et al. 2008); on the ancient breeding and roosting of seabirds (Rick et al. 2009); and a host of other issues (see Braje 2010; Erlandson and Rick 2010; Kennett 2005; Rick 2007). Collectively, these data suggest that Channel Island ecosystems, like most systems around the world, have been influenced (positively and negatively) by ancient peoples, including hunter-gatherers, deep into the human past (see Habu and Hall, this volume; Milner, this volume; Redman 1999; Thompson et al., this volume). Such findings are not only important intellectually, but provide baselines and benchmarks that can help guide the management and long-term conservation of island ecosystems and organisms. In the case of Channel Island mammals, an important component of their histories has been the interactions with ancient Native Americans that spanned millennia. Given the concerted conservation efforts devoted to the endangered island fox (Coonan et al. 2002, 2005, 2010), increased research and conservation of island spotted skunks (Jones et al. 2008), the protection of island deer mice on Anacapa Island during rat eradication (see Howald et al. 2005; Pergams and Ashley 2002), and other studies and measures aimed at preserving the island's unique fauna, historical ecology and archaeology have much to offer these efforts. The key is better integrating archaeology, paleontology, and other historical disciplines with modern biological, ecological, and evolutionary data, and working collaboratively to transcend disciplinary boundaries.

Acknowledgments

This chapter is dedicated to Phil Walker, who transformed our understanding of the ancient ecology and human history of the Channel Islands and much more. I am greatly indebted to Todd Braje, Paul Collins, Jon Erlandson, Dan Guthrie, Courtney Hofman, Jesus Maldonado, Scott Sillett, René Vellanoweth, and Phil Walker for the conversations that helped shape my understanding of Channel Islands human and animal populations. I thank Victor Thompson and Jamie Waggoner for inviting me to participate in the 2009 SAA symposium, and T. Braje, P. Collins, Tim Coonan, C. Hofman, T. R. Kidder, V. Thompson, J. Waggoner, Chris Wolff, and anonymous reviewers for their insightful comments on this manuscript. Any errors of fact or omissions are solely mine.

4

Climate Change, Human Impacts on the Landscape, and Subsistence Specialization

Historical Ecology and Changes in Jomon Hunter-Gatherer Lifeways

JUNKO HABU AND MARK E. HALL

The purpose of this chapter is to use the theoretical framework of historical ecology to discuss key factors that affected changes in Jomon hunter-gatherer lifeways. As an example of prehistoric hunter-gatherer economies, data from the Jomon period (ca. 16,000–2,500 cal. BP) of the Japanese archipelago offers a unique opportunity to examine both short- and long-term changes in human-environment interaction. A large number of rescue excavations in Japan since the 1970s have provided us with fine-grained archaeological data with which to interpret the changing Jomon landscape in relation to the environment. Available lines of evidence include: (1) distribution of various types of sites (e.g., residential bases, processing sites, and ceremonial locations) and landscape features (e.g., roads, paths, and mounds), (2) macro and micro faunal and floral remains, and (3) tool assemblages. Signs of plant cultivation have been reported (e.g., charred seeds, pollen and phytoliths of cultigens), although none of the cultigens excavated from Jomon sites seems to have been an important part of Jomon diet, at least not in terms of quantity. Scientists have also suggested that climate changes, which affected vegetation and the availability of both terrestrial and marine resources, must have been closely linked with the changes in the Jomon culture.

Previous attempts by archaeologists to understand human-environment interaction during the Jomon period have focused primarily on: (1) modeling subsistence-settlement systems in relation to resource distribution (e.g., Akazawa 1980, 1987; Habu 2001), (2) finding cultigens to argue that the Jomon people were food producers, not hunter-gatherers (e.g., Crawford 2006, 2008; Yoshizaki 1995), (3) reconstructing environmental changes on the basis of macro and micro floral data, such as pollen (e.g., Fuji 1984), and (4) discussing the impact of climate change on people's lifeways (e.g., Yasuda 1989; Yasuda and Negendank 2003; Yasuda et al. 2004). So far, very few scholars have actively investigated the importance of human impacts on the Jomon landscape at the local or regional levels.

