Tending the meadows of the sea: Traditional Kwakwaka'wakw harvesting of *Ts'áts'ayem* (*Zostera marina* L.; Zosteraceae)

By

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B.Sc., Yale University, 2002

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ABSTRACT

Eelgrass, *Zostera marina* L. (Zosteraceae), is a flowering marine plant in coastal regions in the Northern hemisphere. Apart from its significance as habitat for a diversity of marine organisms, it has been a direct resource in European and American economies, and once was a food source for people along the Pacific Coast of North America. This interdisciplinary study documented protocols and specifics of the Kwakwaka'wakw *ts'áts'ayem* (eelgrass) harvesting tradition in British Columbia, and how their methods of harvesting affected the remaining plants' growth.

Through interviewing 18 traditional eelgrass harvesters and participating in six harvesting sampling events, I documented the detailed protocols of the Kwakwaka'wakw eelgrass harvesting tradition. Based on the protocols of traditional *ts'áts'ayem* harvesting, I developed harvesting removal experiments in a dense *Z. marina* populations on Quadra Island (2005) and at Tsawwassen (2006) to examine the effects that traditional harvesting of eelgrass would have had on a shoot production and rhizome internode volume, within a growing season. At the Quadra site, a June treatment of between approximately 15 and 56% shoot removal corresponded with shoot regeneration above original numbers. An approximate 60% removal corresponded with the highest new shoot production after treatment, indicating the strong capacity of eelgrass meadows to promote new shoots after removal disturbance. Based on fieldwork with traditional knowledge holders, I estimate that traditionally harvesting would have been between 10-30% removal within areas the size of the experimental plots. Shoot regeneration, net shoot production and rhizome production results at the Quadra site supported the theory that a light amount of harvesting removal such that was conducted by Kwakwaka'wakw harvesters would have been within a level for full regeneration, and possibly even enhanced shoot population and rhizome production (measured by internode volume). Tsawwassen experiment treatment was applied too late in the season to show an effect of harvest, but the design provided efficient methodology for future experiments.

Ecology literature substantiated many of the traditional eelgrass protocols documented in this study, strongly supporting the theory that eelgrass harvesting was a sustainable practice. Scientific literature about pollution also corroborated and explained the observations of elders on the state of today's eelgrass: few locations yielded *ts'áts'ayem* fit to eat, as specimens were small, had heavy epiphytic growth and dark rhizomes that Kwakwaka'wakw consultants had not seen in their youth. The combination of traditional ecological knowledge and scientific inquiry holds much potential for providing a better understanding of eelgrass ecology and dynamics, and for defining concepts of sustainability and conservation of this important resource.

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Preface

> *How had it been in the old days when the magic, and supernatural spirits, and the cannibal man who lived at the north end of the world had dominated life here in this village? How had it been when the hamatsa had come in the night through the great trees, crying his soft and terrible call? He would never know. No man would ever know. But Mark had seen the light of the old, old ways reflected on the faces like the glow from a dying campfire, and he knew that it was the hamatsa who had been freed at last from his holy madness, and was at peace in the deep woods.*
> (Craven 1973, 118)

An interdisciplinary study

To begin to get a sense of the geography of the Kwakwaka'wakw territory, one has to view it from many different vantage points: from the tip of Cape Scott on Vancouver Island looking North towards mountains and inlets of the mainland; from a floatplane flying over the Broughton Archipelago and up Kingcome Inlet and the Dzawada'nuxw; from a 'Namgis seine boat heading to the relatively new village of Alert Bay; from the Narrows of Quatsino Sound and the Koskimouwx people looking out at the Pacific Ocean; from the great cedar wood benches of the Likwadawx bighouse in Campbell River; from the beach of Fort Rupert; from Cape Mudge, imagining the boat of Captain Vancouver on his first encounter with the Kwak'wala speaking peoples.

My particular focal point in this cultural geography is the flowering marine plant, *Zostera marina* L. (Zosteraceae), and how the Kwakwaka'wakw traditionally harvested it for food. Over the last two years, from 2005 to 2007, I have used the right eye of Science, and the left eye of Traditional Ecological Knowledge to try to bring a picture into focus.

For traditional West coast people, a statement about my own perspective from which I present this information is paramount for the legitimacy of the information and the interpretation of my words. I spent most of my life on the West Coast of British Columbia in a family of physicists, geneticists and professors of language. I took my B.Sc. in Ecology and Evolutionary Biology at Yale University in New Haven, Connecticut. My parallel education growing up in BC, in Vancouver, on Quadra Island and visiting Haida Gwaii, was food gathering and visiting villages and territories of First

Nations friends. When I was 15 I was adopted into the Wolf-Raven clan of T'anuu, in Haida Gwaii, and given the name Kihlgula gaaya. When I was 17, I received the name Maa Nulh a Tuk from Simon Lucas of the Hesquiat. After highschool I spent a month with Diane and Larry Brown in Haida Gwaii, learning how to gather food on the reefs at low tide. During this ethnoecology degree, Chief Adam Dick adopted me and gave me the name Mah Pena Tous. From First Nations people I have learned that good food and a healthy self-identity depend on healthy ecosystems.

I also grew up in a family very concerned about the human impacts on our ecosystems and atmosphere. Though my family strongly believes in the scientific method, I was shown that unchecked science has had the power to do serious damage. It made sense to me that contemporary society needs to look at our ecosystems in a different way, a way that uses the power of science to connect us back to our very human responsibilities. It is from this perspective that I convey the information I have acquired about the Kwakwaka'wakw management of an ecologically significant resource.

The timeframe for my study is short. In learning about eelgrass it was not until my second field season that I came to appreciate the significance of this plant; the first season I'd thought that it was so small, so limited in harvesting timeframe (a window of one month), so difficult to get and to peel, that I did not realize its true importance. Only in the second spring, after gathering eelgrass and several other root foods with Nuu-chah-nulth friends, did I realize that *all* foods were like eelgrass—they took work to get, and the timeframe to get them was limited. Only after two weeks eating a more traditional diet (no sugar or flour) did I realize how much sugar there is in the eelgrass rhizome, and that at the end of winter, after a season of eating dried foods, the green, sweet shoots of eelgrass would be extremely desirable. Only after two and a half years of thinking about this and after actively gathering and processing other plants have I begun to realize the importance of the eelgrass and other individual species that were harvested, and how much work, energy and enjoyment was part of harvesting daily food. It was only after a second summer season of living in Kwakwaka'wakw territory that the picture of the West coast is coming into focus.

My study has been an education not only in how to conduct scientific research, but in working with an elder in the traditional process of listening, watching and doing. This process has vastly illuminated my understanding, and gave deeper purpose to my academic pursuits. My primary consultant, chief mentor, teacher and friend in this project has been Kwakxistala, Clan Chief Adam Dick of the Dzawada'nuxw band of Kingcome Inlet. Adam was chosen as a five-year-old to be trained as a Potlatch Speaker. He was kept from residential school to receive instead a rigorous education in the bighouse in Kingcome village by the elders of his time. Today, an elder himself, he is a direct connection to those teachings and elders from the old Kwakwaka'wakw world, when people could still communicate with ravens, and when the Hamatsa came in through the great trees. In his own 79 years of life fishing and living in the Kwakwaka'wakw territory he has witnessed the massive social, political, economic and ecosystem transformations of the 20th century. Today he lives in a world that knows little of the original Kwakwaka'wakw worldview, and he faces the real prospect of his knowledge not surviving into the next generation. He tells me often, "my profession's finished." The last one trained to be a Potlatch Speaker, his vast education remains unexplored. Adam's knowledge of eelgrass harvesting practices is a window into his knowledge, experience and training in the traditional Kwakwaka'wakw world on the West Coast.

While this is a small study of relatively short duration, it has added a perspective of current culture and ecosystem change to my understanding of the coast where I live. The write-up of this study as a Master's thesis is an attempt to portray and synthesize what I have learned over the last three years.

Acknowledgments

A person's accomplishment is a testament to their community.

It has been a privilege as well and an education to work with Kwakxistala, Chief Adam Dick; I'd like to thank him for believing in me. I'd like to thank MayaniŁ, Daisy Sewid-Smith, whose patience, expertise and generosity has been essential to this thesis. I'd like to thank Ogwilogwa, Kim Recalma-Clutesi, who has also been a generous mentor, but also a wonderful auntie/role model/co-conspirer in this study. I'd like to thank Tom Nelson, for his help, enthusiasm and expertise. I'd like to thank and remember Auntie Ethel Alfred, so generous and open even in her hospital bed, where I asked her about *ts'áts'ayem*; I am glad that she was a part of this paper. I also want to thank and remember Charlie Dawson, a wonderful elder I am so glad to have met. I want to extend a deep thanks to all of my consultants for this study - my teachers - who taught me much more than just about harvesting *ts'áts'ayem.*

I want to thank and acknowledge my elders in academia. To Sandy Wyllie-Echeverria, for his contagious enthusiasm and curiosity, to John Volpe for keeping it real, to Eric Higgs for helping me with valuable advice along the way, and to Gerry Allen for her deep love of plants. I'd like to thank my mentor Nancy Turner, for the support throughout this process, but also for her vision, dedication and incredible moral compass through the human maze of challenges of declining cultural knowledge.

My research was conducted in other people's territory. I'd like to thank Marna Disbrow for letting me mess around in her eelgrass meadow for two summers! I'd like to acknowledge Don and Louisa Assu and the Cape Mudge Band for their support on Quadra, and to the Guskimukw and the'Namgis for letting me harvest eelgrass in their territory. I also appreciate the Tsawwassen First Nation, who gave me permission to set my two transects on the eelgrass meadow at Roberts' Bank. To Norman and Donna Stauffer on the Western Moon, and to Stu Hardy for taking us out for an eelgrass expedition in Comox, many thanks. Thanks also to Joy Inglis for advice and inspiration.

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I'd like to acknowledge the institutions: the University of Victoria and the School of Environmental Studies, which have been my home for the last few years. The Department of Fisheries and Oceans has been very helpful with their donations of boats and captains that took me around Quatsino Sound and around Cormorant Island. Linda Hogarth and the Campbell River Museum and Archives were helpful and inspiring.

This work could not have been done without a lot of volunteers. Thanks goes to the Wyllie-Echeverria family who came to Quadra for my first eelgrass harvesting expedition, especially to Rebecca Wyllie-Echeverria for the eelgrass filming, and to Victoria for going for swimming for it! Thank you to my wonderful divers: to Sarah Harper for banging in rebar while I was still upside down, and to Sarika Cullis-Suzuki, my sister, for Mo'orea science inspiration and for zincface dedication. Thank you to Sam Albers, my underwater partner in crime, to Margot Hessing-Lewis, my elder eelgrass sister, to my Mum, Tara Cullis, for measuring rhizomes on the couch, and to my Dad, David Suzuki, for watching my bubbles over transects. Thanks to Ehren Salazar for getting into it in Tsawwassen, and to Adam Carver for latenight map-making. Thanks to Steph Keating for moral support and graphing tutoring! Thank you David Strongman, for the serious eelgrass photoshoots and for enjoying the expeditions, the trials, and the journey as much as I did.

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Thanks to all of you who have supported me, listened to me, and thought about *ts'áts'ayem* with me!

Chapter 1 Introduction

In this project I worked primarily with elders of the Kwakwaka'wakw nation on the north end of Vancouver Island and the adjacent mainland of British Columbia to study the ethnoecology of *ts'áts'ayem*: eelgrass. Eelgrass (*Zostera marina* L.; Zosteraceae), a clonally growing angiosperm living in intertidal and subtidal sandy areas, was commonly harvested by Northwest Coast Kwakwaka'wakw groups in the springtime for food, until approximately thirty years ago.

1.1 Thesis objectives

The overall purposes of this study were:

-to determine the importance of eelgrass harvesting in Kwakwaka'wakw culture;

-to determine the effect that traditional harvesting would have had on the shoot production and size of rhizomes of the plants remaining;

-to use both TEK and ecology to shed light on a non-destructive human-eelgrass relationship.

This study had two branches of investigation: through traditional ecological knowledge, and through ecological research. Specific research objectives are as follows. In chapter 2, my focus was on TEK, learning about eelgrass practices from Kwakwaka'wakw elders. My objectives were: 1) to gauge the traditional Kwakwaka'wakw cultural significance of eelgrass; 2) to determine whether *ts'áts'ayem* (eelgrass) was harvested within a *keeping it living* (sustainable) ethic of First Nations plant harvesting; 3) to determine whether elders observed differences in today's eelgrass health; and 4) to determine reasons why *ts'áts'ayem* is no longer harvested today.

To complement this Kwakwaka'wakw ethnobotany and ethnoecology of *ts'áts'ayem*, I explored the effects of harvesting on the plant itself (Chapter 3). My objectives here were: 1) to develop a methodology for in situ harvesting experiments and examine how harvesting affects and would have affected *Zostera marina* growth post harvest; 2) to determine the effect of harvesting on plots of eelgrass within a season by A) shoot regeneration, B) net shoot production post-treatment, and C) rhizome internode volume.

In Chapter 4, to demonstrate how TEK and ecology research can complement each other, my objectives were 1) to identify eelgrass harvesting statements derived from TEK in this study and to provide scientific support I found for them; 2) to use ecological research to further support the case that traditional harvesting of eelgrass did not have negative impacts on eelgrass populations, and therefore represented a positive relationship. Chapter 4 concludes with some final thoughts about the study.

Finally, Chapter 5 summarizes my findings and recommendations for future interdisciplinary study of eelgrass.

1.2 Traditional Ecological Knowledge

Traditional ecological knowledge (TEK) is a body of knowledge and beliefs about the relationships of living beings (including humans) with other species and their environments. It is holistic, and includes the philosophies and systems of observation and management of the human groups specific to a place that form the basis for natural resource management, nutrition, food preparation, health, education and community and social organization (Berkes 1999; Battiste and Henderson 2000), as well as spiritual understandings for those peoples. “It was a knowledge built on a history, gained through many generations of learning passed down by elders about practical as well as spiritual practices” (Anderson 2005, 4). Similar terms for TEK include local knowledge, indigenous knowledge, traditional knowledge, and traditional ecological knowledge and wisdom.

TEK has parallels to Western Scientific Knowledge and its methods; it is acknowledged that systematic experimentation and empirical knowledge have contributed to traditional ecological knowledge (Battiste and Henderson 2000). Kat Anderson explains: “the rich knowledge of how nature works and how to judiciously harvest and steward its plants and animals without destroying them was hard-earned; it was the product of keen observation, patience, experimentation, and long-term relationships with plants and animals” (Anderson 2005, 4). Some parallels between TEK and scientific knowledge and some challenges to integrating these knowledge systems are discussed in Chapter 4.

1.2.1 The left eye of TEK and the right eye of science

There are many potential benefits in using the two perspectives of Western science and Traditional Ecological Knowledge (TEK) to help us understand the complexities and dynamics of human-environment relationships. For example, it was only through collaboration between geologist John Harper and traditional knowledge holder Kwakxsistala, Adam Dick, that the rediscovery of the *luxiway* to modern society recently occurred; *luxiway* are clam terraces that are evidence of centuries old clam aquaculture by Northwest coast peoples (Ancient Sea Gardens 2005). The two worldviews could be seen as left and right eyes: together they offer a compelling picture of sustainable food production on the coast.

Traditional practices evolve out of experimentation and generations of observation and monitoring of results. Often the reasons for the specific way in which a food is gathered, or why a certain tradition is practiced, or the rationale for a taboo, is not readily conveyed. When I asked Adam Dick why they harvested the eelgrass shoots in May, he said, “Because May is the eelgrass harvesting month!” Scientific inquiry and research can help illuminate the underlying reasons and the inherent wisdom in practices that have simply become “the way it is done.” TEK has much potential for indicating areas where scientific experimentation might yield interesting results, as it brings to bear the accumulated knowledge of people who have been depending upon and manipulating particular ecosystems in specific ways for millennia. Upon investigation there are many ecological reasons why May is the most appropriate month for harvesting eelgrass- relating to growth patterns, seasonal fluctuation and tides (see Chapter 4). Scientific inquiry can confirm, or reject, the rationale for traditional practices, and together the two can help us understand the balance and interactions between humans and plants. TEK can indicate hypotheses, and science can test them.

In the 21st century it is also essential that the TEK from elders be recorded for the use, sustainability, insight and ability to adapt, of current and future generations. Practices that have survived and sustained humans to the present need to be recognized as demonstrating potential insights for current sustainability efforts, as these practices are the results of the overall adaptations to climate change, human population shifts and other fluctuations in nature. Harvesting eelgrass is one example of such a practice.

1.3 An Introduction to Eelgrass (*Zostera marina* L.; Zosteraceae)

> Worldwide, seagrasses rank with mangroves and coral reefs as some of the most productive coastal habitat. (Short and Wyllie-Echeverria 1996, 17)
>
> Seagrasses… rank among the most productive systems in the ocean and constitute one of the most conspicuous and common coastal ecosystems types. (Thayer et al. 1975, 288)
>
> The complex and intricate food webs of an eelgrass meadow rival the world's richest farmlands and tropical rainforests. (Wright 2002, 2)

Eelgrass (*Zostera marina,* L.; Zosteraceae) is one of 58 species of seagrasses worldwide. Eelgrass communities are recognized for their productivity, habitat structure, and function in erosion control. Much of the attention paid to this flowering monocot by ecologists is due to its importance as a structural foundation species that forms and maintains habitat for a host of juvenile creatures in estuaries, beaches and inlets - the nurseries of the ocean.

Geographic range

Zostera marina is found in most temperate coastal regions in the Northern hemisphere. It is one of five species of seagrasses found in the Pacific Northwest; the others are: *Phyllospadix scouleri* Hook, *P. torreyi* Watson, *P. serrulatus* Ruprecht ex Ascherson, Linnaeus, and the invasive *Zostera japonica* Aschers. & Graebn. (Philips 1984). This last species is a flourishing exotic, presumably introduced through the importing of the Pacific oyster (*Crassostrea gigas* Thunberg) from Japan in the 1920s (Harrison 1976). On the Pacific Coast, *Z. marina* extends along the rim of North America from the northwest of Alaska down to the Baja peninsula and along the northwest coast of Mexico. On the Atlantic its range stretches from Greenland to North Carolina; it surrounds Iceland, and occurs on the northwest coast of Russia, along the Norwegian Sea to Europe, where it grows along the English, Danish, and Spanish coastlines. It grows along the Mediterranean, Baltic and Black Sea shorelines. It is also found in the Yellow Sea between mainland China and the Korean Peninsula, and the Sea of Japan (Green and Short 2003, Appendix 3, 282). This vast range reflects the plant's flexibility – eelgrass can tolerate salinities from 10 parts per thousand (ppt) to 40 ppt, and temperatures of 0 – 40 ºC (Phillips 1984).

The phenotypic plasticity of *Zostera marina* is well-known. While not recognized by all ecologists, five ecotypes, or variants, for the North American Pacific coast have been described: *Z. marina* L. var. *izembekensis* Backman in the Bering Sea and embayments; *Z. marina* L. var. *atàm* Backman in the Gulf of California; and *Z. marina* L. var. *typica* Setchell, *Z. marina* L. var. *phillipsii* Backman, and *Z. marina* L. var. *latifolia* Morong along the coastline in between. These variants differ mostly in leaf dimensions and degree of phenologic changes throughout the season (Backman 1991). They are typically associated with different tidal elevations, and are found at different latitudes on the North American coast.

The ecological roles of Zostera marina

Eelgrass, which grows best in estuaries and calm bays along the coast, is important ecologically for several reasons. Much of its major role in the ecosystem is a result of its high productivity; it has an average growth of 500-600 g dry weight/m^2/yr (leaves and roots) (Phillips 1974). Its leaf growth is very rapid – typically 5 mm/day and in some circumstances growth can reach 10 mm/day (Phillips 1984). These growth rates provide large biomass input into the ecosystem, fueling dynamic energy systems.

Epiphytes - organisms living on the plant's surface (including bacteria, algae, sessile and mobile plants and animals from flagellates to nudibranchs) – thrive on eelgrass leaves. Epiphyte loads can be up to 2.3 times the biomass of the eelgrass leaf upon which they live (Kentula 1983). These epiphyte communities are essential for the food web pathways in estuaries – many facilitate the breakdown and enrichment of eelgrass detritus which is a crucial foundation of the food chains of estuaries. A primary trophic pathway in the eelgrass community is: plant detritus→ microbes (fungi, bacteria, flagellates)→ invertebrates (such as gammarid amphipods, which strip and eject particles, promoting a second microbial layer which breaks the detritus into even smaller particles)→ filter feeders and deposit feeders (Phillips 1984). From these organisms an entire web of invertebrate and vertebrate fauna are supported, many of which are human food sources.

Eelgrass feeds more than the ecological community within the immediate vicinity of its beds. Seagrasses in general take up sediment nutrients (especially carbon, nitrogen and phosphorus) through their roots, and translocate them to the leaves where they are absorbed by epiphytes and the water column (Phillips 1984). As well, as much as 45% of eelgrass production in a bed can contribute to nearby estuaries, as detritus carried on currents (Thayer et al. 1977). Through birds and mammals in the food-web, the influence of eelgrass extends even to terrestrial ecosystems. Detritus is an important part of energy cycling. Bacteria coat decomposing eelgrass material and enrich it via enzymatic action, crucial for breaking down eelgrass nutrients to make them available to the food web (Phillips 1984). Through this process the detrital matter actually increases in its levels of nitrogen, phosphorus and organic carbon available to other organisms (Phillips 1984).

Eelgrass also obtains nutrients from the water column and pumps them into the sediment. A direct relationship exists between amount of oxygen in the sediment and leaf area of eelgrass (measured by Leaf Area Index), indicating the importance of the oxygen transport system from the leaves to rhizomes and roots and into the sediment ecosystem (Iizumi et al. 1980). As well, nitrogen fixation has been found to occur on the phyllosphere of eelgrass leaves (Phillips 1984; Smith et al. 1981), as well as N being fixed through bacteria at the rhizosphere (Smith et al. 1981). A positive correlation has been found between eelgrass density and nitrogen in the sediment in which eelgrass grows (Kenworthy et al. 1982).

Eelgrass accumulates metals, and because of its nutrient cycling characteristics is possibly both a reservoir and source of pollution in the water column and sediment. Several studies found trace metals in eelgrass in levels higher than in other organisms in the ecosystem (Phillips 1984). Manganese, iron, copper and zinc were found in an eelgrass community in the Newport River estuary, and the researchers found eelgrass beds were much higher in these metals than surrounding estuaries, indicating the community's efficiency as sediment traps (Wolfe et al. 1976). Eelgrass plants themselves were a significant biological reservoir of the metals relative to all other organisms and parts of the plant.

Mats of intertwined *Z. marina* rhizome and root structures bind the substrate sediment in eelgrass beds, reducing erosion along coastlines (McRoy and Helfferich 1980). In addition, the extensive meadows of eelgrass with their long leaf blades moderate damaging impacts of wave action (Thayer et al. 1977).

Finally, perhaps the most significant value of eelgrass meadows is as habitat for a diversity of organisms. The extensive eelgrass rhizome mats in the sediment, and its long leaves which mitigate current action in the water column, provide a protected habit for a multitude of other organisms, especially juvenile organisms, so much so that eelgrass meadows are known to many ecologists and conservationists as 'the nurseries of the oceans'. It is for this reason that eelgrass meadows have been designated by the Canadian government as protected ecosystems[1]. In his *Community Profile of Eelgrass Meadows of the Pacific Northwest* Phillips (1984) lists 203 species of invertebrates, 76 species of fish, and 80 birds, found in eelgrass meadows of the Pacific Northwest. Many of these species are transient but rely on eelgrass habitat for critical portions of their life cycles (Phillips 1984). Many birds feed on the flora and fauna that eelgrass meadows harbour, but birds are also the primary consumers of the plant itself.

Eelgrass communities support:

-epiphytes (organisms living on the surface of leaves);

-epibenthos (organisms living on the surface of the sediment, including: crabs and shrimp (crustaceae), snails (gastropoda), and sea cucumbers, sea urchins, and starfish (echinodermata);

-fauna living buried in the sediment (including: clams, scallops, cockles, geoducks (pelecypoda), cephalopods and decapod crustaceans (crabs));

-nekton (fish in and above the eelgrass canopy: from Pacific herring (*Clupea pallasi* Valenciennes) to juvenile salmon and cod species);

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[1] Section 35 (1) of the Federal Fisheries Act states that "No person shall carry on any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat." This includes eelgrass meadows. Proceeding to damage eelgrass beds without requesting an authorization under Subsection 35 (2), means persons are liable to prosecution under the Fisheries Act.

-waterfowl (species relying directly on eelgrass include Canada geese (*Branta canadensis*), Black brant (*B. bernicla*), emperor geese (*Philacte canagica*), wigeons (*Anas spp*.), scoters (*Melanitta* spp.), canvasback ducks (*Aythya valisineria*), coots (*Fulica americana*), pintails (*Anas acuta*), mallards (*A. platyrhynchos*), and green wing teals (*A. crecca*), all of which eat eelgrass seeds or epiphytic organisms on the blades. In addition, the epiphytes and biodiversity supported by eelgrass habitats are depended upon by many other birds.

By supporting species that form the basis of major food chains, eelgrass beds feed fauna throughout the oceans and on land as well indirectly. One example is herring: in the spring the Pacific herring pass through eelgrass meadows and spawn directly on the blades, which then provide a protected environment for the herring hatchlings. Herring contribute from 30 to 70% of the summertime food of Chinook salmon (*Oncorhynchus tshawytscha* Walbaum), and also feed Pacific cod (*Gadus macrocephalus*), lingcod (*Ophiodon elongatus*), and many other carnivorous fish. Herring spawn is also an important food of seabirds, grey whales, and many invertebrates (Phillips 1984).

1.4 Humans and Eelgrass

While most people don't realize the importance of seagrass meadows, researchers and governments alike have recognized the high significance of eelgrass as food and habitat for marine resources that are an important part of human economy. For example herring and their roe are an important local food and also serve as the basis for trade and global commerce. Three commercial herring fisheries contribute greatly to the BC fishing industry: herring for food and bait, herring spawn on kelp, and the largest of the three, roe herring. Combined, BC herring landings in 2003 were 29 400 tonnes, and the wholesale value was 102.9 million Cdn$ (Ministry of Agriculture and Lands 2004). This important resource is one of the many species that hides in the shelter of eelgrass meadows where it lays its eggs. Thayer et al. commented: "We must consider the proportionate role of seagrasses in the energetic scheme of all estuarine and coastal productivity, upon which most of the fishery organisms used by man depend during some stage of their development" (Thayer et al. 1975, 295). Recognition is growing for eelgrass and more generally, seagrass beds as an important part of estuarine and coastal ecosystems -- the economic value of eelgrass, due to its support and facilitation of commercially important populations, has been acknowledged as needing protection. Several individuals and organizations are quantifying the economic value of natural systems by calculating the extensive services and functions that healthy ecosystems provide for human economies (Table 1.1). Such economic valuation is important because it remains our society's primary way of giving status, recognition and consideration to individual species or ecosystems.

Table 1.1 Economic Values of Wetland Ecosystems Services. [Adapted from Table 2: Summary of average global value of annual ecosystem services, in Costanza et al. (1997), 256]

	Total hectares (ha X 10^6)	Total value (US$) per ha/yr	Total global flow value (US$/yr)
Estuaries	180	22,382	4,100,000,000,000
Seagrass/algae beds	**200**	**19,004**	**3,801, 000,000,000**
Coral reefs	62	6,075	375, 000,000,000
Tidal marsh/mangroves	165	9,990	1,648, 000,000,000
Swamps/floodplains	165	19,580	3,231, 000,000,000
Lakes/rivers	200	8,498	1,700, 000,000,000

Seagrasses comprise four families within the Alismatales order of angiosperms. Eelgrass, of the Zosteraceae family, has not only indirectly supported people through provision of habitat for commercially important species and ecosystems, but has also been used directly as a raw material from Europe to New England, and as a food on the West coast of North America from Mexico to British Columbia. Its physical characteristics have made it an important resource throughout history. In Europe, as indicated from records, dating back several hundred years, the leaves have been used as furniture stuffing, roof thatching, garden compost and livestock feed. In New England and Eastern Canada it fueled an insulation industry from the 1800s to the 1960s. Table 1.2 lists some of the uses of *Zostera marina* as a material resource in Europe and North America.

Table 1.2 List of general locations, uses and associated terms for *Zostera marina* in Europe and North America

Location	Use	Era	Names (English translations)	Sources
Norway	Stuffing for furniture and mattresses and chinking between cracks; manure—left to rot and mixed with dung; green fodder for cows; ground cover for sheep; used to cook fish in	18-20th centuries, in early 20th c. imported from Denmark and the Netherlands, though it was abundant at home in Norway	Eel grass, Grass sea-weed, Grass kelp, Sea straw, Sea down, Sea eel grass, Man onion, Sea onion, Sea onion grass, Food onion, Food onion kelp Mattress-wash kelp, Mattress wash Mattress onion, Sea rush Swan grass, Sea eel	Hans Strom (1762); P. Kalm (1751) (translated in Alm 2003); Alm (2003, 642)
Denmark	Roof thatch; mattress and pillow stuffing; cattle feed; lining in ditches to preserve ice in winter; burned it to retrieve salt from ashes; filling in bicycle tubes; exported to Brazil and Germany	*Z. marina* ash found in ancient village sites; 1700s-1950s; bicycle tube filling was a late WW2 use; in 1950s 1700-2400 tonnes harvested	Grass-wrack	Alm (2003); Ostenfeld (1908); Cottam (1934); Pendergast (2002)
Sweden	Roof thatch, substitute for straw and birch bark	1700s		Alm (2003)
Germany & Netherlands	Substitute for horse hair in furniture	Pre-1920s		Alm (2003) Ostenfeld 1908
Italy	Packaging for glass from Venice	Pre-1935	'*alga vitriariorum*' (seaweed *vitriariorum*)	Hegi, G. (1935) in Alm (2003)

Table 1.2 Continued: List of general locations, uses and associated words for *Zostera marina* in Europe and North America

Location	Use	Era	Words	Sources
UK	Production of quilted insulation blankets for wall construction in buildings	1930s	'Riverbank' British Empire Product	Pendergast (2002)
New England (Cabot's quilt sent and used in buildings across Canada, the US and Great Britain)	'Banking up' around houses for insulation; thermal and sound insulation industry by Samuel Cabot Inc. in Boston, MA	Late 1800s to 1960s; industry peaks in late 1920s	Cabot's quilt (Samuel Cabot Inc., Boston, MA)	Wyllie-Echeverria and Cox (1999)
Nova Scotia	Banking up; green manure; as dried bedding for animals		Seafelt (Guilfords Ltd.)	Wyllie-Echeverria and Cox (1999)

Eelgrass as a food resource

Eelgrass has been used as a food resource by peoples on the westcoast of North America. Westcoast groups, locations and uses are listed in Table 1.3. The indigenous Seri people of Sonora in northwestern Mexico depended on the seeds of *Z. marina* as a staple grain (Felger and Moser 1973). It was as important to the Seri as bread was to Europeans (Felger 1977). The historical, cultural significance of eelgrass is evident in the very language of the Seri—the ripe fruit is called *Xnois*, and this word features in the names for the month of April, for waterfowl and a landmark (see Table 1.3) (Felger and Moser 1973). The Seri's use of eelgrass seeds was first noted by Spanish colonialists and Jesuit missionaries in the 17th and 18th centuries (Felger 1977). Additionally, eelgrass leaves were used for roofing and lining for baskets, toy ball stuffing and for dolls, which girls still play with (Figure 1.1) (Felger et al. 1980). *Xnois,* the ripe fruit, was harvested in April or early May by men and women when great rafts of the reproductive shoots floated ashore. The timing of this crop was important—its harvest coincided with the height of the pre-summer drought in Northwest Mexico. To harvest *Xnois*, the people waded out into the water and pulled bunches of eelgrass in by hand. The eelgrass was spread out on rocks to dry, and the debris picked out. After several days of drying, the women would place the eelgrass on deer skins, and thresh it with clubs to extract the grain. After this the plants were rolled by hand to loosen any remaining fruit before the grain was winnowed by being tossed into the air from a basket. Some of this grain was stored in pottery containers for times of need. This grain was toasted in pottery vessels, then poured into a basket and pounded to break the seeds open. Chaff was blown away in a second winnowing. Then the seeds were ground on a milling stone. This flour was put in a basket, and used to make a gruel or dough balls, eaten with other foods such as sea turtle oil, honey, or the seeds of the giant cactus, cardon (*Pachycereus pringlei*). There are no records of the Seri eating other parts of the eelgrass plant.

Figure 1.1 Drawing of Seri eelgrass doll. Eelgrass and cloth, made by Ramona Casanova, El Desemboque, Sonora, April, 1972. Drawing by S. Cullis-Suzuki from photo by Helga Teiwes, Arizona State Museum (in *Science*, 1973).

This is the only known case of a submerged marine angiosperm being used as a major food source, made possible due to the unique characteristic of this variant and location of *Z. marina* where 100% of the shoots become reproductive (Felger 1977). Off the central coast of Sonora, winter temperatures are 12-14 ºC, and summer temperatures become 27-32 ºC (Felger and Beck Moser 1980), evidently providing the optimal temperature regime for sexual reproduction of eelgrass.

Nutritional composition of mature *Z. marina* seeds has been found to be similar to that of corn and wheat with a high starch content of 50.9-51.0%, protein content of 9.0-13.2%, similar levels of amino acids to corn, and levels of fat at 1.0-1.4% (Felger and Moser 1973; Irving et al. 1988). The shoots were found to be higher in minerals, fiber and ash (Irving et al. 1988). As *Z. marina* shoots undergo 100% flowering in the Gulf of

California, it has been proposed that this species has potential as a food crop in coastal desert areas which are fresh water limited, and the production of which would not require pesticides or fertilizer (Felger and McRoy 1975; Felger and Moser 1973). Felger and McRoy (1975) suggest that *Z. marina* seeds could potentially be produced on a level comparable to rice.

In the 1970s the Seri were still known as a hunting and gathering people, and many elders still recalled traditional practices; *Zostera marina* seeds were still occasionally harvested in 1980 (Felger and Beck Moser 1980). That the Seri people were able to depend on *Z. marina* as a staple food source is evidence of the high productivity and dependability of *Z. marina*, as well as of a degree of sustainable harvesting on their part.

In the Pacific Northwest of North America, eelgrass was gathered for food by Haida, Nuu-chah-nulth and Kwakwaka'wakw peoples, and likely by others as well (Table 1.3). Boas (1966) noted that "Sea grass, berries, and roots are gathered by the women. The sea grass is cut, formed into square cakes, and dried for winter use" (Boas 1966, 10). As well, the Straits Salish sometimes gathered the rhizomes for consumption, but mostly used the eelgrass grounds for hunting and gathering other creatures (Wyllie-Echeverria 1998). Its valuable characteristics suggest that it was used much more than can has been documented in the literature, or from contemporary memory.

Haida

On Haida Gwaii, the Queen Charlotte Islands, the word for eelgrass or seagrass is *t'aanuu* (Turner 2004). It comes from the word *g'aanuu*, grass [2] (John Williams, Ernie Wilson, James Young). *T'aanuu* is the name of an old village on the East coast of Moresby Island, so named because it has eelgrass or seagrass growing all around it (Turner 2004). People gathered it when the herring spawned on the leaves; the elders at the Skidegate Haida Immersion Program, and some younger Haida also spoke of eating the herring spawn off the eelgrass right in front of Skidegate village (Barbara Wilson, Wally Pollard, pers. comm. 2007). A clue to past consumption of eelgrass is found in C. F. Newcombe's 1897 unpublished manuscript on Haida plant names – under *Zostera* he wrote "roots

[2] John Williams, Ernie Wilson, James Young on recording of Skidegate Haida Immersion Program, 2006

formerly eaten raw or cooked." By the turn of the century the consumption of rhizomes was already out of practice. While there are some records of medicinal use (Turner 2004) it is not generally remembered amongst contemporary elders as a plant that was eaten or used on its own.

Nuu-chah-nulth

In Nuu-chah-nulth territory, the Hesquiat people on the Westcoast of Vancouver Island also used seagrasses. In the early spring they harvested herring spawn on surfgrass (*Phyllospadix* spp.) for food. In his book on British Columbia Coast Names Captain John Walbran writes "Heish-kwi-aht: from Heish-heish-a meaning: To tear asunder with the teeth" (Walbran 1909, 240). He also noted that "Salt water grass called "segmo" drifts ashore around Hesquiat especially at the time of herring spawn, which the Indians tear asunder with their teeth to dislodge the spawn." For Simon Lucas of the Hesquiat, the importance of eelgrass is primarily associated with herring. Eelgrass, surfgrass and various types of kelp were important during the herring spawning season. He reiterated the literature on the name of the Hesquiat: "There's an action word: our people would put the eelgrass between their teeth and pull it out making a sound '*Haish Haisha*;' we ended up with that as our name. …so eelgrass and the herring were important for our people." (However, as the word for surfgrass, *Hashquiits,* is closer to this sound, this is probably the plant he is referring to, not eelgrass). Figure 1.2 shows eelgrass covered in herring spawn. Simon Lucas didn't remember eating the rhizomes on their own, but speculated they were eaten in the past:

> Probably for us, prior to contact, we ate the roots. When it [herring roe] was extremely thick, they would rip the eelgrass off and dry it in the sun with the herring eggs. Later they would put it in water [to rehydrate]. As a little kid I remember that, but once we started using the trees [Western hemlock boughs] it [the eelgrass] faded in the background. Because with the trees you can choose the thickness.

> Prior, our belief was that Mother Earth cleanses herself before herring come in to spawn. So we usually have strong weather just before they spawn. It's the natural way of cleaning the bottom, it cleansed off the eelgrass…. The storms were important for us, so that the herring spawned on the clean eelgrass.[3] (Simon Lucas)

Figure 1.2 Herring roe on eelgrass leaves, British Columbia. Photo courtesy of Dr. D. N. Outram, in Phillips 1984, 51. With permission from the US Fish and Wildlife Service.

While surfgrass (*Phyllospadix spp*.) was apparently not directly eaten, the Hesquiaht did harvest eelgrass for food. Women harvested eelgrass in May when the tide was low, and recognized two types of eelgrass for food: one with greenish-white roots, *č̓a·č̓amasʔi·k*, and one with reddish brown rhizomes, *has̆qi·c*. Both were eaten, but the greenish-white rooted eelgrass was considered more desirable, and was eaten in large amounts. Eelgrass was noted to have grown in soft mud, and had "roots" as thick as a pencil (Turner and Efrat 1982). Eelgrass was also important as an indicator of harvestable birds and fish. The leaves were occasionally gathered when they had spawn on them, but

[3] Simon Lucas, pers. comm. April 4, 2006

the leaves themselves were not eaten.

To the south, the Nitinaht (Ditidaht) people (relate to the Hesquiaht and other Nuu-chah-nulth) on the Southwest Coast of Vancouver Island, also harvested eelgrass in the spring. Eelgrass was called *taba·x,* and it was the young, white rhizomes that were eaten. They were harvested in spring at low tide, but the plants were seldom exposed, and were harvested in a few cm of water. Elders recall that people ate them immediately after pulling them up and rinsing them in seawater. They were known to be very tasty and tender when eaten raw, and were possibly dipped in seal or whale oil (Turner et al. 1983).

The exploration of eelgrass ethnobotany and ethnoecology of the Kwakwaka'wakw Nation is the subject of this thesis and is focused on in Chapter 2.

Table 1.3 Food uses of *Zostera marina*: general locations, recorded food uses and associated traditional words for eelgrass in indigenous languages on the coast of North America

Group and Language	Location	Used	Traditional words associated	Harvest	Source
Seri	Sonora, Mexico	Seeds used as staple flour for the Seri people of Sonora; flour made into thin or thick gruel, eaten with honey, or sea turtle grease and sometimes made into dough balls added to gruel. Eelgrass leaves found in Seri burial (radiocarbon dated 2000 years old).	*xnois* (ripe fruit); *xnois iháat iizax* (April: 'Moon of the eelgrass harvest'); *xnois cacáaso* (black brant: 'Xnois the foreteller,' whose diving is said to foretell the harvest season); *hast xnois* (Marito de Turner: 'eelgrass seed rock'); *Hant xnois* (word for trash: 'land eelgrass-seed,' b/c xnois is harvested with unwanted seed shells and debris); *eaz* (when the plant washes ashore); *xnois hapáha* (toasted and ground seeds) *xnois hapánal* (natural, untoasted fruit: 'fuzzy xnois); *Xnois coinim* (mixture of eelgrass and cardón seeds: 'eelgrass-seeds that is mixed'); *Hatáam* (growing eelgrass, on ocean floor); *xnois coinim* was made by mixing eelgrass seeds with cardon (*Pachycereus*) seeds.	April-May when rafts of eelgrass would float on the water, pre-summer drought. Utricles (fruit) were dried, toasted, pounded and winnowed, then seeds were ground into flour. Eelgrass seeds were stored in pottery for later seasons.	Felger (1977); Felger and Moser (1985)
Haida	Haida Gwaii (Queen Charlotte Islands)	Picked when covered in *k'aaw* (herring spawn); "roots" (rhizomes) eaten raw	*t'aanuu* (eelgrass; also a village – 'Eelgrass town')	Gathered by hand in herring season	Newcombe (1897); Turner (2004); Wally Pollard, Barbara Wilson (pers. comm. 2007)

Table 1.3 Continued. Food uses of *Zostera marina*: general locations, recorded food uses and associated traditional words for eelgrass in indigenous languages on the coast of North America

Group and language	Location	Used	Traditional words associated	Harvest	Source
Ditidaht (Nuu-chah-nulth)	West coast of Vancouver Island	Rhizomes eaten raw	*taba·x* (the 'real' eelgrass); *kalkatcapt* (holdfasts, or edible rhizomes of the eelgrass); *taba·x* (*Phyllospadix scouleri* Hook., and also *Phyllospadix torreyi* S. Wats., [but not 'real' eelgrass])	Harvested in spring at low tide in a few cm of water	Turner et al. (1983)
Hesquiat (Nuu-chah-nulth)	West coast of Vancouver Island	Rhizomes eaten raw	*c̓a·y̓imc* (general name for seagrass, ie. *Z.marina* and *Phyllospadix spp*); *k̓ʷiny̓imc* (seagrass washed up on shore and dried out); *hašqi·c* (brown rooted eelgrass, growing); *hašqi·csmapt* (brown-rooted eelgrass, washed up on the shore); *ƛ̓uqƛ̓uqʔic̓a·y̓imc* (leaves of white rooted eelgrass, lit. 'wide sea-grass'); *č̓a·č̓amasʔi·k* (roots of white-rooted eelgrass, lit. 'given to being sweet')	**Women gathered rhizomes on the May low tides**	Turner and Efrat (1982); Joe Martin, pers. comm. 2006); Walbran (1909, 240); Simon Lucas, (pers. comm., 2006)
Tla-o-quiaht (Nuu-chah-nulth)	West coast of Vancouver Island	Rhizomes eaten raw	*ts'aay'imts* (eelgrass) *haashqiits* (surfgrass)	Women gathered them in the spring	Joe Martin (pers. comm. 2006); Clayoquot Sound Scientific Panel (1995, A-19)

Table 1.3 Continued. Food uses of *Zostera marina*: general locations, recorded food uses and associated traditional words for eelgrass in indigenous languages on the coast of North America

Group	Location	Used	Words associated	Harvest	Source
Northeast coast of Vancouver Island and adjacent islands and mainland	Kwakwaka'wakw (See chapter 2)	Harvested for food, (historically ceremonial); Rhizomes eaten raw, with grease, steamed; old eelgrass used in steaming food in pit cooking (Boas and Hunt 1921, 265, 335)	*k'elpaxu* (eelgrass twisting stick); *ts'áts'ayem* (eelgrass); *tsatsamot* (dead eelgrass); *ts!āla (la*) (tide, current); *k·!Ĭlp(a)* (to twist); *k!ĬlpEla* (twist); *ts'ápalees* (tide when all lays flat); *see'hya* (to peel)	Women gathered the whole plants with a *k'elpaxu* (twisting stick) in May; also harvested by hand on the big low tides	Boas and Hunt (1921); Turner and Bell (1973); Tom Nelson, (pers. comm. 2005); Charlie Dawson (pers. comm. 2005) Adam Dick (pers. comm. 2004)

1.5 Current context: the decline of eelgrass

The context for eelgrass research today is that seagrass ecosystems, and the great biodiversity they support, are in decline in the coastal regions of the Pacific Northwest and around the world (Short and Neckles 1999; Short and Wyllie-Echeverria 1996; Thayer et al. 1975). Many cases of decline have been documented, and several direct causes have been identified. Short and Wyllie-Echeverria (1996) report that globally in the last decade over 290,000 documented hectares of seagrass have been lost, and they estimate that in reality, over 1.2 million hectares have disappeared.

Post World War II industrialization fuelled an increase in urban development and population migration away from rural farms to urban centres, many of which grew up along coastlines. As of 2004, 44 % of the world's population (more people than existed on Earth in 1950) lived within 150 kilometres of the coast (UN Atlas of the Oceans 2004). As a result, a host of human caused impacts are contributing to eelgrass decline. They include: water pollution (runoff and nitrogen loading from urban development, agricultural runoff and shoreline development); mechanical damage (dredging for boat channels, dredging due to commercial dragnet fishing, damage from anchors and boat propeller scarring, as well as shoreline construction); oyster fisheries and invasive species [the growth of the oyster industry in many regions of the Pacific Northwest has coincided with instances of eelgrass decline (Ruiz and Carlton 1995)]; and the growing spectre of climate change (Short and Neckles 1999).

