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Traditional Knowledge of the Ecology of Beluga Whales (*Delphinapterus leucas*) in the Eastern Chukchi and Northern Bering Seas, Alaska

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ABSTRACT. Traditional ecological knowledge (TEK) has been used opportunistically in biological studies of beluga whales (*Delphinapterus leucas*) in Alaska, but no previous research has documented this knowledge systematically. This first such effort, which took place in Norton Bay, Buckland, and Point Lay, Alaska, provided descriptions of migratory and local movements, feeding, calving, ecological interactions, and human influences on distribution and behavior. The results are consistent with those of previous studies but add considerable detail, including descriptions of avoidance and habituation responses to anthropogenic noise, which appear to depend in part on association with hunting activities. Making greater use of TEK will benefit both research and management by providing better information and by expanding the collaborative process developed through co-management.

Key words: beluga whale, white whale, *Delphinapterus leucas*, Bering Sea, Chukchi Sea, ecology, traditional ecological knowledge, TEK

RÉSUMÉ. On a utilisé le savoir écologique traditionnel (SET) quand l'occasion se présentait, dans le cadre des études biologiques portant sur le bélouga (*Delphinapterus leucas*) en Alaska, mais ce savoir n'a jamais fait l'objet d'une étude systématique. Cette première tentative en ce sens, qui a été réalisée à Norton Bay, Buckland et Point Lay, en Alaska, a fourni des descriptions de déplacements migratoires et locaux, de nutrition, de mise bas, d'interactions écologiques et d'influences humaines sur la distribution et le comportement. Les résultats concordent avec ceux d'études précédentes, mais apportent de nombreux détails, y compris la description des réactions d'évitement et d'accoutumance au bruit anthropique, qui semble dépendre en partie de l'association avec les activités cynégétiques. Une plus grande utilisation du SET profitera à la fois à la recherche et à la gestion en fournissant de meilleures informations et en développant plus à fond le processus de collaboration créé par la cogestion.

Mots clés: bélouga, baleine blanche, *Delphinapterus leucas*, mer de Béring, mer des Tchouktches, écologie, savoir écologique traditionnel, SET

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INTRODUCTION

Beluga whales (*Delphinapterus leucas*) are circumpolar in distribution and are hunted by indigenous peoples throughout the Arctic (Kleinenberg et al., 1964). While some previous biological research on belugas has used the expertise of local hunters to plan research and to add to data gathered from scientific observations (e.g., Frost and Lowry, 1990), a practice which continues through the work of the Alaska Beluga Whale Committee (Adams et al., 1993), little has been done to document systematically such local expertise, also known as traditional ecological knowledge (TEK). The primary purpose of this research was to capture TEK data in order to (1) describe beluga ecology as seen by indigenous hunters and elders and (2) identify specific contributions such data can make to scientific understanding of beluga ecology.

In the coastal waters of Alaska, belugas are abundant and widely distributed (Burns and Seaman, 1986; Hazard, 1988; Suydam et al., 1996). They are found in Cook Inlet in the south and from Bristol Bay north through the Bering and Chukchi Seas and across the Beaufort Sea to Canada. O'Corry-Crowe et al. (1997) identify five beluga stocks in Alaska, one of which is shared with Canada, and one or more of which may be shared with Russia. The present study examines the Norton Sound, Kotzebue Sound, and East Chukchi stocks. Belugas are hunted in many communities in Alaska, and the Alaska Beluga Whale Committee coordinates management of the hunt (Adams et al., 1993). Local management organizations, such as the Elim-Shaktoolik-Koyuk Marine Mammal Commission, were also actively involved in this study.

This research documented the TEK about belugas held by elders and hunters in three areas of northwestern Alaska: Point Lay, Buckland, and the Norton Bay communities of Elim, Shaktoolik, and Koyuk (Fig. 1). The study did not attempt to document harvest practices or levels. These communities were selected on the basis of the intensity of their use of beluga. This project was also conducted in Chukotka, Russia (see Mymrin et al., 1999). Studies of

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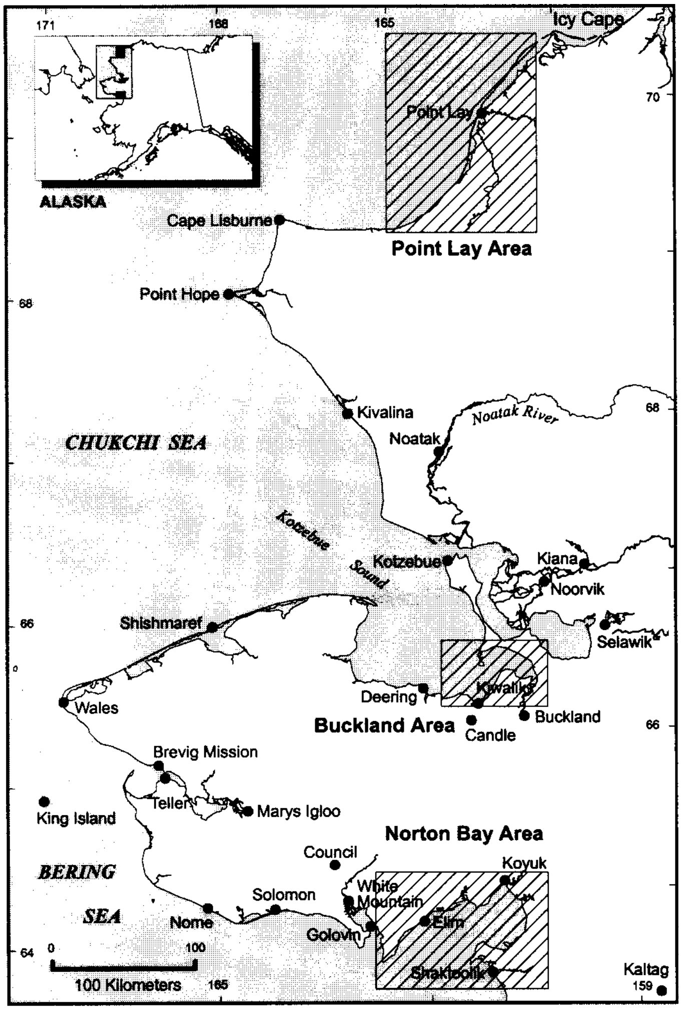

FIG. 1. Locations of study, northwestern Alaska.

TEK and belugas have also taken place in Greenland and Canada (Thomsen, 1993; Byers and Roberts, 1995; McDonald et al., 1997).

Unlike scientific data, which are gathered according to explicit methods and for which verification and review procedures are established, TEK is the product of accumulated observations shared among community members and is analyzed in terms of an implicit model of ecology. The survival of hunters and their ability to provide for the needs of their communities—food, clothing, and shelter—are evidence of the utility of their knowledge, particularly when it pertains directly to hunting success.

