

**Centering Indigenous governance principles, values,
and objectives to build a just blue economy
decision space**

**by
Sarah B. Gutzmann**

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Name: Sarah B. Gutzmann

Degree: Master of Resource Management

Title: Centering Indigenous governance principles, values, and objectives to build a just blue economy decision space

Committee: **Chair: Cliff Atleo**
(Kam'ayaam/Chachim'multhnii)
Assistant Professor, Resource and Environmental Management

Anne Salomon
Supervisor
Professor, Resource and Environmental Management

Andrés Cisneros-Montemayor
Committee Member
Assistant Professor, Resource and Environmental Management

Danielle Denley
Committee Member
Senior Marine Biologist, BC Ministry of Water, Land and Resource Stewardship

Zoe Todd
Examiner
Associate Professor, Indigenous Studies

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Abstract

Transitioning towards a blue economy globally requires governance processes and management strategies that reflect local knowledge, values, and objectives. Decisions about how to use ocean spaces need to consider social equity, environmental sustainability, and resilience to a swiftly changing climate. To inform future decisions about kelp harvest and mariculture activities on the west coast of Canada, we co-developed research questions and methods with the Kwakiutl Nation to document ancestral Kwakiutl governance principles, quantify contemporary community values, and envision resilient and just future management practices within a decision space framework. We found that Kwakiutl governance principles of respect, reciprocity, ‘we are all one’, and responsibility are foundational to kelp-forest human relationships. Moreover, relational and indirect use values of kelp, such as kelp being used by future generations and part of a healthy ocean, were more important to Kwakiutl Nation members than direct uses like kelp as income. Strategic management actions, including the resurgence of Kwakiutl identity and knowledge, were identified as ways to support climate resilient kelp harvest and mariculture practices. While there is interest in developing Nation-owned kelp mariculture operations to participate in the blue economy, economic gain is less important than sustaining wild kelp forests and re-establishing human-kelp relationships within the community. Overall, this work reaffirms that kelps have been and remain important relations to Kwakiutl people for millennia and highlights numerous social-ecological barriers to maintaining these connections such as a lack of boat access, complex permitting processes, and warming coastal oceans. These results emphasize that, among the Kwakiutl Nation, values other than economic gain guide the decision-making space surrounding emerging kelp industries. As countries worldwide develop ‘blue economic’ policies, they can prioritize just governance and social-ecological sustainability by guiding place-based management actions with local trade-off preferences and values, Indigenous knowledge, and governance protocols.

Keywords: blue economy; kelp aquaculture; two-eyed seeing; values-led management; Indigenous governance, mariculture

To Aaron Brotchie (1959 – 2023).

Thank you for showing me how to listen with heart and observe with patience, and for your constant support of and passion for this work. I'll remember our time together whenever porpoises meet my boat, or the kelp tells me it is time to fish.

I promise to find your cedar tree and tell you how large it has grown. I will miss you, my friend, until we meet again.



Ḳaladi (giant kelp patch) sunrise

Photo © Sarah Gutzmann

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Table of Contents

Declaration of Committee	ii
Ethics Statement	iii
Abstract	iv
Dedication	v
Acknowledgements	vi
Table of Contents	vii
List of Tables	ix
List of Figures	ix
List of Acronyms	x
Glossary	xi
Preface	xii
Introduction	1
Methods	4
Study Background	4
Place	4
Positionality	5
Project Co-Design	5
Decision Space	6
Semi-directed Interviews (Kwakiutl Knowledge)	9
Interview Data Analysis	9
Community Survey (Contemporary Values of Kelp)	10
Survey Structure	10
Kelp Valuation	11
Kelp Farming	12
Demographics	12
Survey Data Analysis	12
Kelp Value Importance	12
Kelp Farming	14
Workshop (Resilience and Reconciliation)	14
Workshop Data Analysis	15
Limitations	16
Results	17
Kwakiutl Knowledge	17
Kwakiutl Cosmology	17
Ancestral Governance Principles	17
Teachings of Kelp	19
Contemporary Community Values of Kelp	20
Importance of Kelp Values	20
By Demographic	21
Future Visioning	24

Kelp Farming Trade-offs	24
Observations of Change (Kwakiutl Knowledge)	26
Management Priorities (Kwakiutl Knowledge)	26
Resilience and Reconciliation	28
Discussion	30
Revitalizing Ancestral Governance Principles.....	30
Kelp Valuation	31
Kelp Harvest and Mariculture in a Warming Ocean	33
Reconciliation in the Blue Economy	36
References.....	39
Appendix A. Governing kelp forest-human relationships	51
Appendix B. Contemporary Kelp Values	57
Appendix C. Resilient and Reconciliatory Kelp Management.....	67

List of Tables

Table 1:	Kelp Values.....	11
Table 2:	Kwakiutl governance principles* highlighted by knowledge-keepers as being important for human-kelp relationships	19
Table 3:	Management priorities drawn from knowledge-keeper interviews.....	27

List of Figures

Figure 1:	Kwakiutl territory includes tsaxis (Fort Rupert) which is on the northeast coast of Vancouver Island, British Columbia, Canada	5
Figure 2:	Kelp Forest-Human Relationship Decision Space	8
Figure 3:	Kwakiutl Governance Principles for Kelp	18
Figure 4:	Relative Importance of Kelp Values.....	22
Figure 5:	Mean Ranking of 20 Kelp Values by Demographic.....	23
Figure 6:	Kelp Farming Trade-offs for Kelp Farm Size (A) and (B) Distance from tsaxis.....	25
Figure 7:	Management Practices for Resilience and Reconciliation in a Kelp Harvest and Mariculture Decision Space.....	29

List of Acronyms

BC	British Columbia
KNT	Kwakiutl Nation Territory
SFU	Simon Fraser University

Glossary

blue economy	Describes ocean-based industries which are economically viable, socially equitable, and environmentally sustainable
governance	“The institutions, structures, and processes that determine who makes decisions, how and for whom decisions are made, whether, how and what actions are taken and by whom and to what effect” (Bennett & Satterfield, 2018; p.2)
ḱaladi	Giant kelp patch
ḱaxḱalis	Giant kelp (<i>Macrocystis pyrifera</i>)
management	The “resources, plans, and actions that result from the functioning of governance” (Bennett and Satterfield 2018; p.6).
mariculture	Ancestral and continuing Indigenous wild kelp harvest includes tending practices (Turner 2020, Kobluk et al. 2021). Wild kelp harvest and cultivation can therefore be considered on a mariculture continuum; however, for the purposes of distinguishing between a kelp farm (e.g., kelp is cultivated on lines) and wild harvest (e.g., harvesters collect from and tend to kelp beds) we use between “kelp mariculture” (or “kelp farming”) and “kelp harvest” respectively.
onto-epistemology	Describes the inseparability of being (ontology) and of knowing/knowledge (epistemology) (Barad 2007)
social licence	Legitimacy through public opinion, but also license through legal bodies
social norm	“Social norms are the perceived informal, mostly unwritten, rules that define acceptable and appropriate actions within a given group or community, thus guiding human behaviour” (UNICEF 2021; p.1)
tsaxis	Fort Rupert
wawadi	Bull kelp (<i>Nereocystis luetkeana</i>)

Preface

In my time learning from Kwakiutl knowledge-keepers, one of the lessons shared with me is that Kwakiutl worldview is the underlying fabric that guides and connects all things – all decisions. They expressed the importance of grounding this work in Kwakiutl worldview where for instance:

In a totemic view, in the view that created our language, the land, sea, and sky are one. One being. Our world is one vessel. And nothing is more valid or has any more consideration over any other part of the system.

...

The world of the sun is a mirror image of the undersea realm...kelp forests are the forests of the land. And so, as we concern ourselves about kelp and the way that we handle them, we too have to be concerned about the way that we're handling the forests in the world of the sun.

Mervyn Child (2022)

This worldview is fundamentally parallel to my own as a social-ecological thinker and researcher. My worldview has been shaped by my training in Western science, but also by my time spent building relationships with the land and sea. Thus, while the scope of this work is necessarily focused on a discussion of kelp harvest and mariculture, it is critical to remember that these are but two components of one larger, complex system.

Introduction

Transitioning towards a 'blue economy', where ocean-based industries are environmentally sustainable, economically viable, and socially equitable (Cisneros-Montemayor et al. 2019, 2021), requires that local governance processes, objectives, benefits, and costs guide future management decisions. Among temperate coastal oceans, kelps (seaweeds in the order Laminariales) are of growing interest to economic initiatives. Kelps have high cultural and ecological value (Turner and Bell 1973, Turner 2000, Erlandson et al. 2007) and are susceptible to even slight changes in ocean temperature (Valdez et al. 2003, Krumhansl et al. 2016, Kobluk et al. 2021, Starko et al. 2022). Yet, social-ecological trade-offs among kelp harvest and mariculture practices within the context of a swiftly warming ocean remain underexplored. As such, developing kelp harvest and mariculture industries have the potential to perpetuate and/or exacerbate ocean injustice (Bennett et al. 2021). Therefore, there is the opportunity and need to operationalize just management by centering diverse value-systems, inclusive decision-making processes, and climate resilience from the onset of contemporary kelp industries.

Relationships between kelps and people are long-standing, reciprocal, and adaptive. In fact, kelps have been utilized for millennia (Turner and Bell 1973, Turner 2000, Erlandson et al. 2007, Dillehay et al. 2008) with Indigenous peoples stewarding the coastal land and waters of North America for at least 14,000 years (Turner 2020). Thus, kelps have been an important component of Indigenous economies, a source of food, medicine, materials, and a cultural relation for generations (Keithahn 1963, Turner and Bell 1973, Turner 2000). Today, the coast of British Columbia (BC) is experiencing unprecedented increases in sea water temperature and extreme climatic events, growing kelp market demand, and a social climate that is increasingly demanding reconciliation. These forces are placing coastal Indigenous Nations at the crossroads of numerous social-ecological disturbances which present new challenges and opportunities for scaling-up or beginning kelp industries, where local values, objectives and trade-offs need to be considered. Further complicating the matter, kelp harvest and mariculture management decisions sit within overlapping local, national, and global social-ecological systems each encompassing diverse values, social norms, policies, and regulations.

Management decisions always invoke trade-offs. To navigate these, different strategies for structured decision making exist, like multi-criteria analysis (Conroy and Peterson 2013, Biggs et al. 2022), but rarely do they explicitly address underlying values, social norms, or social licence, nor Indigenous worldviews and governance principles which often contrast from western paradigms. Yet, it is important to explicitly state and acknowledge underlying value systems to promote creative solutions and to avoid conflict over trade-off decisions (Cormick et al. 1996, Retief et al. 2013). Further, values-led management, particularly of place-based societies, is needed for sustained human-place relationships (Artelle et al. 2018). Compared to many structured decision-making strategies, decision space approaches include internal drivers like worldviews and value systems, as well as external drivers such as social norms, license, and institutional context (e.g., laws) (Bossert 1998, Steelman and McCaffrey 2011, Eslie Roman et al. 2017, Pope et al. 2019, Clifford et al. 2022).

There are different methods and definitions for expressing values (Murray and D'Anna 2015, Murray et al. 2016a, Tadaki et al. 2017). For instance, 'values as relations' describe a manner of being and interacting with the environment which determine social norms and expectations and therefore lend themselves to governance principles and law formation (Tadaki et al. 2017). On the other hand, 'values as individual priorities' describe preferences and motivations, and are determined through community engagement (e.g., using Likert scale surveys or Q-methodology), often with the goal of improving decision making inclusivity (Tadaki et al. 2017). However, Indigenous peoples have and continue to experience injustice in marine management and governance decision making processes due in part to the dominant western value systems on which decisions have been made (Turner et al. 2013, Parsons et al. 2021, Kwaxsihalla Wathl'thla [Chief Adam Dick] et al. 2022, Salomon et al. 2023). Thus, describing the diversity of values that exist within a society is one way of addressing the multiple dimensions of environmental justice, being procedural (who is meaningfully included), recognitional (whose identities, knowledges, values, rights are formally acknowledged), and distributive (who has access to the benefits and receives the costs/harms) in decision making processes (Parsons et al. 2021).

Here, in partnership with the Kwakiutl Nation, we co-designed, co-implemented, and co-delivered research that explicitly investigated the diversity of community values surrounding human-kelp relationships. This research arose from community priorities for

and interest in kelp harvest and mariculture, and was shaped by Kwakiutl Hereditary and elected leadership, knowledge-keepers, kelp practitioners, and Guardians from its inception. Specifically, we asked:

1. What Kwakiutl knowledge, ancestral governance principles, and protocols govern kelp forest-human relationships?
2. How does the Kwakiutl Nation value kelp today and does this vary with age, time lived in Kwakiutl territory, gender identity, and occupation?
3. How can Kwakiutl knowledge and contemporary community values support resilient kelp management practices and the negotiation of reconciliation?

Methods

Study Background

We use “kelp” to refer to both *k̑ax̑k̑alis* (giant kelp, *Macrocystis pyrifera*) and *wawadi* (bull kelp, *Nereocystis luetkeana*), as well as sugar kelp (*Saccharina latissima*) for questions pertaining to kelp farming. To distinguish between foundational Kwakiutl values and contemporary community values, we refer to foundational Kwakiutl ‘values as relations’ as ‘governance principles’.

Place

This work took place in Kwakiutl Nation territory. The Kwakiutl Nation are Kwakwaka’wakw (which refers to all people who speak the language Kwak’wala) and have stewarded their territories for at least 9000 years (Kwakiutl Band Council 2018). The Kwakiutl are one of many distinct Kwakwaka’wakw Nations, where “Kwakiutl” (Kwagu’ł) specifically refers to people from *tsaxis* (Fort Rupert) (Figure 1). We use the spelling “Kwakiutl” throughout to align with the spelling used by the Kwakiutl Band Council.



Figure 1: Kwakiutl territory includes tsax̓is (Fort Rupert) which is on the northeast coast of Vancouver Island, British Columbia, Canada

Positionality

We are a team of Kwakiutl Nation leaders and settler-researchers working together to revitalize and uphold right relations with kelp and each other. We have diverse backgrounds in life experiences and profession and are united in our work to actively build new structures and systems that support the reclamation and revitalization of Indigenous rights, governance, economic systems, environmental management, and ways of being. We hold ourselves accountable to future generations and we strove to uplift storytelling methodologies (Corntassel et al. 2009, Chan 2021) and Kwak'wala in this work.

Project Co-Design

We co-developed this research with guidance and consent from Kwakiutl Hereditary and elected leadership and the Kwakiutl Fisheries program, including Kwakiutl Guardians and fishers. This process involved initial meetings with the Fisheries Manager (Kevin Kowalchuk) and Guardians (including Charles Humchitt) to listen to specific information needs and local observations, followed by a meeting with Hereditary

Chief walas 'Namugwis (David Mungo Knox) to identify broader Kwakiutl concerns and research priorities. At the time of this project (2021-2023), commercial kelp harvest took place in Kwakiutl territory and the Nation was experiencing a surge in kelp mariculture proposals. Hence, we additionally met with kelp industry practitioners (including Marc Peeler) alongside Kwakiutl Nation collaborators and the Province of BC (Danielle Denley) to identify areas of mutual interest to increase the applicability of our research to current and future kelp industry partnerships in Kwakiutl territory. These series of meetings allowed us to co-design research questions with Kwakiutl Fisheries that specifically met the needs of the Nation. We then presented our research commitments and co-designed research proposal to the 2022 Kwakiutl Band Council. Only upon receiving the consent and guidance from all parties did we begin our research. All manuscripts that stem from this work will invite the collaborators named here to co-author.

For this research, we followed the First Nations Information Governance Centre (2023) principles of data sovereignty Ownership, Control, Access, and Possession (OCAP®). Specifically, all data collected is owned and controlled by the Kwakiutl Nation and any future reference or use of this data will require their approval. In addition, all research activities were approved by SFU's ethics committee (#30001003).

Decision Space

To inform place-based decision making about kelp harvest and future mariculture with both Indigenous and western knowledge, we conceptualized a decision space that considered both internal and external drivers. Internal drivers include individual worldviews, culture, experience, and understanding, while external drivers include social feasibility (acceptability), institutional context (e.g., decision-making power, budget, mandate), and the state of system knowledge (Clifford et al. 2022). Internal and external factors then manifest in the decisions an individual (or collaboration) makes. For illustration, we conceptualized this decision space like a tree and/or kelp (Figure 2). The way a tree manifests depends on the species of tree that it is (internal factors), the soil and nutrients available to its roots (worldview, where it is grounded), and external environmental conditions like sun, wind, and rain. Likewise, a kelp plant is influenced internally by its species, externally by conditions like current, sunlight, and water temperature, and is grounded by the substrate it grows on. Further, because the context

in which decisions are made varies through time, our decision space framework can also be understood within the context of time, linking past, present, and future social-ecological conditions, values, and objectives. Specifically, we were guided to root this decision-space in ancestral Kwakiutl knowledge and governance principles (the past) which carry vibrantly into the present and are projected into future actions.

To inform the decision space surrounding future kelp harvest and mariculture decisions, we conducted semi-directed interviews, a community survey, and a workshop. Each method addressed one of our specific research questions and targeted a specific sample population of the Kwakiutl Nation. The semi-directed interviews were primarily backwards-looking as they sought to remember ancestral Kwakiutl knowledge from specifically identified knowledge-keepers who hold the authority to speak on these topics. The survey was used to assess present community values among a sample of the entire Kwakiutl Nation, while the workshop with current Kwakiutl leaders (i.e., influential knowledge holders) highlighted alternative potential future actions. Moreover, the semi-directed interviews informed the survey, which were both then reviewed and advanced by the workshop. In this way, the three main research methods linked Kwakiutl knowledge and values through time, informing each other and emphasizing the contemporary relevance of ancestral governance principles and importance of intergenerational knowledge transfer. This decision space framework serves to bring all this information together (Figure 2).

