ENDANGERED SPECIES ACT: SECTION 7 CONSULTATION
DRAFT BIOLOGICAL OPINION

Activities Considered: Proposed Approval of the State of Alaska's Mixing Zone Regulation section [18 AAC 70.240], including most recent revisions, of the Alaska Water Quality Standards [18 AAC 70; WQS].

Agency: U.S. Environmental Protection Agency

Consultation by: National Marine Fisheries Service, Alaska Region

Date Issued: December 20, 2010

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Administrator, Alaska Region

Endangered Species Act Section 7 Consultation
On the
U.S. Environmental Protection Agency's
Proposed Approval of the State of Alaska's Mixing Zone Regulation Section,
of the State of Alaska Water Quality Standards

December 20, 2010

National Marine Fisheries Service
Protected Resources Division
Juneau, Alaska

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Executive Summary

On April 15, 2009, the National Marine Fisheries Service (NMFS) received a letter requesting formal consultation from the United States Environmental Protection Agency (EPA) pursuant to section 7 of the Endangered Species Act (ESA). The EPA requested consultation on their proposed approval of the State of Alaska Department of Environmental Conservation's (ADEC) Mixing Zone Regulation section [18 AAC 70.240], including most recent revisions, of the Alaska Water Quality Standards [18 AAC 70; WQS] relative to the endangered Cook Inlet beluga whale. Attached to the EPA request was the April 2009 Cook Inlet Beluga Whale Effects Analysis for Alaska's Mixing Zone WQS Revisions, which supplements the September 9, 2006 Revisions to the Mixing Zone Regulations of Alaska State Water Quality Standards Biological Assessment. The EPA provided further information upon NMFS' request and all the components necessary to initiate formal consultation were received by April 14, 2010.

This document is the product of this consultation pursuant to Section 7(a)(2) of the ESA and implementing regulations found at 50 Code of Federal Regulations (CFR) Part 402. This consultation considers whether the effects of the action within the action area are likely to jeopardize the continued existence of Cook Inlet beluga whales. In formulating this Biological Opinion, NMFS used information presented in EPA documents as well as other information relating to mixing zones, water quality standards, contaminants and Cook Inlet beluga life history and health. After reviewing the current status of Cook Inlet beluga whales, the proposed action and the environmental baseline for the proposed action, NMFS finds the action is unlikely to jeopardize the continued existence of the Cook Inlet beluga whale. Though Cook Inlet belugas may be exposed to contaminants through the presence of mixing zones, both directly and indirectly, there is insufficient data and/or evidence at the present time to indicate this exposure has resulted in pathology and/or mortality in Cook Inlet beluga whales.

This opinion will be valid upon issuance and remain in force until re-initiation may become necessary. Consultation will be re-initiated if there are significant changes in the type of activities occurring, if new information indicates these actions are impacting the Cook Inlet beluga whale or other listed species/critical habitats to a degree or in a manner not previously considered, or if new species or critical habitats become listed under the Act.

Presentation of the Analysis in this Opinion

Biological opinions are constructed around several basic sections that represent specific requirements placed on the analysis by the ESA and implementing regulations. These sections contain different portions of the overall analytical approach described here. This section is intended as a basic guide to the reader of the other sections of this opinion and the analyses that can be found in each section. Every step of the analytical approach described above will be presented in this opinion in either detail or summary form. Because critical habitat for Cook Inlet beluga whales has not yet been designated, descriptions of the analytical approach are limited to consultations relative to the listed species in question and do not include processes related to listed critical habitat. A final description on conference proceedings pertains to proposed critical habitat.

This opinion will address the EPA's proposed approval of the State of Alaska's mixing zone regulations, including revisions. Its purpose is to provide an assessment of this action on the continued existence of the Cook Inlet beluga whale, as well as to provide measures to conserve the species and mitigate impact.

Description of the Proposed Action

This section contains a basic summary of the proposed Federal action and any interrelated and interdependent actions. This description forms the basis of the first step in the analysis where the various elements of the action are considered and the stressors expected to result from those elements are determined. The nature, timing, duration, and location of those stressors define the action area and provide the basis for our exposure analyses.

Status of the Species

This section provides the reference condition for the species at the listing and designation scale. These reference conditions form the basis for the determinations of whether the proposed action is not likely to jeopardize the species. Other key analyses presented in this section include critical information on the biological and ecological requirements of the species and the impacts to species from existing stressors.

Environmental Baseline

This section provides the reference condition for the species within the action area. By regulation, the baseline includes the impacts of past, present, and future actions (except the effects of the proposed action) on the species. In this opinion, some of this analysis is contained within the Effects of the Proposed Action section because the proposed action is a continuation of the on-going action (i.e., the baseline), which includes current mixing zones in Cook Inlet. This section also contains summaries of the impacts from stressors that will be ongoing in the same areas and times as the effects of the proposed action (future baseline). This information forms part of the foundation of the exposure, response, and risk analyses.

Effects of the Proposed Action
This section details the results of the exposure, response, and risk analyses NMFS conducted for the listed species.

Cumulative Effects
This section summarizes the impacts of future non-Federal actions reasonably certain to occur within the action area, as required by regulation. Similar to the rest of the analysis, if cumulative effects are expected, NMFS determines the exposure, response, and risk posed to individuals of the species.

Conclusion
In this section of the opinion, NMFS presents the summary of the effects identified in the preceding sections and then details the consequences of the risks posed to individuals or Distinct Population Segment at issue. Finally, this section concludes whether the proposed action may result in jeopardy to the continued existence of a species.

Legal and Policy Framework
The purposes of the ESA, "…are to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve the purposes of the treaties and conventions set forth in subsection (a) of this section." To help achieve these purposes, the ESA requires that, "Each Federal agency shall, in consultation with and with the assistance of the Secretary, insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat…"

Jeopardy Standard
The "jeopardy" standard has been further interpreted in regulation (50 CFR 402.02) as a requirement that Federal agencies insure that their actions are not likely to result in appreciable reductions in the likelihood of both the survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution. It is important to note that the purpose of the analysis is to determine whether or not appreciable reductions are reasonably expected, but not to precisely quantify the amount of those reductions. As a result, the assessment often focuses on whether or not a reduction is expected, but not on detailed analyses designed to quantify the absolute amount of reduction or the resulting population characteristics (abundance, for example) that could occur as a result of proposed action implementation.

For the purposes of this analysis, NMFS equates a listed species' probability or risk of extinction with the likelihood of both the survival and recovery of the species in the wild for purposes of conducting jeopardy analyses under section 7(a)(2) of the ESA. A designation of a high risk of extinction indicates that the species faces significant risks from internal and external processes that can drive a species to extinction. The status assessment considers and diagnoses both the internal and external processes affecting a species' extinction risk.

The parameters of productivity, abundance, and population spatial structure are important to consider because they are predictors of extinction risk, the parameters reflect general biological and ecological processes that are critical to the survival and recovery of the listed species, and these parameters are consistent with the "reproduction, numbers, or distribution" criteria found within the regulatory definition of jeopardy (50 CFR 402.02).

Additional requirements on the analysis of the effects of an action are described in regulation (50 CFR 402) and our conclusions related to "jeopardy" generally require an expansive evaluation of the direct and indirect consequences of the proposed action, related actions, and the overall context of the impacts to the species from past, present, and future actions as well as the condition of the affected species and critical habitat [for example, see the definitions of "cumulative effects," "effects of the action," and the requirements of 50 CFR 402.14(g)]. Recent court cases have reinforced the requirements provided in section 7 regulations that NMFS must evaluate the effects of a proposed action within the context of the current condition of the species, including other factors affecting the survival and recovery of the species and the functions and value of critical habitat. In addition, the Courts have directed that our risk assessments consider the effects of climate change on the species and our prediction of the impacts of a proposed action.

Consultations designed to allow Federal agencies to fulfill these purposes and requirements are concluded with the issuance of a biological opinion or a concurrence letter. Section 7 of the ESA and the implementing regulations (50 CFR 402), and associated guidance documents (e.g., USFWS and NMFS 1998) require biological opinions to present: (1) a description of the proposed Federal action; (2) a summary of the status of the affected species and its critical habitat; (3) a summary of the environmental baseline within the action area; (4) a detailed analysis of the effects of the proposed action on the affected species; (5) a description of cumulative effects; and (6) a conclusion as to whether it is reasonable to expect the proposed action is not likely to appreciably reduce the species' likelihood of both surviving and recovering in the wild by reducing its numbers, reproduction, or distribution.

The Need for Conference

The conferencing process, included in Section 7(a)(4) of the ESA, was added to provide a mechanism for identifying and resolving potential conflicts between a proposed action and proposed species or proposed critical habitat at an early planning stage. While consultations are required when the proposed action may affect a listed species, a conference is required only when the proposed action is likely to jeopardize the continued existence of a proposed species or destroy or adversely modify proposed critical habitat. However, federal action agencies may, at their discretion, request a conference on any proposed action that may affect proposed species or proposed critical habitat.

1.0 Description of the Proposed Action

The proposed action, as described in the following sections, is the Environmental Protection Agency's (EPA) proposed approval of the State of Alaska Department of Environmental Conservation's (ADEC) Mixing Zone Regulation section [18 AAC 70.240], including most recent revisions, of the Alaska Water Quality Standards [18 AAC 70; WQS]. Though the action is the EPA approval of the State of Alaska's mixing zone regulations, the analysis of the action is based upon the effects of mixing zones on the health of Cook Inlet beluga whales.

1.1 General Overview

Water Quality Standards (WQS) define the water quality goals of a waterbody by designating the uses to be made of the water as well as setting criteria to prevent or limit water degradation. The WQS program administered by the EPA is based upon the Clean Water Act (33 U.S.C. 1251 et seq.;CWA), which defines broad water quality goals and provides the statutory basis for WQS. Within the CWA is a requirement that all states adopt water quality standards and that the EPA review and approve these standards. States may, at their discretion, adopt certain policies affecting the application and implementation of standards, which may include policies concerning mixing zones [40 CFR 131.13]. The EPA reviews such policies to ensure they are compatible with the State's WQS, technically well-founded and consistent with the CWA.

EPA guidance explains that it is not always necessary to meet all water quality criteria within the discharge pipe to protect the integrity of the water body as whole; rather, it may be appropriate to allow for ambient concentrations above the criteria in small areas or "mixing zones". The basic premise of a mixing zone is that the capacity for dilution of the receiving waters is sufficient to allow for WQS to be met within an acceptable distance beyond the end of the effluent pipe. A mixing zone, therefore, is a limited area or volume of water where initial dilution of a discharge takes place, and where numeric water quality criteria can be exceeded but acutely toxic conditions are prevented (USEPA 2007e). Within a mixing zone an effluent discharge undergoes initial dilution which is extended to cover the secondary mixing in the ambient water body.

According to the State of Alaska's Draft Implementation Guidance for Mixing Zones (ADEC 2005), acute WQS may be exceeded within a smaller area within the mixing zone identified as the Zone of Initial Dilution (ZID), though the acute WQS may not be exceeded at the edge of the ZID (Fig. 1). Under Alaska law, "acute' is defined as "…means of, relating to, or resulting from a level of toxicity of a substance, a substance combination, or an effluent sufficient to produce observable lethal or sublethal effects in aquatic organisms exposed for short periods of time, typically 96 hours or less…" (18 AAC 70.990.1). Chronic WQS may be exceeded throughout the mixing zone but must be met at the edge of the mixing zone. The State defines "chronic" as "…means of, relating to, or resulting from a level of toxicity of a substance, a substance combination, or an effluent sufficient to produce observable lethal or sublethal effects, including effects on growth, development, behavior, reproduction, or survival, in aquatic organisms exposed for a period of time that generally is one-tenth or more of their life span" (18 AAC 70.990.11). Mixing zones allow the WQS to be exceeded at the point of discharge and define a distance from the point of discharge where these standards must be met.

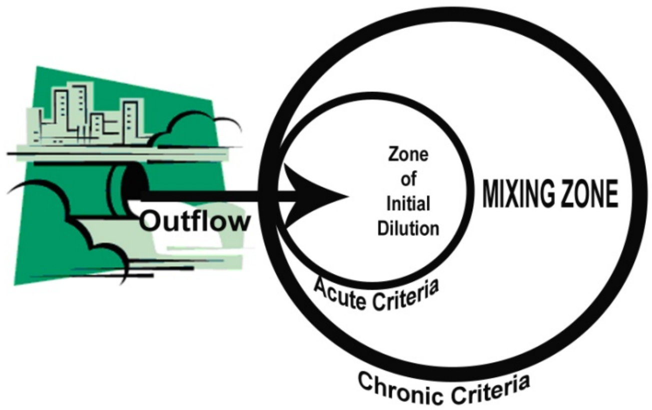


Figure 1. Mixing Zone Configuration and Water Quality Criteria

The EPA has implemented regulations which provide that States may, at their discretion, include in their WQS "policies generally affecting the application and implementation [of state standards], such as mixing zones, low flows and variances" (40 C.F.R. 131.13). When states do include such policies as part of their standards, the policies are subject to EPA review and approval. The EPA reviews such policies to determine if they are: 1. compatible with the State's WQS, 2. technically well founded and 3. consistent with the CWA. The EPA also provides guidance to the State for developing policy on mixing zones (USEPA 1991, 1996). Although this guidance is non-regulatory, it does include several important elements considered to be appropriate for states to include in their mixing zone policies. The elements pertinent to listed species include:

- Mixing zone limitations – as small as practicable, numeric water quality criteria may be exceeded but acutely toxic conditions are avoided. (USEPA 2007e)
- In-zone quality – in-zone quality is specified and lethality to swimming, drifting and sessile organisms is prevented.
- Protection of sensitive areas – restriction of placement that ensures mixing zones do not impinge upon sensitive areas (e.g. breeding grounds, critical habitat etc.). The EPA guidance indicates it may be appropriate to specify certain areas where mixing zones are inappropriate.
- Prohibition of certain pollutants – mixing zones for certain pollutants are prohibited due to concerns about potential effects.
- Zones of passage – protection of migrating fish or other organisms.
- Protection of designated uses.

As authorized by the Clean Water Act and administered by the EPA, the National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Section 301(a) of the CWA provides that the discharge of pollutants is unlawful except in accordance with the terms of a facility's NPDES permit.

In Alaska, a permittee can apply to ADEC for a mixing zone permit under the Section 401 NPDES program. Though the burden of proof for justifying and establishing a mixing zone lies with the permittee, the ADEC has the ultimate discretion in evaluating, authorizing or denying a mixing zone based upon the mixing zone regulations.

Although the EPA action is the proposed approval of the State of Alaska's mixing zone regulations, the fundamental concern is the degree to which mixing zones, as allowed by the ADEC mixing zone regulations, may impact the health of Cook Inlet beluga whales. Relative to Cook Inlet beluga health, ADEC mixing zone regulations under EPA review include certain requirements that must be followed. In applying for a mixing zone, the permittee supplies all information to ADEC necessary to demonstrate compliance with these requirements. In approving or disapproving the application, the State then evaluates the provided information and considers all facets of the proposed mixing zone, including characteristics of the receiving water and effluent, possible effects, mitigation measures and other possible factors. Evidence presented must reasonably demonstrate that the designated uses and overall biological integrity of the water body will be maintained and that the mixing zone will not result in acute or chronic toxic effects outside the boundary of the mixing zone, will not reduce fish or shellfish populations, will not result in irreparable displacement of indigenous organisms and will not adversely affect threatened or endangered species except as authorized under 16 U.S.C. 1531-1544 (Endangered Species Act). Available evidence must also reasonably demonstrate that discharged pollutants will not bioaccumulate, bioconcentrate or persist above background to adverse levels, cause lethality to passing organisms or exceed acute aquatic life criteria beyond the ZID [18 AAC 70.240].

1.2 Background of the State of Alaska's Revision to Mixing Zone Regulations and Consultation History

The ADEC originally adopted, with EPA approval, a mixing zone policy in 1979. Since that time, the policy has been revised several times. In October of 2005, the ADEC proposed further revisions to the mixing zone regulation. In January of 2006, the ADEC repealed its previous mixing zone policy and readopted a new policy, which included proposed revisions. The final regulation was subsequently incorporated into State law on March 23, 2006 and submitted for EPA review on August 14, 2006.

Section 7(a) of the Endangered Species Act (ESA) requires that, using the best scientific and commercial data available, "each federal agency shall, in consultation and with the assistance of the Secretary, insure that any action authorized, funded, or carried out by such agency…is not likely to jeopardize the continued existence of any endangered species or threatened species" (50 CFR 402.01). As the EPA is charged with reviewing state WQS to ensure consistency with the CWA, the federal action of this consultation is the EPA's proposed approval of the State of Alaska's mixing zone regulations. Although the revisions of the existing mixing zone standard were the impetus for the EPA to initiate Section 7 consultation, the EPA had not previously consulted with NOAA on existing ADEC mixing zone regulations. Consequently, both the EPA and NOAA agreed that the consultation would encompass the EPA proposed approval of the entire mixing zone regulation and not just the incremental change due to revisions. The EPA is also aware of the conference process relative to proposed Critical Habitat.

On September 29, 2006 the EPA initiated Section 7 consultation on nine ESA listed marine mammal species under NMFS' jurisdiction. Included in the consultation was the "Revisions to the Mixing Zone Regulations of Alaska State Water Quality Standards Biological Assessment" (BA). While the Cook Inlet beluga whale was included in the 2006 BA, it was considered as a candidate species at that time and NMFS chose to consult on the Cook Inlet beluga whale pending the listing decision, which was finalized on October 22, 2008 (75 FR 4528).

On April 15, 2009 NMFS received a letter from the EPA requesting the initiation of formal ESA consultation on the Cook Inlet Beluga Whale. Included in the EPA letter of request was the "Cook Inlet Beluga Whale Effects Analysis for Alaska's Mixing Zone WQS Revisions" (BA Supplement), dated April 9, 2009, which supplements the analysis in the EPA's 2006 BA. Although the EPA action is the proposed approval of ADEC mixing zone regulations, the underlying question is whether the regulations, and consequently the presence of mixing zones, are likely to jeopardize the population of beluga whales in Cook Inlet. If mixing zones, in compliance with ADEC regulations, are likely to jeopardize the health of Cook Inlet belugas, then the EPA approval of the regulations will consequently result in a jeopardy opinion. The EPA determination that the approval of the State's Mixing Zone Revisions would be likely to adversely affect the Cook Inlet beluga whale, therefore, was based upon mixing zone characteristics relative to beluga whale health. Regarding evidence presented in the EPA determination, the BA Supplement stated that the Cook Inlet beluga has a thick layer of blubber that may store lipophilic contaminants (e.g. Polychlorinated biphenyls (PCBs) and chlorinated hydrocarbons) and may also be exposed to chemicals that bioaccumulate and are biomagnified (e.g. mercury, PCBs, dichlorodiphenyltrichloroethane (DDT)). These, and other chemicals, may be present as mixing zone contaminants from various commercial and municipal sources of discharge. The BA Supplement then compared levels of various chemicals, including those listed above, between Cook Inlet belugas and Arctic/northern populations of beluga whales and stated that, with the exception of hepatic copper, levels were lower in the Cook Inlet population. The BA Supplement further stated that the EPA believes negative consequences are limited because:

1. The presence of Cook Inlet belugas in the vicinity of a mixing zone would probably be minimal.
2. The potential for bioaccumulation is limited because of prohibitions included in the revision. Further, the state will be considering sublethal chronic effects and bioaccumulation when assessing adverse effects.
3. The revision includes size limits for mixing zones, including the requirement that the mixing zone be "as small as practicable".
4. A provision in the revised regulations, paragraph 240(c)(4)(F), makes it a violation of State law for a mixing zone to have any adverse effect on listed species that has not been authorized under the ESA.

The BA Supplement concluded that, despite the above factors, the EPA could not rule out the possibility that approval of the State of Alaska's mixing zone regulation, as revised, would adversely affect Cook Inlet beluga whale population. Consequently, the EPA determined that the action was "likely to adversely affect" Cook Inlet beluga whales.

NMFS subsequently requested further information from the EPA, which was provided both electronically and through direct communication, and all the components necessary to initiate formal consultation were received by April 14, 2010.

1.3 Action Area

The action area is defined as all areas to be affected directly or indirectly by the federal action (50 CFR 402.02). Under the Clean Water Act, State WQS apply to surface waters within State boundaries. The line of ordinary low water and the line marking the seaward limit of inland waters are known as "baseline". Within the first three nautical miles seaward from the baseline, State boundaries overlap with the territorial seas of the United States. Territorial seas are defined as "the belt of the seas measured from the line of ordinary low water along that portion of the coast which is in direct contact with the open sea and the line marking the seaward limit of inland waters, and extending seaward a distance of three nautical miles" [CWA Section 502(8)]. Although ADEC mixing zone regulations encompass all surface waters in the State of Alaska, the relevant action area in this consultation is a subset of waters delineated by the range distribution of Cook Inlet belugas. In Cook Inlet, the seaward limit is defined by the southern edge of Kalgin Island. Therefore, for purposes of this consultation, the action area is defined as all surface waters of the State and marine waters within State boundaries up to three nautical miles from baseline, which includes all of northern Cook Inlet to a southern margin three nautical miles from Kalgin Island and three nautical miles from the ordinary low water line in southern Cook Inlet (Fig. 2).

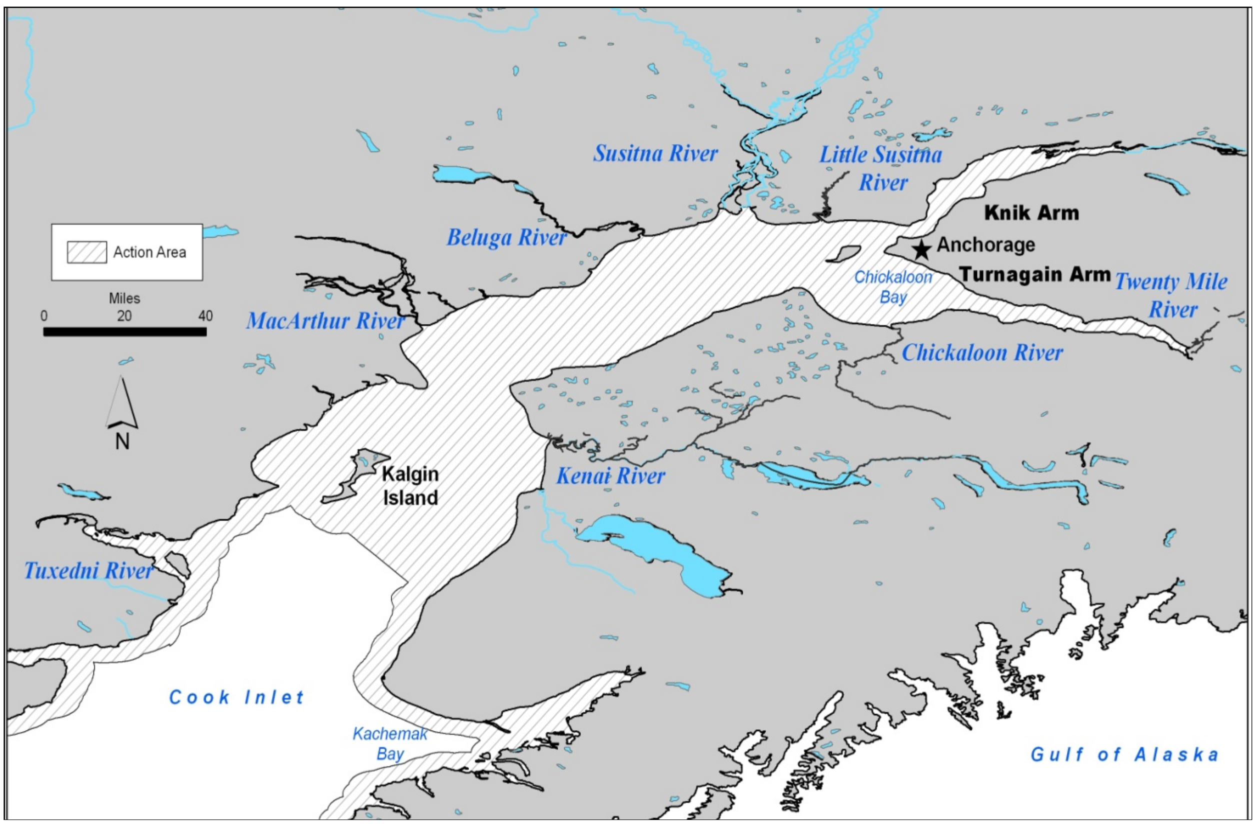


Figure 2. Action Area. Waters of Cook Inlet in which ADEC mixing zone regulations apply.

2.0 Status of the Species

2.1 Species Description

The beluga whale is a small, toothed whale in the family *Monodontidae*, a family it shares with only the narwhal. Belugas are also known as "white whales" because of the white coloration of the adults. The beluga whale is a northern hemisphere species, ranging primarily over the Arctic Ocean and some adjoining seas, where it inhabits fjords, estuaries, and shallow water in Arctic and subarctic oceans. Five distinct stocks of beluga whales are currently recognized in Alaska: Beaufort Sea, eastern Chukchi Sea, eastern Bering Sea, Bristol Bay, and Cook Inlet. The Cook Inlet population is numerically the smallest of these, and is the only one of the five Alaskan stocks occurring south of the Alaska Peninsula in waters of the Gulf of Alaska (Laidre et al. 2000). Beluga whales have a well-developed sense of hearing and echolocation. These whales hear over a large range of frequencies, from about 40-75 Hertz (Hz) to 30-100 kiloHertz (kHz) (Richardson 1995), although their hearing is most acute at middle frequencies between about 10 kHz and 75 kHz (Fay 1988). Most sound reception takes place through the lower jaw which is hollow at its base and filled with fatty oil. Sounds are received and conducted through the lower jaw to the middle and inner ears, then to the brain. Complementing their excellent hearing is the fact that beluga whales have one of the most diverse vocal repertoires of all marine mammals. They are capable of making a variety of vocalizations, including whistles, buzzes, groans, roars, trills, etc., which lead to their nickname as sea canaries. Their vision is reported to also be well developed; they appear to have acute vision both in and out of water and, as their retinas contain both rod and cone cells, are believed to see in color (Herman 1980).

2.2 Life History

Belugas are a slowly reproducing, long-lived (K selected) species. Belugas may live over 60 years with the entire reproductive process for a single calf, from birth to weaning, averaging about 3 years. Calving generally occurs in the spring and summer, after about a 24 month gestation period, and weaning may take as long as two years. Most calving in Cook Inlet is assumed to occur from mid-May to mid-July (Calkins 1983), although Native hunters have observed calving from April through August (Huntington 2000). Surveys conducted from 2005 to 2007 in the upper Inlet by LGL, Inc., documented neither localized calving areas nor a definitive calving season, since calves were encountered in all surveyed locations and months (April-October) (McGuire et al., 2008). While mating is assumed to occur sometime between late winter and early spring, there is little information available on the mating behavior of belugas.

Belugas are opportunistic feeders, preying on a variety of animals which they swallow whole. Species noted in beluga stomach content samples include: octopus, squid, crabs, shrimp, clams, mussels, snails, sandworms, polychaetes and various fish such as cod, herring, capelin, eulachon, flounder, sole, sculpin, pollock, lamprey, lingcod and salmon. The volume and timing of prey items appears to be a function of seasonal availability and the whales will focus on specific species when they are seasonally abundant. Eulachon, an anadromous species that spawns in the upper Inlet, is one of the most important prey items available in the spring. These fish first enter the upper Inlet in April, with two major spawning migrations occurring in the Susitna River in

May and July (Calkins, 1989). In the summer, as eulachon runs begin to diminish, belugas begin to rely heavily on several species of salmon, both outmigrating smolt and incoming adults.

