



Research

“Like the plains people losing the buffalo”: perceptions of climate change impacts, fisheries management, and adaptation actions by Indigenous peoples in coastal British Columbia, Canada

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ABSTRACT. Rapidly developing and complex climate change impacts have profound implications for coastal communities, demanding adaptation actions for both social and ecological systems. Along the coast of British Columbia, Canada, Indigenous peoples developed a tightly coupled social-ecological system that was interrupted by the arrival of settler colonialism in the 1800s. Although both climate change adaptation and the impacts of colonization have been well studied, little research has examined how these themes interact, and the conditions that may support or prevent people’s ability to adapt to the social-ecological changes that emerge. Through a collaborative partnership with four First Nations and their umbrella organization for technical support, we examined people’s perceptions of social and ecological aspects of adaptation to climate change. Using semistructured interviews (n = 50), four key strategies emerged as critical for climate change adaptation: (1) strengthening Indigenous governance autonomy and authority, (2) promoting knowledge sharing for adaptation practices within and among communities, (3) promoting adaptive comanagement among governance scales, and (4) developing learning platforms for climate impacts and adaptive strategies. Actions typically proposed by non-Indigenous government, including marine protected areas and ecosystem-based management were not prioritized. We found diverse attitudes toward climate change impacts, indicating that people’s perceptions of adaptation strategies are strongly influenced by exposure to observable impacts, the social-ecological context in which they live, and perceptions of governance and self-determination. Our study suggests that supporting Indigenous peoples’ ability to adapt to climate change will require transforming the current governance model into one that acknowledges Indigenous social, cultural, and food needs and how these relate to marine resources and territorial management rights.

Key Words: *adaptation; climate change; fisheries; food security; governance; Indigenous stewardship; transformation*

INTRODUCTION

Indigenous peoples are closely connected to natural systems and particularly sensitive to climate change impacts (Wildcat 2013, Green and Minchin 2014; K. Whyte 2016, unpublished manuscript, <https://doi.org/10.2139/ssrn.2770085>). Worldwide, they are already experiencing rapid changes in weather patterns, species distributions, and phenology of their food resources (Turner and Clifton 2009, Petheram et al. 2010, Savo et al. 2016, 2017). Climate vulnerability studies have informed planning and policy, yet often have perpetuated colonial biases by failing to acknowledge the Indigenous capacity for decision making at multiple scales (O’Brien et al. 2009, Cameron 2012, Mcleod et al. 2016). When unaware of this procedural weakness, research methods and processes can limit participation or omit important context, marginalizing Indigenous voices (Kelly and Adger 2000, Veland et al. 2013, McClanahan et al. 2015).

Postcolonial discourse has started to shift the framing of Indigenous peoples as victims of colonization who are vulnerable to environmental change to adaptable peoples occupying geographies of hope (Coombes et al. 2012, Whyte 2014a). Efforts to include Indigenous voices in adaptation and mitigation strategies are essential (Cameron 2012, Coombes et al. 2012, Whyte 2017) because climate change threatens not only Indigenous food security and economies (Savo et al. 2017) but also Indigenous culture, identity (Chisholm Hatfield et al. 2018),

and health (Donatuto et al. 2014, Durkalec et al. 2015). Yet Indigenous voices, values, and worldviews tend to be underrepresented in climate research, policy, and decision making at all governance scales (Petrasek MacDonald et al. 2013, Ford et al. 2016, Maldonado et al. 2016).

In the context of social-ecological systems, adaptation refers to actions that can reduce an impact or that use new opportunities that develop from observed or anticipated change (Smit and Wandel 2006). Adaptive capacity is a relative measure of the latent potential to adapt to a certain threat (Carpenter et al. 2001, Whitney et al. 2017). Research to date emphasizes that adaptation planning must consider the consequences people experience as a result of an adaptation action (Whyte 2014b), that people often have limitations (perceived or actual) in their capacity or authority to influence broader policies, and that values, beliefs, and worldviews influence their perceptions of change and future outcomes (O’Brien and Wolf 2010, Wolf et al. 2013). To identify and prioritize the adaptive actions that are most relevant to a community, therefore, it is important to explore perceptions from individuals with lived experience (Marshall and Marshall 2007, Petheram et al. 2010, Wolf and Moser 2011). Indigenous knowledge systems—collective, values-driven, typically place-based, connected bodies of knowledge, practice, and belief developed over generations—paradigmatically differ from “Western” worldviews (Berkes 2012, Simpson 2014). Indigenous

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peoples have also gained experience from and persisted through environmental change over long time scales to developed cultural practices and knowledge related to invasive species (Reo et al. 2017), floods (Brown and Brown 2009, Horne 2012), and changes in weather patterns (Cunsolo Willox et al. 2012, Turner and Spalding 2013). Because of this long-term, place-based knowledge, Indigenous peoples may have well-developed capacity to respond to novel environmental changes by adapting their way of life, and unique perspectives on adaptation planning.

The goal of this study was to document and examine the perceptions of four Indigenous peoples, the Heiltsuk, Nuxalk, Kitasoo/Xai'xais, and Wuikinuxv First Nations of coastal British Columbia (BC), Canada, regarding climate change, changes to marine-based food security, and climate change adaptation strategies. The research was designed and conducted as a partnership between the University of Victoria and these First Nations, as coordinated by the Central Coast Indigenous Resource Alliance (CCIRA), the umbrella organization they created to support their own initiatives regarding governance, stewardship, and research. The research objectives were to understand First Nations perceptions of climate change impacts, social and ecological adaptation actions (adapted from Whitney et al. 2017), as well as barriers, opportunities, and knowledge gaps for climate change adaptation. We review the social-ecological context of the area, including background on governance, fisheries management, and climate change impacts. We also describe our collaborative research methods and results based on semistructured interviews with community members and an iterative review process with the coauthor team and project partners. Our results are intended to inform adaptation strategies and highlight ways in which climate change adaptation planning could align with governance transformation to promote reconciliation with Indigenous peoples.

SOCIAL-ECOLOGICAL BACKGROUND

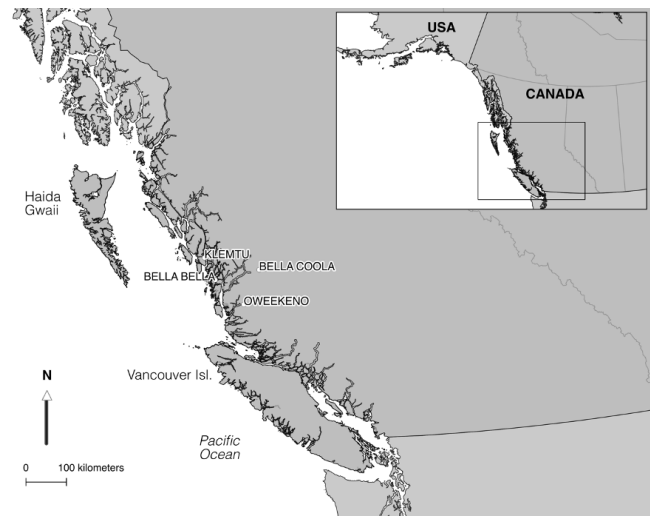
Coastal Indigenous peoples of the Central Coast of British Columbia, Canada

The Heiltsuk, Kitasoo/Xai'xais, Nuxalk, and Wuikinuxv Nations live in communities ranging in population from approximately 80 to 1500 people (Fig. 1). Each Nation has its own dialect as part of three discrete language families (Gessner et al. 2014), which reflects their diverse cultures. Despite impacts from colonization and access to store-bought foods, these First Nations continue to depend upon the land and ocean for food security, trade, and cultural connection, harvesting and preserving food resources that include herring (*Clupea pallasii*), salmon (*Oncorhynchus* spp.), halibut (*Hippoglossus stenolepis*), herring eggs (i.e., roe on kelp), eulachon (*Thaleichthys pacificus*), seaweeds, and many others (Turner 2003, White 2011, Jackley et al. 2016, Gauvreau et al. 2017). Daily life and culture, including language, ceremony, and stories, has revolved around the harvesting of these resources for thousands of years and continues to do so in a modern context (Frid et al. 2016, Gauvreau et al. 2017, Ban et al. 2019, Beveridge et al. 2020)

Overall, marine governance and management of marine resources along the BC coast has been shaped by colonization over the past century (Jones et al. 2004, Ommer 2007). Prior to colonization, First Nations managed both terrestrial and marine areas using well developed methods of stewardship that were embodied in

social, cultural, and economic practices (Trosper 2003, Johnsen 2009). At the turn of the century, growing settler populations and their open access resource extraction practices began to override Indigenous laws and practices for resource management. At the time, the criminalization of traditional Indigenous management practices, e.g., banning of potlaches and Indigenous fishing methods such as weirs and traps (Jones et al. 2004) co-occurred with the rise of commercial fisheries and the ensuing and precipitous declines of marine species (Ommer 2007, Berkes 2015), including cultural keystone species such as salmon (Garibaldi and Turner 2004) and eulachon (Hilland 2013). Systematic privatization of fishing rights and access, combined with federal decision making and enforcement, diminished access to local resources for many coastal Indigenous peoples (Ommer 2007, Turner et al. 2008, Healey 2009, Berkes 2015). The legacy of these policies affected the well-being of First Nations, with lasting impacts on individual and community knowledge, stewardship practices, and culture (Truth and Reconciliation Commission of Canada 2015).