Nonetheless, the information provided by TEK should not be accepted uncritically. Because TEK has no explicit methods for its compilation, it may be difficult—if not impossible—to evaluate the basis for a conclusion or to determine how a generalization is made, though inferences may be drawn by assessing its relevance to hunting or other specific activities. Instead, the data provided by TEK can be reviewed for their consistency with current scientific knowledge; discrepancies can be analyzed for potential biases in either TEK or science; and appropriate ways to resolve the discrepancies can be developed.

In this light, a paper presenting TEK of beluga whales serves two purposes. First, it gives, as faithfully as possible, the perspective of beluga hunting communities on beluga ecology. In the context of beluga management, an understanding of hunters' perceptions is the basis for resolving discrepancies with scientific knowledge and for developing sound management plans that will be accepted and followed by the hunters. Second, this understanding allows beluga biologists and ecologists to consider the information provided by TEK and determine its utility to their work. Again, TEK information should not be accepted uncritically, but should be considered in analyzing current knowledge and in planning future research.

METHODS

Data Collection

The method used in this study was the semi-directive interview (Nakashima and Murray, 1988; Nakashima, 1990; for a thorough discussion of the method in this study, see Huntington, 1998). The interviewer guided participants in the discussions, but allowed the direction and scope of the interview to follow the participants' train of thought. There was no fixed questionnaire, nor was there a pre-set limit on the time for discussions or the topics that had to be covered. I used a combination of individual and group interviews in each community.

I traveled to each community in March and April 1995 for the primary fieldwork. In Norton Bay and Buckland, I hired a local assistant to help with the research as well as with local logistics. For each interview, I started with a list of topics that I wanted to cover and initiated discussions with a general question, such as "When do the belugas arrive, and what direction do they come from?" The resulting discussion led to a number of other topics, interwoven with each other and covering the majority of topics on the list. If the discussion faltered, or if I was not clear on a point, I asked more questions or initiated discussions on a topic we had not yet covered. In this sense, the interviews were similar to a discussion or an extended conversation. The interviews were recorded on audiotape, and my assistant and I took notes.

At the end of each interview, I reviewed the material with the participant or participants as a preliminary check. The research period in each village lasted about one week, at the end of which I conducted a group review session to present my understanding of what I had documented. During this session, participants were able to answer questions I had and add information that had not come up in the original interviews.

I took the raw and compiled maps, the field notes, and the audiotapes with me, and from these I compiled a draft report, which was sent to all participants and to the village assistants for review. Between February and April 1996, I returned to each community to review the draft. At this point, details were added, corrections made, and in one

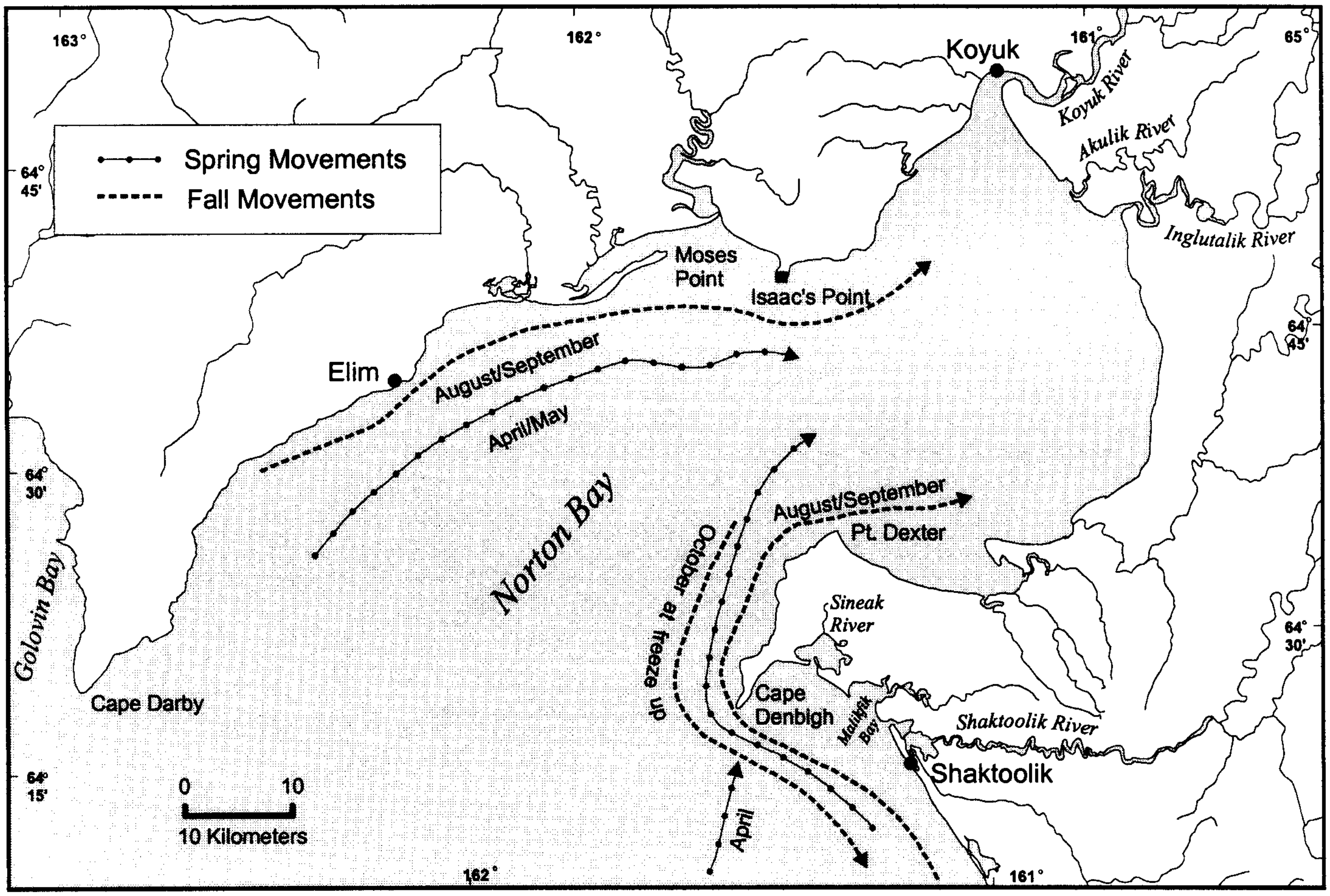

FIG. 2. Beluga migratory and local movements during spring and fall in Norton Bay.

case, detailed fish information was removed from the text and the maps because the participants felt its dissemination could be damaging to their interests as commercial and subsistence fishermen.

Mapping

To record spatial information, we used mylar or acetate overlays on U.S. Geological Survey maps at two scales: 1:250 000 and 1:63 360. We recorded information with permanent ink markers, writing notes along with the geographical data. In most cases, the researchers did the writing, at the direction of the participants. Reference marks were made on the mylars to locate them on the maps and permit entry of the data into a geographic information system (GIS) database, using Arc/Info 7.0.4 software.

