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Trace Metal Burdens in Stranded Seals from Long Island, New York: Potential Evidence for Species Differences in Foraging

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Abstract

Toxic (e.g., Hg, Ag, Cd, and Pb) and essential (e.g., Se, Cu, and Fe) trace element levels were determined in liver samples from four seal species (harp seal [*Phoca groenlandica*], *n* = 35; hooded seal [*Cystophora cristata*], *n* = 7; harbor seal [*Phoca vitulina*], *n* = 34; gray seal [*Halichoerus grypus*], *n* = 10) stranding in Long Island waters between 1988 and 2004 to examine temporal and species-specific patterns in these top marine carnivores. There was no obvious trend in trace metal burdens in seal livers over this time period. Harp and hooded seals are arctic species that have only appeared in Long Island waters in recent years. Their diets are believed to include more invertebrate prey, and this was reflected in significantly higher cadmium (Cd) concentrations (mean = 5.5 to 6.3 µg g^{-1} dry weight vs. 0.5 to 1.4 µg g^{-1} for harbor and gray seals, $p = 0.007$). The highest mercury (Hg) burdens (> 100 µg g^{-1} dry weight) were seen in seven of the eight adult harbor seals and the only adult gray seal; four of five adult harp seals did not show elevated levels. This suggests that migratory harp seals are feeding on prey with a lower Hg burden compared to resident harbor seals that forage in the coastal environment. Copper (Cu) levels were high (70 to 105 µg g^{-1}) in a few juvenile harbor seals as predicted based on Cu-incorporating enzymes essential for growth. A few elevated silver (Ag) values (1.5 to 3.0 µg g^{-1}) were seen in the same adult harbor seals with high Hg burdens. These values may not reflect metal burdens in healthy populations as our samples were obtained from stranded animals, but there was no evidence that any of these seals died as a result of metal toxicity.

Key Words: harp seal, *Phoca groenlandica*, harbor seal, *Phoca vitulina*, stranding, mercury, cadmium, metal burdens

Introduction

Metals or "trace elements" exist in the marine environment due to both natural processes, such as volcanic activity and weathering, and as a consequence of human activity. Many of these elements become concentrated in top predators over time due to bioaccumulation and increasing exposure. Some trace elements (e.g., Cu, Zn, Se, and Fe) are essential for the health of marine vertebrates, whereas several non-essential trace metals (e.g., Hg, Cd, Pb, Ag, and As) are known to exert a toxic effect on mammalian cells when present at high concentrations (Becker, 2000). Marine mammals tolerate higher levels of metals per unit weight than terrestrial mammals due to effective binding of metal ions with both metallothionein proteins and selenium (Se), which is preferentially acquired when metal intake is high (Becker, 2000). After weaning, the majority of the metal burden is attributed to food intake and should, therefore, be related to the composition of the diet as well as the overall condition of the local environment.

From studies of terrestrial mammals, including humans, it is clear that some trace elements can interfere with normal patterns of growth as well as reproductive and immune function. They can also inhibit the uptake and use of other essential elements so that deficiencies and excesses of these elements may have harmful effects on the mammal's health (Krone et al., 1999). High levels of metal contamination in marine mammals have been detected, although no toxic effects have been directly documented (O'Shea, 1999). Mercury (Hg) accumulation has been studied most extensively. This highly toxic element enters the environment through mining activities, combustion of fossil fuels, and through geological sources. The poisonous (e.g., neurotoxic, nephrotoxic, immunotoxic, and mutagenic) effects of Hg are magnified as an individual grows older through the process of bioaccumulation.

Cadmium (Cd) is a non-essential element that may enter the environment as a contaminant from various industrial processes such as mining, petroleum production, and other manufacturing activities. Elevated concentrations have been found in sediments of aquatic ecosystems near industrial areas. Excess Cd can cause disorders of the circulatory, nervous, reproductive, and renal systems (O'Shea, 1999). This metal is also known to accumulate with age and is typically found at highest concentrations in kidney tissue. In mammals, the toxic effects of Cd are usually mitigated by binding with metallothionein proteins, and some very high values have been reported in marine mammal kidneys without apparent ill effect (O'Shea, 1999).

Copper (Cu) is an essential trace element that is known to occur in higher concentrations in young animals, indicating that it is especially important during the active growth phase (Law et al., 1992). Silver (Ag), another potentially toxic trace metal used as a tracer of sewage (Sañudo-Wilhelmy & Flegal, 1992), is known to be positively correlated with both Se and age in marine mammal liver tissues (Becker et al., 1995). High Ag loads could therefore enhance Hg toxicity if the buffering capacity of Se is exceeded.

