CHEMICAL EXPOSURES FOR COOK INLET BELUGA WHALES

A LITERATURE REVIEW AND EVALUATION

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This report is intended to help inform scientists and administrators with the National Marine Fisheries Service in their efforts to conserve and promote the recovery of Cook Inlet beluga whales. It has been produced by toxicologists and environmental scientists in the Oakland and Anchorage offices of URS Corp. The presentation of information and recommendations for additional toxicological investigations represent the professional judgments of the URS authors alone. This report is advisory in nature and does not require NMFS to take any action based on its recommendations.

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TABLE OF CONTENTS

TABLE OF CONTENTS

Tables

Acronyms

APE	alkylphenoxyethoxylate
BPA	bisphenolA
CIB	Cook Inlet beluga
DDT	dichlorodiphenyltrichloroethane
EDC	endocrine disrupting chemical
EPOC	emerging pollutant of concern
HBCD	hexabromocyclododecane
LOAEL	lowest observed adverse effect level
NOAEL	no observed adverse effect level
NMFS	National Marine Fisheries Service
OC	organochlorine
OP	organophosphate
PAH	polycyclic aromatic hydrocarbon
PBDE	polybrominated diphenyl ether
PBT	persistent bioaccumulative toxic
PCB	polychlorinated biphenyl
PFC	perfluorinated compound
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
POP	persistent organic pollutant
POTW	publicly operated treatment works
PPCP	pharmaceutical and personal care product

S/H	steroids and hormones
USEPA	United States Environmental Protection Agency

The National Marine Fisheries Service (NMFS) is currently implementing management strategies that are geared towards promoting the recovery of the beluga whale population in Cook Inlet. The Conservation Plan for this beluga population includes a number of elements related to ensuring the survival and reproductive success of the whales.

The Cook Inlet population of beluga whales has declined from approximately 1,300 animals in 1979 to a current estimate of 321 animals. Aggressive conservation efforts have been implemented from the 1990s onwards and include elimination of subsistence hunting and habitat protection. Despite these measures, the population continues to decrease and recovery is slower than expected. Therefore, NMFS is attempting to identify other causative factors or agents that may play a role in impeding recovery of the population. Because the whales are clustered in a near-shore environment where point and non-point source discharges may release chemicals and disease agents into Cook Inlet, NMFS has identified these as additional factors that may have the potential to adversely affect beluga whale recovery. This report provides a preliminary overview of the potential for chemical exposures to affect the reproductive success of Cook Inlet belugas (CIB).

A review of literature was conducted to evaluate the potential for a variety of chemicals to adversely impact the reproductive success and recovery of the CIB whale population. Chemicals were classified as conventional legacy pollutants or emerging chemicals and further categorized by chemical class, sources, uses, environmental behavior, and potential bioaccumulation and toxicity. A risk-based source to receptor approach was adopted to evaluate the chemicals. Each class of chemicals was evaluated with regard to its potential to occur in Cook Inlet and its potential to exert ecotoxicological effects. Then a judgment was made as to its potential to affect the reproductive success and recovery of the CIB population. Data gaps were identified and recommendations were developed to address the data gaps.

In general, information to characterize CIB exposures to the evaluated chemicals was very limited, particularly with respect to chemical data for water and sediment in Cook Inlet, as well as in the tissues of the foods that the whales may consume. Relevant and marine mammal-specific toxicological information was richest for organochlorine chemicals, sparse for other common chemicals and very limited or absent for the majority of the emerging chemicals and products. Some relevant studies on brominated flame retardants and perfluorinated compounds are in process for CIBs but the final results are yet to be published. The available chemical data indicate that concentrations of the chemicals detected in CIBs are typically lower than those observed in marine mammals from other areas in the Arctic. However, the potential exists for some of the detected chemicals in CIBs, e.g., polychlorinated biphenyls, to be present at concentration ranges associated with the potential for endocrine disruption and immune functions in marine mammals. Copper levels in the liver of CIBs are higher than levels at which renal damage was reported in bottlenose dolphins.

Within the framework of the available information, the evaluated chemicals were identified as probable, possible or unlikely chemicals of potential concern with respect to the recovery of the CI beluga whale population. The purpose of this designation was only to identify which chemicals may warrant further evaluation and is not meant to imply causal relationships of adverse effects. A phased approach is recommended for further evaluation to address the data gaps identified.

The National Marine Fisheries Service (NMFS) is currently implementing management strategies that are geared towards promoting the recovery of the beluga whale (*Delphinapterus leucas)* population in Cook Inlet. The Conservation Plan for this beluga population includes a number of elements related to ensuring the survival and reproductive success of the whales (NMFS 2008).

1.1 BACKGROUND

The beluga whale (*Delphinapterus leucas*) is a small toothed whale that inhabits Arctic and sub-arctic waters, with the exception of a small population in the St. Lawrence Estuary (NMFS 2008). They grow to 12 ft to 14 ft in length, weigh 1300 kg to 1500 kg, and have an average lifespan of about 50 to 60 years. Of the five recognized populations in Alaska, the Cook Inlet population is the most isolated, spending the entire year in Cook Inlet, and has been isolated for several thousand years. The spatial range occupied by the whales has contracted since the mid-1990s and they now spend the great majority of the year in the northern portion of Cook Inlet known as the Upper Inlet (Hobbs et al. 2008). In spring and summer, they are concentrated in the river mouths in the Upper Inlet near Anchorage, where they pursue anadromous fish species such as eulachon and salmon. They also feed on a variety of marine invertebrates and other fish. In the winter they tend to disperse offshore and move toward the mid Inlet.

Calving occurs from mid-May to mid-July and lactation typically lasts longer than a year, possibly up to two years. Given such a long calving cycle, the availability of energy-rich food is very important to the CIB life cycle. Reports of blubber thickness note that in the spring, blubber may be only 2-3 inches thick compared to the fall when it may be 12 inches thick. Thus, summertime feeding on salmon and other fish is critical to pregnant and lactating belugas since breeding may be occurring in late spring to early summer. Intensive summertime use of Knik Arm, Turnagain Arm, Chickaloon Bay and the Susitna River delta areas of the upper Inlet have been noted and coincide with anadramous fish migrations.

The Cook Inlet population of beluga whales has declined from approximately 1,300 animals in 1979 to a current estimate of 321 animals (NMFS 2009). It is estimated that a 47% decline occurred between 1994 and 1998 (NMFS 2008). Since 1999, when subsistence hunting was essentially eliminated as a source of mortality, the Cook Inlet beluga population has declined at a rate of 1.49% per year (NMFS 2009). A 2006 status review predicted a 68% probability that the Cook Inlet stock will continue to decline and become extinct within the next 300 years. Subsequent population modeling analyses place the probability of extinction within 300 years at 41% to 79% in the models that were considered to have parameters most representative of the Cook Inlet beluga population (Hobbs et al. 2008). The National Marine Fisheries Service (NMFS) listed the Cook Inlet beluga whale as endangered under the Endangered Species Act in 2008 (NMFS 2008b). NMFS is currently in the process of designating critical habitat and developing a Recovery Plan for this endangered population.

Conservation efforts for the Cook Inlet beluga (CIBs) were initially focused on significant reduction of subsistence hunting, which was regulated in 1998 and is now co-managed by NMFS and Alaska Native groups. Only a few belugas have been taken for subsistence purposes since 1998. NMFS anticipated that the population would recover at an annual rate of 2% to 6% after subsistence hunting was curtailed but the population continues to decrease (NMFS 2008). Therefore, NMFS is attempting to identify other causative factors or agents that may play a role in impeding recovery of the population. Because the whales are clustered in a near-shore environment where point and non-point source discharges may release chemicals and disease agents into Cook Inlet, NMFS has identified these as additional factors that may have the potential to adversely affect beluga whale recovery. This report provides a preliminary overview of the potential for chemical exposures to affect the reproductive success of Cook Inlet belugas.

1.2 CHEMICAL EXPOSURES

There is little information on the potentially deleterious effects of chemicals on the CIB population. NMFS has some data about levels of traditionally studied contaminants in CIBs (e.g., DDTs, PCBs, PAHs, etc.). However, virtually nothing is known about other emerging pollutants of concern (EPOCs) and their effects on CIB. EPOCs include endocrine disruptors (substances that interfere with the functions of hormones), pharmaceuticals, personal care products, and prions (proteins that may cause an infection), amongst other bacterial and viral agents that are found in wastewater and biosolids. Currently, the Environmental Protection Agency (EPA) does not require monitoring of these types of pollutants, and thus the potential impacts on CIBs from conventional pollutants and EPOCs in wastewater entering Cook Inlet have not been analyzed and cannot be defined at this time.

The potential number of biologically active compounds and agents in the Cook Inlet environment is enormous and there are likely to be complex hydrological and ecological interactions affecting the potency and exposure levels of these compounds for CIBs. In addition, there are several potential vectors (water, sediment, prey) for CIB exposure, and efforts to identify causal links between particular toxins and CIB health will require a multi-phased, long-term research program.

The objective of this report is to help NMFS begin to address this potentially important threat to CIBs by narrowing the list of compounds and agents that should be investigated and focus the research parameters on those most likely to have effects on CIBs. This information can be used to initiate the next phase of the evaluation, which will be to design a conceptual sampling and analysis plan.

This report provides an overview of the literature review, a summary of the findings and conclusions and presents recommendations for further evaluation.

URS pursued a risk-based approach to identifying the potential influence of toxic chemicals on the health and reproductive success of CIBs. This is also consistent with EPA recommendations to evaluate emerging chemicals (Daughton 2001). The risk-based approach attempts to evaluate chemicals by establishing linkages from the sources of the chemicals to the ultimate receptor species (CI belugas) by tracing release mechanisms for the chemicals from their sources, subsequent migration pathways, final exposure media and exposure routes that result in chemical contact with the receptor. By tracing the source to receptor pathway, it is possible to estimate potential exposure doses and quantify potential risks, as long as corresponding toxicity information is available. By the same token, if the source to receptor pathway is demonstrated to be incomplete at any stage, no risks are likely to the receptor. There is no risk where there is no exposure.

The first task was to conduct a broad-based literature review of current research and develop a risk assessment framework for CIBs that identifies those pollutants of most concern. The second task will be initiated after NMFS review of the recommendations from the first task and will develop a conceptual sampling and analysis plan to help NMFS identify the potential costs of additional investigations.

2.1 NATURE OF CHEMICALS UNDER EVALUATION

Both conventional and emerging chemicals are included in this evaluation. However, commonly used terminology to identify chemicals of environmental concern includes a sometimes confusing combination of terms that may refer to chemical groups (e.g., PCBs or DDTs), environmental behavior (e.g., persistent organic pollutants [POPs] or persistent, bioaccumulative and toxic [PBT]), mechanisms of toxicity (e.g., endocrine disrupting chemicals [EDCs]), chemical sources (e.g., coal tars) and uses (e.g., flame retardants).

Many of the legacy chemicals or conventional chemicals with the potential to affect the reproductive health of various species have been much discussed in the literature (e.g., chlorinated pesticides). Emerging chemicals constitute an extremely broad and diverse array of chemicals and physical structures from multiple sources. The sources, uses and environmental behavior of these chemicals can also be very variable and wide-ranging with overlapping and sometimes confusing terminology.

To enable the reader to understand the information presented in the later sections of this report, basic information regarding the broad general groups, chemical classes, and examples of individual constituents were compiled in Table 1. For each of these chemical groups, the sources, uses and relevant environmental behavioral characteristics (e.g., propensity to solubilize in water or remain associated with sediments, potential to accumulate in biological tissues) of the evaluated chemicals were then compiled in Table 2.

2.2 POTENTIAL FOR OCCURRENCE OF EVALUATED CHEMICALS IN WASTEWATER

Although the evaluated chemicals may be released from multiple sources into multiple environmental media, the goal of this report is to focus on sources with the greatest potential for release into Cook Inlet. This includes consideration of wastewater discharges from point sources and non-point sources such as storm water runoff. These are the sources most likely to release into the near-shore environment where the CIB population spends much of its time.

A search of NPDES permit documents and non-point source literature for Cook Inlet and for Alaska revealed a limited amount of specific information regarding the presence or absence of the evaluated chemicals in the discharges. The available information primarily addressed the conventional chemicals that are included in monitoring requirements for permits such as oil and grease, a few metals, and PAHs.

Information on emerging chemicals that were specific to Cook Inlet was very sparse. Therefore, the literature search was expanded to national sources. The most useful and relevant sources included recent publications from USEPA regarding extensive surveys and analyses of wastewater from a sample population of treatment plants around the United States, with differing levels and types of treatment (USEPA 2009). Both untreated influent and treated effluent from the plants were analyzed for a large number of emerging chemicals such as pharmaceuticals, personal care product residues and surfactants.

2.3 POTENTIAL FOR EXPOSURE AND TOXICITY OF EVALUATED CHEMICALS TO CIBS

Within the risk assessment paradigm, it is accepted that “the dose makes the poison” (Klaasen 2008). Thus for adverse effects to occur, a chemical must be toxic and CIBs must be exposed to the toxic chemicals at concentrations that are sufficient to cause an adverse effect. Therefore, to evaluate health risks, it is necessary to understand both the potential for and magnitude of the exposure (exposure dose) and the potential for and severity of the effects (toxicity).

