Status, site fidelity, and behavior of a hunted herd of white whales (Delphinapterus leucas) in the Nastapoka estuary, eastern Hudson Bay

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ABSTRACT

Systematic observations on belugas (Delphinapterus leucas) occupying the Nastapoka River in eastern Hudson Bay were conducted during the summers of 1983 and 1984. The highest herd counts in 1983 and 1984 were 245 and 260 respectively. Neonates represented 19.2% of the herd in 1984. During the same year, the male to female adult sex ratio was estimated to be 1:4.3. Whales identified using natural marks and scars were seen both years, and throughout a same season. In 1984, a minimum average daily presence in the estuary of 30% was calculated for 24 of the most conspicuously marked whales. Average recovery periods of 40 and 24 hours were required for the whales to reoccupy the estuary after disturbances from hunts and motor traffic respectively.

The distribution of belugas in the estuary was found to be influenced mainly by the tide. The behavior of whales was found to be mainly influenced by the total number of whales. Age of whales was shown to be the most important factor in discriminating between classes of behaviors.

The groups found in the estuary were segregated partly according to age of individuals; the mixed age and the similar groups (adults or juveniles). The mixed age groups were larger, more abundant, more stable, and displayed a smaller behavioral repertoire than similar age groups.

RESUME

Des observations systématiques sur les marsouins blancs (Delphinapterus leucas) ont été faites dans l'estuaire de la rivière Nastapoka sur la côte est de la baie d'Hudson pendant les étés de 1983 et 1984. Les plus gros troupeaux de bélugas en 1983 comptaient 245 animaux et 260 en 1984. Les nouveaux-nés représentaient 19.2% du troupeau en 1984. Une méthode d'estimation indirecte de la proportion des mâles adultes versus celle des femelles adultes a produit un rapport de 1:4.3 pendant cette même année. Les marsouins identifiés à l'aide de marques naturelles et de cicatrices, ont été observés d'une année à l'autre et au cours d'une même saison. En 1984, une présence journalière minimum de 30% a été calculée pour 24 des marsouins les plus facilement identifiables. Les périodes moyennes de récupération après les dérangement causés par les chasses et des passages de bateaux dans l'estuaire étaient de 40 et de 24 heures respectivement.

La distribution des bélugas dans l'estuaire était principalement influencée par les marées. Le comportement des bélugas était principalement influencé par leur nombre total. L'âge était le facteur le plus important dans la discrimination entre les classes de comportements.

La ségrégation entre les différents types de groupes était basée, en partie, sur l'âge des individus; les groupes d'âges mixtes et les groupes d'âges semblables (formés d'adultes ou de juvéniles). Les groupes d'âges mixtes étaient généralement plus gros, plus abondants, de composition plus stable et démontraient un répertoire de comportements moins varié que les groupes d'âges semblables.

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INTRODUCTION

White whales or belugas (Delphinapterus leucas) are the most abundant of the odontocete species occupying Canadian arctic waters. During the summer months, belugas congregate only in certain estuaries. The occupation of traditional sites along with indications of differences in the body size of belugas from different areas has led to the delineation of several separate stocks, or populations in Canada (Fraker 1980; Smith et al. 1985; Sergeant 1981; Brodie et al. 1981; Finley et al. 1982; Vladykov 1944; Sergeant 1986). One stock, the subject of this thesis, spends the summer on the east coast of Hudson Bay.

In the 19th century, herds of belugas in eastern Hudson Bay occupied the Great Whale and Little Whale Rivers by the "thousands" during the summer months and there were reports of herds of similar size farther north in Richmond Gulf and in the "Nistabucky" River (probably the Nastapoka River, Francis 1977). Richmond Fort, on Richmond Gulf, was the first beluga hunting site used by the Hudson Bay Company in 1750, where there was a harvest of whale skins valued for their high quality leather. Native whale hunting continued for the next one hundred years or so along the eastern Hudson Bay coast. Then, from 1854 to 1870, modern whaling techniques using nets decimated the Great Whale and Little Whale River herds to the point where the remaining whales would no longer use the rivers, and the "porpoise fishery" had to be abandoned (Francis 1977).

The Nastapoka River estuary is currently the only major concentration area of beluga whales in eastern Hudson Bay. It is also the major site of whale hunting. Approximately 30 whales are taken at this site every year, from a population on which there is as yet little information (Breton-

Provencher 1980; Finley et al. 1982; Smith and Breton 1986) and which has recently been estimated to number 970 (Smith and Hammill 1986).

The first objective of this study was to assess the importance and vulnerability of the Nastapoka beluga herd. Therefore, it was important to obtain a more accurate estimate of the size of the Nastapoka herd and especially its age structure (from size classes, not from precise size measurements); to determine if, and to what degree the whales were site tenacious; and finally to measure the impact of human activities on the estuarine occupation of whales.

The estuarine habit of belugas also creates an excellent opportunity for observers to study their behavior from land, thus minimizing disturbance effects. Several authors have recognized the biases introduced when behavioral observations of whales were conducted from boats (Norris and Dohl 1980; Würsig and Würsig 1980). Previous studies looking at the biology of white whales reported incidentally on their behavior during migration and occupation of estuaries (Kleinenberg et al. 1964; Yablokov et al. 1974; Fraker et al. 1979; Breton-Provencher 1980; Finley et al. 1982). Broad categories of behavior or activity classes have been documented and related, in part, to certain types of underwater vocalizations (Sjare and Smith 1986). The repertoire of behavior reported for captive belugas (Defran and Pryor 1980) was very limited compared to that of other dolphin species. Studies on the behavior of coastal dolphin species have proliferated during the last 10 to 15 years (Saayman and Tayler 1979; Shane 1977; Wells et al. 1980; Würsig and Würsig 1980), and now provide a database for comparisons with belugas.

Thus, the second objective of the present study was to document the behavior and group structure of a herd of belugas during their summer occupation of an estuary. But since the Nastapoka herd is subjected to hunting and repeated disturbances from humans, the objective of the behavioral facet of this study was also to assess and possibly measure the impact of such disturbances on the behavior of white whales in the estuary.

STUDY SITE

The Nastapoka estuary, Northern Quebec (Fig. 1; 56° 55' N, 76° 36' W) is 1.3 km. long from the river mouth to the 30m high water falls and 0.2 km. wide in an east-west orientation. The Nastapoka River originates in the Seal Lakes, 191 km. inland from the coast.

The study site was divided into five areas, or quadrats, from the falls down to the bay (Fig. 2), and the location of these quadrats was the same for both years.

Lamothe (1983) found the average monthly discharge, for the years 1948 to 1978, to be 268 m^3/sec. with peak discharges in June, July, August and September (468.6, 431.8, 403.7 and 392.2 m^3/sec. respectively). In each year, the peak flow occurred in any of these four months. The flow of the river gradually decreased during the winter months then sharply increased from May to June.

In this study, water samples from six stations inside the estuary were taken at various depths for salinity and temperature measurements. These water samples were collected on two separate days during 1984, 10 July and 7 August, on mid to high tides (labeled A to F in Fig. 2). They revealed the existence of two distinct water masses characterized by different salinity and temperature ranges. The river water temperature ranged between 11.2° C and 16.1° C, with 0 PPM salinity. The sea water temperature ranged between 6.6°C and 9.3°C, with salinity increasing from 6 and 15 PPM with depth.

Salinity and temperature/depth profiles of water samples taken from stations located approximately midpoint along the route from the upper quadrats to the bay (Fig. 3: stations A, C, and F) on the 10 July, 1984 indicate that cold saline water intruded below the river water as a wedge from Hudson Bay. The same conclusion can be derived if data from 7 August is used.

Abrupt changes in water temperature, coinciding with variation in tidal height, were measured by the permanent temperature probe (x in Fig. 2). These changes revealed the existence of a dynamic thermocline that advanced and receded with the flow and ebb of tide. There was a lack of a pronounced horizontal salinity-temperature gradient at the surface; the water was fresh in all parts of the estuary.

Because of its topography, the Nastapoka estuary was classified as a submerged delta estuary by Lamothe (1983). From the distribution of its water properties measured in this study, the Nastapoka also appears to fall into the category of a salt wedge estuary as described by Stommel (1964; in Pickard 1979).

MATERIALS AND METHODS

White whales were observed at the Nastapoka River estuary from 20 July to 13 August 1983 and from 21 June to 2 September 1984. All observations were conducted from a 5 meter high tower located on the north shore of the estuary using binocculars, a cassette tape recorder, and a 35mm camera.

Variables

Two types of variables were identified and measured during each observation session: physical variables (including environmental variables, see below) and biological variables. The physical variables were related to the estuarine habitat and were thought to influence the whales and the observer (abiotic factors). The biological variables were related to the evaluation of the size class and behavior of whales (biotic factors). The environmental variables, listed below, were variables that were calculated after the observation sessions, most of them when the observer was back from the field season. The objectives of the data analyses, detailed further, were to explain the variation observed in the biological variables by one or a combination of physical factors that were occurring simultaneously.

