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FORAGING HABITATS OF STELLER'S SEA-EAGLES DURING THE WINTERING SEASON IN HOKKAIDO, JAPAN

SAIKO SHIRAKI[1]
Graduate School of Environmental Earth Science, Hokkaido University, Sapporo 060 0810 Japan

ABSTRACT.—Steller's Sea-Eagles (*Haliaeetus pelagicus*) winter mostly in Hokkaido, Japan. To clarify the temporal changes in foraging habitats used by the eagles throughout the wintering season, and factors affecting their choices of foraging habitats, I surveyed numbers of wintering eagles at 71 sites classified into five foraging habitat types (river basins, river estuaries, lakes or inland bays, coasts, and refuse dumps) from November to April 1991–92, and temporal changes in the food resource abundance at the major feeding sites. Most eagles were observed in river basins during November and December and the number of eagles fluctuated with temporal changes in the number of salmon carcasses in the Syokotsu River. The eagles appeared to move among rivers according to the abundance of available salmon. In mid-February and early March, the eagles were observed in various habitats but not at river basins. The distribution of eagles was affected by fishery activities on coasts, in lakes, and on inland bays during these periods. Estuaries, lakes, and inland bays maintained open water areas in the ice and appeared to be important feeding sites throughout the winter. On Furen Lake, the numbers of eagles did not fluctuate with temporal changes in the amount of food fisheries discarded. It was possible that eagles stayed at Furen Lake even when the abundance of available small fish did not meet their food requirements and indicate that there not currently sufficient, suitable natural foraging habitats on the wintering grounds in Hokkaido during severe winters to maintain the current population of Steller's Sea-Eagles.

KEY WORDS: *Steller's Sea-Eagle*; Haliaeetus pelagicus; *foraging habitat*; *winter*; *fishery*; *Hokkaido.*

Habitos de forrajeo de *Haliaeetus pelagicus* durante la estacion de invierno en Hokkaido, Japón

RESUMEN.—*Haliaeetus pelagicus* pasa la mayoría del invierno en Hokkaido, Japón. Para clarificar los cambios temporales en los hábitos de forrajeo utilizados por las águilas a traves de la estación invernal y los factores que afectan la selección de los mismos, investigué un número de águilas en 71 sitios clasificados, en cinco tipos de habitats de forrajeo (cuencas de ríos, estuarios, lagos, bahías internas, costas y vertederos de desechos) desde Noviembre hasta Abril 1991–92 y los cambios temporales en la abundancia de comida de los principales sitios de alimentación. La mayoría de las águilas fueron observadas en los valles de los ríos durante Noviembre y Diciembre, el número de águilas fluctúo con cambios temporales en el número de restos de salmón en el río Syokotsu. Las águilas aparentemente se movilizaron entre los ríos de acuerdo a la disponibilidad del salmón. A mediados de Febrero y principios de Marzo las águilas fueron observadas en varios habitats distintos a los valles de los ríos. La distribución de las águilas fué afectada por las actividades pesqueras en las costas, en lagos y en las bahías internas durante estos períodos. Los estuarios, lagos y bahías internas mantuvieron áreas abiertas de agua en el hielo, fueron sitios importantes de alimentación durante el invierno. En el lago Furen, los números de águilas no fluctuaron con los cambios temporales en la cantidad de comida que las pesqueras descartadas. Es posible que las águilas se estuvieron en el lago Furen a pesar que la abundancia de pequeños peces no cumplía con los requerimientos alimenticios como tampoco de que había suficiente habitat apropiado para forrajeo en Hokkaido durante los fuertes inviernos como para mantener la población de *Haliaeetus pelagicus.*

[Traducción de César Márquez]

The total number of Steller's Sea-Eagles (*Haliaeetus pelagicus*) in the world is estimated at 7500 with the number of adults estimated at 5600 (del Hoyo et al. 1994). Because of the small population size, this eagle is listed as a vulnerable species (IUCN 1996).