Fig. 1. The study region encompassing the four First Nations we worked with: Heiltsuk (Bella Bella), Kitasoo/Xai'xais (Klemtu), Nuxalk (Bella Coola), and Wuikinuxv (Oweekeno). Names within parentheses in this caption are the present day main communities of each Nation.



Current federal management of marine fisheries is under the jurisdiction of Fisheries and Oceans Canada (DFO). This federal agency also is responsible for scientific monitoring and research and for determining allocation for capture fisheries and aquaculture operations. Meanwhile, Central Coast First Nations have maintained their own Indigenous laws and management practices, and are in the process of reasserting jurisdiction by actively managing fisheries (Government of Canada 2019, Coastal First Nations Great Bear Initiative 2019), informed by living in place for thousands of years (Brown and Brown 2009, Johnsen 2009, Hilland 2013, Kirby and Kotaska 2018).

Climate change impacts

Along the BC coast, ocean temperatures are warming, and inshore waters are becoming less oxygenated, less salinized, and more acidic (Chandler et al. 2017). These changing ocean

conditions are contributing to northward shifts in the distribution of species attempting to track their ecological niche (Ainsworth et al. 2011, Okey et al. 2014, Cheung et al. 2015). Marine fish and invertebrates important to First Nations are projected to decline by up to 64% by 2050 under the IPCC high emissions scenario (Representative Concentration Pathway [RCP] 8.5; Weatherdon et al. 2016). The five anadromous salmon species, which collectively are a staple for First Nations, are projected to decline by 12.1–46.8% by 2050 under RCP 8.5 (Weatherdon et al. 2016), which may severely affect First Nations access to essential nutrients (Marushka et al. 2018).

METHODS

Research development

This research was interview-based and codeveloped over a year and a half by three non-Indigenous authors (CKW, AF, NB) from academia and CCIRA and four Indigenous authors from Central Coast First Nations (PS, BE, JW, IS). Additionally, stewardship directors from each of the four First Nations provided guidance prior to and during the interview phase. The research objectives, interview guide, and adaptation actions were developed among the author team with feedback from CCIRA and partner First Nations. The interview questions also were informed by a recent review of recommended actions for increasing adaptive capacity in coastal communities (Whitney et al. 2017). Community approval as well as approval from CCIRA was granted to CKW and NCB in advance of conducting interviews (in addition to university ethics approval).

Interview methodology

We carried out individual semistructured interviews with community members from four partner First Nations. Semistructured interviews allowed for spontaneous dialogue and insights that might not emerge during a more structured approach (Huntington 2000), and drew on the participants' values and perceptions of climate impacts derived from those values (Wolf et al. 2013). We framed climate change impacts as changes in marine species distributions and availability and, using dialogue and printed index cards, asked participants for their perspectives on a set of proposed social and ecological adaptation actions that had been developed in consultation with project partners from each First Nation. Additional guiding questions explored perceived barriers, opportunities, and knowledge gaps for developing effective adaptation strategies (see Appendix 1 for the complete semistructured interview guide). During the interviews, which flowed based on each participant's interests and lived experience, we also discussed likely impacts of climate change on marine species ranges (Weatherdon et al. 2016) with implications for Indigenous place-based food security and potential adaptation actions.

In one community (Bella Bella, Heiltsuk First Nation), we held a meeting with the hereditary Chiefs to introduce the project and to identify study participants. Elsewhere, we worked with stewardship staff and a local community liaison to identify participants. Some participants were identified through snowball sampling (suggested by other interviewees). We aimed to interview people across demographics; both men and women were included because they may have different roles and experience within the community in terms of food gathering, harvesting, and

management (stewardship). We completed 50 interviews (39 men and 11 women) between May and August of 2018, including 17 participants in Bella Bella (Heiltsuk Nation), 10 in Klemtu (Kitasoo/Xai'xais Nation), 13 in Bella Coola (Nuxalk Nation), and 10 in Wuikinuxv (Wuikinuxv Nation). Interview participants had experience in at least one of the following activities: (1) commercial fishing, (2) fishing and/or food gathering for food and cultural purposes, (3) traditional food preparation, (4) local governance and management of marine areas.

On average, interviews lasted one hour (range ~30–90 min), depending on the range of dialogue beyond the baseline questions. We describe the participants based on the community rather than the Nation because four participants (8%) were non-First Nations; these people worked for a Nation in a planning capacity, e.g., fisheries manager and community planner, or were included because of their long-standing role in the community. Participant ages ranged from 25 to 85, with an average age of 53; we estimated ages for 19 participants who did not share this information. Not all participants responded to all questions, and therefore sample sizes vary by question.

Positionality statement and limitations

We acknowledge and recognize the inherent positionality that may influence this research. We codesigned the research with the four Nations and CCIRA, and their partnership in this research meant that there was community support. The authors include both Indigenous and non-Indigenous scholars working at local and regional scales, which provided opportunities to share perspectives, experiences, and insights to adaptation planning. The interview process was led by a non-Indigenous scholar (CKW), who dedicated time and capacity to research the high priority issues of climate change adaptation with input from CCIRA and the four Nations. Aiming to understand perspectives of climate change adaptation across a region meant that the lead author could spend only up to two weeks in each community to conduct interviews; ethnography approaches would doubtless reveal a more nuanced understanding of the issues and context (Lyons et al. 2016). In each of the four study locations, she was assisted by Indigenous community liaisons who set up and participated in interviews (if appropriate). The Indigenous coauthors guided the interpretation of interviews and results, using their own lived experiences and insights on colonization, adaptation, and environmental governance.

We asked participants to prioritize adaptation actions for their social-ecological system from an initial list of options (from Whitney et al. 2017) and encouraged them to suggest others. By narrowing the range of actions considered initially, we may have obscured or de-emphasized other strategies (Loring and Hinzman 2018). Because we framed this research on climate change adaptation, we may have unintentionally missed other contextual or historical elements of the implications of governance and environmental change. Traditional harvesting practices, trade relationships, identity, and place-based traditional knowledge of native species are all connected to the land and sea, and thus may have been affected by both contemporary social-ecological drivers of change as well as climate change. Nonetheless, our research provides a first overview of Indigenous perspectives on climate change adaptation in this region.

Analysis

The first author transcribed the recorded interviews completely, including references to humor and dialogue, e.g., laughter, aiming to capture the richness and context of the interview in an intermediate style between true naturalism and denaturalism (Oliver et al. 2005). We initially coded interview responses according to specific semistructured interview questions, e.g., values or adaptation actions, and then coded emergent themes in the overall interviews as a second pass coding process using NVivo 12. For the latter, each theme, or code, was defined in the initial coding, and subcategories were recorded as they arose to allow themes to emerge from the participants rather than from predetermined responses (Thomas 2006). We used descriptive statistics (frequencies) to describe and summarize coarse themes (e.g., values, concerns, and fears ascribed to climate change), and detailed responses (e.g., specific social and adaptation actions, barriers, and knowledge gaps for adaptation). We used R (R Core Team 2018) to visualize adaptation actions across communities in radar plots (using the “ggradar” package; Bion 2016). The key recommendations and ways forward were synthesized from the most common adaptation actions and barriers that were shared by the participants, along with insights from the qualitative coding, perspectives from the authors, and feedback with stewardship staff from the Nations over several feedback calls during analysis and drafting of the manuscript.

Our results include illustrative quotes from interviews. When granted permission, we attribute quotes to the persons who contributed them. Otherwise, quotes are presented as anonymous.