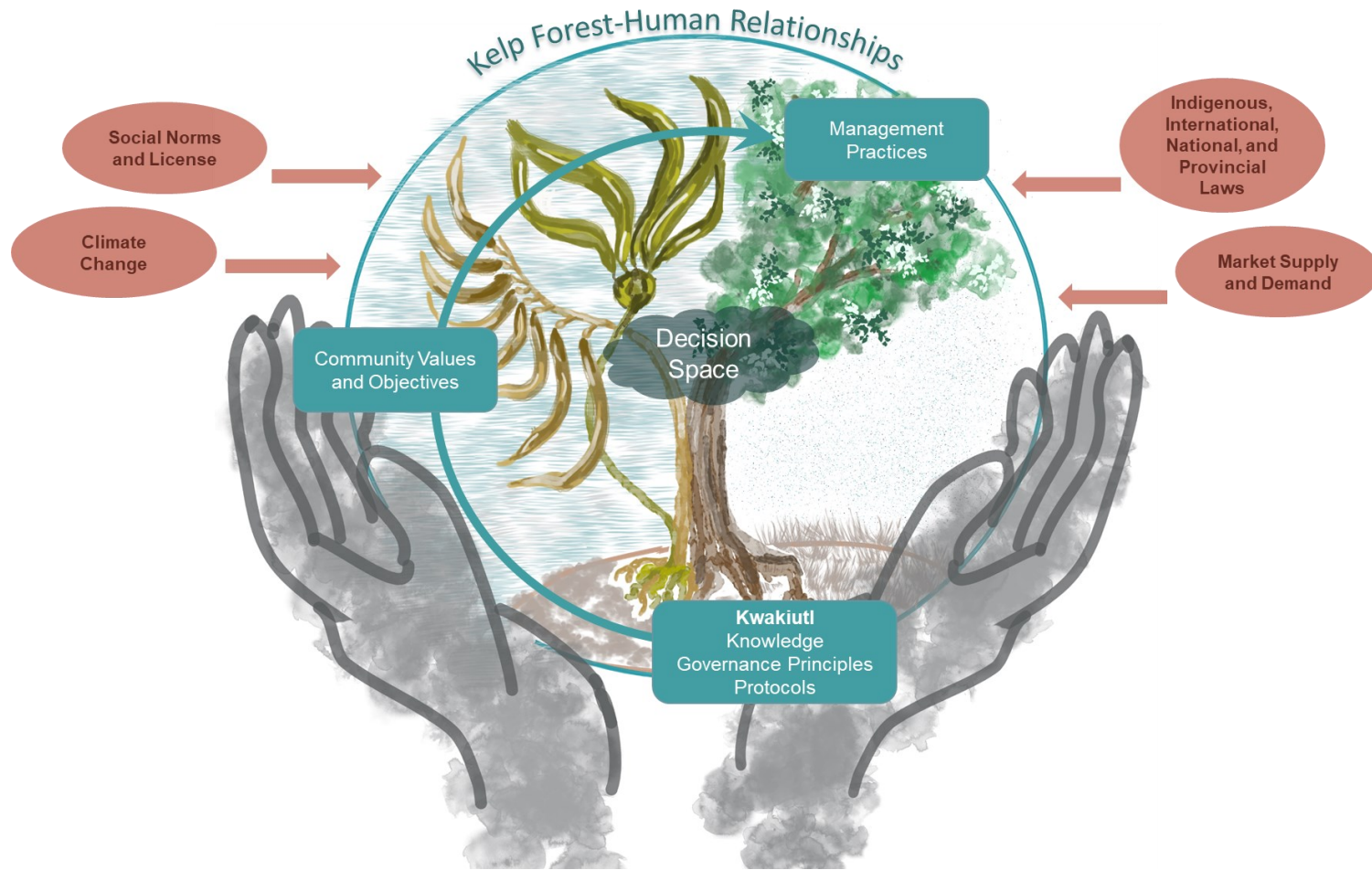


Figure 2: Kelp Forest-Human Relationship Decision Space

The decision space framework serves to bring together ancestral Kwakiutl knowledge and governance principles, contemporary community values, and future management practices (teal boxes) to inform ecologically resilient and socially just kelp management decisions amidst external forces like social norms and social license, climate change, governance processes, and market forces (red bubbles). The hands represent humans stewarding the decision space while being intrinsically part of the social-ecological system, and the teal arrow shows the path we took through the decision space.

Semi-directed Interviews (Kwakiutl Knowledge)

To determine what Kwakiutl knowledge, ancestral governance principles, and protocols should guide kelp forest-human relationships and future management decisions, we conducted semi-directed interviews with knowledge-keepers specifically identified by our Kwakiutl research partners. Initially, individuals were identified as interviewees if they were: 1) Hereditary leaders, and/or 2) Elders with knowledge of ancestral governance principles and/or kelp-human relationships and/or 3) experts in ocean life and fisheries (e.g., Guardians, fishers, kelp harvesters/growers). As interviews progressed, additional contacts were made through snowball sampling. Interviewees were agreed upon with Kwakiutl collaborators and were contacted via established relationships.

In the fall of 2022, we conducted 21 semi-directed interviews in person in tsaxis (Fort Rupert, British Columbia, Canada; Figure 1) and remotely. We asked a series of prompting questions about people's relationship with kelp and ancestral stewardship practices (Appendix A). We also asked about observations of ecological change and social barriers to accessing kelp to understand challenges which should be addressed by future management practices. Prior to each interview, we introduced the research objectives and participants were given time to review the consent form and ask questions. If consent was provided, the interviews began and were audio recorded. On average, interviews lasted one hour, and participants were given honoraria for their time. Respondents were provided with transcriptions of their interviews and were asked to provide edits and/or additions within ten weeks.

Interview Data Analysis

We analysed semi-directed interviews using a mixture of inductive and deductive thematic analysis with Nvivo12 Plus (QSR International Pty Ltd. 2020) as per Braun and Clarke (2012). Deductive thematic analysis was informed by conversations with Kwakiutl Nation members which took place throughout the research partnership leading up to the interviews. As is common to any thematic analysis, results are subject to bias from the inherent perspectives of the researchers and through the act of selecting quotes from the context provided by complete interview transcript. To reduce this bias, we practiced

reflexivity throughout the entire research process (Probst and Berenson 2014, Mackieson et al. 2019) by regularly assessing influences of us, the researchers, on the research and influences of the research on us, the researchers. For instance, reflexive actions included regular self-reflection on our positionality and biases, discussing interim interpretations with colleagues, as well as inviting review and feedback from participants during the workshop (discussed below) and community update presentations (held August 2022 and March 2023).

Community Survey (Contemporary Values of Kelp)

To investigate how the Kwakiutl Nation values kelp today and if these values vary with age, time lived in community, gender identity, and occupation, we distributed a survey to Kwakiutl Nation Members in the winter of 2023. In addition to a weblink, 120 paper copies were delivered to tsaxis residents, particularly elders and others who did not have computer access or were not comfortable using an online survey platform. The online survey was administered through SurveyMonkey and shared via the Fort Rupert Community Events Facebook page and through snowball sampling to reach Kwakiutl Nation members living outside of tsaxis. To encourage participation, survey respondents were offered cash prizes for completing the survey. Cash incentives have been found to be more effective than in-kind incentives for non-face-to-face surveys, in part due to their immediate and transparent value (Ryu et al. 2006).

We received a total of 64 survey responses with 40 being paper surveys (33% of 120 paper surveys distributed) and 24 online surveys. As 370 people live on Fort Rupert reservation (pers. com. Lavina Hunt, 2023), the survey was filled out by ~17% of Kwakiutl Nation members residing in tsaxis either online or as a paper copy. Of the 64 survey responses, 54 Kwakiutl Nation members live in tsaxis, 1 outside of tsaxis, while the remaining 9 did not indicate their location.

Survey Structure

Following a consent request page and confirmation that respondents were >19 years old, participants were directed to the remainder of the survey which could be exited at any time. All questions were anonymous and optional, and all sections of the

survey had open ended comment boxes for participants to share their rationales/additional thoughts as they wished.

Kelp Valuation

First, participants were presented with a table of 20 potential values of kelp (Table 1) determined from the literature on ecosystem valuation (Ament et al. 2017, Klain et al. 2017, Podladly et al. 2020), climate vulnerability (Harper et al. 2022), Indigenous health indicators (Donatuto et al. 2020), and the semi-directed interviews held with Kwakiutl knowledge-keepers at the beginning of this study. While values can be categorized in various ways and are not mutually exclusive, we grouped them into “direct use”, “indirect use” (Chan et al. 2011) and “relational” values (Chan et al. 2016, Tadaki et al. 2017, Klain et al. 2017, Schulz and Martin-Ortega 2018) (Table 1). We defined “direct use” values of kelp as those which were based on the physical use or consumption of kelp, “indirect use” values as those which were based on non-physical use, and “relational” values as those where kelp facilitates a relationship between entities. Participants were asked to indicate each value’s importance on a 5-point Likert scale (least important=1, less important=2, neutral =3, important=4, most important=5). We chose not to use negative values in our Likert scale (e.g., “not important”) to acknowledge all values held some degree of importance. Where given, respondents’ qualitative statements were recorded.

Table 1: Kelp Values

Categories are not mutually exclusive (e.g., while ceremony and medicine directly use kelp, using kelp in this way is spiritual, and therefore can be considered as an ‘indirect use’ or ‘relational’ value).

Direct Use	Indirect Use	Relational
Ceremony	Existence	A place to gather other seafood
Food	Employment	Connection to your ancestors/way of life
Gardening	Learning and teaching	Connection to the ocean
Gifts	Navigation/fishing cue	Ocean health
Income	Physical and mental health	For future generations
Material to make things	Shelter from storms at sea	
Medicine	Something nice to look at	
Trade among Nations		

Kelp Farming

In addition to how Kwakiutl Nation members value kelp today, we sought to understand the community's perspectives on kelp farming. This was of interest to the Kwakiutl Nation because of the recent surge in local, commercial kelp mariculture opportunities and the trade-offs implicit in decisions about kelp farming and other potential uses of ocean space. Specifically, we assessed the trade-offs between; 1) local use vs. external sale of kelp from a farm; 2) small (<30 200m lines; <2 hectares), medium (31 to 50 200m lines; >2 and <4 hectares), or large (>50 200m lines; >4 hectares) kelp farm size (Marine Scotland 2017, Campbell et al. 2019, Menzies et al. 2021); 3) close vs. far kelp farm proximity to tsaxis, using locally known landmarks at 0km, 3km, 5km, 10km, and 20km; and, 4) kelp farms used for harvest vs. habitat (Appendix B). Lastly, respondents were asked 1) if they supported kelp farming overall, 2) to identify any concerns they may have about the ecological impacts of kelp farming, and 3) to identify any concerns they may have about the impacts of climate change to a kelp farm.

Demographics

In the final part of the survey, participants were asked to identify the year they were born (open ended), their gender identity (multiple choice with respectful and culturally sensitive options), occupation (open ended), and the amount of time they have lived in Kwakiutl territory (multiple choice). Age was subsequently calculated from birth year, and occupation was categorized manually.

Survey Data Analysis

Kelp Value Importance

To quantify the extent to which the Kwakiutl Nation varies in their valuation of kelp by age, time lived in Kwakiutl Nation territory, gender identity, and occupation, we evaluated the percentages of participants that rated each value as being least to most important with the 'Likert' R package (Bryer and Speerschneider 2016). We then subset the survey data for complete cases (n = 38) and created groups within the demographic variables of gender, age, occupation, and amount of time spent living in Kwakiutl territory (referred to as "time KNT"). Grouping the data was necessary to create sample sizes of at least five for statistical analysis (i.e., as is recommended for Kruskal-Wallis tests

[Lomuscio 2021, Bedre 2022]; Table B.1; for a comparison of data spread between modeled data and all responses, see Figures B.1 – B.4). Specifically, the demographic groups were: i) ‘early adult’, ‘middle age’, ‘late middle age’, and ‘Elder’ (ages 20-35, 36-50, 51-65, 66+ respectively) for age; ii) ‘15 years or less’ and ‘more than 15 years’ for time KNT; and, iii) male and female for gender, as we removed the data of one individual who identified as two-spirit/nonbinary from gender-based analysis and graphs to protect their anonymity (i.e., n = 37 for gender-based analysis only).

For occupation, we categorized the data twice because the community survey asked for occupation in an open-ended format. First, we narrowed responses into occupation categories for education (including research), natural resource industries (e.g., fishing and logging), health care (including social work and/or traditional medicine), business and admin, tourism/hospitality, Guardians, and trades. We then further grouped data based on hypotheses for how specific kelp valuation may differ between occupations given assumed degrees of separation each had from direct and indirect uses of kelp, modified from concept of economic sector. This process resulted in four occupation groups, being ‘natural resources’, ‘business/trades’, ‘public service’, and ‘tourism/arts’ (Table B.1). For example, we assumed those working in tourism/hospitality, and as artists may value aesthetic properties of kelp which provide inspiration and/or draw tourists more than the other groups. Natural resource workers would value ocean-based uses of kelp like ‘income’, ‘employment’, or ‘for navigation/fishing cues’ more than the other groups. Those who work in public services (healthcare, education, Guardians) may value the kelp for ‘physical and mental health’ or ‘medicine’ more than the other groups. Finally, that business and trades may be the most removed from kelp and therefore value kelp less than other groups overall. However, we expected that cultural values (direct or indirect, e.g., ceremony) and relational values of kelp would be similar across all groups due to shared Kwakiutl identity.

To assess the effect of each demographic variable (n=4) on the importance of each kelp value (n=20), we used a cumulative link model (CLM) or Kruskal-Wallis test. Where CLMs failed to converge or violated the proportional odds assumption, we used Kruskal-Wallis tests. This resulted in 62 CLMs and 18 Kruskal-Wallis tests (Tables B.2 – B.3). We used the R package ‘ordinal’ (Haubo and Christensen 2016) for CLMs and verified that models met the proportional odds assumption using Brant tests (R package ‘gofcat’, Ugba 2022). For time KNT and gender identity, as there were only two groups

within each demographic variable, pairwise significance was given directly by the CLM. Where CLMs indicated that there was a significant difference among occupation or age groups ($p < 0.05$), we used R package 'emmeans' (Lenth 2020) to run pairwise tests and determine which groups were significantly different using Tukey adjusted p values ($p < 0.05$; Table B.4).

We used a Kruskal-Wallis test to assess the effect of age, occupation, time spent living in Kwakiutl territory, and gender identity on the importance of each kelp value (Weaver et al. 2017, McDonald 2022). Where the Kruskal-Wallis test returned a significant p value, we used a Conover-Iman test with a Bonferroni correction for pairwise comparison. We used the R package 'conover.test' (Dinno 2017) for both Kruskal-Wallis and Conover-Iman tests.

Kelp Farming

To examine kelp farming trade-offs and concern about climate change and ecological impacts to/of kelp farming, we summarized the results by the percentage of respondents or by boxplot. Where given, we recorded respondents' qualitative statements.

All quantitative data analysis were done in R (version 4.3.0, R Core Team, 2022). Sample size per question varied as all questions were optional and not every respondent answered all questions.

Workshop (Resilience and Reconciliation)

To assess how Kwakiutl knowledge and contemporary community values can support resilient kelp management and the negotiation of reconciliation, we held a 1-day workshop with 10 community-identified Kwakiutl leaders (i.e., influential knowledge holders) in the spring of 2023. Specifically, workshop participants; 1) reviewed results and interpretations of the semi-structured interviews and survey, 2) described their perceptions of climate change and its impact on kelp harvest and farming and 3) discussed potential adaptations to mitigate future climate impacts on wild kelp harvest and mariculture, as well as identified place-based enablers and barriers to climate solutions, in addition to current knowledge gaps.

To harvest these data, we used 3 activities, a Knowledge Café, a Thought Mapping activity, and a discussion on Future-Visioning. To review the results and interpretations of our semi-directed interviews on ancestral governance principles and knowledge of kelp-human relationships, in addition to our contemporary survey of Kwakiutl kelp values, we used the Wisdom Catchers method during the Knowledge Café. The Wisdom Catchers were several participants who were asked before the activity to 'catch'/remember one piece of knowledge that resonated with them and share it back to the group along with one of their own teachings. In this way we were able to both practice reciprocity and refocus, rephrase, redirect, and/or add to our research findings according to community leaders' perspectives. To document community leaders' perceptions of climate change on kelp harvest and mariculture, we used a mind mapping activity, where in small groups participants discussed their understanding of how climate change can affect kelp harvest and farming by creating visual displays of relationships among key components of the system (Figure C.4). Finally, to envision future climate change impacts, adaptations, barriers, and enablers to kelp harvest and mariculture, we asked workshop participants to discuss their ideas for how to cultivate climate resilient kelp harvest and farming using a 'resilience tree' graphic and sticky notes to capture ideas (Figure C.4).

To start each activity in a good way, we began with a grounding reading from "Embers: One Ojibway's Meditations" by Richard Wagamese, selected at random by a workshop participant. To uphold reciprocity and good relations during the workshop, we introduced the values guiding our workshop, the activities and expectations that were to shape the day and gave time for participants to review and sign the consent form. At the end of the workshop participants were given an honorarium and small thank-you gift.

Workshop Data Analysis

We used emergent thematic analysis to summarize the mind-maps (Figure C.5) and identify key themes from the workshop that addressed climate resilience and the negotiation of reconciliation. These were compiled and compared to literature (Table C.4).

Limitations

We acknowledge that in this work we are predominantly using English and communicating with the written word to share – with consent - Kwakiutl knowledge which, as discussed by Simpson (2004), forces Indigenous ways of being into a western construct.

Kwakiutl ancestors were mariners through and through and so when you're out on the canoes, or out on your boat, it gives you that right perspective. It gives you that right vantage point so you can understand the old place names, the old taboos and belief systems, and the relationality.

Tom Child (2022)

Results

Kwakiutl Knowledge

Kwakiutl Cosmology

Ancestral stories of *kaxkalis* and *wawadi* (giant and bull kelp) illuminate the importance and antiquity of the relationship between the Kwakiutl and kelp. Kelp held a role in saving Kwakiutl ancestors from the Great Flood, and kelp was married for a time to *Tlialagi'lakw* (mink).

Numas [received] this vision from the butterfly landing on his third eye, and then he received the message that he needed to go out to all of the people and give them the warning that a big flood was coming and that they were to build these big canoes. ... And so, he got here and the Chiefs took the word seriously because he traveled a long, long way by foot... And we had 16 canoes, and the canoes are as big as this whole room. So, he had a rock and the [bull] kelp and cut it to a knot ... and it got anchored. They tied the canoes up onto the mountain. And so ... drying kelp and making rope out of it is one of the lifesaving things that had happened because the flood did come.

Marlo Thomas and Gord Twance (2022)

Tlialagi'lakw married many things. He married the frog and the volcanic stone. *Wawadi* the kelp. He married ducks. He married human women. He married; I say he but he was she or maybe both. Or all things supernatural. So, when he married the kelp, we understand that as he swam tirelessly through all of these long blades of kelp, and he explored the realm of the kelp, and he saw how glorious and how wonderful that house was, and that it housed so many things of the Undersea Kingdom and the realm. And you would see the relationship that it had with the sun, and it was so prolific. And he felt like it was his, and he loved being there. But the tide flooded, and the seascape came up and he nearly drowned. So, in that way he understood he wasn't compatible, and he divorced the kelp and he moved on and explored other things.