The increasing pressure on the world's coastal ecosystems represents a giant, uncontrolled experiment in which the results cannot be fully predicted. However, impacts of eelgrass decline on fauna have been observed in many instances - during the eelgrass 'wasting disease' epidemic of the 1930s (thought to be caused by the slime mould *labyrinthula*), numbers of fish, clams, scallops, crabs and Brant geese declined (Phillips 1984). In Chesapeake Bay there was a 71% reduction in biodiversity in a spoil area after dredging (Flemer et al. 1967). While there are many documented cases of eelgrass decline and resulting ecosystem changes from eelgrass loss, the direct cases, causes and consequences of eelgrass decline must still be further researched.

While all this is cause for alarm, it is also apparent that *Z. marina* has a great capacity for recovery. The eelgrass 'Wasting Disease' resulted in a 90-100% decline of eelgrass stocks along the North Atlantic US coast, causing eelgrass from many areas to disappear within two years, 1931-1933 (Philips 1984). Since then however, *Zostera marina* stocks have recovered. That this species was able to rebound from such drastic decline indicates the plant's potential for large-scale recovery.

Many scientists understand the plight of estuarine communities and are realizing the need to integrate efforts, raise awareness about the decline of these ecosystems and involve local communities and individuals in restoration. Many call for the mapping and monitoring of habitats globally, and a commitment to preserving and restoring seagrass habitats on behalf of governments and communities. Phillips and Dukako (2000) make a call for action to halt the destruction of seagrass meadows:

> To do this will necessitate a reorientation of our morals, goals, and value systems. We will continue to need and practice the best science-based information possible. We will need to expand our base of research. We need seagrass scientists who are willing to leave the laboratory occasionally and plunge into the public arena to exchange information…with elected officials from all levels of government, with policy-makers, with legal staff, with economists and with sociologists. A change in human value systems is needed. (Phillips and Dukako 2000, 11)

Global efforts are underway to achieve these goals. In Canada, the Department of Fisheries and Oceans, university scientists and concerned citizens on the east and west coasts are coordinating efforts to monitor and preserve important eelgrass habitats. The Seagrass Conservation Working Group[4] is a network of 12 conservation groups with a goal of mapping 1000 hectares of critical eelgrass habitat and activating local communities to become stewards of their own estuaries. It is similar to the Seagrass Watch program in Australia (www.seagrasswatch.org). It is coordinated by SeaChange, an non-governmental organization in Victoria, and is partnered with 25 groups at federal, provincial, and local levels working for conservation. As well as education and conservation, SeaChange and its volunteers have conducted six eelgrass transplants in Saanich Inlet and, since 1998, have transplanted over 5000 square meters of eelgrass

[4] formerly the BC Coastal Eelgrass Stewardship Project

meadows (Nikki Wright, pers. comm. 2006). It is this type of local engagement and education that is needed to begin to deal with the global eelgrass crisis.

1.6 Chapter 1 conclusions

Eelgrass (*Zostera marina* L.) and its relatives are important structural species for marine coastal areas around the Northern Hemisphere. Their function in habitat creation (forming protective areas for juvenile marine organisms), and high biomass production are two of many ways that eelgrass and other seagrasses support the marine ecosystem. Healthy eelgrass meadows support populations of commercially important fish and other species, and for this reason eelgrass habitats are protected by the Canadian government. The biomass output of eelgrass combined with many useful characteristics has made it directly important to humans as well. Its senesced leaves have been a key part of human economies around the world, the flour from its seeds was a staple food for the Seri people of Mexico, and its rhizomes were eaten by several different peoples on the Pacific Northwest Coast of North America.

Today there is a decline in eelgrass populations around the world due to anthropogenic influences. Because of its function as habitat, this has repercussions on many marine organisms. Fortunately, *Z. marina* has an impressive ability to recover and repopulate, and there are many efforts to restore and protect this important resource. This is the ecological context of the eelgrass ethnobotany of this thesis.

Chapter 2 Traditional Ecological Knowledge of *ts'áts'ayem* (*Zostera marina* L.)

2.1 The Kwakwaka'wakw

My study focused on traditional harvesting of eelgrass, or *ts'áts'ayem,* in the Kwakwaka'wakw tradition. While it is beyond the scope of this paper to describe the recent history of the Kwakwakwa'wakw, it must be noted that in order to accurately analyze and assess the current TEK some awareness is essential: it is through the strain of disease, persecution and systematic assimilation strategies after contact, that today's TEK has survived. This history colours today's interviews and discussions of the past and present, as contemporary elders grew up in the era of residential schools, the potlatch ban and an abrupt restriction of access to traditional ecological resources.

Known in history as the Kwakiutl (or Kwakewlths, KwakiooL, Quackolls, and many others) by anthropologists, the modern term of Kwakwaka'wakw means 'Kwak'wala speaking peoples'[5] and encompasses the speakers of the former Southern Kwakiutl language group. Their territory extends west from Smith's Inlet to Cape Scott, south to Cape Cook, and into the interior of Vancouver Island across to Comox and inland up Toba Inlet and includes the Klinaklini rivershed (Figure 2.1). While they did share economies, traditions and relatives, tribes under this banner speak nine different dialects (Sewid-Smith 1992), have different origin histories, and were separate, politically autonomous groups (Figure 2.1). My study focuses on those speaking the Kwak'wala dialect: people from the Adams River to Fort Rupert to Kingcome Inlet. The number of tribes or social units recognized depends on which political or cultural level is being referred to. For example, the Likwakdawx include the Wewaykum and Weewaikai peoples from Quinsam and Cape Mudge reserves, and the Moskimowx people were a unified alliance of people from Kingcome Inlet, Wakeman's Sound, Hopetown and Gilford Island (Adam Dick, pers. comm. 2006). As the communities have always moved and intermarried, and various communities have amalgamated, distinctions between groups is often complex. For my study I interviewed people across the groupings and villages and note where different consultants originate (Table 2.1, page 38).

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[5] U'mista Cultural Center, www.umista.ca; Powell, 1994

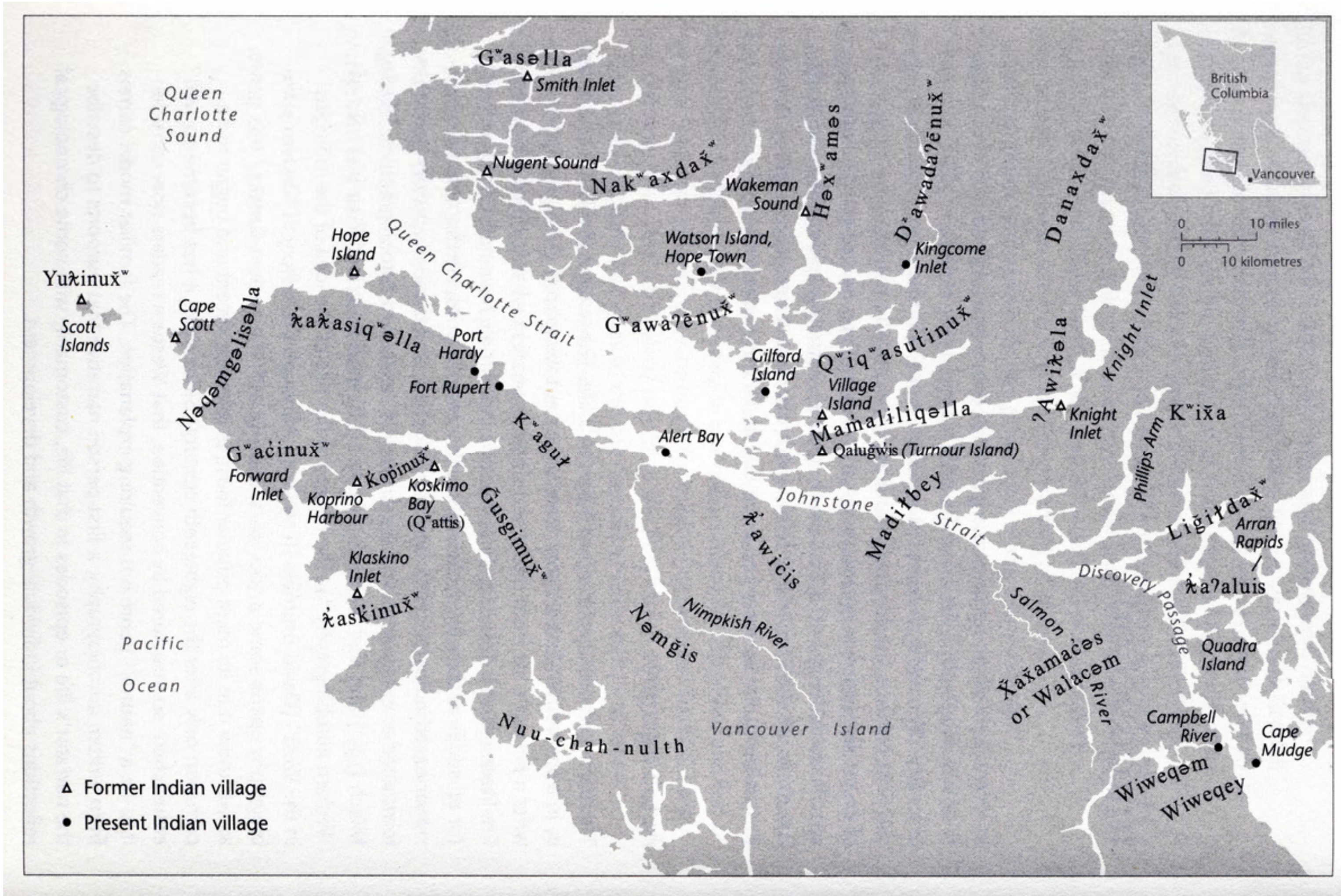

Figure 2.1 Traditional territories of Kwakwaka'wakw sub-groups. From *Paddling to Where I Stand*, with permission (Reid and Sewid-Smith 2004, xviii).

2.1.1 Hunting, gathering and *keeping it living*

> The only trace of agriculture found in this area is a somewhat careless clearing of grounds in which clover and cinquefoil [Pacific silverweed-*Potentilla anserina*] grow and the periodic burning over of berry patches. (Boas 1966,17)

Europeans failed to appreciate Northwest Coast[6] plant management because they didn't see a familiar form of cultivation. But it would not have suited the aims of the land appropriation; an absence of native agriculture helped justify the land takeover by Europeans, as unused, and therefore un-owned, land (Deur and Turner 2005). Failure of Europeans to identify First Nations' active management of the 'wilderness' that surrounded them paralleled their failure to see the potlatch (and specifically the Kwakwaka'wakw Pəssa) as a system of economic investment.

Northwest Coast groups have challenged the anthropology dichotomy of agriculturalist vs. hunter-gatherer societies (Deur 2002a). Like other groups on the NW Coast, the Kwakwaka'wakw had the characteristics of complex societies: permanent structures, ownership of property and large amounts of stored foods, complex hierarchies and ceremony, complex technology, high population densities, highly developed art forms. They modified their environment considerably, but were not viewed as agriculturalists. Part of the challenge for European academics was in the belief that agriculture (of a certain European definition) was a prerequisite for the development of complex societies (Ames and Maschner 1999). To the south, California Indians also did not clearly belong to either category, having begun the process of habitat domestication, and "through coppicing, pruning, harrowing, sowing, weeding, burning, digging, thinning and selective harvesting, [California Indians] encouraged desired characteristics of individual plants, increased populations of useful plants, and altered the structures and compositions of plant communities" (Anderson 2005, 1). In traditional anthropology agriculture has been seen as an evolutionary progression, with a brief transition between the two stages, maintaining a steady state in one or the other (Smith 2005). Civilizations on the Northwest Coast are called 'complex hunter-gatherers' or 'affluent foragers'

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[6] The Northwest Coast is a cultural area, extending over 2000 km along the Pacific Coast of North America from Icy Bay, Alaska to Cape Mendocino, California (Ames and Maschner 1999).

(Ames and Maschner 1999), terms for societies considered in the undefined area between agriculturalist and hunter-gatherer.

As is often the case, the matter of definitions of terms is a major source of debate. Domestication and cultivation have been terms that define agriculture, but different definitions of these terms shift the definitions of agricultural societies (Smith 2005). While native plants used on the NW coast have not fit a traditional definition for domestication[7], NW coast people modified many of the ~300 species of plants they used, and the proliferation and promotion of certain growth forms was due to their management (Turner 2005). Cultivation implies intervention to a lesser extent than domestication, and while there are also many definitions, most involve a degree of manipulating plants and their environments to intensify production. On the NW coast, peoples' manipulation and use of plants as described in ethnographic accounts, have has not been appreciated or recognized (Deur 2002a). In light of this, Deur and Turner (2005) conclude that "…Northwest Coast peoples were actively cultivating plants, as that term is now defined, and that they were doing so prior to European contact" (Deur and Turner 2005, 8).

Tending is a term for the minor modification of environment to encourage the growth of naturally occurring plants in situ, modifying the environment around it to a lesser degree than cultivation (Deur and Turner 2005; Deur 2002b).

Q'waq'wala7owkw: *keeping it living*

Understanding of cultivation and resource management on the Northwest Coast requires a different way of looking at the natural world from which all resources are derived for survival. Nuu-chah-nulth Chief Umeek, Richard Atleo, explaining the concept of wealth and responsibility of a chief's *Hahuulhi* writes, "The word 'subsistence' makes sense only from a Western worldview, which demands that humans dominate the environment and profit from it" (Atleo 2005, x). Emerging in the study of the Northwest Coast is the understanding of the existence and prevalence of an attitude of '*keeping it living*' in traditional resource management. *Q'waq'wala7owkw*: Keeping it living, is a Kwakwaka'wakw term Chief Adam Dick shared with Nancy Turner and Doug

[7] Smith (2005) defines 'domesticate' as having visible genetic changes to the species, and a dependence on humans.

Deur. It is a term used to describe the full range of cultivation methods within a philosophy promoting the continuation of the resource (Deur and Turner 2005). As with food gathering and tending attitudes of the California Indians, *keeping it living* reflects a relationship of reciprocity, continuity, familiarity and continual learning (Anderson 2005). A clear example of this is the practice creating Culturally Modified Trees still visible today: cutting a board from a tree would not kill it; it could continue to be part of the forest that sheltered many other lifeforms including resources used by the Nuu-chah-nulth (Figure 2.2). Songs and thanks given when harvesting berries, cedar, clams, or eelgrass, are evidence of the respect and awareness when harvesting within this philosophy.

Figure 2.2 A living, culturally modified Western red cedar on Nootka Island (Cullis-Suzuki, 2006)

An analogous term for *keeping it living* is 'sustainability.' Plants were harvested in an intentionally sustainable way (Deur and Turner 2005). Harvesting only what is needed is an important rule that comes up often in accounts of protocols for traditional food gathering, demonstrating a delicate balance between gathering food for the immediate future (i.e. storage for winter), and not taking too much to decrease availability in the distant future. Roots, bark, planks, stems, shoots, and rhizomes were taken in ways that did not hinder the growth of the original or remaining plants.

Transplantation, replanting propagules, leaving inedible portions of the plant in the soil, burning, pruning, coppicing, thinning and weeding are sophisticated techniques that people on the coast (and elsewhere) used to ensure the regrowth and sustainability of plant populations (Anderson 2005; Deur and Turner 2005).

Tending and cultivating are part of *keeping it living*, as many techniques acted to proliferate and increase desirable plant production. Some plants have evolved to withstand the natural disturbances of animal digging and feeding, ice scraping, grazing, fires and rains, so much so that many plants have evolved a dependence on such disturbances to complete their life cycle (Anderson 2005). For example, geophytes thrive in disturbed areas, where animals (including humans) are effective dispersal agents, detaching corms, aerating soil, preparing the seedbed, and thinning the plant population; many geophyte beds require periodic disturbance for long term survival (Anderson and Rowney 1999). Anderson (2005) suspects that some species may require thinning to maintain populations so that their cormlets don't overcrowd and perhaps exhaust nutrients. On the Northwest Coast people have been able to profit from this evolution, and have managed plants accordingly; many accounts of traditional resource users have said that plants "need" to be used in order to grow large, or in a manner desirable for consumption (Anderson 2005; Turner 2005; Daisy Sewid-Smith pers. comm. 2006; Tom Nelson, pers. comm. 2006).

Root management[8]

Because of their nutrition, abundance and successful management strategies, species with belowground plant growth were an important part of the food on the entire Pacific coastline. On the Northwest Coast, over 300 plant species were used for materials, foods and medicines, and of these about 25 species were root vegetables (Turner and Peacock 2005). In California, roots were second only to seeds in the traditional diet (Anderson 2005). High in carbohydrates, they were an important source of nutrition. Even salt marsh, or estuarine roots were used. Douglas Deur has described several examples of estuarine root food management on the Northwest coast, with evidence that they were cultivated with positive effects on both ecology and human society (Deur

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[8] Here 'root' is defined broadly, as below-ground plant growth.

2002a; Deur 2002b; Deur and Turner 2005). High use and cultural significance of the rhizomes and roots of springbank clover (*Trifolium wormskioldii*) and the Pacific silverweed (*Potentilla pacifica)* and other indigenous root vegetables, the Kwakwaka'wakw people developed sophisticated root cultivation and enhancement of these salt marsh plants to satisfy demand.

This is the setting for investigating the harvesting of eelgrass rhizomes by the Kwakwaka'wakw. Deur and Turner (2005) describe *tending* as the minor modification of environments to encourage growth of naturally occurring plants in situ, and this is the term I have used to characterise the traditional harvesting of eelgrass. The *keeping it living* philosophy, especially with respect to root and estuary gardening, suggests it is likely that the harvesting of eelgrass by First Nations would have been done sustainably, and would aim to improve the eelgrass meadows for future harvesting. From the perspective of autecology, Chapter 3 explores why eelgrass is a strong candidate for responding to traditional harvesting disturbance in a positive way. For the remainder of Chapter 2, I explore the relationship between humans and *ts'áts'ayem* (*Zostera marina*) in the Kwakwaka'wakw world.

2.2 Ethnoecology objectives

Building on this background of Kwakwaka'wakw harvesting of plants, my objectives for this ethnobotanical study were:

1) to gauge the cultural significance of eelgrass by documenting *ts'áts'ayem* gathering locations, harvesting and preparing practices and traditions from contemporary Kwakwaka'wakw elders through interviews and harvesting expeditions;
2) to determine whether *ts'áts'ayem* was harvested within a *keeping it living* ethic of traditional Kwakwaka'wakw harvesting;
3) to determine whether elders (who were familiar with eelgrass meadows in decades past) observed differences in contemporary eelgrass condition;
4) to determine why *ts'áts'ayem* is no longer harvested today.

A note on orthography: several Kwak'wala systems and symbols of writing have been used in the literature. For interviews and contemporary spellings I have used commonly accepted spellings as well as the recommendations of language specialist MayaniŁ, Dr. Daisy Sewid-Smith, for spellings and us of the Island font for Kwak'wala (international phonetic alphabet symbols and Umista symbols). For words researched in the literature I maintain spellings from original texts.

Kwakwaka'wakw consultants were my primary source of information in this study. I have cited them as I would cite academic sources, with footnotes on the details of the documented personal communication.

2.3 Ethnographic Research Methods

Study Area

The territory of the Kwakwaka'wakw is diverse geographically and ecologically: mountain chains cut by deep inlets, and thousands of islands, large and small. Their territory stretches up from the South of Quadra Island and Campbell River, through

Discovery Passage along the eastcoast of Vancouver Island across to the inlets of the mainland. It is clear why the main mode of transportation was ocean-going canoes (Boas 1966). The Kwakwaka'wakw roam throughout Johnstone Strait and the Broughton Archipelago, out Queen Charlotte Strait and Sound, and around around the North tip of Vancouver Island to the westcoast and Quatsino Inlet. This territory stretches across four of the designated marine ecosections in BC: Johnstone Strait (a vital migration corridor for salmon and whales, full of rich invertebrates), Queen Charlotte Strait, Queen Charlotte Sound on the northern end of Vancouver Island, and the Vancouver Island shelf off the westcoast of Vancouver Island (Cannings et al. 1999). The marine environment was and is still, essential to Kwakwaka'wakw culture. The inlets, intertidal zones and estuaries are exceptionally rich marine ecosystems from which food, spiritual connections and vast wealth has been obtained -- from seals and halibut to seaweed and kelp, from shellfish and octopus and salmon to estuarine root vegetables and herring roe on kelp, crabs and eelgrass.

The coast is marked by a heavy rainfall, and the territory is considered part of the Coastal Western Hemlock Biogeoclimatic Zone with an average rainfall of 178 to 660 cm (with the exception of the Likwakdawx territory in the Coastal Douglas-fir Zone, which is warmer and drier). Parts of this territory are also considered Subalpine Mountain Hemlock zone. While Pacific Coastal peoples have been largely considered as ocean-dependent, terrestrial ecosystems were, and are, critically important as well. Almost every tree and shrub and a host of other plants in their environment were named and used by the Kwakwaka'wakw (Turner and Bell 1973). It was the use of the many resources from the land – western red-cedar logs for dugout canoes, stinging nettles for making nets and fishing line, and western hemlock for twisting eelgrass – enabled people to use the marine resources.

My research area is the scope of the Kwakwaka'wakw territory on Vancouver Island and the mainland, with a few sites beyond (see Figure 2.3, on page 40). Today most of the old Kwakwaka'wakw village sites are not inhabited, and modern towns dot the Northeast coastline of Vancouver Island. Fishing and logging industries have declined. However pulp mills are still a main element of the economy, and fish and shellfish farms are a new growth industry in the area. Despite modern industrialization the area is still rich in marine life, from shellfish to salmon, which people still depend on.

Interviews

I conducted interviews in person and over the telephone with First Nations consultants, and conducted harvesting expeditions to several locations with elders who had harvested eelgrass in their younger days. Consultants came from a number of different Kwakwaka'wakw communities, with the majority from Alert Bay, Campbell River and Cape Mudge (communities are listed in Table 2.1).

Firsthand experience harvesting, preparing or eating eelgrass were the primary criteria for selecting consultants for interviews; however a few individuals who had only witnessed or heard of eelgrass harvesting were questioned as well; experience with *ts'áts'ayem* is noted in Table 2.1. Building from contacts known by my primary consultant and advisor, Chief Adam Dick, as well as personal contacts of my own, selection of participants was based on the Snowball method, a chain referral sampling often used for 'hidden' or 'hard to reach' populations difficult to identify (Faugier and Sargeant 1997). In Snowball sampling, interviewees are asked to suggest other individuals they know who might know about the subject; these contacts are then approached to become participants in the study, enlarging the sample size.

I contacted consultants by phone, asked if they were interested in participating, and provided a letter of informed consent or verbally informed about my study. I asked permission prior to any questioning, and at the end of the study, I wrote up the information they had contributed to my thesis and sent it back to them for their approval and consent to use this information. Interview protocols were approved by the University of Victoria Human Research Ethics Committee (see Appendix A for letter of informed consent and interview schedule). In my thesis, for individuals where the publication of names was not desired, they have been referred to as 'a consultant.' Names have been withheld to maintain privacy. However, when possible without stress to the participant, I have included their names in the text to credit the sources of my information.

Interviews were conducted from November 29th, 2004 to September 30th 2006, and lasted between 30 minutes and 2 hours, depending on the consultant's experience with eelgrass. I recorded interviews by taking notes and usually, with permission, using a Sony HiMD Minidisc recorder. Interview locations varied: in a classroom at the University of Victoria, in home settings, in the field during the harvesting expeditions and several over the telephone. Often a second interview was more informative; some elders had not heard Kwak'wala words for eelgrass spoken for many decades and a period of time after an initial discussion helped jog their memories.[9] Harvesting methods (including tools, timing, protocols), how eelgrass was prepared and eaten, and where it was harvested were the focus of my questions (see Appendix B for Interview schedule). Harvesting locations and the field methods for harvesting eelgrass were determined through the interviews and by practical logistics and accessibility. Harvesting field work was the most informative, as elders conducted many unspoken actions during the harvest, and many memories were triggered by the activity.

My primary teacher and consultant was Kwakxistala, Clan Chief Adam Dick. Growing up in the village of Kingcome Inlet he was not sent to residential school, and was trained instead by the elders to be a traditional Potlatch Speaker and keeper of traditional knowledge. He was my only consultant who recalled the complete harvesting process of *ts'áts'ayem* from the harvesting of the *k'elpaxu* pole to the peeling and eating of the rhizomes, as well as words, stories and songs connected to the plant. His knowledge and guidance facilitated a major part of the *ts'áts'ayem* ethnobotany field research and is the source of much of the information presented in this study. MayaniŁ, Dr. Daisy Sewid-Smith, is a trained Potlatch Recorder and language specialist and Kwak'wala teacher. As well as recalling the process of harvesting and processing eelgrass, her expertise and knowledge of Kwak'wala have made a major contribution to my understanding of the research material. Her re-transliteration of Boas and Hunt's 1921 sections on gathering and peeling eelgrass is significant work that deserves full analysis and interpretation; it is included in this project as Appendix C.

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[9] For example I called Ethel Alfred, 94 years old, in Alert Bay on March 10th, 2005. She remembered gathering eelgrass, but not the Kwak'wala words I used to describe the practice of harvesting it. Soon after, on March 25th, I visited her at Victoria General Hospital. She had been thinking about eelgrass since we spoke on the phone and started talking about the *ts'áts'ayem* and the *k'elpaxu*. They had remembered themselves to her, and in this second conversation, she referred to them with familiarity.

Field methods

Protocol for harvesting eelgrass and locations where it was harvested in the past, as well as where it would be appropriate to conduct an expedition, were determined through the interviews. Selecting, harvesting and preparing the *k'elpaxu* (eelgrass harvesting tool) was conducted with Adam Dick at his home in Qualicum Bay in March 2005, and without him but following his instructions in Tofino in April 2006, prior to eelgrass harvesting seasons. Research vessels were sponsored by DFO (Quatsino, Cormorant Island), Dr. Turner's SSHRC grant (Quadra Island), and courtesy of Gisele Martin (Tofino), and Stu Hardy (Comox).

Eelgrass harvesting expeditions were conducted at the time of the lowest tides of May. The Quadra expedition was video-documented by Aaron Szimanski and AquaCulture Productions, and underwater videography was conducted by Tina and Rebecca Wyllie-Echeverria. The Quadra, Quatsino, Tofino and Comox expeditions were documented by photographer David Strongman, and I personally photographed the Cormorant Island and Fort Rupert trips. Sample specimens from the Quadra and Quatsino locations were pressed and submitted to the UVic Herbarium; accession numbers are cited under 'site' in Appendix E.

2.4 Results

Consultants

Eighteen Kwakwaka'wakw consultants participated in this study (see Table 2.1); one recording of the late Emma Hunt was obtained (courtesy of her grandson Tom Child) and while she was not interviewed she has been included in the data of Table 2.1 and listed as a 'consultant.' Three non-Kwakwaka'wakw First Nations were consulted as well: two Nuu-chah-nulth consultants who recalled the use of eelgrass were interviewed, and one member of the Coast Salish Nation was consulted about his observations of eelgrass health. Kwakwaka'wakw interviewees' knowledge of eelgrass varied from only having witnessed it being eaten by their own elders, to those having seen and/or participated in the process from start to finish (harvesting the *k'elpaxu* through to eating the processed rhizomes).

Ts'áts'ayem sites and Harvesting expeditions

Two *ts'áts'ayem* (eelgrass) harvesting expeditions were conducted in May 2005, and four in May 2006. Figure 2.3 shows the sites visited, as well as locations found in the literature and referred to by elders that were associated with *ts'áts'ayem.* A total of 26 locations were found. Table 2.2 indicates the sources of the locations cited in this study.

Table 2.1 Kwakwaka'wakw Consultants for the study of *ts'áts'ayem*. (~ indicates no information available). *K'lina* is eulachon grease (*Thaleichthys pacificus*). Harvesting tools are recorded as consultants spoke of them.

Consultant	Gender	Age	Experience	Location	Timing	Harvesting Technique	Eaten at home?	Eaten with - ?	Last harvested	Learned about from
1	M	80s	Eating	Broughton Islands; Grassy Point; Hopetown	Associated with getting clams	*K'elpaxu*	Home	Plain	~	Mother and father
2	M	66	Harvesting; eating	Campbell River	Summertime	By hand	On site	~	~1960 (7, 8 yrs old)	Mother
3	F	94	Harvesting	Campbell River; Quadra Island	~	By hand	On site	No	~1924 (11 yrs old)	Mother
4	M	77	Kelpaxu harvest; harvesting; eating	Grassy Point	May (May 24th weekend)	*K'elpaxu*; by hand	On site	*K'lina* (eulachon grease)	1960s, '70s (adult)	The 'Old ladies'
5	F	70	Harvesting; eating	Grassy Point	May	*K'elpaxu*	Home	*K'lina*	1952 (15, 16 yrs)	Grandmother
6	F	94	Harvesting; eating	Grassy Point; Nimpkish River	~	Long pole	Home	*K'lina*	~1927 (under 16 yrs)	Grandmother; mother
7	F	70s	Harvesting; eating	Didn't remember	May	Twisting pole	Home	*K'lina*	~1970s (adult)	~
8	F	75	Harvesting; eating	Grassy Point; Alert Bay; Nimpkish River	May	*K'elpaxu*	Home	*K'lina*; sugar	~1957 (into her 20s)	Both grandmothers; aunt
9	F	86	Eating	Fort Rupert; Deer Island	~	*K'elpaxu*	Home	Plain	1928 (child)	Father
10	M	60s	Listening to harvesting accounts; eating	Fort Rupert	~	By hand	~	Plain	~	~
11	F	70s	Eating	Fort Rupert; Nimpkish River	~	~	Home	Don't know	~1945 (child)	Grandmother
12	F	72	Harvesting; eating	Gilford Island; Egisbalis	Halibut season	Long pole	Home	*K'lina*	~1943 (8, 9 years old)	Grandmother
13	M	Late 60s	Harvesting; eating; cutting to spear perch	Quatsino	Springtime, June	By hand; twisting a lingcod spear	Home	*K'lina*; raw; cooked	~1960s (adult)	Grandmother
14	M	72	Listening to harvesting accounts; eating	Topaze Harbour; Phillips Arm	~	By hand	~	Plain	~1942 (child)	Father, Grandfather

Table 2.1 Continued. Kwakwaka'wakw Consultants for the study of *ts'áts'ayem*. (~ indicates no information available). *K'lina* is eulachon grease (*Thaleichthys pacificus*). Harvesting tools are recorded as consultants spoke of them.

Consultant	Gender	Age	Experience	Location	Timing	Harvesting technique	Eaten where?	Eaten with - ?	Last harvested	Learned from
15	F	late 50s	Harvesting; eating	'little gap' near Village Island	~	by hand, picked on low tide	On site, in the boat	Plain	~1951 (5 yrs old)	Family
16	F	60	Harvesting; eating	Village Island, Bohn Sound	In spring, at the time of the 'sprouts'	Twisting an oar	On site	Plain	1953 (5, 6 yrs old)	Grandmother
17	F	~	Harvesting; eating	Alert Bay	~	~	At home, outside	~	~	~
18	F	~85	Harvesting; eating	Tsulhgwadees, near Village Island	~	Twisting a pole from a dugout	~	*K'lina*, sugar	~1932 (10, 11 yrs old)	Mother

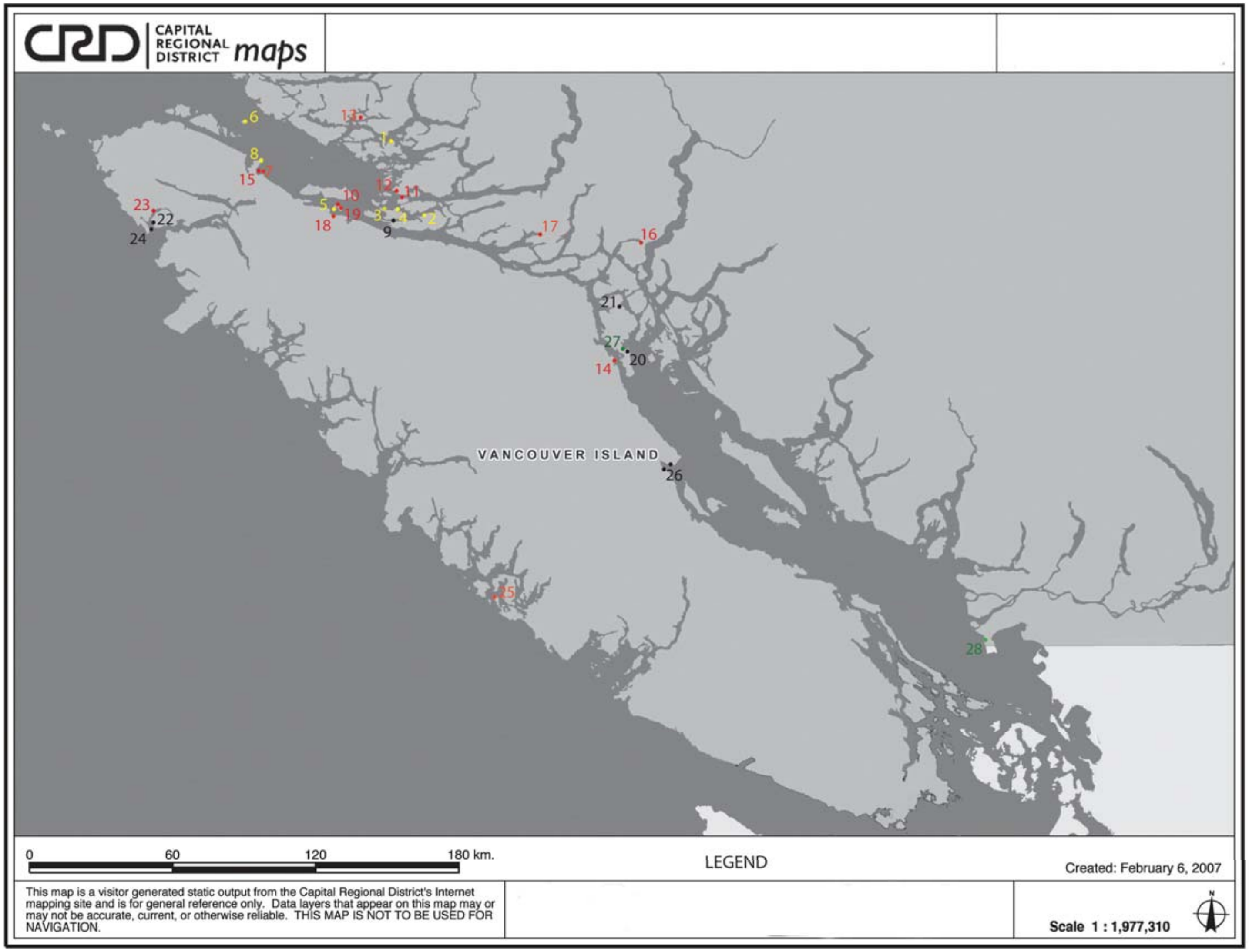

Figure 2.3 Map of specific *ts'áts'ayem* sites. Numbers 1-9 (yellow) are sites listed in the literature; 10-19, 23 (red) are sites listed by consultants; 20-26 (black) are sites visited during this study (Exped); and 27, 28 (green) are the two harvesting experiment sites (Chapter 3).

Table 2.2 Legend to Figure 2.3 indicating site numbers, initials of names of sources of eelgrass locations. 'Exped' indicates the site was visited for this project on a harvesting Expedition.

Site #	Name	English translation	Source
1	ts!āyadē[c]	Having eelgrass	Boas (1934) Map 10.60
2	ts!āyadē[c]	Having eelgrass	Boas (1934) Map 14.110
3	Ts!ä'dē[c]	Having tides, or, Having eelgrass	Boas (1934) Map 11.52
4	Ts!ā'ts!ēsnōkumē[E]	New Vancouver	Boas (1934) Map 11.41; Duff (1960)
5	k·!E'lbadē[c]	Having twisting (of eelgrass)	Boas (1934) Maps 8a.74, 11.33
6	k·E'lx·Ela	Spinning around	Boas (1934) Map 6.41
7	ă[E]wa'gawa[E]lis (on Deer Island)	Passage between islands	**Boas (1934) Map 6.46; SS**
8	dE'mxadē[c]	Having white eelgrass	Boas (1934) Maps 6.134, 6a.31
9	Ë'g·isbalis	Sandy beach at point	Boas (1934) Maps 11.10, 8.28; DN
10	Wā'wałExts!a	Trying to go aboard. Known as Grassy Point, Cormorant I.	Boas (1934) Maps 8.17, 8a.73; AD, DSS, CD, EA, GC, HB, EH LA, Exped
11	Mimkwamlis	Village Island	MM
12	Gwayasdums	Gilford Island	DN
13	Hegam's	Hopetown	CD
14		Campbell River	RD, DD, EC
15	Tsa'xis	Fort Rupert	AH, GH, Exped
16		Phillips Arm	DB
17		Jackson Bay	DB
18		Nimpkish River	HB
19	Yalis	Alert Bay, Cormorant I.	HB
20		Heriot Bay, Quadra I.	Exped
21		Waiatt Bay, Quadra I.	Exped
22		Forward Inlet	Exped
23		Koprino	TN, Exped
24		Kayne's peninsula	Exped
25		Tofino	JM, Exped
26		Comox	Exped
27		Hyacinthe Bay, Quadra I.	Experiment 1
28		Tsawwassen	Experiment 2

2.4.1 Cultural significance of *ts'áts'ayem*

2.4.1.1 *Ts'áts'ayem* in the literature

Eelgrass is *ts'áts'ayem* (pronounced ts'aht-ts'ah-yem) in Kwak'wala, and the harvesting stick is a *k'elpaxu* (pronounced kil-ba-yu), as written in the Boas and Hunt (1921) *Ethnology of the Kwakiutl*, and confirmed by contemporary elders in this study. An important clue to the importance of eelgrass in the Kwakwaka'wakw world is in the Boas and Hunt *Ethnology of the Kwakiutl*, 1921 (provided in Appendix C). In this text, a Kwakwaka'wakw consultant described to George Hunt the man's task of making the pole for gathering eelgrass, the woman's task of harvesting the eelgrass, and how it was eaten. The pole was made from a curved, flexible hemlock sapling (*Tsuga heterophylla*). All the bark was stripped and the pole was taken home to be worked with deer tallow over the fire because "he wishes it to be brittle and stiff" (156). The actual harvesting of the eelgrass is also documented; this was a woman's task. "When winter is passed, then all the women get ready to twist eelgrass…" (510). On the spring tide a woman would take her 'eelgrass gathering canoe' and the 'eel-grass twisting stick' that her husband had fashioned for her to a place where she knew the eelgrass was thick and the sediment sandy. She would secure the vessel with a cedar bark rope attached to a stone anchor. In this record, it is implied that each tool she used—the boat, the paddle, the hat, the stick—was made specifically for eelgrass harvesting. She would push the twisting-stick into the water and twist it until she couldn't twist any more, then pull it up. In the canoe she would prepare the eelgrass by taking a 'span' of eelgrass around the roots.[10] The woman would rinse the eelgrass off in the saltwater, folding it into two spans,[11] then break off the top leaves and throw them away. This process would be repeated with more eelgrass until the tide came up, then she would paddle home to her husband with her harvest. Upon arrival she would call to her husband to invite 'his tribe' to come 'peel' the *ts'áts'ayem*. The husband would prepare the house for guests, spreading eulachon oil [*Thaleichthys pacificus*] dishes out beside mats to sit on. Once the tribe was assembled,

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[10]Helen Codere (1966b) writes about a 'short span' and a 'long span' as Kwakiutl measurements: the short span is from the thumb to the tip of the index finger, the long span is the full stretch of the hand. These, as well as finger widths, she writes, were considered a standard measurement (18). Daisy Sewid-Smith further explained (see section 2.4.1.3).

[11] Two elders from Alert Bay remembered this practice.

the young men were asked to go down and collect the eelgrass from the canoe and bring it up to the house and put in front of the other men. They would sit four to an oil dish and each guest would pick up four pieces (shoots) of eelgrass and take off the small roots. Then on each shoot they peeled off the outer leaves down to the soft inner leaf parts. When each piece had been peeled like this they were lined up and torn to the same length, then torn again to make eight pieces. These eight pieces were then twisted together into a little bundle and dipped into the eulachon oil and consumed.[12] Afterwards the men would take their leftover eelgrass home to their wives in their respective houses. "That is the eel-grass peeling feast given to many tribes, *for it is the food of the first people in the time of the first Indians of the mythical period. Therefore an eelgrass feast is a valuable feast given by a man"* [italics added for emphasis].

This description indicates great cultural importance of eelgrass for the Kwakwaka'wakw in traditional times. The final statement is especially intriguing: that eelgrass was a food of the mythical first people indicates it was highly culturally and perhaps spiritually important, and very valuable for the status of a man.

This account provided a beginning framework for my questions and research about eelgrass harvesting and use. However it raises many questions about exact methodology of harvesting and eating, the timing of harvest, locations of harvest, extent and amounts harvested, and especially the mythology surrounding this 'food of the first peoples.' As I interviewed elders, I also noticed some small differences between contemporary elders' protocols and the Boas-Hunt record. The English translation in *Ethnology of the Kwakiutl* by Boas and Hunt (1921) is accompanied by the original Kwak'wala transcription. Familiar with the fact that meanings often get lost in translation, Dr. Daisy Sewid-Smith, a Kwak'wala language expert, re-transliterated the original Kwak'wala from this text for comparison with the English version they presented in 1921. The entire re-transliteration is presented in Appendix C. Daisy's re-transliteration contains many interesting discrepancies from the Boas-Hunt English translation. A full analysis of these differences, to give detail to the ethnobotany of

[12]When the plants were collected and peeled for this study, it was apparent that eight pieces of eelgrass bundled together would have in fact made quite a large bundle, and this quantity eaten at once might not be accurate, as this would be challenging to dip and eat.

eelgrass, and as a case study of the challenges and mis-communications of ethnography, recording and research, is very necessary in the future.

2.4.1.2 *Ts'áts'ayem* protocols

Practices of harvesting and eating *ts'áts'ayem* are not widely remembered. Some consultants remembered eelgrass from when they were children or youths, 30-60 years ago. Several contemporary elders recalled it was only the "old people" who gathered eelgrass when they were young children. As noted previously, my primary consultant, Chief Adam Dick, was the only source of a complete, first hand account of the process from start (making the tool (the *k'elpaxu*) for twisting) to the finish (the way to peel and eat *ts'áts'ayem*). He harvested it into the 1960s and '70s; he and his family would stop and get *ts'áts'ayem* from their fishing boat on their way home to Kingcome Inlet.[13] His account of *ts'áts'ayem* gathering is the most recent reported to me. By the time I began fieldwork in May 2005, harvesting *ts'áts'ayem* was something that no one had practiced in several decades.

Zostera marina is phenologically flexible, and there is much debate as to how to distinguish whether different phenologies between populations are due to environmental factors or or to genetically distinct variants, or ecotypes. Consultants said that the *ts'áts'ayem* they used to harvest had wide leaves and large rhizomes, and based on their descriptions could be of the ecotype *Z. marina phillipsii* or perhaps even *latifolia*, according to Backman's key (1991). However, to confirm this, further study of distinct variants is needed: identification of different types by elders as well as an in depth survey of the variants from locations which were historically harvested. In this study I do not distinguish variants within *Zostera marina*, but allude to the size of the specimen and comments from the elders. Appendix E does refer to possible variants of *Z. marina*.

Women's work

"My granny used to get it [*ts'áts'ayem*]. My mum and granny were great for going out. They taught me lots about it"[14] (Ethel Alfred).

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[13] Adam Dick, November 29th, 2004.
[14] Ethel Alfred, March 10, 2004

Twelve of the 17 consultants in my study learned about *ts'áts'ayem* from their grandmothers, mothers, or aunts. In our contemporary elders' generation however, men harvested *ts'áts'ayem* too. While it was the older women's initiative, as a boy Adam Dick would row them out and twist the eelgrass up for them to eat in the boat. Helen Beans recounted, "Daisy, Dodo, Alvin, Stevie, Herman, everybody used to go. It was something we used to like doing. We used to go out on an outboard."[15] Tom Nelson used to harvest it for food and also cut a swath of leaves out in order to create a channel to catch the fish, as per his granny's instructions. Daniel Billy said that he heard that in Phillips' Arm, where the eelgrass is deeper, young boys who were good at swimming would be sent to dive for it. His grandfather used to gather it in Topaze Harbour. Sarah Sampare's father was the one who would head out in the boat to get it near Fort Rupert.

Timing

All the consultants remembered that *ts'áts'ayem* was harvested in the spring, and four consultants specified the month of May as the time for harvest. Adam Dick and his family used to get it on Cormorant Island when they left Kingcome Inlet and came for the May 24th Sports Day at Alert Bay. Beyond May the rhizomes become woody and stringy, and according to Helen Beans, "they lose their taste when they get too big."[16] On the colder West Coast in Quatsino, where the growing season may begin slightly later: Tom Nelson recalled harvesting eelgrass into the month of June.

In the second field season (2006), harvesting expeditions for this study took place from May 1 in Tofino through to May 31st in Fort Rupert. Throughout this timeframe the eelgrass rhizomes harvested were generally sweet and tender. At the end of the season, on Cormorant Island on May 29th, while the eelgrass was still sweet, the rhizomes were already becoming slightly fibrous. This was surprising, as our timing was relatively synchronous with when Adam would have harvested it in the past - the May Sports Day was always on the 24th.

[15] Helen Beans, June 21, 2006
[16] Helen Beans, June 21, 2006

Conditions for choosing harvesting location

"They didn't go in the rocky, not in a hard place, rather the soft sand"[17] (Sarah Sampare). In general, people associated eelgrass with sandy beaches or sandbars, and often with crabs and cockles. While he had not harvested it himself, Charlie Dawson knew it grew in shallow, sandy places, and mentioned a connection to clam digging grounds—his parents would go out for eelgrass when they went to dig clams in the Broughton Archipelago[18]. It was associated with crabs; Daniel Billy said, "wherever there is a river, where they get crabs, there's eelgrass. …Wherever there's crabs you'll find it." [19] Helen Beans talked of going to the Nimpkish River to get crabs, "but we kind of forgot about the crabs when we saw the eelgrass."[20] One elder used to gather eelgrass at '*Egisbalis*,' a sandy beach. She did not recall exactly where it was, but there are several *Egisbalis* listed in Boas' *Geographical Place Names of the Kwakiutl* (1934).

