APPENDIX J

CARCASS DISPOSAL INFORMATION

PERSISTENT CONTAMINANTS IN SELECTED SPECIES OF MARINE MAMMALS IN US WATERS: A REVIEW OF THE LITERATURE FROM 1995 THROUGH 2005

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I. INTRODUCTION

As charismatic megafauna, marine mammals are beloved and revered by people around the world. Consequently, mortality events and scientific research involving marine mammals are often of a high public profile. Widely publicized reports of high levels of anthropogenic contaminants in some whale species have incited concern that the carcasses of the whales themselves may constitute a toxicological hazard. This literature review was initiated with a view to gathering the collective data pertaining to levels of persistent contaminants in that subset of marine mammal species in US waters that tends to strand most frequently, so that the potential toxicological hazard generated by carcasses of these animals might be assessed.

II. ENVIRONMENTAL CONTAMINANTS IN SELECTED MARINE MAMMAL SPECIES IN US WATERS

A. Contaminant classes—background information

II.A.1. Persistent organic pollutants (POPs)

II.A.1.*1*. Polychlorinated biphenyls (PCBs) are complex mixtures of synthetic chlorinated compounds produced in the US until 1977 for use as insulators, coolants and lubricants, particularly in transformers and other electrical equipment (ATSDR, 2000). The basic structure of PCBs consists of a biphenyl backbone with 1 to 10 chlorine atoms, yielding 209 possible PCB congeners. Position and degree of chlorination are important determinants of congener toxicity, with more highly chlorinated and coplanar (dioxin-like) PCBs exhibiting greater toxicity than less chlorinated and non-planar congeners. A greater degree of chlorination also confers longer environmental persistence, which can range from months to years (ATSDR, 2000). The highly lipophilic nature of PCBs allows them to accumulate in fatty tissues of organisms or to associate with organic components of sediments in environmental samples. In animals and humans, PCBs are toxic to integumentary, immune, endocrine, reproductive, and nervous systems. At high doses, PCBs have been associated with liver and kidney damage in laboratory animals. PCBs are a known animal carcinogen and considered a probable human carcinogen by the US Environmental Protection Agency (USEPA) and other agencies (ATSDR, 2000), although no increased risk of cancer has been detected in studies of individuals occupationally exposed to PCBs (Ross, 2004). PCBs also have been implicated as environmental endocrine disruptors in wildlife species (Chiu et al., 2000), although this link is controversial (Ross, 2004). While PCBs can persist in the environment for many years, they are susceptible to both anaerobic and aerobic microbial degradation via metabolism of congeners with higher or lower degrees of chlorination, respectively (Abraham et al., 2002).

II.A.1.*2*. Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzo-p-furans (PCDFs) are chlorinated hydrocarbon compounds produced by combustion of waste and organic materials, or as contaminants in chemical manufacturing processes. Both compound classes consist of two benzene rings joined by either one (PCDFs) or two

(PCDDs) oxygen atoms. Like PCBs, PCDDs/PCDFs are environmentally persistent compounds that associate with particulate matter and that are highly lipophilic and prone to biomagnify in the food chain. The most toxic PCDD, 2,3,7,8 tetrachlorodibenzo-*p*-dioxin (TCDD) serves as a standard for comparison of other dioxins and dioxin-like PCBs, the toxicity of which is sometimes expressed in "toxic equivalency factors" (TEQs) of TCDD (ATSDR, 1998). TCDD can cause dermal and hepatic toxicity, and is classified as a human carcinogen. Other PCDDs/PCDFs may cause similar effects, depending upon their structure (ATSDR, 1998).

II.A.1.*3*. DDT (1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane) is an organochlorine pesticide banned in the US in 1972, but still used in many parts of the world for control of malaria-transmitting mosquitoes. Technical grade DDT is a mixture of *p,p'*-, *o,p'*-D, and *o,o'*-DDT isomers and may also contain DDE (1,1-dichloro-2,2-bis(p-chlorophenyl)ethylene) and DDD (1,1-dichloro-2,2-bis(p-chlorophenyl)ethane) as contaminants. The latter two compounds may also be produced via metabolism by some organisms, including microbes in the environment. In temperate regions, soil half-life of DDT is approximately 5 years, but may be up to 4 to 6 times as long, depending on the environmental conditions (ATSDR, 2002a). Like other organochlorines, DDT, DDE and DDD are extremely lipid soluble, tending to biomagnify and to associate with organic matter (soils and sediments) in the environment. At extremely high doses, DDT may be neurotoxic (ATSDR, 2002a). DDT and its metabolites are carcinogens and may also act as endocrine disruptors, although studies on estrogenic effects of DDT have been equivocal (Turusov et al., 2002).

II.A.1.*4*. Chlordane is an organochlorine pesticide used in the US until 1988 (ATSDR, 1994). It is a complex mixture of various chlordane isomers and other compounds, the fractions of which vary depending upon the purity of the preparation. The predominant components identified in technical chlordane were *cis*-chlordane, *trans*-chlordane, *trans*-nonachlor, octachlordane, heptachlor, and *cis*-nonachlor (Dearth and Hites, 1991). Chlordane may persist for decades in the environment and is highly lipid soluble, with oxychlordane comprising the major metabolite that bioaccumulates in fatty tissues (USEPA, 1997). A component of chlordane, heptachlor was also produced and used as a pesticide in its own right. Heptachlor epoxide may be produced by degradation or metabolism of heptachlor (ATSDR, 1993). Chlordane and the related compounds heptachlor and heptachlor epoxide are lipophilic and environmentally persistent (ATSDR, 1994 and 1993). At high doses, chlordane may cause toxic effects in the liver, digestive tract and nervous system (ATSDR, 1994). While data are limited, heptachlor and heptachlor epoxide also have been associated with toxic effects to the nervous and reproductive systems, as well as to liver and kidney in humans or animals, with the epoxide metabolite being more toxic than its parent compound (ATSDR, 1993). Evidence as to carcinogenicity of chlordane is inconclusive (ATSDR, 1994; USEPA, 1997). Heptachlor and heptachlor epoxide are considered possible human carcinogens by the USEPA, while the International Agency for Research on Cancer (IARC) determined that the two compounds are not classifiable with respect to human carcinogenicity (ATSDR, 1993).

II.A.1.*5*. Hexachlorobenzene (HCB) was produced in the US until 1970s, although it continued to be used as a fungicide until 1984. Also, some HCB is formed as a by-product in the manufacture of other chlorinated compounds as well as during incineration of garbage (McGovern, 2004). HCB is ubiquitous and persistent in the environment, with a half-life of up to approximately 6 years in soil, air and surface water, while in groundwater the half-life may be almost twice as long. Like other organochlorines, HCB is insoluble in water, but highly soluble in organic solvents and lipid allowing it to bioaccumulate readily in fatty tissues. HCB is toxic to virtually all organ systems, with the central nervous system, ovary and liver comprising the most vulnerable target organs. The USEPA classifies HCB as a probable human carcinogen based on data from animal studies (ATSDR, 2002b).

II.A.1.*6*. Technical grade hexachlorocyclohexane (HCH), which contains α, β, γ, δ, and ε isomers, was produced in the US until 1983 for use as an insecticide. While other forms of HCH are now banned, γ-HCH (also known as lindane) is still imported for use as an insecticide and topical treatment for lice (Research Triangle Institute, 1999). At high doses, HCHs can result in neural, musculoskeletal and reproductive toxicity. Abnormalities in developmental, endocrine, hepatic, renal, immunologic and hematopoieitic indices associated with HCH exposure also have been documented in humans or animals. Some animal studies have found increased incidence of liver cancer in rodents following chronic oral exposure to HCHs, leading the Department of Health and Human Services to extrapolate that HCHs may be a possible human carcinogen (Research Triangle Institute, 1999).

II.A.2. Toxic metals

1. *Cadmium*
2. *Lead*
3. *Mercury*
4. *Organotins*

Toxic metals are a unique class of environmental contaminants in that they occur naturally, although human activities have allowed them to become more pervasive and accessible to biotic cycles. However, because they are innate to the environment, it is difficult to distinguish “pollutant” from “natural” sources. Moreover, metals are not degraded via microbial or physical action, but may merely metamorphose by alterations in oxidation state and/or in the other elements to which they are bound in compounds.

II.A.2.*1*. Cadmium is a heavy metal often released as a by-product during refining of zinc, copper and lead, and has some industrial uses, such as in batteries and electrical components. There also are natural releases of cadmium to the environment through events such as volcanic eruptions and forest fires. Compared to other metals, cadmium is somewhat unique in that it is taken up and may accumulate to appreciable levels in some plants. In animals, cadmium is sequestered in the kidney and liver. The target organ of cadmium is the kidney; in addition, it is toxic to a number of other organs, including liver, bone and blood vessels. While data are scant, cadmium may be carcinogenic as well (ATSDR, 1999a). Various marine mammals are exposed to or bioaccumulate high levels of cadmium compared to terrestrial species (Woshner et al., 2001a; 2001b).

Although no physiologic requirement can be demonstrated for cadmium in the majority of organisms, some researchers recently have characterized a cadmium-containing enzyme in a marine diatom, refuting the long-held belief that cadmium was not only universally toxic but also functionless in living creatures (Lane et al., 2005).

II.A.2.*2*. Lead is ubiquitous in the environment, both as a result of natural geologic distribution and because of wide industrial applications, including former usage as a gasoline and paint additive. It is also released by combustion of fossil fuels and waste incineration. Lead is believed to be universally toxic, even at very low levels, with no organisms known to date demonstrating a physiologic requirement for lead. Generally, ingested lead is not well absorbed; however, because it is chemically similar to calcium, it may be assimilated and accumulated in tissues in lieu of calcium, particularly in growing organisms that are calcium limited. Although the nervous system (particularly the developing brain) is considered the "target organ" of lead, this metal is toxic to virtually all body systems, including the hematopoietic, cardiovascular, reproductive, immune, gastrointestinal, and musculoskeletal systems. Lead is carcinogenic in laboratory species, but has not been established as a human carcinogen (ATSDR, 1999b).

