Harbor Porpoise, *Phocoena phocoena vomerina,* in Cook Inlet, Alaska

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Introduction

The harbor porpoise, *Phocoena phocoena*, is among the smallest of the six porpoise species in the Family Phocoenidae, with an adult length of 1.4 m to 1.9 m (4.6–6.2 ft). They are rotund, have a stubby beak with small, spade-shaped teeth, and a triangular-shaped dorsal fin (Fig. 1). In general, their dorsal surface is dark gray, becoming lighter gray on the sides, with a white under-belly. The sounds they make when breathing have earned them the nickname "puffing pig." This species is rarely active at the surface but instead presents a low profile when surfacing and often travels alone (Leatherwood et al., 1982). They generally forage on small, pelagic schooling fish in waters less than 200 m (656 ft) deep (Bjørge and Tolley, 2008).

The species is widespread in the Northern Hemisphere, inhabiting coastal and inland waters. There may be as many as four distinct subspecies, of which *P. p. vomerina* Gill, 1865 occurs in the eastern North Pacific (Rice, 1998; Perrin[1]). Alternately referred to

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[1]Perrin, W. 2010. *Phocoena phocoena vomerina* (Gill, 1865). *In* Perrin, W.F. World Cetacea Database. World Register of Marine Species. (Available at: http://www.marinespecies.org/aphia.php?p=taxdetails&id=383568 accessed 2 Sept. 2011).

ABSTRACT—Harbor porpoise, Phocoena phocoena vomerina, *in Cook Inlet, Alaska, are managed as part of the Gulf of Alaska (GOA) stock. It is not known if this population is distinct from porpoise in the GOA stock found outside Cook Inlet. No long-term dedicated studies of harbor porpoise have occurred in Cook Inlet. The objective here is to provide a summary of occurrence in Cook Inlet derived from archaeological data, anecdotal reports, and systematic surveys. Maps were created for each dataset. For 1,500 years, Alutiiq Eskimo subsistence societies occupied lower Cook Inlet until abandoning the region around 600 A.D. During that time, harbor porpoise exploitation increased and eventually made up over one-third of the faunal remains by number at midden sites. The Dena'ina and Chugach Alutiiq continued porpoise hunting into the period of early contact in the late 1700's, after which there is no mention of continued exploitation. Harbor porpoise were rarely mentioned in expedition accounts collected by naturalists in the late 1800's and early 1900's.*

Beginning in 1958, pelagic fur seal, Callorhinus ursinus, *investigators collected cetacean sightings in Alaska waters when seals were not present. However, none of the harbor porpoise sightings occurred in Cook Inlet. With the exception of one net entanglement in upper Cook Inlet in 1956, sightings and strandings (including fisheries bycatch) were not reported in the inlet until the mid-1970's. Interactions with fisheries factored in a quarter of the stranded animals recovered in Cook Inlet.*

Systematic surveys of bird and marine mammal populations increased during the 1970's and continued sporadically to the present day. One dedicated harbor porpoise aerial survey conducted in August 1991 estimated the population at 136 (CV = 63.2%), but this survey did not include the shoreline and many of the bays throughout Cook Inlet. An uncorrected abundance of 249 (CV = 60.7%) in June 1998 was based on offshore sightings obtained during beluga whale, Delphinapterus leucas, *aerial surveys. The largest abundance estimate, 428 harbor porpoise (95% C.I. 26–830), was obtained during vessel surveys designed to count seabirds in lower Cook Inlet during the summer of 1993. Harbor porpoise sighting rates, abundance, and density estimates often were limited by survey area, effort, research platform, and study design. Therefore, each of these estimates is likely biased downward.*

In the last decade the region has seen expansion of the Port of Anchorage, proposals to build a bridge crossing Knik Arm, plans to develop mining operations and supporting infrastructure, hydrokinetic energy generation proposals, oil and gas seismic exploration, and water quality effects from urban areas. The overall effect on harbor porpoise within the confines of Cook Inlet cannot be fully determined until we understand the genetic and demographic population structure of this highly mobile and cryptic species.

Figure 1.—A harbor porpoise, *Phocoena phocoena* (photo courtesy of Ari Friedlaender).

as *Phocoena vomerina* in the literature[2], this synonym is no longer accepted (Perrin[3]). In the eastern North Pacific, harbor porpoise range from California to Alaska, with at least 10 distinct stocks identified within this range (Carretta et al., 2009; Allen and Angliss, 2010). The regional differences between stocks, based on genetic analyses (Rosel et al., 1995; Chivers et al., 2002; Chivers et al.[4]), pollutant residues (Calambokidis and Barlow, 1991), and discontinuities in density, suggest that, unlike the North Atlantic porpoise, *P. p. phocoena*, eastern North Pacific porpoise are not panmictic or migratory. In Alaska waters, harbor porpoise stock structure is unclear, and three stocks are currently recognized for management purposes: Southeast Alaska, Gulf of Alaska (GOA), and Bering Sea (Allen and Angliss, 2010). Porpoises found in Cook Inlet are included in the GOA stock (Fig. 2).

The Cook Inlet region has experienced increasing anthropogenic impacts over the past decade. The National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) is responsible for the management, conservation, and protection of living marine resources within the United States' Exclusive Economic Zone (water three to 200 miles offshore). Given that little is known about harbor porpoise in Cook Inlet and no long-term dedicated studies have occurred in this area, the objective here is to elevate the profile of this cryptic species by providing a summary of harbor porpoise occurrence in Cook Inlet derived from archaeological data collected in the northern GOA, anecdotal reports, and systematic surveys.

Methods

Records of harbor porpoise within Cook Inlet were obtained from a number of sources: zooarchaeological and ethnographic studies, anecdotal accounts of sightings and strandings, and sightings collected during dedi-

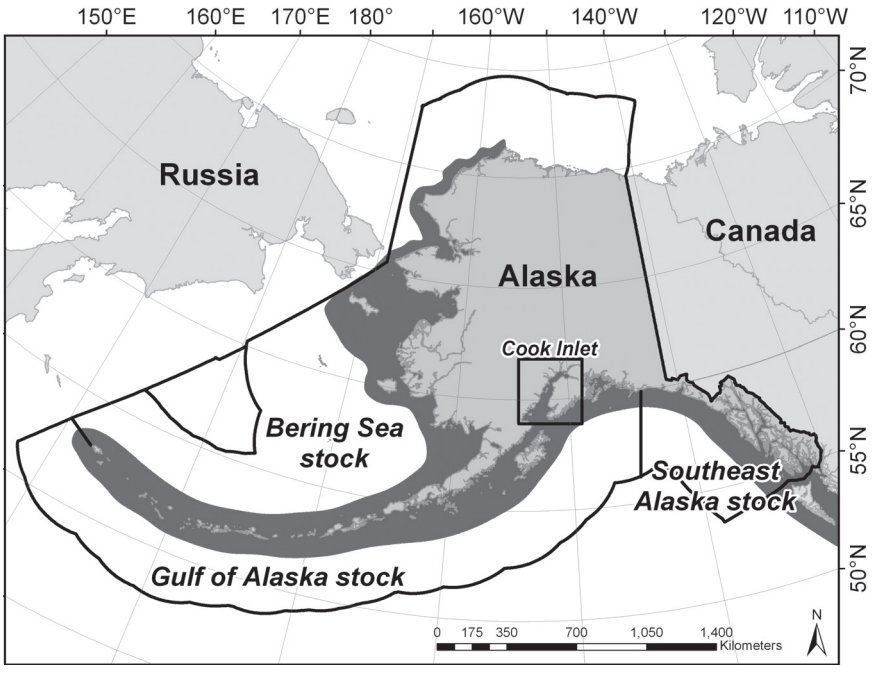

Figure 2.—Range (dark region) of the three Alaska stocks of harbor porpoise.

[2]Biodiversity Heritage Library (Available at: http://www.biodiversitylibrary.org/name/Phocoena+vomerina accessed 2 Sept. 2011)

[3]Perrin, W. 2010. *Phocoena vomerina* Hall & Kelson, 1959. *In* Perrin, W. F. World Cetacea Database. World Register of Marine Species. (Available at: http://www.marinespecies.org/aphia.php?p=taxdetails&id=384302 accessed 2 Sept. 2011).

[4]Chivers, S. J., B. Hanson, J. Laake, P. Gearin, M. M. Muto, J. Calambokidis, D. Duffield, T. McGuire, J. Hodder, D. Greig, E. Wheeler, J. Harvey, K. M. Robertson, and B. Hancock. 2007. Additional genetic evidence for population structure of *Phocoena phocoena* off the coasts of California, Oregon, and Washington. U.S. Dep. Commer., Natl. Mar. Fish. Serv., Southwest Fish. Sci. Cent. Admin. Rep. LJ-07-08, 16 p.

cated marine mammal and seabird surveys. Maps for each dataset were created using ArcView geographical information system software (ESRI[5]). For some datasets, maps were recreated by scanning figures and saving the resulting images as JPEG files. These files were imported into ArcMap as a raster data set layer and saved as a georeferenced map. Effort lines and sighting locations were digitized as graphics and then converted to shapefiles. Plots showing sighting locations were projected using the Alaska Albers Equal Area Conic coordinate system, which provided a more accurate depiction for area-use measurements. Each sighting record on these plots represented a sighting location, not total number of porpoise seen. Maps of Cook Inlet included all available data collected north of lat. 59° N.

Study Area

Cook Inlet, Alaska, (lat. 59°–61.5° N, long. 149°–154° W) is a semi-enclosed tidal estuary covering an area of approximately 20,000 sq. km with 1,350 km of shoreline (Fig. 3). The inlet extends about 370 km southwest from Knik Arm to Cape Douglas and has marine connections with Shelikof Strait and the GOA and freshwater input from many large rivers. In lower Cook Inlet, south of the Forelands, bathymetry consists of an elongated trough (15–30 m deep) that bifurcates around Kalgin Island, with shallow platforms (≤10 m) on either side (Fig. 3). South of Chinitna Bay, the main channel deepens to roughly 70–100 m and widens to extend across the mouth of Cook Inlet from Cape Douglas to Cape Elizabeth; it then slopes downward into Shelikof Strait. In contrast, the bathymetry of the inlet north of the Forelands is predominated by shallow river deltas with a single trough extending into the upper inlet.

Tides in Cook Inlet are semi-diurnal, with two unequal high and low tides per tidal day (tidal day = 24 h 50 min). The mean diurnal tidal range varies from roughly 6 m (19 ft) at Homer to 9.5 m (30 ft) at Anchorage. Three tidal rips (west, midchannel, and east) are commonly observed east of Kalgin Island, extending south to Chinitna Bay. Tidal bores of up to 3.2 m (10 ft) occur in Turnagain Arm. Surface circulation in upper Cook Inlet is driven by the mixing of incoming and outgoing tidewater combined with freshwater inputs. A southward flow along western lower Cook Inlet is due to the Coriolis Force acting on freshwater entering the upper inlet from several large rivers. The Alaska Coastal Current (ACC) flows along the inner shelf in the western GOA and flows northward along the eastern side of Cook Inlet (Fig. 3). The relatively fresh turbid upper Cook Inlet outflow meets and mixes with the incoming ACC water in the central inlet. This mixture flows along western Cook Inlet and outflows to Shelikof Strait.

Sea ice generally forms in October–November, reaches its maximum extent in February, then recedes and melts in March–April. Ice formation in upper Cook Inlet is driven by air temperature, while the air/water temperature and inflow rate of the ACC influence sea-ice formation in the lower inlet. Tidal action and tidal currents often shatter sea ice in Cook Inlet to the extent that there is seldom uniform cover.

Anchorage is the largest city and port in Alaska and the inlet also hosts many fisheries and oil and gas platforms.

Zooarchaeological Surveys and Ethnographic Studies

Stratified refuse mounds known as "middens" provide evidence of a long-established Eskimo culture on the Pacific bays and islands of southern Alaska. Papers describing excavation sites in Cook Inlet were reviewed for proof of harbor porpoise use by these subsistence societies. Ethnographic studies that recount harbor porpoise hunting techniques and use patterns during the period of first contact in the late 1700's were also summarized.

Anecdotal Accounts

In the late 1800's and early 1900's, expeditions to Alaska were undertaken by the U.S. National Museum, U.S. Coast and Geodetic Survey, U.S. Fish Commission, and the U.S. Geological Survey, among others, to document the flora, fauna, topography, and geology. Naturalist reports from these surveys were examined for encounters with "common porpoise" and descriptions of collected specimens.

The NMFS National Marine Mammal Laboratory (NMML) maintains a database of marine mammal observations collected opportunistically by NOAA and U.S. Coast Guard personnel, fisheries observers, fisheries personnel, ferry operators, tourists, or other private boat operators. The NMFS Platforms of Opportunity Program (POP) database includes harbor porpoise sightings since 1958. Separate from the POP collection at NMML, the NMFS Alaska Regional Office (NMFS-AKR) has collected anecdotal accounts of marine mammal sightings and strandings in Alaska. Sources include reports from fishing vessels, charter boat operators, aircraft pilots, NMFS enforcement officers, Federal and state scientists, environmental monitoring programs, and the general public. Harbor porpoise sighting and stranding records compiled by Leatherwood et al.[6] and Manly[7] were reviewed and compared to the POP and AKR datasets.

[5]http://www.esri.com/. Reference to trade names or commercial firms does not imply endorsement by the Natl. Mar. Fish. Serv., NOAA.

[6]Leatherwood, S., L. Lowry, K. Frost, D. Calkins, and R. Barber. 1983. Records of harbor porpoises, *Phocoena phocoena*, and cochito, *P. sinus*, from the northeastern Pacific and adjacent Arctic waters. Unpubl. pap. SC/35/SM5 presented to Int. Whal. Comm. Sci. Committee, 13 p.

[7]Manly, B. F. J. 2006. Incidental catch and interactions of marine mammals and birds in the Cook Inlet salmon driftnet and setnet fisheries, 1999–2000. Prep. by Western EcoSystems Technology Inc., Cheyenne, WY for Natl. Oceanic Atmos. Admin., Natl. Mar. Fish. Serv., Alaska Reg. Off., Prot. Resour. Div., 98 p. (Available at: https://alaskafisheries.noaa.gov/protectedresources/observers/bycatch/1999-2000cookinlet.pdf accessed 7 Apr. 2011).

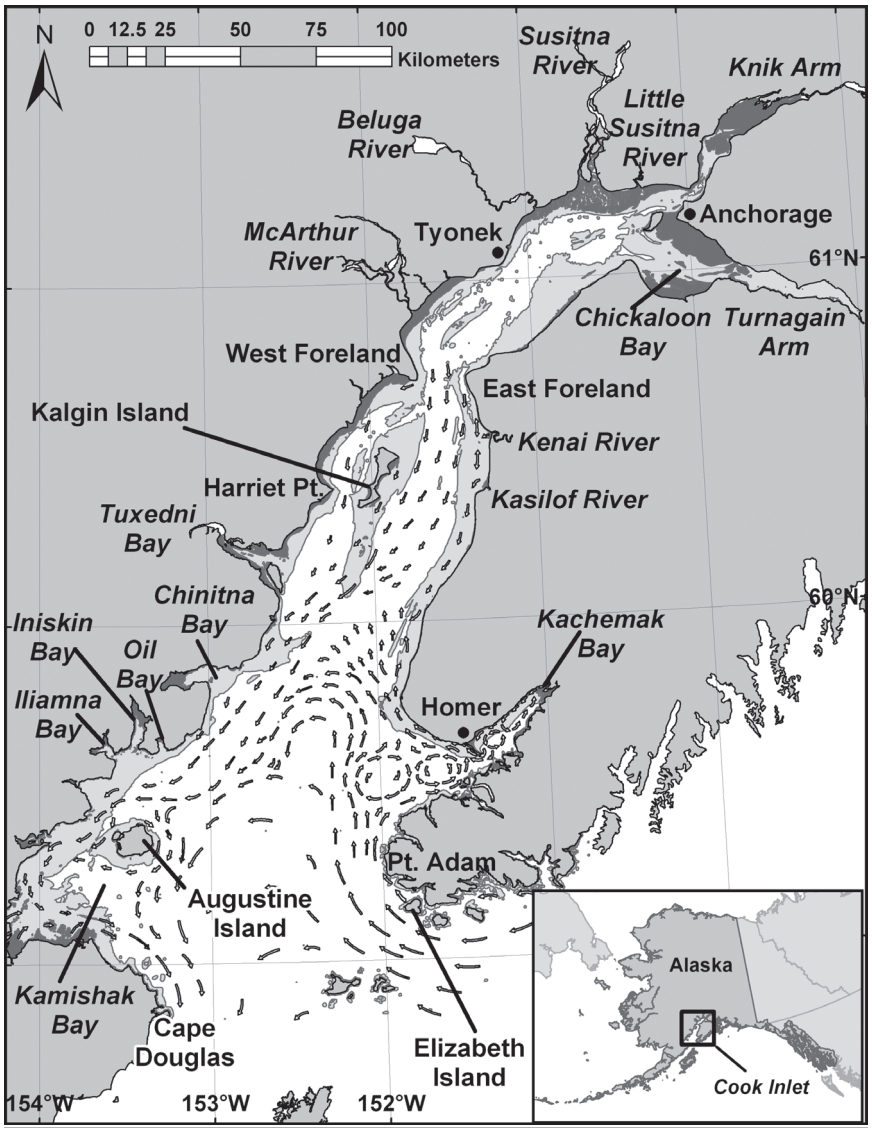

Figure 3.—The Cook Inlet, Alaska, study area, showing landmarks and water features mentioned in the text.

Systematic Surveys

Only one dedicated survey for harbor porpoise has been undertaken in Cook Inlet; an aerial, line-transect survey conducted over 2 days in August 1991 covering 1,873 km (Dahlheim et al., 2000). However, seabird and marine mammal surveys have occurred frequently in different seasons and different areas of Cook Inlet. These studies included: aerial and vessel surveys conducted as part of the Outer Continental Shelf Environmental Assessment Program (OCSEAP[8]) from the mid-1970's into the early 1980's (e.g., Harrison and Hall, 1978; Arneson[9]; Leatherwood et al.[10]); marine bird and sea otter, *Enhydra lutris kenyoni*, studies in the mid-1990's (e.g., Speckman and Piatt, 2000; Agler et al.[11], Bennett[12]; Speckman[13]); aerial surveys to determine abundance and distribution of beluga whales, *Delphinapterus leucas*, from 1964 to 2011 (e.g., Rugh et al., 2000, 2004, 2005, 2010; Shelden et al., 2013; Klinkhart[14]; Murray and Fay[15]; Murray and Calkins[16]; Calkins[17]; Hansen and Hubbard[18]); and marine fish and mammal surveys as part of environmental impact

[8]http://www.arlis.org/docs/vol1/OCSEAP2/authorindex.html

[9]Arneson, P. D. 1980. Identification, documentation and delineation of coastal migratory bird habitat in Alaska. U.S. Dep. Commer., NOAA, OCSEAP Final Rep. 15:1–363 (Available at: http://www.arlis.org/docs/vol1/OCSEAP2/Biological/8498344/FB%20v15.pdf#page=11 accessed 16 June 2011).

[10]Leatherwood, S., A. E. Bowles, and R. R. Reeves. 1983. Aerial surveys of marine mammals in the southeastern Bering Sea. U.S. Dep. Commer., NOAA, OCSEAP Final Rep. 42(1986):147–490. (Available at: http://www.arlis.org/docs/vol1/OCSEAP2/authorindex.html accessed 16 June 2011).

[11]Agler, B. A., S. J. Kendall, P. E. Seiser, and D. B. Irons. 1995. Estimates of marine bird and sea otter abundance in lower Cook Inlet, Alaska during summer 1993 and winter 1994. U.S. Dep. Inter., U.S. Fish Wildl. Serv., OCS Study MMS 94-0063, 124 p.

[12]Bennett, A. J. 1996. Physical and biological resource inventory of the Lake Clark National Park-Cook Inlet coastline, 1994–96. Lake Clark Natl. Park and Preserve, Kenai Coastal Off., P.O. Box 2643, Kenai, AK, 99611. Unpubl. manuscr., 137 p.

[13]Speckman, S. 2002. Chapter 8. Pelagic seabird abundance and distribution in lower Cook Inlet. Piatt, J. F. (Editor), Response of seabirds to fluctuations in forage fish density, p. 64–70. Draft final rep. by U.S. Geol. Survey to Minerals Manage. Serv., Alaska OCS and Exxon Valdex Oil Spill Trustee Council Restoration Proj. (APEX) 00163M.

[14]Klinkhart, E. G. 1966. The beluga whale in Alaska. Alaska Dep. Fish Game, Juneau, Fed. Aid Wildl. Restor. Proj. Rep. Vol. VII, Proj. W-6-R and W-14-R, 11 p.

[15]Murray, N. K., and F. H. Fay. 1979. The white whales or belukhas, *Delphinapterus leucas*, of Cook Inlet, Alaska. Unpubl. pap. SC/31/SM12 pres. to Int. Whal. Comm. Sci. Committee, 7 p.

[16]Murray, N. K., and D. G. Calkins. 1977–1979. Unpubl. field notes from Cook Inlet beluga surveys conducted by the Alaska Dep. Fish Game provided to the Natl. Mar. Mammal Lab. by K. Pitcher, Alaska Dep. Fish Game, Anchorage.

[17]Calkins, D. G. 1984. Belukha whale. Vol. IX of Susitna hydroelectric project; final report; big game studies. Alaska Dep. Fish Game. Doc. 2328, 17 p., and unpubl. field notes/maps available from K. Shelden.

