ANCIENT SHELLFISH MARICULTURE ON THE NORTHWEST COAST OF NORTH AMERICA

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While there is increasing recognition among archaeologists of the extent to which non-agricultural societies have managed their terrestrial ecosystems, the traditional management of marine ecosystems has largely been ignored. In this paper, we bring together Indigenous ecological knowledge, coastal geomorphological observations, and archaeological data to document how Northwest Coast First Nations cultivated clams to maintain and increase productivity. We focus on "clam gardens," walled intertidal terraces constructed to increase bivalve habitat and productivity. Our survey and excavations of clam gardens in four locations in British Columbia provide insights into the ecological and social context, morphology, construction, and first reported ages of these features. These data demonstrate the extent of traditional maricultural systems among coastal First Nations and, coupled with previously collected information on terrestrial management, challenge us to broaden our definition of "forager" as applied to Northwest Coast peoples. This study also highlights the value of combining diverse kinds of knowledge, including archaeological data, to understand the social and ecological contexts of traditional management systems.

Si bien se observa, a partir de la arqueología, un mayor reconocimiento sobre la medida de incursión de las sociedad no-agrícolas en el manejo sus ecosistemas terrestres, el manejo tradicional de los ecosistemas marinos ha sido considerablemente ignorado. En este documento integramos: el conocimiento ecológico Indígena, observaciones geomorfológicas sobre áreas costaneras y datos arqueológicos; con la finalidad de documentar la forma en la cual las Primeras Naciones de la Costa Noroeste cultivaron almejas para mantener e incrementar los niveles de productividad. Nos centramos en el estudio de los "jardines de almejas", los cuales constituyen terrazas amuralladas de la zona intermareal construidos para la ampliación del hábitat y productividad de bivalvos. Nuestra prospección y excavaciones de jardines de almejas en cuatro localidades de la Columbia Británica proporcionan información detallada sobre el contexto ecológico y social, morfología, construcción y las primeras dataciones de estos rasgos. Tales datos exponen la extensión de los sistemas tradicionales de maricultura entre las Primeras Naciones costaneras y junto con la información recopilada previamente sobre el manejo de ecosistemas terrestres, nos plantea el desafío de ampliar nuestra definición de "recolector" tal como se aplica a las poblaciones de la Costa Noroeste. Este estudio pone de manifiesto el valor de combinar diversidad de conocimientos, incluyendo datos arqueológicos, para comprender los contextos sociales y ecológicos de los sistemas de manejo tradicionales.

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Over the past three decades, researchers working with and learning from Indigenous knowledge holders have documented many examples of traditional environmental management among fisher-hunter-gatherers (e.g., Anderson 2005; Berkes 2012; Deur and Turner 2005, ed.; Lightfoot et al. 2013; Williams and Hunn 1980). This research has demonstrated that many non-agricultural societies manipulated their environment to some degree to maintain and/or increase the availability and productivity of desired resources. For some groups, this manipulation was casual, but for others it involved intensive and regular management activities. Indeed, it is precisely because of this continuum of behaviors that anthropologists have long struggled with the hunter-gatherer-agriculturalist classificatory divide (e.g., Ford 1985; Harris 1989; Smith 2001, 2005).

This fuzziness in the extant categories becomes even more apparent when Indigenous management of marine resources and ecosystems is incorporated into social-subsistence classification schemes. For instance, it is well known that the chiefdoms of Hawaii relied on intensive agricultural production that encompassed ecosystems from inland hillsides to the coast (Kirch 1998). This terrestrial cultivation, however, was coupled with an equally intensive system of mariculture, in which large numbers of fish were raised in elite-managed and controlled fresh and saltwater ponds (Costa-Pierce 1987). For Native Hawaiians, like many people of the Pacific, cultivation on land and in the sea formed a physical and conceptual continuum that encompassed ecological knowledge, habitat enhancement, and social, political, and spiritual beliefs and practices (Berkes 2012; Costa-Pierce 1987).

Elsewhere on the social-subsistence spectrum are the socially complex societies of the Northwest Coast of North America, who are typically classified as "foragers" or "complex hunter-gatherers" (e.g., Ames 1994). Decades of research with local First Nations, however, have demonstrated that their traditional subsistence systems, like those of the Native Hawaiian agriculturalists, encompass the management of resources and ecosystems from the sub-alpine to the sub-tidal (e.g., Deur and Turner 2005, ed.; Lepofsky and Lertzman 2008; Turner 2014; Turner et al. 2013). The combined ethnographic and archaeological records indicate that marine management specifically incorporates choices about location, timing, gear size, and catch limits (e.g., Lepofsky and Caldwell 2013; Losey 2010; Moss 2013; White 2011), tenure systems or other cultural proscriptions that limit the amount and timing of harvests (e.g., Drucker 1951; Turner et al. 2005), habitat enhancement (e.g., George 2003; Langdon 2006), and transplanting of finfish to new locations (e.g., Jones 2002; Thornton 2015; Thornton and Kitka 2015; Thornton et al. 2010). These marine management practices are nested within larger social systems that include teachings about ways to behave and oral traditions, rituals, and ceremonies that often promote the well-being of resources and ecosystems (Deur et al. 2014; George 2003; Langdon 2006; Lepofsky and Caldwell 2013; Thornton 2008; Turner 2005, 2014).

Worldwide, much of the research on traditional marine management systems has focused on the management of finfish, with relatively little attention paid to shellfish. The lack of attention on shellfish is striking given that shell middens are among the most common, and certainly the most apparent, coastal archaeological site type in the world. Furthermore, shellfish have been an important source of food and traded items for people for millennia (e.g., Mannino and Thomas 2002; Tabarev 2007) because they are naturally abundant, nutritious, often available for much of the year, easy and safe to harvest, and can be preserved for later consumption.

As several archaeologists have pointed out (e.g., Botkin 1980; Erlandson et al. 2008), the accessibility of many shellfish also makes them vulnerable to overharvesting. Archaeological literature on shellfish is replete with documentation of the effects of overharvesting, evidenced by declining shell abundance and size of targeted/harvested species through time (e.g., Erlandson et al. 2008; Lightfoot et al. 1993; Mannino and Thomas 2002; Swadling 1977), and resource switching to lower ranked shellfish (e.g., Braje et al. 2007; Yesner 1984). While these negative effects on shellfish populations are indisputable, we suggest that there is an equally compelling—but largely ignored—body of knowledge and data on the traditional management of shellfish that should be incorporated into

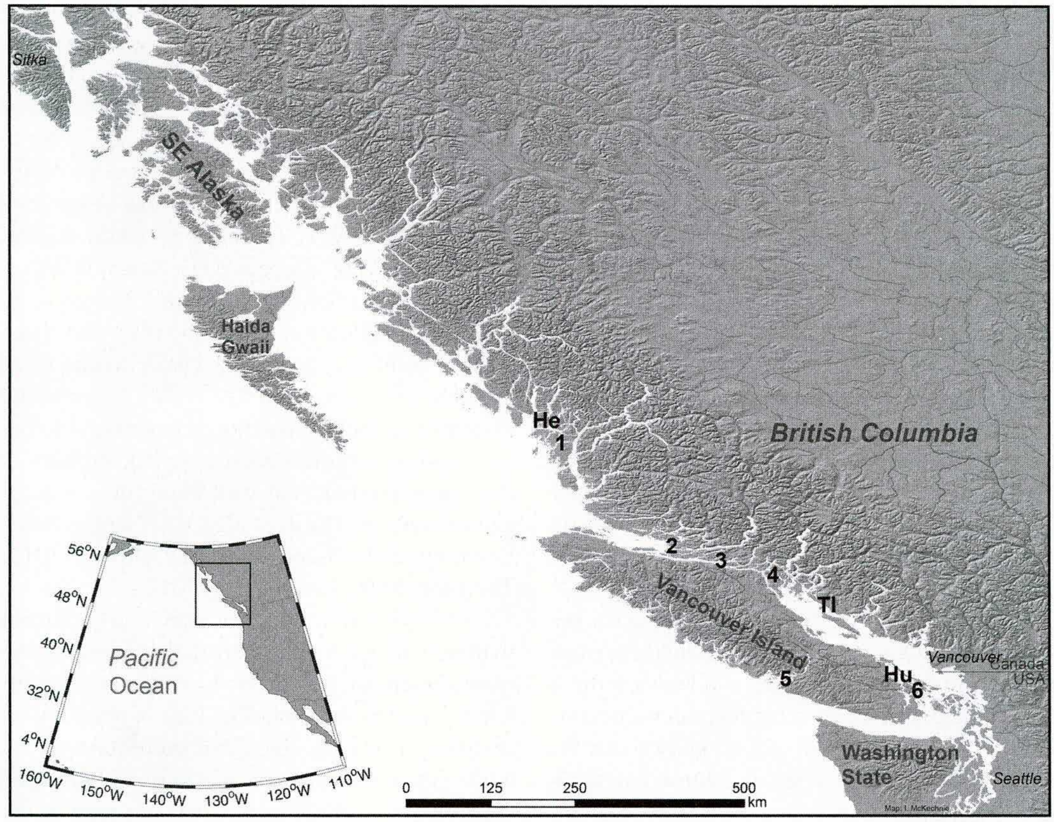

Figure 1. Coastal British Columbia, showing approximate locations of First Nation territories and clam garden sites mentioned in the text: (1) FaTa-77 near Bella Bella; (2) the Broughton Archipelago; (3) Johstone Strait; (4) EbSh-5 and EbSh-13 on Quadra Island; (5) DeSg-10 in Grappler Inlet; and (6) 195IT-E and195IT-W on Russell Island. He = Heiltsuk, Tl = Tla'amin, Hu = Hul'qumi'num First Nations.

discussions of human interactions with marine ecosystems.