In upper Cook Inlet, beluga whales concentrate offshore from several important salmon streams and appear to use a feeding strategy which takes advantage of the bathymetry in the area. The channels formed by the river mouths and the shallow waters act as a funnel for salmon as they move past waiting belugas. Dense concentrations of prey may be essential to beluga whale foraging. Hazard (1988) hypothesized that beluga whales were more successful feeding in rivers where prey were concentrated than in bays where prey were dispersed. Fried et al. (1979) noted that beluga whales in Bristol Bay fed at the mouth of the Snake River, where salmon runs are smaller than in other rivers in Bristol Bay. However, the mouth of the Snake River is shallower, and hence may concentrate prey. Research on beluga whales in Bristol Bay suggests these whales preferred certain streams for feeding based on the configuration of the stream channel (Frost et al. 1983). This study theorized beluga whales' feeding efficiencies improve in relatively shallow channels where fish are confined or concentrated. Because beluga whales do not always feed at the streams with the highest runs of fish, bathymetry and fish density may be more important than sheer numbers of fish in their feeding success. If true, this would imply Cook Inlet beluga whales do not simply go where the fish are, but may be partially dependent on particular feeding habitats with appropriate topography. For example, beluga whales today are seen less frequently at the mouth of the Kenai River, despite high salmon returns to the river. Beluga whales exhibit high site fidelity and may persist in an area with fluctuating fish runs or may tolerate certain levels of disturbance from boats or other anthropogenic activities in order to feed.

Spring and summer feeding appears to be crucial to Cook Inlet beluga energetics. The energy content of various prey species such as eulachon, which may contain up to 21% oil (Payne et al. 1999), and salmon may be vital for beluga sustenance throughout the year (Abookire and Piatt, 2005; Litzow et al., 2006). Native hunters in Cook Inlet have stated that beluga whale blubber is thicker after the whales have fed on eulachon than in the early spring prior to eulachon runs. In spring, the whales were described as thin with blubber only 2-3 inches (5-8 cm) thick compared to the fall when the blubber may be up to 1 ft (30 cm) thick (Huntington, 2000). Eating such fatty prey and building up fat reserves throughout spring and summer may allow beluga whales to sustain themselves during periods of reduced prey availability (e.g., winter) or other adverse impacts by using the energy stored in their blubber to meet metabolic needs. Mature females have additional energy requirements. The known presence of pregnant females in late March, April, and June (Mahoney and Shelden, 2000; Vos and Shelden, 2005) suggests breeding may be occurring in late spring into early summer. Calves depend on their mother's milk as their sole source of nutrition, and lactation lasts up to 23 months (Braham, 1984), though young whales begin to consume prey as early as 12 months of age (Burns and Seaman, 1986). Therefore, the summer feeding period is critical to pregnant and lactating belugas. Summertime prey availability is difficult to quantify. Known salmon escapement numbers and commercial harvests have fluctuated widely throughout the last 40 years; however, samples of harvested and stranded beluga whales have shown consistent summer blubber thicknesses.

In the fall, as anadromous fish runs begin to decline, belugas again return to consume the fish species found in nearshore bays and estuaries. This includes cod and pollock species as well as other bottom-dwellers, such as Pacific staghorn sculpin, and flatfishes, such as starry flounder and yellowfin sole. This change in diet in the fall is consistent with other beluga populations known to feed on a wide variety of food

2.3 Status and Population Dynamics

The Cook Inlet beluga stock has probably always numbered fewer than several thousand animals, but has declined significantly from its historical abundance. It is difficult to accurately determine the magnitude of decline, because there is no available information on the abundance of beluga whales that existed in Cook Inlet prior to development of the southcentral Alaska sub-Region, nor prior to modern subsistence whaling by Alaska Natives (NMFS 2008). In 1979, the Cook Inlet beluga stock was estimated at 1300 animals (Calkins 1989), which subsequently decreased to 653 animals in 1994 and to an estimated 340 in 2010 (NMFS 2010). As surveys prior to 1994 were not designed specifically to estimate total abundance of the population, the accuracy of early abundance estimates is unknown (Hobbs et al. 2000); however, systematic aerial surveys between 1994 and 1998 indicated a 47 percent decline in the population. The decline of this stock in the 1990's was initially attributed to overexploitation by hunters. Although obtaining accurate estimates of the number of belugas taken each year for the Alaska Native harvest has been difficult, records range from "virtually nil" between 1950 – 1970 to 146 possible taken in 1996, averaging about 72 whales per year (Mahoney and Shelden 2000). Consequently, a moratorium (Pub. L. No. 106-31, Section 3022, 113 Stat. 57, 100, May 21, 1999) was placed on beluga hunting beginning in 1999 and the population was designated as "depleted" under the MMPA on May 31, 2000 (65 FR 34590). With severe restrictions in hunting, the population was then expected to increase; however, the population continued to decline and the stock was listed as "endangered" under the ESA in Oct. 2008 (NMFS 2008). Population analysis over the last decade have shown a continued population decrease of 1.1% annually (NMFS 2010).

2.4 Distribution

Belugas generally occur in shallow, coastal waters, and while some populations make long seasonal migrations, Cook Inlet belugas reside in Cook Inlet year round. Distribution of these whales in Cook Inlet, however, does vary with a high site fidelity that appears to be based primarily upon seasonal availability of prey species. Both scientific research and native hunter Traditional Ecological Knowledge (TEK) say beluga whales may move hundreds of miles to exploit seasonal changes in prey distribution (i.e., belugas follow their prey). There is obvious and repeated use of certain habitats by Cook Inlet beluga whales. Intensive aerial abundance surveys conducted in June and July since 1993 have consistently documented high use of Knik Arm, Turnagain Arm, Chickaloon Bay and the Susitna River delta areas of the upper Inlet (Fig. 4). The high use of these areas by belugas is further supported by data from satellite tagging studies.

Distribution relative to prey species

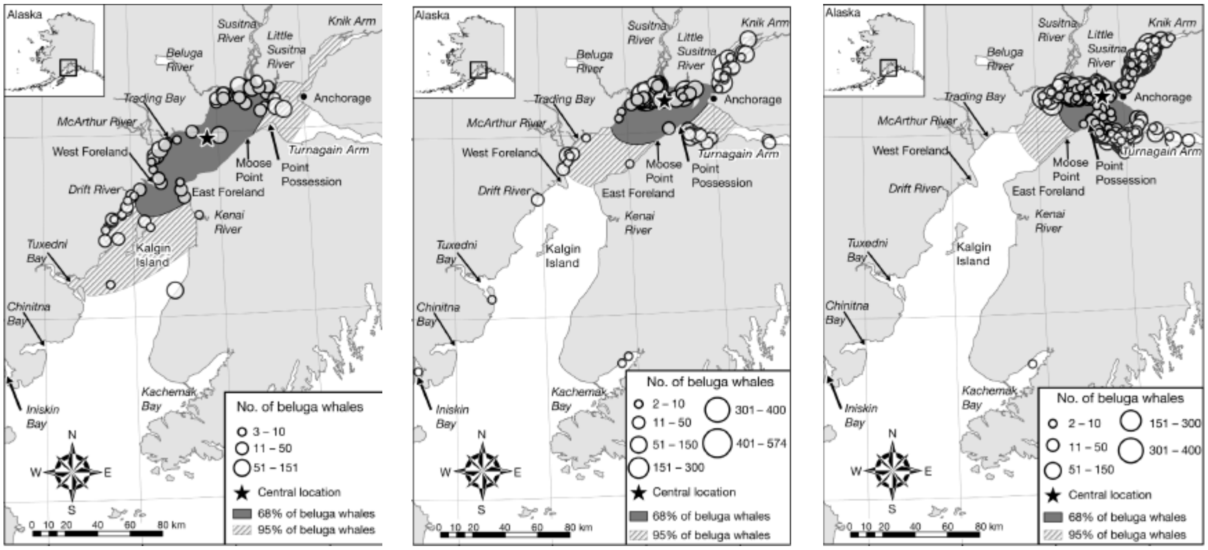
The timing and location of eulachon and salmon runs have a strong influence on belugas' spring and summer movements. Spring prey of Cook Inlet beluga whales includes eulachon and gadids (saffron cod, Pacific cod, and walleye pollock). Eulachon first enter the upper Inlet in April, with two major spawning migrations occurring in the Susitna River in May and July, and beluga whales are regularly sighted in the upper Inlet beginning in late April or early May, coinciding with eulachon runs in the Susitna River and Twenty Mile River in Turnagain Arm. Gadids prefer shallow coastal waters and are found near and in rivers within the zone of tidal influence

(Morrow 1980, Cohen et al. 1990). Adult cod exhibit seasonal movements; saffron cod move offshore during the summer for feeding while Pacific cod migrate to shallower water in the spring to feed (Cohen et al. 1990). Alaskan natives also describe Cook Inlet belugas as feeding on anadromous steelhead trout, freshwater fish such as whitefish, northern pike, and grayling (Huntington 2000), and other marine fish such as tomcod during the spring (Fay et al. 1984). These species are also abundant in the Susitna River system.

Five Pacific salmon species (Chinook, pink, coho, sockeye, and chum) spawn in rivers throughout Cook Inlet in the summer (Moulton 1997, Moore et al. 2000). During this time, anadromous smolt and adult fish concentrate at river mouths and adjacent intertidal mudflats to adjust to changing salinities between salt and fresh waters (ADFG 2004). The coincident occurrence and concentration of beluga whales and adult salmon returns to waters of the upper Inlet from late spring throughout the summer indicates these are likely feeding areas. In Knik Arm, beluga whales are generally observed arriving in May, but tend to concentrate near the Susitna Delta in summer, feeding on the various salmon runs. In addition to frequenting the Susitna and Little Susitna rivers and corresponding flats throughout the summer, belugas also use the smaller streams along the west side of the Inlet, following first the eulachon and king salmon runs and later in the summer the coho salmon runs.

In late summer and fall, data from 14 satellite tagged beluga whales, in conjunction with TEK, indicate that belugas use the streams on the west side of Cook Inlet from the Susitna River delta south to Chinitna Bay. Native hunters report that beluga whales once reached Beluga Lake, 56 km (35 miles) from the Beluga River, and that beluga whales are often seen well upstream in the Kenai and Little Susitna rivers, presumably following the fish migrations (Huntington 2000). Alaska Natives also described calving areas as the northern side of Kachemak Bay in April and May, off the mouths of the Beluga and Susitna rivers in May, and in Chickaloon Bay and Turnagain Arm during the summer (Huntington, 2000).

In summarizing beluga habitat preference relative to physical, biological and anthropogenic factors, summer/fall distribution appears to involve congregation in shallow, relatively warm, low-salinity water near major river outflows in upper Cook Inlet. TEK of Alaska Natives and systematic aerial survey data, however, have also documented a contraction of the summer range of Cook Inlet belugas (Fig. 3). While belugas were once abundant and frequently sighted in the lower Inlet during summer, they are now primarily concentrated in the upper Inlet (Hobbs et al. 2008). These changes in range are evident across 3 periods – between 1978 and 1979 (when data was first well documented), between 1993 and 1997 (during the recorded decline in abundance) and between 1998 and 2008 (when hunting was regulated recovery anticipated). Between the 1970's and 1990's summer range contraction included a move northeastward into upper Cook Inlet which continued into the 2000's as well as a longitudinal shift towards Anchorage between the 1990's and 2000's. Prior to 1995, whales were occasionally seen in low numbers (1-14) in lower Cook Inlet, but only two whales, one dead and one alive, have been observed in lower Cook Inlet since and only one other whale seen south of Pt. Possession or North Foreland since 1995 (Rugh et al. 2000). The reduced range, from > 7000 km^2 to less than 3000 km^2, has occurred in all areas except for northernmost Cook Inlet in an area with the highest degree of human disturbance (Rugh et al. 2010). Range contraction may be a result of decreased number of whales or possibly habitat degradation including changes in prey species availability in lower Cook Inlet (Speckman and Piatt 2000).



June/July 1978-1979 June/July 1993-1997 June 1998 – 2008

Fig. 3 Summer range contraction of Cook Inlet beluga whales, 1998 – 2008 (Rugh et al. 2010)

Belugas may remain in the upper Inlet into the fall, but appear to move west and south, coinciding with the coho run. With the approach of winter, as anadromous fish runs begin to decline, belugas again return to consume the fish species found in nearshore bays and estuaries. Cook Inlet beluga whales concentrate in deeper waters in mid Inlet past Kalgin Island in the winter and make deep feeding dives, likely feeding on such prey species as flatfish, cod, sculpin, and pollock. The narrowing of the Inlet in this area and the presence of Kalgin Island just south of the forelands may cause upwelling and eddies that concentrate nutrients or act as a “still-water shelter area” for migrating anadromous fishes such as salmon, eulachon, and smelt, which are known beluga prey species. The Kalgin Island area may also be rich in biological productivity; for instance, crustaceans are known to occur south of the island (Calkins 1983). The Kalgin Island area may serve as a late-winter staging area for eulachon prior to migration to their natal streams in upper Cook Inlet. If these fish and crustaceans generally are present in this area during late winter, they may be an important food source for belugas in the winter. Saffron cod migrate inshore during winter for spawning (Cohen et al. 1990). Pacific cod move to progressively deeper water as they age, spawning in deeper, offshore waters in winter (Cohen et al. 1990). Flatfish are typically found in very shallow water and estuaries during the warm summer months and move into deeper water in the winter as coastal water temperatures cool (though some may occur in deep water year-round). While the whales concentrate in deeper waters in mid Inlet past Kalgin Island, available information indicates that Cook Inlet belugas move throughout much of the Inlet in the winter months. Belugas will occasionally travel into the upper Inlet in winter, including the upper ends of Knik and Turnagain Arms. Beluga whales regularly gather in Eagle Bay and elsewhere on the east side of Knik Arm, and sometimes in Goose Bay on the west side of Knik Arm. However, their winter distribution does not appear to be associated with river mouths, as it is during the warmer months. The spatial dispersal and diversity of winter prey likely influences the wider beluga winter range throughout the mid Inlet and winter distribution shows a more dispersed pattern predominantly in the central Inlet (Hobbs et al. 2005, Moore et al. 2000). Ice cover does not appear to limit their movements, while tidal cycles may facilitate movement. Cook Inlet belugas have been seen moving with the tides, especially in Turnagain and Knik Arms where tides are extreme and mudflats are extensive. Cook Inlet's semi-diurnal tides may be utilized by belugas on a daily or twice daily basis into feeding and nursery areas (Hobbs et al. 2005). Access to these areas and to corridors between these areas is important. TEK suggests that belugas move in and out of the upper Inlet with the tides from April through November and concentrate at river mouths and tidal flat areas (Huntington 2000).

Distribution relative to calving
The shallow waters of the upper Inlet may also play important roles in reproduction. Since newborn beluga whales do not have the thick blubber layer of adults, they benefit from the warmer water temperatures in the shallow tidal flats areas where fresh water empties into the Inlet, and hence it is likely these regions are used as nursery areas. Hence, the warmer waters from these freshwater sources may be important to newborn calves during their first few days of life (Calkins, 1989) as well as possibly important areas for belugas' seasonal summer molt. TEK of Alaska Natives report that the mouths of the Beluga and Susitna Rivers, as well as Chickaloon Bay and Turnagain Arm, are calving and nursery areas for beluga whales (Huntington 2000). Knik Arm is also used extensively in the summer and fall by cow/calf pairs. Surveys by LGL (Funk et al. 2005) noted a relatively high representation of calves in the uppermost part of Knik Arm. The mouth of Knik Arm has been reported to be transited in the summer and fall by cow/calf pairs (Cornick and Kendall 2008), presumably moving into the upper reaches of the Arm. McGuire et al. (2008) photographically identified 37 distinct belugas with calves in the upper Inlet during 2005-2007. However, because calves were seen in all areas of their study (Susitna River Delta, Knik Arm, Chickaloon Bay/Southeast Fire Island, and Turnagain Arm), they were unable to determine distinct calving areas (McGuire et al. 2008).

Habitat types and value relative to distribution (Fig. 4)
NMFS has characterized beluga whale habitats as part of the conservation strategy presented in the Conservation Plan (NMFS 2008). As a result, Cook Inlet has been stratified into three habitat regions based on differences in beluga use, with Type 1 habitat being the most valuable due to its intensive use by belugas from spring through fall for foraging and nursery habitat, and because it is in the upper Inlet where the greatest potential from anthropogenic impacts exists. Type 2 habitat includes areas with high fall and winter use, and a few isolated spring feeding areas. Type 3 habitat encompasses the remaining portions of the range of belugas within Cook Inlet. While Type 1 habitat is clearly the most valuable of the three types based on the frequency of use, the relative values of Types 2 and 3 habitats are difficult to distinguish because of limited information about belugas' wintering habitats and the challenge in discerning which features in these two habitat types are the most important to belugas.

2.5 Analysis of the Species Likely to be Affected
The State of Alaska mixing zone regulations covers waters within 3 nautical miles from baseline, which includes waters of upper Cook Inlet and 3 nautical miles from the coast south of Kalgin Island. The most valuable habitat types, which include spring-fall distribution, are contained almost exclusively within the action area (Fig. 4). Though winter distribution is more difficult to delineate, it is likely that Cook Inlet belugas occur within the action area, at least part of the time, during winter months as well. Since beluga whale distribution is predominantly driven by the presence of prey species, it follows that prey species are also present in areas where mixing zones may be located. Therefore, the likelihood exists that both beluga whales and their prey

may be exposed to contaminants from mixing zones, both within the mixing zone where WQS are exceeded and out of the mixing zone where contaminants may persist at lower concentrations.

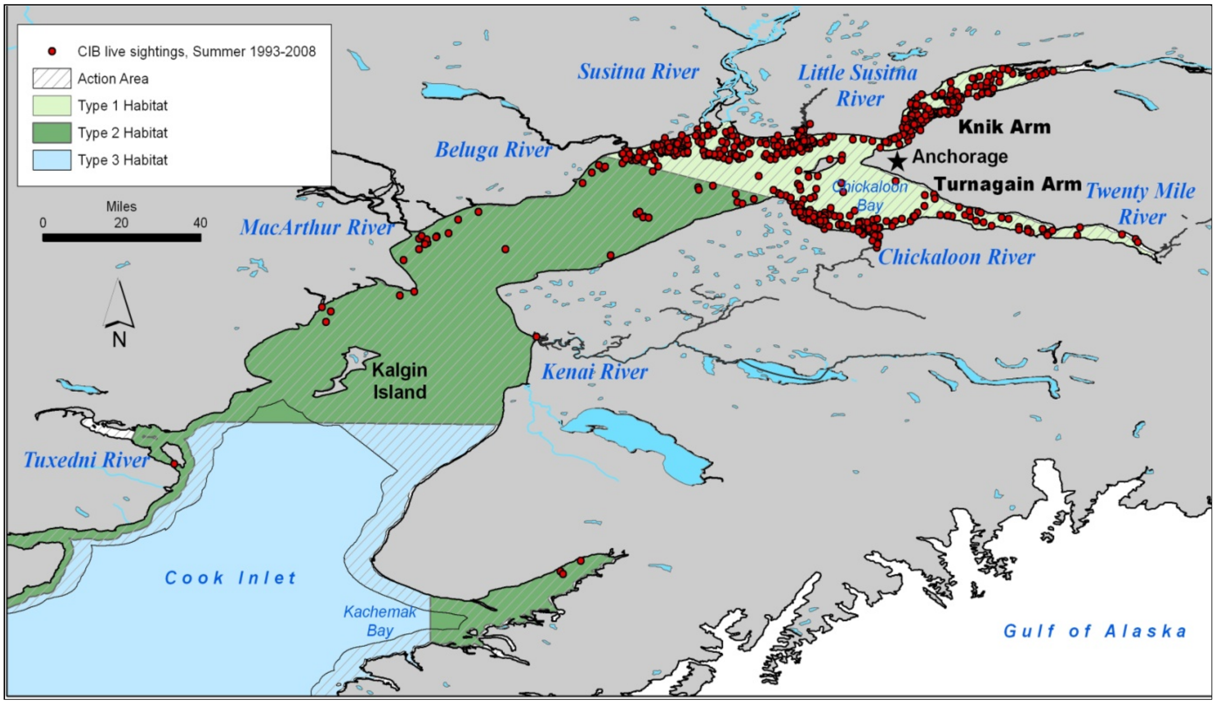


Figure 4. Summer distribution (1993 - 2008) and habitat type of Cook Inlet belugas relative to action area.

3.0 Environmental Baseline

The environmental baseline is described as the past and present impacts of all federal, State, or private actions and other human activities in an action area, the anticipated impacts of all proposed federal projects in an action area that have already undergone formal or early section 7 consultation and the impact of State or private actions that are contemporaneous with the consultation in process (50 CFR 402.02).

3.1 Factors Affecting Species' Environment Within the Action Area

Though hunting pressure has undoubtedly taken a toll on the Cook Inlet beluga population, the continued decline of the population indicates other factors, both natural and anthropogenic, may also be responsible in undermining the recovery of the population. Natural threats include stranding, predation and environmental change. Aside from the subsistence harvest, human induced factors include poaching and illegal harassment, personal use, subsistence and recreational fishing, commercial fishing, development, vessel traffic, noise and pollution. The extent to which these factors influence beluga habitat, prey species and, ultimately, beluga numbers within the action area is unknown.

3.1.1 Natural Factors

Stranding

Beluga whale strandings in Cook Inlet are not uncommon, with a majority occurring in Turnagain Arm. NMFS has reports of over 700 whales stranding in upper Cook Inlet since 1988.

Mass strandings (involving two or more whales) primarily occurred in Turnagain Arm and often coincided with extreme tidal fluctuations (“spring tides”) or killer whale sighting reports (Shelden et al. 2003). The impact of stranding on the Cook Inlet beluga population has been variable. In 2003, for example, over 45 beluga whales were stranded at the far end of Turnagain Arm and were out of the water for roughly 10 hours waiting for the tide to return. From this one event, five belugas were thought to have died as a direct consequence based upon beach cast carcasses found in the following days. In 2007, however, none of the 13 reported beluga whale mortalities were associated with mass strandings (NMFS 2008).

Predation
The Cook Inlet beluga whale stock is preyed upon by killer whales, their only known natural predator. The number of transient killer whales reported in the upper Inlet appears to be small. This may be a single pod with five or six individuals that has extended its feeding territory into Cook Inlet. Given the small population size of the Cook Inlet beluga whales, predation may have a significant effect on beluga abundance. On average one Cook Inlet beluga whale is killed per year by killer whales (Shelden et al. 2003). The effects of killer whale predation were also addressed in status reviews conducted by NMFS in 2006 and 2008; the models demonstrated that killer whale predation on an annual basis could significantly impact recovery. In addition to directly reducing the beluga population, the presence of killer whales in Cook Inlet may also increase stranding through killer whale pursuit of belugas into shallow waters. As such, NMFS considers killer whale predation to be a potentially significant threat to the conservation and recovery of these whales.

3.1.2 Anthropogenic Factors
The upper Cook Inlet region is the major population center of Alaska, with the 2009 population of the Anchorage Borough at 286,174, the Matanuska-Susitna Borough at 88,379, and the Kenai Peninsula Borough at 54,665 (U.S. Census Bureau). Such large numbers of people in a relatively small area present added concerns to the natural environment and to Cook Inlet belugas.

Subsistence harvest
The Cook Inlet beluga whale is hunted by Alaska Natives for subsistence purposes and for traditional handicrafts. The MMPA provides an exemption from the prohibitions of the Act which allows for the harvest of marine mammals by Alaska Natives for these purposes. Alaska Natives have legally harvested Cook Inlet beluga whales prior to and after passage of the MMPA in 1972. The effect of past harvest practices on the Cook Inlet beluga whale population is significant. While a harvest occurred at unknown levels for decades, NMFS believes the subsistence harvest levels increased substantially in the 1980s and 1990s. Reported subsistence harvests between 1994 and 1998 can account for the estimated decline of the stock during that interval. The observed decline during that period and the reported and estimated harvest rates (including estimates of whales which were struck and lost, and assumed to have perished) indicate these harvest levels were unsustainable.

A study conducted by ADFG, in cooperation with the Alaska Beluga Whale Committee (ABWC) and the Indigenous People’s Council for Marine Mammals, estimated the subsistence take of belugas in Cook Inlet in 1993 at 17 whales. However, in consultation with Native elders from the Cook Inlet region, the Cook Inlet Marine Mammal Council (CIMMC) estimated the annual number of belugas taken by subsistence hunters during this time to be greater (DeMaster 1995). There was no systematic Cook Inlet beluga harvest survey in 1994. Instead, harvest data were compiled at the November 1994 ABWC meeting, including two belugas taken by hunters from Kotzebue Sound. The most thorough Cook Inlet beluga subsistence harvest surveys were completed by CIMMC during 1995 and 1996. While some local hunters believed that the 1996 estimate of struck and lost is positively biased, the CIMMC's 1995 to 1996 take estimates are considered reliable (Angliss et al. 2001). Given that there was no survey during 1997 or 1998, NMFS estimated the subsistence harvest from hunter reports. The known annual subsistence harvest by Alaska Natives during 1995-1998 averaged 77 beluga whales.

The harvest, which was as high as 20 percent of the population in 1996, was sufficiently high to account for the 14 percent annual rate of decline in the population during the period from 1994 through 1998 (Hobbs et al. 2000). In 1999 there was no harvest as a result of a voluntary moratorium by the hunters that spring and the permanent moratorium in 2000. During 2000-2003 and 2005-2006 NMFS entered into co-management agreements for the Cook Inlet beluga subsistence harvest. Between 2000 and 2007, subsistence harvests have been 0, 1, 1, 1, 0, 2, 0, and 0 whales, respectively.

Sections 101(b) and 103(d) of the MMPA require that regulations prescribed to limit Alaska Native subsistence harvest be made only when the stock in question is designated as depleted pursuant to the MMPA and following an Agency administrative hearing on the record. NMFS had an administrative hearing in December 2000 where interim harvest regulations for 2001-2004 were developed and another administrative hearing in August 2004 to prepare the long term harvest plan. NMFS published the Cook Inlet Beluga Whale Subsistence Harvest Draft Supplemental Environmental Impact Statement in December 2007 that provided four alternatives on the long term harvest for Cook Inlet belugas. The Cook Inlet Beluga Whale Subsistence Harvest Final Supplemental Environmental Impact Statement, with a set harvest plan, was published in June 2008 and, long-term harvest regulations were implemented.

Poaching and illegal harassment

Due to their distribution within the most-densely populated region of Alaska and their approachable nature, the potential for poaching belugas in Cook Inlet still exists. Although NOAA maintains an enforcement presence in upper Cook Inlet, the area they have to cover is extensive. While poaching is a possible threat, no poaching incidents have been confirmed to date. NOAA Enforcement has investigated several incidences of reported harassment of Cook Inlet belugas, but to date there have been no convictions. The potential, however, for both poaching and illegal harassment exists.

Personal use, subsistence and recreational fishing

Personal use gill net fisheries occur in Cook Inlet. Fishing for eulachon (hooligan) is popular in Turnagain Arm, with no bag or possession limits. The two most significant areas where eulachon are harvested in personal use fisheries are the Twentymile River (and shore areas of Turnagain Arm near Twentymile River) and Kenai River. Other areas where eulachon are harvested include the Big and Little Susitna River and their tributaries, the Placer River, and shoreline areas of Turnagain Arm and Cook Inlet north of the Ninilchik River. Annual harvests have ranged from 2.2 to 5 tons over the past decade. The personal use harvest of eulachon is possibly under-reported as some participants may confuse their harvests as being subsistence and not personal use.

