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CORRECTION

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The article Kwakwaka'wakw "Clam Gardens", written by Douglas Deur, Adam Dick, Kim Recalma-Clutesi, Nancy J. Turner, was originally published Online First without Open Access. After publication in volume 43, issue 2, page 201–212 the author decided to opt for Open Choice and to make the article an Open Access publication. Therefore, the copyright of the article has been changed to © The Author(s) 2015 and the article is forthwith distributed under the terms of the Creative Commons Attribution 4.0 International License (http://creativecommons.org/licenses/by/4.0/), which permits use, duplication, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made.

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Kwakwaka'wakw "Clam Gardens"

Motive and Agency in Traditional Northwest Coast Mariculture

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Abstract The indigenous peoples of the Northwest Coast of North America actively managed natural resources in diverse ways to enhance their productivity and proximity. Among those practices that have escaped the attention of anthropologists until recently is the traditional management of intertidal clam beds, which Northwest Coast peoples have enhanced through techniques such as selective harvests, the removal of shells and other debris, and the mechanical aeration of the soil matrix. In some cases, harvesters also removed stones or even created stone revetments that served to laterally expand sediments suitable for clam production into previously unusable portions of the tidal zone. This article presents the only account of these activities, their motivations, and their outcomes, based on the first-hand knowledge of a traditional practitioner, Kwakwaka'wakw Clan Chief *Kwaxistalla* Adam Dick, trained in these techniques by elders raised in the nineteenth century when clam "gardening" was still widely practiced.

Keywords Clam gardens · Mariculture · Traditional ecological knowledge · Northwest Coast · Kwakwaka'wakw · Clan Chief Kwaxistalla Adam Dick

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Introduction

Archaeologists, anthropologists and other researchers increasingly recognize that the indigenous peoples of the Northwest Coast of North America actively managed clam beds well before European contact, often generating features termed "clam gardens." These anthropogenic ecosystems represent a single element within an entire suite of managed habitats and Indigenous resource management systems in this region (M. K. Anderson 2009; Berkes 2012; Blackburn and Anderson 1993; Boyd 1999; Hunn *et al.* 2003; Lepofsky and Lertzman 2008; Lepofsky and Caldwell 2013; Lepofsky *et al.* 2015; Minnis and Elisens 2000; Turner and Berkes 2006; Turner *et al.* 2009a, b). Over the last 15 years, assessments of previously overlooked practices of plant cultivation (Boyd 1999; Deur 1999, 2000, 2002; Deur and Turner 2005; Lepofsky and Lertzman 2008; Thornton 1999; Turner 1999, 2005; Turner and Clifton 2006; Turner and Peacock 2005; Turner and Wilson 2008), and management of fish resources (Butler and Campbell 2004; Haggan *et al.* 2006; Langdon 2006; Menzies 2006; Thornton *et al.* 2010) have expanded nearly monolithic representations of Northwest Coast aboriginal peoples as "Hunter-Gatherers" towards an understanding of these peoples as active resource managers and cultivators (Deur and Turner 2005).[1]

Within the context of this broader reassessment of Northwest Coast resource management traditions, researchers have recently turned their attention to the human role in the enhancement of clam beds or "clam gardens" in coastal British Columbia. These clam gardens were constructed

[1] In fairness, these revisionary statements on Northwest Coast resource management have roots in an earlier literature that called for a broad revision of the "Hunter-Gatherer" hypothesis in the region. See especially the papers in Williams and Hunn (1982).

and developed in clam-producing areas along the coast to extend and augment clam habitat, effectively concentrating abundant and predictable shellfish resources in readily accessible locations, proximate to villages and within the territorial jurisdiction of aboriginal resource managers. Although the archaeological features associated with these "gardens" have been the focus of a small number of published accounts (Harper *et al.* 1995, 2005; Williams 2006), the presented paper is the first detailed ethnographic account of these practices anywhere on the Northwest Coast An emerging literature, much still unpublished, addresses the integration of ethnographic data more meaningfully into the analysis of archaeological features associated with clam gardens (Caldwell *et al.* 2012; Caldwell 2013; Lepofsky and Caldwell 2013; Lepofsky *et al.* 2015; Jackley *et al.* 2015). Practices relating to clam gardens have been mentioned parenthetically in some larger anthropological accounts, but with little elaboration on their genesis, functions, or the dietary and economic significance of the shellfish harvested from them (Bouchard and Kennedy 1990; Carpenter *et al.* 2000; Deur 2000; Ellis and Swan 1981; Ellis and Wilson 1981; Haggan *et al.* 2004).[2] This paper expands this discussion, utilizing previously unreported ethnographic information regarding traditional management as well as traditional ecological knowledge of invertebrates and their habitats.[3]

In spite of the paucity of ethnographic accounts of clam gardening practices, most recent publications are the result of collaboration among cultural anthropologists, archaeologists, and a primary source consultant with first-hand experience in the management and use of clam gardens, Clan Chief Adam Dick, *Kwaxsistalla. Kwaxsistalla*, Clan Chief of *Qawadiliqalla* (Wolf Clan) within the Tsawataineuk (*Dˀawada7enuxʷ*) tribe of the Kwakwaka'wakw ("Kwakiutl") Nation is the principal source for the data on which this article is based and has also provided important contributions to the larger literature regarding clam gardens. He is one of the few individuals – to the best of our knowledge the only one still living – who was given training during the twentieth century in the motives and mechanisms for clam garden management by family members who were present when these gardens were still actively used and managed by a broad segment of Kwakwaka'wakw society (see below). As the principal aboriginal knowledge-holder, *Kwaxsistalla* is included as co-author – an appropriate mechanism for acknowledging his fundamental contributions to the research presented here. The evidence he has provided, increasingly supported by the growing corpus of archaeological data, suggests that several clam species were a key resource contributing substantively to the stability and food security of Kwakwaka'wakw communities (Moss 1993). As his accounts verify, clam gardens were clearly anthropogenic features, distinct from natural clam beds, constructed to provide a productive and predictable food resource (Caldwell *et al.* 2012; Groesbeck *et al.* 2014).

