# CALIBRATED $^{14}C$ AGES OF JOMON SITES, NE JAPAN, AND THEIR SIGNIFICANCE

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**ABSTRACT.** The traditional archaeological chronology in the Japanese Islands during the Jomon period was essentially based on the relative age given to cord-impressed patterns marked on pottery, as well as the shape of the pottery and the thickness of the cultural layers that were excavated. We aimed to correlate the classical archaeological chronology with calibrated radiocarbon dates, to posit a new chronology for the Jomon period in northeastern Japan. We calibrated 80 accelerator mass spectrometry (AMS) $^{14}C$ dates from NE Japan and reconstructed a chronological timetable for Hokkaido and the Tohoku District. We collected 43 samples from 5 shellmounds and 2 archaeological sites on Hokkaido Island and 4 shellmounds in the Tohoku District in order to determine the calibrated age of their sites. ΔR values used on Hokkaido Island and the Tohoku District were between 282 and −158 yr and between ±0 and −40 yr, respectively. The large ΔR value for the eastern part of Hokkaido Island indicates the influence of the Oyashio Current, while an anomalous ΔR value was obtained from northern Hokkaido Island. These figures show larger apparent ΔR values than those from southwest Japan (Nakamura et al. 2007). The calibrated Jomon period in the investigated area was from 2000 to 200 yr younger than the previous chronology. Calibrated $^{14}C$ ages of the shellmounds investigated ranged between ~6000 and 3000 yr, correlating to the Early Jomon and Final Jomon periods as indicated by the former archaeological chronology of Honshu Island.

## INTRODUCTION

Archaeologists have employed numerous methods to determine the age of excavated sites. The study of archaeological timescales is very important, especially in classifying the time period of a culture and its correlation to other sites. After World War II, many Japanese people were taught that their prehistoric culture was classified into the Stone Age (Paleolithic and Neolithic), the Jomon period, and the Yayoi period. Archaeologists estimated that the beginning of the Jomon and the Yayoi should be dated to 4500 and 2500 BP, respectively.

The first reported radiocarbon age of archaeological samples in Japan was skeptically received. According to Crane and Griffin (1960), Sugihara and Serizawa from Meiji University submitted sent to the University of Michigan shell and charcoal samples collected from Natsushima shellmound, Yokohama. The shell samples were collected from the second or first cultural layer from the bottom of the mound, and designated Natsushima I. This assemblage was considered the earliest manifestation of the Jomon period, the earliest known ceramic culture in Japan (Serizawa 1959). The oyster shell sample was dated 9450 ± 400 BP (M-769) while the charcoal was 9240 ± 500 BP (M-770). Most Japanese archaeologists were surprised at this report and few believed in the accuracy of the dates. Many at that time continued to believe that the earliest Jomon period began ~4500 BP.

Some 40 yr later, $^{14}C$ dates from the earliest Jomon period have been revealed. The Odaiyamamoto I Site Excavation Team (1999) excavated a site in Kanita, Aomori Prefecture, named the Odai Yamamoto I site. At the site, they found several fragments of charcoal and pottery without cord-impressed patterns. Nakamura and Tsuji (1999) reported $^{14}C$ ages of charcoal samples accelerator mass spectrometry (AMS) dated at Nagoya University. The oldest calibrated date was given as 16,520 cal BP (Nakamura and Tsuji 1999; Nakamura et al. 2001). The age of this sample revealed that the pottery was the oldest known in Japan, preceding by 4500 yr the common view that prevailed among Japanese archaeologists at that time. Following the above report, the National

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Museum of History and Culture of Japan announced in March 2003 that the Yayoi period began 500 yr prior to the chronology accepted at the time. The $^{14}C$ dates of Nakamura and Tsuji (1999) were also verified at several AMS $^{14}C$ facilities in order to confirm their accuracy and reliability. The samples used for dating were from soot attached to pottery fragments collected mainly from Kyusyu Island (western Japan).

The $^{14}C$ dating method was introduced in Japan in the beginning of the 1960s; however, most Japanese $^{14}C$ laboratories reported their results without measuring isotope fractionations. This means that they reported not conventional ages but raw measured ages. Without isotope correction, we are unable either to report the correct $^{14}C$ age or to calibrate it to a calendar age. Archaeologists collected different kinds of materials from the same layer in the site and sent them for $^{14}C$ analysis. They expected to receive similar ages for materials collected from the same layer; thus, when they received unexpectedly different $^{14}C$ ages, they felt they could no longer trust $^{14}C$ ages.

Since W F Libby and his colleagues established the $^{14}C$ dating method in the late 1940s, many advances in $^{14}C$ dating techniques have been made. At present, it is possible to date carbon material as small as 1 mg with great precision by AMS $^{14}C$ dating. However, many Japanese archaeologists still prefer their own relative chronology instead of the calibrated $^{14}C$ ages. Recently, the situation has improved and more archaeologists are relying on AMS $^{14}C$ data. Considering this historical background, we strongly urge the use of AMS $^{14}C$ data and the correlation of classical archaeological chronology with calibrated $^{14}C$ ages to reconstruct a new archaeological chronology for northeastern Japan. In this paper, we report the results of our study carried out in the northern part of Japan.

## METHODS AND RESULTS

### Methods

Prehistoric people might have collected their food from not only hills and mountains but also lowlands, such as lagoons, rivers, lakes, and coasts. Many fish bones, empty shells, and other disposed items were dumped near their settlements. These places are usually called “shellmounds” and are very common sites in the Japanese Islands. The Japanese Islands face the Pacific Ocean, the Sea of Japan, the Sea of Okhotsk, and the East China Sea. Therefore, sample materials collected from the above coastal regions might have been subject to different environmental marine reservoirs. Without reservoir correction, we are unable to obtain correct ages or to construct an accurate chronology of archaeological sites. Fortunately, several reports exist with reference to reservoir correction around the Japanese Islands. To determine the reservoir correction of Hokkaido Island, 3 pairs of charcoal and marine samples were collected from the Asahi-Tokoro shellmounds, the Tenneru site (with shellmounds), and the Esan shellmounds. We also collected 2 pairs of charcoal and marine samples from the Sakiyama and Daigikakoi shellmounds in order to determine the reservoir correction on the east coast of Tohoku District. We used the marine data set of Hughen et al. (2004) to calculate the reservoir correction and the IntCal04 data set (Reimer et al. 2004) to calibrate conventional ages.

We calibrated 80 AMS $^{14}C$ dates from sites in NE Japan in order to establish a new chronology for the Jomon period. We also collected 43 samples from 5 shellmounds and 2 archaeological sites in Hokkaido Island, as well as from 4 shellmounds in the Tohoku District. See Figure 1 for details.

$^{14}C$ dating and measurements of isotope fractionation of collected materials from the above-mentioned sites were carried out at the Radiocarbon Dating Laboratory of Nihon University by the β-

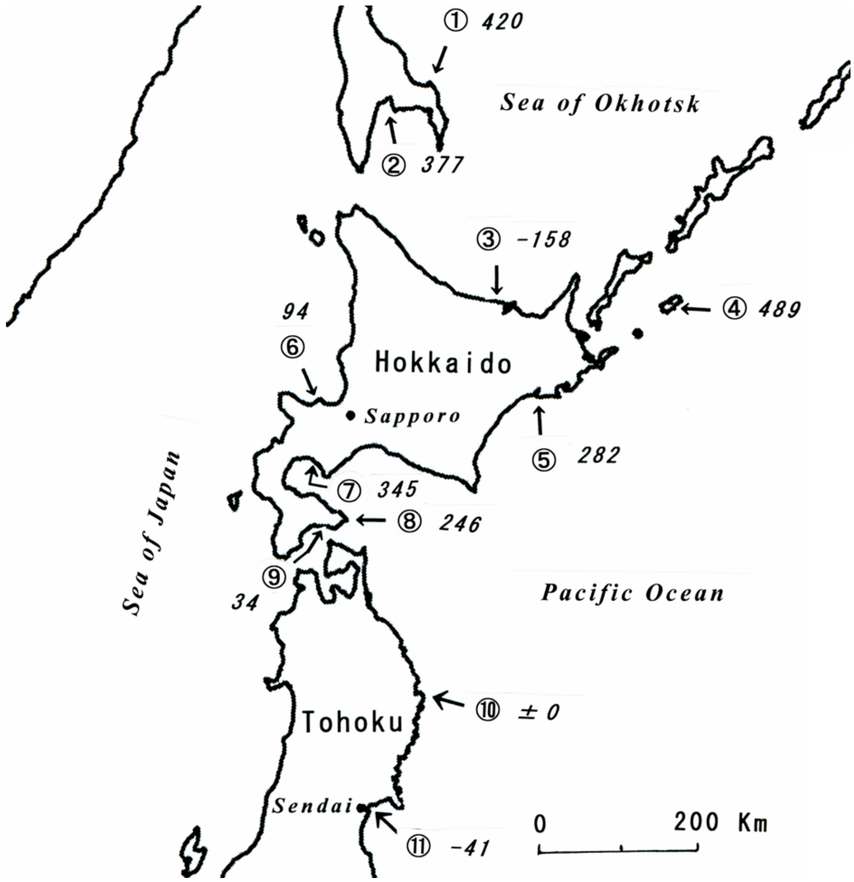


Figure 1 ΔR values given for Hokkaido Island and the Tohoku District. Five ΔR values were newly added to the sites of 3, 5, 8, 10, and 11. Other ΔR values in the figure were compiled from Kuzmin et al. (2007) and Yoneda et al. (2007). The ΔR value for location 3 is temporal (see text). Locations: 1. Svobodnaya, Sakhalin; 2. Gulf of Aniva, Sakhalin; 3. Asahi-Tokoro shellmounds, Kitami, Hokkaido; 4. Shikotan Island, Hokkaido; 5. Tenneru site, Kushiro-cho, Hokkaido; 6. Otaru, Hokkaido; 7. Kitakogane shellmounds, Ponma site, and Takasago shellmounds, Hunka Bay; 8. Esan shellmounds, Esan-cho, Hokkaido; 9. Hokuto site, Hakodate, Hokkaido; 10. Sakiyama shellmounds, Miyako, Iwate Prefecture; 11. Daigikakoi, Satohama, and Nishihata shellmounds, Sendai Bay.

counting method. The equipment used for β-counting were 4 fully automatic gas counting systems and one Quantulus 1220™ machine. In order to determine reservoir corrections for surveyed sites, 3 pairs of charcoal and marine samples were sent to Nagoya University for AMS $^{14}C$ dating. Isotope fractionations were measured by an IsoPrime mass spectrometer. We used NIST samples for checking the modern standard value, and IAEA and Oztech standard samples for isotope analysis. Sample pretreatments were carried out based on Omoto (1996). After isotope fractionation correction, ages of marine samples indicated very similar values.

