D-2.3.1 Biological effect of pollutants for the northern fur seals and sea birds, and bioaccumulation process of pollutants.

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Abstract

To examine the biological effect and bioaccumulation process of pollutants on marine animals, pollution status of northern fur seals and sea turtles by heavy metal and of sea birds by plastic pellets were examined. Analytical method of heavy metal for fur seals and sea turtles were developed, and tissues collected from fur seals off Sanriku and Alaska were analyzed to know body burden of heavy metals, change of heavy metal concentration by age, and its transfer from mother to baby etc. Furthermore, concentration and its seasonal change of heavy metals in hair and of steroid hormone on fur seals were examined. From these results, the possibility of monitoring the biological effects of pollutants on fur seal were discussed. Tissues collected from sea turtles entangled in fishing nets were analyzed to examine the body burden of heavy metal and change of heavy metal concentration by growth etc. Number and occurrence of plastic pellets in stomachs of sea birds collected in the North Pacific Ocean were examined to understand the biological effects by plastic debris on sea birds. We developed the neuston net and examined the distribution of plastic pellets in an ocean by using it. Furthermore, we conducted the beach survey at Ogasawara Islands and discussed the possibility of monitoring the plastic pellets drifted in an open sea. Bioaccumulation process of pollutants were not enough examined, but biological effects by pollutants on fur seals, sea turtles, and sea birds were cleared and found out the possibility of monitoring the biological effects by pollutants on wild animals without killing were found throughout five year's studies.

Key Words Heavy metal, Plastic pellets, Fur seal, Sea bird, Sea turtle

Introduction

Environmental contaminants deteriorate the clarification of ocean and make marine creatures disease directly or indirectly. To construct the global-monitoring system of environment, information concerning to the status of pollution and bioaccumulation process on marine animals are necessary.

Long life wild animals are considered to reflect the concentration of environmental pollutants. So objects of this study are to understand the pollution status of marine animals using northern fur seals in pinnipeds, sea turtles in reptiles, and sea birds, and find the useful materials and methods for monitoring system of biological effect.

Materials and Methods

Tissues (about 10 g) of muscle, liver, and kidney of six adult loggerhead turtles (*Caretta caretta*) entangled in fishing net in Kouchi prefecture in May, 1990, two adult green turtles (*Chelonia mydas*) collected at Ogasawara Islands in 1990, four young loggerhead turtles entangled in drift net in the central North Pacific during June and July in 1991, two green turtles and one hawksbill turtle (*Eretmochelys imbricata*) at Yaeyama Islands in 1992 were collected.

Tissues of hair, muscle, and internal organs were collected from fifty northern fur seals (*Callorhinus ursinus*) caught off Sanriku in April, 1990 and 1991. Samples were also collected from muscle, liver and kidney of thirty three fur seals harvested on St. Paul Island, Pribilof Islands, Alaska in July in 1992.

These samples were digested with a mixture of concentrated nitric, sulfuric and perchloric acid. The concentration of iron, manganese, zinc, copper, and cadmium were determined by atomic absorption spectrophotometry (AAS). For the analysis of low concentrations of elements like muscular copper and cadmium, extraction with 4-methyl-2-pentanone was performed after sodium diethyldithiocarbamate chelation, and measured by AAS described by Honda et al. [1]. Mercury was measured by cold vapor-ultraviolet spectrometry following the method of Akagi and Nishimura [2]. Accuracy of analyses were examined using standard reference materials NIES No.1 (Pepperbush Powder)[3] provided by NIES (National Institute for Environmental Studies).

Stomach contents of 259 sooty shearwaters (*Puffinus griseus*) collected in the North Pacific from April to November 1982, 1987 and 1988, one black-footed albatross (*Diomedea nigripes)* died in captivity after security at Hazaki Shinko, Ibaragi prefecture in 1992 were examined. To understand the distribution of plastic debris, the nesuton net were developed and small plastic debris were collected off Sanriku from May to June in 1993 and in the central North Pacific from May to August in 1993 by using it, respectively. The pellets were examined the shape, number, kind and weight. To develop the monitoring system of plastic debris in an ocean, beach surveys of Chichijima island, Ogasawara Islands were conducted.

Heavy metal concentration of fur seals and sea turtles were studied jointly with Ehime University and plastic pollution were also studied jointly with Hokkaido University.

