Use of the Little Whale and Nastapoka estuaries by humans and beluga during summer 2001

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ABSTRACT

Vessel traffic and the occurrence of beluga whales, *Delphinapterus leucas*, were monitored between July 23 and August 24, 2001, at the Little Whale (56°00'N 76°47'W) and Nastapoka (56°55'N 76°33'W) rivers in eastern Hudson Bay. Disturbance by vessel traffic (mainly freighter canoes) was almost daily at both sites, but Nastapoka is by far the busier place: 208 disturbance events in 31 days compared to 111 at Little Whale in 28 days. Following disturbance, whales were absent for longer periods from Nastapoka than Little Whale (median values 10.5 vs 22.3 hours). At both sites, when whales were not in the estuaries, further vessel traffic increased the duration of absence. This relationship was stronger at Nastapoka ($R_s = 0.823$, n = 12, $p = 0.001$) than at Little Whale ($R_s = 0.523$, n = 21, $p = 0.01$), which may indicate differences in underwater noise dissipation between the open coast at Little Whale versus the marine canyons in Nastapoka Sound. Whales also left the estuaries for no apparent reason, but were seen again much sooner compared to absences following disturbance. Published data on the sightings of individually recognizable belugas at the Nastapoka indicate that these individuals are not the first animals to appear at the river after disturbance. Re-analysis of that data found no difference between the duration of absence of belugas from the river following hunting and motor traffic. The number of whales occupying the Nastapoka has decreased since the mid-1980s when up to 250 beluga could be seen; the maximum count in 2001 was 25 animals. Groups of 100+ animals still occur at Little Whale River. The decrease in the number of whales seen in the Nastapoka likely reflects the combination of a reduction in stock size and the whales' reduced use of the river due to disturbance. Daily boat traffic prevents the seasonal buildup in whale numbers that had been a feature of these estuaries two decades earlier. In August, Inukjuak hunters are the predominant users of the Nastapoka River whereas Little Whale River is used by the Kuujjuaraapimmiut and the Umiujamiut.

INTRODUCTION

In Hudson Bay, two stocks of beluga whales, *Delphinapterus leucas*, have been recognized based on summering areas and genetic make-up (Brown-Gladden et al 1997). The western Hudson Bay population numbers at least 23,000 belugas (Richard et al 1990) whereas the eastern Hudson Bay population is much smaller and is designated as "threatened" by COSEWIC (Reeves and Mitchell 1989). The size of the population on the surface at any time, based on counts during aerial surveys, was estimated to be about 1,000 individuals (650 – 1430: Smith and Hammill 1986, 1014 ± SE 421: Kingsley 2000). These estimates have not been corrected for whales that are diving and thus out of view. Analysis of dive data indicates an addition of 85% to the counts to correct for animals underwater (Kingsley et al 2001). This correction suggests the eastern Hudson Bay stock of belugas numbered ca. 1,900 animals in 1985 and 1993. The large variances associated with these estimates (due to the clumped nature of beluga distribution) prevent the detection of small changes in population size. Recent population modeling, which incorporates harvest levels, suggests the population has declined (Hammill 2001).

Belugas in eastern Hudson Bay summer in the area of the Hudson Bay Arc, which stretches from latitudes 55° to 59°N on the Quebec coast, and west to the Belcher Islands (Smith and Hammill 1986). Several estuaries, notably the Great Whale, Little Whale and Nastapoka, occur in the Arc and are frequented by belugas (Fig. 1). At various times in the 1700 and 1800s, large, commercial fisheries for belugas operated at the Great Whale and Little Whale rivers. The Nastapoka escaped commercial exploitation (Reeves and Mitchell 1987).

Subsistence harvesting of belugas occurs at all three estuaries, with the Nastapoka providing the most whales. Inuit hunters from Kuujjuaraapik take whales opportunistically at the Great Whale estuary; the occurrence of whales there is sporadic but does occur (Lesage and Doidge In Prep; contrary to Kingsley et al 2001). They also hunt at the Little Whale River which is a more certain place to catch beluga, but is a day's boat journey from Kuujjuaraapik. The Inuit of Umiujaq hunt whales on the coast in front of their town, among the Nastapoka Islands, in Richmond Gulf, and occasionally at the Nastapoka River. Presently, hunters from Inukjuak are the primary harvesters of beluga at the Nastapoka. Many of these hunters are the descendants of families who had lived in the area fifty years ago before moving to Inukjuak.

Beluga hunting is limited to native hunters and is governed by the Fisheries Act. A co-management agreement between DFO and the Inuit of Nunavik limits the community harvest by setting quotas and seasons. As part of the agreement, hunters from Puvirnituq and Akulivik, who previously harvested whales at the Nastapoka, now concentrate their harvesting to the north in Hudson Strait where there is a greater probability that western Hudson Bay animals are part of the harvest (de March and Maiers 2001).

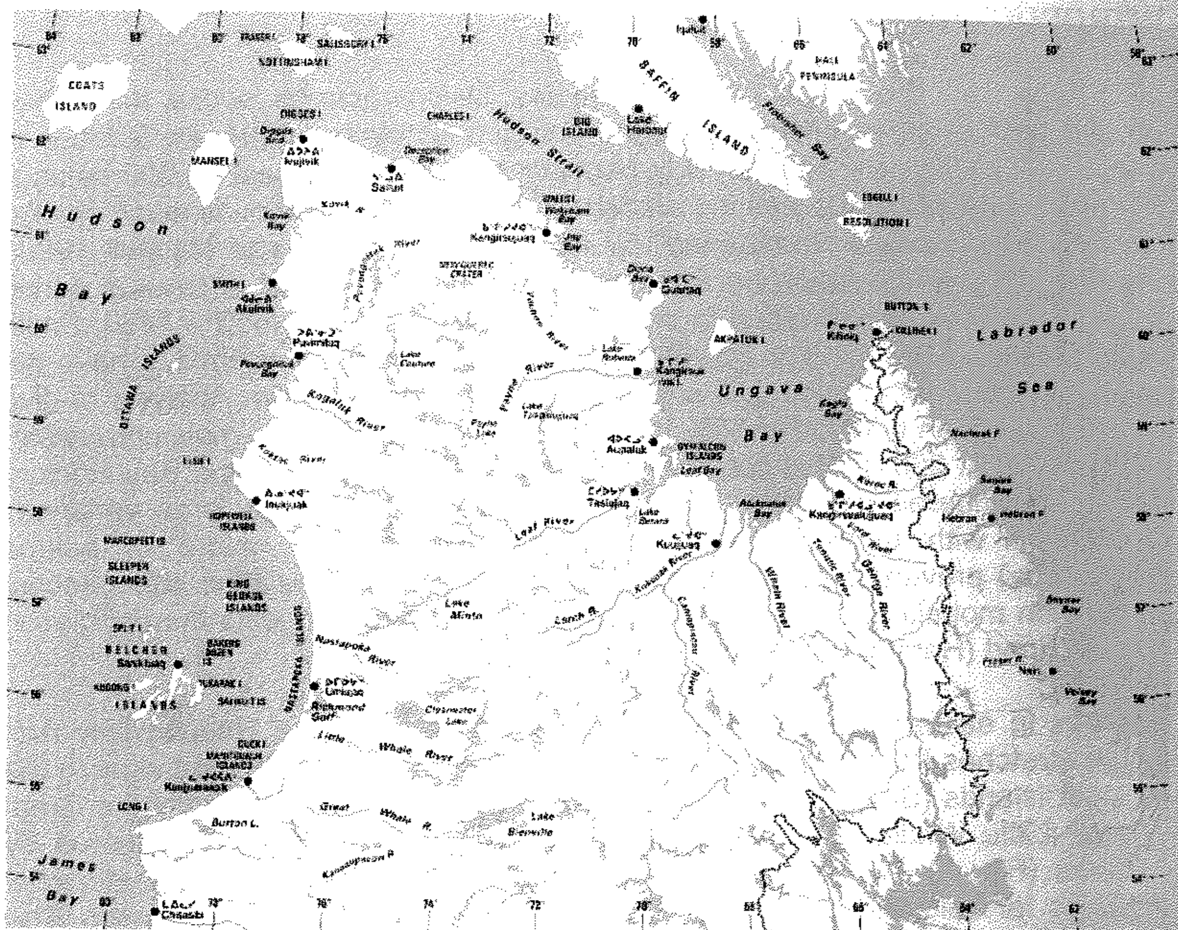


Figure 1. Map of Nunavik. The Nastapoka River is located near the centre of the Hudson Bay Arc, north of the village of Umiujaq. Little Whale River (Great Whale River) is in southern portion of the Arc; the village of Inukjuak is at the top of the Arc.

Besides limiting the number of communities hunting at the Nastapoka, the present management agreement closes the two estuaries to hunting during the month of July and effective in 2001, limits the harvest to 15 animals at each river.

The method of hunting belugas at the Nastapoka has changed in the last ten years. Previously, Inukjuak hunters would come to the Nastapoka on their community boat, a 40-foot long-liner, to fill their quota of whales. In recent years, hunting effort has been more individualistic: hunters come in their own freighter canoes or speed boats which has resulted in many vessels hunting at one time. While the catch is pooled, many more individual boats are now involved in the hunt. This leads to a less organized hunt during which the quota is exceeded.

