“WAYS TO HELP AND WAYS TO HINDER”

CLIMATE, HEALTH, AND FOOD SECURITY IN ALASKA

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WAYS TO HELP AND WAYS TO HINDER:
CLIMATE, HEALTH, AND FOOD SECURITY IN ALASKA

A

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ABSTRACT

This dissertation explores various ecological, socioeconomic, sociopolitical, and biophysical dimensions food security in Alaska. The context for this work is dramatic climatic change and ongoing demographic, socioeconomic and cultural transitions in Alaska's rural and urban communities. The unifying focus of the papers included here are human health. I provide multiple perspectives on how human health relates to community and ecosystem health, and of the roles of managers, policy makers, and researchers can play in supporting positive health outcomes. Topics include methylmercury (MeHg) contamination of wild fish, the impacts of changes to Alaskan landscapes and seascapes on subsistence and commercial activities, and on ways to design sustainable natural resource policies and co-management regimes such that they mimic natural systems. The operating premise of this work is that sustainability is ostensibly a matter of human health; the finding is that human health can provide a powerful point of integration for social and ecological sustainability research.

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INTRODUCTION

Climate change and sustainability research have reached unprecedented levels of salience and momentum world-wide. The sustainability of industrial technologies and world-wide patterns of growth and consumption have come into question (if not already proven themselves unsustainable), and anthropogenic CO_2-induced warming stands as the most notorious, albeit not necessarily the most poignant, indicator. People have begun to look in many places for solutions, primarily, to science, technology, and policy. The need to move environmental research in a direction that better serves the well-being of people and communities through policy is crucial (Bennett 1976, Rappaport 1993), but must be executed carefully, with care for scientific rigor, and with respect for science and politics' great power as epistemological hegemons (Brosius 1999, Kawagley 1995, Nader 1996). Science can help us find pathways through any number of contemporary 'socionatural' challenges, but it can just as easily obscure these possibilities behind abstract intellectual constructs and globally scaled models that alienate us from the place-based nature of the problems we set out to solve (Berry 1982, Hornborg 2009, Shiva 2000). And the politicization of environmental issues can often lead to a complete reframing of discussions that begin in the language of local needs, values, and environmental justice, into a language of trade-offs, stakeholders, and management (Brosius 1999, Escobar 1995). It is essential, therefore, that careful attention be paid to how well these new sustainability research programs engage with local peoples, and work towards serving outcomes that meet their needs and goals in the short and long term.

In the Arctic, a great many climate change-related impacts are already being experienced, often by people in remote communities who lack the resources and institutional support to respond effectively (ACIA 2005, Main et al. 2008). The retreat of seasonal sea ice, permafrost thaw and its myriad impacts on rivers, lakes, and hydrology in general, changes in the timing of seasonal changes, and a modified forest fire regime are all examples of ongoing environmental changes being experienced in the North (ACIA 2005, Chapin III et al. 2008, Hinzman et al. 2005, Overpeck et al. 2005, Wendler and Shulski 2009, White et al. 2007). There is consensus that the myriad, often cumulative impacts of these drivers and agents of change will continue to accrue for people in Alaska and elsewhere in the North. Where change is rapid, unprecedented or unanticipated, the potential for people to continue their way of life may be compromised (Nuttall et al. 2004, Pretty 2009, Wernham 2007); where change is gradual and/or can be predicted, however, people have the opportunity to plan and adapt (Bennett 1976, Buckley 1967, Ebi et al. 2006, Ford 2008).

Yet, climate change is not the first or even most important challenge facing these people and communities of the North (Fazzino and Loring 2009, Keskitalo 2008, Lynch and Brunner 2007, Rattenbury 2006); indeed, many of the people with whom I work are frustrated by the constant and almost obsessive attention given to climate change by the media as well as by researchers and politicians, while so many dramatic challenges to their health and well-being continue to fly under the proverbial radar. High and rising costs of food and fuel, dramatic and rapid changes to the landscape and weather, fisheries closures and other management actions that keep freezers and smokehouses empty, social and political debates and conflicts regarding the development of land, and troubling health trends such as increases in diabetes and heart disease, depression, and alcoholism, are some examples of the many difficult issues that rural Alaskans grapple with every day. Each of these challenges may indeed be attributed or linked to climate change in various ways, and local people understand this perfectly well. Nevertheless, people need to act in response to these challenges now, and it is highly unlikely that the most effective, place-based solutions to problems such as food insecurity, diabetes, cancer, and a lack of job opportunities will have anything to do with the primary or even secondary drivers of global climatic change.

All people have the ability to make good decisions and to plan intelligently for a safe and secure future, provided that they have the resources, information, and support/authority from institutional partners to do so (Irvine and Kaplan 2001). To that end, this dissertation focuses on a set of regional challenges identified by the people with whom I have collaborated, people in rural Alaskan communities like Minto, Fort Yukon, Togiak, Emmonak, and Unalaska. My friends and collaborators in these communities each have their own unique sets of needs, concerns, and goals, and in some cases, face very different sets of challenges; these include recent fisheries closures on the Yukon River, the impacts of environmental change on wildlife populations, policy-based challenges for moose hunters in the Alaskan Interior, and methylmercury (MeHg) contamination of wild foods. Yet, beneath these lay a broad set of shared themes, including community self-reliance and health. I bring these themes together within a discussion of regional food security. Food security provides a language for this research that resonates with my collaborators—a language of health, tradition, and self-reliance—while also allowing me the tools necessary for linking the various drivers, determinants and agents of change—including climate change—within a framework of food systems ecology. The intent is to develop an foundational understanding of contemporary problems from which communities, agencies and policymakers can collaborate to design effective place-based solutions that meet local and regional needs and priorities.

I.1 FOOD SYSTEMS, HEALTH, AND ENVIRONMENTAL CHANGE

The operative premise of this work is that sustainability is ostensibly a matter of human health. Human health is quite literally the 'embodiment' of social and environmental phenomenon (Krieger 2001, 2005): our bodies and minds incorporate, biologically and psychologically, our material, ecological and social experiences and exposures throughout our life-course (ibid). Indeed, there is arguably no aspect of a human's biology that can be completely understood outside of their historical social and ecological contexts (ibid). Likewise, contemporary research in historical ecology has revealed that it is impossible to fully understand the so-called 'natural' landscape outside the context of human interactions (Balee 2006, Bennett 1976, Cronon 1983, McGovern 1980, Redman 1999). Thus, it seems that the pursuit of an understanding of nature and of humanity are one and the same, with human health a much-sought after nexus for integrating the two (Figure I.1).

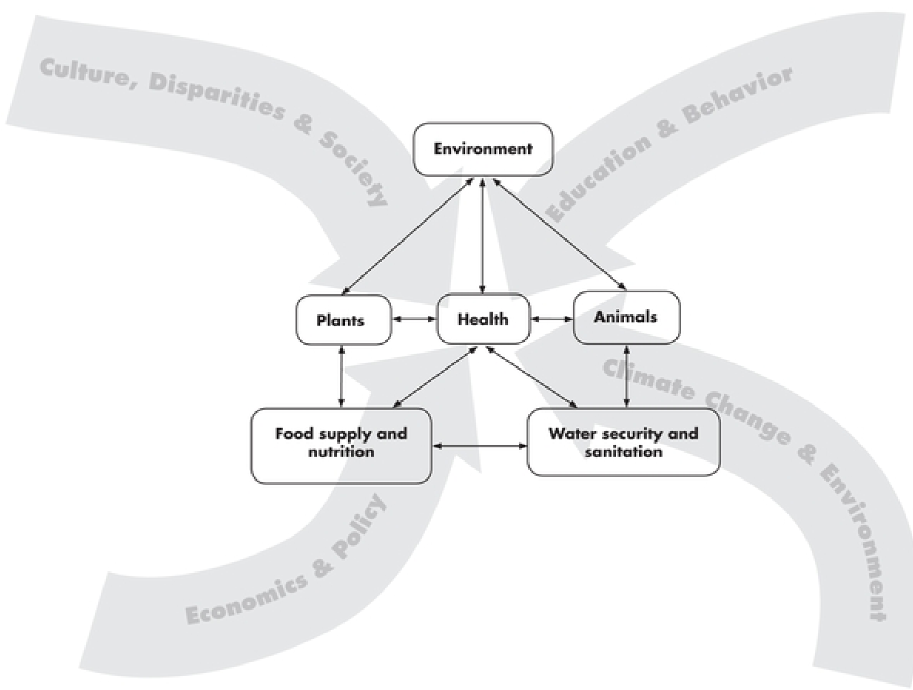

Figure I.1 The 'One World, One Health' Model. The proximate (fast) and global (slow) influences impacting human health, including the interdependence of people, animals, plants, and the environment, and the associated food and water availability, safety, and security. Reproduced from (Mazet et al. 2009). Art by A. Kent.

This dissertation uses a framework of food systems and food systems ecology to bridge social and ecological research methods across this nexus of human health (c.f., Dixon 1999, Ericksen 2008, McMichael 2000). Our lives, our heath, and our relationships with the environment are embedded within food (Hassel 2006, Kloppenburg et al. 1996, Nabhan 2002); we harvest, prepare, we share, we eat, and in many parts of the world we often have to wrangle with the realities of food scarcity and compete for our food to the best of our ability. We develop cultural techniques and technologies to control when, how and how much we eat: we enact traditions that transmit and preserve our food knowledge, we create technologies for taking control over the consistency and safety of our food harvest and supply, and we observe social rules and institutions that govern the distribution of those foods to consumers. These are our 'foodways' (c.f. Usher 1976); within which is embedded a dynamic and intimate relationship between nature and society, one where the preferences/choices we enact in order to fulfill our biophysical needs (like shelter and nutrition) and psychological and cultural needs (like ego, sense of place and belonging, appetite) transforms both us and our environment through the construction of meaning and assignment of cultural significance (Bennett 1976, McMichael 2000).

Like all complex and dynamic systems, the processes and components within food systems are highly interconnected, and food links our household and regional economies to larger economic, political, and ecological landscapes through an array of functional connections and dependencies (Lezberg and Kloppenburg 1996, McMichael 2000, Nestle 2002). But like all ostensibly-human issues, there are real, living faces and voices within these 'systems' which we must recognize if we are to better understand the place-based nature of the contemporary challenges facing health and well-being in rural Alaska. The dinner table is therefore a powerful context through which we come to understand globally-scaled problems at a local level: a place to listen and learn not only of the challenges people face, but also of how people face them, and of the assistance we might provide in the short and long term.

I.1.1 Food Security

When a food system effectively supports health in its various biophysical, social, and ecological dimensions, that person of community is said to be experiencing food security. The most basic definitions of food security usually focus only on whether or not the food system includes equitable physical and economic access to sufficient and safe foods (e.g., WFS 1996). However, in the context that we use it here, food security goes beyond a one-size-fits-all nutritional relationship between food and the individual, to incorporate matters such as the importance of certain foods and food choice, local definitions of hunger, uncertainty and worry about food safety or shortages, and any other psychosocial, sociocultural or environmental stresses that result from the process of putting food on the table (Coates et al. 2006, Maxwell 2001, Pinstrup-Andersen and Pandya-Lorch 2001).

The process of food security can be viewed in three dimensions (Figure I.2) (FAO 2006). Food **availability** involves the amount, type and quality of food a person or community has at its disposal; this can be analyzed in terms of availability from local production, the efficiency of distribution channels for moving food where it needs to be, the vulnerability of those distribution channels to supply and disruption, and the ability of households to procure food through sharing, exchange, etc. Food **access** involves the ability of each person to procure the foods that are available, including physical and logistic access to the locations where foods can be procured, affordability of foods, as well as how food allocation mechanisms such as subsidies, trade agreements, and other government policies work. Limits to access also involve any barriers that exist to whether consumers can acquire foods, when available, that meet their sociocultural and biophysical food needs and preferences. This latter issue of sociocultural and biophysical needs also relates to the third aspect of food security—food **utilization—**which refers to people's ability to derive all potential and needed benefits from the foods they do have access to. Utilization includes obvious factors such as food safety and nutritional quality, but also involves more regionally-specific environmental needs (e.g., vitamin D in high latitudes) and food-gene-culture interactions (Maxwell 2001, Loring and Gerlach 2009, Chen et al. 2007). Chapter 1 provides a more detailed discussion of the relationship between food security and biophysical and psychosocial heath.

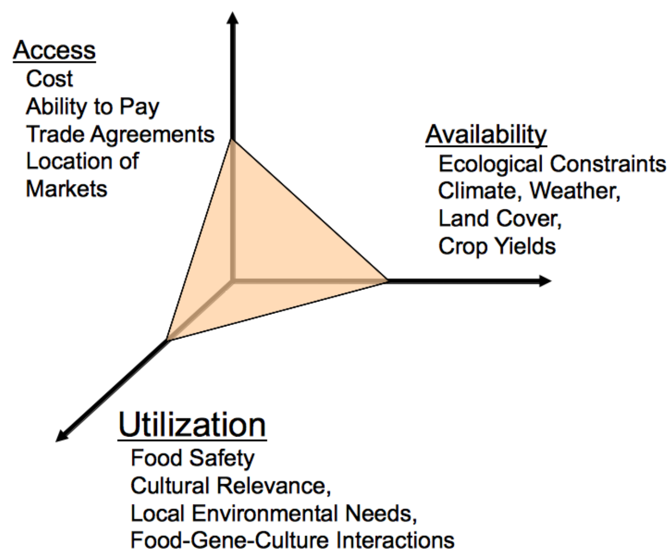

Figure I.2 Three dimensions of food security. A Cartesian approach to visualizing the three dimensions of food security.

I.2 FOOD SECURITY IN ALASKA

For millennia, the regional food systems of Alaska Natives were based almost entirely on wild, 'country foods', including (depending on region) sea mammals, ungulates, fresh and saltwater fish, seasonally available waterfowl, formal and informal gardens, berries, and other plant resources (Loring and Gerlach in press, Nelson 1969, 1986, Norris 2002, Ransom 1946, Spencer 1976, Usher 1976). Long-standing patterns of land-use and landscape features demarcate general, but flexible boundaries around what we might consider each tribal group's foodshed

(Loring 2007). This lifestyle connected Alaska Natives in physical and cultural ways to the land and wildlife, through activities such as food sharing and shared food preparation, the use of specific plant, animal, bird and fish species, travel routes, harvest sites and areas, and camps of modern and historical significance (Campbell 2004, Garibaldi and Turner 2004, Krupa 1999, Simeone 2002).

I.2.1 Contemporary Challenges

Locally harvested, wild subsistence foods remain the most preferred if not the most important component of diet and tradition for many Alaskans, including salmon throughout the state, sea-mammals on the western and northern coasts, and moose and caribou in the interior. However, Alaskans face a number of contemporary challenges in regard to food security, and in particular in regard to the viability of these important subsistence resources (ACIA 2005, Brinkman et al. 2007, Caulfield 2002, Fazzino and Loring 2009, Loring and Gerlach 2009, White et al. 2007). According to the USDA's 2008 report on household food security in the United States, over 12 percent of Alaskan households are food insecure, meaning that at some time during the year they had difficulty providing enough food for all members of their household (USDA 2008). About five percent of those who are food insecure in Alaska are classified as having very low food security, meaning they consistently reduce their food intake, or had disrupted eating patterns, due to inadequate resources for food (ibid). The report also states that a total of 29,400 households in Alaska experience hunger, though it does not provide specific details regarding why they are hungry.

Most research suggests that there is no one clear reason for these trends of food insecurity in the state, but rather that it is the result of complex, synergistic interactions between a wide and disparate set of challenges. Regional and household vulnerabilities to external market shifts in the price or availability of imported foods and fuel (Martin et al. 2008), the multiple, cumulative impacts of climate change, and oil, natural gas and minerals development on the landscape and fisheries and game (Wernham 2007, National Research Council 2002), environmental pollution including bioaccumulation of heavy metals (Jewett et al. 2003, Jewett and Duffy 2007, Rothschild and Duffy 2002, Godduhn and Duffy 2003), and high rates of likely diet-related health challenges like cancer, coronary heart disease, and diabetes (ADHSS 2007) are all examples of the various and disparate drivers that are likely implicated.

Food systems research in Alaska often tends to emphasize rural or subsistence issues on the one hand (e.g., Caulfield 2002, Ford 2009, Kruse et al. 2004, Nuttall et al. 2004, Rattenbury 2006, Robards and Alessa 2004), and 'commercial,' 'industrial,' and/or 'urban' issues on the other (Grossman et al. 1994, Knapp 1997, Woodby et al. 2005), although there are some notable exceptions (Fazzino and Loring 2009, Huskey et al. 2004, Martin et al. 2008, Meadow et al. 2009). Problems emerge when we overuse these categories, however, whether anecdotally or in legalistic ways (Pigg 1992). Though 'rural' and 'urban' make some typological sense, it is difficult, if not impossible, to discuss food security in just 'rural' or 'urban' terms. Many important linkages exist between Alaska's remote communities and highly-populated 'urban' centers that too narrow a view might miss: long-distance social and economic linkages are common, for instance, between families, neighbors, and migrant workers in Alaska (Huskey et al. 2004, Martin et al. 2008). Sharing and co-op style purchasing of food and other supplies are also common (Loring 2007, Magdanz et al. 2002, Reed 1995), as are widespread seasonal migration in and out of remote communities for purposes of employment or subsistence activities (Huskey et al. 2004, Stephanie Martin et al. 2008). These nuances further underscore the importance of situating a discussion in terms of the entire Alaskan food system, with food systems ecology providing a language that highlights rather than obscures the local character of these linkages, feedbacks, and interactions.

I.3 STRUCTURE OF THE DISSERTATION: TRIANGULATING FOOD SECURITY AND HEALTH

As food systems clearly transcend traditional cognitive and theoretical categories, and encompass myriad interacting social, economic, ecological, and political issues, multiple disciplines must be bridged in order to develop an appropriate holistic analytical framework. However, as with the discussion of sustainability and climate change above, care is necessary when engaging these multiple disciplines and methods, to recognize how each frames the problem, and how this can precondition, or even bias research towards a particular subset of findings, management interventions, development strategies, policies, etc. Different disciplinary framings or narratives of food security and insecurity will emphasize different sets of key drivers, and necessarily result in very different outcomes being valued and different solutions being posed (Maxwell 2001). For example, economists might emphasize markets as key to food security (Von Braun and Virchow 2001), agricultural scientists and development scholars might emphasize increased crop science and technology (Collier 2008), conservation scientists may focus on nitrogen run-off, land-use change, or greenhouse gas emissions (IPCC 2007, Daily et al. 1997, Cassman and Harwood 1995), and resilience ecologists will likely focus on governance and policy arrangements that support diversity and adaptability as the solution to undesirable outcomes (Walker and Salt 2006, Fraser et al. 2005, Ford 2009).

'Triangulation' describes a 'mixed methods' technique of approaching a complex question from three concurrent lines of inquiry (Denzin 1978, Jick 1979). The benefit of such an approach are many: it allows researchers to be more confident of their results, arguably a benefit of all mixed methods approaches. It also allows the researcher to draw on an otherwise disparate set of perspectives that may elude easy integration or even be in conflict with one another. This also has the potential for stimulating inventive new methods and interdisciplinary collaborations. At its simplest, triangulation usually involves a process of 'scaling down,' where discrete andoften quantitative methods are used to reinforce broader qualitative analyses (Jick 1979). Triangulation's real strength, however, is that it can also provide a more complete, holistic, and contextual portrayal of the subject(s) under study. The use of multiple lines of inquiry opens the door to some unique conclusions which otherwise may have been neglected by the confines of single methods (Jick 1979). In this sense, triangulation may be used not only to examine the same phenomenon from multiple perspectives, but also to enrich our understanding by allowing for new or deeper dimensions to emerge.

The three components of food security introduced above—availability, access, and utilization—provide an especially good research package for a triangulation approach to food security. Each provides an important, complementary component to food security, but inquiry into each requires a different set of methods and disciplinary perspectives. With these three themes in mind, I have, over the last five years, worked in a number of communities in Alaska to better understand regional and local challenges to food security; accordingly, I have drawn on a variety of ethnographic, participatory, quantitative, and cross cultural research methods and exercises in order to develop the best possible understanding of the determinants and drivers of patterns of food security across the state.

I.3.1 Chapter Outline

Chapter 1 provides background on the Alaska food system and the impacts of changing climate and society, and makes explicit linkages between food security, ecosystem structure and function, and individual and community health. The chapter introduces an integrative health model from social epidemiology that is helpful for conceptualizing the various drivers and determinants of food access, availability, utilization. Chapter 2 discusses a vulnerability approach to studying and projecting the impacts of environmental changes on communities and food systems, and illustrates how this line of research has converged with the realm of social epidemiology, albeit without health as the explicitly-stated concern. This chapter highlights the need for the development of a sound theoretical basis for making accurate regional projections of food system vulnerability, and reviews three areas of theory from social epidemiology that may be leveraged in this task.

Chapter 3 provides a down-scale example of how climate-change-driven phenomena can impact food utilization: the potential exposure to methylmercury (MeHg) contamination in wild foods is projected to increase along numerous pathways. We apply a state-of-the-art method for developing fish consumption advice that balances the risks associated with MeHg exposure with the potential benefits of omega-3 fatty acids that are common in many of Alaska's wild fish species. We show that these are just two of many dimensions of food utilization in the complex milieu of food, culture, and health.

Next, I include two papers (Chapters 4 and 5) that explore interactions between drivers of food access and food availability. Each paper brings together aspects of environmental variability and change, and agency mandates such as conservation and maximum sustainable yield, to understand impacts on local communities' ability to access wild foods, when available. Chapter 4 compares the experiences of commercial fishers in the Bering Sea with those of moose hunters in Interior Alaska; whether policies help or hinder people in their ability to respond to changing environmental conditions proves directly related to how authority is distributed and co-management roles organized local resource users and management agencies. Chapter 5 reviews the case of the disastrous 2009 chinook and chum salmon runs on the Yukon River, and asks the question of whether salmon conservation and community food security are necessarily competing goals. The chapter discusses the differences between single-species and ecosystem-based management, and makes a case that a food-systems approach to the Alaskan socionatural landscape is essential to meeting both long-term conservation and food security goals.

Chapters 4 and 5 also both conclude with recommendations for ways that collaboration can be improved between local peoples and management agencies. We explore this challenge more in Chapter 6, the only paper included that is not directly related to the issue of food security. As I discuss earlier in this introduction, it is essential that research and management be careful and attentive to whether or not the needs of local peoples are being met. Addressing place-based problems requires not just a comprehensive scientific understanding but also an inside perspective that can only be achieved through close collaboration. I take a critical look at contemporary attempts to engage local peoples in the research process, and suggests a new arrangement for finding better success with collaboration.

As I say at the beginning of this introduction, the operating premise of this work is that sustainability is ostensibly a matter of health; this collection of essays hopefully provides both a compelling case and a basis for moving health to the center of the sustainability discussion. My intent is to provide material for moving from 'knowledge to action' (c.f., Hawken 2007, van Kerkhoff and Lebel 2006): furthering both the development of theory and analytical tools, while still meeting my primary goal of providing communities with the facilitation and support they need to create effective place-based sustainability solutions.

The question of what can and will be done remains, and I hope that this dissertation provides something useful for these communities as they work to keep food on the table. As my friend Patrick Smith, once first-chief of the community of Minto, explained to me while we were breaking ground for a new community garden,

> We don't really know what life's going to be like here in 5 or 10 years. My grandfather recognized that change would be important, more important, sometimes than our traditions, but I'm not sure people want

to change, or can see past the way things once were, the way they think they're supposed to be.

His point was not just that change is difficult, but that for communities such as his that are struggling to assemble a contemporary identity, traditions can be as much an asset as an obstacle to change. We agreed that Alaskans are indeed blessed with the ingenuity to adapt to what is certain to be a difficult future, yet neither of us could say what sort of tipping point must first be reached before such changes could begin on a broad scale. I look forward to continuing to offer my resources and advice, such as they are, to these good friends through this interesting time.

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CHAPTER 1

FOOD, CULTURE, AND HUMAN HEALTH, AN INTEGRATIVE APPROACH[1]

1.1 ABSTRACT

Multiple climatic and socioeconomic drivers have come in recent years to interfere with the ability of Alaska's 'bush' communities to achieve food security with locally-available food resources. Livelihoods traditionally centered on the harvest of wild, country foods, are transitioning to a cash economy, with increasing reliance on industrially produced, store-bought foods. While commercially available foods provide one measure of food security, availability and quality of these foods is subject to the vagaries and vulnerabilities of a global food system: access is dependent on one's ability to pay; most importantly, perhaps these foods often do not fulfill many of the roles that country foods have played in these communities and cultures. This transition is having severe consequences for the health of people and viability of rural communities, yet in ways not always tracked by conventional food security methodologies and frameworks. This paper expands the discussion of food security, premised on an integrative model of health that links sociocultural, ecological, psychological, and biomedical aspects of individual and community health. We use the Alaska case to illustrate that if food security is to be understood as a matter of human health, then our definitions of and designs for food security must recognize food's multifaceted and often regionally-nuanced role in creating positive health outcomes.

1.2 INTRODUCTION

Global environmental change is already having dramatic effects on the

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1 Loring, P.A. and S.C. Gerlach. 2009. Food, Culture, and Human Health, an Integrative Approach. *Environmental Science and Policy 12(4):466-478*.

people and places of the north. New environmental trends such as the retreat of seasonal sea ice, landscape drying, and unprecedented shifts in the changing of the seasons and the timing of animal migrations, are just a few examples of the problematic environmental changes being experienced (ACIA 2005, Main et al. 2008). In rural Alaska, for example, where household livelihoods and community food systems are tightly connected to climate, weather, and the landscape, these new environmental conditions are interacting with other contemporary drivers of environmental and socioeconomic change such as industrial lands development and oil, gas and minerals mining, to significantly constrain the use of locally-available wild fish and game resources (Gerlach et al. in press, White et al. 2007, McNeeley 2009). To maintain some measure of food security, many households are transitioning away from reliance on the seasonal harvests of wild foods, to the consumption of imported, store-bought foods (Caulfield 2002, Loring 2007, Reed 1995). But in a global context of rising food and fuel prices, the costs and challenges of living in rural Alaska are on the rise and the loss of wild food options has ramifications not just for the pocketbook, but for individual health and community viability (Ford et al. 2007, Fried and Robinson 2006, Furgal and Seguin 2006, Kuhnlein et al. 2004).

Rural communities are undergoing a dramatic social and economic restructuring, “dying” in the words of some Alaska Natives (Martin et al. 2008 p. 13), as many residents move out of the ‘bush’ and into Alaska’s urban centers for jobs, for cheaper food and fuel, and sometimes for healthcare (Huskey et al. 2004, Goldsmith 2007). Across the state, precipitous declines are being noted in physical and psychological health profiles of Alaska Natives, with near-epidemic increases being observed and projected for Type II diabetes, obesity, coronary heart disease, and cancer, as well as for depression, substance abuse, alcoholism, and violence (ADHSS 2006, Degal and Saylor 2007, Graves 2005, Wernham 2007, Wolsko et al. 2007). The extent and manner to which these health trends are directly or indirectly linked to changes in community food systems still needs extensive research and quantification. In order for communities to understand, plan for, and manage these changes, it is necessary that research identify and strive to understand the many pathways through which fundamental changes to food systems can undermine physical and mental health, as well as community social and cultural and ecological health outcomes (Berner and Furgal 2004 p. 898-900, Gamble et al. 2008). Yet such research remains methodologically constrained by frameworks for evaluating social and cultural change that overlook these "invisible losses" (Turner et al. 2008 p. 1), neither emphasizing nor even acknowledging the many indirect roles that food and food culture play in promoting individual, community, and cultural well-being .

This paper uses the Alaska case to introduce an approach to evaluating the health impacts of food system change, premised on a conceptual model that integrates sociocultural, ecological, psychological, and biomedical aspects of individual and community health (c.f. Clark 2005, Kaplan et al. 2000). We begin with some background on rural Alaska, and review a number of the downscale ways that global environmental change is contributing to changes in Alaska's food systems. Food systems researchers across the world will likely find parallels in the Alaska case, particularly how these ecological changes mix with a variety of sociopolitical, cultural and economic factors to limit the availability of, access to, and utilization of locally-available food resources. We then review literature that explores many of the unique ways that Alaska Native foodways traditionally support the health of individuals and of entire communities. Cupboards and pantries in these communities may remain full, but the new, store-bought foods that fill them are not necessarily perfect replacements for traditional ones. We argue that if food security is to be understood as a matter of human health, then future definitions of food security must recognize these differences, and designs for food security solutions must leverage food's multifaceted and often regionally-nuanced role in creating positive health outcomes.

1.3 RURAL ALASKAN FOODWAYS

For millennia, Alaska Natives, including Athabascan, Eskimo and Aleut groups subsisted on a vast array of wild, country foods, including (depending on region) sea mammals, ungulates such as caribou and moose, fresh and saltwater fish, migratory waterfowl, berries, root-crop gardens, and other botanical resources. This lifestyle connected Alaska Natives in physical and cultural ways to the land and wildlife, through activities such as food sharing and shared food preparation, the use of specific plant, animal, bird and fish species, travel routes, harvest sites and areas, and camps of modern and historical significance (Campbell 2004, Garibaldi and Turner 2004, Nelson 1986, Simeone 2002). Indeed, the familiar working landscape has been no less than the context within which the Alaska Native world-view and identity have historically developed: a context for exploration, experimentation and the development of local knowledge (Barnhardt and Kawagley 2005, Kawagley 1995). Thus, culture in these groups has developed over time as both a place- and plate-based experience, where people achieve personal security through social cohesion and support, where people are linked through the economies of their livelihoods to each other and to particular socio-geographic spaces, and where they are secure in the knowledge that they have access to country foods that are abundant, available and healthy.

While the majority of Alaska Natives now live in Alaska's largest urban centers (Anchorage and Fairbanks), a great many still live in relatively isolated rural communities (Figure 1.1) (Goldsmith 2007). These bush villages are often established at the site of historically-used seasonal camping areas, but sometimes are located in areas that were never used for anything more than short-term, special purpose hunting and collecting activities, such as the village of Anaktuvuk Pass (Hall et al. 1985). Populations range from ten to thirty people in some of the smallest settlements in the Alaskan interior, to well over 600 in the few growing rural hubs like Fort Yukon and Bethel, to as many as 3000-6000 in the largest centers like Barrow, Kotzebue, and Nome (AKDCCED 2007, Wolfe 2000). With rare exception, even the largest of these villages are off of the road system; access to and provisioning from urban centers, whether for food, diesel, gasoline or other commodities and supplies, is limited to air or barge transport. As such, services can be contingent upon fair weather and other ecological conditions such as river water levels, river ice and sea ice extent and quality in the winter (Huskey 2004, Huskey et al. 2004).

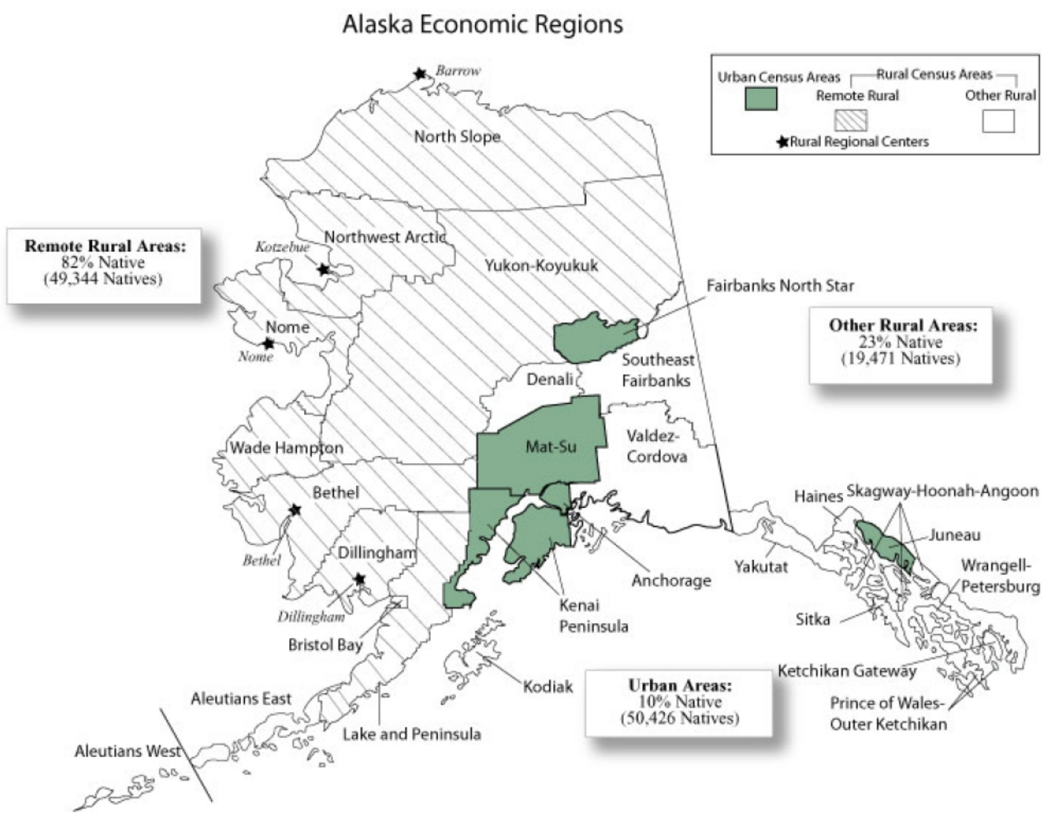

Figure 1.1 Rural and Urban Alaska. Just less than half of the state's population of Alaska Natives occupies the "remote" rural areas of Alaska (shaded area), which represent the lion's share of traditionally-used lands. Weekly food costs in these remote rural areas average from 2-3 times that in urban Alaska, greater than $200/week for a family of four (urban Alaska food costs are already 25% higher than national averages). 1 in 5 Alaska Native families also falls under the poverty line, the highest concentration living in these remote rural areas, with per capita income below $7,000 ($12,000 is the statewide average for Alaska Natives). Map from (Goldsmith 2007).

Food production and procurement options are quite limited in the bush, by a lack of employment opportunities, by the costs and challenges of transport to and from urban supply centers, and by lack of agricultural and manufacturing infrastructure (Colt et al. 2003 p. 3-4, Goldsmith 2007 p. 15, Martin et al. 2008, Paragi et al. 2008). The harvest of wild fish and game continues to be widely preferred by these communities, 'the subsistence lifestyle' having become an emblem of identity and expression of ethnic pride (Kruse et al. 2004, Nuttall et al. 2004, Schumann and Macinko 2007 p. 709). But modern challenges for the Alaska Native subsistence hunter and fisher are very different from those faced even twenty years ago (Nuttall 2001, Nuttall et al. 2004). For instance, subsistence users today require expensive boats, motors, and at times all-terrain or off-road vehicles, and each of these brings a need for cash to meet the high and rising costs of fuel, supplies, and maintenance. Yet cash economies remain limited in many of these communities; they emerged primarily as the result of resource-extraction, e.g., mining, but economic gain has been temporary, and in many places cash-dependency and environmental contamination, not long-term economic development, are the only legacies (Aarsaether et al. 2004, Duhaime 2004). In order to generate this necessary capital, most therefore have to look outside of their communities for employment, moving seasonally to urban centers or leaving rural Alaska altogether (Huskey et al. 2004, Martin et al. 2008).

1.4 GLOBAL ENVIRONMENTAL CHANGE AND OTHER CONTEMPORARY CHALLENGES

In addition to the prohibitive financial costs described above, subsistence hunters and fishers are constrained by the downscale impacts of environmental change, which modify the availability of wild fish and game resources and further limit the ability of people to access them (Hovelsrud et al. 2008, Loring et al. 2008, White et al. 2007). Within the last two decades, and most intensely within the last two or three years, residents have observed changes in the distribution, abundance, and migration patterns fish and game; many cite observations that match with the anticipated phenology of climate change, while others simply note that the "world is not the way it used to be" (Krupnik and Jolly 2002, McNeeley and Huntington 2007). These changes to the landscape can also interfere with peoples' transportation across the landscape and waterways to traditional hunting and fishing areas. As described below, these changes often come without precedent, and are neither explained by the culturally-transmitted knowledge of local experts, nor the textbook science of wildlife biologists and managers (Fleener and Thomas 2003, National Research Council 2004, Schindler 2001).

