Quaternary International 239 (2011) 19–27

Contents lists available at ScienceDirect

Quaternary International

journal homepage: www.elsevier.com/locate/quaint

Shell midden archaeology in Japan: Aquatic food acquisition and long-term change in the Jomon culture

Junko Habu [a,*], Akira Matsui [b], Naoto Yamamoto [c], Tomonori Kanno [d]

[a] University of California, Department of Anthropology, 232 Kroeber Hall, Berkeley, CA 94720-3710, United States
[b] Center for Archaeological Operations, Independent Administrative Institution, National Institutes for Cultural Heritage, Nara National Cultural Properties Research Institute, Japan
[c] Department of Archaeology, Graduate School of Letters, Nagoya University, Japan
[d] Center for Archaeological Operation, Tohoku University, Japan

ARTICLE INFO

Article history:
Available online 26 March 2011

ABSTRACT

This paper reviews recent progress of Japanese shell midden archaeology and discusses how the information from shell middens can help answer some of the key questions in anthropological archaeology today. Over the past several decades, shell midden archaeology in Japan has made significant advances both in terms of theory and method. Active interaction with Japanese and Anglo-American archaeology has resulted in the development of new theoretical approaches, including environmental archaeology, zooarchaeology, and hunter-gatherer archaeology. Methodologically, the adoption of the flotation and water-screening methods has enabled archaeologists to collect quantitative data of faunal assemblages, and sometimes of floral assemblages as well. The dense distribution of shell middens in northeastern Japan and its changes through time are closely related to the regional and temporal variability of the prehistoric Jomon culture (ca. 14,000–500 BC). In this article, shell middens from four regions of Japan are examined: 1) Tohoku, 2) Kanto, 3) Chubu, and 4) Western Japan. The final section of this paper discusses the implications of regional and temporal variability observed among these shell middens.

1. Introduction

Studies of shell middens in Japan have assumed vital roles in the early development of Japanese archaeology, particularly the archaeology of the prehistoric Jomon period (ca. 14,000–500 BC). The first "scientific" excavation of an archaeological site in Japan (see Imamura, 1996, 39–42) was conducted at the Omori shell midden by an American zoologist, Edward Morse, in 1877 (Morse, 1879). Because shell middens were easily identified through surface surveys, archaeologists of the late 19th and early 20th centuries focused their primary research efforts on shell midden sites. During the 1920s and 1930s, many of these shell middens became type sites for establishing Jomon chronological framework on the basis of pottery typology. Skeletal remains from shell middens provided early physical anthropologists with invaluable information to investigate the population history and lifeways of prehistoric people on the Japanese islands (e.g., Kiyono, 1949). Early studies of shell midden distribution made archaeologists realize that the coast lines during the Jomon period were further inland (e.g., Esaka, 1965).

Over the past several decades, shell midden archaeology in Japan has made significant advances in terms of both theory and method. Active interaction with Japanese and Anglo-American archaeology has resulted in the development of new theoretical approaches, including environmental archaeology, zooarchaeology, and hunter-gatherer archaeology (e.g., Akazawa, 1980; Matsui, 1992, 1995, 1996). Methodologically, the adoption of the flotation and water-screening methods has enabled archaeologists to collect quantitative data of faunal assemblages, including shellfish, fish and mammals, as well as environmental indicators, such as land snails (e.g., Isarago Kaizuka Iseki Chosadan, 1981). Early development and systematic applications of daily growth line analysis of clam shells have allowed Japanese scholars to infer the seasonality of shellfish collecting and site occupation (e.g., Koike, 1980). Isotopic analyses of human skeletal remains excavated from shell midden sites have provided invaluable information about prehistoric diet (e.g., Yoneda, 2010).

Given this background, it is clear that Japanese shell midden studies can contribute significantly to understanding key questions in various subfields of environmental anthropology, including historical ecology, cultural ecology, evolutionary ecology and paleontology. These questions include the origins and antiquity of aquatic or marine food exploitation and its consequences, the mechanisms of long-term change in human-environment

* Corresponding author. Fax: +1 510 643 8557.
E-mail address: habu@berkeley.edu (J. Habu).

1040-6182/$ – see front matter © 2011 Elsevier Ltd and INQUA. All rights reserved.
doi:10.1016/j.quaint.2011.03.014

interaction, and human impacts on the local and regional environment. The following sections provide an overview of Japanese shell midden archaeology and discuss how the information from shell middens can help answer these questions. Methodological developments in recent shell midden studies in Japan are also reviewed.

2. Regional variability of shell middens

Overviews of Jomon shell midden archaeology in English can be found in Barnes (1993), Habu (2004, 72–77), Imamura (1996, 67–77), and Kobayashi (2004). Because of their visibility on the ground, many of the large shell middens in Japan have been known for decades. By 1959 (Sakatsume, 1959: ii–iii), 2337 shell middens from the Jomon (ca. 14,000–500 BC), Yayoi (ca. 500 BC–AD250), Kofun (ca. AD250–710) and Nara/Heian (AD710–1192) periods were known. The far left column of Table 1 shows the breakdown of this number for each region (For the location of each region, see Fig. 1). These data indicate that shell middens are distributed more densely in northeastern Japan, especially in the Kanto region (near Tokyo), than in southwestern Japan. The middle column of the table, also taken from Sakatsume (1959), shows the number of shell middens from the Jomon period only. As shown in this column, the data display an even heavier concentration in the Kanto region. More recently, Oikawa (1995) and his colleagues produced a Shell Mound Database, which lists archaeological sites associated with organic remains (Sokendai, 2010). As of 1995, over 4000 sites were listed (Oikawa, 1995), the majority of which are shell middens. Oikawa's (1995) data are presented in the far right column of Table 1. While the total number is significantly larger than that in Sakatsume (1959), the relative frequency for each region shows similar patterns.

The denser distribution of shell middens in northeastern Japan, especially in the Kanto region and, to a certain extent, the Tohoku region, corresponds with a higher density of Jomon sites in northeastern Japan (see Habu, 2004, 2008; Koyama, 1978). What are the implications of this regional variability? How was this related to the changes through time in the number of shell middens in each region? In the following sections, shell middens from four regions of Japan are examined: 1) Tohoku, 2) Kanto, 3) Chubu (including Tokai, Chubu Mountain and Hokuriku in Fig. 1), and 4) Western Japan (Kinki, Shikoku, Chugoku and Kyushu in Fig. 1).

3. Tohoku

Tohoku refers to the northern region of Honshu (the largest island of Japan, see Fig. 1). Most of the shell middens in this region are located on the Pacific side, especially along the coast of Iwate and Miyagi Prefectures (Fig. 2). A dense concentration of Jomon shell middens in the Matsushima Bay area (Miyagi Prefecture) is especially well-known. On the Japan Sea side, the contribution of shellfish to the Jomon diet must have been limited, as only a small number of shell middens are present. This distribution pattern is different from that of Jomon settlement sites (sites associated with one or more pit-dwellings), which are abundant on both the Pacific and Japan Sea sides.

Table 1
Numbers of shell middens in each region by Sakatsume (1959) and Oikawa (1995).

