Study of Late Summer and Fall Movements and Dive Behaviour of Beaufort Sea Belugas, using Satellite Telemetry: 1997.

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EXECUTIVE SUMMARY

We conducted a study of Beaufort Sea belugas, involving tracking and recording dive behaviour between late July and December 1997 using satellite-linked time-depth recorders. This report describes the project's objectives, methods and its salient results.

With the help of hunters from Inuvik, Tuktoyaktuk and Aklavik, seven males and three female belugas were live-captured using seine nets and hoop nets and "tagged" in the delta of the Mackenzie River, Northwest Territories, Canada. Satellite-linked time-depth recorders and transmitters ("tags") were used to obtain detailed behavioural data, to study migration routes from summer to winter areas, and to study habitat preferences and habitat use.

The results of this study document new late summer and fall behaviour of Beaufort Sea belugas. In August 1997, male belugas, unlike males tagged in 1993 and 1995 (Richard et al.1997), did not move to M'Clure Strait and Viscount Melville Sound. Males and females remained in the eastern Beaufort Sea or Amundsen Gulf in August. One female went much farther north (up to 78°N) than any female previously tagged (Richard et al.1997). Fall migration routes into Alaskan and Russian waters were obtained from 9 animals. All generally moved westward across the Alaskan Beaufort Sea, three of them well beyond the coastal shelf, ultimately reaching Wrangel Island in the western Chukchi Sea. This is consistent with results of belugas tracked in 1993 and 1995. Those animals that were tracked into November and December continued their migration south towards the Bering Strait along the coastal shelf of Chukotka, Russia. These results suggest that the fall migration route for Beaufort Sea belugas is along the Russian rather than Alaskan coast of the Chukchi Sea. All animals made frequent dives to depths of 400-600 m, some as deep as 1275 m. The tagged belugas moved rapidly through heavy pack ice, as they had in 1993 and 1995.

1.0 INTRODUCTION

1.1 Background

The U.S. Minerals Management Service, the Fisheries Joint Management Committee, and the Department of Fisheries and Oceans requested this study to address questions related to habitat conservation and hunt management of Beaufort Sea belugas, i.e.: questions requiring knowledge of habitat use and movements by Beaufort Sea belugas through Canadian, Alaskan and Siberian waters in late summer and fall (Duval 1993, Richard et al. 1997). The U.S. Minerals Management Service will use information from this project in support of pre- and post lease decisions related to offshore oil and gas development in the Beaufort Sea, Alaska.

In the past, the behaviour, range and migration routes of Beaufort Sea beluga were deduced from local knowledge, land-based observations and opportunistic or planned aerial surveys. Local knowledge is often based on many years experience but is limited by the geographic range within which local people travel. Land-based observations can also cover a long time frame but they are again limited by the viewing range of observers, a few kilometers. Aerial surveys are not limited in range but rather in time. They are very expensive and therefore not often repeated. Consequently, aerial survey give only occasional snapshots of beluga distribution (usually only when they are concentrated) and give few cues on their behaviour and ecology. In all cases, we only get information on the geographic position of animals. Belugas, however, move in a three dimensional environment. A novel approach is needed to understand in greater detail their short-range and long-range movements and their diving behaviour.

The immense value of satellite telemetry for studying beluga behaviour was clearly demonstrated in a previous study conducted in the Beaufort Sea. Twenty tagged belugas provided totally unexpected results not only in their movements but also in their diving behaviour (Richard et al. 1997). Previous to this study, Eastern Beaufort Sea belugas were thought to spend the summer only in the Mackenzie Delta and surrounding ice-free waters of the eastern Beaufort Sea and Amundsen Gulf before undergoing a migration through Alaskan waters to the Bering Sea where they are presumed to spend the winter (Fraker 1980). Richard et al. (1997) found that ice did not impede their movements into heavy ice pack. Males in particular moved far north of their suspected summering range and east into the Arctic archipelago. Richard et al. (1997) also tracked a few animals during the fall migration and found they traveled further west into the Chukchi Sea than the hypothesized migration route along the Alaskan coastal waters predicted. Male and female belugas frequently dove to depths of several hundred meters, contradicting preconceived notions that belugas prey on pelagic or shallow benthic species and therefore are restricted to coastal waters.

The 1997 tagging study was designed to extend our understanding of Beaufort Sea beluga movement and dive behaviour during late summer and fall by tagging later in the season.

1.2 Study questions

The study was designed to address several primary questions about movement and habitat use: main questions were as follows:

1) What are the fall migration routes of tagged belugas in the Beaufort Sea and the Alaskan and Chukchi Sea, Bering Sea or East Siberian Sea?
2) Which communities could potentially hunt belugas originating from the Canadian Beaufort Sea?
3) How migration routes relate to water depth, distance from shelf break and distribution of pack ice?
4) How much time did the beluga spend within portions of the Beaufort Sea, Chukchi Sea and Eastern Siberian Sea?
5) How does the tagged data relate to MMS BWASP aerial survey profiles?

2.0 METHODS

2.1 Study area

We captured belugas in the delta of the Mackenzie River, Northwest Territories, Canada (Fig. 1). The tagged belugas defined the study area by their movements through the Mackenzie Delta and out into the eastern and western Beaufort Sea, the Chukchi Sea, the Arctic Ocean, and the Bering Strait (Fig. 2.1). The study area therefore includes the continental shelf, slope and abyssal physiographic provinces. The Beaufort Sea is composed of a shallow continental shelf defined by the 100 m contour. The Beaufort Sea continental shelf ranges in width between 50 and 150 km. The Chukchi Sea consists of a relatively wide and shallow platform with water rarely exceeding 100 meters. The abyssal plain of the Arctic Ocean comprises most of the study area and consists of water depths greater than 3000 meters. The landward portions of the Beaufort Sea shelf consist of the Mackenzie Delta and the Amundsen Gulf. The Mackenzie Delta is a shallow estuary along the northwest coast of Canada that is defined a maximum depth of 20 m. The neighbouring Amundsen Gulf is a comparatively deep body of water (max. depths ≥ 400 m).

2.2 Local consultation

Before the field season, we consulted with representatives of Inuvik, Tuktoyaktuk and Aklavik Hunters and Trappers Committees (HTCs). We discussed the objectives of the study, proposed capture methods, local participation, potential capture sites and timing of the field work. The HTCs chose people to assist with the live-captures. There was continued discussion between field staff and the herding crews. We shared opinions about beluga behaviour, capture methods, capture sites and other topics and we made decisions by consensus. While at the hunting camps, field staff discussed the project with hunters present.

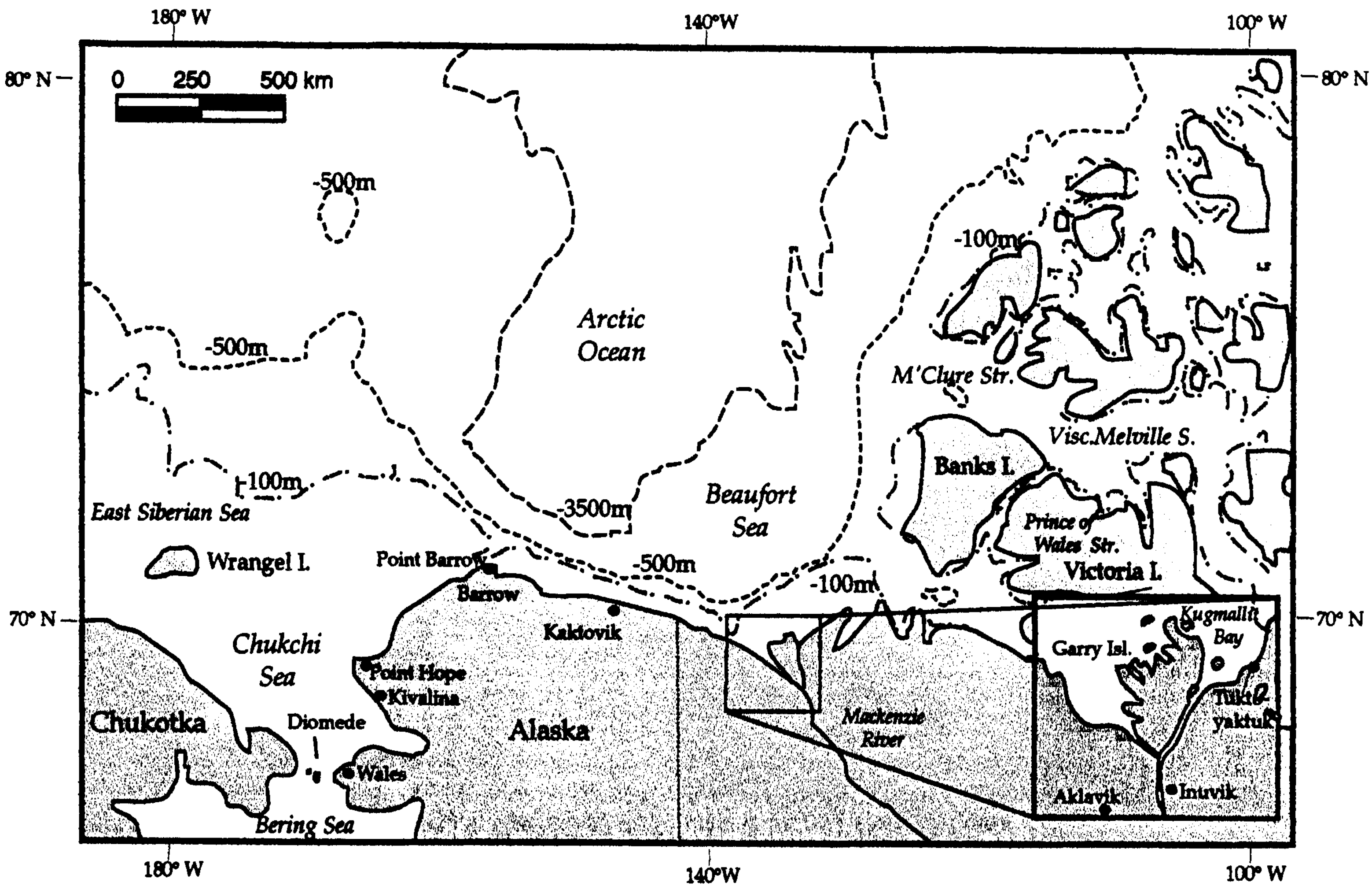


Figure 2.1: Study area and placenames.

2.3 Capture Methods

In general, we first located whales from land or from boats. Belugas deemed suitable for tagging were slowly herded into shallow waters (≤ 2.5 m) by the herding crews composed of 5-7 widely-separated boats which remained 50-100 m behind the whales. As the whales came closer to shore, boats moved towards them to reduce their chances of escape. Once near the shoreline, the net boat would position itself closer to the whales and speed up to deploy the net (150m x 9m seine net with 30 cm stretched dark-green mesh with 2 cm float and #54 lead lines) around them. The whales would get entangled in the net and the capture boats would then approach and restrain them, using hoop nets and tail ropes. Whales were disentangled as quickly as possible and taken onto shore, where they were partially beached to facilitate tagging.