In this paper, we summarize what is known about the ancient management of shellfish, as one aspect of the marine management systems of the Northwest Coast people. Our documentation of these practices is based on a review of the literature, systematic surveys of the coast, interviews about traditional clam management and use, and recently collected archaeological data from intertidal management features locally known by many as "clam gardens"[1] (Figures 1–3). These features consist of a rock boulder wall constructed near the zero tide line; this results in a terrace on the landward side of the wall that significantly expands bivalve habitat and productivity through a variety of abiotic and biotic mechanisms (Groesbeck et al. 2014; Harper et al. 1995). Clam gardens on the Northwest Coast, like the fishponds of the Native Hawaiian agriculturalists, are tangible evidence of ancient maricultural practices. Like terrestrial agricultural systems, these practices encompassed the deliberate modification of biotic and abiotic components of marine ecosystems to enhance resource productivity.

Our work is nested within a larger research collective focused on the traditional use and management of bivalves by Northwest Coast peoples (the "Clam Garden Network" www.clamgarden.com). Our collective research sees the study of ancient mariculture as a means not only for understanding regional and local cultural histories, but also for informing discussions about modern management, food security, governance, and cultural reconnection (Augustine and Dearden 2014; Browne and Mildon 2010; Groesbeck et al. 2014; Pinkerton and Silver 2011). The compilation of

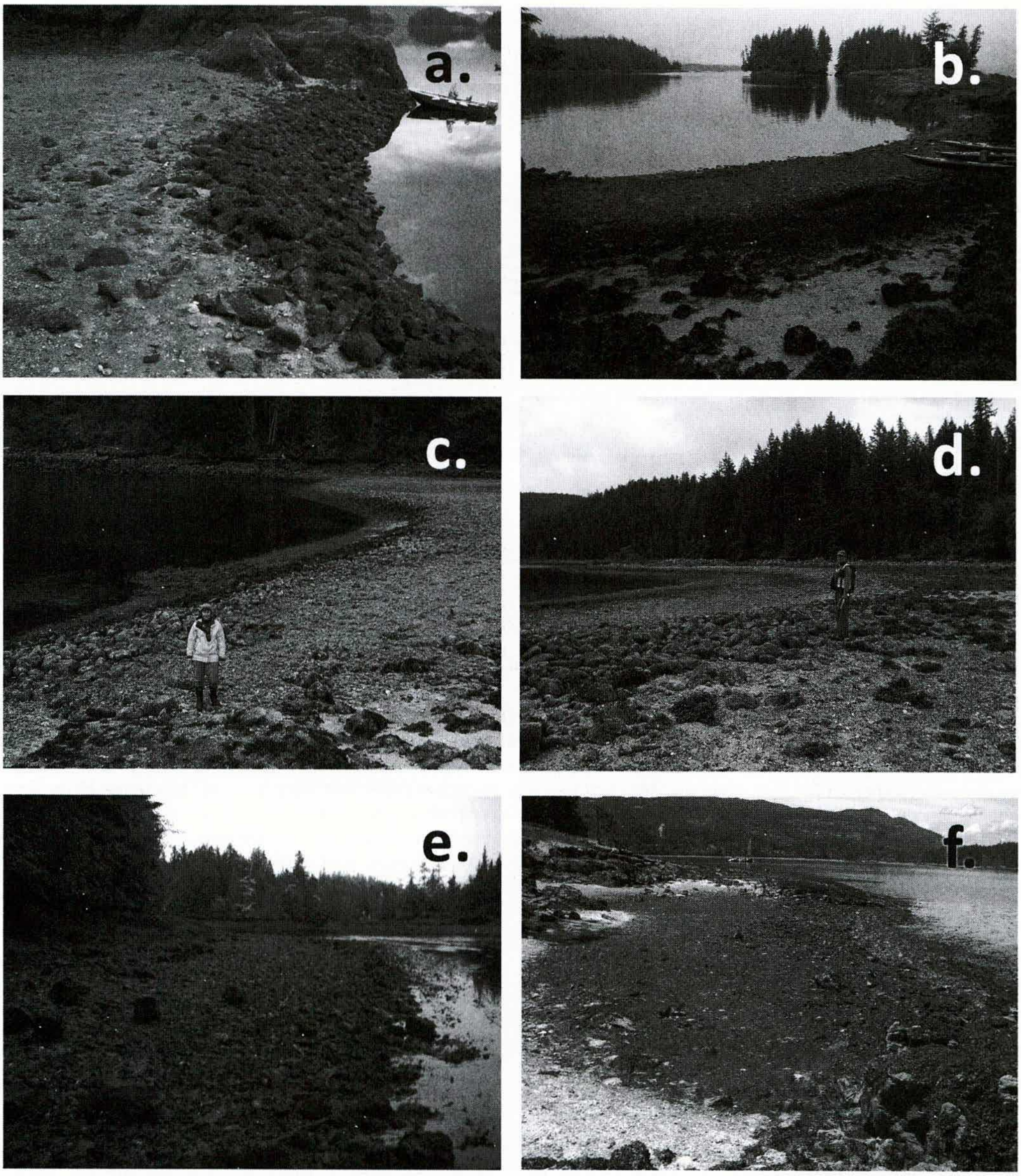

Figure 2. Clam gardens showing variability in form: (a) clam garden in the Broughton Archipelago (EeSp-146), showing rock wall terrace at a .22 m tide. Note the wall composed of similarly sized cobbles and the relatively flat, clear beach landward of the wall. Clam garden sites in British Columbia excavated by the Clam Garden Network team, from North to South: (b) Bella Bella (FaTa-77); (c) Quadra Island (EbSh-13); (d) Quadra Island EbSh-5 (note upper and lower walls; only the upper wall was dated); (e) Grappler Inlet (DeSg-110), west coast of Vancouver Island; (f) Russell Island, Gulf Islands (1951T-W). Note that in (e) and (f) much of the garden wall is submerged and/or obscured by kelp as a result of rising tide or changing sea level, respectively.

information presented here builds on the foundational research of geomorphologist John Harper, marine biologist Mary Morris (Harper 2012; Harper et al. 1995; Harper et al. 2005), and historian and artist Judith Williams (Williams 2006), who turned the region's archaeological attention to the existence of clam gardens. And, of course, it builds on the observations and experiences of the Indigenous knowledge holders of the Northwest Coast, who know that clam gardens and

