

Climate Change and Community Health: Lessons from Canada's East and West Coasts

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Abstract

Over the past decade and more, Canada's east and west coast communities have been under considerable stress from the impacts of interacting environmental, industrial, political, and social changes. Because most Canadian coastal communities are in some way resource dependent, they are especially vulnerable to ecological degradation and associated political responses, as well as to the pressures of globalization. Responses and adaptations to these stresses have varied as a result of differential exposures and adaptive capabilities. Of late, climate experts project that adverse environmental changes will likely challenge the health and well-being of coastal communities already under considerable stress. Researchers anticipate multiple direct and indirect community and population health consequences from climate change. These consequences will vary depending on differential exposures to environmental hazards and other risks combined with the diverse abilities of communities and people to respond effectively and to adapt. Drawing on recent case study work from an interdisciplinary research project, we demonstrate that understanding past experiences dealing with stress provides a basis for understanding the implications of climate change for the future health and well-being of coastal communities and people.

1.0 Introduction

Climate-related changes, both short-term variability and long-term climate change, have serious consequences for everyone, not least for Canadian coastal communities, whose capacity to endure further change continues to be sorely tested (Ommer et al., 2007). Global climate changes are likely to have direct

community and population health impacts related to increases in highly variable climate and weather conditions. Indirect consequences that increase uncertainties of resource-based economic activity also are expected as the local ecology adjusts. How such climate-related changes will affect coastal communities depends, in part, on their social and environmental adaptive capacity, which some propose is best thought of interactively in terms of social-ecological health (Berkes, Colding, & Folke, 2003).

Recent research by the Coasts Under Stress project (Ommer et al., 2007) examined the resiliency of coastal communities under conditions of major economic, social, and environmental change. That research concludes that coastal communities, while remarkably resilient, underwent so much change of their *modus vivendi* in the last century and more that their capacity for further adaptation may have been seriously undermined. The research, moreover, pointed to the importance of coastal communities as stewards of the future health of Canada's coastal waters and as evidence for Canadian claims of sovereignty over major tracts of land, such as a large part of the Arctic coasts of the North American continent. At the same time, many Canadian east and west coast communities are now considered to be vulnerable to climate change, given their location and isolation, exposure to extreme climate variability, and their dependence on environmental resources for continued community health and well-being (Dolan & Walker, 2006; McCulloch, Forbes, Shaw, et al., 2002; Shaw, Taylor, Forbes, Ruz, & Solomon, 1998).

In this paper we share qualitative lessons from our recent bicoastal research project, Coasts Under Stress, a 5-year major collaborative research initiative funded by the Natural Sciences and Engineering Research Council and the Social Sciences and Humanities Research Council, which was carried out by an interdisciplinary team of researchers and based at the University of Victoria in British Columbia and Memorial University of Newfoundland. This work contributes to better understanding of the processes of coastal community vulnerability to climate change. While our research was not directed at studying climate change *per se*, it was focused on understanding the ways in which environmental changes are mediated by social systems to impact people's health and well-being in east and west coast Canadian communities. Selected research findings demonstrate the utility of a social-ecological health framework and how the lessons learned apply in the context of climate change and can therefore contribute to the climate change discourse. While recognizing that the uncertainty created by climate change makes it unlikely that the empirical past will be a window into the future, we consider that our research offers an integrated understanding of the ways in which environmental systems and social systems interact at multiple scales and in particular places to have consequences for people's health and well-being. Our understanding of the integration of various interactive social and ecological components in response to change is important and is a necessary complement to existing vulnerability assessments and climate-change projections.

2.0 Climate Change and Coastal Community Vulnerability

Climate experts project that globally averaged surface temperatures will increase between 1.1 and 6.4 degrees Celsius by the end of the 21st century relative to 1980–1999 temperatures (Intergovernmental Panel on Climate Change [IPCC], 2007). Global average water vapour concentration and precipitation are projected

to increase during the 21st century, along with changes in extreme weather and climate events, including more intense precipitation events and storms, increased periods of drying and higher maximum temperatures. While climate models are inconclusive, it is argued that, even with little or no change in El Niño magnitude, global climate warming will likely lead to more extreme versions of drying and heavy precipitation along with increased risk of droughts and floods that normally occur with El Niño events in many regions of the world. In addition, global mean sea level is projected to rise between .18 m and .59 m relative to 1980–1999 levels (IPCC, 2007).