Region	Sakatsume, 1959		Oikawa, 1995
	All periods	Jomon only	All periods
Hokkaido	127 (5.4%)	11 (1.0%)	224 (5.6%)
Tohoku	280 (12.0%)	190 (17.1%)	611 (15.2%)
Kanto	1038 (44.4%)	664 (60.0%)	1592 (39.5%)
Chubu	210 (8.9%)	89 (8.0%)	459 (11.4%)
Kinki	48 (2.1%)	14 (1.3%)	119 (3.0%)
Chugoku	305 (13.1%)	62 (5.6%)	432 (10.8%)
Shikoku	46 (2.0%)	17 (1.5%)	71 (1.8%)
Kyushu	210 (9.0%)	61 (5.5%)	313 (7.8%)
Okinawa	73 (3.1%)	–	195 (4.9%)
Total	2237 (100.0%)	1108 (100.0%)	4016 (100.0%)

Studies of shell middens have played key roles in the development of Jomon archaeology in Tohoku. During the early 20th century, excavation of the Satohama shell midden (Early–Final Jomon) (Miyagi Prefecture) provided archaeologists with solid data to establish a pottery chronology on the basis of stratigraphic information (Matsumoto, 1919). By the 1970s, a group of archaeologists at Tohoku University began to combine the idea of stratigraphic excavation with the water-screening method. Their goals were threefold: 1) to understand the process of shell midden formation, 2) to estimate the time-span in which each layer was accumulated, and 3) to infer seasonality of hunting and fishing activities. Their focus on the site formation process paralleled the works of Schiffer (1976, 1987) and others in North America who advocated “behavioral” archaeology. In terms of methodology, these Japanese archaeologists adopted a standardized method, in which they sub-divided cultural layers as much as possible, obtained soil samples from individual layers, and screened the soil samples with fine mesh (typically down to 1 mm mesh) to retrieve quantitative data of faunal remains and artifacts.

The excavation of the Nakasawame shell midden, a freshwater shell midden in Miyagi Prefecture (Late–Final Jomon), is a good example of an application of this excavation method (Matsui et al., 1984; Suto, 1984, 1995). The results indicate that subsistence activities focused on freshwater resources, including freshwater mussel (*Unio douglasiae nipponensis* von Martens), Japanese mystery snail (*Cipangopaludina japonica* von Martens), carp (Cyprinidae), and catfish (*Pseudobagrus tokiensis* Döderlein). The site residents also visited the coastal zone to exploit marine food resources, such as asari clam or Japanese littleneck (*Ruditapes philippinarum* Adams & Reeve) and sardine (*Sardinops melanostictus* Schlegel). Based on these results, the excavators concluded that the subsistence focus of the residents of inland sites, such as Nakasawame, included a wide range of resources.

Similar methods were applied to a series of excavations of such shell midden sites as Satohama (Fujinuma and Okamura, 1982), Tagara (Fujinuma, 1986), and Ohora (Kinno, 2001), as well as some non-shell midden sites (Shindo, 1990; Suto, 1997).At the Satohama shell midden, remains of 83 taxa of shellfish, 40 taxa of fish, 19 taxa of birds, and 10 taxa of mammals were retrieved from Final Jomon layers. Asari clams constituted 63.1% of shellfish remains, and 36.1% of fish remains were sardines. Based on seasonality analysis of asari clam (Koike, 1987) and faunal studies, Okamura and Kasahara (1987) presented a “subsistence calendar” of Satohama residents. According to the calendar, fishing and shellfish collecting on the inner bay beach were most common during the spring and early summer even though these activities occurred on a smaller scale in other seasons.

As indicated above, Oikawa (1995)'s Shell Mound Database listed 611 sites from the Jomon to Heian periods in Tohoku. Review of prefectural site maps, site databases and other syntheses allowed collection of detailed information of 408 Jomon shell middens. Fig. 3 shows the numbers of shell middens, settlement sites (sites associated with one or more pit-dwellings) and pit-dwellings from the Initial to Final Jomon periods in Tohoku. As some of the shell midden sites are associated with shell layers from multiple Jomon sub-periods, the total number of shell middens in Fig. 3 (604) is larger than 408. Fig. 3 shows several important characteristics. First, no shell middens are known from the Incipient Jomon. Second, the number of shell midden sites from each sub-period increased significantly from the Initial (54) to the Early (130) Jomon. The

Fig. 1. Prefectures and regions of Japan.

number remained fairly steady for the Middle (129) and Late (137) Jomon periods, with a slight increase for the Final (154) Jomon. This pattern shows a marked contrast with the changes in the number of settlement sites and the total number of pit-dwellings through time. Both the number of settlement sites and the number of pit-dwellings peaked during the Middle Jomon period (Fig. 3), and they decreased significantly for the Late and Final Jomon periods.

Excavations of representative shell middens from each Jomon sub-period have also revealed aspects of long-term changes in shell midden construction. Choshichiyachi (Aomori Prefecture) is a good example of an Initial Jomon shell midden site (Ichikawa, 1980). It consists of a group of small shell middens, the thickness of which measures 20–70 cm. No pit-dwelling from the same period was identified, and only a few artifacts were associated with the middens. Given these lines of evidence, Choshichiyachi was likely to have been a special purpose site with limited activities.

Early and Middle Jomon shell middens tend to be larger in size and associated with large amounts of artifacts. For example, at the Takonoura shell midden (Early–Middle Jomon; Iwate Prefecture), the shell-layers measure as thick as 1.6 m (Kinno, 1987). Some of the Early and Middle Jomon middens also functioned as cemeteries. Many of them are located on hillsides and form a circular configuration. Typically, these large shell middens are part of large settlement sites with many pit-dwellings. The Sakiyama shell midden (Early–Middle Jomon; Iwate Prefecture) is a good example of this type (Takahashi, 1995). The size of Late and Final Jomon shell middens vary. The construction of large shell middens continued (e.g., the Final Jomon Ohora shell midden; Iwate Prefecture), but very few are associated with a large number of pit-dwellings. Many of the small shell midden sites have no pit-dwellings, probably being special purpose sites away from settlements. Some of them are associated with a large number of "evaporation pots" for salt-making (see Habu, 2004, 231–233). Thus, these sites represent not only the acquisition of aquatic food resources but also had close ties with salt-making.

In summary, the history of Jomon shell middens in Tohoku can be divided into three phases. The first phase, the Initial Jomon, was the time when aquatic food resources began to be systematically exploited. The size of shell middens from this phase is usually small, and many of them were probably special purpose sites. The second phase corresponds to the Early and Middle Jomon, during which large shell middens associated with many pit-dwellings were constructed. This implies that intensive shellfish exploitation near residential bases became an important part of subsistence activities. The number of shell midden sites increased slightly from the second to the third phase, the Late and Final Jomon. This is in contrast with the number of settlement sites, which showed a significant decrease from the Middle through to the Final Jomon. In other words, a decrease in the number of large settlements at the end of the Middle Jomon period was not caused by a decline of aquatic food

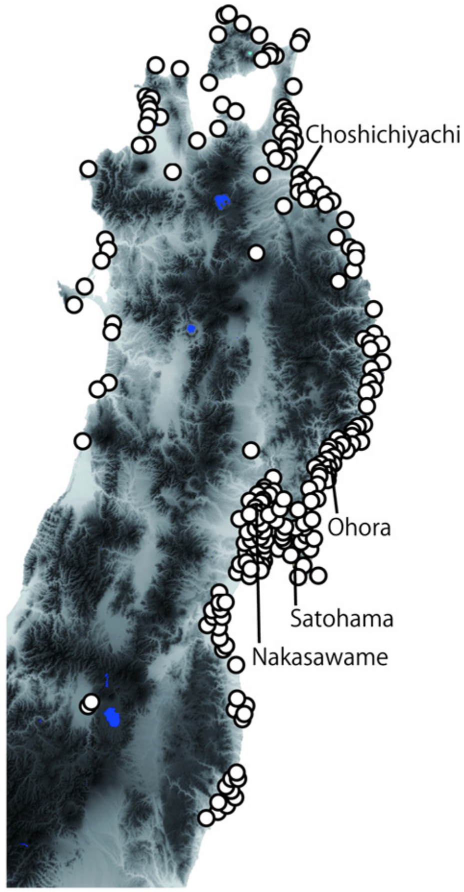

Fig. 2. Distribution of major shell midden sites in Tohoku.

