# Building resilient coastal communities in British Columbia: A case study of climate change and adaptability in Ucluelet, BC

by

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Honours B.Soc.Sc., University of Ottawa, 2007

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# Supervisory Committee

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# Abstract

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This thesis is a study of change and adaptability in a social-ecological system. In order to contribute to efforts toward sustainability on the British Columbia coast, the study focuses on the fisheries and aquaculture sector in Ucluelet, BC to investigate four specific issues, including: how coastal communities experience and deal with change; how global environmental change affects coastal communities; the key factors that build or threaten social-ecological resilience in coastal communities; and how resilience and adaptive capacity can be built to adapt to change and, in turn, shape change for sustainability.

The findings of this thesis have relevance for systems on the British Columbia coast and at large. Above all, the experience in Ucluelet shows that the resilience of these communities is not in their maintenance of stability, but rather in their ability to turn successive experiences of change into opportunities for new cycles of more sustainable development and renewal.

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# Chapter 1: Introduction

## 1.1 Introduction:

Throughout history, natural environments and human societies on the modern day British Columbia coast have interacted and coevolved. Since early history, human groups have survived and flourished on the basis of the natural resources of the Pacific coast, including fisheries resources, timber, and minerals (Marchak et al. 1999; Young and Matthews 2007). Due to the highly dynamic nature of the coastal ecosystem, these societies have been shaped and re-shaped by changes in the ecosystem in which they are embedded (Ommer et al. 2007). At the same time, the coastal ecosystem itself has been profoundly influenced by humans, and more specifically, by changing forces in human societies at local (e.g., type of technology used), regional (e.g., type of management system in place), and global (e.g., economic globalization) scales (Berkes and Folke 1998b; Young 2008; Young and Matthews 2007). These changes have interacted over time to affect the health of ecosystems and communities on the British Columbia coast.

The dynamic and integrated nature of ecological and human systems is a defining feature of the British Columbia coast. However, in the past century or more, and in the past two decades in particular, a misalignment between human societies and the natural environment has resulted in the decline of many coastal ecosystems in BC. This has shown in a decline in ecosystem biomass and overall system complexity (*see* Ainsworth et al. 2002, cited in Ommer et al. 2007). This has been caused in part by local and regional anthropogenic disturbances, including resource overexploitation, unsustainable harvesting practices (i.e., draggers), tourism development, shoreline development, land

and sea-based pollution, eutrophication and siltation (Berkes et al. 2001; Millennium Ecosystem Assessment [MA] 2005). These factors have contributed to a significant loss in the capacity of ecosystems to buffer against disturbances, thus disrupting the structure and functional performance of the ecosystems and the essential services they provide (Berkes and Folke 1998b; Adger et al. 2005; MA 2005).

Larger forces are also at play. Coastal ecosystems are increasingly vulnerable to the impacts of global environmental change, including a rising sea level, which is likely to exacerbate storm surges, coastal erosion, and other coastal hazards, warming air and sea surface temperatures, increased ocean acidification, modification of precipitation and wind regimes, and changing storm frequency and intensity (IPCC 2007a). These disturbance regimes represent an additional disturbance facing coastal ecosystems in British Columbia, particularly where levels of resilience are already low (Walker and Sydneysmith 2008; Adger et al. 2005).

This thesis aims to contribute to efforts that build resilience toward sustainable development in communities on the British Columbia coast, that is, 'development that meets the need of the present without compromising the ability of future generations to meet their own needs' (WCED 1987). For the purposes of this thesis, sustainability implies maintaining the capacity of ecological systems to support ecological, social and economic systems. Ecological systems, or ecosystems refer to self-regulating communities of organisms interacting with one another and with their environment. Social systems that are of primary concern include those dealing with formal and informal institutions, and systems of knowledge (Berkes and Folke 1998b; Berkes et al. 2003b). Institutions are any formal constraints (rules, laws, and constitutions) or informal

constraints (norms of behavior, conventions, and self imposed codes of conduct) that mold interactions in a society (North 1994), or, in resource management systems, that control resource use (Ostrom 1990). It is important to note that social systems, as defined here, encompass the social, cultural and economic aspects of human societies. Hence, the term social system is sometimes interchangeable with socio-cultural or socio-economic system in this thesis. It is also important to note that when I wish to emphasize the integrated concept of linked human and natural systems, I use the term social-ecological system or social-ecological linkages (*sensu* Berkes and Folke 1998a).

Following the work of Berkes and others (2003a), I consider sustainability as a dynamic process, rather than an end product, that requires a system maintain its resilience and adaptive capacity. Resilience and adaptive capacity are key concepts in this thesis, as resilience, which is necessary to sustain adaptive capacity, is used as a way of analyzing change and transitions to more sustainable development pathways in social-ecological systems. This, according to Lambin (2005), is one of the greatest challenges facing humanity in the decades to come. However, it is presently one of the most neglected and the least understood aspects in conventional resource management and science (Gunderson and Holling 2002).

### 1.2 Importance of Coastal Ecosystems:

Coastal ecosystems – coastal lands, areas where fresh water and saltwater mix, and nearshore coastal areas and open ocean marine areas – are a major contributor to both ecological and social systems. From an ecological perspective, coastal ecosystems exhibit remarkably high biological productivity and diversity and provide a number of essential ecosystem services, including nutrient storage and cycling, filtration, shoreline

protection, water regulation, climate regulation, carbon sequestration and oxidation (Berkes et al. 2001; MA 2005). Furthermore, these systems encompass a number of different types of ecosystems, including terrestrial ecosystems, wetlands, rocky or muddy intertidal areas, beaches and dunes, seagrass meadows, kelp forests, nearshore islands and nearshore coastal waters, thus providing important habitat for many types of land and sea-based mammals, birds, amphibians, fish and crustaceans (Costanza et al. 1997; Lemly et al. 2000). Furthermore, coastal ecosystems provide sustenance for people and form the basis for livelihoods in many coastal communities (Ommer et al. 2007; MA 2005; Adger et al. 2005). These systems also have valuable cultural uses including spiritual, recreational, educational and artistic applications that all contribute to human well-being (Garibaldi and Turner 2004).

Despite their value to ecological and social systems, coastal ecosystems all over the world are in a state of decline. According to the Millennium Ecosystem Assessment, coastal ecosystems are among the most productive yet highly threatened systems in the world: "These ecosystems produce disproportionately more services relating to human well-being than most other systems, even those covering larger total areas. At the same time, these ecosystems are experiencing some of the most rapid environmental change" (2005). This is due to a spate of anthropogenic disturbances at local, regional and global scales. These include the abovementioned local and regional impacts (Berkes et al. 2001; MA 2005), as well as global-scale impacts of accelerated environmental change. For the purposes of this thesis, climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity (IPCC 2007a).

While there is increasing evidence of climate change impacts on coastal ecosystems (IPCC 2007a), disentangling the impacts of climate-related stresses from other stresses is difficult, and the ultimate implications of both kinds of disturbances are linked. It is therefore suggested that the challenge for human societies will not be to address linear or predictable future threats, but to build resilience and adaptive capacity to deal with multiple, uncertain and interacting stresses while still maintaining options for development (Gunderson and Holling 2002; Folke et al. 2002; Folke, 2006; Nelson et al. 2007). This challenge is particularly relevant for communities on the British Columbia coast (*see* below).

### 1.3 Coastal Communities in British Columbia:

The combination of climate-related and other disturbances presents a challenge to communities on the British Columbia coast. The resilience of coastal ecosystems in British Columbia has, in many cases, already been eroded as a result of resource overexploitation and other anthropogenic impacts (Adger et al. 2005; Walker and Sydneysmith 2008; Marchak et al. 1999). Furthermore, in the past two decades, the capacity of people and communities to shoulder ecological and social stresses has been pushed to the utmost (Young 2008).

In the early 1990s, the simultaneous decline of the three major resource industries of fishing, forestry and mining severely impacted communities on the British Columbia coast. Throughout the 20$^{th}$ century, the tremendous expansion of BC's resource economies was vital to the development of rural communities in BC. However, the sudden decline of these economies has severely impacted rural and remote portions of the province. In particular, small, rural, resource-based communities on the coast are in

trouble, as the resources and ecosystems that once supported communities have all but disappeared (Ommer et al. 2007; Marchak et al. 1999). This is compounded by complex changes occurring at various scales, including an increasingly powerful First Nations rights movement, increasing competition in global markets and a recent provincial government strategy involving strong neoliberal reforms, which have in many cases excluded small, rural communities from provincial strategies for development (Young 2006b; Young and Matthews 2007).

The culmination of ecological and social (cultural, economic, political) stresses in the past two decades has manifest in the appearance of 'ghost towns' and towns 'in transition' along the British Columbia coast (Marchak et al. 1999; Young 2008; Young and Matthews 2007; Young 2006a). In many communities, incomes have hit historic lows, and there are fewer people living there than there were one hundred years ago (Ommer et al. 2007). What is interesting, however, is that though there is decline in many communities, others seem to be doing relatively well (Page et al. 2007). In most cases, this has involved embracing new opportunities in tourism and/or alternative resource industries such as aquaculture. The successful 'transition' or recovery of a number of communities shows the potential resilience of people and groups to reorganize and create a new society when faced with a shock. This experience begs the question: *What are the elements of human societies that sustain resilience and adaptive capacity in social-ecological systems in the face of change?* According to many, addressing how people respond to change and how society reorganizes following change may be the most important challenge facing contemporary resource and environmental management and science (Gunderson and Holling 2002; Resilience Alliance 2010).

In the past two decades, communities on the British Columbia coast have shouldered severe social-ecological stresses and are now trying to reorganize and recover. Both the ecological and social components of the coastal system are of critical importance to this process. In the context of ongoing change, addressing the elements of human societies that sustain and build resilience and adaptive capacity toward sustainable development in communities on the British Columbia coast is a critical need. This thesis addresses this need through the lens of the concept of resilience.

### 1.4 Introduction to the Resilience Approach:

While previously in human history there have been major events or changes in the ability of ecosystems to support social systems, resilience was so high that nature could be seen as fairly stable. The resilience of the ecosystem allowed it to absorb change and still persist. However, in the present era, human alteration of ecosystems is taking place at wider scales and at a more rapid pace than ever before. This has resulted in modified ecological resilience, and a related increased likelihood of social-ecological surprises or shocks (Folke et al. 2003; Adger et al. 2005). A transition toward sustainability will require a shift in perspectives to one of the world as consisting of complex, rather than stable or predictable, life-supporting ecosystems, not only amongst scientists, but also the general public at large (Folke et al. 2003). This implies a shift in human societies toward resource management and uses that maintain the capacity of ecosystems to sustain ecological and societal needs in the face of ongoing change (Kates and Clark 1996; Gunderson and Holling 2002).

In order to deal with the complex nature of linked social-ecological systems, this study uses the idea of resilience as an organizing concept and scoping device (*sensu*

Berkes et al. 2003b). Thus, the study approaches the issue of change and adaptation in communities on the British Columbia coast through the lens of the concept of resilience.

Resilience is the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks (Resilience Alliance 2010). The concept of resilience has been applied to ecosystems, social systems and social-ecological systems. Ecosystem resilience is defined as the capacity of an ecosystem to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes. A resilient ecosystem can withstand shocks and rebuild itself when necessary (Resilience Alliance 2010; Holling 1973). Social resilience has the added capacity of humans to anticipate and plan for the future, and is defined as the ability of human societies to withstand external shocks to their social infrastructure, such as environmental variability or social, economic or political upheaval (Adger et al. 2005b). However, systems may be ecologically resilient but socially undesirable, or they may be socially resilient but degrade their natural environment (Folke et al. 2003). It is therefore important to address the linked nature of human and ecological systems. Humans are a part of the natural world – we depend on ecological systems for our survival and we continuously alter the ecosystems in which we live from the local to the global scale. This thesis is concerned with these linkages, with an emphasis on social-ecological resilience (Resilience Alliance 2010; Folke et al. 2003).

The concept of resilience, and the use of resilience as a tool for analysis and management in social-ecological systems, is an explorative and rapidly developing area of research. The journal, *Ecology and Society*, as well as a multidisciplinary research

group, the *Resilience Alliance*, are dedicated to the study of the dynamics of complex social-ecological systems in order to discover foundations for sustainability. However, more research is needed to understand the ways in which societies reorganize following change (Resilience Alliance 2010; Berkes et al. 2003b). More work is also required to take resilience into practice in resource analysis and management (Dempster 2010; Marshall and Marshall 2007). It has been suggested that case studies offer a valuable tool to explore resilience in the field (Berkes and Folke 1998a; Berkes et al. 2003a). By continuing to apply resilience in case studies of various social-ecological systems, the approach will continue to develop as a tool in resource analysis and management, with important implications for sustainable development (Folke et al. 2003; Berkes et al. 2003b).

### 1.5 Introduction to the Case Study:

The purpose of this study is to investigate change and adaptability in a social-ecological system and the elements of that system that influence resilience in order to contribute to efforts toward sustainable development in similar systems on the British Columbia coast. The study is focused on Ucluelet, British Columbia.

The District municipality of Ucluelet (population 1 487 in 2006) is located on the southern tip of the Ucluth Peninsula, along the western edge of Vancouver Island on the British Columbia coast (Statistics Canada 2006). The area was chosen because of the dynamic nature of both its coastal ecosystem and social system and the linkages between these two, as well as its recent exposure to social-ecological change. These characteristics are assumed to exist broadly across communities on the British Columbia coast. Therefore, the aim of the thesis is to contribute to efforts for resilience toward sustainable

development in Ucluelet specifically *and* in communities on the British Columbia coast in general, on the basis of the results of the case study.

Given the social-ecological history of the community (explored in detail in Chapter 4), this will be done through a specific focus on the fisheries and aquaculture sector, bearing in mind that a key feature of the history of communities on the BC coast has been the changes that have occurred within and across all resource sectors.

### 1.6 Research Questions:

Understanding that natural environments and human societies are complex, linked and coevolving through time (Holling et al. 1998), I propose the following research question:

- *What can be learned from investigating elements of human societies that sustain and build resilience and adaptive capacity toward sustainable development in social-ecological systems on the British Columbia coast?*

To answer this question, I study the issue of change and adaptation in Ucluelet, British Columbia. To focus the study, I propose four specific questions to address the main research question. These are:

a. *How do coastal communities experience and deal with change in their social-ecological systems?*
b. *How does global environmental change affect social-ecological systems in coastal communities?*
c. *What are some of the key factors that contribute to threatening or building resilience in social-ecological systems in coastal communities?*

d. *How can resilience and adaptive capacity be built to adapt to change and shape change for sustainability?*

To address these research questions, I propose an analytical framework for the cases study based on the work of Folke and others (2003), who deal with the issue of change and adaptation through the lens of resilience. The framework is described in detail in Chapter 2.

## 1.7 Thesis Overview:

This thesis has seven major chapters. Chapter 2, *Literature Review*, reviews the literature on change and disturbance on the British Columbia coast, and the literature on global environmental change in particular. It then reviews the resilience approach, and the role it can play in the analysis of social-ecological systems. Chapter 3, *Methodology*, describes the methodology used to address the posed research questions. Chapter 4, *The Case Study*, reviews the historical and present social, ecological and social-ecological context in Ucluelet. Chapter 5, *Analysis Part I*, presents the results of the case study analysis of climate change in Ucluelet. Chapter 6, *Analysis Part II*, presents the results of the case study analysis of resilience and adaptive capacity in Ucluelet, and what can be learned for other social-ecological systems on the British Columbia coast. Chapter 7, *Conclusion*, recaps the major findings of this research, and points out its major theoretical, methodological, policy contributions, as well as recommendations for future research.

# Chapter 2: Literature Review

This chapter first reviews a history of change and disturbance on the British Columbia coast. Second, it reviews the literature on global environmental change, with specific attention to how it might affect social-ecological systems on the British Columbia coast, and how the issues of change and adaptation are currently approached. Third, it describes the resilience approach and briefly reviews some of the key elements of resilience. Finally, the concept of resilience as a tool for the analysis and management of social-ecological systems is discussed.

## 2.1 A History of Change on the British Columbia Coast:

The British Columbia coastal zone was originally inhabited by indigenous peoples who survived and flourished on the basis of the natural resources of the Pacific coast. Key archaeological sites in the Haida Gwaii region of the northern British Columbia coast indicate the presence of human groups as far back as 10 500 years ago (Ommer et al. 2007). Taken together, these and other early sites show that the Ancestral Haida and other groups were very fluent in marine resource use and organic technologies. In addition, they show human occupation at a time of extreme environmental change, including changing flora and fauna and rapidly rising sea levels, which attests to the resilience of early coastal peoples (Ommer et al. 2007).

Europeans first arrived on the British Columbia coast in the late 18$^{th}$ century. The arrival of seaborne explorers in the 1770s, followed by traders of sea otter pelts, began a significant process of change on the British Columbia coast. The uneven distribution of European trade goods, particularly firearms, as well as the introduction of exotic diseases

to which indigenous peoples had no immunity caused tremendous suffering (*see* Harris 1997/98; Ommer et al. 2007). In the early 19th century, European settlements were sparse and populations were small, mostly concentrated in land-based trading posts along the coast and in the interior. During the second half of the 19th century, however, foreign interests in the territory turned away from modest trading operations (which involved partnerships with First Nations) toward settlement and control over natural resources and lands (Ommer et al. 2007). By the early 1900s, First Nation peoples and claims were limited to reserve allotments, which amounted to a small fraction of the total land area of British Columbia; the vast majority of the province was opened for non-First Nation settlement and development (Harris 1997/98; Ommer et al. 2007).

The primary economic activities in the coastal settlements during the 18th and 19th centuries included small-scale agriculture, fishing and shellfish harvesting, and extractive industries based on forests and minerals. These activities contributed to the development of basic infrastructure and road networks in the province. In turn, improvements in infrastructure and transportation routes in the 19th century increased settlement in coastal areas, and resource-based economic activity began to flourish and expand (Harris 1997/98). For instance, halibut, herring, sardines, hake and salmon all supported major fisheries in the province throughout the 1800s, with salmon showing a particular dominance from a socio-cultural perspective (Garibaldi and Turner 2004).

During the 20th century, the tremendous expansion of British Columbia's resource economies was vital to the development of rural communities in BC, in the postwar period in particular[1]. This involved the rapid expansion of the major traditional resource

[1] In the postwar period in British Columbia, employment in forestry grew threefold from 1945 to 1970, while employment in mining doubled from 1951 to 1981 (Hayter 2000). This was the result of a postwar

industries of fishing, forestry and mining. In addition, from modest beginnings in the commercial sector in the 1960s and 1970s, aquaculture[2] emerged as a major industry in BC from the 1980s onwards. However, in the past century, and in the past two decades in particular, a misalignment between human societies and the natural environment has resulted in the decline of many coastal ecosystems in BC (*see* Chapter 1, Section 1.2). This has been caused in part by local and regional anthropogenic disturbances, which have contributed to a significant loss in ecological value on the coast and in human terms a concomitant loss in social and economic stability (Ommer et al. 2007; Adger et al. 2005b; MA 2005). Furthermore, coastal ecosystems are increasingly vulnerable to the impacts of global environmental change (Adger et al. 2005a). These changes are described in detail below.

In the context of ongoing change (including climate change) on the British Columbia coast, addressing the elements of the human societies that sustain and build resilience and adaptive capacity toward sustainable development is of the utmost importance (Gunderson and Holling 2002; Folke 2006; Folke et al. 2002; Nelson et al. 2007).

## 2.2 Global Environmental Change:

Climate change is defined as any change in climate over time, whether due to natural variability or as a result of human activity (IPCC 2007a). The Fourth Assessment Report of the International Panel on Climate Change (IPCC 2007a) states: "Warming of

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provincial government strategy for rural development, which involved the expansion of rural industry and settlement (Young and Matthews 2007).

[2] At its most basic, aquaculture involves an extension of the principles of agriculture to marine environments (Young and Matthews 2010). In fact, aquaculture in BC can be traced back to Aboriginal harvesting and maintenance of natural clam beds (Tollefson and Scott 2006). Since the 1970s, however, most aquaculture in BC has involved the private enclosure of selected nearshore areas for highly controlled harvesting.

the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level" (Figure 2.1). At continental, regional, and ocean basin scales, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather have also been observed (IPCC 2007a). The Fourth Assessment Report (IPCC 2007a) also states that the observed widespread warming of the atmosphere and oceans, together with ice mass loss, support the conclusion that it is extremely unlikely that global climate change of the past 50 years can be explained by natural causes alone, and that most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations (Figure 2.2).

If greenhouse gas emissions continue at or above current rates[3], it is projected to cause further warming and induce many changes in the global climate system during the 21st century that will very likely exceed those observed during the 20th century (IPCC 2007a). It is projected that global average surface temperature warming for the end of the 21st century will be between 1.1°C to 6.4°C, given the differences between low and high emissions scenarios, and the uncertainty associated with these scenarios[4] (IPCC 2007a; Dawson et al. 2008). It is also projected that global average sea level rise at the end of the 21st century will increase between 0.18 m and 0.59 m relative to 1980-1999 levels (IPCC 2007a). Increasing atmospheric carbon dioxide concentrations also leads to increasing

[3] The IPCC (2007a) reports that even if anthropogenic carbon dioxide emissions were to be stabilized, both past and current emissions would continue to contribute to warming and sea level rise for more than a millennium, due to the time scales required for removal of this gas from the atmosphere.

[4] Best estimates and likely ranges for global average surface air warming for six emissions marker scenarios are given in the Fourth Assessment Report. The best estimate for the low scenario is 1.8°C (likely range is 1.1°C to 2.9°C), and the best estimate for the high scenario is 4.0°C (likely range is 2.4°C to 6.4°C) (IPCC 2007a).

acidification of the ocean, which has already been observed since pre-industrial times (IPCC 2007a). Over the 21st century, average global surface ocean pH is projected to decrease between 0.14 and 0.35 units, corresponding with an increase in acidity (IPCC 2007a). Furthermore, it is very likely that hot extremes, heat waves and heavy precipitation will continue to become more frequent, and that storm events will become more intense as a result of increases in sea surface temperatures (IPCC 2007a).

Observational evidence from all continents and most oceans shows that natural systems in all parts of the world are being affected by the abovementioned climate changes. This includes impacts on natural and human environments. For example, human health has been affected by increases in heat-related mortality, infectious disease vectors, and allergenic pollen. In natural environments, climate change has had a discernible influence on physical systems and biological systems (IPCC 2007b). In the 21st century, these influences are expected to increase. For example, approximately 20 to 30 percent of plant and animal species are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5 to 2.5°C. There are also projected to be major changes in ecosystem structure and function, species' ecological interactions, and species' geographical ranges, with predominantly negative consequences for biodiversity, and ecosystem goods and services. Furthermore, the progressive acidification of oceans due to increasing atmospheric carbon dioxide is expected to have negative impacts on marine shell-forming organisms (e.g., coral reefs) and their dependent species (IPCC 2007b).

Climate change presents a threat to coastal ecosystems (MA 2005). It is likely that the resilience of many coastal ecosystems will be exceeded this century by an

unprecedented combination of climate change and associated disturbances, and other change drivers (e.g., resource overexploitation, land-use change, pollution) (IPCC 2007a; MA 2005). This represents a major challenge facing systems on the British Columbia coast, particularly where levels of resilience are already low (Walker and Sydneysmith 2008; Adger et al. 2005b).

### 2.2.1 Climate in British Columbia:

British Columbia is the most physically and biologically diverse region in Canada. The proximity of the Pacific Ocean and presence of several major mountain chains significantly influence British Columbia's climate and ecosystems. On the coast, mild, moist Pacific air encounters the Coast Mountains to produce a humid, maritime climate with annual air temperatures above 5°C and total annual precipitation exceeding 1000 mm (Figures 2.3 and 2.4) (Rodenhuis et al. 2007; Walker and Sydneysmith 2008). This coastal region of BC is located in the Coastal Western-Hemlock biogeoclimatic zone (Figure 2.3).[5]

Two major ocean-atmosphere phenomena have been observed in coastal British Columbia: 1) the El Niño–Southern Oscillation (ENSO), and 2) the Pacific Decadal Oscillation (PDO). Both are naturally occurring patterns, but their frequency and intensity appear to be changing in response to global climate change (Timmerman, 1999; Walker and Sydneysmith 2008).

The ENSO is a tropical Pacific phenomenon that influences global weather patterns in a cycle of 3 to 7 years. During warm 'El Niño' events, warm waters from the

[5] British Columbia can be divided into 14 biogeoclimatic zones, distinguished by climate, latitude, elevation and distance from the coast. This biogeoclimatic classification system is used widely for both planning and research purposes (Walker and Sydneysmith 2008).

equatorial Pacific migrate up the west coast of North America and influence sea-surface temperatures, sea levels, and local climate in British Columbia. El Niños bring warmer temperatures and less precipitation to BC, whereas cool 'La Niña' events bring cooler and wetter conditions (Rodenhuis et al. 2003).

The PDO is a longer (approx. 20 to 30 year) climate variability pattern similar in effect to ENSO. The positive (warm) PDO phase is characterized by warmer coastal waters and is associated with slightly warmer conditions across BC, and variable effects on precipitation. The opposite occurs during the negative (cold) PDO phase, with cooler and wetter conditions. Shifts between PDO phases result in major changes in climatic and oceanographic regimes, affecting winds and storms, ocean temperatures and currents. The PDO shifted from a negative (cold) to a positive (warm) phase in 1976 (Walker & Sydneysmith 2008; Dawson et al. 2008)[6].

These two climate variability patterns are linked, since the PDO either amplifies or dampens the effects of ENSO events, affecting not only temperature and precipitation but also snowpack, streamflow, growing degree days, frost-free periods, winds, seasonal ocean levels and storm surges. The effects of ENSO and PDO in western North America are widespread and well documented (Rodenhuis et al. 2003).

Understanding the factors that control climate variability in BC is important for a wide range of planning purposes (Walker and Sydneysmith 2008). Furthermore, Walker and Sydneysmith (2008) demonstrate that understanding the prehistoric record of climate variability and change is relevant to the assessment of future climate change in BC. In particular, records of longer-term climate history, in combination with a complex pattern

[6] The PDO may have shifted from warm to cool since the mid to late-1990s; however, it is difficult to positively identify a change between phases until sufficient records have been accumulated, many years after the shift occurs (Dawson et al. 2008).

of climate variability, demonstrate the dynamic nature of BC's climate and the great likelihood that climate 'surprises' will occur in the future.

The major indicators of climate variability and change that have been identified for British Columbia (Walker and Sydneysmith 2008) include: major shifts in climate variability, changing temperature and precipitation, changing frequency and magnitude of extreme weather and weather-related events, changing hydrology, increasing sea levels, storm surges and enhanced coastal erosion, and the reorganization of ecosystems. These are discussed in detail in Chapter 5.

Facing uncertain future climate-related and other changes on the BC coast, it seems that the challenge for coastal communities will not be to address linear or predictable future threats, but to build resilience and adaptive capacity to deal with multiple, uncertain and interacting stresses while still maintaining options for sustainable development (Gunderson and Holling 2002; Folke et al. 2003; Folke 2006; Nelson et al. 2007). This implies human responses that promote capacity-building in the ecological and social components of a system in order to adapt to change (Berkes et al. 2003b).

### 2.2.2 Dealing with Change in Social-Ecological Systems:

Adaptation refers to an adjustment in ecological or social systems in response to observed or expected changes in environmental stimuli and their effects in order to alleviate adverse impacts of change (IPCC 2007b; Nelson et al. 2007). For the last few decades, many researchers in the climate change field have assumed that climate change and human responses are best understood and managed using a vulnerability approach (Nelson et al. 2007). This approach seeks to identify the characteristics of an ecological system (e.g., geographic location, ecological properties) that make it vulnerable to change

and the characteristics of the connected social system that lead to (or detract from) the capacity of human actors to respond and adapt (Dolan and Ommer 2008). The objective of the approach is the reduction of vulnerability[7] through enabled adaptation actions (Nelson et al. 2007).

The vulnerability framework has provided insight into the necessary components of adaptation in human societies. It has recognized that adaptation involves actors, actions, and agency and is an ongoing process (Adger 2001; Burton 2008). However, it has recently surfaced that the approach may not adequately capture intricate processes of change and adaptability in complex social-ecological systems (Dolan and Ommer 2008; Nelson et al. 2007).

Both ecological and social components of systems are complex; they change and evolve through nonlinear and unpredictable processes and feedbacks (Berkes et al. 2003b; Levin 1999). Though vulnerability research has made strides to consider adaptation as a continual process that requires adaptive capacity (Smit and Wandel 2006; Handmer 2003; Francisco 2008), adaptation is nevertheless considered in response to specific risks, and therefore does not account for multiple, unpredictable, and interacting stresses in systems. Furthermore, evaluations of adaptation actions are static in nature – levels of risk are measured before and after specific adjustments have taken place – and therefore do not allow for uncertain and unpredictable future change (Dolan and Ommer 2008; Nelson et al. 2007).

The complexity of social-ecological systems is further increased by the interaction between the social and ecological components (Berkes et al. 2003; Larkin 1977; Clark

[7] Vulnerability is defined in the adaptation literature as the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes (IPCC 2007b; Adger and Kelly 1999; Watts and Bohle 1993; Smith et al. 2003).

and Munn 1986; Ludwig et al. 1993; Gunderson et al. 1995b). Though the vulnerability approach has crossed into the realm of interdisciplinary research by considering together environmental and social vulnerability (van Aalst et al. 2008; Smit and Pilifosova 2003; Dolan and Walker 2006; Klein and Nicholls 1999; Cutter et al. 2000), it is suggested that the approach could be widened further by going beyond current summative exercises and considering more explicitly and qualitatively the ways in which environmental change interacts with and is mediated by social-ecological system components, including how multiple ecological and social stressors interact across scales to change the nature of exposure and the consequences for human well-being (Nelson et al. 2007; Dolan and Ommer 2008). Both the social and ecological domains of a system must be considered simultaneously in order to grasp the complex interplay of social-ecological systems (Folke 2006).

One possible way to address these challenges is to approach the analysis and management of change and disturbance in social-ecological systems using the concept of resilience.

## 2.3 The Resilience Approach:

### 2.3.1 Roots of the Resilience Approach:

#### 2.3.1.1 Complexity

The concept of resilience is rooted in the recognition that the natural state of a system is one of change, rather than one of stability. Until recently, the common scientific (biological) perspective was that systems were linear and predictable, and could therefore be managed to remain in a stable and optimal state (Folke 2006; Berkes et al.

2003b; Holling and Meffe 1996). The more recent recognition that processes in ecology and societies are seldom linear and predictable has led to the notion of complexity (Berkes et al. 2003b). Earlier challenges to the idea of linear causality and reductionist science go back to general systems theory, which emphasizes connectedness, context and feedback between the components of a system. Complex systems theory builds upon general systems theory by incorporating the ideas of nonlinearity, uncertainty, emergence, scale, and self-organization (Berkes et al. 2003b; Kauffman 1993; Levin 1999). These attributes of general and complex systems theory have important implications for resource and environmental analysis and management and are useful in understanding the complex nature of change in social-ecological systems (Holling 2001; Folke 2006; Walker et al. 2002).

The foundation of complex systems theory provides insight into the reasons that conventional approaches to resource and environmental analysis and management are not working well, and in some cases making problems worse. "The lesson from complex systems thinking is that management processes can be improved by making them adaptable and flexible, able to deal with uncertainty and surprise, and by building capacity to adapt to change" (Berkes et al. 2003b, p.9). This notion of adaptive management addresses the importance of a system's capacity for flexibility, diversity, learning and adaptation (Gunderson et al. 1995b; Berkes and Folke 1998b; Berkes et al. 2003b).

#### 2.3.1.2 Social-Ecological Linkages

The notions of connectedness, complexity and adaptive management also underscore the importance of the linkages and feedbacks between social and ecological

components of a system (Berkes et al. 2003b). Until recent decades, both natural sciences and social sciences were very limited in dealing with social-ecological linkages (Berkes et al. 2003b). This changed in the last few decades with the rise of several subfields in the social sciences that explicitly include the environment in the framing of issues. These integrative areas include: environmental ethics, political ecology, environmental history, ecological economics, common property, and traditional ecological knowledge (Berkes et al. 2003b). These areas can be seen as a 'bridge' spanning natural science and social science thinking and provide insight into the complex and dynamic interplay of social-ecological systems.

The abovementioned concepts and tools are now widely used to study change and disturbance in social-ecological systems (Gonzalez et al. 2008). They also provide the theoretical underpinnings of the resilience approach (Folke 2006).

### 2.3.2 Resilience:

The concept of resilience was introduced by C.S. Holling in 1973 as way to understand the complex nature of change in ecosystems. The resilience concept has since been broadened and applied to social-ecological systems (Berkes and Folke 1998b; Berkes et al. 2003b).

The concept of social-ecological resilience (henceforth resilience) incorporates ideas from ecological and social resilience literature (Folke 2006). As defined by the *Resilience Alliance* (2010), and as used in this thesis, resilience has three defining characteristics:

- The amount of change the system can undergo and still retain the same controls on function and structure;

- The degree to which the system is capable of self-organization; and
- The ability to build and increase the capacity for learning and adaptation.

The majority of work on resilience has focused on the first characteristic, that is, the capacity to absorb disturbance and still persist (Gunderson et al. 1995b). However, resilience is not only about being persistent or robust to disturbance; it is also about the opportunities that disturbances open up in terms of recombination of existing processes and structures and renewal of the system in new trajectories. The second and third characteristics of resilience – the capacity for self-organization, learning and adaptation – perform this role. The second and third characteristics of resilience provide a system's adaptive capacity, that is, the capacity to adapt to and shape change (Walker et al. 2002). It is these properties of resilience and adaptive capacity that allow a system to absorb disturbance and reorganize in the face of change (Berkes et al. 2003b).

The concept of resilience is a promising tool for analyzing adaptive change toward sustainability because it provides a way of analyzing how to maintain adaptability, which is, the capacity of actors in a system to influence resilience. In a social-ecological system, this amounts to the capacity of humans to respond within the social domain, and also to respond to and shape ecosystem dynamics in an informed manner (Resilience Alliance 2010; Berkes et al. 2003b). The use of resilience as a tool for analysis does not seek to replace other approaches (e.g., vulnerability research) but rather create a space where ecological and social research can be brought together and integrated with new ideas from resilience in order to better analyze and manage change and transitions to more sustainable development pathways in social-ecological systems (Folke 2006; Anderies et al. 2006).

It is important to note that the resilience approach is a framework for thinking about the dynamics of social-ecological systems, rather than a well-defined theory. This is due to the complexities of describing social-ecological systems (Folke 2006; Anderies et al., 2006). However, through a combination of integrative conceptual development and qualitative analysis of case studies it is possible to use a resilience approach to increase our understanding of social-ecological systems (Anderies et al. 2006; Walker et al. 2002; Walker et al. 2006).

### 2.3.3 The Adaptive Renewal Cycle:

In the field of resilience, the adaptive renewal cycle is used as an heuristic device, or metaphor for interpreting cycles of change in social-ecological systems (Gunderson et al. 1995b; Holling et al. 2002; Walker et al. 2002).

The model of an adaptive renewal cycle proposes that systems evolve though four phases: exploitation, conservation, release, and reorganization (Figure 2.6). During the exploitation phase (r), there is incredible growth and an increase in the organization and accumulation of capital. As the system moves into the conservation phases (K), growth slows and the system becomes increasingly connected, rigid, and vulnerable to disturbance. A disturbance event then triggers a rapid release (Ω) of accumulated resources, leading the system to a reorganization (α) of structures and functions (Folke 2006; Gunderson and Holling 2002). Typically, the front-loop of the system (r to K) is characterized by slow growth and accumulation, and relative predictability, while the back-loop (Ω to α) is characterized by rapid change and uncertainty (Gunderson and Holling 2002). Conventional, often unsustainable, management systems tend to focus on the front-loop of the cycle (which corresponds to ecological succession in ecosystems and

constitutes a development mode in societies) in an attempt to reduce variability and increase efficiency, while ignoring the release and reorganization phases (Berkes et al. 2003b; Holling and Meffe 1996). Yet, these two backloop phases are very important in the overall cycle: it is these phases that create the conditions for self-organization, learning, and adaptation (Folke et al. 1998; Berkes and Folke 2002).

As complex systems are hierarchically structured in a number of levels, many adaptive renewal cycles exist in a system and are linked across space and time scales in a so-called 'panarchy' structure (Figure 2.7) (Gunderson and Holling 2002). The term panarchy is used to capture the interactions between adaptive cycles that operate at different scales (Berkes et al. 2003b). At least two features of panarchy (or cross-scale interaction) may contribute to understanding resilience: (1) disturbance in the small-scale system can cascade to the broader scale (by "revolting" or overwhelming the larger, slower system), and (2) a large-scale system can provide resources (by "remembering" or carrying over elements) for the reorganization and renewal of the smaller-scale system. The memory connection is particularly important during times of reorganization and renewal as it provides sources of self-organization and resilience (Berkes et al. 2003b).

The concepts of the adaptive cycle and panarchy are not unique to the resilience approach (Redman and Kinzig 2003); however, they provide useful tools to help interpret change in social-ecological systems.

## 2.4 Resilience as a Tool for Analysis and Management:

A common perspective until recently was that our ability to sustain our natural resources and ecosystems has been improving. This perspective follows a strong faith in the scientific understanding of ecosystems, the availability of sophisticated tools and

technologies, and the application of economic mechanisms (e.g., individually allocated quotas in fisheries) to solve ecological problems (Berkes et al. 2003b). However, the growing gap between environmental problems and our lagging ability to solve them has led many scientists to reevaluate resource and environmental analysis and management, in the past three decades in particular (Berkes et al. 2003b).

There is an emerging consensus among scientists of the need to look for broader approaches and solutions, not only in regard to resource and environmental problems but also across a wide front of societal issues. There is a call for more creative forms of collaboration between scientists and society, involving a broader range of disciplines and increased pubic participation (Berkes et al. 2003b). There is also agreement that new approaches must be able to deal with the nature of the problems at hand, that is, those that involve complexity, uncertainty, social-ecological linkages, cross-scale interactions, and rapid, transformational change (Walker et al., 2002; Carpenter and Gunderson 2001).

As an alternative to conventional approaches, Folke and colleagues (2003) in the volume *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change* propose dealing with issues of change and adaptation through the lens of resilience. The ultimate objective of their volume is to contribute to efforts towards sustainability, that is, the use of environment and resources to meet the needs of the present without compromising the ability of future generations to meet their own needs. In the volume, and as used in this thesis, sustainability is considered as a process that implies maintaining the capacity of ecological systems to support ecological, social, and economic systems. The specific objectives of the volume are to investigate how human

societies deal with change in social-ecological systems, and how capacity can be built to adapt to change and, in turn, to shape change for sustainability.

Through an investigation of cases and examples that are chosen from a diversity of geographic areas, cultures, and resource types, the authors of the volume – who include both academics and practitioners who come from a diversity of backgrounds – examine ways of building resilience to enhance capacities to deal with change and surprise. The authors conclude that there are four sets of factors (highlighted in many of the case studies) that seem to be required for dealing with change in social-ecological systems. These are: learning to live with change and uncertainty; nurturing diversity for reorganization and renewal; combining different types of knowledge for learning; and creating opportunity for self-organization toward social-ecological sustainability (Folke et al. 2003).

The way these factors are addressed in relation to building resilience for adaptive capacity is presented in the framework shown in Table 2.1. The first category, ‘learning to live with change and uncertainty’, emphasizes the necessity of accepting change and living with uncertainty and surprise, for example, through strategies that take advantage of change and crisis and turn it into opportunity for development (Folke et al. 2003). The second category, ‘nurturing diversity for reorganization and renewal’, illuminates the importance of nurturing diversity for resilience, recognizing diversity not only as insurance to uncertainty and surprise (not putting all eggs in one basket), but also as an important source for enabling more options following disturbance (through memory, or accumulated experience for coping with change) (Folke et al. 2003). The third category, ‘combining different types of knowledge for learning’, addresses the importance of

different forms of knowledge, experience and understanding about the dynamics of ecological systems, their inclusion in management institutions, and their complementarity to conventional management (Folke et al. 2003; Berkes and Folke 1998b). The final category, 'creating opportunity for self-organization', brings these issues together in the context of self-organization, which provides the foundation for evolutionary change in ecosystems and for future sustainable opportunity in human societies (Resilience Alliance 2010; Folke et al. 2003).

The framework laid out by Folke *et al.* (2003) was used by Berkes and Seixas (2005) in the article *Building Resilience in Lagoon Social-Ecological Systems: A Local-Level Perspective* to explore resilience in lagoon social-ecological systems. Through the analysis of case studies, Berkes and Seixas (2005) conclude that while there are by no doubt other ways to categorize factors that affect resilience, it is important to organize them in a way in which they reinforce one another when applied across cases. They also point out that while no single factor will apply across all systems, a category of factors related to, for example, self-organization, will be relevant to all systems. Hence, the use of categories accommodates the differences between cases, while capturing the broader dimensions of each category, which are: uncertainty, diversity, knowledge, and self-organization (Berkes and Seixas 2005). Following the work of Berkes and Seixas (2005), this thesis will employ the framework laid out by Folke and colleagues (2003) to explore resilience in social-ecological systems on the British Columbia coast.

Coastal systems in all parts of the world are currently experiencing enormous, uncertain, and interacting changes across scales. In the face of the unprecedented combination of climate change and associated disturbances, and other change drivers

(IPCC 2007a; MA 2005), it is possible to use the lens of resilience to address change and transitions to more sustainable development pathways in social-ecological systems (Gunderson and Holling 2002).

### 2.5 Summary:

This chapter reviewed the history of change and disturbance on the British Columbia coast. It then introduced the relevant literature on global environmental change, and discussed how this might affect social-ecological systems on the British Columbia coast. It then addressed the issue of dealing with change in complex social-ecological systems. In the final section, it reviewed the resilience approach to analysis and management and presented a framework for dealing with change in social-ecological systems.

**Table 2.1 Building resilience and adaptive capacity in social-ecological systems**

| |
|---|
| Learning to live with change and uncertainty |
| Evoking disturbance |
| Learning from crises |
| Expecting the unexpected |
| Nurturing diversity for reorganization and renewal |
| Nurturing ecological memory |
| Sustaining social memory |
| Enhancing social-ecological memory |
| Combining different types of knowledge for learning |
| Combining experiential and experimental knowledge |
| Expanding from knowledge of structure to knowledge of function |
| Building process knowledge into institutions |
| Fostering complementarity of different knowledge systems |
| Creating opportunity for self-organization |
| Recognizing the interplay between diversity and disturbance |
| Dealing with cross-scale dynamics |
| Matching scales of ecosystems with governance |
| Accounting for external drivers |

**Figure 2.1 Changes in temperature, sea level, and Northern Hemisphere snow cover**

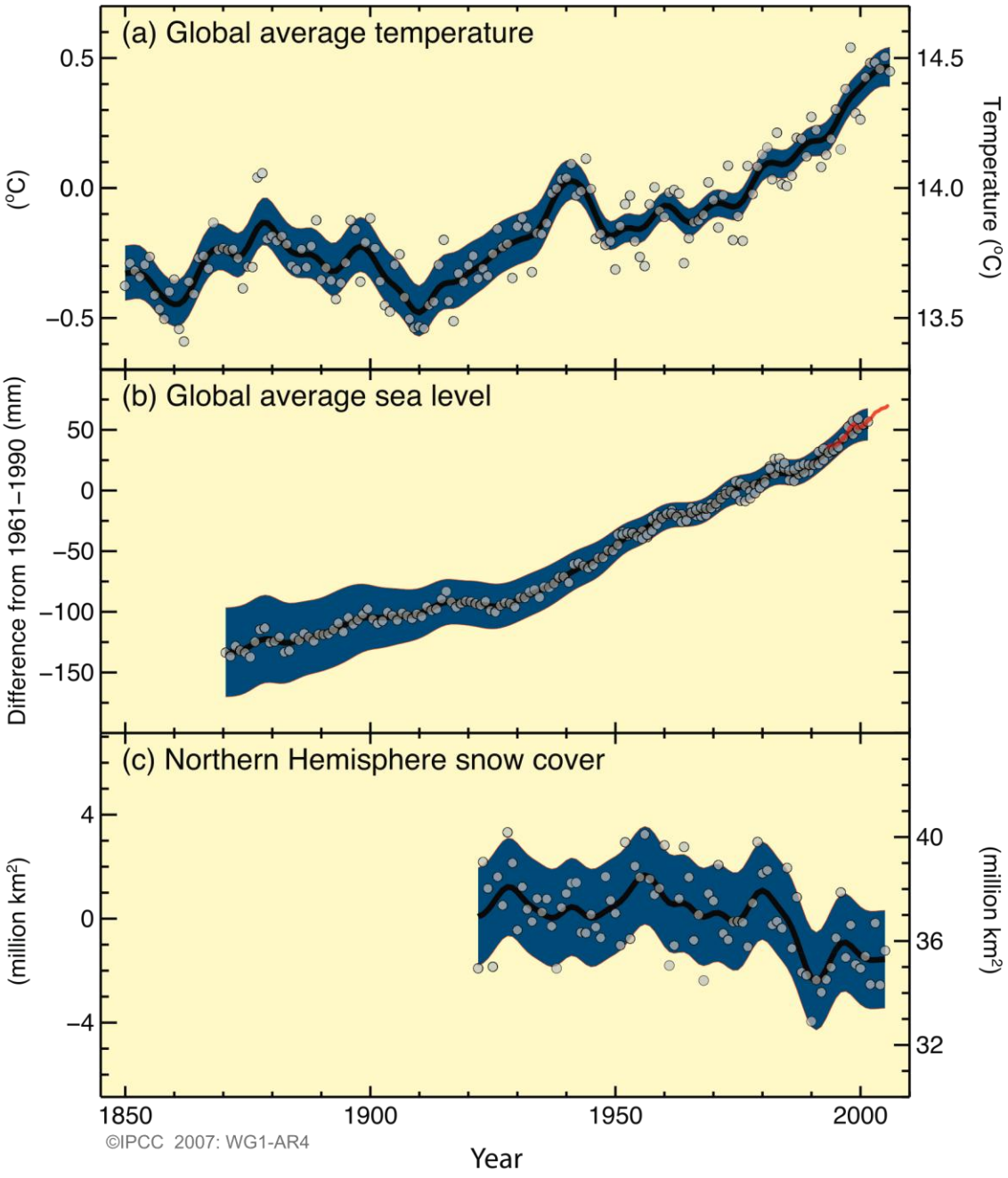


Figure 2.1. Observed changes in (a) global average surface temperature, (b) global average sea level from tide gauge (blue) and satellite (red) data and (c) Northern Hemisphere snow cover for March-April. All changes are relative to corresponding averages for the period 1961-1990. Smoothed curves represent decadal average values while circles show yearly values. The shaded areas are the uncertainty intervals estimated from a comprehensive analysis of known uncertainties (a and b) and from the time series(c) (IPCC 2007a).