Coastal communities are especially vulnerable to specific climate changes, such as accelerated sea-level rise, given the concentration of people and natural and socioeconomic assets in the coastal zone and the dependency of coastal communities on these vulnerable assets. Researchers project that sea-level rise will entail various short- and longer-term effects, such as elevated tidal inundation, increased flood frequency, extreme storm surges, enhanced and accelerated erosion, rising water tables, increased saltwater intrusion, and a variety of associated ecological changes (Clark et al., 1998; Monirul & Mirza, 2003; Wu, Yarnal, & Fisher, 2002). Canada has the longest coastline in the world. Approximately one third of it has been characterized as moderately to highly sensitive to sea-level rise impacts (Shaw et al., 1998). Many coastal regions in Canada already have to deal with rising sea levels. For example, the Atlantic coast, because of a combination of crustal subsidence and sea-level rise, is currently adjusting to rising relative sea levels, and accelerated sea-level rise in combination with increased storminess may increase coastal erosion, flooding, and other storm-related damages in the next several decades (Forbes, Shaw, & Taylor, 1997). Increased flooding, associated with increases in the spring freshet and extreme weather events and changes in storm surge, is very important for low-lying coastal regions, like Richmond and Delta, British Columbia, in the Greater Vancouver area. These heavily populated coastal regions are especially vulnerable to rising sea levels and increased storm surge, as existing protective infrastructures, such as dykes, are probably inadequate (Beckmann, Dunn, & More, 1997).

Such short- and longer-term biophysical disturbances and associated infrastructure damages (for example, shoreline erosion and property damage, as well as damage to municipal water and sewage treatment infrastructure) can potentially impact human health and well-being by increasing risks of physical injury (through, e.g., infrastructure failure), infectious diseases (e.g., contamination of municipal water and associated illnesses), mental-health issues (e.g., psychological stress due to increased risks), and other public health consequences (Haines, McMichael, & Epstein, 2000). Additionally, extreme events, such as storm surges, could damage and/or restrict essential transportation routes (e.g., highways and ferries) that are required for the distribution of food, medical supplies, and other essential goods. Such disruptions are particularly important in remote communities with limited transportation options.

In addition to impacts associated with expected sea-level changes, marine ecosystem changes could have significant implications for coastal people. Already, scientists have discovered significant changes to ocean chemistry, such as increased acidification, oxygen depletion of areas along the west coast of North America, and increased blooms of various species of harmful phytoplankton around the North Pacific (PICES, 2004), which all have implications for ocean

productivity, marine life, and humans. In Canada, research confirms that climate changes, such as increased surface temperatures and storminess, are significant factors stimulating red tide and other harmful algal blooms (HABs) (Mudie, Rochon, & Levac, 2002), from which the direct health consequences—e.g., paralytic shellfish poisoning (PSP) and red tides—can be especially severe (e.g., death from consuming PSP shellfish). These ecological changes also can result in significant economic losses. In Canada, it is estimated that PSP red tides have averaged \$4 million¹ per outbreak from the 1970s to the 1990s (Mudie et al., 2002). In British Columbia, Whyte (1998; cited in Mudie et al., 2002) estimated in 1996 \$10 million to \$20 million in losses as a result of a specific HAB first appearing in British Columbia fish pens in 1976.

Economic losses linked to climate-induced ecosystem changes are not confined to shellfish. British Columbia's salmon fishery has seen significant declines over the last two decades, with total landed value of commercial salmon fishery declining from a high of approximately \$410 million in 1988 to \$55 million in 1998. There have been significant reductions in the standard of living for some affected fishers (Noakes, Beamish, & Gregory, 2002). While the explanations for such decline, which include changes in marine productivity, resource management objectives, and competition from aquaculture (Hyatt & Riddell, 2000; Noakes et al., 2002) are complex and confused, it is probable that production losses are linked to climate-related changes (Beamish et al., 1999). Given that health is in part socially determined (Hertzman, Frank, & Evans, 1994; Raphael, 2001), it can be expected that any changes in income and economic conditions resulting from changes in ecosystem services, including the quantity and quality of plants and marine animals upon which the livelihoods of many coastal peoples depend (McMichael et al., 1999), will have consequences for people's health and well-being. It is well known that poorer health is associated with lower income and lower socioeconomic status, a relationship that exists across all aggregate classes (Evans, Barer, & Marmor, 1994). Thus ecosystem changes that are likely to be exacerbated under climate change (such as increased red tides and reductions in commercially valued fish stocks) will affect people's health and well-being both directly (e.g., PSP) and indirectly (e.g., through changes in jobs and incomes). In addition, those who are already socioeconomically marginalized are less likely to have the economic resources necessary to enable effective response and adaptation to increased stressors.

2.1 A Vulnerability Approach: Exposure and Adaptive Capacity

Of late, researchers argue that the impacts of climate change are best understood using a vulnerability approach (IPCC, 2001; Yohe & Tol, 2002). Here, the consequences of climate change for social systems are dependent on both a system's exposure to climate change and its ability or capacity to adapt. Because exposure tends to be measured according to physical characteristics, such as geographic location or ecosystem properties, many coastal communities and regions are characterized as vulnerable. Adaptive capacity takes into account the fact that physical characteristics alone do not determine vulnerability and that climate change impacts will not be equally distributed across time and space—a result, in part, of the conditions of social systems that constrain or enable response

¹ All dollar figures are in Canadian dollars.

and adaptation to climate changes (McMichael et al., 2003; Yohe & Tol, 2002). The popular vulnerability approach considers together the exposure and adaptive capacity of interacting human-environment systems (Smit & Pilifosova, 2003).

