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Beluga Whale, *Delphinapterus Leucas*, Distribution and Abundance in Cook Inlet, 1993

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ABSTRACT

This report is the first of a multi-year study to determine the distribution and abundance of beluga whales, *Delphinapterus leucas*, in Cook Inlet, Alaska. In 1993, we conducted a literature review, supported a genetics study to assess stock identity, tested survey methods, and performed distributional studies of belugas in Cook Inlet 2-5 June, 25-29 July, and 3, 18 & 19 September. Virtually all (96%) of the sightings were within 1 km of the shore in upper Cook Inlet. In June and July, most of these whales were in large aggregations (up to 260) generally near river mouths where fish runs are known to occur. However, in late September belugas were seen in small groups (<10 animals) dispersed along the coastline north of Kalgin Island. Few whales were seen in lower Cook Inlet (below the Forelands), and of those none were observed south of the Drift and Kenai Rivers. Maximum estimates/counts from the air indicate a minimum abundance of 330 beluga whales in Cook Inlet.

INTRODUCTION

Background

This report describes the first year of research conducted by the National Marine Mammal Laboratory (NMML) to determine the abundance and distribution of beluga whales in Cook Inlet. This study proposes to obtain an empirical estimate of the size of the beluga whale population in Cook Inlet and evaluate stock separation as the first step in assessing the fraction of the population currently removed annually by subsistence users and through incidental take in commercial fisheries. Currently there are insufficient data to make an assessment of a safe level of take, required by the Marine Mammal Protection Act (MMPA). In addition to the various National Marine Fisheries Service (NMFS) organizations, reports from this study will be provided to the Alaska and Inuvialuit Beluga Whale Committee (AIBWC) for use in managing the take of beluga whales by subsistence hunters.

Objectives

The objectives of this study are to:

1. Develop standardized survey techniques for estimating the abundance of beluga whales in Cook Inlet (and elsewhere), which are accurate, reliable, repeatable, and allow for comparisons between surveys at different times, locations, and by different organizations.

2. Determine the abundance and distribution of beluga whales in Cook Inlet. Identify areas of concentration, temporal distribution, and assess the likelihood that this is an isolated stock.

3. Conduct a comprehensive literature review to prepare for evaluating different methods of data collection and analysis (Appendix A).

4. Assist the Alaska and Inuvialuit Beluga Whale Committee (AIBWC) in their assessments of belugas in Norton Sound and Bristol Bay.

METHODS

The NMML aerial surveys over Cook Inlet were designed to test survey methods and begin a systematic series of studies to determine beluga whale distribution and abundance in the area. Flights were based out of Anchorage with the coastline of upper Cook Inlet as the primary study area (Fig. 1). This included surveys of Knik Arm, Turnagain Arm, and the river mouths of the McArthur/Chakachatna, Beluga, Big Susitna, and Little Susitna as far inland as 13 km. Surveys in the lower inlet extended south to Seldovia and Tuxedni Bay on 4 June and 28 July; and to the Kenai and Drift Rivers on 3 and 19 September. These coastal surveys along shore, around river mouths and several kilometers up river(s) maximized survey effort in areas where belugas were expected to occur. We applied standard aerial line transect methodology (e.g., Burnham et al. 1980; Buckland et al. 1993) when appropriate, and surveys were synchronized with low tide, when possible. Systematic transects, generally in the form of a sawtooth transect grid, were flown over the central portion of the upper inlet on 3 June and 27 and 28 July, as well as over the central portion of lower Cook Inlet on 28 July.

Survey aircraft included an Aero Commander (N7UP) used in June and most of July, an Aero Commander Shrike (N900RA) used 25 July, and a Twin Otter (N48RF) used in September. All are twin-engine, high-wing aircraft equipped with bubble windows and a GPS navigation system. In each aircraft, primary observers (Table 1) were seated directly behind the pilot and co-pilot seats. Additional observers, including pilots and the computer operator, provided sighting information whenever possible. Each observer was equipped with an inclinometer to determine sighting angle. Survey effort, environmental conditions (visibility, weather, and sea state), and sighting information (time and location [recorded automatically], number of animals, species, inclinometer angle, side of the aircraft, and relevant comments) were recorded on a portable laptop 386 computer. A second computer and GPS were used to plot the survey course in real time, and provide 10 second updates on position, ground speed, course, distance from shore and predefined waypoints. A survey altitude of 245 m (800 ft) and ground speed of approximately 170 km/hr (90 knots) were kept constant throughout each transect leg.

The viewing angle from the aircraft was generally kept below 14° (horizontal = 0°) during both coastal and sawtooth transect surveys. This provided a 1 km transect swath on each side of the trackline that was regularly searched, although whale sightings could be made out to 3 km in good viewing conditions. To optimize the visibility of the coastal mud flats and allow for photography out the side windows, the aircraft maintained a distance of approximately 1 km (0.5 nm) offshore.

During coastal surveys, when a sighting was made and after a sighting angle was obtained, the aircraft would break off transect and circle a whale group until counts were completed and video or still photographs were collected. Most of the belugas should have surfaced during the several minutes we spent circling the sighting location. If the whales were in shallow water, sightings were mentally mapped using mud plumes and water turbulence as visual location cues, until a group size estimate was made. Counts of belugas in deep water were made by tallying up animals based on a rough mapping of visible surfacings. Large groups (over 100) were sometimes assessed by counting a portion of the group and all observers had at least two good estimates (usually 4 circuits). Observer estimates were recorded independently and provided to the computer operator after the final circuit. Though the visual count is the traditional method, most researchers have not described their methods in sufficient detail to make reliable statistical comparisons between surveys. It is difficult to quantify or determine how important observer experience is in evaluating such an estimate. Therefore, a method for standardizing the counts, referred to as the racetrack method, was introduced during the July survey to provide some standardization among observers and an element of replication between successive counts of the same group.

The flight pattern of the racetrack method consists of several long ovals flown so that the long axis of each oval parallels the long axis of the beluga group, and the width of the oval is greater than the widest portion of the group (Fig. 2). Turns were made beyond the ends of the group. Position and sighting angle were recorded at the extreme ends of the racetrack. Two counts were made during each circuit around the oval, one along each straight side. Each observer recorded estimates independently and provided them to the computer operator after each racetrack was completed.

Photographic equipment included a hand-held single-lens reflex 35 mm camera (Nikon F3) with motordrive and 70-210 mm lens. We used Ektachrome 200 daylight color slide film. A Hi-8 video camera was also available for overview shots and for taping beluga groups for later counts in the laboratory. Selected images on the video tape (approximately 1 every second) were digitized on an image-grabbing computer system. Prints of these grabbed images were then compared to delineate whale surfacings and identify resightings. Counts from these images may provide a more accurate assessment of the number of animals at the surface at any given time and help evaluate whether a correction factor should be developed for submerged whales. The images provide an advantage over aerial estimates in that multiple views of the belugas can be studied without the distractions of inflight demands.

Further we supported a genetics studies at the Southwest Fisheries Science Center (NMFS, La Jolla, CA) to develop a technique to assess stock identity in beluga whales. In addition, we provided samples of beluga whale skin tissue (from dead stranded belugas collect by Ron Morris, NMFS, Alaska Region) along with other samples provided by the AIBWC. We assisted the AIBWC and Alaska Department of Fish and Game (ADF&G) with their survey of beluga whales in Norton Sound and with the analysis of their data.

RESULTS

June Surveys

Four surveys were conducted 2-5 June for a total of 13.4 flight hours (Fig. 3). Survey lengths ranged from 2.5 to 4 hours. Surveys in upper Cook Inlet were synchronized with low tides on 2 and 3 June (near a full moon), but not on other days because the survey area was too large or the timing of the low tide was impractical for our aerial operations. On most days, sea conditions were excellent (Beaufort 0-2), and occasionally increased to Beaufort 3, but Turnagain Arm frequently had windy or tide-rip conditions (Beaufort 4 and higher). All of the water in upper Cook Inlet was muddy, making animals invisible if below the surface.

Total beluga sightings for each day 2-5 June were, respectively, 298, 202, 198, and 128 (Table 2, Fig. 4). These estimates represent the sum of the highest counts made for survey days. Our highest count, 298, was on the day best synchronized with a low tide and involved the most thorough coverage of sites where belugas typically occur. The southernmost beluga sighting occurred in Redoubt Bay, near the southern edge of upper Cook Inlet, and no sightings were made well away from shore. Nearly all of the belugas in this stock appear to be within 1-2 km of shore in upper Cook Inlet during June. Belugas of the belugas in this stock appear to be within 1-2 km of shore in upper Cook Inlet during June. Belugas were generally clumped in groups of 50 to 120, although single animals and small groups were also seen. In shallow water areas, directional swimming was observed on occasion when an entire group would move as a column, sometimes with fish visible in front of the lead animals.

Other marine mammal sightings included 68 harbor seals, 12 sea otters (near Homer), and 5 harbor porpoise (also near Homer). We did not concentrate on potential seal haul sites, so our number is not representative of the local population, but our sighting rates of sea otters and harbor porpoise may have been representative, at least within the width of our trackline.

From the photographs, we selected two examples where aerial passes over large groups had sufficient numbers of images and where multiple images of each surfacing whale was available. In one pass over a group at 12:29 (Roll 1, frames 26-32), the number of visible beluga per image was: 22, 20, 26, 33, 30, 27, 23 (n = 7, mean = 25.9, SD = 4.6) with an accumulated total of 74 individuals during a period of approximately 7 seconds (aerial estimates were 60, 40, 70, and 60). In a pass over another group at 12:46 (Roll 2, frames 11-20), beluga counts were: 15, 10, 11, 15, 8, 16, 13, 4, 4, 4 (n = 10, mean = 10.0, SD = 4.8) with an accumulated total of 59 individuals during a period of approximately 10 seconds (aerial estimates were 82, 60, 40, and 62). Therefore, in these two samples, the photo count of 74 was similar to maximum aerial estimate of 70; and the photo count of 59 was similar to two of the aerial estimates (60 and 62) but was less than the maximum (82).