Our goal for this study was to utilize archived liver samples to determine metal burdens for seals stranding in Long Island, New York, waters between 1988 and 2004. The four species of seals found in the region are the harp seal (*Phoca groenlandica*), hooded seal (*Cystophora cristata),* harbor seal (*Phoca vitulina*), and the gray seal (*Halichoerus grypus).* Both harp and hooded seals are ice-breeding species that typically migrate between sub-arctic and arctic regions of the Atlantic Ocean. However, in recent years, sightings and strandings of these arctic seals have been recorded south of their normal range, including the Long Island region (McAlpine & Walker, 1990; Lucas & Daoust, 2002). Harp and hooded seals are believed to consume more invertebrate prey, particularly as juveniles, compared to harbor and gray seals. The latter two species occur commonly in the coastal habitat along Long Island and eat mostly benthic fish, herring, and occasionally squid (King, 1983).

Because all of the animals we sampled were in very poor physical condition at the time of death, we did not expect our results to necessarily reflect metal burdens in local healthy seal populations. However, we were able to assess whether metal burdens have changed dramatically over this time period and to test for species differences that might provide important information about differential use of local habitat and food resources. The Riverhead Foundation for Marine Research and Preservation has successfully rehabilitated and released many harp and harbor seals over this same time period, and preliminary satellite tracking data suggests that the two species show very different behavior after release (Riverhead Foundation, unpub. data). Although some apparently healthy harp seals have been seen around Long Island in recent years, they may not be directly competing for resources with the locally abundant harbor seals. We hypothesized that liver samples from these two species would show different trace metal burdens based on different dietary preferences and foraging locations.

Materials and Methods

Samples

Between 1988 and 2004, a total of 86 seal liver samples were collected by the Riverhead Foundation for Marine Research and Preservation, which houses the stranding network for marine mammals on Long Island. The seals were either found dead or died during rehabilitation attempts. Most of the seals died at the facility ($n = 58$) or were freshly dead when collected ($n = 16$). The remaining samples were obtained from moderately decomposed carcasses. All samples were kept frozen in clean plastic bags until analyzed, but some of the older samples were also wrapped in aluminum foil and may have been subjected to accidental thawing. Surface contamination was avoided by obtaining clean subsamples from the inner part of the tissue using a sterile scalpel blade. Age of each individual was estimated by the straight length (SL) measurement. A total of seven hooded seal, ten gray seal, 34 harbor seal, and 35 harp seal liver samples were analyzed, representing the relative frequency of stranding of these species over the time period. The vast majority of the samples were from juveniles (mostly pups and yearlings), although we did have samples from one adult gray seal (221 cm SL), four to five adult harp seals (> 150 cm SL), and eight adult harbor seals (> 120 cm SL). None of these animals showed evidence of death by physical trauma, and most had a documented necropsy indicating disease. Respiratory failure was the most common cause of death (48%), and heavy parasite loads were documented in 70% of all necropsies. No liver or kidney lesions were noted.

Chemical Analysis

Liver subsamples (approximately 0.5 g) were weighed in 30 ml beakers that had been acid-washed and dried under a HEPA trace metal clean unit, covered with watch glasses, and dried to constant weight at 68° C. We used dry weights because some samples had been stored for extended periods and possibly thawed, and, therefore, were expected to vary substantially in moisture content. Because we were particularly interested in quantifying Hg burdens, we followed the sample digestion procedure outlined in the EPA Appendix to Method 1631 ("Total Mercury in Tissue, Sludge, Sediment, and Soil by Acid Digestion and BrCl Oxidation," EPA-821-R-01-013, January 2001). Dry weights were recorded, and samples were brought slowly to boil on electric hot plates in 10 ml of a 7:3 mixture of concentrated trace metal grade nitric and sulfuric acid. After the tissue was fully digested (solution clear), 0.02 N BrCl was added to a final volume of 40 ml in order to completely oxidize any remaining methyl Hg into inorganic form. Digested samples were well mixed and allowed to cool before storage in trace metal clean polypropylene tubes at 4° C until analysis.

Concentrations of trace elements (e.g., Hg, Cu, Cd, Ag, and Se) were analyzed by inductively coupled plasma-mass spectrometry (ICPMS) (Finnigan Element 2) in a trace metal clean laboratory. Standard reference material consisting of dogfish liver tissue with known amounts of all measured trace elements (DOLT 3; National Research Council, Canada) and control blanks (consisting of all reagents but no tissue) were included with each batch of sample digestions and were analyzed in the same way. We attempted to analyze all samples for lead and arsenic as well, but these elements proved to be present at levels below the detection limit of our method. Metal values were first corrected by the control blank, and then corrected by the percent recovery for the standard reference material (DOLT 3) for each element in each batch. Hg recoveries (for which the sample digestion protocol was specifically designed) ranged from 90 to 111% in six of the eight batches, with a low of 76% and a high of 144%. Recoveries for other metals were typically below 90%.