In general, adaptive capacity involves complex relationships among political, socioeconomic, and cultural elements that vary across a range of spatial and temporal scales (Adger & Kelly, 1999). It is tightly tied to resilience, defined as the ability of a system to prepare for, avoid, moderate, and recover from climate-related risks and/or change. Building adaptive capacity, then, helps reduce vulnerability but does not expect to provide a precise capacity to handle some future scenario. Instead it seeks to enhance the capacity to absorb and accommodate uncertain and unexpected surprises (Holling, 1973).

Conceptually, adaptive capacity is recognized as a function of multiple determinants, including access to resources (e.g., technology) and economic wealth, knowledge, skills and risk perception, social capital, socioeconomic and political equity, institutions and infrastructure (Smit & Pilifosova, 2001). For example, available resources and their distribution (e.g., income) are important for adaptive capacity across all scales, whether that be the level of the individual, household, community, or nation. As wealth increases, so too does the potential for preparation, recovery, and adaptation to environmental change (Kates, 2000). Wealthy states and communities are better equipped to invest in adaptation strategies, such as new infrastructure and emergency protection measures, and are more likely to have access to technology, which increases the potential range of adaptation options available (Goklany, 1995; IPCC, 2001; Yohe & Tol, 2002). In addition, wealthier communities are better able to invest in the range of assets that communities can draw from for certain aggregate outcomes, that is, social, ecological, human, and economic “community capital” (Beckley, Parkins, & Stedman, 2002; Hancock, 2001). Community capital also facilitates the health of individuals by affecting lifestyle choices, self-esteem and self-efficacy, empowerment, well-being, and access to resources, such as wealth, health services, and natural and social amenities (Kawachi & Berkman, 2000; Wilkinson, 1996; Wilkinson, Kawachi, & Kennedy, 1998).

Knowledge, skills, risk perception, and awareness are also important determinants of adaptive capacity (Barnett, 2001; Davidson, Williamson, & Parkins, 2003). Risk awareness is tied closely to risk communication and the ability and effectiveness of social networks and social infrastructure to support and facilitate information flows and skills. Similarly, social capital and social cohesion are important, as these are needed in transferring and sharing information among people; social capital is also an important safety net in communities and in households, since people often depend on their social relationships in times of stress (Buckland & Rahman, 1999).

Institutional frameworks at community, regional, and national levels that manage climate-change risks and other stresses are important (Smith & Lenhart, 1996). Such are risk-spreading choices (e.g., insurance) by institutions that help individuals and groups cope with climate conditions like floods, storm surge, and wind damage. However, too much dependence on risk spreading may lead to long-term “maladaptive” behaviour (Smit, 1994) that ultimately increases vulnerability. In addition, the importance of social institutions goes beyond their role in directly facilitating (or constraining) adaptations. Social institutions at multiple scales mediate how power is distributed (e.g., democratically and equitably), influencing people’s access to resources and wealth (Tobin, 1999). Institutions mediate

stressors at various scales and shape the ways in which entitlements are distributed from the household to the global scale (Adger & Kelly, 1999). Thus, a number of conditions that limit access to resources and perpetuate inequalities can affect adaptive capacity. Poverty, income inequality, limited employment opportunities, gender and ethnic discrimination, political powerlessness, absence of or limited legal entitlements, and the breakdown of social capital are all recognized as conditions that create and exacerbate individual, household, and community-level vulnerabilities to climate-change impacts and to socioeconomic stressors in general and are linked to social institutions at multiple scales (Adger, 1999; Adger, Bengaminsen, Brown, & Szarstad, 2001; Kates, 2000; Wall & Marzall, 2006).

