Chapter 6

Holocene Sea Level Change and Mawaki Archaeological Site

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Abstract

Lithological units discovered at the Mawaki Archaeological site on the Noto Peninsula were interpreted as part of a sequence in a cycle of marine transgression and regression. Dated coastal horizons were chosen to indicate former sea levels. A Holocene relative sea-level curve was generated on the basis of geological data, micropaleontological data, and ^{14}C dating, and a rapid rise from 8,800 cal yr BP to 6,000 cal yr BP and a succeeding regression of shoreline by coastal sedimentation was observed. Abundant dolphin bones lay just above the top of the sediment deposited in shallow marine environment. Cultural artifacts were found in a terrestrial deposit near the dolphin bone level that is assigned to a period of high, stable sea level after the post-glacial eustatic high-stand. Dolphin bones are associated with stone artifacts and ritual wood columns, which indicates the presence of longstanding fishery- related activities during the early Holocene on the Japan Sea coast.

6.1 Introduction

Owing to its detailed chronology of cultural materials and the Holocene coastal sediments, the Japanese Islands is an important area for Holocene environmental research in eastern Eurasia (Ota et al., 1982). However, intensive tectonic deformation along the convergent plate margin hinders the precise reconstruction of paleoenvironments. The Pacific coast of the islands has undergone intermittent co-seismic uplift as a result of plate subduction, even during the historical era (Yoshikawa et al., 1973). Although the coastal areas on the Japan Sea side of the islands also suffer considerable deformation due to the activity of adjacent tectonic lines (e.g., Okamura et al., 1995), the Noto Peninsula (Figure 6.1) in central Japan is immune to late Quaternary tectonic movements, and few active faults lie in its northern part (Research Group for Active Faults of Japan, 1991). Because the peninsula has been a low-relief continental fragment in the Japan Sea throughout the Neogene, the shelf that surrounds it is narrow and the hydroisostatic effects on the peninsula are minimal. The local tidal range is less than 0.2 m. Thus the coastal sediments are expected to be a sensitive recorder of sea-level changes free from the uncertainties noted above (Itoh et al., 2011).

The Mawaki archaeological site is located on the eastern coast of the Noto Peninsula in central Japan (Figures 6.1 and 6.2). It is a village site with evidence of habitation from around 7,000 to 2,500 cal yr BP. The Mawaki site is surrounded by hills that are about 100 m high and is located on an alluvial plain between 4 m and 12 m above sea level. This archaeological site was discovered beneath the cultivated fields between hilly terrain and the present-day coastal residential area. Archaeological relics, such as a circular array of wood columns from the late Jomon period and tombs and human bones from the middle Jomon period, have been excavated. As an archaeological site in an embayment buried during the Holocene regression, the Mawaki site is characterized by marine animal remains. Numerous dolphin bones were excavated between 1982 and 1983 within the sediments of the late early to earliest middle of Jomon period along with abundant Jomon pottery and other remains (Takada and Takemura, this volume).