2.3.1 Exposure Media and Pathways

CIBs may be exposed to the evaluated chemicals from three media: water, sediment and food (i.e., invertebrates and fish). Airborne chemicals that have been transported long distances may also be deposited into Cook Inlet, as documented for the Arctic in general. The ubiquitous occurrence of many persistent chemicals such as chlorinated pesticides and brominated flame retardants in arctic systems are attributed to long range transport and subsequent deposition. Once they are deposited in Cook Inlet, as in other areas of the Arctic, the chemicals may be distributed in water and sediment and enter the food chain. The nature of exposure may be through direct or indirect exposure pathways. Direct pathways primarily involve ingestion of water or sediment that contains chemicals. Dermal contact with these media may also contribute to the direct pathway, although probably to a much less significant degree. Indirect exposure pathways involve exposure to chemicals through the food-web, i.e., by consumption of prey items such as fish or invertebrates that contain the chemicals in their tissues.

Bioaccumulation is the tendency of a chemical to accumulate in biological tissue (USEPA 1998). Biomagnification is the tendency for a chemical to accumulate in tissues at concentrations greater than the surrounding media and increase in concentration with increasing trophic level, e.g., PCBs). For non-polar organic chemicals, the potential for bioaccumulation can be estimated using the chemical-specific octanol-water partition coefficient (log K_{ow}). Chemicals are typically considered bioaccumulative if the log K_{ow} is in the range of 3.5 to 6.5 with lower bioaccumulation potential outside of this range (USEPA 2000). However, for the evaluated chemicals that are complex or unknown mixtures (e.g., pharmaceuticals), the potential for bioaccumulation could be evaluated only by field reports as to their occurrence in the tissues of aquatic biota such as invertebrates, fish or marine mammals. For chemicals with the potential to bioaccumulate or biomagnify, the exposure dose to the ultimate consumer from these prey items may be far greater than the exposure from direct contact with abiotic media.

2.3.2 Toxicity to Marine Mammals and Prey Species

For all biota, toxicity is a function of exposure and effect levels. Exposure to a chemical and subsequent intake into the body does not automatically mean that adverse effects have occurred or will occur. Even after intake, biological systems have several means of addressing chemical insult including avoidance, excretion, sequestration, detoxification, and transformation to less toxic products. Toxic effects may be exerted if these mechanisms become overwhelmed or ineffective, or if equally toxic or more toxic daughter products result from metabolic processes (e.g., some PAHs).

Toxic effects may occur under conditions of short-term or long-term exposure. Short-term exposures related to events such as chemical spills may lead to animals being exposed to high concentrations of chemicals over a relatively short term period. Such exposures (termed “acute” exposures) may result in severe adverse effects such as mortality or incapacitation. “Chronic” exposures are associated with long-term (e.g., during a sensitive life-stage or life-time or multigenerational exposure duration) exposures to lower chemical concentrations from sources such as continuous discharges and contaminated sediments. Chronic exposures may result in more subtle adverse effects such as alterations in development, growth and reproductive success.

For many chemicals, the risk assessment paradigm applies the concept of a “safe dose or concentration” or “acceptable dose or concentration” below which adverse effects would not be likely to occur (USEPA 1998). Such threshold values may be applied at the population level or the individual level of the target receptor species. For a “depleted species” such as the CIB, the “safe dose” should represent a chemical concentration in whale tissue or in the media to which the whales might be exposed (water, sediment, prey) that would not be likely to cause adverse effects in a single individual whale. When based on controlled exposure and dose-response studies, the threshold values may represent No Observable Adverse Effects Levels (NOAELs) or Lowest Observed Adverse Effects Levels (LOAELs). NOAEL values are typically lower than LOAEL values based on studies that examine the same test endpoints.

In addition to relevant chronic toxicity information on CIBs, the search included literature on other populations of beluga whales, other cetaceans, and related species from which inferences regarding potential effects on CIBs may be drawn. Relevant literature on biomagnification and food web linkages was also included. The literature search focused on identifying chemicals and their associated doses that result in effects on sub-lethal endpoints that are relevant to population sustainability, e.g., growth, development, time to maturity and reproductive success under conditions of chronic exposure.

Direct toxicity of the evaluated chemicals to the CIB prey species (aquatic invertebrates and fish) was also evaluated, since losses in prey populations may impact the dietary needs of the CIB. Toxicity to fish and invertebrates may be evident as acute toxicity (mortality or severe systemic impacts resulting from short-term exposures to high concentrations) or chronic toxicity (sub-lethal impacts on growth and reproduction resulting from long-term exposures to lower concentrations). Endocrine disruption (interference with the normal functioning of hormonal and endocrinal activities and organs) has also been documented and substances causing such effects are termed EDCs.

The sources of toxicological literature that were searched included literature suggested by NMFS as well as peer-reviewed publications, agency-published reports from USEPA and other agencies and toxicological databases. The primary and most useful sources of exposure and/or toxicity literature included the following:

- Reports on the St Lawrence Estuary population of belugas. This population is in a heavily industrialized area and has been studied extensively for potential effects of pollution on the health of belugas.
- ERED - Environmental Residue Effects Database maintained by the US Army Corps of Engineers and the USEPA. Focus is on biological effects and tissue contaminant concentrations measured simultaneously in the same organism. Accessed at: http://el.erdc.usace.army.mil/ered/
- HSDB – Hazardous Substances Database maintained by the National Institutes of Health. Peer reviewed toxicology data for about 5000 chemicals. Accessed at: http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB
- RAIS – Risk Assessment Information System maintained by Oak Ridge National Laboratories database (ORNL). Focus is on terrestrial and aquatic ecological toxicity. Accessed at: http://rais.ornl.gov/tools/eco_search.php
- MEDLINE- Database of medical and veterinary medical information, maintained by the National Libraries of Medicine. Accessed at: http://www.nlm.nih.gov/services/veterinarymed.html
- TOXNET – Toxicology Data Network, maintained by the National Library of Medicine, providing access to multiple databases. Accessed at: http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?index.html
- TOXLINE – Maintained by the National Institutes of Health. References from toxicology literature. Accessed at: http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?TOXLINE
- ATSDR – Toxicological profiles maintained by the Agency for Toxic Substances Disease Registry. Although the emphasis is on human health, information on ecological toxicity is also included. Accessed at: http://www.atsdr.cdc.gov/toxprofiles/index.asp
- Cal-ECOTOX – Ecotoxicological database maintained by the California Office of Environmental Health Hazard Assessment (OEHHA). Includes a few marine mammal species. Accessed at: http://www.oehha.ca.gov/cal_ecotox
- AQUATOX – Aquatic toxicity database maintained by USEPA. Focus is primarily on invertebrates and fish although some aquatic mammalian information is included. Accessed at: http://cfpub.epa.gov/ecotox/
- AGRICOLA – National Agricultural Library's database of agriculture and allied disciplines. Accessed at: http://agricola.nal.usda.gov/

- Peer Reviewed literature – publications focusing on the exposure and/or effects of chemicals on marine mammals

Because of the large number of emerging chemicals and because many of them are multi-chemical products, the database search was not exhaustive or deep. The primary focus of the database search was to see whether exposure or toxicity information relevant to CIBs was available. A detailed review of the nature and quality of the information was not performed.

The large volume of information that was collected, compiled and reviewed is presented in the form of summary tables in this report. This section provides brief summaries of the findings and conclusions of the review. The reader is referred to the accompanying tables for the detailed information.

3.1 TERMINOLOGY FOR EVALUATED CHEMICALS

To simplify the terminology for the current review, the large number of chemicals that may have the potential to adversely impact the beluga whale population are placed into two major categories, as illustrated in Table 1. These are conventional and legacy chemicals, and the EPOCs.

Among the conventional and legacy chemicals, population-level effects are most commonly associated with PBT chemicals, sometimes also called persistent organic pollutants (POP). Table 1 summarizes the most common chemical classes of PBT chemicals (e.g., chlorinated pesticides) and provides examples of individual chemical compounds (e.g., DDT).

Table 1 also lists emerging substances. These may fall into three categories: chemical, physical and biological agents. The chemical agents are commonly known both by chemical class (e.g., phthalates) and by use (e.g., pharmaceuticals). They include numerous types of industrial and consumer products and their chemical intermediates, and the vast number of individual compounds cannot be easily categorized on the basis of chemical class. The emerging physical agents considered here are limited primarily to nanomaterials which are particles and engineered substances of physical dimension less than 100 nanometers (nm) and may be comprised of metals, ceramics, polymers or composite materials. The emerging biological agents are prions which are proteinaceous infectious agents that are associated with neural effects and diseases. Nanomaterials and prions are substances whose chemical properties in the environment are poorly known and understood with respect to ecotoxicity. They are included in the literature review for the purpose of comprehensiveness.

The majority of the evaluated chemicals are complex organic compounds. Halogenated compounds (i.e., chlorinated and brominated compounds) are heavily represented in the class of PBT chemicals. Among the metals, only a few (e.g., mercury, selenium) are generally considered to be of significant concern to organisms at the upper trophic levels such as the CI belugas. This table is meant for illustrative purposes only and does not provide an exhaustive list of the hundreds of individual chemicals that may fall under the two categories or all the constituent chemicals that comprise the category of pharmaceutical and personal care (PPCP) products.

Definitions used by USEPA (2009b) to describe emerging chemicals of concern are included below:

Pharmaceuticals and Personal Care Products (PPCPs) – A variety of pharmaceuticals and personal care products are used by individuals for personal health or cosmetic reasons. Pharmaceuticals include over-the-counter medication (e.g., aspirin, acetaminophen, and pseudoephedrine) as well as medications prescribed by a physician (e.g., Lipitor®, albuterol, amoxicillin). Most ingested pharmaceuticals are only partially metabolized, so a portion is excreted, unmetabolized, in urine or feces. Metabolized and unmetabolized pharmaceuticals are discharged in domestic sewage.

Personal care products include chemicals such as soaps, detergents, shampoo, cosmetics, sun-screen products, fragrances, insect repellants, and antibacterial compounds. An example of a personal care product is triclosan, a potent wide-spectrum antibacterial and antifungal agent. Personal care products enter domestic wastewater from bathing, laundry, and household cleaning.

Steroids and Hormones (S/H) – Steroids and hormones include both naturally occurring compounds and synthetic analogues that are structurally related to one another. Hundreds of distinct steroids are found in plants and animals. Sterols, which are steroid-based alcohols, are the most abundant of the steroids. The most common sterol in vertebrates is cholesterol, which is found in cell membranes and also serves as a central intermediate in the biosynthesis of many biologically active steroids, including bile acids, corticosteroids, and sex hormones.

Hormones are intercellular chemical messengers. They are synthesized and secreted from a cell and act in low concentrations by binding to a stereospecific target-cell receptor to activate a response. Some hormones are classified by chemical structure as steroids. Steroid hormones include the sex hormones, which are, among others, natural estrogens, synthetic estrogens such as EE2 (17 alpha-ethinyl estradiol), progesterone, and testosterone. Other hormones are polypeptides or amino acid-derived compounds. Plant steroids can mimic animal sex hormones.

Alkylphenols and Alkylphenol Ethoxylates (APEs) – Alkylphenol ethoxylates (APEs) are synthetic surfactants used in some detergents and cleaning products. The most common APEs are nonylphenol ethoxylates (NPEs), derived from nonylphenol (NP), which is an alklyphenol. Octylphenol ethoxylates (OPEs), derived from octylphenol (OP), are also common.

Bisphenol A (BPA), also known as 4,4'-isopropylidenediphenol, is an organic compound used primarily to make polycarbonate plastic and epoxy resins. Polycarbonate is used in eyeglass lenses, medical equipment, water bottles, CDs, DVDs, and many other consumer products. Among the many uses for epoxy resins are can coatings, industrial floorings, automotive primers, and printed circuit boards.

Polybrominated Diphenyl Ethers (PBDEs) – Polybrominated diphenyl ethers (PBDEs) are structurally similar to Polychlorinated biphenyl. PBDEs are major components of commercial formulations often used as flame retardants in furniture foam (e.g., pentaBDE), plastics for TV cabinets, consumer electronics, wire insulation, back coatings for draperies and upholstery (e.g., decaBDE), and plastics for personal computers and small appliances (e.g., octaBDE). These chemicals slow ignition and rate of fire growth.

Pesticides – Pesticides are any of a large number of unrelated chemicals that are used to prevent, destroy, or repel a living organism that occurs where it is not wanted (i.e., a pest). Pesticides are often referred to according to the type of pest they control (e.g., insecticides, rodenticides, fungicides). Pesticides include organochlorine, organophosphorus, triazine, and pyrethroid pesticides.

3.2 SOURCES, USES, AND ENVIRONMENTAL BEHAVIOR OF EVALUATED CHEMICALS

The chemical classes identified in Table 1 are associated with a great variety of sources and uses. These are summarized in Table 2 and illustrate that emerging substances may come from both synthetic (e.g., pharmaceuticals) and naturally occurring sources (e.g., mine wastes) and may originate from industrial as well as non-industrial activities. It is also notable that many of the PBT chemicals are ubiquitous in the environment and may be transported aerially over long distances. Deposition of airborne chemicals has been documented as one of the major or primary sources of organohalogens to Arctic systems.