Mervyn Child (2022)

Ancestral Governance Principles

The ancestral governance principles that were highlighted as being important in governing kelp forest-human relationships were *maya'xala* (respect), reciprocity, responsibility, and *namwayut* (we are all one) (Figure 3 and Table 2). In addition,

protocol was highlighted as being an important action for upholding governance principles. For instance, Elder Gordon Twance (2022) said that

You learn through the language. The language is your teacher, and we have keepers that keep the language. So, the first lesson when you're growing, when you're born, it's discipline. That's the first lesson. Discipline is really, really important, and as you grow that discipline is always there, always.

And, knowledge-keeper Ross Hunt Jr. (2022) shared

Protocols [are] an important piece when we go into each other's territories; [it] is that acknowledgement of receiving permission to harvest.

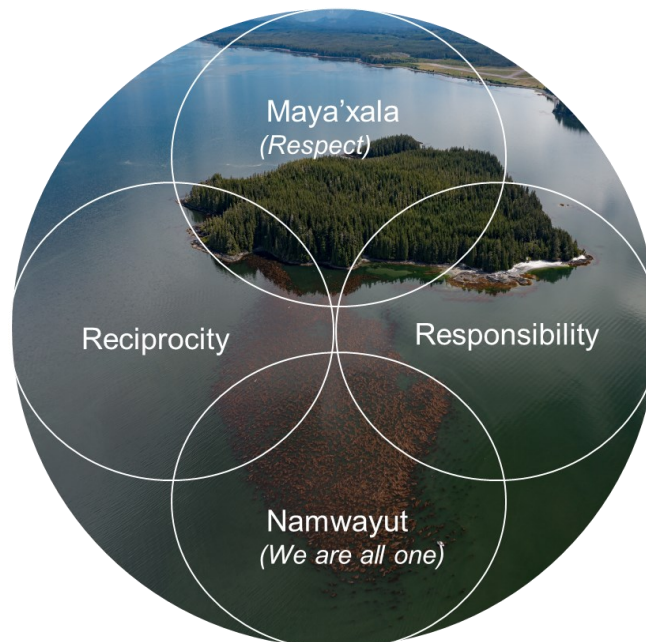


Figure 3: Kwakiutl Governance Principles for Kelp

Dominant Kwakiutl governance principles for governing kelp forest-human relationships discussed by knowledge-keepers. The picture in the background is the kelp bed at Wazulis (Deer Island, East Coast of Vancouver Island, British Columbia, Canada). photo by © Markus Thompson.

Table 2: Kwakiutl governance principles* highlighted by knowledge-keepers as being important for human-kelp relationships

Governance Principle	Perspectives from Knowledge-keepers
Maya'xala (Respect)	<i>Always have respect for what you get from the ocean. How it is used, and why it's used. (Anonymous)</i>
	<i>I believe that in the past our ancestors protected their identity. So, if I knew I was a whale, and if I knew you were a raven, and if I knew you were a salmon. I didn't touch your stuff, regardless of how I felt about you, I might despise you. But I protect my identity and it's my responsibility to honor yours. (Mervyn Child)</i>
Reciprocity	<i>Basil Amber said, we're caretakers were stewards of this land for our future generations, so that's our philosophy. And how do we make it right? In an economic and extractive kind of western, capitalistic worldview. How do you reconcile a paradigm of giving versus paradigm of hoarding? (Tom Child)</i>
Responsibility	<i>Taking care of things. That's something we gotta learn again. Since I was young, people are ruining it. Not just people here - they'd be running in and out of the kelp with their outboards and just tearing it up, not caring, not knowing what [kelp is] there for. (Albert Brotchie)</i>
Namwayut (We are all one)	<i>In a sense of namwayut; we are all one. So, in the sense of the Animal Kingdom and the Bird Kingdom, the Fish and Wildlife species of the ocean that create our ancestors. In a totemic view, in the view that created our language, the land, sea, and sky are one. One being. Our world is one vessel. And nothing is more valid or has any more consideration over any other part of the system. (Mervyn Child)</i>
	<i>You can't just talk about one thing without talking about everything because everything [is connected]. So, we can't compartmentalize, you know we can't separate our lives - 'cause it goes on and on. (Ross Hunt Jr)</i>

*(Everson 2021)

Teachings of Kelp

Four themes of Kwakiutl knowledge of *k̓ax̓k̓əlis* and wawadi emerged from semi-directed interviews with knowledge-keepers, being i) food and material; ii) medicine; iii) ceremony, spiritual practices, and charms; iv) and ocean relations (Table A.1), noting that these groups are interconnected. Herein, we call this knowledge 'teachings of kelp' as was a perspective shared by knowledge-keeper Marlo Thomas. The title 'teachings of kelp' reflects the understanding that *k̓ax̓k̓əlis* and wawadi are beings and teachers; it is not humans that learn about kelp, but rather it is the kelp which shares its knowledge with humans. Wawadi was noted as being uniquely important to Kwakiutl ancestors for its practical uses in carrying *t̓i'na* (eulachon grease), and for making rope, fishing line, and harpoon lines. This kelp was also important in ceremony. For example, it was used in charms to call the Northwest Wind. In the present context, it was noted that Kwakiutl

Nation members most often use *kaxkalis* and wawadi to read the tides for navigation and fishing purposes. And, when washed up on the beach, Nation members collect *kaxkalis* and wawadi for gardening to make fertilizer and to insulate their gardens over winter. *Kaxkalis* is used as a submerged substrate to collect herring eggs/roe (a'ant) when these pelagic forage fish come to shore in the spring to spawn. Herring roe on kelp was a centerpiece in ancestral Kwakiutl economies and continues to be a part of local food sovereignty and trade/income – although, as several interviewees noted, less so in recent years. Some knowledge-keepers interviewed use kelp medicinally, but overall, there is a strong interest in revitalizing medicinal uses of kelp more broadly within the community.

Contemporary Community Values of Kelp

Of the total 64 responses, 33 respondents identified as female, 25 as male, and 1 as non-binary/two spirit. Ages ranged from 23 to 84. For time spent living in Kwakiutl Nation Territory, 4 respondents had lived there 0-5 years, 5 for 5-10 years, 3 for 10-15 years, and 48 for more than 15 years. Occupation wise, there were 4 artists, 9 in business or administrative roles, 10 in education roles (including research), 2 Guardians, 7 working in health services, 11 in natural resource extraction (e.g., fishing, logging), 4 in tourism or hospitality, and 3 in trades. Note that not all participants chose to share this personal information (Figure B.5).

Importance of Kelp Values

The top 3 most important kelp values were all relational values, being kelp ‘for future generations’, a component of ‘ocean health’, and a ‘connection to the ocean’ (Figure 4). These values were rated as ‘important’ (a score of 4) or ‘most important’ (a score of 5) by >95% of survey respondents at 98%, 98%, and 97% respectively. The next most important value of kelp was for its indirect use of ‘existence’, with 94% of respondents indicating that even if they never see or directly use kelp, its existence is important or most important. All other values had some percentage of responses indicating their importance was perceived as being ‘neutral’, ‘less important’ or ‘least important’ (scores of 3, 2, or 1 respectively). ‘Gifts’ and ‘income’ were rated as ‘least’ or ‘less important’, by 11% and 10% of respondents, respectively (Figure 4).

By Demographic

There were 10 kelp values whose importance varied significantly among demographic categories ($p < 0.05$, for details see tables B.2 – B.4). We found a significant effect of time spent living in Kwakiutl territory on the degree to which respondents viewed kelp as an important source of 'food' ($p = 0.02$), 'material to make things' ($p = 0.009$), for 'learning and teaching', ($p = 0.03$), 'ocean health' ($p = 0.003$), 'something nice to look at' ($p = 0.01$), 'for future generations' ($p = 0.008$), and 'physical and mental health' ($p = 0.009$) (Figure 5a). Specifically, individuals who have spent greater than 15 years living in Kwakiutl territory (Figure 5a) reported higher importance of these kelp values than those who lived less than 15 years in the territory. We found no effect of gender identity on the magnitude of importance of any kelp value (Figure 5b) suggesting both Kwakiutl men and women valued kelp similarly. We found that the importance of kelp as 'income' differed significantly by age group. Specifically, Elders (>65 yrs) considered kelp more important for income compared to middle aged individuals (>35 yrs, ≤ 50 yrs; $p = 0.03$; Figure 5c).

Finally, we found that occupation group had a significant influence on respondents' perceptions of the importance of kelp as 'income' and as a 'place to harvest seafood'. Specifically, we found that for those working in natural resource industries, kelp as 'income' was more important than for those working in health/education ($p = 0.008$) or tourism/art ($p = 0.016$). Moreover, results suggest that kelp as 'income' may be more important to natural resource workers than those in business/trades, though this difference was not significant ($p = 0.06$). Interestingly, individuals working in business/trades perceived kelp to be more important as 'a place to harvest seafood' than individuals in health/education ($p = 0.01$), but not when compared to the other groups (Figure 5d).

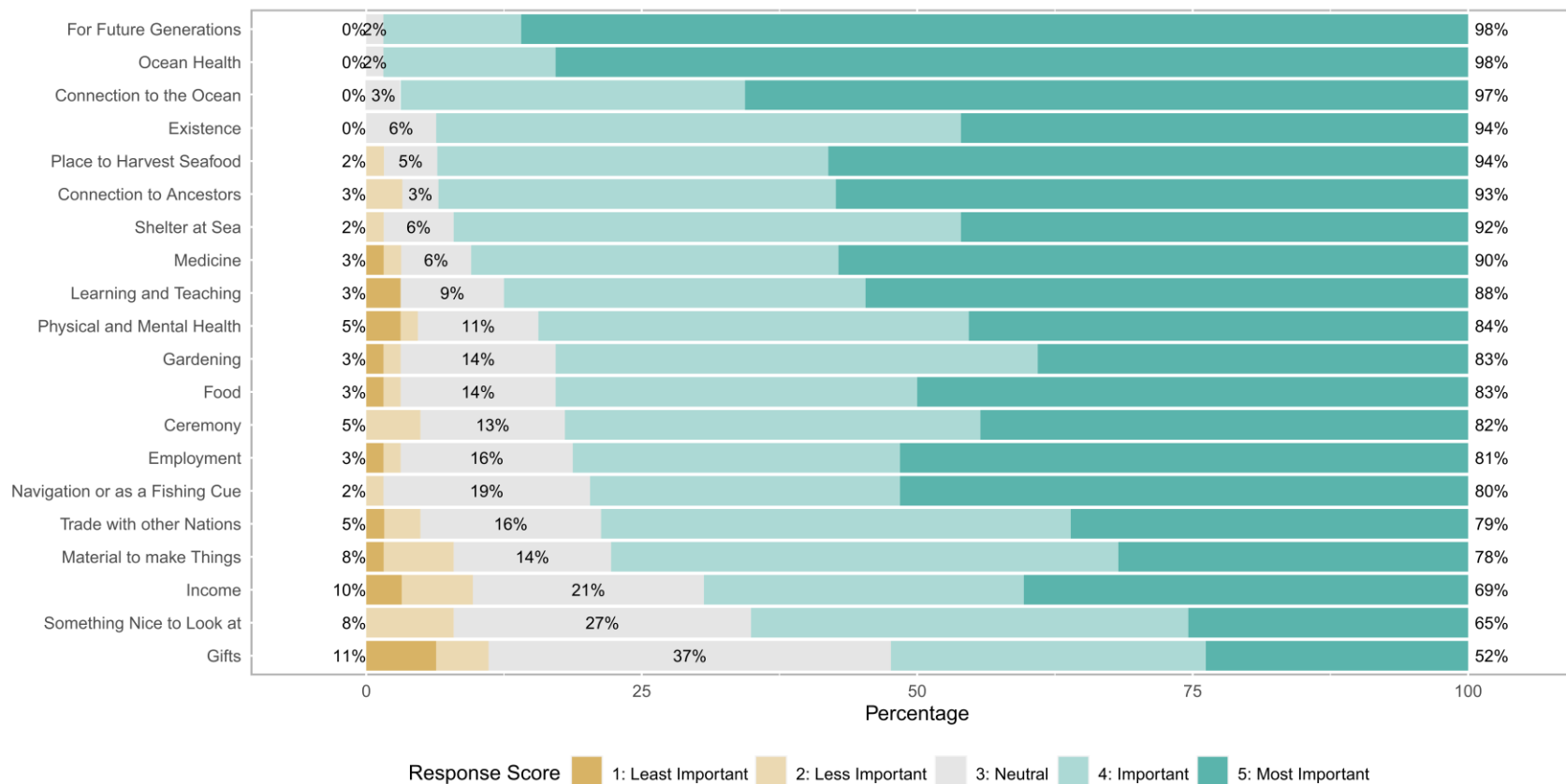


Figure 4: Relative Importance of Kelp Values

Percentages of responses for 20 kelp values by importance rating. Percentages on the left side are combined for scores of 2 and 1 ('least important' or 'less important'). Percentages in the grey bars are for rating scores of 3 ('neutral'). Percentages on the right side of the figure are response scores of 4 and 5 ('important' or 'most important'). The number of responses for each value varies as not all participants gave a score for each value.

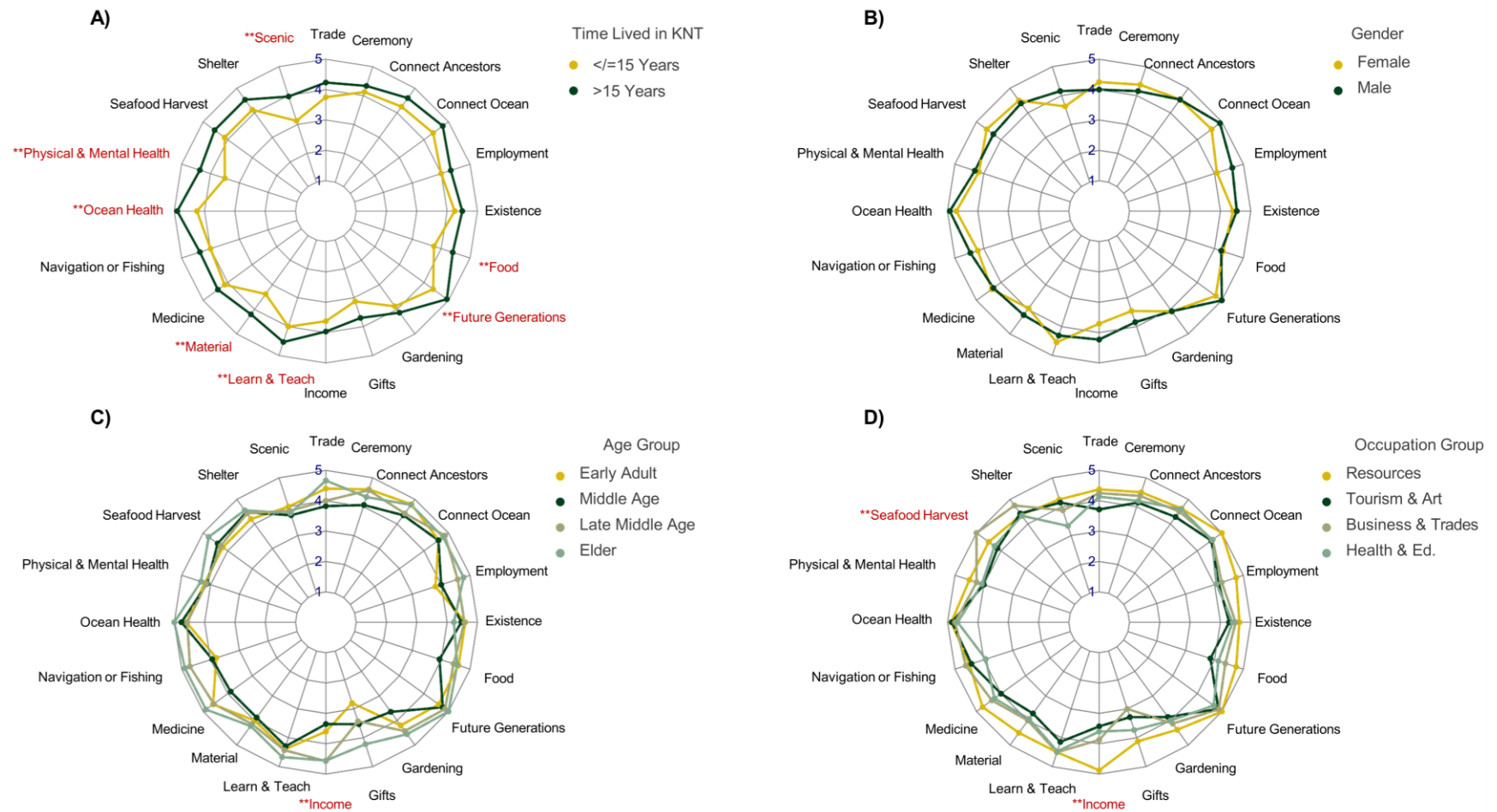


Figure 5: Mean Ranking of 20 Kelp Values by Demographic (A) Time spent living in Kwakiutl Nation territory (KNT), (B) gender identity, (C) age group, (D) and occupation group. Points further from the center denote higher mean importance with blue numbers indicating importance rank (1-5); ** with red text denote significant differences in demographic groups for that kelp value.

Future Visioning

Kelp Farming Trade-offs

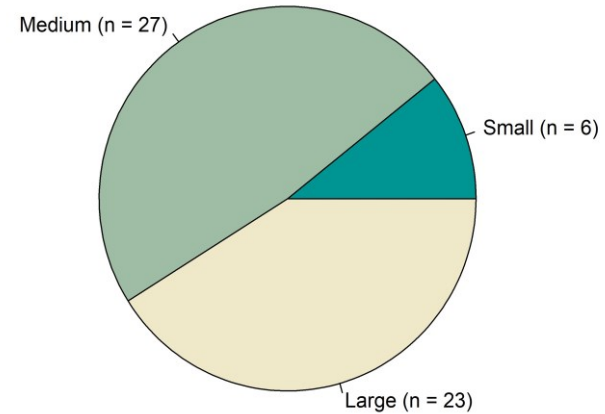
While we found that there is interest overall in the economic opportunity of kelp farming among Kwakiutl community members, other social and environmental benefits were considered equally important. On average, respondents identified that 55% of kelp harvested from a farm should be kept for local use versus sold to external markets (min = 5%, median = 50%, max = 100%, n = 52; Figure C.1). Similarly, respondents tended to take a moderate approach when asked what percentage of kelp should be harvested from a farm, with a mean of 59% (min = 20%, median = 50%, max = 100%, n = 50; Figure C.1), leaving the remainder of kelp as habitat for fish etc.¹ We found that most survey respondents are concerned about the potential impacts of climate change to a kelp farm (67% of respondents; Figure C.2), but not about the impacts of a kelp farm on the environment (17% concerned; Figure C.3.). Yet, despite potential social-ecological trade-offs and environmental concerns, 98% of respondents were in support of kelp farming overall (Table C.3 for rationales).

