science and management, and to legitimize their needs by working with them toward shared goals and aspirations, as described by Kloppenburg (1992):

> "What we call science enjoys a preeminent position among the possible ways of establishing knowledge about the world. Scientific rationality has achieved de facto status as the modern… standard against which all other knowledge claims are compared. Yet in many places, the constitution and character of existing science are being challenged as people come to recognize that the domain mode of knowledge production does not necessarily serve their interests or meet their needs."

Despite incredible advancements in technology and transportation, as well as a global economy where decisions on one side of the planet can have major impacts on the other, the vastness of earth's landscapes and the financial and logistical challenges associated with research present obstacles for investigations conducted under routine Western Science methodologies. It is impossible for Western Science to take place at every location, for every variable at every point in time, especially when a vast majority of projects are centralized at institutions far from study sites. To better understand plant and animal populations on local scales, the collection of Local Knowledge provides stakeholders with the opportunity to contribute to the understanding of resources on which they depend and interact on a day-to-day basis. In addition, conservation programs often need to consider a broader view of "the role of local people, their knowledge and interests, and their social and economic needs" (Berkes 1999). Still, it is important to remember that these knowledge systems did not have completely segregated evolutions (Agrawal, 1995) and that they fundamentally share the goal of revealing knowledge of the world through repeated observation.

This paper will explore the history of Local Knowledge, its historic and contemporary contributions, preeminent authors on the subject, and frameworks for continuing to advance the utilization of this tool to help solve looming environmental problems and wildlife management concerns. I will place emphasis on Indigenous Knowledge, a subset of local knowledge derived in the customs and traditions of indigenous peoples who have survived in many cases for millennia on local landscapes and thus are frequently able to provide not only a lengthened temporal scale of knowledge, but also a complementary glimpse of past lessons, solutions, and approaches to modern problems. The focus on Indigenous Knowledge will also serve as an example by which alternative ways of knowing, those that deviate from Western Science principles and methodologies, are derived and can perhaps be recognized as valid within institutional settings and governmental bureaucracies.

The hope is that by integrating the knowledge of indigenous peoples with western scientific knowledge, both indigenous and non-indigenous communities alike may increase their capacity to understand the environment to improve existing processes for management (Nadasdy 1999). Some have suggested that the inclusion of indigenous knowledge in western bureaucratic management regimes can undermine the power and autonomy of indigenous peoples through the compartmentalization and distillation of knowledge (Nadasdy 1999). According to Nadasdy (1999), "the very idea of such integration implicitly assumes that knowledge is an intellectual product which can be isolated from its social context." This does not however preclude its utilization in helping to solve problems shared by mankind. Out of these questions a truly interdisciplinary field of inquiry has emerged – Ethnobiology.

Ethnobiology

The discipline of Ethnobiology emerged out of what was first termed "Aboriginal Botany" by Powers (1873-1874) and later "Ethnobotany" by J.W. Harshberger (1896). Eugene Hunn (2007) defined this early period of the field as phase 1, or pre-classical ethnobiology. The focus at the time was indeed on flora rather than fauna and emphasized the documentation of plant uses, especially those that could benefit Western Science and society (Hunn 2007). The term "economic botany" quickly emerged from this utilitarian image and was coined by Vestal and Schultes (1939). These authors also recognized that the term includes plant uses that are not necessarily derived from indigenous culture.

E.F. Castetter (1944) later argued that ethnobiology was distinct from Economic Botany as it "consisted of far more than collecting, identifying, and ascertaining the uses of plants by primitive peoples." In his words:

> "ethnobotany is sharply differentiated from economic botany in that it is vitally concerned with the fundamental cultural aspects of plant utilization, while economic botany practically ignores the cultural except in a very general way."

Early studies of indigenous utilization of faunal resources were far fewer than those pertaining to plants (Castetter 1944). In 1914 however, Henderson and Harrington coined

the term “Ethnozoology,” a closely related field of inquiry. Castetter (1944) viewed both fields as “marginal to or straddling both biological science and anthropology.”

By the early 1950s the field had entered Hunn’s second phase (Classical Ethnobiology) and was emerging as “Cognitive Ethnobiology” or “Ethnoscience.” Research had begun to move away from purely descriptive and utilitarian foci and toward a more emic approach (Hunn 2007). Harold C. Conklin (1954) was among the first to argue for this transition that would include indigenous perspectives and language. Emphasis during this period was on how knowledge of both plants and animals is put to use by people (Hunn 2007).

During the 1970s and 1980s researchers began to explore the broader ecological context of local biological knowledge including the links between knowledge and action (Hunn 2007). This began Hunn’s third phase known as “Ethnoecology” (Hunn 2007). The 1990s were included in this period but brought turmoil from what Hunn (2007) referred to as a marriage of “environmentalism and indigenous activism.” The resultant “political ecology” that viewed many local knowledge studies as western hegemony (Escobar 1999), an “instrument of power linked to exploitation of indigenous communities” (Hunn 2007).

The fourth and contemporary stage of Ethnobiology as defined by Hunn (2007) began in the late 90s as a result of the political controversy regarding hegemony. Hunn (2007) admits that the “unprincipled exploitation” of indigenous knowledge is unethical, but also suggests that the debate is off target and overly politicized. He argues that this knowledge is of primary value as a “living tradition” and that its documentation “can assist communities by supporting their claims to land and control of subsistence resources while providing our audience with ethnographic analyses of TEK.”

Expanding Ethnobiological Application

The modern phase of Ethnobiology has greatly expanded the inclusion of faunal studies, especially in relation to economically or gastronomically important species. While it makes sense to study species on which human beings depend, other species may benefit too from the documentation of local and traditional knowledge. The group of organisms collectively known as non-game species (those that are not typically harvested for consumptive purposes), have largely been absent from IK research programs. I should note that the term “non-game” does not denote that these species are unimportant to human beings since they are often important species within local food chains, can serve as indicators of biological health, provide indirect services (such as insect pollination), and often are awarded important aesthetic and cultural value. The cultural services should not be underestimated since non-game can be important contributors to cultural identity and heritage, they can provide spiritual/inspirational/aesthetic benefits, and they can support human economies related to recreation and ecotourism (Chapin 2009).

To better understand the capacity of LK to contribute to our modern understanding of non-game species, I have undertaken a series of LK case studies, primarily with residents of Wrangell, Alaska to ascertain knowledge of and interactions with amphibian species occurring along the Alaska portion of the Stikine River and nearby coastal islands. This is

the traditional homeland of the Kiks.adi clan of the Stikine Tlingit that bear the frog as their major crest. Watershed units are commonly used in traditional ecological systems and one of the most common ways that indigenous peoples identify themselves is in reference to river systems (Berkes et al. 1998). This too is the case for the Stikine Tlingit who have had thousands of years of experience on one of Alaska's most bio-diverse landscapes for amphibian populations. This paper will serve to establish the theoretical framework by which LK is appropriate for the study of these species and how this framework is situated within the historical uses and validation processes thus far established for IK and Western Science hybridization.

Alaska is an exceptional location to study local and traditional knowledge systems given the diverse cultural groups inhabiting the state and the economic and subsistence needs of many residents. In addition, the state is vast, sparsely populated, and has limited transportation infrastructure. It is home to several indigenous cultural groups and while some aspects of their traditional knowledge have changed as a result of acculturation and colonialism, many people maintain close ties to the land and local resources. Travel, resource harvest and safety require detailed knowledge of the landscape, and in some situations the seascape. In addition, Alaska Natives have been at the forefront of integrating indigenous perspectives in policy arenas, research, and development projects (Barnhardt 2005).

Derivations of Local Knowledge

For modern natural and social scientists that have been trained in predominantly western institutions, concrete knowledge is obtained through a systematic process of inquiry requiring experimentation and repetition. This "scientific process" often leads to the accumulation of facts about the world but is not the only system by which knowledge can be obtained. Before the scientific process was widely utilized, knowledge was acquired slowly and much of it was qualitative and derived from local observations (Gadgil et al. 1993). Throughout human history, mankind has depended on careful observations of the natural world. If they learned from these observations, they adapted successfully but if they did not, the consequence was likely death (Berkes 1999). Worldview and the framework for understanding nature continue to be intertwined yet pre-scientific societies often integrated these with moral and religious beliefs in what has become known as a coevolving knowledge-practice-belief complex (Gadgil et al. 1993).

Indigenous knowledge, or Traditional Ecological Knowledge (TEK), is a subset of local knowledge that is passed down through generations and derived from experiences on a landscape. Indigenous peoples are those who are considered the first human inhabitants of a region and thus the local culture with the longest duration of experience interacting with and surviving on that landscape. Globally, indigenous peoples have persisted by utilizing detailed adaptive knowledge (Krech 1999) and by recognizing the inherent connection and interdependence of all organisms. In this way, these societies have survived by attempting to understand the world around them (Barnhardt 2005).