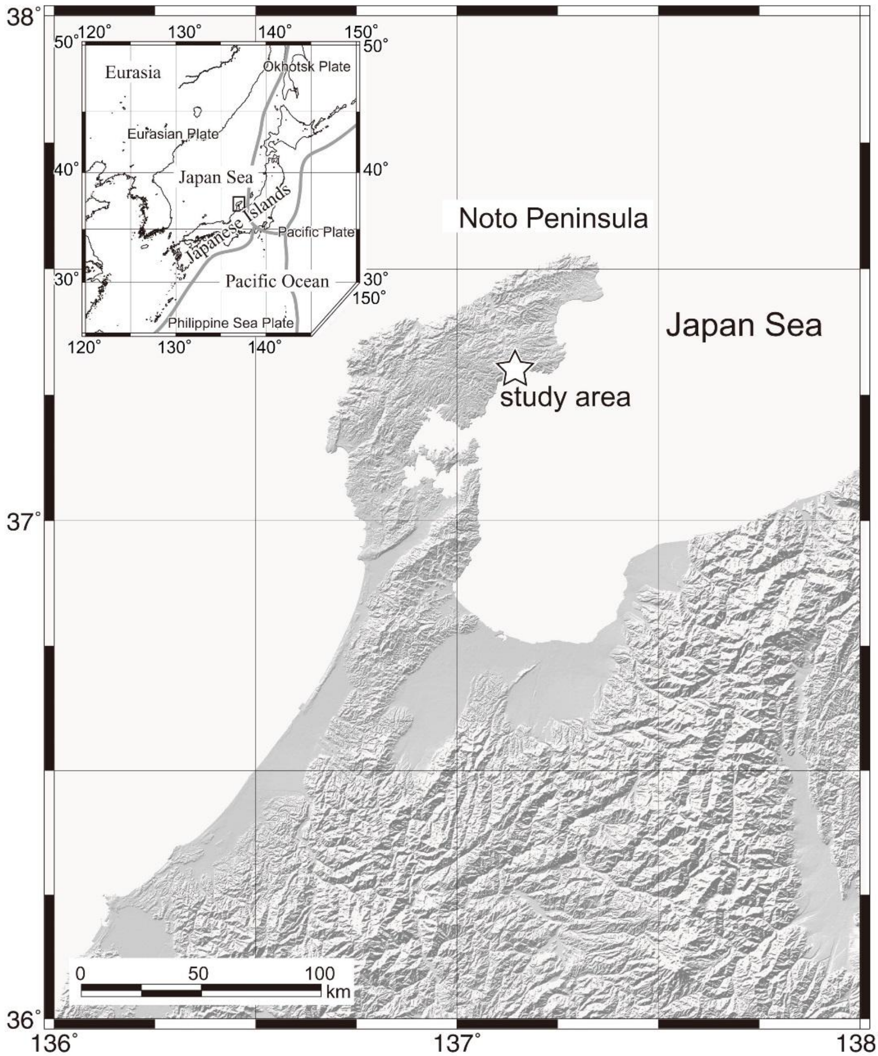

Figure 6.1 *The Noto Peninsula and coastal areas around central Japan with topographic relief on land. The star indicates our study area. (Inset) A synoptic map of the Quaternary tectonic setting around the Japanese Islands. Bold lines show the convergent plate boundary. The box around the central part of the main island of Japan encloses our study area. (Itoh et al., 2011, partly modified).*

The last deglacial sea levels have been studied in many places (Pirazzoli, 1996). The marine transgression in the Japanese Archipelago was very intensive during the middle Holocene, and there are many shell mounds from the Jomon age along the coastal areas. In archeological terms, this transgression is commonly referred to as the 'Jomon Transgression'. Relative sea level studies have been carried out at several sites in Japan (e.g., Nakamura, 2006; Sato, 2008; Tanigawa, 2009). The occurring transgression follows a similar pattern, but the timing and altitude of high-stands of the transgression are different. Eustatic sea-level curves are generally influenced by local or regional disturbances, such as glacio-/hydroisostatic (Daly, 1934; Bloom, 1967) and tectonic (Stewart and Hancock, 1993) effects.

In this chapter, we summarize the descriptions of the lithology and stratigraphy, radiocarbon ages of borehole samples, and dolphin bones and micropaleontological information. Holocene sequences are correlated on the basis of these properties, and classified into sedimentary units corresponding to marine transgression and regression. Eustatic sea-level changes around the Japan Sea are then estimated using the depositional indicators with numerical ages.

Figure 6.2 *The modern embayment and adjacent Mawaki archaeological site on the alluvial plain.*

6.2 Interactions Between Sea Level Change and Human Activities

Transgression and regression are geological phenomena caused by the interaction between sea-level change, sediment discharge from rivers, and coastal erosion. These phenomena interact with human activities in some cases though they occur on a geological time scale that is beyond an average human's life span. Majority of the coastal plains were formed during the regression stage that succeeded the high-stand stage. Moreover, ancient civilizations developed and huge cities were settled on such coastal plains with flat land formed as a result of the regression. The evidences of the effects of the processes and speed of regression on human civilizations are evident from recent studies in the opposite direction.