2.4 Tagging procedure

Once secured, we measured the standard length and determined the sex of each animal. We kept animals longer than 3 m. To those, we attached a satellite transmitter on their dorsal ridge, secured by two straps of flexible belt material laid transversely on each side of the whale (Fig. 2.3). Each strap was held in place with two 6 mm diameter nylon pins, inserted into the dorsal ridge and out through the strap on the other side and fastened with nylon washers and nuts. We also fitted each whale with a flipper identification band (Orr and Hiatt-Saif 1992). The handling time for each animal, including attachment of transmitters, averaged 40 min.

The beluga's dorsal ridge consists of a ridge of skin, connective tissue and blubber with few nerve endings or blood vessels. Attachment of a transmitter to the dorsal ridge causes no visible discomfort to the whale during the attachment procedure and, according to post-release observations which span several weeks, does not appear to affect subsequent behavior. The pins slowly migrate caudo-dorsally through the tissue, eventually allowing release of the whole package within 2-4 months.

2.5 Tag description and data acquisition

During this study, we used three types of tag housings: two designed by the Sea Mammal Research Unit (SMRU) and one designed by Wildlife Computers (WC) (model SDR-T6). The first SMRU tag employed anodized aircraft–grade aluminum tubing to protect the instrumentation and batteries from the effects of water leakage and pressure. This tag, used successfully in 1995, had one cylinder housing the instruments. In the second SMRU model, a newer design, the instruments were incased in a short box-like epoxy mold. The mold was wedged to reduce drag (Fig. 2.3B). In both designs, the whole unit was able to withstand pressures down to depths of 2000 m. The WC tag were built using a similar epoxy-mold design and pressure-resistant to at least depths of 1000 m.

All three tag designs consisted of a housing, sensors to collect information, an antenna, lithium batteries, circuitry to produce the signal itself, and a micro–

Figure 2.2: Live capture of a beluga

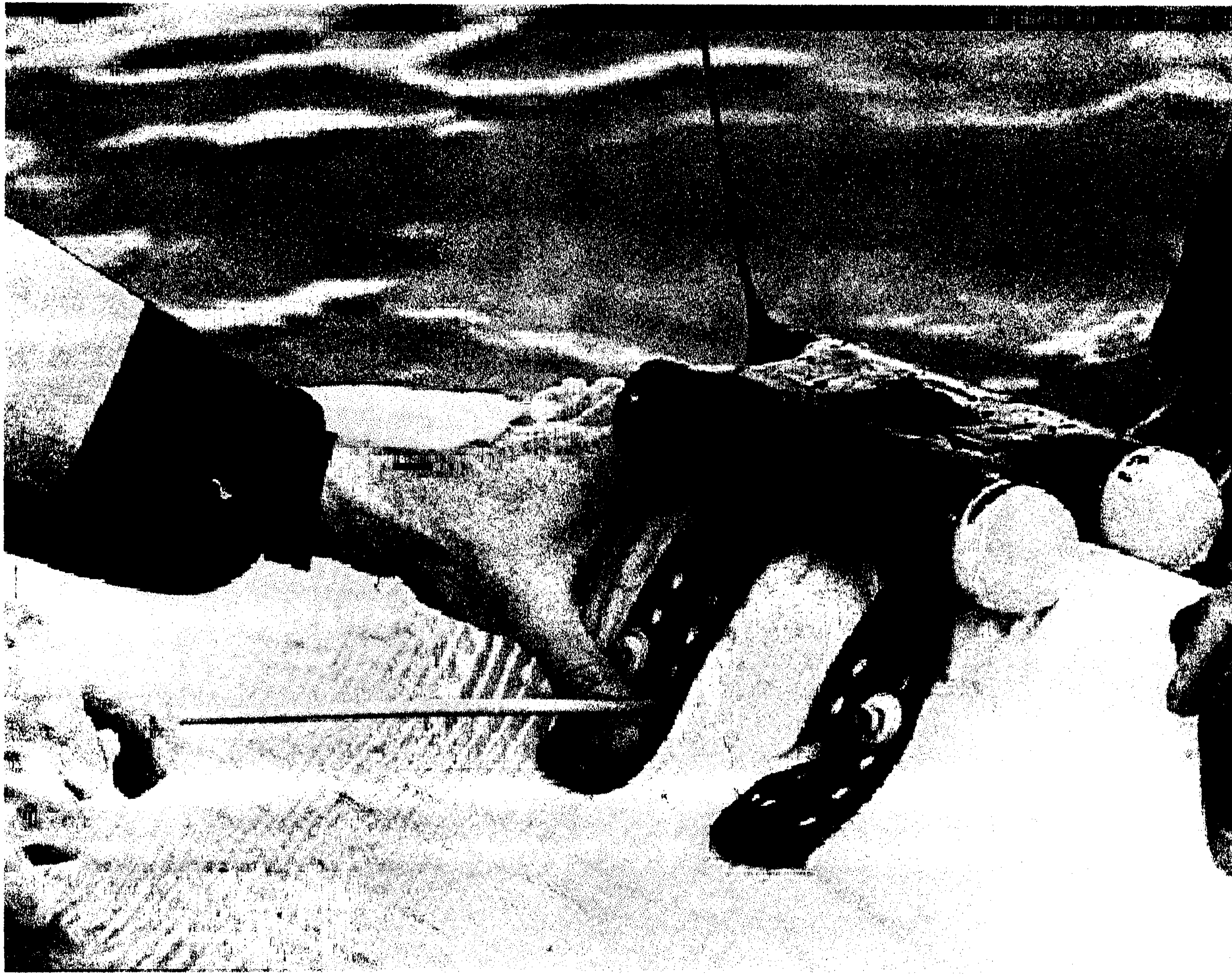


Figure 2.3: Attaching a tag to the dorsal ridge of a beluga

processor. The micro-processor was programmed to control the sensors, collect and compress data, and trigger the transmitter at each surfacing. The tags started transmitting data every time a beluga surfaced and exposed the antenna. Transmissions were repeated every 40 sec. If a NOAA satellite was overhead at the time, Service ARGOS could calculate the geographic position of the transmitter if three or more transmissions were received by the satellite. The transmitter's latitude and longitude was calculated from the difference in signal frequency between repeated signals while the satellite was passing overhead (Anonymous 1996).

The SMRU tags measured the maximum depth of each dive with accuracy of 5 m and stored that information in RAM. The WC tags measured the maximum depth of each dive and store it in one of the following depth categories: 4-6, 6-10, 10-26, 26-50, 50-100, 100-150, 150-200, 200-250, 250-300, 300-350, 350-400, 400+ meters. The counter for each depth category was reset to zero at 02:00, 08:00, 14:00 and 20:00 GMT and the count for the previous 6 hour period was stored in RAM for transmission. When transmitting, the tags broadcast packets of recorded dive data, which were uploaded by any NOAA satellite orbiting overhead. These data were relayed and stored by Service ARGOS.

Dive data is obtained several times a day if there are sufficient uplinks of data to the satellites. At times, dive data cannot be retrieved, either because there too few transmissions or because the antenna is not in direct line of sight of the satellite receiver. We suspect that these problems occur when belugas are traveling in ice and surface only infrequently or in small cracks where the ice acts as a barrier to transmission. This may explain why dive data becomes sporadic for some tags for several days or weeks. Transmission problems probably also occur when tags start to detach from the dorsal ridge and their antennas are no longer upright. This may explain why dive data become progressively fewer and fewer toward the end of a tag's life.

2.6 Data analysis

A variety of factors affect the of a location fix. Because the precision of the estimated locations vary, Service ARGOS provides an index of location fix quality, termed location class (L.C.) (Anonymous 1996). Individual tracks of belugas were derived from location class 0-3 data and smoothed by removing outliers. We plotted the first high quality (L.C. 1-3) location fix obtained every fifth day to follow the progression of each tag over time. Comparison between MMS BWASP survey beluga sightings and this study's results were done by overlaying tracks and MMS sightings. Charts of mean and maximum dive depths during six hour periods around each location were plotted for each SMRU tagged animal. For WC tagged animals, we plotted the median dive depth category and the maximum depth category for each six hour period (as previously defined).

3.0 RESULTS AND DISCUSSION

3.1 Field work

Between July 26 and August 1 1997, we captured and tagged 10 belugas (7 males - 3 females) (Table 3.1). Males were preferred because they retained tags longer than females in previous trials also there were more of them in the capture area and they were easier to catch.

3.2 Transmitter longevity

The longevity of the tags was better than anticipated (Table 3.1). The seven SMRU unit tags provided location fixes for 56 to 120 days (average 79 days) and high quality locations (L.C. 1-3) for 42 to 100 days (average 70 days). One WC tag failed on the first day for reasons unknown but the other two gave locations for 50 and 128 days (average 89 days) and high quality locations for 85 and 129 days (average 107 days).

These results show similar performance in longevity for the SMRU and WC tags (except for one WC tag which malfunctioned at the outset). The only difference (not shown in Table 3.1) is that the transmitters in the SMRU tags were powered by 1/4 watt compared to the 1/2 watt WC tags and ,as a result, gave fewer high quality locations per day. They were designed with a smaller transmitter to save power while allowing longer dive data transmissions. In other words, the SMRU tags provided much more detail on the dive activity of tagged animal at the cost of high quality locations.

Tag type and ID no.	Sex	Standard length(cm)	Tagging date	Days to last LC1-3 location	Date of last location	Days to last location
SMRU 8755	M	400	29-Jul	79	18 -Oct	81
SMRU 8757	M	379	29-Jul	65	05 -Oct	68
SMRU 8754	M	405	31-Jul	79	29 -Oct	90
SMRU 8758	M	421	31-Jul	100	28 -Nov	120
SMRU 10693	M	395	31-Jul	68	12 -Oct	73
SMRU 8756	F	362	1-Aug	42	26 -Sep	56
SMRU 10692	F	338	1-Aug	57	05 -Oct	65
SMRU Mean				70		79
WC 2118	F	374	26-Jul	128	02 -Dec	129
WC 25846	M	374	29-Jul	50	22 -Oct	85
WC 25845	M	426	31-Jul	0	01 -Aug	1
WC Mean				59		72
WC Mean exclud. 25845				89		107

Table 3.1: Details on the tagged belugas and their tag's performance

3.3. Movements and dive behaviour relative to water depth

Figures 3.1 to 3.9 show the tracks of the nine tagged belugas (6 males, 3 females) whose transmitters functioned after release. Eight of the tagged whales (6 males, 2 females) remained only briefly in the Mackenzie delta and, within one to five days, traveled east into Amundsen Gulf (Figs 3.1-3.8). During the early part of September, these eight belugas made a clockwise loop into Amundsen Gulf over a period of 16-26 days, some traveling as far east as to within 100 km of Wollaston Peninsula on Victoria Island (Figs. 3.1-3.7). Their clockwise movements were opposite to the counter-clockwise current gyre of Amundsen Gulf. In Amundsen Gulf, these belugas frequently dove to depths of 200-500 m, many dives taking them down to the seabed.

