Impacts of Vessel Surveys and Tagging Operations on the Behavior of Beluga Whales (*Delphinapterus leucas*) in Cook Inlet, Alaska, 1-22 June 1994

Kim E. W. Shelden

National Marine Mammal Laboratory
Alaska Fisheries Science Center, NMFS, NOAA
7600 Sand Point Way N.E., Bin C15700
Seattle, WA 98115-0070

Abstract

In June of 1994, the National Marine Mammal Laboratory conducted a vessel survey of beluga whales in the northwest corner of Cook Inlet, Alaska. The focus of the survey was a radio-tagging study of a portion of the population found near the Susitna River delta. The impacts of the methods used to tag and study beluga whales from vessel platforms were examined. Using techniques similar to those employed by native hunters, beluga whales were isolated from their groups and pursued. Surfacing behaviors were categorized and analyzed based on initial reactions to tagging attempts, duration of tagging attempts, and whether the animals were in undisturbed or actively pursued groups. Behaviors were broken down into two categories: head lifts and slow rolls. The amount of time an animal was visible at the surface during each type of behavior was also examined. Based on analysis of videotaped pursuits, belugas were more likely to head lift during an approach and tagging sequence than to slow roll. In undisturbed groups, times at the surface were significantly different between head lifting and slow rolling animals, and between juveniles and adults displaying slow rolling behavior. Reactions to disturbance were consistent with those observed in other studies. Despite hunting pressures and tagging activities, belugas never abandoned the study area. Site tenacity, demonstrated by this species in other regions, is apparent in the Cook Inlet population.

Introduction

An absolute abundance estimate is necessary in order to make management decisions regarding the population of beluga whales that seasonally occupies Cook Inlet, Alaska. In 1994, aerial surveys, oceanographic sampling, and radio-tagging studies were conducted to obtain raw counts of beluga groups, characterize beluga habitat, and quantify surfacing behaviors, respectively. This report focuses on the methods we used for tagging and studying belugas from vessel platforms, and the impacts these techniques might have had on individuals and groups of whales. In particular we needed to evaluate how our presence may have affected surfacing rates of tagged whales. These surfacing rates represent the amount of time the average whale would be visible to observers conducting aerial surveys, an important component in the development of a correction factor for the number of animals seen during

aerial surveys (Hobbs *et al.*, this report). Different levels of disturbance and lengths of recovery time may influence the types of surfacing behaviors observed.

Methods

Survey Location and Research Platforms

Vessel surveys for beluga whales were conducted in the waters of Cook Inlet, Alaska, from 1-22 June 1994 by the National Marine Mammal Laboratory (NMML). The focal area

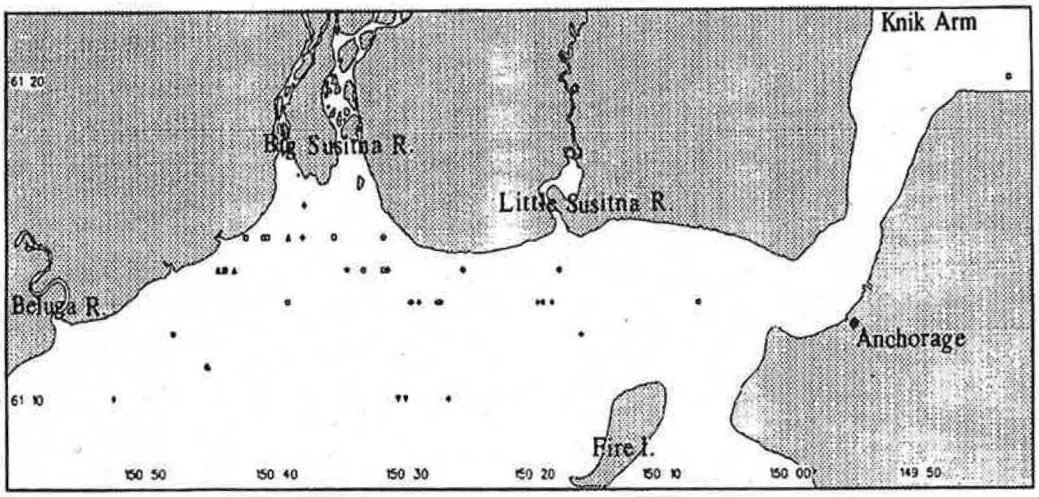

Figure 13. June 1994 survey area. Symbols indicate vessel locations during beluga whale observations (distance to whale groups are not indicated).

for these surveys was the Susitna River delta located approximately 35 km west of Anchorage (Fig. 1). Research vessels were a 6 m (20 ft.) Boston whaler[1] with twin 100 hp propeller engines and a 5 m (16 ft.) Avon rigid-hulled inflatable with 70 hp propeller engine. Operations were based out of Anchorage, where vessels were deployed each survey day at Ship Creek.