Results

There was no apparent trend over the 16-y time period (1988 to 2004) in metal burdens found in these seal liver samples, although this is somewhat confounded by varying numbers of the four species and age groups collected in each year as well as by gaps in the record. Of nine elevated Hg levels (> 100 µg g^{-1} dry weight) found in the entire data set, one was collected in 1992, one in 1994, two in 1995, two in 2002, and three in 2004, reflecting the overall number of stranded animals collected each year (see Appendix 1). Of eight adult-sized (> 120 cm SL) harbor seals, seven had high Hg levels as did the single adult gray seal, while all juveniles had relatively low levels. For the harbor seals, Hg showed a significant

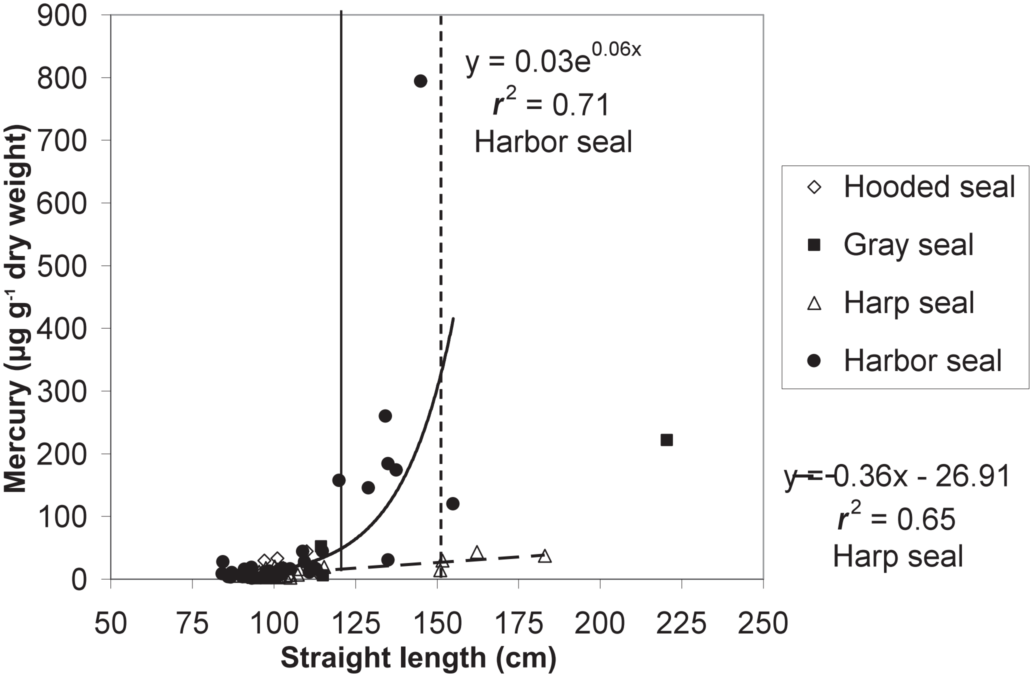

Figure 1. Mercury levels in liver samples from 35 harp seals (four adults, > 150 cm, dashed vertical line) and 34 harbor seals (eight adults, > 120 cm, solid vertical line) stranded on Long Island, New York, between 1988 and 2004 (straight length is used as a proxy for age)

exponential increase with age (as indicated by SL; $y = 0.03e^{0.06x}$, $r^2 = 0.71$; Figure 1). On the other hand, four adult-sized harp seals had low to moderate Hg burdens; a modest linear increase with age is suggested for this species ($y = 0.36x - 26.91$, $r^2 = 0.65$; Figure1). There was a single harp seal sample with a relatively high Hg value of 125 µg g^{-1} dry weight. Unfortunately, no length measurement was available for this individual, but we assume it was an adult. The 34 harbor seal samples (eight adults) had significantly higher Hg burdens than the 35 harp seal samples (four to five adults; *t* test with unequal variances, $t = -2.06$, $p = 0.047$). For harbor seals only, the highly variable Hg values were correlated with Se values in a molar ratio of 1:1 (log-transformed data, $y = 1.0x$ to 0.27, $r^2 = 0.52$; Figure 2).

In contrast to the pattern observed for Hg burdens, the highest Cu values were seen in juvenile harbor seals (up to 105 µg g^{-1} dry weight); all adults (and many juveniles) had values below 40 µg g^{-1} (Figure 3). Unlike Hg and Cu, Cd concentrations were not well-explained by seal age (as estimated by SL) but, rather, differed dramatically by species. Cd levels were significantly higher in the two arctic seal species (harp and hooded seals; our sample contained only four to five adult harp seals and no adult hooded seals) compared to harbor and gray seals (with eight and one adult-sized individuals, respectively; single-factor ANOVA, $p = 0.007$; Figure 4). Ag burdens were generally low (50% of samples had values less than 0.1 µg g^{-1} dry weight; see Appendix 1). The adult harbor seal with the highest measured Hg value (nearly 800 µg g^{-1} dry weight) had the highest Ag burden measured in this study (3.0 µg g^{-1}). The other two elevated Ag values (> 1.5 µg g^{-1}) were also detected in adult harbor seals with elevated Hg.

