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SESSION SUMMARY REPORT

PERSISTENT ORGANIC POLLUTANTS (POPs) IN MARINE MAMMALS: LEVELS AND EFFECTS

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Marine mammals occupy a high trophic level and accumulate high body burdens of persistent organic pollutants (POPs) through placental and lactational transfer as well as through feeding over a long life span. Because they bioaccumulate high levels of POPs and thereby integrate contaminant information in the environment, marine mammals provide a "real world" exposure scenario and an early warning signal about chemicals which present the greatest risk to consumers at the top of the food chain, including humans. This special session focuses on the bioaccumulation of POPs in marine mammals and examines toxicological effects resulting from the accumulation of these compounds as well as exposure pathways, body burdens and trends. The session is comprised of 9 presentations by experts from six (6) countries including Australia, Finland, Italy, Japan, Russia, and the United States.

Marine mammals in many parts of the world carry a plethora of POPs in their tissues including polychlorinated biphenyls (PCBs), dioxins and furans (PCDD/Fs), and chlorinated pesticides (DDT, chlordane, toxaphene) as well as compounds of emerging interest such as the brominated flame retardants (PBDEs), perfluorinated compounds, and polychlorinated naphthalenes. Over the past three decades, elevated concentrations of endocrine-disrupting compounds have been linked with a number of deleterious effects in marine mammals including hormonal abnormalities, skeletal deformities, and reproductive failure, while immunotoxic POPs are widely suspected to have played a role in the viral epizootics that have decimated several populations since the 1980s. Despite a large body of circumstantial evidence, identification of cause and effect relationships between these concentrations and observed health impacts remains a challenging and complicated task. Addressing these concerns, **Fossi et. al**. applied biomarkers of exposure and susceptibility to the effects of endocrine-disrupting contaminants (EDCs) using non-lethal samples (skin biopsies) in four species of Mediterannean cetaceans. They found correlations between DDTs and PCBs and CYP1A1 activity in striped dolphins and common dolphins, and suggested that CYP1A1 induction in skin may be a useful non-lethal marker of exposure to EDCs in cetaceans. To explore interspecies susceptibility, the study measured the induction of target proteins CYP450 1A1-1A2, CYP450 2B4 and the estrogen receptor (ER) in cetacean fibroblast cell cultures treated with EDCs, and found higher induction responses in striped dolphins than in common dolphins. **Routti et.al**. investigated differential POP loads in Baltic ringed and gray seals and their diet, and looked at the utility of using vitamins as potential biomarkers of contaminant levels and effects. They found that ringed seals ingest more PCB and DDT compounds than grey seals, which accounted for their elevated tissue burdens. In both species, DDTs

were the predominant POP. Lower levels of hepatic vitamin A were found in the Baltic seals than in seal reference populations, but a possible effect of POPs on stored vitamin A dynamics was not clear. Higher blubber levels of vitamin E were found in Baltic seals than in the reference populations, and it was speculated that this could result from an increased requirement, and thus increased ingestion, of vitamin E for protection against a POP-induced oxidative response.