The goals of this paper are fourfold: 1) to correct the under-reporting of the importance of clams in the subsistence technologies and seasonal rounds of Kwakwaka'wakw; 2) to highlight the value of a traditionally trained primary source consultant in solving an enduring mystery and correcting an ethnographic oversight; 3) to demonstrate that trained and designated aboriginal resource stewards were participating in the active management of shellfish habitats to achieve specific anticipated dietary and ecological outcomes; and 4) to help situate clam gardens and their associated activities within the larger context of a traditional resource management ethnoecological complex, in which management of an entire range of resources and landscapes is guided by belief systems and social institutions developed over generations – "since the beginning of time," for the Kwakwaka'wakw and other Northwest Coast peoples.

The clam gardens are known in Kwak'wala, the language of the Kwakwaka'wakw, as *loxiwey*, "to roll" a term relating to rolling of rocks out of clam beds and into the lower intertidal zone, a primary activity in their creation and maintenance. We refer to them by this term here.[4] Unless otherwise stated, any quotations and information pertaining to *loxiwey* are from Clan Chief Adam Dick, *Kwaxsistalla*, reflecting his first-hand knowledge and experience. Unless indicated otherwise all aboriginal terms are in Kwak'wala as provided by *Kwaxsistalla*, with orthography reviewed by his close relative,

[2] Curiously, this literature also focused on the use of these features to enhance a single species, the butter clam, though oral histories allude to no fewer than four species being enhanced in clam gardens.

[3] Within Native American and Native Canadian communities of the Northwest Coast, some degree of oral tradition regarding these practices and associated archaeological features has persisted into the present day. Moreover, clam garden practices and features have been referenced briefly in various academic accounts of the region over the last three decades (e.g., Bouchard and Kennedy 1990; Deur 2000). Recent attention has followed the work of geomorphologist, John Harper who identified a number of rock features along the B.C. coast that could not be explained by conventional archaeological interpretations, but seemed to suggest aboriginal management of clam beds (Harper et al. 1995). Seeking Native knowledge holders with an understanding of their origins, he was eventually directed to Chief Adam Dick, who elaborated considerably on the origins and functions of these features. These exchanges and their outcomes were widely publicized as a moment of "rediscovery" in later, popular treatments such as Williams (2006) and Woods and Woods (2005), and certain academic accounts such as Harper et al. (2005) and Caldwell et al. (2012).

[4] This spelling is being used as a conventional Anglicization. Randy Bouchard (pers. comm. to authors, 2003) notes that in the International Phonetic Alphabet the term would be rendered as lúXwxiwey, meaning "rolled rocks forming a wall." The term is an etymological derivative of the Kwakwala term lúXwa "to roll something round" and closely related to the term, lúXw kw "rolled rocks to clear area."

Kwakwaka'wakw historian and language specialist, Dr. Daisy Sewid-Smith, *Mayanilth*.

Loxiwey: The Clam Gardens of the Kwakwaka'wakw

The significance of clams as a food source for generations of Kwakwaka'wakw and other Northwest Coast peoples is generally under-recognized within classic anthropological accounts, with an admittedly justified focus on salmon as a dominant source of nutrition (Deur 1999; Moss 1993). Yet, the evidence suggests that clams were also a key and complementary resource, contributing significantly to the stability and food security of Kwakwaka'wakw and other coastal communities even from earliest times. Although changes in relative sea levels and coastlines in the region since the Pleistocene have confounded the archaeological record, places such as Namu in Heiltsuk Territory on the Central Coast, which show virtually continuous occupancy over nearly 10,000 years or more, are evidence of peoples' enduring reliance on clams and other shellfish (Blukis Onat 2002; Cannon *et al.* 2008; Haggan *et al.* 2006).

Although the Kwakiutl may not have been the originators of the practice, at some point ancestors of the Kwakwaka'wakw and their relatives and neighbors began to intensify clam production. They learned, possibly in the course of routine clam bed harvests, that existing clam habitats could be improved by clearing away large stones to increase the sandy area available to clams, and that beaches could be widened and leveled to create more space suitable for clam production. This beach expansion was carried out within the narrow zone in which clams were found in natural conditions and where there were demonstrable potentials for their survival (Groesbeck *et al.* 2014). Oral tradition suggests that clam harvesters also observed that clams actually grow better when their substrate is disturbed from time to time, and when dense populations of clams are thinned out leaving more space for the smaller ones to grow with less competition (see). Clams continued regenerate as long as the clams were harvested at a rate that did not exceed their reproductive capacity and at a time of the year when their ability to reproduce was not impaired, as long as younger clams were left intact or returned to the beds, and as long as the clam beds were kept clean and maintained. Thus, the clam gardens are clearly anthropogenic features, constructed intentionally to provide a productive and predictable food resource. Despite the fact that they are broadly distributed along the Northwest Coast generally, and especially within Kwakwaka'wakw territories situated within the Broughton Archipelago and adjacent islands in the interior waters between Vancouver Island and the mainland coast – the focus of the current study (Caldwell *et al.* 2012; Harper *et al.* 2005) - they were scarcely noticed until recently by archaeologists (Woods and Woods 2005).