The following are the physical variables recorded at the beginning of each observation session. The time of day (EDT) was obtained from a Timex digital watch and tidal height was read from a tide gauge, accurate to 0.05 m, located in a small adjacent bay approximately 100 meters from the tower. Water temperature was recorded from a temperature probe fixed to the bottom of the estuary in the middle of quadrat no. 3 and was relayed to a YSI telethermometer in the tower. Wind speed and wind direction measurements were read from a portable weather station. Other factors influencing observations such as the state of the water surface, water clarity, and light condition were recorded on an ordinal scale of 1 to 4. At one end of the scale, a value of 1 indicated choppy waters for the water surface variable, opaque water for the water clarity variable and strong glare emanating from the surface of the water for the light condition variable. At the other end of the scale, a value of 4 indicated calm and flat waters for the water surface variable, clear water for the water clarity variable and diffuse light for the light condition variable. A count index variable was created to measure, on an ordinal scale of 1 to 4 (worst to best), the observer's confidence in the count value. This index would also represent a subjective measurement of the fatigue of the observer in order to provide information on the stability or repeatability of the observations.

The environmental variables were: the total number of whales present in the estuary at the time of observation, the time elapsed since the return of the first whale to the estuary after an evacuation, the time elapsed since the last hunt, and the median position (see below) of the distribution of the herd in the estuary. As mentioned above, these were all recorded after the observation sessions.

The biological variables, were evaluated simultaneously on the same whale when it became visible at the surface of the water. The first biological variable recorded was the the size class to which a whale belonged. Previous studies established a reasonably accurate age to length relation of belugas of 0 to 3 or 4 years old (Sergeant 1973). Length of calves relative to adults observed in the Nastapoka estuary was used to approximate size, and later age classes. Five age (size) classes of belugas were defined: neonates (about 1/3 length of adult), 1/2 lengths (1 year old), 2/3 length (2 years old), 3/4 (3 years old or older) (Fig. 5). Relative lengths of calves of different ages could be relatively easily evaluated because of their usual close swimming association with an adult.

The second biological variable evaluated on a whale was the action pattern a whale was observed to perform. Action patterns were assembled in an ethogram of 28 action patterns which was compiled during the first season, and used in the second season in scan sampling. Only those action patterns which were visible above the water surface were incorporated into the ethogram and in the data analyses. An action pattern was defined as a recognizable, reappearing posture or pattern of movement (Packard and Ribic 1982) that could be quickly recognized in the field.

Scan sampling

Scan samples of behavioral states, if sampled frequently enough, can be converted into an estimate of the average duration of this state. However, the observer should try to scan each individual for the same brief period of time, otherwise, a scan sample is equivalent to a series of short focal-animal samples of variable and unknown durations (Altmann 1974).

In the present study, scans sampled events (action patterns only) rather than states. The analogous behavioral states, described later in this section, were called activity classes because they were not assumed to confer specific function. Activity classes were attributed to groups of action patterns which most physically resembled one another for the purpose of constructing activity budgets. When sampled frequently enough, the frequency of action patterns would represent an average duration of the activity class to which they belong, thus informing on the average proportion of time that belugas spent performing action patterns belonging to a particular activity class.

Scan sampling originally consisted of periodically surveying the entire study site from one end of the study area (quadrat 1) to the other (quadrat 5) noting the quadrat, size class and behavior (the first action pattern observed) of each whale as it surfaced. But because whales located in quadrat 5 were often more than 500 meters from the observation tower (see fig. 2), thus were too difficult to observe, only results obtained from whales located in quadrats 1 to 4 (less than 300-400 meters from the tower) were actually used in the more refined analysis. When analyses only required that whales be counted, and not classified in age classes or performing an action pattern, data from all quadrats were used.

Groups of belugas in the Nastapoka did not spend long periods of time underwater. Most were seen to surface frequently within a few minutes (probably because of the shallow waters of the estuary), thus spending on average between 30 sec. and 1 min. underwater. Most whales could be seen swimming under the surface of the water, and the observer could follow a group and sample each whale for size class and behavior as it surfaced.

Depending on the size of the herd, or the number of whales sampled, the duration of scan sessions ranged between 5 and 15 minutes. If the entire scan session could not be instanteneous, each individual whale was observed at the surface of the water for less than a few seconds (with practice, size class could be rapidly evaluated, and so could the first observable action pattern). Therefore, the basic requirement for the validity of scan sampling put forth by Altmann (1974) is met here.

Scan sampling started on 5 July and ended on 2 September 1984, and was performed once approximately every two hours from 9 AM to 9 PM (an average of 6 per day). Observation sessions, thus, were usually two hours apart in order to eliminate, as much as possible, the occurrence of autocorrelated events.

Slightly over 33,000 observations of whales were made over the observation season of 59 days in 1984. Approximately 11 days of these could not be sampled because whales were absent from the estuary due to various disturbances, therefore only 48 days were actually sampled. This total scan sample of 33,000 observations is the result of the multiplication of the mean daily sample of 688 whales by the number of observation days (48). This figure (33,000) is also obtained when the average herd size of 106 whales is multiplied by the number of observation sessions (310). Theoretically, if the same whales were present during a day in the estuary, each whale was sampled approximately 6 times in the course of one day at intervals of two hours. If the same whales were present throughout the observation season (48 days), each whale was sampled approximately 288 times. However, as indications of site fidelity or residency showed (see in a later section), the same whales were probably not sampled more than 30% of the above theoretical rate (about 86 times) throughout the course of this study.

Focal sampling

Focal sampling is defined as a sampling method in which all occurrence of specified actions of an individual, or specified group of individuals, are recorded during each observation period. Once chosen, a focal individual is followed to whatever extent possible during each of its sample periods (Altmann 1974).

In this study, focal samples were done on groups of whales, and all occurrences of action patterns performed by any member of the group were recorded sequentially with the help of a cassette tape recorder.

The focal groups were followed for as long as possible, usually between 2 and 15 minutes, depending on their activity or their swimming speed. Although focal sampling resembled scan sampling in duration, it involved a very different approach to sampling whales. Where scan sampling covered sometimes two hundred whales, focal sampling involved following a small group (average group size of 4 whales) for several minutes, noting once the size class of each individual (for size class composition) and many times their behavior (action pattern) when they were at the surface of the water (for the clustering analysis). During focal sampling, group encounters were also recorded. Focal samples were taken as often as possible on any group that happened to come into view relatively close to the tower (usually quadrat 3). The focal samples were recorded between the scan sampling sessions.

Eighty-two focal samples were obtained in 1984 which lasted a total of 390 minutes. The duration of action patterns was not considered in these samples, since action patterns had already been assumed to be instantaneous, as in the scan samples. Here, the sequences of action patterns and the temporal correlations between action patterns and group encounters were of primary interest.

Where scan samples were used to study the influence of environmental factors on the activity budget of belugas, the focal samples were used to study the group structure and organization of belugas in the estuary, as well as some aspects of their social behavior.

Calculations

The following explain the calculations used in the different sections of this thesis. These follow the order in which the results will be presented.

Human disturbances frequently caused the evacuation of whales out of the estuary. To account for these evacuations, the seasonal growth curve of the Nastapoka herd was plotted using only the highest number of whales counted during any observation session of each week.

It was noted from the beginning that belugas were distributed relatively evenly in a wide central corridor in the estuary. Therefore, a median was thought to be an appropriate measure to quantify the distribution of belugas along the length of the estuary, since a median, or central tendency, is the middle value of a set of measurements arranged in order of magnitude (Daniel 1978). In other words, the median of the distribution of belugas was the position, in units of quadrat, of the whale in the middle of the distribution knowing the count of whales in each quadrat.

Scan samples, which are essentially censuses (Altmann 1974), were also used to obtain estimates on population parameters such as age distributions, in this case size class distribution. Variations of age distributions were calculated for different years, quadrats, season, and time elapsed since the return of whales to the estuary. Blocks of the time periods (season and time elapsed since the return of whales to the estuary) are of equal sample size, but do not necessarily cover equal amounts of time.

An estimate of the sex ratio was derived from the age distribution table (taken from focal samples) on the assumption that for each calf younger than 2 years old (neonates and 1/2 lengths), there had to be a sexually mature female in the herd which was its mother. This assumption rests on the fact that gestation in belugas lasts a little over one year (Sergeant 1973), thus females could not reproduce more often than once every two years.

To study the effect of environmental factors on the behavior of belugas in the estuary, both a univariate (multiple regression) and a multivariate (discriminant analysis) approach were used. Contingency tables of activity classes were constructed to help the interpretation of the behavioral responses to the most influential environmental factors. These were constructed by summing all action patterns belonging to an activity class in each block of environmental variables.

The identification of individual whales was made using scars which some belugas bore on their backs. These scars were believed to have been caused by bullets during hunts. Whales were photographed when close to the tower, or their scars were drawn by hand. Since usually only one side of the whale was visible during identification, only the scars located on the left side of the whales, the side visible when whales swam upstream, were noted. This was to prevent confusion in the identification of whales that had different markings on each side of their bodies.