For most of the survey, the Boston whaler served as the research platform for oceanographic sampling and radio-tag monitoring while the smaller Avon was used for tagging whales. Generally the crew divided into two teams. One team was comprised of a driver, video camera operator, and 1-2 taggers in the Avon. The other team was made up of a driver, oceanographic samplers, and a tag monitor in the Boston whaler.

Tagging Operations and Equipment

Once a beluga group was located, the crew took up their positions in each vessel. GPS position, Beaufort sea state, water depth, and weather condition were noted at the time of the sighting, and a rough estimate was made of the size of the beluga group. When time allowed,

[1]Reference to trade names does not indicate endorsement by the National Marine Fisheries Service.

the group was plotted on a chart form developed for the survey. Vessel position (i.e., GPS location) was noted at the center of the circular chart; lines and circles radiating out from the center noted magnetic bearing and approximate distance, respectively, from the whale group(s) to the vessel. A 7x50 binocular with reticles and a compass helped determine distances from and expanse of the beluga groups. The presence (or absence) of hunters was also documented.

During tagging operations, one or two of the crew were stationed in the bow of the Avon, each outfitted with a suction cup tag clamped to an adjustable pole (4.6 m (15 ft.) maximum length). Tags consisted of a VHF radio transmitter, flotation device, and silicon suction cup. Each tag had a gel plug detachment system that would release the tag after the plug dissolved (see Lerczak, this report, for a detailed description of the tagging system). Preparations usually took place at a distance of approximately 300 m from the whale group with vessels lashed together and engines off. Tagging operations commenced when the Avon driver moved the vessel toward the whale group. The Boston whaler and its crew remained behind, staying within visual range while conducting oceanographic sampling and setting up tag monitoring equipment.

Tagging bouts consisted of an approach on a group, isolation of an individual, and a maximum of three tagging attempts on an individual ending with either a successful deployment and withdrawal from an animal, or an unsuccessful deployment and search for a new animal. The first three survey days (1-3 June) were spent developing tagging methods. The team experimented with fast approaches; slow, steady approaches; and circumventing a group, then stopping engines and waiting for the whales to move past. This met with limited success, with belugas only surfacing within approximately 4.5 m (15 ft.) of the vessel before moving away. On the fourth survey day a local beluga hunter joined the team and provided training in beluga hunting techniques.

Our tagging methods were modified based on this training. Tagging events were scheduled just after low tide. Hunters have determined that it was easier to track the whales when they were in very shallow water. In water <2 m deep whales created "bow waves" as they swam, a small wave in front of the head and a larger wave in front of the flukes. The motion of the flukes also caused circular upwellings or "footprints" on the surface. The hunters used these cues to isolate and follow a whale. The hunting vessel is driven into the wave formed by the flukes, and the animal is followed until it surfaces in front of the vessel in the wave created by its head. This method worked extremely well in shallow water; however, when an animal moved into water >2 m deep, the wave collapsed, which made further tracking impossible. Similarly, if Beaufort sea states were >2, waves made by whales were lost in the confusion of wind-created waves.

To minimize disturbance, each group was studied prior to tagging to determine the best approach direction. At this time, the number of visible whales was estimated and locations recorded. The Avon was driven rapidly toward the edge of the group and an animal would be chosen as a function of proximity to the vessel and consistency in visibility of its "wave ". Small juveniles, identified by their gray skin color, were avoided. The selected animal was then followed as it broke away from the group. Isolation of an individual occurred within seconds and was either due to the individual moving away from the group or to the group distancing itself from the tagging operation. Tagging bouts averaged about 2.7 minutes (max.

10 minutes) from the time an individual was isolated to the time the pursuit ended. After 4 June, tagging bouts were documented by a fourth observer on the tagging vessel using a hand held video camera.

Laboratory Analysis

Video recordings of tagging operations were examined in order to determine the amount of time spent isolating and tagging each beluga whale. The level of harassment during tagging was defined in terms of the number of animals "taken". A "take" indicates that an animal or animals deviated from what might be considered normal behavior. Individual whales isolated from the group and pursued during tagging operations were considered to be "taken by harassment". Individual(s) were classified as "taken incidental to harassment" when they reacted strongly (e.g., rapidly swimming away with sufficient speed to create a wake and white water) to the presence of the vessel as it approached to isolate a single animal for tagging operations. A tagging approach was defined as the isolation and pursuit of an individual whale. Interruption of the pursuit for any reason (e.g., retrieval of a dislodged tag), resulted in a new tagging approach. If the approach was on the same individual it was logged as a second or third attempt. A maximum of three tagging approaches were allowed for each individual.

