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Distribution of Albatross Remains in the Far East Regions during the Holocene, Based on Zooarchaeological Remains

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ABSTRACT—Many albatross remains have been found in the Japanese Islands and the surrounding areas, such as Sakhalin and South Korea. These remains are interesting for two reasons: numerous sites from which albatross remains have been found are located in coastal regions of the Far East where no albatrosses have been distributed recently, and there are some sites in which albatross remains represent a large portion of avian remains, although albatrosses are not easily preyed upon by human beings. We collected data on albatross remains from archaeological sites in the Far East regions during the Holocene and arranged the remains geographically, temporally and in terms of quantity. Based on these results, we showed that coastal areas along the Seas of Okhotsk and Japan have rarely been used by albatrosses in Modern times, though formerly there were many albatrosses. We proposed two explanations for the shrinkage of their distributional range: excessive hunting in the breeding areas, and distributional changes of prey for albatrosses.

Key words: zooarchaeological remain, albatross, Holocene, Far East, avian biogeography

INTRODUCTION

Some zooarchaeological remains of albatrosses (Diomedeidae) have been found at archaeological sites in the northern and eastern Pacific coastal regions of the Aleutian Islands and the northwest coast of North America (Yesner, 1976; Porcasi, 1999a). Based on these remains, hypothetical distributions and abundances of albatrosses during the late Holocene were proposed (Yesner, 1976; Porcasi, 1999a). Albatross remains have also been found in the Japanese Islands and the surrounding areas, such as Sakhalin and South Korea (e.g. Ohba and Ohi, 1976; Nishimoto, 2000; the Rebun Town Board of Education, 2000a). The quantity of remains is much higher there than in the northern and eastern Pacific coastal regions (Yesner, 1976; Porcasi, 1999a). There has been, however, no paleo-ecological research about albatross remains in western Pacific coastal regions, because these excavation reports focused only on human paleo-ecology.

From the perspective of albatross paleo-ecology, albatross remains from archaeological sites in the Far East are interesting for two reasons. The first is that numerous sites at which albatross remains have been found are located in coastal regions of the Far East where albatrosses do not presently occur (e.g. Ohba and Ohi, 1976; Nishimoto, 2000; the Rebun Town Board of Education, 2000a). This suggests that the distributional areas of albatrosses have shrunk in Far Eastern regions recently. The second is that there are some sites in which albatross remains represent more than 70% of the avian remains (e.g. Ohba and Ohi, 1976; Nishimoto, 2000; the Rebun Town Board of Education, 2000a). Albatrosses occur on the open sea except for the breeding season, and are not easily preyed upon by human beings. Thus, finding such large concentrations of remains implies that albatrosses were captured by ancient people because many albatrosses inhabited areas near human dwellings. Alternatively, albatrosses were very important resources, even if they were not easily obtained. Why ancient peoples obtained so many albatross is not clear, but they used albatrosses as materials for bone tools, and might have eaten albatrosses and used their feathers as materials for clothes and/or arrows (Eda and Higuchi, unpublished data). The history of the distributional change of albatrosses remains obscure, because when, where and how many albatrosses were obtained by ancient people is not clear.

For this paper, we collected data on albatross remains from Holocene archaeological sites in Far Eastern regions, such as the Japanese Islands, Sakhalin and South Korea. Then, we analyzed the remains geographically, temporally

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and in terms of quantity. Based on these results, we estimated and compared the Holocene and recent distributions of albatrosses, in order to show the degree of range contractions. Finally, we discuss why and when their range sizes diminished.

MATERIALS AND METHODS

Zooarchaeological remains of Diomedeidae are easily identified to the level of family, by the comparison of adequate osteological specimens because of their distinctive, large long bones (Gilbert *et al*., 1996). On the other hand, identification to species within the family, namely of Short-tailed (*Phoebastria albatrus*), Laysan (*P. immutabilis*) and Black-footed Albatross (*P. nigripes*) in the Far East, has not been elucidated, since identification criteria based on sufficient numbers of osteological specimens have not published (see also Yesner, 1976; Porcasi, 1999b). Although some remains have been reported as Short-tailed or Black-footed Albatrosses, these identifications are uncertain and not testable. In other excavation reports and papers, albatross remains have been reported as Diomedeidae and have not been classified into genera or species. Therefore, in this paper, we arrange the records of zooarchaeological albatross remains at family levels. We also discuss the identification criteria of albatross.

We gathered the excavation reports and papers dealing with archaeological sites in Far Eastern regions to identify archaeological sites in which at least one albatross bone was reported. On Japanese archaeological sites, we referred to the zooarchaeological database of Yamasaki (1998) and Oikawa (2001). At each site at which albatross remains were found, we recorded the geographical location, the period of time, the numbers of identified specimens of albatross remains (Albatross NISP), the minimum numbers of their individuals (Albatross MNI), and the proportion all bird remains comprised of albatross bones (NISP%). In the results, however, we reported only Albatross NISPs and NISP% for easier descriptions, because the two indicators of NISP and MNI were highly correlated (r=0.93, N=112, P<0.001). To determine seasonality of those remains, we also recorded whether the bones were fused or unfused, and whether they included medullary bones or not.

Concerning the time periods of sites, archaeological or historical ages were adopted according to the type of historical materials that were accompanied with the albatross remains, since absolute ages have not been given to a large number of sites by radiocarbon dating. Each archaeological or historical age is assigned a mean (and range) BP (years before present) based on Fujimoto (1988), Utagawa (1988) and Harunari (1999). If a site included more than one cultural age and the remains were reported separately, the albatross remains from two cultural ages were dealt with as if they had come from different sites.

Concerning the number of identified specimens of albatross remains (NISP) in each site, Diomedeidae bones identified from an exact anatomical position, such as the right humerus, the left ulna and the right seventh rib, were counted. The proportion of bird remains in each site which were albatross remains (NISP%) was calculated by dividing NISPs of albatrosses by NISPs of birds and multiplying by 100. The NISP% was used to determine the percentage of albatrosses exploited by ancient people in comparison to the total number of birds exploited among sites, without bias due to differences in the duration of human occupation, quality of bone preservation, sampling precision, or other differences between the excavated areas. As for the statistical analyses, we used sites that yielded at least 10 NISPs of all avian bones in order to avoid the risk of sampling error due to too narrow a sample of excavated areas and/or poorly preserved bones.

The archaeological sites in question were divided and arranged into four ocean coastal areas: the coastal areas of the Sea of Okhotsk, the Sea of Japan, the Pacific and the East China Sea. This is because albatrosses are often observed in the Pacific and the East China Sea, but rarely observed in the Seas of Okhotsk and Japan (Shuntov, 1972; Higuchi *et al*., 1996; Tickell, 2000) , and straits are likely to limit the distributional range of albatrosses.