In the 1980s, concentrations of up to 250 white whales could be seen in the Nastapoka River at any one time (Caron and Smith 1990). More recently, the number frequenting the estuary has declined (Doidge 2001). In 1986, the village of Umiujaq was officially opened. It was the new home of people from Kuujjuaraapik, whose families had lived and hunted in the Richmond Gulf area. They had agreed to relocate when a hydro-electric project had been proposed (but later shelved) on the Great Whale River. The new town resulted in an increase in boat traffic around Nastapoka since residents of Umiujaq now use the area for hunting and fishing.

Belugas vary in their reaction to small boat traffic. In the St. Lawrence, where they are not hunted, they will sometimes approach and follow boats (Blane and Jackson 1994, Lesage et al 1999). In the High Arctic at Cunningham Inlet, where belugas are also not hunted, they do not flee when an outboard motor boat approaches (DWD pers. obs). However, in other areas, fleeing from outboards is the usual reaction (J. Orr, pers. comm.). At the Nastapoka Estuary, whales, with few exceptions, leave the estuary immediately when exposed to noise from outboards (Caron and Smith 1990).

The question arises - is this decline in whale numbers at the Nastapoka due to increased disturbance by motor traffic or is it due to a decline in the size of the beluga population? The collapse of the Hudson Bay Company's commercial fishery in the 1800s after 20 years of heavy exploitation was attributed to the avoidance of whales of the Great Whale and Little Whale rivers (Francis 1977). Indeed, Company personnel noted the belugas' reluctance to enter the nets. However, Finley et al (1982) and Reeves and Mitchell (1987) argue that is more likely that the whale stock was depleted. Some Inuit attribute the present lack of whales in the Kovic estuary, in north-eastern Hudson Bay, to the increase in boat traffic in the area while others believe the stock has been over-hunted. In the St. Lawrence, a decrease in the number of beluga frequenting the waters near Tadoussac and Baie Ste-Catherine is thought to be linked to an increase in boat traffic. The disappearance of beluga from other areas once regularly frequented by belugas (e.g. Manicouagan Banks and Rivière Ouelle) have been attributed to a reduction in population size and range of belugas, or changes in physical-chemical properties of these habitats (Manicouagan Banks) (Sergeant and Hoek 1988, Lesage et al 1999).

The number of whales in the Nastapoka estuary and their reaction to disturbance was recorded during July and August of 1983-4 (Caron 1987, Caron and Smith 1990). Observations, spanning a shorter time, were made in 1993 and 2000 (Doidge 1994b, 2001). The present study is a continuation of that of 2000, in an expanded form, where human disturbance and whale numbers have been documented at the Nastapoka and Little Whale estuaries in the same year. The purpose of the present study is to provide a greater understanding of current use of estuarine habitat by beluga and humans in eastern Hudson Bay.

Description of study sites

Physiography – Eastern Hudson Bay

The waters of the Hudson Bay Arc are generally less than 50 m. However, troughs, up to 100 m deep, run parallel to the eastern shore of the Manitounuk and Nastapoka Islands. A more detailed description of the bathymetry is contained in Kingsley et al (2001). The sea-ice breaks up by mid-June. The average flow of the Little Whale River (211 m^3sec^{-1}) and the Nastapoka (268 m^3sec^{-1}) are similar, and keeps the estuaries ice-free during the spring break-up (Hydro-Quebec 1993, Lamothe 1983). Beluga whales frequent these estuaries from late June to early September. A weak current flows northwards along the coast (DFO 1988). Tidal amplitude is small, ca 2 m. Travel along the coast by boat is possible by late June, but becomes more difficult with stormy weather in September and October until freeze-up in November when travel by boat is no longer possible.

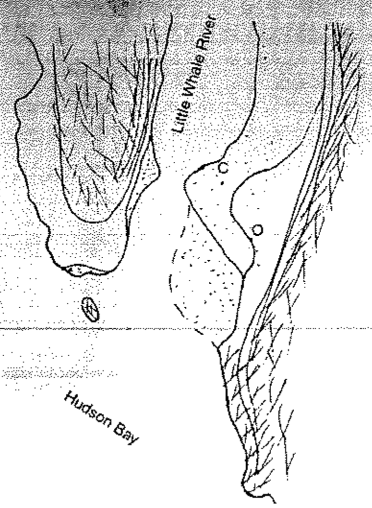
Little Whale River

The Little Whale River enters Hudson Bay at 56°00'N 76°47'W in an area of open coast between the Manitounuk Islands to the south and the Nastapoka Islands to the north (Fig. 1). The community of Kuujjuaraapik (also known as Poste-de-la-Baleine, Great Whale and by the Cree name of Whapmagoostui) is 200 km to the south-west and is the home of 650 Inuit and 725 Cree. Umiujaq, home to 350 Inuit, lies 135 km to the north. The estuary is 2 km wide at its mouth, bounded to the south by an escarpment and a low rocky point on the north. The river channel lies on the north side. It is less than 5 m deep; extensive sandy shoals occur on the southern side of the estuary and are exposed at low tide (Fig. 2).

Little Whale is a stop-over place for Inuit travelling between Kuujjuaraapik and Umiujaq, or from Kuujjuaraapik to Richmond Gulf. Both communities use it for subsistence purposes and camp there to hunt belugas, fish and harvest berries. Cree from Whapmagoostui also use the area for hunting caribou and fishing or for shelter when traveling along the coast.

Nastapoka River

The Nastapoka River flows into eastern Hudson Bay at 56°55'N 76°33'W (Fig. 1). The community of Umiujaq is situated 40 kilometers to the south. The nearest community to the north is Inukjuak (population 1300) which is 200 kilometers or a full day's boat journey away. The archipelago of the Nastapoka Islands is eight kilometers offshore and forms the western boundary of Nastapoka Sound. Upstream, the estuary terminates at the 30 meter high Nastapoka Falls, two



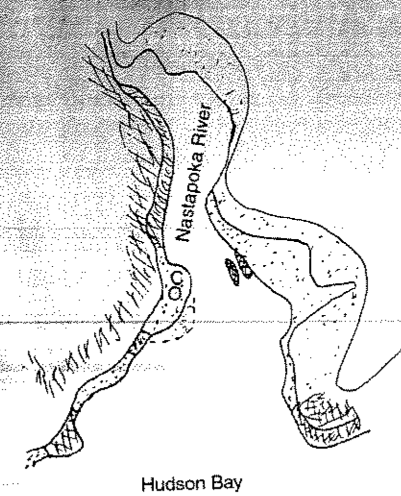


Figure 2. Estuary of the Little Whale River. Top of map faces east. Camp (C) on south side of river, upstream of narrows. Observation point (O) on hill SW of campsite. Rocks are shown as cross-hatching, sand as stipples. Dashed lines outline sandbars exposed at low tide.

Figure 3. Nastapoka Estuary, eastern Hudson Bay. Top of map faces east. Camp (C) on north side of river at Narrows. Observation point (O) on hill next to camp. Rocks are shown as cross-hatching, sand as stipples. Dashed lines outline sandbars exposed at low tide. (Based on Caron 1987).

kilometers from the coast. On each side of the estuary, the Canadian Shield is interspersed by sandy beaches and eskers. A narrows, halfway from the falls to the sea, divides the estuary into inner and outer segments (Fig. 3). A saltwater wedge extends upstream to the Narrows at high tide (Caron 1987).

METHODS

Observational sampling

Observational methods follow those of previous studies: during daylight hours (usually 0800 – 2100H) the estuary was scanned using a 15 to 40 power spotting scope or binoculars (Caron 1987, Doidge 2001, 1994b). When belugas were present, a spotting scope was used to classify whales as young-of-the-year, juveniles or adults (based on body length, shape and colour (Caron and Smith 1990, Doidge 1990a,b). Visibility, sea-state, wind, tide and whale location (offshore, outer estuary, inner estuary) were also recorded.

Throughout the day, the occurrence of any human disturbance on the water, in or near the river mouth, was noted. A continuous propagation of noise, with less than a five-minute interuption, was considered to be a single disturbance event. Thus, a vessel passing by the river, but not stopping, was logged as a single disturbance event. If the vessel entered the estuary, stopped and later left, this was logged as two separate events. A beluga hunt was logged as a single disturbance event (even though it might include many canoes) since the generation of noise was more or less continuous.

An elder hunter from Umiujaq and his family camped at the Little Whale River to provide logistic support for the observation crew. Initially, two Inuit hunters observed the river, but one decided to leave the study for personal reasons. Thus, most observations, between July 25 and August 24 (28 observational days), were made by the remaining observer (PA) who was later joined by another observer (DWD) on August 10. Observations of the estuary were made from a hill on the south side of the river (Fig. 2). There was a hiatus in the observations, August 12-14 inclusive, when the observers returned to Umiujaq for supplies and their return was delayed by bad weather.

Between July 23 and August 22, 2001 (31 days) hourly scans were made of the Nastapoka River. The field party camped on the north side of the river on the sandy spit that forms a narrows, the boundary between the inner and outer estuaries. Most observations were made from an esker (elevation 10 m) just downstream of these narrows, ca 40 m from the river's edge (Fig. 3). Initially, the team consisted of two Inuit hunters from Umiujaq (JN, GI), biologists from Makivik (DWD) and DFO (VL and AR), and a University student (ST). The team was augmented by graduate students who visited the estuary to sample beluga tissue during the first two weeks of August. While it was necessary to make trips to Umiujaq for food and supplies, enough personnel were on hand to observe the river through out the study period.

The two camps communicated via field radio to verify sampling techniques and any logistical needs.