Historical ecology (e.g., Balée 1998, 2006; Balée and Erickson 2006; Crumley 1994a; Erlandson and Rick 2008; Kirch and Hunt 1997; Thompson, this volume; see also Hayashida 2005) can provide a useful theoretical framework to investigate the changing human-environment relationships through the Jomon period. There are several reasons for this. First, historical ecology emphasizes the impacts of human activities on their surrounding environment (see, e.g., Rick, this volume). This is particularly relevant in the context of Jomon archaeology, because the Jomon people were clearly engaged in a significant level of environmental management. For example, many scholars point out that Jomon people's plant utilization affected genetic characteristics of many edible plants, including chestnuts (Sato et al. 2003), elderberries (Tsuji 2002:242), and barnyard grass (Yoshizaki 1995). Thus, when we examine the process of Jomon subsistence intensification, we cannot avoid the issue of human impacts on flora and fauna at that time.

Second, historical ecology also emphasizes historically unique trajectories of human sociopolitical and economic systems in different parts of the world. Given that the long-term change in the Jomon culture does not necessarily fit into the traditional model of unilinear development from simple to complex (Habu 2004), understanding the Jomon historical trajectory is relevant in the context of recent discussions in historical ecology.

Third, with its ties to the French historical school Annales, historical ecology can deal with the concept of processes operating among temporal scales of varying duration: *événement* (event), *conjuncture* (cycle), and *longue durée* (long-term history) (Balée 2006:80). The investigation of culture change during the Jomon period requires the examination of archaeological data with varying time scales, from short-term events and changes within a single pottery phase or several decades to long-term changes that cover periods of several hundreds and more than 1,000 years (e.g., Habu 2001, 2002, 2004).

Data from Sannai Maruyama (Early to Middle Jomon; ca. 5900–4300 cal. BP) and its neighboring sites in Aomori in the Tohoku region of northern Japan provide an excellent opportunity to examine changing human-environmental relationships with varying time scales. Using the perspective of historical ecology, this chapter examines key factors in the debate over the growth and decline of large Middle Jomon sites in this region. Three factors will be discussed: climate change, human impacts on the landscape, and subsistence specialization. Through these discussions, it is suggested that the examination of the interrelation of these factors is indispensable to our understanding of the mechanisms of hunter-gatherer culture change.

Sannai Maruyama and the Middle Jomon

Located in Aomori Prefecture in northern Japan, Sannai Maruyama is currently the largest known Jomon settlement. From 1992 to 1994, the Board of Education of Aomori Prefecture conducted salvage excavation prior to the construction of a baseball stadium (Okada 2003). Results of this excavation revealed that the entire area planned for the stadium was a large Jomon settlement. Features identified from this site included more than 600 pit dwellings, post-molds of raised-floor buildings, water-logged middens, and large mounds filled with refuse deposits (for details, see Habu 2004:108–32; Okada 2003). The stadium construction was halted in 1994, and the site is currently a national historic park (Habu and Fawcett 1999, 2008).

Several lines of evidence indicate that Sannai Maruyama was occupied from the middle of the Early Jomon to the end of the Middle Jomon. In terms of typological chronology of pottery, the site occupation can be divided into 12 phases: Lower-Ento-a to -d, Upper-Ento-a to -e, Enokibayashi, Saibana, and Daigi—10 phases from the oldest to the youngest. Radiocarbon dates indicate that these 12 phases correspond to about 5900–4300 cal. BP.

Since the summer of 1997, Habu has been working on the site material with her students from the University of California, Berkeley. In collaboration with the Preservation Office of the Sannai Maruyama Site, the Berkeley team has examined excavation records and conducted collaborative field/laboratory research on faunal/floral remains, soil samples, artifacts and intra-/inter-site settlement patterns (Habu 2004, 2005, 2006, 2008; Habu and Sato 2008; Habu et al. 2001).

Reexamination of the Sannai Maruyama site is particularly important in understanding the long-term trajectory of the Jomon culture. The ending of the site occupation coincided with the timing of the abandonment of many other large Jomon settlements in northern and central Japan. Thus, examining the growth and decline of the Sannai Maruyama settlement can provide us with clues to understanding the mechanisms of the decline of the Middle Jomon culture in these regions. It is also important to note that this decline roughly coincided with the cooling climate that is said to have occurred at around 4200–4000 cal. BP (e.g., Kawahata et al. 2009; Yasuda 1989).