The proximity of stakeholders to a given resource gives both individuals and communities the ability to observe day-to-day changes (Berkes et al. 2000). People who have lived in a

particular location for many years form a repetitive interaction with the environment and in cases of indigenous dwellings, they build upon generations of accumulated knowledge of best practices for conservation within a local cultural context which may include deep spiritual or emotional connections to land inhabited by one's ancestors (Holen 2012). In these cases there exists a sense of collective memory of ancestral interactions with local landscapes (Holen 2012). While western scientists in wildlife biology often obtain discreet data points from a period in time, Nadasdy (2006) describes the temporal benefit of IK:

> "Elders and hunters do not cover as much ground in a single day as do biologists in a helicopter perhaps, but they see animals all year round and have a good idea of what animals do and where they are throughout the entire year, rather than on a single day in June."

Fikret Berkes, a professor of applied ecology at the University of Manitoba, is among the most widely published modern authors on the subject of TEK and has made significant contributions to the methodologies and theory of TEK research and applications in natural resource management (Holen 2012). He underscores the cultural continuity of practices regarding the interaction of people with the environment (Berkes 1993) and recognizes that personal knowledge systems are globally defined by cultural understandings of local landscapes (Berkes 1999). In this manner, cultural heritage provides information about how people coped with past environmental and social-ecological challenges (Berkes 1998) and includes a mix of scientific insight and artistic expression "evolving by adaptive processes and handed down through generations by cultural transmission" (Berkes 2008). Western and indigenous knowledge systems therefore, can be considered alongside of their associated artistic expressions, as a result of the same intellectual processes that attempt to create order from disorder in our daily lives (Berkes 1999). The language used by indigenous peoples is very different from that of Western Science whereby premodern components included metaphorical imagery and spiritual expression.

Indigenous societies have long sought to understand the regularities in the world around them including unseen patterns of order that impact their very survival (Banrhardt 2005). Their education systems were carefully constructed around observations of natural processes, adaptations for survival, subsistence, and technology (Barnhardt 2005). Rather than using script, information was passed between generations orally and through participant observation (Berkes 2004). But, indigenous knowledge does not merely exist for pragmatic purposes alone, but also as a result of scientific curiosity (Berkes 1999).

Berkes emphasizes the origins of TEK within the aforementioned knowledge-practice-belief (kpb) complex whereby knowledge of species and other environmental phenomena influence the way in which people carry out agriculture, hunting and fishing, and other livelihood activities and leads in turn to cultural perceptions of human identity with ecosystems, including their interaction with natural processes (Berkes 1999). People have evolved as integral components of Social Ecological Systems (SES) and the human-nature relationship is important to cultural identity (Chapin 2009). Worldviews are the frameworks by which groups interpret events and interact with SES (Kofinas 2009). Social and ecological systems are linked and the barrier between the two is arbitrary – the

removal of humans from the ecological system in some societies is purely a cultural construct (Berkes et al. 2003a).

IK is both integrated and situated within cultural contexts rather than a mere assemblage of facts (Thornton and Scheer 2012), and recognizes the human dimension to ecosystem processes and dynamics (Dale et al. 20000; Waltner-Toews & Kay 2005). Indigenous peoples often carry this knowledge and transfer it between generations using idioms that feature symbols, stories, songs, and rites that can be alien to science (Ploeg 1989) but are the mechanisms for cultural internalization (Berkes et al. 2000). From a western scientific perspective, "TEK includes empirical facts or associations based on observations and experience, explanations of fact, a culturally specific way of organizing and understanding information, a set of values, and in a very broad sense, cultural norms about how to do things" (Usher 2000). Still, a straightforward account of indigenous culture, spiritual relationships, and subsistence practices are rarely adequate to address issues as they are perceived by Western Science and thus some degree of integration and compromise is necessary (Sillitoe et al. 1998).

Indigenous systems tend to have substantial moral and ethical contexts and lack separation between nature and culture (Berkes 1999). They recognize interconnectedness among physical, social and spiritual aspects of tradition (Cruikshank 2000). Knowledge, values and identity are handed down to succeeding generations through "cyclical repetition of livelihood activities" (Freeman 1993). The associated knowledge and management of resources are adapted to local areas and the stakeholders are the "managers" since they identify with their community rather than scientific disciplines that are answerable to distant peers and abstract government agencies (Berkes 1999).

Human observations about the world around us are structured through our cosmology – our ideas on the origin of the universe (Berkes 1999) and our worldview – "a comprehensive, especially personal, philosophy or conception of the world and of human life" (Kawagley et al. 1998). Along with worldview, cosmology gives shape to cultural values, ethics, norms for society and norms for human-environmental interactions (Berkes et al. 2000, Skolimowski 1981).

In many dominant western societies of the post-enlightenment period, humans construct themselves as aliens with a self-identity separate from that of the world around them (Evernden 1993). Ecologists trained under these rules are "forced to treat nature as essentially non-living, a machine to be dissected, interpreted, and manipulated" (Evernden 1993). These ecologists practice a scientific mode of thought characterized by an ability to break down observational data and reassemble it in different ways. By contrast, IK is concrete and "relies almost exclusively on intuition and evidence directly available to the senses" (Howes and Chambers 1979).

Both knowledge systems are important if they influence the ways that people perceive and interact with their environment (Chapin 2009). According to Cruikshank (2001) "Local knowledge of the world… has more similarities with contemporary science than differences from it and we need knowledge bridges that work from local concepts as well as from

science if we are to bring broadly based human values to bear on problems such as the conservation of biological and cultural diversity." It is important to remember that both types of "science" have a "plurality of origins and a plurality of practices" (Kawagley et al. 1998).

Traditionally, the relationship between hunters and their prey was much more intimate, a symbiotic relationship that is slowly fading in the modern age (Barnhardt 2005). Traditional knowledge systems are being eroded by social and technological changes (Chapin 2009) and as they continue to experience shifts toward globalization, some knowledge runs the risk of being lost if it is not documented (Harmon 1996).

IK is predominantly maintained orally and thus is tightly linked to language (Chapin 2009). For instance, many indigenous languages translate words into English as "land" yet in the Native tongue, the term carries meaning closer to "ecosystem" because "it conveys a sense of relations of living and nonliving things on the land" (Berkes et al. 1998). By these means, important facts can easily be lost in translation or, perhaps more perilously, lost to history. Loss of language and cultural assimilation often erode IK so efforts to preserve Native languages and traditions are necessary if historic information is to remain intact within IK (Chapin 2009).

Many indigenous peoples, especially those in Alaska, traditionally perceived hunting as ceremonial whereby adherence to certain rules of engagement would convince an animal to allow a hunter to find and kill it, therefore a successful hunt was a gift from the animal rather than a domination or victory by man. The idea of luck was abstract to these peoples and was represented more as an agreement between humans and animals (Nelson 1983). Berkes (1999) explains that "Since animals control the hunt, lack of respect for the animals will affect hunting success because animals can retaliate by returning the discourtesy." Abiding by the established hunting and fishing rules is a major theme of Indigenous stories with the goal of preventing catastrophe.

This idea of respecting prey species in order to obtain food and prevent negative consequences for individuals and their communities extended to non-game species as well. In Alaska, the Tlingit with whom I work believe that all life and even abiotic objects contain spirits and were once akin to human beings. This kinship presents a brother/sister relationship and thus if an animal was to be killed, an even greater reverence was necessary. Failure to respect an animal small or large was said to not only bring great shame to one's family, but also to often result in death and destruction by natural forces.

The kinship relationship to non-game species extended to the frog throughout Tlingit territory where it appeared as a major crest for numerous prominent clans. Several traditional and well-known stories describe the maltreatment of these species and the resultant destruction of entire villages. My work with the Kiks.adi clan of the Stikine Tlingit aims to document these traditional relationships to the frog and how they have changed from the time of European contact to the present. I also plan to identify traditional and contemporary environmental ethics that relate to non-game species that can potentially benefit modern conservation efforts. Furthermore, my work will identify how, if at all,

Kiks.adi cultural knowledge can influence our understanding of historic amphibian populations.

Modern herpetological research of populations typically entails systematic field inventories conducted at specific times and at specific locations. While my work on the Stikine includes these conventional approaches, I am also exploring the ways in which IK and broader LK can contribute within the herpetological discipline by expanding the temporal scale of observational data both throughout the annual cycle and for the past, present and future. By utilizing the knowledge of peoples and their ancestors that have persisted on and explored local landscapes far more frequently than myself, I hope to underscore the utility of this basic tenet of LK. By additionally documenting human-amphibian relationships, I am also evaluating the perceived cultural and environmental services provided by these species to local stakeholders.