Comparisons with previous studies

Published data from the Nastapoka was re-examined and compared to that gathered in 2001. Caron (1987) and Caron and Smith (1990) provide detailed data on the occurrence of whales in this estuary in 1984 including that of individual whales. This data has been re-analysed to investigate if the pattern of use of the estuary has changed over the past 15 years.

Terminology

As discussed in Doidge (1994a), the terminology used by Caron and Smith (1990) to describe and evaluate the presence and absence of whales at the estuary was not used. Terms such as "partial" and "total recovery" to describe the number of belugas in the estuary after disturbance conveys the wrong connotation for the process involved. It is unlikely that the same individuals are the first to appear back in the estuary after belugas have been scared out (See Results and Discussion). Hence, we avoid the term "recovery".

The passage of time is still used as the parameter to measure disturbance and has been defined as follows:

DOA	Duration of Absence – The interval of time that whales are not present (seen) in the estuary. This is assessed through the observational scans or the commencement of a hunt.
DOAD	Duration of Absence following Disturbance – Interval of time between the sighting of whales when a disturbance has occurred between these sightings.
NAR	No Apparent Reason – Interval of time between sightings of whales when whales have left estuary without any apparent disturbance occurring.
DT	Time interval between disturbance events
DE	Disturbance event – A period of noise (usually boat traffic) that is not separated by more than 5 minutes of silence. Thus a number of canoes leaving the estuary over a period time, but within 5 minutes of each other, would be logged as a single disturbance event. Beluga hunts and the associated boat traffic afterwards were considered single events. The interval of 5 minutes is arbitrary.
VT	Vessel traffic is the sum of individual vessels operating within the area. If during a single DE, many canoes left, each canoe would be logged as a single occurrence of vessel traffic.

Caron (1987) re-sighted a number of individuals (recognized by body scars), however no individual whales have been followed since then. Unless otherwise noted, “whales” or “belugas” refer to animals for which the history of estuarine occupation is unknown.

Data manipulation and statistical treatment

Scans were made during daylight hours only - this left a hiatus of 9 to 12 hours during the night. Also, observations could not be made during periods of heavy fog or due to logistical constraints. Therefore, the duration of absence is not considered the time between sightings, but has been adjusted for the time of the whales’ likely return. For example: if no whales are seen at 2100H one evening and whales are observed at 0600H the next day, the best estimate of the time for the end of a DOA is not 0600H, but 0130H (the midpoint of the time interval between observations)[1]. Departure times have been adjusted in a similar manner. In the analysis we have retained both corrected and uncorrected DOAs for comparison with previous studies that have not made this adjustment (Doidge 1994b, 2001) or have not stated if such a correction has been applied (Caron 1987, Caron and Smith 1990).

SAS™ (V8.2) was used for data manipulation and statistical analysis. The interval data was non-normal, therefore the median rather than the mean was used as the measure of central tendency (Sokal and Rohlf 1969). Analysis-of-variance of the ranked data was used to test for statistical differences.

[1] The probability density function of the time of last sightings of the day and the first sightings of the next day were examined and found to be symmetrical mirror images indicating that use of the mid-point was appropriate.

RESULTS

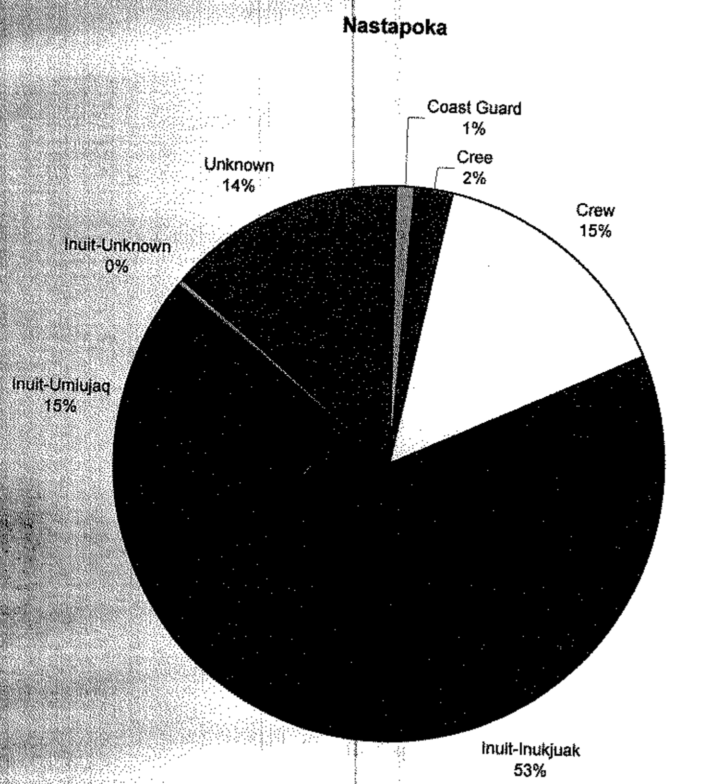
Disturbance

Compared to Little Whale River, Nastapoka is the busier place whether assessed by the number of disturbance events, the total duration of those events, or the amount of vessel traffic. Inuit from Inukjuak were the predominant users of the Nastapoka, but people from Umiujaq also used the river. Little Whale is used by Inuit from Kuujjuaraapik and Umiujaq, along with some whale hunters from Inukjuak who now come to Little Whale when whales are not present at the Nastapoka (Fig. 4).

Vessel traffic

Between July 25 and August 24, 111 occurrences of vessel traffic were recorded at Little Whale River. Vessel traffic occurred on all but 4 of the 28 days of observation at Little Whale River (July 25, August 18, 22, 24) and on all but 5 of the 31 days of observation at the Nastapoka (July 24, August 2,13,21,22). At Little Whale, 67% of the traffic was freighter canoes and 25% speedboats. At Nastapoka, canoes dominated vessel traffic (84%); speedboats were less common (8%).

The groups of people using Nastapoka were similar to Little Whale (Fig. 4). Of the vessel traffic (Nastapoka-Little Whale), 68-48% were Inuit who had come to the river to hunt belugas, to fish, or passed-by while traveling to another area; 15-16% were caused by the observation crew (usually following other disturbance events); 2-3% were Cree from Great Whale who were travelling along the coast; There was a greater proportion of Unknown or Miscellaneous at Nastapoka (14%) than at Little Whale (5%).



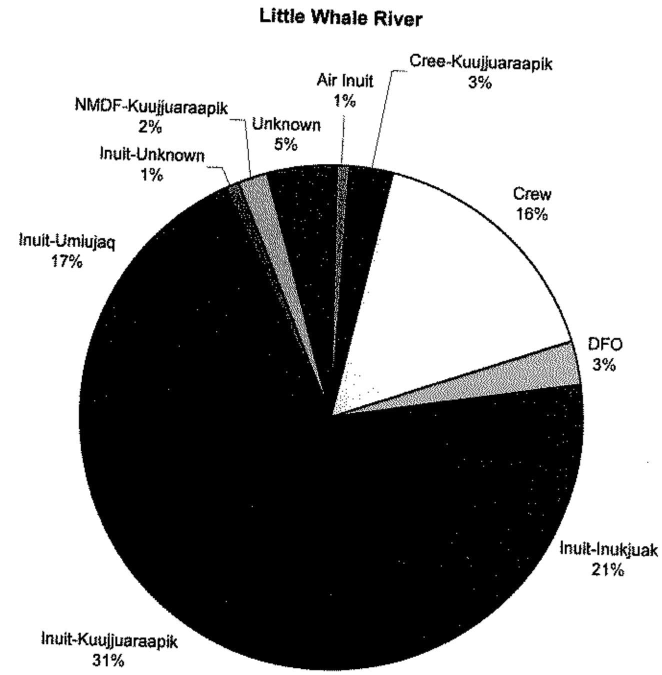


Figure 4. Community use of Little Whale (n =111) and Nastapoka (n=203) estuaries as estimated from vessel traffic.

Disturbance Events and their Duration

At the Nastapoka, 126 disturbances were recorded over the 31-day observation period compared to 74 over 28 days at Little Whale River. These disturbances totaled 44.0 hours at Nastapoka compared to 17.8 hours at Little Whale.

It follows that the higher frequency of disturbances at the Nastapoka would lead to a shorter interval of "Quiet" time between sequential disturbances. Little Whale was significantly quieter than Nastapoka (Sites significantly different: ANOVA on Ranks, $F_{1,196}$ 12.96, $p<0.001$, Table 1).

Table 1. "Quiet Time" Interval of time (hours) between sequential disturbances at Little Whale and Nastapoka rivers, Summer 2001.

	Little Whale	Nastapoka
N	73	125
Median	3.5	1.7
Mean	8.6 ± 9.4	5.4 ± 8.7
Mode	0.67	0.42
Range	0.1 – 37.6	0.1 – 50.1

Hunting

During the study period, 5 hunts took place at Nastapoka and 10 hunts at Little Whale River resulting in the harvest of 14 and 15 whales respectively (Appendix I). Typically, the hunts at the Nastapoka lasted 30 to 45 minutes although motor activity would continue for most of the day while meat and muktuk were transported to camp. Carcasses were towed to the outer estuary and sunk for the animals of the sea to feed on by Inukjuak hunters whereas hunters from Kuujjuaraapik and Umiujaq left the carcasses on the land for the animals there.