The sediment discharge of the Huanghe (Yellow River) in China abruptly increased by ten times ca. 1,000 years ago (Li, 1991; Xue, 1993; Zhang, 1984). The reasons being the cultivation and deforestation is due to the increasing population in the Loess Plateau, the hinterland of the river (Saito et al., 2001). As the sediment discharge increased, regression was accelerated and as a result, huge cities, like Beijing, were developed on the large plain around the lower reach of the Huanghe. Similar accelerations of the regression are found in Changjiang (Yangtze River) in China (Chen, 1998; Hori et al., 2001; Wang et al., 1981). Such accelerations are clearly found not only in the continental big rivers, also found in small rivers, for example, the Yahagi River in central Japan (Sato and Masuda, 2010).

Though the survey area, the Mawaki site, is a small basin when compared to the big basins in continents (Figure 6.2), the Holocene sediment in this area shows transgression and regression similar to the sediment in big basins (Takemura et al., this volume) and the human activities around the basin were well studied (Takada and Takemura, this volume). Therefore, the Mawaki archeological site was suitable for studying the interaction between human activities and geological phenomena.

6.3 Summary of Geoarchaeological Data

In this section, we present an overview history of sea level change on the basis of stratigraphy (Takemura et al, this volume), chronology (Nakamura and Takada, this volume) and paleoenvironmental information of pollen and diatom (Kanehara and Takada, this volume) at the Mawaki archaeological site, and present a precise summary of three viewpoints.

6.3.1 Lithology and Stratigraphy

A drilling survey was carried out at the Mawaki archaeological site in 1998 (see Figure 6.3). For the survey, seventeen boreholes were drilled and continuous records of the Holocene sediments and underlying basement were obtained. Most of the cultural remains found in the strata including dolphin bones have been excavated in the vicinity of borehole C-2, where the sediments are mostly subaerial. C-Line boreholes (C-1 to C-8) were selected for the collection of lithological, micropaleontological, and chronological data. These boreholes are aligned in the north-south direction, namely, from the coastal areas to the shallow marine areas of the Holocene embayment in the northern part of the Noto Peninsula. Detailed lithological descriptions and radiocarbon ages have been obtained from the core samples (Board of Education of Noto Town and Investigating Commission for Mawaki Site, 2002). Auxiliary core B-3 (Figure 6.3 for borehole location) and dolphin bone occurrence elevation with ^{14}C ages were utilized to determine the post-glacial high-stand.