**Figure 2.2. Global and continental temperature change, natural versus natural and anthropogenic forcings**

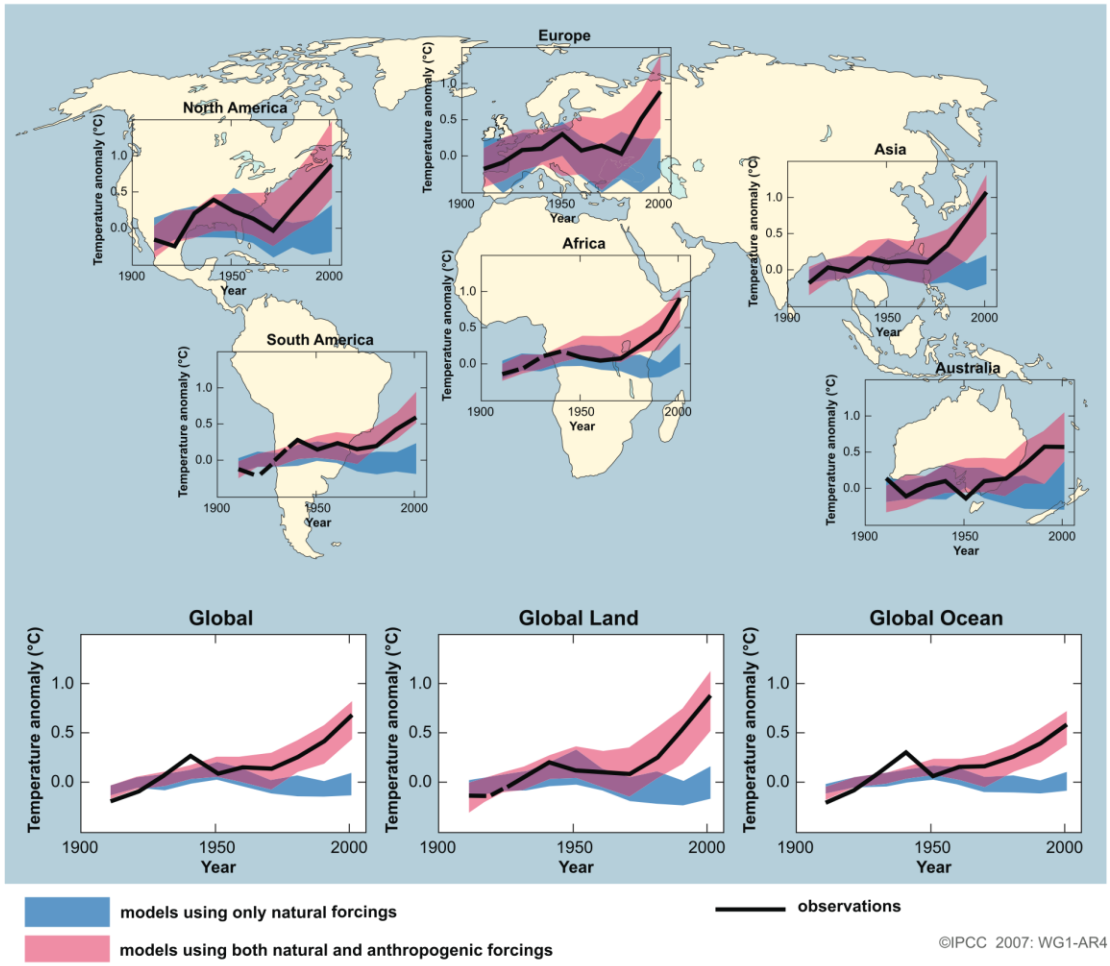


Figure 2.2. Comparison of observed continental- and global-scale changes in surface temperature with results simulated by climate models using natural and anthropogenic forcings. Decadal averages of observations are shown for the period 1906 to 2005 (black line) plotted against the centre of the decade and relative to the corresponding average for 1901–1950. Lines are dashed where spatial coverage is less than 50%. Blue shaded bands show the 5–95% range for 19 simulations from five climate models using only the natural forcings due to solar activity and volcanoes. Red shaded bands show the 5–95% range for 58 simulations (IPCC 2007a).

**Figure 2.3 Annual mean temperature in British Columbia**

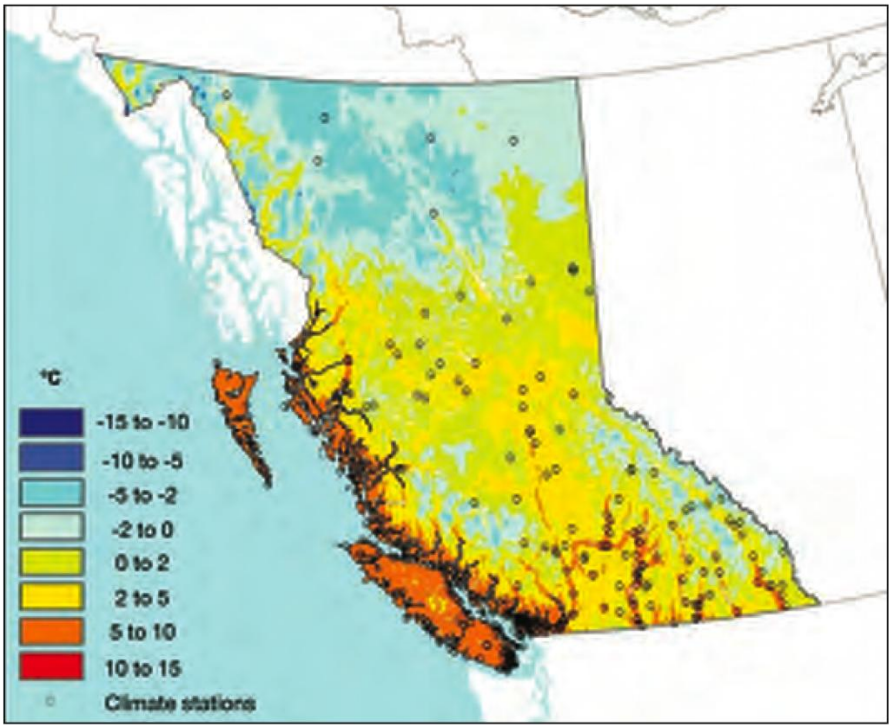


Figure 2.3. Annual mean temperature in British Columbia from 1961-1990 PRISM[8] average. The PRISM numerical method interpolates station observations to a 4 km grid considering physical factors such as slope aspect and elevation. The PRISM model is considered more robust in areas with higher density of data collection stations and at elevations near the stations (Rodenhuis et al. 2007).

[8] Parameter-elevation Regressions on Independent Slopes Model (Rodenhuis et al. 2007)

**Figure 2.4 Annual total precipitation in British Columbia**

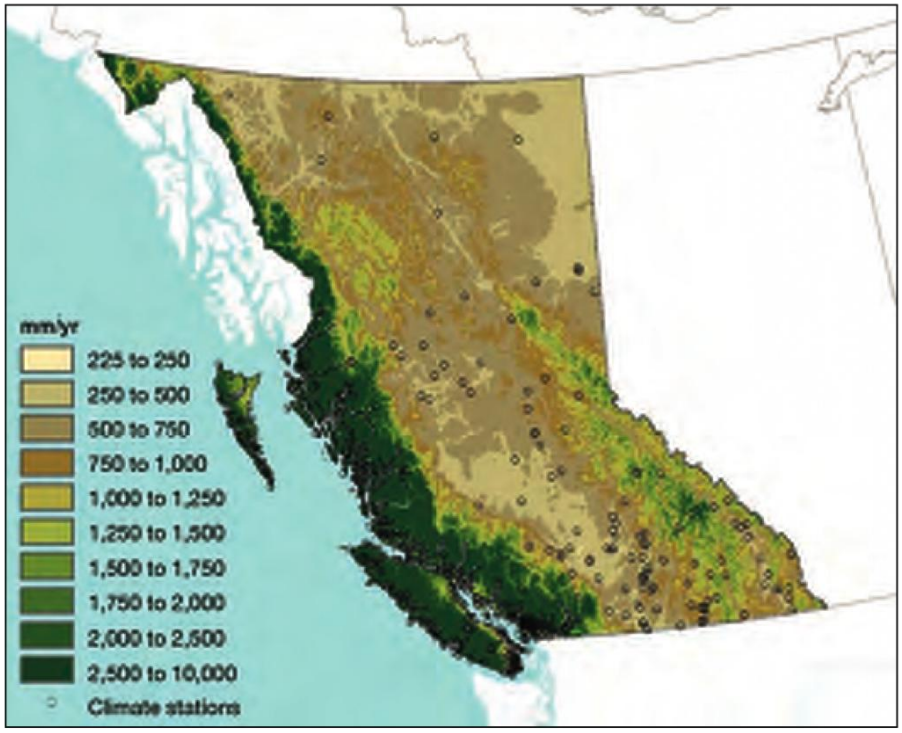


Figure 2.4. Annual total precipitation in British Columbia from 1961-1990 PRISM (*see* Note 8) average. The wettest climates in Canada occur on BC's coast, especially on mountain slopes of Vancouver Island, the Queen Charlotte Islands and the mainland Coast Mountains (Rodenhuis et al. 2007).

**Figure 2.5 British Columbia's biogeoclimatic zones**

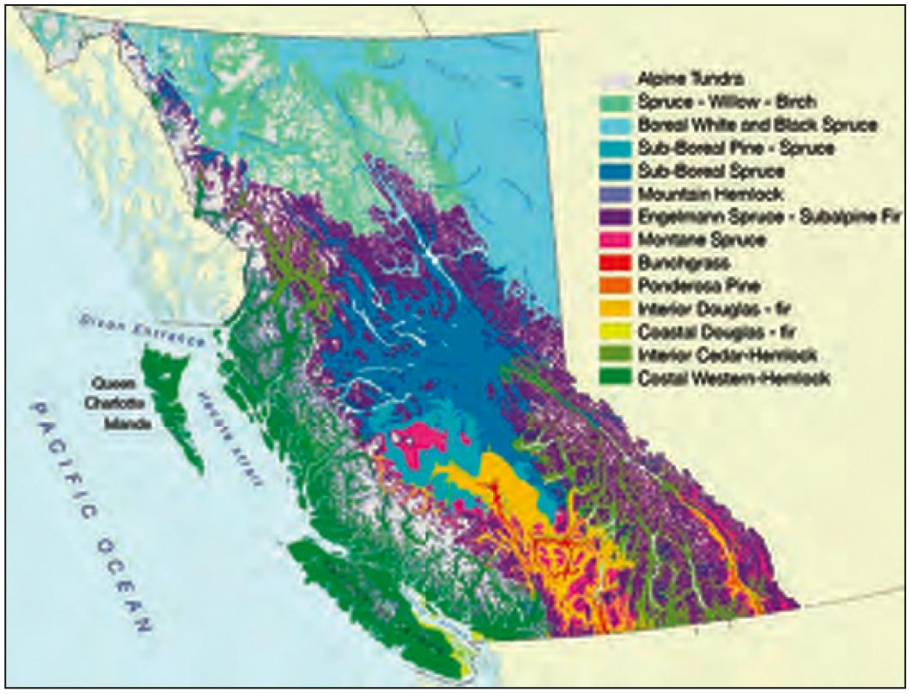


Figure 2.5. British Columbia's 14 biogeoclimatic zones (Walker and Sydneysmith 2008).

**Figure 2.6 The adaptive renewal cycle**

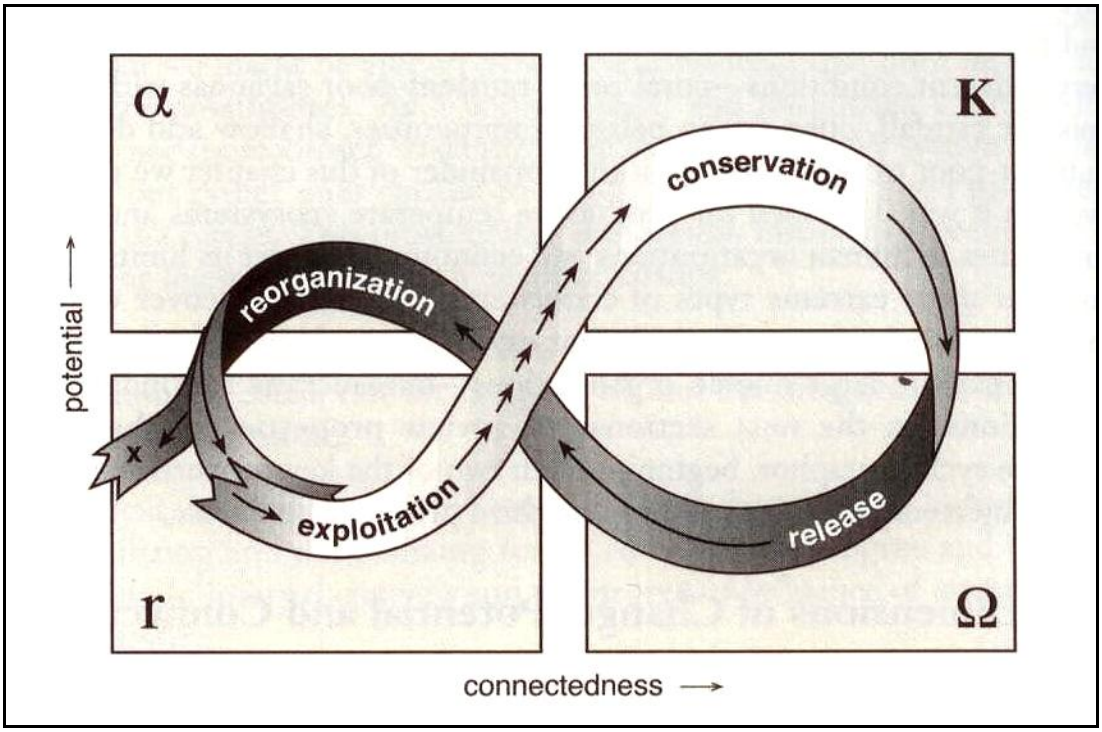


Figure 2.6. A representation of the adaptive renewal cycle showing the four phases (exploitation, conservation, release and reorganization) and the transition between them. The long arrows show quick changes while the closely spaced arrows show slow changes. The 'x' in the bottom left-hand quadrant indicates where potential may leak away from the system and a transition to a less desirable state may occur (Holling and Gunderson 2002, p.34).

**Figure 2.7 The panarchy concept**

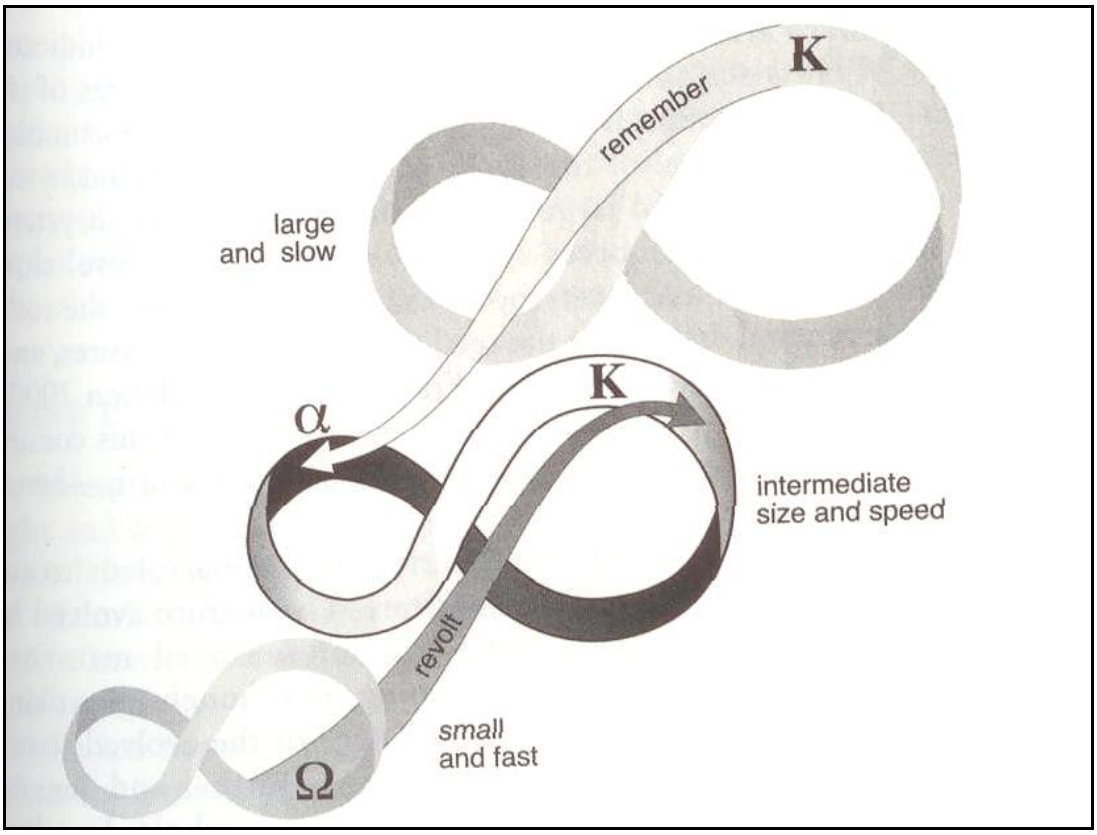


Figure 2.7. The concept of panarchy links adaptive cycles operating at different scales (Holling et al. 2002, p.75).

# Chapter 3: Methodology

This chapter reviews the methodology used to answer the research questions presented in Chapter 1. The chapter first presents the rationale for using a qualitative research approach, integrated with quantitative data. Second, the chapter addresses the researcher bias inherent in the research process. Third, the chapter examines the research methods used to study the issue of change and adaptation in Ucluelet, BC. Finally, the process of data analysis is described.

## 3.1 Rationale for Research Approach:

Understanding the complex nature of social-ecological systems leads to a recognition of the importance of qualitative[9] analysis. As Berkes et al. (2003b) have stated:

> Qualitative analysis follows from the nature of nonlinearity. Because there are many possible mathematical solutions to a nonlinear model and no one 'correct' numerical answer, simple quantitative[10] output solutions are not very helpful (Capra 1996). This does not imply that quantitative analysis is not useful. Rather, it means that there is an appropriate role for both quantitative and qualitative analyses, which often complement each other (p. 7).

For instance, as Lugo (1995) points out, attempts to quantify supposedly sustainable yields in tropical forests rarely leads to ecosystem sustainability. Rather, a strategy focusing on resilience, through an understanding of regeneration cycles and ecological processes at the local level may be the key to sustainability.

---

[9] Qualitative methods are methods used to explain individual experiences, social processes and social structures (cultural, economic, political) (Winchester 2000; Hay 2000).

[10] Quantitative methods involve hypothesis testing and statistical analysis. They are mainly concerned with measurement, causality, prediction, generalization and replication (Bryman 2001).

In order to obtain a local level perspective on the ecological and social components of the universe being studied, to address the research questions presented in Chapter 1, this study uses aspects of an ethnographic, participatory case study approach, integrated with locally specific quantitative and secondary sources of data.

Ethnography is a process; it involves prolonged observation of a social group or system, typically through participant observation in which the researcher is immersed in the field, or through interviews with members of the group. In such ways, the researcher is able to study meaning from the behaviours and interactions observed (Creswell 1998). I used aspects of an ethnographic approach to obtain comprehensive, local level information about the universe being studied. This approach encompassed multiple methods of data collection, including interviews with local people, and extended participant observation and immersion in the field. The field research methods used are presented below.

A participatory case study approach was also used. Participatory research is research that works *with* a community and *for* them by involving local people throughout the research process (Delemos 2006; Kemmis and McTaggart 2000). I used aspects of a participatory approach because it allowed me to: produce in depth information that represents the perspectives and experiences of local people that they themselves have identified as accurate; to ensure that the methods and questions chosen are appropriate, meaningful and relevant to those who will address and use them; provide a full and open account of how and under what conditions ideas arose; incorporate multiple accounts; position participants as stakeholders rather than subjects of the research; and, build trusting and reciprocal relationships with participants to gain deep insights into the real

life-worlds of participating groups (Kidd and Kral 2005; Mahon et al. 2003; Wiber et al. 2004). This approach encompassed multiple methods, including a focus group, key informant interviews, unstructured interviews, and a structured questionnaire, as well as day-to-day interactions with local people. The research methods used are presented below.

In this study, aspects of ethnography and participatory research were combined in order to facilitate a case study of Ucluelet, BC. This combination allowed me to gain in depth information through observation and immersion in the local ecosystem and social system, as well as in depth insight into the perspectives and experiences of local people about topics they themselves identified as meaningful and accurate. Furthermore, as Castree (2005) points out, case study research investigates phenomena in a particular context that can also be found in other places, making the case study unique but not singular. Therefore, I was able to address the research questions from a local level perspective, but also glean elements of resilience that may be robust across social-ecological systems on the BC coast.

It is important to note that there are challenges to qualitative research methods derived from ethnography and participatory research. One commonly stated challenge is the time- and resource-intensive nature of the research for both researcher and participants. In this study, participant's commitments were kept to a set time unless the participant wished to continue. They were also disclosed to the length and other details of their commitment prior to their participation in a consent form, which is presented in Appendix A. In longer interviews such as the focus group, refreshments and healthful snacks were provided to prevent participant fatigue.

Another commonly stated challenge is that qualitative forms of research 'lack rigour', which refers to the conventional use of the term within quantitative research (Kidd and Kral 2005; Baxter and Eyles 1997). In quantitative research, rigour is established through criteria including validity, reliability, objectivity and generalizability (Baxter and Eyles 1997). In qualitative research, it is important to establish rigour using other means. Baxter and Eyles (1997) review eleven main principles for establishing rigour in qualitative research (Table 3.1). Ten of these principles were applied in this study. The missing principle, revisiting respondents, was practiced only in cases where respondents were willing and available; it was not applied in all instances.

A final commonly stated challenge is that community-based research gains are rarely sustained beyond the project's lifespan. This risk will be addressed by providing a summary report of the research findings to Ucluelet's Mayor and Council for consideration in the Official Community Plan (presently under review). The report will also be sent to interested participants as well as local and regional groups and organizations contacted during the course of my fieldwork. The research findings will also be used by West Coast Aquatic to inform their current work to create a Comprehensive Ocean Zoning plan for Barkley Sound and an Integrated Coastal and Ocean Management Plan for the broader West Coast of Vancouver Island (WCVI) area.

## 3.2 Researcher Bias:

As researchers, we bring a set of assumptions, beliefs, theoretical orientations, and expectations to our research that shape our ability to tell the story of others (Jackson 1999; Baxter and Eyles 1997). This subjectivity can affect the direction of the research process and introduce bias (Jackson 1999). Therefore, before undertaking this study, it is

important that I position myself within the research and explore my values and biases (Dempster 2010).

I am a Canadian woman studying geography at the University of Victoria. Prior to my experience in British Columbia, I completed my undergraduate degree in International Development and Globalization at the University of Ottawa, Ontario. I also worked as a research assistant to a professor at the University of Ottawa on the Coastal Communities Project (CCP), which built on the work of its predecessor, the Resilient Communities Project, to investigate 'transitions' in rural, resource-based communities in BC following the collapse of the mining, forestry and fishing industries in the 1990s. I have spent two years on the British Columbia coast, including approximately three months in Ucluelet.

I chose to study the issue of change and adaptation in Ucluelet on the basis of my previous experience researching coastal communities in BC. Ucluelet was selected as a rural coastal community that has undergone significant change, but that also demonstrates the potential resilience of societies to reorganize and recover when faced with a shock. I chose to use the lens of resilience for this study in recognition of the inherently dynamic nature of coastal systems, as well as the intimately linked nature of ecological and social systems on the coast. It was this desire to bridge ecological and social systems analysis and management that led me to the field of geography. Furthermore, I chose to frame the results within the lens of resilience rather than vulnerability, as I believe it promotes the empowerment of the case study community.

Given my background, I am an 'outsider' to the Ucluelet community. However, as Riessman (2002) has stated, following the relationships that are formed when living in

case study communities, it is difficult if not impossible to present data completely bias free. In order to remain mindful of my personal bias during the research process, I practiced critically reflexive research. This involved a careful reflection of my research practices, my position in relation to the research topics and study area, and my relationship with study participants (Al-Hindi and Kawabata 2002; Crang 2003; Baxter and Eyles 1997; Ley and Mountz 2001).

The practice of critically reflexive research is important to establishing rigour through confirmability in qualitative research, that is, similar to the conventional notion of objectivity, the degree to which findings are determined by the respondents and conditions of the inquiry and not by the biases, motivations, interests or perceptions of the researcher (Baxter and Eyles 1997). A detailed description of the research methods and steps of data analysis used in this research is presented below.

### 3.3 Research Methods:

As I began to formulate my research topic and approach in January 2009, I sought an early association with relevant actors and organizations to inquire about topics, questions and methodological processes that would be appropriate for the context and setting in which I would be working (Kesby et al. 2005). Also, from January 2009 to August 2009, I reviewed academic literature, scientific information, government policy documents, census and archival data, planning and management reports, various thematic maps, and other materials in order to obtain information about my research topics and study area.

Prior to conducting fieldwork in the community, a Certificate of Approval from the University of Victoria Human Research Ethics Board (HREB) was obtained. Ethical

considerations included: respect for human dignity of all research participants; respect for free and informed consent of all research participants; respect for privacy and confidentiality of personal information; respect for justice, fairness and equity in the generation and dissemination and information; and, the minimization of harm and the maximization of benefit of the research for the subjects themselves, for other individuals, and for the advancement of knowledge (HREB 2007, 2009). The application of these principles is laid out in a formal participant consent form (*see* Appendix A). Also prior to conducting fieldwork in the community, an assistant researcher was hired to assist the conduct and transcription of interviews.

Finally, prior to conducting interviews in the community, I presented the research goals and design to Ucluelet's Mayor and Council and attending community actors at a bi-monthly council meeting on 8 September 2009. The study's goals were also published in an article in the local newspaper, the *Westerly News*. Comments and feedback were recorded and integrated into the study. Fieldwork was carried out between September 2009 and November 2009. Research methods included interviews (carried out in several formats), participant observation and secondary research. A description of the methods used is presented below.

### 3.3.1 Interviews:

Interviews were carried out in several formats. These included: semi-structured interviews with a focus group and key informants, unstructured interviews, and a structured questionnaire. Interviews were designed to elucidate: socio-demographic characteristics (age, education, employment and residence); local knowledge; the main changes in the local social-ecological system in the last six decades; determinants of

health (individual, community, environmental); elements of the local social-ecological system that build or threaten resilience; and, local indicators of climate variability and change and associated impacts, risk perceptions and adaptation strategies. I focused the interviews by concentrating on the fisheries and aquaculture sector; however, given a diversity of local perspectives and experiences, insights from all areas were gained. Focus group, key informant and structured questionnaire interviews were carried out with 65 people. Interviewees' occupations are listed in Appendix B.

It is important to note that I did not use language that was not brought up by the interviewees themselves (e.g., the use of the terms vulnerability or resilience). Rather, interviewees were encouraged to talk freely about the topics by using terms and phrases that represented their perspectives accurately.

#### 3.3.1.1 Focus group interview

An initial group interview was held with four individuals who held positions in the realm of local politics, community planning and resource management. This interview was conducted to develop a broad understanding of the most important issues and concerns facing the community, as well as to gain consultation and feedback regarding the goals and design of the study (Conradson 2005).

In the group interview, I acted as facilitator, while my assistant researcher moderated and took notes. The interview was audio recorded and later transcribed by the researchers. The Mayor and all four members of the local council were invited on several occasions to participate in this interview at their convenience. Of these, one councillor participated.

#### 3.3.1.2 Key informant interviews

Semi-structured interviews ranging from 40 minutes to two hours were carried out with ten interviewees. The interviewees included knowledgeable resource users, including five local fishers and one shellfish farmer[11], knowledgeable resource scientists and stewards, the director of the local salmon hatchery, a member of council, a local planner, and a community outreach worker. Interviews followed one of two consistent interview scripts focused on similar themes to those listed above. The scripts were designed to accommodate two key stakeholder groups identified for the interviews. The first script was designed for interviewees involved in local politics, community planning and resource management. The second script was designed for interviewees involved in resource extraction (fishing, aquaculture). This allowed information to be gained from both local resource management and local resource use perspectives. The interview guides are presented in Appendices C and D, respectively.

Interviewees were purposefully selected from the two stakeholder groups by the researcher on the basis of information attained in the research process, particularly in the focus group interview, and from other interviewees and members of the community. The interviewees were selected to represent a diversity of stakeholders in the community. This included an attempt to interview an equal number of stakeholders involved in local planning and management, and stakeholders involved in resource extraction in their day-to-day lives (Baxter and Eyles 1997). Thus, the interviewees represented multiple groups in the community, including local resource users, scientists, environmental stewards, educators, policy makers, planners, resource managers, volunteers and social workers.

[11] Of those interviewed, four fishers had been active in local commercial fisheries since the 1960s, one since the 1970s. A local shellfish farmer interviewed had been growing shellfish since the mid-1980s.

Two out of ten interviewees were female. Interviewee ages ranged from approximately 30 to over 70 years of age. Furthermore, interviewees represented both long- and short-term residents in the community.

Interviews were carried out in a semi-structured format, which allowed for greater flexibility than structured interviews, while still maintaining focus through the interview guides (*see* Appendices C and D). Interviews were carried out in person, including in workplaces, homes and other locations and on days and at hours chosen by those interviewed. Interviews were audio recorded and later transcribed by the assistant researcher and myself. Interview transcripts were provided to the interviewees one month after the interviews in order to allow for revisions and additional comments (Parfitt 2005; Kvale 1996; McNamara 1999).

Prior to the interviews, each respondent was provided with a description of the research and their role. They were also asked to sign the participant consent form (*see* Appendix A). Interviewees retained one copy of the consent form, including researcher contact information. After the interview, interviewees were encouraged to ask questions and continue the interview if they thought something was missing, as well as provide feedback to the research, or suggest other members of the community who I should speak to. I have been in touch with each interviewee since their interview to check transcripts and will further provide each a copy of the final results.

#### 3.3.1.3 Unstructured interviews

Unstructured, conversational interviews were carried out with a number of local stakeholders regarding any topics or issues brought up by interviewees (McNamara 1999). Those interviewed included local resource users as well as actors involved in local

politics, community planning and resource management. These interviews were recorded or documented in daily field notes.

#### 3.3.1.4 Structured questionnaire

The questionnaire survey was designed to investigate the opinions local people have of their community and the main themes outlined above. The assistant researcher aided the researcher in the application of the questionnaire to local people. The researchers met regularly to review notes and experiences (households visited, response rates, respondent characteristics, other observations) in order to enhance the consistency and rigour of data collected (Parfitt 2005).

In-person interviews were conducted with a total of 52 residents in the community. Interviews were applied in person to create a more comfortable, personable setting, stimulate a higher response rate, and allow a greater ability to ensure clarity and engage with the interviewee and their surroundings (Parfitt 2005). Information regarding lengths of residency, dwelling counts, family characteristics, household characteristics, education, occupation, employment status, volunteerism, income and age were recorded on a standardized interview sheet, as well as local perceptions regarding the ecological and social change in their community, factors that constrain or enable local capacities to deal with change, and climate change. The questionnaire survey is presented in Appendix E.

The respondents were selected using purposeful sampling. Both researchers worked to select a cross-section of people in the community in order to represent the views of a range of social groups and opinions. The researchers began by dividing the community into regions and selecting a street in each region to begin surveying. The

researchers then visited every third house on the street, beginning with the first house. When there was no answer, we would return in the evening or on the following day. When a street was completed, we would move to the next street.

It is important to note that the sampling design was adjusted as the study progressed. For instance, as many homes were vacant when visited or occupied by a similar socio-demographic group (e.g., stay-at-home parents, retirees), and as irregular work shifts made it difficult to predict 'at home' hours, the researchers decided to begin visiting businesses (every third business on a street, as above). This adjustment provided greater breadth to the data collected (Baxter and Eyles 1997). In total, 65 per cent of local people spoken to (52 out of 80 individuals approached) completed the survey. According to Babbie and Benaquisto (2002), a response rate of 50 percent is adequate for analysis, 60 percent is good and 70 percent is very good. Therefore, the survey yielded a good to very good response rate in the community.

Prior to conducting the questionnaires in the community, a pilot study was carried out with ten respondents. Pilot surveys allow researchers to resolve issues of clarity, redundancy, omission and potential areas of discomfort (Parfitt 2005).

Data collected from questionnaires were transcribed into the SPSS statistical analysis package. Following a review of all interview sheets, a coding sheet for closed- and open-ended survey questions was created to most appropriately capture the responses of the interviewees for quantitative analysis. The coding sheet is presented in Appendix F. A selection of open-ended responses identified for their insight into the survey themes were also transcribed for qualitative analysis.

Those interviewed represented multiple stakeholder groups in the community (*see*

Appendix B). In total, 49.1 percent[12] of those interviewed reported full-time employment status, 35.8 percent reported part-time or seasonal employment, 9.4 reported unemployment, and 5.7 percent were retired. In regard to their highest level of education or training attained, 45.3 percent of those interviewed had a university degree, 37.3 percent had a degree from a community college or training institute, 7.5 percent had a high school diploma, 7.5 percent had some high school, and 1.5 percent has attained other forms of education. In regard to the length of their residency, 54.7 percent had lived in Ucluelet less than five years; 45.3 percent had lived in Ucluelet for 5 years or more. On average, 2.6 people lived in each household surveyed, with 55.1 percent of those interviewed reporting a total household income (before taxes) of less than $50 000, 28.6 percent of between $50 000 and $99 000, and 12.2 percent of $100 000 or more. Finally, interviewees' ages ranged from 18 to 34 (49.1 percent), 35 to 54 (37.3 percent), 55 to 74 (11.3 percent) and 75 and over (1.9 percent). By comparing these numbers with existing quantitative data for the community (Statistics Canada, 2006, *see* http://www.bcstats.gov.bc.ca/census.asp), it is reasonable to conclude that though the sample size was small, it was representative of the broader Ucluelet community.

Prior to the interviews, each interviewee was provided information about the research and their role, and was asked to sign the participant consent form (*see* Appendix A). Interviewees retained one copy of the consent form, including researcher contact information. After each survey, interviewees were encouraged to ask questions and provide addition information if they thought something was missing, as well as provide

[12] All percentages derived from quantitative analysis in this thesis are expressed as valid percents.

feedback to the research. They were also able to provide their contact information in order to receive a copy of the research results.

### 3.3.2 Participant observation:

Using aspects of ethnography, I observed community actors in their daily activities and engaged in community programs and events for the duration of the data collection phase. This included forming relationships with and participating in the daily activities of community actors, participation in community programs and events, and volunteering in the community for two days each week at the Ucluelet Mini Aquarium. This also involved observations obtained during the interviews described above. Data obtained was recorded in daily field notes and other materials gathered (Crang 2003; Kesby et al. 2005). These observations provided me with further insight into the day-to-day perspectives and experiences of local people, the appropriateness and relevance of my research methods and questions, and my own positionality in the community.

### 3.3.3 Secondary sources:

#### 3.3.3.1 Relevant literature

A review of relevant research previously carried out regarding coastal ecosystems and communities in British Columbia, the fisheries and aquaculture sector, stressors and vulnerability, adaptive capacity, resilience and sustainability in coastal systems, and climate change in coastal BC was carried out from January 2009 throughout the research process.

#### 3.3.3.2 Relevant local organizations and groups

The following non-governmental organizations and groups in the West Coast of

Vancouver Island (WCVI) region were consulted during the research process: Ecotrust Canada (Vancouver, Tofino), West Coast Aquatic (Port Alberni), Raincoast Education Society (Tofino), Clayoquot Biosphere Trust (Tofino), Friends of Clayoquot Sound (Tofino), West Coast Community Resources Society (Ucluelet), Ucluelet Community Food Initiative (Ucluelet), Ucluelet Aquarium Society (Ucluelet), Thornton Creek Enhancement Society (Ucluelet), Wild Pacific Trail Society (Ucluelet), Ucluelet Volunteer Fire Brigade (Ucluelet). The following government bodies or groups were also consulted: the District of Ucluelet Mayor and Council, Parks Canada - Pacific Rim National Park Reserve, Natural Resources Canada, Department of Fisheries and Oceans Canada, Canadian Forest Service, Environment Canada, Health Canada, Geological Survey of Canada, Neptune Canada, Pacific Climate Impacts Consortium, Ucluelet Chamber of Commerce, Ucluelet Harbour Authority, Ucluelet Planning Services.

#### 3.3.3.4 Archival research

Archival research was done to trace changes in the local social-economic system, the fisheries and aquaculture sector, and resource management organizations. Archives and materials researched include: reports from the District of Ucluelet, reports from regional non-governmental organizations and groups (e.g., Ecotrust Canada, WCA), reports from the provincial government (e.g. BC Ministry of Forests and Range, BC Job Protection Commission), reports from the federal government (e.g., Fisheries and Oceans Canada, National Research Council of Canada), and other materials.

#### 3.3.3.5 Local news sources

Content analyses of relevant articles from the *Westerly News* (serving Tofino, Ucluelet, Long Beach and area) were collected between September 2009 and April 2010.

#### 3.3.3.6 Statistical information

Additional information regarding population and dwelling counts, age, family characteristics, household characteristics, mobility status, educational attainment, labour force activity, occupation, industry, unpaid work, and incomes were obtained from the 2006 census by Statistics Canada – Industry Canada (Statistics Canada 2006). Statistics referring to ocean temperature, salinity and pH and ocean species counts were obtained from Fisheries and Oceans Canada.

#### 3.3.3.7 Climate information

Instrumental climate records and existing projections of future change for Ucluelet and the Alberni-Clayoquot region were obtained from station-based data and existing data summarized in *Chapter 8: British Columbia* (Walker and Syndeysmith 2008) in *From Impacts to Adaptation: Canada in a Changing Climate* (Lemmen et al. 2008). High-resolution climate data was obtained using the Pacific Climate Impacts Consortium (PCIC) (2010) Plan2Adapt tool, which includes empirical downscaling derived using the ClimateBC program[13]. The results of this analysis are presented in Chapter 5.

## 3.4 Data analysis:

Data analysis was based on the triangulation of data from transcribed interviews, field notes, statistical data gained using SPSS, and external sources including documents and literature (McKendrick 1999). In addition, the main findings from key informant

[13] ClimateBC uses interpolation, an elevation correction on temperature, and the PRISM (Parameter-elevation Regressions on Independent Slopes Model) 4 km high-resolution climatology derived from a multiple regression of weather station data against topographical features. This projected change from Global Climate Models (GCMs) is applied to the high resolution past in order to obtain an estimate of future climate at the same high resolution (www.plan2adapt.ca). Development of this tool has been made possible through funding and support provided by the BC Ministry of Environment and the BC Ministry of Forests and Range Forest Science Program and is a project of Natural Resources Canada's British Columbia Regional Adaptation Collaborative (PCIC 2010).

interviews were checked by the interviewees prior to the analysis of the data. The steps of the data analysis are outlined below.

In Step 1, the assistant researcher and I transcribed the focus group and key informant interviews (10 hours audio-recorded) into individual files. I also transcribed all field notes (80 pages 16 x 21 cm) into a file, and all relevant information from recorded unstructured interviews and open-ended survey questions into a file.

In Step 2, I reviewed questionnaire interview sheets. I began coding responses to each question in preparation for application to the SPSS statistical software package. Closed-ended codes were applied immediately, while open-ended codes were adjusted and added as the analysis progressed. These codes were entered into SPSS as 432 variables. The responses of the 52 interviewees were then entered for each variable. It is important to note that these variables were adjusted, compressed and added to as the analysis progressed, for a total of 620 variables. Frequency tables were calculated for each variable to check the accuracy of the recorded response. In consultation with my supervisor, it was decided that no significant results could be obtained using parametric or non-parametric tests. This was due to the small sample size obtained. Data acquired from variable frequencies are presented in Chapters 5 and 6.

In Step 3, I reviewed transcribed interviews and field notes. I began this process by attaching notes to sentences and/or paragraphs according to the main themes and issues (categories) present. This involved the creation of in-vivo codes (language used by the interviewees) and constructed codes (informed by the researcher's review of relevant literature and the analytical framework of the study) (Jackson 2001).

In Step 4, I coded each sentence and/or paragraph of the transcribed interviews and

field notes according to the main categories present, as identified in Step 3. Using these codes, I organized the information from transcribed interviews and field notes into files according to which of my research questions they addressed (Step 5, 6, 7 and 8).

In Step 5, 6, 7 and 8, I analyzed all information to provide a final resume of data for each of my specific research questions. During this process, I reviewed information from transcribed interviews, field notes, data frequencies obtained using SPSS, and secondary sources. In Step 5, I investigated my first specific research question, *how do coastal communities experience and deal with change in their social-ecological systems?* The results of this analysis are presented in Chapter 4 and Chapter 6, Section 6.1. In Step 6, I investigated my second specific research question, *how does global environmental change affect coastal communities?* The results of this analysis are presented in Chapter 5. In Step 7, I investigated my third specific research question, *what are some of the key factors that contribute to threatening or building resilience in coastal communities?* The results of this analysis are presented in Chapter 6. In Step 8, I investigated my third specific research question, *how can resilience and adaptive capacity be built to adapt to change and shape change for sustainability?* The results of this analysis are presented in Chapter 6. In Steps 5, 7 and 8, the analysis borrowed from various case study examples that have applied the concept of resilience. In particular, the analysis followed the case study examples of Seixas and Berkes (2003) and Berkes and Seixas (2005), as well as the synthesis of lessons learned presented by Folke and colleagues (2003).

Finally, in Step 9, I use what has been learned in Steps 5, 6, 7 and 8 to address my main research question, which is, *what can be learned from investigating elements of human societies that sustain and build resilience and adaptive capacity toward*

*sustainable development in social-ecological systems on the British Columbia coast?* In this step, I reviewed the major findings related to each of the four specific research issues in order to present the main theoretical, methodological, policy and future research contributions of this thesis. These findings are summarized in Chapter 7.

### 3.5 Summary:

This chapter reviewed the methodology used to answer the research questions presented in Chapter 1. It described the rationale for the research approach used. It then described the researcher bias inherent in qualitative research, and how I addressed my bias in this research. Finally, it examined the research methods used, and presented the steps of analysis taken to answer the research questions presented in Chapter 1.

**Table 3.1 Evaluation of rigour in qualitative research (Baxter and Eyles 1997)**

| Principle for establishing rigour | Used |
|---|---|
| Rationale for using a qualitative approach | Yes |
| The use of multiple methods | Yes |
| Information on the selection of respondents | Yes |
| Quotations form interviews with interpretive explanations | Yes |
| Details of interview practices | Yes |
| Discussion of the procedures for analysis | Yes |
| Immersion/lengthy fieldwork | Yes |
| Revisits to respondents | No |
| Verification by respondents | Yes |
| Appeals to interpretive communities | Yes |
| The provision of a rationale for verification (validity) of the findings | Yes |

# Chapter 4: The Case Study

This chapter provides an overview of the social-ecological system of Ucluelet, British Columbia. It first briefly describes the Ucluelet social-ecological system, which has experienced significant changes in the last six decades. It then provides an overview of the socio-economic history of the community and the local coastal ecosystem. Finally, it describes the social-ecological system in the last six decades, divided into four periods according to major changes affecting the system.

## 4.1 The Case Study

The District municipality of Ucluelet (population 1 487 in 2006) is located on the southern tip of the Yuʔłuʔiłʔath Peninsula in the Alberni-Clayoquot region on the western edge of Vancouver Island, British Columbia (Statistics Canada 2006; District of Ucluelet 2005). The area is the traditional territory of the Yuʔłuʔiłʔath First Nation (YFN)[14]. The Ucluelet and YFN communities are connected socially, culturally and (increasingly) politically, though they 'officially' exist as separate town sites (YFN Profile 2010). Ecologically, the communities are closely connected to the Pacific Ocean and the terrestrial lowlands, islands and mountains of the western margin of Vancouver Island (BC Ministry of Environment 2006).

Ucluelet has undergone significant ecological and social (industrial, cultural, political) changes in the last six decades. Until the 1950s, the community was quite isolated, living on subsistence and small-scale commercial activities based on the

[14] The YFN spans nine communities; the main village is Hittatsoo, located across the inner harbour from the town of Ucluelet, and is home to about 200 people.

resources of the forest and the sea. Between 1950 and 1990, Ucluelet experienced a tremendous expansion of its resource-based economies, specifically forestry and fishing. In the mid-1990s, however, the town was struck by a severe shock following a crisis and release of the local forestry and fishing industries. Since the mid-1990s, Ucluelet has been moving towards the recovery and renewal of its social-ecological system, a process that has been difficult following the downturn of the mid-1990s, and in the face of new challenges since 2001.

In order to understand the interactions over time between the social and ecological components of the Ucluelet system, the social-ecological history of the community in the last six decades is reviewed[15]. The overview is divided into four periods according to the occurrence of major changes affecting the system: (1) from 1950 to 1970, a period of major socio-economic changes leading to a tremendous expansion and accumulation of resources; (2) from 1970 to 1993, a period of significant changes in the resource management system resulting in an increasingly rigid industrial-resource structure; (3) from 1993 to 2001, a period of crisis and release in the resource social-ecological structure; (4) the period since 2001, when the system has moved towards recovery and a transition to new, more sustainable development pathways.

The social-ecological system of Ucluelet was chosen for the study because of the dynamic nature of its ecological and socio-economic dimensions as well as the complex interactions between these two, as demonstrated in its cycle of extreme social-ecological expansion, followed by a catastrophic release, and finally leading to a process of recovery and renewal since the mid-1990s. The baseline of 1950 was selected for the study based

[15] This review follows the case study example of Berkes and Seixas (2003).

on the possibility of acquiring reliable information about the period, as stored in the memory of mature members of the community.

### 4.2 Socio-Economic Background:

Prior to the 1950s, there was a small settler population living in Ucluelet. In the 1950s, a government-led program aimed at extensive rural development brought tremendous growth to Ucluelet, particularly in a booming forestry industry and a rapidly expanding small boat fishing fleet. In addition, the completion of roads connecting Ucluelet to Tofino and Port Alberni precipitated a flow of settlers seeking employment opportunities and, for the first time, tourists. The expanding and relatively stable resource-based economy provided a strong socio-economic foundation for a growing community.

From 1970 to 1993, problems of resource overexploitation and conflicts between resource user groups began to shake the socio-economic foundation of the community. Changes in the resource management system provided stability in the resource economy in the short term, but intensified opposition from First Nations and environmental groups. In the late 1980s, the major resource industries were operating at peak production; however, the resource management system had become increasingly rigid in its control (Young and Matthews 2007).

From 1993 to 2001, the community was faced with a catastrophic shock following the crisis and release of the traditional resource economies. As a result of the collapse, Ucluelet experienced a severe increase in problems of unemployment, lost or low incomes, poverty, alcoholism, drug abuse, violence, and outmigration, all which have had lasting implications on individual and community health and well-being.

Since 2001, Ucluelet has been reinventing its social-economic system according to new ecological and social realities. The community has embraced new options in tourism-related development, community forests, sustainable fishing, sustainable forms of aquaculture, and various community services (i.e., education, health, recreation, others). However, the community continues to deal with significant stress associated with the economic downturn of the mid-1990s, and also faces new challenges since 2001 on its journey towards recovery and renewal (Young and Matthews 2007).

### 4.3 The Coastal Ecosystem:

The coastal ecosystem surrounding Ucluelet consists of 670 hectares of terrestrial environment and 478 hectares of marine environment. The ecosystem encompasses a number of smaller ecosystems, including terrestrial ecosystems, wetlands, rocky or muddy intertidal areas, beaches and dunes, seagrass meadows, kelp forests, nearshore islands, and nearshore coastal waters, which provide a number of ecosystem services (District of Ucluelet 2005; BC Ministry of Environment 2006; Demarchi, 1996). The ecosystem is located in the Western Vancouver Island ecoregion in the larger Pacific Maritime Ecozone (Demarchi, 1996), which is part of the Coastal Western Hemlock biogeoclimatic zone (*see* Figure 2.5) (Walker and Sydneysmith 2008; BC Ministry of Environment 2006).

The interaction of climate with the land surface and surface materials creates the unique ecology of the Ucluelet region. Soils and landforms in the area are the result of tectonic plate activity as well as extreme wind and wave exposure from the windward coast. Fertile, moist soils and, young, low-lying landscapes are dominant across the study area. These conditions influences the natural vegetation found in the region (BC Ministry

of Environment 2006; Demarchi, 1996). The terrestrial ecosystem surrounding Ucluelet primarily consists of temperate rainforest crossed by numerous rivers systems, fjords, inlets and low-lying wetlands (BC Ministry of Environment 2006). The forests in the region consist primarily of western hemlock, western red cedar, amabilis fir, and yellow cedar, with minor amounts of red alder, Douglas-fir, and mountain hemlock (BC Ministry of Environment 2006; District of Ucluelet 2005). Smaller plants in the ecoregion include salal, sword fern, salmonberry, old man's beard and more (Demarchi, 1996).

The coastal ecosystem supports an abundance of wildlife and aquatic species. Common terrestrial and marine mammals in the region include mule ("black-tailed") deer, elk, black bear, wolf, cougar, raccoon, mink, marmot, river otter, harbour seal, harbour porpoise, orca, and grey whale. Endangered wildlife living in the area include northern goshawk, peregrine falcon and northern (Steller) sea lion. The region also supports some of the highest populations of bird species in British Columbia. Waterbirds make extensive use of the coastal wetlands as well as nearshore and offshore habitats, including islands, islets, and cliffs. Some resident bird species, including bald eagle and black oystercatcher, also contain significant portions of their world populations in this area. In addition, the region is a significant corridor for millions of migrating bird species, including many shorebirds and waterfowl (Ministry of Environment 2006; District of Ucluelet 2005).