While rare, ethno-herpetological pursuits of this nature have been undertaken to both preserve culture and conserve species most notably that of Dr. Gary Nabhan as published in his book "Singing the Turtles to Sea." His work with the Comcaac peoples of Northwestern Mexico's Sonoran desert documented local reptilian life and human relationships to it through ethnographic interviews and participant observation. Unlike my own non-game research with the Tlingit and community of Wrangell, the Comcaac people described by Nabhan utilized and harvested herpetofauna extensively as subsistence species. Another important difference is that while more temperate and tropical regions support diverse herpetofaunal communities, Alaska is home to only six native amphibians and four reptiles (marine turtles), the latter of which are extremely rare in Alaska waters and are only found in non-breeding populations in years with unusually warm currents. Key related aspects of Nabhan's work will be periodically discussed in this paper.

Nabhan (2003) describes the Comcaac relationship to reptilian life as "naturalistic, aesthetic, mythic, and utilitarian." In one example, Nahban's informant Ernesto Molina of Punta Chueca explained that Leatherback Turtles were said to be able to communicate with people since "they were once people themselves." This mirrors the Tlingit notion of a shared heritage with other species, including direct communication and kinship with the frog, often depicted by the Kiks.adi as a Boreal Toad.

Several other interesting stories and prehistories are shared between the Tlingit and the Comcaac. Nabhan (2003) tells that "Sometime after the world was formed by Hant Caai, 'Earthmaker,' his collaborator, Turtle, dived down to the bottom of the sea and brought up a fistful of mud in the clenched claws of his flipper; with this, he would help Hant Caai make solid ground." A Tlingit origin story likewise describes Raven, the Tlingit creator, having instructed his supernatural companion Frog to dive to the depths of the ocean and to bring back mud that would be made into solid ground, contributing to the formation of Earth's landmasses and resulting in Frog's status as "keeper of all Earthly treasures."

Nabhan's informant Adolfo Burgos of Desemboque tells that plants were once people who were trying to climb high to the tops of the hills during the "Great Flood" (Nabhan 2003). The Tlingit also tell of a Great Flood and having been lead to safety on the mountaintops by

their Brown Bear brethren. While these stories do not have the same herpetological context as the previous examples, they still speak to their joint beliefs in animal kin with a peculiar shared prehistoric event.

While Western Science is unlikely to embrace indigenous mythology as "fact," lessons can be learned about human-environment relationships and traditional rules of engagement that may benefit modern conservation efforts. Berkes (2004) suggests that "our definitions of conservation have perhaps been too simplistic and too Western." Conservation support is often week in developing countries and impoverished communities where the concept is sometimes seen as a concern of the "elite who are insensitive to rural people and their livelihoods" (Berkes 2004). The keys here may be to establish the perceived importance of a resource, educate on the benefit of maintaining biodiversity, utilize local stakeholder knowledge and include local peoples as partners in the management process. TEK addresses these in detail.

A True Dichotomy?

Many similarities and differences exist between IK and Western Science that must be understood and addressed before they can be compatible with one another for the purpose of finding better solutions to management problems. Predispositions of the nature of "truth," including its origins and the process by which it is found and tested, must be removed in order to consider alternative ways of knowing, alternative solutions, and to foster unbiased respect. Practitioners of Western Science must be willing to acknowledge that TEK is also science in the sense that it is "empirical, experimental and systematic" (Battiste 2000). Several key differences and similarities between TEK and modern Western Science are represented in the Venn diagram below, borrowed from Barnhardt (2005):

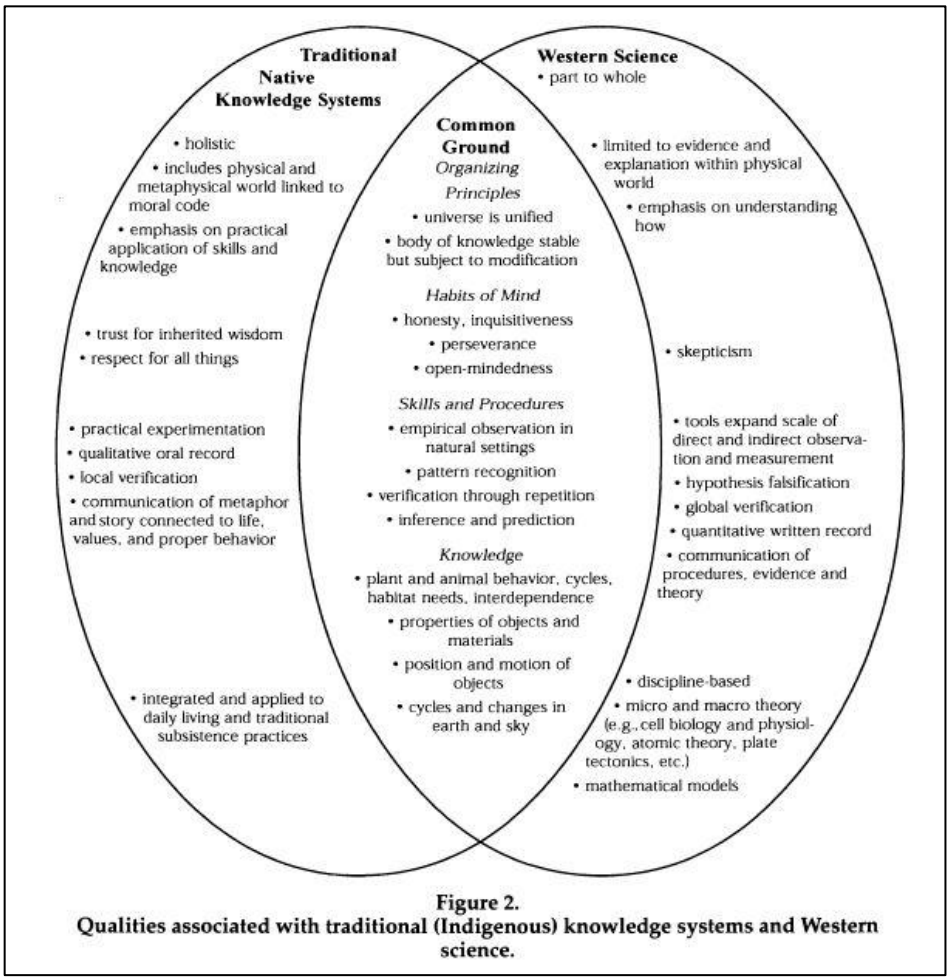

Figure 2.
Qualities associated with traditional (Indigenous) knowledge systems and Western science.

TEK does differ in two important ways from WS in that it is highly localized and has social context (Battiste 2000). It focuses on interrelationships between and among humans and the environment in a particular locality "as opposed to the discovery of universal 'laws" (Battiste 2000). Facts sometimes differ between these knowledge systems making integration difficult (Berkes 2008) but not entirely impossible. Barnhardt clearly defines the conflicts derived in the origin of these systems:

> "The specialization, standardization, compartmentalization, and systemization that are inherent features of most Western bureaucratic forms of organization often are in direct conflict with social structures and practices in Indigenous societies, which tend toward collective decision-making, extended kinship structures, ascribed authority vested in elders, flexible notions of time, and traditions of informality in everyday affairs"

Sources of conflict sometimes arise due to power relationships, differing political agendas, and different relationships to the resources in question (Berkes 1999). Local people spend more time interacting with their environment than do policy makers and therefore maintain a wider array of observations and perceptions (Chapin 2009). Those who are dependent on local resources are often able to assess the actual costs and benefits of development better than someone approaching the situation from the outside (Berkes

1999). Place-based case studies allow for researchers and local stakeholders to interact to define questions and assess evidence (Kates et al. 2000). In addition, we must remember that there are a number of different traditions in Western Science and a range of indigenous knowledge systems, suggesting that caution must be used in generalizing the differences (Berkes 1999). As Reyna (1994) acknowledges:

> "The implication of considering Indigenous and scientific perspectives side by side is not that we can translate another culture's conceptions into scientific discourse or necessarily that we should test them according to its canons – both are relative – or that scientists need to revise their working suppositions regarding objectivity, positivism, reductionism, and so on, to accommodate others' views."

Western scientists are sometimes viewed as controllers, manipulators and exploiters of the environment, and these concepts conflict with the cultural views of many indigenous peoples (Battiste 1998; Cajete 1999), as was discussed in the relationship between indigenous hunters and their prey. Western Science tends to be "impersonal, formal, elitist (only certain college educated individuals are granted status of scientist)" and "mechanistic" (Kawagley et al. 1998). Conversely, Indigenous Science is informal, non-elitist, and incorporates spirit (Kawagley et al. 1998).