To test the geographical differences in NISP%s among the four ocean coastal areas and sub-regions, the two-tailed Kruskall-Wallis test or the Mann-Whitney U test were performed. When Kruskall-Wallis tests showed significant differences, multiple comparisons were performed as in Dunn (1964). Temporal differences of NISP%s in the studied area were tested by the two-tailed Kruskall-Wallis test and Dunn's method with the two span partitioning approaches: archaeological or historical ages and a thousand years before present.

RESULTS

Albatross zooarchaeological remains have been reported from 143 of more than 6,000 sites in Far Eastern regions (about 2.4% of all studied sites, Fig.1, Appendix 1). The total number of albatross remains was more than 7,000. As for quantitatively investigated sites, 65.4±20.3 (range: 1-1414, N=112) albatross remains have been identified. There have been no records of unfused albatross bones, nor of medullary bones in albatross remains, although there have been some records for other birds (The Archaeological Research Center of Tokyo-Prefecture, 1996; Nishimoto, 2000).

The sites in which albatross remains were found were distributed between northern Sakhalin and the southern Ryukyu Islands, from 30 to 35 degrees north latitude. The number of the sites within each of the four coastal areas was, respectively, 20 (15%) along the Sea of Okhotsk, 46 (32%) along the Sea of Japan, 69 (48%) along the Pacific, and 8 (5%) along the East China Sea (Fig. 1). The total numbers of the albatross NISP were, respectively, 398 (5%), 4489 (61%), 2421 (33%) and 20 (0.3%).

The NISP% was significantly different among the four areas (H=13.44, P<0.01, $N_{Okhotsk}$=14, N_{Japan}=28, $N_{Pacific}$=38, $N_{East\ China}$=5). There was a significant difference between the ocean coastal areas of the Sea of Japan and those of the Pacific (Q=3.67, P<0.01). Temporally, the above sites were distributed from the Earlier Jomon (BP 10,000-6,000) to the Edo period (BP350-80). There was a significant difference in the NISP% among all archaeological or historical age units (H=22.85, P<0.01, $N_{Jomon\ Earlier\text{-}Middle}$=10, $N_{Jomon\ Late\text{-}Later}$=25, N_{Yayoi}=2, $N_{Epi\ Jomon}$=4, $N_{Satsumon}$=4, $N_{Okhotsk}$=20, N_{Ainu}=8, $N_{Kofun\text{-}Edo}$=7). In the multiple comparisons, there was a significant difference between the Okhotsk and the Early to Middle Jomon period (Q=3.91, P<0.01). There was also a significant difference in the NISP% among all thousand year units (H=19.30, P<0.01, $N_{>5000}$=7, $N_{>4000}$=3, $N_{>3000}$=22, $N_{>2000}$=6, $N_{>1000}$=27, $N_{<1000}$=20). There was a significant difference between after 1,000 BP and before 5,000 BP (Q=3.71, P<0.01).

Detailed accounts for each of the four areas are as follows.

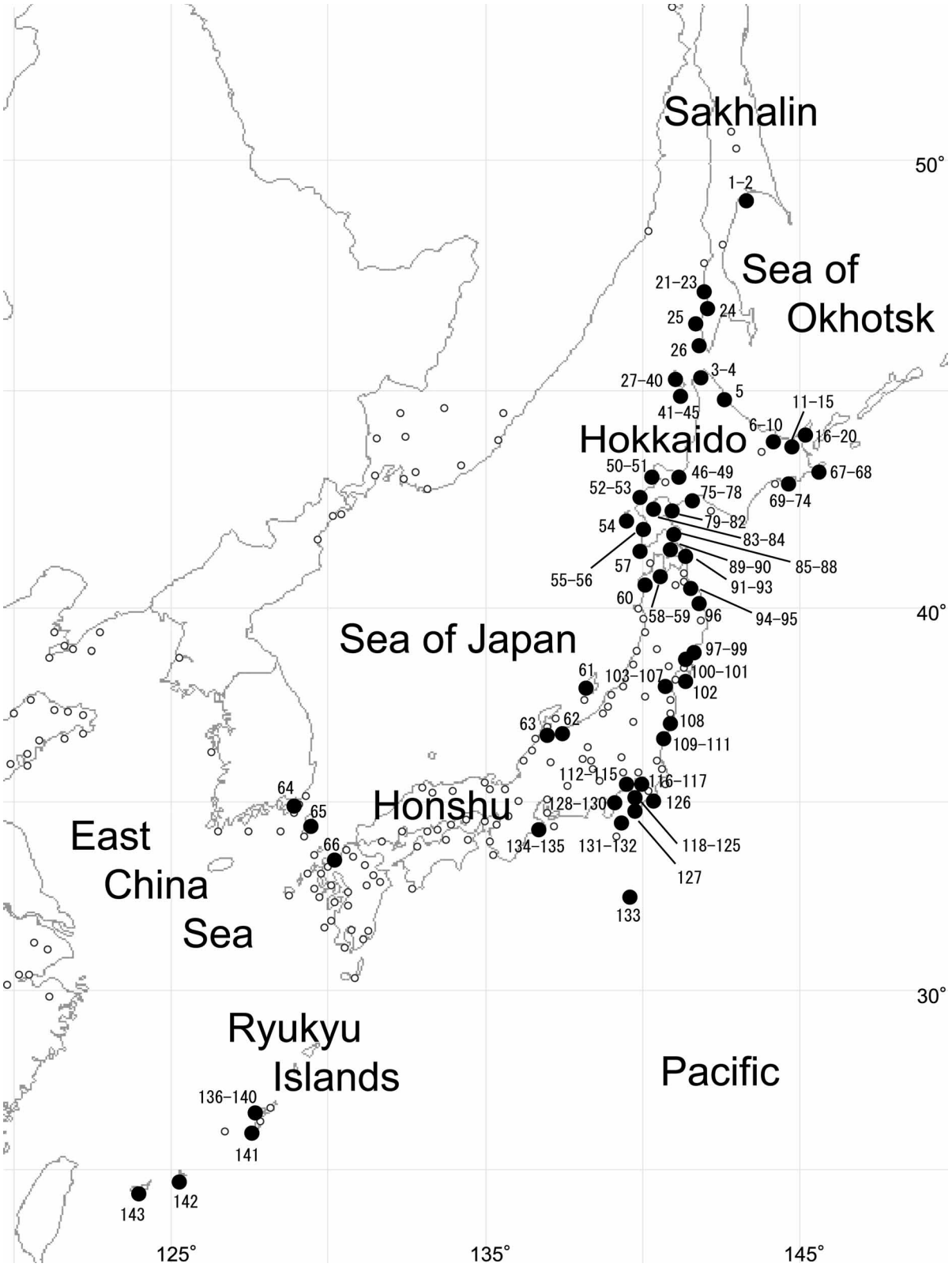

Fig. 1. The geographical distribution of archeological sites at which albatross remains were found (●) and not found (○). Numbers correspond to those in the Appenndix 1. Note that most circles represent more than one site.