We also examined a 7-second segment of video tape with a group identified as having 70 animals, based on the field estimate. During the 7-second segment, it was assumed that no beluga surfaced more than one time. Prints of the 7 digitized images (1 captured for each second of tape time) indicated there were 26 to 29 animals at the surface in each image. Although the number at the surface was fairly constant, the turnover rate varied from frame to frame (i.e., animals identified as resightings compared to new animals were: 17 to 9; 20 to 6; 20 to 8; 18 to 11; 11 to 17; and 21 to 7). Therefore, in this 7-second sample, there were 84 beluga identified after removing resightings.

July Surveys

Five aerial surveys were conducted over Cook Inlet 25-29 July 1993 for a total of 14.8 flight hours (Fig. 5). Survey lengths ranged from 2 to 4 hours. Sea conditions during low tides were excellent (Beaufort 0-2) even in Turnagain Arm where sea states are typically Beaufort 4 and higher. Strong winds during the surveys conducted at high tide (25 and 26 July) produced sea states ranging from Beaufort 2-5. Modification of the counting procedure was made after 27 July. A racetrack pattern was used for the remainder of the surveys. Preliminary results from counts of four groups of belugas showed that the observers correlated well within a single counting pass and that significant variation occurred between counting passes. This variation between passes, however, was due to the number of animals at the surface rather than differences between observers.

Total beluga sightings for each day 25-29 July were, respectively, 125, 198, 230, 260, and 332 (Table 3, Fig. 6). In July, other than one sighting of a lone beluga, group sizes ranged from 26 to 260. This lone animal was also the southernmost sighting which occurred northeast of North Foreland, near Tyonek, well within upper Cook Inlet. Only one sighting occurred offshore (approximately 1.7 km [0.9 nm] from the mud flats). As in June, all the belugas encountered during this survey appeared to be within 1-2 km of shore in upper Cook Inlet. Group integrity was not as tight as that observed in June. Individual whales were spread out over a larger area, most were milling at the surface, and only one group was seen swimming directionally. On a few occasions belugas were observed chasing fish.

The harbor seals, sea otters, and one harbor porpoise were seen near Homer. The other three harbor porpoise were seen near Redoubt Bay.

Photographs were not taken during any of the surveys in July. Analysis of the video tape is still pending.

September Surveys

Coastline surveys were conducted over Cook Inlet on 3, 18, and 19 September for a total of 11 flight hours (Fig. 7). Survey lengths ranged from 3 to 4 hours. Two surveys (3, 19 September) included the coastline north of Kalgin Island. The third survey (18 September) was of the northwest coastline from Tuxedni Bay to the Little Susitna River. All three surveys coincided with low tides. Visibility was generally good with minor glare and Beaufort 1-2 except on 19 September when 25 knot winds seriously restricted visibility.

Total beluga sightings were 197, 12, and 57 for 3, 18 and 19 September, respectively (Table 4, Fig. 8). Racetrack patterns were flown only on 3 September; small group size and hazardous surveying conditions precluded using this method on 18 and 19 September, resulting in raw counts without ranges. Belugas observed on 3 September were traveling (usually rapidly) in small, tight, polarized groups. The largest group consisted of 46 individuals observed rounding the tip of West Foreland headed northeast. Later surveys yielded only small groups (< 10 individuals) dispersed along the coastline throughout the upper and central inlet. Southernmost sightings occurred in the Kenai River (17 belugas) and Big River in Redoubt Bay (7 belugas), approximately 20 km south of upper Cook Inlet. As in June and July, all belugas were within 1-2 km of the coastline.

Other marine mammal sightings included 4 harbor seals hauled out on a rock near the Kenai River. Photographs and video were not taken during the September surveys because group sizes were often small and hazardous weather conditions did not allow us to circle groups.

DISCUSSION

Traditional line-transect sampling techniques are not the most appropriate survey design for beluga whales in Cook Inlet due to their clumped distribution. Surveys of the population in the past have focused instead on known beluga concentration sites in the river mouths of upper Cook Inlet. Unfortunately, in many cases, survey methods were not well documented and therefore are not available for comparison to our surveys.

As in past studies (Calkins 1984), we found the highest concentrations of belugas in river mouths during June and July, while in September belugas were only found in small groups dispersed along the coastline. In June, belugas were often observed in tight columns along the edge of the mud flats during low tide. Whales were aligned on the same directional heading with lead animals breaking off from the front of the main group and chasing fish. Calkins (1979) believed that this type of group formation represented a feeding aggregation, though no food source was observed during his surveys. The large concentrations of belugas that occur in river mouths in Cook Inlet often coincide with spawning runs of anadramous fish.

In July, we only witnessed one group of belugas in tight, polarized formation. All other groups were widely dispersed within the mouth of the rivers with individuals surfacing in many directions. On at least two occasions these belugas were observed chasing fish.

In contrast to June and July, few groups were found in river mouths during the September surveys. Instead, small, tight, fast-moving groups were observed along the coastline of the central inlet as well as the upper inlet. As spawning runs diminish, the larger aggregations of belugas may be breaking down into smaller groups and dispersing throughout the inlet (Table 5), possibly leaving the inlet in search of other prey. Two belugas were sighted in Disenchantment Bay near Hubbard Glacier in the northern portion of Yakutat Bay on 15 September 1993 (R. Ream, NMFS, NMML, pers. comm.) which suggests that dispersal from Cook Inlet had occurred. However, there may be a resident group in Yakutat Bay (Consiglieri and Braham 1982), which would account for this sighting and should be investigated in the future.

Another challenge to counting belugas in September, unrelated to environmental conditions, was their apparent reaction to the aircraft. They sounded as we approached and surfaced after we passed. It is unclear whether this was due to the type of aircraft or change of behavior of belugas in this season (e.g., group size or change in food resources). Similar seasonal changes in avoidance behaviors to vessel traffic were also noted by NMFS personnel surveying the inlet (S. Thumm, NMFS, AK Region, pers. comm.). Reactions to aircraft did not occur in June or July when belugas did not appear disturbed in any way by our survey, even when the shadow of the plane passed over a group. Descending to 150 m (500 ft) during one pass in June did not elicit a response from a group of belugas off Pt. Possession. Caron and Smith (1990) found air traffic below 100 m caused belugas to swim rapidly away from the source, while aircraft above 300 m did not appear to disturb the whales. We found an altitude of 245 m (800 ft) to be a good compromise between visual range and sighting cue size without resulting in any evident disturbance to beluga whales, at least in June and July.

Highest whale counts occurred on those days where surveys coincided with low tides, sea states at Beaufort 1-2, and overcast skies (reducing glare). These conditions were such that visibility was not restricted and our ability to circle groups was not limited. Water turbidity limited our sightings to animals where at least part of their body had broken the surface of the water. These surfacings often resembled an expanding and contracting white oval within the muddy water. Whales were generally at the surface for a period of only three seconds. Glare also made sighting belugas difficult. Debris floating at the surface closely resembled surfacing belugas when seen at distances greater than 2 km. During overcast days, however, belugas were clearly visible at distances out to 3 km.

Strong winds and high tides were also found to affect group size estimates. Strong winds during surveys conducted at high tide on 25 and 26 July produced sea states ranging up to Beaufort 5. These conditions, in addition to the turbidity of upper Cook Inlet, may have contributed to the lower number of sightings for these days. Whitecaps caused by high winds often resembled the backs of surfacing belugas, particularly evident on 5 June in Turnagain Arm. Such hazardous surveying conditions precluded using the racetrack method on 19 September. It is possible that group sizes may have been greatly underestimated by not circling. During high tides we found animals were often more dispersed and therefore more difficult to count. Those surveys that coincided with low tides resulted in the highest counts, even when sea states and wind conditions were not optimal.

At this time, a correction factor has not been applied to the counts made during the 1993 surveys. Variability in whale behavior, water turbidity, tide level, and other environmental conditions described above need to be taken into consideration. For example, Calkins (1979) reported that belugas in Cook Inlet did not surface in unison when in groups larger than 10 animals; instead, as one part of the group submerged, a second surfaced, (then as this group submerged a third surfaced, etc.). Correction factors for animals out of sight should take into account the difference in sightability of belugas in shallow water, where they are near the surface most of the time and leave tracks (i.e. turbulence in the water) and mud trails, versus belugas in deep water, where they dive deeply without leaving evident tracks. Belugas in shallow water were often in dense groups swimming in a column, making it far easier to assess their numbers relative to those seen diving in random directions in deep water. Continued analysis of video and film images, in addition to tagging operations scheduled for June 1994, should help in providing the necessary data for a correction factor.

ACKNOWLEDGMENTS

Ron Morris (NMFS, AK Region) helped with funding and logistical support. The Alaska and Inuvialuit Beluga Whale Committee provided additional support for the genetics study with SWFSC. Our pilot for surveys in June and July was Tom Blaesing of Commander N.W., Ltd., and pilots in September were Mike White and Matt Pickett of NOAA's Aircraft Operations Center. Observers other than the authors were Wayne Perryman (SWFSC), Jeff Laake (NMML), John Lewis (ADF&G), and volunteers from AK Region (Barb Mahoney, Brad Smith, Steve Thumm, and Jeanne Hanson). Rod Hobbs developed the racetrack counting method used during the July and September surveys. Document reviews were provided by Robyn Angliss and Doug DeMaster.

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Table 1. Dates, survey effort, and observers for the 1993 beluga surveys in Cook Inlet, Alaska.

