

A Shared Fate

Toxic chemicals in the oceans and their impact on the health of humans and marine mammals



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INTRODUCTION

The growing presence of toxic chemicals in the marine environment presents a crisis unlike any ever faced on this planet. Vast quantities of toxic chemicals enter the waterways and oceans of the world each day and accumulate then bio-magnify in the marine food chain. In a time when we have reduced the number of large pelagic fish by ninety percent and the bio-mass of the oceans by seventy percent, we are poisoning much of the living marine resources that remain. This has staggering global implications for ocean life and human health.

A level of 100 ppm of mercury has been found in a bottlenose dolphin killed for food in Japan – a level more than 100 times that accepted by Japanese health authorities

There are many ways by which humans absorb, ingest or inhale dangerous chemicals. We intend to show in this report that fish, contaminated by organochlorines and heavy metals, are a newly recognized delivery system for chemicals which may cause a range of negative impacts on human health, including cancer, suppressed immune function and endocrine disruption which affects fertility.

Dolphins, toothed whales, large tuna and swordfish are among the marine creatures with highest levels of contamination because they feed at the apex of the food chain.

This report will document many, but by no means all, the locations where chemical toxicants have been found in marine mammals. Marine

mammals feed at the top of the ocean food chain and thus are sentinels of the health of the waters in which they swim. Because humans eat many of the same fish as marine mammals we are well advised to be aware of the plight of marine mammals around the world. We are only one step removed from them only because we eat fewer fish than they.

Those eating marine mammals are leveraging the concentrations of toxins they ingest – a top predator (human) eating another top predator (a dolphin). We document the levels of contaminants in dolphins killed and eaten at Taiji, Japan. This is among the last of the villages where dolphins are hunted and where the meat is commonly eaten. We find that to have to use evidence of contamination levels in dolphins as a way of ending one of the most barbaric hunts of wild animals on earth to be tragically ironic.

One dolphin eater at Taiji was found to have more than 30 ppm of mercury in his body. A medical specialist advised that he be hospitalized immediately.

Though industrialized nations banned many persistent organic pollutants (POPs) three decades ago, their persistence plagues marine mammals and, increasingly, human beings worldwide. Today overwhelming evidence indicates that heavy metals such as mercury and persistent organic pollutants such as polychlorinated biphenyls (PCBs), dioxins and more recently PBDEs (flame retardants) have an adverse impact on reproductive health, immune and endocrine

function and are carcinogenic for marine mammals and human beings.

Carcinogens are present in the environment of the St. Lawrence Estuary Belugas. Sediments of the Saginaw River, part of Beluga habitat, contain 500 – 4500 ppb of total PAHs dry weight.

Scientists have been finding higher and higher levels of man-made chemicals in marine mammals. In recent years marine mammals have been victims of mass mortalities and alarming population declines. These events have caused marine mammal science to expand their studies of the impact of chemically induced immune suppression, which is emerging as a contributing factor in epizootic events, condemning marine mammals to death from viral agents that are common in the environment and normally harmless.

During the late winters of 2007 and 2008 in two separate Unusual Mortality Events (UME) more than two hundred bottlenose dolphins washed ashore near Galveston, Texas. The cause of this UME is as yet unknown.

In a report that stunned many, the February 2008 issue of Science reported, “The impact of humans has now reached every square mile of earth’s oceans and strongly impacted 40% of marine ecosystems. The implications are ominous for ocean creatures and humans alike. “

Some 100,000 synthetic chemicals are in use today around the world with another 1,000 being introduced into the environment each year. More than 90% have never been tested for their effects on human health. There is abundant evidence that many of these chemicals have serious, even deadly impacts on wildlife and humans.

Chemicals enter the marine environment in many ways – fertilizer run off and use of pesticides in agriculture and home gardening and maintenance; industrial waste, dumping and airborne emissions, even chemicals such as flame retardants used in everyday products are carried around the globe by wind and ocean currents.

San Francisco Bay harbor seals have some of the highest levels of PBDEs ever recorded. A doubling time of 1.8 years was reported in blubber of harbor seals from San Francisco Bay between 1989 – 1998.

The contaminants in our waters are not limited to heavy metals and organochlorines. When drinking water for some 41-million Americans was tested by the Associated Press during 2007, pharmaceuticals were found in alarming quantities. Those reported include antibiotics, mood stabilizers and six hormones. Tests were conducted in the nation’s 50 largest cities and smaller water providers in all 50 states.

A major focus of BlueVoice.org's work is to identify the locations in which marine mammals have displayed high levels of toxic chemicals or been victims of anomalous mortality events. In many of these areas, we see human cancer clusters. We are collaborating with experts in human medicine to identify correlates between contamination in marine mammals and diseases, including cancers, in humans.

Scientists working at Texas A & M have found that the dolphin genome and the human genome as "basically the same."

Dr. Gregory Bossart of the Harbor Branch Research Institute and his colleagues have found orogenital neoplasia in Atlantic bottlenose dolphins in Florida. Lingual papillomas and squamous cell carcinoma and genital papillomas have also been found in Indian River dolphins.

It is important to remember that clean fish are an important component of a healthy diet, providing Omega 3 fatty acids and many other benefits. But that is ONLY TRUE if the fish are relatively free of contamination. While fish with high levels of Omega 3 fatty acids are regarded as heart healthy, they are not so when they contain high levels of mercury which disrupts the nervous system's control of the heart. They then become a serious detriment to the hearts of both humans and marine mammals.

In the spring of 1987 bottlenose dolphins began washing up on the coast of New Jersey. This enormous and highly alarming die-off of hundreds – perhaps thousands of dolphins – has never been satisfactorily explained.

The Center for Disease Control and Prevention conducts a large, ongoing survey that has found 148 chemicals in Americans of all ages, including lead, mercury, dioxins and PCBs.

Other scientists have detected antibacterial agents from liquid soaps in breast milk, infants' cord blood and the urine of young girls. Estrogen excreted by women taking birth control pills has proven to alter the sex of fish. In 2005, the Environmental Working group found an average of 200 chemicals in the cord blood of 10 newborns, including carcinogens and neurotoxins.

Chemicals such as PCBs can be virtually undetectable in water but magnify exponentially up the food chain so that a top predator may have 25-million times the concentrations found in the water it lives in. These toxicants are lipophilic and concentrate in the fatty tissues of mammals.

Chemicals present in many pesticides, petroleum products, plastics, and products such as furniture, computers and baby's clothing can disrupt the endocrinal or hormonal systems of mammals. These chemicals are known as xenoestrogens because they mimic the action of naturally produced estrogens.

Examples of hermaphroditism have been found in fish in the U.K. in Polar bears in Svalbard and alligators with diminutive penises have been reported in Florida.

Man-made chemical pollutants have now made their way into the deep-sea food web contaminating squids and octopods. These species are food for many deep-diving toothed whales and dolphins as well as other predators.

In a study to be published in the journal Marine Pollution Bulletin, Michael Vecchione of NOAA Fisheries' National Systematics Laboratory et al report finding chemical contaminants in nine species of cephalopods.

"It was surprising to find measurable and sometimes high amounts of toxic pollutants in such a deep and remote environment," Vecchione said. Among the chemicals detected were tributyltin (TBT), polychlorinated biphenyls (PCBs), brominated diphenyl ethers (BDEs), and dichlorodiphenyl-trichloroethane (DDT).

Cephalopods are the primary food for 28 species of odontocetes, the sub-order of cetaceans that have teeth and include beaked, sperm, killer and beluga whales and narwhals as well as dolphins and porpoises

This report is part of an effort at prevention of cancers such as multiple myeloma and other B cell lymphomas – cancers that have been clearly proven to be caused by exposure to toxic chemicals. To date prevention of cancer has largely been ignored in favor of treatment.

We call on government to address the introduction of toxic chemicals into our environment in a manner diametrically opposite to the way we now do it.

At this time there is virtually no requirement for testing of chemicals before they are put into use. If public policy operated under a precautionary principle then any indication of harm, rather than retroactive proof of harm, would trigger regulatory action. Today chemicals can be put into the air, waterways, baby clothing and thus into the bloodstreams of all living creatures without prior proof that they are safe.

We make no pretense that the information in this document is exhaustive. Indeed it is merely suggestive of the dreadful crisis we face from heavy metal and organochlorine contamination of the environment. We invite additions, and if necessary, correction to this report.

Toxins in Marine Mammals An Impending Global Catastrophe

This paper documents some of the locations in which marine mammals have displayed high levels of toxic chemicals or been victims of disease or unusual mortality events. It is clear from both the severity and frequency of such events that marine mammals worldwide face major threats to their health and in some populations decline or extinction.

In addition to concern for the marine mammals and health of the oceans we are increasingly aware of the adverse impact high levels of toxins in the oceans are having on human populations, including mercury poisoning, endocrine disruption and cancer. We have launched a research project to identify areas around the world where marine mammals show high toxic levels in proximity to human populations that eat the same fish as those marine mammals.

We are collaborating with cancer specialists to identify correlations between contamination levels in marine mammals and cancers in humans who eat fish from the same area.

This is by no means a complete listing of relevant locations and events and we invite contributions to it.

CALIFORNIA

San Francisco Bay harbor seals have high levels of Polybrominated diphenyl ethers (PBDEs) – flame retardants. A doubling time of 1.8 years was reported in blubber of harbor seals from SFB between 1989 – 1998.

Jianwen She et al, of the Hazardous Materials Laboratory, California Department of Toxic Substances Control in 2002 analyzed samples from 11 archived harbor seals (*Phoca vitulina richardsi*) from the San Francisco Bay and breast adipose tissue samples from 23 women. The levels of PBDEs in human tissue samples were in the low ng/g fat range, with PBDEs 47, 153, 154, 99, and 100 as the major congeners. Average Σ PBDEs (86 ng/g fat) in these California women are the **highest human levels reported to date**. The PBDEs measured in harbor seal blubber were the same major congeners as those measured in the human tissues. PBDE 47 was the highest among all congeners measured in both human tissue and seal blubber samples. The concentrations of PBDEs in harbor seals in the San Francisco Bay have increased dramatically over the past decade, with current levels among the highest reported for this species.

Harbor seals can be used to identify regional contamination hotspots.

In California Sea Lions high levels of DDTs and polychlorinated biphenyls (PCBs) in blubber have been associated with cancer and reproductive failure. Substantial organochlorine (OC) burdens, especially DDTs, are transferred from female sea lions to their fetuses in *utero*.

Urogenital cancer is endemic in California sea lions (CSL). A gamma herpes virus has been identified in 100% of urogenital carcinomas in three different studies. There is a statistical association of cancer in females and the presence of beta hemolytic *Streptococcus*. There is a statistical association between contaminants, particularly PCBs, and urogenital cancer incidence. Urogenital carcinomas in CSLs may involve interaction between a venereal herpes virus, bacterial flora and POPs.

Salmonella bacteria causes diarrhea in animals and humans. A number of fecal pathogens have been identified in California marine mammals. Salmonella prevalence averages 4% in sea lions, harbor seals. Elephant seals and sea otters, as well as many bird species. Marine Mammal Salmonella, Miller et al.

Harmful Algal Blooms (HABs)
There is strong evidence that marine mammal strandings along the coast of California are caused by harmful algal blooms. One of the main culprits is domoic acid poisoning. Domoic acid is a powerful neurotoxin produced by a single-celled algae of the genus *Pseudo-nitzschia*. It accumulates in shellfish and fish that feed on the algae, such as anchovies and sardines.

Marine biotoxins resulting from HABs have been shown to be lethal to dolphins and other marine mammals that have ingested contaminated fish. HABs often involve brevetoxin, a neurotoxin produced by some species of dinoflagellate such as, *Karenia brevis* and *Ptychodiscus brevis*. Brevetoxin is associated with a growing number of 'red tide' events around the world.

In 1998, the first confirmed domoic acid poisoning of marine mammals occurred on the California coast. During a month long period, 70 California sea lions stranded along the central California coast near San Luis Obispo – all suffered from the clinical symptoms of the poisoning, which include head weaving, tremors and convulsions. The majority of the affected animals were adult females of which 50 percent were pregnant. No adult males were affected. Two years later a similar outbreak occurred in the same region when 187 sea lions stranded with the poisoning. More than half of the sea lions affected with domoic acid poisoning died in both instances.

