THE MAGOUN CLAM GARDEN NEAR SITKA, ALASKA: NICHE CONSTRUCTION THEORY MEETS TRADITIONAL ECOLOGICAL KNOWLEDGE, BUT WHAT ABOUT THE RISKS OF SHELLFISH TOXICITY?

Madonna L. Moss
Department of Anthropology, University of Oregon, Eugene, OR, 97403; mmoss@uoregon.edu

Hannah P. Wellman
Department of Anthropology, University of Oregon, Eugene, OR, 97403; hpw@uoregon.edu

ABSTRACT

Located within the Magoun Islands State Marine Park, the Magoun Clam Garden (49-SIT-921) is, to our knowledge, the first clam garden confirmed on the ground in Alaska. Although many "clam gardens" or "clam terraces" constructed by First Nations have been identified in coastal British Columbia, this is the first that we can attribute to Alaska Natives, in this case, to Tlingit ancestors. The site was identified by Madonna Moss, University of Oregon, and Aaron Bean, Sitka Tribe of Alaska, during archaeological survey in July–August 2011. In this paper we review some of the recent theoretical approaches embedded in the study of these features and urge more explicit use of such theoretical resources. We conclude that although niche construction theory (NCT), resource intensification, resource management and conservation, and traditional ecological knowledge (TEK) provide useful frameworks for understanding these kinds of sites, only traditional ecological knowledge, and indigenous cultural knowledge more generally, have recognized the health risks of shellfish consumption caused by paralytic shellfish poisoning (PSP). We suggest that studies of clam gardens must take into consideration such risks, which undoubtedly varied over time and across space.

SITKA SOUND

Along the shorelines of Sitka Sound, approximately fifty precontact archaeological sites have been identified (Alaska Heritage Resource Survey [AHRS] site records and Jay Kinsman, pers. comm. 2011). These include villages, shell middens, fishing weirs and rock alignments, sites with depressions, garden rows, culturally modified trees (CMTs), petroglyphs, camps, subsistence areas, and canoe haul-outs. The sites are located on state, federal, municipal, and private lands. Known sites comprise just a partial sample of the record. For example, we know Native Americans have occupied southeast Alaska for more than 12,000 years (Dixon 2013), but as yet no sites older than 2600 BP have been found in the Sitka Sound region.

Moss's interest in Sitka Sound archaeology began in 1982 when she was stationed in Sitka as an archaeologist working for the Chatham Area of the Tongass National Forest. In a recent review of the archaeological record of southeast Alaska conducted for the Herring Synthesis project (Moss et al. 2010, 2011; Thornton et al. 2010a, 2010b), it was remarkable to discover how little archaeological research has been conducted on precontact sites in and around Sitka, the center of commercial herring fishing today. Although some test excavations have occurred (e.g., Campen et al. 1992; Davis 1985; Erlandson et al. 1990), none of these reports have been published. Sitka National Historical Park has been completely inventoried, but the park only encompasses about 110 acres (Hunt 2010). Within park boundaries, eight precontact sites with charcoal concentrations dating from 2600 BP through the late period have been identified along the Indian River floodplain (Hunt 2010:216–221). Yet overall very little is known about larger patterns of ancient land and resource use in the Sitka Sound region.

In 2011, Moss conducted archaeological survey with the Sitka Tribe of Alaska to investigate Sitka Sound's archaeological sites. During the 2011 survey, five new sites were identified: three shell middens (Krestof Shell Midden #1, Krestof Shell Midden #2, and Cedar Cove Shell Midden), a clam garden (Magoun Clam Garden), and a remnant of another site (Katlian Bay Adze). No new forts, fishing weirs/traps, or rock art sites were found. As reported in Moss (2012), the five newly discovered sites have been recorded with the State of Alaska. Nine radiocarbon samples submitted to the National Ocean Sciences Accelerator Mass Spectrometry Facility (NOSAMS) at the Woods Hole Oceanographic Institution in Massachusetts yielded radiocarbon ages for five archaeological sites and one noncultural locality of geomorphological significance: a raised beach.

THE MAGOUN CLAM GARDEN

The Magoun Clam Garden (49-SIT-921) is located along the center of the east shoreline of one of the Magoun Islands at the south end of Krestof Sound. This island is about 2 km long and is vaguely shaped like the number 7 (Fig. 1). Prior to field survey, Moss identified this locality as a place to examine because it was detected as