The Pacific waters of the coastal ecosystem lie in a transition zone between coastal upwelling (California Current) and downwelling (Alaskan Coastal Current) regions, and experience strong seasonality and considerable freshwater influence (Fisheries and Oceans Canada 2009). This contributes to very high biological

productivity and diversity in the region (Walker and Sydneysmith 2008). The area supports a wide variety of fish, from purely oceanic species such as rockfish, sole, Pacific herring, Pacific halibut and spiny dogfish, to fish that spawn in freshwater, but live as adults in marine waters, such as Pacific salmon, steelhead, coastal cutthroat trout and eulachon, through to the species that only live in fresh water, such as torrent sculpin. In addition to fish, the marine environment supports a wide variety of clams, barnacles, shrimp, crabs, sea star and jellyfish species (Ucluelet Aquarium 2009; Ministry of Environment 2006; WCA 2009).

It is important to note that the coastal ecosystem encompasses a number of smaller ecosystems, such as wetlands and intertidal areas, and at the same time is part of larger ecosystems, such as the Pacific Ocean. Changes in a smaller system, such as localized pollution, or in a larger system, such as ocean acidification, will affect the structure and functioning of the coastal ecosystem across scales. The scope of the present study allows only a superficial exploration of these complex interactions.

## 4.4 A Social-Ecological History in Four Periods:

### 4.4.1 From 1950 to 1970:

In the early 1950s, a period of growth in rural industry and communities began in British Columbia. In 1952, a new provincial government was elected in BC whose platform included extensive rural development. The new government set in place a strategy that would expand rural industry and settlement, particularly affecting the resource sectors of forestry and mining (fisheries being primarily under federal jurisdiction) (Young and Matthews 2007). The strategy involved several reforms including (a) an overhaul in forestry policy that favoured large corporate actors over

smaller firms (Hayter 2000); (b) the construction of a province-wide transportation infrastructure designed to open rural regions of the province to development; (c) establishing conditions on corporate rights that encouraged dispersion of resource production across the territory; and (d) forging agreements with major resource firms to invest in both new or 'instant towns' and existing communities (Young and Matthews 2007).

Meanwhile, the federal government started a programme that sought to modernize and expand the west coast fisheries. As a result of the new programme, the Pacific small boat fishing fleet gained access to new technologies including radios, radars, and sonar. The programme also included subsides to build new vessels, the creation of a Fisheries Prices Support Board to moderate the effects of fluctuating markets, the extension of unemployment insurance to self-employed fishers, and the establishment of loan and vessel-insurance programs (Parsons 1993).

Overall, in the 1950s, federal and provincial government reforms, in combination with a postwar resource-hungry industrial economy in the United States, led to a tremendous expansion of British Columbia's rural resource economy. In Ucluelet, local people report that expansion came as a result of three major local developments: the establishment of the North Coast Logging Company (later bought by MacMillian Bloedel) in 1947, which increased opportunities for employment and brought new amenities and infrastructure to the town; the restructuring of the local small boat fishing fleet, which increased fisher's productivity and incomes and, in turn, attracted new fishers from outside the community; and the completion of roads connecting Ucluelet to

Tofino and Port Alberni, which fostered an inflow of settlers and, for the first time, tourists.

The expansion of the resource industries in the 1950s and 1960s favoured the development of a profitable and durable rural economy for governments, corporate actors, and communities. In Ucluelet, forestry and fishing provided a strong economic foundation, supplemented by small-scale tourist-related activities. Local people benefited from near year-round employment and favourable blue-collar incomes. Meanwhile, governments continued to invest in social development and assistance programmes. This enabled local people to invest capital in the community, including in structures and services like the Ucluelet Volunteer Fire Brigade. In addition, local people invested in one another through close personal relationships and networks, including reciprocal gift giving (firewood, seafood) between neighbours, and informal communication forums about local issues.

#### 4.4.2 From 1970 to 1993:

The resource economies in British Columbia began experiencing problems from about 1970. These were related to resource pressure and emerging conflicts between user groups. Since the mid-1960s, local people and environmental groups grew increasingly concerned with the problems of overexploitation and harmful practices in the forestry and fishing industries. This was exacerbated by conflict between resource-user groups, a result of the problem of overcapacity in both sectors. In the fisheries, there was conflict between commercial, recreational, and First Nations fishers for resource access, leading fishers into a dangerous cycle of acquiring bigger boats and better technology to out perform each other. In forestry, there was conflict between governments and large

industrial actors on the one hand and First Nations groups on the other concerning employment inequity and Aboriginal claims to authority over traditional territory.

The domestic overexploitation of herring in the mid-1960s triggered a revolt of small boat fishers in the province (Parsons 1993). Facing resource overexploitation and the ongoing conflict between groups, local fishers organized themselves in the late-1960s to actively push for license controls to improve prospects for conservation and incomes. The federal government responded in 1967 by closing the BC herring fishery, and in 1968 by introducing license limitation to salmon fisheries, which took in all major fisheries by the end of the 1970s. This marked a transition to a new era of fisheries management; the emphasis shifted from development and assistance programmes and open access fisheries to stringent regulation and control directed in the name of conservation and economic viability (Parsons 1993).

By the late 1970s, license controls had failed to reduce fishing power, and even increased it (Parsons 1993). As a result of the failure of license limitation, the federal government – under its new fisheries arm in 1979, the Department of Fisheries and Oceans (DFO) – introduced the idea of individual transferable quotas (ITQs) in an attempt to sustain the viability of the resource economy. This shift represented an increasingly rigid management system which placed a great deal of faith in the scientific understanding of ecosystems (e.g., in defining the total allowable catch [TAC]), the availability of sophisticated tools and technologies, and the application of market mechanisms to solve environmental problems.

In the 1980s, facing ongoing resource degradation, conflict, and a slump in the market economy, both federal and provincial governments became increasingly rigid in

their control. Instead of responding flexibly to problems, government managers pursued a strategy that sought to make ecosystems more productive, predictable, controllable and economically efficient. This proved successful in securing the stability and productivity of resource flows in the short term: the provincial government successfully ramped up harvest and production rates in forestry and mining throughout the 1980s, while federally managed fisheries reached a historic peak in 1988 and overall fisheries landed value doubled between 1980 and 1987 (Parsons 1993). Furthermore, the aquaculture industry progressively consolidated and expanded into a major industry on the Pacific coast (Young and Matthews 2010). In the longer-term, however, resource degradation and ongoing conflict and discontent associated with BC's resource economy triggered a crisis and release of the existing management structure, which had for decades struggled to maintain stability and productivity in what had become an inflexible and vulnerable system (Young and Matthews 2007).

#### 4.4.3 From 1993 to 2001:

The crisis and release of British Columbia's traditional resource economy came about in two parallel events: one in forestry, and the other in fisheries.

The problems of resource degradation, excess capacity, changes in the market economy, and an increasingly powerful opposition from Aboriginal and environmental groups culminated in a very 'brittle' forestry system by the early 1990s. In 1993, the structure of the forestry industry broke down as a result of a specific trigger event: the provincial government decision to permit unrestricted logging in 74 percent of old growth forests in Clayoquot Sound. The strong public condemnation of the 'Clayoquot Land Use Decision' is (in)famously known as the 'war in the woods', during which over 12,000

citizens attended a logging blockade in the Sound. According to local people in Ucluelet, the consequent recommendations of the Scientific Panel for Sustainable Forest Practices in Clayoquot Sound, made up of local First Nations, non-First Nations local people, and scientific experts, led to a massive release of forestry policy and irreversible changes to the industry – a shift that affected the lives of coastal people and communities throughout BC (Ommer et al. 2007).

In addition to the release of the forestry system, the other major event affecting the resource economy in the early 1990s was an overhaul in the west coast fisheries. From about 1990, BC salmon stocks showed serious signs of decline as a result of overfishing pressure, harmful fishing practices (e.g. draggers), and oceanographic changes (Walker and Sydneysmith 2008). A significant drop in prices for wild salmon also affected the industry, which was due, in part, to increased international competition from aquaculture (Noakes et al. 2002). In 1996, Fisheries and Oceans Canada introduced the Pacific Salmon Revitalization Strategy (commonly known as the Mifflin Plan) in an effort to conserve species stocks and to improve the viability of the fishery. Through a programme of ITQ implementation, licence buybacks, and fishing restrictions, the strategy reduced the west coast fishery by 50 percent between 1995 and 2000. This meant the elimination or severe restriction of several major fisheries in the province (Gislason et al. 1996).

As a result of the Fisheries and Oceans programme to rationalize the west coast fishery, licenses and quota numbers were reduced throughout the fishery. However, experience shows that licence and quota numbers were most significantly reduced in rural communities. From 1994 to 2002, licenses on the west coast of Vancouver Island

declined by 55 percent, while licenced ownership declined by only 30 percent in urban areas. In addition, the number of processing facilities in small communities on the coast declined to a handful (Ommer et al. 2007). Ucluelet is cited as among the fifteen communities in British Columbia most affected by these events (Gislason et al. 1996). At one time the third largest fishing port on the west coast in tonnage of fish landed, Ucluelet's small boat fishing fleet was drastically reduced as a result of the Mifflin Plan. In addition, of three local processing plants that ran twenty-four hour shifts during peak seasons in the early 1990s, one remains, and sits idle for most of the year (Ommer et al. 2007).

In summary, the crisis and release of British Columbia's resource economy was the result of multiple and interacting stresses, including resource degradation affecting the structure and functioning of the coastal ecosystem, changes in management policy objectives, market instability, and socio-cultural crisis and revolt. The collapse of the traditional resource economy greatly affected the socio-economic well-being of people and communities on the British Columbia coast. This is demonstrated in the following quotation from an interview with a commercial fisher in Ucluelet:

> These small communities, their entire health – the health of the community, the health of their citizens – was completely contingent on the stability of the economy in which their community was embedded. When you start to see that start to erode, everything else changes, and you can see it, you can see it in suicide rates, you can see it in alcoholism, you can see it in drug abuse and dependency, you can see it in child abuse and in spousal abuse. There's a direct correlation between the stability of the economic system that you're in, and all those other factors (Commercial fisher, Interview Reference #7).

As well, local people in Ucluelet report a loss of trust in government since the 1990s associated with the decline of their traditional resource industries, an increase in the

number of people seeking social assistance, and an increase in the number of people and families leaving the community (outmigration).

According to local people, by the late 1990s, the Ucluelet socio-economic system showed some signs of recovery. This is largely related to strong local efforts to build new bridges and develop new models for sustainable development. From the early 1990s, local people had responded to feedbacks from their environment and community and begun organizing themselves in efforts to develop more sustainable models of development. One of these models was the West Coast Sustainability Association (WCSA), the creation of a fisher in Ucluelet. The WCSA brought together fourteen First Nation tribes, seven municipalities and local governments, and three Regional Districts in an effort to develop a cooperative resource management process. Though the WCSA faced extreme funding cuts in the 1990s, it successfully negotiated the creation of the West Coast of Vancouver Island Aquatic (now West Coast Aquatic [WCA]) Management Board in 2001. The Management Board is designed to be a forum for local people, groups, and communities to participate more fully in all aspects of the integrated management of regional aquatic resources. This process came forth alongside many like-minded efforts by local people and groups to develop new models for sustainable development in the region, including the Clayoquot Biosphere Project (now the Clayoquot Biosphere Trust [CBT]), the Central Regional Board, the Raincoast Education Society, Ecotrust Canada, and more.

#### 4.4.4 From 2001 to 2010:

In 2001, a new provincial government in British Columbia introduced a policy strategy that sought to significantly reform rural and resource industries in the province

by separating large industrial-resource and local or community-based economies. The strategy involved significant measures to: (a) liberate large corporate actors from non-market obligations, particularly with respect to the environment, labour, and communities; (b) withdraw traditional forms of state involvement in communities, particularly social and administrative services[16]; and (c) introduce new policies and programmes targeting ground-up community development (Young and Matthews 2007). This latter measure involved the introduction of programmes that 'encourage' communities to behave entrepreneurially and thus accept responsibility for local development by establishing competitive and selective pools of funding for 'locally driven' initiatives. According to local and expert sources, such programmes allow the state to minimize its direct involvement in local development, while retaining significant powers through its control over funding decisions (Young and Matthews 2007).

As a result of the separation of large industry and higher governments from local economies, Ucluelet has in the last decade followed a new, more locally-driven model of development. At the same time, however, the community has experienced significant stress associated with the crisis and release of its previous social-ecological system, and now faces new challenges as it moves towards recovery and renewal. This process has been especially difficult following the 'exit' of large industry and government support since 2001.

In the last decade, Ucluelet has been re-inventing itself according to novel ecological and social (economic, political, cultural) realities. Local people report that, following the decline of the traditional resource economy, the community has embraced

[16] At this point, both federal and provincial governments had been downsizing rural development and assistance programs since the end of the development boom in the 1970s.

new options in the tourism industry and in forestry, fishing and aquaculture, and community services. These are here discussed in turn.

Ucluelet has seen a tremendous expansion in tourism is the last ten years. Since about 2001, new options in tourism have opened up in Ucluelet as a result of its geographic location – including its proximity to Tofino, the Pacific Rim National Park, and Clayoquot Sound UNESCO[17] Biosphere Reserve (Dolan and Ommer 2008) – and local environment, which from local accounts has seen significant local forest renewal and the removal of old industrial fixtures from the inner harbour. The District of Ucluelet has embraced new opportunities in tourism by making the community attractive to developers through a comprehensive policy strategy laid out in the Official Community Plan (OCP)[18] (District of Ucluelet 2008), which is designed to secure long-term investment in the community in harmony with the natural environment and community values. This is done through integrated policies that include improvements to community infrastructure, boundary extension, the protection of a green belt and green spaces, the promotion of 'green design' principles (e.g., Leadership in Energy and Environmental Design [LEED]) and others (refer to District of Ucluelet 2008).

In addition to the Ucluelet council embracing new options in tourism, local people and groups have advanced new options for tourism-related development. This has included a stream of new locally-owned businesses (retail, recreation, hospitality), and a notable boost to local initiatives such as the Wild Pacific Trail, the Ucluelet Mini Aquarium, the Pacific Rim Whale Festival, and Ukee Days. Furthermore, local people

[17] United Nations Educational, Scientific, and Cultural Organization (UNESCO).

[18] The Ucluelet Planning Department has won provincial, national, and international awards for sustainable community planning, including the United Nations Environment Programme (UNEP) Livcom gold award for its Official Community Plan in 2006 (District of Ucluelet 2010a).

acknowledge that new investment in local initiatives has allowed local people and groups to showcase local ecological and community resources. An example is the Ucluelet Mini Aquarium, a local non-profit that strives to raise awareness about local marine biodiversity and promote respect for the ocean environment through up-close and 'hands-on' interaction, education programs, and employment and volunteer opportunities (for more information, refer to www.uclueletaquarium.org).

In addition to tourism-related development in the community, Ucluelet has since 2001 explored new options in local forestry. According to local stakeholders, since the reform of rural and resource industries in 2001, locally-owned forestry operations in Ucluelet have existed outside the realm of large-industry and government support, and as a result have struggled to remain viable. In an attempt to reconfigure the forestry industry in the region, the District of Ucluelet and the Toquaht First Nation have for the last decade been negotiating with the provincial government to secure a Community Forest Agreement (CFA)[19], which would allow the communities to decide how to manage the designated forest, and provide opportunities for sustainable management of the resource for multiple, integrated uses (i.e., harvesting botanical forest products, ecotourism), and stable local employment. In 2004, the provincial government invited Ucluelet and the Toquaht Nation to apply for a CFA. At the time of writing in 2010, the CFA had not been issued (Barkley Community Forest 2010).

Since 2001, Ucluelet has also been exploring opportunities to rebuild sustainable local fisheries. According to local stakeholders, in recent years, the small boat fishing fleet in Ucluelet has faced government buy-back schemes, industry consolidation into

[19] The Community Forest Programme is a provincial government programme offering the competitive designation of small forest tenures to 'community-held corporations for the benefit of the entire community' (Young and Matthews 2007).

larger, more powerful vessels, slumping salmon prices, stricter conservation rules, soaring license and quota costs, ongoing monitoring and regulatory reforms (Ecotrust Canada 2004, 2008). Furthermore, as fishers struggle to gain access and meet the bottom line, they are facing increasing uncertainty in their catch as a result of rapidly changing oceanographic conditions (*see* Chapter 5, Section 5.2.1).

The District of Ucluelet and local fishers have for over a decade actively pushed governments to secure rural fishing licenses in order to keep the fishery going in the community (there were about 40 salmon licences in Ucluelet in the early 1990s, now there are fewer than 10). However, strong voices in industry and government continue to sing the mantra that 'bigger is better', that is, that consolidation of licenses and quota into larger vessels is the best option. Nonetheless, fishers in Ucluelet believe there is a future for the small boat fleet, especially one that is highly nimble, diversified in several fisheries, and that can efficiently deliver high-quality sustainable seafood products to conscientious consumers (Ecotrust 2004, 2008).

In 2006, as a result of a partnership between local fishers, a local company (Blue Mosaic), and the non-profit Ecotrust Canada, the model of a fisheries licence bank came into existence on the west coast to address problems of access, conservation, and improved economics for small boat fishers (Ecotrust 2008). The bank is designed to purchase access to licenses and quota, and lease it back to fishers at a rate they can afford. Currently, the bank consists of seven fishers (three from Ucluelet) and holds a halibut licence and a one-and-one-third rockfish licences with attached quota. According to member-fishers in Ucluelet, the problem of access to capital (the bank currently relies on private donor funding) and quota is ongoing, but the model seems to be working.

In addition to the model of a fisheries bank to rebuild a sustainable local small boat fishery, local fishers in Ucluelet have partnered with Ecotrust Canada to explore developing a new low-cost, fuel-efficient vessel, which would lessen operational and capital costs and improve the environmental performance of the small boat fleet. Moreover, the WCA Management Board has since 2001 acted as a forum for local actors, groups, and communities to participate more fully in the integrated management of regional aquatic resources, including fisheries. However, local actors state that the success of the board has been severely hampered by a lack of funding and support from federal and provincial governments, as well as ongoing fragmentation between local communities, First Nations, and other groups. Nonetheless, WCA and many others continue to actively push for an adaptive management process for aquatic resources in the region[20].

In addition to ongoing efforts to rebuild local fisheries, the District of Ucluelet has begun to explore new opportunities in aquaculture. Since 2001, federal and provincial governments have supported aquaculture development in rural regions of the province, including two salmon aquaculture companies operating in Clayoquot Sound (now one of the main farmed salmon producing regions in Canada)[21]. Governments are also moving to involve communities in small-scale aquaculture developments. Similar to Community Forest programs, the government of British Columbia has developed a program called the Shellfish Development Initiative, which "works with coastal and First Nations

[20] For instance, the University of British Columbia (UBC) Fisheries Center is currently working to develop an adaptive management strategy for fisheries in partnership with various groups including local fishers, First Nations, environmental non-governmental organizations (ENGOs), industry, and governments. This would include active fisher involvement in monitoring and management of the resource.

[21] In 2007, aquaculture in British Columbia produced 72,000 tonnes of salmon valued at $364 million. In comparison, the once-mighty wild-capture fishery landed only 20 000 tonnes of salmon valued at $41 million in the province in the same year (BC Ministry of Environment 2008; Young and Matthews 2010).

communities" in providing knowledge and logistical support for locally-driven shellfish aquaculture (BC Ministry of Agriculture and Lands 2007). The federal government has also been active in supporting the development of local and community-driven shellfish aquaculture. The promotion of shellfish aquaculture at the community level is in many ways consistent with traditional First Nations usage of the resource (e.g., in terms of caring for shellfish beds, as well as the principles of group ownership and custody) (Bastien 2004; Young and Matthew 2010).

For many, aquaculture represents a much-needed economic light in coastal regions in the province, capable of countering declines in other resource sectors (Bastien 2004). For many coastal residents, however, the aquaculture industry represents the continued failure of government and industry to preserve coastal resources and ways of life (Young and Matthews 2010; Gerwing and McDaniels 2006). The following quotation from an interview in Ucluelet demonstrates this local perspective:

> I sure saw [the transition to aquaculture] happen in Tofino. I mean, Tofino was a salmon trolling town, it was a trolling town… I really lamented the loss of even seeing the fishing fleet leaving the harbour ever spring. These beautiful boats everybody tidied up all winter. So, you're losing a whole component of people's pride and culture. And a lot of them did not re-invest into the aquaculture industry. You know, it was almost deemed blasphemous to do so (Resource scientist/steward, former commercial fisher, Interview Reference #9).

Many local people interviewed in Ucluelet oppose large salmon operations in Clayoquot Sound, citing ecosystem degradation and harmful implications for fisheries (particularly Pacific salmon) and fishers as the largest issues facing the industry. When asked what elements of the aquaculture industry make it strong in the region, the majority of local people surveyed (56.6 percent) replied that 'they don't know', indicating a lack of information and understanding regarding the industry in the region.

In response to widespread opposition to existing 'net-pen' aquaculture operations in the region, the District of Ucluelet has in the last ten years been exploring alternative models of aquaculture, including closed-containment and land-based systems (*see* Cross et al. 2009). In 2009, the Ucluelet council pledged support for research into developing a closed containment salmon aquaculture facility in the region (Westerly News 2009a). In addition, a number of local people interviewed brought up more traditional, smaller-scale aquaculture options for culturing local shellfish and aquatic plant species as a way to promote local food security and sustainability, a practice that would complement long-established local subsistence foraging and fishing activities (firewood, roots, fungi, seafood). Such visions resemble new forms of aquaculture emerging on the Pacific coast, particularly the multi-species model of Integrated Multi-Trophic Aquaculture (IMTA), which is currently operating in one location on the west coast in Kyuquot Sound (for more information, refer to the Canadian Integrated Multi-Trophic Aquaculture Network [CIMTAN] website, forthcoming; Cross et al. 2009). This model and other alternatives may represent a future for aquaculture in the region that is more consistent with traditional coastal resource uses and ways of life.

A final category of new options Ucluelet has embraced since 2001 is community services (i.e., education, health care, recreation, others). Since 2001, rural communities in British Columbia have witnessed the pulling out of traditional forms of state involvement in social and administrative services. As a result of the gradual 'exit' of government support since 2001, Ucluelet has allotted a great deal of its own resources to maintaining and developing services in the community. At the same time, however, the community has faced problems of unemployment, low incomes, poverty, alcoholism, drug abuse,

violence, and outmigration since the mid-1990s, and is now confronting new stresses associated with an increase in the number of tourists and wealthy outsiders (i.e., developers, absentee landlords), which has created inequity between segments of the population, raised the costs of living (food, housing) for residents, and fostered a transient population that is less likely to 'give back' to the community. This scenario has had implications for local entrepreneurialism, creativity, and involvement in community initiatives, programmes, forums, exchanges, and events.

As a result of the pulling out of government support, in combination with various socio-economic constraints facing the community, Ucluelet has lost certain fundamental services since 2001. In 2007, deepening nursing shortages and a lack of training at the regional Tofino General Hospital led to the closure of obstetric (child birth) services (a service which had been in place for 50 years). In 2009, education cutbacks left School District 70 (Port Alberni, Bamfield, Tofino, Ucluelet) to reconcile a projected $1.8 million net deficit in a couple years time, which forced discussions of closing Ucluelet's elementary school in 2011 (Westerly News 2009b).

Facing the loss of essential community services, the District of Ucluelet and the community have actively pushed governments for support and volunteered extensive local resources to keeping services going in the community. A number of examples include a significant increase in volunteer support at the Food Bank on the Edge and the Thornton Creek Hatchery, an increase in municipal investment in Ucluelet's Royal Canadian Mounted Police Office, and the designation of a paid Chief Fire position in the Ucluelet Volunteer Fire Brigade, a result of a reduction in available community volunteers. In addition to the maintenance of existing community services, the District

and many highly active community members and groups have worked to develop new services in the community. Since 2001, Ucluelet has attracted a Medical Centre and a North Island College Center. In 2007, the District and the volunteer Sea View Seniors Housing Society opened the assisted living Forest Glen Seniors Housing complex. In 2009, the Wild Pacific Trail Society secured a grant to extend the Wild Pacific Trail. In 2010, the District and community opened the new Ucluelet Community Centre, which will provide a space for recreation and community service offices for children and families, a dance studio, a 'teen room', and a main hall for community arts, forums, exchanges, and events. The Community Center will also provides a new space for the Westcoast Community Resource Society (WCCRS), a non-profit that provides outreach and support services to all members of west coast communities from Ucluelet to Tofino and remote surrounding areas. As well, the District and the volunteer Ucluelet Affordable Housing Committee are currently working to develop affordable housing opportunities in the community.

In addition to an active local council and community base, many new initiatives in Ucluelet have benefited from recent investment in the community, particularly tourism-related development. However, as the following quotation from an interview with a Ucluelet community planner/manager demonstrates, securing (even essential) community services has been difficult following the introduction of competitive and selective pools of government funding for community initiatives.

> You're asked to go out and compete for all these grants and stuff to pay for essential things. It's not like we're getting our car souped up; we're just needing wheels. And why do we have to compete to get that money? It's definitely not like we're a European country where some things are just not even questioned, where it's like you know that kids are always going to have hot meals at school, or affordable housing. It doesn't make sense; of course everyone should have

> ample housing… It's really hard on a community (Community Planner/Manager, Interview Reference #4).

In summary, Ucluelet has since 2001 been re-inventing it's local socio-economic system by emphasizing local access and control over new ventures in tourism-related development, community forests, sustainable fishing, sustainable forms of aquaculture, and various community services (i.e. education, health, recreation, others)[22]. At the same time, however, the community has experienced significant stress associated with the crisis and release of its previous social-ecological system, as well as new challenges facing the community as it moves towards recovery and renewal (Young and Matthews 2007). The process has been helped by diversification into new economic sectors (tourism, community forests, aquaculture), which have provided new opportunities for socio-economic recovery in the community, as well as attracted a more diverse population with novel and creative approaches to renewal. Moreover, it has been helped by the ability of the community to recognize their points of weakness and reach for support, including from community organizations (WCCRS), regional forums (WCA, CBT), and neighbouring communities, including a signed agreement between the District of Ucluelet and the YFN council in 2010 that confirmed the communities' commitment to building a strong working partnership based on respect.

Overall, Ucluelet has demonstrated a significant capacity to deal with change and move towards new, more sustainable development pathways. As a result of the changes affecting the town in the last six decades, Ucluelet currently comprises a unique population of long-term residents (mostly former loggers and fishers), new residents

[22] It is worthwhile to note that Ucluelet is currently exploring new options in alternative energy (i.e., the development local wave energy sources). However, these initiatives have thus far hit a brick wall in higher governments before they got off the ground.

(younger people and families), and seasonal residents (seasonal workers, tourists, absentee landlords). This 'mix' has provided a diverse and creative energy in the town, and has also demonstrated a capacity for different groups to come together when necessary, particularly regarding shared values concerning the health of the local environment and community. This is especially important as the community now faces new challenges, including the pulling out of government support, rapid tourism development, and climate change (discussed in detail in Chapter 5). As a local fisher in Ucluelet noted in 2009, "We're at the end of a really long road" (Commercial fisher, Interview Reference #12). The process of recovery and renewal in Ucluelet is ongoing.

### 4.5 Summary:

This chapter provided an overview of the social-ecological system of Ucluelet. It described the case of the Ucluelet system, and provided a brief overview of the Ucluelet socio-economic system and local coastal ecosystem. It then provided an in-depth look at the social-ecological system in the last six decades, divided into four periods according to major changes affecting the system.

# Chapter 5: Analysis and Discussion I

This chapter explores the second specific research question, that is, *how does global environmental change affect social-ecological systems in coastal communities?* The chapter first analyzes indicators of climate variability and change. It then examines the issue of change (impacts) and adaptation in the fisheries and aquaculture sector, and several other key socio-economic sectors in Ucluelet, BC.

## 5.1 Indicators of Climate Variability and Change:

### 5.1.1 Climate Variability:

Ucluelet is located in the Coastal Western-Hemlock biogeoclimatic zone (*see* Figure 2.5). It has a humid, maritime climate with annual air temperatures above 5°C and total annual precipitation exceeding 1000 mm (*see* Figures 2.3 and 2.4; Walker and Sydneysmith 2008). Two major ocean-atmosphere phenomena have been observed in Ucluelet: ENSO and PDO (Rodenhuis et al. 2007; Walker and Sydneysmith 2008).

#### 5.1.1.1 Records of Variability and Change

Natural records, such as lake and ocean sediments, tree rings, glacial ice and landforms, provide insights into climate variability and environmental history prior to instrumental records in British Columbia. These records indicate that BC's long-term climate history has occurred in combination with a complex pattern of shorter-term climate variability, including abrupt changes in climate and inconsistencies in the ENSO and PDO (Walker and Sydneysmith 2008). These findings indicate the dynamic nature of BC's historical climate, and the likelihood that climate 'surprises' will occur in the

future. Furthermore, they indicate that the instrumental record probably does not reflect the full range of variability of the climate system, which may respond unpredictably to changes in forcing, including the ENSO (Rodenhuis et al. 2007; Walker and Sydneysmith 2008).

### 5.1.2 Temperature and Precipitation:

#### 5.1.2.1 Historical Trends

Although there are several long-term instrumental climate records for British Columbia, most stations began recording around 1950, which presents challenges for the identification of longer-term trends (Walker and Sydneysmith 2008). The rate of change (temperature and precipitation) in the province over the 20$^{th}$ century is shown in Figures 5.1 and 5.2, respectively. In the Alberni-Clayoquot region, historical climate records indicate that the climate has experienced warming in mean annual temperature and during the spring and fall seasons, and shifting annual and seasonal precipitation trends (less snow, more rain) (Rodenhuis et al. 2007; Walker and Sydneysmith 2008); PCIC 2010). In addition to instrumental climate records, climate trends stored in the knowledge and memory of local people in Ucluelet suggest that the region's climate has warmed significantly in recent decades. The following anecdotes from interviews in Ucluelet demonstrate this trend.

> It used to be colder and I used to ice skate when I was a kid, which I did, right, but you don't do that, haven't done that for the last 20 years (Commercial fisher, Interview Reference #7).

> A fellow was telling me that when he was a kid he used to go out on commercial, I don't know if they were gill nets or seiners, but he said that the ice used to come through the blocks, like it used to be so cold that it would freeze the salt water, and come in the nets, so you'd get frozen nets. Um, but he, they haven't seen that in a long time, indicating a change in temperature, obviously, which indicates something about the ocean (Resource scientist/manager, Interview Reference #1).

Local people also report shifting seasonal temperature and precipitation trends in recent years. The most common observation mentioned is toward warmer, drier summers and milder, wetter winters. Other changes mentioned by local people include: shifting climate variability patterns (e.g., ENSO), which seem to be increasing in frequency and intensity; an increase in precipitation and extreme weather events; a decrease in streamflow; warming water (including ocean) temperatures and currents; and, declining salmon stocks and other ecological changes (these are described in detail below). 54 per cent of local people surveyed reported that these changes could be attributed to climate change. 79 per cent reported that they are aware of the potential for climate change in the region, while 77 per cent reported that they are concerned about future changes.

#### 5.1.2.2 Future Projections

Global climate models (GCMs) are used to project future climate with reasonable scenarios of future greenhouse gas emissions and physical models of climate that include atmospheric, ocean, ice and land-surface components. Multiple projections and/or models are used to address uncertainty and produce a range of possible futures[23] (PCIC 2010).

To assess future climate in BC, Walker and Sydneysmith (2008) used three large scenario regions (north, south and coast), based on large (> 100 km x 100km) GCM grids. The resulting scenarios are displayed as projected changes from an observed 1961–1990

[23] PCIC multiple projections information is drawn from a set of 30 GCM projections based on results from 15 different GCMs, each using one run of a high (A2) and a lower (B1) greenhouse gas emissions scenario. By the end of the 21st century, these scenarios anticipate an atmospheric concentration of greenhouse gases of approximately 1250 ppm (A2) and 600 ppm (B1), expressed as carbon dioxide (CO2) equivalent. Neither scenario incorporates the effects of international agreements on the reduction of greenhouse gas emissions, though other socio-economic factors like population growth are modelled. Each GCM comes from a different modelling centre (e.g. the Hadley Centre (UK), National Centre for Atmospheric Research (USA), Geophysical Fluid Dynamics Laboratory (USA), and Commonwealth Scientific and Industrial Research Organisation (Australia), etc.) (from PCIC 2010).

mean climate to the 2020s, 2050s and 2080s[24] for temperature and precipitation (Figure 5.3) (*see* Walker and Sydneysmith 2008).

To assess future climate at smaller spatial scales, scenarios of finer spatial resolution are available using regional climate models (RCMs). However, computational costs generally limit RCMs to fewer projections than are available using GCMs. It is also possible to use downscaling methods, which use high-resolution elevation and historical data to generate statistical predictions with enhanced spatial resolution. To assess future climate in the Alberni-Clayoquot region, high-resolution climate data was obtained using the PCIC (2010) Plan2Adapt tool, which includes empirical downscaling derived using the ClimateBC program (*see* Note 13). The results of this analysis are presented in Chapter 5. The resulting scenarios are displayed as projected changes from an observed 1961–1990 mean climate to the 2020s, 2050s and 2080s time periods (*see* Note 24) for annual average (mean) temperature[25] (Figure 5.4), precipitation[26] (Figure 5.5), growing degree days[27] (Figure 5.6) and heating degree days[28] (Figure 5.7). The range of projected

[24] The 2020s, 2050s, and 2080s time periods are used as three representative planning horizons over the 21st century. Results for these three planning horizons are computed by averaging GCM projections over the 2010-2039, 2040-2069, and 2070-2099 periods, respectively (PCIC 2010).

[25] Temperature refers to the average of the nighttime low (minimum temperature) and the daytime high (maximum temperature) (definition from PCIC 2010).

[26] Precipitation (rain plus snow) refers to the total amount of water that results from rainfall plus the amount of water that would result from melting of fallen snow (definition from PCIC 2010).

[27] Growing Degree Days (GDDs) is a derived variable that indicates the amount of heat energy available for plant growth, useful for determining the growth potential of crops in a given area. It is calculated by multiplying the number of days that the mean daily temperature exceeded 5°C by the number of degrees above that threshold. For example, if a given day saw an average temperature of 8°C (3°C above the 5°C threshold), that day contributed 3 GDDs to the total. If a month had 15 such days, and the rest of the days had mean temperatures below the 5°C threshold, that month would result in 45 GDDs (definition from PCIC 2010).

[28] Heating Degree Days (HDDs) is a derived variable that can be useful for indicating energy demand (i.e., the need to heat homes, etc.). It is calculated by multiplying the number of days that the average (mean) daily temperature is below 18°C by the number of degrees below that threshold. For example, if a given day saw an average (mean) temperature of 14°C (4°C below the 18°C threshold), that day contributed 4 HDDs to the total. If a month had 15 such days, and the rest of the days had average (mean) temperatures above the 18°C threshold, that month would result in 60 HDDs (definition from PCIC 2010).

change for each variable over the three time periods (2020s, 2050, 2080s) is shown in Figures 5.8, 5.9, 5.10 and 5.11. In addition, a summary of the projected changes for the three time periods (2020s, 2050s and 2080s) is provided in Tables 5.1, 5.2 and 5.3, respectively.

The projected change in annual temperature (°C) for the Alberni-Clayoquot region, based on a PCIC standard set of 30 GCM projections, from the baseline historical period (1961-1990) is 0.8°C (likely range is 0.4°C to 1.1°C) to the 2020s, 1.4°C (likely range is 0.9°C to 2.2°C) to the 2050s, and 2.4°C (likely range is 1.3°C to 3.5°C) to the 2080s (*see* Figure 5.4; PCIC 2010). These scenarios indicate that the rate of change in temperature in the Alberni-Clayoquot region will be less than other areas of British Columbia (*see* Figure 5.3). However, projected change in the region is large in comparison to historical variability. This indicates that relatively small changes in temperature could have large social-ecological impacts.

The projected change in annual precipitation (%) from the baseline historical period (1961-1990) is 3% (likely range is -2% to 6%) to the 2020s, 6% (likely range is -2% to 11%) to the 2050s, and 8% (likely range is 1% to 16%) to the 2080s (*see* Figure 5.5; PCIC 2010). Seasonal scenarios of precipitation indicate that conditions will be wetter in winter, but significantly drier in summer.

Potential impacts resulting from combined changes in temperature and precipitation in the Alberni-Clayoquot region by the 2050s period include: changes in seasonality of streamflow; increased evaporation; enhanced growth rates of unfavorable algae and bacteria, adversely affecting water quality; and, possible declines in water recharge rates for groundwater sources (PCIC 2010). These and other potential impacts resulting from

change in the Alberni-Clayoquot region are summarized in Table 5.4, and discussed below.

### 5.1.3 Extreme Weather and Weather-related Events:

Extreme weather and weather-related events directly affect British Columbians more than any other climate risk (Walker and Sydneysmith 2008). From 2003 to 2005, the frequency and magnitude of extreme events recorded by British Columbia's Provincial Emergency Program (BC-PEP) rose dramatically as a result of wildfires, storm surges, heavy rains causing flooding and landslides, and drought, all leading to severe personal and economic losses. This increase is consistent with an increase in weather-related hazards, as documented in the Canadian Disaster Database (Public Safety and Emergency Preparedness Canada 2006).

In coastal regions, windstorms, storm surges and floods have major impacts on communities, infrastructure and industry (Walker and Sydneysmith 2008; Adger et al. 2005b). In Ucluelet, local people report that they have experienced an increase in the frequency and magnitude of extreme events in recent years, especially during warm El Nino events. It is important to note that this observation is counter to existing research, which observes an increase in the frequency and magnitude of extreme events during cool El Nina events (Rodenhuis et al. 2007). The following quotations from interviews demonstrate the experience in Ucluelet:

> In '85 we got caught in a massive storm that was a weather event that was connected to an El Niño year [and] that could have very easily been connected to climate change. It was a massive storm – blew between Cape St. James and Cape Scott – it blew out in a matter of less than an hour. It went from zero to 70 [km/h], and then it went to 110 [km/h], and it blew for twelve hours, and it was an indicator, potentially, of what happens when your start upsetting regular patterns of weather. There has been a couple storms in the last couple years that have done

> that, you know, that have been really, incredibly violent (Commercial fisher, Interview Reference #7).
>
> I think we've, you know, we see from El Niño's and how close we've had them together. You know, they used to be nine to twelve years apart, as I understand. It's been going on for 6000 years, as I understand, supposedly, these phenomena. And then we get them really close together, back to back (Resource scientist/steward, former commercial fisher, Interview Reference #9).

62 per cent of local people surveyed in Ucluelet believe that it is 'likely' or 'very likely' that the community will experience an increase in the frequency and/or intensity of storms in the next ten years.

### 5.1.4 Hydrology and Oceanographic Change:

Changes in regional hydrology are linked to temperature and precipitation trends (*see* Section 5.1.2). In recent years, warming temperatures and increasing precipitation trends have increased winter streamflow in coastal BC (Rodenhuis et al. 2007). According to climate model projections, this trend is projected to continue (*see* Figures 5.8 and 5.9; PCIC 2010). Changing temperature and precipitation trends also affect summer streamflow, resulting in earlier spring peak flow and reduced summertime flow (Rodenhuis et al. 2007). In Ucluelet, managers of the Thornton Creek Hatchery and Salmon Enhancement Society report decreasing late summer streamflow in recent years, leading to forced adjustments in the placement of the hatchery's salmon. Such hydrological changes will significantly affect several key economic sectors in Ucluelet and other communities on the BC coast, including fisheries and aquaculture (*see* Section 5.2.1), agriculture (*see* Section 5.2.4), and hydroelectric power generation (*see* Section 5.2.6; Walker and Sydneysmith 2008).

Climate change also affects groundwater systems. Small changes in temperature and precipitation can affect groundwater recharge and discharge rates, and water table depths. Furthermore, an increase in extreme sea levels and storm surges on the coast could impact groundwater quality in coastal regions due to saltwater intrusion and infrastructure damage (Walker and Sydneysmith 2008). According to local people in Ucluelet, the physical location of the community (on a peninsula) makes it particularly vulnerable to such changes.

In addition to changes in surface and groundwater systems, climate change affects ocean systems. The most significant changes currently affecting the global ocean include changes in temperature, salinity, oxygen levels, and acidification (Mitchell and MacDonald 2010). Observations since 1961 show that the average temperature of the global ocean has increased to depths of at least 3000 m and that the ocean has been absorbing more than 80 percent of the heat added to the climate system. Such warming causes seawater to expand, contributing to sea level rise (*see* Section 5.1.5) (IPCC 2007a). In the North Pacific, these trends have occurred in combination with ENSO and PDO patterns. For example, the temperature of the North Pacific warmed significantly as a result of the positive PDO phase since 1976, reaching its peak temperature in 2003 (IPCC 2007a). In addition, the North Pacific Ocean is freshening, which is consistent with changes in precipitation. However, observations do not allow for a reliable estimate of the average change in ocean salinity (IPCC 2007a).

The biogeochemistry of the ocean is also changing. According to local scientists interviewed in Ucluelet, in recent decades, warming temperatures have resulted in the de-oxygenation of the global ocean, as warmer water holds less oxygen. Currently, there are

407 hypoxic (low-oxygen), or dead zones in the global ocean, a number that doubles every two years. This is caused by human-induced eutrophication and global climate change (Mitchell and MacDonald 2010). Furthermore, the total inorganic carbon context of the global ocean has increased by 118 ± 119 GtC[29] between the end of the pre-industrial period (about 1750) and 1994, and continues to increase. This is the result of an increase in carbon dioxide in the atmosphere (more than a quarter of which is absorbed by the global ocean), leading to a decrease in ocean pH (increase in ocean acidity) by an average of 0.1 pH units since 1750 (IPCC 2007a). The acidification of the global ocean has implications for all living things, though most immediately it places pteropods, corals and shellfish (any species that produce calcite and aragonite shells or structures) at risk (Kleypas et al. 2006; Fisheries and Oceans Canada 2009). One commercial fisher in Ucluelet notes that, of all of the issues facing the global ocean, acidification is the one he fears the most (Commercial Fisher, Interview Reference #7).

### 5.1.5 Sea Level Rise:

Sea level rise is consistent with warming. Global mean sea level rose 10 to 20 cm during the twentieth century, and is anticipated to rise another 18 to 59 cm by 2100, largely due to melting glaciers and ice sheets, and thermal expansion of the warming ocean (IPCC 2007a). On British Columbia's coast, relative sea-level change differs from the global trend due to vertical land movements (Abeysirigunawardena and Walker 2008). For instance, during the twentieth century, sea level decreased by 13 cm in Tofino and Ucluelet (Shaw et al. 1998; BC Ministry of Water, Land and Air Protection 2002). However, on the Tofino-Ucluelet coast, the height of damaging extreme high-water

[29] Gigaton of Carbon (IPCC 2007a).

events is increasing at a faster rate than sea-level rise. Such events are strongly influenced by ENSO and PDO. For instance, extreme water levels on the Pacific coast have increased significantly since the positive PDO shift in 1976. Furthermore, during the El Niño events of 1982/1983 and 1997/1998, sea levels from California to Alaska rose as much as 100 cm above average, and more energetic wave conditions produced extensive coastal erosion and infrastructure damage (Abeysirigunawardena and Walker 2008).

Ucluelet is vulnerable to extreme water levels, storm surge flooding and enhanced coastal erosion resulting in damage to coastal infrastructure such as highways, buildings, power lines and freshwater aquifers. In particular, local people report that tourist development and shoreline development on Ucluelet's outermost coast since 2001 have increased the community's exposure to large-scale climate variability patterns and extremes events.

### 5.1.6 Ecosystems:

Climate change impacts biological productivity and diversity and ecosystem distribution. A wide range of studies from a diversity of geographic areas and ecosystem types show that BC's ecosystems are already changing in response to climate change. For instance, Pacific salmon, sardine, anchovy, mountain pine beetle and western red cedar have all shown abrupt change in response to past, relatively small changes in climate (Walker and Sydneysmith 2008). Such changes in species abundance and/or distribution have important implications for ecological and human systems in the province. In Ucluelet, for example, declining numbers of returning salmon is a major concern for local ecological, socio-cultural and economic well-being. Local people in Ucluelet attribute this change to a variety of factors, including climate change.

Species range shifts are also expected to occur (Royal BC Museum 2005), often with little overlap between current and projected distributions and interactions. Unique ecosystems could become reduced in extent and more fragmented, and many species will be forced to migrate over natural and man-made barriers (Overpeck et al. 1991; Walker and Sydneysmith 2008). According to local people in Ucluelet, several non-native southern species have infiltrated into the local ecosystem in recent years, including Brown pelican, California sea lion, horsetails, sardines, sunfish (mola mola), mackerel, and Humboldt squid. Other changes that are expected to affect local ecosystems include an increasing frequency and intensity of wildfires and droughts, outbreaks of pests in terrestrial environments, and growth of unfavourable algae and bacteria in freshwater and marine environments, adversely affecting water quality (PCIC 2010).

It has been suggested that such changes will produce 'novel ecosystems' that will tap our resourcefulness as a society (Hobbs et al. 2009). The following quotation from an interview in Ucluelet provides a local level perspective on this experience:

> I think as climate change, if it does take hold, there will still be animals here, they will just be different animals. But there will be a weird transition period where we're going to lose some of the things that have been here for millennia and something new will happen (Resource scientist/steward, former commercial fisher, Interview Reference #9).

The role of human actors to intervene (or not) in ecosystem change will be of increasing importance in resource and environmental management in the decades to come (Hobbs et al. 2009).

### 5.2 Impacts, Risk Perception and Adaptation:

The impact of biophysical change on human societies depends upon ecological and socio-economic factors across scales, the dynamics of which are explored in detail in

Chapter 6. The following sections examine the issue of climate change, impacts and adaptation in several key socio-economic sectors in Ucluelet.

### 5.2.1 Fisheries and Aquaculture:

The fisheries and aquaculture sector, including commercial and recreational fishing, aquaculture and seafood processing, employs about 105 people in Ucluelet, or 10.3 per cent of the labour force in the community (Statistics Canada 2006; BC Ministry of Agriculture and Lands 2005). This number represents approximately 2 per cent of the fisheries and aquaculture labour force in BC.

Recreational fishing, with close ties to tourism (*see* Section 5.2.3), is the largest component of the British Columbia's fisheries and aquaculture sector (BC Ministry of Agriculture and Lands 2005). Since 2001, recreational fishing is also the largest component of the fisheries and aquaculture sector in Ucluelet. Aquaculture is another major component of the sector in the province, encompassing over 700 site licenses for 30 different species of finfish, shellfish and marine plants (BC Ministry of Agriculture and Land 2005), with sales reaching more than $212 million in 2005 (up from $3 million in 1983) (BC Ministry of Agriculture and Lands 2005). Currently, aquaculture comprises a small component of the fisheries and aquaculture sector in Ucluelet (there are currently two salmon aquaculture companies operating in Tofino, one salmon hatchery operating in Tofino, one salmon hatchery operating in Ucluelet, and a small number of shellfish and marine plant farms in the region). In 2009, the Ucluelet council pledged support for research into developing a closed containment salmon aquaculture facility in the region (Westerly News 2009a).

In Ucluelet, fisheries, and specifically Pacific salmon, are keystone contributors (*sensu* Garibaldi and Turner 2004) to the ecological, socio-cultural and economic fabric of the local community. Local people in Ucluelet, and throughout the West Coast of Vancouver Island (WCVI) region (Ommer et al. 2007; Garibaldi and Turner 2004), cite healthy fisheries, and the health of wild salmon in particular, as fundamental indicators of ecological integrity of the coastal system. Furthermore, access to fisheries to meet the socio-cultural and economic needs of local people makes the health of local fisheries a core priority on the coast (Garibaldi and Turner 2004).