Six of those eight belugas (5 males, 1 female; Figs 3.1-3.6) returned to the Mackenzie delta in late September. Of those six, the five males later went out to the shelf break (Figs 3.1-3.5) and the female returned to Amundsen Gulf (Fig 3.6). The five males (8754, 8755, 8757, 10693 and 25846) moved into Alaskan waters in early to mid-September (Figs 3.1-3.5, Table 3.2) while the female (8756) remained in Amundsen Gulf until her transmissions stopped late September (Fig. 3.6). The two other belugas (male 8758, female 10692), which had circumnavigated Amundsen Gulf, did not return to the delta (Figs. 3.7-3.8). They moved directly to the shelf break in late August and started their migration into Alaskan waters in early September (Table 3.2). The female started off moving along the shelf break but later moved offshore into deep waters (Fig 3.7). The male migrated west along a line about 400-500 km offshore (Fig. 3.8).

The ninth beluga, female 2118, did not follow the others into Amundsen Gulf in August but instead made an exceptional trip almost straight north to about 78°N (Fig. 3.9). This is exceptional since none of the females moved that far north in previous tracking efforts, most staying below 72N (Richard et al. 1977). The farthest north that a tagged female moved in 1993 or 1995 was 74.5°N. The maximum depths indicate that the 1997 female 2118 dove to depths of 400 m or more while moving north but, based on her median dive depths, most of her dives were relatively shallow (i.e.: less than 10 m deep). Female 2118 later moved south to 75°N and proceeded westward on a sinuous track towards Alaskan waters. This is consistent with behaviour observed in males moving through that area in 1995 (Richard et al. 1997). These 1995 belugas made only occasional deep dives which were very deep and V-shaped (ie: they rose immediately after reaching maximum depth). A.R. Martin hypothesized that these dives are used for orientation by acoustic reckoning.

The movements of the six males were also strikingly different from the tracks of most males tagged in early July 1993 and 1995. During those earlier tracking efforts, 12 of the 14 tagged males moved north to latitudes ranging from 74°N to 78°N in mid-July and 11 of them subsequently moved into M'Clure Strait and Viscount Melville Sound (Richard et al. 1977). One other male reached Viscount Melville Sound through Prince of Whales Strait, also in late July. In contrast, none of the 1997 males moved any farther north than 73°N nor did they move into M'Clure Strait or Viscount Melville Sound.

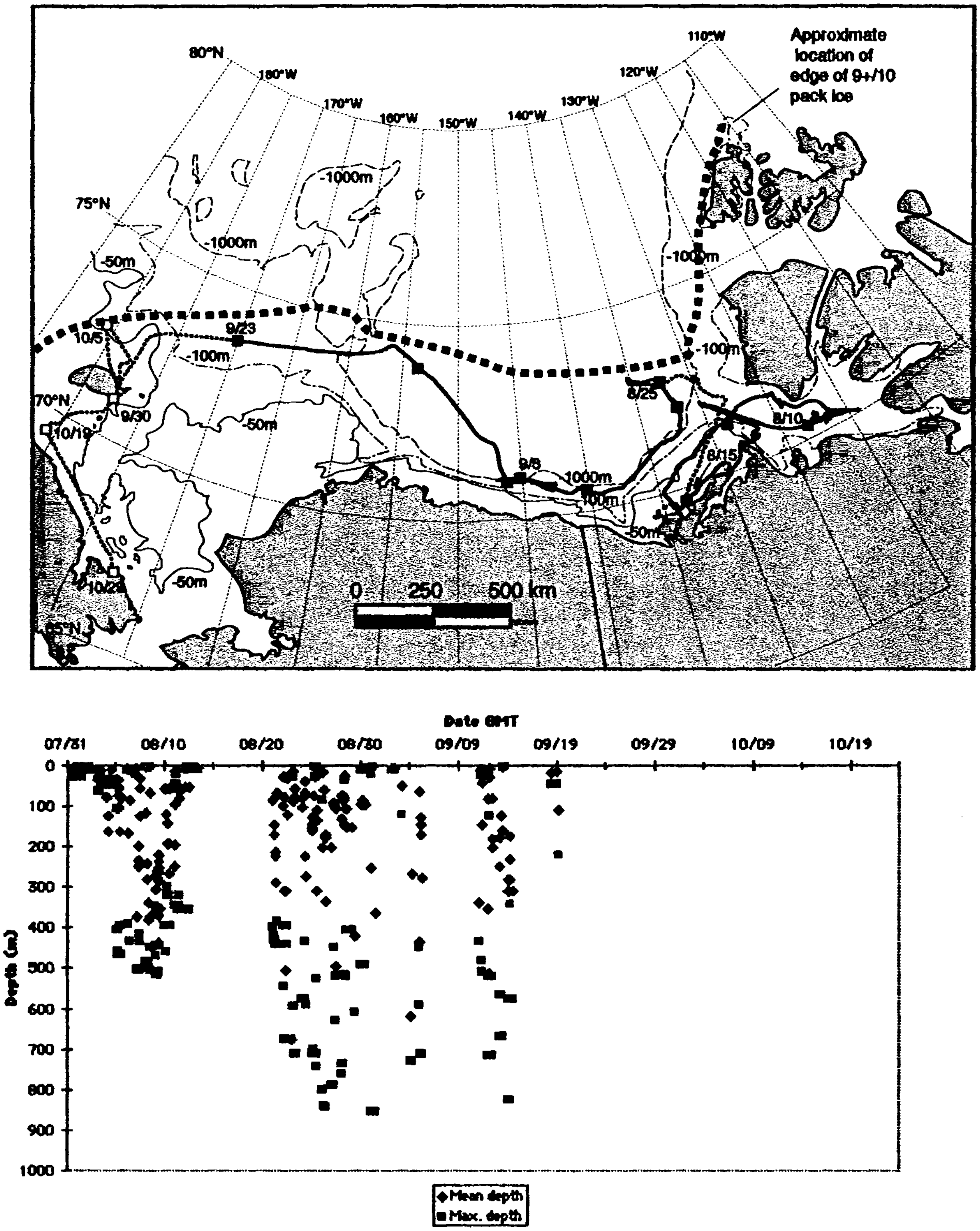
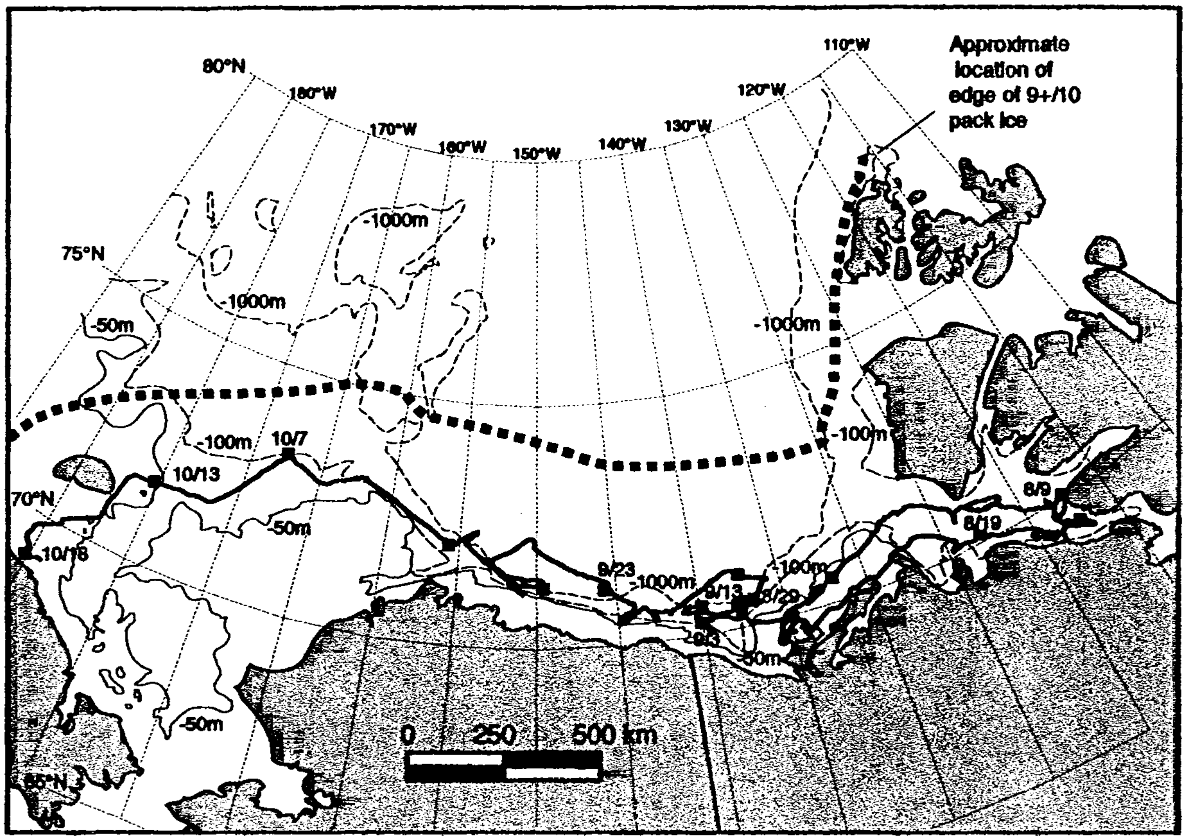


Fig. 3.1: Tracks and dive depths of male 8754, 405 cm, captured July 31. Tracks are derived from location class 0-3 data and smoothed by removing outliers. An open diamond marks the live-capture location. Closed squares are five-day markers from the release date. Periods with no locations for one or more days are represented by a broken line. Below the map is a chart showing the mean and max. depth of dives during each six-hour periods for which data was received by the satellites. The chart time line has tick marks at five- day intervals.