In high latitudes, permafrost, a solid layer of earth beneath the top layers of soil that remains frozen year-round, reaches downward of 500 meters. As such, lakes, rivers, and wetlands are not connected with groundwater in the same way that they are in temperate regions. With climate change this permafrost is thawing, however (Hinzman et al. 2005), and together with abrupt events like storms, flooding, and coastal erosion, the landscape is being transformed (ACIA 2005, Chapin III et al. 2006, Jones et al. 2005). Locals report changes such as the gradual drying of lakes and marshes, landslides (Figure 1.2), and in some cases entire lakes have disappeared (Figure 1.3). Occasionally, these result in catastrophic losses or disruptions of lakes and waterways that are high in subsistence value because of important fish runs and spawning grounds; one dramatic example of this is the Selawik River landslide shown in Figure 1.2, which inundated spawning grounds for sheefish (*Stendous leucichthys*), an important subsistence species, with approximately 36,000 tons of glacial silt in 2007 (Crosby 2008, Hander et al. 2008). The low water levels and blocked waterways that result from such phenomena also make it harder or impossible for the hunter or fisher to access traditional harvest areas.

Figure 1.2 Permafrost Thaw Causes a Dramatic Landslide. A large thawing of permafrost created 'retrogressive thaw slump' along the banks of the Selawik River beginning in 2004. By 2007 (pictured here), it had grown significantly, delivering 650,000m^3 of fine-grained glacial till into the river. This massive delivery has partially dammed the Selawik River, flooding upstream reaches. Downstream, important spawning grounds of sheefish were inundated with silt, possibly compromising their viability. The effects of this event will not be entirely clear for the next 7-12 years, when the fish spawned during this period reach maturity. Photo taken by Ray Hander, used courtesy of the U.S. Fish and Wildlife Service.

Seasonal sea-ice and river-ice, both crucial components of Alaska's ecosystems and important modes of travel in the winter, are also impacted by the warming trend (Hunt et al. 2008, Mills et al. 2008, Overpeck et al. 2005). In Alaska and elsewhere in the Arctic, sea-ice is crucial habitat for walrus, seal, and polar bear. Changes to seasonal thaw and freeze dynamics can limit community access to these marine mammal resources, and can threaten the animal populations themselves (Hovelsrud et al. 2008). In 2007, sea-ice reached an unprecedented minimum-recorded summer extent, followed by the second-lowest in 2008 (NSIDC 2008). When the ice edge is further from the shore, more gasoline is needed to travel the greater distance to harvest game such as walrus and seal (Murray 2008). With the cost of fuel high and continuing to rise (DCA 2007), many families may find that they are financially limited or entirely excluded from the hunt. River ice dynamics are also changing; the timing of fall freeze-up and spring break-up are becoming increasingly variable from year to year, as are water temperatures, though both show a general trend of warming and a longer ice-free period. The timing of these events is linked in many ways to the distribution and movement of fish and game species, and the unpredictability of both river and sea ice conditions can pose real hazards regarding safety when traveling by snowmobile or dog team on the frozen surface.

What makes these changes most difficult to accommodate is their unprecedented and hence less-predictable nature. While hunters and fishers continue to rely on their personal knowledge of the landscape, obtained through personal experience as well as through story and the interactive pedagogy of elders, these new changes are making the environmental cues that they have learned (or been taught) to predict weather and the behavior of animals, less effective (Krupnik and Jolly 2002, Loring et al. 2008, McNeeley 2009). To further complicate matters, as these changes occur to Alaska's ecosystems, wildlife policy implementations made by State and Federal resource management institutions, e.g., Alaska Department of Fish and Game (ADF&G), and the US Fish and Wildlife Service (USFWS) increasingly fail to "fit" (c.f. Young 2002) with the realities on the ground[2].

2 See also Chapter 4 in this volume.

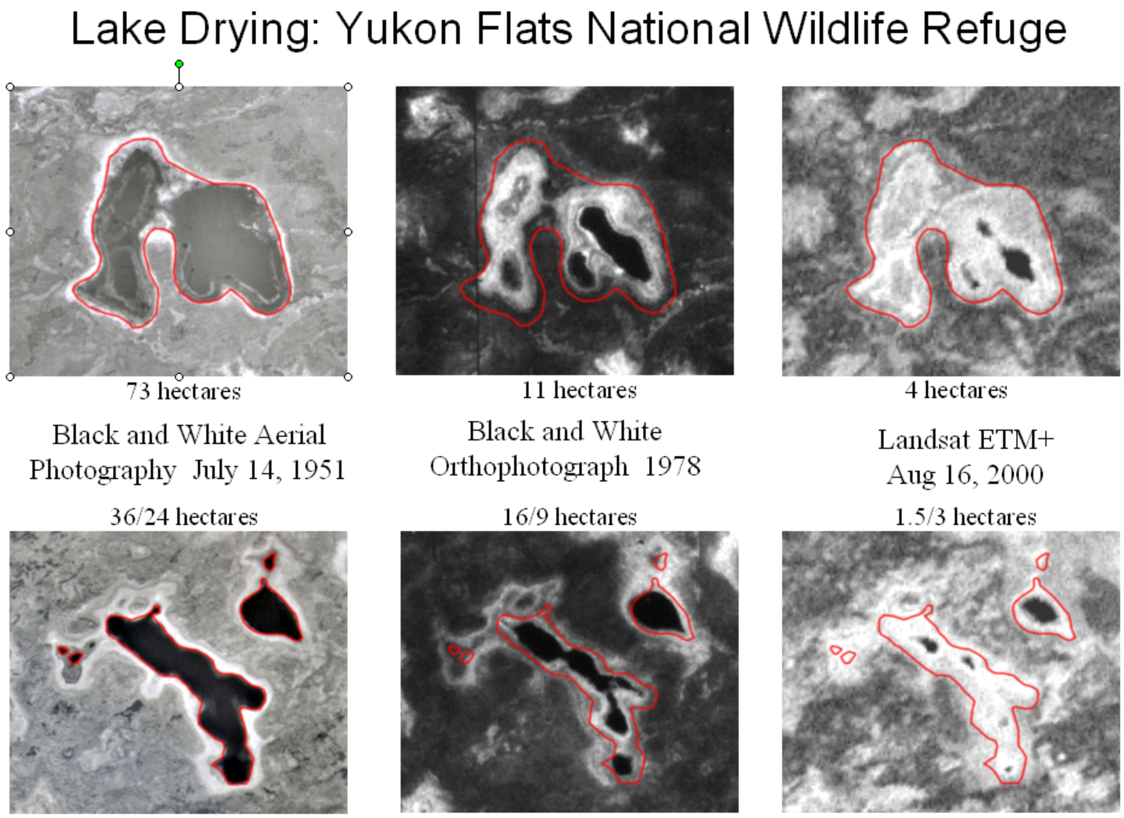

Figure 1.3 Aerial Photos of Lake Drying in the Yukon Flats. This succession of aerial photos show an example of lake drying that is occurring in critical wetlands habitat across the state. Figure courtesy of David Atkinson, University of Alaska Fairbanks.

In the past, Alaska Natives had more flexibility to adjust to ecological variability, by altering their harvest strategies and their seasonal and annual patterns of movement across the landscape. But contemporary wildlife management policies significantly limit this flexibility with hunting and fishing seasons, quotas and bag limits, and periodic unexpected area closures. These policy-making and management agencies cannot respond to change or surprise as quickly as a hunter or fisher needs to, making it difficult for them to effectively adapt and alter their harvest strategies to accommodate changing ecological constraints (Natcher and Davis 2007).

Even in cases where access and availability are not an issue, the safety of wild foods may limit their utilization. Many Alaskan communities are already exposed to dangerous contaminants in their food and water, such as heavy metals (e.g., methylmercury) and persistent organic pollutants (POPs) such as those addressed in the Stockholm Convention[3], from military dump sites and a variety of other sources (Herman et al. 2000). With climate change, some contaminant levels are projected to increase, though the details of these risks are still not well understood (Gantner et al. 2007, Godduhn and Duffy 2003, Schiedek et al. 2007). In some communities, the perception alone of contamination is keeping many people from harvesting foods that are in fact relatively safe (Trainor et al. 2009 in press). Research suggests that the atmospheric transport of contaminants from temperate regions to the Arctic will increase considerably over the next few decades, driven in large part by rises in arctic temperatures and reduced sea ice cover (Macdonald et al. 2005, Meyer and Wania 2007). Whether real or perceived, the degradation and removal of contaminants from northern environments happens more slowly than elsewhere on the planet, so greater bioaccumulation and biomagnification of these compounds in country food resources is certain to remain a significant health concern for these communities in the long term.

For all of these reasons and more, households in rural Alaska are finding that their food needs cannot be met with locally-available wild food resources. Thus, they fill their cupboards with imported foods, either from the village store or from costly periodic provisioning trips to urban supply centers (Loring 2007, Reed 1995). In some cases informal cooperatives have developed between families where one shopper will procure and distribute supplies (e.g., groceries) for several households. In larger, more serviced rural communities, purchasing patterns are much in line with those of other Americans living at or around the poverty line in the lower 48 states (Reed 1995). But in the most remote rural communities, choice

3 The Stockholm Convention on pollutants identifies 12 POPs: 8 organochlorides, Aldrin, Chlordane, DDT, Dieldrin, Endrin, Heptachlor, Mirex and Toxaphene, also hexachlorobenzene (HCB) and the polychlorinated biphenyl (PCB) group; and two groups of industrial by-products: dioxins and furans.

is significantly limited by infrequent and sometimes unreliable shipments, with fresh foods rare and significantly outnumbered by packaged goods with the longest shelf life (ibid).

1.5 RE-EVALUATING FOOD SECURITY FOR RURAL ALASKA

The most common definitions of food security (e.g., WFS 1996) call for equitable physical and economic access to sufficient and safe foods that meet basic dietary needs and individual/cultural preferences. By such definitions, store-bought foods do indeed represent a degree of food security for rural Alaskans, but whether they are sufficient for supporting an acceptable level of individual and community health remains questionable.

Coinciding with the transition to store-bought foods is a dramatic rise in the prevalence of individual and community-scale health problems, many of which were not entirely unexpected (Hurwitz 1977). Near-epidemic rises in the prevalence of obesity, diabetes and heart disease have occurred among Native Alaskan populations; diabetes, which was not thought to be present in Arctic and Subarctic populations in the past, now occurs for 18 out of 1,000 Alaska Natives, nearing levels of other developed countries. Cancer, heart disease, stroke, and cardiovascular disease have also increased at or near these rates (ADHSS 2000, ATSDR 2006, Broussard et al. 1991, Egeland et al. 1998, Kuhnlein et al. 2004, Nobmann et al. 1992). Depression, alcoholism, drug abuse, and violence also challenge many individuals and families (Degal and Saylor 2007, Hesselbrock et al. 2000). At the community scale, these challenges are coupled with a lack of local jobs, a tenuous economic reliance on transfer payments from state and federal agencies, rural out-migration, language loss, and a variety of other social issues (Colt et al. 2003, Goldsmith 2007, Miyaoka et al. 2007). The extent to which these are directly or indirectly related to the food system transition still needs extensive evaluation, but to do so presupposes a methodology for considering these various issues of individual and community health together.

1.5.1 Biophysical and Integrative Models of Health

The human health component of food security frameworks often focus on one or more aspects of 'food utilization,' which involves dietary adequacy, food quality and safety, and food preference (Ericksen 2008). Many tend to elevate "physiological needs" and "nutritional well-being" (quote from FAO 2006 p. 1, e.g., those reviewed in Hoddinott 1999), while other aspects of individual and community health that are met by food and food culture, such as psychological and psychosocial needs, remain understated or absent. However, there can be important social and cultural dimensions to all stages of the food chain, from production to consumption, and each has potential to support or undermine individual, community, and cultural health (Garibaldi and Turner 2004, Nabhan 2004, Price 1939, Wernham 2007 are just some examples). Participation in food procurement and preparation can serve as a rich source of story and a premise for sharing, celebration, and the maintenance of traditions (Nabhan 1998, Schenone 2003, Simeone 2002). Food and foodways can also contribute to sustainability and positive resilience at household and community levels, by contributing to one's sense of role and responsibility within the community, and by strengthening social networks and kinship ties through gifts, sharing and exchange (Feenstra 1997, Kloppenburg et al. 2000, Kruse et al. 2004, Mauss 1990, Rolfe 2006, Trosper 2003). Uncertainty and worry about food are also non-biophysical aspects of the food insecurity experience that can have considerable psychosocial and sociocultural impacts on health (Coates et al. 2006, Maxwell 1996)

Human health is a complex and multi-faceted *social* phenomenon (Clark 2005, Rose 1992 p. 129). But in fairness, it has not always been treated as such in academic research and medical practice. The long-standing tradition in these fields is to focus on physiology, the individual functioning much as a machine (Wulff et al.

1986), and research has shown that prescriptions for health that have followed from this approach tend to be formulaic and generalized (House 2001, Pollan 2008, Willett and Stampfer 2003). Newer, integrative approaches to health (Figure 1.4) begin instead with the assumption that health involves complex feedbacks and interactions between the individual, the household, and the community, with outcomes mediated by biophysical, psychological, social, cultural, and economic circumstances. These include matters at the individual level, e.g., genetics and epigenetic factors, immune system function, etc., as well drivers further up-scale within the community/society, including social and economic stratification, family and community support, the degree of access to quality healthcare services, local awareness of food-related risks, etc.

Just as traditional approaches to health can overlook these influences of society, community, and culture, so too we suggest, do treatments of food security that limit themselves to, or elevate, the physiological aspects of diet in promoting health. Recently there has been a trend in the food security literature to move beyond one-size-fits-all relationships between food and health, to a “more nuanced and individual-focused approach” (quote from Ericksen 2008 p. 236, Maxwell 2001) that incorporates place-based social and cultural considerations of food access and utilization. In order to meet this challenge, it is necessary to begin with a conceptual model of health that is equally as nuanced and place-based. The integrative conceptual model of health described here provides the necessary context for understanding how these social and cultural aspects of food and foodways are linked to individual and community health outcomes.

In the sections that follow, we use an integrative approach to health to organize our evaluation of food security in rural Alaska, given the various ecological and sociopolitical concerns described earlier. These changes in diet, including changes in foods and reduced patterns of physical activity, have obvious potential impacts on biomedical health, as well as some not-so-obvious ones. We review research that has examined, or has at least moved in the direction of understanding, some of these lesser-known links between food and health for Alaska Natives. As we discuss below, there are a number of ways that the traditional Alaska Native food system is locally-adapted to meet specific environmental needs, both directly in terms of physiological needs and indirectly in terms of place-based social and cultural adaptations.

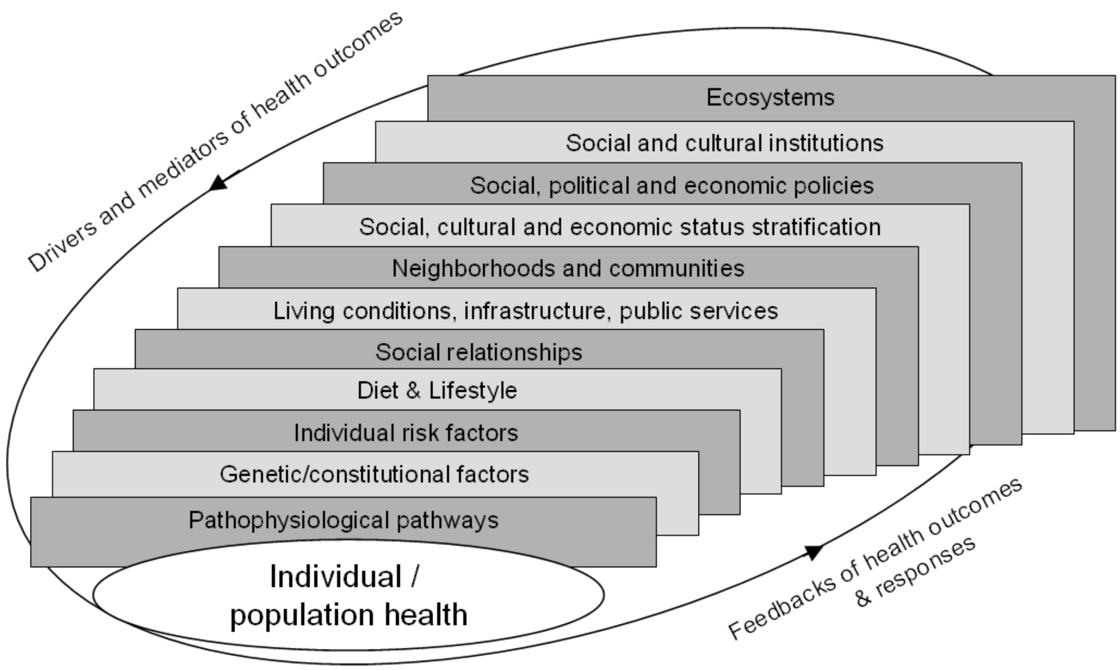

Figure 1.4 An Integrative Health Model. This is a diagrammatic model to illustrate the social epidemiologic approach to understanding the social determinants of health and health disparities. A variety of such diagrams can be found in the social epidemiology literature, all sharing this emphasis on layered, multilevel understandings of health. From the top-down, we can understand the environment to influences individual and populational health first with direct environmental influences, i.e., through food and other environmental exposure, but these are then mediated and distributed by a hierarchy of risk factors and influences on life course, from the very broad scale influences of one's ecosystems, social and economic circumstances, to more fine-scale determinants such as demographics, social relationships and living conditions. The health outcomes for the individual are then determined by an individual or group's vulnerabilities and risk factors, like age, existing injuries or illness, genetic or epigenetic predispositions, and also by socio-economic vulnerabilities that result from forces further up-scale like poverty or a lack of public sanitation. The health outcomes for the individual then feed back through the system, via health outcomes influencing the disposition of one's interaction with the community and environment (adapted from Kaplan et al. 2000).

1.5.2 Individual Risk Factors: Food-Gene-Culture Interactions

First and foremost, research suggests that a decline in the consumption of wild foods poses a number of measurable threats to physical well-being of Alaska Natives. For one, hunting and fishing activities are associated with beneficial physical activity (Samson and Pretty 2006). Research also confirms that wild fish and game exhibit greater nutritional quality than the market foods that are coming to replace them, and there is much evidence to suggest that traditional foods in Alaska support health through nutrition in some very locally-adapted ways (Bersamin et al. 2007, Ebbesson et al. 2005, Kuhnlein et al. 2002, 2004). In one large study of dietary habits in western Alaska, participants in the highest quintile of wild food intake consumed significantly more vitamin A, vitamin D, vitamin E, Iron, and omega-3 fatty acids than participants who consumed the greatest proportion of store-bought foods (Bersamin et al. 2007). The Vitamin D aspect is especially relevant, as deficiency is a problem in high-latitude places like Alaska, where the lack of sunlight during winter months limits synthesis of the nutrient (Berner and Furgal 2004, Chen et al. 2007, Gessner 2003).

There are other protective factors identified for these wild foods as well. Many, such as salmon and marine mammals, are rich in omega-3 fatty acids and selenium, and the consumption of both are associated with reduced rates of prostate cancer (Dewailly et al. 2003). Daily consumption of these have also been associated with improved glucose tolerance (Alder et al. 1994, Ebbesson et al. 2005). Too, wild Alaskan berries are known for their exceptionally high antioxidant activity, and research has shown that nutritional factors such as antioxidants can buffer against the health impacts of pollutants such as heavy metals (e.g. methylmercury) (Cascio 2007, Dubos et al. 2005, Dunlap et al. 2006, Heller and Scott 1967, Kirkwood 2005, Mathers 2006). As discussed above, this is an especially relevant health issue for the region. The loss of these protective factors must be weighed closely when considering the ramifications of transitioning to imported foods that do not offer the same benefits.

1.5.3 Place, Culture, and Psychosocial Health

The connections a person feels to the people and places of their community, and the importance of their roles and responsibilities within it, play a central role in the maintenance of psychological and emotional well-being (Fone and Dunstan 2006, Rolfe 2006). As we describe above, foodways in these communities are the primary context for these relationships between an individual, their household, the community and the landscape. The moose, salmon and seal of Alaska are as much the cultural keystone species for the region as are the milpa crops of Mesoamerica (c.f. Garibaldi and Turner 2004). But as the landscape changes, whether as the result of ecological or 'man-made' forces, people can be cut off from places of historical significance like seasonal camps and traditional harvest areas. Further, as household livelihoods change and hunting and fishing activities become marginalized, structures such as gender roles and other long-standing relationships of power and reciprocity can be destabilized by the new cultural and economic arrangements that emerge (Blue Spruce 1962, Douglas 1979 p. 43, Graves 2005, Kloppenburg et al. 1996).

New research is just beginning to illuminate potential cause and effect relationships between changing participation in traditional cultural activities in Alaska and elsewhere, with the focus on the increased prevalence of psychological and psychosocial syndromes like depression, substance abuse, violence, and suicide (Degal and Saylor 2007, Durkheim 1897, Fraser et al. 2005, Graves 2005, Poppel et al. 2007, Saylor et al. 2006, Sullivan and Brems 1997). For instance, Graves (2005) explored how a decline in the emphasis on Alaska Native men's responsibilities for hunting, fishing and gathering has proven to destabilize gender roles as well the men's perceptions of their overall position within their families and community. This is expressed by men in these communities as feelings of alienation and depression, often leading to alcoholism (ibid); understandingly, these all have significant impacts on women, children, and elders of these households, with outcomes that threaten not only the psychological and cultural well-being of all involved, but their physical health and safety as well. There is, however, no simple equation for predicting such a psychological or psychosocial outcome, as each person in their own way and to their own extent relates to and finds strength in the social roles they play and the geographic spaces with which they are familiar (Patrick et al. 2001).

1.5.4 Different Needs: Age, Gender, Socioeconomic Status

Within any community or region, there are inevitably many such groups who will be impacted differently by changes to food systems or other environmental circumstances, defined perhaps by gender, age, or socioeconomic status. Aging adults (i.e. adults over 65) are another ready example of health impacts being experienced differently. This group tends to have a high proportion of wild foods in their diet, and certainly maintains the greatest preference for wild food[4] (Bersamin et al. 2007, Nobmann et al. 2005). But they may not have the means (e.g. supplies, cash), the time, or the physical ability to go out on the land. For this age group it can also be very challenging to remain in remote villages, especially when afflicted with health problems: as younger people migrate out of the village their social support network is weakened, and limited or inadequate local health care services and infrastructure can make relocation to urban centers a necessity. However, leaving the rural community essentially means leaving behind the possibility of making wild foods a primary component of diet; because of their age, their immune system response and overall ability to cope with illness is diminished; too, these changes come in addition

4 There remains a great need for quantitative dietary assessments of both the rural and urban places in Alaska. The extent to which wild foods are available at all is expected to vary significantly from community to community, though this too needs further research. We can say with certainty that the preference for wild foods is there, it is strong in the older generations, and these foods are consumed whenever they are available. Those works cited above confirm these statements.

to the many outcomes that result from sudden separation from their homes, friends and family, which can be both emotionally and physically devastating (Drew and Silverstein 2007, Fogel 1992, Lewis 2009); thus, they likely have a significantly increased vulnerability to the physical and psychosocial health concerns we have described above (Kirkwood 2005).

1.6 DISCUSSION: COMING OUT OF, OR IN TO, THE FOODSHED

One way to frame these ongoing changes to rural Alaska's food systems is with the concept of the "foodshed" (c.f. Kloppenburg et al. 1996, Loring 2007). In "Coming in to the Foodshed," Kloppenburg and colleagues (1996) first presented this concept, modeled loosely after the concept of the watershed, as a design principle for restoring community health and food security (Kloppenburg and Lezberg 1996). The premise is that healthy communities thrive in healthy ecosystems, which themselves thrive as the result of people being stewards of the lands that provide their livelihoods. The corollary to this premise is that degraded ecosystems can degrade human communities, by reducing local control over the quality, safety, and appropriateness of food, decreasing self reliance by increasing dependency on the global food and fuel network, and by increasing vulnerability through external linkages in the food chain that expose local systems to increased risk and uncertainty (Feenstra 1997, Kloppenburg et al. 1996, Lezberg and Kloppenburg 1996, Sundkvist et al. 2005)[5].

The latter is rather effective shorthand for the changes being experienced in

5 Though a level of local food production is often assumed with the foodshed approach, critics often overstate this aspect (e.g., Born and Purcell 2006). The 'local' aspect of the foodshed is concerned more with the geography of control, not the geography of production, describing with the term "proximity" the capacity and authority of people to control aspects such as quality, safety, and relevance, regardless of whether the food originates locally or from afar (Kloppenburg et al. 1996 p. 38-39, Hinrichs et al. 1998). Thus the argument is not necessarily that a global food system is *incapable* of delivering safe and nutritious food, but that greater localized control over the food chain espouses greater checks and balances over health, safety, and the stewardship of natural resources.

rural Alaska—these communities are ‘coming out’ of their foodsheds. Commercially available foods are providing these communities with one measure of food security, but the transition is eliminating many of people’s traditional roles in the food chain, which as described above are fundamental to maintaining individual and community health and stability. Reliance on these foods also exposes people to new vulnerabilities and economic dependencies: access to food becomes determined by one’s ability to pay, and peoples’ health and livelihoods become vulnerable to unexpected disruptions or variability in supply, pricing, and quality (CES 2009, Gerlach et al. 2008). As just one anecdotal example of the latter, two well-publicized food supply issues of 2007, the California citrus freeze and the bagged-spinach *E. coli* scare, both led to short-term shortages of these in Fort Yukon (a regional center in Interior Alaska) and the small surrounding communities of the Yukon Flats (Loring, unpublished data).

Despite the impossibility of turning back the clock and restoring Alaska Native food systems to the specifics of 100 or 1000 years ago, understanding the process in reverse helps us to identify fundamental principles that should be targeted by policy-makers and community planners when designing food-security solutions for the future. The foodshed’s core principles—including an emphasis on local control over food access, safety, and relevance, the use of locally-produced food resources when possible, self-reliance, equity, and ecological stewardship—are very much congruent with ethnographic and historical accounts of traditional Alaska Native foodways. And as these communities explore new food options, whether new models for the co-management of fish and game, the development of community gardens or other community-supported farming initiatives, or new economic arrangements for importing healthier foods from afar, adherence to these principles as goals offers the best chance that decisions will “focus on what matters” (Turner et al. 2008 p. 7), remaining appropriate to the specifics of local needs, whether cultural, psychological, biomedical, or otherwise.

1.7 CONCLUSION

What we use the case of rural Alaska to stress is two-fold: first is the unpredictable nature of the down-scale impacts of global climate change, and how they can interact synergistically with socioeconomic and sociopolitical circumstances to significantly challenge local food production and procurement. Second, when evaluating these impacts in terms of food security, the case further validates the importance of recognizing that food contributes far more to health than just calories and nutrition. Food and food culture are linked to health in a great variety of ways, with many possible social and cultural dimensions of participation at all steps of the food chain, though the relationships, and the outcomes, may not all be overt or obvious. There are many possible faces of food insecurity; whether quality of life suffers as a matter of chronic hunger in sub-Saharan Africa or chronic obesity, diabetes, alcoholism and depression in sub-Arctic Alaska, each represents some failure of a food system.

The review by Boon and colleagues (2004) shows that definitions of health significantly influence the practice of medicine and design of health policy and healthcare services. So too, we argue, do narrow conceptions of health limit frameworks for evaluating, and strategies for maintaining or restoring, food security. Food security solutions for any region or any set of circumstances that only target the drivers of caloric and nutritive stress can at best be considered mitigative, and while these may be capable of successful hunger mitigation in the short term, they run the risk of institutionalizing food-system inadequacies and health problems in the long-run. Frameworks for food security must be designed to tease out both the overt and the invisible when evaluating the impacts of environmental variability and change on health. Intervention policies and strategies that take an integrated approach to the food-health relationship move us in this direction, so that we might better plan and implement durable, long-term, locally-adapted solutions to food insecurity, wherever in the world it is encountered.

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CHAPTER 2

THE SOCIAL EPIDEMIOLOGY OF ENVIRONMENTAL CHANGE[1]

2.1 ABSTRACT

A growing body of literature details potential impacts of climatic and environmental change on human health. Much of this research identifies a vast array of potential direct and indirect biophysical impacts, yet, the state-of-the-art for projecting and planning for vulnerabilities to these impacts remains limited. Health vulnerabilities to environmental change follow a complex equation, with exposure, sensitivity, and ability to respond all driven by a wide variety of biophysical, psychosocial, and socioeconomic controls over health. While existing vulnerability frameworks can help us think about these interactions, a more developed theoretical basis is necessary for measuring and projecting vulnerability. We discuss how theory from the field of social epidemiology can enable a next generation of vulnerability research: enabling accurate locally- and regionally-scaled projections of vulnerability so that effective pathways for mitigative and preventative action can be identified. Psychosocial theory, political economy theory, and an emerging 'ecosocial' theory of epidemiology are reviewed. We show how each links to analysis and policy making, and provide additional recommendations for the development of vulnerability theory and methods.

2.2 INTRODUCTION

Global climatic change is already having dramatic effects on the people and places of the world, from the tropics to the circumpolar North (IPCC 2007, MA 2005a, ACIA 2005). A broad and comprehensive literature provides much in the

1 Loring, P.A. and S.C. Gerlach. In Preparation. The Social Epidemiology of Environmental Change. *Regional Environmental Change*.

way of enumerating the potential impacts of these changes on ecosystems and human health at global and national scales (CCSP 2008, National Assessment Synthesis Team 2001, Confaloniere et al. 2007, McMichael et al. 2004). The local- and regional-scale manifestations of environmental change and their associated impacts on health can be hard to anticipate, however, especially for rural communities already coping with the numerous difficulties of a changing and globalizing world (Lynch and Brunner 2007, Fazzino and Loring 2009). A number of descriptive, ethnographic accounts of impacts and vulnerabilities continue to be released for communities throughout the world with these complexities in mind (Speranza 2006, Ford et al. 2007, Keskitalo 2008, Alessa et al. 2008, Cinner et al. 2009, Tyler et al. 2007, Winograd 2007). Each of these accounts is illustrative of the many different impacts on health and livelihoods that environmental changes can and will have, from drought and decreased food security to psychological stress and violence; together, they reveal just how many people—too often those with the least capacity to cope and respond—are faced with these impacts *now*.

However, while the models and frameworks employed by the studies above for describing vulnerability are important (see e.g., Ford and Smit 2004, Turner et al. 2003), they remain largely-heuristic and metaphorical, and thus far have proven incapable of providing projections with the precision that effective responses require (Patt et al. 2005). They may help us to describe and think about vulnerabilities (Kaplan 2004), but cannot help us to develop or test explanations for how particular vulnerabilities function: how patterns of impacts and outcomes result from biophysical and social structural processes occurring both within and around the individual, household, or community. In other words, vulnerability analysis remains constrained by the lack of a more fully-developed vulnerability theory.

A sound theoretical basis is essential for moving from metaphor to measurement and projection (c.f., Binford 1983, Merton 1968). To this end, we look to social epidemiology, a research program that shares many common features and goals with vulnerability analysis, for guidance. We highlight three areas of theory that are germane to social epidemiology: psychosocial theory, which is concerned with the how psychological experiences of one's social environment influence health outcomes; political economy theory, which identifies socioeconomic and sociopolitical structures as the primary determinants of health status; and ecosocial theory, which constructs human health as an embodiment of the entirety of biological, material, and social experiences throughout the life course. We also discuss path-dependence path-creation (PDPC) theory as a way to better understand human agency and adaptation. The goal is to assemble the necessary raw materials for the development of a sound theoretical basis for doing vulnerability analysis. Only from here, we argue, can the most effective preventative and mitigative measures be identified for ensuring resilient and healthful futures for people and communities facing uncertain ecological and economic futures.

2.3 VULNERABILITY ANALYSIS

Vulnerability is generally defined as the degree to which some system, subsystem, or system component is likely to experience harm due to some hazard or risk (Turner et al. 2003). A variety of frameworks for describing and evaluating vulnerability exist (Ebi et al. 2006, Ford and Smit 2004, Fraser et al. 2005b, Schroeter et al. 2005, Speranza 2006, DFID 1999), with differences that reflect their discipline of origin, and the organizational levels (e.g., households, communities, economies) and sectors (e.g., natural disasters) of interest (Adger 2006). Most share a description of vulnerabilities as a function of three interrelated factors: *exposure* to some hazard or other condition that represents a risk, *sensitivity* to that risk if exposed, and the *adaptive capacity* to respond, whether via impacts mitigation or actions taken to limit vulnerability in the future (Figure 2.1). Together, exposure, sensitivity, and adaptive capacity involve numerous environmental, biomedical, and social considerations, from the biophysical characteristics of the environmental hazards in question, i.e., magnitude, duration, spatial distribution, etc., to the socioeconomic circumstances that put or keep people in their path. Patterns of vulnerability are also understood as having important spatial and temporal dimensions (Turner et al. 2003): past and present exposures can feed back to influence future vulnerabilities, and place-based outcomes often contribute to, and are influenced by, regional socioeconomic patterns and trends.

Contemporary vulnerability approaches to studying environmental change, also sometimes called 'adaptation policy research' (Ford et al. 2007), begin with the premise that by understanding existing patterns of vulnerability, it becomes possible to reduce future vulnerability to environmental change by increasing adaptive capacity. In the context of the human dimensions of environmental change, adaptation usually refers to an action undertaken to better cope with, manage, or adjust to some changing condition, stress, hazard, risk, or opportunity. It is important to note, however, that adaptation does not only happen in a context of vulnerability (Bennett 1996, Buckley 1967); people act in ways that are anticipatory (actions taken in advance to reduce exposure) and responsive (to mitigate sensitivity) to change, but people also innovate, making spontaneous or planned changes without clear precedent or without the reduction of some vulnerability in mind. We return to this important point a bit later.

Vulnerability studies often 'work backward,' beginning with ethnographic descriptions about vulnerable people and places, and then working towards an understanding of the multiple stressors involved (Kasperson and Kasperon 2001). Ideally, once the pertinent climatic attributes to which people, households, or communities are sensitive have been identified, forecasts of changes to these attributes are then used to identify 'entry-points' for short and long term policy responses (Ebi et al. 2006, Ford et al. 2010). The strategy of this work is to understand the political, social and economic institutions that limit or support decision-making (Adger et al. 2005); the goal is move beyond impact-by-impact mitigation by developing integrative, 'mainstreamed' solutions for reducing vulnerability that target policy in a variety of social domains, including poverty alleviation, education, and sustainable development (Ford et al. 2007).

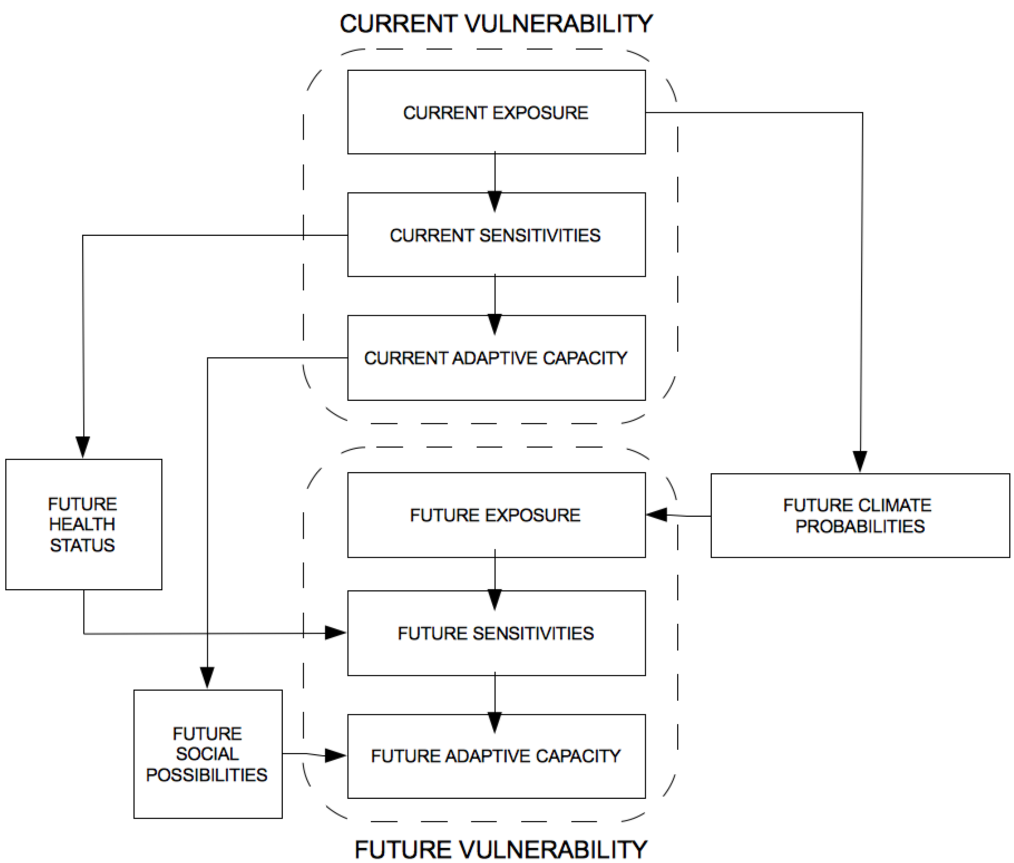

Figure 2.1 Vulnerability. A function of exposure, sensitivity, and response, over time. Adapted from (Ford and Smit 2004)

However, shared observations of patterns and disparities in vulnerability do not necessarily translate to common understandings of cause (Krieger 2001). For the purposes of policy and adaptation, there needs to be a significant degree of confidence in vulnerability models to justify the validity of the entry-points for action that these models identify. Vulnerability frameworks such as the one depicted above are merely heuristic in nature, however. They can be important for *vulnerability thinking*, but they fall short of qualifying as a *vulnerability theory* capable of informing projections with this necessary accuracy (Kaplan 2004, Patt et al. 2005). Heuristic models describe; they are useful because they can simultaneously caution against misleading oversimplifications but still draw focus past extraneous details and to the factors that are believed to be most critical (Kaplan 2004, p. 125-126). Theory, however, explains; it helps us structure our ideas, so as to explain causal connections between specified phenomena, with an interrelated set of premises that can be tested, adjusted, and ideally used to make projections (Kuhn 1970). Without a sound theoretical basis for explaining how vulnerabilities function, it is not possible to make projections or develop scenarios with the accuracy necessary for developing and implementing effective, place-based adaptation strategies.