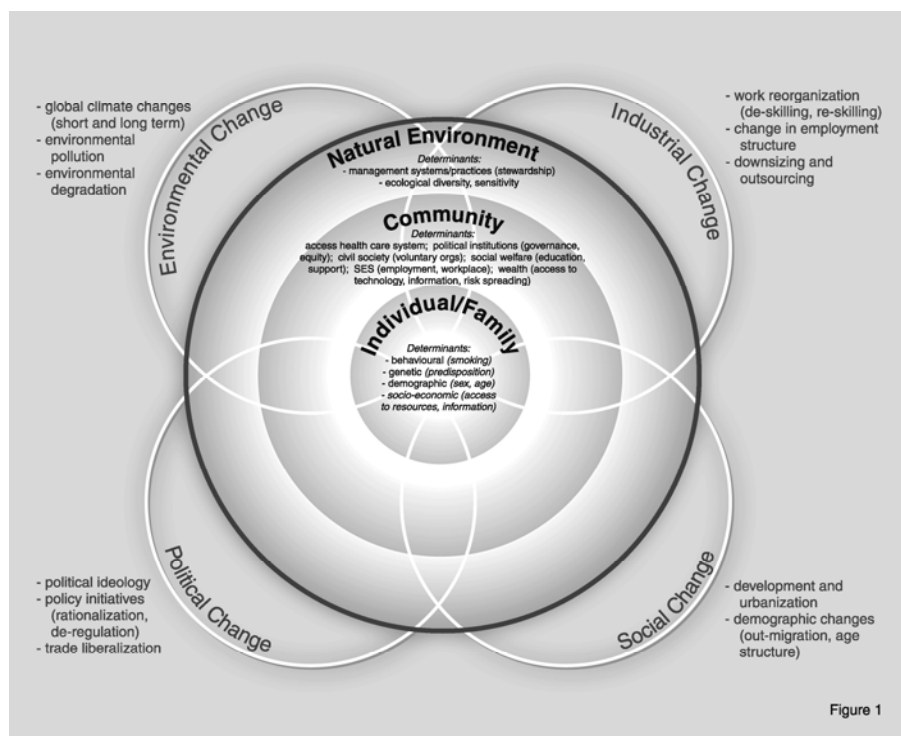
The vulnerability framework in principle is now generally accepted internationally (IPCC, 2001) and in Canada (Government of Canada, 2004). However, the way in which it is applied tends to vary depending on the purpose of an assessment, and the scale at which such assessment is needed (e.g., global comparative analyses and national analyses). Because of the severe consequences of sea-level rise for coastal communities around the world, integrated coastal vulnerability assessment has received international attention (IPCC, 1992). This kind of assessment aims to identify the people and places at risk and to help communities plan for long-term adaptation strategies; it is often grounded in, or is a variant of, the IPCC's (1994) "Common Methodology" (Harvey, Clouston, & Carvalho, 1999; Kay & Waterman, 1993; Klein & Nicholls, 1999; Klein, Nicholls, & Mimura, 1999; Nichols, Berkes, Jolly, & Snow, 2004; Waterman & Kay, 1993; Wu et al., 2002). Much of this literature describes ways to measure vulnerability using various indicators of physical exposure and/or adaptive capacity to create a characterization of place vulnerability (Cutter, Mitchell, & Scott, 2000; McCulloch et al., 2002; Shaw et al., 1998; Wu et al., 2002) intended as a tool or guideline for decision making and/or as a part of broader climate-change assessment exercises. In Canada, coastal vulnerability risk is important, given the number of people and the significant economic activity dependent on and located within Canada's coastal zones. Several studies have applied versions of integrated vulnerability assessment (e.g., McCulloch et al., 2002; Walker et al., 2007). While theory and application of this approach have significantly widened the discourse on climate change, globally and in Canada, and contributed notably to a better understanding and appreciation of conditions of vulnerability, we believe it could be widened still further by going beyond current summative exercises and considering more explicitly and qualitatively the ways in which environmental changes interact and are mediated by social systems to have consequences for people's health and well-being. We offer a social-ecological framework, not as an alternative to existing efforts, but as an aid in unpacking and providing further meaning to complex interactions between environmental changes and human health and well-being in a coastal context.

3.0 A Social-Ecological Framework of Climate Change and Coastal Community Health

Our social-ecological framework (Figure 1) is not unlike some frameworks found in the climate change and adaptation, community health, and population health literatures, which all identify multiple determinants of health and, to some extent, the interdependencies between people, communities, and natural environments (Berkes et al., 2003; Costanza, Norton, & Haskell, 1992; Folke, Berkes, &

Colding, 1998; Parkes, Panelli, & Weinstein, 2003; Wolman, 1995). However, our conceptual framework explicitly identifies the ways in which environmental changes interact with and are mediated by social systems, by including community-level determinants that have consequences for individuals and households (Dolan et al., 2005). Any changes to these ecosystem services—whether from climate change or other anthropogenic stressors (e.g., globalization or trade liberalization)—can have consequences for human health, via direct and indirect exposures (such as stress) and indirect and interactive effects on the mediating social determinants that affect community, households, and individuals. This understanding underscores the fact that environmental change is only one of the many factors that simultaneously affect community and population health (Davidson, Williamson, & Parkins, 2003) and draws attention to the fact that climate-related changes interact with other stresses to influence social-ecological systems. At the same time, any changes to the mediating social determinants (determinants of adaptive capacity) will also affect the way that people can respond to and adapt to ecosystem changes and the way that people and communities interact with their natural environments. In the following section, we present some examples of the ways in which Canadian coastal communities were affected by interacting environment and social changes, using select examples and qualitative narratives drawn from our collective research volume (Ommer et al., 2007). We demonstrate how a social-ecological lens can broaden our understanding of human-environment relations and how examining past events can indeed tell us something about adaptive capacity to climate change in general and adaptation in coastal Canada specifically.