But people were careful to explain that it's not just *any* sandy beach where you can harvest eelgrass. Adam Dick instructed, "You can't, there's only certain places where you can get the eatable ones. They're not all eatable, that eelgrass. You have to know that."[21] Helen Beans confirmed: "it's [eelgrass] usually the places where it's sandy, not every place though." One of the conditions for harvesting eelgrass is that it is free of epiphytes (organisms that grow on the leaves like algae, barnacles, and diatoms).

> And it's only in certain places you can get the clear *ts'áts'ayem*. You know, those ones that we see when we went out with Donna [Stauffer] and them, they were brownish colour with a lot of fuzz [epiphytic growth] on them. And we don't touch that. Just the green ones, very clear… … *ts'áts'ayem*'s about that long, about a foot and a half to two feet. And it's got to be real clear green. That leaves.[22] (Adam Dick)

[17] Sarah Sampare, May 31, 2006
[18] Charlie Dawson, October 10, 2005; one consideration with this comment however, is that clams are usually harvested in wintertime, while eelgrass is season is May.
[19] Daniel Billie, June 20, 2006
[20] Helen Beans, September 18, 2006
[21] Adam Dick, November 29, 2004
[22] Adam Dick, November 29, 2004

Methods of harvesting ts'áts'ayem

Technique 1—harvesting with the *k'elpaxu*

> …in the big tides we'd just go out on the beach and pick it, if it happens to be a big [low] tide when we're out there, a big runout they call it. But if not we'd use a pole. They called it *k'elpaxu*, 'cause you *k'elpa*, you're twisting the pole. It's got to be at least about 12, 14 feet long.[23]
> (Adam Dick)

While not everyone remembered the Kwak'wala term for this harvesting tool, ten of the consultants described using a long tool to twist eelgrass. Harvesting at Grassy Point on Cormorant Island, Ethel Alfred recalled, "you have to have a long pole and swing it up, just go out in a canoe"[24]. Helen Beans also harvested *ts'áts'ayem* from Grassy Point: "they had a pole, a two pronged pole, they used to stick it in the sand. …you shake it off the pole, then you eat it. We used to have a basket full, you know the old fashioned baskets"[25]. She was the only elder who mentioned a "two pronged pole," and I was not able to clarify details of this tool. Some elders who used a twisting stick did not remember the Kwak'wala word for it, but five of them recognized the word *k'elpaxu* after it was mentioned.

Making the *k'elpaxu*

Adam Dick was the only consultant who knew how to make the *k'elpaxu* to twist the eelgrass, and demonstrated how to do it on March 28th, 2005. We drove up the road behind the Big Qualicum Hatchery between Horne Lake and the Inland Highway. Saplings along the forest road and growing in the shade, with few branches, and slow growing were scrutinized for the dimensions that were "just right," according to Adam's specifications. This translated into a hemlock sapling about 5 cm in diameter and of about 370 cm tall. Adam said a red cedar sapling would also be acceptable. He said that the tall but skinny saplings that are perfect for a *k'elpaxu* must not be collected from an

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[23] Adam Dick, November 29, 2004
[24] Ethel Alfred, March 10, 2005
[25] Helen Beans, June 21, 2006. Identification of this kind of 'pack basket' is an important study to further help estimate amounts of eelgrass removed.

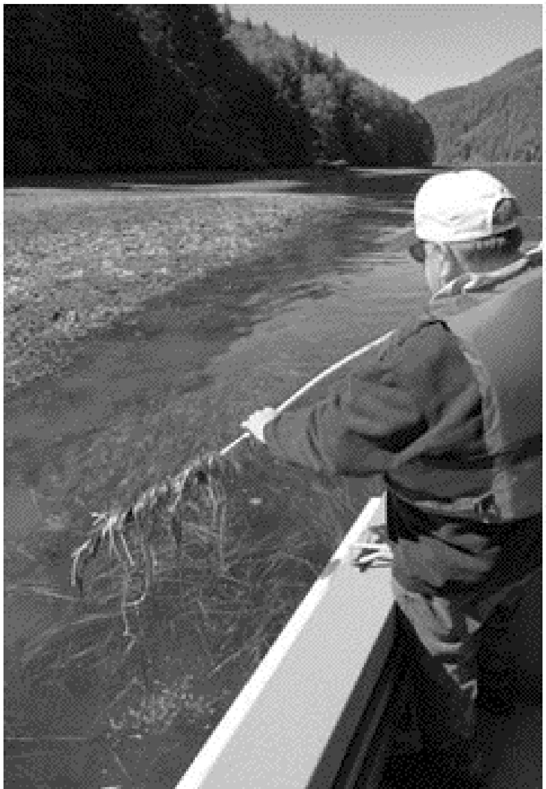
open clear-cut or place with a lot of sun but *inside* the forest—these saplings are shaded by trees, and grow slower but stretch up to reach the sun, and as a result are thinner.

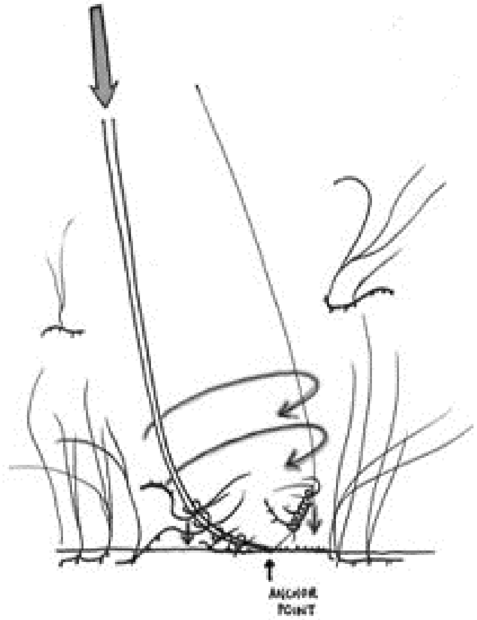
Two saplings of western hemlock (*Tsuga heterophylla*) and one of Douglas-fir (*Pseutosuga menziesii*) were cut down with an axe. The fir was gathered as a comparison. On site Adam used a hatchet to cut off the branches. The denuded saplings were put on the roof of the car and taken home where they were further processed. At home in his garage, Adam shaved off the bark and rough edges from the branches with carving tools, and the poles took on the look of tools. These stripped *k'elpaxu* were 352-362 cm tall, and were left in the garage to dry out and await the *ts'áts'ayem* harvesting time in May. Adam said these implements were used again and again over the years. We used these three *k'elpaxu* throughout the first field season and they were usable into the second summer. Following Adam's process, I harvested two *k'elpaxu* poles outside of Pacific Rim National Park near Tofino at the beginning of the second field season, on April 29th 2006. As Adam had indicated, the saplings of appropriate dimensions were found between forest and a large rock bluff that shaded it (near the old radio tower); one cedar (*Thuja plicata*) and one western hemlock were harvested.

Using the *k'elpaxu*

Twisting the eelgrass with the *k'elpaxu* was prominent in the interviews, and the tool was essential at the locations on Quadra and Comox as the meadows were inaccessible by hand. The first harvest was conducted May 8th, 2005 off Quadra Island with Adam Dick and Daisy Sewid-Smith. Kim Recalma-Clutesi, Dr. Nancy Turner, Dr. Sandy Wyllie-Echeverria and his family, David Strongman and cameraman Aaron Szimanski of Aquaculture productions also participated in the excursion. Off Heriot Island Adam put the *k'elpaxu* in the water, pushed it down to the sediment and began to twist. After a few moments the tool was swung towards the surface, and several strands of eelgrass were wrapped around the flexible end. At this location very little eelgrass of *Z. marina* of the *typica* variety came up; on a good twist only about 5-6 small plants would be on the tip, and often the leaves had ripped off from the rhizomes, resulting in little edible matter on the *k'elpaxu*. These plants were not satisfactory to Adam or Daisy—they were not large enough and the bed was not dense enough for the tool to be properly effective. The second location in Waiatt Bay, where the eelgrass plants were much larger and had a higher density, so here more plants twisted up at a time, about 8-10 ramets (shoots with rhizome and associated roots), Figure 2.6. The quantity of eelgrass removed with the *k'elpaxu* depends on the size, length and density of eelgrass and also the sediment type; if the plants are rooted too securely the leaves rip off and no rhizomes are obtained.

Field comparisons between the Douglas-fir and hemlock *k'elpaxu* revealed why hemlock is the more desirable sapling for making *k'elpaxu*: the unique flexibility and curvature of the top of hemlock trees is essential for the eelgrass to wrap around the end of the tool. The fir *k'elpaxu* did not have much flexibility at all, and the eelgrass leaves did not gain purchase on the stick at all to be pulled up and swung to the surface. This indicates an area of question in the Boas account of making the *k'elpaxu* to make it "brittle and stiff"—this would actually be an undesirable trait in a *k'elpaxu*.





Clockwise from top left:
Figure 2.4 Adam Dick uses the *k'elpaxu* to twist eelgrass in Quatsino Sound, 2005.
Figure 2.5 Diagram of the *k'elpaxu* action: the large arrow pointing downward denotes the pressure from the harvester on the surface of the water above; the smaller arrows pointing downward indicate the resulting flex in the tool which enables the plants to wrap around it as it is twisted from above.
Figure 2.6 The results of the *k'elpaxu* in the dense beds of Quatsino: coils of *ts'áts'ayem*.

Technique 2—harvesting by hand

While Boas (1921) described using a *k'elpaxu*, a "twisting stick", from a canoe as the only way of harvesting eelgrass ("Now, that is all that is to be said about eelgrass, for there is only one way of eating it and harvesting it"[26]), my consultants said that what harvesting technique is used depends on tide, location and timing. In some locations, eelgrass is always subtidal, and only reachable with the use of a long tool. In other locations, however, eelgrass meadows are exposed at average low or extreme low tides (as occur annually in May), and on these occasions people would walk down and pick it in a few inches of water. Six consultants described picking it by hand in this way. Adam Dick mentioned picking it by hand on the "big runouts" (extremely low tides), but did not emphasize this method since most of the time they had to use a *k'elpaxu* because these big tides did not usually fall on the dates when he was in Alert Bay (ie., the May 24th Sports Day).

Daisy Sewid-Smith informed me that for her elders it was important that the plants weren't dried up when they were being harvested; there was a taboo against getting the plants when they were dry and exposed to the air. "The old people don't consider it good when it's dried up. …I don't know, they just don't consider it healthy, it's the ones in the sea that's preferred." When I asked her if you could pick it when the tide was low, she repeated, "…I know that the old people considered it dry if you do that. They prefer it coming out of the sea."[27] Possible biological rationales for this are discussed in Section 4.3. When we began to pick it by hand on the low tides around Quatsino, Tofino, Comox, Cormorant Island and Fort Rupert where the eelgrass was exposed, it was obvious that picking the plant in shallow water was more productive than in dry sand where the rhizomes of the plants would break off and were very difficult to dig, as the sand was compact and hard. But in a few centimeters of water, one could loosen the plant in the sand with the fingers and remove the rhizomes without them breaking off, which corresponds with how people recalled harvesting the plant at low tide, in a few inches of water.

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[26] Kwakiutl consultant in Boas and Hunt (1921)
[27] Daisy Sewid-Smith, January 9, 2006

At Quatsino Sound, Tofino, Comox, Grassy Point, and Fort Rupert it was possible to gather eelgrass by hand on the lowest tides (Figure 2.7). Hand picking proved to be a very effective way of harvesting, as the harvester can be selective and one can remove only the biggest plants with the large rhizomes (Figure 2.8). When picking eelgrass by hand, however, one must remove one plant (shoot and rhizome) at a time. Cleaning and peeling eelgrass rhizomes is quite effort – and time – intensive, so it is most desirable to pick the biggest plants to warrant the effort. Plants to harvest were selected based on size and health (bright colour of eelgrass leaves, absence of epiphytes), as per Adam Dick's instructions. When harvested by hand, thinning at a selective, individual plant level occurs naturally.

Thus, both techniques promote a patchy method of harvesting – removal by hand tends towards a selective removal (possibly thinning), and the *k'elpaxu* removes plants in small bunches, but its harvest will never be very concentrated in one area (complete removal of eelgrass from an area with the k'elpaxu would be impossible). *Zostera marina* morphology is flexible, and different conditions produce different growth forms. Method of removal depended on location – how often the eelgrass was exposed, how long the low tide lasted, and how large the plants were.

Figure 2.7 Gisele Martin, Jen Pukonen and Severn Cullis-Suzuki gathering *ts'áts'ayem* by hand on the sand bar in front of Tofino and Opitsaht; sand bar accessed by Gisele's Nuu-chah-nulth canoe, 2006.

Figure 2.8 Handful of rhizomes gathered by hand at Grassy Point, Cormorant Island, 2005. These rhizomes were as Adam Dick remembered from his youth.

Processing ts'áts'ayem

Eelgrass rhizomes were a fresh food, frequently eaten right away at the site where they were gathered; five of the elders recalled this and spoke of rinsing the rhizomes in seawater and eating them right after harvesting. Ten of the elders spoke of taking them home to prepare right away. Eelgrass was known as a food that was to be eaten immediately. Adam Dick recalled that you would only harvest "just what you wanted to eat, you can't keep it overnight. If you keep it overnight it dries up. You know if you don't water a flower, what does it do in the pot? That's exactly what happens to *ts'áts'ayem* when you keep it overnight."[28] Later he explained further "…if you want to keep it a couple days you have to wrap it in something that you soak, soak this blanket, wrap it up so it doesn't get dried out overnight… but most of the time, 99% you got ta eat it right away."[29] Another elder commented on this as well, "you couldn't save it, you had to eat it right away. You just picked and then you just left it in the boat and people just came along and grabbed what they needed."[30]

Because of this, large amounts of eelgrass for storage were not taken. Sarah Sampare recalled, "He'd [my father] bring home just enough for the family, not too much, not hoard it. That was how we did it with all the resources." However, altogether, considerable amounts were harvested. Helen Beans would collect "…a basket full, you know the old fashioned baskets."[31] The basket of eelgrass would be taken to neighbours. Several elders from Alert Bay mentioned eating "…a whole meal of it," [32] or "a whole plate of it."[33] Assessing the volume of these amounts could aid in estimating amounts of eelgrass harvested by a Kwakaka'wakw community.

Peeling

"Then at home he'd [father] just wash it really good, clean off these [rootlets]. The ends [leaves] are not edible. You peel off the leaves, go to the softer part, the better

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[28] Adam Dick, November 29, 2004
[29] Adam Dick, November 29, 2004
[30] Consultant 16, September 21, 2006
[31] Helen Beans, June 21, 2006
[32] Consultant 7, February 27, 2005
[33] Ethel Alfred, March 10, 2004

part, like the green onions. Then you wrap the leaves around the root like that"[34] (Sarah Sampare).

> *Ts'áts'ayem's* about that long, about a foot and a half to two feet. And it's gotta be real clear green. That leaves. That we peel it, there's roots on them. Then you peel that roots then you get two on the middle, when you peel all the outside ones, then you save those two on the middle ones, then you wrap it on its root, on its *ts'áts'ayem*, then you dip it in the *k'lina* [oolichan grease].[35] (Adam Dick)

Ethel Alfred made the same finger gestures as Adam Dick did in describing the process of preparing eelgrass to eat. On the boat during the first harvesting expedition off Quadra Island Daisy Sewid-Smith gave a demonstration of how to clean, peel and wrap *ts'áts'ayem*. Adam Dick gave a demonstration at home as well. From Daisy's and Adam's demonstrations, the processing of eelgrass was as follows. Plants were harvested from the sediment and rinsed in seawater, then the tops of the leaves were torn off. Once at home or where the harvester was about to eat eelgrass, they would take an eelgrass shoot and take off the white rootlets growing off the rhizome. Then they would peel off the leaves from the outer layer down to the innermost, 'silky' leaf—the newest leaf that was translucent and barely green (Figure 2.9 a). Daisy and Adam used the word *see'hya* (meaning to peel, also used for peeling other things) indicating how to strip to the silky part of the *ts'áts'ayem*[36]. It is quite difficult not to tear this thin leaf away when pulling off the outer leaves. This inner leaf, still attached to the rhizome, was then wrapped around the cleaned rhizome (Figure 2.9 b), producing a wrapped bundle (Figure 2.9 c). Adam and Daisy later remembered that the edible part of the rhizome was broken off after the first four internodes, in keeping with the number four as the sacred number.[37] A biological rationale for consuming only the first four internodes is discussed in Section 4.3.1, page 123. One elder from Alert Bay remembered her aunt bending the edible rhizome in half before wrapping it with the innermost (peeled) leaf. Daisy Sewid-Smith also recalled this practice.

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[34] Sarah Sampare, May 31, 2006
[35] Adam Dick, November 29, 2004
[36] Daisy Sewid-Smith and Adam Dick, February 2, 2006)
[37] Daisy Sewid-Smith, August 28, 2006

Figure 2.9 Adam Dick demonstrates how to peel *ts'áts'ayem* shoots (a, b, c, top to bottom): a) Peeling the leaves off down to the youngest, silky leaf; b) wrapping the leaf around the rhizome; c) the resulting bundles ready to dip in oolichan grease and eat.

Eating ts'áts'ayem

To eat it, Adam described dipping the eelgrass bundles in the *k'lina*, eulachon (*Thaleichthys pacificus*) grease, which his family always carried with them, even on their boat. Helen Beans dipped it in grease or in sugar: "[sugar is] a bit sweet, but sometimes we couldn't get grease. Some years there isn't any. They [eulachons] disappear now and then. Sugar is the next best thing. Same with sprouts [new salmonberry (*Rubus spectabilis*) and thimbleberry (*Rubus parviflorus)* shoots]."[38] Half of the elders who ate *ts'áts'ayem* dipped it in *k'lina* (see Table 2.1).

But Sarah Sampare liked it plain: "I didn't see anyone dip it in grease, but they might have. But my grandparents didn't. You didn't need to. It tasted so good."[39] In fact all the elders who remembered eating *ts'áts'ayem* spoke of eating it with gusto. Ethel Alfred declared, "We used to just love it. We'd clean a whole big plateful. We kids would clean the plate, it was just like candy!"[40] Gloria Hunt's granny would make a big plate of it: "She'd serve it on a plate, just served it with lunch like this watermelon. I really liked it. I can still taste it."[41] After harvesting eelgrass in Quatsino Inlet we prepared many eelgrass rhizomes to recreate a plateful of *ts'áts'ayem* these elders remembered from their childhood (Figure 2.10). Helen Beans was clearly very fond of eelgrass: "There is some around the old breakwater in front of St. Mike's [St. Michael's residential school in Alert Bay]. If you're really desperate for it you can wade out, if you're really craving it. I've done it."[38] Charlie Dawson kept repeating throughout the interview, "Oh yeah. I liked that *ts'áts'ayem*." Other accounts: "I used to love to eat it [*ts'áts'ayem*]… Geez I used to like that stuff. I don't know where you can get it anymore."[42] "I really liked it, it had a beautiful taste. …It used to be real big and juicy"[43] (Sarah Sampare). "Used to eat lots of that [*ts'áts'ayem*]. Oh yeah. Myself. It's something like, you know if you eat salted peanuts, you don't want to stop. You still want to have some, even if you don't want it you gotta have it. Same with *ts'áts'ayem*.

[38]Helen Beans, September 18, 2006
[39]Sarah Sampare, May 31, 2006
[40]Ethel Alfred, March 10, 2005
[41]Gloria Hunt, May 31, 2006
[42]Consultant 12, August 27, 2006
[43]Sarah Sampare, May 31, 2006

It's same with sea urchins too. You keep looking at one, oh, gotta have one. You don't stop until there's no more"[44] (Adam Dick).

Tom Nelson gave the only account of eating cooked eelgrass. In Quatsino, his grandmother would sometimes steam it: "That was our vegetable. …You know how you cook broccoli and asparagus and that? Same way. But she had no hollandaise sauce or anything to put on them!"[45] Instead they used *k'lina.*

In their peak harvest time, eelgrass rhizomes taste quite sweet and have a texture like celery but without the fibers. It is not salty at all; takes a dip in *k'lina* to bring out its taste of the sea.

Figure 2.10 A plate of peeled *ts'áts'ayem* ready to eat. Port MacNeil, May 29, 2006. (Cullis-Suzuki, 2006).

[44]Adam Dick, November 29, 2004
[45]Tom Nelson, January 9, 2006

2.4.1.3 Ceremony around *ts'áts'ayem*

No one could confirm or reject the eelgrass eating ceremony written about by Boas and Hunt (1921), but most ate eelgrass in their youth in an informal manner. In a recording from 1990, Emma Hunt summarizes the practices around *ts'áts'ayem*:

> We used to get a pole, and when the tide's low, there's lots around the point in Alert Bay. So we used to poke that pole down, and you just have to be quick at turning it, and you pull it and all that roots come out, and you'd lay it nicely in the canoe. Go home with a whole bunch. And of course we'd invite all the old people to come and have some. They used to have patios in the olden days. You might think we didn't but they did. All along Alert Bay, outside the big Indian houses. They'd be a, sun, you know where the sun, they'd fix the verandah like a sun porch where the old people would go, where the old people would sit.[46] (Emma Hunt)

This account indicates that in the not so distant past, *ts'áts'ayem* was gathered and brought home in amounts large enough for elders to eat in a manner not unlike the eelgrass feast recorded by Boas and Hunt (1921), described in Chapter 1 (Section 1.4.5).

Daisy Sewid-Smith helped clarify the Boas-Hunt account on bundling 'spans' of eelgrass. A 'span' was a measurement of the length of one's hand, and another 'span' was the measurement of the space between one's hands put together. Daisy said they would gather eelgrass and hold their hands together to measure a span, or bundle of eelgrass.

> …That's what they did. Me, I would just pack it up. … I guess it was so that it was evenly distributed, why they did that. And then too, it's just approximate. These measurements are approximate. Because I've got tiny hands, and my span would be different from a woman with long fingers, or a man, a man's hand. You know. And so it would depend on who's measuring it.[47] (Daisy Sewid-Smith)

They would arrange bunches of eelgrass to take home. "They would pile it up like cord wood. And then that's on, in the canoe, and that's what they would send those young teenage boys to go and pack up. And to place one bundle in front of every

[46] Emma Hunt, 1990
[47] Daisy Sewid-Smith, August 28, 2006

peeler."[48] Reference to "every peeler" indicates that people peeled *ts'áts'ayem* together, as was described in the Boas-Hunt record. Daisy Sewid-Smith said some people bundled the eelgrass, but this was a practice that was fading when she witnessed it. "They weren't as fussy as they were in the early days. They just used their eyes to see whether the bundle was enough. …They used to be really specific. They'd use, well, they measure everything. Counted everything. In the early, early days. Because they were, uh, quite fussy about numbers." Numbers were important because four was the sacred number. "And if you went past four you had to go to eight, and if you went past eight you had to go to 12. That's the way they were. …Well, that's the sacred number. All the dances are done four, songs are done four."[49]

On our way up to Quatsino on an eelgrass expedition, Adam Dick suddenly recalled a *k'elpaxu* song. By the time we arrived, he had forgotten it. One year later, in the eelgrass harvesting month he finally recalled the song, and we recorded it.[50] It was a song sung when one was going out to *k'elpa* the eelgrass.

2.4.1.4 Other associations with *ts'áts'ayem*

Despite the fact that elders today (and younger First Nations people too) are not getting out on the land as much anymore, people still strongly associate eelgrass with Dungeness crabs, cockles and herring; six of the 18 consultants associated eelgrass with at least one of these species. Several people spoke about the general ethos of not taking too much. Chief Hunt said "We'd go down to the beach and get cockles. You use a knife to cut through the [eel]grass and the sand to find them. We'd take just enough, not too much, it was just like the deep freeze."[51] Tom Nelson referred to not having a deep freeze as a child as a serious reason not to overharvest; his grandparents were very angry if too much food was brought home, and would go to waste.[52]

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[48] Daisy Sewid-Smith, August 28, 2006
[49] Daisy Sewid-Smith, August 28, 2006
[50] *K'elpaxu* song, Adam Dick, May 13, 2006. Archived as TAPE # AD 08, TRACK 14.
[51] Alfred Hunt, May 31, 2006
[52] Tom Nelson, January 2006

Ts'ápalees

In Kingcome Inlet, Charlie Dawson mentioned '*ts'ápalees*,' a very interesting word with the same root as *ts'áts'ayem*. "When it's low water, when it's time to change tide, and the *ts'áts'ayem* goes one way. *Ts'ápalees*" (Charlie Dawson, Oct. 2005). It was hard to question Charlie further as he was quite hard of hearing. Adam filled in the gap:

> *Ts'ápalees* -- when the tide changes and the water is near the bottom. You see them [*ts'áts'ayem*] change direction. They all lay down on the bottom of the ocean floor. When you see that, you know the tide is coming up and its time to *k'elpa*. You don't just *k'elpa* any time of the day. When the tide changes... that's when you go to *k'elpa*. *Ts'ápalees*—when the tide starts pushing, when they all lay to the south (or whatever direction). [But] when they stand up again, that's when you *k'elpa*.[53] (Adam Dick)

Ts'ápalees means when tide is running, either ebbing or flowing, and the current is strong enough to push the eelgrass horizontal. Eelgrass is not harvested during *ts'ápalees,* the harvester waits for the eelgrass to stand back up to harvest on the slack.

Later, Adam remembered a story about *ts'ápalees* and Matsah, the mink. He originally said it was a story about *ts'áts'ayem* and Matsah, but later corrected himself that it was Wawadi, the kelp (*Nereocystis luetkeana*), and Matsah. Daisy Sewid-Smith confirmed this.

> Yeah, the mink, the mink went down from the beach. And he proposed to the [*wawadi*], to get married. Cause "I reeeally wanted to marry you, cause I wanna, I wanna *ts'ápalees* with you," you know. And they said "Oh, <KWAKWALA>, you know, you can't breathe underwater." He said, "so I wanna marry you anyhow. I wanna go *ts'ápalees* with you." "Well, if you really want me to, I'll marry you." That's what the [*wawadi*] said to the mink. Matsah, his name was. Matsah, the mink. So, alright, they got together, and the tide was coming up, tide was coming up, he said "Come on, let's *ts'ápalees*. Come on, let's *ts'ápalees*!" And [*wawadi*] says, "No, not yet, it'll be too early. She said, "wait 'til <KWAKWALA >" --means half tide. When it's half tide. "Come on, let's *ts'ápalees*, let's *ts'ápalees*! I really wanna *ts'ápalees* with you!" Said "No, I can't *ts'ápalees* with you, we wait 'til half tide. But you have to pump lots of air into you, cause it's going to take us a long time, you know, when we *ts'ápalees*." Says "When you start run out of breath, you

[53] Adam Dick, November 29, 2005

> '*tehwee'*, you *tehwee*, my side like that, then I'll know you're out of breath now." And the mink says "don't worry about it, I'll be alright. Come on, let's *ts'ápalees*." "Oh my goodness. You don't wanna listen to me. Wait 'til half tide." "Oh come on, I really wanna *ts'ápalees*!"
> Then the tide came. *Hwoooh*. Then everything just went like this, you know, on the bottom. The tide pushed the kelps and everything. And the drifters went by. Then he started scratching the [*wawadi*], but [*wawadi*] wouldn't let go of him. So he let go himself, and then he floated up, then he drifted away. "I don't wanna marry you now," he says. "I don't wanna *ts'ápalees* with you anymore." So he drifted away.
> That's the story of the [*wawadi*] and the mink.[54]

Hunting perch in the meadows

Tom Nelson also gave an account of making a 'perch runway' in the eelgrass for hunting perch.

> What we used to do, at low tide, we'd go down there, and just clearcut the bottom, put a little trail in it, like a little runway for the fish to go through and just like a clearcut, you put a right-of-way through the forest. …You just go with a knife and cut it. And then we used to tie the knife onto our spear, and then you just use that, and just go down there and hack away, hack away on it. We used to just drop our anchor down, drop the anchor with a long rope on it, and just slowly put more line out, and then you know, Grandmother would just hack away on it, to make a path through the grass. And then, after that, you just wait a couple of days, and then you go back there, and here come all these little fish going through there. …When the grass, when it started standing up… just before slack tide, we'd go out there and just drop the anchor and wait for these fish to come into that, it's just like an inlet; cut that grass like that. And then all you did was just spear your perch. Cause the perch were a hard fish to get. [55]
> (Tom Nelson)

There is a depiction of a similar practice by the Coast Salish spearing salmon in a kelp channel cut by hunters in Hilary Stewart's book *Indian Fishing*. There is a drawing with the caption reading: "access channel is cut through kelp bed on a reef in the path of migrating salmon. Fisherman ties up canoe across channel, harpoons fish coming through by easiest route" (Stewart 1977, 73).

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[54] Adam Dick, December 17, 2005. Archived as AD 04, Track 2 (0:18--3:40min)
[55] Tom Nelson, January 9, 2006

2.4.1.5 *Ts'áts'ayem* harvesting locations

Locations cited in the literature (sites 1-9 in Figure 2.3)

There are several place names associated with eelgrass in the literature. These sites are mapped as numbers 1-9 in Figure 2.3, page 40. Boas' *Geographical Place Names of the Kwakiutl* (1934) lists over 2000 Kwakwaka'wakw names for sites around the northern end of Vancouver Island and the mainland; I found nine locations regarding eelgrass or twisting of eelgrass in the maps of the Broughton area. For one of these locations, *Ts!ā'ts!ēsnōkumē*^{E}, or New Vancouver, I found several different references for being associated with eelgrass. "T'sadzisnukwame' [New Vancouver]. That's sea grass. That was another good food. It's down under the water on the beach. You used to peel it. My husband used to go down with a pole and turn it around to pull it up with a root. And then clean it and put it on the plate and eat it with oolachen grease. There's just very few ladies know how to clean that. Maybe someday no one will know about that" (Consultant in Powell and Webster-Cranmer 1994, 10). The last sentence in this quote alludes to the awareness of the consultant of the dissapearance of the practice. Another reference to New Vancouver was found in Duff's (1960) unpublished paper: "About 1890 they [the Tenaktak] moved again, living for a time with the Tlawitsis at Klokwis, then building New Vancouver or Tsatsisnukomi 'eelgrass on point' [note written in on top says 'eelgrass on front'] on Dead Point, Harbledown Island (Mamalilikulla IR 5), where they have lived to the present" (Duff 1960, 25). And finally, Sarah Sampare mentioned that the name meant there was eelgrass there.

Sites described by consultants, but not visited in this study (sites 7, 10-19 in Figure 2.3)

Deer Island, or ă^{E}wa'gawa^{E}lis *(Site 7 in Figure 2.3)*

Sarah Sampare recalled, "My grandfather used to go up to Deer Island and get it [eelgrass]. The south end of the island. They'd *k'elpa*, twist the grass. He'd go between Deer Island and another island. There's a passage where they'd get it."[56] This location is very near a site listed in Boas' Geography (1934) called *ă*^{E}*wa'gawa*^{E}*lis*, translated as

[56] Sarah Sampare, May 31, 2006

‘Passage between islands;’ it is possible this is the same location.

Campbell River (Site 14 in Figure 2.3)

> There used to be lots around where they filled in the mall, both malls I guess, Tyee Plaza and Discovery Plaza… there used to be lots of eelgrass out by the low water mark. Used to be a sand bar there. I used to live on Quadra, we used to row across quite often and eat the eelgrass on one side, and sea urchins on the other, Quadra side. Used to just drift along at the low water, and just pull it out of the water, you know, the grassy part, and then we'd eat the root part.[57] (Ralph Dick)

Phillips Arm and Jackson Bay (Sites 16 and 17 in Figure 2.3)

Listening to his grandfather's stories, Daniel Billy had heard of several locations where eelgrass was harvested:

> Further up North, where we really came from -- Topaze Harbour in Jackson Bay, I heard that's where our people used to pick it and et [eat] it. At real low water you can walk along and eat it. I know, cause I was there in real low tides. My grandfather used to get it from there. In Phillips' Arm it's a little deeper, harder to get it. People used to get it there, my grandfather told me stories about it. That's what my grandfather said. They gotta be in the water, otherwise they just die. They used to dive for them, not too deep, but you won't be able to reach it if you just stick your hand in. I guess they'd know how to get it, they were smart those people.[58] (Daniel Billy)

[57]Ralph Dick, June 18, 2006
[58]Daniel Billy, June 20, 2006

Sites visited for harvesting expeditions (sites 10, 20-26 in Figure 2.3)

Wa'watlExts!a – *Grassy Point (Site 10 in Figure 2.3)*

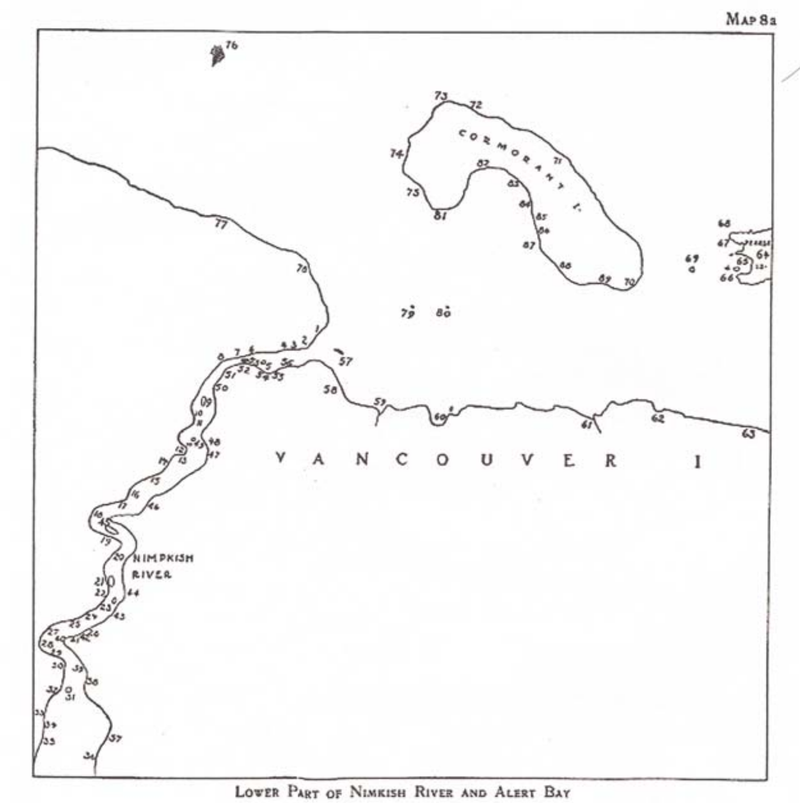

Figure 2.11 Boas' Map 8a of Cormorant Island (Boas 1969). *Wā'waɬExts!a*, Grassy Point is number 73, on Leonard Point at the north tip of Cormorant Island.

> We used to get it at the place called *Wā'waɬExts!a.* That's the name of the place called Grassy Point, near Alert Bay. *Wā'waɬExts!a*. The name of that bar, it's a sand bar towards the very tip, the North end of Cormorant Island.[59] (Adam Dick)

The foremost location for eelgrass harvesting encountered in interviews was a sandbar cited in Boas' geography called *wā'waɬExts!a* (Figure 2.11 number 73; Site 10 in Figure 2.3). Seven consultants had harvested eelgrass at this site. On the charts it's called Leonard Point, but everyone knows it as Grassy Point, whose namesake is only evident at low tide when the abundant *Zostera marina* becomes visible. Seven of the

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[59] Adam Dick, November 29, 2004

consultants in this study gathered eelgrass at this location. Steven Beans said the fast current at Grassy Point is why nothing attaches to the leaves, which makes Grassy Point a clean source of eelgrass.[60] Though he knew the name of the site, Adam did not know what the name meant. It is translated in Boas' Geographical Place Names (1934) as 'trying to come aboard.' On discussion with language specialist Sewid-Smith, a more accurate translation is 'hoping to come aboard;' the word comes from '*watagilla'*—to wish or hope for something[61]. While Boas cites several other names that refer to eelgrass in his Place Names, only Grassy Point was known by the consultants.

On May 29th, 2006 Adam, Russell and Barry Dick, three generations of the family, harvested eelgrass again at Grassy Point. Norman Stauffer's seine boat and skiff brought us to the sandbar. We found the point covered in the large eelgrass we had been looking for (possibly the *phillipsii* variant of *Z. marina*), see Figure 4.1, b, page 135. Plants were very dense, and many spadices were in bloom. The leaves were covered in purple-reddish seaweed resembling the algal epiphyte *Smithora naiadum*, see Figure 4.3, a, page 137. Adam Dick remembered the leaves being clean before. He hadn't seen this seaweed growing on them before; he hypothesized that perhaps it was a bit late in the season (it was May 29th and usually he'd be here around the 24th for the Alert Bay Sports Day).

Using the *k'elpaxu*, an abundance of thick, coiled eelgrass was obtained easily. The high density of large plants, and the soft, sandy sediment made for ideal conditions for using this unselective tool. We then pulled the boat ashore because the tide was very low (a low of 0.4 m) and many of the plants were dried up. Adam said he'd never been there when it was like that; he'd always had to use the *k'elpaxu*. But he indicated that it was okay to pick it as we were, in about 12.5 cm of water: the tide was out quite far and picking by hand was more efficient. When eating them we noticed their sweetness, but also that the rhizomes were a bit fibrous, indicating that we were late in the season. Otherwise, the eelgrass rhizomes and Grassy Point were as Adam Dick remembered.

[60] Steven Beans, May 29, 2006
[61] Daisy Sewid-Smith, August 28, 2006

Nimpkish River Mouth (also Site 10 in Figure 2.3)

Three of the consultants also remembered harvesting eelgrass across from Alert Bay, on Vancouver Island near the mouth of the Nimpkish River. Often while talking about eelgrass other observations about the health of the eelgrass, the state of the environment and the rise in the pollutants of the area were conveyed.

After surveying Grassy Point our expedition continued to the mouth of the Nimpkish River, where the water was colder. Prolific blades of *Alaria* kelp amongst the eelgrass resulted in coils of eelgrass and kelp on the *k'elpaxu*. The *Zostera marina* was smaller, and not as attractive as food as at Grassy Point. The leaves were covered with a different kind of epiphyte, similar to that at Grassy Point. A look at Green Island nearby revealed very small eelgrass with lots of epiphytes and seaweed growing on it. It was not appetizing to Adam Dick.

Tsa'xis - *Fort Rupert (Site 15 in Figure 2.3)*

Chief Alfred Hunt hadn't eaten eelgrass himself, but knew that "the old people used to get it from right out here [beach in front of Fort Rupert]."[62] His wife Gloria remembered visiting her granny in Fort Rupert and "she'd just go out on this beach"[63] to get eelgrass for the grandchildren. On May 31st, 2006, Adam Dick and I collected eelgrass on the Fort Rupert beach straight out from Story Beach Road on the low tide (low of 0.8m). The beach of Fort Rupert is vast and at low water one has to walk for a long time to reach the eelgrass at the edge of the water. The shallowest eelgrass was the tiny invasive *Zostera japonica*. Farther out the eelgrass was larger, small to medium sized *Zostera marina* plants; they looked like the *typica* variant (Figure 4.3a). Flounder-shaped depressions and the countless shells and holes of cockles and horseclams indicated high biomass. The rhizomes were difficult to harvest. They grew very deep and straight down (rhizomes usually grow horizontally just below the surface of the sediment). However, the rhizomes were not brittle. While the plants harvested were of average *Zostera marina* var. *typica* size, they were not satisfactory to Adam or Sarah

[62] Chief Alfred Hunt, May 31, 2006
[63] Gloria Hunt, May 31, 2006

Sampare, an 86 year-old elder who lived in Fort Rupert. When I showed them to her she said, "They were way bigger than that, those are babies!"

Quatsino Sound: Entrance to Forward Inlet (Site 22); Koprino (Site 23); Kayne's Peninsula (Site 24 in Figure 2.3)

Chief Councilor Tom Nelson used to harvest eelgrass right out in front of the village where he grew up, near the Narrows: "You know, there was eelgrass all over the place." He didn't remember the Kwak'wala word for eelgrass readily. As a child he followed his grandparents' instruction to go and pull it up by hand on the low tide, as most of the time in May and June they could harvest it by hand. But sometimes the tide wouldn't be low enough, and he'd be prompted by his grandmother to go out with a boat and use his metal lingcod spear to twist it, just like a *k'elpaxu*. "…At the time, it [the eelgrass] was a lot closer together. And all you'd do is stick it alongside the eelgrass, and then just turn, you know, start twisting the pole right up on the top. …We used to just have to just drop an anchor, out front. It all depends on which way the tide was going, and then you were just right there, above it."[64]

May 25th, 2005 Adam Dick and I headed up to Quatsino to harvest eelgrass with his old friend Chief Tom Nelson. On a DFO boat skippered by Jaime Pepper we headed out through the Narrows on the very low tide. There was large, thick *Zostera marina* everywhere; a lot of it was exposed. Adam said he had never seen *ts'áts'ayem* that you have to harvest by hand—he always used a *k'elpaxu*. But Tom Nelson said that picking eelgrass by hand was normal in Quatsino.

Beyond Kwakwaka'wakw territory: Tofino - (Site 25 in Figure 2.3)

In Tla-o-qui-aht territory, in Tofino, I spoke with Tla-o-qui-aht carver Joe Martin. He remembered "the old lady," his father's aunt, would harvest eelgrass right in front of the village of Opitsaht, at the water's edge in shallow water. "I'm not sure if anyone else did it, I was just a kid and didn't notice."[65]

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[64] Tom Nelson, January 9th, 2006
[65] Joe Martin, May 1, 2006

May 1st, 2006 Joe's daughter Gisele Martin, Jen Pukonen, David Strongman and I canoed out in Gisele's traditional Nuu-chah-nulth canoe to the sandbar between Opitsaht and Tofino to harvest eelgrass. The sandbar was the only place the locals thought it would be clean enough because the sewage gets stuck in the inlets. We paddled into the wind towards Stubbs' Island and harvested plants at the sandbar near Raccoon Island, across from Opitsaht and Tofino. The sandbar was partly out of the water (low of 0.4 m) covered in large eelgrass. It was too windy to use the *k'elpaxu*. We got out on the sandbar to harvest by hand in a few centimetres of water as Joe Martin's great aunt had done. Plants were large: growth was small until the most recent three internodes, indicating the start of the growth season about a month earlier. Rhizome internodes were about two finger-widths in length and pencil thickness in width. Leaves were wide and clean of epiphytes, perhaps due to the extreme tides and windy location. There were many flowering plants; some as long as 1.5 m. It appeared that the more dense the plants were, the smaller they were. Rhizomes looked appetizing, and were very sweet in taste. Plants were difficult to remove because they grew deep (approximately 25 cm) in fine grey sand. I later mentioned this unusual depth of rhizomes to Joe Martin, who said that a storm that winter had shifted the whole sandbar; the unusual depth of the plants could be a result of that. Though she had never harvested eelgrass before Gisele was extremely adept at removing the fat rhizomes from the sand without breaking them. When I brought specimens from this site to Adam Dick, he exclaimed, "That's the one! That's the real *ts'áts'ayem*!" This was the only location besides Grassy Point where we found specimens that met Adam's expectations.

Later Gisele Martin reported that on May 31st, she and her friends and sister set out in the canoe with the *k'elpaxu* from our earlier expedition (May 1st) to collect eelgrass. They tried harvesting close to the harbour, but the plants were too small. About halfway from the Harbour to the sandbar they used the *k'elpaxu* on large eelgrass which was about 120 cm (4 feet) deep on their low tide. She said one would even be able to reach the plants at high tide with the long tool. The eelgrass shoots came out easily with their roots. "It definitely worked… We barely saved any. We ate it all. Then we paddled to Felice Island. We got a huge sugar rush, we just laid on the beach. We all had a great big sugar buzz and got all tired and hungry"[66] (Gisele Martin).

2.4.1.6 Gauging cultural significance of ts'áts'ayem

It is difficult to quantify the cultural significance of a traditionally harvested plant or a harvesting practice. Garibaldi and Turner have introduced the concept of *cultural keystone species*: species that "shape in a major way the cultural identity of a people, as reflected in the fundamental roles these species have in diet, materials, medicine, and/or spiritual practices" (Garibaldi and Turner 2004, 4). They measure "keystone-ness" within a culture by six elements: 1) intensity, type, and multiplicity of use; 2) naming and terminology in a language, including use as seasonal or phonological indicators; 3) role in narratives, ceremonies or symbolism; 4) persistence and memory of use in relationship to cultural change; 5) level of unique position in culture, e.g. it is difficult to replace with other available native species; 6) extent to which it provides opportunities for resource acquisition from beyond the territory. As a means of gauging the cultural significance of *ts'áts'ayem*, I have addressed the cultural keystone criteria qualitatively in Table 2.3. This analysis shows that qualities of *ts'áts'ayem* fit all of the criteria of a cultural keystone species, but it is difficult to determine its cultural significance relative to other culturally important foods. In this analysis it might not rank as highly as some cultural staples such as Western redcedar (*Thuja plicata*), which serves many different material purposes, or Red Laver (*Porphyra abbottiae*), which can be gathered in mass quantities and preserved as food. The fact that eelgrass must be eaten fresh limits its harvest and its use as a trade item. However, eelgrass may have played a significant role as a sweet food in a diet without much sugar, and one which, in the springtime, after a winter of dried foods, may have played a crucial role.

[66] Gisele Martin, Sept. 19, 2006

Table 2.3 Cultural keystone elements of *ts'áts'ayem* in Kwakwaka'wakw culture and rating.