The origin of the domoic acid responsible for this mortality event was a bloom of *P. australis* that developed in Monterey Bay in May of 1998. Anchovies collected during the peak of the bloom had high levels of domoic acid in their tissues. "California sea lions are high level predators, feeding on species that often enter the human seafood market such as anchovies, sardines, salmon and squid," said Dr. Frances Gulland of the California Marine Mammal Center.

“These sub-lethal effects of domoic acid on California sea lions are likely to be similar to effects that could occur in humans if they were to be exposed to similar levels of this toxin by eating contaminated seafood.” – Dr. Frances Gulland

The Marine Mammal Center in Sausalito, California has been one of the leading organizations tracking the strandings of Sea Lions and aiding in their recovery and re-introduction to the wild.

Outbreaks continued in southern and central California waters with nearly 1,000 sea lions affected in 2005.

In 2007 blooms of algae which produce the neurotoxin domoic acid, first appeared in southern California early in the spring and then moved north along the Central Coast. Hundreds of seabirds and marine mammals died.

The domoic acid levels in Southern California have been even higher than those detected in Monterey Bay. Large numbers of marine animals have been affected, including dolphins.

In humans, consumption of seafood contaminated with the toxin causes amnesic shellfish poisoning.

1987-88 EAST COAST OF USA
Beginning in the spring of 1987 bottlenose dolphins began washing up on the coast of New Jersey. This enormous and highly alarming die-off of hundreds of dolphins (in reality the number of deceased dolphins is certainly vastly higher than the number of stranded

dolphins would indicate. Many dolphins were lost at sea and never counted). The strandings progressed from New Jersey south along the Atlantic seaboard finally ending near Cape Canaveral, Florida in early 1988. By one estimate at least 2,500 dolphins were lost. Alarming high levels of contaminants were found in many of the stranded dolphins. After months of study an expert contracted by the US government concluded that the die-off was the result of red tide generated brevetoxin. Many scientists, pointing to the high levels of toxins in many of the dolphins necropsied, disputed this conclusion vigorously and called that finding a cover up.

FLORIDA

Sarasota Bay. Trace elements of methylmercury have been found in bottlenose dolphins in this body of water. High brominated flame retardant (BFRs) concentrations have been detected in dolphins near urban Sarasota Bay and rural St. Joe Bay in the Florida panhandle. The presence of BFRs in all dolphin samples indicates contamination is wide spread.

Dr. Randy Wells is quoted in National Geographic Online as saying that although dolphin numbers in these waters have risen slightly over the last few decades, scientists are trying to understand why so many firstborn calves die: Less than a quarter live out their first year, compared with 70 to 80 percent of subsequent births.

One reason may be man-made pollutants and the transfer of chemical contaminants to calves through milk, according to Wells, a conservation biologist with the Chicago Zoological Society and

director of the Mote Marine Laboratory for Marine Mammal and Sea Turtle Research in Sarasota. Since 1970, Wells has led the world's longest-running dolphin study.

Some dolphins in the Sarasota Bay area have pollutant levels among the highest ever recorded, according to Wells.

East Coast Florida through South Carolina. Several unusual mortality events have occurred in recent years increasing concern for the health of bottlenose dolphins along the east coast of the United States. The heavy metals Aluminium, Chromium, Manganese, Copper, Zinc, Arsenic, Selenium, Strontium, Rubidium, Molybdenm and Vanadium were all discovered in the tissues of dolphins. Levels in blood and skin are above levels thought to be harmful to health.

Indian River, Florida

Dr. Gregory Bossart of the Harbor Branch Research Institute and his colleagues have been studying dolphins and the ecology of the Indian River Lagoon (IRL) for nearly two decades. He has found orogenital neoplasia in Atlantic bottlenose dolphins. Lingual papillomas and squamous cell carcinoma and genital papillomas have also been found in dolphins of this body of water. Bossart's may be the first report of genital papillomas in free ranging bottlenose dolphins from Atlantic coastal waters.

Comprehensive health examinations were conducted from 2003 – 2004 on 155 bottlenose dolphins during capture-release in the IRL and Charleston, SC (CHS). Some 30% of IRL dolphins had infectious diseases such as lobomycosis according to Dr. Bossart. Mucocutaneous

neoplasia associated with novel papilloma and herpes viruses were documented in both populations.

The St. Lucie River which flows into the IRL carries significant quantities of agricultural runoff.

Necropsy and photo identification data on IRL bottlenose dolphins have shown a high prevalence of infectious and inflammatory diseases of the skin and other organs.

Mitchum and Bossart et al have compared OC pesticides, PCBs, PBDEs and polycyclic aromatic hydrocarbons (PAHs) levels in dolphins from the IRL and Charleston, SC (CHS). Mean concentrations of PCBs were similar in the two locations, highest in male dolphins and lowest in females of reproductive age. Total DDT was higher for CHS dolphins compared to IRL dolphins. CHS dolphins had higher PBDEs. The males had among the highest levels of this chemical ever found in marine mammals.

In an abstract entitled Lobomycosis in Atlantic Bottlenose Dolphins from Indian River Lagoon, Florida, Reif et al report the presence of lobomycosis, a mycotic infection caused by a yeast-like organism, among bottlenose dolphins. The prevalence among the dolphins tested from the southern part of the IRL was 30%. "We report the emergence of a rare fungal disease in Florida bottlenose dolphins in epidemic proportions. Humans are also susceptible to *Lacazia loboi*, a yeast-like organism." The report went on to say that environmental stressors may contribute to the

unusually high prevalence of the disease.

According to Dr. Greg Bossart, there is dolphin pox virus in the Indian River Lagoon. This doesn't hurt the animal but points to pathological stress. 100% of IRL dolphins had pox versus the usual 2% found in dolphins in other locations.

Florida Panhandle

In 1999 and 2004 there were two unusual mortality events that took the lives of 227 dolphins in the area of St. Joseph's Bay. The average number of dolphins that strand along the panhandle per year is eight.

More than 103 dolphins died in St. Joseph's Bay and the surrounding area in Florida beginning March 10, 2004. NOAA Fisheries declared an Unusual Mortality Event for the panhandle on March 17. Several forms of algae were found in the surrounding waters. In addition, preliminary results showed domoic acid (a biotoxin produced by *Pseudo-nitzschia*) and brevetoxin (a biotoxin produced by *Karenia brevis*) in samples taken from the dolphins.

Dolphin carcasses that were located (many were not) had been dead for an extended period prior to recovery making tests for cause of death difficult. Preliminary results on dolphin tissues from the initial event indicated the following:

Florida Marine Research Institute (FMRI) scientists detected high concentrations of brevetoxin in dolphin tissues (stomach, liver, kidney, lung, cerebellum) and fluids (blood, urine); the highest

concentrations of brevetoxins were found in the animals' stomachs.

The time period for the Unusual Mortality Event (March – April) corresponds to the timing of similar mortality events in Texas.

Immune panels suggest a high level of parasitic infection and/or compromised immune response in the St. Joseph Bay population of bottlenose dolphins.

Florida, general

The EPA has listed 16 polycyclic aromatic hydrocarbons (PAHs) as priority pollutants because of their carcinogenic effects on aquatic organisms. PAHs have been found around electricity generating plants and in ports in Florida.

Recently manatees have shown symptoms characteristic of PAH accumulation: e.g. impaired immune response, prolonged healing times, and eye pathology.

CHARLESTON, SC (CHS) (See Indian River, Florida for paired studies)

CHS dolphins have a higher levels of persistent chemicals, including emerging chemicals such as perflourinated compounds and PBDEs and higher levels of resistance to antibiotics (70%) than IRL dolphins.

Perflourinated compounds (PFAs) are persistent, bio-accumulating contaminants used in stain repellants, paper protectors, paint and polishes. High concentrations have been detected in plasma of dolphins in Charleston, SC and Delaware Bay, NJ.

Antibiotic resistant E.coli were found in wild dolphins in Florida and South Carolina. The widespread use of

antibiotics in humans, pets and agriculture may lead to the development of multi-drug resistant bacteria. Most antibiotics tested have been shown to be persistent. Resistant genes are readily transmitted creating the potential for establishment of resistant bacteria within aquatic life. The most common bacteria to which dolphins were resistant were Ampicillin, Amoxicillin, Penicillin, Cephalothin, Cefoxitin, Erythromycin, Trimethoprim, Sulphiazol, and Oxytetracycline. *Aquatic Mammals, 1/1/07, Bemiss, Bossart, et. al.*

When drinking water was tested by the Associated Press for some 41-million Americans, pharmaceuticals including antibiotics, mood stabilizers and sex hormones were found. Tests were conducted in the nation's 50 largest cities and smaller water providers in all 50 states.

Rehtanz, Bossart et al reported in 2005 the first known case of cetacean papilloma virus has been detected in a bottlenose dolphins at CHS.

GULF OF MAINE

Susan Shaw, founder of the nonprofit Marine Environmental Research Institute (MERI) in Blue Hill, Maine, which conducts scientific research and education on the impacts of pollution on marine life reported findings at the Marine Mammal Society Conference in Cape Town, South Africa in December, 2007. Her research on northwestern Atlantic harbor seals shows that toxic chemical levels, especially in pups, are as high as any in the world.

According to Dr. Shaw, "Over the past three years this population has experienced recurring disease outbreaks and high mortality rates. While the specific disease agent is unclear, our studies show that these seals carry high levels of PBDEs, PCBs, and other chemicals in their tissues that may be compromising their immune responses."

This population is affected by recurring epizootics and mass mortalities. Some of the young seals are carrying up to 4-thousand ppm of PBDEs in fatty tissues. PCB levels are as high as 60 ppm in the young animals.

Their toxic equivalency for Dioxin like toxicity is also fairly high in the 200 ppt lipid weight range. Also high levels of polyflourinated compounds have been found in these seals.

CAPE MAY, NJ

Hepatic panels suggest impaired liver function for many dolphins sampled near Cape May, NJ

TEXAS

Unusual mortality events have occurred along the Texas coast with alarming frequency. Most recently in 2007 and 2008 during March and April. In 2008 116 bottlenose dolphins were recovered in the Galveston area. Because the dolphins were generally in a state of advanced decomposition when found the cause of death could not be attributed. However there was no indication the deaths were the result of fisheries interaction. Traces of domoic acid were found in the three freshest dolphins from 2007. D. Cowan, a pathologist with the Texas Marine Mammal Stranding Network,

suggested that brevetoxin was involved and warned that this could be harmful to humans.

WESTERN NORTH ATLANTIC AND GULF OF MEXICO

The brominated flame retardant (BFR) and hexabromocyclododecane (HBCD) are products still in use with environmental release levels rivaling that of PCBs prior to its discontinuation. PBDEs are toxicologically similar to PCBs, which were banned decades ago, though little is known about HBCD toxicity. PBDE concentrations are ten-fold greater and increasing more rapidly in Americans than in Western Europe where many of the brominated chemicals have been banned.

WASHINGTON, SEATTLE

The killer whales inhabiting Puget Sound and surrounding waters are some of the best-known and most beloved marine mammals on earth. The identities of all members of the pod are known; in some cases the family tree can be identified going back decades.

These orca may also be the most contaminated marine mammals on earth. And from 1995 – 2000 ten of the males in J, K, and L pods died. While there is no absolute proof that they died from contaminants such as PCBs, their carcasses did contain astronomical levels of these deadly toxins.

According to Dr. Ken Balcomb, “We’ve attributed most of the mortality to the PCB levels in the tissues. Their immune systems are depressed, much like AIDs, so they don’t defend themselves against common bacteria. And also their reproductive systems don’t

develop.” Females survive better than males because when a mother orca nurses her calf she offloads huge amounts of chemicals such as PCBs that are stored in her lipid rich milk. Often first-born calves do not survive. But second and third born survive after the mother is unburdened of much of her toxic load.