When considering kelp farm size and distance from tsaxis, we found that respondents prioritized ecological integrity and building community relationships with kelp. For example, out of 56 respondents, 48% preferred a medium size farm (>2 and <4 hectares; >31 to 50 lines) compared to a large (>4 hectares; >50 lines) farm. Responses indicated that kelp farm size is partially dependent on the selected location (Figure 6a). For location, out of 53 respondents, 51% preferred that a kelp farm be accessible to community members being located 3km away from tsaxis. However, 21% preferred the more distant option of 5km away from town to avoid impeding existing connections to local ocean spaces while remaining accessible. 11% of participants expressed that a kelp farm may need to be even further away (>10km) to avoid pollution point sources (Figure 6b).

¹ This question did not discuss that farmed kelp should be locally sourced (e.g., within 50 km, Freitag 2017) and we acknowledge that non-local kelp genotypes could be problematic if kelp was left on the lines for its reproductive cycle. This consideration was determined to be outside of the scope of a community-oriented survey; however, this would be a consideration for when/if farming was to be implemented in Kwakiutl territory.

A) Kelp Farm Size

Small <30 lines (<2 hectares)	No rationales provided
Medium 31 to 50 lines (>2 and <4 hectares)	If it is going to be close to the islands [in front of Fort Rupert], it needs to not be too large as members travel out to the islands to get clams, crabs, mussels. Start smaller and see the benefits and potential drawbacks or environmental impacts We don't need a whole lot! As our ancestors did, we only took what we could use and trade
Large >50 lines (>4 hectares)	More jobs If there is a market for the larger farm, in an area down the coast a little, why would we not harvest a bigger crop once the infrastructure is set up



B) Distance from tsaxis

3km	I believe [Shell/Peel Islands] harbour offers a protective spot and also hopefully may reduce boat traffic? There used to be a kelp processing plant on Shell Island. Not that I think there should be another one out there, but perhaps one of other islands that would also help to lay claim to them and exercise our sovereignty Accessibility, good growing environment Maintain, keep a watchful eye and [on] progress
5km	The islands around our village are highly utilized and visited by our members. Let's not interrupt that connection The islands tend to get visited quite often especially during the summer months while a little further down the coast would be "out of the way" but still very accessible
>10km	May need to go as far as False Head to eliminate the sewage outfall located in front of the Port Hardy Airport [workshop] The kelp farm locations will also have been considerate of depth and tidal fluctuation. A farm around Fort Rupert beach or shell island may not be deep enough year-round. Will also want to avoid orca sand and gravel, Thomas point as clams there are usually bad, and the outfall near the airport

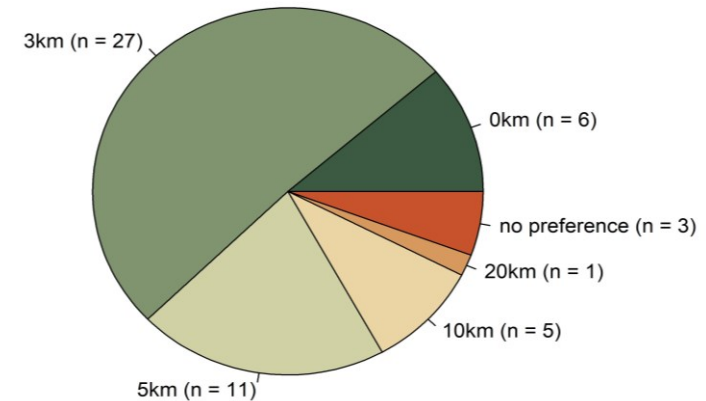


Figure 6: Kelp Farming Trade-offs for Kelp Farm Size (A) and (B) Distance from tsaxis.

A) a larger farm is assumed to take more ocean space away from other uses but produces more kelp. Farm sizes are based on one kelp line being 200 m (Marine Scotland 2017, Campbell et al. 2019, Menzies et al. 2021). B) A farm further away is assumed to take more time, fuel, etc. to access than a farm closer to tsaxis (Fort Rupert) but would leave more ocean space close by for other uses. Where provided, select rationales provided by survey participants are presented in the colour coded boxes.

Observations of Change (Kwakiutl Knowledge)

The semi-directed interviews revealed that there are numerous changes, both ecologically and socially, being observed in the Kwakiutl Nation's relationship with kelp (Tables C.1 – C.2). The social changes discussed created barriers to Kwakiutl-kelp relationships. We heard that there is a paucity of opportunities to learn and teach about kelp, a loss of Kwakiutl knowledge about kelp, and a potentially related lack of interest in kelp within the community. As well, knowledge-keepers spoke about a general inability to access kelp (outside of when it washes up on the beach) due a lack of boat access within the community. Moreover, there are administrative challenges both internal to Kwakiutl Band approval systems and in external provincial permitting processes to harvest, grow, or sell kelp products. Additional changes hampering Kwakiutl-kelp relationships include climate change, pollution, and the loss of Kwakiutl sovereignty through colonial development, jurisdiction, and governance processes.

Ecologically, Kwakiutl-kelp relationships are challenged by overarching symptoms of climate change like increasing ocean temperatures and storm frequency. Moreover, like other areas on the BC coast, Kwakiutl knowledge-keepers reported seeing more 'sick' kelp encrusted by the epiphytic bryozoan (*Membranipora membranacea*). Kelp abundance through time was reported to being site specific with some places have more and others having the same or less kelp in recent years compared to knowledge-keepers' earliest memories. Knowledge-keepers also shared recent observations of wildfire smoke slowing down kelp growth and herring eggs peeling off kelp blades when the eggs should be sticking. To our knowledge, there are no published studies looking into these latter two changes which have potential to impact kelp-human relationships more broadly.

Management Priorities (Kwakiutl Knowledge)

During the semi-directed interviews, knowledge-keepers shared numerous management priorities that would enact Kwakiutl governance principles in kelp harvest and mariculture (Table 3).

Table 3: Management priorities drawn from knowledge-keeper interviews.

Management Priority	Perspectives from Knowledge-keepers
Jobs and training	<i>Kelp will get people on the water. And you start from one thing, eh. And like the kelp will teach you one thing and you move on [to learning more about other things]. (Aaron Brotchie)</i>
Sharing with community	<i>I'm really happy that people are interested in kelp because it brings [knowledge] out and the diversification of our own consciousness is so important. (Corrine Hunt)</i>
Research	<i>[For a kelp farm] it would be monitoring the changes to the environment, to the seabed. I'd want to see some stringent tracking of data. Migratory habits, any new species, [etc.]. (Ross Hunt Jr)</i>
Resurgence of Kwakiutl practice and knowledge	<i>The culture is coming back. Now it's time to bring back everything else too. Learn and teach. But a lot of [teachers] don't [know]. They're still young; young teachers that know the culture, but most of the traditions and food is a lot different than the culture itself. ... How many people [still] eat kelp? That's a new one for me too. (Albert Brotchie)</i>
Limits on wild harvest	<i>I would really be looking at is making a cap, a limit, on how much tonnage are allowed to access to be able to export. (walas 'Namugwis David Knox)</i>
Connection and understanding	<i>As an artist [it is important] to bring [kelp] into what I do, because we don't see it that often, in our artwork. To have the kids and, I mean, the world, have an understanding that this is also a part of our world. It's not just the Ravens and the Eagles and the Bears. (Corrine Hunt)</i>
	<i>Indigenous people have a shorter life expectancy than the rest of Western society so the more attachment that an Indigenous individual has to the land and the longer life expectancy they have, it actually improves the mental, emotional, physical and spiritual state when we're out there. (Marlo Thomas)</i>
Traditional medicines	<i>I'm very interested in medicinal uses. I'm not sure about kelp, but would like to learn more about it. (Anonymous)</i>
	<i>And we're still using kelp, but we're not using it for medicine. We're using it for roe on kelp. Bull kelp we don't ever really touch it no more. (Charles Wilson)</i>
Ecosystem approach	<i>But how to pick a certain thing without hurting it, there's another thing ... If you wipe it out all year, well there's not going to be there next year, right? You gotta save certain things like even [parts of] our beaches, right? OK, we won't dig the clams too much here, so we'll go to another beach. That leaves it to grow for another two years, and we'll come back. ... Same thing with the kelp. (Gord Twance)</i>
Monitoring	<i>Before contact, there was enough for everybody ... there was enough for seals. There was enough for the people, [and] the whole food chain. And when colonization came in that broke the chain. Now the fishermen are blaming the seals, but the fishermen are the culprits themselves, right? Because it wasn't monitored proper. So that's what we see. That's what I see through my eyes. Is the devastation of everything. So, if this kelp is going to go [ahead], it has to be monitored. (Gordon Twance)</i>
Active stewardship	<i>What would happen if you just stopped? Then how would that bed adapt to that, now [that] it's adapting to you harvesting, right? ... The beds that are producing right now the most and cleanest kelp are the beds we've been harvesting. (Marc Peeler)</i>

Management Priority	Perspectives from Knowledge-keepers
Special management areas	<i>There used to be a lot of these little silver [fish] and they would come into the bay of tsax̓is and the humpbacks would be right there feeding, and the dolphins and the porpoises. It's sad to think that [that ecology has changed], and changed the relationships ... all the way up that food chain. I really think the kelp forests within the Bay of tsax̓is should be completely left alone... There are burial grounds on those islands. (Tom Child)</i>

Resilience and Reconciliation

During the workshop, Kwakiutl community leaders identified seven themes of management practices/actions which would cultivate resilient kelp industries (Figure 7). Themes included ‘localizing kelp processes’ (e.g., harvest through to processing would be done by the Kwakiutl Nation with training for youth in particular), ‘local governance’ (e.g., better implementation of Nation-developed land use plans), ‘community outlook’ (e.g., “keep smiling”), ‘community capacity’ (e.g., beginning pilot projects), ‘knowledge sharing’ (e.g., monthly sharing circles), ‘cultural connection and identity’ (e.g. developing book on kelp in Kwak’wala), and ‘active stewardship’ (e.g., long-term monitoring). These seven themes of management practices/actions mirrored the management priorities discussed by knowledge-keepers during semi-directed interviews (Table 3), rationales for kelp farming decisions shared during the survey (Figures 6, C.1, C.2), and resilience principles discussed in the academic literature (Table C.4).

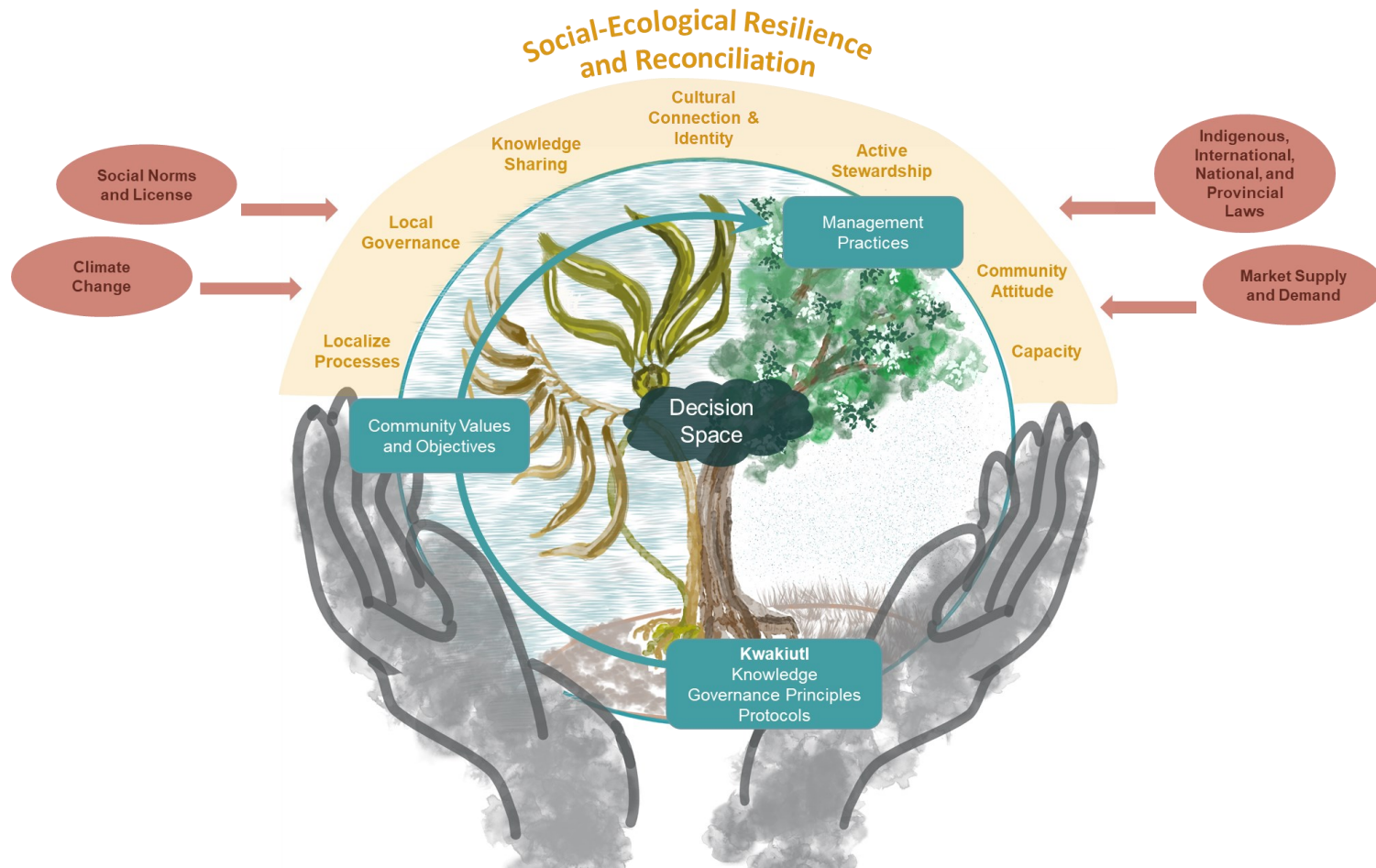


Figure 7: Management Practices for Resilience and Reconciliation in a Kelp Harvest and Mariculture Decision Space

The decision space framework serves to bring together ancestral Kwakiutl knowledge and governance principles, contemporary community values, and future management practices (teal boxes) to cultivate climate resilience and support reconciliation processes (orange arc) in kelp harvest and mariculture amidst external drivers (red bubbles). Specific management practices (orange text) were identified by community leaders at the workshop and are built from our path through the decision space (i.e., the findings of semi-directed interviews [Kwakiutl knowledge, governance principles, and protocols] as well as the survey [community values and objectives]; teal arrow).

Discussion

To develop blue economic systems, ocean industries must become ecologically sustainable and equitably inclusive of local, ocean-dependent people's knowledges, needs, and objectives all within the context of rapidly warming oceans. Ancestral Kwakiutl governance principles, contemporary community values, trade-off preferences, and management practices can help cultivate resilient and reconciliatory place-based kelp harvest and mariculture. First, we found that Kwakiutl governance principles of respect, reciprocity, 'we are all one', and responsibility, which may all be actioned through protocols, are foundational to kelp-forest human relationships and must anchor future decisions about kelp harvest and mariculture (Figure 3). We also found that the most important kelp values were not direct uses of kelp such as 'income', but rather they were relational and indirect uses, such as the value of kelp 'for future generations', as part of a 'healthy ocean', a 'connection to the ocean', and that it simply exists (Figure 4). Although we found that there is interest in kelp farming as an economic opportunity, community connection with and access to kelp, as well as environmental health, are valued more than financial gain (Figure 6). Finally, Kwakiutl leaders perceived strategic management actions, including the resurgence of Kwakiutl culture and capacity building, as critical to supporting local, climate resilient kelp industries (Figure 7). Overall, our findings suggest that revitalizing ancestral Indigenous governance principles and leading management practices with community values and objectives are part of decolonizing the blue economy amidst a rapidly warming ocean.

Revitalizing Ancestral Governance Principles

Kwakiutl governance principles have evolved through a cosmology, worldview and an intimate ecological understanding of social-ecological relationships that has spanned generations. Specifically, the four Kwakiutl Governance principles highlighted for kelp-human relationships (respect, reciprocity, 'we are all one', and responsibility) are consistent with the governance principles of other coastal Nations including the nuučaanuł (Nuu-chah-nulth), Hałtzaqv (Heiltsuk) and Xaayda (Haida) Nations (Salomon et al. 2023) as well as other Kwakwaka'wakw (Everson 2021). While not explicitly discussed by knowledge-keepers during interviews, the governance principles of 'addressing mistakes' (making things right), humility, and accountability/transparency are

also core Kwakwaka'wakw values and principles (Everson 2021) which may play a role in kelp management. Further, the Kwakwaka'wakw values and principles documented by (Everson 2021) are guided by the notion of social-ecological balance. Kwakiutl Nation members spoke to a need for balance (as well as the current social-ecological imbalance due to climate change, pollution, etc.) throughout semi-directed interviews, survey comments, and the workshop (e.g., Figures C.1, C.2). Likewise, the governance principle of balance is common to nuučaanuł, Hałtzaqv, and Xaayda Nations (Salomon et al. 2023).

It is increasingly being recognized that Indigenous ways of knowing, values, laws, and governance processes, which are inextricable from the phenology, people, and ecology of a place, are imperative for restoring planetary health (McGregor et al. 2020, Turner and Reid 2022, Hoogeveen et al. 2023). For example, where predominately western, reductionist resource governance and related management actions have led to biodiversity collapses, Indigenous governance and management principles better meet conservation goals (Lee et al. 2019, Ban et al. 2020, McGregor et al. 2020, Berkes 2021, Atlas et al. 2021, Connors 2023). Alongside this transformation in the worldview underlying social-ecological governance/management (i.e., to where humans are considered a part of nature rather than an externality), aligning resource management with Indigenous teachings requires us to recognize “resources” as beings with rights and agency (Watts 2013, Todd 2017, 2018, Baker 2020, Kanngieser and Todd 2020, Kramm 2020) and, as the Kwakiutl story of Tlisalagi'lakw demonstrates, to consider when/where these beings are not for us. This movement towards recognizing nature's agency echoes Kwakiutl onto-epistemology/cosmology where kelp has been an important relation to the Kwakiutl since the beginning of time; and it demands a fundamental shift in the values systems which underpin contemporary management decisions as our more-than-human relations would no longer be primarily defined by their extractive potential.