Recreational fishing is a very popular sport in Alaska, as evidenced by the intensive fishing during salmon runs and the high number of charter fishing operations. In upper Cook Inlet there are numerous recreational fishing areas targeting primarily salmon, including the hundreds of drainages of the Susitna River; the Little Susitna River; the west Cook Inlet streams; and areas around Anchorage such as Ship Creek. Recreational fishing for salmon in Ship Creek is the most popular stream fishery in the Anchorage area. In lower Cook Inlet, recreational fishing for groundfish such as halibut, rockfish and lingcod are also popular. There are even recreational fishers digging for littleneck clams, butter clams, and razor clams. NMFS is unaware of any beluga whales injured or killed in the Cook Inlet due to personal use, subsistence, or recreational fisheries. However, the most likely impacts from these fisheries include the operation of small watercraft in stream mouths and shallow waters, ship strikes, displacement from important feeding areas, harassment, and prey competition.

Commercial fishing

Several commercial fisheries occur in Cook Inlet waters and have varying likelihoods of interacting with beluga whales (either directly or via competition for fish) due to differences in gear type, species fished, timing, and location of the fisheries. Interactions refer to entanglements, injuries, or mortalities occurring incidental to fishing operations. Given that beluga whales concentrate in upper Cook Inlet during summer (Rugh et al. 2000), fisheries occurring in those waters during that time could have a higher likelihood of interacting with beluga whales.

i) Incidental Take

The term incidental take in regards to commercial fishing refers to the catch or entanglement of animals that were not the intended target of the fishing activity. Reports of marine mammal injuries or mortalities incidental to commercial fishing operations have been obtained from fisheries reporting programs (self-reporting or logbooks), observer programs, and reports in the literature. Murray and Fay (1979) stated that salmon gillnet fisheries in Cook Inlet caught five beluga whales in 1979. Incidental take rates by commercial salmon gillnet fisheries in the Inlet were estimated at three to six beluga whales per year during 1981-1983 (Burns and Seaman 1986). Neither report, however, differentiated between the set gillnet and drift gillnet fisheries. There have been sporadic reports over the years of single beluga whales becoming entangled in fishing nets, however, mortalities could not be confirmed. More recently, NMFS placed observers in the Cook Inlet salmon drift net and upper and lower Inlet set gillnet fisheries in 1999 and 2000. During the two years of observations, only three sightings of beluga whales occurred and no beluga whale injuries or mortalities were reported. Furthermore, during the period 1990 and 2000, fishermen's voluntary self-reports indicated no mortalities of beluga whales from interactions from commercial fishing. NMFS has found the current rate of direct mortality from commercial fisheries in Cook Inlet appears to be insignificant and should not delay recovery of these whales.

ii) Reduction of Prey

Aside from direct mortality and injury from fishing activities, commercial fisheries may compete with beluga whales in Cook Inlet for salmon and other prey species. There is strong indication these whales are dependent on access to relatively dense concentrations of high value prey throughout the summer months. Native hunters have often stated that beluga whales appear thin in early spring (due to utilizing the fat in their blubber layer over winter), and tend to sink rather than float when struck. Any diminishment in the ability of beluga whales to reach or utilize spring/summer feeding habitat, or any reductions in the amount of prey available, may impact the energetics of these animals and delay recovery.

The current salmon management plan for the State of Alaska oversees Inlet fisheries in the lower, middle, and northern districts of the Inlet. Most of these fisheries occur "upstream" of the river mouths and estuaries where beluga whales typically feed. Whether the escapement into these rivers, having passed the gauntlet of the commercial fisheries, is sufficient for the well being of Cook Inlet beluga whales is unknown. Furthermore, the amount of fish required to sustain this population is unknown. Additional research, such as continued stomach and fatty acid analyses, may shed more light on feeding and prey requirements for beluga whales.

At this time, it is unknown whether competition with commercial fishing operations for prey resources is having any significant or measurable effect on Cook Inlet beluga whales.

Development

Southcentral Alaska is the State's most populated and industrialized area. Many cities, villages, ports, airports, treatment plants, refineries, highways, and railroads are situated on or very near to Cook Inlet. Beluga whales are not uniformly distributed throughout the Inlet, but are predominantly found in nearshore waters. Where beluga whales must compete with people for use of nearshore habitats, coastline development (both construction and operation of a project) leads to the direct loss of habitat. Indirect alteration of habitat may occur due to bridges, boat traffic, in-water noise, and discharges that affect water quality. Most beluga habitat in Cook Inlet remains essentially intact, however, extensive sections of Turnagain Arm shoreline have been developed (e.g., rip rap and railroad construction), as have the shorelines of the Anchorage area.

Port facilities in Cook Inlet are found at Anchorage, Point Mackenzie, Tyonek, Drift River, Nikiski, Kenai, Anchor Point, and Homer. The Port of Anchorage is a deep draft facility, the State's largest seaport, and the main port of entry for southcentral and interior regions of the State. It exists along lower Knik Arm in an area that is heavily used by beluga whales. Contractor reports from LGL for the Port of Anchorage (Markowitz, memos to W.E. Humphries, August, September, October and November 2005) indicated that 79 percent of the whales sighted in the lower Knik Arm area entered the area immediately adjacent to the Port. The Point MacKenzie Port is presently configured as a barge port; however, plans call for a bulk loading facility with deep-draft capability. The Drift River facility is used primarily as a loading platform for shipments of crude oil. The docking facility there is connected to a shoreside tank farm and designed to accommodate tankers in the 150,000 deadweight-ton class. Nikiski is home to several privately owned docks (including those belonging to oil and gas companies such as Tesoro and Conoco Philips). Activity here includes the shipping and receiving of anhydrous ammonia, dry bulk urea, liquefied natural gas, petroleum products, sulfuric acid, caustic soda, and crude oil.

Dredging along coastal waterways has been identified as a concern with respect to the Saint Lawrence beluga whales (DFO 1995). There, dredging of up to 600,000 cubic meters of sediments re-suspended contaminants into the water column and seriously impacted the belugas. The Saint Lawrence beluga whale recovery plan contains recommendations to reduce the amount of dredging and to develop more environmentally sound dredging techniques. While the volume of dredging in Cook Inlet is comparable to St. Lawrence (more than 844,000 cubic yards in 2003 at the Port of Anchorage), the material does not appear to contain harmful levels of contaminants.

Even though over 90% of Knik Arm remains undeveloped, several planned or proposed projects have been recently identified in a relatively confined portion of lower Knik Arm (see list below). Knik Arm is an important feeding area for beluga whales during much of the summer and fall, especially upper Knik Arm. Whales ascend to upper Knik Arm on the flooding tide, feed on salmon, then fall back with the outgoing tide to hold in waters off and north of the Port of Anchorage. The primary concern for belugas is that development may restrict passage along Knik Arm.

Other potential development projects include Seward Highway improvements along Turnagain Arm; the south coastal trail extension in Anchorage; Chuitna Coal project with a marine terminal; Pebble Mine with a marine terminal in Iniskin Bay; Diamond Point granite rock quarry near Iliamna and Cottonwood Bays; and the placement of a submarine fiber optic cable by ACS from Nikiski to Anchorage.

Vessel traffic

Most of Cook Inlet is navigable and used by various classes of water craft which pose the threat of ship strikes to beluga whales. While ship strikes have not been definitively confirmed in a Cook Inlet beluga whale death, in October 2007 a beluga washed ashore dead with “wide, blunt trauma along the right side of the thorax” (NMFS unpubl. data), suggesting a ship strike was the cause of the injury.

Port facilities in Cook Inlet are found at Anchorage, Point MacKenzie, Tyonek, Drift River, Nikiski, Kenai, Anchor Point, and Homer. Commercial shipping occurs year round, with containerships transiting between the Seattle/Puget Sound areas and Anchorage. Other commercial shipping includes bulk cargo freighters and tankers. Various commercial fishing vessels operate throughout Cook Inlet, with some very intensive use areas associated with salmon and herring fisheries. Sport fishing and recreational vessels are also common, especially within Kachemak Bay, along the eastern shoreline of the lower Kenai Peninsula, and between Anchorage and several popular fishing streams which enter the upper Inlet. Several improved and unimproved small boat launches exist along the shores of upper Cook Inlet. The MOA maintains a ramp and float system for small watercraft near Ship Creek. Other launches are near the Knik River bridge and at old Knik. Currently, with the exception of the Fire Island Shoals and the Port of Anchorage, no large-vessel routes or port facilities in Cook Inlet occur in high value beluga whale habitats.

Due to their slower speed and straight line movement, ship strikes from large vessels are not expected to pose a significant threat to Cook Inlet beluga whales. However, smaller boats that travel at high speed and change direction often present a greater threat. In Cook Inlet, the presence of beluga whales near river mouths predisposes them to strikes by high speed water craft associated with sport and commercial fishing and general recreation. The mouths of the

Susitna and Little Susitna Rivers in particular are areas where small vessel traffic and whales commonly occur. Vessels that operate near these whales have an increased probability of striking a whale, as evidenced by observations of Cook Inlet beluga whales with propeller scars (Burek 1999).

Vessels associated with the Port of Anchorage are primarily large ships, tankers, and tugs. Sound generated by such vessels may be very loud, but occurs at low frequencies (5 to 500 Hz). While large ships generate some broadband noise, the majority of this sound energy would fall below the hearing range of beluga whales and is not expected to elicit behavioral reaction. There is concern, however, for very loud transient sounds such as may occur when placing containers onto the deck of a large cargo ship, and for operation of fathometers and similar devices operating at frequencies that might mask beluga calls.

Noise

Beluga whales are known to be among the most adept users of sound of all marine mammals, and use sound rather than sight for many important functions. This is not surprising when considering that beluga whales are often found in turbid waters and live in northern latitudes where darkness extends over many months. Beluga whales use sound to communicate, locate prey, and navigate, and may make different sounds in response to different stimuli. Beluga whales produce high frequency sounds which they use as a type of sonar for finding and pursuing prey, and likely for navigating through ice-laden waters.

In Cook Inlet, beluga whales must compete acoustically with natural and anthropogenic sounds. Man-made sources of noise in Cook Inlet include large and small vessels, aircraft, oil and gas drilling, marine seismic surveys, pile driving, and dredging. The effects of man-made noise on beluga whales and associated increased “background” noises may be similar to our reduced visibilities when confronted with heavy fog or darkness. These effects depend on several factors including the intensity, frequency and duration of the noise, the location and behavior of the whale, and the acoustic nature of the environment. High frequency noise diminishes more rapidly than lower frequency noises. Sound also dissipates more rapidly in shallow waters and over soft bottoms (sand and mud). Much of upper Cook Inlet is characterized by its shallow depth, sand/mud bottoms, and high background noise from currents and glacial silt (Blackwell and Greene 2002) thereby making it a poor acoustic environment.

Research on captive animals has found beluga whales hear best at relatively high frequencies, between 10 and 100 kHz (Blackwell and Greene 2002), which is generally above the level of much industrial noise. The beluga whales’ hearing falls off rapidly above 100 kHz. However, beluga whales may hear sounds as low as 40-75 Hz, although this noise would have to be very loud. Anthropogenic noise above ambient levels and within the same frequencies used by belugas may mask communication between these animals. At louder levels, noise may result in disturbance and harassment, or cause temporary or permanent damage to the whales’ hearing.

Although captive beluga whales have provided some insight into beluga hearing and the levels of noise that might damage their hearing capabilities, much less information is available on how noise might impact beluga whales behaviorally in the wild. Alaska Native beluga whale hunters with CIMMC have said that the Cook Inlet beluga whales are very sensitive to boat noise, and will leave areas subjected to high use. Native hunters near Kotzebue Sound report that beluga whales in that region abandoned areas in which fishing vessels were common (NMFS unpubl. data). In the Canadian high Arctic, beluga whales were observed to react to ice-breaking ships at distances of more than 80 km, showing strong avoidance, apparent alarm calls, and displacement (Finley et al. 1990). The whales' activity patterns were apparently affected for up to two days following the event (Whitehead et al. 2000). However, in less pristine, more heavily trafficked areas belugas may habituate to vessel noise. For instance, beluga whales appear to be relatively tolerant of intensive fishing vessel traffic in Bristol Bay, Alaska, and beluga whales are commonly seen during summer at the Port of Anchorage, Alaska's busiest port. Like bottlenose dolphins, beluga whales may shift the frequency of their echolocation clicks to avoid masking by anthropogenic noise (Au 1993; Tyack 1999, 2000).

Cook Inlet experiences significant levels of aircraft traffic. The Anchorage International Airport is directly adjacent to lower Knik Arm and has high volumes of commercial and cargo air traffic. Elmendorf Air Force Base has a runway near and airspace directly over Knik Arm. Lake Hood and Spenard Lake in Anchorage are heavily used by recreational seaplanes. Even though sound is attenuated by water surface, Blackwell and Green (2002) found that aircraft noise can be quite loud underwater when jet aircraft are directly overhead. Richardson (1995) discovered that belugas in the Beaufort Sea would dive or swim away when low-flying (<500 m) aircraft passed directly over them. Belugas may be less sensitive to aircraft noise than vessel noise, but individual responses may be highly variable and depend on the beluga's previous experiences, its activity at the time of the noise, and the characteristics of the noise.

Pollution

Contaminants are a concern for subsistence use as well as for the sustained health of the beluga whale health population (NMFS 2008; Becker et al. 2000). According to Moore et al. (2000), there are four main categories of marine pollution: 1) discharges from industrial activities that do not enter municipal treatment systems; 2) discharges from municipal wastewater treatment systems; 3) runoff from urban, mining, and agricultural areas; and 4) accidental spills or discharges of petroleum and other products.

It is important to note that not all industrial activity is associated with mixing zones. Mixing zones, however, are currently part of the baseline in Cook Inlet, involving both discharges from industrial activities that do not enter municipal treatment systems as well as discharges from municipal wastewater treatment systems. The EPA Region 10 does not maintain a centralized database of NPDES permits that include information on mixing zones in Alaska. Therefore, as an adjunct to the 2006 BA, the EPA provided a spreadsheet, "PCS_ADEC_loc.xls", which incorporates an informal, non-quality assured database of mixing zones provided by ADEC as well as NPDES permit information from the EPA's Permit Compliance System (PCS) database. Updated information beyond 2006 was not available for this consultation. This spreadsheet was used to select for facilities with Cook Inlet as receiving waters (Appendix A, Table 1); however, a current and complete list of facilities with mixing zones that may affect the Cook Inlet beluga whale is not available. Information on mixing zones provided below is from the subset of those 41 facilities with mixing zones located within the action area in Cook Inlet (Fig. 5).

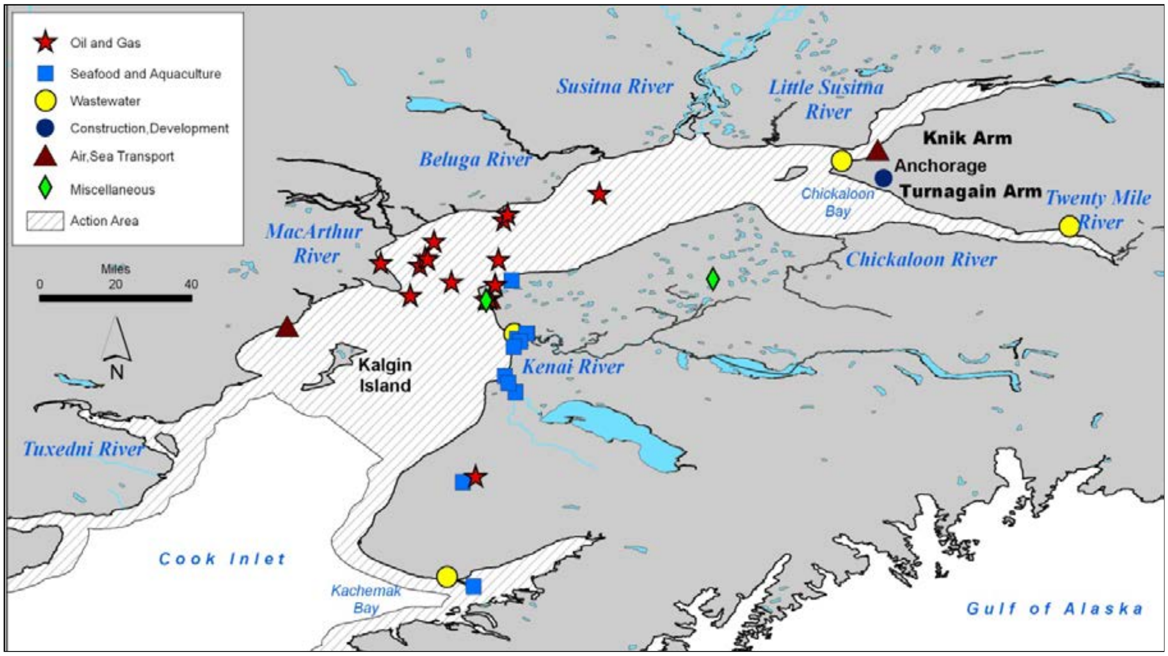


Figure 5. Subset of current mixing zones by industry with Cook Inlet as receiving waters (Girdwood Wastewater Treatment Facility included).

i) Wastewater Treatment:

Ten communities currently discharge treated municipal wastes into Cook Inlet. Wastewaters entering these plants may contain a variety of organic and inorganic pollutants, metals, nutrients, sediments, bacteria and viruses, and other emerging pollutants of concern. Wastewater from the Municipality of Anchorage, Nanwalek, Port Graham, Seldovia, and Tyonek receive only primary treatment, while wastewaters from Eagle River, Girdwood, Homer, Kenai, and Palmer receive secondary treatment. Primary treatment means that only materials that can easily be collected from the raw wastewater (such as fats, oils, greases, sand, gravel, rocks, floating objects, and human wastes) are removed, usually through mechanical means. Wastewater undergoing secondary treatment is further treated to substantially degrade the biological content of the sewage (such as in human and food wastes). Little is known about emerging pollutants of concern (EPOCs) and their effects on belugas in Cook Inlet. 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 agents that are found in wastewater and biosolids. The potential impacts on beluga whales from pollutants and EPOCs in wastewater entering Cook Inlet cannot be defined at this time.

There are 4 wastewater treatment facilities listed in the EPA spreadsheet, including the Asplund Facility in Anchorage as well as treatment facilities in Girdwood, Kenai and Homer. Mixing zone information for each includes:

a. John M. Asplund Water Pollution Control Facility (NPDES Permit No. AK-002255-1)
The John M. Asplund Control Facility, which was first issued an NPDES permit in 1975, is a publicly owned treatment works run by the Municipality of Anchorage. The outfall for the plant is located 800 feet from shore in Knik Arm and has a design outflow of 58 million gallons per day (mgd) or a maximum hourly flow of 154 mgd (USEPA 2000a). Because the point when

initial dilution is completed is continually changing, the definition of the Zone of Initial Dilution (ZID) adopted for this NPDES permit renewal includes an area encompassing those points defined as a sector of a circle with a radius of 2,130 feet. Effluent parameters within the ZID include BOD, pH, total suspended solids/turbidity, fecal coliforms, ammonia and toxic pollutants.

b. Girdwood Wastewater Treatment Plant (NPDES Permit No. AK-004785-6)
The Girdwood Wastewater facility is owned, operated and maintained by the Anchorage Water and Wastewater Utility. The facility discharges into Glacier Creek, which subsequently flows into Turnagain Arm, and was first issued an NPDES permit in 1989. In 1999, the daily flow rate was .405 mgd with a design flow rate of .600 mgd. The mixing zone for this facility extends downstream a distance of 600m long by 2.7 m wide and is designated for fecal coliforms, dissolved oxygen, temperature, total residual chlorine, pH, metals, nutrients and whole effluent toxicity (USEPA 2000b).

c. Kenai Wastewater Treatment Plant (NPDES Permit No. AK-002137-7)
The City of Kenai owns, operates and maintains the Kenai Wastewater Treatment Plant, which was first issued an NPDES permit in 1973. The outfall for the plant discharges directly into Cook Inlet and has a design outflow of 1.33 mgd or an average daily flow of 0.573 million gallons (USEPA 2007d). At high tide, the mixing zone size is defined as the area within a 150 m radius centered on the outfall extending from the marine bottom to the surface (L. Olson, EPA, Pers. Comm.). Mixing zone parameters include fecal coliforms, total residual chlorine, ammonia, metals (including antimony, cyanide, manganese, zinc, nickel, arsenic, cadmium, copper and lead), temperature and pH.

d. Homer Wastewater Treatment Plant (NPDES Permit No. AK-002124-5)
The City of Homer owns and operates the municipal treatment facility, which first received an NPDES permit in 1992. The facility discharges into Kachemak Bay with an annual average flow of 0.4 mgd and a peak design flow of .880 mgd. The outfall extends 2200 feet off shore with a 220 meter mixing zone for fecal coliforms, dissolved oxygen, pH, metals, nutrients and whole effluent toxicity (USEPA 2000e). Concentrations of contaminants and limits of the Homer facility are not listed in either the EPA Permit or Fact Sheet.

ii) Stormwater Runoff:
The Municipality of Anchorage (MOA) operates under a NPDES storm water permit to discharge storm water into Cook Inlet. The MOA's NPDES storm water permit (AKS05255) is a five-year term permit to discharge storm water to Cook Inlet, and is issued jointly to the MOA and the Alaska Department of Transportation and Public Facilities (DOT) by the U.S. Region 10 EPA. The MOA Watershed Management Program (2006) report addresses coordination and education, land use policy, new development management, construction site runoff management, flood plain management, street maintenance, and best management practices. Some of the management practices addressed included: pollutant sources and controls (includes street deicer and snow disposal guidance), illicit discharge management, industrial discharge management, pesticides management, pathogens management, watershed mapping, hydrology, water quality, ecology and bioassessment, and watershed characterization. There has been no comprehensive study or analysis to determine if stormwater discharge has had a detrimental effect on beluga whales. The State of Alaska has acquired permitting authority under the Clean Water Act, and

future permits for this discharge will be issued under the new Alaska Pollutant Discharge Elimination System.

iii) Airport Deicing:

Deicing and anti-icing operations occur from October through May at many airports in and around Cook Inlet, especially Stevens International Airport, Merril Field, Elmendorf Air Force Base, Lake Hood and Lake Spenard. Deicing and anti-icing of aircraft and airfield surfaces are required by the Federal Aviation Administration (FAA) to ensure the safety of passengers. Depending on the application, deicing activities utilize different chemicals. For instance, ethylene glycol and propylene glycol are used on aircraft for anti-icing and deicing purposes, whereas potassium acetate and urea are used to deice tarmacs and runways. All the deicing materials or their break down products eventually make it to the Inlet. The amount the deicing materials break down prior to discharging into Cook Inlet is not clearly known at this time. The potential impacts on beluga whales from deicing agents entering Cook Inlet have not been analyzed and cannot be determined at this time.

iv) Ballast Water Discharges:

Ballast water releases in Cook Inlet are a concern because they can potentially release pollutants and non-indigenous organisms into the ecosystem. It is a recognized worldwide problem that aquatic organisms picked up in ship ballast water, transported to foreign lands, and dumped into non-native habitats, are responsible for significant ecological and economic perturbations costing billions of dollars. The effect of invasive species from such discharges on the Cook Inlet ecosystem is unknown.

v) Military Training at Eagle River Flats:

The Eagle River Flats is a 2,140 acre estuarine salt marsh located at the mouth of Eagle River on Fort Richardson Army Post. Glacially-fed Eagle River flows through the flats before discharging into Eagle Bay of Knik Arm in upper Cook Inlet. Anthropogenic influences on the flats include military training, both historic (Army artillery impact area since 1949) and current (winter firing of artillery into flats) as well as activities associated with the remediation of white phosphorus left from artillery shell residues. The U.S. Army is currently assessing whether this training site is having an adverse affect on Cook Inlet belugas.

vi) Oil and Gas:

Much of the Cook Inlet region overlies reserves of oil and natural gas. Upper Cook Inlet and the Kenai Peninsula have an association with the petroleum industry that dates back to the 1950s. There are 16 platforms in upper Cook Inlet, 12 of which are active today (Figure 6).

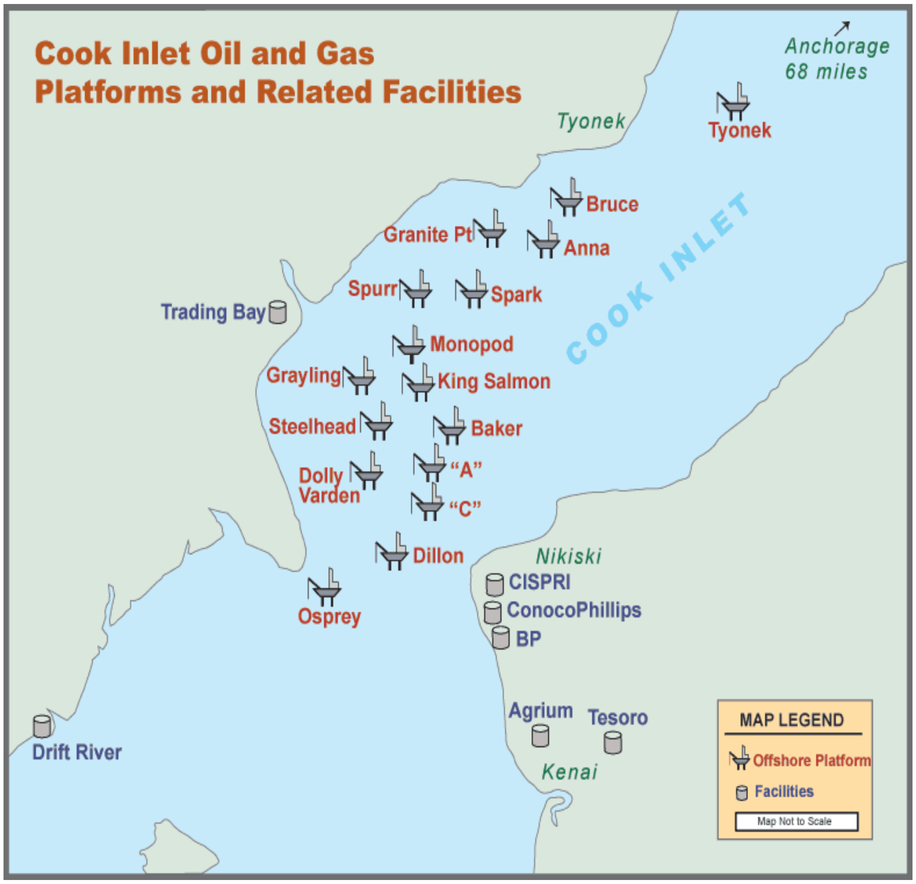


Figure 6. Oil and gas platforms and related facilities in Cook Inlet. Reproduced with permission from Cook Inlet Regional Citizens Advisory Council.

Many of these facilities are covered under the EPA's NPDES General Permit for Oil and Gas Exploration, Development and Production Facilities Located in State and Federal Waters in Cook Inlet (Permit # AKG-31-5000) (USEPA Fact Sheet, Feb. 23, 2006). This permit authorizes certain discharges of pollutants into Cook Inlet from oil and gas exploration, development and production platforms and related facilities. The area of permit coverage includes waters in different regulatory categories. The portion of Cook Inlet north of the southern edge of Kalgin Island is defined as "Coastal Waters" while the first three miles measured from the coastline in the area south of that line is defined as "Territorial Seas". Alaska's Cook Inlet is the only area in the nation where produced water and drilling wastes can be released into coastal waters. In other coastal locations around the country, "zero discharge" is the norm for offshore platforms. Oil and gas facilities in Cook Inlet, however, are exempt from zero discharge according to EPA exemptions as listed in 40 CFR 435.43 and 40 CFR 435.44.

