Review of Literature on Fish Species and Beluga Whales in Cook Inlet, Alaska

Final Report

by

LGL Alaska Research Associates, Inc.

For

DRven Corporation
711 H Street, Suite 350
Anchorage, Alaska 99501

March 20, 2006

Review of Literature on Fish Species and Beluga Whales in Cook Inlet, Alaska.

Edited by

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INTRODUCTION

Development of coal deposits on the west side of Cook Inlet in southcentral Alaska would require construction of a marine terminal on the shore of Upper Cook Inlet. The west side of Upper Cook Inlet is relatively shallow near shore, preventing ships from docking along shore to receive cargo. Regular dredging of the nearshore area to increase the depth for ship passage would be expensive and permanently alter sea floor habitat and potentially affect fish, invertebrates, and marine mammals. A lower-impact solution is to construct and operate a pile-supported trestle that would extend far enough out from shore to deliver coal to ships docked in deep water. Such a solution is proposed in the area known as Ladd, approximately 2.5 km (1.5 mi) north of the Village of Tyonek on the west side of Upper Cook Inlet (Figure 1).

Baseline studies of the biological resources near the proposed docking facility will be required to assess the potential impacts of any marine terminal development on local fish and wildlife populations. The structure proposed for Ladd would include a trestle system extending approximately 3,000 m (10,000 ft) from shore, into water 20 m (65 ft) deep. The impacts of this structure on the local environment will be assessed during a supplemental environmental impact statement (EIS). The EIS will draw on other studies, both existing (from the literature) and new (from baseline monitoring designed to provide new information for the EIS).

As a preliminary step in designing baseline studies, LGL Alaska Research Associates, Inc. (LGL) was contracted by DRven Corporation to complete this literature review of marine fish and mammal populations in Upper Cook Inlet. The review summarizes both published (i.e., peer-reviewed) and unpublished (i.e., “grey” literature) work by agencies, universities, and private industry. The review is intended to summarize existing literature and information describing the biological resources potentially affected by the construction and operation of a marine terminal for coal transport. The literature review will be used to develop more detailed documents such as baseline study plans and an environmental impact statement.

The Ladd area

The Ladd site lies near the southern part of a region where several salmon rivers empty into the west side of Cook Inlet (Figure 1). The strong tidal currents in Upper Cook Inlet (Haley et al. 2000) likely move water back and forth among these river mouths, depending on tidal stage. Overall, the prevailing current travels from the Susitna River watershed, south past the Theodore and Beluga rivers before reaching Ladd. From Ladd, the current would generally move south past the Chuit River and into Lower Cook Inlet. For the purposes of this document, the Ladd area will include only the marine environment, which will be defined as all marine and brackish waters from high tide, extending offshore to the middle of Cook Inlet.

At the northern end of Upper Cook Inlet, the deltas of the Susitna and Beluga rivers result in large intertidal areas that extend several km out into Cook Inlet. The shoreline is

Figure 1. Map of Cook Inlet showing major features discussed in the text.

mainly marshland, with few bluffs. By the time the shoreline reaches Ladd, however, there is more topographic relief and the intertidal area has diminished. The water is still relatively shallow near shore, with mud flats exposed at low tide, but depth increases more quickly with distance offshore and relatively even bathymetric contours. At low tide, water depth is approximately 18 m (56 ft) at a distance of 3,226 m (10,000 ft) from shore. This topography and bathymetry continues southward, past the land outcrop known as North Foreland (Figure 2). Nearshore habitat in the Ladd area is thus more similar to the Cook Inlet coastline to the south than to the north.

Fish populations in the northern end of Upper Cook Inlet include forage fish, which are preyed on by seabirds and marine mammals, salmon and trout (*Oncorhynchus* spp.) that return to nearby rivers, and groundfish that reside on or near the ocean floor. The Susitna, Theodore, Beluga, and Chuit rivers all have salmon runs that are important for subsistence, recreational, commercial and/or personal use fisheries. Wildlife populations include seabirds and marine mammals. Beluga whales (*Delphinapterus leucas)* are known to migrate through area, and to feed and probably calve within 100 km (60 mi) of the study area. Other marine mammals that may occur in the area include harbor seal (*Phoca vitulina*), harbor porpoise (*Phocoena phocoena*), killer whale (*Orcincus orca*), and Stellar sea lion (*Eumetopias jubatus*).

PHYSICAL CHARACTERISTICS OF COOK INLET

Cook Inlet is a tidal estuary approximately 350 km (220 miles) in length located in southcentral Alaska. Cook Inlet has a northeast/southwest orientation and is divided into upper and lower portions by the East and West forelands, prominent land outcrops just north of Kenai (Figure 1). Prominent features of Upper Cook Inlet include Knik Arm and Turnagain Arm that enter Cook Inlet at the northeast end, the Susitna River delta at the northern end, and a number of rivers and small streams entering the northwestern side amid mixed topography.

Many of the rivers and streams that enter Upper Cook Inlet are important spawning areas for anadromous fish such as salmon and eulachon. The largest of these is the Susitna River, located on the north shore of Upper Cook Inlet (Figure 1). The Susitna River delta is also an extensive area of tidal marsh important for migrating and nesting waterfowl, and for summer use by beluga whales. Upstream, numerous tributaries to the Susitna River have runs of all five species of Pacific salmon native to Alaska. The remaining portion of Upper Cook Inlet extends for approximately 100 km from the Susitna River delta, south to the East and West forelands (Figure 1). Prominent rivers include the Little Susitna River, the Beluga River, and the McArthur River located on the northern shore of Upper Cook Inlet. Bluffs are a prominent feature along the shore of much of Upper Cook Inlet.

Lower Cook Inlet extends approximately 200 km (125 miles) from the East and West forelands to Cape Douglas on the Alaska Peninsula and Cape Elizabeth on the Kenai Peninsula where it accesses the Gulf of Alaska through the Kennedy and Stevenson entrances, and Shelikof Strait. Kachemak Bay is a large tidal estuary that is a prominent feature located in the southeastern portion of Lower Cook Inlet. The harbor at the city of Homer located near the mouth of Kachemak Bay is an important base for sport and commercial fishing. Several rivers that have significant runs of anadromous fish and are important for sport fishing are located on the east side of Lower Cook Inlet. These rivers are easily accessible by road and include the Kenai, Kasilof, and Anchor rivers and Deep Creek. Prominent rivers on the west side of Lower Cook Inlet include the Tuxedni River although numerous other rivers and streams enter the west side of Lower Cook Inlet. A large tidal marsh is located in the northwest part of Lower Cook Inlet south of the West Forelands, and numerous bays and coves are located in the southwest portion of Lower Cook Inlet, along with St. Augustine volcano and Katmai National Park.

Cook Inlet lies in the maritime climate zone noted for its mild winters, cool summers and moderate precipitation. Average summer temperatures (June through August) in the area typically range from 6.7 to 19.4 ^{o} C (44 to 67^{o} F). Maximum summer temperatures rarely exceed 21.1 ^{o} C (70^{o} F) and usually occur in August. Average winter temperatures (November through March) typically range from -15.5 to 1.1 ^{o} C (4 to 34^{o} F) although periods with colder temperatures are not uncommon. The coldest temperatures occur in January. The mean annual maximum temperature is 6.1 ^{o} C (43^{o} F) and the mean annual minimum temperature is -1.7 ^{o} C (29^{o} F; Western Regional Climate Center 2005).

Wind, rain, and heavy snowfall are common in Cook Inlet during winter. Average annual snowfall in Anchorage is approximately 178 cm (70 inches). Average annual precipitation is 38 cm (15 inches) in Anchorage with the greatest amounts of precipitation occurring in August and September (Western Regional Climate Center 2005). Prevailing winds in Cook Inlet are south/southwest in summer and north/northeast in winter. At the Port of Anchorage the mean daily wind speed is approximately 14.5 km/hr (9 mph) with common peak winds between 29 and 50 km/hr (18 and 31 mph) although winds may reach more than 121 km/hr (75 mph). Daylight varies in the Cook Inlet area from approximately 5.5 hours at the winter solstice to about 19.5 hours on the summer solstice.

Ice forms in Cook Inlet during winter months. Ice can be particularly concentrated in areas such as Knik and Turnagain arms where the large amount of freshwater from rivers creates high potential for ice occurrence. Rivers begin to freeze-up in October and November and ice begins to form in the upper inlet by early to mid-December when mean ice cover is approximately 50% in the waters near the Ladd area (Mulherin et al. 2001). Mean ice cover increases to approximately 70% in the Ladd area by late February but is reduced to about 30% by the end of March. However, ice cover is variable and break-up may occur as early as mid-March or as late as mid-May.

Cook Inlet bathymetry is varied with numerous shoal areas and adjacent canyons. The depth of the inlet is generally less than 73 m (240 ft), although deeper water is located in the channels and at the mouth of the inlet near the Barren Islands where it drops off steeply to depths ranging from 183-366 m (600-1,200 ft; Mulherin et al. 2001). Vast areas of mudflat are exposed at low tide, particularly in Knik and Turnagain arms including Chickaloon Bay, and the shoreline in Susitna Flats, Redoubt Bay, and Trading Bay areas. Offshore depths are generally greater near the Susitna Flats and the Ladd area than offshore of the Kenai Peninsula. In the Ladd area water depth tapers from zero at the shore to approximately 18 m (60 ft) about 3 km (9,850 ft) offshore with deeper water further offshore.

Surface water circulation within Cook Inlet generally follows a counterclockwise motion (Mulherin et al. 2001). Surface water movement in the offshore waters of the Ladd area is generally to the southwest. The circulation results from the water exchange between the Gulf of Alaska and river outflow within Cook Inlet. Water from the Alaska Current enters Cook Inlet through the Kennedy and Stevenson entrances (Figure 1) and flows northeasterly along the eastern side of the inlet. This water coming from the Gulf of Alaska is relatively clear and saline. During summer months a huge volume of sediment-laden water flows into the inlet primarily from the Knik, Matanuska, and Susitna rivers. This water flows along the western side of Cook Inlet through the Shelikof Strait to the Gulf of Alaska creating a counterclockwise motion within the inlet. During the winter freshwater outflow is reduced substantially.

Tidal fluctuation in Cook Inlet is extreme and the differential between low and high tide can be as great as 12 m (39 ft) although mean values are less. There are two unequal high and low tides each day separated by slightly more than 6 hours. During ebbing and flooding tides current velocity in Lower Cook Inlet ranges from 1.0 to 1.5 m/sec (3.3 to 4.9 ft/sec), increasing to over 2 m/sec (6.6 ft/sec) in Upper Cook Inlet (Mulherin et al. 2001). Tidal current velocity can reach 4.1 m/sec (13.5 ft/sec) in constricted areas such as between the forelands and at the mouths of Knik and Turnagain arms. The strong currents in Cook Inlet cause turbulence which results in large amounts of suspended material in the water. The sediment originates from riverine glacial outflow and coastal erosion and is greatest near the mouths of large rivers.

Tidal currents are stronger than circulation currents created by the exchange of water from the Gulf of Alaska and freshwater systems of the inlet and dominate inlet circulation (Mulherin et al. 2001). Mean tidal fluctuations vary considerably within Cook Inlet. The mean tidal differential is approximately 3.5 m (11.5 ft).in the southern part of the inlet near Kennedy Entrance compared to approximately 7.9 m (25.9 ft) near Anchorage. The mean tidal fluctuation near the Ladd area is approximately 6 m (18 ft). Thus tidal currents are stronger in Upper Cook Inlet than in Lower Cook Inlet and have more influence on water movement. Current speed diminishes at the approach of high or low tide and then reverses as the tide changes. These strong tidal currents create periods of slack tide in Upper Cook Inlet during which there is no current for a brief period while the tide changes direction. Slack tides do not occur in Lower Cook Inlet.

Rip tides (i.e., strong tidal currents that occur where water masses converge or diverge) are a component of Cook Inlet tidal features. Rip tides occur between the generally south flowing, low-salinity water along the west shore of the inlet and the intruding sea water on the east side (Haley et al. 2000). Rip tides can occur at many locations within Cook Inlet but are generally associated with deep channels and follow bathymetric contours. Rip tides occur in the offshore waters of the Ladd area. Salmon are known to occupy rip tides and rip tides are sometimes fished by commercial drift gillnet fishermen in central Cook Inlet.

FISH SPECIES OF COOK INLET

Forage fish species

Overview and recent key studies

Forage fish are primarily schooling fish that serve as the nutritional basis for marine mammal and bird populations as well as larger fish species. Declines in some seabird and marine mammal populations in recent years have prompted studies of forage fish in the Bering Sea, the Gulf of Alaska, and in Lower and Upper Cook Inlet (Robards et al. 2002; Houghton et al. 2005a). Forage fish, as well as other fish groups such as salmonids and groundfish, are also prominent in the diet of beluga whales (Pauly et al. 1998). The dominant forage fish species identified by Piatt et al. (1999) in Cook Inlet include Pacific herring (*Clupea pallasi*), walleye pollock (*Theragra chalcogramma*), capelin (*Mallotus villosus*), Pacific sand lance (*Ammodytes hexapterus*) and eulachon (*Thaleichthys pacificus*). Other forage fish species that have been identified as potential prey for Cook Inlet beluga whales include longfin smelt (*Spirinchus thaleichthys*), and saffron cod (*Eleginus gracilis*).

A few studies have been conducted on forage fish in Upper Cook Inlet in recent years, primarily to describe the ecology of juvenile salmonids and other potential prey for the Cook Inlet beluga whale population. These studies were prompted by potential future construction of a Knik Arm crossing and for expansion of the Port of Anchorage (Houghton et al. 2005a,b). Moulton (1997) also collected data on forage fish presence and relative abundance while studying the growth and feeding of juvenile salmon in Upper Cook Inlet in June, July, and September 1993.

The Moulton (1997) study area included most of Upper Cook Inlet from the East and West forelands to Fire Island, but did not include Chickaloon Bay, Turnagain Arm, or Knik Arm (Figure 2). Fish densities were greater in Upper Cook Inlet in June than in July, and the greatest mean fish densities occurred along the northwest shoreline from the Susitna delta to the North Foreland and the adjacent mid-channel waters. The lowest densities occurred along the southeastern shoreline from Moose Point to Boulder Point. The most abundant forage fish were threespine stickleback (*Gasterosteus aculeatus*) and Pacific herring which comprised 25 and 24 % of the total catch, respectively (Moulton 1997). Eulachon was also a fairly abundant forage fish species (14.3%) as were two salmon species. Other forage fish species combined including walleye pollock, longfin smelt, saffron cod, pacific sandfish (*Trichodon trichodon*), Pacific sandlance, capelin, and ninespine stickleback (*Pungitius pungitius*) comprised approximately 6% of the total Upper Cook Inlet catch (Moulton 1997). Surveys were conducted using trawl net sampling and hydroacoustic techniques.