In examining the abandonment of large Middle Jomon sites, several key questions need to be asked. To begin with, was the cooling climate really related to the abandonment of these large settlements? If so, how? Did vegetation change caused by the cooling climate decrease or increase the total amount of available food resources? What kinds of food resources were strongly affected by the climate change? Alternatively, it is possible that other changes, such as the adoption of new subsistence strategies, were ongoing before the incidence of the cooling climate, and that they were the real cause of the decline of these large sites. In this instance, the climate change might simply have been a trigger rather than the cause. In addition, from the perspective of historical ecology, human impacts on the landscape, as well as the impacts of environmental changes on people's lifeways, should be considered. Reliable ^{14}C dates are needed to nail down the date of settlement abandonment and the onset of a cooling climate.

Answering all of these questions is obviously beyond the scope of this chapter. In the following sections, three issues that are keys to answering these questions are examined: (1) climate change, (2) human impacts on the landscape, and (3) subsistence specialization.

Climate Change

Climate change has been the most commonly cited explanation for the decrease in the number of Middle Jomon large settlements. For example, Yasuda (1989) suggests that the cooling climate at around 4,000 years ago led to the worldwide decline of prosperous cultures and civilizations, including the Middle Jomon culture of the Japanese archipelago. Archaeologists such as Okada (2003) and Kodama (2003) also support the idea that the cooling climate was the main cause of the decline of large settlements at the end of the Middle Jomon period, including the abandonment of Sannai Maruyama.

Figure 4.1 shows radiocarbon dates from Sannai Maruyama and climatic information. The bar in the top section represents the mean for each date (Kobayashi 2004; Tsuji 2006). The line below the calibrated dates shows the oxygen isotope ratios from the Greenland Ice Sheet Project (Grootes et al.

1993; Meese et al. 1994; Sowers et al. 1993; Struiver and Grootes 2000). The bottom line shows the temperature data from the Vostok ice core (Petit et al. 1999; Sowers et al. 1993). The temperature decline at around 4300–4200 cal. BP represented by the Vostok ice core data seems to correspond to the so-called Neoglaciation, the cooling climate that has been referred to by many researchers. From this diagram, the ending date of site occupation occurs shortly after the cooling climate, but the precise timings of these events are yet to be determined.

Together with their colleagues, three scholars—Sei-ichiro Tsuji, Yasunori Yasuda and Hodaka Kawahata—have published climate and vegetation data that are relevant to the study of Sannai Maruyama. Through their analyses of pollen data from Sannai Maruyama, Tsuji (1996, 1997, 1998) and Yoshikawa and Tsuji (1998) suggest that a significant decline in *Castanea*