[18]Hansen, D. J., and J. D. Hubbard. 1999. Distribution of Cook Inlet beluga whales (*Delphinapterus leucas*) in winter. U.S. Dep. Inter., Bur. Land. Manage., Minerals Manage. Serv., Environ. Stud. Sec., Alaska OCS Reg., OCS Study MMS 99-0024, 30 p. + app.

assessments (e.g., Nemeth et al.[19]). Harbor porpoise sightings and effort (tracklines or survey blocks) were extracted from these unpublished field notes, field reports, environmental assessments, and peer-reviewed publications. Data are presented in a chronological order and in some cases multiple datasets are presented within one map. Estimates of harbor porpoise abundance and sighting rates (Dahlheim et al., 2000; Speckman and Piatt, 2000; Hobbs and Waite, 2010; Agler et al.[11]) are also described.

Results

Zooarchaeological Surveys

For a period of about 1,500 years, Alutiiq Eskimo subsistence societies occupied the Kachemak Bay area in Cook Inlet until it was abandoned around 600 A.D. (Workman and Workman, 2010). The "Maritime Kachemak" (Workman, 1998) left behind deep shell middens that preserved faunal remains including porpoise bullae and vertebrae. The late John Lobdell examined faunal remains from Chugachik Island in Kachemak Bay (Fig. 4), where he determined that, among mammals, porpoise utilization by this society was second only to that of harbor seals, *Phoca vitulina* (Lobdell, 1980). Around 250–300 A.D., use of faunal resources intensified and at its peak about 16 seals were killed annually (porpoise remains were not quantified). Lobdell (1980) surmised that resources became depleted within the region of the island sometime before 500 A.D. (based on the reduced number of seal remains in the faunal record).

At the Yukon Island Fox Farm site in Kachemak Bay (Fig. 4), David Yesner found, over the course of a millennium, increased use of porpoise and Pacific halibut, *Hippoglossus stenolepis*, and a decline in sea otter exploitation based on examination of a little over 10,000 mammalian bones (Yesner, 1992). Over one-third of the faunal remains near the end of this period of occupation were from porpoise (Yesner, 1992:173). Similar to what Lobdell (1980) observed at Chugachik Island, Yesner (1992) noted an increase in porpoise in the faunal sample, from 6.3% to 37.9%, during the Kachemak Eskimo occupation on Yukon Island. He also described unique treatment of porpoise bones during the latter period, such as skulls and articulated components surrounded by stones, suggesting a ceremonial aspect. Again, overexploitation of faunal resources, in this case porpoises, may have contributed, in part, to abandonment of the island after 500 A.D. (Yesner, 1992).

Across the inlet, in Tuxedni Bay, Frederica de Laguna unearthed bones of porpoise among other faunal remains at the base of a rock shelter

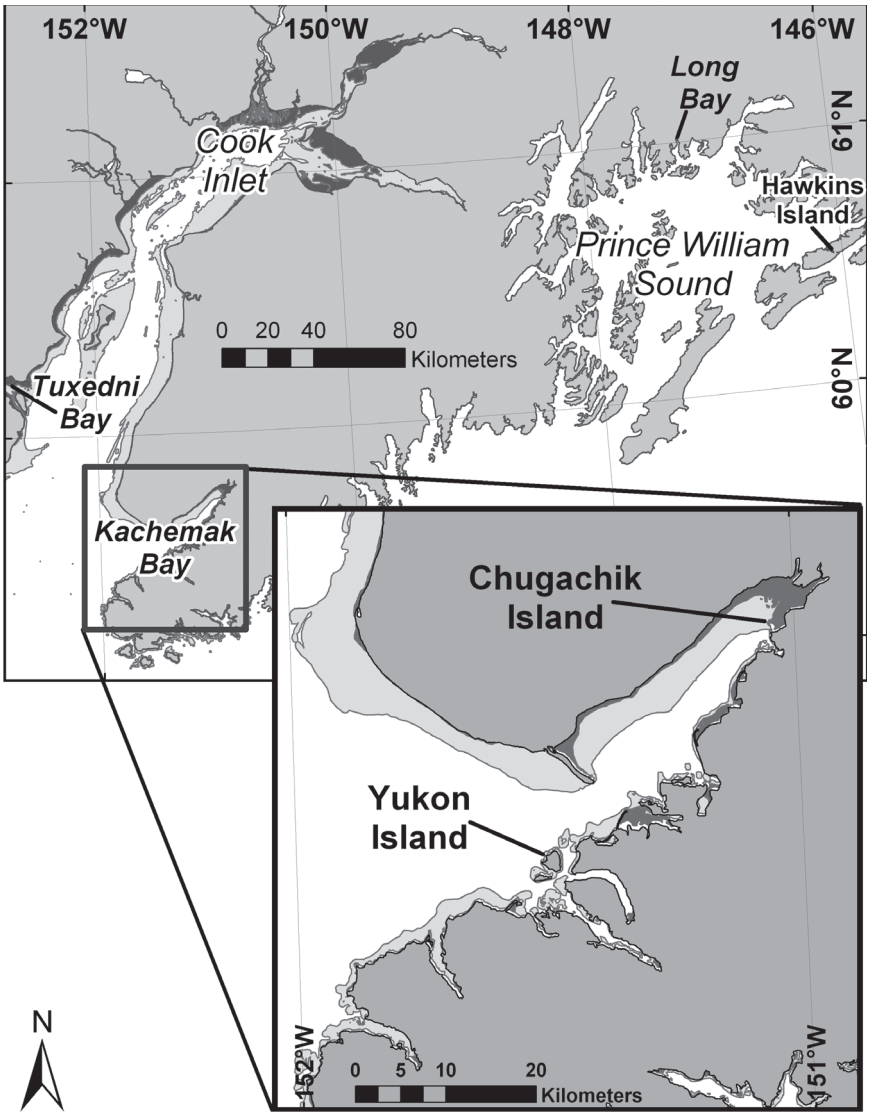

Figure 4.—Archeological sites in Cook Inlet and Prince William Sound containing faunal remains of harbor porpoise.

[19]Nemeth, M. J., C. C. Kaplan, A. P. Ramos, G. D. Wade, D. M. Savarese, and C. D. Lyons. 2007. Baseline studies of marine fish and mammals in Upper Cook Inlet, April through October 2006. Final rep. prep. by LGL Alaska Research Associates, Inc., Anchorage, Alaska for DRven Corporation, Anchorage, Alaska. (Available at: http://www.chuitnaseis.com/documents/project-docs/Baseline-Studies-Marine-Fish-Mammals-LGL-04-07.pdf accessed 5 July 2011).

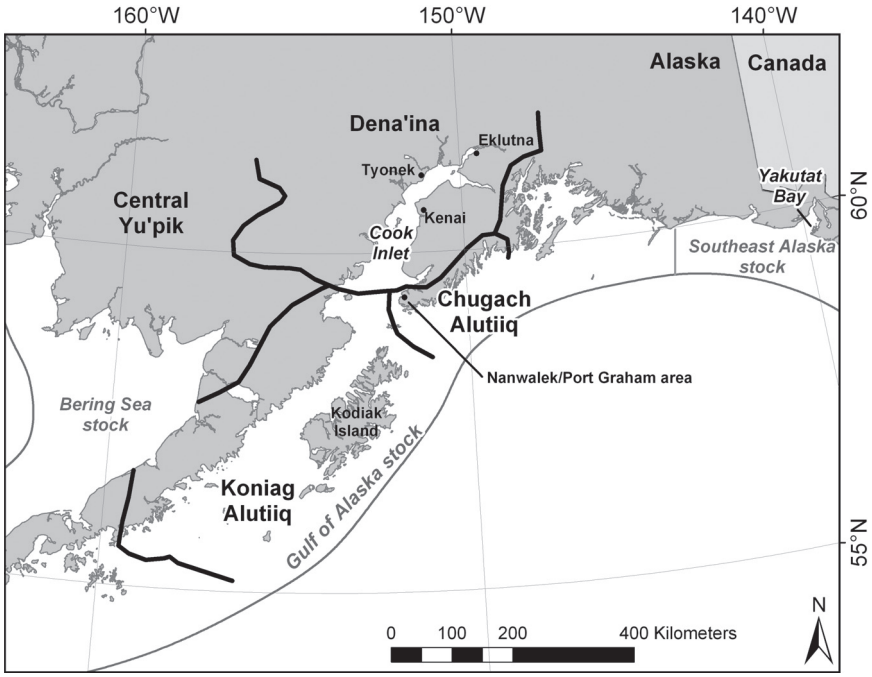

Figure 5.—Ethnographic boundaries of Native subsistence societies surrounding Cook Inlet, Alaska (from Stanek, text footnote 20).

decorated with pictographs (de Laguna, 1975). The majority of animals depicted in these "rock painting" images were sea mammals, including three that appeared to be cetaceans with dorsal fins (Baird, 2006).

Although specimens were not always identified to species, only two types of porpoise occur in Alaska waters, harbor porpoise and Dall's porpoise, *Phocoenoides dalli*. Dall's porpoise are observed in lower Cook Inlet and Kachemak Bay, though they tend to prefer waters greater than 180 m (600 ft) deep (Reeves et al., 2002). Lobdell (1980:143–144) identified porpoise skeletal elements as belonging to "*Phocoena vomerina*." Porpoise remains from archaeological sites in Prince William Sound (Fig. 4) all appear to be from harbor porpoise (Yarborough, 1995).

It is not known if these societies were displaced by the expansion of the Dena'ina Athapaskans into the Cook Inlet regions around 1000 A.D. (Workman and Workman, 2010) or if overexploitation of marine resources led to their demise (Lobdell, 1980; Yesner, 1992). The Dena'ina that settled around Cook Inlet adopted many of the Alutiiq maritime hunting techniques (Reger, 1998) and continued to exploit porpoise in lower Cook Inlet, as evidenced by later excavations at Yukon Island (Yesner, 1992:173). Porpoise hunting continued into the 1800's during the period of first contact between Russian fur traders and Alutiiq and Dena'ina societies (Yesner, 1992:175).

Ethnological Studies

Early contact subsistence use patterns of the Koniag Alutiiq on Kodiak Island included hunting of "sea pigs" during June and July (Merck, 1980:105; Fig. 5) and these patterns were likely similar in Chugach Alutiiq villages near present-day Port Graham and Nanwalek (Stanek[20]; Fig. 6). The Koniag Alutiiq name for the month of July "Managkhat" means "the porpoises give birth" (Davydov, 1977:186). Unfortunately, Dena'ina from Kachemak Bay could recall the names for only the months of January, March, and April (Osgood, 1937:114), none of which included references to porpoise.

According to those interviewed in 1931, the Tanaina (Dena'ina) in Kachemak Bay hunted porpoise after March when hunting conditions were optimal (i.e., "pleasant weather…still water and good light"), and the animals were "found everywhere within their restricted range" (Osgood, 1937:39). These contacts noted that the only marine mammals available to communities in the middle (Kenai-Tyonek) and upper (Eklutna) inlet (Fig. 5) were beluga whales "which share[d] the wider distribution of the hair seal [harbor seal]" (Osgood, 1937:39). Members of these communities would travel to the lower inlet to procure other species such as harbor porpoise and sea otters (Osgood, 1933:697).

Emmons (1991:122) noted the Tlingit in Yakutat Bay did not consume the meat of the smaller, gray "puffing pig," as it "was said to produce an unpleasant body odor"; instead, harbor porpoise were prized for their sinew. Koniag Alutiiq and Dena'ina consumed harbor porpoise and used sinew from the tail stock for sewing, snares, and lashings (Merck, 1980:106; Osgood, 1937:78). Boiling was the principal method for cooking porpoise, although the skin was sometimes eaten raw (Osgood, 1937:44).

There is no mention of porpoise exploitation continuing after the Russian fur trade began (1800's–1880's), followed by the gold rush, and the introduction of commercial fisheries and canneries in lower Cook Inlet around the turn of the century (see Osgood, 1937; Stanek, 1985; Stanek[20]). Marine mammal hunting in the 1940's and 1950's took the form of preda-

[20]Stanek, R. T. 1999. Ethnographic overview and assessment for Nanwalek and Port Graham. Submitted to U.S. Dep. Inter., Minerals Manag. Serv., Anchorage, Alaska, by Div. Subsistence, Alaska Dep. Fish Game, 333 Raspberry Road, Anchorage, AK, 142 p. (Available at: http://www.alaska.boemre.gov/reports/2001rpts/2001_058/CA143500130788.pdf accessed 20 Apr. 2011).

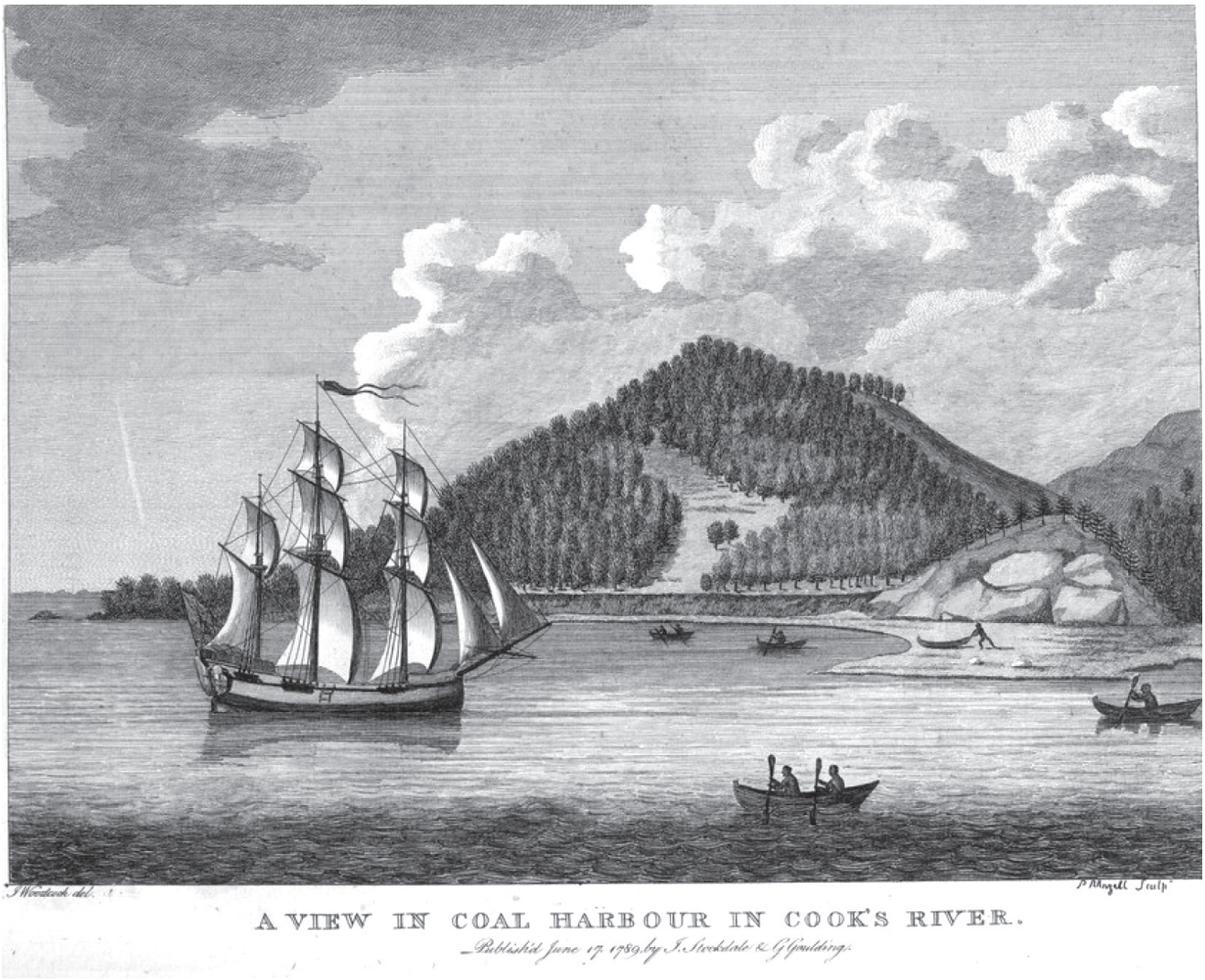

Figure 6.—"A view in Coal Harbour in Cook's River" an engraving depicting early contact near Port Graham, Alaska (Alaska State Library, Alaska Purchase Centennial Collection, ca. 1764–1967, Nathaniel Portlock, ASL-PCA-20 digital archives).

tor control as well as for subsistence and commercial purposes, focusing on Steller sea lions, *Eumetopias jubatus*, harbor seals, and beluga whales (Stanek[20]). Present-day Alutiiq subsistence hunting in lower Cook Inlet includes sea otters (solely for pelts), and sea lions and harbor seals for food (Stanek[20]).

Anecdotal Accounts

Harbor porpoise were rarely mentioned in expedition accounts from the late 1800's and early 1900's (Osgood, 1901a, b; Osgood, 1904; Bailey and Hendee, 1926; Murie, 1959). The few instances of sightings or specimens collected in the Gulf of Alaska included: two skulls from Kanatak (Fig. 7) in 1903, to which Wilfred Osgood stated "so far as I can learn, this is the most northerly record of this species on the Pacific coast" (Osgood, 1904:27); and a sighting of two porpoise among the Shumagin Islands on 23 May 1937 (Murie, 1959). Murie (1959) also summarized an account from Turner (1886:200), who observed harbor porpoise near Kodiak and in the Aleutian Islands. In fact, the majority of sightings and specimens collected during this time period were in waters north of the Gulf of Alaska in the Aleutians (Bailey and Hendee, 1926; Murie, 1959), Pribilof Islands (Murie, 1959), and as far north as Barrow (70°48′ N, 159°17′ W) (Bee and Hall, 1956).

According to Wilfred Osgood (1901a:60), "very little natural history work has been done in the Cook Inlet region" but for a few birds and mammals collected near the mouth of the inlet, at Fort Kenai, and during hunting trips for large game. His "Natural History of the Cook Inlet Region, Alas-

ka" was based upon explorations near Hope in Turnagain Arm (23–31 Aug. 1900) and Tyonek (13–28 Sept. 1900) with brief stops in Seldovia, Homer, Kenai, and Sunrise (where prospectors were the principal informants). The only marine mammal mentioned in this account was the sea otter of which Osgood (1901a:69) noted "sea otters are said to have been seen in Cook Inlet, but owing to the very muddy water it is probable that they were never numerous there, even in times of their greatest abundance elsewhere." If harbor porpoise had been encountered during this expedition, it is likely that Osgood would have made some reference, as only a month earlier (7 July 1900) he described encounters with "common porpoise, *Phocoena phocoena*," in his "Natural History of the Queen Charlotte Islands, British Columbia" (Osgood, 1901b:25).

In their review of the distribution and abundance of marine mammals in the Gulf of Alaska, Calkins et al.[21] noted that "Pelagic fur seal investigators report[ed] a total of 176 animals [harbor porpoise] sighted at 17 locations between 1958 and 1968."[22] A review of the NMFS POP database, which included the NMML pelagic fur seal, *Callorhinus ursinus*, program data, yielded 167 harbor porpoise (50 sightings total) north of 50° N, 135° W from 1958 to 1968, none of which occurred in Cook Inlet (Fig. 7).

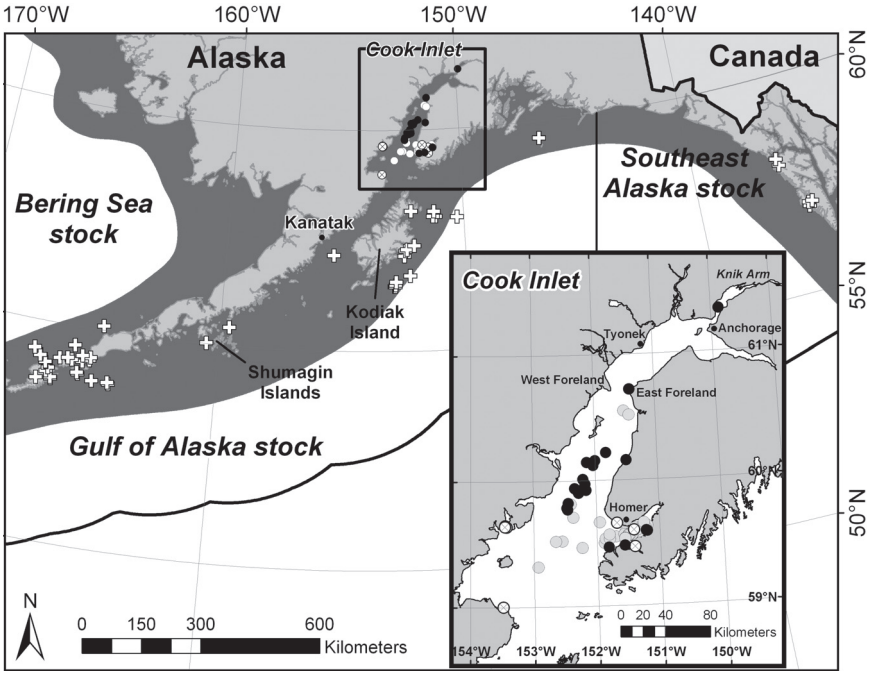

Figure 7.—Anecdotal sightings of harbor porpoise in the Gulf of Alaska from various platforms of opportunity, late 1800's to 2000. These include sightings collected during pelagic fur seal investigations, 1958–1968 (plus symbols); sightings in the Platforms of Opportunity Program (POP) database from Cook Inlet, 1974–1978 (light-colored circles); sightings reported in Leatherwood et al. (text footnote 6), 1976–1978 (circles with X's); and POP sightings supplemented with data from Manly (text footnote 7), 1983, 1999–2000 (dots).

Consiglieri et al.[23] provided an overview of seasonal distribution and relative abundance of marine mammals in the Gulf of Alaska using POP data; sightings reported between 1958 and 1980 were summarized in a series of figures. Data were gathered from four sources: 1) the NMML pelagic fur seal program (1958–1974); 2) the NMML Dall's Porpoise Research Program (operated from NOAA and U.S. Coast Guard ships from 1975 to 1980); 3) an OCSEAP dedicated summer vessel cruise in 1980; and 4) POP observers on NOAA or other ships. The authors mapped harbor porpoise sightings in Cook Inlet during winter, spring, and summer (Consiglieri et al.[23]:269, 271–272).