II.A.2.*3*. Mercury (Hg) is another metal that is apparently toxic to all organisms, even at low levels. Relative toxicity of mercury depends largely on the form of the metal (organic versus inorganic), and as is the case for all toxicants, the route by which exposure occurs. Ingested elemental mercury is not well-absorbed and hence of low toxicity, while exposure to methylmercury by this route is highly toxic, as it is almost completely absorbed. Like other toxic metals, mercury enters the environment from natural sources, such as volcanoes and degassing of the earth's crust. However, anthropogenic activity has dramatically increased mercury emissions, primarily through burning of fossil fuels, as well as through mining and other industrial applications. While mercury is toxic to virtually all body systems, the nervous system and kidney are the primary target organs for organic and inorganic mercury, respectively (ATSDR, 1999c).

II.A.2.*4*. In its inorganic form, tin (Sn) is non-toxic. However, organic forms of tin may be highly toxic. Organotins have a variety of industrial applications, including use of mono- and di-substituted organotins as catalysts and stabilizers in PVC plastics (Appel, 2004). Tributyl tin (TBT) compounds have been widely used as pesticides, particularly in antifouling paints on ships. As such, TBTs are ubiquitous in the aquatic environment, even as their use is being phased out due to concerns with respect to their ecotoxicity (Rüdel, 2003). As with many other toxicants, organotins adsorb onto organic particulates, such that an increase in dissolved organic matter decreases bioavailability of organotins. Also, speciation of organotins is pH-dependent; hence, increasing pH is associated with formation of organotin hydroxides, which are lipophilic and therefore predisposed to bioaccumulate (Fent, 2003). Organotins, especially TBT and triphenyltin (TPT) have been associated with tumorigenicity of the adenohypophysis, developmental toxicity, reproductive toxicity, neurotoxicity and most especially immunotoxicity, with thyrotoxicity apparently consitituting the most sensitive toxic endpoint in mammals (Rüdel, 2003). Gastropods are exceptionally vulnerable to toxic effects of TBT, which disrupts steroid metabolism leading to development of imposex at even minute concentrations. In the environment, organotins undergo aerobic degradation, but can persist for years in anoxic sediments (Fent, 2004).

II.A.3. Miscellaneous contaminants

1. *Polybrominated diphenyl ethers (PBDEs)*
2. *Polyfluoroalkyls (PFAs)*

II.A.3.*1*. Polybrominated diphenyl ethers (PBDEs) are one group of brominated flame retardants that are currently in wide usage. These compounds are added to plastics, particularly those comprising plastic components of computers and televisions as well as to plastic foams and textiles (ATSDR, 2002c; Darnerud et al., 2001). While over 200 PBDE congeners are possible, forms with fewer than four bromine atoms generally are not employed in commercial applications. Release of PBDEs into the environment is believed to occur primarily through incineration and volatilization; leaching from landfills may also serve as a source of PBDE contamination, although studies are lacking to verify this (Darnerud et al., 2001). Like other persistent organic pollutants, PBDEs are resistant to environmental and biotic degradation. Although research is limited, uptake from the environment appears to occur mainly through oral exposure, with absorption efficiency inversely related to degree of bromination (ATSDR, 2002c). PBDEs are lipophilic, and appear to have potential for both bioaccumulation and biomagnification (ATSDR, 2002c). The extent to which PBDEs are metabolized and excreted appears to vary with species and degree of congener bromination (Darnerud et al., 2001). In laboratory studies, effects of PBDEs range from immunotoxicity and thyrotoxicity, to hormone disruption, neurobehavioral abnormalities and developmental toxicity. The limited evidence available to date suggests that PBDEs do not have teratogenic or genotoxic potential. (ATSDR, 2002c).

II.A.3.*2*. Polyfluoroalkyls (PFAs) are a group of compounds comprised chiefly by fluorotelomer alcohols and perfluoroalkyl sulfonamide alcohols (as well as their breakdown products), that were used in a variety of commodities, including surface protectants, paper, insecticides, surfactants, and fire-retardants (Olsen et al., 2003; Seacat et al., 2002). Because of their toxicity and environmental persistence, some PFAs have been banned (Olsen e al., 2003; Seacat et al., 2002). Through metabolism or environmental degradation, fluorotelomer alcohols appear to form carboxylic acids, fluorotelomer carboxylic acids (FTCA), and fluorotelomer unsaturated carboxylic acids (FTUCA) (Houde et al., 2005). Degradation of perfluoroalkyl sulfonamide alcohols yields sulfonic acids (PFSAs) such as perfluorooctane sulfonate (PFOS)—a stable, bioaccumulative, toxic end product that has been found among diverse species from widely different environments (Giesy and Kannan, 2001). Toxicity of PFOS is related primarily to effects on the liver, including hepatocellular hypertrophy and altered lipid metabolism, including decreased cholesterol (Olsen et al., 2003). Some PFAs have been found to act as hepatic peroxisome proliferators or to provoke developmental and neuroendocrine toxicity (Houde et al., 2005).

II.B. Concentrations of environmental contaminants in selected species of marine mammals in US waters

II.B.1. Species addressed

Twelve species of marine mammals are included in this review, based upon the frequency and patterns with which they strand (T. Rowles and J. Whaley, pers. comm.). Species that tend to strand as individuals include: pygmy and dwarf sperm whales (*Kogia breviceps* and *K. simus*, respectively); common bottlenose dolphin (*Tursiops truncatus*); California sea lion (*Zalophus californianus*); harbor seal (*Phoca vitulina*); and elephant seal (*Mirounga angustirostris*). Species that tend to strand *en masse* are represented by: long and short-finned pilot whales (*Globicephala melas and G. macrorhynchus*, respectively); rough-toothed dolphin (*Steno bredanensis*); and white-sided dolphin (*Lagenorhynchus acutus*). Large whale species considered are the gray and humpback whales (*Eschrichtius robustus* and *Megaptera novaeangliae*, respectively).

II.B.2. Databases reviewed, including time period examined and search terms used

The online databases Biological Abstracts, PubMed, and Toxline were searched, using an exhaustive list of key words, including (but not limited to): *Kogia*, *Tursiops*, *Zalophus*, *Phoca*, *Mirounga*, *Globicephala*, *Steno*, *Lagenorhynchus*, *Eschrichtius robustus*, *Megaptera*, elephant seal, dolphin, marine mammal, pinniped, whale, cetacean, polychlorinated biphenyls, PCB, DDT, persistent organic pollutants, pollutant, contaminant, heavy metal, mercury, hexachlorocyclohexane, HCB, chlordane, heptachlor, dieldrin, aldrin, and organochlorine(s). Reports on marine mammals considered for inclusion in this review were confined to those published in peer-reviewed journals from 1995 through 2005 that addressed any of the twelve species designated above in US waters. A few ancillary studies that were either published prior to 1995, or that dealt with marine mammals in non-US waters, were included when those waters were contiguous with US waters, and when other US-based studies for those particular species were lacking. For example, Varanasi et al., 1994, was published outside of the timeframe used as a criterion for inclusion in this review. Nevertheless, I incorporated this study, as well as a few other studies (Tilbury et al., 2002; De Luna and Rosales-Hoz, 2004; Ruelas-Inzunza et al., 2002; Mendez et al., 2002) that addressed contaminants in *E. robustus* from Russian (Bering Sea) and Mexican waters, because contaminant studies for gray whales were limited. Also, because gray whales migrate long distances, whales studied in Mexican or Russian waters likely navigate US waters as well, where they may strand or die and present a carcass disposal problem.

II.B.3. Overview of tissue contaminant concentrations: Literature review summary

II.B.3.*0. General comments upon format of tables and appendices*

This review covers studies done by multiple scientists who were in various geographic locations, attempting to answer different research questions, and using diverse techniques and laboratories. Consequently the data are quite disparate and difficult to harmonize. For this reason, and to make this report as pertinent as possible for future applications, I have compiled as much data as feasible directly from the source papers. However, whenever possible, I attempted to give contaminant concentrations on a wet weight basis (since that is the state of the carcass presented for disposal) and to standardize the units in which data were given, presenting the persistent organic pollutants, PCDD/Fs, PBDEs, and PFAs in ng/g and metals in ug/g. I converted values from ng/g lipid weight to ng/g wet weight for Shaw et al, 2005, Struntz et al., 2004, She et al., 2002 and Gautier et al., 1997. All tables and appendices (in the accompanying Excel file) contain extensive footnotes to accurately characterize the data. In addition, species designations are color-coded in a consistent manner throughout the tables and appendices, to allow for easy location and comparison of text with respect to a given species.