The Context of Knowledge: Kwaxsistalla's Training in Clam Garden Use and Management

In the early 1930s when he was a child, *Kwaxsistalla's* [5]parents, who both held distinct and prominent Clan Chief titles, hid him from the police who came to take the children of the remote mainland village of Kingcome Village, B.C., away to residential school. Prophetic dreams within the Kwakwaka'wakw community led many to accept *Kwaxsistalla* as the future standard bearer of their chiefly protocols in a predicted future time when colonial cultural prosecutions would cease. His sequestration and cultural training started at the age of three or four and took place at both Kingcome and at Deep Harbour, *Kuk*^{w}*aqwisnux*^{w} (literally 'rocks standing vertical'), on a tiny island in the Broughton Archipelago between the northeast coast of Vancouver Island and the British Columbia mainland. For most of his youth, *Kwaxsistalla* resided at *Kuk*^{w}*aqwisnux*^{w} for months at a time, primarily with his father's parents. He routinely helped his grandparents with their seasonal food collecting, an important part of his education. After they had caught and smoked their annual supply of salmon at their smokehouse up the Kingcome River, *Kwaxsistalla*'s grandparents took him to a small cabin at *Kuk*^{w}*aqwisnux*^{w} for the rest of the fall and winter. From his grandparents and various clan leaders, *Kwaxsistalla* received uncommonly intense instruction in all aspects of food harvesting and management, as well as being taught thousands of songs and stories relating to Kwakwaka'wakw knowledge and practices that were viewed as essential to his future ascendancy to pivotal Clan Chief status. Thus, although he did not learn to read or write (and only learned to speak English later in life) his childhood education and experiences were rich and unique. Later, as a practicing Clan Chief, potlatch director, and commercial fisherman, he built on his knowledge and the legacy of his traditional teachers and became himself an educator, not only of Kwakwaka'wakw but of many academic researchers (e.g., Cullis-Suzuki 2007; Deur 2000; Deur and Turner 2005; Deveau 2011; Lloyd 2011; Recalma-Clutesi *et al.* 2007; Woods and Woods 2005). Though his knowledge has not been presented in detail prior to this article, he has served as a principal consultant to most researchers investigating clam gardens in the small and recent literature on clam gardens.

Kwaxsistalla learned how to build and maintain clam gardens, how to harvest clams and cockles and how to take care of the ancient *loxiwey* at *Kuk*^{w}*aqwisnux*^{w} by rolling the large, basketball-sized rocks from the middle of the beach down to the low tide line, churning and aerating the soil with digging

[5] The "clam gardens" are known in Kwak'wala, the language of the Kwakwaka'wakw, as *loxiwey*, "to roll" a term relating to rolling of rocks out of clam beds and into the lower intertidal zone, a primary activity in their creation and maintenance.

sticks, selectively harvesting clams, and removing obstructions such as rocks and old shells. In addition to maintaining existing ancestral *loxiwey*, *Kwaxsistalla* was taught to build a new clam garden. As opportunity has permitted, he has visited *Kuk*^{w}*aqwisnux*^{w} as an adult and dug clams, even though the beach has not been routinely maintained as it was in the past. The *loxiwey* he built as a child is still visible.

Clams in Kwakwaka'wakw Subsistence and Culture

The Kwakwaka'wakw traditionally harvested four species of clams within the Broughton Archipelago and nearby islands: *gulgulum* (littleneck clam, *Protothaca staminea*), *matani* (horse or "gaper" clam, *Tresus nuttallii*), *gawiganux* (butter clam, *Saxidomus giganteus*), and *joli* (cockle, *Clinocardium nuttallii*). These species exhibit minor variations in habitat preference (Table 1; Kozloff 1983; Quayle 1978).

The Kwakwaka'wakw dug clams by inserting a yew-wood digging stick (*kellakw*) into the sandy, gravelly substrate and wiggling it back and forth to loosen the sediments before prying up a chunk of the sediments with its embedded clams. Oral tradition suggests that this activity, called *gwalis peten* ('to wiggle a digging stick to loosen sediment while clamming'), is necessary to the ongoing success of clam production. Loose sediments allowed the clams to be more easily brought to the surface and allowed the sediments to be readily worked using traditional tools; this also aerates the substrate, which would have encouraged the growth of the clams. Intentional churning and aerating of the sediment matrix focused principally on those areas where clams were apparent below the surface. Harvesters were trained to proceed gradually and broadly around the clam beds as they dug, to minimize localized overharvesting The clams were placed into a sturdy open work basket (*lexey*) which, when full, was carried down to the water's edge and swished through the clean water to remove any sand and mud from the clams. Butter clams and cockles, both similar in size, were generally harvested and prepared together.

Often, Kwakwaka'wakw families cooked clams by steaming them. This commonly involved constructing a fire on the beach within a temporary structure of logs to encircle the fire and hold in the clams. Cooking stones were placed inside this form and a fire built atop of them. When the stones were sufficiently hot any unburned wood and the remaining coals and ash would be removed and the clams were poured from the baskets directly onto the hot rocks (Boas 1921). For a small family, such as *Kwaxsistalla* and his grandparents, only a small number of clams, perhaps two or three baskets full, would be cooked at a time. For larger groups, the number of rocks, the fire, and the number of clams cooked would be proportionally larger. Hemlock boughs (*Tsuga heterophylla*), salal branches (*Gaultheria shallon*), or blades of bull kelp (*Nereocystis luetkeana*) were commonly placed on top of the clams to trap the heat and steam, but other plant materials were also sometimes used ("anything that keeps the steam in"), and a covering of a cedarbark mat (*Thuja plicata*) or other material might be placed over the clams. A modest amount of water might be added as well, although *Kwaxsistalla* noted that the clams are so moist they create their own steam in this process. When the clams were sufficiently cooked, their shells opened. This cooking method is called *qyu'ista*. Occasionally, people boiled or steamed clams in bentwood cedar boxes, using heated stones added to the water in the box – a practice called *nek'iya*. Clams could also be roasted directly over the coals of a fire – a practice called *tsisa*. The cooked clams were either eaten immediately or further processed and preserved for storage and trade. Shells were discarded close to processing sites, aggregating over time into the middens that are characteristic of this coastline and are of considerable depth proximate to documented clam garden sites.