Steller's Sea-Eagles breed in the Lower Amur River, and in coastal regions along the western Bering Sea, Kamchatka Peninsula, Okhotsk Sea, and

[1] Present address: Biology Department, Abiko Research Laboratory, Central Research Institute of Electric Power Industry, 1646 Abiko, Abiko-shi, Chiba-ken 270-1194, Japan.

northern Sakhalin Island in northeastern Russia (Lobkov and Neufeldt 1986). After breeding, some eagles migrate southward for winter (Lobkov and Neufeldt 1986). Wintering areas outside breeding areas include the South Primorski region, the Kuril Islands, Sakhalin Island, and the island of Hokkaido, Japan (del Hoyo et al. 1994). There were 2200 Steller's Sea-Eagles wintering on Hokkaido in 1985 (Nakagawa et al. 1987), indicating that Hokkaido is an important wintering area.

Eagles begin migration to Hokkaido by way of the Soya Cape, the northernmost tip of Hokkaido, in late October and depart Hokkaido in early March (Ito 1991). The distribution of wintering Steller's Sea-Eagles in Hokkaido in late November is determined by the abundance of chum salmon (*Oncorhynchus keta*) in rivers (Ueta et al. 1999). In February, most eagles have been recorded on the Rausu coast in Nemuro Strait and in lakes and inland bays in the eastern and northern parts of Hokkaido (Working Group for White-tailed Eagles and Steller's Sea-Eagles 1996). Along the Rausu coast, they gather to eat walleye pollock (*Theragra chalcogramma*) that have fallen out of gill nets during fishery activities and small fish discarded from ice fisheries (nets under the ice) on frozen lakes and inland bays. This suggests that, in Hokkaido, salmon are the major food resource during the early wintering period, and subsequently fish derived from fishery activities become an important food source.

It is important for the conservation of the wintering population of Steller's Sea-Eagle to clarify the status of foraging habitats. There have been no reports on the use of foraging habitats throughout the wintering season. Therefore, the objectives of this study were to clarify the temporal changes in foraging habitats used by Steller's Sea-Eagles throughout the wintering season and to examine the factors affecting the use of foraging habitats.

STUDY AREA AND METHODS

Steller's Sea-Eagles were censused from November 1991–April 1992 at 71 fixed sites established in the northern and eastern parts of Hokkaido (Fig. 1). Selection of these sites was based on the views they provided and accessibility of the observation points. The sites were classified into five foraging habitat types: river estuaries (N = 21, 0–500 m from the river mouth), river basins (N = 9, upper part of the estuary), coast (N = 19), lakes or inland bays (N = 19), and refuse dumps including garbage dumps (N = 3). The census was divided into six periods: 4–10 November in the eastern part and 27–30 November in the northern part, 11–18 December, 12–19 February, 28 February–9 March, 25–28 March and 1–2 April, and 9–16 April. I counted eagles from each site as far as I could see from sunrise to 1500 H when weather did not interfere with observations.

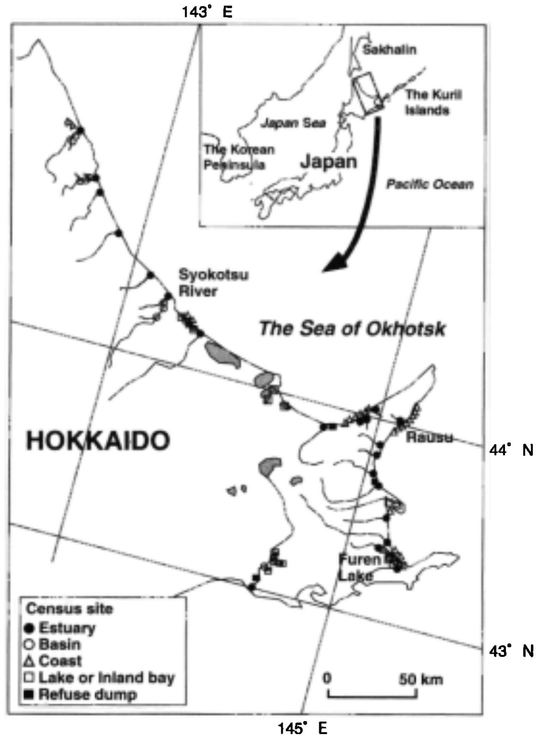

Figure 1. Map of study area and 71 census sites indicated by each foraging habitat type in northern and eastern parts of Hokkaido, Japan.