II.B.3.*1. Persistent organic pollutants (POPs), including PCBs, PCDD/Fs, DDTs, Chlordanes, HCB, and HCHs*

Because organochlorines, as a class, are lipophilic compounds that might be expected to reach highest concentrations in fat (Norstrom, 2002), blubber represents the tissue where maximum organochlorine concentrations are likely. Blubber is also the tissue for which the most data have been generated pertaining to organochlorine contaminants in marine mammals. Reported levels of major persistent organic pollutants (i.e., PCBs, DDTs, chlordanes, mirex, dieldrin, aldrin, endrin, HCHs, HCB, and endosulfans) in the selected cetacean and pinniped species from US waters are provided in Appendices I and II, respectively, and summarized in Table 1, while metadata for studies addressing major persistent organic contaminants in the chosen marine mammals is presented in Table 2. Twenty-one papers focused on organochlorine contaminants in the cetacean species under consideration, while 16 studies examined organochlorines in pinniped species. For all contaminant classes combined, the number of studies and the collective number of individuals sampled for each cetacean species were as follows: *T. truncatus*, 9 studies (two of which, by Reddy et al. dealt with the same animals), 218 sampled; *K. breviceps*, 1 study, 2 sampled; *L. acutus*, 3 studies (two of which, by Tuerk et al., dealt with the same animals), 53 sampled; *G. melas*, 4 studies, 60 sampled (with some overlap between studies and animals, so this number is likely somewhat inflated); *S. bredanensis*, 2 studies (both of which dealt with the same animals), 15 sampled; *E. robustus*, 3 studies, 101 sampled (again, there appears to be some overlap between studies and animals, so this number likely overstates the true number of animals represented); *M. novaeangliae*, 2 studies, 32 sampled. For pinniped species, the number of studies and maximum total number of animals sampled were: *Z. californianus*, 6 studies (Le Boeuf et al., 2002 and Kannan et al., 2004 consider the same animals), 148 sampled; *P. vitulina*, 10 studies, 201 sampled; *M. angustirostris*, 4 studies, 13 sampled (Table 2). I found no studies addressing organochlorine contaminants in *K. simus* or *G. macrorhynchus* in my review of the literature.

Among the species addressed, mean total PCB levels were highest in blubber of *T. truncatus* (240,000 ng/g lipid weight; n=6), which also had the highest single observed concentration of total PCBs, at 1,120,000 ng/g lipid weight. *P. vitulina* had the lowest mean concentration of total PCBs (1.7 ng/g wet weight, n=10). Compared to other species targeted in this review, California seal lions had by far the highest mean blubber concentrations of sum DDTs (143,000 ng/g lipid wgt.; n=36) and sum HCHs (780 ng/g lipid wgt.; n=36), as well as the highest single observed concentration of these contaminants in blubber (1,400,000 and 2,240 ng/g lipid wgt. for sum DDTs and sum HCHs, respectively, with the latter value obtained by adding the standard deviation to the corresponding mean). Compared to other species, *E. robustus* (n=38) and *K. breviceps* (n=2) had low blubber concentrations of sum DDTs (means of 130 and 540 ng/g wet weight, respectively). K. breviceps also had the lowest documented levels of HCHs (1.1 ng/g wet weight), although little significance can be imparted to a sample consisting of two individuals. *L. acutus* displayed both highest mean and overall blubber concentrations of sum chlordanes (8,800 ng/g wet weight; n=23, and 23,900 ng/g wet weight, respectively) and dieldrin (1,810 ng/g wet weight; n=23, and 3,940 ng/g wet weight, respectively). *Tursiops* had the lowest mean and overall blubber concentration of dieldrin (non-detectable) observed, while the lowest mean blubber concentration of sum chlordanes occurred in *K. breviceps*, followed by *E. robustus* (50 and 140 ng/g wet weight, respectively). The highest mean blubber concentrations of mirex (32,000 ng/g wet weight; n=8) and HCB (4,700 ng/g wet weight; n=8) were found in *P. vitulina*, which also had the highest overall blubber concentrations of these two contaminants (60,000 ng/g wet weight and 8,500 ng/g wet weight for mirex and HCB, respectively). Overall, among the species and data represented in this review of the literature, the bottlenose dolphin appears to be the cetacean species most contaminated by persistent organic pollutants, followed by *L. acutus*, while among pinnipeds the California sea lion represents the most contaminated species, followed by harbor seals. A cursory examination of Table 1 reveals that, among the selected cetacean species, *E. robustus*, *K. breviceps* (represented by only two individuals) and *M. novaeangliae* appear the least contaminated with persistent organic pollutants. Such a perfunctorily apparent inference cannot be made with respect to the three pinniped species, however; while blubber concentrations of none of the persistent organic pollutants in *M. angustirostris* exceeds the levels in the other two species, neither are they consistently lower than concentrations observed in *P. vitulina* or *Z. californianus*.

Collectively, four studies have measured PCDD/Fs in blubber from three of the species included in this review (Table 3). For all studies combined, the total number of individuals for each species is: *E. robustus* (n=2), *M. angustirostris* (n=6), and *P. vitulina* (n=75). Two studies, Jarman et al., 1996 and Lake et al., 1995, found no detectable levels of PCDD/Fs in blubber of *E. robustus* (n=2) or *P. vitulina* (n=15), respectively. The highest reported mean concentrations of sum PCDDs and sum PCDFs were 0.279 ng/g lipid weight (n=38) and 0.026 ng/g lipid weight=5), respectively, both of which were in seals from British Columbia, Canada.

II.B.3.*2. Toxic metals, including Hg, Cd, Pb, and Sn*

Twelve studies examined one or more of the toxic metals, Hg, Cd, Pb and Sn, in the cetacean species addressed in this review, while only three studies evaluated one or more of the metals in question in the selected pinniped species. For all metal contaminants combined, the number of studies and the maximum collective number of individuals sampled for each cetacean species were as follows: *T. truncatus,* 5 studies, 148 sampled; *K. breviceps*, 1 study, 3 sampled; *L. acutus*, 1 study, 4 sampled; *G. melas*, 1 study, 9 sampled; *S. bredanensis*, 1 study, 15 sampled; and *E. robustus*, 5 studies, 35 sampled. Similarly for pinniped species, the number of studies and total number of animals sampled were: *Z. californianus*, 1 study, 10 sampled; *P. vitulina*, 2 studies, 13 sampled; *M. angustirostris*, 2 studies, 6 sampled. No studies were found that addressed levels of the specified metal contaminants in *G. macrorhynchus*, *M. novaeangliae*, or *K. sima* between 1995 and 2006 in US waters. Metadata describing studies pertaining to the potentially toxic metals Hg, Cd, Pb and Sn are summarized in Table 4, while reported levels of these metals in the given species over the publication timeframe under consideration are given in Appendix III.

It is difficult to make any generalizations or to draw any meaningful comparisons about the four potentially toxic metals covered by this literature review, because reported data is quite limited and methodologies between studies vary. Overall, ten studies report values on a wet weight basis, while the remaining five present metal concentrations on a dry weight basis, and since raw data generally are not provided, the reader cannot convert data from one form to the other.

II.B.3.*3*. Miscellaneous contaminants: *PBDEs* and *PFAs*

Within the geographic and temporal confines of this review, 6 studies have evaluated concentrations of PBDEs in the selected species of marine mammals (Table 5). Four studies examined PBDEs in blubber of *Tursiops*, *L. acutus*, *S. bredanensis* and *P. vitulina*, while the remaining two studies addressed PBDE levels in *P. vitulina* blood. Among the species in these studies, adult male *Tursiops* demonstrated the highest PBDE contamination, with a mean concentration of 3,110 ng/g wet weight in blubber (range: 126–16300, n=9).

As for PBDEs, PFAs have been assessed in a limited number of individuals and species (Table 6). Kannan et al., 2001 analyzed hepatic concentrations of PFOS in the following species: *K. breviceps* (n=2), *S. bredananensis* (n=2), *T. truncatus* (n=20), *Z. califonianus* (n=6), *M. angustirostris* (n=5), *P. vitulina* (n=3). Houde et al. (2005) conducted a more extensive study of various PFA compounds in *Tursiops* blubber and found concentrations of mean sum PFAs ranging from 778 (n=42) to 1738 (n=47) ng/g wet weight between geographic locations on the eastern US coast.

II.C. Conclusions and comments regarding the nature and adequacy of the available literature database

The studies encompassed by this literature review were conducted to determine concentrations of specific environmental contaminants in various given marine mammal species. Such monitoring investigations generally are undertaken to learn how environmental contaminants may be impacting individual or population health, as well as to indicate whether environmental contaminants might be implicated as a causative factor in stranding events. Tursiops is, by far, the species for which the most comprehensive data exist pertaining to contaminants, and among those contaminants, PCBs have been the most widely analyzed in this species. Of nine studies that sampled a combined total of 218 bottlenose dolphins for PCBs, seven studies evaluated PCBs in blubber, with a combined total sample size of 210 animals. Of these 210 dolphin blubber samples, 129 appear to have been obtained via biopsy, while 81 were apparently from stranded animals. Eighty-one of the 210 blubber samples were taken from dolphins in the Gulf of Mexico, off the FL (including Sarasota Bay), TX, or AL coasts. Sixty-two blubber samples were from Atlantic dolphins, generally from three sites: Beaufort, NC, (n=40) Charleston Bay, SC, (n=11) and Indian River Lagoon, FL (n=17). The remaining 14 blubber samples were from dolphins in San Diego Bay, CA. The blubber PCB data reported among the seven studies is in a variety of formats. Hansen et al., (2004) reported the geometric means of their data, while Wells et al., (2005) did not report means at all. Other studies reported arithmetic means. The number of PCB congeners which comprise "sum PCBs" among these seven studies also vary widely, from ten to eighty-seven congeners, while three studies did not report the identity or number of congeners analyzed. All seven studies report PCB concentrations on a lipid weight basis. However, if the concern is not the consequences of PCB contamination on the dolphin itself, but rather the dispersion of the PCBs contained within the blubber throughout the environment during carcass decomposition or scavenging, the entity of interest is the level of contamination expressed on a wet weight basis. Because individual animal data including blubber percent lipid are not specified in any of these seven studies, conversion of concentration data to a wet weight basis is not possible.