In recent decades, fisheries and aquaculture in BC have changed in response to many factors, including climate variability (Ommer et al. 2007; Young and Matthews 2010). It is predicted that climate change will induce a wide range of responses from fisheries and cultured species in BC (Walker and Sydneysmith 2008). For instance, both local fishers and fisheries scientists report that short-lived species, including sardines, herring and salmon, respond quickly to changes in climate, and populations can collapse or recover without warning in response to even minor changes in temperature (Fisheries and Oceans Canada 2001; Hyatt et al. 2003; Fisheries and Oceans Canada 2009). At the same time, local and scientific sources report that the life histories of longer-lived species, such as geoduck clams, rockfish and halibut, change slowly (sometimes over a decade or longer), making them less vulnerable to climate-induced change (Walker and Sydneysmith 2008).

Fisheries and aquaculture responses will also vary across regions. The WCVI region, for example, supports some of the most biologically productive and diverse marine species in BC (Walker and Sydneysmith 2008). According to local fishers and

scientific studies, some local species in the WCVI region have already shown signs of decline in response to warm water conditions, including sardines, herring and salmon (Fisheries and Oceans Canada 2009). At the same time, local and expert sources note that infiltrations of warm water species from the south, including new predators such as mackerel and Humboldt squid, could potentially threaten salmon and other established coldwater fisheries in the region (King 2005). Furthermore, it is locally acknowledged that – though warmer water may increase productivity in some local shellfish species, including Abalone, clams, scallops and oysters, and some aquatic plants, including kelp, which would, in turn, increase food availability and habitat for other species (e.g., sea bass, rockfish) – past a certain temperature point, or threshold, these species will not grow, and could become more vulnerable to disturbance. For instance, local accounts and scientific research confirm that climate changes such as increased surface temperatures and storminess are significant factors stimulating red tide and other harmful algae blooms (HABs)[30], from which biological health impacts (e.g., paralytic shellfish poisoning [PSP]) can be especially severe (Dolan and Ommer 2008).

#### 5.2.1.1 Risk Perception and Adaptation

In recent decades, local and regional anthropogenic disturbances, in combination with climate change, have threatened the sustainability of fisheries and habitats in BC (Pacific Fisheries Resource Conservation Council 2006). The resulting erosion of ecological resilience places Pacific salmon and other keystone species at risk of repeated

[30] It is estimated that red tides and other HABs have resulted in averaged losses of $4 million per outbreak since the 1970s on Canada's coasts, with one specific HAB resulting in losses of between $10 million to $20 million from the 1970s to the 1990s in British Columbia (Dolan and Ommer 2008).

reduction or elimination where cumulative human impacts, plus climate changes, continue to occur.

Levels of awareness of climate change impacts on the fisheries and aquaculture sector in Ucluelet vary greatly among stakeholder groups. Generally, First Nations, recreational, commercial and local management agency groups are aware that salmon and other local species are vulnerable to climate change. Of local people surveyed, 62 percent believe that climate change will negatively affect wild finfish, 64 percent believe that such changes will negatively affect wild shellfish, and 64 percent that such changes will negatively affect wild marine plants. For aquaculture, 40 percent believe that climate change will negatively affect cultured finfish, 39 percent believe that such changes will negatively affect cultured shellfish, and 35 percent that such changes will negatively affect cultured marine plants. It is important to note that, in all cases, a large number of local people surveyed (ranging from 25 to 29 per cent) replied that they do not know what the impacts will be. Nonetheless, there appears to be a majority consensus that fisheries will change in response to climate variations and that adaptive responses will be required.

A number of adaptation measures have been discussed for fisheries in BC (*see* Walker and Sydneysmith 2008). These include: reducing harvest rates to provide conservation buffers, given increasingly variable stock productivity; reinforcing habitat protection and restoration measures by all sectors to promote the sustainability of capture fisheries; increasing hatchery production of salmon to counter declining productive capacity of freshwater and/or marine habitat; licensing and regulating river systems; enabling processes for shifting harvest opportunities provided by short-lived versus long-

lived species, or from established (e.g., salmon, herring) to relatively unexploited species (e.g., mackerel, squid); and, promoting accelerated development of aquaculture to meet labour force and market demands that capture-fisheries cannot satisfy (Walker and Sydneysmith 2008).

In regard to conservation, Fisheries and Oceans Canada is taking specific actions to achieve conservation of fish stocks and freshwater and marine habitats. Such actions include new (2010/11) Integrated Fisheries Management Plans (IFMP) for the Pacific coast. For instance, the IFMP for crab, with a focus on Dungeness crab (*Cancer magister*), includes a minimum harvestable size limit, limited commercial licensing, area licensing, trap limits, soak limits, sex restrictions, soft-shell restrictions, and gear restrictions (Fisheries and Oceans Canada 2010a). The IMFP for groundfish, including halibut, sablefish, rockfish, lingcod, dogfish, requires 100% at-sea monitoring and 100% dockside monitoring, individual vessel accountability for all catch, both retained and released, individual vessel quotas and reallocation of these quotas between vessels and fisheries to cover catch of non-directed species (Fisheries and Oceans Canada 2010b). The IMFP for southern BC Pacific salmon, including sockeye, coho, pink, chum and chinook salmon, incorporates policy and operational initiatives adopted over the past several years for First Nations, recreational, and commercial fish harvesters (*see* Fisheries and Oceans Canada 2010c). According to local fishers in Ucluelet, IFMPs provide important conservation buffers that reduce the risk of long-term negative impacts to stocks and the social and economic values that are derived from them. However, fishers also reported several gaps in the IFMPs, especially regarding the socio-economic costs of

conservation[31] (particularly for small fishers), and the exclusion of aquaculture from a comprehensive regulatory regime[32].

Another category of adaptation measures that has been raised involves increasing hatchery production of salmon to counter declining productive capacity of freshwater and/or marine habitats. According to local fishers in Ucluelet, there is potential to address the problem of uncertainty in fisheries through species conservation and enhancement programmes, such as the hatchery programme. The national Salmon Enhancement Program (SEP) was launched by Fisheries and Oceans Canada in 1977 to support local hatchery projects such as the Thornton Creek Hatchery in Ucluelet. However, the experience in Ucluelet demonstrates that rural enhancement projects are increasingly subject to competition for narrow pools of government funding, which is increasingly consolidating in large, more centralized operations, placing a significant constraint on salmon enhancement programs in rural and remote regions of the country[33].

Another category involves enabling processes for shifting harvest opportunities provided by short-lived versus long-lived species, or from established (e.g., salmon, herring) to relatively unexploited species (e.g., mackerel, squid). In Ucluelet, local fishers

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[31] For example, on December 23, 2008, Canada and the US ratified new provisions for the Pacific Salmon Treaty, which included a reduction of catch ceilings for the West Coast of Vancouver Island chinook fishery by 30 percent from previous levels. The agreement includes a $30 million fund to help mitigate the impacts of harvest reduction in Canada; however, the allocation of support funds in January 2010 (one year after the implementations of the fishery reductions) meant severe socio-economic strife for small fishers in 2009 (Fisheries and Oceans Canada 2008).

[32] In February 2009, British Columbia Supreme Court (BCSC) ruled that the activity of aquaculture is a fishery which falls under exclusive federal jurisdiction and, in effect, struck down substantial portions of the provincial regulatory regime governing aquaculture. The BCSC has given Fisheries and Oceans Canada until December 18, 2010 to develop and implement a federal aquaculture regulation for BC (Fisheries and Oceans Canada 2010c).

[33] The Thornton Creek Hatchery in Ucluelet has not seen a budget increase since 1991, nor has it received funding for hatchery upgrading (allocated via selective pools of government funding). As a result, the hatchery has not been able to raise employees' incomes in 20 years and is heavily reliant on volunteers to remain viable.

and other local people report that the established fisheries management system does not allow fishers to easily transition from one fishery into another, given stringent, expensive licensing requirements. They also state that the present system has been unresponsive to new opportunities in relatively unexploited fisheries. Specific actions aimed at diversification and shifting harvest opportunities might involve licensing processes that promote participation in multiple fisheries, and increased investment to speed the development of processing, marketing and management infrastructure for newly emergent fisheries (Walker and Sydneysmith 2008). For instance, in Ucluelet, local fishers have already transitioned from fishing salmon to fishing a variety of longer-lived groundfish species, including halibut, rockfish, lingcod and dogfish. In addition to such individual actions, investment in licensing processes such as the model fisheries license bank (*see* Chapter 4, Section 4.4.4), as well as the development of more flexible management infrastructure for newly emergent fisheries, are of vital importance for fisheries on the WCVI and elsewhere in BC.

A final category of adaptation measures that has been raised involves promoting accelerated development of aquaculture. It is acknowledged that socio-economic dislocation and stress in fishing-dependent communities are likely to increase as the climate continues to change. In addition to adaptation actions aimed at sustaining traditional fisheries or developing new ones, local stakeholders in Ucluelet are discussing the development of aquaculture to meet labour force and market demands that capture-fisheries cannot satisfy. It is important to note that local fishers in Ucluelet do not view aquaculture as a replacement for traditional fisheries. In fact, most local people view aquaculture negatively, as a major factor contributing to ecosystem damage leading to the

decline of wild capture fisheries. Furthermore, though some local people are knowledgeable about alternative forms of aquaculture, including closed-containment systems, land-based systems and traditional low-density, multi-species culture systems for growing native finfish, shellfish and marine plants, local stakeholder and public engagement concerning aquaculture is extremely lacking, particularly regarding alternative, more sustainable farming options (e.g., Integrated Multi-Trophic Aquaculture [IMTA]; *see* Cross et al. 2010). If managed properly, such models may represent progressive future options in line with traditional resource uses and livelihoods on the Pacific coast.

In the face of ongoing change, addressing the elements of coastal communities that sustain and build resilience and adaptive capacity, not only within the fisheries sector, but also across sectors, is of the upmost importance. The following sections briefly examine the issue of change and adaptation in other key socio-economic sectors in Ucluelet.

### 5.2.2 Forestry:

The logging and forest product sector employs about 40 people in Ucluelet (from 95 in 2001, and over 200 in 1991). British Columbia's Coast Forest Region covers a total of 16.5 million ha of forest and provides a wide range of social, cultural, economic and biological values and services (BC Ministry of Forests and Range 2008). The coastal forests immediately surrounding Ucluelet principally consist of old growth trees with some younger second growth (BC Ministry of Forests and Range 2009).

Climate changes are considered a contributing factor to forest disturbance by fire and pests, particularly in old growth trees (Walker and Sydneysmith 2008). Coastal forests will also see an increase in the number and intensity of storms, thereby increasing

wind-throw damage. In addition to climate-induced forest disturbance, climate change directly affects tree species, as optimum growth conditions for local populations are relatively narrow (Walker and Sydneysmith 2008). For example, local people in Ucluelet report that cedar trees in the region are prone to heat stress (dryness, yellowing) following warm, dry summer conditions, as occurred in 2009. This is consistent with studies in other regions of the Pacific Northwest, which show that late summer heat appears to stress yellow cedar, negatively impacting present and future tree growth (Laroque and Smith 1999). Although such species may survive in their current location under a changed climate, growth rates will be affected and there will be increased competition from other species more suited to the climate. It is predicted that the potential ranges of species will move northward and upward in elevation (Walker and Sydneysmith 2008).

Forestry operations in the WCVI region will be directly impacted by climate change. Some major impacts will include changes in productivity affecting rotation ages, wood quality, wood volume and size of logs; access to harvesting areas due to warmer and wetter conditions; increases in the frequency and magnitude of extreme weather affecting design and maintenance of logging roads; and, an increase in the probability of landslides and debris flows (Walker and Sydneysmith 2008). These changes will occur in combination with regional and broader issues, including increased competition from countries expected to see significant production benefits from a changing climate (e.g., those in South America and Oceania, which are already replacing BC products in the global market) and changes in consumer preferences. Non-climatic risks to the forestry

sector include loss of forests due to development and increasingly competitive and unpredictable markets (Walker and Sydneysmith 2008).

#### 5.2.2.1 Risk Perception and Adaptation

Climate change will play a major role in shaping the composition and use of forests on the British Columbia coast and, in turn, will affect overall coastal ecosystem biodiversity and connectivity. Some local people in Ucluelet are very knowledgeable about the sensitivity of their forests to climate-induced change, and are concerned about the implications of these changes for forestry and other sectors. According to them, it is of upmost importance that forestry in Ucluelet be adapted to changing climatic conditions. It is also suggested that this be done in combination with other sectors, particularly fisheries (*see* Section 5.2.1) and tourism and recreation (*see* Section 5.2.3).

According to respondents, the most important step toward more sustainable forestry is the establishment of a Community Forest Agreement (CFA) (*see* Chapter 4, Section 4.4.4) in the Ucluelet region. Local people involved in this process state that a CFA will enable 'closer to home' management of the resource by allowing communities to decide how to manage the forest, as well as provide opportunities for sustainable use of the resource for multiple, integrated uses (i.e., harvesting botanical forest products, ecotourism, hydroelectric power generation). At the time of writing in 2010, the Ucluelet-Toquaht CFA had not been issued (Barkley Community Forest 2010).

Other adaptation actions that have been discussed for British Columbia's forests mostly involve short-term adaptations, as the province's wood supply for the next 50 or more years is already 'in the ground'. Short-term adaptations focus on operational changes; for example, the increase in disturbance by fire and pests has resulted in greater

and greater amounts of the harvest being salvaged wood. Furthermore, it seems likely that forest management adaptations will have to consider climate change impacts beyond those directly affecting timber resources in order to maintain biodiversity and ensure landscape connectivity (Walker and Sydneysmith 2008). Longer-term adaptation measures that are being discussed include changes in reforestation practices, especially in species selection, as trees best suited to particular areas change. Planting species that grow well under a wide range of conditions might also help maintain productivity (Spittlehouse and Stewart 2003; Walker and Sydneysmith 2008).

As most of BC's forests are on crown land, the provincial government will play an important role in developing and applying adaptation measures for forest management. The recent actions of the BC Ministry of Forests and Range (MFR), including the launch of a Climate Change Task Team and the Future Forests Ecosystem Initiative (FFEI) in 2005, are a first step in this process (Walker and Sydneysmith 2008). The creation of CFAs such as the Barkley Community Forest, particularly in communities in rural and remote regions of the province, will also play a key role.

### 5.2.3 Tourism, Recreation, Parks and Protected Areas:

Since the decline of forestry and fishing in the 1990s, tourism has been the fastest growing economic sector in Ucluelet (*see* Chapter 4 Section 4.4.4). In 2006, the tourism sector, including accommodation, food and recreation services, provided more than 250 jobs in Ucluelet, approximately 25 percent of total employment in the community (Statistics Canada 2006). The success of this sector is due to a wide range of factors in Ucluelet, including its close proximity to Pacific Rim National Park Reserve, recreational opportunities, and strong community attachment. Ucluelet has embraced tourism

development as a means of economic restructuring and renewal after declines in the resource sectors. However, many local people express concern about the sustainability of the industry. This is due to many factors, including the seasonal nature of tourism-related employment, the infiltration of 'outsiders' who do not nurture the local community or environment, and the potential impacts of environmental change.

Tourism, recreation, parks and protected areas in BC are vulnerable to impacts of climate change. These impacts include: the decline and fragmentation of ecosystems as temperatures change; an increasing frequency and intensity of natural hazards such as wind storms, storm surges, droughts and landslides; and, changing species migration patterns and increasing competition and threats from non-native species, with implication for biodiversity and population sustainability of native species (Walker and Sydneysmith 2008).

#### 5.2.3.1 Risk Perception and Adaptation

Most local people in Ucluelet are aware of the risks associated with the tourism sector. However, if managed properly, tourism-related development is inherently dynamic and responsive to environmental and other changes. Adaptive measures for tourism typically involve a combination of short-term responses, such as marketing strategies aimed at changing tourist behaviour, and longer-term planning in order to adjust to local climate impacts. A key adaptive strategy for weather-dependent tourism is to spread risk by diversifying operations and reducing reliance of single-season activities. For example, Ucluelet is now actively attracting tourists for winter storm watching (District of Ucluelet 2005). Another key adaptive measure is hazard risk reduction, including comprehensive emergency planning and response to deal with extreme weather

events. In Ucluelet, such measures are ongoing, and must continually develop as the climate continues to change.

### 5.2.4 Foraging and Agriculture:

Coastal BC's mountainous landscape and climatic diversity result in limited land suitable for farming. In Ucluelet, a small number of people, about 20 in 2006, or approximately 2 percent of the local labour force, formally engage in the agricultural sector (Statistics Canada 2006). However, foraging and small-scale, or 'backyard' farming represent an important component of local socio-economy, particularly by providing a relatively stable supply of high-quality food (e.g., fruits and vegetables, roots, fungi) to supplement other sources of income.

Local people report that local crops are already being affected by climate change. For instance, local people state that growing conditions have improved for their backyard gardens, while, at the same time, local people report that growing seasons for some local crops (e.g., berries) have changed or become highly uncertain. Projected change in the number of growing degree days in the Alberni-Clayoquot region [34] (*see* Figures 5.6 and 5.10) shows that a longer growing season is expected in the decades to come.

The potential impacts of climate change for agriculture have been assessed in British Columbia (Zebarth et al. 1997). These studies suggest that longer growing seasons and milder winters will increase the range of crop types suitable for growing, thereby providing new opportunities for local foragers and producers. However, there will also be

[34] Projections of future change in annual growing degree days for the Alberni-Clayoquot region, based on a PCIC standard set of GCM projections, from the baseline historical period (1960-1990) are +204 degree days (likely range +102 to +280 degree days) to the 2020s, +361 degree days (likely range +218 to +538 degree days) to the 2050s, and +607 (likely range +303 to +923 degree days) to the 2080s (*see* Figure 5.6; PCIC 2010).

new challenges. These include projected declines in water resources, an increasing possibility of summer drought, and outbreaks of new pests and diseases leading to crop loss (Walker and Sydneysmith 2008).

#### 5.2.4.1 Risk Perception and Adaptation

Local foragers and agricultural producers in Ucluelet are by no doubt accustomed to dealing with uncertainty in weather, markets, predators, pests, and potential incomes. Local responses to address climate-related risks to local growth may be short or long term, ranging from types of practices used to product choices. Local foragers and producers report that they will likely be able to take advantage of new opportunities to harvest crops of improved quality and/or quantity, and/or different crop types. Such responses will not only supplement potential losses of existing foraging and farming activities, but also provide a buffer against unpredictable changes in other socio-economic sectors in the face of change.

### 5.2.5 Water Resource Management:

Water resources are highly sensitive to climate variability and change (Walker and Sydneysmith 2008). Climate changes in hydrology, including reduced streamflow and earlier flow peaks, have significant implications for regional water supplies and uses (Walker and Sydneysmith 2008). In Ucluelet, residents rely on groundwater as a source of drinking water. Furthermore, a number of local industries, including fish hatcheries, seafood processing, parks and tourism, agriculture, and hydroelectric power generation, are major users of groundwater (District of Ucluelet 2005).

It is projected that increased streamflow during winter months (due to increased precipitation falling as rain and reduced snowpack) and an earlier peak flow season will

result in less streamflow during summer months, when water demand is highest. This will profoundly affect local residents and visitors, as well as local salmon habitat and hydroelectric power generation. According to almost all future climate scenarios, it will be very difficult for current water resource management objectives to support fisheries and hydroelectric power generation in the face of projected change (Walker and Sydneysmith 2008).

#### 5.2.5.1 Risk Perception and Adaptation

According to the District of Ucluelet, Ucluelet draws water from supplies with sufficient capacity to sustain the community until approximately 2015. Two water reservoirs, Mercantile Creek and the Lost Show Creek Aquifer (LSCA), allow for water storage to provide adequate water supply during peak demand periods. Nonetheless, as a result of the growing tourism industry, increased demand for groundwater is anticipated in the near future, and Ucluelet is currently exploring additional future water supplies (i.e., Clayoquot Arm, a protected portion of Kennedy Lake) (District of Ucluelet 2008).

### 5.2.6 Energy:

Ucluelet gains electricity from the provincial network, BC Hydro. In 2006, 89 percent of electricity produced in the province was hydro generated (BC Hydro 2006). This makes the energy sector sensitive to the impacts of climate change (Walker and Sydneysmith 2008). The following considerations are beginning to attract the attention of energy researchers and managers: water shortages are already a risk for BC's hydroelectric resources; electricity demand in BC is expected to increase by 33 to 60 percent by 2025 (BC Hydro 2006); and, seasonal and longer term energy demands for

buildings (e.g., increased summer cooling needs, decreased heating requirements)[35] will change across the province in response to climate change (*see* Figures 5.7 and 5.11) (Walker and Sydneysmith 2008).

#### 5.2.6.1 Risk Perception and Adaptation

BC's energy future will rely on actions that have both mitigative and adaptive benefits, to reduce greenhouse gas emissions and reduce demands on climate-sensitive sources of electricity (Walker and Sydneysmith 2008). To date, many programs exist to promote energy efficiency in the province (e.g., BC Sustainable Energy Association, FortisBC 2006). Furthermore, BC Hydro aims to meet about 50 percent of increased electricity demands by 2020 through conservation and efficiency measures, including programs for consumers and industry (Walker and Sydneysmith 2008).

In addition to efficiency improvement to existing energy supplies, BC Hydro's (2006) Integrated Electricity Plan states that at least 50 percent of new power supply needs will come from renewable sources, including hydroelectricity, biomass and wind power. In Ucluelet, renewable energy projects, for example, wave energy, are already in motion; however, they will require increased support from higher levels of government to move beyond the proposal stage.

[35] Projections of future change in annual heating degree days for the Alberni-Clayoquot region, based on a PCIC standard set of GCM projections, from the baseline historical period (1960-1990) are -308 degree days (likely range -428 to -143 degree days) to the 2020s, -529 degree days (likely range -804 to -334 degree days) to the 2050s, and -880 (likely range -1264 to -475 degree days) to the 2080s (*see* Figure 5.11; PCIC 2010).

### 5.2.7 Infrastructure:

Critical infrastructure includes various networks, facilities, systems and services that are key to the well-being and operations of society (Public Safety and Emergency Preparedness Canada 2006). This involves a diversity of systems for energy and public utilities, health care, transportation, food supply, industry, communications and information technology, finance, safety and rescue, and defence (Walker and Sydneysmith 2008).

The impacts of past and recent extreme weather events demonstrate that these interconnected systems are vulnerable to climate change. From 2003 to 2005, British Columbia experienced a significant increase in the number of extreme weather events requiring widespread emergency responses, compared to the previous decade (Walker and Sydneysmith 2008). The British Columbia's Emergency Response Management System (BC-ERMS) recognizes the potential for increasing frequency and severity of such natural hazard risks as wildfires, flooding, drought, and landslides as a result of climate change, with severe implications for critical infrastructure in the province.

#### 5.2.7.1 Risk Perception and Adaptation

At the provincial level, the BC-ERMS addresses natural hazard risks to critical infrastructure through both reactive (e.g., financial claims support following disturbance) and proactive (e.g., support to local authorities and communities for hazard risk-reduction initiatives and education and awareness programs) measures. Locally, there are nine emergency response organizations that are trained to deal with emergencies and disasters in Ucluelet (*see* Appendix G). Ongoing efforts to support local hazard risk-reduction

initiatives and education and awareness programs will be critical as the potential for natural hazard risks to the community increase in response to climate change.

### 5.2.8 Health:

According to local people, the health of the Ucluelet community is a function of interacting environmental, biological and socioeconomic factors (e.g., natural resources, rural setting, immunity, income, access to health care services). Climate change presents both direct and indirect health risks at the individual and community levels. For instance, direct health risks include increases in the number of injuries, illnesses and mortalities related to poor air quality, extreme weather events, and heat. Indirect health risks include exposure to air-, water- and vector-borne diseases and declines in ecosystem health (Ommer et al. 2007; Walker and Sydneysmith 2008).

It is important to note that remote, rural communities are particularly vulnerable to these risks, as they often depend on a limited critical infrastructure for the distribution of food, medical supplies and other essential goods and services (Walker and Sydneysmith 2008). Furthermore, there is a very strong relationship between ecosystem impacts on socio-economic livelihoods and health in remote, rural communities, where livelihoods are most intimately connected to the ecosystem in which they are embedded (Ommer et al. 2007).

#### 5.2.8.1 Risk Perception and Adaptation

There is a need for improved education and awareness of climate change impacts on human health at local, provincial and national levels (Lemmen et al. 2008). Adaptation in the public health sector requires cross-scale and cross-sector approaches encompassing health care workers and administrators, educators, environmental managers,

infrastructure developers, rural and urban planners, politicians and researchers. It also requires more information on prevention, protection and treatment of climate-related health risks, as they will be experienced at the local level, being made accessible to local people (Walker and Sydneysmith 2008).

According to local people in Ucluelet, it is possible that climate change presents a valuable opportunity to bring a diversity of actors and sectors together across scales under a common theme of long-term environmental, biological, and socio-economic health and sustainability. As a local community planner/manager noted, "Climate change is definitely one of those threats that can help do that… it brings a bit of a unity of momentum for new [ways of doing] things" (Community Planner/Manager, Interview Reference #4). The key factors that influence the ability of the community to embrace such new development pathways are presented in Chapter 6.

### 5.3 Summary:

This chapter addressed my second specific research question, that is, *how does global environmental change affect social-ecological systems in coastal communities?* It analyzed several indicators of climate variability and change in the Alberni-Clayoquot region. It then explored the climate change impacts in the fisheries and aquaculture sector, and several other key socio-economic sectors in Ucluelet. Finally, it explored perceptions of risk and possible adaptations in these key sectors. The second part of this analysis, Chapter 6, addresses the remaining specific research questions presented in Chapter 1.

**Table 5.1 Climate Change for Alberni-Clayoquot Region in 2020s Period**

**Climate Change for Alberni-Clayoquot Region in 2020s Period**

| Climate Variable | Time of Year | Projected Change from 1961-1990 Baseline | |
|---|---|---|---|
| | | Ensemble Median | Range |
| Mean Temperature (°C) | Annual | +0.8 °C | +0.4 °C to +1.1 °C |
| Precipitation (%) | Annual | +3% | -2% to +6% |
| | Summer | -11% | -19% to +2% |
| | Winter | +3% | -3% to +9% |
| Snowfall* (%) | Winter | -23% | -41% to -7% |
| | Spring | -30% | -59% to -8% |
| Growing Degree Days* (degree days) | Annual | +204 degree days | +102 to +280 degree days |
| Heating Degree Days* (degree days) | Annual | -308 degree days | -428 to -143 degree days |
| Frost-Free Days* (days) | Annual | +12 days | +5 to +18 days |

Table 5.1. The above table shows projected changes in average (mean) temperature, precipitation and several derived climate variables from the baseline historical period (1961-1990) to the 2020s for the Alberni-Clayoquot region. The ensemble median is a mid-point value, chosen from a PCIC standard set of Global Climate Model (GCM) projections (*see* Note 23). The range values represent the low and high ends of the expected range (i.e., the 10th and 90th percentile of the set). *These values are derived from temperature and precipitation. The variable values shown here are not directly observed or obtained from the GCMs. Instead, they are derived from temperature and/or precipitation using methods described in Wang et al. 2006 (PCIC 2010).

**Table 5.2 Climate Change for Alberni-Clayoquot Region in 2050s Period**

**Climate Change for Alberni-Clayoquot Region in 2050s Period**

| Climate Variable | Time of Year | Projected Change from 1961-1990 Baseline | |
|---|---|---|---|
| | | Ensemble Median | Range |
| Mean Temperature (°C) | Annual | +1.4 °C | +0.9 °C to +2.2 °C |
| Precipitation (%) | Annual | +6% | -2% to +11% |
| | Summer | -18% | -28% to +1% |
| | Winter | +5% | -3% to +13% |
| Snowfall* (%) | Winter | -36% | -54% to -19% |
| | Spring | -52% | -70% to -19% |
| Growing Degree Days* (degree days) | Annual | +361 degree days | +218 to +538 degree days |
| Heating Degree Days* (degree days) | Annual | -539 degree days | -804 to -334 degree days |
| Frost-Free Days* (days) | Annual | +22 days | +14 to +31 days |

Table 5.2. The above table shows projected changes in average (mean) temperature, precipitation and several derived climate variables from the baseline historical period (1961-1990) to the 2050s for the Alberni-Clayoquot region. The ensemble median is a mid-point value, chosen from a PCIC standard set of Global Climate Model (GCM) projections (*see* Note 23). The range values represent the low and high ends of the expected range (i.e., the 10th and 90th percentile of the set). * These values are derived from temperature and precipitation. The variable values shown here are not directly observed or obtained from the GCMs. Instead, they are derived from temperature and/or precipitation using methods described in Wang et al. 2006 (PCIC 2010).

**Table 5.3 Climate Change for Alberni-Clayoquot Region in 2080s Period**

**Climate Change for Alberni-Clayoquot Region in 2080s Period**

| Climate Variable | Time of Year | Projected Change from 1961-1990 Baseline | |
|---|---|---|---|
| | | Ensemble Median | Range |
| Mean Temperature (°C) | Annual | +2.4 °C | +1.3 °C to +3.5 °C |
| Precipitation (%) | Annual | +8% | +1% to +16% |
| | Summer | -20% | -39% to -5% |
| | Winter | +11% | -2% to +21% |
| Snowfall* (%) | Winter | -51% | -73% to -29% |
| | Spring | -71% | -85% to -33% |
| Growing Degree Days* (degree days) | Annual | +607 degree days | +303 to +923 degree days |
| Heating Degree Days* (degree days) | Annual | -880 degree days | -1264 to -475 degree days |
| Frost-Free Days* (days) | Annual | +31 days | +20 to +43 days |

Table 5.2. The above table shows projected changes in average (mean) temperature, precipitation and several derived climate variables from the baseline historical period (1961-1990) to the 2050s for the Alberni-Clayoquot region. The ensemble median is a mid-point value, chosen from a PCIC standard set of Global Climate Model (GCM) projections (*see* Note 23). The range values represent the low and high ends of the expected range (i.e., the 10th and 90th percentile of the set). *These values are derived from temperature and precipitation. The variable values shown here are not directly observed or obtained from the GCMs. Instead, they are derived from temperature and/or precipitation using methods described in Wang et al. 2006 (PCIC 2010).

## Table 5.4 Potential Impacts for the Alberni-Clayoquot region in 2050s/2080s periods

**Potential Impacts for the Alberni-Clayoquot region in 2050s/2080s periods**

| Projections and Variability Effects | Potential Impacts |
|---|---|
| Warmer annual temperature | • Changes in seasonality of streamflow<br>• Increased evaporation<br>• Longer fire seasons may result in more interface fires that threaten communities and infrastructure |
| Winter warming | • Mid-winter thaw events may damage roads and cause ice jams and flooding with damage to infrastructure |
| Warmer, drier summers | • Possibility of more prolonged and intense droughts with lower water supply during periods of peak demand<br>• Reduced soil moisture and increased evaporation, increasing irrigation needs at the same time of year that streamflows are expected to decline<br>• Higher temperatures encourage the growth of unfavorable algae and bacteria, adversely impacting water quality<br>• Possible declines in recharge rates for groundwater sources<br>• Improved potential for high value crops, if sufficient water is available; warmer temperatures may favour weeds, insects and plant diseases |

Table 5.4. The above table shows potential impacts resulting from climate change for the Alberni-Clayoquot region by the 2050s and 2080s periods. It is important to note that the table lists possible impacts only, based on the amount of projected climate change. The local relevance of these impacts and whether or not important impacts are missing must be reviewed and qualified by an appropriate regional adaptation expert. Finally, the results displayed are based on a set of rules for relating climate change to possible impacts; these rules have not yet undergone any peer review and results in this section must therefore be considered preliminary and treated with caution (PCIC 2010).

**Figure 5.1 Trends in annual mean temperature in British Columbia**

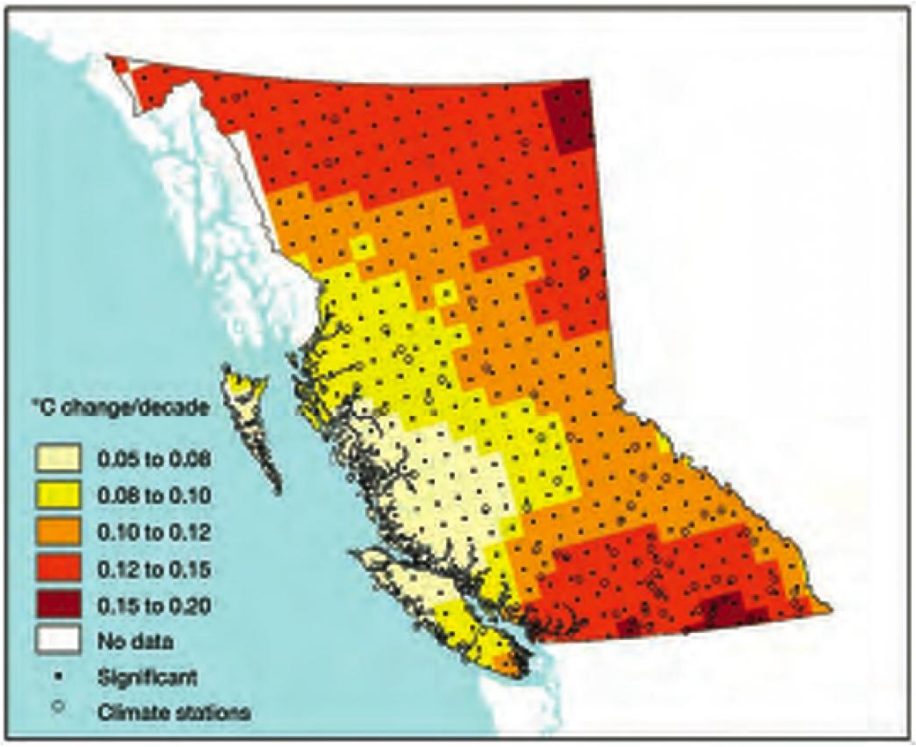



Figure 5.1. Trend in annual mean temperature (in °C per decade) for British Columbia, 1900–2004. Use of annual averages may mask seasonal trends that are larger than the annual average and/or of opposite sign. Long-term trends should be considered in the context of climate variability (Section 5.1.1) (Walker and Sydneysmith 2008).

**Figure 5.2 Trends in annual total precipitation in British Columbia**

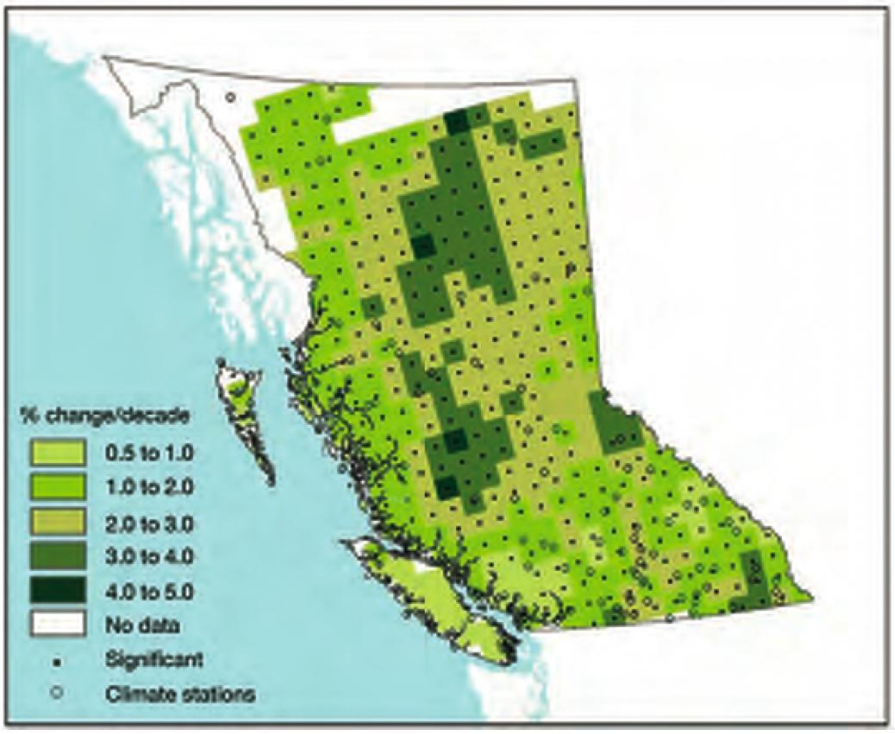



Figure 5.2. Trend in annual total precipitation for British Columbia, 1900-2004, in % change per decade from 1961-1990 (trends shown are relative to what is normal at a given location). Use of annual averages may mask seasonal trends that are larger than the annual average and/or of opposite sign. Long term trends should be considered in the context of climate variability (see Section 5.1.1) (Walker and Sydneysmith 2008).

**Figure 5.3 Projected changes in temperature and precipitation in British Columbia**

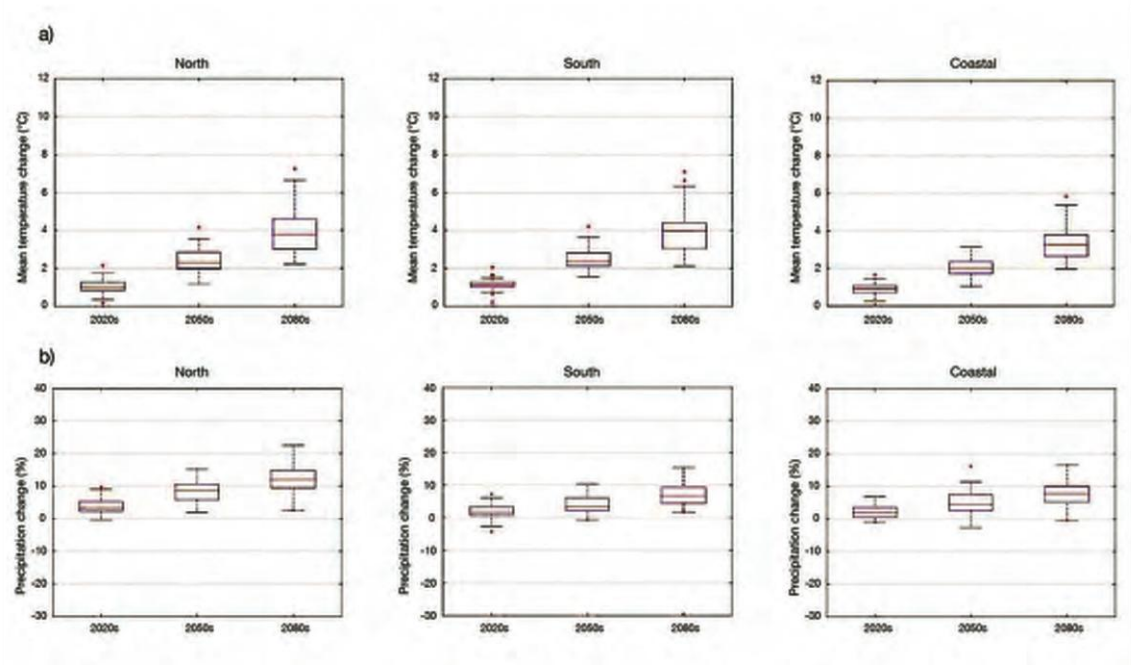
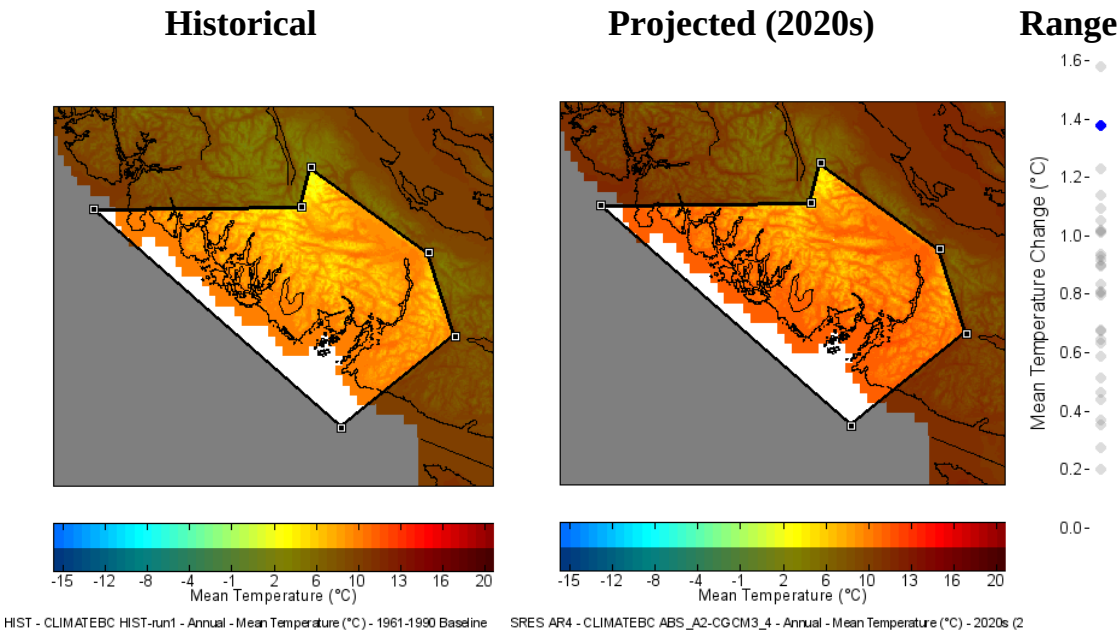



Figure 5.3 Changes from the 1961–1990 historical climate to the 2020s, 2050s and 2080s in a) temperature (°C), and b) precipitation (percent) for three large scenario regions (north, south, coast) in British Columbia, based on large (approximately 100 km$^2$) GCM grids[36] (Walker and Sydneysmith 2008).

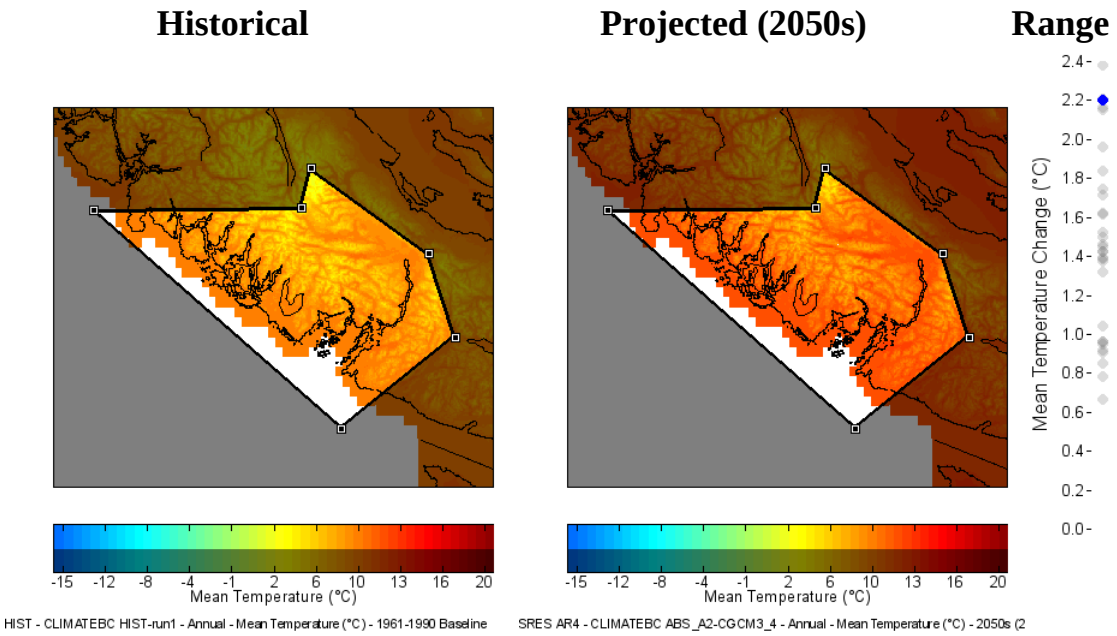
[36]A box-and-whisker plot is a means of providing summary information about a data sample. The box has lines at the lower quartile, median and upper quartile values, and the whiskers are lines extending from each end of the box to show the extent of the rest of the data. The box represents the central 50% of the data sample. The whiskers indicate the maximum and minimum data values if there is a dot located on the lower whisker. If there are outliers in the data, indicated by '+' symbols, then the whisker length is 1.5 times the interquartile range (Lemmen et al. 2008).

**Figure 5.4 Historical and projected annual temperature for the Alberni-Clayoquot region**

(a)




(b)



(c)

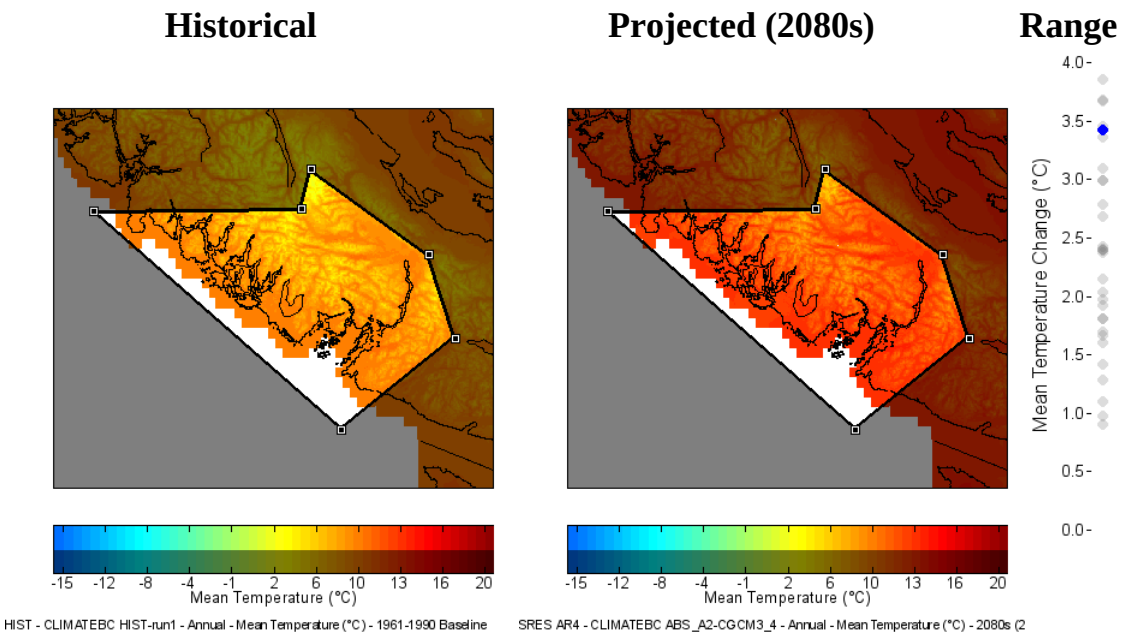
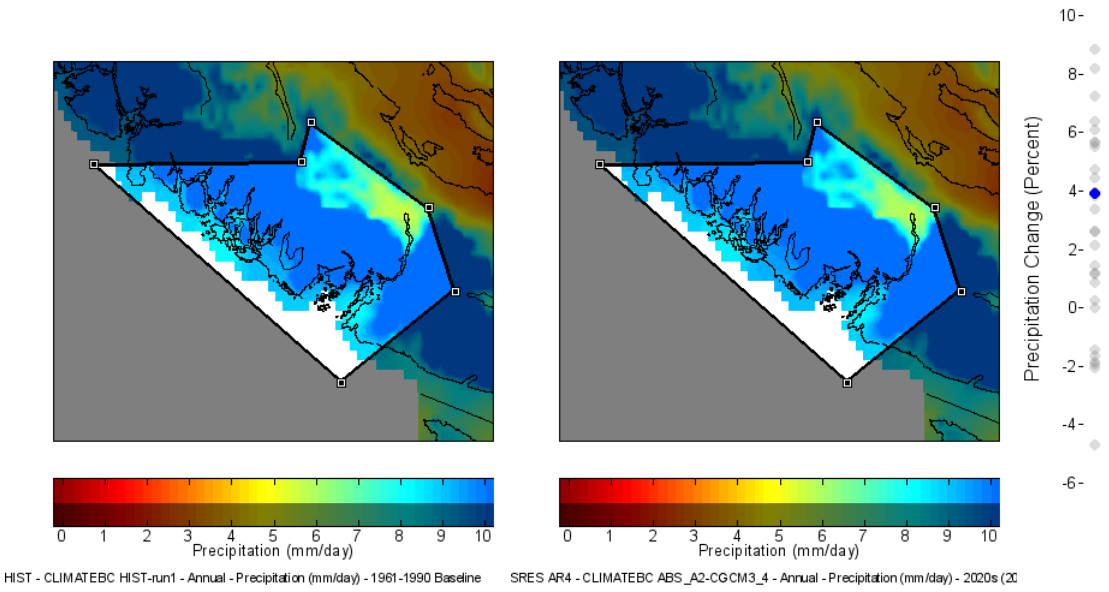



Figure 5.4. The maps show Annual temperature (Degrees C) for the Alberni-Clayoquot region. The historical map on the far left is based on observed and interpolated station data while the projected map shows how this picture will change by the (a) 2020s period, (b) 2050s period, and (c) 2080s period based on a single GCM projection[37]. The range plot at far right shows where the change reflected in the projected map (identified by the blue dot) compares to a PCIC standard set of GCM projections (*see* Note 23) (PCIC 2010).