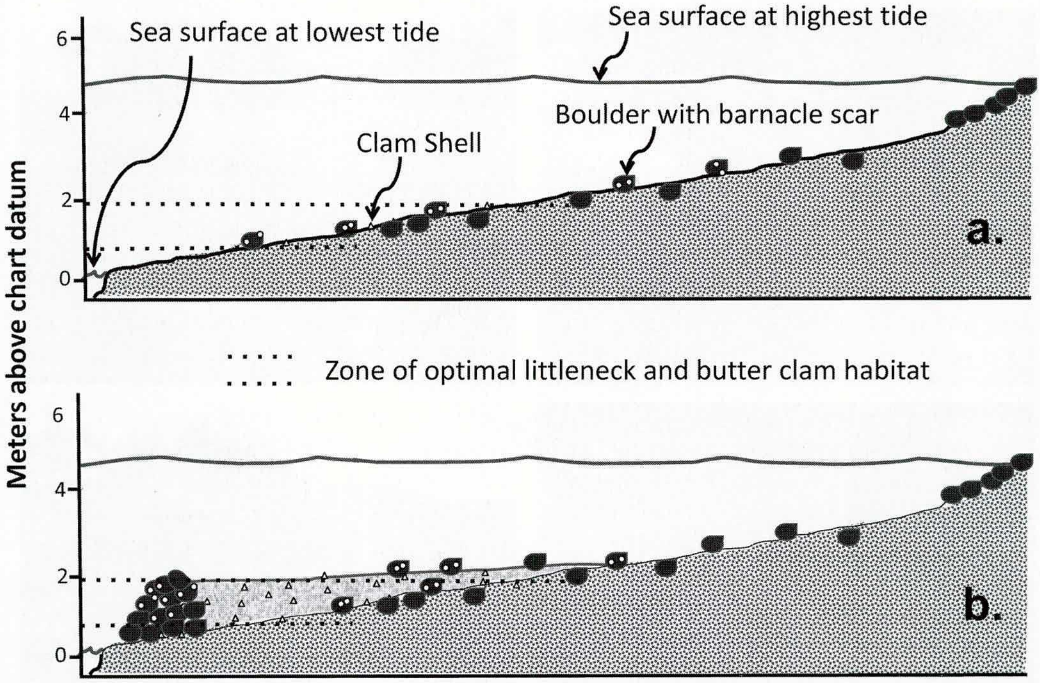

Figure 3. Sequence of clam garden construction, based on Quadra Island sites where falling sea levels exposed base of wall: (a) naturally sloped, unmodified beach (the dramatic drop below 0 m asl is the natural break in slope); (b) infilled clam garden terrace built on the same beach. Some of the rocks used to make the wall had barnacles on them when they were moved to construct the wall. Note that the rock wall was placed on clams that were lying on the surface of the beach. Radiocarbon dating of the barnacles and the trapped clams provides a date for the construction of the terrace wall. Stippled light colored sediment behind the terrace wall indicates the shell hash and coarse sediments that accumulated above the old beach after the terrace wall was built. Note the increase in area of optimal clam habitat by building the wall at a certain tidal height.

other maricultural techniques, and indeed management systems more broadly, have always been a fundamental part of the way that people have interacted with their landscape (Brown and Brown 2009; Deur and Turner 2005, ed.).

In the following sections, we first synthesize the global ethnographic and archaeological evidence for clam management. We then focus on the Northwest Coast, summarizing previous ethnographic evidence and the results of our own interviews with local First Nations. We follow this with a presentation of our archaeological investigations of clam gardens, which provides insights into the ecological and social context, morphology, construction, and age of these features. Collectively, these data demonstrate the extent of shellfish mariculture among coastal First Nations. This compilation also highlights the value of combining diverse kinds of knowledge, including archaeological data, to understand the social and ecological contexts of these systems of knowledge and practice.

Shellfish Management Worldwide

At the global scale, the scant archaeological evidence for shellfish management spans the Holocene and is encompassed within the subsistence systems of agriculturalists and foragers. Practices include moving shellfish to new beds to replenish stocks in Mesolithic Europe (Mannino and Thomas 2002), size selection of clams during the Jomon period (Yamamoto and Iwase 2009), size selection, transplanting, and tending in the Far East during the Neolithic (Rakov and Brodianski 2010; Tabarev 2007), and the creation of water conditions and substrates by the Romans to cultivate oysters (Günther 1897).

Outside of the Northwest Coast, ethnographic evidence for shellfish management is also widespread but sparse. The best evidence comes from a few regions in the South Pacific, Asia, and California, where researchers have a history of working with Indigenous People to record traditional ecological knowledge and to apply this knowledge to modern management (e.g., Blackburn and Anderson 1993; Johannes 1978). Like the management of finfish, shellfish management in these regions includes tenure and other prohibitions on amount or timing of collection (e.g., during spawning and in preparation for festivals; Futter and Moller 2009; Gray and Zann 1985:48; Hickey 2003:118; Johannes 1981; Kato 2006; Smyth 2001), harvest size restrictions (Fraley 2013; Futter and Moller 2009; Johannes 1978:352), habitat enhancement (Futter and Moller 2009), tillage (Baker 1992), and transplanting of shellfish to new locations (Bird et al. 2009; Futter and Moller 2009; Hickey 2002:118). Even less is known about the larger social context in which these management strategies are nested. The extant information, however, illustrates how these behaviors are integrated into systems of respect, teachings about the right way to behave, and deep connections to the spiritual world (Futter and Moller 2009; Kato 2006).

Shellfish Management on the Northwest Coast: The Ethnographic Evidence

Our understanding of traditional shellfish management on the Northwest Coast comes from a review of published and unpublished ethnographic sources and our more recent discussions with coastal First Nations. In particular, we conducted interviews with knowledge holders in the Heiltsuk, Tla'amin-Northern Coast Salish, and Hul'qumi'num First Nations (Figure 1) about a variety of topics associated with shellfish management, harvest, and use. Some of these responses are summarized here.

Northwest Coast peoples valued a variety of gastropods and bivalves for food and other purposes (Barton 1994; Ellis and Swan 1981; Hunn 1993; Kennedy and Bouchard 1974, 1976; Moss 1993; Suttles 1990:28–29; Wessen 1988). Among the most commonly harvested bivalves are littleneck clams (*Leukoma staminea*), butter clams (*Saxidomus gigantea*), cockles (*Clinocardium nuttallii*), horse clams (*Tresus capax, T. nuttallii*) and mussels (*Mytilus californianus, M. edulis/trossolus/galloprovincialis* species complex). These are also the native species for which the greatest amount of ecological knowledge has been recorded.

In general, older ethnographic sources provide few details about the ecological and cultural knowledge or management of shellfish. This absence of information is likely some combination of biases held by early ethnographers against traditional management practices and the particular social-symbolic role of clam harvesting (cf. Deur and Turner 2005; Moss 1993). Ecological knowledge of clams and other bivalves includes information about where, when, and how to harvest (e.g., Shaffer et al. 2004; Turner et al. 2011). Specific beaches and locations within beaches were valued as collection spots because the clams were especially big or abundant. Many coastal First Nations would harvest clams year round, though periods of harvest varied (e.g., Keen 1979). Among many groups, ecological indicators were used to guide the timing of shellfish harvests.

The value of moderated harvesting to maintain healthy bivalve populations was widely recognized by Coastal First Nations. Many note that the regular harvesting of clams in a particular area encouraged greater productivity by reducing overcrowding and maintaining the amount of suitable habitat (David Ellis, personal communication 2013; Ellis and Wilson 1981:4; Marlor 2009:238; Parks Canada 2011), and it was widely understood that digging kept the sediments aerated and created productive shellfish habitat (Deur et al. 2015; Parks Canada 2011; Smith et al. 2014; Woods and Woods 2005). Some people deliberately thinned clam beds to increase productivity (Turner 2005:174). Many First Nations see the unharvested beaches of today as unhealthy, dead, or dying, because of the thick layers of sea lettuce (*Ulva* spp.), the abundance of large dead bivalves, and compact sediment (Parks Canada 2011).

In addition to regular digging, a variety of other practices were applied to maintain and enhance shellfish production. For instance, among many groups, small clams were returned to the beach for later harvesting (Deur et al. 2015; Parks Canada 2011; Smith et al. 2014; Turner 2005:150). In addition, several bivalve species such as cockles, clams, mussels, and oysters were transplanted from productive to unproductive shorelines (interview with Phyllis Dominick, May 16, 1996, on file, Sliammon Treaty Office; Smith et al. 2014) or to places outside of their natural range (Ellis and Wilson 1981:4). Some elders also described adding gravel or clam shells to beaches to enhance shellfish habitat productivity (Deur et al. 2015; Parks Canada 2011).

The transplanting of bivalves to new areas sometimes had a lasting ecological effect. For instance, David Ellis (personal communication 2013) reports finding a colony of California mussels—which normally thrive on exposed shorelines—in a protected, calm channel where people remembered transplanting mussels some time earlier (Ellis and Wilson 1981:4). People noted that, near this same spot, the transplanted mussels were over-harvested and wiped out, presumably because they were on the edge of their ecological niche. Archaeologists should be aware that, similar to ethnobotanically important plants (cf. Lepofsky and Lertzman 2008), culturally valued bivalves located outside of their typical ecological range may be indirect evidence of prior management through transplanting.

Another lasting effect on clam habitat was the widespread practice among coastal First Nations of clearing the beach to varying degrees while clam digging. Cobbles, and sometimes woody debris, were rolled or thrown to the side of the beach while digging to keep the beach "tidy" (Emily August, personal communication 2009; Parks Canada 2011), to make it easier to dig (Charlie Bob, personal communication 2009; Bill Mitchell, personal communication 1974, in Bouchard and Kennedy 1971–1981; Kennedy and Bouchard 1974, 1990:445), to give the clams more room to grow (Deur et al. 2015; Turner et al. 2011; Woods and Woods 2005), and to mark the beds (Suttles 1951:488).

In addition to the clearing of beaches, there is also scattered ethnographic and ethnolinguistic evidence suggesting that building clam gardens occurred throughout the coast and has some time depth. In the late 1920s, Bernhard Stern (1934:47) noted that the Lummi of Washington state had a clam bed on Orcas Island that was "cultivated by its owners" by moving "the largest rocks... to the extreme low water marks, setting them in rows like a fence along the edge of the water." According to Stern, clearing the beach in this way made digging easier.