Date	Flights	Flight hrs	Observers
2-5 June	4	13.4	DW, KS, DR[1]
25-29 July	5	14.8	DW, KS, RH[2]
3, 18-19 Sept	3	11.0	DW, KS, JL, DR[3]

Observers: DW = David Withrow, KS = Kim Shelden, DR = David Rugh, RH = Rod Hobbs, JL = Jeff Laake.
[1] Visitors: Barb Mahoney; Pilot: Tom Blaesing.
[2] Visitors: Barb Mahoney, Brad Smith, John Lewis, Steve Thumm, Jeanne Hanson; Pilot: Tom Blaesing.
[3] Visitors: Wayne Perryman; Pilots: Mike White and Matt Pickett.

Table 2. High counts of beluga whales made during NMML aerial surveys in Cook Inlet June 1993 (listed clockwise by location). Counts are the sum of all groups of belugas within the listed area. Dashes indicate area was not surveyed.

LOCATION	2 JUNE	3 JUNE	4 JUNE	5 JUNE
Redoubt Bay	---	---	0	---
West Foreland	0	---	1	0
Trading Bay	1	---	3	---
North Foreland (Tyonek)	0	0	0	0
Beluga River	8	1	1	0
Big Susitna	90	82	120	0
Little Susitna	17	70	70	120
E of Little Susitna	50	---	0	0
NW side Fire I.	---	0	3	0
Knik Arm (Elmendorf)	80	---	---	0
Turnagain Arm	0	---	---	8
Chickaloon Bay	0	---	---	0
Pt. Possession	52	43	---	0
SW of Possession	0	6	0	0
Kenai River	---	---	0	---
TOTAL	**298**	**202**	**198**	**128**

Table 3. High counts of beluga whales made during NMML aerial surveys in Cook Inlet July 1993 (listed clockwise by location). Counts are the sum of all groups of belugas within the listed area. Dashes indicate area was not surveyed.

LOCATION	25JULY	26JULY	27 JULY	28 JULY	29 JULY
Redoubt Bay	---	---	0	---	---
West Foreland	---	0	0	---	26
Trading Bay	---	30	---	0	31
North Foreland	0	0	---	0	1
Beluga River	0	0	---	0	0
Big Susitna	125	168	230	260	240
Little Susitna	0	0	0	0	0
E of Little Susitna	0	0	0	0	0
NW side Fire I.	---	0	---	---	0
Knik Arm	0	0	0	---	0
Turnagain Arm	---	0	---	---	0
Chickaloon Bay	---	0	---	---	34
Pt. Possession	0	0	0	0	0
SW of Possession	0	0	---	---	0
Kenai River	---	---	0	---	---
TOTAL	**125**	**198**	**230**	**260**	**332**

Table 4. High counts of beluga whales made during NMML aerial surveys in Cook Inlet September 1993 (listed clockwise by location). Counts are the sum of all groups of belugas within the listed area. Dashes indicate area was not surveyed.

LOCATION	3 SEPT	18 SEPT	19 SEPT
Redoubt Bay	0	7	0
West Foreland	46	0	0
Trading Bay	5	1	0
North Foreland	0	0	0
Beluga River	0	4	0
Big Susitna	17	0	0
Little Susitna	16	0	0
E of Little Susitna	0	0	0
NW side Fire I.	0	---	0
Knik Arm	59	0	11
Turnagain Arm	15	---	32
Chickaloon Bay	22	---	14
Pt. Possession	0	---	0
SW of Possession	0	---	0
Kenai River	17	---	0
TOTAL	**197**	**12**	**57**

Table 5. Highest counts of beluga whales made during NMML aerial surveys in Cook Inlet for each survey period in 1993 (listed clockwise by location). Counts are the sum of all groups of belugas within the listed area.

LOCATIONS	2 JUNE	29 JULY	3 SEPT.	19 SEPT.
Trading Bay	1	31	51	0
Big Susitna	90	240	17	0
Little Susitna	17	0	16	0
Knik Arm	80	0	59	11
Turnagain Arm	0	0	15	32
Chickaloon Bay	52	34	22	14
Other	58	27	17	0
TOTAL	**298**	**332**	**197**	**57**

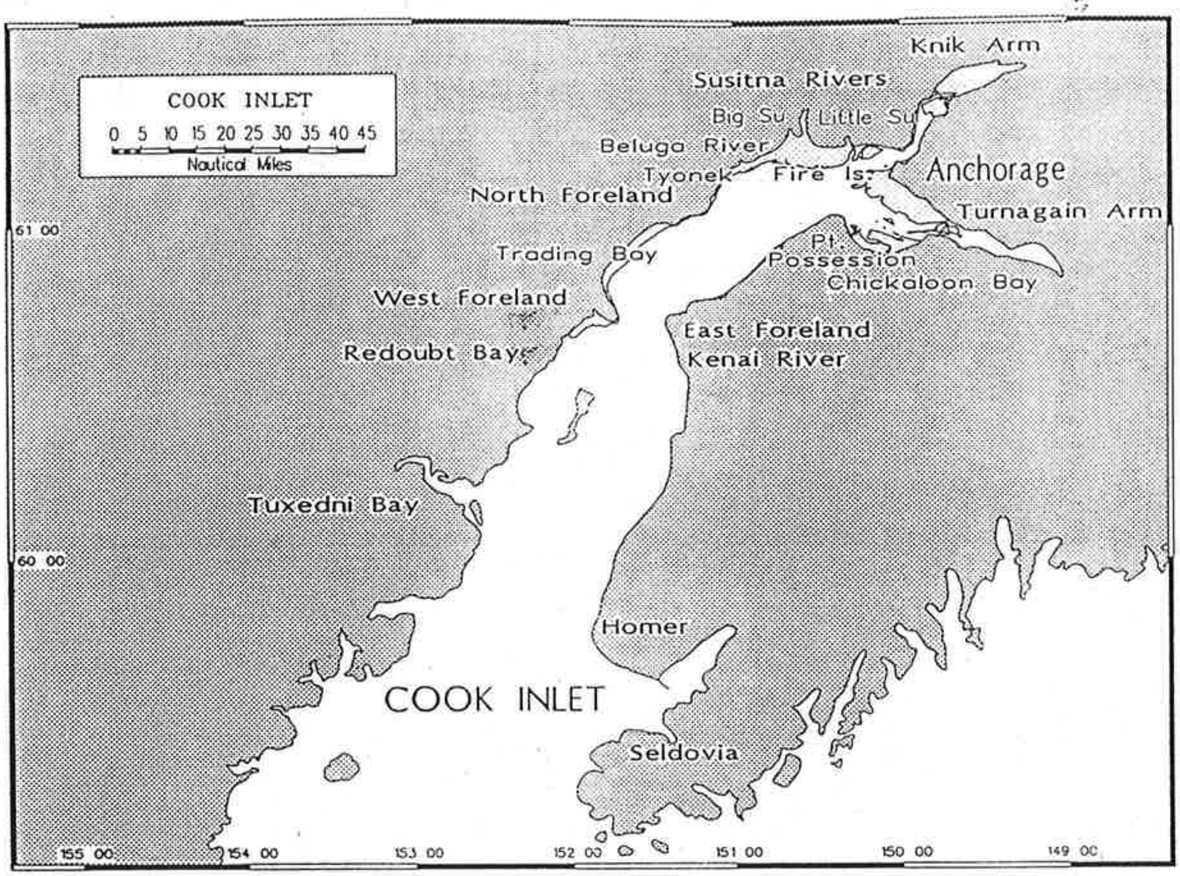
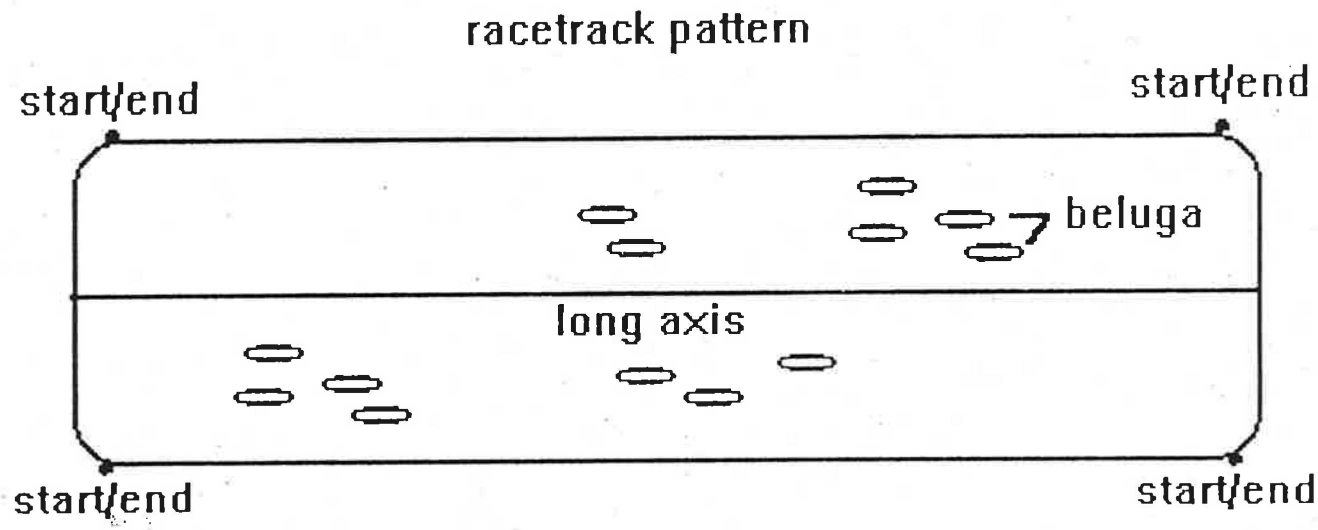


Figure 1. Map of Cook Inlet showing place names referred to in text.



*direction of flight around the racetrack is counterclockwise for two passes and clockwise for two passes.

Figure 2. Schematic of race track survey design.