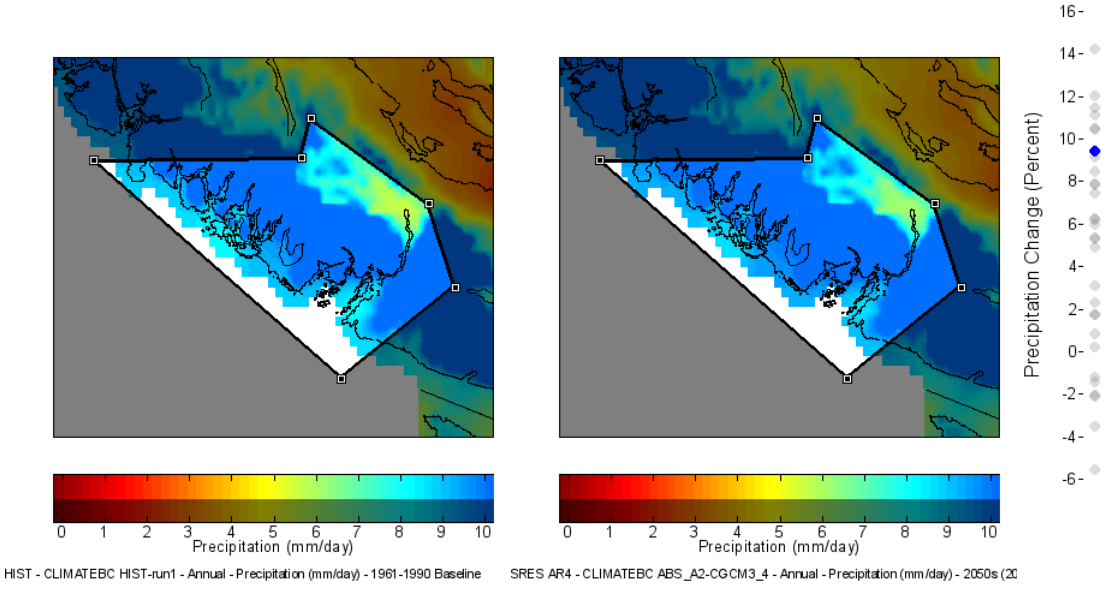
[37] The single projection used for the maps is the CGCM3 A2 run 4. CGCM3 is the Canadian Global Climate Model, developed and run by the Canadian Centre for Climate Modelling and Analysis, Environment Canada, located at the University of Victoria. The A2 specification in the name refers to a relatively high greenhouse gas emissions scenario, one of a range of scenarios developed by the IPCC (PCIC 2010).

**Figure 5.5 Historical and projected annual precipitation for the Alberni-Clayoquot region**

(a)




(b)



(c)

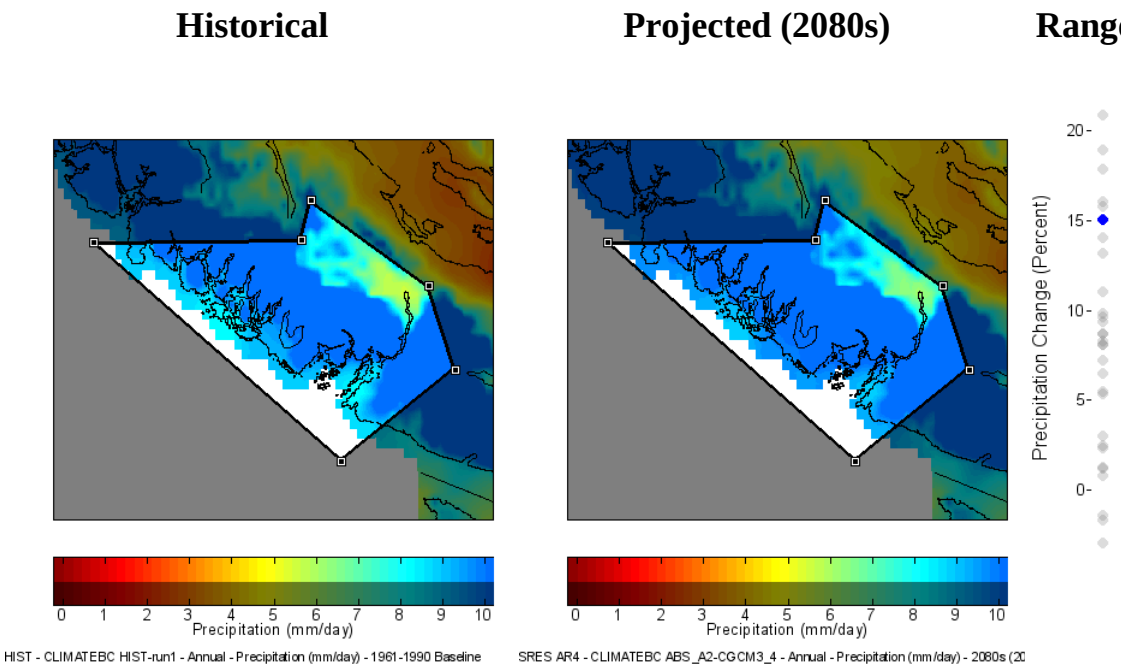
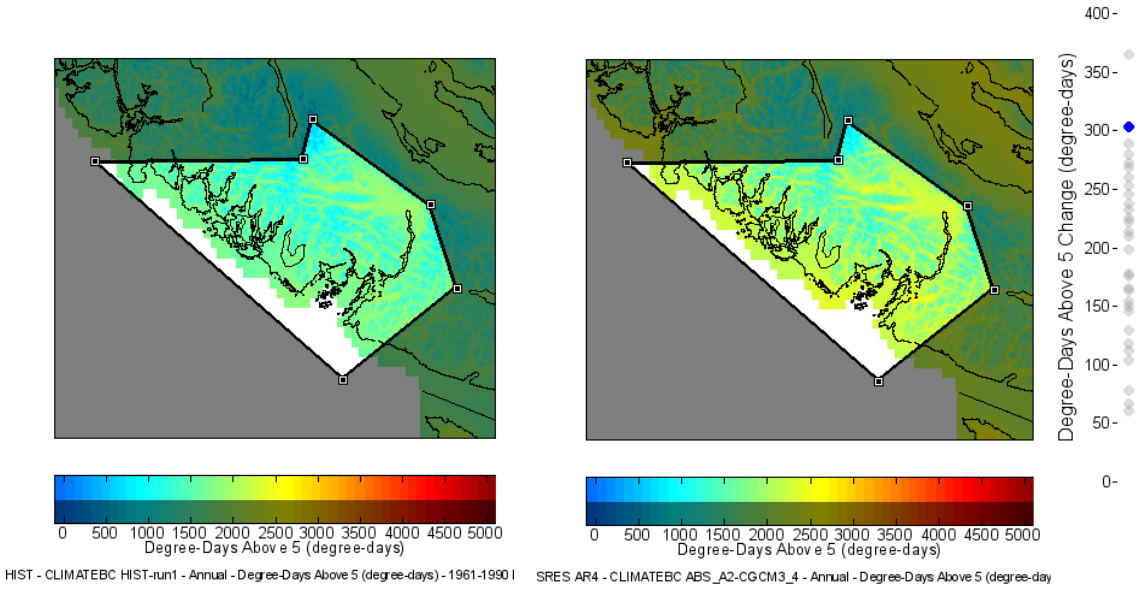



Figure 5.5. The maps show Annual precipitation (rain plus snow) (mm per day) for the Alberni-Clayoquot region. The historical map on the far left is based on observed and interpolated station data while the projected map shows how this picture will change by the (a) 2020s period, (b) 2050s period, and (c) 2080s period, based on a single GCM projection (*see* Note 37). The range plot at far right shows where the change reflected in the projected map (identified by the blue dot) compares to a PCIC standard set of GCM projections (*see* Note 23) (PCIC 2010).

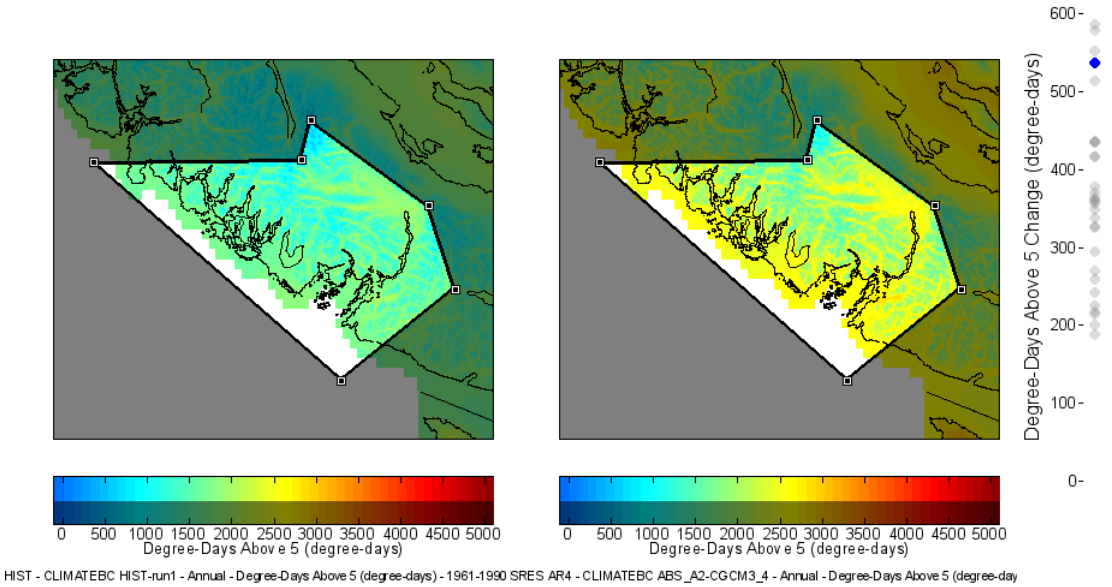
**Figure 5.6 Historical and projected annual growing degree days for the Alberni-Clayoquot region**

(a)




(b)

**Historical** **Projected (2050s)** **Range**




(c)

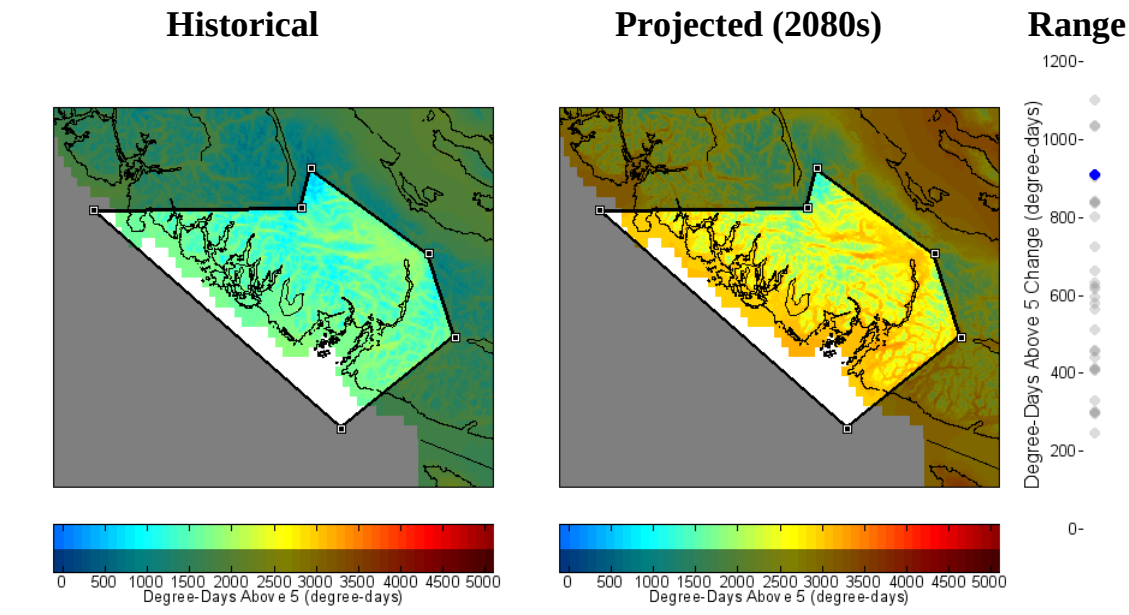
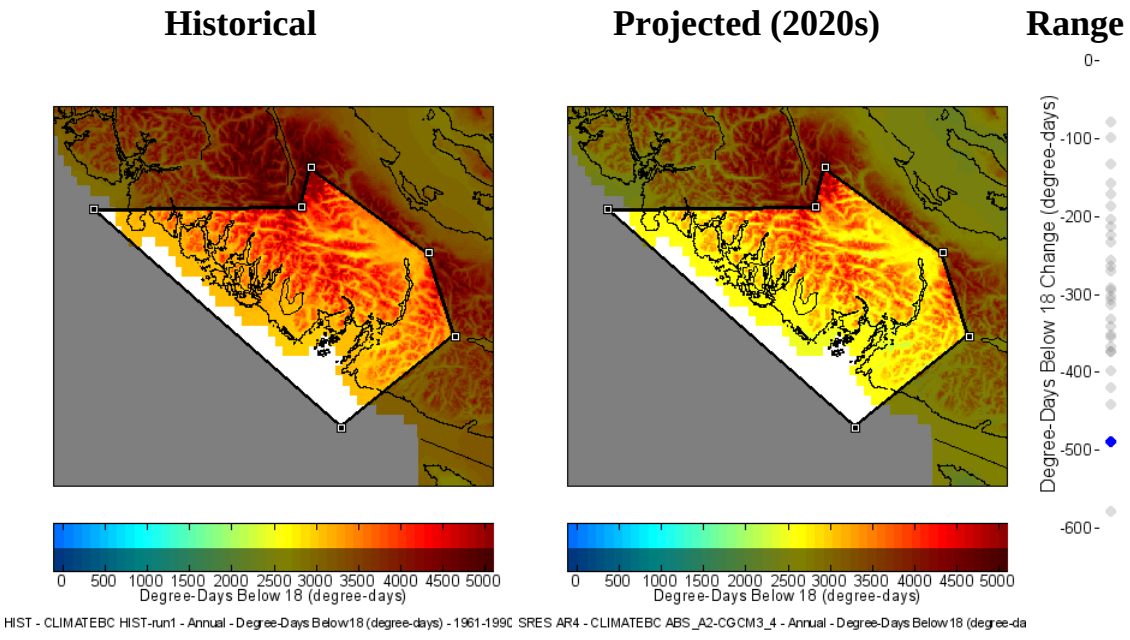


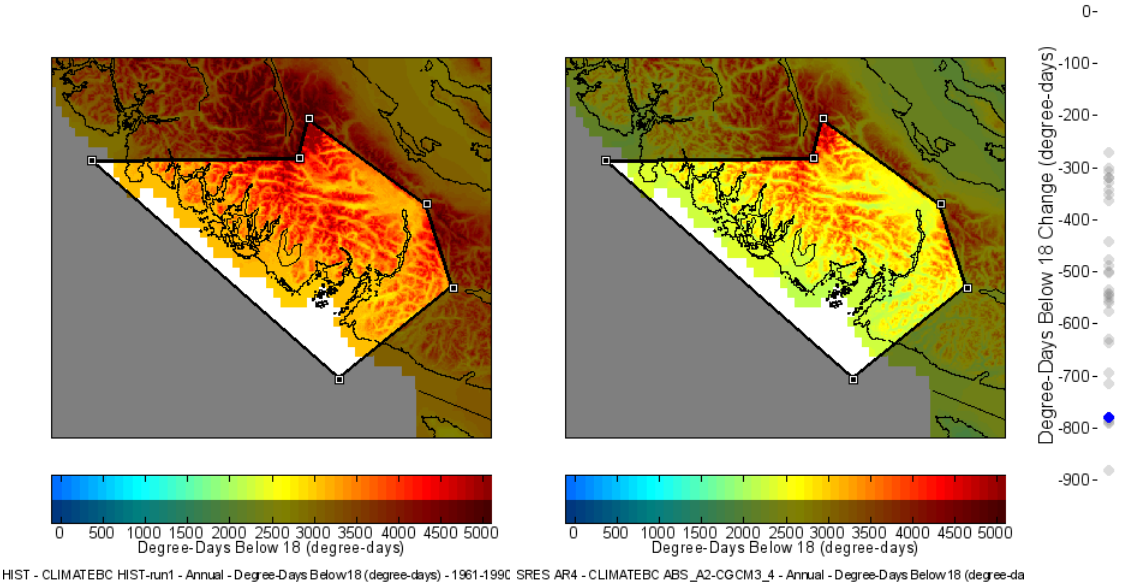

Figure 5.6. The maps show Annual growing degree days (degree days) for the Alberni-Clayoquot region. The historical map on the far left is based on observed and interpolated station data while the projected map shows how this picture will change by the (a) 2020s period, (b) 2050s period), and (c) 2080s period, based on a single GCM projection (*see* Note 37). The range plot at far right shows where the change reflected in the projected map (identified by the blue dot) compares to a PCIC standard set of GCM projections (*see* Note 23) (PCIC 2010).

**Figure 5.7 Historical and projected annual heating degree days for the Alberni-Clayoquot region**

(a)




(b)




(c)

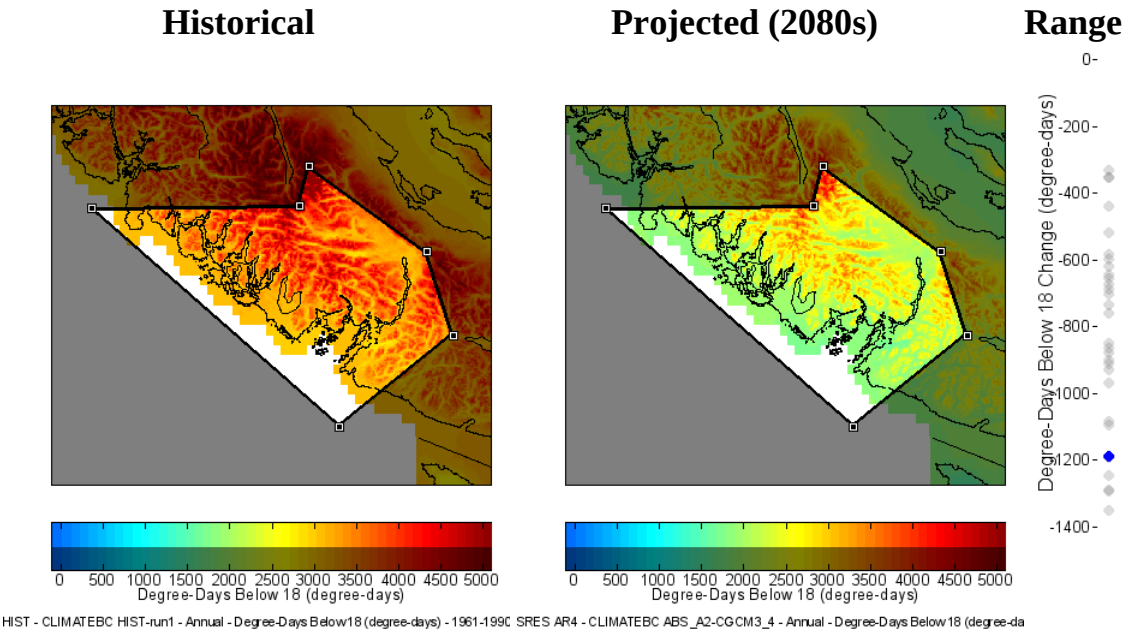
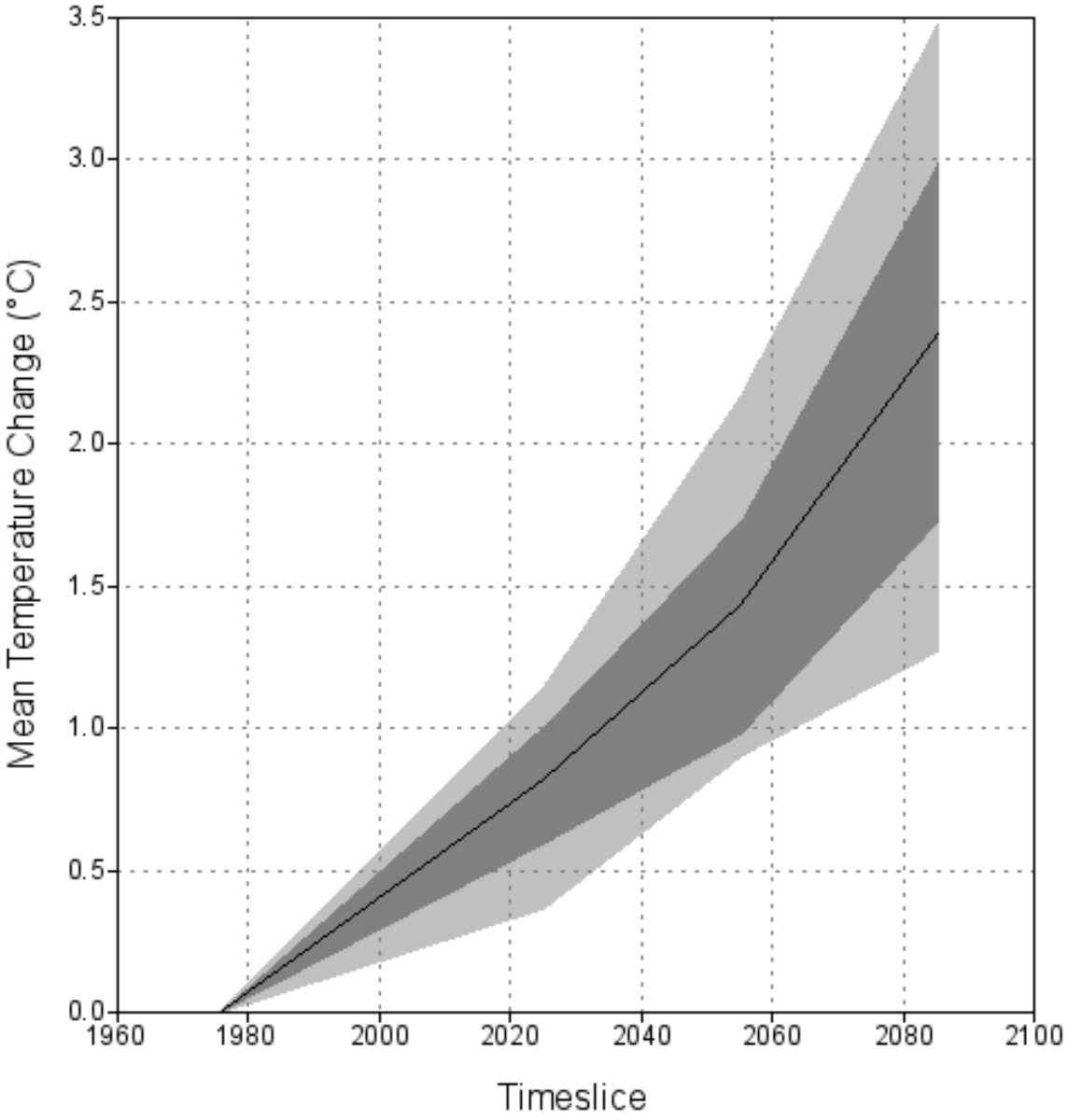



Figure 5.7. The maps show Annual heating degree days (degree days) for the Alberni-Clayoquot region. The historical map on the far left is based on observed and interpolated station data while the projected map shows how this picture will change by the (a) 2020s period, (b) 2050s period), and (c) 2080s period, based on a single GCM projection (*see* Note 37). The range plot at far right shows where the change reflected in the projected map (identified by the blue dot) compares to a PCIC standard set of GCM projections (*see* Note 23) (PCIC 2010).

**Figure 5.8 Range of projected annual temperature change for the Alberni-Clayoquot region**




Annual - Mean Temperature Change - SRES AR4 - CCCMA_CGCM3 A2-run4(Baseline: HIST - CRU_TS

Figure 5.8. This figure shows the range of projected Annual temperature change (Degrees C) for the Alberni-Clayoquot region over three time periods (2020s, 2050s, and 2080s) according to a PCIC standard set of GCM projections (*see* Note 23). The range of change based on this set of projections is indicated as follows:

- The black line indicates the mid-point (median) in the set (PCIC 2010).
- The dark grey shading shows the middle 50% (25th to 75th percentiles), representing half of the projections in the set.
- The light grey shading shows the range according to 80% of the climate change projections used (10th to 90th percentiles).

**Figure 5.9 Range of projected annual precipitation change for the Alberni-Clayoquot region**

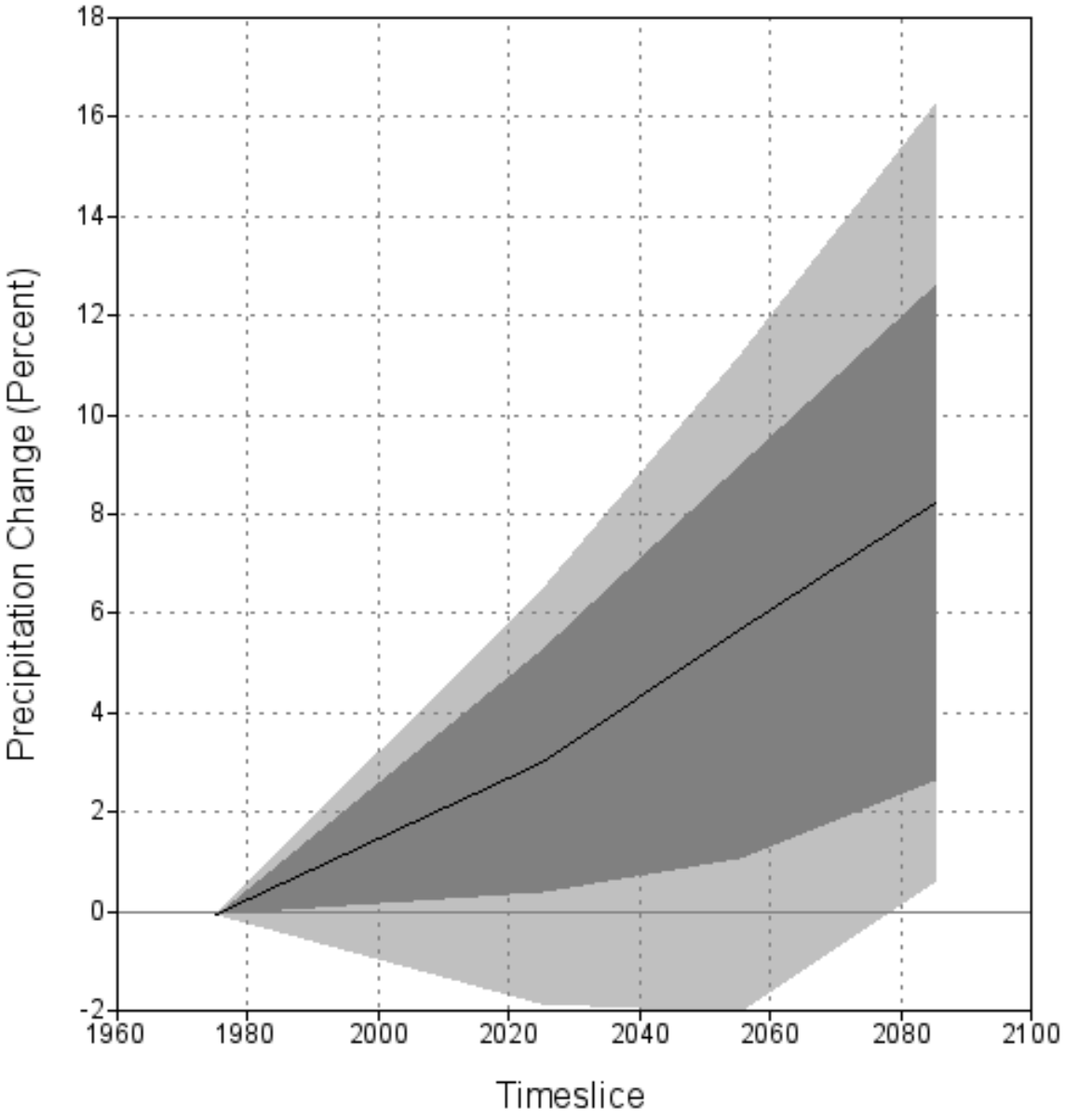
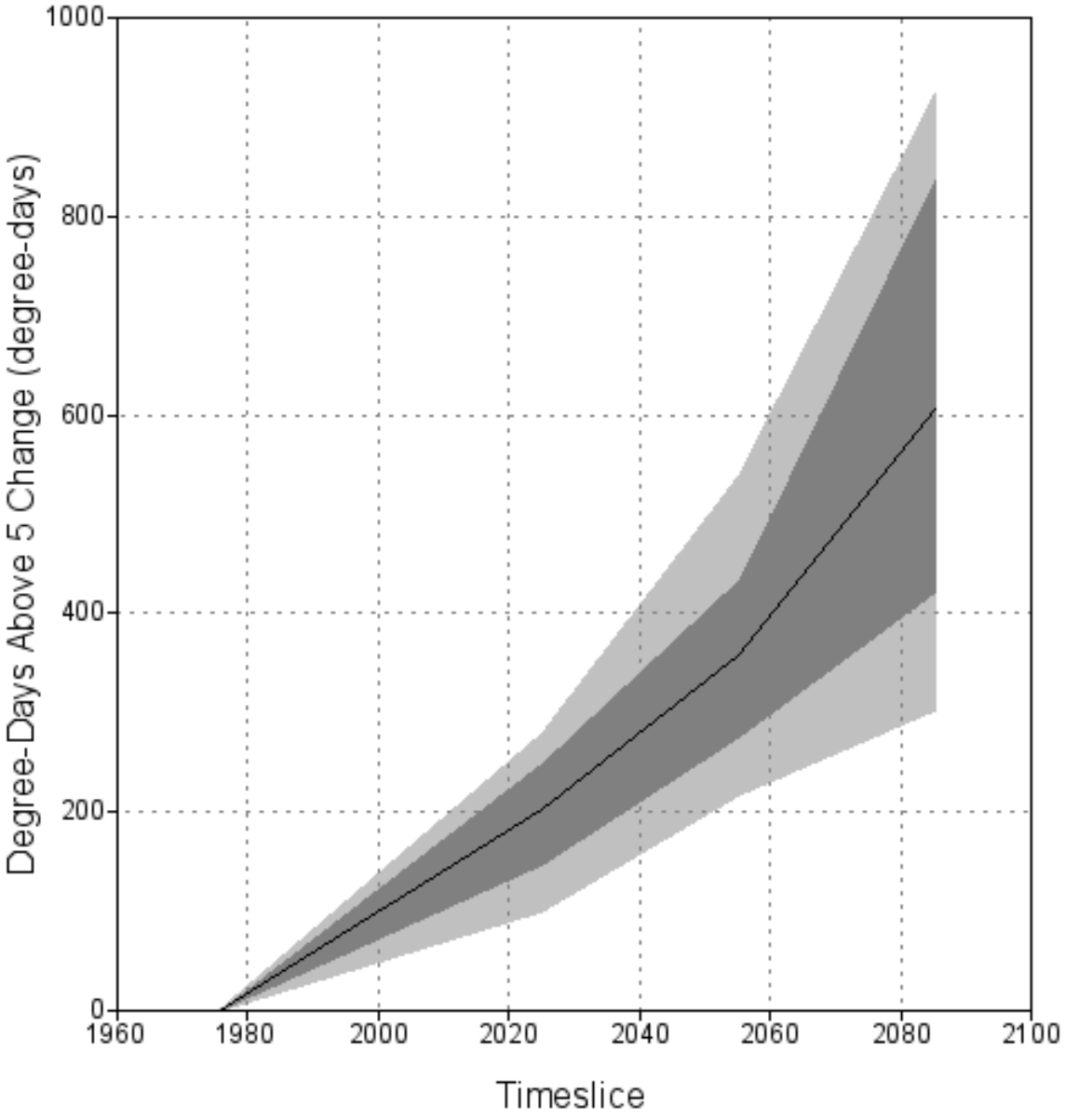



Figure 5.9. This figure shows the range of projected Annual precipitation (rain plus snow) change (percent) for the Alberni-Clayoquot region over three time periods (2020s, 2050s, and 2080s) according to a PCIC standard set of GCM projections (*see* Note 23). The range of change based on this set of projections is indicated as follows (PCIC 2010):

- The black line indicates the mid-point (median) in the set.
- The dark grey shading shows the middle 50% (25th to 75th percentiles), representing half of the projections in the set.
- The light grey shading shows the range according to 80% of the climate change projections used (10th to 90th percentiles).

**Figure 5.10 Range of projected annual growing degree days change for the Alberni-Clayoquot region**

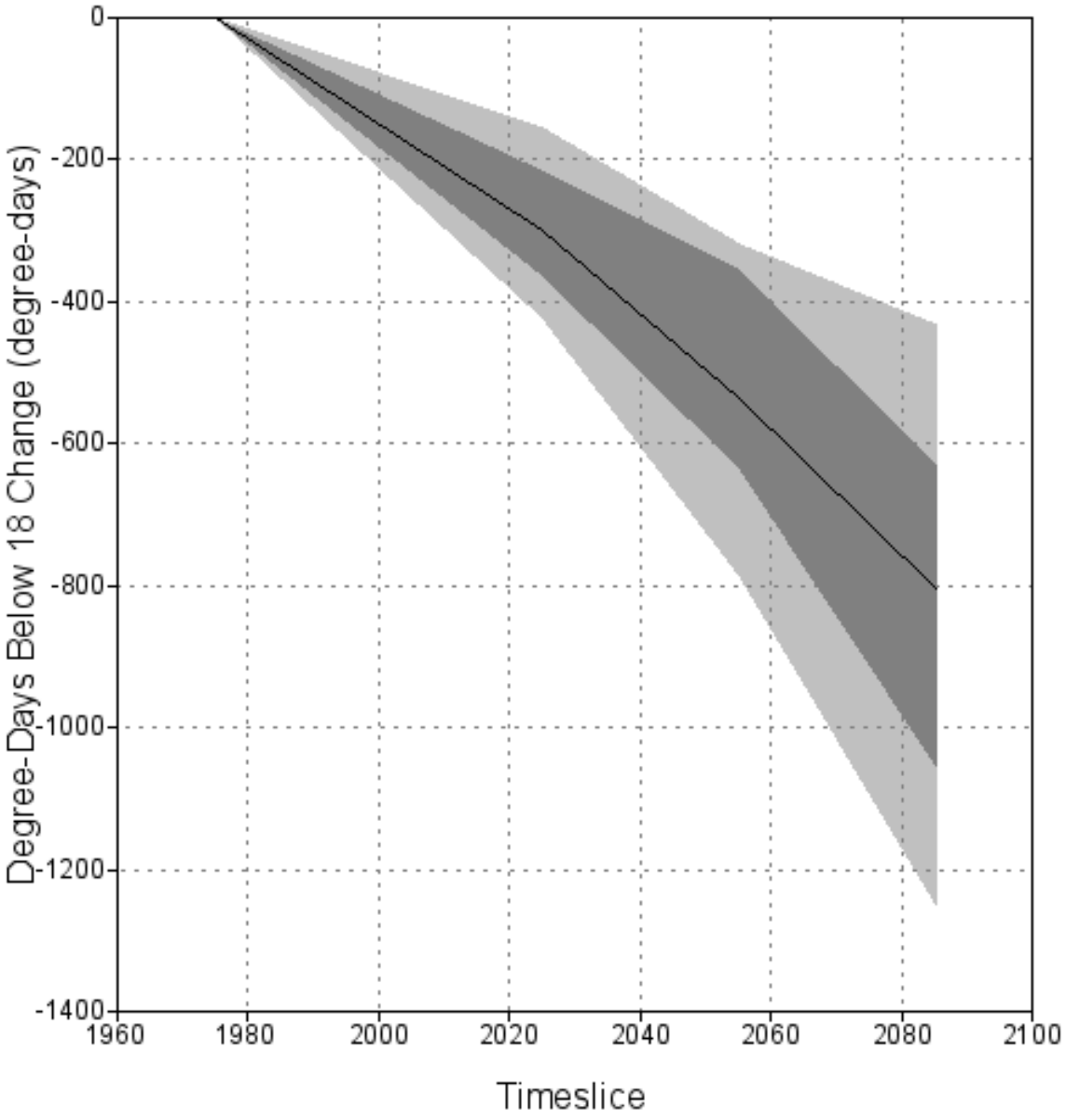



Annual - Degree-Days Above 5 Change - SRES AR4 - CCCMA_CGCM3 A2-run4(Baseline: HIST - CRU_

Figure 5.10. This figure shows the range of projected Annual growing degree days (degree days) change (percent) for the Alberni-Clayoquot region over three time periods (2020s, 2050s, and 2080s) according to a PCIC standard set of GCM projections (*see* Note 23). The range of change based on this set of projections is indicated as follows (PCIC 2010):

- The black line indicates the mid-point (median) in the set.
- The dark grey shading shows the middle 50% (25th to 75th percentiles), representing half of the projections in the set.
- The light grey shading shows the range according to 80% of the climate change projections used (10th to 90th percentiles).

**Figure 5.11 Range of projected annual heating degree days change for the Alberni-Clayoquot region**




Annual - Degree-Days Below18 Change - SRES AR4 - !PCIC Planners ensemble - Alberni-Clayoquot

Figure 5.11. This figure shows the range of projected Annual heating degree days (degree days) change (percent) for the Alberni-Clayoquot region over three time periods (2020s, 2050s, and 2080s) according to a PCIC standard set of GCM projections (*see* Note 23). The range of change based on this set of projections is indicated as follows (PCIC 2010):

- The black line indicates the mid-point (median) in the set.
- The dark grey shading shows the middle 50% (25th to 75th percentiles), representing half of the projections in the set.
- The light grey shading shows the range according to 80% of the climate change projections used (10th to 90th percentiles).

# Chapter 6: Analysis and Discussion II

This chapter addresses the specific research questions: *how do coastal communities experience and deal with change in their social-ecological systems; what are some of the key factors that contribute to threatening or building resilience in social-ecological systems in coastal communities; and, how can resilience and adaptive capacity be built to adapt to change and shape change for sustainability?* The chapter first analyzes the Ucluelet case study with respect to historical changes and social-ecological system dynamics. Second, the chapter identifies key factors that build or threaten resilience. Finally, the chapter uses a framework based on four categories of factors for building resilience and adaptive capacity in social-ecological systems to apply the factors identified in Ucluelet to communities across the British Columbia coast.

## 6.1 Social-Ecological System Dynamics:

The social-ecological history of the Ucluelet system is interesting, as it shows a resilient 'traditional' resource system pre-1950 experiencing rapid change and development in the 1950 to 1970 period, transforming into a less resilient and ultimately non-viable system in the 1970 to 1993 period, undergoing a major crisis between 1993 and 2001, and finally rebuilding resilience since 2001. This chapter evaluates the resilience of the Ucluelet social-ecological system on the basis of its ability to respond to feedbacks and absorb disturbances, its ability for self-organization, and its capacity to learn and adapt[38] (*see* definition of resilience, Chapter 2).

[38] This evaluation follows the case study example of Berkes and Seixas (2003).

Figure 6.1 summarizes the social-ecological phases of the Ucluelet case, as described in detail in Chapter 4, according to the model of the adaptive renewal cycle. The adaptive renewal cycle is used here as a heuristic model to help us understand cycles of change in the socio-ecological system. It is not a predictive model, nor is it the only way to represent these changes.

In the Ucluelet case, the 'traditional' resource system, primarily based on subsistence and small-scale commercial activities, conferred social-ecological resilience until about 1950. From 1950 to 1970, rapid changes in the local socio-economic system, including rapid technological changes, affected socio-ecological resilience as resource pressure increased and local institutions changed. An emphasis on profit-oriented, resource-intensive development began to diminish the importance of local ecological practices and authority.

From 1970 to 1993, the social-ecological system lost resilience. This is due to the intensification of resource pressure and the failures of conventional 20$^{th}$ century resource management. The loss of resilience in this period triggered a resource crisis and ongoing management problems. From 1993 to 2001, facing an erosion of resilience, the system experienced a resource crisis and associated release of the traditional resource-based social-economic model. The 20$^{th}$ century resource model drastically reduced ecological resilience, and subsequent changes in the social-economic system also reduced social resilience.

The rebuilding of social-ecological resilience since 2001 was the result of a series of changes. The most significant of these involved strong local institutions and leaders willing to promote changes and renewal in the local social-ecological system. The system

continues to face significant stress associated with the previous loss of resilience, and also faces new threats. However, the experience since 2001 demonstrates that local resilience is high.

## 6.2 Key Factors that Affect Social-Ecological Resilience:

Having analyzed the case study with respect to historical changes and social-ecological system dynamics, it is possible to turn to the identification of key factors that build or threaten resilience (Seixas and Berkes 2003). The case study allows for the identification of both kinds of key factors.

### 6.2.1 Factors that weaken resilience:

The four factors that weaken resilience, or indicate a reduction in resilience, include: (1) institutional rigidity at higher political levels negatively affecting local management; (2) the breakdown of local and 'supporting' institutions; (3) rapid technological change leading to destructive resource use; and (4) rapid changes in the local socio-economic system[39]. These factors include clusters of elements that influence resilience, as identified by community actors, detailed in Table 6.1. Examples of the factors derived from the Ucluelet case study are detailed in Table 6.2.

#### 6.2.1.1 Institutional rigidity at higher political levels negatively affecting local management

Institutional rigidity appears to be a major factor. From 1970 to the 1990s, federal and provincial management strategies aimed at controlling the variability of target resources (e.g., fish stocks, timber stands) proved successful in securing resource flows in

[39] Factors modified from Seixas and Berkes (2003).

the short term, but over time led decision makers to become too distant from environmental feedbacks, resulting in a resource crisis and ongoing management problems (*see* Table 6.2; Lebel et al. 2006; Folke 2006; Seixas and Berkes 2003). The stability perspective has for some time dominated contemporary natural resource and environmental management (Gunderson et al. 1995b; Berkes and Folke 1998b). This approach tends to solve problems in the short term, like declining yields, but success in controlling one variable leads to changes in variables that operate at other spatial and temporal scales, like nutrients or food web dynamics. The landscape becomes homogenized and more vulnerable to disturbance; hence, resilience is lost (Gunderson at al. 1995b; Folke 2006).

Local people in Ucluelet identified a number of elements of their community that they believe 'weaken' its capacity to deal with change. Several of the elements mentioned can be clustered within the category of institutional rigidity. These include: interference from higher levels of government; resistance to change; leadership that does not embrace new ideas; and, leadership that does not address climate change (*see* Table 6.1). In total, 20.8 percent of respondents in Ucluelet identified one or more of these elements as something that weakens the capacity of the community to deal with change, or indicates a reduction of resilience. The first element, interference from higher levels of government, refers to institutional rigidity at higher political levels restricting the actions of local institutions, groups and/or individuals. An example is the managed consolidation of fishing licenses and quota into larger vessels in the mid- to late-1990s and since 2001, which has created significant barriers to small boat fishers seeking to rebuild a sustainable local small boat fishery on the west coast. The second, third and fourth

elements mentioned (resistance to change, leadership that does not embrace new ideas, leadership that does not address climate change) refer to institutional rigidity across scales, most often trickling down from higher levels to create stasis at the local level. An example is the recent proposal to develop local wave energy sources in Ucluelet, which, according to council, hit a "brick wall" before it could get off the ground (District Councillor, Interview Reference #4).

Managing complex co-evolving systems for sustainability requires the ability to cope with, adapt to, and shape change without losing options for future adaptability. The Ucluelet case demonstrates that the conventional model of optimal management, where systems are assumed to be stable and predictable, has in many respects reduced options and eroded the capacity of life-supporting ecosystems to deal with change (Folke et al. 2003).

#### 6.2.1.2 The breakdown of institutions

##### (*a) The breakdown of 'supporting' institutions*

The breakdown of 'supporting' institutions is a major factor affecting local resilience. Institutions are any formal constraints (rules, laws and constitutions) or informal constraints (norms of behavior, conventions and self imposed codes of conduct) that mold interactions in a society (North 1994), or that control resource use (Ostrom 1990). Ucluelet's remote location and small size require that the community be connected to a broader system of 'supporting' institutions outside of its own boundaries (regional, provincial, federal). The breakdown of federal and provincial level government backing for local institutions since 2001, and the loss of trust in government leadership in the 1990s and since 2001 are examples of when 'breaks' have occurred in this supporting

system. The former example refers to the 'exit' of large industry and government support from small, rural communities since 2001. The resulting introduction of competitive and selective pools of provincial government funding for community initiatives has made securing (even essential) community services very difficult for rural communities such as Ucluelet. The latter example refers to the loss of trust in government following a number of management decisions that disproportionately affected small, rural communities in the 1990s and since 2001. For instance, in fisheries, this included government buy-back schemes, industry consolidation into larger, more powerful vessels, and soaring license and quota costs (*see* Table 6.2).

Local people in Ucluelet identified a number of elements of their community that can be clustered within the category of the breakdown of 'supporting' institutions. These include: lack of support from higher levels of government; lack of available resources, services and support; geographic location (remoteness/isolation); small size; poor access to /quality of health care; and, a lack of education/understanding (*see* Table 6.1). In total, 39.6 percent of local people surveyed identified one or more of these elements as something that they believe weakens the capacity of the community to deal with change, or indicates a reduction of resilience. The elements 'geographic location' and 'small size' both refer to the community's dependence on 'supporting' institutions. The other elements (lack of support from higher levels of government, lack of available resources, services and support, poor access to /quality of health care, a lack of education/understanding) refer to the consequences of dependence when the support system breaks. An example is the loss of fundamental community services due to government cutbacks since 2001, including the closure of obstetric services at Tofino

General Hospital in 2007, and the potential closure of the Ucluelet elementary school in 2011.

The results of the community survey reveal that many local people in Ucluelet are dissatisfied with the provision of health care and education services in their community. In particular, 30.8 percent of local people surveyed are dissatisfied with the quality of elementary and secondary school education (17.3 percent are satisfied), 51.9 percent are dissatisfied with their access higher education (21.2 percent are satisfied), 36.5 percent are dissatisfied with their access to other training programs (13.5 percent are satisfied), 26.9 percent are dissatisfied with their access to health care (42.3 percent are satisfied), 17.3 percent are dissatisfied with the quality of health care (44.2 percent are satisfied), 35.8 are dissatisfied with child care services (18.9 percent are satisfied), and 15.1 percent are dissatisfied with senior care services (35.8 are satisfied)[40]. Since 2001, a lack of support from higher political levels in these areas has placed a significant strain on local institutions in Ucluelet (*see* Section 6.2.1.2b). The importance of strong supporting institutions to strengthening Ucluelet's capacity to deal with change is explored in detail in Section 6.2.2.1b.

*(b) The breakdown of 'local' institutions*

The breakdown of local institutions is another major factor. Local institutions are any formal or informal constraints that mold interactions in a particular society (North 1994), or that control resource use (Ostrom 1990). In Ucluelet, the loss of their traditional resource-based sense of community in the 1990s and since 2001, and the influx of a new

[40] Response percentages not shown: 'Neutral'; and, 'I don't know'.

tourist/transient population with little attachment to the local community or environment since 2001 are examples of the breakdown of local institutions (*see* Table 6.2).