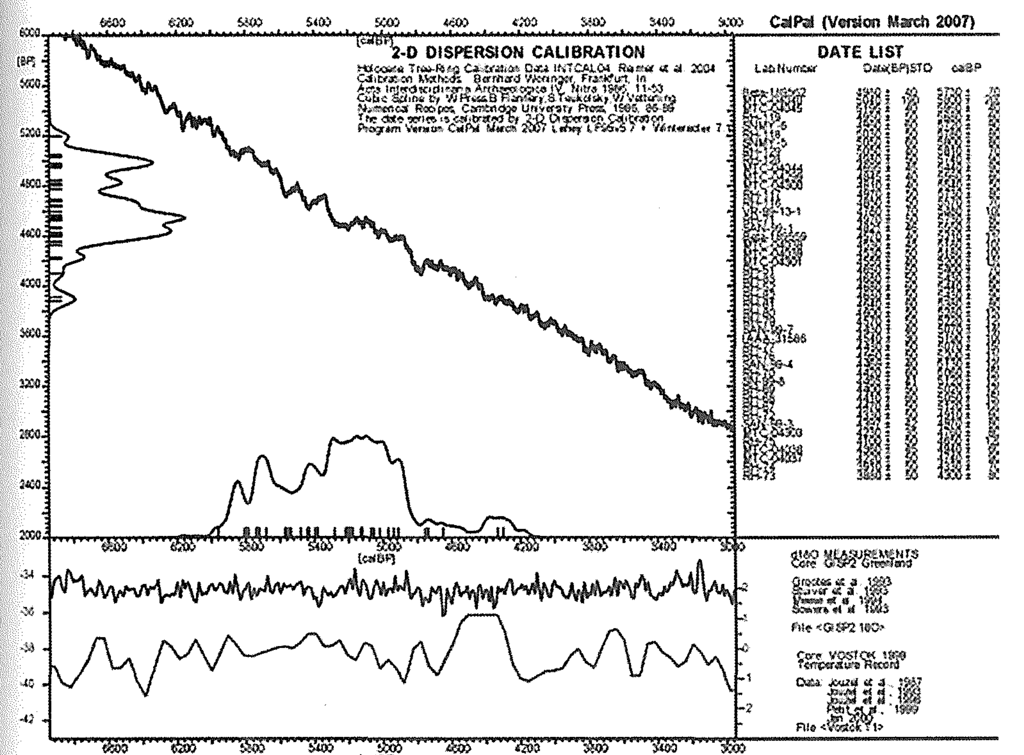

Figure 4.1. Distribution of radiocarbon determination for Sannai Maruyama and data for climate change. The top section shows radiocarbon data from Kobayashi (2004) and Tsuji (2006). The bottom section shows climate data. The top line in the section shows oxygen isotope data from the Greenland Ice Sheet Project 2 (GISP2). The bottom line is temperature data from the Vostok ice core.

(chestnut) pollen, which corresponds to a cooling climate, can be observed during the later phases of the Middle Jomon period. In their more recent publications, Tsuji (2002) and Yoshikawa et al. (2006) emphasize that the increase and decrease of the chestnut pollen at Sannai Maruyama should be seen as the direct measure of the formation and the abandonment of a large-scale chestnut orchard at the site, not as changes in natural vegetation caused by climate change. Unfortunately, the majority of their pollen samples are from the Early Jomon period, not the Middle Jomon period, and this makes it difficult to evaluate the precise timing of the chestnut pollen decline discussed in these articles.

Kitagawa and Yasuda (2004) also examine pollen data from Sannai Maruyama, with a focus on climatic fluctuations for a shorter time span of several hundred years. This fine-grained analysis was made possible by comparing their pollen data from Sannai Maruyama with climate data obtained from high-resolution analysis of annually laminated lacustrine sediments at Lake Suigetsu (Yasuda and Negendank 2003; Yasuda et al. 2004). Their results indicate that, at Sannai Maruyama, several local pollen zones with high percentages of *Castanea* pollen can be identified. In between these zones are the zones with lower percentages of *Castanea*. These latter zones include their local pollen zone III (ca. 5600 cal. BP), zone V (ca. 5400 cal. BP), zone VI (ca. 4600 BP), and zone VIII (the beginning of the Late Jomon period). (There is about an 800-year gap between zones VI and VII due to their core sample structure.) Kitagawa and Yasuda believe that the zones with abundant *Castanea* pollen represent the phases during which semi-cultivation (*hansaibai*) of chestnuts was practiced, and that these periods correspond to a warm climate.

More recently, Kawahata et al. (2009) analyzed environmental records from a marine core (KT05-7 PC-02) obtained from Mutsu Bay of Aomori Prefecture located about 20 kilometers away from the Sannai Maruyama site. Their analysis of sea surface temperature (SST) derived from C_{37} alkenone identified four high periods of SSTs (8300–7900, 7000–5900, 5100–4100, and 2300–1400 cal. BP) with mean values of 23.4, 23.4, 23.8, and 23.5 °C, and four low (?–8300, 7900–7000, 5900–5100, and 4100–2300 cal. BP) periods of SSTs with mean values of 21.6, 22.8, 22.9, and 22.7 °C, respectively. Thus, "the SST clearly fluctuated with a mean amplitude of ~1.5–2.0 °C over the last 10 kyr" (Kawahata et al. 2009:971). On the other hand, their pollen data, including the relative abundance of pollen of *Castanea* and *Quercus* subgen. *Cyclobalanopsis* (oak) seem to suggest that the terrestrial climate was relatively warm between 5900 and 4200 + 100 cal. BP. Kawahata and his colleagues state that the reason behind relatively cold temperatures during 5900–5100 cal. BP remains unclear, but that this apparent discrepancy between the SST and terrestrial temperature data may be attributed to the water column structure in the Tsugaru Straight. According to Kuroyanagi et al. (2006), the water column structure in the Tsugaru Straight before 5000 cal. BP was more stratified than at present, and this may have affected the seasonal shift of alkenone production.

We suggest that, given the fact that the change from low to high SST at 5100 cal. BP roughly coincides with the early phase of the Middle Jomon period (Upper-Ento-b and -c phases), during which significant changes occurred in archaeological data (see below), the change in the SST at around 5100 cal. BP should not be dismissed without further consideration. In particular, the potential impacts of changes in the SST on marine productivity and fishing need to be systematically examined.