2.4 SOCIAL EPIDEMIOLOGY

As with those who perform vulnerability analyses, practitioners of social epidemiology have long sought to understand the complex interplay between environmental, biomedical, and social drivers of health (Antonovsky 1967, Clark 2005, White 2005). In the most general terms, epidemiology is the study of the distribution and determinants of health conditions in populations (Susser 1973), and scholars have been including social features in that study since the 1800s at least (Rosen 1963, see e.g., Durkheim 1897). Driven by the persistence and continued growth of social inequalities in health in both the developed and developing nations of the world, social epidemiologists attempt to incorporate this social dimension as a primary aspect of the etiology of disease (Berkman and Kawachi 2000). The central questions ask who and what are responsible for population patterns of health, disease, and well-being, as manifested in present, past, and changing social inequalities of health.

Modern social epidemiology is rooted in both pattern recognition and pattern explanation, with studies aimed at revealing relationships between exposures and mortality and morbidity (Berkman and Kawachi 2000). The notion of risk is central, and even small variations in health risk between populations are understood as capable of driving tremendous differences in health status (Rose 1992). Age, constitutional factors, and genetic histories (Kirkwood 2005, Allis et al. 2006), socioeconomic and racial-ethnic disparities (House 2001, Crouse Quinn 2006), previous or pre-existing health conditions and exposures (Dubos et al. 2005), the built environment (Hennessey et al. 2008), and availability of and access to quality healthcare services (Johnson et al. 2005, Fiscella et al. 2000) are just a few of the various factors of interest in this study of health outcomes for individuals and populations.

There is a clear convergence between the aims and scope of vulnerability analysis with those of social epidemiology. The two do not necessarily always focus on the same spatial scales, but there is overlap: vulnerability analyses tend to be scaled to the community or region, while social epidemiology studies are focused mostly on populations and demographic sub-groups therein. Ostensibly, both are implemented in the service of developing a better understanding of health outcomes an inequities (Kasperson and Kasperon 2001, DFID 1999); while health is not always explicitly identified as the topic of interest in vulnerability analysis, patterns of individual, household, or community vulnerability fall well within the scope of social epidemiology as described above. Both research programs also stress complexity and employ a systems approach: focusing on the complex interplay between drivers and determinants of outcomes as well as how impacts accrue to influence future patterns. And finally, both seek to identify integrative, mainstreamed ways to mitigate problems with policy change, interventions, and other institutional support for community adaptation.

Given their complementary natures, it stands to reason that these two research programs might have numerous complementary features. Of particular interest are the concepts, models, and theories that the more mature program of social epidemiology research can offer to further the development of vulnerability analysis. In the next few sections I review three areas of theory in social epidemiology that are of value to doing vulnerability analysis: psychosocial theory, political economy theory, and ecosocial theory. These are not perfect (Kaplan 2004, Krieger 2001), but scholars continue to debate and push forward to improve them in order to better understanding the myriad social and biological processes that drive and determine health outcomes. Ecosocial theory is the most recent development in the field, and while not qualifying as fully-developed theory per se, it likely represents both a lucrative point for conjuncture for social epidemiology and vulnerability analysis, as well as a paradigm for the assemblage of an effective vulnerability theory toolkit.

2.4.1 Psychosocial Theory

Psychosocial theory links health and vulnerability to disease with both biophysical as well as psychological circumstances. Whereas earlier epidemiological models focused only on exposure to disease vectors—the so-called 'host-agent' model—psychosocial theory expands this understanding to include host-agent-environment interactions, with 'environment' broadly construed to include the physical as well as the social environment (Cassel 1976). A person's health is hypothesized as having as much to do with their own actions and the nature of the potential hazards as it does their social environment, thus shifting the focus of epidemiology from the specific etiology of illness and disease, to one's susceptibility to illness or disease. Determinants such as rapid social change, marginal status in society, and bereavement are just a few of the various factors that must be considered together when examining why, if exposures are held constant, particular social groups remain disproportionately burdened (Krieger 2001).

In respect to regional environmental change, psychosocial theory has much to offer vulnerability analysis. The connections a person feels to the their home, community, and to the land are all understood as central to the maintenance of psychological and emotional well-being, often providing strength and resilience in times of uncertainty (Fone and Dunstan 2006, Nabhan 1998, Nabhan and Trimble 1994). Conflicts over resources, being isolated from places of historical significance, seasonal camps, or traditional harvest areas, and dealing with food and water insecurity can all have profoundly disturbing effects on people's psychological health (Graves 2005, Hamelin et al. 1999, Wolsko et al. 2006). Given the complex linkages between biomedical and psychological aspects of health (White 2005), such factors will all likely play major roles in the patterns of vulnerability that emerge to a changing landscape or set of environmental hazards.

Psychosocial theory is beginning to be leveraged in order to understand community vulnerability to cultural, ecological, and food systems change (Degal and Saylor 2007, Fraser et al. 2005a, Graves 2005, Wolsko et al. 2007). For instance, Graves (2005) explored how a decline in the emphasis on Alaska Native men's responsibilities for hunting and fishing is reducing household resiliency to numerous social, ecological, and economic challenges. This ongoing transition away from a food system based primarily on wild-caught subsistence foods is destabilizing gender roles in the household, as well the men's perceptions of their overall position within their families and community. This is expressed by men in these communities as feelings of alienation and depression, often leading to alcoholism (ibid); understandingly, these also have significant impacts on women, children, and elders of these households and communities, with outcomes that threaten not only the psychological and physical well-being of all involved, but compromises their ability to respond to social, ecological, and economic challenges in the future (Fazzino and Loring 2009). Similar role changes are also occurring in for the women of these households, and these too need to be better understood in order to understand how ongoing psychosocial health trends will influence individual, household, and community vulnerability to a changing environment.

In the applied context, the application of psychosocial theory emphasizes interventions and other policy actions that emphasizes the strengthening of social supports over efforts designed to reduce exposure to biophysical stressors (Cassel 1976, p. 121). Much success is being found in North America as well as Australia with interventions that focus on these psychosocial dimensions of vulnerability (Brady 1995): culture camps are one example of place-based and culturally-appropriate solutions that are finding much success in strengthening households and communities through the mitigation of such problems as alcoholism, depression, and drug abuse.

2.4.2 Political Economy Theory

Political economy theory in social epidemiology is concerned with the sociopolitical and socioeconomic barriers that can determine health outcomes, including whether or not people have the best information, options, and capital necessary to make the best health choices (Dasgupta 1999, Friedmann 1982, Krieger 2001). A political economy approach explicitly implicates economic and political determinants of health and disease, with the intent on identifying the sociopolitical barriers that exist to people living healthy lives. The underlying hypothesis is that the economic and political institutions that create, enforce, and perpetuate economic and social inequality are the fundamental causes of social inequalities in health outcomes.

Joshua Cinner and colleagues (2009) provide one excellent example of how political economy theory can be used to support a robust vulnerability analysis. Their work with fishing communities along the coast of Kenya examines 10 socioeconomic factors that can restrict or facilitate fishers' readiness to exit artisanal fisheries should they decline as a result of climate change and other drivers. Working in 9 communities, their study finds that poverty and employment opportunities are the strongest factors determining whether or not households can exit a declining fishery. The final model of vulnerability they construct for these communities is one of a 'poverty trap': a situation in which broader national and international economic agendas keep people from mobilizing the necessary resources to overcome either shocks or chronic low-income situations (Berry 1982, Dasgupta 1999).

Many vulnerability analyses are premised on some permutation of political economy theory, though this is rarely explicitly identified. Just as the recommendations that emerge from a psychosocial approach target psychosocial drivers, a political economy approach similarly tends to espouse political economy solutions. For instance, these typically involve the development of local socioeconomic assets, through such methods as education, sustainable development, poverty alleviation, etc. The premise is that vulnerability is reduced when people have the necessary resources, including social, natural, financial, and human resources, to make and enact better lifestyle choices. Cinner and colleagues (2009) recommend building household assets so that individuals reach a threshold level necessary to allow them to respond more effectively to environmental challenges (i.e., to exit the declining fishery). Another, well-known example of an assets-based, political economy approach to vulnerability is the Sustainable Livelihoods Framework (DFID 1999). Some success has been encountered using these asset-based intervention approaches to reducing vulnerability, strengthening individual options through education, financial assistance, and community social interaction and support systems (Saylor et al. 2006, Sharma et al. 2007).

2.4.3 Ecosocial Theory

The most recent developments in social epidemiology involve a move toward models that emphasize health as a dynamic system, with interactions between biomedical, social, and ecological circumstances over space and time. Called 'ecosocial' theory (c.f., Krieger 2001) or also an 'integrative health' approach (c.f., Clark 2005), this is where social epidemiology is most like contemporary approaches to vulnerability research. Ecosocial theory begins from a mental model of human health functioning as a multilevel phenomenon (Figure 2.2), "integrating

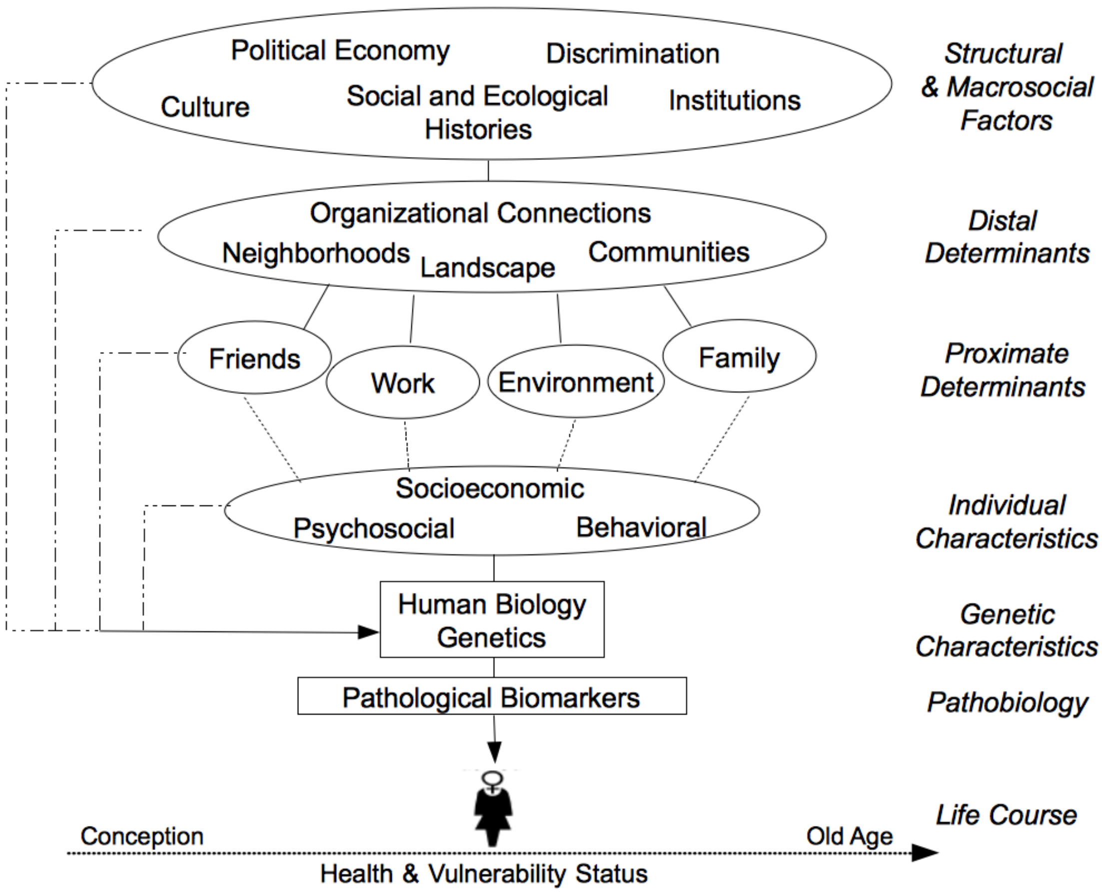

Figure 2.2 An Integrative Health Model. In general, conceptual models of health vary significantly in the extent to which they consider both biomedical and non-biomedical drivers of health. This figure represents an integrative health approach. How the environment influences individual and populational health begins with direct environmental influences, e.g., through food and other environmental exposure, but is mediated by a hierarchy of risk factors and influences on life course, from the very broad scale influences of one's ecosystems, social and economic circumstances, to more fine-scale determinants such as social relationships and living conditions. Solid arrows indicate presumed causal relations among variables; dotted arrows indicate possible, hypothesized synergistic interactions between conditioning variables (at the beginning of the arrow) and the health determinants at the head of the arrow. Figure adapted from (Kaplan 2004).

soma, psyche, and society, within historical and ecological context" (Krieger 2005, p. 351).

The core premise of this theory is that health is an embodied phenomenon: that our bodies literally incorporate, biologically, the material and social world throughout our life-course. The corollary to this hypothesis is that no aspect of our biology can be understood in the absence of knowledge about our social, ecological, and societal histories. Embodiment is very much the antithesis to traditional, sector-based etiological approaches to disease, which deal primarily with de-contextualized, and therefore "disembodied" behaviors, exposures, and genes (Krieger 2001, p. 668). A similar focus on the integration between social and environmental domains (i.e., the notion of the social-ecological system) is common to vulnerability research (e.g., Alessa et al. 2008, Keskitalo 2008, Turner et al. 2003), as well as other contemporary research programs including resilience theory (Holling 1986, Walker and Salt 2006). It is important to note, however, that as used in social epidemiology, ecological theories are not intended as a substitute or even metaphor for social analysis. Social epidemiology practitioners distinguish the social theories upon which they rely from ecological theory (Krieger 2001); rather than employing organic analogies to describe social phenomena, ecosocial theory fully embraces the social production theory of health and disease (i.e., the psychosocial and political economy theories described above), while aiming to bridge this work with biological and ecological analyses through the construct of embodiment.

This newest direction in social epidemiology remains somewhat "sketchy" (Krieger 2001, p. 672), however, and mental maps like the integrative health model depicted above are no less heuristic in nature than the vulnerability model shown in Figure 2.1 (Kaplan 2004). Further elaboration of ecosocial theory's core constructs —embodiment, pathways of embodiment, the cumulative and synergistic interplay between exposure, susceptibility, and resistance, and agency and accountability—is required; the potential uses and benefits of this theory as it unfolds, however, are clear. The social lens and the focus on integration at the individual, organismic level moves research beyond the mere addition of social factors to biological or ecological analysis (or vice-versa), and toward and approach that can generate novel, integrative hypotheses about how health, and therefore health vulnerability, functions

2.5 DISCUSSION: MIDDLE-RANGE THEORY FOR VULNERABILITY ANALYSIS

Systematic investigations of community vulnerability, such as the many cited throughout this paper, cannot make projections sans theory; they can only provide best-guess approximations of what communities will experience as their environments change. That is not to say that vulnerability analyses are entirely without theoretical foundation, but that in many cases the theory in vulnerability analysis remains implicit, taking something of a 'common sense' approach to the identification of pertinent social, political, and economic factors at play. While the products of these studies are important, it remains impossible to move directly from them to accurate projections of health outcomes and recommendations for policy, without first establishing a set of empirically-testable “middle range” theories (Merton 1968, Binford 1983, Kaplan 2004). In other words, it is not sufficient to the task of vulnerability analysis to merely identify patterns and work backwards; needed are theories that describe how vulnerabilities function and interact to influence individual and community health outcomes.

As we have explored, each of the three theories described above can contribute to this need. One additional area of theory that likely has much relevance, in particular to the further elaboration of ecosocial theory, is path dependence path creation (PDPC) theory (Garud and Karnøe 2001, Pierson 2000). PDPC theorizes that all human actions, including innovation, are temporally-located and socially-embedded: embodied, to use the language of ecosocial theory. However, where traditional path dependence theory is widely critiqued for masking the importance of agency, the 'path creation' aspect of this theory incorporates people as 'mindful entrepreneurs' who “meaningfully navigate a flow of events” (Garud and Karnøe 2001, p. 2). PDPC attributes people with a capacity to reflect and to take actions outside the prescriptions of social rules and historical artifacts. Thus, PDPC is not just a theory of human action but also of human adaptation. As noted earlier, not all adaptation happens within a context of vulnerability; as a theory for vulnerability analysis, therefore, PDPC provides a more complete way to consider how people will navigate and be influenced by challenges like environmental change.

Loring and colleagues (2008) provide one implementation of PDPC theory that should be useful to vulnerability research: a diagnostic framework for evaluating ecosystem services (c.f., MA 2005b) called the Services-Oriented Architecture (SOA). Central to the SOA is the concept of 'viability': whether or not an ecosystem service is a practical option for people, and how they make innovative use of that resource, given the mix of ecological, social, and political drivers and determinants at play. The SOA provides a common set of vocabulary for discussing path dependence and path creation within this context, including four interacting factors: reachability, compatibility, awareness, and willingness:

1. *Reachability* is concerned with the practicality of access to an ecosystem service, and is determined by a combination of both ecological constraints (e.g. climate, land-cover) and social impositions (e.g. policies and contracts between individuals and institutions). Reachability can also dictated by costs relative to requisite supplies and technologies, constrained by rising fuel prices, purchase and maintenance costs of technologies needed for successful harvest/use. How policies and contracts vary across different stakeholder groups to reflect these ecological and economic constraints is a key factor in the evaluation of matters such as differential distributions of

access to resources (equity and justice).

2. *Compatibility* means that if reachable, the ecosystem service is usable by the consumer; this moves beyond the resource itself to the incorporation of available methods of harvest/procurement. In the case of food, for instance, compatibility involves such issues as nutritional needs as well as cultural preferences and food choice.
3. *Awareness* involves the level of knowledge held by community members about the resources, such as the knowledge of and skill required to access and develop them (e.g., when and where to hunt or fish), and an understanding of any risks associated with use (contaminants, safety of travel across the landscape or seascape). If environmental conditions change in unprecedented ways, awareness can be compromised; the capacity for innovation however can overcome this problem. Whether or not a user has the resources to innovate is key—including skills, time, accurate and timely information—and when viewed across stakeholder groups, can reflect differences of equity and ultimately, vulnerability.
4. *Willingness.* Resource users must also be willing to use/harvest these resources, to accept any risks or uncertainties necessary, and to participate in any requisite ritual, legal, and economic arrangements associated with their use (e.g., licensure, quota allocation, hunting seasons, etc.). Individuals may also make decisions to act outside of the established parameters—to participate or break these rules (e.g., poaching)—in sometimes clear but more-often sometimes ambiguous cultural contexts. Where risks are involved, and the individual has awareness of these risks, willingness also reflects the acceptance or rejection of these considerations.

Together, these four concepts attempt to characterize the social-ecological context in which people are embedded and must act. Where opportunities for using an ecosystem service are broad, the user has more room to adapt or innovate, and is therefore less vulnerable to changing constraints; likewise, where constraints make the viability of a service very specific in space or time, the user can be more vulnerable to variability and change.

One critique of this implementation of PDPC may be that it more strongly emphasizes path dependence over path creation. The difficulty, however, is that it is largely impossible to anticipate novelty. At best, PDPC theory can help to explain how historical and social factors foster or inhibit novelty; while this will not necessarily explain why certain adaptations occur, it nevertheless can help identify policies that create space for innovation, especially in circumstances where vulnerability to environmental change is at issue.

Like the theories of social epidemiology described earlier, the capacity of PDPC to provide effective and specific 'entry-points' for action is the ultimate test of whether or not it provides a legitimate theoretical base for doing social epidemiology and vulnerability analysis. Whether or not the SOA proves the best or most appropriate implementation of PDPC will likely depend on the questions being asked. PDPC theory, however, shares a common philosophy with the embodiment aspect of ecosocial theory, and this alone is sufficient cause for continuing to explore a partnership between the two. The authors are presently engaged in such an exercise[2], and have found preliminary success applying the SOA in two regions of Alaska for the purposes of identifying health-supporting and vulnerability-reducing policy measures (Loring et al. 2009).

2.6 CONCLUSION

Our goal in linking vulnerability research with social epidemiology is to move beyond the current limitations vulnerability analysis: to make health an explicit, common currency of the vulnerability discussion, and to promote the

2 See Chapter 4, this volume.

development of a theoretical basis for measuring and responding to vulnerabilities. Social epidemiology provides numerous conceptual features that vulnerability frameworks can incorporate: for instance, the life-course and family-history as time-scales for vulnerability analysis. It is in the theory, however, where vulnerability has the most to gain from an engagement with social epidemiology. Psychosocial, political economy, and the emerging ecosocial theories should all prove invaluable for forging a new capacity to understand and respond to changing social and environmental conditions (e.g., Kaplan and Lynch 1997, Yen and Kaplan 1999, Macintyre et al. 2002, Brooks-Gunn et al. 1993).

Perhaps more importantly, however, is how these two research programs can support an integrative approach to designing healthcare policy and other mainstreamed vulnerability solutions. Whether done under the heading of vulnerability or social epidemiology, the goal is the same: to understand how regional environmental changes will impact people, in order to identify appropriate responses. The goal is to link traditional healthcare approaches with education, science, even economic reform to create long-term, equitable public health solutions, often from the bottom-up. Until approaches to health as an embodied and active social phenomenon become more widely adopted, however, both our understanding of the potential cumulative effects of environmental change, and our ability to develop effective mitigation, intervention, and prevention strategies, will remain uncertain.

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CHAPTER 3

A RISK-BENEFIT ANALYSIS OF WILD FISH CONSUMPTION FOR VARIOUS SPECIES IN ALASKA REVEALS SHORTCOMINGS IN DATA[1]

3.1 ABSTRACT

People of the North and elsewhere face a difficult decision of whether or not to consume wild fish, which may contain dangerous levels of contaminants such as methylmercury (MeHg), but are also known to offer a number of positive benefits to biophysical and psychosocial health. An existing data-set for Hg levels in Alaskan fish is reviewed with new methods for developing consumption advice. The goals of this analysis are to increase our understanding of existing contamination risks, to establish whether these risks vary to a degree that warrants more detailed local-scale monitoring, and to identify possible thresholds that may increase risk in the future. We apply a quantitative risk-benefit analysis for eight freshwater, saltwater and anadromous fish species, using dose-response relationships to weigh the risks of MeHg against the benefits of omega-3 fatty acids (EPA and DHA) toward cardiovascular and neurodevelopmental health endpoints. The methodology employed suggests that consumption of many of the fish species reviewed here may lead to increased risk of coronary heart disease and declines in infant visual recognition memory. However, there is significant variation between regions, between studies within the same region, and also within studies, and this variation makes it difficult, if not impossible, to craft consistent consumption advice. We caution that MeHg and omega-3 FA are just two variables in a complicated calculus for weighing the risks and benefits of locally-available and culturally-significant foods.

1 Loring, P.A., Duffy, L.K., and M.S. Murray. In Preparation. A Risk-Benefit Analysis of Wild Fish Consumption for Various Species in Alaska Reveals Shortcomings in Data. *Science of the Total Environment.*

3.2 INTRODUCTION

Mercury (Hg) represents a complex, ongoing global environmental health challenge (Mergler et al. 2007). In the North American Arctic, Hg has been present in food webs throughout the entire Holocene; however, the global biogeochemical Hg cycle has been significantly altered; anthropogenic point source pollution, climate change, and atmospheric transport and deposition of Hg into snowpack, lakes, rivers, and subarctic seas and the Arctic Ocean all contribute to increased Hg availability for methylization and bio-magnification in northern food webs (Murray 2007, Lu et al. 2001, Macdonald et al. 2008, Sunderland and Mason 2007, AMAP 2003). Exposure to methylmercury (MeHg), the bioaccumulative species of Hg, has been linked to a variety of adverse health effects, including increased rates of Coronary Heart Disease (CHD) and developmental delays in children of exposed mothers (Cohen et al. 2005, Van Oostdam et al. 2005, Guallar et al. 2002), making potential exposure a significant issue for many people. Alaskans and other northerners consume a significant amount of fish, much of which is harvested locally (Wolfe 2000); too, almost 50% of the US seafood supply originates from fisheries off the west coast of Alaska (NMFS 2008). However, there continues to be much controversy and uncertainty regarding appropriate precautionary ways to inform the public about the risks of fish consumption, without unintentionally undermining the general willingness to consume foods that are in fact safe, and likely offer a number of benefits to biophysical as well as sociocultural health (Senkowsky 2004, Patterson J. 2002). For instance, many fish contain omega-3 (n-3) fatty acids (FA), which have been shown to reduce cholesterol levels and the incidence of CHD and stroke (Daviglus et al. 2002), lower risk for colitis and type 2 diabetes (Barre 2007, Hudert et al. 2006), and lead to improvement in neurological and psychological disorders such as depression, schizophrenia, and Parkinson disease (Calon and Cole 2007). Even among pregnant women, for whom consumption of many seafoods is generally recommended against (FDA 2004a), fish are shown to have variety of health benefits as long as the intake of contaminants such as MeHg remains low (ibid; Daniels et al. 2004, Mozaffarian and Rimm 2006).

The mere *perception* of contamination, however, has proven to be enough to keep many people from consuming fish (Trainor et al. 2009 in press). Given the potential benefits enumerated above, a continued trend away from these foods is obviously of significant concern. This may be especially the case for the many indigenous communities of the North, where fish and other wild, 'country foods' play keystone sociocultural roles that alternative foods, including store-bought, cannot—supporting not just biophysical needs such as calories and nutrition, but also psychosocial, community, and cultural wellness as well (Bersamin et al. 2007b, Garibaldi and Turner 2004, Loring and Gerlach 2009).

Risk management approaches for difficult concerns such as MeHg usually involve monitoring efforts by agencies, advisories recommending limits on amounts of high-Hg fish consumed, and regulations that control emissions from anthropogenic sources (Sunderland 2007, p.235, e.g., Selin et al. 2010). The effectiveness of these strategies, however, is dependent on the existence of quality information (ibid). Awareness at the local level is a key to reducing vulnerability to environmental health risks such as food contamination (Ginsberg and Toal 2009); good information, such as regionally-specific advisories that weigh actual risk against the *benefits* of fish consumption such as those provided by n-3 FA, can go far toward enabling people to make more effective dietary choices. A challenge, however, in crafting effective advisories about MeHg contamination, is the significant geographic variability in Hg concentrations for fish and shellfish species (e.g., Adams 2004, Andersen and Depledge 1997). In Alaska, signifiant variation in contaminant levels has been observed, both between wild foods (e.g., Burger et al. 2004) and for the same foods but in different regions (Dunlap et al. 2007). The age and size of the fish consumed has also been shown to influence Hg levels and elimination rates (Trudel and Rasmussen 1997). Too, there is some speculation about whether an individual's sensitivity to MeHg once exposed may vary, whether MeHg absorption in the stomach and GI tract may differ as the result of diet, lifestyle, and medical history (Canuel et al. 2005).

This paper provides a first attempt at providing regionally-specific risk-benefit analysis for many of the most important fish species from Alaska's marine and riverine ecosystems. There are three goals: 1) translate, into terms useful for risk managers (and therefore for consumers), the large set of data that exists for regional MeHg contamination of important fish species in Alaska; 2) discover whether MeHg contamination varies regionally at a level significant enough to require the development of regionally-specific consumption advice; and 3) identify though this process any shortcomings in existing data or needs for future monitoring and research. We apply a quantitative approach provided by Ginsberg and Toal (2009) for generating Risk/Benefit Indices (RBIs) for fish consumption, using established dose-response relationships for cardiovascular and neurodevelopmental health endpoints. What we find is that for many species there is indeed significant variation in the RBI, between regions and between data-sets, with some fish species appearing overwhelmingly beneficial in some, while marginal or entirely unsafe in others. Our findings also suggest a need for improved regional monitoring – regions with fish samples identified here as marginally safe, for instance, should be monitored more closely for changes in contamination that could flip consumption advice in the other direction.

The findings also underscore the importance that the communication of information regarding food safety must be done with care given to how that information will be interpreted by the consumer. Though understandingly precautionary in nature, generalized food-item-specific consumption advice such as that currently offered by the FDA and EPA (EPA 2006, FDA 2004b) may encourage people to avoid foods that remain beneficial to their health. The alternative foods that people turn to may have negative ramifications that outweigh the risks of the food avoided. We argue for a place-based approach for monitoring and communicating risk that situates data like these within a broader, integrative context of diet and lifestyle, and conclude with some suggestions for future research.

3.3 METHODS

Ginsberg and Toal (2009) provide a quantitative approach for developing consumption advice for fish, an RBI that incorporates both the potential risks of consuming MeHg and the benefits of consuming omega-3 FA (Figure 2.1). They use dose-response relationships established in the medical literature for both adult cardiovascular, and in-utero neurodevelopmental health endpoints. In particular, they use a dose-response equation for adult CHD mortality (Mozaffarian and Rimm 2006), and one for adult myocardial infarction (MI) risk (Guallar et al. 2002, Ohno et al. 2007). For neurodevelopmental risk and benefit, they use established dose-response relationships for infant visual acuity (visual response memory, or VRM) (Oken et al. 2005).

We apply their method for eight types of fish commonly harvested and consumed in Alaska: pacific halibut (*Hippoglossus stenolepis*), sablefish (*Anopoploma fimbria*), walleye pollock (*Theragra chalcogramma*), northern pike (*Esox Lucius*), arctic grayling (*Thymallus arcticus*), dolly varden/char (*Salvelinus spp.*), chinook (king) salmon (*Oncorhynchus tshawytscha*), and coho (silver) salmon (*Oncorhynchus kisutch*). Data for dolly varden from the Wulik River is included here because of the proximity to the Teck-Cominco 'Red Dog' zinc-lead mine.

Mean (μ) total Hg (THg) is from data compiled by Jewett and Duffy (Jewett and Duffy 2007), from multiple regional studies of wild fish species harvested in Alaska. THg values for dolly varden (*Salvelinus malma malma*) in the Wulik River were also provided by the Alaska Department of Fish and Game (ADF&G) (William Morris, Personal Communication, October 2009). For consistency, we limit our

Net risk/benefit for adult CHD =

[(omega-3 FA mg/meal)

× (no. meals/week) x (1 week/7 days)

× (14.6% lower risk/100 mg omega-3 FA)]

– {[(hair Hg change/fish meal)

× (no. meals/week)] – (0.51 ppm hair Hg)}

× (23% higher risk/1 ppm hair Hg)

Net risk/benefit for infant VRM =

[(omega-3 FA mg/meal)

× (no. meals/week) x (1 week/7 days)

× (2 VRM points/100 mg omega-3 FA)]

– [(hair Hg change/fish meal)

× (no. meals/week)

× (7.5 VRM points/1 ppm hair Hg)]

Figure 3.1 Risk-benefit Equations for CHD and VRM Endpoints. These formulae use dose-response relationships established for methylmercury and omega-3 FA toward cardiovascular and neurodevelopmental health endpoints to create a relative RBI for fish consumption.

study to muscle tissue. Percent MeHg of THg in muscle is converted using appropriate reference values (Jewett and Duffy 2007, Wagemann et al. 1997), listed in Table 2.1. Baseline data for mercury, when available, came from FDA and EPA sources (FDA 2006). Hg and MeHg concentrations are presented in wet weight values as mg kg^{-1} (ppm; μg g^{-1}).

Omega-3 FA values from USDA's SR-21 'HealthTech' database, for fish samples designated in their database as 'Alaska Native' where possible. FAs included are Eicosapentaenoic acid (20:5, n−3; EPA), and Docosahexaenoic acid (22:6, n−3; DHA), as required by the dose-response relationships identified above. Portion sizes are 6 oz. Calculations and graphs were made using OpenOffice.org (Sun Microsystems, Santa Clara, CA). CHD RBI values reflect % improvement in relative risk, VRM values are net change in VRM points. Positive RBI values therefore reflect net-benefit, while negative values reflect net-risk. RBI values are also calculated for each μ THg ± 1 standard deviation (σ) to evaluate margin of error for each RBI.

Table 3.1 Conversion Percentages Tissue Mercury to Methylmercury. Bloom (1992) shows that there can be significant, yet unresolvable statistical variance for %THg as MeHg in fish; here we choose 95% as the baseline value for calculating MeHg, but use more specific values when available (e.g., as provided by Jewett and Duffy 2007).

Species	% THg	Reference
Halibut	95%	Wagemann 1997
Sablefish	95%	Bloom 1992
Pollock	95%	Bloom 1992
Pike	94%	Jewett and Duffy 2007
Grayling	95%	Bloom 1992
Trout	94%	Jewett and Duffy 2007
Salmon	78%	Jewett and Duffy 2007

3.4 RESULTS

Tables 3.2 and 3.3 summarizes the data for each species, shows the RBI for each study based on a consumption level of 1 meal/week, and identifies cases where consumption advice is not consistent within ± 1 σ. With the exception of nearly all pike studies and a small number of studies for other fish, nearly all of the THg values fall below both the USEPA (0.3 mg kg−1) and USFDA (1.0 mg kg−1) action levels for human consumption. Salmon in particular shows negligible risk and exceptional benefits at any level of consumption. However, as illustrated in Figures 3.2-3.4, there should still be concern for the THg levels reported in several fish species, with signficant variation between regions. Several fish species show a net-risk for both CHD and VRM endpoints when consumed at 1 meal/week; VRM risk is present at much lower THg levels than for CHD, with all fish except coho and chinook salmon showing negative VRM-RBI values when consumed once per week. Figures 3.2-3.4 display the calculated risk-benefit indices for CHD and VRM endpoints for the three most commonly-consumed fish species for Interior Alaska:

northern pike, arctic grayling, and chinook salmon.

The most significant finding reported here are the margins of error calculated for each study based on the provided standard deviations (σ). For most studies, THg levels vary so significantly (i.e., σ is so large), that consistent consumption advice cannot be provided within the range of μ THg ± 1σ. Additional comments on findings for individual species are listed below.

3.4.1 Halibut

Two studies for halibut provide values that suggest a net CHD risk, including the EPA baseline, while the three others show a beneficial CHD-RBI. Only one study (Hall et al. 1978) provides the standard deviation, however, and shows the potential for significant risk within the μ-1σ range. VRM indices are within the negative range for all studies, except (Hall et al. 1978), which appears as marginally-safe; again, the margin of error shows the potential for significant risk within the μ-1σ range.

3.4.2 Sablefish

All mean values for sablefish show produce positive CHD-RBI values, agreeing with the FDA value. For VRM there is less agreement, with the FDA baseline and one other study (Hall et al. 1976) showing significant VRM risk. In addition, two of the study means (both from Hall et al. 1978) show the potential for either benefit or risk within the μ-1σ range.

3.4.3 Pollock

Mean values for pollock all fall within the net-benefit range for CHD except for one study (from Hall et al 1978). However, once again, a significant margin of error is shown within ± 1σ. For VRM, all pollock studies produce a negative VRM-RBI except (Robertson and Abel 1990), which is marginally-safe for the mean THg value but has a range of error in both positive and negative directions.

3.4.4 Arctic Grayling

Data for arctic grayling shows the most inconsistency (Figure 2.2). Six study μ for MeHg in grayling show a beneficial or marginal CHD-RBI, while eight show risk. However, 11 out of the 14 study μ show a margin of error that includes both positive and negative CHD-RBI within the $\pm$ 1σ range. VRM-RBI all show risk, but four show the potential for marginal impact or even some benefit.