Discussion

One striking result of this study was the presence of elevated Hg levels in seven of eight adult harbor seal livers (see Appendix 1). The single adult gray seal we sampled also showed elevated Hg. Wagemann & Muir (1984) estimated the limit for Hg tolerance in mammalian liver tissue at 100 to 400 µg g^{-1} wet weight (approximately 400 to 1,600 µg g^{-1} dry weight). Only one of our Hg measurements exceeded this limit (see Figure 1;

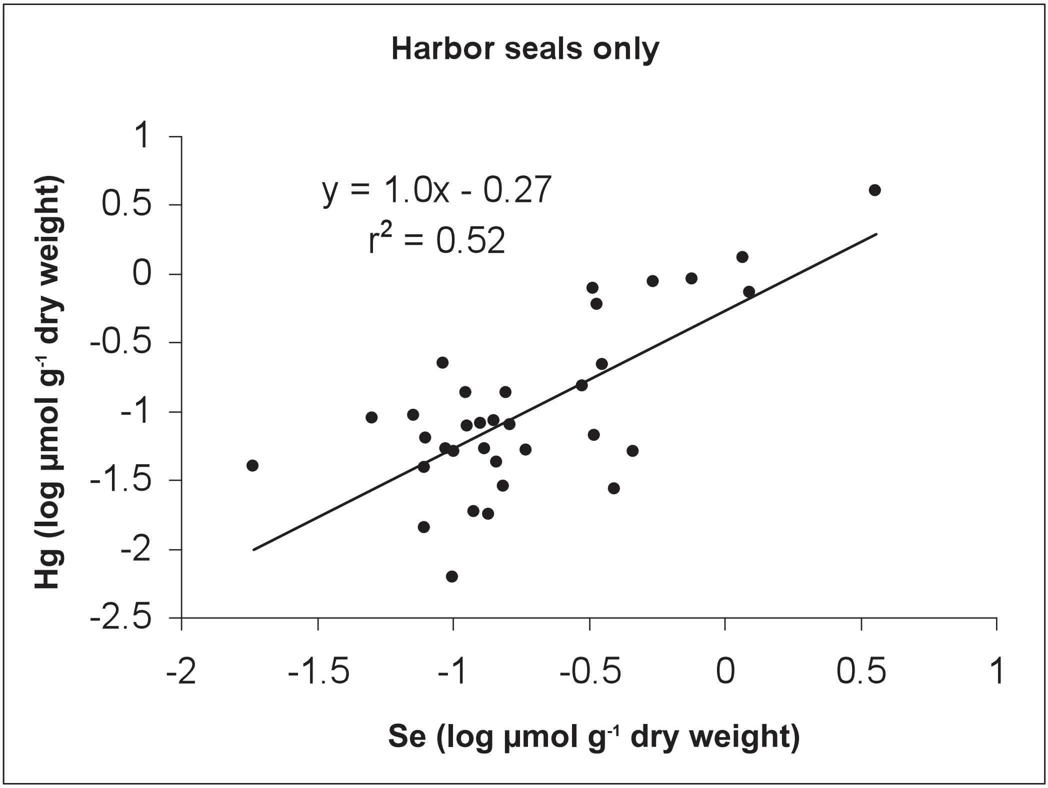

Figure 2. Selenium values were correlated with Hg burdens in liver samples from 34 harbor seals (eight adults) stranded on Long Island, New York, from 1988 to 2004 in a 1:1 molar ratio.