The surfacing behaviors of harassed and undisturbed whales were examined using video footage obtained in the field. Two types of surface behavior were observed - "slow rolls" and "head lifts". A "slow roll" is a surfacing where an animal's head appears then recedes; the back first appears as a thin line on the surface before it arches high out of the water as the whale dives. The lateral indentations along the lower side of the body between the dorsal ridge and caudal peduncle are usually visible during the highest point in the arch. The flukes are rarely observed to break the surface. A "head lift" is similar to the beginning of the "slow roll" behavior: the head appears above the surface then recedes; however, it is not followed by the appearance of the back. In the analysis, "slow roll" behavior was divided into two color categories representing juveniles (gray) and adults (white). Because of the difficulty in determining the color category of individuals displaying "head lift" surfacing behaviors (i.e., the visual cue is small and video image resolution is poor during stop action), this behavioral category was not divided.

Surfacing intervals were obtained from radio-tagged animals by following animals immediately after tagging and logging each visible surfacing or recording radio signals (see Lerczak This report for a description of radio-signal monitoring and analysis). Surfacing intervals were also gathered during focal animal studies in which an untagged animal's surfacings were recorded for as long as the identified animal could be tracked. Only video records were reviewed for this analysis because written logs did not provide the exact moments the animals appeared and disappeared from view.

Results

Whale Reactions to Tagging Operations

Whale responses to our vessel activity did not vary, although we tried different approach methods. Once the vessel approached within approximately 10 m of a whale, it

would move rapidly away from the vessel creating a wave, sometimes cresting in a whitecap. From videotapes of tagging bouts where initial approaches were recorded (25 of 50 recorded segments), 92% of the time belugas demonstrated "head lifting" surfacing behavior (only revealing the top of their heads to breathe) when the vessel began its rapid approach for tagging.

The initial burst of speed observed at the start of each tagging bout lasted for only a short period of time (ranging from less than 1 minute to 2 minutes) after which the beluga began to surface more frequently. Once an animal tired, the vessel driver could follow it at a slower pace. At the termination of a tagging bout, whether or not a tag was attached, the whale usually moved away from the vessel without "slow rolling" at the surface until it was at distances roughly >10 m away from the vessel. Though not quantified, these behaviors are substantiated by field observations made after 93 tagging attempts.

During tagging pursuits, 85% (n=27) of the whales isolated for tagging bouts initially reacted by "head lifting" on the first surfacing. Individuals isolated for tagging varied in the amount of time they spent "head lifting" and "slow rolling" during a chase sequence. Only 15% of the animals approached (n=27) were observed to "slow roll" throughout the entire bout, while 59% exhibited only "head lift" behavior (Table 1). The remainder, 26%, exhibited almost equal preference for the two types of surfacing behavior. Because the duration of a tagging bout was relatively short (average 2.7 minutes), usually only 1-3 surfacings occurred before the bout was terminated.

When engines were off, belugas did not appear to avoid the boats. Whales

Table 1.

Whale #	Number of Head Lifts	Number of Slow Rolls
1	1	0
2	2	1
3	1	1
4	1	1
5	0	1
6	1	0
7	3	0
8	1	0
9	1	0
10	1	0
11	1	0
12	1	1
13	1	0
14	1	0
15	3	0
16	0	3
17	1	1
18	3	0
19	3	0
20	2	0
21	1	1
22	1	0
23	2	0
24	0	5
25	0	7
26	2	0
27	1	1

surfaced as close as 4.5 m and would approach within 2 m or go under the vessels as evidenced by bubbles, "footprints " at the surface, or images moving across the depth sounder. Whales observed beyond 4.5 m would raise their backs above the surface in a high arch ("slow roll") prior to diving. This was apparently a more casual and typical surfacing behavior than was the "head lift", which was a rapid surfacing that minimized the length of time and amount of body area above the water surface.

Harassment of beluga whales during tagging operations was categorized two ways: as those animals that were "taken by harassment" and those that were "taken incidental to harassment" (Table 2). A total of 93 individuals were isolated from their group and pursued during tagging operations. Other individuals (n=77) within the group that reacted strongly to the presence of the vessel, did so only when the vessel was within 10-20 m.

Table 2.

Date	Number of Individuals Taken by Harassment	Number of Individuals Taken Incidental to Harassment[2]	Approximate Distance from Animals at Time of Disturbance[2]	Number of Approaches on an Individual Isolated for Tagging[2]
6/1/94	0	20	10-20 m	0
6/2/94	0	10	10-20 m	0
6/3/94	8	10	10-20 m	1-2
6/4/94	8	5	10-20 m	1-2
6/9/94	14	4	10-20 m	1-2
6/11/94	28	15	10-20 m	1-3
6/13/94	5	1	10-20 m	1
6/14/94	14	5	10-20 m	1
6/15/94	12	7	10-20 m	1-3
6/17/94	4	0	10-20 m	1-2
Total	93	77	-	-

[2] Based on observations made in the field and video footage of tagging bouts where initial approaches were recorded (n=25).

