TRACE METALS IN PELAGIC CETACEANS

by Sylvia Blake, Robin Law and Bryn Jones

CEFAS
The Centre for Environment, Fisheries & Aquaculture Science

Introduction

Metals can enter the environment naturally from the weathering of rocks and volcanic activity, or from antrhopogenic discharge. Many trace metals are essential for growth, although some like mercury and cadmium appear to have little or no biological function. From years of exposure to metals, marine mammals have developed a variety of mechanisms to control their internal concentrations to reduce toxic effects. Uptake of these trace metals can be across the placenta before birth, in milk whilst suckling or from food once weaned.

This study was to determine the concentration of trace metals in the liver tissues of pelagic cetaceans stranded on the coasts of England and Wales. Tissue samples were collected as part of a marine mammal strandings programme operated by the Institute of Zoology and the Natural History Museum (Figure 1). Samples were selected with priority given to adults and those animals that were classified as freshly dead or only slightly decomposed (Law, 1994). The animals studied are listed (Table 1) with their sex, length and age where known. Included were both mysticetes (fin and minke whales) and odontocetes (beaked and pilot whales, etc). Fin and minke whales are mainly open ocean animals, feeding predominantly on euphausiids and some fish. The odontocetes' diet consists largely of cephalopods and a variety of fish, feeding in the deep waters over the continental shelves and slopes or in oceanic waters.

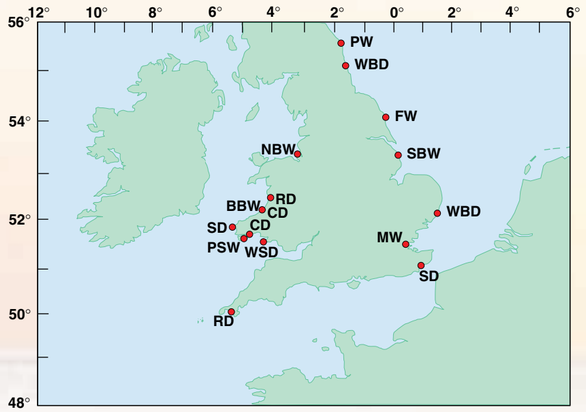

Figure 1. Map of England and Wales, showing the stranding locations of the marine mammals analysed (key to species code in Table 1).

Table 1. Location date and type of pelagic cetacean stranded.

Code	Species	Sex	Length (cm)	Age	Date	Loction
WSD	White-sided dolphin	M	228	9	19/1/94	Rhossili Bay, West Glamorgan
WBD	White-beaked dolphin	F	257	15+	31/12/95	Sizewell, Suffolk
WBD	White-beaked dolphin	F	215	5	6/8/98	Blyth, Northumberland
SD	Striped dolphin	M	219	20	13/2/96	Greatstone-on-Sea, Kent
SD	Striped dolphin	M	219	17	16/7/96	Ramsey Island, Pembrokeshire
CD	Common dolphin	F	208	12	10/6/98	Aberaeron, Ceredigion
CD	Common dolphin	F	209		5/8/98	Saundersfoot, Pembrokeshire
RD	Risso's dolphin	F	262	3	26/11/92	Borth, Ceredigion
RD	Risso's dolphin	M	207	<1	18/3/94	Fishing Cove, Gunwalloe, Cornwall
PW	Long-finned pilot whale	M	502		25/10/97	Beadnell, Northumberland
FW	Fin whale	F	1660		4/2/92	Dane's Dyke, East Yorkshire
MW	Minke whale	F	467		29/10/96	Purfleet, Essex
PSW	Pygmy sperm whale	F	276	7	17/10/97	Manorbier, Pembrokeshire
SBW	Sowerby's beaked whale	M	444	*	30/4/98	Mablethorpe, Lincolnshire
BBW	Blainville's beaked whale	F	411	21+	18/7/93	Aberaeron, Ceredigion
NBW	Northern bottlenose whale	F	610		6/11/98	West Kirby, Wirral

*teeth very worn, so an old animal.

Methodology

Samples were kept at -20°C in glass jars prior to analysis. Approximately 1g of dried liver tissue was digested with nitric acid using a CEM MARS microwave system. The digest was made up to a volume of 25ml. Mercury concentrations were determined using a CETAC M6000 cold vapour atomic absorption spectrophotometer. Chromium, Nickel, Lead, Arsenic, Selenium, Silver, Copper, Zinc and Cadmium were determined using a VG 2+ Inductively Coupled Plasma Mass Spectrometer.

Inductively Coupled Plasma Mass Spectrometer (ICP-MS).

Results

Concentratons of copper, an essential element which can cause anaemia when deficient, ranged from 3.2-19 mg kg^{-1}. For zinc, which is relatively non toxic, concentrations in the liver were 21 to 83 mg kg^{-1}. These values lie within previously established limits for marine mammals (Law, 1996). The chromium and nickel concentrations, with the exception of the Sowerby's beaked whale, were below 1 mg kg^{-1}.

Long finned pilot whale - Globicephala melas

Arsenic concentrations above 2 mg kg^{-1} were seen in the beaked whales, but this is similar to concentrations previously seen in common dolphins from SW England, and pilot whales from Newfoundland (Law, 1996; Law *et al.*, 1997).