The Sea of Okhotsk area (1-20 in Fig. 1)

These 20 sites were distributed between the Middle Jomon (BP 4,600-3,800) and the Ainu period (BP600-100) (Fig. 2a, Appendix 1). Most of the sites (90%) were included in the period BP 1,500 to 600 (the Okhotsk and the Satsumon period) or from BP 600 to 100 (the Ainu period). There were no records of albatross remains during BP 3,800 to 2,000. The total number of albatross remains reached 398, and the mean ± s.e. is 22.1±11.6 (range: 1-176, N=18) per site (Fig. 2a). Most albatross remains were found at the Onkoromanai (3 in Fig. 1, 176 specimens) and the Menashidomari sites (5 in Fig. 1, 133 specimens) in northern Hokkaido. The two sites belong to the Okhotsk period. Except for these, there were less than 10 NISPs in most sites. The mean NISP% was 23.2±6.8 s.e. (range: 1.3–85.7%, N=14) in this area (Fig. 3a). The NISP% of the Promyslovoe 2 (1 in Fig. 1) and the Menashidomari sites (5 in Fig. 1) were much higher than the average (85.7% and 70.4%, respectively).

The Sea of Japan area (21-66 in Fig. 1)

These 46 sites were distributed continuously between the Early Jomon (BP 6,000-4,600) and the Ainu period (BP600-100) (Fig. 2b, Appendix 1). The sites were divided into the four sub-regions for the sake of convenience: the coastal regions of 1) Sakhalin, 2) Hokkaido, 3) northern Honshu, and 4) southern Honshu and the Korean peninsula. About 65% of the sites were distributed to as far as the Hokkaido region (30 sites) and more than half of them were distributed around Rebun and Rishiri Islands (65% of them, 19 sites). The total number of albatross remains reached 4489, and the average was 132.0±52.8 s.e. (range: 1-1414, N=34) per site (Fig. 2b). Particularly, many albatross remains were found at archaeological sites on Rebun Island, in northern Hokkaido: the Kafukai 5 (36 in Fig. 1, 1414 specimens, the Okhotsk period), the Hamanaka 2 site Ha point (34 in Fig.

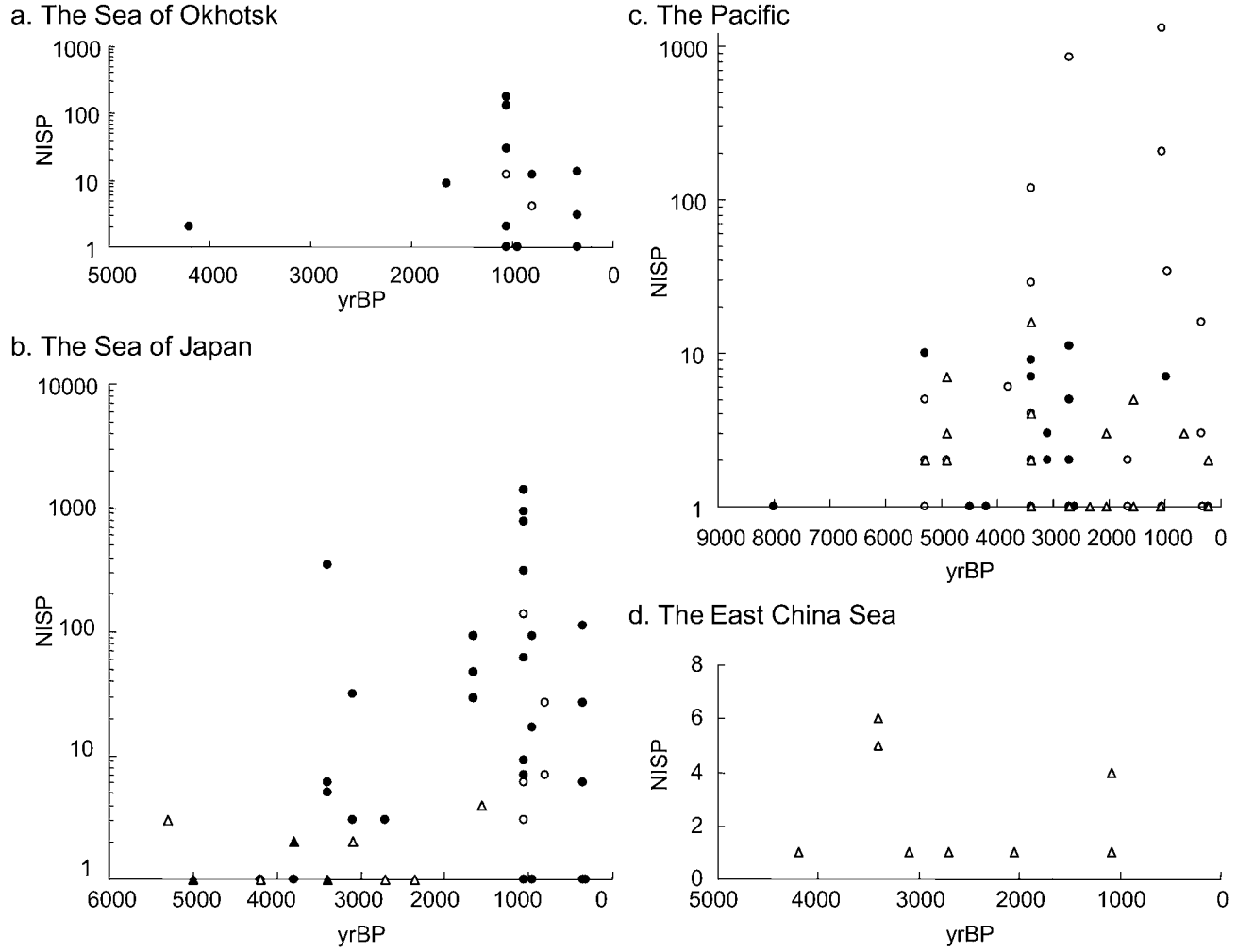

Fig. 2. The temporal change in numbers of albatross remains (NISP) in each coastal area: (a) the Sea of Okhotsk (○: Eastern Sakhalin, ●: Eastern Hokkaido), (b) the Sea of Japan (○: Western Sakhalin, ●: Western Hokkaido, △: North Western Honshu, (c) the Pacific (○: Southern Hokkaido, ●: North Eastern Honshu, △: South Eastern Honshu), and (d) the East China Sea. Each point represents NISPs of each archaeological site. Excluding the East China Sea region, each area is divided into two or three sub-regions for convenience. NISPs in the sites where descriptions of remains were not reported quantitatively count as one.