Despite our presence and the presence of hunters in the area, the belugas never left the immediate survey area during this study. Animals would move 300 to 500 m away from our tagging operation, but once the Avon stopped approaching whales, they would return to within 100 m of the vessel within a short period of time. Beluga groups were present within the Susitna River delta throughout the survey period. Prior to the last 2-3 days of tagging operations (before 15 June), beluga whales were found in large, clumped groups (>50) often surfacing in multiple directions. Thereafter, the animals were more dispersed in groups ranging from 1-20 individuals.

Duration of Tagging Bouts

Between 3 and 17 June 1994, a total of 93 individual beluga whales were isolated for tagging . Of these 93 tagging attempts, 50 were video taped. Analysis of the tape revealed that the average amount of time spent isolating and attempting to tag an animal was 2.7 minutes (CV=0.85, n=50). Only 4 of the 93 attempts resulted in successful deployments of tags. For those attempts captured on video tape, successful tagging attempts averaged 5.5 minutes in length (CV=0.53, n=3). The 47 failed attempts logged on tape were categorized as to the reason tag attachment was unsuccessful. The video record was not complete in 14% of the attempts so the reason for failure in these cases was considered unknown.

The greatest percentage of failures (30%) was due to the animal entering deep water (>2 m in depth). This resulted in the wave collapsing, leaving the tagging team with no visual cue to the whale's location. The average amount of time spent on an attempt, prior to the whale entering deep water, was 2.2 minutes (CV=0.99, n=15). The second highest failure rate (18%) was due to poor attachment of the tag. Tags would dislodge prematurely from the jab stick after coming into contact with the whale at an improper angle or if the pole tip dipped into the water while underway (n=9). Other reasons included: aborting the attempt because the animal was too small or an adult was accompanied by a calf (n=4); aborting the attempt after three unsuccessful approaches had been made (n=4); unable to stay with an animal because it was too evasive (n=3); the whale was lost in low contrast lighting (n=3); or, the wake of the boat was confused with the wake from the whale (n=2).

Surfacing Behaviors of Undisturbed Beluga Whales

Video tape obtained during vessel operations was further analyzed to determine the amount of time undisturbed individual animals were visible at the surface. Both types of surfacing behavior were quantified. Time at the surface for each color category was compared for those animals exhibiting "slow roll" behavior. Juveniles (gray animals) averaged 2.25 seconds at the surface (CV=0.14, n=36) while adults (white animals) surfaced for an average of 2.55 seconds (CV=0.14, n=70). Times at surface were significantly different between gray and white individuals (Fig. 2; t-Test =4.5, d.f.=79, $p << 0.001$). On average, white individuals were at the surface 12% longer than gray animals.

Color categories were combined and averaged in order to compare "slow roll" behavior

to "head lift" behavior. As expected, the amount of time spent at the surface during a "head lift" ($\bar{x}$=1.02 seconds, CV=0.37, n=28) differed significantly from the time spent at the surface during a "slow roll" ($\bar{x}$=2.45 seconds, CV=0.15, n=106) (t-Test=17.9, d.f.=132, p<<0.001). During a "slow roll", animals were at the surface 58% longer than those "head lifting".