Flame retardants used worldwide in manufacturing vehicle parts and computers have been found in Puget Sound orcas. Traces of industrial strength fire retardant have also been detected in wild and farm raised salmon.

Harbor seals in Puget Sound carry seven times the levels of PCBs as their counterparts in the Straights of Georgia, BC, Canada. Levels of PBDEs are approaching those of PCBs, indicating a significant new chemical concern for these marine mammals.

EASTERN NORTH PACIFIC

Using blubber and remote biopsy samples, organochlorine profiles were correlated to the prey species of three different groups of killer whales – resident fish eaters, transient mammal eaters and offshore animals that consume large pelagic fish. Resident fish eaters had low OC contamination in relation to transient killer whales. OC results for some offshore killer whales were high, even though they eat fish. This suggests they eat high trophic level species such as shark or tuna which bio-accumulate contaminants over long lifetimes.

NORTH PACIFIC OCEAN

Stellar sea lions have undergone a drastic decline in population over the past three decades, which has led to their being listed as

endangered. The precise reason for this decline is unknown. However PCBs are present in high concentrations in the environment. High concentrations of POPs have been found to cause adverse effects in the reproductive and immune systems of marine mammals. According to Hulck et al in Persistent Organic Pollutants in Blubber of Male Stellar Sea Lion from Different Locations in the Northern Pacific Ocean, "Our hypothesis is that the Stellar sea lion population decline or the failure to recover is due to long term exposure to POPs. The decline may also be the result of translocation of their prey species due to changes in water temperature."

PBDE compounds were found in blubber from seals harvested in the Bering Sea subsistence harvest in Alaska. Due to their recent introduction PBDEs are a relatively recent suite of chemicals for concern. Their chemical structure is similar to PCBs and they are thought to be disruptive of thyroid function. Results indicate that lower brominated congeners of PBDEs are present in the Bering Sea environment. From *PBDE Compounds in Blubber from Bering Sea Subsistence Harvest of Ice Seals In Alaska, Quackenbush*.

CANADA

St. Lawrence Estuary (SLE) Belugas: The Beluga population has dropped from an estimated 5,000 to a current estimate of 500-600. The SLE Belugas were protected from hunting by the Canadian government starting in 1980 but so far have shown no sign of recovery.

SLE Belugas are contaminated by PAHs. Levels of epithelial cancer of the proximal intestine, gastric cancer, gastrointestinal epithelial cancer, and mammary cancers are high in SLE Beluga.

This is consistent with the hypothesis that PAHs are involved in the etiology of cancer in these animals. Cancer of the proximal intestine is rare among all species including humans except in circumstances where the animal has been exposed to pesticides. It is frequent in bovine and ovine species exposed to herbicides such as 2,4-dichlorophenoxyacetic acid. An interaction between a virus and environmental carcinogenic compounds may be at work in the SLE Belugas. Particles consistent with papilloma viruses have been observed in a significant number of carcasses. Other carcinogens are present in the environment of the SLE Belugas. Benzopyrene has been found in high concentrations in blue mussels after transplantation into the Saguenay River, part of the Beluga habitat. Sediments of the Saguenay River contain 500 - 4500 ppb of total PAH dry weight, a concentration level significantly higher than Osaka harbor where PAH concentrations are 2870 ppb. These chemicals originate from upstream Aluminum smelters. SLE Belugas feed in sediments. These observations suggest that SLE Belugas ingest PAHs in benthic invertebrates (those living at the deepest water level and in sediment) that may contribute to the elevated rate of digestive tract cancers in the population. *Martineau et al*.

Martineau in Cancer in Wildlife reports “The rate of cancer in the SLE Beluga population is higher than in any other population of wild terrestrial or aquatic animals”.

Cancer was observed in 27% of adult animals found dead, a percentage similar to that found in humans. A cancer rate of 163 per 100,000 animals is much higher than in domestic animals and humans. Environmental toxins are thought to be a precipitating factor in these cancers. Thirty per cent of cancers affecting SLE beluga are found in the intestine, close to the stomach.

The human population living in this area is afflicted by rates of cancer higher than found in other parts of Quebec and Canada in general. Some of these cancers are epidemiologically related to PAHs.

The SLE Beluga are also contaminated by heavy metals, PCBs, DDT, and their metabolites, which can, in some cases be more toxic than the original chemical. Gastrointestinal epithelial cancers were the most frequent found in beluga in the SLE. *Martineau, Environmental Health Perspectives*

Cetaceans have high levels of CYP1A and low levels of CYP2B. SLE belugas have elevated levels of both enzymes, probably because CYP are induced by high levels of PCBs.” Elevated CYP1A levels may trigger intestinal cancer by activating ingested PAHs into carcinogenic compounds.” *Martineau Environmental Health Perspectives 3/2002*

PBDEs were determined in blubber samples of 54 stranded adult beluga whales between 1988 and 1999 in the St. Lawrence Estuary. The accumulation of PBDEs in belugas showed exponential increase throughout the time period. Increasing levels of PBDEs have been reported in human milk during this same time period. PBDE levels in beluga from the Canadian Arctic sampled in 1997 was 4% of the levels found in belugas from the SLE between 1997 and 1999. *Lebeuf Environmental Science and Technology, 2004*

CHILE

Aquaculture activities in the study area generate intense organic enrichment producing eutrophication and release of antibiotics. Recently skin lesions have been discovered in marine mammals in this area for the first time.

FAROE ISLANDS

PBDEs in long finned pilot whales from Vestmanna range from 1000 to 5000 ng/g. *Citation from Lebeuf paper (16, 49-51)*. But the levels for pilot whales from Torshavn are in the same range as beluga in the SLE.

A study published in February 2004 in the Journal of Pediatrics indicated that higher than usual mercury levels in the blood of mothers in the Faroe Islands had caused neurological problems in their children.

The island’s residents eat large quantities of very high-mercury pilot whale meat. The study was supported by the U.S. National Institute of Environmental Health Sciences, a part of the National

Institutes of Health, and by the European Commission under its Environment and Climate Research Programme.

HONG KONG

Indo-Pacific Humpback Dolphins

The pesticide DDT showed the highest concentration among the OCs found in the bodies of the so-called Pink Dolphins of this area and the ratio of DDT to its breakdown products suggest there may have been a recent nearby source of DDT into the dolphins' ecosystem, most likely arriving down the Pearl River into the Pearl River Estuary.

Concentrations of both DDTs and PCBs showed the typical pattern of increase with age in males. In females they increased to sexual maturity then decreased as mothers offloaded the contaminants to their newborns through nursing on the lipid rich milk. *Petroleum Hydrocarbons, polycyclic aromatic hydrocarbons, organochlorine pesticides and PCBs in Indo-Pacific humpback dolphins from South China Waters. Leung et al.*

Samuel Hung and colleagues have estimated the population of pink dolphins in the Pearl River Delta to be 1400 individuals while 265 dolphins have been identified in Hong Kong waters. The habitat is perhaps the fastest growing industrial hub in the world. PCBs, OCPs (organochlorine pesticides) PAHs and petroleum hydrocarbons (PHCs) are widespread in the region's waters.

Concentrations of total PCBs ranged from 11,000 to 41,000 ng/g in the males to 2413 to 4663 ng/g in females, again showing the pattern of higher male contamination levels viz females who offload much of

their toxic burden into their first born calf.

A larger proportion of DDT in the blubber samples of dolphins inhabiting the waters adjacent to south China indicates continuous input of DDT into the aquatic ecosystem.

PAHs were detected in all dolphins sampled. PAHs known to be carcinogenic accounted for 16.8%, 44.8% and 27.2% of total PAHs found.

Strandings, mortality and morbidity of Indo-Pacific humpback dolphins in Hong Kong with emphasis on the role of OC contaminants. Jefferson, Hung and Lam

Eighty six specimens were necropsied over the period 1995 - 2004. Many were too badly decomposed to yield information. Six living individuals were also sampled. A large proportion of the stranded dolphins were young of the year. DDT was found in highest concentrations, again indicating there is a contemporary source of DDT contaminating these waters. It was suspected that that high concentrations of contaminants (especially DDTs and PCBs) in some specimens may have led (directly or indirectly) to the deaths of the stranded animals.

ITALY

PCBs were found in the blubber of nine bottlenose dolphins stranded on the eastern Italian coast. PCB 126 was the major contributor to the estimated toxic potency of PCBs in the dolphins. The total PCB concentrations ranged from 3534 to 24375 ng/g wet weight.

JAPAN

See separate document for expanded coverage of toxics in marine mammals and humans in Japan.

MEDITERRANEAN SEA

Mediterranean cetaceans, particularly odontocetes (toothed whales), accumulate high concentration of OC contamination. Some OCs are known to be endocrine disrupting compounds. Marked differences in levels of OCs were found between fin whales (baleen whales) and odontocetes. Organochlorine levels were significantly higher in the *Stenella* dolphin population of the Western Mediterranean Whale sanctuary than in two other study areas.

Mediterranean striped dolphins show much higher levels of mercury than those in the Atlantic. Mediterranean prey exhibit high levels of mercury. Mediterranean bottlenose dolphins had higher levels of mercury than their Atlantic counterparts. In fact, striped dolphins in the western Mediterranean have some of the highest levels of POPs of any marine mammals.

G. M. Troisi, K. Haraguchi, M. P. Simmonds and C. F. Mason. The levels of PCBs and PCB methyl sulphone metabolites were determined in the blubber of six species of cetaceans that originated from the Irish Sea and the Aegean Sea (Mediterranean). Burdens ranging from 2.80 to 27.80 µg/g (lipid weight) total PCBs and 0.03 to 0.58 µg/g (lipid weight) total methyl sulphones were recorded. The highest cetacean methyl sulphone burden (0.58 µg/g⁻¹) was in an Irish Sea harbor porpoise (*Phocoena phocoena*). Methyl sulphone isomer

formation capacity, as determined by PCBs varied considerably between species as follows: harbour porpoise (1:10) > pilot whale (*Globicephalus melas*), white-sided dolphin (*Lagenorhynchus acutus*) (1:50) > common dolphin (*Delphinus delphis*), Risso's dolphin (*Grampus griseus*), and striped dolphin (*Stenella coeruleoalba*), (1:100), and was related to interspecific variation in PCB methyl sulphone formation capacity.

MEXICO

Sirenians in Mexico all have high levels of Haptaclor, Dieldrin and Mirex. All are carcinogens. PCBs and OCPs are very high in Chetumal Bay.

NORTH SEA, BALTIC SEA

The 1998 die-off of 20,000 European harbor seals was the largest such event on record. This mass mortality occurred in a population of 36,000 harbor seals in the North Sea where the seals were killed by phocine distemper virus (PDV). It has been postulated that high levels of mercury and PCBs may interact with the PDV.

Teflon (PFOS) is well absorbed but poorly metabolized with a reported half-life of over eight years. It's long term toxic effects in marine mammals are unclear but experimental exposure with land mammals reduced perinatal survival, and produced hepatotoxicity, thyroid and neurological impairment. High levels were consistently documented in seals in the Baltic Sea. Differing geographical locations affected values. Mediterranean bottlenose dolphins had liver values of 170 – 430 versus Gulf of Mexico at 824. Polar Bears in the Canadian arctic had liver levels as high as 678. There is evidence these levels are increasing

over time. In the Baltic sea levels in one species of seal increased from 1996 at 86 – 180 to 100 – 384 in 1998. Teflon is clearly another significant contaminant to be considered as a contributor to population declines in marine species, which will worsen with its escalating use.

UNITED KINGDOM

Gareth Thomas of Lancaster University et al found

Organohalogenated contaminants in harbor seals from various populations around the British Isles. The investigation took place in 2003. Seals from the southwest Scottish coast had the highest levels of PCBs with seals from eastern England having highest levels of PBDEs. Hyperthyroid effects were correlated with levels of PBDEs in blubber. The researchers found significantly higher levels of PCBs, but not other contaminants, in seals that died of Phocine Distemper Virus than in animals that survive the epidemic. These PCB levels in dead seals were above the estimated threshold for effects on the immune systems of marine mammals.