Extraction of these POP observations yielded 40 sightings in Cook Inlet, all occurring in the lower inlet from 1974 to 1978 and during the months of February–April (n = 15), June (n = 1), and August–September (n = 24; Fig. 7). Seven sightings in Cook Inlet collected by Leatherwood et al.[6] did not match any from the POP database (Fig. 7). These unpublished sightings were reported by Alaska Department of Fish and Game (ADFG) personnel from June–August 1976 (n = 4), June 1977 (n = 1), and April 1978 (n = 2) (Leatherwood et al.[6]).

The POP harbor porpoise sightings recorded in Cook Inlet after 1978 included one sighting in Kachemak Bay in August 1983, with all other sightings (n = 23) occurring in 1999 and 2000 from June–September (Fig. 7). The latter sightings (1999–2000), with the exception of the lone upper inlet sighting in Knik Arm in September 2000, were also reported in Manly[7]. Although anecdotal accounts yielded only one harbor porpoise sighting north of the Forelands, sightings have

[21]Calkins, D. G., K. W. Pitcher, and K. Schneider. 1975. Distribution and abundance of marine mammals in the Gulf of Alaska. Unpubl. doc. prepared for U.S. Dep. Commer., Natl. Oceanic Atmos. Admin., by Alaska Dep. Fish Game, Div. Game, Fairbanks, Alaska, 189 p. (Available at: http:// www.arlis.org accessed 20 Apr. 2011).

[22]Note that the version of Calkins et al., 1975 that appears in the OCSEAP annual report published in May 1977 (Available at: http://www.arlis.org/docs/vol1/OCSEAP2/Annual/5175790/1975-MAR.pdf) does not include this exact quote.

[23]Consiglieri, L. D., H. W. Braham, M. E. Dahlheim, C. Fiscus, P. D. McGuire, C. E. Peterson, and D. A. Pippenger. 1989. Seasonal distribution and relative abundance of marine mammals in the Gulf of Alaska. Final Rep. March 1982. *In* Outer Cont. Shelf Environ. Assessment Program, Final Rep. Principal Investigators, Vol. 61, June 1989, p. 189–280. OCS Study MMS 89-0026. (Available at: http://www.arlis.org/docs/vol1/OCSEAP2/Final/12824468/F%20v61.pdf accessed 20 Apr. 2011).

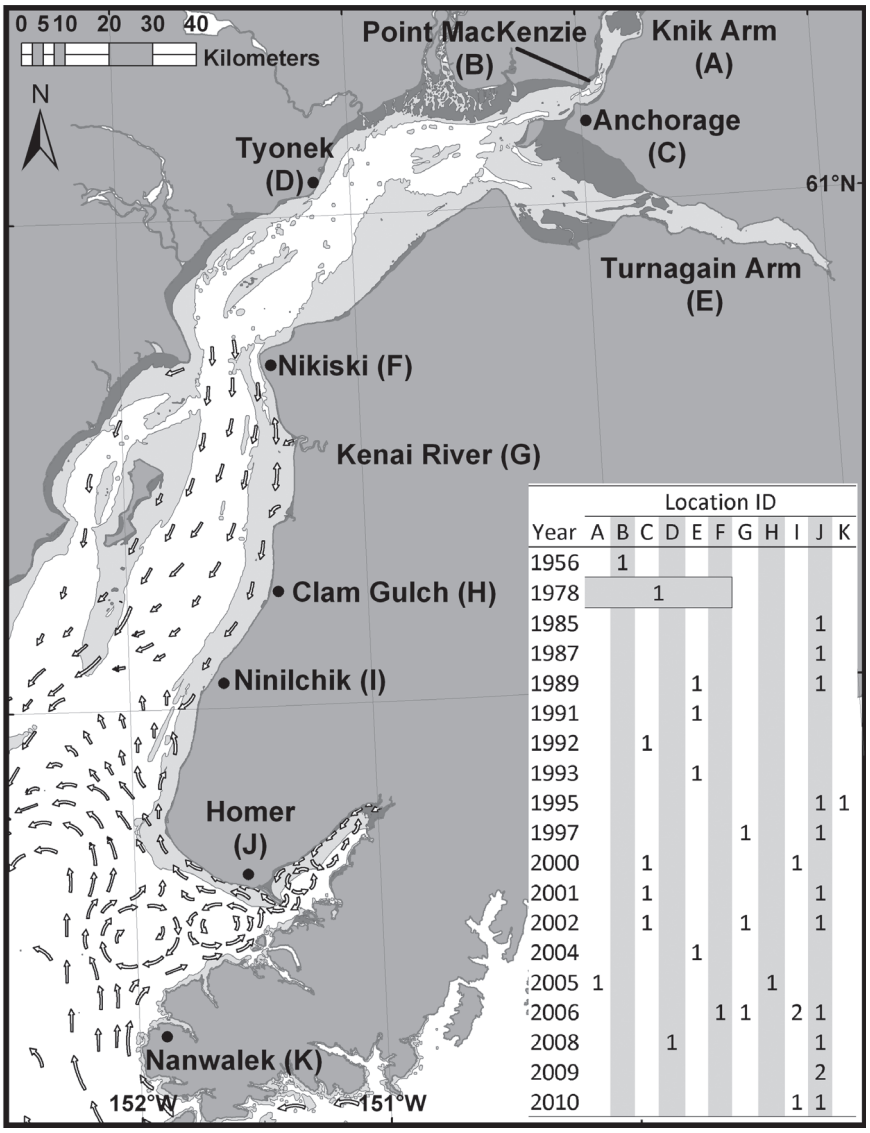

Figure 8.—Stranding reports of harbor porpoise in Cook Inlet, Alaska, 1956 to 2010. Note that the 1978 stranding location was reported as "upper Cook Inlet" in Fay et al. (text footnote 24) and is indicated within a band that includes all upper inlet location ID's.

been recorded during environmental monitoring studies (detailed in the "Systematic Surveys" section), and 35% of reported strandings (12 of 34) occurred in the upper inlet north of Nikiski (Fig. 8).

Stranding reports obtained from NMFS-AKR for the Cook Inlet region included 33 incidents spanning from 1956 to 2010 (Fig. 8). One additional incident not in the AKR database occurred in 1978 and was reported in Fay et al.[24] (Fig. 8). Of these records, 24% listed cause of death as entanglement (n = 6) or possible entanglement (n = 2). Observers of salmon driftnet and setnet fisheries in Cook Inlet reported five harbor porpoise entanglements during the period 1999–2000, of these, four were released without apparent serious injury and one died (Manly[7]:3). Stranded harbor porpoise were documented most often near Homer (35%, n = 12; Fig. 8). In the lower inlet (from Nikiski southward: Fig. 8), strandings were reported from May to August, while in the upper inlet reports spanned from June to November.

Systematic Surveys

The earliest systematic survey accounts of harbor porpoise in Cook Inlet occurred during OCSEAP studies in 1974–78 (e.g., POP database and Leatherwood et al.[6]). Unfortunately, survey effort (i.e., tracklines or blocks) was not provided; therefore, these sightings are included in the "Anecdotal Accounts" section.

From November 1977 through August 1979, Murray and Calkins[16] documented the seasonal distribution of beluga whales in Cook Inlet and also recorded the presence of other marine mammals (including harbor seals; minke whales, *Balaenoptera acutorostrata*; sea otters; and harbor porpoises) during aerial surveys. Survey altitude ranged from 300 to 500 ft (91.4–152.4 m). Harbor porpoise were seen on 2 days in 1978 (Table 1) during this extensive effort that included year-round surveys of coastal and offshore waters (Fig. 9). Unfortunately, no field notes accompanied the survey map which shows the trackline and two large ovals labeled "HP" between Dry Bay and Tuxedni Bay on 22 May.

From February 1982 through March 1983, OCSEAP funded eight large-scale aerial surveys to characterize distribution and abundance of marine mammals in the southeastern Bering Sea, Shelikof Strait, and portions of lower Cook Inlet (Leatherwood et al.[10]). Surveys were flown at an altitude of 750 ft (229 m). The Shelikof Strait study area (referred to as Block 7) was partitioned into six 35-nautical-mile (nmi) wide zones. Only zone 1

[24]Fay, F. H., R. A. Dieterich, and L. M. Shults. 1979. Morbidity and mortality of marine mammals. U.S. Dep. Commer., NOAA, OCSEAP Quarterly Rep. Oct.–Dec. 1978, Vol. 1:3–5. (Available at: http://www.arlis.org/docs/vol1/OCSEAP2/Quarterly/2882649/Q1978-4%20v1.pdf accessed 1 July 2011).

Table 1.—Harbor porpoise sightings recorded during systematic marine mammal surveys conducted in Cook Inlet, Alaska, 1978–2012.

Date or period	Description	Source
1978 May 22	Two large concentrations along the shoreline between Dry Bay and Chinitna Bay, and Chinitna Bay and Tuxedni Bay. Field notes for this day were not included with the effort map so the number of sightings and group sizes could not be determined.	Murray and Calkins (text footnote 16)
1978 June 18	A single porpoise swimming south near Tuxedni Bay.	Murray and Calkins (text footnote 16)
1982 May–early June	Three sightings between Cape Douglas and Douglas Reef.	Leatherwood et al. (text footnote 10)
1982 July	Three sightings mid-inlet between Dry Bay and Kachemak Bay, and on 20 July an adult with newborn calf near Shaw Island. The "adult and calf were milling in 25 fathoms (46 m) of water and dived away promptly, probably in response to the plane" (p. 372)	Leatherwood et al. (text footnote 10)
1991 Aug. 2	Two sightings mid-inlet and one sighting in Chinitna Bay (4 animals total).	Dahlheim et al. (2000)
1993 June 4	Four sightings in Kachemak Bay and one sighting off Harriet Point near Redoubt Bay (5 animals total). The sighting near Redoubt Bay was omitted in error from Rugh et al. (2005:Appendix II).	Rugh et al. (2005); Shelden et al. (2013)
1993 June 7–23	Five sightings (7 animals total), group sizes of 1–2 occurred in lower Cook Inlet. Estimated abundance was 428 (95% CI 26–830).	Agler et al. (text footnote 11);USFWS GIS database
1993 July 27	Two sightings in Redoubt Bay and one sighting in Kachemak Bay (4 animals total).	Rugh et al. (2005); Shelden et al. (2013)
1994–1996 Apr.–Sept.	Throughout the summer, 2–5 animals/observation seen along the coast between Redoubt Point and Chinitna Bay.	Bennett (text footnote 12)
1994 June 3	Three sightings mid-inlet and one sighting in Kachemak Bay (4 animals total).	Rugh et al. (2000, 2005); Shelden et al. (2013)
1994 June 4	About 49 sightings with group sizes ranging from 1 to 5 animals (58 animals total). Most porpoise (41 of the 49 sightings) were along the coast between Tuxedni Bay and Chinitna Bay. Harbor porpoise sightings were so heavily concentrated south of Tuxedni Bay that the computer acquisition program could not keep up, therefore, this is a minimum count based on data available in the beluga whale survey database which does not correspond exactly with Appendix II in Rugh et al. (2005).	Rugh et al. (2000, 2005); Shelden et al. (2013)
1995 July 22	One sighting in Tuxedni Bay, one sighting in Kachemak Bay, and one sighting in Kamishak Bay (5 animals total).	Rugh et al. (2000, 2005); Shelden et al. (2013)
1996 June 14	One sighting of a lone porpoise south of Kalgin Island.	Rugh et al. (2000, 2005); Shelden et al. (2013)
1996 June 15	Seven sightings along the coast and mid-inlet between Tuxedni Bay and Dry Bay (7 animals total).	Rugh et al. (2000, 2005), Shelden et al. (2013)
1996 July 14-31	One sighting of one porpoise in Kachemak Bay on July 18. A sighting rate of 0.05 harbor porpoise per km^2 was calculated for the study area.	Speckman and Piatt (2000); Speckman (text footnote 13);USFWS GIS database
1997 Mar. 12	One sighting near Redoubt Point, one sighting in Kamishak Bay, and one sighting in Kachemak Bay.	Hansen and Hubbard (text footnote 18)
1997 Mar. 13	One confirmed sighting (and two additional sightings that were likely harbor porpoise though species identification was not confirmed) mid-inlet between Homer and Dry Bay.	Hansen and Hubbard (text footnote 18)
1997 June 8	One sighting (3 animals total) near West Foreland.	Rugh et al. (2000, 2005); Shelden et al. (2013)
1997 June 9	One sighting in Iniskin Bay, one sighting in Iliamna Bay, and one sighting in Kachemak Bay (3 animals total). The sighting in Kachemak Bay is missing from Appendix II in Rugh et al. (2005).	Rugh et al. (2000, 2005); Shelden et al. (2013)
1997 July 19–Aug. 8	Six sightings (8 animals total), four sightings in July mid-inlet (6 animals, group size 1–2), and two sightings of single animals in August in Kachemak Bay. Note in Table 8.2 from Speckman (text footnote 13), the total number of animals was reported as 9. A sighting rate of 0.81 harbor porpoise per km^2 was calculated for the study area.	Speckman and Piatt (2000); Speckman (text footnote 13);USFWS GIS database
1998 June 13	Two sightings (2 animals total) mid-inlet off Redoubt Point.	Rugh et al. (2000, 2005); Shelden et al. (2013)
1998 June 14	Eleven sightings (13 animals total) mid-inlet between Tuxedni Bay and Kachemak Bay.	Rugh et al. (2000, 2005); Shelden et al. (2013)
1998 July 21–Aug. 12	Seven sightings (7 animals total), five sightings in July on the west side of the inlet, and two sightings in August in Kachemak Bay. A sighting rate of 0.62 harbor porpoise per km^2 was calculated for the study area.	Speckman and Piatt (2000); Speckman (text footnote 13)
1999 June 10	Nine sightings (11 animals total) mid-inlet between West Foreland and Chinitna Bay.	Rugh et al. (2000, 2005); Shelden et al. (2013)
1999 June 11	Two sightings (2 animals total) between Kalgin Island and Redoubt Bay.	Rugh et al. (2000, 2005); Shelden et al. (2013)
1999 June 14	Twenty-two sightings with group sizes ranging from 1 to 2 (23 animals total) occurred along the coast and mid-inlet between Harriet Point and Kachemak Bay. Most porpoise (15 sightings) were aggregated offshore between Tuxedni Bay and Chinitna Bay.	Rugh et al. (2000, 2005); Shelden et al. (2013)
1999 July 25 – Aug. 16	Nine sightings (12 animals total) occurred in August, four sightings (5 animals including a calf) in mid-inlet, five sightings (7 animals including a calf) in Kachemak Bay. A sighting rate of 1.06 harbor porpoise per km^2 was calculated for the study area.	Speckman and Piatt (2000); Speckman (text footnote 13);USFWS GIS database

Continued on next page.

Table 1.—*Continued*.

Date or period	Description	Source
2000 June 9	Six sightings (7 animals total) along the coast and mid-inlet between Chinitna Bay and Cape Douglas.	Rugh et al. (2000, 2005); Shelden et al. (2013)
2000 June 10	Fourteen sightings between East Foreland and Chinitna Bay, and two sightings in Kachemak Bay (22 animals total).	Rugh et al. (2000, 2005); Shelden et al. (2013)
2001 June 8	Five sightings mid-inlet between Kenai River and Kachemak Bay, and two sightings in the bay (7 animals total).	Rugh et al. (2005); Shelden et al. (2013)
2001 June 9	Fifteen sightings (18 animals total) along the coast and mid-inlet between Tuxedni Bay and Augustine Island.	Rugh et al. (2005); Shelden et al. (2013)
2004 June 5	Nine sightings (9 animals total) along the mid-inlet trackline between Kalgin Island and Augustine Island.	Rugh et al. (2005); Shelden et al. (2013)
2004 June 6	Fifty-seven sightings with group sizes ranging from 1 to 3 (92 animals total) occurred along the coast and mid-inlet between Chinitna Bay and Cape Douglas. Most porpoise (41 of the 57 sightings) were along the coastline between Dry Bay and Chinitna Bay. Harbor porpoise sightings were so heavily concentrated south of Chinitna Bay that the computer acquisition program could not keep up, therefore, this is a minimum count based on data available in the beluga whale survey database which does not correspond exactly with Appendix II in Rugh et al. (2005).	Rugh et al. (2005); Shelden et al. (2013)
2005 Apr.–May	Four sightings in the Knik Arm study area. Effort covered the period July 2004–July 2005.	LGL (text footnote 36)
2005 June 4	One sighting (2 animals total) mid-inlet south of Kalgin Island.	Shelden et al. (2013)
2006 Apr.–Oct.	Sightings occurred in May (17), June (2), July (3), August (5), September (16), and October (7) at the Chuitna River observation site, and only in September (2) at Three Mile Creek (p. 83). Most sightings were of lone animals. Five sightings of single porpoise were recorded during offshore vessel surveys in May (3), June (1), and August (1). Two additional observations were thought to be harbor porpoise based on field descriptions but the month during which these sightings occurred was not reported.	Nemeth et al. (text footnote 19)
2007 Apr. 1–May 15	Eleven sightings (14 animals total) in the Beluga River seismic study area in early May. Most sightings were of solitary animals.	Brueggeman (text footnote 38)
2007 June 8	Three sightings (4 animals total) in offshore waters between Tuxedni Bay and Chinitna Bay.	Shelden et al. (2013)
2007 Sept. 29–Oct. 21	Six sightings (12 animals total) in the Granite Point seismic study area in October. Five of six groups had 2 or 3 porpoises. Seen on 5 days out of 23.	Brueggeman (text footnote 39)
2007 Oct. 16–18	A single harbor porpoise was seen in the vicinity of the Port of Anchorage.	URS (text footnote 41, 42)
2008 June 9	Two sightings (3 animals total) offshore between Kenai River and Tuxedni Bay.	Shelden et al. (2013)
2008 June 10	One sighting (3 animals total) off the southern tip of Kalgin Island.	Shelden et al. (2013)
2009 Mar. 28–Dec. 14	Sixteen sightings (20 animals total) occurred in June (4 sightings, 5 adults), July (3 sightings, 5 adults), August (2 sightings , 2 adults), October (6 sightings, 3 adults and 4 porpoise of unknown age), and November (1 of unknown age) (p. 17). Group sizes ranged from 1 to 3.	ICRC (text footnote 44)
2009 June 7	Thirty-one sightings (41 animals total). Sightings were along the offshore trackline (n = 18) and in coastal waters along the western shoreline (n = 13).	Shelden et al. (2013)
2009 June 8	A lone harbor porpoise was seen in Kachemak Bay.	Shelden et al. (2013)
2010 June 5	Four sightings (5 animals total) along the offshore trackline between Kalgin Island and Tuxedni Bay.	Shelden et al. (2013)
2010 June 7	Five sightings (5 animals total) in coastal waters between Harriet Point and Oil Bay.	Shelden et al. (2013)
2010 July 21–Nov. 20	Two sightings (2 animals total) in the Knik Arm study area. One occurred in July and the other in August.	ICRC (text footnote 45)
2011 June 6	Seventeen sightings (24 animals total) along the west coast, mid-inlet, and in Kachemak Bay. Most porpoise (11 sightings) were mid-inlet between Tuxedni Bay and Augustine Island.	Shelden et al. (2013)
2011 June 7	Four sightings (6 animals total) mid-inlet between Kalgin Island and Tuxedni Bay.	Shelden et al. (2013)
2011 June 28–Nov. 15	Five sightings (6 animals total) in the Knik Arm study area. Two occurred in August (2 animals total), two in October (3 animals total), and one in November.	ICRC (text footnote 46)
2012 May 29	Five sightings (7 animals total) mid-inlet between the Forelands and Chinitna Bay.	Shelden et al. (2013)
2012 May 30	Two sightings (3 animals total) mid-inlet between Anchor Point and Kalgin Island.	Shelden et al. (2013)
2012 May 31	A lone porpoise nearshore between Chinitna and Tuxedni bays.	Shelden et al. (2013)

fell within lower Cook Inlet (Fig. 10). The eight surveys were grouped by season: spring (surveys 1 and 2: mid–late March and May–early June 1982, respectively); summer (surveys 3 and 4: July and August 1982, respectively); fall (surveys 5 and 6: September and late October through mid-November 1982, respectively); and winter (surveys 7 and 8: January and mid-February–early March 1983, respectively).

Tracklines were flown in lower Cook Inlet in each season and were included in Figure 10 only if effort occurred north of Cape Douglas. Harbor porpoise were observed on two on-transect lines (within zone 1 on surveys 2 and 3) and one off-transect line (Fig. 10). During this entire study, newborn harbor porpoise were observed on three occasions, including the survey 3 on-transect sighting (Table 1). Harbor porpoise were not seen in upper Cook Inlet during aerial surveys for beluga whales conducted from May through August 1982 and April through July 1983 (Calkins[17]; Fig. 10). Similar to the beluga whale surveys conducted in the 1970's, survey altitude ranged from 300 to 500 ft (91.4–152.4 m).

During 1–2 August 1991, 1,873 km along a single zigzag track line was flown in Cook Inlet at an altitude of 500 ft (152.4 m) during surveys designed to enumerate harbor porpoise (Dahlheim et al., 2000) (Fig. 11, Table 1). Based on three sightings (four animals total), this effort translated to an encounter rate of 0.54 groups/100 km^2 and an abundance estimate of 136 harbor porpoises (95% confidence interval (C.I.) 11–1,645; coefficient of variation (CV) = 63.2%). Dahlheim et al. (2000) concluded that because counts were not corrected for animals missed on the trackline and all areas were not surveyed (in Cook Inlet this included the coastline and many bays), abundance estimates were likely biased downward. Other compromising factors, such as porpoise surfacing rates, the possibility of clumped distributions, and attraction to or avoidance of the survey platform, were also raised.