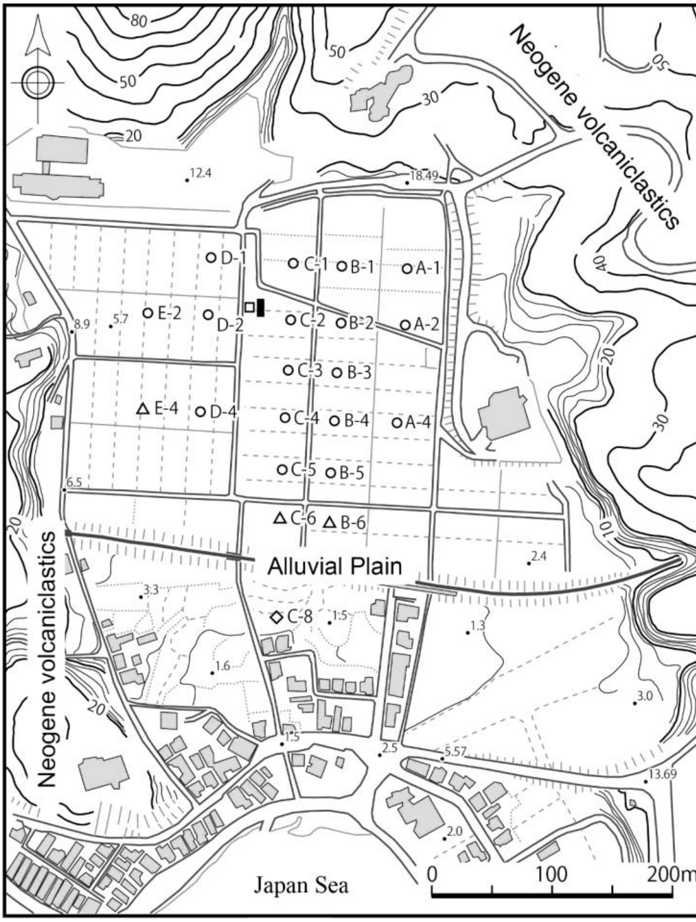

Figure 6.3 *Borehole and geoslicer locations around the Mawaki archaeological site. Open circle: drilling in 1997 & 1998, open triangle: drilling in 2002, open rhombus: drilling in 2005, solid rectangle: geoslicer coring.*

Stratigraphic data obtained from the core samples taken at Mawaki site are summarized by Takemura et al. (this volume). The lithological unit nomenclature is that of Itoh et al. (2011) as follows.

Basement: Miocene volcaniclastics composed of tuff and tuffaceous mudstone.

Unit A: Sands and gravels, poorly sorted, containing charcoal grains.

Unit B: Clays and silts with abundant remains of marine organisms, intercalations of well-sorted sandy layers, containing shell and plant fragments.

Unit C: Silty sands with gravels, well-sorted medium sands, containing abundant shells and plant fragments.

Unit D: Sands and gravels, poorly sorted, containing pottery fragments and charcoal grains.

Unit E: Cultivated soil.

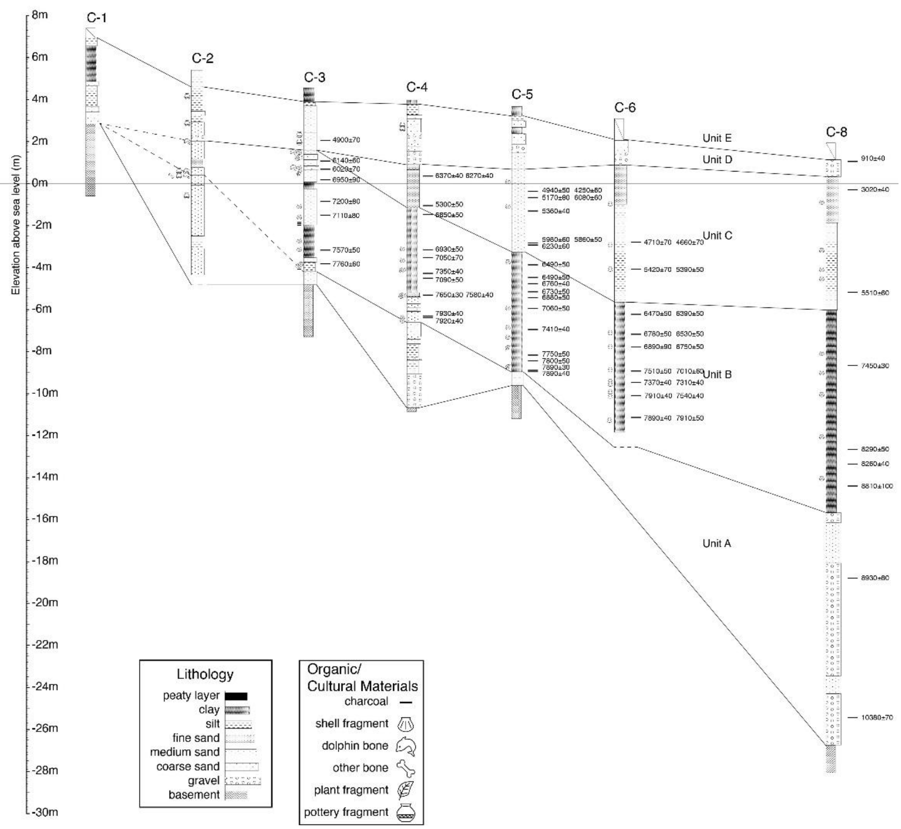

Figure 6.4 *Stratigraphic data for core samples along the C-Line (C-1, C-2, C-3, C-4, C-5, C-6 and C-8). The occurrence of organic/cultural materials is shown on the left side of the lithological columns. Radiocarbon dates are shown on the right side of the columns. Solid lines are the lithological boundaries of units A, B, C and D.*

Information on organic/cultural materials and radiocarbon dates (Nakamura and Takada, this volume) are placed on the left and right sides of the lithological columns, respectively, in Figure 6.4. These data are used later in the discussion of paleoenvironmental reconstruction and the recognition of former sea levels.