## Results

Kuzmin et al. (2001) reported a ΔR of 711 ± 46 yr for Kunashir Island, northeast of Hokkaido, and pointed out the need for a greater value of reservoir correction for marine carbonates. More recently, Kuzmin et al. (2007) reported a ΔR value of 578 yr for eastern Sakhalin Island and the Lesser Kuriles. Yoneda et al. (2001) reported apparent age differences between Japanese deer and northern fur seals from 4500 to 800 BP with estimated ΔR values ~380 yr. Thereafter, Yoneda et al. (2004) reported a 720-yr reservoir correction based on marine organisms collected from the Kitakogane shellmounds, although they had reported a 860-yr ΔR value based on northern fur seals and Japanese deer. More recently, Yoneda et al. (2007) reported significant variability in ΔR for the western North Pacific and surrounding regions (Figure 1). The ΔR values of the East Sakhalin Current, which flows from north to south, was 399 yr, while the Oyashio Current, which flows east off of Hokkaido, was 392 yr. The Soya Current and Tsugaru Current, on the other hand, gave smaller ΔR values of 94 and 34 yr, respectively.

Comparisons of relative archaeological timetables with $^{14}$C ages have been made by several archaeologists. A $^{14}$C chronology based on archaeological materials collected from the prehistoric Japanese Islands was first reported by Watanabe (1963) who introduced 20 $^{14}$C dates measured in the USA. He stated that several $^{14}$C dates previously reported had included incomprehensible ages compared with the former theory of the Archaeological Association of Japan. The $^{14}$C chronology of the Jomon and Yayoi periods was also presented by Watanabe (1966) who classified the Jomon period of Hokkaido and Honshu into the Initial, Early, Middle, and Late; and Early, Middle, Late, and Final periods, respectively. He also pointed out an important discrepancy in which $^{14}$C ages indicated younger ages when compared with dendrochronological ages. After Keally and Muto (1982) reported the first comprehensive summary of the Jomon period with $^{14}$C dates, Kobayashi (2006) compiled previous reports and correlated the former chronological table of the Jomon period with AMS $^{14}$C data.

Coauthor Fukui has prepared a data set listing more than 100 AMS $^{14}$C dates collected mainly from research reports of the Hokkaido Archaeological Operation Center (Hokkaido Maizoubunkazai Center), Aomori Prefecture Archaeological Operation Center, research reports of the City and Town Board of Education in NE Japan, reports of a scientific grant-in-aid of the Monbukagakusho (Usuki 2007; Nishimoto et al. 2009), and archaeological publications (Kobayashi 2006, 2008). (See the Appendix for full references information.) The lead author compiled and calibrated these ages using the IntCal04 calibration data. The results are shown in Table 1. The beginning of the Jomon period listed in Table 1 is based on the charcoal samples collected from Odai Yamamoto I site, Aomori Prefecture, whose age was 16,520 cal BP (Nakamura and Tuji 1999).

## DISCUSSIONS

### Reservoir Correction

The studies of ΔR values around the Japanese Islands that were carried out by Yoneda et al. (2001, 2004, 2007) are highly regarded. However, there are no valuable data for both the Pacific and the Sea of Japan coast along the Tohoku District. We prefer to accept a ΔR value of 345 yr (Yoneda et al. 2004) rather than accepting the 380-yr (Yoneda et al. 2001) or 720-yr ΔR values (Yoneda et al. 2004) for the Kitakogane shellmounds along Hunka Bay, southern Hokkaido Island. They showed significant values for the sedentary marine organisms including porpoises and Japanese sea lions. However, porpoises, Japanese sea lions, and salmon often travel through oceans horizontally and vertically, and grow up eating many kinds of marine organisms. This means they have obviously been influenced by different marine reservoir environments and would indicate different older ages as compared with the ages of shallow water shells and fishes. Considering these ideas, we prefer not to use the 720-yr reservoir correction given for the Kitakogane shellmounds.

The ΔR value for the north coast of Hokkaido Island (Asahi-Tokoro shellmounds) indicated an anomalous negative value (−158 yr) compared with 377 yr (Yoneda et al. 2007), and 95 and 578 yr

Table 1 Division of the Jomon period based on calibrated ages of investigated sites in NE Japan. Full references are listed in the Appendix.

| Period | Site name | cal BP (med) | Conv. BP | Lab code | cal BP | Material[a] | "Shape" (design) | Ref.[b] |
|---|---|---|---|---|---|---|---|---|
| Incipient | Odai Yamamoto 1 | 16,023 | 13,480 ± 70 | Beta125550 | 16,000~16,270 | charred wood | fragment of pottery | 1 |
| | Taisyo 3 | 14,078 | 12,220 ± 40 | Beta194627 | 14,110~14,290 | Adh | nail-marked | 2 |
| Initial | Pitarupa | 9388 | 8410 ± 120 | Beta159070 | 9072~9559 | charred walnut | Akatuki | 3 |
| | Nakano B | 9031 | 8100 ± 90 | Beta101800 | 8655~9250 | charred walnut | Sumiyoshi-cho (Low) | 4 |
| | Tomino 3 | 8905 | 8040 ± 50 | Beta126225 | 8718~9034 | charred seed | Monomidai | 5 |
| | Taisyo 3 | 7994 | 7185 ± 35 | PLD11927 | 7935~8050 | charred wood | Urahoro | 6 |
| | Tomino 3 | 7826 | 6990 ± 50 | Beta126222 | 7700~7770 | charred wood | Higashikushiro II | 5 |
| | Taisyo 8 | 7881 | 7040 ± 40 | Beta226591 | 7790~7950 | carbide | Higashikushiro II, III | 7 |
| | Kiusu 7 | 7747 | 6910 ± 60 | Beta112927 | 7675~7810 | charred wood | Kottaro | 8 |
| | Yukanboshi E14 | 7604 | 6740 ± 50 | IAAA51502 | 7563~7673 | charred wood | Kottaro | 9 |
| | Toyooka 6 | 7525 | 6640 ± 40 | Beta150149 | 7497~7568 | charred wood | Nakacharo? | 10 |
| | Kamaya-cho 3 | 7239 | 6310 ± 60 | Beta152884 | 7200~7280 | charred wood | Higashikushiro IV | 11 |
| | Ohiwa 5 | 7353 | 6420 ± 50 | Beta186224 | 7315~7418 | charred wood | Ko-g lower | 12 |
| Early | Kikyo 2 | 6889 | 6040 ± 50 | Beta239903 | 6750~7000 | Adh | Kikyono | 13 |
| | Ohiwa 5 | 6581 | 5780 ± 50 | Beta186223 | 6529~6640 | charred wood | Ko-f lower | 12 |
| | Ryamunai 3 | 6084 | 5305 ± 30 | PLD3415 | 5990~6180 | charred walnut | Kasugacho | 14 |
| | Tenneru 1 | 5815 | 5085 ± 33 | IAAA62002 | 5740~5920 | charred wood | Higashikushiro V | 15 |
| | Kojohama 2 | 5817 | 5080 ± 40 | Beta150487 | 5737~5914 | charred wood | lower of cylinder-a | 16 |
| | Ohyasawanoda | 5815 | 5050 ± 40 | Beta119438 | 5804~5889 | carbonate | lower of cylinder-a | 17 |
| | Sannaimaruyama | 5508 | 4780 ± 70 | Beta127603 | 5465~5594 | carbonate | lower of cylinder-b | 17 |
| | Yamazaki 5 | 5514 | 4780 ± 50 | Beta150466 | 5447~5603 | carbonate | lower of cylinder-b | 18 |
| | Yamazaki 5 | 5506 | 4760 ± 50 | Beta150463 | 5446~5593 | carbonate | lower of cylinder-c | 18 |
| | Higashiyama 1 | 5407 | 4670 ± 50 | Beta174642 | 5344~5423 | charred wood | lower of cylinder-c? | 19 |
| | Sannaimaruyama | 5395 | 4640 ± 60 | Beta112351 | 5350~5466 | charred wood | lower of cylinder-d2 | 17 |
| Middle | Sannaimaruyama | 5400 | 4640 ± 50 | Beta112348 | 5374~5455 | charred wood | upper of cylinder-a | 17 |
| | Sannaimaruyama | 5403 | 4678 ± 40 | NUTA2-625 | 5343~5418 | Adh | upper of cylinder-b | 17 |
| | Tateno 4 | 5162 | 4520 ± 40 | IAAA51664 | 5046~5310 | charred wood | upper of cylinder-b | 20 |
| | Yukanboshi E14 | 5177 | 4560 ± 40 | IAAA51503 | 5049~5324 | charred wood | Saibesawa VI | 9 |
| | Sannaimaruyama | 5144 | 4469 ± 40 | NUTA2-623 | 5168~5278 | Adh | upper of cylinder-c | 17 |
| | Nigorikawa Sagan | 5122 | 4455 ± 30 | PLD3389 | 4976~5271 | charred wood | Saibesawa VII | 21 |
| | Yamakoshi 4 | 4970 | 4400 ± 40 | Beta160080 | 4876~5038 | charred wood | Saibesawa VII | 22 |
| | Sannaimaruyama | 5026 | 4420 ± 60 | Beta112340 | 4870~5051 | charred wood | upper of cylinder-d | 17 |
| | Ishikura 1 | 4903 | 4340 ± 25 | PLD12080 | 4849~4970 | charred wood | Miharashicho | 53 |
| | Kurachigawa R | 4921 | 4350 ± 40 | Beta174463 | 4840~5030 | charred wood | Miharashicho | 24 |
| | Yamakoshi 2 | 4845 | 4270 ± 40 | Beta150573 | 4825~4867 | charred wood | Miharasicho-Enokibayashi | 25 |
| | Sannaimaruyama | 4626 | 4100 ± 50 | Beta112344 | 4525~4647 | charred wood | Enokibayashi | 17 |
| | Tateno | 4680 | 4144 ± 63 | NU-1798 | 4521~4838 | charred wood | Enokibayashi | 2[c] |
| | Usujiri Pri. Sch. | 4717 | 4170 ± 25 | PLD4816 | 4615~4765 | charred wood | Oanzai B | 26 |
| | Tateno | 4548 | 4060 ± 40 | Beta186245 | 4430~4800 | charred wood | Oanzai B | 27 |
| | Asahitokoro | 4656 | 4125 ± 80 | NU-1788 | 4499~4838 | charred wood | E trench of Tokoro 10 | A,B |
| | Kashiwagigawa 13 | 4648 | 4120 ± 90 | IAAA190 | 4528~4711 | charred wood | Yoichi | 28 |
| | Kashiwagigawa 13 | 4747 | 4230 ± 100 | IAAA191 | 4514~5043 | charred wood | Yoichi | 28 |
| | Sannaimaruyama | 4340 | 3910 ± 50 | Beta186244 | 4285~4416 | charred wood | Saibana | 17 |
| | Asahitokoro | 4656 | 4125 ± 80 | NU-1788 | 4499~4838 | charred wood | Enokibayashi | 2[c] |
| | Toi shellmound | 4363 | 3930 ± 80 | MTC08754 | 4225~4525 | animal bone | Renngadai | 29 |
| Late | Sakaehama 2 | 4301 | 3880 ± 80 | Beta189375 | 4228~4418 | carbonized mat. | Tenyuji-Wakimoto | 30 |
| | Izumisawa 2 | 4081 | 3730 ± 50 | Beta149828 | 3920~4240 | carbide | Tenyuji-Wakimoto | 31 |
| | Yamazaki 4 | 4174 | 3790 ± 40 | Beta150577 | 4144~4236 | charred wood | Tenyuji? | 32 |
| | Zunashigawa | 4047 | 3710 ± 40 | Beta160418 | 3958~4155 | charred wood | Hokuto III Dateyama | 33 |
| | Zunashigawa | 4171 | 3790 ± 40 | Beta160419 | 4075~4296 | charred wood | Hokuto III Dateyama | 33 |
| | Zunashigawa | 4254 | 3840 ± 40 | Beta160420 | 4148~4411 | charred wood | Hokuto III Dateyama | 33 |
| | Ishikura 1 | 3947 | 3635 ± 30 | PLD12076 | 3865~4000 | charred wood | Wakimoto | 23 |
| | Sakaehama 1 | 3986 | 3660 ± 40 | Beta163072 | 3874~4090 | charred wood | Wakimoto | 34 |
| | Tenneru 1 | 4090 | 3736 ± 36 | IAAA61997 | 3980~4160 | charred wood | Hokuto V | 15 |
| | Sakaehama 1 | 3871 | 3570 ± 40 | Beta163071 | 3816~3978 | charred wood | Torisaki | 34 |
| | Kurachigawa R | 3843 | 3550 ± 40 | Beta174470 | 3710~3920 | charred wood | Torisaki | 24 |
| | Ishikura 1 | 3787 | 3525 ± 25 | PLD12080 | 3719~3880 | charred wood | Torisaki | 23 |
| | Uwadai 1 | 3561 | 3340 ± 40 | Beta186266 | 3486~3635 | charred wood | Ohtsu | 36 |