In many areas of the world western influence dominates indigenous cultures in what Corsiglia (2006) describes as Empire Building Societies – societies generally operating by moving into the homelands of indigenous peoples and then managing their traditional resources for the benefit of urban centers. The wisdom generated by an EBS is not usually manifested as a relationship to ecological and environmental phenomena, but rather with the objective of "managing interpersonal difficulties and problems relating to ownership and control of wealth and property" (Corsiglia 2006). Anthropologist Claude Levi-Strauss (1962) argued that:

> "These two ways of knowing are two parallel modes of acquiring knowledge about the universe; the two sciences were fundamentally distinct in that the physical world is approached from opposite ends in the two case: one is supremely concrete, the other supremely abstract."

The natural sciences within Western Science have become so specialized that viewing ecosystems and their processes on a whole is difficult, often subdividing disciplines into various categories and creating scientists that lack a basic understanding of other fields of inquiry (Kawagley et al. 1998). An ornithologist, for example, may lack a basic understanding of the extent of avian predation on insects or small mammals, matters dealt with by entomologists and mammalogists. To the Yupiaq Eskimo however, scientific knowledge lacks this segregation; concepts are interrelated and founded in observational experience (Kawagley et al. 1998)

Three major differences seem to emerge in the comparison of the two knowledge systems as described by Agrawal (1995): "substantive – there are differences in the subject matter and characteristics of indigenous vs. western knowledge; methodological and

epistemological – the two forms of knowledge employ different methods to investigate reality, and possess different world views; contextual- traditional and western knowledge differ because traditional knowledge is more deeply rooted in its context." Hunn et al. (2003) also identifies two important groups offering critiques of TEK use that have hampered integration:

1. Postmodernist – attempts to translate indigenous concepts in order to develop a dialogue with modern scientists and resource management bureaucrats as an extension of modernist hegemony. Some argue that contemporary indigenous people have no traditional knowledge, given that they now use rifles, snow machines and outboard motors. The real problem becomes the definitions of Traditional, Ecological, and Knowledge.

2. Conservation Biology – Dismissive of the possibility that indigenous, traditional, and/or small scale subsistence communities might conserve their natural resources. It tends to define "conservation" strictly as practices designed to conserve biodiversity, either ignoring TEK or judging it irrelevant to people's behavior with respect to environmental resources.

Proponents of TEK often seem to validate its use by pointing out the failures and flaws of Western Science, though Western Science contributions to human knowledge of the world have been undoubtedly extensive and with far reaching positive implications for human survival too. Perhaps the focus on Western Science challenges, and the unquestionably brutal history of colonialism, has prevented some western scientists from fully embracing the alternative. Natural capital, through the framework of political ecology, can be embraced by both knowledge systems (Lansing et al. 1998). To the Skokomish Indians of the Pacific Northwest, salmon have social, symbolic, and economic value while externally salmon have natural capital too (Lansing et al. 1998). It is this natural capital that may be critical in uniting stakeholders from both sides of the isle.

Perhaps the best place to begin integrating Western Science and IK while nurturing a mutual respect for the two knowledge systems is in the classroom. Currently in the United States, "curricula, teaching methodologies, and assessment strategies associated with mainstream schooling are based on a worldview that does not adequately recognize or appreciate indigenous notions of an interdependent universe and the importance of place in their societies" (Kawagley et al. 1998). Indigenous peoples traditionally taught through direct experience in the natural world whereas western education emphasized compartmentalizes knowledge that is decontextualized and taught in a classroom (Barnhardt 2005). For many indigenous students, the western perspective does not relate to their worldviews and appears entirely foreign (Kawagley 1995; Cajete 1999).

My ethnoherpetological work with Stikine peoples and herpetofauna seeks to bridge the gap between local knowledge, indigenous knowledge and Western Science by emphasizing the benefits of each and the potential contributions to knowledge of each to our understanding of amphibian species, both from a management perspective tied to western bureaucratic structures and institutions, and from a cultural perspective that recognizes

cultural and spiritual values that are intertwined. Though some "facts" regarding amphibian observations are being extracted from LK to fit Western Science criteria, most remain with their original cultural context, a true advantage of interdisciplinarity that promotes mutual respects and validity. There is a strong educational component as well that attempts to pull from both knowledge systems to inspire citizen scientists from both spheres of influence and to establish conservation initiatives with shared benefits for all stakeholders.

Evolution of Post-Contact Thought

Marginalization and neglect by the dominant western society in regard to Indigenous Knowledge has lead to its recognition as a "novel and innovative approach to resource management" in the early 21st century (Butler 2006). IK is intimately linked to the experience of colonial domination as it is this experience that separated it as a separate belief system (Butler 2006). This dichotomy in and of itself keeps IK trapped in history (Butler 2006) and suggests completely segregated evolutions that ignore the process of contact and exchange (Agrawal 1995).

Putting humans back into ecosystems requires using all possible sources of ecological knowledge and understanding that may be available (Berkes 2004). Increasingly, it is important to incorporate the dynamic interactions between people and nature, instead of viewing people as mere "managers or stressors" (Berkes 2004). The idea that "environment" is external from human society became standard within western society after the Enlightenment period (Glacken 1967) yet the now indigenous perspective of humans as part of the ecosystem was also widespread in Europe prior to this period (Berkes 1999). It is important not to stereotype however, as these generalizations are not universally true for all cultures (Berkes 1999). In fact, some western traditions reject the idea of an impersonal and secular environment including the conservation ethic of Saint Francis of Assisi who preached and practiced absolute identification with nature (Dubos 2006), the stewardship ethic of Saint Benedict of Nursia who believed that true conservation means not only protecting nature against human behavior but also developing human activities which favor a "creative, harmonious relationship between man and nature (Dubos 2006), and that of the newest Catholic pope that took the name of Saint Francis of Assisi and has called for "the protection of all creation, the beauty of the world" which he describes as meaning "respect for each of God's creatures and respecting the environment in which we live."

Natural resource managers are learning that there are benefits to utilizing local knowledge held by indigenous elders and hunters, acknowledging that this extensive knowledge of local landscapes and the animals that inhabit them can assist in formulating improved management practices (Nadasdy 2005). Elders in particular provide corporate memory for the group, often having the wisdom to interpret "uncommon or unusual events" and helping to "enforce the rules and ethical norms of the community" (Berkes 1999). TEK systematically records and contextualizes local observations that can be used to ground truth environmental events, impacts and projections that are often captured by Western Science at very broad scales (Ames 2007). That said, LK and TEK are typically restricted at

chemical, biochemical or cellular levels because they tend to be "beyond the scope of traditional experiences and perceptions (Berkes et al. 2007), though the phenotypic manifestations of chemical changes within an animal can often be readily perceived (Thornton and Scheer 2012).

The nature of indigenous relations with national governments in North America has changed substantially in the past several hundred years, yet institutional discrimination and struggles over land remain political and ethical issues (Nadasdy 2005). The historic aspects of land ownership and comanagement of resources continue to define modern governmental interactions with indigenous peoples despite the fact that the dominant institution's representatives may not consciously recognize their colonialist approach (Nadasdy 2005). In fact, Nadasdy (2005) suggests that "many government officials are well meaning and are genuinely interested in granting First Nations [Indigenous] peoples a meaningful role in their own governance and management of local resources."

In the 1950s and 1960s, theorists considered TEK as "inefficient, inferior, and an obstacle to development" (Agrawal 1995a). Julian Steward, an American anthropologist, described human-environmental relationships as cultural ecology but focused primarily on technology in subsistence practices rather than on the underlying cultural context of these processes (Holen 2012). Willerslev (2007) notes that "human notions of animism are embodied in symbolic reflections of human social relations and these provide the theoretical framework for much of modern hunter-gatherer research." Slowly, views of toward TEK are evolving to understand the cultural and spiritual relationships that must be considered in relation to the source.

Like many indigenous communities, Tlingit society underwent profound changes in the 19th century when, as a result of the commercial fishing industry in the late 1870s, salmon went from the "foundation of Tlingit economy" to "common property." These peoples who once proudly claimed salmon streams as their ancestral property quickly became "wage-labor fishermen and cannery workers" (Hunn et al. 2001). Prior to this however, important patchy resources from salmon spawning areas to halibut fishing grounds to berry patches were owned, controlled and monitored by individual families (Hunn et al. 2001). According to Hunn et al. (2001):

> "Fish were the primary resource category [among the Tlingit]. According to Murdock's Ethnographic Atlas (1967), fishing (including shell fishing and marine-mammal hunting) accounted for 56-65% of Tlingit subsistence; hunting large land animals (including trapping and fowling) accounted for 26-35% and gathering plants and small land animals (possibly including birds' eggs) for the remaining 6-15% (Hunn et al. 2001)."

Traditional Tlingit practices in Alaska included explicit conservation provisions, such as the people of Kake rotating their sheep hunting locations annually to avoid overharvest (De Laguna 1990). The people of huna developed an understanding of seagull breeding biology through careful nest observation, and subsequently instituted sustainable harvest strategies (Hunn et al. 2001). They cared about and recognized the importance of

sustaining resources that were important quantitatively (available in mass), yet even resources receiving a lower ranking on the Murdock scale (Murdock 1967), such as berries, had an immense spiritual and social significance (Hunn et al. 2001).