6.3.2 Radiocarbon Ages of Borehole Samples and Dolphin Bones

Table 6.1 *^{14}C age data related with the horizons of ancient sea levels.*

			Depth (m)	Elevation (m)	Calibration age (cal yBP)
1	C-3	wood	2.53	2.06	4900±70
2	B-3	shell	3.12	1.47	5140±70
3	Dolphin			3.50	5580-5650
4	B-3	shell	3.38	1.21	6770±50
5	C-3	wood	8.43	-3.84	7760±60
6	C-4	wood	9.30	-5.30	7650±30
7	C-4	shell	9.30	-5.30	7580±40
8	C-4	wood	10.30	-6.30	7930±40
9	C-4	shell	10.38	-6.38	7920±40
10	C-5	wood	12.60	-8.93	7890±40
11	C-6	shell	14.24	-11.14	7890±40
12	C-6	plant	14.24	-11.14	7910±50
13	C-8	plant	16.36	-14.40	8810±100

The ^{14}C ages of shell samples, wood, plant fragments and peat samples separated from sediment cores C-3, C-4, C-5, C-6 and C-8 were measured at the AMS laboratory of the Center for Chronological Research, Nagoya University (Nakamura et al., 2000). After the treatment procedure, the ^{14}C ages were obtained. The oceanic reservoir effect on marine shell samples was calibrated using a calibration program OxCal4.2.4 (Bronk Ramsey, 2009) and IntCal13 or Marine-13calibration data set (Reimer et al., 2013).

Nakamura and Takada (this volume) have estimated the correction value of the local marine carbon reservoir effect, ΔR, for sediment samples from cores C4, C5, and C6. The obtained ΔR values were less reliable with rather large errors, and because the ΔR values were almost consistent with zero within ±1 σ error, ΔR = 0 for calibration of marine samples collected from the Mawaki site. On the basis of probability density distributions against the calendar dates of ^{14}C ages obtained for nine carbonaceous fractions from dolphin bones, ^{14}C ages and their calibrated ages were found to be around 5,580-5,650 cal yr BP, when the carbonaceous fractions dated were separated from more essential and genuine sections of the dolphin bones.

We selected thirteen carbon dating results for the reconstruction of sea level changes around the Mawaki site (Table 6.1) from the age data obtained by Nakamura and Takada (this volume) on the basis of sedimentological information.

6.3.3 Micropaleontological Information

The pollen assemblage at the site indicated a forest comprising broad-leaved deciduous trees such as Qercus and Aesculus (horse chestnut) within the clay and silty sand units (units B and C). The occurrence of pollen grains was very high within units B and C, comprising Lepidobalanus-Aesculus assemblage, Pinus-Lepidobalanus assemblage and Cyclobanopsis-Pinus-(Lepidobalanus) assemblage in an ascending order. This indicated a cycle of marine transgression.

In the middle part of the sequence of boring core sediments (Unit B), *Palaria sulcata* group diatoms were found. Additionally, in the sequence of C-2, the boundary between marine environment and marshy environment was located at about 3 m above the present sea level on the basis of diatom assemblage. Diatom assemblage of the sediments related to dolphin bone occurrence at the excavation site at an altitude of 3.6 - 4.3 m above sea level was analyzed. The composition was characterized by the occurrence of terrestrial diatom and freshwater diatom associated with marine environment diatom such as *Navicula mutica* in the upper part, *Hantzschia amphioxys* and *Navicula munica* in the middle part, and *Grammatophora oceanica*, *Hantzschia amphioxys* and *Navicula munica* in the lower part. Based on the diatom assemblage data, horizons of sediments with dolphin bones were characterized by a sedimentary environment along the shoreline.

