Caring for *lhuq'us* (*pyropia spp.*): Mapping and Remote Sensing of Hul'qumi'num Culturally Important Seaweeds in the Salish Sea

by

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Abstract

Hul'qumi'num communities on south eastern Vancouver Island have concerns about the status and safety of marine foods potentially impacted by environmental change and the urbanization and industrialization of their territories. Collaborative research undertaken with the Hul'q'umi'num' Lands and Resources Society is part of a broader effort to revitalize cultural practices, language, and food systems. *Lhuq'us* (the Hul'q'umi'num' language term for *pohrpyra/pyropia spp.* (commonly known as red laver or black gold)) is a flavourful and nutritious intertidal seaweed that grows on rocky beaches across the Pacific Northwest. Hul'q'umi'num' language, cultural values, teachings, and family histories are all interwoven into the harvesting and consumption of *lhuq'us* in Hul'qumi'num territories. *Lhuq'us* is one of the species that have been persistently mentioned in conversations with state regulatory agencies and though these concerns have been raised for at least two decades there has been no systematic monitoring of the species. There are two broad streams of inquiry taken by thesis thesis. The first, employing ethnographic methodology including interviews and observant participation, seeks to both document the cultural values, oral histories, lived experiences associated with *lhuq'us* as well as concerns for the future collaborators have for *lhuq'us* and *lhuq'us* beaches. The second stream, based in a geographic approach, asks whether Unoccupied Aerial Vehicle (UAV) technologies could be employed to record the status of *lhuq'us* as a baseline for monitoring. Two study sites in the Salish sea were surveyed using UAV techniques: ƛEL,IŁĆ and *St'utl'qulus*. The overall accuracies of the UAV imagery classifications and the particular accuracies of the class representing *lhuq'us* suggest that UAV technologies paired with Google Earth Engine (GEE) object based image analysis (OBIA) methodologies can effectively detect *lhuq'us*. There are serious

concerns and cultural values and practices deeply interconnected with culturally important species like *lhuq'us*. Through holding these concerns and values side by side with systematic observation and analyses maps and materials were created which communities can use to assert their rights, enact their own monitoring of territories and re-prioritize environmental decision-making done by federal, provincial, and municipal management agencies.

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Introduction

Hul'qumi'num communities on south eastern Vancouver Island are engaged broadly in work to revitalize cultural practices, language, and food systems. Part of this work involves documenting and monitoring culturally important species potentially impacted by environmental change and the urbanization and industrialization of their territories. *Lhuq'us* (the Hul'q'umi'num'[1] language term for *porphyra/pyropia spp.*), a seaweed found in the rocky intertidal zone of beaches in the Pacific Northwest, is one of many species that Hul'qumi'num people are concerned about. *Lhuq'us* is a culturally important being, woven into oral histories, stories of place, and in the lived and embodied practice of Hul'qumi'num culture. In 2004 the former Hul'qumi'num-Gulf Islands National Park Reserve Committee (H-GINPR Committee) was formalized with the purpose of engaging Parks Canada in decision making for lands and waters from which Hul'qumi'num people have been alienated from (Abramczyk, 2017). This committee functioned as a cooperative co-management arrangement where members voiced the perspectives, concerns, stories, and histories of the communities they represented (Abramczyk, 2017). Auggie Sylvester, a respected Penelakut Elder, and other knowledgeable people often shared stories about *lhuq'us* in these meetings (personal communication Brian Thom, 2020). Concerns for *lhuq'us* were repeated over the 15 years the committee was active with Elders drawing their collaborator's attention to the seaweed (Personal communication Brian Thom, 2020). Despite the concern expressed by Hul'qumi'num Elders, *lhuq'us* was never included in Species at Risk (SARA) plans nor

[1] Following local spelling conventions Hul'q'umi'num' refers to the language, Hul'qumi'num refers to the cultural and political organizations

formally monitored or protected by the state through other means. The centrality of this species, in contrast to its invisibility in regulatory and co-management processes sparked the community conversation to initiate a research project that shed light on the cultural values associated with *lhuq'us*. In neighbouring W̱SÁNEĆ communities, knowledgeable people have been describing declining abundance of *lhuq'us* for at least the last twenty-five years (Simonsen, Davis, & Haggarty, 1995). The concern is also not localized to southeastern Vancouver Island, changes to the *lhuq'us* bloom have been documented across the Pacific Northwest by harvesters and traditional food practitioners (Clark et al., 2018; Deveau, 2011; Turner and Clifton, 2009). In Hul'qumi'num territories concern for *lhuq'us* is underpinned by broader a Hul'qumi'num practice called *hwule'lum'ut thu tsetsuw'* (Hul'q'umi'num' language phrase that approximately translates to "caring for our beaches"). Following these teachings, Hul'qumi'num families and communities hold the responsibility for caring for places as well as the foods and beings they interact with in place. This project seeks to document and highlight the lived relationships between communities, families, *lhuq'us*, and beaches *lhuq'us* is harvested and in the process create ethnographic materials and maps that will be useful in the continued Hul'qumi'num monitoring and caring for *lhuq'us* and *lhuq'us* beaches. Our collective hope as particpants of this project is that these materials may also be useful for guiding and re-prioritizing environmental decision making by Federal and Provincial parks and other agencies operating in the Salish Sea.

As a collaborative and community initiated project, the collaborators of this research are active agents in shaping the questions, defining the methods, guiding the analysis, and vetting the results. The people I spoke with and the knowledge shared with

me was not unprocessed “data” to be mined and from which “anthropological information” can be created (Paul et al., 2014) but carefully articulated narratives from people who are knowledge makers in their own right. To reflect this collaborative methodology I place myself and my voice in this work instead of in some imagined neutral position. I am a white settler who was born and raised and live on the un-ceded territories of Tla’amin, K’omoks, W̱SÁNEĆ, and Lekwungen Nations and have frequently passed through and visited Hul'qumi'num territories my whole life. Positioning myself in the work alongside my Hul'qumi'num friends and collaborators allows me to make this work and its outcomes active, foregrounding the knowledge shared with me its full context. The knowledge shared with me over the course of this project is deeply personal, referring to family memories and histories, charged with intention, to engage community youth in the revitalization of community practice, and is political in nature, pushing against colonial and neoliberal structures and narratives.

Kathleen Johnnie, a member of the former H-GINPR Committee and the Executive Director of the Hul’q’umi’num’ Lands & Resources Society is the primary collaborator on this project. The Hul’q’umi’num’ Lands & Resources Society is a non-governmental Hul'qumi'num organization dedicated to maintaining traditional practices related to lands and resources in the modern setting; engaging youth and mentoring them in traditional teachings; and to ensuring the Hul’q’umi’num’ language is core to those practices and mentorships (K. Johnnie, personal communication 2019). Kathleen Johnnie articulated the broad research goals of this project as:

> “Documenting species that will potentially be impacted by the ever-increasing marine shipping in the Salish Sea [and working] with Elders and younger generations to connect and revitalize knowledge and practices related to these species.”

(K. Johnnie, personal communication 2019)

The following thesis is divided into two chapters that reflect the two pronged approach taken to (1) document the cultural values, oral histories, lived experiences, and concerns for the future collaborators have for *lhuq'us* and *lhuq'us* beaches and (2) to test whether Unoccupied Aerial Vehicle (UAV) technologies and remotely sensed imagery could be employed to record the current status of *lhuq'us* as a baseline for monitoring. The approach taken is broadly interested in the intersections of meaning making, experience, practice, and place illustrated by Hul'qumi'num people and their relationship with *lhuq'us* and *lhuq'us* beaches. I draw on the fields of both geography and anthropology to build my understanding of *lhuq'us* harvesting places and the cultural meanings associated with them, drawing on place theory developed by geographers, anthropologists, and other social scientists. This framework opens the analysis to the idea that places are not isolated coordinates but porous and fluid, interlinked to one another through fields of meaning and embodied practices on the ground (Massey, 1991). Making explicit the importance of interaction, experience, and embodiment centres the lived experiences and observations of Hul'qumi'num community members, families, and their experiences, knowledge, histories, and relationship with place as core to understanding *lhuq'us* (Kovach, 2010; Smith, 2013; Dyck, 1993; Massey, 1991). Taking seriously the cultural context of *lhuq'us* and *lhuq'us* beaches is critical. It is not enough to simply document where *lhuq'us* beaches are or where *lhuq'us* is on the beach. The cultural values that inform why *lhuq'us* is important and should be protected are foundational to developing baseline information about *lhuq'us*. Through connecting cultural values and practices that the voices brought together in this work clearly demonstrate with systematic observation and analyses using

emergent UAV technologies, taking seriously concerns about culturally important species like *lhuq'us* can guide and re-prioritize environmental decision making done by federal, provincial, and municipal management agencies.

Chapter 1: An Ethnography of *Lhuq'us*

Introduction

In the summer of 2019 I was invited by Kathleen Johnnie as a guest and participant to a Hul'q'umi'num' language and culture immersion camp she had organized. I was invited by Kathleen and her Elders to be part of a collaborative research project on *lhuq'us* (the Hul'q'umi'num' language word for *porphyra* and *pyropia spp*.), a seaweed species culturally important to Hul'qumi'num peoples. Hul'qumi'num[2] practitioners of traditional land and resource use and Hul'qumi'num resource managers initiated the project itself. These practitioners are interested in documenting culturally important species that will potentially be impacted by climate change, development of Hulq'umi'num territories, and the ever-increasing marine shipping in the Salish Sea. The practioners are working with Hul'qumi'num Elders and younger generations to connect and revitalize knowledge and practices related to these species. This thesis is an extension of and is guided by their ongoing work.

On one afternoon during the camp on Saturna Island, Auggie Sylvester, a respected Penelakut Elder and knowledge holder, took a group of us on a walk to *Kw'ulhutsun*, the narrow pass between Saturna and Samuel Islands. When we reached the point where water was rushing into the bay through the narrow opening on a rising tide he sat down and we sat around him. Auggie's great grandson sat beside him, asking questions about his memories of the place. This conversation illustrates the connections between place, people, and beach foods.

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[2] Following local spelling conventions Hul'q'umi'num' refers to the language, Hul'qumi'num refers to the cultural and political organizations

> Auggie: "We lived here all summer, me and my grandparents. Picking seaweed back and forth. You'd go out there and then pick seaweeds and come back. No sooner did we get back to the camp- camp was just over there- no sooner did we get there and a big seine boat would pull in ask us what we had. You tell them "seaweed!" He'd buy it off you right away. He wouldn't wait. He'd give you so much a sack. That was good money those days."
>
> Great Grandson: "You made your own seaweed? You'd use seaweed to eat?"
>
> Auggie: "Seaweed? Yeah don't tell anybody, we'll be fighting them off! [laughs] I used to live here when I was about six years old. Seven years old. We lived here in the summer time. The name of this bay is *Kw'ulhutsun*. We were here, who's the old man? Sandy Jones! He lived here with us. We lived all together. We never said "oh no get out of here you're not from our reserve". No we helped each other set up tents along here and we stayed in tents like what we're staying in now ... and shared our food that we'd get everyday along here. Somebody that's good at hunting the ocean food here, some will be here digging clams, some will be out the gulf because when the tide is this low the urchins come up because the tide's so swift they come right up to the tide line you'd get a rake like this and you'd get *xihwu* (Hul'q'umi'num' language word for sea urchin) along there… So all our food is here ...We all had to live day by day. Our food was caught day by day. Oh we lived good. Those were the good old days."

The recollections Auggie shared illuminate the themes of our project. The connection between histories, language, and the foods are all part of a Hul'qumi'num sense of place[3] and connection to land. Harvesting is not only a food gathering exercise in the practical sense. *Lhuq'us* and *lhuq'us* beaches are connected to Hul'qumi'num senses of place flowing from the long history of relationship between families and the land. Though at face value harvesting *lhuq'us* is seemingly uncomplicated, community members shared with me some of the cultural connections and relationships that underpin the activity including the governance process that relate the harvesting, family histories

[3] As the term is used in Thom (2005).

and relationships contained in place, and teachings that guide the harvest which all connect *lhuq'us* to people and to culture. In this chapter I will describe some of the experiences I had in the summer of 2019 as a privileged guest learning in traditional Hul'qumi'num settlement sites[4] about the practice of harvesting *lhuq'us*, the stories, histories, and cultural meanings around *lhuq'us* harvesting and place, and the concerns community members have for the future of their beaches.

Lhuq'us

Lhuq'us or *Porphyra/ pyropia* spp. (red laver) is a red algae widespread throughout the intertidal zones of colder waters globally and is harvested and consumed worldwide (Turner, 2003; Williams, 1979). *Porphyra* and *pyropia* spp. grows prolifically on rock beaches in the high- mid tidal zones (exposed by most low tides and submerged by most high tides) (Druehl, 2000; Ricketts *et al.,* 1985). There are twenty one *Porphyra* or *pyropia* species native to the Pacific Northwest which are largely indistinguishable without microscopic analysis (Druehl, 2000). Both the genera *porphyra* and *pyropia* are included here because in 2011 there were substantial reorganizations of the two categories (Druehl & Clarckson, 2016) and the terms for non-taxonomist are interchangeable (Guiry & Guiry, 2020). The most commonly consumed species in the Pacific Northwest is *Porphyra abbottiae* (formerly considered the same species as *Porphyra perforata*) (Turner, 2003). The Hul'qumi'num language term *lhuq'us* is the category used here to refer to all of those seaweed species with which Hul'qumi'num peoples have had relationships with for millennia. *Lhuq'us* and other Hul'q'umi'num'

[4] As the term is used by Abramczyk (2017) who carefully tracked the colonial implications of the conventional anthropological terminology of "camps" and "villages".

terms and place names are used in this thesis to reflect the knowledges and categories embedded and encoded in Hul'q'umi'num' language (Wilkins, 1993).

Intertidal seaweed beds are important components of coastal ecosystems. As an abundant and productive marine plant, *lhuq'us* is browsed by marine herbivores including chiton, snails, limpets, crabs, and urchins (Turner, 2003) some of which are also important beach foods for Hul'qumi'num people (Fediuk & Thom, 2003). *Lhuq'us* is also connected to terrestrial ecosystems when it washes ashore and forms wrack deposits that in turn provide food for herbivores and detrivores (Orr *et al*., 2005).

Figure 1: *Lhuq'us*. From left to right, #2 *lhuq'us* on the *smeentuxun* (Hul'q'umi'num' language term for rock wall or clam garden) at Fulford harbour- Saltspring Island. #1 *lhuq'us* harvested on Valdes Island.

Porphyra and *pyropia* spp. are rich in proteins, vitamins, and iodized salt making these species important dietary components (Turner, 2003; Turner & Bell, 1971). Consumption of *porphyra* and *pyropia spp.* likely has a history of over 10,000 years in the Pacific Northwest (Turner, 2014). Turner (2014) considers *porphyra* and *pyropia spp.* an "ancient food" which has likely been consumed since the first peopling of the Americas in the late pleistocene and early holocene because of the abundance and predictability of this highly nutritious food along what Fladmark (1979) termed the Coastal Migration Route (Turner, 2014). In the forty years since Fladmark (1979)

published his work on the coastal migration route, there is continued evidence of people travelling, living, and eating along “the kelp highway” between 13,000 and 11,500 years ago (Erlandson et al., 2007; Braje et al., 2019).

Lhuq’us is one of the many species culturally important to Hul’qumi’num people (HTG, 2011). There is a strong desire in Hul’qumi’num communities to establish a baseline of information about the status of culturally significant species in the Salish Sea which are vulnerable to industrial contamination and other foreseeable large scale ecological changes. *Lhuq’us* is a species frequently identified by Elders as important, but which has received little systematic attention and is generally overlooked by federal and provincial regulatory agencies. In recent years there has been much scientific interest and research on eelgrass (*zostera spp.*) in particular relating to conservation agendas for fisheries, carbon sequestration, and habitat loss (Hodgson & Spooner, 2016; Spooner, 2015). While species such as kelp and eelgrass are also culturally important, community members have been raising concerns about the status of *lhuq’us* specifically for many years. In 1995 Elmer Henry and Tom Sampson, informants from the neighbouring W̱SÁNEĆ communities for the “report on First Nations consultation” the BC Ministry of Environment Land and Parks was writing, stated “ Cole Bay is a seaweed harvesting area. From May to March, seaweed was gathered when the tide line is low. Now there is not much seaweed around” (Simonsen et al., 1995). Indeed at the outset of this project, the centrality of this species, in contrast to its invisibility in regulatory and co-management processes sparked the community conversation to initiate a research project that shed light on the cultural values associated with *lhuq'us*.

Hul'qumi'num People and the Coast Salish World

The knowledge shared with me over the course of this project reaffirm that this is a story where people and their relationships to land are central. I provide here a short introduction to the Coast Salish world and the place Hul'qumi'num peoples have in it to provide context to the individuals who shared with me their knowledge and stories. Drawing boundaries around communities, on a map or conceptually, is a fraught process and I am wary to recreate those boundaries and categories which vastly simplify the complex relationships Coast Salish people have with the land and each other through both local residence groups and the kin group networks (Thom, 2009).

The term "Coast Salish" refers to the group of Indigenous communities connected through kinship, language, and cultural practice in south western British Columbia and north western Washington (Suttles, 1990; Suttles, 1963). I use the term here to recognize the relational life of the people I worked with, not to erase or 'same' the particular local cultures or experiences of any given Coast Salish community. The Coast Salish world encompasses a large area spanning the Salish Sea, the south eastern parts of Vancouver Island, the Fraser River valley and coastal and inland areas of Washington State (Miller, 2016; Suttles 1990). A regional network of familial and social ties noted by ethnographers is a critical part of life and land tenure and is the basis for this broad category of the "Coast Salish world" (Harmon, 2011; Kennedy, 2007). The informants of ethnographers working in this region identify localized residence groups such as a household or a group of houses as the bodies that hold political authority (Suttles, 1963; Barnett, 1955), and non-localized kin groups also hold ceremonial rights and tenure of productive natural resources (Suttles, 2005; Richardson, 1982). The interconnection between groups through kin relationships should not only be viewed as historical, these

relationships continue to be an important part of Coast Salish life (Paul et al., 2014; Morales, 2014). The lives of Coast Salish people best illustrate the idea of a broad Coast Salish world (Harmon, 2011). Auggie Sylvester recalled his own broad ties across the Coast Salish world with stories of trips to and connections with places far from Penelakut Island including Port Angeles, Deception Pass, and Neah Bay (A. Sylvester, personal communication 2019). There is important connectivity between families across cultural and linguistic "boundaries". Kathleen Johnnie, a Hul'qumi'num woman intimately experienced with lands and resources issues in her peoples' territories, put it succinctly: "Our families weave us together in many ways and it's not static like some people would like to believe" (K. Johnnie, personal communication 2019). Culturally and economically important species like *lhuq'us* are often a part of these connections.

Hul'qumi'num peoples, referred to in this thesis, have inhabited south eastern Vancouver Island, the Gulf Islands and the Lower Mainland from time immemorial (Evans et al., 2005). Hul'qumi'num peoples have never ceded title or rights to the Crown or any government agency (Egan, 2012). The partners of this project are largely Penelakut, one of the five Hul'qumi'num speaking First Nations politically unified to be represented collectively in the BC Treaty process under the umbrella of the "Hul'qumi'num Treaty Group" (hereafter, HTG) (Morales, 2014; Egan, 2012; Thom, 2010). This coalition represents the social, economic, ceremonial, and political connections that weave families together across the Coast Salish world; though the member nations are not homogenous and each have their own particular histories and identities (Thom, 2010). Oral traditions trace Hul'qumi'num peoples' connections to land to the First Ancestors who fell from the sky or emerged at different places on the

landscape (Morales, 2014; Marshall, 1999). The many domestic places and settlements that cover Hul'qumi'num territory are evidence that Hul'qumi'num peoples made extensive use of the foods and materials available and maintained prosperous and wealthy societies for millennia (H-GINPR, 2016; Morales, 2014; Evans et al., 2005; Grier, 2003).

Community Concerns and Resistance

The history of *hwulunitum'* (Hul'q'umi'num' language word for non-Indigenous peoples) in Hul'qumi'num territories began in 1791 with Spanish explorers. Two Spanish ships had many encounters with Coast Salish people including an encounter in Porlier Pass (Suttles, 1989). Auggie Sylvester shared with me an account of a violent contact between Spanish ships and Penelakut people that ended in the sinking of a Spanish ship on the north end of Thetis Island (A. Sylvester, personal communication 2019). In 1843, the British Fort Victoria was built in the region and colonial settlement took off shortly after the 1856 gold rush in the Fraser River area. In 1863 a violent shelling of a Penelakut village by a British gunboat (Arnett, 1999) set the tone for a tense period of British and then Canadian rule. By the 1870s and 1880s Indian Reserves were established (Harris, 2003) and state administration of Indigenous lands and affairs solidified, including the potlatch ban (Lutz, 1992; LaViolette, 1961). In 1884, in exchange for the construction of the E&N Railway, Robert Dunsmuir was granted private title to 8380 km^2 of south eastern Vancouver Island, encompassing the majority (~83%) of the Hul'qumi'num territory on Vancouver Island (Egan, 2012; Thom, 2014). Fisheries regulations and enforcement largely marginalized Indigenous economic and governance systems (Harris & Press, 2011).

Access to and use of marine and beach foods and materials including *lhuq'us* over the past 150 years have declined drastically (Fediuk & Thom, 2003; Turner & Turner, 2008; Williams, 1979). This decline can be attributed to the imposition and introduction of colonial policies (Fisher, 1971), western foods (Turner & Turner, 2008), wage economies (Raibmon, 2006; Bierwert, 1999) European land tenure (Egan & Place, 2013; Harris, 1991), industrial, agricultural, and septic contamination (Chan et al., 2019), and the imposition of new harvest management and enforcement systems (Harris, 2009) with their many interconnecting non-linear implications for Indigenous peoples' health, culture, and traditional food systems which carry on to this day (Kuhnlein et al., 2013; Turner, 2014; Turner & Turner, 2008).