Figure 1. Social-ecological Model of Health (adapted from Dolan et al., 2005).



3.1 Communities in Transition: Tales for Canada's East and West Coasts

During the past 20 years, many Canadian resource-dependent communities have been seriously affected by resource degradation, changing resource management regimes, industrial change, community structural changes (e.g., demographics), and related changes in employment opportunities within and between the fishery, forestry, mining, tourism, and service sectors. These changes have involved significant environmental and social transformations that have affected the health and well-being of individuals, families, and communities (Ommer et al., 2007).

In Newfoundland on Canada's east coast, the fishery was the most important sector for more than two centuries. Between 1985 and 2003, however, there was substantial downsizing and reorganization within the industry. Sustained overharvesting practices were further exacerbated by the effects of changing water temperature and together led to the collapse of the groundfish fishery (Finlayson & McCay, 1998; Haedrich & Hamilton, 2000; Rose, 2004). In 1988, groundfish catches in the province had been around 400,000 metric tons. But in 1992, with the stocks close to biological collapse, the federal government had to impose a series of moratoria on groundfish harvesting. The result was the largest loss of jobs and income in Canadian history: Over 30,000 fishery-related jobs were lost almost overnight; many more were lost in related tertiary employment (Canning & Strong, 2002). In 1993, catches were less than 30,000 metric tons, a 90% decline. In general, all east coast communities saw significant changes; no community seemed immune to the effects of the moratoria.

The Canadian west coast has also experienced crises in fisheries related to declining stocks of Pacific salmon, fishing fleet overcapacity, and a 30%–50% decline in prices for all salmon species. During the 1990s, the fishery failed to post profit for 7 of 9 years because of low catches and low prices (Noakes et al., 2002). The Pacific Salmon Revitalization Strategy (Mifflin Plan) was introduced in 1996 in an effort to conserve stocks and to improve the viability of the fishing industry. As such, through a program of early retirement, license buybacks, and gear and area restrictions, the Mifflin Plan reduced the west coast fishing fleet by approximately 50% between 1995 and 2000. This meant the loss of fisher-related incomes for more than 2,500 individuals in the first year of the program, as well as associated job losses in the fishery supply sector (Gislason, Lam, & Mohan, 1996). Since then the volume and value of the commercial fishery and fish processing have substantially declined, reaching historic lows in the late 1990s (Schwindt, Vining, & Weimer, 2003). Even with fewer fishing vessels, the average income per licence declined more than 35% between 1995 and 2000 (Noakes et al., 2002).

Similarly, over this same period and even longer, the forest industry restructured significantly in response to changes in the market economy (e.g., the North American Free Trade Agreement, international duties, and unstable foreign markets), excess capacity, and resource degradation. Mechanization, consolidation (e.g., mill closures and increased mill shuts) and outsourcing were all part of an attempt to reduce industry costs and remain competitive, but they led to significant job losses and/or changes in the nature and quality of work, thus affecting the lives of coastal people (Barnes, Hayter, & Hay, 1999; Hayter, 2000; Hayter & Barnes, 1997).

What has happened on the east and west coasts is the result of interacting environmental, political, industrial, and social changes (Ommer et al., 2007). Both coasts saw dramatic population declines, most notably between 1996 and 2001. Prince Rupert and Port Hardy, communities in British Columbia dependent on multiple industries, lost 12.5% and 13.4% of their population, respectively. Similar changes were seen on the east coast, the most dramatic declines being to inshore fishing communities such as Parson's Pond (19.4%) and Cow Head (23.2%). Even larger fishing and processing communities were not unaffected: Port au Choix, for example, saw an 11.9% decline in population between 1996 and 2006. Only in Tofino, a tourism-based community, were things different: That community experienced a 25.3% increase.

Many declining communities have been left with a significantly reduced tax base (due to lost incomes and property values), eroded social-support services and infrastructure, and outmigration. Outmigration has led to an aging demographic profile with its attendant problems as retired and aging residents have been left behind without family support. Once-prosperous people had to rely on social-support services, which were undergoing cutbacks. For example, in the mid-1990s, federal employment insurance was altered to make it more difficult to qualify, at the very time that many people, especially seasonal fishers and fishing families, needed it most. These changes in communities inevitably had human health consequences, such as increased psychosocial stress, as a result of employment uncertainty, and changes in family dynamics and household relationships (Ommer et al., 2007).