Forty years later, Dorothy Kennedy and Randy Bouchard (1974:48) recorded that the Klahoose-Northern Coast Salish people "cultivate[d] clean clam beds." In 1993, Klahoose Elder Keekus (Elizabeth Harry, whose parents were ethnographic and linguistic consultants for Kennedy and Bouchard in 1971–1981) noted that the clam gardens on Northern Quadra Island built and maintained by her people supported the "best" butter clams (Williams 1997). In several regions, Elders today recall helping to maintain clam garden walls in their youth by rolling rocks to the lower intertidal (Parks Canada 2011; Wood and Woods 2005). Tla'amin Elder Mary George further explained that rock wall features were valued because they attracted a variety of sea creatures, including octopus (Lepofsky 2008). Mary's comment parallels our own observations that the rock walls create reef habitat for a variety of harvestable reef-associated marine taxa that would otherwise be absent from soft sediment beaches.

Several Indigenous terms refer to clearing beaches in association with clam-digging, sometimes to create an intertidal wall (Harper et al. 2005). The Kwakwala term *lúx̱ʷxiwey* for a "clam garden" refers to the rock wall formed by rolling rocks to the lower intertidal (Boas 1948:404; Boas and Hunt 1906:93; Adam Dick and Daisy Sewid-Smith 2003, in Bouchard and Kennedy 2002–2009; Deur et al. 2015; Woods and Woods 2005).[2] In the Ahousaht dialect of Nuu-chah-nulth, the term *t'iimiik̲* ("something being thrown" or "move aside rocks") identifies a particularly good clam beach in Clayoquot Sound that was known as a place where clams were cultivated (Bouchard and Kennedy 1990:386).[3] Finally, the Northern Coast Salish Klahoose and Sliammon (Tla'amin), speakers of Mainland Comox, used the term *wúx̱wuthin* ("held back at the mouth")[4] to refer to the rocks that are piled on the sides of the beach or at the low water mark while digging clams to make it easier to dig in the future. Kennedy and Bouchard [1974:48] note:

> The *Tl'úhus* [Klahoose] people made a conscious effort to cultivate clean clam-beds. As they dug clams, the people removed the rocks from the gravel and piled them on one edge of the beach, or in the water beyond the mark of

the lowest tide. These piles of rocks are called *wúx̱wuthin*.

Like all systems of traditional management, shellfish management on the Northwest Coast was nested within larger systems of tenure and governance (Turner et al. 2005). Throughout the coast, prized clam beds were owned by particular families and access to harvests was controlled by family heads (Moss 1993; Suttles 1951, 1993; Turner 2005:164, 165, 171). Stern (1934:74) noted that among the Central Coast Salish of Washington State, only actively cleared beaches were owned by the tenders, but untended clam beds could be used by anyone. However, given that Indigenous populations were considerably reduced when Stern was conducting his fieldwork, his observations about "untended beaches" may not have applied to other times in history. Commenting on Stern's observations, Kennedy (2000:233) wrote, "While my Klahoose and Homalco friends were not aware that a system of ownership of clam beds was formerly in place, it is likely that in earlier times it was similar to the situation described by Stern." Among the Kwakwaka'wakw, the ownership and maintenance of clam gardens was the express responsibility of high-ranking trained individuals (Deur et al. 2015).

Knowledge about clam harvesting, clam gardens, and the proper ways to interact with clams was codified in songs, dances, and oral traditions (Deur et al. 2015; Kennedy and Bouchard 1974; Lepofsky and Caldwell 2013; Woods and Woods 2005). Furthermore, a myriad of social relations are embedded in the construction of clam gardens and in clam digging more generally. For many, clamming and building rock walls was a family event and a key time for the transfer of knowledge and skills from one generation to the next (Giga'at Nation and Coasts Under Stress (Producers) 2003; Marlor 2009:42; Parks Canada 2011; Woods and Woods 2005).

Shellfish Management on the Northwest Coast: The Archaeological Evidence

The importance of shellfish to Northwest Coast peoples is vividly displayed in the region's many deep, stratified shell middens. These middens, which date to among the earliest occupations of the coast (Fedje et al. 2005), are the very hallmark of coastal settlements, representing countless subsistence events and the use of shell to (re)create livable terrain (Blukas-Onat 1985). Considered on their own, however, these extensive deposits do not necessarily indicate management to maintain or increase shellfish productivity, since we lack detailed information on the harvesting pressures imposed by past gatherers. Furthermore, the very presence of these extensive middens could be used to infer social and spiritual connections to places, the symbolic importance of shellfish, and even ownership and control. However, it can be difficult to track the development of these less tangible aspects of ancient shellfish use and management with archaeological evidence alone.

More specific evidence of ancient marine management systems comes from measurements on and quantification of clams within middens. Specifically, management has been inferred based on several markers, including consistency through time in relative abundance of shellfish (Croes 1992), shell size (Daniels 2009; Hurst 2003; Wessen 1988), a narrow age class range of shells (Croes 1992; Hurst 2003), and the presence of only older and/or larger individuals in middens (thus assuming harvesting proscriptions on younger individuals) (Hurst 2003; cf. Daniels 2009, 2014; Cannon and Burchell 2009; Cannon et al. 2008). Some researchers (Cannon et al. 2008; Croes 1992; Wessen 1988) have further hypothesized that these patterns reflect ownership and control of prime harvesting locales.

Shellfish Management and Clam Gardens

The Distribution of Clam Gardens

Through the systematic aerial and on-the-ground low-tide inventory of coastal morphology, John Harper and Mary Morris have identified and mapped hundreds of clam gardens from the west coast from Alaska to British Columbia (Harper 2012; Harper et al. 1995; Wood and Wood 2005).[5] We surmise, especially given Stern's (1934) observations cited earlier, that the absence of recorded clam gardens in Washington State is at least in part a reflection of the extensive level of industrial shoreline development, as well as a steadily rising sea level throughout the Holocene in localized areas such as the Salish Sea (Fedje et al. 2009; Grier et al. 2009). Furthermore, the ground surveys by Harper and colleagues (e.g., Harper et al. 1995) and by our team in the territories of five distinct ethno-linguistic groups (Caldwell et al. 2012; Fedje and Smith 2009, 2010; Lepofsky and Caldwell 2013; Smith et al. 2012; Smith, Cohen, et al. 2013; Smith, McKechnie, and Sellers 2013) indicate that the number of recorded clam gardens is only a small fraction of the number that still dot the coastline.

Within British Columbia, some regions have relatively higher densities of recorded clam garden sites. While some of this could be accounted for by differences in survey intensity and coverage, areas such as northern Quadra Island (Figure 1) have a higher density of gardens than others. Determining where these features are and are not remains a significant ecological, geomorphological, and cultural question.

Clam Garden Morphology and Ecology

Our observations and excavations (Table 1) indicate that there is a wide variation in setting and form of clam gardens. Clam garden walls are most commonly located along the sides of semi-protected inlets with strong tidal currents and across beaches of varying sizes. We have also observed that some walls were built by pushing rocks away from a narrow (1–2 m) strip of land along the coastal bedrock shelf (Figure 4). Clam gardens tend to be located in areas that are well flushed by tidal currents and tend to be absent from protected areas with stream or river freshwater sources. Furthermore, within inlets rich in clam gardens (e.g., northern Quadra Island), we do not find walls on fine-sediment beaches. However, since clam garden walls influence both sediment and energy, understanding pre-garden clam habitat will require excavating pre-garden beach deposits. Our team is currently undertaking these excavations at several of our study sites.

In some cases, clam garden rock walls are created by adding to the natural rocky intertidal shelves and are largely indistinguishable from it on the ocean side. However, when walls are built on a gently sloping, sandy, or gravelly substrate and at a slightly higher elevation than the natural intertidal slopes, the wall is visible even during low-resolution aerial surveys (Figure 4). At some locations, rocks were removed from the beach and gathered in piles or walls to the sides of the beach or cleared up slope. Unlike the terrace wall at the lower intertidal, these features served to clear the beach and thus to create more space for clam growth, but they would not act as a sediment trap. Because these latter features are more subtle than the lower intertidal walls, we suspect that they may have gone unrecognized as anthropogenic by some geomorphologists or archaeologists.

Our excavations of the intertidal walls reveal that at least some of them were initially constructed as part of a single carefully engineered event. In particular, we observed some walls with rubble fill and others with flat, angular rocks used as the foundation (Figure 5). Rounded cobbles and small boulders were then added to these foundations, both at the time of construction and, we presume, during ongoing maintenance of the cleared beach, as described by local elders. In other cases, such as Grappler Inlet (Figure 2e), the wall height was comparatively short and did not exhibit the same degree of internal structure, suggesting that the wall may have been built up over time as the beach was cleared.