White-tailed Eagles (*H. albicilla*) also winter with Steller's Sea-Eagles in Hokkaido, so I recorded eagles as one of three types: Steller's Sea-Eagles, White-tailed Eagles, and unidentified sea eagles. For the purpose of analyses, unidentified eagles at each site were split into Steller's Sea-Eagles and White-tailed Eagles in proportion to the number of identified birds of each species. At lake and inland bay sites, I estimated the percentage of the area surveyed that was frozen.

The number of Steller's Sea-Eagles observed on the coastal sites of Rausu (Fig. 1), and other coastal sites during mid-February and early March in 1992 was compared by a Mann-Whitney U-test. In some lakes and inland bays, commercial fisheries were operational concurrent with the presence of wintering Steller's Sea-Eagles. To compare eagle use at sites used for commercial fisheries versus nonfishery sites from mid-February to early April in 1992, tests for differences between areas were made with Mann-Whitney U-tests.

I counted eagles and salmon carcasses nearly once a week from November to early December, 1994 along the Syokotsu River (main stream and a tributary), which

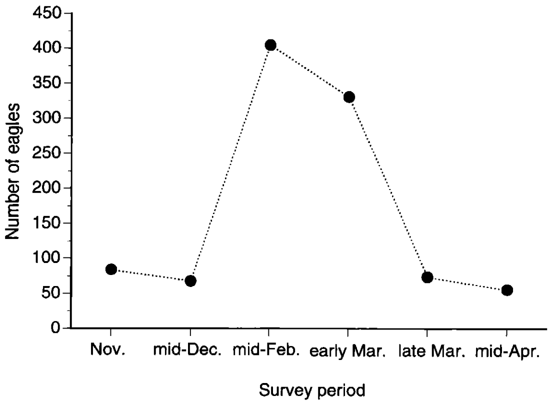

Figure 2. Fluctuation in the number of Steller's Sea-Eagles counted at 71 sites in the eastern and northern parts of Hokkaido, November 1991–April 1992.

empties into the Sea of Okhotsk in northeastern Hokkaido (Fig. 1). Eagles were counted from the mouth to a point 17 km upstream. Salmon carcasses, primarily chum salmon (*Oncorhynchus keta*), were counted on shallows and sand banks at eight fixed 500-m-long zones by walking along the river. The relationship between the number of salmon carcasses and occurrence of eagles was examined by a Kendall rank-order correlation test.

At Furen Lake, one of the major wintering places for eagles, in eastern Hokkaido (Fig. 1), the ice fishery usually starts in late December after freeze-up, and ceases around the beginning of April when the ice begins to melt. I counted Steller's Sea-Eagles, White-tailed Eagles, and unidentified eagles on the western part of Furen Lake during the winters of 1994–95 and 1997. Most of the small fish from the ice fishery operations were dumped directly onto the ice. To estimate the total mass of small fish discarded in this area, I measured the weight of all the fish that were caught with a fishing net and dumped on the ice from 15–20 nets in each survey period. I also counted the nets within the censused area. These surveys were conducted six times from late December to early March in 1994–95, and three times from late January to late February in 1997. The total mass of small fish per week was calculated as: (mean weight of fish in a net per day) × (total number of nets in the surveyed area) × (number of days of fishery conducted in a week). The relationship between the temporal change in the total mass of small fish and the number of eagles observed was examined by a Kendall rank-order correlation test.

RESULTS

In the surveyed area, there was a minimum of 56 Steller's Sea-Eagles during each observation period, with numbers peaking in mid-February at 405 eagles (Fig. 2). During the surveyed periods, the use of foraging habitat types by eagles changed (Fig. 3). However, within a habitat type, many eagles gathered at some sites, while no eagles were observed at other sites. This indicated that the preference of eagles for a feeding site could not always be explained by habitat type alone.