Daily presence of identified whales was recorded as often as possible, and from this record, a frequency of daily presence was counted. The total observation period for each identified whale, used to calculate the rate of daily presence, started with the first day of the identification of that particular whale, and was defined as the total number of days after identification in which there was at least 70% of the weekly maximum herd size of belugas present in the estuary. Counting only those days compensated for the days in which there were too few whales in the estuary to expect to reidentify any whale. This was done to equalize the probability of recognizing any identified whale. The rate of daily presence was calculated by dividing the number of days in which a whale was seen in the estuary with the total number of observation days (defined above) for that particular whale.

Recovery times were calculated by counting the hours it took for the whales to reoccupy the estuary after a disturbance. Partial recovery was declared when the first whale returned to the estuary and total recovery was attributed when at least 70% of the pre-disturbance number of whales had returned to the estuary.

Statistical tests

There were regular intervals of approximately two hours between each scan sampling session (or scan sample) and the average daily presence record showed that identified whales were in the estuary approximately 30% of the days when they were expected to be there (refer to later section). Furthermore, there would sometimes be one or more days between observation days which meant that even more time elapsed between scan samples. The above sampling conditions reduced the possibility of autocorrelated events, or clustering of events, that would produce biases in the statistical tests. Although there must have been some dependence between observations, the degree of such was not thought to prevent altogether the use of integrated and highly informative multivariate statistics, especially when these are used primarily as descriptive tools (Legendre and Legendre 1984).

Several statistical techniques were used to analyze the data. The following analyses were performed on the scan sampling data. Spearman rank correlations (PROC CORR: SAS 1982) were used to find the relationship between the median position of the distribution of belugas in the estuary and the environmental factors prevalent at that time. Chi square (NWA STATPAK 1983) tests were performed on the contingency tables of the age structures, and a deviation statistic Z (Legendre and Legendre 1984) was calculated for each cell to verify which observed frequency deviated significantly from the expected one. Mann-Whitney U tests (Daniel 1978) were used to compare the means of recovery times of whale numbers in the estuary after hunting to the recovery times after motor traffic.

Multiple linear regression analyses (GLM and STEPWISE: SAS 1982) were used to find which environmental factors influenced the display of prominent action patterns (PAP). Since prominent action patterns were action patterns that appeared to serve a greater purpose than the combination of only swimming and breathing, as in the ordinary swimming, only those were used in the regressions. Thus, a ratio of prominent action patterns to the total number of action patterns (prominent action patterns plus ordinary swimming action pattern) counted in one observation session was used as the dependant variable in the analysis. Such a variable has the advantage of being adjusted for herds of any size. An arcsin of the square root transformation (Steel and Torrie 1980) was performed on the ratio of prominent action patterns. Most of the environmental factors were normally distributed and only a few had to be transformed. The residuals of the regression were found to be normally distributed.

A canonical discriminant analysis (CANDISC: SAS 1982) was used to find the differential influence of environmental factors (intrinsic and extrinsic) on the 5 classes of behavior described in this study. This discriminant analysis verified if combinations of envirommental factors could separate, or discriminate, the predetermined classes of behavior. The same square root transformations were done on some of the environmental factors in the discriminant analysis as in the regression analysis, in order to approach normality of the data. The dependent variables in this case were the actual frequencies of the different classes of behavior. The discriminant analysis is robust to conditions of near normality of the descriptive variables, especially since this analysis is used to measure the relative contribution of each descriptive variable to the total discrimination (Legendre and Legendre 1984).

In focal samples, associations between action patterns were found by a clustering procedure (VARCLUS: SAS 1982). The clustering was hierarchical and used the centroid method. It was based on the non-parametric correlation matrix (Spearman rank correlation) of the action patterns. This procedure is similar to the one presented by Packard and Ribic (1982). Transition matrices of following and preceding action patterns were modeled on the ones presented by Lemon and Chatfield (1973). Chi squares were calculated on the rows of the tables to determine if an action pattern was dependent on the preceding one.

RESULTS

Seasonal abundance and distribution in estuary

Maximum numbers

In 1983, whales were present in the estuary before observations started on 19 June but in 1984 the first whales of the season were seen on 23 June. In both years, observations ended before the final departure of the whales. Numbers of belugas fluctuated daily throughout both seasons. These fluctuations were caused in part by human-induced disturbances such as boat traffic and whale hunting. These will be discussed in a later section. The effect of disturbances on the seasonal whale count for this analysis was removed by noting only weekly maximum counts, that is, the maximum number of whales counted at any one time during a particular week (Fig. 4). The highest count for 1983 was 245 and occurred on the 27 July. In 1984 the highest count, 260, occurred on 25 August. During the 1984 season, the herd size gradually increased over the season (July and August), then started to decrease in early September.

Distribution of belugas according to environmental factors

While occupying the estuary, groups of belugas continually swam upstream and downstream. During high tide, whales were usually present in all quadrats, whereas during low tide they were usually seen in the quadrats closest to the bay. At no time were there any barriers preventing the whales from occupying any parts of the estuary. The measure of whale distribution chosen for this analysis was the median position. A Spearman rank correlation between environmental factors and the median of the distribution of whales in the estuary was performed. The results of the Spearman analysis (Table 1) showed that the median position of the whales advanced and receded with the flow and ebb of tide. It also showed that the larger the herd size, the farther upstream whales would swim and the longer the whales were in the estuary without disturbance (longer time after a hunt), the higher upstream they were positioned. High waves, strong northerly winds induced crowding of the upper quadrats (upstream). Higher river water temperature also pushed the whales into the upper quadrats while water clarity (murky water) apparently had the opposite effect. In counts subjectively judged as good, the median position of the herd was farther upstream, or closer to quadrat 1.

Herd Status

Age classes

As mentioned earlier, size classes of belugas were used to estimate age classes. Although coloration is reported here for the different age classes, only the relative size class was used to differentiate between age classes. Whales of the first age class, assumed to be neonates, were of a uniform light brown or beige color. At this stage, the neonate is about one third the length of the accompanying white adult and has a characteristic swimming pattern (described in the ethogram section). During the following three to four weeks the neonates gradually become dark grey. One neonate accompanied by an individually recognizable mother was closely observed during a period of approximately four weeks. At first, a dark grey ring appeared around the neonate's blowhole, then its melon, head, dorsal ridge and finally flanks gradually became darker. This pattern for skin discoloration is not likely to be fixed and might vary among individuals.

In the second age class, the one year old calf is close to one half the length of the accompanying adult and it is of a medium to dark grey color. The body is much thicker around the torso but its tail stock muscles are not as developed as those of older juveniles.

The third and fourth classes are the most difficult to differentiate. Most juvenile or immature whales are of a medium to light grey color. They have lost their earlier roundness and the tail stock muscles are larger. Confusion can arise when only color is used to separate these ~~two~~ classes. Observation of freshly killed whales on the beach showed that larger whales could be either darker or lighter than shorter ones of the same sex. In age class 3 (2 years old), whales are approximately 2/3 the length of a white adult and in age class 4 (3 years old or older), at least 3/4 adult length.

Age class 5 (adults), consists of fully grown and completely white individuals. The previously described age classes will be referred to on the basis of their size classes: neonates (1/3 length), 1/2 length, 2/3 length, 3/4 length, and adults (full length) or whites.

Age structure

The age structure of the 1984 herd was evaluated using two sampling techniques, based on age (size) classification of individuals using a rapid scan sampling technique (sample size = 33,027), or on a group focal sampling technique (sample size = 1618). No significant difference was found between these two estimates of age structures (Chi square = 2.7335 P>0.10). From the scan sampling and the focal sampling respectively, 19.20% and 19.11% of the herd was composed of neonates, 15.39% and 15.89% were 1/2 length calves, 11.37% and 11.69% were 2/3 length whales, 12.73% and 13.73% were 3/4 length whales, and 41.31% and 39.58% were white individuals.

Overall, the age structure of the beluga herd was observed to be relatively stable. No great variations were observed in age structure over time periods or between different sections of the estuary. However, some minor differences were noticed.

To compare between years, age classes 2/3 and 3/4 were combined for 1984 as they were in 1983 (Table 2). The variation between years was found to be significant at the 0.05 level of significance, but not at the 0.01 level. None of the cells showed significant variations at either level.

The age structure variation between the different quadrats of the estuary was found to be significant (Table 3). The age class that contributed the most to the total variation was the 3/4 length whales. These were concentrated in the middle quadrats (2 and 3). The whales from the white age class were often found at the sea end of the estuary, in quadrat 4. Whales of the 2/3 length class were less numerous in the outer quadrat (4), and mostly located in the higher quadrat (quadrat 2). Neonates and 1/2 lengths were more uniformly distributed in the different quadrats.

The age structure was also found to vary significantly with the season (Table 4). The age class that contributed the most to the total variation was, by far, the 2/3 length. The abundance of this age class was seen to sharply decrease after the first quarter of the season, and increase only during the last quarter. The number of neonates were slightly below the expected value during the first quarter of the season, but their levels reached the expected values for the rest of the season. Whales of the 1/2 lengths class were also slightly bellow the expected level at first, but remained stable for the rest of the season.