The existing permit does prohibit discharge in certain areas, including parts of Chinitna, Tuxnedi and Kamishak Bay as well as discharges within the boundaries or within 4000 meters of a coastal marsh, river delta or river mouth or an Area Meriting Special Attention (AMSA), state game refuge (SGR), state game sanctuary (SGS) or critical habitat area (CHA). However, the existing permit also expands the previous coverage area and proposes to authorize discharges from oil and gas exploration as well as new oil and gas development and production facilities located within the expanded area in southern Cook Inlet.

The existing permit also prohibits discharges in waters with a depth less than 5 meters for all facilities, and in waters with a depth less than 10 meters for exploration facilities due to decreased dispersion in shallow waters. For facilities listed in the permit, the depth range for receiving waters varies between 8.319 to 31.12 m with the port depth ranging from 8.23 to 31.09 m. These facilities are allowed to discharge the following: drilling fluids and drill cuttings (exploratory and existing facilities), deck drainage, sanitary wastes, domestic wastes, desalination unit wastes, blowout preventer fluid, boiler blowdown, fire control system test water, non-contact cooling water, uncontaminated ballast water, bilge water, excess cement slurry, mud, cutting, cement at seafloor, waterflooding discharges, produced water and produced sand, completion fluids, workover fluids, well treatment fluids, test fluids and storm water runoff from onshore facilities. Effluent is discharged either directly into Cook Inlet or piped to one of three shore based facilities, which then either discharge directly into Cook Inlet or send treated effluent back to the platform. Little ambient data associated with oil and gas discharges in Cook Inlet exist with the only sediment data collected in the far southern portion of Cook Inlet. Ambient water column data relevant to the existing discharges is also extremely limited.

Concentrations of contaminants in effluents from oil and gas facilities in Cook Inlet are regulated by either state or federal WQS. The oil and gas general permit also allows for the presence of mixing zones, a specified area beyond the end of the effluent pipe where WQS may be exceeded up to the edge of the mixing zone. A subset of oil and gas facilities covered under the general permit that are located in the action area, as well as the year when operation commenced, include the Granite Point Production Facility, Trading Bay Treatment Facility, East Foreland Treatment Facility, Tyonek Platform A (1968), Granite Point Platform (1966), Platforms Anna (1966), Platform Baker (1965), Platform Bruce (1966), Platform Dillon (1966), King Salmon Platform (1967), Dolly Varden Platform (1967), Spark Platform (1968), Cross Timbers Platform A (1964) and C (1967), Spurr Platform (1968), Grayling Platform (1967), Monopod Platform (1966), Steelhead Platform (1986) and the North Foreland Platform . All of these facilities are located in northern Cook Inlet (Fig. 6). Mixing zones for these facilities range from <1 m for acute metals to 3,016 m for total aromatic hydrocarbons (TAH) and Total aqueous aromatic hydrocarbons (TAqH). According to the ADEC Water Quality Standards (18 AAC 70), TAH means "the sum of the following volatile monoaromatic hydrocarbons: benzene, ethylbenzene, toluene and xylene isomers, commonly called BETX". TAqH means "those collective dissolved and water-accomodated monoaromatic and polynuclear aromatic petroleum hydrocarbons that are persistent in the water column, which do not include floating suface oil or grease" (ADEC 2003).

The mixing zones for all facilities have sizably increased with the reissuance of the General Permit. In the previous permit, the EPA determined the mixing zones based on established, standardized criteria. In the reissued permit, the ADEC provided the EPA with mixing zone and dilution calculations that were submitted by industry based on newly projected maximum discharge rates and the maximum predicted pollutant concentrations. The previous and reissued mixing zone sizes are in Table 1. The average increase in size for TAH/TAqH mixing zones is 1501 m; for acute metals, the average increase in mixing zone size is 75 m; and for whole effluent toxicity, the average increase in mixing zone size is 480 m. The average mixing zone size for chronic metals decreased by 53 m. These facilities also have mixing zones for Chemically Treated Miscellaneous Discharges, ranging from 3 to 485 meters as well as mixing zones for Sanitary Waste Water Discharges, ranging from 30 to 260 meters.

			Acute Metals Mixing Zone (m)		Chronic Metals Mixing Zone (m)		TAH/TAqH Mixing Zone (m)	
Facility	**Current Discharge Rate (GPD)**	**Maximum Projected Discharge Rate (GPD)**	**2/17/06 Draft 401 Certification**	**Previous permit**	**2/17/06 Draft 401 Certification**	**Previous permit**	**2/17/06 Draft 401 Certification**	**Previous permit**
Granite Point Production (Onshore)	7,000	193,200	19	20	21	66	2685	955
Trading Bay	5,598,600	8,400,000	<1[b]	42	9[c]	431	2418[a]	1420
E. Foreland	167,040	840,000	142	20	121	106	1794	412
Tyonek A	31,066	31,066	36	20	60	663	36	21
Bruce	11,500	25,200	201	20	218	31	1840	867
Baker	0	45,000	202	22	216	37	3016	555
Dillon	0	193,500	11	20	13	43	2121	405
Anna	51,000	84,000	239	20	262	37	2734	363
Granite Point Production (Platform)			12	None	14	None	1863	None

a Mixing zone will be 5791 m initially, reduced to 2418 by a diffuser on a two year compliance schedule

b Mixing zone will be 124 m initially, reduced to <1 by a diffuser on a two year compliance schedule

c Mixing zone will be 760 m initially, reduced to 9 by a diffuser on a two year compliance schedule

Table 1. Recent changes in size of oil and gas mixing zones with permit reissuance.

Potential oil spills associated with these facilities are also a significant concern with regard to offshore oil and gas production, petroleum product shipment, and general vessel traffic.

vii) Seafood/Aquaculture

Of the 41 facilities listed in the spreadsheet with Cook Inlet as the receiving waters, Seafood and Aquaculture account for 9, with pollock, salmonids, Pacific cod, flatfishes, shellfish and herring comprising the bulk of the biomass by Alaska's seafood industry (USEPA 2001b). Though Seafood Processors are on the Phase 1 Facility List to be transferred to the state APDES with program approval Oct. 31, 2008, the NPDES General Permit for Seafood Processors in Alaska (No. AK-G52-0000) is available through the EPA. This permit covers operations which discharge less than 1000 pounds of seafood waste per day and less than 15 tons of seafood waste per calendar year. Authorization includes discharge of seafood processing wastewater and wastes including the waste fluids, heads, organs, flesh, fins, bones, skin, chitinous shells and stickwater produced by the conversion of aquatic animals from a raw to marketable form; wash-down water including disinfectants; sanitary wastewater and other wastewater. Major pollutants of concern include residues, biochemical oxygen demand, nonpetroleum oil and grease and nutrients coming from waste solids, blood, body fluids, slime, oils and fats from rendering. Ammonia may be present intermittently. Sodium hypochlorite and ammonium chlorides are primary disinfectants which may increase the concentration of free chlorine (USEPA 2001b).

The general permit may apply to off-shore processors (discharging more than 1 nautical mile from shore at MLLW), near-shore processors (discharging from 1 to 0.5 nautical mile from shore) as well as shore-based processors (discharging less than 0.5 mile from shore). Areas where seafood processing discharge is prohibited include protected water resources, Steller sea lion and State Critical Habitat and within one nautical mile of special areas such as National Parks, Preserves, Monuments, Wildlife Refuges and Wilderness Areas, at-risk resources and waterbodies, degraded waterbodies and waterbodies less than 2000 ft. across (USEPA 2001). Mixing zone requirements for these facilities include a 100 foot radius and the following water quality criteria may be exceeded: residues, dissolved gas, oil and grease, fecal coliform, pH, temperature, turbidity, color and total residual chlorine with criteria meeting Alaska WQS at the edge of the mixing zone. A Zone of Deposit (ZOD) of one acre is also allowed on the seafloor bottom, where ADEC has authorized the deposit of settleable solid waste seafood processing waste residues in exceedance of the water quality criteria of 18 AAC 70.020(b) and the antidegradation requirement of 18 AAC 70.015 (USEPA 2001, 2001b). Seafood processors discharging into high current areas may achieve wide-spread dispersal of residues without exceeding the one acre ZOD. Though insufficient data exists to support a specific limitation on the thickness of such waste piles, qualitative observations have suggested that waste piles which are thicker than four feet and which are formed in waters shallower than sixty feet at mean lower low water may release decomposition gases of offensive quantity and quality during certain conditions (e.g., high tidal ranges). Hydrogen sulfide and methane generated by anaerobic decay and released by significant changes in hydrostatic pressure break up the waste pile and eject decomposing solids into the water column and up to the sea surface. Due to a lack of EPA and ADEC funding and personnel, honest and accurate monitoring and reporting of wastewater discharges is the responsibility of the operator (USEPA 2001a).

viii) Miscellaneous

Of the 41 industries listed in the EPA spreadsheet, 2 are in the miscellaneous category, though both include the production of nitrogen fertilizers. One example is Alaska Nitrogen Products (AK-000050-7). This facility is a large nitrogen manufacturing fertilizer complex consisting of two ammonia plants, two urea plants, two associated utility plants and a loading wharf. The facility was originally constructed in 1966-1968 and significantly enlarged in 1977-1978, with an initial NPDES permit issued in 1974. The discharge from this plant is approximately 1600 feet offshore with a maximum effluent discharge rate into Cook Inlet of 1.561 mgd (USEPA 2000f). Mixing zones for Alaska Nitrogen Products include acute mixing zones of 2.5 and 35 meters for metals (mercury, zinc, copper and arsenic) and ammonia, respectively, and chronic mixing zones of 88 meters for metals, whole effluent toxicity and pH and 221 meters for ammonia (USEPA 2000g). The concentrations and limitations of the various parameters in the effluent are not included in the EPA documentation, except for ammonia and organic nitrogen. Based upon the monthly average limit, which is the highest allowable average of daily discharges over a calendar month, the mixing zone for this facility adds an additional 604,538 pounds of ammonia into Cook Inlet per year.

3.1.3 Other

Environmental/Climate Change

There is now widespread consensus within the scientific community that atmospheric temperatures on earth are increasing (warming) and that this will continue for at least the next several decades. There is also consensus within the scientific community that this warming trend will alter current weather patterns. Cook Inlet is a very dynamic environment which experiences continual change in its physical composition; there are extreme tidal changes, strong currents, and tremendous depositions of silt from glacial scouring. Cook Inlet beluga whales must be able to adapt to physical changes in their habitats.

The climate in Cook Inlet is driven by the Alaska Coastal Current (a low salinity river-like body of water that flows through the Pacific Ocean and along the coast of Alaska with a branch that flows into Cook Inlet) and the Pacific Decadal Oscillation (PDO). PDO is similar to El Nino except it lasts much longer (20 – 30 years in the 20th century) and switches between a warm phase and a cool phase. Phase changes of the PDO have been correlated with changes in marine ecosystems in the northeast Pacific; warm phases have been accompanied by increased biological productivity in coastal waters off Alaska and decreased productivity off the west coast of Canada and the US, whereas cold phases have been associated with the opposite pattern.

Prior to 2004 temperatures in the Gulf of Alaska were relatively stable, but in mid 2004 temperatures warmed and stayed warm until late 2006. Sampling of oceanographic conditions (via GAK-1) just south of Seward, Alaska has revealed anomalously cold conditions in the Gulf of Alaska beginning winter of 2006 – 2007; "deep (more than 150m) temperatures are the coldest observed since the early 1970s" (Weingartner 2007). Deep water temperatures are anticipated to be even colder in winter 2007 – 2008 due to deep shelf waters remaining cold throughout the 2007 summer, and Gulf of Alaska temperatures in spring 2008 are predicted to be even colder than in spring 2007 (Weingartner 2007).

The change in water temperature may in turn affect zooplankton biomass and composition. Plankton are mostly influenced by changes in temperature, which may affect their metabolic and developmental rates, and possibly survival rates (Batten and Mackas 2007). Data collected by Batten and Mackas (2007) demonstrated that mesozooplankton (planktonic animals in the size range 0.2 – 20 mm) biomass was greater in warm conditions, and that zooplankton community composition varied between warm and cool conditions, thus potentially altering their quality as a prey resource. In Cook Inlet, mesozooplankton biomass has increased each year from 2004 to 2006; however, sampling from late 2006 to early 2007 suggests biomass values are decreasing; a change most certainly driven by changes in climate (Batten 2007). Therefore, changes in temperature effect changes in zooplankton, which in turn may influence changes in fish composition, and hence, alter the quality and types of fish available for beluga whales. While El Nino events have the potential to affect sea surface temperatures, the effects from the 1998 El Nino warming event in lower Cook Inlet were lessened by upwelling and tidal mixing at the entrance to Cook Inlet (Piatt et al. 1999). It is likely that the physical structure of the Inlet and its dominance by freshwater input acts to buffer these waters from periodic and short-term El Nino events.

Beluga whale use of Cook Inlet, and particularly, feeding habitat, has been correlated to the presence of tidal flats and related bathymetry. Their preference for shallow waters found in Knik Arm, Turnagain Arm, and the Susitna River delta undoubtedly relates to feeding strategy, as has been reported for beluga whales in Bristol Bay (Fried et al. 1979). Frost et al. (1983) theorized beluga whales' feeding efficiencies improve in relatively shallow channels where fish are confined or concentrated. There is evidence these areas are being lost through the deposition of glacial materials. The senescence of these habitats will likely reduce the capacity of the upper Inlet to provide the needs for this population.

At this time however, the data are insufficient to assess effects (if any exist) of environmental change on Cook Inlet beluga whale distribution, abundance, or recovery.

3.2 Status of the Species Within the Action Area

Cook Inlet belugas

Determining the potential impact of mixing zones on the Cook Inlet beluga population involves assessing exposure to contaminants as well as possible effects of exposure. Information on the current contaminant load of Cook Inlet belugas, as well as specific sources of those contaminants, is limited. Analysis for contaminants in Cook Inlet beluga tissues have primarily been from those collected through the Alaska Marine Mammal Tissue Archival Project (AMMTAP). In 1995, liver tissue from a single stranded Cook Inlet beluga was compared to tissues from belugas from Point Lay and Point Hope, Alaska. The Cook Inlet beluga sample was lower than the other two beluga stocks in arsenic, cadmium, mercury, selenium, silver and vanadium, similar in zinc and substantially higher in copper concentrations (Becker 1995). In 2000, samples from 10 male and 10 female Cook Inlet belugas taken during subsistence hunts between 1992 and 1997, were compared to other beluga stocks for PCB's, chlorinated pesticides and elements (including heavy metals). Among Alaskan beluga populations, the Cook Inlet animals had lower concentrations of PCB's and chlorinated pesticides, cadmium, hepatic total mercury, selenium, vanadium and silver, similar levels of methylmercury. Substantially elevated levels of copper (on average 2-3 times higher) were again found relative to other Alaskan beluga stocks (Becker 2000). The latest data, from AMMTAP samples collected between 1997-2006 were analyzed for PCBs, chlorinated pesticides and heavy metals as well as for some of the more recently recognized contaminants including brominated flame retardents, polybrominated diphenyl ethers (PBDEs) and hexabromocyclododecane (HBCD) and the perflourinated compounds (PFCs). As was indicated in previous findings, concentrations of PCBs and chlorinated pesticides were lower in Cook Inlet belugas than in belugas from other Alaskan locations. However, there were no significant differences between concentrations of the PBDEs and HBCD in the Cook Inlet animals and in the other Alaska belugas. Twelve PFCs were determined in the livers of the belugas, but two compounds dominated in both the Cook Inlet animals and the other Alaskan animals – perfluorooctane sulfonate (PFOs) and perfluorooctane sulfonamide (PFOSA). The contaminant database for Cook Inlet belugas that covers 1992-2006 also allows for time trend analysis. Based on this analysis, there has been no increase or decrease in the concentrations of PCBs or chlorinated pesticides in these animals over this time period. However, the levels of PBDEs are increasing in beluga whales from Cook Inlet and other Alaskan locations and a temporal increase is also shown for PFCs in both males and females from all Alaskan locations, including Cook Inlet. Heavy metal analysis, including analysis for copper, is slated for completion by the end of 2010 (P. Becker, NIST, Pers. comm.).

Another population which may be used as a basis for comparison includes the beluga whales of the St. Lawrence River in eastern Canada, which are located in an area of extreme industrial effluent contamination and offer an example of possible adverse effects of contaminants on beluga whales in the wild. The incidence of degenerative, infectious, hyperplastic or neoplastic lesions, including evidence of immuno-supression, found in St. Lawrence beluga whales is considerably higher than found in marine mammals elsewhere or in other species of marine mammals from the same waters (De Guise et al. 1995). Although this beluga whale population has been completely protected since 1979, only a few hundred animals currently remain from around 5000 in 1885. A host of contaminants were found in St. Lawrence belugas, some of which can compromise immune function (Martineau et al. 1994, De Guise et al. 1998a), the most prominent included organochlorines and heavy metals, which are of special interest because of their abundance and known toxicity. The high concentrations of organochlorines, which include pesticides such as DDT, chlordane, mirex and dieldren as well as insulators such as PCBs, and heavy metal in tissues of these animals suggest the importance of industrial contaminants in the decreasing population (Martineau et al. 1988). High concentrations of heavy metals, specifically lead, selenium and mercury, have been found in tissues of 24 stranded St Lawrence beluga whales with 21 tumors found in 12 of 24 animals. High prevalence of tumors suggests the influence of contaminants through direct carcinogenic effects and/or decreased resistance to the development of tumors in the population (Martineau et al. 1994, De Guise et al. 1994, Wagemann et al. 1990). Other non-neoplastic lesions observed included esophageal and gastric erosions and ulcers, periodontitis, pneumonia, adrenal nodules and cysts and mastitis. No such lesions were observed in 36 necropsies of Arctic belugas or in seals and other cetaceans from St. Lawrence.

A causal relationship was established between several compounds of known toxicity and the health and reproductive impairments observed in St. Lawrence belugas (Beland et al. 1993). When immune cells of belugas from native hunts in the Canadian subarctic were exposed *in vitro* to heavy metals and organochlorines, the concentrations of metals that were found to affect the proliferation of beluga lymphocytes were similar to those found in the liver in beluga whales from wild populations (De Guise et al. 1996). With respect to mercury, cadmium and lead, beluga lymphocytes were demonstrated to be sensitive to metals present in their environment at concentrations that are sometimes found in some of their tissues. The possibly altered ability of lymphocytes to proliferate might lead to the inability to mount an adequate immune response in St. Lawrence beluga whales, which was postulated as a possible explanation for the high prevalence of severe diseases observed in that population. (De Guise 1996).

A comparison of the two populations revealed that concentrations of organochlorines, including PCB’s, DDT, toxaphene, chlordane, dieldren, hexachlorobenzene (HCB), hexachlorohexane (HCH) and mirex were all substantially lower in Cook Inlet belugas than in St. Lawrence belugas. With respect to heavy metals, Cook Inlet beluga tissues were lower in mercury and selenium concentrations, higher in zinc and cadmium (though cadmium concentrations for both populations was relatively low) and significantly higher in copper (Becker 2000). There are differences between the two populations, however, that require a measure of caution in making a direct comparison, primarily involving sample collection. Regarding the St. Lawrence beluga whale population, samples were collected from the fifteen or so accessible dead animals found stranded along the shore annually (Beland et al. 1996, 1988), many of which may have died from the associated pathology. Regarding Cook Inlet belugas, tissue samples available through the Marine Mammal Tissue Archival Project were predominantly collected from healthy animals taken during subsistence hunting and would likely not show levels of contaminants resulting in pathology or adverse effects. Of the 206 Cook Inlet beluga stranding events reported since 1985, necropsies were performed on 37. Although no tumors have been found akin to St. Lawrence belugas, most of the Cook Inlet beluga carcasses that are accessible tend to be too decomposed for accurate sample assessment (K. Burek, pers. comm.).

Prey species

One of the methods of exposure to contaminants is through the ingestion of prey species. In an EPA study to determine contaminant loads in Cook Inlet fish species, a total of 81 tissue samples from 7 fish species, 8 invertebrates and 3 species were collected from 4 different sites. Three of the four collection sites (Nanwalek, Port Graham and Seldovia) were located around the southern tip of the Kenai Penninsula. Only one of the collection sites, Tyonek, was located in upper Cook Inlet and only 6 of the 81 composite samples, all from salmon species, were collected from this community (USEPA 2006). Trace metals analyzed include: arsenic, barium, cadmium, chromium, lead, methylmercury and selenium. Analysis did not include copper. Of the 181 chemicals analyzed, approximately half (76) were detected in samples. Although samples were primarily collected from sites at the southern end of Cook Inlet, 33 of the 33 fish samples were positive for metals, PAH's, pesticides and PCB congeners. In shellfish, 15/15 samples detected metals with 10/15 detecting PAH's, in other invertebrates 21/ 21 were positive for metals and 19/21 for PAH's and in plants metals were detected in 12/12 of the samples and 9/12 for PAHs.

In comparing data with that of fish tested throughout Alaska, Cook Inlet species were consistently higher in metal concentrations except for levels of arsenic in Chinook salmon, halibut and Pacific cod (Table 2).

Concentration of Selected Metals Detected in Fish Tissue Samples (mg/kg)

	Sockeye		**Chinook**		**Chum**		**Halibut**		**Pacific Cod**	
	CI[1]	**AK[2]**	**CI[1]**	**AK[2]**	**CI[1]**	**AK[2]**	**CI[1]**	**AK[2]**	**CI[1]**	**AK[2]**
Arsenic	0.35	0.28	0.52	0.57	0.24	0.24	1.26	1.62	4.18	9.13
Cadmium	0.03	<DL	0.11	<DL	0.06	<DL	0.05	<DL	<DL	<DL
Chromium	1.98	<DL	0.18	0.06	0.4	<DL	0.35	0.09	0.52	0.05
Selenium	0.61	0.22	0.36	0.23	0.52	0.25	0.48	0.38	0.58	0.22
Lead	<DL	<DL	0.04	<DL	<DL	<DL	<DL	<DL	<DL	<DL

[1] USEPA 2003, [2] ADEC 2009, <DL = below detectable limits

Table 2. Selected heavy metal concentrations in fish tissues from Cook Inlet (CI[1]) as compared to fish tissue samples throughout other locations in Alaska (AK[2]**).**

4.0 Effects of the Action

The action of this consultation is the EPA's proposed approval of the State of Alaska's current mixing zone regulations. The effect of the action, EPA's proposed approval, depends upon the effect of mixing zones, as regulated by the State of Alaska, on the health of Cook Inlet belugas. If mixing zones, as regulated by the State of Alaska, have an adverse effect on the health of Cook Inlet belugas, then the EPA proposed approval of the mixing zone regulations will have an adverse effect on the health of Cook Inlet belugas. Whether mixing zones have an effect on the elements of the Cook Inlet beluga life cycle depend upon the level to which Cook Inlet belugas and their prey species are exposed to contaminants from regulated mixing zones and the consequences of that exposure.

4.1 Factors to be Considered

4.1.1. Assumptions

Mixing zones are associated with various industrial activities as well as wastewater treatment systems in Cook Inlet. The effect of the action, EPA's proposed approval, is a function of the number, location and regulated characteristics of ADEC approved mixing zones, relative to the health of Cook Inlet belugas. If mixing zones, as regulated by the State of Alaska, have an adverse effect, or lack thereof, on the health of Cook Inlet belugas, then it follows that the EPA proposed approval of the mixing zone regulations will have an adverse effect, or lack thereof. In determining the effect of mixing zones on Cook Inlet belugas, assumptions made by NMFS concern the following:

- The protection afforded by WQS. For the purposes of this consultation, it is assumed that contaminant concentrations of Alaska's WQS, both acute and chronic, are sufficient in protecting aquatic life.
- Whether concentrations of contaminants meet the acute WQS at the edge of the ZID and chronic WQS at the edge of the mixing zones. The presumption with mixing zones in Cook Inlet is that dilution inside the perimeter of the mixing zone will allow for quick and even mixing to meet WQS and that contaminant concentrations outside the mixing zone will be reduced to levels that will not acutely or chronically affect aquatic life. Part of the presumption is based upon the hydrologic characteristics of Cook Inlet, which appear to follow typical estuarine circulation, but are also complex and not well understood. There are many variables that influence the movement of substances throughout Cook Inlet and create a level of unpredictability. Freshwater discharges, for example, include seasonally changing inputs from large river systems in upper Cook Inlet. Depending upon rainfall, flow tends to decrease from June through August and in September is generally drastically reduced (Okkonen et al. 2009). Furthermore, the interaction of tidal currents and bathymetry can result in convergence zones or fronts, which change with the tide, tend to accumulate debris and also organize plankton which subsequently attract marine birds and fish (Schumacher 2005). There are also local currents, including eddy systems, which also change with the tide, such as a strong eddy system east of Point Woronzof, which may potentially change mixing zone dynamics of the Asplund WWT effluent (USEPA 2000a). For the purpose of this consultation, it is assumed that WQS are met at each EPA specified location in the mixing zone.

4.1.2. Proximity of the action and distribution

Mixing zones are currently associated with various industrial activities as well as wastewater treatment systems in Cook Inlet. A subset of mixing zones within the action area includes 41 facilities scattered primarily around upper Cook Inlet, all within the two most valuable habitat areas of the Cook Inlet beluga whale. Regarding future mixing zones, the EPA states that it is not possible to estimate the future number of facilities with authorized mixing zones, where they will be located and what specific pollutants will be granted mixing zones or other details that will be authorized under the State's revised mixing zone policy (USEPA 2006a). Furthermore, the State's revised mixing zone regulation does not categorically prohibit the discharge of any particular pollutant nor does it prohibit the designation of a mixing zone for any specific facility category (USEPA 2007a). Aside from those associated with oil and gas platforms, current mixing zones are all located adjacent to shore, from the tideline to at least 2200 ft. off shore, and it is likely that future mixing zones will be in a similarly close proximity to shore. Mixing zones authorized in the past in marine or estuarine waters have ranged from those with a radius of less than 10 meters to those with surface areas of greater than 200 acres (USEPA 2006a). Cook Inlet belugas are most frequently found within three miles from shore with the bulk of sightings within one mile (Fig. 7).

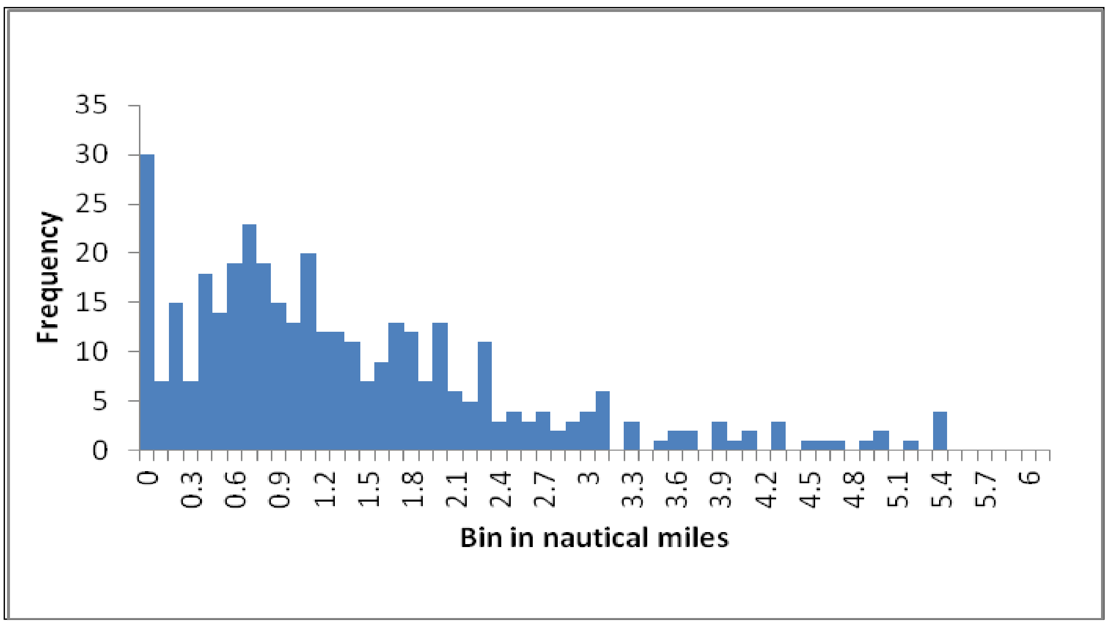


Figure 7. Frequency of Cook Inlet beluga distribution relative to distance from shore. Distances do not account or tide height, the presence of mudflats nor the extent of the area in which the animals were dispersed (NMFS 2010).