Cardigan Bay, Wales Considering current regulations it can be surmised that significant pollutants in UK waters can only be chemicals that were discharged in years past. Persistent Organic Pollutants (that degrade very slowly) and heavy metals, which do not degrade at all, can remain a problem for decades, even centuries after release into the environment.

In Cardigan Bay bottlenose dolphins show significant amounts of PCBs and some heavy metals. Relatively high levels of organochlorines, or heavy metals such as mercury, could be producing chronic effects on the health of the dolphins which inhabit this area. These levels may reduce their ability to resist disease or reproduce.

DOLPHINS ARE NOT FOOD

Toxic Chemicals in Whale and Dolphin Meat in Japan Health Consequences for Japanese Consumers

Some 18-thousand Dall's porpoise are killed each year off Northern Japan. Permits to kill some three thousand dolphins and small whales off the main island of Honshu are in effect. Most of the dolphins taken are slaughtered for meat. An increasing number are taken into captivity and shipped to oceanaria, mostly in Asia.

The recent revelation of extremely high levels of contaminants such as mercury, cadmium and PCBs in dolphin meat has led some Japanese officials, concerned for the health of the citizenry, to examine the policy of eating cetaceans.

For some two decades environmentalists in Japan and from western NGOs have been attempting to stop the brutal slaughter of dolphins and small whales in a few fishing villages in Japan. Initial efforts were based on exposing the brutality of the hunts. That has had considerable impact but has not ended the killing. The revelation of high levels of toxicants in dolphin meat has led to a decrease in demand for dolphin meat.

Dolphin meat is often mislabeled as whale meat in violation of Japanese food safety laws. The change of the meat sold in stores from baleen whales, which are low trophic feeders, to dolphins which are high trophic feeders, subjects those

eating this meat to high levels of heavy metals, such as mercury, and organochlorines like PCBs, dioxins and benzenes.

BlueVoice.org is conducting tests on meat taken from dolphins killed at Taiji, Japan and sold for human consumption. We are also testing hair samples of people who eat whale and dolphin meat to check for levels of contaminants. These tests are conducted in Japanese facilities in consultation with Japanese doctors and scientists.

The first test conducted in 2008 by BlueVoice.org of meat from a bottlenose dolphin taken at Taiji revealed mercury at 7.20ppm - eighteen times higher than the maximum level permitted under Japanese health standards.

Fish caught in Japanese coastal waters average 0.63 - 1.41 pg (pico grams) of mercury. A test by BlueVoice of fish caught in local waters and sold in markets in Taiji, Japan during November 2007 showed ten fish species presented values of .02 ppm to 0.49 ppm of mercury. These are acceptable levels but do not reflect contamination levels for dolphins and small whales taken and eaten in Taiji. The bottom line is that the fish from the Taiji area is safe to eat while dolphin and whale meat is not.

LEVELS OF MERCURY IN DOLPHIN MEAT

In humans, even low-level mercury poisoning has been found to cause memory loss, hair loss, fatigue, depression, difficulty concentrating, tremors, headaches and neurological damage, especially in children. Elevated levels of mercury can lead to heart disease in humans and marine mammals. Because mercury is hard for the body to eliminate, it bioaccumulates.

As news of contamination levels in dolphins became more widely known in Japan the Taiji fishing cooperative sought ways to promote the sale of their product. In an effort to expand the demand, the Taiji fishing cooperative donated dolphin meat to local schools. Taiji, Japan City Councilman Junichiro Yamashita learned of the high levels of mercury in the meat provided to the schools and had samples tested.

The results led him to call dolphin meat served in local schools “toxic waste” because of the high mercury levels.

Mr. Yamashita has led a successful fight to end the practice of giving meat from locally caught dolphins to schoolchildren. Yamashita stated publicly that he and a colleague had found extremely high mercury and methyl mercury levels in samples of meat from pilot whales killed in a local bay and sold in local stores. Pilot whales are actually large dolphins. **Yamashita and another councilman said they were shocked by the results. One dolphin sample had 10 times the health ministry’s advised level of 0.4 ppm for mercury.** The level for methyl mercury was tested at 10.33 times the ministry’s safe level of

0.3ppm. Another sample of dolphin meat tested at 16 times the allowable level of mercury and 12 times the allowable level of methyl mercury. Some of the dolphin meat results were higher than seafood tested during the Minamata catastrophe, according to Dr. Shigeo Ekino of Kumamoto Science University in Kyushu. Dr. Ekino is famous for his study of brain specimens from deceased Minamata victims that reveal even low levels of methyl mercury can damage or destroy neurons. In tests conducted over several years pieces of meat taken from pilot whales slaughtered at Taiji all ran many times the government’s upper limit of 0.4 ppm. One was found to have 11 ppm of mercury and 2.6 ppm of PCBs, in its flesh. The government’s limit on PCBs is 0.5 ppm.

Gyokyo, the leading supermarket in Taiji, stopped selling pilot whale after it was shown to have dangerous levels of mercury. The town’s other supermarket, owned by the fishing cooperative continues to sell the toxic pilot whale meat. The local schools have refused to accept further deliveries of dolphin meat and it appears villagers are eating less of the traditional product.

Dr. Tetsuyo Endo, a researcher at the University of Hokkaido, has published numerous studies showing dolphin meat sold to the public often exceeds government health standards of 0.4 parts per million of mercury. The highest level he has found is 100 ppm from a bottlenose dolphin. Endo has called for a government investigation into the selling of dolphin meat. “Dolphins are not food,” he said.

Dr. Endo has told BlueVoice.org the consumption of organ meat of some dolphins could cause “acute mercury poisoning.” He advises these products be taken off the shelves immediately.

High levels of mercury in marine products is by no means a problem restricted to Japan. It is a worldwide phenomenon. But the problem is amplified many times for consumers of dolphin meat.

Dr. Jane Hightower, an internist in San Francisco warns “some chemicals act synergistically. Together, combinations such as mercury and lead, cadmium or aluminum can cause more risk than mercury alone”. (Consumers of dolphin meat in Taiji show dangerously elevated levels of cadmium, which is thought by some to be a carcinogen). She is also concerned about levels of mercury in terms of heart health.

A mercury level in hair of 2ppm doubles the risk of heart attack and triples the risk of death from heart attack.

The highest concentrations reported of cadmium in kidney and liver of cetaceans have been 125 and 134 ug/wet g in pilot whales.

Mercury levels tested in hair of Japanese populations obtained from 10 districts indicated that 25% of Japanese females of child-bearing age were estimated to be exposed to methyl mercury over the provisional tolerable weekly intake (ptwi) level set by the Japanese ministry of health and welfare. Yasutake et al Journal of Health and Science.

Yasutake et al took hair samples from 8665 individuals from 1999 -

2002, collecting samples in barber shops and primary schools in 9 prefectures. Information was gathered on age, sex, amount and species of fish eaten and artificial waving and coloring of hair. Analysis revealed that mercury levels were significantly correlated with the intake of fish and shellfish.

The Japanese agencies regulating health have set a standard of 0.4 ppm for mercury and 0.3ppm for Methyl mercury - but these levels are not even applied to whale and dolphin products. The United States EPA defines safe levels for methyl mercury at 0.1 ppm.

The mayor of Taiji has said the local dolphin hunting industry has lost US\$1-million from adverse reaction to publication of information about mercury content in dolphin meat. Dolphin and whale meat is still sold and dolphin and whale hunting continues to be subsidized by the government at the expense of Japanese taxpayers. Japanese have vivid memories of the Minamata tragedy in which more than 2,000 people were killed or sickened from consuming fish contaminated with mercury.

Mercury is not the only toxin found in dolphin and whale meat. Whale and dolphin meat can be highly contaminated by both heavy metals and PBOPs (persistent bioaccumulative organic pollutants) such as PCBs, and pesticides such as DDT and chlordanes.

The Japan Fisheries Agency Food Sanitation Committee has advised pregnant women not to eat bottlenose dolphin meat more than once every two months.

PERSISTANT ORGANIC POLLUTANTS – A LINK TO JAPAN’S DECLINING BIRTH RATE?

Organochlorines such as PCBs, dioxins, PBDEs and many other persistent organic pollutants are known to mimic estrogen and other hormones. They are sometimes referred to as endocrine disruptors. Japanese who eat large quantities of fish, and especially those who eat whales and dolphins, may be exposed to very high levels of these endocrine disruptors. Men may become more feminized and women accumulate higher than natural levels of estrogen and estrogen imitators.

A group of Japanese scientists reported in September 2007 that the breast milk of Japanese women tested was contaminated by PCBs. The scientists reported the likely route of ingestion into human bodies was through consumption of fish. “One of the causes of the human contamination is believed to be intake of fish,” said Sochi Ota, associate professor at Setsunan University. It should be emphasized that dolphins, at the apex of the food chain, have far higher concentration of contaminants than most fish.

Sperm counts in Japanese men, already low, are decreasing and chemicals that disrupt human hormones may be to blame, according to a report by Yasunori Yoshimura, a professor of obstetrics and gynecology at Keio University.

An analysis of semen samples from 6,000 Japanese men found a 12 percent decrease in the number of sperm over the past three decades.

Samples taken from medical students in the 1970s contained an average of about 65 million sperm per millilitre of semen. The figures decreased to about 63 million in the 1980s and further dropped to about 57 million in the 1990s.

Environmental chemicals that mimic human hormones could have a role in the decline in sperm counts, Yoshimura said.

Japan has one of the highest life expectancies in the world. The ratio of people aged 65 and over to the whole population more than doubled from 7.07% in 1970 to 18.0% in 2001. This ratio is magnified because of the low recruitment rate of babies into the society.

Japan’s population is aging. A flat population level is only maintained because Japanese are living longer. Recruitment into the population has fallen to a record low. Japan’s population was 127.3 million as of 2001. The annual growth rate fell below 1% in 1977 and by 1999 had dropped to 0.16, a portion of this due to immigration not through birth of Japanese.

The number of people under 15 years of age dropped to a post-war low of 18.28 million in 2001, a decrease of 190,000 over one year.

Whether low sperm counts in Japanese men is related to this phenomenon should be studied on an urgent basis.

Tests on pilot whale meat taken from Taiji found 2.6 ppm of PCBs. The government’s limit on PCBs is 0.5 ppm. In humans, PCBs can cause liver disease, ocular lesions, compromised immune response, reproductive problems and cancer.

Dioxin, recognized widely as a carcinogen, is another toxin found in dolphin and whale meat.

An expert in organochlorine (OC) contamination, Dr. K. Haraguchi, has reported that one meal of 50 grams of whale or dolphin may constitute the TDI (tolerable daily intake) of dioxin for a person weighing 50 kg. A single gram of blubber from the most highly contaminated dolphin sampled would exceed tolerable limits by a factor of three. In humans, OCs can cause effects in reproductive/sexual development, plus immune system damage, thyroid disorders, nervous system disorders, endometriosis and diabetes.

In a study presented to International Whaling Commission (IWC) conference in Australia, Japanese researchers reported finding dioxin levels up to 172 times the tolerable daily intake in marketed whale meat. The study was headed by Koichi Haraguchi of Daiichi University in Fukuoka, Japan. Researchers looked at 38 types of whale and dolphin meat sold in 1999 and early 2000 in Japan.

Dolphin meat showed the highest levels of dioxins. Minke whales from the north Pacific were next highest. Southern Hemisphere Minkes were relatively low in this chemical.

Cetacean products such as bacon/blubber are contaminated to a degree unacceptable for human consumption according to standards set by Japanese health authorities for dioxin-like compounds. Haraguchi 2000.

Researchers concluded people who eat relatively large quantities of fish are at risk for dioxin-induced neurobehavioral effects with particular risk for infants. Simmonds, Haraguchi et al. Human Health Significance of Organochlorine and Mercury contaminants in Japanese whale meat.

TOXICS IN WHALE MEAT

Japan obtains much of its whale meat from its widely rejected pseudo-scientific hunts of whales in the Antarctic and Northwest Pacific. While Japan calls these hunts "research" operations they have been condemned worldwide. Drive fisheries, primarily conducted from the village of Taiji, and harpoon hunts conducted on Dall's porpoise in the north of Japan are additional sources of cetacean meat.