Houghton et al. (2005a) used beach seines and tow nets to sample forage fish in Knik Arm during ice-free months in 2004 and 2005. Data reported included presence, size, and catch per unit effort. Threespine stickleback was the most abundant species captured, comprising 28.1% of the total beach seine catch, and 70.4% of the tow net catch. Other abundant species caught during beach seine sampling were longfin smelt (13.6%) and saffron cod (12.9%). Eulachon and Pacific herring, which comprised 14.3% and 24% of the catch in Upper Cook Inlet, respectively (Moulton 1997), were less abundant in Knik Arm and represented only 5.1 and 1.3% of the Knik Arm beach seine catch and 0.4 and 1.9% of the tow net catch (Houghton et al. 2005a). Houghton et al. (2005b) conducted fish studies with particular emphasis on the behavior and ecology of juvenile salmonids near the Port of Anchorage in support of future expansion of the port and reported results similar to those of their concurrent study for the Knik Arm crossing (Houghton et al. 2005 a).

Abookire et al. (2000) reported that variability in the distribution of forage fish species in Kachemak Bay was related to temperature and salinity by comparing fish communities in the inner and outer bay. Temperature was higher and salinity was lower in the inner bay compared to the outer bay. Juvenile and adult Pacific sandlance, Pacific

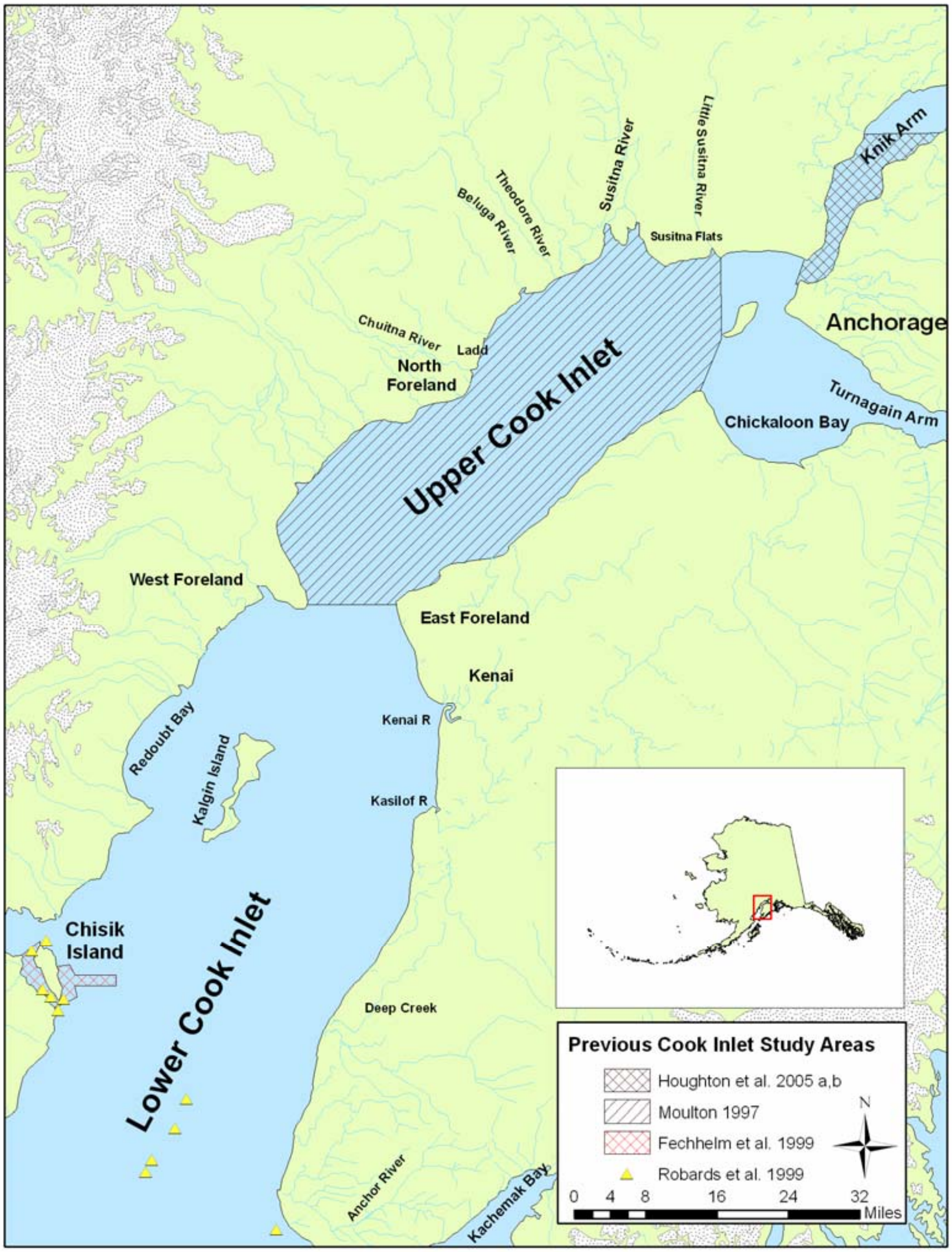

Figure 2. Locations of fish study area in Upper Cook Inlet and near Chisik Island in Lower Cook Inlet.

herring, and smelts (Family Osmeridae) were more abundant in the inner bay. Some members of the cod family (Gadidae) were the only schooling species more abundant in the outer bay. In contrast, relative abundances were not significantly different between the two areas for demersal fish groups.

The nutritional or energetic value of forage fish varies among species and life stage, and is often determined by their lipid content. The most common forage fish species can be divided into lipid-rich species such as Pacific sandlance, Pacific herring, and capelin, and lipid-poor species such as walleye pollock and Pacific cod (*Gadus macrocephalus*) (Abookire and Piatt 2005). Changes in the energy content of forage fish communities, i.e., from lipid-rich to lipid-poor species, can impact higher trophic levels that feed on these species. Robards et al. (1999a) reported that lipid content of Pacific sandlance peaked in spring and early summer, and then declined during late summer and fall as gonads began to develop. Lipid content in juvenile sandlance was relatively low and increased with age. Van Pelt et al. (1997) analyzed various forage fish species and reported that mature pelagic forage fish such as capelin and Pacific sandlance had greater lipid concentration and higher energy value than juvenile age-classes of large demersal and pelagic fish species such as walleye pollock, Pacific cod, Atka mackerel (*Pleurogrammus monopterygius*), and others. However, the availability of schooling forage fish species may be more variable than that of ground fish species that are less variable in distribution (Litzow and Piatt 2003; Litzow et al. 2004).

The majority of forage fish studies in Cook Inlet have focused on Lower Cook Inlet, including Kachemak Bay. Work has been done by many different organizations. The Exxon Valdez Oil Spill Trustee Council has funded studies of seabird populations and productivity in relation to forage fish abundance and distribution in Prince William Sound and Lower Cook Inlet. The Alaska Department of Fish and Game conducts tri-annual, small-mesh trawl surveys for shrimp and associated fish species in Kachemak Bay (Gustafson and Bechtol 2005). The U.S. Fish and Wildlife Service, the U.S. Geological Survey, the Minerals Management Service, and the Alaska Science Center have also conducted numerous studies of forage fish species in Lower Cook Inlet near the Barren Islands, in Kachemak Bay, and near Chisik Island (e.g., Fechhelm et al. 1999; Robards et al. 1999b,c, 2002; Abookire and Piatt 2005; Speckman et al. 2005).

Fish studies in Lower Cook Inlet have demonstrated variability in species abundance and distribution. Abookire and Piatt (2005) reported that Pacific sandlance was the most abundant species captured at three locations combined in Lower Cook Inlet, and that threespine stickleback was only a trace species. Houghton et al. (2005a,b) did not report Pacific sandlance in Knik Arm and Moulton (1997) reported that sandlance comprised only 0.1% of the total catch in Upper Cook Inlet. However, Pacific sandlance comprised 17.6% of the total catch near Chisik Island in the northern portion of Lower Cook Inlet in May, although few sandlance were captured in August (Fechhelm et al. 1999).

Life history summary of Cook Inlet forage fish

Moulton (1997) reported on forage fish caught incidental to trawl net sampling of salmon smolts in Upper Cook Inlet, which included waters in or near the Ladd area. Houghton et al. (2005a, b) surveyed forage in Knik Arm (east of Ladd). Both Fechhelm et al. (1999) and Robards et al. (1999b) studied forage fish in Lower Cook Inlet, southwest of Ladd.

Table 1. Fish species available to beluga whales in Knik Arm, upper Cook Inlet, Alaska by month (table from Houghton et al. 2005a).

Month	Available Fish Species
April	Eulachon, saffron cod
May	Eulachon, Chinook salmon, saffron cod
June	Chinook salmon, saffron cod (questionable)
July	Pink, chum, sockeye, and coho salmon
August	Coho salmon, saffron cod
September	Saffron cod, longfin smelt
October	Saffron cod, longfin smelt
November	Saffron cod

Threespine sticklebacks occur from the Arctic Ocean to central California and Korea in salt, brackish, and freshwater habitats. Threespine sticklebacks reach 100 mm (4 inches) in length but are usually less than 75 mm (3 inches) and are both benthic and pelagic (Mecklenburg et al. 2002). In Upper Cook Inlet, sticklebacks were caught primarily in July (Houghton et al. 2005a,b)

Pacific herring distribution and abundance in Cook Inlet is variable. Pacific herring, which was an abundant species in Upper Cook Inlet (Moulton 1997), was the second most abundant species in the Lower Cook Inlet study (Abookire and Piatt 2005). Most herring occurred in the Barren Islands area in the southern portion of the study area, and very few herring were caught near Chisik Island in the northern portion of the study area. Conversely, Fechhelm et al. (1999) reported that Pacific herring was the most abundant species (79% of total catch) in both trawl and seine nets combined in August 1997 in the Chisik Island area. However, the total herring catch dropped to 8.7 % in May 1998, and no herring were caught in August 1998. Chisik Island is located approximately 80 km (50 miles) southwest of the East and West forelands and is much closer to the upper inlet than are the Barren Islands.

Pacific sandlance occur from the Arctic Ocean through the Bering Sea to southern California and the Sea of Japan. Pacific sandlance are generally found in relatively shallow water to 100 m (328 ft) and reach a length of 28 cm (11 inches; Mecklenburg et al. 2002). Pacific sandlance has a high lipid content and is an important prey species for marine birds (Van Pelt et al. 1997; Abookire and Piatt 2005) and fish. Roseneau and Byrd (2000) reported sandlance in the stomach contents of Pacific halibut in Lower Cook Inlet. Pacific sandlance is a schooling species found both in benthic and pelagic habitats. Sandlance reach sexual maturity at age 2 and spawn once a year in late September and October on fine gravel or sandy beaches soon after the seasonal peak in water temperature (Robards et al. 1999b). Males outnumbered females during spawning in Kachemak Bay by 2:1 (Robards et al. 1999b).

Walleye pollock, which comprised 2.7% and 0.1% of the total catch in Upper Cook Inlet (Moulton 1997) and Knik Arm (Houghton et al. 2005a,b) respectively, composed 8.8% of the total catch in Lower Cook Inlet (Abookire and Piatt 2005). In Lower Cook Inlet, most walleye pollock were caught in the Barren Island area and in Kachemak Bay, and relatively few were caught near Chisik Island. Fechhelm et al. (1999) also reported low abundance of pollock in the Chisik Island area. Although adult walleye pollock is considered a groundfish, younger fish occur in schools are grouped with forage fish species.

Eulachon is also known as hooligan and is seasonally abundant in Cook Inlet. Eulachon was the fourth most abundant species (14.3% of the total catch) but was present for only a brief time in early June in Upper Cook Inlet (Moulton 1997). Dip-netting for eulachon is popular in the spring in Turnagain Arm during annual spawning migration to freshwater. Eulachon occur from the Bering Sea south through the Aleutians to central California. Eulachon are anadromous and reach a length of 25.4 cm (10 inches; Mecklenburg et al. 2002). Eulachon may migrate as far as 160 km upstream to spawn. Most die after spawning, although some may survive to spawn once more. Eulachon comprised 2.1 and 5.1% of the total beach seine catch in Knik Arm studies (Houghton et al. 2005a,b). Moulton (1997) reported that eulachon comprised 14.3% of the total catch in Upper Cook Inlet. Fechhelm et al. (1999) reported that eulachon comprised 26.4 and 44.8% of the total catch near Chisik Island in May and August 1998, respectively. However, no eulachon were captured in August 1997 (Fechhelm et al. 1999). Abookire and Piatt (2005) reported small numbers of eulachon in the Chisik Island area and none in Kachemak Bay or the Barren Islands during mid-water trawl sampling from 1996 to 1999.

Longfin smelt is an anadromous species although landlocked populations are known (Morrow 1980). Longfin smelt is in the same family as eulachon (Osmeridae) and reaches a length of 20 cm (7.9 inches; Mecklenburg et al. 2002). They occur in coastal areas from southcentral Alaska south to central California. Large female longfin smelt may have over 20,000 eggs and the young fish remain in freshwater for approximately one year before moving to marine habitats. Most longfin smelt spawn and die at age two although some females may survive to age three. Longfin smelt was a fairly abundant species in Knik Arm and comprised 13.6 and 22.5% of the total beach seine catch in two recent studies (Houghton et al. 2005a,b). However, longfin smelt comprised only 1.8% of the total tow net catch in Upper Cook Inlet (Moulton 1997). Fechhelm et al. (1999) caught few longfin smelt during trawl sampling near Chisik Island in August 1997 and May 1998, but longfin smelt comprised 15% of the total catch in August 1998.