If current mixing zones in Cook Inlet are used as templates in terms of distribution and proximity, it is highly likely that future mixing zones will overlap with the most valuable Cook Inlet beluga habitat as well as the species' frequently close proximity to shore.

4.1.3. Timing, duration and disturbance frequency

Mixing zones are sustained, long-term chronic events. Though some of the oil and gas facilities are no longer operational, most of the facilities with mixing zones have been operational for many years on a continuous basis. The probability is high that this would be the case with new mixing zones. It is not possible to predict the duration and disturbance frequency, though the greatest disturbance frequency as well as duration of that disturbance would most likely result from both beluga whale and prey species life history events that occur in the nearshore environment, such as summer congregation patterns.

4.1.4. Nature of the effect – availability and toxicity

Based upon the facilities described above, mixing zones in Cook Inlet are currently authorized to exceed water quality standards for ammonia, antimony, arsenic, beryllium, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver, thallium, zinc, cyanide, TAH, TAqH, organic nitrogen, total residual chlorine, chemically treated miscellaneous discharge, sanitary wastewater discharge, processing residues, dissolved gas, oil and grease, fecal coliforms, pH, temperature, turbidity, color, and biochemical oxygen demand. This list of effluent parameters is not complete; rather they are a subsample of information available through a limited number of EPA permitting documents. Within this subset, the concentration of contaminants may potentially exceed WQS from 0 - >100,000 times as a result of mixing zones (Appendix B, Tables 1-10).

Based upon data provided by 8 oil and gas facilities, 3 wastewater facilities and 1 miscellaneous industry (AK Nitrogen), the load of contaminants in pounds that may be added to Cook Inlet per year strictly due to mixing zones is as follows (Appendix C, Tables 1 - 12):

Ammonia	310,905,238
Arsenic	845,737
Cadmium	216,282
Chromium	46,525
Lead	202,392
Mercury	518
Nickel	171,771
Selenium	1,786,303
Zinc	1,951,742
TAH	850,988
TAqH	1,012,506

The above figures are based either upon the Maximum Allowable Effluent Concentration (MAEC), the Measured Maximum Effluent Concentration or the Average Monthly Limitation (AML), which is the highest allowable average of daily discharges over a calendar month. Values are based upon available information; data on all contaminants from all facilities is either unavailable or not significant in the effluent.

Each of the contaminants included in mixing zones has a particular toxicological blueprint. High concentrations of ammonia, for example, can be toxic to fish, particularly salmonids (USEPA 2007d). Furthermore, excessive input of nitrogen from ammonia leads to concern about eutrophication which could diminish the capacity of coastal fish and invertebrate communities to support marine mammals and possibly lead to increase in toxic algal blooms (MMC 1999).

The potential for a contaminant from a mixing zone in Cook Inlet to have a quantifiable toxicological effect on Cook Inlet belugas depends upon a host of factors. Below, copper is examined in detail as a representative of mixing zone contaminants primarily because, thus far, copper has been the only substance noted to be elevated in Cook Inlet beluga whale tissue and also because a fairly large body of knowledge exists pertaining to the element.

Copper

Included in the list of mixing zone contaminants are the heavy metals. Heavy metals are usually divided into essential (Zn, Cu, Cr, Se, Ni, Al) and non-essential metals (Hg, Cd, Pb), with the later being toxic even at low concentrations (Das et al. 2003). Copper is a trace element that occurs naturally in rock, soil, water, sediment and, at low levels, in air. Anthropogenic sources of copper come mostly from activities such as mining and smelting, industrial emissions and effluents, and municipal wastes and sewage sludge. In the mixing zones of assessed facilities in Cook Inlet, levels of copper may exceed WQS from 0 to 385 times (Appendix B, Table 1). The total mass of copper from these facilities that may be currently added annually to Cook Inlet because of mixing zones is 56,313 pounds (Appendix C, Table 13). The Asplund Wastewater Treatment Facility, for example, has added almost 339,000 pounds of copper to Cook Inlet waters between 1986 and 2008 (Appendix C, Table 14). During the 1980s, total copper levels at the Asplund facility would sometimes exceed the previous permit's MAEC of 100 µg/l (which has since been increased to 341 µg/l), which was thought due to leaching of copper from residential plumbing (AWWU 2009). Copper is also used in biocides, including antifouling paint in boats as well as in agricultural fertilizers (Eisler 1998). However, because copper is ubiquitous and originates from both natural and man-made sources, as is the case with many heavy metals, it is extremely difficult to discern respective contributions to levels in Cook Inlet. Samples from streambeds throughout the Cook Inlet basin were found to be statistically different from other NAWQA (National Water Quality Assessment Program) studies with respect to cadmium, copper and lead, though levels of copper from anthropogenic causes could not be determined (Frenzel 2002).

Copper is considered an essential micronutrient and vital for normal growth and metabolism of all living organisms. Some of the physiologic functions known to be copper-dependent, to a great extent through the formation of essential enzymes, include energy production, connective tissue formation, iron metabolism, neurotransmitter synthesis and metabolism, regulation of gene expression as well as functions as an antioxidant (MIC 2007). However, copper is also considered a priority pollutant by the EPA (USEPA 1994). In excess, copper is among the most toxic of heavy metals in marine biota (Hall 1988) and often accumulates and causes irreversible harm to some species at concentrations just above levels required for growth and reproduction (Schroeder et al. 1966).

Factors affecting copper toxicology

The toxicological potential of a contaminant is a function of its environmental availability or the ability of a contaminant to interact with other environmental matrices and undergo transport processes through biological pathways. Availability is specific to the existing environmental conditions and is a dynamic property, changing with environmental conditions (Drexler et al.

2003).The availability of copper in marine systems is complex and multi-faceted with many variables affecting physical and biological processes preceding toxicity including form of copper and presence of other metals, physical characteristics, species/physiology and organism age/size.

The form of copper and the presence of other water constituents, including metals, will influence environmental availability and biological pathways. Soluble copper salts, as an example, are more toxic than insoluble compounds (WHO 2004). The dominant copper species in seawater over the entire ambient pH range are copper hydroxide, copper carbonate and cupric ion. The concentration of each of these forms depends on the complex interaction of many variables, including the concentration of copper and the concentration of bicarbonate, sulfide, carbonate, phosphate, organic ligands and other metal ions hardness, alkalinity, salinity, and pH (UKMSAC 2010, USEPA 1980). Copper interacts with numerous compounds normally found in natural waters. The high concentrations of particulate matter in most estuaries will facilitate the removal of copper from solution by adsorption to suspended particles which in turn may be deposited and accumulate in sediments, though remobilization may occur when sediment is disturbed (ATSDR 2004). The remaining dissolved copper in the water column is likely to be present either as an organic complex or as the cupric ion (Cu^{+2}). Though Cu^{+2} is the most toxic and the most readily available chemical species of copper, bioavailability is again modified by many biotic and abiotic variables (UKMSACP 2010, Eisler 1998). For example, Cu^{+2} is available for interaction with the gills of a sediment dwelling invertebrate, whereas Cu in the form of a sulfide is not. However, resuspension of sediments with copper sulfide may introduce oxygen and result in the release of Cu^{+2} into the water column, making it environmentally available. (Drexler et al. 2003).

The presence of sequestering agents such as organic carbon can also significantly affect the availability and toxicity of copper. In marine copepod survival, the adverse effects of copper were reduced or eliminated by the presence of clay minerals, diatoms, ascorbic acid, sewage effluents, water extracts of humic acids, and certain soil types (Lewis et al. 1972). At Snowslide Creek in the Denali area, for example, concentrations of trace elements including copper were low but toxicity was considered high because of low inorganic carbon concentrations (Frenzel 2002). Some species of phytoplankton and zooplankton showed a seasonal response in sensitivity, with increased sensitivity to copper stress in the spring in part due to the reduced dissolved organic carbon (Winner et al. 1990). However, not all species showed a season-dependent sensitivity (Winner and Owen 1991).

Other physical parameters that may affect copper exposure and toxicity include salinity (Sabatini et al. 2009, Lee et al. 2010), pH, oxygen and temperature. In a water flea, Meador (1991) found a given amount of copper produced more toxicity as pH increased. In a freshwater amphipod, acidification was found to cause an increase in mortality related to the buffering capacity of the sediments and the test concentrations of copper. (Taylor et al. 1994). In a benthic amphipod mortality was higher following copper exposure and low oxygen saturation (Eriksson and Weeks 1994). In brine shrimp, copper uptake increased with increasing temp (Blust et al. 1994).

Another significant factor in the toxicology of copper is the presence of other metals. Minute amounts of heavy metals may be harmless; however lethality may result when in combination with other metals (Frias-Espericueta 2008). In animals, copper may interact with essential trace elements such as iron, zinc, molybdenum, manganese, nickel, and selenium and also with nonessential elements including silver, cadmium, mercury, and lead; interactions may be either beneficial or harmful to the organism and the patterns of copper accumulation, metabolism, and toxicity from these interactions frequently differ from those produced by copper alone (Kirchgessner et al. 1979). In fish, for example, additive or more-than-additive toxicity has been shown to occur with mixtures of salts of copper and mercury, copper-zinc-phenol, and copper-nickel-zinc (Birge and Black 1979). Other examples include:

- Zinc: Mixtures of copper and zinc are generally acknowledged to be more-than-additive in toxicity to a wide variety of aquatic organisms (Birge and Black 1979, Eisler 1993). Furthermore, significant correlations have been noted between zinc and copper in many marine mammals, including ringed seals (Wagemann 1989), melon-headed whale (Endo et al. 2008), killer whales (Endo 2007), bottle-nose dolphin (Lavery 2008), common dolphin (Zhou et al., 2001) and other small cetaceans (Endo 2002). These correlations may be due to the binding of Zn and Cu to metallothioneins (Zhou et al. 2001, Endo et al. 2007a), though uptake of copper from the intestines is also susceptible to competitive inhibition by other transition metals, particularly zinc or iron. (WHO 2004). Sorensen et al. (2008) found the Cu:Zn ratio may be used as an indicator of potential liver disease.
- Iron: In general, concentrations of copper in all tissues of all marine vertebrates examined are positively correlated with concentrations of iron (Eisler 1984), such as in muscle tissue of Weddell seals (Szefer et al. 1994). Mixtures of copper and iron salts were more than additive in toxicity to ova of brown trout (Sayer et al. 1991). In the marine diatom, copper toxicity was thought to be reduced by the presence of colloidal ferric hydroxide, though iron had no effect on the toxicity of the lipid soluble copper complex, copper-oxine (Stauber and Florence 1985, Florence and Stauber 1986).
- Cadmium: In the presence of copper, barnacles tend to accumulate cadmium (Powell and White 1990). Copper-cadmium interactions occurred in Mozambique tilapia during single and combined exposures. Waterborne copper tended to increase whole body cadmium content of tilapia at all tested copper concentrations and exposure durations (as high as 400 µg Cu/L for 96 h); however, cadmium exposure tended to lower copper concentrations in tissues of tilapia (Pelgrom et al. 1994).
- There are many other examples of other heavy metals interactions/correlations with copper. In general, manganese and copper are positively correlated in tissues of marine vertebrates (Eisler 1984). Copper in livers and muscles of Weddell seals was positively correlated with manganese. Silver was also positively correlated with copper in livers of the same species, but in muscles the correlation was negative (Szefer et al. 1994). Copper was also positively associated with arsenic in ringed seals (Wagemann 1989).

The toxicity of copper changes in the presence of other metals and a mix of metals is almost exclusively the case with mixing zones. In Cook Inlet, a “ Probable Effect Concentration”, above which toxicity was likely, reflected that the combined toxicity of arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc was exceeded in 44% of stream bed sediment samples (Frenzel 2002).

Once in a chemical form which allows biological uptake, a number of processes further complicate the ability to predict the toxicological effects of copper. Biomagnification is an increase in the whole organism contaminant concentration from a lower trophic level to a higher trophic level within the same food web (Drexler et al. 2003). Limited data suggests that, except in some lower trophic levels (Edding and Tala 1996), there is little biomagnification of copper in the aquatic food chain (Barwick and Maher 2003, Perwak et al. 1980) and that whole-body concentrations tend to decrease with increasing trophic level (Eisler 1998). Though copper biomagnification in food chains does not appear to occur to any significant extent, bioaccumulation may present a greater concern. Bioaccumulation can be defined as the net accumulation of a contaminant in a tissue of interest or a whole organism that results from exposure. The potential for bioaccumulation of copper in prey organisms to have an impact in predator organisms is of primary concern, especially if copper bioaccumulates to levels in prey that may potentially cause impacts in predators. Bioaccumulation of metals in prey may be quite high, especially in organisms at lower trophic levels such as high volume filter feeders (Drexler 2003). On a micronutrient level, bacteria may accumulate copper and transfer through the food chain (Miranda and Rojas 2006) and alga have also been shown to concentrate copper and pass along to clams (LaBreche et al. 2002). In mollusks and squid, bioaccumulation may be high (Eisler 1998), though again this process is species dependent. Absil et al. (1996) found one species of sediment dwelling bivalve accumulated copper through sediment and food while another did not. The addition of organic ligands caused a reduction in Cu uptake while more copper accumulated when the clam was fed copper rich algae. Cu concentration has also been negatively related to body condition in marine bivalves (Hummel et al. 1997).

In marine mammals, copper levels appear to decrease with age. Endo et al. (2006) found that copper levels were higher in killer whale calves than in adults. In mature striped dolphins, copper in both the liver and kidney were higher at birth, showed a marked decrease to the age of one year and then stabilized (Honda 1983). In bottlenose dolphins, a negative correlation was noted between both copper and zinc concentrations in the liver and body length (Beck et al. 1997). The higher copper in neonates than in mature and immature dolphins may be the result of an initial decrease in first year of life. It was postulated that neonate livers possibly contain cystine-rich copper binding proteins which have either a detoxifying or storage function (Wood and Van Vleet 1996). Samples from beluga whales in the St. Lawrence River and the Arctic also showed a copper decline with age (Wagemann et al. 1990) in liver, kidney, muscle (Wagemen et al. 1989).

Detoxification/Excretion/Regulation

Physiology may play a more important role than water chemistry in the toxicology of copper (Lee 2010). Biological systems have mechanisms to address chemical insult, including avoidance, excretion, sequestration, detoxification and transformation to less toxic products. Adverse effects may still occur, however, if these mechanisms are overwhelmed or ineffective. Once copper or other heavy metals enter biological systems, a number of regulatory and excretory processes come into play, although the extent to which organisms are able to protect themselves against metal toxicity appears to be both species and tissue specific (Giguère et al., 2006). One mode of detoxification is through metallothioneins (MTs), low weight, cysteine-rich proteins found in most vertebrates involved in homeostasis, storage, transport and detoxification of metals (Fuentealba and Aburto 2003, Coyle et al., 2002). Because of their high cysteine content, MTs have a high affinity for metals like Cd, Cu and Zn (Coyle et al., 2002), although, in harp seals, copper was the only metal significantly correlated with MT (Sonne 2009). In aquatic animals, the widespread distribution of MTs has been firmly established, having been reported in at least 80 species of fish and invertebrates, and the toxicological significance of MT induction has also been supported by the numerous studies that have been conducted with aquatic organisms (Roesijadi 1992). In fish, MTs have been shown to allow copper retention for weeks or months after absorption without producing toxic effects (Eisler 1998 from Hogstrand 1991). In Dall's porpoise and northern fur seals, copper accumulates primarily in the cytosol fraction of the liver where it is bound to MTs (Ikemoto et al. 2004, 2004b). Different MTs able to bind Cd, Zn, Hg and Cu have been identified in marine mammals (Tohyama et al. 1986, Mochizuki et al. 1985, Olafson and Tompson 1974) and MT concentrations in marine mammals vary widely, underlying the numerous parameters involved such as physiological status, age, pregnancy and diet (Das et al. 2000). Though MT may serve as potential biomarkers for metal exposure (Marijic and Raspor 2007), the protective response of MTs, as well as other systems such as metallothionein-like proteins (Won et al. 2008), heat stable proteins (Clayton et al., 2000) metal-rich granules (Coyle et al. 2002) or glutathione (Connors and Ringwood 2000), appear to be a function of metal type, species, age and other factors. When metallothionein-like proteins (MTLP) were evaluated relative to Cu toxicity in a variety of polychaetes, species with no MTP suffered high mortality as compared to no mortality in species with MTP. (Won et al. 2008). In zebra mussels, metal detoxification was influenced by the condition of the mussel with the contribution of metal-rich granules and MT becoming more important with increased pollution (Voets et al. 2009). Glutathione, a ubiquitous tripeptide, is believed to play a fundamental role in metal detoxification in mammals. Connors and Ringwood (2000) found that inhibition of glutathione in bivalves created and increased cellular response to Cu, possibly by suppressing MT concentrations.

Organisms also seem to partially protect their metal-sensitive fractions from binding with Cu, Cd and Zn by increasing the proportion of metals in non-toxic forms (Giguère et al., 2006). Though much of the Cu may be sequestered through various systems, non sequestered Cu may also accumulate with increasing concentrations implying that Cu regulation is not complete and may lead to toxicity. The possibility exists of a shift or spillover from a metal-detoxification fraction to a metal-sensitive fraction and onset of toxicity, though this mechanism does not appear to be consistent with all data (Giguere 2006) or with all species. In a marine decapod, copper was regulated over a range of concentrations until regulation broke down when concentrations became too high, whereas a species of amphipod and barnacle showed no evidence of copper regulation (Rainbow and White 1989). Lavery et al. (2009) found MT formed a large metal-MT complex which lead to damage of renal structures in bottlenose dolphins. In humans and many other mammals, the major excretory pathway for absorbed copper is bile. Biliary copper is discharged to the intestine, where, after minimal reabsorption, it is eliminated in the feces. Excretion of copper in bile may be even more important than absorption in regulating total body level of copper (Turnlund et al., 1998). In cetaceans, which do not have gall bladders, bile may be produced in the hepatic duct system (Perrin et al. 2002) and implications for copper excretion are unknown.

Toxicity

Regardless of methods of detoxification and excretion, excess copper may harm living systems and hepatic Cu concentrations respond markedly to increased concentrations in the water. In humans, acute exposure of large doses of ingested copper present with gastrointestinal bleeding, haematuria, intravascular hemolysis, methemoglobinemia, hepatocellular toxicity, acute renal failure and oliguria (WHO 2004). In marine systems, toxic effects of copper have been documented in multiple species throughout all trophic levels, including, but not limited to, marine microalgae (Cid et al. 1995) and diatoms (Stauber and Florence 1985, Florence and Stauber 1986), copepods (Kwok et al. 2008, Sharp and Stearns 1997), gastropods (Lee et al. 2010) including limpets (DePirro et al. 2001), polychaetes (Won et al. 2008), corals (Victor and Richmond 2005, Reichelt-Brushett and Harrison 2000), crustaceans including amphipods (Eriksson and Weeks 1994, Taylor et al. 1994) such as sand fleas (Meador 1991), barnacles (Qui et al. 2005), crabs (Sabatini et al. 2009) and shrimp (Frias-Espericueta 2003), brine shrimp (Blust et al. 1994), mussels (Curtis et al. 2001, Nicholson 1999)/ clams (Sobral and Widdows 1997) and fish (Waser et al. 2009, Johnson et al. 2007, Shaw and Handy 2006, Handy et al. 1999, Marr et al. 1996, Farag et al. 1994,Woodward 1994, Steele 1983, Scarfe et al. 1982).

Concentrations of copper in estuarine and coastal waters in the United States have been measured at 0.3–3.8 and 0.1–5 microgram/l, respectively (Kennish 1998, Perwak et al. 1980). Dissolved copper may cause a range of adverse effects, including acute, chronic and sublethal effects in fish as well as in aquatic invertebrates and algae. Aquatic microcosms showed reduced levels of primary production, dissolved organic carbon production, and macroalgal growth at 9.3 μg/l and substantial structural changes occurred at ≥ 30 μg/l (Hedke 1984). A large body of scientific literature is available on the toxic effects of copper on fish. Elevated copper concentrations, for example, can be directly toxic to fish, resulting in elimination of desirable sensitive species, e.g. salmonids, and possible replacement by less desirable resistant species (USEPA 1987). In assessing the the effect of NPDES authorized toxic discharges on Puget Sound Chinook salmon, LaLiberte and Ewing (2006) described scientific findings that included gill precipitates and respiratory distress, ionic regulatory dysfunction, inhibition of smolt seaward migration, interference of olfactory-mediated behaviors promoting survival and spawning migrations, impairment of avoidance behaviors to lethal concentrations of copper, immunosupression and increased susceptibility to infection. Fish behavior may be disrupted at copper concentrations that are at or slightly above ambient levels. Exposure to low concentrations of copper has resulted in reduced behavioral predator response in juvenile salmonids. Further, impairment of olfaction in juvenile salmonids can manifest in minutes, last for minutes to weeks and potentially result in population level consequences (Hecht et al. 2007). Another study on potential sublethal effects on the peripheral olfactory nervous system of salmon concluded that short-term copper exposure, within a matter of minutes, diminished the responsiveness of olfactory epithelium to natural odorants, thus potentially interfering with the ability of fish to successfully migrate towards natal streams (Baldwin et al. 2003). Though salmonids may actively avoid point source copper at low doses, concentrations of 44 μg /l and above failed to elicit avoidance behavior (Hansen et al. 1999). At low concentrations, copper could serve as barriers to migration or exclude habitats. In fresh-water systems, a storm-water pulse of copper at 13 micrograms/liter caused a >50% loss of sensory capacity, regardless of water hardness. In Cook Inlet, where mixing theoretically moves copper quickly out of the mixing zone, salmon may receive copper in pulses and avoidance behavior may not be possible (Baldwin et al. 2003). In the EPA's 2006 BA, concern was expressed regarding this effect of copper on salmonids.

Biological variables that may affect the concentration of contaminants, including copper, in marine mammal tissues are numerous and include sex, nutritional, health and reproductive status

(Skaare 1996) as well as location. Marine mammals of the Canadian Arctic have a consistently high frequency of occurrence of high metal values (Wagemann 1989). In bearded seal tissues taken near the Red Dog Mine, Alaska, copper was one of the metals with significantly elevated concentration relative to controls (Quakenbush and Citta 2009). Most marine mammal liver tissues contain < 20 µg/g of copper (wet weight), though there is substantial variability between and among species and locations (Appendix D, Tables 1-3). In 1995, a single Cook Inlet beluga liver sample measured copper at 53.78 µg/g wet weight (Becker et al. 1995). Between 1992 and 1996, a sample of 10 animals showed average copper concentrations (µg/g, wet weight) of 48.9 in males and 29.3 in females. The copper concentration in the liver of a single fetus was also measured at 63.63 µg/g wet weight (Becker 2000). Compared to other Alaska stocks, the mean copper concentration in Cook Inlet beluga was 2-3 times higher at the 95% confidence level (Becker 2001a). When compared to beluga whales from ten other North American locations, concentrations of copper in Cook Inlet belugas (µg/g, dry weight) averaged the highest at 162, with the average copper concentration from other locations ranging between 37.3 – 150. The range of hepatic copper concentrations which was thought to contribute to renal damage in south Australian bottlenose dolphins was 16.02 – 29.72 µg/g; however, levels of cadmium and zinc were also elevated (Lavery et al. 2009).

4.2 Analyses for Effects of the Action

For an adverse effect to occur, a chemical must be potentially toxic and Cook Inlet belugas must be exposed to the toxic chemicals at concentrations that are sufficient to cause an adverse effect. The physical properties of a contaminant, including solubility, hydrophilic and lipophilic properties etc. will determine the most likely method for exposure which is possible through two methods: directly through the consumption of, and exposure to, water and sediments or indirectly through the consumption of contaminated prey species. Feeding strategies in particular influence the nature and degree of exposure (MMC 1999).

Indirect Exposure

The 2009 BA Supplement regarding the Cook Inlet beluga did not address indirect effects via consumption of contaminated prey species. However, the 2006 BA did consider potential effects on certain species with respect to essential fish habitat (EFH) throughout Alaska. According to the BA, pollutants authorized in mixing zones include those with known adverse effects, such as petroleum hydrocarbons and bioaccumulative substances. One of the primary EFH concerns was exposure, particularly during sensitive life stages, to concentrations that may create adverse effects and even low concentrations of toxicants may create such effects in species or life stages which are particularly sensitive. Organisms that already demonstrate elevated concentration of certain contaminants, such as lead, copper, cadmium or selenium, may be at greater risk with increased exposure from mixing zones. For example, some of the petroleum hydrocarbons associated with the oil and gas industry have long half-lives and can bioaccumulate in some marine organisms, such as bivalve mollusks. Further, the ability to detoxify these compounds may be lacking in some organisms. Along with chemical contamination, changes in heat and turbidity associated with mixing zones may also affect EFH. Though the mixing zone revisions do provide some provisions for protecting EFH, the EPA determined that, despite these provisions, approval of the mixing zone revisions may adversely affect Gulf of Alaska groundfish as well as Alaska stocks of Pacific salmon. (USEPA 2006a). With respect to the EFH relative to the oil and gas industry, the EPA determined that sublethal effects on EFH in mixing zones may occur as well as indirect effects on EFH species from adverse effects on epibenthic and benthic prey species in the mixing zone. However, these effects were deemed inconsequential because of the relatively small area affected by the few discharge and exploration sites (USEPA 2006b).

Cook Inlet belugas consume a wide variety of prey items. Prey items include both EFH and non-EFH species, resident and non-resident, anadromous species, vertebrates and invertebrates and most, if not all, of these species may be found within the action area during all or part of their life cycles. Very little data are available on juvenile and larval stages of fish species in Cook Inlet (M. Eagleton, pers. comm). The area north of the Forelands, where extensive oil and gas industrial activity and associated mixing zones are located, is considered a salmonid migratory corridor. Other fish species recovered from 3 sites adjacent to Fire Island in upper Cook Inlet include threespine stickleback, longfin smelt, Pacific herring, saffron cod, juvenile snailfish, ninespine stickleback, Pacific cod, juvenile flatfish and unidentified osmerid (NMFS 2009). Mixing zones may indirectly affect beluga whales through a decrease in the quality and/or quantity of prey species, starting from the lowest trophic levels. Bioaccumulation factor values showed the trends of accumulation of most metals were: mollusks> crustaceans> annelids. Mollusks may possibly be unable to discriminate among metals with similar characteristics and/or may possess a variety of detoxification mechanisms to reduce toxicity. Crustaceans, such as barnacles, filter a large volume of water which could increase uptake (Ali and Fishar 2005). Contaminants in invertebrate diets have been suggested as a plausible cause for reduced survival of some fish species by reducing the production of prey items consumed by juvenile fish (Woodward et al. 1995). Salmon fry, for example, spend up to a year in river areas, estuaries and along shoreline prior to ocean migration and diet during that time is composed entirely of benthic invertebrates (Healy 1991). Fish, like beluga whales, may uptake contaminants through their diet which subsequently move up the food chain and may manifest in different ways (Kannan et al. 1993). The toxic effects of contaminants on fish species, or the prey of fish species, may decrease populations, either acutely or chronically, although the process is difficult to verify.