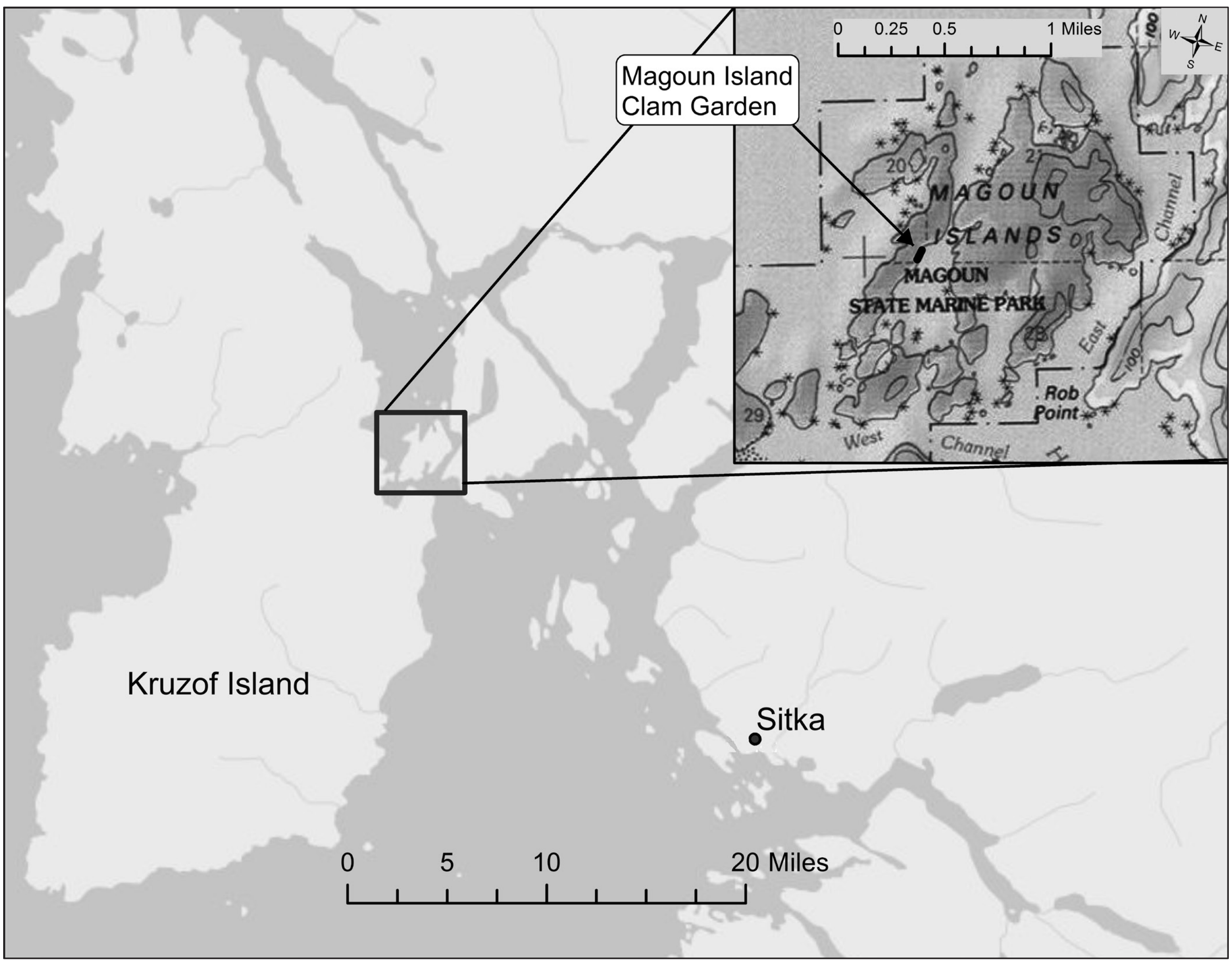

Figure 1: Location of Magoun Clam Garden (49-SIT-921), near Sitka, Alaska. Map by Julia Knowles. Basemap credits: National Geographic Society, i-cubed. Sources: Esri, DeLorme, USGS, NPS Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors and the GIS user community for the background map, and USGS for the inset map.

a possible clam garden by John Harper, of Coastal and Ocean Resources, who did an aerial survey of the Sitka Sound region in 2005 (CORI 2005). Harper suspected a clam garden in the vicinity as indicated in his flight log. Unfortunately, Moss and Bean did not have Harper's photographs in the field, but we did identify a cultural feature, very likely contiguous with the feature Harper identified in 2005. Over an area about 100 m north–south and 75 m east–west, we found a very rich shellfish bed containing dense concentrations of butter clams (*Saxidomus gigantea*) and some horse clams (*Tresus nuttallii*). We visited the site just after the tide hit its low point at –1.5 ft., and extensive eelgrass was observed. Near the water line, we observed that rocks had been accumulated into a linear concentration about 1 m wide (Fig. 2). Although not a discrete "wall," it was clear that rocks had been gathered up, probably while digging clams, and removed for the purpose of making clam digging easier. It seems appropriate to designate this feature as a clam garden; we infer that it was cultivated to promote shellfish harvest through the repeated removal of cobbles from the substrate. To assess the current productivity of the shellfish bed, Moss dug a 10-cm-diameter hole, from which we recovered twelve live butter clams and the paired valves of twelve additional dead butter clams in a matter of minutes. Numerous live cockles were found on the surface of this beach.

From subsequent evaluation of the records available through Alaska ShoreZone (http://www.shorezone.org), and in consultation with John Harper, the features noted from the air by John Harper in 2005 are immediately to the south of the clam garden feature that Moss and Bean identified (Fig. 3). Unfortunately, by the time we left the site, the tides had already covered the suspected clam garden area identified by Harper. In the woods adjacent to the clam garden, we found a CMT with a large scar on the east side and a smaller scar on the west side. We did not see any surface exposures of shell midden here, and the terrain is fairly uneven. The CMT was used in the calculation that the site encompasses an area of 2.7 acres. The site appears to be in good condition and is not currently threatened. It clearly continues to be a place of recent clam digging, even though we visited it at a time when Alaska's Department of Environmental Conservation had issued a warning against consuming local clams.

John Harper (pers. comm. 2016) has generously shared additional photographs of adjacent features that

Figure 2: Low tide (–1.5 ft.) at Magoun Clam Garden (49-SIT-921), looking north, with Sitka Tribe's boat in the background. The rocks accumulated along the waterline were removed during clam digging. Eelgrass is being covered by the incoming tide. Photo by M. Moss, July 29, 2011.

Figure 3: Clam garden photo by Mary Morris, Coastal and Ocean Resources, Inc., Sidney, BC. Photo #6496, taken in July 2005. This locality is immediately south of the location recorded as the Magoun Clam Garden (49-SIT-921). Aerial photography is superior to low-angle photography taken on shore for capturing clam garden features.

reveal a substantially larger clam garden complex than that recorded as 49-SIT-921. At least two additional distinct clam gardens occur on adjacent pocket beaches to the south, covering a straight-line distance from north to south of 430 m, as estimated from photographs and Google Earth. Harper (pers. comm. 2016) noted that he has observed dozens of clam gardens from the air in Sitka Sound. Further, while Moss and Bean were able to confirm the identification of a clam garden (49-SIT-921) on the ground, Harper suggests that such reconfirmation may be unnecessary. The short duration of the low-tide window allowed us to investigate just the single clam garden (49-SIT-921) but precluded us from gauging the extent of the larger features during a single tide. So as Harper has suggested, aerial photography may be the most effective way to identify and map such features in the future. Two shell midden sites identified along Port Krestof are located just 2 km to the southwest of these clam gardens. These may have been the occupation sites associated with the clam gardens; Krestof Shell Midden #1 (49-SIT-917) and Krestof Shell Midden #2 (49-SIT-918) both contain abundant clam shell remains and are dated to ca. 650–565 cal BP and 715–625 cal BP, respectively (Moss 2012).