Kelp Valuation

We found that relational and indirect use values of kelp were more important to Kwakiutl Nation members than direct uses. Our findings mirror those of Arias-Arévalo et al. (2017) who found that rural residents with strong cultural ties to the Otún River watershed in Columbia were most often concerned with relational values. Moreover, the

prioritization of relational values by Kwakiutl Nation members parallels work by Podladly et al. (2020), Kelly and Woods (2021), as well as Sxwpilemaát Siyám and Raphael (2022) on Indigenous economies, definitions of wealth, and wellbeing where economic freedom and development are not confined by profit and financial growth, but rather are created through diverse value systems which align with Indigenous onto-epistemology. Yet, despite many examples of local, plural valuation (e.g., D’anna and Murray 2015, Murray and D’Anna 2015, Murray et al. 2016b, Ament et al. 2017), there is a paucity of studies quantifying relational values at all (Schulz and Martin-Ortega 2018). Furthermore, studies that explicitly quantify relational values in line with Indigenous onto-epistemologies are particularly sparse. A review by Manero et al. (2022) of studies explicitly investigating Indigenous values using market-based methods (e.g., values are monetized) found only four papers between 1976 and 2021 that addressed a holistic set of values (i.e., including relational values). Ultimately, commodifying relational, direct, or indirect values may only be appropriate in select instances (Chan and Satterfield 2020, Manero et al. 2022), and valuation studies must be co-developed with Indigenous partners to avoid the ethical blunders which can occur when questions of “whose values”, “for what purpose”, and “who benefits” are not made clear (Manero et al. 2022).

Our methodology differs from previous studies as we used a Likert scale to quantify the relative importance of 20 kelp values which were decided upon collaboratively with Kwakiutl collaborators. The first trend in kelp valuation that we found was that the amount of time spent living in Kwakiutl territory most often predicted differences in kelp value importance. We found that all 20 kelp values were rated as being more important by those who have lived in Kwakiutl territory for more than 15 years, with the differences in 7 kelp values being statistically significant (Figure 5a). The importance of having a cultural connection and relationship to Kwakiutl territory was echoed by knowledge-keepers in kelp management priorities (Table 3), as a component of resilience (Table C.4). This finding agrees with the work of Whyte (2018) who details how deep relationships with land (re)establish moral obligations between Indigenous peoples and more-than-human kin, facilitating the continuity of associated social infrastructure (e.g., knowledge, language, practice, spiritual connection, etc.). In fact, personal connections to place have also been found to enhance pro-environmental sentiments amongst non-Indigenous individuals (e.g., Mackay and Schmitt 2019, Hunt and Harbor 2019).

The second trend in kelp valuation was that the importance of kelp as ‘income’, varied by participant age and occupation. For age, kelp as ‘income’, was perceived as less important to Kwakiutl respondents in the two youngest age categories than the two oldest. During the semi-directed interviews, knowledge-keepers spoke about the movement in recent years of Kwakiutl people away from harvest-based livelihoods. This observation echoes the works of many which document interrupted economic relationships between Kwakwaka’wakw’ and the ocean (e.g., Mustonen et al. 2021, Kwaxsistalla Wathl’thla [Chief Adam Dick] et al. 2022); however, the importance of kelp in other economic capacities (e.g., for ‘employment’, or ‘as a navigation/fishing cue’) did not differ significantly by age group. We also found that kelp as ‘income’ was most important to individuals who worked in natural resource sectors than those in other occupations. Yet, most kelp values assessed did not differ by occupation. We note that occupation is not the same as personal identity and there can be considerable heterogeneity in identity within coastal communities (Delgado-Ramirez et al. 2023), which may explain the lack of variation in kelp importance by occupation overall. This finding contrasts with studies which have found that people’s environmental values can be predicted by their occupation (e.g., Aoyama et al. 2012, Groth et al. 2015, Iqbal 2020, Dehghani Pour et al. 2023). In sum, this work corroborates that when considering resource valuation of Indigenous Nations, it is important to acknowledge that contemporary Indigenous economies are often a mix of subsistence and market occupations, and that dividing livelihoods may lead to misunderstandings or mask the prevalence of traditional economic systems (Kuokkanen 2011).

Kelp Harvest and Mariculture in a Warming Ocean

[One time] we [saw a humpback whale] kelping. They go in the kelp and they roll around. And we saw one with kelp all around his fins. ... His name is Creeker and it was his first year without his mom ... so he made it [back] here by himself.

Shaelynn Bood (2022)

While Kwakiutl Nation members expressed interest in developing a kelp farm to further participate in the blue economy, they also expressed caution that economic gain should not supersede sustainable wild kelp forests nor re-establishing human-kelp relationships within the community. To implement a kelp farm in Kwakiutl territory, there

are still ecological questions that need to be addressed, such as, where are the best growing conditions for a kelp farm in Kwakiutl territory, and what placement would minimize potential marine mammal entanglement in kelp farm infrastructure? Further, there are aspects of justice to investigate. For example, because placement of a kelp farm could create conflict with residents of the area who have different underlying values and priorities for ocean space, there are questions about whose interests are prioritized, and the systems of power that enable prioritization. That said, we have shown that while economic opportunities (e.g., jobs and shared income) are a desired benefit, they are certainly not the only benefits from a kelp farm, which aligns with recent research of kelp farming that has cited social-ecological benefits including food security (Grebe et al. 2019), novel marine habitat (Forbes et al 2022), and adaptation to sea-level rise (Sultana et al. 2023). Yet, there are no studies (to our knowledge) that detail cultural benefits of kelp farming in coastal BC. Here, we found that kelp farming may be a place for Kwakiutl Nation members to heal by reconnecting with and stewarding the ocean, contribute to reasserting land sovereignty, provide a link to the ocean to facilitate Kwakiutl knowledge, medicine, language revitalization, and an avenue for youth to re-engage with subsistence culture.

Strategic management actions will help create climate resilient kelp industries. Social-ecological resilience is a transformational process which embraces disturbances and/or crises as opportunities to adapt and change in an ever-changing environment (Berkes and Ross 2013, Folke 2016, Folke et al. 2016). Yet, when resilience is actioned by a single value-system, entire species, ecosystems, economies, and/or cultures can be excluded (Zanotti et al. 2020). During the workshop, Kwakiutl community leaders brainstormed management actions which reflected a plurality of kelp values and paralleled resilience principles identified by numerous scholars (e.g., Olsson et al. 2004, Berkes 2007, 2021, Biggs et al. 2012, Berkes and Ross 2013, Folke 2016, Folke et al. 2016, Jackley et al. 2016, Quaempts et al. 2018, Salomon et al. 2019, Ford et al. 2020) (Table C.3). Of note, the theme of ‘cultural connection and identity’ contained all seven resilience principles defined by Biggs et al. (2012), where Kwakiutl leaders’ ideas for management actions were related to: diversity, participation, and polycentricity in governance (principles 1, 6, and 7) through decolonizing band processes with Kwakiutl laws and protocols; connectivity and management (principles 2 and 3) of Kwakiutl knowledge and identity through remembering ancestors teachings, member retreats,

and field trips to reconnect with Kwakiutl territory; as well as, fostering and sharing understanding of kelp systems (principles 4 and 5) through documenting medicinal uses of kelp, for example (Table C.4). With the concept of resilience becoming common in policy spaces in the 2000s, (Zanotti et al. 2020), Kwakiutl knowledge-keepers, community members, and leaders innately know and enact resilience principles in a way that is relatively new to western governance paradigms. Indeed, Indigenous peoples have been adapting to and transforming with change for millennia (Whyte 2018). Consequently, this work repeats the message that Indigenous peoples, and increasingly academia, have been vocalizing, which is that place-based, values-led management and governance creates resilient relations with more-than-human kin (natural resources).

Of course, there are aspects of climate resilience not covered by this work which warrant additional study. For example, kelp supply chains may be negatively impacted by an increased chance of kelp overheating and decomposing during transit and/or processing if air and water temperatures continue to increase (Shaelynn Bood, personal communication, 2022), impacting the resilience of kelp harvest and mariculture products in local and global markets. There are also opportunities to explore kelp farming and planting to mitigate local-scale hypoxia and ocean acidification as part of larger climate resilience strategies (Sultana et al. 2023). Still, efforts to quantify climate resilience to iteratively monitor, evaluate the success of, and adapt management initiatives are needed (Brown and Williams 2015). Finally, while there is a desire among practitioners to implement climate adaptive strategies in BC, capacity limitations emphasize the need to develop effective and resilient processes for collaboration between the groups involved (Whitney and Ban 2019).

Reconciliation in the Blue Economy

Grandfather used to sit me beside the totem pole when I was a little girl and used to tell me stories about it and there's a small little face in the bottom and he said, "that's us." I said, "how come we're small?" He said, "because when you're small, you're going to grow bigger and you're going to have this person's wisdom and this person's wisdom and this person's wisdom." And he was talking about animals. And then there's one that was a whale wrapped around the pole. And he said "This is the keeper of the ocean. You respect it. Only take what we need. Don't overtake. Otherwise, our people are going to go hungry." That's what the old man [said]. He talked to me like that, and I said, "how can people go hungry?" thinking about [grocery] stores and that, and he said, "you know, the store can go empty in one day". But I never thought they would. I thought they had plenty.

Whata Twance (2022)

This research takes place within a much broader context of efforts towards reconciliation following centuries of colonialism, cultural and physical genocide, and marginalization. Reconciliation is the ongoing process of making amends to, creating, and maintaining respectful relations both socially and environmentally (Truth and Reconciliation Commission of Canada 2015, Murdock 2018, Sxwpilemaát Siyám and Raphael 2022). It is a transformational process (Sxwpilemaát Siyám and Raphael 2022) where self-determination lies in the ability to be un-reconciled (Daigle 2019). Hence, we consider reconciliation to be a negotiation, not a done deal. The United Nations Declaration on the Rights of Indigenous People (2007) and associated Canadian Act (2021) affirm that Indigenous People have the rights to self-governance and to participate in decision making, and as scientists it is our responsibility to uphold these rights in our research (Ignace et al. 2023). We have endeavored to do this work in a reconciliatory way, and part of this is the act of truth-telling (Truth and Reconciliation Commission of Canada 2015). Ergo, we recognize and speak honestly about the genocide committed by Canada's colonial power, which brought disease, residential schools, and the banning of Indigenous governance systems (see Turner and Reid [2022] for a detailed account), and we acknowledge the role that science has played in privileging this power (see Salomon et al. [2023] for a detailed account).

Reconciliation needs to occur between societies, as well as between humanity and the environment (Truth and Reconciliation Commission of Canada 2015, Murdock 2018). This work takes place in the Anthropocene, a time marked by immense

environmental challenges including biodiversity loss, pollution, and climate change, and in the aftermath of the COVID-19 pandemic. This is a time of increasing awareness of the interconnection between environmental health and human physical/mental health (Marazziti et al. 2021, Gupta et al. 2021), and the interconnections between colonial governance and environmental crises (Davis and Todd 2017, Murdock 2018, McGregor et al. 2020, Evans 2022). Concurrently, interest in kelp harvest and mariculture are driven by numerous economic, environmental, and social benefits (Yakhin et al. 2017, Grebe et al. 2019, Bak et al. 2020, Sultana et al. 2023). Researching ocean systems using only the linear framework of western science (e.g., research, collect data, publish, assume knowledge is implemented) will not lead to environmentally or socially sustainable ocean development; indeed, we must contextualize research in the priorities and challenges of ocean-dependent peoples and develop applied solutions (Salomon et al. 2018, Singh et al. 2021).

Fortunately, increasing attention is being given to just decision making and research processes which are co-developed and honour multiple knowledge types and underlying values systems (Adams et al. 2014, Salomon et al. 2018, Artelle et al. 2018, Turner 2020), and to forming lasting, mutually beneficial partnerships. Yet, forming successful partnerships for research and decision making is difficult in practice. This difficulty is in part because of the nuance needed when defining 'success', the trust needed between all parties involved, and because agreements are situated within dominant western political, administrative, and legal systems (Nadasdy 2003, Takeda and Røpke 2010, Berkes 2021, Swerdfager and Armitage 2023). Therefore, partnerships require equitable approaches which acknowledge and dismantle power differentials between groups, allowing all to come to the table with equal footing to navigate different worldviews, social norms, license, and legal plurality (Salomon et al. 2018, 2023, Silver et al. 2022). Methodologies employed to bridge, braid, and weave different knowledges and worldviews in management/governance/research partnerships include 'brave-spaces' (Cooper 2022), 'ethical spaces' (Ermine 2007, Nikolakis and Hotte 2022), and 'community-driven collaborative management' (Winter et al. 2021) as well as frameworks like two-eyed seeing (Marshall and Bartlett 2010, Bartlett et al. 2012, Reid et al. 2021) or three-eyed seeing (Ballard 2022). Moreover, the roles of individuals or teams as 'boundary spanners', those who work at the interface of science and community with cultural competency and community trust, can not be understated in the success of

these partnerships (Hatch et al. 2023). Here, our research team functioned as boundary spanners together, and our partnership was key to the success of this project.

Overall, our work demonstrates that as countries develop policies surrounding kelp harvest and mariculture, they can prioritize just governance and social-ecological sustainability by allowing Indigenous knowledge, values, and local objectives to form place-based management actions. As we move towards the goal of a blue economy, it is critical that ocean dependent peoples – like coastal Indigenous peoples in BC – do not continue to shoulder a disproportionate share of the social-ecological costs (relative to local benefits) induced by ocean industries. Developing this equitable economy requires decision making to be guided by locally contextualized trade-offs. Further, we need to collaboratively research, manage, and govern ocean industries with a social-ecological lens and critically plan for climate resilience and reconciliation from their inception. Since Canada is in the process of developing a blue economic strategy with expressed interest in kelp harvest and mariculture (Fisheries and Oceans Canada 2022), there is a unique opportunity in BC to center justice and climate resilience from the beginning of kelp industries as political and regulatory frameworks evolve in step.

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Appendix A.

Governing kelp forest-human relationships

Semi-directed Interview Research Questions:

Values of Kelp

- Tell me about your relationship with kelp.
- Do you gather or use kelp? If yes, what type? (Photographs of kelp types provided)
- How is kelp important to you? How do you use it?
- Are there words, phrases, or stories in your language that can help us gain a better understanding of your relationship with kelp?

Stewardship of Kelp

We've been learning about Kwakwaka'wakw values and principles from the document written by Charlene Everson (2021). How do ancestral principles play out in care for kelp?

** the following are prompts to help us consider the core question above

- [Maya'xala (Respect)] How do you gather kelp? Are there any techniques you use?
- [Humility] Are there any times of year (seasons, conditions) that you go, or do not go, to harvest kelp?
- [Reciprocity] How do you make sure that there will be enough kelp for future years/generations?
- [Responsibility] How do you care for kelp in the areas where you harvest it?
- [Namwayut (we are all one)] Thinking about how everything is interconnected, are there practices that maintain relationships between kelp, humans, fish, and all other species?
- [accountability/transparency] Where do you gather/harvest kelp? (Map will be provided – mark on map if comfortable providing that information)
- [protocol] Are there rules about where you can and cannot harvest kelp? Is there an order to where should be harvested first? Or who should harvest first?

Climate Change and Kelp

- Since your earliest memories of kelp, have you noticed changes in kelp abundance through time? [long term trend]
- Since your earliest memories of kelp, have you noticed changes in where and when kelp grows? [temporal and spatial]
- Since your earliest memories of kelp, have you noticed changes in the way kelp looks, smells, tastes (etc.)?
- What do you think has caused these changes?
- How do you think changes in climate impact kelp forests?
- How do you think changes in climate impact peoples' relationships with kelp?
- What practices [activities/strategies] might you and your community develop to continue your use of and relationship with kelp given the changes you've observed?

Table A.1: Teachings of Kelp. Four themes of Kwakiutl knowledge of *kaxkalis* and wawadi (giant and bull kelp) were determined through semi-directed interviews with knowledge-keepers.

Category*	Type of Kelp	Teaching of Kelp	Example of Knowledge Shared
Food and Material	wawadi	Lacing for <i>ṭubakw</i> (BBQ salmon) sticks	I used it for lacing <i>ṭubakw</i> sticks. I was barbecuing fish on an open fire, and I didn't bring a roll of haywire and a pair of pliers. So, what I found was if I wrapped it with the bull kelp [stipe], it become a spherical bit of knot work, really strong and would bake really hard. And they would fit like a glove onto the top of the <i>ṭubakw</i> stick that they came off [of] (Mervyn Child)
		As siphons to remove water from a flooded boat	They beached their boat, but their boat was full of water. ... And this this old fellow jumped in this little boat and he took off. And then he came back [and] he had like 20 or 30 bull kelp, and then he chopped them, ... and siphoned all the water out of the boat. (Marc Peeler)
		Fishing line, rope, harpoon line	The long like stipe down towards the holdfast is really strong, and so the ancestors used that as fishing line and as a strong fiber for halibut fishing lines like nets and harpoon lines. (Tom Child)
		xum'sa sa 'wawadi (bull kelp heads) to carry <i>tii'na</i> (eulachon grease)	There were a lot of stories of kelp bulbs being used to transfer [and] hold water and oil. (Ross Hunt Jr)
	<i>kaxkalis</i> and wawadi	<i>ḅ</i> lades for <i>kaxkalis a'ant</i> & <i>a'ant sa wawadi</i> (roe on kelp) or eaten directly (steamed, or raw, dried)	the fronds are edible and they were like steamed, or raw or dried. The roe and kelp, the <i>kaxkalis a'ant</i> or <i>a'ant sa wawadi</i> , is something that's done every spring. (Tom Child)
		Fertilizer and over-wintering insulation for gardens	We wait for when the big windy season comes [and then] we're gonna get a whole huge massive body of kelp washing up on the beach. And when that happens, we take the kelp [to] put on our gardens. That's important, it gives it a blanket layer [and] nutrients. (walas Namugwis David Knox)

Category*	Type of Kelp	Teaching of Kelp	Example of Knowledge Shared
		Pit cooking - wawadi stipes to pour water into the pit - kelp blades as a barrier to the hot rocks at the bottom and to hold steam in	They have the kelp at each corner [of the pit cook]. And when everything is covered they pour water through the kelp and it steams everything in the pit. (Corrine Hunt)
Medicine	k̄ax̄k̄alis and wawadi	Sweat lodges and steam baths	We used to have [sweat lodges] on the beach ... but instead of water to put kelp on the stones ... and the steam from that. you breathe, and pray. Kelp it's a huge thing [in] our lives ... It's like cedar or sweet grass (Gord Twance)
		Wrapping to heal sprains	If you get a sprain out there you can wrap kelp around to take the swelling down. (Verna Hunt)
		Essential micronutrients	Bull kelp has a lot of iodine. (Gordon Twance)
		Skin treatment	It's really good for babies that have eczema, you just pop some of that in their bath (Marlo Thomas)
Ceremony, Spiritual Practices, and Charms	wawadi	Head-binding	the gusgimukw (people from x̄wātis/Quatsino) were especially famous for their head binding, so especially with young women they would bind their heads and it was a sign of beauty to sort of permanently influence the shape of the skull and the cranium and then have that long sort of pointed head. And so that was an expression of their nobility and significance to see that done. (Tom Child)
		Charms to call the Northwest wind	There's a story of how a Kwakiutl fisherman used kelp to change the direction of the wind... he took the kelp and he spoke into it. (Ross Hunt Jr)
		Ceremony	[bull kelp used to be used] in ceremony, they buried it under the sand [of the big house] to project their call in the fire. (Andrea Walkus)
			Steam baths to move into the spiritual space