Chronic, low-level exposure may adversely affect reproduction and development, particularly at sensitive life-stages (URS 2010). Reproductive failure in common seals, for example, has been found to be related to diet of fish from polluted areas (Reijnders 1986). Small concentrations of a contaminant may accumulate and stay within a food web over time. In St. Lawrence beluga whales, for example, the high level of mirex in whale tissue was accounted for by the whales feeding on eels contaminated from the chemical for only 10 days a year over the course of 15 years (Beland 1996).

Prey species may also avoid mixing zone areas because of changes in physical parameters. Water discharges from industrial facilities and wastewater treatment facilities, for example, can add heat and increased turbidity to aquatic systems. Though ADEC Water Quality standards include regulations for both temperature and turbidity in marine waters (ADEC 2003), these limits may be exceeded in mixing zones. In the case of seafood processors and mixing zones, surveys indicate that discharges of processing wastes attract and aggregate fish, sea birds and marine mammals (USEPA 2001a). Consequently, the potential also exists for prey species to be attracted to a mixing zone, which may expose prey species to contaminants as well as attract predators such as beluga whales. Potential problems may further arise when a mixing zone becomes an “ecological trap” or a low-quality habitat that animals prefer over other available habitats of higher quality. The presence of a trap may drive local population to extinction (Battin 2004).

4.3 Species Response to the Proposed Action

For an endangered species such as the Cook Inlet beluga, a "safe dose" should represent a chemical concentration in the environment or in whale tissue that would not be likely to cause adverse effects on an individual (URS 2010). However, the difficulty in discussing adverse effects, or lack thereof, with respect to the Cook Inlet beluga is the lack of substantial baseline data.

Exposure and toxicity in marine mammals

The ocean and other large waterways have long been considered as endlessly diluting repositories of environmental pollutants. Consequently, organisms occupying higher trophic levels, such as marine mammals, often accumulate large amounts of contaminants with exposure pathways including runoff, dumping, atmospheric transport and food web transfer (MMC 1999). Toxicity is a function of exposure and effect levels. Animals may undergo acute, short term exposures (relatively high concentrations over a short time period) which may result in severe adverse affects such as mortality or incapacitation or chronic, long term exposures (lower chemical concentrations from sources such as continuous discharges and contaminated sediments) may result in more subtle effects such as alterations in development, growth and reproductive success.

Though marine mammals appear to be able to accumulate relatively high concentrations before toxic effects are noted (Sonne 2009), toxicological effects have been noted in marine mammals akin to other species. Catastrophic viral epidemics have affected some species of marine mammals, all severely contaminated by industrial pollutants, possibly due to immunosupression (De Guise et al. 2003). Toxins have also been implicated as contributing stressors in mass stranding events (Wood and Van Vleet 1996). Disease outbreaks involving marine mammals with high tissues concentrations of organochlorines, for example, appear to have occurred with increasing frequency (MMC 1999, Colborn and Smolen, 1996). Organohalogens, including organochlorines, are the most abundant contaminants in tissues of marine mammals and ample evidence exists of detrimental effects on the immune system (De Guise et al. 2003). Limited data is available of the effects of metals on marine mammals, except perhaps for mercury (Das et al. 2003), though the general immunotoxic potential of different metals has been ranked as follows: mercury>copper>manganese>cadmium>chromium (Lawrence 1981). Marine mammals may be exposed to metals in both organic and inorganic forms of metals with organic forms tending to be more toxic, bioavailable and bioaccumulative. Though the mechanisms by which metals and other accumulating toxins are taken up and distributed by marine mammals are somewhat expected to follow the same principles as with other species, a unique physiological characteristic is the presence of a large blubber layer. This blubber layer may affect the distribution of hydrophobic contaminants, but has little influence on distribution of inorganic forms of metals, the distribution of which is primarily determined by mechanisms that operate in organs such as liver and kidney. (MMC 1999). The large fat content of marine mammals can act as pools for trapping contaminants (Colborn and Smolen 1996) and marine mammals may be exposed to very high concentrations of pollutants from the time of conception via exposure *in utero*, during breast feeding, as well as accumulation from the food chain from adolescence to adulthood (Gregory and Cyr 2003). Potential effects of contaminants may include morbidity and mortality, disruption of endocrine cycles and developmental processes causing reproductive failures or birth defects, suppression of immune system function and metabolic disorders resulting in cancer or genetic abnormalities. Experimental and other evidence has shown that certain contaminants often found in the tissues of marine mammals have deleterious effects on reproduction and the immune system (De Guise et al. 2003, MMC 1999).

Uncertainties and modeling

Though environmental contaminants have been linked to adverse health effects in marine mammals, establishing a direct determination of the effects of specific environmental contaminants has been difficult because of logistical, biological and ethical considerations (De Guise et al. 2003). The measurement of a contaminant concentration does not necessarily relate directly to toxicity or a toxicological effect. Though a great deal of literature is available reporting measured concentrations of contaminants, reliable and quantitative information that relate measured body burdens to observed adverse effects is lacking (URS 2010). This is the case for a number of reasons:

- Numerous effects confound the issue, including variability in toxicity as well as a host of biotic and abiotic factors. For example, few studies have demonstrated a direct relationship between endocrine dysfunction and contamination. Because several factors such as temperature, habitat change etc. can influence endocrine systems, it is difficult to establish causal relationship between environmental contaminant and an endocrine effect (Gregory and Cyr 2003). There is great uncertainty about mechanisms and pathways of contaminants in marine environments and data are always difficult to interpret due to the presence of other contaminants and other stressors (Reddy and Ridgway 2003).
- Species specific differences in the sub-cellular handling of contaminants may indicate differences in sensitivity and health implications (Sonne 2009). Effects of exposure and physiological process of storage, metabolism and elimination are poorly understood and the physiological status of the individual may also modulate toxicity (Reddy and Ridgway 2003, Das et al. 2003).
- Many, if not most, tissue samples are from animals in variable states of decomposition that have stranded with an unknown cause of death. Whether death is related to contaminant burdens is generally unknown. Contaminant levels may also change following death. By the time stranded samples are recovered, extensive degredation has often taken place and the time between death and sampling has been shown to affect analysis. Furthermore, the majority of these cases include no history, progression of clinical illness or mechanisms leading to mortality (Borrel and Aguilar 1990).
- Controlled experiments are unavailable to establish any definite causal relation between pollutant concentrations and physiological changes (Das et al. 2003).

When data providing evidence of direct relationships is lacking, toxicologists often use animal models, such as rats and mice, to conduct controlled investigations to assess the effects of contaminant exposure. The toxicity data collected from studies with laboratory animals is then extrapolated to other species using a risk-based approach. However, while such studies can produce valuable information regarding mechanisms of action, risk assessment and dose-response relationships, the extrapolation of these data to other species or populations must be made very judiciously (MMC 1999). Many pollutants, such as organochlorines and heavy metals for example, are well characterized as immunotoxicants in lab rodents, but demonstration of toxic effects in marine mammals remains a challenge because of a limited immunologic database, limited assay and reagent development, genetic diversity in populations as well as logistical and ethical considerations working with marine mammals (De Guise et al. 2003). Though modeling was applied to Steller sea lions and humpback whales in the initial EPA mixing zone consultation (USEPA 2006a), and NMFS subsequently requested that the EPA conduct similar modeling for the Cook Inlet beluga, the EPA chose to forego the approach for the Cook Inlet beluga because of inherent uncertainties (J. Jennings, EPA, Pers. comm.). These uncertainties stem from:

- Failure to correctly predict threshold doses a sufficient number of times
- Assumes equal sensitivity of all species on a mg/kg-body weight/day basis. The sensitivity/insensitivity of the model species may be incorrectly extrapolated to the test species.
- Allometric extrapolations can result in inappropriately low toxicity thresholds for some species.
- Allometric scaling requires several estimators, all of which are most appropriately represented by a distribution
- A major oversimplification of toxicity extrapolations is the notion that all toxicological processes are dependent upon metabolic rates.

(USEPA 2006a).

The Marine Mammal Commission (MMC) identified the following high-priority uncertainties with respect to toxicants and marine mammals. Unknowns include:

- Pathological effects of persistent contaminants. Knowledge is limited even though very high levels of certain contaminants have been repeatedly documented in marine mammal tissues.
- Relationships between exposure to contaminants and immunotoxicity and other health effects. Large scale die-offs have been reported due to disease, with many of the animals with high levels of contaminants, particularly organochlorines. Though many contaminants in the marine environment, including heavy metals and PAHs, are well characterized as immunotoxicants in lab animals, immunotoxic effects in marine mammals have been demonstrated only to limited extent.
- The role of contaminants in reproductive failure.
- The potential for impacts of endocrine-disrupting contaminants.
- The potential to predict the risk to individuals and populations associated with exposure.
- Future trends with currently know contaminants.
- Future trends with less widely known contaminants.

In conclusion, the MMC recommended model species should be those studied in the wild to a considerable extent and that are also perhaps well represented in marine mammal facilities (MMC 1999).

Cook Inlet beluga response

Among the chemicals evaluated with regard to their potential to contribute to adverse effects on Cook Inlet belugas, the most probable included chlorinated pesticides, chlorinated dielectric fluids, transformer oils, chlorinated dibenzo-p-dioxins and furans, metals and polycyclic aromatic hydrocarbons (PAHs). These chemicals have been reported in environmental media in

Cook Inlet and/or in Cook Inlet beluga whale tissues and known to be associated with adverse effects on reproduction or growth in marine mammals. Though the potential exists for some of the detected chemicals, such as polychlorinated biphenyls, to be present at concentration ranges associated with possible endocrine disruption and immune functions in marine mammals, available data indicates concentrations of the chemicals in Cook Inlet beluga are typically lower than those of marine mammals from other areas, such as the Artic (URS 2010). In tissue samples assessed from Cook Inlet beluga whales, the only contaminant that has been elevated thus far is copper, which was present in higher concentrations in the livers of Cook Inlet belugas than in other beluga whales sampled in Alaska. However, there are a number of difficulties which arise in interpreting these copper levels as detrimental to Cook Inlet beluga health:

- Copper is ubiquitous in the environment, originating from both natural and anthropogenic sources. Though there is no question that mixing zones add to the copper burden in Cook Inlet, the relative contribution of copper from mixing zones is unknown.
- Although concentrations of copper in beluga whales was above the level associated with renal pathology found in another marine mammal species, levels of copper have not significantly increased over time in the limited number of Cook Inlet beluga tissues sampled. Furthermore, in certain marine mammals, including beluga whales, copper levels have been found to decrease with age. It has been postulated that the elevated copper associated with the tissue samples may have come from younger animals and would therefore not accurately represent copper concentrations in the population. Samples from Cook Inlet belugas are currently being analyzed for age with results expected in late 2010 (P. Becker, NIST, Pers. Comm.).
- Though copper levels appear to be elevated in Cook Inlet belugas relative to other beluga populations, there is insufficient data to indicate copper as a source of pathology and/or mortality in Cook Inlet belugas.

In summary, although the current range of Cook Inlet belugas falls almost completely within the action area, it would be difficult to discern the actual overlap, both temporally and spatially, between the whales, their prey species and current mixing zones. However, in considering the possible pathways of exposure as well as the life history of Cook Inlet beluga whales, it is likely that the beluga contaminant load resulting from exposure to mixing zones is low. The whales may come into contact with mixing zone contaminants either through direct contact or indirectly through trophic interactions and the ingestion of prey species. Regarding direct exposure, although the whales may pass through mixing zones, marine mammals do not drink water for osmoregulation (Ortiz 2001). Exposure to contamination from both water and sediments in mixing zones, therefore, is most likely through indirect contact from ingestion of prey species. As opportunistic feeders, the beluga whales of Cook Inlet utilize a wide variety of deep and shallow water species throughout the Inlet. Although they do congregate in certain areas at certain times of year, this congregation is ephemeral and, according to the information provided by the EPA, none of the facilities with mixing zones are currently located near these seasonal areas of congregation, including the Susitna Delta (Fig.8). Furthermore, though data is limited, current contaminant loads in Cook Inlet belugas have not been associated with symptoms of toxicity.

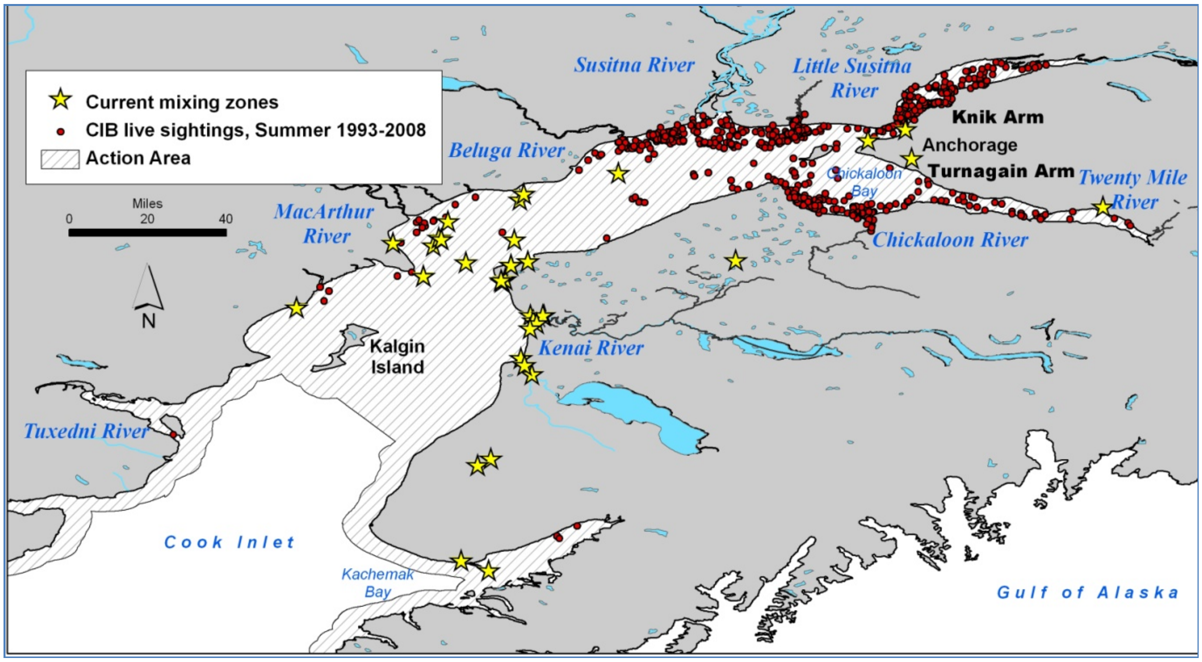


Figure 8. Current mixing zone locations and seasonal beluga whale sightings.

Based upon the best available scientific data, there is currently no evidence to indicate that mixing zones in Cook Inlet have resulted in increased contaminant loads and consequent health effects in Cook Inlet beluga whales. Upcoming 1997 – 2006 data on both concentrations and temporal trends of heavy metals, including copper, as well as age data in Cook Inlet belugas will provide relevant information regarding this conclusion.

5.0 Cumulative Effects

Cumulative effects are defined in 50 CFR §402.02 as: "...those effects of future State or private activities not involving Federal activities that are reasonably certain to occur within the action area of the Federal action subject to consultation." Reasonably foreseeable future Federal actions and potential future Federal actions that are unrelated to the proposed action are not considered in the analysis of cumulative effects because they would require separate consultation pursuant to Section 7 of the ESA. Most structures and major activities within the range of the Cook Inlet beluga whale require Federal authorizations from one or more agencies, such as the Army Corps of Engineers (Corps), Environmental Protection Agency (EPA), and Minerals Management Service. Such projects require consultation under the ESA on their effects to the Cook Inlet beluga whale, and are therefore not addressed here as cumulative impacts.

Port MacKenzie

Port MacKenzie is the center of transportation and development plans for the west side of lower Knik Arm. It currently consists of a 500 foot bulkhead barge dock, a 1,200 foot deep-draft dock with a conveyor system, a landing ramp, and 8,000 acres of adjacent uplands available for commercial or industrial development. The Matanuska-Susitna Borough plans to provide services for bulk commodity storage and a floatplane base to serve Anchorage air taxi and private pilots. The Port MacKenzie project includes plans for the Knik Arm Crossing Bridge, a Cook Inlet ferry service, and an ARRC rail extension.

New developments at Port MacKenzie will add to the disturbance of Cook Inlet beluga whales. Noise levels will increase from construction activities. The build-up of infrastructure at Port MacKenzie will lead to greater vessel traffic on the west side of Knik Arm, with the associated increase in noise and risk of ship strikes and hazardous material releases. The planned floatplane base will increase aircraft noise. There is concern that all of the increases in development within the action area may prevent beluga whales from reaching important feeding areas in upper Knik Arm. The current Marine Terminal Redevelopment Project associated with the Port of Anchorage (POA) expansion is causing disturbance on the lower east side of Knik Arm, and the new development at Port MacKenzie will increase disturbance on the west side. However, usage to date of Port MacKenzie has been very low and levels of increased activity and the timeframe of any increase are uncertain.

Ship Creek

Ship Creek is a popular area for recreational fishing in Anchorage, and currently has a small boat launch located at its mouth. Plans for the Ship Creek area include continued use of the harbor for commercial and recreational fishing, and small boat traffic, construction of a loading facility for the Cook Inlet ferry service, and habitat improvements to mitigate the effects of the POA Marine Terminal Redevelopment Project.

Small vessel activity and the use of a ferry near the mouth of Ship Creek can increase noise disturbance and the risk of ship strikes to beluga whales. The improvements made at the Ship Creek harbor may increase its use by small boats. Noise levels will increase during construction of the ferry terminal and as habitat improvements are being made. Any habitat improvements to the Ship Creek watershed will help to reduce the amount of pollution from runoff entering the Knik Arm, which will help to improve beluga whale habitat.

Pollution

There are many non-point sources of pollution within the action area; such pollution is not federally-regulated. Pollutants can pass from streets, construction and industrial areas, and airports into beluga whale habitat within the action area. The potential for pollution from all sources will increase with population growth, more development, and new commercial activities in upper Cook Inlet. There is a possibility an oil spill could occur from vessels traveling within the action area, or that oil will migrate into the action area from a nearby spill. POA and its tenants have pollution prevention plans in place to help identify potential sources of pollution, and to minimize the risk of spills and releases of contaminants. The POA has plans to improve water quality by treating the storm water discharges that pass from the POA into the Knik Arm.

Regarding point sources of pollution, such as wastewater treatment or oil and gas effluents, the federal nexus has traditionally been covered through the EPA's NPDES permitting program. However, authority over the federal permitting and compliance and enforcement programs is in the process of being transferred to ADEC with the final phase of transfer slated for October 31, 2011. The resultant Alaska Pollutant Discharge Elimination System (APDES) program components will include, among others, domestic discharges, seafood processing and hatcheries, storm water, pretreatment, miscellaneous non domestic discharges, mining as well as oil and gas industries, and Section 7 consultation will no longer be required in permitting discharges from these facilities. However, the State of Alaska WQS do offer protection through beneficial use classifications, where water quality criteria are established for water use classes (18 AAC 70.020.a. (2) A-D). Cook Inlet is protected for beneficial uses of aquaculture, industrial water supply, water contact and secondary recreation, growth and propagation of fish, shellfish, other aquatic life, wildlife, and harvesting for consumption of raw mollusks and other raw aquatic life (EPA 2007d).

There have been several past State oil and gas lease sales in the Inlet. Future sales are anticipated annually, including much of the submerged lands of Cook Inlet. While these sales and APDES permitting for facilities are State matters, many of the subsequent actions that might impact beluga whales are likely to have some federal nexus. Location of drilling structures would require authorization from the Corps. Discharges such as muds and cuttings or produced waters require permitting through the EPA. Oil spills would be one example of an unauthorized activity. In the event an oil spill occurred on State leases in Cook Inlet, the effects on beluga whales are generally unknown; however, some generalizations can be made regarding impacts of oil on individual whales based on present knowledge. Although cetaceans are capable of detecting oil, they do not seem to avoid the oil (Geraci 1990). Beluga whales swimming through an oil spill could be affected in several ways: skin and/or sensory organ damage, ingestion of oil, respiratory distress from hydrocarbon vapors, contaminated food sources, and displacement from feeding areas. These effects could lead to death and would be most pronounced whenever whales were confined to an area of freshly spilled oil.

NMFS recognizes that not enough is known about the effects of each specific threat, and NMFS does not definitively understand the level of impact each threat has on Cook Inlet beluga whales. Cook Inlet beluga whales may be affected by multiple threats at any given time, compounding the impacts of the threats. Without an understanding of how individual threats impact beluga whales, the cumulative effects of all the threats on Cook Inlet beluga whales remain unknown.

6.0 Conclusion

After reviewing the current status of the Cook Inlet beluga whale, the environmental baseline for the action area, the effects of the action and cumulative effects, it is NMFS' biological opinion that the EPA's proposed approval of the State of Alaska's mixing zone regulations, including revisions [18 AAC 70.240], is not likely to jeopardize the continued existence of the Cook Inlet beluga whale.

Salient features leading to this conclusion include:

1. The Clean Water Act provides the statutory basis for Water Quality Standards, which define the water quality goals of a water body and set criteria to limit or prevent water degradation. Instead of meeting WQS at the end of pipe, the presence of mixing zones allows the exceedance of WQS within a defined distance from the end of pipe with dilution allowing WQS to be met at the edge of the mixing zone. The State of Alaska has the authority to include policies regarding mixing zones within their water quality standards, which are then subject to EPA review and approval.
2. Water quality standards are based upon toxicological endpoints. Though toxicological data may be the foundation for WQS, for many reasons it is extremely difficult to determine a direct correlation between a contaminant concentration and a particular

pathologic effect. This is the case with most marine mammals because of an existing lack of data and concurrent circumstances that prevent the collection of data. Toxicologic data regarding the Cook Inlet beluga whale is primarily based upon a very small subset of mostly healthy animals.

3. Toxicological modeling contains too much uncertainty to accurately use in assessing Cook Inlet beluga contaminant loads and effects. Instead, species of other marine mammals, including other populations of beluga whales, may be used for comparative purposes or as proxy species. St. Lawrence beluga whales are an example of a beluga population where correlations were made between environmental pollutants and pathology; however, the contaminants thought to be inherently responsible for St. Lawrence beluga whale pathology were not elevated in Cook Inlet belugas.
4. Cook Inlet belugas may be exposed to contaminants in mixing zones primarily through consumption of prey species. Information regarding transfer of contaminants from mixing zones through trophic levels to Cook Inlet belugas is not available. Consequently, current contaminant loads of Cook Inlet belugas may serve as indices of exposure, though the sources of exposure are unknown.
5. Within the limited Cook Inlet beluga dataset, most of the measured contaminants were similar to or below levels in other beluga populations. Copper was the single exception with measured levels 2-3 times above those normally found in other marine mammals, including populations of beluga whales. This elevation in copper was not thought to jeopardize the Cook Inlet beluga population for the following reasons:
   a. It would be extremely difficult to discern the source of excess copper in either Cook Inlet belugas or prey species. Heavy metals, such as copper, originate as part of the natural landscape as well as from anthropogenic sources. Though mixing zones do contribute to the copper burden in Cook Inlet, there is insufficient data and/or evidence of the extent of this contribution relative to copper loads in Cook Inlet.
   b. Though concentrations of copper in beluga whales was above the level associated with renal pathology found in another marine mammal species, levels of copper have not significantly increased over time in the limited number of Cook Inlet beluga tissues sampled. Furthermore, in certain marine mammals, including beluga whales, copper levels have been found to decrease with age. It has been postulated that the elevated copper associated with the tissue samples may have come from younger animals and would therefore not accurately represent copper concentrations in the population.
6. Though adverse effects are possible with any contaminant, there is insufficient data and/or evidence to indicate that contaminants, including copper, have resulted in pathology and/or mortality in Cook Inlet belugas.

Critical habitat has not yet been designated for this species, therefore, none will be affected.

7.0 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying-out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited under the ESA provided that such taking is in compliance with the terms and conditions of an incidental take statement. Regulations at 50 CFR 402.14 (i)(1) state that where the Service concludes that an action and the resultant incidental take of listed species will not violate section 7(a)(2), and, in the case of marine mammals, where the intentional and incidental taking is authorized pursuant to section 101(a)(5) of the Marine Mammal Protection Act of 1972 (MMPA), the Service will provide with the biological opinion a statement concerning incidental take.

However, because no MMPA section 101(a)(5) authorization has been applied for and issued for the proposed action, no incidental take is authorized at this time. Any take related to the proposed action will result in a violation of the ESA.

8.0 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

The National Marine Fisheries Service recommends the following measures for these purposes:

1. The EPA require that the establishment of new mixing zones by ADEC will be prohibited in areas of Cook Inlet beluga and prey species congregation, including the Susitna River Delta.
2. The EPA require that ADEC consider updated Cook Inlet beluga contaminant concentrations and temporal analysis in determining which effluent constituents may be allowed above WQS in mixing zones.
3. The EPA require ADEC mixing zone permit approvals contain provisions for regular, ADEC-supervised contaminant sampling of water, sediment and aquatic flora and fauna, including beluga prey species, within and adjacent to all mixing zones.

9.0 Reinitiation of Consultation

This concludes formal consultation on this action. As provided in 50 CFR 402.16, reinitiation of consultation is required where discretionary Federal agency involvement or control over the action has been retained and if: (1) the amount or extent of taking specified in the incidental take statement is exceeded; (2) new information reveals effects of this action that may affect listed species or critical habitat in a manner or to an extent not previously considered in this biological opinion; (3) the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this biological opinion; or (4) a new species is listed or critical habitat designated that may be affected by the identified action.