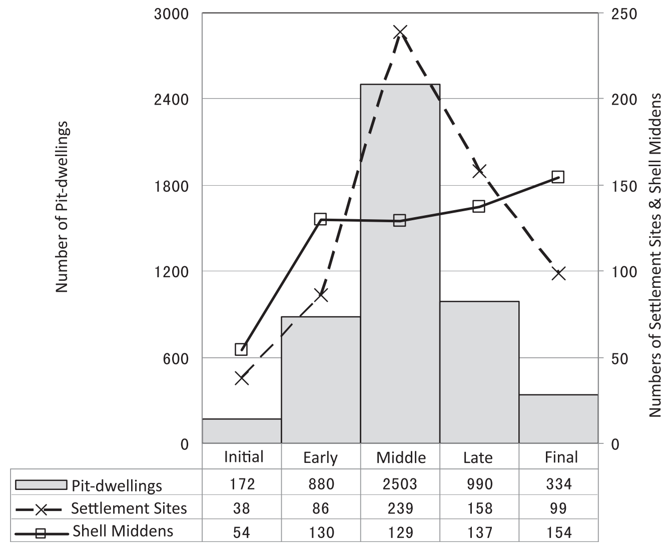

Fig. 3. Changes in the numbers of shell middens, settlement sites and pit-dwellings (compiled from Akita-ken Kyoiku Iinkai, 2001; Aomori-ken Kyoiku Iinkai, 2009; Fujinuma et al., 1989; Fukuda, 1992, 1998, 2007; Iwate-ken Kyoiku Iinkai, 2001; Kusakabe et al., 1991; Miyagi-ken Kyoiku-cho Bunkazai Hogo-ka, 2009; Sato et al., 1998).

exploitation. Most of the Late and Final Jomon middens were constructed away from residential sites and are likely to have been special purpose sites for shellfish collecting and salt-making.

4. Kanto

As indicated in Table 1, the Kanto region is known for an abundance of shell middens. The oldest shell midden in the Kanto region is Natsushima (Kanagawa Prefecture). It is associated with Initial Jomon pottery, and an oyster shell from the bottom layer of the midden is associated with a radiocarbon date of 9450 ± 400 uncal. BP (M-769) (2σ: 9293–7320 BC) (see Habu, 2004, 248–250; Imamura, 1996: 60–62). At this site, evidence of intensive shellfish collecting, as well as fishing and hunting of some sea mammals, is clear. Nevertheless, it is unlikely that marine food dominated the Initial Jomon diet, as shell middens account for only a small portion of the Initial Jomon sites in this region. Habu (2004: 249) suggests that the residents of Natsushima and other Initial Jomon shell middens may have been serial specialists (*sensu* Binford, 1980), who intensively exploited marine food only seasonally and whose staple food for the rest of the year was terrestrial.

Within the Kanto region, regional and temporal variability of shell middens have attracted the attention of many researchers. Many shell middens are clustered in the following three areas: 1) the western half of Tokyo Bay (present-day Tokyo and Kanagawa Prefecture), 2) the eastern half of Tokyo Bay (Chiba Prefecture), and 3) the shoreline of present-day Lake Kasumigaura (Ibaraki Prefecture).

On the western half of Tokyo Bay, many large settlements associated with small shell middens appeared in the second half of the Early Jomon period. Representative examples include Kitagawa, Nanbori, and Nishinoyato (Kanagawa Prefecture). Towards the end of the Early Jomon period, all of these shell middens were abandoned. This was followed by the disappearance of almost all the settlement sites in this area (Habu, 2001). Biologists such as Matsushima and Koike (1979) suggest that the retreat of the sea level after the “Climatic Optimum” might have resulted in the loss of complex coast lines, which then resulted in the decrease in the habitat of littoral mollusc species. Given the scarcity of reliable radiocarbon dates from these sites, the causal relationships between the sea level retreat, changes in the coastal habitat, and the disappearance of shell middens need to be further examined. Shell midden construction on the eastern half of Tokyo Bay and in the Lake Kasumigaura area started during the Initial Jomon and peaked during the Middle and the Late Jomon. An abundance of shell middens in the former area is particularly noticeable. Table 2 shows changes in the number of shell middens on the eastern half of Tokyo Bay. As revealed in the bottom row of this table, the number of shell middens in this area multiplied from the Early to Middle Jomon and it further increased from the Middle to Late Jomon. The latter increase is small in number but noteworthy because this increase occurred in the number of large, so-called “horseshoe” shaped shell middens (see the second row). Some of these middens measure over 100 m in diameter, and most of them are associated with many pit-dwellings. Examples include Horinouchi (over 200 m in diameter; Late Jomon), Kainohana (about 80 m in diameter; Late Jomon – Aikens and Higuchi, 1982, 156–164), Kasori North (about 130 m in diameter; Middle Jomon), and Kasori South (about 170 m in diameter; Late Jomon).

It is worth noting that site density (calculated based on the total number of all sites) and the frequency of large settlements in the

Table 2
Changes in the number of shell middens in the east Tokyo Bay Area (compiled from Chiba-ken Kyoiku Iinkai, 1983).

Shell midden type	Initial	Early	Middle	Late	Final	Total
Small shell midden	45	45	107	107	24	284
Horseshoe-shaped shell midden	0	1	38	53	0	92
Total	45	46	145	160	24	376

Kanto region peaked during the Middle Jomon period, and they decreased significantly from the Middle to the Late Jomon (e.g., Imamura, 1996; Koyama, 1978). Many scholars believe that this is a reflection of the growth and decline of subsistence-settlement systems that were based on an intensive exploitation of plant food. Despite this overall decline in site density at the end of the Middle Jomon period, large shell middens on the eastern half of Tokyo Bay continued to flourish through to the Late Jomon period. This may parallel the change from the Middle to Late Jomon in Tohoku, but a dramatic decrease in the number of shell middens from the Late to the Final Jomon is unique to Kanto.

Because of the large size of these "horseshoe-shaped" shell middens, many scholars assume that an extreme intensification of marine food exploitation occurred at these sites. However, Suzuki (1986) suggests that the seemingly large size of horseshoe-shaped shell middens is due to their longer duration than smaller middens. If this was the case, the uniqueness of these large middens is not the intensity in marine food exploitation per unit time but the long duration of shellfish collecting at the same location. Suzuki's (1986) simulation study also indicates that the maximum caloric intake from shellfish for an Isarago resident would have been only 7–9 percent of the average daily caloric intake. In conclusion, he emphasizes the importance of shellfish may have been its abundance from the late winter to early spring, when other food resources were scarce. Assuming that large shell midden sites in the eastern half of Tokyo Bay were simultaneously occupied settlements, Horikoshi (1972) suggests that the territory of each settlement was only 2–3 km in radius. This is much smaller than the average size of hunter-gatherer site territory of ca. 10 km in radius (e.g., Binford, 1980; Vita-Finzi and Higgs, 1970). If Horikoshi's assumption is valid, this overcrowding must have severely restricted the residential mobility of site occupants (cf. Rosenberg, 1998).

Lastly, but not least importantly, recent excavation of the Middle and Late Jomon Nakazato shell midden (Kita-ku Kyoiku Iinkai, 2000), a lowland shell midden in Tokyo, has made archaeologists realize the importance of understanding variability among Jomon shell middens in the Kanto region. Accumulation of oysters (*Crassostrea gigas* Thunberg) and oriental clams (*Meretrix lusoria* Roding) at this site is extremely thick (as thick as 4.5 m). Unlike large, "horseshoe" shaped middens, Nakazato is not associated with many artifacts. Instead, features with wooden frames, burnt cobbles, burnt shell fragments and charcoal were recovered. Nakajima (2000), the principal investigator of the site, suggests that these features represent steaming of shellfish. Given these characteristics, it is likely that Nakazato functioned as a special purpose site to collect and process shellfish.

