Australian marine mammals and pollutants

Fact Sheet

August 2024

Key points

- Marine mammals are prone to accumulating environmental pollutants due to their longevity and diet, making them excellent sentinels of ocean health.
- A wide range of diseases and clinical signs can result from exposure to environmental pollutants in marine mammals.
- Most pollutants of concern are persistent organic compounds or heavy metals, originating from human activities.
- Pollutants can act synergistically with other pathologies such as infectious organisms to cause disease.

Aetiology

Globally, a very large number of substances capable of polluting the oceans are produced by humans. These can be divided into chemical compounds, often referred to as persistent organic pollutants (POP), and heavy metals. The term "contaminants of emerging concern" (CEC) is often more appropriate and includes pharmaceutical drugs, agricultural residues, nanomaterials (microscopic materials with one external dimension <100nm in size, often bound with a metal or a carbon), personal health care products and plastics including plastic additives [1]. While plastics and microplastics are of great concern in ocean pollution, they are outside the scope of this Fact Sheet.

Only a few classes of chemical compounds have been studied in marine mammals, usually those associated with serious health effects in humans or other terrestrial species. The organohalogens (OH – organic compounds bound to either chlorine, bromine, fluorine, or iodine) include organochlorine (OC) compounds, which are of particular importance due to their toxicity and persistence. Organochlorines include dichlorodiphenyltrichloroethane (DDT) and its metabolites and the polychlorinated biphenyls (PCBs). Some of these compounds, such as the polybrominated diphenyl ethers (PBDE), are included as flame retardants in many manufacturing processes. Many chemical pollutants that have recently been identified as problematic, such as poly-and-perfluoroalkyl substances (PFAS), causing outright toxicity, endocrine disruption, and immunosuppression. Some of these are still poorly understood.

Metal pollutants are either non-essential for the normal functioning of the body or essential but ingested in excessive amounts, with mercury, lead and cadmium the most important [2, 3].

One Health implications

Wildlife and the environment: marine mammals are key sentinels of ocean pollution because most contaminants are obtained via the diet and many marine mammal species are apex predators and bio-accumulators of contaminants [4]. Scavengers consuming dead marine mammals might be exposed to high levels of toxins, particularly if consuming liver, kidney, and blubber. There is significant risk for aquatic organisms that feed on dead marine mammals at sea, especially large whales that form entire ecosystems around their demise as lifelong bioaccumulation of toxins is rapidly and readily available at these feeding hotspots [5]. A range of diseases have been described in marine mammals as a result of exposure to pollutants and evidence indicates environmental pollutants/toxicants may have population level impacts in Australian marine mammals [6-8].

Domestic animals: at present there is no evidence for risk to domestic animals following pollutant exposure in marine mammals. However domestic animals themselves may be exposed to harmful pollutants via environmental exposure as contaminants move across different environmental compartments [4].

Humans: the major risk for humans (other than exposure from environmental contamination) is through consumption of marine mammal products. The risk is lower when consuming herbivorous species such as dugongs (*Dugong dugong*), which are commonly harvested for consumption by Indigenous people in the far north of Australia [9].

Species affected

There is evidence of pollutants in a wide range of marine mammal species within Australian waters as indicated in Table 1.

Table 1: Reports of pollutant exposure in Australian marine mammals

Marine mammal species	Pollutants identified	References
Australian humpback dolphin (*Sousa sahulensis*)	PCB	Cagnazzi et al. 2020 [10]
Australian snubfin dolphins (*Orcaella heinsohni*)	PCB	Cagnazzi et al. 2020 [10]
Burrunan dolphin (*Tursiops australis*)	PFAS	Foord et al. 2024 [7]
Common bottlenose dolphin (*T. truncatus*)	PFAS, PCB, Lead, Cadmium, Mercury, PBDE	Foord et al. 2024 [7], Vetter et al. 2001 [11]; Butterfield and Gaylard 2007 [12]; Law et al. 2003 [13]
Indo-Pacific bottlenose dolphin (*T. aduncus*)	PFAS, PCB, Lead, Cadmium, Mercury	Foord et al. 2024 [7], Vetter et al. 2001 [11]; Butterfield and Gaylard 2007 [12]
Short-beaked common dolphin (*Delphinus delphis*)	PFAS, Lead, Cadmium, Mercury	Foord et al. 2024 [7]; Butterfield and Gaylard 2007 [12]
False killer whales (*Pseudorca crassidens*)	Cadmium	Kemper et al. 1994 [14]
Long-finned pilot whales (*Globicephala melas*)	PCB	Weijs et al. 2013 [15]
Melon-headed whales (*Peponocephala electra*)	PCB	Melcher et al. 2005 [16]

