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Fishing and Early Jomon Foodways at Sannai Maruyama, Japan

By

Mio Katayama

A dissertation submitted in partial satisfaction of the

requirements for the degree of

Doctor of Philosophy

in

Anthropology

in the

Graduate Division

of the

University of California, Berkeley

Committee in charge:

Professor Junko Habu, Chair

Professor Christine Hastorf

Professor Mack Horton

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Abstract

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Doctor of Philosophy in Anthropology

University of California, Berkeley

Professor Junko Habu, Chair

This thesis examines the economic vs. social and symbolic importance of fish in the foodways of the prehistoric Jomon culture (16,000-2300 cal BP) of Japan. To achieve this goal, quantitative analyses of fish remains excavated from a water-logged midden of the Sannai Maruyama site (Aomori Prefecture, Japan) are conducted. Dated to the Lower Ento—a phase (ca. 5900–5650 cal BP) of the Early Jomon Period, the midden was associated with large amounts of organic remains, including fish bones. The perspective employed in this dissertation, foodways, emphasizes the importance of social and cultural roles of food. Rather than focus on bio-ecological aspects and nutritional values of food, this thesis regards food as one of the central elements of individual cultures.

In Japanese archaeology, food of the Jomon Period has been a central theme to the discussion reconstructing the lifeways of prehistoric people of the Japanese archipelago. Large amounts of data, including faunal and floral materials, have been accumulated from numerous rescue excavations of Jomon sites that took place between the 1970s and late 1990s. These archaeological data allowed the development of detailed culture historical studies of the Jomon Period that span over 10,000 years. Within the tradition of Japanese archaeology, however, virtually no scholar has adopted the study of foodways as a theoretical approach. This thesis is one of the few attempts to examine Jomon data from this perspective.

In this thesis, the relations between Jomon people and fish as their food are examined through zooarchaeological and ethnoarchaeological analyses. Soil samples from the “Northern Valley” midden of the Sannai Maruyama site were obtained, and fish remains in these samples were separated, identified, and quantified. The results indicate that two taxa were particularly important in the diet of the Sannai Maruyama residents: *Cobitidae* (loaches) and *Seriola* (yellowtails). These results are used to address the question of why certain fish taxa were selected when the environment provided a great variety of other animals and fish. Energy investments and returns related to fishing and consumption of these two taxa are calculated, and the results are discussed in the context of energy efficiency, the assumption that lies behind the diet breadth model, one of the

optimal foraging models .The results indicate that *Cobitidae* fishing can be explained by cost-benefit calculation, while an abundance of *Seriola* in the assemblage requires another explanation .The results of these analyses are discussed in the context of the study of prehistoric foodways.

I would like to dedicate this dissertation to my family, old and new, for patiently waiting all this time and putting up with my 'almost done' for such a long time.

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Chapter 1

Introduction

The aim of my dissertation is to study the foodways of the residents of the Sannai Maruyama site (Aomori Prefecture, Japan) during the Lower Ento-a phase (ca. 5900 to 5600 cal. BP) of the Early Jomon period. More specifically, this thesis attempts to explore through zooarchaeological and ethnoarchaeological analyses the dynamic relations between Jomon people and their fish diet.

Jomon Sub-Periods	Radiocarbon Dates (cal. BP) *1
Incipient	16,000–11,000
Initial	11,000–7000
Early	7000–5500
Middle	5500–4300
Late	4300–3300
Final	3300–2500

Lower Ento Phases	Radio Carbon Dates (cal. BP) *2
Lower Ento-a	5900–5650
Lower Ento-b through d	5650–5350

*1. Suggested by Habu (n.d.)

*2. From Habu (2004) Based on Imamura (1999)

Table 1-1: Radiocarbon Dates for Jomon Sub-Periods in the Tohoku Region and Lower Ento Phases at Sannai Maruyama

Food has always been part of narratives in archaeological traditions in different parts of the world. In the United States, theoretical implications of the study of foodways have been transforming continuously. During and shortly after the 1960s, many scholars examined the role of food as part of the past “subsistence systems”. In these studies, it was assumed that the surrounding environment dictated to the participants of the systems to exploit certain resources. Aspects of this particular viewpoint, which regards food’s primary role as physiological sustenance, are still present in contemporary American archaeology, especially in the field of hunter-gatherer studies (e.g., Bettinger 1980, 1987; Kelly 1995; O’Connell and Hawkes 198; Smith and Winterhalder 1981, 1992; Winterhalder 1981, 2001).

Since the environment that surrounds us, as well as our physiological blueprint, pose restrictions on foodways, bio-ecological factors are imperative when discussing this subject. The perspective employed in this dissertation, however, emphasizes the importance of social and cultural roles of food. Rather than focus on bio-ecological aspects and nutritional values of food, I regard food as one of the central elements of each culture (Counihan and Van Esterik 1998; Curtin and Heldke 1992; Farb and Armelagos 1980; Fisher 1954; Hastorf and Johannessen 1993; Meigs 1984; Mennell 1985). While the most apparent significance of food may be its biological component, food is often used simultaneously as emotional nourishment, currency, adornment, language, weapon,

and commensality tools, among other uses. This is because of the food's ability to convey symbolic values. Food can be used to communicate intricate and implicit ideas (Barth 1979; Douglas 1966, 1973, 1975, 1984; Meigs 1988).

In the study of food, even when we examine something seemingly simple such as our food selection, it is clear that food carries great significance independent of its nutritional contents. No cultural group exploits and consumes every edible substance in its surrounding environment unless under dire circumstances. The people of each culture have strict ideas of what they consider as The Food, the list of which is selected out of all the edible substances in the environment. Moreover, within the set of what is considered as food, some are valued higher than others for reasons unrelated to caloric or dietary value (Appadurai 1981; Hastorf 2003; Kahn 1986; Mintz 1985; Weismantel 1988). Certain foods are regarded as more valuable because of their assigned symbolic meanings, which are not shared cross-culturally (Bourdieu 1984; Conklin 1993, 1995; Douglas 1973; Falk 1991; Fishler 1988; Lupton 1994; Meigs 1983, 1986, 1997; Ohnuki-Tierney 1993; Sanday 1986). Through the long historical trajectory of each culture, symbolic values and meanings were assigned to each food item. This is a process of transforming an edible natural substance in the biosphere into a cultural substance. Sociocultural aspects of each society, including world view, religious belief, technology, economy, gender relationship, and politics influence this process (e.g. Atalay and Hastorf 2006; Hastorf 1999; Meigs 1986, 1997; Sherrat 1991). In other words, food is a reflection of the culture itself. In turn, the examination of food can reveal how a group of people relate to the world that surrounds them.

In order to delineate the processes and meanings of food selection reflected in Sannai Maruyama fish remains, this dissertation attempts to apply existing ecological models such as the optimal foraging models. Optimal foraging models refer to a series of mathematical models that were developed within the theoretical framework of behavioral ecology. They have been utilized in archaeology to predict and explain human behaviors associated with food and the environment. The developers of these models used the principles of Darwinian evolution, in which individuals are expected to make decisions that will maximize the net rate of return per unit foraging time/costs. By doing so, individuals will ultimately maximize their reproductive success. One of the principal models, the diet breadth model, predicts prey selection made by a forager. A food item, such as a particular fish species, is deemed optimal "if and only if its net energy return per unit handling time is greater than the average return rate (including search time) for all prey types of higher rank" (Smith 1983: 628). Therefore, if a certain fish was selected despite its seemingly disadvantageous status in terms of cost-benefit estimate, the selection was made due to its other qualities such as its symbolic value or taste.

In order to examine this issue, a crucial task is to identify a site that can provide quantitative data of faunal remains associated with detailed information of archaeological contexts. The record from the Sannai Maruyama site provides an ideal setting for this purpose. Research efforts by local archaeologists spanning over the past fifteen years, combined with the superb preservation condition of the zooarchaeological materials at the site, have resulted in a data set of extremely high quality.

As the first step in shedding light on the Jomon food selection process at Sannai Maruyama, I examine faunal remains from the site during the Lower Ento—a phase. I select this phase primarily because of an abundance of fish remains. Moreover, as the

very first occupational phase of this site, foodways of the Lower Ento—a phase must have laid the necessary foundation for the populations of subsequent phases when the site size became larger and site structure became significantly more complex.

Results of my analyses of faunal remains and other relevant data, including ethnographic information and nutritional values of individual fish taxa, suggest that people at Sannai Maruyama chose certain fish taxa not simply based on a cost-benefit calculation. Instead, their criteria of fish selection included other factors. Given these results, I argue that maximizing the energy return per energy investment was not always the primary reason for selecting target fish species at Sannai Maruyama.

In chapter 2, I will present a review of the study of foodways in anthropology and discuss the theoretical orientation of this dissertation. This theory chapter will be followed by a discussion of archaeological background information of the Sannai Maruyama site (chapter 3), food related archaeological materials recovered from Sannai Maruyama (chapter 4), methodology (chapter 5), data collection and analyses (chapter 6), examination of fishing efforts and returns (chapter 7), and finally the conclusion (chapter 8).

Chapter 2

Theoretical Orientation: Foodways in Anthropology

“When one is identified with food one eats one is identified with the whole universe; when we are one with the whole universe we are one with the food we eat.” (Vimalakirti Scripture, Vimalakirti Nirveda)

The above quote from Vimalakirti Scripture, part of the Mahayana Buddhist sutras, captures the essence of how food is viewed in this dissertation, as a reflection of who we are and how we are related to the world that we are part of. In this chapter, I will first discuss this perspective further. This discussion will be followed by the history of the study of food in anthropology and a review of the major approaches to food in social science.

2.1. Introduction: What Are Foodways?

The relationship between people and food has significant influences on culture and society on numerous levels. Food permeates every part of who we are from our physical being to the spiritual one (Arnott 1991; Bynum 1987; Counihan and Van Esterik 1997; Douglas 1966, 1970; Farb and Armelagos 1980; Fisher 1943; Goody 1982; Mintz 1985). Every slice of our society, from politics between nations to daily interaction between family members can be discussed in terms of the roles food plays (e.g. Appadurai 1981; Brown and Mussel 1985; Counihan 1999; Counihan and Kaplan 1997; Dietler and Hayden 2001; Goody 1982; Mintz 1985; Ohnuki-Tierney 1993; Weisner and Schieffehovel 1996). This is not only because we are unable to function if we are deprived of food or even one of the key nutrients, but also we, humans, found foods’ ability to convey values beyond their nutritional contents. This is expressed in how culture overwrites nature at each stage of our relationship with food, even at the very fundamental stage of food selection.

While general physiological necessity is shared by all human populations, we choose to fulfill the needs by consuming different food items that are prepared with significantly different methods. Also, our environments provide us with a variety of edible substances, yet so few of them are regarded as food and worthy of its presence on our plates. In this sense, food is a true construction of culture: what separates food from non-food is not the presence of toxin or other chemical properties, but our cultural rules that have been developed over thousands of years. Just as many of our behaviors are dictated by cultural codes, what we often consider as pure physiological responses, such as hunger and taste, are also the products of the history and socio-cultural environment in which we are born and raised (Arnott 1991; Kahn 1986; Meigs 1983; Ohnuki-Tierney 1993; Shack 1969; Weismantel 1988). Each food item has been carefully selected, and each of us learns what the ‘proper food’ is through growing up consuming the food provided to us by our caregivers. These foods were then developed into ‘cuisine,’ set of food preparation and consumption methods with distinct flavoring principles (E. Rozin 1982, 1983) that are unique to each culture.

While some people might think of a simple dinner at home as a mere occasion to fulfill our basic physical needs, there are always cultural rules superseding our biological acts. For example, if convenience and health were the main concern for busy modern people, then all the food typically served together on a dinner plate could be blended and condensed in a nutritional paste. But not many individuals would prefer a cup of goop over a nicely prepared wholesome meal shared with companions. The modern American culture does not consider nutritious paste in a cup or tube as an ideal meal for people who do not have any particular dietary restrictions. Similarly, while the general nutritional contents of rice and fish, which are typical breakfast items of many East Asian cultures, are more or less the equivalent of cereal and milk nutritionally, they do not often replace the typical American breakfast.

It is not only the food items that are under the control of cultural rules, but also all the associated behaviors related to food are guided by our socio-cultural codes. No matter where you go in the world, there is always a set of proper protocols that you are expected to follow for any food-related occasion. Most of these rules are so naturalized within cultural groups, very much like a language, that you may not even realize that you are following any rigid formula. For example, it is considered bad manners to consume one's dinner of steak and potatoes with fingers in the United States, yet those very same people find it perfectly comfortable doing so with pizza or a hamburger without feeling 'uncivilized' or fearing that they may offend others.

The conglomeration of food selection, preparation methods, consumption manner, and all other related behaviors and beliefs operate as part of foodways, which is one of the central elements of any culture and society, reflecting its own history, environment, technology, politics, economics, ideology, and world view. The concept of foodways pertains to all cultural and social codes regarding food and every food-related activity and belief; from distinctions made on edible and inedible and its procurement methods, processing procedure, consumption manner, to disposal. They reflect an individual's personal and group distinctions such as culture, class, gender, age, and occupation. In turn, foodways are the constant enactment of those distinctions on a daily basis. Each of us learns proper foodways by partaking in its proper form presented to us by our caregivers, and often maintains those foodways for the most part even when we are placed in different socio-cultural environments. At the same time, however, foodways are under continuous influence of one's social milieu and thus constantly go through multiple transformations.

Moreover, an individual reenacts the rituals he or she learned multiple times throughout a day, reinforcing particular ideologies and worldviews, while allowing the same participants to incorporate new elements to the existing one without completely losing the tradition during each episode of enculturation. This static yet flexible nature of foodways is exactly what makes foodways versatile as an analytical approach to any aspect of human culture. Foodways are present in all segments of a society; between family members through daily meals and snacks; between families through parties and celebrations, such as weddings; between communities through production and distribution. Through each of these food-related events, we are recreating and reinforcing our beliefs and worldviews, and as we recreate the rules, we are reinforcing and expressing who we are through food. As French epicurean Brillat - Savarin's (1948) renowned quote summarized: "Tell me what you eat, and I will tell you who you are."

Foodways embody our mostly unspoken understanding about ourselves and the world surrounding us, and they both organize our culture and even determine its direction (Visser 1986). They are our expression of who we are, and what we want others to perceive of ourselves.

2. 2. Study of Food and Foodways: Historical Background

Foodways have been the subject of studies in many disciplines including anthropology. Because of the nature of food, it has been the focus of academic studies in a variety of fields; sociology, political science, economics, ethnic studies, psychology, and history, as well as biological sciences such as nutritional science, toxicology, and even human evolution. In anthropology, food and food-related human behavior had traditionally been studied as part of ethnography, but it never fully became the focus of academic scrutiny until the mid 1900s. The academic discussion of food and foodways took the center stage only from the 1960s both in North America and Europe due to several hindering factors that were shared in all fields of social science (Korsmeyer 1999). For one thing, issues related to food, especially the daily consumption of food, have definitely been regarded mundane and unworthy of in-depth academic discussion. Activities such as cooking and eating were viewed as practical biological activities rather than activities involving philosophy and higher thought, such as politics or fine art are often considered to be. Also, food and its related activities were traditionally viewed as part of our 'natural function' and not worthy of scholarly examinations (Korsmeyer 1999). There was no question about the exact reason why they are, in fact, so 'natural'. Even before the spread of Christianity, since the time of Plato, Western philosophers were taught to despise subject matter involving bodily pleasure and adornments, including food and consumption, and any discussion revealing the detail of our bodily function was regarded as inappropriate even as a subject of ordinary conversation (Korsmeyer 1999). Moreover, the act of eating is at times associated with sexual activity, the other extremely vital and fundamental behavior to all creatures (e.g. Meigs 1984, Pollock 1998), and together they had been left out of academic discourse until the late 20th century. The Western intellectuals that inherited this tradition thus avoided any discussion related to physical activity and pleasure, such as eating and digestion.

In addition, as has been the case with other scholarly disciplines, the field of anthropology has been under the influence of androcentrism until the 1970s. One of the consequences of the lack of women in the field was the disproportional attention paid to certain activities often associated with men, while activities commonly associated with women such as preparation and serving of food were not given the attention that they deserved, since they were considered to have less impact on the overall cultural and social change or structure (Gifford-Gonzalez 1993). Since the 1970s, however, the problem of androcentrism has been systematically recognized, and significant improvements have been made in the last few decades (e.g. Deagan 1985). More needs to be done, but progress has been made in the representation of aspects of food that were previously neglected. This change is contemporaneous with the development of various perspectives of foodways. These multiple perspectives on food and related in-depth analyses would not have developed if scholars had continued to ignore the role and contributions of women and activities associated with them.

2.3. Anthropology of Food

Although this section places emphasis on some of the prominent works from the 1960s on, several significant studies from preceding periods created the foundation for these later works. One of the founding anthropologists of North America, Alfred A. Kroeber (1925, 1960) documented food and food preparation methods of California Native American groups in great detail in order to ‘preserve’ those vanishing cultures. The voluminous records created by him and his students are invaluable sources for the study of Native American foodways by contemporary scholars today. Shortly after Kroeber, a few scholars recorded foodways of exotic cultures while conducting ethnographic research (e.g. Boas 1921; Cushing 1920; Malinowski 1935; Mead 1937). Although their primary purpose was not the study of food, their detailed descriptions did not miss food and food-related activities such as cultivation, preparation, ritual, and consumption. A student of Kroeber, Robert H. Lowie (1939, 1947,) expanded the subject and examined the food practices of the world. However, none of these works resulted in the active discussion of the topic of food.

In Europe, as early as 1902, Earnest Crawley’s *The Mystic Rose* examined food consumption manners in France and revealed the subtle and implicit relationship between sex and religion in French society. Although his innovative view of foodways as a reflection of society is well accepted today, his study did not generate any significant academic reactions from others at that time. In another prominent work almost 20 years after Crawley’s *The Mystic Rose* (1902), Audrey Richards (1939) observed human-food relationships beyond simply physiological reactions in Rhodesia. Unfortunately, anthropological studies of cultures through foodways remained rather sporadic for the following several decades.

While the contributions of the early scholars are undeniable, their works and works of those who immediately followed in their footsteps focused mainly on the foodways of small-scale, non-Western, and ‘exotic’ cultures. Moreover, ethnographic studies of food such as the ones by Kroeber and Lowie were later criticized for lacking any interpretation or failing to provide explanation of the human behavior and remained as simple descriptions of peculiar foodways (Harris 1985, 1987). Fortunately, gradually from the 1960s, the scope of anthropological studies began to depart from the description of peculiar foodways to appreciation of ordinary foodways, even including studies of industrialized societies (e.g., Barthes 1975; Douglass 1973, 1988; Goode 1984; Mintz 1985; Ross 1980; Salaman 1944, 1949).

In the following sections, I will discuss various approaches and uses of foodways developed and employed by more contemporary anthropologists, with a focus on the works of scholars in North America and Europe. The rest of the chapter is not an exhaustive review of all the existing literature on food and foodways: rather, it is a review of major approaches to the subject that affected anthropology of food and foodways today, and more importantly, this dissertation.

Although there are as almost many theoretical approaches as there are individuals studying foodways, the major approaches are divided according to four general perspectives on the food-culture relationship. This is not to say that food can have only one of these roles at a time, or that it has to be one of these. The first perspective, food as

political commensality tools (Arnott 1991; Bynum 1997; Dietler and Hayden 2001; Goody 1982; Kahn 1986; Malinowski 1935; Mennell 1997; Mintz 1985; Powers and Powers 1984; Rappaport 1984; Richards 1951; Young 1971; Weismantel 1988), is not from a single unified theoretical orientation, but is a collection of theoretical perspectives that focus on the issues related to foodways in politics and economy. The second and third perspectives regard food as a medium of communication and symbolism (Douglas 1973; Falk 1991; Farb and Armelagos 1980; Leach 1964; Levi-Strauss 1966; Lupton 1994; Meigs 1983, 1997; Messer 1997; Ohnuki-Tierney 1993), and food as an identify marker (Bourdieu 1984; Fishler 1988; Hastorf 1999; Janik 2003; Parker Pearson 2003; Peggy 1986; Spielmann 1988). Lastly, according to the fourth perspective food and foodways serve particular functions within a culture in relation to its surrounding environment (Bettinger 1980; Broughton 1999; Broughton and O'Connell 1999; Erlandson 2001; Harris 1974, 1979, 1985, 1997; Harris & Ross 1980; Hesse 1990; Katz 1973; Katz, Heidger, and Valleroy 1974; Kennett 2005; Lieberman 1987; Nair 1980; O'Connell and Hawkes 1981; Rappaport 1984; Ross 1978; Smith 1983, 1991; Winterhalder 1981, 1987; Yesner 1983). This perspective is at the extreme end of the overall spectrum of foodways studies and has been very influential in various fields in social sciences, including anthropology. Reviews of these four perspectives are followed by my perspective on theoretical approaches to the study of foodways and how I approach the topic in this dissertation.

2. 3. a. Food, Power, and Commensality

In his study of gift exchange behavior in the Pacific, French anthropologist and nephew of Evans Pritchard, Marcel Mauss (1943), discovered that the exchange of food and other items had significant social values and functions beyond supplementing resource deficiency. He found that in Melanesia, the reciprocity of food between different islands, which sometimes took place over a long period of time to complete a cycle, had a great importance in the development and maintenance of social relations. He concluded that the obligatory exchange of food as gift was functioning as a device of social adhesion between people and groups. He argued that the exchange of food constructs social obligations, and that exchange of food does not only alter the amount and quality of food available but also affects the overall structure of a society.

While some of the discussions of power and politics in the study of foodways have been Marxist oriented (i.e. Goody 1982; Mintz 1985, 1996) with emphases placed on labor, exploitation, and differential access, etc., others (Appardurai 1981; Arnott 1991; Bynum 1997; Cunnihan 1999; Dietler 1990; Dietler and Hayden 2001; Leitch 2000; Meigs 1983, 1986; Sanday 1986; Weismantel 1988; Weisner 1996; Young 1971) take broader approaches. What is shared by all these scholars is the understanding that as the symbolic and economic value of the food becomes more significant, food becomes an even more effective tool for manipulating one's social status.

The role of food in the long political history of human beings was examined by Jack Goody (1982) through his examination of world haute cuisines. In order to answer the question of why there is not a so-called haute cuisine in many of the African cultures, he compared the cuisines of cultures around the world and their close developmental relationships with the social hierarchy. He suggested that the presence of significant

social hierarchy with full time specialization of food producers and preparers are necessary in the development of high cuisines.

Sidney Mintz (1985) also examined a long-term transformation process of political economy and the function of food as the vehicle of international power hierarchy. Through his investigation of the history of sugar, he revealed the social significance of sugar and its role in the British society, which had the political and economic power over their colonial sugar plantations in the Caribbean. He presented the transformation of sugar from high society commodity to a necessity at tea time among the common people, and as the demands for sugar increased, slavery and its influence on the economy of the Central American cultures became more conspicuous.

Finally, Brian Hayden (1996, 2001) and Michael Dietler (1990, 1996, 2001), as well as Christine Hastorf and Sissel Johannessen (1993), all examined the use of food as a tool of political negotiation in archaeological contexts. Their studies show that food and the food-related event such as the feast were commonly used in the negotiation of power in the past.

2. 3. b. Food, Cultural Code, and Metaphor

Nearly half a century after Crawley's examination of French religion and sex through food, his perspective of food as a metaphor of social interaction was finally brought into the center of academic discourse in European social science. Prominent works of European scholars such as Claude Levi-Strauss (1966, 1969, 1973, 1978) and Mary Douglas (1966, 1970, 1973, 1975, 1984) introduced the concept of food as a symbol and its use for social scientists to examine worldviews of both past and present cultures. While many of the contemporaneous American anthropologists were preoccupied with the study of human culture in relation to the environment, in Europe, the innovative research of these scholars laid a foundation for many of today's foodways studies and influenced the generations that followed. Many of the non-ecological approaches after the 1960s are derivatives of the contributions of symbolic, semiotic, and linguistic applications discussed in this section. These approaches made it possible to recognize and utilize food as a tool to examine various aspects of a culture.

Levi-Strauss (1966, 1969, 1973, 1978) introduced the notion of food as a symbol and a tool to understand culture. He applied a linguistic model, equating each cultural element as a phoneme of a language and cultural rules that arrange them as the grammar, and read foodways as if they were texts. Although he was not the first person to introduce the Structuralist approach or to use food to discuss culture, his seminal works combined these two perspectives and influenced many anthropologists both in France and in other countries with different academic traditions.

Under the linguistic understanding of human oral communication, it is assumed that at a very elementary level there is a syntagmatic relation between phonemes that are shared by all the languages, having a vowel system and a consonant system. These are the first to appear in children's language and the last to disappear when an individual loses the ability of to speak. As it is possible to express two sets of oppositions of consonants and vowels forming triangle for each, he argued that cooking, another equally universal practice in all human cultures, could be approached in the same manner in order to organize and understand the unspoken cultural grammar (Levi-Strauss 1966).

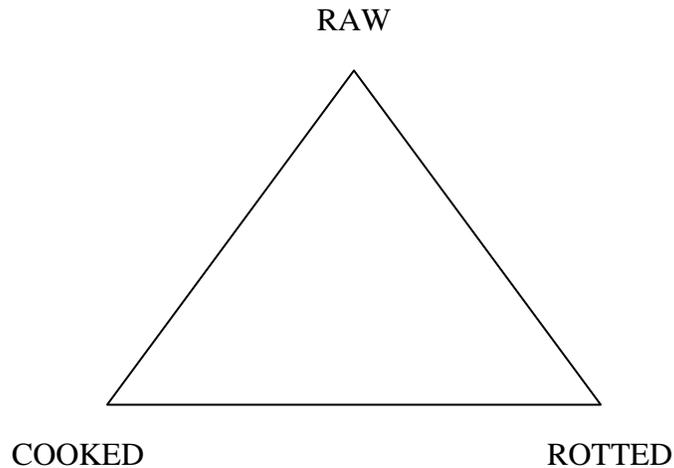


Figure 2-1: Culinary Triangle (Levi-Strauss 1966)

Levi-Strauss developed culinary triangle that has been scrutinized by many anthropologists on its validity and interpretive utility. While most of the criticisms are focused on the Structuralist approach itself rather than the triangle, others attempted to replicate his study on other cultures to examine its effectiveness. Lehrer (1972) examined the triangle and applied it to several well-known cuisines, such as French and Chinese. Although at first glance, the triangle seemingly makes clear the relationship between each of the cooking methods and how it relates to a culture. Lehrer argued that this is grossly simplified when it is used on real-life cooking methods. Once true complexity of a cuisine and multiple cooking methods within a single culture are put in the equation, the triangle no longer holds any structure. Moreover, Levi-Strauss (1966) argued that the transformation that food takes from raw to cooked is the equivalent of nature transforming to culture. Even briefly skimming through world cuisines, there are numerous raw foods that are significantly more sophisticated and intricate than a simple boiled piece of meat. Furthermore, in his triangle, there is no consideration for historical, internal, and external changes that are bound to take place in foodways of any real culture since there is no culture that exists in a vacuum. If the triangle succeeded in representing anything at all, it highlighted the true complexity of the phenomena Levi-Strauss had attempted to simplify or to clarify.

However, this is not to say that his approach no longer holds any integrity or his attempts should be considered entirely futile. The true accomplishment of Levi-Strauss (1966) and his structuralist analysis of foodways were not about how he was able to organize the universe using binary oppositions, but how he developed and secured the perspective of foodways as a vehicle of symbolism, and as a reflection of culture, that are worthy of academic discourses. To this day, his studies are the most influential attempt to study food, and his recognition of food symbolism as the core element of a culture rather than a peripheral element is regarded highly.

Douglas (1966, 1970, 1973, 1975) also takes the position of food and foodways as the vital medium of symbolism and can be used to reveal the hidden disposition of

cultures. She asserts that in any culture, consumption of a meal is a ritual activity, with distinct rules that are expected to be followed by the participants. She attempted to 'read' the contemporary British dietary 'rules', revealing the grammar, similar to what Levi-Strauss did. While Levi-Strauss focused on the states of food, such as cooked, raw, and rotten, Douglas viewed food in the context of a meal in a course of a day, month, and season, for food is always consumed as part of a large cyclical social order. In addition to the British foodways, she examined the food preferences and taboos of various cultures. Instead of seeking the answer in the environment as ecological functionalists did, she sought the answer in how people organize their universes. She argued that in any culture there is always a classification system of the world, creating an order to make nature more tangible and maneuverable. When an element of a culture falls outside the classification categories, it is considered as disorderly and polluting, thus placed under a special category that requires exceptional treatment, such as avoidance in some cases. She explained that the key distinguishing factor of religious proscription of certain food items from edible and non-edible is based exactly on this concept of pollution. When analyzing the prohibition of pork in Leviticus, for example, the terrestrial mammals that are fit for consumption had to meet several criteria, including that they had to chew cud and have hoofs. While pigs have hoofs, they do not chew cud. Hence they did not meet the two important criteria were not fit for consumption.