The Asahi Shimbun (Japan's second most widely circulated newspaper) reported in 2003 that studies of several varieties of whale meat conducted by the Japan health ministry revealed that many samples contained unacceptable levels of toxic chemicals, such as PCBs and methyl mercury. The samples tested were taken from fat and muscle meat from five Baird's beaked whales taken off Northern Japan. The ministry's research group detected PCB levels between 5 and 11 ppm and methyl mercury levels between 0.37 and 1.3 ppm in the whales muscles. The Health ministry limit is 0.5 for PCBs and 0.3 for methyl mercury in sea food.

The Provisional Tolerable Weekly Intake (PTWI) for methyl mercury would be exceeded by an average consumption of only 16g of whale liver products per week.

The highest level of mercury ever detected was 204 ppm in the liver meat of a whale, exceeding the “safe” level by 400 times.

Japanese researchers report that approximately half the intake of dioxins in Japanese people comes from fish.

T-Hg (total mercury) levels found in boiled whale liver were high enough to cause acute intoxication from a single serving. Contamination levels of T-Hg and M-Hg in red meat from toothed whales were 8.94 +/- 13.3 and 5.44 +/- 5.72 ug/wet g. These levels exceeded limits of T-Hg (0.4 ug wet g) set by the Japanese Ministry of Health and Welfare by 22 and 18 times respectively.

The ingestion of 500 mg of mercuric chloride can cause severe poisoning and even death in humans. The consumption of boiled liver provides enough mercury to cause acute renal failure.

A recent study of dolphin and whale meat conducted by the Environmental Investigation Agency (EIA) collected in Wakayama prefecture near Taiji has shown elevated levels of PCBs in dolphin meat. Sample EIA 07-16 was labeled Risso's dolphin meat. But DNA testing showed it was either one of the following: bottlenose, stenella or delphinus. The PCB level was 1.512 pp. A sample of dolphin meat purchased in southwestern Japan was in fact Risso's dolphin and showed a level of PCBs at 1.243 ppm. The Japanese have set a level of .5ppm as a tolerable level for PCBs in meat. So both samples of

dolphin meat sampled by EIA were significantly in excess this benchmark. In both cases levels of mercury and methyl mercury were over regulatory levels.

AMYLOIDOSIS IN WHALES NEAR JAPAN

Amyloidosis is a disease characterized by the tissue deposition of autologous extracellular fibrillar proteins pressing adjacent tissues. There is only one report of it in cetaceans. Among twelve Beaked Whales stranded along the Sea of Japan, Amyloidosis was found in two of them. Livers were particularly swollen with marked atrophy of hepatocytes. Deposition of amyloid in kidneys, heart, spleen, pancreas, adrenals was noted. Amyloidosis is associated with diseases such as Multiple Myeloma. Tajima et al. Journal of Zoo and Wildlife Medicine.

Study Shows Mercury Affects Brain Development

For immediate release: February 06, 2004
Harvard School of Public Health

Boston, MA— With methylmercury a worldwide contaminant of seafood and freshwater fish and known to produce adverse nervous system effects, especially during brain development, researchers from the Harvard School of Public Health and institutions in Japan, Denmark and the Faroe Islands undertook an assessment of possible brain function impairment in adolescent children due to prenatal exposure to mercury when the mothers' diet was high in seafood. The authors found that high levels of mercury passed from mother to child in utero produced irreversible impairment to specific brain functions in the children. The study was carried out in the Faroe Islands and appears in the February issue of *The Journal of Pediatrics*.

Mercury exposures among the children in the study were assessed through analyses of cord blood samples at birth and hair samples taken at ages 7 and 14. Some 1,022 mothers and their children from the Faroe Islands participated in the research. The mothers' hair mercury levels at childbirth in most cases exceeded 1 microgram per gram, the exposure limit recommended by the National Research Council and the U.S. Environmental Protection Agency (EPA).

The Faroe Islands are located in the North Atlantic Ocean between Norway and Iceland. The islands' economy is centered on the fishing industry and fish processing. The diet of the inhabitants includes high intake of seafood and whale meat.

A second paper in *The Journal of Pediatrics* by the same authors reports that the neurological changes are also linked to decreased nervous system control of the heart function. At higher mercury exposures, the children were less capable of maintaining the normal variability of the heart rate necessary to secure proper oxygen supply to the body.

CANCER IN DOLPHINS – AN EMERGING THREAT?

Until recent years cancer was virtually unknown in dolphins. Today a growing number of cancers are being found in dolphins around the world. In cases where dolphins with cancer have been in a state of decomposition that allowed analysis, high levels of POPs have been found, supporting the hypothesis that organic contaminants are implicated in the etiology of the disease. The susceptibility of dolphins to toxicants is made worse because dolphins lack genes that process these chemicals (see technical papers at back of this report). Because of genetic similarities with humans it would be foolish to ignore this trend in dolphins.

Whole populations of dolphins are in danger of extinction due to accumulation of toxic chemicals.

Human beings who eat fish from the environments shared with dolphins afflicted with high levels of contamination would be well advised to take these dangers into account in their selection and levels of consumption of fish.

Only 33 cases of cancer have been found worldwide in cetaceans, other than the SLE Beluga, according to Daniel Martineau. But this does not mean that more cases than this do not exist. In most cases stranded dolphins are found in a state of decomposition that disallows many forms of testing. In addition budgets for such research are sparse.

St. Lawrence Estuary Belugas. The Beluga population has dropped from an estimated 5,000 to current estimate of 500–600. The SLE

Belugas were protected from hunting by the Canadian government starting in 1980 but so far there is no sign of recovery.

SLE Beluga are contaminated by polycyclic aromatic hydrocarbons (PAHs) produced by local aluminum smelters. The extraordinary level of cancer in this population is consistent with the hypothesis that PAHs are involved in the etiology of cancer in mammals. *Daniel Martineau, et al* Cancers found include epithelial cancer of the proximal intestine, gastric cancer, gastrointestinal epithelial cancer and mammary cancer. Cancer of the proximal intestine is rare among all species including humans. It is frequent in bovine and ovine species exposed to herbicides such as 2,4-dichlorophenoxyacetic acid. An interplay between a virus and environmental carcinogenic compounds may be at work in the SLE Belugas. Particles consistent with papillomaviruses have been observed in papillomas found in a significant number of carcasses.

Carcinogens are present in the environment of the SLE Belugas. Benzopyrene was found in high concentrations in blue mussels in the Saguenay River. Sediments of this river, part of Beluga habitat, contain 500 – 4500 ppb of total PAH dry weight, a concentration level significantly higher than Osaka harbor where PAH concentrations are 2870 ppb. The PAHs originate from upstream aluminum smelters. SLE Belugas feed in sediments. These observations suggest that SLE Belugas ingest PAHs in benthic invertebrates that may contribute to the elevated rate of digestive tract

cancers in the population.
Martineau et al.

Martineau: Cancer in Wildlife. “The rate of cancer in the SLE Beluga population is higher than in any other population of wild terrestrial or aquatic animals”. Cancer was detected in 27% of adult beluga whales found dead. The cancer rate of 163 per 100,000 animals is much higher than in domestic animals and humans.

According to Martineau, “The human population living in this habitat is affected by rates of cancer higher than found in other parts of Quebec and Canada in general. Some of these cancers are epidemiologically related to PAHs.”

In 50 Beluga examined in the Canadian Arctic no cancer was found.

The SLE Beluga are contaminated by heavy metals, PAHs, PCBs, DDT, and their metabolites, which can, in some cases be more toxic than the original chemical.

Cancer of the proximal intestine is rare in all animal species and humans except in circumstances where the animal has been exposed to pesticides.

An interaction between viruses and environmental toxicants may be a factor in the high cancer rates among SLE Beluga.

Almeria, Spain. An ovarian tumor was found in a juvenile Cuvier’s Beaked Whale. High levels of PCB congeners were detected. Residue levels of 13 PCB congeners and OC

pesticides were also found. Dioxin-like PCBs were greater than the threshold level for observed effects on reproduction, carcinogenesis and immunity in mammals. Espinosa de los Monteros.

Results of a study by Frenzilli showed a statistically significant increase of DNA damage after PAHs exposure in three species investigated in the Mediterranean – striped dolphin, bottlenose dolphin and a fin whale.

Florida

Six dolphins from three species were found by Greg Bossart along the East Coast of Florida with immunoblastic lymphoma, also referred to as multiple myeloma. One hypothesis is that a retro virus was responsible for these lymphomas. The dolphins were not tested for chemical contaminants but were found in an area into which herbicides from the Lake Okeechobee sugar industry flow.

In April, 2004 J. R. Jabera et al found a bottlenose dolphin stranded alive off **Gran Canaria (Canary Islands)** with hepatosplenic lymphoma, AKA immunoblastic lymphoma; AKA multiple myeloma. The researchers detected eleven PCB congeners, 23 OC pesticides and 16 PAHs in this dolphin. High concentrations of PCBs 153, 180, 138 and 187 found may have been associated with the hepatosplenic lymphoma.

Texas Coast: Two cases of cancer were found among 90 bottlenose dolphins examined along the Texas Gulf Coast from 1991 – 1998. One was a myelogenous leukemia, the other a bile duct carcinoma.

MULTIPLE MYELOMA IN DOLPHINS

Multiple myeloma is a cancer of plasma cells. Recent studies have shown that chemical pollutants play a role in the etiology of this hematological cancer in some cases.

Until recently cancer was virtually unknown in marine mammals. Today it is a growing problem and indications are that chemical contamination is a culprit.

BlueVoice is conducting a worldwide search for incidences of Multiple Myeloma in dolphins and other marine mammals.

In 1997 Dr. Greg Bossart published a paper in which he described the occurrence of Immunoblastic lymphoma (hereafter called multiple myeloma) in five dolphins of three species found along the southeast coast of Florida during a two year period. These were the first reported cases of multiple myeloma in dolphins. It was not possible to conduct tests for pollutants.

In April, 2004 J. R. Jabera et al reported in a paper entitled "Hepatosplenic Large Cell Immunoblastic Lymphoma in a Bottlenose Dolphin with High Levels of PCBs", a case of multiple myeloma in a bottlenose dolphin found in the Canary Islands. The dolphin was found stranded and alive. Eleven PCB congeners, 23 organochlorine pesticides and 16 PAHs were detected in blubber and liver. Jabera concludes "High concentrations of PCBs 153, 180, 138, and 187 found in the liver may have been associated with the hepatosplenic lymphoma (multiple myeloma).

In 2008 Michelle Fleetwood of the Armed Forces Institute of Pathology, wrote of an adult female bottlenose dolphin found dead on a beach at Sullivan's Island, Charleston County, South Carolina. Her diagnosis was B-cell immunoblastic lymphoma (multiple myeloma). She commented in her paper that hematopoietic neoplasms are rare in cetaceans. Contaminant testing on this dolphin's tissues is pending as of June, 2008.

Persistent Organic Pollutants (POPs)

General Facts

- Persistent organic pollutants (POPs) are organic compounds that resist environmental breakdown via biological, chemical, and photolytic processes, some taking as long as a century to degrade.
- POPs exposed to the environment are proven to travel long distances from their origin via wind and ocean currents. Precipitation has been found to carry PCBs (polychlorinated biphenyls)
- POPs therefore can be found globally, even in areas such as the Arctic and Antarctica, far from their source. Human exposures in certain Arctic areas are among the highest worldwide.
- POPs bio-concentrate as they move up through the marine food chain and accumulate in the fatty tissues of living organisms at higher trophic levels.
- Marine mammals around the world carry high burdens of POPs.
- Although many countries have banned these chemicals, they remain stockpiled, are produced or used illegally, or, because of lengthy half-lives, they continue to exist in soil, or other environmental media.
- The United Nations is currently considering the elimination or reduction of twelve of some of the most damaging POPs through the formulation of an

international treaty. Nine of the POPs chemicals under consideration are pesticides that have been extensively used in both developed and developing countries.