6.4 Discussion

Our study has established the Holocene stratigraphy around the Mawaki archaeological site. In the first part, we consider the sedimentary facies, which record a cycle of marine transgression and regression. Indicators of former sea levels have been identified during the course of paleoenvironmental interpretation. Next we present a Holocene eustatic curve along the Japan Sea coast by taking into consideration the effects of tectonic uplift. Finally, the history of the Mawaki archaeological site is described on the basis of the stratigraphic interpretation related to the sea level change.

6.4.1 Paleoenvironments

Radiocarbon ages suggest that the bottom of unit B is a marine transgressive surface. Its age ranges from 8,810 cal yr BP (C-8) to 7,760 cal yr BP (C-3) as shown in Figure 6.4, and this is suggestive of rapid onlapping sedimentation during a remarkable rise in sea-level. The altitudes and ages of coastal sediments at the base of unit B are therefore regarded as an indicator of ancient sea levels.

Unit B in the C-3 core is an upward-coarsening sequence that was deposited during the latter period of the sea-level rise. The sandy wedge of unit C is interpreted as a maximum relict barrier or relict sand-pit developed parallel to the ancient shoreline, and covered by terrestrial sediments with potteries from 4,900 cal yr BP (2.06 m above sea level). Its age is useful for the reconstruction of the sea-level.

In the C-series cores, evidence of higher sea levels has been destroyed by subsequent erosion. Instead we use the record from auxiliary core B-3 (see Figure 6.3 for location) where marine sediments containing oyster shells are preserved at the highest level (1.91 m above sea level) of the Holocene succession despite the absence of age data. Moreover, the age of dolphin bones discovered at 3.50 m above sea level, analyzed by Nakamura and Takada (this volume), are used to obtain ancient shoreline information. We interpret these to mean that the high-stand followed the deposition of transgressive unit B. Silty and well-sorted sands in cores C-4, C-5, C-6 and C-8 are interpreted as estuary and long-shore bar deposits, respectively, in a coastal system.

Using the micropaleontological data of diatom, a cycle of marine transgression and the location of the shoreline were interpreted on the basis of the occurrence of terrestrial diatom species.

6.4.2 Eustatic Sea Levels

Figure 6.5 presents a sea-level change for the Holocene constructed on the basis of the Mawaki depositional indicators described in the previous section. It is characterized by a rapid rise during the period from 8,800 cal yr BP to 6,000 cal yr BP succeeded by a minor fall around the present sea level. Such a trend is generally concordant with previous research (Fujii and Fuji, 1982) based on sea-level indicators along the Japan Sea coast. In Unit C, horizontal isochrones indicate an aggradational sedimentation pattern.

Holocene sea level change is a significant concern for Japanese archaeologists because of the significant influence it had on the waxing and waning of societies during the Jomon period. It has been suggested that the so-called 'Jomon Transgression' was related to the establishment of the Incipient to Early Jomon culture that is preserved in the form of many shell midden sites along certain Japanese coastal areas. However, relative sea levels in the

Japanese Archipelago show considerable variability (e.g., Ota et al., 1982; Moriwaki, 2004) reflecting tectonic and/or hydroisostatic controls on an active plate margin (Pirazzoli, 1996). We present an in situ sea level curve in order to discuss the paleoenvironments of the Mawaki site. Moreover, as mentioned previously, this sea level curve is mostly free from local tectonic effects and may therefore serve as a regional reference curve in East Asia.