The breakdown of local institutions is a key factor indicating a reduction of resilience. Local people identified a number of elements of their community that they believe weaken resilience that can be clustered within the category of the breakdown of local institutions. These include: tourist/transient population who does not care for the local community/environment; local population who does not care for the local community/environment; lack of cohesion; lack of sense of community; lack of environmental consciousness; feeling of helplessness; apathy; people do not believe in climate change; lack of emergency planning; and lack of emergency response (*see* Table 6.1). A total of 30.2 percent of respondents in Ucluelet identified one or more of these elements as something that weakens the capacity of the community to deal with change, or indicates a reduction of resilience. The first element refers to an increase in the number of tourists and wealthy outsiders (developers, absentee landlords) since 2001, which has created inequity between segments of the population, raised the costs of living (food, housing) for residents, and fostered a transient population that is less likely to 'give back' to the community. The second, third, fourth and fifth elements mentioned (local population who does not care for the local community/environment, lack of cohesion, lack of sense of community, lack of environmental consciousness) refer to a loss of sense of community since the 1990s, particularly among resource workers and families who held strong attachments to one another and to the local environment. The sixth, seventh and eighth elements mentioned (feeling of helplessness, apathy, people do not believe in climate change) refer to characteristics of the community that indicate a loss of trust, or

confidence in local institutions. The final element mentioned (lack of emergency planning, lack of emergency response) indicates a failure of local institutions to perform fundamental roles in the community, which is closely related to recent cutbacks from higher institutions and the subsequent drain on local resources (*see* Section 6.2.1.2a).

The importance of strong local institutions to strengthening the capacity of the community to deal with change is explored in detail in Section 6.2.2.1a.

#### 6.2.1.3 Rapid technological change leading to destructive resource use

In the Ucluelet case, technological change was the driving force in many of the changes and conflicts observed. An example is the entry of large corporate actors in the local forestry industry in the 1950s leading to resource depletion and opposition from environmental groups and First Nations. Another example is innovation in the small boat fishing fleet in the 1950s leading to resource depletion and conflict among user groups, as fishers sought to out perform each other. A final example is rapid shoreline development and tourism development since 2001 leading to resource degradation and widespread discontent among local people (*see* Table 6.2).

Local people in Ucluelet identified a number of elements of their community that they believe weaken its capacity to deal with change. Several of the elements mentioned can be clustered within the category of rapid technological change leading to destructive resource use. These include: dependence on the natural resource base (fishing, forestry, other); human-caused degradation of the natural environment/wildlife habitat; threats to biodiversity/uniqueness (e.g., introduction of non-native species); natural environment/surrounding landscape; and, geographic location (exposure) (*see* Table 6.1). In total, 50.9 percent of respondents identified one or more of these elements as

something that weakens the capacity of the community to deal with change, or indicates a reduction of resilience. The first element, dependence on the natural resource base, refers to the significance of the local environment to the community, as well as the human pressure exerted upon it. The second and third elements mentioned refer to this human influence, particularly in regard to local and regional disturbances, including resource overexploitation, unsustainable harvesting practices (i.e., draggers), tourism development, shoreline development, land and sea-based pollution, eutrophication and siltation (Berkes et al. 2001; MA 2005). The final elements mentioned, the natural environment and biophysical exposure, refer to the exposure of the system following a loss of biological diversity and, hence, ecological resilience.

The biological diversity of an ecosystem is essential for ecological resilience, both in terms of absorbing disturbance and in creating the capacity to regenerate and re-organize the system following disturbance (Folke et al. 2003; Folke 2006). In Ucluelet, rapid technological change leading to the erosion of biological diversity resulted in the erosion of ecological resilience, leaving the system more vulnerable to environmental surprise and crisis.

#### 6.2.1.4 Rapid changes in the local socio-economic system

Rapid changes in the local socio-economic system are another major factor. Ucluelet has experienced many changes in its local socio-economic system. Rapid changes in the local economy have impacted the social system that gives support to local institutions in three cases. In the 1950 to 1970 period, the importance of local practices and authority diminished as resource profits became more and more important. In the 1993 to 2001 period, local capability diminished as local industries were lost. And since

2001, local capability diminished as inequity and instability became more common. In each of these cases, rapid changes in the local socio-economic system indicate a reduction in resilience (*see* Table 6.2).

Local people in Ucluelet identified several elements of their community that weaken its capacity to deal with change that can be clustered within the category of rapid changes in the local socio-economic system. These include: the rapid pace of change; dependence on tourism; high cost of living; and, economic inequality (*see* Table 6.1). In total, 17 percent of local people surveyed in Ucluelet identified one or more of these elements as something that weakens the capacity of the community to deal with change, or indicates a reduction of resilience. The elements mentioned by local people that cluster within this category mostly refer to recent changes related to tourism development (dependence on tourism, high cost of living, economic inequality). However, it is important to note that rapid changes in the local socio-economic system have influenced resilience throughout Ucluelet's history. A history of cycles of changes that have occurred over the last six decades in Ucluelet is detailed in Chapter 4, and explored in Section 6.1.

### 6.2.2 Factors that strengthen resilience

The five factors that strengthen resilience include: (1) strong institutions, including elements of robust local institutions, robust 'supporting' institutions, and leadership; (2) creating political space for experimentation; (3) equity; (4) communication; and (5) the use of different types of memory and knowledge[41]. These factors include clusters of elements that influence resilience, as identified by community

[41] Factors modified from Seixas and Berkes 2003.

actors, detailed in Table 6.3. Examples of the factors derived from the Ucluelet case study are detailed in Table 6.4.

#### 6.2.2.1 Strong institutions

*(a) Robust local institutions*

Robust local institutions appear to be a major factor. In the Ucluelet case, the growth of the local socio-economic system in the 1950 to 1970 period and the reinvention of the system in the 1990s and since 2001 involved responsive and robust local institutions (*see* Table 6.4). Robust local institutions comprise of formal and informal constraints that influence the ability of a system to respond to disturbances and changes in resilience. For instance, robust local governance institutions for monitoring and responding to environmental and social changes are important, as they determine the tightness of feedbacks among social and ecological components (Adger and Kelly 1999; Handmer et al. 1999; Mendis et al. 2003; Walker et al. 2006; Nelson et al. 2007; Seixas and Berkes 2003). Furthermore, local sources of social capital are important, as they provide a community with options and networks of support during periods of change or crisis (IPCC 2007b; Matthews 2003; Adger 2003; Dolan and Walker 2006; Ostrom and Ahn 2003; Pretty 2003).

Local people in Ucluelet identified a number of elements of their community that they believe ‘strengthen’ its capacity to deal with change. Several of the elements mentioned can be clustered within the category of robust local institutions. These include: a strong sense of community; community spirit/pride; people helping/supporting one another; volunteerism; independence; geographic location (remoteness/isolation); small size; community-based learning initiatives: community-based action initiatives;

community planning; emergency planning; and, emergency response (*see* Table 6.3). In total, 54.7 percent of respondents identified one or more of these elements as something that they believe strengthens the community's capacity to deal with change. The majority of these elements (a strong sense of community, community spirit/pride, people helping/supporting one another, volunteerism, independence, geographic location, small size, community-based learning initiatives, community-based action initiatives) indicate a rich socio-cultural fabric and enduring community attachment (Dolan and Walker 2006). The remaining elements (community planning, emergency planning, emergency response) indicate the presence and effectiveness of local governance and management institutions.

The analysis of factors that strengthen resilience in Ucluelet suggests that both formal and informal local institutions are important aspects of resilience. 88.5 percent of local people interviewed in Ucluelet stated that a strong local government and strong local organizations and other agencies are important for building local capacities to deal with change. It appears that local people are quite satisfied with local institutions. For instance, 73.6 percent of local people surveyed are satisfied with the provision of basic services (water, sanitation) (11.3 percent are dissatisfied), 56.6 percent are satisfied with community facilities (26.4 percent are dissatisfied), 49.1 percent are satisfied with community planning (17 percent are dissatisfied), and 58.5 percent are satisfied with emergency planning/response (13.2 percent are dissatisfied). There are also some areas in which people are less satisfied. For instance, 35.8 percent of respondents are satisfied

with the enforcement of municipal policies and regulations (22.6 are dissatisfied)[42]. This indicates an area that requires future attention.

In addition to formal local institutions, 98.4 percent of local people interviewed in Ucluelet believe that having a strong community (social capital) is important for building local capacities to deal with change. 52.8 percent of local people surveyed identified elements of social capital as something that makes their community strong. Table 6.5 shows the level of participation of local people surveyed in different aspects of the Ucluelet community. The table shows that 94.2 percent of respondents have participated in community events, 82.7 percent have volunteered in the community, 65.4 percent have signed a petition about a local issue, and 78.8 percent have been involved in other community activities (*see* Table 6.5). It is important to note that since the 1990s there has been concern among local people that elements of their sense of community have been lost. It is acknowledged, however, that while certain elements of the community were depleted following the release period (1993 to 2001), others were recombined, rebuilt, or acquired. An example is a new local energy and enthusiasm for community-based entrepreneurialism and sustainability. Such elements are particularly important as the community moves forward in the reorganization phase (Walker et al. 2006; Matthews 2003).

*(b) Robust 'supporting' institutions*

Robust supporting institutions appear to be another major factor. In the Ucluelet case, the success of local institutions and management processes consistently involved the support of institutions at higher political levels, including regional, provincial and

[42] Response percentages not shown: 'Neutral'; and, 'I don't know'.

federal levels. An example is the strong government backing provided to the community in the 1950 to 1970 period. Another example is the responsive government rule changes that overhauled the traditional resource-based socio-economic model in the 1993 to 2001 period. A final example is the introduction and enforcement of stronger conservation rules since 2001 (*see* Table 6.4; Chapter 5, Section 5.2.1.1).

Local people identified a number of elements of the Ucluelet community that they believe strengthens the capacity of the community to deal with change. It is important to note, however, that local people did not identify any elements that can be clustered within the category of robust supporting institutions (*see* Table 6.3). This indicates a failure of institutions at higher political levels in their provision of resources, services and support to the local community (e.g., education, health care) in recent years (*see* Section 6.2.1.2a). Nonetheless, it is locally acknowledged that the support of institutions at higher political levels is important to strengthening the capacity of the community to deal with change. For instance, 88.5 percent of local people surveyed believe that access to elementary and secondary school education is important for building local capacities to deal with change, 90.4 percent believe that the quality of elementary and secondary school education is important, 73.1 percent believe that access to higher education (college, university) is important, 86.5 percent believe that access to health care is important, and 86.5 percent believe that the quality of health care is important.

The analysis of factors that strengthen resilience in Ucluelet suggests that the presence and effectiveness of critical institutions at higher political levels was the driving force in many of the changes affecting resilience. The support of institutions at higher political levels contributed to the success of local institutions and management processes

(*see* Table 6.4), whereas the breakdown of institutions at higher levels led to stress and a significant strain on local resources, reducing resilience (*see* Section 6.2.1.2b). The presence and effectiveness of institutions operating at different social and ecological scales is widely recognized as a particularly important determinant of adaptive capacity and resilience (Seixas and Berkes 2003; Yohe and Tol 2002; Klein and Nicholls 1999; IPCC 2007b; Adger 2003; Olsson and Folke 2001; Dolan and Walker 2006; Nelson et al. 2007).

*(c) Strong leaders with credibility and willingness to promote change*

Strong leaders with credibility and willingness to promote change appear to be a major factor. Since 2001, the Ucluelet council and other active local leaders were driven to change local development models, whereas previous leaders had no such interest, as the old resource-based model suited them well (*see* Table 6.4).

Local people in Ucluelet identified a number of elements of their community that they believe strengthen its capacity to deal with change. 3.8 percent of people surveyed identified strong leadership as an element of their community that strengthens local capacities to deal with change (*see* Table 6.3). An example is role of local leaders in the transformation of the Ucluelet social-ecological system since the 1990s. Transformability is the capacity to create a fundamentally new system when the existing system is untenable (Holling and Gunderson 2002; Walker et al. 2006). The transformation of the Ucluelet system was triggered by a resource crisis in the early 1990s, but also came in response to the failure of past policies and actions, and shifts in social values (Walker et al. 2006). Individual actors played an essential role in this process, particularly by providing leadership, trust, vision and motivation for change (Folke et al. 2003; Nelson et al. 2007).

Strong leaders with credibility and willingness to promote change were the driving force in many of the changes observed in the Ucluelet case, particularly since the 1990s. Given the dynamic nature of social-ecological systems, there is no single style of leadership that guarantees adaptability and transformability. Leadership needs to be a dynamic process, including changes in leaders and multiple leadership roles, that is responsive to prevailing social and ecological conditions. Moreover, although no individual actor can dictate the trajectory taken, the maintenance of critical resources and the management of cross-scale linkages can increase the probability of desirable outcomes (Walker et al. 2006).

#### 6.2.2.2 Political space for experimentation

In the Ucluelet case, policy changes since 2001 have allowed local peoples' input for the formulation of new local industries and initiatives, creating political space for experimentation (Seixas and Berkes 2003). In particular, new federal and provincial government programmes and major changes brought in by the local council since 2001 showed that all governments were open to ideas by local people (*see* Table 6.4).

Local people in Ucluelet identified a number of elements of their community that they believe 'strengthen' its capacity to deal with change. Several of the elements mentioned can be clustered within the category of political space for experimentation. These include: creating new opportunities; people are adaptive/open to change; economic diversity; and, tourism development (*see* Table 6.3). In total, 26.4 percent of respondents in Ucluelet identified one or more of these elements as something that they believe strengthens the capacity of their community to deal with change. These elements refer to changes since 2001 that opened up space for local input regarding the formulation of new

development trajectories in the community. An example is the creation of the locally-driven Wild Pacific Trail. Another example is recent negotiations between the Ucluelet council and the Toquart First Nation and the provincial government to secure a Community Forest Agreement (CFA), which would allow the communities to decide how to manage the designated forest. Another example is local council's pledge to support research for the formulation of alternative models of aquaculture in the region (*see* Chapter 4, Section 4.4.4). These and many other changes add up to a new energy and enthusiasm for locally-driven, sustainable development trajectories, arising from the creation of political space for experimentation.

The creation of political space for experimentation seems to be important as the Ucluelet community moves forward in the reorganization phase, particularly for opening up spaces for local entrepreneurialism and creativity, leading to new socio-economic opportunities and new pathways toward sustainability. 92.3 percent of local people surveyed identified opportunities for employment as important to strengthening local capacities to deal with change, and 88.5 percent identified a healthy environment as important to strengthening this capacity. Political space for experimentation plays an essential role in promoting and uniting these elements in Ucluelet.

#### 6.2.2.3 Equity

Equity in resource access and allocation was the driving force in many of the changes observed in the Ucluelet case. The open access resource model in the 1950 to 1970 period, as well as new models of forestry and fishing since 2001, led to a more equitable model of resource access and allocation and benefit among user groups, whereas the model in the 1970 to 1993 period led to a loss of equity and conflict among

user groups, resulting in the breakdown of the social-ecological system (*see* Tables 6.4 and 6.2, respectively).

Local people identified a number of elements of the Ucluelet community that they believe 'strengthen' its capacity to deal with change. The elements mentioned which can be clustered within the category of equity include: access to abundant natural resources, and access to local food sources (*see* Table 6.3). In total, 13.2 percent of local people surveyed identified one or both of these elements as something that they believe strengthens the capacity of the community to deal with change. These elements both refer to equity in access to and allocation of natural resources. Equity in access to and allocation of other resources that were not mentioned but may play an important role in local capacities in the face of change include: economic wealth and technology (closely tied to wealth). For instance, as the wealth and/or technological capability of an individual or a community increases, so to does the potential for preparedness, recovery and adaptation (Dolan and Walker 2006; Mendis et al. 2003; IPCC 2007b).

The analysis of factors that influence resilience in Ucluelet suggests that equity is an important aspect of resilience. When managing for equity, it is important to consider the issues of equity in process and equity in outcome. Equity in process refers to the fairness of institutions, their open-mindedness, and how they incorporate the values and ideas of the individual and the collective. Equity in outcome refers to the distribution of resources within a society. For instance, as Lebel and colleagues (2006) point out, it is important to consider for whom resilience is being managed, and to what purpose (Nelson et al. 2007).

#### 6.2.2.4 Communication

Communication also appears to be a major factor. In the mid-1960s, local fishers detected resource overexploitation, and in the 1970s and 1980s local people recognized the threat posed by industrial forestry (too efficient); in both cases, the local knowledge generated by qualitatively interacting with local resources was successfully communicated to the provincial and federal levels. In addition, in 1993, the creation of a co-management forum in the forestry sector led to more sustainable use of the resource, and since 2001 the creation of the West Coast Aquatic (WCA) Management Board in the fisheries sector has allowed for the integration of different types of knowledge across regional, provincial and federal scales (*see* Table 6.4).

Local people in Ucluelet identified a number of elements of their community that they believe strengthen its capacity to deal with change. Several of the elements mentioned can be clustered within the category of communication. These include: communication between community members; collective/cooperative decision-making; and, access to information (*see* Table 6.3). 9.4 percent of respondents identified one or more of these elements as something that they believe strengthens local capacities to deal with change. The first element, communication between community members, refers to effective communication within the Ucluelet community. In Ucluelet, 83 percent of local people surveyed report that they talk about local issues with other people in the community. The second element mentioned, collective/cooperative decision-making, refers to the involvement or input of local people in governance at various scales. For instance, the involvement of local fishers and other actors in the WCA Management Board constitutes a forum for collective, or cooperative management (co-management) of

aquatic resources. However, as a result of a lack of funding and support from institutions at higher political levels and ongoing fragmentation between groups, the success of the Board has been severely hampered (for more information about the status of the Board, *see* Chapter 4, Section 4.4.4). The final element mentioned, access to information, refers to the ability of local people to acquire information about issues, policy and actions taking place across scales. In particular, 92.5 percent of respondents stated that access to information about local issues was important to strengthening the capacity of their community to deal with change.

Information and awareness are widely identified as important determinants of adaptive capacity and resilience (Mendis et al. 2003; IPCC 2007b). These determinants are closely tied to risk communication and the ability and effectiveness of social institutions and networks to support and facilitate flows of information across scales (Seixas and Berkes 2003; Adger 2003; Dolan and Walker 2006).

#### 6.2.2.5 Use of different types of memory and knowledge

Another important aspect of resilience concerns the use of different types of memory and knowledge for learning and innovation. In particular, the combination of scientific and local, practical knowledge appears to be an important aspect of resilience (Seixas and Berkes 2003; Folke et al. 2003). An example is the creation of a co-management forum in forestry in 1993 and in fisheries and aquaculture since 2001 using both scientific and local ecological knowledge. Another example is the development of new models of forestry and fishing (and potentially aquaculture) since 2001, inspired by traditional ecological practices and management, as well as outside arrangements (*see* Table 6.4).

Local people in Ucluelet identified a number of elements of their community that they believe strengthen its capacity to deal with change. Several of the elements mentioned can be clustered within the category of combining different types of memory and knowledge. These include: local knowledge/experience; experience with environmental change; experience with social change; environmental consciousness; close connection to natural resource base; and, ingenuity/creative problem solving (*see* Table 6.3). Second only to robust local institutions, 52.8 percent of local people surveyed identified one or more of these elements as something that they believe strengthens local capacities to deal with change. The first five elements (local knowledge/experience, experience with environmental change, experience with social change, environmental consciousness, close connection to natural resource base), refer to the local ecological knowledge and ecological and social memory of people in Ucluelet. Memory is the accumulated experience and history of the system, and it provides sources for self-organization and resilience. Chapter 2 (Section 2.3.3) describes that adaptive renewal cycles depend on the existence of memory for the cycle to resume (the 'remember' connection). For instance, social memory (including experience for dealing with change) is important for the capacity of a social-ecological system to adapt to and shape change (Berkes et al. 2003b). This suggests that disturbances may be important for building resilience in social-ecological systems (Berkes and Folke 2002; Berkes et al. 2003b).

The final element mentioned, creative problem solving, refers to the importance of novelty in social-ecological systems. Novelty, or the ability to innovate, allows the reorganization phase of the adaptive renewal cycle to respond creatively to change (the 'revolt' connection), and is an essential element of adaptability and hence of resilience.

The use of different forms of knowledge as a source of novelty can expand the range of information and approaches available to a community for improving social-ecological capacity and sustainability (Berkes et al. 2003b).

The analysis for factors that strengthen resilience in Ucluelet suggests that the use of different types of memory and knowledge is a major factor affecting resilience. As Walker and colleagues (2006) point out, the capacity to adapt to and shape change, and to manage resilience requires learning and innovation using a combination of various sources of information and knowledge. The use of local ecological and social memory as a source of self-organization, and the use of different forms of local and traditional knowledge as a source of novelty appear to play a critical role in navigating change and strengthening social-ecological resilience toward sustainable development.

### 6.3 Building Resilience: Lessons from the Ucluelet Case:

The characteristics identified in the Ucluelet case provide a local-level, community-based perspective for understanding resilience in a social-ecological system. Having identified the key factors that influence resilience in Ucluelet, it is possible to explore characteristics of resilience that may be robust across communities on the British Columbia coast (Berkes and Seixas 2005). To generalize the factors identified in the Ucluelet case, I use a framework based on four categories on factors for building resilience and adaptive capacity in social-ecological systems. These are: learning to live with change and uncertainty; nurturing diversity for reorganization and renewal; combining different types of knowledge for learning; and creating opportunity for self-organization toward social-ecological sustainability (*see* Chapter 2, Table 2.1). This framework emerges from the work of Folke and colleagues (2003) in the volume

*Navigating Social-Ecological Systems: Building Resilience for Complexity and Change.* In this volume, the authors sought to investigate how human societies deal with change in social-ecological systems, and how capacity can be built to adapt to change and, in turn, to shape change for sustainability. They conclude that there are four sets of factors that seem to be required for dealing with change in social-ecological systems. Under each category, the Ucluelet case generated a number of items for building resilience. These are summarized in Table 6.6.

### 6.3.1 Learning to live with change and uncertainty

In the category learning to live with change and uncertainty, Folke and colleagues (2003) challenge the notion that systems can be managed for stability and security and propose building resilience through the acceptance of the inevitability of change and the pursuit of adaptability to live with uncertainty and surprise. The category deals with this challenge by emphasizing learning and taking advantage of opportunity arising from disturbance.

Coastal social-ecological systems are constantly changing, and disturbance is common. A number of factors from the Ucluelet case can fall within the category of learning to live with change and uncertainty. These include: evoking change in social institutions; learning from crises; and, accepting disturbance, uncertainty, surprise, and crisis for development[43]. The first of these, evoking change in social institutions, involved local leaders promoting change in order to facilitate the reorganization and renewal of local management processes following the 1990s collapse (*see* Table 6.4; Section 6.2.2.1a, c). This is closely related to the second factor, which involves the

[43] Factors modified from Folke and colleagues (2003) and Berkes and Seixas (2005).

capacity of the community to learn from crises; for example, where the reorganization and renewal of the local social-ecological system since 2001 has been informed by the failures leading to collapse (*see* Table 6.4).

The third factor in this category is the existence of disturbance, uncertainty, surprise, and crisis as an accepted part of local development. In Ucluelet, the community has learned to accept uncertainty and surprise and evolve policy and actions to cope with their effects by spreading risks through diversification of resource use patterns and livelihood activities (Davidson-Hunt and Berkes 2003; Blann et al. 2003). For example, the development of the community license bank in the local small boat fishery allowed fishers to diversify their catch (e.g., from salmon to a variety of groundfish species), and many local people have diversified their livelihood activities (e.g., in tourism, community forestry, aquaculture, foraging and backyard gardens) in order to spread risks. In addition to diversification, local coping mechanisms such as gift exchanges between neighbours (e.g., firewood, roots, fungi, seafood) and the presence of strong community organizations (e.g., Food Bank on the Edge, WCCRS) help members of the community deal with uncertainty and surprise and accept disturbance and crisis as part of living within a complex ecosystem.

According to Folke and colleagues (2003), creating space or platforms for dialogue and innovation following crisis is key to stimulating learning and opportunity following crises. This space opens the way for institutional and social learning, drawing on the memory and vision of the local community, expanding the temporal frame of reference, and reorganizing models of development based on a revised understanding of the conditions leading to the crisis. In this way, institutional and social learning play an

essential role in the capacity of the community to respond with experience to future crises.

### 6.3.2 Nurturing diversity for reorganization and renewal

The second category emphasizes the importance of diversity for resilience, not only as insurance for uncertainty and surprise (as described in the previous section), but also for the provision of various components that make reorganization and renewal possible following a shock or disturbance. In this category, memory – ecological and social – is significant, because it provides a framework of accumulated experience for coping with change (Folke et al. 2003).

A number of factors from the Ucluelet case can fall within the category of nurturing diversity for reorganization and renewal. These include: nurturing ecological memory through diversity; sustaining social memory for renewal, reorganization and novelty; and, enhancing social-ecological memory at multiple scales[44]. The first of these emphasizes ecological memory. Ecological memory is the composition and distribution of organisms and their interactions in space and time, and includes their life-history experience with environmental fluctuations. This memory plays a key role in the persistence of the ecosystem in the face of change (Folke et al. 2003). Factors from the Ucluelet case that nurture ecological memory and biological diversity include strong local and supporting institutions supporting policy and actions to protect local species, especially keystone species (i.e., salmon), and habitats (*see* Table 6.4; Chapter 4, Section 4.4.4). For example, the stronger enforcement of conservation rules for fisheries by institutions at higher political levels since 2001 (*see* Chapter 5, Section 5.2.1.1), and

[44] Factors modified from Folke and colleagues (2003) and Berkes and Seixas (2005).

strong local support for the Thornton Creek Hatchery and Salmon Enhancement Society since 2001. Such measures play a significant role in building resilient landscapes in the face of change.

The second factor in this category is sustaining social memory for reorganization and renewal. Social memory is an accumulation of a diversity of experiences with change and adaptations, either at the level of institutions (institutional memory, a subset of social memory) or of the individual resource user. Social memory provides a context for social responses to change, increases the likelihood of flexible and adaptive responses, and seems to be important during periods of reorganization and renewal, because it draws on experience, but also allows for novelty within the framework of accumulated experience (Folke et al. 2003). In Ucluelet, social memory is sustained through strong local institutions, organizations, individual carriers of memory and knowledge, and other actors with diverse, yet overlapping roles in the community. Folke and colleagues (2003) hypothesize that such a combination of groups contributing to social memory, their diversity, and their overlapping functions provides resilience for reorganization and novelty, and therefore enhances adaptive capacity in the face of change.

The third factor in this category is enhancing social-ecological memory across scales. Nurturing ecological memory requires ongoing human adjustments to ecological feedback, which must be framed by a diverse and evolving social memory that includes an intimate knowledge of ecosystem dynamics (Folke et al. 2003). According to Folke and colleagues (2003), this includes the knowledge of local resource users and other local stewards and leaders, whose observations often include an understanding of long-term and large-scale ecological changes. In the Ucluelet case, an example of enhancing social-

ecological memory across scales is the creation of the WCA Management Board in 2001, which allowed local resource users and other actors to share knowledge and experience about ecosystem dynamics across levels. The creation of this multi-scale space allowed human actions affecting the local ecosystem to be framed within a social memory that is in tune with local ecosystem dynamics, therefore creating potential to foster resilience and adaptive capacity in the social-ecological system.

### 6.3.3 Combining different types of knowledge for learning

It has been argued that all forms of relevant information should be mustered to increase knowledge and understanding for improved management of complex ecosystems (Berkes and Folke 1998b; Walker et al. 2006). The third category of factors identified by Folke and colleagues (2003) addresses the significance of different types of knowledge and their combination.

In Ucluelet, there are several factors that contribute to knowledge combination for learning. These include: combining local/practical and scientific knowledge; enhancing knowledge of ecosystem processes and functions; fostering coupled social-ecological management; and, creating cross-scale platforms to share knowledge[45]. The first of these concerns combining local, practical knowledge and scientific knowledge. It has been argued that only a fraction of the dynamics of an ecosystem are likely to have been the subject of careful scientific observation, but a large proportion would be part of the experience of local people living within that system; therefore, different forms of local, practical knowledge may be a valuable complement to scientific knowledge, especially in monitoring environmental change (Gadgil et al. 2003; Levin 1999; Folke et al. 2003;

[45] Factors modified from Folke and colleagues (2003) and Berkes and Seixas (2005).

Nelson et al. 2007). An example of combining local and scientific knowledge from the Ucluelet case is the sharing of local resource users' qualitative observations and experiences of ecosystem change and adaptive responses in the WCA Management Board. This example also shows evidence of the second factor, building knowledge of ecosystem processes and functions, the knowledge of which requires continuous development, drawing of social-ecological memory. However, the potential for local knowledge systems to further enrich scientific understandings of complex ecosystems and their changes is evident in the Ucluelet case.

The third factor in this category addresses the importance of coupled social-ecological management of ecosystems. Learning how to sustain social-ecological systems requires a social context within which to develop and act. In Ucluelet, for example, local resource practices do not exist in a vacuum, but are framed in a social context, which includes a historical and cultural attachment to natural resources (*see* Table 6.3). Folke and colleagues (2003) stress the importance of a social context that embeds knowledge of ecosystem dynamics in local institutions and their memory. Such coupling between knowledge of ecosystems and local institutions is an important characteristic of self-organized systems (Folke et al. 2003).

The fourth factor in this category is creating platforms to share knowledge across scales. In Ucluelet from 1970 to 1993, the resource management system did not share knowledge about ecosystem change across scales, resulting in a resource crisis and ongoing management problems. The creation of the Scientific Panel for Sustainable Forest Practices in Clayoquot Sound in 1993 and the WCA Management Board in 2001 are examples of creating platforms and involving actors and institutions across scales for

knowledge sharing about complex ecosystem management, which comprises adaptive co-management (Holling 1978; Folke et al. 2003). However, the potential exists to refine and enhance such platforms in Ucluelet and elsewhere on the BC coast.

### 6.3.4 Creating opportunity for self-organization toward social-ecological sustainability

In the final category, creating opportunity for self-organization toward social-ecological sustainability, Folke and colleagues (2003) focus on the self-organizing capacity of systems, that is, the simple set of rules that govern adaptive processes related to the capacity of the system to tolerate and deal with change.

In Ucluelet, there are several factors that contribute to creating opportunity for self-organization. These include: recognizing the interplay between sustaining and developing; dealing with multiple spatial and temporal scales; matching scales of ecosystems and governance; and, accounting for external socio-economic drivers[46]. The first factor in this category involves recognizing the interplay between sustaining and developing in the face of change. As Folke and colleagues (2003) point out, responding to and shaping change can take different pathways. Adaptation may focus on reducing the impacts of change, or it may turn the space created by change into options for renewal and novelty. In Ucluelet, for example, there is a dynamic interplay between sustaining elements of the traditional resource-based system and at the same time taking advantage of new opportunities for development in the midst of change. It is this interplay that has allowed the Ucluelet system to reinvent itself by bringing in novelty, while at the same time retaining what has been learned from past experiences. This interplay between

[46] Factors modified from Folke and colleagues (2003) and Berkes and Seixas (2005).

change and memory is a prerequisite for building resilience for adaptive capacity in social-ecological systems.

The second factor in this category involves dealing with multiple spatial and temporal scales. The Ucluelet case shows that the presence of robust supporting intuitions is an important complement to the work of local actors and institutions, as decision-making and actions that take place at distant spatial and temporal dimensions can profoundly affect the local community (*see* Tables 6.2 and 6.4). Considering these dimensions, Alcorn et al., (2003) describe how is important for communities to not depend on external actors, but create local incentives for strategies to cope with change and learn from experiences. At the same time, however, Low et al. (2003) acknowledge that when problems occur at smaller levels, it is important that larger, overlapping units can temporarily step in or provide support. According to Folke and colleagues (2003), managing these cross-scale dynamics is essential for building resilience in local social-ecological systems.

The third factor in this category involves matching scales of ecosystems and governance. Attempts to match scales of ecosystems and governance are evident in the Ucluelet case in the creation of the WCA Management Board, which involves both horizontal (community-to-community) and vertical (local, regional, provincial, federal) linkages that mirror the complexity of the ecosystem being managed. Moreover, as Carlsson (2003) observes, such arrangements are valuable in that local actors, closely connected to the resource system, are in a better position to understand and manage ecosystem change than remote levels of governance. However, as we have seen, such arrangements are necessary and difficult to accomplish (*see* Chapter 4, Section 4.4.4).

The fourth factor in this category is accounting for external social-economic drivers. Even if a community is dynamic in its response to local ecosystem change and builds social-ecological resilience, it may be vulnerable to external socio-economic or ecological drivers (Folke et al. 2003). This is exemplified in Ucluelet where the local system is overwhelmed by shocks entering from larger scales, such as rapid tourism development, or climate change. In Ucluelet, the community has been able to deal with shocks by building social capacity at the local level through robust local institutions and other social mechanisms (*see* Table 6.4; Section 6.2.2.1a). However, in the face of global-level change, the community must also look beyond its borders in order to build social-ecological resilience for adaptive capacity and sustainability. The presence of robust supporting institutions and linkages, cross-scale communication, and knowledge sharing will all be increasingly important in the face of such change (Folke et al. 2003).

## 6.4 Summary:

This chapter addressed the specific research questions: *how do coastal communities experience and deal with change in their social-ecological systems; what are some of the key factors that contribute to threatening or building resilience in social-ecological systems in coastal communities; and, how can resilience and adaptive capacity be built to adapt to change and shape change for sustainability?* It analyzed the Ucluelet case study with respect to historical changes and social-ecological system dynamics. It then turned to the identification of key factors that build or threaten resilience. Finally, it used the framework presented by Folke and colleagues to apply the factors identified in Ucluelet to social-ecological systems across the British Columbia coast.

**Table 6.1 Key factors that weaken social-ecological resilience**

| Key Factors | Ideas Mentioned | Response % |
|---|---|---|
| 1. Institutional rigidity at higher political levels negatively affecting local management | • Interference from higher levels of government<br>• Resistance to change<br>• Leadership does not embrace new ideas<br>• Leadership does not address climate change | 20.8 |
| 2. Breakdown of institutions | | |
| a. Breakdown of 'supporting' institutions | • Lack of support from higher levels of government<br>• Lack of available resources, services and support<br>• Geographic location (remoteness/isolation)<br>• Small size<br>• Poor access to /quality of health care<br>• Lack of education/understanding | 39.6 |
| b. Breakdown of local institutions | • Tourist/transient population who does not care for the local community/environment<br>• Local population who does not care for the local community/environment<br>• Lack of cohesion<br>• Lack of sense of community<br>• Lack of environmental consciousness<br>• Feeling of helplessness<br>• Apathy<br>• People do not believe in climate change<br>• Lack of emergency planning<br>• Lack of emergency response | 30.2 |
| 3. Rapid technological change leading to destructive resource use | • Dependence on natural resource base (fishing, forestry, other)<br>• Human-caused degradation of the natural environment/wildlife habitat<br>• Threats to biodiversity/uniqueness (e.g. introduction of non-native species)<br>• Natural environment/surrounding landscape<br>• Geographic location (exposure) | 50.9 |
| 4. Rapid changes in the local social-economic system | • Rapid pace of change<br>• Dependence on tourism<br>• High cost of living<br>• Economic inequality | 17 |
| 5. Other | • None/I don't know | 20.8 |

**Table 6.2 Key factors that weaken social-ecological resilience**

| Key Factors | Examples from the Ucluelet case study |
|---|---|
| 1. Institutional rigidity at higher political levels negatively affecting local management | Changes in federal and provincial management strategies from 1970 to 1993 created highly centralized and rigid institutions, leading to a resource crisis and management problems |
| 2. Breakdown of institutions | |
| a. Breakdown of 'supporting' institutions | Loss of industry and federal and provincial government backing for local institutions since 2001, and loss of trust in government leadership in the 1990s and since 2001 |
| b. Breakdown of local institutions | Loss of sense of community in the 1990s and since 2001, and influx of new tourist/transient population with little attachment to community since 2001 |
| 3. Rapid technological change leading to destructive resource use | Entry of large corporate actors in local forestry industry in the 1950s led to resource depletion and triggered opposition from environmental groups and First Nations, as more efficient technologies were not accessible to First Nations<br>Innovation in the small boat fishing fleet in the 1950s led to resource depletion and triggered conflict among user groups, as fishers sought to out perform each other<br>Rapid shoreline development and tourism development since 2001 led to resource degradation and widespread discontent among resource user groups and other local people |
| 4. Rapid changes in the local social-economic system | Rapid changes in local economy in the 1950-1970 period impacted the social system that gives support to local institutions; the importance of local practices and authority diminished as resource profits became more and more important<br>Rapid changes in local economy in the 1993-2001 period impacted the social system that gives support to local institutions; local capability diminished as local industries were lost<br>Rapid changes in local economy since 2001 impacted the social system that gives support to local institutions; local capability diminished as inequity and instability became more common |

**Table 6.3 Key factors that strengthen social-ecological resilience**

| | Key Factors | Ideas Mentioned | Response % |
|---|---|---|---|
| 1. | Strong institutions | | |
| | a. Robust local institutions | • Strong sense of community<br>• Community spirit/pride<br>• People help/support one another<br>• Volunteerism<br>• Independence<br>• Geographic location (remoteness/isolation)<br>• Small size<br>• Community-based learning initiatives<br>• Community-based action initiatives<br>• Community planning<br>• Emergency planning<br>• Emergency response | 54.7 |
| | b. Robust 'supporting' institutions | • N/A | 0 |
| | c. Strong leaders with credibility and willingness to promote change | • Strong leadership | 3.8 |
| 2. | Political space for experimentation | • Creating new opportunities<br>• People are adaptive/open to change<br>• Economic diversity<br>• Tourism development | 26.4 |
| 3. | Equity | • Access to abundant natural resources<br>• Access to local food sources | 13.2 |
| 4. | Communication | • Communication between community members<br>• Collective/cooperative decision-making<br>• Access to information | 9.4 |
| 5. | Use of different types of memory and knowledge | • Local knowledge/experience<br>• Experience with environmental change<br>• Experience with social change<br>• Environmental consciousness<br>• Close connection to natural resource base<br>• Ingenuity/creative problem solving | 52.8 |
| 6. | Other | • None/I don't know | 26.4 |

**Table 6.4 Key factors that strengthen social-ecological resilience**

| Key Factors | Examples from the Ucluelet case study |
|---|---|
| 1. Strong institutions | |
| a. Robust local institutions | Strong informal social infrastructure in the 1950-1970 period, and a responsive local council and local organizations (formal social infrastructure) and informal social infrastructure since the late 1990s |
| b. Robust 'supporting' institutions | Strong government backing in the 1950-1970 period, responsive government rule changes in the 1993-2001 period, and a stronger enforcement of rules since the 1993-2001 period were central to successful local institutions and management |
| c. Strong leaders with credibility and willingness to promote change | The local council and active local leaders since 2001 were determined to change local development models, whereas previous leaders had no such interest, as the old model suited them well |
| 2. Political space for experimentation | Some new federal and provincial government programmes and major changes brought in by the local council since 2001 showed that all governments were open to ideas by local people |
| 3. Equity | The open access resource model in the 1950-1970 period, as well as new models of forestry and fishing since 2001, led to a more equitable model of resource access and allocation and benefit among user groups |
| 4. Communication | Local fishers detected resource overexploitation in the mid-1960s, and local people recognized the threat posed by industrial forestry (too efficient); the local knowledge generated by qualitatively interacting with the resource was successfully communicated to the federal and provincial levels |
| | The creation of a co-management forum in forestry in 1993 and in fisheries since 2001 using federal, provincial, regional and local knowledge |
| 5. Use of different types of memory and knowledge | New models of forestry and fishing since 2001 were inspired by pre-1950s practices and management, as well as outside arrangements |
| | The creation of a co-management forum in forestry in 1993 and in fisheries since 2001 using both scientific and local ecological knowledge |

**Table 6.5 Local participation in different aspects of the community**

| Community Activity | Response % |
|---|---|
| I have signed a petition about a local issue | 65.4 |
| I have wrote or spoke to a government official about a local issue | 50 |
| I have volunteered in the community | 82.7 |
| I have been involved in a local team, club or group | 53.8 |
| I voted in the last municipal election | 69.2 |
| I have participated in community events | 94.2 |
| I have been involved in other community activities | 78.8 |

**Table 6.6 Building resilience and adaptive capacity in social-ecological systems on the British Columbia coast**

| |
|---|
| Learning to live with change and uncertainty |
| Evoking change in social institutions |
| Learning from crises |
| Accepting disturbance, uncertainty, surprise, and crisis for development |
| Nurturing diversity for reorganization and renewal |
| Nurturing ecological memory through diversity |
| Sustaining social memory for renewal, reorganization and novelty |
| Enhancing social-ecological memory at multiple scales |
| Combining different types of knowledge for learning |
| Combining local/practical and scientific knowledge |
| Enhancing knowledge of ecosystem processes and functions |
| Fostering coupled social-ecological management |
| Creating cross-scale platforms to share knowledge |
| Creating opportunity for self-organization |
| Recognizing the interplay between sustaining and developing |
| Dealing with multiple spatial and temporal scales |
| Matching scales of ecosystems and governance |
| Accounting for external socio-economic drivers |

**Figure 6.1 Different phases of Ucluelet's social-ecological system**

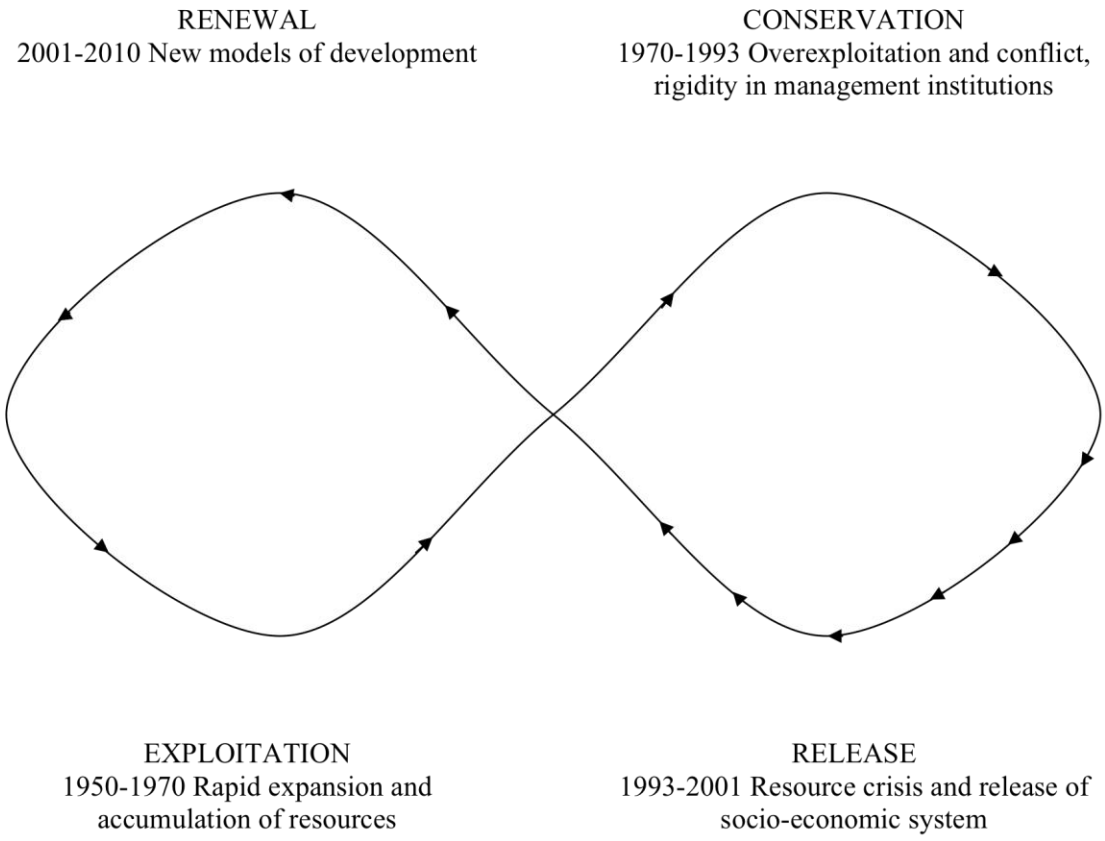



Figure 5.1 Different phases of Ucluelet's social-ecological system according to Holling's (1986) adaptive renewal cycle.

# Chapter 7: Conclusion

This thesis is a study of change and adaptability in a social-ecological system and the elements that influence resilience in that system in order to contribute to efforts toward sustainable development in similar systems on the British Columbia coast. The study focuses on the fisheries and aquaculture sector in Ucluelet, British Columbia in order to address the main research question: *What can be learned from investigating elements of human societies that sustain and build resilience and adaptive capacity toward sustainable development in social-ecological systems on the British Columbia coast?* In particular, it investigates four specific issues including: (a) how coastal communities experience and deal with change; (b) how global environmental change affects coastal communities; (c) the key factors that build or threaten social-ecological resilience in coastal communities; and (d) how resilience and adaptive capacity can be built to adapt to change and, in turn, shape change for sustainability. This chapter recaps the major findings related to each of the four specific research issues in order to present the main theoretical, methodological, policy and future research contributions of this investigation and address the main research question of this thesis.

## 7.1 Major Findings:

### 7.1.1 Change in Social-Ecological Systems:

*How do coastal communities experience and deal with change in their social-ecological systems?*

The case study of Ucluelet demonstrates that it is possible to study the dynamics of a social-ecological system. Chapter 4 shows that although changes in the ecological system and the social system may occur at different paces, they are intimately related to one another and feedback interactions can be observed (Seixas and Berkes 2003). In Chapter 6, Section 6.1, the system is analyzed through cycles of change. The analysis reveals that in the last six decades, the Ucluelet system moved from being a fairly resilient 'traditional' resource system pre-1950 to a rapidly developing system, eventually transforming into a less resilient and non-viable system in the 1970 to 1993 period. This situation led to a major resource crisis and socio-economic release between 1993 and 2001. In response to this crisis, strong local institutions and leaders promoted a series of changes in the local system, including the creation of a co-management board (WCA) for marine resources and the promotion of local access and control over new ventures in tourism, community forests, sustainable fishing, sustainable forms of aquaculture, and various community services, rebuilding resilience into the system. Though the system continues to face significant stress associated with the previous loss of resilience, and also faces new threats (e.g., rapid tourism development), the experience in since 2001 demonstrates that local resilience is high.

### 7.1.2 Climate Change, Impacts and Adaptation:

*How does global environmental change affect social-ecological systems in coastal communities?*

Chapter 5 investigates the potential impacts of climate change in Ucluelet, as well as local perceptions of risk and proposed adaptive responses. Using a combination of instrumental climate records and climate trends stored in the memory of local people,

Chapter 5 reveals that climate in Ucluelet is highly dynamic, with important implications for the ecological and social components of the system. Furthermore, the results of a downscaled analysis of future change reveals that, though the rate of change in the study region will be less than other areas of British Columbia (*see* Figure 5.3a), the projected changes are large in comparison to historical variability, indicating that relatively small changes could have large social-ecological impacts.

The major climate-related changes projected for the study region are: increasing mean annual temperatures, wetter winter conditions, significantly drier summer conditions, increasing frequency and intensity of extreme weather and weather-related events, significant changes in regional hydrology, changing oceanographic conditions, an increasing frequency and magnitude of extreme sea level events, and changes in biological productivity and diversity and ecological distribution leading to the reorganization of ecosystems (*see* Chapter 5, Section 5.1). The major sectoral impacts of these changes are summarized in Chapter 5, Section 5.2. In the fisheries and aquaculture sector, it is revealed that climate change will induce a wide range of responses, including differences in short- versus long-lived species and native (coldwater) versus exotic (warm water) species. There also appears to be consensus among local stakeholder groups that adaptive responses will be required. Examples of proposed strategies include increased investment in flexible licensing processes such as the model fisheries license bank, and the development of sustainable forms of aquaculture, including closed-containment, land-based and multi-species culture (e.g., IMTA) systems (*see* Chapter 5, Section 5.5.1.1).

In facing ongoing change, addressing the elements of coastal communities that sustain and build resilience and adaptive capacity across sectors is important. Though the

ultimate implications of all kinds of disturbances facing the system are linked, one important contribution of this research is that climate change presents a valuable opportunity to bring a diversity of actors and sectors together across scales under a common theme of long-term environmental, biological, and socio-economic health and sustainability. However, the analysis demonstrates that the present level of local stakeholder and public engagement regarding the issue of change and adaptation is extremely lacking. The critical role of local institutions and leaders and good cross-scale communication when dealing with change and disturbance is presented in Chapter 6, and summarized below.