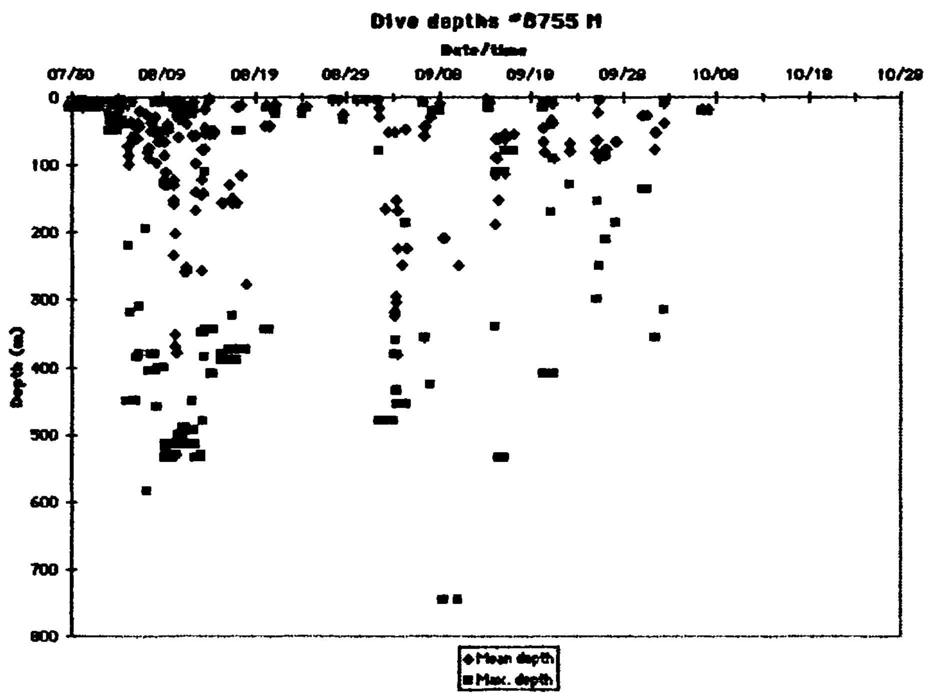
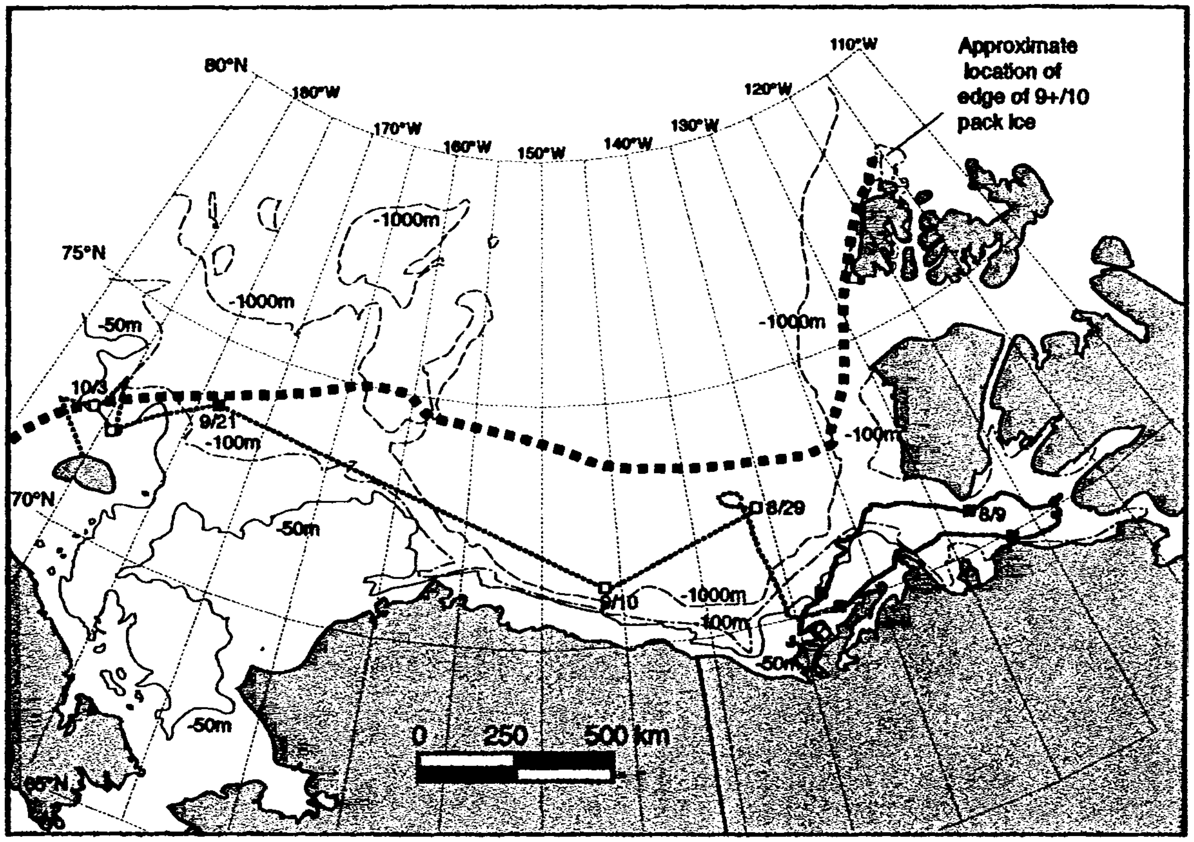


Fig. 3.2: Tracks and dive depths of male 8755, 400 cm, captured on July 29. Tracks are derived from location class 0-3 data and smoothed by removing outliers. An open diamond marks the live-capture location. Closed squares are five-day markers from the release date. Periods with no locations for one or more days are represented by a broken line. Below the map is a chart showing the mean and max. depth of dives during each six-hour periods for which data was received by the satellites. The chart time line has tick marks at five- day intervals.



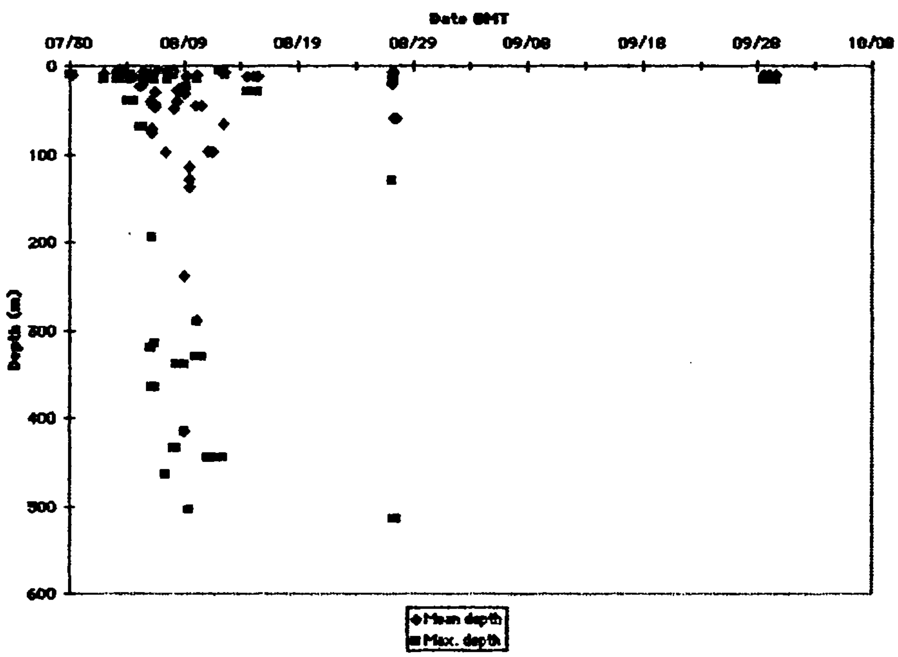
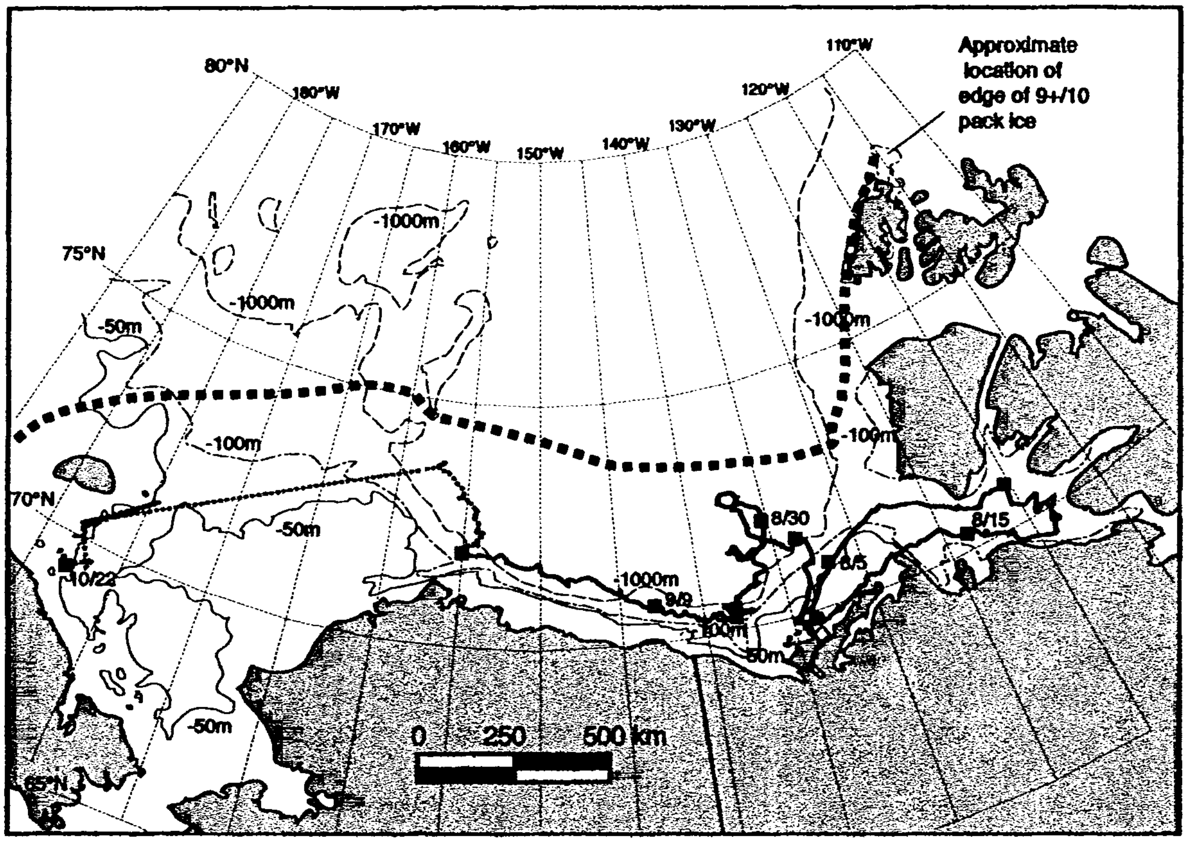


Fig. 3.3: Tracks and dive depths of male 6757, 379 cm, captured on July 29. Tracks are derived from location class 0-3 data and smoothed by removing outliers. An open diamond marks the live-capture location. Closed squares are five-day markers from the release date. Periods with no locations for one or more days are represented by a broken line. Below the map is a chart showing the mean and max. depth of dives during each six-hour periods for which data was received by the satellites. The chart time line has tick marks at five- day intervals.