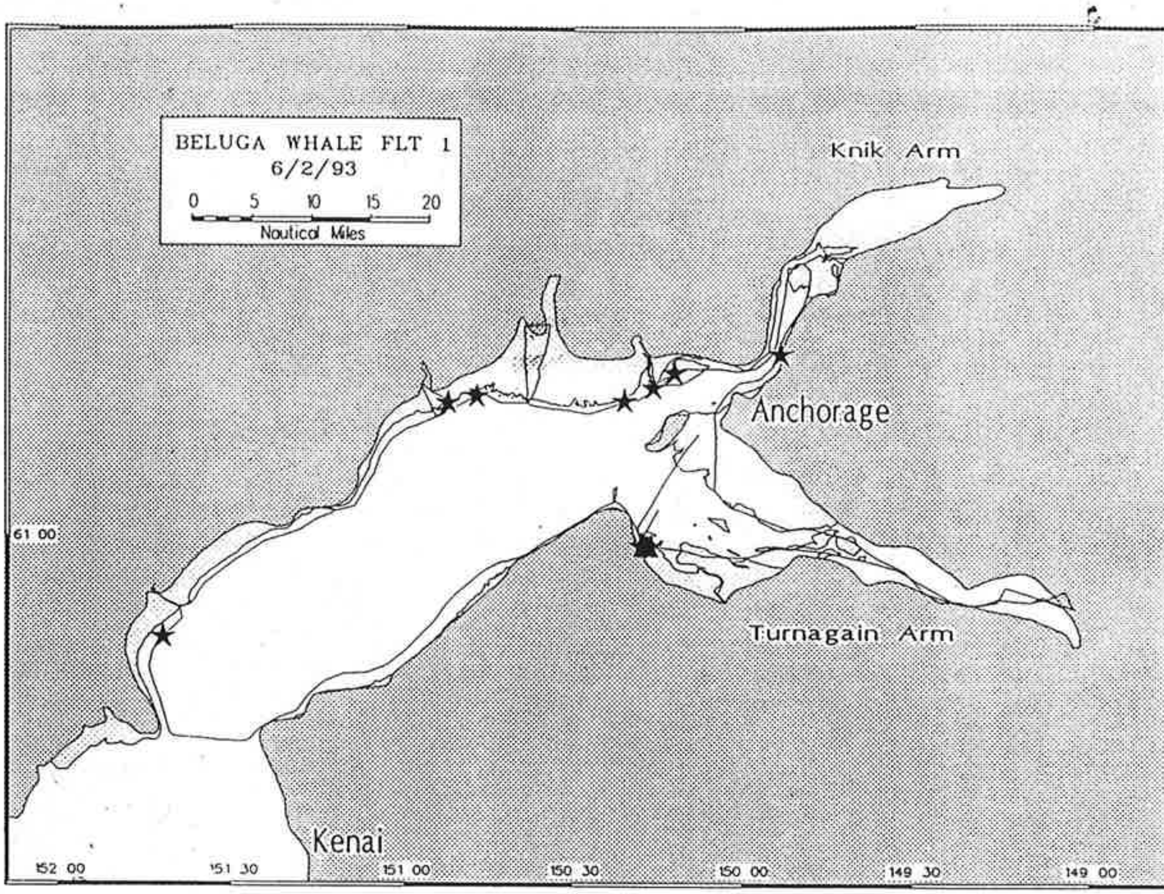


Figure 3a. June 1993 survey tracklines and beluga whale sightings (★ indicates location of group, not group size).

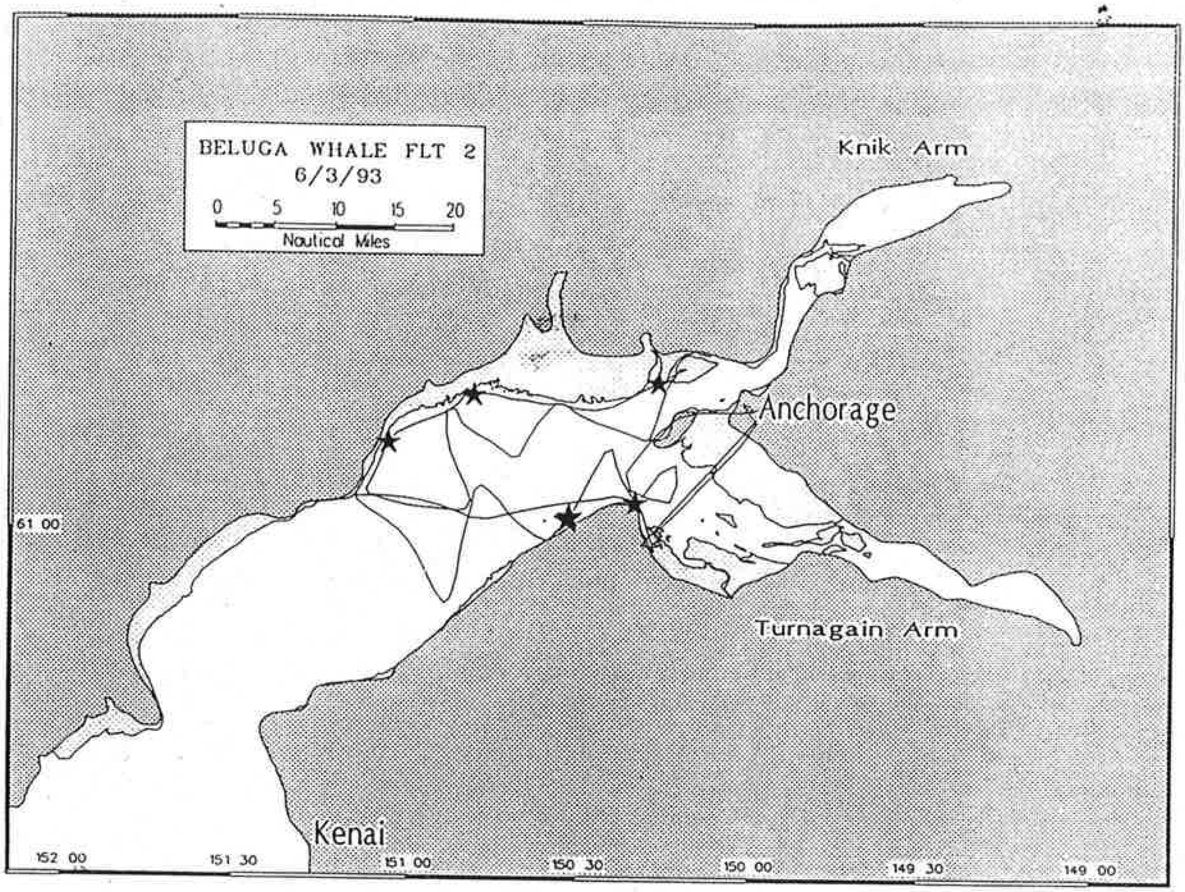


Figure 3b. June 1993 survey tracklines and beluga whale sightings (★ indicates location of group, not group size).

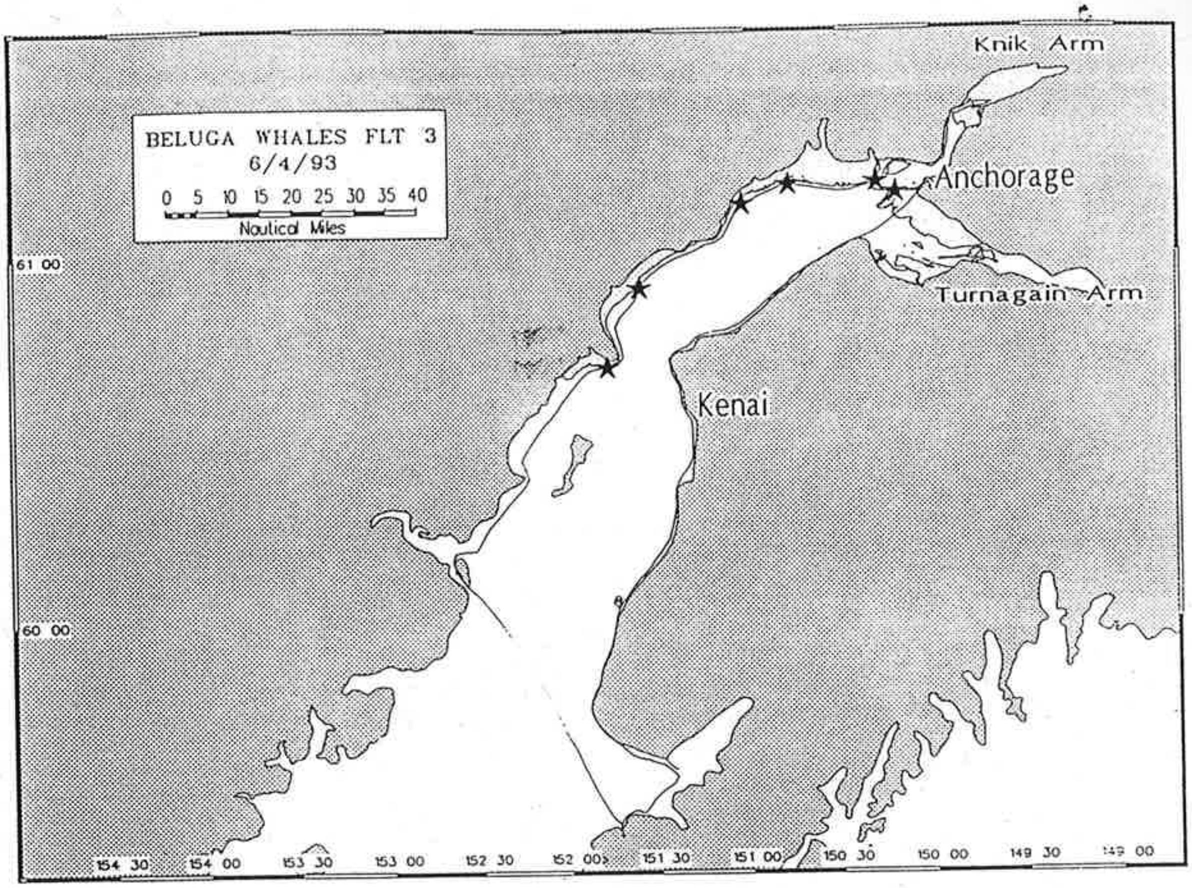


Figure 3c. June 1993 survey tracklines and beluga whale sightings (★ indicates location of group, not group size).