5. Chubu

The Chubu region can be divided into three sub-regions: Tokai (the Pacific side of Chubu), Hokuriku (the Japan Sea side) and Chubu Mountain (see Fig. 1). The majority of shell middens in this region are located either in the Tokai or Hokuriku sub-regions. As shown in Table 1, the total number of shell middens in the Chubu region is not large. This does not mean, however, that shell midden archaeology in Chubu did not produce important results. Excavations of three shell middens are particularly noteworthy.

In the Tokai sub-region, the discovery of the Mazukari shell midden changed the archaeologists' view of early Holocene transgression (Yamashita et al., 1980; Yamashita, 2008). Boring tests prior to the construction of a train station on the Utsumi Plain of Chita Peninsula revealed the presence of a large number of potsherds and shell fragments deep under an alluvial deposit. Subsequent boring tests indicated that an Initial Jomon shell midden is located on top of a "buried hill". A radiocarbon date of 8330 ± 260 uncal. BP (Gak-7950) (2σ: 7542–6366 BC) was obtained from granular ark (*Tegillarca granosa* L). The elevation of the top of this shell midden is about 10 m below the present-day sea level (BSL). On top of this shell midden is an accumulation of marine silt and sand deposits over 12 m thick (i.e., the top of these deposits is about 2 m above present-day sea level). They must have accumulated after the shell midden was abandoned during and after the Holocene transgression period. Artifacts and ecofacts reported from this site are similar to other Jomon shell middens in Tokai. They include a large number of potsherds, 30 stone tools, a bone tool, shells, fish and mammal remains, and human skeletal remains. The discovery of the Mazukari shell midden is important in three respects. First, prior to this excavation, most archaeologists assumed that Jomon shell middens are typically located on top of hills, and thus practically no shell middens were lost due to the Holocene transgression. Data from Mazukari, on the contrary, revealed that this was not the case. Second, geologists and biologists indicate that the sea level was as low as −40 m asl at about 10,000–9000 years ago. The sea level began to rise ca. 9000 years ago, and it became roughly the same as the present-day sea level or slightly higher between 6500 and 5500 years ago. In this context, marine transgression during the Initial and Early Jomon period was a phenomenon in which the sea water flowed into the deep, coastal valleys that were formed during the Pleistocene. Under this circumstance, marine transgression could have occurred even when the sea level itself was lower than the present-day sea level (Yamashita, 2008, 7). Third, the excavation of Mazukari made archaeologists realize that the topography during the early–middle Holocene was radically different from that of today (Yamashita, 2008, 8). After the discovery of this shell midden, archaeologists began to pay more attention to buried valleys and hills, which must have been prominent during the Jomon period but are now covered by the later sediment. This in turn is affecting their excavation plans as well as the way Japanese archaeologists reconstruct Jomon landscapes.

Another good example of the lowland shell midden in Tokai is the Muro shell midden cluster (Aichi Prefecture). Located on the Atsumi Peninsula, this shell midden cluster consists of seven Late–Final Jomon shell middens, the largest of which is the Onishi shell midden. Radiocarbon dates from these middens range from 1400 to 500 BC. Unlike typical shell middens in this region, relatively few artifacts and fish/mammal bones were found from these middens. Most of the shell assemblage (77–95%) is dominated by a single species, oriental clam (*M. lusoria* Roding). The elevations of these middens are not high, only about 1–3 m above sea level (Iwase, 1998, 2003; Iwase et al., 2002). Given these lines of evidence, Iwase (2003) suggests that these middens were special purpose sites, where clams were intensively processed possibly for trade. For the moment, the residential area of people who harvested these shells is not known. Measurements of clam shells from Muro indicate that the distribution of shell size here differs from the natural distribution. Only a few of the shells measure below 3 cm in length. The most commonly harvested clams were between 4.0 and 4.5 cm in length. Iwase (2005) suggests that the Jomon people, who were well aware of the conservation of their resources, collected the clams selectively on the basis of their size. Results of daily growth line analysis indicate that, although the clams were collected throughout the year, the peak of the clam collection was from the spring to summer (Kuramoto, 1996, 1997; Toizumi, 1998).

In the Hokuriku sub-region, the excavation of the Torihama shell midden has provided new lines of evidence to infer characteristics of Jomon subsistence and wood-working (Torihama Kaizuka Kenkyu Group, 1979–1987). Located at the meeting point of two rivers in Fukui Prefecture, Torihama is a waterlogged Early Jomon shell midden site. It was also associated with Incipient and Initial Jomon remains. The site was first excavated in 1962 by a research group of Doshisha and Rikkyo Universities. After several additional small-scale excavations, a series of rescue excavations were conducted from 1975 to 1986 prior to a major river improvement program. In particular, the 1975 excavation, which covered 184 m^2, resulted in the discovery of large amounts of organic remains. They included a lacquered comb, rope, basket and fabric fragments, coprolites, and macro plant remains such as bottle gourds (*Lagenaria* sp.), egoma [*Perilla frutescens* (L) Britton var. *japonica*] or shiso mint (*P. frutescens* var. *crispa*), and chestnut (*Castanea crenata* Siebold & Zucc.). Later, the 1981 excavation revealed the presence of dugout canoes (see Habu, 2010). Based on the analysis of macro and micro floral remains, Nishida (1983) suggests that the function of the Torihama settlement changed through time from a temporary nut-gathering camp of the Initial Jomon to a sedentary village site of the Early Jomon.

6. Western Japan

As evident from Koyama's (1978) study, Jomon site density for southwestern Japan (the Kinki, Chugoku, Shikoku and Kyushu regions) is much lower than that for northeastern Japan. With the exception of part of Kyushu (Saga, Nagasaki and Kumamoto Prefectures), relatively few shell midden sites have been known from these regions. However, two recent excavations of submerged shell middens have contributed significantly to Jomon environmental archaeology: Awazu and Higashimyo.

The Awazu site (Iba et al., 1999; Iba, 2000) is located at the bottom of Lake Biwa in Shiga Prefecture, the largest freshwater lake in Japan. Previous surveys of the lake-bottom and lake shores by the Board of Education of Shiga Prefecture identified approximately 100 sites that were submerged. One was the Awazu site associated with two Middle Jomon shell middens. When a new ship route was proposed in 1990, two areas of the lake-bottom were drained with vertical steel sheet piles and pumps, and a test excavation was conducted prior to dredging a channel. This revealed the presence of Initial Jomon artifact and ecofact concentrations as well as a new Middle Jomon shell midden: Shell Midden No. 3. Radiocarbon dates from the Initial Jomon layers include 9600 $\pm$ 110 uncal. BP (NUTA-1825) (2σ: 9268–8706 BC [94.8%], 8669–8657 BC [0.6%]) and 9290 $\pm$ 140 uncal. BP (NUTA-1835) (2σ: 9121–9003 BC [4.3%]; 8918–8896 BC [0.7%], 8872–8250 BC [90.4%]) (Toshio Nakamura, personal communication). These layers included large amounts of plant-based organic remains such as nuts, including chestnuts (*C. crenata* Siebold & Zucc.), but with no shells. These layers were also associated with plant seeds, including bottle gourds (*Lagenaria siceraria* (Molina) Standl.) and beans (*Vigna* spp.).