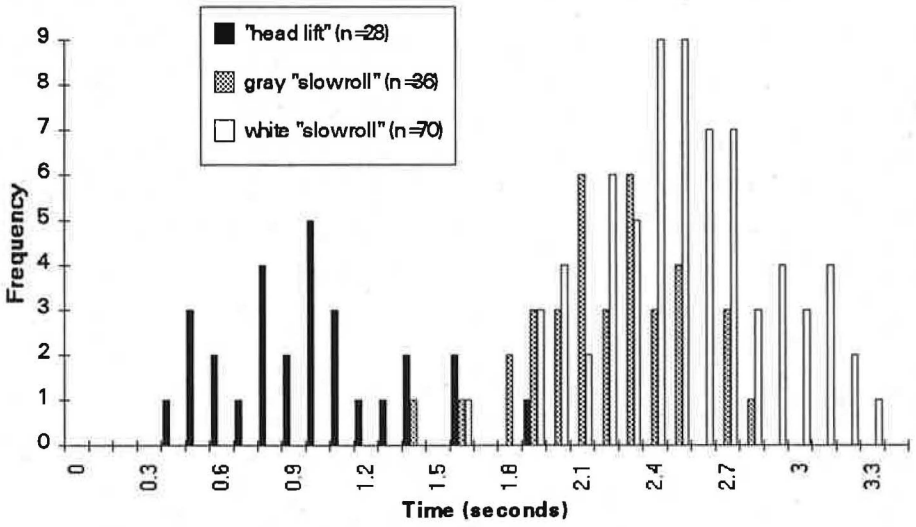

Figure 2

Variation in Surfacing Behaviors of Video-Tracked Individuals

Time at the surface was calculated from video footage of an undisturbed adult beluga accompanied by a calf. The pair were not accompanied by any other belugas, enabling the field crew to track them continuously on video for 2 one-minute segments and 1 six-minute segment during the 16 minute encounter. The observation team attempted to keep the vessel a distance of 100 m away so as not to disturb the pair. Although no "head lift" surfacings were observed, 7 complete "slow roll" surfacings were captured on video for the adult and 8 for the calf. The average amount of time spent at the surface was 2.77 sec. (CV=0.08) for the adult and 1.42 sec. (CV=0.23) for the calf. Adult/calf surfacings were not always synchronized. Only 8 possible sequential surfacings were available for the adult and 6 for the calf (Fig. 3). Some calf surfacings were not captured on video (the audio portion of the tape indicates the calf was at the surface though it was not visible on the videotape). Reasons for missed calf surfacings include: difficulty in judging where the next surfacing will occur; the brevity of time spent at the surface; the calf surfacing on the far side of the adult; or the lack of contrast between calf and water making it difficult to discern from the background.

Video footage was also available of a recently tagged, and therefore harassed, whale. For the entire length of the video segment (5.25 minutes), only "head lift" surfacing behavior was observed. Time at the surface averaged 1.34 seconds (CV=0.23, n=28; Fig. 4). The average amount of time spent below the surface was 9.63 seconds (CV=0.26, n=26). Toward the end of the tracking time, the amount of time spent below the surface appeared to increase, although the time at the surface did not appear to change (Fig. 4). One surfacing was not captured on film as evidenced by the gap before the last 3 surfacings (audio data from the tape placed the animal at the surface, though it was not in the field of view of the camera).