Table 2 also summarizes a few of the environmental properties that may be of relevance to evaluating exposure for Cook Inlet belugas. There is also great variability in the physical/chemical properties and behavior of chemicals that directly affects the media of environmental exposure and the degree to which biota may be exposed. Aquatic biota such as the Cook Inlet belugas would likely be exposed to soluble chemicals primarily through the water ingestion pathway and to hydrophobic (water repelling), lipophilic (dissolving in fatty substances) chemicals such as PCBs through sediment ingestion or through the consumption of prey.

It is also interesting to note that there are chemicals with intermediate or unknown behavior. For example, the perflouoronated compounds (PFOS and PFOA) exhibit both hydrophobic and lipophobic properties, i.e., they tend to repel both water and fatty media. Thus, despite their widespread occurrence, their potential to accumulate in tissues may be low. Additionally, the huge diversity of pharmaceutical and consumer chemicals are likely to vary widely in their potential for persistence, uptake and transformation in the environment.

3.3 POTENTIAL FOR OCCURRENCE OF EVALUATED CHEMICALS IN COOK INLET WASTEWATER

The evaluated chemicals may enter the environment through a variety of sources and mechanisms (e.g., aerial deposition, point source discharges). However, discharges that enter Cook Inlet in the vicinity of the preferred habitat of the CI belugas may be of particular relevance and significance with regard to identifying potential exposures. Table 3 presents the results of the search to identify permitted and non-point source discharges to Cook Inlet and the results of chemical monitoring of the permitted discharges, supplemented by information from national wastewater studies.

Among the legacy chemicals, local and national sources have identified the occurrence of several pesticides of all classes (chlorinated OC, organophosphate OP and triazine pesticides, pyrethroids), metals, and petroleum hydrocarbon chemicals in effluent wastewater. Compounds representing certain classes of emerging chemicals, primarily phthalates (numerous industrial and consumer uses), a variety of antibiotic and non-antibiotic pharmaceuticals, phenols (detergents and cleaning products) and sterols (synthetic and natural hormone products) were detected in effluent wastewater.

The most relevant and recent study of emerging chemicals in wastewater is a study released by USEPA (USEPA 2009). In a staged study of nine publicly operated treatment works (POTWs), EPA initially focused on six types of emerging chemicals: pharmaceuticals and personal care products (PPCPs), steroids and hormones (S/H), alkylphenols and alkylphenol ethoxylates (APEs), bisphenol A (BPA), polybrominated diphenyl ethers (PBDEs) and pesticides. Five of the nine treatment plants in the study included both primary and secondary treatment in their wastewater processing. The remaining four did not have primary treatment but included secondary treatment consisting of oxidation ditches, sequential aerobic/anaerobic treatment, or sequential batch reactors. All nine POTWs had chlorine or ultra-violet disinfection of their effluent. EPA did not collect intermediate samples to evaluate the efficacy of various stages or types of treatment.

Where the wastewater studies included analysis of both untreated influent and treated effluent wastewater, it was noted that the level and type of treatment resulted in the removal and reduction in concentration of the chemicals, often by an order of magnitude or more. Typically, no chemical class was completely removed by treatment, even if fewer representatives were detected in effluent, compared to influent (e.g., chlorinated pesticides and antibiotics). Numerous PPCPs were detected in both influent and effluent. However, sterol concentrations were significantly reduced in effluents and the 15 analyzed hormones detected in untreated influent were not detected in effluent. APEs and BPA were infrequently detected in influent and even more infrequently reported in effluent. PBDE congeners were detected in both influent and effluent, but usually at lower concentrations in the effluent. A large number of pesticides that were detected in untreated influent were not detected in effluent, particularly the OC, OP and triazine pesticides. However, at least a few representatives of each class were detected in effluent.

The Asplund Water Pollution Control Facility at Point Woronzof serves the entire Anchorage area. This is a primary treatment facility that provides screening, grit removal, sedimentation, skimming, and chlorination of incoming wastewater (NMFS 2008). Data on emerging chemicals in the discharged wastewater are not available. However, since primary treatment consists essentially of removal of solid phase material, it is likely that any chemical present in soluble form in the influent water will remain in the discharged effluent. It is also likely that the type of reduction in the numbers and concentrations of chemicals seen in the EPA study would not be observed here at the same magnitude due to the lack of secondary treatment.

The presence or potential for occurrence of the evaluated chemicals in non-point source runoff was also evaluated. Local sources report the detection of dieldrin, PCBs, metals, PAHs, petroleum hydrocarbons and phthalates in runoff entering Cook Inlet (USEPA 2009b, ARC 2008, Frenzel 2002). Numerous national studies have also documented the occurrence of PPCPs and other emerging chemicals in urban and rural receiving waters, although generally at low concentrations (USGS 2002).

The absence of data regarding the occurrence and concentrations of the evaluated chemicals, particularly emerging chemicals, in wastewater discharges to Cook Inlet and in the near-shore surface water of Cook Inlet itself represents a data gap.

3.4 ECOTOXICITY AND BIOACCUMULATION OF EVALUATED CHEMICALS

The potential ecotoxicity of the chemicals was evaluated in relation to three aspects that are relevant to the reproductive success and recovery of the CI beluga whale population: (a) direct toxicity to prey species that could result in low food availability to CIBs; (b) bioaccumulation potential of the evaluated chemicals that could lead to subsequent indirect exposure for CIBs that could result in indirect toxicity to CIBs through ingestion of prey containing the bioaccumulated chemicals and (c) toxicity to CIBs through direct exposure pathways such as ingestion of water and sediment under conditions of acute or chronic exposure or indirect exposure through the foodweb.

3.4.1 Direct Toxicity to CIB Prey Species (Invertebrates and Fish)

As expected, a large amount of information is available regarding direct toxicity and NOAEL and LOAEL-based concentrations in sediment and water for conventional and legacy chemicals (i.e., pesticides, PCBs, PAHs, metals) in relation to aquatic invertebrates and fish. Among the emerging chemicals, toxicity information is available for some chemical groups such as the flame retardants, detergents and plasticizers (e.g., PBDEs, phenols, phthalates). There was limited or no information regarding other chemical groups such as PPCPs. There is limited information regarding the toxicity of nanomaterials to aquatic invertebrates and fish. No relevant information was found regarding prions.

The direct toxicity of the evaluated chemicals to CIB prey species showed a range of acute and chronic toxicity potential. As noted in Table 4, a large number of chlorinated chemicals are not acutely toxic to fish and invertebrates at the range of concentrations typically seen in the environment but are known to exert toxic effects on reproduction and development, particularly at sensitive life-stages, under conditions of chronic, low-level exposure. Some of the evaluated chemical classes are less persistent but more closely associated with acute toxicity to aquatic biota. These include some of the pyrethroid pesticides, OP pesticides, the lighter PAHs and surfactants.

Little information was available regarding the toxicity of PPCPs and other emerging chemicals to aquatic invertebrates and fish. In general, they appear to have low potential for acute toxicity, and low to moderate or unknown potential for chronic toxicity. The lack of comprehensive toxicity information for these chemicals constitutes a significant data gap.

The toxicity of nanomaterials to aquatic invertebrates has been reported in a few studies that suggest behavioral changes due to nanoparticle exposure may lead to increased risk of predation and reproductive decline in invertebrates and developmental impairment in fish embryos but the findings are still under review and debate (Lovern et al. 2007, USEPA 2007).

Overall, due to their low potential for acute toxicity (at environmental concentrations), sudden or short-term impacts to CIB food supplies such as fish-kills or rapid die-offs related to the evaluated chemicals appear to be unlikely. The one exception is potential toxicity related to deicing glycols that are heavily used at Anchorage airports and anecdotal reports of fish-kills observed in the vicinity. Glycols are soluble and non-persistent compounds that are generally not considered to be toxic to aquatic biota. Chronic no-effects concentrations for freshwater invertebrates are estimated at 8,590 mg/l (Inchem, undated). However, heavy usage of glycols followed by permitted discharges or non-point runoff may lead to localized areas of high concentrations in receiving waters at several airport locations around the country. The potential appears to exist for such conditions to occur in Cook Inlet, near the Ted Stevens International Airport.

3.4.2 Bioaccumulation Potential

In reviewing the bioaccumulation potential of the evaluated chemicals, as listed in Table 4, it is apparent that this phenomenon is well-established for PBT and legacy chemicals such as the chlorinated pesticides, PCBs, dioxins and certain metals. These chemical classes have been detected in the tissues of aquatic invertebrates, fish and marine mammals in the Arctic regions

(AMAP 2002). This is also true for the polybrominated and perfluoronated compounds and many phthalates (Goertz et al 2009, Noel et al 2009, Ylitalo et al 2009).

However, among the other emerging chemicals, reports of occurrence in aquatic tissue appear to be limited to a few antidepressants and antihistamines and musk-based fragrances in fish liver, based on a pilot study (USEPA 2008). Whether emerging chemicals have been analyzed but not found in aquatic tissue or whether they have not been analyzed at all is unknown. This finding is a source of uncertainty and is considered a significant data gap identified in this literature review.

Existing literature documenting bioaccumulation in CI belugas includes the following chemicals: organochlorine pesticides such as DDTs, chlordanes, dieldrin, mirex, PCBs, mercury, selenium, silver, vanadium, cadmium and copper.

Some preliminary research appears to indicate some potential for bioaccumulation for naomaterials (Luo 2007). No information was found regarding bioaccumulation potential for prions.

3.5 TOXICITY TO BELUGA WHALES/MARINE MAMMALS

Although the literature is rich in reports of measured concentrations of some of the evaluated chemicals in marine mammals, reliable and quantitative information that related measured body burdens to observed adverse effects is lacking, especially within a dose-response context (Letcher et al. 2009, Vos et al 2003). The greatest amount of information is on persistent organic pollutants such as organochlorine residues (PCBs, DDTs, chlordanes, lindanes), measured primarily in blubber, followed by fewer studies on methylmercury and other metals in liver and muscle tissue. Very little or no relevant toxicity information was available for marine mammals regarding the majority of the emerging chemicals including nanomaterials and prions.

Organochlorines

A wide range of effects associated with organochlorines has been reported for marine mammals, including cancer, OC-induced immunosuppression and increased susceptibility to infection, premature parturition, thyroidal dysfunction, compromised lactation, morphological lesions, and other effects, especially in the published literature about the St. Lawrence Estuary beluga whales and some others (Ross et al. 1996, Lebeuf et al 2001, 2004, 2007, 2009, Montie 2006). However, there is very little literature regarding dose-response relationships or reliable NOAELs and LOAELs for marine mammals. The only examples of acceptable threshold concentrations of chemicals in marine mammal tissue that were reported in the literature are for PCBs. Kannan et al. (2000) and Loseto et al. (2009) provide the following threshold values:

PCB endocrine effects threshold = 1.3 mg/kg, lipid

PCBs disease-associated mortality threshold = 10 mg/kg, lipid

PCBs immunotoxicity threshold = 17 mg/kg, lipid

Metals

Some metals are trace elements that are considered to be essential micronutrients and marine mammals, like other biota, may be able to regulate the uptake of such chemicals to some degree (e.g., copper, nickel, zinc). Other metals such as cadmium, lead and mercury are non-essential and potentially toxic. Marine mammals appear to be able to accumulate relatively high concentrations of metals before toxic effects are noted (Sonne et al. 2009). Prolonged exposure to metals such as cadmium, copper and zinc may be associated with renal damage and bone malformation in south Australian adult bottlenose dolphins (Lavery et al. 2009). Mercury toxicity may be manifested as sensory and motor deficits, lethargy and anorexia. Although metals may be expected to exert adverse effects on marine mammals, there is little reliable dose-response information or NOAEL or LOAEL data. Some evidence of detoxification of metals in marine mammals has also been reported. Selenium exposure has been reported to reduce the toxicity of mercury by inhibiting the methylation of mercury.

AMAP (1998, 2002) and Fant et al. (2001) provide a threshold value for total mercury and cadmium in marine mammals based on a small sample of one dolphin species:

Mercury liver damage threshold = 60 mg/kg wet weight, liver

Cadmium liver damage threshold = 200 mg/kg wet weight, liver

In the study by Lavery et al. (2009), renal damage evidence was interpreted for a few metals as follows:

Metal	Mean Low renal damage concentration (mg/kg in liver)	Mean High Renal damage concentration (mg/kg in liver)
Copper	16.02	29.72
Cadmium	4.55	37.00
Zinc	73	178

PBDEs

Among the emerging chemicals, information on PBDEs is also available, although there is little evaluation of acceptable or threshold concentrations. Other than PBDEs, no studies were found that measured levels of any of the remaining emerging chemicals in marine mammal tissue. While marine mammal exposure to emerging chemicals with potentially endocrine disrupting effects is frequently mentioned in the literature, there were no readily available studies that had quantitatively evaluated either the exposure or the effects for marine mammals. Some suggestive evidence regarding the endocrine disrupting potential, immunosuppression potential or other adverse effects associated with emerging chemicals has been published on the basis of cell culture exposure studies (DeGuise et al. 1998, Gauthier et al. 1999). However, it is difficult to derive threshold concentrations that can be applied in the field or to whole animal data using these laboratory data.

PPCPs

The available toxicity information for the majority of the PPCPs is focused primarily on laboratory studies of terrestrial mammals such as rats, mice and guinea pigs as well as in vitro cell culture and sub-cellular studies. The interpretation and use of these data to infer toxicity or the lack of it to marine mammals must be performed with caution and an understanding of the uncertainties involved. This is discussed further in Section 4.0.

