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Brief Communication

Evidence of stabilizing lead concentrations in livers and kidneys of St. Lawrence Beluga (*Delphinapterus leucas*) from 1982 to 2007

Michael Belanger[1] and Carin Wittnich [1,2,*]

[1]*Oceanographic Environmental Research Society, Barrie, Ontario, Canada.*
[2]*Departments of Physiology & Surgery, University of Toronto, Canada.*

Abstract

Liver/kidney samples from male (n=3) and female (n=7) beluga whales (*Delpinapterus leucas*) stranded along the St Lawrence river (2006- 2007) were analysed for lead (Pb) levels and compared to levels reported in the 1980's. Our data (2006-2007) showed a decrease of Pb in liver and kidney (< 1.32 ug/g dry weight) when compared to samples taken between 1982-1987 (liver maximum values 2.13 ug/g dry weight; kidney maximum values of 1.75 ug/g dry weight). This implies a stabilization or even a slight decrease of lead contamination in this species over a 20 year period. This data could be used to help establish time lines of how long heavy metals such as lead take to make their way through ecosystems, into the tissues of top predators, and to the establishment of better environmental protective measures. [JMATE 2018; 10(2):6-10]

Keywords: Beluga whales, Delpinapterus leucas, kidney, lead, liver, St Lawrence River.

Introduction

Heavy metals can be found naturally in the environment and are continuously being released into the air, ground, or water through natural processes such as volcanic eruptions (1). As well, these elements have been produced and dispose of into the environment by humans since early Greek/Roman times (17). Their properties are such that they accumulate within the various ecosystems which results in increasing concentrations within various tissues (liver, kidney, bone, teeth) (10). In severe heavy metal contamination of the marine environment, this eventually results in catastrophic events where humans are directly affected. For example, in the past, mercury contamination resulted in the deaths of thousands of humans in Minamata, Japan (8).

The effects of marine environmental contamination by heavy metals are also insidious as it may take decades or centuries before any outward signs of problems may reveal themselves. As well, their chemical affinity to store within certain tissues makes it difficult to detect using typical diagnostic methods such as blood analysis. Eventually their high concentrations cause numerous medical problems such a neurological disease or birth defects, or increases the susceptibility to disease in predators (cetaceans, sharks) higher up on the food chain. This makes isolated human populations (native American or Inuit cultures) or animal species (St Lawrence belugas), that are more dependent on contaminated prey species (seals, whales, fish), at a higher risk of poisoning. For sub-populations of certain marine species this can even result in their extermination. The St Lawrence beluga whale is one sub-population which has suffered from exposure to many types of contaminants (heavy metals, organochlorines) coming from industry effluents that historically were poured directly into the St Lawrence river or its tributaries (3).

One of the earliest articles discussing the effects of humans on the habitat of beluga whales (*Delpinapterus leucas*) from the St Lawrence River area was published in 1974. It revealed that water temperatures had changed due to the damming of the river, which affected beluga calving and feeding (18). (Figure 1a,b) Since then much has been published on this sub-population of belugas, that live in the lower downstream portion of the St Lawrence river, especially in relation to the intense concentration of pollutants that have been washing down from various industrialized areas upstream for many decades (3). As a result, this sub-population of belugas has historically been exposed to extremely high toxic levels of dangerous chemicals such as heavy metals (lead- Pb, mercury- Hg) and organochlorines (polychlorinated biphenyls- PCBs) (3,5,12,14). The levels of some of these toxins are so high that any animal found stranded has to be disposed

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Correspondence: Carin Wittnich (oersvet@gmail.com)
Address: Rm 3259 Medical Science Bldg, 1 king's College Circle, University of Toronto, Toronto, ON, M5S 1A8.

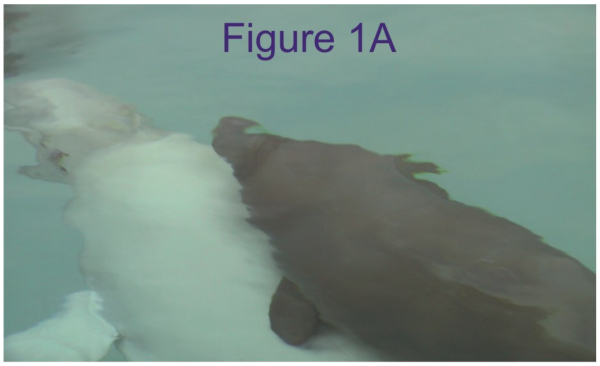

Figure 1: (a). Female beluga with young calf. Notice the colour differentiation between the young calf (dark) and mature female (white); (b). A young still-born beluga calf. Reproduced with permission from OERS.