Our field surveys suggest that clam garden rock walls, and the terraces landward of them, were built at specific tidal heights, thereby maximizing optimal clam habitat (Groesbeck et al. 2014; Harper et al. 1995; Wood and Wood 2005). We found that clam gardens on Quadra Island (Figure 1) contained four times as many butter clams and over twice as many littleneck clams relative to non-walled beaches. Moreover, transplant experiments showed that juvenile little neck clams grew 1.7 times faster and were more likely to survive in clam gardens than non-walled beaches (Groesbeck et al. 2014). Similarly, recent research on British Columbia's Central Coast, 250 km north of Quadra Island, revealed that clam gardens encompassed twice the biomass and density of butter clams than unmodified beaches (Jackley et al. 2015). In both cases, we found that differences in clam biomass between the two beach types were most pronounced at the upper tidal elevation of ideal clam habitat.

In several ways, the construction and maintenance of clam gardens increases clam habitat, improves clam productivity, and makes clamming more efficient. In some cases, clam gardens even created clam habitats where none previously ex-

Figure 4. Google Earth image of clam garden EbSh-13 on Quadra Island, British Columbia. The image shows two clam garden forms. The clam garden wall on the main bay (to left, seen as a dark, distinct line at the lower intertidal) illustrates the first form. In this main bay, there was a large rock-covered beach prior to wall construction, and the garden wall was created by moving rocks to just landward of the natural marine shelf. This form is highly visible even in low-resolution aerial surveys, as the original beach underlies the base of the wall. The second type is in the small bay to the right of the photo. In this case, there was only a very narrow upper intertidal zone prior to wall construction; the intertidal zone was expanded and the wall was created by moving rocks to an existing break in slope, making it almost invisible in low-resolution air photos, since there is no gently sloping original beach highlighting the wall's location. This latter type also occurs outside bays, alongside steep rock and bedrock outcrops where there was no naturally occurring upper intertidal area prior to wall construction. The garden wall thus creates a narrow strip of clam habitat where there was none prior.

isted. For instance, we have located many gardens built into bedrock clefts, along relatively steep bedrock shorelines, on boulder beaches, and on silty deposits that could not have supported productive clam habitats without enhancements. In all clam gardens, the building of the garden wall results in the accumulation of coarse sand and broken barnacle shells (which make up the vast majority of shell hash captured landward of the wall) in a relatively flat terrace that is ideal substrate for clam growth (Figures 6 and 7; Quayle and Bourne 1972:27). Shell hash has been found to increase settling cues for larval clams (Greene et al. 2013) and to improve conditions for shell growth (Thompson 1995). This enhanced substrate, in combination with the placement of the wall at specific tidal heights, turned these otherwise less productive locations into valuable clam harvesting locations. Furthermore, as people kept the beach "tidy" by clearing boulders while digging clams, the area in which clams could grow increased, and future digging was more efficient. Collectively, these observations support earlier hypotheses by Harper and others (Woods and Woods 2005) about the relative productivity of clam garden beaches and their importance in the social and ecological landscapes of Northwest Coast peoples.

Dating Clam Gardens

We conducted exploratory excavations at six study sites (Figure 1) to develop a protocol for dating clam garden features. To retrieve datable material, we excavated trenches in the beach terrace on the landward side of the rock wall, as well as within the rock wall itself. In the beach

Table 1. Radiocarbon Dates from 2013 Excavations of Six Clam Gardens in British Columbia.

Site No.(Tidal Ht)[a]	Context	UCI Lab No.	Material	Lab Date	Cal age B.P.[b]	Interpretation
FaTa-77 (+.95 m)	Trench land side of terrace wall, from zone of dead clam shells at interface between shell hash and pre-garden beach, ~ 70 cm bs; ~20 cm above Canada chart datum[c]	132189	Clam shell	9505 ± 30	10180–9673	Shell sitting on old beach, provides max. constraining date for wall construction
FaTa-77 (+.95 m)	As above	132190	Clam shell	9380 ± 30	10044–10052	As above
EbSh-13 (+1.17 m)	Trench ~ 11 m landward of terrace wall, from pre-garden beach deposits, ~ 53 cm bs, ~20 cm below surface of pre-garden beach; ~1m above Canada chart datum[c]	132182	Barnacle scar on buried mafic cobble	4075 ± 25	3734–3386	Barnacle scar on cobble buried in old beach. Date for pre-garden beach deposits.
EbSh-13 (+1.17 m)	Trench ~ 9 m landward of terrace wall at interface of garden shell hash and pre-garden beach, ~ 32 cm bs; ~1.2 m above Canada chart datum[c]	132181	Barnacle scar on buried mafic cobble	870 ± 25	231–0[d]	Dates pre-garden beach surface, prior to terrace in-filling.
EbSh-13 (+1.17 m)	Trench ~ 12 m landward of terrace wall in zone of dead clams just above interface of shell hash and pre-garden beach, ~ 24 cm bs; ~2.0 m above Canada chart datum[c]	132183	Clam shell	890 ± 25	239–0[d]	Dates clam that dies sometime post-garden construction; provides min. date for garden wall construction
EbSh-13 (+1.17 m)	As above	132184	Clam shell	895 ± 25	241–0[d]	As above
EbSh-13 (+1.17 m)	Base of garden wall, towards back of wall, buried in silt; cobble from pre-garden beach surface used in wall construction ~.0 m Canada chart datum[c]	132185	Barnacle scar on buried mafic cobble	980 ± 25	301–0[d]	Dates construction of wall
EbSh-13 (+1.17 m)	Base of garden wall, near sea edge; ~.0 m Canada chart datum[c]	132186	Barnacle scar on buried mafic cobble	-50 ± 25	Modern date; contains bomb carbon	Modern date associated with intrusive barnacle into loosely constructed edge of wall

EbSh-5 (upper garden) (+2.52 m)	Base of garden wall between rocks; ~1.7 m above Canada chart datum[c]	132188	Clam shell	1410 ± 25	669–488	Clam trapped by cobbles during or after wall construction; provides min. date on wall construction and date on clam garden use
EbSh-5 (upper garden) (+2.52 m)	Base of garden wall, 4 cm below base of wall in old beach sediments; ~1.3 m above Canada chart datum [b]	132187	Clam shell	2545 ± 25	1863–1548	From old beach surface, Provides max. constraining date on wall construction.
DeSg-110 (+.57 m)	Base of garden wall ~40 cm bs, cobble buried in silts. ~.17 m above Canada chart datum[c]	132193	Barnacle scar on buried mafic cobble	1070 ± 25	502–266	Dates wall construction.
DeSg-110 (+.57 m)	Below base of wall, buried in silts, ~56 cm bs, ~.1 m above Canada chart datum[c]	132194	Barnacle scar on buried mafic cobble	5350 ± 25	5568–5236	Dates barnacle on pre-garden beach, inundated and thus preserved by rising sea level
1951T -1 wall1[e] (-.15 m)	From landward side of garden wall, 23 cm bs, ~.38 m below Canada chart datum [b]	132191	Barnacle scar on buried cobble	1560 ± 25	1208–1043	Dates wall maintenance event associated with landward expansion of the wall with rising sea level
1951T -2 wall[e] (-.15 m)	From landward side of garden wall, 15 cm bs; ~.30 m below Canada chart datum[c]	132192	Barnacle scar on buried cobble	1120 ± 25	432–291	As above

[a] Tidal height of wall relative to Canada chart datum, lowest low water large tide (LLWLT).
[b] All dates were calibrated at 2σ using Calib 7.0 with the Marine 13 calibration curve, with the following local marine reservoir corrections. FaTa-77: 331 ± 80 (McLaren et al. 2014); EbSh-5 and EBSh-36: 419 ± 60 (McNeely et al. 2006); DeSg-110: 320 ± 68 (McNeely et al. 2006); 1951T-1: 0 and 1951T-2: 400 (Deo et al. 2004).
[c] Canada chart datum, lowest low water large tide (LLWLT).
[d] The calibration program does not allow these dates to be fully calibrated because the nominal Delta-R corrected ^{14}C ages are younger than the marine curve. Based on location relative to sea level and the absence of bomb carbon in the samples, we suspect that these samples date within the last 100–200 years, but no later than the early twentieth century.
[e] Parks Canada site designation.