Result

Heavy metal pollution on sea turtles

Body burden of heavy metals in each organs which were calculated by multiplying concentration of heavy metal to weight of organ or tissue were shown in Figure 1. Concentrations of zinc and manganese were high in carapace. Burden of cadmium is high in both liver and kidney and they accounted for approximately 90 % of total body burden.

Concentration of heavy metal in blubber of sea turtles was shown in Figure 2. Although concentration of manganese, cadmium, and copper of both loggerhead turtle and green turtle were almost same level as concentration of minke whale , northern fur seal, and other marine mammals. But concentration of zinc of both turtles are about 40 times higher than that of marine mammals. This results are recognized to be characteristics of sea turtles.

Heavy metal pollution on northern fur seals

Body burden of heavy metals in norther fur seals were shown in Figure 3. Burdens of mercury, copper and cadmium were high in liver, and nickel and lead were high in hair.

Concentration of cadmium in kidney occupied dominantly in a total body burden. High concentration of heavy metals in hair are noticeable.

Concentration of mercury in liver on Asian fur seals collected off Sanriku were higher than that of Pribilof fur seals (Fig.4). On the contrary, concentration of cadmium in kidney on Asian fur seals were lower than that of Pribilof fur seals. The result indicate that discrimination of fur seal origin is possible by heavy metal.

To develop the monitoring system of environmental contaminants in wild animals without killing, guard hair (10 squire cm) were collected from the back of neck, breast and abdominal of fur seal (Fig.5). Relationship between concentration of mercury in hair and muscle on northern fur seal was shown in Figure 6. Concentration of mercury in hair is positive relationship to it in muscle.

Seasonal variation of concentration of heavy metal in hair on fur seals were shown in Figure 7. Concentrations of copper, zinc, iron, mercury, cadmium , and lead were approximately stable during November-March. Although concentrations of manganese and zinc were stable during November-February, it gradually increased in March. Concentrations of copper and zinc in hair collected during November-March in captivity were significantly higher than that of hair collected in April and July in the wild. Concentrations of mercury and cadmium in hair collected during November-March in captivity were lower than that of hair collected in April and July in the wild.

Plastic pollution on sea birds

5,526 plastic pellets were discovered in the 259 stomachs of sooty-shearwater. Of them, virgin plastic pellets accounted for 31.3%, and plastic fragments accounted for 68.7%. Occurrence of plastics destroyed by burn were zero in western North Pacific in 1982, 0.5 fragments in the central North Pacific in 1987, and 9.3 fragments in the eastern North Pacific in 1988.

12 plastic particles was discovered in the gizzard of black-footed albatross. These particles were estimated to be take with food from parents during chick stage at the breeding island. 413 and 2,041 plastic pellets were collected off Sanriku and in the central North Pacific using neuston net (size; 20x50cm , mesh;1.8mm and 0.33mm), respectively. Fragments of paint were dominantly observed in both areas. The number of plastic pellets in central North Pacific was numerous more than off Sanriku. It is due to wind and current.

Plastic debris of 84,165 pieces were collected at 187 places at Futami port and Kominato port, Chichijima Island, Ogasawara Islands. Of them, plastics fragments and virgin plastics pellets were many.

Discussion

In this study the concentration of cadmium in kidney on northern fur seals collected off Sanriku was lower than that of northern fur seals at Pribilof Islands. The difference is related to concentration of cadmium in sea water in the North Pacific and Bering Sea [1]. On the other hand, concentrations of cadmium in liver and kidney on fur seals collected in 1990-92 in this study were higher than that of fur seals collected off Washington coast in 1970-1971 [4]. It is necessary to examine whether pollution of northern fur seals by cadmium have been developing or not. Mercury concentration in liver on fur seals was lower than the values reported by Anas [4]. The reason is unknown.

Cadmium concentration of northern fur seals in the present study was higher than those of weddell seal (*Leptonychotes weddelli*) [5], California sea lion (*Zalophus californianus*) [6] and steller sea lion *(Eumetopias jubatus)* [7], but were lower than that of Antarctic fur seal *(Arctocephalus gazella)* [8], ross seal *(Ommastophoca rossi)* [9]. Cadmium concentration of norther fur seals in the present study seems to be the highest among the Pinnipeds next to Antarctic fur seal and Ross seal. Cadmium concentration has been considered to have a relation to their feeding habits. Northern fur seals are opportunistic feeder and take fish and squid [10]. Concentrations of cadmium in squid are reported different by area [7]. Difference of cadmium concentration in Pinnipeds may be related with concentration of cadmium in squid.