There is a long history of colonization and there is an equally long history of Hul'qumi'num resistance against these forces and processes (Thom, 2005; Stadfield, 1999). These include a suite of legal actions beginning with a petition to the provincial and federal governments and to the crown in London in 1909 and 1911 to recognize legal title and use of territories and lands (Foster & Berger, 2008). Although this action was subsequently refused by the Canadian state it marks the beginning of the legal strategy of Hul'qumi'num people which continues in the form of treaty negotiations, signing interim agreements with provincial and federal government agencies, petitioning the Inter-American Commission of Human Rights, and other legal actions (Thom 2019; Thom 2014). I have also seen that resistance takes the form of land based practice and the passing down of and protecting cultural knowledge. These take place through the actions of individuals, families and more formal bodies such as the Hul'q'umi'num' Lands and Resources Society. The Hul'q'umi'num' Lands and Resources Society is the primary

partner for this project. They are a non-governmental Indigenous organization with the mandate of connecting Hul'qumi'num land based practices and Hul'q'umi'num' language by hosting Elders, youth and other community members at Hul'q'umi'num' language and culture camps. Actions including organized restoration projects or harvesting cultural foods are acts of resistance and resilience.

The desire to revitalize cultural practices and to restore and conserve harvesting areas in the face of marine shipping expansion interweave with broader concerns about food sovereignty within Coast Salish communities. Traditional food and food systems are threatened in the Pacific Northwest as a result of intersecting environmental and cultural changes wrought by colonization, globalization, and industrialization (Turner & Turner, 2008). Access to healthy and culturally safe traditional marine foods is of critical importance in Indigenous communities on Vancouver Island (Donatuto et al., 2011; Turner & Turner, 2008; Mos et al., 2004; Fediuk & Thom, 2003). Despite all of the barriers to harvesting, processing, and consumption of *lhuq'us* the practice persists to the present attesting to the cultural significance of *lhuq'us* and the resilience of the communities who harvest it (Ayers, 2005; Fediuk & Thom, 2003). In 2004, 22% of responding Hul'qumi'num community members reported eating seaweed in the past year (Ayers, 2005) and ŁEKES (the SENĆOŦEN term for *porphyra* and *pyropia spp.)* continues to be prepared and eaten at community gatherings in nearby Tsawout and Pauquachin communities (W̱SÁNEĆ First nations) (Evans et al., 2015a; Evans et al., 2015b). The critically important FNFNES report shows that "seaweed" is the most commonly consumed traditional plant food in the coastal region of BC (Chan et al., 2019).

Theoretical Framing for an Ethnography of Seaweed

I first met Kathleen Johnnie in early February. She had invited me to a camp at *Kw'ulhutsun* to participate in the restoration project that she and her Parks Canada partners were running. In the winter, low tides are after midnight so under the full moon we carried equipment and food to the beach at *Kw'ulhutsun.* Under the light of floodlights the Hul'qumi'num practitioners demonstrated how to 'turn over' the beach, breaking up and agitating the top layer of the beach with trowels. I remember the feeling of the beach standing at the water line at *Kw'ulhutsun*, the water in the bay inky black, calm at low slack tide, clams spitting water into the cold air, illuminated by the floodlights. At the end of the night, tired and damp in my tent I reflected on the conversations I had in my notebook. I wrote "caring for the beaches isn't just a mental act, caring for the beach requires our bodies, our interaction to turn over the sediment" (fieldnotes, 2019). In a later language lesson the phrase (caring for our beaches) which describes a suite of practices for caring for beaches.

The approach taken in this thesis is broadly a collaborative one interested in the intersections of meaning making, experience, practice, and place illustrated by Hul'qumi'num people and their relationship with *lhuq'us* and *lhuq'us* beaches. Critical to my understanding of *lhuq'us* harvesting places and the cultural meanings associated with them is the theoretical position that places take on meaning through mutual interactions between people and their physical environment (Memmott & Long, 2010).

In the 1970s, Tuan (1977) and other humanistic geographers and social scientists challenged the conventional physical, quantitative, uninhabited, and measurable understanding of place (Hubbard et al., 2004). Drawing from the philosophies of

phenomenology, a human centered understanding of place was brought forward by these scholars arguing that places are created and maintained by our interactions with them (Hubbard et al., 2004; Tuan, 1977). This view highlights connection and embodiment: the idea that "nature", "places", and "landscapes" are not inert, strictly biological or geological objects "out there" but dynamic, both active agents and cultural constructions created and re-created through interactions and overlaid with intersecting social, cultural, and political values (Grewe-volpp, 2006; Haraway, 1991; Massey, 1991). Places then, are not isolated coordinates but porous and fluid interlinked to one another through fields of meaning and embodied practices on the ground (Massey, 1991). Considering beaches where *lhuq'us* is harvested as these multifaceted places (Hubbard et al., 2004) gives a framework for examining the placemaking work done by Hul'q'umi'num people and the cultural, political, emotional, and spiritual values that are entwined with *lhuq'us* beaches.

A conversation I had with Auggie Sylvester about Hul'qumi'num' place names illustrate this point. Auggie Sylvester had taken us for another walk along the path out to *Kw'ulhutsun*, the point at Winter Cove. In the recording I tried to repeat the word *Kw'ulhutsun* but did not get the pronunciation right. Auggie gently chided me:

> "No swearing out of you! *Kw'ulhutsun*. *Kw'ulhutsun* because the water pours in and when it's dropping it's pouring out and the old people named it that: *Kw'ulhutsun*. Pouring out, pouring in."
> (A. Sylvester, personal communication 2019)

After a few more tries I finally said it right while he patiently listened. Later that evening during the nightly Hul'q'umi'num language lesson Auggie Sylvester reminded us:

> "The little pronunciation is important. It's important to say it right so the next person behind you says it right- say it like the old people, who didn't write it."
> (A. Sylvester, personal communication 2019)

There is a connection between the places and the ancestors who first named them and saying place names comes with responsibility. The places and their names are evoking ancestral memories of what a place is like or what you might find there (Basso, 1996). In his work bringing out a map of SENĆOŦEN place names, W̱SÁNEĆ scholar Phillip Kevin Paul reflected that each SENĆOŦEN words and place names portray a unique way of understanding, connecting the speaker to teachings, histories and observations of place (Paul, 1995). This is what Auggie Sylvester is reminding us of when he says "pronunciation is important". It's important to not only preserve the words of those ancestors and the observations or connections they had with the land, but evoke them continually into the future.

Experiences and practices like finding, harvesting, and preparing *lhuq'us* are instances of both people interacting with their environment and that environment in turn interacting with them (Thom, 2005; Lakoff & Johnson, 1980). Places themselves evoke histories and stories. Basso (1996) describes place as an archive of knowledge and wisdom. The agency of places through embodied experience was described by Kathleen Johnnie in a similar way. During one of the language lessons on Russell Island, Auggie Sylvester was noticing that some of the words on the worksheet he had helped create with Kathleen Johnnie needed editing.

> Auggie Sylvester: "you know, I think we're going to wind up fixing more words there."
> Kathleen Johnnie: "-laughs- I think part of the thing was we weren't here at the beach [when we made the language lessons] and when he's here at the beach or when he's hearing or seeing something being done then it's easier for him to make the sentences. But when you're sitting in a boardroom ..."
> (A. Sylvester & K. Johnnie, personal communication 2019)

Through the interaction with him, being in place harvesting seaweed, evokes for Auggie Sylvester language, histories, and stories. Places and the causes for us to dwell in them contain knowledge (Basso, 1996) and gather meaning making them actors in the social lives of people, engaging, influencing, and guiding practice (Thom, 2005). Similar work completed in northern Alberta found that harvesting areas can evoke historical, familial, social, spiritual, and emotional experiences and stories for Elders and harvesters and that these stories and knowledges are contained within the places themselves (Baker, 2016). Understanding the cultural values embedded within *lhuq'us* beaches allow further understanding of contemporary concerns and visions for the future.

Methods for an Ethnography of Seaweed

The lived experiences and observations of community members and Hul'qumi'num belief systems and knowledge are the core of this project (Smith, 2013; Kovach, 2010; Dyck, 1993). The ethnographic materials come from audio recording and careful note taking during a focus group arranged by the Hul'q'umi'num' Lands & Resources Society, participatory harvesting with community members, ongoing conversation with my Hul'qumi'num friends and partners, and participant observation during immersion camps in the spring and summer of 2019. The focus group session was held in the HTG office in Cowichan Valley, the harvesting trip took place on Galiano Island and Valdes Island, and the language and culture camps were on Saturna Island, Russell Island, and Saltspring Island.

For the Hul'qumi'num collaborators there is a tension about what knowledge to share and with who knowledge should be shared. Hul'qumi'num community members

are navigating these tensions and doing their own work in sharing their knowledge for various projects. The people I spoke with and the knowledge shared with me was not unprocessed "data" to be mined and from which "anthropological information" can be created (Paul et al., 2014) but carefully articulated narratives from people who are knowledge makers in their own right. The theoretical framing that prioritizes experience and relationship flows into the methodology used in this project. Taking a community-based approach which prioritizes both tangible results for partners and their voices in all stages of the work for this project required the development of relationships between myself and the collaborators. Because of this I place myself and my voice in this work instead of in some imagined neutral position. I am a white settler who was born and raised on the un-ceded territories of Tla'amin, K'omoks, W̱SÁNEĆ, and Lekwungen Nations and have frequently passed through and visited Hul'qumi'num territories my whole life. My family and I have been the unwitting beneficiaries of the same colonial policies and industries described earlier and like other Canadians, are only now starting to realize the scale and implications of these histories.

In the fall of 2017 I was working on another collaborative research project with Cowichan Tribes, another one of the five members of the HTG. Our team of graduate student researchers were creating educational materials about the importance of *Ye'yumnuts*, a Cowichan ancestral site that was to be commemorated for community youth and the general public. At one of the community meetings a respected Cowichan Elder Luschiim gave us advice for doing work in the community and I have attempted to follow this advice in this project. Luschiim told our class:

> "You don't find much material written about Cowichan because we were very protective of our culture our language our *xe'xe'* our sacred ways. It

> worked good but it also but it didn't work for us because "we've got nothing that must not be important to you" but it was that important. that's why it was not written down. But now I'm finding we're finding that yeah we have to document some of these things so people know, they'll know a little about the sacredness here. So a lot of that is happening now and I have to say I'm glad although I'm not happy about it. I am glad that it is happening so people will know about our sacredness our *xe'xe'* things.
>
> So just *xe'xe'* is sacred and *xe'xe'* is something that is sacred to you. A lot of our ways our *xe'xe'*. That we don't splash it around, meaning we don't just tell everybody about what's *xe'xe'*, yes I will talk about it a little bit but I won't get into the real sacred parts of our life here. Like you know about the spirit dancers or the winter dancers? Well I can talk winter dances but I won't get into the detail about it."
> (Luschiim- as cited on Commemorating Ye'yumnuts website https://sites.google.com/view/commemorating-yeyumnuts/)

A similar sentiment was echoed by Auggie Sylvester at the beginning of my involvement in this project: "The ancestors told us, 'Don't talk about it' but now no one harvests anymore". Auggie Sylvester and Luschiim are talking about this tension between sharing information and keeping it private. Luschiim highlights the weight of the work being done by graduate researchers and faculty anthropologists and how he is navigating these tensions as collaborator of this work. The implications of this are that collaborators of research are active agents in shaping the questions, defining the methods, guiding the analysis, and vetting the results. This is very much the nature of collaborative research (Lassiter, 2005; Campbell & Lassiter, 2014). In collaborative research the researcher is not the sole broker for knowledge creation. For example attending to and caring for beaches is connected to spiritual matters but this kind of knowledge wouldn't be appropriate to share or publish publicly (H-GINPR, 2016) and though the importance of this component of *lhuq'us* harvesting and *lhuq'us* beaches cannot be under stated the specifics were not shared in conversations I was included in.

There is a history of exploitative research in Hul'qumi'num territories, completed to the benefit of the researcher and/or not returned back to the Hul'qumi'num community as detailed in part by my colleague Abramczyk (2017). I completed an ethics review through the UVic Ethics Board and followed their standards. However, as I learned in the first meeting with the Hul'q'umi'num' Lands and Resources Society, these forms are primarily designed to protect the interests of the university. The Hul'q'umi'num' Lands & Resources Society have their own concerns and agendas when it comes to doing research in the community, particularly the intellectual property rights of Elders and community members who share knowledge. Additional conditions were added to the consent forms as we discussed research relationships and agreed that the knowledgeable people who shared with us during field work must retain the intellectual property rights over their knowledge. Knowledge shared with me in this project has *intention*. As a researcher and collaborator on this ongoing project, I have responsibility to respect these intentions; to connect Elders and youth on the land for sharing knowledge about culturally important species and practices to take seriously the knowledge and concerns being shared. The recordings and transcripts created are stewarded by Kathleen Johnnie and held permanently by the Hul'q'umi'num' Lands & Resources Society.

Building relationships and trust between myself and the Hul'qumi'num practitioners that started this project and those who chose to share with me are incredibly important. I would not have been able to complete my part of the work without these relationships. In the same meeting for UVic Anthropology/Cowichan Tribes'

Commemorating Ye'yumnuts project, Luschiim gave us this advice on the topic of making relationships in community:

> "I'll put it this way if you got here and you didn't have Brian [Thom- UVic] and Dianne [Hinkley- Cowichan Tribes staff] here with you I'd be "Hey what's going on?" and you wouldn't be getting answers and you'd have to work up that relationship first and it may take time, especially if you are totally unknown to here to me. it's going to take several visits before I start to open up. But with Brian and Dianne here, and I'm glad Dianne is here, who somewhat knows you guys and being a student of Brian's that opens up some doors for you. But yeah they need to build some kind of relationship first."
>
> (Luschiim- as cited on Commemorating Ye'yumnuts website https://sites.google.com/view/commemorating-yeyumnuts/)

Audio recordings were made during focus group sessions, language lessons, and several walks led by Auggie Sylvester. During the focus group session some questions and topics of discussion were planned prior to meeting but the interviews were open ended to allow broader connections unforeseen by me to be made (Bernard, 2011). During the walks I and other including community youth asked questions in an unstructured manner allowing Auggie Sylvester to explain the most important aspects of the places, histories, or plants he wanted to. These recordings were made on a Zoom H1n audio recorder. I also kept detailed "fieldnotes" of observations and reflections of experiences during interviews, meetings, and beach visits (Emerson et al., 2011). Generally these notes included conversations I had with the collaborators of the project and descriptions of and reflections on personal experiences such as walks or activities experienced throughout the day.

In developing my own understanding and relationship to this work I realized the participant observation during events and more informal conversations were critical for the project. Conversations happened on the beaches of the southern Gulf Islands or at

language lessons or mealtimes at camp. These experiences on the land are critical for my understanding of the importance of place and were important for building relationships with the knowledgeable people who contributed to this project.

Analysis of the notes and transcripts was done with NVivo. I used the NVivo software to code this material into themes using free coding. This means simply attaching one or more 'theme marker' to excerpts of the transcripts or fieldnotes first using specific labels such as "timing of harvest" or "climate change" and then grouping these together into broader categories like "*Lhuq'us* harvesting practices" or "environmental concerns". This practice allows the important narratives and knowledge people were sharing *lhuq'us* and place to emerge and for connections to be made between seemingly disparate topics (DeWalt & DeWalt, 2001).

To complement the knowledge shared with me and my experiences with Hul'qumi'num practitioners I reviewed ethnographic literature for relevant information about seaweeds and beach foods. This approach was advocated for by Luschiim in the same meeting:

> …One of the things that happened with people like me and Elders in the past is that we get asked the same questions over and over and over and that's why I say do some research and find out the material that is out there and then come forward with some things that need to be clarified for that group or person.
>
> (Luschiim- as cited on Commemorating Ye'yumnuts website https://sites.google.com/view/commemorating-yeyumnuts/)

There is a long history of ethnographic work in Island Coast Salish communities with one of the first being a small excerpt informed by Lekwungen people in 1891 by Franz Boas (Boas, 1890). In my coming to terms with the insights and practices of

anthropologists working in, with and for Coast Salish communities, I completed both a more general overview of ethnographic materials written about political structure (Suttles, 1974), relations to the land (Rozen, 1985), and relationships between the human and non human world (Jenness, 2016; Amoss, 1987). I prioritized reading work informed by Hul'qumi'num peoples (Morales, 2014; Thom, 2005; Rozen, 1985) or nearby W̱SÁNEĆ communities (Jenness, 2016; Suttles, 1974). On the specific topic of seaweed harvesting the work done by Melvin Williams (1979) (field work completed in 1967 with W̱SÁNEĆ and Lekwungen people) is the only dedicated ethnographic account on *lhuq'us* harvesting, and was instrumental background chronicling knowledge and practice of nearly half a century before my time. To complement this account I completed a keyword search of a large collection of ~800 digitized Coast Salish ethnographic and grey literature sources (including theses, journal articles, book chapters, Traditional Use Studies, testimonials, guide books, information pamphlets published by Coast Salish communities, and Hul'q'umi'num language dictionaries) assembled by my supervisor (https://www.brianthom.ca/coast-salish-bibliography) for information pertaining to seaweed and particularly *lhuq'us*.

The results of this search are included alongside my accounts of the work completed between February and August 2019. Kelp (*macrocystis spp.* and *nereocystis spp.)* red laver (*porphyra/pyropia spp.*) and to a lesser extent bladderwrack (*fucus gardneri*) and eelgrass (*zostera spp.*) were the most commonly identified seaweeds in these works. Other substantive works on *porphyra* and *pyropia* spp. has also been done with Kwakwaka'wakw and Gitga'at communities by the renowned ethnobotanist Nancy

Turner and her students (Deveau, 2011; Turner & Clifton, 2009; Turner, 2003). These works also provide important general context.

As I read these ethnographies, however, I bear in mind that the critiques levelled against them. Much of the ethnographic work done by Franz Boas and those that followed him until the mid-nineteenth century were working with the rationale and approach of salvage anthropology with the prioritization of the "traditional" and "authentic" and silencing of the "modern" and "inauthentic" parts of the lived experiences of their Coast Salish informants (Abramczyk, 2017; Kew 1994). The salvage anthropology paradigm pays little attention to adaptation or resilience preferring to focus on the processes of assimilation (Clifford, 1989). These accounts cast societies in them as normative and static with no account for the dynamic nature of culture and practice (Paul et al., 2014; Fabian, 1983; Clifford, 1989).

Anthropologists working at this time were also working under the assumption that the Coast Salish world was a "receiver area" for cultural developments originating in core cultural groups to the north (Miller, 2007). Homer Barnett (1938) for example, working under this framework sought to find the presence or absence "cultural traits" for the assumed static groups he was comparing in tabular formats. This led him to conclude for example that "only the Comox and some of the northeastern groups made use of seaweed cakes." (Barnett, 1938). Finally, harvesting *lhuq'us*, was work largely done by women in the past, and was largely overlooked similar to other beach foods such as shellfish due to the mostly male ethnographers prioritizing the lives and roles of men in societies (Moss, 1993). Despite these critiques, there is knowledge contained within these ethnographies that are very relevant and important where the voices of those who were sharing

knowledge to the ethnographers comes through. I will integrate these highlights of my intensive survey of these sources alongside my own original ethnography below.

Hul'qumi'num People and Their Relationship With *Lhuq'us*

In the summer of 1967 Melvin Williams, a student of Wayne Suttles completed his field work in W̱SÁNEĆ and Lekwungen communities. The experiences he had were published in a 1979 ethnographic work on the seaweed harvesting practices. Williams detailed the practices of harvesting, preparing, selling, and consuming *lhuq'us*. Like Williams' predecessors the work is not as much concerned with place, governance, community aspirations, concerns, or community values as the places and practices of *lhuq'us* so clearly evoke. These dimensions of *lhuq'us* harvesting are critical to understand Hul'qumi'num visions and concerns for contemporary and future relationships with *lhuq'us* and beaches. This chapter expands on the work done by Williams (1979) by understanding the practices surrounding *lhuq'us* harvesting and consumption taking these dimensions into account. I describe when, where, and how *lhuq'us* is harvested and then attend to the systems of management and teachings around caring for the beaches are connected to these practices weaving in the importance of places and the histories and stories they hold.

Harvesting

I arrived early on a sunny morning to the Marina in front of the small town of Chemainus. It was late spring and cars were filling the queues waiting for the ferry to take them to Penelakut Island. The harbour was full of log booms and was busy with activity. I heard laughter carrying across the water and saw Auggie Sylvester sitting with

two other people at the back of a small aluminum fishing boat. Kathleen Johnnie's car pulled up behind me and I helped her carry the buckets she brought for the *lhuq'us* as well as our lunch to the boat. After we got settled in the boat we slipped the lines from the dock. Small talk faded as the roar of the engine filled our ears and we sped across the calm water, around Penelakut Island and toward Porlier Pass, the opening between Galiano and Valdes Islands. This, Auggie Sylvester told us, is where we'll find the *lhuq'us*.