Once the symbolisms of certain foods are established, each individual holds the symbolic value as part of their worldview, while modifying it constantly from external influences. Roland Barthes (1979) also used the linguistic models to study culture similar to both Levi-Strauss and Douglas. While Levi-Strauss originally applied the structuralist analysis to cultural phenomenon often represented with words, Barthes applied the analysis to material symbols. He viewed material culture, especially food, as an attitude that an individual can take, and a sign and a system of communication that is also an indirect observation of the mental life of a given society. Many individuals within a society share each food item that embodies all those symbolisms across age, gender, class, occupation, etc. Barthes saw a change in food use as a change in its symbolism. He explained that the change of food and taste are often tied to the transformation of what the particular food item symbolizes at the time. For example, a cup of coffee, which has an ample amount of caffeine, long appreciated for its stimulant property, has become the preferred drink at break time as a way of relaxation. Overriding the nutritional value by the cultural value is a common practice, as all cultures give symbolic value to food and food-related behaviors. When the symbolic values of an item are so great, food can evoke strong emotion to the participants even when the food itself does not offer much in terms of nutrients. There is no single food item that has an innate value shared by all cultures. The values are assigned through numerous historical contingencies.

Although the above three scholars came from very different academic traditions and their approaches differ from each other, their importance and influences are unquestionable. What made their studies so important is that they emphasized food and foodways bearing multiple meanings and symbolisms reflecting the worldview of a society. Moreover, through their analyses, these approaches delineate the underlining codes operating in any given society. Their effort made it possible for the scholars following them to further extend the symbolic value of foodways to study other elements of cultures, such as issues of identity and ethnicity.

2. 3. c. Food, Identify, and Communication

As discussed above, foodways can symbolize unspoken cultural codes and worldviews. Whether a particular food item is as expensive and unusual like white truffles or as abundant and inexpensive as a bag of Cheetos, it symbolizes something more than fungus and greasy starch, respectively. Each symbolism associated with foodways is context dependent and based on various social/cultural values, such as economy, nutrition, aesthetic, texture, seasonality, and association to name a few. The access to certain foods is not equal to all individuals due to their surrounding environment, economics, and prescribed power hierarchy. Through repeated exposure to those foodways loaded with symbolism, emotional attachments to food items or food-related behaviors are bound to develop over time (Falk 1991). Regardless of how a meaning became associated with a particular food originally, people begin to identify themselves with a certain food for what it socially stands for. In this sense, we truly become what we eat.

Although food was not the central theme in his discussion of habitus and distinction, Pierre Bourdieu (1984) illustrated how an individual's 'free will' to choose certain foods is in fact under the constant control of the social milieu. His study illustrated how there is no such thing as personal choice truly independent of external circumstance such as life experience, and every food item is socially constructed. Consequently, people belonging to similar social background associate themselves with particular foodways, and thus certain foodways become the distinction marker. For example, in the United States, Thanksgiving dinners may come with some variations between households, but commonly the meal includes turkey, mashed potatoes, cranberry sauce, and pumpkin pie. Jell-O salad with Cool Whip may be crucial components for some families, while others might add chestnut stuffing or some exotic ingredients. Furthermore, even when the income of the family transforms, they tend to cook what they consider 'traditional,' because of the social memories imbedded in the particular food combination.

In addition, because of the tight association between certain symbolisms and foods, people can use foodways to communicate with others without words (e.g., Appadurai 1981; Fishler 1988; Janik 2003; Lupton 1994; Naghan 1998; Ohnuki-Tierney 1993; Powers and Powers 1984). For example, it is acceptable for someone to bring foie gras and champagne for a lunchtime lecture, but not without making any implicit statement of his/her status, wealth, and attitude. In this case those two food items are more than just fattened animal organs and fermented fruit juice, but also they are symbols of one's fondness of French cuisines, wealth, and willingness to create distinction from the others. Moreover, in case of *foie gras*, consumption of it displays one's attitude toward animal welfare issues, and selection of Champagne over local sparkling wine shows one's attitude toward local industry and consideration toward carbon footprints. In this case food can be used intentionally or unintentionally to express certain attitudes and ideas, such as how the individual belongs to a group of people with certain ideologies. Furthermore, food and consumption, unlike many other aspects in our lives, are part of our daily lives, thus any food-related activity, such as lunch or snack, can be the place of communication. This means that each individual can express thoughts, beliefs, and

desires among other emotions to other individuals through food. Since each symbol is laden with social values, they are extremely useful in expressing a variety of ideas and emotional states from animosity to affection depending on the context of use. Therefore, foodways are the ideal medium of communication and enactment of relationships between an individual and others: it is a suitable analytical tool for us to understand interactions and associations between individuals as well as groups.

During the past several decades, there have been a series of foodways studies on the issues concerning distinction, identity, and communication. Though their subjects vary from a small remaining population of a Native American tribe to the contemporary Indian society, where old traditional foodways are still practiced, many of the social categories addressed in foodways studies deal with categories such as class, religion, ethnicity, gender, and nationality.

In his classic article on foodways and class, Arjun Appadurai (1981) discusses caste system of India through its rules of foodways. The traditional Hindu caste system is well known for its strict rules concerning food, reinforcing the existing hierarchical relation between individuals through their handling of food. For example, certain food items can be given from one caste to another, while the other way around is not only deemed insulting, but prohibited. However, when the food item is cooked, the same rule does not apply any longer. At each transaction, the difference of caste, or the difference in social status, is being expressed and strengthened.

While the caste system of India discussed by Appadurai (1981) focused on the transaction of certain food items between the people of different castes, in Leviticus, the religious law deals with types of food that do not meet their criteria, thus not fit for consumption. The ecological functionalists interpreted the prohibition of pork in Leviticus as hygienic precautions to reduce the health risk of pork consumption and illogical nature of raising pigs in the dry environment with herd animals such as sheep and goats. Douglas (1975) explained how the proscription acted as an identity marker that created distinction from the neighboring ethnic groups by rejecting their food.

In terms of ethnicity and foodways, William Powers and Marla Powers (1984) presented a case study on the cultural consequence of losing traditional foodways. In their discussion of Oglala foodways, their traditional ritual food, dogs, had been replaced by wheat and beef. They discussed the importance of reviving the traditional food in order to maintain an ethnic pride.

Another area of focus on foodways as identity is the relationship between gender issues and foodways. Discussion of gender issues in social science has inevitably affected the direction of foodways studies since the 1980s. Although their foci of interest vary, they all attempted to improve and illuminate the role of women in society, both past and present. Both Sigrid Arnott (1991) and Caroline Bynum (1987) presented a feminist view of the Christian women in Europe during the Middle Ages. While their counterpart male monks are often depicted as portly and having healthy appetite for food and wine, the women of monasteries were often portrayed as thin and frail – almost to the point of wasting away, avoiding food even when they were offered it. Through examination of historical documents, both argue that those women, who seemingly avoided eating, were in fact taking control of their bodies in the society where women did not own or have charge of much else. Their skinny physiques endowed them with saintly status and the

aura of supernatural power, thus resistant to the society's expectations and responsibilities of women.

On the other hand, Carol Adams (1990) and Susan Bordo (1986, 1993) focused their studies on the status of contemporary women and issues of food. Adams, who identifies herself as 'eco-feminist,' equated the treatment of farm animals to treatment of women in the contemporary U.S. According to her, consumption of meat only supports the androcentrism and masculinity. Thus, she argues that it is important for us, especially women, to practice vegetarianism. The attempt to improve women's role in society is also the main focus in the works by Bordo (1986, 1993), Counihan (1999), and Counihan and Kaplan (1998) who express concerns over the increase of anorexia in the United States in the last three decades. While managing weight to avoid obesity and other related ailments are good, they believe that the 'ideal' female body shape presented in the media is warping the sense of women's physical being, to the point they reject eating.

In addition to the above-mentioned social categories, there are other significant foodways studies on identity. Emiko Ohnuki-Tierney (1993), for example, delineated the relationship between national identity and foodways. She presented her study on rice and development of national identity through historical, archaeological, and sociological studies of Japan, illuminating the symbolic importance of this single cultigen.

2. 3. d. Food, Function, and Environment

The legacy of Franz Boas directed much of American anthropology in the early half of the twentieth century to be dominated by Historical Particularism. Scholars continued to study cultures in terms of their own history and uniqueness, and rejected any generalization and the study of human culture as a whole. However, by the 1930s, a small group of anthropologists, such as Leslie White, became increasingly dissatisfied with 'cultural idealism' and began to apply an ecological framework based on behavioral ecology and eventually connected anthropology with other natural science disciplines. By the 1960s, cultural ecology became very fashionable among the American anthropologists, and its variations have been especially popular among archaeologists. Its emphasis on the influence of environment on human culture and 'scientific' analysis of cultural elements attracted many scholars. In the last half of the twentieth century, American anthropology has seen multiple variants of cultural ecology, many of which produced influential works of the study of human foodways.

Cultural Materialism was the fundamental approach that sought strong ties between culture and environment (Harris 1979). Marvin Harris's approach to foodways was built upon the assumption that "dietary habits are the outcome of determinative processes in which biopsychological, technological, economic, demography, and environmental factors predominate" (Harris 1987:5). He provided 'rational' explanations to the elaborate rituals and symbolisms related to food of various cultures using 'scientific knowledge,' and provided explanations to 'harmful' foodways or 'cultural riddles' as earlier anthropologists such as Lowie labeled them, in terms of environment.

For example, Harris (1974, 1985) explained the Hindu religious codes prohibiting the consumption of beef in India. Previously, this religious code was regarded as peculiar and unreasonable for not allowing the people to eat the cows when other food is scarce. He explained that the belief of the sacred cow developed because of

their great value as farm animals far more exceeding their value as food. Similarly, he provided logical explanation for the Aztec cannibalism as a way to cope with the environment, which, based on his studies, lacked sufficient amount of protein. According to his study, sacrifice and subsequent consumption of a part of the population not only eliminated the competition over limited food resources but also provided much needed protein to the consumers. Harris's approach was welcomed and replicated by many others (e.g., Katz 1973; Katz, Heidger, and Valleroy 1974; Lieberman 1987; Rappaport 1968), elucidating the cultural rules and taboos as rational and environmentally fit coping mechanisms.

This approach was criticized for failing to provide any explanation of differential solutions adopted for the same problems faced by different cultural groups occupying similar environments, and sometimes Harris himself failed to consider all the variables even in terms of a single environment. Nonetheless, this approach demonstrated the close ties between cultures and environment, which was not fully recognized previously. Moreover, ecological approaches to human diet are not a completely futile attempt filled with overly simplified and generalized understanding of complex foodways. There are several significant studies of foodways in terms of human bio-cultural evolution. Solomon Katz (1987) examined the cultural factors of fava bean consumption in the circum-Mediterranean region intertwined with biological evolution of the population. What is initially believed as a mere cultural proscription of seemingly innocent legume was revealed as a biological evolutionary tactic to reduce the risk of favism. Similar studies include the relationship between lactose intolerance and adoption and invention of particular dairy methods, and reliance of maize in combination with beans supplying the essential amino acids, aiding the growth of Meso-American population (Katz, Hediger, Valleroy 1975). These studies attempting to expose the 'true' functions behind foodways are even more promising these days with the advancements in chemistry, genetics, immunology, and other biological science fields.

In archaeology, ecological perspectives introduced in the 1960s were hailed as the solution to the stagnant culture historical archaeology, with its aim to provide explanations to archaeological phenomena. Two major factions of ecological perspectives developed in the 1960s, cultural ecology and behavioral ecology, both of which continue to be utilized today producing new theories and hypotheses on human-environment interactions in prehistory (e.g., Broughton and O'Connell 1999). In archaeological applications of these approaches, subsistence is regarded as one of the main functional systems of human adaptation to their environment. The aim of studying subsistence was to develop models and theories that can be applied cross culturally, by relying on the use of mathematical models and abstract representation of the environment mostly developed in biological sciences (e.g., MacArthur and Pianka 1966).

In the case of behavioral ecology, human behaviors including foodways reflect a Darwinian paradigm of natural selection by prioritizing actions that will optimize their effort, thus maximizing their chance of survival and reproductive success (Smith 1983). Within this framework, a series of mathematical models were developed to predict and explain human behaviors related to food.

According to the proponents of this theoretical perspective, this unconscious decision guided by evolutionary force was the base of critical decision-making, such as foraging strategies (Emlen and Emlen 1974; Smith 1983; Winterhalder 1981, 1987;

Yesner 1983), mating behavior (Daly and Wilson 1983; Dickemann 1979; Smith 1983), and mobility and settlement patterns (Smith 1981, 1985; Hames 1983). In examining characteristics of foraging strategies, several explicit models that examine specific aspects of foraging behavior were developed. These include models of optimal prey choice or diet breadth (O'Connell and Hawkes 1981; Winterhalder 1987), marginal value theorem (e.g., Feit 1973; Ross 1978; Winterhalder 1977), and patch choice (e.g., Harpending and Davis 1977; MacArthur and Pianka 1966; Shoener 1971). Among these models, the model of the optimal prey choice, or the diet breadth model, specifically evaluates the relative value of prey choices in relation to the energy investment and return involved in the acquisition of preys. Simply stated, the diet breadth model asserts that individuals tend to select food that provides the greatest return compared to the energy invested.

However, some of the earlier attempts to apply these models adopted a rather simplified attitude toward human physiology and food, and at times failed to prove its effectiveness. Moreover, many of these models did not reflect much of the non-biological aspects of human food relationship beyond efficiency and convenience. For example, much of the food choices made by hunter-gatherers were interpreted by cost-benefit calculations (e.g., Lee 1968; Winterhalder 1981, 1987; Winterhalder and Smith 1981), when in reality the decision to incorporate a certain edible item as food can be based on a variety of reasons. Despite these challenges, ecological approaches to the study of foodways in a subsistence system continue to add new insights to human-environment relationship to food and remain major parts of the contemporary archaeology (Broughton and O'Connell 1999; Erlandson 2001; Kennett 2005).

2. 4. The Application of Behavioral Ecological Model to the Study of Foodways at Sannai Maruyama

As an attempt to examine the selection of fish by the residents of Sannai Maruyama, one of the behavioral ecological models, optimal foraging models, is applied to the Sannai Maruyama faunal data. Although as I discussed above, the primary purpose of these models is to examine food-related behavior in terms of cost and return, they could provide insights greater than this scope. For one thing, if the result of the cost benefit calculation show that a particular fish was selected despite high investment, it is possible that there were other values associated with the fish.

2. 4. a. Optimal Foraging Models

Optimal foraging models are a series of formal mathematical models that were originally developed during the 1960s and 1970s within the field of behavioral ecology. The primary goal of the use of evolutionary ecological models is to explain diverse animal behaviors that influence reproductive success, including food acquisition strategies, of all living species of animals - human and others (Smith 1991). The models attempt to examine those behaviors in a tangible and predictable manner using mathematical formulae and simplified models of the actual universe free of 'real life constraints'. The most basic assumption shared by all the models is that natural selection

favors foragers that select behaviors that will result in the high likelihood of reproductive success.

It is important to clarify that the word ‘forager’ in this context is not used in the same sense as Lewis Binford’s Collector-Forager spectrum, or a human subsistence practice that exclusively relies on foraging/collecting as opposed to hunting or fishing. Rather, in the discussion of optimal foraging, a forager is simply an individual who employs various strategies to acquire food from his/her surrounding environment.

One of the main criticisms of optimal foraging models is that they are derived from the biology of non-human animals, thus not fit to be applied to study complex human cultures. Lee (1979: 434), among others, warned us by stating the following: “mechanical models drawn from animal behavior and animal ecology, however sophisticated, cannot do justice to any but the simplest of cultural ecological phenomena.” Furthermore, early post-processual critiques during the 1980s and 1990s questioned the use of optimal foraging models for its blatant dismissal of the role of culture. In the process of reducing the real world into simple testable models, culture specific traits such as religious beliefs were intentionally left out. While the simplification allowed the development of universally applicable models, some argued that they no longer hold utility.

Despite these criticisms, many supporters of optimal foraging models share the counter arguments by Smith (1991: 35): “the virtues of the use of models are: (1) logical clarity, (2) the ease with which they lend themselves to precise manipulation and generation of hypothesis, (3) direct, often quantitative test implications, and (4) ability to generate novel insights.” In addition, using optimal foraging models, David Hurst Thomas (2008) studied the Guale food selection. The result of his work showed how these models do have the potential to reveal cultural characteristics or values precisely because the data do not support the model. Following his example, principles behind the diet breadth model, one of the optimal foraging models, are applied to Sannai Maruyama data to see if optimization was the reason for fish selection, or if there were other possible cultural reasons.

2.4. b. Diet Breadth Model

The diet breadth model is designed to answer the question: of all the available food items, which ones should an efficient forager select (Bettinger 1980; Winterhalder 1981, 1987; Winterhalder and Smith 1981). The model supposes that, in order to achieve optimum reproductive success, an individual forager should select food that will provide the most energy return with minimum investment and risks. The fundamental principle is that by minimizing their effort to produce the greatest return, there will be enough nutrients and time to support the most important behavior, reproduction.

If the residents of Sannai Maruyama during the Lower Ento–a phase fished optimally, then the faunal data are expected to show high representation of fish taxa with high returns. If not, then it is possible that there were other reasons for selecting their fish during the Lower Ento–a phase. In chapter 5, I will present how the principles of this model will be applied to the Sannai Maruyama faunal data.

In order to lay the foundation for the rest of the thesis, in the next chapters I will provide the archaeological background information of the Sannai Maruyama site that are relevant to the fish and fishing practices during the Lower Ento-a phase.

Chapter 3

Archaeological Background: Sannai Maruyama

As I discussed in the previous chapter, the framework of foodways is a useful analytical tool to discuss human behavior in an archaeological setting. However, in order to delineate the intricate web of actions and beliefs through food from often ambiguous archaeological record, however, it is crucial to acquire a data set with adequate contextual information. The archaeological record from the Sannai Maruyama site offers an ideal setting for the examination of foodways.

The Sannai Maruyama site is a Jomon period hunter-gatherer settlement located at the northern end of the Honshu Island (Figure 3-1). It was occupied primarily during the Early and Middle Jomon periods (5900-4300 cal. B.P.). As of 2010, the site is in its 18th year of extensive archaeological research, providing an ideal setting for exploring key questions in the study of Jomon and hunter-gatherer foodways. In this chapter, I provide background information of the Sannai Maruyama site including the history of archaeological investigations and their results, with an emphasis on the findings from the Lower Ento—a phase of the Early Jomon period (ca. 5900 – 5650 cal BP) (Habu 2004). English overviews of the site have been presented by Habu (2002, 2004, 2008), Habu and Okada (1995), Okada (2003) and others. Thus, this chapter is meant to provide only background information relevant to the thesis.

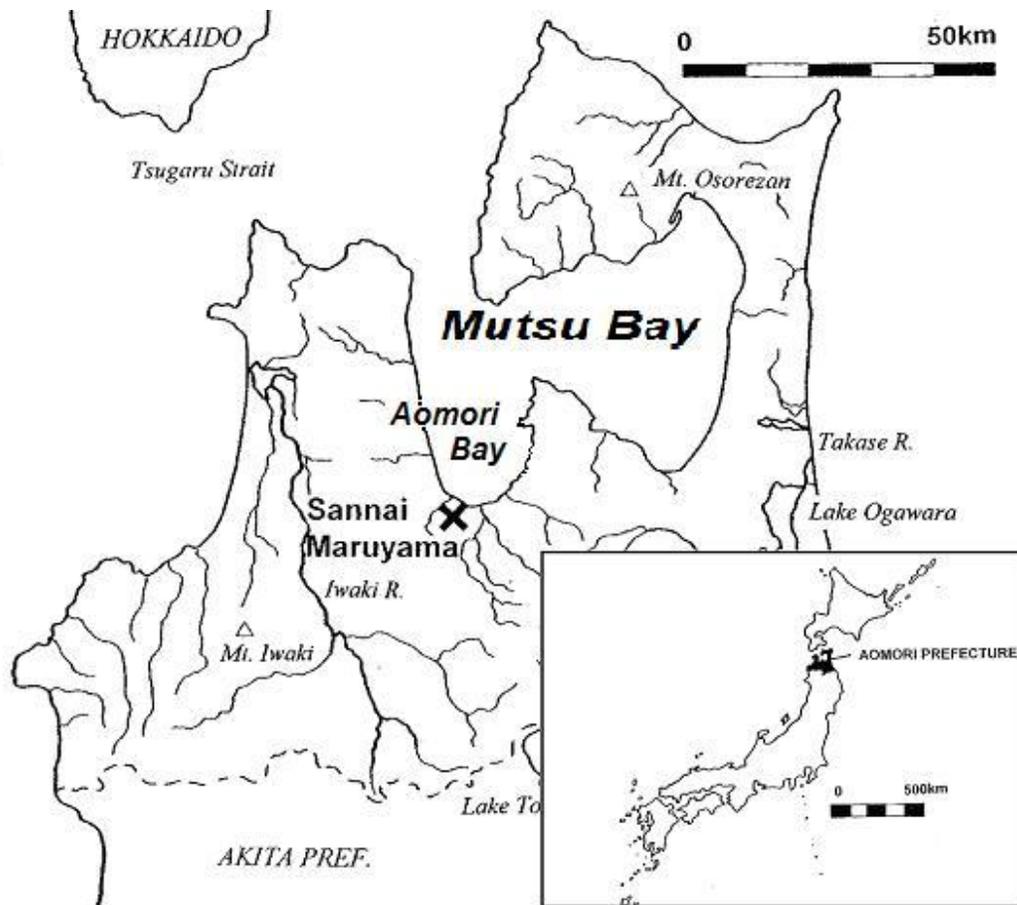


Figure 3-1: The Location of Aomori Prefecture and the Sannai Maruyama Site (Modified from Habu 2004: 109)

3. 1. Site Location

The Sannai Maruyama site is located on the edge of a plateau, approximately twelve to eighteen meters above sea level. The site overlooks Aomori Plain facing Mutsu Bay to the north. Today, the site is surrounded by several streams, including the Okidate River to the north. The Okidate River eventually merges into the Sannai River, and then flows into the Mutsu Bay.

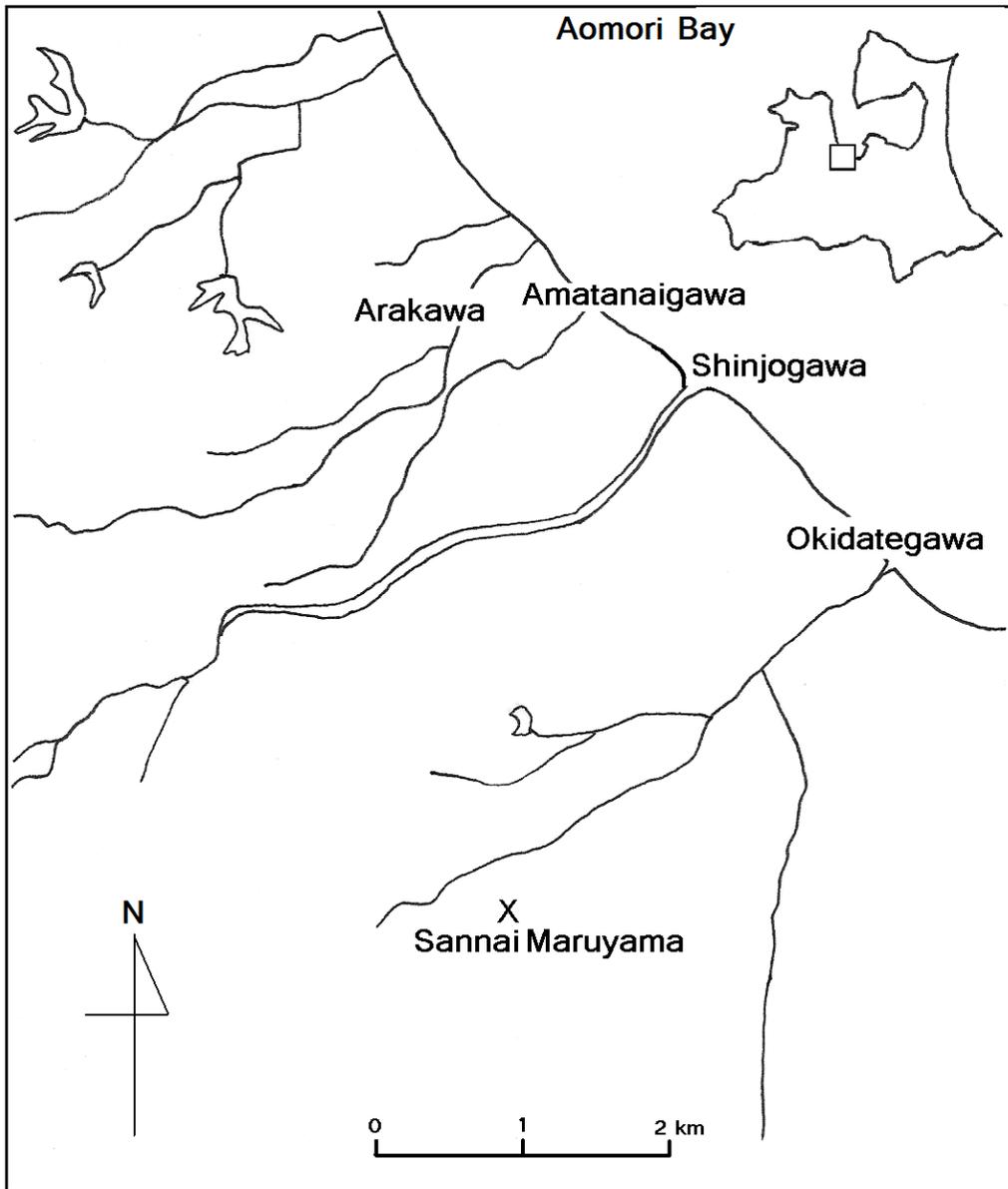


Figure 3-2: Site Location, Showing Streams and Bay (Partially Modified from Aomori-ken Kyoiku Iinkai 1994)

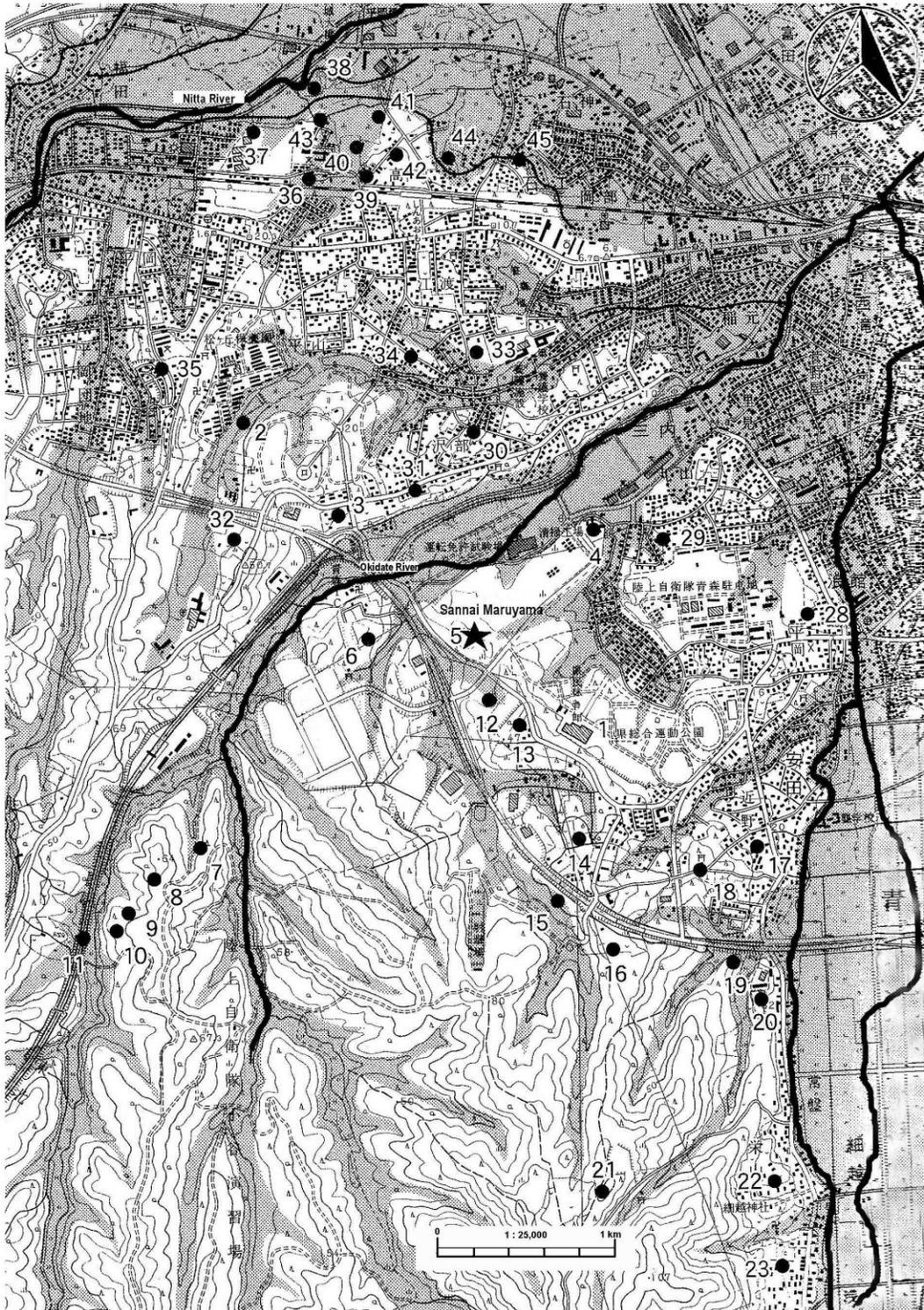


Figure 3-3: Location of the Sannai Maruyama Site and Its Surrounding Area
 Shaded Area Indicates Low Elevation and Each Dot Represents an Archaeological Site (Modified from Aomori-ken Kyoiku Iinkai 2002 a: 8)

Today, the plateau on which the site is located is approximately 3.6 kilometers away from the bay. The paleo-environmental reconstruction based on soil cores taken from multiple locations within the Aomori Plain indicates, however, that the environment that surrounded the site was quite different during the Early Jomon period. Takahashi (1995, 2003) suggests the presence of a large lagoon that was stretching from the bottom of the plateau to the bay (Figure 3-4). The lagoon was protected by a series of low sand dune rows. His boring core data indicate that the area between the bay and the plateau was a calm lagoon of brackish water during the early occupation of the site, including Lower Ento—a phase, providing a wealth of aquatic resources, such as fish, as well as various animals that subsisted on them. Moreover, the lagoon provided the residents of Sannai Maruyama and their neighbors with an ideal access route to the Aomori Bay and beyond.