Non-game species also played a critical spiritual and social role in traditional Tlingit culture as described in depth by Ream (2012). This relationship too has evolved as western culture, technology, and Christianity have heavily eroded Tlingit society and knowledge systems. In my own herpetological work, it is evident that traditional relationships to non-game species, while often intact among elders in terms of the practice of mutual respect, now often lack the spiritual kinship components of the past. Relying on published literature for glimpses of past relationships as well as on key respondent interviews and mailed surveys for contemporary attitudes, I hope to identify components of this change and its corresponding implications on herpetofaunal knowledge, interactions, and management strategies.

TEK has thus far been largely used to study the human scale of experience that deals with hunted species, physical geography, navigation and safety, with the bulk of these undertaken with resource management in mind (Thornton and Scheer 2012). The potential applications of TEK go far beyond this however, as it can assist stakeholders in the playing a role in the development process and in preserving valuable skills, technologies, artifacts and problem solving strategies that may be useful for all of humankind. Additionally, as noted previously, TEK can offer values and beliefs that are important within a knowledge system if they lead to "a moral code of ethics about the environment" (Berkes et al. 1998).

Utility of Hybridization

Where ecological concerns are on the rise and faith in technological solutions is declining, TEK and LK may provide cause for optimism (Menzies 2006), considering that they have had a significant influence on many research projects and management strategies to date (Huntington 2000) and that many of our environmental problems are not easily understood by western conventional means (Berkes 2004). It is widely recognized that this knowledge can contribute to the conservation of biodiversity (Gadgil et al. 1993), rare species (Colding 1998), protected areas (Johannes 1998), ecological processes (Alcorn 1989) and sustainable resource use in general (Schmink et al. 1992; Berkes 1999). Nadasdy (1999) offers that:

> "By integrating the knowledge of aboriginal people, who have spent their lives out on the land with that of scientific experts, we will increase our overall understanding of the environment and this new integrated knowledge will allow improvements in existing processes of environmental impact assessment and resource management."

In order to manage wildlife species effectively, it is necessary to obtain long-term data relating to population fluctuations, to know the cause of change in species abundance, to understand methods for obtaining desired management outcomes, and to realize the impact of human activity on the population itself (Nadasdy 2006). Western Science and LK

can interact to promote conservation by members of both parties (Berkes 2004) and to define "a social definition of conservation that validates and encourages small scale conservation efforts that links conservation with [local] issues" (Brosius and Russell 2003). Additionally, cultural connections to the environment are "powerful social forces that can foster stewardship and social-ecological sustainability (Chapin 2009).

Promoting conservation ethics and responsible resource stewardship are among the key aspects of TEK that may influence societal attitudes toward sustainability. TEK calls for stability and balance between the environment and communities by ensuring that attitudes, values and strategies serve to "prevent waste, hoarding and environmental degradation" and to communicate these between generations (Corsiglia 2006). TEK contains wisdom that encourages the development of values, attitudes, habits, and actions for respectful interactions and relationships with the environment (Corsiglia 2006). In addition, many resource use practices among indigenous peoples tend to conserve biodiversity since many traditional groups rely on a multitude of species rather than just a few for cash income and exports (Berkes 1999).

A conservation ethic can arise when resources are important, limiting, predictable, and depletable, as well as if these are controlled by a social group that can reap the benefits of local conservation efforts (Berkes 1989). Research based on local participation is also important for empowering indigenous peoples and rural communities (Berkes 2004). It treats indigenous peoples as more than objects of research, but as collaborators for understanding and managing the environment (Nabhan 2003). Understanding TEK and its underlying frameworks then may accelerate the implementation of alternative management systems when it is established that human control of the environment is indeed limited (Berkes 2000). TEK therefore has the capacity to modify our views of the natural world and to encourage the protection of natural diversity (Nabhan 2003).

The trend in TEK studies is to approach the subject in a participatory fashion that allows the community to become a partner in the process of knowledge creation and sharing (Berkes 1999). In this manner, using knowledge and perspective from the community can help to build a broader database of knowledge than can Western Science studies alone (Berkes et al. 2000). The paradigm shift to community-based conservation has emerged out of three conceptual shifts in applied ecology, "a shift from reductionism to a systems view of the world, a shift to include humans in the ecosystem, and a shift from an expert based approach to participatory conservation and management (Levin 1999; Bradshaw & Bekoff 2001, Ludwig 2001). A consideration in collecting TEK is that obtaining the information from diverse sources is usually laborious, time-consuming and costly (Tripathi and Bhattarya). Thornton and Scheer (2012) compiled several recent and successful collaborative projects into the borrowed table below:

Table 4. Collaborative projects that bridge LTK and science: examples from the literature.

Examples	Focus	Methods
Baines 1992	Various subjects, focusing on fish and fishing	Researchers resident in community, reciprocal training
Carmack and Macdonald 2008	Water and ice-related phenomena (Arctic Canada)	Dialogue with elder
Fernandez-Giminez et al. 2006	Beluga whales (Alaska)	Comanagement committee
Fienup-Riordan 1999	Geese (Alaska)	Interviews
Gearheard et al. 2006	Sea ice (Alaska/Canada)	Knowledge exchange with field trips
Hall et al. 2009	Oyster fishery (New Zealand)	Participatory monitoring
Krupnik 2002	Ice and weather (Alaska)	Workshop and locally led documentation project
Moller et al. 2009b	Seabird harvest (New Zealand)	Long-term research partnership
Norton 2002	Sea ice (Alaska)	Symposium
Obura et al. 2002	Local fish monitoring (Tanzania)	Community engagement in research
Tremblay et al. 2008	Local climate (Arctic Canada)	Community-based monitoring

Some opposition to the resource management capability of indigenous peoples stems from the social and economic changes (erosion) that have occurred due to assimilation with the dominant society, causing a loss of knowledge and alteration of practices (Berkes 1999). In one example, the Inupiat of Kotzebue Sound in Alaska were shown to have incorporated practices that favor individual decision making instead of traditional cooperative hunting which corresponded to a sharp decline in the local beluga whale population (Morseth 1997). There will undoubtedly be negative examples of modern indigenous practices just as there are of western practices too; every management system has evolved through trial and error resulting in both benefits and consequences. But, we should acknowledge that there is always a gap between ideal practices and actual practices – practice is not always true to belief (Callicott 1982). These beliefs describe how people ought to behave, not how they actually do (Callicott 1982).

Despite the inevitability of occasionally unsuccessful practices and cultural erosion in both knowledge systems, a multitude of success stories regarding the integration of TEK with Western Science are emerging. In Alaska and Canada, there are numerous thriving indigenous cultures and state and federal agencies are striving to document local knowledge and practices (Holen 2012). Some examples of TEK insights come from the Canadian North where local knowledge "far exceeds that of the Western scientist who has a seasonally limited research period (Berkes 1999). Scientists have documented Inuit knowledge of species life cycles and distributions, interactions between narwhals and killer whales, and interactions between eider ducks and great black-backed ducks (Berkes 1999; Freeman 1993). A list of recent species-specific studies involving the collection of local and traditional knowledge was compiled by Thornton and Scheer (2012) and is borrowed here on the next page.

On the North Slope of Alaska, the knowledge of indigenous elders about bowhead whale populations and behavior was used to correct erroneous population counts made using Western Science techniques (Bingham 1997). In another example, the Sitka Tribe of Alaska has been a collaborator on numerous IK studies and even formed the Sitka Herring Research Planning Group for the establishment of regular communication and new research and management priorities that link local fishing knowledge and practices to marine ecosystem management (Thornton & Scheer 2012).

Table 1. Species-specific studies.