Category*	Type of Kelp	Teaching of Kelp	Example of Knowledge Shared
	kaxkalis and wawadi	Healing, connection to the ocean, to ancestors and way of life	I'm told by my Elders that same medicine that's on the land you can find in the ocean... There is a brother and sister. They're connected. They carry the same medicine, they carry the same teachings. And you know, like the teaching that Gord always has is, you know, we have to have a clear mind before we go out. We have to not be angry. We have to be peaceful, we have to because the environment can take our life. Whether it be the mountain. Whether it be the water. It's powerful enough to take our life, so it's powerful enough to take our pain. (Marlo Thomas)
Ocean Relations	kaxkalis and wawadi	Anchor to the undersea kingdom	When I was young...I was told that if I was ever stuck out there when the weather turned to go to the kelp bed because it's anchored to the House of the Undersea Kingdom. (Andrea Walkus)
		Shelter from storms	the ancestors probably spent half their life out there just going to and from the places that they needed to get to within their seasonal movements, their seasonal round and then also just food harvesting and going out to gather medicines and all those things so. You know the kelps were always part of that, like as sanctuaries in a storm (Tom Child)
		A place to gather seafood	They'd use their long spears [in a kelp bed] to wrap it around and pull it up. And then wrap it around the front of the canoe to sort of anchor it ... and that's where the fish and crabs were (Maggie Sedgemore)
		Indication of tides for navigation & fishing	Cause whichever way the kelps' direction is going, that's what the tide's doing (walas Namugwis David Knox)
			My dad fished for 75 years and he used everything in the ocean to see what the tides were doing, where the fish would go, and all those things. But kelp were surprisingly important in that process... There's areas where we always knew there would be kelp. (Corrine Hunt)
	The Kwakiutl people, they live on the water; their transportation is water. So a lot of times it's foggy, and in your mind you know which way the tides are going. [if the kelp is] this way, well, you're going South. If the kelp is going this way, you're going north. And you just follow the kelp beds. (Gordon Twance)		

Category*	Type of Kelp	Teaching of Kelp	Example of Knowledge Shared
			We read kelp as the tide. When the tide drops, kelp just sits flat. And then when you get that tide, then you start getting the spaghetti kelp, so that's what you know when it's time to set your net. (Albert Brotchie)
		An indication of seasonal timing (e.g., travel, harvest)	I don't know if kelp was used in that way, but I assume it was just because it's such an obvious and an important signal. You know it's life cycle is so fascinating and when it does grow, it just grows so fast and changes the seascape (Tom Child)
		Something to play with (as kids)	Well, we're not kids no more so we can't whip each other (Charles Wilson)
		Something beautiful	They're so beautiful. I grew up in Alert Bay and we'd walk the beach every day (Corrine Hunt)
		Part of an Indigenous economy	A'ant is not just food. It was produced in such a quantity that it was made into a commodity for trade and other things. (Tom Child)

*these categories are not mutually exclusive as everything is connected

Appendix B.

Contemporary Kelp Values

The portion of the community survey which asked about specific kelp farm trade-offs was structured as follows:

1. Participants were introduced at a high level to kelp farming, and what a farm might physically look like (based on NOAA Fisheries 2020), including that sugar kelp (*Saccharina latissima*) may be the species farmed (opposed to giant kelp or bull kelp).
2. Slider question on the trade-off between keeping kelp for local use and selling it for shared profit. The amount of kelp that may come from a farm was based on Menzies et al. (2021) and Cascadia Seaweed (2023). The slider went from 0% to 100% of kelp being kept for local use (100% to 0% sold).
3. Multiple choice question on the trade-off between kelp farm distance from community and access (e.g., a kelp farm closer to town would take away from other community ocean uses, but it would be easier to get too [taking less time and boat fuel (Ferguson et al. 2022)]). This question used local landmarks to illustrate distance, which were 0km (e.g., Fort Rupert Beach), 3km (e.g., Peel/Shell Islands) 5km (e.g., Port Hardy Airport/Keogh Shoals), 10km (e.g., False Head), 20km (e.g., Cluxewe), and an option for 'other'.
4. Multiple choice question on the trade-off between kelp farm size and competing ocean space (a larger farm takes more space from other uses). Kelp farm size was based on Marine Scotland (2017), Campbell et al. (2019), and Menzies et al. (2021). Kelp farm sizes were illustrated to scale.
5. Slider question on the trade-off between kelp harvest and leaving some on lines to be habitat for local ocean life. The slider went from 0% to 100% of kelp being harvested from a farm (100% to 0% habitat).
6. Binary (yes/no) questions about overall support for a kelp farm, concern about climate change (similar to Whitney and Ban (2019) and Harper et al. (2022)), and concern about ecological impacts associated with kelp farming

Table B.1: Number of people in each group of modeled data for time spent living in Kwakiutl Nation Territory (KNT), Occupation Sector, Gender Identity, and Age Group.

Time Spent Living in KNT	n
<=15 years	8
> 15 years	30
Occupation Sector	n
Natural Resources	8
Business and Trades	8
Public Service (Health Services, Education, Research, Guardians)	15
Tourism/Hospitality and Arts	7
Gender	n
Male	13
Female	24
Age Group	n
Early Adult (> 20 and <= 35)	5
Middle Age (> 35 and <= 50)	17
Late Middle Age (> 50 and <= 65)	7
Elder (> 65)	9

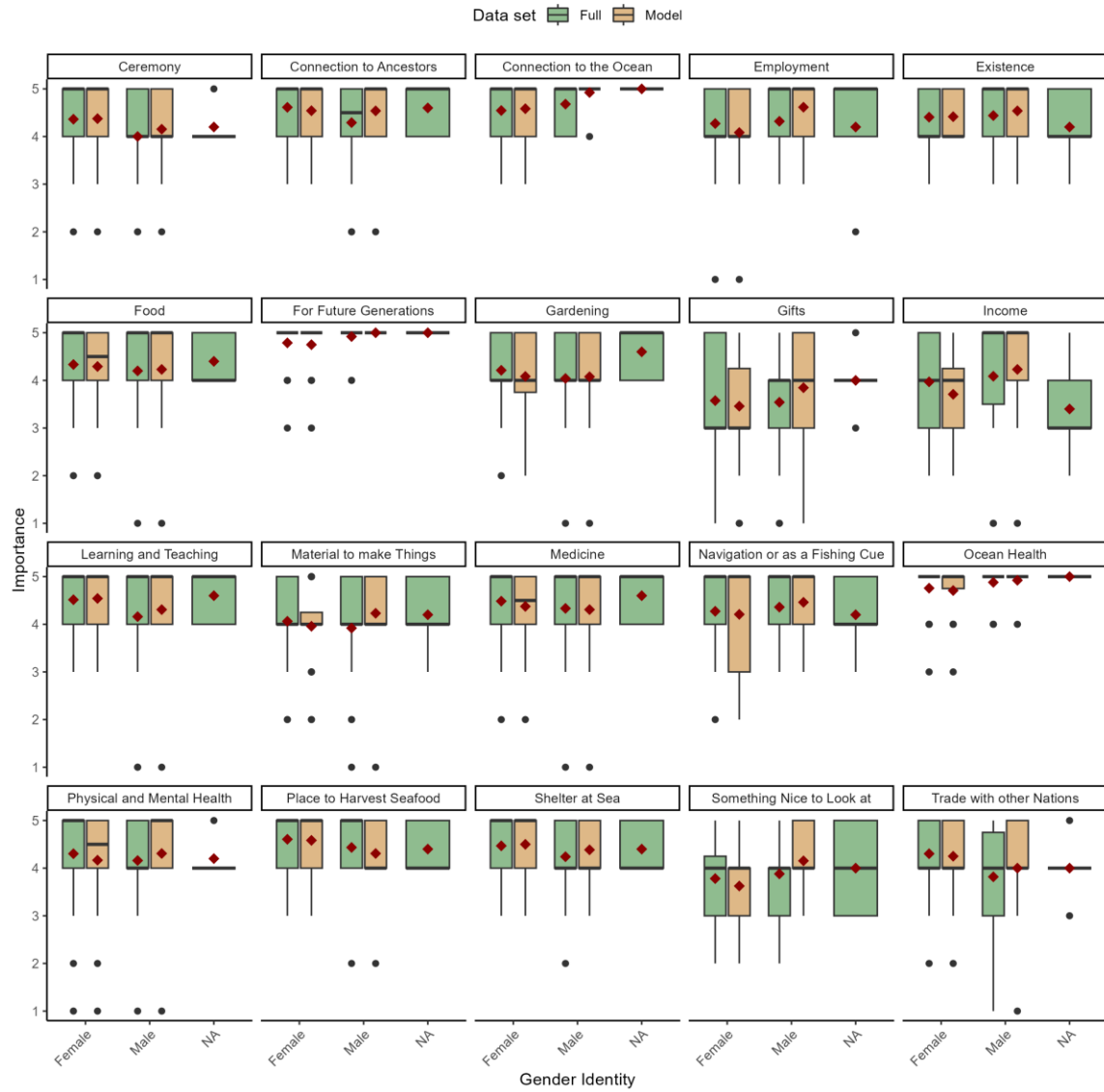


Figure B.1: Comparison of kelp value importance scores between full survey data (n~64, green) and complete cases (n = 37, brown) by gender identity. Red diamonds are mean scores. Note that the modeled cases are contained within the full survey data.

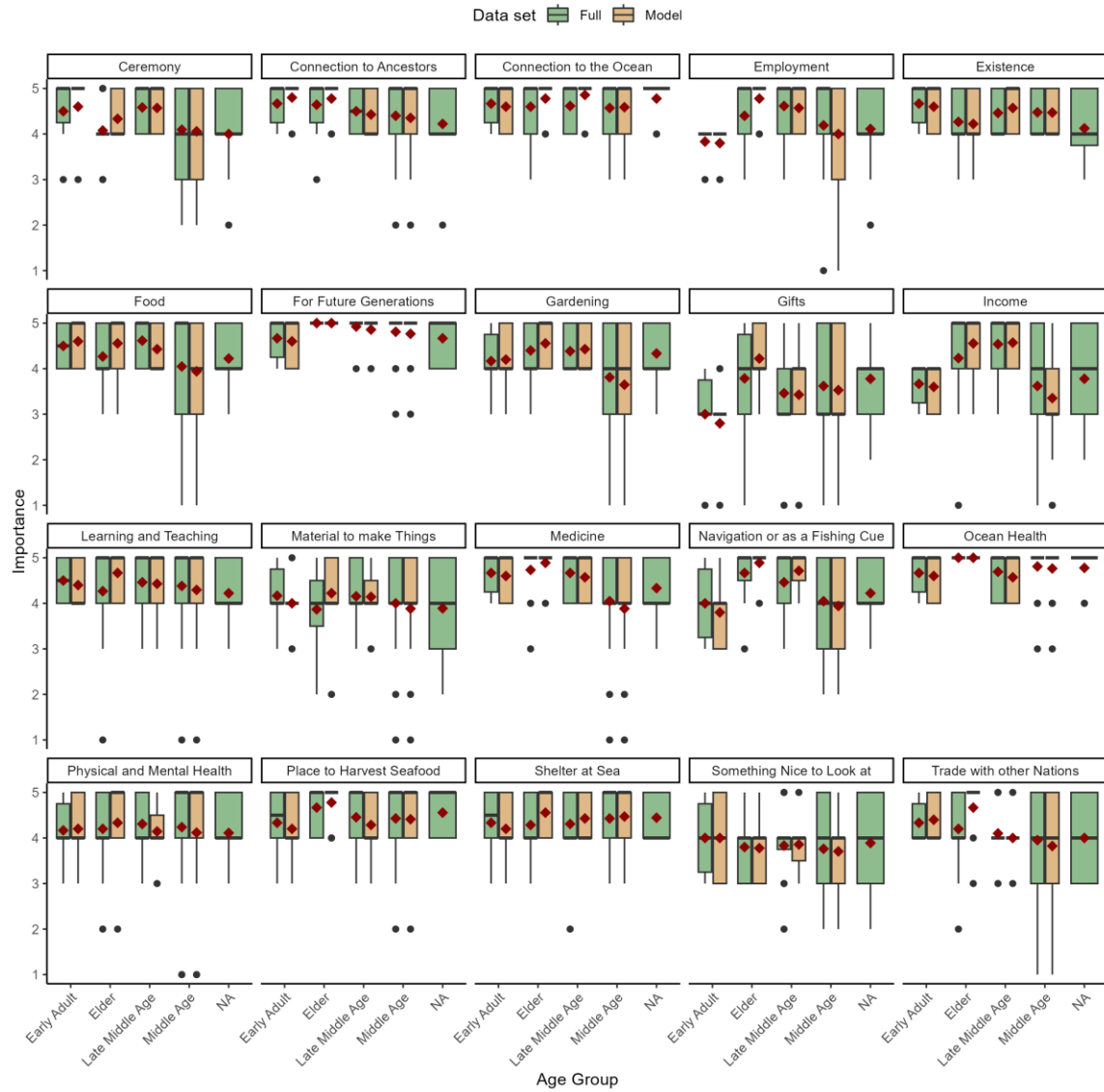


Figure B.2: Comparison of kelp value importance scores between full survey data (n=~64, green) and complete cases (n = 38, brown) by age group. Red diamonds are mean scores. Note that the modeled cases are contained within the full survey data.

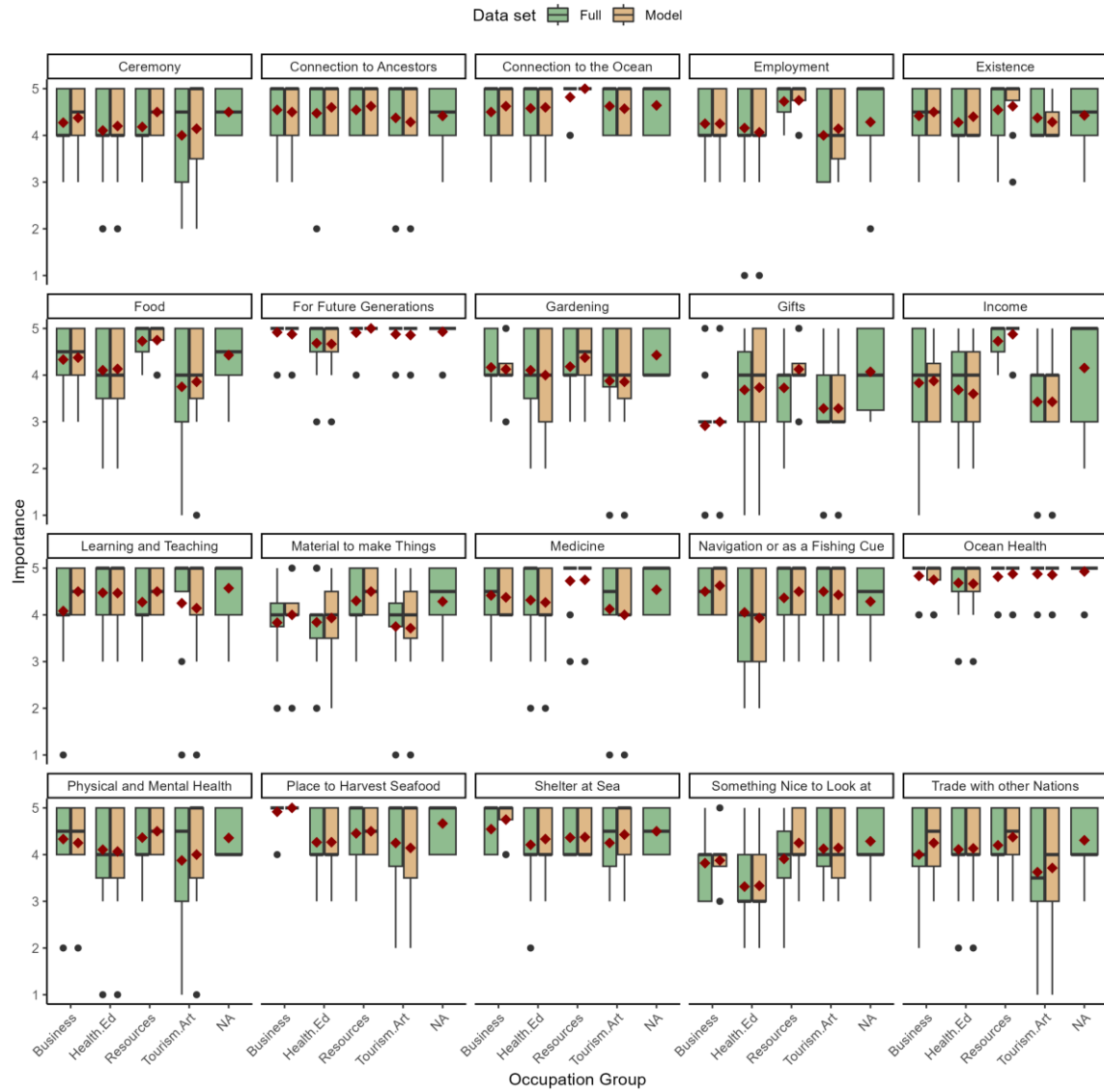


Figure B.3: Comparison of kelp value importance scores between full survey data (n=~64, green) and complete cases (n = 38, brown) by occupation group. Red diamonds are mean scores. Note that the modeled cases are contained within the full survey data.