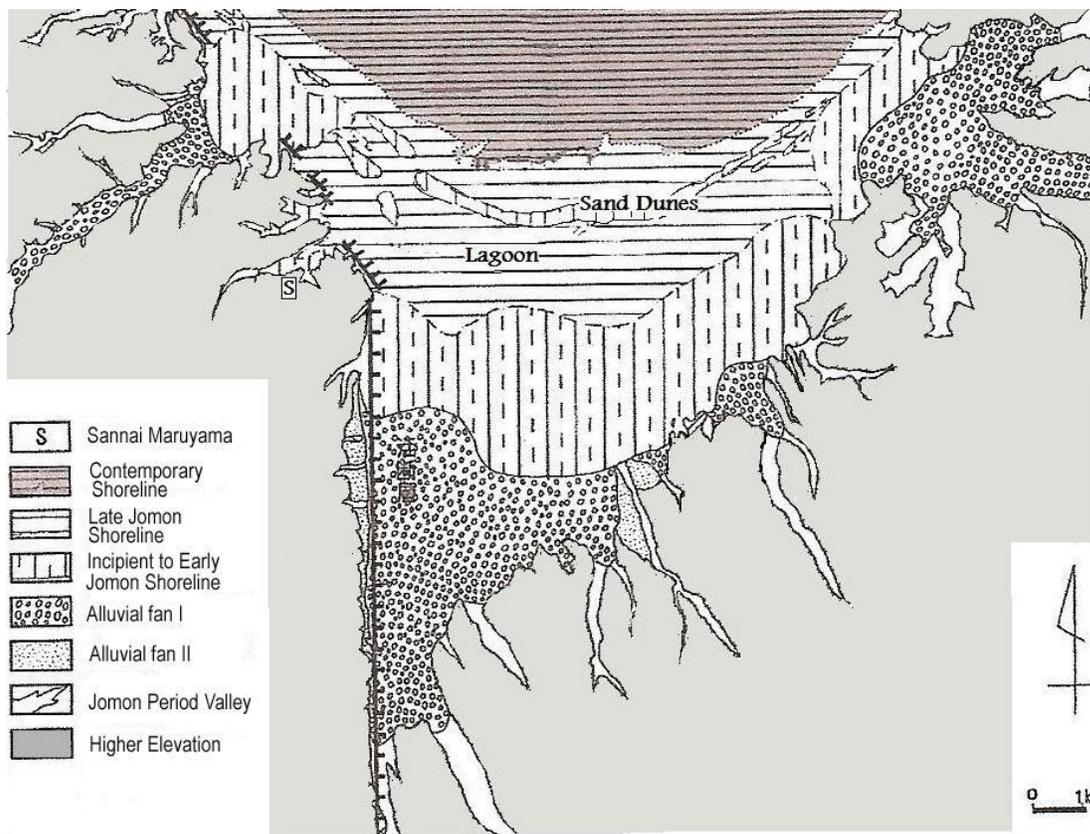


Figure 3-4: Geological Conditions that Surrounded the Sannai Maruyama Site and Aomori Bay (Modified from Takahashi 2005: 174).

Figure 3-5 shows the reconstruction presented by Kubo et al. (2006). Although the extent of the lagoon area is slightly smaller than Takahashi’s (2005), their study depicts the presence of a marshy lagoon during the early occupational phase of the Sannai Maruyama site.

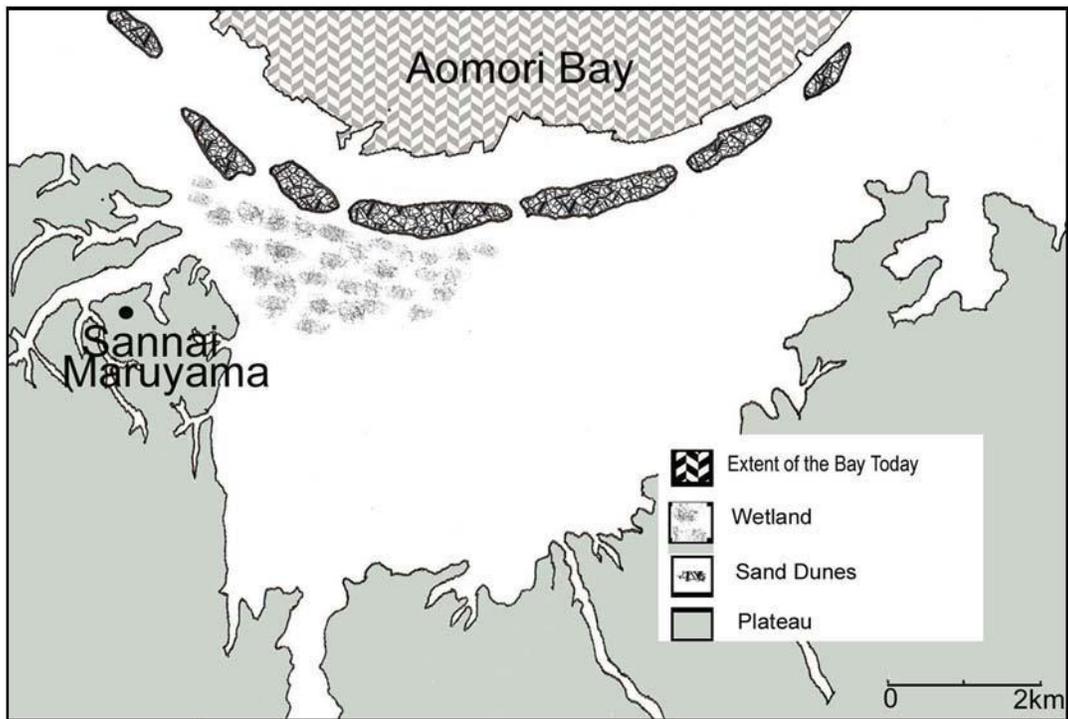


Figure 3-5: The Geological Reconstruction of the Area by Kubo et al.) (Modified and redrawn from Kubo et. al.2006: 15)

The analyses of the boring cores taken at O’ono (approximately three kilometers east of the site) by Kubo et al. (2006) indicate the presence of *Coscinodiscus marginatus*, which is typically found in the oceanic environment, as well as *Palaria sulcata* and *Thalassiosira oestruppi*. Both of the latter two species are commonly associated with an inner bay environment (Kubo et al. 2006:15).

These scholars all suggest that the lagoon extended all the way to the Northern Valley and Southern Valley areas of the Sannai Maruyama Site (see Figure 3-8) from the Mutsu Bay. If this was the case, then the site residents of the Early Jomon Period had a relatively easy access to the Mutsu Bay (Aomori Kenshi Hensan Koukobukai 2002) and beyond. Therefore, these sites residents had a convenient access to a wide range of fish and other resources from a variety of aquatic habitats.

Right beside the site, there are small streams at the bottom of a ravine. At these small freshwater streams, the available fish are: Anguillidae (eels), Cobitidae (loaches), Osmeridae (smelts), Cottidae (sculpins), Cyprinidae (minnows), and Salmonidae (salmons and trouts). Although some of species in these families can be quite large, most of them are between a few inches (i.e., Cobitidae) to a little over a foot (i.e., Anguillidae). Some of the small fish can be caught by using baskets or nets, while larger fish can be caught by using fishing rods.

Down the streams where the freshwater meets the bay water, the site residents could encounter fish taxa such as: Platycephalidae (flathead), Tetradontidae (blow fish), Gobiidae (gobies), Hermiramphidae (sayori), and Mugilidae (mullet). In the brackish water area, the type and size of potential prey varies greatly. Moreover, within the bay, the available fish near the shores include: Chondrichthyes (cartilaginous fish), Sparidae

(sea bream) Embiotocidae (surfperch), Monacanthidae (filefish), Scorpaenidae (scorpion fish), Clupeidae (herrings and sardines), and Labridae (wrasse). These can be caught with fishing rods cast from the land.

On the other hand, if the site residents took a watercraft and traveled away from the shore but still remained in the bay, their potential prey could include: *Scomber* (mackerels), *Gadus* (cod), Sparidae (sea breams), Pleuronectidae (flatfish). Finally, if the site residents traveled further to outside of the bay, then they could find fish such as: *Seriola* (yellowtail), Istiophoridae (marlins), and larger species of Scombridae, e.g., *Thunnus* (tunas) and *Katsuwonus* (bonito). These fish are significantly larger than the ones found in the small freshwater streams or near shore areas of the bay. Some of the fish, such as tuna (*Thunnus*) and yellowtail (*Seriola*) can easily be larger than three feet in length. Moreover, in order to catch these fish, the use of sturdy fishing gear and watercraft is essential.

3.2. The Sannai Maruyama and Neighboring Sites

While the areas surrounding the site allowed residents to have access to a variety of resources, the Sannai Maruyama site was not a solitary settlement in this area during the Jomon period. The surrounding area was shared with residents of neighboring sites throughout the entire occupation of the site. As shown in Figure 3-3, there are seventeen sites within one kilometer radius of the Sannai Maruyama site. A total of 45 Jomon sites are shown in the figure. Table 3-1 lists the names and periods of these neighboring sites. Those that are indicated from the Early and Middle Jomon are contemporaneous with Sannai Maruyama.

Site Number	Site Name	Period
1	Chikano	Early to Final Jomon
2	Sannai Reien	Early to Middle Jomon
3	Sannai Sawabe (1)	Incipient to Late Jomon
4	Kosannai	Early to Late Jomon
5	Sannai Maruyama (1)	Early to Late Jomon
6	Sannai	Middle to Late Jomon
7	Iwatari Kotani (2)	Early to Late Jomon
8	Iwatari Kotani (1)	Jomon, historical
9	Iwatari Kotani (3)	Middle Jomon
10	Iwatari Kotani (4)	Early to Late Jomon
11	Kumazawa	Incipient to Late Jomon

12	Sannai Maruyama (5)	Middle Jomon
13	Sannai Maruyama (3)	historical
14	Sannai Maruyama (4)	Early to Middle Jomon
15	Sannai Maruyama (6)	Early to Middle Jomon
16	Yasuda (2)	Early to Middle Jomon
17	Yasuda (1)	Early Jomon
18	Yasudachikano (1)	Early to Late Jomon
19	Sakaeyama (3)	Unspecified Jomon, Yayoi, historical
20	Hosogoshikan	Historical
21	Sakaeyama (4)	Historical
22	Sakaeyama (1)	Historical
23	Sakaeyama (2)	Unspecified Jomon, historical
24	Asahiyama (2)	Unspecified Jomon, historical
25	Asahiyama (3)	Unspecified Jomon, historical
26	Asahiyama	Unspecified Jomon, historical
27	Hosogoe	Final Jomon, historical
28	Namidate (2)	Middle and Final Jomon
29	Namidate (1)	Early Jomon
30	Sannai Sawabe	Middle Jomon
31	Sannai Sawabe	Unspecified Jomon, historical
32	Sannai Sawabe	Historical
33	Ewatari	Early Jomon
34	Ishie	Early Jomon
35	Shinjo Hiraoka	Historical
36	Shinjo Hiraoka	Late Jomon, historical
37	Nishi Koko	Yayoi, historical
38	Nishi Baipasu	Early and Late Jomon
39	Takama (1)	Early Jomon
40	Takama (2)	Early and Late Jomon
41	Takama (3)	Late Jomon,

		historical
42	Takama (4)	Early and Late Jomon
43	Takama (5)	Early and Late Jomon
44	Takama (6)	Unspecified Jomon, historical
45	Okabe	Unspecified Jomon

Table 3-1: List of Surrounding Sites (Translated from Aomori-ken Kyoiku Iinkai 2002a: 6, 7)

As Figure 3-3 and Table 3-1 indicate, the residents of Sanani Maruyama shared the area with many others. It is likely that the residents closely interacted with the people who occupied many of the contemporaneous sites shown in Figure 3-3.

Note that prior to the rescue excavation from 1992 to 1994, part of what is collectively known as Sannai Maruyama today was considered to be independent sites: Kosannai, northern section of Chikano, Sannai Maruyama (1), and Sannai Maruyama (2). All of these areas are now designated as part of the Sannai Maruyama site by Aomori Prefecture.

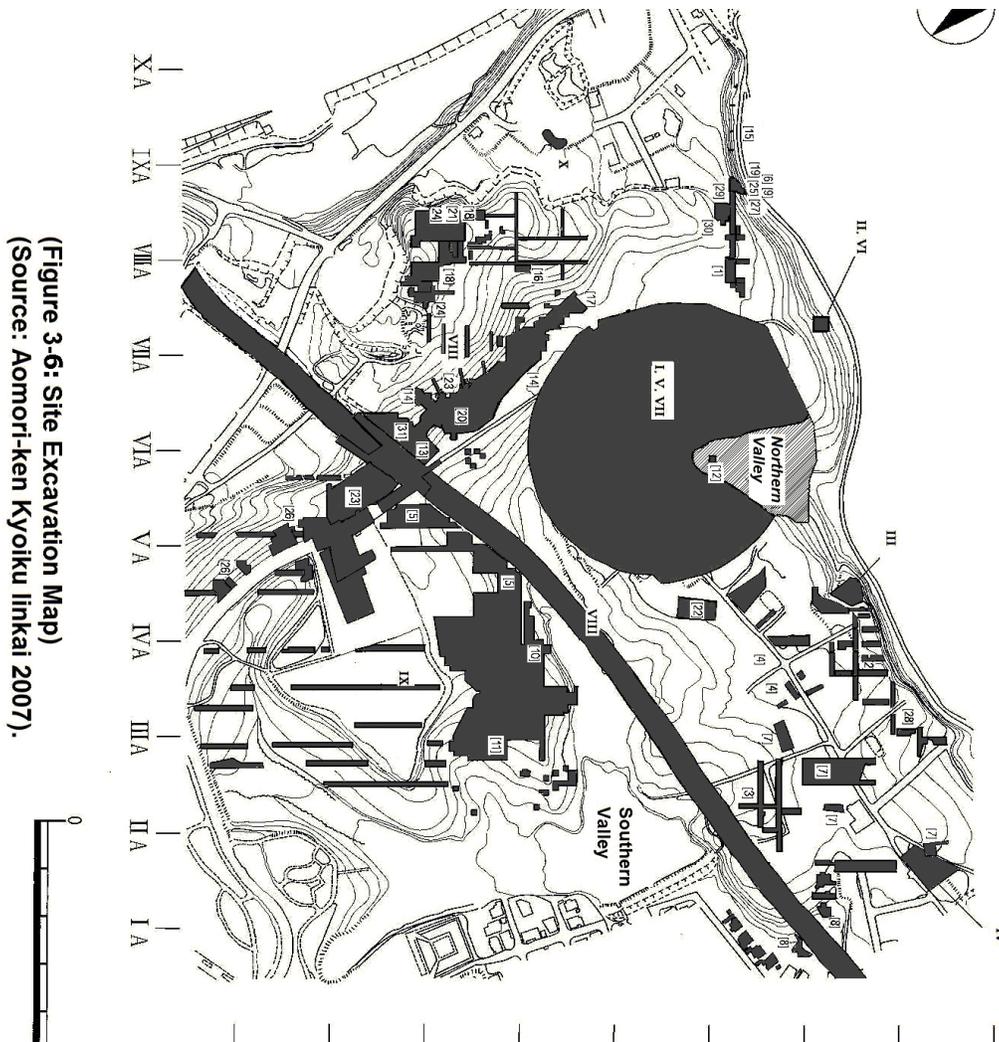
3.3. History of the Excavation of the Site

The Sannai Maruyama site was known to the local inhabitants and travelers as early as the 16th century as an area where artifacts, such as clay figurines and potsherds, were scattered about (Okada 1995). Prior to the large-scale rescue excavation in the 1990s, the area saw a couple of seasons of small-scale archaeological investigations: a local high school student team and archaeologists from Keio University excavated a small portion of this site during the 1940s and 1950s. These excavations unearthed pottery, clay figurines, stone tools, stone ornaments in and around semi-subterranean dwellings from the Ento phases of the Middle Jomon period (Ichikawa 1996).

Apart from these small scale excavations, until the 1970s, the site and the surrounding area had been left to be used as agricultural fields and residential areas by local residents, with relatively untouched wooded patches surrounding them. In 1976, Aomori Prefecture constructed a community park with a swimming pool, tennis court, track field, and baseball field in the southern part of the Sannai Maruyama site complex. At the time of the excavation, the excavation area was called the Chikano site. Today, part of the Chikano site is incorporated into the Sannai Maruyama site. The rescue excavation that preceded the construction of this community park resulted in the recovery of a large number of clay and stone artifacts, as well as the discovery of 56 burial pits forming a long path (Aomori-ken Kyoiku Iinkai 1974, 1977; Ichikawa 1996). Even though it was not a small park, the construction left more than half of what is now recognized as the Sannai Maruyama site intact. During the following decade and a half, part of the remaining site area continued to be utilized as agricultural fields, and the rest remained as an undeveloped open area to which local residents had access.

The largest and most recent series of excavations at Sannai Maruyama began in 1992 by the Board of Education of Aomori Prefecture as rescue excavation prior to a large-scale expansion of the community park. The expansion plan included a soccer stadium, baseball stadium, and parking lots. This construction project provided archaeologists of the Board of Education of Aomori Prefecture, who were assigned to work at Sannai Maruyama (hereafter referred to as ‘the site archaeologists’), with a unique opportunity to investigate the archaeological history of an area at such a large scale. The initial three rescue excavation seasons between 1992 and 1994 revealed a massive Jomon settlement with over 500 pit-dwellings. Because of this excavation result, the site was identified to be the largest Jomon site in Japan at that time. Based on the sheer size of the site, along with the discovery of large features and other historically valuable findings, the site archaeologists appealed to the prefectural governor to permanently preserve the site. Efforts by the site archaeologists with the help of local and national media and the involvement of the local people were rewarded: they managed to convince the prefectural governor that Sannai Maruyama as an archaeological site had more importance than the planned community park expansion. As a result, the prefectural governor called off the construction of the sports facility indefinitely, and the decision to preserve the site as a historical park was approved in 1996 (for more detailed discussion of the preservation effort of the site, see Habu and Fawcett 1999).

In order to oversee and manage the entire operation of the site, including archaeological research, the Sannai Maruyama Historical Site Preservation and Utilization Promotion Office (Sannai Maruyama Iseki Hozon Katsuyo Sujishin-shitsu), a special unit within the Cultural Properties Protection Division of the Board of Education of Aomori Prefecture was set up in 2008 (the predecessor of this unit was called the Preservation Office of the Sannai Maruyama Site [Sannai Maruyama Iseki Taisaku-shitsu]). Albeit at a much smaller scale than the initial rescue excavations of 1992, 1993, and 1994, the site archaeologists continue to excavate at and around the site every year. Moreover, with the encouragement of the Preservation and Utilization Promotion Office, archaeologists from outside of the Aomori Board of Education have been conducting collaborative investigations, creating additional interpretations to the occupational history of the site (for examples of such collaborative efforts, see e.g. Tsuji and Noshiro 2006, and Umehara and Yasuda 1996). As of 2007, 35 acres have officially been designated as the national historic site area, and multiple excavations throughout this site area have been carried out by the Board of Education of Aomori Prefecture. Figure 3-6 shows the estimated boundaries of the Sannai Maruyama site and the areas of both full and test excavations conducted between the 1970s and 2007. These excavations were carried out by archaeologists of either the Board of Education of Aomori Prefecture or the Board of Education of Aomori City. In Figure 3-6, the shaded areas represent the excavated portion of the Sannai Maruyama site as of 2007. The section with diagonal lines in Figure 3-6 indicates the Northern Valley Area, where the faunal assemblages used in this thesis have been recovered from. Summaries of these rescue and test excavations are provided in Appendix A-1.



(Figure 3-6: Site Excavation Map)
 (Source: Aomori-ken Kyōiku Inkkai 2007).

As a result of these excavations, a wide array of archaeological materials has been recovered. Most of the excavation results have been published by Aomori City and Aomori Prefecture Boards of Education, with the exception of some of the excavations from the initial three seasons (i.e., excavations from 1992 to 1994). This limitation is due to the sheer volume of the archaeological materials from the excavations in 1992-1994.

3.4. Site Chronology

Based on the stylistic analysis of excavated pottery, the entire occupational history of the site during the Jomon period is divided into twelve phases spanning from the Early Jomon to Middle Jomon Periods. The site occupation began during the Early Jomon Period, the pottery chronology sequence of which is the Lower Ento-a, Lower Ento-b, Lower Ento-c, and Lower Ento-d phases from the oldest to the youngest. These Early Jomon phases are followed by the pottery chronology sequence of the Middle

Jomon Period: the Upper Ento–a, Upper Ento–b, Upper Ento–c, Upper Ento–d, Upper Ento–e, Enokibayashi, Saibana, and finally Daigi 10 phases from the earliest to the most recent.

To establish relative chronology at each site, traditionally, Japanese archaeologists relied primarily on stylistic analyses of pottery instead of the use of conventional radiocarbon dating or AMS analyses. At Sannai Maruyama, however, several independent AMS analyses have been carried out at different locations of the site (Imamura 1999; Kobayashi 2005; Tsuji 1999, 2006). Overall, the dates from these studies on the basis of the AMS method confirm the reliability of existing pottery chronology. Furthermore, these AMS examinations provide us with a more accurate estimate of the duration of each phase and sub-period.

Atmospheric data from Reimer et al (2004):OxCal v3.10 Bronk Ramsey (2005): cub r:5 sd:12 prob usp[chron]

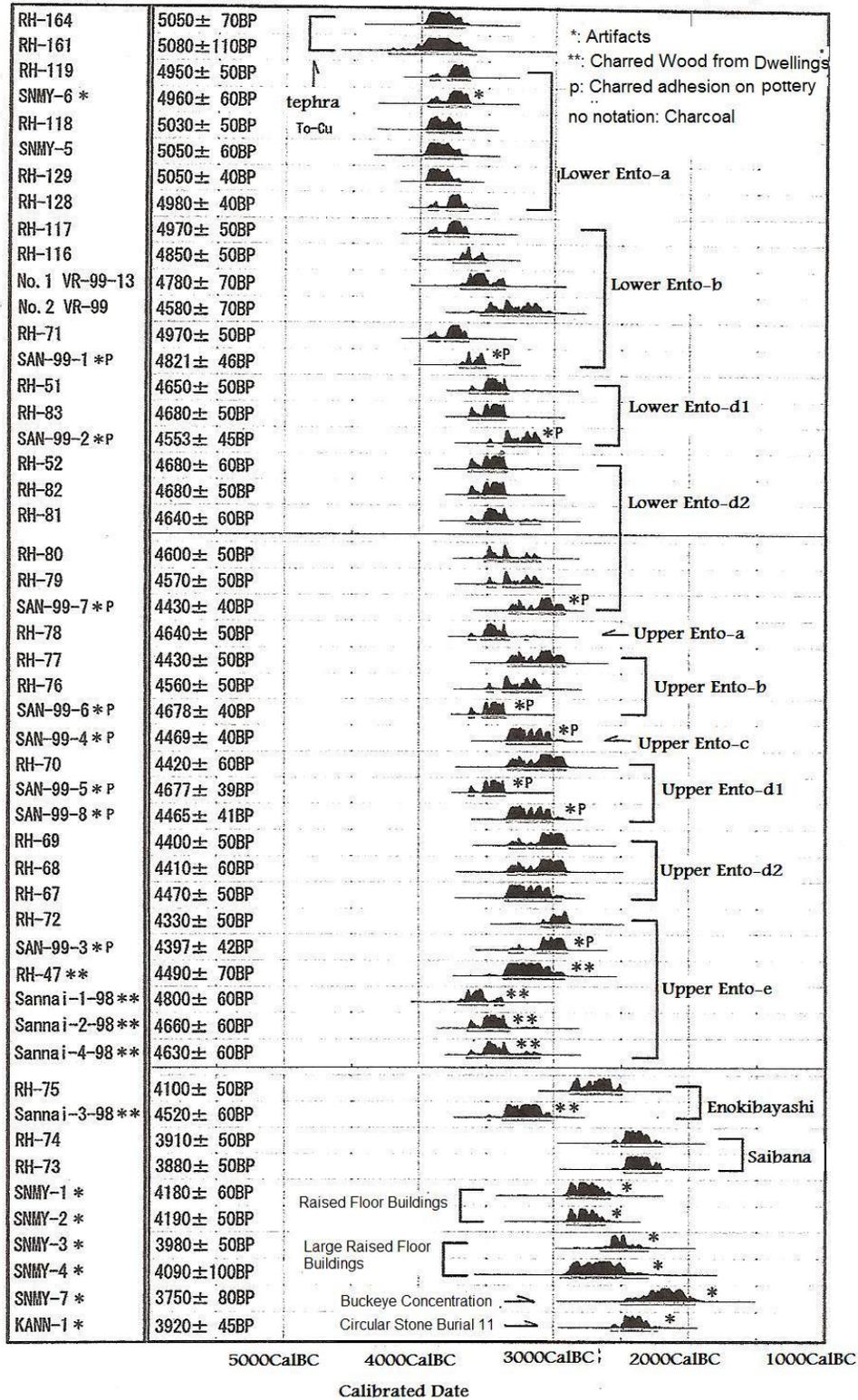


Table 3-2: One-Sigma Ranges of Calibrated Dates (Modified from Tsuji 2006: 45)

In addition, Nakamura et al. (1998) took ten charred wood pieces from Lower Ento—a layers of the Sixth Transmission Tower Area and conducted a series of AMS analyses at Nagoya University. Table 3-3 lists the results of their analyses.

Sample #	$\delta^{13}\text{(‰)}$	C14 (yr BP \pm 1 σ)	Calibrated Dates (1 σ range)
SAN-1	-25.8	4779 \pm 87	3649-3502 BC (80.5%) 3425-3381 BC (19.5%)
SAN-2	-25.6	4732 \pm 83	3628-3651 BC (35.1%) 3545-3498 BC (24.8%) 3457-3378 BC (40.1%)
SAN-3	-26.3	5145 \pm 90	4040-4015 BC (10.1%) 4007-3899 BC (50.5%) 3883-3800 BC (37.5%)
SAN-4	-26.4	4842 \pm 86	3714-3611 BC (56.3%) 3606-3514 BC (43.7%)
SAN-5	-25.9	4781 \pm 92	3651-3501 BC (78.0%) 3427-3381 BC (19.6%)
SAN-6	-26.7	5103 \pm 87	3977-3794 BC (100%)
SAN-7	-25.8	5005 \pm 88	3938-3858 BC (39.7%) 3818-3703 BC (60.3%)
SAN-8	-25.9	5077 \pm 84	3962-3790 BC (100%)
SAN-9	-26.6	5108 \pm 106	3997-3771 BC 97.3%)
SAN-10	-26.8	4970 \pm 119	3937-3860 BC (28.2%) 3817-3648 BC (71.8%)

Table 3-3: AMS Dates of Charred Woods Excavated from Lower Ento—a Layers of the Sixth Transmission Tower Area (Nakamura et. al. 1998: 31

As Table 3-3 indicates, all the dates from the Lower Ento—a layers fall approximately within the range of 4750 to 5100 uncalibrated BP, or approximately 3500-3900 calibrated BP.

3.5. Climate

Today, Aomori Prefecture is known in Japan for its relatively harsh climate. It has long cold winters and hot, humid, summers. In an average year, the Aomori plain sees the snow as deep as 150 centimeters from early November to late February, with the temperature reaching as low as minus 6 centigrade in February. After the rainy season in June and early July, the temperature reaches well above 30 degrees centigrade with high humidity. In addition, in some summers, *yamase*, the cold wind with high moisture content, hits this region, creating havoc to local agricultural industry.