The age composition of the first groups of whales to reoccupy the estuary after a disturbance, which forced their evacuation from the estuary, was also found to be significantly different from the age composition of whales arriving later (Table 5). The classes which varied the most were the 2/3 lengths, the whites, and to a lesser extent, the 3/4 lengths. Whales of the 2/3 and 3/4 length classes were slightly below their expected values when first returning to the estuary, while the white individuals were above their expected values for this same period. The most stable classes were the neonates and the 1/2 lengths.

Sex ratio

The sex ratio of adults (white belugas) was calculated from data obtained in focal samples. It had the most detailed information on the associations between females and calves and on groups of adults without calves. Two assumptions based on information from previous biological studies were made : the first one was that gestation lasts more than one year (Sergeant, 1973), therefore, neonates and 1/2 length calves must have one mother present in the Nastapoka herd; second, since lactation is known to last sometimes up to 2 years, an adult seen with a 2/3 length calf (2 or 3 years old) was assumed to be female.

The percentage of adult females present in the Nastapoka estuary was indirectly calculated by summing the percentages of neonates, 1/2's and whites accompanied by 2/3 length calves:

19.11% neonates
\+ 15.89% 1/2 lengths
\+ 0.25% white accompanied by 2/3 length calves
\---
= 35.25% sexually mature females.

A small proportion of neonates and 1/2 lengths, closely accompanied by 3/4 lengths assumed to be their mothers, had to be subtracted from the above percentage of mature females in order to obtain the percentage of white adult females only:

35.25% adult females
- 3.09% 3/4 lengths with neonates or 1/2 lengths

= 32.16% white adult females.

Subtracting from the total percentage of whites the percentage of white females, we obtained the percentage of white males:

39.58% whites
- 32.16% white females

= 7.42% white males.

The white male to female sex ratio is estimated to be 1:4.33. Thus, if females not accompanied by calves are present in the herd, the above sex ratio would be skewed even more in favor of females.

Occupation of the estuary by known individuals

Identification through scars and natural marks

Individual identification is especially difficult in belugas. Adult belugas of both sexes are of a uniform white color. Juveniles and sub-adults may have individually recognizable coloration patterns but these are transitory and only help identification over a short period of time. The site fidelity of belugas occupying the Nastapoka herd was tested using individual identification through scars and natural markings located on their backs and heads. Most of these scars appeared to be old gun-shot wounds. Other scars, such as raking marks, could have been teeth marks inflicted by conspecifics or possibly from predators such as polar bears (Ursus maritimus) (Smith 1985). Only the scars located on the left side of the whales were considered because it was the side which was most often seen from the tower as the whales swam upstream. Some scars were very conspicuous and distinctive which made the identification of some whales relatively easy (Fig. 6). Other scars were smaller and less conspicuous and could only be recognized when the whales were close to the tower.

Calendar of estuary occupation

In 1983, 18 whales were identified among which 14 were seen on two or more days during the same season. Of these 14 whales, at least eight were seen the following year. In 1984, a total of 46 whales, mainly whites and 3/4 lengths, were identified. These whales were seen on a regular basis from early July to late August at the end of the study (Table 6). The same identified whales were seen before and after hunts and disturbances and some were often among the first whales to reoccupy the estuary indicating strong site tenacity. A list of all identifications is given in Appendix no. 2.

Average daily presence

The average proportion of daily presence of identified whales was calculated from the identification data of 1984. A minimum average daily presence of 30% was estimated for 24 of the most conspicuously marked individuals. This was calculated by dividing the number of days in which an identified individual was seen (Table 7, col. 3) by the total number of observation days in which there were at least 70% of the maximum number of whales counted during that week (Table 7, col. 2). The daily presence rate is the average proportion of days in which an identified whale was sighted when there were enough whales in the estuary to expect to sight an individual. This way, the rate is adjusted to compensate for days in which there were too few whales in the estuary. Only the most conspicuously scarred individuals were used to calculate the average daily presence in order to compensate for ease of sight. The average daily presence is considered to be an underestimate because of the inherent difficulties of recognizing individuals.

Impact of human disturbances

Behavioral responses

The Nastapoka estuary is well known among native communities as a good whale hunting area, and is hunted regularly by hunters of Kuujjuarapik, Inukjuak, and Umiujak (see Fig. 1). Shores of the estuary are also used as a camping sites for other game hunters travelling in the area. The most evident behavioral reaction of whales to motor noise (usually hunters) was to quickly abandon the estuary. Most animals would immediately head offshore when approaching speed boats were present outside the limits of quadrat 5. Whales which were situated in the upper quadrats (1 or 2) would continue to swim upstream in a regular motion and would only react to approaching boats when these were closer, such as in outer quadrat 4. When individually pursued, some whales would leap out of the water. When the whales were being cut off by speed boats, some whales would lift their heads out of the water for a brief moment before resuming their flight.

Other whales used different escape strategies which usually consisted of remaining motionless close to the shores or swimming far upstream, almost to the Nastapoka Falls. One exceptional incident occurred during a hunt in 1984. An adult accompanied by a neonate and an older juvenile (2/3 length) was being pursued into a small adjacent bay and was repeatedly fired upon. The animals eventually swam out beyond the boat, toward the open water. The adult then did a tail stand rising out of the water up to its pectorals and faced the boat at a distance of some 20 meters. It was then shot in the neck and killed.

Air traffic did not appear to cause any change in swimming direction of the whales except when float-planes landed or took-off close to the whales. In those cases, the whales began to swim downstream.

Noise from motor boats located approximately 1 km. or more outside the estuary only caused the whales to recede into the downstream portion of the estuary whereas motor traffic in the estuary (quadrats 1-4) and each hunt caused the whales to completely desert the area. On a few occasions, however, the whales were seen to depart on their own when there was no apparent disturbance.

On at least one occasion, the whales were observed to depart from the upstream quadrats (1 and 2) at the precise moment when an observer was walking close to the sandy north shore of quadrat 2. On one occasion, a bullet hitting the water surface in quadrat 2 also appeared to be the cause of a mass exodus from the upper quadrats.

Recovery Time

The time required for whales to reoccupy the estuary after hunts and motor traffic disturbances is listed in Tables 10 and 11 respectively. The total recovery time was defined as the time it took for at least 70% of pre-disturbance number of whales to return to the estuary after a disturbance. The partial recovery time was defined as the time it took for the first whale to return. There were no significant differences between hunting and motor traffic partial recovery times (Mann-Whitney U=25.5, P>0.10). There was, however, a significant difference between hunting and motor traffic total recovery times (Mann-Whitney U=13.0, P=0.0158). Regardless of the type of disturbance, it took the same amount of time for the first whale to reappear in the estuary. It took longer, however, for whales to return to their pre-disturbance numbers (total recovery) after a hunt (approximately 40 hours) than after a motor traffic disturbance alone (24 hours on average).

The return of individually identified whales to the estuary, as opposed to the return of any whales, after disturbances varied greatly (Tables 8 and 9). Recovery periods for whale no. 1 ranged between 33 hours and 165 hours (almost 7 days) and for whale no. 3, between 104 hours and 372 hours (15.5 days). For the 18 re-identifications following disturbances, the average recovery period was 185 hours or 7.7 days.

Behavior

Ethogram

The ethogram presented here contains all the action patterns observed in the belugas occupying the Nastapoka River estuary. An action pattern is defined as a recognizable, reappearing posture or pattern of movement (Packard and Ribic 1982). As stated in the Materials and Methods section, only the action patterns visible above the surface of the water were considered.

Previous studies looking at the biology of white whales reported incidentally on their behavior during migration and occupation of estuaries (Kleinenberg et al. 1964; Yablokov et al. 1974; Fraker et al. 1979; Breton-Provencher 1980; Finley et al. 1982; Sjare and Smith 1986). Behavior reported for captive belugas (Defran and Pryor 1980) was found, in this study, to underepresent the behavioral repertoire of the species. This behavioral repertoire, called an ethogram, was constructed to enable comparisons between belugas and other odontocetes, and eventually between different stocks or populations of belugas.

The major portion of the ethogram of belugas was constructed in the 1983 season. A few additional action patterns were incorporated into the ethogram during the 1984 season, as they became visible (Table 10). Some of the action patterns are illustrated by line drawings (Fig. 7).

The action patterns were divided into five main activity classes: swimming, display swimming, aerial, interactive, and epimeletic. The names chosen for the action patterns are as consistent as possible with those reported for other cetacean studies. Complete references to action patterns and their possible function are reported for many odontocete species in Appendix no. 1.

The period of estuarine occupation represents only a portion of the annual cycle of belugas, therefore the present ethogram can only be a partial description of the total behavioral repertoire. It must also be stressed that belugas seen at the Nastapoka estuary are part of a population that has been extensively hunted in the past and still is, though at a much reduced rate, and caution must be used when behavioral comparisons with undisturbed populations of belugas are made.