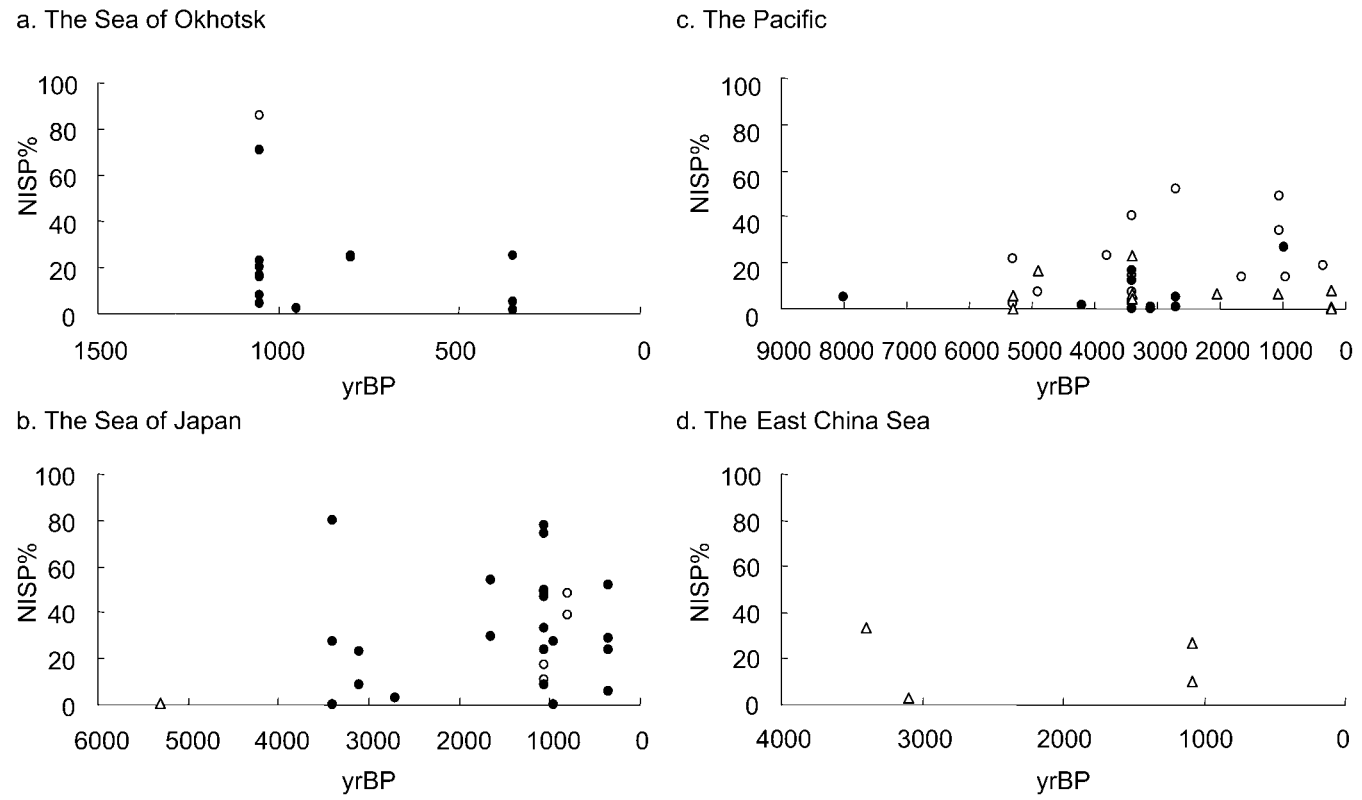

Fig. 3. The temporal change in proportion of albatross remains represented in all bird remains (NISP%) in each coastal area: (a) the Sea of Okhotsk (○: Eastern Sakhalin, ●: Eastern Hokkaido), (b) the Sea of Japan (○: Western Sakhalin, ●: Western Hokkaido, △: North Western Honshu, (c) the Pacific (○: Southern Hokkaido, ●: North Eastern Honshu, △: South Eastern Honshu), and (d) the East China Sea. Each point represents NISP%s in each archaeological site. Except tor the East China Sea region, each area is divided into two or three sub-regions for convenience. Considering sampling errors, NISP%s are shown for sites where more than ten avian remains were found (see text for details).

1, 926 specimens, the Okhotsk period), the Kafukai A (38 in Fig. 1, 771 specimens, the Okhotsk period), the Funadomari (27 in Fig. 1, 342 specimens, the Late Jomon period) and the Kafukai 6 sites (33 in Fig. 1, 306 specimens, the Okhotsk period). Except for the above northern islands' sites at most 20 albatross remains were found at most sites. The mean NISP% was 30.5±4.4 s.e. (range: 0.05-79.5%, N=28) in this area (Fig. 3b). Geographically, most calculated NISP%s were from the Hokkaido and the Sakhalin region sites because of a lack of quantitative description or too small a sample size in other sub-region sites. Between the NISP%s of the Sakhalin and those of the Hokkaido region sites, there were no significant differences (U=52.50, P>0.05, $N_{Sakhalin}$=5, $N_{Hokkaido}$=22). The NISP%s of the Funadomari (79.5%), the Hamanaka 2 site Ha point (77.8%) and the Kafukai 6 sites (74.3%) were much higher than the average.

The Pacific area (67-135 in Fig. 1)

The 69 sites were distributed continuously from the Earlier Jomon (BP 10,000-6,000) to the Edo period (BP400-100) (Fig. 2c, Appendix 1), and the oldest albatross remains have been recorded in this area. The sites were conveniently divided into three sub-regions: the coastal regions of Hokkaido, northern Honshu and southern Honshu. These three sub-regions occupied about one third of the sites, respectively. The total number of albatross remains reached 2,393, and the mean was 46.6±25.6 s.e. (range: 1-1046, N=52) per site (Fig. 2c). Most albatross remains were found in the northern Hokkaido region: the Benten-jima (67 in Fig. 1, 1,046 specimens, the Okhotsk period), the Nusamai (71 in Fig. 1, 839 specimens, the late Jomon period), the Onnemoto (68 in Fig. 1, 203 specimens, the Okhotsk period) and the Kotan-onsen sites (84 in Fig. 1, 119 specimens, the Late Jomon period). Except for these four sites, there were less than 10 NISPs in most sites. The mean NISP% was 12.5±2.3 s.e. (range: 0.2-56.4%, N=38) (Fig. 3c). There was a significant difference in the NISP%s for the three sub-regions (H=9.75, P<0.01, $N_{Hokkaido}$=14, $N_{northern\ Honshu}$=11, $N_{southern\ Honshu}$=13). In the multiple comparisons, there was a significant difference between the Hokkaido and the northern and southern Honshu region (for northern, Q=2.98, P<0.01; for southern, Q=2.42, P<0.05). The NISP% of the Benten-jima (56.4%), the Nusamai (51.8%) and the Kotan-onsen sites (40.5%) were much higher than the above mean.