RESULTS

We need to adapt to these changes so that he could say to his kids, “let’s go fishing,” as opposed to saying well, “When I was two my dad took me fishing, but we can’t do that anymore.” Howard Humchitt, Knowledge holder, Heiltsuk Nation

Observations of climate change

All interview participants noted substantial changes in the availability and abundance of traditional marine resources in recent decades. Some participants acknowledged that species declines may also reflect fisheries and aquaculture mismanagement, and therefore climate change was not necessarily the sole driver of change (Quote 1, Appendix 2). Nearly all participants (49 of 50) shared observations of impacts that they attributed to climate change: earlier berry harvests, changing salmon migration timing such that salmon that used to spawn at different times are now spawning at similar times, rapid glacial melt, warmer and drier summers, more intense winter storms, and changing volume and timing of peak river flows (Table 1; Quote 2, 3, Appendix 2). These changes were seen as likely to disrupt and decrease the quality of salmon spawning habitat and also reduce the ability to access and harvest anadromous fish. Some also noted the interconnectedness of ecosystem function and climate change. “Lots [has changed]...! Because everything changes around the climate ... that cycle is out of line now, because of the climate” (Crystal Tallio, Marine Use Committee Member, Nuxalk Nation).

More than half (62%) of participants stated the importance of spending time on the water and land as the primary value in their way of life, particularly with a focus on food harvesting (Table 2).

“In our way of life? Oh, the food...” (Hrwana [Eleanor Schooner], Elder, Nuxalk Nation). Younger participants shared that it is important to them to connect with their territory; as Charles Saunders (mid-20s Guardian Watchman, Nuxalk Nation) stated: “I just like being out on the land. Don’t have to worry about much, where you are going, or what you are doing.”

On the outer coast communities (Bella Bella, Klemtu) some participants noted that they now travel further north to access fish than in previous decades (Table 3). Many noted the impacts on their abilities to harvest (Table 3; Quote 4, 5 in Appendix 2). Concerns about the impacts of environmental change on social and cultural values were apparent throughout the interviews (Table 4). Many participants shared themes of cultural loss, as climate change impacts have already affected the seasonality and location of important food species, and how future changes in marine resources will further impact the ability of elders to pass on traditional knowledge (Table 4; Quote 6 in Appendix 2). The changing biocultural relationship between First Nations and their traditional territory was also a concern for participants as a harbinger of cultural loss (Table 4; Quote 7 in Appendix 2).

Adaptation actions for ecological and social systems

Many participants wanted to discuss climate change impacts and develop community-based strategies to manage those impacts. For instance, some commented that “It’s good that this research is happening,” and “We never talk about these things ... We need to, and this project is the beginning.” Several participants highlighted that particular actions cannot be implemented in isolation but must be part of a broader governance transformation. “At the end of the day, we have to find balance. There’s a very unbalanced ecosystem right now” (Kelly Brown, Stewardship Director, Heiltsuk Nation).

Participants had diverse opinions about the adaptation actions that we proposed, and many participants selected many actions rather than a single leading action. Perspectives on specific ecological and social adaptation action varied by First Nation (Fig. 2), which illustrates the diverse perspectives and context across the region. Across Nations, the primary ecological adaptation action identified was to improve fisheries management (44% of participants identified this as the most important action, n = 48 responded; Fig. 3), followed by the development of regional forums for education and training opportunities to support stewardship and monitoring practices among communities (23% of participants). A Guardian Watchman (member of the First Nations monitoring and stewardship program) from the Nuxalk Nation explained how monitoring practices within and among communities could be improved.

We are the frontline workers, and we have to notify our community with what’s going on and what resources we have.... I think we need a big reminder, tomorrow things could happen, and then we will get the blame, I think anyway, and that’s why we have to notify the community we see every day and have meetings every month or every two months. (Roger Harris, Guardian Watchman, Nuxalk)

Few participants considered marine protected areas (MPAs), ecosystem-based management (EBM), or developing and using more climate change projections in management to be priority actions. However, several participants seemed interested in MPAs if they were managed for, and/or by Indigenous peoples. For

Table 1. Perceived climate impacts on the marine and coastal environment. Quotes without direct attributions are anonymous.

Perceived climate impact	Main concerns	Representative quote
Milder temperatures	Human health Salmon spawning success Berry quality	<i>Well, you look at the winters now, it's so warm now. There's no winters anymore. That's when you could tell when the fish are going to come, it freezes up solid you know, water and everything protects the fish. No other animal can get at them, like... everything's for a reason. Now those reasons are taken away by man made errors.</i> (Cecil Moody, Elder, Nuxalk Nation)
Less snow, glacial retreat	Summer drought and fire hazard Glacial retreat	<i>...when I was younger, we never used to have water shortages here. You know, the rainforest, living in the summer, it would rain right through... it's just going to start staying dry until September.</i> (Justin Neasloss, Hereditary Chief, Kitasoo/Xai'xais Nation) <i>With all those glaciers gone that used to be up and down our valley and all the way to ... out to the open sea ... It's just not cold anymore.</i> (Jason Moody, Fish & Wildlife Coordinator, Nuxalk Nation)
	Reduced river flows for local hydropower generation (mitigation efforts) Reduced river flows for spawning salmon	<i>...forest fire is a concern, and, I guess for me, the biggest one ... is all about infrastructure, and the biggest thing is our hydropower, because I've seen over the past five years where we've actually got into a low water situation three times now, two times during the summer, once in the winter. I never thought we would see low water, this was during the winter but then again we were used to colder weather during the winter in the past, but it has always been so mild over the course of the past, maybe 20 years ...</i> (Darren Edgar, Executive Director, Band Office, Kitasoo/Xai'xais Nation)
Changing seasonality	Shorter harvesting season Unpredictable harvesting season	<i>Sometimes you'll have herring spawns that are early or late, you know, a couple of years ago we didn't have seaweed at all ... Now this year we're harvesting seaweed while the herring are spawning ... nobody's ever done that. You know, so I think about impacts ... climate change [is] impacting the timing of when we're harvesting ... our people relied really heavily on things like the moon ... the size of the moon to help you know and predict when things like the herring were going to spawn ... those things are shifting.</i> (William Housty, Hereditary Chief, Heiltsuk Nation) <i>Probably one of the biggest things is the trends of resources that are available ... they are so unpredictable now. For seaweed ... for herring ... for salmon returns ... a lot of these have changed in the last at least five years.</i> (Kelly Brown, Stewardship Director, Heiltsuk Nation)
Increasingly intense storms	Increased risk while traveling or fishing from a vessel Inability to leave the village to purchase foods/supplies	<i>... it seems like between the spaces, between one storm and the next, it's shrinking.</i> (Peter Siwallace, marine use planner and Hereditary Chief, Nuxalk Nation) <i>We are noticing more and more that the winds are picking up more in the summer time and less in the winter time. It still blows in the winter time, but I've seen it ... I've seen it where it's more rough in the summer time than in the winter time now. There's climate change, definitely.</i> (Wally Webber, Hereditary and Elected Chief, Nuxalk Nation)
More marine invasive species	Impacts to native species Disgust/disinterest in harvesting invasive species	<i>Yeah, certain different species, so many different fish that aren't native to here. They are showing up more and more in the past years, and we've talked about El Nino, but even in the off years, they are showing up anyway.</i> (Fisher, Heiltsuk Nation) <i>Well, I'm really concerned about the, you know, the green crab. I think that's gonna affect a lot of our, you know, ceremonial and traditional food gathering, yeah ... because they say it's very invasive...</i> (Teacher, Heiltsuk Nation)
Algae blooms	Interference with fishing Fear/concern about impact on fish	<i>... it's just terrible. Other times I would be fishing with my net and would pick up so much as plankton and algae, you couldn't get any fish with it. Not at all.</i> (Stu Humchitt, Fisher, Heiltsuk Nation)

example, Randy Carpenter (Guardian Watchman, Heiltsuk Nation) stated: “I think they should be starting to close down some areas, just for food fish only.” Others expressed the inadequacy of current compliance monitoring and enforcement efforts for protected areas (Quote 8 in Appendix 2).

For 38% of participants (n = 47) the priority social adaptation action was to strengthen social networks, community groups, and intergenerational knowledge sharing. Other leading priorities were stronger Indigenous governance (self-determination; 19% of participants), and more Indigenous participation in regional and higher scales of management and decision making (19%). Frank Johnson (Elder, Wuikinuxv Nation) highlighted that, “It should be the other way around. Adapt their culture into ours, not ours into theirs.” Some participants prioritized community infrastructure improvements in preparation for sea level rise (13% of interviewees), and a need to develop alternative careers and economies (11% of interviewees). As Jennifer Walkus (Council member/Community leader, Wuikinuxv Nation) shared, “the only thing I can think of is if we start trying to push politically to try and make the changes to slow it [climate change] down, but

we also need to prepare for the worst because I think it will come at some point.”