Table 1 The four major Clam species of the *loxiwey*

Kwak'wala name	English name (Scientific name)	Description	Habitat
gulgulum	littleneck clam, (*Protothaca staminea*)	Relatively small clams, 4–6 cm across, white to tan shells, often with brownish markings; shallow radiating and concentric ridges across the outer shell	Mid- to upper sub-tidal and intertidal zone, burrows up to 8 cm deep in gravel mixed with coarse sand or mud and broken shell
matani	horse or "gaper" clam (*Tresus nuttallii*)	Large ovate-elongate chalky white or yellow shell with truncate end, up to 20 cm long, with dark brown or black covering especially around the edges	Middle and low intertidal and subtidal to 30 m deep, protected bays and foreshore; buried up to 1 m deep, in mud and sand of protected bays and foreshore
gawiganux	butter clam (*Saxidomus giganteus*)	Shell white to slate grey, up to 15 cm long, large, black external hinge ligament, well-developed concentric ridges but no radial ridges	Intertidal and subtidal up to 40 m deep; buried to 25–35 cm, in mud, sand and gravel substrate
joli	cockle (*Clinocardium nuttallii*)	Thick, light tan shells, up to 14 cm aross, with distinctive radial ribs; prominent large, pointed "foot"	Mostly low intertidal and subtidal up to 30 m deep; occupies surface, barely buried by sediments, in muddy fine sand

A common method of preserving clams for winter use or trade was to smoke-dry them. The clams were steam-cooked in the usual way, then removed from their shells and skewered on a cedar stick, and the flesh inserted around two parallel sticks in a "figure 8." Several clams were skewered together on a set of these sticks, all with their adductor muscle "buttons" on one side. The skewers full of clams were then commonly placed near fires or – if quantities were sufficient – hung from the rafters of smokehouses until they were thoroughly smoked, then stored away until needed.

Cockles and littleneck clams, especially the former, were sometimes cracked open and eaten raw, often right on the beach, a practice known as *t'pa*. In general, all parts of the clams except the black tip of the siphon were eaten. Each part has its own flavor and texture; the "button" or muscles are firm and chewy, the exterior mantle edge parts somewhat elastic, and the plump centre part soft and tender. For the horse clam, however, typically only the long siphon was eaten, due to the unpalatability of the remainder of the clam. This contemporary information matches earlier literatures addressing aboriginal use of clam resources (cf. Boas 1921; Ellis and Swan 1981; Ellis and Wilson 1981).

Despite some variability by species and provenience, clams are nutritious, being significant sources of protein, Omega-3 fatty acids, Vitamin B-12 and a wide spectrum of essential minerals such as iron, selenium, copper, potassium, and phosphorus. This has ostensibly contributed to their significance both within the dietary repertoires of Kwakwaka'wakw communities and as a risk-reducing food of importance during temporary declines in salmon procurement (Turner *et al.* 2009a, b; Table 2) (see below).

The Kwakwaka'wakw traditionally gathered clams only in the winter months. This was said to be done to avoid the widespread threat of harmful algal blooms (such as paralytic shellfish poisoning, known as PSP or "red tide") – the rapid increases in waterborne algae that are ingested by the shellfish, making them temporarily toxic to humans – and because clams are considered to be at their prime edible stage then (Jamieson 1986). Clams could be gathered as early as October and as late as the end of February or early March though it is possible that dates may have varied among locations historically. After this season, the Kwakwaka'wakw had to avoid clams. If clams are unsafe due to red tide, their flesh is said to have a greenish cast. *Kwaxsistalla* cautioned, "When that clam is turning green a little bit we don't eat them anymore [because this indicates potential algal contamination]…. they told me as soon as the herring spawns, leave the shellfish alone!"

As well as the edible flesh of the clams, their shells had diverse uses within the traditional toolkit of the Kwakwaka'wakw. For example, *Kwaxsistalla* reports that his grandmother used clam shells to scrape beaver hides. In recent times, Kwakwaka'wakw people sometimes crushed the shells and used them in their gardens. Especially the large horse clam shells could be used as containers for collecting tree pitch from Sitka spruce (*Picea sitchensis*) and other types of coniferous trees, which was used as medicine, glue and waterproofing for baskets and canoes. Clam shells were used for a variety of other purposes, such as containers for food and oil, ladles, and ornaments.

Table 2 Nutrient composition of Northwest Coast Clams

Nutrients (per 100 g edible portion)	Clams, raw	Clams, boiled, steamed
Moisture	81.8 g	63.6 g
Energy	71 kcal/ 297 kj	101 kcal/422 kj
Protein	12.8 g	15.6 g
Fat	1 g	2 g
Carbohydrate	2.6 g	5.1 g
Fibre	0 g	0 g
Ash	1.9 g	3.7 g
SAFA	0.094 g	0.19 g
MUFA	0.08 g	0.17 g
PUFA	0.28 g	0.55 g
Retinol	90 μg	171 μg
B Carotene	0 μg	0 μg
Vitamin A	90 RE μg	171 RE μg
Vitamin A	90 RAE μg	171 RAE μg
Thiamine	0.08 mg	0.15 mg
Riboflavin	0.213 mg	0.43 mg
Niacin (NE)	4.2 mg	8.1 mg
Folic acid (DFE)	16 μg	29 μg
Vitamin B_{12}	49.4 μg	99 μg
Zinc	1.37 mg	2.73 mg
Iron	14 mg	23 mg
Calcium	46 mg	92 mg
Phosphorus	169 mg	338 mg
Sodium	56 mg	112 mg
Magnesium	9 mg	18 mg
Copper	344 μg	690 μg
Manganese	0.5 mg	1 mg
Selenium	24.3 μg	64 μg