Nanomaterials

Data regarding the toxicity of nanomaterials to marine mammals were not found. Preliminary data reporting toxicity to terrestrial mammals (rats) under laboratory conditions have been reported (Handy et al. 2008). However, extrapolation of rat data to marine mammals is highly uncertain and should be undertaken with caution and an understanding of the assumptions involved.

Therefore, there are significant data gaps concerning toxicity information for marine mammals. High-quality dose-response data are limited for the chlorinated chemicals and minimal or non-existent for the emerging chemicals.

3.6 POTENTIAL FOR ECOTOXICITY OF EVALUATED CHEMICALS FOR COOK INLET BELUGAS

As shown in Table 5 and Table 6, data for tissue concentrations in CI belugas are limited to organochlorines and metals from the years 1992 to 1996 (Becker et al. 2000, 2001). Preliminary data from more recent studies are also available, covering the years 1998 to 2006 (Becker 2009).

PCBs in Cook Inlet Belugas

In Becker et al (2000), mean PCB concentrations in male CI belugas averaged 1.49 ± 0.70 mg/kg in blubber of males, and 0.79 ± 0.56 mg/kg in blubber of females. Total DDT concentrations averaged 1.35 mg/kg ± 0.73 in blubber of males and 0.59 mg/kg ± 0.45 in blubber of females.

These PCB values are in the range where endocrine disruption effects may have the potential to occur and are approximately an order of magnitude lower than the thresholds for immunotoxicity and immunosuppression. Levin et al. (2005) and Shaw et al. (2005) reported enhanced lymphocyte proliferative responses (an indicator of contaminant-induced alteration in non-specific immune function) and altered immune and endocrine function biomarkers in free-ranging harbor seals at PCB concentrations in blubber as low as 2.5 to 3 mg/kg.

In a study of California sea lions, LeBoeuf et al. (2003) did not find any evidence that population growth or the health of individual sea lions had been compromised at mean total PCB concentrations of 12 mg/kg blubber weight and mean total DDTs concentrations of 37 to 41 mg/kg blubber wet weight. The PCB and DDT concentrations in CI belugas are at least an order of magnitude lower than in the California sea lions. However, it should be kept in mind that the lack of effects in the sea lion field study may not be directly comparable to CI belugas due to the differences in species, diet, and other factors.

The use of the threshold concentrations for PCBs in marine mammal tissue is subject to uncertainty. The reviewed publications varied in their use of terminology regarding lipid, blubber, dry weight and wet weight. Some authors consider blubber and lipid to be synonymous and interchangeable terms. Others differentiate between them, considering blubber to be a combination of lipids and water. Therefore, it is important to ensure that comparisons of tissue concentrations and threshold levels are based on consistent assumptions of measurement media and units.

Metals in Cook Inlet Belugas

Mercury concentrations in liver of CI belugas averaged 5.4 mg/kg (wet weight, ww) in males and 2.5 mg/kg ww in females. The dry weight concentrations of total mercury for the measured animals averaged 16.3 mg/kg. These values are below the mercury liver threshold value of 60 mg/kg. However, there is a high degree of uncertainty associated with this threshold value.

Copper concentrations in the liver of CIBs are substantially higher (160 mg/kg mean) than the high renal damage values (29 mg/kg) reported for Australian bottlenose dolphins in Lavery et al. (2009). Zinc values in CIBs (102 mg/kg) are intermediate between the low and high renal damage values reported in Lavery et al. (73 mg/kg and 178 mg/kg).

However, it is noted that direct application of no effects and effects levels from other field studies and species is fraught with uncertainty and should be viewed only as a preliminary comparison to determine whether further evaluation is warranted.

Emerging Chemicals in Cook Inlet Belugas

Becker (2009) also reported preliminary data on concentrations of a few emerging chemicals in CIBs. These include fire retardant compounds such as PBDEs (24 congeners) and hexabromocyclodecane (HBCD, 3 isomers), as well as 15 perflourinated compounds. Compared to belugas from the Chukchi Sea, CIBs had slightly lower levels of PBDEs (approximately 13 nanograms per kilogram, ng/kg) and higher levels of HBCD (approximately 2 ng/kg), compared to belugas from the Chukchi Sea. Further analyses are in progress.

The data for the other chemicals could not be evaluated at this time due to a lack of readily available threshold concentrations. However, toxicity reference values are available for some non-cetacean marine mammals (e.g., otters). If needed, these could be used to develop body burden-based screening levels for marine mammals.

Designation of Chemicals

Following the review described above, the evaluated chemicals were classified with regard to their potential to contribute adverse reproductive effects on CI belugas (Table 7).

Chemicals were designated as **probable, possible or unlikely** with respect to whether there is sufficient reason to evaluate them further for potential adverse effects on Cook Inlet Belugas.

Chemicals were designated as **probable chemicals of potential concern** if they were reported in environmental media in Cook Inlet and/or in Cook Inlet beluga whale tissues and if they are known to be associated with adverse effects on reproduction or growth in marine mammals (e.g., PCBs). The organochlorines and PAHs are included in this designation.

Chemicals were designated as **possible chemicals of potential concern** if they are known to be or are suggested to be associated with adverse effects on growth or reproduction in marine mammals (e.g., PFOS) or if they are known to be toxic to beluga whale dietary items (fish and invertebrates), but if there was insufficient data as to the presence of these chemicals in Cook Inlet media and in beluga whales (e.g., pyrethroids). Some metals, polybrominated compounds, perfluoronated compounds, phthalates, surfactants, alkylphenols, triazine and organophosphate pesticides, antibiotics and hormones are included in this category.

Unlikely chemicals of potential concern are those that are associated with low toxicity to marine mammals and aquatic biota (e.g., glycols), chemicals whose toxicity is unknown but whose environmental concentrations appear to be at extremely low levels (e.g., nutraceuticals) and chemicals for which the current state of the literature does not appear to support their potential for toxicity to beluga whales (e.g., prions).

It is noted that the terms probable, possible, and unlikely do not refer to the likelihood of adverse effects on the Cook Inlet beluga whale population but to whether there is sufficient reason to evaluate them further. A probable chemical of concern does not automatically mean that it is causing adverse effects to belugas in Cook Inlet. It means only that that there is probable cause to evaluate it further.

3.6.1 Data Gaps

Based on the review conducted, data gaps that are potentially relevant to the reproductive success of CI belugas were identified. They include the following:

3.6.2 Site-Specific Data Gaps

- It is not clear whether the availability of prey is adequate to meet the CI beluga population's dietary needs on a year-round basis. If there are local influences, such as discharge of deicing compounds and other chemicals from point and non-point sources, along the shoreline that may affect the long-term viability and abundance of prey populations, this may contribute to reduced food availability for the CI belugas in localized areas of their preferred habitat.
- Data gaps exist in characterizing chemical exposure to CI belugas from the abiotic and biotic exposure media. Data on the occurrence of the evaluated chemicals (legacy as well as emerging chemicals) in the point source discharges, non-point runoff, sediments and receiving water in the preferred habitat areas of Cook Inlet are lacking. Although some earlier sediment data exist for Cook Inlet, collected during dredging operations, it is not known if these samples are representative of the preferred habitat areas of the CI belugas.
- Data on the concentrations of these chemicals in prey tissue are also lacking. Therefore, potential exposures to chemicals from direct contact with sediments and water and through indirect pathways such as through the food-web cannot be characterized at this time.
- Data gaps related to the life history of the whales that could obviously affect exposure and/or the level of contamination present in whales include developing an understanding of the whether chemical exposures may occur at the most sensitive reproductive and developmental life-stages, e.g., during breeding and nursing for females and young.

3.6.3 Literature Data Gaps

- Although there is a vast amount of exposure and body burden literature for marine mammals with respect to chlorinated and brominated PBTs, there is far less usable information regarding dose-response assessments for these chemicals. Therefore, it is difficult to identify readily available toxicity reference values representing NOAELs and LOAELs that could then be used to evaluate whether the observed body burdens and tissue concentrations present unacceptable risk levels.

- Toxicity and dose-response data are minimal for the majority of the emerging chemicals and products, for all biota, including aquatic invertebrates, fish and marine mammals.
- Relevant and usable toxicity data are completely lacking for certain classes of emerging chemicals such as nanomaterials and prions.

The use of the tissue screening concentrations for PCBs, mercury and other metals for marine mammals is subject to high uncertainty due to a great deal of variability in how these values are reported and used as well as their relevance to multiple marine mammal species. The origin and use of these values should be clarified in terms of whether they apply to lipid, blubber or whole body data and whether the species data from which they were derived are appropriate for use with CIB data.

Based on the above information, recommendations were developed as to whether field sampling of each chemical group would be useful for further evaluation. Field sampling and additional evaluation is divided into three phases that get progressively more complicated and expensive.

The recommendations include the collection of both biological and chemical data to fill the data gaps identified earlier.

4.1 BIOLOGICAL DATA

It is recommended that the availability of prey on a year-round basis be confirmed, in particular for the species of the most significance to CIB diets during breeding and lactation in their preferred habitat areas. This would be helpful in ensuring that local sources or areas of contamination have not affected prey abundance in the areas where CI belugas prefer to feed.

4.2 ANALYTICAL DATA

A phased approach is recommended to address data gaps related to chemicals and is summarized in Table 7.

The decision making process would be progressive, with the results of Phase 1 informing the need to undertake additional efforts for a particular contaminant.

- Phase 1 would involve collecting site specific water, sediment, and biological samples that could be tested to see if certain chemicals are present in the environment and food base of belugas and in what concentrations. This phase addresses the question, "What are CI belugas exposed to?" It would also answer the question, "What are the prey species of CIBs exposed to?"
- Phase 2 would involve collecting tissue samples from belugas (and/or analyzing existing tissue samples) and testing for body loads of particular chemicals. This addresses the question, "How much contaminants have CI belugas absorbed?"
- Phase 3 would involve additional literature review to look for specific toxicological effects thresholds for chemicals, comparing them with information collected in Phase 1 and 2, and evaluating the potential for toxic effects in the populations of CIBs and their prey species. This addresses the question, "Are CI beluga exposure levels likely to be affecting their growth or reproductive capacity?" It would also answer the question, "Are exposure levels likely to be toxic enough to prey species that their abundance and availability to CIBs may be affected?"

In the event that chemicals without readily available toxicity information for marine mammals are identified at the end of Phase 3, the available mammalian toxicity data, based on other mammalian groups, may be reviewed and used to develop reference toxicity values for marine mammals.

A review of literature was conducted to evaluate the potential for a variety of chemicals to adversely impact the reproductive success and recovery of the CI beluga whale population. Chemicals were classified as conventional legacy pollutants and emerging chemicals and further categorized by chemical class, sources, uses, environmental behavior, and potential toxicity. A risk-based source to receptor approach was adopted. Each class of chemicals was evaluated with regard to its potential to occur in Cook Inlet and its potential to exert ecotoxicological effects. Then a judgment was made as to its potential to affect the reproductive success and recovery of the CI beluga population. Data gaps were identified and recommendations were developed to address the data gaps.

In general, site-specific information to characterize CI beluga exposures to the evaluated chemicals was very limited. Relevant and marine mammal-specific toxicological information was richest for organochlorine chemicals, sparse for other common chemicals and limited or absent for the majority of the emerging chemicals and products. Some relevant studies on brominated flame retardants and perfluorinated compounds are in process for CIBs but the final results are yet to be published.

Within the framework of the available data, chemicals were identified as probable, possible or unlikely chemicals of potential concern with respect to the recovery of the CI beluga whale population. The purpose of this designation was only to identify which chemicals may warrant further evaluation and is not meant to imply causal relationships of adverse effects.

A phased approach is recommended for further evaluation. The first two phases would consist of sampling and analysis of environmental media (water and sediment at relevant locations within Cook Inlet), prey species tissue, and beluga whale tissue (if feasible) to characterize the nature and magnitude of chemical occurrence and concentrations. The third phase would consist of evaluating the collected data in relation to available toxicity information to perform an ecological risk assessment. The risk assessment will assist in identifying those chemicals, exposure media and pathways which may have the greatest potential to affect the health of CIBs.