While we found much evidence of poorer health linked to changes in the natural resource sectors, we found also that communities and individuals were not hapless victims of their natural and social environments, but that they responded both purposively and autonomously to these changes. Indeed, while we found many examples of industrial downsizing and closure, we also found examples of adaptations related to species harvested and processed, products generated, and new professionalization legislation affecting individual rights of access of fishers.

On the east coast, shellfish fisheries, particularly of crab and shrimp, have expanded since the early 1990s and become the dominant species harvested today. The production value of the fishery in 2002 reached an all-time high at over \$1 billion, and the landed value of shellfish made up 82% of total landed value of fish. Snow crab is now the most commonly processed and the highest revenue-producing species. Such adaptations have not been equally distributed, however: Changes have varied across communities. Communities such as Port au Choix, White Bay, and those in the Labrador Straits area have managed to survive as a result of adaptations that involved diversification of the type of species harvested and processed. The Labrador Straits area has seen centralization to a single plant and some success with diversification to multiple species. In Port au Choix, the fish plant that had earlier diversified to a mix of cod and shrimp has continued with shrimp production since the cod moratorium, albeit with a significant reduction of workers (from over 400 to 150). In White Bay South, an existing crab plant was able to continue production and a new shrimp plant in the area created approximately 100 new fish-processing jobs. White Bay South, however, was less affected by the moratoria because it was already somewhat diversified and less dependent on groundfish.

On the west coast, similar adaptations to changes in fishery, forestry, and other resource sectors have occurred. Communities and governments have had to look for new economic opportunities beyond traditional resource-based industries. Many communities are turning to tourism. For example, Ucluelet, at one time the third-largest port on British Columbia's west coast in terms of tonnage of fish landed, experienced drastic reductions in its fishing fleet and associated employment at three local fish plants. These changes, in addition to job losses in the forestry sector, led to heightened concern over the near future viability of the community. However, Ucluelet has embraced tourism and seen some benefits through an increase in tourism-related jobs, largely a result of the town's proximity to Tofino (42 km distant)—a community that has seen an explosive growth of tourism-related business due in part to the Pacific Rim National Park and the Clayoquot Sound UNESCO Biosphere Reserve.

These examples show that communities, while being especially vulnerable to changing environmental and social conditions, also are still considerably resilient or adaptable, at least in the short term. Diversification has allowed communities to retain viable operations, while providing continued, albeit reduced and changed, employment opportunities. However, these adaptations are not without the problems of an aging workforce, as well as threats of stock collapse, as shown, for example, in more recent shrimp size reductions on the east coast, reminiscent of the cod fishery experience and reported declines in hake catches on the west coast (Ommer et al., 2007). In addition, there is general concern that the neoliberal economic model that demands a flexible workforce (where people are offered part-time jobs or piece work and are required to be on call when needed) is eroding the traditional adaptive flexibility of coastal communities, which have survived for generations on an ever-changing range of seasonal jobs to provide an adequate income overall. There is a general sense on both coasts that tourism cannot replace the fishery because of a short season and low earnings: It does not offer a living wage, nor does it help to keep young people in the community long term. Furthermore, its success hinges on the success of other sectors, like local businesses that have to then maintain the restaurants and bed-and-breakfasts in the off-season. Statements such as this from a west coast resident capture this general concern:

Tourism is now growing, but that is a whole different thing, and it doesn't provide full-time employment, so it is not anything that many people can raise a family on. The way I see it, tourism makes a handful of millionaires richer, and it provides part-time work at \$10 or \$12 an hour for 3 months a year. (Ommer et al., 2007, p. 340)

Aquaculture (salmon and shellfish) is another expanding industry on both coasts, supported by both provincial and federal governments who are optimistic that it can provide stable employment, and opportunities for advancement, as well as a marketable substitute for endangered or commercially extinct stocks. Salmon aquaculture is particularly important to the local economies in Port Hardy and Tofino, British Columbia. In 2004, there were two companies in Tofino providing direct year-round employment for approximately 245 people, though not all employees were Tofino residents. However, this expansion of aquaculture occurs in conjunction with concerns about its environmental impacts and incompatibilities with other marine resource users. Despite a seemingly positive economic outlook, there are tensions even among Tofino residents; some favour recent community

development activities and describe their communities as “booming,” “diverse,” and “improving.” Others are more sceptical and question the long-term economic viability and stability of expanding aquaculture and tourism industries and describe their communities as “seasonal,” “terrible,” and “overly dependent” (Ommer et al., 2007, p. 336).