Sampling techniques also influence the levels of organochlorines measured in blubber. Of the seven studies that quantified blubber PCBs, only two (Salata et al., 1995 and Finklea et al., 2000) stipulated that full-thickness blubber samples were obtained. Kuehl and Haebler (1995) and Johnson-Restrepo (2005) did not specify how blubber samples were taken. The remaining three research teams employed biopsy methods, including remote dart (Hansen et al., 2004), punch (Reddy et al., 2001) and wedge (Wells et al., 2005) biopsy. All of these biopsy techniques are inherently biased towards collection of the outermost portion of the blubber. However, Aguilar and Borrell (1991) and Severinsen et al., (2000) documented that organochlorines are not homogenously distributed throughout this tissue in species of two baleen whales and a phocid seal, respectively, but rather stratified such that contaminant levels in the outermost blubber are significantly greater than that of the innermost blubber layer. Moreover, this difference was not attributable merely to variation in lipid content (Severinsen et al., 2000). Struntz et al., 2004 noted the heterogeneous morphological and histological structure of *Tursiops* blubber. Consequently, it would be imprudent to assume that PCBs or other organochlorine contaminants are homogenously dispersed throughout blubber of bottlenose dolphins. Rather, contaminants concentrations obtained from blubber biopsy specimens likely overestimate blubber contaminant burdens, and should be interpreted with caution.

The above summary briefly illustrates the extremely limited nature of the database for the most thoroughly studied species and contaminant combination (*Tursiops* and PCBs) among those considered by this review. For other contaminants and species, the data are even scantier. Certain generalizations might be made about the distribution of particular contaminants within tissues, and among individuals in a given population. For example, it is generally understood that species higher trophic species such as dolphins are more prone to bioaccumulating higher levels of some contaminants than species that feed at lower trophic levels, such as baleen whales. Also, lipophilic contaminants such as PCBs tend to be at highest levels in blubber of adult males, because contaminant levels increase with age, and because females can depurate some of their acquired contaminant load through transfer to offspring (Wells et al., 2005). This latter phenomenon accounts for the observation that immature animals may have higher blubber PCB concentrations than adults, when levels are evaluated on a lipid weight basis. Despite such documented patterns of PCB accumulation within *Tursiops,* overall the data are quite limited with respect to samples sizes, tissues analyzed and geographic locations represented.

Contaminant monitoring studies tend to focus on tissues that represent target organs of a given toxicant or are sites of bioaccumulation. Because few tissues are assayed, there is generally insufficient information to infer the total body burden of a given contaminant for an individual in a given population. Moreover, patterns of contaminant accumulation will vary based upon exposures. Individuals from highly contaminated areas will not serve to represent animals from less contaminated regions, and vice versa. The heterogeneous nature of contaminants data published for the selected marine mammals in US waters encompassed by this review make it difficult to compare between studies, much less to unify this disparate research into an assemblage with utility for other applications such as the evaluation of the potential toxicological environmental hazards posed by decomposing carcass. At current, the database for the contaminants in the species encompassed by this review is inadequate to support such an assessment.

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Table 1. Summary of Concentrations of Major Organochlorine Contaminant Classes in Blubber of Selected Marine Mammal Species from US Waters as Reported in Literature from 1994-2005

Table 1. Summary Data for Some Persistent Organic Pollutants, Including PCBs, DDTs, Chlordanes, Mirex, Dieldrin, HCHs and HCB in Blubber of Selected Marine Mammal Species from US Waters, Reported 1994 through 2005.
For each species, the lowest and highest overall means among reported studies are given, followed by the corresponding sample size, as well as overall ranges for animals in all studies combined.

CETACEANS	Analyte (ng/g)	Lipid (%)	∑ PCBs	∑ DDTs	∑ chlordanes	mirex	dieldrin	∑ HCHs	HCB
T. truncatus[a]	Lowest mean (n)	19.9 (4)	5644 (6)	3988 (6)	548 (6)	20.3 (2)	ND (2)	109 (33)	ND (9[b])
	Highest mean (n)	39.4 (9)	240000 (6)	51906 (5)	7022 (5)	663 (4)	1550 (5)	234 (14)	3360 (5)
	Overall range	1.2 - 82.8	420 - 1120000	428 - 87281	195 - 10553	ND - 6540	ND - 3120	9 - 354	ND - 5730
K. breviceps[c]	Mean (n)	3.4 (2)	560 (2)	540 (2)	50 (2)	NA	NA	1.1 (2)	5.5 (2)
	Overall range	2.6 - 4.1	290 - 830	400 - 680	27 - 73	NA	NA	1.1 - 1.1	1.4 - 9.7
L. acutus[c]	Lowest mean (n)	43.8 (6)	9410 (9)	4090 (9)	2200 (9)	40.4 (9)	293 (9)	91 (9)	50.6 (9)
	Highest mean (n)	43.8 (6)	29400 (23)	15900 (23)	8800 (23)	73.7 (15)	1810 (23)	301 (23)	237 (23)
	Overall range	17.2[f]	490 - 62700	498 - 43300	285 - 23900	18.4 - 112	62.6 - 3940	50.4 - 821	11[d] - 606
G. melas[c]	Lowest mean (n)	39 (16)	4172 (11)	6000 (16)	1221 (11)	27 (11)	262 (7)	57.5 (11)	200 (16)
	Highest mean (n)	75 (16)	12000 (6)	18336[a] (16)	3000 (6)	56[a] (16)	441 (11)	104[a] (16)	370 (6)
	Overall range	17.7[d] - 88	1087[d] - 25000	ND[a,d] - 42046[a,e]	55[a,d] - 5800	ND[c,d] - 90[a,e]	56.8 - 674[e]	ND[c,d] - 157[a,e]	ND[a,d] - 620
S. bredanensis[c]	Mean (n)	53 (15)	18392 (15)	9285.5 (15)	3825 (15)	269.3 (15)	233.8 (15)	26.0 (15)	28.8 (15)
	Overall range	38 - 73.3	643 - 43301	146 - 23139	74.1 - 2093	16.4 - 664	9.03 - 1220	2.6 - 177	0.4 - 67.4
E. robustus[c]	Lowest mean (n)	8.5 (22)	220 (38)	130 (38)	140 (17)	NA	NA	NA	100 (38)
	Highest mean (n)	48 (17)	1600 (22)	444 (22)	340 (22)	NA	160 (22)	NA	510 (24)
	Overall range	0.6 - 73	120 - 10000	11 - 2940	13 - 2200	ND - 100	4 - 1600	NA	17 - 2900
M. novaeangliae[c]	Lowest mean (n)	NA	897[a] (12)	NA	NA	1.8 (6)	308 (6)	104 (6)	73.4 (6)
	Highest mean (n)	44.9 (7)	1153 (7)	NA	385.6 (6)	7.2[a] (12)	363.4[a] (13)	108.1[a] (12)	172.2[a] (13)
	Overall range	27 - 63	301[a,d] - 2958	NA	125.6 - 728.3	ND - 11.1[a,e]	52.7 - 777	33.8 - 242	15.8 - 293.1[a,e]
PINNIPEDS									
Z. californianus[c]	Lowest mean (n)	4.2 (9)	1300 (5)	13947 (9)	457 (9)	NA	NA	57 (9)	ND[g]
	Highest mean (n)	50 (36)	48158 (12)	143000[a,h] (36)	3420[a] (36)	NA	190[a] (36)	780[a] (36)	ND[g]
	Overall range	1 - 88	ND - 410000[a]	456 - 1400000[a]	17 - 9450	NA	220[f]	6.5 - 2240[a,e]	ND[g]
M. angustirostris[c]	Lowest mean (n)	74 (4)	550 (6)	11000[a] (2)	1095[a] (2)	NA	NA	122[a] (2)	30 (4)
	Highest mean (n)	85 (2)	6979 (4)	12418 (4)	1118 (4)	NA	28[a] (2)	184 (4)	32.5[a] (2)
	Overall range	18 - 93	460[d] - 10440	3000[a] - 19800	290[a] - 1900[a]	NA	19[a] - 37[a]	44[a] - 279	14.8 - 43[a]
P. vitulina[c]	Lowest mean (n)	40 (3)	1.7 (10)	314 (5)	205 (5)	4.9 (3)	5 (5)	33[a] (2)	5.3 (9)
	Highest mean (n)	89 (2)	40376 (3)	8790 (3)	4015 (3)	32000 (8)	364[a] (4)	220[a] (4)	4700 (8)
	Overall range	16 - 95	ND - 78474	130 - 13612	80 - 8938	1.2 - 60000	3 - 1060[a]	22.4[a] - 425[a]	2.79[d] - 8500

Abbreviations: ND, the analyte was not detected above the limit of detection; NA, not available

[a]ng/g lipid weight

[b]Largest sample with this mean

[c]ng/g wet weight

[d]Value obtained by subtracting the SD from the corresponding mean

[e]Value obtained by adding the SD to the corresponding mean

[f]Standard deviation of mean above

[g]ND in either of two studies that address this analyte

[h]∑DDTs refers to p,p' forms of DDE, DDD and DDT only

Table 2. Metadata for Persistent Organic Pollutants, Including PCBs, DDTs, Chlordanes, HCHs and HDB in Selected Marine Mammal Species from US Waters, Reported 1994 through 2005.
An "X" in a given contaminant column denotes that contaminant was analyzed.