of as toxic waste (4). These toxins may result in the near extinction of this cetacean population due to unusually high numbers of various medical conditions (infectious diseases, tumors, immuno-suppression), stillborn or deformed fetus/young, or breeding difficulties, most probably caused by the pollutants found in their environment (3,10). (Figure 1b)

Heavy metals such as lead have been studied extensively in the past but most recently organochlorines and other contaminants have become the focus of studies in the St Lawrence beluga (12). The last known reference to lead levels within St Lawrence beluga whale tissues was published by Wagemann *et al* in 1990 using carcasses that were found stranded between 1982 to 1987 (19). Therefore, the objective of this study was to measure more recent beluga whale tissue levels of lead and compare them to those taken 2 decades prior to confirm whether this heavy metal had declined, stabilised, or had risen. This could help to elucidate how long it takes for measures, undertaken in the 1970's to lower contaminants such as lead, to start having a positive effect in the ecosystem and how long it takes for a top predatory species such as the beluga whale to remove them from their tissues. This knowledge could help create measures that will reflect more logical and appropriate standards of protection for threatened cetacean populations and other top predators.

Methods

The liver and kidney samples used for this study were taken in 2006 and 2007 from a total of 10 animals (n= 3 males and n=7 females) found stranded along the St Lawrence River esturay (Figure 2). The samples were taken during necropsy and kept frozen until analysis for lead (Pb) concentrations (ug/g wet weight).

The analysis on the tissue was performed via closed vessel microwave digestion and analysed for Pb by ICP-OES based on Anderson (2). When these samples were run the measurable limits of detection for this assay was < 0.40 ug/g wet weight (2008). Duplicates were run for quality control to ensure reproducibility was within 15% and that method blanks and second source calibration controls varied less than 10%. All concentrations are reported as ug/g wet weight and conversions to dry weights were done to compare values to previously published data using the wet weight to dry weights conversion factor from Yang and Miyazaki (20). No biopsy was taken if advanced autolysis of the organ was noted.

Belugas were aged using the standard tooth dentinal growth layer group assessment (GLG) technique detailed by Lockyer *et al* (13).

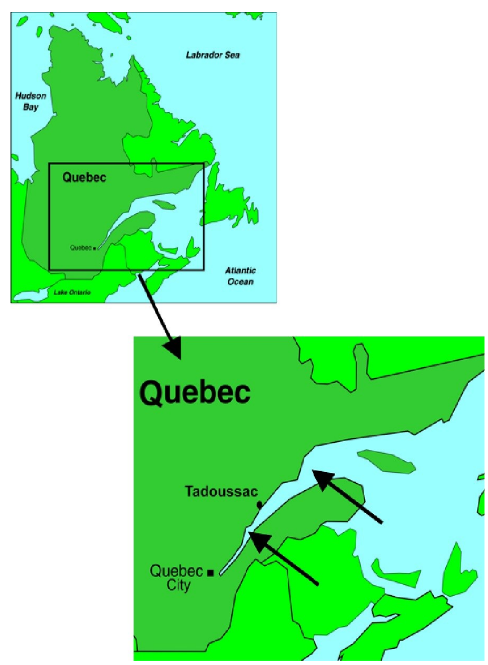

Figure 2: Map of the St Lawrence River estuary. Area between the 2 dark arrows indicate approximate region where the beluga whales were found. Figures modified from https://en.wikipedia.org/wiki/Eastern_Canada.

Results

The female belugas ranged in age between 5 to 55 years of age (mean 36.9 ± 16.6, n=7) and most were considered to be mature. However, the mean age of the group of females slightly goes up to 42.2 ± 9.6 (n=6), if the youngest, being 5 years old, is removed from the calculation of mean age of the group. The ages of the males ranged between 24 to 58 years old (mean 44.0 ± 17.8, n=3) and were all considered to be mature animals (Table 1).