Species not indicated; variability is expected across different clam species, at different times of year, and across differing environmental conditions. (From Turner *et al.* 2009a:36–37)

The Structure and Cultural Context of The *Loxiwey*

The Kwakwaka'wakw recognized two general categories of clam beds: those that occurred naturally (*ixstawis*), and those that were anthropogenic (*loxiwey*), the latter being central to Kwakwaka'wakw subsistence. In contrast, *ixstawis* were sought out relatively infrequently and opportunistically, such as when people were traveling. As *Kwaxistalla* explains, "You can look for a nice *ixstawis* [clam bed], where you can dig clams, where you can *tsixa* [dig] a *tsixlamis* [natural clam bed,

being dug], when you're traveling." The *lokiwey*, by contrast, were readily identified by their rock structures in terrace-like configurations along the lower tideline, their relatively clear beaches, as well as by the extraordinarily high density of clams.

The *loxiwey*'s defining characteristic is that they were actively monitored and maintained over generations. Their ownership by a clan or lineage was recognized; not only the harvesting and distribution of the clams, but also the traditional maintenance of the *loxiwey* itself was under the authority of the *Ugwamay*, or Clan Chiefs and their designates (a point critical to understanding why *Kwaxistalla's* childhood training involved so much instruction on the matter of *loxiwey* maintenance (cf. Turner *et al.* 2005). Foremost among the tending practices was the relocation of any large, movable rocks from the main beach area to the zone along or just above the low-tide line. (Accordingly, to the extent that these features are reported in the works of Boas (1948, 1906), they tend to serve as markers of this position within the tidal column.) As the term *lokiwey* implies, the clam gardens are understood to be a cumulative outcome of this process:

> "clam beds from which rocks have been rolled." As *Kwaxsistalla* notes, "that's why you call it *lokiwey*, because you roll those rocks!" Today, linear features, sometimes containing thousands of rocks rolled in this manner, are still visible by the around intact *lokiwey.*

Clams and *lokiwey* are featured in a number of Kwakwaka'wakw cultural performances, suggesting their importance even in antiquity. Narratives describe how the first *lokiwey* was created by Mink, a powerful being who established the precedent for a number of cultural activities and subsistence technologies according to Kwakwa'wakw oral tradition. *Kwaxsistalla* also can recount ancient songs and stories in which the *lokiwey* is featured; one such song has a refrain to the effect of "I will go down to the beach and roll the rocks [to help my mother]," sung by young [dog children] wishing to help their human mother by providing her with food. (In this story, other dog siblings sang about hunting and fishing for the mother – both songs suggest the traditionally important role of women in the shellfish harvest (Moss 1993).) In *Kwaxsistalla*'s words, Kwakwaka'wakw oral tradition indicates "People have been doing this, building their *lokiwey*, since the beginning of time. There are some maybe 2,000 years old on the coast," which is said to explain, in part, why these managed environments appear in songs and oral traditions associated with the distant time of spirit beings before the advent of modern humanity.[6]

[6] Another song and story cycle conveyed by *Kwaxsistalla* mentions the pronounced appetite for these clams by *Tsunaqwa*, a wild being of the forest (Woods and Woods 2005). Stories of this being are found up and down the coast, sometimes in association with clams and other natural resources.

In the cosmology of the Kwakwaka'wakw and other indigenous peoples of the Northwest Coast, clams have been regarded as having families and societies equivalent to those of humans, and with their own abilities and needs. As *Kwaxsistalla* expressed it, "We had the same voice at the beginning of time – all the animals, the people." Thus, humans maintained and enhanced the habitats of culturally-preferred species, influenced not only by general knowledge of the species and ecosystems, but guided by notions of reciprocity and responsibility to the species on which they depended. Clams were like their own relatives in a different form; Kwakwaka'wakw harvesters were motivated to ensure that clams were able to thrive and have their needs met; if this was done consistently, it was understood that clams would continue to support the interests and needs of humans by presenting themselves more abundantly for harvest (Turner 2005; Turner and Berkes 2006). These factors provided powerful incentives for clam resource intensification – informed by caloric considerations, certainly – but refracted through a particular worldview that mediated Kwakwaka'wakw understandings and responses to environmental causes and effects.

Furthermore, the clams harvested and processed from the *loxiwey* served not only as a regular food and as a survival food, but also as a valued trade product. Clams obtained from these cultivated beds and dried could be exchanged to procure other desired resources such as herring eggs, eulachon grease, berries, and root vegetables - contributing in diverse ways to the economic and social capital of Kwakwaka'wakw communities.

The Mechanics of Clam Gardening

It is reasonable to hypothesize that, consistent with Kwakwaka'wakw oral tradition, the construction of the *lokiwey* served to expand the total numbers and enhance the size and productivity of clams along the coast (Groesbeck *et al.* 2014; Harper *et al.* 1995; Jackley *et al.* 2015). Relying on natural processes and species already existing in situ in the intertidal zone, using careful observation and monitoring, and guided by cultural beliefs, the creators of the *lokiwey* produced environments that replicated "ideal" natural clam beds, positioned at optimum elevations within the intertidal zone, with sandy and well-aerated sediment.

In terms of the physical design of the *loxiwey*, the general pattern is for a substantial bulwark of rocks to be built up towards the low-tide line around and across a small bay or cove. On the ocean side the sea floor drops off dramatically. On the landward side, the deposition of sand and gravel forms a terrace with the surface flat or very gently sloping towards the upper beach. This creates a relatively wide area of open beach that is submerged at high tide and exposed at low tide. Their intertidal provenience provides for moisture and thermal regulation of clams, but also facilitates suspension feeding:

when the tide is up, they thrust their double-tubed siphons up through a hole in the sand, drawing in water and filtering out phytoplankton, zooplankton and other organic material. Human modified clam gardens allowed for a shallow, laminar layer of water to accumulate on the accumulated sediments, allowing these functions to continue while also keeping clams in accessibly shallow portions of the tidal column.