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Appendix A. Subset of facilities with Cook Inlet as receiving waters

NPDES_ID	ACTIVITY	CODE_EXPAN	NAME_1	NAME_2	RECEIVING_
AK0000396	AIRSEATRANSPORT	MARINE CARGO HANDLING	COOK INLET PIPELINE CO	DRIFT RIVER TERMINAL	REDOUBT BAY COOK IN
AK0001058	AIRSEATRANSPORT	MARINE CARGO HANDLING	TESORO ALASKA PETROLEUM	KENAI PIPELINE FACILIT	COOK INLET
AKS052426	AIRSEATRANSPORT	MARINE CARGO HANDLING	ANCHORAGE PORT OF	MS4	COOK INLET
AKR10B931	CONSTRUCTIONDEVELOP	GEN CONTRACT-INDUST. BLDG	TRIAD HOSPITALS INC	VALLEY HOSPITAL	SPRING CREEK/COOK IN
AKR10B932	CONSTRUCTIONDEVELOP	GEN CONTRACT-INDUST. BLDG	BOVIS LEND LEASE INC	VALLEY HOSPITAL	SPRING CREEK/COOK IN
AKR10BE60	CONSTRUCTIONDEVELOP	GEN CONTRACT-RES NOT SIN	DISCOVERY CONSTRUCTION I	AURORA PARK SUBDIVISIO	COOK INLET
AK0000507	MISCELLANEOUS	NITROGEN FERTILIZERS	AGRIUM U.S. INC	NON-DOMESTIC WWTP	COOK INLET
AKR05A543	MISCELLANEOUS	NITROGEN FERTILIZERS	AGRIUM U.S. INC	KENAI OPERATIONS PLANT	COOK INLET
AK0000841	OILANDGAS	PETROLEUM REFINING	TESORO ALASKA PETROLEUM	KENAI (NIKISKI) REFINE	COOK INLET
AK0001155	OILANDGAS	NATURAL GAS LIQUIDS	CONOCOPHILLIPS ALASKA IN	KENAI LNG PLANT	COOK INLET
AK0053309	OILANDGAS	CRUDE PETROLEUM & NATURAL	FOREST OIL CORP	OSPREY PRODUCTION PLAT	COOK INLET
AKG285001	OILANDGAS	CRUDE PETROLEUM & NATURAL	UNOCAL	GRANITE POINT TANK FAR	COOK INLET
AKG285002	OILANDGAS	CRUDE PETROLEUM & NATURAL	UNOCAL	TRADING BAY TREATMENT	COOK INLET
AKG285003	OILANDGAS	CRUDE PETROLEUM & NATURAL	XTO ENERGY INC	E FORELANDS TREATMENT	COOK INLET
AKG285004	OILANDGAS	CRUDE PETROLEUM & NATURAL	UNOCAL	ANNA PLATFORM	COOK INLET
AKG285005	OILANDGAS	CRUDE PETROLEUM & NATURAL	UNOCAL	BAKER PLATFORM	COOK INLET
AKG285006	OILANDGAS	CRUDE PETROLEUM & NATURAL	UNOCAL	BRUCE PLATFORM	COOK INLET
AKG285007	OILANDGAS	CRUDE PETROLEUM & NATURAL	UNOCAL	DILLON PLATFORM	COOK INLET
AKG285009	OILANDGAS	CRUDE PETROLEUM & NATURAL	UNOCAL	DOLLY VARDEN PLATFORM	COOK INLET
AKG285011	OILANDGAS	CRUDE PETROLEUM & NATURAL	CONOCOPHILLIPS ALASKA IN	TYONEK PLATFORM A	COOK INLET
AKG285012	OILANDGAS	CRUDE PETROLEUM & NATURAL	XTO ENERGY INC	PLATFORM A	COOK INLET
AKG285013	OILANDGAS	CRUDE PETROLEUM & NATURAL	XTO ENERGY INC	PLATFORM C	COOK INLET
AKG285016	OILANDGAS	CRUDE PETROLEUM & NATURAL	UNOCAL	GRAYLING PLATFORM	COOK INLET
AKG285017	OILANDGAS	CRUDE PETROLEUM & NATURAL	UNOCAL	MONOPOD PLATFORM	COOK INLET
AKG285019	OILANDGAS	CRUDE PETROLEUM & NATURAL	UNOCAL	STEELHEAD PLATFORM	COOK INLET
AKG285024	OILANDGAS	CRUDE PETROLEUM & NATURAL	FOREST OIL CORP	OSPREY PRODUCTION PLAT	COOK INLET
AKG520402	SEAFOODAQUACULTURE	FRE OR FROZ PCK FISH SEA	OCEAN BEAUTY SEAFOODS IN	S: NIKISKI PLANT	COOK INLET
AKG520437	SEAFOODAQUACULTURE	FRE OR FROZ PCK FISH SEA	THE FISH FACTORY LLC	S: HOMER FACILITY	COOK INLET KACHEMAK
AKG520478	SEAFOODAQUACULTURE	FRE OR FROZ PCK FISH SEA	PACIFIC STAR SEAFOODS IN	S: KENAI FACILITY	COOK INLET KENAI RI
AKG520480	SEAFOODAQUACULTURE	FRE OR FROZ PCK FISH SEA	INLET FISH PRODUCERS INC	S: KENAI PLANT	COOK INLET KENAI RI
AKG520481	SEAFOODAQUACULTURE	FRE OR FROZ PCK FISH SEA	SALAMATOF SEAFOODS INC	S: KENAI FACILITY	COOK INLET KENAI RI
AKG520483	SEAFOODAQUACULTURE	FRE OR FROZ PCK FISH SEA	SNUG HARBOR SEAFOODS INC	S: KENAI FACILITY	COOK INLET KENAI RI
AKG520485	SEAFOODAQUACULTURE	FRE OR FROZ PCK FISH SEA	DEEP CREEK CUSTOM PACKIN	S: KASILOF COHO SHORE	COOK INLET KASILOF
AKG520486	SEAFOODAQUACULTURE	FRE OR FROZ PCK FISH SEA	INLET FISH PRODUCERS INC	S: KASILOF K-BEACH PLA	COOK INLET KENAI RI
AKG520487	SEAFOODAQUACULTURE	FRE OR FROZ PCK FISH SEA	INLET FISH PRODUCERS INC	S: KASILOF RIVER PLANT	COOK INLET KASILOF
AKG520492	SEAFOODAQUACULTURE	FRE OR FROZ PCK FISH SEA	KASILOF RIVERSIDE PROPER	S: KASILOF FACILITY	COOK INLET KASILOF
AKG520540	SEAFOODAQUACULTURE	CANNED & CURED FISH & SEA	DEEP CREEK CUSTOM PACKIN	S: DEEP CREEK CUSTOM P	COOK INLET
AK0021245	WASTEWATER	SEWERAGE SYSTEMS	HOMER CITY OF	WASTEWATER TREATMENT P	KACHEMAK BAY - COOK
AK0021377	WASTEWATER	SEWERAGE SYSTEMS	KENAI CITY OF	WASTEWATER TREATMENT P	COOK INLET
AK0022551	WASTEWATER	SEWERAGE SYSTEMS	ANCHORAGE MUNICIPALITY	JOHN M. ASPLUND WPCF--	KNIK ARM OF COOK INL

Table 1. Subset of Facilities with Cook Inlet as Receiving Water from EPA "PCS_ADEC_Loc" Spreadsheet (does not include Girdwood Wastewater Treatment Facility)

Appendix B. Effluent contaminant exceedance of Water Quality Standard due to mixing zones in a subset of facilities

Number of times WQC potentially exceeded in mixing zone

Acute WQC

Parameter	Trading Bay	Platform Anna	Granite Point	East Foreland	Platform Bruce	Tyonek A	Platform Baker	Platform Dillon	Asplund WWT	Kenai WWT	Girdwood WWT
Ammonia	4 - 71	17 - 155	6 - 60	0 - 11	7 - 107	2 - 11	10 - 143	0	180		
Arsenic	1 - 25	0 - 10	<1 - 21	4 - 12	<1 - 16	9 - 37	<1 - 17		135		
Cadmium	0	0	0 - <1	0 - 3	0	0 - <1	0 - <1	0	141		
Chromium	<1	0 - 2.78	0 - 3	0 - 11	0 - 2	0	0 - <1		140		
Copper	12 - 55	8 - 20	13 - 35	7 - 24	2 - 385	73 - 278	0 - 117	<1 - 2	101		
Lead	23 - 60	0 - 1	3 - 9	13 - 48	0 - 1	5 - 21	0 - <1	5	140		
Mercury	<1	0 - 3	<1 - 3	0 - <1	0 - 3	0	0	0 - <1	108		
Nickel	13 - 182	0 - 438	<1 - 24	0 - 36	0 - 4	9 - 180	2 - 108	16	118		
Selenium	3 - 50	<1 - 17	<1 - 17	3 - 55	<1 - 13	0 - 3	<1 - 18		142		
TAH	1639 - 1969	10899 - 12399*	1400 - 2020	2129 - 2556	6549 - 9169	8 - 14046	1186 - 15667	2821 - 3099	180.00		
TAqH	1141 - 1369	8283 - 11597	587 - 7756	1067 - 1737	557 - 7364	67 - 175586	794 - 10494	1908 - 2259	180.00		
Zinc	0 - 9	95 - 662	2 - 36	0 - 36	237 - 547	0 - 97	77 - 166	13 - 15	138		
Chronic WQS											
Ammonia	0 - 10	1 - 33	0 - 9	0 - 2	<1 - 15	0 - <1	<1 - 20	0		3.7	0.9
Arsenic	<1 - 13	0 - 4	0 - 11	2 - 6	0 - 8	4 - 19	0 - 8			0	0
Cadmium	0	0	0 - <1	0 - <1	0	0	0	0		0	NA
Chromium	0	0	0 - <1	0 - <1	0	0	0			NA	NA
Copper	7 - 17*	5 - 13	8 - 22	4 - 16	<1 - 246	46 - 178	0 - 74	<1 - 1		6.4	4.9 - 8.4
Lead	0 - 1	0	0 - <1	0 - 2	0	0	0	0		0	0
Mercury	0	0 - 1	0 - 2	0 - <1	0 - 1	0	0	0		NA	NA
Nickel	<1 - 19	0 - 48	0 - 3	0 - 4	0	<1 - 19	0 - 11	<1		0	0
Selenium	0 - 12	0 - 3	0 - 4	<1 - 13	0 - 2	0	0 - 4			NA	NA
Silver	0 - 9	0 - 298	0 - 16	20 - 22*	1 - 4	0 - 88	74	11		NA	NA
Zinc	0 - 8	86 - 598	1 - 16*	0 - 33	214 - 495	0 - 87	69 - 150	12 - 23		1	0

*Excludes the Projected Maximum (Maximum Predicted Effluent Concentration)

NA = not available

Table 1. Number of times WQS potentially exceeded in mixing zones by facility and parameter.

Parameter	Chronic Water Quality Criteria (microgm/l)[1]	Trading Bay: Effluent Concentration (microgm/l) MEC [1,2]	PM [1,3]	AML [1,4,5,6]	Number of times WQC exceeded[7]: MEC	PM	AML
Ammonia	2200	12,000	158400	106000	4.45	71.00	47.18
Arsenic	36	71.6	945		0.99	25.25	
Cadmium	8.8	0.6	2.7		0	0.00	
Chromium	50	6.1	80.52		0	0.61	
Copper	3.7	103	206	47	26.84	55	11.70
Lead	8.5	200	520		22.53	60	
Mercury	0.94	0.35	0.945	0.6	0	0.01	
Nickel	8.3	115	1518	1000	12.86	181.89	119.48
Selenium	71	276	3643		2.89	50	
TAH	10[1,5]	16,400	19704	18000	1,639.00	1,969.40	1,799.00
TAqH	15	17,126	20551	19700	1,140.73	1,369.07	1,312.33
Zinc	86	6.9	91	900	0	0.06	9

Parameter	Acute Water Quality Criteria (microgm/l)[1]	Effluent Concentration (microgm/l) MEC [1,2]	PM [1,3]	AML [1,4,5,6]	Number of times WQC exceeded[7]: MEC	PM	AML
Ammonia	15000	12,000	158400	106000	0	9.56	6.07
Arsenic	69	71.6	945		0.04	12.70	
Cadmium	40	0.6	2.7		0	0	
Chromium	1079	6.1	80.5		0	0	
Copper	5.78	103	206	47	16.82	34.64	7.13
Lead	217	200	520		0	1.40	
Mercury	1.8	0.35	0.945	0.6	0	0	0
Nickel	75	115	1518	1000	0.53	19.24	12.33
Selenium	290	276	3643		0	11.56	
Silver	2.3	1.44	19	23	0	7.26	9.00
Zinc	95.1	6.9	91	900	-1	0	8.46

[1] EPA 2007c

[2] MEC = Measured Maximum Effluent Concentration (microgram/liter)

[3] PM = Projected Maximum or Maximum Predicted Effluent Concentration (microgram/liter)

[4] AML = Average Monthly Effluent Limitation (microgram/liter)

[5] Average Monthly Limitation

Table 2. Trading Bay WQS exceedance due to mixing zone by parameter.

Parameter	Chronic Water Quality Criteria (microgm/l)[1]	Platform Anna Effluent Concentration (microgm/l) MEC [1,2]	PM [1,3]	AML [1,4,5,6]	Number of times WQC exceeded[7] MEC	PM	AML
Ammonia	2200	39,000	514,800	343,000	16.73	233.00	154.91
Arsenic	36	29	378		0	10	
Cadmium	8.8	0.5	2		0	0	
Chromium	50	14	189		0	2.78	
Copper	3.7	33	79	53	7.92	20.35	13.32
Lead	8.5	1.54	20		0	1.35	
Mercury	0.94	1.69	3.8	3.8	0	3.04	3.04
Nickel	8.3	3.21	42	3,640	0	4.06	437.55
Selenium	71	96	1,272		0.35	16.92	
TAH	10[1,5]	124,000	173,600	109,000	12399.00	17350.00	10899.00
TAqH	15	124,260	173,964	125,080	8283.00	11596.60	8337.67
Zinc	86	8,260	56,994	22,000	95.05	661.72	254.81

Parameter	Acute Water Quality Criteria (microgm/l)[1]	Effluent Concentration (microgm/l) MEC [1,2]	PM [1,3]	AML [1,4,5,6]	Number of times WQC exceeded[7] MEC	PM	AML
Ammonia	15000	39,000	514,800	343,000	1.60	33.32	21.87
Arsenic	69	29	378		0	4.48	
Cadmium	40	0.5	2		0	0	
Chromium	1079	14	189		0	0	
Copper	5.78	33	79	53	4.71	12.67	8.17
Lead	217	1.54	20		0	0	
Mercury	1.8	1.69	3.8	3.8	0	1.11	1.11
Nickel	75	3.21	42	3,640	0	0	47.53
Selenium	290	96	1,272		0	3.34	
Silver	2.3	0	0	687	0	0	297.70
Zinc	95.1	8,260	56,994	22,000	85.86	598.31	230.34

[1] EPA 2007c

[2] MEC = Measured Maximum Effluent Concentration (microgram/liter)

[3] PM = Projected Maximum or Maximum Predicted Effluent Concentration (microgram/liter)

[4] AML = Average Monthly Effluent Limitation (microgram/liter)

[5] Average Monthly Limitation

[6] EPA Fact Sheet for Cook Inlet General Permit (AKG-31-5000) Re-issuance

[7] Effluent Concentration less Water Quality Criteria

Reasonable Potential to Exceed

Table 3. Platform Anna WQS exceedance due to mixing zone by parameter.

		Granite Point					
		Effluent Concentration (microgm/l)			Number of times WQC exceeded[7]		
Parameter	**Chronic Water Quality Criteria (microgm/l)[1]**	**MEC [1,2]**	**PM [1,3]**	**AML [1,4,5,6]**	**MEC**	**PM**	**AML**
Ammonia	2200	15000	19800	132,000	5.82	9.00	60.00
Arsenic	36	59	774		0.63	21.49	
Cadmium	8.8	1	8		0	0.93	
Chromium	50	12	160		0	3.20	
Copper	3.7	50	130	67	12.51	35.14	18.11
Lead	8.5	32	74		2.76	8.66	
Mercury	0.94	1	3	3.1	0.49	3.28	3.30
Nickel	8.3	13	176	196	0.60	21.20	23.61
Selenium	71	95	1258		0.34	17.72	
TAH	10[1,5]	16840	20208	14,000	1,683.00	2,020.80	1,400.00
TAqH	15	8814	116345		586.60	7,756.33	
Zinc	86	233	3076	1500	1.71	35.77	17.44

		Effluent Concentration (microgm/l)			Number of times WQC exceeded[7]		
Parameter	**Acute Water Quality Criteria (microgm/l)[1]**	**MEC [1,2]**	**PM [1,3]**	**AML [1,4,5,6]**	**MEC**	**PM**	**AML**
Ammonia	15000	15,000	19,800	132,000	0	1.32	8.80
Arsenic	69	59	774		0	11.21	
Cadmium	40	1.1	8.14		0	0.20	
Chromium	1079	12	160		0	0.15	
Copper	5.78	50	130	67	7.65	22.49	11.59
Lead	217	32	74		0	0.34	
Mercury	1.8	1.4	3.08	3.1	0	1.71	1.72
Nickel	75	13.3	176	196	0	2.35	2.61
Selenium	290	95	1,258		0	4.29	
Silver	2.3	2	25	37	0	10.87	16.09
Zinc	95.1	233	3,076	1,500	1.45	32.34	15.77

[1] EPA 2007c

[2] MEC = Measured Maximum Effluent Concentration (microgram/liter)

[3] PM = Projected Maximum or Maximum Predicted Effluent Concentration (microgram/liter)

[4] AML = Average Monthly Effluent Limitation (microgram/liter)

[5] Monthly Average Limitation

Table 4. Granite Point WQS exceedance due to mixing zone by parameter.

Parameter	Chronic Water Quality Criteria (microgm/l)[1]	East Foreland					
		Effluent Concentration (microgm/l)			Number of times WQC exceeded[7]		
		MEC [1,2]	PM [1,3]	AML [1,4,5,6]	MEC	PM	AML
Ammonia	2200	1,790	23,628	16,000	0	10.74	7.27
Arsenic	36	181	434		4.03	12.06	
Cadmium	8.8	2	26		0	2.95	
Chromium	50	40	528		0	10.56	
Copper	3.7	31	90	60	7.38	24.32	16.22
Lead	8.5	120	408		13.12	48.00	
Mercury	0.94	0.46	0.78	0.50	0	0.83	0.53
Nickel	8.3	0	0	301	0	0	36.27
Selenium	71	297	3,920		3.18	55.21	
TAH	10[1,5]	21,300	25,560	24,000	2,129.00	2,556.00	2,400.00
TAqH	15	21,714	26,057	16,000	1,446.60	1,737.13	1,066.67
Zinc	86	80	1,056	3,100	0	12.28	36.05

Parameter	Acute Water Quality Criteria (microgm/l)[1]	Effluent Concentration (microgm/l)			Number of times WQC exceeded[7]		
		MEC [1,2]	PM [1,3]	AML [1,4,5,6]	MEC	PM	AML
Ammonia	15000	1,790	23,628	16,000	0	1.58	1.07
Arsenic	69	181	434		1.62	6.29	
Cadmium	40	2	26		0	0.65	
Chromium	1079	40	528		0	0.49	
Copper	5.78	31	90	60	4.36	15.57	10.38
Lead	217	120	408		0	1.88	
Mercury	1.8	0.46	0.78	0.50	0	0.43	0.28
Nickel	75	0	0	301	0	0	4.01
Selenium	290	297	3,920		0.01	13.38	
Silver	2.3	54	205	46	22.48	89.13	20.00
Zinc	95.1	80	1,056	3,100	0	11.10	32.60

[1] EPA 2007c

[2] MEC = Measured Maximum Effluent Concentration (microgram/liter)

[3] PM = Projected Maximum or Maximum Predicted Effluent Concentration (microgram/liter)

[4] AML = Average Monthly Effluent Limitation (microgram/liter)

[5] Average Monthly Limitation

[6] EPA Fact Sheet for Cook Inlet General Permit (AKG-31-5000) Re-issuance

[7] Effluent Concentration less Water Quality Criteria

Reasonable Potential to Exceed

Table 5. East Foreland WQS exceedance due to mixing zone by parameter.

Platform Bruce

Parameter	Chronic Water Quality Criteria (microgm/l)[1]	Effluent Concentration (microgm/l) MEC [1,2]	PM [1,3]	AML [1,4,5,6]	Number of times WQC exceeded[7] MEC	PM	AML
Ammonia	2200	18,000	237,600	158,000	7.18	107.00	70.82
Arsenic	36	46	606		0.28	15.83	
Cadmium	8.8	1	7		0	0	
Chromium	50	11	147		0	1.94	
Copper	3.7	9	123	1,429	1.51	32.24	385.22
Lead	8.5	1.55	20		0	1.35	
Mercury	0.94	0.8	3.6	4	0	2.83	2.94
Nickel	8.3	3	40	3	0	3.82	
Selenium	71	75	997		0.06	13.04	
TAH	10[1,5]	65,500	91,700	78,000	6,549.00	9,169.00	7,799.00
TAqH	15	8,369	110,471	91,700	556.93	7,363.73	6,112.33
Zinc	86	20,500	47,150	28,000	237.37	547.26	324.58

Parameter	Chronic Water Quality Criteria (microgm/l)[1]	Effluent Concentration (microgm/l) MEC [1,2]	PM [1,3]	AML [1,4,5,6]	Number of times WQC exceeded[7] MEC	PM	AML
Ammonia	15000	18,000	237,600	158,000	0.20	14.84	9.53
Arsenic	69	46	606		0	7.78	
Cadmium	40	1	7		0	0	
Chromium	1079	11	147		0	0	
Copper	5.78	9	123	1,429	0.61	20.28	246.23
Lead	217	1.55	20		0	0	
Mercury	1.8	0.8	3.6	4	0	1.00	1.06
Nickel	75	3	40	3	0	0	
Selenium	293	75	997		0	2.40	
Silver	2.3	5	11	7	1.17	3.78	2.17
Zinc	95.1	20,500	47,150	28,000	214.56	494.79	293.43

[1] EPA 2007c

[2] MEC = Measured Maximum Effluent Concentration (microgram/liter)

[3] PM = Projected Maximum or Maximum Predicted Effluent Concentration (microgram/liter)

[4] AML = Average Monthly Effluent Limitation (microgram/liter)

[5] Average Monthly Limitation

[6] EPA Fact Sheet for Cook Inlet General Permit (AKG-31-5000) Re-issuance

[7] Effluent Concentration less Water Quality Criteria

Reasonable Potential to Exceed

Table 6. Platform Bruce WQS exceedance due to mixing zone by parameter.

Parameter	Chronic Water Quality Criteria (microgm/l)[1]	Tyonek A: Effluent Concentration (microgm/l)			Tyonek A: Number of times WQC exceeded[7]		
		MEC [1,2]	PM [1,3]	AML [1,4,5,6]	MEC	PM	AML
Ammonia	2200	6,100	25,620	16,100	1.77	10.65	6.32
Arsenic	36	372	1,376		9.33	37.22	
Cadmium	8.8	1	13		0	0.48	
Chromium	50	4	47		0	0	
Copper	3.7	272	1,034	328	72.51	278.46	87.65
Lead	8.5	50	185		4.88	20.76	
Mercury	0.94	0	0	0.05	0	0	0
Nickel	8.3	80	1,056	1,500	8.64	126.23	179.72
Selenium	71	20	264		0	2.72	
TAH	10[1,5]	63,850	140,470	90	6384.00	14046.00	8.00
TAqH	15	1,013	2,633,800	1,750	66.53	175585.67	115.67
Zinc	86	5	66	8,400	0	0	96.67

Parameter	Acute Water Quality Criteria (microgm/l)[1]	Effluent Concentration (microgm/l)			Number of times WQC exceeded[7]		
		MEC [1,2]	PM [1,3]	AML [1,4,5,6]	MEC	PM	AML
Ammonia	15000	6,100	25,620	16,100	0	0.71	0.07
Arsenic	69	372	1,376		4.39	18.94	
Cadmium	40	1	13		0	0	
Chromium	1079	4	47		0	0	
Copper	5.78	272	1,034	328	46.06	177.89	55.75
Lead	217	50	185		0	0	
Mercury	1.8	0	0	0.05	0	0	0
Nickel	75	80	1,056	1,500	0.07	13.08	19.00
Selenium	293	20	264		0	0	
Silver	2.3	0	0	205	0	0	88.13
Zinc	95.1	5	66	8,400	0	0	87.33

[1] EPA 2007c

[2] MEC = Measured Maximum Effluent Concentration (microgram/liter)

[3] PM = Projected Maximum or Maximum Predicted Effluent Concentration (microgram/liter)

[4] AML = Average Monthly Effluent Limitation (microgram/liter)

[5] Average Monthly Limitation

[6] EPA Fact Sheet for Cook Inlet General Permit (AKG-31-5000) Re-issuance

[7] Effluent Concentration less Water Quality Criteria

Reasonable Potential to Exceed

Table 7. Tyonek A WQS exceedance due to mixing zone by parameter.

Platform Baker

Parameter	Chronic Water Quality Criteria (microgm/l)[1]	Effluent Concentration (microgm/l)			Number of times WQC exceeded[7]		
		MEC [1,2]	PM [1,3]	AML[1,4,5,6]	MEC	PM	AML
Ammonia	2200	24,000	316,800	211,000	9.91	143.00	94.91
Arsenic	36	48	635		0.33	16.64	
Cadmium	8.8	1.4	12		0	0.36	
Chromium	50	4.7	62		0	0.24	
Copper	3.7	2.02	27	435	0	6.30	116.57
Lead	8.5	0.979	13		0	0.53	
Mercury	0.94	0.23	0.391	0.30	0	0	0
Nickel	8.3	26.7	352	907	2.22	41.41	108.28
Selenium	71	103	1,360		0.45	18.15	
TAH	10[1,5]	11870	156,684	128000	1186.00	15667.40	12799.00
TAqH	15	11926	157,423	150700	794.07	10493.87	10045.67
Zinc	86	8000	14,400	6700	92.02	166.44	76.91

Parameter	Acute Water Quality Criteria (microgm/l)[1]	Effluent Concentration (microgm/l)			Number of times WQC exceeded[7]		
		MEC [1,2]	PM [1,3]	AML[1,4,5,6]	MEC	PM	AML
Ammonia	15000	24,000	316,800	211,000	0.60	20.12	13.07
Arsenic	69	48	635		0	8.20	
Cadmium	40	1.4	12		0	0	
Chromium	1079	4.7	62		0	0	
Copper	5.78	2.02	27	435	0	3.67	74.26
Lead	217	0.979	13		0	0	
Mercury	1.8	0.23	0.391	0.30	0	0	0
Nickel	75	26.7	352	907	0	3.69	11.09
Selenium	293	103	1,360		0	3.64	
Silver	2.3			173			74.22
Zinc	95.1	8000	14,400	6700	83.12	150.42	69.45

[1] EPA 2007c

[2] MEC = Measured Maximum Effluent Concentration (microgram/liter)

[3] PM = Projected Maximum or Maximum Predicted Effluent Concentration (microgram/liter)

[4] AML = Average Monthly Effluent Limitation (microgram/liter)

[5] Average Monthly Limitation

[6] EPA Fact Sheet for Cook Inlet General Permit (AKG-31-5000) Re-issuance

[7] Effluent Concentration less Water Quality Criteria

Reasonable Potential to Exceed

Table 8. Platform Baker WQS exceedance due to mixing zone by parameter.

		Platform Dillon					
		Effluent Concentration (microgm/l)			Number of times WQC exceeded[7]		
Parameter	**Chronic Water Quality Criteria (microgm/l)[1]**	**MEC [1,2]**	**PM [1,3]**	**AML [1,4,5,6]**	**MEC**	**PM**	**AML**
Ammonia	2200			1460			0
Arsenic	36						
Cadmium	8.8	2.1			0		
Chromium	50						
Copper	3.7	5.6		9.3	0.51		1.51
Lead	8.5	50			4.88		
Mercury	0.94	0.4		1.2	0		0.28
Nickel	8.3			140			15.87
Selenium	71						
TAH	10[1,5]	28220		31000	2821.00		3099.00
TAqH	15	28647		33900	1908.80		2259.00
Zinc	86	1400		1200	15.28		12.95

		Effluent Concentration (microgm/l)			Number of times WQC exceeded[7]		
Parameter	**Acute Water Quality Criteria (microgm/l)[1]**	**MEC [1,2]**	**PM [1,3]**	**AML [1,4,5,6]**	**MEC**	**PM**	**AML**
Ammonia	15000			1460			0
Arsenic	69						
Cadmium	40	2.1	17		0	0	
Chromium	1079						
Copper	5.78	5.6	14	9.3	0	1.42	0.61
Lead	217	50	170		0	0	
Mercury	1.8	0.4	1.28	1.2	0	0	0
Nickel	75			140			0.87
Selenium	293						
Silver	2.3			28			11.17
Zinc	95.1	1400	2240	1200	13.72	22.55	11.62

[1] EPA 2007c

[2] MEC = Measured Maximum Effluent Concentration (microgram/liter)

[3] PM = Projected Maximum or Maximum Predicted Effluent Concentration (microgram/liter)

[4] AML = Average Monthly Effluent Limitation (microgram/liter)

[5] Average Monthly Limitation

[6] EPA Fact Sheet for Cook Inlet General Permit (AKG-31-5000) Re-issuance

[7] Effluent Concentration less Water Quality Criteria

Reasonable Potential to Exceed

Table 9. Platform Dillon WQS exceedance due to mixing zone by parameter.