Burrowing clams along the entire Northwest Coast are most available during the lowest tides of the month, which occur during the new moon and full moon phases. These "spring" tides occur about every two weeks, with about four to five low tides per cycle. During the two-to-three-hour period around such low tides, clam digging can be very productive. Although the species in the upper intertidal zone (such as some mussels and barnacles) can be collected more regularly, the best time for clams, cockles, chitons, and sea urchins is during these very low tides, when the sea level is below mean lower low water. The frequency of the lowest tides limits the amount of time people can easily dig clams. Since clams are available for only a limited time each month, we can better appreciate why clam gardens are such a remarkable innovation.

CLAM GARDENS IN BRITISH COLUMBIA

In the 1990s, John Harper began identifying rock walls in the intertidal zone during his aerial surveys of coastal British Columbia. In the Broughton Archipelago, part of the aboriginal territory of the Kwakwaka'wakw (formerly known as Kwakiutl), across a 150,000-hectare area Harper mapped 365 features that he called "clam terraces" or "clam gardens" (Harper et al. 1995). These features were found along low-energy beaches, occurring at the 0-tide level (as measured in British Columbia). Comprised of ridges of gravel to boulder-sized clasts, they run across small bays along the mostly rocky shoreline. Alongside pocket beaches, these ridges create a sandflat that extends from the rock wall to the middle intertidal zone (Fig. 4). These rock structures enlarge the area in the intertidal zone favored by two of the preferred clam genera in the Northwest Coast region: *Saxidomus gigantea* (butter clam) and *Leukoma staminea* (littleneck clam, formerly *Protothaca staminea*). Not only do clam gardens increase the amount of productive habitat, but they make clam digging easier. The clam gardens clearly qualify as mariculture (Moss 2011:43–46), defined as the cultivation, management, and harvesting of marine organisms in their natural habitat or in specially constructed rearing enclosures.

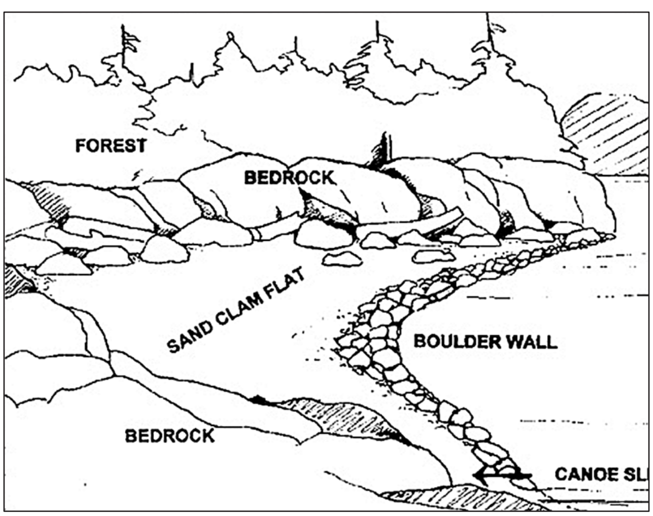

Figure 4: John Harper's drawing of a clam garden in the Broughton Archipelago. Coastal and Ocean Resources, Inc., Sidney, BC.

Clam gardens are known as *luxwxiwey*, or "place of rolling rocks together," in the Kwakw'ala language (Harper et al. n.d.a). Kwakwaka'wakw elder Adam Dick remembers clam gardens from his youth, and clam gardens figure into Kwakwaka'wakw legend, song, and ceremony. Although none of the clam gardens have been directly dated, more than 175 shell middens occur in the area, and some are c. 2000 years old (Harper et al. 1995; Mitchell 1967). Because the Broughton clam gardens occur along discrete pocket beaches, they are localities particularly well suited for creating, managing, and controlling resources via ownership by specific social groups.

One local resident of the Broughton Archipelago, Billy Proctor, began constructing his clam garden in 1957 and harvested it continuously through the mid-2000s (Harper et al. n.d.b). The original beach area is estimated at 53 m^2 and the current beach area is 81 m^2. The sustained harvest was 600 butter clams per year. The construction of a clam garden increases clam habitat by removing boulders, thus providing more productive beach area for clams to occupy, and the boulder walls decrease the beach gradient, enlarging the most productive zone of the beach for butter clams. The finer matrix of the beach makes clam digging easier. Digging clams also aerates the beaches; elders have told Harper that "worked beaches" are more productive than nonworked beaches.

Clam gardens represent substantial investments in infrastructure that enhanced the productivity of key resources. They are part of the "built environment" of the Northwest Coast (Grier 2014; Mackie 2001). Clams were consumed fresh, but large quantities were also dried, smoked, and stored for future use—as feast foods, winter supplies, travel provisions, and for trade. The clam mariculturalists of the Broughton Archipelago were especially industrious, and John Harper's research has inspired archaeologists to identify clam gardens elsewhere on the Northwest Coast. Although the number and density of clam gardens in the Broughton Archipelago is currently unmatched anywhere else, clam gardens have been identified within the territories of Coast Salish, Nuu-chah-nulth, and Heiltsuk (Caldwell et al. 2012; Grier 2014; Harper et al. 1995, 2005, 2007; Lepofsky and Caldwell 2013; Lepofsky et al. 2015), and now Tlingit groups.

Caldwell et al. (2012:219) take a typological, classificatory approach to modifications such as clam gardens in their survey of Northern Coast Salish "intertidal resource management features." The authors acknowledge the active role that indigenous peoples took in managing their environment but strive to find better ways to describe intertidal beach/rock modifications beyond the labels "clam garden" or "fish trap" (Caldwell et al. 2012:220). From aerial surveys, they identified specific elements (using descriptors of overall shape such as hook, heart, V, crescent, linear, cleared bedrock, etc.) that composed intertidal features at fifty-one locations (Caldwell et al. 2012). The authors assert that this breakdown is necessary to fully understand the purpose of each feature and that more research will be required to understand the "social context underlying" the features and the full range of management activities that were carried out in these locations (Caldwell et al. 2012:230–231). Activities that might be represented range from "incidental clearing of beaches while digging clams, to extensive feats of engineering to enhance clam production and capture a range of marine taxa" (Caldwell et al. 2012:230). More specific interpretations of individual features await the results of ancillary studies, such as the contents of adjacent terrestrial sites, study of geomorphological settings, and traditional ecological knowledge.