Based on an examination of pollens recovered from the site, Yoshikawa (2005) and Yoshikawa, et al. (2006) suggest that the vegetation at the site at the beginning of the site occupation resembles that of the area today. Their pollen analyses indicate that, prior to the occupation of the site, there was a forest of deciduous, broad-leaf trees, such as *Quercus* (oak), *Fagus* (beech), *Ulmus* (elm), *Zelkova*, and *Acer* (maple) at and around the

site. Right after the site occupation began in the middle of the Early Jomon period, there was a decrease in the amount of the pollen of deciduous, broad-leaf trees. At the same time, the above-listed tree taxa were replaced by edible or what they categorized as more ‘useful’ taxa, such as *Juglans* (walnut), then slightly later *Castanea* (chestnut). Around the water-logged areas, such as the Northern and Southern Valleys, these scholars observed a concentration of *Alnus japonica* (alder) for the Early Jomon period. The amount of the pollen of *Alnus japonica* decreased around 4850 BP and the area was taken over by such trees as *Cyperaceae* (sedge), *Lysichiton camtschaticensis* (skunk cabbage), and *Persicaria*, which were associated with herbaceous plants such as *Impatiens textorii*, and various ferns (Yoshikawa 2005; Yoshikawa, et. al. 2006).

According to a series of marine core examinations in Mutsu Bay, the terrestrial climate of the area during the beginning of the site occupation was in the midst of the warming trend (Kawahata et. al.2009; Takahashi 1995). Examination of marine cores taken from Mutsu Bay and analysis of foraminiferas and mollusks in sediments by Kawahata et al. (2009) indicate that, between 5900 and 5100 Cal BP the terrestrial climate was warm, while the sea surface temperature was low.

3.6. Dwellings and Population Estimate

As of 2009, only two dwellings dated to the Lower Ento—a phase have been found at the site. Even though the site has already been excavated quite extensively, there is a possibility that additional dwellings from this particular phase may exist. Therefore, two is a conservative estimate, and the actual number of dwellings may increase as the site excavation continues or when a new dating technique that does not rely on artifacts found *in situ* is employed in the future. For example, dwellings from this phase may be under the artificial mounds, which have been only partially excavated.

Also, the relatively small number of dwellings may be due to the challenges of dating archaeological features at the site. As discussed above, the chronological designation of features at Sannai Maruyama has mostly relied on stylistic examination of the artifacts such as pottery and clay figurines found *in situ*. This strategy helps clarify the chronological sequence of features that are often found overlapping each other at the site. Many features including dwellings that do not bare any chronologically identifiable artifacts, however, are left undated.

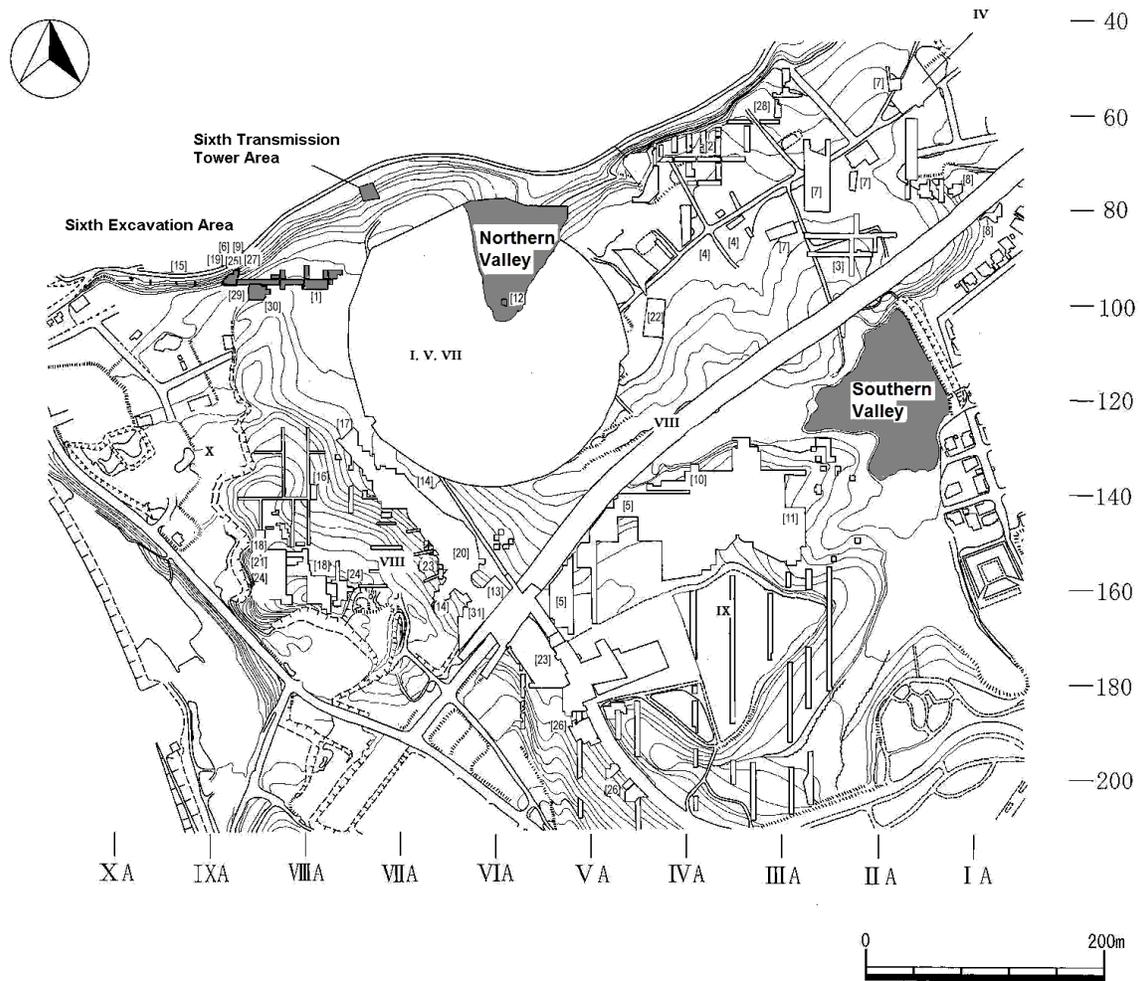
The dwellings from the Lower Ento—a phase have diameters of approximately four meters and are circular to semi-circular in shape. According to Sannai Maruyama Iseki Taisakushitsu, the hearth is located at the center of the dwelling floor, about 30cm deep in the ground (Sannai Maruyama Iseki Taisakushitsu 1999).

Using archaeological data and documents from early historical period as an analogy, Koyama (1984) estimated the number of people living in each Jomon dwelling to have been four to five. Even if the number of dwellings is doubled as a result of future excavations, when Koyama’s estimate is applied, the population of the site during the Lower Ento—a phase is below twenty. This is a stark contrast to how the site population is portrayed by Okada (1995a, 1995b) and others (e.g., Umehara 1995): these scholars all suggest that the settlement of Sannai Maruyama had over five hundred people at the peak of its site size.

3.7. Other features

Although the total number of features for the entire occupation is very high at Sannai Maruyama, the features associated with Lower Ento—a artifacts are limited. In addition to the dwellings mentioned above, other features associated with the Lower Ento—a phase are a handful of storage pits and the lowest portions of the water-logged middens.

While the storage pits did not offer much in terms of their contents due to poor preservation conditions, the middens offered completely different stories. The three middens, Northern Valley, the Sixth Excavation Area, and the Sixth Transmission Tower Area (see Figure 3-7), have been excavated at least partially and their contents examined.



**Figure 3-7: Locations of the Water-logged Middens
(Modified from Aomori-ken Kyoiku Iinkai 2007: 1-2)**

Site residents took advantage of the natural topography of these areas and discarded refuse to the gully and the bottom of the plateau, which have been water-logged since the time of the site occupation. Due to the water table level, a large amount of the organic materials, such as botanical and faunal remains, that would not have survived otherwise

were recovered from the early phases of the site occupation, including the Lower Ento–a phase. The contents of these middens have been used in the reconstruction of the paleoenvironment, subsistence, and technology, among other aspects of the site and the site residents’ lifeways. The faunal assemblages used in this thesis were all retrieved from one of these water-logged middens, the Northern Valley. In the next chapter, I will discuss the fish, fishing, and other food related archaeological materials from the Lower Ento–a phase of the site.

Chapter 4

Food Related Archaeological Materials at Sannai Maruyama

The food and food related archaeological materials from the Lower Ento–a phase at Sannai Maruyama include pottery, stone tools, clay figurines, bone and antler tools, wooden tools, lacquer wares, basket and textile fragments, as well as plant and animal remains. Due to the large number of materials recovered from the site, analyses and quantification of these archaeological materials are still ongoing. While several quantitative examinations of plant and animal remains are available (Ishikawa 2007, 2008; Kim 2001; Minaki 1995; Minaki et.al. 1998a, 1998b ; Nishimoto 1995, 1998, 2006; Noshiro and Suzuki 2008; Sato 1997, 1998; Sato, Habu and Hosoya 2002; Sato, Yamanaka, Takahashi. 2003; Toizumi 1998, 2006; Tsuji 1996, 1997, 1998), in the case of artifacts, a final tally of each artifact type has yet to be published, with the exception of the Sixth Transmission Tower area. From this particular water-logged midden, most of the archaeological materials have been identified and catalogued with chronological information. Thus, in order to provide examples of the food and food-related tools from the Lower Ento–a phase, in this chapter, I present the archaeological materials found in the Sixth Transmission Tower area, as opposed to the Northern Valley area, from where the faunal assemblages used in this thesis have been recovered.

Moreover, many of the artifacts listed in this section are not likely to have been used directly for fishing or fish-processing per se. Many of them, however, may have been essential for the production of fishing tools and processing tools. One way to determine the function of these tools is the analysis of chemical residues, but, for artifacts from Sannai Maruyama, so far this has not been carried out extensively. Therefore, I do not intend to propose in this section that all of these artifacts were used for fishing, fish consumption, and/or fish-related toolmaking. Instead, through the examination of these tools, this section outlines the extent of the technologies and resources that were available to site residents at the time of the Lower Ento–a phase.

4.1. Bone and Antler Fishing Tools

The types of fishing tools found at Sannai Maruyama are J-shaped fishhooks, composite fishhooks, and harpoon heads; examples of each type are shown in Figure 4-1, Figure 4-2, and 4-3, respectively. Tables 4-1, 4-2 and 4-3 present the measurements and other information for all the recovered specimens from the Sixth Tower area.

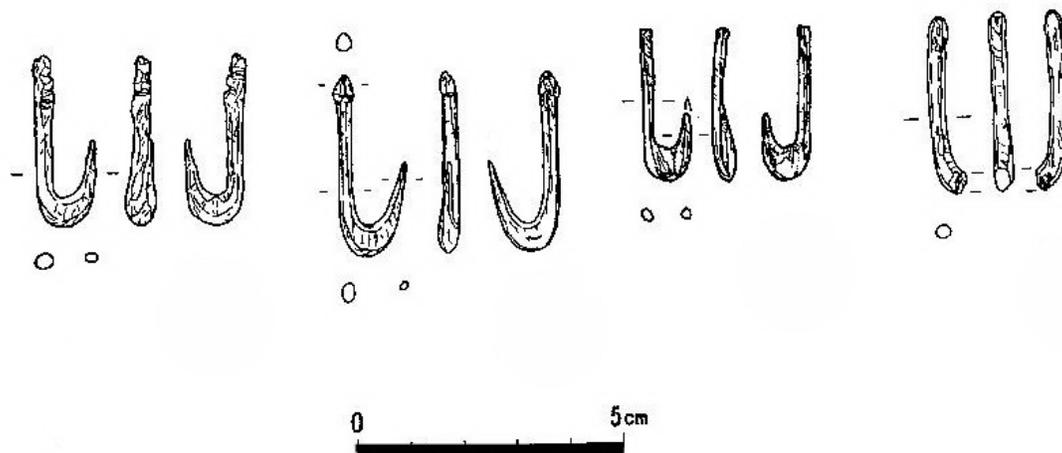


Figure 4-1: Examples of Fishhooks from the Sixth Transmission Tower Area (From Aomori-ken Kyoiku linkai 1998: 137).

While other bone tools such as needles and awls found at the site are mostly made of ribs and metacarpals of wild boar and deer, most of the fishhooks, composite fishhooks, and harpoon heads are made out of deer antlers. Despite the superb preservation conditions of organic materials at this location in general, some of the specimens were recovered as fragments. In Table 4-1 the numbers in brackets indicate the measurement of the existing portion (i.e., the particular piece was a fragment, and the complete measurement was not available).

Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Skeletal Element	Animal
32	10	4.5	0.6	n/a	Terrestrial Mammal?
34	14	3.5	0.6	Antler	Deer
28.5	4	2	0.3	Antler	Deer
(33.5)	5	3.5	0.5	Antler	Deer
(30)	12	4	0.4	Antler	Deer
(25)	3.5	1.5	0.2	n/a	Terrestrial Mammal?
(28)	5.5	4	0.3	Antler	Deer
(15)	3	1.5	0.1	n/a	Terrestrial Mammal?
(11)	2	1.5	0.1	n/a	Terrestrial Mammal?
(13)	3	2	0.1	n/a	Terrestrial Mammal?
(5)	(3.5)	(1.5)	0.1	n/a	Terrestrial Mammal?
(28)	(9)	4	0.3	Antler	Deer
(25)	(5)	2.5	0.2	Antler	Deer

(46)	(15)	3	1.7	n/a	Terrestrial Mammal
(47.5)	(4)	3	0.8	n/a	Terrestrial Mammal
24	13	4	0.5	Antler	Deer
28.5	11	3	0.7	Antler	Deer
32.5	15.5	3	0.8	Antler	Deer
(10.5)	4	3	0.2	n/a	n/a
(34.5)	7	3.5	0.7	n/a	Terrestrial Mammal
(47)	5	4	1.4	n/a	Terrestrial Mammal

Table 4-1: List of Fishhooks from the Sixth Transmission Tower Area (From Aomori-ken Kyoiku linkai 1998: 137) n=21

Table 4-1 lists all the J-shaped fishhooks recovered from the Lower Ento–a layers of the Sixth Transmission Tower Area. The length of the smallest complete fishhook is 10.5 millimeters and the largest complete hook is 47 millimeters. These lengths are comparable to the contemporary fishhooks used in the area today. The general shape of these pieces is very similar to their contemporary counterparts. Some of them have an eye or a notch at the top in order to secure a thread or cordage and have a bend creating a J-shape. Most of them do not have a barb at the tip, as you would expect to see in the contemporary fishhooks.

In addition to the fishhooks, the site residents also produced and utilized composite fishhooks during Lower Ento–a phase. Table 4-2 and Figure 4-2 show the only known example of a composite fishhook.

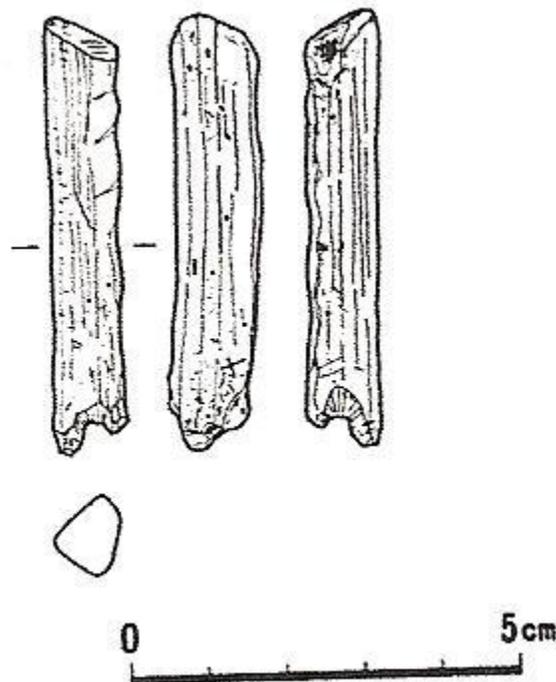


Figure 4-2: Example of a Composite Fishhook (Aomori-ken Kyoiku Iinkai 1998: 137)

Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Material	Animal
(55)	11	10	5.5	Antler	Deer

Table 4-2: Example of a Composite Fishhook (Aomori-ken Kyoiku Iinkai 1998: 137)

This particular specimen is a piece of fishhook shank that is broken near the bottom where it would have been secured to an end piece with a point. Because of the large length of this piece, it was most likely intended for a large fish such as tuna and mature yellowtail instead of a small fish such as anchovy or sardine.

In addition to fishhooks, the site residents also utilized harpoon heads. Figure 4-3 and Table 4-3 list some examples.



Figure 4-3: Examples of Harpoon Heads from the Sixth Transmission Tower Area (from Aomori-ken Kyoiku Iinkai 1998: 134).

Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	Material	Animal
65	8.5	4	1.9	n/a	Mammal
67	11	4.5	3.1	Antler?	Deer?
68	10	7	3.7	Antler	Deer
62	10	4.5	2	Antler	Deer

Table 4-3: Harpoon Heads from the Sixth Transmission Tower Area (Aomori-ken Kyoiku Iinkai 1998: 134)

All the harpoon heads found from Lower Ento—a phase are toggle type harpoon heads. Similar to the composite fishhooks, they are likely to have been used for large prey. Watanabe (1984) suggests that toggle harpoons were used to capture marine mammals, such as seals, sea lions, and walruses, as well as a variety of large fish such as tuna and sharks.

As it is presented above, the residents of Sannai Maruyama during the Lower Ento—a phase obviously had technology sufficient to capture a variety of aquatic animals, small and large. Types of mammals and fish caught by the site residents are presented in later sections.

4. 2. Stone Tools

Stone tools are one of the most abundant types of artifacts that were recovered throughout the site. As I mentioned previously, there has not been a complete quantification of all the excavated materials, including stone tools. Nevertheless, for the Six Transmission Tower Area, a tally of stone tools dated to the Lower Ento—a phase is available. Needless to say, the total number of stone tools for this phase is expected to be significantly higher once the quantification of all the specimens is completed by the site archaeologists.

Table 3-7 lists the numbers and relative frequencies of the stone tools found from the Lower Ento—a phase.

Figure 4-4: Stone Tools from the Sixth Transmission Tower Area (Aomori-ken Kyoku Iinkai 1998: page)

Stone Tool Category	Raw Count	Percentage
1. Cutting and Scraping Tools		
a. Scrapers	263	36.9%
b. Stemmed Scrapers	167	23.4%
c. Semi-circular Chipped Stone Tools	9	1.3%
d. <i>Ishibera</i> [elongated] scrapers	8	1.1%
e. Notched Tools	2	0.3%
f. Polished Axes	6	0.8%
2. Grinding and Pounding Tools		

a. Grinding Stones	34	4.8%
b. Mortars	2	0.3%
3. Other Tools Potentially Related to Fish-processing, or the Production of Fishing Tools		
a. Awls	110	15.4%
b. Whetstones	2	0.3%
4. Hunting Tools		
Arrowheads	63	8.8%
Spear Points	3	0.4%
5. Non-tools		
Cores	37	5.2%
Miscellaneous	7	1%
Total	713	100.0%

Table 4-4: Stone Tools Recovered from Layers VI-a and VI-b the Sixth Transmission Tower Area (Aomori-ken Kyoiku Iinkai 1998)

Although not all of these categories of stone tools were directly involved in fishing or fish processing, tools in the first three categories could have been utilized for fishing, fish and other food processing, or the production of fishing-related tools. Therefore, in this section I will briefly discuss these three categories of stone tools: 1. Cutting and Scraping Tools, 2. Grinding and Pounding Tools, and 3. Other Tools that are potentially related to fish processing or the production of fishing tools.

4. 2. 1. Cutting and Scraping Tools

Cutting and Scraping tools recovered from the Lower Ento—a phase layers include scrapers, stemmed scrapers, semi-circular chipped stone tools, *ishibera* [elongated] scrapers, notched tools, and polished axes. All the stone tools in this category, though different in shape, size, and production process, are considered to have been used for cutting and scraping various types of materials. These functions are crucial in the production of food through fish processing such as scaling, gutting, and disassembling. At the same time, many of these tools are also suitable for modifying plant matters such as hemp for producing ropes, baskets, and nets. Even though each of these tools was designed in a way to serve certain purposes, the actual function of each tool type is undetermined. Tools in this category can be divided into two general types; ones that do not take any particular set shape or material and others that are consistently made by a limited range of materials into a predetermined form.

The rest of the cutting and scraping stone tools that fall in the latter category take more specific forms, most likely reflecting a particular function that each tool type served. In order of relative frequency from the highest to the lowest, the tool types in this category are: stemmed scrapers, semi-circular chipped stone tools, *ishibera* [elongated]

scrapers, notched stone tools, and polished axes. The actual manner in which most of these tools were used is undetermined. This includes the question of whether they were hafted. Based on their shapes and sizes, however, they are likely to have been secured with a thread or cordage to users' hands or to wooden handles.

Polished axes have been recovered from the Lower-Ento—a layers in both complete and incomplete conditions. While the cutting and scraping tools discussed above are all flake tools, polished axes are core tools: as the name suggests, they are made by polishing the surface of the tools to create smooth, sharp cutting edges.

4. 2. 2. Grinding and Pounding Tools

A variety of shapes and sizes of grinding stones and mortars have been recovered dated to the Lower Ento—a phase. Based on ethnographic examples, archaeologists have traditionally assumed that these stone tools were utilized for processing plant food such as nuts and seeds. There is also a possibility, however, that these tools were used to process fish and other animals remains as well (i.e., Aomori Kenshi Hensan Koukokuikai 2002). In order to determine the function of grinding and pounding tools, chemical residue analysis and starch grains analysis were applied to a small number of specimens from later phases of the site occupation (Shibutani 2008, 2010; Kamijo 2010). Results of their examinations were not able to identify the plant taxa, but nevertheless showed that many of these tools were used to process starchy plant materials.

4. 2. 3. Other Stone Tools Potentially Related to Fish Processing or the Production of Fishing Tools

4. 2. 3. a. Awls

Flaked stone tools with sharp pointy ends are classified as awls. Figure 3-11 shows some examples.

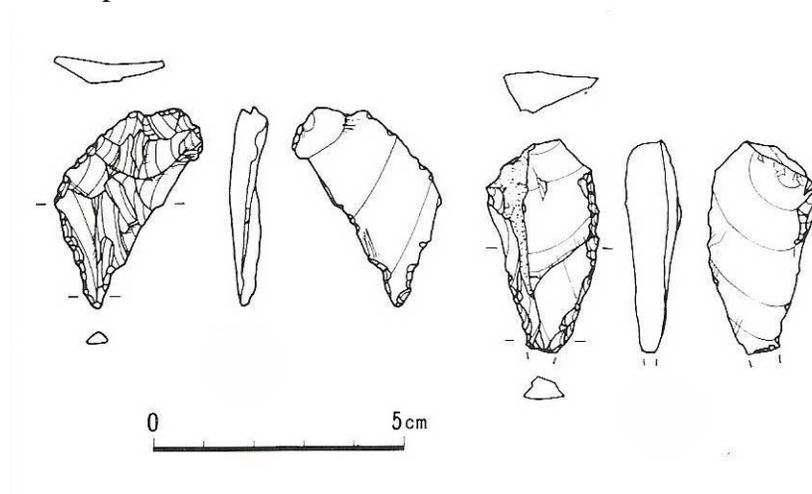


Figure 4-4: Examples of Stone Awls from the Sixth Transmission Tower Area (Aomori-ken Kyoiku Iinkai 1998: 69)

Some of them have a little handle at one end while others have untouched wide ends. It is possible that some of them were secured to the users' hands or to handles. Based on the shape and the material, Saito (1998: 41) suggests that some of the awls may have been recycled from other tools such as arrowheads. In terms of fishing and fish processing, awls could have been used for the production of fishing tools, such as fishhooks and nets.

4. 2. 3. b. Whetstones

Stones with evidence of repeated use of polishing, such as smooth grooves, are generally classified as whetstones. Only two pieces of whetstones have been found from the Lower-Ento—a layers of the Sixth Transmission Tower Area (Figure 3-12). They were nevertheless potentially very important for the production of fishing tools.

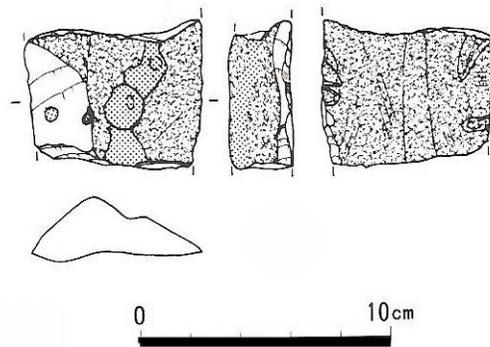


Figure 4-5: Example of Whetstone Fragment (Aomori-ken Kyoiku Iinkai 1998: 123).

As discussed above, all the fishhooks, toggle fishhooks, and harpoon heads are made of mammal bones or antlers. Whetstones must have been essential for processing these raw materials, making them into their fine shapes, smoothing the surface, and sharpening the tips.

4. 3. Pottery

The main pottery type at Sannai Maruyama are called Ento, or cylindrical, pottery, also found throughout the Tohoku region, in a wide range of sizes and decorations. The bottom of the later, Lower Ento—a pottery, is generally narrower than the top, creating a bucket shape more so than Lower Ento—b pottery (Aomori Kenshi Hensan Koukoubukai 2002: 118). Many of the ceramics found at the site have exterior discolorations indicating they had close contact with direct heat, such as from cooking.

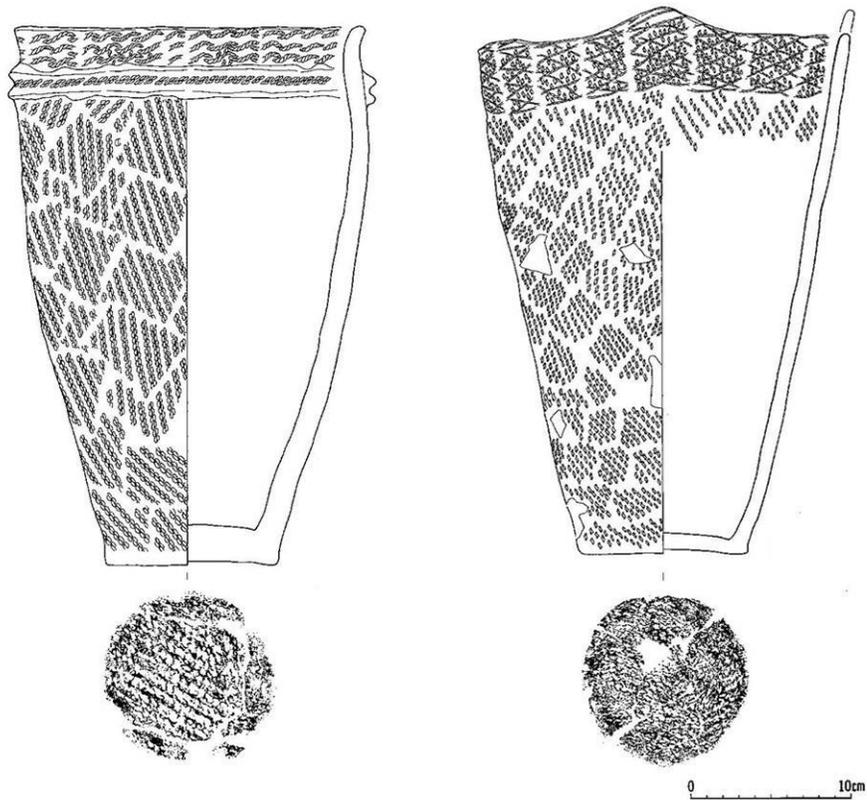


Figure 4-6: Examples of Lower Ento-a Pottery (Aomori-ken Kyoiku linkai 1998: 158).

The possible uses of pottery in relation to fishing and fish processing is cooking, such as boiling and stewing. In addition, pottery may also have been used for short-term storage of live fish. Some of the freshwater species such as loaches can be easily stored in a pottery vessel with fresh water with some mud covering the bottom, creating easily accessible food source (see chapter 7). Only a limited number of chemical residue analyses have been conducted so far, and they seem to indicate that pottery was used to process both marine and terrestrial materials (i.e., Heron 2010).

4. 4. Basketry, Woven Fibers, and Wooden Artifacts

Fragments of woven textile, baskets, and wooden objects have been found almost exclusively from the water logged areas of the site. Although the number of pieces that were recovered from the Lower Ento-a phase is relatively small, these findings are significant. These small fragments indicate the ability of the site residents to produce tools such as nets and baskets that were necessary for catching fish in various habitats.

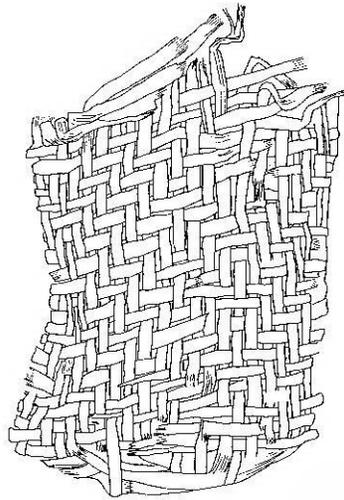


Figure 4-7: An Example of Woven Container (Aomori-ken Kyoiku Iinkai 1998: 152)

A hundred and two pieces of wooden objects have been reported from the Lower-Ento—a phase of the Sixth Transmission Tower Area. With the few exceptions of carved bowl fragments, the function of the majority of these objects is undetermined. Many of them are elongated sticks of various lengths ranging from 100 to 437 millimeters, with the width ranging from six to 80 millimeters. Some of the wooden pieces are coated with lacquer and dye using techniques similar to the lacquer ware production today. Analysis by Noshiro and Suzuki (2008), who published the identification of the taxa of these wood objects, indicates that 36.5% of these objects were made of *Castanea* (chestnut) and 17.5 % were *Thuopsis dolabrata* (Hiba cedar). *Acer* (maple), *Fraxinus* (ash), and *Quercus* (oak) were also commonly used. In addition, *Magnolia*, *Actinidia*, *Hydrangea paniculata* (panicked hydrangea), *Prunus*, *Rhus trichocarpa* (sumacs), *Vitis*, *Kalopanax pictus* (castor), *Paulownia tomentosa* (Foxglove) were also utilized to produce various wooden artifacts.