Pygmy sperm whales (*Kogia breviceps*)	PCB	Melcher et al. 2005 [16]
Sperm whales (*Physeter macrocephalus*)	PCB	Evans et al. 2004 [17]
Strap-toothed whale (*Mesoplodon layardii*)	Cadmium	Kemper et al. 1994 [14]
Unspecified beaked whale	PCB	Gaus et al. 2005 [18]
Australian fur seals (*Arctocephalus pusillus doriferus*)	PCB	Taylor et al. 2018 [8]
Australian sea lions (*Neophoca cinerea*)	PCB	Taylor et al. 2018 [8]; Gaus et al. 2005 [18]
Leopard seals (*Hydrurga leptonyx*)	Cadmium	Kemper et al. 1994 [14]
New Zealand fur seals (*A. forsteri*)	POP, HM	Hall et al. 2023 [19]
Dugong (*Dugong dugong*)	POP, PCB, Cadmium, PBDE	Vetter et al. 2001 [11]; Kemper et al. 1994 [14]; Weijs et al. 2019 [20]; Hermanussen et al. 2008 [21]

Epidemiology

Marine mammals are key sentinels of ocean health due to their trophic level (the position of the animal in the food chain), their longevity, use of multiple habitats across a wide region of the oceans, the propensity of fatty tissues to accumulate harmful pollutants and the cumulative effects these pollutants have on them [4, 22]. Marine mammals are exposed simultaneously to multiple stressors of both natural and anthropogenic origin. The cumulative stress can combine with the toxic effects of pollutants to produce disease [1, 2]. These same factors together with large body surfaces that can increase exposure and occasionally low metabolic rates (e.g. dugongs and bowhead whales) predispose marine mammals to the effects of environmental pollutant [23].

POP, heavy metals and other non-essential metals bio-accumulate in the food web, with increasing concentrations at higher trophic levels (this includes many of the marine mammal species) [2]. The pollutant risk is dependent on the feeding strategy and the distribution of the host species. Dietary intake of pollutants will also vary with fluctuations in prey species, animal age, sex and physiological status (i.e. lactating vs non-lactating), as these all influence feeding behaviour [2]. Herbivorous dugongs, despite their size, longevity and large amounts of body fat have much lower POP concentrations [20] compared to apex predators such as dolphins [7]. Strictly inshore species, especially those exposed to terrestrial run-off, often demonstrate higher levels of POP, as shown in Australian humpback and snubfin dolphins [10] and inshore dolphin species [18].

The distribution of pollutants within the body varies with both pollutant and tissue type. Organohalogens accumulate in the highest concentrations in the body's fat stores. Distribution of metal pollutants in tissues varies but they tend to accumulate in the liver and kidney (and for some compounds also bone) [2, 3].

There are large geographic, species and temporal gaps in our knowledge of Australian marine mammal environmental toxicology. Most samples are opportunistically obtained from strandings and bycatch with a lack of targeted live animal surveillance [24]. The sub-lethal effects are mostly unstudied and it is often difficult to prove the link between exposure and effects. For those Australian species that have been subject to toxicological assessments, sampling has largely occurred over a limited part of their distribution and only as opportunistic cross-sectional studies.

There is limited data for OHs in Australian marine mammals [10]. Historically, concentrations of some pollutants were lower in Southern Hemisphere marine mammals compared to those in the Northern Hemisphere, with considerable variations between species and geographical areas [25]. More recent information suggests that POP levels in dolphins in SA are increasing over time [26].

Metals are introduced into the environment by both natural (e.g. weathering of volcanic soils) and anthropogenic means, such as run-off from industry. Trophic transfer varies between species. Australian marine mammals have levels of mercury reflecting ingestion from both natural and anthropogenic sources and levels may be influenced by an individual's proximity to urbanised and industrial run-off [27]. Most animals are exposed through ingestion via their food source. In rare instances pollutants are absorbed through the skin and mucosal membranes (e.g. byproducts of oil spills) [3].

Clinical implications

A wide range of clinical effects including alopecia [28], immunosuppression [29, 30], reproductive failure [31], endocrine disruption [3] and neoplasia [2] have been associated with environmental pollutant accumulation and exposure in marine mammals. The immunosuppressive effects of OCs may make individuals more susceptible to opportunistic infections [29, 32-34]. Endocrine disruption, reproductive failure and bone lesions associated with OCs have been reported in marine mammals [6, 15, 30, 35, 36].

