

PHOTO DIARY

Ancient Ecology: The Quadra Island Clam Gardens

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With an exceptionally high density of long-term habitat sites, Northern Quadra Island hosts numerous clam gardens adjacent to large village sites. Photo Credit: Kieran Cox, Hakai Institute.

For millennia, humans around the world have managed terrestrial and marine ecosystems. Along the northeastern Pacific, First Nations and Native Americans sustained large, vibrant populations by developing diverse resource management strategies that increased food production and food security. The legacy of these practices continues to shape coastal ecosystems today. Beginning some 3,500 years ago, Indigenous Peoples of the northeastern Pacific coast created and enhanced clam habitat and clam production by building “clam gardens”—intertidal rock walls and associated soft sediment terraces. These cultivated ecosystems provide easy to access, predictable, and abundant shellfish and other species that are staple foods among coastal communities. The tending of bivalves in clam gardens in the northeastern Pacific is part of a larger system of resource management that spans terrestrial and marine environments, and encompasses cultural knowledge and practices about how to interact with human and non-human beings.

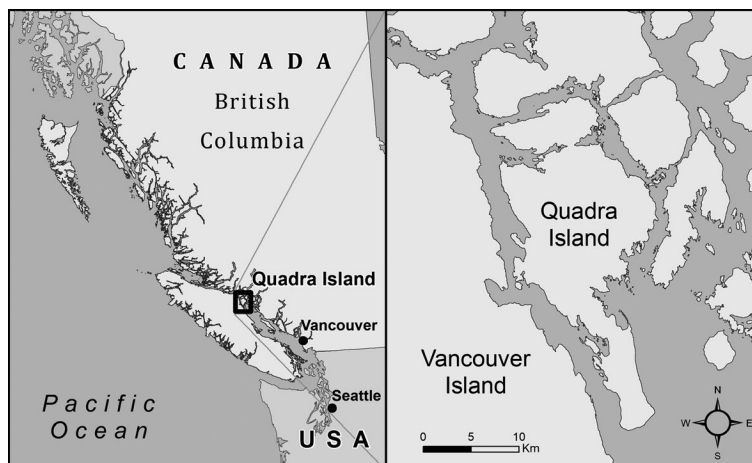
Clam gardens, and the knowledge that is embedded within them, have been a central part of the lives of coastal First Nations for millennia. Despite this, western scholars were slow to understand their importance, and indeed their existence. This was in large part because of preconceived notions that northeastern Pacific Indigenous peoples were “hunter-gatherers” rather than cultivators, who were not intimately connected to or knowledgeable about their lands and seas. In the case of clam gardens, these preconceptions disintegrated in the early 2000s when Kwakwaka’wakw Clan Chief Kwaxistalla Wathl’tla Adam Dick shared his cultural knowledge about clam gardens with coastal geomorphologist John Harper and ecologist Mary Morris, who had observed extensive intertidal rock walls running parallel to the shore while mapping coastal habitats within the Broughton Archipelago for British Columbia’s Ministry of Sustainable Development. This led to a cascading wave of recognition on the part of the western scientific community about the central role that clam management played in ecosystem creation and management on the northeastern Pacific coast.

Since that time, there has been a burgeoning of research on clam management and clam gardens, and a subsequent revitalizing of the ecological and cultural importance of these management systems. Much of this research is founded on collaborations between indigenous knowledge holders and

western scientists (some of whom are indigenous themselves), and reflects a sharing of knowledge and goals that have resulted in new discoveries. Many of these cross-community conversations about and explorations of clam gardens are facilitated through the Clam Garden Network, a group interested in the current social and ecological context of traditional clam management. To date, clam gardens have been identified along many parts of the northeastern Pacific coastline, including southeast Alaska, Haida Gwaii, the north and central coasts of British Columbia, the east and west shores of Vancouver Island, the Gulf Islands and San Juan Islands of the state of Washington.