Table 1 Division of the Jomon period based on calibrated ages of investigated sites in NE Japan. Full references are listed in the Appendix. *(Continued)*

| Period | Site name | cal BP (med) | Conv. BP | Lab code | cal BP | Material[a] | Shape (design) | Ref.[b] |
|---|---|---|---|---|---|---|---|---|
| | Washinoki | 3562 | 3330 ± 40 | Beta213963 | 3470~3620 | soil | Shirasaka | 37 |
| | Usujiri Pri. Sch. | 3600 | 3360 ± 40 | Beta201633 | 3550~3690 | charred wood | Hokkema | 38 |
| | Nodaoi 1 | 3562 | 3330 ± 40 | Beta163044 | 3460~3650 | charred wood | Hokkema | 39 |
| | Usujiri Pri. Sch. | 3460 | 3245 ± 25 | PLD4817 | 3395~3490 | charred wood | Doubayashi | 40 |
| | Kiusu 4 | 3379 | 3150 ± 40 | Beta150594 | 3440~3640 | charred wood | Doubayashi | 41 |
| | Yahurai 7 | 3397 | 3170 ± 30 | IAAA51914 | 3349~3449 | charred wood | Doubayashi | 42 |
| | Hamanaka 2 | 3256 | 3035 ± 35 | PLD6457 | 3160~3355 | charred wood | Doubayashi? | 43 |
| | Karinba 3 | 3204 | 3002 ± 32 | NUTA2-5461 | 2996~3080 | varnish | Gotennyama | 44 |
| Final | Kawaratai 1 | 3136 | 2960 ± 30 | MTC06395 | 3060~3220 | Adh | Ohora B | 45 |
| | Namabuchi 2 | 3024 | 2890 ± 30 | PLD3201 | 2920~3110 | charred wood | Kaminokuni | 46 |
| | Tenneru 1 | 2989 | 2866 ± 35 | IAAA61996 | 2930~3070 | charred wood | older than Nusamai | 15 |
| | Tuishikari 2 | 2989 | 2685 ± 20 | PLD6631 | 2750~2845 | charred walnut | Hamanakaoomagari | 47 |
| | Namabuchi 2 | 2746 | 2610 ± 35 | PLD3208 | 2700~2790 | charred wood | Hamanakaoomagari | 46 |
| | Higashi9sen 6 | 2745 | 2610 ± 40 | Beta150884 | 2722~2763 | carbonized mat. | Tannetou L | 48 |
| | Higashi9sen 6 | 2576 | 2490 ± 40 | Beta150885 | 2349~2462 | carbonized mat. | Tannetou L | 48 |
| | Higashi9sen 6 | 2428 | 2390 ± 40 | Beta150886 | 2349~2462 | carbonized mat. | Tannetou L | 48 |
| | Tsuishikari 2 | 2426 | 2410 ± 25 | PLD3374 | 2350~2500 | charred walnut | Obora A | 49 |
| | Kamicharo | 2540 | 2455 ± 15 | PLD6831 | 2360~2550 | charred wood | Midorigaoka | 50 |
| Zoku-Jomon *(Post-Jomon)* | H37 Sakaemachi | 2093 | 2110 ± 70 | Beta90897 | 1991~2155 | carbonized mat. | Nimaibashi | 51 |
| | Esan shellmound | 2321 | 2300 ± 40 | PLD3157 | 2307~2357 | charred wood | Esan | 52 |
| | Tokorogawa-Kako | 2144 | 2150 ± 30 | IAAA52406 | 2109~2157 | charred wood | Utsunai IIa | 53 |
| | Esan shellmound | 1999 | 2040 ± 40 | Beta186174 | 1920~2116 | deer bone | Esan | 54 |
| | K435(2nd) | 1842 | 1900 ± 50 | Beta126132 | 1715~1947 | charred wood | KouhokuC2D | 55 |
| | K39 | 1682 | 1770 ± 30 | IAAA52375 | 1605~1745 | charred wood | KouhokuC2D | 56 |

[a]Adh = adhesive to the pottery fragments.
[b]See Appendix for full references information.
[c]Omoto, unpublished data.

Table 2 Results of ΔR determinations for the sites 3, 5, 8, 10, and 11 in Figure 1.

| Lab code | Material | $\delta^{13}C$ (‰) | Conv. age | cal terrestrial | Marine $^{14}C$[a] | ΔR (yr) | Remarks |
|---|---|---|---|---|---|---|---|
| **Asahi Tokoro shellmound** | | | | | | | |
| NUTA-14266 | Charcoal | –24.90 | 4031 ± 26[b] | 4482 ± 57 | 4341 | | NU-1788 |
| NUTA-14267 | *Meretrix lusoria* | 1.30 | 4183 ± 26 | | | –158 | NU-1789 |
| NU-1788 | Charcoal | –24.90 | 4135 ± 80 | 4656 ± 73 | 4475 | | NUTA-14266 |
| NU-1789 | *Crassostrea gigas* | 1.30 | 4197 ± 71 | | | –278 | NUTA-14267 |
| **Esan shellmound** | | | | | | | |
| Beta-186174 | Thighbone of deer | –23.50 | 2040 ± 40 | 1999 ± 54 | 2384 | | |
| Beta-186175 | Vertebrae of *Bothidae* | –13.00 | 2630 ± 40 | | | 246 | |
| **Tenneru site** | | | | | | | |
| IAAA-61997 | charred wood | –26.34 | 3736 ± 36 | | | | |
| IAAA-70583 | charred walnut | –27.53 | 3615 ± 32 | | | | |
| | Average | | 3666 ± 48[b] | 3997 ± 44 | 4004 | | |
| IAAA-70581 | Crassostrea gigas | –0.63 | 4256 ± 32 | | | 252 | |
| IAAA-70582 | Spipura solidissima | 1.01 | 4312 ± 32 | | | 308 | |
| NU-1787 | Mya (Arenomya) japonica Jay | –0.60 | 4290 ± 75 | | | 286 | |
| | Average | | 4286 ± 88 | | | 282 | |
| **Sakiyama shellmound** | | | | | | | |
| NUTA-14275 | Charcoal | –25.00 | 4926 ± 27[b] | 5642 ± 26 | 5296 | | |
| NUTA-14268 | *Anthocidaris crassipina* | –2.40 | 5296 ± 27 | | | ±0 | |
| **Daigikakoi shellmound** | | | | | | | |
| NUTA-14270 | Charcoal | –28.60 | 5001 ± 28[b] | 5726 ± 53 | 5370 | | |
| NUTA-14269 | *Crassostrea gigas* | 1.80 | 5329 ± 27 | | | –41 | |

[a]Marine median $^{14}C$ age.
[b]10 yr were extracted from each charcoal sample due to uncertainty of years lost by burning.