Timing of Harvests

Hul'qumi'num community members demark two types of *lhuq'us*, 'number one' and 'number two'. The terms "number one" and "number two" *lhuq'us* are terms Chinese and Japanese buyers would call *lhuq'us* and have since been adopted by Hul'qumi'num people and persist to this day, despite the economic dynamics of this trade not being active for decades (Williams, 1979). Number one and number two are harvested at different times of the year and may be distinct species of *porphyra* or *pyropia spp.* Number one *lhuq'us* is greener and blooms between March and May (A. Sylvester, personal communication 2019; Williams, 1979). Number two *lhuq'us* is harvested later in the summer and is thicker and darker in colour (Auggie personal communication; HTG, 2011). Number one *lhuq'us* is the more desirable of the two because of its taste and texture (HTG, 2011). The word *lhuq'us* applies to both number one and number two. In the 'Ecosystem guide', a book published by the Hul'qumi'num community as a reference guide for Hul'q'umi'num' language terms for plant and animals, the thicker number two

*lhuq'u*s is also called *pulh ta lus*[5] (HTG, 2011). After a walk to *Kw'ulhutsun* where we gathered some *lhuq'us* I asked Auggie Sylvester about *pulh ta lus* he said:

> *"Pulh ta lus.* That must be [the late] Roy Edwards' word for the thicker ones. What you got [at *Kw'ulhutsun*] the later ones, the number twos". (A. Sylvester, personal communication 2019)

When we went harvesting *lhuq'us* it was the beginning of June. At first we stopped in a little bay on the west side of Galiano Island. We walked down the slippery rocks looking for *lhuq'us* but we could only find a few small fronds. Auggie Sylvester: "We must be late! The old people would harvest [number one *lhuq'us*] in April before clam digging so the clams aren't green from seaweed".

Harvesting number one *lhuq'us* is an activity done at the end of spring (Williams, 1979). Simonsen et al.'s (1995) work with W̱SÁNEĆ communities recorded community members harvesting brown edible seaweed in March alongside clams. This is during the bloom of the number one *lhuq'us*. Auggie Sylvester says that the *lhuq'us* is ready to pick when it is dark brown; older *lhuq'us* turn ghost-like pale. The timing of the harvest is also linked to harvesting clams. Auggie Sylvester describes why it's important to finish seaweed harvesting early in the year. Standing on the beach at Winter Cove he gestures to the thick layer of green seaweed wrack washed up on the beach.

> "Here's what dies on our beaches all this. Turns the mud black all the seaweed. Sometimes the old people would rake that up and move it up to where the tide can't reach it and that fertilizes the land up there. The seaweed. So we've got to watch that when we've got a good clam beach and these get there. The calms will eat it then the clams turn black inside the bodies of the clams that's why you don't pick after [clams] April because these are all on our beaches then."
> (A. Sylvester, personal communication 2019)

[5] Spelling of the word as found in the Ecosystem Guide (HTG, 2011). Spelling may need to be crosschecked by a fluent Hul'q'umi'num' speaker.

The number one *lhuq'us* harvest fits into the pattern of seasonal circulation throughout Hul'qumi'num territories or 'seasonal rounds'[6] and is linked to the care of productive clam beaches. *Lhuq'us* harvesting had to be done before various seaweed species released from the rocks and washed up on the beach.

A third harvest of *lhuq'us* occurs in the winter (Jenness, 2016; HTG, 2011; Evans et al., 2015a; Evans et al., 2015b). This growth is tastier than the spring bloom but the fronds are smaller and more difficult to harvest (HTG, 2011). Diamond Jenness' informants remember this fresh *lhuq'us* was used to supplement the preserved foods consumed over the winter (Jenness, 2016, p.6). Sophie Misheal, a Songhees Elder who worked with Melvin Williams (1979) also recounts a winter *lhuq'us* harvest (p. 65). In a published version of the W̱SÁNEĆ 13 moon calendar (a calendar that describes some of the seasonal patterns of movement on the land and the foods and resources associated with these movements), fresh seaweed is included in the list of foods used in the winter to supplement the staple of dried salmon (Evans et al., 2015a, p. 51). David Rozen (1978) recorded the time of collection for *lhuq'us* as "year-round" (p.35).

Harvesting Places

Seeing that the *lhuq'us* was sparse on the inside of Galiano, Auggie Sylvester decided we should check on the outside, *S'utl'qulus* (Hul'q'umi'num language place name- Facing Outside). We clambered back into the boat and headed north up Trincomali Channel where we could see several large freighters anchored on the inside of Valdes Island. The tide was still dropping and water was rushing out the small gap between

[6]As anthropologists have long termed Hul'qumi'num seasonal travel around food systems (Abramczyk, 2017).

Valdes and Galiano Islands. The engine roared against the eddies and agitated water as we passed through Porlier Pass. We were hopeful that we would find some number one *lhuq'us* here because Auggie said "They [*lhuq'us*] don't like the warm water. Out in the gulf it's cooler". Auggie Sylvester told us that number one *lhuq'us* is found "out the gulf" (*S'utl'qulus*) and number two *lhuq'us* is "found on the inside". We arrived at the rocky outer shore of Valdes Island facing *St'utl'qulus*. Dried into mats all along the high tide line were patches of *lhuq'us* still growing on the rocks. We took five gallon pails and following Auggie's direction began to pick the *lhuq'us*.

Lhuq'us is harvested throughout Hul'qumi'num territory. In my review of the relevant ethnographic materials there were 60 references (Appendix A) to specific (ie Porlier Pass, Flat Top Islands) or general places (ie Saanich Inlet, Richmond/Vancouver) *lhuq'us* is harvested in Hul'qumi'num territory and adjacent areas.

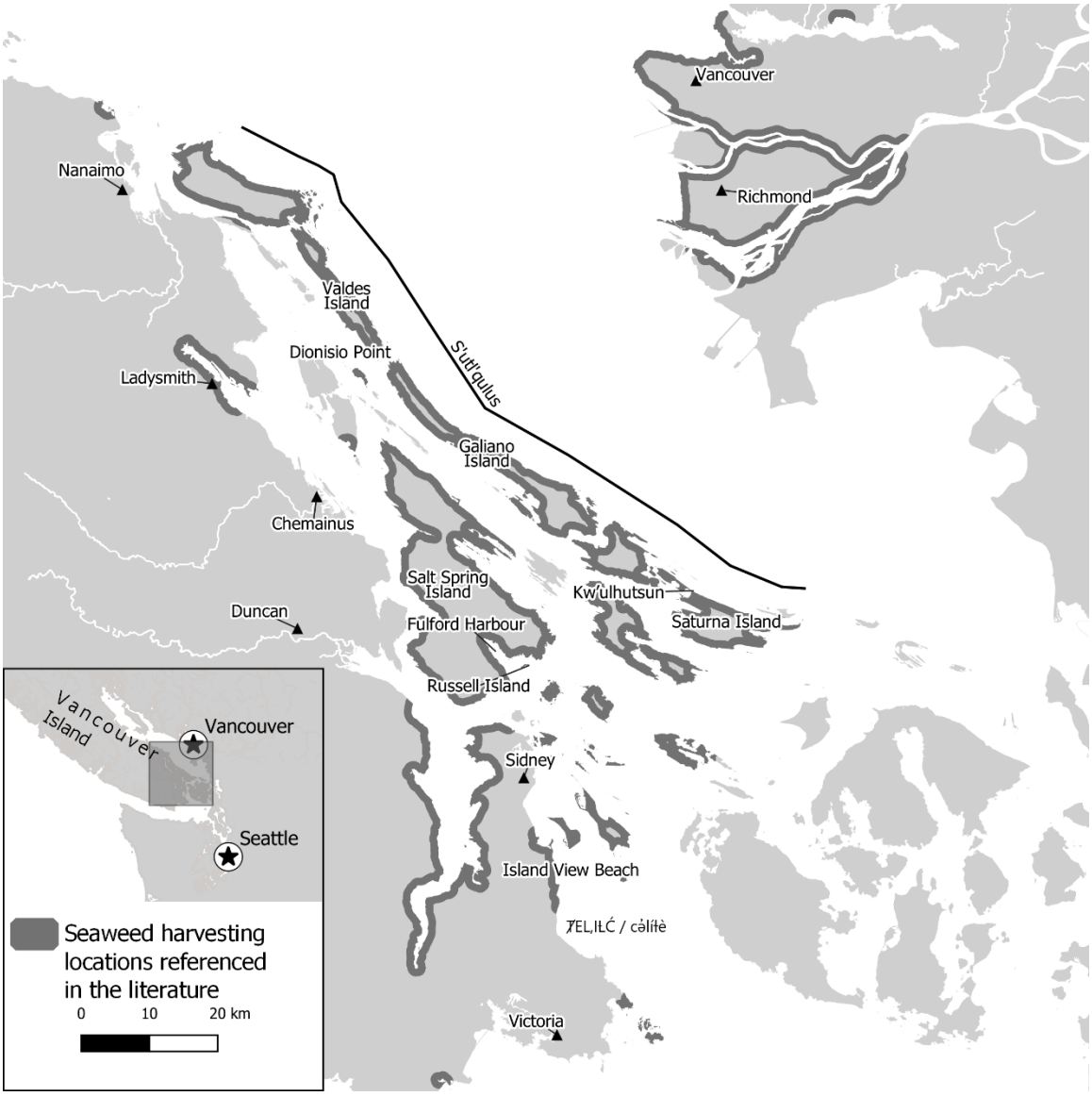

Figure 2: *Lhuq'us* harvesting places referenced in the literature. 294 documents were reviewed including ethnographic texts, Traditional Use Studies, theses, and documents published by Hul'qumi'num and other Coast Salish communities. In these documents 60 places were identified as *lhuq'us* harvesting areas. For reference list refer to appendix A.

Each of these places shown in Figure 2 are places with deep personal or familial meaning. In all the time I spent on the land with community members the salience of the places underpinned our discussions about *lhuq'us*. The Hul'q'umi'num' word that was

used to describe this to me by many community members was *pa'nuxw*. In our first focus group meeting in the HTG office I asked about places people harvest and Auggie Sylvester answered "each family has their own spot- *pa'nuxw*". Here's how Aggie describes this concept in a conversation we were having about another respected Elder the late Roy Edwards who worked with Brian Thom fifteen years previous.

> **Auggie Sylvester:** Roy Edwards. Yeah his favorite area was out on the outside of Gabriola.
> **Jack:** Is there a Hul'q'umi'num' word for that?
> **Auggie Sylvester:** What?
> **Jack:** Your favorite place?
> **Auggie Sylvester:** *Pa'nuxw*- your pet place, your favorite place, everyone would have one, every beach was someone's *pa'nuxw*.
> **Jack:** Were they secret?
> **Auggie sylvester:** No everyone knew "oh that's his *pa'nuxw*"

Pa'nuxw as I have come to understand it is, in part, a concept centered on the relationship between individuals or families and places. Often these are places people from all over would return to and live at for a significant part of the year harvesting a variety of foods (A. Sylvester, personal communication 2019; Evans et al., 2015a; Bouchard, 1992; Rozen, 1979; Williams, 1979). In this way, these places become nodes of social and cultural importance (Donatuto et al., 2011). One morning on Russell Island we were sitting in a circle in the shade of a tree after breakfast. Auggie Sylvester said before going out fishing or harvesting his grandfather would sit in a circle and tell stories and they would only go when he was ready. "Stories about people turning into rocks, people turning into whales" (A. Sylvester, personal communication 2019. Auggie Sylvester then told us the story of the woman who turned into a killer whale, a story about his encounters with sasquatch, and stories about Penelakut warriors sinking spanish boats on the north end of Thetis Island. These are the types of social and cultural

connections that are conjured and maintained through dwelling and experience at these places.

Ancestral presence is also linked to place (Thom, 2017; Boyd, 2009). Fog rolled in on a rainy morning at winter cove and Auggie Sylvester and I took a walk together to the beach. Low cloud and mist obscuring everything but the outline of the far shore across the bay.

> "When we used to camp here we would hear voices coming across [points at Samuel Island] and we could never figure it out. My Grandfather told me "it's the ancestors. All the people who used to live here."
> (A. Sylvester, personal communication 2019)

As we walked along the path Auggie Sylvester explains:

> "The path goes so it doesn't go over the people buried here under the rocks it can go around but it can't go over. The people buried here died here. We didn't bring them home we buried them where they died. Out along the outside around the point."
> (A. Sylvester, personal communication 2019)

The *lhuq'us* harvesting place on the east side of Gabriola Island, the late Roy Edwards' *pa'nuxw*, is also the place where *Xeel's* (The Transformer) changed a Hul'qumi'num ancestor into stone. The places *lhuq'us* is harvested are places with multiple overlapping and interconnected meanings (Thom, 2005). In ancestral places people must act appropriately and respectfully toward the ancestors (Thom, 2017; Thom, 2005). The ancestral presence and agency at places like winter cove and the Flat Top Islands tie *lhuq'us* beaches into Hul'qumi'num ways of being in and experiencing the world. There are many ways *lhuq'us* beaches are, as Roy Edwards said, "not just any old place where we used to pick" (Thom, 2005).

2.4.4 Harvesting, Drying, and Eating *lhuq'us*

As the tide dropped on Valdes Island we followed Auggie Sylvester down the steep flat sandstone beach looking for the patches of the nearly black *lhuq'us*. The number one *lhuq'us*, though late in the season, was still abundant along the shore of *S'utl'qulus.* The patches higher up on the beach were already partially dried by the sun and we had to peel them off the rocks in large swaths. Lower down on the beach the fronds were still wet and could be picked by pinching them at the base. Soon our pails begin to fill and we sit down next to each other on the rock looking across towards the mainland. It was a clear day and we could make out the busy shipping port in Tsawassen directly across from us. Auggie Sylvester begins to recount his experiences harvesting *lhuq'us*, teachings his grandfather gave him, and histories of the places we just travelled through. Auggie Sylvester remembers in the old days:

> "[They] would go along all day. The Indian way of life. Keep going along from Gabriola to East point. Boats would pass by and pick seaweed or drop off more people. The beaches would be shared by families for seaweed. They would go along scraping into piles until the tide began to rise then pick up piles and fill bags".
> (A. Sylvester, personal communication 2019)

The *lhuq'us* would be scraped off of the flat rocks into piles that would dry in the sun in the morning as the tide dropped with custom scraping tools a saw blade from a handsaw attached to a handle or a garden hoe (A. Sylvester, personal communication 2019; Williams, 1979). When the tide started to turn they would double back and fill burlap sacks with the *lhuq'us* and load the sacks into a boat. The *lhuq'us* would then be brought home and be laid out on a sheet in the sun or packed loosely and hung in a mesh bag hung inside if it was early in the year (A. Sylvester personal communication 2019). The same methods for harvesting and drying are repeated by Sophie Misheal, who worked with Melvin Williams (1979) and by respected Tsawout Elder Elsie Claxton (Evans et al.,

2015a). The *lhuq'us* is finished drying when "it cracks like a cracker" (A. Sylvester, personal communication 2019). Sophie Misheal and Elsie Claxton also recall compacting *lhuq'us* into cedar boxes for long term storage (Williams, 1979; Evans et al., 2015a). Once dried, exposure to rain or moisture will spoil the *lhuq'us* (Williams, 1979; Evans et al., 2015a).

Lhuq'us is eaten fresh or dried and re-cooked in other meals. Auggie Sylvester prefers to eat *lhuq'us "*Sprinkled in chowder, with salmon, [or] fresh off the beach" (A. Sylvester, personal communication 2019). One man at the Russell Island camp said that he considers *lhuq'us* to be a health food because of the nutrients it has. The knowledgeable people Melvin Williams (1979) worked with used *lhuq'us* as a flavouring for a variety of dishes. Dried, fresh, or fried in animal fat *lhuq'us* would be sprinkled on top of soups and chowders or eaten with salmon or other fish. *Lhuq'us* could also be eaten on its own dried or fresh as a snack or stewed (A. Sylvester, personal communication 2019; Williams, 1979). *Lhuq'us* can also be used medicinally (K. Johnnie, personal communication 2019; Evans et al., 2015a; Williams, 1979). One woman told me that "seaweed" is used to treat skin conditions like eczema, while Kathleen Johnnie told me that a woman she knows harvests *lhuq'us* from Fulford Harbour to use as medicine.

Figure 3: *Lhuq'us* harvesting. From left to right: *lhuq'us* drying on a tarp at Winter Cove camp. *Lhuq'us* in clam chowder at Russell Island camp.

Trade, Sale, and Access

> We used to come here [Winter Cove] and camp for seaweed and clams. People from all over: Saanich, Kuper Island would camp at the point. Big boats would come in and buy clams and seaweed- lots of people would come to camp.
> (A. Sylvester, personal communication 2019)

One theme that is very prominent in the literature about beach food harvesting in Coast Salish territories is its connection to sources of community wealth as an item for trade and sale. Beach foods, particularly those that could be readily preserved such as clams and *lhuq'us* are considered important trade items (Evans et al., 2005; Williams, 1979; Suttles, 1974). Beach foods are not just about eating but they are part of the socioeconomic structures in communities, much like salmon fishing is for Stó:lō on the Fraser River (Bierwert, 1999). Beach foods have contributed to the tangible wealth of traditional Hul'qumi'num communities (H-GINPR, 2016). The ancient and historic wealth of Hul'qumi'num communities must be attributed in part to the intensive harvesting of shellfish and other beach foods on managed beaches (H-GINPR, 2016). Dried seaweed in cedar boxes was an important trade item in the regional trade network.

Auggie Sylvester described trade networks going as far as Washington and Oregon for items such as guns and goat wool (A. Sylvester, personal communication 2019). The economic importance of *lhuq'us* and other beach foods continued from this millennia-old context with the trade with Chinese and Japanese immigrants who first started arriving in Hul'qumi'num territories in 1880s (Littlefield, 1995). *Lhuq'us* was brought to Victoria's Chinatown or to canneries to sell or would be bought off the beach at harvesting locations by workers on seine boats who would follow *lhuq'us* harvesters as they moved between Gabriola Island and Saturna Island (A. Sylvester, personal communication 2019; Evans et al., 2015a; Littlefield, 1995; Williams, 1979; Turner & Bell, 1971). Number one *lhuq'us* was the most valuable type of *lhuq'us* in the market in Chinatown (A. Sylvester, personal communication 2019). This trade lasted until at least the 1970s (Williams, 1979) and Auggie Sylvester still remembers bringing sacks of *lhuq'us* to Victoria's Chinatown and being chased down the street by people bidding for his harvest (A. Sylvester, personal communication 2019). You could get eight or nine dollars per pound, "good money in [those] days" (A. Sylvester, personal communication 2019).

The centrality of beach foods like *lhuq'us* declined in the mid-twentieth century as barriers to accessing beach foods have become increasingly pervasive. There is a constellation of colonial processes that have created contemporary food insecurity in Hul'qumi'num communities (Turner, 2014; Fediuk & Thom, 2003). Long standing issues such as privatization and development of the foreshore, increasing contamination, reduced abundance, and increasing regulation have diminished access to traditional foods (Rozen, 1985; Fediuk & Thom, 2003). Loss of time and opportunity to practice harvesting foods is of particular concern for a time and labour intensive food such as

lhuq'us (Turner & Turner, 2008). Intertidal seaweed beds have been negatively impacted by industrialization including dredging and dock/marina construction (Short and Wyllie-Echeverria, 1996) and pollution (Turner, 2003). The provincial government has furthered excluded access for *lhuq'us* and related foreshore harvesting through their extensive licensing policies. The issuing of commercial licenses for harvesting in the Strait of Georgia and Johnstone Strait, as well as tenuring the foreshore all make harvests in some places impractical (Fediuk & Thom, 2003). Private ownership of property inland from important beaches also inhibits access (Fediuk & Thom, 2003). Approximately two thirds (65.07%) 174.28km/ 267.82km of the coastline identified in the literature (see figure 2) as being places for *lhuq'us* harvesting are fronted by privately held property (see figure 4). This change of the foreshore into private ownership has reduced access and in some cases confined the areas *lhuq'us* can be attained to federal, provincial, and municipal parks which come with their own suite access related issues.

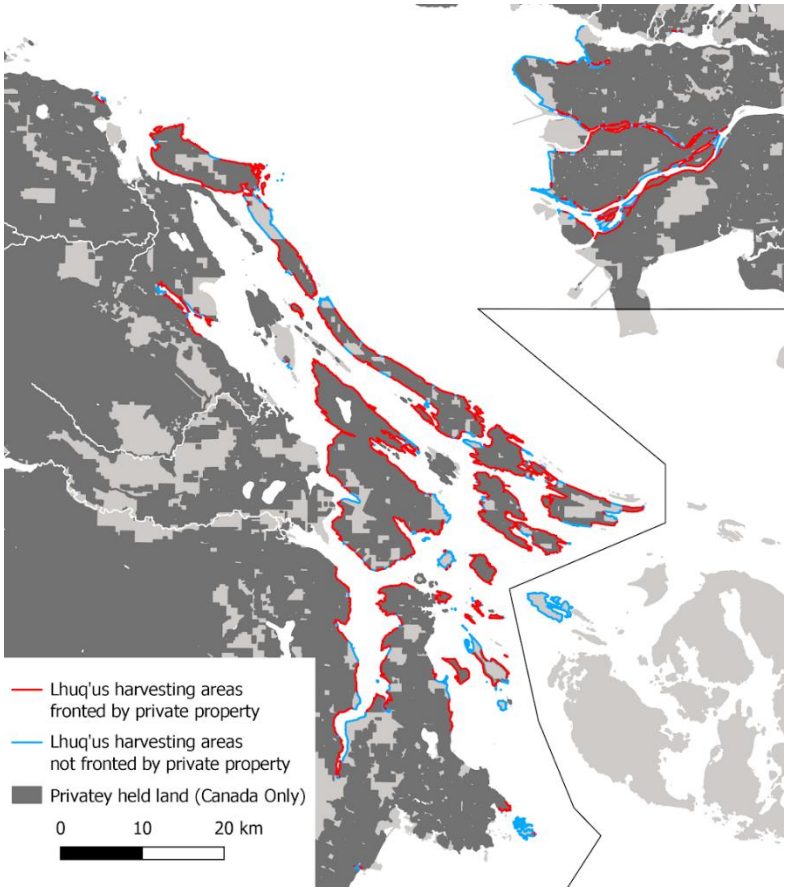

Figure 4: *Lhuq'us* harvesting beaches and privately held land. Approximately two thirds (65.07%) 174.28km/ 267.82km of the coastline identified in the literature (see Appendix A) as being places for *lhuq'us* harvesting are fronted by privately held property (BC cadastral).