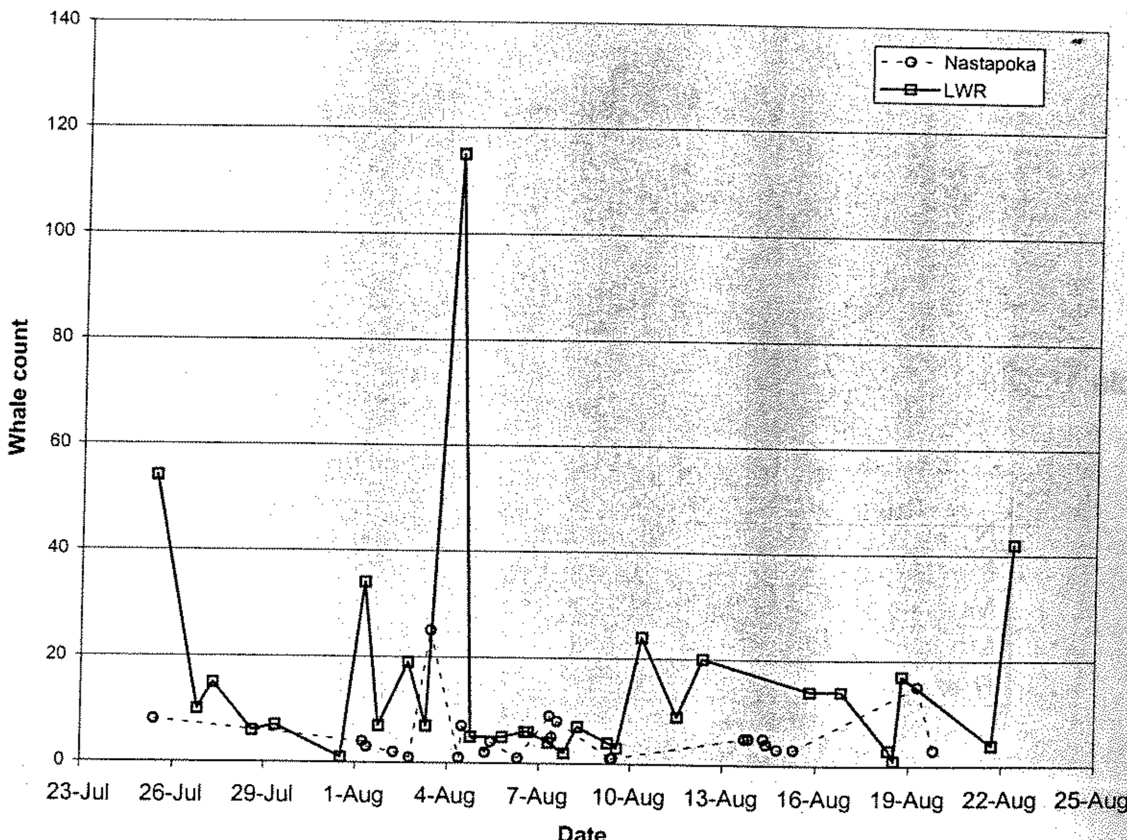


Figure 5. Counts of beluga whales in the Little Whale and Nastapoka estuaries, summer 2001.

Whale occurrence

At the Nastapoka, belugas were sighted on 15 of the 31 days of observation. The maximum of 25 animals was seen on August 3 (Fig. 5). Whales occurred on almost a daily basis at Little Whale River; whales were observed on 24 of the 28 days of observation. The highest count was 115 whales on August 4. During a storm on August 13, when precise counts were not possible, over 100 beluga were estimated to be in the river. Similarly, on August 15, the estimate was 50+ and on August 21, the estimate was 100+.

Due to heavy boat traffic and hunting activity, whales did not remain in the estuaries for extended periods. At Little Whale River, the median time was 7 hours whereas at the Nastapoka 50% of the groups remained in the estuary for less than 2 hours (Significant difference between sites: ANOVA on ranks $F_{1,41}$ 5.43, $P = 0.025$, Table 2).

Table 2. Duration of presence (hours) of beluga at Little Whale and Nastapoka Estuaries.

	Little Whale	Nastapoka
No. of groups	23	20
Median	7.0	1.8
Mean ± SD	9.9 ± 14.7	3.6 ± 5.5
Range	0.5–69.5	0.5–22.4

Herd Composition

During 50 scans at the Nastapoka and 91 at Little Whale River, the composition of the herd was recorded (Table 3). Note that this sample includes sequential scans and is thus biased by repeated observations of some groups.

Because whales did not remain in the estuaries for long (due to frequent disturbance), we consider these whales to be social groups or "pods". Pod type was determined by examining each of the sequential scans (when whales were present) and tallying the stage-classes present. Thus the sample is based on number of pods, not the number of scans and avoids the bias in Table 3. The frequency of occurrence of different pod types is presented in Table 4. Pods made up of all three stage-classes are the most frequently seen at both Little Whale and Nastapoka, but they dominate the sightings at Little Whale (68% of pods observed). The larger pod size at Little Whale may increase the likelihood that young-of-the-year are seen there compared to the Nastapoka where less whales and smaller pods occur.

Table 3. Group size and stage composition of beluga herds seen at the Little Whale and Nastapoka rivers, summer 2001 (based on all scans).

Stage		Little Whale (91 scans)	Nastapoka (50 scans)
Young-of-the-Year	No. in group	2.1 ± 2.6	1.3 ± 1.3
	Median	1	1
	Range	0 – 11	0 – 5
	% of total	9.7%	22.7%
	Total of counts	190	66
Juvenile	No. in group	3.1 ± 2.6	0.7 ± 1.1
	Median	3	0
	Range	0 – 11	0 – 5
	% of total	14.5%	12.0%
	Total of counts	284	35
Adult	No. in group	16.4 ± 26.6	3.8 ± 3.7
	Median	7	3
	Range	0 – 144	1–25
	% of total	75.9%	65.3%
	Total of counts	1489	190
Overall	No. in group	21.6 ± 28.6	5.9 ± 4.6
	Median	13	5
	Range	1–152	1–25
	Total whales	1,963	291

Table 4. Pod types at Little Whale and Nastapoka rivers, Summer 2001.

Pod type	YOY	Juv.	Adult	Little Whale	Nastapoka
All classes	X	X	X	25 (68%)	8 (37%)
Adults only	O	O	X	6 (16%)	6 (27%)
Young & Adults	X	O	X	1 (1%)	6 (27%)
Juveniles & Adults	O	X	X	5 (14%)	1 (1%)
Juveniles only	O	X	O	0	1 (1%)
Total no. of pods				37	22

Response to disturbance

Duration of absence

Whales immediately left the estuaries when disturbed by motor traffic. For half of the occurrences, beluga would not be seen again in the estuaries until 10 to 11 hours afterwards at the Little Whale and Nastapoka respectively. At Nastapoka, the duration-of-absence (DOA) was much more variable than at Little Whale (Table 5).

Table 5. Duration of Absence (hours) of beluga from the Little Whale and Nastapoka rivers, summer 2001.

		Little Whale	Nastapoka
DOA	X ± SD	19.9 ± 18.4	25.1 ± 39.9
	Range	2.0 – 81.5	1.1 – 163.4
	N	29	23
	Median	15.0	12.3
	Between Sites	$F_{1,50}$ 0.83, P=0.37	
DOA $_{Corrected}$	X ± SD	14.5 ± 14.9	24.3 ± 39.4
	Range	2.0 – 69.0	1.1 – 159.2
	N	27	23
	Median	10.2	11.0
	Between Sites	$F_{1,48}$ 0.15, P=0.70	

Table 6. Duration of Absence after disturbance (hours) of beluga from the Little Whale and Nastapoka rivers, summer 2001.

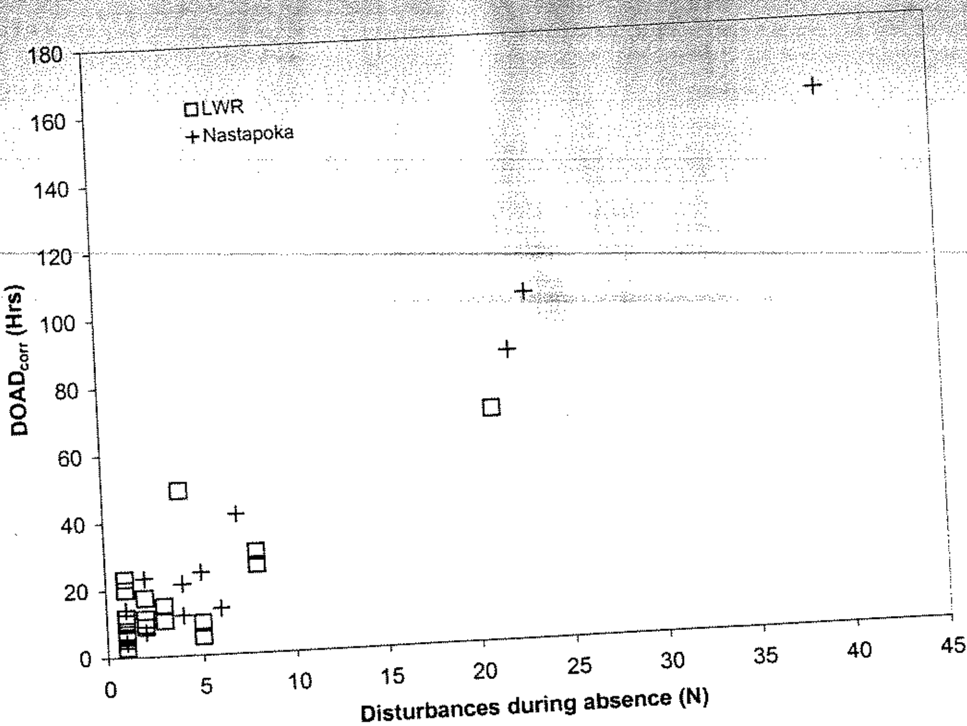
		Little Whale	Nastapoka
DOAD	X ± SD	22.2 ± 19.1	44.1 ± 48.4
	Range	2.8 – 81.5	4.3 – 163.4
	N	24	12
	Median	15.4	22.3
	Between Sites	$F_{1,34}$ 2.79, P=0.10	
*DOAD $_{Corrected}$	X ± SD	16.4 ± 15.9	42.5 ± 48.2
	Range	2.8 – 69.0	4.3 – 159.2
	N	22	12
	Median	10.5	22.3
	Between Sites	$F_{1,32}$ 4.69, P=0.038	