3.4.5 Northern Pike

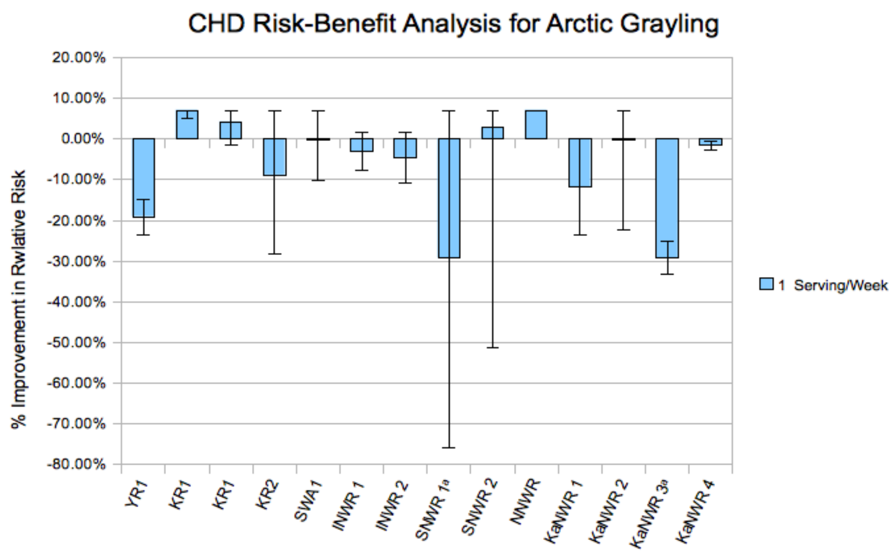
In agreement with previous assessments such as Jewett and Duffy (2007), all pike μ THg are shown to be a net-risk for both CHD and VRM endpoints (Figure 2.3). However, four study μ (Mueller et al. 1993, 1995) show the potential for marginal CHD impact or some benefit within the μ+1σ range.

3.4.6 Trout

An 'oily fish,' all trout study μ show a net-benefit for CHD. One study (Gray et al. 1996) shows potential for risk, due to an extremely large σ. For VRM, two studies plus the FDA baseline show trout as providing a net-benefit to VRM, while two others, however, show risk. Note also that there is no evidence of contamination of trout on the Wulik River that stands out from other rivers in Alaska.

3.4.7 Salmon

Easily the highest of the fish in terms of omega-3 FA content, it is not surprising that all of the THg values assessed for chinook and coho salmon show significant benefits for both CHD and VRM endpoints.



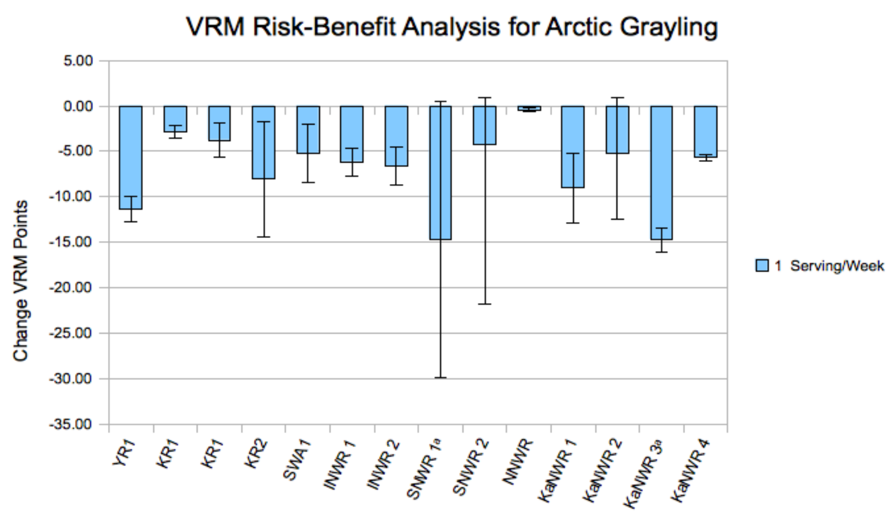
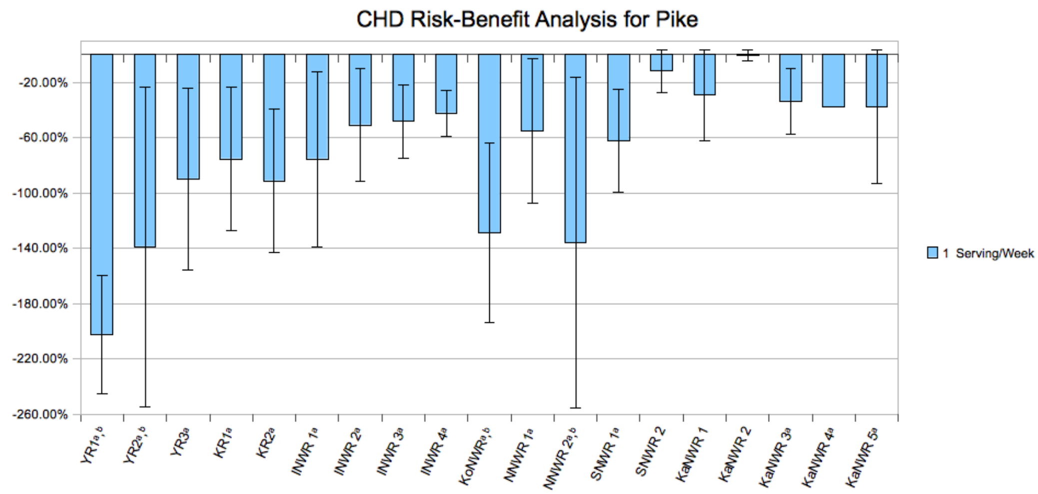


Figure 3.2 Risk-benefit Analysis for Arctic Grayling. The majority of study μ for grayling show a net-risk at the 1 meal/day level. Like other fish types, however, several show a margin of error that includes both possible net-benefit and net-risk within the μ ± 1σ range. Data labels on the X-axis can be matched to entries in Table 3.3.

a. Tissue MeHg value for these studies are above EPA action level of 0.30 ppm.



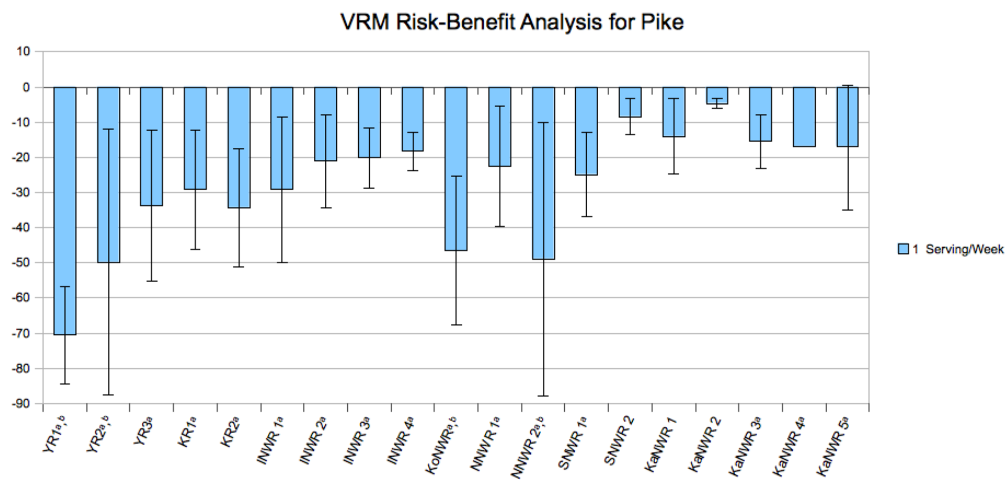
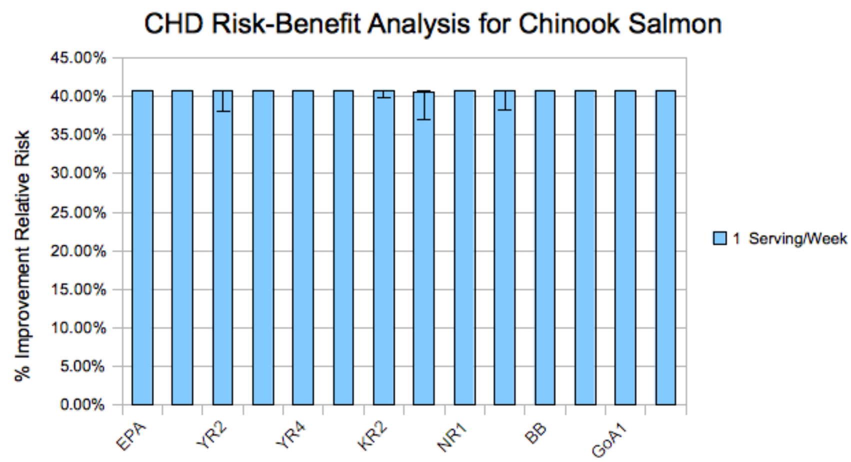


Figure 3.3 Risk-benefit Analysis for Northern Pike. In agreement with previous assessments such as Jewett and Duffy (2007), all pike values analyzed here are shown to be a net-risk for both CHD and VRM endpoints. Data labels on the X-axis can be matched to entries in Table 3.2.

a. Tissue MeHg value for these studies are above EPA action level of 0.30 ppm.

b. Tissue MeHg values for these studies are above FDA action level of 1.00 ppm.



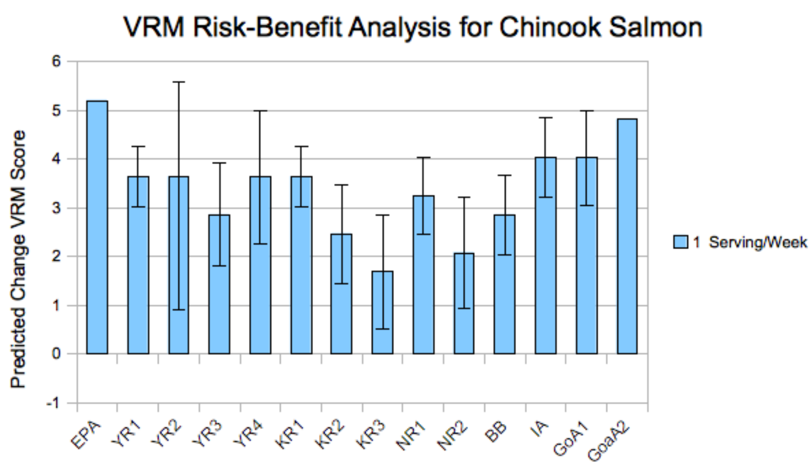


Figure 3.4 Risk-benefit Analysis for King Salmon. All of the study values assessed here for chinook (shown here) and coho both offer significant benefits for both CHD and VRM endpoints. Data labels on the X-axis can be matched to entries in Table 3.2.

Table 3.2 Details for marine and anadromous fishes in Alaska.

Species and Region[a]	**Year**	**µ THg (SD)**	**Reference**	**CHD-RBI**	**VRM-RBI**
Halibut *Hippoglossus stenolepis*					
EPA - Reference	n/a[b]	0.28 (n/a)	(EPA 2003)	-7.46%	-10.35
Bering Sea	n/a	0.15 (n/a)	(Hall et al. 1976a)	11.50%	-4.17
Gulf of Alaska	n/a	0.20 (n/a)	(Hall et al. 1976a)	4.21%	-6.55
SE Gulf of Alaska	n/a	0.26 (n/a)	(Hall et al. 1976a)	-4.54%	-9.4
Gulf of Alaska	1971-74	0.06 (0.37)	(Hall et al. 1978)	21.64% *	0.11 *
Sablefish *Anopoploma fimbria*					
FDA - Reference	n/a	0.22 (n/a)	(FDA 2006)	29.14%	-3.68
N. Gulf of Alaska (Kodiak)	n/s	0.04 (n/a)	(Hall et al. 1976b)	49.49%	4.88
N. Gulf of Alaska (Kodiak)	1971-74	0.12 (0.137)	(Hall et al. 1978)	43.72%	1.07 *
SE. Gulf of Alaska	n/a	0.28 (n/a)	(Hall et al. 1976b)	20.39%	-6.53
SE. Gulf of Alaska	1971-74	0.14 (0.056)	(Hall et al. 1978)	40.81%	0.12 *
Walleye Pollock *Theragra chalcogramma*					
FDA - Reference	n/a	0.06 (n/a)	(FDA 2006)	13.20%	-1.05
SE Bering Sea	1976	0.04 (0.038)	(Robertson and Able 1990)	13.20%	-0.09 *
N. Gulf of Alaska (Kodiak)	1971-95	0.1 (0.095)	(Hall et al. 1978)	11.07% *	-2.71
N. Gulf of Alaska (Kodiak)	1971-74	0.36 (0.220)	(Hall et al. 1978)	-27.57% *	-15.31
SE. Gulf of Alaska	1971-74	0.14 (0.225)	(Hall et al. 1978)	4.51% *	-4.85
Chinook Salmon *Oncorhynchus tshawytscha*					
EPA - Reference ("Salmon, Pacific")	2003	0.01 (n/a)	(EPA 2003)	40.80%	5.2
YR1 - Yukon R. (The Rapids)	2001	0.05 (0.016)	(Jewett and Duffy 2007)	40.80%	3.64
YR2 - Yukon R. (Beaver)	2001	0.05 (0.070)	(Jewett and Duffy 2007)	40.80%	3.64
YR3 - Yukon R. (Andreafsky R.)	1997	0.07 (0.027)	(Zhang et al 2001)	40.80%	2.86
YR4 - Yukon R. (Andreafsky R.)	2000	0.05 (0.035)	(Zhang et al 2001)	40.80%	3.64
KR1 - Kuskokwim R. (Bethel)	2001	0.05 (0.016)	(Jewett and Duffy 2007)	40.80%	3.64
KR2 - Kuskokwim R. (Bethel)	2000	0.08 (0.026)	(Zhang et al 2001)	40.80%	2.47
KR3 - Kuskokwim R. (Bethel)	1999	0.10 (0.030)	(Zhang et al 2001)	40.80%	1.68
NR1 - Nushagak R. (Portage Ck.)	2000	0.06 (0.020)	(Zhang et al 2001)	40.80%	3.25
NR2 - Nushagak R. (Portage Ck.)	1999	0.09 (0.029)	(Zhang et al 2001)	40.80%	2.08
BB - Bristol Bay	1971-74	0.07 (0.021)	(Zhang et al 2001)	40.80%	2.86

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Table 3.2 (continued)

Species and Region of Study[a]	**Year**	**μ THg (SD)**	**Reference**	**CHD-RBI**	**VRM-RBI**
Chinook Salmon *Oncorhynchus tshawytscha*					
IA - Interior Alaska	1971-74	0.04 (0.021)	(Hall et al 1978)	40.80%	4.03
GoA1 - N. Gulf of Alaska	1971-74	0.04 (0.025)	(Hall et al 1978)	40.80%	4.03
GoA2 - SE Gulf of Alaska	1971-74	0.02 (0.000)	(Hall et al 1978)	40.80%	4.81
Coho Salmon *Oncorhunchus kisutch*					
EPA - Reference (“Salmon, Pacific”)	2003	0.01 (n/a)	(EPA 2003)	40.80%	5.2
Yukon R. (Andreafsky R.)	2000	0.06 (0.012)	(Zhang et al 2001)	66.56%	6.77
Yukon R. (Andreafsky R.)	1999	0.04 (0.016)	(Zhang et al 2001)	66.56%	7.56
Kuskokwim R. (Bethel)	2000	0.06 (0.014)	(Zhang et al 2001)	66.56%	6.77
Kuskokwim R. (Bethel)	1999	0.05 (0.006)	(Zhang et al 2001)	66.56%	7.17
Nushagak R. (Portage Ck.)	2000	0.06 (0.011)	(Zhang et al 2001)	66.56%	6.77
Kvichak R. (Levelock)	1999	0.05 (0.004)	(Zhang et al 2001)	66.56%	7.17
Innoko Nat'l Wildlife Ref.	1991	0.05 (n/a)	(Zhang et al 2001)	66.56%	7.17
N. Gulf of Alaska	1971-74	0.11 (0.072)	(Mueller et al 1996)	66.12%	4.82
SE. Gulf of Alaska	1971-74	0.05 (0.061)	(Hall et al 1978)	66.56%	7.17
SE. Gulf of Alaska	1971-74	0.03 (0.015)	(Hall et al 1978)	66.56%	7.95

a. Abbreviations (e.g., GoA1) are solely for identification purposes on Figures 2.2-2.4, and do not necessarily connote identical sampling sites or study areas between studies. See 'reference' column to identify the study cited. b. n/a = data not available.

*. Indicates that the RBI changes direction (benefit to risk, risk to benefit) within a range of $\mu \pm 1\sigma$. See also e.g., Figure 2.3.

Table 3.3 Details for freshwater fishes in Alaska.

Species and Region of Study[a]	Year	μ THg (SD)	Reference	CHD-RBI	VRM-RBI
Northern Pike *Esox lucius*					
YR1 - Yukon R. (Andreafsky R.)	2000	1.51 (0.296)	(Jewett et al. 2003)	-202.35%	-70.53
YR2 - Yukon R. (Andreafsky R.)	1997	1.07 (0.803)	(Duffy et al. 1999)	-138.86%	-49.82
YR3 - Yukon R. (Paimiut and Emmonak)	1997	0.73 (0.456)	(Duffy et al. 1999)	-89.80%	-33.83
KR1 - Kuskokwim River (Aniak, George and Takotna R.)	2000	0.63 (0.359)	(Jewett et al. 2003)	-75.37%	-29.12
KR2 - Kuskokwim River (Gweek and George R.)	1997	0.74 (0.359)	(Duffy et al. 1999)	-91.25%	-34.30
INWR1 - Innoko Nat'l Wildlife Refuge	1997	0.63 (0.439)	(Mueller and Matz 2002)	-75.37%	-29.12
INWR2 - Innoko Nat'l Wildlife Refuge	1996	0.46 (0.283)	(Mueller and Matz 2002)	-50.85%	-21.12
INWR3 - Innoko Nat'l Wildlife Refuge	1993	0.44 (0.184)	(Headlee 1996)	-47.96%	-20.18
INWR4 - Innoko Nat'l Wildlife Refuge	1991	0.40 (0.115)	(Mueller et al 1996)	-42.19%	-18.30
KoNWR1 - Koyukuk Nat'l Wildlife Refuge	1991	1.00 (0.448)	(Mueller et al 1996)	-128.76%	-46.53
NNWR1 - Nowitna Nat'l Wildlife Refuge	1991	0.49 (0.363)	(Mueller et al 1996)	-55.17%	-22.53
NNWR2 - Nowitna Nat'l Wildlife Refuge	1987	1.05 (0.827)	(Snyder-Conn et al. 1992)	-135.97%	-48.88
SNWR1 - Selawik Nat'l Wildlife Refuge	1988	0.54 (0.257)	(Mueller et al 1993)	-62.39%	-24.89
SNWR2 - Selawik Nat'l Wildlife Refuge	1987	0.19 (0.109)	(Mueller et al 1993)	-11.89% *	-8.42
KaWR1 - Kanuti Nat'l Wildlife Refuge	1989	0.31 (0.229)	(Mueller et al 1995)	-29.20% *	-14.07
KaWR2 - Kanuti Nat'l Wildlife Refuge	1988	0.11 (0.028)	(Mueller et al 1995)	-0.35% *	-4.66
KaWR3 - Kanuti Nat'l Wildlife Refuge	1987	0.34 (0.163)	(Mueller et al 1995)	-33.53%	-15.48
KaWR4 - Kanuti Nat'l Wildlife Refuge	1986	0.37 (n/a[b])	(Mueller et al 1995)	-37.86%	-16.89
KaWR5 - Kanuti Nat'l Wildlife Refuge	1985	0.37 (0.384)	(Mueller et al 1995)	-37.86% *	-16.89
Arctic Grayling *Thymallus arcticus*					
YR1 - Yukon R. (Andreafsky R.)	2000	0.26 (0.030)	(Jewett et al. 2003)	-19.09%	-11.39
KR1 - Kuskokwim R. (George R.)	2000	0.08 (0.015)	(Jewett et al. 2003)	7.10%	-2.83
KR2 - Kuskokwim R. (Tuluksak R.)	1997	0.10 (0.040)	(Duffy et al. 1999)	4.24% *	-3.78
KR3 - Kuskokwim R. (3 rivers and tributaries)	n/a	0.19 (0.133)	(Gray et al. 1994)	-8.88% *	-8.06
SWA1 - Southwestern Alaska	n/a	0.13 (0.068)	(Gray et al. 1994)	-0.13% *	-5.21
INWR1 - Innoko Nat'l Wildlife Refuge	1997	0.15 (0.032)	(Mueller and Matz 2002)	-3.05% *	-6.16
INWR2 - Innoko Nat'l Wildlife Refuge	1996	0.16 (0.043)	(Mueller and Matz 2002	-4.51% *	-6.64
SNWR1 - Selawik Nat'l Wildlife Refuge	1988	0.33 (0.319)	(Mueller et al. 1993)	-29.30% *	-14.72 *
SNWR2 - Selawik Nat'l Wildlife Refuge	1987	0.11 (0.370)	(Mueller et al. 1993)	2.79% *	-4.26 *

(continued next page)

Table 3.3 (continued)

Species and Region of Study[a]	Year	μ THg (SD)	Reference	CHD-RBI	VRM-RBI
Arctic Grayling *Thymallus arcticus*					
NNWR1 - Nowitna Nat'l Wildlife Refuge	1987	0.03 (0.004)	(Snyder-Conn et al. 1992)	7.10%	-0.45 *
KaNWR1 - Kanuti Nat'l Wildlife Refuge	1988	0.21 (0.081)	(Mueller et al. 1995)	-11.80%	-9.01
KaNWR2 - Kanuti Nat'l Wildlife Refuge	1987	0.13 (0.152)	(Mueller et al. 1995)	-0.13% *	-5.21 *
KaNWR3 – Kanuti Nat'l Wildlife Refuge	1986	0.33 (0.028)	(Mueller et al. 1995)	-29.30%	-14.72
KaNWR4 – Kanuti Nat'l Wildlife Refuge	1985	0.14 (0.008)	(Mueller et al. 1995)	-1.59%	-5.69
Trout *Salvelinus spp.*					
FDA - Reference	n/a	0.03 (n/a)	(FDA 2006)	28.38%	2.39
Dolly Varden (PWS)	1996-97	0.16 (0.046)	(Jewett and Duffy 2007)	17.03%	-3.64
Dolly Varden (Kuskokwim R.)	n/a	0.25 (0.230)	(Gray et al. 1996)	4.04% *	-7.87 *
Dolly Varden (Innoko Nat'l Wildlife Refuge)	1991	0.04 (0.004)	(Mueller et al 1996)	28.38%	2.01
Dolly Varden (Wulik River)	2003-08	0.02 (0.006)	ADF&G Personal Communication	28.38%	2.99

a. Abbreviations (e.g., GoA1) are solely for identification purposes on Figures 2.1-2.3, and do not necessarily connote identical sampling sites or study areas between studies. See 'reference' column to identify the study cited. b. n/a = data not available

*. Indicates that the RBI changes direction (benefit to risk, risk to benefit) within the range of $\mu \pm 1\sigma$. See also e.g., Figure 2.2

3.5 DISCUSSION

For millennia, Alaska Natives have relied on a vast array of wild game, fish, and botanical resources from Alaska's landscapes and seascapes. Though challenged now by a variety of factors, the use of these 'country foods' continues extensively across the state, and they remain highly preferred over store-bought foods by the majority of Alaska Natives as well as by many Native Alaskans of Euroamerican descent. In terms of sheer numbers, wild fish easily stand out as the most consistently and heavily relied-upon local food resource in Alaska (Wolfe 2000). As noted, Alaska's coastal fisheries also provide roughly 50% of the seafood consumed in the United States. It is especially important, therefore, in respect to not just Alaska but to concerns of individual health and community self-reliance and sustainability nation-wide, that we find a quantitative and reliable way to come to terms with the safety of these important and valued resources.

The exercise reported here was undertaken with this goal in mind. Ginsberg and Toal's method is designed to provide information of practical significance to consumers, for providing consumption advice that integrates multiple concerns into an easy-to-read risk/benefit index. The first important finding is that while the vast majority of studies reviewed here provide MeHg values that are below FDA and EPA action levels, several still show a net-risk for CHD and VRM endpoints when consumed once a week, based on this method. Salmon, for instance, appear to be quite safe even when consumed frequently, whereas northern pike shows a significant amount of risk. These findings are mostly as anticipated; habitat for northern pike is much more conducive to mercury methylization, and as piscivores in a closed food web, MeHg bioaccumulation would greatly outpace that expected for salmon in an the open river / open ocean habitat.

Our analysis also reveals, however, that current data-sets for MeHg contamination of Alaska's wild fish have significant practical shortcomings: many having a degree of internal variability that leave us with no sound basis for crafting reliable consumption advice. Given this uncertainty, a precautionary approach would seem reasonable, and one next step would be to develop and deploy more precise, regionally-specific monitoring efforts, perhaps targeting confounding factors like fish age and size, so that more consistent consumption advice may be provided. Community-members that we work with have expressed great interest in participating in such initiatives, recommending events such as fishing derbies that can engage the entire community in a monitoring process that allows them to take more control over the safety and quality of what they eat.

Still, omega-3 FA and MeHg remain only two variables in a complex set of social, cultural, and economic drivers and determinants of health[2]. If Alaska Natives are advised against eating wild foods that are important nutritionally, economically, and culturally, what foods will they replace them with? How will they procure them, and at what expense? Will the foods they choose be appropriate nutritional and cultural substitutes? And how do people cope with the stress of the realization that the lands which have nourished their people for millennia are now poisoning them?

It is widely understood that wild fish and game exhibit greater nutritional quality than do the market foods that are coming to replace them, and there is much evidence to suggest that traditional foods in Alaska support health through nutrition in some very locally-adapted ways (Bersamin et al. 2007a, Kuhnlein et al. 2002, Ebbesson et al. 2005, Mohatt et al. 2007). Nevertheless there is already a clear, ongoing transition in rural diets away from country foods and toward foods purchased at the store, with contamination, and at times the mere perception of contamination, just one of several drivers (Godduhn and Duffy 2003, Loring and Gerlach 2009). This 'nutrition transition' has not been without its share of implications for individual and community health, and a variety of ongoing research looks beyond the biophysical aspects of health to include possible economic, nutritional, even psychological and psychosocial outcomes. Foodways in rural, high-

2 See Chapter 1 in this volume.

latitude communities are the primary context for the development of relationships between the individual, the household, the community and the landscape. The connections a person feels to the people and places of their community, and the importance of their roles and responsibilities within their family and community, have all also been shown to play a central role in the maintenance of psychological and emotional well-being (Wolsko et al. 2007, Graves 2005, Fone and Dunstan 2006).

Given that wild foods play so many important roles in the lives and health of the people of Alaska, one next step for health researchers and practitioners is to find ways to move beyond the single-variable risk management approaches that characterize contemporary fish consumption advisories, and towards a more holistic approach. The Ginsberg and Toal RBI is an appreciable advance in this direction, yet even it is constrained by the complex role of food in health. What of the other potential protective factors in traditional diet and lifestyle habits? Given that salmonids are so high in n-3 FA, for instance, one testable scenario would examine whether one or more servings of salmon per week are sufficient to off-set the risks of one or more separate servings of northern pike. Another, similar avenue worth examining would be the contribution of antioxidants to this risk-benefit equation, from berries (a traditional food in Alaska that has been found to be exceptionally high antioxidants) and other traditionally-used wild botanical resources. The goal is to develop comprehensive dietary advice that not only manages the risks of environmental contamination, but also supports people in their need to partake of culturally-valued foods.

3.6 CONCLUSION

As our understanding of the complex and inherently social nature of health improves, we learn to develop more integrative approaches to health assessment that incorporate multiple variables from social, political, economic, and ecological domains (e.g., Bhatia and Wernham 2008, Clark 2005). The risk-benefit analysis method used here is indeed an important first step in this direction. Nevertheless, methylmercury and omega-3 fatty acids remain just two variables in an incredibly complex calculus of health, and much work remains to identify the many relationships between changing foodways in the Arctic and ongoing challenges like depression and alcoholism, cancer, obesity, and type-2 diabetes. Moving forward, it is essential that we organize our tools for assessment within a broad and integrative framework that can provide regionally-appropriate guidance for health practitioners and community members alike. The uncertainty in MeHg data revealed here may be something of an opportunity in this regard, by which we must learn to compensate for uncertainty in one domain by increasing our understandings of other, non-biophysical aspects of health. And as we develop more precise ways to measure the biophysical risks such as MeHg, it is important that we continue to ground our advice within an integrative understanding of health.

3.7 REFERENCES

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CHAPTER 4

WAYS TO HELP AND WAYS TO HINDER: POLICY FOR SUCCESSFUL LIVELIHOODS AND RESOURCE CONSERVATION IN AN UNCERTAIN CLIMATE[1]

4.1 ABSTRACT

This paper applies a diagnostic framework to understand differences in experience of weather, environmental change and variability, and policy, as reported in 2007 and 2008 by two groups of resource users in Alaska. The commercial fishers of the Bering Sea and the moose hunters of Interior Alaska both face similar challenges regarding the impacts of a changing climate on wild fish and game, but tell very different stories regarding whether these impacts hinder their ability to pursue secure livelihoods. In both regions, people describe dramatic changes in the weather, landscape and seascape conditions, and distributions of fish and game. A key finding is the difference in the degree to which harvest policies such as quotas and seasons foster adaptability in the face of environmental change, by situating day-to-day decision making authority in the hands of the resource users. Though considered favorably and believed to alleviate concerns regarding safety on the coast, these aspects of policy were discussed as problematic by those in the Interior. Many describe hunting during prescribed seasons as less fruitful, more costly, and more dangerous in recent years, and are often left with the difficult decision to hunt or fish out of season in order to feed their families. Users in both regions described myriad ways that scientists and policymakers could help by providing quality, timely information such as weather forecasts and other useful scientific information. Our findings also demonstrate the usefulness of the diagnostic framework employed for the analysis of resilience and vulnerability in social-

1 Loring, P.A., Gerlach, S.C., and David E. Atkinson. In Review. Ways to Help and Ways to Hinder: Policy for Successful Livelihoods and Resource Conservation in an Uncertain Climate. *Arctic.*

ecological systems.

4.2 INTRODUCTION

> *Late summer and early fall of 2007 in Interior Alaska saw a lot of rain. Too much, really, which among other problems proved to be quite the challenge for those of us looking for moose in the Minto Flats. One time in particular, I was out on the water with my friend Patrick Smith, then the second tribal chief of the village of Minto. We were heading back after a long and unsuccessful day of searching all his customary spots. The weather had turned rainy and cold, the visibility was poor, and the water just too darned high. On the trip home we encountered another hunting party from Minto, three younger men, each standing waist-deep in the muck and trying, in vain, to pull a bull moose they had shot out of the water and up onto the bank. They had timed their shot for just as the moose jumped out of the water, normally the right thing to do. But with the high water and wet conditions, the downed bull had slipped down the muddy bank. When we found them, the moose was under nearly 3 feet of water and the men were shivering and waterlogged, their lips blue with cold. It took the five of us another two hours to get that fifteen hundred-pound beast onto dry ground, where it could finally be gutted and packed on their skiff. We very nearly lost it, and that would have meant losing a winter's worth of meat for two families at least.*
>
> --Adapted from the field notes of Philip A Loring

The 'subsistence' lifestyle, as it is often called in Alaska, is by no means easy. But with flexibility and expertise, favorable weather and environmental conditions, and access to sufficient fuel, supplies, time, information, and luck, it can provide a sound basis for a healthful, self-reliant, and culturally, spiritually, and ecologically sustainable living (Campbell 2004, Kawagley 1995, Nelson 1986). However, events like those related in the vignette above are increasingly common in Alaska and elsewhere in the North, with the unfortunate caveat that they rarely share such a fortunate ending. Livelihoods based on the ecosystem services of the land and sea are increasingly constrained, by a changing climate and highly-variable daily and seasonal environmental conditions, by a patchwork of land tenure, and by complicated and sometimes conflicting resource management regimes that are struggling to keep pace with unprecedented rates of ecological change (Ford 2009, White et al. 2007, Tyler et al. 2007, Nuttall et al. 2004, McNeeley 2009, Krupnik and Jolly 2002, Keskitalo 2008). And in the midst of rising food and fuel prices, oil, minerals, and natural gas exploration, and an uncertain global economy, the impacts of a changing climate only further aggravate what is already a system under significant stress (Fazzino and Loring 2009, Lynch and Brunner 2007).

Identifying natural resource governance strategies that can successfully foster adaptability for communities while maintaining conservation and sustainability goals is an import research need (Chapin III et al. 2006, Ford 2008, Ford et al. 2010). In 2007, the authors visited the Alaskan communities of Unalaska (commonly known as Dutch Harbor), Togiak, Fort Yukon, and Minto, to perform a needs assessment regarding what kinds of institutional support (e.g., forecasts, advisories, research) would be most helpful to the people of these fishing and hunting communities, in light of the many ongoing challenges they face. We quickly realized that while communities across the state are indeed experiencing a similar set of challenges related to the increased variability of weather and other environmental conditions, the degree to which these changes are impacting local livelihoods varies considerably between the subsistence communities of the Alaskan Interior and the communities fishing out of the Bering Sea and Aleutian Islands (BSAI) area. In both regions, people described encountering myriad changes to the landscape and seascape that match with other accounts of and projections for climate change in the North (e.g, ACIA 2005, Krupnik and Jolly 2002, McNeeley and

Huntington 2007, Loring and Gerlach 2009). Mostly, people spoke on issues of personal safety, and the challenging decisions they must make on a daily and seasonal basis in order to maintain successful livelihoods based on wild fish and game. But, whereas people in the Interior repeatedly discussed how policies such as hunting and fishing seasons exacerbated the difficulties brought by climate change, people on the coast described how recent changes in fisheries policy had increased their ability to adapt to changing conditions, thereby ameliorating many of the dangers their “deadliest catch” lifestyle is known for.

In order to better understand, and hopefully extract lessons from these differences in experience in Alaska, this paper employes an ecosystem services-based diagnostic framework (Loring et al. 2008) to identify how policy and policy-enforcement serve either to help or hinder people's ability to navigate new and changing ecological constraints on resources. Of particular interest is how policy creates roles for managers and resource users in each system, and whether these roles are appropriately matched with participants' competencies and with the scale of the ecological challenges they face (Goetz 2004, Pomeroy and Rivera-Guieb 2005, Jorgensen and Lyons 2008).

The importance of matching ecological and social scales in the design of natural resource governance systems is widely discussed (Ommer 2007, Young 2002, Kofinas et al. 2007) but the mechanics for successfully implementing local participation and co-management are only beginning to be understood (Nadasdy 2003, Goetz 2004). Many caution against superficial treatments of 'local' solutions as a management panacea (Born and Purcell 2006, Ostrom et al. 2007), and some question, in light of the complex nature of global environmental change, the capacity of local institutions and expertise for contributing to outcomes of stewardship and sustainability (e.g., Lopez-Hoffman et al. 2006, Sutherland et al. 2004, Wohling 2009). Our findings contribute to this discussion by identifying specific roles for local users and management institutions that draw on the strengths of each to successfully foster flexibility and innovation in response to environmental challenges. This means, for instance, entrusting resource users with the authority to make ad-hoc harvesting decisions within day-to-day and week-to-week timeframes in response to short-term environmental variation (as in the long open seasons that characterize the BSAI fishery), while reserving the weight of broader institutional mandates for providing the resource user with quality institutional support, e.g., information and forecasts, and for securing the integrity of the resource-base at large, e.g., through ecosystem-scale management and the enforcement of international treaties. Too, our analysis illustrates the diagnostic capability of the chosen ecosystem services analytical framework, for facilitating effective cross-regional comparisons and for enhancing discussions of community resilience and vulnerability through the use of a common vocabulary. Recommendations for future research are also provided.

4.3 STUDY AREAS AND METHODS

Two cases are explored in detail: subsistence moose (*Alces alces*) hunting in Interior Alaska and commercial ground-fish fishing in the BSAI region (Figure 4.1). The company fishing town of Unalaska, known to many as Dutch Harbor or just ‘Dutch,’ is an epicenter of commercial fishing in Alaska. Well-known even within popular culture world-wide as a result of the television reality-based series 'Deadliest Catch', Dutch is home-base to the largest commercial fishing port in the US and one of the largest and most productive ground-fish and crab fisheries in the world. These BSAI fisheries provide nearly 50% of the US seafood supply (NMFS 2008). Fishers and processors working in the BSAI fishery produce about 1/3 of the total US crab catches on average (Woodby et al. 2005:18). It is the ground-fish fisheries easily dominate the state’s commercial harvest, however, with an average of 4.2 billion pounds harvested per year for the 5-year period of 1998-2002 (salmon, herring and shellfish harvests for this same period were each in the millions) (ibid, p. 4). Management of these commercial fisheries fall to a mix of state and federal agencies and international treaties, and regulation can be quite hard to navigate, with often-nuanced details regarding jurisdictional authority, total allowable catch (TAC), regular and emergency openings, and geographic restrictions varying significantly from species to species. In general, however, the State of Alaska has management authority over all salmon, herring, and shellfish populations; the US Federal government has management authority over the majority of ground-fish, excepting those within three nautical miles of shore; and salmon and Pacific Halibut are governed by commissions established by international treaties between the United States and Canada, the Pacific Salmon Treaty of 1985 and the International Pacific Halibut Commission (1953) respectively.