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(Kuzmin et. al 2007) given for the southern coast of Sakhalin. This suggests an influence of meteoric water or contamination of the sample material, or otherwise a result of $^{14}C$ dating by unsuitable paired samples. We then checked samples collected from the Asahi-Tokoro shellmounds and noticed that unsuitable paired samples might have caused such an anomalous figure. That is, a charcoal sample (NUTA-14266) was collected from E trench (E-113) in layer 5 on 20 October 1958, while a *Meretrix lusoria* (NUTA-14267) sample was collected from A Trench (A-19/20) in layer 6 on 23 October 1958. The charcoal sample was collected 10 cm below the shell layer. The authors consider the accumulated time lag between the charcoal and shell layers negligible. The age of *Meretrix lusoria* (4166 ± 26 BP: NUTA-142267) seems to show a reasonable age as the age is similar to sample NU-1789, 4197 ± 71 BP (Table 2). This results indicates that charcoal sample NUTA-14266 shows an obviously older age, which was quite reasonable because it was located at a lower layer than the shell layer. Thus, we conclude that the ΔR value of −158 yr for the north coast of Hokkaido Island is obviously anomalous and should be treated as temporal. However, we are unable to completely rule out the other 2 possibilities: i.e. the influence of meteoric water and contamination of sample materials.

We obtained ΔR values of 88 and 282 yr for the Esan shellmounds and Tenneru site, respectively (Table 2). These figures seem well matched with figures given for eastern Hokkaido and the southern part of Hokkaido (Hakodate) by Yoneda et al. (2007). We also used a ΔR of 282 yr for the east coast of Hokkaido instead of the 392 yr value (Yoneda et al. 2007), and we used a 254-yr value for the northern coast of Hunka Bay instead of 345 yr (Yoneda et al. 2004). The ΔR value was calculated based on ΔR values from the Tenneru site and Esan shellmounds. We calculated 0 yr and –40 yr of ΔR for the Sanriku coast and Sendai Bay, respectively. The figures were calculated from the data set of the Sakiyama and Daigikakoi shellmounds. The ΔR values for the investigated areas are summarized and shown in Table 2 and Figure 1. The large ΔR on the east and north of Hokkaido Island indicate the strong influence of the Oyashio Current. These results express apparently larger ΔR values than those of SW Japan reported by Nakamura et al. (2007).

### Calibrated Chronology of Sites in NE Japan

The beginning of the Jomon period was determined to be 16,520 cal BP, given for the age of Odai Yamamoto I site, but the original $^{14}C$ ages used for calibrations were 13,780 ± 170 (NUTA-6510) and 13,480 ± 70 (Beta-12550) (Nakamura and Tsuji 1999). The 16,520 cal BP (Nakamura and Tsuji 1999) date does not indicate a median provable age but only indicates the uppermost provable age. Considering our confidence in $^{14}C$ counting and standard deviation, we strongly propose using a median value of 16,020 cal BP instead of 16,520 cal BP.

The boundary ages of each Jomon period are given in Table 1 and determined mainly on the relative ages estimated by the characteristic shape and design of pottery excavated from the sites of NE Japan. The former chronological table for Hokkaido (Hokkaido Archaeological Operations Center 2009) was given with conventional ages. We calibrated about 80 AMS $^{14}C$ data sets related to the archaeological chronology for Hokkaido and the Tohoku District. The original data set was primarily based on charcoal or charred wood samples, and we used the IntCal04 program for calibration. After calibration, we found slight time shifts between the old and new timetables. The oldest site in Hokkaido is Taisyo-3, near Obihiro City, whose calibrated age was 14,078 cal BP (Beta-194627; Table 1). The pottery from Taisyo-3 was characterized with a "nail-marked" relief on it. It is generally accepted among Japanese archaeologists that the "nail-marked" design followed the "plain (non-marked)" pottery. Considering the climatic environment in the last glaciations, several hundred years of time lag might have occurred when the "nail-marked" design was transferred from Honshu to Hokkaido.

Table 3 Divisions of the Jomon period and their correlations with different regions in Japan. Correlations of Keally and Muto (1982), Sahara (1987), Yamamoto (2001), and Kobayashi and Nishimoto (2003) were reported by Kobayashi (2006).

| Divisions | Keally and Muto 1982 | Sahara 1987 | Yamamoto 2001 | Kobayashi and Nishimoto 2003 | Hokkaido[a] 2009 | This study |
|---|---|---|---|---|---|---|
| Incipient | 12,800 | 12,000 | — | 15,000 | 14,000 | 16,000 |
| Initial | 10,500 | 10,000 | — | 12,500 | 9000 | >10,000 |
| Early | 6900 | 6000 | 7150 | 7000 | 6000 | 7000 |
| Middle | 4500 | 5000 | 5350 | 5470 | 5000 | 5400 |
| Late | 3500 | 4000 | 4350 | 4420 | 4000 | 4300 |
| Final | 2700 | 3000 | 2950 | 3200 | 3000 | 3200 |
| Yayoi | 2550 | 2300 | 2650 | 2350 | — | 2400[b] |
| Region | Kyushu | — | Hokuriku | East Japan | Hokkaido | Hokkaido, Tohoku |

[a]Hokkaido Archaeological Operation Center.
[b]Beginning of the Post-Jomon period in Hokkaido.

According to the calibrated data set, the Incipient, Initial, Early, Middle, Late, and Final Jomon periods in Hokkaido and the Tohoku District dated 2000, 1000, 1000, 300, and 200 yr earlier, respectively, compared to the former chronological table (Table 3). In Honshu Island, the Post-Jomon period is called the Yayoi period, and is characterized by rice paddy crops in the alluvial lowland. However, Hokkaido Island was in a cold enough geographical zone to cultivate rice. The Post-Jomon culture in Hokkaido Island is therefore termed the Zoku Jomon (Post-Jomon). Calibrated dates suggest that the beginning of the Post-Jomon in Hokkaido Island was 2400 cal BP (Table 4). Dates in Table 4 range between about 6000 and 3000 cal BP and are correlative with the Early Jomon and Final Jomon periods as indicated by the former archaeological chronology of Honshu Island (Table 3).

Table 4 Calibrated ages of investigated sites in Hokkaido Island and Tohoku District.

| Code nr | Material[a] | $\delta^{13}C$ (‰) | Conv. age | cal BP[b] | ΔR[c] | cal BP[d] | Location |
|---|---|---|---|---|---|---|---|
| **Asahi Tokoro shellmound** | | | | | | | |
| NU-1788 | Charcoal | –24.52 | 4135 ± 80 | 4666 | — | — | E trench |
| NU-1789 | *Meretrix lusoria* | –0.12 | 4197 ± 71 | 4284 | –158 | 4502 | A trench |
| NU-1790 | *Meretrix lusoria* | –0.59 | 4052 ± 70 | 4082 | –158 | 4299 | A trench |
| NU-1791 | *Crassostrea gigas* | –0.05 | 4117 ± 70 | 4176 | –158 | 4387 | A trench |
| NU-1792 | *Crassostrea gigas* | –0.17 | 4124 ± 72 | 4186 | –158 | 4397 | B trench |
| NU-1793 | *Meretrix lusoria* | 1.92 | 4352 ± 59 | 4493 | –158 | 4699 | C trench |
| NU-1794 | *Crassostrea gigas* | –0.03 | 4179 ± 79 | 4261 | –158 | 4477 | C trench |
| NU-1804 | *Meretrix lusoria* | –0.05 | 4112 ± 60 | 4169 | –158 | 4380 | A trench |
| NU-1805 | *Meretrix lusoria* | –0.61 | 4146 ± 58 | 4223 | –158 | 4430 | A trench |
| NU-1806 | *Meretrix lusoria* | 0.97 | 4081 ± 70 | 4124 | –158 | 4336 | C trench |
| **Tenneru site** | | | | | | | |
| IAAA-61997 | charred wood | –26.34 | 3736 ± 36 | 4090 | — | — | |
| IAAA-70583 | charred walnut | –27.53 | 3615 ± 32 | 3925 | — | — | |
| IAAA-70581 | *Crassostrea gigas* | –0.63 | 4256 ± 32 | 4366 | 282 | 3975 | |
| IAAA-70582 | *Spipula solidissima* | 1.01 | 4312 ± 32 | 4443 | 282 | 4049 | |
| NU-1787 | *Mya (Arenomya) Japonica Jay* | –0.60 | 4290 ± 75 | 4409 | 282 | 4025 | |
| **Kitakogane shellmound** | | | | | | | |
| NU-1830 | *Crassostrea gigas* | 1.40 | 5813 ± 64 | 6232 | 254 | 5956 | No.17 Shell M. R36-3 |
| **Ponma site** | | | | | | | |
| NU-1829 | *Crassostrea gigas* | 1.61 | 4090 ± 70 | 4137 | 254 | 3792 | H-5-003 grid |