Swimming activity class

Belugas show several types of swimming patterns. The ordinary swimming was recognized when there was a gentle breaking of the water surface when whales came up to breathe, followed by a slight bend in their backs when continuing their forward swimming motion. It was the most common mode of locomotion observed and was not associated with any particular event or context. All age classes, except neonates, performed the ordinary swimming in a similar fashion. Upon surfacing for air, neonates jumped higher than necessary and caused the water to splash around them. The gentle rolling of the back, observed in older whales, was not seen in neonates.

Descriptions of ordinary swimming available in the literature often came from studies conducted in aquaria using underwater viewing equipment (refer to Appendix no. 1). These report detailed and subtle movements of the flukes in addition to the obvious up and down pumping action of the tail which could not be discerned in belugas of this study.

A beluga was considered to be skimming when it was swimming over a short distance with the head out of the water up to at least the level of the eye. Skimming in belugas could not be associated with any specific context. The action pattern in which a whale briefly exposed only its blowhole or sometimes its head (up to eye level) when surfacing to breathe was called the head up. This action pattern was most often seen in slow moving belugas.

Sounding or vertical diving was recognized in belugas by an unusually sharp bending of the tail immediately prior to a dive. On relatively few occasions the tail flukes were raised completely out of the water resulting in the tail up action pattern. Sounding in belugas did not appear to be associated with any alarm or special situations. Sounding is a whaler's term reported very early in the literature for sperm whales, Physeter catodon, (Caldwell et al. 1966). Sounding or vertical diving in belugas thus appears to be essentially the same as reported for other species.

Leaping in belugas was recognized when a whale projected itself out of the water exposing at least the forward half of its body during the initial thrust and re-entered the water head first. Adult belugas did not usually clear the water when leaping. Juveniles more often displayed this action pattern by clearing the surface of the water. It appeared to be an escape reaction immediately following a group disruption. Leaping is described by many authors as a jump over the water with a head first reentry. Leaping has been seen in dall porpoises, Phocoenoides dalli (Morejohn 1979), and in killer whales, Orcinus orca (Martinez and Klinghammer 1978). Leaps can be performed singly or several times in rapid succession. Single leaps were the general rule in belugas in this study. Leaps have been observed in fast moving groups of dolphins (Leatherwood and Walker 1979), and when riding the bow of ships (Morejohn 1979). In alarm situations, leaping has the advantage of lessening the drag of fleeing dolphins (Hester et al. 1963).

Display swimming activity class

The side and back swimming action patterns were put in a separate activity class because they differed from the usual upright swimming patterns. The term display swimming does not confer a function to the action patterns belonging to this activity class.

Belugas were often seen swimming on their side. Side swimming with the pectoral flipper emerging occurred mostly during social interactions. On rare occasions, female belugas were seen nursing neonates while on their side. Females of several species also adopt a side position to help their nursing newborns, but older calves usually must reach the teats by diving beneath the females (McBride and Kritzler 1951; Tavolga 1966).

Erections were seen in side swimming males, and belugas were sometimes seen side swimming with their ventral surfaces close together. On some occasions one animal would turn onto its side beside another one swimming in a regular (ordinary) position. This sequence of events would often provoke tail slaps. In some species, side swimming has been associated with play behavior (Townsend 1914; Tayler and Saayman 1972). In others, it is apparently part of sexual behavior or agonistic behavior (Morejohn 1979; Hamilton 1944; Yablokov et al. 1974). It was found that side swimming was the normal way to swim for some bottlenose dolphins, Tursiops truncatus, that usually live in muddy waters (Leatherwood 1975).

Belugas were often seen swimming on their backs during social interactions, especially in large white or large 3/4 length whales that were in rosette formations (see below). Presumed females accompanied by calves were also seen swimming on their backs just below the surface of the water, sometimes waving their tails from side to side forming an undulating lateral "S" shape. The back swimming action pattern has been reported to be part of locomotor play, high speed chases, sexual encounters, and social interactions in other dolphin species (Layne and Caldwell 1964; Tayler and Saayman 1972; Saayman et al. 1973; Wursig and Wursig 1979; Norris and Dohl 1980; Pilleri et al 1980). It has also been seen to be a common mode of swimming for feeding dolphins. Apparently this position, as well as the side position, improves the animals' echolocation signals (Leatherwood 1975). Some authors also mention an evident lateral action of the tail during back swimming (Layne and Caldwell 1964).

Aerial activity class

Breaching, aerial spin, spy hop, tail stand, pitch polling and tail wave were grouped into the aerial activity class because they appeared to involve some form of aerial visual display or communication. The breaching and the aerial spin action patterns were not a dominant component of the behavioral repertoire of belugas. They were performed singly, most often in periods when groups were disrupted. These aerial action patterns seemed to cause additional commotion in the herd. When breaching, a whale emerged from the water at an angle close to the vertical and fell onto its side, back or front. In the aerial spin, the whale emerged from the water with considerable forward speed at an angle close to the horizontal performing an airborne spin or longitudinal rotation before falling back in the water.

There are several variations of the breaching pattern reported in the odontocete literature (Caldwell et al. 1966; Martinez and Klinghammer 1978; Ford and Ford 1981). In all the descriptions, the first component, which was the projection of the body above the water surface, was present. Variations come from the manner in which whales fall back onto the water surface. Some dolphins show greater acrobatic abilities. The Hawaiian spinner dolphin, Stenella longirostris, (Norris and Dohl 1980b) can make several longitudinal revolutions before hitting the water surface. Other species of dolphins can also do what authors call spiral leaps or noisy leaps which require some kind of airborne twisting (Pilleri and Knuckey 1968; Wursig and Wursig 1979; Saayman and Tayler 1979). Larger species of odontocetes such as the killer whale, Orcinus orca (Martinez and Klinghammer 1978; Ford and Ford 1981), and the narwhal, Monodon monoceros (Silverman 1979), usually show a lesser degree of aerial agility. Some authors think that these movements play a role in communication between individuals (Norris and Dohl 1980a).

Visual inspection of aerial surroundings appeared to be the function of at least three aerial action patterns seen in belugas. These involved stationary vertical positions with at least the head of the whale above the water surface. They were termed the spy hop, the tail stand and pitch polling. In belugas, the spy hop involved a single small up and down movement of a whale above the water surface exposing the head and sometimes the pectoral insertions. The pitch polling pattern occurred when a whale would turn along its longitudinal axis while remaining in the vertical position with the head out of the water. When a whale exposed its body to at least the flippers and retained this position for a few seconds, it was called a tail stand. This last pattern was extremely rare.

Spy hops and head up positions have been described and reported for killer whales (Ford and Ford 1981), and narwhals (Silverman 1979). Pitch polling was first described for sperm whales and in pilot whales, Globicephala scamonni (Caldwell et al. 1966), and in captive killer whales (Martinez and Klinghammer 1978).

The tail wave action pattern was recognized in belugas as a lateral motion of the tail above the surface of the water. No function or context could be discerned for this pattern. It might have been only a variation of the tail up action pattern, described in the swimming activity class, occurring immediately prior to a vertical.

Interactive activity class

All the action patterns belonging to this group were performed in groups, and when sometimes one individual directed its actions toward another individual. Some action patterns involved hitting the water surface with the head, flippers, or flukes. These were witnessed during social interactions and some, like the tail slaps, seemed to be aimed at other belugas. Flipper slaps and head bobs were usually performed in rapid succession by the same individual whereas tail slaps and head slaps were usually performed singly.

Striking the water surface using the tail and flukes, called lobtailing, was first described for sperm whales (Caldwell et al 1966). It was later seen in other species of whales and dolphins and could be a single event or a repeated motion (Norris and Prescott 1961; Yablokov et al 1974). It has been reported in feeding situations as a way to herd fish, during play, in initiation of social interactions, and in agonistic encounters prior to a chase (Caldwell et al 1966; Norris and Prescott 1961; Saayman et al 1973; Yablokov et al 1974; Saayman and Tayler 1979). Tail slaps were also directed at conspecifics during mock-battles or sexual encounters as a defense mechanism (Saayman et al 1973; Yablokov et al 1974).

Head slaps and flipper slaps were performed singly or in rapid succession in belugas, as in other species (Tayler and Saayman 1972; Martinez and Klinghammer 1978; Silverman 1979). Head bobs are thought to occur in aggressive situations (Ford and Ford 1981).

In a rosette formation, the belugas are typically at the surface of the water with their heads close together, sometimes with their mouths open in a display, or actually trying to bite or butt one another. The rosette typically occurred in groups of large whites and 3/4 length whales and was not considered to be a true action pattern but rather a consequence of several whales facing one another.

The formation resembling a rosette was first reported for sperm whales during a whale fisheries operation, and was thought to be a manifestation of care giving or epimeletic behavior. As one whale was shot, "all the individuals of the herd (20-30 whales) made a circle like a marguerite flower centering around the wounded animal" (Nishiwaki 1962). There are numerous other reports of epimeletic or care giving behavior directed toward conspecifics and sometimes toward other species or even inanimate objects (Caldwell and Caldwell 1972; Yablokov et al. 1974 for a review). In belugas of this study, however, the rosette formation did not appear to be an epimeletic behavior because it was mostly associated with rather aggressive interactive action patterns.