General Health Effects

- POPs can disrupt the endocrine, reproductive, and immune systems. The developing brain and nervous system may be most vulnerable.
- POPs are capable of causing behavioral problems, cancer, diabetes and thyroid problems.
- According to a landmark longitudinal study, babies whose mothers ate large amounts of highly contaminated fish (PCBs were measured) from Lake Michigan had lower birth weights, smaller head circumferences and shorter attention spans than babies whose mothers did not eat fish. Followed over 11 years, the exposed children have continued to do poorly in a range of skills and development tests, including deficits in general intellectual functioning, short- and long-term memory, and attention span.
- The health of marine mammals has deteriorated significantly over the past two decades. Many of the newly emerging and resurgent diseases are

associated with immune system dysfunction and suggest a broad environmental distress syndrome.

- Marine mammals present a metabolic imbalance, so they are considered one of the most vulnerable organisms with respect to long-term toxicity of man-made chemicals such as organochlorines. Cetaceans (whales and dolphins) are known to have a poor ability to detoxify organic pollutants because they lack isozymes that are required to detoxify DDT and PCBs.

“The Dirty Dozen”

These 12 POPs are often referred to as the “dirty dozen”:

Aldrin – an organochlorine insecticide;

- A pesticide used to control soil insects. It has been widely used to protect crops such as corn and potatoes, to protect wooden structures from termites.
- It is oxidized in the insect to form dieldrin, a neurotoxin.
- It is a carcinogen as well as a mutagen.
- It binds strongly to soil particles, is resistant to leaching into ground water. It is released from soil by volatilization.
- Due to its persistent nature, aldrin is known to bio-concentrate.
- Aldrin is toxic to humans causing headache, dizziness, nausea, general malaise, and vomiting, followed by muscle twitchings, myoclonic jerks, and convulsions.
- Occupational exposure to aldrin, in conjunction with dieldrin and endrin, has been associated with a significant increase in liver and biliary cancer. –Aldrin may affect immune responses.
- Many countries, including the US have ended its usage and manufacture
- It is a carcinogen as well as a mutagen.

Chlordane – a manufactured pesticide;

- Chlordane is a broad spectrum contact insecticide that has been used on agricultural crops as well as being used extensively in the control of termites
- Banned in US in 1988 by the EPA;
- Chlordane sticks strongly to soil particles at the surface and is not likely to enter groundwater. As a result it can stay in the soil for over 20 years and breaks down very slowly.
- Bio-concentrates in fish, mammals, and birds;
- In both humans and animals, it can damage nervous and digestive systems, and liver – Has caused convulsions and death;
- Recent human studies have linked chlordane exposure with prostate and breast cancers.

DDT – a synthetic pesticide

- DDT is a toxicant;
- It has a half life of 2–15 years, and is immobile in most soils
- Breakdown products in the soil environment are DDE and DDD, which are also highly persistent and have similar chemical and physical properties.
- Banned in the US for most uses in 1972.

- Subsequently banned for agricultural use worldwide, but is still used to a limited extent in mosquito control in certain parts of the world
- The use of DDT was found to be a major factor in the bald eagle and the peregrine falcon population decline, as it caused the birds' egg shells to thin.
- DDT and its metabolic products DDE and DDD magnify through the food chain
- DDT bio-concentrates significantly in fish and other aquatic species, leading to long-term exposure to high concentrations.
- At the chronic level, individuals who consumed contaminated fish increased diabetes occurrences;
- The EPA, in 1987, classified DDT as a probable human carcinogen.
- In 2007 a Canadian study found a positive association between DDE and non-Hodgkins Lymphoma.
- Tests conducted by the CDC in 2002 showed that more than half of subjects tested had detectable levels of DDT or metabolites in their blood,
- The USDA tested cows milk samples in 2005 and found that 85% had detectable levels of DDE.

Dieldrin – an insecticide;

- Closely related to aldrin which itself breaks down to form dieldrin
- it accumulates as it is passed along the food chain.
- Long-term exposure is toxic to many animals (humans included) far greater than to the original insect targets.
- Currently banned in most of the world.
- Linked to Parkinson's disease, breast cancer and immune, reproductive, and nervous system damage.

Endrin – an insecticide/rodenticide;

- Banned in many countries;
- It is likely to adsorb onto the sediments in surface water.
- An insecticide used on cotton, maize, and rice; a rodenticide used to control mice and voles.
- It can bio-concentrate in the fatty tissues, of organisms living in water. It is very toxic to aquatic organisms, namely fish, aquatic invertebrates, and phytoplankton.
- Half-life in soil estimated at over a decade.
- endrin poisoning in humans primarily affects the nervous system. Food contaminated with endrin has caused several clusters of poisonings worldwide, especially affecting children.

Heptachlor – an insecticide;

- Similar to the insecticide chlordane
- The U.S. has banned the sale of heptachlor products in the United States and virtually eliminated its use for any purpose
- Has a very stable structure, thus it can remain in environment for decades;
- Possible human carcinogen.

Hexachlorobenzene (HCB) – a fungicide;

- A fungicide formerly used as a seed treatment, especially on wheat.
- Known animal carcinogen (liver, kidney, thyroid);
- Probable human carcinogen;

- After its introduction as a fungicide in 1945, for crop seeds, this toxic chemical was found in all food types.
- Banned in the U.S in 1966;
- In humans it can cause liver disease, skin lesions, ulceration, hair loss, thyroid damage;
- Human and animal studies have demonstrated that HCB crosses the placenta to accumulate in fetal tissues and is transferred in breast milk.
- Extremely toxic to aquatic creatures. Risk of bioaccumulation in an aquatic species is high

Mirex – an insecticide, flame retardant;

- Listed as a persistent, accumulative, and toxic pollutant by EPA in the U.S.
- It was used to control fire ants and as a flame retardant in plastic, rubber, paint, paper and electronics.
- Mirex is transported across the placenta and can be passed from mother to child through breast milk;
- Most effected in animals is the liver;
- Proven to cause cancer in mice and rats and is a carcinogenic risk to humans;
- Toxic for a range of aquatic organisms, with crustacea being particularly sensitive.
- Mirex induces pervasive long-term physiological and biological disorders in vertebrates.
- There is evidence of accumulation of mirex in aquatic and terrestrial food chains to harmful levels
- Mirex is one of the most stable of the organochlorine insecticides and is it is widespread in the environment.
- All uses of mirex as a pesticide were banned in the U.S. in 1978.
- mirex is still used in the USA mainly as a flame-retardant in plastics, rubber, paint, paper and electronics.
- Effects on organisms combined with its persistence suggest that mirex presents a long-term hazard for the environment

PCBs (polychlorinated biphenyls)

- Used as coolants/insulating fluids, also used in flexible PVC coatings of electrical wiring and electronic components, pesticide extenders, cutting oils, flame retardants, hydraulic fluids, sealants (used in caulking, etc), adhesives, wood floor finishes, paints, and in carbonless copy paper.
- PCBs are very stable compounds and do not degrade readily.
- Despite being banned in the 1970s due to their high toxicity, PCBs still persist in the environment.
- Prior to the ban estimates have put the total global production of PCBs on the order of 1.5 million tons.
- PCBs have been detected globally in the atmosphere, from the most urbanized areas that are the centers for PCB pollution, to regions north of the Arctic Circle, carried by wind currents.
- Bio-concentrates in animals;
- PCBs can be transmitted to children via breast milk as well as through the placenta.
- In humans, PCBs can cause liver disease, ocular lesions, lessened immune response

- Babies born to women exposed to PCBs have been shown to weigh less, have problems with motor skills, a decrease in short-term memory, and compromised immune systems.
- PCBs alter estrogen levels in the body and contribute to reproduction problems.
- Endocrine Disrupting Chemicals (EDC's) such as PCBs pose a serious threat to reproduction in top-level predators.
- Biological magnification of PCBs has led to polar bears and whales that have both male and female sex organs and males that cannot reproduce.
- Effects on animals are liver, stomach, thyroid damage, plus immune system changes, changes in behavior, impaired reproduction.
- Some studies indicate that PCBs are associated with cancer in humans, such as cancer of the liver and biliary tract. Recent research by the National Toxicology Program has confirmed that PCB126 is a carcinogen.
- PCBs are known to induce Vitamin A deficiency in mammals, an affect that may be associated with impairment of the immune system, reproduction and growth.

PCDDs (Polychlorinated dibenzodioxins) – commonly referred to as **DIOXINS;**

- Dioxins are teratogens (cause birth defects), mutagens, potential human carcinogens;
- Known to accumulate in humans and wildlife due to dioxins' ability to dissolve in fats and oils and their tendency to be water insoluble. This means that even small amounts in contaminated water can bio-concentrate up the food chain to dangerous levels.
- In humans, they can cause effects in reproductive/sexual development, plus immune system damage, thyroid disorders, nervous system disorders, endometriosis and diabetes.
- In animals and fish, studies have shown dioxin exposure to cause cancer birth defects, liver damage, endocrine damage, and immune system suppression.
- Studies have shown that exposure to dioxin increases the ratio of female births to male births among a population.
- Concentrations of dioxins are found in all humans today, with higher levels found in persons living in more industrialized countries.
- The estimated elimination half-life for dioxins in humans ranges from 7.8 to 132 years.
- Dioxin enters the general population almost exclusively from ingestion of food, specifically through the consumption of fish, meat, and dairy products since dioxins are fat-soluble and readily climb the food chain
- Because Dioxins are lipophilic, breast fed children usually have substantially higher dioxin body burdens than non-breast fed children until they are about 8 to 10 years old.
- According to the EPA, 80% of Dioxin emissions are caused by coal burning plants, municipal waste incinerators, metal smelting, diesel trucks, land application of sewage sludge, burning treated wood and trash burn barrels. Dioxins are also generated in bleaching fibers for paper and textiles.

Polychlorinated dibenzofurans

- highly toxic;
- Properties and chemical structure similar to dioxins;

Toxaphene – an insecticide;

- highly toxic
- Banned in US in 1990, outlawed in 1991 by the Stockholm Convention
- Exposure can cause damage to lungs, nervous system, kidneys and can be fatal

Additional POPs

PBDEs – (Polybrominated diphenyl ethers) flame retardants

- PBDEs are used in plastic, foam and textiles in clothing, computers, televisions, furniture and cars.
- PBDEs have been found at high levels in indoor dust
- Research has linked some chemicals in the flame retardants to effects on thyroid function on brain function, reduced male fertility and damaged ovarian development and the development of the embryonic nervous system, impacting motor skills and behavior.
- These chemicals were banned in Europe in 2004/2005. In August 2003, California became the first state to ban two forms of the fire retardants chemicals known to accumulate in the blood of mothers and nursing babies. In April 2007 Washington banned the use of PBDEs and in May 2007, the state of Maine passed a bill phasing out the use of DecaBDE.
- levels of concentration in humans and marine mammals continue to increase, particularly in the United States.
- Studies have found that PBDEs accumulate in human blood, fat tissue and breast milk. It has been found that a woman can pass these chemicals to her unborn child through the placenta.
- In the United States levels in human breast milk are 40 times higher than in Europe and are steadily rising.
- Marine mammals like bottlenose dolphins, harbor porpoises, pilot and beluga whales have been found to be contaminated with PBDEs. Birds including cormorants and glaucous gulls, and popular food fish including salmon and tuna have also been found to carry high concentrations of PBDEs

PFCs – perflorinated compounds;

- PFCs are used as industrial and commercial surfactants – wetting agents that lower the surface tension of liquid.
- In contrast to the majority of organic pollutants that are deposited in fatty tissue, perflorinated contaminants circulate in the blood and accumulate primarily in the liver.
- PFCs are synthetic molecules that are thought to bioaccumulate and are believed to be extremely resistant to physical degradation, biodegradation, and biotransformation.
- Science has begun to demonstrate clear links between chemicals such as phthalates, bisphenol A, and perflorinated compounds found in consumer products including baby bottles, toys, and cosmetics to reproductive disorders.