Table 4 Calibrated ages of investigated sites in Hokkaido Island and Tohoku District. *(Continued)*

| Code nr | Material[a] | δ13C (‰) | Conv. age | cal BP[b] | ΔR[c] | cal BP[d] | Location |
|---|---|---|---|---|---|---|---|
| **Takasago shellmound** | | | | | | | |
| NU-1832 | *Meretrix lusoria* | 2.44 | 4520 ± 72 | 4710 | 254 | 4374 | A table |
| **Esan shellmound** | | | | | | | |
| Beta-186174 | Japanese deer thighbone | –23.50 | 2040 ± 40 | 1999 | — | — | |
| Beta-186175 | Vertebrae of *Bothidae* | –13.00 | 2630 ± 40 | 2365 | 246 | 2015 | |
| **Hokuto site** | | | | | | | |
| NU-1795 | Charcoal | –25.31 | 4002 ± 69 | 4261 | — | — | H-1 |
| NU-1796 | Charcoal | –23.75 | 4201 ± 53 | 4726 | — | — | H-2 |
| NU-1797 | Charcoal | –23.91 | 4109 ± 70 | 4640 | — | — | H-5 |
| NU-1798 | Charcoal | –27.32 | 4144 ± 63 | 4680 | — | — | H-7 |
| **Sakiyama shellmound** | | | | | | | |
| NU-1811 | *Mytilus coruscus* | 0.36 | 4712 ± 70 | 4957 | ±0 | — | SMS-1S No.5G 011 |
| NU-1814 | *Anthocidaris crassipina* | –3.31 | 4835 ± 69 | 5127 | ±0 | — | SMS-2SU No.6G 064 |
| NU-1815 | *Mytilus coruscus* | 0.70 | 5158 ± 64 | 5517 | ±0 | — | SMS-3S No.5G 131 |
| NU-1816 | *Anthocidaris crassipina* | –3.58 | 4942 ± 62 | 5280 | ±0 | — | SMS-3SU No.5G 131 |
| NU-1817 | *Mytilus coruscus* | 0.69 | 5132 ± 64 | 5494 | ±0 | — | SMS-4S No.5G 249 |
| NU-1818 | *Anthocidaris crassipina* | –3.20 | 5098 ± 63 | 5459 | ±0 | — | SMS-4SU No.5G 249 |
| NU-1819 | *Mytilus coruscus* | 1.28 | 5338 ± 62 | 5726 | ±0 | — | SMS-5S No.3G 322 |
| NU-1820 | *Mytilus coruscus* | 1.43 | 5448 ± 73 | 5816 | ±0 | — | SMS-6A No.3G 331 |
| **Satohama shellmound** | | | | | | | |
| NU-1810 | *Crassostrea gigas* | 0.29 | 4338 ± 72 | 4477 | –41 | 4536 | Daikakoi 140-R2 |
| **Nishihata shellmound** | | | | | | | |
| NU-1828 | *Ruditapes philippinarum* | 0.08 | 3217 ± 67 | 3033 | –41 | 3088 | 42R1 |
| **Daigikakoi shellmound** | | | | | | | |
| NU-1821 | *Gemmula deshaysi* | 0.72 | 5238 ± 62 | 5602 | –41 | 5646 | CS77L14a |
| NU-1822 | *Turbo comatus coreensis* | 2.14 | 5243 ± 62 | 5608 | –41 | 5651 | CS77L14d |
| NU-1823 | *Crassostrea gigas* | 3.10 | 5239 ± 75 | 5604 | –41 | 5649 | CS77L14f |
| NU-1825 | *Ruditapes philippinarum* | 3.83 | 5282 ± 62 | 5646 | –41 | 5691 | CS77L6a |
| NU-1826 | *Turbo comatus coreensis* | 2.46 | 5275 ± 62 | 5639 | –41 | 5684 | CS77L6a |
| NU-1827 | *Meretrix lusoria* | 0.08 | 5263 ± 63 | 5628 | –41 | 5672 | CS77L6a |
| NU-1835 | *Crassostrea gigas* | 0.74 | 5529 ± 76 | 5916 | –41 | 5969 | CS77L15c |
| NU-1836 | *Turbo (Lunella)* | 2.47 | 5322 ± 62 | 5686 | –41 | 5734 | CS77 a 8d |
| NU-1837 | *Gemmula deshaysi* | 1.53 | 5291 ± 62 | 5655 | –41 | 5701 | CS77 a 10b |

[a]Species names in italics are marine shells or animals.
[b]Median value without ΔR correction.
[c]Italic letters indicate estimated ΔR value.
[d]Median value after ΔR correction.

Table 5 shows that very good agreement exists between the calibrated ages and estimated archaeological ages, except for the Ponma site. The calibrated age of Ponma site is 74 yr older than the estimated archaeological age (Table 4). This slight time shift may due to the estimated ΔR value (254 yr) given for the north coast of Hunka Bay, for which we need a more accurate ΔR value. It is now possible to correlate archaeological sites and events already reported with a newly constructed chronological timetable.

## CONCLUSION

Conventional ages of different kinds of marine samples give very similar results, irrespective of how the raw $^{14}C$ ages indicated different ages without isotope fractionation. This proves that isotope fractionation is indispensable in obtaining accurate ages and constructing chronological tables for the sites.

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Table 5 Comparison of the calibrated ages with relative archaeological ages of the investigated sites in NE Japan.

| Site name | Incipient | Initial | Early | Middle | Late | Final | Post-Jomon[a] |
|---|---|---|---|---|---|---|---|
| Start (cal BP) | 14,000 | 10,000 | 7000 | 5400 | 4300 | 3200 | 2400 |
| End (cal BP) | 10,000 | 7000 | 5400 | 4300 | 3200 | 2400 | — |
| Asahi Tokoro | | | | [b] | | | |
| Tenneru | | | | | [b] | | |
| Kitakogane | | | [b] | | | | |
| Takasago | | | | [c] | [d] | | |
| Ponma | | | | | [b] | | |
| Esan | | | | | | | [b] |
| Tateno | | | | [b] | | | |
| Sakiyama | | | [b] | [b] | | | |
| Satohama | | | | [b] | | | |
| Nishihata | | | | | | [b] | |
| Daigikakoi | | | [b] | | | | |

[a]Hokkaido Island only.
[b]Indicates calibrated age coincident with archaeological age.
[c]Indicates calibrated age.
[d]indicates estimated archaeological age.

The ΔR values for Hokkaido Island and the Tohoku District ranged between 282 and −158 yr (temporal data) and between ±0 and –40 yr, respectively. The large ΔR values for eastern Hokkaido Island indicate the strong influence of the Oyashio Current, while the negative ΔR value for the northern coast of Hokkaido Island indicates anomalously low values, suggesting the influence of meteoric water or contamination of sample material, or are the result of $^{14}$C dating by unsuitable paired samples. We believe unsuitable paired samples might have caused the anomalous figures. However, we are unable to contradict completely the 2 causes discussed. The ΔR values given for Hokkaido Island indicate apparently larger local reservoir collections than those of SW Japan reported by Nakamura et al. (2007). We need to collect new paired samples in order to determine the correct ΔR values for north of Hokkaido Island and north of Hunka Bay, southern Hokkaido Island.

The calibrated Incipient, Initial, Early, Middle, Late, and Final Jomon periods in Hokkaido Island and the Tohoku District were set 2000, 1000, 1000, 400, 300, and 200 yr earlier, respectively, compared with the former chronological table (Hokkaido Archaeological Operations Center 2009). The calibrated ages of collected samples from archaeological sites on Hokkaido and the Tohoku District ranged between about 6000 and 3000 yr, correlative with the Early Jomon and Final Jomon periods as indicated by the archaeological chronology of Honshu Island.

In order to reconstruct a precise archaeological chronology for NE Japan, we need more accurate data related to the reservoir corrections and calibrated $^{14}$C data for archaeological sites in the investigated areas. AMS $^{14}$C data will undoubtedly contribute to the development of archaeological studies. Therefore, we strongly recommend reporting calibrated $^{14}$C data for archaeological studies.

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## REFERENCES

Crane HR, Griffin JB. 1960. University of Michigan radiocarbon dates V. *Radiocarbon* 2:31–48.

Hokkaido Maizoubunkazai Center [Hokkaido Archaeological Operations Center]. 2009. Chosa Nenpou 21: Hokkaido Maizou-bunkazai Center [Annual Research Reports 21: *Hokkaido Archaeological Operations Center*]. In Japanese.

Hughen KA, Baillie MGL, Bard E, Beck JW, Bertrand CJH, Blackwell PG, Buck CE, Burr GS, Cutler KB, Damon PE, Edwards RL, Fairbanks RG, Friedrich M, Guilderson TP, Kromer B, McCormac G, Manning S, Bronk Ramsey C, Reimer PJ, Reimer RW, Remmele S, Southon JR, Stuiver M, Talamo S, Taylor FW, van der Plicht J, Weyenmeyer CE. 2004. Marine04 marine radiocarbon age calibration, 0–26 cal kyr BP. *Radiocarbon* 46(3):1059–86.

Keally CT, Muto Y. 1982. Jomon jidai no nendai [Dating of the Jomon period]. In: Kato S, Kobayashi T, Fujimoto T, editors. *Jomon bunka no kenkyu*. Volume 1. Tokyo: Yuzankaku. p 246–75. In Japanese.

Kobayashi K. 2006. Jomon jidai kenkyu ni okeru tanaso14 nendaisokutei. Kokuritu Rekishiminzoku Hakubutsukan Kenkyuhokoku [Radiocarbon dating in archaeological studies of the Jomon period]. *Reports of the National Museum of Japanese History* 133:51–69. In Japanese.

Kobayashi K. 2008. Soran jomondoki [Superintendence of the Jomon pottery]. Tokyo: AMU Promotion. 1322 p. In Japanese.

Kobayashi K, Nishimoto T. 2003. Nendai ga wakaruto rekishikan ga kawaru: Jomon jidai no kouseido hennen: Tokubetsutenji-zuroku. Rekishi wo saguru science. Kokuritu Rekishi Minzoku Hakubutukan [Radiometric ages change historical view points: high accuracy chronology of Jomon period. Special exhibition display: Science helps us understand our ancient history]. Tokyo: National Museum of Japanese History. In Japanese.

Kuzmin YV, Burr GS Jull AJT. 2001. Radiocarbon reservoir correction ages in the Peter the Great Gulf, Sea of Japan, and eastern coast of the Kunashir, southern Kuriles (northwestern Pacific). *Radiocarbon* 43(2A): 477–81.

Kuzmin YV, Burr GS, Gorbunov SV, Rakov VA, Razjigaeva NG. 2007. A tale of two seas: reservoir age correction values ($R$, $\Delta R$) for the Sakhalin Island (Sea of Japan and Okhotsk Sea). *Nuclear Instruments and Methods in Physics Research B* 259(1):460–2.

Nakamura T, Tsuji S. 1999. Aomori-ken Kanita-cho Odaiyamamoto I iseki kara hakkutsusareta biryo dokihuchakubutsu no AMS $^{14}C$ nendai. Sekkijidai no syuryo to Jomon bunka no kaishi no gimon heno kaito: Odaiyamamoto I iseki hakkutsu chosadan hensyu [AMS $^{14}C$ age of extremely small quantities of carbonized materials adhered to the surface of pottery fragments excavated from the Odaiyamamoto I site, Kanita town, Aomori Prefecture]. In: Odaiyamamoto I Site Excavation Team. *Investigations of the End of Paleolithic Culture and the Beginning of the Jomon Cultur*e. p 107–11. Tokyo: Odaiyamamoto I Site Excavation Team. In Japanese.