Far from Dutch, not just geographically but also socially, culturally, and economically, are Minto, Fort Yukon, and the other remote rural communities of the Yukon Circle region of Interior Alaska, a predominantly-wetland area at the confluence of the Yukon and Tanana River Flats, with Fort Yukon the regional hub and Fairbanks the primary urban outlier. For millennia, Alaska Natives living in the region have subsisted on a diverse array of wild, country foods, primarily including ungulates such as moose (*Alces alces*) and caribou (*Rangifer tarandus*) and salmon (*Oncorhynchus spp.)*, but also including (depending on region) sea mammals and a variety of other fresh and saltwater fish, migratory waterfowl, berries, root-crop gardens, and other botanical resources. As stated above, 'subsistence' is the widely used term to describe this lifestyle, legally defined as the "customary and traditional use of wild, renewable, fish and wildlife resources for food and other non-commercial purposes" (Alaska Statute 16.05.940(33)). Note that while this term may be codified in law and practice, it falls far short of capturing the varied and important roles of the wild food harvest in local culture, tradition, and worldview (Berger 1985, Case 1984, Gerlach et al. in press, Sacks 1995).

Figure 4.1 Map of Alaska. This map identifies the study locations and other geographic reference points discussed here. Map by Nicole Dufour, University of Alaska Fairbanks Department of Anthropology.

Like the BSAI, the governance of subsistence harvests is also difficult to navigate, with state and federal jurisdictions creating a barely-workable patchwork of rules and regulations (Caulfield 1992, Huntington 1992): on state lands, access and harvest is governed by the Alaska Department of Fish and Game (ADF&G); on federal lands, these might be governed by the US Department of Fish and Wildlife

(USFWS), the National Park Service (NPS), or the Bureau of Land Management (BLM). There are also many privately-held lands. All in all, jurisdictional authority is sometimes unclear to say the least, and not just regarding regulations but also enforcement, with other state and federal agencies such as the Alaska State Department of Transportation (DOT) and the U.S. Coast Guard (USCG) playing roles as well.

4.3.1 Methods

Field work included one-on-one semi-structured interviews and informal round-table discussions in the communities of Minto (population 190), Fort Yukon (population 587), and Unalaska (Dutch Harbor, population 3551) (AKDCCED 2007), completed in the summers of 2007 and 2008. Participants were identified first by suggestion of local leaders (e.g., tribal council; harbormaster) and then using the snowball method, where interviewees were asked to recommend additional participants. A total of 38 people were interviewed, 23 in Unalaska, 10 in Fort Yukon, and 5 in Minto, all of which spoke English. People were asked to describe the challenges they face to making a successful harvest, environmental or otherwise. Discussions were initiated using non-leading, open-ended questions about determinants of harvest success, followed up with targeted questions designed to identify concerns about weather conditions, access and availability of wild fish and game, and issues of personal safety. Climate change or changes in policy were not specifically prompted, but as discussed later, both came up early and often in conversations with people from both regions, and were pursued appropriately with follow-up questions. Transcripts were analyzed for content using Verity K2 software by Verity, Inc.

Our interview questions (and subsequent analysis) were informed by an ecosystem services-based diagnostic framework developed by Loring and colleagues (2008). Called the Services-Oriented Architecture (SOA), this is a information framework that provides meta-data for describing an ecosystem service's 'viability'— whether or not it is a practical option for a particular group of users, given a mix of ecological, social, and political drivers and determinants, including weather, ecological changes, social, cultural, and economic policies. Using standardized meta-data is an essential step forward in the study of ecosystem services, as it allows for easy comparison and analysis between regions, ecosystem services, or stakeholder groups (de Groot et al. 2002). The SOA framework emphasizes both opportunities and constraints and therefore is also useful in discussions of resilience and vulnerability (e.g., Ford and Smit 2004, Walker et al. 2006): where opportunities for using the ecosystem service are broad, the user has more room to adapt and is therefore more resilient to changing constraints; likewise, where constraints make opportunities for ecosystem service use very specific in space or time, the user can be more vulnerable to variability and change.

The SOA categorizes an ecosystem service's viability into four interacting factors: reachability, compatibility, awareness, and willingness (see below), and aspects of each were captured in our follow-up questions:

1. Reachability is concerned with the practicality of access to a resource, and is determined by a combination of both ecological *constraints* (e.g. climate, land-cover) and social impositions (e.g. *policies* and *contracts*). Reachability can also dictated by energy costs relative to requisite supplies and technologies, constrained by rising fuel prices, purchase and maintenance costs of technologies needed for successful harvest/use. How *policies* and *contracts* vary across different stakeholder groups to reflect these ecological and economic constraints is a key factor in the evaluation of matters such as differential distributions of access to resources (equity and justice).
2. Compatibility means that, once reached, the resource is usable by the consumer; this moves beyond the resource itself to the incorporation of available methods of harvest/procurement.

3. Awareness involves the level of knowledge held by community members about the resources, such as the knowledge of and skill required to access and develop them (e.g., when and where to hunt or fish), and an understanding of any risks associated with use (contaminants, safety of travel across the landscape or seascape). If environmental conditions change in unprecedented ways, awareness can be compromised. Whether or not a user has accurate and timely information is key, and when viewed across stakeholder groups, can reflect differences of equity that manifest in the distribution and availability of information.
4. Resource users must also be willing to use/harvest these resources, to accept any risks or uncertainties necessary, and to participate in any requisite ritual, legal, and economic arrangements associated with their use (e.g., licensure, quota allocation, hunting seasons, etc.). Individuals ultimately make decisions to participate or break these rules (e.g., poaching) in sometimes clear but more-often sometimes ambiguous cultural contexts. Where risks are involved and the consumer has awareness of these risks, willingness also reflects the acceptance or rejection of these considerations.

In the sections that follow we describe the factors influencing the viability of moose hunting in the Interior and ground-fish (e.g., pollock) fishing in the BSAI, drawing both on interview responses as well as supporting literature on these systems (cited as appropriate). As will become clear, while there are many similarities between the two cases, there are also obvious differences in terms of regulatory configuration and the location/distribution of decision-making authority. Some might argue that given the significant differences between the predominantly ‘commercial’ fisheries of the coast and the ‘subsistence’ harvests of the Interior, the sheer scale of the operation as well as real differences in the cultural and regulatory contexts, that the comparison is inappropriate and contrived. The annual salmon harvest in the Interior, for instance, is barely a fraction of the quantities harvested in places like Southeast Alaska, Prince William Sound, and Bristol Bay; and these regions also represent just a fraction of the total productivity of the combined ground fisheries of the Bering Sea (Woodby et al. 2005, p. 4). Nevertheless, salmon and other wild food resources like moose and caribou are crucial economic, nutritional and cultural resources for these communities. Both the Interior and Coastal systems are also managed under similarly-overlapping and evolving combinations of state and federal regulations regarding the allocation of sustainable harvests across commercial, subsistence, and recreational uses. Too, those who fish out of Dutch overwhelmingly report that they do not see a clear distinction between what they do for a living as 'commercial' versus 'subsistence,' with harvest productivity often as tightly linked to their families' economic security as it is for the residents of the Interior, and these seasonal harvests an equally-important part of their self-identity, culture, and community (including for those whose only time on Alaskan shores comes in the brief moments between fishing trips). Thus, what we are comparing is very much the same: people's abilities to make a living off of Alaska's wild food resources, regardless of whether the activities have been institutionally-classified as 'commercial', 'subsistence', or otherwise, with both the similarities and the differences between the two cases proving informative.

4.4 MOOSE-HUNTING VIABILITY IN THE YUKON CIRCLE

Moose (*Alces alces)* is the most widely used big game animal in Interior Alaska (Andrews 1988, Brown et al. 2004, Caulfield 1983), and an important aspect of regional food systems that also include fish, small game and plants, and food from the store as well (Loring 2007, Reed 1995, Wheeler 1998). Most hunting occurs during the fall, when people hunt the male, or 'bull' moose in riparian (river) and wetlands regions surrounding the Yukon, Koyukuk, Porcupine, Tanana, and Nenana rivers, among others. Hunting generally involves travel up and down river by boat, or across dry lands by all terrain vehicles (ATV). With a few exceptions for emergencies, traditional uses, and hunting by proxy, the regulated limit is one moose per person, per year. Though not always enough to feed even a small family for a year, sharing and trading is common, and a single moose often goes to several families' smokehouses and freezers. An average of 7,055 moose have been harvested in Alaska each year from 2002–2007, providing a rough estimate of 2,000 tons of meat (ADF&G 2009c). Though negligible when compared to the total amount of red meat being imported annually into the state (Paragi et al. 2008), moose remains a rural cornerstone, whether considered in nutritional, economic, or cultural terms.

Regional climatic and environmental changes are already having a notable, though unpredictable and often non-linear effect on subsistence activities including the moose hunt, through changes in hydrology, seasonality and phenology, land cover and fish and wildlife abundance and distributions (White et al. 2007, Rattenbury 2006, Loring and Gerlach 2009, McNeeley 2009). With the general warming trend in Alaska, river ice conditions are changing; there is a longer ice-free period now, winter ice is thinner and more unpredictable, changes in precipitation and snow pack affect water levels in both the fall and spring, and the timing of fall freeze-up and spring break-up are shifting in unpredictable ways (Hunt et al. 2008, Mills et al. 2008, Wendler and Shulski 2009, Euskirchen et al. 2007). Landscape conditions like forage distribution and availability, river conditions such as water levels, and weather conditions such as temperature, precipitation, and wind speed and direction, can all impact the distribution and behavior of moose as well as other wild species[2] (Adams and Dale 1998, Van Ballenberghe and Miquelle 1993, Vivas

2 Changes in seasonality and river conditions impact more than moose, although moose are the primary focus here. Safety issues related to travel where winter ice is thin and where open water occurs in places where it is not expected, are problems discussed more frequently by residents of the Interior (Schneider 2009 Personal Communication; Gerlach Field Notes, 2008/09). Too much or too little snow makes overland travel difficult, hard on snow machines and other equipment, and sometimes dangerous as well (Rattenbury 2006). In recent interviews with community

and Saether 1987, Chapin III et al. 2006). Such changes can also make the environmental cues that hunters use to predict the weather and location of animals less reliable (Krupnik and Jolly 2002). Take for example the story used to introduce this paper; of Patrick's many usual hunting sites—small lakes or boggy areas that he has been visiting for many years—some were too flooded, and we did not encounter a single moose that day.

Conditions for moose hunting are most ideal when brush and other ground cover is thinning (making travel across the landscape easier), water levels in the river are not too high, pests such as mosquitoes and flies are sparse, and temperatures cool (roughly 60˚F or less) so that the meat can be processed and transported without worrying about quick spoilage. Not surprisingly, these conditions tend to converge in the early fall, sometime between late August and mid September. Ideally, moose should be hunted earlier rather than later in this period, in order to get bulls at their fattest—having gained their weight through the summer, bull moose begin to lose weight in September as they enter the mating season (rut). Catching a well-fattened moose is essential; not only does it make for good meat but also provides a thick layer of fat that is used by Alaska Natives with a number of other wild foods, for instance in a dish with berries called "Indian ice-cream," or for stuffing the otherwise-lean grouse (*Dendragapus canadensis*)(Loring field notes, August 2009). Getting a moose well before the rut is also important because the physiology of the rut has a negative impact on the quality and suitability of the meat. Those interviewed explained that when bulls enter the rut they begin to 'stink': the meat becomes increasingly less palatable, and much care

residents in the Yukon Flats, we have been surprised by the fact that village residents have been more vocal about problems with changing river conditions and spring waterfowl hunting than they have been about the fall moose hunt (Gerlach Field Notes, July/August 2009). Problems with the fall moose hunt and changes in seasonality and regulatory constraints have become the "norm," but it seems that earlier break-ups in the spring and problems with the important waterfowl hunt are new topics of discussion (Gerlach Field Notes, July/August 2009). Spring is a time when country food stores, especially moose, are typically running short, and waterfowl are the important transition food that holds people over until the summer fish season begins.

has to be taken during this time to avoid the animal's almost-noxious gland

Table 4.1 Overview of Viability for Moose Hunting in Interior Alaska. A viability analysis of the services provided by the land to an Alaska Native family, including the physical, political, social, cultural, and economic aspects of the services use. The Loring et al. (2008) meta-model brings together a variety of down-scale influences that are relevant to understanding the viability of an ecosystem service for a particular set of consumers.

Moose hunting and factors that influence viability	
Constraints	Factors of abundance and distribution, for example, animal birth rate, predation pressure, and compensatory mortality. Also includes changing landscape cover and browse availability, river water levels, forest fires, etc
Policies	• State and federal policies may limit take or access • Social and cultural institutions may dictate/limit take, or require take at certain times for ceremonial reasons
Contracts	The Alaska Department of Fish and Game assigns licenses to hunters, some on a first-come or lottery basis. Hunters agree to harvest the prescribed number of animals. Contracts for moose management can also exist between agencies and tribal corporations for moose management, access to state/federal land, and so on
Compatibility	Natural ecological variability requires a compatible harvest strategy of mobility and adaptability
Reachability	Must have access to necessary equipment and landscape where resources are present, and be capable of harvesting them • Practical hunting range is limited by living in fixed communities, cost of fuel, range of boats, etc. • Access can be limited by changes in weather, landscape, fire, legislation, land-ownership • Ability includes time and resources, for instance, if the hunters' circumstance influence them to take a wage-earning job during hunting season, or if they cannot afford gasoline to power a snowmobile
Awareness	Must have local knowledge as to harvest areas, wildlife movement, and must have the appropriate hunting skills
Willingness	• Ritual may dictate certain procedures before, during, and after the hunt • Must be willing to accept risks of travel across landscape where there may be danger • Must be willing to observe policies and enter into appropriate contracts with resource managers and land owners (or be willing to accept the consequences of not doing so.

secretions (Paragi 2009 Personal Communication). Some parts of the moose such as the liver and kidneys, which are normally prized delicacies, become entirely inedible during this time.

Beyond the costs and frustrations of a failed hunt, which include not just the need to find food elsewhere but also the money lost to fuel and other supplies, the uncertainty and unpredictability of conditions can also pose hazards to physical safety. Death by unintentional injury (e.g., drowning, all-terrain vehicle injuries) is common in rural Alaska; in 2008 the death rate was 52.4 per 100000, compared to a national average of 38.5 (AKDHSS 2008). Drowning, in particular, has been as high as 10 times the national average (Lincoln et al. 1996) and Alaska Native males ages 30-39, the group most likely to be on the land hunting and fishing, have the highest rates in the state (ibid). Despite falling in the last decade as the result of aggressive intervention and awareness campaigns, the drowning rate remains more than twice the national average, and deaths by unintentional injury in general have remained stable (AKDHSS 2008). Many fear that these will get worse as conditions change, and their confidence in their ability to predict the weather and the landscape decreases. High water levels, fire, and permafrost thaw slumps are all examples of new, climate-change related obstacles to safe transportation across the landscape which may cut off access to traditional harvest areas (Loring and Gerlach 2009, Hander et al. 2008). Residents of the Interior discuss more frequent encounters with thin winter ice and where open water occurs in places where it is not expected (W. Schneider pers. comm. 2009). Too much or too little snow also makes overland travel difficult, dangerous, and hard on snow machines and other equipment as well (Rattenbury 2006).

In the past, Alaska Natives had the flexibility to adjust when and where they hunted, making them quite able to adjust to the variability of weather and the landscape and still make a safe and successful moose hunt (Binford 2002, Loring et al. 2008). Today, however, hunters are constrained in this regard, by state and federal wildlife management paradigms that situate most authority over when, where, and how-much to hunt with regulatory regimes that are too slow or too removed from local circumstances to adjust to these challenges of environmental change. As Loring et al (2008) describe:

> Changing land cover, weather, and seasonality are modifying the abundance and migration patterns of terrestrial animal populations, both spatial and temporally ... [Too], these new ecological constraints to the viability of country food services are often aggravated, rather than mitigated, by state and federal regulatory structures that govern the use of wild fish and game (policies and contracts). State- and federal-level resource management agencies such as the Alaska Department of Fish and Game, the Bureau of Land Management, and the National Park Service, all exercise extensive control over the use of country food services, both geographically and temporally, through wildlife reserves, game management units, open and closed hunting seasons, quotas, area closures, and so on. (Loring et al. 2008, p.485)

Specific hunting openings are set by the State Board of Game (BoG), which meets only 2-3 times between November and April (Board of Game 2009), and therefore well in advance of any accurate knowledge about weather or land/water conditions (e.g., an early fall). In the Interior, open hunting season generally begins and ends in September, and lasts two to three weeks, though there is much variation in the specific dates for the 20+ management areas that encompass the majority of moose habitat in the Interior (ADF&G 2009a). The rationale for this timing is that the season should begin late enough to allow for the best possible hunting conditions, but end just before the onset of the rut, which conventional wisdom holds begins on or near the 24th of September each year (Paragi 2009 Personal Communication, Van Ballenberghe and Miquelle 1993, but see McNeeley 2009). The only allowance for *public* input in these dates is in the form of local advisory committees, which can submit proposals for changes, but these must also come in advance of the BoG meetings (ADF&G 2009a, p. 6), and therefore well in advance of any possible knowledge of the relevant seasonal conditions for that year. The system therefore leaves absolutely no room[3] for hunters or anyone else to adjust hunting activities in response to daily and weekly conditions as they unfold. Despite no clear conservation basis for not opening the season earlier (Paragi 2009 Personal Communication), days and weeks of ideal hunting weather and river conditions can pass by with hunters forced to stay home.

When the primary season finally opens, rural hunters report finding themselves in a race for moose despite conditions, and despite whether or not the moose are still fit for consumption. Many describe facing the difficult decision: 1) to hunt in season, risking travel across a potentially-unsafe landscape or waterway, when moose may not be available or appropriate for consumption 2) to break the law by hunting out of season when travel is safer and the moose harvest more viable (an option that rural people are not comfortable with); or 3) to not hunt at all, which necessarily implies a need to rely more heavily on store-bought foods that (if and when available and affordable) are imperfect nutritional and cultural substitutes.

4.5 FISHING VIABILITY IN THE BERING SEA AND ALEUTIAN ISLANDS REGION

As described in detail earlier, the BSAI is one of the world's most active and important fisheries regions. Fishing operations out of communities like Dutch Harbor range in size from the small family vessel (Alaska Native and non-Native) fishing for household and limited market use to large fleet vessels (100m+ in length) capable of freezing fish while out on the open water. Predicted changes in sea ice and changes in weather patterns will likely create a mix of new challenges for these fishers. Changes in the distribution of seasonal sea-ice cover, and changing

3 There are some limited-registration based hunts as well, where a small number of harvest tickets are given on a first-come first-serve basis, which allow hunting at other times, or for cow (female) moose. These registration events often cause much conflict and strain for the rural communities where they are held, however (Patrick Smith 2009 Personal Communication). They are held in rural areas under the pretense of making the tickets more available to rural residents (Tom Paragi 2009 personal communication), but nevertheless draw a significant influx of urban and non-native hunters who have the resources to camp overnight in order to stand in line (see also Loring 2007).

surface and subsurface water temperatures, for instance, can have dramatic influence on the location of desirable fish (Hannah et al. 2009, Mikol 1997). High storm and wave activity can cause mixing of fish sizes and species, decreasing the potential value of the catch and increasing bycatch/bycatch mortality, an extremely problematic phenomenon which brings international treaties and issues of sustainability into the regulatory mix (Alverson et al. 1994, Davis 2002, Mikol 1997). It remains unclear, however, whether a warming climate will increase storm activity, increase the intensity of storms, make storm activity more unpredictable, or all of the above (Atkinson 2005); no one interviewed could confirm a consistent change in storm frequency or intensity, but all agreed that weather conditions had become more unpredictable, and that their ability to rely on weather forecasts and information from other fishers was more important now than ever.

Many fishers also reported a general trend of pollock populations tracking further northward, with anecdotal reports of fishers having to travel past the Pribelof Islands, a range unprecedented at least since the mid 1980s if not longer. Like the hunters of the Interior, more time is being spent searching, which may not prove to be much of a problem for the largest commercial fishing operations with enough financial capital to absorb the new costs, but even a few more hours of searching can be particularly difficult for the smaller-scale fishing operations that can not afford the additional costs of fuel. The extra distance traveled also has an impact on the quality of fish such as pollock—both in the time it takes to get it back to the processing, and also whether or not fish are feeding sufficiently to be of favorable size. More time on the water also increases risk exposure in an area where storm waves can exceed the length of smaller fishing craft (~15m).

A tradeoff between personal safety and harvest success similar to the one now faced in the Interior has long-characterized the so-called “deadliest catch” lifestyle of the fishery’s participants. For years the shellfish and groundfish fisheries of the BSAI region were managed under what are called derby-style fishery

Table 4.2 Overview of Viability for Fishing in the Bering Sea. Note that there are many obvious similarities between the details presented in Tables 4.1 and 4.2, despite seeming like entirely different scenarios. Includes details from (Ginter 1995, McCay 1995, Woodby et al. 2005) as well as material provided by interviewees.

BSAI fishing and factors that influence viability	
Constraints	Factors of abundance and distribution, for example reproductive success, predation pressure by other predators and by-catch, as well as thermoklines and mixing due to storms.
Policies	Federal and International Treaties govern Total Allowable Catch (TAC), equipment used, and by-catch limits.
Contracts	Must be a participant in the established Limited Access Privilege (LAP) system.
Compatibility	Natural ecological variability requires a compatible harvest strategy of mobility and adaptability
Reachability	Must have access to landscape where resources are present and be available/capable of harvesting them • 8-9 months seasons create little practical limits to when fishing can be attempted • Practical fishing range remains limited by cost of fuel and range of boats, but can be enhanced by the financial capital available to large corporations. • Longer trips are also possible when 'tender' vessels are available for freeze-storing fish on open water • Access can be limited by extreme weather as well as by access to individual quotas, but this is mitigated by long-open seasons.
Awareness	• Must have local knowledge of fish movement and concentrations, which may or may not be shared. • Must also have knowledge for safe and favorable weather and ocean conditions, for instance access to quality forecasting. This presently can necessitate short trips to sites where weather conditions are considered an indicator for weather in the desired fishing location.
Willingness	• Must be willing to participate in a privatized management system, or to poach and accept the consequences if caught • Must be willing to accept risks of travel across open seas where there may be dangerous conditions

management regimes, with established time slots for open fishing (typically 24–48 hours at a time), during which participants would have to race to catch as many pounds as they could (ADF&G 2009b). This model frequently forced fishers to engage in unsafe fishing practices; as fishing openings were necessarily set in advance of accurate weather forecasting, fishermen were economically compelled to participate virtually regardless of conditions. "[The] system we had was murder," (Clem Tillion, quoted in ADF&G 2009b, p. 38), "you send all these little boats out to fish regardless of what kind of weather it would be." More recently, however, this has changed, and unlike the hunters of the Interior, who see the risk associated with their lifestyle increasing while returns decrease, coastal fishers report the opposite: they now enjoy much more flexibility in deciding when and where to fish, flexibility that makes their profession significantly safer and much less vulnerable to these potential impacts of climate change on storm and sea conditions.

This flexibility is made possible by Limited Access Privilege (LAP) approaches to fisheries management that is now common to the governance structures of a number of Alaska's commercial fish and shellfish populations, taking such forms as cooperatives and Individual Fishing Quotas (IFQs) and Community Development Quotas (CDQs) (Criddle and Macinko 2000, Holland and Ginter 2001). In 1995, both the Alaskan Halibut and North Pacific Sablefish fisheries were 'rationalized,' meaning LAP-type systems were implemented, followed by the BSAI crab populations in 2005 (NOAA 2008). In general this 'rationalization' means 'privatization', of access to fishing resources, whereby so-called 'open-access' fisheries become labeled 'private property' and governments take responsibility for setting and enforcing a variety of conditions over its use, such as an annual quota, gear restrictions, or seasonal openings. LAP systems usually begin with the identification of an annual Total Allowable Catch (TAC) that is divided into shares to be distributed to communities, harvesters and processors, often accompanied by some set of incentives for users to participate in cooperatives or to improve the efficiency of their operations in terms of by-catch and discards. Participants in the fishery, whether individuals, vessels, or entire communities, own or lease these shares, which prescribe (usually) how much fish can be harvested and/or what gear can be used (ibid). IFQs, for instance, as defined by the Magnuson-Stevens Fisheries Conservation and Management Act (MSFCMA) are limited access permits to harvest predetermined quantities of fish. IFQs represent a sort-of "quasi-privatization" of the fisheries (Criddle and Macinko 2000), in that permittees receive some of the attributes of private property, such as the privilege to decide when and how to use the quota shares. Reserved from the quota holders, however, are other 'rights' one might normally association with private property: including outright ownership and the ability to decide how much of the resource can be harvested in aggregate. These remain in the domain of state and federal governments, as does the responsibility to manage the fishery for outcomes of sustainability and the public trust (National Research Council 1999).

The benefits usually associated with rationalization methods like IFQs and cooperatives are: increased economic efficiency; improved conservation and stewardship; and improved safety (Criddle and Macinko 2000) though limited access systems also come with their own set of caveats that must be evaluated (which we discuss later). The most commonly reported benefit of LAPs during our interviews with people fishing the BSAI was improved safety. The dangerous 'race' effect caused by derby-style management has been nearly eliminated with fixed quotas that can be filled at any time during an extended fishing period—8 and a half months for sablefish, 9 months for halibut, for instance (NOAA 2008). In this way, authority and decision making has been more appropriately scaled: broad decisions regarding Total Allowable Catch (TAC) remain with governing bodies that have the resources to facilitate a decision making process that (ideally) incorporates all appropriate information and relevant stakeholders; hour-to-hour day-to-day, even month-to-month decisions, on the other hand, are left with the capable judgments of the fishers themselves.

Table 4.3 Comparison of Policy as a Determinant of Viability. Both user groups are willing to do what is necessary to make a living, whether that involves fishing in unsafe seas, hunting out of season, or eating less-desirable and less-healthful foods. Both groups encounter changing environmental conditions, but the hunters of the Interior lack the authority to effectively respond to those changes. The BSAI case shows, however, that when institutional capacity is used to provide quality information, and the resource users are trusted to use that information wisely and to act within the confines of their resource-use agreement, that the resource base can still be effectively secured.

Viability Factors	BSAI	Interior Alaska
Compatibility	An increase in ecological variability makes it even more important that users can adopt a harvest strategy of mobility and adaptability.	
Reachability	• 8-9 month fishing season creates broad opportunities to respond to weather and reports of distribution/abundance of fish • Must have a quota in this limited access system	• Short, fixed openings limit people's ability to legally adjust to variability in distribution and abundance • Anyone can hunt, but families can at best only afford one hunting trip
Awareness	• A wide variety of weather forecasts are available from state and federal institutions • Information about conditions is shared within fleets of the same corporate interest • Competing fishers less-likely to share information	• Traditional cues used to anticipate the weather, landscape conditions, and the movement of game are proving less reliable • Access to weather reports is often limited to local radio • Condition reports of the landscape are shared between hunters, but information gathering is limited by costs of travel • State and federal institutions are not necessarily aware of, or able to respond to changing daily and weekly conditions.
Willingness	• Fishing the BSAI is dangerous, but this has been effectively reduced by policy (reachability) • Could further be reduced by better information (awareness) regarding sea conditions, water temperatures, etc.	• Many face the difficult decision hunting out of season in order to provide food for their families • When cash is used to buy replacement foods from the store, these are less preferred, and often come at the expense of other needs, including heating fuel

4.6 DISCUSSION

In each of the two scenarios, users of the respective resources need to enter into particular contracts with the managing authorities, each of which are clearly situated within a set of policies that must be observed. In the BSAI, this contract involves the ownership of a quota within a limited-entry fishery. In the Interior, the formal contract is a hunting license obtained for what is essentially an unlimited-entry system (with the exception of a rural preference given on federally-managed lands). Holding the obvious differences aside for the moment, we can focus on the question of what circumstances allow for the positive experiences of viability in the BSAI and the negative experiences of viability in the Interior. This difference can be summed up in terms of whether policy situates authority such that people are enabled to make appropriate decisions in response to these day-to-day events, fostering adaptation and thus mitigating any cumulative effects of change, or if policy limits people in their adaptive response, even unintentionally. Table 4.3 summarizes these difference between the two cases.

As already discussed, climate change is impacting the coastal and interior systems in similar ways, with distribution and abundance of fish and game species impacted in ways that have been described by both groups as 'unprecedented' and 'highly variable.' These environmental changes are happening at broad spatial and temporal scales, affecting entire landscapes, watersheds, and ice sheets at multi-decadal (successional), annual, and seasonal time-frames (Figure 4.2). The hunter and fisher, however, experience the 'down-scale' impacts of these changes on the landscape and seascape at weekly and even daily time-frames. Traditional approaches to policy-making and regulation, which these people rely upon to help them adapt to these new ecological circumstances, operate at yet a *third* set of spatial and temporal scales, characterized by management-units and park boundaries, state, national, and international jurisdictions, and by the timelines of legislative sessions, election cycles, and fiscal years (Biermann and Dingwerth 2004, Brock and Carpenter 2007, Huntington 1992). These policy regimes, such as the Board of Game procedures described in Section 3 above, tend to be limited by a decision-making process that can take months, if not years, to complete. Too, they tend to deal only reactively with environmental change and surprise, operating from the perspective of outcomes mitigation (e.g., last-minute "emergency" amendments to hunting and fishing regulations).

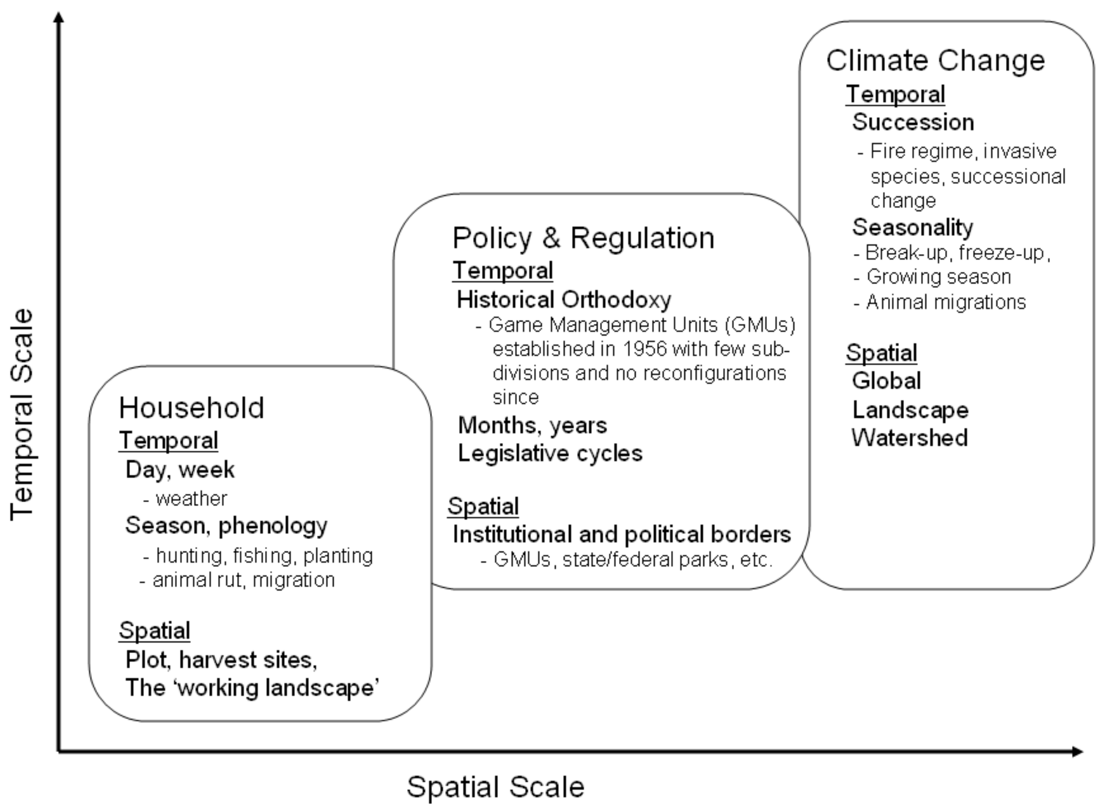

Figure 4.2. Three Sets of Very Different Spatial and Temporal Scales. Examples of the fundamental differences between environmental change, the household experience, and policy-making, for Interior Alaska.

As we show in the case of Dutch Harbor, however, it is quite possible to accommodate the challenges of climate change with a co-management policy paradigm that situates an appropriate amount of authority and responsibility with the resource users themselves. That is not to say that local control is simply 'better', but that it is possible to identify and delegate appropriate roles to co-management participants that are best suited to their respective competencies. In the case of the rationalized fishery, for example, BSAI fishers are entrusted with the authority to make ad-hoc resource decisions within day-to-day and week-to-week timeframes, in response to the so-called 'fast' variables of environmental change (Chapin III et al. 2002). 'Slower' matters, such as securing the integrity of the resource-base at large via the enforcement of international treaties, and for providing quality institutional support and facilitation to resource users, are reserved for the weight of broader institutional mandates and capacities (Berkes 2005).

It is not uncommon to see in the sustainability science literature recommendations for policies that support the kind of flexibility and adaptability that we have observed in the BSAI fishery (Adger et al. 2005, Chapin III et al. 2006, Eriksen and Kelly 2007, Ford 2008, Nelson et al. 2007). However, practical examples of how to operationalize co-management to foster this local adaptive capacity while also securing broad conservation goals remain rare, with Alaska's ground-fish fisheries offering some important exceptions. From our comparison, we have identified four areas for experimentation and further study, in order to better understand and design the roles and relationships for co-management. These are 1) regulatory style and goals, with a focus on an ecosystem approach; 3) improved forecasting and indicators; 3) a model for local participation based on engagement with local expertise rather than the collection of local knowledge; and 4) the issue of privatization.

4.6.1 Regulatory Style and Goals

Many question the paradigmatic differences between environmental challenges such as those posed by climate change, and the 'goodness of fit' of the traditional operational style of state-based resource governance (Biermann and Dingwerth 2004, Karkkainen 2004, Ommer 2007, Young 2002). It is clear, for instance, that moose do not herd or group themselves in an orderly and consistent way that corresponds to the checkerboard pattern of Alaska's parks, preserves, and Game Management Units (GMUs), so the potential for the latter to enable effective state-wide conservation goals must be considered. That is not to say that spatial organizational constructs like GMUs are not important, useful, and in many cases appropriate, just simply that there may be a need to find new spatial and temporal benchmarks for managing these ecosystems that are *more* appropriate, and conducive to local responses to changing conditions.

The ability to respond to natural variation, to build not only redundancy but flexibility and alternatives into harvest strategies is part and parcel to healthful outcomes, whether the measure is resilience, sustainability, or self-reliance (Loring and Gerlach in press, Rappaport 1968, Binford 2002, Robards and Alessa 2004). Managing for single ecological variables such as the increased efficiency and/or stability of a particular fish or game population, though valid and appreciable as conservation goals, will not necessarily serve to enhance resilience or reduce vulnerability of ecosystems and the communities who rely on them, especially if those management measures prove to reduce overall flexibility of actors in the system (Brinkman et al. 2007, Wilson 2006). People need the ability to adjust not just where and when, but *what* they harvest, and this speaks to a need for a more holistic and varied management approach. In the case of Interior Alaska, for example, shortages in the harvest of one species (e.g., moose) are traditionally mitigated through increased harvests of other resources (e.g., salmon). To not anticipate and manage for increased reliance on salmon during times when moose are scarce, for instance, is to ignore the basic functioning of the system. Institutionalizing such ecosystem-based management approaches, with adaptive seasons and take-limits, however, could be quite difficult to achieve with regulatory structures as currently organized around more narrow goals for the maintenance/conservation of individual species.

Management agencies are nevertheless in the best position and have the necessary resources to handle ecosystem-scale management, they simply need to consider new ways to blend their jurisdictions and mandates across the traditionally-secularized worlds of conservation, commerce, and subsistence management, in ways that mimic the variability in natural systems and facilitate multi-resource adaptation and response (Savory 1988, Sayre 2006). In some cases, it may be possible to merely "bridge" the differences between local environmental variability, community needs, and broad-scale management goals (e.g., Shultz 2009), but given the "wicked" nature of these global environmental trends (Chapin III et al. 2008), an equally paradigm-changing, perhaps at times ad-hoc approach to management might be necessary.