Fig. 2. Radar plots describing the different primary social (left) and ecological (right) adaptation actions identified by participants in the four First Nations (Heiltsuk, Kitasoo/Xai'xais, Nuxalk, Wuikinuxv). Adaptation strategies are the same as those listed in Table 4. FN: First Nation; EBM: ecosystem-based management; MPAs: marine protected areas.

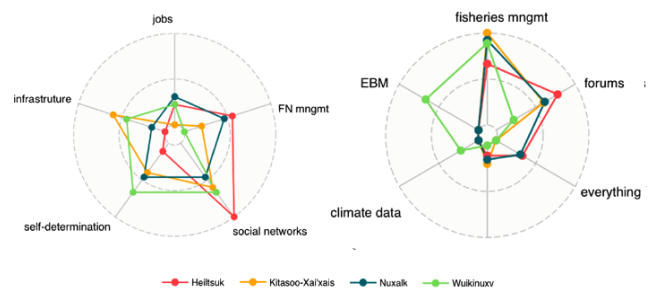


Table 2. Values related to participants' ways of life. Quotes without direct attributions are anonymous.

Value	Expression	Representative quote
Identity	Food sustenance	... food harvesting is a big part of our culture. Language, ceremony ... Those are all cornerstones of our culture and that's what makes us Heiltsuk people, being able to do those things. (William Housty, Hereditary Chief, Heiltsuk Nation) It'll probably have to be the food that we get out in the sea and the land. You can live off there. I could eat fish every day if I can. (Rick Neasloss Sr., Fisher, Kitasoo/Xai'xais Nation)
	Knowledge of the Land	Salmon. I never tire of eating it. (Peter Siwallace, Marine Use Planner and Hereditary Chief, Nuxalk Nation) My whole sense of identity comes from the territory and my connection to it and my ability to be out on it and to be able to understand and predict my reactions to it. And I think that's where a lot of the fear and uncertainty for people comes in, is that you can't predict anymore what your relationship will be. (Councillor, Heiltsuk Nation)
	Sense of belonging	I value my way of life, being able to eat my fish, my foods, and to continue our trading ... The work I need to be able to do as a Stalm'tc, as a hereditary chief ... (Rhonda Sandoval, Hereditary Chief, Nuxalk Nation) I am who I am, I'm Nuxalkmc. I value that now. Not not only that. You think of a white man. He's only got one name. One last name. Me? I've got a name that's got a story behind it, I can say that I have a name, a story behind my name. (Cecil Moody, Elder, Nuxalk Nation)
Tradition	Connection to ancestors	I think everything starts and ends with the water and the land. So for me it's everything is tied into it. Whether you look at our complex social hierarchies we've had prior to colonization, to our stories, our creation stories for placing geographical areas ... so that's what it means to be place-based peoples. (Saul Brown, Reconciliation Negotiator, Heiltsuk Nation) The teachings, the information that was passed down. Really thankful for being able to have the knowledge to preserve food, salmon, and wild meats. (Ernie Tallio, Guardian Watchman, Nuxalk Nation) What do I value about my life? My spiritual place and the people that raised me ... and family. (Derik Snow, Fisher, Nuxalk Nation)
	Intergenerational responsibility	Values? Protecting the resources for my kids and my grandkids. So ... my values is protection of the future. (Roger Harris, Guardian Watchman, Nuxalk Nation) I have to say the ocean has a lot to do with that, but not only that, the protection of our land and the areas we live in. Taking care of sensitive, cultural areas, to conserving fishing areas that need being ... if you see stocks are low, start conserving in areas, so they are not lost for the future generations. (Justin Neasloss, Hereditary Chief, Kitasoo/Xai'xais Nation)
Freedom	Access to the land/ocean	I feel like it is hard to explain sometimes, because things like this seems so obvious to me, and to say yeah, the ocean has always been part of my life. It's right there. (Des Lawson, ReLaw Project, Heiltsuk Nation) Just living here, is something. I mean ... Keeps you alive, I guess. Connection with the earth. Basically. (Frank Johnson, Elder, Wuikinuxv Nation)

Figure 3. Adaptation strategies, descriptive icons used during interviews, detailed explanations, and proportions who selected certain actions as the primary effective adaptation strategy (48 participants spoke to the topic of ecological adaptation strategies, and 47 to the question of social adaptation strategies.) EBM: ecosystem-based management. Icons courtesy of <https://thenounproject.com/>.

Adaptation strategy	Adaptation action	Detailed explanation	Primary action
Social adaptation actions		Strengthen social networks and community groups; support intergenerational knowledge sharing	18/47 or 38%
		Encourage more Indigenous participation and engagement in regional/higher level management and decision making	9/47 or 19%
		Support stronger local governance (community/First Nation)	9/47 or 19%
		Community infrastructure improvements (particularly in preparation for sea level rise)	6/47 or 13%
		Develop alternative livelihoods e.g., help people to change careers away from fishing	5/47 or 11%
Ecological adaptation actions		Avoid fisheries overexploitation, promote better fisheries management	21/48 or 44%
		Develop regional forums, education, and training opportunities to support stewardship/monitoring practices among communities	15/48 or 23%
		Develop better networks of marine protected areas	3/48 or 6%
		Take an ecosystem-based approach to fisheries management / EBM (manage for population, species, and ecosystem diversity)	3/48 or 6%
		Use more climate change projections into stewardship decisions	1/48 or 2%
		It's all connected – All of the above are needed (everything)	5/48 or 10%

Emergent themes

Four additional actions emerged unprompted from the inductive coding of the interviews beyond the adaptation actions we asked about, along with some potential implementation strategies that have particular relevance both across scales and at certain scales of governance and management, e.g., federal and provincial governance, regional organizations such as CCIRA, First Nations governance (Fig. 4).

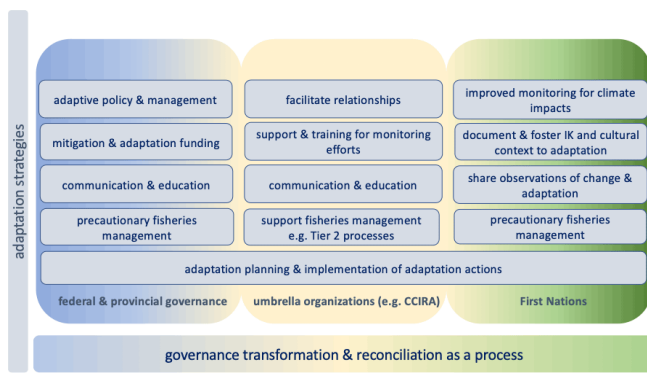
Strengthening Indigenous governance autonomy and authority

When discussing barriers for climate change adaptation, participants spoke to issues of self-determination, governance, and capacity for First Nations and Indigenous knowledge to influence decision making (38% of participants mention this unprompted, n = 47; Quote 9 in Appendix 2). “Our inability to be legitimized as knowledge keepers is a big factor ... Until they [Crown Government] understand the legitimacy and the importance of traditional knowledge, then we’re going to continue to have this struggle. I don’t have any answers except to say it’s really frustrating” (Councillor, Heiltsuk Nation). The social impacts of colonialism reduced Indigenous autonomy and self-reliance over several generations; recovery will not happen overnight. The legacy of colonialism from the federal government was something that some participants (14% of participants, unprompted) spoke to directly as something that must shift in order to enable efforts for climate change adaptation (Table 5, Quote #1).

Table 3. Perceived consequences on participants’ way of life from climate change impacts on the marine and coastal ecosystem. Quotes without direct attributions are anonymous.