The development of the *loxiwey* involved the removal of obstacles both to digging and to clam proliferation. "We roll those big rocks down the beach, get them out of the way so we can dig… you don't do that and you have all those rocks in the way." Winter storms might shift the sands and even the boulders, and uncover more rocks over time, and this is one reason why the *loxiwey* need ongoing maintenance (cf. Caldwell *et al.* 2012). As rocks removed from the surface of the clam beds were placed in large numbers along a zone corresponding to the average lowest low-tide line (*walamox'galis*), over time, sediment accumulates on the upslope portion of these terrace-like rock features, often resulting in the gradual seaward expansion of the harvestable clam beds.

Traditional harvesters also recognized that removing the larger clams and leaving the smaller, juvenile ones allowed more space for growth. On this point *Kwaxsistalla* noted, "You leave the small ones behind." If the small ones were dug up incidentally, they were simply returned to the *loxiwey* with the expectation that they would reoccupy areas where the concurrent removal of larger clams left a fortuitous gap in the sediment matrix.

Kwaxsistalla reports Kwakwaka'wakw oral tradition noting that all clam beaches, including *lokiwey*, where the sediments are being actively dug have higher clam productivity, with higher growth rates and larger clam sizes and presumably faster clam growth rates. The regular turning of the soil results in a rearrangement of the sediment matrix; brief experiments undertaken with *Kwaxistalla's* guidance show that traditional digging and aeration techniques allow the fine clay and silt-sized particles to wash away in successive high tide cycles, leaving sand-size particles in situ disproportionately (a point requiring more systematic attention). The absence of this effect is seen in long-abandoned *lokiwey*, where sediments can become anaerobic. As *Kwaxsistalla* observed, "When we don't dig, the dirt it gets dark; [it] smells bad." Sediment of that type is called *kwen'xlis*. Moreover, clams harvested from such anaerobic conditions were said to be often undesirable, with dark and unpleasant-tasting flesh: a condition called *ya'yeks. Kwaxsistalla* stressed, "They're *ya'yeks*…they're no good; you don't touch it…When you get clams, the first thing you do is break one. If it's dark, it's *ya'yeks*; you don't use it." Clams with this property were historically found on unmanaged beaches, but were also said to appear if maintenance had been lagging or discontinued at a *lokiwey.*

The placement of sediment dug out during the clam harvest appears to be another factor enhancing the productivity of the clam beds. When clams are dug in the *loxiwey*, multiple holes are commonly dug together in clusters, creating expanding, shallowly excavated pools on the surface of the clam flats. The clam diggers do not generally replace all the sediment into these holes. Rather, at the end of the harvest, much of the sand and mud is left stockpiled on the margins of the holes. Rising tidewaters flush medium-sized sediment into the holes, while fine particles are carried away by the tide and coarser sediment, rocks and clamshells remain on the margins. Refilling a recently dug hole was explained to be unnecessary and often counterproductive.

In addition, when any sediment was returned to the vicinity of the holes after the clams were selected, the diggers would remove empty clamshells (*gwen'galis* 'clam shell containing sediment' or *xalis* 'empty clam shell') and broken clamshell pieces (*kabilis*), tossing them aside, as part of the ongoing tending of the beds. This appears to have gradually increased the concentration of fine-grained sediments within the zone of clam habitation and facilitated the removal of subsurface obstacles to clam growth. It also likely served, intentionally or not, to gradually reduce irregularities in the surface of the *loxiwey*, as hummocks were excavated and fine sands were redistributed across the flats, settling in the lowest places (Harper *et al.* 1995; Deur 2005; Williams 2006).

Cumulatively, these outcomes insured that the total area available for clam production was increased: "That's what the *lokiwey* is all about!" Although the *loxiwey* might be cleaned and maintained concurrently with the clam harvests, it is also clear that maintenance and harvesting were conceptualized as two separate activities. Oral traditions suggest that *loxiwey* maintenance was sometimes carried out independently of the harvest, possibly at a different time of year if people were in the area.

The Position of *Loxiwey* Within Kwakwaka'wakw Subsistence, Resource Management and Seasonal Rounds

Clams have been a key element of Kwakwaka'wakw subsistence, travel, and settlement patterns for millennia. As *Kwaxsistalla* often observed: "Wherever you see clam shells, that's where people lived." Harvesting and processing the clams, and tending the *loxiwey* were activities that families and clans included in their seasonal rounds, or seasonal travelling cycles within their territories and sometimes to neighboring areas for visiting and trade. Because clams were a wintertime resource, people relied on them particularly at times when other food might not be available before the start of the growing season, and if stored winter food supplies had been used up or for some reason destroyed. Thus, in addition to their role as a regular and favourite food source, clams – "as predictable as the tides" – were a "fall back" food that could, at times, mean the difference between survival and starvation.

In his childhood, *Kwaxsistalla* and his grandparents lived right beside the *loxiwey* at Deep Harbour, *Kuk*^{w}*aqwisnux*^{w} during the winter so were able to dig clams there at any time between October and March. Kwakwaka'wakw people living up rivers, such as at Kingcome, however, had to rely on their relatives living on the islands and outer coastline to bring them clams, or else had to travel out to the clam beds during the winter and very early spring to harvest clams themselves. Right after the end of the usual clam harvesting period, around late February, people started their seasonal travels to harvest the other food resources and materials they needed for the year. *Kwaxsistalla* recalled, "We keep moving through the season."