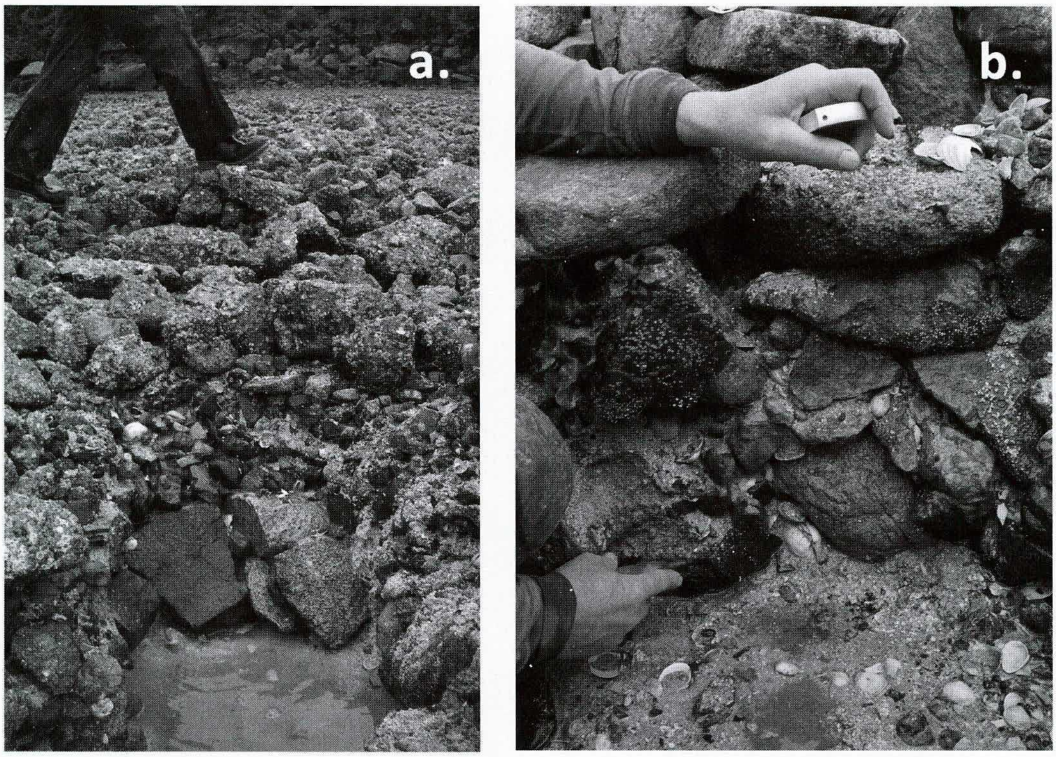

Figure 5. Excavation of clam garden walls: (a) trench in lower wall at EbSh-5 (note angular rocks taken from upper beach (top of photo) used to construct the base of the wall, indicating deliberate construction of the initial wall in a single event); (b) close-up of lowermost construction of upper wall at EbSh-5 (note horizontal placement of rocks taken from upper intertidal zone, indicating deliberate construction of the initial wall in a single event.) The trowel is pointing to a clam that was in the upper zone of the beach at the time the wall was built. This clam returned an age of ~1700 B.P. (132187, Table 1) and provides a maximum constraining date on the construction of this wall.

trenches, we sought clams that died at the interface between the old beach surface and the infilled terrace sediment (the shell hash), as well as barnacle basal plates ("barnacle scars") on rocks found at this interface. Within the rock walls, we sought barnacle scars on the most deeply buried rocks in the lower foundation of the wall, as well as wood debris or bivalves on the old beach surface that either had been trapped by wall construction or had settled in the wall or terrace matrix sometime after the wall was built.

Dating clams and barnacles in clam gardens offers advantages and some significant challenges. On the one hand, clams and barnacles are both relatively short lived and thus are ideal datable material. On the other, since clamshells can survive in beach sediments relatively unscathed for millennia (Meldahl et al. 1997), there is often no way to know a priori whether a shell situated between the old beach surface and the constructed wall died when the wall was built on top of it, or whether it was in the beach deposits long before wall construction. Thus, radiocarbon dating a shell on the old beach surface provides a maximum constraining date for wall construction but cannot be assumed to reflect wall construction specifically (e.g., #132189, 132190, 132187, Table 1). Shells found in the wall matrix or clam garden terrace, on the other hand, provide a date for wall or garden use and a minimum constraining date on construction (e.g., 132183, 132184, 132188, Table 1). Together, the upper and lower shells provide a bracketed age for wall construction.

Unlike shells, exposed barnacle tests and their basal plates rarely survive longer than a year in conditions of normal exposure (C. Harley personal communication, 2013; Harley and O'Riley 2011). Thus, dating buried barnacle scars provides a date for the narrow window of time between when the barnacle is exposed and eroding and

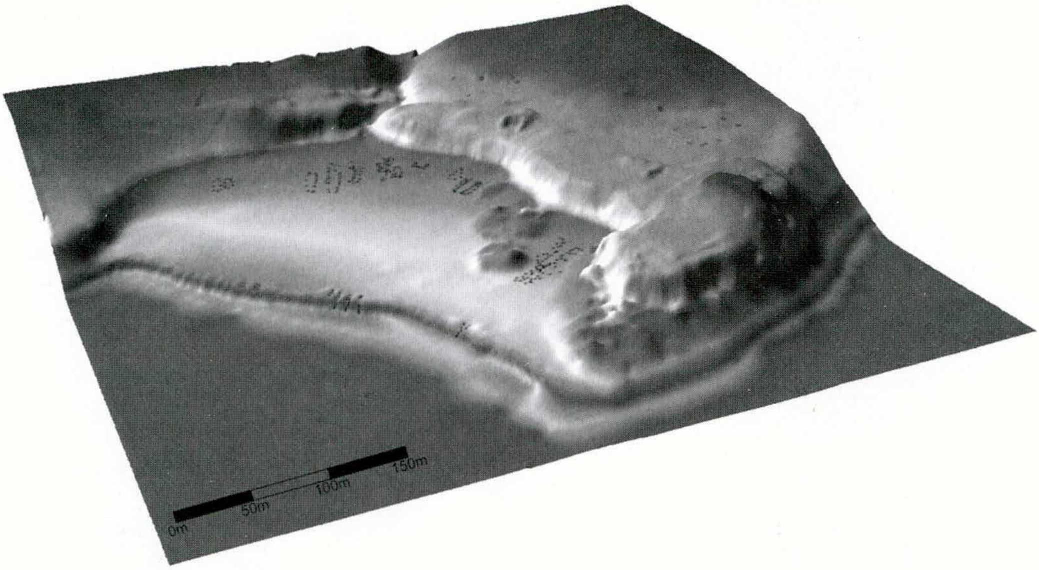

Figure 6. Three-dimensional model of a clam garden and adjacent large shell midden with house platforms at site EbSh-13 on Quadra Island. The beach depicted is the same as the main bay shown on the Google Earth image in Figure 4. The dark line seaward of the beach is the clam garden wall with canoe skids in it. Note the flat beach created landward of the terrace wall. There is an elevation gain of < 1m from the flat landward of the terrace wall to the top of clam habitat (see Figure 7). Model by Sue Formosa.

the complete submersion of the rock by water or saturated sediments (at which time decomposition should be dramatically reduced). As long as submersion of the barnacle is associated with the building of the clam garden, it offers a precise chronological estimate of a wall construction. In the beach trenches, we selected barnacle scars on boulders from the original beach surface that had been covered (and preserved) by the infilling of the terrace with sediment after the wall was built (e.g., 132181, cf. 132182, 132194, Table 1). In the wall itself, if a barnacle-covered rock was used in construction, the barnacle scar will date the placement of that rock in water-saturated beach sediments during either wall construction or ongoing wall maintenance (e.g., 132185, 132193, 1951T-1, 1951T-2, Table 1).

The five clam gardens we excavated in southern British Columbia were constructed in the late Holocene. Our oldest radiocarbon determination is ca. 1000 B.P. (1951T-1 Table 1), presumably dating a wall maintenance event, given that the sample is from near the top of the wall and in a region of rising sea level. Thus, the original wall at this site on eastern Vancouver Island was likely first constructed sometime time prior to 1,000 years ago, although confirmation requires further testing.

Not surprisingly, since garden walls were placed relative to ideal clam habitat, the age of garden walls is closely associated with sea level histories. The four walls we firmly dated (132185, 132193, 1951T-1, 1951T-2, Table 1) are associated with current sea levels and thus returned relatively recent ages (i.e., within the last 1,000 years). In areas of falling sea levels (e.g., Quadra Island and West Coast of Vancouver Island, British Columbia; sites EbSh-13, EbSh-5, and DeSg-110; e.g., Dallimore et al. 2008; Verdonck 2006), older walls would be stranded high on the beach and may be mostly dismantled. In the case of rising sea levels (e.g., Gulf Islands, British Columbia; site 1951T; Fedje et al. 2009), older walls would be submerged and thus more difficult to locate and excavate.