In summary, even though the Lower Ento—a phase is the first occupational phase of the site, clearly. The site residents possessed a high level of skills and knowledge for tool production. Given this, they must have been able to produce a variety of tools for fishing and fish processing.

4. 7. Floral Remains: Plant Use at the Site

Analyses of floral remains are essential to reconstruct the plant portion of the foodways at Sannai Maruyama. Macro floral remains recovered from the Sannai Maruyama site include charred and uncharred nuts, seeds, and wood fragments. Micro floral remains consist of pollen, phytoliths, and diatoms. A large portion of these floral remains were recovered from the water-logged areas of the site.

Floral remains from the water-logged areas of the site are characterized by an abundance of *Castanea*, *Juglans*, *Vitis*, *Rubus*, *Actinidia*, *Morus*, and *Sambucus* (Tsuji 1997, 1998). At the bottom of the Northern Valley, heavy concentrations of *Juglans* and fruit seeds, such as *Sambucus*, were identified. The size of each concentration measured

about 10 to 30 centimeters in diameter. The thickness of these concentrations measured three centimeters or more. Many of the shell fragments of *Juglans* show the evidence of hitting on the surface, most likely from cracking of these shells for consumption (Minaki 1995).

In the Sixth Transmission Tower Area, a large amount of *Sambucus* seeds is associated with a smaller amount of *Actinidia arguta*, *Rubus*, *Vitis*, and *Aralia* (Tsuji 1998). These concentrations are often accompanied by *Morus*, *Actinidia polygama* and *Broussonetia*. Moreover, fungi, which are often involved in the fermentation of fruits, were identified on the surface of the *Sambucus* remains. It is also worth noting that not all of these fruits can be harvested during the same season. Based on seasonality, Tsuji (1998) suggests that, in order to produce some kinds of fermented fruit beverage, some of these fruits were stored and mixed with fruits of later harvest.

In addition to these fruit seeds, several common Jomon cultivars such as *Lagenaria*, Fabaceae, *Arctium*, *Perilla*, and *Chenopodium* were also found (Aomori-ken Kyoiku-cho Bunka-ka 1996). Also, using DNA analyses, plant geneticists suggest that the residents of Sannai Maruyama controlled the surrounding vegetation by tending and intentionally fostering the growth of certain plants with preferred traits. A series of DNA analyses of *Castanea* by Sato (1998) and Sato et al. (2003) indicate that genetic diversity in DNA structure among *Castanea* specimens from Sannai Maruyama is lower than that among modern wild *Castanea*. These scholars suggest that the lower genetic diversity at Sannai Maruyama is a result the bottle-neck effect, which is commonly associated with the process of domestication. DNA and morphological analyses of *Vitis* by Ishikawa (2007, 2008) show that the size of the seeds is larger at and around the site. He suggests that this is the result of the tending of plants with larger fruits by the site residents.

4. 8. Faunal Remains

Characteristics of the faunal assemblage from the Sixth Transmission Tower Area of Sannai Maruyama are very different from that of typical Jomon sites for two reasons. First, the taxa that characterize the assemblage from Sannai Maruyama are unusual for Jomon sites. Second, high representation of fish remains in comparison to mammal remains is also noticeable.

4. 8. a. Mammals

Analyses of mammal remains from the Sixth Transmission Tower Area were carried out by Nishimoto (1995, 1998). Table 3-8 shows a summary of the mammal assemblage from Sannai Maruyama in comparison with an average Jomon faunal assemblage compiled by Nishimoto (1995)

Taxa	Typical Jomon Site Assemblage *2	Sannai Mammal Assemblage *1
<i>Cervis nippon</i> (deer)	39.3%	1.4%
<i>Sus scrofa</i> (boar)	37.7%	2.7%
<i>Lepus</i> sp.(hare)	3.3%	36.5%

<i>Nyctereutes</i> spp. (raccoon dog)	6.7%	2.7%
<i>Meles meles</i> (bager)	2.9%	0
<i>Macaqa</i> sp.(macaque)	2.2%	0
<i>Pteromys</i> sp.(flying squirrel)	2%	37.8%
<i>Lutra</i> sp.(otter)	1.2%	0
<i>Martes</i> sp. (sable)	1.1%	0
<i>Ursus</i> sp. (bear)	n/a	1.4%
<i>Sciurus</i> sp.(squirrel)	n/a	4.1%
<i>Vulpes</i> sp.(fox)	n/a	5.4%
<i>Mustela</i> sp.(weasel)	n/a	6.8%
<i>Phoca</i> sp. (seal)	n/a	1.4%
Others	3.5%	0%
Total	99.9	100.2

*1 Sannai Maruyama Assemblage n=2400

Table 4-5: Comparison of Mammal Assemblages between Typical Jomon Sites (Nishimoto 1995: 209) and Sixth Transmission Tower at Sannai Maruyama (Nishimoto 1998: 58)

As indicated in Table 4-5, the majority of mammal remains from Sannai Maruyama were *Lepus* (wild rabbits) and *Pteromys* (flying squirrels). *Cervus Nippon* (Sika deer) and *Sus scrofa* (wild boars), which dominate mammal assemblages of typical Jomon sites, are only 4.1 percent in total. In contrast, wild rabbits and flying squirrels, which are not common at most other Jomon sites, are over seventy percent at Sannai Maruyama. Based on this result, Nishimoto (1995) suggested that the large mammals may have been over hunted by the Jomon people, resulting in population decline.

4. 8. b. Fish

Another notable characteristic of the faunal assemblage from the Sixth Transmission Tower Area at Sannai Maruyama is the greater abundance of fish over mammals. Table 4-6 summarizes Toizumi's (1998) analysis of fish vertebrae from the Sixth Excavation Area. His samples for this analysis consisted of vertebrae samples collected in the field at the time of the excavation and those retrieved through water-screening using 4 millimeter mesh. The results of his analysis indicate the presence of a variety of fish from both the inner and outer bay.

Taxa	NISP	MNI	MNI %
Chondrichthyes	3928	n/a	n/a
<i>Clupea pallasii</i>	5	1	0.10%
Clupeidae	2747	52	4.70%
<i>Conger</i> sp.	6	1	0.10%
<i>Oncorhynchus</i> sp.*1	128	0	0.00%
Cyprinidae	262	0	0.00%

<i>Gadus macrocephalus</i>	358	8	0.70%
<i>Hyporhamphus sp.</i>	22	2	0.20%
Beloniformes	7	1	0.10%
<i>Scorpaenidae spp.</i>	1596	24	2.10%
Synanceiidae	373	15	1.30%
Platycephalidae	68	3	0.30%
<i>Pleurogrammus sp.</i>	24	2	0.20%
<i>Hexagrammos sp.</i>	843	18	1.60%
Hemitripterae	9	2	0.20%
Cottidae	1	1	0.10%
<i>Lateolabrax sp.</i>	236	7	0.60%
<i>Seriola sp.</i>	13049	545	48.70%
<i>Trachurus japonicus</i>	1	1	0.10%
<i>Coryphaena sp.</i>	82	1	0.10%
sparidae	602	26	2.30%
Sciaenidae	7	2	0.20%
<i>Oplegnathus sp.</i>	30	2	0.20%
Embiotocidae	628	17	1.50%
Mugilidae	28	2	0.20%
Labridae	3	1	0.10%
Gobiidae	5	1	0.10%
<i>Sphyræna sp.</i>	13	2	0.20%
Scomber	3557	116	10.20%
<i>Auxis sp.</i>	30	2	0.10%
<i>Katsuwonus pelamis</i>	66	3	0.30%
<i>Thunnus sp.</i>	1	1	0.10%
<i>Scomberomorus sp.</i>	4	2	0.20%
Paralichthyidae	1614	42	3.80%
<i>Pleuronectidae spp.</i>	6356	145	13%
Soleoidei	15	2	0.20%
Monacanthidae	329	17	1.50%
Tetradontidae	1321	52.84	4.70%
Unidentified Teleostei	196	0	0.00%
Unidentifiable Teleostei	1298	0	0.00%
Total	39848	1119.84	100.00%

*1 Due to its cartilaginous bones, there are only fragments found. Thus the number reflects the number of fragments recovered.

Table 4-6: Results of Toizumi's (1998) Analysis of Fish Vertebrae from the Sixth Transmission Tower (Retrieved with 4mm mesh screen or collected at the time of the excavation) (compiled from Toizumi 1998)

Toizumi's (1998) analysis is important because the results clearly indicate that the site residents had access to the inner and outer bay during the Lower Ento—a phase. The limitation of this analysis was that it examined only these fish remains collected either in the field or through the 4 millimeter meshed screen, thus unsystematic. In the field of zooarchaeology today, it is known that the hand collection of faunal remains at the time of the excavation is not a suitable method to produce reliable quantitative data.. This is due to the low visibility of the bones in a muddy condition. The use of the 4 millimeter meshed screen is suitable only if the sampling is aiming for large faunal remains. In the case of fish, however, 4mm is not fine enough to retrieve remains of smaller species such as loaches and anchovies.

As a follow-up, Toizumi (2006) screened a smaller amount of soil samples from the same area using 4, 2, and 1 millimeter meshed screens. As indicated in Table 4-7, this systematic collection did increase the recovery rate of smaller specimens, such as Cobitididae.

Taxa	NISP	MNI	MNI %
Chondrichthyes	3	1	3.4%
<i>Konosirus punctatus</i>	1	1	3.4%
Clupeidae	14	2	6.9%
<i>Engraulis japonicus</i>	2	1	3.4%
<i>Plecoglossus altivelis</i>	3	1	3.4%
Salmonidae	2	1	3.4%
Cyprinidae	1	1	3.4%
Cobitididae	20	2	6.9%
Belonidae	1	1	3.4%
<i>Hyporhamphus</i>	23	2	6.9%
Scorpanidae	5	1	3.4%
<i>Hexagrammos</i>	2	1	3.4%
<i>Seriola</i>	2	2	6.9%
<i>Coryphaena</i>	1	1	3.4%
<i>Oplegnathus</i>	1	1	3.4%
Embiotocidae	5	2	6.9%
Mugilidae	1	1	3.4%
Gobiidae	7	2	6.9%
<i>Scomber</i>	1	1	3.4%
<i>Pleuronectidae</i>	2	1	3.4%
Monacanthidae	1	1	3.4%
Tetradontidae	1	1	3.4%
Teleostei	7	1	3.4%
Total	106	29	100.0%

Table 4-7: Results of Toizumi's (2006) Analysis of Fish Vertebrae from the Sixth Transmission Tower Area (Retrieved with 4, 2, and 1mm mesh screen) (after Toizumi 2006)

In Table 4-6, taxa with the highest frequency are *Seriola* (48.7%), followed by Pleuronectidae (13.0%) and *Scomber* (10.4%). The percentages in this table create an impression that site residents focused their fishing efforts on these three taxa. However, when the smaller specimens recovered from 4, 2, and 1mm meshed screens are included in his 2006 analyses, the frequency differs greatly.

In Table 4-7, the results of Toizumi's systematic analysis of fish vertebrae retrieved with 4, 2, and 1mm mesh screen show that the dominance of *Seriola*, *Pleuronectidae*, and *Scomber* is no longer significant. The results of Toizumi's analyses revealed the following: (1) the site residents exploited a wide range of fish, the size of which ranges from less than 10 centimeters to over one meter, (2) the site residents fished in various types of aquatic environments, including the brackish water zone, near the shore, and off the coast (both inner and outer bay zones), (3) characteristics of the archaeological fish assemblage are very similar to those of what is available in and around the Mutsu Bay today, and (4) fishing could have taken place throughout the year.

4. 9. Summary

In this chapter, I presented a summary of the archaeological materials related to fish, fishing, and food from the Lower Ento-a phase. As this chapter shows, archaeological investigations at Sannai Maruyama over the past 20 years have produced a large amount of data. So far, efforts on the study of food at Sannai Maruyama have focused on the production of a list of foods consumed at the site. Discussion on other aspects of foodways, such as why those specific food items were selected, has been virtually absent.

Chapter 5

Methodology

As discussed in the previous chapter, at Sannai Maruyama during the Lower Ento–a phase, the site residents had access to a wide range of fish from a variety of habitats. In order of distance from the site, those habitats can be divided into five distinctive zones: (1) streams around the site, (2) the brackish water zone where the rivers meet the bay, (3) the near-shore inner bay, (4) the outer-shore inner bay, and (5) the outer bay. In addition, multiple currents, both warm and cold, meet in the areas outside of the bay, creating extremely productive fishing ground. Today, most of these areas are popular among both professional and hobby fishers in and outside of Aomori Prefecture. Given the abundance of fish in the environment and available fishing-related technologies, the questions I pose regarding the selections of fish by the Sannai Maruyama residents during the Lower Ento–a phase are the following:

- (1) When their surrounding environment provided abundant potential prey, was the reason for exploiting these specific taxa that of optimization?
- (2) Why did the residents of Sannai Maruyama during the Lower Ento–a phase choose to go after particular fish taxa?

In this chapter, I will discuss how the diet breadth model, one of the optimal foraging models, can aid in answering the first question. Other possible reasons, including ones based on non-ecological perspectives, will not be tested, but they will be discussed in chapter 8.

5. 1. Diet Breadth Model and Its Issues

The diet breadth model concerns prey choice and diet breadth to answer the following question: “out of the array of available prey types, which ones should an efficient forager attempt to harvest?” (Smith 1983: 627). The model supposes that, in order to achieve optimum reproductive success, an individual forager should select food that will provide the most energy return with minimum investment and risks. The primary strategy of determining the prey choice using this model is to examine the rates of investment and return of each food item. The potential prey choices are ranked from the highest to lowest by the investment – return ratio, with the prey that provides the highest return compared to investment being ranked as the highest. The model predicts that a forager will pursue prey when an “abundance of higher ranked types (i.e. those with higher energy acquisition to energy cost ratios) decreases to the point where it is economically viable to take prey types with lower return rates (Madsen and Schmitt 1998: 446)”. When a forager is successful in selecting optimal food, the resulting returns should always be higher than the investments. The use of this model can aid in predicting which food the residents of Sannai Maruyama should pursue among all the available food items. Even though the diet breadth model is designed to be general enough to be applied to any species, there are several problems with the assumptions in this particular case. Most of the problems stem from the fact that the forager in question is human and the prey is fish.

One of the fundamental assumptions of the model regards the prey distributions: prey exists in the environment evenly (Smith 1983: 628). The main reason for this assumption is to eliminate the real life complications from the model. This assumption may hold true to some species, however, this is simply not the case with fish. Even within a small area in the ocean, for example, each fish species has its own preferred area and depth. For example, some tend to be under the sand while others prefer to be among the seaweed. Even within each habitat, the change in water temperature, etc. can easily alter the exact location of the fish on an hourly basis.

Moreover, when the environment goes through changes, the abundance of all the potential prey is believed to increase or decrease altogether (Winterhalder 1981). In the case of fish, however, this may not be the case. For example, if the current shifts and the water temperature cools down, this will result in a change in the type and variety of fish that exist in a particular spot: not all the fish species increase or decrease in their abundance in unity.

Other problems of the diet breadth model are unique to the examination of fish selection behavior of the Sannai Maruyama residents. First, the diet breadth model divides the foraging effort into two phases: (1) time spent searching (search time) and (2) time spent pursuing, capturing, and eating the prey (pursuit/handling time) (Winterhalder 1981). The search time ends when the forager encounters the prey and makes a decision to pursue it. However, in the case of fish, a forager never truly encounters the fish. In most cases, fish live in areas that are not visible to the foragers. Thus, most commonly, no search time is involved in fishing.

Second, the model assumes that the forager searches for prey in the environment without having any particular prey in mind, and that an encounter with a prey occurs at random. This is highly unlikely in fishing. Each fish species vary greatly in its size, habitat, and food/bait. Therefore, in order to catch a fish, one has to have an idea of which fish to pursue so that he or she can have appropriate gear in hand prior to foraging. For example, if a forager carries only a short line and a fishhook, it is very difficult to catch fish that live in deep water. On the other hand, if he/she has only a small net, catching a large fish such as snapper will not happen. Therefore, in the case of fishing, a forager can not search for all the possible food items simultaneously.

Because of these constraints that are unique to fish and fishing, it is not appropriate to apply the diet breadth model directly to the fish data from the Sannai Maruyama site. However, the principle behind the model – a forager selects his/her target species on the basis of cost-return efficiency – can still be tested.

5. 2. Examination of Cost-Return Efficiency

Following the argument above, in this section, I will outline my method to evaluate the investments that are involved in capturing and processing fish and the nutritional returns.

Conventionally, the energy estimates are divided into the search cost, handling cost, and subsequent energy returns. Search cost refers to the time spent to locate a potential prey, “whether the predator is physically moving through the environment (i.e. encounter hunting) or waiting for a prey item to wander by (i.e. intercept hunting)” (Broughton 1999). Handling cost is the time a forager spends pursuing, killing, and

processing the prey for consumption. Energy returns are the nutritional and caloric returns acquired from consumption.

In order to assess the amount of the effort required and the energy acquired, I will examine the following five phases of activities.

1. Travel: energy required to travel between the site and known fishing locations.
2. Fishing: the number of hours spent in fishing.
3. Processing: scaling, gutting, etc. to minimally process the catch.
4. Storability: processes to extend the duration during which the catch is edible.
5. Consumption: nutritional value.

The conventional currency of calories will be used to examine the travel and consumption. The remaining activities will be evaluated by other means such as the weight of the catch and the length of the time required for each stage. Contemporary fishing records, ethnoarchaeological studies, and nutritional studies will be used to extract necessary data for the examination of each phase. When possible, I rely on studies that replicated the technology of the Early Jomon residents of Sannai Maruyama. In other cases, contemporary data will be used.

Ethnoarchaeological observations could provide us with reasonably accurate estimates of the energy expenditure of past activities. In order to obtain the most reliable estimate, repeated observations may be helpful.¹ Thus, when multiple experiments or observations are available, all the experiments or observations will be examined. The actual estimates for the energy expenditure of fishing-related activities, together with the description of the sources from which those estimates are derived, will be presented later in chapter 7.

When estimating the amount of energy that is required for these activities and the amount of energy that can be retrieved by consuming the prey, one encounters the complication of variability in human behavior. That is, there are almost always multiple strategies to accomplish a single task. In order to catch a salmon, for example, one could use a number of different tools or go fishing to different locations. The rationale for choosing one strategy or location over another may be cultural, political, or environmental, or it may simply be a reflection of individual's personal preference. Accordingly, in their attempts to reconstruct past peoples behaviors with help from ethnoarchaeological studies, archaeologists are often left to make multiple assumptions regarding past peoples' actions. When there is more than one strategy or method that may have been taken by the site residents, I will use the simplest strategy/method for my energy estimate. For example, ethnographical examples indicate that there are multiple ways to cook/prepare each fish. Depending on the strategy employed, the energy investment and return rates could vary significantly. In this case, in estimating the time for processing the prey for consumption, the minimal processing strategy is chosen over other elaborate cooking methods. That is, my estimate is based on how much work is absolutely necessary in order to make a fish edible.

¹ Based on his own series of experiments, Simms (1987) argues that it is not essential in archaeology to conduct repeated experiments or observations, as long as the condition in which the observation is made is typical. Thus, in his opinion, the results derived from the one instance should suffice.

If the fish assemblage at Sannai Maruyama is dominated by the taxa that are optimal in terms of the energy investment/return rate, then the data are consistent with the principles of behavioral ecology. However, if the results of my analysis suggest that a certain taxon of fish were caught despite its lower return rate, then there are three explanations: (1) taxa with higher returns were not accessible (2) the target fish taxa were selected based on a reason or reasons other than optimization, or (3) the assumption the model is based on is incorrect.

5. 3. Conclusion

In order to answer my questions, the above methodology will be applied to the taxa with the highest representations. While the area surrounding the Sannai Maruyama site had thousands of fish that can be consumed, an attempt to evaluate all of them would be impractical, if not simply impossible. Thus, my research will focus on a few taxa that are abundantly found at the site. Examining a limited number of taxa out of the recovered faunal remains is also consistent with the principles of the diet breadth model, which focuses on the highly ranked prey only.

As discussed in the previous chapter, Toizumi (1998, 2006) compiled a list of fish taxa compiled for the Lower-Ento-a phase of the Sannai Maruyama site. However, his initial analyses (1998) are developed based on the specimens collected by hand-picking during excavation and by the use of 4 millimeter meshed screens. Thus, the result does not provide a fair representation of the proportion of different taxa: small fish are likely to be under-represented. His subsequent analyses (Toizumi 2008) included specimens recovered from the use of 4, 2, and 1 millimeter meshed screens, but the total NISP is still extremely small, only a little over one hundred (n=106). Given this small sample size, the resulting MNI for each taxon was 1, 2, or 0 for most of the taxa. In other words, Toizumi (2008) does not provide sufficient quantitative data to identify highly ranked taxa. An additional analysis of fish remains from the Lower Ento-a phase is necessary before I conduct an evaluation of cost-return efficiency. Accordingly, the next chapter presents my original analysis of fish remains from the Lower-Ento-a phase.

Chapter 6

Quantitative Analyses of Fish Remains

This chapter presents results of my quantitative analyses of fish remains from the Lower Ento—a phase of the Sannai Maruyama site. As I discussed in the previous chapter, since the rescue excavation in 1994, archaeologists of the Board of Education of Aomori Prefecture (hereafter the site archaeologists) have been collecting a large amount of soil samples from the water-logged middens of the site. Two of the largest are the Northern Valley and the Sixth Transmission Tower areas, where the anaerobic soil condition aided in the preservation of organic remains. So far, only a small fraction of those samples have been examined, and the rest are stored for future studies.

With permission from the Preservation Office of the Sannai Maruyama Site, I was able to analyze part of the soil samples from the Northern Valley Area that included a large amount of faunal remains, including fish bones. This gave me the opportunity to obtain data necessary to address my research questions without causing further destruction of the site. The results are used in the next chapter to explore the issues of foodways of the Sannai Maruyama residents during the Early Jomon Period.

6. 1. Excavation of Northern Valley

The faunal remains analyzed in this dissertation project were collected during the rescue excavation in 1994 (see Figure 3-2) from the Northern Valley Area, which was part of the Planned Baseball Stadium Area. Although the area is called ‘valley’, it is more like a prehistoric gully that led to the Okidate River. The length of the gully that is recognizable today is approximately 90 meters (Aomori-ken Kyoiku Iinkai 1996: 26). This area, along with the Sixth Transmission Tower Area, produced by far the largest collection of soil samples containing organic materials from the Early Jomon period.

Because of the level of the water table in this area and the continuous seeping of water from the plateau, the contents of the gully have been saturated since the time of the site occupation. Moreover, Early Jomon site residents selected areas that are topographically lower than the rest of the site for their refuse disposal locations. They eventually filled up most of the water-logged portion of these lower areas, including the Northern Valley Area, with their trash. On the other hand, areas of the refuse disposal from the Middle Jomon period, such as the artificial mounds, were dry. Due to the high soil acidity, organic remains in these dry middens did not survive well. Given the superb preservation condition of faunal remains in the Northern Valley Area, an analysis of faunal remains from this area can provide us with an excellent opportunity to understand characteristics of Early Jomon foodways.

6. 1. a. Sample Collection Area: I-Trench Extension (*Ai-Torenchi Kakucho*)

During the initial stage of the excavation of the Northern Valley Area in 1994, Trenches A through J were opened to investigate the nature and use of the water-logged

area by site residents. Some of these trenches were further expanded to identify the extent of specific features while others were excavated to examine the preservation condition of organic materials. I-Trench Extension (*Ai-Torenchi Kakucho*) was an expansion of the I-Trench to examine the arrangement of wooden posts that were believed to have formed a retaining wall. According to the site director of the rescue excavation, the I-Trench Extension area had extremely dense cultural layers. These layers contained a large quantity of organic materials such as plant seeds and faunal remains as well as the earthen retaining wall (Okada 2006).

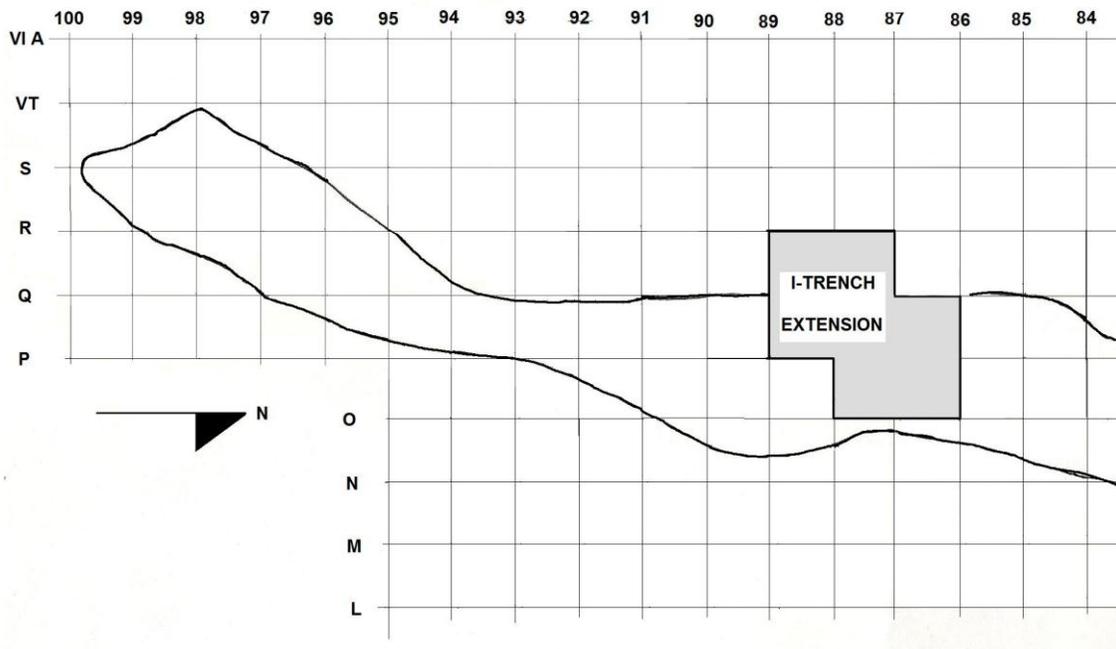


Figure 6-1: Diagram of the Northern Valley Area and I-Trench Extension (each square measures 4 x 4 meters).

For my analysis, it was crucial to select samples from the area with abundant faunal remains. Thus, I chose to examine the samples from the I-Trench Extension. Before outlining my sampling strategy, I will first describe how the soil samples were initially collected by the site archaeologists, and how those samples were processed and stored prior to my analyses.

6. 2. Condition of the Faunal Remains from the Northern Valley Area

I-Trench Extension soil samples were collected between October 19th, 1994 and December 19th, 1994 during the rescue excavation of the Northern Valley Area. As was the case with some other water-logged excavation areas of the site, the site archaeologists carried out 100 per cent sampling of the excavated soil for water screening. The area was excavated by cultural layers, as opposed to by arbitrary layers, based on soil morphology. As a result, the I-Trench Extension was divided into twenty-three layers. The total number of the layers is twenty-four if the topsoil cleaning (*Jomen seisou*) is included as an independent layer.

According to then site director, Yasuhiro Okada, some of the boundaries of these layers may not always correspond to distinct depositional episodes, but the layer numbers do represent the recovery sequence during the excavation (Okada 2006). Okada further asserts that, based on the observation of archaeological materials and stratigraphy, the general chronological order of the soil layers still stand, since there was no significant soil disturbance that would affect the general chronological sequence (Okada 2006). Thus, for example, Layer 1 is more recent than Layer 5, and Layer 15 is older than Layer 6. The chronological order of the layers is discussed in more detail later in this chapter.

Due to the uneven terrain of the Northern Valley Area, the number of bags of soil samples from each layer varies significantly (Table 6-1).

Layer	Number of Sample Bags
Topsoil cleaning	12
1	27
2	26
3	93
4	7
5	19
6	12
7	14
8	14
9	10
10	46
11	76
12	5
13	5
13b	1
14	6
15	122
15b	1
16	110
17	10
18	33
19	14
20	4
21	12
22	27
23	38
Total	744

Table 6-1: total numbers of sample bags per layer

In the end, a total of 744 soil samples were collected from the twenty-four layers of the I-Trench Extension. Following the collection of soil samples, for two years (1995 and 1996) the samples went through a water-screening process to reduce the volume for storage. In order to capture the faunal and floral remains within the soil samples, the site archaeologists water-screened these samples with geological screens of four, two, and one millimeter mesh. This means that, unfortunately, the materials smaller than 1 millimeter were not retrieved by this process unless they were tangled up in fiber, soil clumps, and other larger materials. For each sample, the recovered materials were sealed in three air-tight bags and separated according to the mesh size, (i.e., three bags for 4mm, 2mm, and 1mm mesh), with sterilized water inside to prevent further damage to the organic remains inside.