The *loxiwey* also served as an enhanced ecosystem for other animals. While people were tending and harvesting their *loxiwey*, they would also harvest other marine foods in the vicinity: barnacles and sea cucumbers, for example. (Sea cucumbers were observed to be particularly abundant among the large rocks that bounded the *loxiwey* at Deep Harbour, *Kuk*^{w}*aqwisnux*^{w}.) Predators, including raccoons, mink, and river otters, also scavenge the *loxiwey* at low tide. Sea ducks and geese sometimes feed at *loxiwey*, churning the sediment while it is still saturated and pliable, in search of small clams, worms, and other invertebrates that might be dislodged. While oral tradition on this point is unclear some of these animals might have been hunted at the *loxiwey* historically, a type of "garden hunting" that would have both protected the clams from excessive predation and provided people with supplemental food. The traditional root gardens were used for hunting in this way, as documented for the Nuxalk of Bella Coola, with the roots sometimes being dug up and left as bait for geese and other game birds (Deur 2000; Edwards 1979; Lloyd 2011).

Anthropogenic Ecosystems, Disintensification, and Revitalization

Essential to their significance, *lokiwey* served to geographically 'fix' an immobile food resource in predictable and larger concentrations, often proximate to major populations and within the territorial control of clans. Indeed, it is possible that villages in close proximity to good clam beds experienced greater food security over time, and grew larger and more enduring as a result. Many *loxiwey* had associated settlements or encampments which served not only to shelter the people digging clams and tending the clam beds, but as temporary outposts supporting a whole range of other activities associated with the seasonal round. A few, however, are found in isolation (Lepofsky *et al.* 2015). Oral tradition, supported by unsystematic observations of *loxiwey* sites along the coast, suggests that other structures such as "canoe skids" are often associated with them, sometimes as part of the same larger rock structures. It may be, too, that the stone fish traps that predominate up and down the coast (Haggan *et al.* 2006; White 2006), that rely on similar rock structures with analogous functions, may have effectively coevolved alongside *loxiwey* as part of a larger suite of intertidal technologies. Chronometric dates have been largely elusive and still pending for many parts of the coast, though the archaeological investigations of clam garden development outside of the Kwakwaka'wakw territory are beginning to suggest the chronology of those areas (Lepofsky *et al.* 2015). Certainly, evidence suggests that the stone fish traps, eelgrass meadows, seaweed harvesting rocks, clam gardens, wooden weirs and traps on the salmon rivers, *t' killakw* root gardens, crabapple "orchards" and key tended berry patches may all be anthropogenic ecosystems within a complex integrated resource management system for the Kwakwaka'wakw and other Northwest Coast Indigenous Peoples (Ames 1991; Deur 1999).

Kwaxsistalla and *Mayanilth* recount oral traditions suggesting that entire clans or villages might return to their clam gardens, or even establish new clam gardens, at times when fish numbers were depressed. At a time known as *wayamgalis* ('no salmon running'), with the realization that the salmon would not return that year, the Clan Chiefs had to make the decision to mobilize their people to the clam gardens, incurring considerable risk and cost, sometimes building new houses and other infrastructure. Oral tradition suggests that people recognized that major environmental disruptions, such as destructive freshets occurring during the spawning season, resulted in the absence of fish for some time (commonly, 4 years for salmon). Similar temporary declines apparently occurred in eulachon numbers, and again, people might rely on the clam gardens to carry them through that year, reducing risk as well as abrupt fluctuations in the economic and social life of the affected communities (cf. Suttles 1987).

The *loxiwey* thus appears to have helped facilitate large and stable populations as reported from the period before the first Europeans arrived. This was especially true of the Broughton Islands and vicinity, which was known throughout the Kwakwaka'wakw realm for its many clam gardens and its large villages; as *Kwaxsistalla* emphasized: "This area was most populated anywhere on the coast…until the smallpox came." Echo Bay on Guilford Island was cited as one such community, its population reported by *Kwaxsistalla* to have been supported in part by the community's proximity to dependable clam gardens (Donald and Mitchell 1975; Moss 1993).

The epidemics and dislocation that arrived on the Northwest Coast in the years following (and preceding) direct contact with European peoples (Boyd 1990) resulted in catastrophic population decline and a concomitant "disintensification" (Brookfield 1972) of many formerly managed resources within Kwakwaka'wakw territory and beyond. Still, during the late nineteenth and early twentieth century, the *loxiwey* were used in ways that allowed Kwakwaka'wakw

communities to persist and adapt to rapidly changing circumstances. In the wake of the agonizing demographic contractions of the nineteenth century, the cumulative demand on clam resources had been in rapid decline and subsistence-based incentives for intensifying clam production would have abated. Moreover, the labor and social mechanisms that were critical to the maintenance of the *loxiwey* were undermined by myriad forms of displacement, including the loss of children to residential schools.

Simultaneously, aboriginal communities sought inroads into emerging cash and barter economies drawing upon traditional skills and resources while sometimes adopting non-Native food products or prioritizing higher-value and higher-prestige traditional food products in the repertoire of retained Native food practices (Lutz 2008). Of key importance for Kwakwaka'wakw leadership in these years was insuring the continuity of social and ceremonial practices in the face of disruptive changes, using traditionally harvested natural resources in ways both old and new. *Kwaxsistalla* notes that by the 1930s, the sale of clams was an important means of achieving the wealth required for maintenance of traditional protocols and prerogatives. The *loxiwey* in the Broughton Islands and vicinity were central to this economic enterprise. *Kwaxistalla* recalls gathering clams at the *loxiwey* with his grandparents for sale to a commercial buyer who passed through the area periodically by boat and man purchased clams from Kwakwaka'wakw families for sale in the Vancouver market. *Kwaxistalla* worked the flats, gathering clams into gunnysacks to be sold for 50 cents a sack for butter clams and 25 cents a sack for the horse clams. The latter were buried shallower and not as highly valued. As a child, *Kwaxistalla* could fill two or three gunnysacks at a time. As before contact, women were critical to this commercial harvest: "when I was quite young, we used to dig clams every winter. You know, when everybody, all the men [were] in the Big House potlatch, and all the women are out digging clams. You know, for 50 cents a [50-lb potato] sack."