Elements indicating a cultural keystone	***Ts'áts'ayem* for the Kwakwaka'wakw**
1. Intensity, type, and multiplicity of use	-intensity: appears to have been intensely harvested in May -uses: eaten (raw, steamed, with and without *kl'ina*); used to gauge tide (*ts'ápalees*); perch fishing; used for steaming in pit cooks
2. Naming and terminology in a language, including use as seasonal or phenological indicators	-seven words specifically associated with *ts'áts'ayem;* related word to *ts'ápalees* - eelgrass condition indicated a tide -at least nine recorded place names referring to eelgrass, including the common name for Leonard Point, Cormorant Island, of "Grassy Point"
3. Role in narratives, ceremonies or symbolism	-Boas-Hunt record of ceremonial eelgrass meal -*k'elpaxu* song -used as a symbol on Emma Hunt's daughter's button blanket (Tom Child, pers. comm.)
4. Persistence and memory of use in relationship to cultural change	-beloved by elders in this study, missed as a sweet food, name *ts'áts'ayem* remembered, but not often discussed, not prevalent in daily consciousness
5. Level of unique position in culture, e.g. it is difficult to replace with other available native species	-not replaceable by other native species -it was a rare sweet food in May, potentially very important in the diet after winter
6. Extent to which it provides opportunities for resource acquisition from beyond the territory	-not a trade item; *ts'áts'ayem* had to be eaten fresh -however, was shared among family and village groups, and in the past eelgrass meadows may have been shared resources with other groups.

2.4.2 Keeping the *ts'áts'ayem* living: Was eelgrass harvested in a way that enhanced its growth?

> [Would it] *help* the [eelgrass] plants to harvest it? I assume there is, because we found that… we weren't allowed to harvest clams the way we used to, we found a lot of the beds are dying. Because we used to cultivate it, you know, the people would work on it, cultivate it, loosen the sand so that oxygen could get down. …And I imagine, if you don't harvest it, that it gets smaller and smaller, like everything else.[67]
> (Daisy Sewid-Smith)

Elders did not recall being taught to harvest *ts'áts'ayem* specifically in a manner that enhanced growth. However, when I inquired about this possibility, three of my consultants indicated that the ethic of harvesting to ensure a resource's enhancement was the ethic for harvesting all plants. Tom Nelson corroborated Daisy's statement, saying, "[*ts'áts'ayem* is] like any other stuff, if you don't harvest it, it'll grow wild."[68] When plants were not harvested they 'grew wild', meaning they were not as large or as desirable as those in tended areas. This harvester-resource relationship extended to all plants and animals that the Kwakwaka'wakw depended on.

> …Well, they did it with everything. It's hard for people to believe. And until we did the clam gardens, no one believed we did that. I mean, like your berries: my granny said they would singe that so that it would produce a lot more berries. You know. And they did it with everything and the old people felt that if you don't, if you don't use it, if you don't take some things, you know, they always watched you so you didn't over take, overharvest a lot of things, if there's a danger of that, then you're asked to move to another area and they sometimes put a copper up to state that that area you could not harvest. And that was to prevent you from, they felt too many people were taking things out of these and they would do that prevent people from overharvesting. So they were quite careful of overharvesting.[69] (Daisy Sewid-Smith)

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[67] Daisy Sewid-Smith, January 9, 2006
[68] Tom Nelson, May 25, 2005
[69] Daisy Sewid-Smith, January 9, 2006

2.4.3 Documenting change: consultants' observations of today's *ts'áts'ayem*

Finding eelgrass free of epiphytic leaf growth today (and perhaps in the past), is not easy. Most of the plants we found at all the locations we visited had a thin to thick layer of epiphytic growth on the leaves, which was distasteful to Adam Dick and Daisy Sewid-Smith. Adam had never seen epiphytic growth as was seen in the field around Quadra Island, Quatsino, Comox, and even Grassy Point. As well, several populations had dark (brown to black) rhizomes, and some even smelled of sulfur. Finding plants of the right size was difficult too. Adam Dick and Tom Nelson talked about rhizomes "the size of a pencil" and "the size of my little finger"[70]. Therefore, most of the plants harvested in the field expeditions were not satisfactory; it was only in Tofino and at Grassy Point that eelgrass of the desired size was obtained, where rhizome thickness reached 6 mm. At the Heriot Island site on Quadra, Daisy Sewid-Smith demonstrated that small eelgrass didn't peel right - the leaves just split as she was peeling it because the plants were too small.

Finding a harvesting site free of pollution was an important factor in determining harvesting sites - while large eelgrass can be seen at low tide in front of the village of Alert Bay on Cormorant Island, Steven Beans said, "We never touched it on this side [in front of Alert Bay] because of all the garbage and stuff."[71] Indeed, the seascape has seen much development and pollution since the elders in this study had harvested *ts'áts'ayem* in their youth. The development of the Elk Falls Pulp and Paper has shifted the traditional resource areas of Campbell River considerably. Daniel Billy's father used to get eelgrass right at the Campbell River mouth, but he felt it wouldn't be worthwhile today, with the pulp mill.

> …my dad used to eat it [eelgrass]. He used to get it right at the Campbell River before the pulp mill. That was before the pulp mill. The pulp mill polluted everything, it didn't take long. They're still doing it, but putting it in deeper water. Everything else is polluted, all our shellfish is polluted, we're not allowed to eat it anymore.[72] (Daniel Billy)

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[70] Tom Nelson, January 9, 2006; Adam Dick, May, 2005
[71] Steven Beans, May 29, 2006

> The [Elk Falls] pulp mill came in 1949. It used to shoot out on the beach, used to be foam all over the beach. Outside the lighthouse was one of our largest clam beds on the coast, everyone would come… used to dig clams there in the winter months. Now we haven't dug there in some 50 years. The cod are starting to come back, but all our home fish, perch, rock cod, are not around anymore. How do you prove what it's from? It could take you forever to prove, legal fees are too costly for us.[72] (Ralph Dick)

Daniel Billy also cited Menzies Bay as an eelgrass source, where today there is a heavy log processing site:

> Menzies Bay (just North of pulp mill) I know my grandfather used to say they used to get it, but I don't think it would be worth it now, it would be so polluted, so I haven't checked it out. I don't think you can walk out and pick them.[73] (Daniel Billy)

Three of the consultants also remembered harvesting eelgrass across from Alert Bay, on Vancouver Island near the mouth of the Nimpkish River. Helen Beans spoke about the Nimpkish River mouth (Site 10 in Figure 2.3) as being a favourite location for gathering ts'áts'ayem. Often while talking about eelgrass other observations about the health of the eelgrass, the state of the environment and the rise in the pollutants of the area were conveyed:

> We used to go to Grassy Point but they had a sewer line out there. So we went to the [Nimpkish] river. The Nimpkish River had the best ones. Green Island. Used to be just green when we used to go for crabs. Everything is changing. Everything disappeared with the sewage pipe. Piper's Point everything disappeared, the kelp, they're back now. Now they got a treatment plant. Across the bay at the mouth of the river was the best place.[74] (Helen Beans).

Several of the eelgrass sites visited in our expeditions may well have been affected by contamination, as they were near point sources pollution. On May 29th, 2006, after our survey of Grassy Point our field expedition continued to the mouth of the Nimpkish River, where the water was colder. Prolific blades of *Alaria* kelp amongst the eelgrass

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[72]Ralph Dick, June 18, 2006
[73] Daniel Billy, August 22, 2006
[74] Helen Beans, June 21, 2006

resulted in coils of eelgrass and kelp on the *k'elpaxu*. The *Zostera marina* was smaller, and not as attractive as food as at Grassy Point. The leaves were covered with a different kind of epiphyte, similar to that at Grassy Point. A look at Green Island nearby revealed very small eelgrass with lots of epiphytes and seaweed growing on it. It was not appetizing to Adam Dick.

On May 30th, 2006, we traveled near Cormorant Island to Double Bay on Hansen Island (included in Site 19, Figure 2.3) where Russell and Barry Dick knew there was eelgrass where the fishing boats used to tie up. The bays look ideal for the plant: a shallow slope, a stream running into the bays and fine sand sediment. Large Dungeness crabs scuttled amongst a few old tires and some rotting logs. Donna and Norman Stauffer, Russell and Barry Dick remembered lots of eelgrass there when they would come to catch crabs. But there was no eelgrass in sight. Norman recalled there was a log boom in both bays 20 years ago, which might suggest a cause of decline; however Barry had been here about five years ago, and there had been plenty.

On May 8th, 2005 I visited two sites on Quadra Island with Daisy Sewid-Smith and Adam Dick. This expedition site was based on logistics and feasibility; we did not have a first hand recollection of harvesting eelgrass at these sites. However Sewid-Smith felt that 'the old people' had harvested eelgrass all around the Island, and at Waiatt Bay, an old village site. The first stop was Heriot Island near a *luxiway*, or clam garden (Site 20, Figure 2.3). Eelgrass here was too sparse and too small to be satisfactory. At Waiatt Bay (Site 21) the plants were larger[75] but covered in epiphytes which was also unappealing. When I spoke with Sewid-Smith later she reiterated that it was too small: "Yeah, but I think a lot of that was pollution, because I think the pulp mill here has destroyed a lot of things even though they won't admit it."

In Quatsino Sound we collected specimens from five locations with a lot of high variation (including Site 22-24 in Figure 2.3). Many plants were in flower. We found what Adam called "ugly eelgrass," really the surfgrass *Phyllospadix serrulatus*, growing in a pebbly beach. Both Adam Dick and Tom Nelson agreed that the specimens collected were not satisfactory for eating. The plants were not large enough, and the rhizomes were black; Appendix E lists sample quotes corresponding to eelgrass samples. Tom

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[75] Uvic herbarium accession number 45929

speculated that the Island Copper Mine, which dumped 400 million tons of tailings into adjacent Rupert Inlet over its active lifetime from 1970 to 1995 (Uvic Archives Acc. No. 2000-069), might be a cause of the eelgrass' unappealing appearance. Tom said the mine drastically changed the ecology of the inlet.

> Another place we used to get the eelgrass was at Varney Bay, just you know before you go through the Narrows, from the top end, from Coal Harbour. There's a lot of eelgrass there. The only reason I didn't take you there is because of the pollution that came out, you know the siltation from the mine site, eh.
>
> I couldn't understand DFO; they allowed Utah Mines to dump all that waste into Rupert Inlet, when to this day DFO is very, very strict on not harming eelgrass today. You know, they really put up a big stink today about eelgrass. But I tried and tried to bring it to their attention. And it was the same thing with the pulp mill. The pulp mill there, there was a real big bad kill of herring two times. And I tell you, it [dead herring] was just about five feet deep, all piled up in that one little bay there, when you're in Port Alice, going to the mill. When the tide going out, they all piled up there in that little bay there, dead.[76] (Tom Nelson)

At Tofino (Site 25 in Figure 2.3) at the end of May, Gisele Martin also harvested eelgrass from the mudflats behind Opitsaht, where there was no current, and found the rhizomes there were dark and "rotten." Her father, Joe Martin, told me that recently he had noticed brown epiphytes growing on eelgrass in Browning Passage, where it used to be clean there. He speculated that it is the fish farms and sewage outflows that are causing this. Sewage flows directly from the villages of Tofino, Opitsaht, and Hotsprings. Boat traffic adds pollution too. I asked him about how this affected herring spawn, and he said the herring prefer clean surfaces; "they used to spawn all over Opitsaht on the sand bar, on Stubbs Island… but not anymore." Whales don't come anymore either. Local biologist Eric Baron said the Brant geese aren't going to Stubbs Island as much anymore either because of the epiphytes' growth on the plants.[77]

Locations, specimen observations and potential sources of pollution are cited in Appendix E, page 185.

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[76]Tom Nelson, January 9, 2006
[77] Eric Baron, May, 2006

2.4.4 Alienation from the *ts'áts'ayem* meadows

> We just lived off the stuff in the sea, eh? I don't know why people don't eat [*ts'áts'ayem*] now… they gradually forgot, got lazy.[78] (Ethel Alfred)

> That's all we did when we were kids, high water, low water… we'd go out in the rowboat. We never used to pack a lunch when we were kids, we could just go and get clams, build a fire, find some wild crabapples, salmonberries, huckleberries… I was about 7, 8 years old—that was in '46, '47, '48. We left Quadra in the fall of 1949. We ate it [eelgrass] for a little while after that, but not long. I don't know why we stopped, I guess I was going to school, didn't have time.[79] (Ralph Dick)

Almost all of the consultants had not gathered *ts'áts'ayem* since they were young children in the 1940s and '50s. Half of the consultants spoke of learning about or gathering eelgrass with a grandparent. There appeared to be a pattern amongst the consultants - the childhood period of eelgrass gathering with elders ended when they went to residential school, or when their grandparents passed away. As a child, Chief Councilor Ralph Dick used to row over to Campbell River regularly to visit his Grandma and collect *ts'áts'ayem*, but today "I haven't been in a rowboat in 50 years"[80]. Development of harvesting grounds was a barrier to gathering *ts'áts'ayem*. For example, the waterfront of Campbell River has undergone big changes since eelgrass harvesting days. I asked Cape Mudge Chief Councilor Ralph Dick where exactly it would be harvested and he replied:

> If you know where the telephone office building is, it'd be right behind. Straight out from Boston Pizza, go straight out the beach towards Quathiaski Cove. It would be out right where the breakwater was. I know because my grandmother's house used to be right where the Boston Pizza is. At the real low water, I'd imagine it's still there. There should be some there. There used to be a real lot of eelgrass there. I think we all ate it when we were kids. I knew my parents did. I would think there should be some outside the breakwater part.[81] (Ralph Dick)

Ninety-four year-old Eleanor Cliffe used to row her mother along the shore of Quadra Island and across to Campbell River to collect eelgrass. Looking out from her little house

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[78] Ethel Alfred, March 10, 2005
[79] Ralph Dick, June 18, 2006
[80] Ralph Dick, June 18th, 2006
[81] Ralph Dick, June 18, 2006

behind the McDonald's and Wendy's in August 2006, it was hard to believe that this had been waterfront property, and the site where she had rowed her mother to collect eelgrass. Lack of access to boats is another barrier to getting out on the land and sea.

There are also social barriers, health issues and social strife that have redirected life on the land. Food gatherers today lack peers to gather with: "I used to have a partner, but he died… We can't get out there anymore. We're all getting old, and the young people don't do it..."[82] (Helen Beans). Yet another reason given for limited food gathering was fear of the legal system:

> The last time I harvested? You mean *ts'áts'ayem*? Oh, my lord. I must have been about 15, 16. That was quite a few years ago. Yeah. 'Cause actually as the years went by, we were alienated more and more from our way of life… Slowly, because the old people were still so afraid of being put in prison, like they did when the potlatch laws were in place, they just started practicing it less and less. …it's just that a lot of the laws have just kind of turned people off, that they just don't go out and harvest anymore. They don't know one day from the next what's against the law.[83] (Daisy Sewid-Smith).

The decline of *ts'áts'ayem* appears to be part of a larger general trend of a decline in food gathering in the Kwakwaka'wakw culture and around the world (Turner and Turner 2007).

[82] Helen Beans, June 21, 2006
[83] Daisy Sewid-Smith, January 9, 2006

2.5 Discussion

Significance of eelgrass

"We ate it like candy."

Love of *ts'áts'ayem* was striking. The elders who remembered it *really* enjoyed '*ts'áts'ayem*. People made the effort to harvest eelgrass. Helen Beans, harvesting '*ts'áts'ayem* into her adulthood, talked about '….going out to the breakwater if you're craving it real bad….'[84] Eelgrass rhizomes contain considerable sugars; Gisele Martin described a "sugar high" after harvesting and eating a lot of eelgrass.[85] While it might seem like a lot of effort today, in an era when refined sugar was nonexistent, and when greens were limited, and after a season of eating dried winter foods, eelgrass would have been worth the effort to harvest. In the context of traditional diet, season and deep TEK and understanding of surrounding environment, in traditional times, *ts'áts'ayem* season must have been eagerly anticipated and enjoyed. This is not the case today; those who know about eelgrass are elders who have not harvested the food in a long time.

More research is needed to determine amounts of eelgrass removed each season, by an individual, by a whole village, and within a region. Investigation of quantities used is necessary to further understand the role of eelgrass in the old Kwakwaka'wakw tradition. Estimations based on Helen Beans' remarks about gathering 'a whole basket' could be made to approximate eelgrass removal by group of harvesters, and perhaps a whole village. Figure 2.3 begins to show the range of eelgrass harvest: at least 20 of the 26 sites listed in this study were locations where eelgrass was traditionally gathered. This indicates that while the impact was seasonal and moderate, this tradition had a wide geographical range, and was common to most people within the large population of the Kwakwaka'wakw. Human use and effects on eelgrass meadows in this territory would have been considerable. It would be necessary for the Kwakwaka'wakw to ensure sustainable harvesting practices in order not to diminish the viability of these important eelgrass ecosystems. A mapping project identifying current eelgrass beds (the eelgrass mapping network makes data available for this region) and traditional spring land use and

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[84] Helen Beans, September 18, 2006
[85] Gisele Martin, September 19, 2006

village sites would be informative to gauge the overlap between people and eelgrass and indicate possible future harvest sites.

Ts'áts'ayem is an example of the TEK embedded in the language of the Kwakwaka'wakw. The word *ts'áts'ayem* is inherently connected to *ts!a*: tide. To break down the word one finds all kinds of relationships between them. Eelgrass is not separate from the currents in which it grows; it is not fragmented into a single organism to be studied. In studying the word *ts'áts'ayem* one can also learn about the tide, about *ts'ápalees*: when the tides rushes so that the kelp and eelgrass lie flat on the ocean floor, and about the culture whose language reflects inherent ecological knowledge.

Given the ceremony recorded by Boas and Hunt (1921), the 16 eelgrass-associated words and names, the breadth of territory harvested, and the relish with which elders recalled *ts'áts'ayem*, it is apparent that the species *Zostera marina* was highly culturally important to the Kwakwaka'wakw. Yet, eelgrass use began to decline while the contemporary elders in this study were small children in the 1940s and 50s. There are clues that allude to its greater former ceremonial and spiritual import, such as in the Boas-Hunt record, the reference Emma Hunt made to watching elders gather on the verandah to eat *ts'áts'ayem*, the name of the village *ts!a'ts!esnokume* (New Vancouver) referring to eelgrass, the harvesting song that Adam Dick remembered, and the near-ceremonial precision with which the elders described the wrapping of the innermost leaf around the rhizomes. Unfortunately, the true historical significance of *ts'áts'ayem* may never be known.

Table 2.3 shows that qualities of *ts'áts'ayem* fit all of the criteria of a cultural keystone species, but it is difficult to rank its cultural significance relative to other culturally important foods. It is important to note that in any diet diversity is extremely important, and *ts'áts'ayem* was a food that diversified and enriched a diet which did not have much sugar. In considering cultural significance, elders' love and appreciation of this food should be emphasized, as well as the importance of the addition of this fresh, sweet green to the diet after winter. Overall, *ts'áts'ayem* as a cultural food is a strong symbol of the depth and diversity of the Kwakwaka'wakw world.

Tending the meadows of the sea

> The word *tending*, as in the title, *Tending the Wild*, is meant to encapsulate the essence of the relationship that the indigenous people of California had with the natural world in pre-Columbian times. It also suggests the timeless wisdom inherent in this relationship, wisdom that we sorely need today. *Tend* means “to have the care of; watch over; look after.” Thus the word connotes a relationship of stewardship, involvement, and caring very different from the dualistic, exploit-it-or-leave-it-alone relationship with nature characteristic of Western society. (Anderson 2005, 358)

The ethos of *tending* extended throughout the Pacific Northwest. Turner and Berkes (2004) have discussed the development of a ecological conservation ethic that “transcends individual species and resources” (Turner and Berkes 2004, 1) and suggest that a specific ‘intention to conserve’ is not always possible to distinguish from the worldview and ethic in which resource gathering was conducted. Though Kwakwaka’wakw consultants could not tell me of specific teachings or protocols for tending eelgrass meadows, their keen observation of ecosystem elements and eelgrass health suggests that at the height of *ts’áts’ayem* harvesting, the import of eelgrass as habitat for these other species would not have been ignored by conscious resource users, and careless or unsustainable harvesting would not have been tolerated.

While other estuarine root foods (such as springbank clover and Pacific silverweed) had specific ownership and land tenure protocols (Deur 2002a; Deur and Turner 2005), in the literature and in the interviews I did not find that eelgrass sites had distinct ownership. Reasons for this could be because such ownership history has been forgotten, and there were in fact some forms of restriction, rights or ownership, either by village or family or clans, or because there weren’t, possibly because the eelgrass can sustain several different groups removing quite a lot of eelgrass from the same area.

It is difficult to tell how much disturbance the Kwakwaka’wakw would have created harvesting eelgrass in a meadow. The impact would depend on the size of community, the size of the eelgrass bed, and how many low tides or access occasions there were in a given month of May. How much disturbance could a meadow tolerate? The biological mechanism that would respond to this tending is the subject of my parallel line of questioning in my experiments in Chapter 3. What growth response would traditional harvesting incite in *ts'áts'ayem*?

Elders' comments on today's eelgrass: comparison with an ecological 'normal'

Few sites we visited recently yielded the quality of eelgrass that Adam Dick, Daisy Sewid-Smith or Tom Nelson recollected. Grassy Point – a place cited on many accounts – and Tofino were the only places I visited where the eelgrass was as Adam Dick remembered it. Plants observed were consistently too small. I did not visit enough eelgrass sites that used to be harvested to determine whether lack of harvesting has led to a decline in the meadows, or of the plants or ramets on an individual level. With the overall decline in eelgrass ecosystems today (Thayer et al. 1975; Short and Burdick 1996; Short and Neckles 1999), it could be important to explore whether sites that used to be harvested have changed because they are no longer harvested. An important continuation of this study (that would significantly contribute to eelgrass documentation) would be to bring elders to the sites they remembered, and record their observations on the similarities and differences of plants and ecosystem of today as compared to the past.

Eelgrass plants were also often covered in epiphytes or had dark and sulfur-smelling rhizomes. Elders named 'pollution' as the cause of these undesirable traits. However, this seemed to be the catch-all culprit, and there may in fact be many causes of these characteristics (for example development and disturbance of the shoreline, the shifting of populations, climate change, the introduction of *Zostera japonica*) in addition to the more obvious pollution from many point sources. The seascape has changed so much since their youth that many new causes may have compounded to produce the new qualities of eelgrass.

In describing what was 'normal' in their youth (which was often before much of today's development and pollution), the accounts of these consultants provide a baseline record of eelgrass ecosystem health. This could be significant for assessing the present status of eelgrass meadows, for indicating areas that have been impacted by an ecological change, or understanding symptoms of a greater environmental issue. Chapter 4 explores the intersection of eelgrass biology and TEK to help understand current ecological dynamics of eelgrass meadows.

Why has harvesting of ts'áts'ayem declined?

Ts'áts'ayem is one of many traditional foods no longer harvested on the Northwest Coast, and it is one element of a general pattern of nutrition transition from traditional foods occurring around the world. By today's standards, *ts'áts'ayem* is difficult to get: one has to know the right season and the right spot, know and wait for the right tide, have a boat or access to the site, and have the know-how to use a boat as well as gather eelgrass. One has to plan ahead and make the right harvesting tool. It seems like a lot of effort today. But in a time when rowboats were the equivalent of the car, and when people knew the tides like a bus schedule, gathering eelgrass and other foods would not have been the impossible task it seems today. It might be something looked forward to, like berry or *a'ant* harvesting season (herring roe on kelp), and enjoyed with friends. There are many reasons why people don't harvest *ts'áts'ayem* anymore. This food resource is a classic example of the dietary transformation that Turner and Turner (2007) describe in Figure 2.12. All nine factors listed are reasons why *ts'áts'ayem* is no longer harvested.

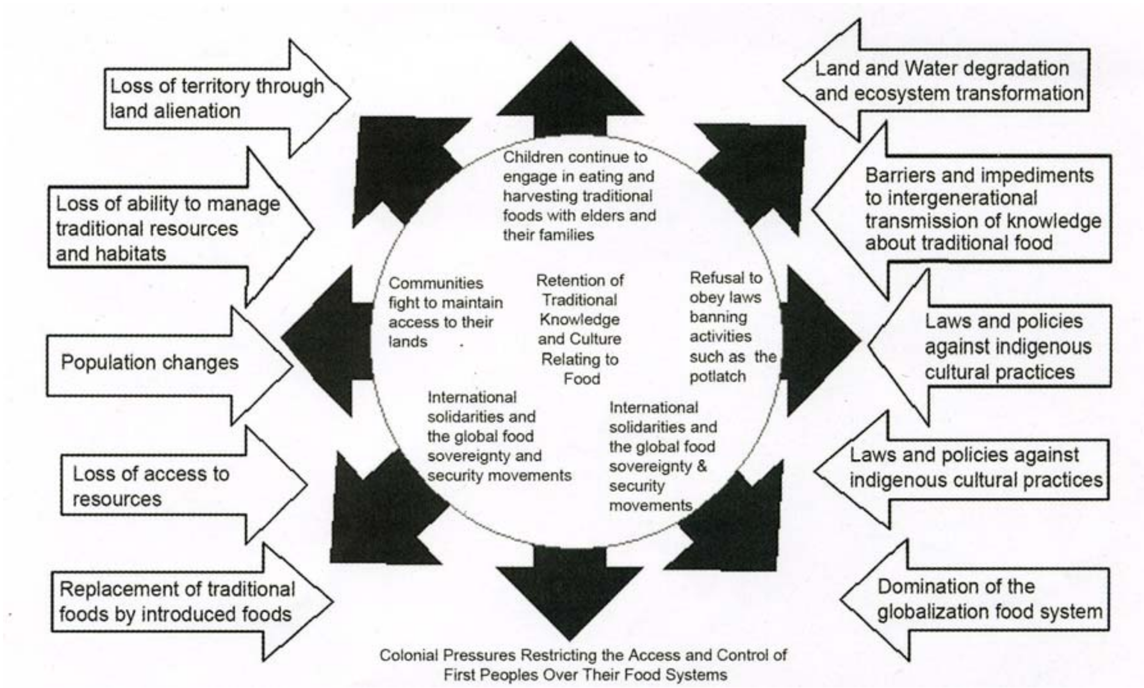

Figure 2.12 Diagram showing the compounding factors for the dietary transformation of First Nations in British Columbia since the arrival of Europeans (1700s). With permission from Turner and Turner 2007, 61.

Deterioration of traditional harvesting grounds is one major reason why harvesting has declined. Changes in ecosystem health have influenced the desirability of *ts'áts'ayem* as a food. Of the locations visited for this study, few of them yielded *ts'áts'ayem* that was acceptable to the consultants. Pollution has negatively affected seagrasses around the world, and is a likely cause of the decline in health of the specimens harvested in this study. Consultants decried the pollution of their traditional areas.

Several elders mentioned loss of access as the reason that they stopped gathering. On an island such as Cormorant Island, people's interaction with natural resources is limited unless they have a boat, and today people have cars instead of boats as they used to. Another reason people have stopped is fear of the law. Several elders spoke of the shock of finding that their common food harvesting practices were against the law. Many of them are now afraid of gathering any traditional foods at all.

The abundance of new sources of sweetness is another factor: in the past *ts'áts'ayem* might have been a desired food and rare source of sugar, but today many new sugars are promoted through mass marketing and easy availability, and now dominate the palates of most people, decreasing the appreciation and desire for traditional foods (Turner and Turner 2007).

Today, there are serious barriers to the transmission of intergenerational knowledge. Huge experience and generation gaps separate elders and youth. This came up often among elders when speaking about prospects for revitalizing the *ts'áts'ayem* tradition: "If you talk about *ts'áts'ayem* to the younger generation they don't even know what you're talking about"[86] (Sewid-Smith). Sarah Sampare said, "Nowadays, the young people been wandering away from the real."[87] Because of this, loss of knowledge of the environment is often lamented by today's elders. It is a factor in the cessation of harvesting *ts'áts'ayem*. For today's Kwakwaka'wakw, knowing where to go for *ts'áts'ayem*, and about the tides and all the know-how once innate to land-users, is not common. As children, several Likwadawx elders spoke of rowing between Quadra Island and Campbell River. Today, that seems implausible. Discovery Passage is known as extremely dangerous. But children rowed across daily, knowing the tides well, and how to maneuver boats.

Another factor is time. May is a busy food gathering month. If time for food gathering is limited (for example due to the modern workday), time gathering eelgrass might be eclipsed by priorities of harvesting other foods (for example seaweed and salmonberry sprouts as well as halibut, spring salmon and shellfish are also harvested in May), or preparing for the harvesting summer season. The fact that *ts'áts'ayem* can't be preserved may make it a secondary food to harvest if time on the land and water is limited. The window of *ts'áts'ayem*'s availability is small, as gathering it is dependent on the low tides in May, which might cause it to be forgotten compared to foods that are accessible over a longer time.

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[86] Daisy Sewid-Smith, January 8, 2006
[87] Sarah Sampare, May 31, 2006

There are repercussions to the decline of harvesting eelgrass. Eelgrass is an exemplary of a clean, nutritious food that used to constitute a significant part of the traditional diet. The nutrition of eelgrass is briefly addressed in Chapter 4. The decline of use of traditional foods amongst indigenous people has had serious impacts on the health of people living often in marginalized conditions. First Nations are among the poorest people in Canada and their health is often compromised because of it (Kuhnlein and Turner 1991). Decline in traditional foods has occurred in tandem with a decline in aboriginal people's health (Anderson 2005); this is part of the nutrition transition seen in countries around the world. Roots contain carbohydrates as well as essential vitamins and minerals, and green vegetables also contribute important nutrients (Kuhnlein and Turner 1991). The diversity of plants, sites and gathering techniques was an important part of the health of the First Nations in terms nutrition, physical exercise and sense of community. Wild foods and the lifestyles they represent are often much more wholesome and healthy for people. People who still live traditional hunter-gathering ways tend to be very healthy (Anderson 2005, 327). Ethnonutritionist Harriet Kuhnlein (1984), and other researchers suggest that better access to traditional foods (local foods with high nutritional value) would improve the nutritional intake in First Nations. Besides direct nutrients received from eelgrass, the practice of going out on the water to harvest was part of a healthy lifestyle that encouraged physical activity and emotional and psychological well-being.

Challenges and considerations for TEK research

Research that involves human minds and memories is a challenge. The challenge is not only with the consultants, but with the researcher. As well as the complications of potential mis-understanding, mis-communication and mis-interpretation, much of the reported research has had many biases that must be acknowledged and considered. Many of the traditional plant harvesting practices were carried out by women, who, in the times of Franz Boas and his contemporaries, did not usually associate with these male anthropologists. If gathering *ts'áts'ayem* was a male project, there might be more accounts of it in the literature. There are many other biases that come into play in the ethnography, including different dialects, translators and politics. Imagine Boas, a

German anthropologist, who worked with George Hunt, a half-Tlingit but who grew up in Fort Rupert, and who had a wife from Blunden Harbour, who spoke Nakwakdawx, a different dialect, and likely had different practices from other tribal groups. Teasing out history from the circumstances of those who recorded it is challenging.

There are also challenges to human memory. Sometimes traditions not practiced for a long time are a bit hazy in elders' minds. Memories from youth can often be jogged, but sometimes it is difficult to know how much information should be given by the researcher to stimulate memory but so as to not influence recollections. Determining accuracy of reports depends on triangulation and cross-referencing information given by different consultants and from historical and ethnographic sources, and ultimately on the researcher's experience and understanding of the general material, and personal judgment of the understanding of the consultant.

The general challenges of loss of culture and social upheaval are also a challenge for the ethnoecological researcher. The First Nations on the coast are still in the aftershocks of residential schools, land takeover, cultural upheaval, and generations of lost children. These circumstances affect politics, interpersonal relations and trust of outside researchers. Sensitivity and perspective of the researcher is paramount in this endeavour. While there are movements for renewal of cultural knowledge and traditional food systems, it is often difficult to find clarity in the midst of a syndrome of loss of culture.

2.6 Chapter 2 conclusions

In the past, the Kwakwaka'wakw people lived off the land and sea, living seasonally with intimate knowledge of the ecosystems on which they depended. They evolved sustainable plant management practices out of necessity and intimate ecological observation and knowledge.

In the past 200 years the Kwakwaka'wakw people have undergone major cultural, social and lifestyle changes which have affected their relationship with the natural world today. Most contemporary Kwakwaka'wakw are not familiar with *ts'áts'ayem* (*Zostera marina*). Eighteen Kwakwaka'wakw elders who recalled harvesting or eating *ts'áts'ayem* were consulted in my study. The most recent, concerted harvest was, at best, some 30 years ago. Participating in this project was virtually the first time these *ts'áts'ayem* experts had talked about, harvested or tasted its sweet rhizomes in decades.

From the expertise and memories of several elders, I conducted and documented *ts'áts'ayem* harvesting in 2005 and 2006. *Ts'áts'ayem* was harvested on the low tides of May. Locations for the harvest were determined based on health and size of individual eelgrass plants in a meadow, and, for efficiency of harvest and ostensibly for sustainable harvest reasons, based on health and size of the meadow. Elders recalled consuming large *Z. marina* plants. Two methods of harvesting were identified, one in locations where the low May tides exposed plants so they could be gathered by hand in a few centimeters of water, and one in locations where the plants were subtidal. In subtidal areas, the *k'elpaxu* (hemlock twisting stick) was employed to twist the plants up into a boat. The specificity of eelgrass protocols (tools, harvesting, peeling, eating), the words and place names associated, and the breadth of territory in which it was harvested, pointed to the expertise inherent in the traditional practitioners, and also the cultural importance of this species. Elders remembered eating sweet *ts'áts'ayem* longingly; eelgrass was an important part of the seasonal food gathering round for the Kwakwaka'wakw.

The ethos of *keeping it living* was a Kwakwaka'wakw conservation ethic extended towards plant (and animal) resources so that they were not overharvested, and were often gathered in a way that enhanced the production of desired foods and qualities in those foods. While contemporary elders do not recall being specifically taught to enhance or tend the eelgrass beds, this ethic and their expertise in the field makes it probable that eelgrass was harvested as a sustainably managed resource.

In ten of the twelve sites visited in this study, elders were not satisfied with the samples obtained. They pointed out specific indicators of edibility and health of eelgrass that were undesirable: heavy epiphytic growth, small size of plants and dark colouring of rhizomes. They attributed these traits to pollution. At each site there were indeed sources of pollution that might have contributed to the poor eelgrass condition.

The loss of *ts'áts'ayem* use and knowledge is one example of a worldwide trend in loss of TEK. The ease of obtaining store-bought food and prevalence of sugars in the diet, alienation from the land, loss of traditional knowledge, pollution of the resource and disconnect between generations are a few of the reasons that the harvesting of *ts'áts'ayem* is not continued today. The cessation of this practice represents a significant loss to a part of Kwakwaka'wakw identity, to their nutrition and health, to the ecological understanding of eelgrass, and to a greater body of human knowledge and understanding of our natural world.

Chapter 3 Clonal response of *Z. marina* L. to harvesting disturbance

3.1 Introduction

In the *keeping it living* tradition of the Kwakwaka'wakw people, plant harvesting practices were conducted in a way that ensured the sustainability of a resource (section 2.2). Because of this, I was interested in eelgrass shoot re-generation, and net shoot production post-harvest in harvested plots to determine whether eelgrass meadows were harvested with this ethic or effect. As well, it is often seen in traditional root harvesting that plants were thinned or harvested in a way that increased the size of the desired plant part (Anderson 2005). Elders recalled rhizomes dimensions "the size of a pencil,"[88] much larger than the average rhizome we observed in this study. Therefore, rhizome internode volume was a measurement of interest to test whether harvesting enhanced the size of the plant.

My objectives in this ecology component were:

1) to develop a methodology based on traditional Kwakwaka'wakw harvesting for in situ experiments to examine how harvesting would have affected *Zostera marina* growth post harvest;
2) to test the effect of harvesting on plots of eelgrass within a season by A) shoot regeneration, B) net shoot production post-treatment, C) rhizome internode volume (see Experimental questions Section 3.1.3, page 97)

3.1.1 Reproduction of *Zostera marina* L.

Zostera marina L., eelgrass, is a seagrass with a simple shoot system of one terminal shoot and none to several lateral shoots, with a below-sediment rhizome and roots at depths of 3.0 to 20.0 cm (Philips 1984). The plant reproduces by two modes: clonally through the addition and expansion of new ramets (a 'ramet' is a leaf-bearing shoot, together with a portion of rhizome and associated roots), and sexually by seed production and establishment of new genets (a genet is a genetically distinct plant, and may comprise several ramets). In the springtime, *Z. marina* produces generative shoots which are branched spikes of flattened inflorescences (Ackerman 1993). Lateral leaf shoots (a leaf shoot is a bundle of leaves and single basal meristem) grow from its main

[88] Adam Dick, Tom Nelson, pers. Comm. 2006

rhizome (Figure 3.1). Environmental conditions have effects on growth patterns and reproduction strategies. Latitude (Phillips 1983), water temperature (Phillips 1977), seasonal fluctuations (Dennison 1987; Phillips 1984), depth (Dennison 1987; Krause-Jensen et al. 2000; Middelboe et al. 2003), and disturbance (Olesen and Sand-Jensen 1994a; Roberston and Mann 1984) are some of the factors that dictate strategies for energy investment and growth in an eelgrass meadow's cycle. The mechanisms for determining mode of reproduction and distribution of growth energy are complex.

In response to the diversity of environmental variables, *Zostera marina* is extremely flexible in its reproductive strategies; this is a significant factor for its success and large range. Phillips et al. (1983b) outline three distinct reproductive strategies which are typical for populations of *Z. marina* along the Pacific coast: 1) an annual strategy in the Gulf of California where 100% of the plants flower in March, set seed in April and decay after that as the water temperatures increase; 2) a perennial strategy in intertidal plants in the Central range from California to Alaska (the intertidal zone undergoes high flux in water temperature, salinity, radiation, grazing, disturbance and wave action), characterized by higher flowering and seed production than their counterparts in subtidal zones; and 3) a perennial strategy in subtidal eelgrass in the same Central range which has the least flowering response. For this study, I am concerned with the third perennial strategy seen in eelgrass in the Pacific Northwest which reproduces primarily vegetatively through clonal expansion.

3.1.1.1 Vegetative reproduction

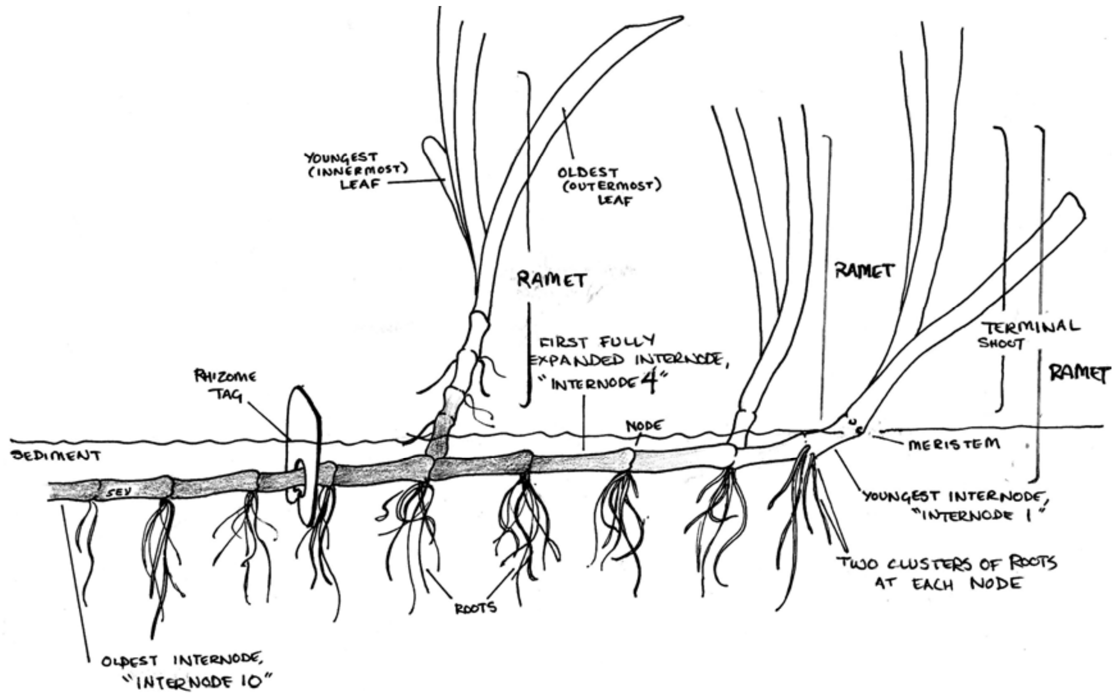

Figure 3.1 Anatomy of three eelgrass ramets (the ramet: a shoot with its rhizome and associated roots). Roots grow in two clusters at each node. The 'Rhizome tag' was set after treatment application to gauge internode growth and Plastochrone Interval (see methods, section 3.2). Middle internode denoted is 'Internode 4,' the first fully expanded, mature internode segment.

The primary form of growth and exploiting resources by seagrasses is by vegetative extension of the ramet. The meristem divides by intercalary growth (growth away from the area of initiation), meaning the photosynthetic tissues of the leaves grow away from the rhizome (Thayer et al. 1984). Individual eelgrass plants can make ramets that are potentially independent by vegetative means. The main rhizome extends as a shoot, which sets down roots at nodal points for nutrient uptake; thus it advances below the sediment in this way, with the leaf shoot extending into the water column for photosynthesis. The leaf axil is capable of initiating side branches, which develop from the nodes, forming new shoots, or ramets. *Zostera marina*'s growth strategy is a *mono-meristematic leaf replacing form* (Short and Duarte 2001). An interconnected mat of rhizomes allows for the translocation of resources, and sharing of nutrients (Marba et al. 2002).

The plastochrone interval (PI) is the basic unit of time between initiation of two successive leaves on a seagrass shoot (Jacobs 1979; Sand-Jensen 1975). The physical structure of eelgrass is such that a new rhizome internode is produced in the same time as a new leaf is formed (Duarte et al. 1994; Phillips 1984; Sand-Jensen 1975). PIs are species specific, but also depend on latitude, environmental conditions and time in the season (Sand-Jensen 1975). For *Z. marina*, the annual average PI of 15.3 days has been documented (Short et al. 2001), however there is much variation due to latitude, depth and specific population, and PIs vary widely throughout the year (Gaeckle and Short 2002). I consider the plastochrone interval in timelines for specimens in my experiments.

In terrestrial plants, the spectrum of clonal growth programs ranges from a 'guerrilla strategy' early in the clone's establishment, where widely spaced ramets push out into a foreign environment, and a 'phalanx strategy' later in the clone's expansion, where ramets have become tightly packed and interconnected, and advance on a front, excluding other species from the clonal area (Lovett-Doust 1981). *Zostera marina* is known for such a phalanx growth form (Olesen and Sand-Jensen 1994b), however Sintes et al. (2006) point out that seagrasses transition between the two strategies at some point in a clone's establishment, and that a lot of variation exists between timing and duration of the transition between stages.

3.1.2 Three influences on vegetative growth

Three factors that influence clonal growth relevant to the investigation of anthropogenic removal of eelgrass meadows are explored in this chapter: season, plant density and disturbance.

Season

In the Pacific Northwest, the growth season for *Z. marina* extends approximately from April to September (Phillips et al.1983; Philips 1984). In Limfjorden, Denmark[89] it was found that when light availability was highest in May-June, eelgrass leaf shoot formation rate was also highest (Olesen and Sand-Jensen 1994b). Highest flowering densities were also in May, though no seedlings established within the populations examined. As the season progresses the size of individual shoots increases to a

[89] Latitude: 56º 55'N

maximum in the summer, after which a large senescence of leaves and shoots begins (late summer). In all populations eelgrass plants die back to a dormant state during the wintertime (Olesen and Sand-Jensen 1994a). When daylight increases in the spring, the surviving plants have low epiphytic loads and spatial opportunity for expansion, and conditions for rapid growth returns. Some of the factors involved in the effects of seasonality are temperature, nutrient loads and epiphytic growth (Phillips 1984).

Plant density

Examples from terrestrial plants can be informative for developing hypotheses for seagrass growth and population dynamics. In conjunction with thinning experiments in cultivated plant populations, Yoda et al. (1963) studied different wild plant populations (from roadside weeds to stands of trees), and found that across a diversity of plant species, *self-thinning* occurs in a population when the plant coverage has exceeded a certain threshold; self-thinning is where there is a decrease in plant density after some maximum density is reached. The population operates to maintain the critical density threshold. Furthermore, they found there was a constant negative slope of 3/2 for the relationship of log(p*)-log(w*)[90]. They termed this phenomenon *the 3/2th power law of self-thinning*, and it has been found to apply to a wide range of species of plants (Yoda et al. 1963; White and Harper 1970).

In the context of these theories based on terrestrial plant growth, biomass-density relationships of 29 eelgrass populations in Europe, Japan and North America[91] were analyzed (Olesen and Sand-Jensen 1994a). While self-thinning did not occur as explicitly as expected based on terrestrial research (ie. adhering to the –3/2 power rule), populations exceeding a ‘global summer median biomass’ experienced a net decline in shoot density. Parallel to this, in Netarts Bay, Oregon, a threshold measurement of eelgrass biomass production was found (measured by Leaf Area Index - a value expressing the combined the effects of shoot density and leaf surface area on overall biomass), above which leaf area was negatively correlated with shoot density, and resulted in a selective loss of small shoots in mid summer (Kentula and McIntire 1986).

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[90] w* = average weight of individual plants and p*= average plant density
[91] All populations were within 30º and 56º N latitude.

Olesen and Sand-Jensen (1994a) hypothesize that eelgrass populations might not express self-thinning as in terrestrial populations because the optimal conditions for growth end before a maximum density threshold is reached. Most populations did not reach such high population density levels, except for a short summer period at maximum biomass. It has been found that the -3/2 power law does not apply as readily to clonal plants where density mediation of population can occur through other mechanisms besides self-thinning (de Kroon 1993). For example, Schmid and Harper's (1985) study of *Bellis perennis,* a grassland perennial daisy, found that the clones of this phalanx species can self-regulate by limiting its own shoot recruitment; eelgrass stands may have this capacity as well (Olesen and Sand-Jensen 1994a).