6. 3. My Sampling Strategy to Collect Fish Remains

Since analyzing all the 744 samples was not realistic for this project, it was essential to select smaller, representative samples. In doing so, there were several conditions that my samples strategy had to meet: 1. after I take samples for my analyses, the amount of soil samples that will be left from each layer must be large enough for future studies, 2. each soil sample for my analysis must contain a sufficient amount of faunal remains, and 3. soil samples for my analyses need to be taken from at least two chronologically distinct layers so that changes through time can be examined.

To satisfy these conditions, my sampling strategy involved three phases. First, I carried out a test analysis of one sample bag each from eleven layers that satisfied the first condition. Then, after examining the contents of these test samples, I selected two target layers and expanded the sample size: Layers 3 and 15. Lastly, the number of samples from Layer 15 was expanded to make sure that the species representation was not due to the number of sample bags.

6. 3. a. Sampling Strategy – First Stage

For the initial test sampling, I focused on eleven layers (Layers 2, 3, 5, 8, 10, 15, 16, 18, 19, 22, and 23). These layers were selected because they have relatively large numbers of samples, thus meeting the first condition. Sample bags were first visually inspected without being opened, and bags with some visible faunal remains were selected from each layer. Even though these samples were already water-screened, the selected samples were cleaned again with water to wash off small debris using a set of nested geological screens of 4, 2 and 1 millimeters. A 0.5 millimeter mesh screen was used to capture materials that broke off during the storage and handling process, and the resulting recovered materials were added back to the 1 millimeter samples.

Faunal remains were collected from each sample in the water-logged condition so that floral remains in the sample will not be damaged (i.e., if the sample was dried at this stage, that would have resulted in significant damages on plant seeds and other floral remains). Out of the collected faunal remains, only fish remains were then separated out, and subsequently dried to foster the ease of identification.

For the purpose of my analysis, only fish remains were collected. Although non-fish faunal remains were extremely scarce, some of my samples contained a small

amount of mammal bones and teeth. These non-fish faunal remains, along with lithic debitage, floral remains, small potsherds, and other materials, were sealed in bags with sterilized water and returned to the storage.

The results of this first stage of examination indicate that Layers 3 and 15 had the highest amount of fish remains. Moreover, Layer 3 has 93 bags of soil samples and Layer 15 has 122 bags. These numbers ensure that enough samples will be left for future analyses. Thus I selected Layer 3 and 15 for further analyses.

6. 3. b. Sampling Strategy- Second Stage

In my second stage of analysis, I water-screened and analyzed an additional seven samples each from Layers 3 and 15. I followed the same sample collection procedure as I implemented during the first stage. Again, all the non-fish remains were sealed in air-tight bags with water and returned to the storage for future analyses. Table 6-2 shows the record of the weight and volume of these soil samples at the time of the initial water-screening in 1996.

Layer	Sample Number	Volume (cc)	Weight (g)	Collection Date
3	30519	4600	6539	10/31/1994
3	30521	4300	6182	10/31/1994
3	31105	3590	4603	10/28/1994
3	31116	5180	7534	10/26/1994
3	31164	3900	5390	10/28/1994
3	31168	4370	5808	10/24/1994
3	31192	3900	4740	10/28/1994
15	30211	4000	5348	11/25/1994
15	30214	3980	5200	11/25/1994
15	30258	3960	4911	12/1/1994
15	30321	3000	4165	11/27/1994
15	30293	4180	5924	11/28/1994
15	30297	3600	5091	11/28/1994

**Table 6-2: Soil Sample Weight and Volume
(Courtesy of the Preservation Office of the Sannai Maruyama Site)**

Once the sorted fish remains dried, a local zooarchaology specialist, Mayumi Wakayama, aided me with the identification process. Contemporary and archaeological comparative collections at the Preservation Office of the Sannai Maruyama Site and the East Asian Archaeology Laboratory of the University of California, Berkeley (UC Berkeley) were used for identification. The archaeological comparative specimens of UC Berkeley were developed using fish remains from the Sixth Transmission Tower Area of the Sannai Maruyama site, with the help of a Japanese ichthyologist, Hajime Komiya. Contemporary comparative collections were developed in Aomori from 1997 to 2007 to cover all the representative local fish species. Additional fish species from other areas

within Japan were also included in the contemporary comparative collections to increase the coverage.

As a result of my first round of analysis, 1153 specimens were identified and quantified. In the case of cartilaginous fish, due to their skeletal anatomy, it is difficult to identify and quantify them at the genus or species level. Thus, they were simply labeled as Chondrichthyes (sharks/rays). On the other hand, teleostei species were identified in as much detail as possible.

Sample Number/Taxa	30521	30519	31116	31164	31168	31192	31105	NISP	NISP %
Chondrichthyes	6	3	1	0	0	0	1	11	1.9%
<i>Scomber</i>	34	4	10	3	20	1	3	75	13.2%
Paralichthyidae	1	1	2	0	2	0	0	6	1.1%
Pleuronectidae	0	2	2	1	0	0	1	6	1.1%
<i>Seriola</i>	4	2	2	1	4	2	0	15	2.7%
Salmonidae	18	2	0	2	3	0	0	25	4.4%
Clupeidae	16	23	9	16	11	7	7	89	15.7%
Embiotocidae	14	1	14	2	19	1	0	51	9.0%
Hexagrammidae	3	2	1	0	1	0	0	7	1.2%
Gobiidae	13	0	0	0	0	0	0	13	2.3%
Cobitidae	138	1	19	7	83	2	0	250	44.1%
<i>Tribolodon</i>	10	0	0	0	3	0	0	13	2.3%
Hemipteridae	0	0	0	0	3	0	0	3	0.5%
Hyporhamphus	0	0	0	0	0	1	0	1	0.2%
Monacanthidae	0	0	0	0	0	0	2	2	0.4%
Total	257	41	60	32	149	14	14	567	100.0%

Table 6-3: NISP of Identified Fish Remains Recovered from Eight Samples From Layer 3.

Sample Number/ Taxa	30211	30214	30258	30321	30297	30293	NISP	NISP %
Chondrichthyes	7	6	3	1	2	8	27	9.7%
<i>Scomber</i>	3	2	1	4	3	3	16	5.8%
Paralichthyidae	0	0	0	1	0	0	1	0.4%
Pleuronectidae	6	3	0	0	0	5	14	5.0%
<i>Seriola</i>	8	21	44	0	10	20	103	37.1%
Salmonidae	1	0	0	0	0	0	1	0.4%
Clupeidae	36	24	17	1	2	7	87	31.3%
Embiotocidae	6	4	0	0	0	5	15	5.4%
Hexagrammidae	0	0	0	0	0	6	6	2.2%
Gobiidae	0	0	0	0	0	0	0	0%
Cobitidae	0	4	0	0	0	1	5	1.8%
<i>Tribolodon</i>	0	0	0	0	0	0	0	0%
Hemirhamphidae	0	0	0	0	0	0	0	0%
Hyporhamphus	0	0	0	0	0	0	0	0%
Monacanthidae	0	0	0	0	2	1	3	1.1%
Sphyracidae	0	0	0	0	0	0	0	0%
<i>Sebastes</i>	0	0	0	0	0	0	0	0%
Total	67	64	65	7	19	56	278	100.0%

Table 6-4: NISP of Identified Fish Remains Recovered from the First Six Samples from Layer 15

Tables 6-3 and 6-4 list the numbers of identified specimens (NISP). As indicated, 567 and 278 specimens were identified from Layer 3 and Layer 15 respectively.

6. 3. c. Sampling Strategy – Third Stage

In order to examine if the species representation will still stand when the sample size is increased, I examined an additional seven samples for Layer 15. Table 6-5 lists the weight and volume of the additional soil samples from Layer 15. Table 6-6 lists the number of identified specimens (NISP). As indicated, 308 specimens were identified in these additional soil samples.

Layer	Sample Number	Volume (cc)	Weight (g)	Collection Date
15	30312	4600	6431	11/24/1994
15	30217	5000	7011	11/28/1994
15	30245	3600	5148	11/25/1994
15	30273	3980	5510	11/25/1994
15	30264	3350	4448	11/25/1994
15	30274	3450	4635	12/1/1994
15	30277	5400	7983	12/25/1994
15	30282	5490	7866	11/24/1994

Table 6-5: Soil Sample Weight and Volume for the Additional Eight Samples from Layer 15 (Courtesy of the Preservation Office of the Sannai Maruyama Site)

Sample Number/ Taxa	30312	30217	30245	30273	30264	30274	30277	30282	NISP total	NISP %
Chondrichthyes	5	0	1	1	1	3	3	5	19	6.2%
<i>Scomber</i>	0	0	0	9	0	0	0	0	9	2.9%
Paralichthyidae	0	0	0	0	0	0	0	0	0	0%
Pleuronectidae	9	5	4	3	10	0	6	0	37	12.0%
<i>Seriola</i>	20	13	8	19	7	14	3	1	85	27.6%
Salmonidae	0	0	0	0	0	frag	0	0	0	0%
Clupeidae	5	2	25	8	24	14	1	5	84	27.3%
Embiotocidae	3	0	3	1	1	2	2	0	12	3.9%
Hexagrammidae	4	2	3	4	0	1	0	0	14	4.6%
Gobiidae	0	0	0	9	8	1	0	0	18	5.8%
Cobitidae	0	3	0	0	14	3	0	0	20	6.5%
<i>Tribolodon</i>	0	0	0	0	0	0	0	0	0	0%
Hemirhamphidae	0	0	0	0	0	0	0	0	0	0%
Hyporhamphus	0	0	0	0	0	0	0	0	0	0%
Monacanthidae	4	0	0	3	0	0	0	0	7	2.2%
Sphyracnidae	0	0	0	0	2	0	0	0	2	0.7%
<i>Sebastes</i>	0	0	0	0	0	0	0	1	1	0.3%
Total	50	25	44	57	67	38	15	12	308	100.0%

Table 6-6: NISP of Identified Fish Remains Of Additional Fight Samples from Layer 15.

As these tables indicate, when the number of samples was doubled, the representation of the identified specimen did not change significantly. Moreover, although the number of bags analyzed for these two layers are different, the number of identified specimens are about the same, 567 and 590 for Layers 3 and 15 respectively.

The difference in NISP between these layers may be explained by one or more of the following: 1. differential preservation conditions of the faunal remains in these two layers, 2. the limitation in my identification ability of some species resulting in some species being left unidentified, and 3. the NISP actually reflects the true representation of the deposits.

The first possibility that the difference in NISP is the result of differential preservation condition between the two layers is unlikely. Since both of these layers contain similar fish species and plant remains with more or less the same degree of damage, it is likely that both of these layers were under similar preservation conditions.

The second explanation that the difference in NISP is the result of my limited identification ability of some of the species is possible, but unlikely. Although the identification was based on extensive contemporary and archaeological comparative collections, there are thousands of different species present in and around Aomori. Hence, it is possible that there are species not included in the comparative specimens, thus affecting my identification ability. However, for the most part, my identifications have been aided and confirmed by the faunal specialist at the site as well as a leading Japanese archaeo-ichthyologist, Hajime Komiya. Therefore, it is unlikely that it was simply my identification ability affecting the overall NISP.

Accordingly, the third explanation that the NISP actually reflects the true representation of the deposit is most likely the case in this scenario. In order to compare the two layers in terms of the number of identified specimens, the NISP was added for each species for the two layers.

	NISP	NISP %	NISP	NISP %
Taxa	Layer 3	Layer 3	Layer 15	Layer 15
Chondrichthyes	11	1.9%	46	7.9%
<i>Scomber</i>	75	13.2%	25	4.3%
Paralichthyidae	6	1.1%	1	0.2%
Pleuronectidae	6	1.1%	51	8.8%
<i>Seriola</i>	15	2.7%	188	32.3%
Salmonidae	25	4.4%	1	0.2%
Clupeidae	89	15.7%	171	29.3%
Embiotocidae	51	9%	27	4.6%
Hexagrammidae	7	1.2%	20	3.4%
Gobiidae	13	2.3%	18	3.1%
Cobitidae	250	44.1%	25	4.3%
<i>Tribolodon</i>	13	2.3%	0	0.00%
Hemipteridae	3	0.5%	0	0.00%
Hyporhamphus	1	0.2%	0	0.00%
Monacanthidae	2	0.4%	10	1.7%
Total	567	100.00%	583	100.00%

Table 6-7: NISP Total for Two Layers.

As indicated in Table 6-7, for Layer 3, the species with relatively high NISP are *Scomber*, Clupeidae, and Cobitidae. For Layer 15, the species with relatively high NISP are *Seriola* and Clupeidae. It is important to keep in mind that a high NISP simply means that there is a higher representation of the vertebrae from these species than from the others, and it does not necessarily mean that the actual number of individuals for these species were higher. Since each fish species has a different number of vertebrae, in order to compare the species representation, it is necessary to convert the NISP data to the minimum number of individuals (MNI).

6. 4. MNI of the Fish Remains

In order to calculate MNI, NISP was divided by the number of vertebrae of contemporary comparative specimens. Tables 6-8 and 6-9 indicate the MNI, NISP, and their percentages for Layers 3 and 15.

Taxa	MNI	MNI %	NISP	NISP %
chondrichthyes	n/a	0%	11	1.9%
<i>Scomber</i>	3	13.0%	75	13.2%
Paralichthyidae	1	4.4%	6	1.1%
Pleuronectidae	1	4.4%	6	1.1%
<i>Seriola</i>	1	4.4%	15	2.6%
Salmonidae	1	4.4%	25	4.4%
Clupeidae	2	8.7%	89	15.7%
Embiotocidae	2	8.7%	51	9%
Hexagrammidae	1	4.4%	7	1.2%
Gobiidae	1	4.4%	13	2.3%
Cobitidae	6	26.1%	250	44.1%
<i>Tribolodon</i>	1	4.4%	13	2.3%
Hemipteridae	1	4.4%	3	0.5%
Hyporhamphus	1	4.4%	1	0.2%
Monacanthidae	1	4.4%	2	0.4%
Total	23	100.00%	567	100.00%

Table 6-8: MNI, MNI percentage, NISP, and NISP percentage for Layer 3.

Taxa	MNI	MNI %	NISP	NISP %
chondrichthyes	n/a	0%	46	7.9%
<i>Scomber</i>	1	4.2%	25	4.3%
Paralichthyidae	1	4.2%	1	0.2%
Pleuronectidae	2	8.3%	51	8.7%
<i>Seriola</i>	8	33.3%	188	32.1%
Salmonidae	1	4.2%	1	0.2%
Clupeidae	4	16.7%	171	29.2%
Embiotocidae	1	4.2%	27	4.6%
Hexagrammidae	1	4.2%	20	3.4%

Gobiidae	1	4.2%	18	3.1%
Cobitidae	1	4.2%	25	4.3%
<i>Tribolodon</i>	0	0%	0	0%
Hemipteridae	0	0%	0	0%
Hyporhamphus	0	0%	0	0%
Monacanthidae	1	4.2%	10	1.7%
Sphyraenidae	1	4.2%	2	0.3%
<i>Sebastes</i>	1	4.2%	1	0.1%
total	24	100.0%	586	100.0%

Table 6-9: MNI, MNI percentage, NISP, NISP percentage for Layer 15

As Table 6-8 indicates, for Layer 3, Cobitidae has the highest MNI of 6, followed by *Scomber* with MNI of 3. This representation pattern is different from simply looking at NISP: for Layer 3, the taxa with the highest NISP are Cobitidae and Clupeidae. For Layer 15, however, the taxa with the highest MNI and NISP are the same; *Seriola* and Clupeidae.

6. 5. Chronological Information for Layers 3 and 15

As I mentioned above, Okada (personal communication, 2006) states that the numbering of the layers of the Northern Valley Area reflects the original stratigraphic sequence, and that both Layers 3 and 15 should fall within the duration of the Lower Ento-a phase. To confirm these observations, the AMS radiocarbon dating method was applied to the most abundant type of floral remains from the two layers: elderberry seeds. Nine seeds from Layer 3 and seven seeds from Layer 15 were selected for this purpose. These samples were sent to Beta Analytic Inc. for AMS analyses. Table 6-10 and Figures 6-2 and 6-3 show the results of the AMS analyses. Figures 6-4 and 6-5 show the results of the calibrated dates using the OxCal program.

Sample No. (Layer)	Conventional Radiocarbon Age	Calibrated 1 σ Range	Calibrated 2 σ Range	Intercept of Radiocarbon Age with Calibration Curve
B253797 (Layer 3)	4850 \pm 40 bp	3660 to 3640 Cal. BC (5600 to 5590 Cal. BP)	3700 to 3630 Cal. BC (5650 to 5580 Cal. BP)	3640 Cal. BC (5590 Cal. BP)
B253798 (Layer 15)	4920 \pm 50 bp	3720 to 3650 Cal. BC (5670 to 5600 Cal. BP)	3790 to 3640 Cal. BC (5740 to 5590 Cal. BP)	3700 Cal. BC (5649 Cal. BP)

Table 6-10. Results of the AMS Analysis.

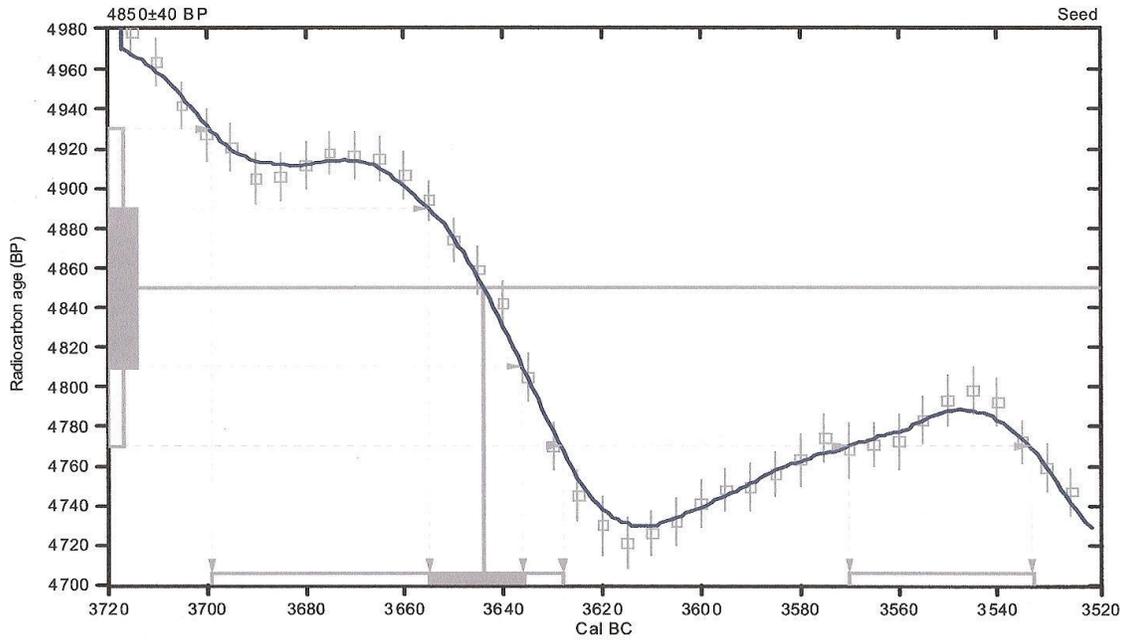


Figure 6-2: Calibration Curve of the Radiocarbon Date from Layer 3 (B253797)

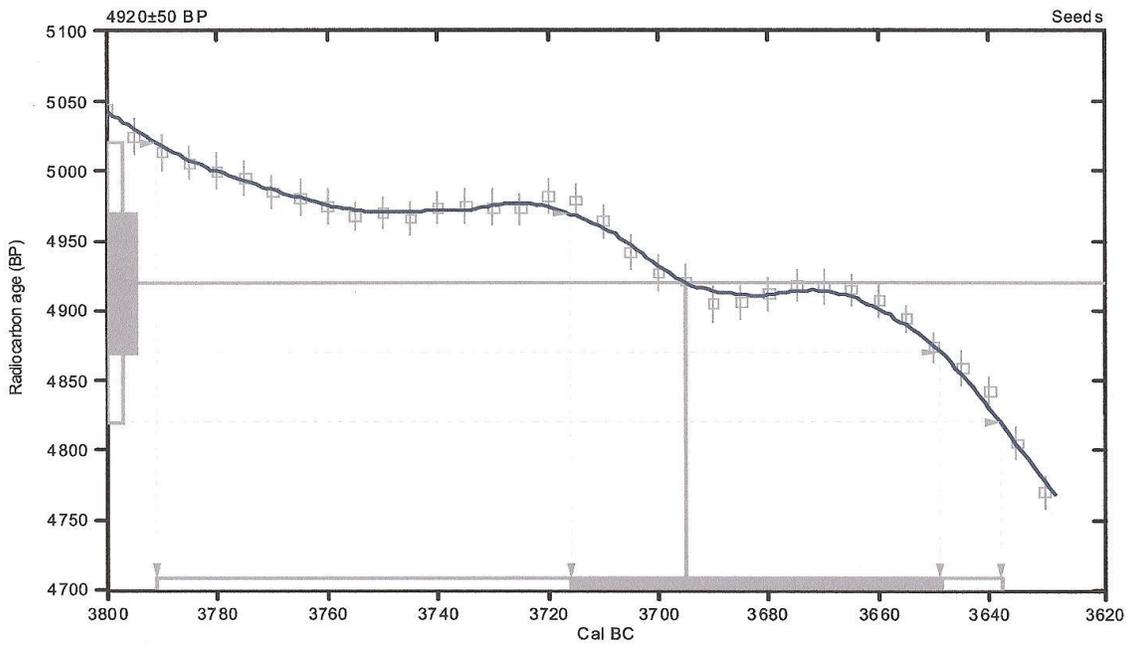


Figure 6-3: Calibration Curve of the Radiocarbon Date from Layer 15 (B253798)

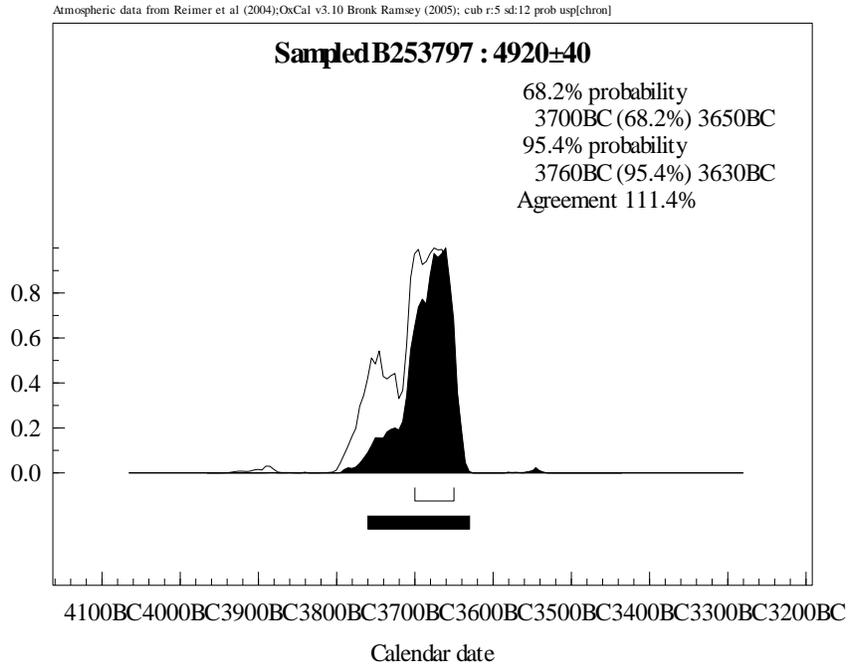


Figure 6-4: AMS Date Range of Elderberry Seeds from Layer 3: B253797

Figure 6-4 shows the result of calibration for the sample from Layer 3. The two sigma range, 3760 to 3630 B.C., places Layer 3 towards the earlier part of the Lower Ento-a phase of the site occupation (see Nakamura et. al. 1998, Tsuji 2006).

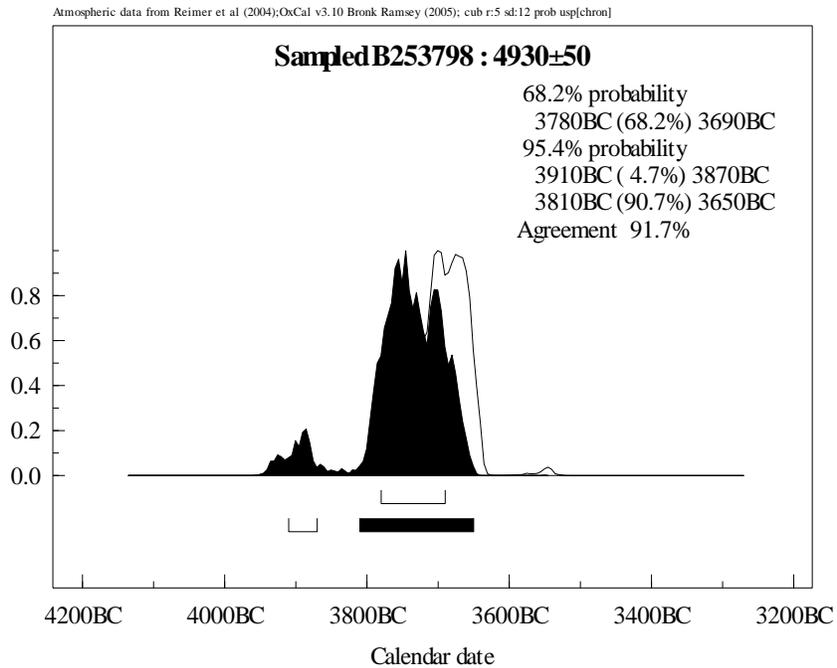


Figure 6-6: AMS Date Range of the Elderberry Seeds from Layer 15: B253798

Figure 6-6 shows the result of the calibration of the AMS date for Layer 15. The two sigma range of 3910 B.C. to 3870 B.C. at 4.7percent, and 3810 B.C. to 3650 B.C. at 90.7

percent, places the Layer 15 sample towards the early part of the Lower Ento–a phase as well.

The results of these AMS analyses indicate that Layers 3 and 15 are associated with dates that are very close to each other. As I mentioned before, the reason for selecting two chronologically distinct layers was to examine the changes of faunal remains through time. However, the result of the AMS analyses show that these layers are very close to each other. Therefore, comparing the assemblages from Layers 3 and 15 to each other to understand changes through time is not appropriate in this case. Although the stratigraphical sequence indicates that Layer 15 is older than Layer 3, the difference was not clearly reflected in the AMS dates. In the future, more AMS dates from these layers should be collected to clarify this issue.

6. 6. Conclusion

In this chapter, I presented the background information, methods, and results of my faunal analysis. The results of my faunal analysis suggest that, in Layer 3, loaches had the highest MNI of six (26.1%), while yellowtail had a MNI of one (4.4%). On the other hand, in Layer 15, loaches' MNI was 1 (4.2%), while yellowtail's MNI was eight (33.3%). As I discussed earlier in this chapter, the two sigma ranges of the radiocarbon dates from these two layers overlap significantly, and they are both within the expected duration of the Lower Ento–a phase. Some of the possible explanations of the differences in the assemblage composition between the two layers are 1. microvariability, 2. change in consumption behavior, and 3. change in the use of loaches.

1. Microvariability: it is very possible that the two layers reflect two different consumption incidents, one with discarded yellowtails and the other with loaches. Thus, the difference is not necessarily reflecting the transformation of behavior through time.
2. Change in consumption behavior: the difference in taxa representation does reflect changes from preference of yellowtail to preference of loaches even though the shift probably occurred within a short period of time.
3. Different uses of loaches: the low representation of loaches in Layer 15 and the high representation in Layer 3 can be explained as a change in the use of loaches. Among contemporary fishers, loaches, especially the small individuals, are used as live baits. Thus, the difference can be explained in terms of the change in the use of loaches from bait to food.

The above explanations are obviously speculative and further examinations are necessary. In the next chapter, the taxa with the highest representations will be examined using the principles behind the diet breadth model.

Chapter 7

Testing the Optimal Foraging Model

The final stage of the data analysis is to examine if the characteristics of fish assemblages from the Sannai Maruyama site are consistent with the optimal foraging model. In the previous chapter, I presented the results of analyses of fish skeletal remains recovered from Layers 3 and 15 of the Northern Valley area. These layers were selected among the Lower Ento–a layers because of the well-preserved condition of fish skeletal remains. The purpose of my faunal analyses was to supplement the existing list of taxa compiled by Toizumi (1998, 2006) to determine which taxa have high representations. The use of small-meshed screens (2, 1, and 0.5mm) allowed consistent recovery of smaller taxa such as loaches, herrings, and gobies that would have had very low representations otherwise.