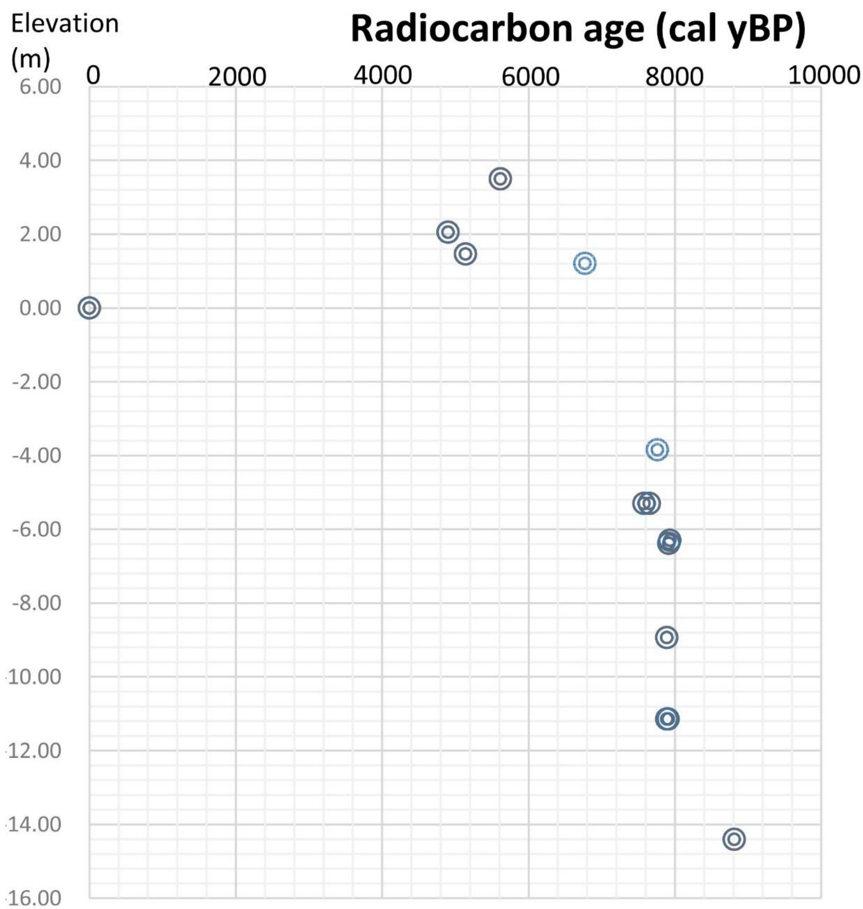

Figure 6.5 *A Holocene sea-level change plot obtained from the Mawaki Archaeological Site.*

6.4.3 History of the Mawaki Archaeological Site Related with the Discovery of Dolphin Bones

Holocene sediments from the Mawaki archaeological site on the Japan Sea coast yielded many animal bones-remains, Jomon pottery and stone remains. The most characteristic remains are dolphin bones intercalated in the strata of the late-early to early-middle Jomon period found as a discrete, stratified occurrence. These strata also contain stone implements including many flint arrowheads, stone arrows, stone knives and scrapers.

As Itoh et al. (2011) summarized, the coexistence of many dolphin bones, human stone remains and scraped wooden columns can be attributed to dolphin fishery. Abundant dolphin bones were recorded at the top of the marine sequence (boundary between units C and D) and located in the seashore environment. Cultural materials were found in a subaerial deposit (unit D) just above the dolphin bone occurrence level. A stable high sea level subsequent to the rapid post-glacial transgression resulting in a lagoonal environment and a deep inlet around the Mawaki site has been clarified on the basis of paleoenvironmental study. The Mawaki site must have been a suitable configuration for thriving fisheries-related activities from the earliest through to the latest Jomon periods. The dolphin fishery itself has continued along the coastal area till the present day (e.g., Hiraguchi, 2006).

6.5 Summary

The paleoenvironment around the Mawaki archaeological site in central Japan has been reconstructed on the basis of a geological survey by utilizing precise stratigraphic correlation and numerous ^{14}C age data. As a result, four lithological units have been identified and interpreted as a sequence in a cycle of Holocene marine transgression and regression. Relative sea-level changes in the Holocene along the Japan Sea coast are characterized by a remarkable rise between the

period from 8,800 cal yr BP to 6,000 cal yr BP and a succeeding regression of shoreline by coastal sedimentation around the present level. These changes are not attributed to local tectonic disturbance rather to a regional eustatic trend. It worth noting that horizons containing abundant dolphin bones are representative of a period of high, stable sea level after the post-glacial eustatic high-stand. Dolphin bones are associated with stone artifacts (arrowheads, knives and scrapers) and ritualistic wood columns, implying the presence of fishing activities throughout the Jomon period along the Japan Sea coast.

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