The East China Sea area (136-143 in Fig. 1)

The eight sites were distributed from the Okinawa Early IV (BP 3,800-3,000) to the Gusuku period (BP1,400-800)

(Fig. 2d, Appendix 1). The total number of albatross remains rose to 20 and the mean was 2.5±0.8 s.e. (range: 1-6, N=8) per site (Fig. 2d). The number of albatross remains was fewer throughout this area than in other areas; the most albatross remains were recorded in the Kogachibaru site (136 in Fig. 1, the Okinawa Early IV), but that was only six. The average NISP% was 19.1±5.5 s.e. (range: 3.2–33.3%, N=5, Fig. 3d).

DISCUSSION

The zooarcheological records of albatross remains from a site suggest that albatrosses were distributed to the areas where ancient people lived in those days, except for trade. However, the absence of albatross remains from a site dose not enable us to argue that albatrosses were not distributed near the sites, since these remains was gathered by ancient people for their preferences, such as taste of the meat, the color of feathers, and the ease of hunting (Montevecchi and Hufthammer, 1990). Similarly, a scarcity of remains could result from there being few albatrosses and/or a lack of interest in albatrosses from ancient people. On the other hand, in order to accumulate many albatross remains in archaeological sites, except for trade, many albatrosses should have been distributed in the range where ancient people lived. Therefore, we will focus on sites with a large number of Albatross NISP and high NISP%. To discuss the distribution of albatrosses, we assumed that there was no trade of albatrosses in the studied areas and periods. This assumption seems reasonable because birds including albatrosses are considered a minor food source for ancient people lived in Japanese Islands (e.g. Ohba and Ohi, 1976; Niimi, 1994).

The geographical distribution of zooarcheological albatross remains suggests that the distributional range of albatrosses included the four following areas: 1) the western Pacific near Japan, 2) the Sea of Okhotsk near Sakhalin and Hokkaido, 3) the Sea of Japan near Sakhalin, Honshu and the Korean peninsula and 4) the East China Sea near the Ryukyu Islands. Comparing the estimated older distributional range of albatrosses with the present one, which is largely limited to the Pacific and the East China Sea, we can recognize that coastal areas along the Seas of Okhotsk and Japan are rarely used by albatrosses (Shuntov, 1972; Higuchi *et al*., 1996; Tickell, 2000). However, there are many sites in which high NISP%s have been recorded in the Seas of Okhotsk and Japan suggesting that formerly there were many albatrosses. It is not likely that albatrosses were hunted on the ground in their breeding season, when they might have unfused bones or bones including medullary bones, since we cannot find those bones.

Why has the distributional range of albatrosses contracted? Two explanations, which are not mutually exclusive, may be suggested: 1) excessive hunting in the breeding areas, and 2) distributional changes of prey for the albatross species.

Excessive hunting in the breeding areas: In the coastal areas of the Seas of Japan and Okhotsk, zooarchaeological albatross records exist almost continuously from the Early Jomon (about 6,000-4,600 BP) to the Ainu period (about 600-100 BP) and from the Epi-Jomon (about 2,000-1,300 BP) to the Ainu period, respectively. It is known that Short-tailed Albatrosses were over-hunted by human beings during the end of the 19th century to the early 20th century in their breeding areas, such as the Izu, the Ogasawara, and the Senkaku Islands (Fujisawa, 1967; Hasegawa and DeGange, 1982; Higuchi *et al*., 1996). This hunting resulted in the extinction of the albatross species in many local breeding areas. At almost the same time, many Black-footed and Laysan Albatrosses were also hunted in their breeding areas in the Hawaii and the Midway Islands (Tickell, 2000). Meanwhile, we do not have any reports of excessive hunting in their breeding areas before the late 19th century. Therefore, it seems likely that the disappearance of albatrosses from the Seas of Japan and Okhotsk was associated with over-hunting in their breeding areas. This is consistent with the hypothesis that the decrease of the population size and their breeding areas caused the reduction of their distributional ranges. However, decrease of the population size may not necessarily result in the reduction of the range. Further studies of how decrease of the population size changes distribution will be required.

Distributional changes of prey for albatross species: If distributional changes of prey, such as fish and squid, caused reduction of range in albatrosses, it might be associated with the spatial fluctuations of warm and cold ocean currents. During the Holocene, some fluctuations of ocean currents surrounding Japan have been reported (e.g. Kito *et al*., 1998). As a result of fluctuations, the ocean environmental conditions, such as sea-surface temperatures, salinities and temperature differences between the surface and the bottom water, would have changed. Environmental conditions are considered to be factors that determine the distributional patterns and aggregation areas of fishes (e.g. Maravelias and Reid, 1997). Seabird distribution could be determined by the distributional patterns of prey (e.g. Weimerskirch *et al*., 1994; Decker and Hunt, 1996). Therefore, it may be considered that albatrosses do not occur now in the Seas of Japan and Okhotsk because the two ocean areas are not appropriate for their foraging. It is also quite possible that some changes of distribution occurred due to ocean current fluctuations within studied period, although this cannot be determined because we use approximate time frames. Comparisons of the distributional range of prey among temporal and geographical scales are difficult, and further studies are necessary.

In this paper, we did not compile reports of albatross zooarcheological remains at the species level, but only at the family level. As mentioned, albatross remains have not been identified at species levels based on clear identifying criteria. In addition to not having identification criteria, there

is another problem. That is, even if we develop identifying criteria on the basis of modern osteological specimens, it is not clear whether these criteria could apply to albatross zooarchaeological remains or not. In particular, identification criteria based on the size might be ambiguous, since this character is variable through time (e.g. Kurten, 1965; Davis, 1977).

Taking these factors into account, we have tried to develop identifying criteria using two methods: one is the thin-plate spline method that enables us to analyze the component shapes of materials independent from their size (Bookstein, 1989), and the other is mitochondrial DNA analysis that enables us to analyze the materials independent of their size and shape. These identifying criteria have been applied to albatross remains and have been partially successful. In the near future, we will discuss the distribution of albatross remains at the species level.