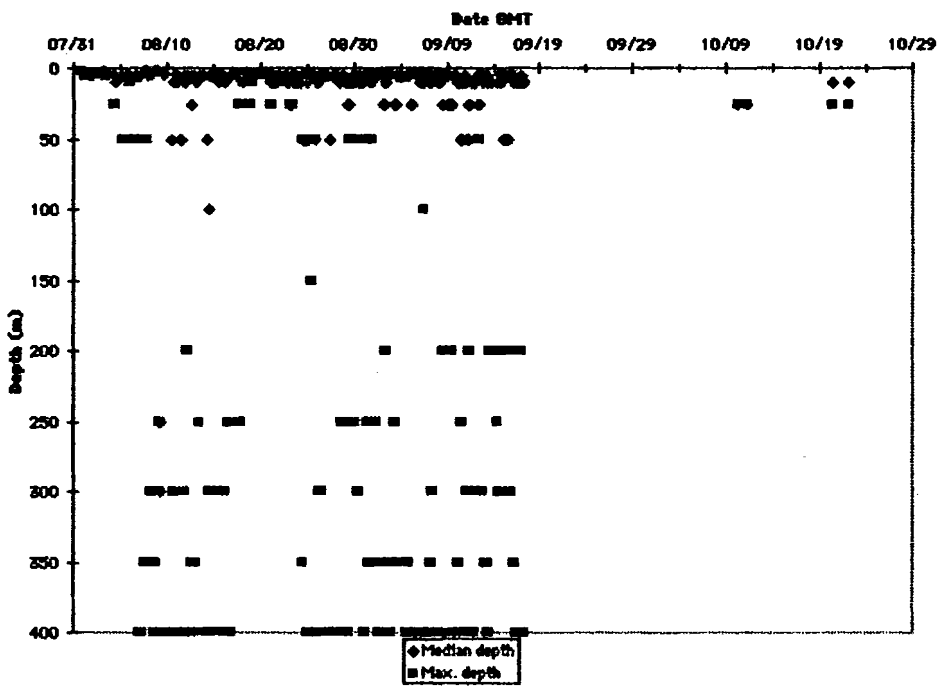
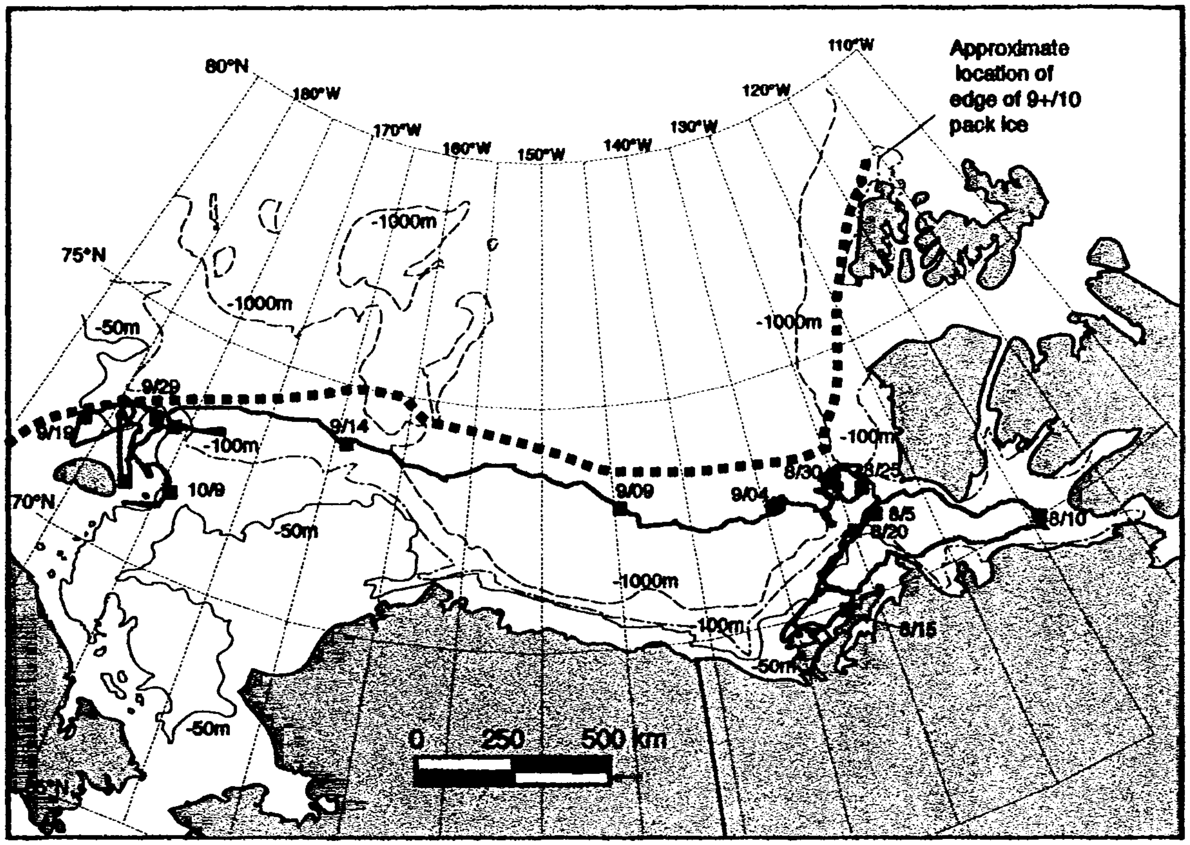


Fig. 3.4: Tracks and dive depths of male 25846, 374 cm, captured on July 29. Tracks are derived from location class 0-3 data and smoothed by removing outliers. An open diamond marks the live-capture location. Closed squares are five-day markers from the release date. Periods with no locations for one or more days are represented by a broken line. Below the map is a chart showing the mean and median. depth categories of dives during each six-hour periods for which data was received by the satellites. The chart time line has tick marks at five- day intervals.



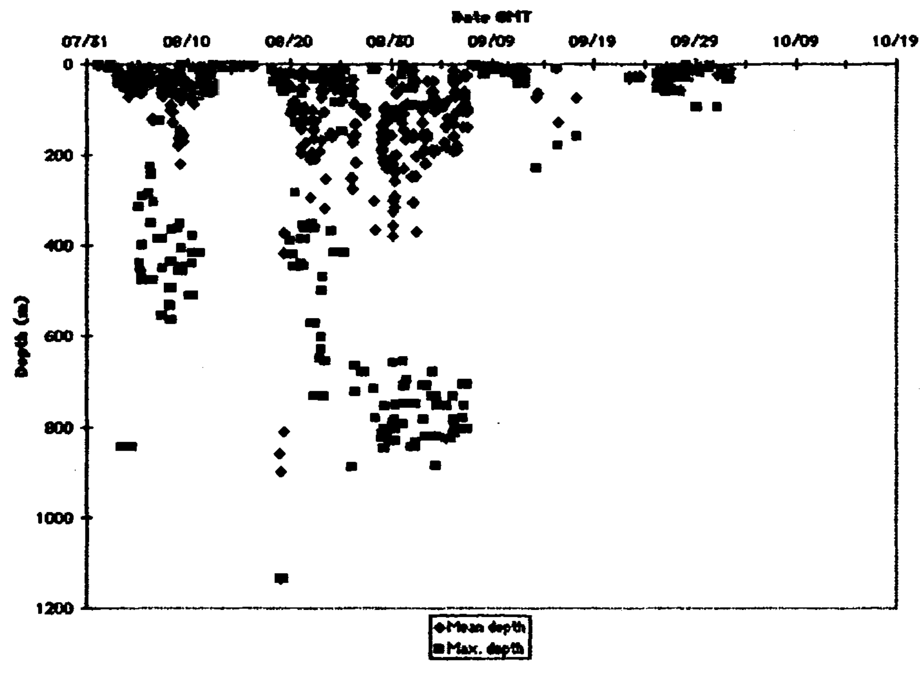
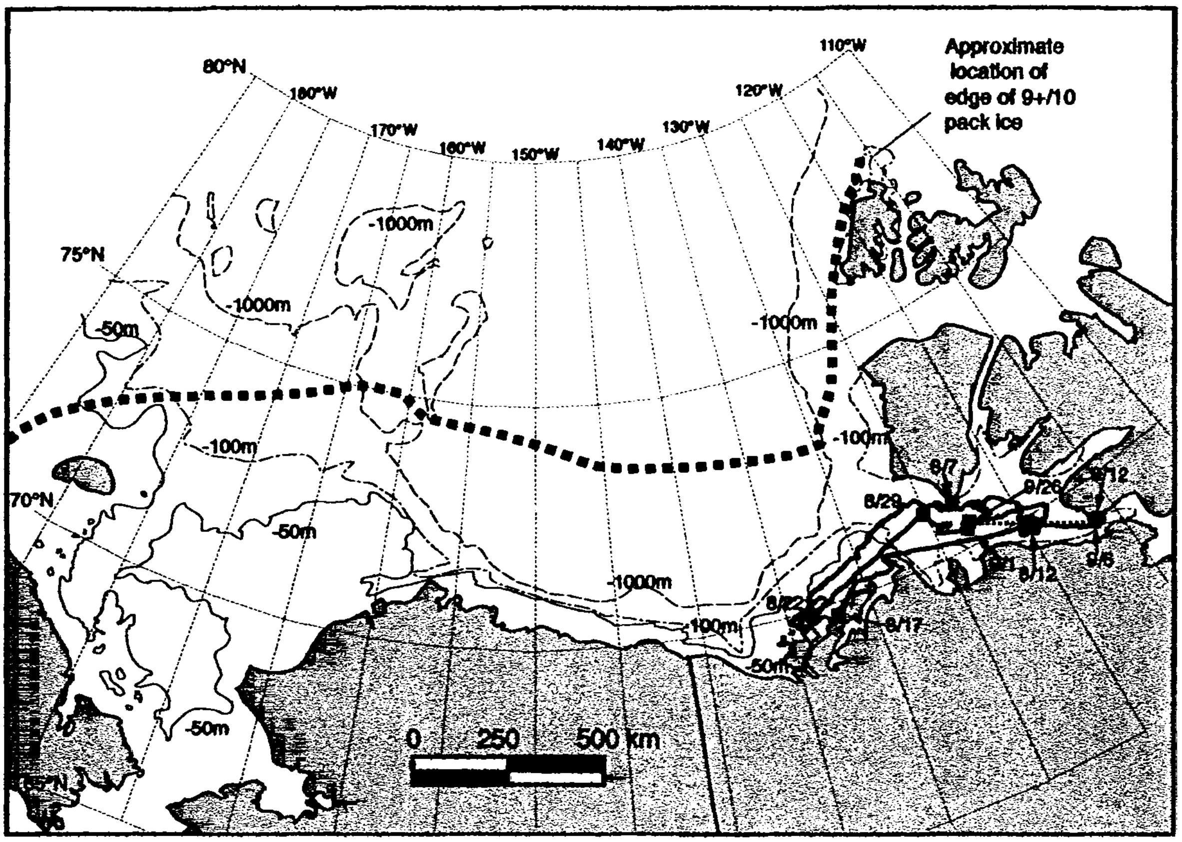


Fig. 3.5: Tracks and dive depths of male 10693, 395 cm, captured July 31. Tracks are derived from location class 0-3 data and smoothed by removing outliers. An open diamond marks the live-capture location. Closed squares are five-day markers from the release date. Periods with no locations for one or more days are represented by a broken line. Below the map is a chart showing the mean and max. depth of dives during each six-hour periods for which data was received by the satellites. The chart time line has tick marks at five- day intervals.