LTK collected	Species	Source
Current abundance and spatial distribution of species	Beluga whales	Carter and Nielsen 2011
	Bumphead parrotfish	Aswani and Hamilton 2004, Dulvy and Polunin 2004
	Bowhead whales	Noongwook et al. 2007
	Goliath grouper	Cavaleri Gerhardinger et al. 2009b
	Ivory gull	Mallory et al. 2003
	Oysters	Hill et al. 2010
	Polar bears	Dowsley and Wenzel 2008
	Spatial variation in emergence of sooty shearwater chick	Moller et al. 2009a
Migratory or seasonal movements	Beluga whale	Huntingdon et al. 1999, Mymrin et al. 1999
	Bowhead whale	Noongwook et al. 2007
	Brazilian coastal fish	Silvano et al. 2006
	Cod	Murray et al. 2008
	Jaraquis	Batista and Lima 2010
	Pomatomus saltatrix	Silvano and Begossi 2005
Sightings of species	Dugongs	Rajamani and Marsh 2010
	Sharks	Rasalato et al. 2010
Stranding incidents	Dugongs	Rajamani and Marsh 2010
Health of species	Condition of polar bears	Dowsley and Wenzel 2008
Size of species	Patterns in size of *Puffinus griseus* chicks	Moller et al. 2009a
Life history	Goliath grouper	Cavaleri Gerhardinger et al. 2006
	Jaraquis (size of sexual maturity, growth, mortality)	Batista and Lima 2010
Stock structure	Cod	Gosse et al. 2003, Murray et al. 2008
Key habitats	Gadoid fishes	Bergmann et al. 2004
Spawning and nursery areas	Cod	Ames 2007
	Goliath grouper	Aguilar-Perera et al. 2009
	Multiple fish species	Knutsen et al. 2010
Past abundance	Beluga whales	Carter and Nielsen 2011
	Chinese bahaba	Sadovy and Cheung 2003
	Cod stocks	Rosenberg et al. 2005
	Frigate tuna	Venkatachalam et al. 2010
	Goliath grouper	Aguilar-Perera et al. 2009
	Herring	Jones 2007, Thornton et al. 2010
	Lobster (*Jasus frontalis*)	Eddy et al. 2010
	Multiple finfish species (local extinction)	Lavides et al. 2009
Behavior	*Carangidae* fish aggregation	Hamilton and Walter 1999
	Polar bears	Keith et al. 2005, Lemelin et al. 2010
	Dugongs	Johannes and MacFarlane 1991
Reproduction-related behavior	Breeding of geese in relation to storm surges	Fienup-Riordan 1999
	Calving in beluga whales	Huntingdon et al. 1999, Mymrin et al. 1999
	Nesting-site fidelity in sea turtles	Johannes and Neis 2007
	Parental care in jaraquis	Batista and Lima 2010
	Reproduction in various coastal fish	Silvano et al. 2006
	Reproduction in *Pomatomus saltatrix*	Silvano and Begossi 2005
	Spawning of longfin emperor	Hamilton 2005
	Spawning behavior of various reef fishes	Boomhower et al. 2007
	Lunar cycles and fish reproduction	Johannes et al. 1981
Feeding behavior	Beluga whales	Huntingdon et al. 1999, Mymrin et al. 1999
	Jaraquis	Batista and Lima 2010
	Polar bears	Lemelin et al. 2010
	Pomatomus saltatrix	Silvano and Begossi 2005
Effect of physical environment	Effects of lunar periodicity on fish	Aswani and Hamilton 2004
	Reactions of eider to shifting ice pack	Gilchrist and Robertson 2000
	Effects of climate variability on Arctic char	Knopp 2010
Human-animal interactions and effects	Polar bears	Keith et al. 2005, Lemelin et al. 2010
	Reactions of seals to fishing nets	Moore 2003
	Reactions of tuna to fishing devices	Moreno et al. 2007b

Borrowed from Thornton and Scheer (2012).

In another example from southwest Alaska, as told by R.S. Nelson (Kawagley et al. 1996):

> "A group of scientists participating in a public hearing provided data demonstrating that Beluga whales did not feed on salmon. A group of local Alaska Natives (mainly Yupiaqs) persuaded the scientists to visit a nearby beach where they opened the stomach of a recently harvested Beluga. When several large salmon spilled out, one of the elders reported to have said, "How'd those get there then?"

Ecosystem services that provide spiritual, inspirational and aesthetic services are important motivations for conservation (Chapin 2009). The most common element of all religions in human history has been an inspiration from nature that leads to a belief in nonphysical beings (de Groot et al. 2005). Many traditional societies have succeeded in managing local resources, in part because their religious or ritualistic representation of management practices uses emotionally powerful cultural symbols to promote moral codes and responsible management systems (Anderson 1996). In the arctic and subarctic regions of North America, reciprocity forms the basis for human-animal relationships among indigenous peoples and is "essential for human survival" (Nadasdy 2005). Among the overarching rules that support responsible management practices are those described by Nadasdy (2005):

1. Don't talk or think badly about animals. This includes laughing at animals, making fun of them, or saying (or thinking) anything derogatory about them. It also includes boasting about your hunting abilities (especially in such a way as to deny the animal's pivotal role in the process.)

2. Don't bother or play with animals. If an animal offers itself to you, you must accept the gift graciously or risk offending the animal. This means that you must kill animals quickly and with a minimum of suffering. You should never bother or otherwise torment an animal before killing it. It also means that you should not wound or kill an animal if you do not need the meat.

3. Proper treatment of animal remains. Proper treatment varies from place to place and by species.

4. Don't waste the meat. You must not waste meat or kill excessively. To throw any meat away or allow it to rot is tantamount to having both killed the animal needlessly and treated its remains improperly.

In North America, catch-and-release sport fishing has been a topic of concern among many indigenous peoples for decades since they believe that fishing should only be undertaken to obtain food, otherwise it is an act of torment for the animal (Nadasdy 2005). To the Yupik Eskimos of Alaska to whom fish are not considered a limited resource (only the ability to catch the resource is considered limited), catch-and-release fishing, including capture for the purposes of tagging and examining, disrupts the reciprocal relationship between humans and fish (Holen 2012). Many North American indigenous groups believe that if an animal is offended or its remains are treated inappropriately, the animal's spirit will be

injured and it will not return again in subsequent years to be made available for human exploitation.

To the Salish, the proper return of a salmon carcass to the water allows the "salmon people" to put the skin and bones on again in order to return later (Anderson 1994). This practice is recognized by western scientists as a valuable traditional practice that can enrich the gravel beds where salmon spawn and provide nutrients to their young (Holen 2012). In Alaska, the Tlingit saying "aat ya atunei" means "respect for everything provided by the Holy Spirit" and requires that an individual's harvest not exceed his or her needs (Hunn et al. 2003).

Nabhan's work with the Comcaac found that these indigenous people encode cultural knowledge of geographically restricted species in their language – "knowledge about where these organisms live, when they reproduce, and what they are 'good for' (Nabhan 2003). As Nabhan argues, "this is knowledge that would likely not be found among neighboring communities if the Comcaac themselves ever 'lost' or 'abandoned' it, for whatever reasons" (Nabhan 2003). Unfortunately, my work on the Stikine has provided preliminary evidence that knowledge related to amphibians has been severely eroded and many details that may have been encoded within the Tlingit language among the Kiks.adi has been lost considering that few people of that clan in Wrangell are fluent in their native tongue, even at a basic level. This does not mean that all beneficial facts regarding amphibian species were lost in translation, only that those that were may be gone for good.

Cultural dispersal and aboriginal introduction are terms to describe the movement of species on a landscape by indigenous peoples (Nabhan 2003). Many groups have done this intentionally, an example being Nabhan's description of Chuckwalla dispersal to various islands by the Comcaac to make them available for future harvest (Nabhan 2003). Sometimes these dispersals are unintentional. Geckos are considered the quintessential "camp followers" and are capable of riding along with humans in boat and baggage (Nabhan 2003). It is well documented that Polynesians inadvertently introduced four genera of geckos to the Hawaiian Islands (Austin 1999; McKeown 1978). Several Kiks.adi stories in Wrangell report having found frogs in boats too, moving from island to island as stowaways.

The spiritual representation of non-game species among the Stikine Tlingit has clearly been an emotionally powerful tool in traditional conservation. In the case of the frog, they have long been deeply feared because of their powerful abilities to affect weather, health, and survival. Stories tell of human nobility being taken by the Frog People, and of entire villages being destroyed out of vengeance for transgressions against these animals. Among the Kiks.adi, the connection is deepened as they approach these species as physical representations of their ancestors. To kill a frog would be to kill a family member, to offend one would be to disrespect and shame the entire clan. Clearly this conservation ethic, derived in cultural spirituality, has served to prevent unnecessary killing of these species.

In yet another example, native Alaska frogs have been found to be taken into homes and classrooms frequently as pets and educational tools. This has likely had a negative impact

on local amphibians as it removes breeding individuals from natural populations, facilitates the spread of disease, and modifies population genetics. In contrast, Tlingit elders in Wrangell suggest that taking these animals from the wild and caging them in a confined area was a disrespectful act that violated the free will of the animal. Traditionally, this type of violation was immensely feared to bring about catastrophe. In this way, the observational approach to amphibians in the wild was and remains a conservation ethic that can alleviate human-induced pressure on these species.

Challenges and Approach

Joint management of resources by governmental agencies and local stakeholders is a mechanism by which the Western Science and LK systems and perspectives can increase the likelihood of effective policy implementation (Chapin 2009). Negotiating differences in worldview to achieve effective management potentially requires the establishment of common language and protocols to develop shared visions of outcomes (Kofinas 2009). Western scientists and educators are increasingly interested in traditional cultural approaches of achieving sustainability and sustained yield (Snively 2006). It is therefore fundamental to develop the capacity to tap into LK if we are to integrate livelihoods and wellbeing into "resilience-based ecosystem stewardship (Kofinas and Chapin 2009).