Because of their high trophic position and widespread distribution, marine mammals are valuable sentinel species for POP contamination, providing insights into possible sources, transport pathways and the distribution of POPs on a global scale. Our knowledge of the fate of POPs is continuously expanding by looking for new chemicals in tissues of marine mammals and their prey, studying temporal trends and examining contaminants in a variety of species collected from locations around the world. **Amirova et.al**. presented results of the Arctic Monitoring and Assessment Program (AMAP) project, focusing on recent studies of dioxin-like PCBs and PCDD/Fs in tissues of marine mammals from the Russian Arctic. PCBs and PCDD/Fs were highest in blubber followed by liver> kidney>muscle tissues. Species variability in bioaccumulation was evidenced by the higher ratios of dioxin-like PCBs/PCDD/Fs in ringed seals and bearded seals compared with lower ratios in gray whale and walruses. A study by **Gaus et.al.** aimed to establish baseline information on PCDD/F accumulation by the only strictly herbivorous marine mammal, the dugong, from Queensland, Australia, and to determine potential exposure pathways and associated health risks. Their results suggested that exposure of dugongs to PCDD/Fs is related to the local contaminant concentrations in their inshore seagrass habitats, which in turn is governed by terrestrial runoff and sediment transport within river plumes in Queensland. ∑PCDD/F and the TEQ of ∑PCDD/F in dugongs were surprisingly high compared to those reported in marine mammals elsewhere, while in contrast, the contribution of PCBs to the TEQ was relatively low. Using a probabilistic calculation of intake rates and compared to the LOAELs at which physiological effects have been observed in other mammals, the study suggests that up to 21% of the population may be at risk for toxic effects of PCDD/Fs. **Maruya et. al**. examined PCBs (Aroclor 1268) and toxaphene in the fish prey (croakers, mullet, and perch) of bottlenose dolphins in estuaries along the Georgia-Florida Atlantic coastline, USA. They found significantly higher levels of PCBs in fish from the Turtle/Brunswick (TB) River estuary, where several industrial USEPA Superfund sites were located, including two that emitted PCBs (as Aroclor 1268) and toxaphene. Using a simple dietary exposure model, the predicted accumulation level of PCBs (22 µg/g) suggested that organochlorines may pose a health risk to resident TB bottlenose dolphins. **Imanishi et.al**. presented results of the first comprehensive study of toxaphene and mirex in cetaceans from Asia-Pacific waters including Japan where these chemicals have never been registered. They found higher levels in specimens from Japan than in cetaceans from other regions where toxaphene had been used. They also found higher levels in offshore species compared with coastal species, suggesting long-range atmospheric transport of toxaphene from high-use regions such as the former Soviet Union, Southeast Asia, and the United States to the Japan Sea. In contrast, mirex (the least transportable POP) was detected at lower concentrations in cetaceans from Japan compared with cetaceans from surrounding regions where it was used including Hong Kong, Brazil, India, and the Philippines. **Kajiwara et.al.** examined the pattern of contamination by dioxin-related compounds including non- and mono-*ortho* coplanar PCBs and PCDD/Fs in cetaceans from Japanese coastal waters during 1998-2001. The study found higher contaminant loads in blubber of coastal species than in cetaceans that migrate along the Pacific coast, and suggested that uncontrolled, low-temperature burning of wastes in dumping sites in China and Southeast Asia are likely sources of PCDD/Fs in the Japan Sea. While PCDD concentrations were higher in coastal cetaceans and PCDFs were higher in offshore cetaceans, coplanar PCBs were detected at much higher levels in all samples analyzed, from 4,000 to 15,000 times higher than PCDD/Fs, and thus represent the greatest toxic

risk for cetaceans around Japan. **Shaw et.al.** reported results of the first comprehensive analysis of organohalogen compounds in harbor seals inhabiting the northwestern Atlantic coast, USA. PCBs, DDTs, and chlordanes were detected in seal blubber at surprisingly high concentration ranges, similar to ranges reported in seals from polluted areas of Europe; their mean PCB burdens were two-fold higher than the estimated threshold level for adverse effects including effects on immune function in the species. Comparisons at three time points suggested that declines in PCB concentrations in northwestern Atlantic coast harbor seals may have leveled off in the 1980s, possibly reflecting continued cycling of PCBs in the ecosystem. In view of the past susceptibility of these seals to viral epizootics, the study suggests that current levels of POP contamination may pose a health risk to the population.

Elevated levels of POPs found in marine mammals inhabiting industrial coastal regions often signal the existence of a regional contamination problem; however, interlaboratory differences in analytical techniques can make it difficult to compare data between regions, or over time. Addressing this issue, a paper by **Kucklick** summarized results of the NIST/NOAA interlaboratory comparison exercise program which was initiated in 1991 using marine mammal blubber. In the exercise, laboratories are requested to perform analyses on an unknown sample and a control or reference material (SRM 1945, frozen, cryohomogenized pilot whale blubber) that has been certified for concentrations of target analytes. The exercise, which expanded from less than 10 participating laboratories in 1991 to 24 laboratories in 2003, has been an important source of new data on SRM 1945 and an important means of comparing data on compounds of emerging interests.

Overall, this session provided an overview of established and emerging research initiatives that help to elucidate the accumulation, possible sources, and metabolic fate as well as the potential health effects of POPs in marine mammals.