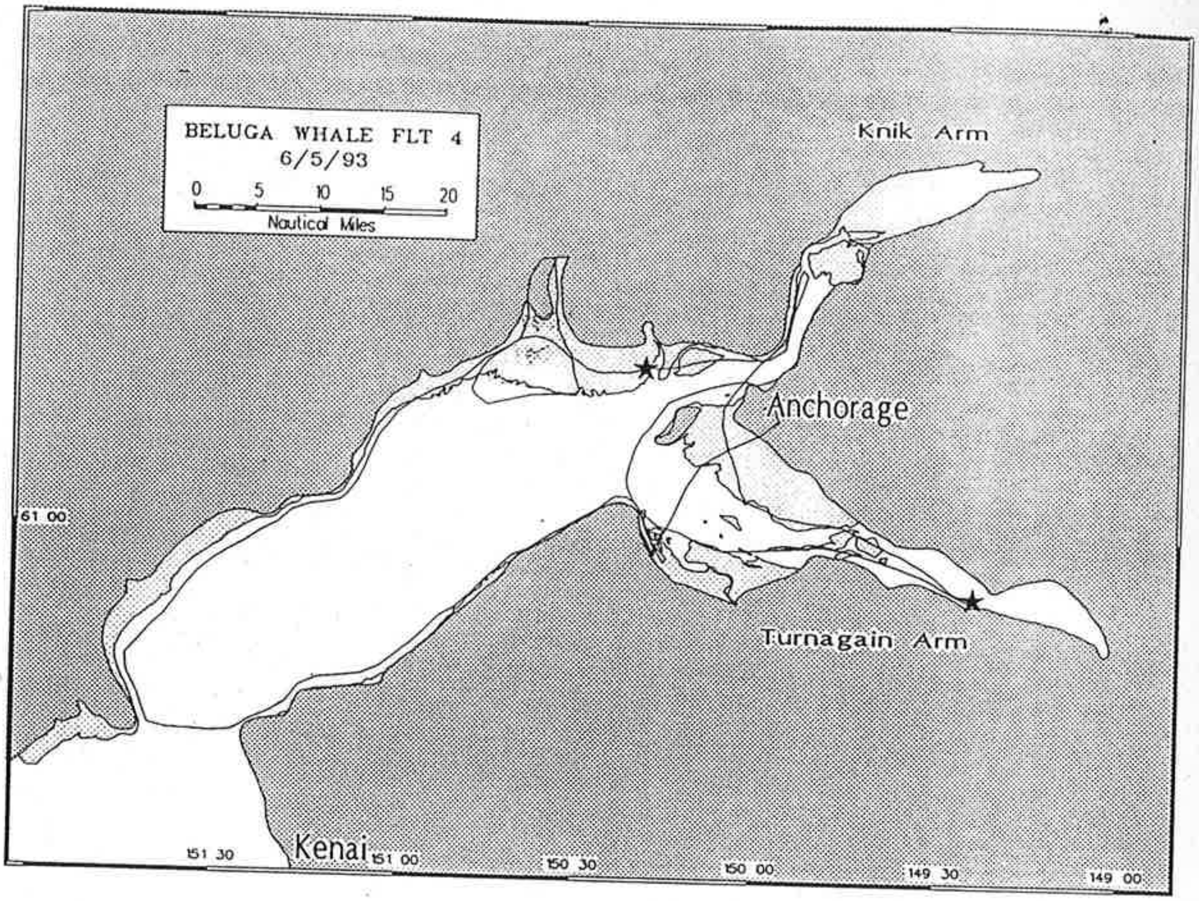


Figure 3d. June 1993 survey tracklines and beluga whale sightings (★ indicates location of group, not group size).

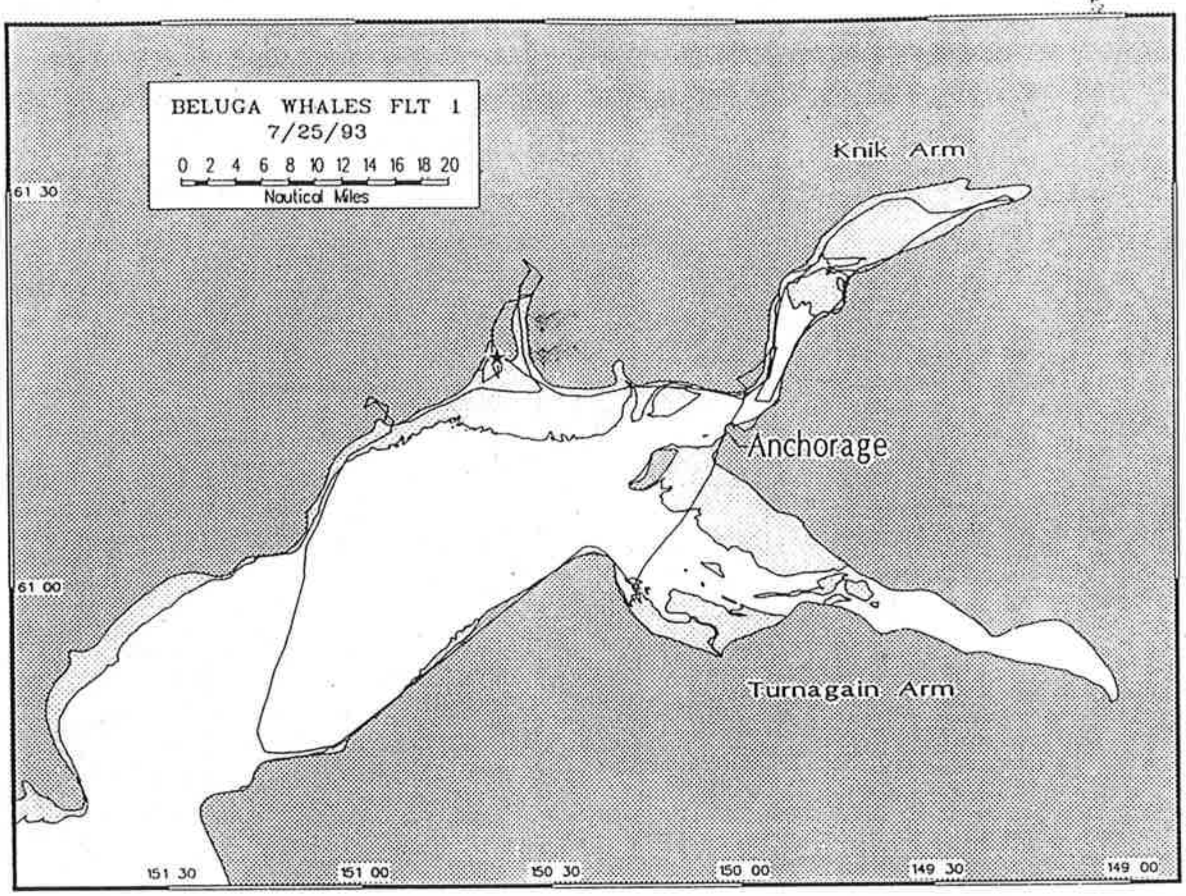


Figure 4a. July 1993 survey tracklines and beluga whale sightings (★ indicates location of group, not group size).

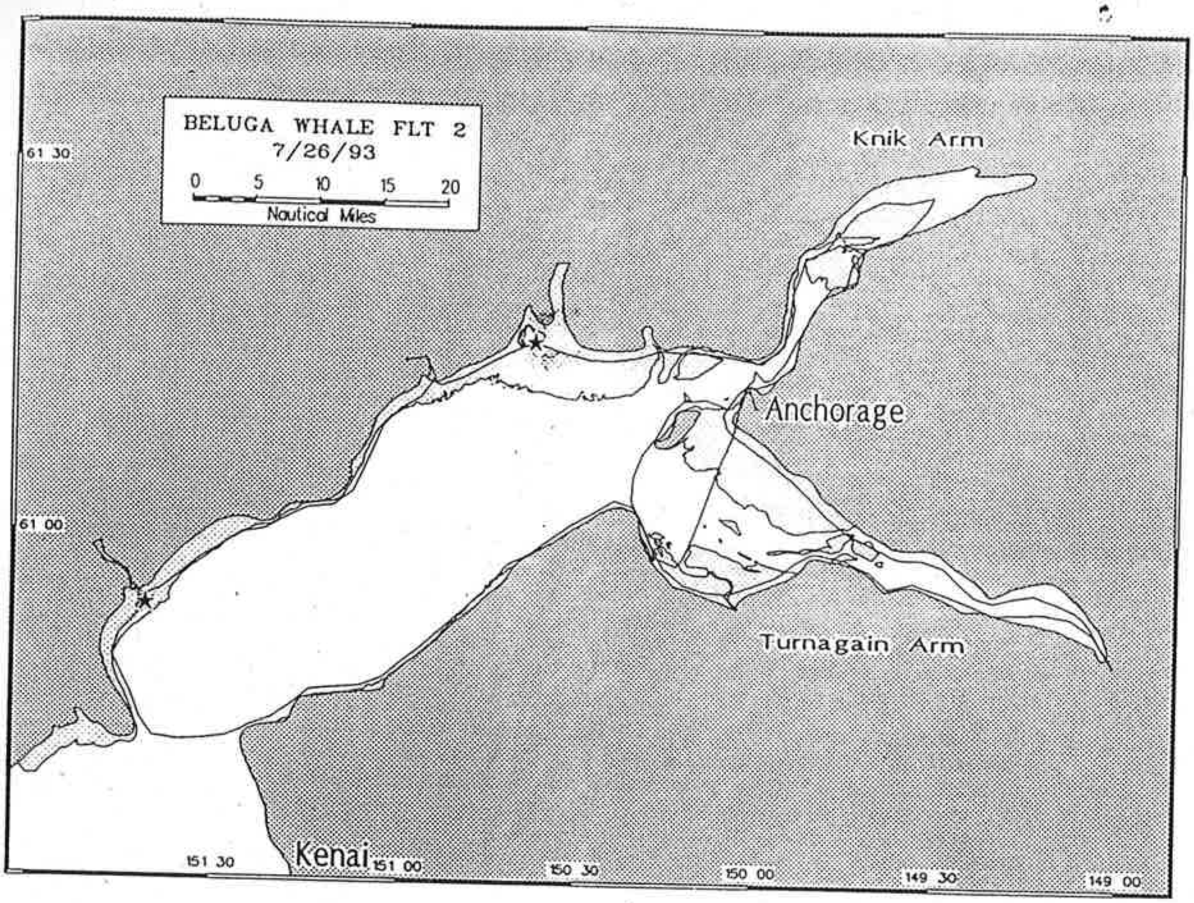


Figure 4b. July 1993 survey tracklines and beluga whale sightings (★ indicates location of group, not group size).