Lepofsky et al. (2015) report investigations of clam gardens at several additional locations in British Columbia: near Bella Bella in Heiltsuk territory, Quadra Island in Laich-Kwil-Tach (Southern Kwakwaka'wakw) and Coast Salish territory, Grappler Inlet in Huu-ay-aht territory (Nuu-chah-nulth), and the Gulf Islands in Hul'qumi'num territory (Coast Salish; see also Grier 2014). They point out that knowledge of clam harvest and use is incorporated into songs, dances, and oral traditions (Lepofsky et al. 2015:243; see also Harper et al. 2005; Moss 1993, 2013a). Some of their First Nation interlocutors noted that the rock walls themselves attracted octopus (another key food) and that beaches that have not been periodically harvested for clams become "unhealthy, dead or dying" due to the lack of aeration (Lepofsky et al. 2015:241–242). They suggest that in some cases clam gardens created clam habitat in places "where none previously existed," and they are developing ways of dating clam gardens by sampling barnacle scars (Lepofsky et al. 2015). These investigators view clam gardens as signatures of ancient land tenure and traditional resource management systems.

Groesbeck et al. (2014:2) performed an experiment on Quadra Island, British Columbia, to determine if artificially constructed raised terraces in the intertidal zone increased clam growth productivity. They found that littleneck clams grew 1.7 times faster in clam gardens than outside of them, using nonwalled beaches as controls. Although we cannot know if the nonwalled beaches were adequate controls, nor can we rule out other variables, smaller clams were also more likely to survive in clam gardens when compared to nonwalled clam beaches. They found that clam gardens had four times the number of butter clams and twice the number of littleneck clams as nonwalled clam beaches. By reducing the slope of the beach, clam gardens expanded ideal clam habitat at tidal heights that provided optimal conditions for clam growth and survival. The authors suggest that studying indigenous management practices is useful not only for First Nations but for the potential application to global food production (Groesbeck et al. 2014:11). Groesbeck et al. (2014:11) also point out that the ability to produce food is a way to maintain autonomy, and that indigenous groups need to emphasize their "rights to access traditional lands and resources and secure sustainable food production into the future" (see also Jackley et al. 2016).

THEORETICAL APPROACHES TO CLAM GARDENS

Clam gardens, in addition to fishing weirs and traps, have become the focus of a new level of discussion about intertidal zone modification and resource management by indigenous peoples on the Northwest Coast. These archaeological features are understood to reflect resource stewardship, but the degree, intent, and intensity of modification and management may vary across time and geography. While many authors have acknowledged the need for integrated approaches in interpretation, sometimes studies assemble a bricolage of theories that stem from fundamentally different (and sometimes conflicting) orientations. We urge caution in applying each theoretical framework, as each has its limits. We suggest that applications of Western theoretical frameworks to indigenous practices run the risk of imposing modern Euro-American values and interpretations onto past lifeways. For this reason, when using theoretical frameworks and interpretations such biases should be acknowledged, so as to avoid potentially erasing indigenous understandings of what the frameworks seek to explain.

Optimal Foraging Theory and Niche Construction Theory both derive from evolutionary ecology and have become popular approaches to studies of hunter-gatherer subsistence strategies and behavior. Optimal foraging theory assumes humans will exploit resources and behave in certain, predictable ways to maximize and/or optimize available resources. Niche construction theory proposes that humans (and all other species) make changes both intentionally and unintentionally to their environments, which in turn alter selective pressures on the niche inhabitants and their descendants. Ethnographic analogy, oral history, and oral traditions have all contributed to what has become known as traditional ecological knowledge, an approach that has gained currency over the last thirty-five years. Through these kinds of studies, archaeological, ecological, and historical phenomena are better understood within the broader context of the cultural understandings provided by people with local, long-term, emic knowledge.

EVOLUTIONARY ECOLOGY

Evolutionary ecology has become a popular way to address food-acquisition strategies of hunter-gatherer societies, although for the Northwest Coast we prefer to conceive of these societies as fisher-hunter-gatherers (Moss 2010, 2011). Evolutionary ecology considers the interaction between "evolutionary forces" and ecological variables in the development of "specific adaptations" (Broughton and O'Connell 1999:153). The evolutionary ecology approach is well liked by many archaeologists, especially zooarchaeologists, because it provides ways to quantify, and even predict, which resources will be exploited in what sequence, and it allows for such predictions to be tested (Broughton and O'Connell 1999:154; Lupo 2007). Evolutionary ecology assumes societies will "adapt" to changing conditions in ways that "maximize fitness," regardless of the "mechanisms" that underlie the adaptation and whether the changing conditions are social or ecological (Broughton et al. 2010:373). Evolutionary ecology uses formal optimization models that address "fitness-related costs and benefits in specific socio-ecological contexts," and examines how human behavioral reactions to socioecological conditions "create novel selective pressures that in turn drive other changes in morphology and behavior" (Broughton et al. 2010:372). Optimization models should be used carefully, however. Bamforth (2002) has explained how food and nourishment in and of themselves do not equate with fitness in the Darwinian sense. One can be well nourished yet not reproduce, thus appearing less fit due to a lack of relative reproductive success (Bamforth 2002:438). Bamforth (2002:449) allows that optimal foraging models can be productive, but that "asserting unsubstantiated connections to evolutionary theory or simply using Darwinian terminology" will not help us understand how evolutionary processes have shaped our species.

BEHAVIORAL ECOLOGY AND OPTIMIZATION MODELS

Behavioral ecology also assumes that humans behave adaptively in response to environmental and social circumstances, and that these behaviors are "shaped by natural selection" (Bird and O'Connell 2006:1). It focuses more attention on "fitness-related behavioral trade-offs" that organisms confront in specific environments and the associated patterns of behavior (Bird and O'Connell 2006:2). Optimal foraging theory (OFT) presumes that "maximizing the rate of nutrient acquisition enhances fitness" (Bird and O'Connell 2006:4), a point with which Bamforth takes issue, as explained above. The frequently used OFT prey choice model aims to determine whether a hunter would take prey s/he encounters or continue searching for prey with a better energetic trade-off (Bird and O'Connell 2006:5). These optimization models assume that (1) prey will be encountered randomly, (2) higher-ranked prey (prey with a higher net energy yield) will always be taken, and (3) lower-ranked prey will be taken in the absence of encounters with higher-ranked prey (Bird and O'Connell 2006:5). The model assumes that a hunter-gatherer knows which prey is highly ranked and can calculate in the moment whether or not to take a prey species upon encounter (Bird and O'Connell 2006:5). If the prey are not dispersed randomly but found in patches, foragers will make decisions based on how productive a patch is and the cost of traveling to and from or staying in the patch based on net energetic yields (Bird and O'Connell 2006:5).