Consultations and Permissions

In accordance with the ethical principles set forth by the Interagency Arctic Research Policy Committee (1992), I signed a data ownership agreement for my research with the local tribal councils established under the Indian Reorganization Act of 1934 (also known as the IRA Councils). The agreement stated that I would obtain written consent from each participant; that I would review all information with the participants prior to publication; that the data collected during the project would remain the property of the village; and that permission was granted to me to use those data for this research. The participant release forms signed by each participant spelled out the terms of the project and the right of review and allowed participants to choose whether their names or photographs of them could be used in publications.

THE COMMUNITIES

Norton Bay Area

Three villages are located on Norton Bay, at the northeast corner of Norton Sound (Fig. 2). Shaktoolik and Koyuk are Iñupiaq villages, with respective populations of approximately 200 and 250. Elim is Iñupiaq and Yup'ik, with a population of approximately 280. These three communities often cooperate on beluga hunts, which in this area are centered in Norton Bay. In spring, hunters from Elim and Shaktoolik hunt from the ice edge near their villages, but in fall the three communities do most hunting cooperatively inside Norton Bay. As a result of other

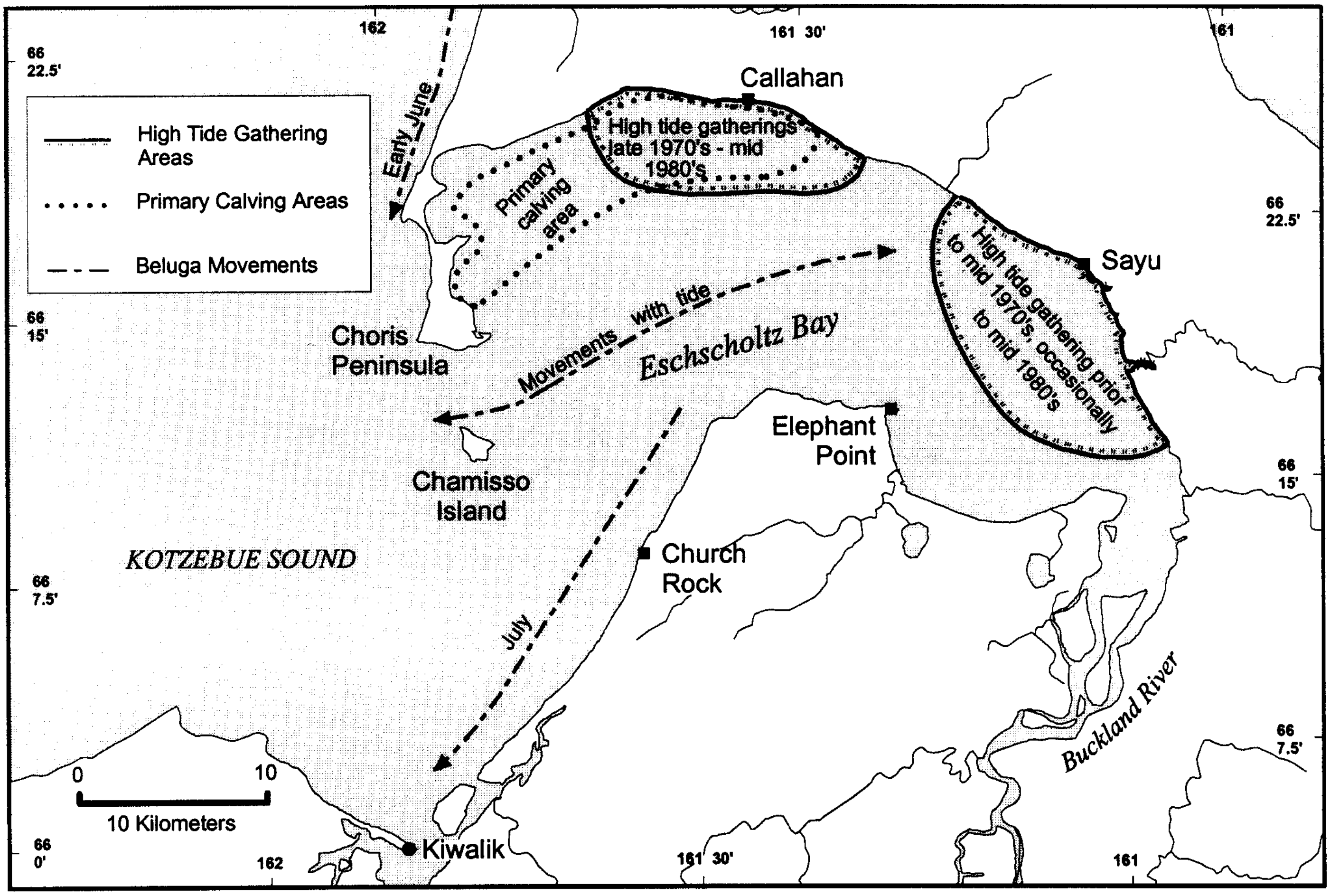

FIG. 3. Beluga movements, calving areas, and gathering areas in Eschscholtz Bay.

activities, and from contact with other villages along the coast, the villagers' knowledge of belugas extends beyond the immediate area of Norton Bay.

Buckland Area

Buckland is an Iñupiaq community of about 400 people, located on the Buckland River about 25 km upstream from the river mouth at Eschscholtz Bay (Figs. 3 and 4). Like other Native villages in Alaska, Buckland relies heavily on hunting and fishing. Buckland residents also engage in reindeer herding. Belugas have been a large part of the subsistence cycle perhaps for millennia (Lucier and VanStone, 1995), although recent declines in local abundance have changed harvesting patterns (Morseth, 1997). Buckland residents hunt belugas in Eschscholtz Bay. They also hunt seals and occasionally belugas in Kotzebue Sound, and through contact and cooperative hunting with other communities, they are familiar with the patterns of beluga migration through much of the sound.

Point Lay Area

Point Lay is an Iñupiaq village of approximately 200 people, located on the Chukchi Sea coast of the North Slope of Alaska (Fig. 5). After being nearly abandoned in the 1960s, the village was reestablished in the 1970s. The beluga hunt began again, using skiffs powered by outboard engines to herd belugas into shallow water. Point Lay depends on belugas to a greater extent than any other community in Alaska. Up to two-thirds of the annual subsistence production by weight is beluga (Alaska Department of Fish and Game Community Profile Database), all of it taken in one or two cooperative hunts in early summer. Point Lay hunters take belugas near the community, usually herding them from the south to the shallows inside Kasegaluk Lagoon near the village. They are most familiar with belugas in the area between Omalik Lagoon and Point Lay, although they also have hunted belugas as far north of the village as Icy Cape.