Perceived climate impact	Consequence	Representative quote
Lower fish/seaweed abundance	Farther travel to fish	<i>Some families will target other species, and some guys, myself included will go further... getting to the [fishing] spot and then moving around and finding the fish out there, and spending the whole day of fishing out there, I'm looking at a 100-mile day, where a 100-mile day was nowhere near what we would ever even imagine growing up ... that would be at most a 60-mile day, if not less. Yeah, so access to plentiful amounts is definitely getting further away from the village.</i> (Howard Humchitt, Knowledge holder, Heiltsuk Nation)
	Reduced catch rates	<i>I do think oolichan was an early harbinger of climate change. Because there's next to no oolichan.</i> (Jennifer Walkus, Community Leader and Researcher, Wuikinuxv Nation)
Social impacts	Less sharing within community Less resources available to share & trade	<i>Everything is getting harder to get as time changes, climate change. Slow coming.</i> (Murray Barton, Knowledge holder, Kitasoo/Xai'xais Nation)
	Fishers taking more risks	<i>Yeah... so I don't know if that has to do with climate change, or if it's being overfished, or if people just aren't sharing anymore. But that's definitely another pattern that I see that has changed.</i> (Teacher, Heiltsuk Nation)
	People shifting away from fishing	<i>It's terrible, we're having to travel further and that's at a higher risk to harvest the things that are necessary to us. That's a big concern of mine.</i> (Travis Hall, Marine Use Planner, Heiltsuk Nation)
	Fear about natural hazards (e.g., forest fires)	<i>I don't really know much about fishing, but from what I'm picking up these past few years, it's really declining. That's one of the reasons why my mom kept me on land.</i> (Charles Saunders, Guardian Watchman, Nuxalk Nation)
		<i>... the way the weather is now, lightning can touch off a real forest fire here, and we're far from being equipped to do anything about it ... We will sit in our boats and watch the forest burn, if that's what happens, you know ...</i> (Darren Edgar, Executive Director, Band Office, Kitasoo/Xai'xais Nation)

Fig. 4. Adaptation actions that emerged from these interviews across scales, from federal and provincial governance, to regional umbrella organizations, to First Nations governance. Throughout, reconciliation and governance transformation are processes that all scales can work toward. IK: Indigenous knowledge; CCIRA: Central Coast Indigenous Resource Alliance.



Most participants (80%) shared long standing frustration with federal and provincial governments in the context of fisheries management and climate change adaptation. “All this stuff [marine resources], it’s just totally mismanaged. Totally. This is

why I say they’re trying to wipe the Native people out ... A silent wake” (Cecil Moody, Elder, Nuxalk Nation). Nuxalk Elder Hrwana (Eleanor Schooner) explained her perception of the Federal government’s suppression of First Nations leadership: “We have to have a voice. We have to have concern.” However, many people we spoke with (52%, n = 50) expressed hope for either cultural revitalization, the potential to adapt to new food species, the ability of their community to work together for climate change mitigation, or a combination of those possibilities. “On that front we’ve tried to change it, with our hydro where we’re trying to change to more clean energy, trying to get away from the fuels, the fossil fuels” (Darren Edgar, Kitasoo/ Xai'xais Nation). Although the legacy of colonialism and the ongoing efforts to revitalize culture were a main focus, some participants framed the future in a positive light, highlighting that Indigenous peoples and knowledges will continue to adapt to a changing climate.

Like I said, our people are really adaptable. ... It's been since time immemorial where people have amended their way of life to the resources that are coming ... and making a part, an intricate part of who we are as a people, and that's what's been built over time ... I think different resources that are coming here, the exotic species that enter our waters, definitely our people would consider utilizing those resources ... I mean, that's, that's the kind of stuff that our people adapt to very quickly. (Kelly Brown, Heiltsuk Nation)

Table 4. Perceived concerns and fears related to climate change in terms of values and ways of life. IK = Indigenous Knowledge.

Value	Concern	Representative quote
Tradition	Food insecurity	<i>With the changes, and if it continues the same way, maybe there's just going to be no harvestable food in the ocean. It won't be a reliable way to feed our families anymore, if it continues.</i> (Justin Neasloss, Hereditary Chief, Kitasoo/Xai'xais Nation) <i>The temperatures changing, that's our concern because it's going to affect our wild salmon.</i> (Roger Harris, Guardian Watchman, Nuxalk Nation) <i>It makes my stomach turn to think about whether or not we will never have salmon come back here. That's hard for me to contemplate. You know, that that would ever happen. It may not be in my lifetime, but it might happen in somebody else's lifetime. That's scary.</i> (Kelly Brown, Stewardship Director, Heiltsuk Nation)
Identity	Cultural loss	<i>If they don't look after it [local resources, especially salmon] now, they'll [the community] have a tough time later on. That welfare gets cut off. And I see that day coming ... It will be pretty damn tough.</i> (Cecil Moody, Elder, Nuxalk Nation)
	Loss of IK	<i>When I look at our mountains and I see no snow, I wonder what's going to happen to us..."</i> (Hrwana, Elder, Nuxalk Nation) <i>So I asked my grandfather and he was telling me ... you got to be careful because there's a lot of things changing so fast, I don't recognize it. Which is very fearful because our institutions of knowledge may not be able to adapt quickly enough to the climate change. So that's the first thing that comes to mind.</i> (Saul Brown, Reconciliation Negotiator, Heiltsuk Nation)
	Changing access	<i>... we're looking through a pinhole in the wall at our territory and that's all we can see; and all these fishing lodges and stuff have full access. They can go wherever but we're just stuck looking through the little hole in our territory ... We have to look through this little hole, and we have to take turns walking up to this little hole and that's what the SEAS program and stuff is, that's the little hole we look through.</i> (Charles Saunders, Guardian Watchman, Nuxalk)
	Changes in biocultural relationship	<i>It's like the plains people when they lost the buffalo. If we lose herring, we lose a major part of who we are.</i> (Saul Brown, Reconciliation Negotiator, Heiltsuk Nation)

Trade and knowledge sharing as adaptation

While Indigenous communities have always adapted to environmental change, participants expressed concern and uncertainty about how they will adapt to rapid climate change impacts on their coastal culture. Participants identified opportunities for developing adaptation actions and practices, including increasing capacity within and among these First Nations to understand and act on climate change adaptation (Quote #2, Table 5). They also spoke to the need to develop avenues for sharing harvests to mitigate declines in the abundance and distribution of traditional foods, as few participants (29%, of 41 responses) thought that fishers would travel further north to track the redistribution of target species (Quotes 11 and 12 in Appendix 2). The reasons included access restrictions such as fuel costs, lack of fishing vessels, territorial boundaries among First Nations (Quote 13, Appendix 2), and lack of institutional support for adaptive management of area-based commercial fishing licensing. Sharing or trading fisheries resources could be part of the solution to changing access to marine food species. As Jennifer Walkus (Council member/Community leader, Wuikinuxv Nation) explained, "...trading for what we need has always been a part of First Nations culture and I think that'll continue." Some participants shared that increasing trade among First Nations might be an adaptive response to access traditional foods as marine species shift north: "Just have to go further for it, or trade for it, eh?" (Rick Neasloss Sr., Fisher, Kitasoo/Xai'xais Nation). Other participants highlighted that existing trade relationships are based on traditional food species, not novel ones; of the participants who responded (n = 42), 62% thought that trade will likely decline as traditional foods decline. This potential impact of climate change will affect more than just food availability, as trade relationships are tied to marriage, management, and inter-Nation politics (see Quotes 14 and 15 in Appendix 2).

As traditionally available food species shift north, novel species, which some participants called "invasive," will be more readily available near communities. Some people said, "we will adapt" and harvest other species "within reason" (39% of 41 responses; Quote 19 in Appendix 2). Others (22%), however, thought they

would not target novel species, resulting in lower marine harvests; reasons included disinterest and disgust in novel species, although some respondents suggested that education around harvesting and preparation of novel species might influence people's decision to harvest such species.

Adaptive comanagement among governance scales

Nearly half the participants (49% of 45 responses) thought that First Nations local governance was the most effective governance scale for adaptation planning and decision making: "I think it would be your local government because people back east, they don't grasp what's happening out here" (Alex Chartrand, Wuikinuxv Nation). Prior to colonization, community-wide stewardship practices included managing how people use and access resources within each First Nation's territory in the long term, as depicted in traditional use agreements among neighboring First Nations. These self-sufficient community-based stewardship practices were reflected in the participants' perspectives of the importance of environmental monitoring and marine management for climate change adaptation (Quotes #3-5, Table 5; Quote 16 in Appendix 2).

Participants highlighted challenges caused by competing interests and industries that have affected Indigenous access to their territories and harvesting rights (Table 3) and a need for collaboration if climate change adaptation is to be effective: "I think comanagement is the way governments have to go ... All governments have to learn, if you can listen to First Nations of the world, you'll be in a better place, but if you try to do it all on your own, you'll screw up supremely. You can't dig yourself out of it" (Wally Webber, Elected & Hereditary Chief, Nuxalk).

Education platforms for climate impacts and adaptive strategies

Participants highlighted the need for more education and communication about climate change (Quotes #6-7, Fig. 3). They suggested sharing platforms to educate community members as to how climate change is affecting Indigenous peoples around the world, thereby broadening perspectives (Quotes #8-10; Table 5). This sentiment of self-reliance and the need for proactive planning

Table 5. Adaptation actions suggested by interview participants for particular scales of management and priority adaptation themes.