In the first two periods, November and mid-December, nearly all eagles were observed in river basins. On the Syokotsu River, there was a significant correlation between the number of salmon carcasses and the number of Steller's Sea-Eagles from 10 November–8 December (Kendall rank-order correlation test, $\tau = 0.90$, $P = 0.028$) (Fig. 4). Because few eagles were observed in other habitats during these periods, the eagles appeared to stay at, or leave rivers depending on the abundance of salmon carcasses. After the mid-December period, eagles disappeared from river basins and were observed in various other habitats (Fig. 3). During mid-February and early March, many eagles were observed at sites along the Rausu coast. In early March, eagles were found at significantly higher densities along the Rausu coast than at other sites on the coast (Mann-Whitney *U*-test, $Z = -2.15$, $P = 0.032$), but no significant difference was found between these sites in mid-February ($Z = -1.24$, $P = 0.22$). Steller's Sea-Eagles were observed at refuse dumps from mid-February to mid-April eating garbage (Fig. 3). In particular, many eagles were observed at one refuse dump during mid-February and early March.

Eagles were observed in lakes, inland bays, and river estuaries throughout the census period (Fig. 3). In mid-February, when ice fisheries were present on lakes and inland bays that were nearly frozen over, eagles gathered more at fishery sites and they fed upon small fish, such as *Myoxocephalus stelleri, Pholidapus dybowskii,* and *Pleuronectes pinnifasciatus* that had been discarded by fishermen ($Z = -2.32$, $P = 0.020$) (Fig. 5). After mid-February, the surfaces of lakes and inland bays gradually melted and subsequently the activities of the ice fisheries decreased. At these sites where there were open water areas in the ice, I sometimes observed eagles trying to catch fish while perching on the ice around open water. In early March at about 70% of the study sites, water surfaces were incompletely covered by ice while, at other sites, they were completely covered with ice. During this period, there were no differences in the number of eagles between the fishery and nonfishery sites ($Z = -1.30$, $P = 0.19$) (Fig. 5). In late March, water surfaces were partially covered with ice at all but one of the sites and eagles gathered more at nonfishery sites than at fishery sites ($Z = -2.02$, $P = 0.043$) (Fig.