Capelin is another member of the smelt family that is found from the Arctic Ocean to the Strait of San Juan de Fuca. It occurs across the Pacific Ocean to Japan and Korea as well as in the Atlantic Ocean. Capelin reach a length of 25.2 cm (10 inches) and spawn on gravel beaches below the tide line. Capelin were not reported in Knik Arm by Houghton et al. (2005a,b) and occurred in very low numbers in Upper Cook Inlet (Moulton 1997). Fechhelm et al. (1999) did not report capelin in the Chisik Island area although Abookire and Piatt (2005) reported that capelin comprised 23.5% of the total catch in the Chisik Island area from 1996 to 1999. Speckman et al. (2005) reported that capelin were present in the Barren Island area but not in the Chisik Island area during sampling in 1997 and 1998. In 1999 this trend changed and capelin, as well as other species that had been present in the Barren Islands area in 1997 and 1998, were captured in the Chisik Island area. Roseneau and Byrd (2000) reported the amount of capelin consumed by Pacific halibut varied among years during a 5-year study in Lower Cook Inlet.

Saffron cod occur in the Chukchi and Beaufort seas south through the eastern Bering Sea to southeast Alaska. Saffron cod reach a length of 55 cm (22 inches). They usually occur in coastal waters to a depth of 60 m (197 ft) but may enter brackish water and rivers to the limit of tidal influence (Mecklenburg et al. 2002). Saffron cod feed on fish and small crustaceans and reach sexual maturity at age three. They spawn in winter and females may produce over 200,000 eggs. The planktonic young hatch from April to June. Saffron cod comprised almost 13% of the total catch during beach seine sampling in Knik Arm (Houghton et al. 2005a,b). Saffron cod comprised only 1.4% of the total catch during Upper Cook Inlet tow sampling (Moulton 1997). Fechhelm et al. (1999) did not report saffron cod in the Chisik Island area.

Salmonid fish species

Overview and recent key studies

In Cook Inlet, the salmonid group is represented by five species of Pacific salmon, steelhead trout (*Oncorhynchus mykiss*), and Dolly Varden. Adult salmon return from marine habitats to their natal freshwater rivers and streams to spawn in summer and fall. Eggs are laid and develop in gravel substrates. Fry emerge from the gravel in the spring and remain in freshwater for variable amounts of time. Depending on the species and the distance from the spawning area to marine waters, fry may remain in fresh water for only a few days or weeks, or may remain in fresh water for one to two years. As the fry transition to brackish and marine habitats they become smolts. Smolts may spend several years in marine habitats before returning to freshwater to spawn. Smolts feed on a variety of prey including amphipods, euphausiids, copepods, decapod larvae, pteropods, and fish (Auburn and Ignell 2000) although feeding patterns likely vary among cohorts (Kline and Willette 2002). As salmon return to freshwater they undergo physiological changes in body shape and color. All salmon die after spawning. Steelhead and Dolly Varden may spawn more than once.

Salmon are managed by several different divisions of the Alaska Department of Fish and Game (see Fish Management section, below). Management actions include assessments of participation in the fisheries, harvest levels, and the relative or actual size of different salmon populations. Fishery participation is measured by surveys of angler days for recreational fisheries, and by number of permits issued for subsistence, personal use, and commercial fisheries. Harvests are monitored for all these fisheries, and reported as number of salmon harvested, or tons of herring and eulachon harvested (Tables 2 and 3). Salmon population size, usually referred to as “run” size, is estimated from surveys of the number of adults returning to different areas that are measured annually (Table 4). Even where these surveys do not yield an exact count of the fish, they can be useful for comparing the relative strength of a run from one year to the next, thereby generating estimates of abundance changes over time. Depending on the species and type of fishery, these records may extend back annually for decades. The result is a good record of run timing and strength to several indicator rivers located in Upper Cook Inlet.

The Chuit and Theodore rivers are the closest streams to the proposed construction site where salmon returns are monitored by ADF&G (Table 3; Figure 1). Only Chinook salmon are monitored on these two rivers. Sockeye salmon are monitored on the Yentna River (tributary to the Susitna River) and Fish Creek (in Knik Arm); coho salmon on Fish Creek and the Little Susitna River; and chum salmon on Clearwater Creek.

Juvenile salmon are not usually monitored by the ADF&G; most information thus comes from individual research projects conducted intermittently. In Upper Cook Inlet, two recent projects include those by Moulton (1997) and by Houghton et al. (2005b). Moulton's study targeted juvenile salmon migrating throughout marine areas of Upper Cook Inlet, and included surveys in the Ladd area. Houghton's study targeted juvenile salmon near the Port of Anchorage, and did not include sampling in the Ladd area. Results from these studies are reported in greater detail below, by species.

Table 2. Commercial harvest of Upper Cook Inlet (Northern District)[a] salmon, 2001 - 2004 (Fox and Shields 2005).

		Number of salmon			
Species	Harvest method	2001	2002	2003	2004
Chinook	Commercial set gillnet	1,811	1,895	1,670	2,058
Sockeye	Commercial set gillnet	50,848	33,100	48,487	27,286
Coho	Commercial set gillnet	45,928	50,292	24,015	44,130
Pink	Commercial set gillnet	4,355	6,224	1,564	2,017
Chum	Commercial set gillnet	2,202	4,901	3,483	2,148

[a] The Northern District is 50 miles long, averages 20 miles in width and is divided into two subdistricts. Demarcation for the Northen District is north of a line drawn at Boulder Point on the Kenai Peninsula.

[b] The NCI sportfish management area includes all freshwater drainages and adjacent marine waters of UCI between the southern tip of Chisk Island and the Eklutna River, excluding the upper Susitna drainage above the Oshetna River confluence. Divided into four major units; Knik Arm Unit, Eastside Susitna Unit, Westside Susitna Unit, West Cook Inlet Unit (Ivey and Sweet 2004).

Table 3. Harvest of smelt, herring, and salmon (subsistence and recreational fisheries) in Upper Cook Inlet, 2001 - 2004 (Fox and Shields 2005).

Species and district		2001	2002	2003	2004
Commercial herring			Tons of herring		
Eastside		9.9	16.2	3.7	6.7
Chinitna Bay		-	1.9	0.0	0.1
Tuxedni Bay		-	0.0	0.0	0.0
Subsistence salmon			Number of salmon		
Tyonek subdistrict	Chinook	976	898	973	1,080
	Sockeye	172	76	89	51
	Coho	49	127	29	0
	Pink	4	17	5	15
	Chum	6	4	10	0
Yentna subdistrict	Chinook	0	0	0	0
	Sockeye	545	454	553	441
	Coho	50	133	67	146
	Pink	10	14	2	36
	Chum	4	31	8	3
Smelt			Tons of smelt		
		3.9	4.5	3.1	NA
Recreational salmon			Number of salmon		
Northern Cook Inlet	Chinook	37,215	31,196	32,401	na
	Coho	89,893	99,155	na	na
	Sockeye	20,565	11,946	na	na

Fisheries were closed for years with dashed lines

Table 4. Escapement goals and escapement of Upper Cook Inlet salmon, 2001 - 2004 (Hasbrouck and Edmondson 2005).

Major tributaries - East to West		Escapement Goals	Type	Escapement 2001	2002	2003	2004	Survey Type
Chinook								
	Alexander Creek	2,100-6,000	SEG	2,282	1,936	2,012	2,215	SAS
	Chuitna River	1,200-2,900	SEG	1,501	1,394	2,339	2,938	SAS
	Deska river	13,000-28,000	BEG	27,966	28,535	39,257	57,934	Weir
	Lewis River	250-800	SEG	502	439	878	1,000	SAS
	Little Susitna River	900-1,800	SEG	1,238	1,660	1,114	1,694	SAS
	Theodore River	500-1,700	SEG	1,237	934	1,059	491	SAS
Coho								
	Fish Creek (Big Lake watershed)	1,200-4,400	SEG	9,247	14,651	1,231	na	Weir
	Little Susitna River	10,100-17,700	SEG	30,587	48,308	11,127	40,199	Weir
Sockeye								
	Fish Creek (Big Lake watershed)	20,000-70,000	SEG	43,486	90,483	91,952	22,157	Weir
	Yentna (Index for Susitna)	90,000-160,000	SEG	83,532	78,591	180,813	71,281	Sonar
Chum								
	Clearwater Creek	3,800-8,400	SEG	14,570	8,864	7,200	na	PAS
Pink								
	No stocks with an escapement goal							

SAS = Single aerial survey
PAS = Peak aerial survey
SEG - Spawning Escapement Goal

-Chinook fishing is most productive from 1 mile south of the Theodore River to the Susitna River (Fox and Shields 2005). Chinook salmon enumeration is only done at one site, the Deshka River weir.
-Sockeye salmon fishery is managed with an integration of an offshore test fishery, and an escapement enumeration by sonar and weir.
-No UCI pink salmon stocks with escapement goals.

Pink salmon life history

Overview

Pink salmon (Oncorhynchus gorbuscha) are the smallest of the Pacific salmon in North America, with maximum lengths of 76 cm (30 inches) and weights of 6.4 kg (14 lb; Mecklenburg et al. 2002). Pink salmon are also called humpback salmon or "humpies" due to the large hump that forms on the back of spawning males. When adults return to freshwater, male color patterns change from steely blue above with silver sides to brown or black above; females become olive green above with a light belly. Females may deposit as many as 1,500 to 2,000 eggs in a gravel nest in freshwater or occasionally in intertidal areas. The eggs hatch during the winter and the developing fish, or alevins, remain in the gravel using their yolk sacs for nourishment. Fry emerge from the gravel in late winter or early spring and immediately move downstream to marine waters.

In the ocean, juvenile pink salmon molt feed on plankton and larval fish, and may reach four to six inches in length by their first winter. They spend the next year in the open ocean, returning the following fall to spawn in their natal streams. This is generally the shortest life cycle of the Pacific salmon (two years from hatching to spawning).

Because pink salmon spawn at two years of age, two separate lines of unrelated fish develop in alternating odd and even year cycles. In some locations one line may be dominant over the other in abundance. In the Cook Inlet region, larger pink runs occur during even years. Adult pink salmon return to rivers and streams throughout Upper

Cook Inlet. They are harvested in commercial and subsistence fisheries, but usually in the course of effort directed at other species.

Adults probably feed relatively little in Cook Inlet because they are close to entering their natal stream. Based on the diets of juvenile pinks in Prince William Sound and the northern Gulf of Alaska, pink salmon are known to feed on a mixture gastropods, cladocerans, copepods, and bivalves early on, ranging to larger prey such pteropods, larvaceans, amphipods and euphausiids later in the summer (Boldt and Haldorson 2003).

Distribution and run timing

Adult pink salmon return to Upper Cook Inlet from early July to mid-August, with Westside Susitna drainages having peak runs in July. Upper Cook Inlet pink salmon runs are even-year dominated, with the 2000 and 2002 returns being characterized as strong or very strong, as opposed to diminished returns since the mid-1980s. However, harvest levels of pink salmon have been low, owing to restrictions in place to ensure sockeye salmon escapement. Pink salmon returns in 2004 were deemed average to above average (Fox and Shields 2005).

Juvenile pink salmon were the most abundant salmon reported by Moulton (1997) during tow net sampling in Upper Cook Inlet in June and July of 1993, comprising 16.5% of the total catch. Pink salmon were caught in 92% of the tows in June, and comprised approximately 25% of the total catch. Pink salmon numbers decreased in July, when they occurred in only 70% of the tows. Pink salmon were abundant throughout the study area from the East and West forelands to Fire Island near Anchorage, but were most abundant in mid-June near the mouth of the Susitna River. However, a large number of pink salmon was also caught in a single mid-channel tow in mid-July in the eastern portion of the study area.

Houghton et al. (2005a) did not capture any pink salmon smolt in Knik Arm during beach seine activities in 2004, although few were expected. The larger even-year pink runs in Cook Inlet produce a larger number of odd-year outmigrants, and the numbers of pink salmon smolt expected in even years are much lower. In 2005, Houghton et al. (2005a) captured 33 pink salmon, which was 1.9% of all juvenile salmonids. Most pink salmon were captured in May and were young-of-the-year outmigrants between 31 and 40 mm (1.2 to 1.6 inches) in length.

Houghton et al. (2005a) also captured pink salmon smolt during tow net sampling in Knik Arm. Pink salmon smolt were most abundant in May and numbers declined in June and July. Houghton et al. (2005a) reported that adult pink salmon comprised 0.4% of the total beach seine catch and were captured only in July.

Juvenile pink salmon captured by Moulton (1997) in June ranged from 35.9 to 36.3 mm (~1.4 inches). Larger fish were present in July and by mid-July fish ≥ 40 mm outnumbered fish ≤ 40 mm with a mean length of 41.5 mm (1.6 inches). Mean lengths of pink salmon were similar in all regions of the study area in June, but in July were greater in the western portions of the study area. Moulton (1997) suggested that the apparent lack of growth in June may have been due to continual emigration of small pink salmon that masked any growth that may have occurred.

Chum salmon life history

Overview

Chum salmon (O. keta), also known as dog salmon, are harvested commercially in salt and fresh water and are an important subsistence resource in rural Alaska communities. Chum can reach a length of 109 cm (43 inches) and weigh up to 20.8 kg (46 lb; Mecklenburg et al. 2002). Chum salmon are more widely distributed than other Pacific salmon species and range from California to the Arctic Ocean of Russia (Lena River) and Canada (Mackenzie River). At sea, chum salmon are greenish-blue dorsally with black spots and are difficult to distinguish from sockeye and coho salmon. As chum salmon adults prepare to enter fresh water, they develop vertical green and purple patterns on their sides and males develop a hooked jaw with prominent teeth. Chum salmon spawn in coastal streams and intertidal areas but may also travel great distances inland. Some chum salmon are known to migrate up the Yukon River to the Yukon Territory to spawn, a distance of over 2,000 miles. Females may lay up to 4,000 eggs.

Chum fry move toward marine waters soon after hatching, usually shortly after ice breaks up from their natal rivers. Chum may not feed before reaching saltwater, thus making marine food resources of special importance. Juvenile chum in Cook Inlet are thought to enter marine water from late May through July. By their first winter, Cook Inlet chum salmon have moved into the Gulf of Alaska and spend three to four years in the ocean before returning to natal streams (ADF&G 1994). Returning chum salmon arrive in Cook Inlet in early July and spawning runs continue through early August.

Distribution and run timing

Adult chum salmon are not well represented in Westside Susitna drainages of the Upper Cook Inlet. Their peak run timing is mid-July through mid-August, however their run continues into September (ADF&G 1994). Upper Cook Inlet chum stocks are only monitored at one location, Clearwater Creek, with an escapement index generated by peak run time aerial survey counts (Hasbrouck and Edmundson 2005). Chum production in the Susitna River declined in the mid-1980's to the mid-1990's but a steady increase in production has been observed in Upper Cook Inlet since the mid-1990's (Fox and Shields 2005).