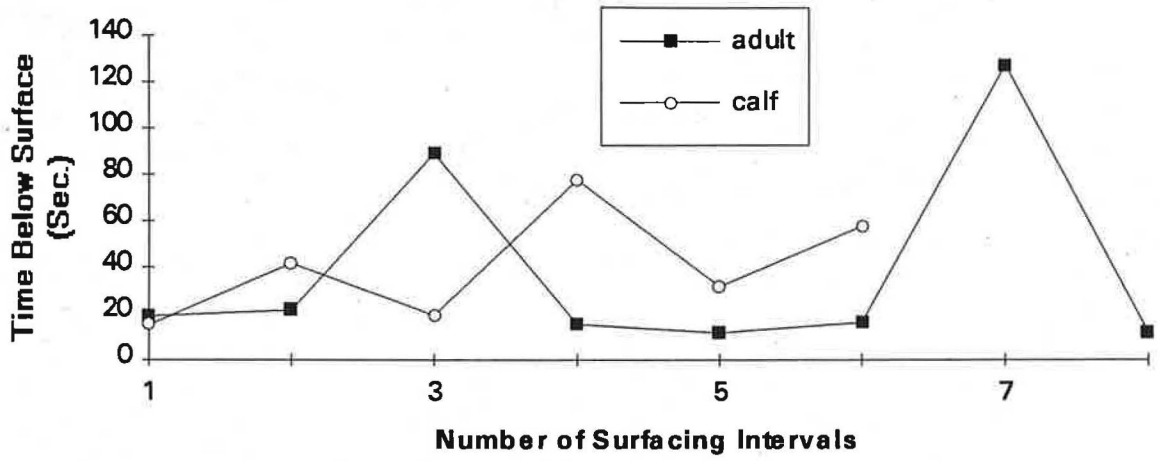

Figure 3

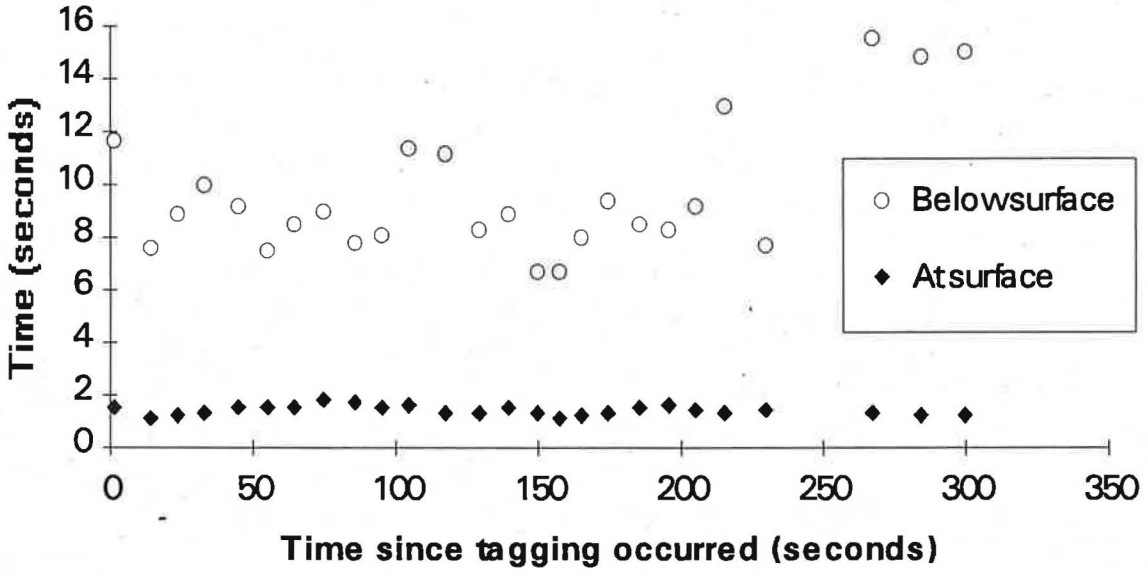

Figure 4

Because of this, 2 dives were removed from the data because the precise time that one dive ended and the other dive started could not be determined reliably. The amount of time spent at the surface prior to and just after a dive appeared to vary more for shorter dives than longer dives (Fig. 5), but this has not been tested statistically to date. Tracking terminated when the suction-cup tag released prematurely from the whale.

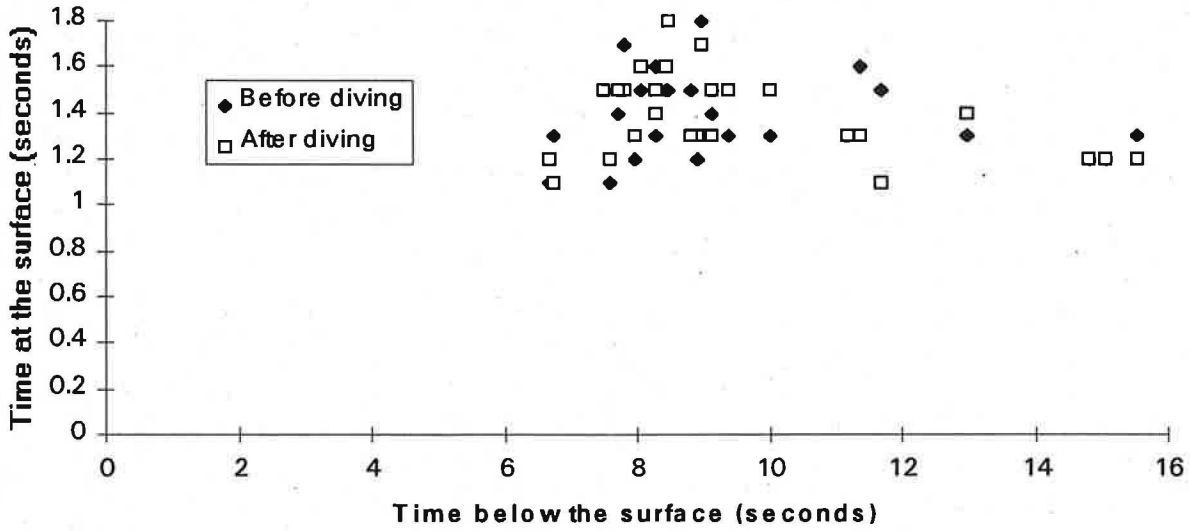

Figure 5

Discussion

The presence of beluga whales in Cook Inlet was first documented in the published literature in 1963 (Klinkhart 1966). During this time, belugas have been subjected to oil drilling and seismic operations, potential interactions with commercial and subsistence fisheries, heavy vessel traffic, low-flying aircraft, and annual subsistence hunts. In spite of this, belugas continue to occupy the upper inlet each summer and have been observed to remain in the inlet throughout all seasons (Calkins 1984). In other regions these whales have demonstrated a strong attachment to certain estuaries, a behavior referred to as site tenacity or fidelity (Finley 1982; Finley *et al.* 1982; Caron and Smith 1990). Belugas continue to return to these estuaries after a disturbance (i.e., hunters, vessel and/or aircraft traffic). Surprisingly, adults accompanied by calves were usually the first to return. This site fidelity behavior seems to be demonstrated by the belugas in Cook Inlet as well.

It is not known why beluga groups appeared to be more dispersed near the end of the field season (mid-June). This type of dispersal is usually not observed until later in the summer after a season of hunting and with the end of fish spawning runs (Calkins 1984; B. Mahoney, pers. comm.). Belugas have been observed in dense aggregations at river mouths during these fish runs (Calkins 1984). Large herd formations have been shown to be associated with heavy concentrations of food organisms in a small feeding area (Bel'kovich 1960). According to the Alaska Department of Fish and Game, spawning runs of king salmon (*Oncorhynchus tshawytscha*) were particularly poor in June, especially in the Susitna river systems (Medred 1994). Eulachon (*Thaleichthys pacificus*) runs appeared to have ended by 9 June because we no longer saw large numbers of dying fish in the Susitna region. This decline in available prey might be one explanation for the early dispersal of belugas because vessel and

hunting activities did not appear to affect group structure prior to this time.