Hwule'lum'ut thu Tsetsuw' (Caring for our Beaches): Governance, Management and Teachings

With our buckets full of *lhuq'us* we returned to the boat pulled up to the beach at *St'utl'qulus,* on the outside of Valdes Island, gingerly jumped in trying not to get our shoes too wet and motored south to return to Chemainus. Just offshore of the beach where we were harvesting was a small islet and even from a distance we could see the shapes of many sea lions hauled out on the warm rocks. Over lunch, Auggie Sylverster

shares a story with us, pointing to this rock and recounting a time when he was hunting with his grandfather. He saw a sea lion and wanted to take it for the family but his grandfather told him not to. “Why not,” Auggie asked. His grandfather explained “Because it’s too much to eat. Too much for the family. It would be too much”. Auggie was sharing a teaching to take only what you need, framing it like he often does with a story where he learned that teaching.

The specific practices of travelling to select beaches at certain times of the year to harvest, dry, consume, and trade *lhuq’us* are underpinned by a series of specific teachings and broader governance and management regimes. In his testimony to the National Energy Board on the TMX project the late Willie Seymour, a respected Stz’uminus Elder, recounted the origin story of Stz’uminus people (one of the founding HTG First Nations).

> “There's a mountain just above Stz'uminus area called *Kw'enenus*[7]. When Creator made this world -- the ocean, the streams, the rivers, the lakes, the ponds, the islands -- and he sat there and observed his creation and he was happy with it, but there was something missing. So he went to a swamp and he got a tadpole and made a dipper out of it. He went to the stream and he got water. He poured it on top of that mountain. When it hit the mountain, it started to roll down. It turned into ice cubes. When it was hitting the lakes, the rivers, the streams and the ocean, all of ocean life was created, including the killer whale, the seal, sea urchin, crab, octopus, seaweeds. Everything that's within the ocean was created, trout, steelhead in the rivers. And he looked at the ocean, and he was happy with what he saw. And that's why our people respect the sacredness of the ocean because that's [...] where we get our sustenance [.]
> (National Energy Board (NEB), 2014)

This short excerpt from a much longer story speaks to the sacred connection Hul’qumi’num people have with marine life including seaweeds; these are not mere

[7] Spelling as found in (NEB, 2014). Spelling may need to be crosschecked by a fluent Hul’q’umi’num’ speaker.

"weeds" but beings wrought into the earth at the beginning of time. They are a fundamental, culturally significant part of Hul'qumi'num lives. Auggie Sylvester builds on this:

> You know I think everything's important to us. You asked is there something that's important. That didn't sound right to me. Like the government always asks "oh which land is important?" And I go 'you close your eyes and you look around. Close your eyes and look around. You can't see nothing but Indian people talking, that time'. That was a long time ago when the Indians, only the Indian people lived here but if you close your eyes and say 'well that's only the Indian people that's here again' then all the everything here, that's the medicine that's been with us as we grew up and grow up.
> (A. Sylvester as cited in Huggins et al., 2018)

The importance of marine foods including seaweeds can be traced back to the beginning of time and Hul'qumi'num people have had relationships with these organisms since then and will continue these relationships into the future. From this deep relationship with *lhuq'us* and other foods and medicines comes practical advice for harvesting. Laura Sylvester, another respected Penelakut Elder and Auggie' Sylvester's wife put it in plain, direct terms when I asked if there were any teachings for harvesting or caring for *lhuq'us*, mirroring Auggie Sylvester's sea lion story: " don't take it all - never over harvest" (Personal communication Laura Sylvester, 2019).

Tending and Managing Beaches

The decisions of where and when to harvest *lhuq'us* are not made arbitrarily in Hul'qumi'num communities. Families have deep ties to particular places and inherited rights and responsibilities through these histories and genealogies (Barsh, 1991; Suttles, 1974; Suttles, 1960). The teachings do not just play out at the level of the individual but also influence larger decision making. Planning where and when to go harvesting *lhuq'us*

and other beach foods is part of the broader Hul'qumi'num governance and management of beaches. Auggie Sylvester explained to me that there is a time of year when big house ends called *pulxa'us "*the time of year when everyone is talking" (A. Sylvester, personal communication 2019). *Pulxa'us* was Auggie's answer to my question about how to take care of *lhuq'us*. A time of year when families met and planned their activities for the upcoming months.

> *Pulxa'us* is the meeting of the families. Meeting of heads of families or spokespersons to decide and record where people are going. The longhouse is like parliament it's the government. A longhouse could have seven families in it each family has a spokesperson, get together to decide on things. It could take a long time until everyone agrees "that's how we'll do it". *Pulxa'us*. Not majority rule, everyone agrees. There's no higher power than the individual and the family…
> (A. Sylvester, personal communication 2019)

Williams (1979) similarly recorded communication networks between harvesters for systematic harvesting to ensure no patch was over harvested or left untended. This type of collaborative management still exists today, though perhaps articulated differently through families and communities.

Particular management and modification practices would occur on the beaches, including clearing rocks, turning over sediments, constructing and maintaining rock barriers, and transplanting species (Deur, 1999; Suttles, 1974) all of which enhance productivity of clam species and other beach foods such as seaweeds, mussels, sea cucumber, octopus, chiton, scallop and oysters (A. Sylvester, personal communication 2019; H-GINPR, 2016; Lepofsky et al., 2015). During a walk along the beach at Winter Cove Auggie Sylvester noted that there were not many clams squirting

> The old people say if you turn it over enough times it will come back to life. So you get a rake and you go and rake along (gesturing). Or they'll come along and they'll move all these rocks to one side. Out of the way so

> that when they come in with their canoes they don't have to drag their canoes over the rocks. Make it a canoe run. There's too much rocks here. (A. Sylvester, personal communication 2019)

Practices that enhance one species, for example transplanting mussels and seeding them on a new beach can be positive for other species such as *lhuq'us* because mussels "clean the water" (A. Sylvester, personal communication 2019). Transplanting mussels may have other positive effects on the growth of *lhuq'us* and in turn enhance mussel growth and the health of beaches. There is literature that suggests *porphyra*/*pyropia spp.* interact with *mytilus spp.* (Mussels) as co-ecosystem engineers, altering the abiotic environmental conditions of the intertidal zone affecting which species are able to inhabit rocky shore lines (Gutierrez et al, 2019; Borthagaray & Carranza, 2007; Gutiérrez et al., 2003). *Porphyra* /*Pyropia spp.* preferentially grow epiphytically on mussel beds reducing the temperature and levels of desiccation in the beds, enhancing the survival of mussels and of other species which live in mussel beds (Gutierrez et al, 2019). *Mytilus spp.* beds alter water flow, trap sediments and nutrients, ameliorate temperature variation, alter macroinvertebrate predator behaviour, and reduce desiccation rates enhancing species richness by providing habitat to macroinvertebrates that would otherwise not be able to survive on the rocky shores where mussel beds are found (Gutierrez et al, 2019). Archaeologically mussels are well represented in shell mildens along the pacific north west, suggesting that mussels are another 'ancient food' with a deep history and connection to the lives of people on the coast, intertwined with places, belongings, and diets (Matson & Coupland, 1994).

One of the most distinctive modifications to beaches is the construction of rock walls running parallel to the shoreline. These features are called, by some Penelakut

Hul’q’umi’num’ speaker's, *smeentuxun* (the Hul’q’umi’num’ words for “rock” and “wall” combined) (K. Johnnie, personal communication 2019) or commonly “clam gardens” (though they enhance multiple species including octopus, sea cucumber, and *lhuq’us*, not just clams (H-GINPR, 2016)). There are at least 65 *smeentuxun* in Hul'qumi'num territory (H-GINPR, 2016). *Smeentuxun* can be quite extensive and required engineering and planning expertise to construct and maintain them. For example the *smeentuxun* in Fulford Harbour is almost a kilometre in length. Auggie Sylvester describes one of the ways the *smeentuxun* are built.

> [We would get] boom sticks, tie them together and bring them, float them in on a high tide to where all the rocks we need. Then load them all up and then move the rocks while the tide’s high and anchor it where we need that for the rock wall and then unload it.
> (A. Sylvester, personal communication 2019)

Smeentuxun enhance the food production of a beach in many different ways. They are built just off of the beach and the area behind fills with sediment levelling the beach and expanding the habitat for clams and other shellfish. The addition of rocky substrate also expands habitat for other beach foods including *lhuq’us*, chiton, sea cucumber, and octopus (H-GINPR, 2016; A. Sylvester, personal communication 2019).

Part of the initiative lead by the Hul'q'umi'num' Lands and Resources Society is to restore and maintain *smeentuxun* and tend to beaches in the Gulf Islands. Their initiative brings together community members to speak Hul’q’umi’num’ language and embodied practices of caring for beaches through reconstructing and maintaining rock wall features and enhancing shellfish harvesting areas by “turning over” or aerating the substrate (H-GINPR, 2016). Caring for the beach is an embodied practice with places like *Kw’ulhutsun* at the centre, a node for culture and experience.

Community Concerns and *Lhuq'us*

The fishing boat speeds back to Porlier Pass. The water is now turbulent as we pass though, rushing in on a rising tide. Auggie recalls fondly taking his kids here in his boat to play in the turbulent water. As we approach the east side of Kuper Island our boat pilot, a Penelakut man who works as a resource manager for the tribe slows the boat. He points out to us the distinct change in the colour of the water caused by sediment from the Fraser River penetrating into the 'inside' of the Gulf Islands noting that any oil from an oil spill would be able to penetrate this deep as well. He tells us:

> The sediment filled water used to be an indicator of where to look for fish- if you see the muddy water fish are getting pushed to that side. Now I see it as where the oil will go and it's all over, from Tent Island all the way to the other side of Penelakut. That's where the oil will go and kill everything. We won't have to worry about managing resources because there won't be any more left. And it's really bad because I care so much about that. The salmon, clams, everything will be gone. I think of our children and grandchildren. They won't have it like we had it and we don't even have it like Auggie's time. It's hard to go home and think "well, oh well" and move on.
> (Anonymous, personal communication 2019)

The last minutes of the trip as we sped back into Chemainus Harbour my thoughts were heavy with the weight of what was shared with us. Laughter returned to our voices as we said good-bye but I carried with me these stakes for the project and concerns for the future of these places.

Marine Shipping

Understanding the deep interconnection between place culture people and *lhuq'us* re-contextualizes for me, a white settler, contemporary governance and environmental concerns of the community members I spoke with. The impetus by Hul'qumi'num community members for research about *lhuq'us* is born of immediate concerns about the

compounding impacts of long climate change, increasing contamination, reduced abundance, industrialization of the Port of Vancouver and the region in general and restricted access on marine foods (Fediuk & Thom, 2003). This overarching concern drives the rationale behind this research to explore and document how these issues relate to *lhuq'us* harvesting.

The TMX project and the related increase in marine shipping the imminent large scale project related to this constellation of environmental concerns. As the development of the TMX project progresses the community concern about contamination wrought by the increased marine shipping becomes more pressing. The Strait of Georgia, Puget Sound, and Juan de Fuca Strait are heavily trafficked by commercial shipping vessels with 54,000 vessels transiting this area carrying an estimated 110 million m^3 of oil as both cargo and fuel between 2011 and 2012 (Nuka Research, 2013). However, less than one percent of these vessels were oil tankers (Nuka Research, 2013). Currently the Trans Mountain Pipeline carries 48,000 m^3 of crude oil per year to Westridge Marine Terminal (Tsleil-Waututh Nation (hereafter, TWN), 2015). Upon completion of the TMX project this amount will nearly triple to 142,000 m^3 increasing oil tanker traffic, in some projections, from 3-4 per month to 34 per month (TWN, 2015). High profile catastrophic oil spills such as the Exxon Valdez spill in Prince William Sound (1989) and the Deepwater Horizon spill in the Gulf of Mexico (2010) as well as smaller scale, lower profile, localized events such as the sinking of the Queen of the North (2006) , the spill from Westridge Terminal, Burrard Inlet (2007), and the Marathassa spill in English Bay, Vancouver (2015) and a series of accidents involving smaller towing vessels in the Salish Sea have affected people, food systems, and ecosystems (Rosenberger *et al.*, 2017; TWN,

2015; Turner, 2014; Kelso & Kendziorek, 1991). As the late Stz'uminus Elder Willie Seymour put it:

> An oil spill will devastate our people. We're already struggling and to totally lose the resources which is so important to us would be inhuman. It would be unacceptable in any culture.
> (NEB, 2014)

The Salish Sea is already a heavily trafficked waterway. In 2018 the marine traffic lanes across from *st'utl'qulus* saw between 200-300 shipping vessels including container ships, tankers and barges per month (Figure 5). As the traffic increases to the port of Vancouver increases there is increasing need for deep sea ship anchorages and areas in the Southern Gulf Islands have been selected by Transport Canada and partners to be used for this purpose. In the study area there are 41 deeps sea ship anchorages, 26 of which (63.4%) are within three kilometres of an Indian Reserve (Figure 5). Hul'qumi'num communities have concerns over these anchorages and have brought them up in reference to projects that increase marine traffic in the Salish sea (Including TMX and Roberts Bank terminal 2) (BC Environmental Assessment Office (BCEAO), 2017a; BCEAO, 2017b; Lyackson First Nation, 2017). Lyackson First Nation details concerns including: light pollution, marine noise pollution, reduced water quality, increased wake, increased risk of oil spill, and reduced access to beaches all contributing to decreasing marine food quality and social, mental, and spiritual well being (Lyackson First Nation, 2017). Considering all of these cumulative impacts and that consulted nor did they consent to the allotment of the existing anchorages, these anchorages are seen as infringements on their Aboriginal rights (Lyackson First Nation, 2017). These vessels do not have to pay a mooring fee like the ones on the mainland and provide no direct benefit to local communities who take on the risks of this increased traffic (Anonymous, personal

communication 2019). In the area surrounding Penelakut Island, Valdes Island, Galiano Island, Thetis Island, and Ladysmith Harbour, in close proximity to Lyackson, Penelakut, Stz'uminus, and Halalt communities, there are 21 deep sea ship anchorages 18 of which (85.7%) are within three kilometers of an Indian Reserve (figure 6). One man I spoke to felt that if vessels are going to anchor there particularly on the inside of Valdes Island then they should be made to pay similar to the ships on the mainland (Personal communication, anonymous).

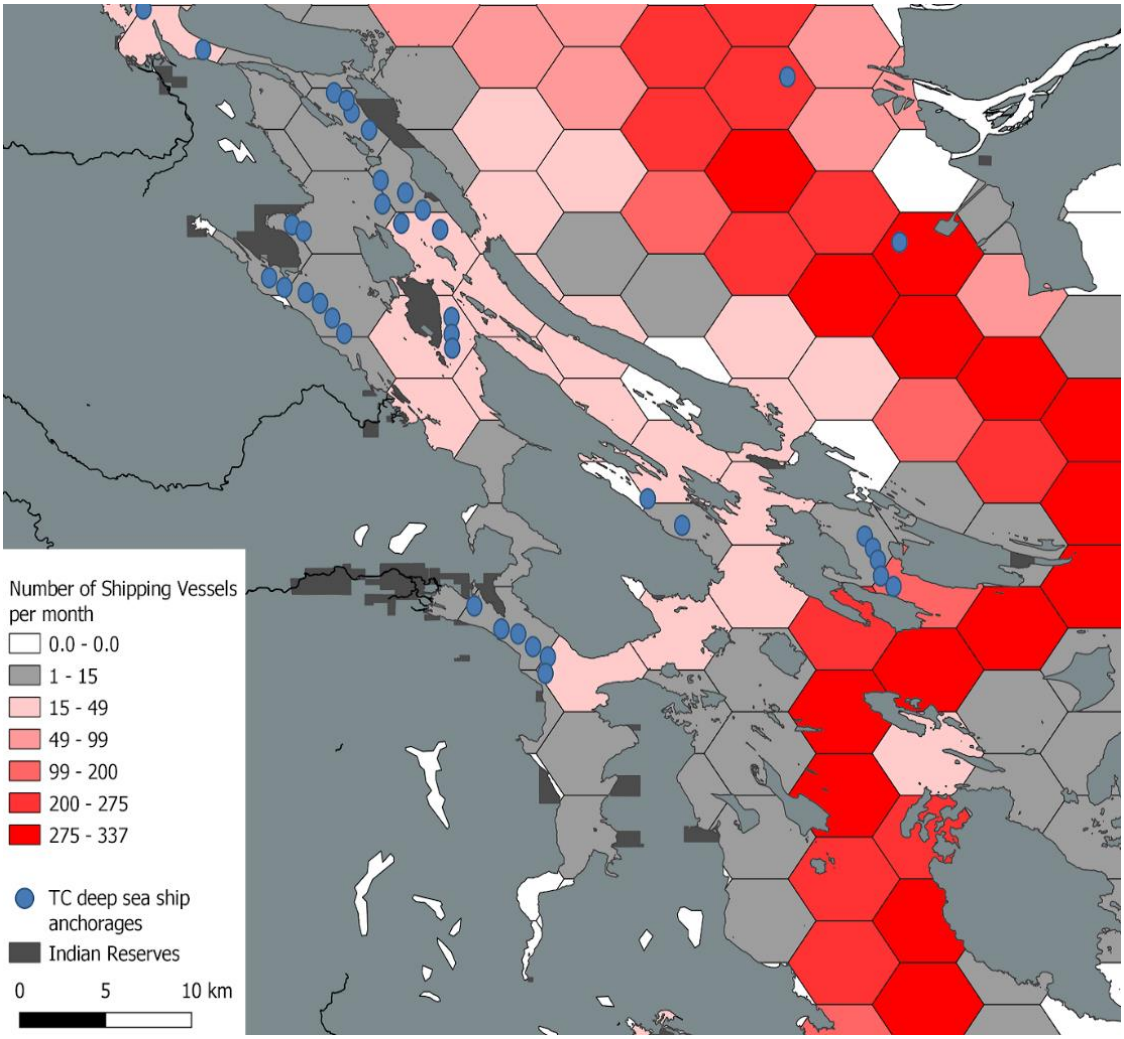

Figure 5: Monthly Shipping traffic and anchorages. Using freely available AIS data (National Oceanic and Atmospheric Administration (NOAA), 2019) the number of cargo ships was calculated per month to illustrate where there is already heavy vessel traffic in the Salish Sea. Between 200-300 shipping vessels transit the water in front of *St'utl'qulus* per month. Anchorages designated for large shipping vessels by Transport Canada are considered additional sources of risk on the interior of the Gulf Islands by Hul'qumi'num community members. There are 41 deep sea ship anchorages in the area, 26 (63.4%) of which are within three kilometres of an Indian Reserve.

Pollution and Contamination

> The pollution comes in from the other side- Vancouver. It takes 2 hours to get across. It washes up on our beaches. That's one of our own studies.

> The scientists asked: “where does all this mud come from [on Penelakut Island]?” It comes from there, through Porlier Pass.
> (A. Sylvester, personal communication 2019)

Pollution and heavy metal contamination is already a concern for consuming other beach foods in Hul’qumi’num territories (Figure 6) (Fediuk & Thom, 2003). Today, contaminant related closures of shellfish beaches are widespread, affecting over a third of suitable shellfish harvesting beaches in BC (Howlett & Rayner, 2004). Dioxins from pulp and paper mill effluent (Ayers, 2005; Wiseman & Gobas, 2002), Paralytic Shellfish Poisoning (PSP) (Evans et al., 2005; Ketchen et al., 1983), and fecal coliform from agricultural runoff and discharge of human wastes (Ayers, 2005; Evans et al., 2005) are the primary sources of this contamination. The water quality monitoring regime has been criticised for not testing for a wide enough array of contaminants (Howlett & Rayner, 2004), not measuring water quality on a fine enough spatial and temporal scale (ie keeping closed beaches that could be open) (Evans et al., 2005), and not being structured effectively to improve water quality in closure areas (Holst et al., 2011; Howlett & Rayner, 2004). Food, social, and ceremonial as well as recreational harvests, regulated by Hul’qumi’num bands, occur year round except on beaches closed for contamination (Evans et al., 2005).