Chum salmon smolts were the second most abundant salmon reported by Moulton (1997) in Upper Cook Inlet and comprised 10.2% of the total catch. Chum salmon showed a steady increase in size through the study period with mean lengths ranging from 43.6 mm (1.7 inches) in early June to 57.7 mm (2.3 inches) in mid-July. The growth rate of chum smolt appeared to be greater in July than in June and may have been related to warmer temperatures or to a decrease in the numbers of smolt emigrating from freshwater (Moulton 1997).

During beach seine sampling in Knik Arm, Houghton et al. (2005a) captured only five juvenile chum in 2004 and concluded that most chum had probably migrated out of the area before sampling began in late July. Sampling in 2005 began earlier than in 2004 and small numbers of juvenile chum were captured in April with significant increases in May and June. As in 2004, no chum smolts were captured with beach seines in July 2005. Chum salmon smolts were the most abundant salmon captured in tow net sampling in Knik Arm (Houghton et al. 2005a). Chum smolt were most abundant in May and numbers declined in June and July. Houghton et al. (2005a) reported that adult chum salmon composed 0.1% of the total beach seine catch. Adult chum salmon were caught in July.

Coho salmon life history

<u>Overview</u>

Coho salmon (O. kisutch), also known as silver salmon, is a popular commercial and sport fishing species. Coho salmon reach 108 cm (43 inches) in length and weigh up to 17.7 kg (39 lb; Mecklenburg et al. 2002). Coho salmon spawn in many types of freshwater habitats and are known to migrate up the Yukon River to the Alaska/Canada border. Adults in salt water are bright silver above with small black spots on the upper back. Spawning adults have dark backs and heads with maroon or reddish sides.

Adult coho salmon return to spawn later than other species and may be found in spawning streams from July through November. The timing of spawning runs may vary depending on environmental conditions, and barriers in small headwater streams they often spawn in. Females deposit 2,000 to 4,500 eggs into gravel beds.

Juvenile coho salmon usually rear from one to three winters in freshwater (ADF&G 1994). Juvenile coho salmon can establish winter territories in freshwater pools and lakes, and may move between brackish estuarine water during spring and summer for feeding and move back to freshwater in the fall (ADF&G 1994). Most coho spend approximately 18 months at sea before returning as adults to natal streams. Some, known as jacks, return to freshwater after only six months at sea.

<u>Distribution and run timing</u>

Adult coho salmon are well represented throughout Upper Cook Inlet with runs beginning in July and continuing into October. The peak of the run in the west-side Susitna area, an early-run stock, is generally in the last week of July (Ivey and Sweet 2004). The Little Susitna River has proven to be a good indicator of coho run strength throughout the region, and the Susitna River drainage supports the largest coho stock in Upper Cook Inlet. The greatest recreational harvest of coho salmon generally occurs in the Knik and Eastside Susitna Management Units, followed closely by the Westside Susitna Unit (Ivey and Sweet 2004). Lake Creek is the greatest contributor to sport fish catches in the Westside Unit.

In Knik Arm, juvenile coho salmon was the second most abundant juvenile salmon species captured in beach seines in 2004, and the most abundant species in 2005 (Houghton et al. 2005a). Coho salmon smolts were captured as early as April and were present in Knik Arm into late November. In both 2004 and 2005, catches of juvenile coho peaked in July, but continued into August. In 2005, coho salmon were distributed throughout Knik Arm but were more abundant on the west side (Houghton et al. 2005a). Several cohorts were present throughout the study period and a relatively high frequency of 101-140 mm coho captured in June 2005 may have resulted from the smolt release from Ship Creek hatcheries. Houghton et al. (2005a) reported that adult coho comprised

0.9% of the total beach seine catch and that most adult coho were captured in July with smaller numbers in August.

In northern Cook Inlet, catch rates of juvenile coho salmon were highest in mid-June and mid-July, and the greatest numbers were caught near the Susitna River delta. Juvenile coho were the only salmon caught in September.

Sockeye salmon life history

Overview

Sockeye salmon (O. nerka), also called red salmon, reach 84 cm (33 inches) in length and weigh up to 7 kg (15.4 lb; Mecklenburg et al. 2002). Sockeye salmon range from northern California to the Russian and Canadian Arctic Ocean as well as the western Pacific Ocean south to Japan. It is an important species in commercial, sport, and subsistence fisheries. In marine habitats, sockeye salmon are greenish-blue above, and silver on the sides. As they move to fresh water both male and female sockeyes turn dark red on the back and sides and pale olive green on the head and upper jaw. Males develop a hump on the back and a hooked lower jaw as in other salmonid species.

Sockeye typically spawn in lakes or rivers associated with lake systems, although some populations spawn in river systems without lakes. Female sockeye salmon deposit 2,000 to 4,500 eggs in gravel nests. When lakes are available, sockeye fry may spend one to three years in freshwater before returning to the ocean. In systems without lakes, sockeye generally spend less time in fresh water (ADF&G 1994). Some sockeye salmon populations are landlocked (i.e., kokanee) and spend their entire life in freshwater.

Sockeye spend one to four years in the ocean (typically 2 or 3) before returning to natal streams to spawn.

Distribution and run timing

Adult sockeye salmon are present from June to October in Upper Cook Inlet waters (ADF&G 1994) with a historic peak return to the southern boundary of Upper Cook Inlet marine waters of July 15th (Shields and Willette 2005). Approximately 50% of Susitna River sockeye are thought to be produced in the Yentna River tributary (Ivey and Sweet 2004). Sockeye salmon runs in the Susitna River drainage have been somewhat depressed in recent years (Fox and Shields 2005). Adult sockeye salmon are enumerated in the Yentna River and Fish Creek.

Juvenile sockeye salmon were caught in Upper Cook Inlet in June than July, but in limited numbers (Moulton 1997). During June, juvenile sockeye were caught throughout the study area in Upper Cook Inlet; in July, they were caught mostly in the eastern and middle portions of Moulton's (1997) study area (Figure 2). Age-1 (one winter in freshwater) was dominant in the June tows, but ages-0 and -1 were caught in equal numbers in July. No sockeye salmon were caught in September.

In Knik Arm in 2004, juvenile sockeye were the most frequently caught salmon during beach seining from July to November (Houghton et al. 2005a). Catches peaked in August 2004. In 2005, juvenile sockeye catches were low in April and May, peaked in June, and continued in July. Based on length measurements, two cohorts of sockeye (ages-0 and -1) were present in Knik Arm during both years. Juvenile sockeye in Knik Arm appeared to have substantial body growth from July through September 2004.

Chinook salmon life history

Overview

Chinook salmon (O. tshawytscha), also known as king salmon, is the largest of all Pacific salmon species. Chinook salmon reach a length of 160 cm (63 inches) and may weigh 61.2 kg (135 lb) although they are rarely over 23 kg (51 lb; Mecklenburg et al. 2002). Chinook salmon occur from central California and Japan north to the Chukchi Sea of Alaska and Russia. In marine waters Chinook salmon are bluish-green above, silvery on the sides, and white below. During spawning, they may be reddish to copper or nearly black. Males develop a ridge on their back and a hooked upper jaw. Smaller fish are generally males and older larger fish are composed of a higher proportion of females. Females may deposit 2,000 to 17,000 eggs in gravel beds.

Chinook fry hatch in spring and most juvenile Chinook remain in freshwater until the following spring when they begin to move toward marine habitats. The smolts feed on plankton and insects in fresh water, but in the ocean Chinook salmon feed on a variety of forage fish species, including herring and sandlance as well as squid and crustaceans. Chinook may remain in the ocean for two to six years before returning to spawn in their natal streams. Chinook salmon spawn in rivers throughout southcentral Alaska, including the Susitna, Beluga, Theodore, and Chuit rivers in Upper Cook Inlet.

Distribution and run timing

Adult Chinook salmon are only enumerated at one location in Upper Cook Inlet, at the Deshka River weir (Fox and Shields 2005). Chinook salmon enter tributaries on the west side of the Susitna River in May and June, continuing until August, with peak recreational harvests occurring at the mouth of Alexander Creek during the first week of June, and at the mouth of the Deshka River during mid-June (Ivey and Sweet 2004).

Moulton (1997) captured juvenile Chinook salmon smolts along the northwest shore of Upper Cook Inlet in the Susitna, Tyonek, and Trading Bay regions (Moulton 1997). Catch rates peaked in mid-June and mid-July, and no Chinook smolts were caught in September. Chinook smolts captured in June were primarily age-1, while those captured in July were ages-0 and -1. Small numbers of age-2 and -3 juvenile Chinook were also caught.

In Knik Arm, Chinook salmon comprised 25.6% of all juvenile salmon captured from April to July 2005 (Houghton et al. 2005a). Peak abundance occurred in June and there was no significant difference in the catch per unit effort among stations throughout the arm. In April, most of the Chinook were age-0 fish from 30 to 40 mm (1.2 to 1.6 inches) in length. Beginning in May, fish greater than 61 mm (2.4 inches) dominated the catch, many of which appeared to be of hatchery origin. Multiple cohorts were also present in tow net samples collected in May. Chinook smolt abundance declined in Knik Arm in mid- to late summer.

Steelhead life history

<u>Overview</u>

Steelhead trout is a salmonid species that has both freshwater and anadromous populations. Freshwater steelheads are known as rainbow trout that live in lakes and streams. Steelhead, like salmon, spend their adult lives in the ocean and move into freshwater streams to spawn. Steelhead trout reach 122 cm (48 inches) in length and may weigh 23.6 kg (52 lb; Mecklenburg et al. 2002).

The northwestern limit of the freshwater range of steelhead is the southern tributaries of the Kuskokwim River and the Port Moller region of the Alaska Peninsula. Steelhead are also found in the Gulf of Alaska and the Bering Sea west through the Aleutian Islands to Kamchatka. They are also found south along the Pacific coast to Mexico. Steelhead are not abundant in Cook Inlet.

<u>Distribution and run timing</u>

Moulton (1997) did not report any steelhead during tow net sampling in Upper Cook Inlet. Houghton et al. (2005a) captured small numbers of steelhead in Knik Arm in July during beach seine sampling.

Dolly Varden life history

<u>Overview</u>

Dolly Varden (Salvelinus malma) occur from the Arctic Ocean to Washington state and Japan and Korea. Dolly Varden are anadromous but freshwater populations are also known. They reach a length of 100 cm (39.4 inches) and are popular among sport fishermen. Dolly Varden are generally found in freshwater lakes and streams but are also know to occur in Cook Inlet.

<u>Distribution and run timing</u>

Fechhelm et al. (1999) reported that Dolly Varden comprised 37.4% of the total catch during trawl and seine net sampling near Chisik Island during May although numbers in August were much lower. Moulton (1997) and Houghton et al. (2005a,b) did not report Dolly Varden in Upper Cook Inlet or in Knik Arm.

Groundfish species

Overview and recent key studies

Groundfish is a term used to describe fish species that inhabit the seafloor during a portion of their life cycle, typically as adults. Groundfish are also referred to as demersal, benthic, or bottom dwelling fish. However, many species are pelagic, either free swimming or as planktonic larvae, during early life stages. Groundfish in pelagic stages may serve as forage species for larger fish, and marine birds and mammals. The groundfish group includes flatfish such as halibut, flounders, and sole, rockfish, pollock, some members of the cod family, and others. Some groundfish species that are normally found in deep water as adults move into shallower water to spawn. Abookire et al. (2001) reported that spatial variability of juvenile groundfish abundance in Kachemak

Bay was related to depth. Juvenile groundfish were concentrated either in relatively shallow water less than 20 m (66 ft) deep, or in water 50-70 m (164-230 ft) deep depending on the species. Mueter and Norcross (2000) sampled juvenile groundfish along the south side of the Alaska Peninsula and reported a generally decreasing trend in catch per unit effort (CPUE) from west to east. The lowest CPUE was recorded at locations near the mouth of Lower Cook Inlet. Lower Cook Inlet and the Gulf of Alaska support a large commercial and sport fishing industry and numerous studies of groundfish and other fish populations have been conducted in these areas. Information on groundfish distribution near the Ladd area is based on incidental catch of groundfish in Upper Cook Inlet. The groundfish species discussed below are some of the species that are common in Cook Inlet or are species that have been considered as prey species for Cook Inlet beluga whales.

Life history summary of Cook Inlet groundfish

Pacific cod (Gadus macrocephalus) in the eastern Pacific Ocean are found from central California to the Bering Sea with unconfirmed reports to the Chukchi Sea. Pacific cod are distributed throughout southcentral Alaska and are found primarily in benthic habitats in water depths ranging from 15 to 550 m (49 to 1,804 ft). Pacific cod was one of the most abundant species captured during sampling in Kachemak Bay (Abookire et al. 2001). Pacific cod feed on other fish species including walleye pollock, flatfishes, Pacific sandlance, and Pacific herring as well as on crab and shrimp. They may reach 120 cm in length but the average length in trawl catches is 70 to 75 cm (27.5 to 29.5 inches; Mecklenburg et al. 2002). Pacific cod usually spawn in relatively deep water during the winter and move to shallower waters to feed. Males become sexually mature at age-2 and females at age-3. Breeding occurs annually and fecundity increases with increasing size of female fish. Eggs develop on the ocean floor and development is affected by temperature. Optimal temperatures for egg development are around 3.5 to 4°C (38.3 to 39.2°F). Larvae are moved by ocean currents and have been found in Cook Inlet in May to July. Larvae feed on copepods and other plankton. Young Pacific cod are often found in shallow coastal waters and move to deeper water with age. Robards et al. (1999b) reported small numbers of Pacific cod near Chisik Island.

Rockfish (Sebastes spp.) is a diverse group of approximately 30 species. Most species will reach a length of 51 to 61 cm (20 to 24 inches). Rockfish have boney plates or spines on the head and a large mouth. The spines may be venomous and many species are brightly colored. Some rockfish species inhabit shallow, nearshore waters in areas with a rocky bottom. Other species are pelagic and inhabit the water column in either shallow or deeper water. Some rockfish species are extremely long-lived and may live to 200 years (Mecklenburg et al. 2002). Rockfish give birth to live young that feed primarily on plankton. Larger rockfish feed on forage species such as sandlance, herring, other rockfish, and crustaceans. Rockfish are important in commercial fisheries and are often taken in fisheries targeting other species such as halibut and salmon. Some species have been overexploited and recovery has been slow. Rockfish are abundant in the southern portion of Lower Cook Inlet.