DISTRIBUTION, ABUNDANCE, AND MIGRATION

Norton Bay Area

In April and May, and occasionally in March, the belugas arrive in Norton Bay either from the south, along the coast past Besboro Island and Shaktoolik, or from the southwest, past Cape Darby and Elim (Fig. 2). Both the

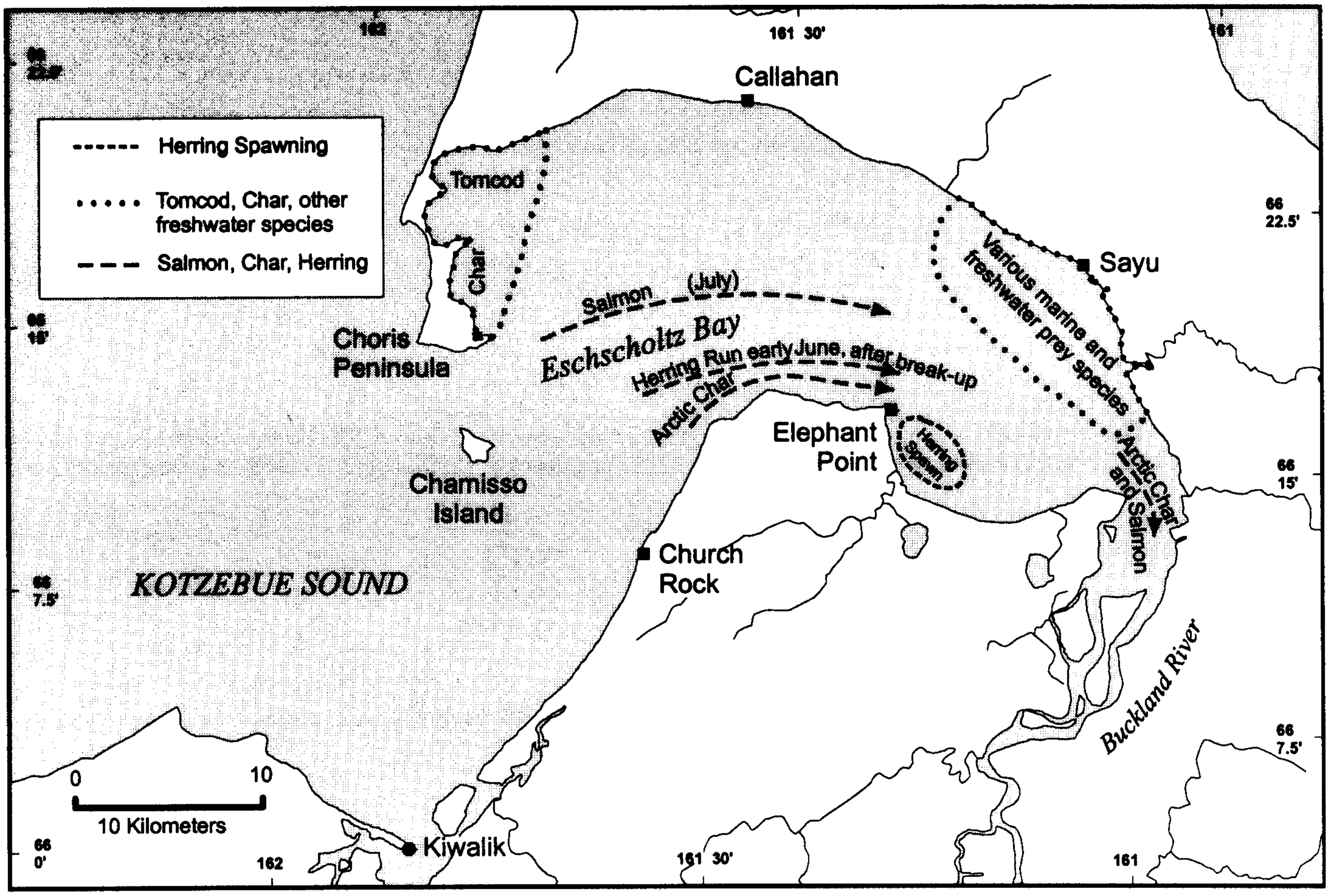

FIG. 4. Distribution and movement of fishes preyed on by belugas in Eschscholtz Bay.

time of their arrival and the direction from which they come are influenced primarily by the ice in Norton Sound. In years of heavy ice, the belugas arrive later; if the sound is relatively ice free, the belugas come early. If the Bering Strait is blocked with ice, more belugas may come to Norton Bay than in years when the migration into the Chukchi Sea is unimpeded.

The fact that belugas lighten from dark gray to white as they age helps identify their migration patterns. The small, light gray or off-white subadult belugas come first, followed by females with calves and young males and females, and then the large males. This migration generally takes place along the ice edge. Belugas typically breathe three or four times, then dive again. Once they reach Norton Bay and the nearby area, the belugas feed and stay until the ice breaks up.

Formerly, many belugas would stay in Norton Bay during the summer (June to September), while others continued their migration to the west without staying for any length of time. When the belugas arrived, those that would stay in the area and those that would continue migrating would be mixed together. Today, however, few belugas stay in Norton Bay all summer.

In the fall, the belugas return to Norton Bay, arriving from the west past Elim in late August and September as well as from the south past Shaktoolik in September (Fig. 2). This migration generally takes place closer to shore than the spring migration, since the shore ice has not yet formed. The belugas may come in small groups of two to seven or in a big group. Sometimes the big groups travel in a long line, which indicates that they are headed for a particular destination, such as the bay, in order to feed. They gather in the bay until the ice begins to form, usually in late September or early October, and then migrate to the south past Shaktoolik.

Once they arrive in Norton Bay in the spring, the belugas follow the tide in and out of the bay, as well as towards and away from the shore. The ice in the bay generally forms an indentation between Cape Darby and Cape Denbigh, and from here the belugas gather in small coves and swim under the ice, especially later in May when the ice is rotten and breathing holes are easy to find. When the ice melts in the bay, rather than drifting out into Norton Sound, the belugas are more likely to stay. A south wind helps keep the ice in Norton Bay.

In the fall, the belugas range throughout the bay, again following the tide and the fish. They have been seen up several of the rivers, including the Koyuk (as far as Dime Landing, 50 km upstream), the Akulik, and the Inglutalik. As the ice begins to form, belugas are capable of breaking through up to 5 cm of ice to breathe.