.Renal dysfunction of animals are occurred when animals take cadmium of 200-600 μg/g for long period [11]. Renal cadmium concentration of three fur seals indicated more than 100μg/g in this study. There is no information for renal dysfunction on northern fur seals, but cadmium are remained in body and increase with age same as other marine mammals [12, 13]. Monitoring of cadmium of northern fur seals must be continued.

The presence of metallothionein or metallothionein-like protein were observed in the liver and kidney of northern fur seal [14]. Metallothionein induced upon cadmium exposure. Quantity and ability of metallothionein must be examined in future.

Hair of northern fur seals molt during August-October and grow after November [15]. Higher concentration of zinc and copper in hair of fur seals during November-March may relate to grow the keratin and pigment in hair. Hair have possibility of biological monitoring of heavy metals without killing, and besides convenience to handling, transport and store due to their durableness. Hair may be useful as an indicator of heavy metal accumulation in northern fur seals.

Plastic debris at beach in Ogasawara Islands were many at the inlet or bay where wind were blown and tide were coming from offshore. If movement of wind and tide flow were understood, monitoring of plastic debris in an open sea would be accomplished.

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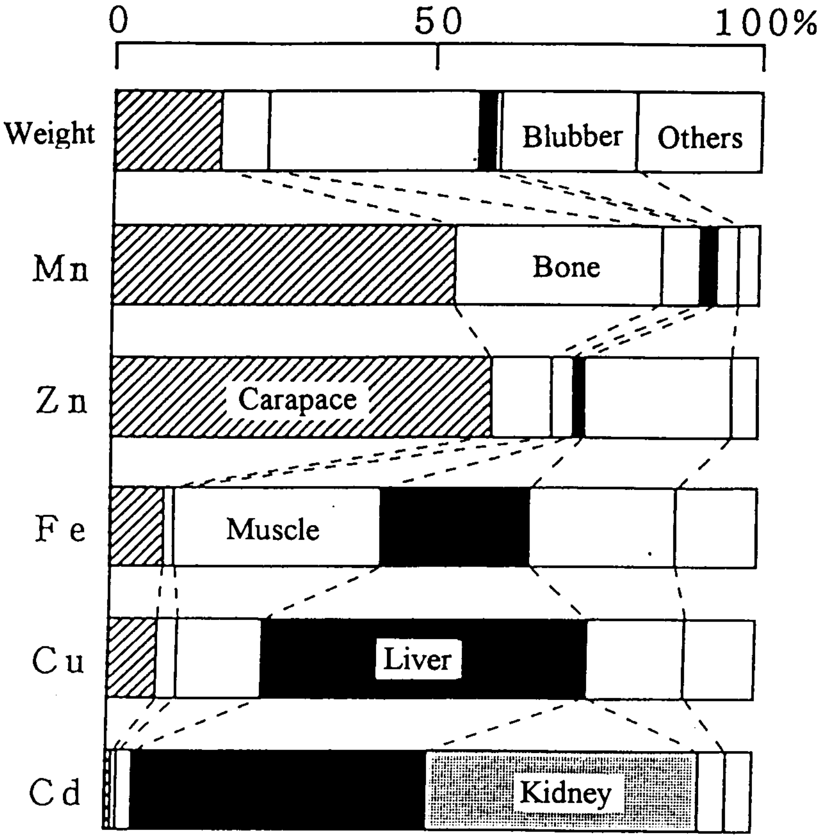

Fig. 1. Body burden of heavy metals of Green sea turtle.