The clam gardens on northern Quadra Island, within the Discovery Islands located off the east coast of Vancouver Island, British Columbia, have been the focus of many ecological and archaeological studies by various members of the Clam Garden Network. Quadra Island lies within the traditional territories of the Northern Coast Salish and Kwakwaka’wakw First Nations. The oceanographic and geophysical characteristics of the area support productive and diverse bivalve communities, of which Indigenous People were the beneficiaries. Intensive indigenous settlement is reflected in the area’s abundance, variety, and age of archaeological sites, including clam gardens and settlements composed of thick layers of clamshells. Today, local First Nations continue to harvest clams from the clam garden beds, but the gardens are not managed with the same intensity as they were during prior millennia.

Clam garden research on Quadra island brings together researchers from diverse disciplines, with varied knowledge and toolkits. For instance, research developed by Nicole Smith, Dana Lepofsky, Christina Neudorf, Louie Wilson, Christine Roberts, Ginevra Toniello, Olav Lian, and Keith Holmes as part of an on-going collaboration between the Hakai Institute and the Clam Garden Network, focused on determining the age of clam gardens. To date the gardens, they employed various techniques including, radiocarbon dating of barnacle scars and shells trapped within and at the base of the wall; optical luminescence dating to determine the last time the beach sediments under the walls were exposed to sunlight; and comparisons of wall heights to former shoreline positions. The team determined the clam gardens are at least 3,500 years old.



Due to its rich cultural history Northern Quadra Island, British Columbia, has been the focus of numerous archaeological, ethnobiological, and ecological research. Map generated by Keith Holmes, Hakai Institute.

Surveys of bivalve communities, transplant experiments, and biophysical assessments lead by Anne Salomon and her team of Amy Groesbeck, Kirsten Rowell, Dana Lepofsky, Natasha Salter, Louie Wilson, Christine Roberts, and Marco Hatch, have revealed that clams in clam gardens can be twice as productive as beaches without constructed clam gardens due to more favorable ecological and oceanographic conditions in the gardens.

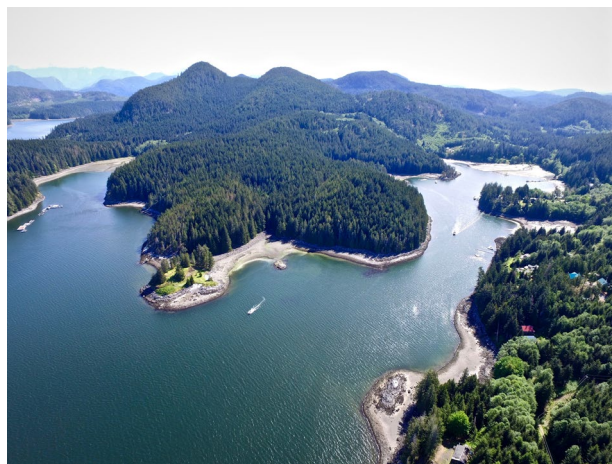
Motivated by ecological observations of Indigenous Peoples, ecologists Sarah Dudas, Kieran Cox, and Morgan J. Black, in collaboration with the Hakai Institute, have evaluated the effects of clam gardens on a range of coastal biota. To do this, they conducted annual surveys of the fish and invertebrate communities at multiple clam gardens and unwallled beaches throughout Northern Quadra Island and Calvert Island on British Columbia's central coast. Taking a holistic approach to assessing biodiversity responses has allowed these ecologists to expand the scientific understanding of clam gardens beyond bivalves, and quantify how entire ecological communities benefit from the presence of garden walls.

The ecosystem and food system benefits of clam gardens extend beyond the soft sediment beach to the rock wall. The clam garden walls contain elevated biomasses of a wide variety of traditional foods, including red rock crabs *Cancer productus*, sea cucumbers *Holothuroidea* spp., snails, and a variety of seaweeds. At first glance, clam rock walls appear to be more structurally complex than nearby unmodified rocky beaches, with clam gardens having higher rugosity and interstitial space. The Coastal Communities and Ecology Lab, developed by Marco Hatch at Western Washington University with support from Northwest Indian College, is working to understand the role of habitat complexity in supporting traditional Coast Salish food systems. Hatch and his graduate student, Amy Cline, are assessing habitat complexity and environmental factors present along with a variety of rocky beaches, including clam garden rock walls, to predict the quantity and type of Coast Salish foods present in the region. Based on their findings within the northeastern Pacific, Hatch and his team hope that illuminating the role of human-mediated habitat complexity in providing traditional foods will broaden our understanding of the importance of clam gardens.