In my analyses of fish remains in chapter 6, the taxa with the highest representations are *Seriola* (yellowtail), which is 33.3 % (MNI) in Layer 15 and Cobitidae (loach), which is 26.1 % (MNI) in Layer 3. Clupeidae has the third highest representation in Layer 15 (16.7 %), but this taxon will not be a focus of this chapter, as this may include multiple species. Due to the preservation condition of the specimens and my identification ability, I was not able to identify them any further to the genus or species level. In other words, although Clupeidae as a family has a relatively high representation, since this particular family includes fish that greatly differ in size, habitats, and seasons, I decided it is not appropriate to include this taxon in this study. Cobitidae, too, is a family that includes many species. However, in the case of Cobitidae, they all occupy the same freshwater habitats and share similar size and seasonality. Therefore, they are selected to be the subject of this study.

If the model and assumptions stand, then both *Seriola* and Cobitidae will have overall higher returns than investments. For each taxon, I will evaluate their economics by examining the five categories of activities below:

1. Travel
2. Fishing
3. Processing
4. Preservation
5. Consumption

The above five categories will be examined through the data gathered from contemporary observations and examinations of fishing methods, processing, and preservation strategies, as well as through nutritional analyses. To develop the estimates that most closely capture the fishing and fish consumption manners of the Jomon period, fishing records developed on contemporary commercial fishery practices were not included. For example, commercial fishing of yellowtails today regularly involves large vessels that locate schools of fish using detection radars, then captures the fish using one or more of the following methods: fixed nets, set nets, gill nets, and trotlines. They also rely on mechanical motors to pull the nets and lines, and on-board refrigeration and

processing systems to immediately preserve the catch. The data gathered from these methods no longer carry the same investment/return ratio as Jomon fishing, and thus will not contribute to a discussion of the Jomon fishing and fish-processing strategies.

Moreover, the evaluation of energy investments will be greatly influenced by the method of processing employed. In ethnographic examples of fish-processing and consumption, there is significant variability in cooking methods even in a single culture. In Japan, for example, one of the simplest methods of preparing large fish is *sashimi*, in which fresh fish is filleted and eaten raw with seasoning. Its preparation can be as short as a few minutes, depending on the size of the fish. On the other hand, cooking fish can be as elaborate and time-consuming as one wishes it to be. A single carcass can be filleted, boiled, cured, dried, fermented, shaved, and stewed to make broth. Both of the above dishes can be done using the same species, yet the resulting nutritional yields and the processing effort differ greatly. In order to assess the processing effort required for the two taxa properly, I will examine the minimum preparation required for both taxa.

Furthermore, without modern refrigeration technology, preservation in general is a major issue for fish. When the catch exceeds the amount that can be consumed within a day or two, they will not be edible for too long without refrigeration or other proper preservation methods. Unless it is possible to keep the fish alive in fish tanks, once a fish is caught, it begins to degenerate immediately. In order to prolong the shelf life of fish, it is crucial to develop a preservation method. The preservation methods that do not require modern refrigerators or irradiation techniques are drying, smoking, fermentation, and salt-curing. Again, in order to assess the preservation effort involved in the two taxa, I will examine the minimum preservation practices.

Therefore, when possible, I will use data derived from contemporary fishing and fish processing methods that the residents of Sannai Maruyama also were able to carry out using the equipment found at the site. In the next section, I will first present the taxa information and then the archaeological fishing techniques.

7. 1. Information on the Two Taxa: *Seriola* and *Cobitidae*

Understanding the natural history of the contemporary yellowtails and loaches gives us clues to their roles in the environment during the Early Jomon period. To capture these preys effectively, the fishers of Sannai Maruyama must have had intimate knowledge of their habitats, life cycles, and seasonality.

7. 1. 1. *Seriola* (yellowtail)

In contemporary Japan, *Seriola* (yellowtail) is an important commercial fish commonly consumed at homes and eateries. Because of the high demands, the yellowtail farming technology has improved over the years, and though fishing of wild yellowtails continues, much of what is available in the market today is farm-raised.

The wild individuals of yellowtail are known to grow up to 150 centimeters (Konishi 1985). In Japan, they are known as *shusse-uo*, meaning they acquire different names as they grow larger. In the Aomori area, yellowtail changes names in the following order; *shokko-inada* – *fukurage* – *warasa* – *buri* (Aomori-ken Gyogyo Kyodo Kumiai Rengokai 2007). They are found between the Japan Sea and the Pacific coast (Shiogaki et

al. 2004). The ones found around Aomori are believed to be spawned in southern Japan Sea, near South Korea, then swim up north during the spring and summer all the way to the Sea of Okhotsk. During the fall and winter, they swim back southward (Aomori Sangyo Gijutsu Senta 2007). The commercial fishing season for yellowtail in the Aomori area begins in late spring and ends in early fall (Aomori-ken Gyogyo Kyodo Kumiai Rengokai 2007). They are normally found in relatively warm water with surface temperatures of 13 to 23 degree centigrade (Hirai 1966). They live anywhere between 6 meters to 20 meters deep; the younger individuals tend to be closer to the surface while the mature ones tend to stay deeper (Aomori-ken Gyogyo Kyodo Kumiai Rengokai 2007). When they are traveling northward, they are most active between 3am and sunrise, when they subsist on small fish such as *Trachurus* (*aji*/ Spanish mackerel), *Sardinops* (*iwashi*/sardine), squid (Decapodiformes), and *Scomber* (*saba*/mackerel).

In present day Aomori, the known fishing locations for mature yellowtails are along the Japan Sea coast and Tsugaru Strait, where the two warm currents, Tsushima Warm Current and Tsugaru Warm Current, drift toward the north and northeast. Much smaller individuals can be found inside the bay at times (To'o Nippo 1999).

7. 1. 2. Cobitidae (loaches)

Cobitidae, or loaches, are small fresh-water fish found throughout the entire Japanese archipelago in shallow ponds and streams. Aomori Prefecture has been known as one of the main suppliers of loaches to fish markets in Tokyo (Sato 1967). There used to be so-called *dojo densha* (loach trains) carrying loaches from Aomori to Tokyo (Sato 1967). The average length of a loach is approximately 6 to 14 centimeters (Kawabe and Mizuno 1995) and 5 to 10 grams in weight (Kagaku Gijutsu-cho 1990). They prefer habitats with muddy bottoms such as small slow running streams and swamps, and subsist on bottom dwellers and other organic matters that live in the mud (Kawabe and Mizuno 1995). Because of their abundance, loaches have a prominent role in the Japanese culture, as reflected in popular nursery rhymes and Shinto rituals (Yasumuro 2005).

What distinguishes loaches from other freshwater fish is their unique ability to breath not only with gills but also with their intestines. This intestinal breathing mechanism allows loaches to thrive in conditions that other fish cannot survive due to oxygen deprivation (Makino 1996). Even when the habitat loses the body of water for fish to freely swim around, as long as there is enough moisture in the soil and they can swallow the air through their mouths, they can survive. Moreover, when the temperature is below fifteen degrees centigrade during the winter time, they become immobile but remain alive (Makino 1996). These characteristics make loaches very accessible as long as there are enough freshwater habitats.

7. 2. Archaeological Fishing Technology

7. 2. 1. *Seriola*

Among the contemporary non-commercial yellowtail fishers around Aomori, the main fishing method is the use of line and pole casting from a boat off the shore. At

Sannai Maruyama, though there was no watercraft or fishing lines, more than twenty fishhooks were recovered from Lower Ento—a layers of the Sixth Transmission Tower area. As I mentioned in chapter 4, because this does not include specimens recovered from other areas of the site, the total number of fishhooks from this period is expected to be much higher. Nevertheless, the average size of the complete specimens resembles the fishhooks used by contemporary yellowtail fishers.

	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)
Average size of fishhooks from Layers VIa and VIb ^{*1}	27.5	7.3	2.9	0.50
Average size of contemporary fishhooks for yellowtails ^{*2}	21.5	12	n/a	0.56

Table 7-1: Comparison of Archaeological and Contemporary Fishhooks

^{*1}Aomori-ken Kyoiku Inkai 1998

^{*2}110mall 2004, Naturum 2010

The above table shows the similarity between the fishhooks from the Lower Ento—a phase and the ones commonly recommended for and used in contemporary non-commercial yellowtail fishing (110Mall 2004). Thus, the fishhooks recovered from the Lower Ento—a layers are comparable to contemporary yellowtail fishhooks in terms of their overall size. In the evaluation of the yellowtail fishing endeavor in the following sections, this line and hook method will be applied.

7. 2. 2. Cobitidae

The verbs often used to describe loach fishing in Japanese are *suku* 'u, meaning to scoop, and *horu*, meaning to dig. Fishing for loaches is considered scooping or digging because it requires scooping/lifting of the mud at the bottom where loaches are. A simple handheld winnowing fan can be used to scoop the mud and loaches together, then the mud can be washed off using water to clean the loaches.

Another relatively uncomplicated method of catching loaches is the use of basket traps. It requires a cylindrical basket made with plant materials such as bamboo or reed that can be used with or without bait inside (Yasumuro 2005).

The basket can be simply left in the slow running streams or other shallow bodies of water with muddy bottoms. They can be used without construction of flow-guiding structures such as weirs. Because of the simplicity of catching loaches, loach fishing was something people, including children, practiced casually around their homes historically in Japan (Yasumuro 2005).

Among the artifacts recovered from the Lower Ento—a layers of Sannai Maruyama, there are multiple fragments of artifacts, such as basket fragments, that could have been used for loach fishing.

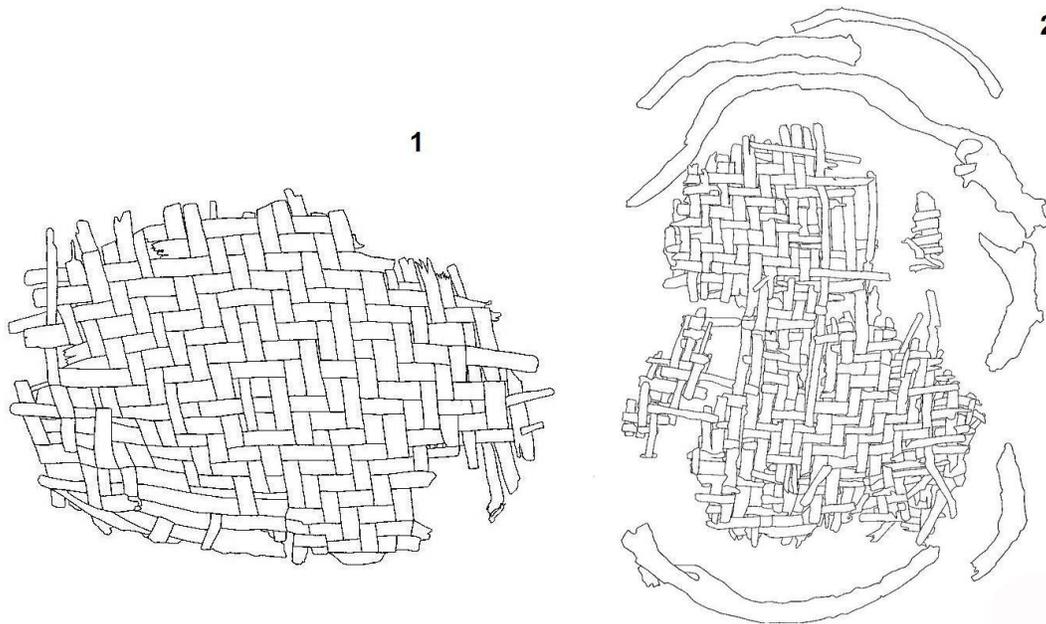


Figure 7-2: Examples of Baskets from the Sixth Transmission Tower Area (Aomori-ken Kyoiku Iinkai 1998)

	Length (mm)	Width (mm)	Thickness (mm)
1	153	213	1
2	225	282	1

Table 7-2: Measurements of the Examples of Baskets from the Sixth Transmission Tower Area (Aomori-ken Kyoiku Iinkai 1998)

The above figure and table discuss two examples of baskets found from the Lower Ento—a layers of the Sixth Transmission Tower Area. Since loaches are neither large like eels that can slither out of the basket, or small like a baby guppy that can slip out from a loosely woven basket, these pieces in their complete forms would be suitable to catching loaches. Therefore, the use of basket and handheld nets will be used in the evaluation of the effort involved in catching loaches.

7. 3. Application of the Diet Breadth Model on *Seriola* and Cobitidae

As I mentioned in the beginning of this chapter, the hypothesis being tested is if the two taxa with highest representations – *Seriola* and Cobitidae – were the optimal choices for the Sannai Maruyama residents during the Lower Ento—a phase. According to the optimal foraging models, only the prey that results in greater returns than the investments are pursued by efficient foragers. In this section, the two taxa are examined for the below five activities in terms of the efforts and returns.

1. Travel; distance and energy involved.

2. Fishing; use of line/hook or basket and wait for catching.
3. Processing; scaling, gutting, etc. to minimally process the catch.
4. Storage; ease of storing to be consumed later
5. Consumption; nutritional value of each taxon.

7.3.1 *Seriola*

7.3.1.1. Travel

Due to their preference of warm water, yellowtails swim up and down the Tsushima Warm Current that runs west of Aomori Prefecture and along the Tsugaru Warm Current between Hokkaido and Aomori Prefecture. These areas are known as the fishing locations of yellowtails among contemporary fishers (To'o Nippo 1999).

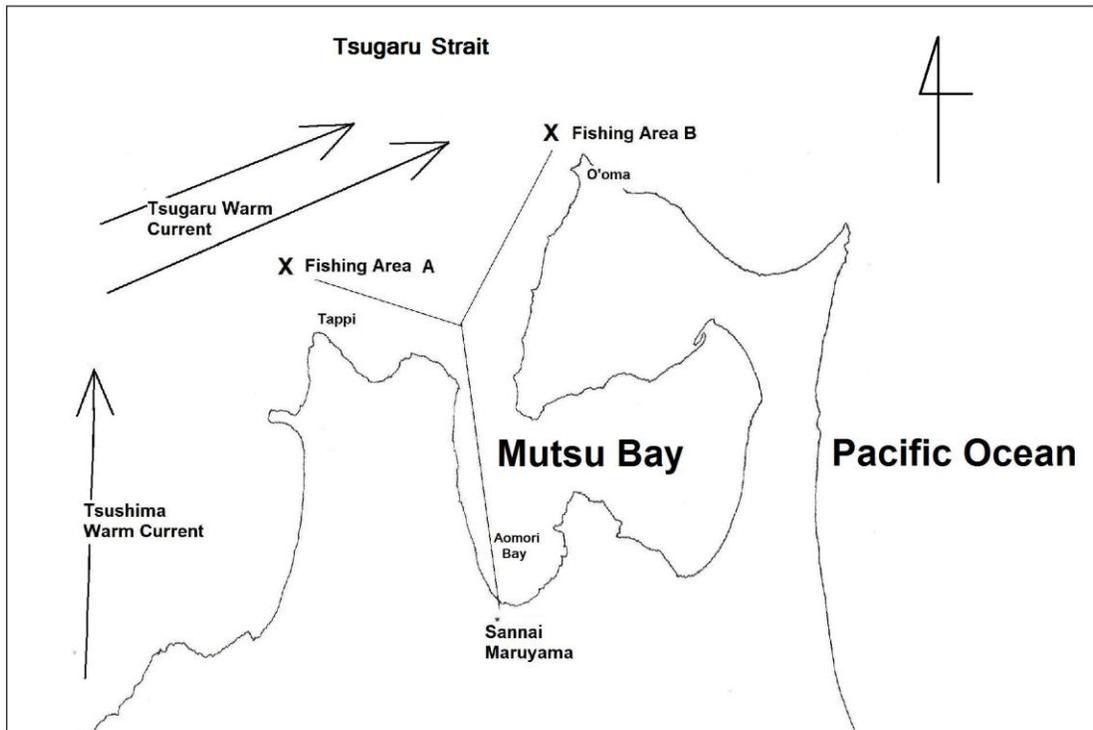


Figure 7-3: Locations of Contemporary Yellowtail Fishing (Modified from To'o Nippo 1999)

Therefore, it was imperative for the site residents to travel most of the distance by the use of watercraft to reach the fishing locations. Whether they travel on land to the opening of the bay or to the Japan Sea coast before switching the transportation strategy to watercrafts, the travel distance from the site is considerable. The distance between the site and the closest fishing spot in Tsugaru Strait off the coast of Cape Tappi (marked as Fishing Area A in the above figure) is approximately 75 kilometers, and to reach the second closest spot off the coast of O'oma (marked as Fishing Area B) is approximately 92 kilometers.

In order to calculate the energy expenditure required in traveling to the fishing points, the MET (Metabolic Equivalent of Task) intensities by Ainsworth, et. al. (2000) is used. MET is a unit of measurement used to evaluate the intensity of exercise that can be converted to kilocalories. Based on Ainsworth, et al.'s Compendium of Physical Activities, rowing a canoe with moderate effort equals 7 METs, by traveling at an average of 7.965 kilometers per hour. Then, the MET rates were converted to energy by using the formula below (Kosei Rodo-sho 2006).

$$\text{Energy (kCal)} = \text{METs} \times \text{Body Weight} \times \text{Time (h)} \times 1.05.$$

The table below shows the energy required to travel to the two locations.

Fishing Locations	Distance (km)	Speed (km/hr) ^{*1}	Time Spent (hr)	Energy (kCal) ^{*2}
A: Tappi	75	7.965	9.4	3460
B: O'oma	92	7.965	11.6	4263

^{*1} based on "canoeing, rowing with moderate effort" = 7 METs

^{*2} estimates for a 50kg individual

Table 7-3: Time and Energy Required for One-Way Travel from the Sannai Maruyama Site to the Yellowtail Fishing Locations

The above table summarizes the distance, time spent, and energy required to travel to the fishing locations. In order to reach the known fishing point near Tappi, it takes approximately 3460 kilocalories, while reaching the point near O'oma, requires approximately 4263 kilocalories. These energy expenditures reflect only a single direction. When the return trip is considered, it is 6920 kilocalories for Tappi and 8526 for O'oma for a single fishing expedition.

7. 3. 1. 2. Fishing

As I mentioned earlier in the chapter, the fishing data for yellowtails were taken from fishing records of a hobby fisher as opposed to from commercial fishing in Aomori. Table 7-4 shows the results of eight yellowtail fishing trips that took place in Tsugaru Strait, off the coast of Sunagamori from 2005 to 2007. Although these are hobby fishing trips, the fishing equipment used included line length counters and fish detection radars, both of which aid in locating and efficiently suspending the bait and hook at the right depth. Therefore, the resulting catches of these fishing trips are expected to be significantly higher than that of the Jomon counterpart, as they did not have any such aids in their fishing effort.

Trip	Dates	Fishing Area	Inada/Fukurage (2.5kg avg)	Warasa (5kg avg)	Buri (7kg avg)	Total
No.1	11/25/2007	Tairadate ^{*1}	8	0	0	8
No.2	9/29/2007	Sunagamori ^{*1}	1	0	0	1
No.3	9/15/2007	Sunagamori	0	0	0	0
No.4	10/14/2006	Sunagamori	0	0	0	0
No.5	11/2/2005	Sunagamori	0	1	0	1
No.6	10/8/2005	Sunagamori	0	0	0	0

No.7	9/4/2005	Asamushi ^{*2}	0	0	0	0
No.8	8/27/2006	Sunagamori	0	0	0	0
Weight (kg)			22.5	5	0	27.5

Table 7-4: Results of Eight Yellowtail Fishing Trips in Aomori (Fishing Club Chodokai 2009)

^{*1} Near Tappi

^{*2} In Aomori Bay

Most of the fishing trips were made during the season when schools of yellowtails are migrating southwest back to the South Japan Sea through Tsugaru Strait. Even though these fishing trips were made with the specific purpose of catching yellowtails, only three days resulted in catch. Moreover, although the fishers were after large mature individuals, *huri*, the individuals caught were much smaller. The date with the highest number of catch is November 25th, 2007, when the total catch was eight fish the size of *fukurage*, which is significantly smaller than *huri*. When the total weight of *inada/fukurage* is calculated, it is 22.5kg for nine individuals, while *warasa* is 5kg for one. In total, the eight trips yielded 27.5kg, or 3.4kg per trip.

These results show that yellowtail fishing is not a reliable subsistence practice. Even with the knowledge of the migration route and depth of the fish using fish detection radar, the result is not always guaranteed. When yellowtail fishing records by other fishers in the Aomori area are compared, their results also showed similar inconsistency with their catch. The Jomon counterparts may have had better skills and knowledge, but with their limited range of technology and fishing tools, the fishing results may be similar.

7. 3. 1. 3. Processing

Minimal processing required in yellowtail consumption is to cut the flesh to pieces. If the fish is not processed at all, the scale-covered skin would be difficult to bite through with one's teeth or to eat flesh off the bones and skin effectively. Moreover, although it is possible to eat the small scales, the eating experience is significantly improved when the scales are removed prior to consumption. Therefore, even though preparation of yellowtails for consumption can be relatively simple, it requires processing tools.

7. 3. 1. 4. Storability

In the case of yellowtail, keeping the fish alive in the water near the site was not an option, since the technology to do so was not available. Moreover, freezing is not a suitable method, since the season for the school of yellowtail to run by Aomori is summer to early fall, when the temperature never reaches low enough for a fish to freeze. That leaves the other three methods: dehydration (including smoking), fermentation, and salt-curing. However, due to its size and high moisture and lipid contents, yellowtail cannot be dried without first reducing the size by cutting them into small pieces. The flowchart below (Figure 7-4) shows the minimal steps that need to be taken to preserve yellowtail by drying, smoking, fermentation, and salt-curing.

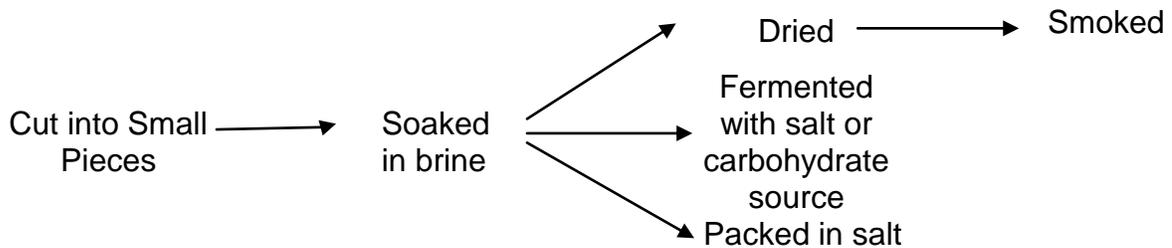


Figure 7-4: Flowchart of Minimal Fish Processing for Yellowtail Preservation

There have been so-called salt production pottery (*seien-doki*) found all over the Japanese archipelago from the Late and Final Jomon periods (Habu 2004). Although this particular type of pottery is not found within the Sannai Maruyama assemblage, it is possible that the site residents produced salt using other methods. Moreover, carbohydrate sources to create fermentation can be acquired in the forms of wild grains or fruits. Therefore, any of these strategies could have been employed to preserve yellowtails and other fish at the site. Regardless of which preservation strategy is taken, storage of yellowtail for later consumption requires a considerable effort and additional ingredients.

7. 3. 1. 5. Consumption

In order to examine the return rates of yellowtail from consumption, the nutritional data were taken from *Standard Tables of Food Composition in Japan* (Kagaku Gijutsu Shigen Chosa-kai 2003). In addition, to illustrate how consumption of yellowtail could contribute to meeting the daily nutritional requirements, the Daily Recommended Value of nutrients and the percentage of nutritional contents of yellowtail are presented in the Table 7-5.

Nutrients	Nutrients (per 100g)	Daily Recommended Value ^{*1}	Nutrients %
kCal	257	2050	12.5%
Protein (g)	21.4	55	38.9%
Lipid (g)	17.6	n/a	n/a
Carbohydrate (g)	0.3	n/a	n/a
Sodium (mg)	32	n/a	n/a
Potassium (mg)	380	2000	19.0%
Calcium (mg)	5	600	0.8%
Magnesium (mg)	26	250	10.4%
Phosphorus (mg)	130	700	18.6%

Iron (mg)	1.3	12	10.8%
Zinc (mg)	0.7	9	7.8%
Copper (mg)	0.08	1.6	5.0%
Manganese (mg)	0.01	3	0.3%
Retinol (µg)	50	540	9.3%
Carotene (µg)	0	n/a	n/a
Vitamin D (µg)	8	2.5	320.0%
Vitamin E (mg)	2	8	25.0%
Vitamin K (µg)	0	55	0.0%
Vitamin B1 (mg)	0.23	0.8	28.8%
Vitamin B2 (mg)	0.36	1	36.0%
Niacin (mg)	9.5	13	73.1%
Vitamin B6 (mg)	0.42	1.2	35.0%
Vitamin B12 (µg)	3.8	2.4	158.3%
Folic Acid (µg)	7	200	3.5%
Vitamin C (mg)	2	100	2.0%

**Table 7-5: Nutritional Percentage of Yellowtail [per 100g]
(Kagaku Gijutsu Shigen Chosakai 2003).**

^{*1} Values for a female 18-29 years old.

As the above table shows, yellowtail could provide close to or over 100 percent of some nutrients by consuming merely 100 grams. Obviously, there is no reason to fulfill the entire nutritional requirements by consuming a single food, and it was clearly not the case as reflected in the midden contents of Sannai Maruyama. However, the nutritional data show that yellowtail can be an excellent source of many of the essential nutrients that aid in survival and reproduction.

7. 3. 1. 6. Energy Investments vs. Returns

Based on the eight fishing expeditions presented above, the average net gain (kg) of yellowtail per fishing trip is 3.4 kg. If the site residents processed each fish and discarded some of the bones and internal organs, then approximately 30 percent of the total body weight, approximately 1.0 kilogram would be eliminated (Kagaku Gijutsu-cho 1990). This would leave 2.4 kilograms for consumption, which can be roughly converted to 6168 kilocalories.

Although the energy return of 6168 kilocalories is significantly more than one individual's energy requirement for a day, it is not an adequate return when the energy investment is considered. Simply traveling to and back from a fishing location near Tappi requires a minimum of 6920 kilocalories. This does not include the energy spent while fishing, processing, or transporting the carcass. Moreover, if the catch was shared with other individuals upon returning to the site, the energy return to the forager could decrease significantly.

In addition to the insufficient energy return, there are also serious risks associated with yellowtail fishing. In order to fish yellowtail, a forager has to travel out of the bay, where there is more likelihood for encountering accidents. Moreover, when energy

investments involved in preparation of equipments such as watercrafts and fishhook are included, yellowtail fishing investments significantly outweigh the returns.

7. 3. 2. Cobitidae

7. 3. 2. 1. Travel

Unlike yellowtails, loaches can be found in shallow streams, ponds, and swamps at and around the site, such as Okidate River and its small tributaries. The distance between the site and the closest point of the river is approximately 0.4 kilometers, which requires merely 16.8 kilocalories to travel.

Fishing Locations	Distance (km)	Speed (km/hr) ^{*1}	Time Spent (hr)	Energy (kCal) ^{*2}
Okidate River	0.4	6.4	0.06	16.8

^{*1} based on “walking on firm surface at brisk pace” = 5 METs

^{*2} estimate for a 50kg individual

Table 7-6: Time and Energy Required for One-Way Travel from the Sannai Maruyama Site to Okidate River

Using the same formulae as yellowtail, in order to make a trip from and to the site, the energy invested is approximately 33.6 kilocalories for a 50 kilogram individual.

7. 3. 2. 2 Fishing

In order to develop the fishing estimates for loaches, fishing data were taken from the environmental studies by Sorachi Sogo Shinko Kyoku of Iwamizawa City (2006, 2009). Between 2005 and 2009, a series of loach fishing experiments were carried out to examine the ecosystem of the area. In 2005 and 2006, the experiments were conducted by placing a simple basket trap in a shallow stream with a muddy bottom. The basket was left overnight for the fish to swim inside, and then retrieved the next day for its contents to be quantified. Table 7-7 shows the results of the experiments in 2005 and 2006.

Year	Basket 1	Basket 2	Basket 3	Basket 4	Average per basket
2005 *1	191	38	5	n/a	78
2006 *2	140	n/a	n/a	200+	170

Table 7-7: The Number of Individuals Captured with Basket Trap
(*1 Sorachi Sogo Shinkokyoku 2005, *2 Sorachi Sogo Shinkokyoku 2006)

The first two baskets were set in stagnant water with mud accumulation at the bottom, whereas the third basket, which yielded only five individuals in 2005, had running water. The result of the 2005 experiments revealed that areas with stagnant to slow-moving water and mud accumulation attract more loaches. This knowledge though new to the contemporary non-loach fishers, was probably common sense among the Jomon loach fishers.

Then, in 2009, they attempted to catch Cobitidae using simple handheld nets. This particular experiment took place in a stream of approximately one meter in width and ten centimeters in depth, a typical slow-running small stream of the area with a muddy bottom. After two hours, they were able to capture over 5000 individuals. When the total number of fish is divided by the number of people who participated (n=20) to determine per individual result, one gets 250 fish per person.

