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Heavy Metal Concentrations in Cetaceans from Korean Coast

Hee Gu Choi*, Pyoung Joong Kim, Pil Yong Lee, Sang Soo Kim
Zang Geun Kim[1] and Hyo Bang Moon

Environment Management Division, National Fisheries Research & Development Institute, Busan 612-902, Republic of Korea
[1]Coastal & Offshore Fisheries Ecology Division, National Fisheries Research & Development Institute, Busan 612-902, Republic of Korea

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For the first time the concentrations of copper, zinc, lead, cadmium and crome in the tissues from 17 specimens of cetaceans of Korean coast were determined. The measured concentrations of trace elements were considerably lower than the concentrations previously reported in cetaceans. In inter-species, Cd levels were higher in the kidney of Stejneger's beaked whales and the stomach, liver and lung of Risso's dolphin than in the tissues of minke whale and humpback whale.

Key words: Heavy metals, Copper, Zinc, Lead, Cadmium, Crome, Cetaceans, Korean coast

Introduction

Coastal areas are the most productive systems in terms of providing important nursery areas and habitats, but they are also the repository for toxic agents and hazardous materials from industrial, agricultural and urban sources. All marine mammals alive today have been exposed to chemical compounds and trace elements introduced to aquatic systems by human activities. Cetaceans were considered especially interesting because of their position at the top of the food chain and the consequent expectation that contaminant levels might be relatively high. Ingestion of heavy metals in food or absorption via the water by marine mammals may result in the bioaccumulation of these elements in their tissues.

The heavy metals, Cd, Hg and Pb, although naturally present in marine environments, are nutritionally non-essential. Dietary exposure to elevated concentrations of these metals can be toxic to top consumers. Other metals, such as Cr, Cu, Fe, Mn and Zn are essential elements, but may also become toxic if excessively high concentrations are accumulated in tissues (Johnston, 1976; Elliott and Scheuhammer, 1997; Bowles, 1999). Many investigations have reported the accumulation of heavy metals in marine mammal (Augier et al., 1993; Wenzel et al., 1993; Malcolm et al., 1994; Szefer et al., 1994; Beck et al., 1997; Sepulveda et al., 1997; Caurant et al., 1999).

The main objective of this study is to report baseline concentrations of copper, zinc, lead, cadmium and crome in cetaceans stranded or entangled in fishing gear from Korean coast. The present communication is the first report on heavy metal concentrations in Korean marine mammals.

Materials and Methods

Cetacean samples were collected from 17 specimens stranded or entangled in fishing gear from Korean coast, whose names and biometry are listed in Table 1. Sample sizes vary greatly among species and no one species were sufficient individuals for a detailed examination of the effects of age and locality on contaminant levels. The specimens were dissected, and samples of the organs and tissues including muscle, skin, intestine, kidney, bladder,

*Corresponding author: hgchoi@nfrdi.re.kr

Table 1. Main characteristics of cetaceans stranded or entangled in fishing gear

Sample no.	Common name	Date	Sex	Length (cm)	Sampling area
1	Minke whale	10/12/98	?	470	South Coast (Geoje)
2	〃	18/04/99	?	440	East Coast (Uljin)
3	〃	21/04/99	♀	445	East Coast (Gangwondo)
4	〃	29/04/99	♀	458	East Coast (Yeongdeok)
5	〃	17/05/99	?	398	East Coast (Yangyang)
6	〃	20/05/99	♂	460	East Coast (Pohang)
7	〃	03/06/99	?	420	East Coast (Yeongdeok)
8	〃	02/08/99	♀	480	East Coast (Pohang)
9	〃	12/08/99	♀	580	East Coast (Ulsan)
10	Finless porpoise	28/05/99	?	130	West Coast (Inchon)
11	〃	10/06/99	?	150	South Coast (Tongyeong)
12	〃	28/03/00	?	167	East Coast (Gijang)
13	Stejneger's beaked whale	30/03/99	♀	516	East Coast (Samcheok)
14	〃	21/03/00	♀	510	East Coast (Samcheok)
15	Common dolphin	11/05/99	?	210	East Coast (Uljin)
16	Humpback whale	20/06/99	♂	750	East Coast (Uljin)
17	Risso's dolphin	23/04/00	♂	240	East Coast (Busan)

stomach, heart and liver were separated, after biometric measurements. All samples were stored at −20℃ until analysis.

For the analysis of copper, zinc, cadmium, lead and crome, samples (5~10 g) were digested to transparent solution with a mixture of nitric and perchloric acid after the standing 2 days with nitric acid. The resulting digest was gently evaporated almost to dryness. The final residue was dissolved in 2% nitric acid. Cu and Zn were determined by flame atomic adsorption spectrophotometry (Varian Spectra 55). Cd, Pb and Cr were analyzed by graphite furnace atomic adsorption spectrometry (Varian Spectra, Zeemann/880). As analytical quality control, standards of the NRC Canada (dogfish muscle DORM-2) were analyzed using the same procedure. Detection limits were 0.2 μg/g wet for Cu, 0.4 μg/g wet for Zn, 0.003 μg/g wet for Cd, 0.03 μg/g wet for Pb and 0.03 μg/g wet for Cr. Our results were in good agreement with the certified values with recoveries of more than 90% for five elements.