Measuring the physical structure (e.g., wall heights, design, and relative age) of clam gardens is critical in understanding their construction, geography, and history. However, mapping clam gardens presents a unique challenge as these structures are exposed only during very low tides. Annually, there are a handful of days during which the tide level is sufficiently low for long enough to allow these extensive rock walls to be mapped. This challenge led the Hakai Institute geospatial team to find creative ways to survey these features. The team used remotely piloted aerial systems (i.e., drones) to map clam gardens, which allow for rapid high-resolution imagery collection and the ability to generate a three-dimensional model of the shoreline. With a short low tide window to capture imagery, field mapping methods are focused on speed and accuracy. Prior to the drone flight, surveyed targets are distributed throughout the study area. These targets are later used to spatially reference the data and build accurate three-dimensional models of the exposed shoreline. High elevation drone flights capture the extent of the clam

gardens in the larger study area while lower altitude flights reveal the structural complexity and more detailed elevation data. These data are used for comparative and historical analysis that are useful to both archaeologists and ecologists today.

Results from the drone surveys on Quadra Island revealed an extensive 15 km of clam garden rock walls. Centimeter resolution imagery and elevation models were used to determine the distribution and age of these structures. Advances in drone technology have made it practical to create accurate digital models for these elusive ancient landscapes. Digital three-dimensional modelling of clam gardens from drone



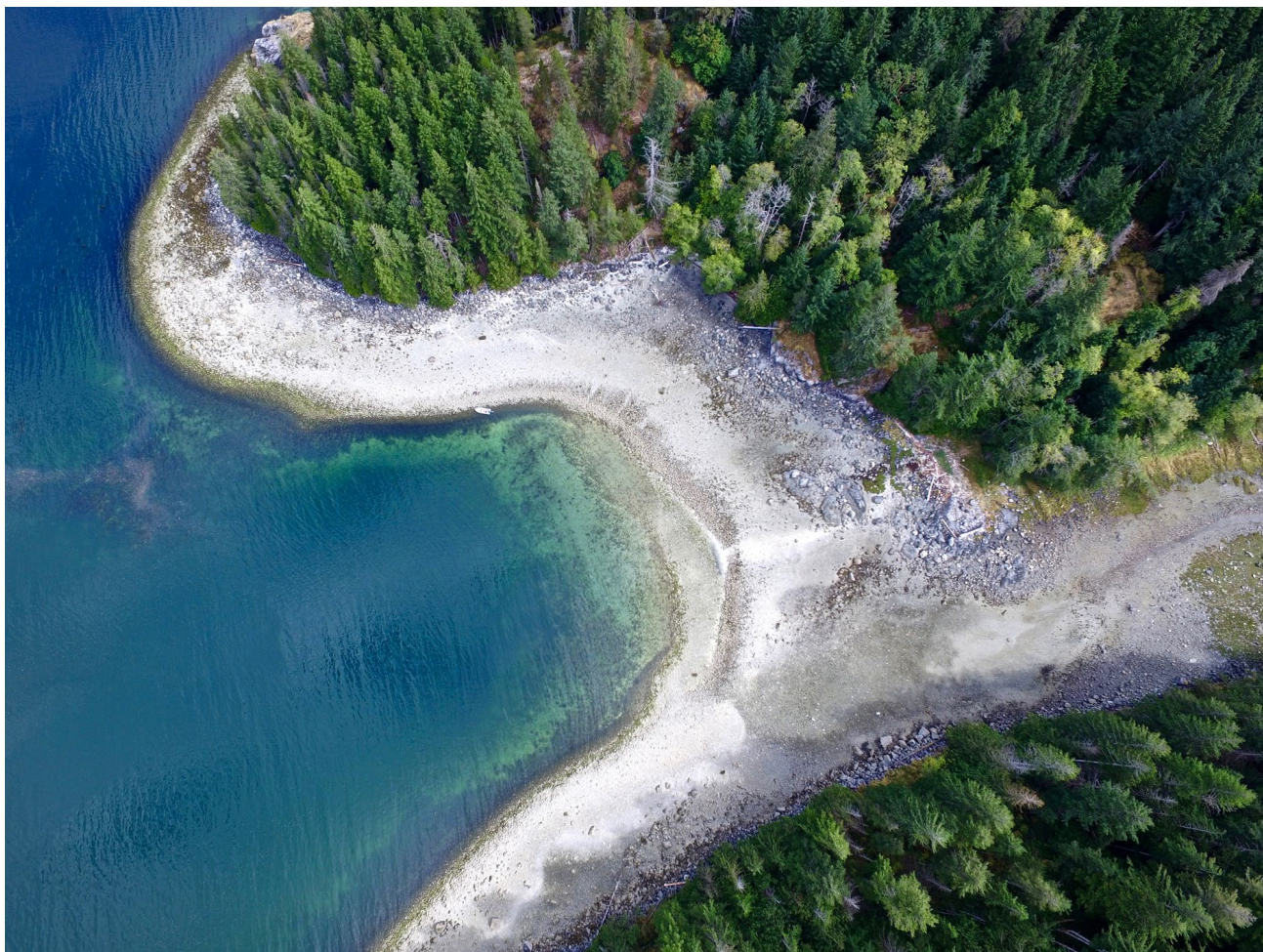
Northern Quadra Island, British Columbia. The Hakai Institute's geospatial team has currently mapped 42 km of shoreline, with 15 km found to have clam garden rock walls visible at low tide. Photo Credit: Keith Holmes, Hakai Institute.