Adaptation theme	Specific adaptation action	Scale/responsibility	Representative quote
Strengthening Indigenous governance autonomy and authority		Community Regional National	#1: <i>So, I think the biggest barrier honestly is the colonial legacy. And so that's, you know, the language ... state sponsored residential schools, church sponsored residential schools, attacking of our knowledge systems and the intergenerational transfer of knowledge ... the removal and dispossession of our land and waters, and basically putting us on these tiny reserves, relegating us to reserves and then the whole racist narrative of who and what Indigenous people are ... and how that ties into climate change is because as the climate changes, scientists are finally starting to validate [Indigenous knowledge]. But that was all put at risk through colonization and so I think that's the biggest barrier right now and going forward, is reconstituting ourselves and then ... putting the land and the water at the forefront of all that decision making ... And I think, so that's a major barrier too, is not understanding the interconnectedness that, again goes to that legacy of colonization. And we're too busy fighting to be recognized as peoples and to have our knowledge validated that we're not actually meaningfully contributing as much as we could be to the systems and solutions that be. We have a lot to offer but oftentimes we're fighting just to assert our rights to be ... we have to go to court to prove our existence. That's where we start, prior use and occupancy ... custom areas to fish ... instead of actually trying to inform solutions in the greater Canadian society because at the very brink of it, that's what we're fighting against. (Saul Brown, Reconciliation Negotiator, Heiltsuk Nation)</i>
Promote knowledge sharing for adaptation practices within and among communities	Support IK and cultural insights into climate change impacts and adaptation	Community National	#2: <i>I think that will likely be really important to engage with the community on climate change adaptation in general, is helping them to understand it in a very cultural context because that's where people's understanding of the territory comes from. Our whole language and our calendar and the names for different things are tied to the things that we harvest in the places that we go. So much of how people see the marine and terrestrial territory is lived through the language and the culture. So, I think that cultural context will be important in giving people a sense of security that will be helpful. (Councillor, Heiltsuk Nation)</i>
Promote adaptive comanagement among governance scales	Increased monitoring for climate change impacts and perceptions	Community Regional	#3: <i>Okay, in regard to the ocean, I think there should be more monitoring, more studies like what you guys are doing now, that's a good thing. So that everybody is aware of what is going on here in the territory. And then it helps us regulate, like for instance this year there was less salmon so we should probably intervene and say no fishing or no overfishing. (George Johnson, Hereditary Chief and Elder, Wuikinuxv Nation)</i> #4: <i>If we don't have the salmon, we're not a people, because we are the salmon people. So we have to monitor what's going on around this world and keep reminding people of what's going on. (Derik Snow, Fisher, Nuxalk Nation)</i>
	More collaboration in climate change research	Community Regional National Academia	#5: <i>Probably having more conversations with science and knowledge holders here, in identifying what the trends have been, and affirming what our people are seeing... We don't do that enough... I think we should collaborate more, have Heiltsuk more involved in the research that's taking place." (Kelly Brown, Stewardship Director, Heiltsuk Nation)</i>
Develop learning platforms for climate impacts and adaptive strategies	Increase discussion within and among communities of climate change impacts and adaptation	Community Regional	#6: <i>There are a lot of people here that bark about, climate change and climate change, but there is nobody here that knows a lot about it. (Peter Johnson, Knowledge holder, Wuikinuxv Nation).</i> #7: <i>Yeah, it's be good to get more conversation about this ... Trying to adjust. Trying to adjust to the way things are, versus what they used to be... (George Johnson, Elder, Wuikinuxv Nation)</i> #8: <i>Well I think right now the education part of it is super important, so engaging with youth and school-age kids and elders, the in between people is important too. I think that would be a really good next step is to provide that education and get people talking and get people motivated to do something about what's going on. (Des Lawson, Relaw Project, Heiltsuk Nation)</i> #9: <i>To me, it would be education and communication, because what we do is affecting everything else around us, and a lot of our young people they don't care or they're just not involved. Having that scientific knowledge behind that when you're educating one community would be very good ... It would be something to know what's going on around the world, globally, and it's not just Bella Coola ... I think that's what should be implemented here, but I don't know if it would work everywhere else. (Crystal Tallio, Marine Use Committee, Nuxalk Nation)</i>
	Share research with community members		#10: <i>With [CCIRA, they] do lots of camera shots, video shots. It would be nice to get that into a slide show presentation for each community along the coast, and see what changes happen since they started ... So it will be nice to share that for each community that they worked in and show the changes since they have started. I think that would be a start. I think that would open their community's eyes. (Roger Harris, Guardian Watchman, Nuxalk Nation)</i>

(con'd)

Facilitated discussions about climate change and adaptation with community members	Community	#11: <i>Getting it from the actual stewardship department out to the people. Newsletters are good ... but other than that, actually having to go out and talk to these people, one on one, that works better, and that doesn't get done all the time right ... It's better if people go out and talk to them. Pressing on how important it is, and not just sending a newsletter out saying, here, change! So, it's just better to talk, like right now, one on one, talking back and forth, you're writing stuff down. It just seems better, they would be able to convey their feelings better rather than just on a piece of paper. The people getting interviewed would see the importance on it, rather than just ok it's just another piece of paper.</i> (Alex Chartrand, Wuikinuxv Nation) #12: <i>Yeah. I think it's to get our people to realize like, this is happening and it's happening. We might be in this little pocket of paradise here, but it is going to affect us to a great extent too, if we can try to slow it down in any way we can, you know, the sun isn't going to help us. Just keeps getting hotter and hotter! We live in a rainforest, we need rain.</i> (Crystal Tallio, Marine Use Committee, Nuxalk Nation) #13: <i>with I guess all species of everything, learning how to harvest, something different, whether it be clams or crabs or other types of fish.</i> (Fisher, Heiltsuk Nation)
Education on harvesting practices for novel species	Community	#14: <i>...people can go out to see how's its done....Then, once they... the people who harvest, and then maybe throughout the years, building up, refining the new way of fishing or harvesting, whatever it is, then they'd start taking people out, this is how we are doing it ... almost start over again, like we do with the fishing now, got to start passing it on, passing it onto other people, so they know the ways to catch them [new species] too...</i> (Justin Neasloss, Hereditary Chief, Kitasoo/Xai'xais)
Proactive planning on climate change adaptation	Region	#15: <i>I think with respect to adapting, it would be to have that kind of detailed conversation around what's expected. I mean, I think that some people have some ideas of what's expected in certain areas. It's going to get hotter, it's going to, species range are going to shift. But that's probably the extent of a number of people. As far as the details of how it's going to pan out. You know if they could, and First Nations up and down this coast in general, get a better handle as to what would reasonably expected about species range shifts, and lead that into sort of an economic conversation rather than sort of a big depression ...</i>
Investments in alternative livelihoods (e.g., shellfish aquaculture)		<i>You know here's an opportunity ... and shellfish is definitely one of those for sure. I think shellfish is at least you know, outside of more run of the river or whatever, is probably the easiest one to do, because it's something you can bite off. It's like a chunk that you can actually take and do something with.</i> (Dave Rolston, Fisheries manager, Wuikinuxv Nation)

was shared by many who felt that change can come from within the Nation via education, learning, and investment in adaptation strategies. “I think it [adaptation] has to come from the community ... I really believe that people should be empowered to know that they can make, make those changes” (Ernie Tallio, Guardian Watchman, Nuxalk Nation). Others specified that this is something that local stewardship offices should be focusing on more (Quotes #11-12, Table 5; Quote 17 in Appendix 2). Specific education and learning platforms around harvesting novel species and developing alternative livelihoods through mariculture (shellfish aquaculture) were also proposed (Quotes #13-15, Table 5).

DISCUSSION

Across the four First Nations of BC's Central Coast, people are worried about current and projected climate change impact on their communities, expressing consistent frustration with the decline of cultural keystone foods, particularly salmon, and the role of poor fisheries management in that decline; climate change presents further cumulative impacts to marine species. Priority actions that emerged from the perspectives of coastal First Nations included strengthening Indigenous governance, promoting knowledge sharing for adaptation strategies, implementing comanagement of fisheries, and creating education and learning platforms for climate change and adaptation initiatives. Other actions that are often proposed by Western science and management, such as marine protected areas,

ecosystem-based management, or improving the resolution and accuracy of climate projections, were not prioritized. Although these broad themes of cogovernance are reflected in the social-ecological adaptation literature (Whitney et al. 2017), participants expressed the complexity of climate change adaptation in the context of colonialism, and some considered reconciliation a prerequisite to implementing effective adaptation actions for climate change. Legacies from the colonial history of the Canadian government emerged as barriers to proactive climate change adaptation, and participants expressed a strong desire for self-determination and cultural revitalization as related to both management and harvesting practices. This included trade, which has always been an important part of First Nations culture (Brown and Brown 2009, Turner 2016) and continues to be today (Moody 2008). These findings highlight that addressing climate change adaptation requires recognition of the diverse and cumulative challenges facing Indigenous peoples worldwide (Huntington et al. 2019) and provide insights for proactive strategies to support Indigenous ways of life. Maintaining Indigenous peoples' access to traditional lands, waters, and resources is critical to both reconciliation and the adaptive capacity of Canada's Indigenous and coastal communities (Bennett et al. 2018).