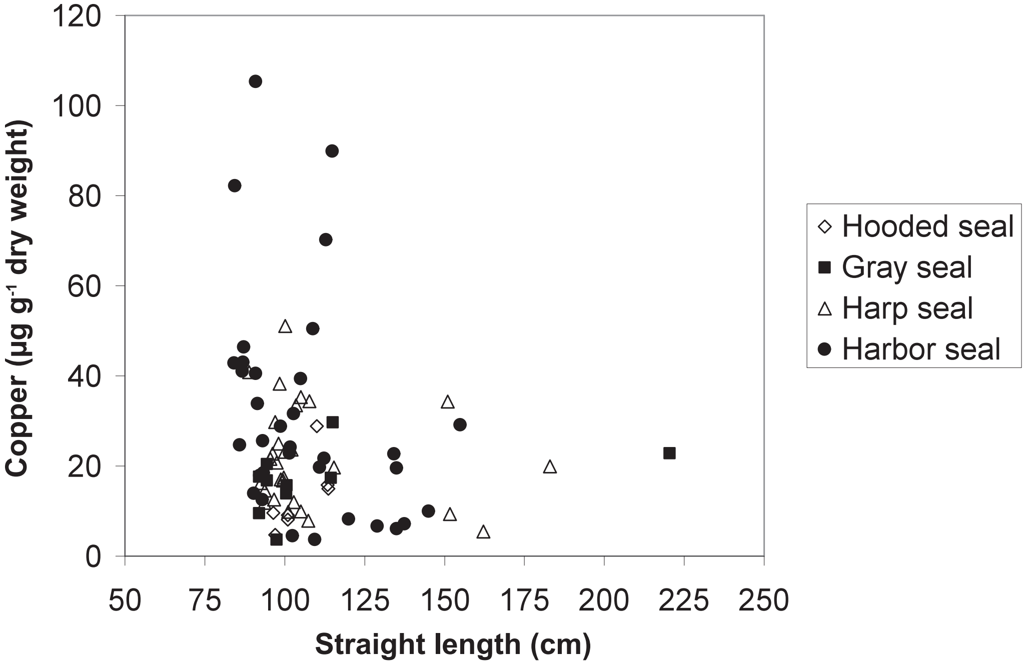

Figure 3. Copper concentration in liver samples from seals stranded on Long Island, New York, from 1988 to 2004 (straight length is used as a proxy for age)

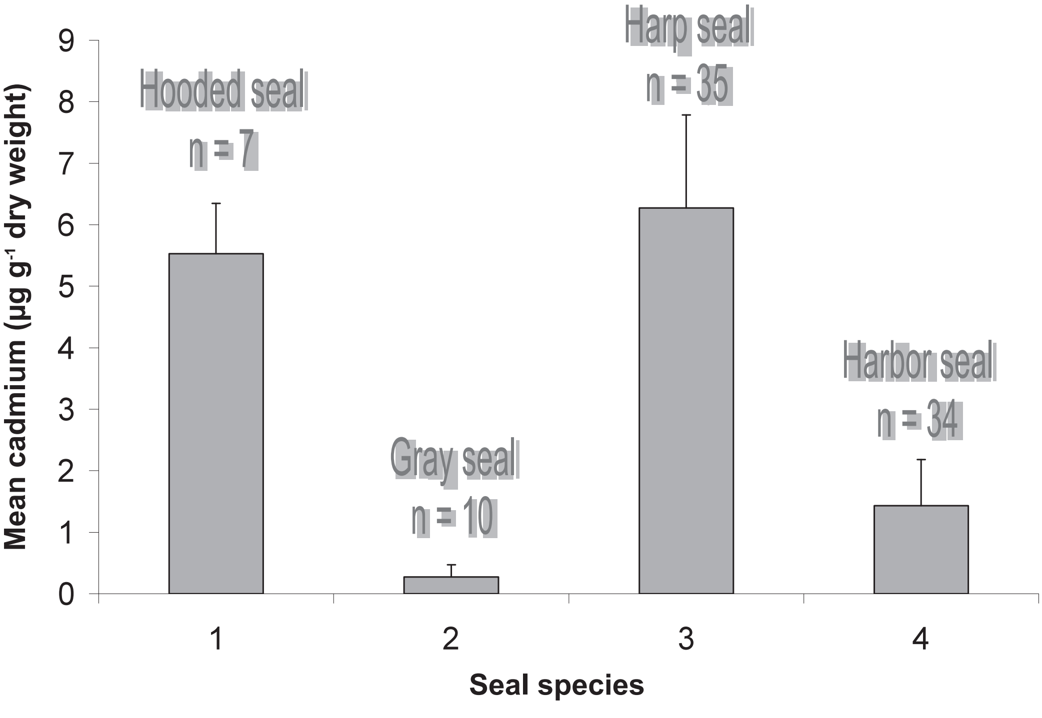

Figure 4. Mean (± standard error) cadmium values in four seal species stranded on Long Island, New York, from 1988 to 2004; harp and hooded seals native to the Arctic have significantly more Cd than coastal resident gray and harbor seals (single-factor ANOVA, $p = 0.007$).