4.6.2 Seasonal Wildlife and Weather Forecasts and Indicators

Management regimes employ a wide variety of monitoring and forecasting techniques to meet their goals, although many are arguably tailored to the so-called 'single-species' approach mentioned above. Most common in the Interior, for instance, are observational monitoring of regional populations and population densities and post-hoc harvest reports (e.g., Brown et al. 2004). These continue to provide high-quality quantitative data, but alternatives may exist that provide a more complete indication of ecosystem health,indicators that can continue to serve overall conservation interests and mandates while also providing invaluable additional information and support to the users. Both conservation and safety concerns call for new, higher-quality weather and storm forecasting, with new 'products' designed with accessibility and ease-of-use in mind. People on the coast as well as the Interior stress their need for improved forecasting in several domains: weather, seascape conditions such as surface currents and subsurface water temperature, sea and river ice conditions, and forecasted timing of seasonal changes like break-up and freeze-up. Improvements and innovations in these and other 'pre-season' forecasting products could go far for the end-user when making decisions about where and when to hunt or fish (Criddle 1996). Many fishers in the BSAI, for example, now need to make day-long trips just to check the weather at particular 'indicator' locations that they have learned will reveal something about fishing conditions elsewhere. And in the Interior, regional weekly forecasting in a similar vein could support both increased harvest success in the short term and also longer-term knowledge of the future of Alaska's terrestrial ecosystems.

Hunters and fishers may also be able to help in this regard; managers in Alaska currently deal with a significant amount of uncertainty regarding the impacts of changing environmental conditions on moose, salmon, and other managed species (McNeeley 2009, National Research Council 2004, John Lindermann Personal Communication). Moose hunters in Norway have been shown to have great capacity for monitoring moose populations and for incorporating this information into effective, conservation *and* subsistence-minded resource management decisions (Solberg and Saether 1999). Experienced Alaska Native and other moose hunters in Alaska are no less well informed, no less keen, nor are they less environmentally aware than are other high latitude moose and caribou hunters. Initiatives for the development of these indicators and forecast tools might also represent a fine starting-point for innovative new collaboratory arrangements between user groups and managing agencies.

4.6.3 Participation of Local Experts

This leads to the third recommendation that emerges from our analysis. As shown in the cases described above, and in numerous other case-studies from elsewhere in the world (e.g., Cinner and Aswani 2007, Haggan et al. 2007, Orlove et al. 2009), local resource users often have significant advantages over management agencies when it comes to identifying and responding to local, daily- and weekly-scaled impacts of environmental change. Recently, however, some have questioned the capacity of local knowledge and institutions, particularly in regards to the appropriateness of scale, for dealing with contemporary environmental challenges (Sutherland et al. 2004, Wohling 2009). Skepticism is appreciable insofar as scientific rigor is valued, but such skepticism can also be driven by cognitive misunderstandings that result from an approach to collaboration where local peoples are treated as repositories of data, not as expert collaborators themselves[4] (Durie 2004, Huntington 2000, Kawagley 1995).

Co-management arrangements that treat local resource users as experts, beginning with trust and assumptions of validity and then moving toward an understanding of how knowledges and competencies can reinforce and complement one another, can provide a powerful basis for collaboration. No co-management arrangement, however well designed, will lead to successful outcomes if the participants feel that there is no legitimacy to the role they play (Turner et al. 2008). In the BSAI, for instance, numerous fishers noted that the new management system "allowed them be fishermen, not just deck-hands." Presently, however, many hunters of the Interior describe feeling almost entirely irrelevant to the state management regime, trying to participate through the venues provided them by ADF&G and the BoG, but never capable of affecting any significant change through that participation. Meanwhile, local people continue to contribute what they can; unofficial, locally-initiated attempts to contribute to the stewardship of moose populations, such as an ongoing bear-hunting derby in Fort Yukon designed to reduce predation pressure, continue with apparent, but unevaluated and

4 See also Chapter 6 in this volume for a more complete discussion.

unacknowledged success.

4.6.4 The Issue of Privatization

The final point is less related to the design of co-management roles and more an area for caution; though we have identified evidence of benefits with the LAP approach as implemented in the BSAI, the recommendations here should not be taken as an endorsement of LAP approaches to fisheries management, by either the authors or by those interviewed. LAPs represent an unprecedented privatization of otherwise open-access resource, a change that carries a number of widely-acknowledged and debated caveats, for social equity, justice, and environmental stewardship to name but three (see e.g., Anderson 1995, McCay 1995, Mansfield 2007). Fishers today may indeed experience a greater degree of safety in their livelihoods, but a number of other impacts to Dutch Harbor and Alaska's many fishing households and communities have been experienced, the merits of which are debatable. Alvin Osterback, Director of the Port of Dutch Harbor, suggests that the real change worth talking about since the rationalization is the economic decline that is still ongoing. "There used to be around 270 boats out on the water," he said "and now we're down to 50, many of which operate out of Seattle rather than here." Many fishing operations consolidated as a direct result of implementing IFQ and cooperative systems in Alaska (Criddle and Macinko 2000), often down to one vessel from many, with some even selling their quotas outright to another operation. This consolidation has created both winners and losers, and had its effect on local fishing culture: "It used to be that every year we had a ceremonious 'blessing of the fleet' that was a big 'to-do' down by the docks," adds Harbormaster John Days, "last year we said a few brief words in the [Harbormaster's] office." Some residents also report important and long-term area businesses like suppliers, welders, and restaurants closing down. Even the Alaska Commercial Company, Alaska's largest chain of rural grocery and merchandise stores, closed their Dutch

Harbor store in 2009 after operating there for 50 years. “We used to be a thriving community, now we’re just a company town with UniSea owning everything and the only ones making any money,” said one fisher who wished to remain anonymous, “at first it seemed like the changes were good for everyone but now restaurants, stores, bars and hotels have closed and what’s left is loosing its lacquer quick.” Similar signs of change and economic strain show across the western Alaskan coast. Many rural ‘subsistence’ communities, for instance, were at first significantly marginalized by the fishery rationalization, and the CDQ ‘fix’ deployed to a handful of rural coastal communities since has brought its mix of conflicts and benefits to say the least (Mansfield 2007).

The National Research Council found that the many long-term implications of rationalization have yet to be realized and understood, despite the initial indicators of success and cheerleading from agencies such as the National Marine Fisheries Service (National Research Council 1999). We concur with their findings, and in our opinion much more open discussion must be had amongst all groups of stakeholders before rationalization is suggested for any other system, terrestrial or otherwise. Any dramatic policy measures must be met with a cautionary eye towards vulnerability and resilience to climate-change-related stressors like those already being experienced by Alaska's coastal region. Based on our anecdotal observations, though the LAP approach as currently implemented in the BSAI seems to decrease vulnerability and increase resilience at the scale of the fisherman or vessel, it nevertheless may *increase* vulnerability and *reduce* resilience at the community and regional scale.

We recommend that alternative paths be imagined that maintain the benefits of the LAP approach, while eliminating the need to accomplish this through such a dramatic privatization of the resource. Fisheries trusts such as those currently being experimented with in Alaska and New England (e.g., CCCHFA 2009) where non-profit organizations consolidate quotas to create a quasi-commons for participating fishermen, may be a step in this direction and are worth additional research.

4.7 CONCLUSION

The goal of adaptive co-management is the implementation of effective resource governance strategies that meet community needs as well as broader conservation and sustainability goals. If a premise this approach is indeed ‘learning by doing’, then it stands to reason that Alaska, a place experiencing some of the most pronounced climate-induced environmental changes in the world, is an ideal stage for careful, reflexive attention to what aspects of policy and regulation work, and what do not. Cross-regional comparisons, such as the one reported on here, are a crucial move forward in this regard: the Services Oriented Architecture allowed us to focus in on the drivers and determinants of path dependence in two largely-disparate systems, and to take away meaningful guidance on how policy structure can make community-reliance on ecosystem services more adaptable in the face of change. And given that the North has been identified as an important bell-weather of climate change impacts for the rest of the world (IPCC 2007), the lessons learned here have obvious portability to similar climate-change-related issues of resource governance and environmental justice worldwide.

Adaptability as design principle for environmental policy is broadly discussed (Chapin III et al. 2006, Nelson et al. 2007, Ford 2008, Ford et al. 2010) but often only in the most general terms; here we have contributed to this discussion by identifying specific roles for participants in co-management that make the most of their respective competencies, and are scaled appropriate to the spatial and temporal dynamics of environmental change. The current management paradigm of Interior Alaska, and the old paradigm of the BSAI, formally acknowledge little-to-no ability for stewardship with the users themselves, and therefore leave bureaucrats to deal with issues that their bureaucracies are simply just not situated to handle.

But local resource users have repeatedly proved that they do have the capacity, intelligence, expertise, and ethic to make a great many of these down-scale harvest decisions themselves, and to know when consultation with agency biologists and other outside experts is necessary. Only where policy-makers embrace people's strengths and knowledge in this regard, and treat them as legitimate local experts, will the kind of dramatic adaptation be possible that so many agree is crucial to meeting short-term needs as well as influencing climate trajectories in the long term.

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CHAPTER 5

ARE WE ASKING TOO MUCH OF THE YUKON RIVER?[1]

5.1 ABSTRACT

By the terms set by international treaty for the conservation of Yukon River salmon, 2009 was a management success. It was a particularly devastating year for the rural communities along the Yukon River in Alaska, however; for many reasons, including annual variability in chinook and chum salmon runs, difficulties in monitoring, and imperfect information, the smokehouses and freezers of many Alaska Native families were left empty, and Alaska's Governor Sean Parnell petitioned the US Federal Government to declare a fisheries disaster. This paper reviews the social and ecological dimensions of salmon management in 2009 in an attempt to reconcile these differing views regarding management success, and the apparently-competing goals of salmon conservation and food security. We show how a breakdown in observation and understanding of the Yukon system undermines effective adaptive management. We also show how sector-based, species-by-species management approaches contribute to the differential distribution of impacts for communities down and up river. Unknowns and research needs are highlighted, and we show where these create opportunities for collaboration between management authorities and local communities.

5.2 INTRODUCTION

The Yukon River is a cultural, spiritual, economic, and ecological backbone for many communities in Alaska and Northern Canada. Along its 3,200-kilometer journey from British Columbia and through Yukon Territories and Alaska to the

1 Loring, P.A., and S.C. Gerlach. In Preparation. Are We Asking Too Much of the Yukon River? *Conservation Biology.*

Bering Sea (Figure 5.1), the Yukon and its tributaries and distributaries support numerous lowland boreal forest and tundra ecosystems, as well as 50 rural and urban communities. At the center of the intimate and complex relationship between this river and its people are salmon—chinook (a.k.a. king) salmon (*Oncorhynchus tshawytscha*), chum (a.k.a. dog) salmon (*Oncorhynchus keta*), and coho (*Oncorhynchus kisutch*) salmon—which support important subsistence and commercial fisheries in both the US and Canada. As with the salmon elsewhere in Alaska and the Pacific Northwest, these salmon are not just important economically but are also important cultural icons, and the stewardship of these salmon runs is a matter that evokes broad public emotion and mobilizes significant political will.

Figure 5.1 The Yukon River Basin. Map courtesy of the US Geological Survey.

Management of Yukon River salmon is also a matter that, as of late, has attracted a significant amount of debate and visibility within state, national, and international politics and medias. In 2009, the Alaska Department of Fish and Game (ADF&G) enacted numerous subsistence and commercial fishing closures on the river, based on a perception that minimum conservation goals for the run were in danger of not being met. Ultimately, these internationally-agreed-upon goals were not only met but exceeded, and the year was considered by many to be a management success. However, the lack of commercial and reduced subsistence fisheries proved disastrous for many communities along the river, with smokehouses uncharacteristically empty and families left coping with little prospect for food security for the coming winter. The impacts of not having a commercial chinook salmon fishery were considered so severe that Alaska Governor Sean Parnell petitioned the federal government to declare a fisheries disaster for the region. In a context of a changing climate and rising food and fuel prices, the cumulative, long-term effects of these closures on Alaska's rural communities likely have yet to be realized.

Is it possible to reconcile the perceptions of management success on the one hand with perceptions of disaster and the realities of food insecurity on the other? This paper looks to these two, seemingly incongruous perceptions of the Yukon system as an opportunity for learning. We use the 2009 case to explore the complex interplay between what appear to be competing goals of food security and natural resource conservation. We focus primarily on chinook management, though link this through a discussion of impacts to the management of other fish and terrestrial species as well. Policymakers have arguably gone to great lengths to reconcile competing 'uses' of Yukon River salmon—commercial and subsistence as well as conservation goals—but while managers continue to strive to be adaptive in their approach to balancing management mandates with the needs of the communities along the river, the cost of this adaptive process may be too high, both for the Yukon

River Basin ecosystems and for the people who live there. As we show below, the cumulative impacts of management decisions and enforcement are not always immediate or straightforward, but rather are synergistic, temporally and spatially scaled, and have numerous direct and indirect impacts on rural livelihoods, community health and well-being, and sustainability. Is it too much to ask of the Yukon River to sustainably support both commercial and subsistence fisheries down-river, up-river, for the US as well as Canada? Or, is it perhaps too much to ask of regulatory agencies and managers, who must make precise in-season predictions in what is an inordinately complex and constantly changing system? We tease apart the various management mandates, challenges, and approaches in order to find answers to these questions. The insights we draw, though regionally-scaled, have great importance for how we define and address conservation, sustainability, and food security goals at pan-Arctic as well as global scales.

5.3 METHODS

Our research involved an extensive set of one-on-one interviews with a variety of different participants in the Yukon River salmon fisheries. Semi-structured interviews were conducted in the fall of 2009 with state and federal agency representatives, including ADF&G Commercial Fisheries and Subsistence divisions, and the Yukon River Drainage Fisheries Association, and with representatives of the non-governmental organizations Pacific Environment and The Council of Athabascan Tribal Governments. Residents of several rural Alaskan communities were also interviewed, by phone with residents of Marshall and Emmonak (both at the mouth of the Yukon), and in person in communities up-river, including Beaver, Tanana, Chalkyitsik, and Fort Yukon. Interviewees, who ranged in age from 40 to 90 years, were selected based on previous acquaintance and by recommendation from community and tribal leaders for their familiarity with the Yukon system. In Fort Yukon, Loring and Gerlach also engaged local input via a call-in radio show broadcast to the many communities of the Yukon Flats region (Figure 5.3).

5.4 THE YUKON RIVER

The Yukon River basin is arguably the defining geographic and ecological feature of northwest North America, covering the vast majority of Yukon Territory in Canada, as well as an enormous band of land across the middle of Alaska (Figure 5.1). The name 'Yukon' means great river in the language of the Gwich'in Athabascan peoples who have lived along the river for millennia. The river's drainage is over 850,000 km^2, and includes dozens of tributaries and distributaries, including the Porcupine, the Tanana, the and the Chandalar (Yukon River Panel 2005). Generally considered to start just south of Whitehorse, Canada, the Yukon passes directly through numerous urban and rural communities (Figure 5.2) including Whitehorse and Dawson City in the Yukon Territory, and many remote rural communities in Alaska. The Yukon River Drainage's confluence with the drainage of the Tanana River in Interior Alaska creates a rich and productive riparian lowland habitat that supports several rural communities as well as Fairbanks, the state's second-largest urban center. Further down river, after the small villages of Pilot Station and Mountain Village, the main channel of the Yukon frays into a delta that converges with the delta of the Kuskokwim River to the south, this confluence creating another rich cultural and ecological landscape that supports numerous remote communities scattered throughout the Yukon-Kuskokwim, or 'Y-K' Delta.

The Yukon River has several features that make it stand out from other large, salmon-bearing rivers in the Pacific Northwest (e.g., the Fraser River in British Columbia). Most notably is the importance of the river to the subsistence food system in Alaska. Alaskans rely heavily on the river for subsistence purposes; for millennia, Alaska Natives have made seasonal homes along the Yukon River and relied on it for food, water, and transportation (Mishler and Simeone 2004, Nelson 1986, Raboff 2001). Today over 90% of residents in Alaska's rural communities continue to rely heavily on wild fish (primarily salmon, but also including northern pike, various species of whitefish, and halibut on the coast) (Wolfe 2004); many also rely on the moose, caribou, waterfowl, and miscellaneous small-game that call the ecosystems of the Yukon River Basin home. A small but important commercial salmon fishery has also established on the Yukon, mostly in the communities of the Y-K Delta, where the money made on the commercial salmon catch often represents a fisher's entire annual salary (Goldsmith 2008). Table 5.1 provides a summary of the Yukon River fisheries in Alaska and Canada.

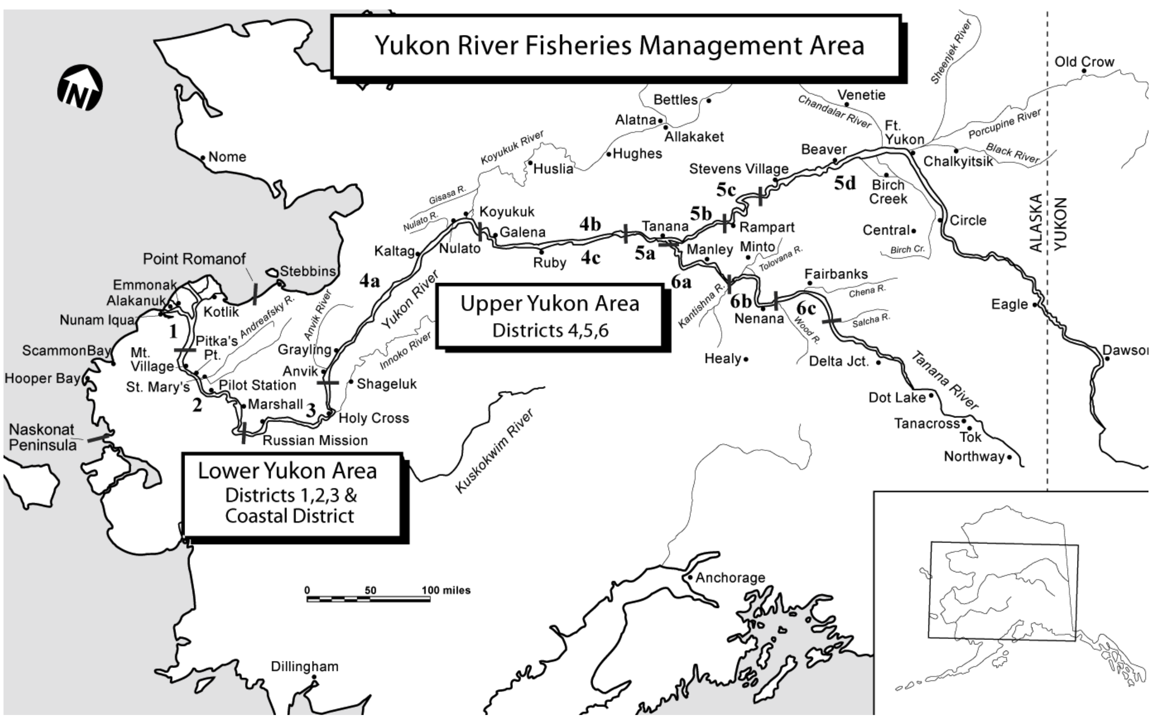

Figure 5.2 Management Areas and Communities of the Yukon. Map from (ADF&G 2004)

5.4.1 Yukon River Salmon

Yukon River salmon include an annual run of chinook, a summer and fall chum (almost all chum in the Canadian portion of the drainage are fall chum), and a smaller but important coho run. Salmon are an anadromous fish species, which describes a life-cycle whereby the fish hatch and rear in freshwater (1-2 years), spend a portion of their lives maturing the ocean (3+ years), and finally return to fresh water to spawn and die (National Research Council 1996). This complex life-cycle introduces numerous points of vulnerability, whether to disruptions to riverine habitat (e.g., dams) or predation or any possible mortality while at sea (National Research Council 1996). Trawling by-catch from the Bering Sea pollock fishery is one notorious example of at-sea mortality for Yukon salmon that we will discuss in more detail later. Salmon are highly adapted to these various vulnerabilities, however (National Research Council 1996); each fish produces hundreds of eggs when they spawn, resulting in far more juvenile progeny than necessary to replace the parentage population. There is also little development along the Yukon to speak of, and the absence of dams make it the longest free-flowing river in North America; together with the hundreds of streams that peel off the Yukon along its long and meandering course, the river is an exceptionally productive, albeit inordinately complex salmon habitat (National Research Council 2004).

Table 5.1 Summary of Yukon River Salmon Fisheries. Average number of fish harvested, 2002-2004. Data from (ADF&G 2008). Note that the designation in Canada's fisheries management is 'aboriginal', whereas in Alaska, 'subsistence' does not refer only to Alaska Native users.

		Chinook	Summer Chum	Fall Chum	Coho
US	Subsistence	50,468	70,079	46,127	19,851
	Commercial	40,239	18,884	5,035	15,158
CAN	Aboriginal	6,581	n/a	2,405	0
	Commercial	2,388	n/a	6,487	7

As a food item salmon are highly valued throughout the region, socially, culturally, and economically (Nabhan 2006, Woody et al. 2003). They are important as a 'keystone' species for several indigenous peoples throughout Northwest North

America, and in Alaska, are the major source of protein for people and sled dogs in rural communities for much of the year (Dunlap 2007, Wolfe 2000). Nutritionally, they are also rich in important omega-3 fatty acids, which researchers are showing play numerous important roles in local diets (Ebbesson et al. 2005, Ginsberg and Toal 2009, Mohatt et al. 2007). On the market, these wild fish fetch a high price as a regionally-branded, luxury food item that is high in nutrition and widely perceived to be sustainably-managed (Knapp et al. 2005). Salmon byproducts are also part of a growing market in nutritional supplements (e.g., fish oil) and pet products (ibid).

5.4.2 Biophysical Challenges and Impacts of Climatic Change

The ecosystems of Alaska are experiencing some of the pronounced impacts of climate change on Earth, and in this the Yukon River Basin is no exception (Chapin III et al. 2006, McBean 2005, Whitfield 2003). In high latitudes, lakes, rivers, and wetlands are not connected with groundwater in the same way that they are in temperate regions, as permafrost—a solid layer of earth beneath the top layers of soil that remains frozen year-round—can reach downward 10-20 meters in Interior Alaska and Yukon. With climate change this permafrost is thawing, however (Hinzman et al. 2005), and together with abrupt events like storms, flooding, and coastal erosion, the hydrology of the Yukon River Basin and Delta are being transformed (ACIA 2005, Chapin III et al. 2006, Jones et al. 2005). Locals and researchers have both reported changes such as the gradual drying of wetlands, dramatic permafrost-thaw landslides (Crosby 2008, Hander et al. 2008), and in some cases the rapid disappearance of entire lakes high in subsistence value.

Other ongoing changes to the Yukon and its tributaries include rising water temperatures as well as a longer ice-free period (Hunt et al. 2008, Juday 2007, Mills et al. 2008). It remains unclear as to what the impacts on salmon of warmer water temperatures will be; however, as individual salmon runs are often highly adapted to their particular ecological and climatological conditions, numerous possible negative impacts have been hypothesized (Bryant 2009). One possibility is that warmer spawning and incubation waters will prompt young fish to migrate to the ocean too early, when marine food resources are still low (ibid). Rising water temperatures are also a potential driver for increases in the prevalence of salmon parasites such as *Henneguya salminicola (Marcogliese 2001)*. River ice dynamics are also changing; the Yukon also freezes seasonally, which is an important feature both for the people who travel along the river in winter, as well as for understanding the year-to-year changes to the river and riverbed that erosion from the often-dramatic spring break-ups can cause (National Research Council 2004, White et al. 2007). In the ocean, climatic changes are also anticipated to impact salmon runs in unpredictable ways, including possible inundation of low-level spawning areas by storm surges and rising sea-levels (Bryant 2009). Possible increases in the severity or frequency of storms can also drive the mixing of ocean salmon with pollock and other fish, potentially adding to the problem of by-catch. Despite any uncertainty about these possible impacts, there is consensus that stewardship plans for Yukon River salmon can no longer afford to hold ecological conditions constant (Fleener and Thomas 2003, National Research Council 2004).

5.5 THE PACIFIC SALMON TREATY AND THE YUKON RIVER SALMON AGREEMENT

The Yukon River salmon fisheries fall within the international jurisdiction of the Pacific Salmon Treaty (PST) signed by the US and Canada in 1985. The PST was drafted to address questions of fairness in the interception of salmon originating in one nation by the fisheries of the other nation. The PST, which covers salmon stocks in Alaska as well as in Idaho, Washington, Oregon, Yukon Territory and British Columbia, officially recognizes the dilemma that that many salmon returning to the U.S. Pacific Northwest are harvested in Canadian fisheries, and that likewise, a substantial number of Canadian-origin salmon are intercepted in US fisheries. As both countries derive benefits from these shared salmon resources, finding a way to share these harvests fairly was considered an opportunity to promote sustainable management of both the salmon and their habitat (Yukon River Panel 2005). When signed, the PST was a widely-lauded political and conservation accomplishment in an era of public agitation over dams and other river development and several near-collapses of salmon populations (ibid., National Research Council 1996).

The primary mandate of the PST is conservation, via both the elimination of overfishing as well as the restoration of degraded salmon populations (Pacific Salmon Treaty 1985). The PST set limits to the number of salmon that can be harvested in each fishery, taking into account existing data on annual variations in abundance of salmon stocks and the desire to reduce interceptions and avoid undue disruption to existing fisheries. Most of the stipulations of the PST deal with ocean fisheries intercepting salmon hundreds of miles from their river of origin; trans-boundary river scenarios like the Yukon are noted, but the PST does not, however, specifically address Yukon River stocks other than in the creation of a Joint Technical Committee (JTC) directed to compile information on the fishery and oversee salmon research needs (Yukon River Panel 2005).

The establishment of a permanent, codified agreement for the Yukon came in 2001, following a devastatingly poor chinook run in 2000. The Yukon River Salmon Agreement (YRA) establishes an international commitment to conservation, restoration, and sustainable harvest of Yukon salmon. Both countries agreed to manage their salmon fisheries to ensure enough spawning salmon are available to meet minimum sustainable escapement (MSE) requirements and to provide for harvests, when possible, according to the harvest sharing arrangements. Escapement is the term for the portion of the returning salmon run that avoids harvest (escapes) and thus assumedly reaches spawning grounds. The MSE is thus the minimum number of spawners thought necessary to maintain the population.

Some guidelines for setting the MSE are laid out in the YRA[14], but specific goals are determined by the JTC through an adaptive management process, refined each year based in-season monitoring and historical data for escapement and recruitment (those fish that return to spawn from a particular parentage year, or that year's 'reproductive potential') (J. Hilsinger pers. comm. 2009). Both countries share the obligation to meet these annually-set minimum escapement objectives. Ideally, however, escapement objectives are set to not just maintain a viable salmon population but also to maximize for a surplus of recruits above MSE, thus allowing sustainable harvests by subsistence and commercial fisheries in the US and Canada (Figure 5.3). As explained earlier, spawning salmon produce significantly more progeny than necessary for simple replacement, and this creates a sustainable harvest opportunity if recruitment can be maximized. Under the agreement conservation remains the first priority, however, and both countries have agreed to limit or even close fisheries outright to protect spawning escapement in years of low runs. It is also important to note that guidelines for setting Canadian escapement goals are based on estimates that 50% of Yukon River salmon are bound for spawning grounds in Canada (Yukon River Panel 2005).

With populations of Yukon River salmon at distressing lows when the YRA was established, the agreement also addresses the need to rebuild Canadian-origin stocks back to 'historical' levels. When actual escapements fall below spawning escapement objectives set in the YRA, the JTC can recommend a rebuilding program to be implemented by both countries. However, artificial propagation (i.e., hatcheries) is not allowed by the agreement as a substitute for effective fishery regulation, and as such no hatcheries have to date been implemented on the Yukon for restoration or enhancement purposes. Rather, management actions for restoration purposes have focused on maximizing escapement via fisheries

14 Escapement objectives for salmon that spawn in the main-stem Yukon River in Canada must be be greater than 80,000 chum salmon and 33,000 to 43,000 Chinook salmon. The Escapement objective for chum salmon within the Porcupine River in Canada must be between 50,000 and 120,000 chum salmon upstream of the Fishing Branch River weir site.

closures, and more recently, changes to allowed fishing technologies (i.e. nets) in order to allow the largest (and therefore most productive) spawners through.

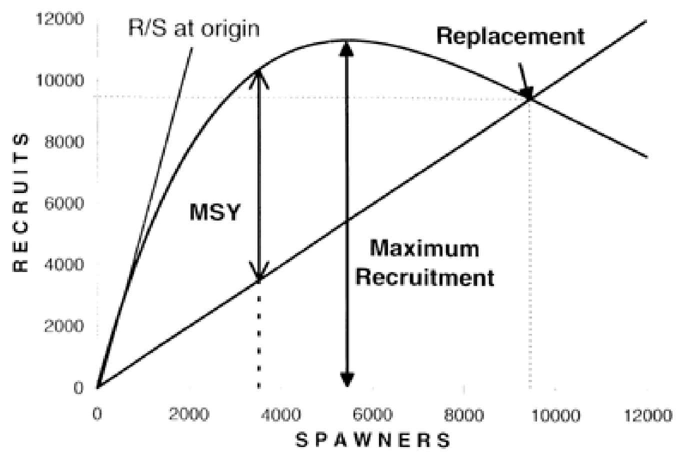

Figure 5.3 The Ricker Curve. Displays a hypothesized relationship between the number of spawners and the recruits from that parentage. Recruits represent the reproductive potential of returning adults. The curve illustrates the surplus production of salmon, where more than sufficient progeny are produced to replace parentage. This creates a maximum sustainable yield that ideally can be managed for in addition to minimum conservation escapement goals. Redrawn from (NRC 1996).

5.5.1 In-season Adaptive Management

In Alaska, ADF&G are in the difficult position of having to meet not only the primary mandate of conservation but also having to attend to the hugely important subsistence and commercial fisheries each year. Each year projections and management plans for salmon are made pre-season, but these must often be revised through in-season actions. In-season decisions regarding how to structure fishing windows, through emergency subsistence closures and commercial openings[14], need to be made for a management area before the fish have passed that part of the river; managers use both adaptive projections and models for the strength and timing of salmon runs as well as in-season monitoring in order to make these decisions. The primary monitoring locations including Pilot Station

14 By default, subsistence fishing is open on the river, and is closed by 'emergency' order; commercial fisheries are by default closed, and must likewise be opened.

(sonar) at the mouth of the river for assessing run strength, various test fishery to gauge abundance, and finally another sonar station at Eagle just before the Canadian border (J. Linderman pers. comm. 2010). 'Trigger points' are identified that when reached prompt actions (i.e., closures on subsistence fisheries or openings for commercial fisheries) in the various Yukon River management areas.

The difficulties inherent to this approach are many. The Yukon is a turbid river, which makes fish counting particularly problematic. The great length of the Yukon also means that there are many opportunities for mortality between Pilot Station and Eagle; too, the it means that results from actions taken down-river may not be realized for up to a month. If returns appear to start strong but then taper down quickly, for instance, there is a chance that the harvest allowed down-river may be in excess of the number actually available above MSE. As fishing openings and closures are scheduled using projections regarding run timing, there are also chances for openings to be misaligned with when the salmon actually pass by the waiting communities (J. Linderman pers. comm. 2010). As we discuss later, the significant political and public pressure that is on ADF&G to meet these multiple goals creates a situation where in bad years, the impacts of closures are differentially distributed between rural communities, with impacts tending to be felt most by the Alaskan communities furthest up-river. We discuss these issues in specific respect to the events of and leading up to 2009 in the sections below.

5.6 RECENT MANAGEMENT HISTORY AND THE 2009 'DISASTER'

As mentioned earlier, the Yukon experienced three very poor chinook runs beginning in 1998. Together these were a mobilizing event, because up to that point the chinook runs on the river had been relatively stable (J. Hilsinger pers. comm. 2009). In 2001, ADF&G responded by significantly limiting commercial harvest openings, and implementing closures to shorten subsistence fishing windows from 7 days to 24-48 hours. There were a number of years following these changes, 2001-06, where runs, though not as big as seen in the 1980s or 1990s, met both MSE and subsistence needs (Figure 5.4). Poor runs resumed in 2007, however, and a particular concern was raised regarding the health of the Canadian stock; whereas Canadian spawners were considered to contribute roughly 50% of the Yukon chinook run, genetic testing showed the Canadian contribution had fallen as low as 35-37% (J. Linderman pers. comm. 2009). In 2007 and 2008 MSE were not met, though both subsistence and commercial fisheries were allowed in 2007; in 2008, ADF&G managers tried to accommodate the 2007 data and this new concern for Canadian stocks through complete closures of the commercial fishery, but MSE was still not achieved.

Thus, there were significant pressures in 2009 for ADF&G to turn chinook management around. By the terms set out in the PST and YRA, management of chinook salmon in 2009 was indeed a great success[15]. The MSE target was 48,000 fish, and preliminary numbers show total escapement in the neighborhood of 70,000 fish (YRDFA 2009), a huge improvement over the especially poor escapement the year prior, and making 2009 the first year since 2005 to meet the MSE goal. The 2009 escapement was also possibly the highest escapement on record. The secondary goal of the YRA, equitable harvest sharing between the US and Canada, was also met in 2009, with harvest openings occurring for both countries and total catches falling near a 75%-25% US-CAN split (YRDFA 2009).

5.6.1 Conservation Success, Food Security Disaster

The majority of residents of rural Alaska, however, considered the 2009 chinook run to be both an environmental and economic disaster. After initially

15 It is worth mentioning that management actions taken in 2007 and 2008 cannot be attributed to what ultimately proved to be a strong 2009 return. The chinook life-cycle is on average 6 years, which means the dominant parentage for 2009 came from fish that spawned in 2003, a year when MSE was exceeded and there were relatively large subsistence and commercial harvests. The question of success, therefore, is whether or not management decisions for fishing in 2009 made it possible for MSE to be met despite a low total run size.

allowing a subsistence fishery for much of the lower Yukon area districts, based on fish counts that looked promisingly strong, projections for the chinook run were revised down. In response, ADF&G chose not to open a commercial fishery on the river, and to significantly limit the subsistence fisheries further up-river. Not surprisingly, all rural communities along the river expressed particular dissatisfaction with these management decisions. Fishers of the community of Marshall, AK, for instance, received extensive local and national media attention for their “fish-in” protest of the commercial fisheries closure, in which they illegally took 100 chinook and then confessed this act to the media (Demarban 2009). This came on the heels of a flurry of media attention in 2007 and 2008 for Marshall, Emmonak, and the other Yukon-Kuskokwim Delta communities, who reached out to the national media to raise awareness of a “heat or eat” dilemma prompted by skyrocketing global food and fuel prices (Fazzino and Loring 2009). For many commercial fishers in the region, chinook salmon represent most if not all of their income for the year, so the lack of a commercial fishery was understandably devastating for communities already coping with several years of difficult economic circumstances. In response, Alaska state Governor Sean Parnell petitioned the federal government to declare a fisheries disaster for the state's commercial chinook fishery; as of writing the state still waits on the federal government's decision.