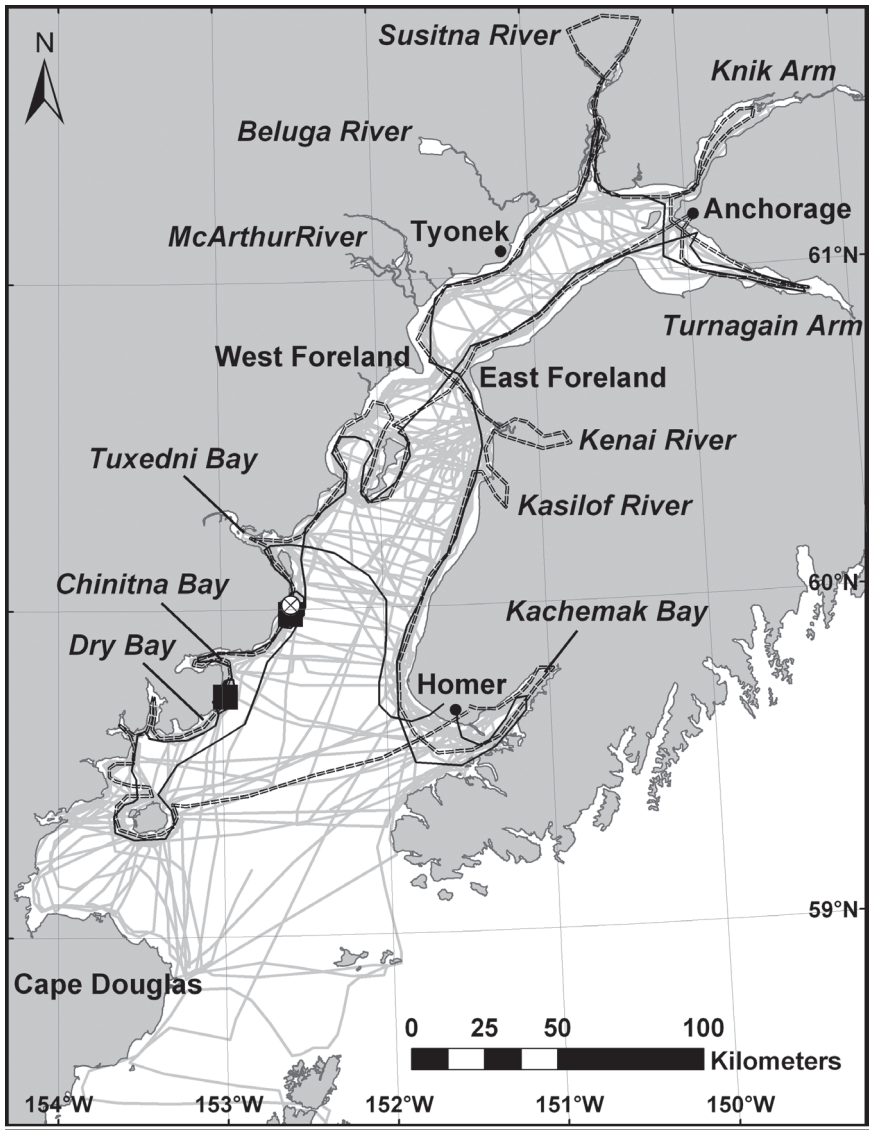

Figure 9.—Harbor porpoise sightings and survey effort in Cook Inlet, Alaska, November 1977 – August 1979 from Murray and Calkins (text footnote 16). Effort without porpoise sightings is shown in light gray. Sightings occurred on 22 May 1978 (squares on the solid black trackline) and 18 June 1978 (circle on the dashed black trackline).

In 1993, NMFS began a series of annual aerial surveys in Cook Inlet to document abundance and distribution of beluga whales (Rugh et al., 2000, 2004, 2005, 2010; Shelden et al., 2013). Surveys were flown at an altitude of 800 ft (245 m) and included recording the presence of all marine mammals observed within the study area. The number of harbor porpoise sightings collected between 1993 and 2012 was highly variable ranging from 0 to 66 sightings per year (Fig. 12–13, Table 1). Survey effort during the beluga whale abundance surveys was fairly consistent across most years with at least two survey flights covering lower inlet waters (south of the Forelands) and multiple flights occurring over the upper inlet (see Appendix for survey effort/ area by year for 1993 to 2012 for this study, and all subsequent

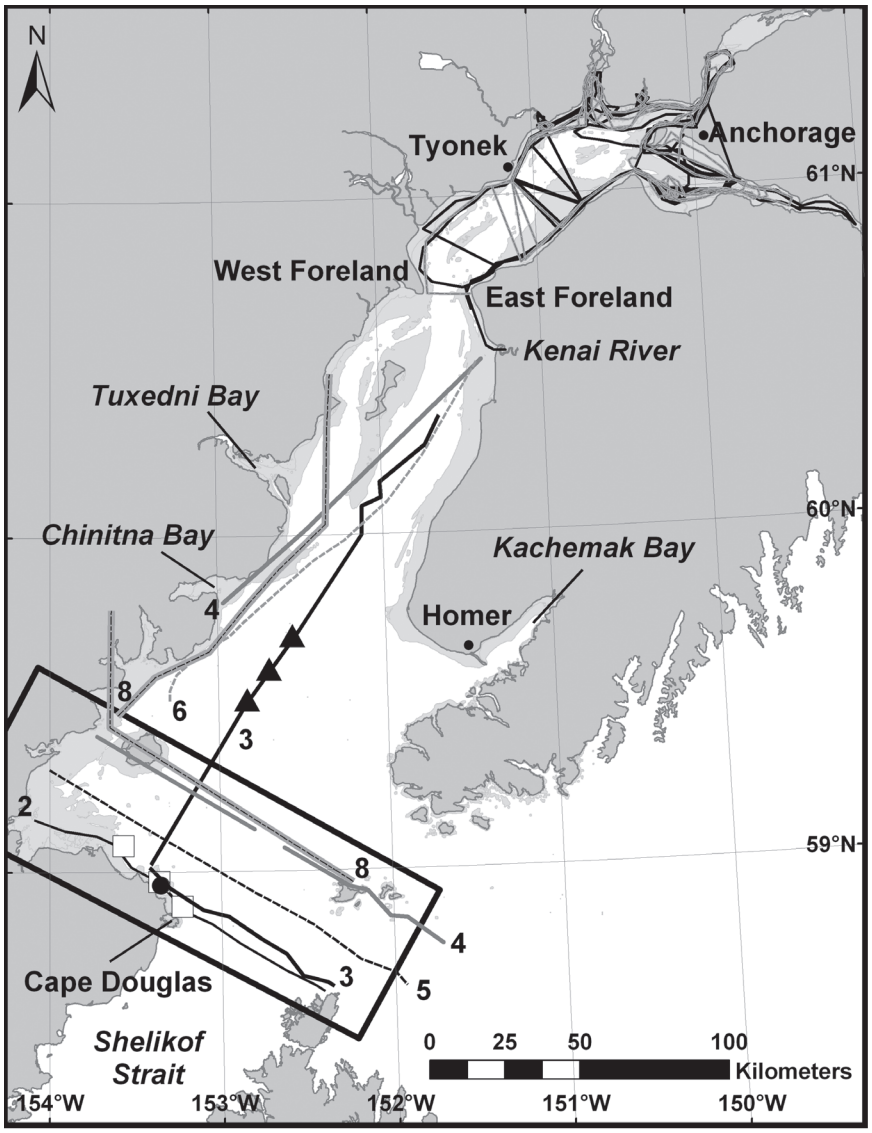

Figure 10.—Harbor porpoise sightings and survey effort in lower Cook Inlet, Alaska (south of the Kenai River) from Leatherwood et al. (text footnote 10) and survey effort in upper Cook Inlet from Calkins (text footnote 17), 1982–1983. Survey Block 7, Zone 1 from Leatherwood et al. (text footnote 10) is shown as the box north of Shelikof Strait. Only surveys with effort collected north of Cape Douglas were plotted and are identified as: 2 (May–June 1982), 3 (July 1982), 4 (August 1982), 5 (September 1982), 6 (October–November 1982), and 8 (February–March 1983). Sightings include: survey 2 on-transect (squares), survey 3 on-transect (circle), and survey 3 off-transect (triangles). No porpoise were observed in the upper inlet from May–August 1982 (black lines) and April–July 1983 (gray lines) (Calkins, text footnote 17).

systematic surveys presented herein). Surveys on a smaller scale, primarily focused on the inlet north of the Forelands, occurred in May (Rugh et al.[25]), August (Rugh et al.[26, 27], Shelden et al.[28–32], Sims et al.[33]), September (Withrow et al.[34]; Shelden et al.[35]), and October (Shelden et al.[35]). However, harbor porpoise were not observed during these efforts.

Hobbs and Waite (2010) used harbor porpoise sightings from the June 1998 beluga whale aerial survey in their abundance calculation for the GOA. Effort included only the offshore sawtooth trackline which covered 1,355 km (and coincidentally

[25]Rugh, D. J., K. T. Goetz, and C. L. Sims. 2006. Aerial surveys of belugas in Cook Inlet, Alaska, May 2006. Unpubl. field rep., 8 p. (Available at: http://www.fakr.noaa.gov/protectedresources/whales/beluga/survey/report0506.pdf accessed 19 July 2011).

[26]Rugh, D. J., K. T. Goetz, and B. A. Mahoney. 2005. Aerial surveys of belugas in Cook Inlet, Alaska, August 2005. Unpubl. field rep., 8 p. (Available at: http://www.fakr.noaa.gov/protectedresources/whales/beluga/aerialsurvey05.pdf accessed 19 July 2011).

[27]Rugh, D. J., K. T. Goetz, C. L. Sims, and B. K. Smith. 2006. Aerial surveys of belugas in Cook Inlet, Alaska, August 2006. Unpubl. field rep., 9 p. (Available at: http://www.fakr.noaa.gov/protectedresources/whales/beluga/survey/aug2006.pdf accessed 19 July 2011).

[28]Shelden, K. E. W., K. T. Goetz, and J. A. Mocklin. 2007. Aerial surveys of belugas in Cook Inlet, Alaska, August 2007. Unpubl. field rep., 11 p. (Available at: http://www.fakr.noaa.gov/protectedresources/whales/beluga/survey/aug2007.pdf accessed 19 July 2011).

[29]Shelden K. E. W., K. T. Goetz, L. Vate Brattström, B. A. Mahoney, M. Migura-Krajzynski, and B. S. Stewart. 2008. Aerial surveys of belugas in Cook Inlet, Alaska, August 2008. Unpubl. field rep., 11 p. (Available at: http://www.fakr.noaa.gov/protectedresources/whales/beluga/survey/aug2008.pdf accessed 19 July 2011).

[30]Shelden K. E. W., K. T. Goetz, L. Vate Brattström, and B. A. Mahoney. 2009. Aerial surveys of belugas in Cook Inlet, Alaska, August 2009. Unpubl. field rep., 11 p. (Available at: http://www.fakr.noaa.gov/protectedresources/whales/beluga/survey/august09.pdf accessed 19 July 2011).

[31]Shelden K. E. W., L. Vate Brattström, and C. L. Sims. 2010. Aerial surveys of belugas in Cook Inlet, Alaska, August 2010. Unpubl. field rep., 12 p. (Available at: http://www.fakr.noaa.gov/protectedresources/whales/beluga/survey/august2010.pdf accessed 19 July 2011).

[32]Shelden K. E. W., L. Vate Brattström, and C. L. Sims. 2011. Aerial surveys of belugas in Cook Inlet, Alaska, August 2011. Unpubl. field rep., 10 p. (Available at: http://www.fakr.noaa.gov/protectedresources/whales/beluga/survey/august2011.pdf accessed January 25, 2012).

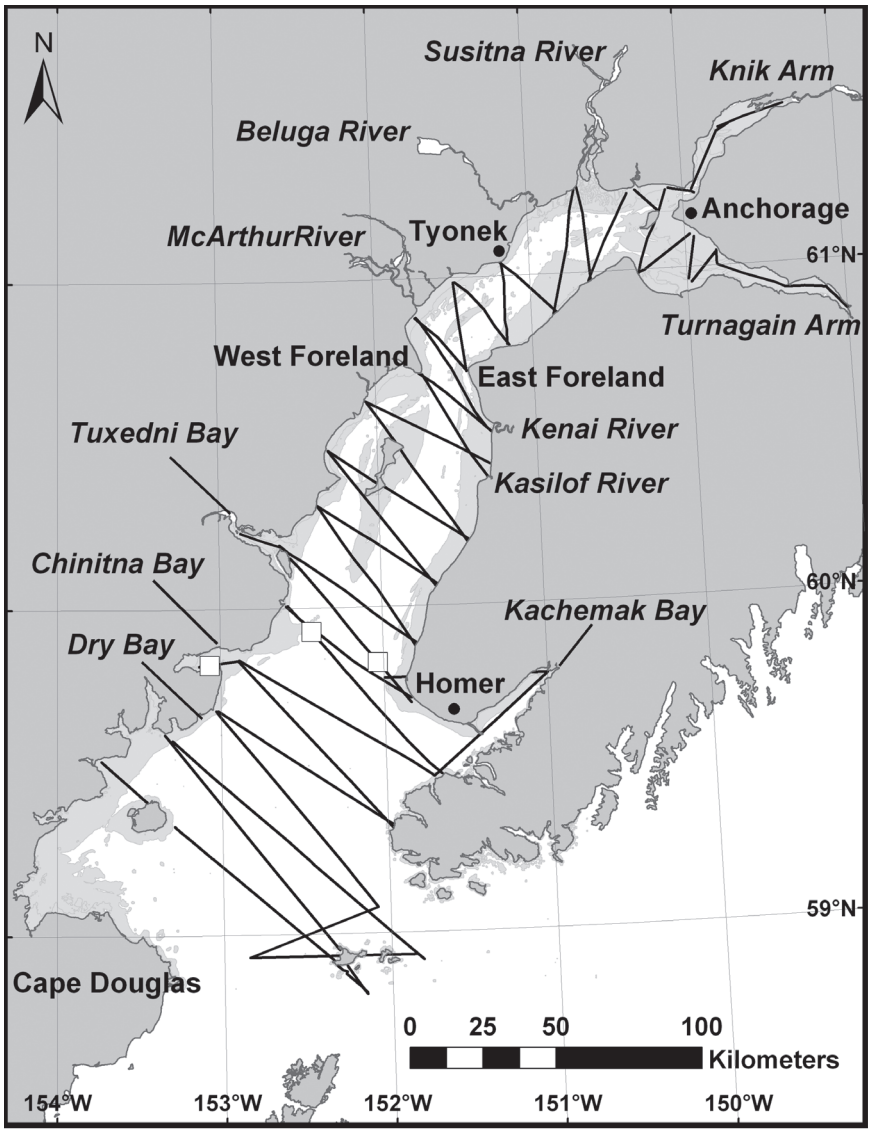

Figure 11.—Harbor porpoise sightings and survey effort in Cook Inlet, Alaska, 1–2 August 1991 from Dahlheim et al. (2000). Sightings occurred on 2 Aug. (squares).

included all harbor porpoise sightings, see Appendix Fig. A6). Corrections for perception bias and g(0) were not calculated because observers could not monitor the trackline beneath the plane. Only the correction for availability (2.96, CV = 18%) was applied. The result was a conservative estimate of 249 (CV = 60.7%), with a known negative bias, based on a subsample of the sightings (8 of the 13 sightings). Much of Kamishak Bay and the coastline south of Chinitna Bay were not surveyed because of poor sighting conditions.

Surveys of seabirds and marine mammals in lower Cook Inlet, covering 17,452 km^2 south of Kasilof River and Redoubt Bay, also occurred in the summer of 1993 and in the winter of 1994 (Agler et al.[11]). Harbor porpoise (5 sightings, 7 animals) were observed during the summer boat surveys (Fig. 14) which comprised 411 transects randomly placed throughout the study area (see Appendix Fig. A1). An abundance of 428 harbor porpoise (95% C.I. 26–830) was estimated from this effort (Agler et al.[11]:121), with the caveat that surveys were designed to detect seabirds and sea otters within 100 m of the vessel and observers were also searching the air 100 m above the vessel. The issues raised by Dahlheim et al. (2000) also apply regarding porpoise behavior, suggesting this estimate may be negatively biased as well. Porpoise were not seen during the winter aerial survey (Appendix Fig. A1), which was flown at an altitude of 200 ft (61 m). Likewise, harbor porpoise were not reported during winter boat surveys of the eastern portion of the lower inlet (Appendix Fig. A1).

From 1994 to 1996, a study was undertaken to monitor and inventory the physical and biological resources of Lake Clark National Park (Bennett[12]). Aerial surveys were conducted at varying altitudes below 1,640 ft (500 m) two to four times per month from April through September covering regions between Redoubt Point and the head of Chinitna Bay. Ground and boat-based surveys supplemented the aerial effort. Marine mammal sighting locations were not provided in the document though it was noted that "harbor porpoises (2–5 animals/observation) were sighted along the coast throughout the summer" (Bennett[12]:69). NMFS aerial surveys also

[33]Sims, C. L., L. Vate Brattström, and K. T. Goetz. 2012. Aerial surveys of belugas in Cook Inlet, Alaska, August 2012. Unpubl. field rep., 11 p. (Available at: http://alaskafisheries.noaa.gov/protectedresources/whales/beluga/survey/august2012.pdf accessed 14 Nov. 2013).

[34]Withrow, D. E., K. E. W. Shelden, D. J. Rugh, and R. C. Hobbs. 1994. Beluga whale, *Delphinapterus leucas*, distribution and abundance in Cook Inlet, 1993. *In* H. Braham and D. DeMaster (Editors), Marine Mammal Assessment Program: status of stocks and impacts of incidental take; 1993, p. 128–153. Annu. Rep. submitted to Off. Protected Resour., NMFS, NOAA, 1335 East-West Highway, Silver Spring, MD 20910. (Available at: http://www.fakr.noaa.gov/protectedresources/whales/beluga/reports/withrowetal1993.pdf accessed 19 July 2011).

[35]Shelden K. E. W., K. T. Goetz, C. Sims, and B. A. Mahoney. 2008. Aerial surveys of belugas in Cook Inlet, Alaska, September and October 2008. Unpubl. field rep., 9 p. (Available at: http://www.fakr.noaa.gov/protectedresources/whales/beluga/survey/sept_oct08.pdf accessed 19 July 2011).

found porpoise in this region during the beluga whale abundance surveys from 1994 to 1996 (Fig. 13, Table 1, Appendix Fig. A2–A4).

From 1995 to 1999, vessel-based marine bird and mammal surveys were conducted in lower Cook Inlet, south of Kalgin Island, during July and August (Speckman and Piatt, 2000; Speckman[13]). Linear kilometers surveyed per year ranged from 820 to 2,052 and included nearshore and offshore habitats (Appendix Fig. A3–A7). Harbor porpoise sightings occurred in all years but 1995 (Fig. 14, Table 1).

In 1997, winter aerial surveys for beluga whales in ice-free areas of Cook Inlet occurred from 12 February through 14 March (Hansen and Hubbard[18]). The surveys covered 9,406 km of trackline and were flown at an altitude of 1,000 ft (304.8 m). Sightings of harbor porpoise were reported on 2 out of the 10 survey days (Fig. 15, Table 1).

Additional year-round aerial surveys documenting beluga whale distribution were conducted by NMFS between the annual surveys in June 2001 and June 2002 (Rugh et al., 2004). Surveys conducted in July–November 2001, January–February 2002, and April 2002 covered all coastal areas in the upper inlet north of the Forelands and included an offshore sawtooth trackline that extended as far south as Harriet Point and Kasilof River (Rugh et al., 2004). No harbor porpoise encounters occurred during the year-round effort (Rugh et al., 2004, 2005) (Appendix Fig. A9).

In July of 2004, LGL[36] began a 13-month study of beluga whale habitat use in Knik Arm. Observers at nine shore-based sites logged 1,899 sessions (average length = 6 h) for a total of over 14,000 h of monitoring effort (Appendix Fig. A11). This shore-based operation was supplemented by 140 boat surveys (748 h total effort). Harbor porpoise were seen on a few occasions in April and May 2005 (Table 1). In 2006, LGL also documented marine fish and mammals as part of the environmental assessment for the Ladd Landing coal trestle (Nemeth et al.[19]). Shore-based surveys were in operation from mid-April to the end of October at five sites on the west side of the upper inlet. Offshore surveys were also conducted from vessels and aircraft (survey altitudes ranging from 800–1,000 ft (244–305 m)) from May through October, as weather allowed.