The interactive action patterns that seemed to be most energetic in belugas, such as chasing, rolling and tumbling, were performed in groups of adults or juveniles in what appeared to be aggressive or play situations. Chasing could follow or precede rolling and tumbling. The pursued individuals were sometimes accompanied by calves and they were often seen to leap. Most of the rolling was done when several belugas were participating in the event. Rolling without tumbling was often seen in whales accompanied by calves but this action pattern could not be associated with any function.

Rolling over in the water several times in a row by a single animal is reported for several dolphin species (McBride and Hebb 1948; Pilleri et al. 1980). The tumbling action pattern has been classified as a play behavior for bottlenose dolphins (Townsend 1914). Chasing is widely reported for dolphin in captivity, and in free-ranging species (Saayman et al 1973; Silverman 1979). It has also been associated with courtship and feeding sessions (Saayman et al 1973).

Head butting was rarely observed in belugas and it appears to be an aggressive action pattern. Ramming occurs in attack situations in sperm whales (Caldwell et al 1966). During increased sexual activity, fighting seems more often to involve hitting with snout and tail (McBride and Hebb 1948).

Sexual behavior in belugas could only be identified in very few instances. Erections were seen preceding the disruption of a group and were accompanied by much tumbling and chasing by large grey individuals (3/4 length). In addition to the normal male-female sexual activities, numerous cases of male-male, mother-young and interspecific sexual activities have been reported in the dolphin literature, mostly from captive situations (McBride and Hebb 1948; Tavolga and Essapian 1957; Caldwell and Caldwell 1972; Tayler and Saayman 1972; Pilleri et al. 1980).

Epimeletic activity class

The term epimeletic or care giving behavior, first used by Caldwell and Caldwell (1966), was assigned, in belugas, to the action patterns in which care or help was received, such as in riding and suckling.

Riding neonates were often seen swimming above an adult and, as the adult surfaced to breathe, the neonate was carried for a brief period of time. Neonates were also seen just crossing over the back of adults as these were surfacing. Larger calves were rarely seen riding on other whales, but it happened on occasion. The cross-back action pattern was recorded separately from the riding action pattern, like the latter, the cross-back appeared to give the calves a certain amount of upward lift and help the neonates as the groups swam upstream against the current of the Nastapoka River.

Tomilin (1967) reports that some authors have seen female belugas carrying their young on their back. He maintains that it is impossible to explain how the calf could hold to the slippery back of the adult, or why such behavior should be necessary when the calf can swim very well on its own. Others authors (see Tomilin 1967 for a review) deny the occurrence of such behavior and explain the reports to be an optical illusion created by the coordinated movements of the calf and the cow when they break the surface as they are observed in lateral view.

Neonate belugas had to surface to breathe more often than did adults. It is possible that the strong current existing in the Nastapoka estuary promoted the riding response in neonates. Observations from an elevated vantage point, such as in this study, reduced possible optical illusions caused by lateral viewing.

The finless porpoise, Neophocaena asiaeorientalis, is known to carry its young on its back, even at considerable speed. The wart-like excrescences present on the back of the adult presumably prevents the young from sliding off the adult (Pilleri and Peixun 1979). Other observations of free-ranging dolphins moving with dead young or objects at the surface or underwater show that they could easily carry their young (Hubbs 1953; McBride and Kritzler 1951; Smith and Sleno 1986).

The hydrodynamic shape of the body of a porpoise is very efficient.

Under certain circumstances, relatively small force is needed to assist their locomotion (Kelly 1959 in: Norris and Prescott 1961). A form of assisted locomotion, termed echelon-formation occurs when a smaller animal places itself alongside an adult. This relationship was seen in mother-young pairs of pacific striped porpoises, Lagenorhynchus obliquidens (Norris and Prescott 1961).

Suckling bouts in belugas were presumed to occur when a calf was seen repeatedly diving close to the genital region of the accompanying adult for brief periods of time. No evidence of milk was ever observed at the water surface. In a description of a suckling bout in a young free-ranging sperm whale, it is reported that the calf lies parallel to the parent with the head in the same direction holding the teat sideways in the angle of the jaw with its snout protruding from the surface (Caldwell et al. 1966). In captive bottlenose dolphins, Tursiops truncatus, the infant may suckle several times in a bout and surface between suckling. In the beginning, for about two weeks, the female rolls to her side to help the infant locate its source of food, but the young must roll from then on (McBride and Kritzler 1951; Tavolga and Essapian 1957). Suckling in a captive newborn beluga was observed at the Vancouver Aquarium (Hewlett 1978). The female would slow down and stop pumping her tail, holding it slightly elevated, then the calf would roll to one side, grasp the nipple and start nursing. It occurred sporadically at first, then a regular pattern of one feeding every 45 minutes to one hour was established.

Factors influencing the activity budget of belugas

Total activity budget

The overall activity budget of the belugas of the Nastapoka estuary (Table 11) represents the frequency of occurrence of all the action patterns observed during the 1984 season. The budget was strongly dominated by the ordinary swimming action pattern, it represented close to 90% of all action patterns observed in the estuary.

The swim (or swimming) activity class, excluding the ordinary swimming action pattern, was the prevalent activity class. It represented 4.31% of the total activity budget, with the head up greatly exceeding all other swimming patterns. The interactive class was the second most abundant activity class with a proportion of 2.52% of the total budget, and was dominated by the tail slap. The swim (or swimming) display class, representing 2.29% of the total budget, was dominated by the side swimming pattern which accounted for 96% of that activity class. The epimeletic and the aerial activity classes were the least common and accounted for 0.64% and 0.45% respectively of the total budget. Riding was the most common epimeletic action pattern. In the aerial activity class, breaching, spy hopping and tail waving were the action patterns most often observed.

Relative influence of environmental factors

It was hypothesized that the activity budget of the belugas could be influenced by extrinsic and/or intrinsic factors. To investigate this topic, the behavioral data taken concurrently with environmental variables were analyzed using a multiple linear regression. As mentioned earlier, the probability levels calculated by the statistical methods are indicative of the relative importance of each factor to the model being investigated.

The ordinary swimming action patten was thought to represent only a combination of swimming and breathing motions, thus not conveying interpretable information to the observer other than a normal or regular state of activity of swimming whales. Other action patterns, however, appeared to serve some functions even if these functions could not be fully understood in the course of this study. Therefore a ratio (R) of the number of prominent action patterns (PAP, which are all those listed in Table 11 except ordinary swimming) to the total number of action patterns (TBEH, including the ordinary swimming action pattern) was chosen as the dependant variable on which environmental factors, the independent variables, were regressed. The dependant behavior variable expressed as a ratio, and not as a pure frequency, had the advantage of being a measure adjusted for herds of any size.

For the general multiple linear regression, the quadrat division was not considered and the age structure of the Nastapoka herd was assumed to be stable, thus excluding the age and quadrat variables in the equation. The inverse sine transformation was applied on the square root of the ratio of PAP, a ratio transformation suggested by Steel and Torie (1980) when the denominators are unequal and when the percentages range between 0 and 20%. Environmental factors that were not normally distributed were also transformed. The following equation is the general multiple linear regression equation showing the transformations:

$$\mathrm{ARCSIN}\ R^{1/2} = \mathrm{TM} + \mathrm{TIDE} + \mathrm{WS} + \mathrm{WC} + \mathrm{WT}^{1/2} + \mathrm{SIN(WDIR)} + \mathrm{WSP} + \mathrm{TBEH}^{1/2} + \mathrm{CI} + \mathrm{MED}^{1/2} + \mathrm{OBS} + \mathrm{HT}^{1/2} + \mathrm{ET}^{1/2}$$

where R = ratio of PAP, TM = time of day, TIDE = tidal height, WS =

water surface condition, WC = water clarity, WT = river water temperature, TBEH = total number of action patterns counted in a particular observation session (including the ordinary swimming action pattern), CI = Count index, MED = median estuary position of the herd, OBS = observation number, HT = time elapsed after a hunt and, ET = time spent in estuary. The residuals of this equation were plotted and their distribution was found to be reasonably normal. The combination of all the environmental factors explained 43.67% of the total variation in behavior of the belugas observed in the estuary (F = 9.38, p = 0.0001).

A stepwise technique was then applied to the general regression equation in order to obtain a model containing only the factors significant at the 0.05 level (Table 12). Seven factors were thus entered into the model explaining 37.16% of the total behavioral variation. Included in order of importance, these factors were: the total number of whales present in the herd ($TBEH^{1/2}$), the water clarity (WC), the time spent in the estuary($ET^{1/2}$), the median position of the herd ($MED^{1/2}$), the count index (CI), the wind speed (WSP), and the time of day (TM).