NICHE CONSTRUCTION THEORY

Niche construction theory (NCT) is a framework in which the activities of humans or other organisms modify their environments by engaging in ecosystem engineering (Fuentes 2009:172; B. Smith 2011), therefore altering the selective pressures on themselves and their descendants (Broughton et al. 2010:372). The primary goal of environmental engineering is to "increase [the human] share of the annual productivity of the ecosystems they occupy" by manipulating plant and animal resources for "both [. . .] abundance and reliability" (B. Smith 2011:836). NCT aims to predict changes in "human phenotypes as a result of changes in socio-ecological conditions"; niche construction is conceived as driving changes in phenotypes (Broughton et al. 2010:373). Theorists allow that changes in phenotypes or behavior can also result from cultural transmission or from patterns of persistence and variability in technology, without resulting in genetic change (Broughton et al. 2010:374; Laland et al. 2010:140). The oldest example of niche construction in the Americas may be that of late Pleistocene field burning in Amazonia, as claimed by Dillehay (2013:388–389).

Bruce Smith (2011:837) classifies niche construction activity into six types, and clam gardens neatly fall within with his sixth category: "landscape modification to increase prey abundance in specific locations." We argue that the investment of building clam gardens represents efforts to manipulate animal resources for "abundance and reliability" (B. Smith 2011:836). This idea is reinforced by Billy Proctor's experience (Harper et al. n.d.b) and Groesbeck's et al. (2014) experiment, which showed that clam garden construction increased yields and quality, which would in turn incentivize the behavior of creating the gardens and encourage subsequent transmission and persistence of the technology and associated cultural components across generations. Younger family members would inherit the modified intertidal environment from their parents, elders, or other teachers, a process sometimes called "ecological inheritance" (Odling-Smee and Laland 2011). Yet Grier (2014:233) has pointed out that NCT does not allow archaeologists to analyze the "critical social dimensions" of constructed cultural landscapes. For Grier (2014:234), ownership involves both the owners' institutionalized privilege and restriction of access by others, aspects of sociopolitics that NCT does not easily accommodate, nor are easily read from the archaeological record.

OPTIMAL FORAGING THEORY AND PATCH CHOICE MODELS

Under a behavioral ecology framework, clam gardens might be placed under the "patch choice model." Because clam gardens are discrete entities, they form a "patch" in which the clam abundance, and the time required to handle and harvest the shellfish, should be predictable (Lupo 2007:149). After the initial investment of constructing the clam terrace or garden—be it building the wall, removing larger rocks from the substrate, or other modification—the handling time required to harvest more of presumably bigger clams (Groesbeck et al. 2014) should decrease. Following Monks's (1987) "prey as bait" model, patch creation would also decrease search and handling time for other species lured to the clam garden, for example, octopi hiding among rocks (Lepofsky et al. 2015). In some ways, this "prey as bait" model is analogous to "garden hunting" (B. Smith 2011) in that the constructed niche attracts other species beyond the ones initially targeted. As mentioned above, these models require some assumptions that clam gardens will or will not be harvested based on net energetic yields (Bird and O'Connell 2006:5; Lupo 2007:149). Behavioral ecology assumes random encounter rates, which may therefore preclude its application to clam gardens, which are intentionally constructed and purposefully harvested. If behavioral ecology does not allow for nonrandom encounters, then clam gardens fit better within a NCT framework.

TRADITIONAL ECOLOGICAL KNOWLEDGE

Traditional ecological knowledge (TEK) has its roots in old-fashioned ethnography. Many an anthropologist working in Alaska or along the Northwest Coast knows that working with local people "on the ground" yields experiential insights into how weather, access, and technology facilitate use of a variety of natural resources (water, plants, animals) essential for human survival and success in challenging environments. We now understand that most environments have long histories of human-environmental engagement and are not "pristine" or "natural." Traditional ecological knowledge describes aboriginal, indigenous, or other forms of traditional knowledge regarding "the relationship of living beings (including humans) with one another and with their environment" (Berkes 1999:8). Johnson (1992:4) defined TEK as:

> knowledge built up by a group of people through generations of living in close contact with nature. It includes a system of classification, a set of empirical observations about the local environment, and a system of self-management that governs resource use. The quantity and quality of traditional environmental knowledge varies among community members, depending on gender, age, social status, intellectual capability, and profession. . . . With its roots firmly in the past, traditional ecological knowledge is both cumulative and dynamic, building upon experiences of earlier generations and adapting to new technological and socioeconomic changes of the present.

Although TEK has become widely recognized in academic scholarship and by policy makers over the last thirty-five years, from this definition we can see how deeply Western categories and concepts are embedded in such a pursuit. Few indigenous languages have translations for the words, "ecological" or "management" or "governance" (Nelson 2005:293). Inherent in most indigenous knowledge systems is the idea that the "natural" is not separated from the "cultural" world. As Nelson (2005) has pointed out, defining TEK is a bit like defining culture, and sometimes the definitions closely resemble each other. What we might parse as "ecological" or "environmental" knowledge is encompassed within a larger intellectual knowledge system that incorporates "all aspects of reality, the entire human social environment" (Nelson 2005:293). By dissecting what is termed "ecological" or "empirical," Western science loses the larger sociocultural, religious, and spiritual context of indigenous ways of knowing. Nelson (2005:304) shows that when TEK is treated as an authoritative object rather than situated knowledge, it is vulnerable to criticism or refutation, missing the point entirely. Instead of addressing indigenous resource rights or critical habitat loss, the scientific pursuit is then focused on the "accuracy" of TEK. For example, Hensel and Morrow (1998) described how many Alaska Natives were unaware of or uninterested in hunting and fishing regulations, and have simply continued to hunt and fish. Anthropologists have studied Alaska Native subsistence with the intent to document traditional ecological knowledge, to benefit Alaska Natives, fish and wildlife managers, and fish and wildlife themselves (Moss 2010). Although researchers have sought TEK, Hensel and Morrow (1998:70) warn that "decontextualizing pieces of local knowledge and reincorporating them as information in scientific reports seriously misrepresents indigenous perspectives." Thornton (2001:95) observed that "agencies tend to pursue TEK in an acquisitive and colonizing manner not unlike that of artifact hunters in the nineteenth and early twentieth centuries." Hensel and Morrow (1998:70) showed how different worldviews led managers and Alaska Natives to talk past each other: "Conservation for biologists concerns population numbers and future reproduction. For traditional Yupiit, it concerns proper human behavior." In this way, biological discourse itself, such as an announcement that "no fish are available," can become a self-fulfilling prophecy as it upsets the animals upon which the Yupiit depend (Hensel and Morrow 1998:70). Attempts at "co-management" may be well meaning, but power inequalities inhere in the relationship between managers and Alaska Native and First Nation communities.