Shell Midden No. 3 consisted of alternate layers of shells and nutshells dated to the Middle Jomon period. A total of 78% of the shells are *shijimi* or seta freshwater clam (*Corbicula sandai* Reinbardt). Daily growth line analyses indicate that 62% of these clams were collected in July and August, and 88% were collected from May through October. Nutshell remains were dominated by three taxa: acorns (genus *Quercus*), horse chestnuts (*Aesculus turbinata* Blume, 31%), and water chestnuts (*Trapa* sp. 28%). Acorn remains includes both deciduous oaks (*Quercus* subgenus *Quercus*) and evergreen oaks (*Quercus* subgenus *Cyclobalanopsis*), but 98% were identified as a single species of Japanese evergreen oak [*Quercus. gilva* Blume, also called *Cyclobalanopsis. gilva* (Blume) Oerst., Japanese name *ichii-gashi*]. In addition to shells and nuts, remains of fish (crucian carp: *Carassius*spp., carp: *Cyprinus carpio* L, bagrid catfish: *Pelteobagrus nudiceps* Sauvage, and catfish: *Silurus* spp.), reptiles (softshell turtle: *Pelodiscus sinensis* Wiegmann), boar (*Sus scrofa* L) and sika deer (*Cervus nippon* Temminck) were also recovered (Iba, 2000, 139–142).

The excavation of the Awazu site provided several lines of evidence to infer Jomon subsistence activities and their changes through time (Iba et al., 1999; Iba, 2000). First, archaeologists who analyzed the Awazu data concluded that the alternate layers represent seasonal cycles of subsistence activities by the Middle Jomon residents of this site: intensive shellfish collecting and fishing in the spring to early summer, and nut collecting in the fall. Judging from the evidence of intensive food-processing activities and the scarcity of pottery and other artifacts, it is likely that Midden No. 3 was a seasonal laboring site. Second, simulation studies of caloric estimates of excavated food remains indicate that the total estimated caloric value for Midden No. 3 is 20,210,775 Kcal, of which nuts represent 52%, fish 20.0%, shellfish 16.7%, reptiles 0.1% and mammals 10.8%. Third, results of this excavation suggest the importance of nuts in overall Jomon diet. In particular, an abundance of horse chestnuts (38.9% of the total estimated diet) indicate that, by the beginning of the Middle Jomon period, the Jomon people had mastered a sophisticated processing technology to remove the tannic acid. Finally, Iba et al. (1999, 143–144) suggest that changes in the nut assemblage from the Initial to the Middle Jomon periods were related to the climate and vegetation change: evergreen oaks that thrive in the warm climate replaced deciduous oaks (for the climate change during these periods, see Endo and Kosugi, 1989).

Higashimyo (Saga-shi Kyoiku Iinkai, 2006, 2008) is another excellent example of a submerged Jomon shell midden. Located in Saga Prefecture in northwestern Kyushu, Higashimyo is dated to the Initial Jomon period. Today, the site is buried under the alluvial deposit of the Saga Plain. During the Initial Jomon period, however, the site was on a low hill, facing the mouth of a river that flew into the Ariake Sea. The site is dated to ca. 5900–5700 BC (Nakamura, 2008). The end of the site occupation is marked by a marine clay deposit, which preserved Initial Jomon organic materials in anaerobic conditions. The first excavation from 1993 to 1996 yielded 167 burnt cobble clusters (probably remains of earth ovens), 19 stone tool clusters and 7 burials, as well as large numbers of potsherds and lithics. Most of these archaeological remains are dated to the Initial Jomon period. The second excavation, which started in 2003, revealed the presence of six shell middens, all of which are dated to the Initial Jomon period. Table 3 lists the estimated size of these six shell middens. Full-scale excavation of Shell Midden No. 2 and its surrounding area was conducted from 2004 to 2006 (Saga-shi Kyoiku Iinkai, 2006, 2008). In addition to the shell midden itself, over 158 storage pits were found. Many of these pits were associated with baskets, wooden vessels and other fibrous raw materials. The number of baskets was more than 700. There were also many wooden vessels and fibrous containers, presumably for storing nuts. The most abundant type of acorn remains was evergreen oak (*Q. gilva*), followed by a small amount of deciduous oak, such as sawtooth oak (*Quercus. acutissima* Carruth.), and walnuts (*Juglans* spp.). Some of the storage pits seemed to have been recycled to store raw materials for wood-working and basket-making. Although Jomon wood-working sites have previously been

Table 3
Size of the six shell middens at Higashimyo (Saga-shi Kyoiku Iinkai, 2008).

Midden no.	Long axis (m)	Size (m^2)
No. 1	30	300
No. 2	40	400
No. 3	20	200
No. 4	45	430
No. 5	15	40
No. 6	55	330+

reported (see Habu, 2004, 214–221), this site is currently the oldest example with a substantial amount of such remains.

In sum, the richness of organic materials from the Higashimyo site has provided archaeologists with an excellent opportunity to examine not only the exploitation of aquatic food but also diverse subsistence activities and food storage. Large amounts of baskets and wood containers demonstrate that the antiquity of sophisticated craft work goes back to the Initial Jomon period.

7. Discussion and conclusion

From the above, it is clear that Jomon shell midden archaeology has provided clues to answer several key questions in Japanese and world archaeology. The first issue is the beginning of intensive marine food exploitation and its consequences. Data from Natsushima, Mazukari and other Initial Jomon shell middens indicate that intensive exploitation of marine shellfish in Honshu go back to ca. 8000–7000 BC. This timing corresponds to the transition from highly mobile generalists (foragers *sensu* Binford, 1980) of the Incipient Jomon period to more sedentary specialists or collectors (Binford, 1980) of the Early Jomon period (see Habu, 2004: 245–252). It is likely that intensive shellfish collecting occurred as part of the rapid expansion of target food resources and following subsistence intensification during the Early Holocene. This does not imply, however, that shellfish and other marine food became the staple food during and after the Initial Jomon period. As discussed above, the contribution of shellfish to the Initial Jomon diet seems to have been limited. For the Early to the Final Jomon periods, there is no evidence indicating heavy reliance on shellfish or other marine food. Carbon and nitrogen isotope studies of Jomon skeletal remains suggest that terrestrial food dominated the bulk of the Early to Final Jomon diet in Honshu (Yoneda, 2010). These lines of evidence indicate that the importance of Jomon shellfish collecting was not its dominance in the overall diet or its caloric value. As pointed out by Suzuki (1986), a main advantage of shellfish is its seasonal abundance when other food resources were scarce. Results of growth line analyses at Satohama and Muro partially support this proposition. Equally importantly, shellfish collecting must have provided diversity in Jomon food and subsistence strategies, which helped decrease the vulnerability of Jomon subsistence-settlement systems to climate change and other disturbances. Thus, a failure in shellfish collecting could have caused a major problem in Jomon subsistence-settlement systems even if its caloric contribution was small. For example, the decline of shell midden construction in the western half of the Tokyo Bay and the following disappearance of settlement sites at the end of the Early Jomon period are suggestive of the critical role of shellfish in the overall Jomon foodways and subsistence activities.

Second, Jomon shell midden archaeology can contribute to an understanding of long-term changes in human-environment interaction. Discoveries of buried or submerged lowland shell middens, such as Mazukari and Higashimyo, have provided new data with which to reevaluate the impacts of Early Holocene marine transgression on people's lifeways and landscapes. Quantitative data of temporal and regional variability in the number of shell middens are excellent sources to infer long-term changes in the exploitation of aquatic food and its regional variability. An abundance of shell middens in the Tohoku and Kanto regions correspond to the higher density of Jomon sites in these regions than in the other regions. In this regard, one could make a general statement that aquatic food was important in the development of complex hunter-gatherer cultures in Tohoku and Kanto. On the other hand, the growth and decline of shell midden construction in these regions do not quite overlap with those of settlement sites. An abundance of Late Jomon shell middens after the decline of overall site density at the end of the Middle Jomon implies that shellfish exploitation was not negatively affected by the factors that caused a significant decrease in overall site density. Archaeological studies of changes in other aspects of Jomon subsistence-settlement systems, as well as analyses of climate data (e.g., Kawahata et al., 2009), will be key to develop models of long-term culture change.