Results

Trace elements in tissues

The results of heavy metal analyses of the collected tissues from cetacean stranded or entangled in fishing gear are summarized in Table 2. Cd and Zn concentrations were highest in the liver, whereas Cr was highest in the kidney and stomach. Cu concentrations were almost uniform among these tissues and organs. Pb concentrations in the tissues except the intestine, liver and lung were below the detection limit of 0.03 μg/g wet weight. Muscle, skin and heart tissues were generally characterized by low concentrations of the metals analyzed.

Trace elements according to individual

Heavy metal concentrations in the tissues of five species are shown in Table 3. Comparing between species, Cd residues were considerably higher in the kidney of Stejneger's beaked whale, the intestine of finless porpoise and the stomach, liver and lung of Risso's dolphin than in the tissues of minke whale and humpback whale. The mean Pb concentrations in all tissues of four species except humpback whale (<0.03~0.120 μg/g) were below the detection limits. Cu concentration was the highest in the stomach of minke whale (mean 11.89 μg/g), while Zn was the highest in the liver of Risso's dolphin. The highest of mean Cr concentrations were found in the kidney of minke whale and the stomach of Risso's dolphin.

Discussion

There were great differences between the accumulation properties of Cu, Zn, Pb, Cd and Cr in the tissues. For example Cd concentrated primarily in the liver (mean 0.086 μg/g) then in the kidney (mean

Table 2. Mean and range of metal concentrations (μg/g wet weight basis) in tissues of cetaceans from Korean coast

Tissue	Cu	Zn	Pb	Cd	Cr
Muscle	1.11 (0.31~2.29)	6.55 (4.54~8.97)	<0.030 –	0.010 (<0.003~0.020)	0.058 (<0.030~0.076)
Skin	2.19 (1.00~4.47)	5.90 (3.05~11.37)	<0.030 –	0.019 (0.008~0.036)	0.080 (0.056~0.093)
Intestine	1.23 (0.35~2.70)	8.05 (1.68~15.38)	0.054 (<0.030~0.120)	0.027 (<0.003~0.073)	0.078 (<0.030~0.130)
Kidney	1.01 (0.72~1.63)	13.01 (10.81~17.28)	<0.030 (<0.030~0.048)	0.078 (0.019~0.222)	0.154 (0.062~0.337)
Bladder	0.53 (0.48~0.58)	4.43 (2.33~6.54)	<0.030 –	0.016 (0.009~0.023)	0.043 (0.042~0.044)
Stomach	3.61 (0.50~11.89)	7.12 (4.18~10.96)	<0.030 –	0.076 (0.010~0.271)	0.154 (0.041~0.400)
Liver	1.80 (1.00~2.41)	17.44 (9.04~29.94)	0.047 (<0.030~0.059)	0.086 (0.034~0.191)	0.080 (0.042~0.116)
Heart	0.96 –	4.15 –	<0.030 –	0.009 –	0.082 –
Lung	1.44 (0.81~1.97)	2.54 (2.20~2.88)	0.044 (<0.030~0.068)	0.050 (0.012~0.095)	0.050 (0.037~0.062)
Ovary	0.72 –	5.75 –	<0.030 –	0.033 –	0.080 –

0.078 μg/g), which is a non-essential element with no biological function. Honda (1985) found that hepatic levels above 20 μg/g can initiate detrimental effects to other organs, such as the kidneys. Heavy metal accumulation in cetaceans from Korean coast was considerably lower than those previously reported (Falconer et al, 1993; Szefer et al., 1994; Beck et al., 1997; Bowles, 1999). Pb was detected in only intestine, liver and lung. These results were similar to those reported in other study (Beck et al., 1997). Pb is non-essential element and higher levels can occur in animals close to anthropogenic sources. Cr levels were low and vary little among tissues (0.043~0.154 μg/g wet weight). Thompson (1990) reported that levels found in marine mammals are usually below 1.0 μg/g wet weight. Cu and Zn concentration in cetaceans from Korean coast did not exceed mean 5 μg/g and 20 μg/g, respectively. Cu and Zn concentrations in our cetaceans were lower than previously reported (Falconer et al., 1993; Szefer et al., 1994; Beck et al., 1997; Bowles, 1999). These are both essential elements serving in the formation or function of many enzymes involved in metabolism, and concentrate primarily in the liver (Beck et al., 1997). Zn concentrations reported here were also the highest in the liver, while Cu concentrations were the highest in the stomach.