Mercury

General

- It is a powerful neurotoxin
- Can cause major brain damage in developing fetuses, and mild tremors and emotional disorder in adults who are exposed.
- Is responsible for many historical poisoning instances.
- Currently, seafood is the main source of exposure since mercury builds up in aquatic animals and can reach considerable levels at peaks of both salt and fresh water food chains.
- Normally seen as a thick, silvery-white liquid.
- It is the only metal in liquid form at room temperature.
- *Methyl mercury* is quickly ingested by fish, concentrating in aquatic food chains, achieving significant levels in top predatory animals via bio-magnification.
- According to *Harte et al.*, "Methyl mercury is also rapidly absorbed by people who eat fish and can readily pass through the placenta of pregnant women, exposing developing fetuses, and through the blood-brain barrier into the brain."

Exposure

- Mercury exposure is dependent upon its form; mercury vapor and methyl mercury are the most probable forms, as they are almost totally absorbed into the body.
- Methyl mercury exposure:
 - Fish/fish products – **94%**
 - Inhaling mercury vapor – **6%**
- Individuals consuming large amounts of fish get above-average exposure.
- According to the EPA, individuals consuming over 30 pounds of fish yearly are at high risk.
- Some example species of concern:
 - Freshwater – pike, trout, bass
 - Marine – tuna, shrimp, snapper, halibut

Distribution

- Mercury has a tendency to be found near manufacturers using it, and also close to mines, smelters, municipal solid waste incinerators, and fossil-fueled power plants (Mercury is a contaminant in ores and fuels).
- Mercury is utilized in:
 - Making electrical materials, including batteries, smoke detectors, mercury lamps/switches – **56%**
 - Producing chlorine/caustic soda – **12%**
 - Anti-mildew agent found in paints – **10%**
 - Industrial/control instruments – **6%**
 - Other – **16%**

Health Effects

Methylmercury (commonly found in fish) has major effects related to the nervous system (especially in developing fetuses and small children).

- Mildest exposures – malaise, blurred vision, pins-and-needles tingling.
- More severe exposures – vision loss, lessened hearing, speech disorders, shaky movements/unsteady gaits.
- Most severe exposures – mental derangement and coma (most common result is death).

Prenatal/early childhood are the most vulnerable times to methyl mercury poisoning, as this is a time of fast brain development.

- **Methyl mercury exposure to pregnant women (mild)** – later accomplishment of baby's developmental stages, minor neurological abnormalities in baby.
- **More severe** – major developmental effects, including unusual location of brain structures, impairment of motor/mental development – severe cerebral palsy, spasticity, incontinence, blindness, poor language development); effects cannot be reversed.

Example of methyl mercury contamination – Minamata Bay, Japan: industrial chemicals infected fish, exposing many people to large amounts of mercury.

Mercury vapor

- **Mildest exposures** – loss of memory, tremors, anxiety/irritability, insomnia, appetite loss, introversion.
- **Moderate** – major mental disorders/motor disturbances, damage to kidney.

- **High-level** – Lung damage, death.
- Evidence shows high abortion rates in pregnant women exposed to mercury vapor.

Inorganic mercury compounds

- Not very toxic, as they are not well absorbed.
- Large consumption (several grams) – death by kidney failure, nerve damage.

Prevention

- Individuals who consume fish and other seafood should reduce/eliminate consumption of contaminated fish species.

Environmental Effects

- Industrial inorganic mercury discharges are converted by bacteria in fresh and sea water (as well as in sediments) into organic *methyl mercury*.
- Via bio-magnification, low-food-chain fish quickly accumulate methyl mercury, and higher-level aquatic organisms are therefore exposed.
- Fish such as swordfish, pike and trout contain greater methyl mercury concentrations than the waters of their origin.
- Another environmental process involves acid rain; acid can cause the organic mercury to convert to forms quickly taken in by aquatic organisms, thus exposing more humans to methyl mercury.
- Mercury is toxic to fish and other marine and freshwater life forms.

Regulatory Status

- Mercury content in water is regulated by the EPA;
- Food – FDA
- Workplace air – OSHA

Mercury is noted as a “hazardous air pollutant” by the Clean Air Act of 1990.

Additionally, it is on the EPA “community right-to-know” list.

Glossary

Amyloidosis is a disease characterized by the tissue deposition of autologous extracellular fibrillar proteins pressing adjacent tissues. Amyloidoses can affect different organ systems or be particular to one organ. Some are inherited. Other forms result from diseases causing abnormal protein production – for example immunoglobulin light chains in multiple myeloma.

Bio-magnification: Chemicals such as PCBs can exist at levels that are virtually undetectable in water but magnify exponentially up the food chain so that a top predator may have 25-million times the concentrations found in the water it lives in. This process takes place as the toxin is absorbed into plankton, which are then eaten by small fish, which are then eaten by ever larger fish and eventually marine mammals or humans thus concentrating the toxicant.

Brevitoxin: a neurotoxin produced by some species of dinoflagellate such as *Karenia brevis* and *Ptychodiscus brevis*. A marine neurotoxin associated with 'red tide' catastrophes on coastal areas around the world.

BFRs: brominated flame retardants persist in the environment, bioaccumulate in the food chain and in the bodies of marine mammals and humans. They cause adverse health effects in the young. The breast milk of American women contains the highest levels of BFRs in human breast milk found anywhere in the world.

Bisphenol A (BPA) is a plastic strengthener. A basic component of plastics found in baby bottles, sippy cups and juice bottles, dental sealants, DVDs and the linings of food and beverage containers. The CDC has found BPA in 92 percent of Americans age 6 and up. They mimic hormones, with effects even at levels down to parts per billion.

Cadmium. Side effects of cadmium toxicity include muscle cramps, salivation, sensory disturbances, liver injury, convulsions, shock, renal failure. Other potential effects of long-term cadmium exposure include: high blood pressure, iron-poor blood, liver disease, nerve or brain damage, lung damage, fragile bones, intestinal damage.

CYP1A1 is a gene activated by exposure to POPs. It is thus a biomarker of exposure. CYP1A1 is a gene that encodes a member of the cytochrome P450 superfamily of enzymes. It is primarily involved in metabolism of chemical contamination and drugs. Cytochrome P450 is a very large and diverse superfamily of hemoproteins found in bacteria, archaea and eukaryotes.

Dioxin: Dioxins denote the chlorinated derivatives of polychlorinated dibenzodioxins (PCDDs), which are part of the family of halogenated organic compounds. They bio-accumulate in humans and wildlife due to their lipophilic properties.

The largest sources of dioxins in the USA are Dupont's Edge Moor, (DE), DeLise (Miss) and New Johnsonville, TN. Of all the toxic chemicals dioxin is the most

wide-spread and toxic. In laboratory animals dioxin has been shown to be carcinogenic (causing cancer), teratogenic (causing birth defects) and mutagenic (causing genetic damage). The International Agency for Research (IARC) on Cancer of the World Health Organization has concluded that dioxin is carcinogenic to humans.

Domoic acid is produced by a single-celled algae in the genus *Pseudo-nitzschia*. It is a potent neurotoxin. It accumulates in shellfish and fish that feed on the algae, such as anchovies and sardines.

Epizootic Event. An epidemic. Large number of animals sickened or killed.

Ethylene Oxide is a known human carcinogen. A chemical used in the production of ethylene glycol and other chemicals, and as a sterilant for foods and medical supplies. Ethylene oxide gas kills bacteria (and their endospores), mold, and fungi. In animals, ethylene-oxide can cause reproductive effects, including mutations and miscarriages.

(HABs) Harmful Algal Blooms. A dense concentration of phytoplankton, algae or cyanobacteria in a marine or aquatic environment that causes production of natural toxins. An HAB is not synonymous with Red Tide although the terms are sometimes used interchangeably. HABs are often associated with mass mortality events affecting dolphins, manatees, other marine mammals and fish. They have been associated with various types of shellfish poisonings and can irritate eyes and mucous membrane tissues in humans.

Heavy Metals such as mercury, cadmium, zinc and others. In excess heavy metals can be toxic, due to the potential for cellular damage. Heavy metals bio-accumulate in the marine environment concentrating through the food chain. Apex predators such as tuna, swordfish, dolphins and humans who eat large quantities of these species are liable to be afflicted with mercury poisoning.

Leptospirosis: Leptospirosis is caused by the highly mobile, aerobic, spirochete bacteria *Leptospira interrogans*. It is spread through contact with the urine of infected animals and is highly contagious. There is a danger of cross transmission from animal hosts to humans. Epizootic outbreaks have occurred among marine mammal populations of the West Coast of the USA.

Lipophilic. Attracted to fat. POPs are attracted to fat rich mammalian milk, that is then transferred from mother to calf through nursing. This unburdens the mother of much of her POPs but starts the calf off with a toxic load of these chemicals. Thus firstborn calves receive an extra-large dose of toxicants compared to later-born calves that come every two to three years, when the toxic load is lighter.

Lobomycosis: a fungal infection of the skin. In the Indian River region of Florida lesions have been found in dolphins on the dorsal fin, head, flukes, and peduncle.

Mercury: Humans absorb mercury in the form of methyl mercury (MeHg) primarily by eating fish and shellfish which accumulate through the marine food

web. MeHg is formed from mercury by microorganisms in the aquatic environment. It bio-accumulates, magnifying from plankton to smaller fish to larger fish which have the highest concentrations. Marine mammals, including dolphins and whales as well as large fish such as tuna, swordfish and species of shark show high concentration of MeHg.

The nervous system of a fetus is considered particularly vulnerable to mercury contamination.

Methyl Mercury. While not a POP, is capable of altering growth-related signaling in human breast cancer cells. It may be considered an endocrine-disrupting compound and thus potentially carcinogenic.

Multiple Myeloma. A cancer of plasma cells, a malignant proliferation of plasma cells derived from B lymphocytes. A B-cell lymphoma involving bone and blood. In recent years incidence has been rising and occurring in younger population groups. Diseases such as MM likely result from synergies of causation including genetic predisposition and environmental factors.

Nanogram equals 1 billionth of a gram

Nematode, also called “round worms” are found in marine and terrestrial environments. They are a form of parasite.

Orogenital neoplasia: A neoplasia is an abnormal proliferation of cells and is the scientific term for what is commonly called cancer. Orogenital neoplasias consist of lingual papillomas, squamous cell carcinomas and genital papillomas. They have been found in Atlantic bottlenose dolphins studied from January 2000 to January 2005. Tumors were found primarily in adult dolphins of both sexes living in free-ranging and captive conditions. First known report of genital papillomas in free-ranging bottlenose dolphins from Atlantic coastal waters came after study that covered 2000 - 2005. Bossart et al.

Papillomas

Genital papilloma a benign epithelial tumor. In this context the term frequently refers to infections caused by human papillomavirus.

Papillomaviruses infect animals ranging from birds to manatees dolphins and humans. Papillomaviruses replicate in body surface tissues such as the skin, or the mucosal surfaces of the genitals, anus, mouth, or airways. Cancers caused by "high-risk" HPV types kill several hundred thousand people per year.

Lingual papillomas are those affecting the tongue.

PAHs. Polycyclic aromatic hydrocarbons.. By product of combustion of diesel and other fuels. Also from fats in meat cooked by grilling. Grilling heats the fats which then rise to adhere to the meat being cooked. PAHs occur in oil, coal, and tar deposits. Some PAHs have been identified as carcinogenic, mutagenic ,and teratogenic.

PBDEs Polybrominated diphenyl ethers are increasing in the environment. PBDEs are a class of brominated flame retardants that, like other persistent organic pollutants have been found in humans, animals and biota worldwide. Unlike other POPs the key routes of human exposure are not through food but from their use in household consumer products and household dust. PBDEs are added to plastics, polyurethane foam, textiles, and electronic equipment to reduce the likelihood of ignition and the burn rate if products do catch fire. Lorber.

High levels of PBDEs have been found in Americans. These levels have doubled every three to five year over the past thirty years and are 10 – 40 times higher than in Europe and Asia. Production of deca-BDE continues on a massive scale in the United States and should be considered a health threat to Americans. Professor Ake Mergman of the University of Sweden has said “The PBDE levels we’re seeing in the US are the highest in the world.” Professor Martin van de Berg of Utrecht University, Netherlands reports “The perinatal effects of PBDEs, especially on brain development are very real. Are we already seeing effects in the general population.”