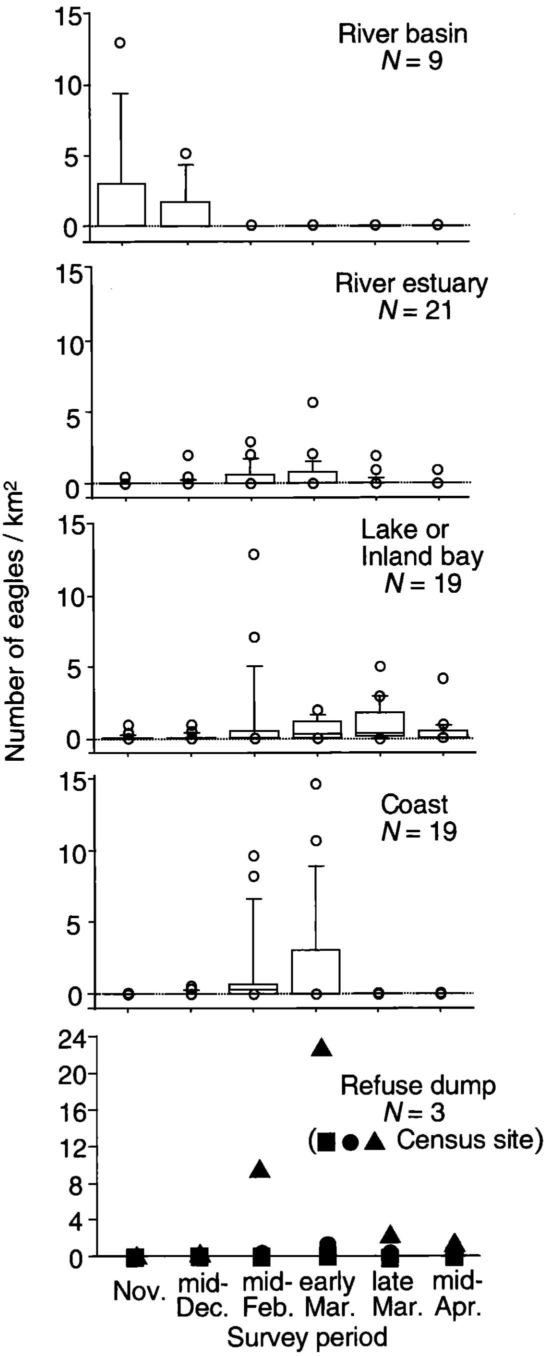

Figure 3. Box plot of the number of Steller's Sea-Eagles/km^2 in each foraging habitat type counted in the eastern and northern parts of Hokkaido, November 1991–April 1992. Boxes cover the middle 50% of the data and center lines indicate medians. Tops of boxes indicate number of eagles/km^2 within 75% of the data and bottoms indicate number of Steller's Sea-Eagles/km^2 within 25% of the data. Whiskers indicate the range of 90% of the data. Open circles represent outlying numbers. N = number of census sites. Sample size at the refuse dump was not enough to make a box plot.

5). In mid-April, one site was about 40% covered with ice, while other sites did not have ice. There was no difference in the number of eagles between the fishery and nonfishery sites, although most eagles were counted at the sites with partial ice cover ($Z = -1.12$, $P = 0.27$) (Fig. 5). Thus, these results indicated that frozen lakes and inland bays which are partly thawed could be good feeding sites under natural conditions for eagles. Similarly, as many estuaries had an open area throughout the winter, eagles could capture prey.

There were no significant relationships between the mass of discarded fish and the number of eagles in 1994–95 (Kendall rank-order correlation test, $\tau = 0.20$, $P = 0.57$) or in 1997 ($\tau = -0.33$, $P = 0.60$) (Fig. 6). There were two possible explanations for this result. There was enough small fish for the eagles throughout the wintering period on Furen Lake or the eagles stayed at Furen Lake even when food was scarce. To evaluate these two explanations, I calculated the food requirement of eagles (including White-tailed Eagles) eating small fish on this lake as follows: the mass of small fish per eagle was lowest in late February 1995, when 330 Steller's Sea-Eagles and White-tailed Eagles were recorded in total. Average daily food consumption by White-tailed Eagles has been estimated to be 514 g (male = 456 g, female = 571 g; Love 1979). If an eagle ate 514 g of fish/d at Furen Lake, 330 eagles would have eaten 1187 kg/wk, which was less than the total mass of discarded fish (2161 kg/wk) in late February 1995. However, competitors for fish included gulls, *Larus schistisagus, L. argentatus, L. glaucescens,* and *L. hyperboreus,* which were the largest consumers of discarded fish on Furen Lake (Lobkov unpubl. data), as well as Black Kite (*Milvus migrans*) and crows (*Corvus macrorhynchos* and *C. corone*). These competitors usually approached and ate discarded fish sooner than sea eagles, and the eagles fed on the rest. Therefore, it was possible that there was an insufficient amount of small fish for the eagles in late February and the second explanation applied.

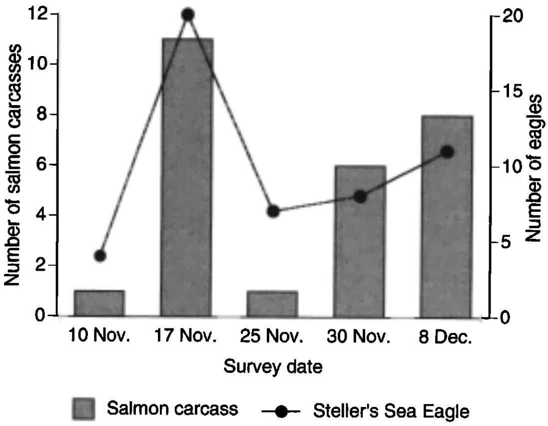

Figure 4. Relationship between the numbers of Steller's Sea-Eagles and salmon carcasses at the Syokotsu River from 10 November–8 December 1994.