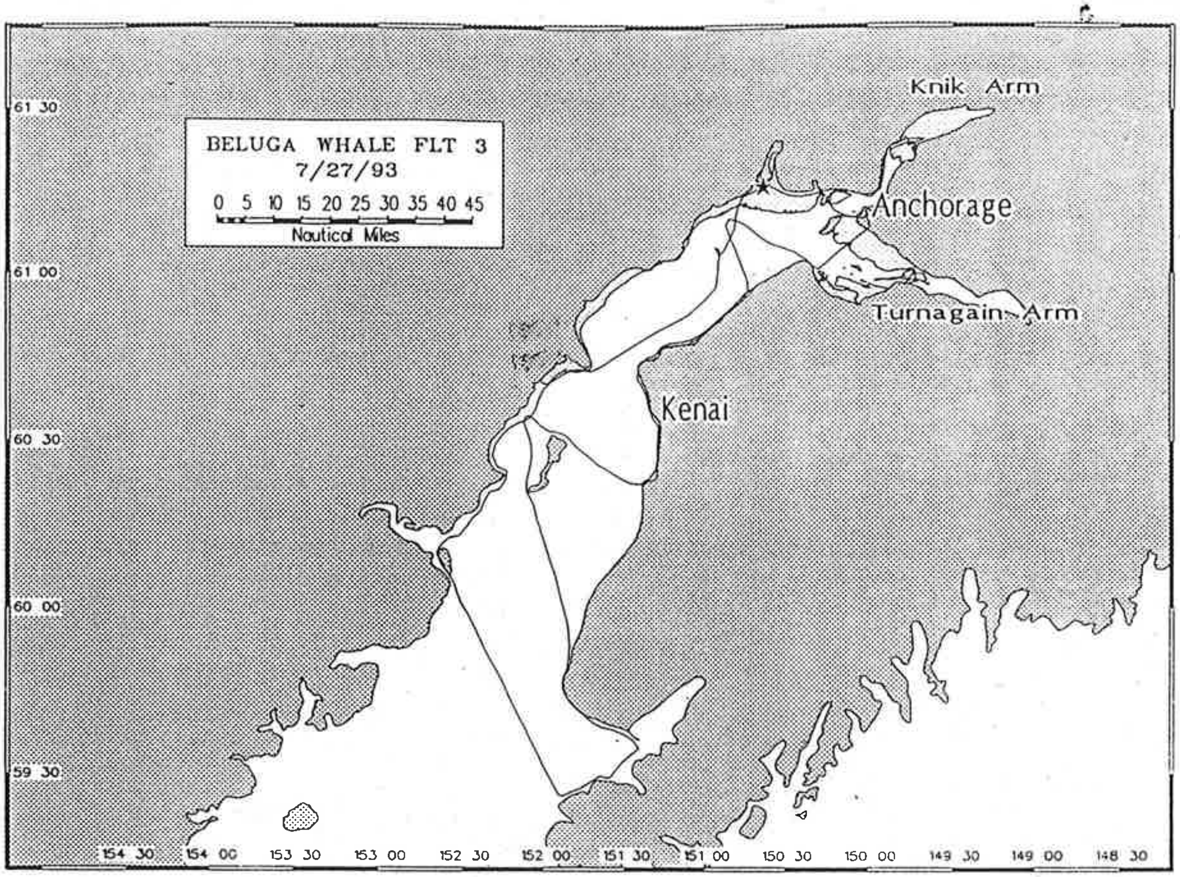


Figure 4c. July 1993 survey tracklines and beluga whale sightings (★ indicates location of group, not group size).

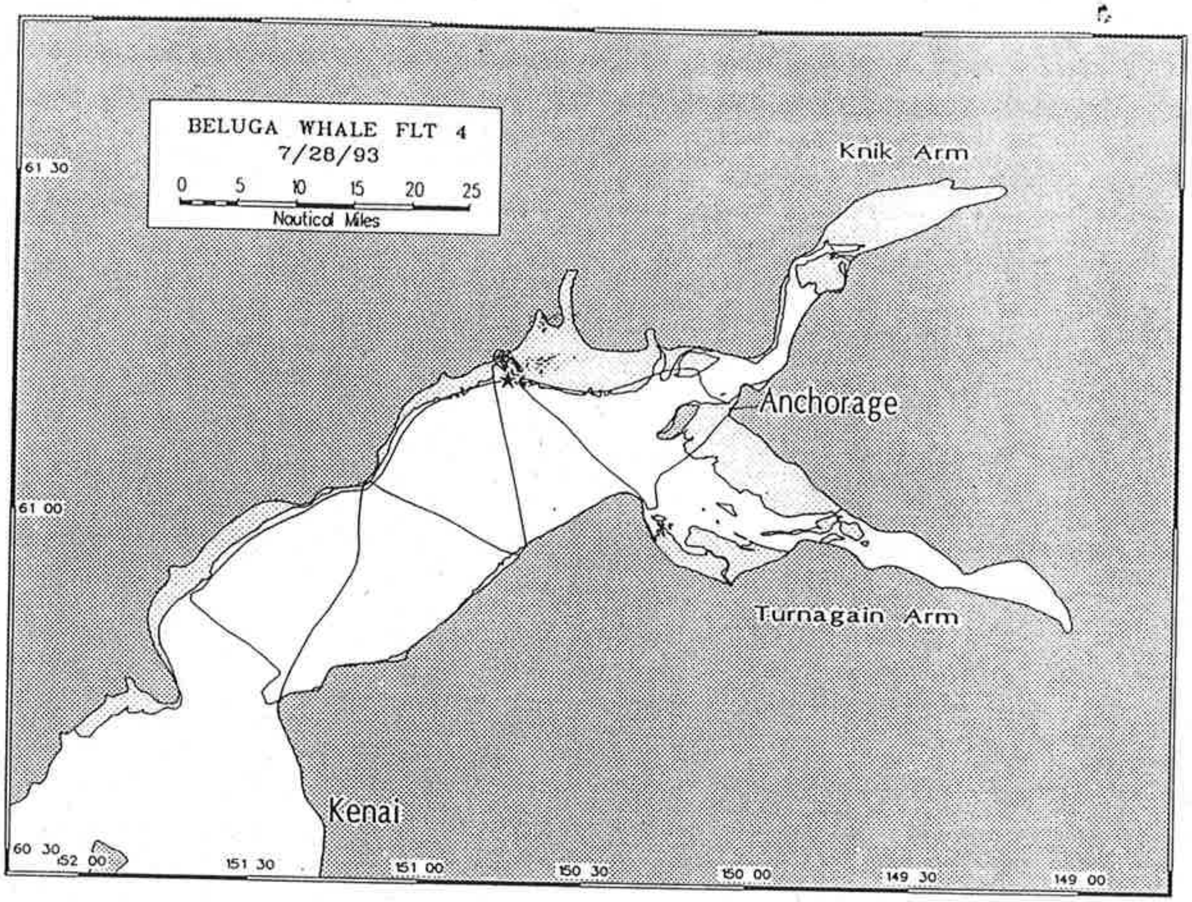


Figure 4d. July 1993 survey tracklines and beluga whale sightings (★ indicates location of group, not group size).