Asplund

Parameter	Water Quality Standard (microgm/l)[1]	MAEC[2]	Effl - WQC	No. of times WQC Exceeded
Ammonia	9800	1,774,000	1,764,200	180
Antimony	146	20,607	20,461	140
Arsenic	36	4,882	4,846	135
Beryllium	11	1,513	1,502	137
Cadmium	8.8	1,250	1,241	141
Chromium	50	7,038	6,988	140
Copper	3.1	317	314	101
Lead	8.1	1,140	1,132	140
Mercury	0.025	3	3	108
Nickel	8.2	978	970	118
Selenium	71	10,136	10,065	142
Silver	1.9	257	255	134
Thallium	2130	306,567	304,437	143
Zinc	81	11,249	11,168	138
Cyanide	1	181	180	180
TAH	10	1,810	1,800	180
TAqH	15	2,715	2,700	180

Kenai

Parameter	Chronic Water Quality Criteria (microgm/l)[1]	MEC[2]	AML[3]	Effl - WQC	No. of times WQC Exceeded
Ammonia	820	3,830		3,010	3.7
Arsenic	36	29		0	0
Cadmium	8.8	1		0	0
Copper	3.1	23		20	6.4
Lead	8.1	0.373		0	0
Nickel	74	2.45		0	0
Zinc	81	123		42	1
Total Residual Chlorine	7.5		23	16	2.1

Girdwood

Parameter	Chronic Water Quality Criteria (microgm/l)[1]	MEC[2]	AML[3]	MEC - WQC	AML - WQC	No. of times WQC Exceeded
Ammonia	1430	10400		8970		0.9
Arsenic	50	3		-47		0
Copper[5,6]	3.4	20	42000000	16.6		4.9
Lead	0.5	2		1.5		0
Nickel	31	20		-11		0
Silver	7.2	0.2		-7		
Zinc	47	30		0		0

[1] EPA 2000b

[2] MEC = Measured Maximum Effluent Concentration (microgram/liter)

[3] Average Monthly Limitation (micrograms/liter) or highest allowable average of daily discharges over a calendar month

[5] Average Monthly Limitation = 42 g/l or .21 lbs/day

[6] EPA 2000c

Reasonable Potential to Exceed

Table 10. Asplund, Kenai and Girdwood WWT WQS exceedance due to mixing zone by parameter.

Appendix C. Mass of effluent contaminants added annually due to mixing zones

Annual Mixing Zone Addition to Contaminant Load (Pounds)

Facility	Ammonia	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	TAH	TAqH	Zinc
Granite Point	75,341	13	0	0	37	14	0	3	33	9,769	5,107	85
Trading Bay	2,619,549	898	0	0	1,093	4,833	0	2,693	32,313	413,626	431,822	0
E. Foreland	34,826	366	0	0	142	281	0	0	0	53,729	54,761	0
Tyonek A	1,297	31	0	0	30	4	0	7	80	5,958	93	0
Anna	86,006	0	0	0	12	0	0	0	0	31,291	31,355	2,063
Baker	28,229	2	0	0	58	0	0	2	30	1,603	1,610	1,070
Bruce	11,796	1	0	0	108	0	0	0	0	4,958	632	1,546
Dillon	0	NA	0	NA	3	24	0	77	NA	16,400	16,645	764
	2,857,044	1,311	0	0	1,484	5,156	0	2,781	32,456	537,334	542,026	5,528
Asplund	307,415,459	844,425	10,133,105	46,525		197,236	518	168,990	1,753,847	313,654	470,481	1,946,047
Girdwood	16,169	0	NA	NA		0	NA	0	NA	NA	NA	NA
Kenai	12,027	0	0	NA		0	NA	0	NA	NA	NA	168
	307,443,656	844,425	216,282	46,525		197,236	518	168,990	1,753,847	313,654	470,481	1,946,215
AK Nitrogen	604,538	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total	310,975,585	845,737	216,282	46,525	1,484	202,392	518	171,771	1,786,303	850,988	1,012,506	1,951,742

Table 1. Mass of effluent contaminants (in pounds) added annually due to mixing zones by contaminant and facility.

Ammonia

Facility	Liters per Month[1]	Effluent Concentration (microgm/l)	Basis	Mixing Zone Concentration = Effluent Concentration - Chronic WQS	Micrograms per month	Pounds per month	Pounds per year
Granite Point	21,940,247	132000	AML	129800	2,847,844,033,705	6,278	75,341
Trading Bay	953,923,774	106000	AML	103800	99,017,287,699,680	218,296	2,619,549
E. Foreland	95,392,377	16000	AML	13800	1,316,414,807,568	2,902	34,826
Tyonek A	3,527,928	16100	AML	13900	49,038,200,442	108	1,297
Anna	9,539,238	343000	AML	340800	3,250,972,220,429	7,167	86,006
Baker	5,110,306	211000	AML	208800	1,067,031,878,184	2,352	28,229
Bruce	2,861,771	158000	AML	155800	445,863,971,781	983	11,796
Dillon	21,974,315	1460	AML	0	0	0	0
							2,857,044
Asplund	6,586,616,532	1,774,000	MAEC	1,764,200	11,620,108,885,754,400	25,617,955	307,415,459
Girdwood	68,137,412	10,400	MEC	8,970	611,192,589,228	1,347	16,169
Kenai	151,037,931	3,830	MEC	3,010	454,624,171,768	1,002	12,027
							307,443,656
AK Nitrogen	177,270,835		MAL			1849 (lbs/day)[2]	604,538
						Total	310,905,238

[1] Based on Maximum Projected Discharge Rate

1 gallon = 3.7854118 liters

1 pound = 453592370 micrograms

[2] Based on MAL

Table 2. Mass of ammonia (in pounds) added annually due to mixing zones by facility.

Arsenic

Facility	Liters per Month[1]	Effluent Concentration (microgm/l)	Basis	Mixing Zone Concentration = Effluent Concentration - Chronic WQS	Micrograms per month	Pounds per month	Pounds per year
Granite Point	21,940,247	59	MEC	23	504,625,676	1	13
Trading Bay	953,923,774	71.6	MEC	35.6	33,959,686,340	75	898
E. Foreland	95,392,377	181	MEC	145	13,831,894,717	30	366
Tyonek A	3,527,928	372	MEC	336	1,185,383,838	3	31
Anna	9,539,238	29	MEC	0	0	0	0
Baker	5,110,306	48	MEC	12	61,323,671	0	2
Bruce	2,861,771	46	MEC	10	28,617,713	0	1
Dillon	21,974,315	NA	MEC				
							1,311
Asplund	6,586,616,532	4,882	MAEC	4,846	31,918,743,714,072	70,369	844,425
Girdwood	68,137,412	0	MEC	0	0	0	0
Kenai	151,037,931	0	MEC	0	0	0	0
							844,425
						Total	845,737

[1] Based on Maximum Projected Discharge Rate

1 gallon = 3.7854118 liters

1 pound = 453592370 micrograms

Table 3. Mass of arsenic (in pounds) added annually due to mixing zones by facility.

Cadmium

Facility	Liters per Month[1]	Effluent Concentration (microgm/l)	Basis	Mixing Zone Concentration = Effluent Concentration - Chronic WQS	Micrograms per month	Pounds per month	Pounds per year
Granite Point	21,940,247	1	MEC	-7.8	0	0	0
Trading Bay	953,923,774	0.6	MEC	-3.1	0	0	0
E. Foreland	95,392,377	2	MEC	-1.7	0	0	0
Tyonek A	3,527,928	1	MEC	-2.7	0	0	0
Anna	9,539,238	0.5	MEC	-3.2	0	0	0
Baker	5,110,306	1.4	MEC	-2.3	0	0	0
Bruce	2,861,771	1	MEC	-2.7	0	0	0
Dillon	21,974,315	2.1	MEC	-1.6	0	0	0
							0
Asplund	6,586,616,532	1,250	MAEC	1,241	8,175,308,439,518	18,023	216,282
Girdwood	68,137,412	NA	NA	NA	NA	NA	NA
Kenai	151,037,931	1	MEC	0	0	0	0
							216,282
						Total	216,282

[1] Based on Maximum Projected Discharge Rate

1 gallon = 3.7854118 liters

1 pound = 453592370 micrograms

Table 4. Mass of cadmium (in pounds) added annually due to mixing zones by facility.

Chromium

Facility	Liters per Month[1]	Effluent Concentration (microgm/l)	Basis	Mixing Zone Concentration = Effluent Concentration - Chronic WQS	Micrograms per month	Pounds per month	Pounds per year
Granite Point	21,940,247	50	MEC	0	0	0	0
Trading Bay	953,923,774	6.1	MEC	-43.9	0	0	0
E. Foreland	95,392,377	40	MEC	-10	0	0	0
Tyonek A	3,527,928	4	MEC	-46	1	0	0
Anna	9,539,238	14	MEC	-36	0	0	0
Baker	5,110,306	4.7	MEC	-45.3	2	0	0
Bruce	2,861,771	11	MEC	-39	0	0	0
Dillon	21,974,315	NA	NA	NA	NA	NA	
							0
Asplund	6,586,616,532	317	MAEC	267	1,758,626,614,044	3,877	46,525
Girdwood	68,137,412	NA	NA	NA	NA	NA	NA
Kenai	151,037,931	NA	NA	NA	NA	NA	NA
							46,525
						Total	46,525

[1] Based on Maximum Projected Discharge Rate

1 gallon = 3.7854118 liters
1 pound = 453592370
micrograms

Table 5. Mass of chromium (in pounds) added annually due to mixing zones by facility.

Lead

Facility	Liters per Month[1]	Effluent Concentration (microgm/l)	Basis	Mixing Zone Concentration = Effluent Concentration - Chronic WQS	Micrograms per month	Pounds per month	Pounds per year
Granite Point	21,940,247	32	MEC	23.5	515,595,800	1	14
Trading Bay	953,923,774	200	MEC	191.5	182,676,402,644	403	4,833
E. Foreland	95,392,377	120	MEC	111.5	10,636,250,076	23	281
Tyonek A	3,527,928	50	MEC	41.5	146,409,016	0	4
Anna	9,539,238	1.54	MEC	0	0	0	0
Baker	5,110,306	0.979	MEC	0	0	0	0
Bruce	2,861,771	1.55	MEC	0	0	0	0
Dillon	21,974,315	50	MEC	41.5	911,934,093	2	24
							5,156

[1] Based on Maximum Projected Discharge Rate

1 gallon = 3.7854118 liters
1 pound = 453592370 micrograms

Asplund	6,586,616,532	1140	MAEC	1131.9	7,455,391,252,571	16,436	197,236
Girdwood	68,137,412	2	MEC	0	0	0	0
Kenai	151,037,931	0.373	MEC	0	0	0	0
							197,236
						Total	202,392

Table 6. Mass of lead (in pounds) added annually due to mixing zones by facility.

Mercury

Facility	Liters per Month[1]	Effluent Concentration (microgm/l)	Basis	Mixing Zone Concentration = Effluent Concentration - Chronic WQS	Micrograms per month	Pounds per month	Pounds per year
Granite Point	21,940,247	1	MEC	0.06	1,316,415	0	0.03
Trading Bay	953,923,774	0.35	MEC	0	0	0	0
E. Foreland	95,392,377	0.46	MEC	0	0	0	0
Tyonek A	3,527,928	0	MEC	0	0	0	0
Anna	9,539,238	1.69	MEC	0.75	7,154,428	0.02	0.19
Baker	5,110,306	0.23	MEC	0	0	0	0
Bruce	2,861,771	0.8	MEC	0	0	0	0
Dillon	21,974,315	0.4	MEC	0	0	0	0
							0.22

[1] Based on Maximum Projected Discharge Rate

1 gallon = 3.7854118 liters
1 pound = 453592370
micrograms

Asplund	6,586,616,532	3	MAEC	2.975	19,595,184,183	43	518
Girdwood	68,137,412	NA	NA	NA	NA	NA	NA
Kenai	151,037,931	NA	NA	NA	NA	NA	NA
							518
						Total	518

Table 7. Mass of mercury (in pounds) added annually due to mixing zones by facility.

Nickel

Facility	Liters per Month[1]	Effluent Concentration (microgm/l)	Basis	Mixing Zone Concentration = Effluent Concentration – Chronic WQS	Micrograms per month	Pounds per month	Po[illegible] per[illegible]
Granite Point	21,940,247	13	MEC	4.7	103,119,160	0	
Trading Bay	953,923,774	115	MEC	106.7	101,783,666,643	224	2,[illegible]
E. Foreland	95,392,377	0	MEC	-8.3	0	0	
Tyonek A	3,527,928	80	MEC	71.7	252,952,444	1	
Anna	9,539,238	3.21	MEC	-5.09	0	0	
Baker	5,110,306	26.7	MEC	18.4	94,029,629	0	
Bruce	2,861,771	3	MEC	-5.3	0	0	
Dillon	21,974,315	140	AML	131.7	2,894,017,351	6	[illegible]
							2,[illegible]
Asplund	6,586,616,532	978	MAEC	969.8	6,387,700,712,734	14,082	168[illegible]
Girdwood	68,137,412	20	MEC	-11	0	0	
Kenai	151,037,931	2.45	MEC	-71.55	0	0	
							168[illegible]
						Total	171[illegible]

[1] Based on Maximum Projected Discharge Rate

1 gallon = 3.7854118 liters

1 pound = 453592370 micrograms

Table 8. Mass of nickel (in pounds) added annually due to mixing zones by facility.

Selenium

Facility	Liters per Month[1]	Effluent Concentration (microgm/l)	Basis	Mixing Zone Concentration = Effluent Concentration - Chronic WQS	Micrograms per month	Pounds per month	Pounds per year
Granite Point	21,940,247	95	MEC	24	526,565,923	1	14
Trading Bay	953,923,774	276	MEC	205	195,554,373,588	431	5,173
E. Foreland	95,392,377	297	MEC	226	21,558,677,283	48	570
Tyonek A	3,527,928	20	MEC	0	0	0	0
Anna	9,539,238	96	MEC	25	238,480,943	1	6
Baker	5,110,306	103	MEC	32	163,529,790	0	4
Bruce	2,861,771	75	MEC	4	11,447,085	0	0
Dillon	21,974,315	NA	NA	NA	NA	NA	
							5,769

[1] Based on Maximum Projected Discharge Rate

1 gallon = 3.7854118 liters

1 pound = 453592370 micrograms

Asplund	6,586,616,532	10,136	MAEC	10,065	66,294,295,394,580	146,154	1,753,847
Girdwood	68,137,412	NA	NA	NA	NA	NA	NA
Kenai	151,037,931	NA	NA	NA	NA	NA	NA
							1,753,847
						Total	1,759,616

Table 9. Mass of selenium (in pounds) added annually due to mixing zones by facility.

TAH

Facility	Liters per Month[1]	Effluent Concentration (microgm/l)	Basis	Mixing Zone Concentration = Effluent Concentration - Chronic WQS	Micrograms per month	Pounds per month	Pounds per year
Granite Point	21,940,247	16840	MEC	16830	369,254,353,523	814	9,769
Trading Bay	953,923,774	16400	MEC	16390	15,634,810,649,304	34,469	413,626
E. Foreland	95,392,377	21300	MEC	21290	2,030,903,713,994	4,477	53,729
Tyonek A	3,527,928	63850	MEC	63840	225,222,929,225	497	5,958
Anna	9,539,238	124000	MEC	123990	1,182,770,086,887	2,608	31,291
Baker	5,110,306	11870	MEC	11860	60,608,228,330	134	1,603
Bruce	2,861,771	65500	MEC	65490	187,417,403,799	413	4,958
Dillon	21,974,315	28220	MEC	28210	619,895,440,227	1,367	16,400
							537,334

[1] Based on Maximum Projected Discharge Rate

1 gallon = 3.7854118 liters

1 pound = 453592370 micrograms

Asplund	6,586,616,532	1,810	MAEC	1,800	11,855,909,757,600	26,138	313,654
Girdwood	68,137,412	NA	NA	NA	NA	NA	NA
Kenai	151,037,931	NA	NA	NA	NA	NA	NA
							313,654
						Total	850,988

Table 10. Mass of TAH (in pounds) added annually due to mixing zones by facility.

TAqH

Facility	Liters per Month[1]	Effluent Concentration (microgm/l)	Basis	Mixing Zone Concentration = Effluent Concentration - Chronic WQS	Micrograms per month	Pounds per month	Pounds per year
Granite Point	21,940,247	8814	MEC	8799	193,052,231,530	426	5,107
Trading Bay	953,923,774	17126	MEC	17111	- 16,322,589,690,070	35,985	431,822
E. Foreland	95,392,377	21714	MEC	21699	2,069,919,196,335	4,563	54,761
Tyonek A	3,527,928	1013	MEC	998	3,520,872,233	8	93
Anna	9,539,238	124260	MEC	124245	1,185,202,592,509	2,613	31,355
Baker	5,110,306	11926	MEC	11911	60,868,853,932	134	1,610
Bruce	2,861,771	8369	MEC	8354	23,907,237,614	53	632
Dillon	21,974,315	28647	AML	28632	629,168,601,367	1,387	16,645
							542,026

[1] Based on Maximum Projected Discharge Rate

1 gallon = 3.7854118 liters

1 pound = 453592370 micrograms

Asplund	= 6,586,616,532	2,715	MAEC	2,700	17,783,864,636,400	39,207	470,481
Girdwood	68,137,412	NA	NA	NA	NA	NA	NA
Kenai	151,037,931	NA	NA	NA	NA	NA	NA
							470,481
						Total	1,012,506
							313,654
						Total	850,988

Table 11. Mass of TAqH (in pounds) added annually due to mixing zones by facility.

Zinc

Facility	Liters per Month[1]	Effluent Concentration (microgm/l)	Basis	Mixing Zone Concentration = Effluent Concentration - Chronic WQS	Micrograms per month	Pounds per month	Pounds per year
Granite Point	21,940,247	233	MEC	147	3,225,216,279	7	85
Trading Bay	953,923,774	6.9	MEC	0	0	0	0
E. Foreland	95,392,377	80	MEC	0	0	0	0
Tyonek A	3,527,928	5	MEC	0	0	0	0
Anna	9,539,238	8260	MEC	8174	77,973,729,254	172	2,063
Baker	5,110,306	8000	MEC	7914	40,442,961,130	89	1,070
Bruce	2,861,771	20500	MEC	20414	58,420,199,743	129	1,546
Dillon	21,974,315	1400	MEC	1314	28,874,250,566	64	764
							5,528

[1] Based on Maximum Projected Discharge Rate

1 gallon = 3.7854118 liters
1 pound = 453592370 micrograms

Asplund	6,586,616,532	11,249	MAEC	11,168	73,559,333,429,376	162,171	1,946,047
Girdwood	68,137,412	NA	NA	NA	NA	NA	NA
Kenai	151,037,931	123	MEC	42	6,343,593,094	14	168
							1,946,215
						Total	1,951,742

Table 12. Mass of zinc (in pounds) added annually due to mixing zones by facility.

Copper

Facility	Liters per Month[1]	Effluent Concentration (microgm/l)	Basis	Mixing Zone Concentration = Effluent Concentration - Chronic WQS	Micrograms per month	Pounds per month	Pounds per year
Granite Point	21,940,247	67	AML	63.3	1,388,817,622	3	37
Trading Bay	953,923,774	47	AML	43.3	41,304,899,397	91	1,093
E. Foreland	95,392,377	60	AML	56.3	5,370,590,845	12	142
Tyonek A	3,527,928	328	AML	324.3	1,144,107,079	3	30
Anna	9,539,238	53	AML	49.3	470,284,420	1	12
Baker	5,110,306	435	AML	431.3	2,204,074,948	5	58
Bruce	2,861,771	1429	AML	1425.3	4,078,882,664	9	108
Dillon	21,974,315	9.3	AML	5.6	123,056,167	0	3
							1,484
Asplund	6,586,616,532	317	MAEC	314	2,067,538,929,395	4,558	54,698
Girdwood	68,137,412	32	AML	29	1,948,729,995	4	52
Kenai	151,037,931	23	MEC	20	3,005,654,823	7	80
							54,829
AK Nitrogen	NA						
						Total	56,313

[1] Based on Maximum Projected Discharge Rate

1 gallon = 3.7854118 liters
1 pound = 453592370 micrograms

Table 13. Mass of copper (in pounds) added annually due to mixing zones by facility

Historical Copper - Asplund WWT (AWWU 2009)

Year	Average Concentration in effluent (µg/l)	Effluent Concentration - WQS (µg/l)	Average flow (mgd)	Gallons per month	Liters per month	Micrograms per month	Pounds per month	Pounds per year
1986 - 2002[1]	150[2]	146.9	40	1,200,000,000	4,542,494,160	667,292,392,104	1,471	299948[3]
2003	88	84.9	28	840,000,000	3,179,745,912	269,960,427,929	595	7,142
2004	83	79.9	29	870,000,000	3,293,308,266	263,135,330,453	580	6,961
2005	90	86.9	28	840,000,000	3,179,745,912	276,319,919,753	609	7,310
2006	84	80.9	28	840,000,000	3,179,745,912	257,241,444,281	567	6,805
2007	63	59.9	28	840,000,000	3,179,745,912	190,466,780,129	420	5,039
2008	66	62.9	29	870,000,000	3,293,308,266	207,149,089,931	457	5,480
								338,686

1 Prior to 2000, data from a single effluent sample collected annually.

2 Based upon maximum value of yearly sample

3 Total 1986-2002

Table 14. Historical copper added to Cook Inlet due to Asplund WWT facility mixing zone.

Appendix D. Copper concentrations in marine mammals

Cetaceans

Common Name	**Species**	**Location**	**Concentration in Liver (mg/kg wet)**	**Source**
Beluga whale	Delphinapterus leucus	Western Arctic	11.3	Wagemann et al. 1996
Beluga whale	Delphinapterus leucus	Eastern Arctic	19.2	Wagemann et al. 1996
Blainville's beaked whale	Mesoplodon desirostris	England, Wales	5.6	Law 2001
Fin whale	Balaenoptera physalus	England, Wales	3.2	Law 2001
Killer whales - adult	Orcinus orca	Japan	11.5	Endo 2007
Killer whales - calves	Orcinus orca	Japan	10.4	Endo 2007
Long-finned pilot whale	Globicephala melas	England, Wales	4.7	Law 2001
Melon-headed whale	Peponocephale electra	Japan	5.94	Endo et al. 2008
Minke whale	Balaenoptera acutorostrata	England, Wales	4.9	Law 2001
Narwhal	Monodon monoceros	Baffin Island, Canada	5.27	Wagemann et al. 1983
Pygmy sperm whale	Kogia breviceps	Argentina	10.3	Marcovecchio et al. 1990
Pygmy sperm whale	Kogia breviceps	England, Wales	9.5	Law 2001
Small cetaceans	Odontoceti, Delphinidae	Japan	10.2	Endo 2002
Sowerby's beaked whale	Mesoplodon bidens	England, Wales	19	Law 2001
Bottlenose dolphin	Tursiops truncatus	South Carolina	10.78	Beck et al. 1997
Bottlenose dolphin	Tursiops truncatus	South Australia	21.18	Lavery 2008
Bottlenose dolphin	Tursiops truncatus	Israel Mediterranean	8.9	Roditi-Elasar et al 2003
Bottlenose dolphin	Tursiops gephyreus	Argentina	77.7	Marcovecchio et al. 1990
Bottlenose dolphin	Tursiops truncatus	British Isles	8.3	Law et al 1991
Common dolphin	Delfinus delphis	England, Wales	9.7	Law 2001
Common dolphin	Delfinus delphis	South Australia	11.35	Lavery 2008
Common dolphins	Delfinus delphis	Portugal	5.73	Zhou 2001
Common porpoise	Phocoena phocoena	British Isles	10 - 59	Law et al 1991
Common porpoise	Phocoena phocoena	Scotland	7.2	Falconer et al. 1983
Franciscana dolphin	Pontoporia blainvillei	Argentina	16	Marcovecchio et al. 1990
Indo-Pacific bottlenose dolphin	Tursiops aduncus	South Australia	19.56	Lavery 2009
Risso's dolphin	Grampus griseus	England, Wales	5.2	Law 2001
Striped dolphin	Stenella coeruleoalba	Italy	7.73	Cardellicchio et al. 2000
Striped dolphin	Stenella coeruleoalba	Japan	8.1	Honda et al 1983
Striped dolphin	Stenella coeruleoalba	British Isles	11	Law et al 1991
Striped dolphin	Stenella coeruleoalba	England, Wales	5.4	Law 2001
Striped dolphin	Stenella coeruleoalba	Israel Mediterranean	9.7	Roditi-Elasar et al 2004
White-beaked dolphin	Lagenorhynchus albirostris	British Isles	6.8	Law et al 1991
White-beaked dolphin	Lagenorhynchus albirostris	England, Wales	7.5	Law 2001
White-sided dolphin	Lagenorhynchus acutus	England, Wales	11	Law 2001

Table 15. Measured copper concentrations (mg/kg wet weight) in cetacean liver tissues

Pinnipeds

Common Name	Species	Location	Concentration in Liver (mg/kg wet)	Source
Bearded Seal	Erignathus barbatus	Alaska	24.65	Quakenbush 2009
Bearded Seal	Erignathus barbatus	Alaska	22.69	Dehn et al. 2005
Grey seal	Halichoerus grypus	British Isles	22	Law et al. 1991
Harbor seal	Phoca vitulina	British Isles	8.1	Law et al. 1991
Harbor seal	Phoca vitulina	Japan	13.1	Tohyama et al. 1986
Ringed Seal	Phoca hispida	Alaska	10.82	Dehn et al. 2005
Ringed Seal	Phoca hispida	Canada	9.25	Dehn et al. 2005
Spotted Seal	Phoca largha	Alaska	10.2	Dehn et al. 2005

Table 16. Measured copper concentrations (mg/kg wet weight) in pinniped liver tissues

Cetaceans and Pinnipeds

Common Name	Species	Location	Concentration in Liver (mg/kg dry)	Source
Common dolphin	Delfinus delphis		7.8 - 29.3	Carvalho et al. 2002
Common dolphin	Delfinus delphis		22	Kannan et al 1993
Bottlenose dolphin	Tursiops truncatus		16 - 25	Carvalho et al. 2002
Bottlenose dolphin	Tursiops truncatus		6.8 - 232	Wood and Van Vleet 1996
Bottlenose dolphin	Tursiops truncatus			Marcovecchio et al. 1990
Bottlenose dolphin	Tursiops truncatus		10.8	Beck et al 1997
Beluga whale	Delphinapterus leucas	Mackenzie Delta, Arctic	50.3	Wagemann et al. 1990
Beluga whale	Delphinapterus leucas	Grise Fiord, Arctic	39.1	Wagemann et al. 1990
Beluga whale	Delphinapterus leucas	Pangnirtung, Arctic	60.7	Wagemann et al. 1990
Beluga whale	Delphinapterus leucas	Eskimo Point, Arctic	117	Wagemann et al. 1990
Beluga whale	Delphinapterus leucas	Nastapoka, Arctic	150	Wagemann et al. 1990
Beluga whale	Delphinapterus leucas	St. Lawrence, Canada	37.3	Wagemann et al. 1990
Ringed Seal	Phoca hispida	Admiralty Inlet, Arctic	64.3	Wagemann et al. 1989
Ringed Seal	Phoca hispida	Pb-Zn Mine, Canada	35.1	Wagemann et al. 1989
Ganges River dolphins	Platanista gangetica	Ganges River, India[1]	180	Kannan et al. 1993
Bottlenose dolphin	Tursiops truncatus	Florida	29	Wood and Van Vleet 1996

[1]Heavily polluted - Kannan et al 1993

Table 17. Measured copper concentrations (mg/kg dry weight) in marine mammal liver tissues