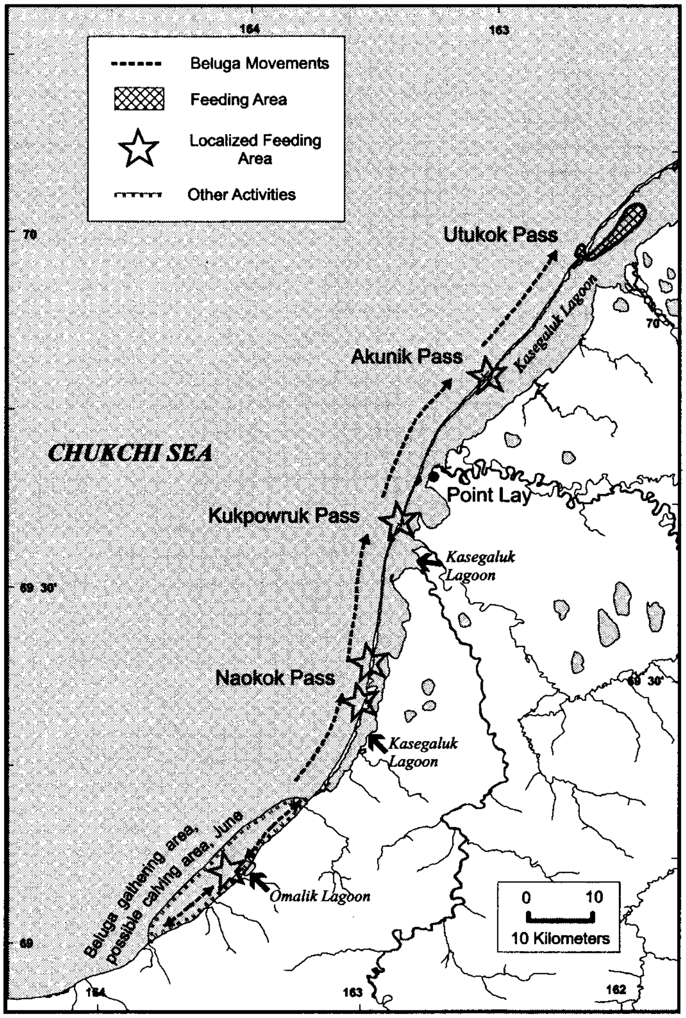

FIG. 5. Beluga movements, feeding areas, and a possible calving area near Point Lay. The passes indicated on the map are places where belugas may enter Kasegaluk Lagoon.

Tide and time of day are determining factors in local movements. Between Shaktoolik and Cape Denbigh, by Malikfik Bay and the Sineak River, and by Moses Point, belugas follow the tomcod as they approach the shore with the rising tide in evening. This behavior is less common today than previously.

Buckland Area

In Kotzebue Sound, belugas undertook a predictable migration until the 1970s, when their migration patterns changed. This section describes both the former and the present patterns; possible reasons for the change are discussed below, under Response to Disturbance.

The belugas arrive in northern Kotzebue Sound in early June after the ice goes out, passing by Sissauliq (or Sheshaulik), near the mouth of the Noatak River (Fig. 1), then traveling south past Kotzebue and along the Baldwin and Choris Peninsulas to the entrance to Eschscholtz Bay (Fig. 3). They travel in large groups, with groups of old whales leading the way.

Once belugas arrive in the Choris Peninsula area, they enter Eschscholtz Bay between the peninsula and the Chamisso Islands, through a deep channel. If the ice is still thick in the bay, they stay outside the Chamisso Islands until wind and current have opened passages through the ice in the bay (Fig. 3).

Belugas enter the bay with the flooding tide and move in and out with the tide for the duration of their time in the area. During these movements, large bulls lead the group. Depending on wind, weather, and other factors, the belugas may leave the bay altogether at low tide, or they may stay in the deeper water at the northwestern end of the bay. Most belugas stay in the Eschscholtz Bay area from mid-June until July, though some are seen in August.

Another group of older, male belugas often arrives late, in July; these older males are known as the "flat bottoms," because the undersides of their abdomens are broader than those of younger belugas. These are large belugas, slightly tinted reddish-yellow. Once they arrive at Eschscholtz Bay, they join the belugas that are already there.

The belugas swim into the bay following the deep channel along the northern shore. When leaving the bay, they also swim through its middle. When the Buckland hunters have stopped hunting for the season, usually by early July, the belugas also travel along the southern shore, past Elephant Point. They enter and leave the bay on both sides of the Chamisso Islands. In late June, they also start to move southwest towards Kiwalik (Fig. 3). Until the patterns changed in the late 1970s and early 1980s, the belugas regularly gathered at the eastern and southeastern ends of the bay (Fig. 3) at high tide, and occasionally went up the Buckland River after salmon (*Oncorhyncus* spp.).

In mid-July, belugas leave Eschscholtz Bay and head southwest towards Kiwalik, past Motherwood Point, and into Kotzebue Sound. Information given to Buckland hunters by Deering hunters indicates that the belugas then migrate past Deering, Goodhope Bay, and Cape Espenberg.

Beluga distribution has changed dramatically in the Kotzebue Sound region in the past few decades. While belugas were once hunted from Sissauliq and Kotzebue to Eschscholtz Bay and Kiwalik, they are now seen only infrequently in the area. At first, the belugas stopped coming close to Kotzebue, although they continued to appear as usual in Eschscholtz Bay. By the late 1970s, the belugas had stopped coming to the eastern part of the bay. In 1982 hunting was good, though not in the eastern end of the bay; but by the mid-1980s, belugas no longer gathered in Eschscholtz Bay (Fig. 3).

Point Lay Area

At Point Lay, belugas arrive south of the village in June, usually gathering at Omalik Lagoon before moving farther up the coast (Fig. 5). If the ice is still in along the coast, the whales may gather farther south or bypass Omalik altogether.

Once at Omalik, the belugas gather to feed, and perhaps to calve; they arrive in groups over a period of perhaps two weeks. Omalik is regarded as a biologically active area. The belugas gather within several kilometers north and south of Omalik, but the area just offshore from the lagoon is the most important area.

After gathering in the Omalik area for a couple of weeks, the belugas migrate north along the coast past Point Lay. The ice along the coast determines the timing of this move, where belugas pause, and whether they follow the shore. In years when winter storms have left heavy ice along the shore, the belugas may stay several kilometers offshore, and may even bypass Omalik Lagoon altogether, gathering instead at the inlets into Kasegaluk Lagoon (Fig. 5). If there is ice in the area, the belugas do not enter the inlets or the lagoon.

Some large, white belugas may scout the ice conditions ahead, returning to Omalik if they encounter ice. If there is ice along the coast, the belugas stay at Omalik until it has gone. If the belugas are already migrating north from Omalik when they encounter ice, they return to the previous inlet to wait. Typically, this migration takes place in early July, although it may come as early as late June or as late as the second half of July. Once the belugas are north of Point Lay, they continue to Utukok Pass (Fig. 5) and Icy Cape (Fig. 1), where they may gather temporarily. Little is known about their movements beyond that point.

When the belugas are moving along the coast from Omalik to Icy Cape, they proceed slowly, feeding as they go. This passage may occur in two or three pulses. The belugas enter the inlets that lead into Kasegaluk Lagoon (Fig. 5), as long as the tide or current is going out. Once in the lagoon, however, they stay in the deep channels near the inlets: they do not enter one inlet and exit another unless hunters are herding them. The big, white belugas lead the groups, which can range from a few animals to hundreds and include adult and young belugas.

The beluga migration and associated behavior in the Point Lay area have not significantly changed over time. Belugas do not enter the lagoon as often as they used to, but this may reflect changes in hunting patterns by the village or bathymetric changes in the passes into the inlet.