Third, excavations of lowland shell middens, such as Awazu and Higashimyo, have revealed that the archaeology of submerged shell middens is critical not only for the study of aquatic food but also terrestrial food, especially nuts, and organic artifacts. Both Awazu and Higashimyo indicate the importance of nut collecting in the Jomon diet. In particular, data from Awazu helped archaeologists understand the seasonal cycles of both aquatic and terrestrial food acquisition.

Fourth, Jomon shell midden data shed light on the issues of resource conservation and human impacts on the local environment. Clam shell measurements at Muro indicate that the residents collected only large clams. This was interpreted as a reflection of their resource conservation efforts. Not all the Jomon shell middens show similar patterns of shell measurements, however. For example, Ishizuka's (2009) study of shell measurements of yamato-shijimi brackish clam (*Corbicula japonica* Prime) at 12 Early Jomon sites in Saitama Prefecture indicates that size selection occurred only in the early phase of the shellfish collecting, and that over-harvesting eventually forced the residents to exploit all sizes of shellfish that were available in the area. In order to further pursue the issue of resource conservation vs. overexploitation, accumulation of similar data from other shell midden sites will be critical.

Finally, methodological developments in Jomon shell midden studies are also noteworthy. Excavations of Nakasawame and Satohama in Tohoku combined water-screening and flotation methods with their detailed stratigraphic approach to obtain quantitative data of ecofacts and artifacts. Excavators of the Isarago shell midden in Tokyo used arbitrary layers as their sampling unit to conduct simulation studies of the shell midden volume and caloric contribution of shellfish to Jomon diet. In both cases, the amount of information retrieved from these samples is enormous. When combined with other scientific analytical methods, such as AMS dating and micromorphology, these data can provide archaeologists with solid databases to infer changes in subsistence strategies with a fine-grained chronological scale.

Acknowledgments

We thank Mark Hall, Lilian Karali-Gianakopoulou, Marco Madella and two anonymous reviewers for their constructive comments. Any errors, of course, are our own. With the wealth of materials from Japanese shell middens, each of the four authors, Kanno, Habu, Yamamoto and Matsui, drafted the four regional sections of Tohoku, Kanto, Chubu and Western Japan respectively. Habu then put the four sections together in English. She is also the primary author of the first two sections and the final section. Due to the word limit, this review does not cover data from Hokkaido and Okinawa.

References

Aikens, C.M., Higuchi, T., 1982. Prehistory of Japan. Academic Press, San Diego.
Akazawa, T., 1980. Fishing adaptation of prehistoric hunter-gatherers at the Nittano site, Japan. Journal of Archaeological Science 7, 325–344.
Akita-ken Kyoiku Iinkai [Board of Education of Akita Prefecture], 2001. Akita-ken Iseki Chizu (Yuri-Chiku-Ban). (Archaeological Site Maps of Akita Prefecture: The Yuri Area). Akita-ken Kyoiku Iinkai, Akita (in Japanese).
Aomori-ken Kyoiku Iinkai [Board of Education of Aomori Prefecture], 2009. Aomori-ken Iseki Chizu. (Archaeological Site Maps of Aomori Prefecture). Aomori-ken Kyoiku Iinkai, Aomori (in Japanese).
Barnes, G.L., 1993. China, Korea, and Japan. Thames and Hudson, London.