*Sites significantly different, p <0.05, ANOVA on ranked data

Table 7. Duration of Absence after no-apparent-reason (hours) of beluga at the Little Whale and Nastapoka rivers, summer 2001

		Little Whale	Nastapoka
NAR	X ± SD	8.8 ± 8.0	4.5 ± 4.9
	Range	2.0 – 17.5	1.1 – 15.7
	N	5	11
	Median	4.0	2.2
	Between Sites	$F_{1,14}$ 2.84, P = 0.11	
$NAR_{Corrected}$	X ± SD	6.3 ± 4.6	4.4 ± 4.6
	Range	2.0 – 12.3	1.1 – 15.7
	N	5	11
	Median	4.0	2.2
	Between Sites	$F_{1,14}$1,63, P = 0.22	

Although the estuaries did not differ in the overall time interval that whales were absent (Table 5, DOA), the sites differed significantly when disturbance was taken into account (Table 6, $DOAD_{Corrected}$). Within the estuaries the duration-of-absence following disturbance was longer than when whales left for no apparent reason (NAR). No difference between sites was found in NAR, however, the small sample size, especially from Little Whale River, limits the power of statistical comparisons (Table 7).



ig. 7. Relationship between duration-of-absence (DOAD) and the number of disturbances occurring during absence.

actors affecting Duration-of-Absence

At both sites, the duration of absence when disturbance occurred (DOAD) was related to the number of disturbance events occurring during the absence (Fig. 7). This relationship was particularly strong at the Nastapoka ($R_s = 0.82$, $p=0.001$, $n = 12$), but also significant at the Little Whale River ($R_s = 0.52$, $p=0.01$, $n = 21$).

Table 8. Duration of absence of identified beluga from the Nastapoka Estuary after hunts and motor traffic (Data source Caron 1987, Caron and Smith 1990).

Activity	Whale ID	Stage Class	Absence (hr)	Date
Hunt	N8	3/4	380	12-Jul-84
	N10	White & Neonate	117	12-Jul-84
	N11	White & Half	117	12-Jul-84
	N3	White & Half	144	3-Aug-84
	N39	White	56	3-Aug-84
	N15	White	48	3-Aug-84
		Mean ± SD	144 ± 122	
		Median	117	
		Range	48 – 380	
		N	6	
Motor	N1	White & Half	165	7-Jul-84
	N3	White & Half	372	7-Jul-84
	N4	White & Neonate	372	7-Jul-84
	N7	3/4	574	7-Jul-84
	N8	3/4	106	7-Jul-84
	N10	White & Neonate	42	25-Jul-84
	N20	3/4	236	25-Jul-84
	N19	3/4	169	25-Jul-84
	N26	White	177	25-Jul-84
	N23	White & Neonate	123	20-Aug-84
	N1	White & Half	33	24-Aug-84
	N3	White & Half	104	24-Aug-84
		Mean ± SD	206 ± 159	
		Median	167	
		Range	33 – 574	
		N	12	

Re-examination of published data on individual animals

During 1984 a number of individuals that had distinctive scars were re-sighted (Caron 1987, Caron and Smith 1990). The time for re-appearance in the estuary of these animals varied greatly whether after hunting or motor traffic (Table 8). The effect of the type of disturbance on individuals was not examined by Caron and Smith (1990). Similar to the herd's re-appearance, the identified whales showed no difference in the duration-of-absence after hunting or after motor traffic (Ranked ANOVA, $F_{1,16}$ 0.55, P = 0.47). These individual whales were also away from the estuary, on average, for much greater periods and showed greater variability than whales-in-general, indicating that they were not part of the first herds to re-appear to estuaries following a disturbance (33 - 574 hr vs 2 - 48 hr, Tables 4 and 5 in Caron and Smith 1990).

Doidge (2001) noted that the duration-of-absence of these known individuals decreased over the observation period by approximately 1 day in 5 (Fig. 8). This change is greatest in July - a time when whale numbers in 1984 at the Nastapoka showed the greatest rate of increase (Caron and Smith 1990, Figure 2, p. 73). Re-analysis of Caron's (1987) data indicates that this reduction in duration-of-absence is not a seasonal effect ($F_{1,51}$ = 2.96, p=0.087), but rather related to the decrease in motor traffic from July to August ($F_{1,51}$ = 254, p<0.001). The decrease in the duration-of-absence likely accounts for the build-up[2] in whale numbers during August 1984.

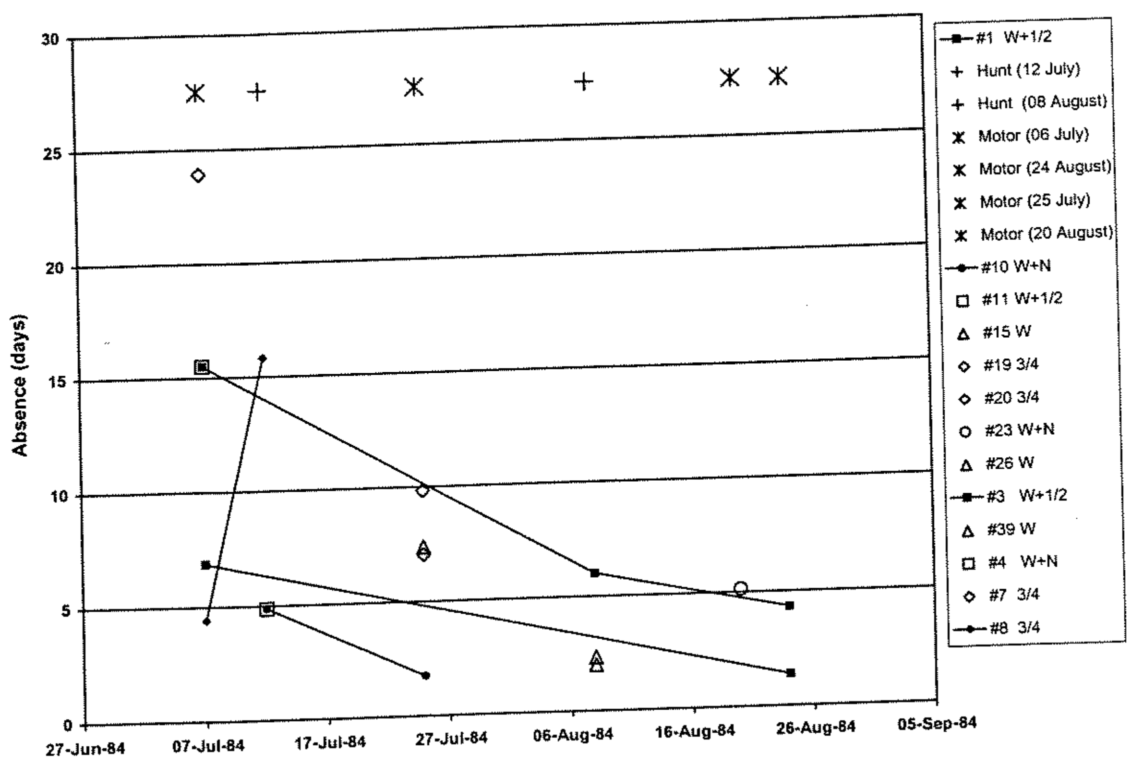


Figure 8. Duration-of–absence of identified whales from the Nastapoka River during summer 1984. Whales re-sighted once are designated by a single point, whales re-sighted more than once connected by a line. Dates of hunts (+) and motor traffic (X) at top of the graph. Data source: Caron 1987, Caron and Smith 1990. Reduction in duration-of-absence is not a seasonal effect but due to a reduction in vessel traffic (See text).

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[2] Caron and Smith (Fig. 2, p. 76, 1990) shows an increase in whale numbers with season rather than an "attrition".

DISCUSSION

Role of estuaries

The importance of estuaries to belugas has been inferred from the occupation of estuaries despite disturbance (Finley et 1982), the site-fidelity of individual whales (Caron 1987, Caron and Smith 1990), the thermal benefits of warm estuarine waters to the young (Sergeant 1973, Sergeant and Brodie 1975, Breton-Provencher 1979) and all age-classes (Fraker et al 1979), physiological factors such as the moulting of skin (Finley et al 1982, St. Aubin and Geraci 1989, St. Aubin et al 1990) and the predictably ice-free habitat offered by estuaries in spring (Breton-Provencher 1979). On the basis of the above, estuaries are generally considered to be critical habitat for belugas. Caron (1987) points out the only common feature of all estuaries that are frequented by belugas "is the presence of warmer and fresher waters compared to the surrounding seas". River current is another feature in common. Belugas occur in places such as West Greenland and Svalbard, where estuaries do not exist (Heide-Jorgensen and Teilman 1994, Lydersen et al 2001). In Svalbard, belugas spent more than 50% of their time at glacier fronts – areas where there is a fresh water influx and high prey abundance but no thermal advantage (Lydersen et al 2001).