Individuals and households on both coasts have taken steps to respond to changing environmental and social conditions, which resulted in both planned and unforeseen consequences. On the west coast, families had to make tough decisions in direct response to changing socioeconomic and environmental conditions. While these decisions were deemed financially responsible or necessary, they had implications for communities and their households. For example, two west coast respondents articulated what they saw as the cumulative impact of the Mifflin Plan (Ommer et al., 2007, pp. 248–249):

And family fishing, they had that big buyout a few years ago when they started the conservation measures, which were really needed and most people recognize that, you know that if they don't start saving the salmon stocks, that it is going to be bad forever and get worse and worse. But it is the same thing, they kind of forced a lot of guys to sell their boats and so there are very few trawlers; there is more concentration in the big companies that own boats.

When I moved here 15 years ago, a good deal of the fishing fleet was based in Prince Rupert so it meant that the incomes that were earned remained in the community over the wintertime. Again, regulatory changes have changed that whole mix a lot, so I would say that the bulk of the people who are fishing in the north are actually southern vessels, so the money goes south.

At the household level, the Mifflin Plan had significant consequences. For example, one coastal family took the fisheries buyback but expressed anxiety and regret at the change in their lives. “Financial-wise we made a good decision. But lifestyle ... it ended all my dreams of what I had [en]visioned for us” (Ommer et al., 2007, p. 257). Those who decided to stay in the commercial fishery continue to live with the stress of the unpredictability in harvests, fluctuating prices for fish, offshore competition, and fish plant downsizing and closures.

On the east coast, changes in the fishery decreased real incomes mostly for male fish harvesters, especially those in small inshore boats. This coincided with policy and other changes associated with commercial fishing (increased license fees, observer fees, union, professional and wharfage fees, and fishing further offshore), which together led to an increase in the local real costs of fishing. One adaptation by fishing families has been for women to work as crew with their husbands. Women's work in the industry, however, remains invisible as a result of discriminatory fishing employment insurance legislation that does not properly recognize onshore work traditionally done by women, along with official efforts to professionalize the fishery that target men who are assumed to be full-time fishers. As a result, many women are not receiving appropriate support or training for their roles aboard fishing boats and are frustrated by fishing policies and practices that compromise their health and well-being (Grzetic, 1994). Furthermore, women (and men) experience increased stress, given that fishing together involves greater household risks, both economic and physical. These arrangements not only

increase a family's economic vulnerability to downturns in that sector, but also increase the seriousness of the impact of parents' boating accidents on children, given that husbands and wives are fishing in the same vessel. As one woman notes, "I mean I'm out there ... we're out there together and if anything happens to one of us, it's going to happen to both of us. ... So I think about when I'm out there—I think about, well if anything happened today, them two little youngsters home themselves. That's what I think about, right?" (Ommer et al., 2007, p. 257). However, despite such known and potentially serious risks, these are deliberate decisions to make a living wage for the family.

Other adaptations have also brought about further health exposures. In the east coast fish-processing industry, injuries have tended to be related to cuts, falls, and cumulative trauma disorders (Solberg, Vezina, & Molgaard, 2005). In snow crab processing, however, there is the added problem of allergies and asthma (Cartier et al., 2004; Howse et al., 2006). The necessary prevention, diagnosis, and compensation infrastructure for occupational allergy and asthma are significantly different from those needed for acute injuries, but research indicates that institutional adaptations in health and safety have not kept up with industrial adaptations in the fishery, contributing to problems with exposure, diagnosis, treatment, and compensation of these occupational diseases experienced by workers (Neis et al., 2004).

In addition, because the expanding shrimp and crab industry has generated growth in the boat-building and fiber-glassing industry in Newfoundland and Labrador since the mid-1990s, this has introduced new occupational hazards, in this case increased exposures to styrene by boatbuilders; styrene is a known neurotoxin. Despite the positive effect of offering alternative employment in rural communities, this new and somewhat unregulated industry has created some concern for provincial occupational health and safety officials. Thus, while rural diversification has meant access to employment and incomes for many individuals in the shellfish industry and related activities (i.e., boatbuilding), it has also created new occupational health hazards for fish plant and boatbuilding workers, which may have long-term, and in some cases serious, health consequences. One fishplant worker clearly described his situation: "There is more than once that I cried, my dear. I couldn't get me fingers open ... couldn't get me fingers apart. And you wouldn't dare say, you know, that you couldn't go back. You had to go back" (Ommer et al., 2007, p. 266).

In short, east and west coast communities have undergone fundamental environmental and social changes in the last decade or more. Ecological degradation has interacted with political and other industrial and social changes to profoundly alter natural resource industries, the economic condition of coastal communities, and the lives of individuals and families. At the community level, the changing shape of resource industries, such as a greater reliance on shellfish (east coast) and other species like hake (west coast), and new economic activities, such as tourism and aquaculture, represent adaptation to environmental and social change. Economic activities such as tourism and aquaculture offer hope for struggling coastal communities. However, there remains great uncertainty as to the ability of these activities to meet the needs of individuals and families, given the lower wages, job insecurity, and instability associated with newly created employment opportunities, especially in tourism. Community-level adaptations to changing conditions are not without consequences, as people's lives situated

within changing rural economies are fundamentally altered, both economically and socially as well as with respect to changes in the nature of health exposures (e.g., respiratory illnesses, exposures to toxins, and injuries and accidents).