The total number of whales in the estuary (TBEH) explained 22.73% of the total behavioral variation. As the total number of whales increased in the estuary, the ratio of prominent action patterns (PAP) decreased. As the water clarity (WC) increased, the ratio of PAP decreased. As the time spent in the estuary (ET) increased, the ratio of PAP also decreased. As the median of the herd distribution (MED) approached the downstream portion of the estuary, more of the PAP were displayed. The count index (CI), which was a subjective measurement of the quality of the observations, also seemed to have a small effect on the PAP count. In counts judged as good by the observer, a higher proportion of PAP displayed by the belugas was recorded.

Wind speed also increased the proportion of PAP. Finally, a slight decrease in the display of PAP occurred as the time of day passed.

Activity classes differentially influenced by environmental factors

After determining that some environmental factors had an effect on the total proportion of PAP displayed by the belugas, it was further hypothesized that classes of action patterns could be differentially influenced by the same or other environmental factors. A canonical discriminant analysis was used to verify if a combination of physical, temporal, biological, and density factors measured during the scan sampling sessions could effectively separate the behavioral activity classes from each other. In the discriminant analysis, the quadrat and age variables were included.

The data were first tested using the multivariate Wilks' Lambda test (Wilks 1932 in: Legendre et Legendre 1984) in order to see if some discrimination between the 5 activity classes could be achieved. It indicated that there were some differences between the position of the centroids of the activity classes ($f = 15.98$, p [illegible] less than 0.01). The centroids are the mean coordinates of the distribution of each activity class along the discriminant axes. The position or coordinates of the activity class centroids are represented in a three dimensional graph (Fig. 8). Each dimension corresponds to one of the discriminant functions or canonical axes.

Generalized distances (Mahalanobis: in Legendre et Legendre 1984) between the centroids of the classes and their associated probabilities (Table 13) indicate that the swim and aerial activity class were very close together, as were the display swim and the aerial activity class. It showed that there was more distance were between the swim and display swim class centroids. It also showed that the interactive and epimeletic activity classes were the farthest from each other and from the other activity class.

The canonical coefficients for each discriminant function are listed in Table 14. Three linear combinations, out of a possible four, were found to be important. Most of the discrimination between the activity classes occurred along the first canonical axis. It showed that age, having the highest value (positive or negative) of coefficient, was the most important discriminating factor of the entire analysis. Quadrat and time elapsed after a hunt also had some degree of discriminating power. Along the first canonical axis, the epimeletic activity class was isolated from the other classes. The second canonical axis permitted further discrimination between the interactive and swim activity classes. It showed that three factors shared most of the discriminating power; water clarity, quadrat and time elapsed after a hunt. Finally, the third canonical axis separated the display swim activity class from the other classes. It had the least overall discriminating power, and it separated the display swim class from the interactive class. The most important factors in this last linear combination were the month, the quadrat, the time spent in the estuary and the time elapsed since the last hunt.

Partial activity budgets

Contingency tables of activity classes were constructed in order to help interpret the effects of the most influential environmental factors found in the above discriminant analysis. The continuous environmental factors (HT: time elapsed since a hunt; OBS: period of the season; ET: time elapsed since the return of whales in the estuary) were separated into blocks of approximately the same number of action patterns. Discrete factors (WS: water clarity; AGE; QD: quadrat) were put directly in contingency tables.

The activity budget of different age classes showed that as whales increase in age, they displayed less of the ordinary swimming pattern and more of all other action patterns (Table 15). Action patterns of the epimeletic activity class involved mostly neonates, while the aerial patterns were displayed mostly by 1/2 length calves. The display swim patterns were most often seen in 2/3 length whales, the interactive patterns were dominant in 3/4 length whales and the adults displayed most of the swimming action patterns.

The activity budget in the different quadrats showed that the proportion of all activity classes increased with a downstream position (Table 16). Sounding, an action pattern of the swim activity class, was an exception to this, it increased in the upstream quadrats.

As the water became clearer, the proportion of the interactive and the aerial activity classes increased while the proportion of the other classes decreased, the sharpest decline occurring in the swim activity class (Table 17). There was a consistent decrease of aerial activity with the increase in time elapsed from a hunt (Table 18). Epimeletic, aerial and interactive activity classes decreased as the season progressed while the display swim activity class increased (Table 19). The aerial activity class decreased with the time spent in the estuary, as it did with the time elapsed after a hunt. The proportion of swim and interactive activity classes also decreased with the time spent in the estuary (Table 20).

Herd structure and social behavior

Structure of groups

Belugas were often observed to approach the mouth of the estuary in fairly large groups (50 or more whales). When the whales entered the estuary, they would disperse into smaller groups, ranging between 2 and 25 individuals. Lone whales were also present in the estuary herd. Here, groups are defined as any number of whales swimming in very ~~close~~ proximity to one another. The boundaries of groups were usually easily discernable because whales did not tend to disperse widely from one another in the estuary, although the groups were smaller they tended to be closely knit.

Two basic types of groups were identified, the mixed age groups (MAG) and the similar age groups (SAG). The mixed age groups were composed mostly of females and calves, and the similar age groups were composed of all adults or all juveniles. Table 21 is an inventory of all the members of 272 groups, which comes exclusively from focal sampling. The most common groups observed in the estuary were the MAGs of 4 or more animals (140 groups). Groups of whites and 3/4 lengths were the most numerous and attained the largest size (12 whales) of all SAGs. Couples and triads (one adult per group) were the least common groups along with the singletons. The largest groups were MAGs and the smaller groups were either MAGs or SAGs. (Fig. 9). The mean group sizes for MAGs and SAGs were 7.67 and 4.54 respectively.

Group stability

Focal sampling revealed that groups were not stable units. MAGs and SAGs often joined or broke away from other groups. In the 45 focal samples which started as MAGs sessions (total of 234 min.) 16 group changes occurred. MAGs joined or split from other MAGs an average of 4.1 times per hour. In the 37 focal sampling sessions which started as SAGs (total of 156 min.) there were 21 group changes. SAGs joined or split up from other SAGs an average of 8.14 times per hour. Group changes also occurred between the two types of groups. MAGs and SAGs joined or split up 47 times during the total focal sampling period (83 samples, 390 min.) on average 7.23 times per hour. MAGs mixed with other MAGs significantly less often than SAGs mixed with other SAGs (X^2= 4.7825, $p<0.05$) or than SAGs mixed with MAGs (X^2= 4.3798, $p<0.05$). There was, however, no significant difference in group changes between SAGs and, SAGs and MAGs (X^2= 0.2033, $p>0.50$). In comparison, MAGs were more stable than SAGs, and SAGs were involved in most of the encounters between groups.

Membership stability of groups was also verified using individual identification. In Appendix 2, every identification is listed along with information about the group age structure and the presence of other identified whales in the same group. Although the closest associations were between a mother and a calf, on some occasions a particular parent was seen unaccompanied by its calf, a neonate or a 1/2 length (ID #3, 7-07-84, 14-08-84; ID #10, 1-08-84). Identified whales were seen in either a SAG or MAG. ~~On some~~ occasions, however, these were seen to change group type. No permanent associations between 2/3 length and older whales were noted. Whales of both group types were seen accompanied by different individual whales.

Behavioral repertoire of groups

In addition to the differences in size, composition and stability, the two types of groups also displayed different behavioral repertoires

(Table 22). Encounters between MAGs and SAGs are also represented in this table (SAGs + SAGs, MAGs + MAGs, and MAGs + SAGs). Some action patterns listed in the formal ethogram are absent from the list of behaviors seen during focal sampling, but three additional action patterns were recorded: bubbles, stirring, and head out. Bubbles were evident as big pockets of air rising to the surface. Stirring was a rare event witnessed in whales that were located close to the tower. Its purpose, or even its occurrence are still a mystery. This action pattern occurred when a whale was close to the bottom of the water column and as the whale appeared to be moving, patches of brown reddish water appeared at the surface of the water. Finally, the head out action pattern was recorded when a whale kept its head out of the water, without moving foward or down. This action pattern was considered to be slightly different from the spy hop in which a whale lifted its head out of the water only for a very brief moment.

Focal samples that began as SAGs (similar age groups) displayed 22 of the 25 action patterns (88.0%) observed during the total focal sampling period (6.5 hrs), while those that started as MAGs (mixed age groups) only displayed 12 (48.0%). During the different group encounters, more different action patterns were observed when SAGs joined other SAGs, than when MAGs joined other MAGs (56.0% and 32.0% respectively). Encounters between SAGs were characterized by more aggressive and dynamic action patterns such as tumbling, rolling, head bobbing, tail kicking, rosette formations and open mouths. Encounters between MAGs were overall less energetic and involved more head up, spy hop, skimming, side and back postures and, as could be expected, neonate riding and suckling which were exclusive to MAGs. When SAGs mixed with MAGs, a lot of side postures, chasing, tail kicking and leaping were observed. However no rosette formations, open mouth or tumbling were witnessed during these encounters. The MAG + SAGs' total repertoire (52.0%) was less than that of SAGs but still more than that of MAGs.