The function of estuaries as calving grounds suggested by Sergeant (1973) was dismissed by Caron (1987) since her observations over two summers (1983-84) at the Nastapoka did not show a pronounced seasonal increase in neonate numbers. Also, the peak of parturition for the eastern Hudson Bay population occurs before the period of estuarine occupation (Doidge 1990b).

The thermal benefit of warmer estuarine waters is directly proportional to the temperature difference between the whale's body and the surrounding water. In summer, the temperature of the Nastapoka estuary varies from 11° to 18°C compared to 0° to 9°C offshore. Conductive heat loss for whales in the estuary is 2/3 of that offshore. Calves in the estuary should be able to meet this loss by basal metabolic heat production alone, although younger animals may have to remain active when in cooler waters offshore (Doidge 1990c).

The Inuit observe that warm, flowing, fresh water and sand banks on which to rub enhances the moulting process (Finley et al 1982). The pronounced rubbing behaviour associated with moulting belugas at Cunningham Inlet in the High Arctic is not seen at the Nastapoka which is attributed to differences in sighting conditions between the two sites (Smith et al 1994). However, most whales have already moulted by June when they enter eastern Hudson Bay estuaries (Doidge 2001). Estuaries likely promote the moulting process; theoretical calculations suggest that beluga can moult in water 5°C or greater (Boily 1995).

Estuaries are considered to be important feeding areas for beluga by Breton-Provencher (1979) who found the stomachs of two belugas harvested at the Great Whale River and two at Little Whale River to contain prey. The likelihood that beluga were feeding at the Nastapoka was dismissed by Caron (1987) who points out that "feeding in such a small region is unlikely and empty stomachs of whales harvested in the area support this idea". Indeed, only 3 of 83 stomachs examined during a four-year study at the Nastapoka and Little Whale rivers were full (Doidge 1990b). The others were either empty or contained trace amounts of hard parts of fish or crustacea. None of the stomachs that Belanger examined during the net fishery in the 1850s at the Little Whale contained fish (Reeves and Mitchell 1987). This lack of food items has been attributed to the regurgitation of food by beluga while they are being chased during the hunt (Reeves and Mitchell 1987). During four years of observing Inuit hunts of beluga at the Nastapoka River during the 1980s regurgitation was not observed (Doidge 1990b). When whales enter the estuary, they may have full stomachs, likely from feeding offshore. Of the twelve adult whales that were harvested shortly after they had appeared at the Nastapoka in 2001, three had prey in their stomachs (Appendix I). If estuaries are used for feeding, the amount of disturbance at the Nastapoka is now too great to permit belugas to spend sufficient time in the estuary to feed.

Estuarine use by whales

In August, belugas can still be found in the Nastapoka and Little Whale estuaries even in spite of almost daily disturbance by vessel traffic. Within hours of disturbance, belugas can sometimes be seen again at the Little Whale and Nastapoka estuaries. Although identifiable individuals in the 1983-84 study took ca. 10 times longer to re-appear at the estuary compared to first belugas sighted, they still return to estuaries despite disturbance. The degree of use of the estuaries by individual beluga indicates the importance of the habitat to the species. Different family groups and individuals may use the estuary at different times and to different degrees. If left undisturbed, many small groups enter the estuary and remain for sometime which results in a build-up in numbers. Caron and Smith (1990) found adults with calves to be the first to re-occupy the estuary, an indication that this group may spend a higher proportion of time there. Based on the re-sightings of identifiable animals, mainly white adults and large grey animals, they estimated that these animals passed a minimum of 30% of the 59-day study period in the estuary during 1984.

Whales (in general) appear at the estuary in a shorter time than the identified whales that had just previously occupied the estuary because these animals are likely not the ones that were subject to the disturbance. Some of the animals that are offshore are likely headed towards the estuary and are unaware that disturbance has occurred. These animals then arrive at the estuary. The size of the population and the amount of disturbance in the area probably influence the rate at which animals appear at the estuary.

The Nastapoka Estuary no longer experiences the build-up in whale numbers that it did at the time of Caron and Smith's study. In 2001, groups composed of all ages were the most frequent and thus the most likely to be the first to appear after an absence (Table 4). Once there, groups did not remain for long (Table 2) due to the frequent disturbance by vessel traffic. Group size has also decreased at the Nastapoka since 1984 (Table 10).

Table 9. Duration of absence after disturbance of beluga herds frequenting the Nastapoka and Little Whale estuaries between 1984 to 2001 (DOAD hours-uncorrected)

		Little Whale	Nastapoka
1984[1]	X ± SD	....	17.7 ± 14.1
	Range	....	2 – 48
	Median	....	16
	N	....	13
1993[2]	X ± SD	21.1 ± 15.1	28.6 ± 24.9
	Range	2 – 45	9 – 69
	Median	20	16
	N	11	5
2000[3]	X ± SD	....	30.5 ± 30.9
	Range	....	1 – 98
	Median	....	27
	N	....	9
2001	X ± SD	22.2 ± 19.1	44.1± 48.4
	Range	2 – 82	4 – 163
	Median	15	22
	N	24	12

Sources: [1]Caron and Smith 1990, [2]Doidge 1994, [3]Doidge 2001

The pattern of estuarine use appears to be different at Little Whale. There, large groups of whales still appear at the estuary, a situation similar to that observed in 1993 (Table 10). At Nastapoka, whales are absent from the river for longer periods than at Little Whale and the maximum duration of these absences has increased since 1984 (Table 9). Although, the median time of absence has not changed over the years, long periods of absence are becoming more and more common.

The distribution of whales seen during aerial surveys (Smith and Hammill 1986, Kingsley 2000) and recent satellite tracking of whales tagged at the Nastapoka and Little Whale indicate that belugas pass most of their time out of the estuaries in the waters between the coast and the Belcher Islands (Doidge and Hammill 2000, Kingsley et al 2001). A rough approximation of average estuarine use can be estimated from the portion of the population occupying estuaries versus offshore habitat. The source of data is somewhat crude (associated with high variance), but the calculation does furnish another estimate of estuarine use. The aerial survey in 1985 (Smith and Hammill 1986) estimated the surface population at 968 whales with an additional 474 animals in "traditional sites of coastal concentration," (139 whales at Nastapoka, 48 in Richmond Gulf and 287 at Little Whale). If all animals in the shallow estuaries are seen from the air, and assuming an additional 85% of the animals offshore are underwater and not seen during the offshore survey (Kingsley et al 2001), approximately[3] 21% of the population would have been in estuaries, of which, 6% (139/2265) were at the Nastapoka. Based on time sampling theory, these percentages represent the equivalent portion of time-activity budget of the average animal over the summer season. The higher proportion of time (30%) spent in the Nastapoka by whites and large greys accompanied by young (Caron and Smith 1990) would indicate that this habitat was more important to this group than to other classes of beluga.

Not all data support the above conclusion. Smith and Hammill (1986) found no difference in the size classes of animals seen inshore (estuaries) versus offshore. Satellite tagged animals in 1999 included two females with calves. These animals did not return to the estuary over a 60 and 90-day period respectively (Doidge and Hammill 2000). However, their use of the estuary previous to tagging is not known. The sex ratio of the harvest at the Nastapoka is close to unity (Doidge 1990, Lesage and Doidge In Prep.) indicating equal use of estuarine habitat by both sexes. Smith et al (1994), based on adult – calf associations, calculated a sex ratio that was strongly skewed towards females (1:3.2). Since females and young occupy the more upstream portion of the estuary compared to males and their observation site was near this position (Caron 1987), their sightings may be biased towards females and young. Although some hunters attempt to select males only, the sex ratio of the harvest is unity (Doidge 1990b, Lesage et al. 2001) The small number of whales, harvested in 2001 as they appeared at the estuary, is skewed towards males (Appendix I). However, given the great changes since the 1980s in the number of whales occupying the Nastapoka, the present situation may not reflect the past.

[3] 474/(968*1.85+474)*100, estimate is approximate as whales are not always in estuaries

Table 10. Herd composition of beluga whales at the Nastapoka and Little Whale rivers, 1984 – 2001.