Nakamura T, Taniguchi Y, Tsuji S, Oda H. 2001. Radiocarbon dating of charred residues on the earliest pottery in Japan. *Radiocarbon* 43(2B):1129–38.

Nakamura T, Nishida I, Takada H, Okuno M, Minami M Oda H. 2007. Marine reservoir effect deduced from $^{14}C$ dates on marine shells and terrestrial remains at an archaeological site in Japan. *Nuclear Instruments and Methods in Physics Research B* 259(1):453–9.

Nishimoto T, Fujio S, Kobayashi K, Ozaki H, Imamura M, Miyata Y. 2009. Yayoi noukouno kigento higashi ajia–Tansonendai niyoru koseidohennentaikeino kouchiku: Kenkyuseikahokokusyo. Heisei 16~20 nen monbukagakusyo kagakukenkyuhihojokin gakujutusoseikenkyuhi [The origin of Yayoi cultivation and East Asia—The construction of a highly accurate chronological system by $^{14}C$ dating. Report of Grant–in-Aid for Creative Scientific Research]. p 146–57.

Odaiyamamoto I Site Excavation Team, editors. 1999. *Odaiyamamoto I iseki no kouko-gaku chosa—Kyusekki bunka no syumatsu to Jomon bunka no kigen ni kansuru mondai no tankyu* [Investigations of the End of Paleolithic Culture and the Beginning of the Jomon culture]. Tokyo: Odaiyamamoto I Site Excavation Team. 144 p. In Japanese.

Omoto K. 1996. *Nihon daigaku nendaisokutei manual* [Radiocarbon dating manual for Nihon University]. Department of Geography, College of Humanities and Sciences, Nihon University. 102 p. In Japanese.

Reimer PJ, Baillie MGL, Bard E, Bayliss A, Beck JW, Bertrand CJH, Blackwell PG, Buck CE, Burr GS, Cutler KB, Damon PE, Edwards RL, Fairbanks RG, Friedrich M, Guilderson TP, Hogg AG, Hughen KA, Kromer B, McCormac G, Manning S, Bronk Ramsey C, Reimer RW, Remmele S, Southon JR, Stuiver M, Talamo S, Taylor FW, van der Plicht J, Weyhenmeyer CE. 2004. IntCal04 terrestrial radiocarbon age calibration, 0–26 cal kyr BP. *Radiocarbon* 46(3):1029–58.

Sahara M. 1987. *Taikei Nihon no rekishi* [A schema of Japanese history]. Tokyo: Syogakukan. 350 p. In Japanese.

Serizawa C. 1959. Nihon saiko no bunka to doki no kigen [The oldest Japanese culture and origin of pottery]. *Kagaku* 29(8):404–8. In Japanese.

Usuki I. 2007. Hokkaido niokeru kodai kara kinsei no iseki no rekinendai: Kagakukenkyuhihojokin seikahokokusyo Kagakukenkyuhihojokin kibankenkyu kenkyuuseikahokokusyo [Report of calendar age from ancient to modern times related to sites of Hokkaido]. *Report of Grant–in-Aid for Scientific Research* (B2). 99 p. In Japanese.

Watanabe N. 1963. Nihon sensijidai ni kansuru $^{14}$C nendai siryou [Radiocarbon dates of archaeological materials from prehistoric Japan]. *The Quaternary Research* 2(6):232–40. In Japanese with English abstract.

Watanabe N. 1966. Jomon oyobi Yayoi jidai no $^{14}$C nendai [Radiocarbon dates of the Jomon and Yayoi periods in Japan]. *The Quaternary Research* 5(3–4):157–68. In Japanese with English abstract.

Yamamoto N. 2001. 2000 Nen no gakkaidoko. Kanren kagakukenkyu. nendaisokutei. Jomon jidai kenkyukai [Trend of academic activity in 2000, related scientific studies and $^{14}$C dating]. *Jomon Jidai* 12:222–4. In Japanese.

Yoneda M, Hirota M, Uchida M, Uzawa K, Tanaka A, Shibata Y, Morita M. 2001. Marine radiocarbon reservoir effect in the western North Pacific observed in archaeological fauna. *Radiocarbon* 43(2A):465–71.

Yoneda M, Shibata Y, Morita M, Hirota M, Suzuki R, Uzawa K, Ohshima N, Dodo Y. 2004. Interspecies comparison of marine reservoir ages at the Kitakogane shell midden, Hokkaido, Japan. *Nuclear Instruments and Methods in Physics Research B* 223–224:376–81.

Yoneda M, Uno H, Shibata Y, Suzuki R, Kumamoto Y, Yoshida K, Sasaki T, Suzuki K, Kawahata H. 2007. Radiocarbon marine reservoir ages in the western Pacific estimated by pre-bomb molluscan shells. *Nuclear Instruments and Methods in Physics Research B* 259(1):432–7.

## APPENDIX: REFERENCES FOR TABLE 1 (ALL IN JAPANESE)

1.Nakamura T, Tsuji S. 1999. Aomori-ken Kanita-cho Odaiyamamoto I iseki kara hakkutsusareta biryo dokihuchakubutsu no AMS $^{14}$C nendai. Sekkijidai no syuryo to Jomon bunka no kaishi no gimon heno kaito: Odaiyamamoto I iseki hakkutsu chosadan hensyu [AMS $^{14}$C age of extremely small quantities of carbonized materials adhered to the surface of pottery fragments excavated from the Odaiyamamoto I site, Kanita town, Aomori Prefecture]. In: *Odaiyamamoto I Site Excavation Team. Investigations of the End of Paleolithic Culture and the Beginning of the Jomon Culture*. p 107–11. Tokyo: Odaiyamamoto I Site Excavation Team. In Japanese.

2.Geo-Science Laboratory. 2006. Housyaseitanso nendaisokuteihokoku: Obihiro, Taisyo isekigun 2. Obihiro-shi kyouikuiinnkai [$^{14}$C dating report of Taisyo 2 sites, Obihiro City, Hokkaido]. In: *Research Report of Buried Cultural Property of Taisyo 2 sites*. Obihiro City Board of Education. p 437–45.

3.Shin Engineering Consultants. 2002. Pitarupa isekiniokeru housyaseitanso nendaisokutei: Pitarupa iIseki. Monbetsu-cho Kyoikuiinkai [$^{14}$C age of Pitarupa sites, Monbetsu Town, Hokkaido]. In: *Pitarupa sites*. Monbetsu Town Board of Education. p 92–4.

4.Geo-Science Laboratory. 1998. Housyaseitannso niyoru nendaisokuteikekka: Hakodate-shi Nakano B iseki. Hokkaido Maizobunkazai Center Chousa Houkokusyo [Report of $^{14}$C dating of Nakano B sites, Hakodate City, Hokkaido]. *Research Report 120 of Hokkaido Archaeological Operations Center*. p 599–600.

5.Geo-Science Laboratory. 1999. Tomino 3 isekino housyaseitanso nendaisokuteikekka: Osyamanbe-cho Tomino 3 iseki. Hokkaido Maizobunkazai Center Chousa Houkokusyo [Report of $^{14}$C dating of Tomino 3 sites, Osyamanbe Town, Hokkaido]. *Research Report 131 of Hokkaido Archaeological Operations Center*. p 281–6.

6.Nishimoto T, Fujio S, Kobayashi K, Ozaki H, Imamura M, Miyata Y. 2009. Yayoi noukouno kigento higashi ajia Tansonendai niyoru koseidohennentaikeino kouchiku: Kenkyuseikahokokusyo. Heisei 16~20 nendo monbukagakusyo kagakukenkyuhihojokin gakujutusoseikenkyuhi [The origin of Yayoi cultivation and East Asia—The construction of a highly accurate chronological system by $^{14}$C dating]. *Report of Grant–in-Aid for Creative Scientific Research*. p 148–9.

7.Geo-Science Laboratory. 2008. Housyaseitanso nendaisokuteikekka: Obihiro Taisyo isekigun 3. Obihiro-shi Kyoikuiinkai [Report of $^{14}$C dating of Taisyo 3 sites, Obihiro City, Hokkaido]. In: *Research Report of Buried Cultural Property of Taisyo 3 sites*. Educational Board of Obihiro City. p 351–5.

8.Geo-Science Laboratory. 1998. Kiusu iseki: Housyaseitanso nendaisokuteikekka hokokusyo: Chitose-shi Kiusu 7 iseki (5). Hokkaido Maizobunkazai Center Chousa Houkokusyo [Report of $^{14}$C dating Kiusu sites 7(5), Chitose City, Hokkaido]. *Research Report 127 of Hokkaido Archaeological Operations Center*. p 233–4.

9.Palynosurvey Co. 2006. Yukanboshi E14 iseki syutsudohinno sizenkagakubunseki: Yukanboshi E14 iseki.

Eniwa-shi Kyoikuiinkai [Scientific analysis of excavated materials collected from Yukanboshi E14 sites, Eniwa City, Hokkaido]. In: *Yukanboshi E14 sites*. Eniwa City Board of Education. p 85–6.

10. Palynosurvey Co. 2001. Toyooka 6 isekiniokeru housyaseitanso nendai ($^{14}C$) sokutei: Kitahiyama-cho Toyooka 6 iseki. Kitahiyama-cho Kyouikuiinnkai [$^{14}C$ dating of Toyooka 6 sites, Kitahiyama Town, Hokkaido]. In: *Toyooka 6 site, Kitahiyama Town*. Kitahiyama Town Board of Education. p 136–8.

11. Tsuji S. 2001. Kamayacho 3 isekino higashikushiro IVsikidokihougansoukara sanshita mokutan housyasei-tansonendai: Kamayacho 3 iseki. Toi-cho Kyouikuiinnkai [$^{14}C$ age of charcoal sample excavated from Kamaya 3 sites, (Higashikushiro IV type pottery), Kamaya Town, Hokkaido]. In: *Kamaya 3 sites*. Toi Town Board of Education. p 40.