NATURAL HISTORY

Feeding

Norton Bay Area: Beluga feed on a variety of fish. In Norton Bay, there are several runs of salmon of different species, herring (*Clupea pallasi*), tomcod (*Eleginus gracilis*), flounder (*Liopsetta glacialis, Platichthys stellatus*), smelt (*Osmerus mordax*), sculpins (*Cottus* spp., *Myoxocephalus quadricornis*), other species of fish, and shrimp (*Pandalus* spp.). The eastern end of the bay, rich in sea plants, makes good fish habitat. The herring are the first to return to Norton Bay in the spring, usually in April, followed by the tomcod.

During their fall run, the herring come into the bay in early September. Near the river mouths and up the rivers there are also burbot (*Lota lota*), whitefish (*Coregonus* spp.), trout (*Salvelinus* spp.), pike (*Esox lucius*), grayling (*Thymallus arcticus*), arctic char (*Salvelinus alpinus*), and sheefish (*Stenodus leucichthys*). Some of these may gather in particular streams or at particular places in certain streams. Many of these fish descend to the bay in April and return to the streams in August.

Throughout Norton Bay in spring, belugas feed under the ice, first on herring and later on tomcod. They go far under the rotting ice in late spring. When belugas remained plentiful in the bay during the summer months, they would feed throughout the bay, following the fish, especially the salmon runs. The few belugas that do remain in the bay today continue this pattern. In fall, the belugas also feed throughout the bay. The area in front of Shaktoolik was a common evening feeding area prior to the 1940s.

Buckland Area: In Eschscholtz Bay, there are arctic char, salmon, herring, smelt, tomcod, invertebrates (e.g., isopods and copepods), whitefish, and small fish called *sauñilaq*. The gathering areas at the eastern end and the northern part of the bay are good feeding areas, as are the bays on the eastern side of the Choris Peninsula, primarily for arctic char and tomcod (Fig. 3). Belugas feed throughout the bay. When hunters have checked harvested animals, the stomachs have usually contained food such as herring or other fish.

Arctic char are common in the small coves on the eastern side of Choris Peninsula. They also swim along the south side of the bay and up the Buckland River. Salmon begin their main runs in mid to late July. Tomcod are plentiful in the northwest part of the bay and in fall in the lower Buckland River, as are clams in the shallows southeast of Elephant Point. Herring follow the south shore of Eschscholtz Bay in June (Fig. 4), and can be located by the flock of seagulls (*Larus* spp.) above them.

Point Lay Area: Belugas feed at Omalik Lagoon and along the coast as they move north in June and July (Fig. 5). Many species of fish are present at this time of year, including herring, smelt, salmon, flounder, and capelin (*Mallotus villosus*). The fish move into the inlets when the tide is going out, which may help explain the corresponding beluga movements. The fish also move close to the shore. Apart from Omalik, there are no regular gathering areas. The stomachs of harvested belugas are usually found to be empty, although hunters point out that there is plenty of time during the herding drive from Omalik to Point Lay for the belugas to void their systems.

Fish that belugas prey on are common throughout the nearshore area. Omalik Lagoon is especially rich in clams (*Macoma calcerea*), crabs (*Paralithodes camtschatica, Chionoecetes opilio*), sea plants, and fish, especially herring but also smelt, flounder, and salmon. Along the coast, beginning in June, capelin and other fish are found near the shore and entering the inlets, usually when the current is going out. Arctic char and pink salmon (*Oncorhyncus gorbuscha*) come later. Grayling and trout are found in the lagoon as well.

Feeding behavior of belugas is distinct from their migrating behavior. When feeding, belugas mill about, and they may be heading in any direction when they surface to breathe. When migrating, all the belugas surface heading in the same direction. Seagull flocks indicate the presence of feeding belugas, and they are more spread out when flying above belugas than when flying above herring.

In Norton Bay, there is concern that increasing beaver (*Castor canadensis*) populations are affecting the fish, and hence the marine mammals, of the area. Beaver dams may harm the spawning habitat of many fish, changing the fish patterns of the area. Beavers build dams near springs, where silver salmon (*Oncorhyncus kisutch*) and chum salmon (*Onchorhyncus keta*) spawn. They have dammed most sloughs of the Shaktoolik River, and these sloughs, which have become grassy, now make poor spawning habitat.

Calving

Belugas calve throughout Eschscholtz Bay, as well as earlier in the migration. The primary calving area is the deeper, calmer, and usually ice-free northwestern part of the bay (Fig. 3), but the eastern end is also a calving area. Norton Bay and Point Lay residents had little knowledge about calving areas, although Omalik Lagoon may be a calving area (Fig. 5).

Belugas are thought to calve at any time during the year. During birth, other belugas may help the mother, pushing her up for air and swimming over her back. Newborn calves have been seen in June and in September, often being carried on the backs of their mothers. In Norton Bay, small fetuses have been seen in females harvested in March. In Point Lay, near-term fetuses are rarely seen, though small fetuses (30 cm or shorter) are seen occasionally. Near-term females must come up for air more often than other belugas.

Usually, belugas give birth to one calf at a time, although twins have been seen on occasion. The newborn belugas swim close to their mothers, sometimes riding on the mothers' backs just caudal to the flippers, and sometimes holding onto the mother's flipper with a curled flipper. The mother may also help the newborn along with her flippers. In this way, the newborn can breathe more frequently than the mother can. Females with young do not rise as high out of the water when breathing. The calf may stay with its mother up to a year. Belugas about 2 m in length are often seen swimming with a group of belugas.

Molting

In Norton Bay, belugas generally molt in the spring, when the sun starts to get strong in May and June. In Eschscholtz Bay, molting takes place in July. In spring, a thin layer of old skin covers the thicker new skin. The older layer separates easily from the new skin, although belugas sometimes rub on the sea ice to help shed it. Before the molt, adult belugas are yellow; after the molt, they are bright white, with soft skin. Very old, large, male belugas may have yellowish skin.

Belugas are fat when they arrive in Eschscholtz Bay, although younger belugas are thinner and have thinner blubber. Beluga *maktak* (skin and blubber) is thicker in spring (the "winter coat") and thinner in fall. Some belugas have scars in their skin, perhaps from ice or other animals, as well as from old bullet wounds.

Avoidance Behavior

Belugas avoid killer whales (*Orcinus orca*) and harbor porpoises (*Phocoena phocoena*), both of which are seen in Norton Bay in June, July, and August. Killer whales were more common before the 1950s. If killer whales are in the area, belugas do not go out with the tide and may end up stranded in the shallows until the following high tide. Killer whales typically stay in deeper water, rarely coming farther in than the line between Point Dexter and Moses Point, though they have been seen near Isaac's Point in late summer. Porpoises enter farther into the bay, and at high tide may come within a few kilometers of the shore in the northern and eastern parts of the bay. Killer whales are also found south of Shaktoolik, offshore between the village and Beeson Slough, especially in August when there are south winds. Here too, if killer whales are in the deeper water, the belugas stay close to the beach.