Source	Species	Contaminant Classes Analyzed						Date Sampled	Event	Location	Source data characterization Arith.(A) or Geo. (G) Mean; lw or ww; % lipid given?; individual animal data provided?
		PCBs (# of congeners)	DDTs	Chlordanes*	HCHs	HCB	Tissue (n)				
CETACEANS											
Hansen et al., 2004	T. truncatus	X (15)	X	X		X	blubber (62)	1995-2000	B	NC, SC, FL	G; lw; yes; no
Reddy et al., 2001; 1998	T. truncatus	X (10)	X	X	X	X	blubber (14) blood (16)	1994	B	CA	NR; lw; no; yes
Salata et al., 1995	T. truncatus	X (NR)	X	X	X	X	blubber (33)	NR	S	TX, FL	A; lw; no; no
Kuehl & Haebler, 1995	T. truncatus	X (NR)	X[a]	X		X	blubber (24)	1990	S	TX, FL	A; lw; no; no
Finklea et al., 2000	T. truncatus	X (87)					blubber (10)	1990	S	TX	A; lw; no; yes
Johnson-Restrepo et al., 2005	T. truncatus	X (NR)					blubber (20)	1991-2004	S & B[d]	FL	A; lw; yes; no
Wells et al., 2005	T. truncatus	X (22)					blubber (47) blood (NR) milk (NR)	2000-2001	B	FL	NR[f]; lw; no; no
Watanabe et al., 2000	T. truncatus	X (35)	X[a]	X	X	X	liver (6)	1989-94	S	FL	A; ww; yes; yes
	K. breviceps	X (35)	X[a]	X	X	X	liver (2)	1991-92	S	FL	A; ww; yes; yes
Tuerk et al., 2005a,b	L. acutus	X(55)	X	X	X	X	blubber (47)	1993-2000	S	MA	A;ww; no; no
Weisbrod et al., 2001	L. acutus	X (27)	X	X	X	X	blubber (6) skin (6) liver (6) lung (2) kidney (2)	1994-96	S	MA, NY	A; ww; yes; no
	G. melas	X (27)	X	X	X	X	blubber (11) skin (3) liver (8) heart (4) muscle (6) kidney (3) testis (1)	1990-96	S	MA, NY	A; ww; yes; no
Weisbrod et al., 2000	G. melas	X (27)	X	X	X	X	blubber (16) liver (17)	1990-96	S	MA	A; lw; yes; no
Becker et al., 1997	G. melas	X (33)	X	X		X	blubber (7)	NR[b]	NR[b]	MA	A; ww; no; no
Tilbury et al., 1999	G. melas[b]	X (17)	X	X		X	blubber (22) liver (25) kidney (9) brain (8) ovary (2)	1986-90	S	MA	A; ww; yes; no
Struntz et al., 2004; Tuerk et al., 2005a	S. bredanensis	X (33)	X	X	X	X	blubber (15)	1997	S	FL	A; lw; yes; yes
Varanasi et al., 1994	E. robustus	X (NR)	X	X		X	blubber (22) liver (10) brain (1)	1988-91	S	CA, WA & AK	A[c]; ww; yes; no
Tilbury et al., 2002	E. robustus	X (17)	X	X		X	blubber (17) liver (14) kidney (6) brain (6) muscle (3)	1994	H	Russia (Western Bering Sea)	A; ww; yes; no
Krahn et al., 2001	E. robustus[b]	X (17)	X	X		X	blubber (62)	1996 & '99	B & S	WA	A; ww; yes; no
Metcalfe et al., 2004	M. novaeangliae	X (25)	X[a]	X	X	X	blubber (25)	1993-99	B	Canada	A; lw; no; no
Gauthier et al., 1997	M. novaeangliae	X (19)	X[a]	X	X	X	blubber (7)	1991	B	Canada	A; lw; yes; yes
PINNIPEDS											
Lieberg-Clark et al., 1995	Z. californianus	---	X[a]				blubber (7)	1988-92	S	CA	G; ww; no; no
Hayteas & Duffield, 1997	Z. californianus	X (NR)	X[a]				blubber (5)	1991-95	S	OR	G; ww; no; yes
	P. vitulina	X (NR)					blubber (10)	1991-95	S	OR	G; ww; no; yes
	M. angustirostris	X (NR)					blubber (1)	1991-95	S	OR	G; ww; no; yes
Kajiwara et al., 2001	Z. californianus	X (NR)	X[a]	X	X	X	blubber (12) liver (9)	1991-97	S	CA	A; ww; yes; yes
	P. vitulina	X (NR)	X[a]	X	X	X	liver (10)	1991-97	S	CA	A; ww; yes; yes
	M. angustirostris	X (NR)	X[a]	X	X	X	blubber (4)	1991-94	S	CA	A; ww; yes; yes
Kannan et al., 2004; Le Boeuf et al., 2002	Z. californianus	X (NR)	X[a]	X	X		blubber (36)	2000	S	CA	A; lw; yes; no
	M. angustirostris	X (NR)	X[a]	X	X	X	blubber (2)	2000	S	CA	A; lw; yes; no
Lake et al., 1995	P. vitulina	X (18)	X[a]	X		X	blubber (9) liver (9)	1990-92	S	NY, MA	A; ww; no; no
Young et al., 1998	P. vitulina	X (20)					blood (16)	1990	S	CA	A; ww; no; no
Hong et al., 1996	P. vitulina	X (73) X (54)	X[a]			X	blubber (8) liver (8)	1990	S	WA	A; ww; no; no
Krahn et al., 1997	P. vitulina	X (17)	X	X		X	blubber (15)	1992-93	S & H	WA, OR, AK	A[f]; ww; yes; no[f]
Ross et al., 2004	P. vitulina	X (109)					blubber (60)	1996-97	B	Canada; WA	A; lw; no; no
Neale et al., 2005a	P. vitulina	X (10)	X[e]				blood (17)	2001-02	B	CA	A; ww & lw, no, no
Neale et al., 2005b	P. vitulina	X (11)	X[e]				blood (35)	2001-02	B	CA	NR; ww & lw; no; no
Shaw et al., 2005	P. vitulina	X (20)	X	X	X	X	blubber (30)	2001-02	S	MA, ME, NH, NY	A; lw; yes; yes
Debier et al., 2005a	M. angustirostris	X (141)					blubber (6)	2002	B	CA	A; lw & ww; yes; no
Debier et al., 2005b	Z. californianus	X (NR)	X				serum (12)	2002	B	CA	A; ww & lw; yes; no
Ylitalo et al., 2005	Z. californianus	X (17)	X				blubber (76)	1993-2003	S	CA	A; ww & lw; yes; no

Abbreviations: NR, not reported; S, stranded; B, biopsied; H, subsistence harvest; A, arithmetic mean; G. geometric mean; lw, reported on a lipid weight basis; ww, reported on a wet weight basis

*Number of chlordane isomers analyzed varied between studies

[a]Only *p'p'* isomers of DDT, DDE and DDD were analyzed; in some studies, not all three *p',p'* isomers were analyzed.

[b]In Appendix I, see footnotes "g," "h" and "j" for Becker et al.(1997),Tilbury et al.(1999) and Krahn et al. (2001), respectively, regarding study overlap

[c]Means exclude values below limit of detection

[d]From archived samples; from source text it appears that 14 are from stranded dolphins and the remaining 6 were biopsies

[e]4,4' DDE only

[f]Ranges only were given for data (except for some data subsets in Wells); data provided in graphic format only

Table 3. Polychlorinated dibenzo-p-dioxins and -furans (PCDD/Fs) Contaminants in Tissues of Selected Marine Mammal Species from US Waters, Reported 1995 through 2005.

	Source: Jarman et al., 1996 Event: Stranding			Source: Ross et al., 2004 Event: Biopsy									Source: Lake et al., 1995 Event: Stranding			Source: Debier et al., 2005a Event: Biopsy		
	Location: British Columbia, Canada (Vancouver Is. & Denman Is.)			Location: BC, Canada (Queen Charlotte Strait)			Location BC, Canada (Strait of Georgia)			Location: WA (Puget Sound)			Location: NY & MA			Location: CA (Ano Nuevo Is.)		
	Date Sampled: 1987-88 Species: *Eschrichtius robustus* Tissue: Blubber			Date Sampled: 1996-97 Species: *Phoca vitulina* Tissue: Blubber			Date Sampled: 1996-97 Species: *Phoca vitulina* Tissue: Blubber			Date Sampled: 1996-97 Species: *Phoca vitulina* Tissue: Blubber			Date Sampled: 1990-92 Species: *Phoca vitulina* Tissue: Blubber			Date Sampled: 2002 Species: *Mirounga angustirostris* Tissue: Blubber		
Analyte (ng/g wet weight)	n	Mean	LOD[b]	n	Mean[a,c]	SE	n	Mean[c]	SE	n	Mean[c]	SE	n			n	Mean[c]	SD
2,3,7,8-TCDD	2	ND	<2										15[d]					
1,2,3,7,8-PnCDD	2	ND	<5										15[d]					
1,2,3,4,7,8-HxCDD													15[d]					
1,2,3,6,7,8-HxCDD	2		<8										15[d]			6	0.007	NR
1,2,3,7,8,9-HxCDD	2	ND	<8										15[d]					
1,2,3,4,6,7,9-HpCDD	2	ND	<10															
1,2,3,4,6,7,8-HpCDD	2	ND	<10										15[d]			6	0.008	NR
OCDD	2	ND	<20										15[d]			6	0.017	NR
∑ 2,3,7,8-PCDDs				5	0.072	0.006	38	0.256	0.031	17	0.119	0.011						
∑ PCDDs				5	0.096	0.01	38	0.279	0.032	17	0.119	0.016				6	0.032[e]	0.023
2,3,7,8-TCDF	2	ND	3										15[d]					
1,2,4,7,8-PnCDF	2	ND	<5															
1,2,3,7,8-PnCDF													15[d]					
2,3,4,7,8-PnCDF	2	ND	<5										15[d]			6	0.007	NR
1,2,4,8,9-PnCDF	2	ND	<5															
1,2,4,6,8,9-HxCDF	2	ND	<8															
1,2,3,4,7,8-HxCDF													15[d]					
1,2,3,6,7,8-HxCDF													15[d]					
1,2,3,7,8,9-HxCDF													15[d]					
2,3,4,6,7,8-HxCDF													15[d]					
1,2,3,4,6,9-/1,2,3,6,8,9-HxC	2	ND	<8															
1,2,3,4,6,8,9-HpCDF	2	ND	<10															
1,2,3,4,6,7,8-HpCDF													15[d]					
1,2,3,4,7,8,9-HpCDF													15[d]					
OCDF													15[d]			6	0.01	NR
∑ 2,3,7,8-PCDFs				5	0.022	0.002	38	0.016	0.002	17	0.01	0.001						
∑ PCDFs				5	0.026	0.004	38	0.025	0.013	17	0.01	0.001				6	0.017[e]	0.005

Abbreviations: ND, the analyte was not detected above the limit of detection; SE, standard error of the mean; SD, standard deviation; NR, not reported

[a]Arithmetic

[b]LOD-limits of detection for individual PCDD/F congeners

[c]ng/g lipid weight

[d]All samples were near or below limits of detection (3-5 pg/g).