Also, looking at their pollen data in more detail, an interesting pattern can be found. While *Castanea* pollen was more abundant during ca. 5900–4100 cal. BP than in the preceding and following periods, the peak of the relative abundance of *Castanea* pollen (Kawahata et al. 2009:970) was between 5900 and 5000 cal. BP. Results of our change point analysis of the *Castanea* pollen data also confirms that a major change occurred at around 5000 cal. BP, after which *Castanea* pollen began to decrease (Habu and Hall, 2010). Results of these studies indicate that climate changes reflected in pollen and other data should be examined further with a more fine-grained timescale.

In summary, while climate data show extremely interesting patterns, the causal relationships between climate change and shifts in Jomon people's lifeways need to be further examined with more data. A major problem is the scarcity of reliable radiocarbon dates that would allow us to identify the precise timing of these climate changes as well as of the changes in Jomon people's lifeways represented in archaeological data. At the same time, the possibility of examining changes in varying temporal scales, including millennium-scale changes in relation to global warming/cooling and changes in a shorter time spans such as those discussed by Kitagawa and Yasuda (2004), makes this avenue of research exciting in the context of historical ecological approaches.

Human Impacts on the Landscape

As outlined previously in this chapter, several scholars have suggested the possible importance of tending chestnut trees and/or cultivating plants at

Sannai Maruyama. Kitagawa and Yasuda (2004) link the results of their pollen analysis at Sannai Maruyama with earlier discussions on semi-cultivation (*hansaibai*) (e.g., Nakao 1976; Sakatsume 1961) during the Jomon period, and suggest that the tending of chestnut trees occurred repeatedly at the site during the warm climate phases. Their view of chestnut tending is cyclical with a timescale of several hundred years. Furthermore, they suggest that a similar practice of tending chestnut trees continued in the Aomori area through to the Final Jomon period. They also argue against Hatayama's (1997) suggestion that the fluctuation in chestnut pollen might have been caused by accidental fires.

Tsuji (2002), whose earlier work (Tsuji 1999) acknowledged the impact of cooling climate on the lifeways of Sannai Maruyama residents, and his collaborators (Yoshikawa et al. 2006) emphasize the degree of artificial alternation of the vegetation at the site, namely the establishment of chestnut orchards. Based on their pollen data, these scholars suggest that the alternation of the vegetation started shortly after the beginning of the site occupation and continued for the following 1,700 years. Furthermore, Yoshikawa et al. (2006:65–66) argue that the reduction in the relative frequency of chestnut pollen toward the end of the Middle Jomon period was not a result of the cooling climate but a reflection of site residents' intentional choice to shift their subsistence focus from chestnuts to buckeyes (*Aesculus*). They suggest that, after the Sannai Maruyama settlement was abandoned, the vegetation at the site went back to the "natural" forest of *Quercus* and *Fagus*.

From the perspective of historical ecology, the possibility of large-scale, artificial modifications of vegetation raises the question of their long-term impacts on the local and regional landscapes. Changes in vegetation reflected in pollen, diatoms, and macro-floral remains data, as well as changes in faunal assemblages, can help us understand aspects of the long-term impacts of the forest modification suggested by these scholars. It is also likely that the alternation of the vegetation affected people's perception of cultural landscapes.

Subsistence Specialization: Changes in Diversity in Staple Food

Lastly, but not least importantly, changes in settlement size, subsistence strategies, and ritual practice should be examined. The following analysis focuses on the long-term impacts of the shift in diversity of staple food.

Figure 4.2 summarizes changes through time at Sannai Maruyama in the number of pit dwellings, characteristics of stone tool assemblages, and the number of clay figurines (Habu 2008). The bar graph shows changes in the minimum number of pit dwellings identified in each phase. Some interesting trends are apparent in this diagram. First, the graph shows that only Upper-Ento-d and Upper-Ento-e phases are definitely associated with more than 50 pit dwellings. For the other 10 phases, the numbers of associated dwellings are much smaller, representing a medium or even a small settlement. Second, the graph shows fluctuations through time as opposed to a smooth and gradually increasing curve. If settlement size is correlated with strategies in securing food resources, this fluctuating pattern might support the model suggested by Kitagawa and Yasuda (2004) in which cyclical changes in subsistence activities were suggested. Despite such fluctuations, the long-term trend indicates that the high point of the Sannai Maruyama settlement can be identified at the Upper-Ento-d and -e phases.