The up-river Alaskan communities of the Yukon Flats were arguably the hardest hit by the 2009 chinook closures; though not as outspoken as communities down-river, people of the Yukon Flats communities rely more heavily on salmon for subsistence purposes than elsewhere on the river, and in the past they have been the most impacted by difficult years (Figure 5.5). The authors visited these communities both during and after the 2009 closures, and witnessed a number of empty smokehouses and freezers that we had not encountered in our collective 20 years experience in the region. Following the closure we interviewed 8 long-time

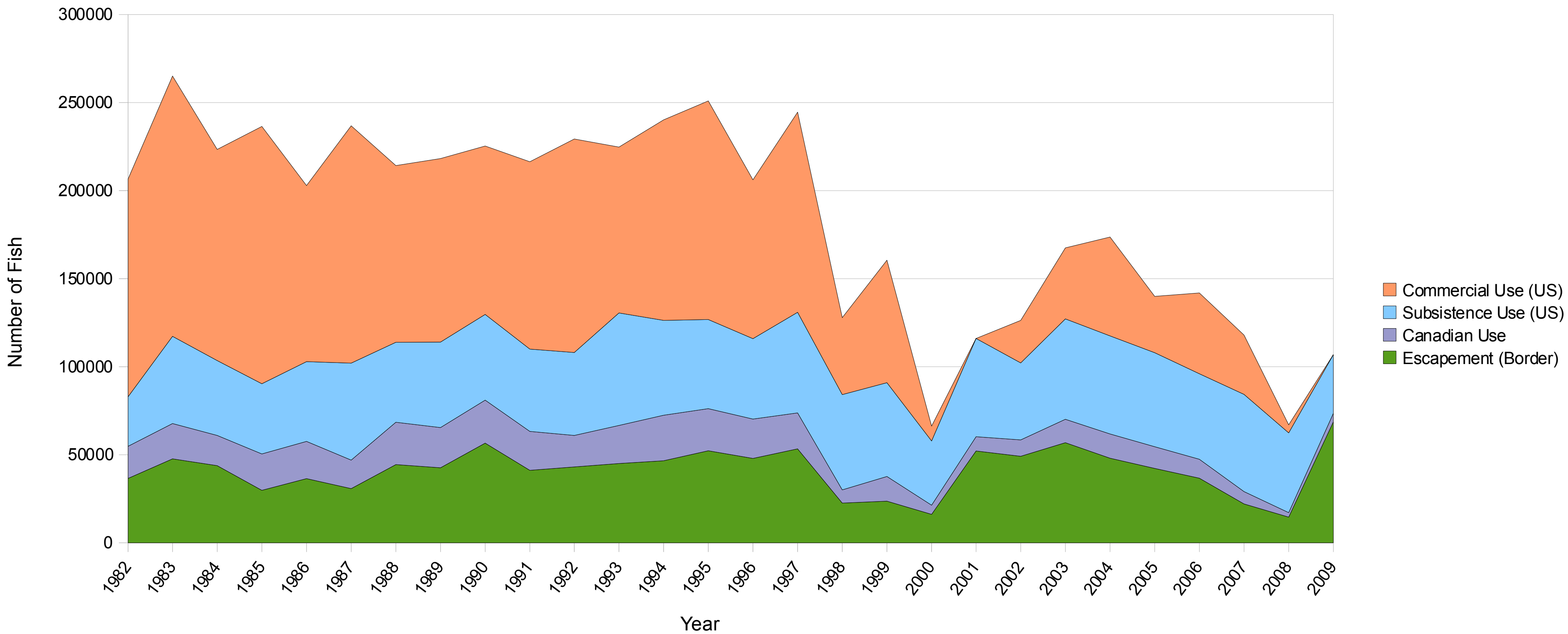

Figure 5.4 Relative Proportion of Chinook Use, 1982-2008. This graph shows the relative proportion of fish that escape and go to US and Canadian fisheries since 1982. These are stacked for comparison, not cumulative, which means the zero point for each region begins at the top of the previous region, not the X axis. Note that 'commercial use' includes only salmon caught along the river, and not salmon caught in ocean fisheries. A variety of interesting points are worth note. First is the relatively small proportion of the fishery that goes to Canadian fisheries. Second is that the prioritization of subsistence fisheries over commercial fisheries in the US appears to be effectively implemented, with the relative proportion of subsistence use remaining more or less stable, while commercial use varies more greatly and follows MSE more closely, especially since 1997. Also note the large commercial fisheries that were allowed in 1998 and 99, despite the low escapement. Data from (JTC 2009, 2010) and (ADF&G 2008) and (D. Jallen, pers. comm. 2010) .

fishers in the small community of Fort Yukon (approx 600 people); though some subsistence fishing had been allowed for upper Yukon districts, all reported that the closures resumed before the fish actually made it to the waters where they set their fish-wheels. In combination with the fact that the 2009 chum run was possibly the worst on the river since 1995 (ADF&G 2009), the local consensus is that 2009, in terms of food security, is the worst year they can remember.

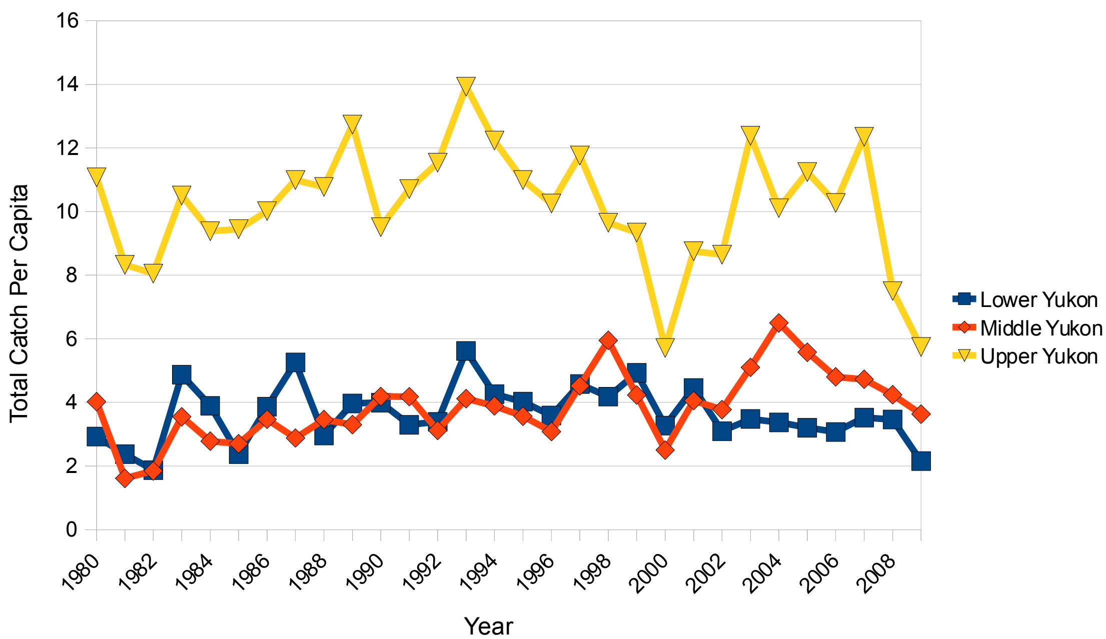

Figure 5.5 Per Capita Fish Use for Lower, Middle, and Upper Yukon Communities. Upper Yukon communities use a significant amount more fish per-capita than communities down-river. They also experience a greater proportion of the impacts during poor run years, e.g., in 2000 and again in 2009. Data from (ADF&G 2008, JTC 2009)

Enforcement of the up-river closures also put a significant financial strain on many households. Whereas down-river fishers use drift-nets to catch salmon, fishers up-river use large wooden fish-wheels (Figure 5.6), which are set out in the river at traditionally-used family fishing sites, often a day's travel or more from the community, to be checked for fish periodically, perhaps once a day. Though these slow-turning wheels can be stopped rather easily with just a large log, state officials enforcing the closures insisted that the wheels be removed entirely from the river. The cost and manpower of such a task forced many people to have to spend a significant amount of cash for fuel, money that many had saved to for the upcoming moose hunt in the fall. In addition, enforcers for other agencies (e.g., AK Department of Motor Vehicles) were unusually active in the region during this time, ticketing people for not wearing life jackets or for not having up-to-date registrations on the boats that they had to put in the water in order to move their fish-wheels. Whether this convergence of enforcement was by happenstance or design is not clear, but the understandable perception of the Fort Yukon residents interviewed was that they were being unfairly targeted. We return to a discussion of the impacts of enforcement later.

5.7 PROBLEMS IN MANAGEMENT: VARIABLES AND UNKNOWNS

Some critics of the management actions taken in the 2009 season point to the final escapement numbers of approximately 70,000 fish as evidence that actions were overly conservative and at the expense of the well-being of rural communities; the 12,000 fish surplus, they argue, though only a fraction of the total subsistence harvest during a good year, would still have fed many families. Managers at ADF&G, however, respond that 12,000 fish is well below the possible precision of in-season escapement-based management (C. Fleener, pers. comm. 2009). In other words, they assert that there is simply too much uncertainty inherent to the Yukon system to have managed the stock with any more precision; in their assessment, it is better to have erred on the side of conservation than to have allowed a fishery and once again fallen short of meeting MSE and fulfilling our obligations to Canada (ibid).

The effectiveness of salmon management is commonly measured only by whether or not spawning escapement objectives are met (National Research Council 1996, Yukon River Panel 2005). However, as described above, escapement as a management tool is at best imprecise, and its effectiveness is contingent on managers' ability to efficiently estimate run size, preferably in-season, and on the presence of well developed monitoring programs in all fisheries (National Research Council 1996, p. 373).

Figure 5.6. Athabascan Fish-wheel. This water-powered fish-wheel turns slowly with the water, scooping up fish as they pass, which then slide into a submerged holding area on the right. This fish-wheel is approximately 15' wide by 20' long. Photo by Philip Loring.

These competencies are crucial because of fundamental, often habitat-driven uncertainties regarding the escapement-recruitment relationship for any salmon population (National Research Council 1996, p. 281). In practice, observing anything close to the ideal relationship depicted in Figure 5.3 is uncommon, even in cases where there are decades of high-quality monitoring data (Natural Research Council 1996, p. 278). Indeed, in-season fishery management based on escapement is considered so potentially fraught with uncertainty that the National Research Council recommends that the best way to ensure conservation goals is to only allow salmon fisheries in the terminal spawning streams (National Research Council 1996, p. 292).

In Alaska, where complete salmon brood data is only available for 1982-2002 (ADF&G 2008), escapement-based management has produced less than consistent results (Figure 5.7). As we discuss below, there is likely both are numerous variables and uncertainties that likely contribute to the apparent lack of any relationship between escapement and recruitment of chinook on the Yukon, including the challenges of climate change as described above, possible changes to the size of chinook as the result of fishing practices, and ocean by-catch from the Bering Sea pollock fishery. These are issues that must be addressed if an escapement-recruitment model is to be effective for consistently meeting conservation goals and when possible also providing for community needs.

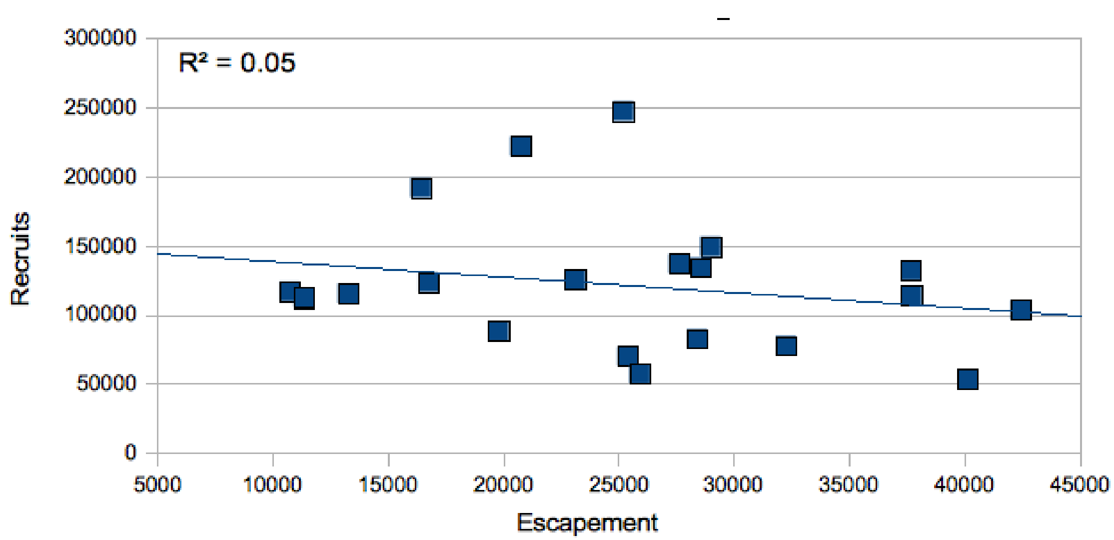

Figure 5.7 Recruitment and Escapement, 1982-2002. Complete brood data for this date range is plotted here. No relationship is evident. See again Figure 5.3 for the ideal hypothesized relationship between recruitment and escapement.

5.7.1 Ocean By-catch

Variability in marine survival is the biggest unknown of the salmon's life-cycle, and is considered potentially the the most likely factor weakening the strength of the escapement-recruitment relationship (National Research Council 1996, p. 278). In Alaska, ocean mortality is a high-profile and much debated concern, especially in the question of the health of the Yukon runs. The large commercial pollock fishery of the Bering Sea, which provides nearly 50% of the seafood consumed in the US (NMFS 2008), is under extensive scrutiny for the role that salmon by-catch played in 2009. State managers largely discount the role of by-catch, explaining that the fish caught at sea are a mix of salmon from many of the Pacific Northwest and Alaska rivers, and that the proportion in any given year of those fish that are bound to Western Alaska is likely low. Estimates place the proportion of Bering Sea by-catch destined for the Yukon as low as 3% (Witherell et al. 2002) or as high as 25% (C. Fleener pers. comm. 2009) or even 60% (Myers and Rogers 1988). It is likely, however, that these proportions will vary, creating the potential that by-catch in particular years may significantly impact specific meta-populations or brood years (Witherell et al. 2002).

The general public, however, and especially the subsistence and commercial fishers of the Yukon River communities, feel quite strongly that by-catch is a signifiant issue. To their credit, the short-term anecdotal evidence in support of this explanation is compelling. Chinook caught as by-catch are typically 1-2 years from returning to their rivers to spawn (Witherell et al. 2002). In 2007 an unprecedented number of salmon were lost to by-catch, over 129,000 fish. That two years of low runs on the Yukon immediately followed this anomalously-high by-catch should at least raise some question about a possible correlation (See table 5.2). Ultimately there is the possibility for this to be the most significant or most irrelevant of problems; but as human actions are the only aspect of at-sea mortality that managers have the potential to influence (C. Fleener pers. comm.. 2009), it is an issue that clearly requires further attention.

Table 5.2 Annual Recruitment for Chinook Salmon, 1998-2009. Note the comparison between the total number of chinook entering the Yukon each year and the number lost to by-catch in 2007. Even if 1/10 of this was destined to return in 2009, that would have raised the total return to above the mean for this period. Data from (JTC 2009) and (YRDFA 2009).

Year	Count at Pilot Station
1997	195,647
1998	87,852
1999	144,723
2000	44,428
2001	99,403
2002	123,213
2003	268,537
2004	156,606
2005	159,441
2006	169,403
2007	125,553
2008	130,643
2009	122,474
Mean	140,609
2007 by-catch	129,530

Federal agencies also do their part to respond to these concerns; human observers are regularly placed on pollock fishing ships by the National Oceanic and Atmospheric Administration (NOAA) in an attempt to better quantify the by-catch phenomenon, though the task before them is great. They are often met with hostility by commercial fishers, and the use of genetic methods to identify salmon by river has yet to be leveraged in any large-scale way. Also, the North Pacific Fisheries Management Council (NPFMC), part of NOAA's National Fisheries Management Service has pursued the implementation of by-catch limits for the

Bering Sea ground-fish fisheries to begin in 2011 (NPFMC 2008), an initiative that may have gained momentum as the result of 2009's poor chinook and chum runs.

5.7.2 Where are the Fish Spawning?

As noted, the YRA is structured around an estimate that 50% of Yukon River chinook spawn after passing into Canada via the main-stem of the river. This figure, which is monitored primarily through the use of genetic identification (D. Evenson *pers. comm.,* April 2010), is a lynch-pin in the entire chinook management approach. However, recent interviews with the hunters and fishers of the community of Fort Yukon raise questions regarding this estimate. Many of those interviewed suggest that the migration paths of many chinook may be changing. The main-stem of the Yukon River is not the only route into Canada; too, there are multiple tributaries and countless terminal streams that feed into the upper Yukon before the Canadian border. Locals are reporting to us that chinook salmon are increasingly traveling up the Chandalar, Black, and Porcupine rivers (see again Figure 5.1), the latter of the these likely providing a second path into Canada for many spawners.

Strays among salmon are common, and significant changes in salmon migration is not unprecedented. The eldest of those interviewed, for instance, recall a time several decades ago when more chinook took alternate paths, and they suspect that now the fish are beginning to follow these paths again. However, while commercial fisheries managers believe that chum salmon spawning grounds are changing quite significantly (D. Evenson *pers. comm.,* April 2010), they are confident that the makeup of the chinook stock is remaining constant, based primarily on genetic sampling. There is some question, however, whether genetics are a tool capable of picking up fast changes in upper-Yukon populations. If up-river salmon were to begin spawning in lower-yukon habitat in significant numbers, this would likely be noticed (M. McPhee, *pers. comm.*, April 2010); however, any significant change in up-river spawning genetics would likely take decades to manifest (ibid), and still would not necessarily be picked up without terminal-stream genetic monitoring in these new spawning locations (ibid). Too, genetic monitoring surely would not be able to *anticipate* in-season changes or disturbances to the river system that could divert spawners to alternate routes.

Thus, the question of where chinook are spawning is arguably unresolved. If local observations of change are accurate, then it is possible that the current management approach is overemphasizing the role of Canadian stock in the composition of Yukon River salmon. Indeed, it would provide an alternate hypothesis for explaining the recently identified decline in the relative proportion of Canadian fish. There are hundreds of streams where spawning salmon could depart from the Yukon before it passes through to Canada, and as rivers change, spawning grounds change (National Research Council 2007). Given the myriad ongoing climatic and ecological changes that the Yukon River Basin is experiencing, the need to monitor for how these changes are influencing the location of spawning grounds and the composition of the fishery is clear. A vast majority of the Yukon's terminal spawning streams are especially remote (J. Hilsinger pers. comm. 2009), however, and the costs and logistics of monitoring these remote portions of the river system are considered to be too great by ADF&G (ibid); but, as we discuss below, the cost of not addressing these points of uncertainty may be higher still.

5.7.3 Where are the Big Fish?

Finally, there is much concern that the Yukon chinook population is decreasing in size in response to selective fishing pressures that favor the largest fish. The relevance of this to conservation and fishing concerns is that the largest, oldest salmon tend to be the most productive spawners; if the escaping fish get smaller, production of progeny beyond replacement could decline such that the maximum sustainable yield decreases. The few studies on this widely-reported phenomenon have been inconclusive, with decreases observed in some tributaries but increases in others(JTC 2006). Common sense suggests, however, that nets designed to let all but the largest fish through could indeed cause a change in the population over time in favor of fish that remain smaller at spawning age. There is, for instance, consensus that eight-year-old chinook salmon are 'extinct'. In addition to net selectivity, other hypotheses have been presented to explain decreases in size where this has been observed, including the impacts of climatic and other at-sea environmental change on salmon feeding; if food is less available, salmon may indeed grow less before making the return trip. Despite the uncertainty, actions are being taken to address this component of the Yukon salmon problem; the Joint Technical Committee continues to pursue the question, and communities have engaged with the Board of Fish to identify new gill net standards that will also allow larger fish to pass escape capture. There are proponents and skeptics for the latter solution, and this is likely an adaptive management question that remains far from being solved.

5.8 DISCUSSION: ARE WE ASKING TOO MUCH?

As established in international treaty and as implemented by ADF&G, the primary mandate for the management of Yukon River salmon is conservation. In 2009, this appears to be a goal very different from, and potentially-incompatible with, a goal of rural food security. However, as we explore below, conservation in a single-species context is a very different proposition than conservation in an ecosystem context. While we can frame the happenings of 2009 independently in terms of an agency's success to conserve salmon, or their failure to equitably serve the various stake-holder groups in Alaska, we can also choose to look at 2009 as an indicator for the need to develop a more robust and holistic approach to fish and wildlife management, in which conservation and food security are not competing but complementary processes.

Yukon salmon conservation is clearly managed in a single-species context; in a regional ecosystem or food systems context, however, management goals and metrics for success are quite differently defined. In a single-species context, for instance, there are no mechanisms or metrics for identifying and responding to impacts across species or between regions, as in the case of the differential distribution of impacts between lower and upper Yukon communities described earlier. Salmon are a lynch-pin in a complex regional food system, and there are numerous possible pathways that management actions may impact not just human communities but other aspects of the Yukon River Basin ecosystems as well. For instance, the Yukon Flats has a notoriously-depressed moose (*Alces alces*) population. Local experts that we interviewed, however, report observing preliminary signs of recovery in the moose population, including numerous sightings of young cows. What might the impacts be on this apparently-recovering moose population from the increase in hunting that results from the salmon shortage? Like salmon, moose play an important role in local foodways, and the ability to rely more heavily on moose during times of shortage of salmon is a key aspect of the adaptive subsistence strategy that has allowed Alaska Natives to live so successfully on the Alaska landscape for so long. The cost of enforcement may have undermined many people's ability to hunt for moose in the fall, but we were assured by everyone that the moose hunt would occur nonetheless, in force and out of season if necessary, in order to keep food in the freezers and on the kitchen tables. Given that the chum salmon subsistence fisheries were also closed for the majority of Alaskans in 2009 (ADF&G 2009), significant compensatory predation pressure on other resources should be anticipated; this would likely not be limited to moose, but could extend to whitefish, waterfowl, small game, and could cascade to have impacts on habitat as well.

The challenge is to find a paradigm for integrating knowledge of climate futures and natural environmental variability with place-based drivers of change such as predation and harvest, while still serving regional goals such as single-species conservation and ecosystem and human health. A holistic, ecosystems-based management approach makes it possible to effectively take these interconnections and dependencies into account (c.f. Savory 1988, Wilson 2006). Managing for a flexible and adaptable food system, we argue, provides an ecosystem-based approach, but also includes the human dimensions of the ecosystem, linking specific goals for the health and conservation of individual species to broader goals of human health and community stability (Kloppenburg et al. 1996, Leopold 1966, Sayre 2006). From a food systems perspective, salmon conservation, moose conservation, and food security are complementary, not mutually exclusive goals. Internationally-agreed-upon metrics for salmon conservation would not have to change, per se, but the system implementing them would need to become more flexible and integrated in design, mimicking the flexibility and interconnectedness of the natural system being managed, so that these multiple goals can be pursued together. Too, acknowledging that these species exist within a food system highlights rather than obscures the complex relationships therein, and allows managers to better track the impacts of a changing climate, a changing landscape, and changing communities (Ericksen 2008).

Numerous political and institutional barriers likely exist, however, to the implementation of such a dramatic change. Alaska's natural resources are arguably some of the most heavily managed and contested in the world (Behnke 2002, Caulfield 1992); corporate, state, and federal interests create a cluttered patchwork of competing jurisdictions, mandates, and agendas. Even at the just state level, ADF&G is split into numerous independently-operating divisions which do not necessarily have clearly aligned mandates, philosophies, or practices. At least three divisions of ADF&G are interested in some aspect of the salmon fisheries: Commercial Fisheries, Subsistence, and in a somewhat oblique way, Wildlife Conservation. PST and YRG protocol are implemented by the Commercial Fisheries division, whose mandate is "to protect, maintain, and improve the fish, shellfish, and aquatic plant resources of the state, consistent with the sustained yield principle, for the maximum benefit of the economy and the people of Alaska" (ADF&G 2010a), which itself is at least in partial conflict with the conservation-based mandate of the PST. The mission of the Division of Wildlife Conservation is similar—to "conserve and enhance Alaska's wildlife and habitats and provide for a wide range of public uses and benefits." Wildlife is for the most part not engaged in salmon management, as their mandate to conserve 'habitat' oddly does not include salmon habitat. Still, there can be some confusing overlap between the two, for instance in the conservation of bear species, who rely heavily on salmon and salmon habitat for survival (ADF&G 2010b, T. Paragi pers. comm. 2010).

Such organizational divisions create cognitive and jurisdictional challenges to creating and implementing management policies that are scaled to the ecosystem or watershed or food system rather than to individual species. However, organizations like ADF&G remain arguably in the best position, and in possession of the best resources, to facilitate a complex task like ecosystem-based management (Berkes 2005). Everyone involved wants a system that works better, and the managers at ADF&G clearly do everything in their power to meet community needs. The challenge is therefore not only a matter of having the best scientific understanding of the system but also of having the political will to implement the necessary changes to our social and cultural institutions (T. Paragi pers. comm.

2010). Whether or not the events of 2009 will mobilize the political will necessary to instantiate such a regime change, however, remains to be seen.

5.8.1 Opportunities for Collaboration

Barring a dramatic and admittedly-unlikely overhaul of fish and game management in the state, there are still opportunities for improving the current system in ways that both improve food security for rural communities and strengthen agency capacity to meet conservation goals. In particular, monitoring the impacts of changes in climate and the landscape on salmon spawning grounds is a key need; for ADF&G, however, this is a task they are just not equipped to handle. Commercial Fisheries Division is already significantly taxed by the duties they perform in service of the JTC (J. Hilsinger pers. comm. 2010). New genetic monitoring techniques are being deployed throughout Alaska's salmon fisheries for a variety of investigative purposes (ibid.); genetic change, however, lags behind landscape change and is not an appropriately-scaled observational technique for monitoring what can be rapid and down-scale changes in geographic distribution. As described earlier, the remoteness of terminal streams presents logistic and financial challenges to physically monitoring spawning grounds. Nevertheless, if spawning locations and the overall composition of the chinook run are in fact changing it needs to be addressed, or management goals may disproportionately favor US or Canadian stocks.

The task is not out of reach, however; hunters and fishers throughout the world have been repeatedly shown to posses great capacity for monitoring wildlife populations and for incorporating this information into conservation- and subsistence-minded resource management decisions (Cinner and Aswani 2007, Solberg and Saether 1999, Stanley and Rice 2007). The subsistence hunters and fishers of Alaska are no less well informed, no less keen, nor are they less environmentally aware than local peoples elsewhere. Many local residents possess extensive geographic and ecological knowledge of the Yukon and its tributaries, which combined with their proximity to these terminal streams would reduce the problems of cost and logistics. Being engaged as partners in the conservation of Yukon salmon would also go far towards fostering a relationship of trust between subsistence users and resource managers, in place of the mistrust and antagonism that dominates the relationship today. Too, a more robust terminal stream monitoring program would potentially open the door for the creation of terminal stream fisheries (as recommended by the NRC) that would support local food needs without undermining conservation goals. Increased capacity and trust for collaboration would also likely go far towards improving the actions being taken to address the question of changing fish size.

5.9 CONCLUSION

By anyone's reckoning, 2009 was a difficult year on the Yukon. While there is some silver lining in the success as measured with the metrics of international treaty, few are entirely happy with the final outcomes. The intent of this paper is not to place blame, however, as everyone involved works hard, and share intentions that are both honorable and for the most part congruent. Rather, we detail this case to identify the social and ecological circumstances that set the stage upon which these events played out. If there are lessons that managers and conservationists in Alaska and elsewhere can take from this case, it is that observation and understanding are important, coupled aspects of effective natural resource management, especially in a context of environmental variability and change. Without the highest-quality, up-to-date information, even the best understandings of and models for system dynamics are rendered impotent (Pilkey and Pilkey-Jarvis 2007).

More and better science and monitoring can go far to alleviate some of the problems experienced in 2009; however, reorienting management around an ecosystem-based approach is clearly the long term need. Focusing on the system as a food system extends that ecosystem approach to the human dimensions of natural resource management, a challenge that many ecosystem-based management regimes have yet to achieve (St. Martin et al. 2007). It is also crucial that everyone involved recognize the natural uncertainty and variability of the Yukon system. Policymakers need consider new ways to blend these jurisdictions and mandates of the traditionally-secularized worlds of conservation, commerce, and subsistence management, in ways that mimic the variability and interconnectedness inherent to the Yukon system. We are asking too much of the Yukon River, and for that matter of Yukon River managers, if we ask them to consistently and uniformly provide for both a thriving salmon population and thriving human communities without the support of the rest of Alaska's landscapes and seascapes. Alaska's natural resources are a great asset, and if we organize and scale our own social institutions appropriately, they can make our lives easier, not harder.

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CHAPTER 6

CROSS-CULTURAL LITERACY, COLLABORATION AND THE NEW SCIENCE[1]

6.1 ABSTRACT

Collaborative ecological research is constrained by frameworks for cross-cultural sharing that are organized around notions of difference rather than common ground. In the quest to collect 'local knowledge' and make it compatible with science, it is frequently dismantled, manipulated, and ultimately rendered meaningless; likewise, local people frequently dismiss or mistrust the values and and intentions of the scientific 'outsider.' Conservatism and skepticism persists on both sides regarding the appropriate roles of local knowledge in science; in the interest of salvaging good intentions and even better opportunities for the advancement of knowledge, an alternate paradigm of scientific collaboration is suggested: rather than looking to research local knowledge, scientists should endeavor to engage local experts in the entire research process, from observation to understanding and response. I review the epistemological nature of the challenges facing cross-cultural collaboration in science, and discuss a goal of cross-cultural literacy as a requisite competency to effective cross-cultural collaboration, whereby collaborators find common ground, where conversations begin on terms of trust, and where assumptions of validity replace ethnocentric oversimplifications. Some examples are given of work that has attempted such collaboration, and recommendations are made for clearer ways to think about the challenge.

6.2 INTRODUCTION

We have achieved little in the last decade in the way of establishing 'ideal'

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conversations between scientists and communities. Much is made of the importance of such collaborations; initiatives for involving 'local knowledge' in dialogues about issues such as climate change, conservation, and environmental sustainability are common, and represent the lion's share of institutional efforts to involve indigenous or otherwise 'local' peoples in designing responses to these challenges (Nadasdy 1999, p. 1). The intentions of researchers and policymakers are valid and appreciable, and the widespread recognition that local knowledge is worthy of attention represents an important step toward the full participation of communities in the management of their lands and resources (Lambert 2003). However, when one reviews the 'state-of-the-art' of collaboratory research and resource management, one more often finds work that undermines, rather than empowers, the standing of local peoples in institutional management arrangements (Nadasdy 2005)—by questioning the accuracy, validity, and relevance of local knowledge and practices (e.g., Howard and Widdowson 1997, Lopez-Hoffman et al. 2006, Smith and Wishnie 2000, Wohling 2009), or by being selfish with the products of learning that collaboration achieves (Irvine and Kaplan 2001, Nadasdy 1999)—than one finds honest attempts to develop legitimate cross-cultural sharing (e.g., Huntington 2000, Hassel 2006, Orlove et al. 2009).

Despite a continued trend toward interest in collaboration and community-based participatory research, there remains recurring conservatism and even skepticism regarding the role of local knowledge in the sustainability sciences[2]. Perceived differences between 'local' and 'scientific'[3] knowledge systems, once

2 Here I use the term 'sustainability science' to denote a broad set of disciplinary and interdisciplinary research programs that share the applied context of the science-based management of ecosystems, including conservation biology, restoration ecology, resilience theory, etc.

3 When I use the terms 'scientist' and 'science' in this paper, they should be understood as shorthand for the those who are engaged in the practice gaining and applying knowledge through use of the 'scientific method' within a formalized institutional setting (e.g., university), and for that institution, respectively. Use of the terms should not be taken to suggest that local experts do not qualify as scientists in their own right, especially insofar as 'science,' in the broadest sense, describes a systematized knowledge-base or prescriptive practice that is capable of resulting in a

thought of as opportunities for bringing a broadened perspective to contemporary issues, are often eyed as reasons for skepticism and caution (Sutherland et al. 2004, see also Wohling 2009, Collier 2008). In the interest of salvaging good intentions and even better opportunities for the advancement of knowledge, this paper argues for a paradigm shift in collaboration between scientists and community members. I review the challenges that have preoccupied and limited collaboration between scientists and communities thus far, and describe an alternative collaboratory arrangement that avoids these traps. I describe a research process that involves three themes—observation, understanding, and response (after SEARCH 2003)—and argue that collaboration limited to a discussion of the first, i.e., observation and data gathering, can never fully engage the place-based knowledge and synoptic understanding that local people often have to share. Rather than looking to collect local 'knowledge,' we should instead look to partner with local 'experts,' and legitimately engage people in conversation throughout the learning and planning process. I discuss a goal of cross-cultural literacy as a requisite competency to effective cross-cultural collaboration, whereby collaborators find common ground, where conversations begin on terms of trust, where problems are defined together, and where assumptions of validity replace ethnocentric oversimplifications. Only from such beginnings, I argue, can research collaboration be possible where intellectual property rights are maintained, where the benefits of learning are shared by all, and where local people are enabled to take ownership of the health and sustainability of their lands and resources.

6.3 LOCAL, TRADITIONAL, ECOLOGICAL KNOWLEDGE

Local knowledge is defined many ways. In the academic literature of the last few decades, in particular regarding topics such as sustainability and climate change, the idea has most generally been used to denote a type of knowledge

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prediction or predictable type of outcome.

different from scientific knowledge, usually knowledge about the environment and of uses of the environment, gained not through the scientific method but acquired from one's day-to-day experiences and from the lessons of one's parents, grandparents, and traditional practices (Usher 2000). A variety of descriptors have been recommended for this category of knowledge: indigenous knowledge, *traditional* knowledge, traditional *ecological* knowledge, *local* ecological knowledge, and so on. Whether invoked to capture some unique epistemological quality, to reinforce intellectual property rights, or to simply provide a descriptor for a kind of knowledge that has been deemed important but still 'other' than science, is not always clear. All of these terms have been extensively disassembled and critiqued, however (e.g., Morrow and Hensel 1992, Nadasdy 1999, Dove 2006) an exercise I will not repeat here. Suffice to say that terms like 'indigenous,' 'traditional,' 'ecological,' and 'local' are each heavily contested and often politically and / or ideologically freighted (Born and Purcell 2006, Brush 1993, Tomsen 2002, Agrawal 2005). Traditional ecological knowledge (TEK) is the term that seems to have gained the widest acceptance (Usher 2000) For reasons that will become clear as this paper proceeds, I prefer to discuss collaboration in terms of 'local expertise.' For consistency, I will use 'local knowledge' when referring the works of others.

Despite disagreements over terminology, there has been near consensus for the past 20 years or more that local knowledge can be of value for increasing ecological understanding and for addressing contemporary environmental issues. Local knowledge is, in many circumstances, considered to represent hundreds to thousands of years worth of acquired experience (Berkes 2008), and this time-depth is one of many reasons that the inclusion of local knowledge is considered to be important for scientific research and ecological understanding (Orlove et al. 2009). Those engaged in historical ecology, for instance, often identify local peoples as having access to more, and higher-quality information about the environment, especially where other long-term observational and instrumental records are unavailable (Egan and Howell 2001). Others seek out local knowledge for its holistic and synoptic quality (Nabhan 2000, Barnhardt and Kawagley 1999), and look to it to complement existing scientific models and lines of inquiry that have on their own failed to elicit understandings for complex phenomena (e.g., Heise et al. 2003, National Research Council 1996, 2004). Cogent arguments are also made based on these and other points for the importance of local knowledge in dialogues about health and well-being, and ecosystem conservation and sustainability planning (Berkes and Henley 1997, Huntington 2000, Usher 2000, Hassel 2006).

Much of the work pursuing this integration of local knowledge with scientific research and management practices treats local peoples as potential 'repositories' of valuable data. One often reads about local knowledge research, where local people are enlisted as informants to fill in knowledge gaps about historical environmental conditions, or to be observers and monitors of current conditions and changes. There are a number of commonly identified challenges to such efforts, however: one is the challenge of how to elicit local knowledge, which may be difficult to access because of communication barriers or because it is encoded in behavior, beliefs, or other tacit knowledge structures (Fazey et al. 2006, Huntington 2000); another, is how to make that knowledge, once recorded, compatible with scientific and management processes:

> The assumption is that traditional knowledge is expressed in a form that is vastly different from, and largely incompatible with, that of science, [so] there are a whole host of essentially technical problems that accompany the effort to integrate them. Most of these problems relate to difficulties in accessing and collecting TEK or with translating it into a form that can be utilized. (Nadasdy 1999, p. 2)

These challenges are premised on notions of difference between the nature of local and scientific knowledge. To the extent that science consists of systematic observation to make sense of the world, all people practice a form of science (Cajete 1999, Nader 1996). Nevertheless, scientists often prefer a quite narrow definition of what qualifies as science (e.g., Popper 1959), and on these terms, both scientists and indigenous scholars often identify a number of fundamental differences between western science and local knowledge, differences believed to challenge the incorporation of local knowledge into the research process (Figure 6.1). Local observational techniques are commonly described as qualitative or otherwise sub-scientific, and local knowledge is characterized as anecdotal, intuitive, and oral (Nadasdy 1999, e.g., Lopez-Hoffman et al. 2006); western science, on the other hand, is seen as a quantitative and rigorous process, one that produces knowledge that is replicable, reductionist, analytical, and literate (ibid).