[e]On a wet weight basis means (SD) were: 0.025(0.017) and 0.014(0.004) for∑ PCDDs and ∑ PCDFs, respectively.

Table 4. Metadata for Toxic Metal Pollutants, Including Mercury (Hg), Cadmium (Cd), Lead (Pb) and Tin (Sn) in Selected Marine Mammal Species from US Waters, Reported 1994 through 2005.
An "X" in a given metal contaminant column denotes that metal was analyzed.

		Metal Contaminant Analyzed								
Source	**Species**	**Mercury**	**Cadmium**	**Lead**	**Tin**	**Tissue (n)**	**Date Sampled**	**Event**	**Location**	**Comments**
CETACEANS										
Ruelas-Inzunza et al., 2002	*E. robustus*	X (THg & MeHg)	X	X		Kidney (4) Liver (4) Muscle (4)	1999	S	Mexico (Gulf of California)	DW
Tilbury et al., 2002	*E. robustus*	X (THg)	X	X		Brain (6) Kidney (6) Liver (5)	1994	H	Russia (NW Bering Sea)	WW
Varanasi et al., 1994	*E. robustus*	X (THg)	X	X	X[a]	Brain (1) Kidney (10) Liver (10)	1988-1991	S	CA, WA & AK	WW
De Luna & Rosales-Hoz, 2004	*E. robustus*			X		Bone (8) Epidermis (8) Kidney (2) Muscle (8)	1999	S	Mexico (Ojo de Liebre Lagoon)	DW
Mendez et al., 2002	*E. robustus*		X	X		Blubber (5) Heart (7) Kidney (5) Liver (5) Lung (7) Muscle (5)	1999	S	Mexico (Sinaloa & Baja California Sur)	DW
Mackey et al., 1995	*G. melas*	X (THg)	X			Liver (9)	1990-1990	S	MA	WW
	L. acutus	X (THg)	X			Liver (4)	1993	S	MA	WW
Beck et al., 1997	*T. truncatus*	X (THg)	X	X		Liver (34)	NR	S	SC	WW
Kuehl & Haebler, 1995	*T. truncatus*	X (THg)	X	X		Liver (24)	1990	S	TX & AL (Gulf of Mexico)	WW
Meador et al., 1999	*T. truncatus*	X (THg & MeHg)	X[c]	X[c]		Blubber (4) Kidney (30[b]) Liver (30[b])	1990-1991	S	TX	DW[f]
	T. truncatus	X (THg & MeHg)	X[c]	X[c]		Kidney (13[b]) Liver (14[b])	1990-1991	S	FL	DW
Wood & Van Vleet, 1996	*T. truncatus*		X			Kidney (21) Liver (29) Muscle (21)	1990-1994	S	FL	DW
Kannan et al., 1997	*T. truncatus*				X[d]	Blubber (1) Brain (1) Heart (1) Liver (16) Kidney (17) Melon (1) Muscle (11)	1989-1994	S	FL	WW
	K. breviceps				X[d]	Kidney (2) Liver (3) Muscle (2)	1989-1994	S	FL	WW
Mackey et al., 2003	*S. bredanensis*	X (THg)	X		X[e]	Kidney (15) Liver (15)	1997	S	FL (Gulf of Mexico)	WW
PINNIPEDS										
Lake et al., 1995	*P. vitulina*	X (THg)				Liver (7)	1990-1992	S	NY & MA	WW
Owen & Flegal, 1998	*M. angustirostris*			X		Blood (4)	1994-1995	B	CA	WW
Kajiwara et al., 2001	*M. angustirostris*				X[d]	Liver (2)	1991-1994	S	CA	WW
	P. vitulina				X[d]	Liver (6)	1991-1997	S	CA	WW
	Z. californianus				X[d]	Liver (10)	1991-1997	S	CA	WW

Abbreviations: THg, Total mercury; MeHg, organic (methyl) mercury; NR, not reported; S, stranded; B, biopsied; H, subsistence harvest; WW, reported on a wet weight basis; DW, reported on a dry weight basis

[a]Total tin was analyzed in kidney and liver of seven animals

[b]Maximum analyzed for this tissue at this location

[c]Analyzed in kidney and liver only

[d]Sum of butyltins, including mono-, di- and tri-butyltin

[e]Total tin

[f]Except for blubber, which was reported as WW

Appendix III. Mercury, Cadmium, Lead and Tin in Tissues of Selected Marine Mammal Species from US Waters, Reported 1994 through 2005. All concentrations are reported on a wet weight basis, except where noted otherwise by an asterisk*.

Mercury (Hg)

Species	Tissue	Mean ug/g	Min.	Max.	n	Location	Date Sampled	Event	Reference
E. robustus	kidney[a]	277*	140[j]	NR	4	Mexico (Gulf of California)	1999	Stranding	Ruelas-Inzunza et al., 2002
E. robustus	kidney[b]	51*	22[j]	NR	4	Mexico (Gulf of California)	1999	Stranding	Ruelas-Inzunza et al., 2002
E. robustus	liver[a]	185*	82[j]	NR	4	Mexico (Gulf of California)	1999	Stranding	Ruelas-Inzunza et al., 2002
E. robustus	liver[b]	42*	34[j]	NR	4	Mexico (Gulf of California)	1999	Stranding	Ruelas-Inzunza et al., 2002
E. robustus	muscle[a]	145*	82[j]	NR	4	Mexico (Gulf of California)	1999	Stranding	Ruelas-Inzunza et al., 2002
E. robustus	muscle[b]	109*	40[j]	NR	4	Mexico (Gulf of California)	1999	Stranding	Ruelas-Inzunza et al., 2002
E. robustus	brain[a]	0.022	0.002[h]	NR	6[g]	Russia (NW Bering Sea)	1994	Subsistence harvest	Tilbury et al., 2002[i]
E. robustus	kidney[a]	0.034	0.001[h]	NR	6[g]	Russia (NW Bering Sea)	1994	Subsistence harvest	Tilbury et al., 2002[i]
E. robustus	liver[a]	0.16	0.061[h]	NR	5[g]	Russia (NW Bering Sea)	1994	Subsistence harvest	Tilbury et al., 2002[i]
E. robustus	brain[a]	ND	ND	ND	1	CA, WA & AK	1988-91	Stranding	Varanasi et al., 1994
E. robustus	kidney[a]	0.034	ND	0.06	10	CA, WA & AK	1988-91	Stranding	Varanasi et al., 1994
E. robustus	liver[a]	0.056	0.009	0.12	10	CA, WA & AK	1988-91	Stranding	Varanasi et al., 1994
G. melas	liver[a]	40.3	1.00	112.0	9	MA	1990-91	Stranding	Mackey et al., 1995
L. acutus	liver[a]	10.36	1.00	22.70	4	MA	1993	Stranding	Mackey et al., 1995
S. bredanensis	kidney[a]	5.8	0.9	15	15	FL (Gulf of Mexico)	1997	Stranding	Mackey et al., 2003
S. bredanensis	liver[a]	70	3.4	235	15	FL (Gulf of Mexico)	1997	Stranding	Mackey et al., 2003
T. truncatus	liver[a]	17.8	<0.5	146.5	34	SC	NR	Stranding	Beck et al., 1997
T. truncatus	liver[a]	0.96	0.15	2.23	5[o]	TX & AL (Gulf of Mexico)	1990	Stranding	Kuehl & Haebler, 1995
T. truncatus	liver[a]	4.39	1.72	8.36	5[g]	TX & AL (Gulf of Mexico)	1990	Stranding	Kuehl & Haebler, 1995
T. truncatus	liver[a]	45.5	5.1	87.8	9[p]	TX & AL (Gulf of Mexico)	1990	Stranding	Kuehl & Haebler, 1995
T. truncatus	liver[a]	25.9	6.1	48.7	5[q]	TX & AL (Gulf of Mexico)	1990	Stranding	Kuehl & Haebler, 1995
T. truncatus	blubber[b]	0.6	0.4	0.7	4	FL	1991-92	Stranding	Meador et al., 1999[c,d]
T. truncatus	kidney[a]	33*	1.0	89	29	TX	1991-92	Stranding	Meador et al., 1999[c,d]
T. truncatus	kidney[a]	68*	11.2	110	12	FL	1991-92	Stranding	Meador et al., 1999[c,d]