Appendix 1); this animal presented no unusual findings on necropsy. A few examples of possible liver disease in marine mammals with elevated Hg levels have been reported such as bottlenose dolphins (*Tursiops truncatus*) with Hg > 234 µg g^{-1} dry weight (Rawson et al., 1993) and a single beaked whale (*Mesoplodon densirostris*) with Hg of 248 µg g^{-1} wet weight (~1,000 µg g^{-1} dry weight) (Law et al., 1997). While a few studies have attempted to make a connection between high Hg levels and pathology (e.g., Siebert et al., 1999; Bennett et al., 2001), in many cases, very high Hg burdens appear to be tolerated by marine mammals (for summary, see O'Shea, 1999). Several attempts to link marine mammal mass mortality events to high toxic metal loads have failed (e.g., Baikal seal [*Phoca sibirica*]: Watanabe et al., 1996; Caspian seal [*Phoca caspica*]: Anan et al., 2002).

Harbor seals in this study had a wide range of Hg burdens, which appeared to be buffered by a 1:1 molar ratio with Se (see Figure 2). Several previous marine mammal studies have also shown a 1:1 molar ratio of Hg to Se, particularly when high levels of Hg have accumulated in the system (Meador et al., 1993, 1999; Law et al., 2001). When Hg burdens are low, the correlation between Hg and Se is often weak, and the ratio much lower (e.g., walrus [*Odobenus rosmarus rosmarus*]: Wagemann & Stewart, 1994; bowhead whale [*Balaena mysticetus*], Krone et al., 1999). This pattern is typical of marine mammals feeding at a lower trophic level in the food chain as compared to strictly piscivorous species (O'Shea, 1999).

Saeki et al. (2001) found Ag burdens of about 0.1 to 4 µg g^{-1} dry weight in livers of three pinniped species from the North Pacific (e.g., northern fur seal [*Callorhinus ursinus*], Steller sea lion [*Eumetopias jubatus*], and harbor seal). Ag levels were significantly correlated with both Hg and Se in all three species. Similarly, the three elevated Ag values (1.5 to 3.0 µg g^{-1} dry weight) in our seal liver samples from Long Island waters were all found in adult harbor seals that also had high Hg loads (see Appendix 1). This suggests possible ingestion of highly contaminated prey by some individuals in this coastal environment.

Cu is an essential trace element that is known to occur in higher concentrations in young animals. This is consistent with our finding that the highest Cu values were detected in juveniles, particularly in four young harbor seals with values above 70 µg g^{-1} dry weight (see Figure 3). These values are similar to those reported for harbor and gray seal samples from the UK (up to approximately 100 µg g^{-1} dry weight; Law et al., 1991), but lower than the maximum value reported for Caspian seals (about 175 µg g^{-1} dry weight) by Anan et al. (2002).

Another important result of this study was the significantly higher Cd levels (5.5 to 6.3 µg g^{-1} dry weight) found in livers from the arctic species (harp and hooded seals) compared to the more coastal harbor and gray seals (0.5 to 1.4 µg g^{-1} dry weight; see Figure 4). In the northeast Atlantic Ocean, cephalopod prey was found to be a major source of Cd for top marine predators in the higher latitudes (Bustamante et al., 1998). Consumers of any invertebrate prey appear to have increased Cd burdens compared to strict piscivores (Watanabe et al., 2002). Two species of baleen whale, which feed on krill and other large zooplankton, have been reported with very high Cd values (bowhead: up to 88 µg g^{-1} dry weight, Krone et al., 1999; minke whale [*Balaenoptera acutorostrata*]: estimated from wet weight value of 48 µg g^{-1} at nearly 200 µg g^{-1}dry, Law et al., 2001). In addition, elevated Cd values (> 100 µg g^{-1} dry weight) were found in walrus liver samples from the high Arctic (Wagemann & Stewart, 1994). In this case, because the principal prey species (clams) were relatively low in Cd, the high values in walrus liver were attributed to possible accidental ingestion of sediment, which should be rich in Cd, based on the highly mineralized underlying geology (Outridge et al., 1997). None of these animals appeared to be suffering toxic effects from these high Cd burdens.

In three seal species from Alaska, Dehn et al. (2004) found that renal Cd was highest in young animals feeding mainly on invertebrates, and it was lower in older animals that had switched to a fish diet, or in species which were primarily fish-eaters. Our results imply that the migrant harp and hooded seals we sampled on Long Island consumed more invertebrate prey during their lives in the Arctic, compared to harbor and gray seals. Preliminary satellite tracking of seals that were rehabilitated by the Riverhead Foundation suggests that upon release in Long Island waters, harp seals swam immediately for deep water and headed north, while harbor seals remained in local coastal waters (Riverhead Foundation, unpub. data). Both the Hg and the Cd data support our hypothesis that these species may not utilize local food resources in the same way, which is important in light of increasing numbers of healthy harp seals (including some adults) that have been recently seen in Long Island waters (Riverhead Foundation, unpub. data). Our results also confirm that metal burdens in liver samples may serve as a useful indicator of trophic level and ecological niche for various species (see also Das et al., 2000, 2003).