imagery will allow future analyses to be done. Measuring transect lines, elevation points, and habitat complexity metrics are all possible without the threat of the tides sweeping researchers away.

Research into clam gardens along the West Coast of North America is an interdisciplinary and cross-cultural effort involving numerous partners, including the Clam Garden Network, Gulf Islands National Park Reserve, Hakai Institute, Heiltsuk Tribal Council, Northwest Indian College, University of Victoria, Simon Fraser University, Royal Roads, Western Washington University, University of Saskatchewan, and other academics ranging from Alaska to Washington. Using an array of techniques, these researchers are investigating a range of topics including, species responses, habitat alterations, and the role that maintaining clam gardens plays in ensuring healthy ecosystems. Although these structures have played a role in shaping coastal ecosystems for millennia and have been a critical part of sustainable marine resource management that existed for thousands of years, they have yet to be fully understood by the scientific community. However, through the hard work and collaborative effort of many individuals, we are one step closer to understanding another part of the history of coastal ecosystems.

Project Partners

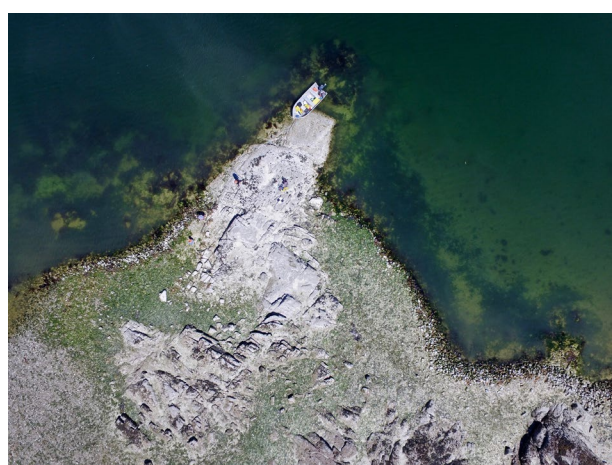
A collaboration between the Hakai Institute, Clam Garden Network, Ecological Interactions Research Program, and the Coastal Marine Ecology and Conservation Lab, has



In specific instances, multiple rock walls were built. Radiocarbon dating suggests that construction of staggered walls may have been potentially to compensate for changing sea levels. Photo Credit: Keith Holmes, Hakai Institute.



Conducting aerial surveys at low tides revealed the cultural modified landscapes only visible at very low tides, including the anthropogenic rock walls surrounding this small island. Photo Credit: Keith Holmes, Hakai Institute.



Aerial surveys reveal the extent to which clam gardens shape coastal ecosystems. An extensive rock wall can be seen adjacent to the waterline, which extends the bivalve habitat by as much as 15 m past its natural shoreline. Photo Credit: Keith Holmes, Hakai Institute.