Sablefish (Anoplopama fimbria), also known as black cod, is an important species in the fishing industry. Although sablefish occur in Cook Inlet, most are harvested in deeper water outside of the inlet. Sablefish may reach a length of 114 cm (45 inches) and weigh up to 25 kg (55 lb; Mecklenburg et al. 2002). Their range extends from the Bering Sea south in the Pacific Ocean to central Baja California. Adult sablefish are found in waters from 150 to 1,500 m (492 to 4,920 ft) in depth although juvenile sablefish occupy shallower waters. Adult sablefish feed on a variety of forage fish species and other groundfish and invertebrates. Sablefish spawn in deep water but the eggs float to the surface where they develop while drifting with currents. Sablefish exhibit diurnal vertical migrations in the water column by rising near the surface during the day and moving to deeper water at night.

Order Pleuronectiformes is composed of flatfish including halibut, sole, and flounders, and in adults both eyes are on the same side of the head. The larvae are free swimming and the eyes are located on opposite sides of the head. As the larvae mature, one eye migrates to the other side of the head, an adaptation for living on the bottom where adult flatfish spend most of the time. Some species, such as Pacific halibut, are important in commercial and sport fisheries in Lower Cook Inlet. Less information is available on flatfish occurrence in Upper Cook Inlet compared to Lower Cook Inlet. Below we discuss some species that are known or are likely to occur in Upper Cook Inlet.

Pacific halibut (Hippoglossus stenolepis) is the largest member of the flounder family and is important in commercial and sport fisheries. Sport fishing is popular in Lower Cook Inlet at least as far north as Deep Creek. Pacific halibut average about 15 kg (33 lb) in commercial catches but may reach 267 cm (105 inches) in length and weigh up to 226 kg (498 lb), although there are reports of fish weighing up to 363 kg (800 lb; Mecklenburg et al. 2002). Males and females reach sexual maturity at approximately 7 to 8 years and 8 to 12 years, respectively. Females may lay 2 to 3 million eggs annually depending on the size of the fish and spawning occurs during the winter months. The fertilized eggs rise to the surface and are dispersed by currents to areas with shallow waters. Young halibut eventually become bottom dwellers in these shallow waters where they may spend 5 to 7 years. Although halibut are essentially bottom dwellers, they sometimes leave the bottom to feed on forage fish such as pollock, herring, and sandlance.

Flathead sole (Hippoglossoides elassodon) is a common flatfish in Lower Cook Inlet. Flathead sole range from the Bering Sea through the Aleutian Island south to northern California and Japan. They occur on silty or muddy bottoms near shore to depths over 1,000 m, although more commonly at depths less than 366 m (1,200 ft; Mecklenburg et al. 2002). Flathead sole reach a length of 56 cm (22 inches) and are often taken during bottom trawling activity. Flathead sole was the most abundant groundfish taken in Kachemak Bay in 2000 during trawl sampling conducted by ADF&G (Gustafson and Bechtol 2005).

Yellowfin sole (Pleuronectes asper) occur from the Beaufort Sea through the Aleutian Islands to British Columbia and Korea. They reach a length of 49 cm (19 inches) and a weight of 1.8 kg (4 lb; Mecklenburg et al. 2002). Yellowfin sole is a long lived species that is common in Lower Cook Inlet. They are found on the outer shelf in winter but move to shallower water in the summer to spawn. Yellowfin sole feed on benthic and epibenthic invertebrates and fish. Moulton (1997) and Houghton et al. (2005a,b) did not report any yellowfin sole from Upper Cook Inlet or Knik Arm.

Fechhelm et al. (1999) reported small numbers of yellowfin sole in the Chisik Island area in August 1997as well as small numbers of *arrowtooth flounder (Atheresthes stomias)* and *butter sole (Pleironectes isolepis)* in the Chisik Island area. These species were not reported by Houghton et al. (2005a,b) or Moulton (1997) in Upper Cook Inlet. Arrowtooth flounder is a common North Pacific flatfish that is experiencing increased commercial fishing pressure (Bouwens et al. 1999a,b). It is a common species in Kachemak Bay and the northern Gulf of Alaska. Arrowtooth flounder larvae are planktonic for about 145 days before becoming benthic. The mean hatching period occurs around mid-April. Arrowtooth flounders become benthic around the first week of September although there is a high degree of variability around these dates (Bouwens et al. 1999a). Arrowtooth flounders in Kachemak Bay were approximately 40 mm (1.6 inches) in length when they become benthic and reach a mean standard length of 211 mm (8.3 inches) by age-2 (Bouwens et al. 1999b).

Starry flounder (Platichthys stellatus) occurs from the Beaufort and Chukchi seas to southern California and Korea. Starry flounders reach a length of 91 cm (36 inches) and a weight of 9.1 kg (20 lb). They are found on soft bottoms from intertidal areas to a depth of 375 m (1,230 ft), but usually less than 100 m (328 ft) and in estuaries and up rivers to the limit of tidal influence, as well as in marshes and coastal lakes (Mecklenburg et al. 2002). Starry flounder was reported in small numbers in Knik Arm (Houghton et al. 2005a,b), in Upper Cook Inlet (Moulton 1997), and in the Chisik Island area of Lower Cook Inlet (Fechhelm et al. 1999; Robards et al. 1999b).

Walleye pollock (Theragra chalcogrmma) is an abundant species in the Bering Sea and the Gulf of Alaska, and is found in Cook Inlet. Pollock range from the Chukchi Sea south through the Bering Sea and Pacific Ocean to central California and Japan. Pollock reach 91 cm (36 inches) in length and are an important species in commercial fisheries. Walleye pollock are demersal and may occur at depths to 950 m (3,117 ft), but are also pelagic and occur in schools near the surface and in mid-water habitats (Mecklenburg et al. 2002). Small pollock feed on copepods and other zooplankton and larger pollock feed on fish. Although walleye pollock is grouped with groundfish, young pollock is the dominant forage fish species that is consumed by larger fish, adult pollock, and many marine bird and mammal species (Schumacher et al. 2003). Pollock consistently spawn in the Shelikof Strait area and was the second most abundant groundfish species captured during small-mesh trawl sampling in Kachemak Bay in 2000 (Gustafson and Bechtol 2005). However, pollock may be less abundant in the upper portions of Cook Inlet. Fechhelm et al. (1999) captured small numbers of pollock during mid-water trawl sampling near Chisik Island in Lower Cook Inlet. Likewise, walleye pollock in Upper Cook Inlet comprised only 2.7% of the total catch during tow net sampling (Moulton 1997), and Houghton et al. (2005a) reported very low pollock numbers in Knik Arm during beach seine sampling.

COOK INLET FISHERIES MANAGEMENT

Overview

Humans harvest salmon, eulachon, herring, and trout in Upper Cook Inlet. These harvests are managed by the ADF&G, and may fall into any of several different management categories. Subsistence fisheries exist for salmon, and are managed by ADF&G's Commercial Fisheries Division (ADF&G/CF). The ADF&G/CF also manages commercial fisheries for salmon and herring. Personal use fisheries exist for salmon, herring, and eulachon, and are managed by the ADF&G Sport Fish Division (ADF&G/SF). The ADFG/SF also manages recreational fisheries for salmon and several species of trout. The commercial, subsistence, and recreational fisheries have different harvest limits, seasons, and regulatory boundaries (Figures 3 and 4).

Commercial fisheries

The ADF&G manages commercial fisheries for salmon and herring in Cook Inlet. The entire portion of Cook Inlet north of Anchor Point is considered the Upper Cook Inlet management area, and is subdivided into the Central and Northern districts (Fox and Shields 2005; Figure 3). Within these two districts, harvest statistics are reported for 32 statistical areas and sub-areas. On the west side of Upper Cook Inlet (closest to the proposed dock), particularly important commercial fisheries include the sockeye salmon fishery in the Big River area and the Chinook salmon fishery between the mouths of the Theodore and Susitna rivers (Fox and Shields 2005). As of 2004, commercial salmon fishers must use gillnets to harvest salmon in the Upper Cook Inlet management area. In the Central District, gillnets may be either set or drifted with the current. In the Northern District, these gillnets must be fixed in place (i.e., set gillnets).

For the ten year period from 1995 through 2004, commercial salmon harvests in the Upper Cook Inlet management area averaged 3.5 million fish, with an average annual ex-vessel value of $17.5 million (Fox and Shields 2005). Sockeye salmon were by the far the most important part of the harvest, accounting for greater than 80% of the harvest and 90% of the ex-vessel value.

Salmon returns in the Upper Cook Inlet management area appear relatively stable, with optimistic outlooks for continued strong commercial harvests. Sockeye salmon have been locally depressed in the Crescent Lake, Big Lake, and Susitna River drainages in recent years, but none of these stocks are considered a yield concern. Chum salmon returns were reduced from the mid-1980's through the mid-1990's, but appear to have been increasing since 1995. Coho and Chinook salmon returns and harvests have been relatively high in recent years.

Herring fisheries in Upper Cook Inlet are managed according to the Central District Herring Recovery Management Plan, which sets harvest limits by sub area. In recent years, these limits have not been reached, and the number of fishers participating in the fishery has dropped. The average annual harvest for the 7 years from 1998 through 2004 was 13.8 tons, which is substantially lower than the harvests in the 1980's and early 1990's (Fox and Shields 2005).

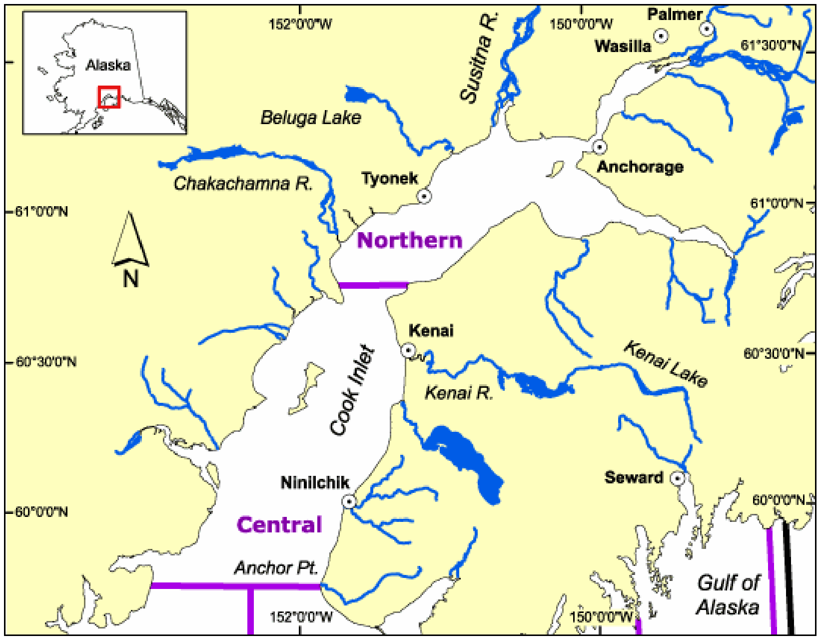

Figure 3. Map of Upper Cook Inlet management area for commercial fisheries, showing boundaries of the Central and Northern subdistricts. Map provided by the ADF&G.

Subsistence fisheries

Five subsistence salmon fisheries currently operate in the Upper Cook Inlet management area. Two of these – the Tyonek and Yentna – target salmon in the vicinity of the proposed dock. The remaining three operate in Lower Cook Inlet, south and east of the study area. All the subsistence salmon fisheries are managed by the ADF&G.

The Tyonek subsistence fishery has operated since 1980 and is permitted in the Tyonek Subdistrict of the Northern District (Figure 3). The fishery is open to all Alaskans, but is composed almost entirely of residents of the Village of Tyonek. This fishery primarily targets Chinook salmon, and runs from May 15 through June or July, depending on Chinook run strength elsewhere in Cook Inlet. For the ten years from 1995 through 2004, an average of 71 subsistence fishers participated in the fishery, harvesting an average of 929 Chinook salmon per year (Fox and Shields 2005).

The Yentna River subsistence salmon fishery has operated since 1996. The fishery operates on the mainstem Yentna River between Martin Creek and the Skwentna River, and only allows salmon to be taken with fishwheels. Sockeye salmon are targeted by the fishery, but coho, pink, and chum salmon may also be taken. Participation in the fishery has ranged from 16 to 25 fishers per year, with an average annual harvest of 464 sockeye salmon (Fox and Shields 2005).

Personal use fisheries

The ADF&G also manages personal use fisheries for salmon, herring, and eulachon (hooligan) in the Upper Cook Inlet management area. The salmon fisheries take place on the Kenai and Kasilof rivers, south and east of the proposed dock, and on Fish Creek, a tributary entering Knik Arm to the north of the proposed. The personal use fisheries may consist of gill nets and/or dip nets, and target sockeye salmon. The methods and dates of the fishery vary according to run strength of sockeye salmon. The dip net fisheries generally operate from late June through early August on the Kasilof River, and from early to late July on the Kenai River. The Fish Creek personal use fishery only operates when more than 70,000 sockeye are projected to return to Fish Creek. The fishery has not opened since 2001.

The eulachon fisheries take place in salt water from April 1 through May 31, and in freshwater from April 1 through June 15. Eulachon may be harvested anywhere by dipnet, or in the Kenai River by drift gillnet. The herring personal use fishery is allowed in the Upper Cook Inlet management area from April 1 through May 31. Herring may be harvested by dipnet or gillnet in most places, but only by dipnet in Turnagain Arm.

Recreational fisheries

The proposed project area at Ladd lies in the West Cook Inlet management unit for sport (recreational) fisheries (Figure 4). Major fisheries exist for both coho and Chinook salmon on several rivers in the Unit, including several that are within 25 km of the Ladd area (Ivey and Sweet 2004). The Ladd area may also be relevant to fish populations migrating to or from the nearby Westside Susitna, Eastside Susitna, Knik Arm, and Anchorage units. Major species targeted in these units include Chinook, coho, and sockeye salmon, and rainbow trout.

The Chinook salmon recreational fishery is open from January 1 to June 30 within the West Cook Inlet management unit. The annual average harvest for the five years from 1998 through 2002 was 976 Chinook salmon in the entire Unit. Chinook salmon escapement goals have been set on the Lewis (250-800 fish), Theodore (500-1,700 fish), and Chuit (1,200-2,900 fish) rivers. The Chuit River is considered the best indicator of Chinook run strength in the Unit (Ivey and Sweet 2004).