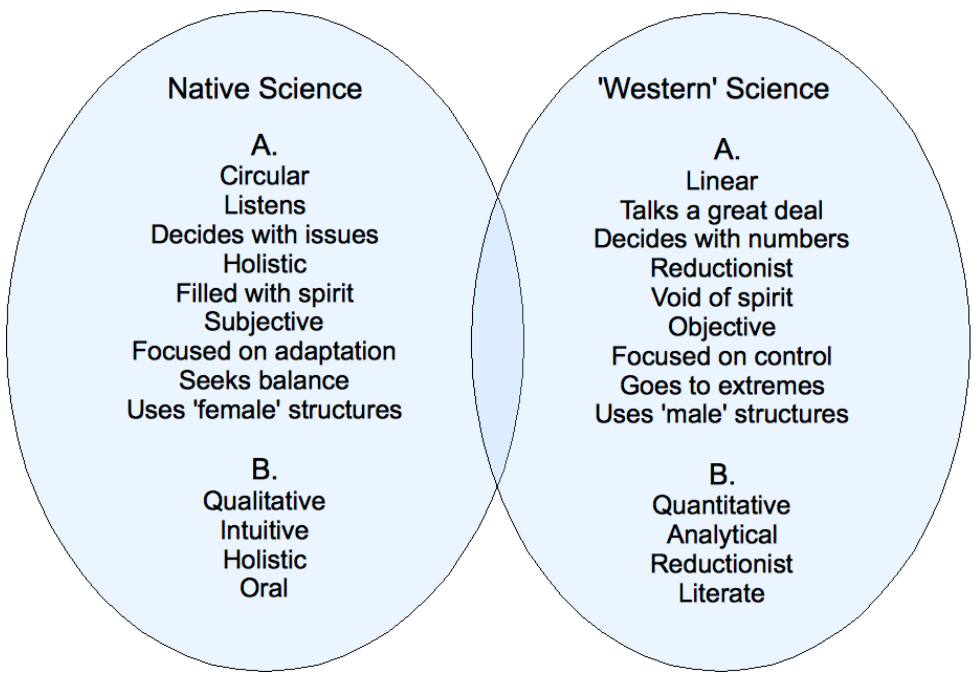

Figure 6.1 The 'Western' and 'Native' Science Dichotomy. As described from: A) an Alaska Native perspective (RuralCAP 1994); and B; from a scientific perspective (Nadasday 1999). “Basic philosophical differences” between the two systems tend to be stressed over points of common ground (quote from RuralCAP 1994).

These differences are assumed to exist more often than they are actually evaluated on a case-by-case basis, however. As Usher (2000) shows, for instance, local knowledge can hardly be labeled non-rigorous or non-replicable, given that so many people base their livelihoods and indeed their very survival on their knowledge of the weather, seasons, and landscape (Campbell 2004, Hassanein 1999, Krupnik and Jolly 2002). Factual observations shared by local peoples are often very precise, hypothesis-driven, and recalled in extraordinary detail (Cajete 1999, Usher 2000). In my own research experience, people often avoid making any kind of generalization beyond their direct personal experience, and are quick to defer to another whom they believe knows more. Though scientists' observations can indeed be more instrumented, quantified, and recorded than local knowledge, they are nevertheless often more similar in principle than different.

6.4 SPEAKING THE SAME, YET DIFFERENT LANGUAGE

It is important to acknowledge that knowledge systems are never identical, and that there can be many philosophical differences between a local knowledge system and the institution of western science. Many have argued that this is an opportunity for a broadened perspective and an increased capacity for learning in scientific research (e.g., Huntington 2000, Berkes and Henley 1997, Usher 2000). That local knowledge is qualitative and holistic, for instance, has been identified as being complementary to the quantitative and reductionist nature of science:

> It makes good sense to involve people who spend a lot of the time on the land in environmental assessment and management, for the obvious reason that they get to see things more often, for longer, and at more different times and places than is normally the case for scientists. These observations, and the resulting hypotheses, can complement observations that contemporary scientists are in a position to make (but aboriginal people are not) through such techniques as magnification, remote sensing, or chemical or genetic analysis. (Usher 2000, p. 188)

Recently, however, these differences are have also been cast as shortcomings, and in some cases as threats to the very integrity of the scientific process (Specter 2009), with properties like qualitative paired instead with words like 'imprecise', 'anecdotal', and 'danger' (see e.g., Lopez-Hoffman et al. 2006, Smith and Wishnie 2000, Sutherland et al. 2004, Wohling 2009) . Too, one frequently encounters the suggestion that addressing challenges like climate change and resource scarcity will be difficult, complex, even a "struggle" (Ostrom 1990, Dietz et al. 2002, Chander and Sunder 2004, Ostrom et al. 2007, Allen and Holling 2008). From here, it is not too far of an intellectual leap, given the common preconceptions regarding the non-scientific nature of local knowledge, to question the validity of local knowledge in the context of these inordinately complex challenges. Wohling (2009), for example, contends that "[local knowledge] is not adapted to the *scales* and *kinds* of disturbances that contemporary society is exerting on natural systems" (emphasis mine). Similarly, Smith and Wishnie (2000) dismiss several historical cases of indigenous conservation as irrelevant because their circumstances did not match the magnitude or complexity of contemporary problems. Sutherland and colleagues (2004) suggest that past and present ecosystem management practices, whether successful or otherwise, have been based on "anecdote and myth" rather than rigorous evidence-gathering and hypothesis testing (p. 305), and argue for a new regime of rigor in management practices. And Lopez-Hoffman and colleagues (2006) argue that local knowledge is a social phenomenon that must be contrasted and reconciled with 'ecological' realities (p.15), and they proceed to expose, through a process of scientific validation, various shortcomings of local observations and resource management practices.

6.4.1 Lost in Translation

What should we make of this conservatism? Are initiatives to include local knowledge proof that we, as a society are guilty, as Specter (2009) argues in his book *Denialism,* of turning away from 'real' science in favor of magic and mysticism? Or are these scientific assessments of the validity of local knowledge themselves flawed, more a product of ethnocentrism and a limited approach to collaboration than of fundamental inaccuracies or irreconcilable epistemological differences? I argue the latter; that the perceived shortcomings of local knowledge are a product of this extractive approach to collaboration, and of ethnocentric oversimplifications regarding the nature of local knowledge. Where local knowledge is treated as merely a set of data, to be collected, vetted, and integrated into existing scientific and management bureaucracies, the important context of that knowledge—the local expert, their knowledge system and world-view, and their rights as holders of intellectual property—are marginalized (Bielawski 1996). As Huntington explains, "when gathering [local knowledge], it is especially important to consider the cultural context in which the interactions take place" (Huntington 2000, p. 1271). I take Huntington and Bielawski's sentiment one step further, and argue that it is important to consider not just the cultural but the individual and social contexts of knowledge, recognizing the importance of people as experts and as learners, not merely repositories for static data.

To go to a community in search of collaboration, but to seek only data, is to ignore the importance of world-view for putting that data into context. It is, in other words, to commit the heresy of paraphrase. Brooks (1975) first introduced this notion as a literary principle, arguing that meaning in poetry is irreducible, because meaning is as related to the content of a poem as it is to its form. He emphasized the importance of considering all aspects of a poem together: its structure, tension, balance, irony, statement, and subject matter. In other words, he argued that one cannot understand the meaning of a poem through its words alone, but that one has to experience the poem as a whole. In the case of cross-cultural sharing, the poem provides an effective analogy for the relationship between facts, knowledge, and the knowledge system, and of the shortcomings of collaborations that are limited to the collection of data.

A knowledge system is the framework within which a person's expertise develops, where learning happens and knowledge finds internal consistency. It is what A.O. Kawagley (1995) describes as "principles we acquire to make sense of the world around us" (p. 7), including how people answer such questions as what is real, and what is knowable. Facts in a knowledge system are analogous to words in a poem, their meaning and validity tied up in how each fact relates to one another, how they fit within a person's ideas about the structure of the world, how they change over time through the process of learning, and how they relate to ideas such as real and unreal, good and bad, right and wrong, etc. Facts are to knowledge what the words in a poem are to the meaning of that poem; knowledge is more than the accumulation of facts, so when evaluated as such, it is impossible to not come to limited or even entirely incorrect conclusions about their meaning and validity.

For instance, consider in more detail the argument made by Lopez-Hoffman et al. (2006) in their paper entitled "Sustainability of Mangrove Harvesting: How do Harvesters' Perceptions Differ from Ecological Analysis?" Their research was intended to examine "the concept of sustainability from both biological and social perspectives" (p. 2), in order to "clearly define" "contrasting definitions" (p. 1). First, they perform a science-based analysis on the effects of mangrove harvesting on forest structure, using controlled experiments and computer simulations "to understand sustainability from an ecological [read: factual] perspective" (p. 2). Next, they interview a number of mangrove harvesters, asking them "how they understand the concept of sustainability" (p. 2), to describe whether they believe sustainability of the mangroves to be an issue, and whether or not they believe their current harvesting practices to be sustainable.

Of the 40 mangrove harvesters interviewed, three responded that they were concerned about the sustainability of current practices; the rest felt comfortable that they were acting in a sustainable way, citing behavior such as not cutting the younger trees, and personal observations about mangrove proliferation. Their scientific analysis, however, showed a quite different picture: that harvest levels were significantly higher than those deemed sustainable by their ecological experiments and models:

> The most outstanding result of this study was the apparent difference

> between the ecological and sociological conceptions of sustainability. In some situations, harvesting levels, considered sustainable by the harvesters, were not ecologically sustainable because overtime they would cause a decline in mangrove population numbers. Furthermore, if the ecological goal is maintaining the mangrove population completely unchanged, then ecologically sustainable harvesting is impossible. (p. 15)

These discrepancies between scientific and local understandings of sustainability lead the authors to the conclusion that a new mangrove management regime is necessary, one guided first by science. The uses of local knowledge in management, they argue, should be limited to “monitoring the long-term effects of harvesting,” as this is the only area where, in their evaluation, there is sufficient consistency between local and scientific competencies. “Although local knowledge may be imprecise and qualitative,” they conclude, “it is … useful for monitoring the long-term effects of harvesting” (p. 15).

The problem with these conclusions is that their analysis evaluates the validity of local expertise, indeed, of the entire local knowledge system, based only on a snapshot of knowledge in time, and ignores the broader context of learning, experimentation, and sharing that is fundamental to any knowledge system (Hassanein 1999).

Knowledge is fluid, and as learning happens, consensus does not always move in a positive direction[4] (Oppenheimer et al. 2008). Periods of negative learning, where individual beliefs and consensus move further away from truth, are common even for the western science community, evidenced recently, for instance, by early models of ozone layer depletion and deglaciation of the West Antarctic ice sheet (ibid). In the case of the mangrove harvesters, consensus regarding

4 “Discussion of the direction of learning inevitably leads to the question, 'direction toward (or away from) what?', e.g., a true state of belief. The question of whether a true state of belief exists has been addressed extensively but not conclusively for centuries … For current purposes, we will assume that a functionally or provisionally true (“good enough”) state exists and is eventually attained” (Oppenheimer et al. 2008, p. 157) Thus, 'negative learning' invokes the idea of 'going down the wrong road.'

sustainability may have proved inaccurate at one point in time, but that is not a sufficient basis for devaluing the entire knowledge system; otherwise, the very same critique could be levied at western science. Being wrong for a time does not preclude people from continuing to learn, and from revising their opinions as they continue to observe and interact with the world around them. Lopez-Hoffman et al. do admit that "local knowledge is heterogeneous," (p. 14) and they also note the importance of learning and sharing. Yet their conclusions and recommendations ignore, and effectively disenfranchise local peoples from continuing in, that learning process.

6.5 REFORMING THE COLLABORATION PROCESS

In order to avoid such problems, and realize the potential of cross-cultural collaboration in science, the goal should be to move away from commodifying local knowledge as a research product, and toward the incorporation of local experts into the entire research process.

The Study of Environmental Arctic Change project (SEARCH 2003) describes applied ecological research as involving three phases: observing change, understanding change, and, where necessary, responding to change. As I have described in this paper, collaborations between communities and scientists tend to be dominated by activities of the first phase, observation. This is an important and necessary component of the research process, but when collaboration is *limited* to observation, the uses of local knowledge by scientists seems more in the character of a salvage operation than an exchange of ideas between mutually-respecting peers. To engage local experts in the process of understanding change, however, is to include them in the very core of the 'sciencing' process, beginning with the identification of questions and problems, and through such activities as observation, analysis, synthesis, modeling, hypothesis testing, impacts assessment, etc. As shown above, when local experts are not involved in this process, it is not only possible but likely that their knowledge and observations will be incorrectly interpreted and evaluated. In cases where local experts are involved in the process of understanding, however, the problem of paraphrase is effectively eliminated, replaced by the benefits of bringing multiple perspectives, each with their own set of analytical tools and synthetic competencies, to bear on the research problem (e.g., Adams et al. 1993, Huntington 2000). "By cooperating in the analysis of data, the two groups … find common understanding and jointly develop priorities for management and future research" (Huntington 2000, p. 1271).

The third phase of the SEARCH research process, responding to change, refers to how the learning process translates into action, through policy change, impacts planning and mitigation, and individual and community adaptation. Including community participation in designing responses to change can help to ensure that practices and technologies adopted make sense within local social and cultural circumstances (Kottak 1990); responses can be designed with more awareness of the risks involved, more purview over questions of ethics and justice, and more likelihood of success for new initiatives through buy-in (Vogel et al. 2007, Irvine and Kaplan 2001). Many local people are skeptical of the intentions behind the interest in collaboration from the science community, because in practice the benefits of collaboration are often one-way, with outcomes such as learning, increased competencies, and power within management bureaucracies skewed in favor of scientists and managers, while the risks of adopting new practices and technologies remain primarily on shoulders of the communities themselves (Irvine and Kaplan 2001, O'Brien and Leichenko 2000). Concerns about intellectual and cultural property are also widespread among indigenous communities (Kimberly Declaration 2002, Hansen and VanFleet 2003). If people are fully involved in synthesis and planning activities however, they (and therefore their communities) are better situated to benefit from the learning process, and to remain in control of the uses of their intellectual and cultural property.

Huntington (2000) describes one noteworthy case that illustrates many of these benefits: the Alaska Inuvialuit Beluga Whale Committee (AIBWC). Established in 1988, the AIBWC fully engaged scientists and whale hunters in a way that enabled them to challenge old assumptions and bring fresh insights to difficult problems. Whale hunters were involved in the conservation and management issues of the Beluga whale “from the roots up” (Adams et al. 1993 p. 136) active in monitoring efforts, research design and implementation, and the preparation of management plans. Local involvement also enriched the discussion of ethics in research, and the group effectively resolved existing conflicts regarding debated research techniques, such as collaring and tagging, which had been considered cruel and disrespectful by many Alaska Natives (Huntington 2000). In this way, local collaborators were also able to control the uses of their knowledge, and be sure that it was used only to support activities which they believed to be ethical. The AIBWC achieved significant trust and buy-in from all participants and continues to be regarded with legitimacy and respect by other national and international organizations, such as the International Whaling Commission and the Arctic Marine Resources Commission (Adams et al. 1993), and the group won the Environmental Hero award from the US National Oceanic and Atmospheric Administration (NOAA) in 2002, for its successful stewardship of beluga whales.

6.6 DISCUSSION: TOWARD CROSS-CULTURAL LITERACY

Achieving the sort of results described by Huntington above requires that we move away from discussions of the differences and contradictions between our knowledge systems, in favor of an exploration of common ground (Barnhardt and Kawagley 2005). Participants from all cultures must be willing to become literate in the art of cross-cultural communication: to develop their ability to see “people, problems, issues, and solutions from various cultural orientations” (Arvizu and Saravia-Shore 1990 p. 368) To be literate in a subject does not mean being an expert. It means sharing a common vocabulary that allows meaningful communication. One can be literate in art, mathematics, or poetry without being an expert in the practice and/or history of those subjects. So too is the challenge of cross-cultural literacy. It is not an academic exercise, i.e., learning as much as one can about the other's culture. Rather, it is a process of showing and gaining respect, through listening and open minds, and through the development of a common vocabulary for meaningful conversation, with the terms of that conversation set upon assumptions of trust and validity.

One is sure to encounter many differences between how a climate scientist, a caribou hunter, a small-scale farmer, or any other local expert understands the world. Each is sure to have noteworthy qualities that set them apart: one may be quite secular while the other is embedded within spirituality; one may tend toward skepticism while the other trusts received wisdom, and so on. But typologies like those shown in Figure 6.1 that focus on these aspects offer us little more than archetypes, or caricatures; that these 'differences' between knowledge systems necessarily cause contradictions, however, is very much an ethnocentric assumption. In practice, one more often encounters a mixture of these traits coexisting within the same individual (Barnhardt and Kawagley 2005): "It is not unusual for [people] to live comfortably with the contradictions of different bodies of knowledge" (Durie 2004, p. 1140).

Cross-cultural literacy makes it possible for people to see these differences not as contradictions that limit knowledge, but as complementary perspectives that can further enhance knowledge (Holthaus 2008). Once the preoccupation with difference is discarded, one finds numerous cognitive similarities between knowledge systems that make sharing these different perspectives possible. Figure 6.2 provides an alternative to the typology presented in Figure 6.1, where the emphasis is on several points of common ground that exist between science and the local knowledge-systems of Alaska Natives (after Barnhardt and Kawagley 2005).

Both share an ecological approach to their understanding of the principles that organize the natural world, and strive to use their understanding of those principles to create more efficient and sustainable practices. Both value knowledge and the pursuit of knowledge. Both have extensive understandings of the weather and of the behavior, distribution, and life-cycles of plants and animals. And both look for indicators and patterns, and are disposed toward hypothesis testing and the development of predictive models. In other words, there exists numerous starting-points for the development of a shared vocabulary and the pursuit of common goals.

Consider the first point, for example: the shared ecological approach to organizing and understanding the natural world. This is a way of thinking that emphasizes the relationships and interactions between biotic and abiotic features of the environment, e.g., people, plants, climate, rocks, soil, topography, etc., and it is as fundamental to contemporary applied science paradigms as it is to many indigenous world-views (Kawagley 1995, Chapin III et al. 2009). As common ground, the ecological approach provides a vocabulary of concepts that can facilitate sharing and collaboration, including ideas such as interconnectedness, food webs, population cycles, habitat, disturbances, competition, mutualism, and so forth. These concepts are important not because they facilitate translation of knowledge in the sense described earlier, nor because they provide a lowest common denominator between disparate systems. Rather, they are important because they can facilitate meaningful discussion—of knowledge, observations, concerns, hypotheses, and predictions—in a way that allows all participants to bring their fullest competencies to bear on shared problems. They provide a language by which people from multiple knowledge systems can do science and plan for the future together.

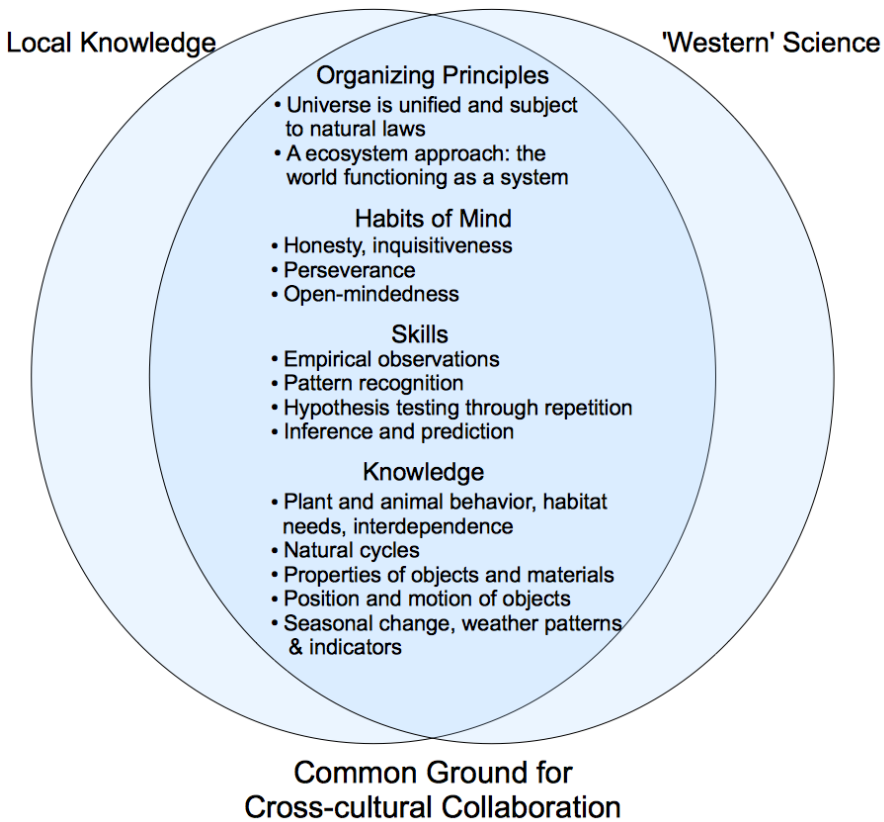

Figure 6.2 Cross-cultural Literacy Seeks Common Ground. As shown in Figure 1, so-called 'western' and 'indigenous' science are often described using a taxonomy of difference and opposites. This figure focuses instead on the common ground that exists between these knowledge systems: shared fundamental principles that can provide a basis for effective collaboration. Adapted from Barnhardt and Kawagley (2005).

6.7 CONCLUSION: A NEW SCIENCE

> This science will work by establishing a second center of experience distinct from our own. … We will not alter their arts, we will not meddle with their lives. Through comparison our culture will rise into awareness and disassemble; then we will draw an ellipse around two centers of equal power, and between those centers find a way to genuine improvement. (Glassie 1995, p. 12)

Overconfidence and other cognitive biases are among the most significant challenges that currently face scientific practice (Oppenheimer et al. 2008) and local knowledge research of the past decade provides an excellent case in point. Preoccupied by difference, the discourse on the uses of local expertise in science has led to little more than increased skepticism and the further entrenchment of ideological positions on both sides of the discussion (Durie 2004). In the quest to make local knowledge more compatible with science, it is frequently dismantled, manipulated, and ultimately rendered meaningless; likewise, local people frequently dismiss or mistrust the values and and intentions of the scientific outsider. However, if we stop questioning *how* our collaborators know what they know, and instead focus on how our knowledges and competencies can reinforce and complement one another, this can provide a powerful basis for scientific inquiry.

Mason Durie (2004) describes this as "research at the interface," a conversation between people from multiple world-views, who seek out common ground that will encourage rather than inhibit insight and innovation. The expanded collaboratory arrangement I have argued for here can provide the structure for that conversation, and cross-cultural literacy can provide the vocabulary for doing an entirely new kind of science. The goal is not a "purer" but a "fuller" science: where many methods of inquiry from many ways of knowing can collaborate to reduce uncertainty and increase knowledge (Roszak 1972, quotes from Nader 1996). Health researchers are on the cutting edge of this work, making significant advances in our understanding of human health through community-based participatory approaches that engage local expertise regarding healing and wellness (e.g., Clark 2005, House 2001, Kleinman et al. 2006, Loring and Gerlach 2009, Mutschler 1992, Wolsko et al. 2007, 2006, Mohatt et al. 2007, Durie 2004). Similarly, successful cross-cultural collaboration in domains such as climate and sustainability science might go far toward reducing this phenomenon of negative learning, which as Oppenheimer and colleagues (2008) describe, continues to significantly limit some of today's most urgent lines of scientific inquiry.

Some see the unprecedented and complex nature of the environmental challenges of the day and argue these as a reason to retreat from such collaboratory experiments, and to regroup around scientific conservatism. However, *not* moving towards a more complete collaboration in environmental sustainability science and management practices reinforces a role of receivership for communities, rather than developing regional and local ownership of regional and local issues (Nadasdy 2005, Irvine and Kaplan 2001) and perpetuates a top-down, help-us-help-you paradigm of practice that has repeatedly failed to successfully address these complex contemporary issues (Dagget 2005, Karkkainen 2004, Sayre 2006). If we can instead find a path to cross-cultural literacy, and remove the ego and ethnocentrism from how we design scientific collaborations, an exchange of ideas becomes possible that may make even the most complex challenges seem less daunting.

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CONCLUSION

> Nature does require
> Her time of preservation, which perforce
> I her frail son amongst my brethren mortal
> Must give my attendance to.

William Shakespeare, *Henry VIII*. Act III. Sc. 2. L. 147

> Health is a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity.

World Health Organization (1946)

People often talk and think about sustainability in dramatically different ways, though these differences are rarely understood or even recognized. Some contend that sustainability requires a continued commitment to development and growth, while others argue that growth and sustainability are mutually exclusive phenomena. Many focus on the practicalities of sustainability in technical, economic, or scientific terms, while others discuss its more normative aspects, including ethics, equity and justice. The subject matter of sustainability, i.e., the sustainability of *what?*, can also vary quite dramatically from a single species or single habitat, to a community or region faced with various forms of environmental change and extreme events, to even broader concerns and 'crises' such as global and 'directional' trends like population growth, climate warming, biodiversity loss, and non-renewable resource extraction. And for each of these perspectives on sustainability, there exist myriad contested solutions, which range in nature and scale from economic to ecological, cultural to technical, local to global.

Arguably, each of these perspectives has the potential to enhance or to narrow the language and tools with which we discuss and pursue 'sustainability solutions'. Each frames the problem quite differently; if recognized, these differences can be a benefit for interdisciplinarity and cross-cultural collaboration; if overlooked, however, they can precondition and even bias research towards a particular subset of findings, management interventions, development strategies, and policies (Brosius 1999, Maxwell 2001, Rappaport 1993). This is the two-fold challenge of sustainability: how do we engage the realms of science and policy in the process of tackling locally scaled and defined problems, without losing control over locally negotiated definitions of needs, wants, hopes, concerns, and values? And in so doing, how do we not also lose sight of regional and global concerns—how each community's actions might impact or undermine the needs, wants, hopes, concerns, and values of others?

I have been repeatedly confronted with the reality of these challenges while doing this work. As I suggest in the introduction to this volume, climate change is just one puzzle piece of many in the milieu of contemporary challenges facing Alaskans (albeit a key one). Too, while sustainability is a comfortable notion, it does not seem to live up to the long-term goals that my collaborators continue to express and pursue: goals of health, self-reliance, self-determination, and security. It is instructive to this point that I have been unable to find any words in the native languages of Alaska that satisfactorily translate to 'sustainability', while many translations avail that effectively communicate the latter set of locally-defined priorities.

Thus, while this dissertation is ostensibly about sustainability, it is not explicitly about sustainability. Rather, it maneuvers through numerous locally-identified issues, each chapter addressing separate but related aspects of health and food security in rural Alaska. On their own, each chapter examines a manageable piece of the food system that can be worked with and improved; together they create something of a mosaic—an impression of a food system that is failing and vulnerable, but that nevertheless retains great potential to provide for healthful and resilient communities. Like a palimpsest, the darkest lines show a picture of an unhealthy and unsustainable present, yet this picture is drawn upon the traces of a more flexible, adaptable, and healthful past. With some luck, imagination, and willingness to change, I believe that these traces can provide guidelines for building a more healthful and more sustainable future.

A lesson of this work is, therefore, that sustainability need not be the primary focus of attention in order for it to be effectively served as a goal. Like food security, sustainability is best treated as a process rather than a state condition: an ethic to be managed with rather than an outcome to be managed for. The distinction, though nuanced, is powerful; it redirects our attention from problems defined and identified by some wholly-ecological, economic, or political calculus for sustainability, and instead to projects that serve the betterment of the human condition. Managing for sustainability involves the identification and redesign of practices deemed unsustainable; managing with a sustainability ethic, however, means building capacity, helping people and communities to solve problems and adapt to circumstances that constrain their ability to pursue healthful and secure livelihoods. In the former, we are constantly consumed by the work of being sustainable; in the latter however, sustainability emerges from the work of being healthy.

I argue, therefore, for nothing less than a complete reorientation of the sustainability discourse around the concept of health. Researchers of historical ecology continue to uncover evidence of how countless human societies, in the pursuit of their own health and well-being, contributed to the stability, structure, and biodiversity of their environments (Balee 2006, Cronon 1983, McGovern 1980, Redman 1999), though this was rarely a primary or explicit goal (Smith and Wishnie 2000). This new understanding of our history gives testament to the fact that we have more often lived as gardeners of 'wild' and 'natural' places than as destroyers. This should not be surprising given *Homo* spp.'s two-plus million year tenure; it is, after all, an axiom of evolutionary biology that nature favors those organisms that leave their environment in better shape for their progeny, and eliminates those who do not (Darwin 1859, Lovelock 2000). And, as we learn more about the intimate role that humans have played in the structure and function of the world's ecosystems, we also continue to learn more about the fundamental role that these environments, in return, play in shaping our own physical, psychological, and sociocultural health outcomes (Clark 2005, Krieger 2005, Ommer 2007). As I discuss in chapters 1 and 2, the traditional notion of human health as a mechanistic, entirely biophysical phenomenon is rapidly being replaced by a new, 'ecosocial' model of health functioning as an integrative relationship between individuals and their biophysical, cultural, and socioeconomic environments (Figure C.1).

Given this reciprocal, mutualistic relationship between people and their environments, a sustainability ethic must therefore be both anthropocentric and ecocentric (c.f., Hawken 1993, Quinn 2006, Schumacher 1973). This is a significant point of departure from the entirely ecocentric ethic that has characterized the last few decades of the environmental movement, an ethic that has done little but increase the perceived division between people and nature (Dagget 2005, Sayre 2006). To identify sustainability as simultaneously ecocentric and anthropocentric is not to say that the sustainability of each human community is not entirely contingent on a set of biophysical or ecological parameters unique to each place; rather, it is to say that a purely-ecological calculus of sustainability is insufficient; that not only must systems be sustainable in the barest sense they also must be desirable. It is to recognize that the human condition is characterized, in the majority of the world, by unease and disease, to identify this as the outcome of unsustainable practices, and to recognize that pursuing sustainability is not a matter of making countless sacrifices, but of pursuing countless gains.

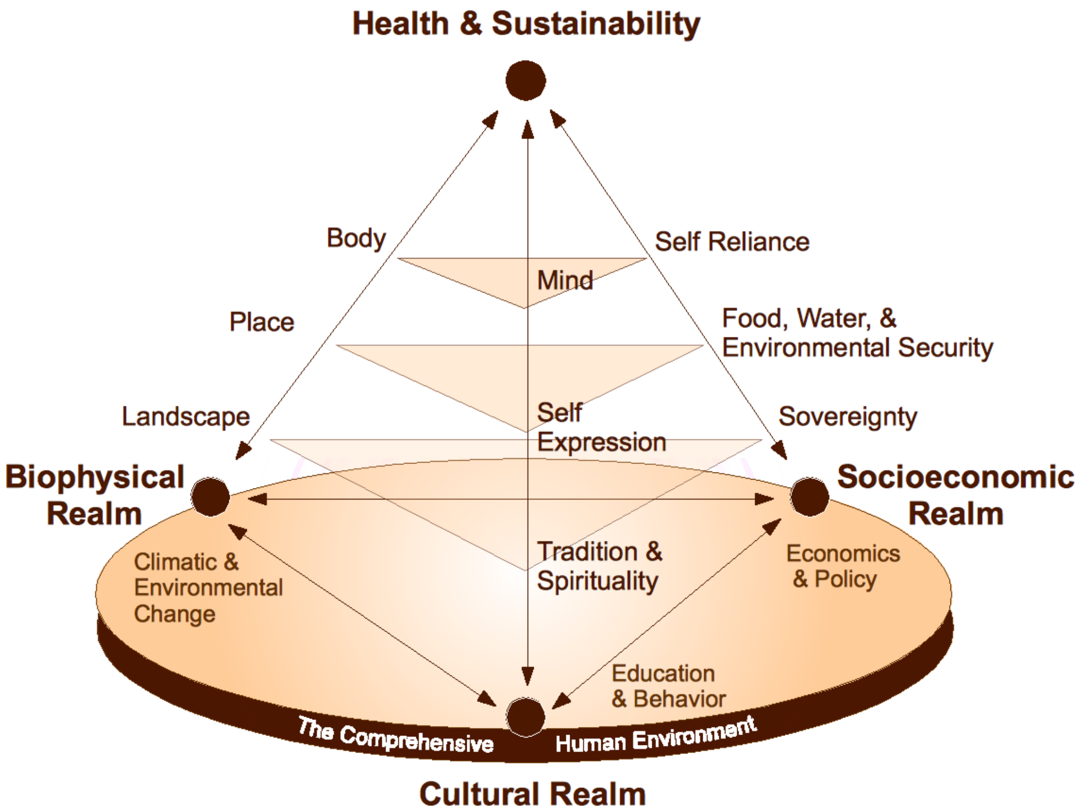

Figure C.1 A World View for Sustainability. This diagram depicts a sustainability ethic based on health as an embodied and enculturated phenomenon of the human experience. The 'comprehensive human environment' represents a simultaneously anthropocentric and biocentric frame of reference, in which exists biophysical, cultural, and socioeconomic realms. The legends on the circle identify slower processes of change in each domain, e.g., education, policy, climate. Each slice along the tetrahedron suggests different levels of organization, from the individual to the society. Health and sustainability are depicted as emergent properties, influenced by, and influencing the dynamics in each realm. After (Kawagley 1995) .

The opportunity in this change of perspective is that it makes people entirely vested in the outcomes of social-ecological reform, something notably absent from the environmental movement, and an omission arguably to blame for the movement's lack of progress toward stemming the tide of environmentally-destructive behavior (Gould et al. 1996, Young 2009). Self interest is a far more powerful motivator than guilt.

Ishmael author Daniel Quinn once quipped, "The world is not in any sense in danger from itself. The world is in fact not in any danger at all. It is we who are in danger" (n.d.). His point is well made; we have for many years been preoccupied by this imagined need to save the world from the impacts of humanity. Yet, practically speaking, it is not the world that needs saving from humanity, but humanity that needs saving from itself:

> Man's use of nature is inextricably intertwined with man's use of Man, [and] remedies for destructive use of the environment must be found within the social system itself. The need for radical reform of our present, compartmentalized ecological control systems simply reflects the need for equally radical reorganizations of human institutions. (Bennett 1976, p. 311)

It is my intent with this work to provide some insights into how we might begin such a reform. It is likely that there is no genetic code within us that predisposes us towards being either gardeners or destroyers of Eden (Balee 2006, p. 76). It stands to reason, therefore, that it is our social environs that fill in the missing pieces of the human behavior puzzle, and move us in one direction or the other (ibid). If we can identify what it is about our societies that make people environmentally insecure and lead them to behave in ways that are environmentally destructive and unsustainable, we can learn to change the rules of the game, with the goal being a future where health, and therefore sustainability, comes naturally. As I have shown, food security, and in more general terms environmental security, can provide manageable pieces through which we can engage with the aspects of our societies that hinder people in their ability to live healthy lives and to confront and adapt to environmental change when they occur.

What's next? For researchers, the mandate continues to be to improve how we engage with the communities that we purport to research, and with the policymakers to whom we imagine ourselves as advisors. Basic science has failed because it is too slow; applied science has failed because it is either too politic or not enough. Imagining a new and more potent paradigm for generating knowledge and putting that knowledge into action arguably means shedding much of the institutional dogma that we carry regarding science as an institution. Collaboration must become more open and inclusive, and knowledge more organic, driven by necessity and innovation rather than funding and tenure. The 21st century information economy is nothing less than a revolution; that it has thus far only powered increased skepticism of science is not a failing of those who participate in the dialog, but of those who do not.

Moving sustainability science into a more anthropocentric space also means that we must learn to practice a new kind of 'reconciliation ecology' (c.f., Rosenzweig 2003), which, rather than attempting to isolate itself from subjective human matters in the service of a purer science, learns to comfortably and explicitly admit these values into a fuller and more inclusive scientific enterprise. Finding ways for human communities to coexist and participate in natural communities, not merely how to minimize and mitigate human impacts, is the task at hand. The goal, therefore, is not to create a more scientific approach to sustainability and its complexities, but a more human one. While sustainability science research programs like resilience theory are able to identify many of these best-practices for designing ecologically-sustainable systems, decisions regarding how to operationalize them in lifestyle and culture must ultimately be reconciled through a partnership with local people, and a process of innovation and experimentation that creates solutions appropriate to each place. As I describe above, I believe that human health provides the necessary medium for partnerships between scientists, policymakers, and community-members for working through these difficult and admittedly subjective matters.

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APPENDIX A

PHILIP ALLEN LORING BIOSKETCH

Philip A Loring is an anthropologist and writer trained under Dr. S. Craig Gerlach (PhD anthropology, Brown University, 1989). Philip received his MA in anthropology from the University of Alaska Fairbanks in 2007 and his BA in liberal studies from Florida Atlantic University in 2005. In 2008 Philip was selected as a Fulbright fellow but chose instead to pursue an opportunity studying with the Sonoran Institute in Tucson, AZ. His interests are food systems, sustainability and self-reliance, health, and nutrition, natural systems farming, intellectual property rights, and the anthropology of science and technology. He writes a monthly column on matters of food, health and nutrition for the *Ester Republic,* a local (Alaskan) periodical, and has served as co-editor of the Anthropological Papers of the University of Alaska.

Philip's work is most influenced by the art of Keith Haring, the mentorship of Dr. Gerlach, and the writings of Daniel Quinn, T.S. Eliot, Gary Nabhan, Angayuqaq O. Kawagley, Sinclair Lewis, and Stephen King.

APPENDIX B

CREATIVE COMMONS LICENSE INFORMATION