With regard to clam gardens in British Columbia, ethnographic information and TEK have been documented from First Nations (e.g., Harper et al. 2005; Lepofsky et al. 2015). One principle that has been repeatedly stated is that the more you dig, the more productive the clam bed. In Southeast Alaska, we have yet to gather specific TEK knowledge related to building, maintenance, or use of clam gardens, and these practices are not described in the region's ethnographies. Yet critical aspects of shellfish use are incorporated into Tlingit intellectual traditions, as will be discussed below.

RESOURCE INTENSIFICATION AND THE RISE OF SOCIAL COMPLEXITY

Clam gardens have also been viewed as evidence for resource intensification (Groesbeck et al. 2014), and in association with social factors and systems that restrained and/or regulated harvests for a variety of purposes (Campbell and Butler 2010; Grier 2014; Groesbeck et al. 2014; Smith and Wishnie 2000). The idea of resource intensification enabling the rise of social complexity is commonly cited in the development of Northwest Coast complexity, primarily with regards to the mass capture of salmon (Carlson 1998; Fladmark 1975; Moss et al. 1990). At Namu, for example, salmon were the principal staple food more than 6000 years ago (Cannon 1991). Because fishing weirs and traps involve mass capture of salmon (and/or other species), researchers have often linked the development of weir and trap fishing to other technological or socioeconomic "advancements" (Byram 2002:2, Caldwell 2008; Eldridge and Acheson 1992; Greene et al. 2015; Moss et al. 1990; Moss and Erlandson 1998; but see also Elder et al. 2014; Langdon 2006; Losey 2010; and Moss 2013b for other emphases). If we lump clam gardens along with weirs/traps and other intertidal modifications, one might argue that they also contributed to social complexity and represent resource intensification beyond a niche construction interpretation (e.g., Grier 2014). Groesbeck et al. (2014:2) viewed use of clam gardens not only as evidence of First Nations making landscape alterations to increase clam yields but also as an indication of "complex systems of resource management." Groesbeck et al. (2014:9) also refer to land tenure systems and portray clam gardens as intentional cultural investments that aim to maintain resource sustainability.

CONSERVATION AND RESOURCE MANAGEMENT

Along similar lines of thinking, clam gardens can be interpreted as evidence of deliberate conservation and resource management. Yet Smith and Wishnie (2000:493) caution against characterizing small-scale societies as "conservers or even creators of biodiversity," and argue that "conservation" should be restricted to cultural phenomena that have been explicitly designed to "prevent or mitigate resource overharvesting or environmental damage." That a way of life or a cultural practice appears sustainable does not necessarily indicate deliberate conservation, according to Smith and Wishnie (2000:508). They suggest certain societal features make a group more or less likely to engage in conservation, such as if they control access to land or physically confine resources (Smith and Wishnie 2000:505–506). Inferring such "social parameters" from the archaeological record that enforce rules regarding resource use is easier said than done. Groesbeck et al. (2014:9) wrote that "territorial access rights, via family-based proprietorship" formed a "governance system" that may be responsible for the productivity of the clam garden. While control over resources may have resulted in resilience and prevented overharvesting, we believe one should be wary of declaring social systems and ownership as deliberate attempts to conserve resources as Smith and Wishnie require. Indigenous groups may have different definitions for "conservation" than non-indigenous scholars, who advocate what might be considered a modern (and ethnocentric) approach derived from scientific models adopted by contemporary national, provincial, and state governments today. The term *management* itself may be offensive to some indigenous groups.

In the book *Northwest Coast: Archaeology as Deep History*, Moss (2011:45–46) described the fisher-hunter-gatherers of the Northwest Coast as resource stewards who had "vested interests in maintaining the resilience of the ecosystems of which they were a part," using concepts and terms that derive from a contemporary resource management perspective. The term *stewardship* is also used in *Staying the Course*, a review of TEK among coastal First Nations and their relationship with the environment and desire for sustainability (Brown and Brown 2009). Although such approaches have been productive in acknowledging the practical wisdom embedded in indigenous practices of the past, they can also incorporate ethnocentric or Western notions that may or may not be relevant to the archaeological phenomenon under study.

Cannon and Burchell (2009) identified an archaeological pattern they interpreted as evidence of management and resource conservation of shellfish beds on the central coast of British Columbia in Heiltsuk territory. Cannon and Burchell examined the growth-stage profiles of *Saxidomus gigantea* shells and found more intensive harvest of sites farther away from the long-term residential sites and less intensive harvest nearby. In other words, occupants of the longer-term residential sites had preserved some proximate shellfish beds as "insurance," resources they could draw upon in times of need. Intensity of harvest was gauged by the relative proportions of senile-stage vs. mature-stage clams. In Cannon and Burchell's (2009:1059) words, "[t]he predominance of senile specimens at long-term residential sites, especially villages, is therefore strongly indicative of less intensive harvest and, potentially, active conservation efforts." They argue that if clam beds are owned, people can choose to allow them to "lie fallow" for a time to sustain their productivity, and that this practice has a 7000-year antiquity at Namu (Cannon and Burchell 2009:1059). The authors go on to suggest that clam gardens "might then simply represent a further stage in a much longer regional history of regulation and maintenance of clam production" (Cannon and Burchell 2009:1059). Cannon and Burchell make a good case for regulated harvest and management and conservation of the type Wishnie and Smith (2000) consider rare among foraging societies. Pierce (2011) showed that Cannon and Burchell's growth-stage method could also be used with littleneck clams.