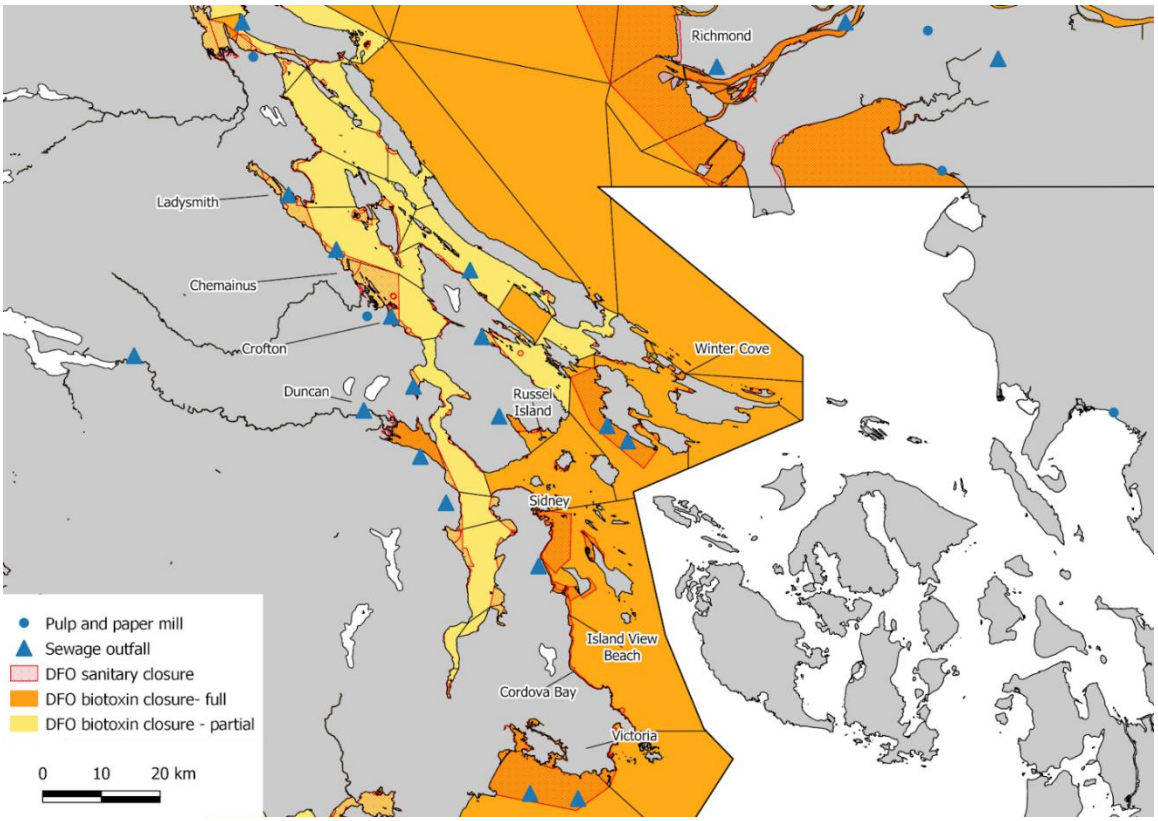

Figure 6: Sanitary and biotoxin closures. Most Beaches in Hul'qumi'num territories are affected by some level of closure of bivalve harvesting. It is both illegal and unsafe to harvest bivalves in closed areas. The safety of other beach foods such as *lhuq'us* may be degraded by the same vectors that have closed bivalve harvesting. Biotoxin closures refer to closure put in place when harmful bacteria, viruses and marine biotoxins that are associated with paralytic shellfish poisoning (PSP), amnesic shellfish poisoning ASP) and diarrhetic shellfish poisoning (DSP) are detected in the water (DFO, 2020). Sanitary closures are additional emergency, seasonal, or annual closures put in place when marine biotoxins (such as fecal coliform) are in the water (DFO, 2020). Pulp mills and sewage outfalls in the area have been included because they are often considered sources for some of the contamination that causes these closures (Ross, 2006, Regional District of Nanaimo (RDN), 2017).

Because *lhuq'us* has very thin fronds (one to two cells thick (Shubert, 1984) *lhuq'us* readily absorbs heavy metals and other pollutants to the extent that in other regions it is used as an indicator species for contamination (Arici & Bat, 2016). To assess the levels of contaminants in *lhuq'us* samples were taken from the *lhuq'us* harvested on Russell Island, Winter Cove and supplemented by samples we harvested from Island

View Beach and Cordova Bay in W̱SÁNEĆ territories. Dried samples were sent to TrichAnalytics Inc. to complete an analysis of biometal content (see Appendix B for full report). The First Nations Food, Nutrition & Environment Study (hereafter, FNFNES) (Chan et al., 2019), a ten-year study investigating contaminants and the status of traditional foods in Canada found that seaweeds were the second highest contributor to Cadmium intake and the highest contributor for Arsenic intake in the Coastal BC study area.

Table 1: Arsenic and Cadmium concentrations of Gulf Island *lhuq'us* and concentrations found by FNFNES across the Pacific region (Chan et al., 2019)

	FNFNES mean	FNFNES standard deviation	Cordova Bay	Russell Island	Winter Cove	Island View Beach
Arsenic	25.27 mg/kg	13.37mg/kg	30.6mg/kg	30.2mg/kg	39.3mg/kg	21.8mg/kg
Cadmium	3.99mg/kg	2.10mg/kg	3.23mg/kg	1.73mg/kg	2.02mg/kg	2.74mg/kg

The concentrations of cadmium and arsenic in the samples taken during this study fell within the ranges measured in the FNFNES report (Chan et al., 2019). The samples taken at Winter Cove had the highest concentration of Arsenic but the concentration value measured was not significantly higher than the FNFNES population mean. While not enough samples were taken to fully understand the risk posed by consuming *lhuq'us*, these preliminary results suggest that the *lhuq'us* on Vancouver Island and the Gulf Islands are not significantly more contaminated than *porphyra* and *pyropia spp.* found in other areas in the Pacific region. This is important, as it indicates that even in this area *lhuq'us* continues to be a viable, healthy choice for the Hul'qumi'num communities who

want to keep it that way. The FNFNES report supports this with the median hazard quotient levels for cadmium and arsenic indicating that risk of an adverse health effect is not likely (Chan et al., 2019).

The Tolerable Dietary Intake (TDI) as set by Health Canada and the WHO of arsenic for a 60kg adult is 65.7 mg/year (Deveau, 2011; WHO, 2011). For the same hypothetical 60kg adult the TDI of cadmium is 21.9 mg/year (WHO, 2011). The FNFNES reports for the Pacific region that seaweed is eaten in 15.2 meals/year and the average portion size of seaweed is 8g. This means that on average 0.1216kg of seaweed is being consumed in the Pacific Region per year. Based on the metal concentrations found in the FNFNES report (Chan et al., 2019) (from which the samples taken in the Gulf Islands were not significantly different) this hypothetical 60kg person would consume 4.67% of the TDI of Arsenic and 2.21% of the TDI of Cadmium. Again, these numbers point to the idea that *lhuq'us* is a healthy, viable traditional food, which in contrast to shellfish which is widely closed, is available and connects strongly to ancestral cultural practices. Though shellfish have been regulated into a difficult corner for many Hul'qumi'num people (Thom, 2020), our baseline for *lhuq'us* is in a strong position.

Concerns of health go beyond the physical. Knowing the cultural importance of *lhuq'us* as an embodied part of Hul'qumi'num culture frames these concerns not only in terms of food security but also highlights "Less tangible" dimensions of health such cultural transmission and community cohesion that occurs on the beaches (Donatuto et al., 2011).

Climate Change

The concerns about pollution and increasing industrialization of waterways are happening in the context of a changing climate. *Lhuq'us* transitions between two distinct life phases annually based on cues from environmental conditions such as water temperature and sunlight. The timing of the *lhuq'us* bloom may be impacted by several climatic changes occurring in the Pacific Northwest (Clark et al., 2018). Across the Pacific Northwest people are finding that a particular set of conditions that made the bloom and subsequent harvest and preparation predictable and stable (including ocean temperature and sunny days) are becoming more variable.

In recent years (2013-2016) sea surface temperature has been anomalously high for long periods in the north eastern Pacific Ocean (Hu et al., 2017; Peterson et al., 2016; Hartmann, 2015) This type of marine heatwave have been shown to be increasing in frequency, duration and intensity over the last several decades and is strongly linked to increasing average sea surface temperature (Oliver, 2019). Anthropogenic climate change is then driving both the increasing average sea surface temperature and the changing properties of marine heatwaves (Oliver, 2019). Such changes may have implications for marine and intertidal ecosystems. On the central coast the 2013-2016 marine heat wave coincided with a decreased abundance of *porphyra/pyropia spp.* (Clark et al., 2018). I asked Auggie Sylvester if he's noticed any changes in *lhuq'us* availability or abundance:

> **Auggie:** Yes, there's years the #2s' don't show up at all and the #1s' well we were lucky to find them, sometimes they're gone.
> **Jack:** why do you think that is?
> **Auggie:** the ocean. The temperature, the pollution, climate change to name a few. They don't like the warm water. Out in the gulf it's cooler

Impacts of environmental change and industrialization of the region are concerns in the community not just because they may cause the abundance of *lhuq'us* to decline

but because of how this decline impacts community members and their access to safe beach foods.

Conclusion

> "Our young ones are not interested in our traditional foods because they are not exposed to it. We need to get out there. Dig clams teach them how to steam clams and gather seaweed. We need to get kids out there doing it."
> - Respected Tsartlip Elder May Sam (Evans et al., 2015a).

Lhuq'us is an important species in its own right like other better recorded species (such as clams and salmon). Though traditional food systems have been impacted by a suite of colonial policies and structures as well as neoliberal pressures *lhuq'us* and the places it is harvested continue to be animated by Hul'qumi'num culture, stories, language, and histories. Relationship with place as mediated through relationship with *lhuq'us*, relationship with plants animals and materials are all part of the way Hul'qumi'num connections to land are made. *Lhuq'us* harvesting (and harvesting of other culturally important materials and foods) is integral to the meanings and stories of place and are embodiments of the relationship people and families have with places. Understanding where and when *lhuq'us* is harvested is important but the context in Hul'qumi'num ways of being in the world gives other non-Hul'qumi'num people and I a better understanding of the importance of the places and why they need to be cared for. The people who shared with me over the course of our project have intention for the knowledge, it is not shared lightly. I think one of the key intentions for this information is for community youth. The work Kathleen Johnnie is doing to connect elders, youth, land, language, and traditional foods is vital and is linked to the many future aspirations of community leaders. This

context dovetails with the next chapter which describes an experimental methodology for monitoring the abundance of *lhuq'us* which would give community managers and traditional food practitioners insight into what the key drivers of change are which and in turn inform how best to continue revitalization and restoration efforts.

Chapter 2: People, Pixels, and *Lhuq'us*: Benefits and Challenges of Applying UAV Mapping Imagery for Hul'qumi'num Concerns

Introduction

The broad goals of this project, as articulated by the Hul'q'umi'num' Lands and Resources Society, are to document culturally significant species potentially impacted by environmental change and increasing marine shipping in the Salish Sea, and to develop benchmark information about these species against which future changes can be measured and monitored to contribute to larger efforts Hul'qumi'num communities are making to self-govern marine foods and revitalize cultural practices. (K. Johnnie, personal communication 2019). Chapter 2 describes some of the interconnections between *lhuq'us* (Hul'q'umi'num' language term for *porphyra* and *pyropia spp.*) place, language, and culture as well as describing broadly community concerns around beach foods. This chapter describes initial attempts to use emergent Unoccupied Aerial Vehicle (UAV) technologies to create useful maps and materials to navigate these concerns. The goal of the quantitative methodology is to test a method of creating benchmark data that future changes can be measured against, is useful for Hul'qumi'num managers and traditional food practitioners, and is useful for supporting ongoing revitalization and restoration efforts and broader work being done by community leadership to protect aboriginal rights from infringement. This chapter describes the benefits and challenges of using Unoccupied Aerial Vehicle (UAV) technologies, cloud computing platforms, and open source GIS packages to fulfill the stated need for benchmark information to map *lhuq'us*, the methods and results of the mapping project and finally the opportunities and future recommendations for how these mapping techniques might be scaled into a larger monitoring program.

Summary of *Lhuq'us* and Cultural Importance

Porphyra and *pyropia spp.* grows prolifically on protected and exposed rocky beaches in the high- mid tidal zones (exposed by most low tides and submerged by most high tides) in cold water, temperate oceans on all continents (Druehl, 2000; Ricketts *et al.*, 1985). *Pyropia* and *porphyra spp.* grow both on rock substrate as well as epiphytically on mussels or other algae (Druehl, 2000; Ricketts *et al.*, 1985). There are twenty one *Porphyra* and *pyropia* species native to the Pacific Northwest which are largely indistinguishable without microscopic analysis (Druehl, 2000). Both the genera *porphyra* and *pyropia* are named here because in 2011 there were substantial reorganizations of the two categories (Druehl & Clarckson, 2016) and no taxonomic analysis was done on the samples harvested to confirm species. There are likely several marine algae species harvested by Hul'qumi'num people on account of the several distinct harvesting times (Williams, 1979) which may be either *porphyra* or *pyropia spp*. As much as possible I rely on the Hul'qumi'num language term *lhuq'us* to refer to all of those *porphyra* and *pyropia spp.* with which Hul'qumi'num peoples have had relationships with for millenia. *Lhuq'us* and other Hul'q'umi'num' terms and placenames are used in this thesis to reflect the knowledge and categories embedded and encoded in Hul'q'umi'num' language (Wilkins, 1993).

Lhuq'us is one of the many species culturally important to Hul'qumi'num people. Like many important foods and goods, *lhuq'us* is featured in stories about the creation of the Hul'qumi'num world. As described in Chapter two there is a rich set of knowledges about how, when, and where to pick, prepare, and use *lhuq'us* informed by Hul'qumi'num teachings. Family histories and connections to place are interwoven with

stories of harvesting, preparing, eating and selling *lhuq'us*. Harvesting *lhuq'us* is an embodiment of Hul'qumi'num culture or as Auggie Sylvester, a respected Penelakut Elder, puts it part of a "way of life" (A. Sylvester, personal communication 2019). *Lhuq'us* and the beaches it is harvested on are managed according to particular Hul'qumi'num governance structures and these systems of management remain important to this day.

Lhuq'us **Life Cycle and Ecological Importance**

Some of the basic, fundamental scientific works completed on *porphyra* and *pyropia spp.* have researched the life cycle of these algae. In 1949 Kathleen Drew, a British botanist demonstrated the link between the familiar bladed phase of *porphyra* and *pyropia spp.* and the filamentous microscopic "conchocelis" phase that grows a crust on exposed rock and on the shells of intertidal molluscs and barnacles. The conchocelis phase was once thought to be a different species of marine algae all together (Druehl & Clarckson, 2016; Drew, 1949). This breakthrough, critically important to the Japanese aquaculture industry, is celebrated in Japan by a memorial in her name and a day, called "Drew festival" dedicated to her work (Harris et al., 2013).

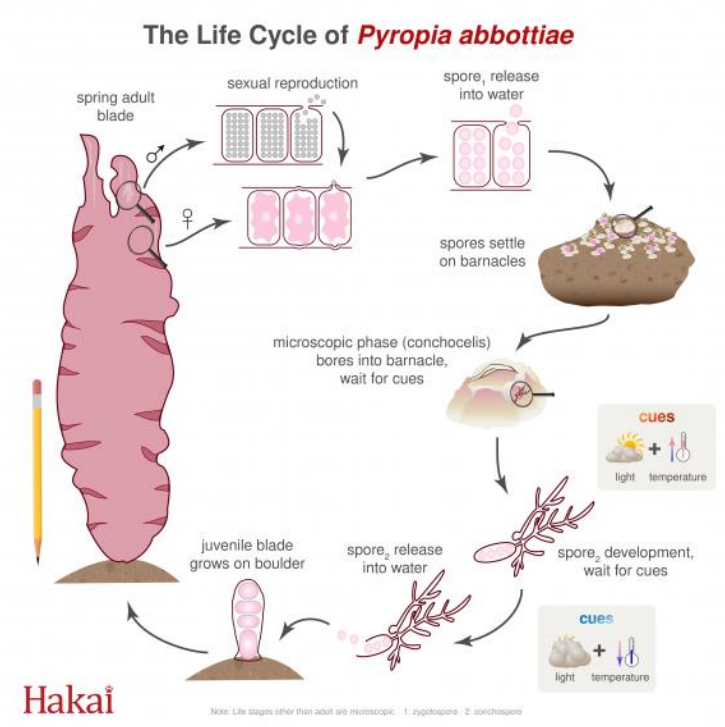

Figure 7: Life cycle of *porphyra* and *pyropia spp.* (Kellogg, 2018).

Intertidal algae beds are important components of coastal ecosystems. As an abundant and productive marine plant, *lhuq'us* is browsed by marine herbivores including chiton, snails, limpets, crabs, and urchins (Turner, 2003). There is literature that suggests *porphyra* and *pyropia spp.* interact with *mytilus spp.* (Mussels) as co- ecosystem engineers, altering the abiotic environmental conditions of the intertidal zone affecting which species are able to inhabit rocky shore lines (Gutierrez et al, 2019; Borthagaray & Carranza, 2007; Gutiérrez et al., 2003). *Mytilus spp.* beds alter water flow, trap sediments and nutrients, ameliorate temperature variation, alter macroinvertebrate predator behaviour, and reduce desiccation rates enhancing species richness by providing habitat to macroinvertebrates that would otherwise not be able to survive on the rocky shores where mussel beds are found (Gutierrez et al, 2019). *Porphyra* and *Pyropia spp.* often grow epiphytically on mussel beds reducing the temperature and levels of desiccation in

the beds, enhancing the survival of mussels and of other species which live in mussel beds (Gutierrez et al, 2019). *Lhuq'us* is also connected to terrestrial ecosystems when it washes ashore and forms wrack deposits that in turn provide food for herbivores and detrivores (Orr et al., 2005).

Baselines and Shifting Baselines

The baseline information that the Hul'q'umi'num' Lands and Resources Society were interested in documenting at the outset of this project are a set of data that gives managers and practitioners information against which they can track variations (both natural and anthropogenic) and make harvesting and management decisions based on these changes (Dayton et al., 1998). Baseline information to track changes and health of intertidal algae will be useful for monitoring the impacts of urbanization and industrialization and ensuring access to safe culturally important foods within the framework of revitalizing and enacting Hul'qumi'num governance, culture, and food practice. These same kinds of data are, I expect, of interest to closely related neighbouring Coast Salish communities, whose members similarly value culturally significant ŁEKES (as it is said in the SENĆOŦEN language, Montler 2018:311)). It is important to recognize that the data created for this baseline do not represent an unchanged ecosystem. Traditional foods and food systems are threatened in the Pacific Northwest as a result of intersecting environmental and cultural changes wrought by colonization, globalization, and industrialization (Turner & Turner, 2008). Though quantifying the precise magnitude of the changes is difficult, it is known that macro algae communities including kelp, eelgrass beds, and intertidal areas have substantially changed over the past 150 years. Large scale changes in these ecosystems are a result of

physical disturbances including runoff and sewage disposal, changes in water quality, and land use changes (such as urbanisation and agriculture) which have non linear effects on nearshore marine communities (Short and Wyllie-Echeverri, 1996). *Porphyra* and *pyropia spp.* are known to be impacted by similar environmental changes (Harris et al., 2013). In the 1940s productive and economically important *porphyra/pyropia spp.* beds in Japan were impacted by fertilizer runoff from land based agriculture and industrial pollution (Harris et al., 2013). It is important to recognize that large scale changes have already happened in the intertidal zones of Hul'qumi'num and neighbouring Coast Salish communities' territories to avoid "shifting baseline syndrome" where the accepted thresholds of "normal" environmental conditions are shifted and decoupled from historical norms (Soga and Gaston, 2018).

Though there is a long history of cumulative changes in the region measuring current patterns of spatial and temporal variation will provide useful information (Garbulsky and Paruelo, 2004) because changes in Hul'qumi'num and neighbouring Coast Salish communities' territories and in the Pacific Northwest generally are ongoing. *Porphyra* and *pyropia spp.* is an important species to many Indigenous communities across the Pacific northwest. *Porphyra* and *pyropia spp.* transition between two distinct life phases annually based on cues from environmental conditions such as water temperature and sunlight. The timing of the *lhuq'us* bloom may be impacted by several climatic changes occurring in the Pacific Northwest (Clark et al., 2018). Across the Pacific Northwest people are finding that a particular set of conditions that made the bloom and subsequent harvest and preparation predictable and stable (including ocean

temperature and sunny days) are becoming more variable. I asked Auggie Sylvester if he's noticed any changes in *lhuq'us* availability or abundance:

> **Auggie:** Yes, there's years the #2s' don't show up at all and the #1s' well we were lucky to find them, sometimes they're gone.
> **Jack:** Why do you think that is?
> **Auggie:** the ocean. The temperature, the pollution, climate change to name a few. They don't like the warm water. Out in the gulf it's cooler.

This concern about the status of *lhuq'us* has been long standing, in neighbouring W̱SÁNEĆ communities people have been expressing concern for at least the last twenty five years (Simonsen, Davis, & Haggarty, 1995). In 1995 Elmer Henry and Tom Sampson, W̱SÁNEĆ informants for the "report on First nations consultation" the British Columbia Ministry of Environment Land and Parks was writing, stated " Cole Bay is a seaweed harvesting area. From May to March, seaweed was gathered when the tide line is low. Now there is not much seaweed around" (Simonsen et al., 1995). The concern is also not localized to southeastern Vancouver Island, changes to the *lhuq'us* bloom have been documented across the Pacific Northwest by harvesters and traditional food practitioners. In 2016 Heiltsuk and Wuikinuxv Coastal Guardian Watchmen noticed a decline in the quality and quantity of *Porphyra* and *pyropia spp.* (Clark et al., 2018) on the central coast of BC. In partnership with the Hakai Research institute these practitioners and managers are investigating the relationship between these declines and warmer water, lack of sunlight, or other environmental conditions related to the anomalously warm ocean temperature in 2016 (Clark et al., 2018). Kwakwaka'wakw people on Northern Vancouver Island working with Deveau (2011) are concerned that non-point industrial and domestic pollution sources are impacting the quality and health of *porphyra* and *pyropia spp.* (Deveau, 2011). Helen Clifton a Gitga'at Elder from

Hartley bay (Northern coastal BC) describes how since the late 1990's the weather patterns in the spring when *porphyra* and *pyropia spp.* is blooming have become variable, unpredictable, and notably more rainy decreasing the accessibility of the food by making the harvest and particularly the sun drying of *porphyra* and *pyropia spp.* less reliable (Turner & Clifton, 2009; Turner, 2003). Changes to the predictability of the *lhuq'us* bloom is making harvesting and preparing *Porphyra* and *pyropia spp.* (already an expensive and time intensive activity) much less reliable and further reduces access to the culturally valuable species (Turner & Clifton, 2009).

These observations made by peoples across the Pacific Northwest indicate that monitoring of this culturally important species is needed to understand what changes are happening and what the drivers of these contemporary changes are. Despite concerns being raised for at least the last two decades there have been no concerted monitoring programs for *lhuq'us* by state management agencies and concerns around *lhuq'us* have remained relatively invisible. The need for baseline information of culturally important species in Hul'qumi'num and neighbouring communities is compounded by community concerns around the impacts and risks posed by expanding marine shipping in the Salish Sea including the Trans Mountain Pipeline Expansion project (TMX), the Roberts Bank Terminal 2 expansion project, among other smaller scale projects. There are additional concerns over long-term climate change impacts on culturally significant landscapes and practices. The most useful type of baseline information would have a large temporal and geographic scope at a fine geographic scale so that even small changes across large areas and over time could be identified. Conventional ecological research is constrained by the short time period of scientific studies but Turner and Clifton (2009) suggest that

Indigenous and community monitoring are uniquely situated to carry out longer term monitoring with the added benefit that the information created is trusted and in the control of those communities who have desire for this information. Because *lhuq'us* is sensitive to a variety of abiotic conditions and it may be a useful indicator species for monitoring these changes in the future (Kellogg, 2018).