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Table 1 - Chemical Compounds Reviewed for Toxicological Effects in Cook Inlet Beluga Whales

Classification	Common Name(s)	Chemical Class	Example Indevidual Constituents
Priority Pollutants/ Conventional Pollutants	Persistent bioaccumulative toxic (PBT), Pesticides and Herbicides, Persistent Organic Pollutants (POPs)	Chlorinated pesticides	DDTs, aldrin, dieldrin, chlordane, endosulfan, mirex, toxaphene mixtures
		Organophosphates/ carbamates	Malathion, methyl-parathion, chlorpyrifos, diazinon, carbaryl, aldicarb
		Triazines	Atrazine, cyanazine, simazine
		Chlorinated dielectric fluids, transformer oils	209 PCB congeners, aroclor mixtures
		Chlorinated dibenzo-p-dioxins and furans	75 Dioxin congeners (PCDDs), 135 furan congeners (PCDFs)
		Metals	Methyl mercury, selenium, butyltins, cadmium
		Polycyclic aromatic hydrocarbons (PAHs)	Benzo(a)pyrene, anthracene, pyrene
		Hydrocarbons (Non-PAH, chlorinated and non-chlorinated compounds)	Alkanes, alkenes
		Glycols	Ethylene glycol
Emerging Substances of Concern	Global Organic Contaminants (GOC), including persistent bioaccumulative toxins (PBT) and POPs	Polybrominated flame retardants	Polybrominated diphenylethers (PBDEs)
			Polybrominated biphenyls (PBBs)
			Polybrominated dibenzo-p-dioxins (PBDDs)/ Polybrominated dibenzo-p-furans (PBDFs)
		Hexabromocyclododecanes (HBCDs; HBCDDs)	C12H18Br6; 16 stereoisomeric forms (CAS# 25637-66-4)
		Perfluoronated compounds (PFCs)	Perfluoro-octane sulfonates (PFOS)
			Perfluoro-octanoic acid (PFOA)
		Phthalates/ phthalate esters/ alkylated phthalates	Diethyl phthalate, butyl benzyl phthalate
	Pharmaceutical and Personal Care Products (PPCP)	Prescription and over-the-counter drugs	Penicillins, tetracyclines, clofibric acid, aspirin, ibuprofen, prozac
		Diagnostic agents	Amidated, iodinated aromatics
		Dietary supplements, nutraceuticals	Cholestin, huperzin, kava, other herbal products
		Fragrances, sunscreens, cosmetics, soaps, conditioners	Methylbenzylidene camphor, oxybenzone
		Alkylphenols, alkylphenol ethoxylates (APEs)	Nonylphenol, octylphenol
		Consumer plastics	Bisphenol A (BPA) (2,2-bis(4-hydroxydiphenyl) propane)

Table 1 - Chemical Compounds Reviewed for Toxicological Effects in Cook Inlet Beluga Whales

Classification	Common Name(s)	Chemical Class	Example Indevidual Constituents
	Endocrine Disrupting Chemicals (EDC)	Natural and synthetic hormones	Estradiols, thyroxine analogs
		Surfactants	4-nonylphenol; "alkylphenol polyethoxylate surfactants"; o-, m-, or p-nonylphenol
		Pesticides	Lindane, methyl-parathion; permethrin; triazines
	Pesticides and Herbicides	Synthetic pyrethroids	Bifenthrin, cypermethrin, permethrins, esfenvalerate
	Nanomaterials	Engineered particles with dimension less than 100 nm	Nanotubes, nanoparticles
	Prions	Prions (Considered a "pest" under FIFRA because they share many of the same traits as pest microorganisms)	Abnormal, infectious forms of proteins, lacking genetic material, residing in cells of the central nervous system

Table 2 - Sources and Potential Pathways of Marine Contamination

Chemical Class	Example Individual Constituents	Sources	Uses	Behavior In Aquatic Environment
Chlorinated pesticides	DDTs, aldrin, dieldrin, chlordane, endosulfan, mirex, toxaphene mixtures	Pesticides for insect and vector control (e.g., mosquito and termite)	Insecticides banned in USA in 1970s, but still in use in other parts of the world	Hydrophobic, lipophilic, bioaccumulative, persistent, slow degradation to breakdown products
Organophosphates/ Carbamates	Malathion, methyl-parathion, chlorpyrifos, diazinon, carbaryl, aldicarb	Industrially manufactured	Broad-spectrum insecticides in agricultural and residential use (nervous system toxins)	Lower persistence than organochlorines, variable metabolism, dissolved, adsorbed
Triazines	Atrazine, cyanazine, simazine	Industrially manufactured	Herbicides, weed control (photosynthesis inhibition)	Varied: persistence, metabolism, dissolved, adsorbed. Moderate solubility and bioaccumulation
Chlorinated dielectric fluids, transformer oils	209 PCB congeners, Aroclor mixtures	Transformer oils, electrical equipment	Legacy chemicals -coolants and lubricants in transformers and other electrical equipment. Banned in USA since 1970s	Hydrophobic, lipophilic, bioaccumulative, persistent, slow degradation to breakdown products
Chlorinated dibenzo-p-dioxins and furans	75 Dioxin congeners (PCDDs), 135 furan congeners (PCDFs)	Emissions from waste incinerators, impurities and by-products from chlorinated bleaching	No intentional uses	Hydrophobic, Sorbs to sediment; bioaccumulative
Metals	Methyl mercury, selenium, butyltins, cadmium	Naturally occurring elements, mine wastes, also by-products of crude oils, mining and industrial products	Industrial uses for mercury include dental products, batteries, antiseptic creams. Selenium is an essential trace element that is used in electronics, glass, pharmaceuticals and pesticides	General tendency to accumulate in sediment; bioaccumulative (methyl mercury, selenium)
Polycyclic Aromatic Hydrocarbons (PAHs)	Benzo(a)pyrene, anthracene, pyrene	(Petrogenic) Asphalt, coal tar, MGP residues, and (Pyrogenic) incomplete combustion of coal, oil and gas, other organic wastes	Naturally occurring	Sorbs to sediment; low molecular weight (LMW) PAHs are more water- soluble and less persistent than higher molecular weight (HMW) PAHs

Table 2 - Sources and Potential Pathways of Marine Contamination

Chemical Class	Example Individual Constituents	Sources	Uses	Behavior In Aquatic Environment
Hydrocarbons (Non-PAH, chlorinated and non-chlorinated compounds)	alkanes, alkenes	Oil & tar deposits; industrial distillation	Fuels; solvents	Dissolves, aqueous
Glycols	Ethylene Glycol	Industrially manufactured	De-icing chemicals and agents	Soluble, non-persistent
Polybrominated flame retardants	Polybrominated diphenylethers (PBDEs)	Industrially manufactured, up to 209 possible congeners	Flame retardant in televisions, computers, textiles	Sorbs to sediment; bioaccumulation observed for some congeners
	Polybrominated biphenyls (PBBs)	Industrially manufactured, no longer produced in US	Flame retardant in construction and electrical equipment	Sorbs to sediment; persistent, bioaccumulative
	Polybrominated dibenzo-p-dioxins (PBDDs)/ Polybrominated dibenzo-p-furans (PBDFs)	Contaminant from combustion of flame retardants	No intentional uses	Sorbs to sediment; persistent, bioaccumulative
Hexabromocyclododecanes (HBCDs; HBCDDs)	$C_{12}H_{18}Br_6$; 16 stereoisomeric forms (CAS# 25637-66-4)	Industrially manufactured	Flame retardant coating for thermal foams and furniture fabrics	Persistent, bioaccumulative; Apparent biomagnificaction
Perfluoronated compounds (PFCs)	Perfluoro-octane sulfonates (PFOS)	Industrially manufactured	Fluoropolymers that repel both water and oil, Protective coating in food contact packaging, textiles and carpets	Persistent, Bioaccumulative, hydrophobic and lipophobic (i.e., do not accumulate in fatty tissues)
	Perfluoro-octanoic acid (PFOA)	Industrially manufactured	Fluoropolymers that repel both water and oil, Teflon coating, grease-resistant food-packaging	Persistent, Bioaccumulative, hydrophobic and lipophobic (i.e., do not accumulate in fatty tissues)
Phthalates/ phthalate esters/ alkylated phthalates	Diethyl phthalate, butyl benzyl phthalate	Industrially manufactured; plastic wastes	Vinyl softeners used in flooring, adhesives, plastic clothing, toys, kitchen ware	Sorbs to sediment; LMW esters more soluble than HMW esters
Prescription and Over the Counter drugs	Penicillins, tetracyclines, clofibric acid, aspirin, ibuprofen, prozac	Industrially manufactured; limited natural occurrence	Antibiotics, blood lipid regulators, anti-inflammatory drugs, tranquilizers	Varied: persistence, metabolism, dissolved, adsorbed, biological activity
Diagnostic agents	Amidated, iodinated aromatics	Industrially manufactured	Contrast media for soft-tissue X-rays	Not readily metabolized in the environment
Dietary supplements, nutraceuticals	Cholestin, huperzin, kava, other herbal products	Industrially manufactured and/or concentrated; natural occurrence	bioactive food supplements	Varied: persistence, metabolism, dissolved, adsorbed, biological activity

Table 2 - Sources and Potential Pathways of Marine Contamination

Chemical Class	Example Individual Constituents	Sources	Uses	Behavior In Aquatic Environment
Fragrances, sunscreens, cosmetics, soaps, conditioners	Methylbenzylidene camphor, oxybenzone	Industrially manufactured	Sunscreen agents	Varied: persistence, metabolism, dissolved, adsorbed, biological activity
Alkylphenols, alkylphenol ethoxylates (APEs)	Nonylphenol, octylphenol	Industrially manufactured as stabilizers, emulsifiers and dispersants for resins and plastics	Detergents, cleaning products	Lipophilic; bioconcentrates, low to moderate bioaccumulation
Consumer plastics	Bisphenol A (BPA) (2,2-bis(4-hydroxydiphenyl) propane)	Industrially manufactured as an intermediate for epoxy resins and polycarbonate plastics	CDs, DVDs, eyeglass lenses, water bottles	Hydrophobic; sorbs to organic materials, degraded/metabolized biologically (as opposed to abiotically); low bioaccumulation potential
Natural and synthetic hormones	Estradiols, thyroxine analogs	Industrially manufactured and/or concentrated; natural occurrence	Medicinal	Varied: persistence, metabolism, dissolved, adsorbed, biological activity
Surfactants	4-nonylphenol; "alkylphenol polyethoxylate surfactants"; o-, m-, or p-nonylphenol	Industrially manufactured	Detergents; cosmetics; spermicide	Generally soluble, aqueous
Pesticides	Lindane, methyl-parathion; permethrin; triazines	Industrially manufactured	Insecticides; fungicides	Varied: persistence, metabolism, dissolved, adsorbed
Synthetic pyrethroids	Bifenthrin, cypermethrin, Permethrins, esfenvalerate	Industrially manufactured	Pyrethrum-based broad-spectrum insecticides	Low to moderate persistence, varied metabolism, dissolved, adsorbed
Engineered particles with dimension less than 100 nm	Nanotubes, nanoparticles	Industrially manufactured	Apparel, electronics, medicine, cosmetics, sunscreen (titanium dioxide)	Quantum particles may function as solids, liquids or gases, in aggregate or single
Prions (Considered a "pest" under FIFRA because they share many of the same traits as pest microorganisms)	Abnormal, infectious forms of proteins , lacking genetic material, residing in cells of the central nervous system	Meat processing, landfill leachate, medical waste	By-product, no intentional uses	May attach to biosolids and particles in wastewater treatment

Table 3 - Potential for Occurrence of Evaluated Chemicals in Cook Inlet

Chemical Class	Example Individual Constituents	Detected In Influent Wastewater?	Detected In Enfluent Wastewater?	Detected In Non-Point Runoff?	Detected In Cook Inlet?
Chlorinated pesticides	DDTs, aldrin, dieldrin, chlordane, endosulfan, mirex, toxaphene mixtures	21 including DDTs, aldrin, dieldrin, chlordanes, heptachlors, BHC	7 including dieldrin, chlordane, heptachlor, BHC (USEPA 2009), aldrin, BHC and DDE (AWWU 2005)	Dieldrin (USEPA 2009b)	No information available
Organophosphates/ Carbamates	Malathion, methyl-parathion, chlorpyrifos, diazinon, carbaryl, aldicarb	8 including chlorpyrifos, malathion, diazinon, parathion	4 including diazinon	No information available	No information available
Triazines	Atrazine, cyanazine, simazine	4 including atrazines and simazine	6 including atrazines and simazines (USEPA 2009)	No information available	No information available
Chlorinated dielectric fluids, transformer oils	209 PCB congeners, Aroclor mixtures	No information available	BHC (AWWU 2009)	Aroclor (ARC 2008) 2 PCBs (USEPA 2009b)	No information available
Chlorinated dibenzo-p-dioxins and furans	75 Dioxin congeners (PCDDs), 135 furan congeners (PCDFs)	No information available	No information available	No information available	No information available
Metals	Methyl mercury, selenium, butyltins, cadmium	No information available	10 metals (AWWU 2005), 12 metals (AWWU 2009), 11 metals (NMFS 2006)	9 metals (Frenzel 2002), 19 metals (ARC 2008), 5 metals (USEPA 2009b)	6 metals (Cook Inlet keeper 2006), 6 metals (USEPA 2007b), 2 metals (USEPA 2006), 9 metals (USEPA 2000), (Epstein 2006), (Alaska: Eagle River Flats)
Polycyclic Aromatic Hydrocarbons (PAHs)	Benzo(a)pyrene, anthracene, pyrene	No information available	TAH (AWWU 2005, AWWU 2009, NMFS 2006), benzo (a)pyrene (AWWU 2005)	6 PAHs (ARC 2008), benzo(a)pyrene (USEPA 2009b)	TAH [Cook Inlet keeper 2006, USEPA 2007, USEPA 2009 (NPDES permit)], PAHs (CIRCAC 1999, USEPA 2007)