Young-of-the-year		Little Whale	Nastapoka
1984[1]	X ± SD	....	...
	Range	....	...
	Per cent of group	....	19%
	No. scans	....	490
1993[2]	X ± SD	4.5 ± 4.2	2.2 ± 2.5
	Range	0 – 15	0 – 8
	Per cent of group	23%	19%
	No. scans	30	9
2000[3]	X ± SD	....	0.8 ± 1.1
	Range	....	0 – 3
	Per cent of group	....	15%
	No. scans	....	28
2001	X ± SD	2.1 ± 2.6	1.3 ± 1.3
	Range	0 – 11	0 – 5
	Per cent of group	12%	23%
	No. scans	91	50
Juvenile		**Little Whale**	**Nastapoka**
1984[1]	X ± SD	....	...
	Range	....	...
	Per cent of group	....	27%
	No. scans	....	490
1993[2]	X ± SD	8.0 ± 7.3	1.6 ± 1.8
	Range	0 – 26	0 – 5
	Per cent of group	23%	23%
	No. scans	30	9
2000[3]	X ± SD	....	1.1 ± 1.3
	Range	....	0 – 4
	Per cent of group	....	22%
	No. scans	....	28
2001	X ± SD	3.1 ± 2.6	0.7 ± 1.1
	Range	0 – 11	0 – 5
	Per cent of group	18%	11%
	No. scans	91	50
Adult		**Little Whale**	**Nastapoka**
1984[1]	X ± SD	....	...
	Range	....	...
	Per cent of group	....	54%
	No. scans	....	490
1993[2]	X ± SD	22.7 ± 24.9	8.6 ± 12.2
	Range	2 – 95	0 – 40
	Per cent of group	64%	58%
	No. scans	30	9
2000[3]	X ± SD	....	3.2 ± 2.4
	Range	....	0 – 8
	Per cent of group	....	63%
	No. scans	....	28
2001	X ± SD	16.4 ± 26.6	3.8 ± 3.6
	Range	0 – 144	0 – 5
	Per cent of group	70%	64%
	No. scans	91	50

Notes: [1]Caron and Smith 1990, their Table 6. n=490 scans (incorrectly given as n = 33,027 which was number of animals scanned). 1/3 length animals defined as YOY; ½ and 2/3 length combined as Juveniles; ¾ and white as Adults.
[2]Doidge 1994.
[3]Doidge 2001.

Why have whale numbers at the Nastapoka decreased since mid 1980s?

At Nastapoka, the maximum count of 25 belugas made in August 2001 (and earlier counts in 1993, 1999, 2000) do not approach the 250 maximum observed in 1984. Possible explanations for this include: disturbance has caused belugas to avoid the estuary, or the population of whales has decreased. A decrease in the population could be general, or local, ie only the population of whales that frequents the estuary has decreased.

Disturbance

In 1984, Caron and Smith (1990) recorded 13 disturbances to beluga (7 hunts and 6 motor traffic) over a 59-day period. The norm at that time was for one hundred or more whales to be in the river whereas presently, whales are generally absent. One hundred and twenty-six disturbance events by motor noise were recorded in 2001 over a period of 31 days, a major increase from 1984.

The time it takes for whales to appear at the Nastapoka estuary after a disturbance has also increased (Table 9). It is expected that population size and duration of absence would be inversely related. If whales were away from the estuary, on average, for a longer period of time, they would return less frequently which would decrease the number of whales in the estuary at any one time. If the population has decreased, but duration-of-absence remains constant, the number in the estuary would also be expected to decrease.

The duration-of-absence is related to the number of disturbance events at the estuaries, even if whales are absent at the time of disturbance (Figure 7). This relationship is stronger at Nastapoka which may be due to the noise from outboards being reflected within Nastapoka Sound, whereas at Little Whale, where it is an open coast, the sound may be dissipated offshore. Thus noise levels may be higher around Nastapoka causing less whales to occupy the area. If, however, the overall population has decreased but beluga now prefer the Little Whale River, the counts at Little Whale would be expected to show little or no decrease.

The decrease in whales seen at the Nastapoka may be influenced by the construction of the village of Umiujaq, which is only an hour's boat ride away. However, in August, most boat traffic is from Inukjuak and associated with the beluga hunt.. There has also been a change in hunting methods. In the mid 1980s, the beluga hunt of the Inukjuamiut operated from that community's long-liner, which came to Nastapoka carrying several freighter canoes. By the late 1990s, the community boat was no longer used. Hunters from Inukjuak now come to Nastapoka in freighter canoes and speedboats. In August 2000, more than eighty people, with twenty canoes, camped at the Nastapoka. The Nastapoka's popularity increased further in 2001 when 167 people in 33 canoes and the community's long-liner were at the river during the first week of August. Each family hoped to return home with muktuk.

A small number of Cree from Great Whale use both rivers as a base for caribou hunting and fishing. Although Cree use of the coastal zone has increased in the last twenty years, only a few Cree families venture as far north as the Nastapoka to hunt.

Evidence of avoidance – other factors

In the 1980s, up to 40 belugas might be harvested at the Nastapoka in one year (Doidge 1990b). This was before the estuary was closed to hunting in July, so the harvest was then more spread out over the summer. Presently, most hunting is concentrated in early August as soon as the season opens. In 2000, 40 whales were harvested within 8 days; in 2001, 14 taken in a period of 7 days. Thus the disturbance from hunting is now concentrated in early August. Also, carcasses are disposed of in the sea, at the mouth of the estuary. The large number of carcasses, deposited over a short period, may cause whales to avoid the river.

Evidence of population depletion

The aerial surveys of 1985 and 1993 have large variances associated with the estimates (Smith and Hammill 1986, Kingsley 2000). Thus, these surveys are limited to detecting only large changes in stock size. Simulation models, which incorporate recent harvest levels, predict the population has declined (Hammill 2001). Examination of the age structure of the harvest shows a drop in the median age of the animals in the harvest, an indication that the population could be depleted (Lesage et al 2001). A more detailed analysis of age-structure is underway to examine if changes have occurred since the 1980s in the age of whales harvested at the Nastapoka and Little Whale estuaries (Lesage and Doidge In prep).

When the beluga population is large, the likelihood that groups are approaching the estuary is high, whereas when the population is smaller, this probability is lower. When there is a high probability of groups entering the river, the duration-of-absence would be low. The mean and variance associated with duration-of-absence would be greater when the population is smaller. As the population becomes very small, the mean and range would be expected to approach the values in Table 8 which are based on only a few individuals.

Physiographic Factors

The physiographical features of the Hudson Bay Arc, including differences between Little Whale River and the Nastapoka may influence whale distribution. As stated earlier (Introduction), the Little Whale River enters Hudson Bay in a region of open coast where there is no island archipelago directly offshore, whereas the Nastapoka flows into Nastapoka Sound. The Sound may act to trap vessel noise, amplifying the disturbance effect; noise at Little Whale may be dissipated into the open waters off shore.

Belugas are believed to follow coastlines as an anti-predator strategy when threatened (Lydersen et al 2001). The difference in coastlines could therefore explain some of the differences in whale occurrence between Little Whale River and Nastapoka. At Little Whale, there is a single coastline to follow, that of the mainland, whereas at Nastapoka the offshore island chain offers an additional two coasts which to follow. Belugas are dispersed within the Hudson Bay arc (Smith and Hammill 1986, Kingsley 2000). Those that are near shore would be expected to flee towards the coast when disturbed which should lead to more whales at Little Whale River than at the Nastapoka.

SUMMARY and CONCLUSIONS

Large groups of fifty to hundred belugas can be seen at the Little Whale River whereas during the last fifteen years the number of belugas observed in the Nastapoka estuary has declined sharply. Several disturbance factors have likely caused the decline: boat traffic in the area is now almost daily; beluga hunting is now concentrated in the first week of August which may cause greater disturbance than harvesting in the past that occurred from June to September. A reduction in numbers at the Nastapoka is not direct evidence that the eastern Hudson Bay population has declined because the concomitant increase in disturbance makes the situation difficult to interpret. Older individuals may have changed their distribution pattern over time to remain offshore. The decrease in the overall mean age of the population may indicate a reduction in population size, or a changing distribution of older animals away from the estuary. However, the results of simulations, based on current harvest levels, indicate the size of the stock has been reduced.

The degree to which estuaries are important to beluga is not clear. Apart from aerial surveys, and to some extent satellite tagging, most other studies of belugas generate data that is specific to belugas in estuaries. Estuaries are the sampling sites. This can introduce a land-based bias when assessing what habitat is critical for the species. However, use of estuarine habitat in August, as assessed by the number of whales that occupy the habitat over time, has sharply decreased due to boat traffic. The Little Whale and Nastapoka estuaries are closed to hunting in July, but we lack data on boat traffic for that month.

Belugas in estuaries are highly susceptible to hunting pressure as they are easier to catch there. This makes the estuaries very attractive places for Inuit to hunt belugas. The hunt for subsistence food requires expenditures for boats, rifles, fuel and food. Hunters thus wish to maximise their return, especially those that have traveled far to reach the estuaries. Thus a decrease in the number of whales in the estuaries is of concern to them, but opinions differ as to the cause of the change in whale abundance.

The number of belugas occurring in estuaries is difficult to predict. The presence of whales is influenced by the amount of boat traffic occurring in the estuaries, regardless of whether belugas are present at the time of disturbance. Boat traffic appears to have a greater effect on the duration of absence at Nastapoka than at Little Whale. It is speculated that this is related to sea-bottom topography.

To determine if noise and the change in distribution patterns in older individuals can be important factors in the reduction in the number of belugas seen at the Nastapoka estuary, noise levels should be measured and movements of individual whales in and out of estuaries should be tracked. Such assessments are planned for 2002.

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REFERENCES

Blane, J.M. and R. Jackson. 1994. Impact of ecotourism boats on the St. Lawrence beluga whales. Environmental Conservation 21:267-269.

Boily, P. 1995. Theoretical heat flux in water and habitat selection of phocid seals and beluga whales during the annual moult. J. theor. Biol. 172:235-244.