Belugas remained in the survey area throughout the field season. On two days when hunting coincided with our tagging operations (3-4 June), whales were observed to move away, up and downstream, but never to fully abandon the river delta. Belugas appeared to recover quickly from disturbance as evidenced by the responses we observed to our vessel activity. Caron and Smith (1990) reported the return of belugas to areas previously disrupted by hunting activities or motor traffic in as little as 2 hours time after a disturbance. However, this recovery time varied significantly between identified individuals (ranging from 33 h. to 574 h.).

According to Kleinenberg *et al.* (1964), though easily alarmed by loud noises, belugas are not shy and have often been seen swimming close to large and small vessels. On a number of occasions, after unsuccessful tagging attempts, we would turn off the engines and observe the whale groups. At such times, the belugas typically surfaced within 4.5 m of the vessel. If we ran the vessel parallel to a moving group then stopped ahead of it, the whales would initially move away. However, within a few minutes, they would return to their original course and surround the vessel as they passed by. On two occasions (4 June), we observed hunters using this same method to get close to the whales.

Because we used methods similar to those used by the hunters to approach and tag whales, similar reactions to our presence would be expected. Caron and Smith (1990) described the reactions of belugas to hunting methods used in the Nastapoka Estuary, eastern Hudson Bay. As hunting vessels rapidly approached, many animals would leave the estuary. However, others did not react to the vessels until they had approached to within 500-1000 m. Pursued whales would either porpoise through the water or only reveal the tops of their heads to breathe ("head lifting") as they fled. Though we did not observe "porpoising" behavior, animals did flee rapidly, and only revealed their heads at the surface when first pursued. Fleeing from disturbances has also been documented for belugas hunted in Russian waters (Kleinenberg *et al.* 1964). Animals appeared less frequently at the surface, rapidly changed course, and moved away from the source of the disturbance. In terms of a hunted animal, a head lift presents a smaller target.

One tagged animal we were able to track for a short period of time continued to exhibit head lift behaviors until we lost sight of it. A factor that will need to be considered in future studies is the amount of time it takes an animal to recover from tagging. Because we were unable to visually track radio-tagged whales for long periods of time, it is not known when normal surfacing behaviors resumed. We did note a change in the behavior of the individual whale mentioned above. This animal had been pursued for 5.4 minutes. Approximately 4 min. after tagging, the whale began to make longer dives (Fig. 4) as it approached a group of belugas. Unfortunately, the tag released prematurely and once within the beluga group, the animal could not be distinguished from the other whales. These longer dives may reflect the return to a normal swimming pattern. Short dive intervals following a tagging event may be the result of oxygen debt, and once sufficiently aerobic, the animal may remain submerged longer.

Head lifting behavior appeared to be correlated with disturbance. Although, Smith *et al.* (1994) observed this behavior frequently when belugas were in shallow water and when

large numbers of animals occupied an area, in the undisturbed groups we studied under the same conditions, fewer animals were observed head lifting. From videotape recordings obtained during vessel operations, we noted that during slow roll surfacings adult belugas took an average of 0.3 seconds longer to submerge than juveniles. Slow rolling animals were also at the surface an average of 1.43 seconds longer than animals displaying head lifting behavior. Considering the amount of body area exposed during a surfacing, one would expect head lifting animals and the smaller, slow rolling juveniles to disappear from view more rapidly than the larger, white adults. The distance of the animal from the vessel during a surfacing may have influenced whether the whale slow rolled or head lifted. Although attempts were made to limit the sampling area to a distance from the vessel where both behaviors could be easily observed and whales were unlikely to be disturbed, it is probable that the sample was biased toward slow rolling animals that were white (adults), which were far easier to see than head lifting by adults or the behaviors of gray individuals. Analysis of video recordings from the aerial surveys was also affected by these biases (Waite and Hobbs, this report).

Video footage of an "undisturbed" adult with calf consistently showed the animals displaying slow roll behavior (Fig. 3). This does not necessarily mean that the pair were not bothered by our presence. During one tagging encounter that involved an adult with a calf (Table 1, no. 24 and 25), both animals surfaced this way the entire time. For an adult with a calf this type of surfacing may be necessary. Traveling this way, the adults body experiences increased drag while the calf gains an energetic benefit (Kelly 1959; Lang 1966). In this respect, a younger animals can maintain speed with an adult (Fish 1993). Despite our presence, neither cow/calf pair separated. Adults with calves may be a special case and are not usually targeted for hunting or tagging.