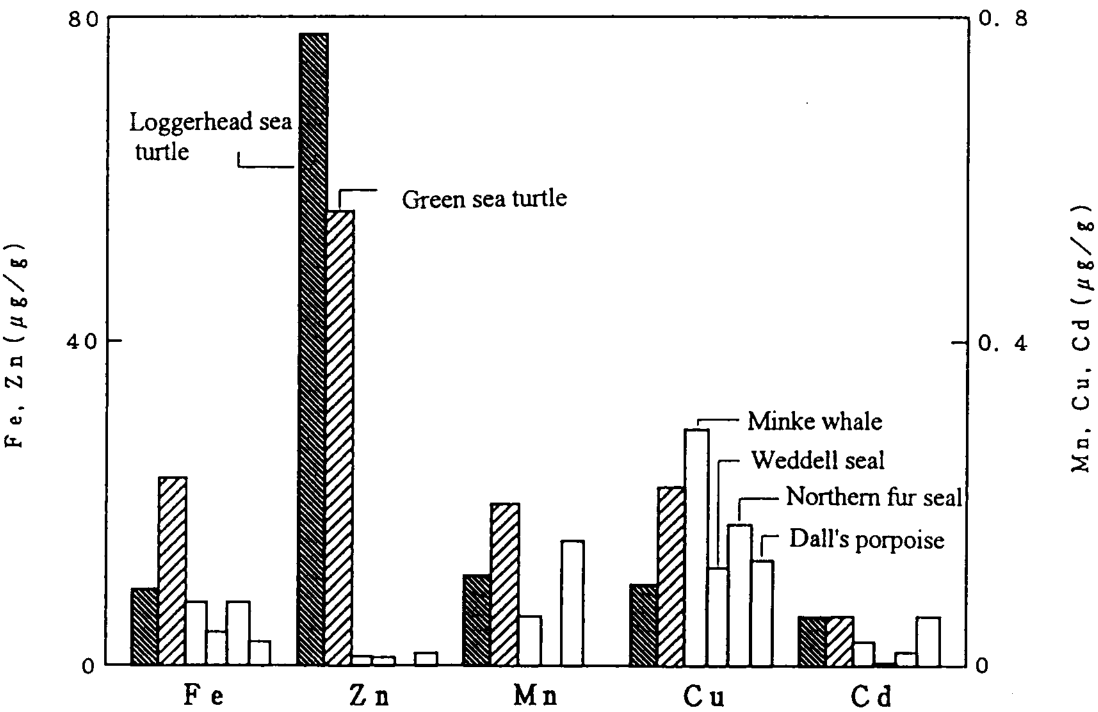

Fig.2 Concentration of heavy metal in blubber of sea turtle and marine mammals.

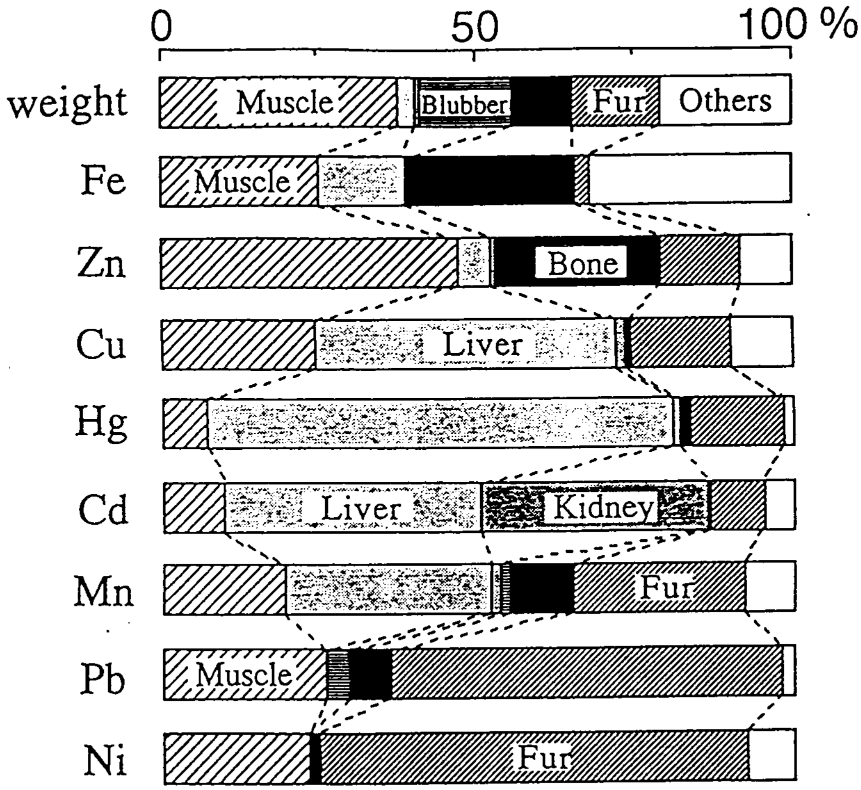

Fig.3. Body burdens of heavy metals in northern fur seal collected off Sanriku.
(First low show the percentage of each organs weight per body weight)