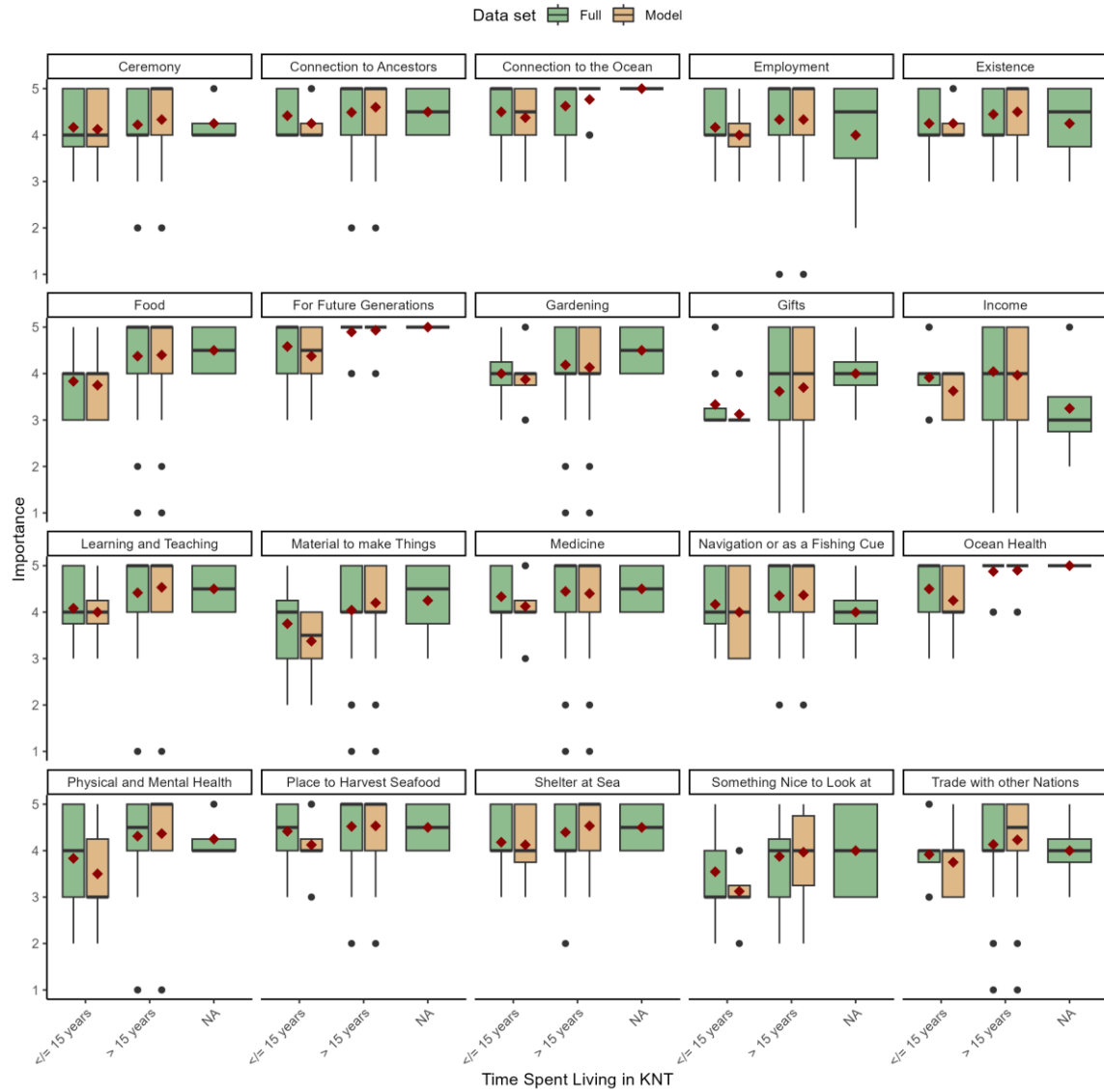


Figure B.4: Comparison of kelp value importance scores between full survey data (n~64, green) and complete cases (n = 38, brown) by time spent living in Kwakwiltl Nation Territories. Red diamonds are mean scores. Note that the modeled cases are contained within the full survey data.

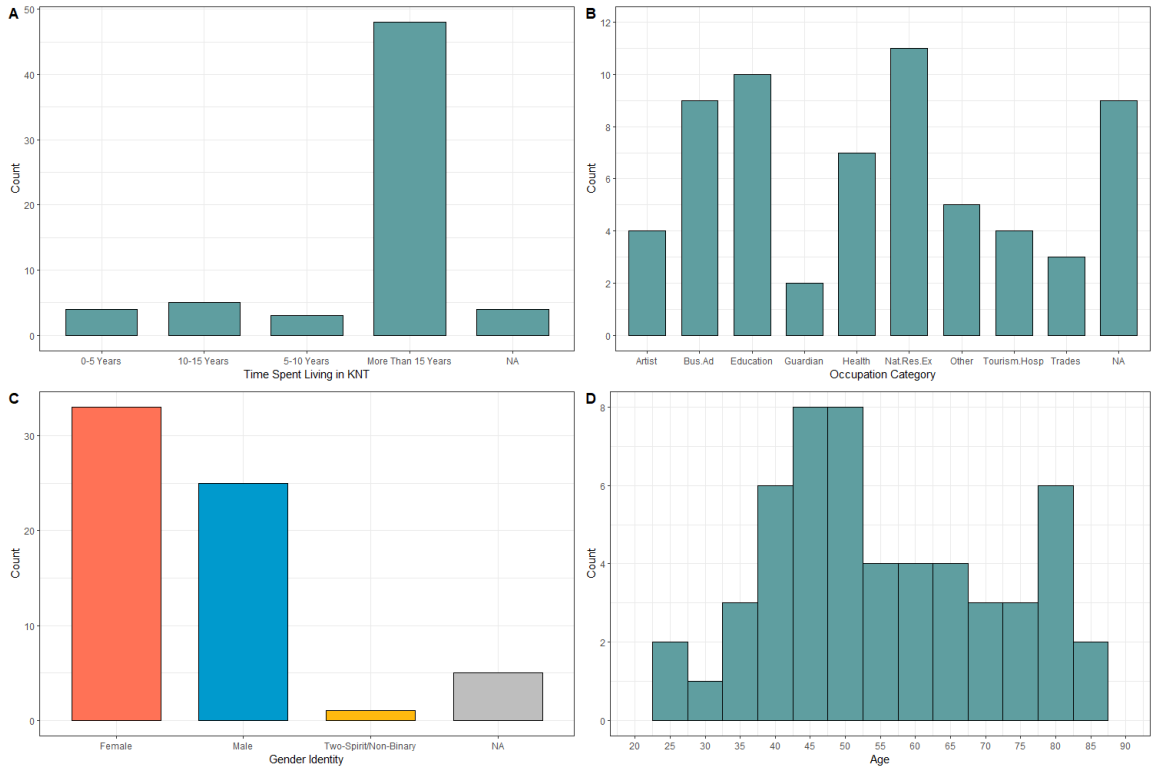


Figure B.5: Demographic distributions: (A) time spent living in Kwakiutl Nation Territory, 4 respondents had lived there 0-5 years, 5 for 5 10 years, 3 for 10-15 years, and 48 for more than 15 years. (B) Occupation wise, there were 4 artists, 9 in business or administrative roles, 10 in education roles (including research), 2 Guardians, 7 working in health services, 11 in natural resource extraction (e.g., fishing, logging), 4 in tourism or hospitality, 3 in trades, and 5 with other occupations. (C) 33 respondents identify as female, 25 as male, and 1 as non-binary/two spirit. (D) Ages ranged from 23 to 84. Note that of the 64 total responses, not all participants chose to share this personal information.

Table B.2: Cumulative link model (CLM) outputs. Estimates are in log odds. Red highlighted cells have AF, which stands for “assumptions failed” or FtC for “failed to converge”; kelp values which CLMs failed to meet assumptions or to converge were modeled with Kruskal-Wallis tests (Table B.3). Yellow highlighting shows significant p-values (< 0.05) which were then investigated pairwise (Table B.4). P values with ** had no pairwise significance. The n for Gender Identity is 37 to protect participant anonymity. N = 38 for Age Group, Occupation Group, and Time Spent Living in Kwakiutl Nation Territories (Time KNT).

Kelp Value	Age Group (reference = Early Adult)								Occupation Group (reference = Business/Admin/Trades)								Gender Identity* (reference = female)				Time Spent Living in Kwakiutl Nation Territories (reference = <= 15 years)			
	Log Likelihood	Residual Degrees of Freedom	Middle Age		Late Middle Age		Elder		Log Likelihood	Residual Degrees of Freedom	Guardian/Education/Health		Natural Resources		Tourism and Arts		Log Likelihood	Residual Degrees of Freedom	Male		Log Likelihood	Residual Degrees of Freedom	> 15 Years	
			Estimate	P value	Estimate	P value	Coefficient	P value			Estimate	P value	Estimate	P value	Estimate	P value			Estimate	P value			Estimate	P value
Food	AF	AF							-42.3	31	-0.36	0.66	1.06	0.31	-0.59	0.55	-42.56	32	0.22	0.74	-41.23	33	1.68	0.02
Medicine	-34.4	31	-1.54	0.14	-0.10	0.93	1.60	0.25	AF	AF							-38.88	32	0.27	0.70	-38.89	33	1.09	0.14
Material to make Things	-45	31	0.08	0.93	0.35	0.75	0.84	0.42	-44.11	31	-0.25	0.77	1.05	0.27	-0.35	0.73	-42.17	32	0.95	0.17	-41.64	33	2.21	0.01
Gifts	AF	AF							AF	AF							-49.89	32	0.73	0.25	-49.98	33	1.22	0.09
Ceremony	-40.73	32	-1.59	0.20	-0.72	0.59	-1.39	0.28	AF	AF							-40.5	33	-0.59	0.37	-41.67	34	0.61	0.41
Trade with other Nations	-42.87	31	-0.89	0.33	-0.84	0.41	1.22	0.28	-45.66	31	-0.29	0.73	0.21	0.82	-0.76	0.46	-44.09	32	-0.36	0.58	-44.6	33	1.27	0.08
Employment	AF	AF							-39.28	32	-0.12	0.88	1.50	0.15	-0.17	0.86	-38.39	33	1.30	0.07	-40.29	34	0.99	0.18
Physical and Mental Health	-45.13	31	0.41	0.67	-0.18	0.86	0.52	0.62	AF	AF							-43.05	32	0.30	0.65	AF	AF		
Learning and Teaching	AF	AF							-35.9	32	0.01	0.99	0.00	1.00	0.33	0.77	-32.66	33	-0.24	0.73	-33.53	34	1.76	0.03
Place to Harvest Seafood	AF	AF							FtC	FtC							-32.23	33	-0.68	0.32	-34.35	34	1.37	0.08
Income	-45.53	31	-0.42	0.63	1.92	0.07	2.11	0.04	AF	AF							-48.79	32	1.26	0.07	-51.14	33	0.77	0.24
Navigation or as a Fishing Cue	-35.5	32	0.32	0.72	1.99	0.08	3.06	0.02**	-39.52	32	-1.28	0.14	-0.16	0.87	-0.35	0.73	-39.18	33	0.45	0.50	-40.39	34	0.83	0.26
Ocean Health	FtC	FtC							-22.05	33	-0.17	0.86	0.82	0.54	0.67	0.62	-19.86	34	1.40	0.22	-17.8	35	2.79	0.00
Something Nice to Look at	-45.83	32	-0.60	0.55	-0.34	0.76	-0.50	0.64	-41.63	32	-1.31	0.11	0.95	0.31	0.74	0.46	-43.18	33	1.20	0.07	-42.5	34	2.06	0.01
Existence	-29.28	33	-0.50	0.63	-0.11	0.92	-1.33	0.25	-28.89	33	-0.37	0.66	0.89	0.41	-0.81	0.44	-29.15	34	0.63	0.37	-29.45	35	1.01	0.22
Connection to the Ocean	-25.35	33	0.10	0.92	1.33	0.34	0.81	0.50	FtC	FtC							-22.62	34	1.99	0.08	-24.92	35	1.35	0.11
Connection to Ancestors	-31.01	32	-1.39	0.25	-1.51	0.25	-0.13	0.93	-32.66	32	0.09	0.92	0.19	0.86	-0.28	0.79	-31.53	33	0.37	0.61	-30.93	34	1.45	0.06
Resource for Future Generations	FtC	FtC							FtC	FtC							FtC	FtC			-15.42	35	2.70	0.01
Shelter at Sea	-33.94	33	0.85	0.40	0.51	0.65	0.93	0.40	-33.11	33	-1.36	0.16	-1.38	0.18	-0.99	0.37	-33.26	34	-0.41	0.54	-33.39	35	1.14	0.16
Gardening	AF	AF							-46.63	31	-0.08	0.91	0.62	0.48	0.00	1.00	-45.96	32	0.22	0.73	-46.43	33	0.76	0.27

AF = Assumptions Failed
FtC = Fails to Converge
** no pairwise significance
* n = 37

Table B.3: Kruskal-Wallis model outputs. Yellow highlighting shows significant p-values (< 0.05) which were then investigated pairwise using Conover-Iman tests. P values with ** had no pairwise significance. The n for Gender Identity is 37 to protect participant anonymity. N = 38 for Age Group, Occupation Group, and Time Spent Living in Kwakiutl Nation Territories.

Kelp Value	Age Group			Conover-Iman Pairwise Difference (Bonferroni adjusted p value)	Occupation Group			Conover-Iman Pairwise Difference (Bonferroni adjusted p value)	Gender Identity*			Time Spent Living in Kwakiutl Nation Territories			Conover-Iman Pairwise Difference (Bonferroni adjusted p value)
	Kruskal-Wallis X ²	p-value	df		Kruskal-Wallis X ²	p-value	df		Kruskal-Wallis X ²	p-value	df	Kruskal-Wallis X ²	p-value	df	
Food	2.14	0.54	3												
Medicine					3.57	0.31	3								
Material to make Things															
Gifts	5.33	0.15	3		5.54	0.14	3								
Ceremony					0.32	0.96	3								
Trade with other Nations															
Employment	8.19	0.04**	3												
Physical and Mental Health					0.44	0.93	3					5.39	0.02	1	0.009
Learning and Teaching	0.97	0.81	3												
Place to Harvest Seafood	3.18	0.37	3		8.28	0.04	3	Business - Health.Ed: 0.012 Health.Ed - Resources: 0.0076 Resources - Tourism.Art: 0.0157 Business - Resources: 0.06							
Income					10.11	0.02	3								
Navigation or as a Fishing Cue															
Ocean Health	5.07	0.17	3												
Something Nice to Look at															
Existance															
Connection to the Ocean					4.10	0.25	3								
Connection to Ancestors															
Resource for Future Generations	3.68	0.30	3		2.93	0.40	3				3.04	0.08	1		
Shelter at Sea															
Gardening	5.55	0.14	3												

* n = 37

** no post hoc significance

Table B.4: Pairwise cumulative link model (CLM) tests for significant differences in the importance score (as determined by survey respondents) for help as values in which there was an overall significant difference (Table B.2). Only Income x Age Group had significance between Middle Age and Elder categories (yellow highlighting).

Income	Age Groups	Estimate	Tukey adjusted p
	Early Adult - Middle Age	0.42	0.96
	Early Adult - Late Middle Age	-1.92	0.26
	Early Adult - Elder	-2.11	0.18
	Middle Age - Late Middle Age	-2.34	0.05
	Middle Age - Elder	-2.53	0.03
	Late Middle Age - Elder	-0.19	1.00
Navigation or as a Fishing Cue	Age Groups	Estimate	Tukey adjusted p
	Early Adult - Middle Age	-0.32	0.98
	Early Adult - Late Middle Age	-1.99	0.30
	Early Adult - Elder	-3.06	0.10
	Middle Age - Late Middle Age	-1.67	0.29
	Middle Age - Elder	-2.74	0.09
	Late Middle Age - Elder	-1.07	0.85

Appendix C.

Resilient and Reconciliatory Kelp Management

Table C.1: Select observations of change discussed by interview participants.

Observation	Perspectives from Knowledge-keepers
Warmer water and more kelp turn over	We've seen it with heat waves. So last year, two years ago, when we had that massive heat wave and that change in water temperature... it turns the kelp over immediately. (Marc Peeler)
Increased Storms	[For] 30 years I've been witnessing the seasons getting later and later, and also the storms are intensifying while the world is getting hotter and hotter; it gets the more intense. (walas 'Namugwis David Knox)
Less rain, snow, streamflow	We haven't had rain now [for about] 50 days here. [It is] very, very rare that ever happens. Have you taken a look at the river by Pioneer Inn? When you go drive by there the water is nothing compared to what it used to be years ago. And no snow to back up what little rain we did get. (Verna Hunt and David Hanuse)
Amount of kelp variable (less, more, same)	We'll go through a bed, harvest it, and then leave it alone, go somewhere else. You keep watching and monitoring it. But we've been surprised [by] how much it's been coming back when we're harvesting. (Marc Peeler)
	22 years [I] have been doing this. All the beds that are here I have I've seen the whole time. There's only one spot that there was a bed that there is no longer a bed and that was Keogh Shoal. (Marc Peeler)
	Shell Island used to be completely surrounded by kelp, and there was only one way in that I could remember by boat. But now it doesn't seem like it's an issue getting around it. It used to be [that] you'd have to make some pretty wide berths around some of the islands because there was so much kelp and now ... that abundance isn't there anymore. (Ross Hunt Jr)
Pollution and contamination	Well my lifetime, this beach has gotten so polluted. When I first moved here, my father used to wake me up before the sun even woke up and we'd go down the beach and you would see lanterns all along the beach. And that's all of the families getting their food for the day ... But now we can't even dig off this beach anymore, [its] so contaminated. And that's what I'm hoping that kelp might be able to help fix [by] cleaning our shores. (Ross Hunt Jr)
Wildfire smoke reducing kelp growth	[Smoke from forest fires] seemed to slow everything down ... things weren't growing as quickly and it wasn't to the point where we were worried [about harvesting], but we did notice it definitely slowed down in [its] reproduction. (Marc Peeler)

Observation	Perspectives from Knowledge-keepers
Variable seasons (month and a half late in 2022)	I witnessed this year, everything [was] a month and a week later, nothing was put in the ground till a month and a week later 'cause everything was too wet. Then we got all this moisture until July. And August it dried up. Summer just started in August. September was dry, and now we're past middle October, and its still dry. (walas 'Namugwis David Knox)
More sick kelp (bryozoans)	I've noticed that a lot of the kelp are rotten. I think if anything we should, just like if you're working in the woods, you space them out, get rid of the rot and leave the good ones because the rot will get into new ones and they'll start rotting (Charles Wilson)
Peeling herring eggs	I've noticed [for] a lot of the herring that spawned in the kelp that I harvested, [the eggs] were peeling... off when they should be sticking to it. (walas 'Namugwis David Knox)

Table C.2: Select barriers to kelp access discussed by interview participants.