While the confounding factors of species and age precluded a rigorous analysis of temporal trends in metal burdens in seals over this time period, the nine samples with high Hg levels were spread out over the years of this study, from 1992 to 2004. We had only seven samples from earlier years (1988 to 1991), all from juvenile harbor seals because those were the only seals stranding in Long Island waters at that time (see Appendix 1). A review of temporal trends in metal contamination found in bivalve mollusks over the same time period suggested that Hg and Se levels showed an increasing trend in some parts of Long Island Sound (O'Connor & Lauenstein, 2006). The one extremely high Hg level we detected in harbor seal liver (nearly 800 µg g^{-1}) was found in a sample from the most recent year of analysis (2004), which is at least not inconsistent with this report from the much more sedentary mollusks. O'Connor & Lauenstein also reported a long-term decline in Cd levels over this time period in mussels and oysters in the area, but this is more difficult to compare with our results. The high Cd levels detected in arctic harp and hooded seals that strand in Long Island waters probably reflect Cd acquired primarily from prey consumed elsewhere. Nevertheless, our study provides an example of useful information that can be obtained from marine mammal stranding networks and a baseline for future studies of contaminant trends.

Acknowledgments

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Appendix 1. Metal levels in seal liver samples collected between 1988 and 2004 by the Riverhead Foundation for Marine Research and Preservation in Long Island, New York

Sample and year	Species	Length (cm)	Batch	Hg μg g^{-1}	Se μg g^{-1}	Ag μg g^{-1}	Cd μg g^{-1}	Cu μg g^{-1}
2495-01	Cc	97.05	5	29.81	11.24	0.09	3.92	4.73
1206-94	Cc	101	7	15.13	4.74	0.46	5.06	8.1
2100-98	Cc	101	6	33.41	17.5	0.12	4.87	9.08
1205-94	Cc	110	8	44.5	9.08	0.17	4.68	28.87
1938-97	Cc	113.4	6	9.46	13.5	0.3	10.35	15.81
1207-94	Cc	113.6	2	12.35	9.26	0.18	4.58	14.98
2068-98	Cc	96.4	5	10.38	8.15	0.03	5.25	9.58
1223-94	Hg	92	7 & 9	9.435	4.43	0.9015	0.0505	17.6075
1240-94	Hg	92	6	2.77	6.35	0.035	0.03	9.48
1459-95	Hg	94.4	3	1.98	8.32	0.045	0.004	20.43
3084-04	Hg	94.5	6	1.01	76.61	-0.03	0.03	16.76
1975-97	Hg	97.5	7 & 9	1.005	7.98	-0.065	0.0445	3.628
1255-94	Hg	100.5	5	3.45	13.57	0.4	0.07	13.86
2941-03	Hg	100.6	3	6.38	15.06	0.33	0.05	15.73
2769-02	Hg	114.45	4	52.08	15.25	1.01	0.46	17.37
2939-03	Hg	115	2 & 9	5.886667	6.386667	0.213333	0.01	29.69
1282-94	Hg	220.4	6	221.98	99.93	0.31	1.99	22.8
1268-94	Pg	88.9	7	5.12	3.2	0.01	5.36	40.8
1246-94	Pg	92.5	4	16.8	11.51	0.06	1.86	16.17
1949-97	Pg	93.6	7, 8 & 9	4.06	6.79	0.060667	2.156667	11.80667
1460-95	Pg	93.8	3	3.7	4.22	0.09	3.5	14.52
1214-94	Pg	95.5	5	11.67	10.66	0.03	3.8	21.53
2812-02	Pg	96.2	2	7.79	7.81	0.46	2.96	22.74
2604-01	Pg	96.7	7	7.94	2.48	0.04	2.78	12.55
3097-04	Pg	97	8 & 9	5.83	6.996667	0.132833	1.565667	29.72767
1201-94	Pg	97.5	6 & 9	17.59	7.43	0.1173	6.91	20.72
1225-94	Pg	98.1	7 & 9	6.57	7.67	0.06305	3.725	24.925
1222-94	Pg	98.35	5	9.13	6.89	0.47	4.36	38.23
2261-99	Pg	98.8	6	3.63	2.38	0.28	4.8	17.02
2383-00	Pg	99.5	5	3.95	8.22	0.06	9.13	16.76
3079-04	Pg	99.7	8	5.25	6.5	0.09	3.03	17.44
2938-03	Pg	100	3	6.515	7.555	0.20275	1.725	23.16
1261-94	Pg	100.2	4 & 6	20.03	21.015	0.19655	3.79575	51.065
2770-02	Pg	101.05	7	2.98	13.81	-0.04	1.87	9.84
3091-04	Pg	102.1	8	11.72	6.38	0.1	9.41	23.61
1215-94	Pg	102.85	7	17.53	3.41	0.008	8.08	12.01
1410-95	Pg	103.5	3	4.77	7.65	0.44	5.66	33.43
1281-94	Pg	105	7 & 9	6.765	12.285	0.095	1.7975	35.3
3072-04	Pg	105	6 & 9	2.42	9.9	-0.03098	0.67195	9.934
1284-94	Pg	107.35	4	7.17	5.64	0.0155	1.48	7.83
1483-95	Pg	107.7	8	15.78	0.26	0.15	3.61	34.34
2560-01	Pg	115.4	5	19.4	10.56	0.006	5.79	19.68
3062-04	Pg	151	4	14.3	11.38	1.12	52.45	34.32
2237-99	Pg	151.7	5	29.65	13.99	0.02	3.79	9.34
1272-94	Pg	162.2	3	43.3	18.33	0.23	7.11	5.46
3048-04	Pg	183	3	37.2	17.26	0.25	15.6	19.9
3069-04	Pg	UNK	8	4.86	9.785	0.19395	15.07	20.84
3074-04	Pg	UNK	8	5.53	5.03	0.07	3.4	11.48
3081-04	Pg	UNK	8	7.3	6.1	0.06	1.82	19.76
3099-04	Pg	UNK	8	125.68	16.67	0.53	15.75	18.64