A central theme was the importance of Indigenous self-determination in order for First Nations to engage and contribute to climate change adaptation. This colonial legacy persists in

Central Coast First Nations and was previously described by Turner et al. (2008) as an indirect lost opportunity for proactive planning. A lack of trust between governments may limit collaboration on the transformative change necessary to engage in effective climate change adaptation actions. The cumulative impacts of external problems and policies related to colonization have constrained the ability of Indigenous peoples to engage in resource management decision making (Turner et al. 2013). In coastal BC, place-based Indigenous knowledge systems have persevered in many First Nations through cultural revitalization programs (e.g. ReDiscovery youth camps, <http://rediscovery.org/>; Supporting Emerging Aboriginal Stewards [SEAS] program, <http://www.emergingstewards.org/seas-program>). These programs provide hopeful examples of how Indigenous peoples may reclaim self-determination and lead their own adaptation pathways (Turner and Spalding 2013, Eckert et al. 2018, Reid 2019).

Specific climate change adaptation actions included sharing knowledge of traditional harvesting practices and stewardship of traditional territories. First Nations in this area are already seeing the impact of changes that can be attributed to climate change, and in some cases are adapting accordingly. Declining access to seafood was a recurring theme, and participants feared the future loss of food security due to the synergistic effects of climate change and poor fisheries management among other social-ecological phenomena (Cheung et al. 2013, Asch et al. 2018). In many cases, Indigenous people on the Central Coast can no longer travel to harvest marine foods because they have fewer boats or cannot afford the fuel due to economic hardship so have limited access to their traditional territories. Indigenous peoples in this region historically tended landscapes in ways that increased the abundance of traditional foods, including clam gardens, which increase shellfish productivity (Groesbeck et al. 2014, Jackley et al. 2016). Re-establishing such practices could support both food sovereignty and autonomy (Menezes 2001), while helping First Nations engage in place-based monitoring practices, e.g., Gitga'at environmental monitoring (Thompson et al. 2019).

As traditional marine food species shift north with warming ocean temperatures (Weatherdon et al. 2016) and warm adapted species move north into the region, some First Nations may be willing to adapt and develop new harvesting practices applicable to novel species. In contrast to what has been observed in the East Coast fisheries (Young et al. 2019), not all First Nations in the Central Coast have the capacity to travel further north to access target species. Developing learning platforms for harvesting and preparation practices for novel species may be effective as part of adapting to climate change. Globally, human communities have developed novel harvesting and food production practices over millennia, which illustrates the human capacity for both ecological transformation and the potential for human adaptation to ecological change (Boivin et al. 2016). Although non-native or novel species are typically perceived as a negative impact on natural and human systems, reframing this narrative to consider the potential benefits of novel species, including economic, conservation (Schlaepfer et al. 2011), and food security benefits, is an important first step.

Many of the climate change adaptation actions perceived to be effective related to governance and policy changes, including a need for a governance transformation that enables fisheries

comanagement. For example, in BC, salmon fisheries have declined in recent decades, which has in turn affected coastal and Indigenous communities (Turner et al. 2008, Walters et al. 2019); as Cullon (2017:307) explains, “no longer are salmon the basis of well-being for a community... People speak of a fear that their grandchildren will not know a life with salmon.” In recent years, the culture of Canadian federal fisheries management has started to shift toward reconciliation with Indigenous peoples. Examples of this include joint technical working groups between Fisheries & Oceans Canada and First Nations for a variety of species including salmon and crab, perhaps signaling the beginning of a new governance paradigm, and the forthcoming Fisheries Resources Reconciliation Agreement on the North and Central Coast (Government of Canada 2019). Further south, First Nations and DFO have engaged in a lengthy process to develop the Fraser Salmon Management Council, a cogovernance structure for Fraser River salmon management (<https://frasersalmon.ca/>). Also for salmon, the almost 15-year old national Wild Salmon Policy is guided by principles including honoring the importance of salmon to First Nations and including First Nations in salmon governance, management, and conservation (Irvine 2009). Very little progress, has been made to implement these strategies (Price et al. 2017) although an implementation plan was recently developed (Fisheries and Oceans Canada 2018).

The interest in learning and sharing platforms for adaptation strategies by interview participants suggests an opportunity for Indigenous peoples to develop adaptation options across geographies and governance scales. The rapid and recent rate of change, and the enormity of the challenge, may be why education and communication arose so often. Developing visualization tools for climate change and climate change adaptation in Central Coast First Nations could increase awareness and therefore adaptive capacity (e.g., Sheppard et al. 2011). Some of the First Nations collaborating in this project aim to incorporate climate change adaptation into their resource stewardship and management programs. For example, one of the consistent statements from the Heiltsuk community is that “we have always adapted”; “Adapting to Change” is one of the articulated Heiltsuk “Fundamental Truths” (Fundamental Truth #7, Brown and Brown 2009). This perspective is reflected in stories that describe Indigenous resilience through periods of past environmental change, such as floods (Brown and Brown 2009, Horne 2012), past climatic shifts (S. Brown 2018, *personal communication*), and resource decline.

Indigenous communities have adapted to environmental, social, and cultural change for hundreds and thousands of years. Things are different now; change is faster and harvesting success more unpredictable (Turner and Clifton 2009, Fernández-Llamazares et al. 2015). The growing discourse around Indigenous peoples and climate change is uneven by geographic region and population. These differences are influenced by variation in political circumstances, the perceived level of risk (i.e., much focus on the Arctic), and the extent of involvement by Indigenous communities in climate change research and adaptation planning (Ford et al. 2016, Belfer et al. 2017). In a multiyear project across six regions in the southern hemisphere, sharing adaptation responses to shifting species ranges due to climate change revealed insights into cultural values of adaptation, and the value of

participatory methods for developing adaptation strategies (Hobday et al. 2016). Modern management considers only the past several decades, thus obscuring long-term social-ecological trends; in contrast, considering local knowledge, diverse knowledge systems, and longer management time scales in coastal fisheries management may lead to better outcomes that are ecologically sustainable and socially just (Savo et al. 2017, Lee et al. 2019).

Conclusions and future directions

Future work can build on our results in several ways. First, given the key theme of communication that emerged across the four communities, we recommend developing information tools in the format preferred by each community. A potentially useful model developed and tested in Australia uses stepwise “adaptation pathways” to guide coastal communities through adaptation initiatives while including diverse perspectives, complexities, and uncertainties. A key result of this project was that, to be effective, adaptation strategies must consider the complete set of community values (Lin et al. 2017). Second, many interviewees discussed the need to develop locally driven climate change monitoring programs; other communities in coastal BC (Gitga'at First Nation; Thompson et al. 2019) and elsewhere have begun to pursue these types of initiatives (Thompson et al. 2020). Since completing our interview research, climate action coordinators are in the process of being hired across the Coastal First Nations region, including within the Central Coast. Finally, throughout this research we found a clear theme of self-governance and the need for transformative change in management practices in order to support Indigenous peoples in developing their own adaptation actions that are culturally and social-ecologically relevant, with support from other governance scales.

Responses to this article can be read online at:
<https://www.ecologyandsociety.org/issues/responses.php/12027>

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Data Availability:

The data that support the findings of this study may be available on request from the corresponding author, CKW. These data are not publicly available because of agreements with the participants and collaborating First Nations, who have ownership over this information indefinitely as determined by both research agreements with the Nations and CCIRA, as well as university ethics approval. Ethical approval for this research study was granted by the University of Victoria Human Research Ethics Board, #17-252.