Binford, L.R., 1980. Willow smoke and dog's tails. American Antiquity 45 (1), 4–20.
Chiba-ken Kyoiku Iinkai [Board of Education of Chiba Prefecture], 1983. Chiba-ken Shozai Kaizuka Iseki Shosai Bunpu Chosa Hokokusho. (Report of the Detailed Surveys of Shell Midden Sites in Chiba Prefecture). Chiba-ken Kyoiku Iinkai, Chiba (in Japanese).
Endo, K., Kosugi, M., 1989. Chikei kankyo. (Geological environment). In: Nagai, M., Nasu, T., Kanaseki, H., Sahara, M. (Eds.), Yayoi Jidai no Kenkyu [The Study of the Yayoi Period], vol. 1, pp. 131–147. Yuzankaku, Tokyo.(in Japanese).
Esaka, T., 1965. Seikatsu no butai. (The living environment). In: Kamaki, Y. (Ed.), Nihon no Kokogaku, II [Japanese Archaeology], vol. 2, pp. 399–415. Kawade Shobo, Tokyo. (in Japanese).
Fujinuma, K. (Ed.), 1986. Tagara Kaizuka [The Tagara Shell Midden]. Miyagi-ken Kyoiku Iinkai [Board of Education of Miyagi Prefecture], Sendai (in Japanese).
Fujinuma, K., Okamura, M., 1982. Satohama Kaizuka I. (The Satohama Shell Midden), vol. I Tohoku Rekishi Shiryokan [Tohoku History Museum], Tagajo, Miyagi. (in Japanese).
Fujinuma, K., et al., 1989. Miyagi-ken no Kaizuka. (Shell Middens in Miyagi Prefecture). Tohoku Rekishi Shiryo-kan [Tohoku History Museum], Tagajo, Miyagi (in Japanese).
Fukuda, T., 1992. Aomori-ken no kaizuka shutsudo shizen ibutsu ichiran. (A list of ecofacts from shell middens in Aomori prefecture). In: Aomori-kenritsu Kyodokan [Aomori Prefectural History Museum] (Ed.), Ogawara-ko Shuhen no Kaizuka [Shell Middens Near Lake Ogawara]. Aomori Kenritsu Kyodokan, Aomori, pp. 109–125 (in Japanese).
Fukuda, T., 1998. Honshu hokuhen no kaizuka iseki soran. (A list of shell middens in northern Honshu). Aomori-kenritsu Kyodo-kan Chosa Kenkyu Nenpo. (Annual Bulletin of the History Museum of Aomori Prefecture) 22, 79–104 (in Japanese).
Fukuda, T., 2007. Honshu hokuhen no kaizuka iseki soran, II. (A list of shell middens in northern Honshu, part II). Aomori-kenritsu Kyodo-kan Chosa Kenkyu Nenpo. (Annual Bulletin of the History Museum of Aomori Prefecture) 31, 1–16 (in Japanese).
Habu, J., 2001. Subsistence-Settlement Systems and Intersite Variability in the Moroiso Phase of the Early Jomon Period of Japan. International Monographs in Prehistory, Ann Arbor.
Habu, J., 2004. Ancient Jomon of Japan. Cambridge University Press, Cambridge.
Habu, J., 2008. Growth and decline in complex hunter-gatherer societies. Antiquity 82, 571–584.
Habu, J., 2010. Seafaring and the development of cultural complexity in Northeast Asia. In: Anderson, A.J., Barrett, J.H., Boyle, K.V. (Eds.), The Global Origins and Development of Seafaring. McDonald Institute, University of Cambridge, Cambridge, pp. 159–170.
Horikoshi, M., 1972. Jomon jidai no shuraku to kyodo soshiki: Tokyo-wan engan chiiki o rei to shite. (Settlement and social organization during the Jomon period, with special reference to the coastal area of Tokyo Bay). Sundai Shigaku. (Sundai Journal of History) 31, 1–29 (in Japanese).
Iba, I., 2000. Biwa-ko no suichu koko iseki: Awazu kotei iseki no baai. (Submerged archaeological sites in Lake Biwa: awazu case). In: Matsui, A., Makino, K. (Eds.), 1999, Kodai-ko no Kokogaku [Archaeology of World Lakes]. Kubapuro, Tokyo, pp. 155–168 (in Japanese with English title and summary).
Iba, I., Matsui, A., Nakajima, T., 1999. The awazu shell midden: a submerged site at Lake Biwa. In: Kawanabe, H., Coulter, G.W., Roosevelt, A.C. (Eds.), Ancient Lakes: Their Cultural and Biological Diversity. Kenobi Productions, Belgium, pp. 135–145.
Ichikawa, K., 1980. Choshichiyachi Kaizuka Hakkutsu Chosa Hokokusho. (Excavation Report of the Choshichiyachi Shell Midden). Aomori-ken Kyoiku Iinkai [Board of Education of Aomori City], Aomori.
Imamura, K., 1996. Prehistoric Japan. University of Haewai'i Press, Honolulu.
Isarago Kaizuka Iseki Chosadan [Excavation Team of the Isarago Shell Midden Site], 1981. Isarago Kaizuka Iseki. (The Isarago Shell Midden Site). Isarago Kaizuka Iseki Chosakai [Committee for the Excavation of the Isarago Shell Midden Site] (in Japanese).
Ishizuka, T., 2009. Yamatoshijimi no saizu no hensen to seiiku kankyo. (Changes through time in the size of *Corbicula* and its habitats). In: Okkoshi-shiki Symposium Jikko Iinkai [The Organization Committee for the Symposium of Okkoshi-Style Pottery] (Ed.), Okkoshi-shiki Doki to Sono Jidai [The Period Associated with Okkoshi Style Pottery]. Fujimi Shiritsu Mizuko Kaizuka Shiryokan [Mizuko Shell Midden Museum of Fujimi City], Fujimi, Saitama, pp. 100–103 (in Japanese).
Iwase, A., 1998. Mikawa-wan tobu no shinden kaihatsu ni tomonau higata kankyo no kaihen ni tsuite. (Impacts of the development of new rice paddy fields on the tidal flat environment in the East Mikawa Bay Area). Dobutsu Kokogaku. (Zooarchaeology) 10, 1–15 (in Japanese).
Iwase, A., 2003. Aichi-ken ni okeru Kako-jo-gata Kaizuka ni tsuite. (Shell Middens of Aichi Prefecture as Processing Sites), Kansai Jomon Ronshu, pp. 189–205. (in Japanese).
Iwase, A., 2005. Aichi-ken Muro Kaizuka-gun ni okeru hamaguri no sentaku-teki saishu ni tsuite. (Selective clam shell collecting at the Muro shell midden sites in Aichi prefecture). Kodaigaku Kenkyu 171, 16–26 (in Japanese).
Iwase, A., et al., 2002. Toyohashi no kankyo-shi to Kaizuka. Toyohashi-shi Kyoiku Iinkai [Board of Education of Toyohashi City], Toyohashi (in Japanese).
Iwate-ken Kyoiku Iinkai [Board of Education of Iwate Prefecture], 2001. Iwate-ken Iseki Maizo Bunkazai Joho Kensaku System Ver. 1.02. (Archaeological Database of Iwate Prefecture, Ver. 1.02). Iwate-ken Kyoiku Iinkai, Morioka (in Japanese).
Kawahata, H., Yamamoto, H., Ohkushi, K., Yokoyama, Y., Kimoto, K., Ohshima, H., Matsuzaki, H., 2009. Changes of environments and human activity at the Sannai-Maruyama ruins in Japan during the mid-holocene hypsithermal climatic interval. Quaternary Science Reviews 28, 964–974.
Kinno, R., 1987. Takonoura Kaizuka. (The Takonoura Shell Midden). Ofunato Shiritsu Hakubutsu-kan [Ofunato City Museum], Ofunato.
Kinno, R., 2001. Iwate-ken Ofunato-shi Ohora Kaizuka Han'i Kakunin Chosa Hokokusho. (Report of the Test Survey of the Ohora Shell Midden, Ofunato City, Iwate Prefecture). Iwate-ken Kyoiku Iinkai [Board of Education of Iwate Prefecture], Morioka (in Japanese).
Kita-ku Kyoiku Iinkai [Board of Education of Kita Ward], 2000. Nakazato Kaizuka. (The Nakazato Shell Midden). Kita-ku Kyoiku Iinkai, Tokyo (in Japanese).
Kiyono, K., 1949. Kodai Jinkotsu no Kenkyu ni motozuku Nihon Jinshu-ron. (A Theory on Japanese Race Based on Analysis of Skeletal Remains). Iwanami Shoten, Tokyo (in Japanese).
Kobayashi, T., 2004. Jomon Reflections. Oxbow Books, Oxford.
Koike, H., 1980. Seasonal Dating by Growth-line Counting of the Clam, *Meretrix lusoria*: Toward a Reconstruction of Prehistoric Shell-Collecting Activities in Japan. University of Tokyo Press, Tokyo.
Koike, H., 1987. Asari no seicho-sen bunseki. (Daily growth line analysis of asari clam). In: Tohoku Rekishi Shiryo-kan [Tohoku History Museum] (Ed.), Satohama Kaizuka V [The Satohama Shell Midden], vol. 5, pp. 48–53. Tohoku Rekishi Shiryo-kan, Tagajo, Miyagi. (in Japanese).
Koyama, S., 1978. Jomon subsistence and population. Senri Ethnological Studies 2, 1–65.
Kuramoto, T., 1996. Onishi kaizuka shutudo hamaguri no seicho-sen bunseki. (Daily growth line analysis of clams excavated from the Onishi shell midden). In: Toyohashi-shi Kyoiku Iinkai [Board of Education of Toyohashi City] (Ed.), Onishi Kaizuka, II [The Onishi Shell Midden], vol. II, pp. 79–84. Toyohashi-shi Kyoiku Iinkai, Toyohashi. (in Japanese).
Kuramoto, T., 1997. Suijin kaizuka shutudo hamaguri no seichosen bunseki. (Daily growth line analysis of clams excavated from the Suijin shell midden). In: Toyohashi-shi Kyoiku Iinkai [Board of Education of Toyohashi City] (Ed.), Suijin Kaizuka [The Suijin Shell Midden]. Toyohashi-shi Kyoiku Iinkai, Toyohashi, pp. 133–135 (in Japanese).
Kusakabe, Y., et al., 1991. Fukushima-ken no Kaizuka. (Shell Middens in Fukushima Prefecture). Fukushima-ken Kyoiku Iinkai, Fukushima (in Japanese).
Matsui, A., 1992. Wetland sites in Japan. In: Coles, B. (Ed.), The Wetland Revolution in Prehistory. WARP (Wet Land Archaeology Research Project) Occasional Paper, vol. 6. WARP and the Prehistoric Society, Exeter, pp. 5–14.
Matsui, A., 1995. Postglacial hunter-gatherers in the Japanese Archipelago. In: Fisher, A. (Ed.), Man and Sea in the Mesolithic: Coastal Settlement Above and Below Present Sea Level. Oxbow Books, Oxbow, pp. 327–334.
Matsui, A., 1996. Archaeological investigations of anadromous salmonoid fishing in Japan. World Archaeology 27 (3), 444–460.
Matsui, A., et al., 1984. Dobutsu izontai. (Faunal remains). In: Suto, T. (Ed.), Nakasawame Kaizuka [The Nakasawame Shell Midden]. Tohoku Daigaku Bungakubu Kokogaku Kenkyu-kai [Archaeological Association, Faculty of Letters, Tohoku University], Sendai, pp. 96–131 (in Japanese).
Matsumoto, H., 1919. Miyako-jima Satohama oyobi Kesen-gun Usozawa kaizuka no doki. (Pottery from the Satohama and Usozawa shell middens). Gendai No Kagaku. (Science Today) 7 (5), 10–42, 7(6), pp. 20–48. (in Japanese).
Matsushima, Y., Koike, H., 1979. Shizen kaiso ni okeru naiwan no kankyo fukugen to Jomon jidai no iseki. (Reconstruction of the littoral environment using the result of natural shell deposit analysis, with special reference to the distribution of Jomon sites). Kaizuka. (Shell Midden) 22, 1–9 (in Japanese).
Miyagi-ken Kyoiku-cho Bunkazai Hogo-ka [Cultural Affairs Section of the Agency of Education of Miyagi Prefecture], 2009. 2008 Nendo-ban Iseki Chimei-hyo. (A List of Archaeological Sites of Miyagi Prefecture). http://www.pref.miyagi.jp/bunkazai/maizou/kato-index1.html (accessed 10.03.11). (in Japanese).
Morse, E.S., 1879. Shell Mounds of Omori. Memoirs, Science Department. University of Tokyo, Tokyo.
Nakajima, H., 2000. Toshin ni nemuru Jomon bunka no saihakken: Tokyo-to Nakazato kaizuka. (Rediscovery of a Jomon Site in Tokyo Metropolis: The Nakazato Shell Midden in Tokyo). In: Shiroi Kuni no Uta. (In: Essays on Northern Land), vol. 528, pp. 22–25. (in Japanese).
Nakamura, T., 2008. Higashimyo iseki no nendai. (Dates from the Higashimyo site). In: Proceedings, Public Symposium, Ariake no Umi to Nihon-jin [The Sea of Ariake and the Japanese People]. Board of Education of Saga Prefecture, Saga, pp. 24–25 (in Japanese).
Nishida, M., 1983. The emergence of food production in Neolithic Japan. Journal of Anthropological Archaeology 2, 305–322.
Oikawa, A., 1995. Kaizuka database no suryo-teki bunseki. (Quantitative analysis of shell-mound database) (2). Jinbun Kagaku to Computer. (Humanities and Computer) 25 (7), 59–66 (in Japanese with English title and summary).
Okamura, M., Kasahara, N., 1987. Satohama Kaizuka VI. (The Satohama Shell Midden), vol. VI Tohoku Rekishi Shiryo-kan, Tagajo, Miyagi. (in Japanese).
Rosenberg, M., 1998. Cheating at musical chairs: territoriality and sedentism in an evolutionary context. Current Anthropology 39, 653–684.
Saga-shi Kyoiku Iinkai [Board of Education of Saga City], 2006. Higashimyo Iseki. (The Higashimyo Site). Saga-shi Kyoiku Iinkai, Saga (in Japanese).
Saga-shi Kyoiku Iinkai [Board of Education of Saga City], 2008. Higashimyo Iseki, II. (The Higashimyo Site), vol. II Saga-shi Kyoiku Iinkai, Saga. (in Japanese).
Sakatsume, N., 1959. Nihon Kaizuka Chimei-hyo. (A List of Shell Middens in Japan). Doyokai, Tokyo (in Japanese).
Sato, Yoshihiro, et al., 1998. Iwate no Kaizuka. (Shell Middens in Iwate). Iwate-ken Bunkazai Aigo Kyokai [Cultural Property Association of Iwate Prefecture], Morioka (in Japanese).