Table 3 - Potential for Occurrence of Evaluated Chemicals in Cook Inlet

Chemical Class	Example Individual Constituents	Detected In Influent Wastewater?	Detected In Enfluent Wastewater?	Detected In Non-Point Runoff?	Detected In Cook Inlet?
Hydrocarbons (Non-PAH, chlorinated and non-chlorinated compounds)	Alkanes, alkenes	No information available	Oil and grease (AWWU 2005, AWWU 2009, NMFS 2006)	Diesel and gasoline (USEPA 2009b), (USEPA 2009c)	Oil and grease [USEPA 2007b, Epstein 2006, USEPA 2009c (NPDES permit)], TAqH [Epstein 2006, USEPA 2007, USEPA 2009c (NPDES permit)]
Glycols	Ethylene Glycol	No information available	No information available	Detected in runoff and receiving waters near airports	No information available, likely to be present near Anchorage airport (Alaska Center for the Environment)
Polybrominated flame retardants	Polybrominated diphenylethers (PBDEs)	8 congeners (USEPA 2009)	8 congeners (USEPA 2009)	No information available	No information available
	Polybrominated biphenyls (PBBs)	No information available	No information available	No information available	No information available
	Polybrominated dibenzo-p-dioxins (PBDDs)/ polybrominated dibenzo-p furans (PBDFs)	No information available	No information available	No information available	No information available
Hexabromocyclododecanes (HBCDs; HBCDDs)	C12H18Br6; 16 stereoisomeric forms (CAS# 25637-66-4)	No information available	No information available	No information available	No information available
Perfluoronated compounds (PFCs)	Perfluoro-octane sulfonates (PFOS)	No information available	No information available	No information available	No information available
	Perfluoro-octanoic acid (PFOA)	No information available	No information available	No information available	No information available
Phthalates/ phthalate esters/ alkylated phthalates	Diethyl phthalate, butyl benzyl phthalate	No information available	4 phthalates (AWWU 2005), 2 phthalates (AWWU 2009)	3 phthalates (ARC 2008), 1 phthalates (USEPA 2009b)	No information available

Table 3 - Potential for Occurrence of Evaluated Chemicals in Cook Inlet

Chemical Class	Example Individual Constituents	Detected In Influent Wastewater?	Detected In Enfluent Wastewater?	Detected In Non-Point Runoff?	Detected In Cook Inlet?
Prescription and Over the Counter drugs	Penicillins, tetracyclines, clofibric acid, aspirin, ibuprofen, prozac	22 antibiotics (USEPA 2009); 22 pharmaceuticals other than antibiotics;	17 antibiotics (USEPA 2009); 16 pharmaceuticals other than antibiotics;	No information available	No information available
Diagnostic agents	Amidated, iodinated aromatics	No information available	No information available	No information available	No information available
Dietary Supplements, Nutraceuticals	Cholestin, huperzin, kava, other herbal products	No information available	No information available	No information available	No information available
Fragrances, sunscreens, cosmetics, soaps, conditioners	Methylbenzylidene camphor, oxybenzone	No information available	No information available	No information available	No information available
Alkylphenols, alkylphenol ethoxylates (APEs)	Nonylphenol, octylphenol	4 nonylphenol, octylphenol and ethoxylates (USEPA 2009)	2 nonylphenol, octylphenol and ethoxylates (USEPA 2009)	No information available	No information available
Consumer plastics	Bisphenol A (BPA) (2,2-bis(4-hydroxydiphenyl) propane)	Not detected	Not detected	No information available	No information available
Natural and synthetic hormones	Estradiols, thyroxine analogs	10 sterols; 15 hormones; (USEPA 2009)	10 sterols; 0 hormones; (USEPA 2009)	No information available	No information available
Surfactants	4-nonylphenol; "alkylphenol polyethoxylate surfactants"; o-, m-, or p-nonylphenol	No information available	No information available	No information available	No information available
Pesticides	Lindane, methyl-parathion; permethrin; triazines	No information available	No information available	No information available	No information available
Synthetic pyrethroids	Bifenthrin, cypermethrin, permethrins, esfenvalerate	4 permethrins	1 permethrin	No information available	No information available

Table 3 - Potential for Occurrence of Evaluated Chemicals in Cook Inlet

Chemical Class	Example Individual Constituents	Detected In Influent Wastewater?	Detected In Enfluent Wastewater?	Detected In Non-Point Runoff?	Detected In Cook Inlet?
Engineered particles with dimension less than 100 nm	Nanotubes, nanoparticles	No information available	No information available	No information available	No information available
Prions (Considered a "pest" under FIFRA because they share many of the same traits as pest microorganisms)	Abnormal, infectious forms of proteins , lacking genetic material, residing in cells of the central nervous system	Unknown, no analytical methods developed	Unknown, no analytical methods developed	Unknown, no analytical methods developed	Unknown, no analytical methods developed

Table 4 - Summary of Ecotoxicological Information for Evaluated Chemicals

Chemical Class	Example Individual Constituents	Detected In Any Aquatic Tissue in the Field?	Toxicity To Fish/ Aquatic Invertebrates	Potential or Demonstrated Toxicity To Marine Mammals	Marine Mammal Dose-Response Information Available?
Chlorinated pesticides	DDTs, aldrin, dieldrin, chlordane, endosulfan, mirex, toxaphene mixtures	Invertebrates, fish, marine mammals	Low to high acute toxicity at environmental concentrations. Known reproductive and developmental toxicity with chronic exposure.	Yes, primarily from food-web exposure from air-borne deposition and sediment-sorbed sources. Possible immunosuppression and carcinogenesis. Bioaccumulation in marine mammal tissue has been demonstrated.	DDT data for bottlenose dolphins, northern fur seal, California sea lions, and Southern sea otters
Organophosphates/ Carbamates	Malathion, methyl-parathion, chlorpyrifos, diazinon, carbaryl, aldicarb	No information available	Moderate to high acute toxicity.	Unknown	None; may need to use terrestrial mammalian data
Triazines	Atrazine, cyanazine, simazine	No information available	High toxicity for algae but low acute toxicity to invertebrates and fish.	Unknown	None; may need to use terrestrial mammalian data
Chlorinated dielectric fluids, transformer oils	209 PCB congeners, aroclor mixtures	Invertebrates, fish, marine mammals	Low acute toxicity at environmental concentrations. Known reproductive and developmental toxicity with chronic exposure	Yes, primarily from food-web exposure from air-borne deposition and sediment-sorbed sources. Possible immunosuppression and carcinogenesis. Bioaccumulation in marine mammal tissue has been demonstrated.	PCB data for bottlenose dolphins, harbor seals, northern fur seals, and California sea lions

Table 4 - Summary of Ecotoxicological Information for Evaluated Chemicals

Chemical Class	Example Individual Constituents	Detected In Any Aquatic Tissue in the Field?	Toxicity To Fish/ Aquatic Invertebrates	Potential or Demonstrated Toxicity To Marine Mammals	Marine Mammal Dose-Response Information Available?
Chlorinated dibenzo-p-dioxins and furans	75 dioxin congeners (PCDDs), 135 furan congeners (PCDFs)	Invertebrates, fish, marine mammals	Low acute toxicity at environmental concentrations. Known reproductive and developmental toxicity with chronic exposure	Yes, primarily from food-web exposure from air-borne deposition and sediment-sorbed sources. Possible immunosuppression and carcinogenesis. Bioaccumulation in marine mammal tissue has been demonstrated.	Dioxin data for harbor seals
Metals	Methyl mercury, selenium, butyltins, cadmium	Invertebrates, fish, marine mammals	Low acute toxicity at environmental concentrations. Known reproductive, developmental and behavioral toxicity with chronic exposure. Organic forms (methyl mercury) more toxic than inorganic forms.	Yes, from food-web sources as well as uptake from water and sediment. Bioaccumulation in marine mammal tissue has been demonstrated. Some marine mammals may have the capacity to regulate mercury body burden.	Data available for Hg in ringed seal, Mercury and Selenium data for California sea lions; butyl tins for southern sea otters
Polycyclic Aromatic Hydrocarbons (PAHs)	Benzo(a)pyrene, anthracene, pyrene	Invertebrates, fish, marine mammals	Acute exposures to LMW PAHs associated with mortality to water-column biota. Chronic exposure to HMW PAHs associated with systemic, reproductive and developmental effects.	Yes, from food-web sources as well as uptake from water and sediment. Possible carcinogenesis and reproductive impacts. Bioaccumulation in marine mammal tissue has been demonstrated.	Crude Oil data for sea otters
Hydrocarbons (Non-PAH, chlorinated and non-chlorinated compounds)	alkanes, alkenes	Unknown	Moderate to severe toxicity under acute and chronic exposures, primarily associated with aliphatic fraction.	Unknown	None; may need to use terrestrial mammalian data

Table 4 - Summary of Ecotoxicological Information for Evaluated Chemicals

Chemical Class	Example Individual Constituents	Detected In Any Aquatic Tissue in the Field?	Toxicity To Fish/ Aquatic Invertebrates	Potential or Demonstrated Toxicity To Marine Mammals	Marine Mammal Dose-Response Information Available?
Glycols	Ethylene glycol	Not bioaccumulative	Low toxicity, no effect levels of 8,590 mg/L, localized toxicity may occur if concentrations exceed 8,590 mg/L.	Low potential for direct toxicity may impact prey species	No information available
Polybrominated flame retardants	Polybrominated diphenylethers (PBDEs)	Invertebrates, fish, marine mammals	Low acute toxicity. Larval development and population growth effects under chronic exposure. Potential endocrine disruptors.	Possible endocrine disruption effects. Possible immunosuppression and carcinogenesis. Bioaccumulation in marine mammal tissue has been demonstrated.	None; may need to use terrestrial mammalian data
	Polybrominated biphenyls (PBBs)	Invertebrates, fish, marine mammals	AhR-mediated toxicity to fish during sensitive life stages.	Possible endocrine disruption effects. Possible immunosuppression and carcinogenesis. Bioaccumulation in marine mammal tissue has been demonstrated.	None; may need to use terrestrial mammalian data
	Polybrominated dibenzo-p-dioxins (PBDDs)/ Polybrominated dibenzo-p-furans (PBDFs)	Invertebrates, fish, marine mammals	Potentially similar to PBDEs and PBBs.	Possible endocrine disruption effects. Possible immunosuppression and carcinogenesis. Bioaccumulation in marine mammal tissue has been demonstrated.	None; may need to use terrestrial mammalian data
Hexabromocyclododecanes (HBCDs; HBCDDs)	$C_{12}H_{18}Br_6$; 16 stereoisomeric forms (CAS# 25637-66-4)	Birds, mammals, fish, aquatic organisms	Mortality in invertebrates and fish.	Developmental toxicity and endocrine disruption in terr mammals? Bioaccumulation in marine mammal tissue has been demonstrated.	None; may need to use terrestrial mammalian data

Table 4 - Summary of Ecotoxicological Information for Evaluated Chemicals

Chemical Class	Example Individual Constituents	Detected In Any Aquatic Tissue in the Field?	Toxicity To Fish/ Aquatic Invertebrates	Potential or Demonstrated Toxicity To Marine Mammals	Marine Mammal Dose-Response Information Available?
Perfluoronated compounds (PFCs)	Perfluoro-octane sulfonates (PFOS)	Invertebrates, fish, marine mammals (liver)	Low to moderate acute toxicity.	Possible endocrine disruption, developmental effects; bioaccumulation demonstrated in marine mammals	None; may need to use terrestrial mammalian data
	Perfluoro-octanoic acid (PFOA)	Invertebrates, fish, marine mammals (liver)	Low acute toxicity, less toxic and bioaccumulative than PFOS.	Possible endocrine disruption, developmental effects. Bioaccumulation demonstrated in marine mammals.	None; may need to use terrestrial mammalian data
Phthalates/ phthalate esters/ alkylated phthalates	Diethyl phthalate, butyl benzyl phthalate	Invertebrates, fish, marine mammals	Low to moderate toxicity associated with LMW phthalates. HMW phthalates considered to be unavailable for toxicity. Endocrine disruption effects not conclusive.	Possible endocrine disruption effects. Bioaccumulation in marine mammal tissue has been demonstrated, some metabolization and elimination may occur. Atmospheric transport a possible source.	None; may need to use terrestrial mammalian data
Prescription and Over the Counter drugs	Penicillins, tetracyclines, clofibric acid, aspirin, ibuprofen, prozac	2 antidepressants (norfluoxetine, setraline) and one antihistamine (diphenylhydramine) in fish liver and fillets in EPA's pilot study (2008)	Low acute toxicity. Low to high chronic toxicity. Known and potential endocrine disruption effects.	Unknown	None; may need to use terrestrial mammalian data
Diagnostic agents	Amidated, iodinated aromatics	No information available	No information available but some toxicity possible.	Unknown	None; may need to use terrestrial mammalian data
Dietary supplements, nutraceuticals	Cholestin, huperzin, kava, other herbal products	No information available	No information available but some toxicity possible.	Unknown	None; may need to use terrestrial mammalian data