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Appendix 1. Semi-structured interview guide

1. What type of job(s) do you typically do?
2. How do you depend on the ocean? For fishing, income, food, other?
3. How much experience do you have in fishing/food gathering? How long have you done it for?
4. What do you value most about your way of life?
5. When you think of climate change, what comes to mind?
6. How do you think these changes are or will affect your way of life?
7. Can you think of some actions you think would be effective for you and your community to adapt to climate change?
8. Which of the following social adaptation actions would be more effective in your community?
 - a. Develop alternative livelihoods (help people to change careers)
 - b. Support stronger local governance
 - c. Community infrastructure improvements
 - d. Strengthen social networks and community groups; support intergenerational knowledge sharing
 - e. More local participation in regional/higher level management and decision making
9. Which of the following ecological adaptation actions are likely to be effective in your community?
 - a. Develop better networks of marine protected areas (MPAs)
 - b. Avoid fisheries over-exploitation
 - c. Use more climate change projections into stewardship decisions
 - d. Develop regional forums, education, and training opportunities to support stewardship/monitoring practices among communities
 - e. Applying ecosystem-based management (EBM) approaches to fisheries
10. How do you think you would respond if climate change were to significantly affect your way of life and access to marine resources?
11. How do you think fishers and food harvesters might respond or adapt to changes in marine resource availability?
12. Generally, how do you think climate change may affect trade between communities/First Nations?
13. Do you feel that your community has the resources to act on climate change/implement adaptation actions?
14. Do you see any barriers to climate change adaptation in your community?
15. What do you think are the knowledge gaps in incorporating climate change adaptation in your community?

Appendix 2: Supplementary Quotes

Observations and impacts of climate change

Quote 1

“We have watched the numbers of some of the salmon decline to nothing... I think climate change has a lot to do with it, but I also think salmon farms...is that part of climate change or part of [fisheries]? or part of both? Who can you blame... Partially you can blame climate change, but I also think a lot of it has to do with the salmon farms that are all spread all over the place...” (Wally Weber, Hereditary and Elected Chief, Nuxalk Nation)

Quote 2

“Berries have been coming later too, not staying around as long. That's what I noticed... Later and they go faster.” (Charles Saunders, Guardian Watchman, Nuxalk Nation)

Quote 3

“You talk to the fishermen here and they will tell you, all the species have started to come in together. It used to be the chinook, chum, and the pinks and then the sockeye and then the coho. Now it's the chum, no, it's the springs, chum, and pinks coming in all at once, with the sockeye. All at once. So it's...getting crazy. The coho, there's the odd coho coming in now, but it's usually a fall fish. Things are getting kinda wacky out there.” (Wally Weber, Hereditary and Elected Chief, Nuxalk Nation)

Quote 4

“I remember when I first moved up here [from Bella Bella], I was able to fill up two boxes with about 30 fish in one morning. It's not like that anymore.” (James Anderson, Fisher, Kitasoo-Xai-xais Nation)

Quote 5

“In 2016, I'm trying to think of the percentage, maybe 2 percent came back [Pyropia seaweed], and that was in living memory. Nobody had ever recalled a time when seaweed didn't come back. You know the Blob is the first time ever, an event such as that was ever recorded. So, I think that's climate change.” (Mike Reid, Fisheries manager, Heiltsuk Nation)

Quote 6

“You know, there's so much knowledge that people have about marine resources and the territory that comes from intergenerational knowledge that's been passed down to them because the rate of change was so slow that from one generation to the next you could pass on your knowledge of where a good fishing spot for certain species is or what time of year you can expect certain things in certain places. And it seems like at a really accelerated pace, that intergenerational knowledge is no longer true. And I think that really leaves people reeling. In a social sense it creates some challenges in terms of relationships with younger generations where you start to feel like you don't have the knowledge to pass down what was passed down to you, which is really hard for folks.” (Councillor, Heiltsuk Nation)

Quote 7

“Well, they say when you look after something for a long time, you take care of it. But look at Mother Earth now, she's withering. She's going downhill. Fast. The reason I'm saying that, is you look up north. The Arctic Circle, how fast it's melting. And even that's... You look at the polar bear, he's looking around, where's the ice? He's starving. Can't find that food, the seal anymore. No ice to go, the way he used to hunt it. That's why I say, you have to look after the economics of your territory. You don't look after that; you're going to be in trouble” (Cecil Moody, Elder, Nuxalk Nation)

Adaptation actions for ecological and social systems

Quote 8

“We should have a stronger say in the MPAs out there. Because the government themselves say, you can't go here, you can't go there. But they let the sport fishermen come in here and they take out so many fish, and then they come over here and say you can't go fishing here. They say that to First Nations people. So that doesn't work. Take a hike, politely.” (Peter Johnson, Knowledge holder, Wuikinuxv Nation)

Priority actions

Quote 9

“And Indigenous knowledge will evolve and adapt as well. So I think that it's just two different ways of relating the world and they can go hand in hand and I think you've got to make space for ours. Inherently make space for ours because we've been pushed to the side and the margins for far too long. And it's on Canadians not Indigenous people to do that.” (Saul Brown, Reconciliation coordinator, Heiltsuk Nation)

Quote 10

I don't think we need more data, to be honest, one of the best things to do is integrate not Indigenous knowledge into the decision-making system, but actually integrate Indigenous knowledge keepers into decision making... Yeah, at the governance level I think you've got to make space for... even before that, make space for Indigenous governance systems to be part of that revitalization, be part of the solution” (Saul Brown, Reconciliation coordinator, Heiltsuk Nation)

Quote 11

“Our people don't go up there [further north to go fishing. If there's no fishing we just stay home...Some, they follow the fish...Not too many though. We don't have good enough boats to go!” (Hrwana, Elder, Nuxalk).

Quote 12

“[As marine species shift north] No, [they'd] just go to the grocery store. It's just too far, expensive. Too far away, too much money in fuel. Believe it or not, our people have forgotten how to live on the ocean...” (Wally Weber, Hereditary and Elected Chief, Nuxalk Nation)

Quote 13

“Well, there is a big understanding, quite an understanding between one band to the next, you don't go into their area, because if you do, they consider you're stealing their fish.” (Elder, Heiltsuk Nation).

Quote 14

“Hopefully I have enough family up north to send me fish!” (Alex Chartrand, Wuikinuxv Nation).

Quote 15

“I mean, it absolutely would [affect trade]. I can't definitively pin any one thing on climate change necessarily but in years when we had bad herring seasons, or really low seaweed growth, it's definitely impacted trade relationships because the things that we have to offer, we suddenly don't have. It's not viable enough to maintain those relationships with what we can harvest. Which means that, for sure, relationships suffer. People diet changes. And for sure, relationships across communities suffer when that happens.” (Councillor, Heiltsuk Nation)

Quote 16

“I mean, we've adapted to everything... We've lost our language, not 100%, we're revitalizing that... but how are we going to manage the resource that's going to leave here because of climate change. And what are our people going to do to shift their culture, their way of life, without... without herring? I mean that would be huge for us. Without salmon... without crab... without prawns... without shellfish? I mean, these things would be a detriment to the culture. So.. we're seeing that every day. We're trying to adapt... to figure out what we can do....if salmon continue to deplete... we have to do something.” (Kelly Brown, Stewardship Director, Heiltsuk Nation)

Quote 17

“I see in our office now that they are really trying to help and come and support things that are going on now, that we should step up and do more. Like yourself coming in and actually talking about it and reminding our Nation about stuff like this. I think it gives them a big reminder for sure about what we should do to protect what we have left. I think they need a reminder; I think anyway. Sometimes they do talk about it, they put it back on the back burner and they forget about it because there are a lot of other projects going on. But this is, I think the main thing that they should be concentrating on.” (Roger Harris, Nuxalk Guardian Watchman).

Quote 18

“I think with respect to adapting, it would be to have that kind of detailed conversation around what's expected. I mean, I think that some people have some ideas of what's expected in certain areas. It's going to get hotter, it's going to, species range are going to shift. But that's probably the extent of a number of people. As far as the details of how it's going to pan out. You know if they could, and First Nations up and down this coast in general, get a better handle as to what

would reasonably expected about species range shifts, and lead that into sort of an economic conversation rather than sort of a big depression. You know here's an opportunity. You know, and shellfish is definitely one of those for sure. I think shellfish is at least you know, outside of more run of the river or whatever, is probably the easiest one to do, because it's something you can bite off. It's like a chunk that you can actually take and do something with. “ (Dave Rolston, Fisheries manager, Wuikinuxv Nation)

Quote 19

“Well we rely on salmon. This whole community does. As the temperatures rise, I think our salmon is going to move up north where it's cooler. And the species down south are gonna come this way. So, we'll probably have to adapt to whatever is coming in, start harvesting it...To what degree I don't know. They might not say they would, but they might...” (Peter Siwallace, Marine Use Planner, Nuxalk Nation).