The middle part of the diagram summarizes changes in lithic assemblage characteristics (for details, see Habu 2008:574–77). In the beginning of the site occupation, the lithic assemblage is characterized by an abundance of stemmed scrapers. They are considered to have been used for processing meat and fish. The following several phases (the Lower-Ento-b to Upper-Ento-a phases) are characterized by a mixed assemblage with arrowheads and grinding stones as well as stemmed scrapers. Arrowheads must have been used for hunting, and grinding stones are typically considered to have been plant-food processing tools. During the next three phases (the Upper-Ento-b to -d phases), the lithic assemblage is characterized by the dominance of grinding stones. This abundance of grinding stones was suddenly interrupted in the Upper-Ento-e phase, when the arrowhead became the most dominant type of lithic tool.

Assuming that characteristics in the lithic assemblage reflect subsistence activities, these archaeological patterns seem to indicate a general long-term trend in changes in subsistence strategies. Specifically, if grinding stones were a plant-food processing tool as suggested by many archaeologists, then we are observing a gradual increase in the reliance on a particular type of plant food that was processed by a single type of stone tool—the grinding stone. It is likely that this implied a significant reduction in subsistence diversity. A sudden decrease in the relative frequency of grinding stones is likely to indicate the decline of this extreme specialist type of economy.

The top part of the diagram shows changes in the number of clay figurines. To date, more than 1,600 clay figurines or figurine fragments have

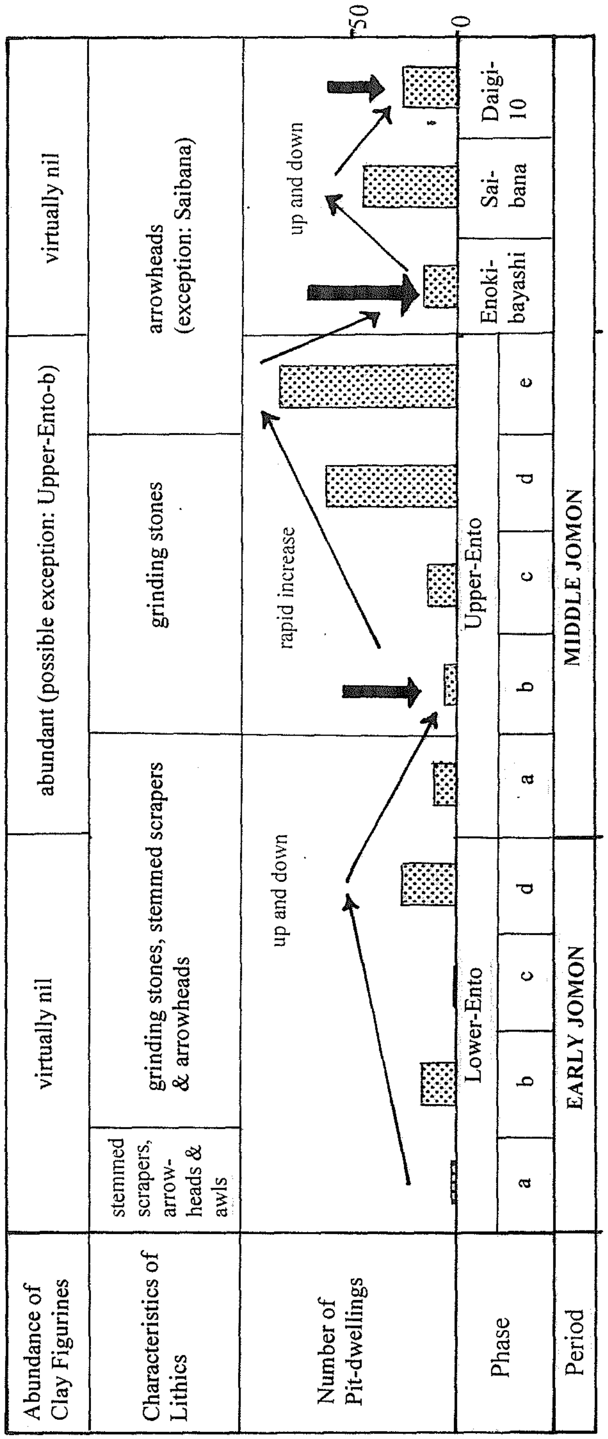

Figure 4.2. Summary of observed archaeological patterns at Sannai Maruyama (from Habu 2008:580).