Killer whales are seen in Kotzebue Sound in summer, and both killer whales and porpoises are sometimes seen in the area between Choris Peninsula and the Chamisso Islands. Killer whales and porpoises have been seen offshore north of Church Rock, and killer whales have been seen infrequently in the middle of the bay and to the northeast of Elephant Point. Near Point Lay, killer whales are sometimes seen near Icy Cape, though encounters between belugas and killer whales are uncommon in this area.

Belugas also stay away from gray whales (*Eschrichtius robustus*), which are sometimes found in Eschscholtz Bay and occasionally in the lower reaches of the Buckland River. At one time, a gray whale was stranded in the bay, and the belugas kept away from the area. Once when a gray whale died in the bay and its oil spread across the waters, the belugas did not enter Eschscholtz Bay. Gray whales come near shore off Kasegaluk Lagoon. When gray whales come in, the belugas swim out to deeper water. Belugas seek refuge from predators by hiding in the sea ice.

The Ice Edge

The ice edge in Norton Bay determines beluga feeding and distribution patterns in spring. In early spring, the ice edge in Norton Bay is approximately between Point Dexter and Moses Point. Later in spring, the middle of the ice edge inside Norton Bay retreats inward past Isaac's Point, roughly following the contour of the bottom of the bay. The remaining ice rots in place.

Sea ice, tide, and water depth are determining factors for beluga distribution in Eschscholtz Bay. After breaking up in June, the sea ice moves in and out with the tide, mostly through the area south of the Chamisso Islands. The ice does not move entirely out of the bay, and there may be large daily and yearly variations in the extent and movement of the ice. The northwestern part of the bay is usually free of ice. Wind also drives ice movements and water levels in the bay. An east wind pushes the ice out and lowers the water level. With a west wind, ice may stay in the bay during the tide cycle, holding the belugas in the east end of the bay. By early July, the ice has usually left the bay.

Near Point Lay, the ice now breaks up earlier and forms leads closer to shore than in the past. The ice breaks up by July, leaving only stranded bergs and a few floating pieces in the area.

RESPONSE TO DISTURBANCE

The beluga migration through the Norton Bay area has not changed much in recent decades, though some variations in distribution are noted. In spring and fall, belugas continue to gather in Norton Bay. Some other areas are used less by belugas than in the past, probably as a result of increased human activity.

Belugas no longer approach the beach as closely as they did, probably because of the prevalence of outboard motors. Until the late 1940s, belugas could be found right along the beach in many areas, but they are rarely seen there today. While belugas still feed in the Norton Bay area, the patterns are different today than in the 1940s.

Beluga behavior has changed in response to bigger and faster outboard engines. The first outboard engines, which arrived in the late 1920s and early 1930s, were four and eight horsepower motors. With those, hunters could approach belugas within hunting range. Today, however, even with much more powerful engines, it is difficult to come close to belugas. When a big group is chased, it splits apart. This is a change from the old days, when the big groups would stick together.

While some of the observed changes started in the 1950s, most changes have occurred since then. Some large shifts in distribution began in the 1970s with the start of the commercial herring fishery in the area. The noise from the processor ships and the increase in quantity and frequency of boat traffic have led to fewer belugas in the bay in the summer. Previously, there were belugas by Isaac's Point in June, but since the commercial herring fishery began, these are no longer seen.

Buckland hunters have given many possible explanations for the disappearance of belugas from Eschscholtz Bay, among which is the increased use of high-powered outboard motors. Since these were first used in the Kotzebue area and then gradually became more common in Buckland, this theory would help to explain why the belugas disappeared from the Kotzebue area first.

The entrance to Eschscholtz Bay is narrow, and noise in the migratory path could disrupt the herd, resulting in avoidance of Eschscholtz Bay. Increases in airplane traffic—Buckland has up to five scheduled flights a day—may further increase the overall noise to which belugas are exposed in this area.

Another explanation for the belugas' disappearance from Eschscholtz Bay is the ice entrapment and subsequent deaths of thousands of belugas in Seniavin Strait, Chukotka, Russia, in the winter of 1984–85 (Armstrong, 1985; Ivashin and Shevlagin, 1987). It is unknown, however, whether the belugas that died were part of the same stock hunted in Eschscholtz Bay. Buckland hunters were informed of this event by biologists, and the timing coincides approximately with the decline in belugas appearing in Eschscholtz Bay.

A third explanation is that belugas were overharvested in Eschscholtz Bay in the early 1980s, when the annual harvest was greater than 100 belugas, not including struck-and-lost animals. This overharvesting took place over three or four years. If the remaining belugas were avoiding the primary hunting area, this theory might explain the shift away from the eastern end of the bay towards the Chamisso Islands.

A combination of factors is also possible. There is no knowledge of previous changes in migratory patterns, and hunters and elders regarded all these explanations as speculative.

DISCUSSION

The results of this research are consistent with current scientific understanding of belugas in this region (Burns and Seaman, 1986; Hazard, 1988; Frost and Lowry, 1990; Frost et al., 1993; Suydam et al., 1996). Since previous researchers have made substantial use of the observations of local residents, this similarity is hardly surprising. Nonetheless, the fact that two types of understanding attained through very different means converge and complement each other is encouraging to those seeking to develop common bases for understanding and managing marine mammal populations in Alaska.

The current research has confirmed general behavioral traits such as use of estuaries (Smith et al., 1990), although the reasons for this affinity are still not clear. Several possible explanations, rather than advantages in feeding, have been advanced: warm estuarine waters may help the molt (Watts et al., 1991; Frost et al., 1993; Smith et al., 1994); shallow water may provide protection from killer whales (Sergeant and Brodie, 1969); and a warmer environment may allow use of subcutaneous fat for somatic growth (St. Aubin and Geraci, 1989). In this study, however, the occasional use of river mouths and rivers in summer and fall (e.g., the Buckland River and several rivers flowing into Norton Bay) was associated with feeding, as has been noted elsewhere (Sergeant, 1973; Watts and Draper, 1988).

Hunters' descriptions of feeding behavior and the association of sea gulls and other sea birds with feeding belugas are also consistent with published accounts (Kleinenberg et al., 1964; Seaman et al., 1982; Frost et al., 1983; Lowry et al., 1985; Hazard, 1988). Kleinenberg et al. (1964) report over 100 kinds of organisms found in beluga stomachs, though Lowry et al. (1985) question whether some invertebrates found in beluga stomachs might be secondary prey, which actually come from the stomachs of fish consumed by belugas. Hunters' descriptions of belugas feeding on a variety of prey species depending on season and local abundances are also consistent with current scientific understanding of beluga feeding habits.