Olesen and Sand-Jensen (1994b) further examined a potential cause of the influence of density on growth by looking at the effects of self-shading of eelgrass stands as a factor for recruitment limitation. While they found shoot density remained relatively constant over the growing season (March-August) in Limfjorden, Denmark, there was a high mortality of young and small leaf shoots in late summer, as well as a lower recruitment of vegetative side branches. The authors suggested that young shoot die-off coincided with the high self-shading in late summer, as new shoots (smaller than older shoots with taller leaves) were an expendable cost, surviving only if they had room, which by late summer was at a minimum. They also found that at the time of maximum *total* biomass in midsummer, density had declined since the spring in 30% of the populations; this supports Yoda et al.'s (1963) *total plant yield* theory which states that as the self-thinning progresses, individual ramets get larger.

Disturbance

The crowding effects of high-density eelgrass meadows that ultimately result in self-shading and die-off can be alleviated by moderate disturbance. In their literature review of eelgrass population dynamics studies, Olesen and Sand-Jensen (1994a) found that in established eelgrass beds, the biomass of leaf shoots at the beginning of the season had a significant inverse relationship with net shoot density increase between spring and summer. Eelgrass populations with unusually low biomass in early spring (i.e., caused by winter ice scour or die-off due to high temperatures the previous summer) experienced a higher and longer shoot recruitment throughout the summer.

One case example of this is in Nova Scotia, where the formation and movement of winter ice annually removes almost all of a dense *Z. marina* meadow. Robertson and Mann (1984) found that in Nova Scotia, by the end of the following growing season the population had recolonized. In perennial eelgrass beds with low disturbance, seedling germination and survival is observed to be very low (Phillips et al. 1983); however, at this disturbed site, new seedlings established readily in the space scoured by the winter ice. Seedlings grew more prolifically and larger, without the presence of a mature canopy, and the remaining mature plants branched five times more where there was no canopy (Robertson and Mann 1984). Shading experiments with cloth confirmed these findings, but did not reduce new seedlings' growth as much as the mature ramets. Therefore, the authors proposed that nutrient availability is also a factor for seedling establishment and survival. This population had adapted to the winter ice by putting high energy input into forming very strong roots: mature perennial eelgrass plants in this population annually allocated 43% of their biomass production to rhizomes and roots, whereas four other comparison populations had 15% to 31% below-ground production in a year. The authors reasoned that strong roots increased the meadows' ability to withstand ice scour, and the increased carbohydrate reserves aided regrowth in the spring, speeding post-disturbance recovery. This was an example of a densely populated eelgrass bed in which disturbance allowed for both sexual reproduction and clonal expansion.

3.1.3 Experimental questions

My shoot removal treatment intended to mimic traditional eelgrass harvesting. The treatment involved different intensities of removal of eelgrass shoots in small plots. Research questions at both sites in my in situ experiments were:

Question 1: How do different intensities of harvesting treatment affect shoot regeneration? Shoot regeneration was measured as the difference between the number of shoots per plot at the end of the respective experiment and the original number counted pre-treatment. This measurement represented the shoot re-generation with respect to the original pre-treatment densities within one growing season.

Question 2: How do different intensities of harvesting treatment affect net shoot production-post treatment? Net shoot production-post treatment was measured as the number of new shoots produced after treatment by the end of the season.

Question 3: How do different intensities of harvesting affect the internode volume output of remaining rhizomes? Volume of internode 4 was chosen as it was grown post-treatment (based on Netarts Bay plastochrone interval data) but is the youngest fully expanded, or 'mature' internode (Short and Duarte, 2001), and has lower variation than younger internodes.

3.2 Methods

3.2.1 Site selection

The primary experiment was conducted in a subtidal *Zostera marina* meadow in Hyacinthe Bay, Quadra Island (June-September 2005). A supplementary experiment was conducted in an intertidal meadow at Tsawwassen (July-September 2006). Criteria for site selection were: dense *Z. marina*, relatively even water depth, general uniformity of density of the meadow, green, healthy plants, low disturbance and impact from humans (to approximate pre-contact conditions), accessibility and protection from wind. Health of eelgrass was visually determined by size, density, epiphyte load and general desirable characteristics for edibility according to Kwakwaka'wakw descriptions from interviews. The density of shoots was an important factor for the analysis. Treatment groups were tested for differences of their original (pre-treatment) shoot densities.

Hyacinthe Bay, Quadra Island, May-September 2005: 50° 07’04” N, 125° 13’33” W
Site #27 in Figure 2.3, page 40

At low tide a sand bar extends to a small island forming a bay around a continuous *Z. marina* bed in a small sub-bay on the west side of Hyacinthe Bay. To characterize and choose the boundaries of the sampling area, a 100 m characterization transect (C transect) was established parallel to the beach through the middle of the *Z. marina* meadow. Ten plots were set South to North along the C transect and measured for depth, shoot density and sediment to determine if the area was adequately homogeneous. Sediment was sand and in a few plots, sand and small pebbles. Specimens from each plot were taken and pressed and were submitted to the UVic herbarium[92]. The area is not often visited by people nowadays, but was historically used by First Nations, but not for several centuries and there was no indication that this bay had been used for eelgrass harvest in the past.

Tsawwassen, July-September 2006: 49° 03’22” N, 123° 07’22” W
Site #28 in Figure 2.3, page 40

This site was off the south side of the ferry terminal at Tsawwassen. Two areas of dense *Zostera marina* were chosen for two 100m transects set parallel to the pier, approximately 200 m out beyond the high tide mark. Transect A was set beyond the second ferry archway towards the sea – at a low of 0.9 m it was still in ~20 cm of water. Transect B was located near the first ferry arch (driving to the ferry). This transect was shallower, and completely exposed on a low tide of 0.9 m. The substrate was fine sand. Specimens at the Tsawwassen location were larger than those at the subtidal Quadra site. This site was subject to much more use than the Quadra site, including crabbing, clamming, pulling boats along on low tides, and potential pollution from the ports and human activity.

[92] Accession numbers 45912 to 45921

3.2.2 Experimental design
Quadra site 2005

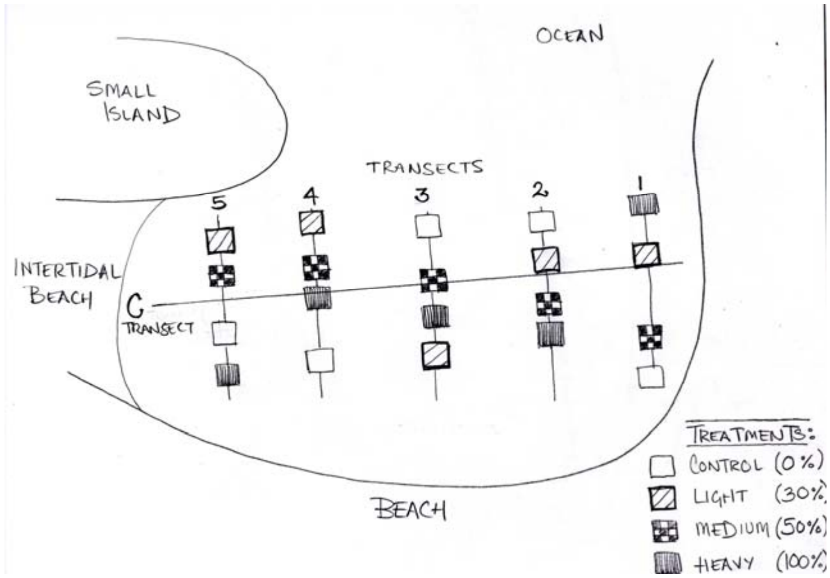


Figure 3.2 Quadra Experiment design, 2005. Location: in a sub-bay of Hyacinthe Bay, Quadra Island.

At the Quadra site harvesting was conducted subtidally on low tides with SCUBA. A complete randomized block design was used for the disturbance experiment; while the site was relatively uniform and blocks were not gradients but random transects, randomization of the plot sites and treatments was used to minimize depth and plot shoot densities as factors. Using the C transect as a reference, five 30 m transects were set perpendicular to the C transect (West to East) at random distances along the transect, set with flagging tape and 0.46 m pieces of rebar. On each transect, four square PVC quadrats of $0.0625m^2$ (0.25 m X 0.25 m) were set with rebar for a total of 20 quadrats (Figure 3.2). Distance between them was chosen at random using a stopwatch, but not within 2 m of each other. Shoot densities and depths were counted and measured pre-treatment (May 20, 23, 2005). Treatment was non-selective removal by hand of eelgrass shoots in bunches of three to mimic the patchy *k'elpaxu* removal (Section 2.5.1.1). On each transect, the four plots were treated at four different intensities (based on May shoot counts): 1- control (no removal); 2- light (~ 30% of all plants removed); 3- medium (~50% removed); and 4- heavy (100% removed). Order of harvesting treatments along each transect was randomly chosen with a die (excluding number 5 and 6). Treatments were applied June 9-12 (near the beginning of the summer growing season for *Zostera marina*, and the traditional harvesting month of May). Eight bread tags (see the 'rhizome tag' in Figure 3.1) per plot were set on the rhizome beneath the youngest internode to record internode growth, as per methods from Short and Duarte (2001).

To examine shoot regeneration and net shoot production post-treatment, shoot densities were counted mid season (July 12), and then again at the end of the season (Sept. 2-4), prior to the destructive sampling of plants with tagged rhizomes, which were harvested for rhizome volume measurement. Where eight tagged plants could not be found in a plot, untagged samples were randomly selected and removed for measurement. Plants were removed with as much intact rhizome as possible. Measurements were taken of the widths and lengths of the rhizome internodes from the youngest (number 1) to 10th oldest internode (number 10).

Tsawwassen site 2006

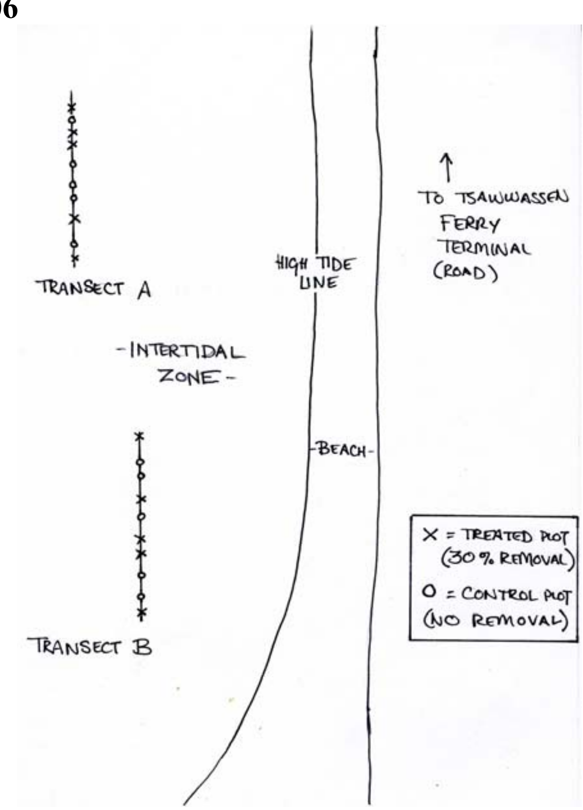


Figure 3.3 Tsawwassen experiment design. Location: South side of ferry terminal, Tsawwassen, BC. Both transects are in the intertidal zone, a large *Z. marina* meadow. Transect A is deeper, and exposed only on the lowest tides.

Characterization and treatment were conducted on the low tides of July 23-25, 2006. Two transects of 100 m were set at two different exposures on the beach: transect A was more often submerged (deeper), and transect B was more often exposed (see Figure 3.3). Ten plots were determined at random along the 100m transects and marked with rebar and flagging tape. A circular plot of 0.503m^2 (0.80 m diameter) was chosen to mimic the radius of harvesting of an individual picking eelgrass in a stationary position. Along each transect, five of the plots were treated, and five were controls (order chosen at random using a coin toss). Sediment type and shoot density per quadrat were recorded before treatment. Treatment was simplified into two categories: light removal vs. control. Treated plots were thinned by hand to remove one third (~33%) of the original number of plants in each plot; plants removed were selected as ones appearing to have the thickest rhizomes. Individual shoots were removed while under 5-10 cm of water as per traditional gathering (and as this is most effective for removal of intact rhizomes, see Section 2.5.1.2). Remaining plants in the plots were selected at random for tagging: plastic bread bag tags were set beneath the youngest rhizome node on six plants per plot. The experiment ended September 6th, 2006 when shoots in each plot were counted (to address research questions 1 and 2) and the tagged shoots were removed for measurement of: number of branches, length and width of longest leaf, width, length and volume of rhizome internodes from the youngest back 10 internodes (to address question 3). When 6 plants with tags could not be found in a plot, random, untagged samples were removed and measured.

3.2.3 Statistical analysis

Initial exploration: For output variables (net shoot differences, rhizome internode volumes) scatter matrices were created in SPSS version 11.5, (SPSS Inc., Chicago IL) to visually check for environmental trends in the data (potential confounding factors were depth, original density, and transect). As well, the Manifold System 6.5.0 program was used to create spatial autocorrelation surfaces to determine whether patterns were random or suggested influences of these factors on the data sets. This allowed me to rule out environmental influences and focus on the factors of interest: original density, treatment, prior growth, transect (as a proxy for depth at Tsawwassen).

Data analyses were performed using SPSS version 11.5 (SPSS, Inc., Chicago IL). For Power analyses, G Power Version 2.0 was employed, and detectable differences were based on the differences of mean values between groups in the results, as well as effect-size conventions (large effect = 0.40, medium effect = 0.25). Data sets from each experiment were analyzed separately.

Shoot regeneration was measured as the difference in shoots between the end of experiment[93] and pre-treatment, original densities[94]. *Net shoot production-post treatment* (here called '*net shoots*') was measured as the difference in shoot numbers between the end of the experiment and initial, post treatment densities[95]. For *internode 4 volume*, the non-independent specimens in each plot [8 plants/plot (Quadra) and 6 plants/plot (Tsawwassen)] and the mean internode 4 volumes were calculated and those indices used in the analysis (n= 20, and n= 16). Internode volume was found according to the volume of a cylinder: $A=\pi r^2 h= \pi(\text{width}/2)^2 * \text{length}$ (width and lengths of internodes were measured from samples).

The following null hypotheses were tested using General Linear Models: H01: *Harvesting treatment has no effect on shoot regeneration*; H02: *Harvesting treatment has no effect on the net shoot production post-treatment;* H03: *Harvesting treatment has no effect on the volume of internode 4*. Treatment was removal of shoots in plots at three different intensities (30%, 50%, 100%). Other factors explored in each analysis of outputs were: transect, original density, post-treatment density, depth, and internode 9 biomass (an older growth increment to indicate the influence of the individual's growth pattern). Assumptions of normality and equal variances were determined by the residuals of the shoot differences using Shapiro-Wilk test (as $n<50$), and Levene's test, and by examining Q-Q plots and standardized residuals. An alpha value of $p= 0.05$ was used as the threshold for significance. Data had normal distribution and equal variances ($p > 0.05$) unless stated otherwise in the results.

Experimental design fit ANCOVA analysis. However, where more than two factors were continuous, a regression model was explored (higher power than ANOVA).

[93] End of Experiment: on Quadra= Sept.2, '05, at Tsawwassen= Sept. 6, '06
[94] Original densities: Shoots counted on Quadra= May 20, '05, at Tsawwassen= July 22, '06
[95] Initial post-treatment densities: counted at Quadra on June 13, '05, at Tsawwassen on July 25, '06

Where two models with equal parameters were found, the model explaining more variation (R^2) was chosen. Reduced models found using backward selection (elimination) for ANOVA and regression models; interaction effects and factors were removed where they were not significant. As the sample size was relatively small (n= 20 or n= 16), and there was high variation in the data, simple (reduced) models were selected, based on their conformity to the assumptions of the models, and Akaike's Information Criterion (using 'AIC corrected' because of small sample sizes, and assuming equal distribution of errors). ANOVA tables are included in Appendix D.

3.3 Results

Site characterization

Quadra

Visual inspection of spatial autocorrelation surface indicated no environmental trends for depth, transect or original shoot densities. Mean original density was 29.0 shoots/plot (SE=2.58). Original shoot densities had a range of 15 – 55 shoots per plot, but original densities for treatment groups were not significantly different (one-way ANOVA $F_{3,16} = 0.211$, p= 0.887, for means see Table 3.1). However, post hoc power analysis indicated a low power (0.350) for detecting differences between original densities of 20 plots, and that for power > 0.80 sample size needed to be over 48.

Tsawwassen

The mean original shoot density per plot was 51.0 shoots/plot (SE= 4.04); the range of original shoots per plot was 22-106. Original density means between groupings of treatment, transect (Table 3.2) were not significantly different (T-test transect: t(18)=-0.253, p>0.05; treatment: t(18)= 1.243, p> 0.05); however power was low (power = 0.448; for power > 0.80, n needs to be > 52).

3.3.1 Question 1: How do different intensities of harvesting treatment affect shoot regeneration?

Timelines

Quadra

Confidence intervals (95%) for the means of shoots per plot of the treatment groups show overlap (Figure 3.4). However, the summer trajectories of the groups' means with confidence intervals included are presented to illustrate the trend of the shoot counts throughout the experiment (Figure 3.4). Trends are as follows: between Time 0 (the start of the experiment June 13) and July 2, the mean densities of all groups increased in shoot number, but by the Sept. 2 shoot count, the *control* group, which had had the highest initial density at Time 0, had decreased below its initial number. Meanwhile, the other groups had continued to increase in shoot number. The *light* harvest group showed the sharpest increase in mean shoots over the season, ending the summer in Sept. '05 with more shoots than its original density, and the highest average shoot count of all treatment groups at that date. The *medium* harvest group had reached approximately its same original pre-treatment density mean; the mean of the *heavy* harvest group had not recovered to its pre-treatment density, but was increasing.

Tsawwassen

At the Tsawwassen site experimental treatment was applied late in the season (July 25). There was an overall loss of shoots between July to September 2006 in both groups (Table 3.2, Figure 3.5). Both *control* and *treatment* had parallel slopes in decline; an effect of treatment on the shoots was not apparent.

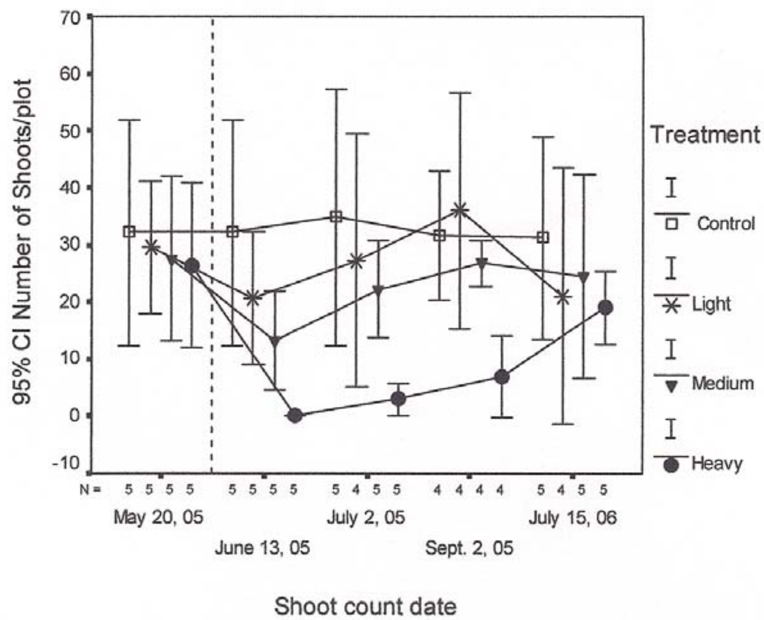


Figure 3.4 Confidence intervals (95%) and means of number of shoots per plot (0.25m X 0.25m) at the Quadra site for the four treatment groups for summer 2005. Markers depict the means of the treatment groups; means are based on 4-5 plots per treatment. Original shoot densities were counted May 20-23, treatment was applied June 11-12. Dotted vertical reference line just before June 13 indicates the beginning of the post-treatment growth. Note: date axis is not to scale.

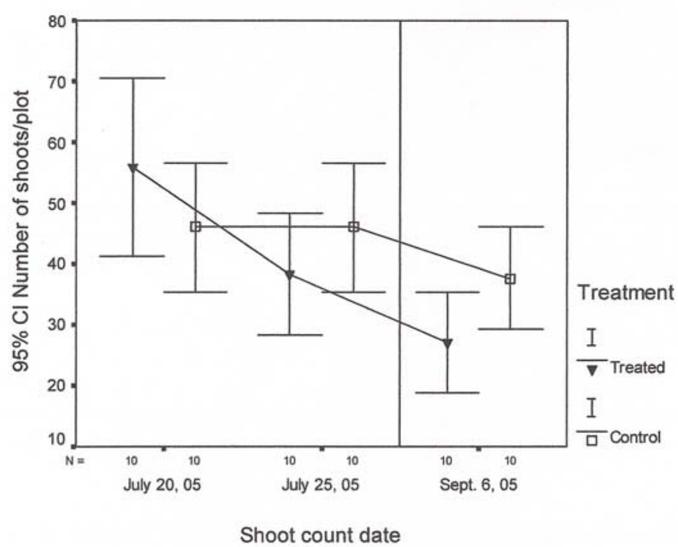


Figure 3.5 Confidence Intervals (95%) for number of shoots/plot (0.503 m^2) at the Tsawwassen site for the treatment groups throughout experiment July 22 – Sept. 6, 2006. Markers depict mean shoot numbers. Application of the treatment occurred July 23-24; vertical line at July 25 denotes the start of new growth measured. Means based on 10 plots per Treatment. Note: Date axis is not to scale.

Table 3.1 Quadra site mean values for shoot counts and shoot production per plot (plot = $0.0625m^2$) among treatment groups (2005). Original density and post-treatment density are factors, shoot regeneration and net shoots are the measured response variables. Post-treatment density was calculated based on original numbers – number of removed shoots.

Treatment	Mean original density (Std Error-SE) (May 23)	Mean post-treatment density (SE) (June 13)	Mean shoot regeneration (SE) (May 23 - Sept. 2) Figure 3.6	Mean net shoots (SE) (June 13-Sept. 2) Figure 3.7, 3.8	Mean final density (Sept. 2) (SE)
Control	36.2 (7.6)	36.3 (7.6)	-4.5 (5.6)	-4.5 (5.6)	31.7 (3.5)
Light	33.3 (6.0)	24.3 (5.9)	-0.7 (2.3)	13.5 (5.5)	36.0 (6.5)
Medium	28.0 (6.7)	13.0 (3.9)	-1.3 (7.5)	13.7 (4.7)	26.8 (1.3)
Heavy	27.8 (6.6)	0	-20.7 (6.4)	7.0 (2.3)	7.0 (2.3)

Table 3.2 Tsawwassen mean values for shoot counts and shoot production per plot (plot = $0.503m^2$) among treatment groups (2006). Original density and post-treatment density are factors, shoot regeneration and net shoots are the measured response variables. Post-treatment density was calculated based on original numbers – number of removed shoots.

Plots	Mean original density (July 22) (Std Error)	Mean post-treatment density (July 25) (SE)	Mean shoot regeneration (Sept.6 – July 22) (SE)	Mean net shoots (Sept.6 – July 25) (SE)	Mean final density (Sept.6) (SE)
Control (n=10)	46.00 (4.693)	46.00 (4.693)	-8.400 (4.510)	-8.40 (4.510)	37.60(3.727)
Treated (n=10)	55.90 (6.439)	38.30 (4.415)	-28.9 (4.813)	-11.30 (3.347)	27.00

Shoot regeneration
Quadra

The mean shoot regeneration measurement in each treatment group showed an average decline in shoots (Table 3.1). However, the scatter of the shoot regeneration vs. removal data shows that half of the plots achieved a net increase of shoots above their original densities (Figure 3.6). Shoot regeneration above original densities was observed in a range of 0 to 75% removal. 100% removal did not result in full regeneration of shoots to original densities by the end of one season. Original shoot density was clearly one of the factors for shoot regeneration – in the 0% removal category (control group), the two plots that experienced a net decline in shoots were in the high-density category of 36-55 shoots, while the two control plots of the medium-low original density of 20-25 shoots experienced a net increase over the time period. While there was no statistical difference between groups for original density (site characterization), the test had low power, and numbers did vary within the treatment groups, making it difficult to isolate the effect of treatment.

A reduced multiple linear regression model (R^2= 0.716, $F_{3, 11}$= 9.266, $p<0.005$) confirmed that factors of percent removed (treatment) and original density had significant influences on shoot regeneration (percent removed ß= -23.759, $p<0.005$; original density ß= -0.800, $p<0.005$; depth ß=1.698, $p>0.05$). In a one-predictor regression model focusing on treatment, a near significant quadratic relationship was found for the output of shoot regeneration with percent shoots removed (treatment), (R^2= 0.359, $F_{1,13}$= 3.637, p= 0.056, Figure 3.6). The regression curve indicated that removal between 14 and 56% would result in above-original shoot regeneration, and removal for maximum regeneration would occur at 35.5%. Predictive power for this model was 0.65 (for power of 0.80, sample size needs to be 22).

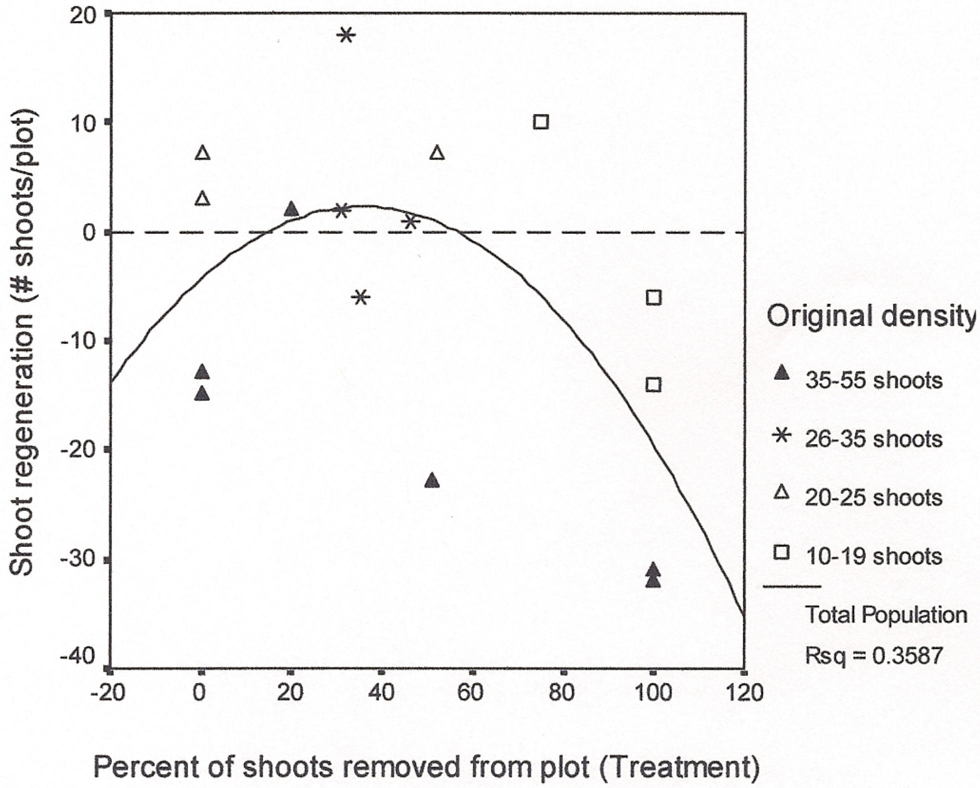


Figure 3.6 Quadra shoot regeneration vs. percent removal (treatment). Shoot regeneration = shoot difference between Sept. 2 and May 20 (original density). Marker shapes indicate the original densities of the plots. Treatments were approximately 30%, 50% and 100% removal of original shoots in each plot, control had no removal. Dotted line indicates regeneration over original densities (above). Curve indicates the regression line: $Y= -4.333 + 37.356x - 52.562x^2$ ($R^2= 0.359$, $F_{1,13}= 3.637$, $p= 0.056$). Maximum shoot production with respect to original densities was at 35% removal of original densities.

Tsawwassen

In an analysis of covariance, factors of shoot removal (treatment), original density and transect influenced the output shoot regeneration (ANCOVA: $R^2= 0.886$; removal $F_{1, 16}= 21.097$, $p<0.000$, $Eta^2= 0.569$; Transect $F_{1, 16}= 22.909$, $p<0.000$, $Eta^2= 0.589$; Original density $F_{1, 16}= 56.238$, $p<0.000$, $Eta^2= 0.779$).

3.3.2 Question 2: How do different intensities of harvesting treatment affect net shoot production-post treatment (net shoots)?

Quadra

Net shoots (shoot production from Time 0 to Sept. 2) was a measure of the new shoot production after harvesting by the end of the season. Original density and treatment were significant influences in a reduced model (ANCOVA R^2= 0.625; treatment $F_{3,11}$= 3.258, p= 0.063, Eta^2= 0.470; original density $F_{3,11}$= 4.997, p<0.05, Eta^2= 0.312). In a simple display of the data, net shoots showed a significant quadratic relationship when plotted with percent of original shoots removed (R^2=0.422, $F_{1,13}$= 4.75, p<0.05, Figure 3.7). Positive net shoot production occurred in all treated plots; the only plots that sustained a net decrease in shoots were the two controls which began with high original density. Highest net shoots occurred at a shoot removal of approximately 60%.

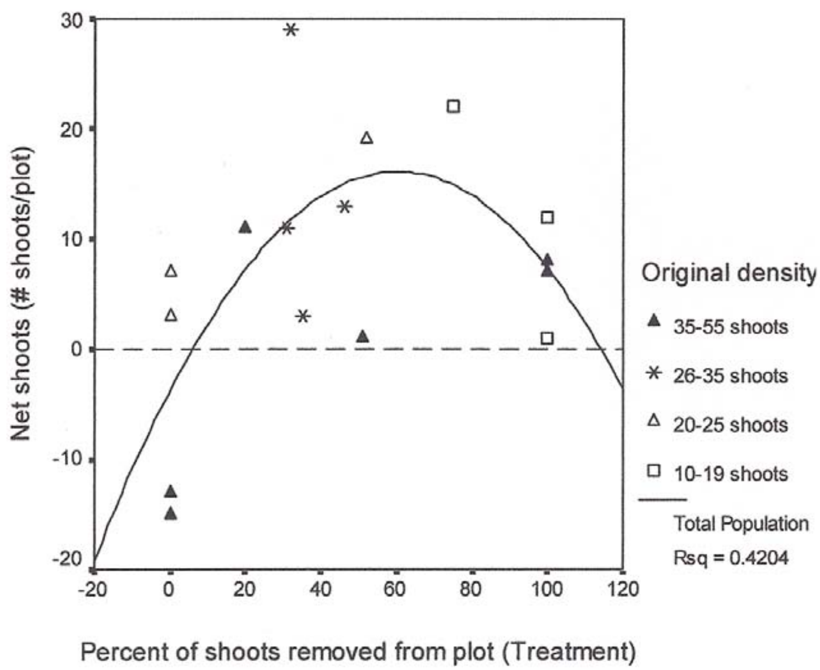


Figure 3.7 Net shoots (net shoot production post-treatment) vs. Percent removal (treatment). Marker shapes indicate the original densities of the plots. Treatments were approximately 30%, 50% and 100% removal of original shoots in each plot, control had no removal. Dotted horizontal line indicates net positive production (above). Curve indicates the significant regression line Y= -3.752 + 66.270x – 55.189x^2 (R^2=0.422, $F_{1,13}$= 4.75, p<0.05). Maximum net shoots was observed at approximately 60% removal of original densities.

Initial post-treatment density (number of shoots/plot remaining immediately after treatment at Time 0) was a different way of looking at shoot reponse to harvesting treatment. In a simple one-factor regression, net shoots had a significant quadratic relationship with initial post-treatment density ($R^2 = 0.466$, $F_{1,13} = 5.66$, $p<0.05$; Figure 3.8). Maximum net shoots occurred at an initial post-treatment density of approximately 12 shoots. It should be noted that the two high original density controls have large influence on the curve.

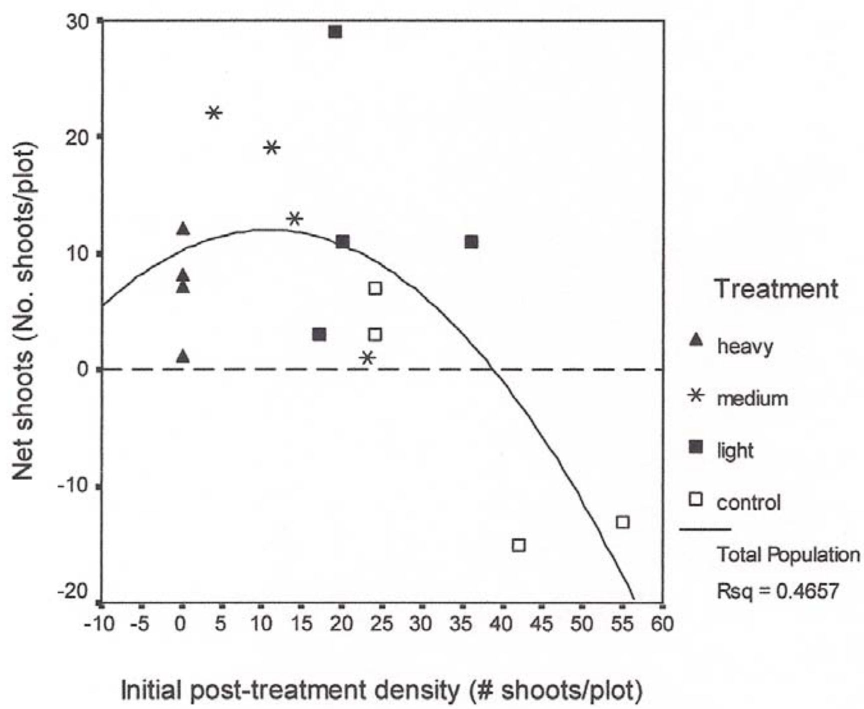


Figure 3.8 Net shoots (net shoot production post-treatment) vs. Initial post-treatment density (June 13). Marker shapes indicate the treatment applied to each plot. Dotted horizontal line indicates net positive growth (above). Curved line indicates significant regression $Y= 10.237 + 0.324x - 0.0151x^2$, $R^2 = 0.466$, $F_{1,13} = 5.66$, $p<0.05$). Maximum shoot re-population occurred at an initial post-treatment density of approximately 12 shoots per plot.

Tsawwassen

In an analysis of covariance model (R^2= 0.756), original density and transect had significant effects on net shoots, but treatment did not (ANCOVA: original density $F_{1,11}$=25.892, p<0.000, Eta^2= 0.618; treatment ; transect $F_{1,11}$= 25.955, p<0.000, Eta^2= 0.619; treatment $F_{1,11}$= 0.333, p>0.05, Eta^2= 0.020). Figure 3.9 indicates that plots in the deeper transect had greater losses of shoots than the shallower. An independent t-test confirmed net shoots were different in each transect (t-test t(18)= -3.109, p<0.05).

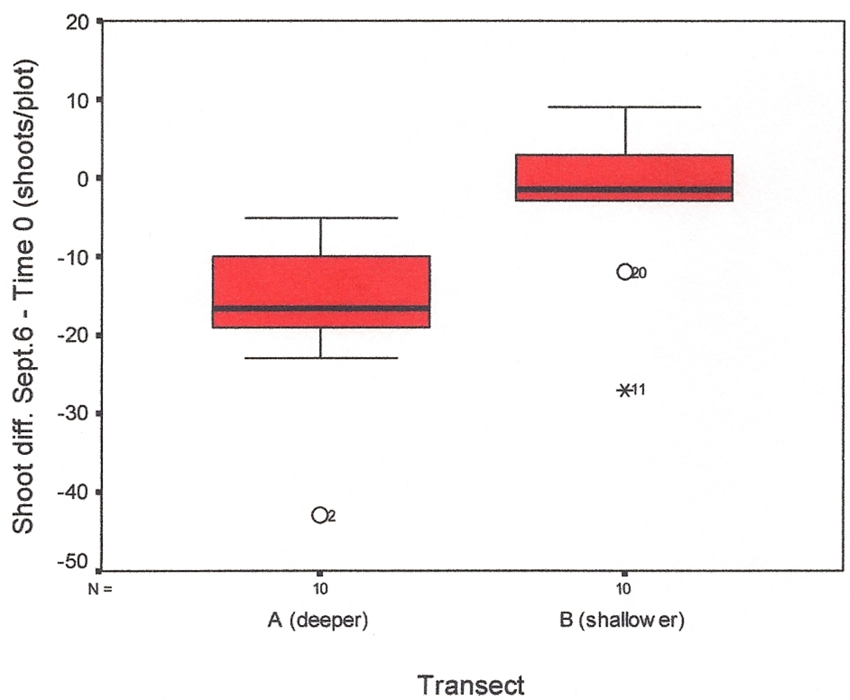


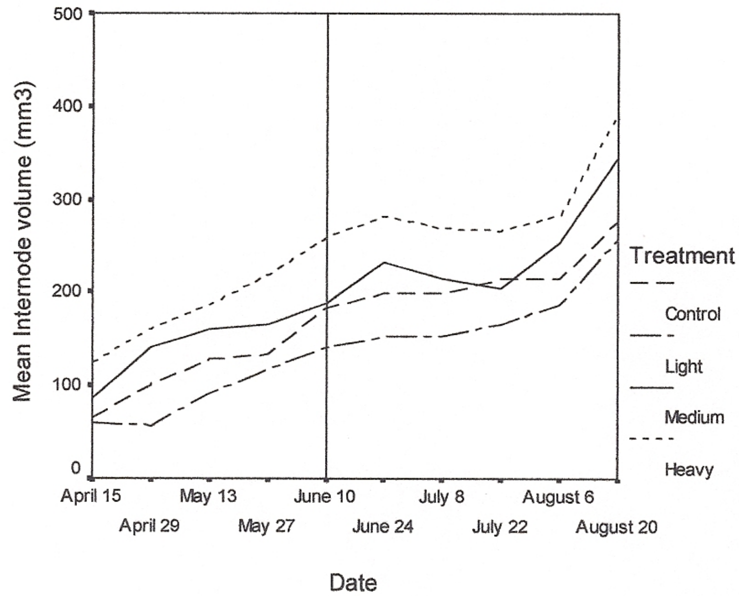
Figure 3.9 Boxplots for net shoots at Tsawwassen site (September 6 – July 24) in the two transects: A) deeper, and B) shallower. Center lines depict median, and the box depicts the upper and lower quartiles; whiskers include 95% of all data points.

3.3.3 Question 3: How do different intensities of harvest affect internode volume?

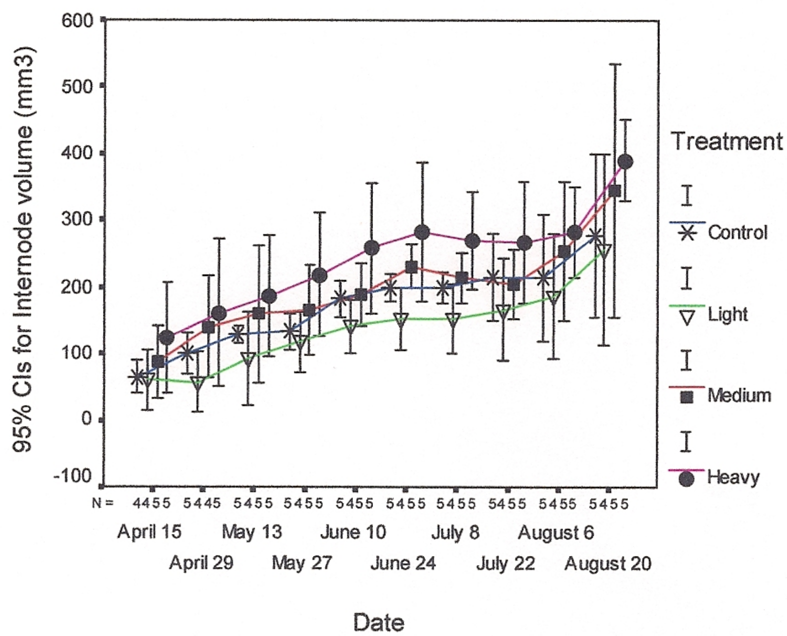
Internode biomass timelines: Quadra

Forty-two of the 160 originally tagged plants were located on Sept. 2, '05. Due to this low sample size, as well as sampling error due to difficulties tagging underwater, the plastochrone interval (PI) of 14 days (rounded from 13.2) from Kentula and McIntire

(1986) data from Netarts Bay, Oregon, was used in a timeline of internode volume means for the Quadra site (Figure 3.10a, b). Variation in the means of the treatment groups is high; confidence intervals overlap. As in Figures 3.4, 3.5, this graph does not show statistically significant trends, but illustrates avenues for further research. Treatment was applied June 11-12 (approximately at the vertical axis); about one internode later (June 24) the mean volumes for the *medium* and *heavy* treatment groups displayed a plateau in production, while the *light* and *control* groups showed no real response to the treatment, continuing to increase. Three to four PIs later, the *heavy* and *medium* groups increased, and plants in all treatments made a sharp increase in volume production, with *heavy* and *medium* making the highest increase.



a) Trajectories of mean internode volumes



b) Internode means and 95% Confidence Intervals

Figure 3.10 Quadra site (2005) volume trends for internodes corresponding to plastochrone interval start dates for Netarts Bay data (PI = 14 days): A) trajectories of the means, vertical axis denotes the beginning of growth after Treatment (applied June 10-12th, 2005); B) 95% Confidence Intervals. Note: means based on 4-5 samples (average volumes from quadrats).

Tsawwassen

A higher return of tagged plants (64 of 120 tagged plants) at this site was due to a shorter length of experiment (43 days) and experienced, improved tagging techniques. The range of internodes grown after the tag was 1 to 6, the mean was 3.4 internodes. The average PI was 12.03 days (standard error= 0.674), with a range of 4 to 16 days. PI distributions were not normal, but had equal variances. PIs were not significantly different in groupings of transect or treatment (T-Test: transect $F_{1, 15}$= 3.615, p> 0.05; treatment $F_{1, 15}$= 0.213, p>0.05), however, the power of this analysis was low (p= 0.22) and sample size would need to be ~150. Variation within the sample volumes was too great to indicate trends of internode volumes and graphs are not included.

Internode four volume

Quadra

For effect of removal on the volume of internode 4, a significant reduced regression model (R^2= 0.538, $F_{3,14}$=5.439, p<0.011) indicated only percent removal as a near significant factor (p= 0.069); factors of original density and internode 9 volume were not significant. Percent removal and volume 4 had a correlation of 0.642 (p<0.01).

Tsawwassen

At the Tsawwassen site transformation of the volume 4 data was necessary to meet assumptions of normality. A reduced regression model for 1/(volume of internode 4) was significant but had a low R^2 of 0.325; it indicated only the factor of internode 9 volume contributed to the transformed output variable (internode 9 volume ß= -1.288E-05, p<0.05; original density ß= 4.698E-05, p = 0.178). Post-hoc power analysis showed that for a large effect size, this linear model had a power of 0.63; an appropriate sample size would be n= 28.

3.4 Discussion

Data from each experiment was assessed separately. There were different considerations for each experiments: different exposures (subtidal, intertidal), different locations and different timing and design of experiments. Intra-specific population diversity is very high in *Z. marina* (Phillips 1983; Backman 1991), these factors likely influenced the outcome and response of the experiments and must be considered and accounted for in future experiments. At the Tsawwassen site there was much higher variation in the plants. This was expected, as intertidal populations have a much higher flux and variation in growth, since they are exposed more often (Phillips et al. 1983). Most important to consider for the Tsawwassen data is that the experimental treatment was applied late in the growing season, likely too late to influence the variables of interest as the original density of this experiment was the shoot numbers of late July. As well, by July the density of plants had likely already reached a maximum, and the net loss between July and September might not indicate an actual overall increase of shoots between May and September.

Question 1: How do different intensities of harvesting treatment affect shoot regeneration?

The Quadra shoot counts provided a picture of shoot regeneration in corresponding to the removal treatment within a season. While sample sizes were small (n= 4-5) and variation was wide for conclusive trajectories, mean trajectories illustrated trends and encourage further inquiry in this area (Figure 3.4). The trends of these means suggested that a light removal (30%) (perhaps alleviating room for new shoots to grow) can correspond with higher shoot growth within a harvested area such as these plots. This was supported by the multiple regression analyses of shoot regeneration which indicated significant effect of percent removal and original density. The quadratic curve fitted to scatter of the shoot regeneration data vs. percent removal (Figure 3.6) indicated that the eelgrass plots of this size ($0.0625m^2$) regenerated to levels above original densities for removal between 15% and 56%; the highest numbers surpassing original densities occurred at approximately a 35% removal. This suggests that if a small area, like these plots, was harvested within such a range, original or higher shoot densities would be attained by the end of the season.

At the Tsawwassen site, transect and treatment had an influence on shoot regeneration; however, the effect of treatment does not indicate a true impact of removal. Treatment was a 30% removal applied in late July, and the final shoot count (determining shoot regeneration numbers) was conducted in early September. The effect of treatment on amount of regeneration is probably due to the short timeframe of the experiment. An earlier application of treatment is essential.

Question 2: How do different intensities of harvesting treatment affect net shoot production-post treatment?