Barrier	Perspectives from Knowledge-keepers
Need for teaching, learning, and training	Our younger generation would starve if anything happens in the now. 'cause they wouldn't know what to do to survive. There's no training of any kind. (Whata Twance)
	Teaching something in the school is totally different. You don't feel that texture, you don't feel that's how it smells. ... When I first came here, [I thought] "Oh the beach stinks. How come people live here?" but ... now I smell the beach [and] I'm home. (Gordon Twance)
Lack of interest in kelp	We people growing up we need to get more stories from our elders and the traditional ways of how they harvest everything. And then we can pass it on to our kids so the kids can actually learn something. But that's the other thing too - do the kids want to know? With technology these days, that's all they want. (Albert Brotchie)
Internal and external processes (e.g., permitting)	It's the permission part. Because of other bylaws or whatever, so that's why [fishery proposals are] all shut down. (David Hanuse)
Boat access	Now we're depending on the band with their band boats and that to go food fishing ... because you would need a boat to go to the islands here to get cleaner products than to go down to the beach. (Lucille Brotchie)
	We no longer had our own mode of travel, and it's the guys that have the boats that can go out and do the harvesting. (Verna Hunt)
Loss of Kwakiutl knowledge	It all depends how you are brought up. And [by who] you're brought up. Are they culturally knowledgeable? Because through banning the potlatch ... that's when the values of protocols change for all Kwakwaka'wakw. (walas 'Namugwis David Knox)
	We're losing our [knowledge of] how to use the kelp. How do you use [it]? What's going on? Like nowadays people don't know how to crab. It's so simple, but they don't know how. (Gord Twance)
Climate change and pollution	Pollution and global warming and all of those things are actually inhibiting us with our relationship with the land. (Marlo Thomas)
Loss of sovereignty	We had autonomy. In the last 20 or 30 years the trend has been going more and more to hand outs, you know, what can the band office do? We need food. Growing up, we used to be able to just go out [and] get our own food. (Ross Hunt Jr.)

Table C.3: Select perspectives on kelp farming from anonymous survey.

98% of survey respondents support kelp farming overall
"If done safely to protect the oceans but still provide[s] for the community with food and employment; this could be great"
"It needs to be environmentally sound and not be driven by greed and money. Habitat and biodiversity need to weigh equal to economy. Also economic gains must be reflected in jobs, ongoing [and] sustainable. Growing it and processing it need to be local as well as potential for future entrepreneur and small business"
"time to teach next generation"
"I believe as an economic value it is important as well as learning more about the uses of kelp"
"I like the idea that it has medicinal qualities, bringing back our ways of our ancestors"
"if qualified operator can be found"
"be respectful, fair and follow through with economic development, hiring of Kwakiutl 1st nation, train, teach shareholders, not just someone to deal with... tell you get what you want and walk away. Set the example, lead, work as if it was your land or family"

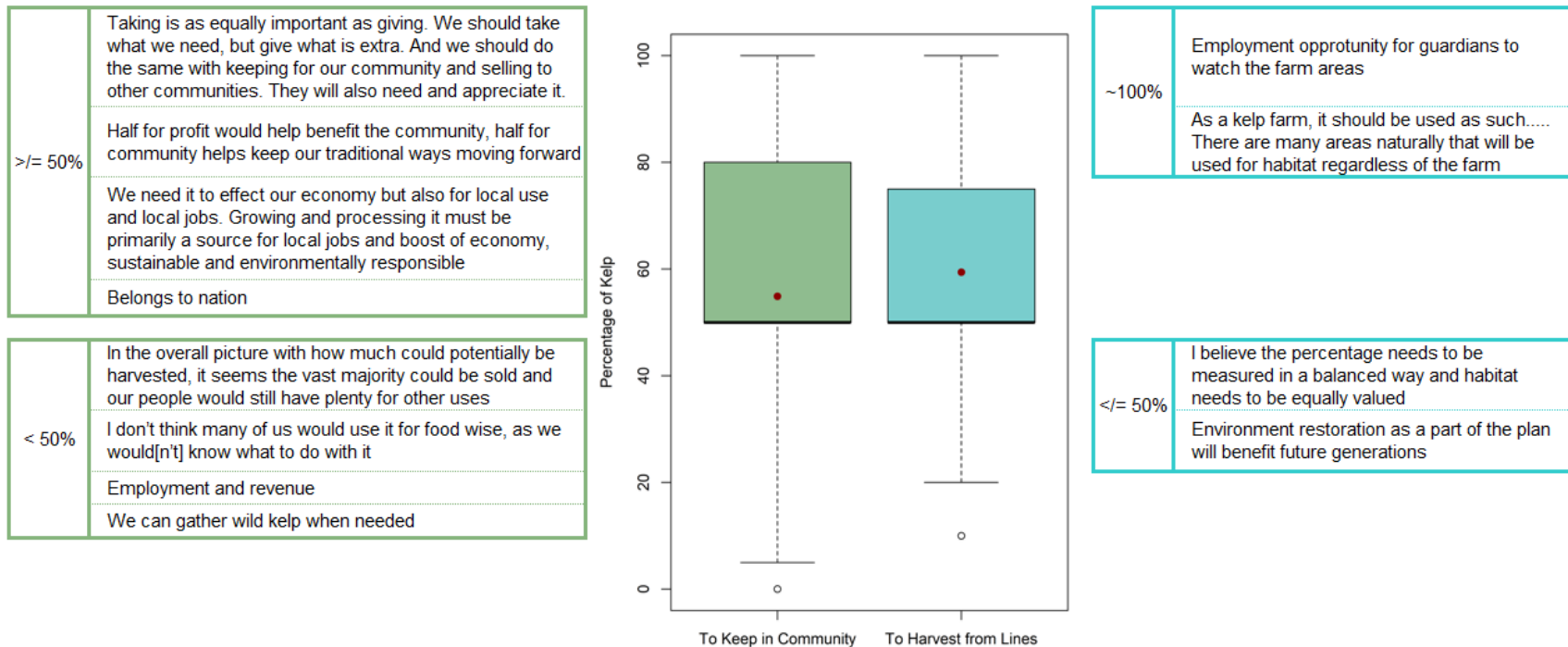
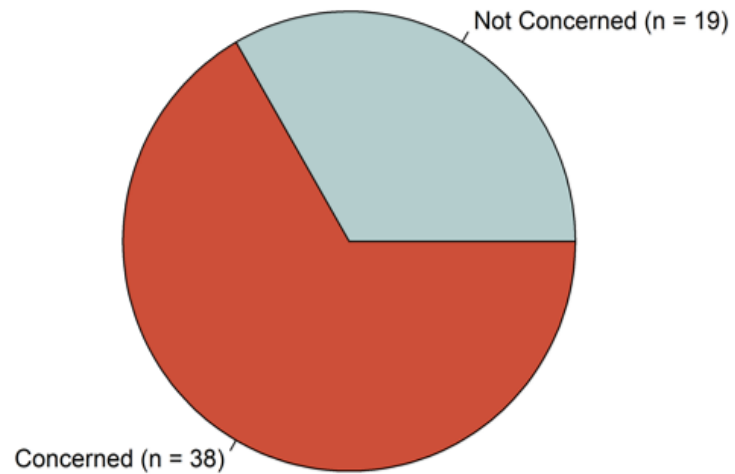


Figure C.1: Kelp farming trade-offs between percentage of kelp to keep in community (vs. sell) in green and to harvest from lines (vs. leave on lines) blue. Red points are mean response values for each option. Open circles are outlier responses. Survey respondent rationales for choices are presented in matching coloured boxes.

"We are already seeing changes caused by climate change; the ocean is our refrigerator and our grocery store we must become more actively involved in environmental protection and restoration."

"Climate change is already showing us more severe weather patterns"

"Warmer waters, more displaced animals using more of it!"



"I think the rich nutrient waters of the north island would help and work well in the ecosystem"

"It depends what flows through our waters and beaches."

"Kelp farming would benefit climate change"

Figure C.2: Number of respondents concerned that climate change will negatively impact a kelp farm; 38/57 (67%). Select qualitative rationales for these perspectives are presented in colour-coordinated tables.

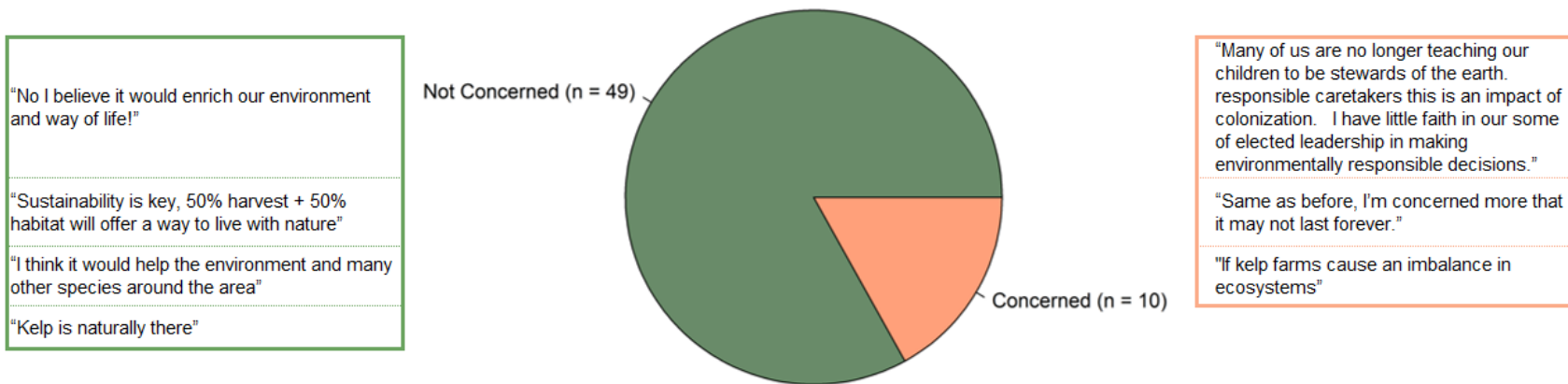


Figure C.3: Number of respondents concerned that a kelp farm will negatively impact a kelp farm; 10/59 (17%) Select qualitative rationales for these perspectives are presented in colour-coordinated tables.

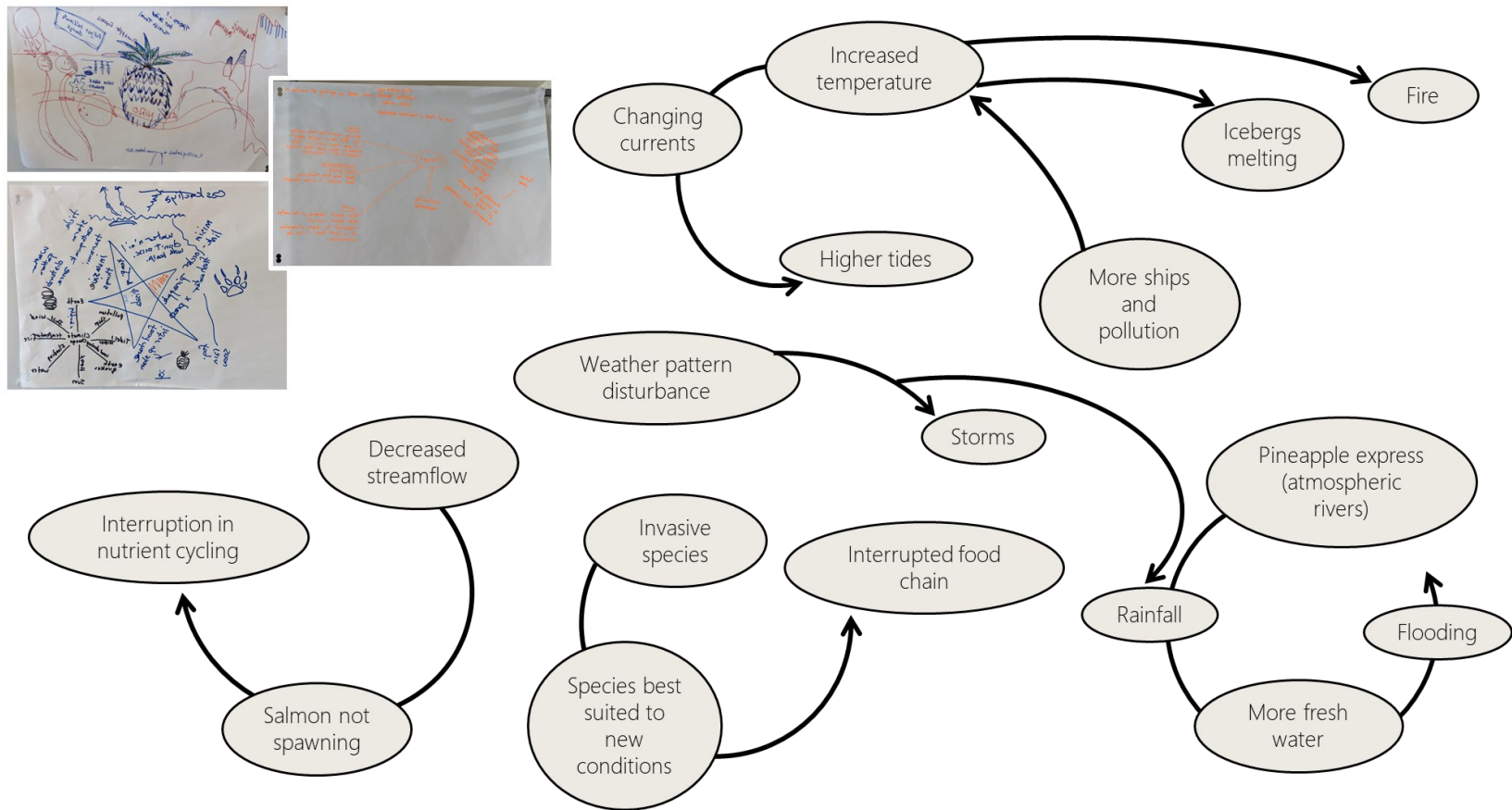


Figure C.5: Summary of Climate Change Thought-Mapping activity from workshop held March 10, 2023. Pictures of the mind maps from the 3 groups are in the top left. Themes were summarized by taking all unique ideas (i.e., common points are not represented multiple times) and grouping them into loops that represent the main ‘cause and effect’ pathways discussed.

Table C.4: Themes of management actions to support resilience highlighted during the workshop held March 10, 2023 and supporting resilience literature. Themes were determined from workshop data using emergent thematic analysis.

Management Action Theme	Ideas from community leaders	Social-ecological system resilience principle (1-7)* (Biggs et al. 2012)	Other supporting resilience literature
Community Outlook	<ul style="list-style-type: none"> - “Do good for all not just one family” - “Help each other to better the environment” - “Keep smiling” - “Understanding our relationships to each other” - “Living community” 	<ul style="list-style-type: none"> - Connectivity – in community (2) 	(Olsson et al. 2004, Berkes 2007, Berkes and Ross 2013, Folke 2016)
Local Governance	<ul style="list-style-type: none"> - “Vote for change” - “Adopt a policy and implement” - “Structure in leadership” - “Apply land use plan” - “Don’t forget the role of women” - “Stop the corruption at the top” - “Follow what is written” - “Taxes from resource operations to community” 	<ul style="list-style-type: none"> - Diversity - in governance (1) - Participation in management/governance (6) - Polycentric governance (7) 	(Olsson et al. 2004, Berkes 2007, 2021, Berkes and Ross 2013, Folke 2016, Folke et al. 2016, Salomon et al. 2019)
Localize Processes	<ul style="list-style-type: none"> - “Food security” - “Value added, jobs, learning” [e.g., harvest and process kelp in community] - “More community involvement” - “Have opportunities for youth to stay and work in and for the nation” - “You learn more from doing it yourself. Keep kelp farm by and for community” - “Self determination” 	<ul style="list-style-type: none"> - Diversity - in livelihoods (1) - Connectivity - in process (2) - Participation (6) 	(Berkes 2007, Berkes and Ross 2013)

Management Action Theme	Ideas from community leaders	Social-ecological system resilience principle (1-7)* (Biggs et al. 2012)	Other supporting resilience literature
Capacity	<ul style="list-style-type: none"> - “Push the band for a book on criteria of eligibility for funding for education” - “Need support in community for careers” - “Need consistent income in order to plan for the future. Think more collective and less individual” - “Encourage youth to get formal training and education” - “Royalty money from kelp to educate future workers from community” - “Look at maps in treaty office” - “Pilot projects” 	<ul style="list-style-type: none"> - Foster understanding (4) - Learning (5) - Participation in management/governance (6) 	(Olsson et al. 2004, Berkes 2007, Berkes and Ross 2013, Folke 2016, Folke et al. 2016)
Knowledge Sharing	<ul style="list-style-type: none"> - “Chat chat chat” - “Sharing knowledge as often as you can and as openly as possible” - “Teaching next generation” - “Monthly sharing circles talking about medicinal uses, knowledge and getting people back to utilizing this resource” - “Get together and learn, and learn what questions to ask” 	<ul style="list-style-type: none"> - Connectivity - of knowledge (2) - Foster understanding (4) - Learning (5) 	(Olsson et al. 2004, Berkes 2007, 2021, Berkes and Ross 2013, Brown and Williams 2015, Folke 2016, Folke et al. 2016)

Management Action Theme	Ideas from community leaders	Social-ecological system resilience principle (1-7)* (Biggs et al. 2012)	Other supporting resilience literature
Cultural Connection and Identity	<ul style="list-style-type: none"> - “Sea field trips to old villages and beside rivers and streams” - “Ancestors teachings” - “Retreats for members” - “4 or more tribes in this village” - “Apply traditions and stop active colonialism” - “We are more than just a #, 626” - “Kwakiutl band customs; decolonize” - “Book explaining kelp in kwak’wala with medicinal uses, stories; colouring pages” 	<ul style="list-style-type: none"> - Diversity - in governance (1) - Connectivity - of identity, Kwakiutl knowledge, principles (2) - Slow variables - legal systems, values, traditions (3) - Foster understanding (4) - Learning (5) - Participation in management/governance (6) - Polycentric governance – indigenous governance (7) 	(Berkes 2007, 2021, Berkes and Ross 2013, Folke et al. 2016, Jackley et al. 2016, Quempt et al. 2018, Salomon et al. 2019)
Active Stewardship	<ul style="list-style-type: none"> - “Guardians” - “Long term monitoring, less short term thinking” - “Starting a small kelp farm that is created 100% by the nation” - “Stay on the right path” 	<ul style="list-style-type: none"> - Connectivity - of community to environmental status (2) - Slow variables - e.g., monitoring climate change (3) - Learning (5) 	(Olsson et al. 2004, Berkes 2007, Brown and Williams 2015, Folke et al. 2016)

* The seven principles for resilience discussed by Biggs et al. (2012) are:

- 1) Maintaining diversity and redundancy
- 2) Manage connectivity
- 3) Manage slow variables and feedback
- 4) Foster an understanding of social-ecological systems as complex adaptive systems
- 5) Encourage learning and experimentation
- 6) Broaden participation
- 7) Promote polycentric governance systems