Table 4 - Summary of Ecotoxicological Information for Evaluated Chemicals

Chemical Class	Example Individual Constituents	Detected In Any Aquatic Tissue in the Field?	Toxicity To Fish/ Aquatic Invertebrates	Potential or Demonstrated Toxicity To Marine Mammals	Marine Mammal Dose-Response Information Available?
Fragrances, sunscreens, cosmetics, soaps, conditioners	Methylbenzylidene camphor, oxybenzone	2 musk fragrances (galaxolide, tonalide) in fish tissue in EPA's pilot study (2008)	Low acute and chronic toxicity for synthetic musk fragrances.	Unknown	None; may need to use terrestrial mammalian data
Alkylphenols, alkylphenol ethoxylates (APEs)	Nonylphenol, octylphenol	No information available	Moderate acute toxicity, moderate to high chronic toxicity, possible endocrine disruption effects in fish.	Possible endocrine disruption effects	None; may need to use terrestrial mammalian data
Consumer plastics	Bisphenol A (BPA) (2,2-bis(4-hydroxydiphenyl) propane)	Invertebrates, fish	Low to moderate acute toxicity. Low to moderate chronic toxicity. Possible endocrine disruption effects in snails.	Possible endocrine disruption effects	None; may need to use terrestrial mammalian data
Natural and synthetic hormones	Estradiols, thyroxine analogs	No information available	Low to moderate acute toxicity. Low to moderate chronic toxicity. Possible endocrine disruption effects.	Possible endocrine disruption effects	None; may need to use terrestrial mammalian data
Surfactants	4-nonylphenol; "alkylphenol polyethoxylate surfactants"; o-, m-, or p-nonylphenol	No information available	Moderate acute toxicity, moderate to high chronic toxicity, possible endocrine disruption effects in fish.	Possible endocrine disruption effects	None; may need to use terrestrial mammalian data
Pesticides	Lindane, methyl-parathion; permethrin; triazines	Unknown	Some apparent toxicity demonstrated at the cellular level and in some invertebrates and fish.	See below	See below
Synthetic pyrethroids	Bifenthrin, cypermethrin, permethrins, esfenvalerate	No information available	Moderate to high acute toxicity, possible reproductive effects.	Unknown	None; may need to use terrestrial mammalian data

Table 4 - Summary of Ecotoxicological Information for Evaluated Chemicals

Chemical Class	Example Individual Constituents	Detected In Any Aquatic Tissue in the Field?	Toxicity To Fish/ Aquatic Invertebrates	Potential or Demonstrated Toxicity To Marine Mammals	Marine Mammal Dose-Response Information Available?
Engineered particles with dimension less than 100 nm	Nanotubes, nanoparticles	Unknown	Some apparent toxicity demonstrated at the cellular level and in some invertebrates and fish.	Unknown	None
Prions (Considered a "pest" under FIFRA because they share many of the same traits as pest microorganisms)	Abnormal, infectious forms of proteins , lacking genetic material, residing in cells of the central nervous system	In tissues of infected terrestrial animals	Unknown	Unknown; "Mad cow" disease in cattle	None

Table 5 - Evaluation of Potential Toxicity to Cook Inlet Belugas

Chemical Class	Example Individual Constituents	Detected in Cook Inlet Belugas (Becker & Pugh 2000, Becker et al. 2000, Becker 2009)	Detected In Other Beluga Stocks
Chlorinated pesticides	DDTs, aldrin, dieldrin, chlordane, endosulfan, mirex, toxaphene mixtures	Tested for 15 persistent chlorinated pesticides including metabolites of DDT, chlordane-related compounds, HCB, HCH, dieldrin, and mirex. Lower concentration of PBTs compared to other stocks.	St Lawrence: Beland 1993, De Guise 1995 & 1998, Gauthier 1998 & 1999, Hobbs 2003, Lebeuf 2007, Letcher 2000, Martineau 1987 & 1994, Muir 1990, Stern 2005 Canadian Arctic: Stern 2005 Svalbard, Norway: Andersen 2001 & 2006 Alaskan north coast: Wade 1997 Greenland: Vorkamp 2004, Lebeuf 2001
Organophosphates/ carbamates	Malathion, methyl-parathion, chlorpyrifos, diazinon, carbaryl, aldicarb	No information available	No information available
Triazines	Atrazine, cyanazine, simazine	No information available	No information available
Chlorinated dielectric fluids, transformer oils	209 PCB congeners, aroclor mixtures	Tested for 31 PCB congeners. Higher concentrations in males than females. Lower concentration of PCBs compared to other stocks.	St Lawrence: Beland 1993, De Guise 1998, Gauthier 1998, Hickie 2000, Hobbs 2003, Lebeuf 2007, Letcher 2000, Muir 1990, Stern 2005, Vorkamp 2004, Wilson 2005 Canadian Arctic: Stern 2005 Svalbard, Norway: Andersen 2001 Alaskan north coast: Wade 1997 Greenland: Vorkamp 2004 Arctic: Wilson 2005, Lebeuf 2009
Chlorinated dibenzo-p-dioxins and furans	75 Dioxin congeners (PCDDs), 135 furan congeners (PCDFs)	No information available	St Lawrence: Beland 1993, Gauthier 1998
Metals	Methyl mercury, selenium, butyltins, cadmium	Tested for 19 elements and methyl mercury. Comparatively low levels of mercury, selenium, silver, vanadium and cadmium relative to other stocks while copper was higher. Hepatic methyl mercury levels were similar to other stocks. Relatively high concentration of silver that may be a species-specific phenomenon.	St Lawrence: Beland 1993, Gauthier 1998, Martineau 1994 Canadian Arctic: Outridge 1997 Greenland: Vorkamp 2004
Polycyclic aromatic hydrocarbons (PAHs)	Benzo(a)pyrene, anthracene, pyrene	No information available	St Lawrence: Beland 1993, Martineau 1988 & 1994 & 2002, Wilson 2005

Table 5 - Evaluation of Potential Toxicity to Cook Inlet Belugas

Chemical Class	Example Individual Constituents	Detected in Cook Inlet Belugas (Becker & Pugh 2000, Becker et al. 2000, Becker 2009)	Detected In Other Beluga Stocks
Hydrocarbons (Non-PAH, chlorinated and non-chlorinated compounds)	Alkanes, alkenes	No information available	St Lawrence: Beland 1993, De Guise 1998, Tomy 2000 Arctic: Tomy 2000
Glycols	Ethylene glycol	No information available	No information available
Polybrominated flame retardants	Polybrominated diphenylethers (PBDEs)	Analyses in progress (Becker 2009)	St Lawrence: Lebeuf 2004
	Polybrominated biphenyls (PBBs)	Analyses in progress (Becker 2009)	No information available
	Polybrominated dibenzo-p-dioxins (PBDDs)/ polybrominated dibenzo-p-furans (PBDFs)	Analyses in progress (Becker 2009)	No information available
Hexabromocyclododecanes (HBCDs; HBCDDs)	C12H18Br6; 16 stereoisomeric forms (CAS# 25637-66-4)	Analyses in progress (Becker 2009)	No information available
Perfluoronated compounds (PFCs)	Perfluoro-octane sulfonates (PFOS)	Analyses in progress (Becker 2009)	No information available
	Perfluoro-octanoic acid (PFOA)	Analyses in progress (Becker 2009)	No information available
Phthalates/ phthalate esters/ alkylated phthalates	Diethyl phthalate, butyl benzyl phthalate	No information available	No information available
Prescription and over the counter drugs	Penicillins, tetracyclines, clofibric acid, aspirin, ibuprofen, prozac	No information available	No information available
Diagnostic agents	Amidated, iodinated aromatics	No information available	No information available
Dietary supplements, nutraceuticals	Cholestin, huperzin, kava, other herbal products	No information available	No information available
Fragrances, sunscreens, cosmetics, soaps, conditioners	Methylbenzylidene camphor, oxybenzone	No information available	No information available

Table 5 - Evaluation of Potential Toxicity to Cook Inlet Belugas

Chemical Class	Example Individual Constituents	Detected in Cook Inlet Belugas (Becker & Pugh 2000, Becker et al. 2000, Becker 2009)	Detected In Other Beluga Stocks
Alkylphenols, alkylphenol ethoxylates (APEs)	Nonylphenol, octylphenol	No information available	No information available
Consumer plastics	Bisphenol A (BPA) (2,2-bis(4-hydroxydiphenyl) propane)	No information available	No information available
Natural and synthetic hormones	Estradiols, thyroxine analogs	No information available	No information available
Surfactants	4-nonylphenol; "alkylphenol polyethoxylate surfactants"; o-, m-, or p-nonylphenol	No information available	No information available
Pesticides	Lindane, methyl-parathion; permethrin; triazines	No information available	No information available
Synthetic pyrethroids	Bifenthrin, cypermethrin, Permethrins, esfenvalerate	No information available	No information available
Engineered particles with dimension less than 100 nm	Nanotubes, nanoparticles	No information available	No information available
Prions (Considered a "pest" under FIFRA because they share many of the same traits as pest microorganisms)	Abnormal, infectious forms of proteins , lacking genetic material, residing in cells of the central nervous system	No information available	No information available

Table 6 - Available Tissue Concentration Data for Cook Inlet Belugas

Group	Name	Mean Concentration in Males (mg/kg wet)	Mean Concentration in Females (mg/kg wet)	Tissue
organochlorides	Total PCB's [2]	1.49 ± 0.70	0.79 ± 0.56	blubber
organochlorides	Total DDT's [2]	1.35 ± 0.73	0.59 ± 0.45	blubber
organochlorides	Toxaphene [2]	2.40 ± 1.06	2.02 ± 0.46	blubber
organochlorides	Chlorodane compounds [2]	0.56 ± 0.25	0.30 ± 0.22	blubber
organochlorides	Dieldrin [2]	0.09 ± 0.05	0.06 ± 0.05	blubber
organochlorides	Hexachlorobenzane [2]	0.22 ± 0.09	0.15 ± 0.13	blubber
organochlorides	Hexachlorocyclohexane [2]	0.21 ± 0.07	0.17 ± 0.05	blubber
organochlorides	Mirex [2]	0.01 ± 0.01	0.01 ± 0.00	blubber
Metals/Inorganics	Sodium (Na) [2]	1331 ± 191	1204 ± 200	liver
Metals/Inorganics	Magnesium (Mg) [2]	149.8 ± 16.9	134.5 ± 26	liver
Metals/Inorganics	Chlorine (Cl) [2]	1610 ± 269	1312 ± 198	liver
Metals/Inorganics	Potassium (K) [2]	2898 ± 310.8	2849 ± 322	liver
Metals/Inorganics	Calcium (Ca) [1]	41.6 ± 6.46	26.7 ± 2.91	liver
Metals/Inorganics	Vanadium (V) [1]	0.041 ± 0.012	0.034 ± 0.022	liver
Metals/Inorganics	Manganese (Mn) [1]	2.17 ± 0.33	2.651 ± 0.72	liver
Metals/Inorganics	Iron (Fe) [1]	316.9 ± 116.7	235.0 ±149.0	liver
Metals/Inorganics	Cobalt (Co) [1]	0.009 ± 0.002	0.0281 ± 0.041	liver
Metals/Inorganics	Copper (Cu) [1]	48.93 ± 39.79	29.26 ± 20.09	liver
Metals/Inorganics	Zinc (Zn) [1]	27.26 ± 2.265	24.38 ± 1.591	liver
Metals/Inorganics	Arsenic (As) [1]	0.078 ± 0.023	0.356 ± 0.329	liver
Metals/Inorganics	Selenium (Se) [1]	4.347 ± 1.561	2.620 ± 1.547	liver
Metals/Inorganics	Bromine (Br) [1]	17.83 ± 4.26	17.28 ± 7.321	liver
Metals/Inorganics	Rubidium (Rb) [1]	1.765 ± 0.267	1.387 ± 0.174	liver
Metals/Inorganics	Silver (Ag) [1]	6.778 ± 4.169	4.383 ± 4.463	liver
Metals/Inorganics	Cadmium (Cd) [1]	< 1	0.63 ± 0.155	liver
Metals/Inorganics	Cesium (Cs) [1]	0.051 ± 0.024	0.0644 ± 0.0094	liver
Metals/Inorganics	Mercury (Hg) [1]	5.454 ± 3.471	2.568 ± 1.816	liver
Metals/Inorganics	Methylmercury (Me-Hg) [1]	1.74 ± 0.66	0.52 ± 0.25	liver

Table 6 - Available Tissue Concentration Data for Cook Inlet Belugas

Group	Name		Units	Mean Concentration	Tissue
Metal	Copper (Cu)	1	mg/kg dry	162 ± 130	liver
Metal	Cadmium (Cd)	1	mg/kg dry	2.39	liver
Metal	Mercury (Hg)	1	mg/kg dry	16.3 ± 13.0	liver
Metal	Selenium (Se)	1	mg/kg dry	14.3 ± 7.0	liver
Metal	Zinc (Zn)	1	mg/kg dry	102 ± 10.7	liver
Brominated Flame Retardants	Polybrominated diphenyl ethers (PBDEs)	2	ng/g wet	13	not stated
Brominated Flame Retardants	Hexabromocyclododecane (HBCD)	2	ng/g wet	2	not stated

Notes
mg/kg dry = milligram per kilogram dry weight
mg/kg wet = milligram per kilogram wet weight
ng/g wet = nanogram per gram wet weight
1 Becker et al. 2000.
2 Becker. 2009.