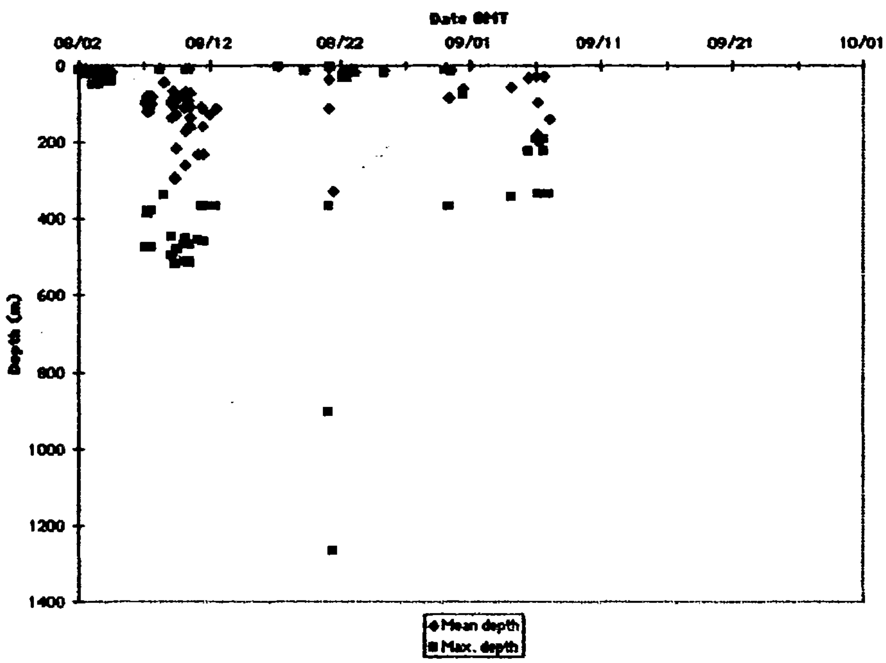
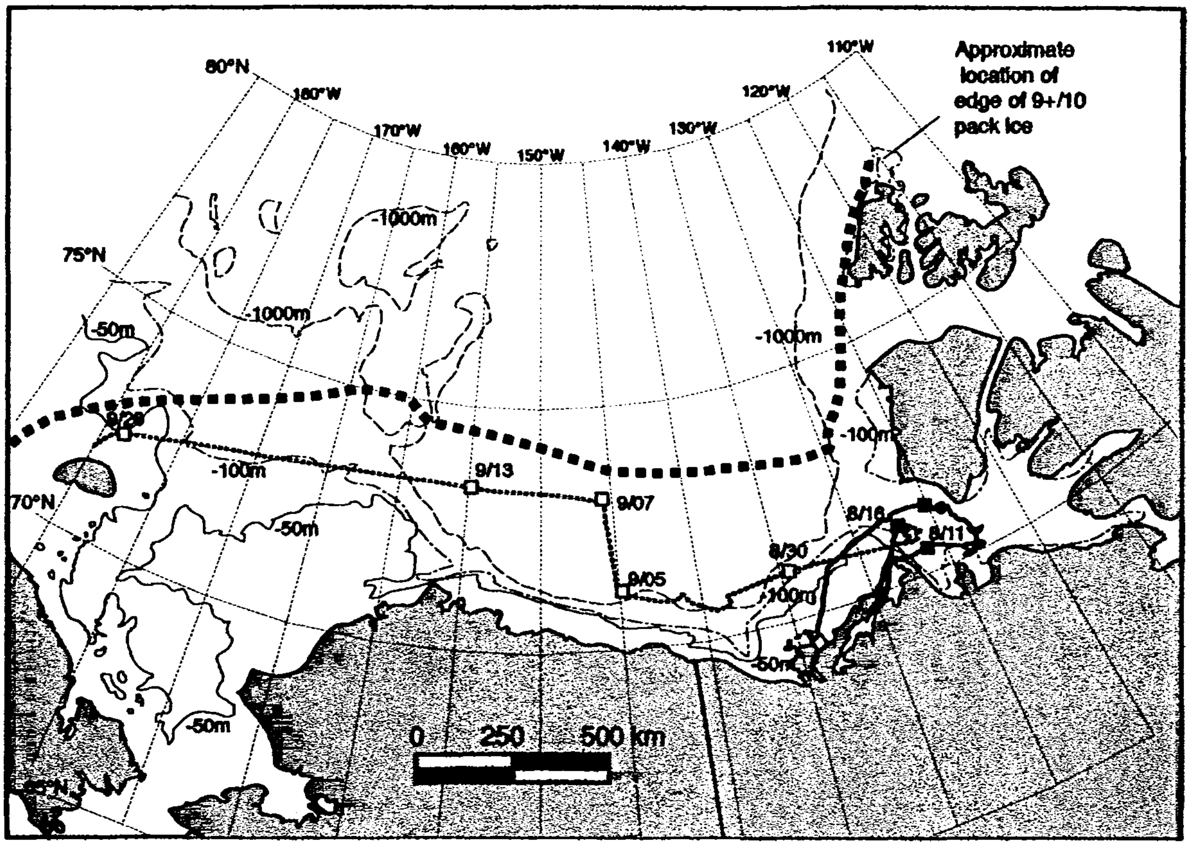


Fig. 3.6: Tracks and dive depths of female 8756, 362cm, captured Aug. 1 with calf. Tracks are derived from location class 0-3 data and smoothed by removing outliers. An open diamond marks the live-capture location. Closed squares are five-day markers from the release date. Periods with no locations for one or more days are represented by a broken line. Below the map is a chart showing the mean and max. depth of dives during each six-hour periods for which data was received by the satellites. The chart time line has tick marks at five- day intervals.



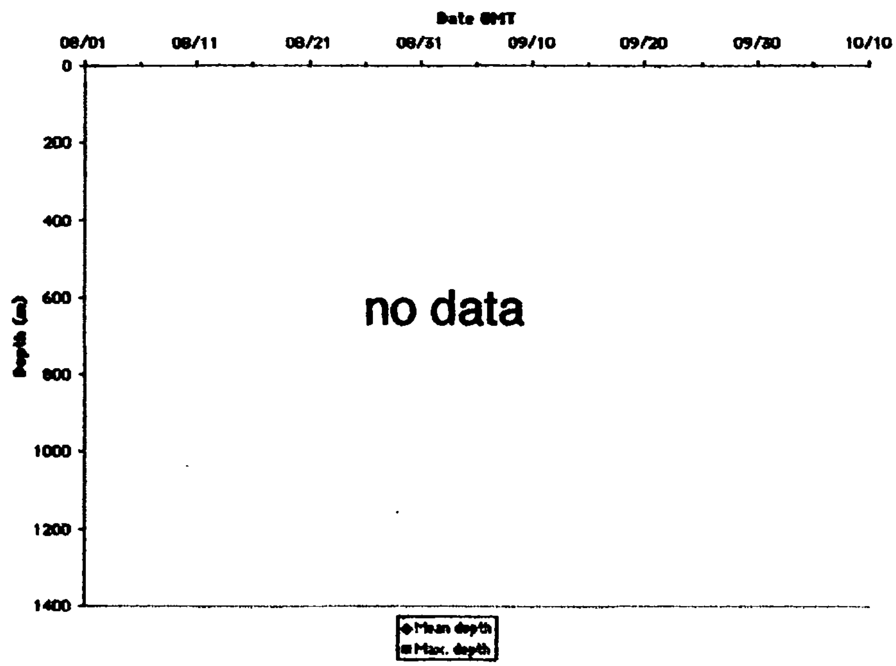


Fig. 3.7 Tracks and dive depths of female10692, 338cm, captured Aug 1 with calf. Tracks are derived from location class 0-3 data and smoothed by removing outliers. An open diamond marks the live-capture location. Closed squares are five-day markers from the release date. Periods with no locations for one or more days are represented by a broken line. Below the map is a chart showing the mean and max. depth of dives during each six-hour periods for which data was received by the satellites. The chart time line has tick marks at five- day intervals.

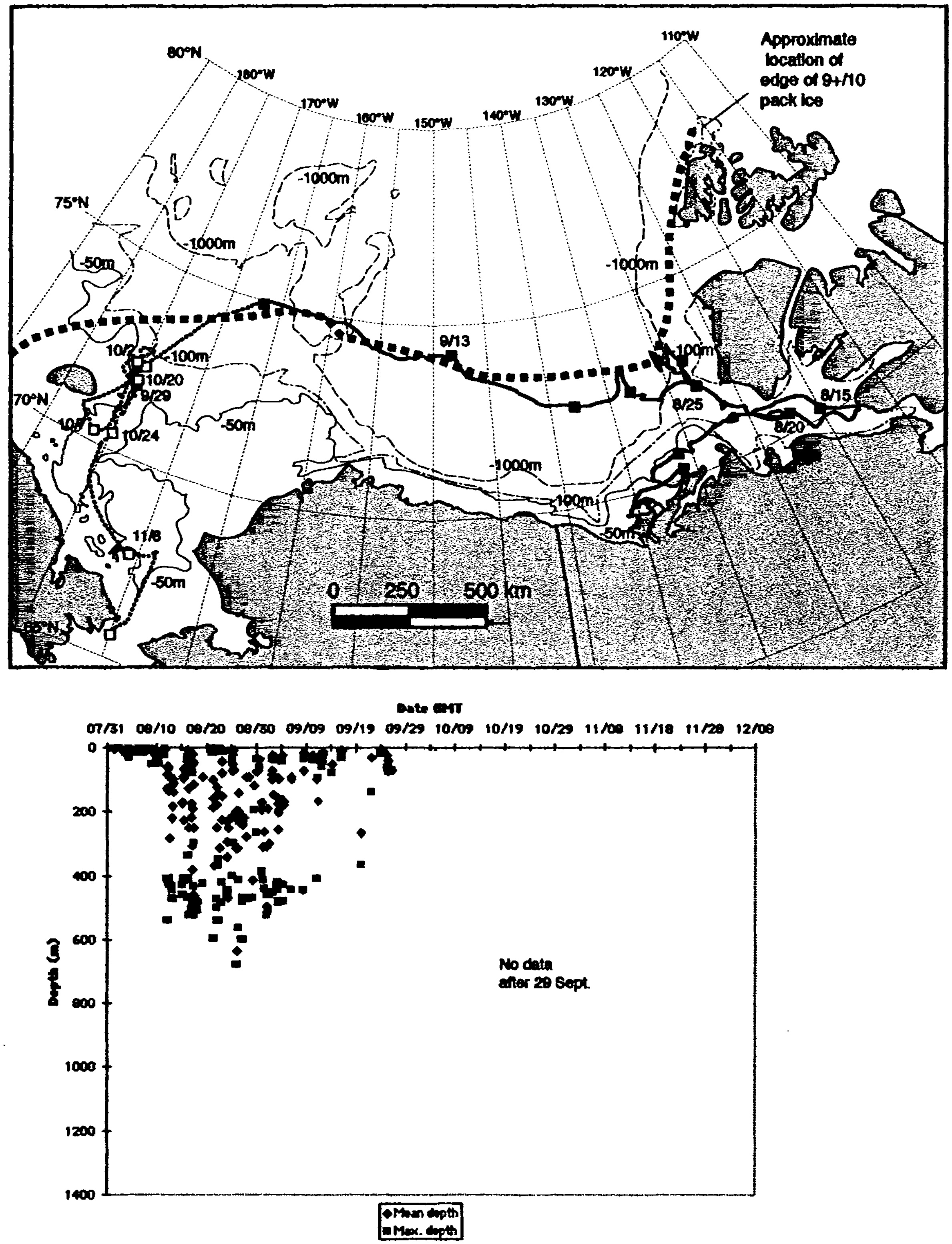


Fig. 3.8: Tracks and dive depths of male 8758, 13'8", captured on July 31. Tracks are derived from location class 0-3 data and smoothed by removing outliers. An open diamond marks the live-capture location. Closed squares are five-day markers from the release date. Periods with no locations for one or more days are represented by a broken line. Below the map is a chart showing the mean and max. depth of dives during each six-hour periods for which data was received by the satellites. The chart time line has tick marks at five- day intervals.