Coho salmon recreational harvests averaged 11,308 fish per year from 1998 through 2002 in the West Cook Inlet management unit. The Kustatan (42% of total harvest) and Chuit (21%) were the major producers of salmon harvested during this 5-year period (Ivey and Sweet 2004). Other major fisheries include those on Polly Creek and the Theodore River. Escapement goals have not been developed for coho in any rivers within the Unit.

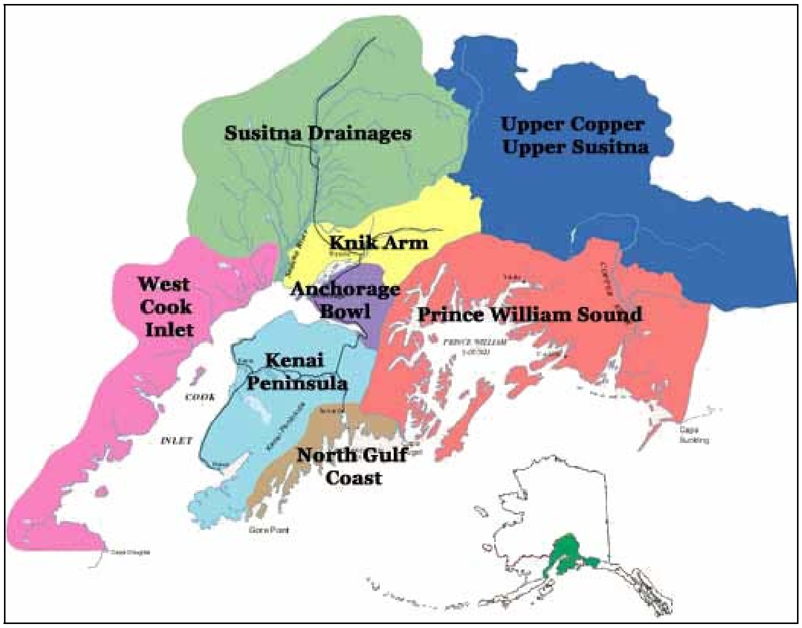

Figure 4. Southcentral Alaska recreational fishery management area, including units in Cook Inlet. Map provided by the ADF&G.

MARINE MAMMALS IN COOK INLET

Beluga Whales

Abundance

Abundance estimates for Cook Inlet beluga whales over the last several decades have ranged from 150-1300 whales. Estimates of historical population levels of Cook Inlet beluga whales are problematic, as surveys prior to 1994 yielding raw counts ranging from 150 to 479 (e.g. Klinkhart 1966; Harrison and Hall 1978; Murray and Fay 1979; Calkins 1979) were generally non-systematic or incomplete, and failed to correct for whales not seen below the surface (Rugh et al. 2000). As an approximation of historical abundance, NOAA Fisheries calculated an estimate of 1,293 beluga whales in 1978 (NMFS 2005). This number was based on a count of 479 whales from a 1978 aerial survey in Cook Inlet (Calkins 1979) with a correction factor of 2.7 developed for submerged beluga whales in Bristol Bay (DeMaster 2000), and was used to derive a value (1,300) for the beluga whale carrying capacity (K) of Cook Inlet to be used for management purposes (NMFS 2005).

From 1994 to the present, the National Marine Mammal Laboratory (NMML) has conducted annual systematic aerial surveys covering an estimated 13-33% of Cook Inlet, including a 3 km (1.9 miles) wide strip along shore and approximately 1,000 km (621 miles) of off-shore transects (Figure 5; Rugh et al. 2000, 2005). Surveys designed to coincide with known seasonal feeding aggregations were generally flown on 2-4 days per year in June-July at or near low tide in order to reduce the search area (Rugh et al. 2000). From June 2001 to June 2002, surveys were flown during most months in an effort to assess seasonal variability in beluga whale distribution within Cook Inlet (Rugh et al. 2004).

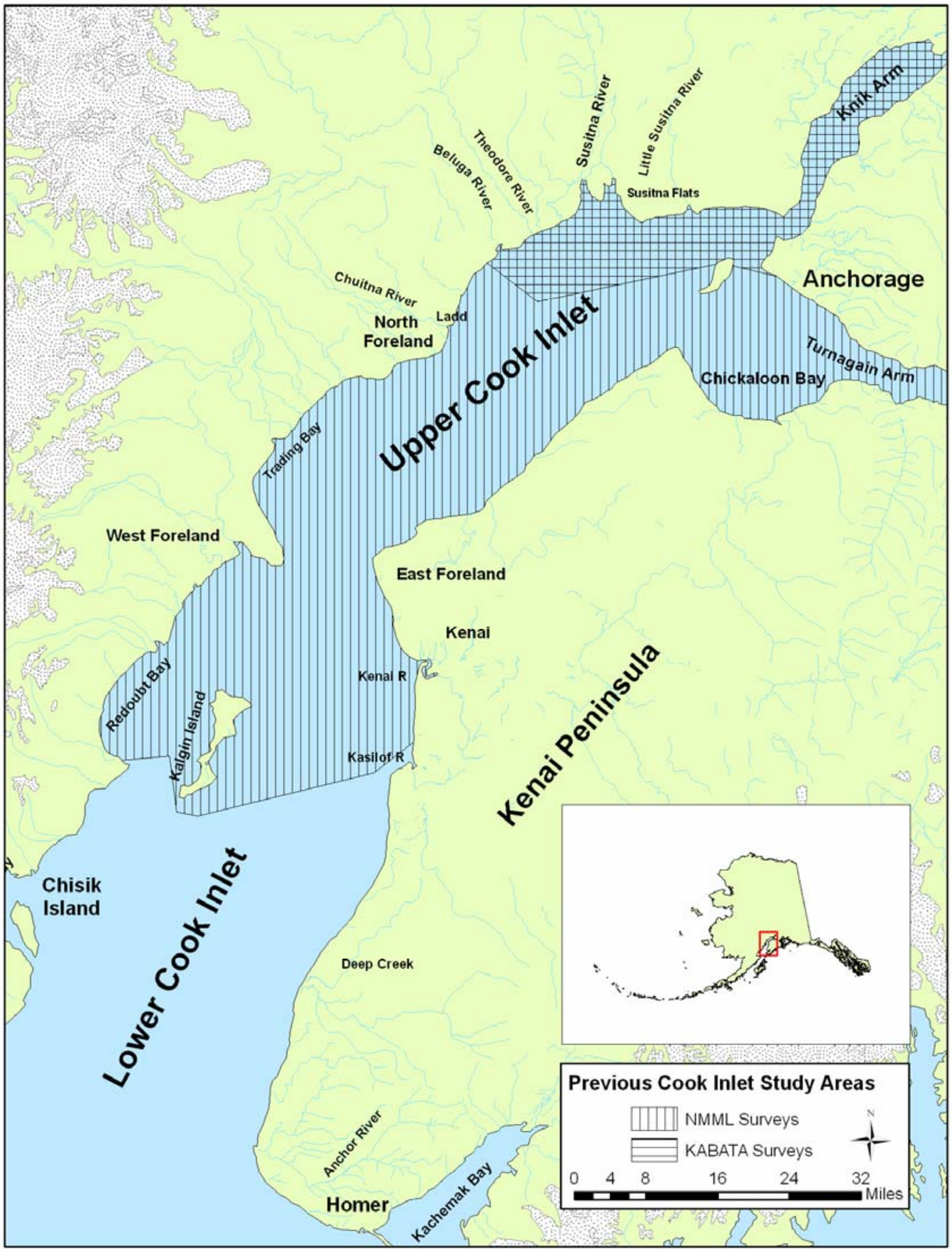

Figure 5. Locations of aerial (NMML surveys, Rugh et al. 2005) and boat-based (KABATA surveys, Funk et al. 2005) surveys during studies of Cook Inlet beluga whales.

Abundance estimates from these recent aerial surveys indicated an average population decline in Cook Inlet beluga whales of roughly 14% per year during the mid-1990s, followed by stabilization over the past several years (NMFS 2005). From 1994 to 1998, estimates of beluga whale abundance in Cook Inlet dropped from 653 to 347. Monte Carlo simulations indicated a 47% probability of a 50% decline in Cook Inlet beluga whales (Hobbs et al. 2000a). From 1998 to 2005, abundance estimates ranged from 278 to 435. The 95 % confidence interval on the 2005 abundance estimate was 194 to 398 (NOAA 2006, available online at http://www.publicaffairs.noaa.gov/releases2006/jan06/noaa06-r103.html). These estimates put abundance of beluga whales in Cook Inlet below the Optimum Sustainable Population (OSP) of 780 whales (60% of *K*) as defined by NOAA Fisheries. Current Cook Inlet abundance is estimated to be less than 50% of the OSP, resulting in the designation of Cook Inlet beluga whales as "depleted" under the Marine Mammal Protection Act (MMPA; Angliss and Lodge 2004).

Use and classification of habitat in Upper Cook Inlet

Historically beluga whales believed to be from the Cook Inlet population were reported in areas outside of the inlet such as Yakutat and Prince William Sound. In recent years the reduced population appears to be confined to the inlet. Current summer and fall activity is concentrated in the upper inlet where beluga whales congregate near the mouths of rivers and along tidal flats. Movements during the summer and fall appear to be influenced by the timing and location of eulachon and salmon runs (NMFS 2005) and tidal fluctuations (Funk et al. 2005). During the summer and fall beluga whales are concentrated near the Susitna River mouth, Knik Arm, Turnagain Arm, and Chickaloon Bay. Far fewer whales are observed during the winter months, possibly due to lower survey effort and reduced visibility resulting from the presence of ice. During the winter, beluga whales concentrate in deeper waters in the mid-inlet to Kalgin Island although occasional sightings are reported in the upper inlet in Knik and Turnagain arms.

NMFS is currently in the process of developing a habitat classification system in an attempt to quantify the relative importance of the various areas of Cook Inlet as beluga whale habitat. NMFS has developed a preliminary classification system in its Draft Conservation Plan (NMFS 2005) that describes and locates habitat types based on their perceived value as habitat for beluga whales (Figure 6). The habitat types range from 1 to 4 in descending order of "relative value" as proposed by NMFS (2005).

Type 1 habitat is termed "High Value/High Sensitivity" and includes what NMFS believes to be the most important and sensitive areas of the inlet for beluga whales and includes the mouth of the Susitna River, the east side of Knik Arm, and Chickaloon Bay. Type 2 habitat is termed "High Value" and includes summer feeding areas and winter habitats in water where whales typically occur in lesser densities or in deeper waters, where they may be less prone to disturbance. Type 2 habitat includes the west side of Knik Arm, Turnagain Arm, and the northern portion of Upper Cook Inlet (Figure 6). Type 3 habitat is located in offshore waters of the mid-inlet and near shore waters of the mid- and lower inlet. Type 3 habitat includes winter habitat areas, secondary summering sites, and historic sites. Type 4 habitat includes the open waters of the remaining portion of Lower Cook Inlet (Figure 6). The Ladd area is located in Type 3 habitat.

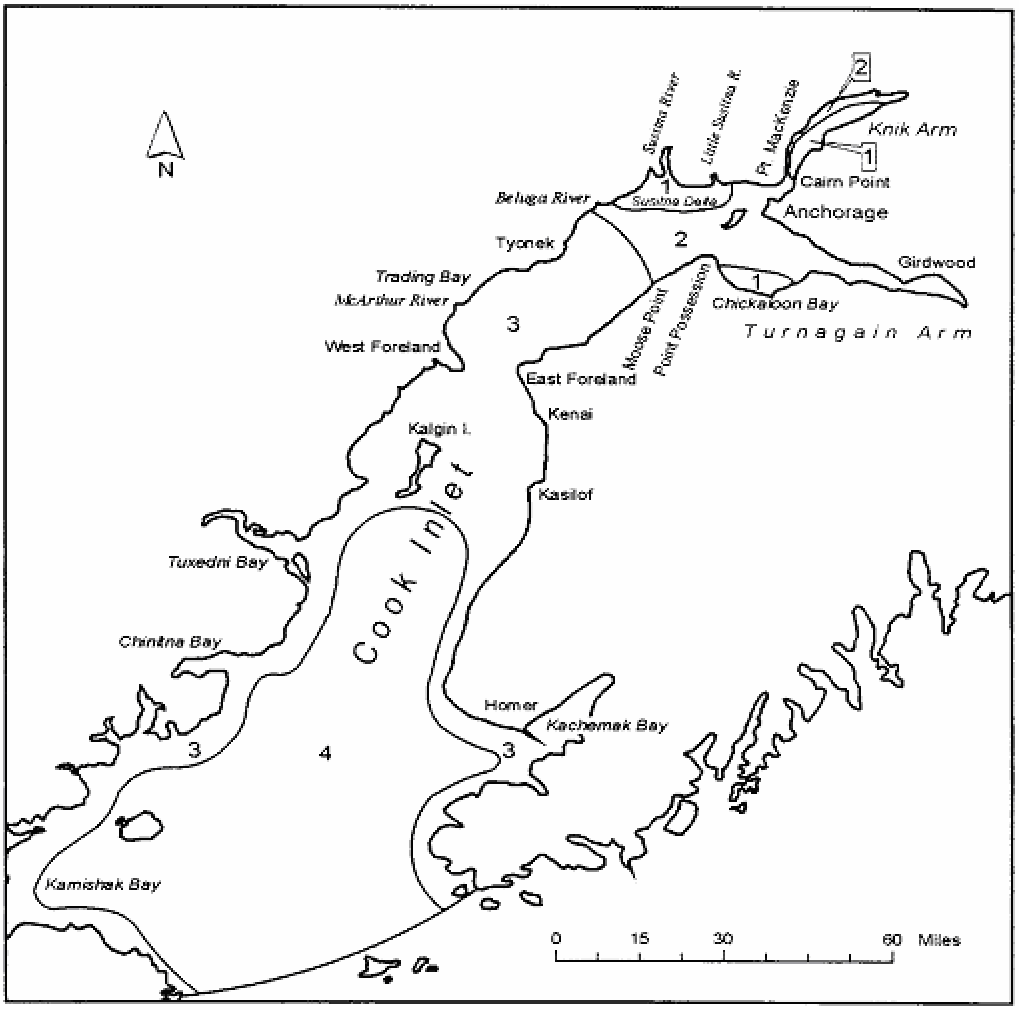

Figure 6. Locations of beluga whale habitats in Cook Inlet characterized as Types 1, 2, 3, and 4 by NMFS. The map is taken from the NMFS (2005) Draft Conservation Plan for the Cook Inlet Beluga (Delphinapterus leucas).