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Appendix 1. Details of the archaeological sites in which albatross remains were found. The archaeological or historical time periods represent the age of each site (or layer) estimated from the type of potteries and ceramics. yrBP represents the mean (and range) of absolute ages before 1950 that correspond to each archaeological or historical time period. Each Albatross NISP and All Avian NISP represents numbers of albatross remains and all bird remains, respectively. Each NISP% represents the proportion of albatross remains out of all bird remains. Circles mean that descriptions of remains were not reported quantitatively, and less than signs (<) indicate that not all remains were reported.

No.in Fig.2	Name of Site	Archaeological or Historical Time Period	yrBP(range)	Albatross NISP	Albatross MNI	All Avian NISP	NISP%	Reference
1	Promyslovoe 2	Okhotsk	1,050(1,500-600)	12	1	14	85.7	Panteleev (1997)
2	Promyslovoe 1	Okhotsk to Ainu	800(1,500-100)	4	1	16	25.0	Panteleev (1997)
3	Onkoromanai	Okhotsk	1,050(1,500-600)	176	25	876	20.1	Oba & Ohi (1973)
4	Onkoromanai	Okhotsk to Ainu	800(1,500-100)	12	3	50	24.0	Oba & Ohi (1973)
5	Menashi-domari	Okhotsk	1,050(1,500-600)	133	15	189	70.4	Esashi-Town Board of Education (1994)
6	Asahi-tokoro	Middle	4,200(4,600-3,800)	2	1	–	–	Komai (1963)
7	Kawanishi	Okhotsk	1,050(1,500-600)	2	2	13	15.4	Aoyagi (1995)
8	Sakaeura 2	Okhotsk	1,050(1,500-600)	30	6	131	22.9	The Department of Literature in The University of Tokyo (1972)
9	Tokorogawa-kako	Okhotsk	1,050(1,500-600)	2	1	9	–	Tokoro-Town Board of Education (1996)
10	Raitokoro-kawaguchi	Ainu	350(600-100)	1	1	3	–	The Department of Literature in the University of Tokyo (1980)
11	Moyoro	Epi Jomon	1,650(2,000-1,300)	9<	2<	–	–	Yonemura (1950)
12	Futatsu-iwa	Okhotsk	1,050(1,500-600)	2	1	12	16.7	Historical Museum of Hokkaido (1982)
13	Furetoi	Ainu	350(600-100)	3	1	5	–	Yonemura (1989)
14	Hamamokoto-jinja	Ainu	350(600-100)	1	1	1	–	Abashiri-City Board of Education (1996)
15	Tanneushi	Ainu	350(600-100)	3	2	12	25.0	Nishimoto et al. (1991)
16	Otafukuiwa-doukutsu	Satsumon	950(1,300-600)	1	1	47	2.1	Rausu-Town Board of Education (1991)
17	Matsunorigawa-hokugan	Okhotsk	1,050(1,500-600)	1	1	13	7.7	Rausu-Town Board of Education (1984)
18	Otafukuiwa-doukutsu	Okhotsk	1,050(1,500-600)	1	1	25	4.0	Rausu-Town Board of Education (1991)
19	Oshokomanai-kako-higashi	Ainu	350(600-100)	13	5	261	5.0	Shari-Town Board of Education (1992)
20	Otafukuiwa-doukutsu	Ainu	350(600-100)	1	1	78	1.3	Rausu-Town Board of Education (1991)
21	Novoyablochnoe 2	Okhotsk	1,050(1,500-600)	3	1	6	50.0	Panteleev (1997)
22	Antonovo	Okhotsk	1,050(1,500-600)	7	1	40	17.5	Panteleev (1997)
23	Sadovniki	Okhotsk to Ainu	800(1,500-100)	27	3	56	48.2	Panteleev (1997)
24	Ivanovka	Okhotsk	1,050(1,500-600)	138	22	1297	10.6	Panteleev (1997)
25	Orlovka	Okhotsk	1,050(1,500-600)	6	3	18	33.3	Panteleev (1997)
26	Kuznetsovo 1	Okhotsk to Ainu	800(1,500-100)	7	1	18	38.9	Panteleev (1997)
27	Funadomari	Late	3,400(3,800-3,000)	342	11	430	79.5	Rebun-Town Board of Education (2000a)
28	Hamanaka 2 R point	Late	3,400(3,800-3,000)	5	2	1507	0.3	Nishimoto (2000)
29	Hamanaka 2 R point	Later	2,700(3,000-2,400)	3	1	97	3.1	Nishimoto (2000)
30	Hamanaka 2 R point	Epi Jomon	1,650(2,000-1,300)	93	8	318	29.2	Nishimoto (2000)
31	Oshonnai	Epi Jomon	1,650(2,000-1,300)	29	3	98	29.6	Rebun-Town Board of Education (2001b)
32	Jubeizawa 2	Satsumon	950(1,300-600)	1	1	2219	0.0	Matsutani (1986)
33	Kafukai 6	Satsumon	950(1,300-600)	92	11	341	27.0	Rebun-Town Board of Education (2001a)
34	Hamanaka 2 Ha point	Okhotsk	1,050(1,500-600)	926	62	1190	77.8	Maeda & Yamaura (1992)
35	Hamanaka 2 R point	Okhotsk	1,050(1,500-600)	7	1	79	8.9	Nishimoto (2000)
36	Kafukai 5	Okhotsk	1,050(1,500-600)	1414	72	2895	48.8	Rebun-Town Board of Education (2000b)
37	Kafukai 6	Okhotsk	1,050(1,500-600)	306	24	412	74.3	Rebun-Town Board of Education (2001a)
38	Kafukai A	Okhotsk	1,050(1,500-600)	771	82	3279	23.5	Oba & Ohi (1973)
39	Jubeizawa 2	Ainu	350(600-100)	27	4	94	28.7	Matsutani (1986)
40	Kafukai 6	Ainu	350(600-100)	112	8	216	51.9	Rebun-Town Board of Education (2001a)
41	Tanetonnai	Epi Jomon	1,650(2,000-1,300)	47	3	87	54.0	The Investigation Team of the Tanetonnai Site (2001)
42	Matawakka	Okhotsk	1,050(1,500-600)	61	10	131	46.6	Rishiri-Fuji-Town Board of Education (1978)
43	Rishirifuji-machiyakuba	Okhotsk	1,050(1,500-600)	9	3	27	33.3	Rishiri-Fuji-Town Board of Education (1995)
44	Tanetonnai	Okhotsk	1,050(1,500-600)	○	–	–	-	The Investigation Team of the Tanetonnai Site (2001)
45	Tanetonnai	Ainu	350(600-100)	○	–	–	–	The Investigation Team of the Tanetonnai Site (2001)
46	Fugoppe doukutsu	Middle	4,200(4,600-3,800)	○	–	–	–	Natori (1970)
47	Oyachi	Middle to Late	3,800(4,600-3,000)	1	1	1	–	Inui (1998)
48	K435	Satsumon	950(1,300-600)	1	1	4	–	Archaeological Research Center of Hokkaido-Prefecture (1993)