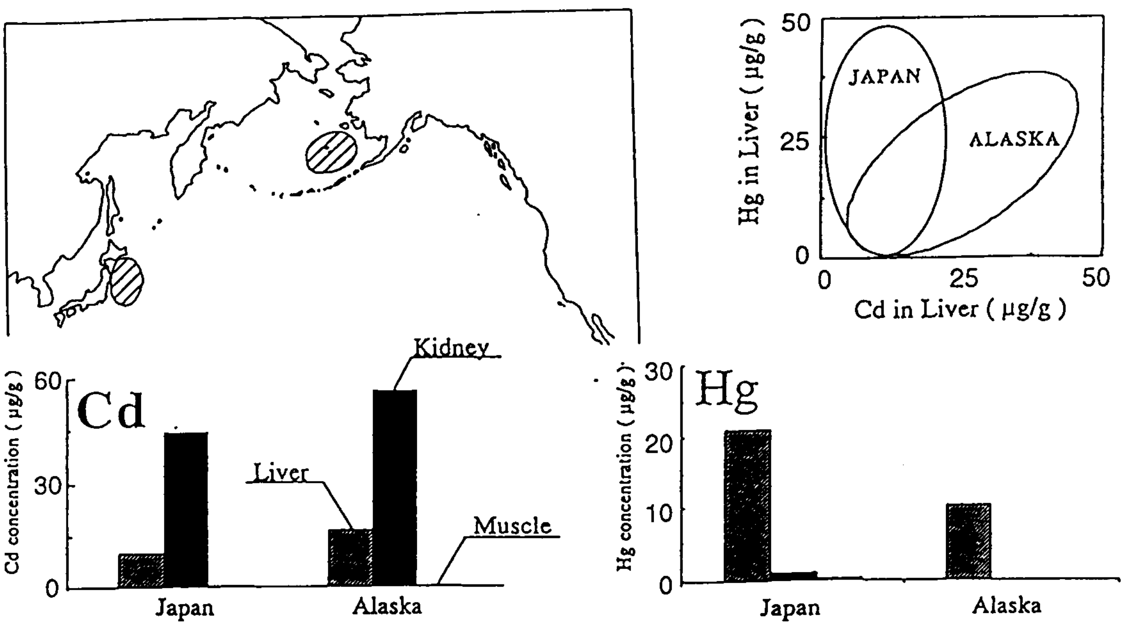

Fig.4 Comparison of Cd and Hg contaminants level in muscle, liver and kidney of northern fur seals collected off Sanriku and on the Pribilof Islands.

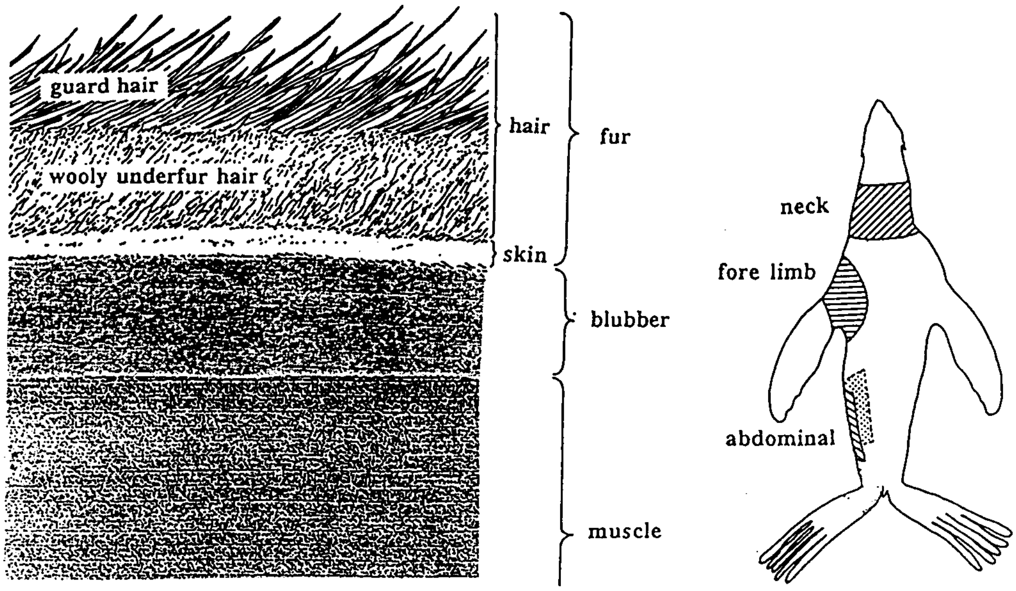

Fig. 5. Samples of hair collected of northern fur seal and its composition.