PBDEs are found in fabrics, upholstery, foam mattresses, circuit boards, computer casings and televisions. And are found in indoor dust.

PBDEs negatively impact learning, memory, sperm counts and thyroid function in rats and mice.

PCBs Polychlorinated Biphenyls were used in industrial applications and in electrical transformers, adhesives and paints. They were banned in the late 1970s in the United States and elsewhere. They are generally decreasing in the environment. PCBs are highly resistant to breaking down and thus persistent in the environment. They have been linked to cancer and impaired fetal brain development. PCB increased starting in 1920 reaching their high point in the late 1970s and having been dropping since thru 1980 by 50%. There is no indication of a decline after 1985. PCBs were banned in 1977 in the USA.

PFCs Perfluorinated compounds are an emerging class of anthropogenic contaminants. They are used as industrial and commercial surfactants (as wetting agents that lower the surface tension of a liquid, allowing easier spreading). In contrast to the majority of organic pollutants that are deposited in fatty tissue, perfluorinated contaminants circulate in the blood and accumulate primarily in the liver. PFCs have worldwide distribution and exhibit toxicological effects in lab animals. PFCs are synthetic molecules that are thought to be extremely resistant to physical degradation, biodegradation, and biotransformation. PFCs have been detected in ringed seals in the Arctic including Canada, Greenland and the Baltic Sea. Bentzen

Phthalates are plastic softeners. Used in products including rubber duckies, vinyl shower curtains and certain medical tubing and IV bags. Also used in fragrances, body lotions, nail polishes and shampoos. Can produce abnormalities in reproductive tract and decline of sperm quality. A Danish study has shown that higher levels of a particular phthalate in mothers breast milk correlated with lower testosterone in male babies.

POPs Persistent Organic Pollutants, sometimes called PBOPs (persistent bioaccumulative organic pollutants). POPs emitted in Asia travel to the west coast of North America on the wind, dropping out along the way, deposited on the surface of oceans or aquatic ecosystems, forced into food webs very effectively.

Pg pico grams

TDI tolerable daily intake. Quantity of a substance which may be ingested daily without harm.

PTWI Provisional Tolerable Weekly Intake. Quantity of a substance which may be ingested weekly without harm.

Triazines. Herbicides including atrazine, symazine, and cyanazine. Widely used in United States. The incidence of breast cancer in the United States has increased for the past three decades. Exposure to excess estrogen, in synthetic forms such as in organochlorines, has been identified as a risk factor for the development of breast cancer. Organochlorines, such as the triazine herbicides, are thought to be implicated in the etiology of human breast cancer. A survey conducted in Kentucky revealed a statistically significant increase in breast cancer risk with medium and high levels of triazine exposure.

Xenobiotic: a chemical which is found in an organism but which is not produced by that organism. It can also cover substances that are present in much higher concentrations than are usual. Antibiotics are xenobiotics in mammals. The term is also used in the context of pollutants such as dioxins and polychlorinated biphenyls.

Trichloroethylene (TCE) a solvent used in adhesive, paints and spot removers. The National Academy of Sciences reported in 2006 that TCE is a likely carcinogen. It is known to cause cancer in lab rats. The report said TCE is a possible cause of kidney cancer, reproductive and developmental damage, impaired neurological function and autoimmune disease, reported John Heilprin of the AP.

Unusual Mortality Event (UME) can be designated by the National Marine Fisheries Service in the event of the death of a large number of marine mammals. This designation releases funds to investigate the event.

Xenoestrogens: Chemicals present in many pesticides, petroleum products, plastics, and products such as furniture, computers and baby's clothing can disrupt the endocrinal or hormonal systems of mammals. These chemicals are known as xenoestrogens because they mimic the action of naturally produced estrogens.

THE INABILITY OF DOLPHINS TO METABOLIZE CERTAIN PCBs

As we learn of the increasing levels of organochlorine and heavy metal pollution in fish and mammals in the sea we are simultaneously finding dolphins have a lesser capacity than birds and terrestrial mammals to process these toxicants. The convergence of these factors pose catastrophic risk to dolphin populations worldwide.

In a paper entitled CAPACITY AND MODE OF PCB METABOLISM IN SMALL CETACEANS five Japanese scientists (Shinsuke Tanabe et al) determined that all species of small cetaceans can metabolize some of the lower chlorinated biphenyls. They further determined that **the metabolic capacity to process certain PCBs of small cetaceans was extremely low as compared to those of birds and terrestrial mammals.** They found that small cetaceans have no capacity to metabolize a group of PCBs with adjacent non-chlorinated meta and para carbons in biphenyl rings.

CYP1A1 – A Telltale Gene

CYP1A1 – Because CYP1A1 is activated by exposure to POPs it is considered a bio-marker for those chemicals. It is also a possible trigger for cancer.

Although dolphins share most human mammalian genes, including CYP1A and CYP2B, they lack the ability to adequately catabolize type I and II dioxins, which therefore preferentially accumulate. Observed results of these bioaccumulations are suppressed immunity, infections, and cancers, including B-cell lymphomas and “myeloma-like” immunoblastic lymphomas. (*Bossart*) Studies are now underway to correlate recent bioaccumulation of POPs in dolphins and humans, genetic predispositions and myeloma onset. Probability calculations for risk of developing myeloma will support interventions to reduce both contamination of the marine environment and elimination of toxic exposures. *Durie and Jones*.

CYP1A1 is a gene that encodes a member of the cytochrome P450 superfamily of enzymes. It is primarily involved in xenobiotic and drug metabolism. It is inhibited by fluoroquinolones and macrolides; induced by aromatic hydrocarbons. There are 3 main subtypes of CYP1A: M1, M2 and M3.

CYP1A1 and CYP1B1 are regulated by the Aryl hydrocarbon receptor, a ligand activated transcription factor. They are part of the Phase I reactions in drug metabolism.

CYP1A1 in deep blubber was significantly higher in dolphins from Charleston Harbor, SC than from the Indian River Lagoon in Florida. It was highest in pregnant-lactating dolphins. In all dolphins CYP1A1 in the deep blubber layer was positively related to concentrations of OH-PCBs in plasma. The OH-PCBs have the potential to interfere with thyroid hormone function. *Monte et al*

Cetaceans have high levels of CYP1A and low levels of CYP2B. St. Lawrence Estuary belugas have elevated levels of both enzymes, probably because CYP are induced by high levels of PCBs.” Elevated CYP1A levels may trigger intestinal cancer by activating ingested PAHs into carcinogenic compounds.” *Martineau. Environmental Health Perspectives 3/2002*

The Striking Similarity Between Human and Dolphin Genomes

Humans and dolphins may be genetically more similar than anyone had previously imagined.

Scientists working at Texas A & M have found that the dolphin genome and the human genome as “basically the same.” Dr. David Busbee and his team including Mark Evans compared human chromosomes with those of dolphins and concluded that dolphins hold many of the same chromosomes as humans.

This similarity may help accelerate the mapping of dolphin genes.

“We started looking at these and it became very obvious to us that every human chromosome had a corollary chromosome in the dolphins,” said Busbee.

DNA is wound into a spool that constitutes a chromosome. Genes are organized along the chromosome. Two complimentary strands of DNA are wound together to produce the chromosome. Each chromosome carries different genes. Dolphins have 44 chromosomes and humans have 46.

The International Myeloma Foundation Identifies Potential Link Between Genetic Pathways And Environmental Risks For Myeloma

North Hollywood, CA, and Atlanta, GA,
December 11,2007

The International Myeloma Foundation (IMF) <http://www.myeloma.org> today said findings from its myeloma DNA bank identified genetic links to bone disease in multiple myeloma, a cancer of cells in the bone marrow, that in some cases can also include bone deterioration. These findings also may both support and explain associations that have been observed between environmental toxins such as dioxins and benzene, and an increased risk for myeloma. The findings were made with resources from Bank On A Cure® (BOAC), the world's first repository of DNA samples created to advance the understanding of myeloma. They were presented at the 49th Annual Meeting of The American Society of Hematology in Atlanta on December 11th.

The study found that genetic pathways associated with the ability to neutralize environmental toxins are defective in patients with classic myeloma (myeloma with bone involvement). These pathways are identified as specific segments of genes called single nucleotide polymorphisms or SNPs that are known to be associated with toxin metabolism and DNA repair. These findings are in line with observations of patient populations and groups of workers including firefighters that had previously demonstrated a correlation between increased risk for myeloma and exposure to hydrocarbons and related chemicals.

"Identifying these genetic pathways was unexpected," said Brian G.M. Durie, M.D., chairman of the International Myeloma Foundation and lead author of the BOAC presentation. "We were looking at bone biology and the SNPs associated with toxin metabolism fell into place. Now, working back through the gene pathways, we have a robust model of myeloma bone disease that may explain the epidemiological observations."

*Abstract #816: "Genetic Polymorphisms Identify the Likelihood of Bone Disease in Myeloma: Correlations with Myeloma Cell DKK1 Expression and High Risk Gene Signatures" Brian G. M. Durie, MD, Chairman, International Myeloma Foundation

New Bioaccumulations of Toxins in Resident Coastal Dolphins Signal Dangers of Human Myeloma.

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Dolphins and humans are exposed to the same toxins in seafood. Over 2 billion people worldwide rely on seafood as their major source of protein and 60% of people live in coastal areas. Resident coastal dolphins are exposed to marine pollution in the same fashion as humans who frequently consume seafood, thus any indication of disease in dolphins has implications both for humans who eat regularly from the same areas and/or are otherwise exposed to the same toxins.

Although ecotoxicologic studies of marine environments are very complex, (Irwin: Aquatic Mammals 31: 195–225, 2005), the bottlenose dolphin is a sentinel species for biomonitoring purposes. Tissue levels of many known carcinogens such as DDT, DDE, dioxins (e.g. PCDDs and 2,3,7,8 TCDD), BaP, PAHs, and more recently PFC and PBDEs (water repellants and fire retardants), reflect bioaccumulation in both dolphins and humans. Target sites where human and dolphin disease have been contrasted and compared are: North America (Alaska; Puget Sound; San Francisco Bay; Gulf Coast and Florida; St. Lawrence Seaway); Japan (Osaka Bay); Sweden; Coastal UK and Hong Kong (Pearl River estuary). For Alaska, Florida, Japan, Sweden and coastal UK, there are highly significant correlations between fish contamination/ consumption and excess risk of human myeloma. Inuit people who eat contaminated fish, have high organochloride (dioxins) levels in blood and tissues and an increased risk of myeloma. Likewise for Swedish fisherman comparing Baltic (more contamination) versus west coast levels of dioxins and myeloma. In Japan, a case control study provides a highly significant odds ratio of 5.89 for agriculture/ fisheries as occupational factors. A separate study gives an annual age adjusted incidence of 7.03/100,000 for the Osaka Bay fishing region. Around Lake Okeechobee Florida an incidence rate of 6.52/100,000 correlates with both contamination and commercial fishing licenses.

Although dolphins share most human mammalian genes, including CYP1A and CYP2B, they lack the ability to adequately catabolize type I and II dioxins, which therefore preferentially accumulate. Unfortunately, observed results of these bioaccumulations are suppressed immunity, infections and cancers particularly B–cell lymphomas and “myeloma–like” immunoblastic lymphomas (Bossart: J. Vet Diagn Invest 9: 454–458, 1997). This pattern of diseases in turn corresponds with the local and systemic effects exemplified in Balb/c mice during pristane–induced plasmacytogenesis and in humans exposed to toxins.

Newly recognized persistent organic pollutants such as water repellants (PFCs) and flame–retardants (PBDEs) are a particular concern, both because of rapid recent bioaccumulation in dolphins with associated disease manifestations plus the potential for wide global dispersal and diverse routes of human exposure. Numerous consumer goods contain PBDEs, including electronics, carpets,

furniture and textiles. Genetic studies help refine probability calculations to assess risk using the union rule for independent events. Studies are now underway to correlate recent bioaccumulations in dolphins and humans, genetic predisposition and myeloma onset. Probability calculations for risk of developing myeloma will support interventions to reduce both contamination of the marine environment and elimination of human toxin exposures.