Appendix 1. (continued)

No.in Fig.2	Name of Site	Archaeological or Historical Time Period	yrBP(range)	Albatross NISP	Albatross MNI	All Avian NISP	NISP%	Reference
49	Okawa	Ainu to Meiji	325(600-50)	○	–	–	–	Yoichi-Town Board of Education (1991)
50	Chatsu-douketu	Late to Later	3,100(3,800-2,400)	3	1	13	23.1	Tomari-Town Board of Education (1989)
51	Kannon-doukutsu	Satsumon	950(1,300-600)	○	–	–	–	Ishizuki & Ishikawa (1984)
52	Sakaeiso-iwakage	Late	3,400(3,800-3,000)	6	2	22	27.3	Mineyama (1973)
53	Setauchi-chashi	Ainu	350(600-100)	1	1	18	5.6	Mineyama (1975)
54	Aonae	Satsumon	950(1,300-600)	17<	–	–	–	Civil Engineering Research Institute of Hakodate & Okusiri-Town Board of Education (1979)
55	Mitsuya	Late to Later	3,100(3,800-2,400)	31	4	370	8.4	Ohba & Watanabe (1967)
56	Katsuyama-joukan	Ainu	350(600-100)	6	1	25	24.0	Kaminokuni-Town Board of Education (1983)
57	Teramach	Middle to Late	3,800(4,600-3,000)	1	1	8	–	Matsumae-Town Board of Education (1988)
58	Sannaimaruyama	Early	5,300(6,000-4,600)	3	1	637	0.5	Aomori-Prefecture Board of Education (1998)
59	Oura	Middle	4,200(4,600-3,800)	○	–	–	–	Kaneko (1982)
60	Kamegaoka	Later	2,700(3,000-2,400)	1	1	–	–	Ichikawa & Suzuki (1984)
61	Hamahashi-meotoiwa	Kofun	1,550(1,700-1,400)	4	1	–	–	Aikawa-Town Board of Education (1969)
62	Sakai A	Middle to Later	3,800(4,600-3,000)	2	1	6	–	Hashimoto (1992)
63	Osakai-doukutsu	Later to Yayoi	2,350(2,400-1,700)	○	–	–	–	Himi High School History Club (1964)
64	Tongsamtong	Chodo	5,000(6,000-4,000)	○	–	–	–	Sample (1974)
65	Saka	Middle to Late	3,800(4,600-3,000)	2<	–	–	–	Masahayashi et al. (1989)
66	Kuwabarahigushi	Late	3,400(3,800-3,000)	1	1	4	–	Fukuoka-City Board of Education (1996)
67	Benten-jima	Okhotsk	1,050(1,500-600)	1046	70	1856	56.4	Nishimoto (2003)
68	Onnemoto	Okhotsk	1,050(1,500-600)	203	26	596	34.1	The Department of Literature in Tokyo University of Education (1974)
69	Higashi-kushiro	Earlier to Middle	8,000(10,000-3,800)	○	–	–	–	Sawa et al. (1962)
70	Musagawa 1	Early to Middle	4,900(6,000-3,800)	2	1	29	6.9	Archaeological Research Center of Kushiro-City (1998)
71	Nusamai	Later	2,700(3,000-2,400)	839	28	1621	51.8	Archaeological Research Center of Kushiro-City (1999)
72	Mitsuura	Epi Jomon	1,650(2,000-1,300)	○	–	–	–	Sawa & Nishi (1976)
73	Nusamai	Satsumon	950(1,300-600)	34	5	243	14.0	Archaeological Research Center of Kushiro-City (1996)
74	Nusamai	Ainu	350(600-100)	16	1	87	18.4	Archaeological Research Center of Kushiro-City (1999)
75	Misawa 4	Early	5,300(6,000-4,600)	1	1	6	–	Archaeological Research Center of Hokkaido Prefecture (1980)
76	Uenae	Early	5,300(6,000-4,600)	1	1	51	2.0	Tomakomai-City Board of Education (1976)
77	Yanagidate	Early	5,300(6,000-4,600)	2	1	99	2.0	Tomakomai-City Board of Education (1976)
78	Benten	Ainu to Meiji	325(600-50)	○	–	–	–	Archaeological Research Center of Tomakomai-City (1980)
79	Irie	Late	3,400(3,800-3,000)	○	–	–	–	Oshima & Tsunoda (1994)
80	Minami-usu 6	Epi Jomon	1,650(2,000-1,300)	2	1	15	13.3	Mitsuhashi (1983)
81	Minami-usu 7	Epi Jomon	1,650(2,000-1,300)	2	1	8	–	Mitsuhashi (1983)
82	Usu-oyakotsu	Ainu	350(600-100)	3	1	6	–	Date-City Board of Education (1993)
83	Kotan-onsen	Early	5,300(6,000-4,600)	5	1	23	21.7	Yakumo-Town Board of Education (1992)
84	Kotan-onsen	Late	3,400(3,800-3,000)	119	10	294	40.5	Yakumo-Town Board of Education (1992)
85	Yunokawa	Middle to Late	3,800(4,600-3,000)	6	2	26	23.1	Hakodate-City Board of Education (1997)
86	Toi	Late	3,400(3,800-3,000)	29	7	198	14.6	Furuyashiki et al. (1993)
87	Ishikura	Late	3,400(3,800-3,000)	4	1	58	6.9	Hakodate-City Board of Education (1999)
88	Esan	Epi Jomon	1,650(2,000-1,300)	1	1	1	–	Ogasawara (1984)
89	Doumancha	Later	2,700(3,000-2,400)	5<	–	–	–	Esaka et al. (1967)
90	Ohma	Later to Heian	2,616(3,000-768)	○	–	–	–	Aomori-Prefecture Museum (1998)
91	Sachi	Later	2,700(3,000-2,400)	1	1	5	–	Kaneko (1967a)
92	Hamashira	Heian	967(1,166-768)	7	1	26	26.9	Meeting for Edition of the History of Higashi-dori-Village (1999)
93	Iwaya-douketsu	Edo	216(350-82)	○	–	–	–	Aomori-Prefecture Museum (1998)
94	Choushichiyaji	Earlier	8,000(10,000-6,000)	1	1	19	5.3	Ichikawa et al. (1980)
95	Yawata	Later	2,700(3,000-2,400)	1	1	7	–	Kudo et al. (1988)
96	Akamido	Earlier	8,000(10,000-6,000)	○	–	–	–	Aomori-Prefecture Museum (1998)