Net production of shoots post-treatment (net shoots) was analysed to look at the possibility of stimulation of biomass production by removal disturbance of this type. At both Quadra and Tsawwassen sites, original density significantly influenced net shoot production. If net shoot production over a growing season is negatively related to original density, it is possible that higher density alleviation (removal) could promote higher numbers of new shoots; this has been suggested by Olesen and Sand-Jensen (1994a). The single factor model for Quadra net shoots furthered this idea – positive net shoots produced occurred after 6.0% shoot removal, and greatest new shoot production at Quadra was observed a level of shoot removal of 60% (Figure 3.7). It is not surprising that even at removal level of 100% there was positive net shoot production, as quadrats were quite small, and ramets from the eelgrass plants surrounding the plots grew into the cleared space. The heavy removal caused by this experiment was therefore not so damaging as to halt overall production of new shoots. At the Tsawwassen site, treatment did not have an effect on net shoots. This is probably due to the late application of removal; at this time in the growing season the meadows have passed their initial growth spurt when there would likely have been a positive response to new space formed by moderate disturbance**.** At this site were net losses of shoots in both treated and untreated plots. This is possibly due to the fact that the experiment likely started after the summer shoot maximum, and by late July shoot numbers were already starting to decline;

therefore the net shoots recorded does not accurately represent new shoot production over the entire season.

A different way of looking at the treatment was by assessing net shoots with respect to initial shoot density after treatment – the shoots left to repopulate the plot (Figure 3.8). According to the significant regression curve (R^2=0.466), the maximum new shoot production corresponded with 12 shoots remaining post-treatment per plot. The effects of original density, percent removal and initial post-treatment density as well as plot size are interconnected and correlated, and further research and adjusted experiment design is needed to determine the influence of each. There is a dynamic balance between availability of space and enough plant material remaining to recolonize. Possible mechanisms of shoot stimulation need to be examined: shoot removal (space alleviation) or disturbance (possibly promoting compensatory growth). As well, the translocation of nutrients amongst ramets of one genet may influence the production response after damage.

Tsawwassen results indicated an influence of transect (depth/exposure block) on net shoots produced post-treatment. Plants in the shallower transect had a higher net shoot production over the duration of the experiment (though still an average net loss). This is somewhat surprising, as higher intertidal exposure is thought to be a reason to expect shoot production to be lower. However as net production and light irradiance are correlated (Dennison 1987), it is possible that by the end of the summer, shallower transects might show lower shoot loss due to more light available; deeper growing plants might already be starting to die back from loss of light. Future experiments must take depth into consideration as a factor for shoot production.

Question 3: How do different intensities of harvesting affect the volume of internode 4?

Question 3 addressed the possible enhancement effect of thinning eelgrass beds through traditional harvesting on rhizome biomass, measured by internode volume. The plastochrone interval (PI) was presented as a means to track the growth history and potential response to treatment or other influences throughout a season. Lessons from this tagging process at Quadra 2005 were important to inform the experiment in Tsawwassen the following season. At the Tsawwassen location, an average PI of 12 days was found, but internode volume variation was very high, and more samples are needed. Ideally, a PI establishing study would be conducted in conjunction with an experiment – many tags would be set at common depths and plant densities to provide a large sample of tagged rhizomes. This way, standard protocols for establishing PI could be followed. Rhizome internodes among samples could be compared to each other back in increments of time to examine growth patterns.

Assuming a common PI (from Netarts Bay data), the Quadra mean trends indicate volume output followed a seasonal incline (Figure 3.9). This might be related to resource storage towards the end of the season. Removal (treatment) was followed an internode or two later by a brief decrease of mean growth in the medium and heavy harvest plots seen in early July, an internode or two later than in the treatment. If actually related to treatment, this indicates a strong capacity of eelgrass volume to rebound after an initial shock, and potentially the capacity to exploit new space created by disturbance. The trajectories showed no visible effects on internode production by light removal (~30%). Larger sample size and better experimental assessment of PI are needed to adequately examine this. If the timeline indicates a viable trend supported by further study, it suggests that traditional harvesting at this level (30%) would not have negatively impacted volume output of the rhizomes remaining in the harvested areas.

Analysis of covariance of Quadra internode 4 volume indicated percent removal (treatment) might have influenced the volume of internode 4 (near significance). A positive correlation between removal and internode size did not negate the possibility of thinning to increase the size of rhizome internodes. The Tsawwassen site could not contribute to this theory, but indicated that past internode growth had an influence on the internode 4 volume. A sample size of 80 to 100 is projected to have high enough power for an ANOVA design to pick up a medium effect size of treatment on volume. As well as more samples, more precise methods of measurement are required to examine the influence of shoot removal on internode dimensions.

Sustainable shoot removal

Questions 1 and 2 about shoot production relate to the sustainability of eelgrass harvesting. Single factor regression models explained less than 50% of the variation

(R^2), but nonetheless indicate trends for future investigation. At Quadra, a light removal of shoots (about 30%) of my plots consistently had a positive effect, or no impact on shoot production and internode volume in all avenues explored (timelines, general linear models). Based on my observations of eelgrass harvests by Kwakwaka'wakw elders, the extent of harvest within a site was variable, but I estimate removal ranged from 10 to 30% of an area of approximately 0.25m by 0.25m, and would not have exceeded 40%. Assessed with the results of my Quadra experiment, this indicates that traditional harvesting (which resulted in patchy removal) was within the range that would ensure that plants would have re-grown to fill the gaps created by the end of the season (shoot regeneration), and also could potentially have increased the net density by the end of the summer (net shoots). Such harvest therefore did not negatively impact the eelgrass meadows by the end of the season, and could thus be considered a sustainable practice.

The *Intermediate Disturbance Hypothesis* (Connell 1978) suggests that an intermediate level of disturbance in ecosystems is necessary to sustain high species diversity. Connell used examples of tropical reefs and rainforests, but this has been shown in many ecosystems, including aquatic plants (Trémolières 2004). An experiment examining the species diversity in eelgrass meadows with respect to varying amounts of harvesting disturbance could test whether eelgrass meadows adhere to this hypothesis, and if, therefore, an intermediate amount of *ts'áts'ayem* harvesting disturbance could have enhanced the species diversity of an eelgrass meadow. On the individual species level, the response of different populations to disturbance and environmental variability depends on their reproduction strategies and plasticity (Townsend 1989). While the response values for Figures 3.6, 3.7, and 3.8 were of the individual species population of eelgrass (as opposed to species diversity), the quadratic regression curves for *net shoot production* and *shoot regeneration* versus harvesting treatment (disturbance) resemble the relationship of *species diversity* versus *disturbance* of the Intermediate Disturbance Hypothesis. Further analysis of the patch dynamics of eelgrass populations, reproduction strategies and response to disturbance is needed to confirm how traditionally harvesting would have fit into the spectrum of population response to disturbance.

It is difficult to draw conclusions after a single season, as there is large interannual variation in the growth of *Z. marina*, and the plants might not show the full extent of resource abundance or depletion until the following growing season. Study of the effect of harvesting on the shoots of the following spring season is needed. As well, there were many potential factors that were not fully examined, including original densities (and their underlying influences). After field research with elders, it is clear that traditional eelgrass harvesters removed plants only from eelgrass meadows of high density (Tofino sandbar and Grassy Point populations which were old harvest sites had very high density; I estimate at >50 shoots per $0.0625m^2$ area). This was for efficiency of removal, but also for quality of eelgrass found in such beds. This makes these sites good candidates for benefiting from density alleviation. Olesen and Sand-Jensen (1994a) hypothesize that at high density plots, the reduction of density resulting from harvesting can lead to higher shoot recruitment.

The significant effects of original shoot density (early season density) and treatment (shoot removal) in the multiple regression models on net shoot production post-treatment by the end of the season at the Quadra site corroborate the observation of Olesen and Sand-Jensen (1994a; 1994b), who found that net shoot recruitment over a summer was negatively related to densities of eelgrass leaf shoots at the beginning of the season. They posit it is possibly due to self-shading impacts of high populations during the growing season (1994b). They found eelgrass populations that had lower than usual densities in the spring (because of late summer die-off the previous year, or ice scour over the winter) sustained higher net increase of shoots (ostensibly due to more room and resources) (Olesen and Sand-Jensen 1994a). Following this theory, traditional harvesting, which decreased shoot density early in the growing season, could have resulted in an increase in net growth. The Tsawwassen experiment indicated that original density had a negative correlation with both shoot regeneration and net shoots; this further contributes to Olesen and Sand-Jensen's (1994a) findings that high density at the beginning of the season has a negative relationship with shoot recruitment.

Challenges to the experiment

Low sample size was the major tradeoff for managing the logistical complexities of the subtidal experiment. Logistics of working within the constraints of tides, weather, getting to and from the locations of subtidal plots and the general conduct of activities underwater added several dimensions of complexity to the Quadra Island experiment. Simple tasks took up too much of the limited time underwater: the post-treatment densities are estimated, as these plots were not counted immediately before harvest (June 10-12), and they were counted earlier (May 20-23), adding significant sampling error to the data. This sampling error was negated in the Tsawwassen experiment, as shoot counts were conducted right before treatment. The Tsawwassen design methology could easily be replicated for greater sample size. In future experiments with larger sample size, it would be important to include blocks or strata of factors such as depth or exposure. Variation of depth at the Quadra site was minimized to avoid using depth as a contributing factor.

Tagging of rhizomes with plastic bread tags and the relocation of tagged plants was quite inefficient; it led to low recovery later, and ultimately a low sample size for PI establishment. The second experiment, in Tsawwassen was conducted to establish a more efficient and simplified experimental protocol. Set up, treatment, relocation time, effort, and expense were much diminished, as was dependence on the weather for undertaking the experiment. One cost of this greater accessibility is that the meadows at Tsawwassen have more human disturbance, as people routinely use the area to launch boats and collect shellfish and crabs. I tried to avoid the traffic by setting my transects as close to the end of the eelgrass bed as possible, close to the ferry terminal. Another problem could be influences on eelgrass from pollution sources nearby, including the ferry and commercial port. This was not accounted for in my study.

3.5 Chapter 3 conclusions

Literature on clonal plant development indicates many factors that influence the flexible growth strategy of vegetatively reproducing terrestrial plants, and of *Zostera marina* itself, including genetic factors, geographical location, season, density and disturbance level and type. *Zostera marina* is very adaptable; it reacts and allocates resources to the strategy that will most benefit its particular conditions. High densities at the beginning of the growth season appear to hinder the amount of new shoot recruitment over the summer growth period.

Harvesting experiments were carried out at two locations. Treatment was applied in June at Quadra (2005), and in late July at Tsawwassen (2006). Quadra shoot counts through the summer showed that the mean light removal (30%) resulted in a higher than original mean shoot density by early September. Quadra data indicated that maximum shoot regeneration to above original (pre-treatment) densities occurred at approximately 35% removal (treatment), and maximum net shoot production post-treatment corresponded with a 60% removal, indicating that in a small area, remaining shoots can repopulate fully and produce high numbers of new shoots at such harvesting levels. Scatter plots and linear models showed that original density was also a significant factor at both sites, and supported the theory that early season density alleviation could result in higher new shoot production over a season. These combined results support the theory that patchy disturbance at a low to medium level in early summer, such that Kwakwaka'wakw harvesters conducted, would have been within levels for full shoot regeneration, and could potentially have increased the shoot population and production of an eelgrass meadow by the end of the summer.

Visual assessment of Quadra internodes using a general plastochrone interval, and analysis of internode 4 volume (a measure of biomass production of the remaining rhizomes after treatment) indicated potential for a "thinning effect." The Tsawwassen site showed that previous growth (older internode volume) was a factor. Larger sample sizes are needed.

The Tsawwassen site treatment was applied too late in the season to give conclusive results on treatment impacts, but reflected the influence of characteristics, such as growth patterns, variation at different locations and elevations or exposures. Efficiency was much higher in this second experiment, and this design will facilitate larger sample sizes in future experiments. A combination of the two experiments could create an appropriate design to further investigate my research inquiries.

Chapter 4 Traditional Ecological Knowledge and Ecology

4.1 Objectives

This chapter strives to bring together the two perspectives of TEK and ecology science. My objectives are:

1) to demonstrate how TEK and ecology research can complement and strengthen each other by identifying distinct eelgrass harvesting inferences and/or strategies derived from TEK in this study and providing scientific validation I found for them; and
2) to support the case that traditional harvesting of eelgrass was conducted in a way that did not have negative impacts on eelgrass populations, and that eelgrass beds were tended in a sustainable way.

4.2 Methods

To demonstrate the potential symbiosis of TEK and ecology research, I present eelgrass harvesting statements and ideas inferred from traditional protocols and practices around eelgrass harvesting, followed by supporting scientific rationale from scientific research. I propose that scientific hypotheses can be derived from the TEK inferences. An additional opportunity for applying TEK is in ecological monitoring; field observations with consultants during the eelgrass harvesting expeditions, which are potentially highly relevant in monitoring the state of eelgrass populations, are included in Appendix E.

4.3 Results: TEK inferences and scientific rationale

4.3.1 Eelgrass as a food

The specific Kwakwaka'wakw techniques and protocols around harvesting and preparing eelgrass rhizomes maximized the nutritional benefit of these plants for human consumption.

Inference: Rhizomes are a good source of carbohydrates.

There is enough sugar in eelgrass to warrant Gisele Martin's "sugar high." Eelgrass was a rare source of sugar in the Kwakwaka'wakw diet after the winter season. The rhizomes are the main carbohydrate storage organs for eelgrass and have been found to harbor more than 50% of their dry weight as sucrose (Kikuchi et al. 2001). This is one reason why the rhizomes are so desirable. Mature eelgrass leaves have too much cellulose for humans to digest (Bjorndal 1980), and the roots that grow from the rhizome have one tenth the carbohydrates of rhizomes (Kraemer and Alberte 1995). Many plants' rhizomes are carbohydrate reserves, but the proportion of sugar, rather than starch, in *Z. marina*'s non-structural carbohydrate (NSC) reserves is higher relative to most plants. In Chincoteague Bay, Maryland/Virginia, Burke et al. (1996) found sugar to be 84% of the NSC in the rhizomes. They also found the mean estimate of sugar in rhizomes to be at a 1991 peak in their June 4 sampling: their sampling yielded an average sugar content of 229.0 mg/g, with starch at 41.9 mg/g. The authors hypothesize that sugar may be more readily available than starch in order to allow the plant to respond more rapidly to environmental stresses, and this might be one of the strategies contributing to this eelgrass's ability to recover from environmental impacts.

Inference: Only the first 4 internodes should be eaten.

Daisy Sewid-Smith and Adam Dick spoke of breaking off the rhizome for consumption at the first four internodes (discarding the remaining rhizome). Daisy explained that four is the sacred number; everything was done in multiples of four, if possible. This eelgrass protocol makes sense from the physiological perspective of *Zostera marina*. As the rhizome system matures, it lignifies, becoming tougher and more woody. The first four internodes of the rhizomes – the youngest – have a constant biomass (Kraemer and Alberte 1993), after which biomass increases with age until internode 12, indicating lignification. The fourth internode is the youngest to be considered fully expanded and therefore fully mature (Short and Duarte 2001). The first four internodes are the most tender and digestible. Internodes 2-9 also have the highest soluble carbohydrate levels, and nitrogen metabolism occurs in these first four rhizomes, indicating a high level of chemical activity occurring in this portion of the plant (Kraemer and Alberte 1993). These studies indicate that an optimal level of nutrition available to humans in the rhizomes is in the first four internodes, and implies a chemical and nutritional explanation for this practice in eating *ts'áts'ayem*.

Inference: The innermost leaf of each shoot is worth eating.

Kwakwaka'wakw consultants described and demonstrated a process of peeling off the eelgrass leaves down to the innermost, youngest leaf and wrapping it around the rhizome segment for consumption. The largest component of a seagrass leaf is fiber (cell wall constituents), which is very difficult to digest (Bjorndal 1980). The peeling process is very labour intensive and quite challenging to do; it is not immediately apparent why they would bother with keeping just the youngest leaf. However, eelgrass research in Humboldt Bay, Frimodig and Ferson (in press) indicated that black brant geese (*Branta bernicla*) have developed a similar taste: they select and graze on the same innermost, youngest leaves. These inner leaves contain the most nitrogen and protein (Thayer, Bjorndal et al. 1984), and of all the leaves, they contain the least amount of cellulose. This is reflected in other seagrasses: in Italy's seagrass, *Thalassia oceanica*, Pirc (1975) found that nitrogen values decreased with age of leaf; high levels were found in the youngest, innermost two leaves (the next highest levels were in the rhizomes). He also found that the starch content in rhizomes was low through the winter until May, when a rapid increase led to highest levels in mid-summer. In a study in the Bahamas, green turtles (*Chelonia mydas*) have been found to revisit the same grazing sites of the seagrass *Thalassia testinudum*, maintaining a consistent crop of young leaves. As the blades get older, lignin increases and the digestible cell contents decrease (Bjorndal 1980). With their low lignin content, the young leaves are an important aspect of these animals' nutrition. It is likely that people, like the brants and the turtles, would find the innermost leaves nutritious and digestible, making the peeling process worthwhile.

Inference: Dried up eelgrass plants are not good to eat.

Daisy Sewid-Smith recalled a taboo against harvesting dry, exposed plants. From my field experiences, it became clear that plants that were completely exposed were difficult to remove from the dried out sediment, so picking in water for ease of extraction would be an obvious practice. Consultants who recalled that eelgrass was collected by hand on the low tides mentioned that it was gathered in a few inches of water. There are other possible reasons that harvesting dried up eelgrass was not encouraged. Water coverage has been noted in ecological studies as a factor for health of the plants (Jacobs 1979); Kentula and McIntire (1986) found eelgrass plants in their tide pool transects were much healthier overall than plants in transects which were exposed at low tide. As eelgrass leaves photosynthesize, the byproduct O_2 is produced by the rhizomes and roots (Iizumi, Hattori et al. 1980), forming an oxic shield around its rhizomes (Joel Elliot[96], pers. comm. 2006). When eelgrass is exposed to too much organic matter, or to the air, sulfides begin oxidizing, diminishing the O_2 barrier (Elliot, pers. comm. 2006). If the rhizomes are exposed for too long, sulfide can intrude into the rhizome, and start killing cells of the plant. This is noticeable by a “rotten egg” smell of sulfur. It is possible, therefore, that the taboo of Daisy’s elders was related to the sulfuric intrusion of eelgrass rhizome when exposed too long, which may have had a negative effect on their taste and edibility.

Inference: Harvesting in May is optimal for human consumption.

Kwakwaka’wakw consultants stated that May is the season for eelgrass harvesting. At this time the physical characteristics of eelgrass are optimal for its consumption. Because eelgrass growth has a high minimum light requirement (Backman and Barilotti 1976), highest growth rates (and lowest Plastochrone intervals) occur during the period of May-June (Dennison 1987; Jacobs 1979; Kentula and McIntire 1986). The high growth rate in May ensures that new shoots and rhizomes are tender because they have not yet lignified and are not yet “stringy” to eat.

As well as being the most physically appealing at this time, this is also the season when the plants are nutritionally the best to gather. Spring is the main period of non-structural carbohydrate accumulation in the rhizomes (Burke et al. 1996). Eelgrass is efficient at translocating reduced sugars from photosynthesizing eelgrass leaves to the rhizomes (Kikuchi et al. 2001). In Woods Hole, Massachusetts, researchers found net photosynthesis to be at a peak in the month of May (Dennison 1987), meaning that sugar

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[96] Dr. Joel Elliot, Associate Professor, Department of Biology, University of Puget Sound.

production is at a maximum as well. As well, springtime is when the rhizomes would be at their sweetest. Harvesting eelgrass in May takes advantage of the window where nutrition, digestibility and access intersect.

In Pirc's (1985) study of *Posidonia oceanica* in the Gulf of Naples in Italy[97], he found that rhizomes at different depths on a scale of 5m, 15m and 30m had varying amounts of soluble carbohydrates at different points during the year (of which the mean annual value was 80.3% sucrose). Samplings in April and June revealed highest levels of soluble carbohydrates in the rhizomes, and rhizomes at the intermediate depth (15m deep) yielded the highest levels of soluble carbohydrates by far. Investigation of the relationship between depth, season and carbohydrate levels in *Zostera marina* might further indicate rationale for the timing and depth of traditional *ts'áts'ayem* harvest.

"Clean" (bright green) eelgrass leaves were another requirement of the consultants for choosing eelgrass meadows for harvesting; epiphytic growth was considered distasteful to them. This is another rationale for a harvesting season in May. At this time the plants are clear of epiphytic growth compared with later in the season. During the winter, when general biomass and biodiversity in the eelgrass meadow is lower, much of the old leaf biomass with epiphytic loads from late summer has senesced, and by the spring the remaining plants are pared down but clean and healthy (Ron Thom[98], pers. comm. 2006).

Inference: Eelgrass must be harvested only from 'clean' meadows.

It was stressed by several elders they would only harvest eelgrass from meadows that were bright green and "clean" – clear of epiphytes (see above). Choice of harvesting location was important: epiphyte loads vary with the season, but also with the location and its particular currents, nearby sources of pollution, the local temperature of the water, the weather and other factors. Epiphytes have been found to reduce eelgrass photosynthesis by up to 31% during the optimal light conditions (Sand-Jensen 1977); this decrease in photosynthesis would mean lower sugar production, and in turn might affect taste of the rhizomes. As well as obscuring photosynthesis in the leaves, epiphyte loads

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[97] Latitude of 40º 43'N

[98] Ron Thom, Battelle Marine Station, Sequim Bay.

are an indication of the nitrogen content of seagrass leaves. As the leaves age and senesce, their epiphytic load increases, which correlates with a decrease in their nitrogen content. In Nova Scotia, Harrison and Mann (1975) found that for *Z. marina* nitrogen content in terms of percent of dry weight was 2.9 % in green leaves, 2.0 % in senescent leaves and 1.3 % in dead leaves. While fully mature leaves of *Z. marina* were not eaten by Kwakwaka'wakw consultants, they are a good indicator of general health of eelgrass plants, and may correlate with nutritional value of rhizomes.

4.3.2 Harvesting techniques and sustainability

Inference: Harvesting in May is best for the eelgrass meadows.

As well as being nutritionally advantageous, harvesting in May is also a good resource management strategy. Section 3.1.4 explores research indicating that removal of plants in dense beds early on in the growing season allows for new ramet expansion and the establishment of new seedlings more than in undisturbed beds (Olesen and Sand-Jensen 1994a; Robertson and Mann 1984). Kentula and McIntire (1986) found that early in the growing season leaf surface area was positively correlated with shoot density until a certain threshold Leaf Area Index[99] is reached, after which the correlation becomes negative and shoot density decreases.

Results at the Quadra experiment site showed that after the June 10-12th treatment net shoot production increased with percentage removal until approximately 50% removal after which net recruitment declined (Figure 3.7). At the Tsawwassen site, treatment was conducted in late July, and there was no measurable difference in growth after treatment. I suspect that this was a result of the late treatment – at this late point in the growing season the growth form is already set; populations cannot respond as flexibly to environmental disturbance as earlier on. Early harvest, such as the Kwakwaka'wakw harvest in May, was conducted at a time when eelgrass populations could adjust their growth strategy to increase shoot production, as well as alleviating density to create more space. This timing ensured the recovery and even enhancement of the disturbed beds by the end of the growing season.

[99] A value expressing the combined the effects of shoot density and leaf surface area on overall biomass

Inference: Harvesting from large, abundant eelgrass meadows is a best practice.

Traditional eelgrass gatherers harvested at stable eelgrass sites on which they could depend year after year; they generally returned to the same locations every spring. They also required large, dense and healthy eelgrass populations. This is logical not only for harvesting efficiency and maximization of the best and healthiest eelgrass yields for energy output, but also for the longevity of the eelgrass meadow; small patches of eelgrass are less stable than larger ones. Seagrass patch survival and expansion has been found to relate positively to patch size and also varies with species (Kendrick et al. 2005; Marba and Duarte 1998; Olesen and Sand-Jensen 1994c). Olesen and Sand-Jensen found that in Limfjorden, Denmark (latitude 53º 35'N) eelgrass patches smaller than a critical threshold size of 32 shoots had a high likelihood of disappearing. Reasons may be due to stand stability: if plants are too few they are more vulnerable to the elements. Therefore, people returned to large, healthy eelgrass populations, such as Grassy Point on Cormorant Island the Kwakwaka'wakw meadows, that were stable and resilient to damage. Examining longterm effects in eelgrass meadows of multiple year harvesting could add greatly to this discussion.

Inference: Harvesting from intermediate depths is a best practice.

As previously discussed, eelgrass harvesting occurred on the low tides of May. People harvested either at the edge of the water when the plants were nearly exposed, or at subtidal populations accessible with a harvesting tool of approximately 3.6 m (12 feet in length). Harvesting in these ways meant that eelgrass was consistently gathered at an intermediate depth: at the edge of the subtidal or deeper. Depth is a factor that affects the plants' productivity and stability of eelgrass stands. Middelboe et al. (2003) found intermediate and deeper eelgrass populations to be more stable than those of shallow meadows. Shallow stands were variable spatially and temporally due to physical disturbance by waves, ice and currents. The researchers found no significant differences between variability of shoot density from intermediate to deep waters; they posit that the effects of reduced disturbance cancelled out the risk of light limitation at depth: "spatio-temporal variability in shoot density and biomass relative to means declined at higher mean values probably because self shading and space limitation set an upper boundary on eelgrass abundance" (Middelboe et al. 2003, 1). The Kwakwaka'wakw harvested from populations at an intermediate depth. Harvesting eelgrass at this depth ensured that eelgrass was harvested at the optimal depth for the stability of eelgrass populations.

In my experiments, the subtidal experiment at Quadra showed an overall increase in production and less variation than the intertidal experiment at Tsawwassen, which had an overall decrease of production over the time of the experiment. At Tsawwassen the shallower, more often exposed transect (B) had a higher shoot production, but also a higher variation and larger shoot differences than the deeper transect (A). This may be a result of the exposure of the intertidal plants, which might be more susceptible to weather and environmental impacts than those living underwater. If deeper populations have a more stable production rate, this could be another reason the Kwakwaka'wakw selection of subtidal or near subtidal meadows optimized sustainability.

Inference: Harvesting eelgrass could increase shoot production.

Several elders spoke of harvesting practices in line with the *keeping it living* ethic. They indicated that all plants were harvested in a way that could benefit production. While they were not taught specifically to harvest eelgrass with this intention, they thought it probable that their traditional protocol would lead to increased production. Alleviating density could enhance shoot recruitment over a summer, but also might even aid the recruitment of new shoots in the eelgrass community, as discussed in Section 3.1.2. Hacker and Wisehart found higher seedling densities in oyster-dredged beds than in reference areas. They found seed production of August plants was highest in dredged beds. They suggest that while eelgrass may initially be negatively impacted by oyster dredging disturbance, rapid recovery can occur due to enhanced recruitment of seedlings in the open spaces created (Hacker and Wisehart, in press).

As well, some meadow fragmentation may allow for genetic diversification. If, in large monospecific stands, physical disturbance creates gaps promoting the establishment of sexual progeny, this might offset the monopolization of dominate genotypes. Reusch et al. (1998) suggest that genetic diversity, like species diversity, may be important for enhancing the strength and consistency of ecosystems. However, in a follow up study in

2006, Reusch found no competitive advantage of more heterozygous genotypes over less heterozygous ones, nor any effects of the experimental disturbance on clonal diversity.

Research on other clonally reproducing plants has indicated that disturbance by grazing birds, which might have similar effect to traditional human harvesting, can benefit plant production. For example, wapato, *Sagittaria latifolia,* a freshwater aquatic tuber-bearing plant, has evidently had a symbiotic relationship with migrating ducks and swans (Darby 2005). Like eelgrass, it is primarily vegetative, with the rare establishment of seedlings and its underground parts were traditionally harvested for food. The Chinookan speaking people of the Lower Columbia River gathered huge quantities of its starchy tubers from vast fields of the wapato. The highly productive plant co-evolved with ducks and swans, as each year hundreds of thousands of birds feed on wapato fields in the fall and spring to the Lower Columbia along the Pacific Flyway. The manner in which they feed results in the plants being stirred and broken up and the partially eaten tubers and rhizomes can float away and grow into whole new plants in a new location (Darby 2005). This type of disturbance might also affect *Zostera marina*. In their study of black brants (*Branta bernicla*) and their eelgrass eating habits, Adam Frimodig and Susannah Ferson in Humboldt Bay in Northern California found that the grazing of black brant had a positive growth effect on eelgrass plants, due to reducing leaf biomass (shading) as well as adding nitrogen rich faecal matter (Frimodig, pers. comm.2006; Johnson 2007).

In my subtidal Quadra experiment (mimicking patchy harvesting with the *k'elpaxu* in subtidal meadows) significant models for shoot regeneration and net shoot production indicated that a 20-50% removal of shoots corresponded with an increase of shoots higher than original densities (counted in May), and that a 60% removal of shoots in a plot corresponded the highest number of new shoots by the end of the summer. This indicates that when a moderate amount of subtidal plants are removed in this manner, plants left in the area can have a higher recruitment of shoots by the end of the season than no harvest (control). Shoot regeneration and net shoot production post-treatment had negative correlations with original densities of shoots, suggesting, as Olesen and Sand-Jensen theorize (1994a) than some alleviation of density would increase summer shoot production.

Inference: Harvesting eelgrass could result in larger remaining rhizomes.

As with shoot production, elders did not recount being specifically taught to harvest *ts'áts'ayem* in a way to make rhizomes grow larger the next season. However, they indicated that enhancement was an ethic common to the harvesting of plants and resources in general, see Chapter 2 (Section 2.5.6). Elders consulted for this study were dissatisfied with the size of the eelgrass plants we harvested (see comments in Appendix E). Was the reduced size they noted a result of lack of traditional management, or to new environmental conditions? Or was this simply reflective of natural variation, as the elders were not familiar with all the locations that were visited or the type of eelgrass these places produced? Grassy Point, which had not been harvested in decades, yielded large eelgrass plants (possibly of the *phillipsii* variant) of the remembered desired size.

While the results of my Quadra experiment did not negate the effect of thinning (treatment had a significant, positive effect on the volume of internode 4), studies with a larger sample size are needed to further explore the thinning effects hypothesis with more certainty. It is also likely that the recollected large size of rhizomes indicates that it may have been predominantly the larger variant of *Z. marina* var. *phillipsii* that was harvested; most of the plants that we visited for this study were of the *typica* variant, or even the smaller species, *Z. japonica* (Appendix E). We found *ts'áts'ayem* of the "right" size only at three locations: in Quatsino, where Tom Nelson had harvested *ts'áts'ayem* as a boy; at Grassy Point where Adam had harvested as a youth; and in Tofino where Joe Martin remembered his great aunt gathering it. However, it is possible that populations of the different variants have shifted, or that morphology has changed (due to factors such as development or climate changes).

4.3.3 Eelgrass decline

Inference: The dark colour and bad smell of the rhizomes are due to pollution.

Elders were unsatisfied by the eelgrass they saw at 10 of the 12 locations we visited; they said that the eelgrass and rhizomes were polluted (see Comments in Appendix E). They observed a black colour of the rhizomes, small size, bad smell and epiphytic growth on the leaves they had not seen in previous decades when they had harvested eelgrass. It is important to keep in mind that these consultants may not have been familiar with the variants of *Z. marina* that we encountered, and that they had not been to several of those specific locations before—*Z. marina* growth is very specific to location. However, they are intimately familiar with the characteristics of healthy *Z. marina*, as well as having extensive general plant knowledge. At each site there was a major source of pollution that was not present at the time of their earlier familiarity with the plantfrom the mid 1900's (Appendix E).

Pollution such as increased organic matter in the sediment can indeed be a reason for the darkness of the rhizomes and a sulfuric smell. Organic matter in this case could be faecal matter from fish farms, waste from human sources, or the sedimentation of detritus from phytoplanktonic blooms in the water column; all these inputs have been increased by human development on the coasts. Increased organic matter in the sediment increases the oxygen demands on the system (Borum and Sand-Jensen 1996), and can be a source of stress on the below-ground tissues of seagrasses (Holmer and Bondegaard 2001). The O_2 barrier around the rhizomes can get overwhelmed by sulfides if there is too much organic matter in the sediment, resulting in sulfide intrusion (David Young,[100] pers. comm. 2006). Bacteria in eelgrass sediment oxidize organic matter using O_2 from the interstitial water, and environmental nitrate and nitrite as electron acceptors. After the nitrate and nitrite are used up sulphate reduction begins, resulting in sulfide (Iizumi et al. 1980). The presence of sulfide (indicating that no O_2, nitrate or nitrite are left in the interstitial area in the sediment) can be identified by a reduced zone with a black colour and the "rotten egg" smell of hydrogen sulphide (Holmer and Bondegaard 2001; Iizumi et al. 1980), such as what wrinkled the noses of the consultants.

Holmer and Bondgaard's studies (2001) showed strong negative effects of water column hypoxia and sulfide presence on eelgrass, resulting in lowered sucrose in the rhizomes and some treated plants even rotting in the meristemmatic region. These studies support the elders' hypothesis that pollution (ie. organic matter in the water column) is affecting the plants' health.

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[100] David Young, US Environmental Protection Agency

4.4 Discussion

4.4.1 TEK and ecosystem monitoring

Today, amidst serious ecological destruction and climate change, scientists and ecologists need to learn as much as possible about the natural, or pre-industrial, state of ecosystems and individual species. Observations of elders, as eelgrass experts, could direct ecologists to areas of study, and areas of inquiry into ecological impacts. Appendix E presents a table of sites we visited on harvesting expeditions, and specimen descriptions, with consultants' comments. This study shows the potential of engaging with elders to examine contemporary ecosystem health, using eelgrass as an indicator species. As noted, only three locations – Koprino (Quatsino Sound), Grassy Point (Cormorant Island) and Tofino (Vancouver Island) – yielded satisfactory eelgrass according to the elders' assessments (see also photos of eelgrass samples of varying quality and type, Figures 4.3 and 4.4). This suggests that ecosystems have undergone much change in the past decades. Eelgrass is already recognized as a species that can indicate ecosystem health, and therefore the observations of TEK experts on this plant could provide direct input into the understanding of the current health of the coastal ecosystems. More acknowledgement and analysis of current observations of traditional resource users should be incorporated into the study of ecological change.

Figure 4.1 “The real *Ts’áts’ayem*” (Adam Dick, 2006): A) Eelgrass specimen from Tofino sandbar; B) rhizome from Grassy Point, Cormorant Island; C) Eelgrass rhizome from Tofino sandbar.

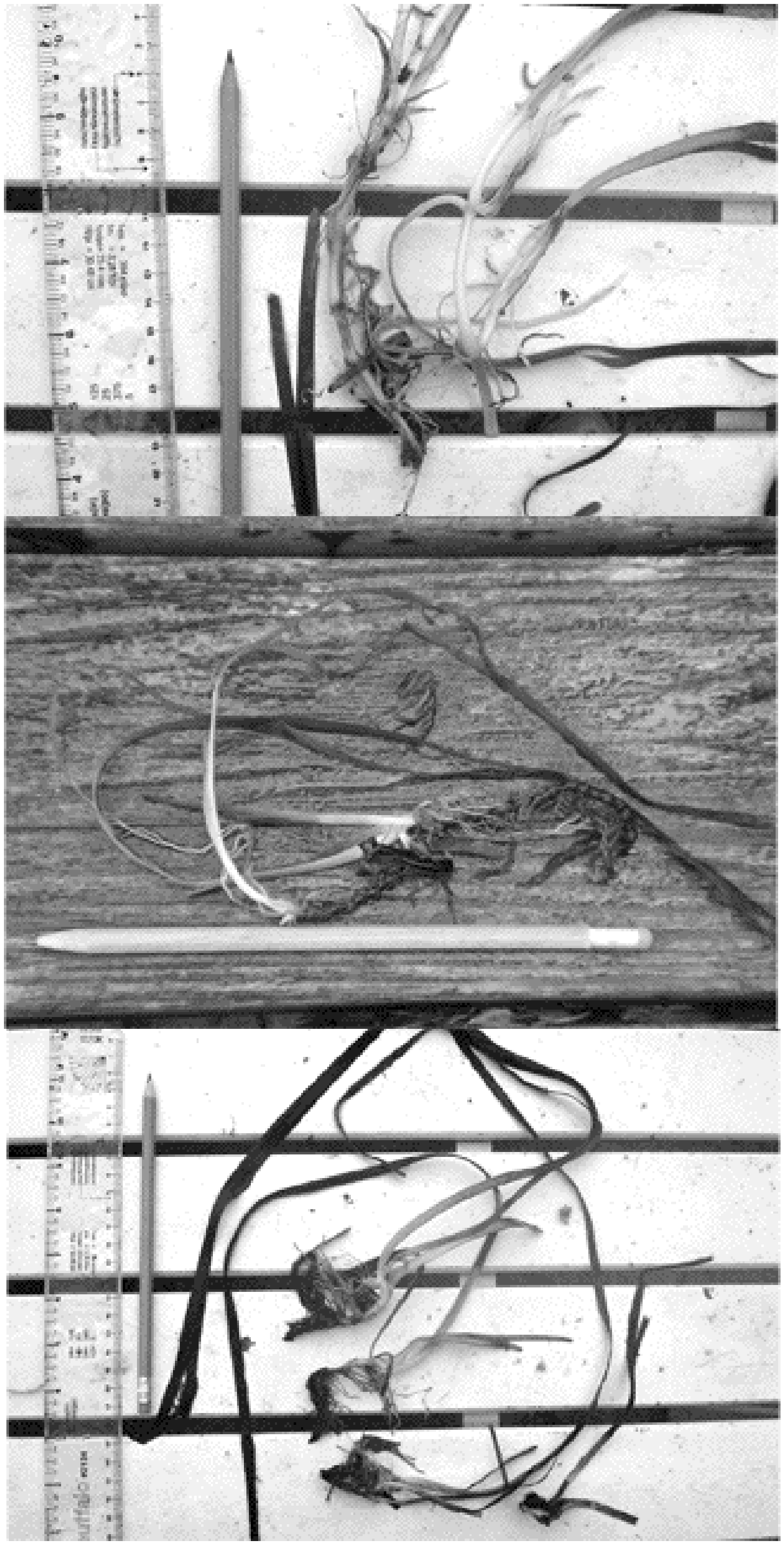

Figure 4.2 Eelgrass specimen variation from 2006 expeditions: A) Eelgrass from Fort Rupert; B) eelgrass from Comox; C) Eelgrass from Green Island, near Cormorant Island.

Figure 4.3 Examples of distasteful eelgrass: A) Grassy Point eelgrass and resulting pink seawater from epiphytic seaweed, 2006; B) Quadra specimen from Heriot Island (elders did not like its dark rhizome and small size) 2005; C) Rhizomes from Tofino sandbar — dark and smelly, 2006.

4.4.2 The challenge and importance of different worldviews

The concept and ethics of *Keeping it Living* (Section 2.2.1) are often a challenge to concepts of modern conservation, which often focuses on a 'hands off' approach. California Indian and other traditional peoples say that human-plant interactions are *necessary* for the sustainability of certain species, an idea which runs counter to the modern concept of wilderness. In a conversation with Kat Anderson, restoration ecologist William Jordan referred to the "coin of alienation" – two positions treating nature as an abstraction – that nature is to be used and exploited, and that nature is not to be touched, to yield a wild wilderness (Anderson 2005). The result of such a dichotomy has been increasing ecological destruction and human alienation from the natural world and ever-increasing environmental deterioration, as evidenced in the 2005 Millennium Ecosystem Assessment.

This clash of approaches has presented a barrier between the Western scientific conservationists and traditional land users, and is a major challenge, as well as opportunity, for the partnership between the two. "Tending the wild" is an alien concept for Western conservationists. California Indians had a high population density, of about one person per two square miles, showing that there was a high risk of over-harvesting. Their basic principle: do not harvest everything (Anderson 2005). Kat Anderson calls this a 'tempered use' of nature. Modern harvesting constantly breaks this rule. In addressing this difference in perspective and relationship with the natural world, TEK can offer important insights (Berkes 1999; Deur and Turner 2005; Posey 1999; Turner 2005).

In my own research I witnessed the difference in training and practice from the two different worldviews, but also the benefit of learning from the other perspective. It was evident when Jen Pukonen, a Master's student at UVic studying the traditional root foods of the Nuu-chah-nulth, and I, went with Tla-o-quiat friend, Gisele Martin, to gather silverweed (*Potentilla pacifica*) roots. Jen informed us of the methods she had read that people used to harvest the silverweed roots – flipping over pieces of sod and picking out the tap roots. Jen and I began to harvest silverweed plants, picking the thick roots along with the entire plant. Jen and I had done it in a way that resulted in a pile of biomass, but relatively little to eat. After doing this for awhile, we noticed that Gisele had interpreted it entirely differently: when she flipped over the sod, she only picked the roots out from the dirt, and left the tops of the silverweed plants in with the rest of the grass so that they'd grow again. When we asked Gisele why she did it that way, considering she'd never seen anyone harvest silverweed before, she just said, "I just assumed that's what you meant, I assumed that's how they did it." The way Gisele was harvesting was far less disrupting of the environment—after she moved from a patch of silverweed turf, it looked the same as when she had arrived. Jen's and my plots, by contrast, were obviously disturbed. Jen had several silverweed plants growing at home which she had propagated from partial roots, which suggested that silverweed has the capacity to grow back from root fragments and rootstocks of plants left in the soil. While Gisele had not been taught to harvest these roots in this way, the Nuu-chah-nulth teachings she's had harvesting other traditional foods and from being on the land with her relatives had given her different inclinations and intuitive tendencies to harvest in a way that keeps ecosystems living.

Once we observed Gisele's harvesting technique, Jen and I immediately recognized the sensibility of such a protocol, but had never thought to do it that way. It revealed a serious bias inherent in our interpretation of written harvesting instructions due to our training and upbringing. However, it was because of our academic research that we were engaging in this ancient practice. Training affects how information is absorbed and interpreted, and in researching traditional foods it is important that young indigenous food gatherers be involved and consulted in the gathering of the traditional food sources by outside researchers. The worldviews of both parties can complement each other to address research questions. It is my hope that this ethnoecological study can somehow be used to inform and educate people of the importance of maintaining a balanced relationship with eelgrass beds.

4.4.3 Potential contributions to Restoration

This analysis of the traditional harvesting of eelgrass has relevance for the contemporary harvesting of eelgrass shoots for transplantation. Currently there are many restoration efforts that transplant eelgrass shoots from healthy ecosystems to depleted meadows. Kwakwaka'wakw harvesting inferences could serve as protocols for eelgrass restorationists to ensure the least damage to donor meadows. As well, building off of my harvesting experiments, further study could test the possibility of an 'optimal' level of removal that would not only be sustainable for the donor meadow but even beneficial for its production of new shoots throughout the growing season. This optimal level could serve as a guideline for amounts harvested from donor meadows.

Focal restoration

Today, the main relationship between humans and eelgrass is a destructive one. Construction, pollution and mechanical damage are the mechanisms of human destruction of eelgrass beds, but the underlying cause is a larger disconnect between humans and the ecosystems around them. A different relationship is needed; we need to address the fundamental cause of eelgrass destruction and reintroduce the mentality of *keeping it living*[101]. I submit that there may be a role for the tradition of eelgrass harvesting to contribute somehow to the *focal restoration* of eelgrass meadows. Eric Higgs introduced the concept: "focal restoration is shaped by engaged relationships between people and ecosystems" (2003, 186). It is restoration not only of ecosystems, but of human values, sense of place and relationship to environment, while people participate in the act of restoration. Focal restoration goes deeper than just technical restoration; it "…rebuilds our concern with things that matter" (Higgs 2003, 226). An example of focal restoration is the eelgrass transplants organized by SeaChange – replanting of eelgrass shoots by volunteers from a community in places where eelgrass used to grow. This kind of event adds to the volunteers' understanding of, and care for, ecosystems in their own community, and in the process of the restoration, deepens their relationship to their home places and renews and creates stories of these places. While there are many kinds of restoration of eelgrass today, at both professional and community levels, and traditional eelgrass harvesting (either through education about this practice in history, or the engaging in the practice itself) could potentially contribute to the focal restoration of human-eelgrass relationships by imparting traditional concepts of working in harmony with ecosystems as well as adding to a sense of history and continuity. In this way, TEK and the science of ecology could come together to help reestablish sustainable relationships between humans and their environments. I intend to contribute

[101] See section 2.1.1

the findings of this project back to the Kwakwaka'wakw as a record of a sustainable traditional management practice, and as a compelling aspect of Kwakwaka'wakw heritage and knowledge, and also to add to the focal, community restoration underway by groups like SeaChange. Over the next months I will consult Kwaksistala and other Kwakwaka'wakw about the most effective and appropriate ways to return what I have learned to the communities where the knowledge belongs.

4.5 Chapter 4 Conclusions

Using the perspectives of traditional ecological knowledge and scientific research in combination, it is clear that the protocols applied in traditional harvesting of eelgrass made it a sustainable practice – a good example of the *keeping it living* strategy explored by Deur and Turner (2005). In my research of scientific literature and in my two ecology experiments, it is clear that the timing, depth, and choice of eelgrass harvesting sites by the Kwakwaka'wakw coincided with optimal conditions for new shoot recruitment and recovery over the growth season, and that their harvesting techniques ensured the stability of the eelgrass population in a meadow, and likely an increase of shoot densities. Protocols surrounding the harvesting time, as well as peeling and eating eelgrass, also ensured that the nutritional qualities of the plant were maximized for the consumers. The rationale found for these practices reflected in ecological studies indicates the expertise of traditional harvesters and resource users; ecologists would do well to take into account the observations of indigenous elders on the current state of the ecosystems they knew so well in times of less development and ecosystem damage.

The benefits of perspective and a fuller degree of understanding outweigh the many challenges of navigating the interdisciplinary research of ethnoecology. It is my hope that my integrated results portray a more complete image of Kwakwaka'wakw-eelgrass interactions in the past, and the potential for enhanced and more sustainable human-seagrass interactions in the future in light of the worldwide decline of this important family of plants.