TEK can benefit the management of ecosystems if it is appropriately integrated into conservation plans and used to maintain biodiversity / prevent endemic extinctions (Nabhan 2003). As touched on previously, there are a number of significant challenges that must be overcome to fully integrate and utilize TEK as a coequal tool. The differences in approach to knowledge systems and legitimacy are among the greatest of these obstacles (Berkes 2008). There are a series of linked issues including "worldviews, cultural survival, ownership of knowledge or intellectual property rights, empowerment, local control of land and resources, cultural revitalization, and self determination (Berkes 1999).

Joint management is a "shift away from autocratic and paternalistic modes of management that rely on the combined efforts of traditional specialists and peoples"(McGoodwin 1990). Collaboration and co-production of knowledge is a potentially beneficial way of bridging the gap between the two knowledge systems (Thornton and Scheer 2012). To maintain the current inertia toward integration, unique approaches may be necessary to successfully represent IK within Western institutions (Thornton and Scheer 2012).

The process of creating joint management regimes is problematic when indigenous perspectives and involvement become or when TEK representatives become politically sidelined in the western management system (Holen 2012). Some individuals arising from Western Science backgrounds also perceive the observations of indigenous peoples as mere complications to the more occasional but intensive observations made under Western Science protocols (Nadasdy 2006), complications that seemingly replace scientific rigor with political correctness (Huntington 2000). Many western scientists are furthermore unfamiliar with social science methods and are not prepared to use these to obtain TEK, which otherwise remains out of reach (Huntington 2000). Even when they do embrace the goal of integration, they often seek to compartmentalize and distill TEK

according to external criteria of relevance that seriously distorts it in the process (Nadasdy 1999). The spiritual dimensions of TEK in particular are unlikely to be embraced by natural scientists (Berkes et al. 1998). Nadasdy (1999) describes the attitude of western managers toward indigenous peoples in Canada's Yukon Territory that were providing detailed observations of sheep populations:

> "Resource managers are typically interested in information on the numbers of sheep sighted by First Nations members and the years and locations of these sightings. They are not interested in (nor are they able to make use of) a wide variety of the elements of an aboriginal hunter's world view (which to her or him are directly related to sheep), such as the stories, values, and social relations that transmute those sheep from a set of population figures into sentient members of the social, moral, meaning-filled universe of the hunter and his or her family."

The current state of affairs dictates that a new integrated knowledge would be used by scientists and resource managers rather than the indigenous hunters and trappers from which is was derived – a process that concentrates power within government rather than within indigenous communities (Nadasdy 1999). At very least, putting indigenous views on the development agenda is starting to validate cultural traditions and to represent a perspective that needs to be sympathetically accommodated (Sillitoe et al. 1998). It can be quite difficult to have a sympathetic awareness of others views but keeping an "open and flexible mind" can help to appreciate alternative approaches. On the opposite side of this coin, it is also important to guard against any romantic tendency to idealize (Sillitoe et al. 1998), as not all traditional practices are ecologically wise (Berkes et al. 2000), nor are all western solutions are acceptable.

By overlooking the role that IK and LK can play in understanding the world around us, western scientists have not sufficiently understood the human-environment relationship of indigenous peoples (Nazarea and Nazarea-Sandoval 1995) though more and more people are recognizing and promoting its importance for sustainable development (Tripathi and Bhattarya). We must ask ourselves "what is knowledge and how is it legitimized?" (Nadasdy 2005). According to Westley (1995), "management is about bringing together old knowledge, from diverse sources, into new perspective for practice.

From the Indigenous side of the isle, distrust and marginalization arising from the colonial experience has influenced their need to control their own knowledge, which must be balanced against the need to share insights as part of the "common heritage of mankind (Berkes 1999). The holders of TEK are sometimes reluctant to share their knowledge because of these issues of control and ownership over it (Huntington 2000). In addition, the localized relevance of their knowledge can be a significant barrier as western scientists attempt to fit it into broader management models (Sillitoe et al. 1998).

TEK is culturally embedded giving equal emphasis to a shared belief system and knowledge of the natural world where they actively participate alongside other species (Berkes 1999; Nadasdy 1999; Usher 2000). To understand the culturally embedded meanings, western scientists must conduct research with Indigenous people and not "of" them (Ingold 2008).

This allows TEK research to explore how indigenous groups "build cultural identity and a sense of place" (Berkes et al. 2002; Pickering et al. 2010). It also assists in the understanding and development of an indigenous ethos to existing western resource management paradigms (McGoodwin 1990). In addition, there is hope that integration of the two systems will empower aboriginal peoples and communities (Nadasdy 1999).

Project design should assist local communities in building the capacity necessary for collection, analysis and dissemination of data so that their participatory ability to effect resource management is strengthened (Obura et al. 2002). One example of an emerging tool in the documentation and integration of TEK is that of Geographic Information Systems (GIS) which, along with many other methodologies, is viewed as an exciting development that permits the spacial relationships of knowledge to be examined and has until now, been under explored in this capacity (Tripathi and Bhattarya 2004). According to Tripathi and Bhattarya (2004), "there is a greater likelihood that information stored in a GIS environment will actually be shared, since it is in a central spacial repository and can easily be accessed and analyzed."

The process of integration of LK with Western Science in my amphibian work will include a substantial GIS component that maps observational data against (or in compliment to) systematic inventory and historical data of amphibian occurrence and distribution in the Stikine region. I will consider the local indigenous ethos of this region in relation to amphibians and try to identify those components that are likely to benefit conservation efforts, including those that have already been identified and discussed here, such as restricting the taking of pets and embracing respect through ancestral spirituality. I will provide an account of the perceived cultural, recreational, and aesthetic value of amphibians to local indigenous and non-indigenous residents alike, providing a broader range of resource valuations than is typically afforded to non-game fauna. In addition, I will document TEK not only for use in management, but equally for the preservation of culture and posterity. Elder interviews will be archived and made available to the community at large.

My work brings stakeholders to the table in discussions regarding local non-game research and management. It attempts to understand how these resources are important to them and why. By implementing a strong citizen science and educational component, we are working together toward common goals. Though amphibians indeed appear to be an important cultural resource to Wrangell, these undertakings may establish the foundations for expanded works that can benefit other species and other components of local and traditional culture.

The state of the modern world necessitates that most indigenous peoples understand western society but not at the expense of their own knowledge and practices (Barnhardt 2005). In order to explore alternative solutions to world problems, Non-indigenous people too must recognize the co-existence of multiple worldviews and knowledge systems (Barnhardt 2005). Resilience theory and knowledge of social ecological systems are emerging approaches to describing the "practical activities that create linkages among

humans and other constituents of an ecosystem"(Berkes et al. 2002), and to hybridizing knowledge systems for the purpose of enhancing the human experience.

Resilience through Hybridization

Prior to exploring the capacity of research to understand social-ecological system dynamics and its implications for sustainability, it is important to acknowledge the evolution of thought that allowed environment to be considered as an SES (Folke 2006). Just as many mainstream studies have ignored the role of humans as components of the environment, so does social research often ignore the role of environment on humans (Berkes et al. 2003). To understand an ecosystem, one must first understand the human groups associated with it including how they are organized and how they behave (Folke 2006). Holling (2001) provides three relevant characteristics of human systems:

> 1. Foresight and intentionality. Human foresight and intentionality can dramatically reduce or even eliminate the boom and bust character of some cycles.
>
> 2. Communication. Organisms transfer, test, and store experience in a changing world genetically. Humans uniquely add the ability to communicate ideas and experience.
>
> 3. Technology. The scale of the influence exerted by every animal other than humans is highly restricted

The complexity of sustainable resource management requires a systems approach that includes combining biophysical and socio-economic dimensions in interdisciplinary pursuits to understand the interrelatedness of system components (Barr and Dixon 1998). This requires the ability to observe and interpret essential ecosystem processes and variables to improve social capacity that can respond to feedback and change (Carpenter et al. 2001; Berkes and Folke 1998; Becker and Ostrom 1995). Human activities have become globally interconnected and intensified through technology, capital markets and systems of governance causing a seemingly decreased capacity of the environment to continue to sustain development at the current pace (Folke 2005). Given that we are now in an era of increased transformation, ecosystem management must build and maintain resilience as well as social flexibility that can cope, innovate and adapt (Holling 2001).

Management of SESs for long-term sustainability is challenging since it is difficult to forecast the future that is filled with uncertainty (Berkes et al. 2002). This uncertainty, while we often try to manage it out of the system, is inevitable and requires that we prepare to live with it (Folke 2006). Instead of controlling the system we may need to learn to live within the system (Walker et al. 2002). The adaptive capacity of society is restricted by the resilience of the SESs on which they depend suggesting that greater human resilience leads to a greater ability to absorb shocks and perturbations and to adapt to change (Berkes et al. 2002).