Table 7 - Summary of Chemical Evaluation and Recommendations

Chemical Class	Example Individual Constituents	Chemical Of Potential Concern For Cook Inlet Belugas?[1]	[2] PHASE 1: Water, Sediment, Invertebreate/ Fish Tissue	PHASE 2: Marine Mammal Tissue	PHASE 3: Ecological Risk Assessment	Rationale For Recommentdation
Chlorinated pesticides	DDTs, aldrin, dieldrin, chlordane, endosulfan, mirex, toxaphene mixtures	PROBABLE	**YES**	**YES**	**YES**	Documented presence in Cook Inlet Beluga whale tissue, documented potential for adverse effects on growth and reproductive success.
Chlorinated dielectric fluids, transformer oils	209 PCB congeners, aroclor mixtures	PROBABLE	**YES**	**YES**	**YES**	Documented presence in Cook Inlet Beluga whale tissue, documented potential for adverse effects on growth and reproductive success.
Chlorinated dibenzo-p-dioxins and furans	75 Dioxin congeners (PCDDs), 135 furan congeners (PCDFs)	PROBABLE	**YES**	**DEFER**	**DEFER**	Documented potential for adverse effects on reproductive success. However, no data on environmental concentrations of dioxins in Cook Inlet. Suggest completing Phase 1 before deciding if Phase 2 and 3 would be useful.
Metals	Methyl mercury, selenium, butyltins	PROBABLE	**YES**	**DEFER**	**YES**	Documented potential for adverse effects on growth and reproductive success. Suggest completing ecological risk assessment based on environmental data before deciding if marine mammal tissue data would be useful. Copper concentrations in liver may warrant further evaluation for potential renal damage.
Polycyclic aromatic hydrocarbons (PAHs)	Benzo(a)pyrene, anthracene, pyrene	PROBABLE	**YES**	**YES**	**YES**	Documented potential for high molecular weight PAHs to cause cancer and other adverse effects. Suggest a one-time sampling for environmental and tissue concentrations of PAHs (Phase 1 and 2) and ecological risk assessment (Phase 3) to evaluate if PAHs are a chemical of concern.
Hydrocarbons (Non-PAH compounds)	Alkanes, alkenes	UNLIKELY	**YES**	**DEFER**	**DEFER**	Appear to have a low potential for adverse effects but cannot be ruled out. Suggest completing a Phase 1 survey in environmental media before deciding if Phase 2 and 3 would be useful.

Table 7 - Summary of Chemical Evaluation and Recommendations

Chemical Class	Example Individual Constituents	Chemical Of Potential Concern For Cook Inlet Belugas?[1]	[2] PHASE 1: Water, Sediment, Invertebreate/ Fish Tissue	PHASE 2: Marine Mammal Tissue	PHASE 3: Ecological Risk Assessment	Rationale For Recommentdation
Glycols	Ethylene glycol and deicer formulations	UNLIKELY	**YES**	**DEFER**	**DEFER**	Appear to have a low potential for adverse effects but fish kills in the vicinity of the airport and consequent loss of prey to Belugas cannot be ruled out. Suggest completing a Phase 1 survey in environmental media before deciding if Phase 2 and 3 would be useful.
Polybrominated flame retardants	Polybrominated diphenylethers (PBDEs)	POSSIBLE	**YES**	**YES**	**YES**	Potential to cause endocrine disruption and other adverse effects. Airborne deposition may be a significant additional source. Suggest a one-time sampling for environmental and tissue concentrations (Phase 1 and 2) and ecological risk assessment (Phase 3) to evaluate if PBDEs are a chemical of concern.
	Polybrominated biphenyls (PBBs)	POSSIBLE	**YES**	**YES**	**YES**	Potential to cause endocrine disruption and other adverse effects. Airborne deposition may be a significant additional source. Suggest a one-time sampling for environmental and tissue concentrations (Phase 1 and 2) and ecological risk assessment (Phase 3) to evaluate if PBBs are a chemical of concern.
	Polybrominated dibenzo-p-dioxins (PBDDs)/ polybrominated dibenzo-p-furans (PBDFs)	POSSIBLE	**YES**	**YES**	**YES**	Potential to cause endocrine disruption and other adverse effects. Airborne deposition may be a significant additional source. Suggest a one-time sampling for environmental and tissue concentrations (Phase 1 and 2) and ecological risk assessment (Phase 3) to evaluate if PBDDs/ PBDFs are a chemical of concern.
Hexabromo-cyclododecanes (HBCDs; HBCDDs)	$C_{12}H_{18}Br_6$; 16 stereoisomeric forms (CAS# 25637-66-4)	POSSIBLE	**YES**	**YES**	**YES**	Potential to cause endocrine disruption and other adverse effects. Airborne deposition may be a significant additional source. Suggest a one-time sampling for environmental and tissue concentrations (Phase 1 and 2) and ecological risk assessment (Phase 3) to evaluate if HBCDs are a chemical of concern.

Table 7 - Summary of Chemical Evaluation and Recommendations

Chemical Class	Example Individual Constituents	Chemical Of Potential Concern For Cook Inlet Belugas?[1]	[2] PHASE 1: Water, Sediment, Invertebreate/ Fish Tissue	PHASE 2: Marine Mammal Tissue	PHASE 3: Ecological Risk Assessment	Rationale For Recommentdation
Perfluoronated compounds	Perfluoro-octane sulfonates (PFOS)	POSSIBLE	**YES**	**YES**	**YES**	Potential to cause endocrine disruption and other adverse effects. Airborne deposition may be a significant additional source. Suggest a one-time sampling for environmental and tissue concentrations (Phase 1 and 2) and ecological risk assessment (Phase 3) to evaluate if PFOS are a chemical of concern.
	Perfluoro-octanoic acid (PFOA)	POSSIBLE	**YES**	**YES**	**YES**	Potential to cause endocrine disruption and other adverse effects. Airborne deposition may be a significant additional source. Suggest a one-time sampling for environmental and tissue concentrations (Phase 1 and 2) and ecological risk assessment (Phase 3) to evaluate if PFOA are a chemical of concern.
Phthalates/ phthalate esters/ alkylated phthalates	Diethyl phthalate, butylbenzylphthalate	POSSIBLE	**YES**	**YES**	**YES**	Potential to cause endocrine disruption and other adverse effects. Airborne deposition may be a significant additional source. Suggest a one-time sampling for environmental and tissue concentrations (Phase 1 and 2) and ecological risk assessment (Phase 3) to evaluate if phthalates are a chemical of concern.
Prescription and over-the-counter drugs	Penicillins, tetracyclines, clofibric acid, aspirin, ibuprofen, prozac	POSSIBLE	**YES**	**DEFER**	**DEFER**	Suggestive potential for adverse effects on reproductive success. However, no data on environmental concentrations of pharmaceutical chemicals in Cook Inlet. Suggest completing Phase 1 before deciding if Phase 2 and 3 would be useful.
Diagnostic agents	Amidated, iodinated aromatics	UNLIKELY	**YES**	**DEFER**	**DEFER**	Unknown potential for adverse effects on reproductive success. However, no data on environmental concentrations of diagnostic agents in Cook Inlet. Suggest completing Phase 1 before deciding if Phase 2 and 3 would be useful.

Table 7 - Summary of Chemical Evaluation and Recommendations

Chemical Class	Example Individual Constituents	Chemical Of Potential Concern For Cook Inlet Belugas?[1]	[2] PHASE 1: Water, Sediment, Invertebreate/ Fish Tissue	PHASE 2: Marine Mammal Tissue	PHASE 3: Ecological Risk Assessment	Rationale For Recommentdation
Dietary Supplements, Nutraceuticals	Cholestin, huperzin, kava, other herbal products	UNLIKELY	**YES**	**DEFER**	**DEFER**	Unknown potential for adverse effects on reproductive success. However, no data on environmental concentrations of dioxins in Cook Inlet. Suggest completing Phase 1 before deciding if Phase 2 and 3 would be useful.
Fragrances, sunscreens, cosmetics, soaps, conditioners	Methylbenzylidene camphor, oxybenzone	UNLIKELY	**YES**	**DEFER**	**DEFER**	Suggestive potential for adverse effects on reproductive success. However, no data on environmental concentrations of personal care chemicals in Cook Inlet. Suggest completing Phase 1 before deciding if Phase 2 and 3 would be useful.
Alkylphenols, alkylphenol ethoxylates (APEs)	nonylphenol, octylphenol	POSSIBLE	**YES**	**YES**	**YES**	Potential to cause endocrine disruption and other adverse effects. Airborne deposition may be a significant additional source. Suggest a one-time sampling for environmental and tissue concentrations (Phase 1 and 2) and ecological risk assessment (Phase 3) to evaluate if APEs are a chemical of concern.
Consumer plastics	Bisphenol A (BPA) (2,2-bis(4-hydroxydiphenyl) propane)	POSSIBLE	**YES**	**YES**	**YES**	Potential to cause endocrine disruption and other adverse effects. Airborne deposition may be a significant additional source. Suggest a one-time sampling for environmental and tissue concentrations (Phase 1 and 2) and ecological risk assessment (Phase 3) to evaluate if BPAs are a chemical of concern.
Natural and synthetic hormones	Estradiols, thyroxine analogs	POSSIBLE	**YES**	**DEFER**	**DEFER**	Suggestive potential for adverse effects on reproductive success. However, no data on environmental concentrations of dioxins in Cook Inlet. Suggest completing Phase 1 before deciding if Phase 2 and 3 would be useful.

Table 7 - Summary of Chemical Evaluation and Recommendations

Chemical Class	Example Individual Constituents	Chemical Of Potential Concern For Cook Inlet Belugas?[1]	[2] PHASE 1: Water, Sediment, Invertebreate/ Fish Tissue	PHASE 2: Marine Mammal Tissue	PHASE 3: Ecological Risk Assessment	Rationale For Recommentdation
Surfactants	4-nonylphenol; "alkylphenol polyethoxylate surfactants"; o-, m-, or p-nonylphenol	POSSIBLE	**YES**	**YES**	**YES**	Potential to cause endocrine disruption and other adverse effects. Airborne deposition may be a significant additional source. Suggest a one-time sampling for environmental and tissue concentrations (Phase 1 and 2) and ecological risk assessment (Phase 3) to evaluate if surfactants are a chemical of concern.
Pesticides	Lindane, methyl-parathion; permethrin; triazines	POSSIBLE	**YES**	**DEFER**	**DEFER**	Documented potential for adverse effects on survival and reproductive success. However, no data on environmental concentrations of dioxins in Cook Inlet. Suggest completing Phase 1 before deciding if Phase 2 and 3 would be useful.
Engineered particles with dimension less than 100 nm	Nanotubes, nanoparticles	UNLIKELY	**NO**	**NO**	**YES**	Unknown potential for adverse effects on reproductive success. No readily available sampling and analytical methods. Suggest further literature review and discussion of potential for adverse effects.
Organochlorines	DDTs, aldrin, dieldrin, chlordane, endosulfan, mirex, toxaphene mixtures	PROBABLE	**YES**	**YES**	**YES**	Documented presence in Cook Inlet Beluga whale tissue, documented potential for adverse effects on growth and reproductive success
Organophosphates/ carbamates	Malathion, methyl-parathion, chlorpyrifos, diazinon, carbaryl, aldicarb	POSSIBLE	**YES**	**DEFER**	**DEFER**	Limited potential for adverse effects on mortality and growth, but of low environmental persistence. No data on environmental concentrations of OP and C pesticides in Cook Inlet. Suggest completing Phase 1 before deciding if Phase 2 and 3 would be useful.
Triazines	Atrazine, cyanazine, simazine	POSSIBLE	**YES**	**DEFER**	**DEFER**	Limited potential for adverse effects on mortality and growth of prey items for Belugas, but of low environmental persistence. No data on environmental concentrations of triazine pesticides in Cook Inlet. Suggest completing Phase 1 before deciding if Phase 2 and 3 would be useful.

Table 7 - Summary of Chemical Evaluation and Recommendations

Chemical Class	Example Individual Constituents	Chemical Of Potential Concern For Cook Inlet Belugas?[1]	[2] PHASE 1: Water, Sediment, Invertebreate/ Fish Tissue	PHASE 2: Marine Mammal Tissue	PHASE 3: Ecological Risk Assessment	Rationale For Recommentdation
Synthetic pyrethroids	Bifenthrin, cypermethrin, permethrins, esfenvalerate	POSSIBLE	**YES**	**DEFER**	**DEFER**	Limited potential for adverse effects on mortality and growth of prey items for Belugas, but of low environmental persistence. No data on environmental concentrations of pyrethroid pesticides in Cook Inlet. Suggest completing Phase 1 before deciding if Phase 2 and 3 would be useful.
Prions (Considered a "pest" under FIFRA because they share many of the same traits as pest micro-organisms)	Abnormal, infectious forms of proteins , lacking genetic material, residing in cells of the central nervous system	UNLIKELY	**NO**	**NO**	**NO**	Unknown potential for adverse effects on reproductive success. No readily available sampling and analytical methods. Suggest further literature review and discussion of potential for adverse effects.

1 The terms Probable, Possible, and Unlikely DO NOT refer to the likelihood of adverse effects on the Cook Inlet Beluga whale population but to whether we have sufficient reason to evaluate them further. A probable chemical of concern does not automatically mean that it is causing adverse effects to belugas in Cook Inlet - it means only that we have probable cause to evaluate it further.

2 These recommendations indicate whether field sampling of each chemical group would be useful for further evaluation. Field sampling and additional evaluation is divided into three phases that get progressively more complex and expensive. The decision making process would be progressive, with the results of Phase 1 informing the need to undertake additional efforts for a particular contaminant. Phase 1 would involve collecting site specific water, sediment, and biological samples that could be tested to see if certain chemicals are present in the environment and food base of belugas and in what concentrations. This phase addresses the question, "What are CI belugas exposed to?" Phase 2 would involve collecting tissue samples from belugas (and/or analyzing existingtissue samples)
and testing for body loads of particular chemicals. This addresses the question, "How much contaminants have CI belugas absorbed?" Phase 3 would involve additional literature review to look for specific toxicological effects thresholds for chemicals, comparing them with information collected in Phase 1 and 2, and evaluating the potential for toxic effects in the population. This addresses the question, "Are CI beluga exposure levels likely to be affecting their growth or reproductive capacity?"