Distribution

Observations of Cook Inlet beluga whales outside of Cook Inlet and south of the Alaska Peninsula are rare, suggesting that the range of this stock is generally limited to Cook Inlet (Rugh et al. 2000). Historically, beluga whales have been sighted in both Upper and Lower Cook Inlet. In recent years beluga whales have been sighted more frequently in the upper inlet with some sightings in the middle portion of the inlet north of Kalgin Island (NMFS 2005). The range of beluga whales in Cook Inlet appears to have contracted over the past 30 years based on anecdotal information coincident with decreased abundance (Speckman and Piatt 2000).

Factors likely influencing beluga whale distribution within Cook Inlet include prey availability, predation pressure, sea ice cover and other environmental parameters, reproduction, sex and age class, and human activities (Rugh et al. 2000; Kingsley 2002). Seasonal movement patterns and site fidelity of beluga whales in Cook Inlet appear to be closely linked to prey availability, with whale distribution coinciding with salmon and eulachon concentrations (Moore at al. 2000).

Cook Inlet beluga whales display site fidelity to summer concentration areas, being reliably found in just a few areas each year (Seaman et al. 1985) typically near river mouths and the associated shallow, warm and low salinity waters (Moore et al. 2000). During annual aerial surveys conducted in June and July, most beluga whales were sighted in the Susitna River delta, Chickaloon Bay and Knik Arm (Rugh et al. 2000, Rugh et al. 2002; Figure 1). Spring aerial survey results indicate some inter-annual variability in whale distribution from 1993 to 2005, with the greatest number of whales counted during May-July in the Susitna delta in most years, but higher counts in Chickaloon Bay and Knik Arm in a few years.

During 2001-2002, nine aerial surveys conducted on 16 days spread evenly throughout the year indicated seasonal movement and residency patterns within the inlet (Rugh et al. 2004). Of the 33 beluga whale group sightings during these 9 aerial surveys, the greatest proportion occurred in the Susitna and Chickaloon areas in July, in Turnagain Arm in August, in Knik Arm in September, and in the mid-Cook Inlet between Point Possession and Kalgin Island in January through April.

These observations generally agree with less systematic information collected previously indicating that during winter and spring Cook Inlet beluga whales shift their distribution to the south and are more dispersed in the upper to middle, and possibly the lower reaches of Cook Inlet (Angliss and Lodge 2004; Moore et al. 2000). Historic records of beluga whales during winter months include sightings in the upper and mid-Cook Inlet during the winters of 1975-1977 (Harrison and Hall 1978; Calkins 1989). Beluga whale sightings in January have also been reported from offshore drilling platforms south of Tyonek (Rugh et al. 2000). In 1997, beluga whales were consistently sighted in mid-Cook Inlet (10 group sightings, mean group size =15 whales) during February-March aerial surveys (Hansen and Hubbard 1999). Beluga whales were noted in surveys of Lower Cook Inlet during September 1994-1996 (Bennett 1996).

Beluga whales may move seasonally in relation to sea-ice concentration in winter; however it has been suggested that sea ice may not be the most important factor in seasonal shifts in distribution (Moore et al. 2000). Lower counts of beluga whales during winter aerial surveys may be due in part to reduced sightability from obstruction by sea ice (Rugh et al. 2004).

Seasonal movements of 14 beluga whales in Cook Inlet from satellite tracking studies undertaken from 2000-2003 were described by Hobbs et al. (2005) and the general seasonal patterns were consistent with information reviewed above. All whales remained within Cook Inlet the entire time that they were tracked. During the study tags were applied between 29 July and 13 September and the number of tracking days varied among whales from 2 to 240. Several whales were tracked through March. The whales used Upper Cook Inlet intensively between summer and late fall and dispersed to mid-inlet offshore waters during the winter. Four whales moved as far south as the Kenai and Kasilof rivers, and Chinitna and Tuxedni bays during winter. During the summer and fall whales were concentrated in specific areas near the mouths of rivers or bays and traveled between Knik Arm, Turnagain Arm, and Chickaloon Bay.

Funk et al. (2005) conducted an intensive 1-year study for the Knik Arm Bridge and Toll Authority (KABATA) in Knik Arm and the northern portion of Upper Cook Inlet that characterized the timing and distribution of beluga whales in the study area (Figure 5). Seasonal patterns in Knik Arm were consistent with those identified by previous aerial and satellite tag information. In addition, Funk et al. (2005) identified a relatively strong tidal pattern of whale use of Knik Arm not previously described. Beluga whales were most abundant in Knik Arm during the late summer and fall (mid-August to November). During this time, beluga whales moved with the tides ranging as far up as Eklutna on flooding tides. As the tide ebbed the whales moved south to Eagle Bay and the Sixmile Creek area (Figure 1). They remained in this area during the low-tide period and then moved back to the upper arm at high tide. Whales were very rarely observed in Knik Arm during the winter and beluga whales occurred in low numbers in Knik Arm during the spring and early summer. Funk et al. (2005) also conducted periodic boat surveys of the Susitna River delta and found beluga whales there in the early summer before moving into Knik Arm and Turnagain Arm in the late summer and fall.

Beluga whale distribution and level of use at locations near the Ladd area (such as the Beluga and Susitna rivers) is relatively well known. Specific data describing beluga whale distribution and use of the Ladd area are results from a NMML satellite tracking study. The data are available online at http://nmml.afsc.noaa.gov/CetaceanAssessment/ceatdist.htm. Whales were captured and satellite transmitters were attached during the summer months. The data were limited by battery life and durability of the transmitters. The transmitter life ranged from approximately 2 days to 8 months (Hobbs et al. 2005).

The study was conducted from 1999 to 2003 and data are based on a small number of whales that were equipped with satellite tracking devices. One whale was tagged in late May 1999 and location data are available through most of September 1999. The whale remained primarily in the area between the Little Susitna River and the Beluga River until mid-August when it moved to Knik Arm. It remained in Knik Arm with occasional movements back to the Little Susitna River area until mid-September when it moved into Turnagain Arm and Chickaloon Bay. This whale approached the Ladd area in early July when it spent a few days near the Beluga River.

Two whales tagged in September 2000 both moved through the Ladd area at some time between September 2000 and mid-January 2001. One whale transited through or near the Ladd area several times during October through December but did not appear to linger in the area. The other whale spent most of the time in Chickaloon Bay and Turnagain Arm but transited near the Ladd area in mid- to late December.

In 2001, satellite data indicated that one of five tagged whales was located near the Ladd area for a few days in August, and a second whale spent a few days near the Beluga River in September. Most of the activity of tagged whales in September through November was concentrated in Knik and Turnagain arms and Chickaloon Bay. None of the tagged whales were again near the Ladd area until late November or early December. At this time, most whale satellite locations were scattered throughout much of Upper Cook Inlet excluding Knik and Turnagain arms. The same whale that was present near the Beluga River in September appeared to pass through the Ladd area in late November or early to mid-December. From mid- December through mid-March 2002, none of the tagged whales were recorded in the Ladd area, although whale locations were recorded in areas offshore of the Ladd area.

During 2002, satellite data are available for four whales from August through October, and for three whales from August through March 2003. Two transmitters were still active in April 2003 and one in May 2003. Transmitters on four other whales apparently failed by September. No tagged whales were recorded within the Ladd area in August 2002 although some whales were recorded in offshore locations. During September, three tagged whales spent some time near the mouth of the Beluga River, although most whale locations were recorded in Knik Arm, and to a lesser extent in Turnagain Arm, the Susitna Flats area, and Trading Bay. Two tagged whales appeared to use the Ladd area sporadically during October. No whale locations were recorded in the Ladd area during November; however tagged whales appeared to use areas near Ladd sporadically during December 2002 and January 2003. A tagged whale was again recorded sporadically near the Ladd area in April and near the Beluga River in May 2003.

Group size and structure

In Cook Inlet, as elsewhere, beluga whales are highly gregarious (NMFS 2005). Beluga whales observed in the Susitna area during annual June-July aerial surveys were found in only two groups in 6 of the 8 survey years and in 4-5 groups in other years (Rugh et al. 2000). More than 20 whales were present in these groups 71% of the time ($n = 17$; Rugh et al. 2000). However these surveys were conducted when the whales were known to be grouped in seasonal feeding aggregations and group size may be reduced at other times of the year. Smaller groups are also commonly observed in the Upper Cook Inlet, traveling or resting together (Hobbs et al. 2000b). Social structure and genetic relationships among group members have not been examined thoroughly to date, although native hunters have noted that belugas apparently form consistent family groups with whales of different ages traveling together (Huntington 2000).

Funk et al. (2005) reported 14 groups of over 25 whales and one group of about 100 whales in Knik Arm during the August through November 2004 period. During summer 2005, seven groups of over 50 and three groups of over 100 whales were observed during boat surveys in the Susitna area.

Representation by age class and sex is not well known for the beluga whales of Cook Inlet. During aerial surveys conducted in the mid-inlet during 1978, Murray and Fay (1979) estimated a ratio of 1:6 immature to mature beluga whales based on the proportion of gray whales in counts. However, such counts may underestimate sub-adult representation due to difficulty detecting smaller, darker juvenile whales from the air in the highly turbid waters of Cook Inlet. Mahoney and Shelden (2000) compiled data on size and sex for a small sample ($n = 34$) of the whales harvested from 1992-1998, and age estimates based on dentin layers in the teeth of half of these whales. Mean length was 12.1 ft (3.7 m), range 8-15 ft (2-5 m); mean estimated age was 10.5 years; the sex ratio of males to females was 1.27:1 (based on tabular data from Mahoney and Sheldon 2000). Native hunters interviewed in 1998-1999 reported seeing a greater proportion of gray whales than they recalled from the past, perhaps indicative of a shift in beluga whale age class distribution caused by high levels of adult whale harvest in the 1990s (Huntington 2000). Funk et al. (2005) reported that adults comprised 40-75% of the whales in Knik

Arm and subadults comprised 20-50%. Calves represented 0-15% of the whales observed in Knik Arm. In the Susitna area, adults comprised 65-70% of the whales observed, and subadults and calves comprised 25-30% and 5% of the observed whales, respectively.

Reproduction

As elsewhere, beluga whales in Cook Inlet reproduce seasonally. The calving season has been estimated to last from mid-May to mid-July (Calkins 1983). During interviews, Alaska Natives reported a slightly more extended calving period lasting from April through August, with calving believed to take place in Kachemak Bay in the lower inlet in April and May, off the Beluga and Susitna Rivers in May, and in Chickaloon Bay during the summer (Huntington 2000). Belugas with near-term fetuses have been harvested in the Susitna delta in May and neonates are seen there throughout the summer, indicating that the area may be important for calving or nursing (Huntington 2000). Mating is thought to follow the calving period (NMFS 2005).

Feeding Ecology

<u>Feeding Behavior</u>

Beluga whales appear to feed most efficiently in summer months, possibly building up energy reserves for the winter. Belugas are reported by Native hunters to have only 5-7.6 cm (2-3 inches) of blubber in April and May but up to 30.5 cm (12 inches) in the fall (Huntington 2000). Beluga whales are commonly found in shallow estuaries but also occur in deep submarine canyons where they may dive to depths of 800 m (2,625 ft; Reeves et al. 2002). Beluga whales feed throughout the water column and on the sea floor, often congregating at river mouths and estuaries during seasonal fish runs. Beluga whales appear to focus their foraging efforts at streams and rivers where fish are highly concentrated (Fried et al. 1979; Hazard 1988; NMFS 2005). During the spring and summer beluga whales prey on salmon and eulachon, often entering river channels on the high tide to capture fish (Huntington 2000). Funk et al. (2005) reported beluga whales feeding at low tide in Eagle Bay and Sixmile Creek area in Knik Arm.

<u>Prey of Cook Inlet Belugas</u>

Beluga whales are known to feed on a wide variety of fish species and other marine organisms including octopus, squid, crabs, shrimp, clams, mussels, snails, and sandworms (NMFS 2005 and references therein). Pauly et al. (1998) reviewed the literature on diet composition of marine mammals and characterized beluga whale diet as being composed of 20% benthic invertebrates, 5% small squid, 5% large squid, 20% small pelagic fishes, 10% mesopelagic fishes (predominantly fish of the family Myctophidae and other groups of the deep scattering layer), and 40% miscellaneous fish consisting mainly of demersal groundfish such as gadoids and perciforms, but also including anadromous fishes. NMFS (2005) reported that beluga whale prey species include capelin, cod, herring, smelt, flounder, sole, sculpin, lamprey, lingcod, and salmon.

The diets of beluga whales in Baffin Bay and the St. Lawrence estuary varied by age class (Kleinenberg et al. 1964; Lesage et al. 2001). In the St. Lawrence estuary, analyses of stable isotope ratios indicated that males occupied a higher trophic level than females, suggesting use of different foraging habitats by the two sexes during the summer (Lesage et al. 2001). Differential feeding habits by age and sex class were also reported in Alaska, where sub adult beluga whales fed on small prey such as shrimp, adult females more often consumed small fish, and adult males generally preyed on larger fish such as adult salmon (Lowry et al. 1985).

In 1986, 13 spaghetti tags deployed on adult salmon migrating up the Susitna River were collected from the stomach of a male beluga found dead in Cook Inlet (Calkins 1989). Native hunters found adult Chinook salmon up to 1.2 m (4 ft) in length in the stomachs of harvested whales (Huntington 2000). Stomach content analyses have also identified eulachon in a large proportion of belugas examined by NOAA Fisheries (Moore et al. 2000). Eulachon represent a lipid-rich food source, and occur in large numbers during two spawning runs of several hundred thousand to several million at the Susitna River each May and July (Calkins 1989; NMFS 2005). Anecdotal reports of beluga whales feeding in Cook Inlet indicate a diet also including Pacific herring, Pacific tomcod (*Microgadus proximus*), lingcod, steelhead trout, flatfish and whitefish (Huntington 2000; Morris 1992; NMFS 2000).

There is little information on winter diet of beluga whales in Cook Inlet. Stomach contents of a beach cast whale in April included saffron cod, walleye pollock, Pacific cod, eulachon, tanner crab (*Chionoecetes bairdi*), bay shrimp (*Crangon franciscorum*), and polychaetes (NMFS 2005). Houghton et al. (2005a) conducted beach seine sampling in the Knik Arm of Upper Cook Inlet during the summer and fall of 2004 and the summer of 2005. Based on extrapolations of data collected in 1983 (Dames and Moore 1983) and on their own data, Houghton et al. (2005a) determined the fish species that were available and mostly likely to comprise Cook Inlet beluga whale diets in Knik Arm by month (Table 1).