12. Geo-Science Laboratory. 2004. $^{14}C$ nendai: Shikabe-cho Ohiwa 5 iseki. Hokkaido Maizobunkazai Center Chousa Houkokusyo [Report of $^{14}C$ age of Ohiwa 5 sites of Shikabe-cho, Hokkaido]. *Research Report 201 of Hokkaido Archaeological Operations Center*. p 31–5.

13. Paleoenvironment Research Institute. 2008. Kikyo 2 iseki niokeru housyaseitanso nendaisokutei: Hakodateshi Kikyo 2 iseki [$^{14}C$ dating report of Kikyo 2 sites, Hakodate City, Hokkaido]. In: *Kikyo 2 sites*. Hakodate City Board of Education. p 148–50.

14. AMS $^{14}C$ Dating Group of Paleoenvironment Research Institute. 2005. Housyaseitanso nendaisokutei: Kyowacho Ryamunai 3 iseki (1). Hokkaido Maizobunkazai Center Chousa Houkokusyo [$^{14}C$ dating report of Ryamunai 3 site, Kyowa Town, Hokkaido]. *Research Report 220 of Hokkaido Archaeological Operations Center*. p 73–4.

15. Institute of Accelerator Analysis. 2008. Housyaseitanso nendaisokuteikekka: Kushirocho Tenneru 1 iseki. Hokkaido Maizobunkazai Center Chousa Houkokusyo [Report of $^{14}C$ dating Tenneru 1 sites, Kushiro Town, Hokkaido]. *Research Report 254 of Hokkaido Archaeological Operations Center*. p 311–24.

16. Geo-Science Laboratory. 2001. Housyaseitanso nendai ($^{14}C$) sokutei: Shiraoicho Kojohama 2 iseki. Hokkaido Maizobunkazai Center *Chousa Houkokusyo* [$^{14}C$ dating report of Kojohhama 2 site of Shiraoi Town, Hokkaido]. *Research Report 158 of Hokkaido Archaeological Operations Center*. p 167.

17. Tsuji S, Nakamura T. 2001. Jomonjidai no kouseidohennen: Sannaimaruyamaisekino Nendaisokutei. Daiyonki Kenkyu [A high accuracy chronology of the Jomon era: $^{14}C$ dating of Sannaimaruyama sites]. *The Quaternary Research* 40(6):471–84.

18. Geo-Science Laboratory. 2002. Housyaseitanso nendaisokuteikekka: Yakumocho Yamazaki 5 iseki. Hokkaido Maizobunkazai Center Chousa Houkokusyo [$^{14}C$ dating report of Yamazaki 5 sites, Yakumo Town, Hokkaido]. *Research Report 165 of Hokkaido Archaeological Operations Center*. p 465–76.

19. Paleoenvironment Research Institute. 2004. Iwanai-cho Higashiyama 1 isekiniokeru housyaseitanso nendaisokuteikekka: Iwanai-cho Higashiyama 1 iseki. Iwanai-cho Kyoikuiinkai [$^{14}C$ dating report of Higashi-yama 1 sites Iwanai Town, Hokkaido]. In: *Higashiyama 1 sites*. Iwanai Town Board of Education. p 198–200.

20. Institute of Accelerator Analysis. 2008. Tateno 4 iseki housyaseitanso (AMS) sokuteikekka: Hokuto-shi Yafurai 6 iseki, Yafurai 11 iseki, Tateno 4 iseki. Hokkaido Maizobunkazai Center Chousa Houkokusyo [Report of $^{14}C$ dating of Yafurai 6, 11 sites and Tateno 4 sites, Hokuto City, Hokkaido. *Research Report 235 of Hokkaido Archaeological Operations Center*. p 155–7.

21. AMS $^{14}C$ Dating Group of Paleoenvironment Research Institute. 2007. Nigorikawa sagan iseki no housyaseitanso nendaisokutei nituite: Nigorikawa sagan iseki (3). Hokkaido Maizobunkazai Center Chousa Houkokusyo [$^{14}C$ dating report of left bank of Nigorigawa River 3 sites, Mori Town, Hokkaido]. *Research Report 246 of Hokkaido Archaeological Operations Center*. p 225–8.

22. Geo-Science Laboratory. 2002. Yamakoshi 3・4 iseki kara syutsudoshita tankabutsuno housyaseitanso nenndaisokutei: Yakumocho Yamakoshi 3, 4 iseki. Hokkaido Maizobunkazai Center Chousa Houkokusyo [$^{14}C$ age of carbonate material excavated at Yamakoshi 3 and 4 sites, Yakumo Town, Hokkaido]. *Research Report 166 of the Hokkaido Archaeological Operations Center*. p 222–7.

23. Geo-Science Laboratory. 2010. Housyaseitanso nendaisokutei: Mori-machi Ishikura 1 iseki. Hokkaido Maizo-bunkazai Center Chousa Houkokusyo [Report of $^{14}C$ dating of Ishikura 1 sites, Mori Town, Hokkaido]. *Research Report 266 of the Hokkaido Archaeological Operations Center*.

24. Geo-Science Laboratory 2004. Housyaseitanso nendaisokutei: Moricho Kurachikawa ugan iseki. Hokkaido Maizobunkazai Center Chousa Houkokusyo [$^{14}C$ report of the right bank site of Kurachigawa River, Mori Town, Hokkaido]. *Research Report 196 of Hokkaido Archaeological Operations Center*. p 309–11.

25. Geo-Science Laboratory. 2002. Yamakoshi 2 iseki housyaseitanso nendaisokuteikekka: Yakumo-cho Yamakoshi 2 iseki. Hokkaido Maizobunkazai Center Chousa Houkokusyo [$^{14}C$ report of Yamakoshi 2 sites, Yakumo Town, Hokkaido]. *Research Report 163 of Hokkaido Archaeological Operations Center*. p 167–70.

26. Nishimoto T, Fujio S, Kobayashi K, Ozaki H, Imamura M, Miyata Y. 2009. Yayoi noukouno kigento higashi ajia—Tansonendainiyoru kouseidohennentaikeino kouchiku—Kenkyuseikahoukokusyo. Heisei 16~20 nen Monbukagakusyo kagakukenkyuhihojokin gakujutusouseikenkyuhi [The origin of Yayoi cultivation and East Asia—Construction of a highly accurate chronological system by $^{14}C$ dating]. *Report of Grant-*

*in Aid for Creative Scientific Research*. p 146–7.

27. Geo-Science Laboratory. 2007. Housyaseitanso niyoru nendaisokutei: Hokuto-shi Tateno iseki (1). Hokkaido Maizobunkazai Center Chousa Houkokusyo [$^{14}$C report of Tateno 1 sites, Hokuto City, Hokkaido]. *Research Report 237 of the Hokkaido Archaeological Operations Center*. p 177–82.
28. Palynosurvey Co. 2003. Tankazaino nendaisokuteito jushidoutei: Kashiwagikawa 13, 14 iseki II. Eniwa-shi Kyouikuiinkai [$^{14}$C dating of charred wood and the identification of material collected from Kashiwagi 13, 14(II) sites, Eniwa City, Hokkaido]. In: *Kashiwagi 13(II) sites*. Eniwa City Board of Education. p 32.
29. Nishimoto T, Fujio S, Kobayashi K, Ozaki H, Imamura M, Miyata Y. 2009. Yayoi noukouno kigento higashi ajia—Tansonendainiyoru kouseidohennentaikeino kouchiku—Kenkyuseikahoukokusyo. Heisei 16~20 nen Monbukagakusyo kagakukenkyuhihojokin gakujutusouseikenkyuhi [The origin of Yayoi cultivation and East Asia—construction of a highly accurate chronological system by $^{14}$C dating]. *Report 152 of Grant-in Aid for Creative Scientific Research*. p 53.
30. Geo-Science Laboratory. 2004. Sakaehama 2, 3 isekinoikoukara kensyutusareta tankazaino housyaseitanso nendaisokutei: Sakaehama 2, 3 iseki. Yakumo-cho Kyoikuiinkai—$^{14}$C dating of charred wood excavated at Sakaehama 2 and 3 site, Yakumo Town, Hokkaido. In *Sakaehama 2 and 3 sites*. Yakumo Town Board of Education]. 349–54.
31. Geo-Science Laboratory. 2003. Juukyoshi yukamenyori kensyutsusareta tankabutsuno housyaseitanso nendaisokutei: Izumisawa 2 iseki A chiten: Fizumisawa 2 iseki. Kikonai-cho Kyoikuiinkai [$^{14}$C dating of carbonate material excavated from the floor of a settlement at Izumisawa 2 sites, Kikonai Town, Hokkaido. In: *Izumisawa 2 sites*. Kikonai Town Board of Education]. 248–52.
32. Geo-Science Laboratory. 2001. Housyaseitanso nendaisokuteikekka: Yakumo-cho Yamazaki 4 iseki. Hokkaido Maizobunkazai Center *Chousa Houkokusyo* [Research report of $^{14}$C dating Yamazaki 4 sites, Yakumo Town, Hokkaido]. *Research Report 162 of Hokkaido Archaeological Operations Center*. p 353–60.
33. Geo-Science Laboratory. 2002. Dai 1gou juukyoshikara syutsudoshita tankazaihen no housyaseitansonendai-sokutei: Zunashigawa iseki III. Furano-shi Kyoikuiinkai [$^{14}$C dating of charred wood pieces excavated at No.1 settlement of Zunashigawa sites III, Furano City, Hokkaido]. In: *First Settlement Sites of Zunashigawa sites III*. Furano City Board of Education. p 62–6.
34. Geo-Science Laboratory. 2002. Yakumocho Sakaehama 1 iseki housyaseitanso nendaisokuteikekkahokoku: Yakumo-cho Sakaehama 1 iseki. Hokkaido Maizobunkazai Center Chousa Houkokusyo [Report of $^{14}$C dating of Sakae-machi 1 sites, Yakumo Town, Hokkaido]. *Research Report 175 of Hokkaido Archaeological Operations Center*. p 207–10.
35. Geo-Science Laboratory. 2004. Housyaseitanso nendaisokutei: Mori-cho Kurachigawa ugan iseki. Hokkaido Maizobunkazai Center Chousa Houkokusyo [Report of $^{14}$C dating of the right bank site of Kurachigawa River, Mori Town, Hokkaido]. In: *Research Report 196 of Hokkaido Archaeological Operations Center*. p 309–11.
36. Geo-Science Laboratory. 2005. Housyaseitanso nendaisokutei: Mori-cho Uwadai 1 iseki. Hokkaido Maizo- bunkazai Center Chousa Houkokusyo [$^{14}$C dating report of Uwadai 1 sites, Mori Town, Hokkaido]. *Research Report 217 of the Hokkaido Archaeological Operations Center*. p 219–21.
37. Geo-Science Laboratory. 2008. Housyaseitanso nendaisokutei: Washinoki iseki. Mori-cho kyouikuiinkai [$^{14}$C dating report of Washinoki sites, Mori Town, Hokkaido]. In: *Excavation Report of Buried Cultural Property of Washinoki sites*. Mori Town Board of Education. 164 p.
38. $^{14}$C dating Group of National Museum of Japanese History. 2006. Hokkaido Hakodate-shi Usujiri shogakko isekisyutsudo tankabutsuno $^{14}$C nendaisokutei: Usujiri shogakko iseki. Hakodate-shi Kyoikuiinkai [$^{14}$C dating of carbonate samples excavated at Usujiri Primary School, Hakodate City, Hokkaido]. In: *Excavation Report of Buried Cultural Property of Usujiri Primary School*. Hakodate City Board of Education. p 237–41.
39. Geo-Science Laboratory. 2003. Nodaoi 1 isekikara syutsudosita tankabutsuno housyaseitanso nendaisokutei: Yakumo-cho Nodaoi 1 iseki. Hokkaido Maizobunkazai Center Chousa Houkokusyo [$^{14}$C dating of carbonate material excavated at Nodaoi 1 sites, Yakumo Town, Hokkaido]. *Research Report 183 of Hokkaido Archaeological Operations Center*. p 167–71.
40. Nishimoto T, Fujio S, Kobayashi K, Ozaki H, Imamura M, Miyata Y. 2009. Yayoi noukounokigen to higashi ajia—Tansonendai niyoru kouseidohennentaikeino kouchiku—Kenkyuseikahoukokusyo. Heisei 16~20 nen Monbukagakusyo kagakukenkyuhihojokin gakujutusouseikenkyuhi [The origin of Yayoi cultivation and East Asia—construction of a highly accurate chronological system by $^{14}$C dating]. *Report of Grant-in Aid for Creative Scientific Research*] 146–7.
41. Geo-Science Laboratory. 2003. Housyaseitanso nendaisokutei: Chitose-shi Kiusu 4 iseki (9). Hokkaido Maizo-bunkazai Center Chousa Houkokusyo [$^{14}$C dating report of Kiusu 4 sites, Chitose City, Hokkaido]. *Research Report 180 of the Hokkaido Archaeological Operations Center*. p 125–30.
42. Institute of Accelerator Analysis. 2006. Housyaseitanso niyoru nendaisokuteikekka hokokusyo: Hokuto-shi Yahurai 7 iseki · Yahurai 8 iseki. Hokkaido Maizobunkazai Center Chousa Houkokusyo [$^{14}$C dating report of Yahurai 7 sites, Hokuto City, Hokkaido]. *Research Report 223 of Hokkaido Archaeological Operations Center*. p 215–22.