Appendix 1. (continued)

No.in Fig.2	Name of Site	Archaeological or Historical Time Period	yrBP(range)	Albatross NISP	Albatross MNI	All Avian NISP	NISP%	Reference
97	Kaitori	Late	3,400(3,800-3,000)	1	1	343	0.3	Kusama & Kaneko (1971)
98	Tagara	Late to Later	3,100(3,800-2,400)	3	1(1<)	981	0.3	Hirasawa et al. (1986)
99	Kaitori	Later	2,700(3,000-2,400)	1	1	108	0.9	Kusama & Kaneko (1971)
100	Nakazawahama	Later	2,700(3,000-2,400)	2	1	6	–	Sato & Gamo (1987)
101	Osozawa	Later	2,700(3,000-2,400)	○	–	–	–	Oikawa & Kaneko (1977)
102	Izushimayamashita	Early to Late	4,500(6,000-3,000)	○	–	–	–	Henmi & Henmi (1973)
103	Daigigakoi	Middle	4,200(4,600-3,800)	○	–	–	–	Yamaki et al. (1975)
104	Nigade	Late to Later	3,100(3,800-2,400)	2	1	289	0.7	Goto (1972)
105	Satohama nashinoki-higashi point	Early	5,300(6,000-4,600)	10	–	–	–	Historical Museum of Tohoku Region (1994)
106	Satohama kazakoshi point	Late	3,400(3,800-3,000)	2	1	72	2.8	Historical Museum of Tohoku Region (1997)
107	Satohama west point	Later	2,700(3,000-2,400)	○	–	–	–	Okamura et al. (1986)
108	Usuiso A point	Later	2,700(3,000-2,400)	11	2	223	4.9	Otake & Yamasaki (1988)
109	Ohata	Middle	4,200(4,600-3,800)	1	1	82	1.2	Magome (1974)
110	Ohata	Late	3,400(3,800-3,000)	9	1	75	12.0	Magome (1974)
111	Tsunatori C point	Late	3,400(3,800-3,000)	7	2	43	16.3	Kaneko & Wada (1968)
112	Sanya	Late	3,400(3,800-3,000)	4	1	98	4.1	Tokyo Electric Power Company & Urban Development Corporation of Chiba-Prefecture (1973)
113	Iidamachi	Edo	216(350-82)	2	1	224	0.9	The Investigation Team of the Iidamachi Site (2001)
114	Kasai-jou	Edo	216(350-82)	2	1	26	7.7	The Investigation Team of the Katsushika-ku (1994)
115	Shiodome	Edo	216(350-82)	1	1	526	0.2	Archaeological Research Center of Tokyo-Prefecture (1996)
116	Miyamotodai	Late	3,400(3,800-3,000)	1	1	16	6.3	Funabashi-City Board of Education (1974)
117	Denpuku-ji-ura	Early to Middle	4,900(6,000-3,800)	3	1	18	16.7	Yokosuka-City Board of Education (1988)
118	Saihiro	Late	3,400(3,800-3,000)	2	1	43	4.7	Kaneko et al. (1971)
119	Ourayama-douketsu	Yayoi	2,050(2,400-1,700)	1	1	16	6.3	Kaneko (1967)
120	Bishamon B	Yayoi	2,050(2,400-1,700)	1	1	5	–	Kenmochi & Nishimoto (1986)
121	Maguchi	Yayoi	2,050(2,400-1,700)	1	1	6	–	Kenmochi & Nishimoto (1986)
122	Bishamon C	Yayoi	2,050(2,400-1,700)	1	1	8	–	Kenmochi & Nishimoto (1986)
123	Sotoumi	Yayoi	2,050(2,400-1,700)	○	–	–	–	Kenmochi & Nishimoto (1986)
124	Natagiri	Kofun	1,550(1,700-1,400)	1	1	3	–	Yokosuka-City Board of Education (1979)
125	Hamamoroiso	Asuka to Heian	1,084(1,400-768)	1	1	16	6.3	The Investigation Team of the Hamamoroiso Site (1998)
126	Nittano	Early	5,300(6,000-4,600)	2	1	33	6.1	Society for the study of Archeology of Rikkyo University (1975)
127	Natagiri douketu	Late	3,400(3,800-3,000)	16	4	69	23.2	Kaneko & Wada (1958)
128	Haneo	Early	5,300(6,000-4,600)	2	1	892	0.2	Research Institute for Cultural Properties, Tamagawa (2003)
129	Ikego	Yayoi	2,050(2,400-1,700)	3	1	18	16.7	The Kanagawa Archaeological Foundation (1999)
130	Yuigahama	Kamakura	668(768-568)	3<	1<	–	–	The Investigation Team of the Yuigahama-Minami Site (2001)
131	Teppouba-iwakage	Early to Middle	4,900(6,000-3,800)	2<	–	–	–	Hayakawa & Taniguchi (1986)
132	Shimotakado	Later to Yayoi	2,350(2,400-1,700)	○	–	–	–	The Investigation Team of Archaeological Sites in Oshima-Town (2001)
133	Kurawa	Early to Middle	4,900(6,000-3,800)	7	2	8	–	Hachijyo-Town Board of Education (1987)
134	Otsukumi	Later	2,700(3,000-2,400)	1	1	5	–	Okamoto (1966)
135	Otsukumi	Kofun	1,550(1,700-1,400)	5	1	8	–	Okamoto (1966)
136	Kogachibaru	Okinawa Early IV	3,400(3,800-3,000)	6	1	27	22.2	Anri & Shimabukuro (1987)
137	Chiarabaru	Okinawa Early IV to V	3,100(3,800-2,400)	1	1	31	3.2	Oshiro et al. (1987)
138	Shimnugu-dou	Okinawa Early V	2,700(3,000-2,400)	1	1	1	–	Okinawa-Prefecture Board of Education (1985)
139	Nagarahara-nishi	Okinawa Late I	2,050(2,400-1,700)	1	1	8	–	Ie-Village Board of Education (1979)
140	Heshikiya-toubaru	Okinawa Late IV	1,084(1,400-768)	4	1	15	26.7	Okinawa-Prefecture Board of Education (1996)
141	Takamine-furujima	Okinawa Late IV	1,084(1,400-768)	1	1	10	10.0	Toyomijyou-Village Board of Education (1990)
142	Nagamazuku	Yaeyama I	4,200(4,600-3,800)	1	1	1	–	Okinawa-Prefecture Board of Education (1984)
143	Shimotabaru	Okinawa Early IV	3,400(3,800-3,000)	5	1	15	33.3	Okinawa-Prefecture Board of Education (1986)