4.0 Lessons for Climate Change and Coastal Communities

Our research has contributed to the understanding of coastal community vulnerability and adaptation to climate change in a number of ways. First, it is clear that industrial responses to social-ecological change have, more often than not, exacerbated community vulnerabilities and undermined their adaptive capacity. Industry has achieved flexibility for itself at the cost of community adaptability and flexibility. This has been exacerbated by policy initiatives, such as provincial and federal government resource-management regulations and health-care and educational services downsizing, that involved government cutbacks and cost-saving adjustments in institutional infrastructure. Our research underscores the importance of resiliency, flexibility, and adaptability within communities, as well as the need for institutions to respect community sustainability requirements, such as adaptable occupational health regulations for the protection of workers in emerging industries or adaptable regulatory institutions for the protection of natural resources that fill the gap in the fishery (e.g., snowcrab and hake).

From the perspective of coming climate change, it is important not only to have social institutions that can manage a range of risks but also to ensure that institutions themselves do not undermine adaptive capacities of individuals and households, in their own search for appropriate adaptations. Individual and household decisions are already constrained, there being a limited range of choices. Having enough information and being aware of “risks” (whether related to climate change, economic vulnerabilities, or health consequences) at the institutional level does not necessarily translate into the best choices coming forth for other scales of operation. The needs of a city and a small rural community are very different, for example. One-size-fits-all policies will not work under the constraints of climate change. People and households make decisions, some by choice, others out of necessity, in response to multiple stresses. In the absence of an understanding of the local context within which individuals and households are operating, their decisions may appear irrational to those operating at a different scale, be that the level of the firm, the province, region, or nation. Therefore decisions taking place at broader scales, such as those concerning environmental, institutional, political, and social changes, must be seen in the context of the local level and adjusted accordingly if they are to make local sense (Fabricius, Folke, Cundill, & Schultz, 2007). Recognition that responses to external stresses and to the changing nature of economic and social relations are not necessarily decisions arising from “free choice” underscores the fact that adaptation too may be less about an apparently rational decision based on accurate risk information at a broad level and more about immediate concerns and necessities, especially when household resilience strategies are in jeopardy.

This underlines the importance of scale in understanding adaptation and adaptive capacity and the important question of *whose* adaptation (Adger, Arnell, & Tompkins, 2005; O’Brien et al., 2004) is under consideration. How we characterize adaptation or adaptive capacity will vary according to scale, whether we are considering individuals, groups, or geographic communities or regions. Community-level economic diversification is an adaptation to globalization, but

the flexible workforce that has been set up in response results in decreased flexibility at the level of the household. This is not good enough: A good adaptation is one in which the outcome is win-win, not one part of the system winning and the other losing. The impacts and costs of adaptation are scale-dependent and will vary depending on who is doing the adapting, whether individuals, households, communities, industry, or governments.

Furthermore, how one characterizes adaptation depends not only on geographic and institutional scale but also on temporal scale: whether it is based on long-term sustainability, short-term economic prosperity that resembles past affluence, or something in between. This is why we now hear calls for mainstreaming climate change and the integration of climate change adaptation planning into policies and decisions at multiple scales and within all levels of government (Wall & Smit, 2005, 2007).

Finally, our social-ecological framework and the case study examples presented here demonstrate the interactive and nonlinear nature of environment and health relationships, including atmosphere and climate, and show that the capacity to adapt is dependent on the very health determinants through which climate changes are, in part, functioning. Stressors interact to affect the way change proceeds; people, communities, and environments learn from their experiences and respond (Ford, Smit, & Wandel, 2006; Gunderson & Holling, 2002); taken together, these interactions can change the nature of exposure and/or consequences for community and population health and well-being. For example, moving from a single-species to a multiple-species fishery may offer some hope for many coastal communities and their residents. However, this adaptation may have unforeseen consequences, such as increased exposures to occupational hazards or increased and continued future livelihood uncertainties and psychosocial stress associated with adaptations taken. Thus, while recent economic changes in coastal communities have had some negative health consequences for individuals (e.g., isolation, psychosocial stress, and depression), their responses and adaptations also have health consequences that may not be immediately obvious. By adopting a social-ecological framework, we widen our perspective on the environment-and-health nexus and the potential health consequences not only of environmental changes but also of our adaptations to these changed conditions. Climate change is and will continue to be a significant challenge for people, communities, organizations, governments, and institutions at all scales. Our social-ecological framework represents not an alternative to existing efforts but a complement to provide more meaning to complex interactions between environmental changes, community social conditions, and human health and well-being.

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