43.Nishimoto T, Fujio S, Kobayashi K, Ozaki H, Imamura M, Miyata Y. 2009. Yayoi noukouno kigento higashi ajia Tansonendainiyoru kouseidohennentaikeino kouchiku—Kenkyuseikahoukokusyo. Heisei 16~20 nen Monbukagakusyo kagakukenkyuhihojokin gakujutusouseikenkyuhi [The origin of Yayoi cultivation and East Asia—construction of a highly accurate chronological system by $^{14}C$ dating]. *Report of Grant-in Aid for Creative Scientific Research*. p 156–7.
44.Shin Engineering Consultants. 2004. Karinba 3 iseki syutsudosiryono housyaseitanso nendaisokutei kekka: Karinba 3 iseki (3). Eniwa-shi Kyoikuiinkai [$^{14}C$ dating report of Karinba 3 sites, Eniwa City, Hokkaido]. In: *Karinba 3 sites*. Eniwa City Board of Education. p 217–8.
45.$^{14}C$ Dating Group of National Museum of Japanese History. 2006. Kawaradai (1) iseki syutsudo dokihuchaku-butsu no $^{14}C$ nendaisokutei: Kawaradai (1), (4) iseki, Ohkawazoe (2) iseki, Minakami iseki. Aomori-ken Maizobunkazai Center Chousa Houkokusyo [$^{14}C$ dating report of carbonized materials adhered to the surface of pottery excavated at Kawaradai 1 sites]. In: *Report 409 of Kawaradai 1 and 4 sites, Ohkawazoe 2 and Minakami sites, Aomori Prefecture*. Aomori Prefecture Archaeological Operations Center. p 39–46.
46.Paleoenvironment Research Institute. 2005. Kitahiyamacho Namabuchi 2 isekino housyaseitanso nendaisokutei kekka: Kitahiyamacho Namabuchi 2iIseki. Hokkaido Maizobunkazai Center *Chousa Houkokusyo* [$^{14}C$ dating report of Namabuchi 2 sites of Kitahiyama Town, Hokkaido]. *Research Report 214 of Hokkaido Archaeological Operations Center*. p 85–91.
47.AMS $^{14}C$ Dating Group of Paleoenvironment Research Institute. 2007. Housyaseitanso nendaisokutei: Tuishikari 2 iseki (9). Hokkaido Maizobunkazai Center Chousa Houkokusyo [$^{14}C$ dating report of Tuishikari 2 sites (9), Ebetsu City, Hokkaido]. *Research Report 240 of Hokkaido Archaeological Operations Center*. p 110–31.
48.Geo-Science Laboratory. 2001. Tankazaihen no housyaseitanso nendaisokutei nituite: Higashi 9 sen 6 iseki. Furano-shi Kyoikuiinkai [$^{14}C$ dating of charred wood collected from Higashi 9 Sen sites, Furano City, Hokkaido]. In: *Higashi 9 Sen sites*. Furano City Board of Education. p 119–23.
49.AMS $^{14}C$ Dating Group of Paleoenvironment Research Institute. 2005. Housyaseitanso nendaisokutei: Ebetsushi Tuishikari 2 iseki (6). Hokkaido Maizobunkazai Center Chousa Houkokusyo [$^{14}C$ dating report of Tuishikari 2 sites (6), Ebetsu City, Hokkaido]. *Research Report 215 of Hokkaido Archaeological Operations Center*. p 51–5.
50.AMS $^{14}C$ Dating Group of Paleoenvironment Research Institute. 2007. Housyaseitanso nendaisokutei: Kamicharo iseki. Hokkaido Maizobunkazai Center Chousa Houkokusyo [$^{14}C$ dating report of Kamicharo sites, Shiranui Town, Hokkaido]. *Research Report 245 of Hokkaido Archaeological Operations Center*. p 83–6.
51.Paleoenvironment Research Institute. 1998. 7-4 H37 iseki Sakaemachi chiten no housyaseitanso nendaisokuteinituite: H37 iseki Sakaemachi chiten. Sapporo-shi Kyoikuiinkai [$^{14}C$ dating of akaemachi H37 sites of Sapporo City]. In: *Research Report 57 of Cultural Property of Sapporo City*. Sapporo City Board of Education. p 128–9.
52.Paleoenvironment Research Institute. 2005. Housyaseitanso nendaisokutei: Esan kaizuka II. Juyouisekino kakuninnotameno hakkutsuchosa Hokokusyo. Hokkaido Maizobunkazai Center Chousa Houkokusyo [$^{14}C$ dating report of Esan shellmound II, Esan Town, Hokkaido]. In: *Research Report 5 for Confirmation of Important Sites*. Hokkaido Archaeological Operations Center. p 69–72.
53.Usuki I. 2007. Hokkaido niokeru kodaikara kinseino isekino rekinendai: Kenkyuseikahokokusyo. Monbukagaku-syo kagakukenkyuhojokin kibankenkyu [Calendar age of human ruins from ancient times to modern times in Hokkaido Island]. *Report of Grant-in-Aid for Scientific Research* (B) (2):28.
54.Geo-Science Laboratory. 2004. $^{14}C$ nendaisokutei: Esancho Esan Kaizuka. Juyouisekino kakuninnotameno hakkutsuchousa Hokokusyo. Hokkaido Maizobunkazai Center Chousa Houkokusyo [$^{14}C$ dating report of Esan shell mounds, Esan Town, Hokkaido. In: *Research Report 4 for Confirmation of Important Sites*. Hokkaido Archaeological Operations Center. p 76–8.
55.Paleoenvironment Research Institute. 2000. 5-6 K435 isekino housyaseitanso nendaisokutei: K435 iseki Dai2ji chosa. Sapporo-shi Kyoikuiinkai [$^{14}C$ dating of K435 site, Sapporo City (the 2nd research)]. In: *Research Report 63 of Cultural Property of Sapporo City*. Sapporo City Board of Education. p 37–8.
56.Usuki I. 2007. Hokkaido ni okeru kodaikara kinseino isekino rekinendai: Kenkyuuseikahokokusyo. Monbukagakusyo kagakukenkyuhojokin kibankenkyu [Calendar age of human ruins from ancient times to modern times in Hokkaido Island]. *Report of Grant-in-Aid for Scientific Research* B) (2):99.
A.Kigoshi K. 1963. Tokoro iseki syutsudohin no $^{14}C$ sokutei (Ohotsukukai engan・Shiretoko-hantou no Iseki) [$^{14}C$ measurement of excavated material from Tokoro site (Sites along Okhotsk Sea and Shiretoko Peninsula)]. Johkan. College of Literature, University of Tokyo. p 247–9.
B.Komai K. 1963. Asahitokoro kaizuka (Ohotsukukai engan・Shiretoko-hantou no Iseki) [Asahitokoro shellmound (Sites along Okhotsk Sea and Shiretoko Peninsula)]. Johkan. College of Literature, University of Tokyo. p 1–223.