Mercury (Hg) (continued)									
Species	Tissue	Mean ug/g	Min.	Max.	n	Location	Date Sampled	Event	Reference
T. truncatus	kidney[b]	4.5*	1.3	10.4	23	TX	1991-92	Stranding	Meador et al., 1999[c,d]
T. truncatus	kidney[b]	9.9*	1.4	19	13	FL	1991-92	Stranding	Meador et al., 1999[c,d]
T. truncatus	liver[a]	212*	8.3	1404	30	TX	1991-92	Stranding	Meador et al., 1999[c,d]
T. truncatus	liver[a]	304*	18	1312	13	FL	1991-92	Stranding	Meador et al., 1999[c,d]
T. truncatus	liver[b]	6*	0.9	23	24	TX	1991-92	Stranding	Meador et al., 1999[c,d]
T. truncatus	liver[b]	11*	2.5	24	14	FL	1991-92	Stranding	Meador et al., 1999[c,d]
P. vitulina	liver[a]	38.5	31.6	49.3	4	NY & MA	1990-92	Stranding	Lake et al., 1995
P. vitulina	liver[a]	69.9	16.0	138	3	NY & MA	1990-92	Stranding	Lake et al., 1995

Cadmium (Cd)									
Species	Tissue	Mean ug/g	Min.	Max.	n	Location	Date Sampled	Event	Reference
E. robustus	blubber	0.16*	ND	0.16	5[g]	Mexico (Sinaloa & Baja California Sur)	1999	Stranding	Mendez et al., 2002
E. robustus	heart	0.68*	0.16	1.81	7[g]	Mexico (Sinaloa & Baja California Sur)	1999	Stranding	Mendez et al., 2002
E. robustus	kidney	15.4*	1.93	35.1	5[g]	Mexico (Sinaloa & Baja California Sur)	1999	Stranding	Mendez et al., 2002
E. robustus	liver	1.77*	0.81	3.62	5[g]	Mexico (Sinaloa & Baja California Sur)	1999	Stranding	Mendez et al., 2002
E. robustus	lung	1.16*	0.1	5.26	7[g]	Mexico (Sinaloa & Baja California Sur)	1999	Stranding	Mendez et al., 2002
E. robustus	muscle	0.86*	0.05	2.34	5[g]	Mexico (Sinaloa & Baja California Sur)	1999	Stranding	Mendez et al., 2002
E. robustus	kidney	5.7*	1.4[j]	8.0	4	Mexico (Gulf of California)	1999	Stranding	Ruelas-Inzunza & Paez-Osuna, 2002
E. robustus	liver	1.1*	1.0[j]	NR	4	Mexico (Gulf of California)	1999	Stranding	Ruelas-Inzunza & Paez-Osuna, 2002
E. robustus	muscle	0.4*	0.2[j]	NR	4	Mexico (Gulf of California)	1999	Stranding	Ruelas-Inzunza & Paez-Osuna, 2002
E. robustus	brain	0.1	0.01[h]	NR	6[g]	Russia (NW Bering Sea)	1994	Subsistence harvest	Tilbury et al., 2002[i]

Cadmium (Cd) (continued)									
Species	**Tissue**	**Mean ug/g**	**Min.**	**Max.**	**n**	**Location**	**Date Sampled**	**Event**	**Reference**
E. robustus	kidney	0.59	0.11[h]	NR	6[g]	Russia (NW Bering Sea)	1994	Subsistence harvest	Tilbury et al., 2002[i]
E. robustus	liver	0.21	0.04[h]	NR	5[g]	Russia (NW Bering Sea)	1994	Subsistence harvest	Tilbury et al., 2002[i]
E. robustus	brain	0.02	0.02	0.02	1	CA, WA & AK	1988-91	Stranding	Varanasi et al., 1994
E. robustus	kidney	4.1	0.14	6.1	10	CA, WA & AK	1988-91	Stranding	Varanasi et al., 1994
E. robustus	liver	4.3	0.06	6.2	10	CA, WA & AK	1988-91	Stranding	Varanasi et al., 1994
G. melas	liver	7.88	2.8	14.3	9	MA	1990-91	Stranding	Mackey et al., 1995
L. acutus	liver	0.42	0.24	0.86	4	MA	1993	Stranding	Mackey et al., 1995
S. bredanensis	kidney	1.73	0.05	3.94	15	FL (Gulf of Mexico)	1997	Stranding	Mackey et al., 2003
S. bredanensis	liver	0.54	0.01	1.02	15	FL (Gulf of Mexico)	1997	Stranding	Mackey et al., 2003
T. truncatus	liver	0.051	0.009	0.27	34	SC	NR	Stranding	Beck et al., 1997
T. truncatus	liver	0.06	0.01	0.08	5[o]	TX & AL (Gulf of Mexico)	1990	Stranding	Kuehl & Haebler, 1995
T. truncatus	liver	0.11	0.08	0.16	5[g]	TX & AL (Gulf of Mexico)	1990	Stranding	Kuehl & Haebler, 1995
T. truncatus	liver	0.43	0.10	1.34	9[p]	TX & AL (Gulf of Mexico)	1990	Stranding	Kuehl & Haebler, 1995
T. truncatus	liver	0.31	0.11	0.64	5[q]	TX & AL (Gulf of Mexico)	1990	Stranding	Kuehl & Haebler, 1995
T. truncatus	kidney	1.9*	ND	4.2	30 (11 ND)	TX	1991-92	Stranding	Meador et al., 1999[c,d]
T. truncatus	kidney	4.4*	ND	5.2	13 (5 ND)	FL	1991-92	Stranding	Meador et al., 1999[c,d]
T. truncatus	liver	0.32*	ND	0.7	14 (8 ND)	TX	1991-92	Stranding	Meador et al., 1999[c,d]
T. truncatus	liver	1.6*	ND	1.6	11 (10 ND)	FL	1991-92	Stranding	Meador et al., 1999[c,d]
T. truncatus	kidney	1.3*	ND	6.4	21	FL	1990-94	Stranding	Wood & Van Vleet, 1996
T. truncatus	liver	0.2*	ND	1.7	29	FL	1990-94	Stranding	Wood & Van Vleet, 1996
T. truncatus	muscle	ND	ND	ND	21	FL	1990-94	Stranding	Wood & Van Vleet, 1996

Lead (Pb)

Species	Tissue	Mean ug/g	Min.	Max.	n	Location	Date Sampled	Event	Reference
E. robustus	bone	50*[k]	NR	NR	2[l]	Mexico (Ojo de Liebre Lagoon)	1999	Stranding	De Luna & Rosales-Hoz, 2004
E. robustus	bone	20*[k]	NR	NR	3[g]	Mexico (Ojo de Liebre Lagoon)	1999	Stranding	De Luna & Rosales-Hoz, 2004
E. robustus	bone	30*[k]	NR	NR	3[m]	Mexico (Ojo de Liebre Lagoon)	1999	Stranding	De Luna & Rosales-Hoz, 2004
E. robustus	epidermis	15*[k]	NR	NR	8	Mexico (Ojo de Liebre Lagoon)	1999	Stranding	De Luna & Rosales-Hoz, 2004
E. robustus	kidney	30*[k]	NR	NR	2[l]	Mexico (Ojo de Liebre Lagoon)	1999	Stranding	De Luna & Rosales-Hoz, 2004
E. robustus	muscle	15*[k]	NR	NR	2[l]	Mexico (Ojo de Liebre Lagoon)	1999	Stranding	De Luna & Rosales-Hoz, 2004
E. robustus	muscle	22*[k]	NR	NR	3[g]	Mexico (Ojo de Liebre Lagoon)	1999	Stranding	De Luna & Rosales-Hoz, 2004
E. robustus	muscle	18*[k]	NR	NR	3[m]	Mexico (Ojo de Liebre Lagoon)	1999	Stranding	De Luna & Rosales-Hoz, 2004
E. robustus	blubber	1.06*	0.33	1.78	5[g]	Mexico (Sinaloa & Baja California Sur)	1999	Stranding	Mendez et al., 2002
E. robustus	heart	2.31*	1.28	3.4	7[g]	Mexico (Sinaloa & Baja California Sur)	1999	Stranding	Mendez et al., 2002
E. robustus	kidney	2.09*	0.34	6.12	5[g]	Mexico (Sinaloa & Baja California Sur)	1999	Stranding	Mendez et al., 2002
E. robustus	liver	2.06*	0.78	3.62	5[g]	Mexico (Sinaloa & Baja California Sur)	1999	Stranding	Mendez et al., 2002
E. robustus	lung	1.21*	0.36	4.40	7[g]	Mexico (Sinaloa & Baja California Sur)	1999	Stranding	Mendez et al., 2002
E. robustus	muscle	1.11*	0.42	1.8	5[g]	Mexico (Sinaloa & Baja California Sur)	1999	Stranding	Mendez et al., 2002
E. robustus	kidney	0.6*	0.3[j]	NR	4	Mexico (Gulf of California)	1999	Stranding	Ruelas-Inzunza & Paez-Osuna, 2002
E. robustus	liver	0.9*	0.8[j]	0.9	4	Mexico (Gulf of California)	1999	Stranding	Ruelas-Inzunza & Paez-Osuna, 2002
E. robustus	muscle	0.6*	0.4[j]	NR	4	Mexico (Gulf of California)	1999	Stranding	Ruelas-Inzunza & Paez-Osuna, 2002