Discussion

Clam gardens are just one of a suite of archaeological and ecological features that provide tangible evidence of the spatial and temporal extent

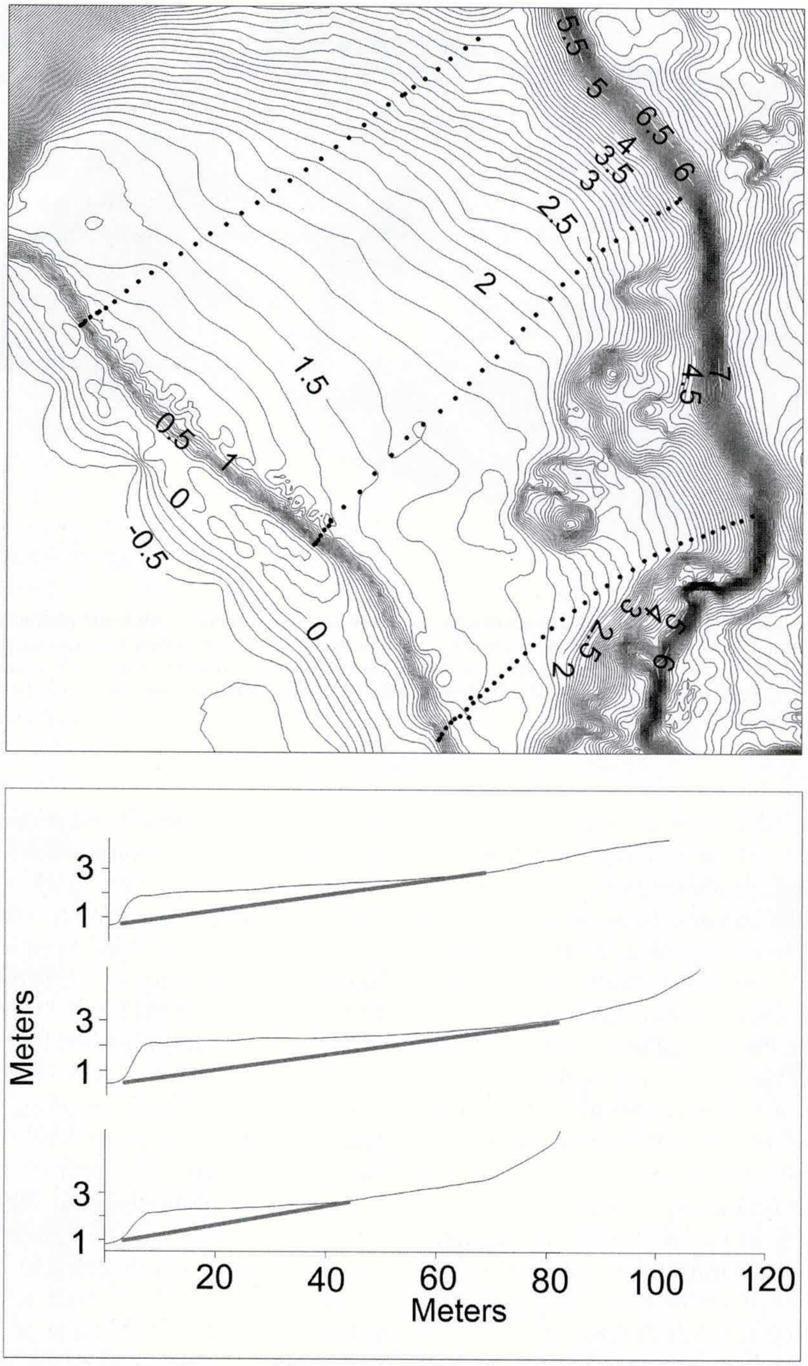

Figure 7. Elevation of three transects along clam garden terrace of EbSh-13 on Quadra Island, British Columbia, shown in Figure 6. The locations of the transects are shown in the upper image of the beach and the elevation cross-sections in the lower image. The Y-axis in the cross-sections shows meters above Canada chart datum, lowest low water large tide (LLWLT); the straight lines represent the projected slope of the beach prior to the infilling associated with the construction of the terrace wall. The projected slope runs from the top of the cleared beach to the base of the wall, which rests on the old beach surface visible today. Based on this projection, infilling landward of the terrace wall begins in the three transects ~1.9 m. Our excavations in the southernmost transect confirmed that this projection approximates the slope of the old beach surface and the amount of infilling. Note the similarities in the height of the wall and thus the tidal height of the created habitat landward of the three locations along the wall.

of resource management systems of Northwest Coast peoples. From clam gardens in the lower intertidal zone to fish traps in the upper intertidal (e.g., White 2006, 2011), from estuarine root gardens (Deur 2005) to berry gardens and orchards on the forest edges (Turner et al. 2013), and from culturally modified trees in the forests (e.g., Stryd and Eldridge 1993) to fire-maintained open patches on mid to upper slopes (e.g., Lepofsky et al. 2005; Turner 1999), management practices to sustain and enhance productive resources and habitats have left their footprints. Within the marine environment, archaeological and ethnographic information indicates that Northwest Coast people managed a suite of taxa, including a variety of finfish, bivalves, and seaweeds (Turner and Clifton 2006). The prevalence and diversity of evidence for marine resource and ecosystem management and, indeed, its time depth indicate just how central mariculture was to the social-ecological systems of Northwest Coast peoples. This information in turn challenges us to keep reassessing long-held anthropological notions about how peoples typically classified as either hunter-gatherers or agriculturalists interacted with the land- and seascapes.

Shellfish management specifically, as one aspect of traditional mariculture, was widespread on the Northwest Coast. Across the region, techniques used to cultivate clams included a myriad of management practices normally associated with the cultivation of terrestrial resources, including terracing, marking boundaries, ownership, tilling, thinning, substrate enhancement, selective harvesting, the returning of juveniles for later harvesting, and transplanting. Based on our ecological experiments (Groesbeck et al. 2014), we know that these practices increased clam production manyfold. In addition, our archaeological surveys and excavations indicate not only that clam gardens, specifically, expanded prime harvesting zones for clams within existing clam beaches, but also that, in some cases, these features created a habitat where there was little to none before (i.e., by accumulating sediments on bedrock or on boulder-cobble lag beach surfaces). The cumulative increased efficiency and return on investments for food production and its influence on socioeconomic systems were undoubtedly significant. Considered in this light, the enormous shell middens that line our coastline take on added importance.

As we fine-tune our understanding of these activities and how they relate to biotic (e.g., availability of prey, feeding rates, density dependence, clam thermal tolerance) and abiotic factors (e.g., sea level change, substrate type, sedimentation rates), we will undoubtedly find more and more evidence of shellfish management in the archaeological record. However, only some of this evidence will be in the form of rock walls at the lower intertidal. Cleared beaches without rock walls, rock piles along the sides of beaches, and subtle changes in size and age of clams and abundance in shell middens are among the many other potential tangible indicators of ancient shellfish management and the creation and enhancement of ecological niches by humans (cf. Smith 2011).

Our investigations of clam gardens indicate that there is significant variation in the ecological and cultural contexts of clam gardens. For instance, in some cases (e.g., the Grappler Inlet wall we excavated), the wall morphology suggests that the clam garden wall was built over an extended period of time. In this case, habitat expansion would also have been gradual. In other cases (e.g., both sites on Quadra Island), habitat expansion would have been accomplished almost immediately with the building of the terrace wall in what appears to be a single construction event. We have much to learn about the differential social effects of a gradual versus dramatic increase in food production in particular places.

Indeed, as permanent modifications to the landscape, clam gardens have huge potential to inform the social context of past food production. From a materialist perspective, these features reflect both the substantial time and labor required to initiate them and the subsequent significant returns on this investment (cf. Brookfield 1984, 1986). However, the building and maintenance of these permanent features are also tied to intergenerational teachings about marine ecology (Berkes and Turner 2006), connections to family traditions, rights and title to knowledge (how to build the features, associated songs, stories, ceremonies, dances, and artistic representations), and systems of land tenure, which extend well beyond purely economic aspects of management systems.

Detailed studies of clam gardens and other marine management features in specific cultural contexts (e.g., Caldwell et al. 2012; White 2006) provide the rare opportunity to understand how and whether these corporeal and non-corporeal rights are expressed through time and across space. Based on our formal and informal surveys and our increasing understanding of the role of sea level change in feature visibility, we surmise that, in many regions, clam gardens were built anywhere they could be built (e.g., rocky shores, bedrock clefts). As a result, in some cases, major settlements are directly associated with gardens and, in other cases, they are not. Thus, given the ease with which people could travel considerable distances by boat to bring back large, heavy harvests (Ames 2002), proximity to gardens may not reflect access or control.

Given the context of changing sea levels, and the dismantling or submersion of older management features, the sample of clam garden and other intertidal management features will always be biased toward more recent sites. Currently, the extant corpus of recent clam garden dates are in line with region-wide evidence that management in the form of mass harvesting and habitat enhancement intensified in the last two millennia concurrent with other socioeconomic changes (e.g., Moss et al. 1990; Weiser and Lepofsky 2009). However, this interpretation may simply be an artifact of taphonomic processes in the archaeological record and the close association of clam gardens with sea levels. In our focal study areas, detailed temporal and spatial surveys of settlements and gardens combined with zooarchaeological analyses of associated shell middens will help parse out the many ways in which clam gardens influenced and were influenced by past social landscapes. Furthermore, dating clam gardens will help fine-tune local sea level curves, and, in areas where sea level histories are well understood (e.g., Dallimore et al. 2008; Fedje et al. 2009), sea level data can be used to estimate clam garden age.