CLAM GARDENS AND PARALYTIC SHELLFISH POISONING

One topic conspicuously absent from the theoretical discussion thus far is that clams, especially butter clams (*Saxidomus gigantea*), are susceptible to paralytic shellfish poisoning (PSP), posing a serious risk to people consuming them. When people consume shellfish contaminated with toxic phytoplankton (dinoflagellates in the genus *Alexandrium*, formerly thought to be *Gonyaulax*), death can occur within hours (Horner 1996:8; Moss 1993). Moss and Bean collected *Saxidomus* from the Magoun Clam Garden on July 29, 2011, but chose not to consume them because the Alaska Department of Environmental

Conservation had issued warnings that were being broadcast on the local public radio station, KCAW. Although the incidence of PSP has increased in the past few decades, probably due to climate change and pollution (Claassen 1998:33; Martin 2015a, 2015b; Wright et al. 2008), we know from ethnographic and early historical data that PSP is not exclusively an industrial phenomenon.

Twenty-one molecular forms of saxitoxin cause PSP; the name derives from the genus name for butter clam, *Saxidomus*, from which they were first identified (RaLonde 1996a:1). Saxitoxins are neurotoxins that lead to tingling around the mouth, numbness, vomiting, diarrhea, and double vision, followed by respiratory paralysis and even death (Fortuine 1975). As RaLonde (1996a:2) has described:

> The toxicity of PSP toxins is estimated to be 1,000 times greater than cyanide and symptoms appear soon after consuming toxic shellfish. There is no antidote for PSP, and all cases require immediate medical attention that may include application of life support equipment to save a victim's life. If the dosage is low and proper medical treatment is administered, symptoms should diminish in approximately nine hours.

Although most toxic algal blooms in Alaska tend to occur in May, June, and July, toxins can be retained in the ecosystem, reproduce, and "bloom" in other months (Gessner 1996; RaLonde 1996a). Winds, tides, and ocean currents can also concentrate or disperse toxic algae. Butter clams have a "distinctive ability" to chemically bind saxitoxin, which they can retain for up to two years (RaLonde 1996a:4). The earliest known historical incidence of paralytic shellfish poisoning in Tlingit territory occurred in 1799, when 135 Koniag men hunting sea otters for the Russian American Company died from eating mussels on Chichagof Island (Khlebnikov 1976:145; Tikhmenev 1978:110). In 1801, three Europeans from the *Atahualpa* ate mussels from a beach near a Chilkat village, suffering horribly. Yet William Sturgis explained that the "Indians distinguish them [poisonous mussels] and eat the others without any ill effects" (Jackman 1978:119–120). We know that mussels can accumulate more than 20,000 micrograms (μg) of saxitoxin per 100 grams of tissue, substantially more than butter clams (7750 μg) or littleneck clams (580 μg). Yet the Food and Drug Administration (FDA) considers anything more than 80 μg to be unsafe (RaLonde 1996b:10–11). In both historical cases, the victims of shellfish poisoning were foreigners to Tlingit territory, probably unfamiliar with local conditions. Shellfish are also subject to amnesic shellfish poisoning (ASP) and diarrhetic shellfish poisoning (DSP).

Moss (1993) suggested that the unpredictable nature of shellfish toxicity helped explain some of the ambiguities regarding the economic importance of shellfish as well as the emic view of shellfish as associated with poverty, laziness, and ritual impurity. Certainly, intimate geographic knowledge played a role in avoiding toxic shellfish; certain shellfish beds apparently were more vulnerable to poisoning than others (de Laguna in Emmons 1991:149). Traditional Tlingit warnings against shellfish consumption "when the grouse hoots" or "when the herring spawn" in the spring (Newton and Moss 2005 [1984]:17) may reflect awareness of PSP. Emmons (1991:149) documented Tlingit use of emetics to treat mussel poisoning. PSP was a real danger, and probably accounts, at least in part, for negative attitudes toward shellfish on the part of the Tlingit (Moss 1993). Although the archaeological record demonstrates many Tlingit people relied heavily on shellfish, the elite claimed not to have subsisted on shellfish. Tlingit ideology points to an ethic in which social rules regarding shellfish consumption were applied differentially based on gender, rank, and life stage. Moss (1993) further argued that the social and symbolic meaning of shellfish to the Tlingit made sense because of the danger of paralytic shellfish poisoning, a risk those at the top of the social hierarchy could avoid more often than those in the middle or the bottom.

Elsewhere on the Northwest Coast, other groups also heavily relied on shellfish as a food source while simultaneously having "mixed feelings" about their value. Other Northwest Coast groups associated status with particular foods, as did the Tlingit. While the Tlingit highly valued seal, silver salmon, and eulachon grease, shellfish were associated with sickness and poverty, similar to some Tsimshian thinking. As they did for the Tlingit, shellfish had sexual associations for the Haida (Moss 1993). The association of shellfish with female sexuality is consistent with Northwest Coast–wide taboos on sexual activity. When men prepared for hunting expeditions, they and their wives refrained from sexual relations and shellfish consumption to ensure good luck in the hunt.

Moss (1993) suggested that the scarcity of ethnographic information about Tlingit shellfish use was the result of both androcentric bias on the part of ethnographers and also the social and symbolic value attached to shellfish by the Tlingit themselves. More recently, Moss (2013a) described a similar dynamic evident in Kwakwaka'wakw sources. Kwakwaka'wakw villages had a line of houses in a row parallel to the beach and in front of them was a street. On the sea side of the street were the "small shacks used by menstruating women, sick people, widows, and the infirm. . . . On the beach, too, were the latrines: holes dug in the sand near enough to the sea to be flushed out at high tide" (Ford 1941:11). The beach was therefore an unclean place from the standpoint of ritual purity. Harper (pers. comm. 2009) noted that clam gardens are rarely located in front of large village sites; perhaps it was important to dig clams in more remote areas away from the previously mentioned activities that occurred on the beach in front of a village, to avoid contaminated clams. This might be an alternative explanation for patterns described by Cannon and Burchell (2009) in intensity of clam harvest in sites proximate to and distant from villages like Namu.