Archaeologists Nicole Smith, Dana Lepofsky, and Ginevra Toniello take samples from within the clam garden beds to date when they were built and last actively used. Note the dinner plate sized boulders that line the rock wall for nearly 200 m in this area. Photo Credit: Keith Holmes, Hakai Institute.



As clam gardens are submerged the majority of the time, portable fish weirs deployed along clam garden walls play a critical role in evaluating how higher trophic levels respond to clam gardens. Photo Credit: Kieran Cox, Hakai Institute.



To determine the relationship between habitat complexity and indigenous foods, a series of transects were completed along a gradient of rocky intertidal complexity, ranging from low rugosity bedrock to complex clam garden rock walls. Results of these surveys will illuminate the impact of clam gardens on indigenous food systems beyond bivalve production. Photo Credit: Marco Hatch.

formed a multi-faceted research initiative currently researching clam gardens. Keith Holmes joined the research effort as a geospatial scientist at Hakai Institute, and maps coastal ecosystems and species across the coast of British Columbia. Similarly, Sarah Dudas' association with the clam gardens started when she joined the Clam Garden Network and the Hakai Institute. Dudas' research focuses on the influence of human activities on coastal ecosystems. As PhD candidates and Hakai Scholars supervised by Dudas, Kieran Cox and Morgan J. Black focus on investigating what drives marine biodiversity in coastal ecosystems and how biodiversity



Mapping coastal habitats is a rigorous process that requires utilizing ground control points to allow for resulting images to be georeferenced. The use of unmanned aircraft systems have shaped and will continue to shape the way coastal and marine ecosystems are mapped. Note the checkered GPS targets to be used to reference the three-dimensional model in a geographic information system. Photo Credit: Keith Holmes, Hakai Institute.

responds to habitat alterations. Dudas, Cox, and Black's work within clam gardens focuses on understanding how the hundreds of species that live within coastal systems respond to the presence of clam gardens. At the Coastal Communities and Ecology Lab at Western Washington University, Marco Hatch and Amy R. Cline are both actively involved in clam garden research. Hatch is a member of the Samish Indian Nation and assistant professor at Western Washington University. Cline is a Chukchansi Tribal member and a graduate student working with Hatch at Western Washington University. Cline began researching clam gardens with Skye Augustine and Hatch when she was a student at Northwest Indian College. Archaeologist Dana Lepofsky and marine



The resulting three-dimensional reconstructions can then be quantified using spatial analysis software to calculate an array of digital elevation metrics including surface complexity, slope, and rugosity. Photo Credit: Keith Holmes, Hakai Institute.



As research efforts expand along the central coast, the Hakai Institutes geospatial team has begun to map the unique cultural history of the coast, including investigations into clam garden within Kwakshua Channel, Calvert Island. The result of these aerial surveys will be combined with associated biodiversity assessment to further the knowledge surrounding how long term shellfish cultivation has shaped ecosystems along the coast. Photo Credit: Keith Holmes, Hakai Institute.



Coastal surveys into this topic are now being conducted along the central coast. Here, Krystal Bachen, Neha Acharya-Patel, Sarah Dudas, Josh Silberg, Adrienne Mason, and Kieran Cox converge on one of the Hakai Institute's biodiversity monitoring sites on Calvert Island as part of the ongoing biodiversity and clam garden research going on in the area. These labor-intensive coastal surveys requires a suite of researchers from various backgrounds. Photo Credit: Margot Hessing-Lewis, Hakai Institute.

ecologist Anne Salomon have been studying clam gardens around Quadra Island since 2008, and initiated the Clam Garden Network back in 2011. Archaeologist Nicole Smith



Scientific research into clam gardens has only just begun, and presents a unique opportunity to further our understanding on the history of coastal habitats, resource extraction, and human-ecosystem interactions that have persisted for millennia. Photo Credit: Kieran Cox, Hakai Institute.

started studying clam gardens in 2008 while working for Parks Canada and joined the Network in 2011. These researchers are just a few members of the diverse community who are currently researching the topic of clam gardens. More information of clam gardens, the Clam Garden Network, and on-going research on clam gardens can be found at www.clamgarden.com 