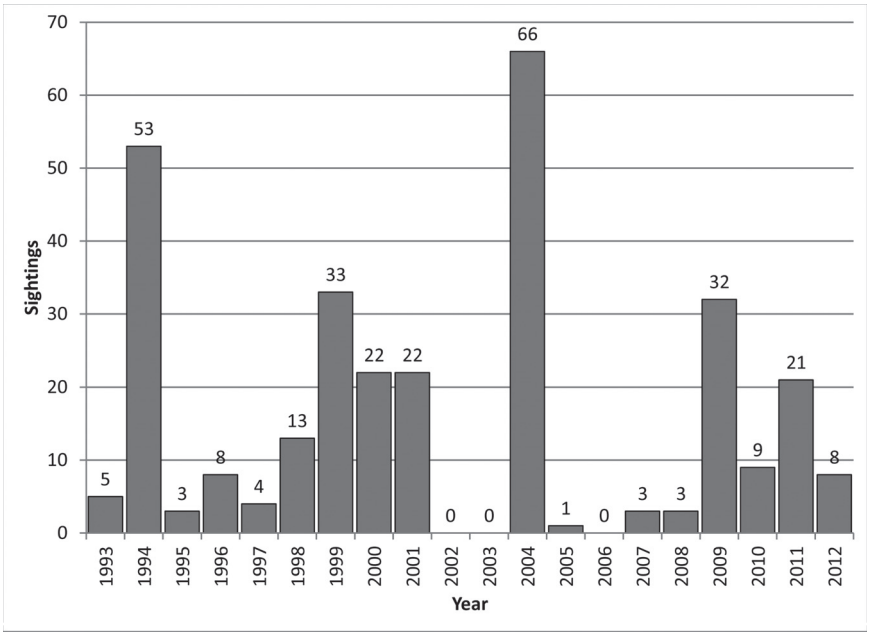

Figure 12.—Harbor porpoise sightings collected during aerial surveys conducted by the National Marine Mammal Laboratory in Cook Inlet, Alaska, 1993–2012.

Harbor porpoise were recorded at two of the shore-based observation sites: the Chuitna River which operated 20–23 days per month (with the exception of April, $n = 6$ d) and at the Three Mile Creek site operating 1 day per month (Fig. 16, Table 1). Behaviors observed included feeding (primarily from May through July, and secondarily in October), traveling (primarily from August through October), diving (secondarily from August through October), and socializing (secondarily in May). Harbor porpoise were not observed in Turnagain Arm during a land-based beluga whale monitoring study conducted by LGL from May through November in 2006 (Markowitz et al.[37]).

Marine mammal surveys were conducted during three oil and gas seismic operations in upper and lower Cook Inlet in 2007. Seismic operations extended from shore out to water depths of about 25 m. One survey was conducted in the upper inlet near Beluga River from mid-April to mid-May 2007 (Brueggeman et al.[38]). A

[36]LGL. Unpubl. data, presented in the Final Environmental Impact Statement and Final Section 4(f) Evaluations prepared by Knik Arm Bridge and Toll Authority and AK Dep. Trans. & Public Facil., for the Fed. Hwy. Admin., Juneau, AK (Available at: http://www.knikarmbridge.com/project-documents.html and http://www.knikarmbridge.com/FEIS%20CD%202/Appendices/Appendix%20F-all%20121807.pdf accessed 5 July 2011) from the study by Funk, D. W., T. M. Markowitz, and R. Rodrigues (Editors). 2005. Baseline studies of beluga whale habitat use in Knik Arm, Upper Cook Inlet, Alaska, July 2004–July 2005. Rep. from LGL Alaska Res. Assoc., Inc., Anchorage, AK, in association with HDR Alaska, Inc., Anchorage, AK, for Knik Arm Bridge and Toll Authority, Anchorage, AK, Dep. Transport. Public Facil., Anchorage, AK, and Fed. Hwy. Admin., Juneau, AK.

[37]Markowitz, T. M., T. L. McGuire, and D. M. Savarese. 2007. Monitoring beluga whale (*Delphinapterus leucas*) distribution and movements in Turnagain Arm along the Seward Highway. Prep. by LGL Alaska Res. Assoc., Inc., 1101 E. 76th Ave., Suite B., Anchorage, AK 99518 for HDR Alaska, Inc., 2525 C Street, Suite 305, Anchorage, AK 99503 on behalf of Alaska Dep. Transport. Public Facil., P.O. Box 196900, Anchorage, AK 99519-6900, 42 p. (Available at: http://www.fakr.noaa.gov/protectedresources/whales/beluga/development/sewardhwy0407.pdf accessed 24 Oct. 2011).

[38]Brueggeman, J. J. 2007. 2007 spring marine mammal monitoring program for the Cono-

total of 11 groups of 14 harbor porpoises were observed during 636 h of helicopter, 195 h of land-based, and 1194 h of vessel surveys (Fig. 17, Table 1). A second survey was also conducted in the upper inlet near Granite Point from late September to late October (Brueggeman et al.[39]). A total of 6 groups of 12 harbor porpoises were observed during 110 h of helicopter and 493 h of vessel surveys (Fig. 17, Table 1). The last survey was conducted in the lower inlet near North Ninilchik from 25 October to 7 November (Brueggeman et al.[40]). No harbor porpoises were observed during 173 h of vessel surveys.

Beginning in October 2007, as part of the Port of Anchorage (POA) marine terminal development project, marine mammal observers monitored pile driving operations in Knik Arm during which a single harbor porpoise was seen (URS[41,42]; Table 1, Fig. 17). In 2008, the POA continued monitoring pile driving operations from 24 June to 14 November during which harbor porpoise were not observed (Cornick and Saxon-Kendall[43]). POA marine mammal observers reported 20 harbor porpoise during the late March to mid-December 2009 monitoring period (ICRC[44]; Table 1). In 2010, POA

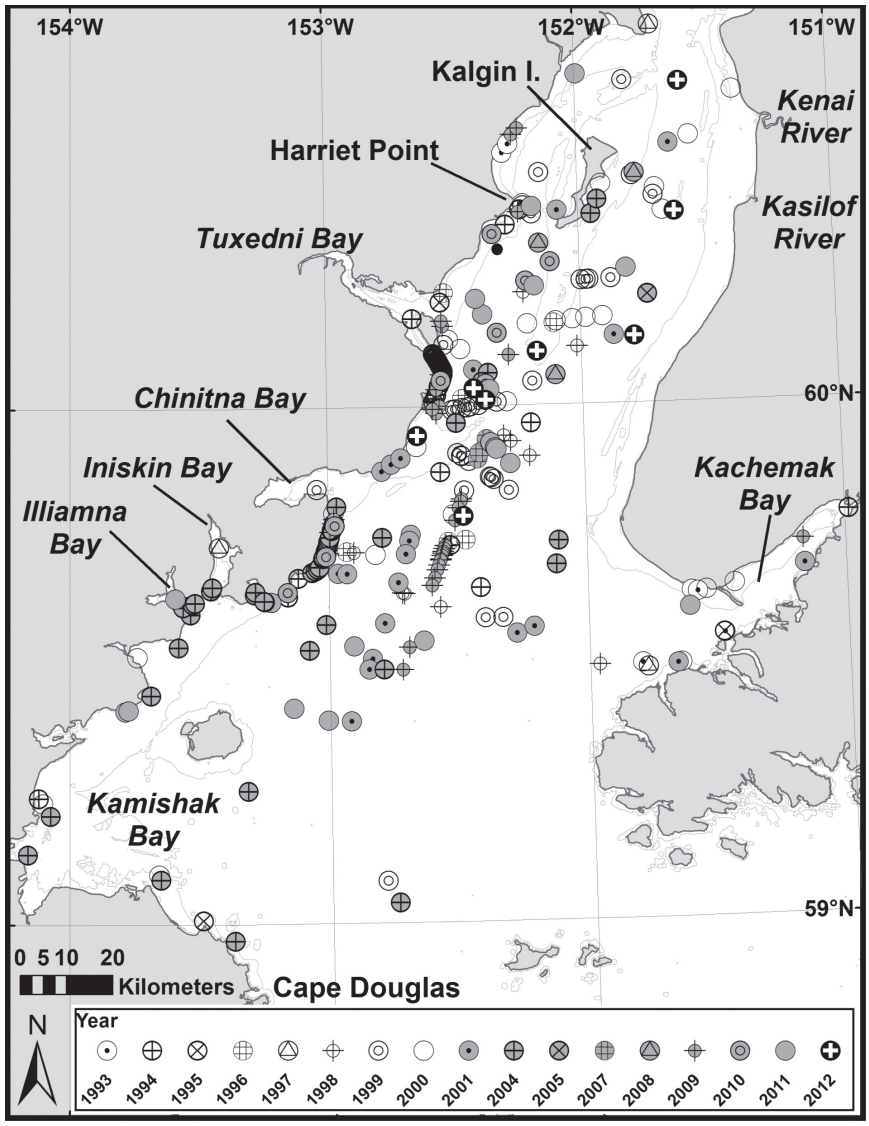

Figure 13.—Harbor porpoise sighting locations during aerial surveys conducted by the National Marine Mammal Laboratory in Cook Inlet, Alaska, 1993–2012.

coPhillips Beluga River seismic operations in Cook Inlet Alaska: 90-day report. Prep. by Canyon Creek Consulting, Seattle, WA, for ConocoPhillips Alaska, Inc., 38 p.

[39]Brueggeman, J. J. 2008. 2007 fall marine mammal monitoring program for the Union Oil Company of California Granite Point seismic operations in Cook Inlet Alaska: 90-day report. Prep. by Canyon Creek Consulting, Seattle, WA, for Union Oil Co. of California, 34 p.

[40]Brueggeman, J. 2008. 2007 fall marine mammal monitoring program for the Marathon Oil Company North Ninilchik seismic operations in Cook Inlet Alaska: 90-day report. Prep. by Canyon Creek Consulting, Seattle, WA, for Marathon Oil Co., 18 p.

[41]URS Corporation. 2007. Port of Anchorage Marine Terminal Development Project Underwater Noise Survey Test Pile Driving Program, Anchorage, Alaska. Rep. from URS Corp. for Integrated Concepts & Res. Corp., 109 p. (Available at: http://www.fakr.noaa.gov/protectedresources/whales/beluga/development/portofanc/urs_noisereport1207.pdf accessed 19 July 2011).

[42]URS Corporation. 2008. Application for 2008 incidental harassment authorization for construction activities associated with the Port of Anchorage marine terminal redevelopment project. Prep. for U.S. Dep. Transport., Maritime Admin., 400 Seventh St., S.W., Wash., D.C. 20590; Port of Anchorage, 2000 Anchorage Port Rd., Anchorage, Alaska 99501; and Integrated Concepts & Res. Corp., 421 West First Ave., Ste 200, Anchorage, AK 99501, 180 p. (Available at: http://www.nmfs.noaa.gov/pr/pdfs/permits/poa_iha.pdf accessed 19 July 2011).

[43]Cornick, L. A., and L. Saxon-Kendall. 2009. Distribution, habitat use and behavior of Cook Inlet beluga whales and other marine mammals at the Port of Anchorage marine terminal redevelopment project June–November, 2008: Scientific marine mammal monitoring rep. for 2008. Prep. for U.S. Dep. Transport., Maritime Admin., 400 Seventh St., S.W., Washington, D.C. 20590; Port of Anchorage, 2000 Anchorage Port Rd., Anchorage, Alaska 99501; and Integrated Concepts & Res. Corp., 421 West First Ave., Ste 200, Anchorage, AK 99501, 180 p. (Available from author L.A. Cornick, accessed 19 July 2011)

[44]ICRC. 2010. 2009 annual marine mammal monitoring report: construction and scientific marine mammal monitoring associated with the Port of Anchorage marine terminal redevelopment project. Prep. by Integrated Concepts & Res. Corp., 421 West First Av., Ste 200, Anchorage, Alaska 99501 for U.S. Dep. Transport., Maritime Admin., 1200 New Jersey Ave., S.E.,

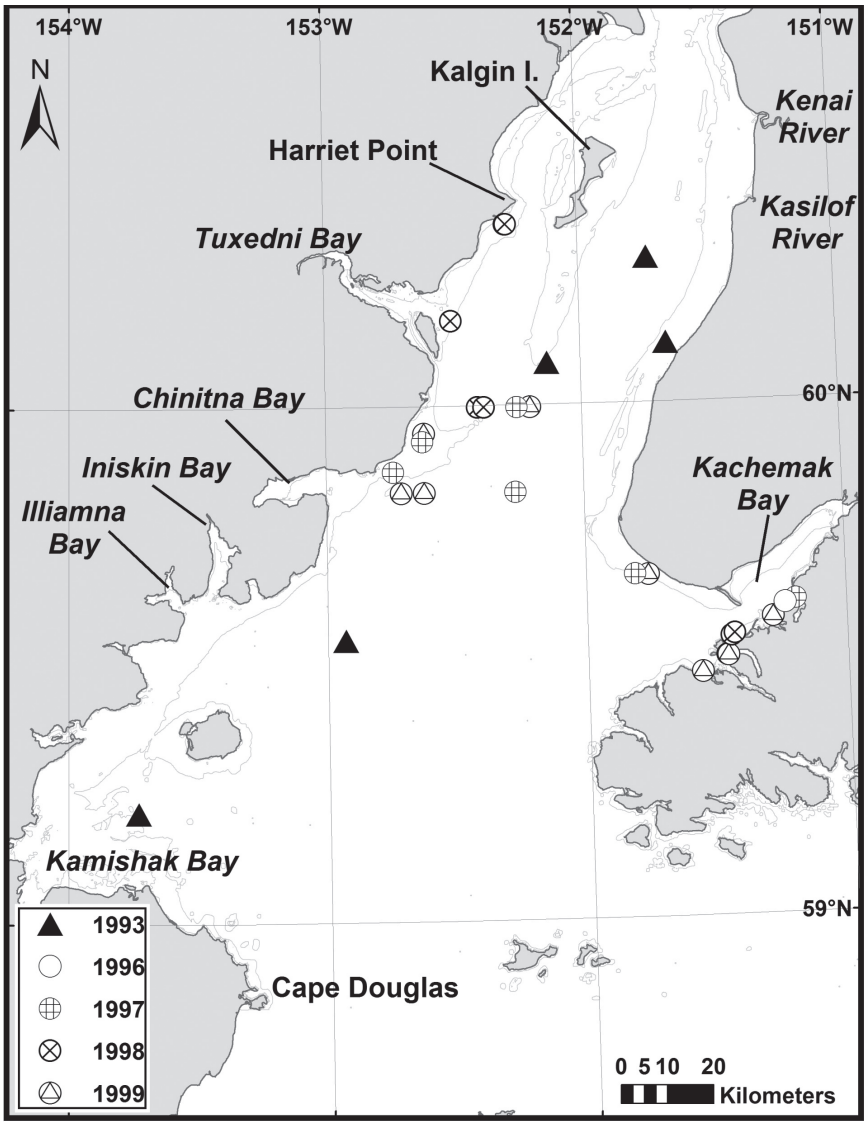

Figure 14.—Harbor porpoise sighting locations during marine bird and mammal boat surveys in lower Cook Inlet. Sightings occurred in June 1993 (Agler et al., text footnote 11); July 1996, July–August 1997, July–August 1998, and August 1999 (Speckman and Piatt, 2000; Speckman, text footnote 13; USFWS GIS database).

marine mammal observers recorded only two harbor porpoise during 106 days of observation between late July and late November (ICRC[45]; Table 1). The 2011 monitoring program ran from late June to mid-November, documenting six harbor porpoise in the Knik Arm monitoring area (ICRC[46]; Table 1).

Discussion

Harbor porpoise are a cryptic species, presenting a low profile when surfacing and often travelling alone. Despite being difficult to detect, these porpoise were reported in Cook Inlet waters in all months except December and January. Harbor porpoise were also found in coastal as well as offshore waters of the inlet. Overall, these porpoise appear to be widespread throughout the inlet though occasionally large aggregations are found in coastal and offshore waters of the lower inlet.

The sightings, abundance estimates, and density estimates presented here were at times limited by survey area, effort, research platform, and survey design. The only dedicated harbor porpoise survey, Dahlheim et al. (2000), did not include coastline surveys. The 1998 abundance estimate, based on sightings obtained during beluga whale surveys, also excluded coastal survey effort (Hobbs and Waite, 2010). As observed during the 18 years covered by these same surveys, in some years coastal habitats in Cook Inlet are heavily used by harbor porpoise.

Archaeological and ethnographic studies suggest harbor porpoise were historically abundant in the lower inlet and occupied a restricted range. Present-day harbor porpoise continue to occupy regions such as Kachemak Bay and the coastline near Tuxedni Bay. Although harbor porpoise were not hunted in the upper inlet or mentioned in expedition accounts from the early 1900's, it appears that by the 1950's at least a few porpoise were entering the upper inlet as far as Knik Arm (i.e.,

Wash., DC 20590 and Port of Anchorage, 2000 Anchorage Port Rd., Anchorage, Alaska 99501, 99 p. (Available from author L.A. Cornick, accessed 19 July 2011).

[45]ICRC. 2011. 2010 annual marine mammal monitoring report: construction and scientific marine mammal monitoring associated with the Port of Anchorage marine terminal redevelopment project. Prep. by Integrated Concepts & Res. Corp., 421 West First Ave., Ste 200, Anchorage, Alaska 99501 for U.S. Dep. Transport., Maritime Admin., 1200 New Jersey Ave., S.E., Wash., DC 20590 and Port of Anchorage, 2000 Anchorage Port Rd., Anchorage, Alaska 99501, 96 p. (Available from author L.A. Cornick, accessed 19 July 2011).

[46]ICRC. 2012. 2011 monthly marine mammal monitoring reports: construction and scientific marine mammal monitoring associated with the Port of Anchorage marine terminal redevelopment project. Prep. by Integrated Concepts & Res. Corp., 421 West First Ave., Ste 200, Anchorage, AK 99501 for U.S. Dep. Transport., Maritime Admin., 1200 New Jersey Ave., S.E., Washington, DC 20590 and Port of Anchorage, 2000 Anchorage Port Rd., Anchorage, AK 99501. (Available from author L.A. Cornick, accessed 31 Jan. 2012).

entangling in set nets). The increased number of porpoise sightings in the upper inlet in recent years may be an artifact of increased marine mammal monitoring of anthropogenic activities that may affect ESA-listed Cook Inlet beluga whales. However, it is possible that contraction of the range of beluga whales into the upper reaches of the inlet (Rugh et al., 2010) has opened habitats to harbor porpoise that were previously occupied by beluga whales.

Habitat overlap is likely for these species as both beluga whales and harbor porpoise in Cook Inlet forage on similar prey. Harbor porpoise feed mostly on smaller, pelagic schooling fish, and they also consume crustaceans and squid in some regions (Bjørge and Tolley, 2008). Of these schooling fish, a number of anadromous smelt species (Family Osmeridae) and Pacific herring, *Clupea pallasii pallasii,* occur in Cook Inlet. A review of fish species in Cook Inlet conducted by LGL Alaska Research Associates, Inc. (Rodriguez et al.[47]) noted most forage fish studies have occurred in the lower inlet. From the few studies that have occurred in the upper inlet, Moulton (1997) found herring abundant during sampling periods in June, July, and September of 1993, with smelts such as longfin smelt, *Spirinchus thaleichthys*, and capelin, *Mallotus villosus*, in small numbers, and eulachon, *Thaleichthys pacificus*, very abundant but only in early June. During the ice-free months (April–November) from 2004 to 2005, Houghton et al.[48] found smelt present in Knik Arm only in April–May (eulachon) and September–October (longfin smelt). Harbor porpoise sightings in the upper inlet also appear to peak during these times. Of the 103 harbor porpoise sightings that have been reported in the upper inlet since 2005 (Table 1), 35 occurred in May, 8 in June, 7 in July, 11 in August, 18 in September, 22 in October, and 2 in November. Though many of the studies reporting porpoise sightings did not span this entire time period, those that did also noted peaks in harbor porpoise detection in April–early June and September–October (e.g., Nemeth et al.[19], ICRC[44]). Group sizes were small (1–5 animals), and thus far, large aggregations of harbor porpoise have not been observed in the upper inlet.

The occurrence of larger numbers of porpoise in the lower inlet may be driven by greater availability of preferred prey and possibly less compe-

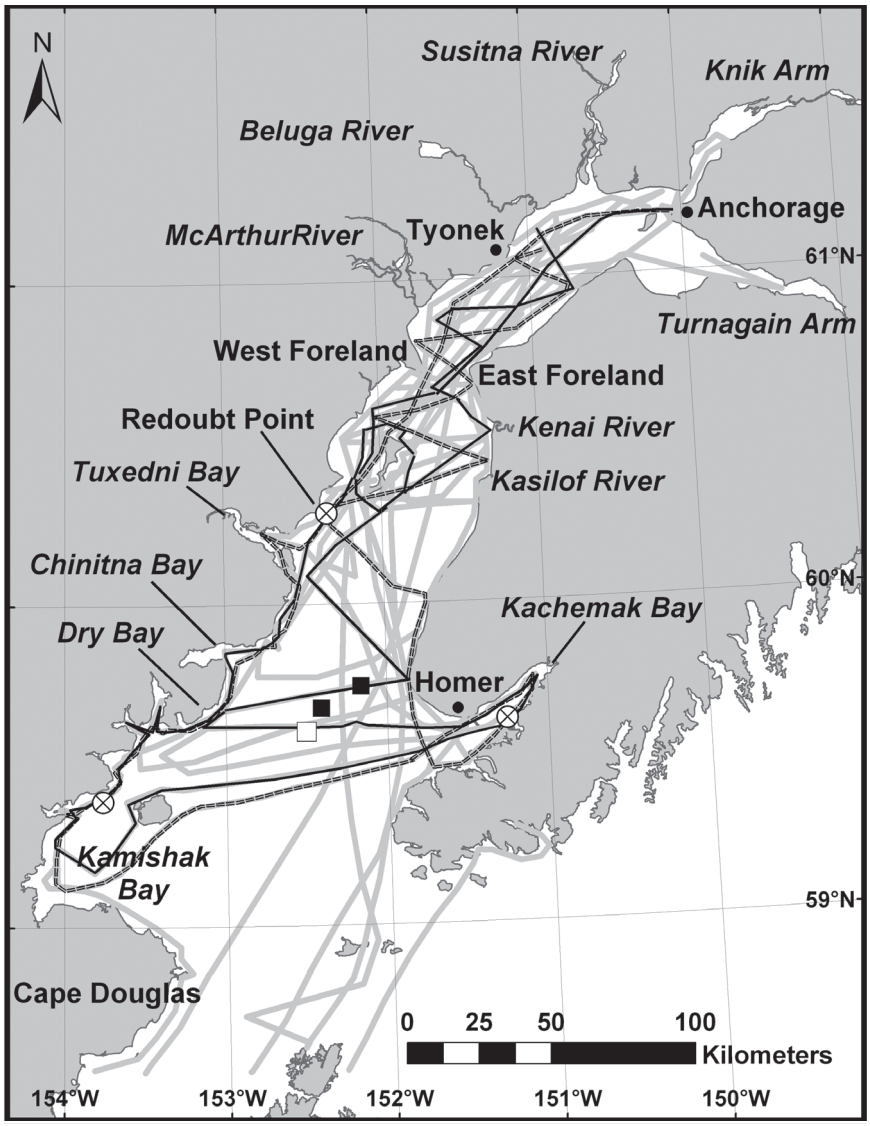

Figure 15.—Harbor porpoise sightings and survey effort in Cook Inlet, Alaska, winter 1997. Sightings occurred on 12 March (circles on dashed black effort line) and 13 March (squares on solid black effort line). Dark squares indicate species was likely harbor porpoise but identification was not confirmed (Hansen and Hubbard, text footnote 18). Effort without porpoise sightings is shown in light gray.