Chapter 5 Conclusions

5.1 Summary

My project was an ethnoecological case study of Kwakwaka'wakw use of *ts'áts'ayem*, eelgrass, or *Zostera marina* L. (Zosteraceae). Its characteristics at the individual plant and population levels have made it an essential food web and structural element of the oceans in the Northern hemisphere. As a consequence of its important role, it has indirectly supported the human economy through fostering and sheltering commercially harvested marine resources at key stages in their lifecycles. As well, *Z. marina's* physical characteristics and high productivity have made it a direct resource for humans, used in building and stuffing material in Europe and North America, as well as for fodder for cattle and sheep, and compost for gardens. In Eastern North America eelgrass use as an insulation material became a thriving industry. Eelgrass was also a food source: the Seri people of northwestern Mexico depended on its seeds as a staple, and on the Northwest coast of North America, its rhizomes were a part of the traditional seasonal diet in the spring for several indigenous groups, including the Kwakwaka'wakw people, who call it *ts'áts'ayem*. Unfortunately, contemporary human caused degradation of eelgrass from development and pollution are creating a worldwide decline of this species. Scientists and conservationists have identified the need for new perspectives to call attention to and help alleviate the decline of eelgrass; all insights into eelgrass ecology are needed, especially ones that could provide models for sustainable practices.

Northwest Coast indigenous people have presented a quandary for anthropologists. Traditional resource management of plants of this region has not fit with Western concepts of agriculture or cultivation, and yet their highly sophisticated art and social structure did not fit with the characteristics of the anthropological category of hunter-gatherer society. The *keeping it living* ethic of plant resource management of the Kwakwaka'wakw is beginning to be investigated by academics, and has revealed sophisticated practices and explicit tending that enhanced plant resources and enabled their sustained use over many generations.

Until it was done for this project, *ts'áts'ayem* had not been harvested for food by the Kwakwaka'wakw for at least thirty years. Contemporary elders recall harvesting the sweet rhizomes of *ts'áts'ayem* in the spring, specifically in the month of May. They were harvested in two ways: by hand during low tides in areas where the eelgrass was exposed, and with a *k'elpaxu*, a twisting stick for subtidal meadows at low tides, or more generally at higher tides. In six harvesting expeditions in the East, West, and Northern parts of Vancouver Island, techniques demonstrated by elders revealed the precision of tools and the specificity of protocols, as well as a deep understanding of environment and resources. Based on elements distinguishing cultural keystone species (from Garibaldi and Turner 2004), as well as the extent of territory harvested, specificity of protocol and fondness for eating the plant, *ts'áts'ayem* appears to have been a very significant species for the Kwakwaka'wakw. Elders deemed most of the *Z. marina* specimens we examined as too small in comparison to the plants they remembered from the past.

While elders had not been taught to harvest specifically with the intention of enhancing eelgrass meadows, elders indicated that a sustainability and enhancement ethic was an attitude extended to the harvesting of all plants. Their precision and expertise in eelgrass and ecology suggested that eelgrass would not have been harvested in a destructive manner. *Ts'áts'ayem,* eelgrass, would have been harvested in line with the *keeping it living* ethos described by Deur and Turner (2005).

Consultants' overall field observations of eelgrass ecology were that the plants they saw at nearly all the sites we visited were unsatisfactory, and different from the plants they knew as youths; they reasoned that this observed change was due the effects of pollution of the ocean.

Today people do not harvest eelgrass. Alienation from the land, fear of contamination from pollution and the many cultural and lifestyle shifts of the 20^{th} century have caused traditional practices of food gathering to decline worldwide (Turner and Turner 2007); changed access to resources and different social relationships between generations have modified the transmission of traditional knowledge, including the practice of harvesting *ts'áts'ayem*. The ethnoecology of *ts'áts'ayem* is a case study of a global decline of traditional knowledge and *keeping it living* practices today.

To complement the knowledge of elders regarding eelgrass, I conducted two *in situ* harvesting experiments at Quadra Island (2005) and Tsawwassen (2006). I developed a methodology of gauging some of the effects of traditional harvesting on eelgrass. I examined the shoot regeneration, net shoots produced after treatment, and internode volume 4 corresponding with different intensities of removal (harvest treatment). Trends of the subtidal Quadra experiment indicated that a light harvest (30% removal) ended up with a higher than original shoot density, suggesting potential enhancement from this harvest intensity. Shoot counts were more informative: percent removal (treatment) and Original density had significant effects on shoot regeneration. Significant quadratic regressions indicated optimal percentages of shoot removal in the plots: for shoot regeneration with respect to pre-treatment densities, removal of approximately 35% yielded a higher than original density regeneration; for net shoot production post-treatment, a removal of 60% corresponded with the highest number of new shoots. These density-removal studies suggest that some light-to-moderate amount of disturbance can correspond with an increase of shoot density, and that some degree of removal (representing harvesting) can correspond with shoot production enhancement.

In the more variable, intertidal population at Tsawwassen, depth block (transect) and original density were significant factors for shoot recruitment at the intertidal population in Tsawwassen. Original densities were significant negative factors for shoot regeneration and net shoot production at both sites, supporting this research and others (Sand-Jensen and Olesen 1994a) that moderate alleviation of pressure of high density by patchy disturbance would not negatively influence the recruitment of new shoots.

Examination of the growth timelines indicated an overall increase of internode volume production in the subtidal Quadra population throughout the summer, but an overall decline in the internode volume of the intertidal Tsawwassen population. While intertidal meadows might receive more sunlight, deeper meadows are less susceptible to the harsh effects mid-summer over-exposure and other environmental factors, as well as possible human disturbance, the use of intertidal sites, while reducing the time and effort of the experiment, has a cost of variation and external influences on the plants. Examination of the volume of the youngest fully expanded mature internode (internode 4) needs further study to give conclusive results on the influence of treatment.

Perspectives of TEK and science can challenge and complement each other. TEK can offer insight for the development of hypotheses, and science can find explanations for traditional practices, revealing the reasons for time-developed human interaction with natural resources. The ethnoecology of *ts'áts'ayem* is an example of this complement. There is indeed a biological rationale for the traditional practices and protocols for harvesting eelgrass. Traditional protocols have strong benefits from the nutritional perspective. They ensured human consumption of the healthiest and most beneficial eelgrass shoots. As well, timing, choice of meadows, depth of harvest, and method of harvest, all are undertaken in the best possible way from the point of view of maintaining the eelgrass population. By harvesting at the beginning of the season in the traditional manner, Kwakwaka'wakw harvesters decreased high eelgrass densities in the spring, which has been found to promote new shoot growth in an eelgrass meadow throughout the summer. The scientific explanations I have presented for traditional practices indicate there is much to be exchanged between traditional resource users and ecologists concerned about eelgrass and marine ecosystems in general.

Elders' observations in the field can provide a reference point for eelgrass ecosystems from 30 to 70+ years ago, and can help us understand the impacts of current development and environmental change. Biases, mistrust and preconceptions from the past are worth overcoming to try and find common understanding for the management of this essential plant and habitat, as well as to help document this important aspect of cultural heritage.

5.2 Recommendations

This project is my first step in the study of the traditional management of eelgrass. Studies that would further this investigation could include:

- A study estimating amount of *Zostera marina* harvested traditionally by a given group. Figure 2.11 gives a small indication of the extent of traditional eelgrass harvest, and H. Beans gives some indications of amounts; an estimation of removal and impact on the meadows of the

Kwakwaka'wakw area would be vital to truly assessing the importance of actively practicing sustainability.

- A mapping project overlaying eelgrass meadows with traditional resource areas and harvesting sites. I believe that many of the old village sites in sheltered bays were located near eelgrass meadows, and would most likely have been eelgrass harvesting sites.
- An eelgrass ecosystem health monitoring study; expeditions with elders to old sites they remember harvesting from would provide important insights on how and to what degree contemporary meadows have changed.
- A carbohydrate and nutrient analysis of eelgrass rhizomes over a growing season; a comparison of nutritional qualities of different variants of *Zostera marina*, and of different depths, different age classes and different parts of the plants.
- Further study (with larger sample sizes) of the growth response to harvesting disturbance, following up on the findings of the research done at the Quadra (2005) site, and building on the methodology of the Tsawwassen (2006) study (Chapter 3); exploration of the possible mechanisms for shoot stimulation, ie. removal (space alleviation), disturbance (compensatory growth), and remaining density of shoots (to repopulate harvested area).
- Consideration of the relevance and opportunities for eelgrass harvesting to the development of focal restoration of eelgrass meadows with participation by local First Nations communities.

5.3 Ethnoecology of *ts'áts'ayem:* final thoughts

After two seasons of researching *ts'áts'ayem*, my research came to have a deeper meaning. My picture of the coast had shifted, thanks to the stories and information that my consultants had shared. My idea of science and ways of understanding had also shifted. As I knelt in the meadow of Robert's Bank in September, pulling up plants within the border of my hula hoop plot, I realized that if one is thinking about the outcome of an action (here I was hoping for results for the experiment), one naturally begins to do it with intention. In science, this is called *bias*. But in a more natural context, it could be called tending, gardening, or harvesting with the future in mind. If I were a Kwakwaka'wakw person, harvesting eelgrass from a meadown that I had been to many seasons before, and knew I would visit for many seasons to come, it would be completely natural to remove the plants in a way that would thin them out and encourage their regrowth, or at least to harvest in some way that would not harm the plants' production for next year. I thought back to my experience of a focal practice gathering silverweed roots near Tofino with Gisele Martin and Jen Pukonen, and how Gisele's natural inclination in harvesting was right in line with the *keeping it living* concept. It is hard to reason that eelgrass harvesting would *not* have been conducted in the same spirit. As people pulled up shoots from a few inches of water, they would have innately harvested in a manner that would benefit (or at the least, would not negatively impact) the production of the plants for the next season, and that would not significantly disturb the ecosystem from which they obtained crabs, clams, and herring eggs. Sitting there in the eelgrass meadow, I realized that in traditional times, that was the ethos of harvesting; sustainability was the general mode of doing things. The reason it was hard to believe, was because I was from a time and society where we are trained daily to do the opposite.

As my research progressed, my M.Sc. experience shifted from "doing research for a degree" to become "focal" research – research made meaningful because of history, the stories, tales of traditions, and social and ecological context, and that has focused my purpose. This *focal* research has anchored my new sense of life on this coast, and it has also transformed my role in the picture. To learn about traditional methods, I stepped back and forth from the role of academic researcher to the role of an apprentice. As someone with whom knowledge holders have shared information, the ethnoecology student has a responsibility to keep the knowledge alive, and I believe, to try to keep the practices alive. If we, as researchers, and as inhabitants of the Northwest Coast, take our ecological knowledge on as our responsibility, the traditional elements of respect and sustainability on this coast will survive to inform a 21st century relationship with the land and sea that is needed by all.

Cited References

Ackerman, J.D. "Pollen Germination and Pollen Tube Growth in the Marine Angiosperm *Zostera Marina* L." *Aquatic Botany* 46 (1993): 189-202.

Alm, T. "On the Uses of *Zostera Marina*, Mainly in Norway." *Economic Botany* 57, no. 4 (2003): 640.

Ames, Kenneth M., and Herbert D. G. Maschner. *Peoples of the Northwest Coast: Their Archaeology and Prehistory*. London: Thames and Hudson Ltd., 1999.

Anderson, M. K. *Tending the Wild: Native American Knowledge and the Management of California's Natural Resources*. Berkeley, CA: University of California Press, 2005.

Anderson, M. K., and D. L. Rowney. "The Edible Plant *Dichelostemma captitatum*: Its Vegetative Reproduction Response to Different Indigenous Harvesting Regimes in California." *Restoration Ecology* 7, no. 3 (1999): 231-40.

Atleo, Richard. "Preface." In *Keeping It Living*, edited by D. Deur and N.J. Turner, vii-xi. Seattle: University of Washington Press, 2005.

Backman, T. W. H. "Genotypic and Phenotypic Variability of *Zostera marina* on the West-Coast of North-America." *Canadian Journal of Botany-Revue Canadienne De Botanique* 69, no. 6 (1991): 1361-71.

Battiste, Marie, and James (Sa'ke'j) Youngblood Henderson. "What Is Indigenous Knowledge?" In *Protecting Indigenous Knowledge and Heritage: A Global Challenge*, edited by Marie Batiste and James (Sa'ke'j) Youngblood Henderson, 35-56. Saskatchewan: Purich Publishing Ltd., 2000.

Berkes, Fikret. *Sacred Ecology: Traditional Ecological Knowledge and Resource Management*. Philadelphia, PA: Taylor & Francis, 1999.

Bjorndal, K. A. "Nutrition and Grazing Behavior of the Green Turtle *Chelonia Mydas*." *Marine Biology* 56 (1980): 147-54.

Boas, Franz. *Geographical Names of the Kwakiutl Indians*. New York: AMS Press, Inc., 1934. Reprint, 1969.

———. *Kwakiutl Ethnography*. Edited by Helen Codere. London, UK: University of Chicago Press, Ltd., 1966.

———. *Race, Language and Culture*. New York: The Free Press, a Division of MacMillan Publishing Co., Inc., 1940. Reprint, 1966.

Boas, Franz, and George Hunt. *Ethnology of the Kwakiutl: Based on Data Collected by George Hunt*. Edited by Anonymous, *Thirty-Fifth Annual Report of the Bureau of American Ethnology to the Secretary of the Smithsonian Institution* (1913-1914) Washington, DC: Government Printing Office, 1921.

Burke, M. K., W. C. Dennison, and K. A. Moore. "Non-Structural Carbohydrate Reserves of Eelgrass *Zostera Marina*." *Marine Ecology-Progress Series* 137, no. 1-3 (1996): 195-201.

Cannings, Richard, S. Cannings and M. de Jong Westman. *Life in the Pacific Ocean*. Vancouver, BC: Douglas and McIntyre, 1999.

Chesworth, J. C., M. E. Donkin, and M. T. Brown. "The Interactive Effects of the Antifouling Herbicides Irgarol 1051 and Diuron on the Seagrass *Zostera Marina* (L.)." *Aquatic Toxicology (Amsterdam, Netherlands)* 66, no. 3 (2004): 293.

Clayoquot Sound Scientific Panel for Sustainable Forest Practices. "Nuuchahnulth Words: Appendix V." A-19. First Nations' Perspectives on Forest Practices in Clayoquot Sound, Rep 3, Victoria, BC: Cortex Consulting, 1995.

Clutesi, George. *Potlatch*. Sidney, BC: Gray's Publishing Ltd., 1969.

Codere, Helen. *Fighting with Property: A Study of Kwakiutl Potlatching and Warfare, 1792-1930*. Seattle: University of Washington Press, 1966b. Reprint, 2.

Connell, J. H. "Diversity in Tropical Rain Forests and Coral Reefs." Science 199, no. 4335 (1978): 1302-1310.

Costanza, R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. O'Neill, J. Paruelo, R.G. Raskin, P. Sutton, and M. van den Belt. "The Value of the World's Ecosystem Services and Natural Capital." *Nature* 387 (1997): 253-60.

Cottam, C. "The Eelgrass Shortage in Relation to Waterfowl." *Trans. Amer. Game Conf.* 20 (1934): 272-79.

Craven, M. *I Heard the Owl Call My Name*. New York: Dell Publishing Co., 1973.

Darby, M.C. "The Intensification of Wapato (*Sagittari latifolia*) by the Chinookan People of the Lower Columbia River." In *Keeping It Living*, edited by D. Deur and N.J. Turner, 194-217. Seattle, Wa: University of Washington Press, 2005.

Dennison, W. C. "Effects of Light on Seagrass Photosynthesis, Growth and Depth Distribution." *Aquatic Botany* 27, no. 1 (1987): 15-26.

Deur, D. "Plant Cultivation on the Northwest Coast: A Reconsideration." *Journal of Cultural Geography* 12, no. 2 (2002b): 19-35.

———. "Rethinking Precolonial Plant Cultivation on the Northwest Coast of North America." *Professional Geographer* 54, no. 2 (2002a): 140.

Deur, D., and N.J. Turner. *Keeping It Living*. *Traditions of Plant Use and Cultivation on the Northwest Coast of North America*. Seattle: University of Washington Press and Vancouver: UBC Press, 2005.

Duarte, C. M., N. Marba, N. Agawin, J. Cebrian, S. Enriquez, M.D. Fortes, M.E. Gallegos, M. Merino, B. Olesen, K. Sand-Jensen, J. Uri, and J. Vermaat. "Reconstruction of Seagrass Dynamics: Age Determinations and Associated Tools for the Seagrass Ecologist." *Marine Ecology-Progress Series* 107 (1994): 195-209.

Duff, Wilson. "The Southern Kwakiutl." 101, 1960.

Felger, R.S. "Ancient Crops for the 21st Century." Paper presented at the New agricultural crops, Boulder 1979.

———. "Indian Utilization of Eelgrass (Zostera Marina L.) in Northwestern Mexico: The Spanish Colonial Record." *The Kiva* 43, no. 2 (1977): 89-92.

Felger, R., and C.P. McRoy. "Seagrasses as Potential Food Plants." In *Seedbearing Halophytes as Food Plants*, edited by G.F. Somers, 62-74. Newark: University of Delaware, 1975.

Felger, R., and M. Beck Moser. "People of the Desert and Sea; Ethnobotany of the Seri Indians." Tuscan: University of Arizona Press. 376-82, 1985.

———. " Seagrasses in Seri Indian Culture." In *In Handbook of Seagrass Biology: An Ecosystem Perspective*, edited by R.C. and McRoy Phillips, C.P., 261-76. New York: Garland STPM Press, 1980.

———. "Eelgrass (*Zostera Marina* L.) in the Gulf of California: Discovery of Its Nutritional Value by the Seri Indians." *Science* 181, no. 4086 (1973): 355-56.

Flemer, D.A., H.J. Dovel, H.J. Pfitzenmeyer, and D.E. Jr. Ritchie. "Spoil Disposal in Upper Chesapeake Bay.Ii. Preliminary Analysis of Biological Effects." Paper presented at the Proc. National Symposium on Estuarine Pollution, Stanford, CA 1967.

Gaeckle, J. L., and F. T. Short. "A Plastochrone Method for Measuring Leaf Growth in Eelgrass, *Zostera Marina* L." *Bulletin of Marine Science* 71, no. 3 (2002): 1237.

Galois, Robert. *Kwakwaka'wakw Settlements, 1775-1920: A Geographical Analysis and Gazetteer*. Vancouver: UBC Press, 1994.

Garibaldy, Ann, and N.J. Turner. "Cultural Keystone Species: Implications for Ecological Conservation and Restoration." *Ecology and Society* 9, no. 3 (2004): 1-18.

Green, E.P., and F.T. Short. *World Atlas of Seagrasses*. Berkeley: Prepared by the UNEP World Conservation Monitoring Centre. University of California Press, 2003.

Harrison, P. G. "*Zostera-Japonica*-(Aschers and Graebn) in British-Columbia, Canada." *Syesis* 9 (1976): 359.

Harrison, P. G., and K. H. Mann. "Detritus formation from eelgrass (*Zostera-marina* L.) – relative effects of fragmentation, leaching and decay." *Limnology and Oceanography* 20, no. 6 (1975): 924-934.

Holmer, M., and E. J. Bondgaard. "Photosynthetic and Growth Response of Eelgrass to Low Oxygen and High Sulfide Concentrations During Hypoxic Events." *Aquatic Botany* 70, no. 1 (2001): 29-38.

Iizumi, H., A. Hattori, and C. P. McRoy. "Nitrate and Nitrite in Intersitial Waters of Eelgrass Beds in Relation to the Rhizosphere." *Journal of experimental marine biology and ecology* 47 (1980): 191-201.

Jacobs, R.P.W.M. "Distribution and Aspects of the Production and Biomass of Eelgrass, Zostera-Marina L, at Roscoff, France." *Aquatic Botany* 7, no. 2 (1979): 151-72.

Kendrick, G. A., C. M. Duarte, and N. Marba. "Clonality in Seagrasses, Emergent Properties and Seagrass Landscapes." *Marine Ecology-Progress Series* 290 (2005): 291-96.

Kentula, M. E. "Production Dynamics of a Zostera Mraina L. Bed in Netarts Bay, Oregon." Oregon State University, 1983.

Kentula, M. E., and C. D. McIntire. "The Autecology and Production Dynamics of Eelgrass (*Zostera-Marina* L) in Netarts Bay, Oregon." *Estuaries* 9, no. 3 (1986): 188-99.

Kenworthy, W. J., J. C. Zieman, and G. W. Thayer. "Evidence for the Influence of Seagrasses on the Benthic Nitrogen-Cycle." *Oecologia* 54, no. 2 (1982): 152.

Kikuchi, K., Y. Kawasaki, and S. Sato. "Effect of Seasonal Changes on the Carbohydrate Levels of Eelgrass *Zostera Marina* at Odawa Bay." *Fisheries Science* 67, no. 4 (2001): 755-57.

Kraemer, G. P., and R. S. Alberte. "Impact of Daily Photosynthetic Period on Protein-Synthesis and Carbohydrate Stores in *Zostera-Marina* L. (Eelgrass) Roots -

Implications for Survival in Light-Limited Environments." *Journal of experimental marine biology and ecology* 185, no. 2 (1995): 191-202.

Kuhnlein, Harriet V. "Traditional and Contemporary Nuxalk Foods." *Nutrition Research* 4 (1984): 789-809.

Kuhnlein, Harriet V., and N.J. Turner. *Traditional Plant Foods of Canadian Indigenous People: Nutrition, Botany and Use*. 9 vols. Vol. 8, *Food and Nutrition in History and Anthropology*. Amsterdam: Gordon and Breach Science Publishers S.A., 1991.

Lovett-Doust, L. "Population Dynamics and Local Specialization in a Clonal Perennial (*Ranunculus Repens*). I. The Dynmaics of Ramets in Contrasting Habitats." *Journal of Ecology* 69 (1981): 743-55.

Marba, N., and C. M. Duarte. "Rhizome Elongation and Seagrass Clonal Growth." *Marine Ecology-Progress Series* 174 (1998): 269-80.

Marba, N., M.A. Hemminga, M.A. Mateo, Y.E.M. Mass, J. Terrados, and E. Gacia. "Carbon and Nitrogen Translocation between Seagrass Ramets." *Marine Ecology-Progress Series* 226 (2002): 287-300.

McRoy, C. P., and C. Helfferich. "Applied Aspects of Seagrasses." In *Handbook of Seagrass Biology*, edited by R.C. Philips and C. P. McRoy, 297-343. NY and London: Garland STPM Press, 1980.

Middelboe, A. L., K. Sand-Jensen, and D. Krause-Jensen. "Spatial and Interannual Variations with Depth in Eelgrass Populations." *Journal of experimental marine biology and ecology* 291, no. 1 (2003): 1.

Millennium Assessment Panel. "Millennium Ecosystem Assessment." 2005. http://www.millenniumassessment.org/en/Reports.aspx# (Accessed October 2006).

Olesen, B., and K. Sand-Jensen. "Biomass-Density Patterns in the Temperate Seagrass Zostera-Marina." *Marine Ecology-Progress Series* 109, no. 2-3 (1994a): 283.

———. "Demography of Shallow Eelgrass (*Zostera marina*) Populations-- Shoot Dynamics and Biomass Development." *Journal of Ecology* 82 (1994b): 379-90.

———. "Patch Dynamics of Eelgrass Zostera-Marina." *Marine Ecology-Progress Series* 106, no. 1-2 (1994c): 147.

Ostenfeld, C.H. "On the Ecology and Distribution of the Grass-Wrack (*Zostera marina*) in Danish Waters." In *Report of the Danish Biology Station to the Board of Agriculture*, edited by C.G. Joh Petersen, 1-62. Copenhagen: Danish Biology Station, 1908.

Pendergast, H.D.V. "Useful Marine Monocots-- More Collections Than Data?" *Economic Botany* 56, no. 2 (2002): 110-12.

Philips, R.C. "The Ecology of Eelgrass Meadows in the Pacific Northwest: A Community Profile." edited by U.S. Fish and Wildlife Service, 1984.

Philips, Ronald C., C. Peter McRoy, and Unesco. *Seagrass Research Methods*. Edited by Anonymous, *Monographs on Oceanographic Methodology*. Paris: Unesco, 1990.

Phillips, R. C. "Seagrasses and Coastal Marine-Environment." *Oceanus* 21, no. 3 (1978): 30.

———. "Transplantation of Seagrasses, with Special Emphasis on Eelgrass, *Zostera marina* L." *Aquaculture* 4, no. 2 (1974): 161.

Phillips, R. C., W. S. Grant, and C. P. McRoy. "Reproductive Strategies of Eelgrass (*Zostera marina* L)." *Aquatic Botany* 16, no. 1 (1983): 1.

Phillips, R. C., C. McMillan, and K. W. Bridges. "Phenology of Eelgrass, *Zostera-Marina* L, Along Latitudinal Gradients in North-America." *Aquatic Botany* 15, no. 2 (1983): 145.

Phillips, Ronald C., and C. Peter McRoy. *Handbook of Seagrass Biology: An Ecosystem Perspective*. New York: Garland STPM Press, 1980.

Pirc, H. "Growth Dynamics in *Posidonia oceanica* (L.) Delile: I. Seasonal Changes of Soluble Carbohydrates, Starch, Free Amino Acids, Nitrogen and Organic Anions in Different Parts of the Plant." *Marine Ecology* 6, no. 2 (1985): 141-65.

Posey, Darryl, ed. *Cultural and Spiritual Values of Biodiversity*. London. UK: Intermediate
Technology Publications, 1999.

Powell, Jay. "The Kwak'wala Language." In *Kwakwaka'wakw Settlements, 1775-1920: A Geographical Analysis and Gazetteer*, edited by Robert Galois, 12-16. Vancouver: UBC Press, 1994.

Rasheed, M. A. "Recovery and Succession in a Multi-Species Tropical Seagrass Meadow Following Experimental Disturbance: The Role of Sexual and Asexual Reproduction." *Journal of Experimental Marine Biology and Ecology* 310, no. 1 (2004): 13.

Reid, Martine, and Daisy Sewid-Smith. *Paddling to Where I Stand: Agnes Alfred, Qwiqwasutinuxw Noblewoman*. Translated by Daisy Sewid-Smith. Vancouver, BC: UBC Press, 2004.

Reusch, T. B. H., and S. L. Williams. "Variable Responses of Native Eelgrass *Zostera Marina* to a Non-Indigenous Bivalve Musculista Senhousia." *Oecologia* 113, no. 3 (1998): 428.

Robertson, A. I., and K. H. Mann. "Disturbance by Ice and Life-History Adaptations of the Seagrass Zostera-Marina." *Marine Biology* 80, no. 2 (1984): 131-41.

Sand-Jensen, K. "Biomass, Net Production and Growth Dynamics in an Eelgrass (*Zostera Marina* L.) Population in Vellerup Vig, Denmark." *Ophelia* 14 (1975): 185-201.

———. "Effect of Epiphytes on Eelgrass Photosynthesis." *Aquatic Botany* 3 (1977): 55-63.

Sewid-Smith, Daisy. *Liqwala/Kwakwala Book I*. Campbell River: Education Centre, School District 72, 1992.

———. *Prosecution or Persecution?* British Columbia: Nu-yum-balees Society, 1979.

Short, C.A., R.G. Coles, and C. Pergent-Martini. "Global Seagrass Distribution." In *Global Seagrass Research Methods*, edited by C.A. Short and R.G. Coles, 5-30: Elsevier Science, 2001.

Short, C.A., and C. M. Duarte. "Measurement of Seagrass Growth." In *Global Seagrass Research Methods*, edited by C.A. Short and R.G. Coles, 155-82. Amsterdam: Elsevier, 2001.

Short, C.A., and S. Wyllie-Echeverria. "Global Seagrass Declines and Effects of Climate Change." In *Seas at the Millennium*, edited by C. Sheppard, 10-11. New York: Pergamon, 2000.

Short, F. T., and D. M. Burdick. "Quantifying Eelgrass Habitat Loss in Relation to Housing Development and Nitrogen Loading in Waquoit Bay, Massachusetts." *Estuaries* 19, no. 3 (1996): 730.

Short, F. T., and E. P. Green, eds. *World Atlas of Seagrasses*. Berkeley, CA: UNEP World Conservation Monitoring Centre, 2003.

Short, F. T., and H. A. Neckles. "The Effects of Global Climate Change on Seagrasses." *Aquatic Botany* 63, no. 3-4 (1999): 169.

Short, F. T., and S. Wyllie-Echeverria. "Natural and Human-Induced Disturbance of Seagrasses." *Environmental Conservation* 23 (1996): 17-27.

Sintes, T, N. Marba, and C. M. Duarte. "Modeling Nonlinear Seagrass Clonal Growth: Assessing the Efficiency of Space Occuptation across the Seagrass Floar." *Estuaries and Coasts* 29, no. 1 (2006): 72-80.

Smith, Bruce D. "Low-Level Food Production and the Northwest Coast." In *Keeping It Living: Traditions of Plant Use and Cultivation on the Northwest Coast of North America*, edited by N.J. Turner and D. Deur, 37-67. Seattle: University of Washington Press andVancouver: UBC Press, 2005.

Thayer, G. W., K. A. Bjorndal, J. C. Ogden, S. L. Williams, and J. C. Zieman. "Role of Larger Herbivores in Seagrass Communities." *Estuaries* 7, no. 4A (1984): 351-76.

Thayer, G. W., D. A. Wolfe, and R. B. Williams. "Impact of Man on Seagrass Systems." *American Scientist* 63, no. 3 (1975): 288-95.

Townsend, C. R. “The Patch Dynamics Concept of Stream Community Ecology.” *Journal of North American Benthological Society* 8, no. 1 (1989): 36-50.

Trémolières, M. “Plant Response Strategies to stress and Disturbance: the Case of Aquatic Plants.” *Journal of Bioscience* 29, no. 4 (2004): 461-470.

Turner, N.J. *The Earth's Blanket: Traditional Teachings for Sustainable Living*. Vancouver: Douglas & McIntyre Ltd., 2005.

———. *Plants of Haida Gwaii*. Winlaw, BC: Sono Nis Press, 2004.

Turner, N.J., and Bell. "Ethnobotany of the Southern Kwakiutl Indians of British Columbia." *Economic Botany* 27, no. 3 (1973): 257-310.

Turner, N.J., and F. Berkes. "Coming to Understanding: Developing Conservation through Incremental Learning in the Pacific Northwest." *Human Ecology* (2004).

Turner, N.J., and B.S. Efrat. *Ethnobotany of the Hesquiat Indians of Vancouver Island*. 2 vols. Vol. 2, *Cultural Recovery Paper*. Victoria: The British Columbia Provincial Museum, 1982.

Turner, N.J., and S. Peacock. "Solving the Perennial Paradox: Ethnobotanical Evidence for Plant Resource Management on the Northwest Coast." In *Keeping It Living*, edited by N.J. Turner and D. Deur, 101-50. Seattle: University of Washington Press and Vancouver: UBC Press, 2005.

Turner, N.J., R. Smith, and J.T. Jones. ""A Fine Line between Two Nations": Ownership Patterns for Plant Resources among Northwest Coast Indigenous Peoples." In *Keeping It Living*, edited by N.J. Turner and D. Deur, 151-80. Seattle: University of Washington Press and Vancouver: UBC Press, 2005.

Turner, N.J., J. Thomas, B. F. Carlson, and R. T. Ogilvie. *Ethnobotany of the Nitinaht Indians of Vancouver Island*, Occasional Papers of the British Columbia Provincial Museum. Victoria: British Columbia Provincial Museum, 1983.

Turner, Nancy J., Iain J. Davidson-Hunt, and Michael O'Flaherty. "Living on the Edge: Ecological and Cultural Edges as Sources of Diversity for Social-Ecological Resilience." *Human Ecology* 31, no. 3 (2003): 439-61.

Turner, Nancy J., and Katherine L. Turner. "Traditional Food Systems, Erosion and Renewal in Northwestern North America." *Indian Journal of Traditional Knowledge* 6, no. 1 (2007): 57-68.

University of Victoria Environmental Science Archives. Island Copper Mine fonds. Acc No. 2000-069. http://gateway.uvic.ca/archives/featured_collections/esa/fonds_island_copper_mines/default.html (Accessed March 2007)

Valencia, M.E., J.L. Atondo, and G. Hernandez. "Nutritive Value of *Zostera marina* and Cardon (*Pachycereus pringlei*) as Consumed by the Seri Indians in Sonora Mexico." *Ecology of Food and Nutrition* 17 (1985): 165-74.

Walbran, Capt. John. *British Columbia Coast Names 1592-1906*. Vancouver, BC: Douglas & McIntyre, 1971.

White, J., and J.L. Harper. "Correlated Changes in Plant Size and Number in Plant Populations." *Journal of Ecology* 58, no. 2 (1970): 467-585.

Woods, Diane, and Kim Recalma-Clutesi. "Ancient Sea Gardens: Mystery of the Pacific Northwest." Toronto, ON: Aquaculture Pictures Inc., 2005.

Wright, N. 2002. Eelgrass Conservation for the B.C. Coast: A Discussion Paper. Prepared for B.C. Coastal Eelgrass Stewardship Project. (June 1, 2002). http://www.stewardshipcentre.bc.ca/eelgrass/discussionpaper.pdf. (accessed October, 2004).

Wyllie-Echeverria, S., and J.D. Ackerman. "The Seagrass of the Pacific Coast of North America." In *World Atlas of Seagrasses*, edited by E.P. Green and F. T. Short, 199-206. Berkeley, CA: University of California Press, 2003.

Wyllie-Echeverria, S., P. Arzel, and P. A. Cox. "Seagrass Conservation: Lessons from Ethnobotany." *Pacific Conservation Biology* (2000): 329-34.

Wyllie-Echeverria, S., and P.A. Cox. "The Seagrass (*Zostera marina* [Zosteraceae] Industry of Nova Scotia (1907-1960)." *Economic Botany* 53, no. 4 (1999): 419-26.

Yoda, K., T. Kira, H. Ogawa, and K. Hozumi. "Self-Thinning in Overcrowded Pure Stands under Cultivated and Natural Conditions." *Journal of Biology* 14 (1963): 107-29.

Appendix A Human Research Ethics Certificate of Approval and Participant letter of information and consent form

Human Research Ethics Board
Office of Research Services
University of Victoria
Technology Enterprise Facility, Room 218
Tel (250) 472-4545 Fax (250) 721-7836
Email ethics@uvic.ca Web www.research.uvic.ca

University of Victoria

Human Research Ethics Board
Certificate of Approval

Principal Investigator	Department/School	Supervisor
Severn Cullis-Suzuki **Graduate Student**	**ENVI**	**Dr. Nancy Turner**
Co-Investigator(s): **Nancy J. Turner, Research Liaison, UVic**		

Project Title: **Effects of Traditional Harvesting Practices on Productivity of Zostera Marina L. Zosteraceae (Eelgrass), in a British Columbia Coastal Ecosystem**

Protocol No.	Approval Date	Start Date	End Date
438-04	**23-Nov-04**	**23-Nov-04**	**22-Nov-07**

Certification

This certifies that the UVic Human Research Ethics Board has examined this research protocol and concludes that, in all respects, the proposed research meets appropriate standards of ethics as outlined by the University of Victoria Research Regulations Involving Human Subjects.

Dr. Richard Keeler
Associate Vice-President, Research

This Certificate of Approval is valid for the above term provided there is no change in the procedures. Extensions or minor amendments may be granted upon receipt of a "Research Status" form.

438-04 Cullis-Suzuki, Severn

Participant letter of information and consent form
Introduction

My name is Severn Cullis-Suzuki and the research I am conducting is for my Master's thesis in Environmental Studies under Dr. Nancy Turner at the University of Victoria.
I can be contacted at (250) 721-8021, or severncs@uvic.ca
Dr. Turner's contact number is (250) 721-6124, or nturner@uvic.ca

This letter is an invitation to you, the participant, to participate in a research study titled "Effects of traditional First Nations harvesting practices on the growth of eelgrass in Southern British Columbia." This project is being funded through research grants to my supervisor Nancy Turner from a major collaborative research initiative, Coasts Under Stress and Social Sciences and Humanities Research Council of Canada.

Today, eelgrass is in a worldwide decline. First Nations people harvested and used the marine plant eelgrass (Zostera. marina) in past times for food and other purposes. The purpose of my study is to research the effects that traditional harvesting would have had on eelgrass beds in order to add to our understanding of this important ecosystem. Based on the information and direction I learn from the participants, I will create an experiment to physically measure the effects of harvesting on the eelgrass ecosystem.

Conditions for Participating

Participation in this research is entirely voluntary.
My procedure: if you decide to participate, I will interview you about your knowledge of and experiences with eelgrass. I hope to learn about the cultural significance of eelgrass and the methods used to harvest and prepare it. I am asking participants if they know how it is harvested, and whether they can demonstrate the harvesting. I am also interested in other information about traditional use of eelgrass: how it is prepared? Who would have harvested it, and at what time of year? And, how much eelgrass would people have used in the past?
The information will be audio taped, and in some instances, videotaped, with your consent. During the interviews you may decline to answer any question asked of you with no consequences.
I will try to eliminate any potential inconveniences to you as a participant in this study. The eelgrass harvesting demonstration may be somewhat of an inconvenience, as it will involve some extra time and effort, however this will take place only if the participant is fully comfortable and willing.
As a participant you may withdraw from this study at any time with no consequences. In this case an agreement on use of the data given before withdrawal (deciding whether data will or will not be used for my thesis), will be made between yourself, the participant, and myself, the researcher, based on your consent.

Benefits/Risk:

Benefits: I hope that this process will benefit you as a participant by giving you a forum to talk about traditional knowledge about culturally important plants and environments, and to teach information about an important traditional process. Information you provide will be acknowledged in my thesis and in any presentations from my research.
Risks: The only risk I can foresee is possibly getting wet during any eelgrass harvesting demonstrations. Because of this, I will ensure that we proceed only at your comfort level and will arrange a support (rescue) boat if we are harvesting in deep water.

Compensation:

Any costs incurred during the procedures will be covered by funds allocated to my project through my own research applications and my advisor's research funds. I will offer you a modest honorarium or gift in kind for your time and participation, but it is important for you to understand that this should not be a primary reason why you would participate in this study. Your participation should be entirely voluntary.

Access to Information and Confidentiality/Publication of Results

People who have access to this information will be myself and my academic advisors.
I am not planning to keep you or other participants of this project anonymous-- I intend to give full credit to the participants for the information I learn, as you are acting as knowledgeable consultants teaching about traditional resource management. However, I will gladly provide anonymity as requested to me verbally by you, the participant. I will use this data for my Master's thesis, and this may involve presentations based on my findings to academic circles, and names will be given credit or anonymity based on you, the participant's wishes. At some point I may wish to develop a paper for publication based on my work with you; if I do, I will ask you to review my manuscript before I submit it for publication.

Data will be kept confidential in my office at Sedgewick, University of Victoria, until plans for presentation of my thesis or publication, at which point as a participant you will be asked to review your contributions to these papers and for your consent to present the information you provided. After completion of this project, data collected as audiotape, videotape and in written form will be copied and given to you and other the participants and your community, as you wish. Copies of the research materials will be kept at the University of Victoria in the research files of my supervisor, Dr. Nancy Turner for a length of time decided upon by yourself and Dr. Turner, unless you request that the materials and information provided by you be destroyed.

This research is important because eelgrass is an important resource of which more knowledge is needed to help understand how to restore and manage it. Therefore, it's important to research the level of understanding and management of First Nations who harvested this resource, as this may help shed light on sustainable practices. Also, this is important as a study to further research the degree of stewardship and sustainable management practices of First Nations people as stewards of the land.

You are invited to participate because of your knowledge and willingness to share information about eelgrass and traditional harvesting. You were recruited based on personal communications with my academic advisors. I will provide you with a summary of the research once my Master's has been completed, and a copy of our interview at your request, as well as photographs and other materials from our work together.

If you have ANY questions about the procedure or the project, please ask me, the researcher, so that we make sure that we fully understand each other.

You may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Associate Vice-President Research at (250) 472-4545 or ovprhe@uvic.ca

A copy of this letter and consent form will remain with the participant (you) and one with the researcher (myself, Severn Cullis-Suzuki).

______________________________ ______________________________

Severn Cullis-Suzuki date

AGREEMENT AND SIGNATURES

Participant Consent

I affirm that I have read this consent form and understand and agree to participate in this study.

Name: ____

Signature: _____________________________________

Date: ____

Principal Researcher

I affirm that the above form is complete and accurate and that the research will be conducted in accordance with the University of Victoria regulations, policies and procedures.

Name: Severn Cullis-Suzuki

Signature: _____________________________________

Date: ____

Appendix B Interview Schedule

Background
What is your name?
Where are you from, where did you grow up?
How old are you?

Eating eelgrass
Have you ever eaten eelgrass? Did you ever see anyone eat it/gather it? When was the last time you ate it? What did you call it?

Where did you eat it?
What parts were eaten? How did you prepare it? Did you cook it? Was it stored?
Did you eat it with k'lina (eulachon grease)? With sugar?
Did you ever eat it with herring roe?
Did you eat it as a complete meal, or as part of a meal? Did you eat it with people?

Gathering eelgrass
Have you gathered it? When was the last time you gathered it?
Who did you harvest with? Who taught you how to harvest it? Who gathered it/prepared it for you? Did you get any other foods like crabs, cockles… (what other species are associated)?

How did you gather it? With a tool? What was it called? How much did you get?

Where did you harvest it? Did you go to the same place every year? What time of year?
Do you know if there's any eelgrass there today?
What was the extent of a harvesting area? Were sites allowed to rest?
Did lots of people get it?

What did it used to look like?

Contemporary use
When did you last harvest it? Do you go anymore?
Why don't you (or others) gather it anymore?
Would you eat eelgrass from that location today?

Are there any stories behind eelgrass? Songs? Ceremonies?
(Boas reported that it was said that eelgrass was the food of the first peoples in mythical time…)
Are there any words or tides associated with eelgrass? (ie. Tsapalees, Ts!a…)

Have you used eelgrass for anything else? Do you know of any uses? Some people gathered the leaves when the herring come in to spawn. Have you done this?

Appendix C Transliteration of Eelgrass accounts by Dr. Daisy Sewid-Smith
From Boas, F. and G. Hunt (1921). *Ethnology of the Kwakiutl: based on data collected by George Hunt*. In the Thirty-fifth annual report of the Bureau of American Ethnology to the Secretary of the Smithsonian Institution. Washington, Government Printing Office. (Part 1) 1913 ̄1914

GATHERING EEL GRASS

Twisting for Eel grass
Ḱəlppa x̌a ċaċay̓əm mi
Pages 510 ̄ 514

Kwak'wala transcription from Boas	**Sewid-Smith transliteration**
1. We, hem maʔax̌s laʔi q̓ʷax̌ʔənx̌a, la ʔəs həyaqqa x̌a dᶻəwənx̌ x̌i, laʔi x̌ʷanaɬʔid di da naxʷxʷa ċidaq qa qas k̓əlp peƛ̣ x̌a ċaċay̓əm mi.	Now, when it is growing season (spring), when winter has past, this is when all the women get ready to go and twist for eel̄ grass.
(According to Franz Boas you fit pages 155 ̄156 here "Pole for Gathering eel grass.")	(According to Franz Boas you fit pages 155 ̄156 here "Pole for Gathering eel grass.")
2. We, la ʔəm laƛ̣ ƛ̣i ğənəm mas sa bəgʷanəm mi k̓əlppaƛ̣ x̌a ċaċay̓əm mi.	Now, the man's wife will go and twist for eel̄grass.
3. We, hem mis gal ʔəx̌ʔid sus sis k̓əlpsay yas si siwayuw̓ w̓a, λuw wis q̓əldᶻanēy̓ y̓i dənsʔən dənəm ma.	Now, the first thing she takes is her eelgrass twisting paddle, also her anchor line of cedar bark rope.
4. We, hem mis sis k̓əlpəmɬ ɬi ƛ̣ətəmɬ ɬa, qax̌s himənaɬɬa maʔi ƛ̣ətəmal li da k̓əlp pex̌ x̌a ċaċay̓əm mi, qax̌s himənaɬɬa maʔi kʷəsxəğəm malla x̌a dəmsx xi wap pex̌s laʔi nix̌ustud di da ċidaq qax̌ x̌is k̓əlbayuw̓ w̓ax̌s laʔi xəlk̓ʷətbēy̓ y̓a ċaċay̓əm mi lax̌ ʔubēy̓ y̓as.	Now, also her eel grass twisting hat, because anyone who twists for eel grass always wears a hat, because the women generally get sea water splashed in their faces when they pull up their twisting sticks with eeLgrass twisted around the end.
5. We, hem mis la kʷəsxəğəm maʔac cix̌s laʔi ċuċəx̌ud x̌a ċaċay̓əm mi.	Now, that is when they get splashed in the face, when they are washing the eelgrass
6. We, he ʔəm la giɬ ɬas sa k̓əlpəmpɬ ɬi ƛ̣ətəmɬ ɬa.	Now, this is the purpose of wearing an eelgrass twisting hat.

7. We, la willa dənc̓issəlla qix̌s laʔi lənc̓issəlla lax̌ x̌a ƛ̓əmaʔis si lax̌ hənidiᶻ as sas sis k̓əlbac̓iƛ ƛi c̓agoɬ xʷaxʷagʷəm ma.

Now, she carries everything with her when she goes down to the beach where her harvesting canoe is beached, a small ancient canoe.

8. We, hem mis sis celayuw̓ wi ƛuw̓ w̓is k̓əlbayuw̓ wa x̌a c̓ac̓ayəm mi.

Now, also included is her bailer and her eelgrass twisting stick.

9. We, la wix̌ʷstənd x̌is c̓agoɬ ɬi xʷaxʷagʷəm ma.

Now, she pushes her small ancient canoe into the water.

10. We, la ʔəx̌ʔaɬəx̌səlla x̌ən la ƛiƛəqəlla suw̓ w̓a.

Now, she puts all the things I have mentioned into the canoe.