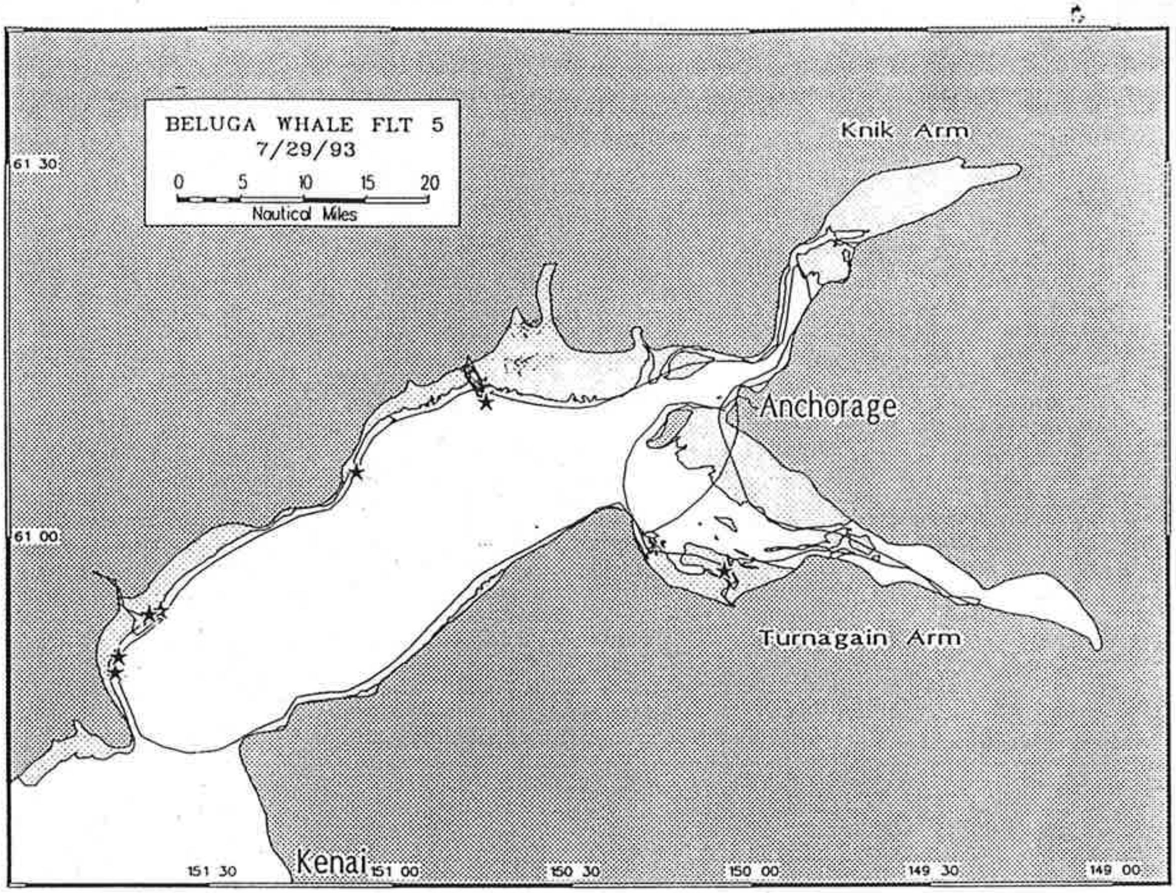


Figure 4e. July 1993 survey tracklines and beluga whale sightings (★ indicates location of group, not group size).

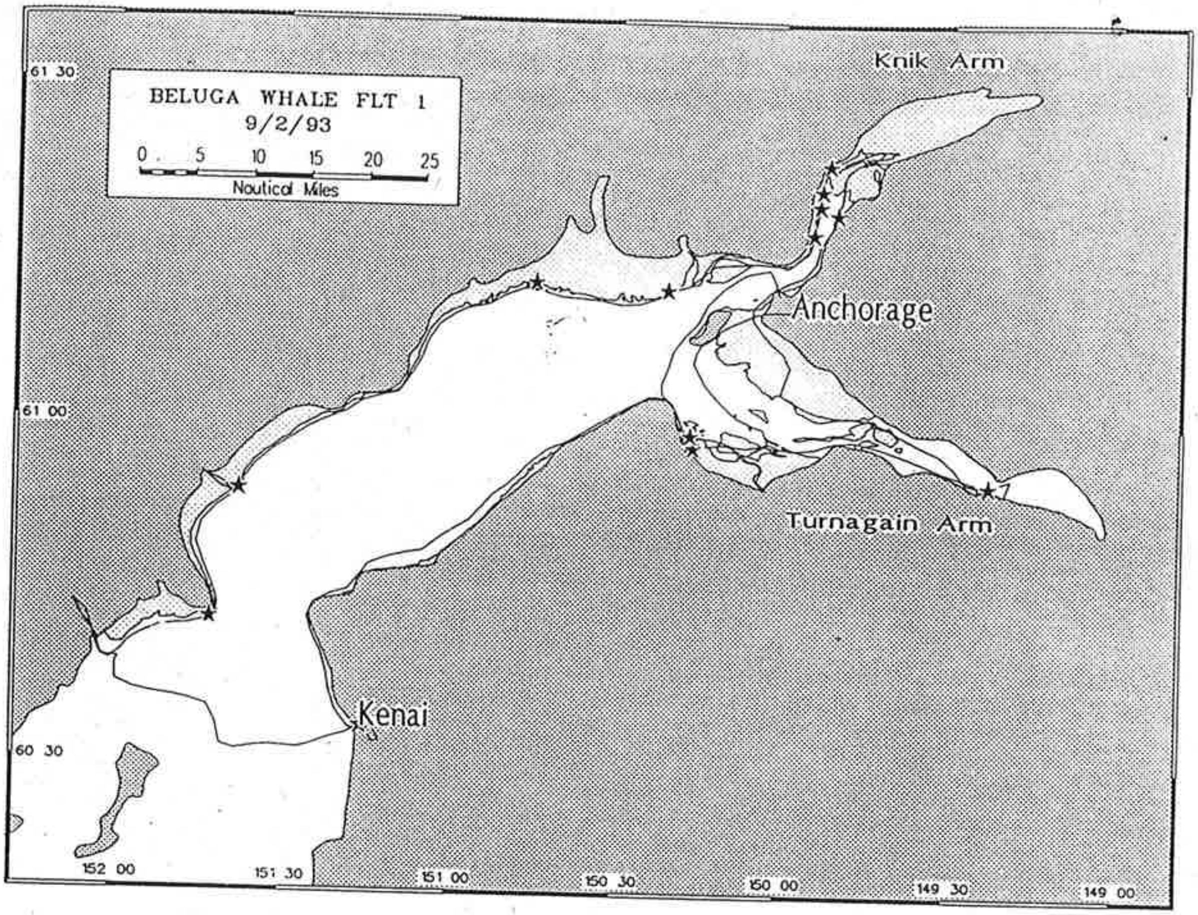


Figure 5a. September 1993 survey tracklines and beluga whale sightings (★ indicates location of group, not group size).

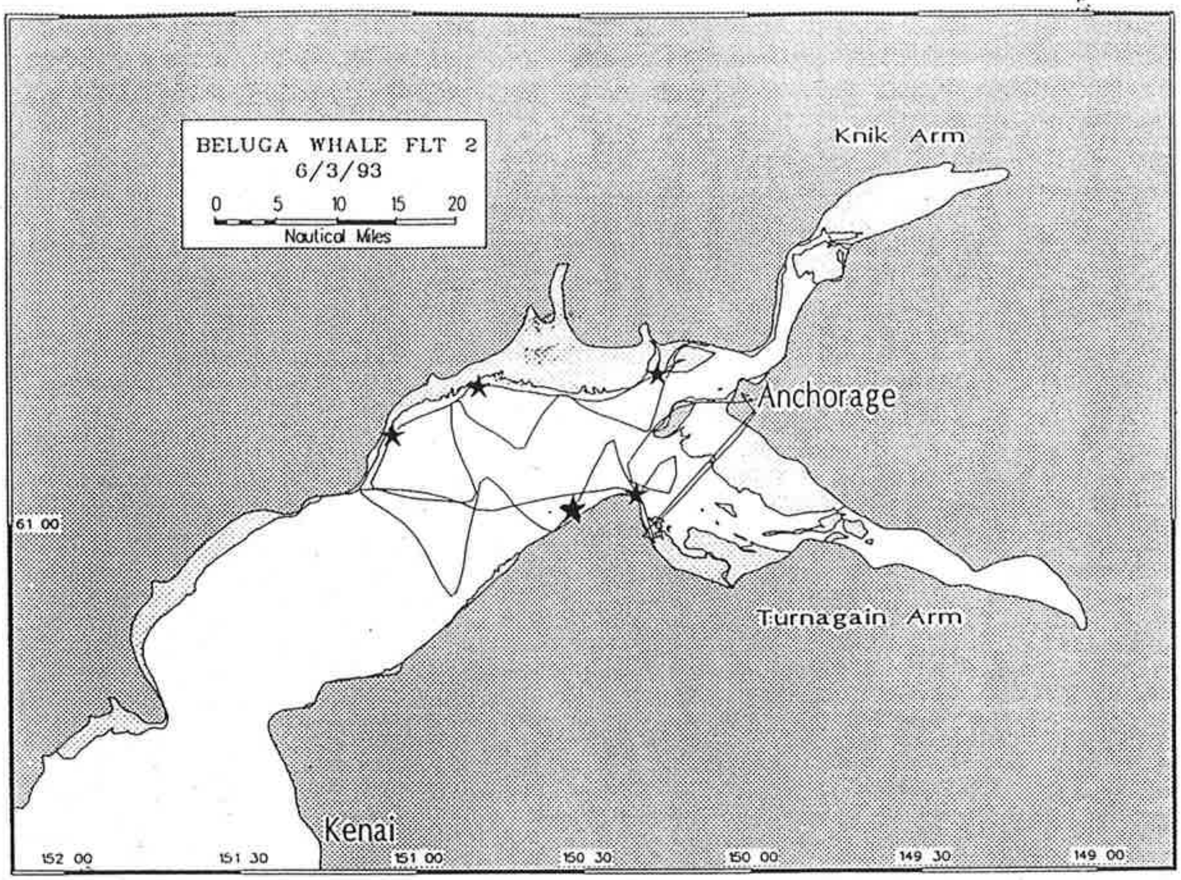


Figure 5b. September 1993 survey tracklines and beluga whale sightings (★ indicates location of group, not group size).