[47]Rodriguez, R., M. Nemeth, T. Markowitz, and D. Funk. 2006. Review of literature on fish species and beluga whales in Cook Inlet, Alaska. Final rep. prep. by LGL Alaska Res. Assoc., Inc., Anchorage, AK, for DRven Corp., Anchorage, AK, 55 p. (Available at: http://www.chuitnaseis.com/documents/projectdocs/Literature-Review-Marine-Fish-Mammals.pdf accessed 25 Jan. 2012).

[48]Houghton, J., J. Starkes, M. Chambers, and D. Ormerod. 2005. Marine fish and benthos studies in Knik Arm, Anchorage, Alaska. Rep. prep. for the Knik Arm Bridge and Toll Authority, and HDR Alaska, Inc., Anchorage, AK, by Pentec Environmental, Edmonds, WA.

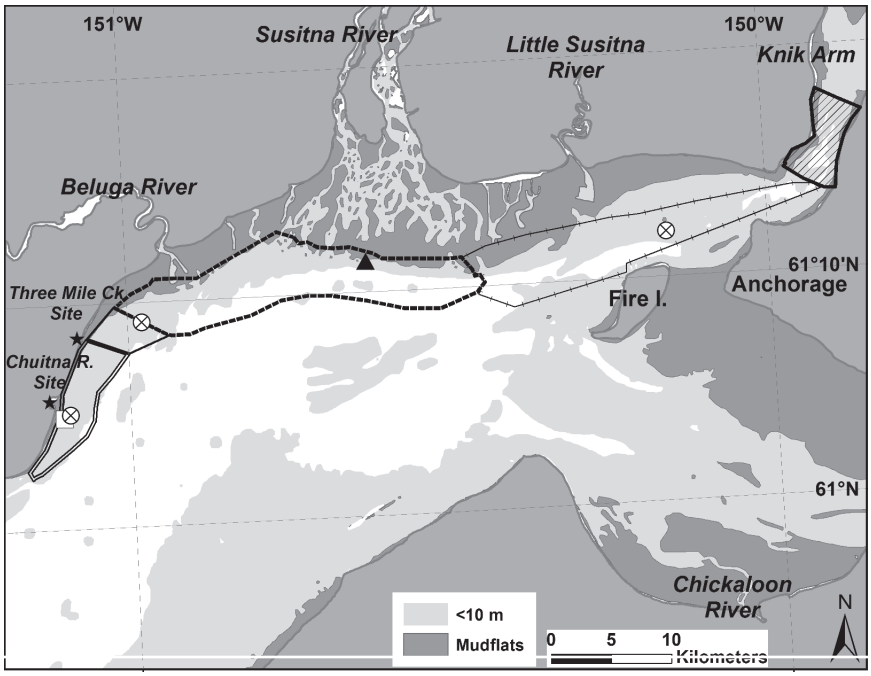

Figure 16.—Ladd Landing study areas (5 zones) and land-based observation sites (stars) where harbor porpoise were observed from May through October 2006 (Nemeth et al., text footnote 19). Sightings from land-based sites are reported in Table 1. Sightings obtained during vessel/aerial surveys are from May (circles), June (triangle), and August (square).

tition with beluga whales, as belugas move into upper inlet waters to forage on Pacific salmon, *Oncorhynchus* spp., during the summer months. In the lower inlet, forage fish studies have occurred in Kachemak Bay, near Chisik Island in Tuxedni Bay, and northeast of the Barren Islands (e.g., Abookire and Piatt, 2005; Speckman et al., 2005; Fechhelm et al.[49]). Smelts and/or herring were present in all regions but dominant species varied from year to year, region to region, and sometimes season to season. Speckman et al. (2005) found the highest densities of herring and longfin smelt in warm waters <40 m deep, but herring peaked in clearer, more saline waters while longfin smelt peaked in more turbid, fresher waters. Capelin densities peaked in clear, saline waters that were much deeper (50–110 m) and colder. Fronts and eddies, formed where upper inlet outflow meets the ACC south of Tuxedni Bay, may aggregate prey. Studies of North Atlantic harbor porpoise suggest preferences for areas with stronger currents that aggregate prey along fronts (e.g., Johnston et al., 2005; Marubini et al., 2009; Gilles et al., 2011). Given schooling prey occupy a range of oceanographic domains in the lower inlet, this may explain some of the interannual variability in harbor porpoise encounter rates in offshore versus nearshore areas during systematic surveys (e.g., NMFS beluga whale survey data). Sveegaard et al. (2011, 2012) found that the distribution of satellite-tagged North Atlantic harbor porpoise was largely driven by herring abundance and that although ranges occupied were wide, several key areas were heavily used, some of which were far from the original tagging site.

Large fluctuations in harbor porpoise sightings observed interannually may be attributed to sampling

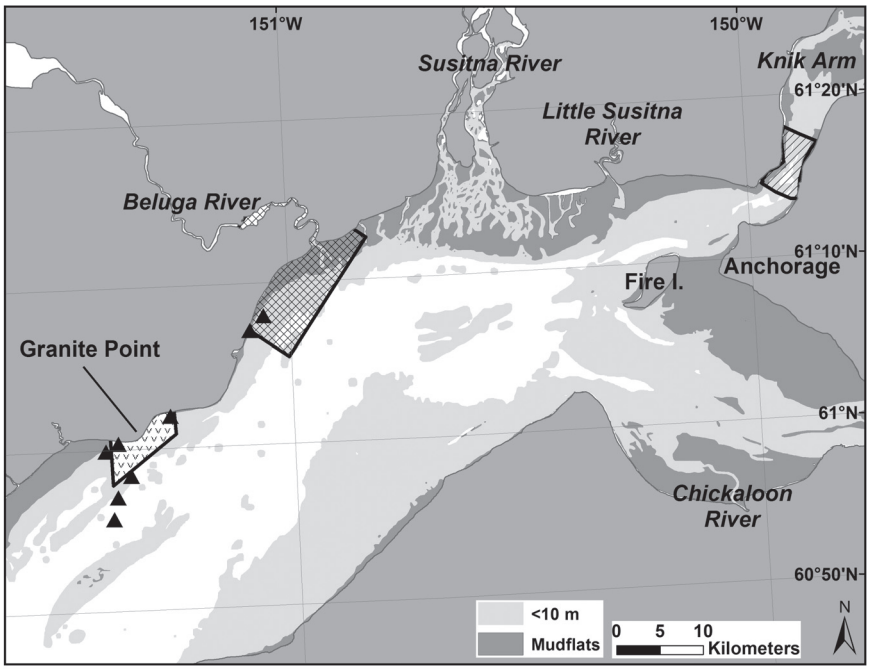

Figure 17.—Seismic study boundaries surveyed 14 April to 13 May 2007 near Beluga River and 29 September to 21 October 2007 near Granite Point (Brueggeman, text footnote 38 and 39, respectively), and the Port of Anchorage (POA) study area in Knik Arm, 2007–2011. Seismic study harbor porpoise sightings (triangles) occurred in May near Beluga River, and in October near Granite Point. Sightings during the POA study are presented in Table 1 and occurred in all years but 2008.

[49]Fechhelm, R. G., W. J. Wilson, W. B. Griffiths, T. B. Stables, and D. A. Marino. 1999. Forage fish assessment in Cook Inlet oil and gas development areas, 1997–1998. Report prepared by LGL Alaska Res. Assoc., Inc., Anchorage, AK, and BioSonics, Inc., Seattle, WA, for USDOI, Minerals Manage. Serv., Anchorage, AK.

only a portion of their effective range (e.g., Marubini et al., 2009). While a number of harbor porpoise populations found along the coastline of the eastern North Pacific seem to have established home ranges (Chivers et al., 2002), the extent of area used by Cook Inlet harbor porpoise is not known. To date, genetic sampling and tagging studies have not been undertaken in Alaska waters.

Harbor porpoise are incidentally caught in driftnet and set gill net fisheries throughout their Northern Hemisphere range. Fisheries bycatch, often at unsustainable levels, is currently the greatest anthropogenic threat to harbor porpoise (Bjørge and Tolley, 2008). Interactions with fisheries factored in a quarter of the stranded animals recovered in Cook Inlet. In the last decade the region also has seen expansion of the Port of Anchorage, proposals to build a bridge crossing Knik Arm, plans to develop mining operations and supporting infrastructure, hydrokinetic energy generation proposals, oil and gas seismic exploration, and water quality effects from urban areas. The overall effect on harbor porpoise within the confines of Cook Inlet cannot be fully determined until we understand the genetic and demographic population structure of this highly mobile and cryptic species.

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Literature Cited

Abookire, A. A., and J. F. Piatt. 2005. Oceanographic conditions structure forage fishes into lipid-rich and lipid-poor communities in Lower Cook Inlet, Alaska, USA. Mar. Ecol. Prog. Ser. 287:229–240.

Allen, B. M., and R. P. Angliss. 2010. Alaska marine mammal stock assessments, 2009. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-206, 276 p.

Bailey, A. M., and R. W. Hendee. 1926. Notes on the mammals of northwestern Alaska. J. Mammal. 7(1):9–28.

Baird, M. F. 2006. Frederica de Laguna and the study of pre-contact pictographs from coastal sites in Cook Inlet and Prince William Sound, Alaska. Arctic Anthropol. 43(2):136–147.

Bee, J. W., and E. R. Hall. 1956. Mammals of northern Alaska on the Arctic slope. Mus. Nat. Hist., Univ. Kansas (Lawrence), vol. 8, 309 p.

Bjørge, A., and K. A. Tolley. 2008. Harbor porpoise *Phocoena phocoena*. *In* W. F. Perrin, B. Würsig, and J. G. M. Thewissen (Editors), Encyclopedia of marine mammals, 2nd ed., p. 530–532. Acad. Press, N.Y.

Calambokidis, J., and J. Barlow. 1991. Chlorinated hydrocarbon concentrations and their use for describing population discreteness in harbor porpoises from Washington, Oregon, and California. *In* J. E. Reynolds III and D. K. Odell (Editors), Marine mammal strandings in the United States, p. 101–110. U.S. Dep. Commer., NOAA Tech. Rep. NMFS 98.

Carretta, J. V., K. A. Forney, M. S. Lowry, J. Barlow, J. Baker, B. Hanson, and M. M. Muto. 2009. U.S. Pacific marine mammal stock assessments: 2008. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-434, 334 p.

Chivers, S. J., A. E. Dizon, P. J. Gearin, and K. M. Robertson. 2002. Small-scale population structure of eastern North Pacific harbour porpoises, (*Phocoena phocoena*), indicated by molecular genetic analyses. J. Cetacean Res. Manage. 4(2):111–122.

Dahlheim, M., A. York, R. Towell, J. Waite, and J. Breiwick. 2000. Harbor porpoise (*Phocoena phocoena*) abundance in Alaska: Bristol Bay to southeast Alaska, 1991–1993. Mar. Mammal Sci. 16:28–45.

Davydov, G. I. 1977. Two voyages to Russian America, 1802–1807. Transl. by C. Bearne. R. A. Pierce (Editor), Limestone Press, Kingston, Ontario, 268 p.

de Laguna, F. 1975. The archaeology of Cook Inlet, Alaska. 2nd ed. Alaska Hist. Soc., Anchorage, 264 p. [Originally publ. 1934 by Univ. Pa.]

Emmons, G. T. 1991. The Tlingit Indians. Anthropological papers of the American Museum of Natural History, vol. 70. F. de Laguna (Editor), Univ. Wash. Press, Seattle, 488 p.

Gilles, A., S. Adler, K. Kaschner, M. Scheidat, and U. Siebert. 2011. Modelling harbour porpoise seasonal density as a function of the German Bight environment: implications for management. Endang. Species Res. 14:157–169 (doi: 10.3354/esr00344).

Harrison, C. S., and J. D. Hall. 1978. Alaskan distribution of the beluga whale, *Delphinapterus leucas*. Can. Field-Nat. 92(3):235–241.

Hobbs, R. C., and J. M. Waite. 2010. Abundance of harbor porpoise (*Phocoena phocoena*) in three Alaskan regions, corrected for observer errors due to perception bias and species misidentification, and corrected for animals submerged from view. Fish. Bull. 108:251–267.

Johnston, D. W., A. J. Westgate, and A. J. Read. 2005. Effects of fine-scale oceanographic features on the distribution and movements of harbour porpoises *Phocoena phocoena* in the Bay of Fundy. Mar. Ecol. Prog. Ser. 295:279–293.

Leatherwood, S., R. R. Reeves, W. F. Perrin, and W. E. Evans. 1982. Whales, dolphins, and porpoises of the eastern North Pacific and adjacent Arctic waters. U.S. Dep. Commer., NOAA Tech. Rep. NMFS-CIRC 444, 245 p.

Lobdell, J. E. 1980. Prehistoric human populations and resource utilization in Kachemak Bay, Gulf of Alaska. Ph.D. dissert., Dep. Anthropol., Univ. Tenn. Knoxville, 291 p.

Marubini, F., A. Gimona, P. G. H. Evans, P. J. Wright, and G. J. Pierce. 2009. Habitat preferences and interannual variability in occurrence of the harbour porpoise *Phocoena phocoena* off northwest Scotland. Mar. Ecol. Prog. Ser. 381:297–310.

Merck, C. H. 1980. Siberia and Northwestern America 1788–1792: The journal of Carl Heinrich Merck, naturalist with the Russian scientific expedition led by Captains Joseph Billings and Gavril Sarychev. R.A. Pierce (Editor), Transl. by F. Jaensch. Materials for the study of Alaska history, no. 17. Limestone Press, Kingston, Ontario, 216 p.

Moulton, L. L. 1997. Early marine residence, growth, and feeding by juvenile salmon in northern Cook Inlet, Alaska. Alaska Fish. Res. Bull. 4(2):154–177.

Murie, O. J. 1959. Fauna of the Aleutian Islands and Alaska Peninsula. *In* O. J. Murie and V. B. Scheffer (Editors), Fauna of the Aleutian Islands and Alaska Peninsula, p. 1-364. U.S. Dep. Inter., Fish Wildl. Serv., North Am. Fauna 61.

Osgood, C. 1933. Tanaina culture. Am. Anthropol. 35:695–717. (Available at: http://onlinelibrary.wiley.com/doi/10.1525/aa.1933.35.4.02a00070/pdf accessed 28 April 2011).

_____. 1937. The ethnography of the Tanaina. Yale Univ. Publ. Anthropol. 16, 229 p.

Osgood, W. H. 1901a. Natural history of the Cook Inlet region, Alaska. U.S. Dep. Agric., Wash., North Am. Fauna 21:51–87.

_____. 1901b. Natural history of the Queen Charlotte Islands, British Columbia. U.S. Dep. Agric., Wash., North Am. Fauna 21:7–50.

_____. 1904. A biological reconnaissance of the base of the Alaska Peninsula. U.S. Dep. Agric., Wash., North Am. Fauna 24, 86 p.

Reger, D. R. 1998. Archaeology of the northern Kenai Peninsula and upper Cook Inlet. Arctic Anthropol. 35(1):160–171.

Reeves, R. R., B. S. Stewart, P. J. Clapham, J. A. Powell, and P. A. Folkens. 2002. Guide to marine mammals of the world (Natl. Audubon Soc. field guide ser.). Alfred A. Knopf, Inc., N.Y., 528 p.

Rice, D. W. 1998. Marine mammals of the world. Soc. Mar. Mammal. Spec. Publ. 4, 231 p.

Rosel, P. E., A. E. Dizon, and M. G. Haygood. 1995. Variability of the mitochondrial control region in populations of the harbour porpoise, *Phocoena phocoena*, on inter-oceanic and regional scales. Can. J. Fish. Aquat. Sci. 52:1210–1219.

Rugh, D. J., B. A. Mahoney, and B. K. Smith. 2004. Aerial surveys of beluga whales in Cook Inlet, Alaska, between June 2001 and June 2002. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-145, 26 p.

_____, K. E. W. Shelden, and R. C. Hobbs. 2010. Range contraction in a beluga whale population. Endang. Species Res. 12-69-75 (doi:10.3354/esr00293).

_____, _____, and B. A. Mahoney. 2000. Distribution of belugas, *Delphinapterus leucas*, in Cook Inlet, Alaska, during June/July 1993–2000. Mar. Fish. Rev. 62(3):6–21.

_____, _____, C. L. Sims, B. A. Mahoney, B. K. Smith, L. K. Litzky, and R. C. Hobbs. 2005. Aerial surveys of belugas in Cook Inlet, Alaska, June 2001, 2002, 2003, and 2004. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-149, 71 p.

Shelden, K. E. W., D. J. Rugh, K. T. Goetz, C. L. Sims, L. Vate Brattstr m, J. A. Mocklin, B. A. Mahoney, B. K. Smith, and R. C. Hobbs. 2013. Aerial surveys of beluga whales, Delphinapterus leucas, in Cook Inlet, Alaska, June 2005 to 2012. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-263, 122 p.

Speckman, S. G., and J. F. Piatt. 2000. Historic and current use of lower Cook Inlet, Alaska, by belugas, *Delphinapterus leucas*. Mar. Fish. Rev. 62(3):22–26.

_____, _____, C. V. Minte-Vera, and J. K. Parrish. 2005. Parallel structure among environmental gradients and three trophic levels in a subarctic estuary. Prog. Oceanogr. 66:25–65.

Stanek, R. T. 1985. Patterns of wild resource use in English Bay and Port Graham, Alaska. Alaska Dep. Fish Game, Div. Subsistence, Tech. Pap. 104, 241 p. (Available at: http://www.arlis.org/docs/vol1/A/20699197.pdf accessed 10 Apr. 2011).

Sveegaard, S., J. Nabe-Nielsen, K. J. Stæhr, T. F. Jensen, K. N. Mouritsen, and J. Teilmann. 2012. Spatial interactions between marine predators and their prey: herring abundance as a driver for the distributions of mackerel and harbour porpoise. Mar. Ecol. Prog. Ser. 468:245–253.

_____, J. Teilmann, J. Tougaard, R. Dietz, K. N. Mouritsen, G. Desportes, and U. Siebert. 2011. High density areas for harbor porpoises (*Phocoena phocoena*) identified by satellite tracking. Mar. Mammal Sci. 27:230–246.

Turner, L. M. 1886. Contributions to the natural history of Alaska. Arctic Ser. Publ. with the Signal Service, U.S. Army, No. 2, Wash. D.C., 226 p.

Workman, W. B. 1998. Archaeology of the southern Kenai Peninsula. Arctic Anthropol. 35(1):146–159.

_____ and K. W. Workman. 2010. The end of the Kachemak Tradition on the Kenai Peninsula, southcentral Alaska. Arctic Anthropol. 47(2):90–96.

Yarborough, L. F. 1995. Prehistoric use of cetacean species in the northern Gulf of Alaska. *In* A. P. McCartney (Editor), Hunting the largest animals: native whaling in the western Arctic and subarctic, p. 63–82. Stud. Whaling 3, Occas. Publ. 36, Can. Circumpolar Inst., Edmonton.

Yesner, D. R. 1992. Evolution of subsistence in the Kachemak tradition: evaluating the North Pacific maritime stability model. Arctic Anthropol. 29(2):167–181.

Appendix.—Systematic survey effort and harbor porpoise sightings in Cook Inlet, Alaska, 1993–2012.

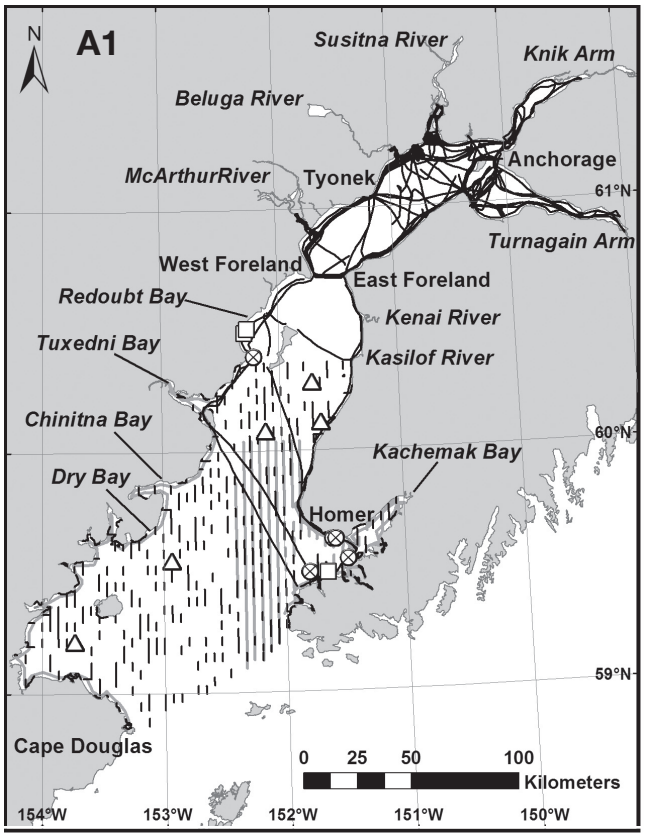


Figure A1.—Harbor porpoise sightings and survey effort in Cook Inlet, Alaska, summer of 1993 and winter of 1994. Aerial trackline effort in the upper and lower inlet (thin black lines) during 2–5 June 1993, 25–29 July 1993, and 3, 18–19 September 1993 beluga whale aerial surveys (Withrow et al., text footnote 34); Rugh et al., 2000; 2005). Sightings occurred on 4 June (circles) and 27 July (squares). Survey effort in lower Cook Inlet, Alaska, during summer boat surveys 7–23 June 1993 (black dashed line segments), winter aerial 9 & 16, 17 February 1994 (gray lines along shoreline), and winter boat surveys February–March 1994 (gray vertical and dashed lines) from Agler et al., text footnote 11. Porpoise were only observed during the summer boat surveys, five sightings (triangles) (USFWS GIS database).