The levels of lead within all but one of the samples (liver and kidneys) were below the measurable limits of the assay which was <0.4 ug/g wet weight (<1.32 ug/g dry weight). Only one kidney sample came back with a measured value of 1.7 ug/g wet weight (4.25 ug/g dry weight ug/g). (Table 1)

SEX	AGE (years)	LIVER Wet Weight (ug/g)	KIDNEY Wet Weight (ug/g)
Female	5	<1.0	<1.0
Female	44	<0.4	<0.4
Female	28	<0.4	<0.4
Female	55	<0.4	<0.4
Female	38	<0.4	<0.4
Female	38	<0.4	<0.4
Female	50	<0.4	<0.4
Male	50	<0.4	<0.4
Male	24	<0.4	<0.4
Male	58	no sample taken	1.7

Table 1: Sex, age, and Pb levels in liver and kidney of belugas sampled during 2006 and 2007. Less than symbol (<) indicates levels below assay detectable limits at that time.

Discussion

Heavy metals are a complex group of pollutants that are naturally found in nature, produced through human activities, and once they enter an organism can bioaccumulate in various tissues (1,15). Once in the organism, their impact is varied depending upon the system affected and cause adverse effects at the molecular level (8). Cetaceans may detoxify certain heavy metals (mercury) by using selenium which further complicates studies looking at this type of pollutant (11). In marine mammals and humans, heavy metals usually enter the body through the ingestion of fish/invertebrates which themselves have ingested smaller species with smaller amounts of heavy metals (6). These heavy metals are stored in various 'soft' tissues such as liver, kidney, fat/blubber or in 'hard' tissues such as bones or teeth (7,10). Once within the tissues, their half life depends on where they were stored: in 'soft' tissues it varies between weeks or months versus 'hard' tissues where it may take decades for some levels to drop (9). For example, in humans, the half life of lead in blood is 27 days while in bones it is 30 years (15).

Once lead had been recognised to have extremely harmful effects in humans, it would still take decades, from the 1960's to 1980's, to remove it from gasoline which was the leading source of human produced lead (16). One of the earliest studies to examine lead in the St Lawrence belugas was published by Wagemann *et al* in 1990 which reported on samples that had been taken between 1982-87 (19). This showed that in those beluga livers, lead had a mean of 0.59 ug/g dry weight and ranged from 0.004 to 2.13 ug/g dry weight. Our samples, taken from belugas that had stranded 21 years later (2006 and 2007), reveal that the values of lead in liver samples were below 1.32 ug/g dry weight or a minimum drop of 38 percent from the highest values seen by Wagemann *et al* (19). When comparing lead levels in kidneys from the Wagemann samples (0.005-1.76 ug/g dry weight) versus our kidney samples from 2006 and 2007, the same ratio holds true with our samples being 25 percent lower than the highest values from over 20 years ago (19). There was only one exception in our animals where the kidney was 4.25 ug/g dry weight, more than double the highest 1982-86 value.

It might be questioned as to why the half life of lead within our samples is not closer to the expected 50 percent after over 30 years of lead being banned in numerous substances. Numerous factors must be considered such as how much lead is still being produced by natural or human activities and how much of it is still being released from areas where lead has been stored. A recent study of Antarctic ice cores has revealed that an estimated 660 tons of industrial lead was deposited over that region for over 130 years (15). It is then quite reasonable to assume that the same must hold true for areas such as the Arctic and areas north of the St Lawrence river where the effects of climate

Change (warming temperatures) will continue to release heavy metals such as lead over decades if not centuries. This continual release of lead and other heavy metals will slow down the half life process of these pollutants within the various tissues of fish (the food source of belugas) and that of the belugas themselves. However, it is clear from our more recent data that lead concentrations in liver and kidney within the St Lawrence belugas have dropped overall.

Unfortunately there is currently no way of comparing the amount of lead being ingested by the beluga from the local fish populations as there is a serious gap of knowledge related to lead levels in their prey species located in the St Lawrence river estuary. Either there are older known levels of lead in local fish populations and no recent levels or vice versa. The same holds true for lead levels in vegetation, sediment or invertebrates found in the St Lawrence estuary where this sub-population of belugas live. However, if the assumption is that lead levels have decreased overall within the environment since lead was removed from many substances over the past 30 plus years, then our data supports the fact that St Lawrence beluga tissue lead levels are decreasing. This information could help in determining the efficacy of legislation in controlling the production of pollutants, how long the effects of pollutants may have on key predatory species such as cetaceans, and help create long term measures to protect species throughout the world that may be affected by such long lasting pollutants.

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