By studying undisturbed beluga groups and tracking known individuals (undisturbed and harassed), we were able to quantify the amount of time animals were spending at the surface during different surfacing behaviors. In turn, this information can be compared to data collected from aerial videotapes (Waite and Hobbs, this report) and radio-tag signal recordings (Lerczak, this report). These comparisons are presented in Waite and Hobbs (this report). If head lifting behavior is influenced by level of disturbance, the difficulty will be in determining at what level a large proportion of the group will display this behavior. Correction factors for population counts may need to be developed for harassed and undisturbed groups as well as groups occupying shallow and/or deep water habitats. Further documentation of these surfacing behaviors will be necessary to better quantify levels of harassment and recovery times.

Acknowledgments

Assistance for this study was provided by the Alaska Beluga Whaling Committee and its affiliates in Anchorage, and the NMFS Alaska Regional Office, Anchorage. Funding was provided by the NMFS' Office of Protected Resources, Marine Mammal Assessment Program. Special thanks go to Ron Morris, Barbara Mahoney, and Lt. Steve Thumm for their advice, time, and equipment dedicated to this project. In addition, we would like to thank the National Biological Service (USFWS) for providing a second vessel platform (Boston whaler),

and Larry Dugan for serving as a driver during the first days of the survey. Dente Owens (CIMMC) demonstrated beluga whale hunting techniques to the tagging crew. Staff support was provided by Joanne Wejak, Colleen Lee, and Karen May. Reviews of this document were provided by Doug DeMaster, Rod Hobbs, Jim Lerczak, Dave Rugh, and Janice Waite. Tagging operations were conducted under NMFS Research Permit No. 897 under provisions of the Marine Mammal Protection Act and Endangered Species Act.

Literature Cited

Bel'kovich, V.M. 1960. Some biological observations on the white whale from the aircraft. Zool. Zur. 30:1414-1422.

Calkins, D.G. 1984. Susitna hydroelectric project final report: big game studies. Vol. IX, belukha whale. Document No. 2328. Alaska Dept. of Fish and Game, Anchorage. 17p.

Caron, L.M.J., and T.G. Smith. 1990. Philopatry and site tenacity of belugas, *Delphinapterus leucas*, hunted by Inuit at the Nastapoka estuary, eastern Hudson Bay. Pages 69-79 In: T.G. Smith, D.J. St. Aubin, and J.R. Geraci, eds. Advances in research on the beluga whale, *Delphinapterus leucas*. Can. Bull. Fish. Aquat. Sci. 224.

Finley, K.J. 1982. The estuarine habitat of the beluga or white whale, *Delphinapterus leucas*. Cetus 4(2):4-5.

Finley, K.J., G.W. Miller, H. Allard, R.A. Davis, and C.R. Evans. 1982. The belugas (*Delphinapterus leucas*) of northern Quebec: distribution, abundance, stock identity, and catch history and management. Can. Dep. Fish. Oceans Tech. Rep. 1123. 57p.

Fish, F.E. 1993. Influence of hydrodynamic design and propulsive mode on mammalian swimming energetics. Aust. J. Zool. 42(1):79-101.

Hobbs, R.C., J.M. Waite, D.J. Rugh, and J.A. Lerczak. 1995. Preliminary estimate of the abundance of beluga whales in Cook Inlet based on NOAA's June 1994 aerial survey and tagging experiments. Unpublished document submitted to the Alaska Beluga Whale Committee Science Workshop, Anchorage, AK, April 5-7, 1995. (also within this report).

Lerczak, J.A. 1995. Radio-tagging of beluga whales in Cook Inlet, Alaska, June 1994. Unpublished document submitted to the Alaska Beluga Whale Committee Science Workshop, Anchorage, AK, April 5-7, 1995. (also within this report).

Kelly, H.R. 1959. A two-body problem in echelon-formation swimming in porpoise. U.S. Naval Ordnance Test Station, China Lake, California, Tech. Note 40606-1.

Kleinenberg, S.E., A.V. Yablokov, V.M. Bel'kovich, and M.N. Tarasevich. 1964. Beluga (*Delphinapterus leucas*): investigation of the species. Akad. Nauk SSSR, Moscow. (Transl. from Russian by Israel Prog. Sci. Transl., 1969, 376p.).

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

Lang, T.G. 1966. Hydrodynamic analysis of cetacean performance. Pp. 410-432 *In:* K.S. Norris (ed.) Whales, dolphins and porpoises. Univ. of California Press, Berkeley.

Medred, C. 1994. Where have all the kings gone? Anchorage Daily News, October 16, 1994. Section B, p. 1-2.

Smith, T.G., M.O. Hammill, and A.R. Martin. 1994. Herd composition and behavior of white whales (*Delphinapterus leucas*) in two Canadian arctic estuaries. Meddr Grønland, Biosci. 39:175-184.

Waite, J.M., and R.C. Hobbs. 1995. Group count estimates and analysis of surfacing behavior of beluga whales from aerial video in Cook Inlet, Alaska, 1994. Unpublished document submitted to the Alaska Beluga Whale Committee Science Workshop, Anchorage, AK, April 5-7, 1995. (also within this report).