Thyroid hypoplasia in aborted Australian fur seal (*Arctocephalus pusillus doriferus*) foetuses was suspected to originate from endocrine disrupting toxicants [37]. Australian fur seal pups have high PFAS levels that could possibly cause immunosuppression and endocrine disruption [38]. A symmetrical alopecic syndrome in Australian fur seals may be associated with higher levels of heavy metals and POP [28], as well as with lower overall body condition scores [39].

The effect of excessive mercury tissue concentrations is the most commonly reported metal toxicity in marine mammals. Studies suggest mercury can cause immunosuppression by impairing lymphocyte function [40].

Pathology

The types of pathology caused by environmental toxicants is extremely varied. It is beyond the scope of this document to cover all the various possible pathologies but they can cause liver disease, kidney disease, immunosuppression, reproductive disorders, neurological disease and disrupt the endocrine system [3]. As an example, bottlenose dolphins from SA waters had renal damage and bone malformations associated with chronic exposure to metal pollutants [41].

Diagnosis

The overall health of the host should be evaluated as toxicants often cause co-morbidities or predispose to other pathological conditions [2]. Physiological status should be taken into account when interpreting toxin accumulation in tissues, because some lesions may be toxin-induced or naturally acquired. For example, pulmonary and renal fibrosis occurs naturally in geriatric bowhead whales (*Balaena mysticetus*) but can be clinically significant in younger animals exposed to cadmium toxicity [42, 43].

In cases of suspect metal toxicity it is important to examine selenium status as this element has a protective effect against heavy metals such as mercury [3].

Laboratory diagnostic specimens and procedures

Live marine mammals:

- Subcutaneous fat (at least 1g) wrapped in foil and frozen for OH
- Whole blood (1ml) frozen for OHs and metals often transient sample
- Hair/fur (seals – at least 100ug) for metals, PFAS etc.
- Skin biopsies
- Milk, frozen

Post-mortem examination: samples listed above plus:

- Liver (at least 5g) frozen for metals
- Kidney (at least 5g) frozen for metals
- Skeletal muscle (at least 5g frozen) for metals

Procedures include:

- Gas chromatography-mass spectrometry (GC-MS): OHs
- Atomic absorption spectrophotometer: metals
- Inductively coupled plasma mass spectrometry (ICP-MS): metals
- Histopathology
- Biomarkers: determine exposure through gene activation, stress markers, genetic erosion.

Whenever possible, always record the mass and the length of the animal. More detailed sampling guidance is available in https://www.dcceew.gov.au/sites/default/files/documents/cetacean-protocols.pdf.

Research

For adequate baseline information on the pollutant challenge faced by Australian marine mammals, surveillance activities need to be greatly expanded and repeated more frequently. Sampling and testing for known pollutants and CECs should be performed on all marine mammal deaths [2]. The longevity of most marine mammals allows for significant deductions to be made from the negative effects seen in marine mammals to potential effects in humans and domestic animals. Due to the omnipresent ecological nature of pollutants, understanding their effects in one of the largest groups of marine apex predators will allow us to understand pollutant effects in entire ecosystems.

Surveillance

Wildlife Health Australia administers Australia’s general wildlife health surveillance system, in partnership with government and non-government agencies. Wildlife health data is collected into a national database, the electronic Wildlife Health Information System (eWHIS). Information is reported by a variety of sources including government agencies, zoo-based wildlife hospitals, sentinel veterinary clinics, universities, wildlife rehabilitators, and a range of other organisations and individuals. Targeted surveillance data is also collected by WHA. See the WHA website for more information https://wildlifehealthaustralia.com.au/Our-Work/Surveillance and https://wildlifehealthaustralia.com.au/Our-Work/Surveillance/eWHIS-Wildlife-Health-Information-System.

We are interested in hearing from anyone with information on these conditions in Australia, including laboratory reports, historical datasets or survey results that could be added to the National Wildlife Health Information System. If you can help, please contact us at admin@wildlifehealthaustralia.com.au.

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Wildlife Health Australia recognises the Traditional Custodians of Country throughout Australia. We respectfully acknowledge Aboriginal and Torres Strait Islander peoples' continuing connection to land, sea, wildlife and community. We pay our respects to them and their cultures, and to their Elders past and present.

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