been excavated from Sannai Maruyama. Looking at their typological characteristics, the majority of these figurines are dated to the Upper-Ento-a, -c, -d or -e phases. The number of clay figurines decreased sharply from the Upper-Ento-e to the following Enokibayashi phase. In other words, a major decline in the number of clay figurines did occur between the Upper Ento-e phase and the Enokibayashi phase, which coincided with the sharp decrease in the number of pit dwellings, as previously discussed.

In summary, an increasing reliance on plant food can be observed from the end of the Early Jomon to the middle of the Middle Jomon period. The resulting specialist type of economy was suddenly interrupted at the beginning of the Upper-Ento-e phase, after which both settlement size and the number of clay figurines decreased significantly. Thus, in terms of causal relationships, these data seem to indicate that a major change occurred first in the realm of subsistence strategies, which was then followed by changes in settlement size and ritual behavior (as represented by the number of figurines).

Based on these archaeological findings, Habu (2008) suggested a hypothesis that the increase and decrease in settlement size at Sannai Maruyama was correlated with the development and decline of subsistence intensification, with a focus on a particular type of plant food. This hypothesis by no means implies that other factors were unrelated to the growth and decline in site size at Sannai Maruyama: the observed archaeological patterns can also be a reflection of many other factors, such as changes in site function. It is important to note that, although there are numerous dwellings from the Upper-Ento-d and -e phases, the majority of these dwellings are extremely small, typically measuring only between 2.5 and 4 meters in long-axis length. These are much smaller than typical Jomon pit dwellings. Thus, during these phases, the site could have functioned as a seasonal, short-term residential base, or the place of aggregation of a large number of people for a seasonal get-together (Habu 2004:129–30).

A key issue to our understanding of the development and decline of the Middle Jomon culture in the Aomori area is the identification of the type or types of plant food that were processed using the large number of grinding stones. As discussed, many scholars suggest that the staple food for the Middle Jomon residents of the Sannai Maruyama site was the chestnut. However, preliminary results of our analysis of macro-floral remains from Sannai Maruyama and two other neighboring sites indicate that nuts utilized by the residents of these sites during the early and middle phases of the Middle Jomon period were not limited to chestnuts. A quantitative analysis of the waterlogged midden deposit of the Sannai Maruyama No. 9 Site (a small residential site located about 500 meters away from Sannai Maruyama proper) (Aomori-ken Maizo Bunkazai Chosa Center [Archaeological Center of Aomori Prefecture] 2007, 2008) indicates that buckeyes were commonly used during an early phase of the Middle Jomon period, possibly as early as the Upper-Ento-a phase. Our excavation of another small residential site, Goshizawa Matsumori (Habu 2009), has revealed that the fills of a pit dwelling and two flask-shaped storage pits, all of which are dated to the Middle Jomon Upper-Ento-a phase, include a large number of walnut shell fragments. Furthermore, Middle Jomon layers from Sannai Maruyama proper have also yielded a large number of walnut shell fragments (Habu 2006). Given these lines of evidence, it is too early to conclude that chestnut was the sole staple food that was associated with the rise of the Middle Jomon culture in this region. Rather, we need to think of the possibility that the development of the Middle Jomon culture in this region was based on a mixed-nut economy.

Concluding Remarks

As the next step of our research at Sannai Maruyama and its neighboring sites, we have begun our attempts to examine various lines of evidence. Systematic examination of reliable ^{14}C dates from archaeological sites is indispensable to identify the timings of changes in subsistence, settlement, and society. In addition, obtaining new lines of evidence for climatic changes will be critical. These include pollen and phytolith analyses and oxygen isotope ratios of marine shells from multiple sites. Third, residue analyses of pottery and stone tools can help us greatly in obtaining information about the Jomon diet. Most importantly, we need to examine characteristics of the site in relation to changes in regional settlement patterns.