Descriptions of specific local movements and patterns, behavior, and ecological interactions have added to documented knowledge about belugas. Kleinenberg et al. (1964) and Hazard (1988) note the general tendency of belugas to enter bays and come closer to shore with a rising tide and to follow local abundances of prey species. The behavior of belugas at the passes into Kasegaluk Lagoon, where they enter when the tide is ebbing rather than flowing, may indicate better local feeding conditions under those circumstances, as well as a different response in a narrow pass than in a broad bay.

Of particular interest are the broad interactions among species, extending in the case of beaver in Norton Bay into what is usually regarded as the terrestrial ecosystem. Kleinenberg et al. (1964) found an association between high riverine runoff and beluga concentration in estuaries. They posit prey species concentrations as the main causal link, with arctic cod concentrations increasing in years of high runoff. Sergeant and Brodie (1975) describe abandonment of the Manicouagan Bank in the Gulf of St. Lawrence by belugas after hydroelectric dams upstream caused changes to riverine flow and estuarine water temperature. Calkins (1983) predicts similar disruptions of belugas, including changes caused by impacts to prey species, if a hydroelectric dam is built on the Susitna River. While beaver dams are unlikely to affect overall water flow volume, their effects on prey distribution may contribute to shifts in beluga distribution. The identification of such potential (though indirect) influences on beluga ecology is a useful complement to scientific inquiries focused more narrowly on belugas.

The calving period reported by Buckland and Point Lay informants is consistent with existing information for Alaska, as is the Norton Bay informants' description of neonates in June (Hazard, 1988). The Norton Bay report of occasional neonates in September is consistent with existing information from eastern Canada and perhaps Russia (Tomilin, 1957; Sergeant, 1973), but has not been reported previously in Alaska. The Norton Bay statement that calving may occur at any time of year has been reported previously (e.g., Tomilin, 1957), but such reports are disputed (e.g., Kleinenberg et al., 1964). Reports that calves stay with their mothers for a year are consistent with Burns and Seaman's (1986) estimate of a 12–18 month lactation period, and Sergeant's (1973) conclusion that lactation ends when the calf is between one and two years old. Braham (1984), however, estimates that lactation lasts 18 to 32 months, and results from Chukotka (Mymrin et al., 1999) indicate a two-year lactation period.

Descriptions of the frequency of encountering fetuses in harvested belugas are problematic. Braham (1984) estimates the pregnancy rate of mature females at 40%. Burns and Seaman (1985) give a birthrate of .33, i.e., one calf per female every three years. The TEK documented here indicates a lower frequency. Suydam (pers. comm. 1997) suggests that butchering practices may lead to non-detection of fetuses, especially early in the gestational cycle. Since much of the harvest in the three areas of this study takes place in summer and fall, and thus after much or most of the calving season has passed, encountering near-term fetuses may be less likely than during a spring hunt.

The description of female belugas carrying neonates adds to observations of wild and captive female belugas carrying inanimate objects as possible surrogates for lost calves (Smith and Sleno, 1986; Kilborn, 1994).

Of particular significance are the descriptions in this study of beluga avoidance of anthropogenic noise, in particular in response to outboard-powered boat traffic in Kotzebue Sound, Eschscholtz Bay, and Norton Bay, and larger ship activities around Norton Bay. These descriptions have implications for environmental impact assessment of offshore oil and gas activities, shipping, and loading of ships. Results in this study indicate that belugas avoid anthropogenic noise, though a certain degree of habituation occurs, particularly for constant noises (as opposed to variable ones).

Mymrin et al. (1999) documented similar observations in Chukotka, Russia, with indications that belugas have habituated to considerable noise in the port area of the Anadyr River. This is consistent with the findings of Byers and Roberts (1995) that, in the Mackenzie Delta, Canada, belugas were seen to habituate to fixed platforms but not to moving sources such as boats and helicopters, and with the findings of Stewart et al. (1983) and Richardson et al. (1995), who describe varying degrees of habituation and avoidance that appear correlated with frequency of exposure to noise and association of noise with hunting. Belugas avoid noise that is associated with hunting activity or in an area of hunting pressure. When the noise is not associated with hunting, belugas are capable of habituation to considerable noise, as is the case in Bristol Bay (Richardson et al., 1995) and the Anadyr River.

As noted in the introduction, the process by which TEK is compiled is not explicit. Some observations or statements reported in these Results may seem beyond what one might learn from even a lifetime of careful observation. For example, identifying the sex of belugas leading the migration appears difficult without harvesting a representative sample. With harvested bowhead whales (*Balaena mysticetus*), experienced hunters often mistake males for females and vice versa, even though an examination of the killed and landed animal leaves little room for uncertainty (author's observations). While it is tempting to say that this information is of little consequence to the hunt and therefore unlikely to be reliable, the observations of mother–neonate interactions are similarly non-utilitarian, and yet they conform directly with other observations of wild and captive belugas.

There is no simple test for evaluating or estimating the reliability of information derived from TEK. The reader must consider carefully the uses he or she intends for the information; gauge whether the information is pertinent and what the consequences are if it is inaccurate; and finally decide how best to make use of it in each particular situation. In planning research, TEK may help frame the questions or hypotheses. In analyzing results, it may help illuminate or challenge specific points. In management, it may shed light on hunters' perspectives of appropriate means of managing hunting methods and harvests. In each case, the threshold for reliability may be different. Then again, scientific findings also must be scrutinized and challenged (e.g., by the peer review process) and their utility evaluated for each purpose to which they are put. Accepting TEK without question denies it the status of worthwhile data; critical evaluation and careful use give TEK the status it deserves, provide an opportunity for accessing information not otherwise available, and allow TEK to be considered along with scientific knowledge in the effort to better understand the natural world.

CONCLUSIONS

Data concerning local behavioral patterns are useful in developing management strategies for subsistence hunting and assessing and minimizing environmental impacts (Stevenson, 1996). Both tasks require accurate data and benefit from the active cooperation of local users of the resource. Using TEK expands the pool of available data and can help establish a cooperative approach in the formulation of research questions, data needs, and management strategies. The benefits of such cooperative approaches have been documented in numerous studies (e.g., Pinkerton, 1989; Huntington, 1992; Richard and Pike, 1993). By increasing the areas of collaboration to include research, we can extend these benefits into other areas of the management process.

The rewards of working with TEK are commonly expressed using the future tense. While improvements are certainly possible, available methods of documenting TEK, such as the one used in this study, are effective. What remain to be developed are better means of integrating TEK approaches with those of Western science, better ways of using TEK in resource management, and a better understanding of how TEK can help conservation, including sustainable use of living resources.

This research shows that an effective methodology used in a collaborative research process with elders and hunters can document a wide range of useful and detailed information. The benefits of such research include a better understanding of the ecology of a region or a species, as well as cooperation in research, which aids the cooperative management strategies that are increasingly common in Alaska and elsewhere in the Arctic. Effective processes for applying documented indigenous knowledge to management, conservation, and biological research, however, remain elusive, and require additional investigation.

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