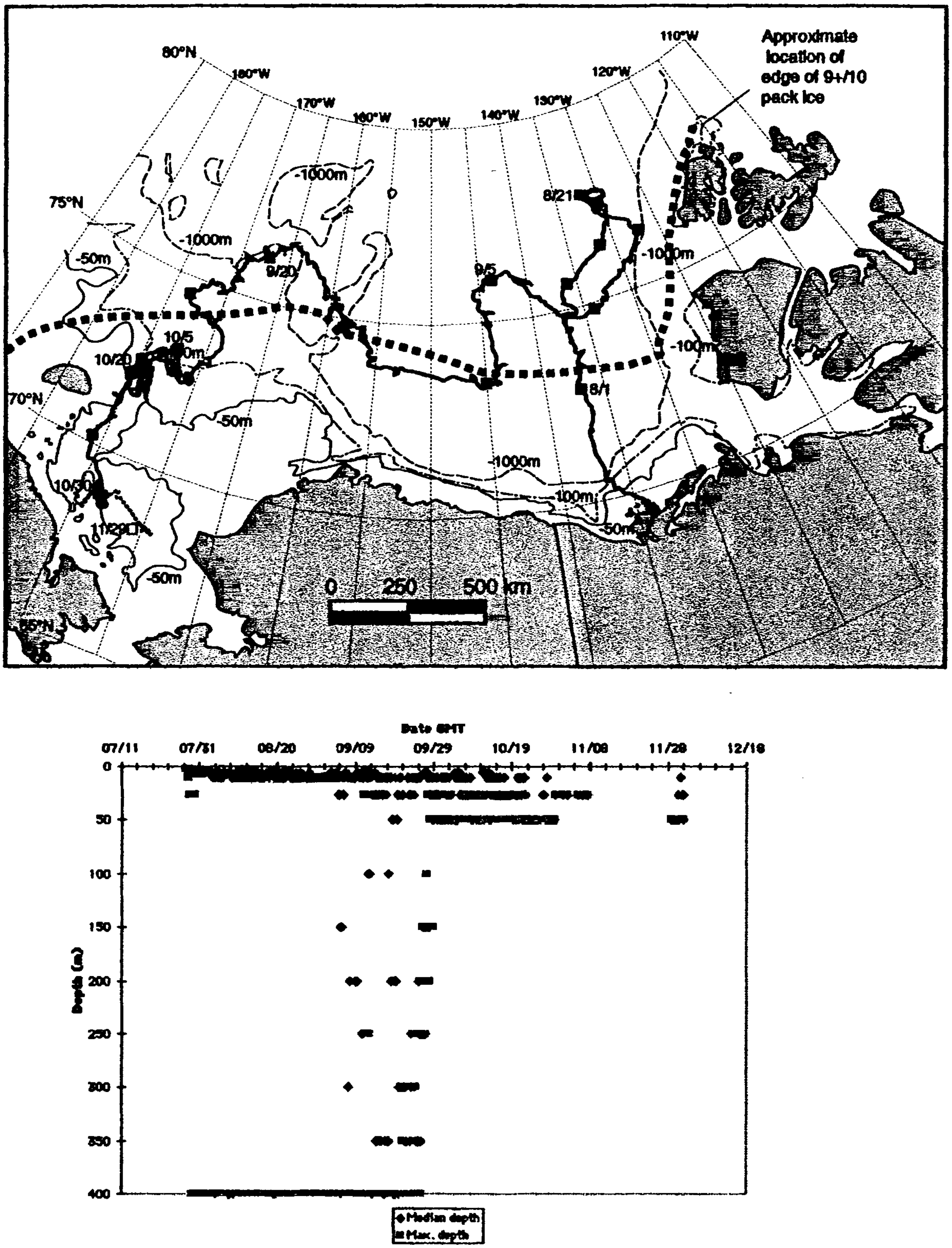


Fig. 3.9: Tracks and dive depths of female 2116, 374 cm, captured July 26 with calf. Tracks are derived from location class 0-3 data and smoothed by removing outliers. An open diamond marks the live-capture location. Closed squares are five-day markers from the release date. Periods with no locations for one or more days are represented by a broken line. Below the map is a chart showing the mean and median. depth categories of dives during each six-hour periods for which data was received by the satellites. The chart time line has tick marks at five- day intervals.

Although the dive data of the eight belugas migrating through Alaskan waters is spotty, it is clear that most of them dove to depths of several hundred meters during their travel (Figs 3.1-3.2, 3.4-3.5 and 3.9). Their mean (or median) dive depths varied from shallow to deep in the course of the same day. This suggests that their migratory movements through Alaskan waters may not have been constant but were instead punctuated with periods of deep dives.

The eight belugas reached the western Chukchi Sea by late September or early October and remained in the waters northeast and east of Wrangel Island until mid to late October. Their dives were relatively shallow (less than 50 m deep) as was to be expected in this shallow sea.

Tag no.	Sex	Date into Alaskan waters (>143°W)	Date into W.Chukchi Sea (>170°W)	Date move south of Wrangel I. (<70°N)	Date locations stopped
2118	F	4 Sept.	23 Sept.	29 Oct.	2 Dec.
8754	M	5 Sept.	24 Sept.	18 Oct.	29 Oct.
10692	F	6 Sept.	~19 Sept.	-	5 Oct.
8757	M	8 Sept.	20 Sept.	-	5 Oct.
10693	M	8 Sept.	15 Sept.	-	12 Oct.
25846	M	9 Sept.	~25 Sept.	22 Oct.	22 Oct.
8758	M	11 Sept.	21 Sept.	24 Oct.	28 Nov.
8755	M	21 Sept.	9 Oct.	17 Oct.	18 Oct.
8756	F	-	-	-	26 Sept.

Table 3.2: Dates of migration into different areas by tagged belugas

3.4 Movements relative to ice

Sea ice conditions in the Beaufort Sea from August to October 1997 were similar to median ice conditions estimated from a 15 year survey (1959-1974) by the Canadian Atmospheric Environment Service (Markham 1981). The approximate edge of heavy (≥ 9/10) pack ice for August to October 1997 is mapped in Figs. 3.1-3.9. All but one of the nine whales stayed south of the edge of the heavy pack ice in August. The ninth beluga, female 2118, spent August in the heavy ice-covered waters west of Banks and Prince Patrick Islands at latitudes in excess of 74°N. Interestingly, this female had a calf with her when she was released.

Unlike most male belugas tagged in early July 1993 and 1995 (Richard et al. 1997), none of the 1997 males, which were tagged in the last week of July, moved into the Canadian Arctic Archipelago. It was suggested that they may have been hindered in doing so by the heavy multi-year pack ice reported to have blocked M'Clure Strait in August 1997. Inspection of the tracks shows none of the tagged belugas actually approached M'Clure Strait (Figs. 3.1-3.8). Furthermore, several animals tagged in 1993 and 1995 traveled hundreds of kilometers into heavy pack ice (9+/10). This is also true of female beluga 2118 tagged in 1997 (Fig. 3.9). Unless they had inspected the M'Clure Strait ice conditions earlier in the season, there must be another reason for their choice not to go there. A plausible explanation might be that male belugas captured in the Mackenzie Delta in late July are less prone to venture into the Archipelago so late in the season. In previous years, the males that moved to Viscount Melville Sound arrived there in late July. Had the 1997 males tried to reach Viscount Melville Sound, they would have arrived two weeks later than their 1993 and 1995 counterparts. Nevertheless, it is noteworthy that one male tagged in 1993 and another in 1995 did not go into the Archipelago, despite the fact that both were caught in early July (Richard et al. 1997). There may therefore be other reasons, perhaps food-related, which caused these males to remain in the southern Beaufort Sea and Amundsen Gulf.

Most tagged whales migrated through Alaskan waters well south of the edge of the heavy pack (Fig. 3.1-3.5 and 3.7). Male 8758 followed the edge of the pack during his westward movement (Fig. 3.8). Female 2118 started her movement westward well inside the pack ice but turned south at about 145°N to reach the edge of the pack which she then followed westward (Fig. 3.9).

During the months of October, tagged belugas moved about in the waters east or south of Wrangel Island, southeast of the edge of the pack (Figs 3.1-3.2, 3.3, 3.5, and 3.7-3.8). In November, new ice started forming and the edge of the pack slowly moved southward and eastward (National Ice Center, 1998). The two tags still transmitting (Figs 3.8-3.9) were tracked moving south parallel to the new ice edge.

The above observations suggest that most tagged belugas took advantage of open water or loose ice in late summer and early fall to move about the Beaufort Sea and migrate but both males and females are capable of crossing through heavy pack. They appear to avoid the formation of new ice in the western Chukchi Sea in November by migrating south towards the Bering Strait.

3.5 Movements in relation to MMS BWASP survey sightings

The U.S. Minerals Management Service flew aerial surveys of marine mammals that included the sightings of beluga whales in the Beaufort Sea between the months of September and October 1997 (S. Treacy, in press). Figs 3.10 and 3.11 show their flight coverage tracks and beluga sightings. They predominantly found belugas on the outer portion of the shelf and inner portion of the Beaufort Sea continental slope. The northern limit of the flight tracks defines most of the observed belugas except for some scattered sightings on the inner shelf in waters depths less than 40 m.

To compare the survey results to our own, we overlaid the survey sightings over tracks obtained using L.C. 1-3 fixes for seven of the eight tagged belugas that moved through that area (Fig. 3.11). None of our tagged animals ventured as far inshore as the coastal beluga survey sightings but there is a fairly good overlap between survey sightings made in the shelf break zone and four of the beluga tracks (males 8754, 8755, 8758, 25846). On the other hand, male 10693 migrated west about 200 km north of the survey sightings. Similarly, when female 10692 reached 145°W, she tracked north about 170 km before resuming her westward movement (Fig. 3.7).