In conclusion, we have attempted to demonstrate that archaeological data from Sannai Maruyama and its neighboring sites provide us with a unique opportunity to examine changing human-environmental interactions in a small-scale prehistoric society. Currently available data indicate that subsistence specialization at Sannai Maruyama may have been the principal factor that allowed the site population to grow, but that the growth was not sustained after several hundred years. We hypothesize that a decrease in subsistence and food diversity, which was a result of subsistence specialization, made the Sannai Maruyama economic system more vulnerable to minor changes in other variables. Cooling climate may have been a factor that triggered the population decline, but we still do not have enough ^{14}C dates to nail down the timing in relation to the archaeological sequence. In any case, examination of socioeconomic factors, as well as climate change, is critical in understanding the mechanisms of long-term human-environmental dynamics.

The link between climate change and the rise and fall of highly developed cultures has been a topic of debate in popular literature (e.g., Diamond 2005; Fagan 2000, 2004, 2008; Yasuda 2004; cf. McAnany and Yoffee 2010) as well as in environmental archaeology (e.g., Anderson et al. 2007). As demonstrated in many of these debates, climate change itself is not always a sufficient explanation for culture change. Nor did cooling climate always result in the decline or collapse of a particular culture. For example, in their discussion on the emergence of the "collector" type (*sensu* Binford 1980) of complex hunter-gatherer subsistence-settlement systems on the Northwest coast of North America, Prentiss and Chatters (2003) suggest that the Neoglacial temperature downturn shortly after 4000 uncal. BP brought new pressures upon hunter-gatherers in this region. They hypothesize that this ultimately resulted in the decimation of most other systems. In central California, the climate change at about 4500 to 4000 cal. BP seems to have triggered population movements and a resulting population increase, as well as the elaboration of burial practice (Kennett et al. 2007; Moratto 1984).

Finally, we need to ask whether the decrease in the number of large settlements at the end of the Middle Jomon period was really a "collapse" or "decline." Although the average size of settlements from the following Late Jomon period is much smaller than that of the Middle Jomon period settlements, the Late Jomon period was characterized by complex rituals, sophisticated material culture, and signs of craft specialization, such as pottery production (Habu 2004:chapter 7). Thus, the last question is tied to whether settlement size and population are valid indicators for measuring the success of a prehistoric hunter-gatherer culture.

Acknowledgments

Our research at the Sannai Maruyama and Goshizawa Matsumori sites have been conducted in collaboration with the Preservation Office of the Sannai

Maruyama Site, the Archaeological Center of Aomori Prefecture, and the Board of Education of Aomori City. The contents of this paper benefited from discussions with Kent Lightfoot, Hodaka Kawahata, and members of the above-listed organizations. We would like to thank these individuals and institutions. Financial support for the Berkeley Sannai Maruyama and Goshizawa Matsumori project was provided by the Center for Japanese Studies, the Archaeological Research Facility, the Hellman Family Faculty Fund and the Committee on Research Grants of the University of California–Berkeley, and by the Henry Luce Foundation. All opinions and views expressed in this article are those of the authors, and not the individuals or organizations listed above, the Bureau of Land Management, or the Department of the Interior.

5

Cumulative Actions and the Historical Ecology of Islands along the Georgia Coast

VICTOR D. THOMPSON, JOHN A. TURCK, AND CHESTER B. DEPRATTER

> They catch fish, gather shellfish, and build towns and villages on the strand and in small embayments. Their coastal activities have been so numerous and varied that their total effect has been significant. One of their most persistent activities has been the building of shell mounds, which are large piles chiefly of refuse resulting from various uses of shellfish. . . . they cover as much as 10 per cent of the shoreline. . . . these mounds have been instrumental both in holding the coast line against retrogression and in aiding progression.
>
> John Davis, "Influences of Man Upon Coast Lines"

John Davis wrote the above words more than 50 years ago in a chapter in the seminal volume *Man's Role in Changing the Face of the Earth* (Thomas 1956). A professor of botany at the University of Florida at the time of its publication, Davis considered shell mounding significant enough to include in his worldwide overview of the influence of humans on coastlines. Indeed, shell accumulations that are the products of human behavior, either in the form of intentionally mounded architecture or refuse remains, occur worldwide (e.g., Bailey and Milner 2002; Erlandson 2001; Thompson and Worth 2011). While great strides in understanding shell middens and mounds have been made in the latter part of the twentieth and early twenty-first centuries (e.g., Rick and Erlandson 2008; Fish et al., this volume; Milner, this volume), we still do not fully understand the dynamic interaction between these structures in the context of human-environmental interactions in coastal environments (see Pennings, this volume).