Year	Method	Catch	Average per person
2009	Handheld Net	5000+	250

Table 7-8: The Number of Cobitidae Captured with Handheld Net
(Sorachi Sogo Shinko Kyoku 2009)

When the time required in catching loaches is considered, the use of baskets yielded more results per effort than the handheld net method. With the basket method, the time required was to place each basket in an appropriate spot in a stream. There was no digging of mud searching for loaches or holding a fishing rod and waiting for a catch. Once the forager arrives at the location, it is just a matter of a few minutes to place the basket and a few more minutes the following day to retrieve the basket. On the other hand, in order to capture 250 fish using handheld net, it took two hours per individual.

Year	Average per forager	total weight estimate (g) *1	Time Required
2005 (basket trap)	78	585	A few minutes
2006 (basket trap)	170	1275	A few minutes
2009 (handheld net)	250	1875	Two hours

*1 calculated as 7.5grams per fish (Makino 1996).

Table 7-9: Average Catch per Forager and Total Weight

Table 7-9 shows the average number of loaches caught per fishing trip and resulting net weight gain. When the total weights for the basket traps method are averaged, it is 930 grams of loaches per experiment for a very short period of time spent. Therefore, in order to catch loaches, as long as a trap is set, considerable returns can be expected with relatively small effort. Even in the case of scooping with the handheld net, the return was significant.

7. 3. 2. 3 Processing

Unlike yellowtails and other large fish, the loach can be eaten whole from its skin to bones. However, as is the case with all the freshwater fish, loach should not be eaten raw to avoid dangerous parasitic infection. Therefore, the minimal processing in the case of loaches is heat treatment. Whether through boiling or cooking over a flame, the use of heat is necessary for loach consumption. Beyond heating, due to its relatively small size and soft skin, no additional effort such as scaling or butchering is required.

7. 3. 2. 4. Storability

According to Makino (1996), because of their unique intestinal breathing ability, Cobitidae can easily be kept alive in small vessels for an extended period of time. If a large number of other fish are kept in a small container, the fish will deplete the oxygen supply by breathing them out through their gills. However, with loaches, they can swim up to the surface and ‘gulp’ the air to maintain their oxygen supply. This ability allows a large number of loaches to be stored alive in a relatively small container without an artificial air circulation system (Makino 1996; 11, 40).

If a vessel with water is not available, then an alternative method in storing loaches is by dehydration. Their small body size allows the dehydration of a whole carcass relatively easily, without skinning or taking the carcass apart in any way. Thus preparations required for long-term storage of loaches is not only possible but relatively simple without an additional curing agent or the smoking process.

7. 3. 2. 5. Consumption

In the same manner as the examination of the return rates of yellowtail from consumption, the nutritional data of loaches were taken from *Standard Tables of Food Composition in Japan* (Kagaku Gijutsu Shigen Chosa-kai 2003). In addition, to illustrate how consumption of loaches could contribute to meeting the daily nutritional requirements, the Daily Recommended Value of nutrients and the percentage of nutritional contents of loaches are presented in the table below.

Nutrients	Nutrients (per 100g)	Daily Recommended Value ^{*1}	Nutrients %
kCal	79	2050	3.9%
Protein (g)	16.1	55	29.3%
Lipid (g)	1.2	n/a	n/a
Carbohydrate (g)	trace	n/a	n/a
Sodium (mg)	96	n/a	n/a
Potassium (mg)	290	2000	14.5%
Calcium (mg)	1100	600	183.3%
Magnesium (mg)	42	250	16.8%
Phosphorus (mg)	690	700	98.6%
Iron (mg)	5.6	12	46.4%
Zinc (mg)	2.9	9	32.2%
Copper (mg)	0.08	1.6	5.0%
Manganese (mg)	0.38	3	0.3%
Retinol (µg)	13	540	9.3%
Carotene (µg)	25	n/a	n/a
Vitamin D (µg)	4	2.5	160%
Vitamin E (mg)	0.6	8	7.5%

Vitamin K (µg)	1	55	1.8%
Vitamin B1 (mg)	0.09	0.8	11.3%
Vitamin B2 (mg)	1.09	1	109%
Niacin (mg)	4	13	30.8%
Vitamin B6 (mg)	0.1	1.2	8.3%
Vitamin B12 (µg)	8.5	2.4	354.17%
Folic Acid (µg)	16	200	8%
Vitamin C (mg)	1	100	1%

**Table 7-10: Nutritional Percentage of Loaches [per 100g]
(Kagaku Gijutsu Shigen Chosakai 2003).**

*¹ Values for a female of 18-29 years old

Similar to yellowtails, loaches could provide over 100 per cent on some of the nutrients by consuming 100 grams, and are an excellent source of many of the essential nutrients that aide in survival and reproduction.

7. 3. 2. 6 Energy Investments vs. Returns

The above sections examined the economics of the loaches in terms of fishing and consumption. The trip between the fishing location and the site is estimated to cost 32 kilocalories. For the use of basket traps, a forager has to make two trips altogether, totaling 64 kilocalories for the entire expedition. Based on the total average weight of loaches per fishing trip, the nutritional return can be roughly converted to 983 kilocalories (Kagaku Gijutsu-cho 1990). Thus, the energy return is significantly higher than the travel cost between the site and the fishing area. Moreover, unlike migratory fish, loaches stay within the same area, thus further increasing the reliability as a food source.

7. 4. Conclusion

In this chapter, diet breadth model, one of the principle models of the optimal foraging theory, was used to examine the fish found at Sannai Maruyama. Yellowtail and loaches were selected because of their ubiquity among the faunal remains from the Lower Ento–a layers of the Northern Valley area. I examined these two taxa to see if fishing them was optimal or not. The results of my examinations showed that fishing for loaches was optimal, while yellowtail was not.

Chapter 8

Discussion and Conclusion

The preceding chapter presented a series of analyses based on the general principles of the diet breadth model. Five categories of activities (travel, fishing, processing, preservation, and consumption) were examined to answer the following questions:

- (1) When their surrounding environment provided abundant potential prey, was the reason for exploiting these specific taxa that of optimization?
- (2) Why did the residents of Sannai Maruyama during the Lower Ento-a phase choose to go after particular fish taxa?

If, in fact, the residents of Sannai Maruyama during the Lower Ento-a phase selected their foods to optimize their efforts, then the results of the analyses would have indicated larger overall energy returns than investments for both taxa.

For loaches, the examinations of the five categories of activities show that the energetic returns from loach fishing are far greater than the investments, and efficiency may have been the reason for the exploitation. The examination also suggested that loaches are relatively accessible and effortless to catch in large amounts from areas close to the site. On the other hand, for yellowtails, the results of the analyses indicate that the energy efficiency of fishing yellowtail was far from optimum. From traveling to processing and preservation, yellowtail fishing and consumption require more energy. Yet the residents of Sannai Maruyama had reasons to include it in their foodways.

As I discussed in the beginning of this thesis, Lower Ento-a phase was the earliest occupational phase of the Sannai Maruyama site. Therefore, it can be argued that the foodway of this phase laid the foundation for the later phases. The number of dwellings grew from only a handful during the Lower Ento-a phase to over fifty during its peak at the Upper Ento-e phase during the middle of the Middle Jomon period (Habu 2008). Thus, while yellowtail fishing alone was not optimum in terms of the efficiency of energy investment vs. return, the overall food choice was not detrimental to the point of causing a population decline. In other words, when looking at the long-term change of the settlement, the foodways of the site, including the decisions made on what taxa to pursue, were more than sufficient to support the population.

In this chapter, I will first discuss the significance of loach and yellowtail fishing as part of the Sannai Maruyama foodways. Then, I will propose alternative explanations for the prevalence of yellowtail fishing.

8. 1. Loaches and Yellowtail in Sannai Maruyama Foodways

The results of my examinations in the previous chapter indicate that loaches were indeed optimal choices for the residents of Sannai Maruyama. This result was somewhat

unexpected, as the optimal foraging theory commonly assumes that the exploitation of large animals are generally more energy efficient than that of smaller animals and plants (e.g. O'Connell and Hawks 1981). On the other hand, the results of my analyses showed that including yellowtail in the diet was not economical in terms of energy investment. Unlike fish and other food found in the immediate surroundings of the site, capturing and consuming fish from the bay and beyond require a significantly larger investment of energy. Yet, the residents of Sannai Maruyama had reasons to spend the extra energy and take the risks associated with yellowtail fishing. Although my analysis does not elucidate the specific reasons for their fish selection behavior, the results suggest that the net energy gain may not have been the primary reason (see 8.2). In this case, it is possible that the residents of Sannai Maruyama saw yellowtail to have non-economic value.

8. 1. 1. Loaches and Reconstruction of Jomon Foodways

The above result regarding loaches certainly challenges conventional narratives of Jomon foodways and the characterization of the Jomon people as maritime-adapted hunter-gatherers. In the discussion of animals as Jomon food, large animals, such as sika deer, wild boar, snappers and tunas, are commonly credited as the main sources of animal protein (e.g., Kobayashi 1977). Often times, the Jomon people are depicted as maritime people whose lives were closely tied to the sea (Akazawa 1981; Barnes 1993). However, the results of my analysis indicate that the residents of Sannai Maruyama could have acquired a significant amount of animal-derived food without venturing out to the bay and beyond. Despite their close proximity to the sea, the site residents did not have to rely on marine resources if they so wished. Moreover, the importance of small freshwater fish such as loaches in Jomon foodways may have been underplayed for some time. This conventional interpretation of Jomon hunters and fishers assumes that these people invested a significant amount of effort in hunting large prey since they seemingly provided large returns. This interpretation may partially be because of the projection the contemporary Japanese diet that does not regard small mammals and fish as major sources of food. The results of my analyses indicate that small freshwater fish such as loaches might in fact have been an important source of nutrition with only a small amount of labor investment.

8. 1. 2. Fishing and Division of Labor at Sannai Maruyama

Based on the physiological design of the reproductive organs, scholars such as Bird (1999) and Hawks (1990) believe that women are better off staying near their residences and tending their offspring. Since women have a shorter period of reproductive availability than men, it is more advantageous to focus on taking care of offspring than taking risks by venturing out in search of prey away from the settlement. In ethnographic examples of hunter-gatherers, women and children tend to stay near their settlements and collect berries and seeds (Murdock 1968; Woodburn 1968). If this was the case in Sannai Maruyama, then it could have been the role of women and their offspring to catch loaches along with other food also available in the immediate surroundings.

This interpretation fits the common narratives of the division of labor used in the reconstruction of Jomon subsistence (Okamoto 1975). These narratives often depict women and children collecting acorns and berries to supplement the diet while men are out hunting large animals. What my analyses indicate, however, is the possibility that the subsistence activity of women and children could have provided the majority of the nutrients to support the entire population. The data that I have collected do not allow discussion of the social status of women at the site or argument that women were more or at least equal to their male counterparts. The data show, however, that they were not at the mercy of others in terms of their food. Thus, the prominence of loaches in their overall diet may be closely related to the significance of women and children in Sannai Maruyama subsistence, as they were able to provide constant sources of food.

At the same time, this division of labor would allow men or any other willing individuals to pursue yellowtails and other fish that require more energy investments without damaging the fitness of the entire population. As long as there were a few individuals dedicated to the tasks of acquiring sustenance, foraging activities such as yellowtail fishing can still be supported.

8. 1. 3. Fishing and Seasonality

Having loaches as part of the foodways as opposed to other fish may also have affected the timing and length of the site occupation. Based on the ethnographical examples of hunter-gatherers, Habu (2004) argued that the Sannai Maruyama site may have been a seasonal settlement during the Lower Ento-a phase. The analyses of faunal and floral remains from the water-logged areas of the site seem to support her suggestion. On the other hand, Okada (2003) views the site as a permanent settlement where the residents lived throughout the year for the entire duration of the site occupation history.

Loaches, as I discussed in the previous chapter, can be kept alive in a container with water for quite a long time. Unlike other types of fish, loaches have breathing mechanisms that allow them to thrive without elaborate fish tanks for an extended period of time. In Shiga Prefecture, in preparation for a loach ritual season, the residents keep loaches in a pot with raw soy beans (Yasumuro 2008). The relative ease of live storage allows the residents of the site to stay at the same place through a period of relative food scarcity, such as winter, when the snow may prevent fishing or other foraging activities in the streams or the bay. Therefore, loaches may have contributed to the length and timing of the site occupation by providing food during the seasons when other food was scarce.

Moreover, seasons of fishing need to be considered also in relation to the harvest of other important food sources. The most prominent food remains from the Early Jomon period other than fish remains are the nut remains, such as walnuts, buckeyes, and acorns, and they are all harvested in the fall to early winter. As I discussed in the last chapter, the fishing season of yellowtail outside of the Mutsu Bay is late summer to early fall. Therefore, fishing of yellowtail does not interfere with the season of nut harvesting, a major food gathering activity.

The change in the stone tool assemblage at Sannai Maruyama shows a significant increase in the quantity of grinding and pounding tools, which are believed to have been used for nut processing (Habu 2004). By the Middle Jomon period, the floral remains and stone tool assemblage characteristics point to the importance of nut-based subsistence. If

fishing of yellowtail and other important taxa conflict with nut collecting and processing, then it would have been difficult to support such a subsistence practice.

8. 1. 4. The Role of Fish to the Sannai Maruyama Residents and Their Neighbors

The importance of freshwater resources, such as loaches, could have influenced the relationship between the residents of Sannai Maruyama and its neighbors. As seen in chapter 3, the Sannai Maruyama site was surrounded by several other Early Jomon sites. In contemporary Omori Ward in Shiga Prefecture, communities' ties to the loaches and other freshwater fish affect their power dynamics between the communities in terms of access to the streams and their resources. The community that leads the ritual asserts its importance by managing the freshwater resources and the use of the streams through rituals. Yasumuro (2008) argues that one of the functions of these rituals is social maintenance mechanism between the communities, and loach fishing can also be viewed as a way of recognizing the bond between the communities that share the streams, their common valuable interests. Similarly, the residents of Sannai Maruyama may have had close interactions with their neighbors while sharing the freshwater resources.

However, it is also possible that the residents of the neighboring sites did not catch and/or eat loaches to the same extent. As discussed in Chapter 2, simply because an edible item is abundant in the environment, it does not automatically become food. Due to the relative ease of access, it is expected that they would also exploit loaches. Foodways, however, often result from a complex historical cultural process, involving various symbolisms and worldviews. Until examinations of faunal remains at the neighboring sites are conducted, the role of loaches to residents at those sites, and the nature of the interaction between them and the Sannai Maruyama residents regarding the freshwater resources, will remain unclear.

8. 1. 5. Fishing and Consumption of Small Fish at Sannai Maruyama and Beyond

Because very few faunal analyses at Jomon sites have adopted the water-screening method (Habu 2004), our current understanding of the importance of small fish in overall Jomon foodways is still limited. Systematic analyses of faunal and other organic remains with the use of fine mesh screens at other Jomon sites is indispensable to shed light on the relative importance of small freshwater fish and their role in other Jomon sites (Komiya 1980, 1998; Matsui 1992, 1996; Nishimoto 1998; Toizumi 1998).

The analyses in previous chapters demonstrated that although loaches and other freshwater fish were readily available, the residents of Sannai Maruyama invested their energy into traveling to the Mutsu Bay and beyond and to catch fish such as yellowtail and others. In order to understand the social and cultural significance of this practice, additional examinations of archaeological data from Sannai Maruyama and the neighboring sites are necessary. In the following section, I will discuss possible alternative explanations that can be explored in the future.

8. 2 Alternative Explanations for Yellowtail Fishing

The results of my analyses in previous chapters showed that yellowtail is not the fish that energy-efficient foragers should pursue. The investments of time and energy that were

required in preparation of fishing tools for traveling, fishing, and consumption, are significant. It is possible that the assumption that diet breadth model is based on and/or my application of the model are at fault, or the data I selected and used are not completely appropriate to examine the economics of yellowtail fishing.

Alternatively, it is possible that the energy investment to fish yellowtail was significantly lower than my estimate. For example, if yellowtail fishing was conducted only as a side practice of routine journeys across the sea, especially across the Tsugaru Strait between the Sannai Maruyama site and Hokkaido, then the energy cost to fish yellowtail would have been much lower than my estimate. As pointed out by many scholars, Hokkaido is not too far away from the Sannai Maruyama site, and the ocean does not seem to have been a serious barrier for the movement of prehistoric people. Evidence of trade with Hokkaido, including results of provenience studies of obsidian, is reported from Sannai Maruyama. The shortest route from Sannai Maruyama to Hokkaido is through the Tsugaru Strait, where several contemporary yellowtail fishing spots are located. On the other hand, given that the weight of yellowtail can be anywhere from two to seven kilograms, this scenario is rather unlikely. Without a large watercraft, it would have been extremely difficult to catch and carry multiple large fish. If their watercraft was already carrying trade items, additional weight from fish would easily have overloaded the watercraft.

Moreover, my analyses showed that the site residents made the decision to venture out to the bay and beyond when they had other food sources readily available in their immediate surroundings. In the above section, I discussed how fishing of such uneconomical fish can still be part of the foodways at Sannai Maruyama by implementing a division of labor. Then, the question to be discussed here is “why did the residents of Sannai Maruyama during the Lower Ento-a phase choose to go after yellowtail?” As an answer, I suggest that yellowtail offered other, perhaps less tangible values to the residents of Sannai Maruyama. In this section, I will discuss the possible alternative reason of exploiting economically costly food, in this case yellowtail, by drawing from ethnographical examples.

8. 2. 1. Symbolic Significance of Fish

As I discussed in Chapter 2, an edible item does not automatically gain social significance, and food consumption at Sannai Maruyama was no exception. Among all the edible substances in the environment, the residents of Sannai Maruyama had their own distinct idea of what food was, following its own rules developed over the course of its history. An edible item, in this case yellowtail, was incorporated into their diet, and somewhere during the process, it must have gained symbolic significance.

As seen in the study of the religious codes regarding food selection decision among the ancient Israelites by Mary Douglas (1984) and Jean Solar (1997), symbolism of food is closely tied to how and why a culture selects its food (see also Bourdieu 1984, Counihan and Kaplan 1998, Meigs 1983). This may have been the case with yellowtail at Sannai Maruyama.

Among Hokkaido Ainu, hunting of bears was practiced even though its economic value was not necessarily more significant than other food (Watanabe 1983). This practice was supported by dividing families into hunting people and fishing people (Watanabe 1983). The year-round food acquisition roles are inherited patrilineally. The family that has the right to hunt bears also oversees the ritual of the bear, the highest-ranking deity among the Hokkaido Ainu. In this case, hunting success, though not guaranteed, resulted in great social prestige. Moreover, the family that bore the right to hunt bears also possessed knowledge regarding the environment and the method of exploiting it through technology and ritual that are not shared with other families (Watanabe 1983).

At Sannai Maruyama, people may also have hunted/fished certain animals, such as yellowtail, for its symbolic significance instead of economic significance. Moreover, such practice could also be supported by implementing interfamilial division of labor, in which a family or families could pursue non-economical animals while other families support them by pursuing more economically profitable food items. The family or families that possessed the right to fish yellowtail may have had similar prestige for their knowledge and skills.

If a similar practice took place in Sannai Maruyama, then, it may be possible to examine it archaeologically. If different prey were assigned to different families, then the difference may be reflected as the difference in the tool assemblages. As I presented in Chapter 7, the tools required to fish loaches are significantly different from tools required in yellowtail fishing. For loach fishing, the minimum tools could be as simple as a digging stick and/or a basket. On the other hand, for fishing yellowtail, along with the fishing rod, fishhook, line and weight, a watercraft and a navigation tool such as an oar are all necessary. This distinction is seen in these tools themselves, as well as in the tools to produce them.

Conclusion:

This thesis attempted to explore the role of fish through the examination of fishing and consumption of fish at Sannai Maruyama during the Lower Ento-a phase. More specifically, the thesis focused on the question of why certain fish were selected when the environment provided a great variety of animals and fish. The existing examinations of the faunal remains from Sannai Maruyama (Nishimoto 1995, 1998, 2006; Toizumi 1998, 2006) have already succeeded in developing a list of fish taxa exploited by the Sannai Maruyama residents. Using these results as well as those of my own analysis, I examined how much and what kinds of investments were required in traveling, fishing, processing, storing, and consumption of two taxa, loaches and yellowtails. The data were analyzed using one of the optimal foraging models, the diet breadth model, in conjunction with ethnographic data on fish and fishing. The results of my analyses suggest that the residents of Sannai Maruyama selected certain fish for its efficiency while others were caught for different reasons. These results were discussed within the broader framework of foodways.

In Japanese archaeology, food of the Jomon Period has been a focus of discussion when reconstructing the lifeways of prehistoric people of the Japanese archipelago. The wealth of data, including faunal and floral materials, has been accumulated from numerous rescue excavations of Jomon sites that took place between the 1970s and late 1990s. These archaeological data allowed the development of detailed culture historical studies of the Jomon Period that span over 10,000 years. Within the tradition of Japanese archaeology, however, virtually no scholar has adopted the study of foodways as a theoretical framework. This thesis is one of the few attempts to examine characteristics of Jomon societies from this perspective.

The results of my examinations illuminated the role of one of the small fish taxa, loaches, in the foodways of the Sannai Maruyama residents. As I discussed earlier, loaches have several advantages over other fish:

1. Unlike larger fish, such as yellowtail, the small size of the loach carcass allows easy consumption of the whole fish, making nutrients from the internal organs and bones more accessible.

2. They are easily caught with minimal equipment. Thus, long hours of preparation of tools are not needed.
3. Since their habitats are the streams near the site, long trips to the bay that may or may not result in any catch are unnecessary, and
4. The most important advantage of loaches is the ease of live storage that simply cannot be done with other fish. At Sannai Maruyama, the function of many of the large vessels found throughout the occupation history is unclear. These pots do not have burn marks that would indicate the use of fire (Okada 1995). Their shape and size make them ideal containers for loaches, allowing the site residents to keep loaches for those times when other foods became scarce.

All the above reasons make loaches an ideal food item. Despite the abundant presence of this accessible and convenient food near the site, the residents of Sannai Maruyama sought larger, more challenging fish in the bay and beyond. In order to catch these large fish, site residents had to invest extra energy in preparing the equipment, traveling, fishing, transporting, and processing. I suggest that the Sannai Maruyama residents sought yellowtails because their symbolic value exceeded their economic value. As seen in ethnographic examples, cultures can adopt subsistence activities that seem to contradict the primary purpose of providing food. In the case of Sannai Maruyama, some of the individuals may have either volunteered or been assigned to loach fishing to provide a constant source of food, while others traveled away from the site in search of yellowtail. Whether this was a sexual division of labor based on physiological differences of the two sexes as discussed by Bird (1999) or interfamilial differentiation of labor as discussed by Watanabe (1983) is not clear from the available data.

The fishing practice of combining uneconomical and economic taxa from the streams and the ocean may also have resulted in other kinds of benefits, such as overall group fitness as reflected in the site size and population increase (Okada 1995a, 1995b, 1997, 1998, 2003). Residents of Sannai Maruyama during the earliest phase of the site occupation were enjoying great food variety by incorporating foods from different habitats. This may have been the key to the population expansion that took place during the later phase of the site occupation. Additional analyses of faunal and floral data from Sannai Maruyama and other Jomon sites are necessary to further examine this possibility.

Throughout this thesis, I have attempted to examine one element of the cultural complexity of the Sannai Maruyama residents during the Lower Ento-a phase through food. As I discussed earlier, I believe that the examinations of food could reveal many aspects of a culture. This dissertation studied only one aspect of how people made decisions regarding their food; many other approaches can be taken to learn more about their food choices.

The rich data from Sannai Maruyama and other Jomon sites allow a much wider array of questions to be asked by incorporating the perspective of the study of foodways. It is my hope that such attempts will increase our overall understanding of the way people lived at Sannai Maruyama on the Japanese archipelago. This in turn will broaden our understanding of middle Holocene hunter-gatherers.

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Appendix

Excavation Area *1	Year	Excavation Area and Purpose	Research Unit
I	1992	Baseball Stadium Area main investigation	Aomori Prefecture Buried Cultural Property Research Center
II		6th Transmission Tower Area main investigation	Aomori Prefecture Buried Cultural Property Research Center
III		7th Transmission Tower Area Main Investigation	Aomori Prefecture Buried Cultural Property Research Center
IV		8th Transmission Tower Area Main Investigation	Aomori Prefecture Buried Cultural Property Research Center
V	1993	Baseball Stadium Area Main Investigation	Aomori Prefecture Buried Cultural Property Research Center
VI		6th Transmission Tower Area Main Investigation	Aomori Prefecture Buried Cultural Property Research Center
VII	1994	Baseball Stadium Area Main Investigation	Aomori Prefecture Buried Cultural Property Research Center
VIII		Baseball Stadium: Planned Road Construction Area Test Excavation	Board of Educatino of Aomori City
IX		Planned Soccer Field Test Excavation	Aomori Prefecture Buried Cultural Property Research Center
X		Planned Tennis Court Test Excavation	Aomori Prefecture Buried Cultural Property Research Center
XI		Chikano Area Test Excavation	Aomori Prefecture Buried Cultural Property Research Center
[1]	1995	Excavation in Northern District to Determine Spatial Extent of the Settlement Property	Preservation Office of the Sannai Maruyama Site
[2]		Excavation in Northern District to Determine Spatial Distribution of the Storage Pits	Preservation Office of the Sannai Maruyama Site
[3]		Excavation in Northern District to Determine Spatial Distribution of the Storage Pits	Preservation Office of the Sannai Maruyama Site
[4]		Excavation in Northern District to Determine Spatial Extent of the Burial Pits	Preservation Office of the Sannai Maruyama Site
[5]	1996	Excavation in Southern District to Determine Spatial Extent of the Settlnenet	Preservation Office of the Sannai Maruyama Site
[6]		Excavation in Northern District to Investigate the Water- logged area	Preservation Office of the Sannai Maruyama Site
[7]		Excavation in Northern District to Determine Spatial Extent of the Burial Pits	Preservation Office of the Sannai Maruyama Site

[8]		Excavation in Northern District to Determine Spatial Extent of the Burial Pits and Road Area	Preservation Office of the Sannai Maruyama Site
[9]		Excavation in Northern District to Investigate Features Near Large Wooden Posts	Preservation Office of the Sannai Maruyama Site
[10]		Excavation in Southern District to Identify the Site Area and Changes Through Time	Preservation Office of the Sannai Maruyama Site
[11]	1998	Excavation in Southern District to Identify the Site Area and Changes through Time	Preservation Office of the Sannai Maruyama Site
[12]		Excavation in Northern Valley Area to Examine Water-logged Organic Materials and Features	Preservation Office of the Sannai Maruyama Site
[13]		Excavation in Northern District to Determine Spatial Distribution of Burial Features	Preservation Office of the Sannai Maruyama Site
[14]	1999	Excavation in Northern District to Determine the Spatial Distribution of Burials with Stone Circles	Preservation Office of the Sannai Maruyama Site
[15]		Excavation in Northern District to Determine the Distribution Area of Cultural Layers	Preservation Office of the Sannai Maruyama Site
[16]		Excavation in Northern District to Determine the Dates of Dwellings	Preservation Office of the Sannai Maruyama Site
[17]	2000	Excavation in Northern District to Determine Spatial Distribution of Burials	Preservation Office of the Sannai Maruyama Site
[18]		Excavation in Northern District to Identify the Site Area and Changes through Time	Preservation Office of the Sannai Maruyama Site
[19]		Excavation in Northern District for Detailed Investigation of the Features with Large Posts and Other Features	Preservation Office of the Sannai Maruyama Site
[20]	2001	Excavation in Northern District to Determine Spatial Distribution of Burials with Stone Circles and Dates of Road Features	Preservation Office of the Sannai Maruyama Site
[21]		Excavation in Northern District to Determine Spatial Distribution of Burials	Preservation Office of the Sannai Maruyama Site
[22]		Excavation in Northern District to Determine Spatial Distribution of Dwellings and Clay Mining Pits	Preservation Office of the Sannai Maruyama Site
[23]	2002	Excavation in Southern District to Determine Spatial Distribution of Burials and Road Features	Preservation Office of the Sannai Maruyama Site
[24]		Excavation in Northern District to Determine Spatial Distribution of Burials	Preservation Office of the Sannai Maruyama Site
[25]		Excavation in Northern District for Detailed Examination of Features	Preservation Office of the Sannai Maruyama Site

		with Large Posts	
[26]	2003	Excavation in Southern District to Determine Spatial Distribution of Burials and Road Features	Preservation Office of the Sannai Maruyama Site
[27]	2004	Excavation in Northern District for Detailed Examination of the Features with Large Posts	Preservation Office of the Sannai Maruyama Site
[28]		Excavation in Northern District to Determine Spatial Distribution of Burial Pits	Preservation Office of the Sannai Maruyama Site
[29]	2005	Excavation in Northern District for Detailed Examination of the Features with Large Posts and Burned House	Preservation Office of the Sannai Maruyama Site
[30]	2006	Excavation in Northern District for Detailed Examination of the Features and Large Post	Preservation Office of the Sannai Maruyama Site
[31]	2007	Excavation in Northern District for Detailed Examination of the Burials with Stone Circles.	Preservation Office of the Sannai Maruyama Site

1* Corresponds to Figure 3-2 (Site Excavation Map)

Table A-1: Summary of Archaeological Excavations Conducted by Research Unit of Aomori City and Aomori Prefecture (Translated and Partially Modified from Aomori-ken Kyoiku Iinkai 2007: 1-2)