A significant outstanding question is the degree to which the information presented here about Northwest Coast intertidal management represents shellfish management practices of other coastal peoples. We hypothesize that some kind of shellfish management was indeed widespread in many traditional societies, as reflected in the disparate archaeological and ethnographic information compiled in this paper. The richness of the known ethnographic and archaeological record of the Northwest Coast is in part due to the fact that we are fortunate to work along coastlines that are relatively undisturbed and to be able to collaborate with Indigenous Peoples who still have and are willing to share their ecological knowledge.

It may also be that the Northwest Coast environs are better suited to shellfish management than some other regions. Vulnerability to overharvesting is in part related to availability and success of larval recruitment, growth, and survival. On islands, where many zooarchaeological studies document resource depression (e.g., Braje et al. 2007; Erlandson et al. 2008), shellfish population health is limited by larval source populations (Mannino and Thomas 2002; Thaker 2011). On the Northwest Coast, with countless small embayments, larval supply may not have been a limiting factor in shellfish population health. Where clam larvae are delivered by currents to clam garden beaches, settled clams have increased rates of survival and growth (Groesbeck et al. 2014), further buffering against the effects of overharvesting and increasing food security.

While we suspect that some kind of traditional shellfish management occurred or is still occurring in many places around the world, we are less sure about whether clam gardens specifically are unique to the Northwest Coast. In our diverse research network, we have several working hypotheses about why clam gardens may be unique to this region. Some of us note the correspondence of the distribution of clam gardens with the previously glaciated coastline and posit that the cobble and boulder-armored beaches common to this region created an ideal habitat for clams and for building garden walls. Others of us hypothesize that the distribution has to do with the region's extreme tidal range (~5 m), resulting in a wider range over which the ideal tidal clam habitat can be extended. That is, it would be more difficult to change beach slope in regions with narrow inter-tidal ranges because the wall would have to be built underwater, and the narrow range means that the wall height would have to be built with great precision. Finally, some posit that the Northwest Coast may also have favorable climatic conditions for this type of habitat building structures—high humidity and relatively mild temperatures that result in less danger of desiccation or freezing. We suspect that the success of clam gardens is due to a combination of these and other physical and climatic attributes.

An additional reason for the perceived absence of clam gardens elsewhere may have to do with how elusive these features are. On the Northwest Coast, many clam gardens are only visible during three daylight hours for about a six-day window, four months of the year (May–August; ~72 hr/yr); one might see only a few of the features in a normal field day and fail to recognize any consistent pattern. In places with rising sea levels, many of these features may never be exposed. We encourage archaeologists working in areas of glaciated coastline where clams were an important part of traditional subsistence economies (e.g., Japan, northern Australia) to work with coastal geomorphologists to conduct beach surveys on the lowest low tides of the year and to take sea level histories into account.

While the record of over-harvesting is clear, archaeologists need to be open to the possibility of alternative hypotheses about human-shellfish relationships and the importance of coastal environments to humans overall (Erlandson 2001; Rick and Erlandson 2009). For instance, does the absence of small clams in middens indicate optimal foraging (to target higher ranked prey), or a deliberate management strategy to reduce overharvesting and increase overall clam yields by re-seeding the beach with smaller and thus younger clams (cf. Daniels 2014; Whitaker 2008)? What would clam growth, abundance, and species variability look like in a long-term, managed ecosystem? How does this vary between site types (Cannon and Burchell 2009) or between cultural groups?

Conclusions

Understanding the many dimensions of belief and behavior encompassed within traditional marine management systems requires blending diverse kinds of knowledge and data. From the archaeological record, the relative species abundance, size, and season of harvest of the clams in middens can provide insights into rules about clam harvesting, whereas the spatial relationship of clam gardens to settlements, coupled with traditional knowledge and the ethnographic record, can inform us about ancient tenure systems. Clam gardens and cleared beaches, in combination with traditional ecological knowledge, provide evidence of habitat enhancement and creation to enhance bivalve production. Combined with ecological surveys and experiments, these data can in turn provide estimates of energy input and output associated with traditional management practices. Finally, oral knowledge, including songs, stories, place names, and memories, provide insights into the more "subtle ecologies" associated with management (Wyndham 2009), as well as the deeper social values and meaning encompassed within the marine management system—meanings which can often be invisible in the material record.

This investigation of ancient mariculture takes us one step further toward understanding the breadth of beliefs, knowledge, and practice that are incorporated into traditional resource management systems. As a result, we are better situated not only to understand ancient management systems, but also to honor this ecological knowledge and to incorporate it into conserving the region's natural and cultural landscapes today. Furthermore, documenting ancient marine management systems is at the heart of discussions about Indigenous rights to access and manage resources within their traditional territories today (Pinkerton and Silver 2011; Silver 2013). From a resource management perspective, clam gardens and related traditional management practices can help contemporary resource managers simultaneously improve both ecological and cultural integrity by improving bivalve health and creating opportunities for cultural connections. Revitalization of traditional management techniques such as clam gardens affords opportunities to restore both ecological conditions and active cultural landscapes.

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Notes

1. Long-time British Columbia coastal resident Billy Proctor shared the term "clam garden" with John Harper in 2000. He noted that the term came from Kwakwaka'wakw Elders Billy Sandy Willie, Peter Moon, and Tom Wamish.

2. The Kwakwala term *lúx̣ʷxiwey* (Chief Adam Dick and Dr. Daisy Sewid-Smith 2003, in Bouchard and Kennedy 2002–2009), sometimes anglicized as "lokiwey," has been translated by Boas (1948:404) as "rolled together; low tide mark" or as "where the stones roll" (Boas and Hunt 1906:93). Dick and Sewid-Smith (2003, in Bouchard and Kennedy 2002–2009) provided the translation "rolled rocks forming a wall," which they said was derived from *lúx̣ʷa*, "to roll something round."

3. A key to the practical orthography used to transcribe this term can be found in Bouchard and Kennedy (1990:571–573); these same authors noted that "the meaning of *t'iimiik̲* originated from the practice of looking after this clam bed by moving the rocks aside" (Bouchard and Kennedy 1990:386). Their recent review of the background materials on which these statements were based provides more nuanced information. Ahousaht Elder Peter Webster in 1984 told archaeologist and ethnographer Denis St. Claire: "*t'iimiik̲*, so this word connects to [is translated as] 'something thrown'; *t'iimiik̲*, it's the place where they used to dig clams" (Webster 1984, in St. Claire 1984). Ahousaht Elder Dr. George Louie confirmed this same term in 1989 with Randy Bouchard: "*t'iimiik̲* [is translated as] 'move aside rocks' as in cultivating a clam beach (GL); particularly good clam beach (GL)" (Louis 1989, in Bouchard and Kennedy 1989–1990).

4. See Kennedy and Bouchard (1983:147–148) for a key to the practical orthography used to transcribe this term. Mainland Comox Coast Salish is better known to speakers of this language as *éy7á7juuthem* (Kennedy and Bouchard 1983:22–23; 1990:441). The root of *wúx̲wuthin* is *wux̲w*; the lexical suffix *–thin* refers primarily to "mouth." An initial analysis of the root *wux̲w* suggests that its meaning is related to "rocks piled up to create a barrier." The materials reviewed indicate that *wúx̲wuthin* was used to refer to the following types of rock structures: those which characterize "clam gardens;" "rock corrals" used in and beside rivers and creeks; and rock structures used in association with river weir-traps, tidal weirs, and canoe skids. Bill Mitchell in 1974 said *wúx̲wuthin* was "like a breakwater;" Dr. Elsie Paul made the same observation in 2008 (Bouchard and Kennedy 1971–1981; Lepofsky 2008).

5. A few areas of British Columbia have been formally inventoried, including a portion of the Broughton Archipelago (353 clam gardens inventoried over 698 km of shoreline; Harper et al. 1995), Johnstone Strait (81 clam gardens surveyed over ~100 km of shoreline; Harper 2007; Harper and Still 2010) and Quadra Island (133 clam gardens surveyed over 111 km of shoreline; Harper and Morris 2004; Harper and Still 2010; Figure 1). Observations during the ShoreZone survey program (> 100,000 km of shoreline surveyed at low tide) have identified clam gardens in other areas, between Sitka, Alaska, and southern British Columbia; observations indicate the clam gardens tend to occur in clusters. On the Broughton Archipelago there are hundreds of unsurveyed clam gardens.

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