Breton-Provencher, M. 1979. Etude de la population de belugas de la region de Poste-de-la-Baleine (Nouveau Quebec). GIROQ. Rapport a l'Hydro-Quebec, Projet Grande-Baleine (mandat OGB/76-1) 100 p.

Brown-Gladden, J.G., M.M. Ferguson and J.W. Clayton. 1997. Matriarchal genetic population structure of North American beluga whales *Delphinapterus leucas* (Cetacea: Monodontidae) Mol. Ecol. 6:275-281.

Caron, L.M.J. 1987. Status, site fidelity and behaviour of a hunted herd of white whales (*Delphinapterus leucas*) in the Nastapoka estuary, eastern Hudson Bay. MSc Thesis, McGill University, Montreal. 136 p.

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

de March, B.G.E. and L.D. Maiers. 2001. Stock discrimination of belugas (Delphinapterus leucas) hunted in eastern Hudson Bay, northern Quebec, Hudson Strait and Sanikiluaq (Belcher Is.) using mitochondrial DNA and 15 mitochondrial loci. Canadian Science Advisory Secretariat. DFO. Research Document 2001/050. 29p.

DFO. 1988. Sailing Directions : Labrador and Hudson Bay. 6th Edition. Ottawa. 458 p.

Doidge, D.W. 2001. Use of the Nastapoka Estuary by humans and beluga during summer 2000. Report 12-405. Submitted to Environment Canada Species at Risk program (Ref. P1HQ-2000-1-0001). Makivik Corporation. Kuujjuaq. March 2001. 20 p

Doidge, D.W. 1994a. Land-based observations of beluga whales at the Little Whale and Nastapoka rivers, eastern Hudson Bay. Summer 1993. Report submitted to the Aboriginal Fisheries Strategy of the Department of Fisheries and Oceans Canada. Makivik Corporation, Kuujjuaq, Qc. 30 p.

Doidge, D.W. 1994b. Coastal reconnaissance survey of belugas in eastern Hudson Bay, August 21, 1993. Report submitted to the Quebec Federal Fisheries

Development Program of the Department of Fisheries and Oceans Canada. Makivik Corporation, Kuujjuaq, Qc. 8 p.

Doidge, D.W. 1990a. Age-length and length-weight comparisons in the beluga, *Delphinapterus leucas*, Pages 59-68 *in* Advances in research on the beluga whale. T.G. Smith, D.J. St. Aubin and G.R. Geraci (ed.). Can. Bull. Fish. Aquat. Sci. 224.

Doidge, D.W. 1990b. Age and stage based analysis of the population dynamics of beluga whales, *Delphinapterus leucas*, with particular reference to the Northern Quebec population. Ph.D. Thesis, McGill University, Montreal. 190 p.

Doidge, D.W. 1990c. Integumentary heat loss and blubber distribution in the beluga, *Delphinapterus leucas*, with comparisons to the narwhal, *Monodon monoceros*. Pages 129-140 *in* Advances in research on the beluga whale. T.G. Smith, D.J. St. Aubin and G.R. Geraci (ed.). Can. Bull. Fish. Aquat. Sci. 224.

Doidge, D.W. and M.O. Hammill. 2000. Movements of beluga tagged at the Nastapoka River, Summer 1999. Report 12-375 submitted to World Wildlife Fund Canada and the Department of Fisheries and Oceans. Makivik Corporation, Kuujjuaq, Qc. 10 p.

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

Fraker, M.A., C.D. Gordon, J.W. McDonald. J.K.B. Ford and G. Cambers. 1979. White whale (*Delphinapterus leucas*) distribution and abundance in relationship to physical and chemical characteristics of the Mackenzie Estuary. Can. Fish. Mar. Serv. Tech. Rep. 863. 56p.

Francis, D. 1977. Whaling on the Eastmain. Beaver 308:14-19.

Hammill, M.O. 2001. Beluga in Northern Quebec: Impact of harvesting on population trends of beluga in eastern Hudson Bay. Canadian Science Advisory Secretariat. DFO. Research Document 2001/025. 18p.

Heide-Jorgensen M.P. and Teilman J. 1994. Growth, reproduction, age structure and feeding habits of the white whale (*Delphinapterus leucas*) in West Greenland waters. Meddr Gronland, Biosci. 39:195-212.

Hydro-Quebec. 1993. Grande-Baleine Complex. Part 2. Hydroelectric complex. Book 7. Cumulative Impacts. Hydro-Quebec. Aug. 1993. 88p.

Kingsley, M.C.S. 2000. Numbers and distribution of beluga whales, *Delphinapterus leucas*, in James Bay, eastern Hudson Bay, and Ungava Bay in Canada during the summer of 1993. Fish. Bull. 98:736-747.

Kingsley, M.C.S., S. Gosselin and G.A. Sleno. 2001. Movements and dive behaviour of belugas in Northern Quebec. Arctic 54:262-275.

Lamothe, P. 1983. Etude préliminaire d'environnement, Projet Nastapoca – Eau Claire. Report presented to Vice President, Environment, Hydro-Quebec. May 1983. 125 p.

Lesage, V., C. Barrette, M.C.S. Kingsley and B. Sjare. 1999. The effect of vessel noise on the vocal behavior of belugas in the St. Lawrence River estuary, Canada. Marine Mammal Science 15: 65-84.

Lesage, V., D.W. Doidge and R. Fibich. 2001. Harvest statistics for beluga whales in Nunavik, 1974-2000. CSAS Res. Doc. 2001/022. DFO. Ottawa. 35 p.

Lesage, V and W. Doidge. In Prep. Age distribution of the harvest of beluga whales in eastern Hudson Bay, 1983 to 2001. Institute Maurice Lamontagne, DFO. Mont-Joli, QC.

Orr, J.R., D.J. St. Aubin, P.R. Richard and M.P. Heide-Jorgensen. 1998. Recapture of belugas, *Delphinapterus leucas*, tagged in the Canadian Arctic. Mar. Mamm. Sci. 14:829-834.

Reeves, R.R. and E. Mitchell. 1989. Status of white whales, *Delphinapterus leucas*, in Ungava Bay and Eastern Hudson Bay. Can. Field-Nat. 103:220-239.

Reeves, R.R. and E. Mitchell. 1987. History of the white whale *Delphinapterus leucas* exploitation in eastern Hudson Bay. Can. Spec. Publ. Fish. Aquat. Sci. 95:45p.

Richard, P.R., J.R. Orr and D.G. Barber. 1990. The distribution and abundance of belugas, *Delphinapterus leucas*, in eastern Canadian waters: a review and update. Pages 23-38 *in* Advances in research on the beluga whale. T.G. Smith, D.J. St. Aubin and G.R. Geraci (ed.). Can. Bull. Fish. Aquat. Sci. 224.

Sergeant, D.E. 1973. Biology of white whales (*Delphinapterus leucas*) in western Hudson Bay. J. Fish. Res. Board Can. 30:1065-1090.

Sergeant, D.E. and W. Hoek. 1988. An update on the status of white whale *Delphinapterus leucas* in the Saint Lawrence Estuary, Canada. Biological Conservation 45:287-302.

Sergeant, D.E and P.F. Brodie. 1975. Identity, abundance and present status of white whales, *Delphinapterus leucas*, in North America. J. Fish. Res. Board Can. 32:1047-1054.

Smith, T.G. and M.O. Hammill. 1986. Population estimates of the white whale, *Delphinapterus leucas, in James Bay*, eastern Hudson Bay and Ungava Bay. Can. J. Fish. Aquat. Sci. 43:1982-1987.

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

Sokal, R.R. and F.J. Rohlf. 1969. Biometry. W.H. Freeman and Company. San Francisco. 776 p.

St. Aubin, D.J., T.G. Smith and J.R. Geraci. 1990. Seasonal epidermal molt in beluga whales, *Delphinapterus leucas*. Can. J. Zool. 68:359-367.

St. Aubin, D.J. and J.R. Geraci. 1989. Seasonal variation in thyroid morphology and secretion in the white whale, *Delphinapterus leucas*. Can. J. Zool. 67:263-267.

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Appendix I. Biological information of beluga whales harvested at or near the Nastapoka River, summer 2001.

ID	Date	Location	Sex	Length	Colour	Reprod. Status	Foetus	Stomach
DLN01-01	01-Aug-01	Nastapoka	M	350	W			Empty
DLN01-02	01-Aug-01	Nastapoka	M	370	W			Empty
DLN01-03	01-Aug-01	Nastapoka	F	344	W	LP	M 20.5 cm	Small pieces of fish
DLN01-04	03-Aug-01	Pointe de la Baleine Blanche	M		G			
DLN01-05	03-Aug-01	Pointe de la Baleine Blanche	M		W			
DLN01-06	03-Aug-01	Pointe de la Baleine Blanche	M		G			Small shrimp-like decapods and fish
DLN01-07	03-Aug-01	Pointe de la Baleine Blanche	M		W			
DLN01-08	03-Aug-01	Pointe de la Baleine Blanche	M		G			
DLN01-09	03-Aug-01	Pointe de la Baleine Blanche	M	365	W			
DLN01-10	04-Aug-01	Nastapoka	F	350	W/LG	L	N	Small shrimp-like decapods and fish
DLN01-11	04-Aug-01	Nastapoka	F	198	DG			Milk
DLN01-12	07-Aug-01	Nastapoka	M	390	W			
DLN01-13	07-Aug-01	Nastapoka	M	400	W			
DLN01-14	07-Aug-01	Nastapoka	M	383	W			