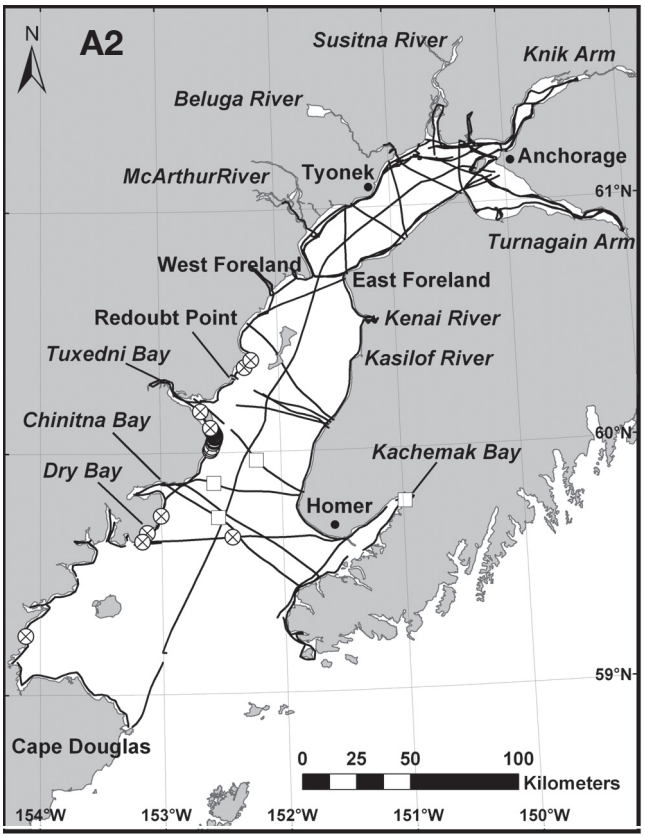
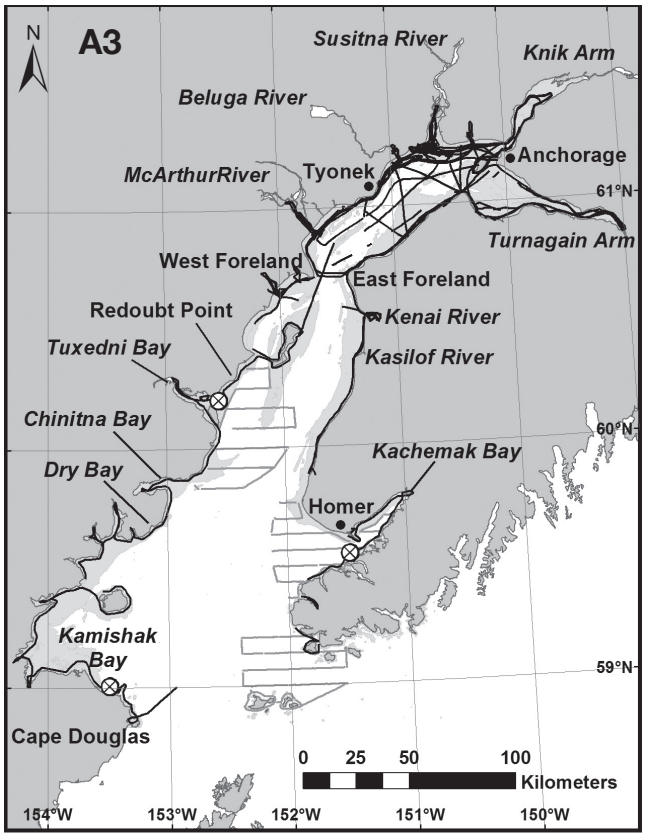


Figure A2.—Harbor porpoise sightings and survey effort in Cook Inlet, Alaska, summer 1994. Aerial trackline effort in the upper and lower inlet (black lines) during beluga whale aerial surveys, 1–5 June (Rugh et al., 2000; 2005). Sightings occurred on 3 June (squares) and 4 June (circles). Aerial, boat, and ground survey effort also occurred from April to September between Redoubt Point and Chinitna Bay (Bennett, text footnote 12), harbor porpoise were observed during the study but sighting locations were not provided.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McArthurRiver
Tyonek
Anchorage
61°N
Turnagain Arm
West Foreland
East Foreland
Redoubt Point
Kenai River
Tuxedni Bay
Kasilof River
Chinitna Bay
60°N
Kachemak Bay
Dry Bay
Homer
Kamishak Bay
59°N
Cape Douglas
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Kilometers
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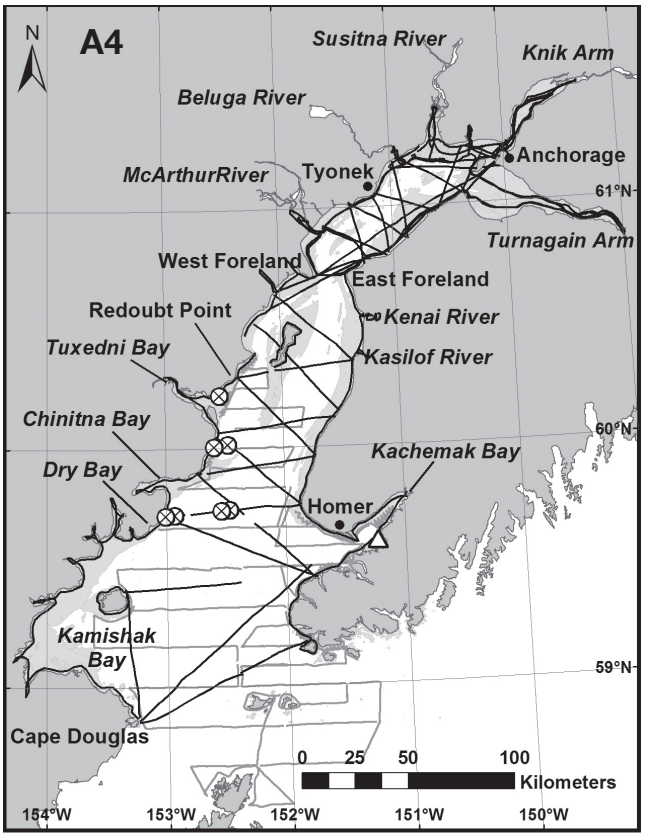
151°W
150°W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Tyonek
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61°N
Turnagain Arm
West Foreland
East Foreland
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Kenai River
Tuxedni Bay
Kasilof River
Chinitna Bay
60°N
Kachemak Bay
Dry Bay
Homer
Kamishak Bay
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Cape Douglas
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Kilometers
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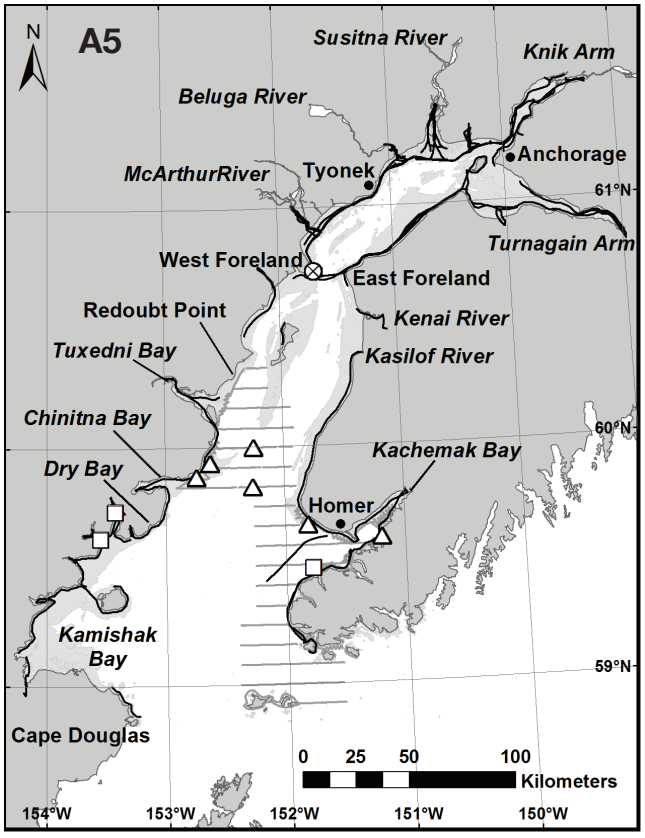
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McArthurRiver
Tyonek
Anchorage
61°N
Turnagain Arm
West Foreland
East Foreland
Redoubt Point
Kenai River
Tuxedni Bay
Kasilof River
Chinitna Bay
60°N
Kachemak Bay
Dry Bay
Homer
Kamishak Bay
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Cape Douglas
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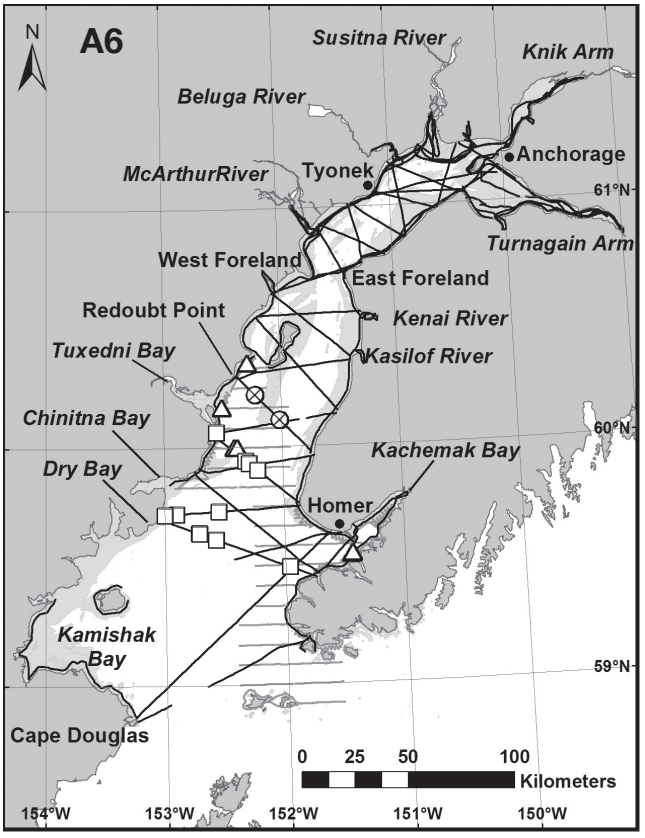
A6
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Anchorage
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Turnagain Arm
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Redoubt Point
Kenai River
Tuxedni Bay
Kasilof River
Chinitna Bay
60°N
Kachemak Bay
Dry Bay
Homer
Kamishak Bay
59°N
Cape Douglas
0 25 50 100
Kilometers
154°W
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152°W
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150°W

Figure A3. (Opposite page, top left)—Harbor porpoise sightings and survey effort in Cook Inlet, Alaska, summer 1995. Aerial trackline effort in the upper and lower inlet (black lines) during beluga whale aerial surveys, 18–26 July (Rugh et al., 2000; 2005). Sightings occurred on 22 July (circles). Marine bird and mammal surveys in the lower inlet (gray lines) from 10 to 23 August did not encounter harbor porpoise (Speckman and Piatt, 2000). Aerial, boat, and ground survey effort also occurred from April to September between Redoubt Point and Chinitna Bay (Bennett, text footnote 12), harbor porpoise were observed during the study but sighting locations were not provided.

Figure A4. (Opposite page, top right)—Harbor porpoise sightings and survey effort in Cook Inlet, Alaska, summer 1996. Aerial trackline effort in the upper and lower inlet (black lines) during beluga whale aerial surveys, 11–17 June (Rugh et al., 2000; 2005). Sightings occurred on 15 June (circles). Marine bird and mammal surveys in the lower inlet (gray lines) from 14 to 31 July encountered one harbor porpoise (triangle) in Kachemak Bay (Speckman and Piatt, 2000; Speckman, text footnote 13; USFWS GIS database). Aerial, boat, and ground survey effort also occurred from April to September between Redoubt Point and Chinitna Bay (Bennett, text footnote 12), harbor porpoise were observed during the study but sighting locations were not provided.

Figure A5. (Opposite page, bottom left)—Harbor porpoise sightings and survey effort in Cook Inlet, Alaska, summer 1997. Aerial trackline effort in the upper and lower inlet (black lines) during beluga whale aerial surveys, 8–10 June (Rugh et al., 2000; 2005). Sightings occurred on 8 June (circle) and 9 June (squares). Marine bird and mammal surveys in the lower inlet (gray lines) from 19 July to 8 August recorded six sightings of harbor porpoise (triangles) four in the mid-inlet in July and two in Kachemak Bay in August (Speckman and Piatt, 2000; Speckman, text footnote 13; USFWS GIS database).

Figure A6. (Opposite page, bottom right)—Harbor porpoise sightings and survey effort in Cook Inlet, Alaska, summer 1998. Aerial trackline effort in the upper and lower inlet (black lines) during beluga whale aerial surveys, 9–15 June (Rugh et al., 2000; 2005). Sightings occurred on 13 June (circles) and 14 June (squares). Marine bird and mammal surveys in the lower inlet (gray lines) from 21 July to 12 August recorded seven sightings of harbor porpoise (triangles), five sightings in July on the west side of the inlet, and two sightings in August in Kachemak Bay (Speckman and Piatt, 2000; Speckman, text footnote 13; USFWS GIS database).

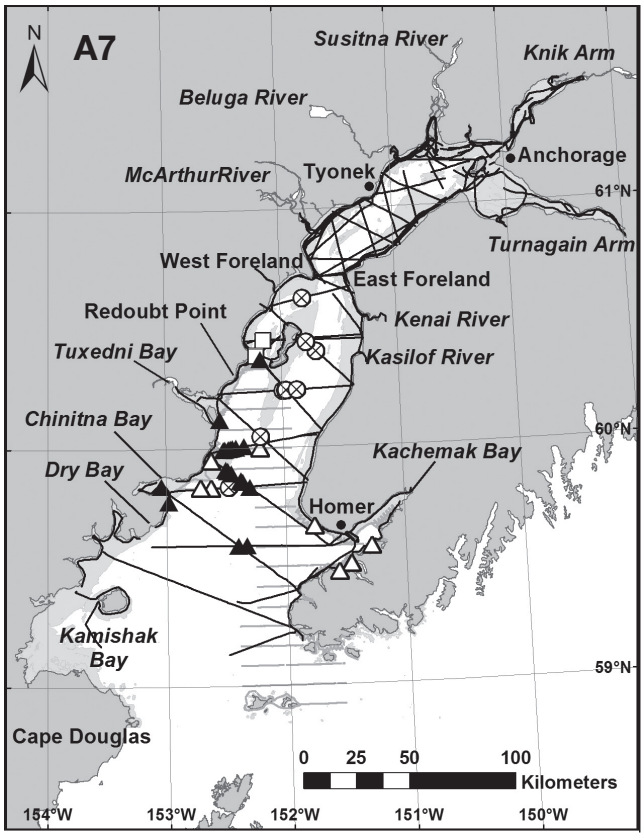
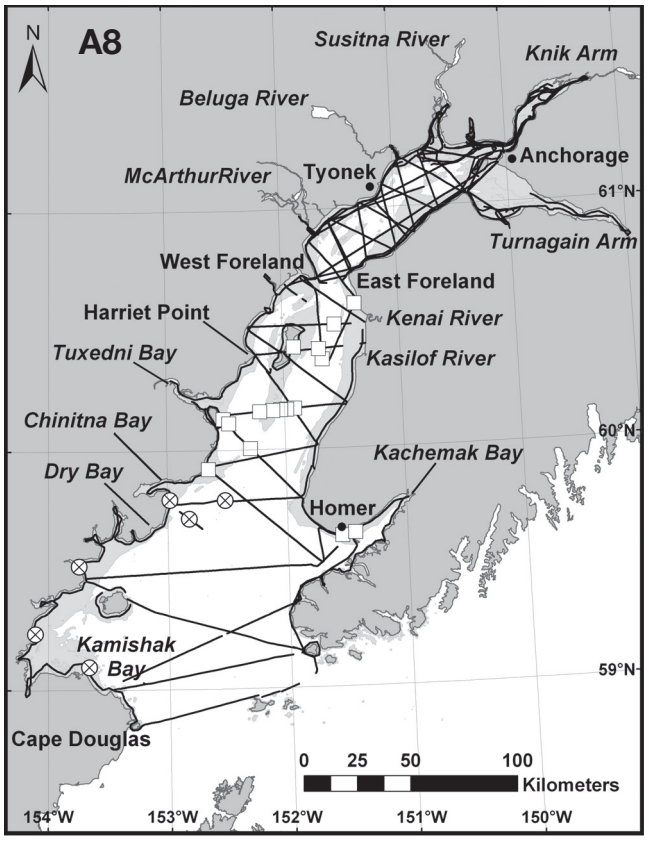


Figure A7.—Harbor porpoise sightings and survey effort in Cook Inlet, Alaska, summer 1999. Aerial trackline effort in the upper and lower inlet (black lines) during beluga whale aerial surveys, 8–14 June (Rugh et al., 2000; 2005). Sightings occurred on 10 June (circles), 11 June (squares), and 14 June (black triangles). Marine bird and mammal surveys in the lower inlet (gray lines) from 25 July to 16 August recorded nine sightings of harbor porpoise in August (white triangles), four sightings (5 animals including a calf) in mid-inlet, five sightings (7 animals including a calf) in Kachemak Bay (Speckman and Piatt, 2000; Speckman, text footnote 13; USFWS GIS database).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Harriet Point
Kenai River
Tuxedni Bay
Kasilof River
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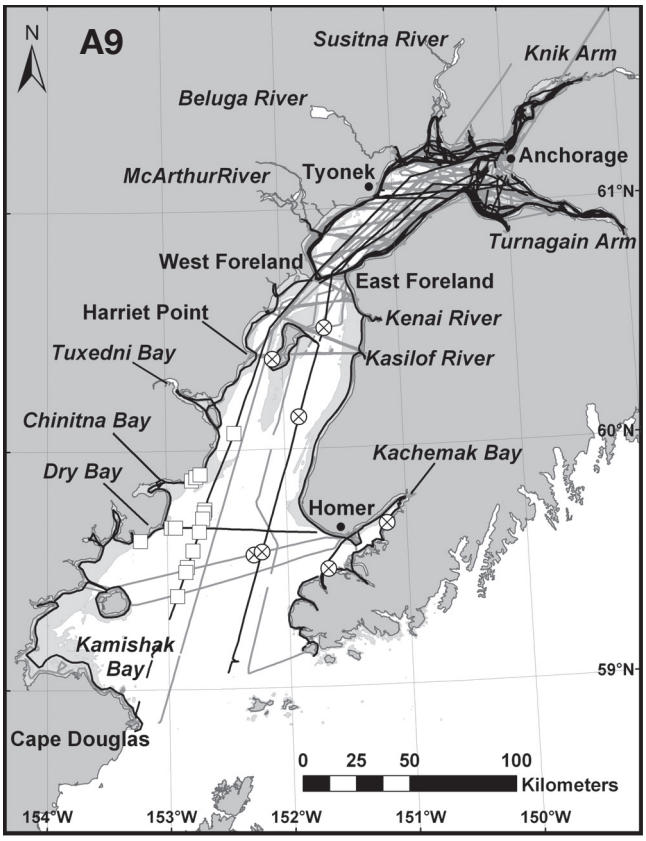
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Tuxedni Bay
Kasilof River
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Kachemak Bay
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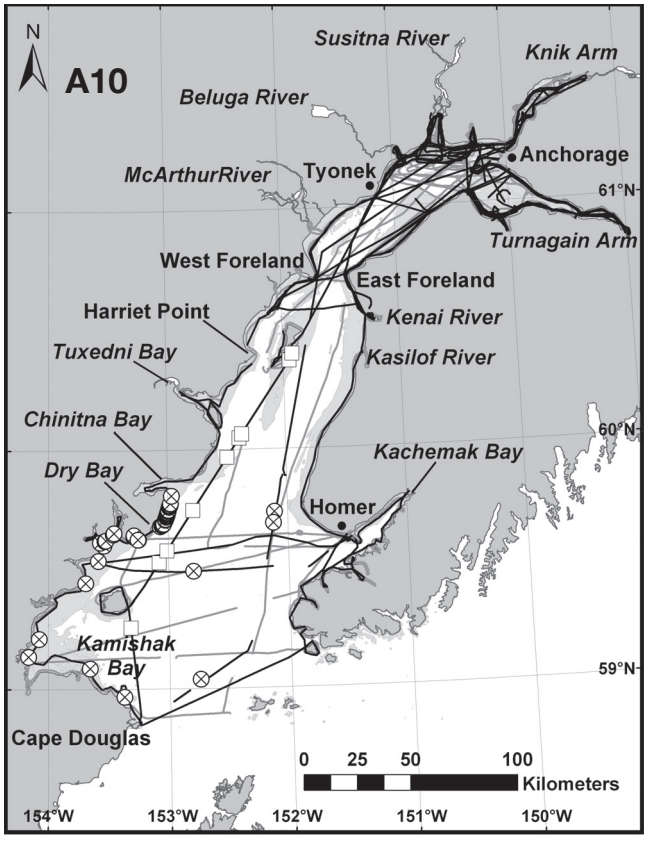
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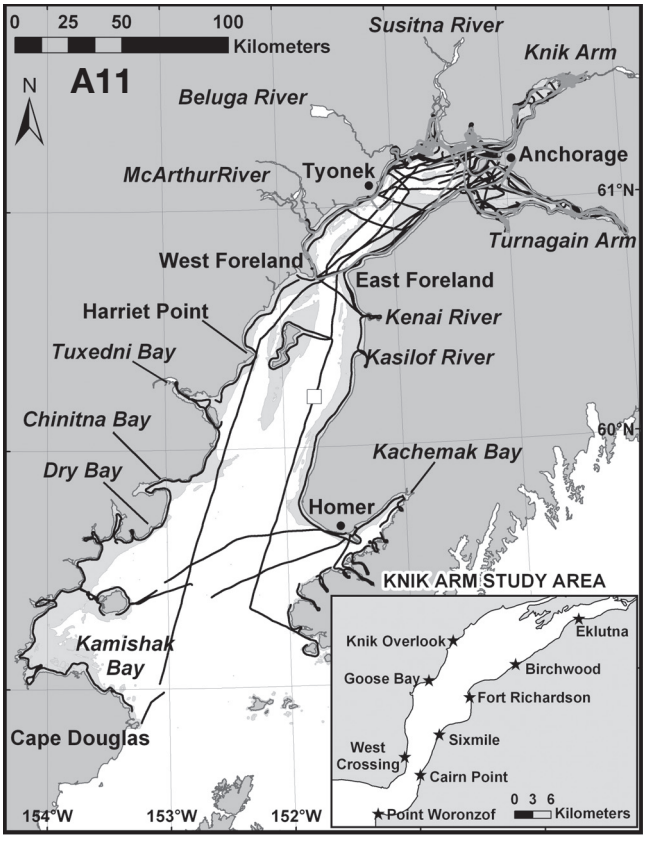
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Harriet Point
Kenai River
Tuxedni Bay
Kasilof River
Chinitna Bay
60°N
Kachemak Bay
Dry Bay
Homer
KNIK ARM STUDY AREA
Kamishak Bay
Cape Douglas
Knik Overlook
Eklutna
Goose Bay
Birchwood
Fort Richardson
Sixmile
West Crossing
Cairn Point
Point Woronzof
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Figure A8. (opposite page, top left)—Harbor porpoise sightings and survey effort in Cook Inlet, Alaska, summer 2000. Aerial trackline effort in the upper and lower inlet (black lines) during beluga whale aerial surveys, 7–13 June (Rugh et al., 2000; 2005). Sightings occurred on 9 June (circles) and 10 June (squares).