UAV Literature Review

Traditional satellite platforms for remote sensing provide coverage for large areas with a wide range of spectral information being measured at reliable frequencies (Ventura et al., 2018). However, in contexts where high spatial resolution and temporal flexibility is required these traditional platforms may not provide suitable data (Klemas, 2013). In the context of this project the flexibility required is most importantly related to timing: timing flights to coincide with low tide and the bloom of *lhuq'us*. In recent years technological advances of UAV platforms including: battery life, navigation, payload capacity, and sensors (photographic, video, multispectral, thermal, LiDAR), as well as advances in imagery computation (Green et al., 2018; Pereirat et al., 2009), together with increasing need for tools for environmental monitoring, have led to the expansion of UAV remote sensing (Ventura et al., 2018). UAV technologies provide a suite of advantages that seem to align with the logistical needs of creating baseline data about *lhuq'us.* The surveys done for this project are a proof of concept to identify whether these methodologies could be scaled up to a larger monitoring program.

The use of unmanned aerial vehicle (UAV) technology for remote sensing and monitoring offers access to very high resolution data at a much lower cost than high resolution imagery from satellite based platforms (Konar & Iken, 2018; Madurapperuma

and Dellysse, 2018; Guichard et al., 2000). The term UAV includes any aircraft that operates without a human pilot onboard and there is a wide suite of aircraft that have been used for remote sensing including kites, balloons, blimps, multirotor helicopters and fixed wing aircraft (Konar & Iken, 2018; Madurapperuma & Dellysse, 2018; Kelmas, 2015; Guichard et al., 2000). UAVs are relatively low cost (compared to high resolution satellite imagery), flexible in use and timing, relatively high spatial coverage (compared to ground studies), and provide high resolution imagery and data providing new insight into ecological phenomena that would be challenging to detect at scales researchers and communities are interested in (Ventura et al., 2018; Konar & Iken, 2018; Madurapperuma & Dellysse, 2018). For Indigenous communities who have their own particular research needs, data that can be fully controlled, operated, and analyzed by the community is attractive.

There have been many applications of UAV technology in the coastal zone including significant work on intertidal wetlands and seagrass meadows (Konar & Iken, 2018; Klemas, 2015; Hossain et al., 2015; Lathrop et al., 2006). The flexibility in use and timing that UAV technologies offer are particularly advantageous for environmentally variable contexts such as the intertidal zone. The ability to gather imagery that matches low tide conditions or avoids cloud cover improves the ability of researchers to detect and delinitate intertidal algal communities (Klemas, 2015). The extent of large coastal features like coastal wetlands, kelp forests, and seagrass meadows were studied by researchers using traditional satellite platforms but the application of UAV technology has allowed researchers to map biomass, health, and changes in distribution over time at a finer spatial and temporal scale (Konar & Iken, 2018; Klemas, 2015). UAV technologies

have expanded the suite of species, ecological communities, and coastal processes that can be studied using remote sensing methodologies (Klemas, 2015; Ventura et al., 2017). Intertidal ecological communities on rocky shores have been traditionally studied using ground based quadrat sampling, measuring parameters such as percent cover abundance, and biomass (Konar & Iken, 2018). This type of data has been the mainstay in long term monitoring and impact studies such as research on the impacts of the EXXON Valdez disaster (Konar & Iken, 2018). These methodologies are limited in spatial extent because they are time intensive, making covering large areas costly (Konar & Iken, 2018; Nahirnick et al., 2018; Hossain et al., 2015). Quadrat sampling methodologies persist because they have high "taxonomic resolution" which is important in species rich areas such as the intertidal zone (Konar & Iken, 2018). Because UAV technologies have the capability to offer very high resolution imagery, features such as *mytilus spp.* (mussels), *ulva spp.* (sea lettuce), *fucus spp.* (rockweed), and *porphyra/pyropia spp.*, which appear in distinct patches on beaches, have all been successfully detected (Tait et al., 2019; Gomes et al., 2018; Madurapperuma & Dellysse, 2018; Konar & Iken, 2018; Ventura et al., 2018; Guichard et al., 2000). Measurements of these rocky intertidal species of interest include: density, patch size, extent, and biomass (Tait et al., 2019; Gomes et al., 2018; Konar & Iken, 2018; Madurapperuma & Dellysse, 2018; Ventura et al., 2018; Guichard et al., 2000). Depending on the research needs of the project UAV technologies may be a useful tool for intertidal algae monitoring. In the mid tidal zones, where *pyropia/porphyra spp.* are found, UAV provides comparable data as ground survey. The true color orthomosaics created from UAV data of entire beaches provide a useful

repository of information for managers if there is a need to revisit community composition even years later (Konar & Iken, 2018).

While the majority of research projects applying UAV technologies have studied subtidal macroalgal communities such as kelp and seagrass some researchers have applied these emergent technologies to the intertidal zones of rocky beaches. Researchers who have applied UAV technologies in the intertidal zone of rocky beaches have used a variety of approaches. The methodologies that have been used by previous research projects to gather and validate remotely sensed data on rocky intertidal beaches will be used to inform the methodology used to map *lhuq'us*. Gomeas et al. (2018) were investigating the density, size and reproductive output of *mytilus spp.* beds on rocky beaches. The research team flew an octocopter at an altitude of 30 metres collecting images with ~1 cm resolution (Gomeas et al., 2018). They collected ground reference data using quadrat samples and a garmin GPS (Gomeas et al., 2018). Training data was derived from the image (100+ points per class) and the UAV imagery was classified per pixel (Gomeas et al., 2018). The overall accuracy of the classified image when compared to the collected quadrat points was 86.5%. Konar and Iken (2018), seeking to test the applicability of UAV technologies for the long term monitoring program of the Exxon Valdez oil spill in the Gulf of Alaska flew a quadcopter carrying a RGB gopro camera over three rocky intertidal sites and one seagrass bed. Because this study required compatibility with existing long term data very high "taxonomic" resolution was required (Konar & Iken, 2018). To achieve distinctions at the species or genus level the UAV was flown at very low altitude (5m) sacrificing beach coverage (50m transects) for very high spatial resolution (Konar & Iken, 2018). Orthomosaics were compared to quadrat

samples (20 samples per transect). Konar and Iken (2018) found that quadrat sampling still achieved better taxonomic resolution but concluded that if the goal of monitoring is to track changes in overall community structure using classification categories at the genus level UAV technologies are effective (Konar & Iken, 2018). Guichard et al. (2000) were interested in the fine scale ecological processes in the intertidal zone and the relationship between *fucus spp.* biomass and fine scale topographic variability (Guichard et al., 2000). Using a helium blimp flown at 80m and 50m carrying a standard 35mm RGB camera and an Infrared sensor. The resulting orthomosaic had a spatial resolution of 2cm (80m flight) and 1cm (50m flight) (Guichard et al., 2000). 22 quadrats sampled for training and validation of the imagery along with samples of the *fucus spp.* to estimate biomass (Guichard et al., 2000). The pixel based classification used by the researchers identified *fucus spp.* and estimated the biomass of the algae with 73% accuracy (Guichard et al., 2000). Guichard et al. (2000) suggest that taking an object based approach would improve the classification. Ventura et al. (2019) conducted research on three different intertidal ecosystems in the Mediterranean sea. Flying a quadcopter with an onboard RGB GoPro camera at an altitude of 40m they created orthomosaics with 3.5cm resolution (Ventura et al., 2019). An object based approach was used for classification, using an algorithm to identify and delineate shapes as ‘superpixels’ (Ventura et al., 2019). Training and validation data were derived from the imagery (no field data was collected in situ) (Ventura et al., 2019). The classification identified algal communities of interest with >80% accuracy (Ventura et al., 2019). Following these foundational cases and based on the taxonomic resolution required for our project a RGB camera taking images with a spatial resolution of ~2cm was an appropriate place to start with initial UAV surveys.

Methodology

Study Sites

Two study sites were selected for UAV mapping: ȾEL,IŁĆ[8] and *St'utl'qulus*. ȾEL,IŁĆ refers to what is now known as Cordova Bay and was selected to represent the "inside" type beach where number 2 *lhuq'us* is harvested because it was easily accessible and the site of an ongoing collaborative work between W̱SÁNEĆ First Nations, the municipality District of Saanich, and professor Brian Thom in UVic's Anthropology Department. The imagery captured here became doubly useful as it was ancillary to ongoing discussions about ȾEL,IŁĆ / *cə́líłč*, a W̱SÁNEĆ and Lekwungen settlement site, as a part of a broader W̱SÁNEĆ and Lekwungen cultural landscape. The surveyed area was expanded to photograph an unrecorded archaeological fish trap feature on the beach. *St'utl'qulus* on Galiano Island was selected as a representative beach of the important "outside" area which is an important harvesting area for the earlier blooming "number 1" *lhuq'us*. The place name refers to a long area running along the outside of the Gulf Islands. The specific location at Dionisio Point is the location of an extensive Hul'qumi'num settlement site including five house features and is an important and sacred place and part of broader Hul'qumi'num cultural landscapes (Grier, 2012; Rozen, 1985). Furthermore it is in the management plan of the Dionisio Point Provincial Park to inventory the intertidal algae of the park to better manage these important ecological features, a management item that was yet to be fulfilled since it was written in 1995 (Ministry of Environment, Lands, and Parks (MOELP, 1995). Similarly protecting the

[8] The SENĆOŦEN spelling "ȾEL,IŁĆ" is used here as opposed to the Lekwungen "*cə́líłč*" reflecting the partners of the project.

integrity foreshore ecosystems of ȾEL,IŁĆ are included in the newly written draft Cordova Bay land use plan (District of Saanich, 2020). The imagery taken is and has already been useful for discussions about Indigenous land values and may be part of ongoing management strategies by Hul'qumi'num partners as well as provincial and municipal land managers. Each of these sites represent one of many beaches identified by traditional food practitioners as important for *lhuq'us* harvesting (figure 2).

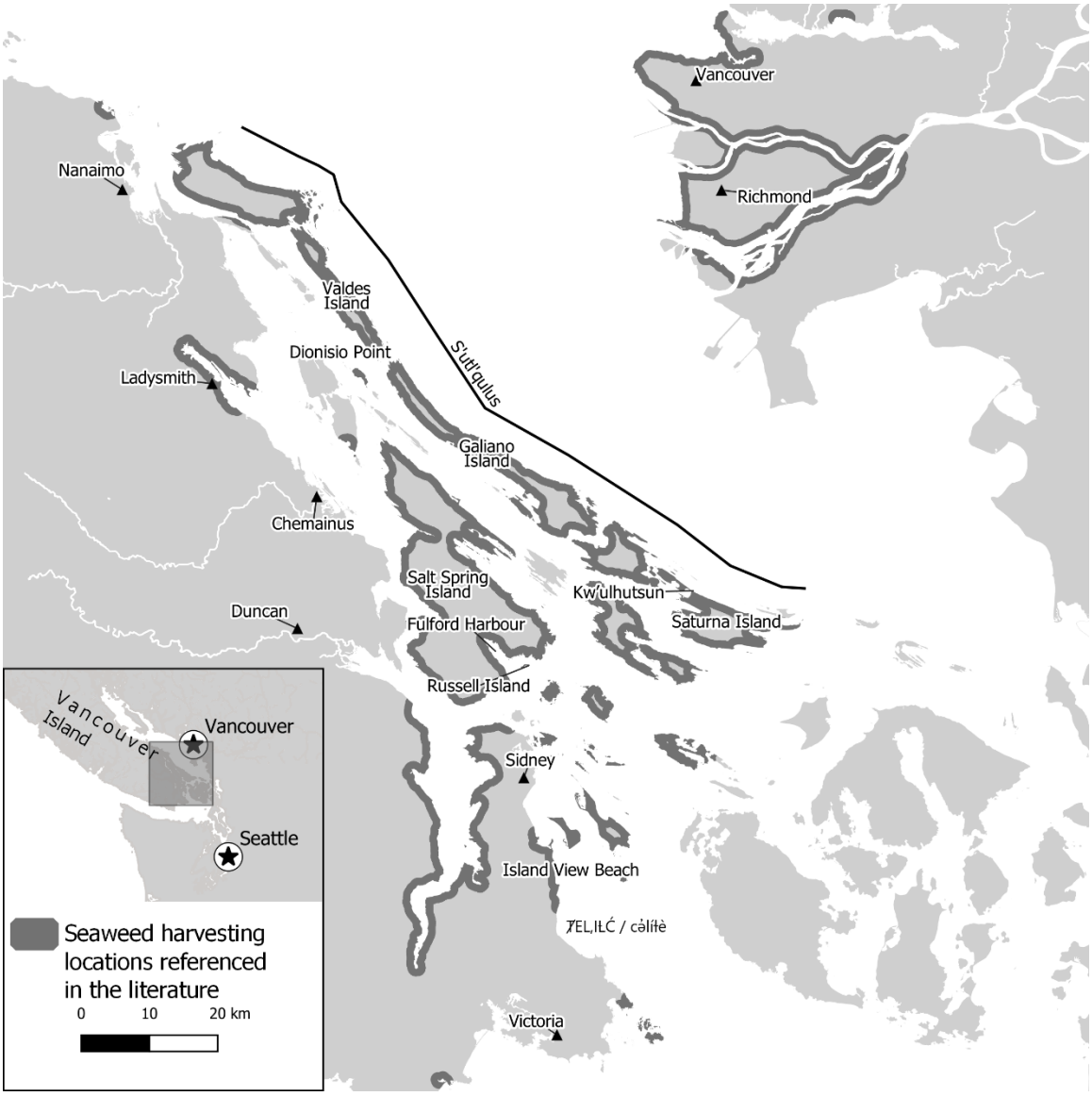

Figure 8: *Lhuq'us* harvesting places referenced in the literature. 294 documents were reviewed including ethnographic texts, Traditional Use Studies, theses, and documents published by Hul'qumi'num and other Coast Salish communities. In these documents 60 places were identified as *lhuq'us* harvesting areas. Note the locations of the UAV surveys *S'utl'qulus* / Dioniso Point and ȾEL,IŁĆ / *cə̀líłč.*

Ground Reference Data Collection

Ground reference data was collected at each of the sites to be used for validating the accuracy of the classification following (Gomeas et al., 2018). To ensure

there was enough time to cover the extent of the study area at both beaches the collection of ground reference points occurred over two days. Before going to the study sites, the maps of the study area were created to delineate the flight plans. *Lhuq'us* grows in the middle intertidal zone between the low high-high-water (LHHW) and the high high-low-water (HHLW) lines (Ricketts *et al.,* 1985). The study area was drawn between the approximate low and high tide lines. Within this area points were randomly generated and numbered. The research team navigated to these points on the beach using a handheld GPS and flagged and labelled each point. A quadrat was placed at each point and the percent coverage of identifiable algae genus was estimated by plain sight. The algae was identified using the identification charts in Druehl (2000). Each quadrat was also recorded using a digital camera. A Trimble Catalyst d-GPS and precision level mounted on a surveying pole was used to get higher precision coordinates for each flag after the quadrats were measured. At the ƮEL,IŁĆ study area, due to technical issues, only fifteen points were collected with the d-GPS with an average precision of 70cm. A further 91 quadrat points were collected using a handheld Trimble GPS with an estimated average precision of 3m. At the Dioniso Point study area 61 points were captured with the d-GPS with an average precision of 2cm. After the surveys the estimated percent coverage of the contents of the quadrats were classified to create training data useful for calibrating the classification of the imagery and assessing the accuracy of the classification. Percent coverage estimates were converted to the ordinal categories A (abundant >40% coverage), C (common > 10% coverage), and F (few <10% coverage). For each study site the ground reference data was categorized based on the most common coverage classes in the quadrat (coverage classes ranked A (abundant) and C (common)).

This approach generated “pure classes” such as rock, or *Ulva spp.* where quadrats could be described by one dominant class and mixed classes such as *pyropia/porphyra spp.* / rock where the coverage was patchy with two dominant coverage types. Following Ventura et al. (2019) additional classes were created to reduce errors. With reference to the particular imagery of each site one additional class was created at *St’utl’qulus* (shadow) and two at ȾEL,IŁĆ (Shadow and wet sand) independently of the collected ground data. This process generated 5 classes at *St’utl’qulus* and 6 at ȾEL,IŁĆ.

The categorization of coverage types follows those used by other researchers collaborating with Kathleen Johnnie on another community led project on Valdes Island to measure species abundance and diversity (Lamb & McDaniel, 2013). This classification system is also used in the citizen science data collection called the Shorekeepers Atlas which has data on beaches throughout the Salish Sea (Macdonald & MacConnachie, 2011). Putting the data collected in context with these other similar surveys may be useful in the future if they are both included in a larger baseline dataset.

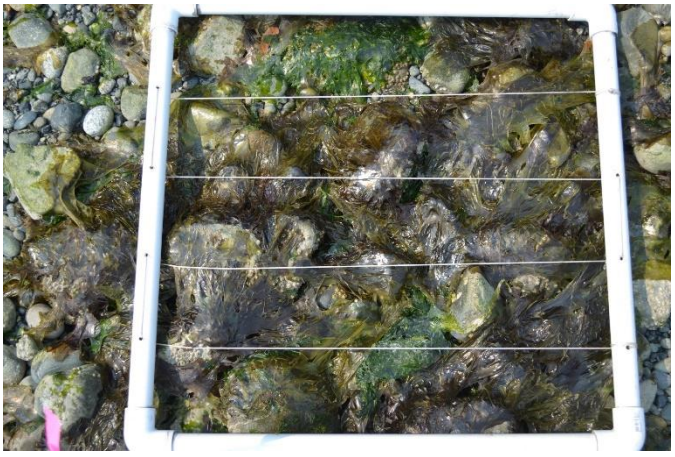

Figure 9: sample quadrat taken Contemporaneous to UAV imagery at ȾEL,IŁĆ.

UAV Image Acquisition and Processing

Pacific UAV (PUAV) (Sidney BC) was contracted to operate the UAV flights for the project including clearance logistics. In Canada, commercial UAV operators must fly with clearance from Transport Canada and hold a Standing Special Flight Operations Certificate (SFOC). All of the restrictions and requirements outlined by this certificate were followed. Within the study area, flight lines were generated by the operator to adequately cover the entire area of interest. Dialogue with Saanich parks and BC parks was conducted to obtain all necessary permissions to complete the surveys.

Prior to the flight Ground Control Points (GCPs) were distributed across the beach (12 GCPs at ȾEL,IŁĆ , 10 GCPs at Dioniso Point). The flight plan at ȾEL,IŁĆ was extended beyond the cobble beach (*lhuq'us* habitat) to include a previously identified undocumented archaeological site of interest to W̱SÁNEĆ First Nations. This extension made additional GCPs and an additional flight by the UAV mandatory. Two types of GCPs were used: large particle boards (24x24 inch) and small corrugated plastic boards (12x 12 inch). All boards had the same black and white checkered pattern on them. GCP coordinates for the beach survey area were collected using the same Trimble Catalyst d-GPS to give ~2cm precision to match the UAV imagery.

The PUAV pilot flew a consumer grade DJI Phantom 4 pro quadcopter UAV with an onboard, gimbal stabilized, CMOS 20 megapixel RGB digital camera set to nadir to collect the aerial photography. The flights were programmed into the onboard navigation software of the UAV by the operator. During the flights an observer monitored image coverage of the target area in real time and monitored the airspace surrounding the UAV for hazards and changes in weather. The UAV was flown at an altitude of 60m with an approximate pixel resolution of 2cm. Images were taken with relatively high endlap

(75%) and sidelap (65%) to give suitable feature detection for image stitching in the mosaicking process. Imagery was stitched together and georectified by PUAV.

Image Classification

The orthomosaics were uploaded onto the cloud based remote sensing platform Google Earth Engine (GEE). GEE was used because it is freely accessible, relatively user friendly, and powerful, harnessing Google cloud-based computing. An object based analysis was used, because *lhuq'us* occurs on the beach in patches which are much larger than the pixel size of the high resolution imagery, rendering pixel-based analysis impractical (Ventura et al., 2019; Blaschke et al., 2014; Lathrop et al., 2006; Guichard et al., 2000). Object based analysis requires the analyst to strike a balance between objects that are easily interpreted and objects that reflect the detail of the imagery (Blaschke et al., 2014; Lathrop et al., 2006). This was achieved using an iterative process of adjusting the thresholds of object generating parameters such as size, shape, texture, and pattern to create meaningful objects which have utility for managers (Blaschke et al., 2014).

Object based remote sensing methods rely on the grouping of small patches of pixels that are both similar spectrally and nearby spatially. These small homogenous regions are called "superpixels". The Google Earth Engine algorithm employed to create superpixels is called Simple Non-Iterative Clustering (SNIC). To run SNIC first a layer of 'seed' points was generated from which the superpixels are calculated. In the SNIC algorithm the shape and size of the superpixels are dictated by the parameters: compactness, connectivity, and neighbourhood size. The weighting of these parameters changes where the algorithm decides where to draw the boundary between adjacent pixels. Compactness in this algorithm refers to the relative weighting of the spatial and

spectral distance. Changing the compactness value changes whether it should favour cells with similar values (spectral distance) or cells that are closer to the 'seed' (spatial distance). The higher the compactness value the more tightly constrained the superpixels are to the initial seed. Connectivity in this algorithm refers to which cells should be considered adjacent. The value of connectivity can be either four or eight (including or excluding diagonal cells). Some regional processes, such as image segmentation, will have inconsistencies near image tile boundaries. The neighbourhood size parameter defines a tile size to avoid these boundary artifacts. The values used for these parameters were: compactness: 3, connectivity: 8, and neighborhood Size: 256.