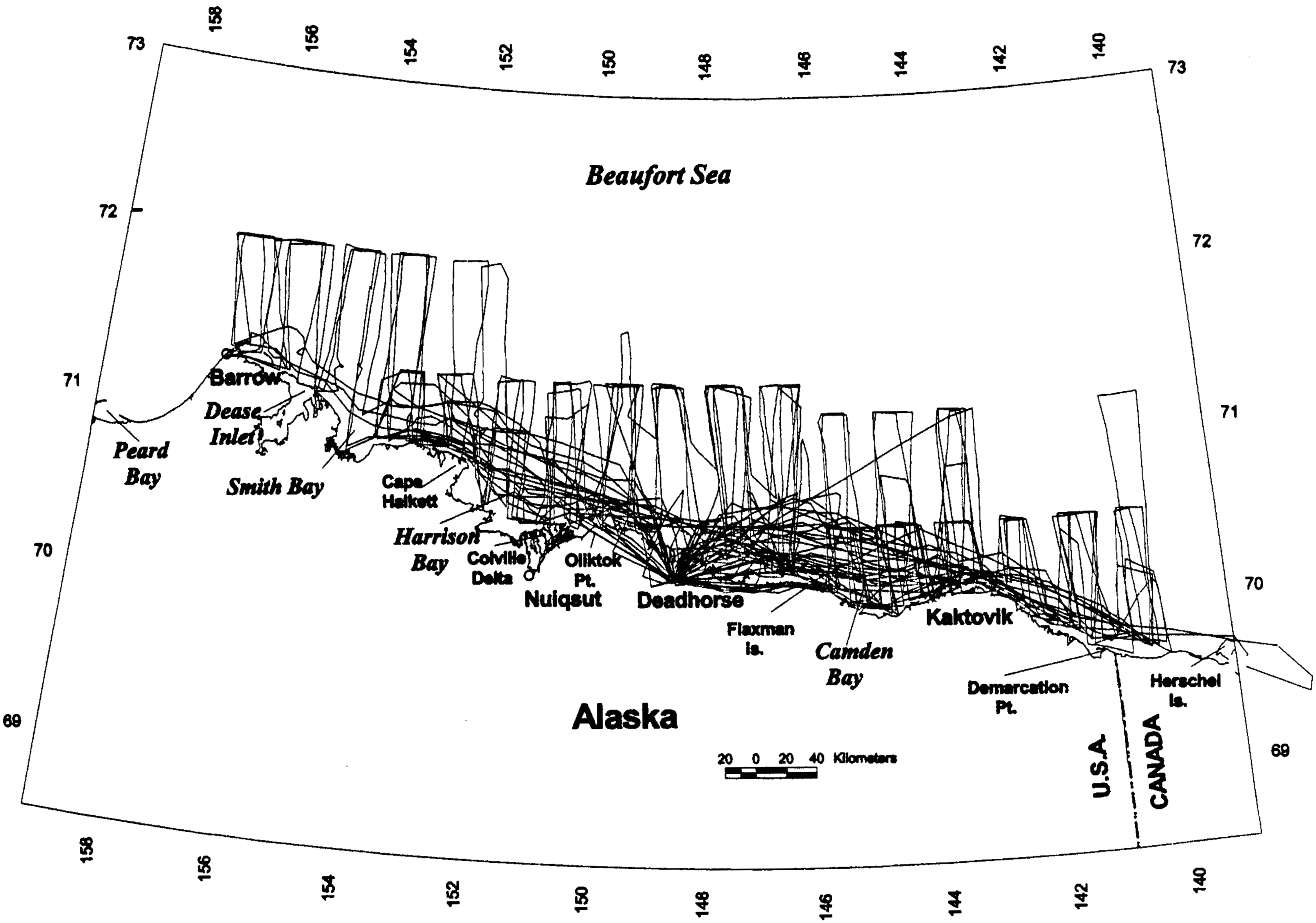


Fig. 3.10: BWASP Survey Flight Lines for September 3 through October 18, 1997

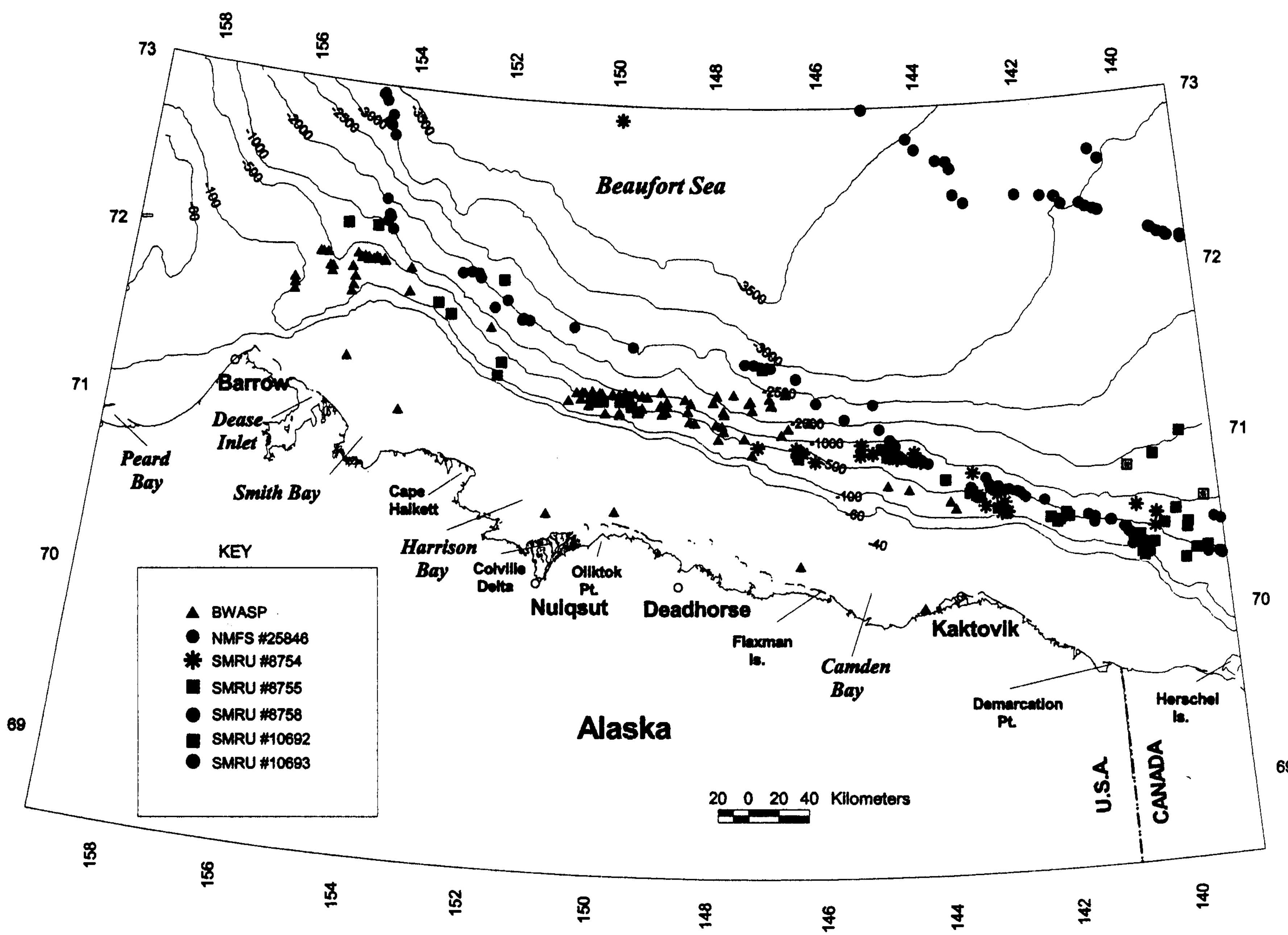


Fig. 3.11: Comparison of Tagged Beluga Locations and Beluga Sightings from MMS BWASP Aerial Survey for 1997

This is consistent with results obtained in 1993 and 1995 (Richard et al. 1977). Few fall locations were obtained in those years but the ones that were obtained showed two males migrating through the Alaskan Beaufort Sea about 400 km offshore of the shelf break and one male and a female migrating close to it.

These combined results suggest that the MMS BWASP surveys are useful in documenting the fall occupation of the Alaskan shelf and shelf break by belugas. They also show that the BWASP surveys' scope encompasses only a portion of the fall beluga population in the AlaskanBeaufort Sea. Other belugas migrate several hundred kilometers to the north along the edge of the pack ice.

3.6 Fall migration and stock identity

Fraker (1980) hypothesized that the fall migration of Beaufort Sea belugas ran along the Alaskan shelf and south through the Chukchi Sea to their suspected wintering area in the Bering Sea. In our tracking study, roughly half of the belugas which moved through Alaskan waters in 1993, 1995 and 1997 did so close to the shelf. One of the males tagged in 1993 migrated west and traveled through the Arctic Ocean. It was last located in the East Siberian Sea on 22 August (Richard et al. 1997). Another male tagged in 1995 was moving northwest toward the East Siberian Sea when last located at Sea ~165°W on 27 September. In 1997, one female (2218) also migrated towards the East Siberian Sea in late September before gradually moving southward into the Chukchi Sea. She was last located on 2 December north of the Bering Strait. Prior to the 1997 tagging, it was suggested that the two males may have been headed for the eastern Siberian Sea or western Chukchi Sea where observers had previously seen hundreds of belugas during fall walrus surveys (J. Burns, Fairbanks, AK, pers. comm.). This year's results confirm the movement of belugas into the Western Chukchi Sea and its use for several weeks prior to migration south towards the Bering Strait. The tracks of the few tags that worked into November and December suggest that the ultimate destination of belugas is indeed the Bering Sea as suggested by Fraker, but that they reach it by moving along the Russian side of the Chukchi Sea rather than the Alaskan side.

If most Beaufort Sea belugas transit through the Siberian Sea in the fall then the stock must also be hunted in Chukotka (Russia). The Russian catch is not well documented but is thought to be in the low tens (K. Frost, Alaska Dept. Fish & Game, Fairbanks, pers. comm.).

4.0 CONCLUSIONS

Monitoring the movements and dive behaviour of Beaufort Sea belugas has offered new insights into beluga behaviour in late summer and fall. While the patterns of use of the Beaufort Sea and Amundsen Gulf by males and females was similar to previous years, males did not go into the Arctic archipelago as many tagged males had done in past years. It is unclear whether ice conditions or other ecological factors caused this variance in behaviour.

Tracking through Alaskan waters showed that about half of the tagged animals (male and female) migrate far offshore of the Alaskan coastal shelf. The comparison with sightings of the MMS BWASP surveys show that other tagged belugas migrated close to the areas along the shelf where most of the survey sightings were made. These results suggest that BWASP surveys are useful in documenting beluga occupation along the shelf and shelf break.

This study confirms the use of the Western Chukchi Sea in the fall and demonstrates the subsequent migration of tagged belugas south towards the Bering Strait in November. Ice cover does not appear to be a factor in determining beluga movement in summer. A female moved hundreds of kilometers through heavy pack in August, as had done most tagged males and one female in previous tracking efforts (Richard et al. 1997). In the fall, ice cover may determine the trajectory of migrating belugas. Most belugas migrated south of the edge of the heavy pack in September and October. In November, movements south towards the Bering Strait correspond to the formation of new ice pack in the western Chukchi Sea.

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