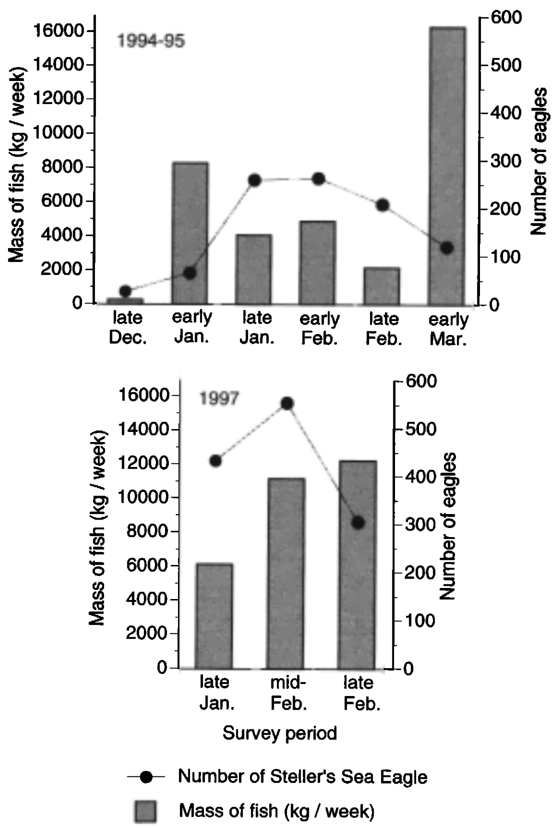

Figure 6. Temporal fluctuations of number of Steller's Sea-Eagles and the mass of discarded fish in the western part of Furen Lake in the wintering seasons of 1994–95 and 1997.

DISCUSSION

The movements and distribution of Bald Eagles (*Haliaeetus leucocephalus*) are influenced by food availability during winter (Southern 1964, Steenhof et al. 1980, Grubb 1984, Griffin and Baskett 1985, Isaacs and Anthony 1987). My study and the study of Ueta et al. (1999) have shown that Steller's Sea-Eagles move among river basins according to changes in the abundance of salmon carcasses. Some Steller's Sea-Eagles tracked by satellite moved from their breeding areas in northern Sakhalin, the nearby continental seaboards, and the Amur River to Hokkaido via the Soya Cape during late fall (Ueta et al. 2000, McGrady unpubl. data). After a short stay in Hokkaido, these eagles migrated to the Kuril Islands (Fig. 1), where numerous salmon were available, and returned to Hokkaido in January and February (Ueta et al. 2000, McGrady unpubl. data). Their return was likely related to the number of available salmon which decreased in the Kuril Islands. This finding suggests that, across the wintering range, movements of Steller's Sea-Eagle are affected by the distribution of salmon during the early wintering season.

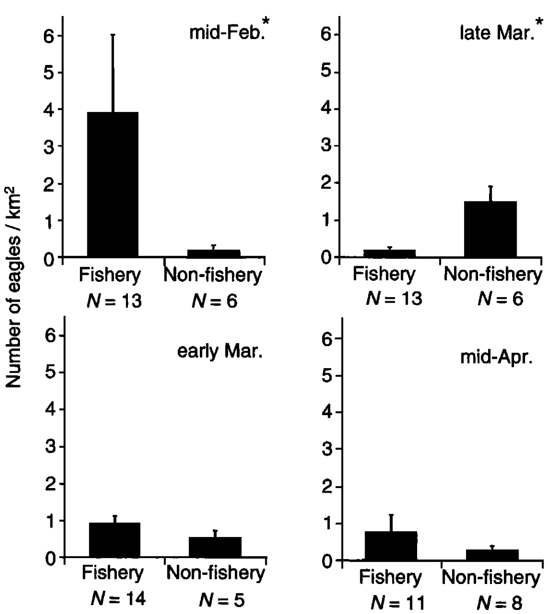

Figure 5. Mean number of Steller's Sea-Eagles/km² at commercial fishery and nonfishery sites in the lake and inland bay habitats in 1992. Mean is shown with standard deviation (thin vertical bars). *Significantly different (Mann-Whitney *U*-test).