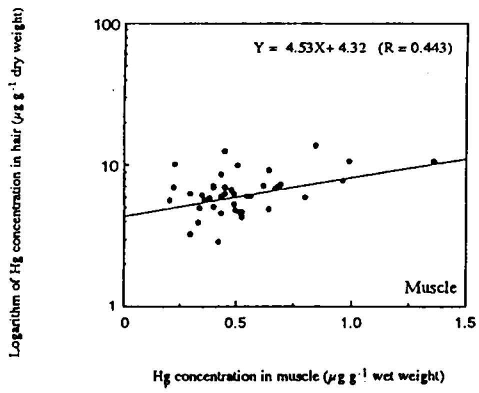

Fig.6. Relationship between Hg concentration in hair and muscle of northern seal collected off Sanriku.

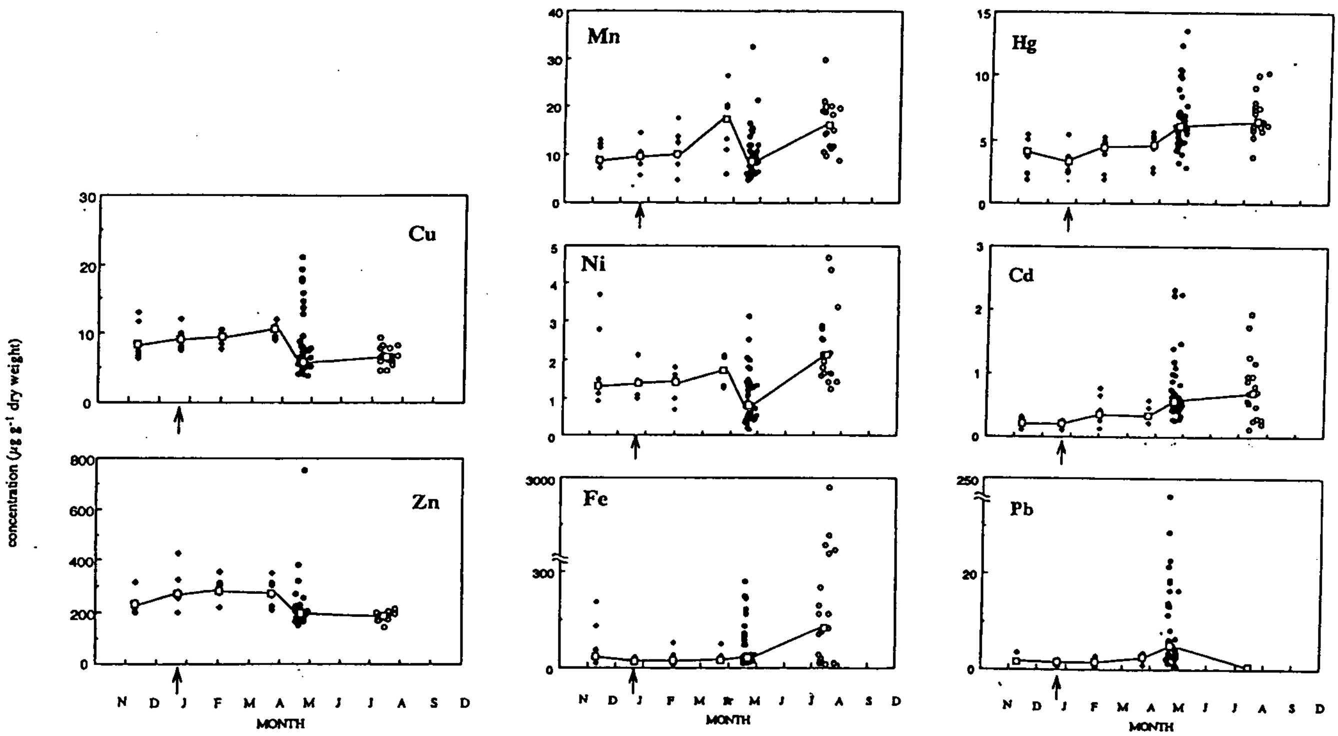

Fig.7. Seasonal variation heavy metal concentration in hair of northern fur seal.
Otaru ◆ Sanriku ● Pribilof ○ —□— Median