Once the superpixels were created, measurements of the pixels were taken to help categorize them. The average value of the red, green, and blue bands and the standard deviation among all three bands within was used to represent the spectral qualities of the superpixel. The area, width, and height, and perimeter length were used to represent textural elements of the superpixels. Each of these parameters were added as a band for each superpixel. The imagery at the *St'utl'qulus* was over exposed in some areas which impacted the accuracy of the classification. To address this issue the image was resampled using the algorithm Hue Saturation Value (HSV) (Nahirnick, 2018; Fletcher et al., 2009). HSV is a digital enhancement technique that correlates colours into components that can help make features more distinct (Fletcher et al., 2009). The digitally enhanced values were added as a band to each superpixel.

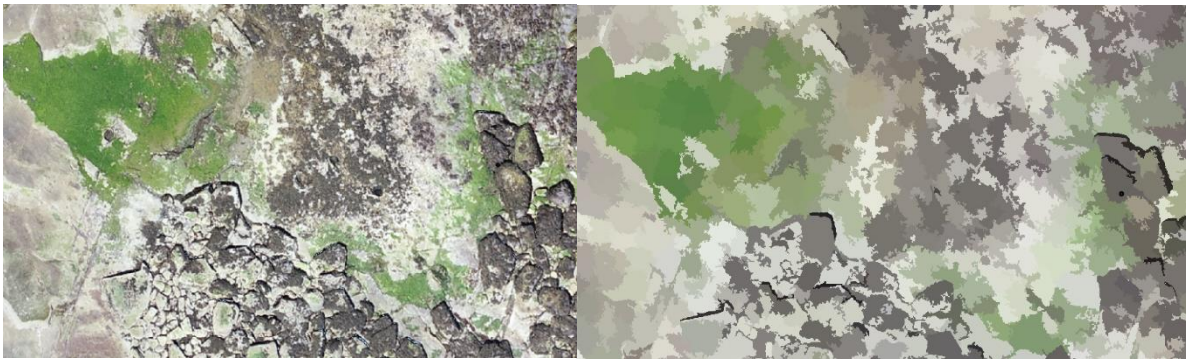

Figure 10: Sample of the raw imagery and the GEE superpixels coloured by their mean colour.

Once objects were created, the data sets were created to train the classifier following Gomeas et al. (2018) and because the resolution of the imagery allowed it, training data was derived from the imagery. Approximately 100 points were selected for each class at both study sites. Next, validation data points were created. The hig precision GPS point data from the ground was translated into ~50x50cm and put into the same classes. For classes with few validation points supplemental validation points were drawn until all classes had a similar number of validation points. Because the majority of the validation points collected at TEL,IŁĆ were at a lower accuracy, the geometry data was drawn within 3m of the points based on a visual assessment of the imagery. A “random forest” classifier was then trained using the training data. The classifier selected superpixels with attributes that reflectedthe training data. The spectral characteristics of each outputted class are summarized in Appendix E and Appendix F by colour band (Red, Green, and Blue). To assess the accuracy of the classification of the validation data was overlain on the classified imagery and error matrices were generated.

Results

The accuracy of the classified maps were assessed using error matrices. To produce an error matrix the validation data is overlain on the classified image. A matrix is then generated expressing how many of the known validation data points in each class align with the generated classification. This method to accuracy assessment describes the individual accuracies of each class in terms of "producer's" and "user's" accuracies along with both errors of omission and errors of commission (Congalton & Green, 2019). "Producer's accuracy" refers to the likelihood that real features on the ground are shown correctly on the classified map (Congalton & Green, 2019). "User's accuracy" is also referred to as 'reliability' and describes how often a class on the map will appear on the ground (Congalton & Green, 2019). An omission error is inverse of the producer's accuracy (producer's accuracy= 100%- omission error) and refers to the case when a pixel is excluded from the class the validation data shows it should belong to (Congalton & Green, 2019). A commission error is the inverse of user's accuracy (user's accuracy= 100%- omission error) and refers to the cases when a pixel is included in a class other than the one the validation data defines it as.

ƮEL,IŁĆ

A total of 106 quadrats were taken at ƮEL,IŁĆ. *Lhuq'us* was recorded in 58 of the quadrats (54.7%). In these 58 quadrat *lhuq'us* was classified (C) in 35 of them (60.3%) and most commonly found along with the 'rock/ sand' class. To represent this the class that represents where *lhuq'us* is found on the beach is called Rock (A)/ pyropia (C). The recorded environmental conditions during the flight at ƮEL,IŁĆ were high haze with a visibility of 24.1km (Environment Canada) and a low tide of 0.0m at the nearest tidal

station (Fisheries and Oceans Canada, 2018). Six general cover classes were used to classify the imagery (Table 2). The complete error matrix for ƬEL,IŁĆ can be found in Appendix C.

Table 2: ƬEL,IŁĆ User's and Producer's Accuracy

User's Accuracy		Producer's Accuracy	
sand/rock (A)	98.9%	sand/rock (A)	90.3%
Ulva spp. (A)	78.9%	Ulva spp. (A)	78.1%
Shadow	83.5%	Shadow	83.3%
Pyropia spp. (A)/ rock	75.3%	Pyropia spp. (A)/ rock	87.3%
Wet sand (A)	61.7%	Wet sand (A)	93.1%
Ulva spp. (A)/ rock (C)	83.9%	Ulva spp. (A)/ rock (C)	60.5%

The overall validation Accuracy of the ƬEL,IŁĆ classification was 85.5%. The rock (A)/ pyropia (C) class works well in rock areas where *lhuq'us* is only mixed with rock features but in areas where *lhuq'us* is mixed with *ulva spp.* the classifier is less successful in distinguishing areas where *porphyra/pyropia spp.* is absent. The rock (A)/ *porphyra/pyropia spp.* (C) class had an omission error of 12.7% and a commission error of 24.7% most often being confused with the *ulva spp.* (A)/ rock (C) and *ulva spp.* (A). The *ulva spp.* (A)/ Rock (C) class has an omission error of 39.5% and was most commonly confused with the *ulva spp.* (A)/ Rock (C) class. These two classes are spectrally similar, accounting for this confusion (Appendix E). Rock (A)/ *porphyra/pyropia spp.* (C) class represents 21.4% of the beach analyzed (3905.33m^2 of 18220.15m^2) and according to the ground data the *porphyra/pyropia spp.* represented 17% on average of the quadrats classified as representing the "patchy class" so ~663.92m^2 had *porphyra/pyropia spp.* on it when it was surveyed in August 2018. The error matrix analysis suggests that this figure is likely overestimating rock/*porphyra/pyropia spp.* and under estimating *ulva spp.* and *ulva spp.*/ rock areas.

St'utl'qulus

Porphyra/pyropia spp. were found in 19 of the 61 (31.1%) quadrats recorded at *St'utl'qulus*. Of these 19 quadrats *lhuq'us* was classified as (F) in 15 (78.9%) of them. All of the quadrats that *porphyra/pyropia spp*. was recorded in also had a mix of *fucus spp.* and bare rock. The class to represent *porphyra/pyropia spp.* is reflecting these smaller patches that had mixed species type. Because the imagery at *St'utl'qulus* was taken relatively late in the spring the number one *lhuq'us* was relatively sparse and patches were mixed with the dominant *fucus spp*. In the classification these "patchy" areas were delineated as a proxy for the *porphyra/pyropia spp.* habitat. The recorded environmental conditions during the Dioniso flight were clear with a 40.2km visibility (Environment Canada, 2019) and a low tide of 0.3m at the closest tidal station (Fisheries and Oceans Canada, 2019). Five classes were used to classify the imagery (Table 3). The complete error matrix for *St'utl'qulus* can be found in Appendix D.

Table 3: *St'utl'qulus* Producer's and User's Error

User's Accuracy		Producer's Accuracy	
Ulva spp. (A)	71.4%	Ulva spp. (A)	99.7%
Rock (A)	86.5%	Rock (A)	95.4%
Fucus spp (A)	93.1%	Fucus spp (A)	87.9%
Rock-Fucus spp (A)/ pyropia (F)	93.8%	Rock-Fucus spp (A)/ pyropia (F)	70.4%
Shadow	91.5%	Shadow	97.3%

The overall validation accuracy of the *St'utl'qulus* imagery was 88.9%. The rock/*fucus spp.* (A)/ *porphyra/pyropia spp.* (F) class had the highest omission error (29.6%) most commonly being confused with the rock (A) class. The class with the highest commission error was the *ulva spp.* class (28.6%) most commonly being

confused with the *fucus spp.* (A) class. These classes are spectrally which is why they were more often confused with each other (Appendix F). The rock/*fucus spp.* (A)/ *porphyra/pyropia spp.* (F) class represents 7.6% of the pixels analyzed (369.1m^2 of 48762.3m^2) and according to the ground data the *porphyra/pyropia spp.* represented ~8% on average of the quadrats classified as representing the "patchy class" so ~29.5m^2 had *porphyra/pyropia spp.* on it when surveyed in June 2019. This figure underestimates the total area in favour of the

'rock' class.

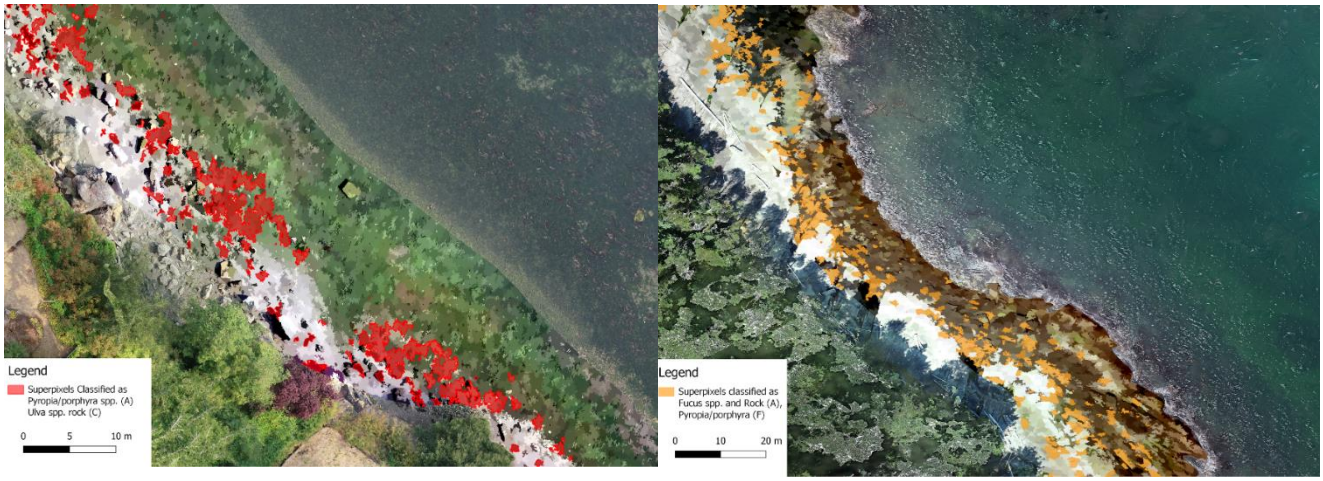

Figure 11: Samples of Classified imagery. *St'utl'qulus* on the left and *T*EL,IŁĆ on the right.

Sources of Error

There are a number of sources of error that contribute to the results of the classifications. Working with very high resolution imagery introduces its own set of challenges including high impacts of sunlight variation, sensor noise, and habitat variation (Hossain et al., 2015). Nahirnick et al. (2018) found that several environmental conditions including sun angle and wind speed have significant effects on the quality of

produced imagery and classifications, particularly for surveying subtidal algae species but these factors are relevant to the intertidal area surveyed in this project. As seen in the *St'utl'qulus* imagery, light exposure problems impacted the accuracy of the classification. This could be attributed to the sun angle during the survey and to the equipment used for the survey. The camera used for the imagery collection has a rolling shutter which is known to cause light exposure problems (Konar & Iken, 2018). Wind and vibration also introduce blurring effects to the imagery (Konar & Iken, 2018). Similar to the findings of (Lathrop et al., 2006) features had differing spectral responses at different tidal heights as seen with wet sand at ȾEL,IŁĆ. The inconsistent spectral responses within and between images is a known source of error for UAV imagery and can be minimized (Nahirnick et al., 2018; Lathrop et al., 2006). While these issues were addressed by splitting the classes they certainly introduced some level of error. Low spectral differentiation between classes is also a known source of error in imagery classification (Ventura et al., 2018). The effects of this can be seen in the produced classifications with high levels of confusion between similar classes (Appendix E and Appendix F). Classes that represent mixed cover types are likely to be confused with other classes. For example, at ȾEL,IŁĆ the class that represents regions of mixed *ulva spp.* and rock is spectrally very similar to the class that represents regions of mixed *pyropia spp.* and rock (Appendix E). Though the classes were distinguishable, there were limitations in identifying *porphyra/pyropia spp.* using only visible light and indirect measurements of shape.

Gathering more and different types of information may ameliorate these errors. For example *porphyra/pyropia spp.* has a significantly different spectral signature in the infrared bands as compared to green (like *ulva spp.*) and brown algaes (like *fucus spp.*)

(Kromkamp et al., 2006). There are some issues with applying the imagery captured as a benchmark in general. The difficulty of capturing a transient bloom event was not adequately addressed in the methodology of the project. Each gives one snapshot of the condition of the beach but likely does not give an accurate representation of the seasonal state. For example during a harvesting trip two weeks prior to the flight at *St'utl'qulus, pyropia spp.* appeared in large patches that were no longer present when the UAV survey occurred.

Figure 12. Image of larger patches of *lhuq'us* at *St'utl'qulus*. Earlier in the year during a harvesting session there were large distinct patches not present during the survey.

People and pixels: The Tensions Between Community Knowledge and Remote Sensing

The results of the initial UAV surveys suggest that these emergent technologies could be important tools for the future of Hul'qumi'num practice around caring for beaches. These maps and following ones that build information about the status of

lhuq'us can be powerfully leveraged to advance Hul'qumi'num concerns and aspirations. I position the maps created using UAV technology at the intersection between Hul'qumi'num ways of knowing and resurgence. These maps however are not inert, there are particular tensions in making them that must be recognized to have a more complete context for them. Maps are representations of the world and because of the choices cartographers make when creating maps, including, excluding, and simplifying certain information and knowledge, maps recreate and reinforce ways of seeing the world (Hunt & Stevenson, 2017; Willow, 2013; Sletto, 2009; Glasson et al., 2005). In the context of colonial powers these cartographic decisions are political, translating landscapes into Eurocentric terms (Hunt & Stevenson, 2017). Cartography is among the many tools of standardization used by states to make complex and "illegible" systems legible (Scott, 1989). Transforming Indigenous knowledge and places to maps can reinforce uneven power relations between the state or researchers and Indigenous communities or objectify knowledge in ways that do not serve Indigenous interests (Willow, 2013). In this sense, anthropology, geography, and history, as fields of study, are implicated as "the science[s] of imperialism" (as cited in Smith, 2013), constructing hegemonic and totalizing discourses which create and control "the other" (Smith, 2013). Cartography continues to uphold nationalist and colonialist constructions of Canada to this day (Hunt & Stevenson, 2017). Maps and map-making can impose and reinforce false dualisms such as nature/culture, indigenous/non-indigenous, scientific/local knowledge prevalent in western academia (Sletto, 2009).

There is a movement by environmental managers and conservationists to 'integrate' Indigenous knowledge into science (Ayers et al., 2012; Blaser, 2009;

Nadasdy, 1999; Cruikshank, 1998). In Canada, this movement is based in part in constitutional responsibilities to consult and engage with Indigenous peoples (Canadian Charter, 1982; Department of Justice (DOJ), 2012) and in part the inadequacy of scientific management institutions to reach holistic conservation goals (Ayers et al., 2012; Stevenson, 1996). Many authors have explored the implications for Indigenous knowledge within this state-centric context and problematized the category of 'TEK' (Nadasdy, 1999; Cruikshank, 1998). The conventional explanation of the difficulty in 'integrating' TEK into scientific management regimes is the contrasting forms of knowledge (qualitative as opposed to quantitative, holistic as opposed to reductionist for example) (Blaser, 2009; Nadasdy, 1999). This explanation creates a false dichotomy between Indigenous and Western knowledge, ignoring the politics of knowledge and the asymmetrical power relations underlying the arenas in which TEK and scientific knowledge are to be integrated (Nasr and Scott, 2011; Blaser, 2007; Shaw et al., 2006; Nadasdy, 1999; Cruikshank, 1998). 'TEK' is a category constructed by Western managers which has built in assumptions and restrictions of what can be considered 'traditional' or 'ecologic' or 'knowledge' which are contested at the fundamental level (Nadasdy, 1999). In the context of national and international level resource management and planning, TEK is framed as supplementary data to be incorporated and used by western resource managers to achieve their own goals (Nadasdy, 1999). This framing actively compartmentalizes and distills the knowledge shared by Indigenous people and communities, emphasizing only information which is numerical or mappable, stripping away relational and holistic qualities (Willow, 2013; Nasr and Scott, 2011; Nadasdy, 1999; Cruikshank, 1998; Stevenson, 1996). The types of acceptable information and

knowledge and the formats they can be shared in are shaped by perceptions of what TEK is (or isn't) (Nasr and Scott, 2011; Stevenson, 1996).

The field of remote sensing is not removed from these ongoing dialogues as it has long been used for a vast suite of environmental mapping programs and has also recently been applied to the mapping of concerns of Indigenous communities. (Dennis et al., 2005; Lauer & Aswani, 2008; Nanidoo & Hill, 2006; Maynard et al., 2010). In their extensive review of "community based monitoring" programs and projects Thompson et al. (2020) found that while many projects use language about collaborative and participatory methods the collaboration is often limited to data collection with 76% of the reviewed projects not including partnered communities in project initiation or in making management decisions. A similar pattern is reflected in the remote sensing literature (Thompson et al., 2020). Projects that are initiated by and generate maps and data that advance community concerns and governance systems (eg. Lauer & Aswani, 2008) are doing different work than those that silo collaboration to data collection or simply extract community knowledge as a window to the past (Cruikshank, 1998). Though the tools of remote sensing are powerful and no doubt can be applied to ameliorate environmental and social concerns of communities these projects run the risk of being extractive or tokenizing, taking only that information which is deemed by the practitioners to be valuable with a more loose conceptualization of the context of the information. In the literature that Thompson et al. (2020) reviewed Indigenous consultants are generally not seen as active agents in knowledge creation. The partnered communities are most likely not included in the shaping and framing of questions nor in the application of the data.

Analysis that misses these important steps of collaboration might have blind spots to the socio-political status of partnered communities and their future aspirations as well as to the important cultural drivers of the work. If the only community knowledge of importance is the past and Indigenous communities are cast as historical and static, they would be taken as conceptually disconnected from political and contemporary discourses about sovereignty, management and futures of Indigenous communities (Weiss, 2019). In my short experience working on this project with Hul'qumi'num people, the knowledge that was "for the kids" (A. Sylvester, personal communication 2019) was very important, connecting ancestral places of importance with contemporary work to protect these places into the future. The "limited" collaboration projects may also miss the key drivers to why such species or environments are of concern in the first place. The intersections between land and language and culture is what animates *lhuq'us* and is the fundamental context for Hul'qumi'num efforts to conserve and restore *lhuq'us* beaches and practices. There is a certain truth to what Smith (2013) says about the insulating power of academic departments and disciplines to the critiques of colonialism. Researchers doing work with and for communities whether they are trained in geomatics, ecology, geography, or anthropology should not disregard the colonial critiques made by Indigenous scholars as not applicable to their own distinct field and take their own role as collaborators seriously (Smith, 2013).

Though the projects might be branded as such, the efforts of western resource managers to include TEK in their work has more often not given a voice and stage to Indigenous knowledge and instead extended the social and conceptual networks of western scientific resource management into communities, collecting and concentrating

knowledge within institutions (Nadasdy, 1999). In this way knowledge is common property to be accessed and controlled (Boxberger, 2007). The conventional framing of Indigenous knowledge as data to be wielded by resource managers does not make room for Indigenous decision making or control (Nadasdy, 1999). This power of narrative making that the tools and methods of cartography (and remote sensing) offer, however, can be inverted and wielded by communities to secure or uphold land rights and to convey powerfully their own sovereignty, concerns, and visions for the future (Hunt & Stevenson, 2017; Bryan & Wood, 2015; Willow, 2013; Sletto, 2009). There are certainly dangers, tensions, ironies, and pitfalls to this approach. The power of maps derives from their rhetoric weight and ability to make simple, static, and abstract the complex, fluid, experiential spatial interactions between individuals and their landscape (Sletto, 2009). For example, see the *lhuq'us* literature map in the previous chapter generalizes and perhaps obfuscates the complex relationships Hul'qumi'num people have with *lhuq'us* harvesting places, which are contingent on familial relationship, seasonality, and teachings are concealed made simple and static as grey polygons (Figure 2). Out of context, this may reinforce commonly held western understandings of boundaries, ownership, and relationships to land (Sletto, 2009). Despite the tensions and pitfalls inherent to the process, counter-maps can still challenge hegemonic understandings of power relations (Sletto, 2009), for example recontextualizing privately held land and parks as important places for the food systems and rights-based economies of local communities. Counter-mapping initiatives take control of the information that is being generated acted to promote self-determination of environmental decision making in Anishinaabe territory (Willow, 2013) generated information that is in the control of and is

trusted by those communities providing one way for communities to make decisions about environmental management (Baker, 2017). The resurgence work the Hul'q'umi'num' Lands and Resources Society is doing (and the work being done in the communities at large) is ongoing and UAV mapping is one tool that can be used by practitioners of traditional harvesting and management to address their own concerns and needs that arise from their way of seeing and being in the world. Caring for beaches in the Hul'qumi'num community's contemporary context is ever complicated by colonial structures and policies, neoliberal forces, and a changing environment. UAV mapping, though complicated in its own right, is a powerful tool that has the potential to protect species and places culturally important to Hul'qumi'num people into the future.