The resilience approach allows for interdisciplinary collaboration in the management of transitions toward sustainable development (Folke 2006). It can be defined as a system that has the capacity to absorb disturbances and to reorganize while simultaneously undergoing change and retaining the same general "function, structure, identity and feedbacks"(Holen 2012). It is an important element of how societies adapt to external changes (Berkes et al. 2002). Similarly, adaptability is the capacity of the system's actors to influence its resilience (Holen 2012).

SESs produce resilience by logging and utilizing disruptive experiences to the system, in turn providing both the system and its inhabitants with useful memory that can be used in preparation of future events of the same nature (Berkes et al. 2002). Still, a common response to disturbance in the past has been to increase control over resources through domestication and simplification of landscapes in order to increase production, to avoid fluctuations, and to reduce uncertainty (Holling and Meffe 2002; Redman 2001). These conventional western management paradigms have emphasized centralized institutions that utilize command-and-control policies based on cause-effect thinking and mechanistic views of nature that aim to make ecosystems more productive, predictable and controllable (Berkes 2004). Unfortunately for man, this uncertainty is vast and often unpredictable, causing targets to continually shift and to require redefinition (Kates et al. 2001). But, it has also been suggested that the reduction in the range of natural variation that has been used to increase predictability may lead to a loss of system resilience, leaving it more susceptible to crises (Holling and Meffe 1996).

To rectify the situation, policy makers are slowly transitioning from an approach that assesses the maximum sustainable yield of individual species at a single broad scale to a more general focus on managing important ecological processes that sustain harvests and ecosystem services at many scales (Carpenter et al. 2001; Folke et al. 2002; Hughes et al. 2005). Berkes argues that policies must adapt in the same fashion as indigenous practices have over time (Holen 2012), allowing the consideration that connecting the present to the past can reestablish resilience (Gunderson 1997).

Indigenous peoples themselves have begun to reconsider their roles in the management process as they seek to blend old and new practices to fit contemporary conditions (Barnhardt 2005). They are currently working to demonstrate that a significant paradigm shift is under way in which their knowledge systems are recognized to contain an adaptive integrity of their own (Barnhardt 2005). Simply acknowledging alternative explanations and potentially valuable solutions to world problems is a constructive step in building critical resilience to support not only sustainability of ecosystems, but the very survival of the human race.

Conclusion

Local and traditional knowledge provide alternative approaches and solutions to problems that face wildlife management in North America, particularly in relation to 1) spatial and temporal observational data on populations and their behavior 2)the development of

conservation ethics that promote sustainability and biodiversity, and 3) valuation of resources beyond their direct consumptive worth. Reciprocally, attention to IK acknowledges its legitimacy and coequal value as compared to western knowledge systems.

Shifts in management regimes that permit the integration of local and traditional knowledge give local stakeholders the ability to participate in the development of research and subsequent policies that impact them personally, contributing local scales of knowledge and voicing localized concerns in a manner that may address their needs more effectively. It also serves to bring humans back into the system and thus acknowledging the existence of social-ecological systems that are innately intertwined rather than mutually exclusive. By recognizing these interconnected components of life on earth and by considering all possible solutions to environmental problems, we gain resilience by increasing our adaptive capacity – our ability to withstand perturbations to the status quo.

Wildlife research in particular stands to gain immensely from the use of local and traditional knowledge. Conventional Western Science investigations are limited in their capacity to provide long-term datasets due to logistical and financial constraints. Detailed knowledge of ecosystems exists within local communities where people interact with and reside within local landscapes on a day-to-day basis. Indigenous Knowledge has the additional benefit of temporal scale, offering detailed adaptive information regarding local landscapes and ways to sustainably persist within them, information that has been passed orally through many generations.

It is becoming widely accepted that local and traditional knowledge systems contain a wealth of data that can benefit mankind in the modern age, though the major challenge is accessing, recording and utilizing these, while doing so in a manner that benefits local peoples and enhances cultural integrity. This is no small task and often entails intensive, laborious and expensive implementation of community research programs. The goal should be then to limit these barriers by working with stakeholders to establish efficient networks of knowledge transmission. Ethnographic studies that document historic knowledge should therefore be succeeded and supplemented with long-term citizen science programs and joint management initiatives.

Alaska has emerged at the forefront of local and traditional knowledge legitimization and integration whereas a plethora of studies have been undertaken to address these issues over the past several decades. Like other parts of the sparsely populated yet naturally rich arctic and subarctic regions, the same financial and logistical constraints to Western Science research paradigms exist, perhaps presenting an even greater need for knowledge acquisition to ensure sustainability. Despite its incredible resources, the harsh climates of Alaska have demanded that its indigenous peoples acquire extremely detailed environmental data in order to survive, as they have for almost ten thousand years.

Many studies have utilized TEK in Alaska to better understand wildlife populations in a manner that could not be captured through observations at a single point in time or during a single season. As mentioned, these have been almost exclusively related to knowledge of

subsistence species or resources that are directly harvested for consumption and human exploitation. The benefits have begun to be realized, yet I propose that we can continue to expand this knowledge by exploring its capacity to inform non-game management too.

Again, the term "non-game" should not suggest that species falling within this category are unimportant to social-ecological systems. On the contrary, many non-game species play a critical ecological role in their environments and often have immense yet under recognized value to local peoples. Preservation of biodiversity increases human resilience within social-ecological systems and is therefore a worthy endeavor. Within these frameworks my study examines one such important taxa – amphibia – in a series of case studies that may elucidate the value of (or lack thereof) local and traditional knowledge in non-game research and management.

Berkes, Nadasdy and Nabhan are among the greatest contributors and inspirations leading to the theoretical framework of this interdisciplinary undertaking. Berkes has provided the foundations of TEK theory, legitimacy and integration within natural resource management regimes that are dominated by westernized governments and policies. Nadasdy built upon these premises, particularly within the field of wildlife biology, to expand the integration of detailed adaptive traditional knowledge to subsistence species in the North, exploring and validating TEK as a sometimes superior method of understanding species populations at various temporal and spatial scales. Lastly but perhaps most importantly, Gary Nabhan and his ethno-herpetological work with indigenous peoples in Sonoran Mexico, embraced not only the potential contributions of TEK to the field of herpetology, but also substantially enhanced cultural integrity through coequal emphasis on ethnographic documentation and recognition of Comcaac peoples.

It is my hope that three overarching themes will emerge from this ethnoherpetological investigation, including 1) an improved understanding of amphibian diversity and distribution within the Stikine-Le Conte Wilderness and nearby landscapes, 2) an understanding of the extent and availability of local herpetological knowledge in the community of Wrangell and 3) documentation of the perceived ecological, cultural, recreational, and aesthetic services provided by local amphibian species. If these goals are achieved, they may lend insight as to how non-game research in Alaska can proceed by utilizing local stakeholder contributions.

I have established that a major challenge of utilizing local knowledge alongside of Western Science is formulating methodologies that effectively and efficiently capture this knowledge and apply it more broadly for implementation in actual management processes. To facilitate this within non-game research in Alaska, my study additionally explores the use of several techniques to capture local knowledge, including ethnographic interviews, in-person questionnaires, mailed surveys, passive and active citizen science programs, and service learning projects for K-12 schools, coupled with conventional Western Science amphibian inventories. If one or more of these is deemed successful, it is my hope that its utility can be expanded in the study of other species, communities and landscapes.

The intended contributions of this study to cultural preservation within the Kiks.adi clan of the Stikine Tlingit should not be understated. In addition to exploring indigenous knowledge and values as they relate to herpetofauna, I proceed with equal emphasis on acknowledging, upholding, and supporting the cultural integrity of the Kiks.adi people. This study will and has archived the life accounts of respected elders, some of whom have already passed away, in order to not only honor their memory, but also to retain aspects of their ancestral knowledge for posterity, aspects that may otherwise have been lost to history. Furthermore, the project has allowed for documented historical knowledge within the literature to resurface, aiding in the revitalization and acknowledgement of past cultural realities that have seemingly been lost in the process of assimilation.

It is with great humility, enthusiasm and hope that I proceed in these pursuits. I strive to in some small way contribute to the resilience of mankind, the conservation of species, and the enhancement of responsible stewardship of earth's resources. By emphasizing local knowledge, local involvement, and education, I intend to inspire increased attitudes and practices of stewardship, rather than ownership, as so elegantly captured by Aldo Leopold (1950):

"We abuse land because we regard it as a community belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect. There is no other way for land to survive the impact of mechanized man, nor for us to reap from it the esthetic harvest it is capable, under science, of contributing to culture."

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