Such participation in clam harvesting has been widely reported along the British Columbia coast as one of the first points of aboriginal entry into the wage economy (Lutz 2008; Williams 2006). Thus, while the clam beds were used in a different way in these new economic circumstances, they still served as "risk-reducing" resources, helping to sustain families and traditional cultural practices during challenging times, their precise values fluctuating with the vagaries of markets and resource availability. These traditional resources allowed families to enter into the cash economy, or to maintain their participation after the decline of other more lucrative industries such as fur trapping. Over time, clams persisted as part of an evolving seasonal round and a mixed subsistence and cash economy that was increasingly restructured to accommodate Native participation as wage labor in commercial fishing, logging, and other natural resource industries.

Discussion

In recent years, a bold and wide-ranging revisionist movement has prompted the careful rethinking of the resource management practices of the aboriginal peoples of the Northwest Coast of North America We have come to accept that the peoples of this region had sophisticated and purposive mechanisms for enhancing plots of native roots, berry patches, salmon stocks, and many other key resource types (e.g., Deur and Turner 2005). Clams can now be added to this list. Recent studies have demonstrated that the practices associated with clam bed management demonstrably enhanced localized clam output, and the Northwest Coast abounds in archaeological features associated with these practices (Caldwell *et al.* 2012; Groesbeck *et al.* 2014; Lepofsky and Caldwell 2013). As this paper illustrates, the aboriginal peoples of the Northwest Coast carried out these practices in patterned and intentional ways based on an understanding of environmental causes and effects within the intertidal zone and with the unambiguous goal of enhancing clam bed productivity. The ethnographic, archaeological, and auto-ecological evidence exhibits internal consistencies suggesting that clam "gardening" was indisputably part of the resource management toolkit of aboriginal Northwest Coast peoples and should be factored into future discussions of resource use and management on this coast generally.

The fact that clams were utilized extensively by the aboriginal peoples of the Northwest Coast of North America had never been in dispute. Classic sources demonstrate that these resources were sought out in the course of the seasonal round, and communities often relocated to clam beds as part of their larger seasonal round (e.g., Boas 1921). However, with our access to the rich corpus of Kwakwaka'wakw oral and technological tradition through *Kwaxistalla*, Clan Chief Adam Dick, we can now expand considerably on the ethnographic data regarding traditional clam use. Clams were not only sought out opportunistically, but such methods as stone removal, terracing, selective harvesting, and the regular aeration of the soil matrix allowed the Kwakwaka'wakw and other aboriginal harvesters of the region to enhance the output of clam beds. Such actions placed larger and more predictable concentrations of clams in accessible locations– proximate to large concentrations of human settlement but also within the defined and defensible territories of harvesters' clans and villages. Though clams were certainly an enduring staple in good times, they might be sought out disproportionately in the course of the seasonal round, but oral tradition asserts that they were also used as risk-reducing resources during times of resource scarcity. The large and immobile populations of clams in actively managed beds helped to offset abrupt downturns in the availability of more mobile and variable species. As a technological response to communities' resource demands and resource risk, clam gardening was an elegantly

simple yet critical mechanism of resource enhancement that insured the stability of human communities over the long term. Oral traditions suggest that these functions bolstered social, demographic, and economic stability, and had myriad implications for inter-village rank and relations that deserve further investigation (Donald and Mitchell 1975; Suttles 1987).

Clam gardens and other managed landscapes continued to hold critical roles in Kwakwaka'wakw society in the wake of the riveting changes of the nineteenth and early twentieth centuries, as they sustained families, provided trade items, and served as a venue for the training of children (Turner and Turner 2008). Clams from managed beds that sustained vast villages and offset perturbations in resource availability in the precontact period were revisited and maintained for both commercial harvests and subsistence purposes. These managed clam beds continue to have relevance for aboriginal peoples today as occasional sources of supplementary food, as a symbolically charged locus of cultural significance as they struggle to retain portions of their traditional food practices for reasons both dietary and cultural, and as a window into the traditional technologies, economies, values and knowledge of their ancestors. Through the current research and recent studies of clam gardens in allied subfields cited here, aboriginal peoples also witness a powerful demonstration of the veracity of their oral traditions. Traditional knowledge of clam bed management, nearly lost, has been sustained through the work of *Kwaxistalla*, Clan Chief Adam Dick, and a handful of others who have endeavored to recover what living knowledge of this practice that remains. Long overlooked, and apparently consequential in many domains of aboriginal life, these distinctive subsistence features deserve greater attention through expanded ethnographic and archaeological documentation and the expanded use of test plots to measure the long-term effects of documented traditional management techniques on clam productivity (Groesbeck *et al.* 2014; Jackley *et al.* 2015). Investigations of the spatial and temporal correlation between clam garden distribution and settlement density (and stability) on the Northwest Coast might also require consideration pending additional data on clam garden distribution; oral tradition and informal analysis suggest positive correlations between these phenomena. Archaeological efforts to examine these questions are now underway, aided by the findings of ethnographic studies with knowledgeable elders including *Kwaxistalla*. It is certain that we will soon know much more about clam gardens throughout the region. The clam gardens of the Kwakwaka'wakw may yet hold the potential to teach us more and to sustain aboriginal communities into the future. Northwest Coast peoples were active managers of the landscape, modifying not only particular species but entire habitats with purpose and forethought toward specific ends. This was true of berries, root grounds, and fish runs; now, clearly, we can add the clam beds to the growing list of habitats and species so managed.

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