### 7.1.3 Social-Ecological Resilience:

*What are some of the key factors that contribute to threatening or building resilience in social-ecological systems in coastal communities?*

In analyzing social-ecological resilience through cycles of change in Chapter 6, Section 6.1, it is possible to identify some key factors that build resilience into the system and some that threaten it (Section 6.2). In this case study, four key factors that weaken resilience were identified. These are: rigid institutions at higher political levels negatively affecting local management, the breakdown of institutions across scales, rapid technological change leading to destructive resource use, and rapid changes in the local socio-economic system. In addition, five key factors that strengthen resilience were identified. They include: strong institutions (local level, higher level, and leadership), creating political space for experimentation, equity, good cross-scale communication, and the use of different types of memory and knowledge. Other case studies would probably generate other factors. The identification of the factors shown here was guided by an

analysis of the most critical components of the system being studied as local stakeholders identified them, as well factors identified in other case studies (e.g., Seixas and Berkes 2003) and literature on resilience.

The analysis of key factors that build or threaten resilience in the Ucluelet system demonstrates that the development of adaptation strategies to address future threats will first require management of the elements of the system that strengthen its resilience, and those that weaken it. In other words, there are critical components of the system that precede adaptation, that is, that must be addressed prior to the implementation of specific adaptive actions. In considering the factors listed above, it is possible to gain a deeper understanding of these components, and hence of resilience and adaptability in the system being studied.

This analysis of social-ecological resilience greatly benefits from the longer time frame used to consider the resilience of the system. In the case of the Ucluelet social-ecological system in the last six decades, resilience may be viewed as the ability of the system to turn successive experiences with change into opportunities for a new cycle of more sustainable development and renewal. The view from Ucluelet has relevance for social-ecological systems on the rest of the British Columbia coast and at large.

### Building Resilience and Adaptive Capacity for Sustainability:

*How can resilience and adaptive capacity be built to adapt to change and shape change for sustainability?*

Using the local level perspective gained in the case study of Ucluelet, it is possible to search for factors or archetypes of resilience that are robust across social-ecological systems on the BC coast. As Berkes and Seixas (2005) point out, "identifying

factors for building resilience at the local level is an important first step that helps us understand what resilience might look like 'on the ground'" (p. 973). Having identified the key factors that influence resilience in Ucluelet, I was able to cluster factors that build resilience in a coastal social-ecological system following the framework of Folke and colleagues (2003) (Chapter 6, Section 6.3). This framework is based on four categories of factors (identified through cases studies) that seem to be required for dealing with change in social-ecological systems. These are: learning to live with change and uncertainty; nurturing diversity for reorganization and renewal; combining different types of knowledge for learning; and creating opportunity for self-organization toward social-ecological sustainability (Folke et al. 2003). Under each category, the Ucluelet case generated a number of items for building resilience (*see* Table 6.6).

The factors organized in Table 6.6 pertain to the local level because the objective was to understand resilience at the local level. By no doubt there are other ways to cluster the factors. However, as Berkes and Seixas (2005) conclude, what is important is that they are organized in a way in which they reinforce one another when applied across cases. While no single factor will be robust across systems on the BC coast, a cluster of factors dealing with, for example, nurturing diversity, will be relevant to all systems. Hence, the use of categories, as organized in Table 6.6, accommodates the differences between systems, while also capturing the broader dimensions of each category (Berkes and Seixas 2005).

The factors identified in this thesis are not novel, rather they are aligned with existing case studies and literature on resilience and therefore represent surrogates or archetypes of resilient pathways that can be applied to a variety of social-ecological

systems experiencing similar issues on the British Columbia coast or elsewhere. By continuing to apply this framework in case studies of other similar social-ecological systems, it is possible to make the framework, and resilience analysis and management in general, a more practical tool for considering resilience and adaptive capacity in these systems. This step is key for building resilient pathways towards sustainability in social-ecological systems on the BC coast.

## 7.2 Contributions to Literature:

This section recaps the major contributions of this dissertation in four areas: to theory, to methodological approaches, to policy, and to future research.

### 7.2.1 Theoretical Contributions:

This thesis aims to contribute to a better understanding of complexity, social-ecological linkages and the concept of resilience in social-ecological systems dealing with change.

This study provides insights about complex processes and feedbacks within and between ecological and social system components across scales. The concepts and tools gained from such insights are widely used to study change in social-ecological systems (Gonzalez et al. 2008) and provide the theoretical foundation for the resilience approach (Folke 2006). The study also provides insights into the analysis of interacting ecological and social aspects of a system through a historical perspective, according to the phases of the adaptive renewal cycle. As observed by Holling (2001):

> One of the principal aims [of a historical approach] is to define where in their respective adaptive cycles each of the sub-system is now. Action that would be appropriate at one phase of the cycle might not be appropriate at other phases. Knowing where you are helps you to define what actions need to be taken (p. 402).

The ultimate theoretical contribution of this research is to show that it is possible to use the concept of resilience to study change and sustainability. In particular, the analysis shows that resilience is a promising tool for analyzing adaptive change because it provides a way of analyzing how to maintain adaptability, that is, the capacity of human actors in a system to influence resilience, including the capacity of humans to respond within the social domain, but also to respond to and shape ecosystem dynamics in an informed manner (Resilience Alliance 2010; Berkes et al. 2003b). The analysis shows that a system becomes more resilient and sustainable as it becomes more flexible (learning to live with change and uncertainty), diverse (nurturing diversity for reorganization and renewal) and capable of learning (combining different types of knowledge for learning) and adapting (creating opportunity for self-organization) in the face of ecological and/or social disturbance. Conversely, a system loses resilience and sustainability as it becomes more rigid and less capable of learning and adapting in the face of change (Seixas 2002).

### 7.2.2 Methodological Contributions:

The methodology used in this research provides some tools to investigate the various aspects of a complex social-ecological system in the face of change. These aspects include the ecological and social (cultural, economic, political) components of the universe being studied. In particular, the study demonstrates the use of aspects of an ethnographic, participatory case study approach, integrated with locally specific quantitative and secondary sources of data, including climate data, in order to investigate the issue of change and adaptation in a social-ecological system. This approach provided

a local level perspective, as the objective of the thesis is to understand change and resilience at the local level. In addition, the issues investigated in this study can also be found in other places, making the case study unique but not isolated. The lessons learned in this case study are therefore transferable to other social-ecological systems experiencing similar issues on the British Columbia coast.

The analysis also reveals certain limitations of the approach. The resilience approach is a framework for thinking about the dynamics of social-ecological systems; it is not a well-defined theory, nor does it offer specific procedures for its application. This ambiguity can lead to subjectivity and bias in the research process. I addressed these issues by reducing the system being studied to its most critical components, as local stakeholders identified them. The approach used was also informed by existing case studies (e.g., Seixas and Berkes 2003) and literature on resilience. As proposed by Berkes and Folke (1998b), case studies offer a valuable tool to explore resilience in the field. By continuing to apply resilience in cases studies of various social-ecological systems, it will help to determine the most useful guidelines for using the approach. This in turn will make resilience analysis and management a more practical tool and increase its use in resource and environmental management and science (Dempster 2010; Resilience Alliance 2010).

### 7.2.3 Policy Contributions:

The primary policy contribution of this thesis concerns the identification of key factors that seem to be required for building resilience toward more sustainable resource use and socio-economic development. In particular, the analysis of key factors that build or threaten resilience in the Ucluelet system demonstrates that there are critical

components of the system that precede adaptation, that is, that must be addressed prior to the implementation of specific adaptive actions. In considering the factors identified in this study, it is possible to gain a deeper understanding of these components, and hence of resilience and adaptability in the case study system.

Based on the key factors identified in this case study, I propose some key issues that could be addressed in the context of the environmental and socio-economic development agenda on the British Columbia coast. These are:

1. The urgency of building a flexible, adaptive management model. Such a model must be capable of responding to ecological and social feedbacks and continually learning and adapting to new situations and surprises (Holling 1978).
2. The need to incorporate participatory approaches and diverse forms of knowledge into management (Berkes and Folke 1998b; Folke et al. 2003). Such a cross-scale arrangement must involve both horizontal (community-to-community) and vertical (local, regional, provincial, federal) linkages that mirror the complexity of the ecosystem being managed. However, as we have seen, such arrangements are necessary and difficult to accomplish.
3. The importance of creating space for locally-driven entrepreneurialism and creativity (e.g., community forests, community-based aquaculture) (Alcorn 2003), while at the same time sustaining connections to larger, overlapping units that can temporarily step in or provide support when it is needed (Low et al. 2003).
4. The need to nurture ecological diversity through policies and actions aimed at protecting and enhancing species and habitats, including through effective monitoring and enforcement (Folke et al. 2003).

5. The need to build a shared vision of the future through integrated approaches to management, including taking into consideration both costs and benefits of developments of the natural resource base. Assessments should include the ecological costs, as well as the human benefits, of such interventions.
6. The importance of building a diverse and evolving knowledge base at the local level that includes an intimate knowledge of ecosystem dynamics, including the knowledge and memory of local resource users and other stewards.

This list is not exhaustive. However, these policy implications align with this and other case studies and literature on resilience and can be used as guidelines for managing for resilience in social-ecological systems on the British Columbia coast.

#### 7.2.4 Future Research Contributions:

The Ucluelet case study presents a number of venues for future research. I propose the following primary future research opportunities to build upon the findings of this thesis.

First, I propose a further investigation of one or all of the following topics in one (e.g., fisheries and aquaculture) or multiple resource sectors in Ucluelet in order to provide an in-depth community planning booklet on the topic(s) addressed: (a) social-ecological dynamics and feedback interactions; (b) climate change; (c) factors that build or threaten resilience; and/or (d) pathways for building resilience toward sustainability.

Second, I propose a further investigation of one or all of the following topics in one (e.g., fisheries and aquaculture) or multiple resource sectors in coastal communities throughout British Columbia in order to develop a framework for future assessments on the topic(s) addressed: (a) social-ecological dynamics and feedback interactions; (b)

climate change; (c) factors that build or threaten resilience; and/or (d) pathways for building resilience toward sustainability.

Finally, I propose the continual application of case study analyses to the framework laid out by Folke and colleagues (2003) in order to identify factors for building resilience that are robust across social-ecological systems on the British Columbia coast. This would provide additional insight into the factors I have identified in Table 6.6 and contribute to a continual learning curve for understanding change and resilience at the local level in social-ecological systems on the BC coast.

## 7.3 Concluding Comments:

*What can be learned from investigating elements of human societies that sustain and build resilience and adaptive capacity toward sustainable development in social-ecological systems on the British Columbia coast?*

The issue of change and adaptability in social-ecological systems has several key aspects. The findings of this thesis point out: the need to understand the dynamics of linked social-ecological systems; the need to investigate climate change (and other disturbances) in a local level context; the need to understand the key factors that build or threaten social-ecological resilience in a system; and the need to search for factors of resilience that are robust across other social-ecological systems in order to contribute to efforts toward sustainability.

The findings of this thesis have relevance for social-ecological systems on the British Columbia coast and at large. Above all, the experience in Ucluelet has shown that the resilience of communities on this coast is not in their maintenance of stability, but

rather in their ability to turn successive experiences of change into opportunities for new cycles of more sustainable development and renewal.

# Bibliography

Abeysirigunawardena, D. S. and Walker, I. J. (2008). Sea level responses to climatic variability and change in Northern British Columbia. *Atmosphere-Ocean*, 46(3), 277-296.

Adger, W. N. (2001). Scales of governance and environmental justice for adaptation and mitigation of climate change. *Journal of International Development*, 13, 921-931.

Adger, W. N. (2003). Social capital, collective action, and adaptation to climate change. *Economic Geography*, 79(4), 387-404.

Adger, W. N., Arnell, N. W. and Tompkins, E. L. (2005a). Successful adaptation to climate change across scales. *Global Environmental Change*, 15, 77-86.

Adger, W. N., Hughes, T. P., Folke, C., Carpenter, S. R. and Rockstrom, J. (2005b). Social-ecological resilience to coastal disasters. *Science*, 309, 1036-1039.

Adger, W. N. and Kelly, P. M. (1999). Social vulnerability to climate change and the architecture of entitlements. *Mitigation and Adaptation Strategies for Global Change*, 4, 253-266.

Ainsworth, C., Heymans, J.J., Pitcher, T.J. and Vasconcellos, M. (2002). Ecosystem models of Northern British Columbia for the time periods 2000, 1950, 1900 and 1750. *Fisheries Centre Research Reports*. 10(4).

Al-Hindi, K. F. and Kawabata, H (2002). Towards a more fully reflexive feminist geography. *In* Moss, P. (Eds.) *Feminist geography in practice: Research and methods.* Oxford: Blackwell.

Alcorn, J.B., Bamba, J., Masium, S., Natalia, I. and Royo, A.G. (2003). Keeping ecological resilience afloat in cross-scale turbulence: An indigenous social movement navigates change in Indonesia. *In* Berkes, F., Colding, J. and Folke, C. (Eds.) *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*. Cambridge: Cambridge University Press.

Anderies, J. M., Walker, B. H., and Kinzig, A. P. (2006). Fifteen weddings and a funeral: Case studies and resilience-based management. Ecology and Society, 11(1). Retrieved from http://www.ecologyandsociety.org/vol11/iss1/art21/.

Babbie, E. and Benaquisto, L. (2002). *Fundamentals of Social Research: 1st Canadian Edition*. Canada: Nelson.

Barkley Community Forest (2010). http://www.barkleyforest.ca/.

Barry, J. (2007). *Environment and Social Theory* (2nd ed.). New York: Routledge.

Bastien, Y. (2004). Recommendations for change. *Report of the Commission for Aquaculture Development to the Minister of Fisheries and Oceans Canada*. Retrieved from http://www.dfo-mpo.gc.ca/aquaculture.

Baxter, J. and Eyles, J. (1997). Evaluating qualitative research in social geography: Establishing 'rigour' in interview analysis. *Royal Geographical Society*, 22, 505-525.

BC Hydro (2006). 2006 integrated electricity plan and long term acquisition plan. *BC Hydro*. Retrieved from http://www.bchydro.com/rx_files/info/info43514.pdf.

BC Ministry of Agriculture and Lands (2006). Shellfish Development Initiative. *BC Ministry of Agriculture and Lands*. Retrieved from http://www.agf.gov.bc.ca/fisheries.

BC Ministry of Agriculture and Lands (2005). About the agriculture industry: Industry significance…some facts. *BC Ministry of Agriculture and Lands*. Retrieved from www.agf.gov.bc.ca/grape/publications/documents/overview_grapes_dec2004.pdf.

BC Ministry of Environment (2008). Seafood data tables and graphs. *BC Ministry of Environment*. Retrieved from http://www.eng.gov.bc.ca/omsd/fishstats/graphs-tables/index.html

BC Ministry of Environment (2006). British Columbia's coastal environment. *BC Ministry of Environment*. Retrieved from http://www.env.gov.bc.ca/soe/bcce.

BC Ministry of Environment (2004). Weather, climate and the future: BC's Plan. *BC Ministry of Environment*. Retrieved from http://www.env.gov.bc.ca/air/climate/cc_plan/pdfs/bc_climatechange_plan.pdf.

BC Ministry of Forests and Range (2008). Coast Forest Regions. *BC Ministry of Forests and Range.* Retrieved from http://www.for.gov.bc.ca/rco/.

BC Ministry of Water, Land and Air Protection (2002). Indicators of climate change for British Columbia. BC Ministry of Water, Land and Air Protection. Retrieved from http://www.env.gov.bc.ca/air/climate/indicat/pdf/indcc.pdf.

Berkes, F. and Folke, C. (Eds.) (1998a). *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience.* New York: Cambridge University Press.

Berkes, F. and Folke, C. (1998b). Linking social and ecological systems for resilience and sustainability. *In* Berkes, F. and Folke, C. (Eds.), *Linking Social and Ecological*

*Systems. Management Practices and Social Mechanisms for Building Resilience*. Cambridge: Cambridge University Press.

Berkes, F. and Folke, C. (2002). Back to the future: Ecosystem dynamics and local knowledge. *In* Gunderson, L.H. and Holling, C.S. (Eds.). *Panarchy: Understanding Transformations in Systems of Humans and Nature*. Washington, D.C.: Island Press.

Berkes, F. and Seixas, C. (2005). Building Resilience in Lagoon Social-Ecological Systems: A Local-Level Perspective. *Ecosystems*, 8(8), 967-974.

Berkes, F., Colding, J. and Folke, C. (Eds.) (2003a). *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change.* Cambridge: Cambridge University Press.

Berkes, F., Colding, J. and Folke, C. (2003b). Introduction. *In* Berkes, F., Colding, J. and Folke, C. (Eds.) *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change.* Cambridge: Cambridge University Press.

Berkes, F., Mahon, R., McConney, P., Pollnac, R.B. and Pomeroy, R.S. (2001). *Managing Small-scale Fisheries*. Ottawa: International Development Research Center (IDRC).

Blann, K. Light, S. and Musumeci, J.A. (2003). Facing adaptive challenge: practitioners' insights from negotiating resources crises in Minnesota. *In* Berkes, F., Colding, J. and Folke, C. (Eds.) *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*. Cambridge: Cambridge University Press.

Bryman, A. (2001). *Social Research Methods*. Oxford: Oxford University Press.

Burton, I. (2008). Moving forward on adaptation. *In* Lemmen, D. S., Warren, F. J., Lacroix, J. and Bush, E. (Eds) *From Impacts to Adaptation: Canada in a Changing Climate 2007* (329-386). Government of Canada, Ottawa, Canada.

Capra, F. (1996). *The Web of Life*. New York: Anchor Books.

Carlsson, L. (2003). The strategy of the commons: History and property rights in central Sweden. *In* Berkes, F., Colding, J. and Folke, C. (Eds.) *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*. Cambridge: Cambridge University Press.

Carpenter, S. R., and Gunderson, L. H. (2001). Coping with collapse: Ecological and social dynamics in ecosystem management. *Bioscience*, 51(6), 451-457.

Clark, W.C. and Munn, R.E. (Eds.). (1986). *Sustainable Development of the Biosphere*. IIASA/ Cambridge University Press.

Conradson, D. (2005). Focus groups. *In* Flowerdew, R. and Martin, M. (Eds.) *Methods In Human Geography* (128-143). Essex: Pearson, Harlow.

Costanza, R., dArge, R., deGroot, R., Farber, S., Grasso, M., Hannon, B., et al. (1997). The value of the world's ecosystem services and natural capital. *Nature,* 387(6630), 253-260.

Crang, M. (2003). Qualitative methods: Touchy, feely, look-see? *Progress in Human Geography*, 27(4), p. 494-504.

Creswell, J. W. (1998). *Qualitative inquiry and research design: Choosing among five traditions*. Thousand Oaks: SAGE Publications.

Cross, S., Liston, M., Bartsch, A. and Liutkus, M. (2009). Diversification of finfish aquaculture production systems: Eco-benefits and potential metrics for assessing the environmental performance of these systems. *Aquametrix Research, Discussion Paper Prepared for Fisheries and Oceans Canada.*

Cutter, S. L., Mitchell, J. T. and Scott, M. S. (2000). Revealing the vulnerability of people and places: A case study of Georgetown County, South Carolina. *Annals of the Association of American Geographers,* 1 (4), 713-737.

Davidson-Hunt, I.J. and Berkes, F. (2003). Nature and society through the lens of resilience: Toward a human-in-ecosystem perspective. *In* Berkes, F., Colding, J. and Folke, C. (Eds.). *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*. Cambridge: Cambridge University Press.

Dawson, R., Werner, A.T. and Mudock, T.Q. (2008). *Preliminary Analysis of Climate Change in the Cariboo-Chilcotin Area of British Columbia*. Pacific Climate Impacts Consortium (PCIC), University of Victoria, Canada. Retrieved from http://pacificclimate.org/docs/publications/CaribooChilcotinClimate.08Sept08.pdf.

Delemos, J. L. (2006). Community-based participatory research: changing scientific practice from research *on* communities to research *with* and *for* communities. *Local Environment*, 11(3), 329-338.

Demarchi, D.A. (1996). An Introduction to the Ecoregions of British Columbia. *Ministry of Environment, Lands and Parks.* Retrieved from http://www.env.gov.bc.ca/ecology/ecoregions.

Dempster, C. (2010). Resilience of social-ecological systems (SESs): A case study of water management in the Iraqi Marshlands. *M.A. Thesis,* Department of Geography, University of Victoria, Canada.

District of Ucluelet (2010a). District awards. Retrieved from http://www.ucluelet.ca/district/districtawards.php.

District of Ucluelet (2010b). Emergency preparedness. Retrieved from http://www.ucluelet.ca/district/communityplan_emergencyplanning.php.

District of Ucluelet (2008). *Official Community Plan*. Retrieved from http://www.ucluelet.ca/district/communityplan.php.

District of Ucluelet (2005). Community Profile. Retrieved from www.ucluelet.ca/communityprofile/docs/Community%20Profile.pdf.

Dolan, A. H. and Ommer, R. (2008). Climate change and community health: Lessons from Canada's east and west coasts. *Journal of Rural and Community Development*, 3(2), 27-46.

Dolan, A. H. and Walker, I. J. (2006). Understanding vulnerability of coastal communities to climate change related risks. *Journal of Coastal Research*, 39, 1317-1324.

Ecotrust Canada (2008). *Fisheries Licence Bank Briefing.* Vancouver, Canada: Ecotrust Canada.

Ecotrust Canada (2004). *Catch-22: Conservation, Communities, and the Privatization of B.C. Fisheries*. Vancouver, Canada: Ecotrust Canada.

Environment Canada (2007). Canada's government taking action on adaptation and climate change issues. Retrieved from http://www.ec.gc.ca/default.asp?lang=Enandn=793255F0-1andnews=91E1F38E-C53C-404B-9512-22EA69C08787.

Eyles, J. and Smith, D. M. (1988). *Qualitative Methods in Human Geography.* Cambridge: Polity Press.

Fisheries and Oceans Canada (2010a). *Pacific Region Integrated Fisheries Management Plan – Crab by Trap*. Fisheries and Oceans Canada. Retrieved from http://www-ops2.pac.dfo-mpo.gc.ca/xnet/content/mplans/mplans.htm?.

Fisheries and Oceans Canada (2010b). *Pacific Region Integrated Fisheries Management Plan – Groundfish*. Fisheries and Oceans Canada. Retrieved from http://www-ops2.pac.dfo-mpo.gc.ca/xnet/content/mplans/mplans.htm?.

Fisheries and Oceans Canada (2010c). *Pacific Region Integrated Fisheries Management Plan – Salmon, Southern BC*. Fisheries and Oceans Canada. Retrieved from http://www-ops2.pac.dfo-mpo.gc.ca/xnet/content/mplans/mplans.htm?.

Fisheries and Oceans Canada (2009). State of physical, biological, and selected fishery resources of Pacific Canadian marine ecosystems. *Fisheries and Oceans Canada, Canadian Science Advisory Secretariat (CSAS) Research Document 2009/022.*

Fisheries and Oceans Canada (2008). Pacific Salmon Treaty. *Fisheries and Oceans Canada*, 162 p. Retrieved from http://www.pac.dfo-mpo.gc.ca/fm-gp/species-especes/salmon-saumon/pol/pst-tsp/tor-mandat-eng.htm.

Fisheries and Oceans Canada (2001). Fish stocks of the Pacific coast. *Fisheries and Oceans Canada*, 162 p. Retrieved from http://www-comm.pac.dfo.

Folke, C. (2006). Resilience: The emergence of a perspective for social–ecological systems analyses. *Global Environmental Change*. 16(3), 253-267.

Folke, C., Berkes, F. and Colding, J. (1998). Ecological practices and social mechanisms for building resilience and sustainability. *In* Berkes, F. and Folke, C. (Eds.). *Linking Social and Ecological Systems. Management Practices and Social Mechanisms for Building Resilience*. Cambridge: Cambridge University Press.

Folke, C., Colding, J. and Berkes, F. (2003). Synthesis: Building resilience and adaptive capacity in social-ecological systems. *In* Berkes, F., Colding, J. and Folke, C. (Eds.) *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change.* Cambridge: Cambridge University Press.

Folke, C., S. Carpenter, T. Elmqvist, L. Gunderson, C.S. Holling, and B. Walker. (2002). Resilience and Sustainable Development: Building Adaptive Capacity in a World of Transformations. *AMBIO*, 31, 437-440.

Francisco, H. A. (2008). Adaptation to climate change: needs and opportunities in Southeast Asia. *ASEAN Economic Bulletin*, 25(1), 7-19.

Gadgil, M., Olssom, P., Berkes, F. and Folke, C. (2003). Social-ecological learning and adaptation. *In* Berkes, F., Colding, J. and Folke, C. (Eds.) *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change.* Cambridge: Cambridge University Press.

Garibaldi, A. and Turner, N. (2004). Cultural keystone species: implications for ecological conservation and restoration. *Ecology and Society*, 93(3). Retrieved from http://www.ecologyandsociety.org/vol9/iss3/art1/.

Gerwing, K. and McDaniels, T. (2006). Listening to the salmon people: Coastal First Nations' objectives regarding salmon aquaculture in British Columbia. *Society and Nature,* 19, 259–273.

Gislason, G., Lam, E. and Mohan, M. (1996). *Fishing for Answers: Coastal Communities and the BC Salmon Fishery*. Victoria, Canada: ARA Consulting Group Inc. for the BC Job Protection Commission.

Gonzalez, J. A., Montes, C., Rodriguez, J., and Tapia, W. (2008). Rethinking the Galapagos Islands as a complex social-ecological system: Implications for conservation and management. *Ecology and Society*, 13(2). Retrieved from http://www.ecologyandsociety.org/vol13/iss2/art13/.

Gunderson, L. H. and Holling, C. S. (Eds). (2002). *Panarchy: Understanding Transformation in Human and Natural Systems.* Washington: Island Press.

Gunderson, L.H., Holling, C.S. and Light, S.S. (Eds.) (1995a). *Barriers and Bridges to the Renewal of Ecosystems and Institutions*. New York: Columbia University Press.

Gunderson, L.H., Holling, C.S. and Light, S.S. (1995b). Barriers broken and bridges built: A synthesis. *In* Gunderson, L.H., Holling, C.S. and Light, S.S. (Eds.). *Barriers and Bridges to the Renewal of Ecosystems and Institutions*. New York: Columbia University Press.

Handmer, J.W., S. Dovers, and Downing. T.E. (1999). Societal vulnerability to climate change and variability. *Mitigation and Adaptation Strategies for Global Change.* 4, 267-281.

Handmer, J. (2003). Adaptive capacity: what does it mean in the context of natural hazards? *In* Smith, J. B., Klein, R. J. T. and Huq, S. (Eds.) *Climate Change, Adaptive Capacity and Development* (51-70). London: Imperial College Press.

Harris, C. (1997/87). Social power and cultural change in pro-colonial British Columbia. *BC Studies*. 115(116), 45.

Hay, I. (2000). *Qualitative Research Methods in Human Geography*. Oxford: Oxford University Press.

Hayter, R. (2000). *Flexible Crossroads: The Restructuring of British Columbia's Forest Economy*. University of British Columbia Press, Vancouver, Canada.

Hobbs, R.J., Higgs, E. and Harris, J.A. (2009). Novel ecosystems: Implications for conservation and restoration. *Trends in Ecology & Evolution*, 24(11), 599-605.

Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics*, 4, 1-23.

Holling, C.S. (Ed.) (1978). *Adaptive Environmental Assessment and Management*. London: Wiley.

Holling, C.S. (1986). The resilience of terrestrial ecosystems: Local surprise and global change. In Clark, W.C. and Munn, R.E. (Eds.). *Sustainable Development of the Biosphere*. IIASA/ Cambridge University Press.

Holling, C. S. (2001). Understanding the complexity of economic, ecological, and social systems. *Ecosystems*, 4, 390-405.

Holling, C.S. and Meffe, G.K. (1996). Command and control and the pathology of natural resources management. *Conservation Biology* 10: 328-337.

Holling, C.S., Berkes, F. and Folke, C. (1998). Science, sustainability and resource management. *In* Berkes, F. and Folke, C. (Eds.) *Linking Social and Ecological Systems. Management Practices and Social Mechanisms for Building Resilience*. Cambridge: Cambridge University Press.

Holling, C. S., Gunderson, L. H., and Ludwig, D. (2002). In search of a theory of adaptive change. *In* Gunderson, L. H. and Holling, C. S. (Eds.) *Panarchy: Understanding Transformation in Human and Natural Systems* (3-22).

Human Research Ethics Board (HREB), University of Victoria (2007). Human research ethics: Overview and annotated guidelines for completing the Human Research Ethics Board application for ethics approval for human participant research. Retrieved from http://www.research.uvic.ca/forms/index.htm#HREC.

Human Research Ethics Board (HREB), University of Victoria (2009). Annotated guidelines for completing the Human Research Ethics Board application for ethics approval for human participant research. Retrieved from http://www.research.uvic.ca/forms/index.htm#HREC.

Hyatt, K.D., Stockwell, M.M. and Rankin, D.P. (2003). Impact and adaptation responses of Okanagan River sockeye salmon Oncorhynchus nerka to climate variation and change effects during freshwater migration: stock restoration and fisheries management implications. *Canadian Water Resources Journal*. 28, 689–713.

Intergovernmental Panel on Climate Change (2007a). *Climate Change 2007: The Physical Science Basis* (Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change). Retrieved from http://www.ipcc.ch/ipccreports/ar4-wg1.htm.

Intergovernmental Panel on Climate Change (2007b). *Climate Change 2007: Impacts, Adaptation and Vulnerability* (Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change). Retrieved from http://www.ipcc.ch/ipccreports/ar4-wg2.htm.

Intergovernmental Panel on Climate Change (2001). *Climate Change 2001: Impacts, Adaptation and Vulnerability* (Contribution of Working Group II to the Third

Assessment Report of the Intergovernmental Panel on Climate Change). Retrieved from http://www.ipcc.ch/ipccreports/tar/wg2/index.htm.

Jackson, W. (1999). *Methods: Doing social research* (2nd ed.). Scarborough, Canada: Prentice Hall Allyn and Bacon Canada.

Jackson, P. (2001). Making Sense of Qualitative Data. In Limb, M and Dwyer, C. (Eds.), *Qualitative Methodologies for Geographers* (199-214). London: Arnold.

Jorgensen, D. L. (1989). *Participant Observation: A Methodology for Human Studies*. Newbury Park: Sage Publications.

Kates, R.W. and Clark, W.C. (1996). Expecting the unexpected. *Environment.* 6(11), 28-34.

Kauffman, S. (1993). *The Origins of Order*. New York: Oxford University Press.

Kemmis, S. and McTaggart, R. (2000). Participatory action research. *In* Denzin, N. K. and Lincoln, Y. S. (Eds.). *Handbook of Qualitative Research* (2nd ed.) (657-605). Thousand Oaks, CA: Sage Publications.

Kesby, M., Kindon, S. and Pain, R.. (2005). 'Participatory' approaches and diagramming techniques. *In* Flowerdew, R. and Martin, M. (Eds.). *Methods In Human Geography* (144 – 166). Essex: Pearson, Harlow.

Kidd, S. A. and Kral, M. J. (2005). Practicing participatory action research. *Journal of Counseling Psychology*, 52(2), 187-195.

King, J. R. (Ed.) (2005). Report of the Study Group on Fisheries and Ecosystem Response to Recent Regime Shifts. *North Pacific Marine Science Organization (PICES), Scientific Report 28*. Retrieved from http://www.pices.int/publications/scientific_reports/Report28/Rep_28_default.aspx.

Klein, R. J. T. and Nicholls, R. J. (1999). Assessment of coastal vulnerability to climate change. *Ambio*, 28 (2), 182–187.

Kleypas, J.A., Feely, R.A., Fabry, V.J., Langdon, C., Sabine, C.L. and Robbins, L.L. (2006). *Impacts of Ocean Acidification on Coral Reefs and Other Marine Calcifiers. A Guide for Future Research.* Report of a workshop sponsored by NSF, NOAA and the USGS. Retrieved from http://www.isse.ucar.edu/florida/.

Kvale, S. (1996). *Interviews: An Introduction to Qualitative Research Interviewing*. Sage Publications.

Lambin, E. F. (2005). Conditions for sustainability of human-environment systems: Information, motivation, and capacity. *Global Environmental Change*, 15(3), 177-180.

Larkin, P.A. (1977). An epitaph for the concept of maximum sustained yield. *Transactions of the American Fisheries Society* 106, 1-11.

Laroque, C.P. and Smith, D.J. (1999). Tree-ring analysis of yellow-cedar (*Chamaecyparis nootkatensis*) on Vancouver Island, British Columbia. *Canadian Journal of Forest Research*. 29(1), 115-123.

Lebel, L., Anderies, J. M., & Campbell, B. (2006). Governance and the capacity to manage resilience in regional social-ecological systems. *Ecology and Society*, 11(1). Retrieved from http://www.ecologyandsociety.org/vol11/iss1/art19/.

Lemly, D. A., Kingsford, R. T., and Thompson, J. R. (2000). Irrigated agriculture and wildlife conservation: Conflict on a global scale. *Environmental Management*, 25(5), 485-512.

Lemmen, D. S., Warren, F. J., Lacroix, J. and Bush, E. (Eds). (2007). *From Impacts to Adaptation: Canada in a Changing Climate 2007*. Government of Canada, Ottawa, Canada.

Levin, S.A. (1999). *Fragile Dominion: Complexity and the Commons*. Reading, MA: Perseus Books.

Ley, D. and Mountz, A. (2001). Interpretation, representation, positionality: Issues in field research in human geography. *In* Limb, M. and Dwyer, C. (Eds.), *Qualitative Methodologies for Geographers* (234-237). London: Arnold.

Low, B., Ostrom, E., Simon, C. and Wilson, J. (2003). Redundancy and diversity: Do they influence optimal management? *In* Berkes, F., Colding, J. and Folke, C. (Eds.) *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*. Cambridge: Cambridge University Press.

Ludwig, D., Hilborn, R. and Walters, C.J. (1993). Uncertainty, resource exploitation, and conservation: Lessons from history. *Science* 260: 17-36

Lugo, A. (1995). Management of tropical biodiversity. *Ecological Applications*, 5, 956-961.

Mahon, R., Almerigi, S., McConney, P., Parker, C. and Brewster, L. (2003). Participatory methodology used for sea urchin co-management in Barbados. *Coastal and Ocean Management*, 46, 1-25.

Marchak, P., Aycock, S. and Herbert, D. (1999) *Falldown: Forest Policy in British Columbia.* Vancouver: David Suzuki Foundation.

Marshall, N. A., and Marshall, P. A. (2007). Conceptualizing and operationalizing social resilience within commercial fisheries in northern Australia. *Ecology and Society*, 12(1). Retrieved from http://www.ecologyandsociety.org/vol12/iss1/art1/.

Matthews, R. (2003). Using a social capital perspective to understand social and economic development in coastal British Columbia. *Horizons: Policy Research Initiative*, 63, 25–29.

McKendrick, J. (1999). Multi-method research: An introduction to its application in population geography. *Professional Geographer*, 51(1), 40-50.

McNamara, C. (1999). *General Guidelines for Conducting Interviews*. Minnesota.

Mendis, S., Mills, S. and Yantz, J. (2003). *Building Community Capacity to Adapt to Climate Change in Resource-based Communities*. Department of Geography, University of Saskatchewan. Natural Resource Institute, University of Manitoba, Prince Albert, 1-89.

Millennium Ecosystem Assessment (MA) (2005). Ecosystems and human well-being: Wetlands and water, synthesis. Washington, DC: *World Resources Institute*. Retrieved from http://www.millenniumassessment.org/documents/document.358.aspx.pdf.

Mitchell, A. and MacDonald, D. (2010). The Crisis Facing the World's Coasts and Oceans and the State of Canada's Coasts and Oceans. Keynote Address, Coastal Zone Canada Conference 2010, Charlottetown, Prince Edward Island, Canada.

Morton, A., Routledge, R., Peet, C. and Ladwig, A. (2005). Sea lice (*Lepeophtheirus Salmonis*) infection rates on juvenile pink (*Oncorhynchus gorbuscha*) and chum (*Oncorhynchus keta*) salmon in the nearshore marine environment of British Columbia. *Canadian Journal of Fisheries and Aquatic Science*, 61, 147–157.

Naylor, R., Eagle, J. and Smith, W. L. (2003). Salmon aquaculture in the Pacific Northwest: A global industry. *Environment*, 45 (8), 8–39.

Nelson, D. R., Adger, W. N., and Brown, K. (2007). Adaptation to environmental change: Contributions of a resilience framework. *Annual Review of Environment and Resources*, 32, 395-419.

Noakes, D.J., Beamish, R.J. and Gregory, R. (2002). British Columbia's commercial salmon industry. *North Pacific Anadromous Fish Commission*, Document 642.

North, D.C. (1994). Economic performance through time. *American Economics Review*,

84, 359-368.

Ommer, R. E. and the Coasts Under Stress (CUS) team (2007). *Coasts Under Stress: Restructuring and Social-Ecological Health*. Montreal and Kingston: McGill-Queen's University Press.

Olsson, P. and Folke, C. (2001). Local ecological knowledge and institutional dynamics for ecosystem management: A study of the Lake Racken watershed, Sweden. *Ecosystems* 4: 85-104.

Ostrom, E. (1990). *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge: Cambridge University Press.

Ostrom, E., and Ahn, T.K. (2003). A social science perspective on social capital: social capital and collective action. *Revista Mexicana de Sociología LXV*. 1, 155-233.

Overpeck, J.T., Bartlein, P.J. and Webb, T.I. (1991). Potential magnitude of future vegetation change in eastern North America: comparisons with the past. *Science*, 254, 692– 695.

Pacific Impacts Climate Consortium (PCIC) (2010). Plan2Adapt. Retrieved from http://www.plan2adapt.ca/.

Page, J., Enns, S., Malinick, T. and Matthews, R. (2007). Should I stay or should I go?: Investigating resilience in B.C.'s coastal communities. *In* Tepperman, L. and Dickinson, H. (Eds.) *Reading Sociology: Canadian Perspectives* (260-263). Toronto, Canada: Oxford University Press.

Parfitt, J. (2005). Questionnaire design and sampling. *In* Flowerdew, R. and Martin, M. (Eds.) *Methods In Human Geography* (78-109). Essex: Pearson, Harlow.

Parsons, L. S. (1993). *Management of Marine Fisheries in Canada*. Canadian Bulletin of Fisheries and Aquatic Sciences 225, National Research Council of Canada and Department of Fisheries and Oceans, Ottawa, Canada.

Pretty, J. (2003). Social capital and the collective management of resources. *Science*. 302(5652), 1912-1914.

Public Safety and Emergency Preparedness Canada (2006). British Columbia Emergency Response Management System (BCERMS). *Public Safety and Emergency Preparedness Canada*. Retrieved from http://www.pep.gov.bc.ca/bcerms/bcerms.html.

Redman, C. L., and Kinzig, A. P. (2003). Resilience of past landscapes: Resilience theory, society, and the longue durée. *Conservation Ecology*, 7(1). Retrieved from http://www.ecologyandsociety.org/vol7/iss1/art14/.

Riessman, C. K. (2002). Analysis of personal narratives. *In* Gubrium, J. F. and Holstein, J. A. (Eds.), *Handbook of Interview Research: Context and Method* (695-710). Thousand Oaks: Sage.

Resilience Alliance. (2010). http://www.resalliance.org.

Rodenhuis, D. R., Bennett, K. E., Werner, A. T., Murdock, T. Q., Bronaugh, D. (2007). Hydro-climatology and future climate impacts in British Columbia. *Pacific Impacts Climate Consortium*, University of Victoria, Victoria, Canada.

Royal BC Museum (2005a): Climate change map series. *Royal BC Museum*. Retrieved from http://www.pacificclimate.org/impacts/rbcmuseum/.

Selfa, T. (2008). The politics of community-based conservation in natural resource management: A focus for international comparative analysis. *Environment and Planning*, 40, 948-965.

Shaw, J. Taylor, R. B., Solomon, S., Christian, H. A., Forbes, D. L. (1998). Potential impacts of global sea-level rise on Canadian coasts. *Canadian Geographer*, 42(2), 365-379.

Seixas, C. (2002). Social-ecological dynamics in management systems: Investigating a coastal lagoon fishery in Southern Brazil. *Ph.D. dissertation*, Natural Resource Institute, University of Manitoba, Winnipeg, Canada.

Smit, B. and Pilifosova, O. (2003). From adaptation to adaptive capacity and vulnerability reduction. *In* Smith, J. B., Klein, R. J. T. and Huq, S. (Eds.) *Climate Change, Adaptive Capacity and Development* (9-28). London: Imperial College Press.

Smit, B. and Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change*, 16, 282-292.

Smith, J. B., Klein, R. J. T. and Huq, S. (2003). Introduction. *In* Smith, J. B., Klein, R. J. T. and Huq, S. (Eds.) *Climate Change, Adaptive Capacity and Development* (1-7). London: Imperial College Press.

Spittlehouse, D.L. and Stewart, R.B. (2003). Adapting to climate change in forest management. *Journal of Ecosystems and Management.* 41, 7–17

Statistics Canada (2006). 2006 Community Profiles. Statistics Canada. Retrieved from http://www.bcstats.gov.bc.ca/census.asp.

Timmermann, A. (1999). Detecting the nonstationary response of ENSO to greenhouse warming. *Journal of Atmospheric Sciences*. 56(14), 2313–2325.

Tollefson, C. and Scott, R. (2006). Charting a course: Shellfish aquaculture and indigenous rights in New Zealand and British Columbia. *BC Studies*. 150, 3-41.

Turner, K.R. (2000). Integrating Natural and Socio-Economic Science in Coastal Management. *Journal of Marine Systems*, 25, 447-460.

Ucluelet Aquarium (2009). *Some Creatures of Clayoquot and Barkley Sounds: A Life History Manual*. Ucluelet Aquarium Society. Retrieved from: http://www.uclueletaquarium.org/publications.html.

van Aalst, M. K., Cannon, T. and Burton, I. (2008). Community level adaptation to climate change: The potential role of participatory risk assessment. *Global Environmental Change*, 18, 165-179.

Walker, I. J. and Sydneysmith, R. (2008). Chapter 8: British Columbia. *In* Lemmen, D. S., Warren, F. J., Lacroix, J. and Bush, E. (Eds) From *Impacts to Adaptation: Canada in a Changing Climate 2007* (329-386). Government of Canada, Ottawa, Canada.

Walker, B., Carpenter, S., and Anderies, J. (2002). Resilience management in social-ecological systems: A working hypothesis for a participatory approach. *Conservation Ecology*, 6(1), 1. Retrieved from http://www.ecologyandsociety.org.ezproxy.library.uvic.ca/vol6/iss1/art14/.

Walker, B., Gunderson, L., and Kinzig, A. (2006). A handful of heuristics and some propositions for understanding resilience in social-ecological systems. *Ecology and Society*, 11(1). Retrieved from http://www.ecologyandsociety.org/vol11/iss1/art13/.

Watts, M.J. and H.G. Bohle. (1993). The space of vulnerability: The causal structure of hunger and famine. *Progress in Human Geography*, 17, 43-67.

WCED (1987). Our Common Future. *World Commission on Environment and Development*. Oxford: Oxford University Press.

West Coast Aquatic (WCA) (2009). Barkley Habitat Overview. *West Coast Aquatic.* Retireved from http://www.westcoastaquatic.ca/Barkley_Habitat.htm.

Westerly News (2009a). Closed containment salmon farming to be researched - Ucluelet council provides letter of support. *Westerly News*. May 14, 2009.

Westerly News (2009b). Cuts forcing tough decisions on school district. *Westerly News*. November 17, 2009.

Wiber, M., Berkes, F., Charles, A. and Kearney, J. (2004). Participatory research supporting community-based fishery management. *Marine Policy*, 28, 459-468.

Winchester, H. P. M. (2000). Power, subjectivity and ethics in qualitative research. *In* Hay, I. (Ed.) *Qualitative Research Methods in Human Geography* (37-49). Oxford: Oxford University Press.

Yohe, G. and Tol, R.S.J. (2002). Indicators for social and economic coping capacity - moving toward a working definition of adaptive capacity. *Global Environmental Change*. 12, 25-40.

Young, N. (2006a). Distance as a hybrid actor in rural economies. *Journal of Rural Studies*, 22 (3), 253–266.

Young, N. (2006b). New economic spaces and practices in coastal British Columbia. *Ph.D. dissertation*, Department of Sociology, University of British Columbia Vancouver, Canada.

Young (2008). Radical neoliberalism in British Columbia: Remaking rural geographies. *Canadian Journal of Sociology*. 33(1), 1-32.

Young, N. and Matthews, R. (2007). Resource economies and neoliberal experimentation: the reform of industry and community in rural British Columbia. *Area.* 39(2), 176-185.

Young, N. and Matthews, R. (2010) *The Aquaculture Controversy in Canada: Activism, Policy, and Contested Science*. Vancouver, Canada: University of British Columbia Press.

Yuʔłuʔiłʔath First Nation (YFN) (2010). Profile. Retrieved from http://ufn.ca/index.php?option=com_content&task=view&id=22&Itemid=37

Zebarth, B., Caprio, J., Broersma, K., Mills, P. and Smith, S. (1997). Effect of climate change on agriculture in the British Columbia and Yukon. *In* Taylor, E. and Taylor, B. (Eds.). *Responding to Global Climate Change in British Columbia and Yukon, Volume 1, Canada Country Study: Climate Impacts and Adaptation*. Environmental Canada and BC Ministry of Environment, Lands and Parks.

Zhang, X., Vincent, L.A., Hogg, W.D. and Niitsoo, A. (2000). Temperature and precipitation trends in Canada during the 20th century. *Atmosphere-Ocean*, 38 (3), 395–429.

# Appendix A

## Participant Consent Form Template

*Department of Geography, University of Victoria*

You are invited to participate in the study *Building resilient coastal communities in British Columbia: a case study of climate change and adaptation in Ucluelet, British Columbia* that is being conducted by Mary Liston, M.A. Geography Candidate, University of Victoria.

I am conducting this research as part of the requirements for a Graduate degree in Geography. The research is being conducted under the supervision of Dr. Mark Flaherty, who is a faculty member in the Department of Geography at the University of Victoria. You may contact him if your have any further questions by email at flaherty@mail.geog.uvic.ca or by telephone at (250) 721-7337.
This research is funded by National Science and Engineering Research Council of Canada. The purpose of this study is to increase our understanding of the ability of Canada's remote and resource-based coastal communities to deal with climate change. In particular, the study will investigate the impacts of climate change on fishery and aquaculture resources in Ucluelet and the ability of the community of Ucluelet to deal with these impacts.

You are being asked to participate in this study to help us gain a better understanding of how local people in Ucluelet perceive changes affecting their community, and the ability of their community to deal with these impacts. Your participation will include a _____ minute interview.

Your participation in this research is completely voluntary. If you decide to participate, you may decline to answer any question and or withdraw from the interview at any time. If you withdraw from the interview your information will not be used.

Your anonymity and confidentiality in this research will be protected by using codes and/or pseudonyms in the storage and dissemination of the research findings. The findings of the study will be shared with the local community and with others in a community meeting, community summary report, research thesis, and scholarly presentations and publications. All information gathered will be stored on a protected computer server with access limited to Mark Flaherty and myself and will be erased from the server after a period of five years.

You may contact me regarding this study by email at mkliston@uvic.ca or by telephone at (250) 896-9671.

You may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Human Research Ethics Office at ethics@uvic.ca or by telephone at

(250) 472-4545.

Your signature below indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by the researchers.