Natural Mortality

Stranding events

Stranding events are fairly common in Cook Inlet, with reports of 804 beluga whale strandings in Upper Cook Inlet (primarily in Turnagain Arm) since 1988 (NMFS 2005). Most mass strandings coincide with spring tides, during which whales may be beached for 10 hours or more (NMFS 2000). Although most whales survive these stranding events, at least 129 mortalities have been associated with stranding in this 17-year period (7.6 per year, NMFS 2005). Stress, hyperthermia and damage to internal organs were often the causes of death (NMFS 2005).

Predation

Killer whales in Cook Inlet prey on beluga whales (Shelden et al. 2003). In 1993, a stranded killer whale found in Turnagain Arm regurgitated a large piece of beluga flesh before dying (NMFS 2000; Shelden et al. 2003). Although local observations of killer whale predation are uncommon (NMFS 2000; Huntington 2000), studies indicate a mean mortality rate exceeding one beluga whale per year (from 1985 to 2002) due to killer whale predation and/or stranding to avoid killer whales (Shelden et al. 2003). Stranding events have been correlated with the presence of killer whales, and Native hunters believe that belugas intentionally strand themselves in order to escape killer whale predation (Huntington 2000).

Disease

Necropsied Cook Inlet beluga whales have been found to host a variety of endoparasites, including nematodes, trematodes, cestodes and acanthocephalans (NMFS 2000). The relative importance of these organisms in beluga whale mortality rates is unknown.

Under-ice Entrapment

Cook Inlet beluga whales are not generally prone to entrapment in sea ice. Sea-ice entrapment has been known to cause mortality in arctic beluga populations (Moore et al. 2000).

Human Impacts

Subsistence Hunting/Commercial Whaling

The beluga whale is one of three whale species hunted by Native Americans in the United States in recent years (Lavigne et al. 1999). Alutiiq and Dena'ina Athabaskan Indians have lived in and utilized the marine resources of the Cook Inlet area since prehistoric times, harvesting beluga whales each year (Mahoney and Sheldon 2000). In the 1930s and 1940s, the Dena'ina in Tyonek harvested about 6-7 whales per year (Fall et al. 1984). An approximate harvest rate from 1940-1979 has been estimated at 10 whales per year, but there is little supporting documentation from beluga whale hunts at the time (Hazard 1988). Increasing Native population in the Anchorage area combined with more efficient hunting methods may have led to increased hunting pressure on the Cook Inlet beluga population beginning in the early 1990s (Mahoney and Shelden 2000). From 1994 to 1998, NMFS estimated 67 whales per year (range 21-98) were taken, a number sufficiently high to account for the estimated 14% annual decline of Cook Inlet beluga whales during this time (NMFS 2005). Actual mortality may have been higher, given the difficulty of estimating the number of whales struck and lost during the hunts (DeMaster 2000). Hammill et al. (2004) suggested that declines in the Hudson Bay beluga whale population in recent years were also due to high harvest levels. During 1999 and 2000, the subsistence harvest was zero due to self-imposed limits and federal guidelines. Native subsistence harvests continue at very low levels (currently a maximum of two whales per year), and will continue to be permitted so long as the hunting does not interfere with stock recovery (NMFS 2005).

In the early to mid-1900s, small scale commercial hunting of beluga whales also occurred in Cook Inlet. In the early 1900s a few hundred beluga whales were harvested commercially over a number of years, followed by a period of 20-30 years without commercial harvest and small-scale harvests resuming during the 1940s and 1950s. Sport hunting of a small number of whales took place in the early 1960s, but was already declining by the mid-1960s prior to being outlawed with the passage of the Marine Mammal Protection Act in 1972 (Mahoney and Sheldon 2000).

Interactions with Fisheries

Direct and indirect interactions of marine mammals with fisheries are a concern for resource managers worldwide. In Alaska, interactions have been noted between a number of cetaceans and fisheries, including killer whales, Pacific white-sided dolphins(*Lagenorhynchus obliquidens*), Dall's porpoises (*Phocoenoides dalli*), minke whales (*Balaenoptera acutorostrata*), and gray whales (*Eschrichtius robustus*; Northridge and Hofman 1999). While indirect interactions may occur regularly, direct interactions between beluga whales and fisheries resulting in mortality in Cook Inlet appear to be fairly infrequent. From 1979 to 1983, an estimated 3-6 beluga whales per year died due to salmon gillnet entanglement in Cook Inlet (NMFS 2000; Burns and Seaman 1985). Single beluga whales became entangled in nets near Fire Island in July 1989, near the Susitna River in July 1990, and in the Kenai area in August 1996 (Moore et al. 2000). Marine mammal observers at drift and set gillnet salmon fisheries in Cook Inlet during 1999 and 2000 reported no interactions between beluga whales and gear (Payne 2002). During 141 days of observation in 1999, only three sightings of beluga whales were made at gillnet set locations in the Upper Cook Inlet (Moore et al. 2000; NMFS 2000). No interactions between beluga whales and fishing gear were reported by observers on northern Gulf of Alaska groundfish trawl, longline or pot fisheries (NMFS 2000). Direct mortality due to vessel strikes and fishing net entanglements rarely occur in Cook Inlet and do not appear to significantly impact beluga whales at present (NMFS 2000; Moore et al. 2000).

Contaminants

Although Cook Inlet beluga whales spend a greater proportion of the year in proximity to urban areas than other beluga populations, they carry relatively low levels of potentially toxic contaminants. Cook Inlet beluga whales had lower concentrations of polychlorinated biphenyls (PCB's) and heavy metals in their blubber and livers than those found in other beluga whale stocks (Becker et al. 2000). PCB levels of Cook Inlet beluga whales were roughly half those of beluga whales in the Alaskan Arctic, and much lower than the St. Lawrence estuary population.

Anthropogenic Noise

Human-made sounds potentially affecting beluga whales include vessel and aircraft noise, dredging and construction activities, oil and gas exploration and production, geophysical surveys, sonar, explosions, and ocean science studies. Although beluga whales can detect a wide range of sound frequencies, including frequencies as low as 40-75 Hz at relatively high decibel levels (Awbrey et al. 1988; Johnson et al. 1989), their hearing is most acute in the 10-100 kHz range (Richardson et al. 1995; Tyack 2000), well above the frequency at which the energy of most industrial noise is focused.

Other than a few observations of beluga whale responses to vessel noise in the high Arctic (Finley et al. 1990), quantitative data on beluga whale reactions to anthropogenic noise are limited. However, a number of studies on the effects of noise exposure on the hearing of captive beluga whales indicated that noise of sufficient decibel level and duration can cause shifts in the hearing thresholds of beluga whales (Finneran et al. 2000, 2002, 2005). These shifts in hearing threshold were temporary at the sound levels tested and the whales' hearing thresholds generally returned to pre-exposure levels within minutes. In Knik Arm, ambient background noise from currents and glacial silt partly mask some noises, and rapid sound attenuation is likely due to shallow water depths and soft substrate (Blackwell and Greene 2002, in NMFS 2005).

Population level impacts, if any, of anthropogenic noise on beluga whales are unknown. Blackwell and Greene (2002) observed beluga whales swimming within a few meters of the hull of a docked cargo freighter in the Port of Anchorage. Lerczak et al. (2000) reported that even when being pursued by power boats during tagging operations in Cook Inlet, the whales did not leave the immediate area. If the pursuit vessel stopped, the whales would approach to within 100 m after approximately 15 minutes, and if the engines were stopped the whales would approach closely or pass under the boat.

Other Disturbance

Due to the proximity Cook Inlet beluga whales to human population centers and industry, habitat degradation has been noted as a possible threat to this stock (Norris 1994). Although coastal development may change near shore habitats in Cook Inlet, there are presently few data available on potential effects of development, positive or negative, on beluga whales (NMFS 2005).

Other Marine Mammal Species

Beluga whale is the most abundant and commonly observed marine mammal species in Upper Cook Inlet. Other marine mammal species that are likely to occur in Upper Cook Inlet include harbor seal, Steller seal Lion, harbor porpoise, and killer whale.

Harbor Seal

The Gulf of Alaska stock of harbor seals, which includes Cook Inlet seals, is not classified as a strategic or depleted stock and is not listed under the Endangered Species Act (ESA; Angliss and Lodge 2004). The most recent population estimate for this stock was 28,917 harbor seals in 1998 (Angliss and Lodge 2004). They occasionally forage near river mouths during salmon runs in the summer and fall and are sometimes found in freshwater habitats. Harbor seals haulout at traditional sites on tidal flats, and coastal or offshore rocky areas. Female harbor seals give birth at the haulout sites that sometimes contain large numbers of seals.

Harbor seals are more abundant in Lower Cook Inlet than in the upper inlet, but they also occur in Upper Cook Inlet throughout the year. A traditional haulout site is located near the West Forelands, although harbor seals have also been reported to haulout intermittently near the Susitna Flats and in Turnagain Arm at Chickaloon Bay (D. Rugh 2005, pers. comm.; NOAA Fisheries, unpublished data). Small numbers of harbor seals have also been reported in Knik Arm. In annual marine mammal surveys conducted by NOAA Fisheries from 1994 to 2005, there were 3 sightings of harbor seals in Knik Arm (unpublished data, NOAA Fisheries, D. Rugh 2005). Twenty-two sightings of harbor seals were reported during baseline studies in Knik Arm over a 13 month period (LGL, unpublished data). These sightings occurred during October and September 2004 and June through September 2005.

Steller Sea Lion

The western U.S. stock of Steller sea lions, which includes Cook Inlet, is listed as "endangered" under the Endangered Species Act (ESA) and "depleted" under the Marine Mammal Protection Act (MMPA). The western stock is distributed throughout the Bering Sea, the North Pacific Ocean, and the Gulf of Alaska east to 144°W (Loughlin 1997). The most recent minimum estimate (2001-2002) of this population was 34,779 animals, including pups (Angliss and Lodge 2004).

Steller sea lions range from California through the North Pacific Ocean and the Bering Sea to Japan. They are most abundant in the Aleutian Islands and the Gulf of Alaska. Steller sea lions occur in coastal and pelagic areas, and use protected haulout areas for resting and pupping. They are not known to migrate, but may move great distances on occasion. Typically they move from exposed outer coastal areas used in the summer to more protected areas in the winter. Steller sea lions feed on a wide variety of schooling and groundfish including walleye pollock, Pacific cod, Atka mackerel, sculpin, capelin, sand lance, rockfish, Pacific herring, and salmon, as well as invertebrates such at octopus and squid.

Steller sea lions are more abundant in Lower Cook Inlet than in the upper inlet. Steller sea lion critical habitat has been established at locations in the southern portion of Lower Cook Inlet. This habitat includes a 20 nautical mile buffer around all major haulouts and rookeries. Haulouts and rookeries are located in Prince William Sound, the south side of the Kenai and Alaska peninsulas, Kodiak Island, and throughout the Aleutian Islands. Haulouts in the Lower Cook Inlet area are located near the mouth of the inlet at Gore Point, Elizabeth Island, Perl Island, the Barren Islands, and Chugach Island. Steller sea lions gather on traditional rookeries from mid-May through mid-July to give birth and breed. No haulouts occur in Upper Cook Inlet and animals are rarely sighted north of Nikiski.

Harbor Porpoise

Harbor porpoises are small cetaceans reaching lengths of approximately 1.5 meters (4.9 ft) as adults. They mate sometime between July and August and give birth between May and July of the following year to a single calf (Boyd et. al 1999). They are often observed in harbors, bays and near river mouths but may also occur in offshore areas. Harbor porpoises feed on a variety of schooling fish with herring of primary importance. Squid is also important in harbor porpoise diets (Bowen and Siniff 1999).

Harbor porpoises occur throughout Alaska waters (Lowry et al. 1982). The Gulf of Alaska stock of harbor porpoises, which includes Cook Inlet animals, is not classified as a strategic or depleted stock and is not listed under the ESA (Angliss and Lodge 2004). In 2000, the minimum population estimate for the Gulf of Alaska stock was 25,536 animals (Angliss and Lodge 2004). Dahlheim et al. (2000) estimated 136 animals during vessel-based surveys for an average density of 0.72 harbor porpoises per 100 km^2 (38.6 mi^2) for all of Cook Inlet in 1991. Harbor porpoises occur in Upper Cook Inlet throughout the year in small numbers but are more abundant in the lower inlet.

Small numbers of harbor porpoises were reported incidentally in Upper Cook Inlet during a recent study of beluga whales. This included four harbor porpoise sightings in

Knik Arm during a one-year study and a dead harbor porpoise found floating in the near-shore waters north of Eagle Bay in (LGL Alaska Research Associates, Inc., unpublished data). The number of harbor porpoises using Knik Arm is unknown but appears to be low.

Killer Whale

The Eastern North Pacific Stock of killer whales includes transient and resident killer whales in the Gulf of Alaska and Cook Inlet. The stock is not classified as a strategic or depleted stock and is not listed under the ESA (Angliss and Lodge 2004). Killer whales feed on fish and marine mammals and are sometimes divided into populations based on differences in diet. The killer whales found in Cook Inlet are included as part of the Eastern North Pacific stock for assessment purposes. In 2000, the "resident" (i.e. fish consuming) stock minimum population estimate was 723 animals. In 2001, the "transient" (marine-mammal consuming) stock minimum population estimate was 346 animals (Angliss and Lodge 2004).

Killer whale males reach lengths of nearly 6 m (19.7 ft) at sexual maturity. Females reach almost 5 m (16.4 ft). Killer whales in the Northeast Pacific typically give birth to a single calf approximately 2.5 m (8.2 ft) long sometime between October and March following a 12-15 month gestation period (Boyd et al. 1999). However, some groups are known to calve year-round (Reeves et. al 2002). Males live 50-60 years and females may live to age 90. Highly social animals, matrilineal pods of animals cooperate when hunting and protect and teach younger members. Males may be solitary or associated with a family pod (Reeves et. al 2002).

Killer whales are rare in Upper Cook Inlet. The number of killer whales using Knik Arm is unknown but is suspected to be low. Shelden et al. (2003) reported 11 sightings of killer whales in Upper Cook Inlet from the Susitna Flats east into Turnagain Arm and north into Knik Arm over the last 20 years. Two of these sightings were recorded in the southern portion of Knik Arm. There were no killer whale sightings during two recent marine mammal studies in Upper Cook Inlet and Knik Arm (Funk et al. 2005; Ireland et al. 2005).

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