Lead (Pb) (continued)									
Species	**Tissue**	**Mean ug/g**	**Min.**	**Max.**	**n**	**Location**	**Date Sampled**	**Event**	**Reference**
E. robustus	brain	0.014	0.003[h]	NR	6[g]	Russia (NW Bering Sea)	1994	Subsistence harvest	Tilbury et al., 2002
E. robustus	kidney	0.028	0.005[h]	NR	6[g]	Russia (NW Bering Sea)	1994	Subsistence harvest	Tilbury et al., 2002
E. robustus	liver	0.06	0.013[h]	NR	5[g]	Russia (NW Bering Sea)	1994	Subsistence harvest	Tilbury et al., 2002
E. robustus	brain	0.06	0.06	0.06	1	CA, WA & AK	1988-91	Stranding	Varanasi et al., 1994
E. robustus	kidney	0.053	ND	0.10	10	CA, WA & AK	1988-91	Stranding	Varanasi et al., 1994
E. robustus	liver	0.12	0.02	0.27	10	CA, WA & AK	1988-91	Stranding	Varanasi et al., 1994
T. truncatus	liver	<0.10	NR	NR	34	SC	NR	Stranding	Beck et al., 1997
T. truncatus	liver	0.45	0.08	1.47	5[o]	TX & AL (Gulf of Mexico)	1990	Stranding	Kuehl & Haebler, 1995
T. truncatus	liver	0.26	0.04	0.88	5[g]	TX & AL (Gulf of Mexico)	1990	Stranding	Kuehl & Haebler, 1995
T. truncatus	liver	0.68	0.2	2.12	9[p]	TX & AL (Gulf of Mexico)	1990	Stranding	Kuehl & Haebler, 1995
T. truncatus	liver	0.48	0.09	1.20	5[q]	TX & AL (Gulf of Mexico)	1990	Stranding	Kuehl & Haebler, 1995
T. truncatus	kidney	0.17*	ND	1.6	30 (11 ND)	TX	1991-92	Stranding	Meador et al., 1999[c,d]
T. truncatus	kidney	0.08*	ND	0.14	13 (11 ND)	FL	1991-92	Stranding	Meador et al., 1999[c,d]
T. truncatus	liver	0.3*	ND	2.6	30 (11 ND)	TX	1991-92	Stranding	Meador et al., 1999[c,d]
T. truncatus	liver	0.09*	ND	0.2	13 (10 ND)	FL	1991-92	Stranding	Meador et al., 1999[c,d]
M. angustirostris	blood	0.13[n]	0.071[n]	0.21[n]	4[o]	CA	1994-95	live animal collection	Owen & Flegal, 1998

Tin (Sn)

Species	Tissue	Mean ug/g	Min.	Max.	n	Location	Date Sampled	Event	Reference
E. robustus	kidney	0.04[r]	ND	0.05	7	CA, WA & AK	1988-91	Stranding	Varanasi et al., 1994
E. robustus	liver	0.04[r]	ND	0.04	7	CA, WA & AK	1988-91	Stranding	Varanasi et al., 1994
K. breviceps	kidney	0.062[e]	0.059	0.065	2	FL	1989-94	Stranding	Kannan et al., 1997
K. breviceps	liver	0.39[e]	0.35	0.41	3	FL	1989-94	Stranding	Kannan et al., 1997
K. breviceps	muscle	0.021[e]	0.016	0.026	2	FL	1989-94	Stranding	Kannan et al., 1997
S. bredanensis	kidney	0.053[r]	0.01	0.14	15	FL (Gulf of Mexico)	1997	Stranding	Mackey et al., 2003
S. bredanensis	liver	5.4[r]	3.8	7.3	15	FL (Gulf of Mexico)	1997	Stranding	Mackey et al., 2003
T. truncatus	blubber	0.63[e]	0.63	0.63	1	FL	1989-94	Stranding	Kannan et al., 1997
T. truncatus	brain	0.11[e]	0.11	0.11	1	FL	1989-94	Stranding	Kannan et al., 1997
T. truncatus	heart	0.05[e]	0.05	0.05	1	FL	1989-94	Stranding	Kannan et al., 1997
T. truncatus	kidney	0.20[e]	0.025	0.67	16	FL	1989-94	Stranding	Kannan et al., 1997
T. truncatus	liver	1.4[e]	0.11	11.34	17	FL	1989-94	Stranding	Kannan et al., 1997
T. truncatus	melon	0.19[e]	0.19	0.19	1	FL	1989-94	Stranding	Kannan et al., 1997
T. truncatus	muscle	0.041[e]	0.013	0.11	11	FL	1989-94	Stranding	Kannan et al., 1997
M. augustirostris	liver	0.08[e]	0.06	0.099	2[f]	CA	1991-94	Stranding	Kajiwara et al., 2001
P. vitulina	liver	0.034[e]	0.002	0.091	6[f]	CA	1991-97	Stranding	Kajiwara et al., 2001
Z. californianus	liver	0.045[e]	0.024	0.087	10[f]	CA	1991-97	Stranding	Kajiwara et al., 2001

Abbreviations: ND, the analyte was not detected above the limit of detection; NR, not reported

*dry weight

[a]Total Hg

[b]Organic (i.e., methyl) Hg

[c]Mean ratios of dry to wet weight were 0.26 and 0.22 for TX liver and kidney, respectively (n=31), and 0.29 (n=14) and 0.23 (n=13) for FL liver and kidney, respectively.

[d]Means for analytes with data below detection limits (ND) were determined with maximum likelihood method for censored data. Means with no ND values were estimated following the procedure of Gilbert (1987) for lognormally-distributed data.

[e]Sum of butyltins, including mono-, di- and tri-butyltin

[f]Data for individual animals and organotins given in cited source.

[g]Juveniles

[h]Standard error of the mean
[i]For values below the limit of detection (LOD), one-half the LOD was used to calculate the mean

[j]Standard deviation

[k]Value extrapolated from graph

[l]Calves

[m]Adults (both sexes)

[n]ug/dl
[o]sucklings (live, for Owen & Flegal, 1998; stranded, for Kuehl & Haebler, 1995)

[p]Adult males

[q]Adult females

[r]Total Sn

Euthanasia Questionnaire Response Summary

Responder	Species	Stranding Type*	Frequency (or #) of Euthanasia in past year	Euthanasia Agent & Route	Induction Agent & Route	Adverse Reactions?	Disposal Methods	Comments
MarMamCenter, CA	*Zalophus californianus* *Mirounga angustirostrus* *Phoca vitulina*	I	96/796	pentobarb IV, IC	tiletamine/zolazepam IM	No	Renderer	no disposal problems
HBOI, FL	*Tursiops truncatus* *Kogia breviceps* *Kogia simus*	I	4	pentobarb +- phenytoin IC, IP	---	No	Beach burial Landfill	no disposal problems
Nat'l Aquarium, MD	*Phoca vitulina* *Pagophilus groenlandicus* *Tursiops truncatus* *Phocoena phocoena*	I	1 in 2003 avg. 1.9/yr (11 yrs)	pentobarb.+ phenytoin	tiletamine/zolazepam diazepam	Yes - lack of sedation	not indicated	generally not problematic
C. Harms, NCSU	*Tursiops truncatus* *Kogia breviceps* *Kogia simus* *Grampus griseus*	I	done 3-4	pentobarb +- phenytoin IV, IC	xylazine, acepromazine	Yes - hyperexcitability in G. gri. with xylazine or metomidate	Beach burial (if drugs admin.) disposal at sea (no drugs)	no disposal problems
W. McFee, NOS, SC	*Kogia breviceps* *Kogia simus* *Ziphius cavirostris*	I, P	~60% 1 in past yr.	pentobarb IV, IC	---	Yes - excitability in K. bre.	Burial	no disposal problems
Mote Mar Lab, FL	*Tursiops truncatus* *Kogia breviceps* *Kogia simus* *Globicephala macrorhynchus* *Lagenodelphis hosei*	I, M (Kogia & Glob.)	1-3/yr.	pentobarb. IV	xylazine	No	not indicated	Disposal problematic, did not elaborate
Cape Cod SN, MA	*Lagenorhynchus acutus* *Phocoena phocoena* *Delphinus delphis* *Globicephala melas*	I, M	179/403 over 5 yr period	pentobarb.+- phenytoin	---	Yes - hyperexcitability in cetaceans (T. tru., L. acu., D. del., G. mel.)	truck off Cape to landfill tow to sea & sink	Disposal very problematic, no rendering service avail., landfill won't accept, perception that whale remains contain contaminants, high cost
VA Marine Sc. Museum, VA	*Phoca vitulina* *Delphinus delphis* *Kogia breviceps*	I	7 in 2003	pentob. +- phenytoin	xylazine diazepam	Yes, Observed violent death throes in D. delphis w/ or w/o induction agent, and appeared to have violent rx to acepromazine also, slight excitability in Grampus w/ xylazine	commercial carcass dispo. co. to transport to landfill burial landfill	Difficulty procuring heavy eqp't.

Euthanasia Questionnaire Response Summary

Responder	Species	Stranding Type*	Frequency (or #) of Euthanasia in past year	Euthanasia Agent & Route	Induction Agent & Route	Adverse Reactions?	Disposal Methods	Comments
Litz, NOAA Fisheries SER, Southeast US, PR & Virgin Is	*Tursiops truncatus* *Kogia spp.* *Steno bredanensis* *Globicephala spp.*	I, P, M	68/474 from 1995-2000 (may be more-do not keep these stats.)	pentobarb. IV, IC	---	---	landfill	Disposal very problematic in mass strandings or with large cetaceans
George, GA DNR	*Feresa attenuata* *Kogia breviceps*		5 Kogia breviceps (3 adults/2 calves) 1 Feresa attenuata in 2004	Euthasol (390mg/mL) Gunshot	Xylazine (100mg/mL)	Yes- "Convulsions" prior to death seen with xylazine alone	left on beach buried on site landfill	Disposal in remote areas where removal of the carcass isn't possible precluding use of barbituates for euthanasia due to relay toxicosis concerns.

*I = individuals
P = pairs
M = mass