Schiffer, M.B., 1976. Behavioral Archaeology. Academic Press, New York.
Schiffer, M.B., 1987. Formation Processes of the Archaeological Record. University of New Mexico Press, Albuquerque.
Shindo, A., 1990. Surihagi Iseki. (The Surihagi Site). Miyagi-ken Kyoiku Iinkai [Board of Education of Miyagi Prefecture], Sendai (in Japanese).
Sokendai [Graduate University for Advanced Studies], 2010. Kaizuka Iseki Database. (Shell Mound Database). http://aci.soken.ac.jp/soars/SelectLocale.do (accessed 18.02 11). (in Japanese).
Suto, T., 1984. Nakasawame Kaizuka. (The Nakasawame Shell Midden). Tohoku Daigaku Bungakubu Kokogaku Kenkyu-kai [Archaeological Association, Faculty of Letters, Tohoku University], Sendai (in Japanese).
Suto, T., 1995. Jomon Banki Kaizuka no Kenkyu II: Nakasawame Kaizuka II. (A study of Final Jomon Shell Middens vol. II: The Nakasawame Shell Midden), vol. II The Archaeological Association, Faculty of Letters, Tohoku University, Sendai. (in Japanese).
Suto, T., 1997. Hanaizumi-cho Nakagami Iseki no Chosa. (Excavation of the Nakagami site, Hanaizumi Town). Hanaizumi-cho Kyoiku Iinkai. (Board of Education of Hanaizumi Town) Hanaizumi, Iwate (in Japanese).
Suzuki, K., 1986. Volumetry and nutritional analysis of a Jomon shellmidden. In: Akazawa, T., Aikens, C.M. (Eds.), Prehistoric Hunter-Gatherers in Japan. University Museum, University of Tokyo, Tokyo, pp. 55–72.
Takahashi, K., 1995. Sakiyama Kaizuka: Han'i Kakunin Chosa Hokokusho. (The Sakiyama Shell Midden: Report of a Test Excavation). Miyako-shi Kyoiku Iinkai [Board of Education of Miyako City], Miyako (in Japanese).
Toizumi, G., 1998. Suijin kaizuka (dai 2 kaizuka) shutsudo hamaguri no seicho-sen bunseki. (Daily growth line analysis of clams excavated from the Suijin shell midden (midden no. 2)). In: Toyohashi-shi Kyoiku Iinkai [Board of Education of Toyohashi City] (Ed.), Suijin Kaizuka (Dai 2 Kaizuka). (The Suijin Shell Midden (Midden No. 2)). Toyohashi-shi Kyoiku Iinkai, Toyohashi, pp. 199–217 (in Japanese).
Torihama Kaizuka Kenkyu Group [Torihama Shell Midden Research Group], 1979–1987. Torihama Kaizuka, 1–6. (The Torihama Shell Midden), vols. 1–6 Fukui-ken Kyoiku Iinkai [Board of Education of Fukui Prefecture] and Wakasa Rekishi Minzoku Shiryokan [Wakasa History and Folklore Museum], Fukui (in Japanese).
Vita-Finzi, C., Higgs, E.S., 1970. Prehistoric economy in the Mount Carmel area of Palestine: site catchment analysis. Proceedings of the Prehistoric Society 36, 1–37.
Yamashita, K., 2008. Mazukari kaizuka no chosa to seika nit suite. (On the archaeological study of the Mazukari shell midden and its results). In: Proceedings of the 2008 Aichi Meeting of the Japanese Archaeological Association, Aichi, pp. 1–14 (in Japanese).
Yamashita, K., Matsushima, Y., Watanabe, M. (Eds.), 1980. Mazukari Kaizuka. (The Mazukari Shell Midden). Minami-Chita-cho Kyoiku Iinkai [Board of Education of Minami-Chita Town], Minami-Chita-cho, Aichi (in Japanese).
Yoneda, M., 2010. Shoku-seitai ni miru Jomon Bunka no tayosei. (Jomon cultural diversity reflected in food ecology). Kagaku. (Science Journal) 80 (4), 383–388 (in Japanese).