The number of Steller's Sea-Eagles fluctuated in response to the abundance of salmon carcasses in the river basin. Meanwhile, the number of eagles did not correlate with the mass of small fish in Furen Lake. The availability for Bald Eagles is often highly variable in time and space, resulting in frequent movements in search of food (Stalmaster and Gessaman 1984), while more available prey probably allows eagles to stay in some areas rather than move to others (Isaacs et al. 1996). In addition, Bald Eagles are able to withstand long periods of food deprivation (Stalmaster and Gessaman 1984). Because Steller's Sea-Eagles remained in Furen Lake in spite of apparent food shortages, I concluded that the food shortage was tolerable for them and that staying at Furen Lake was more advantageous than moving to another foraging habitat. It may be that the eagles did not have other feeding places with better food availability.

Recently, Steller's Sea-Eagles have begun to appear in mountainous areas to feed on deer (*Cervus nippon*) carrion abandoned by hunters (Kurosawa 1998). Since the mid-1990s, with the decrease in the commercial catch of walleye pollock along the Rausu coast, Steller's Sea-Eagles have tended to disperse from the Rausu region (Working Group for White-tailed Eagles and Steller's Sea-Eagles 1996). Concurrently, because the number of deer has greatly increased and more deer have been hunted in order to lessen agriculture damage, more deer carrion are being made available to eagles (Kurosawa 2000). Thus, Steller's Sea-Eagles may begin to gather in mountain areas which have become more profitable foraging habitats than fisheries in recent years. Eagles have tended to change their feeding areas in recent years among areas where human activities supply food during severe winter seasons. This fact suggests that suitable, natural foraging areas during severe winter are insufficient to maintain the current population of Steller's Sea-Eagles.

In addition, these anthropogenic food sources may not be ideal for maintaining populations due, not only to their lack of stability but also for their potential for containing pollutants. Whole and partial carcasses of deer shot by hunters are left in the field (Kim et al. 1999, Iwata et al. 2000), and lead fragments embedded in tissue are often ingested by eagles during and after the hunting season (Iwata et al. 2000). Forty six eagles were found to have died from lead poisoning during 1997–99 (Kurosawa 2000). No regulation on the use of lead bullets has been introduced by the Japanese government. If the use of lead shot is not restricted, lead poisoning might cause a decline in the population (Kim et al. 1999, Iwata et al. 2000, Ueta and Masterov 2000). The Environmental Agency of Japan announced the banning of lead bullet use in Hokkaido beginning in the fall of 2000.

In this study, lakes, inland bays, and river estuaries with areas of open water could be feeding places under natural conditions during severe winters. Kuril Lake in south Kamchatka, Russia, is one of the largest wintering areas for Steller's Sea-Eagles, and they stay to feed on salmon from October to March (Ladigin et al. 1991). A similar situation occurs in Hokkaido, where some eagles overwinter at a few rivers by feeding on salmon carcasses that remained from fall salmon runs (Shiraki 1996). Thus, salmon could be one of the important food resources for eagles late in the fall season. However, in many rivers in Hokkaido, most of the salmon are captured in the lower part of rivers during the fall season to collect eggs for artificial propagation (Shiraki 1996). Therefore, during severe winters, salmon carcasses available to eagles are very scarce in most of the rivers. In addition, eagles require shallows and sand banks for feeding, and suitable forest areas for perch sites and shelter. Most rivers in Hokkaido are unsuitable habitats for eagles owing to alternations of river walls and river beds, and the cutting of riverside forests (Shiraki 1996). Steller's Sea-Eagles' winter movements are associated with the fluctuation of food resources over the wintering range. Therefore, it is desirable to conserve wintering habitats not just in Hokkaido, but over the entire wintering range of the species.

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