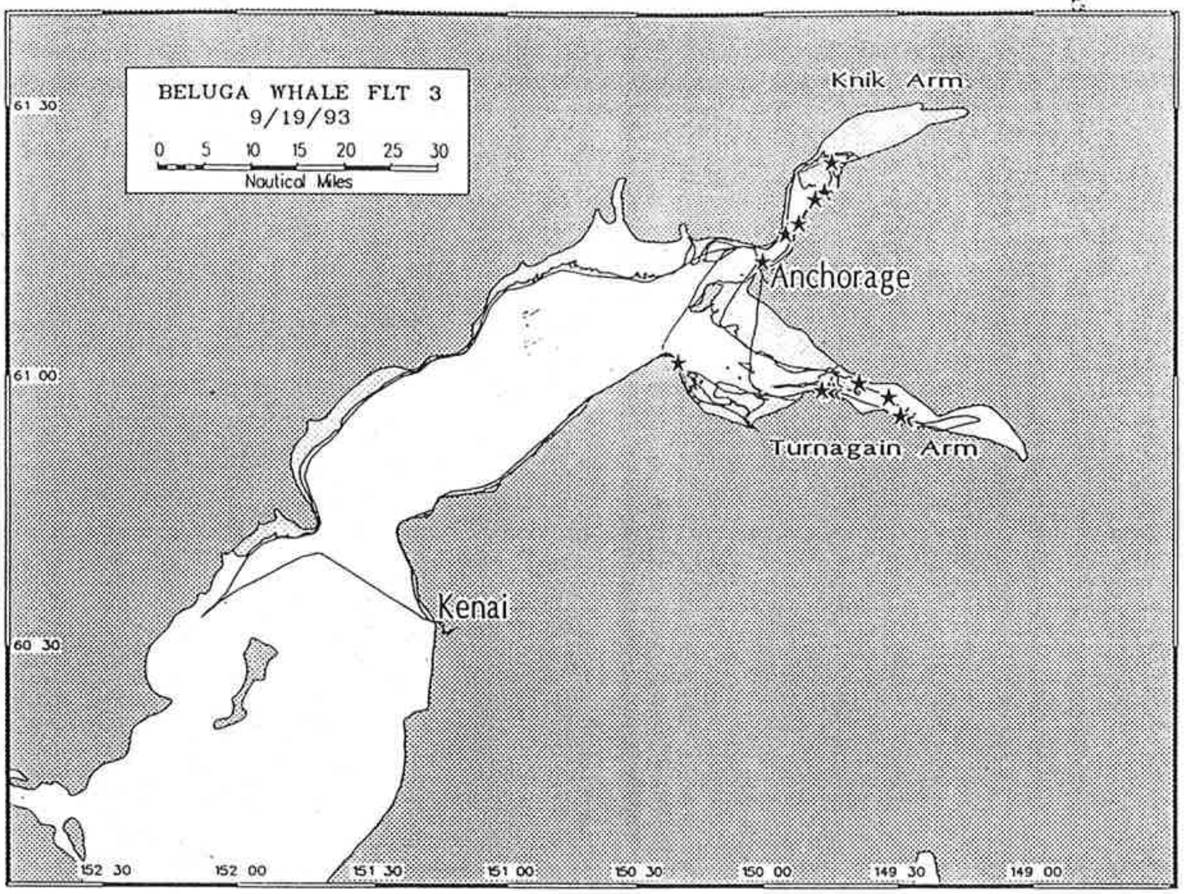


Figure 5c. September 1993 survey tracklines and beluga whale sightings (★ indicates location of group, not group size).

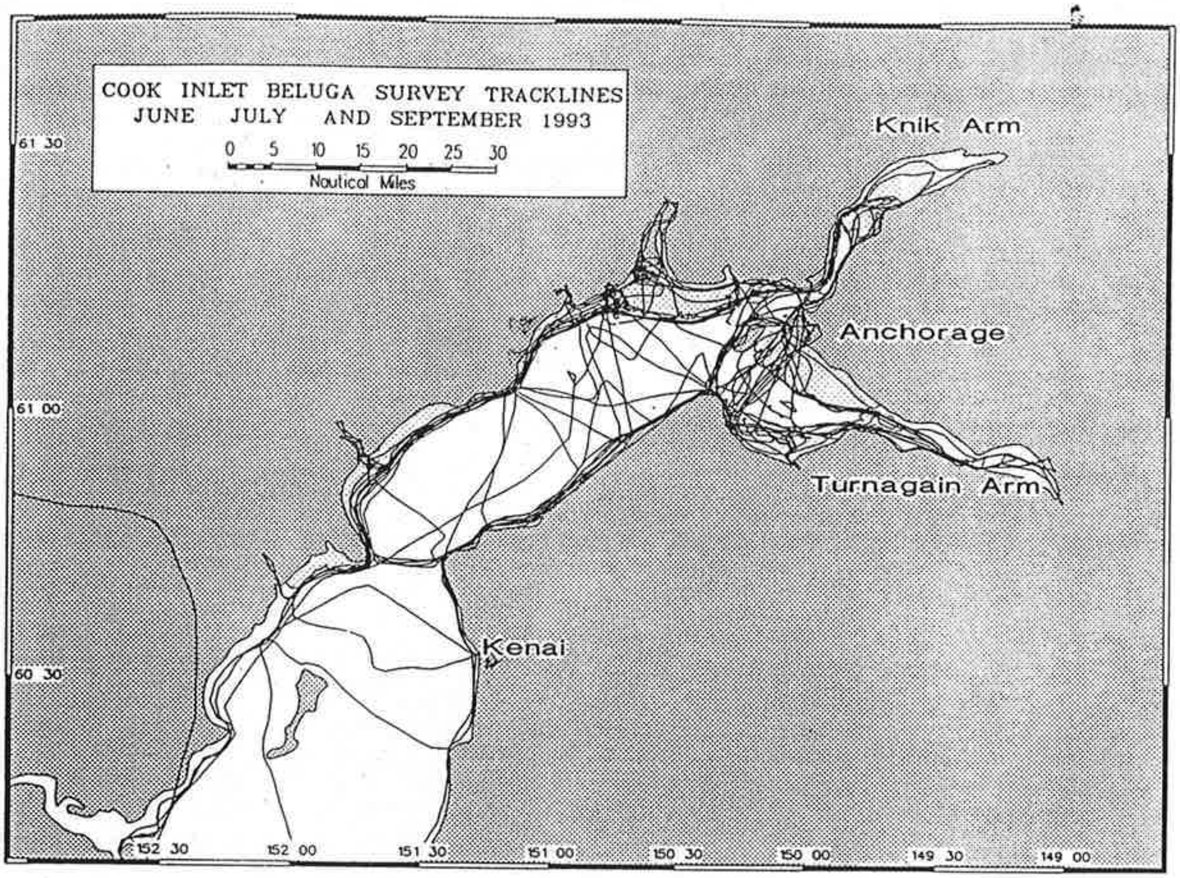


Figure 6. Tracklines for June, July and September 1993, combined.

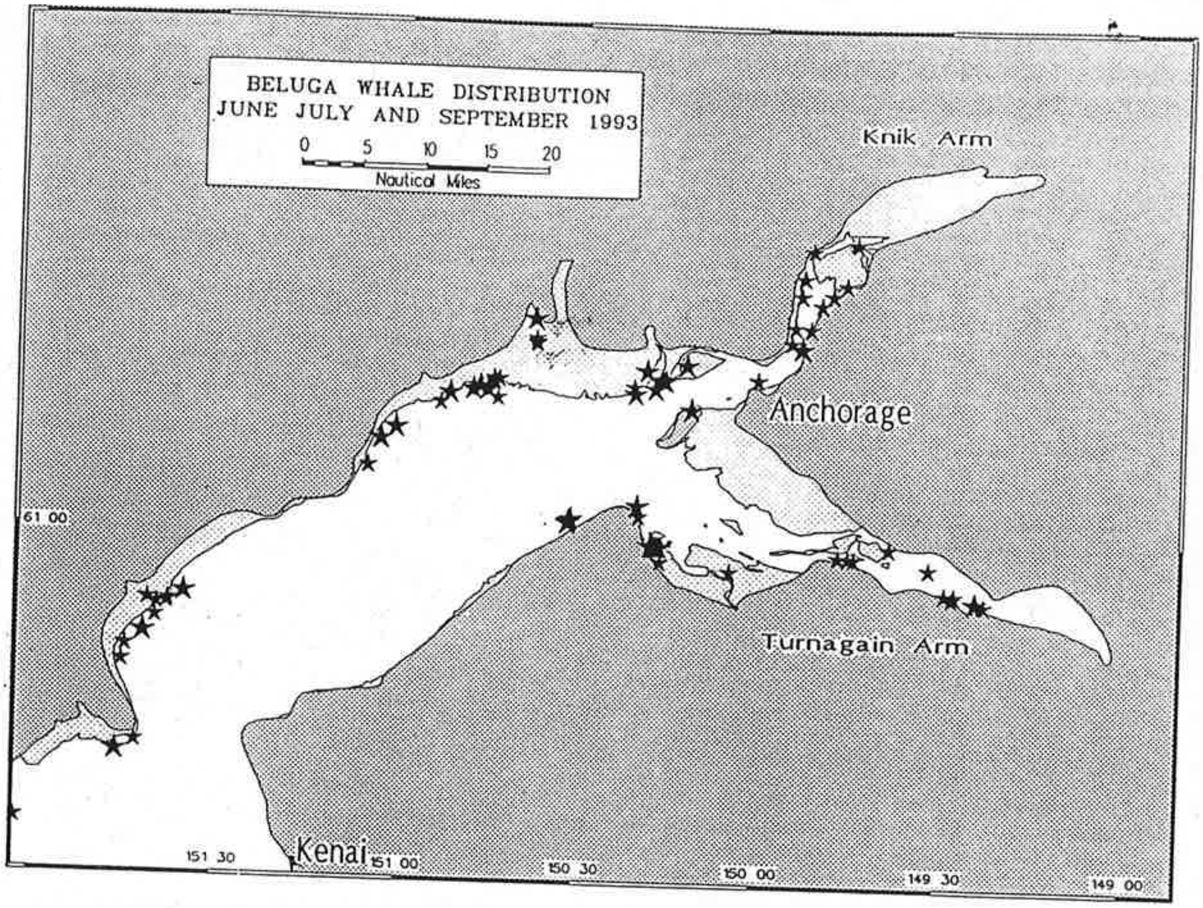


Figure 7. Beluga whale sighting locations during the June, July and September 1993 surveys, combined.