Sample and year	Species	Length (cm)	Batch	Hg μg g^{-1}	Se μg g^{-1}	Ag μg g^{-1}	Cd μg g^{-1}	Cu μg g^{-1}
3126-04	Pg	UNK	8	8.33	9.88	0.04	3.11	13.33
3144-04	Pg	UNK	6	8.51	24.135	0.019	1.59	27.59
2046-97	Pv	84.2	5	8.44	11.52	0.005	1.16	42.84
3038-04	Pv	84.4	8	27.31	8.82	0.3	0.28	82.19
2483-00	Pv	86	7	3.59	10.68	0.04	0.16	24.61
2727-01	Pv	86.8	2	2.84	6.24	-0.01	0.21	40.98
1291-94	Pv	87	6	5.49	31.1	0.04	0.003	42.95
0870-92	Pv	87.2	5	10.13	7.99	0.19	0.7	46.33
1407-95	Pv	90.39	6	3.76	9.47	0.02	0.06	13.89
0724-91	Pv	91	6	15.58	8.95	0.37	0.55	105.3
3033-04	Pv	91	3	7.73	6.2	0.1	0.16	40.52
2869-02	Pv	91.5	5	5.645	12.14	0.76655	0.2044	33.825
1185-94	Pv	92.25	5	10.73	10.33	0.05	25.32	17.83
2064-97	Pv	93	4	10.46	14.73	-0.01	0.22	12.45
2820-02	Pv	93.2	7	18.64	5.66	-0.04	0.25	25.53
2750-02	Pv	93.35	2	1.25	7.92	0.08	0.07	18.41
2891-03	Pv	98.7	8	12.68	6.29	0.08	0.06	28.74
0874-92	Pv	101.5	6	10.15	36.51	0.07	0.22	22.82
1013-93	Pv	101.75	6	13.41	26.38	0.01	0.31	24.14
1204-94	Pv	102.5	8	7.94	1.46	0.02	0.04	4.43
0883-92	Pv	102.8	5	17.11	11.25	0.14	0.8	31.59
2734-01	Pv	105	5	15.84	12.93	0.03	0.28	39.38
2042-97	Pv	108.9	6	43.97	28.18	0.096	1.06	50.4
1239-94	Pv	109.5	5	27.3	12.43	0.08	0.33	3.65
0409-88	Pv	111	8	10.61	7.49	0.16	0.06	19.7
1256-94	Pv	112.4	7	17.81	4	0.03	0.48	21.69
0760-91	Pv	113	2	16.15	10.07	0.23	0.4	70.2
0869-91	Pv	114.9	7	44.64	7.32	0.86	1.1	89.86
1493-95	Pv	120	8	157.12	26.05	0.68	0.6	8.17
1527-95	Pv	129	2	145.23	98.11	2.35	0.84	6.63
2860-02	Pv	134.2	4	259.64	92.94	0.8	1.62	22.68
2921-03	Pv	135	2	30.2	23.73	0.02	0.51	6.01
2930-02	Pv	135	5	183.75	60.32	0.21	0.84	19.47
0886-92	Pv	137.5	7	173.9	43.44	1.5	2.35	7.13
3124-04	Pv	145	4	793.745	285.42	2.9933	1.338	9.88125
3082-04	Pv	155	7 & 9	119.64	26.96333	0.2074	6.188333	29.128

Note: Cc = *Cystophora cristata*, Hg = *Halichoerus grypus*, Pg = *Phoca groenlandica*, and Pv = *Phoca vitulina*