In addition to these inter-tissue variations, inter-specimen differences in metal concentrations were observed, mainly concerning Cd. In Cu, Zn, Pb and Cr, it was difficult to find the species-specific differences because of narrow ranges of heavy metals levels. The Cd levels were higher in the kidneys of Stejneger's beaked whale and the stomach, liver and lung of Risso's dolphin than in the tissues of minke whale and humpback whale. Species-specific differences can occur as results of diet. Generally a diet of krill is likely to contain a higher cadmium content than the fish-baked diet (Thompson, 1990). Honda et al. (1987) measured high concentrations of several metals in Antarctic krill taken from the stomachs of southern minke whales. However, the heavy metals concentrations of our minke whale were low. Comparison of concentrations between different species is still difficult because of the number of uncontrolled variables that can affect the levels reported: biological characteristics, particularly sex, age and diet, etc (Elliots et al., 1997; Bowles, 1999).

In conclusion, the concentrations of trace elements in cetaceans from Korean coast were relatively low compared with values reported in other studies. These

Table 3. Trace elements concentrations (μg/g wet weight basis) difference at inter-species of cetaceans

Species	Tissue	Cu	Zn	Pb	Cd	Cr
Minke whale (*Balaenoptera acutorostrata*)	Muscle	1.29 (0.35~2.92)	8.97 (1.27~22.06)	<0.030 (<0.030~0.052)	0.0100 (<0.003~0.026)	0.076 (<0.030~0.241)
	Skin	1.00 (0.30~1.99)	3.05 (2.87~3.27)	<0.030 –	0.008 (0.008~0.009)	0.092 (0.071~0.114)
	Intestine	0.86 (0.45~1.27)	3.33 (0.86~5.81)	<0.030 (<0.030~0.036)	0.06 (0.021~0.030)	0.070 (<0.030~0.112)
	Kidney	0.87 (0.77~0.98)	11.04 (9.48~12.60)	0.032 (<0.030~0.045)	0.040 (0.010~0.070)	0.337 (<0.030~0.671)
	Bladder	0.48	6.54	<0.030	0.023	0.042
	Stomach	11.89 (7.64~16.14)	7.30 (1.69~12.90)	<0.030 (<0.030~0.032)	0.011 (0.007~0.016)	0.101 (0.028~0.174)
	Heart	0.96	4.15	0.031	0.009	0.082
	Liver	2.00 (0.54~5.64)	9.04 (1.22~23.98)	0.035 (<0.030~0.054)	0.034 (0.006~0.092)	0.116 (<0.030~0.380)
Finless porpoise (*Neophocaena phocaenoides*)	Muscle	0.31	5.75	<0.030	<0.003	<0.030
	Skin	4.47 (1.50~7.44)	11.37 (8.83~13.92)	0.031 (<0.030~0.042)	0.036 (0.006~0.067)	0.056 (0.055~0.057)
	Intestine	0.64 (0.41~0.87)	14.36 (11.44~17.28)	<0.030 –	0.073 (0.012~0.133)	0.134 (0.092~0.160)
	Heart	8.57	21.01	<0.030	0.017	0.105
	Ovary	0.72	5.75	<0.030	0.033	0.080
Stejneger's beaked whale (*Mesoplodon stejnegeri*)	Muscle	0.56 (0.40~0.72)	4.54 (3.35~5.73)	<0.030 –	0.020 (0.010~0.026)	0.070 (<0.030~0.120)
	Intestine	1.59	15.38	<0.030	0.017	0.105
	Kidney	1.63	12.90	<0.030	0.222	0.153
	Stomach	0.93	6.04	<0.030	0.011	0.041
Humpback whale (*Megaptera novaeangliae*)	Skin	1.09	3.27	<0.030	0.012	0.093
	Intestine	2.70	1.68	0.120	0.006	0.092
	Kidney	0.72	10.81	0.048	0.019	0.062
	Stomach	1.12	4.18	0.035	0.010	0.074
	Liver	2.41	13.33	0.059	0.034	0.083
	Lung	0.91	2.88	0.068	0.012	0.062
Risso's dolphin (*Grampus griseus*)	Intestine	0.35	5.49	<0.030	<0.003	0.030
	Kidney	0.81	17.28	<0.030	0.031	0.064
	Bladder	0.58	2.33	<0.030	0.009	0.044
	Stomach	0.50	10.96	<0.030	0.271	0.400
	Liver	1.00	29.94	<0.030	0.191	0.042
	Lung	1.97	2.20	<0.030	0.255	0.037

results suggest that contamination of cetaceans with these metals is not as yet a serious problem in the region. Our data can only give a first hint of heavy metal burden of Korean cetaceans. Establishing databases on contaminants in marine mammals will help in understanding the role of contaminants in mortality events and provide a basis for investigating, predicting and mitigating these events.

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