11. We, gəl mis si wilx̌sax̌s, laʔi k̓ʷax̌ƛənd x̌is k̓əlbac̓iƛ ƛi xʷaxʷagʷəm ma.

Now, when everything is on board, she goes and sit at the stern of the small canoe that she will use to harvest the eelgrass.

12. We, la daxʔid x̌is k̓əlpsay yas si siwayuw qas six̌ʷʔid de qas le lax̌ x̌is q̓aɬ ɬi wokʷ kʷəs c̓ac̓ay̓əm mi.

Now, she takes up her eelgrass twisting paddle and paddles to a place where she knows that there is thick eelgrass.

13. We, hem mis sa, təlǧʷis sas ʔigis q̓ʷax̌x̌as sas sa c̓ac̓ay̓əm mi.

Now, another thing I would like to mention, eelgrass grows in soft sand.

14. We, gəl mis si lagaʔa lax̌ x̌a k̓əlbad da x̌a c̓ac̓ay̓əm max̌s laʔi ʔəx̌ʔid x̌a dənsʔən ni dənəm ma qas mukʷbənd des sa t̓isəm mi laq qas q̓əlstənd des.

Now, when she arrives at the place where you harvest eelgrass she takes a cedar bark rope and ties a stone on the end and uses it as an anchor.

15. Wa, ʔomis si ʔawənənsəllax̌s, laʔi mukʷʔaɬəx̌sas lax̌ x̌a ƛəx̌əx̌stəweɬ ɬex̌ si.

Now, when the anchor touches the bottom, she ties the anchor line to the stern seat.

16. Wa, gəl mis si ğʷaƚƚaɬəx̌səx̌s, laʔi dagəƚƚəx̌s x̌is k̓əlbay̓uw̓ wi qas mitsənd des wiɬbay yas qas midəns ses lax̌ x̌a dəmsx xi wappa qas ƛ̓ənx̌alis ses lax̌ x̌a ʔigidᶻəgʷis si lax̌ q̓ayas sas sa c̓ac̓ay̓əm max̌s, laʔi k̓əlpʔid da.	Now, when she is ready, she picks up her twisting stick and dips the thinner end into the salt water and than she pushes it down to the sandy ocean floor where there is thick eelgrass, and she starts twisting.
17. Wa, la mid da c̓ac̓ay̓əm mi la k̓əlp̓ənēy̓ x̌a k̓əlbayuw̓ wi.	Now, the eelgrass is wrapped around the twisting stick.
18. We, gəl mis si gʷaɬ səxʷc̓c̓a k̓əlpəlid da k̓əlbayuw̓ w̓ax̌s, laʔi nix̌ustud di da k̓əlpʔinux̌ʷ x̌ʷi c̓ədaq x̌is k̓əlbayuw̓ w̓i.	Now, when the twisting stick will no longer twist the experienced women pulls up her twisting stick.
19. We, gəl mis si gax̌ niɬʔid di da c̓ac̓ay̓əm max̌ laʔi ʔaʔodᶻaʔaqqa qʷiɬk̓əwisʔid x̌is k̓əlbayuw̓ w̓i.	Now, when the eelgrass comes in sight she immediately reverses how she is twisting the twisting stick to anti clockwise.
20. We, hem mis la laweyas sa c̓ac̓ay̓əm mi.	Now, this is how the eelgrass comes off.
21. We, la q̓ʷisʔid x̌a nəmp̓ənk ki lax̌ x̌əns q̓ʷaq̓ʷaxc̓anay̓ y̓ix̌ gegəƛ̓əlla lax̌ x̌a ʔugʷəmay̓ y̓as, yəx̌ x̌əns ğʷəyuw̓ w̓i ƛ̓up̓əks.	Now, she grasps a bundle, one span thick starting at the top, at what we refer to as roots.
22. We, la c̓ux̌ʷx̌ʷəɬtal laq lax̌ x̌a dəmsx xi wap pa qa lawēy̓ y̓es sa ʔigis si.	Now, she washes it in salt water to wash off the sand.
23. We, gəl mis si wilox̌s laʔi baɬʔid x̌a maɬp̓ənk ki lax̌ x̌əns q̓ʷaq̓ʷaxc̓anay̓ y̓ix̌, gegəƛ̓əlla lax̌ ʔawanoy̓ y̓as sa ƛ̓upək kas six̌s laʔi p̓uqol lax̌ ʔiwax̌sday̓ y̓as.	Now, when the sand is all off she measures two spans, starting from the upper end of the roots and she breaks off the lower end.
24. We, gəl mis si wiwəlxsʔax̌s laʔi gigaʔaƚƚəx̌s sas lax̌ x̌is naliɬəx̌s si.	Now, when she finishes breaking off the lower ends she lays it in front of her.

25. We, la xʷilaqqa midəns sas sis k̓əlbayuw̓ w̓i.	Now, she immediately puts the twisting stick back into the water.
26. We, ʔomis si nəqəmgəɬtəw̓ēy̓ x̌is gal li ğʷigilas sa.	Now, she just followed everything she did before.
27. We, gəl mis si q̓əyoƛ̓ ƛ̓əx̌s laʔi y̓əx̌ʷx̌ʷa, qax̌s lixxa maʔi k̓əlpdəm ma wallas si xac̓ay̓ ya.	Now, she has harvested enough when the tide rises, because the only time you twist for eel̓grass is when the tide is really low.
28. We, gəl mis si k̓ʷayusdis sa yəxʷxʷax̌s laʔi dənxʔid x̌is q̓əlcəm mi qas le nenakʷ kʷa.	Now, when the tide completely rises she pulls up her anchor and goes home.
29. We, gəl mis si lagalis lax̌s ƛ̓əmaʔis sas sis gukʷ kʷax̌s laʔi loɬtow̓ lax̌ x̌is k̓əlbac̓iy̓ c̓agoɬ ɬa, qas dagəɬɬəx̌s x̌is q̓əlcəm mi qas le dosdisəl laq.	Now, when she arrives at the beach of her house she disembarks from her old eel̓grass harvesting canoe, and she picks up her stone anchor and takes it ashore.
30. We, gəl mis si ɬək̓ʷətʔid di q̓əldᶻaʔanoy̓ y̓as six̌s, laʔi məxʷʔalis saq.	Now, when the anchor line gets taut, she places the stone on the beach.
31. We, hixʔid da mis si yalaqqa x̌is ɬawənəm mi qa les ƛ̓ilalla x̌is gukʷkʷəlut ti qa gax̌ x̌es sixxa x̌a c̓ac̓ay̓əm mi.	Now, she immediately sends her husband to go and call his people to come and peel the eel̓grass.
32. We, hixʔid da mis si n̓an̓ağigay̓ y̓a bəgʷanəm max̌ waɬdəm mas sis ğənəm mi.	Now, the man immediately did what his wife asked him to do.
33. We, la ƛ̓ilal lax̌ x̌is gukʷkʷəlut ti.	Now, he went and called his people.
34. We, gəl mis si gax̌ ʔaʔēdaʔaq qax̌s, laʔi hixʔid da ʔəm ʔixʷʔid x̌is gukʷ kʷi, qas ƛ̓əpsistaliɬ ɬelles sa ɬiʔəlway̓ y̓i laq qa k̓ʷadᶻoy̓ sa sixxa ƛ̓ax̌ x̌a c̓ac̓ay̓əm mi.	Now, when he returns, he immediately clears his house, and spreads cedar mats all around the floor of the house for the eel̓grass peelers to sit on.

35. We, gəl mis si ğʷał?alił łaxs la?i ?əx?id xis ċiċəbaċiy λuẇ ẇa ƛ̓inna qa gax xes ğʷalił ła.	Now, when he was finished he went and fetched his oil dishes and the ooligan oil so it would be ready.
36. We, gax xi huğʷiƛəl li da sixxa ƛax xa ċaċaẏəm mi.	Now, the eel̃grass peelers started arriving one by one.
37. We, gəl mis si willa?ēy ƛəxs, la?i da bəgʷanəm mi hillax xa həyał łes sis nəmmummut ti qa les ğəmxusdis sax xa ċaċaẏəm mi.	Now, when all the eel̃grass peelers arrived, the man went and hired the teenaged sons of his fellow clansman to go and carry the eel̃grass up from the beach.
38. We, hix?id da mis si lax daxʷ xʷi da həyał?a qas le ğəmxusdis saq, qas le ğəmxiƛəl laq qas le ğəmxəmliləl las lax ?uxʷdᶻamolił łas sa sixxaƛ ƛaq.	Now, immediately the young men went and carried the eel̃grass up from the beach, and carried it into the house and placed it in front of each peeler.
39. We, la ?əx?id di da bəgʷanəm ma xa ƛ̓inna qas k̓ʷənxcol les lax xa ċiċəbaċiy.	Now, the man went and fetched the ooligan oil and poured it into the oil dishes.
40. We, gəl mis si q̓ʷałxoċəwakʷ kʷəxs la?i kaxdᶻamolił łas (by the teenaged sons) lax xa sixxa ƛax xa ċaċaẏəm mi lax ƛ̓asalił łas.	Now, when all the oil dishes were filled it was placed (by the teenaged sons) in front of the eel̃grass peelers.
41. We, la ma?ēmał łalid da bibəgʷanəm max xa nałnəm mixλa ċiċəbaċ ċe.	Now , two men shared one oil dish.
42. We, la λa gʷiłłəmalił łi da ċaċaẏəm mi lax xa sixxa ƛaq.	Now, the eel̃grass is scattered in front of the eelgrass peelers.

43. We, gəl mis si ğʷał ʔalił łəx̌s laʔi hixʔid da ma bibəgʷanəm mi daxʔid x̌a maʔēmuc̓aq qi c̓ac̓ayəm ma qa k̓ʷəlwel le x̌a ʔəmʔəmay̓ y̓i ƛ̓up̓p̓əks.	Now, when this is done the men immediately take four pieces of eel̓grass and pluck off the small roots.
44. We, gəl mis si wilox̌s laʔi sixxollax̌ x̌a wiwakʷəyaya ʔugʷiday yas ʔux̌sday̓ y̓as gegeƛ̓əlla lax̌ ʔəwanoy̓ y̓a sa λəkʷ kʷi ƛ̓up̓p̓əks.	Now, when all the small roots are off they peel off the body of leaves at the tail end (leave end) beginning with the leaf closes to the thick root (main root).
45. We, gəl mis si lagaʔa sixxa yas lax̌ təltəlq̓ʷəğēy̓ y̓a sa c̓ac̓ay̓əm max̌s laʔi ʔit ʼʔid he ğʷixʔid x̌a yudəxʷ c̓aq qi.	Now, they stop when they reach the soft part (the silky leaf in the middle) of the eel̓grass then they repeat this procedure with the remaining three pieces.
46. We, gəl mis si willa la he ğʷikʷ kʷəx̌s laʔi q̓əp̓əxʔid dəx̌ ƛ̓up̓p̓ək kas sixs laʔi yaʔēdəxʷdən lax̌ x̌əns q̓ʷaq̓ʷaxc̓anay̓ y̓ix̌ y̓əx̌ ʔəwosğəm mas sas six̌s, laʔi kukəx̌ʷsʔən dəq.	Now, when all the eel̓grass has been peeled in this manner they gather the roots together and measure the roots three fingers in length, and they break off the longer pieces.
47. We, la ʔitʼʔid kukəx̌ʷsʔən daq qa nəm mes ʔəwasğəm mas sas, ga ğʷəł łi ga. (fig.)	Now, they break them off again so that they are all the same length, like this (fig.)
48. We, la həmałgʷənnał c̓aq qoł łax̌s laʔi y̓əłcəms qʷiqʷəƛ̓əx̌s da yas, laq ga gʷeł łi ga.(fig.)	Now, when they have eight (root) pieces they tie them together with their leaves, in this manner. (fig.)
49. We, hem mis la dałła sus si da (1) ʔax̌s laʔi c̓əpʔids lax̌ x̌a ƛ̓inna qas c̓asc̓əsʔid deq.	Now, everyone follows the same procedure.
50. We, naxʷaʔəm he ğʷigil li waʔokʷ kʷas.	Now, when they finish eating they would pick up what they did not eat and go out of the house.
51. We, gəl mis si ğʷał c̓asc̓əs səx̌s laʔi ʔoʔəm ğəmx̌əlił x̌is k̓ic̓ay̓away̓ y̓i qas le huqəwəls sa.	Now, they all went home to their houses and placed the left over eel̓grass in front of their wives.

52. We, la huğʷiɬ lax̌ x̌is giguk̓ʷ k̓ʷi qas ğiğəmx̌əmliɬ ɬəl les sis mamut ti c̓ac̓ay̓əm lax̌ x̌is ğəğənəm mi.

Now, this is what they hold on to when they dip the eel̓grass into the ooligan grease and eat it.

53. We, laʔəm hewax̌x̌a nax̌ʔid dəx̌ wap pax̌s laʔi huqəwəls sa ƛuw̓s laʔi hugʷiƛ̓ lax̌ x̌is giguk̓ʷ k̓ʷi.

Now, they never drank water before they left, or when they arrived at their own houses.

54. We, heʔəm sixxilagiɬ ɬa x̌a c̓ac̓ay̓əm ma q̓inəm mi liʔəlqʷəlaƛ̓ƛ̓a ya, qax̌s hemma wallaʔas sa gal li bəgʷanəm ma, galaʔoɬ ɬix̌ bəkʷəmgalis sa naxʷxʷa nuxʷnəmis sa.

Now, this is the eel̓grass peeling feast given for many tribes, and it started with the first people, the first people of the mythical period.

55. We, hem mis lagiɬ ɬas ʔAwilaxsillakʷ kʷa c̓ac̓ay̓əm max̌s c̓asilaʔēd da bəgʷanəm mi.

Now, this is why they have this ritual for the eelgrass when a man gives an eel̓ grass peeling feast.

56. We, laʔəm ğʷaɬɬa c̓ac̓ac̓al lex̌ x̌a c̓ac̓ay̓əm mi, qax̌s nəmxʔid da ɬa maʔi c̓ac̓ec̓inay̓ y̓aq ƛuw̓ w̓a loƛ̓ƛ̓əllaʔinay̓ y̓aq.

Now, that is all that is to be said about eel̓grass, for there is only one way of eating it and harvesting it.

Notes from Daisy Sewid-Smith

7. The translator translates "C̓agoɬ" as little old but it means small and ancient. C̓agoɬ's were small retired canoes that have become too old to be used safely as war canoes or messenger canoes.

13. "hem mis sa" translates as "another thing I would like to mention.

14. The translator translates "q̓əlstənd" as throwing a stone in the water. Q̓əlstənd comes from the word q̓əlcəm (anchor). Q̓əlstənd means you are throwing your anchor in the water, not just a stone.

15. The translator uses "so that it is vertical." This is not in the text.

16. The informant uses the word ğʷaɬɬaɬəx̌səx̌s (ğʷaɬ̱ ready ɬaɬəx̌səx̌s̱ onboat / canoe). The translator uses "puts the tip into the water". The informant uses the word "wiɬbay" which means the thinner end of the pole. ʔigidᶻ əgʷis means the sandy ocean floor. "dəmsx" is salt water but sea water and ocean has also been used to translate this word, we also call table salt "dəmsx."

18. K̓əlpʔinux̌ʷ means experienced eel grass̄ twister.

19. ʔaʔodᶻaqqa means to reverse.

21. The translator translates this as "and she squeezes one span around it, beginning at the head end. That is what we refer to as the roots" q̓ʷisʔid means to squeeze or grasp. When you are squeezing liquid out of something you use squeeze. When you take hold of something you use grasp. nəmp̓ənk is one span.One span is when you measure with your thumb and little finger extended. When you measure a bundle you encircle the c̓ac̓ay̓əm with both your hands thumb and little fingers touching. My finger span is six inches and it is still six inches if I encircle it. People with larger hands or longer fingers will be longer. This was approximate measurements but it worked.

27. I don't know what the translator refers to as spring tide. The word given is y̓əx̌ʷx̌ʷa which is high tide.

29. dosdisəlla means carrying something ashore or from the beach.

31. The informant uses the word gukʷkʷəluɬ. The literal translation is "the people you live with."

33. gukʷkʷəlut means your people, the people you are living with.
Lilqʷalaƛēy is tribe (see 54)

37. The translator uses the term "the young men of his Numaym." The informant says "həyaɬ ɬes sis nəmmimmut ti." which translates as, "the teenaged sons of his fellow clansman." The informant does not use the term "numayəm" he uses the term "nəmmimmut."
numayəm = clan nəmmimmut = your fellow clansmen

41. The translator translates this sentence as, "There are four men to each oil dish." The word for four is m̓uw, and the word for two is maɬ. The plural term for two is maʔēmaɬ, which is what the informant uses.

44. The Nak̓ʷaxdax̌ʷ call body ʔugʷiday and we (Kʷak̓ʷalla) call it ʔuk̓ʷinēy. The informant refers to the leaves as the body.

48. The informant states they tie eight root pieces together. My people wrapped the silky leaf around the root which is still attached, one at a time and dip it in the ooligan grease.

55. The translator translates ʔAwilaxsilla as "a valuable feast." It is much more than that, they would have this ritual year after year since the first man (gal li bəgʷanəm ma). Each generation would pass it on to the next generation.

POLE FOR GATHERING EELGRASS

Pages 155 - 156

Kwak'wala transcription from Boas	**Sewid-Smith transliteration**
1. We, hem mis gal la ʔaley sus sa bəgʷanəm mi lax̌ x̌a ʔaƛ̓iy wakaɬɬa q̓ʷaq̓ʷax̌adᶻəm ma.	Now, the first thing a man would search for in the forest would be a young bent hemlock tree.
2. We, gəl mis si q̓a qix̌s laʔi cak̓əx̌ud dəq, yəs sis k̓əmλayuw wi.	Now, when he finds it he cuts it at the bottom, with his dressing adz.
3. We, gəl mis si t̓axʔid dəx̌s laʔi baɬʔid dəq yəs sa nəq̓əbud des babəƛaway yi lax̌ x̌əns baƛex̌s, laʔi cakud dəx̌ ʔux̌toy yas.	Now, when the tree falls he measures (the length) by hand span, and half a span to the middle of the chest, and this is where the top of the tree is cut off.
4. We, la maɬdənxsow wi wagid das sas ʔux̌toy̓ y̓as lax̌ x̌əns q̓ʷaq̓ʷaxc̓anēy̓ yix̌.	Now, the width at the top is two fingers thick.
5. We, la ʔəx̌ʔid x̌is nəx̌x̌aɬ ɬa k̓away̓uw̓ wa qas k̓ax̌ol lex̌ x̌əxʷʔənay̓ y̓as λuw̓ x̌udᶻ igēy yas.	Now, he goes and get his straight knife and cuts off the bark and inner bark.
6. We, gəl mis si wilox̌s laʔi mamaɬdənxsolla wagid das sas lax̌ x̌əns q̓ʷaq̓ʷaxc̓anay̓ y̓ix̌ yəx̌ x̌a wiɬɬətoy̓ y̓i.	Now, when it is all off (the outer bark and inner bark) it is not quite two fingers thick where it is thin at the top of the tree.
7. We, la həlsəlla ʔəm λaλakʷaɬ ɬi da ʔəbsbay̓ y̓as.	Now, the other end is barely thicker.
8. We, la x̌ənƛəlla wakaɬɬa ğawēy̓s sa wiɬbēy yi, yəx̌ x̌a λəkʷbēy yi.	Now, it is more curved than the thinner end, the thicker end.
9. We, la mimuxʷballa x̌a luʔəlxʷsəm mi da waxsbay yas.	Now, at each end there is a round knob.

10. We, gəl mis si gʷaɬ ɬəx̌s laʔi nenakʷ kʷa, dal laq.

Now, when he finished he goes home, carrying it.

11. We, gəl mis si la laʔēƛ lax̌ x̌is gukʷ kʷax̌s laʔi kadənulis sas sa k̓əlbayuw̓ w̓i lax̌ x̌is ləğʷiɬ ɬi.

Now, when he enters his house he puts the twisting stick by the side of the fire.

12. We, la ʔəx̌ʔid x̌a yasəkʷ kʷas sa ğiwas si qas gax̌ x̌e gigaliɬ ɬas lax̌ x̌is ʔiʔax̌x̌əllas sax̌ x̌a k̓əlbayuw̓ w̓i.

Now, he goes and fetches deer tallow and brings it to where he is working on the twisting stick.

13. We, la ʔəx̌ʔid x̌a k̓əlbayuw̓ wi qas kakadəƛal les lax̌ x̌is ləgʷiɬ ɬi.

Now, he takes the twisting stick and pushes it back and forth over the fire.

14. We, la ʔəm wiqʷilel laq qa nəmmanakʷkʷəl les c̓əlğʷənakʷəl li ʔugʷiday̓ y̓as.

Now, he pushes it back and forth so that the whole surface of the stick will heat up evenly.

15. We, gəl mis si ʔollak̓alla la c̓əlxʷʔid dəx̌s laʔi ʔəx̌ʔid x̌a yasəkʷ kʷi qas yəlsʔid des lax̌ x̌a k̓əlbayuw̓ w̓i.

Now, when the stick becomes very hot he takes the tallow and rubs it all over the twisting stick.

16. We, gəl mis si məğʷəgit x̌a yasəkʷ kʷax̌s laʔi xʷilaqqa ʔəm la kakadəƛal las lax̌ x̌is ləğʷiɬ ɬi.

Now, when the stick is completely covered with tallow, he pushes it back and forth over the fire.

17. We, gəl mis si ʔəlaq xix̌ʔid di da yasəkʷʔənēy̓ y̓as six̌s laʔi xʷillaqqa yəlsʔid sa yasəkʷ kʷi laq.

Now, when the tallow is about to catch on fire he immediately rubs more tallow on the stick.

18. We, gəl mis si la məğʷəgit x̌a yasəkʷ kʷax̌s laʔi katʾaliɬ ɬas lax̌ x̌a ʔuniğʷiɬ ɬas sis gukʷ kʷi qa halabal les wədəxʔid da.

Now, when the stick is completely covered with tallow he stands it at the corner of the house so that it will quickly cool.

19. We, la ʔəm nix qa ƛ̓əmx̌ʔid des qa ƛ̓ax̌ x̌es, lagiɬ ɬas he ğʷigillas sa yasəkʷ kʷi laq.

Now, he wants the stick to be brittle and stiff, that was the reason he rubbed the stick with tallow.

20. Wa, gəl mis si wədəxʔid dəx̌s laʔi ʔəx̌ʔid x̌a kadᶻəkʷ kʷi ƛuw̓ w̓a k̓əlbayuw̓ w̓i.	Now, when the stick cools off he goes and fetches soft cedar bark and the twisting stick.
21. We, la digitʔid sa q̓uyaʔakʷ kʷi kadᶻ əkʷ kʷi laq, qa lawey̓ y̓es yasəkʷʔənēy̓ y̓as.	Now, he rubs soft shredded cedar bark all over the stick to remove all the tallow.
22. We, gel mis si willax̌s, laʔi ğʷaɬɬa.	Now, when all the tallow has been removed, he is finished.
23. We, la ʔəm ğʷaɬ lax̌ x̌iq.	Now, this is where it ends.

Notes from Dr.Daisy SewidSmith

2. The k̓əmƛayuw̓ is dressing adz. It leaves designs on a log. It has a shorter handle than the qəndᶻayuw̓. The qəndᶻayuw̓ is an adz that cuts thin slices off a log.

3. The informant does not mention the length but how the measurement is done. The translator however, states it is two fathoms and a half, which would be twelve and a half feet long. Twisting sticks can be of various lengths depending on how deep the eel grass is.

4. Maɫ is two and the translator translates it as two finger widths thick. The informant also states it is two finger widths thick. However, Adam Dick has made many twisting sticks and he states that this would be too thick for the top. He said it is approximately one finger thick.

5. X̌əxʷʔənay is your hard outer bark, when you peel this off you end up with the x̌udᶻigē y or inner bark. The translator translates x̌udᶻigēy̓ as sap. Ğʷəlik is sap and sap is the fluid also referred to as pitch or gum.

6. The informant uses the word mamaɫdənxsolla or not quite two fingers thick. The translator translates it as finger width and a half thick. This is closer to the width Adam Dick mentioned under note 3 of one finger thick.

8. The informant obviously switched the words wiɫbēy and
ƛəkʷbēy by mistake. The translator picked up on it and translated it as "The tip is more curved than the butt. If we reverse the two words, it would read:

"We, la x̌ənƛ̓əlla wakaɫɫa ğawēys sa ƛəkʷbēy̓ y̓i,
yəx̌ x̌a wiɫbay yi."
Now, it is more curved than the thicker end,
the thinner end.
The twisting stick is curved at the thinner end,
Not the thicker end.

9. I have never seen twisting sticks with knobs. I contacted Adam Dick to verify this. He said twisting sticks do not have knobs. It is the halibut sticks that have knobs or knots to keep the leader from slipping off. (see first set of comments). If you are going to put a line on something you need a knob to keep it in place. There is no line on a twisting stick.

15. This text is not in the Kʷak̓ʷakalla dialect. The word "yəlsʔid" tells me it is in the Nak̓ʷaxdax̌ʷ dialect. The Kʷak̓ʷala word for rub is ğəlsʔid. Franz Boas' assistant George Hunt had a Nak̓ʷaxdax̌ʷ wife. There are other words but I will not list them.

Appendix D Regression and ANOVA tables for Chapter 3 (Results section 3.3)

H01: Different intensities of removal have no effect on shoot regeneration.

QUADRA: SHOOT REGENERATION
Reduced multiple regression

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.846(a)	.716	.639	8.209

a Predictors: (Constant), Depth, Percent removed, Original density
b Dependent Variable: Shoot regeneration

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1873.183	3	624.394	9.266	.002(a)
	Residual	741.217	11	67.383		
	Total	2614.400	14			

a Predictors: (Constant), DEPTH, PERCENT REMOVED, ORIGINAL DENSITY
b Dependent Variable: Shoot regeneration

Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	24.883	14.839		1.677	.122	-7.777	57.542		
	PERC_REM	-23.759	5.926	-.690	-4.010	.002	-36.802	-10.717	.871	1.148
	DEPTH	1.698	3.725	.084	.456	.657	-6.502	9.897	.752	1.330
	ORIGNUM	-.800	.217	-.724	-3.684	.004	-1.278	-.322	.667	1.499

a Dependent Variable: Shoot regeneration

ONE-PREDICTOR REGRESSION: Curve estimation
Independent: PERCENT REMOVED (Treatment)

Dependent	Mth	Rsq	d.f.	F	Sigf	b0	b1	b2
SHOODIFOR	LIN	.188	14	3.24	.093	2.0158	-16.472	
SHOODIFOR	QUA	.359	13	3.64	.056	-4.3331	37.3553	-52.562

$Y = -4.333 + 37.356x - 52.562x^2$

TSAWWASSEN: SHOOT REGENERATION
ANCOVA

Levene's Test of Equality of Error Variances(a)
Dependent Variable: SHOOT REGENERATION

F	Df1	df2	Sig.
.188	3	16	.903

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.
a Design: Intercept+HARV_INT+TRANSECT+ORIG_NO

Tests of Between-Subjects Effects
Dependent Variable: SHOOT REGENERATION

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	5327.967(a)	3	1775.989	41.267	.000	.886
Intercept	419.794	1	419.794	9.754	.007	.379
HARV_INT	907.953	1	907.953	21.097	.000	.569
TRANSECT	985.934	1	985.934	22.909	.000	.589
ORIG_NO	2420.267	1	2420.267	56.238	.000	.779
Error	688.583	16	43.036			
Total	12973.000	20				
Corrected Total	6016.550	19				

a R Squared = .886 (Adjusted R Squared = .864)

Parameter Estimates

Dependent Variable: SHOOT REGENERATION

Parameter	B	Std. Error	T	Sig.	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
Intercept	28.633	4.816	5.945	.000	18.423	38.843	.688
[HARV_INT=1]	-14.044	3.058	-4.593	.000	-20.525	-7.562	.569
[HARV_INT=2]	0(a)	.	.	.	.	.	.
[TRANSECT=1]	-14.070	2.939	-4.786	.000	-20.301	-7.838	.589
[TRANSECT=2]	0(a)	.	.	.	.	.	.
ORIG_NO	-.652	.087	-7.499	.000	-.836	-.468	.779

a This parameter is set to zero because it is redundant.

H02: Different intensities of removal have no effect on net shoot production post-treatment (net shoots).

QUADRA: NET SHOOTS
SINGLE-PREDICTOR REGRESSION: Curve estimation (Figure 3.6)
Independent: PERCENT REMOVED

Dependent	Method	Rsq	d.f.	F	Sigf	b0	b1	b2
SD-PTMT	LINEAR	0.110	14	1.72	.211	2.9145	9.7508	
SD-PTMT	QUADRTC	0.422	13	4.75	.028	-3.7519	66.2693	-55.189

$Y= -3.752 + 66.270x – 55.189x^2$

SINGLE-PREDICTOR REGRESSION: Curve estimation (Figure 3.7)
Independent: POST-TREATMENT DENSITY

Dependent	Method	Rsq	d.f.	F	Sigf	b0	b1	b2
SD-PTMT	LINEAR	0.310	14	6.30	.025	14.4918	-.3905	
SD-PTMT	QUADRTC	0.466	13	5.66	.017	10.2374	.3236	-.0151

$Y= 10.237 + 0.324x – 0.0151x^2$

ANCOVA

Levene's Test of Equality of Error Variances(a)

Dependent Variable: NET SHOOTS

F	df1	df2	Sig.
1.143	3	12	.371

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.
a Design: Intercept+TREATMENT+ORIGNUM

Tests of Between-Subjects Effects

Dependent Variable: NET SHOOTS

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1206.666(b)	4	301.666	4.575	.020	.625
Intercept	734.248	1	734.248	11.136	.007	.503
HARVINT	644.398	3	214.799	3.258	.063	.470
ORIGNUM	329.478	1	329.478	4.997	.047	.312
Error	725.272	11	65.934			
Total	2817.000	16				
Corrected Total	1931.937	15				

a Computed using alpha = .05
b R Squared = .625 (Adjusted R Squared = .488)

Parameter Estimates

Dependent Variable: NET SHOOTS

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval		Partial Eta Squared	Noncent. Parameter	Observed Power(a)
					Lower Bound	Upper Bound			
Intercept	18.379	6.511	2.823	.017	4.048	32.710	.420	2.823	.729
[HARVINT=1]	-8.015	5.950	-1.347	.205	-21.110	5.080	.142	1.347	.234
[HARVINT=2]	8.243	5.794	1.423	.183	-4.511	20.996	.155	1.423	.255
[HARVINT=3]	6.853	5.742	1.193	.258	-5.785	19.490	.115	1.193	.194
[HARVINT=4]	0(b)	.	.	.	.	.	.	.	.
ORIGNUM	-.410	.183	-2.235	.047	-.814	-.006	.312	2.235	.531

a Computed using alpha = .05, b This parameter is set to zero because it is redundant.

TSAWWASSEN: NET SHOOTS

ANCOVA

Levene's Test of Equality of Error Variances(a)

Dependent Variable: NET SHOOTS

F	df1	df2	Sig.
.270	3	16	.846

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.
a Design: Intercept+TRANSECT+ORIG_NO+TREATMENT

Tests of Between-Subjects Effects

Dependent Variable: NET SHOOTS

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2275.161(a)	3	758.387	16.536	.000	.756
Intercept	350.725	1	350.725	7.647	.014	.323
TRANSECT	1190.333	1	1190.333	25.955	.000	.619
ORIG_NO	1187.461	1	1187.461	25.892	.000	.618
TREATMENT	15.287	1	15.287	.333	.572	.020
Error	733.789	16	45.862			
Total	4989.000	20				
Corrected Total	3008.950	19				

a R Squared = .756 (Adjusted R Squared = .710)

Parameter Estimates

Dependent Variable: NET SHOOTS

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
Intercept	20.142	4.972	4.051	.001	9.602	30.682	.506
[TRANSECT=1]	-15.459	3.034	-5.095	.000	-21.892	-9.027	.619
[TRANSECT=2]	0(a)	.	.	.	.	.	.
ORIG_NO	-.457	.090	-5.088	.000	-.647	-.266	.618
[TREATMENT=1]	1.822	3.156	.577	.572	-4.869	8.513	.020
[TREATMENT=2]	0(a)	.	.	.	.	.	.

a This parameter is set to zero because it is redundant.

T-Test

Group Statistics

	TRANSECT	N	Mean	Std. Deviation	Std. Error Mean
NET SHOOTS	T-A (deeper)	10	-17.20	10.539	3.333
	T-B (shallower)	10	-2.70	10.318	3.263

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
NET SHOOTS	= variance assumed	.000	1.000	-3.109	18	.006	-14.50	4.664	-24.299	-4.701
	Equal variances not assumed			-3.109	17.992	.006	-14.50	4.664	-24.299	-4.701

H03: There is no effect of different intensities of removal on the volume of rhizome internode 4.

QUADRA: INTERNODE 4 VOLUME
Reduced Multiple regression

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.734(a)	.538	.439	35.49398

a Predictors: (Constant), ORIGNUM, VOL9, PERC_REM
b Dependent Variable: VOL4

ANOVA(b)

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	20555.888	3	6851.963	5.439	.011(a)
	Residual	17637.515	14	1259.822		
	Total	38193.403	17			

a Predictors: (Constant), ORIGNUM, VOL9, PERC_REM
b Dependent Variable: VOL4

Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	110.126	28.768		3.828	.002		
	VOL9	.461	.266	.381	1.733	.105	.681	1.468
	PERC_REM	51.633	26.205	.435	1.970	.069	.676	1.478
	ORIGNUM	-.937	.821	-.237	-1.141	.273	.765	1.307

a Dependent Variable: VOL4

Collinearity Diagnostics(a)

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions			
				(Constant)	VOL2	PERC_REM	ORIGNUM
1	1	3.494	1.000	.01	.01	.02	.01
	2	.367	3.086	.01	.00	.50	.08
	3	.088	6.287	.21	.92	.16	.04
	4	.051	8.264	.78	.07	.33	.88

a Dependent Variable: VOL4

Correlations

		PERC_REM	VOL4
PERC_REM	Pearson Correlation	1	.642(**)
	Sig. (2-tailed)	.	.003
	N	19	19
VOL4	Pearson Correlation	.642(**)	1
	Sig. (2-tailed)	.003	.
	N	19	19

** Correlation is significant at the 0.01 level (2-tailed).

TSAWWASSEN INTERNODE 4 VOLUME
*Internode 4 volume data transformed: Trnsvol4= (1/volume 4)

REDUCED MULTIPLE REGRESSION

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.570(a)	.325	.241	.0023952

a Predictors: (Constant), ORIG_DEN, VOL9
b Dependent Variable: TRNSVOL4

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.000	2	.000	3.853	.043(a)
	Residual	.000	16	.000		
	Total	.000	18			

a Predictors: (Constant), ORIG_DEN, VOL9
b Dependent Variable: TRNSVOL4

Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.007	.002		4.432	.000		
	VOL9	-1.288E-05	.000	-.616	-2.754	.014	.843	1.186
	ORIG_DEN	4.698E-05	.000	.315	1.409	.178	.843	1.186

a Dependent Variable: TRNSVOL4

Collinearity Diagnostics(a)

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions		
				(Constant)	VOL9	ORIG_DEN
1	1	2.781	1.000	.01	.03	.01
	2	.163	4.137	.15	.94	.06
	3	.056	7.016	.84	.03	.93

a Dependent Variable: TRNSVOL4

Appendix E Table 0.1 Description of eelgrass harvested at locations throughout study with Consultants' comments on specimens. Variants determined based on Backman's key (1991), mostly based on leaf width.

Location (date)	Consultant(s)	Site	*Z. marina* var.	Description	Sample comments	Possible pollution Source?
Quadra Island (May 8, 2005)	Adam Dick, Daisy Sewid-Smith	Heriot Bay	*phillipsii*	Eelgrass quite small, sparse & not great for twisting;		Right adjacent to an oyster lease; salmon farms nearby
		Waiatt Bay; U.Vic herbarium accession # 45929	*phillipsii*	Larger eelgrass, size acceptable to AD and DSS. Some flowering. Leaves were heavily covered in bryozoans, distasteful to AD and DSS; they wondered why they were so covered. It wasn't what they remembered. About 1-3 living (edible) root nodes; AD and DSS agreed the rhizomes "weren't right," there weren't enough light brown-orange root nodes; most were black and dead; they suggested maybe this is due to pollution.		Fish farm nearby
Quatsino Sound (May 25, 2005)	Adam Dick, Tom Nelson	Koprino; Accession # 45933 and 45934	*typica or phillipsii*	Acceptable, still small.		Mine tailings; nearby fish farms
		In front of Koprino village; Accession # 45930-45931	*phillipsii*	(Koprino in front of village) Perfect eelgrass! Sandy sediment, easy to pull out with k'elpaxu		Mine tailings; nearby fish farms

Table 0.1 Continued. Description of eelgrass harvested at locations throughout study with Consultants' comments on specimens.

Location (date)	Consultant	Site	*Z. marina* variant	Description	Sample comments	Possible pollution Source?
Quatsino Sound (May 25, 2005)	Tom Nelson, Adam Dick	Browning Inlet (Kayne's Peninsula) Accession # 45938	*phillipsii*	*Z. marina* even smaller than near Heriot Island on Quadra. Some flowering. TN used to harvest here. Never seen black rhizomes (AD and TN). Herring were spawning here on the eelgrass in March 2005 (Jaime Pepper).	TN: …they used to get pretty big, eh. They used to be the size of a pencil and sometimes a little bigger than a pencil. But they were nice eelgrass. You know we used to just eat that thing just the way it was. Just pull them out of the bottom and you, they were nice and soft too. SCS: Not like the stuff we found, it didn't look right? TN: Oh no, I wouldn't have eaten that stuff. They were black! …You know, it's very interesting to see it that colour… …'cause I know that eelgrass used to come out pretty good. Another place we used to get the eelgrass was at Varney Bay, just you know before you go through the Narrows, from the top end, from Coal Harbour… …There's a lot of eelgrass there. The only reason I didn't take you there is because of the pollution that came out, you know the siltation from the mine site, eh.	Mine tailings - Island Copper Mine site (Utah Mines); Fish farm nearby TN: When they started dumping the waste into Rupert Inlet. You know they dumped lots. And then, you know, we weren't allowed to dig any more there clams either. Just when you came around, when you come out of Coal Harbour, when you turn that corner to go to Rupert Arm? We used to go harvest our clams there. Next thing you know, we were told not to harvest any more clams there.
		Entrance of Fulward Inlet Accession # 45935-45936	*Phyllospadix serrulatus* Ruprecht ex Ascherson, L.	(Fulward entrance) A lot of branching. Rhizomes not the right colour, were grey-whitish. Good size but not right roots, later determined this was *'Phyllospadix serrulatus'*. Some acceptable, but still small.	TN: You know, I was surprised when we went out [in Quatsino] that they were black. Cause they're usually the brown colour. You know what those little nuts, …I used to call it a hazelnut, is it filbert? You know the colour of it? Well that's the colour that the roots used to be.	Mine tailings; nearby fish farms

Table 0.1 Continued. Description of eelgrass harvested at locations throughout study with Consultants' comments on specimens.

Location (date)	Consultant	Site	*Z. marina* variant	Description	Sample comments	Possible pollution Source?
Tofino (April 30, 2006)	Personal observations	Grice Bay mudflats;	*phillipsii*	Small eelgrass at the shallow region; larger eelgrass deeper, some flowering		Tofino
		Inlet at Cox Bay (across from Long Beach)	*phillipsii*	Large meadow of dried up *latifolia* covering the inlet. Rhizomes very long and brittle - hard not to break.		
Tofino (May 1, 2006)	Gisele Martin, Joe Martin	Sand bar (near Raccoon Is. in front of Tofino and across from Opitsaht)	*phillipsii*	Lots of plants, quite dense. Eelgrass rhizomes deep; some about 25cm deep in fine, grey sand. Stalks and stems were very wide. Many flowering plants were as long as 1.5m. Quite clear of epiphytes too, fast current here. Noticed that the more dense the plants were, the smaller they were. Internode growth small until about the last three, then they larger. Internodes = about two fingers wide in length, and about the size of a pencil in width.	AD: "That's the real one, the real *ts'áts'ayem*!"	Tofino, Opitsaht (sewage); however fast flow of water
Comox (may 14, 2006)	Stu Hardy Adam Dick	Off the docks in Comox Harbor;	*typica; Z. japonica*	Eelgrass shallow, some dried up. Some flowering. Smallish plants, some edible rhizome. Leaves clean, some brown, woody roots. Sediment: sandy like salt grains. Not that desirable, but some still edible;	SH: There was a sewage treatment plant, but it never worked properly. All the eelgrass disappeared. But it's [the eelgrass] coming back. It's been coming back in the last seven years. They moved the sewage treatment plant to Kai Bay.	Old site for sewage treatment plant; Comox homes
		Sand bar in front of harbor		Leaves covered in brown epiphytes. Sediment: sandy. Plants quite deep, not as thick as SH remembered.	SH: This whole Comox Bay used to be full of eelgrass… used to be so thick, as a kid you could hardly walk through it.	Old site for sewage treatment plant; Comox homes
		Gartley Beach	*Z. japonica.*	Lots of *sargassum* (Stu says it's always been here). Seaweed epiphytes growing on the leaves. Some black rhizomes. Not desireable at all according to AD	SH: The herring spawn along Gartley beach, but not in the harbour anymore. There was a sewage treatment plant, but it never worked properly.	Old site for sewage treatment plant; Comox homes

Table 0.1 Continued. Description of eelgrass harvested at locations throughout study with Consultants' comments on specimens.

Location (date)	Consultant	Site	*Z. marina* variant	Description	Sample comments	Possible pollution Source?
Cormorant Island (May 29, 2006)	Adam Dick, Stephen Beans, Helen Beans	Grassy Point	*phillipsii*	Thick, large eelgrass like we'd seen in Tofino. Many spadices blooming. The leaves were covered in purple-reddish seaweed. At first Adam said this was normal, but then he said that we'd hit it a bit too late (we're May 29th, usually he'd be here around the 24th for Sports day); he didn't remember seeing this seaweed before, he remembered the leaves being very clean. Rhizomes looked great though a bit over-mature too—a bit woody/stringy. Otherwise, the eelgrass were as AD remembered.	SB: There's lots of current off Grassy Point, so that stuff doesn't stick to it... ... I noticed there's a lot of stuff in the water, brown scum on the water. You put your line in and it gets covered. Just floating in the water, brown mud, like sewage in the water. Since about 6-7 years ago, the gill nets up North used to have to clean their nets every 15 minutes. Now it's showing up here.	Fish farms nearby; near sewage treatment plant
		Mouth of Nimpkish River	*phillipsii and typica (?)*	Water colder. Lots of *Alaria* kelp in the eelgrass. Difficult to twist the eelgrass up without getting a lot of seaweed. Eelgrass was a bit smaller here, not as good as Grassy Point. Leaves covered in epiphytes here; not the same kind of seaweed as Grassy Point. Spotted good sized Dungeness crabs in the eelgrass.	HB: The Nimpkish river had the best ones. Green Island. Used to be just green when we used to go for crabs. Everything is changing. Everything disappeared with the sewage pipe. Piper's point everything disappeared, the kelp, they're back now. Now they got a treatment plant.	Fish farms nearby; old sewage treatment plant
		Green Island	*typica* & *Z. japonica (?)*	Small. Epiphytes and seaweed growing on it. Not desirable to eat.		Fish farms nearby; old sewage treatment plant
		Alert Bay	*typica* & *Z. japonica*	At the end of the beach in front of the village there was quite a bit of small eelgrass that was completely dry; possibly *Z. japonica*. At the water there was larger eelgrass (var: *typica*). Collected it by hand.		Fish farms nearby; old sewage treatment plant; village

Table 0.1 Continued. Description of eelgrass harvested at locations throughout study with Consultants' comments on specimens.

Location (date)	Consultant	Site	*Z. marina* variant	Description	Sample comments	Possible pollution Source?
Hanson Island (May 30, 2006)	Adam Dick, Norman Stauffer	Double Bay	NONE	The bay looks ideal for eelgrass: sandy, shallow slope, a small stream entered the bays. 5 dungeness crabs scuttled about a few old tires and rotting logs. But NO EELGRASS! Used to be a log boom here, about 20 years ago (NS); AD and SB didn't remember this log boom; its time there must have been brief.	Norman, Donna, Crow, Barry remember lots of eelgrass there, because they'd catch crabs in the grass. Now there's nothing. Barry had been here about 5-6 years ago, and there'd been plenty of eelgrass.	Log boom
Fort Rupert (May 31, 2006)	Alfred Hunt, Gloria Hunt, Adam Dick, Sarah Sampare	Beach in front of village	*phillipsi, and or typica*	Evenly spaced eelgrass; rhizomes very interconnected, and very brittle. Not quite right for eating-- blades wide but rhizomes small.	SS: They were way bigger than that; those are babies!	Rupert Village
Tofino (May 31, 2006)	Gisele Martin	Opitsaht sand bar	*?*	Got good rhizomes; ate lots, very tasty; they had a "sugar high" afterwards.	GS: We got a huge sugar rush, we just laid on the beach, we all had a great big sugar buzz and were all tired and hungry. It was a huge sugar rush! We could tell the kids that they can't bring candy but they can eat the sugar root!	Tofino, Opitsaht, but fast current.
		Behind Opitsaht village	?	Stinky, rotten.	GS: The next time I went canoeing I dug some up but it was terrible! It was behind Opitsaht but it was where there was no current. It was where it was really stinky, you know the smell of mud flats. …it was really gross. It was like a rotten root. If you could take the essence of mud flat and put it into a root, that's what it was like. …now I know, don't get the dark ones. Darker brown ones were sweeter than the white ones, but these ones were way darker. Too dark.	The dump is not far from behind the Opitsaht village. Also sewage from Tofino and Opitsaht (gets stuck in inlets)