To the Kwakwaka'wakw, the beach and shellfish were both impure, with female associations. As Berman (1992:140) observed, a Kwakwaka'wakw woman's "legitimate trips to gather food might be used as a cover for her illicit affairs." Berman recounted a story in which a woman collecting cockles had intercourse with her husband's brothers (Boas and Hunt 1905:282–287). A secluded locale along the beach was often the place for illicit sexual activity. This is similar to a story about an adulterous Tlingit woman's use of clams to trick her husband so she could be with her lover (Moss 1993:642; Olson 1967:32). Harper (pers. comm. 2009) noted that most but not all clamming beaches required a canoe trip from the village; we have no additional data as to whether such trips were also occasions for illicit activity.

From other information described in Moss (2013a), we can infer an association between clams and poverty and low status among the Kwakwaka'wakw. Calling someone a "clam digger" or a "clam feeder" was clearly an insult. Sources mention old women looking for shellfish on the beach during times of starvation or famine (Boas 2002:297, 391). Daisy Sewid-Smith told John Harper (pers. comm. 2009) that "sometimes the salmon runs failed" and then the tribes relied on clams. As Harper suggested, clams provide a way to buffer risk when faced with scarcity of key resources. Shellfish have functioned as a famine or "fall-back" food, used in times of economic desperation. Among the Kwakwaka'wakw, high-status foods were those presented at feasts: seal, oolachan oil, cranberries mixed with oolachan oil, and mountain goat fat (Berman 1991:261–262).

In his treatise *Geographical Names of the Kwakiutl Indians*, Boas (1909:13, 18) recorded a number of shellfish-related place names in Kwakw'ala, including words that translate to: having horse clams; having clams; having mussels; having sea eggs; having poisonous clams; of mussels on rock; of cooking chitons; of clam digging. On Boas's Map 10, "Kingcome Inlet," which encompasses the Broughton Archipelago clam gardens documented by Harper et al. (1995), three localities are marked as having clams or clam digging, one with mussels, another with small mussels, another with giant chitons, and another with sea eggs (Boas 1909). The practice of naming these places indicates that these locales and the resources they contained were widely known, used, and remembered. This supports the idea that various shellfish taxa were of economic and social importance. Yet on this same map, locality 16 is *dzo' dzade*," "having clam poisoning" (Boas 1909:13), and locality 121 is *do yade*, "having poisonous clams." The distinction between the two words and their usage is not clear. Also on Map 10 are two marked localities that are translated to "having rotten clams," although they are two different words (*ku'nxade* and *kwe'kungade*; Boas 1909:Map 10). Whether rotten clams are distinct from poisonous clams is also unclear. On Map 6, "Fort Rupert and the north coast of Queen Charlotte Sound," one place is marked as having clam digging and another as where chitons are cooked, but there is another "place of clam poison" (*do'yas*; Boas 1909). On Map 8a, "Lower Part of Nimkish River and Alert Bay," locality 44 is *dzo'dzis*, "poison clams on beach" (Boas 1909). Although more maps contain references to different shellfish taxa, the following maps contain clam-related localities without any places marked as hazardous: Maps 3, 4, 8, 11, 14 (Boas 1909). Taken together, these Boas maps document that the Kwakwaka'wakw had very specific geographic knowledge as to where clams were safe and where they were not.

Other sources confirm that the Kwakwaka'wakw were aware that poison clams were caused by the "red tide" (Walens 1981:123). It seems likely that the hazards of shellfish toxicity were one of the reasons for mixed feelings about the value of shellfish. The Kwakwaka'wakw clearly were aware of the dangers of consuming shellfish, and some of the protected waters within their territory must have been at risk of contamination. Kwakwaka'wakw territory overlaps with one of three main centers of shellfish toxicity in coastal British Columbia (Gaines and Taylor 1985).

Although I have not pursued all ethnographic sources for all coastal First Nations in British Columbia, the Tla'amin (2012) explain on one of their websites that although clams have always been an important part of their diet, they were harvested especially during the winter "when there was no danger of eating shellfish contaminated by red tides (also known as paralytic shellfish poisoning)."

All of this suggests that Northwest Coast people were well aware of health risks posed by clams, and such knowledge certainly must have figured into people's choices about where to collect clams and where to build clam gardens. For clam gardens, sites located at some distance from villages with good ocean circulation were probably preferred. This topic has not been explored in recent studies of clam gardens but must certainly help account for their spatial distribution across the Northwest Coast. While the Magoun Clam Garden is located a substantial distance from present-day Sitka, it occurs along a narrow waterway in which the circulatory conditions have not been documented. Furthermore, the Magoun Clam Garden is but a single example; obviously, additional survey work is necessary to examine whether or not it is part of a broader pattern of clam garden construction across Tlingit territory.

CONCLUDING THOUGHTS ON CLAM GARDENS: WHAT'S MISSING?

Although clam digging is often assumed to be a simple task, and clams are assumed to be abundant and reliable resources, a great deal of technical local knowledge is involved in knowing where and when to gather clams safely. The places people chose to build clam gardens certainly must have fulfilled a variety of criteria archaeologists have yet to recognize or adequately document. Nearly all the theoretical frameworks discussed here provide productive ways to think broadly about the role of clam gardens in indigenous coastal cultures of Alaska and the Northwest Coast. Each has limitations, and all suffer from different types of biases, so we urge explicit recognition of these shortcomings when invoking these theories. We agree that in many cases, intertidal zone modifications may have served different functions over time, with diverse cultural, behavioral, and symbolic meanings. They have formed an ecological inheritance and persistence of technology and "management" across time to the present day, and it is important to consider these archaeological features in their full cultural context. The Magoun Clam Garden is a single example, but it is the first clam garden to be recorded on the Alaska Heritage Resource Survey in the State of Alaska. Additional survey work during low tides is necessary to document other clam gardens preserved in the intertidal zone. The success of fishing weir and trap surveys across Southeast Alaska (Moss 2013b; J. Smith 2011) should make us optimistic about the prospect of identifying additional clam gardens in Tlingit territory. We also hope to be able to use aerial photography more effectively to identify likely clam gardens within the Tlingit region. In the meantime, we suggest that in our enthusiasm to document clam gardens, we not forget the risks of consuming clams, at least at some times and in some places. By evaluating the practical constraint of the vulnerability of clams to paralytic shellfish poisoning and other sources of contamination in different settings, we might more comprehensively understand the archaeological patterning of clam gardens across the North Pacific coast.

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