_____

*Name of Participant* *Signature of Participant* *Date*

***A copy of this consent will be left with you, and a copy will by kept by the researcher.***

# Appendix B

## Participant Occupations

Focus group, key informant, unstructured and structured questionnaire interviews were carried out with 65 people during fieldwork, including individuals in the following occupational fields:

- Arts and design
- Unemployed/retired
- Education
- Public service/utilities
- Real estate/property management
- Trades
- Tourism, recreation and hospitality
- Resource enhancement
- Transportation
- Health care
- Small business
- Community outreach
- Community planning
- Politics
- Retail
- Environmental science/stewardship
- Resource harvesting/processing
- Resource management/protection and public safety

# Appendix C

## Key Informant Interview Guide I

*Target participants:* local planners (land use and community), local resource managers, local emergency managers, local harbour authority reps, local service providers, members of council, community-based organization reps

Section A: Background information

2. What is your position/ job title in Ucluelet?
3. How long have you been in this position?
4. What is the role of your position/job in terms of resource management and planning?
5. Are you're a full time resident of Ucluelet? How long have you lived in this community?
    a. If not, do you feel you are a part of the Ucluelet community?
    b. What community do you reside in?
6. Are you involved in this community outside of your role as _____? How?

Section B: Perceptions of social and environmental change and community resilience

*I am interested in your perception of changes that have occurred in your community and how these changes may have impacted the community*.

7. Have you noticed any major social changes in this community over your time here? (health, education, cultural, socio-economic, demographic, social support and/or services) If yes, please describe. When did you notice these changes? What do you think caused these changes?
8. Have you noticed any environmental changes in this community over your time here? If yes, please describe. When did you notice these changes? What do you think caused these changes?

*I am interested in the characteristics of your community that make it capable of coping with disruptive changes.*

*Please consider, the term Health is defined broadly as a 'state of complete physical, mental and social well-being' (WHO).*

9. What factors affect the health of people in this community?

   a. environmental factors (access to resources, quality of air, quality of freshwater),
   b. socio-economic factors (employment, income),
   c. education-related factors (access to, quality of education and training),
   d. life-style factors (diets, drug and/or alcohol use),
   e. health care factors (access to, quality of)
10. How would you assess the level of interaction between community members in Ucluelet?
   a. sharing information about local issues,
   b. people volunteering in the community,
   c. involvement in community organizations,
   d. political participation,
   e. community events,
   f. other activities
11. How would you assess the level of available resources, services and support to this community from government agencies, community organizations or other agencies that you feel are important?
12. How does this community cope with or adapt to disruptive changes?
13. What events or changes have occurred in this community that provide a basis for your assessment of how the community has reacted to disruptive change?

Section C: Climate change profiling

*I am particularly interested in your perceptions of climate change and how it may affect you and your community.*

14. Are you aware of the potential for climate change in this area?
   a. Are you concerned about climate-related changes occurring in Ucluelet? Why or why not?
15. Have you noticed any changes in Ucluelet that may be attributed to climate change? If yes, please explain. When did you notice these changes?

*It has been predicated that as a result of climate change, coastal storms may become more frequent and intense, and air and ocean currents and temperatures may change.*

16. If these changes do occur, what is your role as _____ in Ucluelet?
17. Do you feel that you have access to adequate resources and support to effectively perform this role? At the local level? At the regional level?
18. Is climate change addressed in resource management and planning in Ucluelet? Please describe.
19. Do you feel the location of Ucluelet makes it more or less vulnerable to climate change? How?
20. How do you foresee climate change impacting ocean resources in Ucluelet?
   a. wild finfish harvests?
   b. wild shellfish harvests?
   c. wild aquatic plant harvests?

   d. aquacultured finfish harvests?
   e. aquacultured shellfish harvests?
   f. aquacultured aquatic plant harvests?
21. How do you think the impacts of climate change on these resources would affect people living in Ucluelet?
   a. wild-caught ocean resources?
   b. aquacultured ocean resources?

Section D: Resilience profiling

22. What characteristics does your community have that might help it cope with and adapt to climate change?
   a. what assets and resources does this community have that might help it cope with and adapt to climate change?
23. What, if any, characteristics of your community make it more susceptible to the impacts of climate change?
24. Are there things you could recommend that would make your community more capable of dealing with the impacts of climate change on ocean resources?
   a. wild-caught ocean resources?
   b. aquacultured ocean resources?

Section E: Moving forward

25. Could you suggest any individuals or organizations that I could contact to provide further insight or opinions on the matters addressed in this questionnaire?

# Appendix D

## Key Informant Interview Guide II

*Target participants:* local fishers and aquaculture farmers, local fisheries and aquaculture managers

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Section A: Background information

1. What is your position/ job title in Ucluelet?
2. How long have you been doing this work?
3. Are you a full time resident of Ucluelet? How long have you lived in this community?
    a. If not, do you feel you are a part of the Ucluelet community?
    b. What community do you reside in?
4. Are you involved in the Ucluelet community outside of your work as _____? How?

Section B: Perceptions of social and environmental change and community resilience

*I am interested in your perception of changes that have occurred in your community and how these changes may have impacted the community.*

5. Have you noticed any major social changes in this community over your time here? (health, education, cultural, socio-economic, demographic, social support and/or services) If yes, please describe. When did you notice these changes? What do you think caused these changes?
6. Have you noticed any environmental changes in this community over your time here? If yes, please describe. When did you notice these changes? What do you think caused these changes?

*I am interested in the characteristics of your community that make it capable of coping with disruptive changes.*

*Please consider, the term Health is defined broadly as a 'state of complete physical, mental and social well-being' (WHO).*

7. What factors affect the health of people in this community?
    a. environmental factors (access to resources, quality of air, quality of freshwater),
    b. socio-economic factors (employment, income),
    c. education-related factors (access to, quality of education and training),
    d. life-style factors (diets, drug and/or alcohol use),

    e. health care factors (access to, quality of)
8. How would you assess the level of interaction between community members in Ucluelet?
    a. sharing information about local issues,
    b. people volunteering in the community,
    c. involvement in community organizations,
    d. political participation,
    e. community events,
    f. other activities
9. How would you assess the level of available resources, services and support to this community from government agencies, community organizations or other agencies that you feel are important?
10. How does this community cope with or adapt to disruptive changes?
11. What events or changes have occurred in this community that provide a basis for your assessment of how the community has reacted to disruptive change?

Section C: Climate change profiling

*I am particularly interested in your perceptions of climate change and how it may affect you and your community.*

12. Are you aware of the potential for climate change in this area?
    a. Are you concerned about climate-related changes occurring in Ucluelet? Why or why not?
13. Have you noticed any changes in Ucluelet that may be attributed to climate change? If yes, please explain. When did you notice these changes?

*It has been predicated that as a result of climate change, coastal storms may become more frequent and intense, and air and ocean currents and temperatures may change.*

14. How do you foresee climate change impacting ocean resources in Ucluelet?
    a. wild finfish harvests?
    b. wild shellfish harvests?
    c. wild aquatic plant harvests?
    d. aquacultured finfish harvests?
    e. aquacultured shellfish harvests?
    f. aquacultured aquatic plant harvests?
15. How do you think the impacts of climate change on these resources would affect people living in Ucluelet?
    a. wild-caught ocean resources?
    b. aquacultured ocean resources?
16. Do you feel the location of Ucluelet makes it more or less vulnerable to climate change? How?
17. What characteristics make wild ocean fisheries strong in Ucluelet?
18. What characteristics make aquaculture strong in Ucluelet?
19. What are the most important issues facing wild ocean fisheries in Ucluelet?

20. What are the most important issues facing aquaculture in Ucluelet?
21. What is the future of wild ocean fisheries in Ucluelet?
22. What is the future of aquaculture in Ucluelet?

Section D: Resilience profiling

23. What characteristics does your community have that might help it cope with and adapt to climate change?
    a. what assets and resources does this community have that might help it cope with and adapt to climate change?
24. What, if any, characteristics of your community make it more susceptible to the impacts of climate change?
25. Are there things you could recommend that would make your community more capable of dealing with the impacts of climate change on ocean resources?
    a. wild-caught ocean resources?
    b. aquacultured ocean resources?

Section E: Moving forward

26. Could you suggest any individuals or organizations that I could contact to provide further insight or opinions on the matters addressed in this questionnaire?

# Appendix E

## Structured Questionnaire

*Target participants:* local community members

Section A: Background information

1. Are you a full time resident of Ucluelet?
    a. Yes
    b. No

2. How long have you lived in this community?
    _____

3. What do you like most about your community?
    _____

4. What do you like least about your community?
    _____

Section B: Perceptions of social and environmental change and community resilience

*I am interested in your perception of changes that have occurred in your community and how these changes may have impacted the community.*

5. What are the most important social changes you have noticed in this community over your time here? (health, education, cultural, socio-economic, demographic, social support and/or services)
    _____
    _____
    _____

6. What are the most important environmental changes you have noticed in this community over your time here?
    _____
    _____
    _____

7. Do you talk about these changes with other people in Ucluelet?
    a. Yes
    b. No
    c. I don't know

8. In what ways does this community cope with or adapt to disruptive changes?
   _____
   _____
   _____
   _____

9. What events or changes have occurred in this community that provide a basis for your assessment of how the community has reacted to disruptive changes?
   _____
   _____
   _____

*I am interested in characteristics that make you and your community capable of coping with disruptive change.*

10. On a scale of 1 to 5 (1 being very dissatisfied, 5 being very satisfied), please indicate your satisfaction with the following in Ucluelet:

| | Very dissatisfied | | | | Very satisfied | I don't know |
|---|---|---|---|---|---|---|
| a. Your main occupation | 1 | 2 | 3 | 4 | 5 | |
| b. Your ability to cover your costs of living (food, housing, basic services) | 1 | 2 | 3 | 4 | 5 | |
| c. Your disposable income (money not required to cover your costs of living) | 1 | 2 | 3 | 4 | 5 | |

11. Please indicate your satisfaction with the following aspects of education in Ucluelet:

| | Very dissatisfied | | | | Very satisfied | I don't know |
|---|---|---|---|---|---|---|
| a. Access to formal education (elementary school, high school) | 1 | 2 | 3 | 4 | 5 | |
| b. Access to formal education (college, university) | 1 | 2 | 3 | 4 | 5 | |
| c. Quality of formal education (elementary school, high school) | 1 | 2 | 3 | 4 | 5 | |
| d. Access to other training programs | 1 | 2 | 3 | 4 | 5 | |

12. Please indicate your satisfaction with the following components of health in Ucluelet:

| | Very dissatisfied | | | | Very satisfied | I don't know |
|---|---|---|---|---|---|---|
| a. Access to health care | 1 | 2 | 3 | 4 | 5 | |
| b. Quality of health care | 1 | 2 | 3 | 4 | 5 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| c. Quality of air | 1 | 2 | 3 | 4 | 5 | |
| d. Quality of freshwater | 1 | 2 | 3 | 4 | 5 | |

13. On a scale of 1-5 (1 being not very important and 5 being very important), please indicate how important the following characteristics of your community are to strengthening its capacity to deal with disruptive change:

| | Not Important | | | | Very Important | I don't know |
|---|---|---|---|---|---|---|
| a. Opportunities for employment | 1 | 2 | 3 | 4 | 5 | |
| b. Income | 1 | 2 | 3 | 4 | 5 | |
| c. Access to formal education (elementary school, high school) | 1 | 2 | 3 | 4 | 5 | |
| d. Access to formal education (college, university) | 1 | 2 | 3 | 4 | 5 | |
| e. Quality of formal education (elementary school, high school) | 1 | 2 | 3 | 4 | 5 | |
| f. Access to other training programs | 1 | 2 | 3 | 4 | 5 | |
| g. Access to health care | 1 | 2 | 3 | 4 | 5 | |
| h. Quality of health care | 1 | 2 | 3 | 4 | 5 | |
| i. A healthy environment (clean air and freshwater) | 1 | 2 | 3 | 4 | 5 | |

*I am interested in the level of interaction between community members in Ucluelet.*

14. Which of the following community activities have you been involved in?

| | Yes | No | Please Specify: |
|---|---|---|---|
| a. Signed a petition about a local issue | Yes | No | |
| b. Wrote or spoke to a government official about a local issue | Yes | No | |
| c. Volunteered within the community | Yes | No | |
| d. Involved in local team, club, or group | Yes | No | |
| e. Voted in the last municipal election | Yes | No | |
| f. Participated in community events | Yes | No | |
| g. Other activities | Yes | No | |

15. How important are the following items to building a strong community in Ucluelet?

| | Not Important | | | | Very Important | I don't know |
|---|---|---|---|---|---|---|
| a. Cooperation between community members | 1 | 2 | 3 | 4 | 5 | |
| b. Access to information about local issues | 1 | 2 | 3 | 4 | 5 | |
| c. Local people volunteering within the community | 1 | 2 | 3 | 4 | 5 | |
| d. Involvement of local people in community organizations (local teams, clubs, or groups) | 1 | 2 | 3 | 4 | 5 | |
| e. Political participation | 1 | 2 | 3 | 4 | 5 | |
| e. Local government agencies, community organizations or other agencies working with community members | 1 | 2 | 3 | 4 | 5 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| f. Community events | 1 | 2 | 3 | 4 | 5 | |

16. How important is a strong sense of community to strengthening the capacity of your community to deal with disruptive change?

| Not Important | | | | Very Important | I don't know |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | |

*I am interested in the level of available resources, services and support to this community from government agencies, community organizations or other agencies in Ucluelet.*

17. Please indicate your satisfaction with local government agencies, community organizations or other agencies regarding the following activities in Ucluelet:

| | Very dissatisfied | | | | Very satisfied | I don't know |
|---|---|---|---|---|---|---|
| a. Communicating with local people about local issues | 1 | 2 | 3 | 4 | 5 | |
| b. Enforcement of municipal policies and regulations | 1 | 2 | 3 | 4 | 5 | |
| c. Community planning | 1 | 2 | 3 | 4 | 5 | |
| d. Working with community members | 1 | 2 | 3 | 4 | 5 | |
| e. Provision of community facilities (community centre, parks, recreational and cultural facilities) | 1 | 2 | 3 | 4 | 5 | |
| f. Provision of basic services (water, sanitation) | 1 | 2 | 3 | 4 | 5 | |
| g. Provision of transportation services (roads, pathways) | 1 | 2 | 3 | 4 | 5 | |
| h. Provision of communication services (telephone, internet) | 1 | 2 | 3 | 4 | 5 | |
| i. Provision of child care services | 1 | 2 | 3 | 4 | 5 | |
| j. Provision of senior care services | 1 | 2 | 3 | 4 | 5 | |
| k. Management of natural resources (land-based resources) | 1 | 2 | 3 | 4 | 5 | |
| l. Management of natural resources (marine/water-based resources) | 1 | 2 | 3 | 4 | 5 | |
| m. Emergency response (police, ambulance, fire) | 1 | 2 | 3 | 4 | 5 | |

18. How important are the activities of government agencies, community organizations or other agencies to strengthening the capacity of your community to deal with disruptive change?

| Not Important | | | | Very Important | I don't know |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | |

Section C: Climate change profiling

*I am particularly interested in your perceptions of climate change and how it may affect you and your community.*

19. Are you aware of the potential for climate change in this area?
    a. Yes
    b. No
    c. I don't know

20. Are you concerned about climate-related changes occurring in Ucluelet?
    a. Yes
    b. No
    c. I don't know

21. Have you noticed any changes in Ucluelet that may be attributed to climate change?
    a. Yes (please specify)

    _____
    _____
    _____

    b. No
    c. I don't know

22. On a scale of 1 to 5 (1 being very unlikely, 5 being very likely), how likely is it that Ucluelet will experience the following in the next ten years?

| | Very Unlikely | | | | Very Likely | I don't know |
|---|---|---|---|---|---|---|
| a. Sea level rise | 1 | 2 | 3 | 4 | 5 | |
| b. Increase in air temperatures | 1 | 2 | 3 | 4 | 5 | |
| c. Increase in ocean temperatures | 1 | 2 | 3 | 4 | 5 | |
| d. Increase in the frequency of storms | 1 | 2 | 3 | 4 | 5 | |
| e. Increase in the intensity of storms | 1 | 2 | 3 | 4 | 5 | |
| f. Increased rate of change in land-based resources | 1 | 2 | 3 | 4 | 5 | |
| g. Increased rate of change in freshwater resources | 1 | 2 | 3 | 4 | 5 | |
| h. Increased rate of change in ocean resources (finfish, shellfish, aquatic plants) | 1 | 2 | 3 | 4 | 5 | |

*It has been predicated that, as a result of climate change, coastal storms may become more frequent and intense, air and ocean currents, temperatures and chemical compositions may change, and various ecological shifts may occur.*

23. On a scale of 1 to 5 (1 being a very negative impact, 5 being a very positive impact), how do you foresee climate change impacting ocean resources in Ucluelet?

| | Very | | | | Very | I don't |
|---|---|---|---|---|---|---|

| | Negative Impact | | | | Positive Impact | know |
|---|---|---|---|---|---|---|
| a. Wild finfish | 1 | 2 | 3 | 4 | 5 | |
| b. Wild shellfish | 1 | 2 | 3 | 4 | 5 | |
| c. Wild aquatic plants | 1 | 2 | 3 | 4 | 5 | |
| d. Aquacultured finfish | 1 | 2 | 3 | 4 | 5 | |
| e. Aquacultured shellfish | 1 | 2 | 3 | 4 | 5 | |
| f. Aquacultured aquatic plants | 1 | 2 | 3 | 4 | 5 | |

24. On a scale of 1 to 5 (1 being a very negative impact, 5 being a very positive impact), how do you think the impacts of climate change on these resources would affect people living in Ucluelet?

| | Very Negative Impact | | | | Very Positive Impact | I don't know |
|---|---|---|---|---|---|---|
| a. Wild ocean resources | 1 | 2 | 3 | 4 | 5 | |
| b. Aquacultured ocean resources | 1 | 2 | 3 | 4 | 5 | |

25. What characteristics make wild ocean fisheries strong in Ucluelet?

_____
_____
_____

26. What characteristics make aquaculture strong in Ucluelet?

_____
_____
_____

27. What are the most important issues facing wild ocean fisheries in Ucluelet?

_____
_____
_____

28. What are the most important issues facing aquaculture in Ucluelet?

_____
_____
_____

29. On a scale on 1 to 5 (1 being less vulnerable, 5 being more vulnerable), do you feel the location of Ucluelet makes it more or less vulnerable to climate change?

| Less Vulnerable | | | | More Vulnerable | I don't know |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | |

Section D: Resilience profiling

30. What characteristics does your community have that might help it cope with and adapt to climate change?

_____
_____
_____

31. What, if any, characteristics of your community make it more susceptible to the impacts of climate change?

_____
_____
_____

32. Are there things you could recommend that would make your community more capable of dealing with the impacts of climate change on ocean resources?
    a. wild-caught ocean resources?

_____
_____
_____

    b. aquacultured ocean resources?

_____
_____
_____

Section E: Demographic information

*I am going to ask you some questions about your personal and household information. This information will be combined with other survey results for statistical purposes. No individuals will be identified in publications or presentations, nor will results be presented in such a way that individuals could be identified.*

33. Including yourself, how many people live in your household?

_____

34. Do you have any dependent children or seniors living in the household?
    a. Yes, dependent child(ren) (please specify number) _____
    b. Yes, dependent senior(s) (please specify number) _____
    c. Yes, other (i.e., dependent sibling, dependent adult) (please specify number) _____
    d. No

35. What is the highest level of education or training that you have?
    a. Elementary school (K to grade 8)
    b. Some high school
    c. High school diploma
    d. Community college/technical institute
    e. University degree

f. Other education or training, please specify
_____

g. No education or training

36. What is your main occupation?

_____

37. What is your present employment status (for your main job)?
a. Unemployed
b. Full-time
c. Part-time or seasonal
d. Retired
e. Student

38. What is your total annual household income before taxes, including income from all members of your household?
a. Up to $49,999
b. $50,000 to $99,999
c. $100,000 or more
d. I don't know

39. Are you the primary earner of this household income?
a. Yes
b. No (what is the occupation of the other primary income earner(s) in your home?)
_____

40. Of the following, what age category do you belong to?
a. 18-24
b. 25-34
c. 35-44
d. 45-54
e. 55-64
f. 65-74
g. 75 or over

Section F: Moving Forward

*Thank you for your time and important contribution to this research. Do you have any additional comments or feedback you would like to provide regarding the topics discussed in this questionnaire?*

_____
_____
_____
_____
_____

*Please feel free to contact me at any time with any questions or comments you might have. If you wish to provide your contact information, a summary of the results of this research will be provided to you for your participation. Thank you.*

Contact Information:

Notes:

# Appendix F

## Structured Questionnaire Coding Sheet

For all questions:
98 Not relevant
99 No response

Interview reference no.:

#

Interview performed by:

1 Mary K. Liston
2 Research Assistant

Date:

Dd/mmm/yy

1. Are you a full time resident of Ucluelet?
    1. Yes
    2. No

2. How long have you lived in this community?

    #.##

3. What do you like most about your community?
    0. Not mentioned
    1. Mentioned

Mention of:

Natural environment/surrounding landscape
Geographic location
Opportunities for employment
Small size
Quiet, slow pace
Lifestyle/way of life
Tight sense of community
Community spirit/pride
Environmental consciousness

Strength of personal relationships
People helping one another
People/friendliness
Good place to raise children
Local businesses/ownership
Independence
Recreation/activities
Nothing/I don't know

4. What do you like least about your community?
    0. Not mentioned
    1. Mentioned

Mention of:

Degradation of natural environment/habitat for wildlife
Development
Geographic location
Remoteness/isolation
Fast pace in summers/slow pace in winters
Weather/rain
Small size
Gossip/speculation/lack of privacy
Drinking water
Tourism
Tourists/transient population who does not care for the local community/environment
Local population who does not care for the local community/environment
Resistance to change
Local leadership/council
Leadership does not embrace new ideas
Leadership does not include young population in planning/decision-making
Poor enforcement of municipal policies and regulations
Lack of opportunities for employment
Lack of opportunities for youth
Incomes
Costs of living (food, housing)
Access to/quality of education (elementary, high school)
Access to post-secondary education
Available resources/services/support (for the general community)
Available resources /services/support (for young people, families)
Available resources /services/support (for seniors, elders)
Limited recreation/activities for families
Families moving away from Ucluelet
Availability of local food sources
Pollution/garbage

Alcohol, drug use
Violence
Nothing/I don't know

5. What are the most important social changes you have noticed in this community over your time here?
    0. Not mentioned
    1. Mentioned

Mention of:

Collapse of resource-based economy (logging, fishing)
Increase in fisheries regulations/limitations
Diversification of economic activity
Rise of tourist-based economy
Shift to seasonal economic activity
Shift in community role (from producers to service providers)
Decrease in community-based employment
Lost of way of life/sense of community
Decrease in commitment to community/volunteerism
Tourists/transient population does not care for the local community/environment
Local population does not care for the local community/environment
Decrease in opportunities for employment
Decrease in incomes
Decrease in access to employment insurance
Increase in economic inequality
Development (community center, seniors housing, resorts, golf course, housing)
Increase in costs of living (food, housing)
Increase in number of big businesses
Increase in turnover rate for small businesses
Increase in turnover rate for local RCMP
People moving away from Ucluelet
New people moving to Ucluelet
Increase in transient/new population
Increase in population
Population increase has stopped
Increase in birthrate
Young families moving to Ucluelet
Young families moving away from Ucluelet
Young people moving to Ucluelet
Young people moving away from Ucluelet
Increase in environmental consciousness (awareness of issues, desire to maintain health of beauty of the local community/environment, a culture of sustainability)
Increase in diversity/more cosmopolitan population
Increase in environment/sustainability-based initiatives (e.g. beach clean-ups, shore-bird initiative, Ukee Local Food Initiative)

Initiation of community recycling program
Increase in knowledge/understanding of local food issues
Increase in engagement with First Nations
First Nations' Treaty settlement
Decrease in quality of local news sources/newspaper
Cutbacks to education system
Cutbacks to health care services
Initiation of new heath care services (weekly medical laboratory)
Decrease in available resources/services/support for young families
Increase in available resources/services/support for young families (daycare)
Decrease in recreation/activities for young people/families
New Search and Rescue Hall in Tofino
Increase in enforcement of municipal policies and regulations
Increase in alcohol/drug use
Decrease in alcohol/drug use
Increase in mental health issues
Increase in instances of poverty/homelessness
Increase in violence
None/I don't know

6. What are the most important environmental changes you have noticed in this community over your time here?
    0. Not mentioned
    1. Mentioned

Mention of:

Forest renewal
Restoration of coastal/marine ecosystems and species' habitats
Decrease in salmon returns/stocks
Changes in marine species/community assemblages (species abundance, types of species present)
Appearance of non-native species (natural shift)
Appearance of non-native species (human introduced)
Degradation of natural environment for industry (forestry, fishing)
Degradation of natural environment for development
Degradation of freshwater/groundwater sources
Degradation of wildlife habitat/corridors
Changes in the resource base
Exploration  for mining at Catface Mountain
Changes in weather/seasonal patterns
Increase in air temperatures in summer
Decrease in air temperatures in summer
Increase in air temperatures in winter
Decrease in air temperatures in winter
Increase in precipitation in summer
Decrease in precipitation in summer

Increase in precipitation in winter (rain)
Increase in precipitation in winter (snow)
Decrease in precipitation in winter (rain)
Decrease in precipitation in winter (snow)
Constantly changing/fluctuating/uncertain
None/I don't know

7. Do you talk about these changes with other people in Ucluelet?
    1. Yes
    2. No
    3. I don't know

8. In what ways does this community cope with or adapt to disruptive changes?
    0. Not Mentioned
    1. Mentioned

Mention of:

They don't
Manage to adapt as needed
Reactions vary
Acceptance/apathy
New opportunities
Shift to tourist-based economy
Collective/cooperative decision-making
Education/understanding
Community learning initiatives/programs/events
Protest, sign petitions, write or speak to government
Community action initiatives/programs (recycling program)
Community resources/services/supports
Complain but take no action
Feeling of helplessness
People move away from Ucluelet
New people move to Ucluelet
Resistance to change
Openness to change
People help/support one another
Community spirit/pride
Environmental consciousness
Drug/alcohol use
Violence
I don't know

9. What events or changes have occurred in this community that provide a basis for your assessment of how the community has reacted to disruptive changes?
    0. Not Mentioned

1. Mentioned

Mention of:

Closure of mine
Moratorium on forestry, 1995
Decline of commercial fisheries, 1990s (salmon, herring)
Shift to tourist-based economy
Development (Black Rock Resort, Community Center)
Bankruptcy of development projects (Wyndansea Oceanfront Golf Resort)
Economic downturn
Increase in costs of living (food, housing, land/property)
Seasonal nature of the economic activity
Decrease in opportunities for employment/incomes
Decrease in available resources/services/supports
Increase in flow of people/traffic
Degradation of wildlife habitat/wildlife corridors (has brought species into the community proper, e.g. bears, cougars)
Cutbacks to health care services
Deaths in the community
Lack of collective/cooperative decision-making
None/I don't know

10. On a scale of 1 to 5 (1 being very dissatisfied, 5 being very satisfied), please indicate your satisfaction with the following in Ucluelet:

10.1. Your main occupation
1. Very dissatisfied
2. Dissatisfied
3. Neutral
4. Satisfied
5. Very satisfied
6. I don't know

10.2. Your ability to cover your costs of living
1. Very dissatisfied
2. Dissatisfied
3. Neutral
4. Satisfied
5. Very satisfied
6. I don't know

10.3. Your disposable income
1. Very dissatisfied
2. Dissatisfied
3. Neutral
4. Satisfied

5. Very satisfied
6. I don't know

11. Please indicate your satisfaction with the following aspects of education in Ucluelet:

11.1. Access to formal education (elementary, high)
1. Very dissatisfied
2. Dissatisfied
3. Neutral
4. Satisfied
5. Very satisfied
6. I don't know

11.2. Access to formal education (college, university)
1. Very dissatisfied
2. Dissatisfied
3. Neutral
4. Satisfied
5. Very satisfied
6. I don't know

11.3. Quality of formal education (elementary, high)
1. Very dissatisfied
2. Dissatisfied
3. Neutral
4. Satisfied
5. Very satisfied
6. I don't know

11.4. Access to other training programs
1. Very dissatisfied
2. Dissatisfied
3. Neutral
4. Satisfied
5. Very satisfied
6. I don't know

12. Please indicate your satisfaction with the following components of health in Ucluelet:

12.1. Access to health care
1. Very dissatisfied
2. Dissatisfied
3. Neutral
4. Satisfied
5. Very satisfied

6. I don't know

12.2. Quality of health care
1. Very dissatisfied
2. Dissatisfied
3. Neutral
4. Satisfied
5. Very satisfied
6. I don't know

12.3. Quality of air
1. Very dissatisfied
2. Dissatisfied
3. Neutral
4. Satisfied
5. Very satisfied
6. I don't know

12.4. Quality of freshwater
1. Very dissatisfied
2. Dissatisfied
3. Neutral
4. Satisfied
5. Very satisfied
6. I don't know

13. On a scale of 1-5 (1 being not very important and 5 being very important), please indicate how important the following characteristics of your community are to strengthening its capacity to deal with disruptive change:

13.1. Opportunities for employment
1. Not important
2. Not very important
3. Neutral
4. Important
5. Very important
6. I don't know

13.2. Income
1. Not important
2. Not very important
3. Neutral
4. Important
5. Very important
6. I don't know

13.3. Access to formal education (elementary, high)

1. Not important
2. Not very important
3. Neutral
4. Important
5. Very important
6. I don't know

13.4. Access to formal education (college, university)

1. Not important
2. Not very important
3. Neutral
4. Important
5. Very important
6. I don't know

13.5. Quality of formal education (elementary, high)

1. Not important
2. Not very important
3. Neutral
4. Important
5. Very important
6. I don't know

13.6. Access to other training programs

1. Not important
2. Not very important
3. Neutral
4. Important
5. Very important
6. I don't know

13.7. Access to health care

1. Not important
2. Not very important
3. Neutral
4. Important
5. Very important
6. I don't know

13.8. Quality of health care

1. Not important
2. Not very important
3. Neutral
4. Important
5. Very important
6. I don't know

13.9. A healthy environment
1. Not important
2. Not very important
3. Neutral
4. Important
5. Very important
6. I don't know

14. Which of the following community activities have you been involved in?

14.1. Signed a petition about a local issue(s)
1. Yes
2. No

Please specify:

14.2. Wrote or spoke to a government official about a local issue
1. Yes
2. No

Please specify:

14.3. Volunteered within the community
1. Yes
2. No

Please specify:

14.4. Involved in a local team, club or group
1. Yes
2. No

Please specify:

14.5. Voted in the last municipal election
1. Yes
2. No

Please specify:

14.6. Participated in community events
1. Yes
2. No

Please specify:

14.7. Other activities
1. Yes
2. No

Please specify:

15. How important are the following items to building a strong community in Ucluelet?

15.1. Cooperation between community members
1. Not important
2. Not very important
3. Neutral
4. Important
5. Very important
6. I don't know

15.2. Access to information about local issues
1. Not important
2. Not very important
3. Neutral
4. Important
5. Very important
6. I don't know

15.3 Local people volunteering within the community
1. Not important
2. Not very important
3. Neutral
4. Important
5. Very important
6. I don't know

15.4. Involvement of local people in community organizations
1. Not important
2. Not very important
3. Neutral
4. Important
5. Very important
6. I don't know

15.5. Political participation
1. Not important
2. Not very important

3. Neutral
4. Important
5. Very important
6. I don't know

15.6 Local government agencies, community organizations or other agencies working with community members

1. Not important
2. Not very important
3. Neutral
4. Important
5. Very important
6. I don't know

15.7. Community events

1. Not important
2. Not very important
3. Neutral
4. Important
5. Very important
6. I don't know

16. How important is a strong sense of community to strengthening the capacity of your community to deal with disruptive change?
    1. Not important
    2. Not very important
    3. Neutral
    4. Important
    5. Very important
    6. I don't know

17. Please indicate your satisfaction with local government agencies, community organizations or other agencies regarding the following activities in Ucluelet:

    17.1. Communicating with local people about local issues
    1. Very dissatisfied
    2. Dissatisfied
    3. Neutral
    4. Satisfied
    5. Very satisfied
    6. I don't know

    17.2. Enforcement of municipal policies and regulations
    1. Very dissatisfied
    2. Dissatisfied
    3. Neutral

4. Satisfied
5. Very satisfied
6. I don’t know

17.3. Community planning
1. Very dissatisfied
2. Dissatisfied
3. Neutral
4. Satisfied
5. Very satisfied
6. I don’t know

17.4. Working with community members
1. Very dissatisfied
2. Dissatisfied
3. Neutral
4. Satisfied
5. Very satisfied
6. I don’t know

17.5. Provision of community facilities
1. Very dissatisfied
2. Dissatisfied
3. Neutral
4. Satisfied
5. Very satisfied
6. I don’t know

17.6. Provision of basic services
1. Very dissatisfied
2. Dissatisfied
3. Neutral
4. Satisfied
5. Very satisfied
6. I don’t know

17.7. Provision of transportation services
1. Very dissatisfied
2. Dissatisfied
3. Neutral
4. Satisfied
5. Very satisfied
6. I don’t know

17.8. Provision of communication services
1. Very dissatisfied

2. Dissatisfied
3. Neutral
4. Satisfied
5. Very satisfied
6. I don't know

17.9. Provision of child care services
1. Very dissatisfied
2. Dissatisfied
3. Neutral
4. Satisfied
5. Very satisfied
6. I don't know

17.10 Provision of senior care services
1. Very dissatisfied
2. Dissatisfied
3. Neutral
4. Satisfied
5. Very satisfied
6. I don't know

17.11 Management of natural resources (land-based)
1. Very dissatisfied
7. Dissatisfied
8. Neutral
9. Satisfied
10. Very satisfied
11. I don't know

17.12 Management of natural resources (marine/water-based)
1. Very dissatisfied
2. Dissatisfied
3. Neutral
4. Satisfied
5. Very satisfied
6. I don't know

17.13 Emergency response
1. Very dissatisfied
2. Dissatisfied
3. Neutral
4. Satisfied
5. Very satisfied
6. I don't know

18. How important are the activities of government agencies, community organizations or other agencies to strengthening the capacity of your community to deal with disruptive change?
    1. Not important
    2. Not very important
    3. Neutral
    4. Important
    5. Very important
    6. I don't know

19. Are you aware of the potential for climate change in this area?
    1. Yes
    2. No
    3. I don't know

20. Are you concerned about climate-related changes occurring in Ucluelet?
    1. Yes
    2. No
    3. I don't know

21. Have you noticed any changes in Ucluelet that may be attributed to climate change?
    1. Yes
    2. No
    3. I don't know

    If 21.1,
    0. Not mentioned
    1. Mentioned

Mention of:

Degradation of natural environment (contributing factor to climate change)
Increase in flow of people/traffic (contributing factor to climate change)
Increase in ocean water temperatures
Decrease in river levels
Declining salmon stocks/returns
Changes in marine species/community assemblages (species abundance, types of species present)
Appearance of non-native species (natural shift)
Changes in weather/seasonal patterns
Increase in the frequency/intensity of extreme weather events
Increase in air temperatures in summer
Decrease in air temperatures in summer
Increase in air temperatures in winter
Decrease in air temperatures in winter

Increase in precipitation in summer
Decrease in precipitation in summer
Increase in precipitation in winter (rain)
Increase in precipitation in winter (snow)
Decrease in precipitation in winter (rain)
Decrease in precipitation in winter (snow)
Constantly changing/fluctuating/uncertain
Glacial retreat (media-based observation)

22. On a scale of 1 to 5 (1 being very unlikely, 5 being very likely), how likely is it that Ucluelet will experience the following in the next ten years?

22.1 Sea level rise
1. Very unlikely
2. Unlikely
3. Neutral
4. Likely
5. Very likely
6. I don't know

22.2 Increase in air temperatures
1. Very unlikely
2. Unlikely
3. Neutral
4. Likely
5. Very likely
6. I don't know

22.1 Increase in ocean temperatures
1. Very unlikely
2. Unlikely
3. Neutral
4. Likely
5. Very likely
6. I don't know

22.1 Increase in the frequency of storms
1. Very unlikely
2. Unlikely
3. Neutral
4. Likely
5. Very likely
6. I don't know

22.1 Increase in the intensity of storms
1. Very unlikely
2. Unlikely
3. Neutral

4. Likely
5. Very likely
6. I don’t know

22.1 Increased rate of change in land-based resources

1. Very unlikely
2. Unlikely
3. Neutral
4. Likely
5. Very likely
6. I don’t kno

22.1 Increased rate of change in freshwater resources

1. Very unlikely
2. Unlikely
3. Neutral
4. Likely
5. Very likely
6. I don’t know

22.1 Increased rate of change in ocean resources

1. Very unlikely
2. Unlikely
3. Neutral
4. Likely
5. Very likely
6. I don’t know

23. On a scale of 1 to 5 (1 being a very negative impact, 5 being a very positive impact), how do you foresee climate change impacting ocean resources in Ucluelet?

23.1 Wild finfish

1. Very negative impact
2. Negative impact
3. Neutral
4. Positive impact
5. Very positive impact
6. I don’t know
7. Both positive and negative impacts

23.2 Wild shellfish

1. Very negative impact
2. Negative impact
3. Neutral
4. Positive impact
5. Very positive impact
6. I don’t know

7. Both positive and negative impacts

23.3 Wild aquatic plants
1. Very negative impact
2. Negative impact
3. Neutral
4. Positive impact
5. Very positive impact
6. I don't know
7. Both positive and negative impacts

23.4 Aquacultured finfish
1. Very negative impact
2. Negative impact
3. Neutral
4. Positive impact
5. Very positive impact
6. I don't know
7. Both positive and negative impacts

23.5 Aquacultured shellfish
1. Very negative impact
2. Negative impact
3. Neutral
4. Positive impact
5. Very positive impact
6. I don't know
7. Both positive and negative impacts

23.6 Aquacultured aquatic plants
1. Very negative impact
2. Negative impact
3. Neutral
4. Positive impact
5. Very positive impact
6. I don't know
7. Both positive and negative impacts

24. On a scale of 1 to 5 (1 being a very negative impact, 5 being a very positive impact), how do you think the impacts of climate change on these resources would affect people living in Ucluelet?

24.1 Wild ocean resources
1. Very negative impact
2. Negative impact
3. Neutral
4. Positive impact
5. Very positive impact

6. I don’t know
7. Both positive and negative impacts

24.2. Aquacultured ocean resources
1. Very negative impact
2. Negative impact
3. Neutral
4. Positive impact
5. Very positive impact
6. I don’t know
7. Both positive and negative impacts

25. What characteristics make wild ocean fisheries strong in Ucluelet?
0. Not mentioned
1. Mentioned

Mention of:

Abundance of species
Diversity of species
Natural environment
Geographic location (ecology, biodiversity)
Low impact on natural environment/wildlife habitat
Market conditions
Seasonal changes
Strong history
Fisher commitment
Community attachment
Economic opportunity
Local knowledge/experience
Infrastructure (processing/distribution)
Management (government regulations/monitoring/enforcement)
Nothing (they are not strong)
I don’t know

26. What characteristics make aquaculture strong in Ucluelet?
0. Not mentioned
1. Mentioned

Mention of:

Natural environment
Geographic location (remoteness/isolation)
Political environment
Fisheries decline
Reliability
Market conditions
Labour force

Economic opportunity
Community interest
Local knowledge/experience
Infrastructure (processing/distribution)
Nothing (it is not strong)
I don't know

27. What are the most important issues facing wild ocean fisheries in Ucluelet?
    0. Not mentioned
    1. Mentioned

Mention of:
Declining stocks
Migratory stocks
Over harvesting
Uncertainty
Seasonal closures
Management (government regulations/monitoring/enforcement)
Fishing practices (dragging)
Cross-border issues
Economic downturn
Markets conditions (competition)
High costs (equipment, maintenance, fuel)
Human degradation of natural environment/wildlife habitat (hydroelectric Run of River Power projects)
Aquaculture
Recreational/sport fisheries
Increase in ocean water temperatures
Changes in ocean currents
Changes in marine species/community assemblages (species abundance, types of species present)
Appearance of non-native species
Lack of environmental consciousness
Lack of community involvement
Labour force
I don't know

28. What are the most important issues facing aquaculture in Ucluelet?
    2. Not mentioned
    3. Mentioned

Mention of:
High impact on natural environment/wildlife habitat
Political environment
Management (government regulations/monitoring/enforcement)
Contamination
Introduction of non-native species (Atlantic salmon)

Disease/parasite transfer to wild species
Unnatural
Increase in ocean water temperatures
Changes in ocean currents
Lack of education/understanding
Labour force
Environmental activism
Misinformation
Social license (public opinion)
I don't know

29. On a scale on 1 to 5 (1 being less vulnerable, 5 being more vulnerable), do you feel the location of Ucluelet makes it more or less vulnerable to climate change?
    1. Less vulnerable
    2. Slightly less vulnerable
    3. Neutral
    4. Slightly more vulnerable
    5. More vulnerable
    6. I don't know

30. What characteristics does your community have that might help it cope with and adapt to climate change?
    0. Not mentioned
    1. Mentioned

Mention of:

Natural environment/surrounding landscape
Biodiversity
Abundance of resources
Forest renewal
Moderate maritime climate
Local food sources
Geographic location (remoteness/isolation)
Independence
Small size
Tight sense of community
Access to information
Collective/cooperative decision-making
Communication between community members
Volunteerism
Emergency planning
Emergency response
Experience with environmental change
Experience with social change
Connection to natural resource base
Economic diversity

New opportunities
Tourist-based economy
Local knowledge/experience
Community spirit/pride
Environmental consciousness
Ingenuity/creative problem solving
Community learning initiatives/programs/events
Community action initiatives/programs
Leadership
Community planning
People are adaptive/open to change
People help/support one another
None
I don't know

31. What, if any, characteristics of your community make it more susceptible to the impacts of climate change?
    0. Not mentioned
    1. Mentioned

Mention of:

Natural environment/surrounding landscape
Geographic location (exposure)
Geographic location (remoteness/isolation)
Human degradation of the natural environment/wildlife habitat (development)
Threats to biodiversity/uniqueness (non-native species)
Dependence on natural resource base (logging, fishing, other)
Dependence on tourism
Economic inequality
Emergency planning
Emergency response
Small size
Available health care services
High costs of living
Rapid pace of change
Leadership does not embrace new ideas
Leadership does not address climate change
Interference from higher levels of government
Lack of support from higher levels of government
Tourist/transient population does not care for the local community/environment
Local population does not care for the local community/environment
Apathy
Resistance to change
People do not believe in climate change
Lack of environmental consciousness

Feeling of helplessness
Lack of education/understanding
Lack of community cohesion
Lack of sense of community
None
I don't know

32. Are there things you could recommend that would make your community more capable of dealing with the impacts of climate change on ocean resources?

    32.1 Wild-caught ocean resources?
        0. Not mentioned
        1. Mentioned

Mention of:

Sustainable practices
Tighter management of commercial fisheries (government catch regulations, tracking of catch from each vessel, enforcement)
Tighter management of recreational/sport fisheries (government catch regulations, tracking of catch from each vessel, enforcement)
A holistic management approach
Marine stewardship/wildlife habitat protection
Research
Education/understanding
Community learning initiatives/programs/events
Community forums/exchanges for communication
Community involvement
Collective/collaborative decision-making
Community action initiatives/programs
Support for local hatcheries/enhancement programs
Support for local fishers
Support for local food/seafood
Sustainable practices for all businesses
Closure of commercial fisheries
None/I don't know

    32.2 Aquacultured ocean resources?
        0. Not mentioned
        1. Mentioned

Mention of:

Sustainable practices
Alternative systems (closed containment, land-based)
Harvest of native species
Harvest of aquatic plants

Harvest of shellfish
Low species density harvesting
Education/understanding
Community learning initiatives/programs/events
Community forums/exchanges for communication
Community involvement
Collective/collaborative decision-making
Community action initiatives/programs
Closure of all farms
None/I don't know

33. Including yourself, how many people live in your household?

    #

34. Do you have any dependent children or seniors living in the household?
    1. Yes, dependent child(ren)
    2. Yes, dependent senior(s)
    3. Yes, other(s)
    4. No

    If 34.1, please specify number:
    #
    If 34.2, please specify number:
    #
    If 34.3, please specify number:
    #

35. What is the highest level of education or training that you have?
    1. Elementary school (K to grade 8)
    2. Some high school
    3. High school diploma
    4. Community college/technical institute
    5. University degree
    6. Other education or training
    7. No education or training

    If 35.6, please specify in
36. What is your main occupation?
    1. Photographer
    2. Retired
    3. Student
    4. Stay At Home Parent
    5. College Instructor
    6. Community Recycling Coordinator
    7. Property Manager (Accommodation/Events, Housing)
    8. Exterior Maintenance

9. Carpenter
10. Tree Planter
11. School Bus Driver
12. Truck Driver
13. Labourer
14. Culinary Artist
15. Aquarium Interpreter
16. Tourism Operator
17. Tourism Designer (Design and Marketing)
18. Fisheries Port Supervisor
19. Accounting Clerk (Hospitality)
20. Fashion Designer
21. Hostel Manager
22. Hostel Worker
23. Recreational Activity Instructor (Surfing, Snowboarding)
24. Small Business Owner (Retail, Local Foods Grocery, Recreation/Sport Service, Hospitality, Trades)
25. Small Business Apprentice (Local Art)
26. Small Business Manager (Retail, Bookstore)
27. Store Clerk (Retail, Local Art)
28. Server (Restaurant/Bar)
29. Medical Professional
30. Chiropractor
31. Nurse
32. Doula
33. Child Caregiver
34. Parks Canada Employee (Administration, Resource Management and Public Safety)
35. Tla-o-qui-aht First Nation Tribal Parks Employee (Guardian)
36. Environmental Educator
37. Community Outreach Director
38. Community Outreach Coordinator
39. Librarian
40. Writer

37. What is your present employment status (for your main job)?
    1. Unemployed
    2. Full-time
    3. Part-time or seasonal
    4. Retired
    5. Student

38. What is your total annual household income before taxes, including income from all members of your household?
    1. Up to $49,999
    2. $50,000 to $99,999

3. $100,000 or more
4. I don't know

39. Are you the primary earner of this household income?
    1. Yes
    2. No

If 39.2, what is the occupation of the other primary earner(s) in your home?
1. Self-Employed
2. Coast Guard
3. Fisher
4. Aquaculture Manager
5. Tug Boat Driver
6. Fishing Charter Driver
7. Carpenter
8. Construction Worker
9. School Teacher
10. Tourism Operator
11. Service Worker (Hospitality)
12. Store Clerk (Service, Retail)
13. Recreational Activity Instructor
14. Small Business Owner (Hospitality, Trades, Sales/Marketing)
15. Server (Bar/Restaurant)
16. Chiropractor
17. Child Caregiver
18. Adult Educator
19. Environmental Educator
20. Mechanic
21. Electrician
22. Hostel Manager

40. Of the following, what age category do you belong to?
    1. 18-24
    2. 25-34
    3. 35-44
    4. 45-54
    5. 55-64
    6. 65-74
    7. 75 or over

Additional notes:

# Appendix G

## Emergency Preparedness

West coast emergency responders and their roles (District of Ucluelet 2010b).

| Emergency Organization | Role |
|---|---|
| **District of Ucluelet Emergency Planning Committee**<br>- Paid & Volunteer | Develop the emergency plans for the District of Ucluelet including- preparation, response, and recovery<br>Management of Incidents via the EOC |
| **Emergency Social Services (ESS)**<br>-Volunteer | Provides primary services (food, shelter, basic personal care) to evacuees of small and large emergencies and disasters for up 72 hours. |
| **Ucluelet Volunteer Fire Brigade (UVFB)**<br>- Volunteer | Fire Fighting<br>Road Rescue<br>Community education |
| **Search and Rescue (SAR)**<br>-Volunteer | Search and rescue for missing people |
| **BC Ambulance (BCAS)**<br>-Paid | On-scene and Pre-hospital medical care<br>Medical transport |
| **Coast Guard**<br>-Paid and Volunteer | Aids to Navigation,<br>Waterways Management,<br>Marine Communications,<br>Environmental Response |
| **Rangers**<br>-Volunteer | Provides a military presence in remote, isolated, and coastal communities |
| **Police/RCMP**<br>-Paid | Crime control<br>Community service<br>Order maintenance |
| **Victim Services**<br>-Volunteer | Emotional Support<br>Referrals ( Professional support organizations)<br>Information and practical assistance |