Figure A9. (opposite page, top right)—Harbor porpoise sightings and survey effort in Cook Inlet, Alaska, summer of 2001 to summer of 2002. Aerial trackline effort in the upper and lower inlet during beluga whale aerial surveys (Rugh et al., 2004; 2005) is shown as black lines for 5–12 June 2001 (indicating porpoise were seen), and gray lines for all other surveys without porpoise sightings (2, 26–27 July 2001; 27 August 2001; 15, 18 September 2001; 12, 15 October 2001; 9 November 2001; 22–23 January 2002; 25–26 February 2002; 2 April 2002; and 4–11 June 2002). Sightings in 2001 occurred on 8 June (circles) and 9 June (squares).

Figure A10. (opposite page, bottom left)—Harbor porpoise sightings and survey effort in Cook Inlet, Alaska, summer 2003 and 2004. Aerial trackline effort in the upper and lower inlet during beluga whale aerial surveys (Rugh et al., 2005) is shown as gray lines for 31 May to 12 June 2003 (indicating porpoise were not seen), and black lines for 2–9 June 2004. Sightings in 2004 occurred on 5 June (squares) and 6 June (circles).

Figure A11. (opposite page, bottom right)—Harbor porpoise sightings and survey effort in Cook Inlet, Alaska, 2005. Inset map shows the Knik Arm study area and observation sites in operation from July 2004 to July 2005 (LGL, text footnote 36) where four sightings were recorded in April–May 2005. Aerial trackline effort in the upper and lower inlet during beluga whale aerial surveys is shown as black lines for 31 May to 9 June 2005 (Shelden et al., 2013) and gray lines (indicating porpoise were not seen) for 11–12 August 2005 (Rugh et al., text footnote 26). The one sighting in June 2005 occurred on 4 June (square).

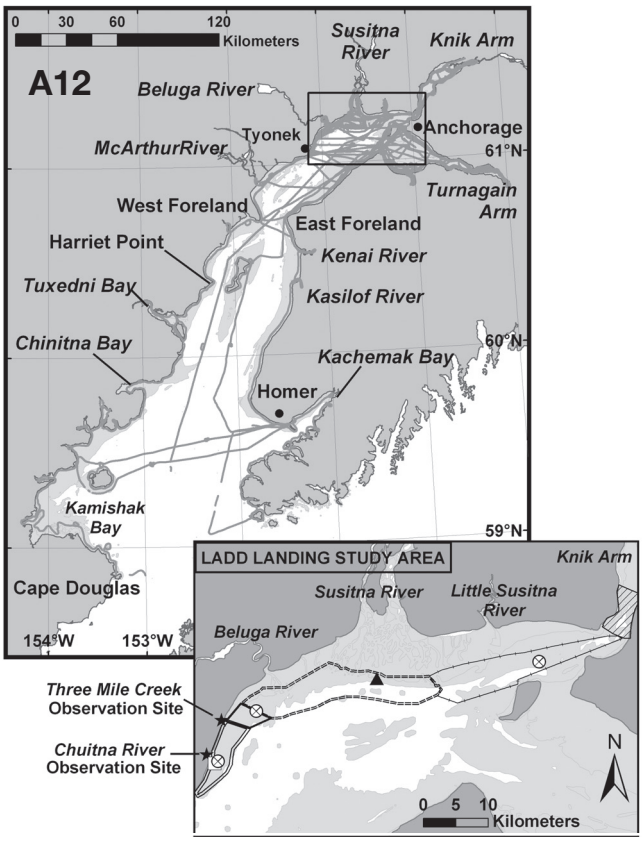
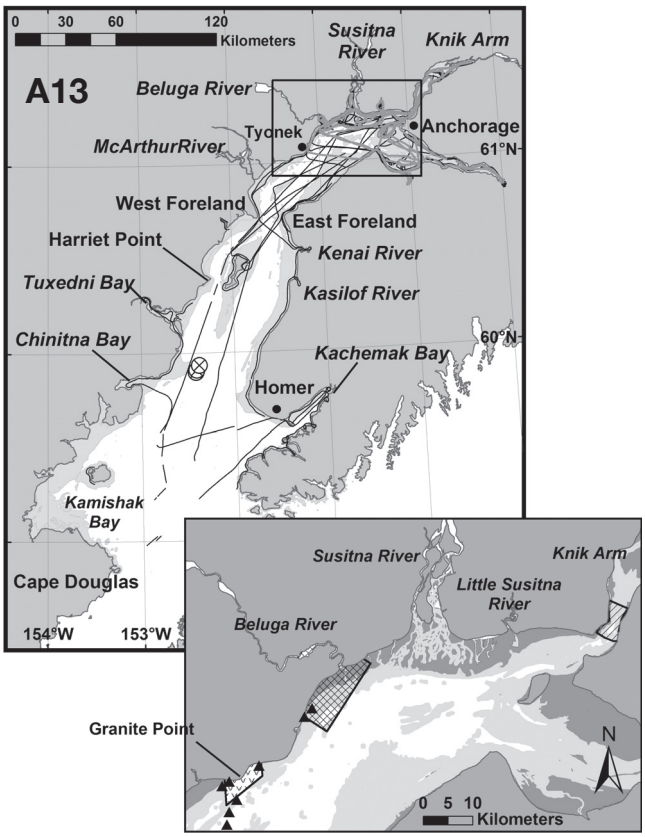


Figure A12.—Harbor porpoise sightings and survey effort in Cook Inlet, Alaska, 2006. Inset map shows the Ladd Landing study areas and land-based observation sites (stars) where harbor porpoise were observed from May through October (Nemeth et al., text footnote 19). Sightings obtained during vessel/aerial surveys are from May (circles), June (triangle) and August (square). Aerial trackline effort in the upper and lower inlet during beluga whale aerial surveys is shown as gray lines (indicating porpoise were not seen) for 2–3 May (Rugh et al., text footnote 25), 6–15 June (Shelden et al., 2013), 16–17 August (Rugh et al., text footnote 27).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Kenai River
Tuxedni Bay
Kasilof River
Chinitna Bay
60°N
Kachemak Bay
Homer
Kamishak Bay
Cape Douglas
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Little Susitna River
Beluga River
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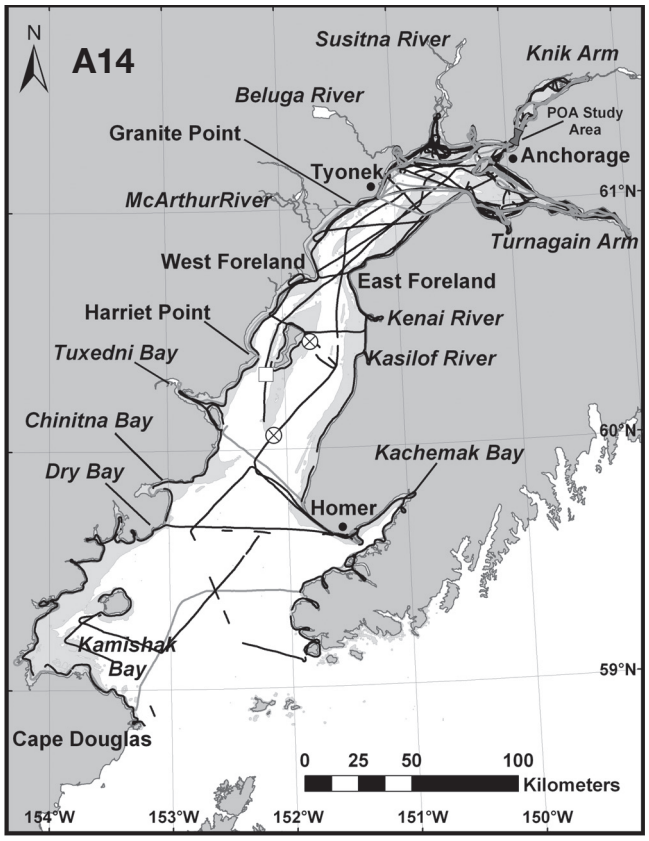
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East Foreland
Harriet Point
Kenai River
Tuxedni Bay
Kasilof River
Chinitna Bay
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Dry Bay
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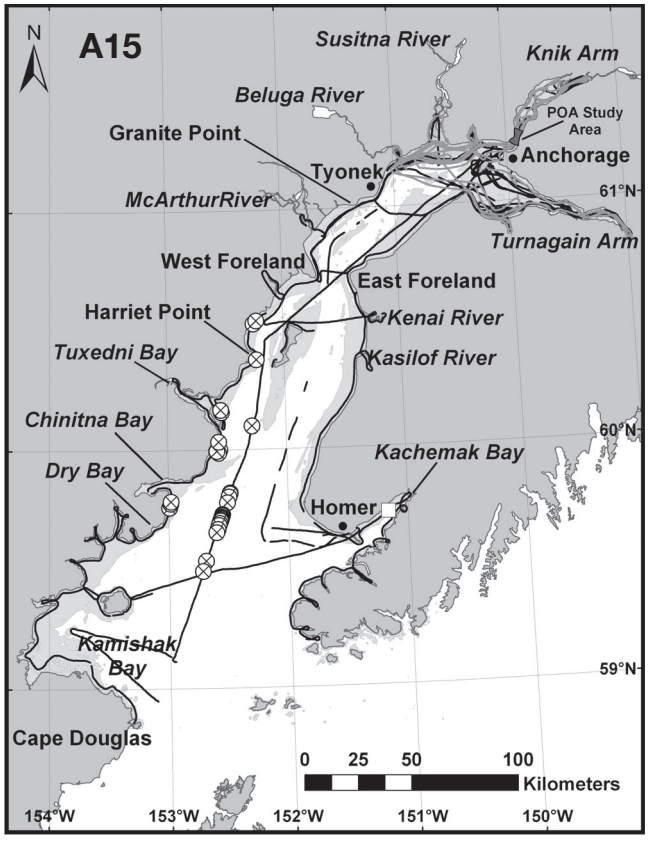
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Harriet Point
Kenai River
Tuxedni Bay
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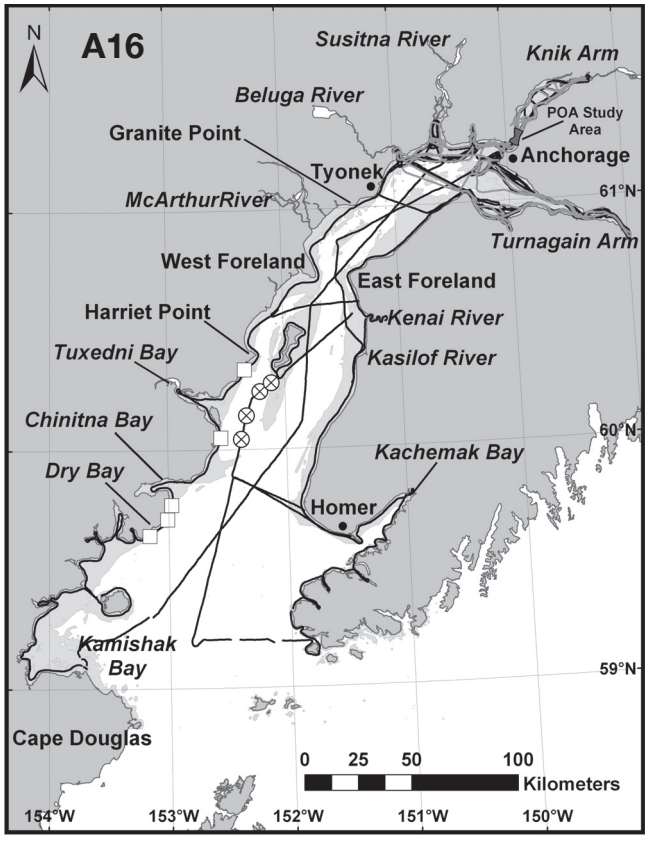
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East Foreland
Harriet Point
Kenai River
Tuxedni Bay
Kasilof River
Chinitna Bay
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Dry Bay
Kachemak Bay
Homer
Kamishak Bay
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Cape Douglas
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150°W

Figure A13. (opposite page, top left)—Harbor porpoise sightings and survey effort in Cook Inlet, Alaska, 2007. Inset map shows the seismic study boundaries surveyed 14 April to 13 May near Beluga River and 29 September to 21 October near Granite Point (Brueggeman, text footnote 38 and 39, respectively), and the POA study area 16–18 October 2007 (URS, text footnote 41). Aerial trackline effort in the upper and lower inlet during beluga whale aerial surveys is shown as black lines for 7–15 June (Shelden et al., 2013) and gray lines (indicating porpoise were not seen) for 1–2 August (Shelden et al., text footnote 28). Sightings occurred on 7 June (circles).

Figure A14. (opposite page, top right)—Harbor porpoise sightings and survey effort in Cook Inlet, Alaska, 2008. Aerial trackline effort in the upper and lower inlet during beluga whale aerial surveys shown as black lines for 3–12 June (Shelden et al., 2013) and gray lines (indicating porpoise were not seen) for 12–14 August (Shelden et al., text footnote 29), 19–20 September, and 22 October (Shelden et al., text footnote 35) . Sightings occurred on 9 June (circles) and 10 June (square). No porpoise were observed in the POA study area from 24 June to 14 November (Cornick and Saxon-Kendall, text footnote 43).

Figure A15. (opposite page, bottom left)—Harbor porpoise sightings and survey effort in Cook Inlet, Alaska, 2009. Aerial trackline effort in the upper and lower inlet during beluga whale aerial surveys shown as black lines for 2–9 June (Shelden et al., 2013) and gray lines (indicating porpoise were not seen) for 11–13 August (Shelden et al., text footnote 30). Sightings occurred on 7 June (circles) and 8 June (square). Porpoise were observed in the POA study area June–August and October–November during the 28 March to 14 December monitoring period (ICRC, text footnote 44).

Figure A16. (opposite page, bottom right)—Harbor porpoise sightings and survey effort in Cook Inlet, Alaska, 2010. Aerial trackline effort in the upper and lower inlet during beluga whale aerial surveys shown as black lines for 1–10 June (Shelden et al., 2013) and gray lines (indicating porpoise were not seen) for 17–20 August (Shelden et al., text footnote 31). Sightings occurred on 5 June (circles) and 7 June (squares). Porpoise were observed in the POA study area in July and August during the 21 July to 20 November monitoring period (ICRC, text footnote 45).

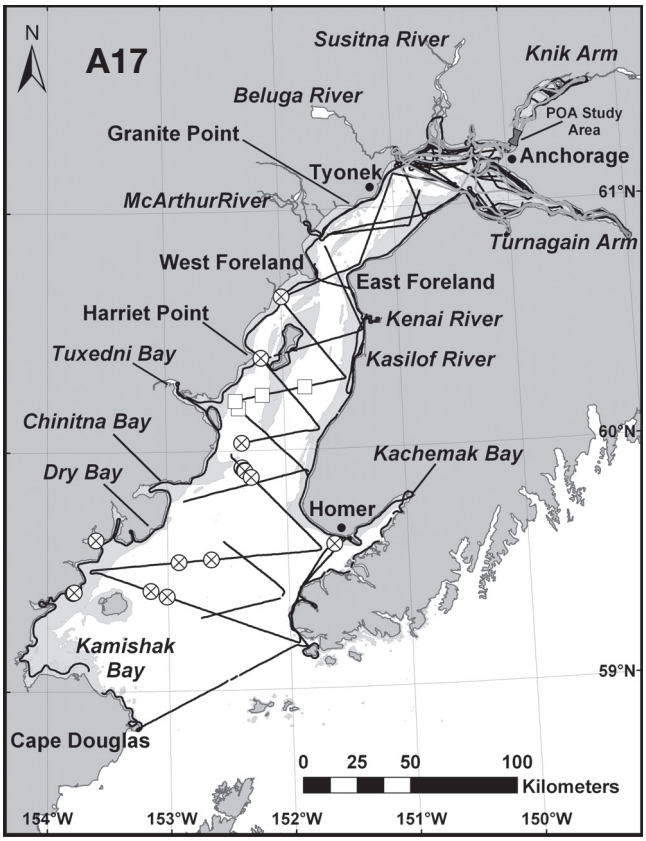

Figure A17.—Harbor porpoise sightings and survey effort in Cook Inlet, Alaska, 2011. Aerial trackline effort in the upper and lower inlet during beluga whale aerial surveys shown as black lines for 31 May–9 June (Shelden et al., 2013) and gray lines (indicating porpoise were not seen) for 9–11 August (Shelden et al., text footnote 32). Sightings occurred on 6 June (circles) and 7 June (squares). Porpoise were observed in the POA study area in August, October and November during the 28 June to 15 November monitoring period (ICRC, text footnote 46).

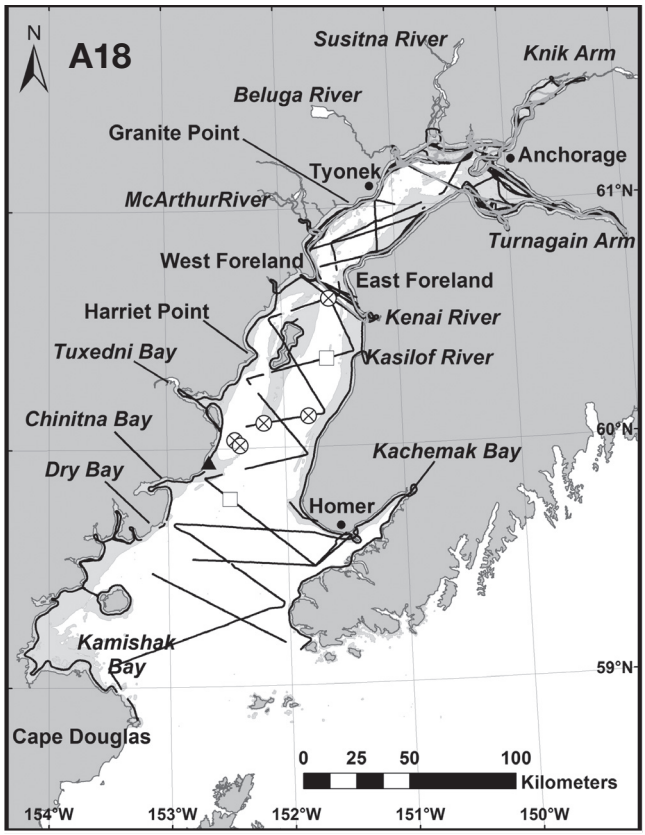

Figure A18.—Harbor porpoise sightings and survey effort in Cook Inlet, Alaska, 2012. Aerial trackline effort in the upper and lower inlet during beluga whale aerial surveys shown as black lines for 29 May to 7 June (Shelden et al., 2013) and gray lines (indicating porpoise were not seen) for 7–9 August (Sims et al., text footnote 33). Sightings occurred on 29 May (circles), 30 May (squares), and 31 May (triangle).