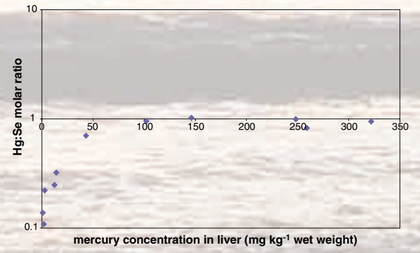

Figure 2. Hg:Se ratios in marine mammals

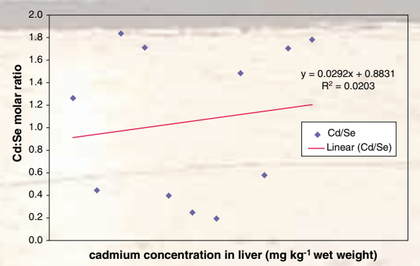

Figure 3. Cd:Se ratios in marine mammals

High levels of mercury were determined in two beaked whales (248-322 mg kg^{-1}) and a minke whale (259 mg kg^{-1}). The beaked whales feed offshore in deep waters remote from anthropological discharges. Bioaccumulation of mercury through the food from oceanographic processes leads to enhanced mercury bioaccumulation in prey (Monteiro *et al.*, 1996). When the molar ratios of mercury to selenium concentration are calculated, an increasing trend is seen in the mercury to selenium ratio until a 1:1 ratio is established. This demonstrates the detoxification of methyl mercury by complexation with selenium to form mercuric selenide (Figure 2). For cadmium no correlation is observed (Figure 3). This is because cadmium is detoxified instead by complexation with proteins called metallothioneins. The highest cadmium levels were observed in the minke whale, (48mg kg^{-1}). This is unusual in that it's diet consists mainly of euphausiids and small fish rather than squid which are naturally high in cadmium. The Bioavailability of cadmium is low once the metallothionein complex has been formed, although an excess of metallothionien complexes in the liver may increase the risk of other diseases as they may be displaced and can form pathological lesions. Also values of cadmium as low as 20 mg kg^{-1} may cause renal dysfunction in some marine mammals (Fujise *et al.*, 1998). (Table 2).

Table 2. Concentration of trace metals in liver tissues of pelagic cetaceans.

Species	Tissue	%TS	Cr	Ni	Cu	Zn	As	Se	Ag	Cd	Pb	Hg
WSD	liver	33.3	0.34	0.35	11	61	0.67	24	1.6	5.9	0.16	43
WBD	liver	30	0.34	0.34	7.5	34	0.43	19	2.5	<0.03	0.36	12
SD	liver	26.5	0.52	0.53	5.4	37	0.73	56	0.61	0.99	<0.04	146
CD	liver	24.6	0.21	0.31	9.7	58	0.6	42	2.4	0.38	0.05	102
RD	liver	29.9	0.26	0.71	5.2	37	0.36	4.6	0.08	0.2	0.17	2.6
PW	liver	26.5	0.25	0.31	4.7	45	<0.13	2.1	<0.07	0.1	<0.05	0.74
FW	liver	26.8	0.69	0.74	3.2	47	0.21	5.8	<0.05	3.1	<0.04	1.6
MW	liver	28.1	0.35	0.49	4.9	50	1.9	123	2	48	0.39	259
PSW	liver	31.4	0.57	0.68	9.5	21	0.18	17	0.35	3.2	0.08	14
SBW	liver	30.9	1.7	1	19	83	2.3	133	5.5	20	0.11	322
BBW	liver	33.8	0.63	0.75	5.6	41	2.5	95	0.74	6.2	0.05	248

Concentration is in mg kg^{-1} wet weight.

Discussion

CEFAS is participating in an ongoing programme to study the dynamics of metals and organic contaminants, including, organochlorines, butyltins and polychlorinated biphenyls in marine mammals, and their possible effects on immune function and thus the susceptibility of these animals to infectious disease.

Sperm Whale - Physeter macrocephalus

References

Law, R. J. (1994). Collaborative UK Marine Mammal Project: Summary of data produced 1988-1992. Fisheries Research Technical report, MAFF Directorate of Fisheries Research, Lowestoft, 97, 42pp.

Law, R. J. (1996). Metals in marine mammals. In. Interpreting Environmental Contaminants in Wildlife Tissues, eds N. Beyer, G. Heinz and A. W. Redmon-Norwood, pp. 357-376. Lewis Publishers, Inc., Chelsea Michigan.

Law, R. J., Stringer, R.L., Allchin, C.R. & Jones, B.R. (1996). Metals and organochlorines in sperm whales (*Physeter macrocephalus*) stranded around the North Sea during the 1994/95 winter. *Marine Pollution Bulletin*, **32**. 72-77.

Law R. J., Allchin, C.R., Jones, B.R., Jepsom, P.D., Baker, J.R. and Spurrier, C.J.H. (1997). Metals and organochlorines in tissues of Blainville's beaked whale (*Mesoplodon densirostris*) and a killer whale (*Orcinus orca*) stranded in the United Kingdom. *Marine Pollution Bulletin*, **34**, 208-212, 1997.

Monterio, L.R., Costa, V., Furness, R.W. and Santos, R.S. (1996). Mercury concentrations in prey fish indicate enhanced bioaccumulation in mesopelagic environments. *Marine Ecology Progress Series*, **141**, 21-25.

Fujise, Y., Honda, K., Tatsukawa, R. & Mishima, S. (1988). Tissue distribution of heavy metals in Dall's porpoise in the northwestern Pacific. *Marine Pollution Bulletin*. **19**, 226-230.

The Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Burnham Laboratory, Remembrance Avenue, Burnham-on-Crouch, Essex, CM0 8HA, UK

http://www.cefas.co.uk