Opportunities and Recommendations for Future Work

The discussion about *lhuq'us* harvesting and this proposed monitoring tool is situated in a broader discussion about Hul'qumi'num food security, food sovereignty, and rights. Hul'qumi'num people are people largely displaced and dispossessed from their territories and the economies that are connected to the land (Fediuk & Thom, 2003). The constellation of colonial structures and processes including the establishment of Indian Reserve system, the potlatch ban, the large scale dispossession of land, the imposition of fisheries regulations, residential schools, and many more have largely marginalized Indigenous economic and governance systems and contributed to the poverty that is widespread in First Nations communities across Canada (Thom, 2014; Egan, 2012; Harris & Press, 2011; Lutz, 1992; Fisher, 1971). These historical and ongoing systems contribute to the high unemployment and dramatically low household income found in

Hul'qumi'num communities (Fediuk & Thom, 2003). Alienation of Hul'qumi'num people from beach foods and economies in turn impacts the food security and health of communities (Holst et al., 2011; Donatuto et al., 2011; Evans et al., 2005; Mos et al., 2004).

The interest in *lhuq'us* part of a larger Hul'qumi'num body of work by leadership toward improving lives of community members including recognition of aboriginal rights and title (Fediuk & Thom, 2003). In Hul'qumi'num territories Aboriginal title and rights are based on Hul'qumi'num law (Evans et al., 2005). In Canada Aboriginal rights were recognized and affirmed by section 35 of the Canadian constitution in 1982 (Canadian Charter, 1982). Though the definition is contested, these rights broadly include rights to land, subsistence activities, cultural practices, and self determination (Slattery, 2007). The United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) was adopted by Canada in 2016 and BC in 2019 and further affirms and defines the rights to self determination for all peoples (United Nations (UN), 2008). Articles 11, 20, 24, 25 specifically addresses food security, protecting the rights to practise culture, rights to subsistence practices and traditional/economic activities, rights to maintain relationships to land and resources, and rights to highest attainable physical and mental health (Jonasson et al., 2019). The contemporary barriers to access and concerns for status of *lhuq'us* and *lhuq'us* beaches can be considered a rights problem. *Lhuq'us* and *lhuq'us* harvesting is entwined with cultural values, is a part of Hul'qumi'num peoples connection to land, Hul'q'umi'num' language, Hul'qumi'num economies, and is a safe and nutritious food. The work that the Hul'q'umi'num' Lands and Resources Society are doing brings together language and land, youth and elders for the health and wealth of communities.

The Hul'q'umi'num' Lands and Resources Society desire for baseline information is informed by this context.

There is concern in Indigenous communities in the Salish Sea and across the Pacific Northwest about the changing status of *porphyra/pyropia spp.* and the use of UAV monitoring can be a tool to track these changes and demand of regulatory agencies that these changes be taken seriously. The proposed and ongoing industrial marine shipping development in the Salish Sea compounds these concerns and sharpen the desire for baseline information. In a 25 year retrospective report about the Exxon Valdez disaster in southeast Alaska the American National Oceanic and Atmospheric Administration (Shigenaka, 2014) stated the long term restoration and monitoring programs " showed the great value of one of the rarest of all oil spill commodities [is] pre-spill data" (Shigenaka, 2014). Ongoing monitoring of Hul'qumi'num beaches have the potential to be profoundly impactful and valuable in the case of a marine shipping disaster. The impacts of oil spill compounding on concerns about climate change, urban and industrial development all violate the rights of Hul'qumi'num people including those recognized in the Canadian constitution and those affirmed in the UNDRIP. Though Hul'qumi'num peoples have largely been displaced from their land and economies UAV technology may be one that can be used to continue to assert and defend their rights and practice the care and responsibility they have to their beaches. As we have seen in the above analysis the tools and technologies of mapping have inherent tensions but they also have a great potential to be used to protect human rights, monitor and mitigate impacts of climate change, and be a part of the work of *Hwule'lum'ut thu tsetsuw'* (Caring for our (Hul'qumi'num) beaches).

This project demonstrates that UAV technology could be applied to monitoring *lhuq'us* and where the key benefits and challenges are for this work to be scaled up in the future. Not all the recommendations are technical, I think the lessons about how to structure collaborative work and the cultural meaning and importance of *lhuq'us* and the places *lhuq'us* is harvested are critically important. There is a strong desire to leverage cartographic tools and technologies for the purposes of Indigenous communities in many contexts but the potential for extractive and tokenizing work should be recognized and navigated. This means centering relationship between project partners (e.g. Baker, 2017) as well as the objectives, values, and leadership of community in the project itself (Thompson et al., 2020). All projects that seek to hold side by side scientific and Indigenous values systems will face the tensions and ironies discussed above but those that recognize these tensions may navigate them in favour of community empowerment more often (Thompson et al., 2020). Future research on *lhuq'us* in Hul'qumi'num territories must remember the foundational goals of maintaining traditional practices related to lands and resources in the modern setting, engaging youth in these practices; and ensuring the Hul'q'umi'num' language is core to those practices and mentorships (K. Johnnie, personal communication 2019). Monitoring the health of *lhuq'us* is an important part of this but not without context in Hul'qumi'num peoples' visions for the future.

The results of the classification show that, while imperfect, UAV technology can adequately detect and classify *lhuq'us* and could be used to leverage a larger scale monitoring program across the Coast Salish cultural landscape. Carrying on with UAV monitoring would build a set of baseline data of extent, variation, and patchiness of intertidal algae beds at a scale that would not be captured by traditional satellite imagery

like LANDSAT and more accessible than high resolution satellite imagery. To adequately map *lhuq'us* multiple flights could be flown monthly over beaches identified by the community of particular concern or those identified in the literature (Figure 2) throughout the spring to capture the number one *lhuq'us* bloom. The ~2cm spatial resolution was adequate for the classification done in these initial surveys. The GEE code editor console proved to be a powerful tool for classification and has a very active online support community. The publicly available GEE web console could be used to analyze pre-segmented imagery or explore raw imagery. Maps can be applied to holistic considerations of fishery health, restoration programs, and monitoring places where culturally important species grow to protect the heritage and cultural value derived from these places. Based on the results of the initial UAV surveys it is clear that multiple surveys of beaches would be required to fully capture the blooms of *lhuq'us* and to fully understand the level of variation of extent. At ȾEL,IŁĆ there was considerable classification confusion between rock/ *ulva* spp. class and rock/*pyropia spp.* class. Because *lhuq'us* appear both in distinct patches and mixed with other algae (Turner, 2003) additional spectral information in the infrared bands might be necessary to differentiate these classes with high overlap. *Porphyra/ pyropia spp.* is known to have distinctly high reflectance in the infrared as compared to *ulva spp.* and *fucus spp.* (species commonly found with *lhuq'us* at the two sites) (Kromkamp et al., 2006).

The results of this chapter provide leverage for future monitoring and future considerations for monitoring of both toxicology and extent and variability of *lhuq'us*. Recurring sampling over time will give a picture of the status of *lhuq'us* and harvesting beaches, the natural variations within intertidal algae communities and, and the effects

human activities have on *lhuq'us*. Federal, provincial, and municipal managers shared interest in monitoring and managing sensitive intertidal algae (MOELP, 1999, District of Saanich, 2020, H-GINPR, 2016) and they are potential partners for future work on *lhuq'us* monitoring.

Conclusions

A through line of this work is the Hul'q'umi'num' phrase *Hwule'lum'ut thu tsetsuw'* (Caring for our beaches). The work done in this chapter demonstrates how emergent UAV technologies might be applied to the ongoing work being done by Hul'qumi'num practitioners to care for beaches that have deep cultural meaning. Though the intersecting issues of poverty and vastly restricted access to beaches and beach foods are ever pressing in Hul'qumi'num communities today, the desire and responsibility people have to care for beaches remains. As the work of resistance and resurgence against colonial and neoliberal forces unfolds, UAV technologies might prove a powerful tool for continuing care and asserting and defending aboriginal rights. While federal, provincial, and municipal regulatory agencies share needs for baseline information about intertidal macroalgae communities they also have obligations recognize and respect the aboriginal rights of people living in the Salish Sea and to avoid infringement of those right to the greatest possible extent. UAV mapping may be a crucial component of demands made by communities to protect the rights of people who wish to harvest *lhuq'us* and other beach foods and maintain relationships with the important places where these foods are found.

Mapping the extent, and over time, the variation of *lhuq'us* on beaches will give a picture of the status of *lhuq'us* as industrial and urban development in the Salish Sea

continues. The results of these preliminary surveys with overall accuracies of 85.5% at ȾEL,IŁĆ and 88.9% at *St'utl'qulus* and the user accuracies of the specific *porphyra/pyropia spp.* classes was 75.3% at ȾEL,IŁĆ and 93.8% at *St'utl'qulus* suggest that UAV technologies paired with GEE object based methodologies can effectively detect *lhuq'us* with relatively simple methodology. The imagery and classification will be valuable in creating baseline information and monitoring programs in the future and will be stored in the University of Victoria's Scholars Portal Dataverse to be accessed by those completing this work in the future. Though there are tensions and contradictions inherent in map making emergent UAV technologies paired with the deep and experiential knowledge of practitioners of Hul'qumi'num food systems may become part of the broader strategy Hul'qumi'num communities use to care for their beaches.

Conclusions

The first Hul'qumi'num campout I attended was in February 2018 during the winter low ides. I spent nights turning over the beach under the full moon at *Kw'ulhutsun* and having conversations with the Parks Canada staff, other volunteers, and Hul'qumi'num practitioners learning about shellfish ecology and beach geomorphology. A throughline of these conversations was, as I wrote in my field notes one night, that caring for the beaches isn't just a mental act, caring for the beach requires our bodies, our interaction with the land and collectively with other people to turn over the sediment. This lesson about embodiment, has extended from a reflection about the importance of human interaction in stewarding marine ecosystems to a reflection about how I conceptualize and place this project. The knowledge shared with me over the course of this project is deeply personal, referring to family memories and histories, charged with intention, to engage community youth in the revitalization of community practice, and is political in nature, pushing against colonial and neoliberal structures. The conversations about *lhuq'us* that I was a part of evoked broader concerns and aspirations about governance, community values, and concerns. Hul'q'umi'num' language was interwoven into all of these conversations. Hul'qumi'num concepts like *pulxa'us* (a term related to Hul'qumi'num governance systems) and *pa'nuxw* (a term related to Hul'qumi'num families and their connection to particular places) all informed discussions about *lhuq'us*. It is my contention that through connecting cultural values and practices that the voices brought together in this work clearly demonstrate with systematic observation and analyses using emergent UAV technologies, taking seriously concerns about culturally

important species like *lhuq'us* can guide and re-prioritize environmental decision making done by federal, provincial, and municipal management agencies.

Just like caring for beaches, being a collaborator requires my presence and is a practice in itself. As a collaborator on this project I have responsibility to respect and take seriously the intentions and concerns that were shared with me, they cannot be separated from the ethno-biological knowledge about *lhuq'us*. The maps and other materials created over the course of this project are grounded in the context given through the people whose knowledge and concern and care they imperfectly represent. Instead of an imagined objective view from nowhere (Haraway, 1991), I have tried to follow the intentions of the collaborators and partners of the project. These intentions were to create maps and ethnographic materials that will be useful and support their broader work in advocating for and enacting their self governance and expressing their concerns about the status of culturally important species that can continue to be built upon after the end of this project. This framework acknowledges those contradictions, tension, and difficulties embedded in research and mapping that the authoritative and positivist voices might gloss over or erase.

The pilot study to use emergent UAV technologies to create useful maps and materials to develop baseline information about *lhuq'us* interact explicitly with community concerns for impacts on access, safety, and the protection of aboriginal rights to cultural practices and food security. The goal of the quantitative methodology is to test a method of creating benchmark data that future changes can be measured against, is useful for Hul'qumi'num managers and traditional food practitioners, and is useful for supporting ongoing revitalization and restoration efforts. The use of UAV technologies,

freely accessible and powerful cloud computing platforms, and open source GIS packages can be harnessed to fulfill the stated need for benchmark information about *lhuq'us*. The overall accuracies of the UAV imagery classifications was 85.5% at ȾEL,IŁĆ and 88.9% at *St'utl'qulus* and the user accuracies of the specific *porphyra/pyropia spp.* classes was 75.3% at ȾEL,IŁĆ and 93.8% at *St'utl'qulus* suggest that UAV technologies paired with GEE OBIA based methodologies can effectively detect *lhuq'us*. With the development of shipping projects in the Salish Sea impending, scaling these techniques into a larger monitoring program can be a way for proponents of these projects to fulfill protections of culturally important species, places, and the aboriginal rights that they are connected to. The construction of the projects and the related infrastructure put into motion the concerns for rights asserted by communities and highlight the responsibility of the Canadian and provincial state to honor and protect these rights. The imperative to build baseline data about culturally important species will also inform the drivers of the changes Elders and traditional food practitioners have already observed and inform Hul'qumi'num decision makers in addressing and ameliorating these changes. UAV surveys are a cost effective way to cover a relatively large area and paired with GEE and its dual processing capabilities make the methodologies described here a promising tool to be used by Indigenous governments. The imagery and data collected in chapter two will be permanently store at the th data repository in Uvic library to continue to be made accessible to researcher in the future wishing to harness them to understand how beaches are in the Salish Sea are changing.

Opportunities to carry on this work include continuing to develop a baseline of number 1 and number 2 *lhuq'us* blooms, incorporating other sources of data into the

baseline such as previous beach surveys and citizen science data, and testing the effectiveness of both more complex methodologies such as adding infrared data or using more accessible analysis platform such as GEE explorer. This work needs to continue to emphasize language, youth engagement, and the initiative of community leadership and voices. During the last summer Hul'q'umi'num' immersion camp in the summer of 2019 we returned to *Kw'ulhutsun.* The fog and rain of the winter were replaced with August clear skies. In the afternoon we went swimming in the bay at the beach we had spent long winter nights tending. One of the youth asked me to point out the "seaweed Auggie said was special" (fieldnotes, 2019). Together we found (and ate) some number two *lhuq'us* growing along the beach (some of which were included in the toxicology samples described in chapter 2). I reflected on the ways places take on meaning through interaction and saw how *lhuq'us*, central to Auggie Sylvester's histories of *Kw'ulhutsun* continue to be a conduit of interaction and place building today.

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Appendix

Appendix A: Reference list for figure 2.

location	reference	location	reference
Cape Keppel	(AXYS Environmental Consulting (AXYS), 2002)	Gabriola Island	(NEB, 2018)
Hammond Bay	(Bouchard, 1992)	Dyer Rocks	(Simonsen et al., 1995)
Shingle Point	(Candler et al., 2014)	Coles Bay	(Simonsen et al., 1995)
Sleil-Waututh	(Cass, 2018)	Senanus Island	(Simonsen et al., 1995)
Montague Harbour	(Evans et al., 2005)	Gabriola Island to Mayne Island	(Tera Environmental Consulting (TEC), 2014)
Portland Island	(Evans et al., 2015a)	Richmond/Vancouver	(TEC, 2014)
Moresby Island	(Evans et al., 2015a)	Boatswain bank	(TEC, 2014)
South Pender Island	(Evans et al., 2015a)	Steveston	(TEC, 2014)
Saturna Island	(Evans et al., 2015a)	Fraser River	(TEC, 2014)
Rubly Island	(Evans et al., 2015a)	Valdes Island	(TEC, 2014)
Gooch Island	(Evans et al., 2015a)	Flat Top Islands	(TEC, 2014)
Reay Island	(Evans et al., 2015a)	Breakwater Island	(TEC, 2014)
Brethour Island	(Evans et al., 2015a)	Gabriola Passage	(TEC, 2014)
Sheep Island	(Evans et al., 2015a)	Gossip Island	(TEC, 2014)
Domville Island	(Evans et al., 2015a)	Porlier Pass	(TEC, 2014)
Forrest Island	(Evans et al., 2015a)	False Narrows	(TEC, 2014)
Little Group Islands	(Evans et al., 2015a)	Ladysmith Harbour	(TEC, 2014)
Coal Island	(Evans et al., 2015a)	East Point	(Williams, 1979)
D'arcy Island	(Evans et al., 2015a)	Island View Beach	(Williams, 1979)
Sannichton Bay	(Evans et al., 2015a)	Cowichan Head	(Williams, 1979)
Northern tip of Saanich Peninsula	(Evans et al., 2015a)	Beach Below Cowichan Head	(Williams, 1979)
Stuart Island	(Evans et al., 2015a)	Cordova Channel Beach	(Williams, 1979)
10 Mile Point	(Evans et al., 2015a)	Russell Island	(Wilson et al., 2009)
James Island	(Evans et al, 2015a; Evans et al., 2015b)	Saltspring Island	(Wilson et al., 2009)

Sidney Island	(Evans et al., 2015a; Evans et al., 2015b)	Reid Island	(Wilson et al., 2009)
Mayne Island	(Evans et al., 2015b)	Fulford Harbour	(Wilson et al., 2009)
Pender Island	(Evans et al., 2015b)	Retreat Island	(Wilson et al., 2009)
Discovery Islands	(Evans et al., 2015b)	Lamalchi Bay	(Wilson et al., 2009)
Saanich Inlet	(Evans et al., 2015b)	Witty's Lagoon	(Williams, 1979)

Appendix B: Biometal analysis results

Sample ID		Cordova Aug 30	Winter Cove Aug 25	Russell Island July 13	Island View Sept 9
Parameter	DL (ppm)	(ppm)	(ppm)	(ppm)	(ppm)
7Li	0.003	0.564	0.655	0.842	0.737
23Na	1.37	34,200	29,977	27,715	28,279
24Mg	0.037	7,266	9,520	9,210	9,161
27Al	0.011	10.4	4.19	23.8	17.2
31P	15.1	5,435	5,958	3,294	4,336
39K	2.14	39,776	31,301	26,092	40,452
44Ca	5.99	1,876	2,072	3,044	1,899
51V	0.018	1.62	2.16	1.42	1.77
52Cr	0.035	1.14	1.13	1.14	1.13
55Mn	0.004	18.6	21.7	17.0	17.5
57Fe	0.290	292	91.7	123	135
59Co	0.002	0.253	0.165	0.308	1.30
60Ni	0.017	2.35	1.03	4.65	18.7
63Cu	0.004	4.11	4.05	14.0	10.2
66Zn	0.030	10.4	9.2	19.5	19.0
75As	1.13	30.6	39.3	30.2	21.8
77Se	0.048	0.506	0.407	0.414	0.548
88Sr	0.0002	23.3	26.7	37.3	23.6
95Mo	0.002	4.60	3.00	3.33	2.35
111Cd	0.001	3.23	2.02	1.73	2.74
118Sn	0.009	0.013	0.014	0.087	0.070
202Hg	0.005	0.020	0.015	0.030	0.031
208Pb	0.0015	0.178	0.013	0.723	0.082
238U	0.0001	0.008	0.017	0.016	0.037

Notes:

ppm = parts per million

DL = detection limit

Appendix C: *T*EL,IŁĆ Error Matrix

	Classified Data							
		Sand/rock (A)	Ulva spp. (A)	Shadow	Pyropia spp (A)/ rock (C)	Wetsand (A)	Ulva spp (A)/ rock (C)	total
Reference Data	Sand/rock (A)	11632	91	4	175	974	1	12877
	Ulva spp. (A)	12	2986	327	363	108	26	3822
	Shadow	43	190	1822	35	97	0	2187
	Pyropia spp (A)/ rock	74	137	28	3100	0	214	3553
	Wetsand (A)	0	158	0	0	2141	0	2299
	Ulva spp (A)/ rock (C)	0	224	0	442	151	1253	2070
	total	11761	3786	2181	4115	3471	1494	26808

Appendix D: *St'utl'qulus* error Matrix

	Classified data						
		Ulva spp. (A)	Rock (A)	Fucus spp. (A)	Rock- fucus spp. (A)/ pyropia spp. (F)	shadow	total
Reference data	Ulva spp. (A)	1035	0	2	0	1	1038
	Rock (A)	106	4740	0	123	0	4969
	Fucus spp. (A)	222	0	2251	0	88	2561
	Rock- fucus spp. (A)/ pyropia spp. (F)	76	563	148	1868	0	2655
	shadow	11	0	16	0	960	987
	total	1450	5303	2417	1991	1049	12210

Appendix E: Mean pixel values of classes at *St'utl'qulus*

Name	Band 1 mean	Band 1 stdDev	Band 2 mean	Band 2 stdDev	Band 3 mean	Band 3 stdDev
Ulva spp. (A)	223.17	34.25	226.96	35.33	219.30	36.14
Rock (A)	136.62	46.86	135.24	49.22	132.26	46.95
Fucus spp. (A)	157.62	48.04	156.46	51.68	138.24	47.42
Rock- fucus spp. (A)/ pyropia spp. (F)	198.73	47.87	200.75	50.53	192.44	48.95
shadow	112.34	56.10	109.90	57.26	108.44	53.70

Appendix F: Mean pixel values of classes at ȾEL,IŁĆ

Name	Band 1 mean	Band 1 stdDev	Band 2 mean	Band 2 stdDev	Band 3 mean	Band 3 stdDev
Sand/rock (A)	171.97	44.31	168.40	44.18	156.86	45.09
Ulva spp. (A)	107.30	38.58	116.86	37.18	91.74	35.21
Pyropia spp (A)/ rock	122.64	51.96	122.49	50.29	104.15	48.73
shadow	106.21	54.80	107.47	52.33	93.06	50.09
Wetsand (A)	125.01	37.59	129.61	35.39	105.59	35.57
Ulva spp (A)/ rock (C)	129.61	53.12	129.39	51.46	109.68	50.36