Cluster of action patterns in groups

A cluster analysis was performed on the non-parametric (Spearman) correlation matrix of action patterns and group changes in order to identify close temporal associations between them. Since focal samples were of relatively short duration (average of 5 minutes), temporal associations signifies those that occurred in the same focal sample. MAG and SAG focal samples were analysed separately (Figs. 10 and 11).

In the MAG samples, seven major clusters with low or negative inter-cluster correlation were identified. Three clusters were formed of only one action pattern each: tail wave, stirring and tail kick. Splitting of the original group was accompanied mostly with bubble blowing and sounding. Skimming was closest to biting. Joining and splitting from SAGs was accompanied by rolling chasing and leaping. The largest cluster included the back swim, head up, riding, head out, side swim, and suckling, and was characteristic of encounters involving MAGs only.

In the SAG samples, there were also seven major clusters with relatively low and negative inter-cluster correlations. The largest cluster which included splitting from other SAGs contained biting, tumbling, open mouth, head out, back swimming, rolling, tail wave, tail kick, flipper slap and sounding. Open mouth and head out occurred most often in rosette formations. Two clusters comprised only one action pattern each, bubbles and head slap. Close couples of action patterns were riding and aerial spin, and chasing and leaping. Splitting of the original group was closest to skimming and head up to breathe.

Sequences of action patterns in groups

Correlations between action patterns do not provide information on the sequence of these events. For this purpose, transition matrices of preceding and following action patterns during the MAG and SAG focal samples (Table 23 and 24) were constructed according to the model given in Lemon and Chatfield (1973). These matrices were subjected to chi-square analysis to reveal possible dependencies between two adjacent acts. Sequences of events in groups should more closely resemble a complex web, rather than a simple chain of probable events. It was expected that a high degree of variability at each action pattern step existed.

In the MAG samples, eight action patterns were found to be dependent ($p<0.05$) on the preceding action pattern, and are identified by an asterisk in Table 23. No group changes were dependent on the preceding action pattern. In the SAG samples, 23 action patterns were found to be dependent on ($p<0.05$) the preceding one, and are identified by an asterisk in Table 24. Two group changes, mixing with SAGs and splitting from MAGs, were dependent on the preceding action pattern. Overall, more action patterns in SAGs were dependent on the preceding one than were those in MAGs.

The estuary habitat appears to provoke a break-up of larger groups which had travelled together in the open waters of Hudson Bay. The different groups were different in age (size) class composition, size, group stability, behavioral repertoire, associations between action patterns and group encounters, and degree of stereotypy of sequences of action patterns. MAGs were larger, more abundant and showed greater membership stability (less group changes) than SAGs. Their behavioral repertoire, on the other hand was smaller but showed a lesser degree of stereotypy in sequences of events than SAGs.

DISCUSSION

The exact reasons for the occupation of estuaries by belugas are not yet defined clearly. Studies still underway indicate that the answer could lie in a combination of behavioral and physiological factors (St-Aubin et the summer are extremely varied in their morphology, water properties and level of productivity (Fraker 1980). The only apparent factor common to all arctic estuaries is the presence of warmer and fresher waters compared to the surrounding seas.

The study site at the Nastapoka estuary allowed long term observations of belugas at close range because of excellent water clarity and shallow depths. The frequency and regularity of Inuit hunting at this estuary enabled me to observe the behavior of whales for a sufficiently long time between each disturbance.

There were some problems related to the age determination method. Although age structure are usually based on age classes, in this study, they were based on size classes which were found to correspond relatively well to age classes in other studies (Sergeant 1973). In such an age classification, individual variations, birth periodicity and sexual dimorphism are likely to produce some overlapping in older age classes, but for the neonates and 1 year olds, which are easily distinguishable from the others, the probability of error is minor.

Another problem arose when disturbances occurred too close together in time. This did not allow the whales to fully recover to their pre-disturbance numbers and must have influenced the analyses.

Numbers of belugas slowly increase at the Nastapoka estuary and remain at a peak for several weeks during the summer months. The total estuarine occupation period is longer at the Nastapoka estuary than in high arctic estuaries such as the Mackenzie estuary (Fraker et al. 1979), and Cunningham Inlet, Somerset Island (T. G. Smith pers. com.) but comparable to estuaries of the western Hudson Bay region (Sergeant, 1973). This probably relates to the longer summer period in lower latitudes.

The concept of a median position of the herd in the estuary was useful in assessing the relative influence of the environmental factors on the distribution of the whales. Inside the Nastapoka estuary, the distribution of belugas was mostly related to the tidal cycle, with whales advancing and retreating with the flow and ebb of the tide. Larger herds of whales were seen higher upstream than smaller ones, indicating that whales generally preferred to occupy quadrats not too distant from the open ocean. When these were filled or too crowded, whales had to occupy the quadrats higher upstream which were farther from the open waters of the bay.

In rough seas, such as during periods of choppy water surface and high northerly winds, whales tended to occupy the upper portion of the estuary in greater numbers, suggesting that they could also use the estuary as a shelter. In these cases, the observations might also have been biased because of reduced visibility of whales in the quadrats 4 and 5 because of their proximity to the open ocean where waves were highest.

As time went by after the return of the whales to the estuary following a hunt or a disturbance, they tended to occupy the upstream quadrats in greater numbers. It is impossible to separate the effect of herd size and passage of time on the position of the belugas in the estuary.

Whales tended to occupy the upstream quadrats in smaller numbers when the water was turbid. Perhaps this was related to them being reluctant to stay in a confined environment when their underwater vision was restricted.

When the river water was warmer, whales tended to occupy the upstream quadrats in greater number. This factor was the least significant to the distribution of whales and further investigation is needed to explain this result.

The count index was an attempt to measure the variability or repeatability of the same observer. I wanted to find out if the condition of the observer, such as fatigue, significantly influenced the results of the observations. When the observer felt fatigue, he tended to miss whales located in the most upstream quadrats. This had the effect of biasing the median position of the herd toward a more downstream location. This effect was found to be very minor however.

No significant difference was found between the age structures obtained from the two sampling techniques, scan and focal. Therefore, a smaller sample of age structure would be sufficient to evaluate accurately the average seasonal age structure and could be utilized with some degree of confidence in the future.

As mentioned in the Results, no great variations were observed in the age structure in the beluga herd in the Nastapoka estuary during the 1984 summer season. The statistically significant variations picked up by the analyses were small and are, in several cases, difficult to explain. Nevertheless, possible explanations are offered below.

The average age structures of 1983 and 1984 were found to be slightly different, but, no age class by itself was shown to vary significantly between the two years. The combined age classes of 2/3 length and 3/4 length whales were found to be somewhat lower in 1984. The age distribution of the Nastapoka herd appears, thus, to be fairly stable over this two year period.

The age class composition of the herd was shown to vary slightly within the 1984 season. All age classes exhibited some variations. The largest variation occurred in the 2/3 length class when, between the dates of the 17 July and 7 August, where it decreased by 50 percent. This dramatic decline could be an indication that weaning of this age class is occurring during this period. The neonate proportion only varied from 17.43% to 20.44% within the same season. If the estuary was used as a calving ground, as suggested by Sergeant (1973), we should have seen a much more pronounced seasonal increase. Variations in other age classes were of small amplitude and cannot be explained without further investigation.

Significant variations in age composition were found between quadrats of the estuary. Young calves (neonates and 1/2 lengths) were uniformly distributed in all quadrats, indicating uniform utilization of the whole estuary by pairs of mothers and young calves (since calves were accompanied by adults assumed to be their mothers). The 3/4 length whales were mostly located in the middle of the estuary and the whites were mostly located in the outer portion of the estuary. This tendency for certain age classes to utilize certain habitats more than others could indicate that, perhaps, the different age classes do not occupy the estuary for the same reasons, or for the same purpose. This topic needs further investigation since it relates directly to the question of why belugas occupy estuaries in the first place.

The age composition of the whale herd was observed to vary following the recovery periods, when the whales were gradually re-occupying the estuary. Among the first whales to return to the estuary, there was a predominance of white individuals. Whites would then gradually decrease in number and remain at a number below their expected levels. This could indicate that adult individuals (white) would only stay in the estuary for relatively short periods of time. During the first few hours, there was a lack of 2/3 and 3/4 length individuals, indicating a somewhat longer recovery period for these age classes. It is possible that these age classes would only return to the estuary if whales had already occupied the estuary for some time. Neonates and 1/2 length calves were again the most stable age classes, indicating that these classes, along with their mothers, were the most regular visitors of the estuary.

The average proportion of neonates (19.2%) in the Nastapoka herd is one of the highest among those that have been published to date for belugas. In the literature, percentages of neonate belugas in estuaries usually ranged between 8% and 14% (Sergeant 1973; Breton-Provencher 1980; Finley et al. 1982; Davis and Finley 1979; Heyland 1974), and exceptionally it ranged between 18% and 23.8% (Norton and Harwood 1985). Several reasons could explain the high percentage of neonates in this study. The differences in age structure could be due to differences in surveying techniques, where the majority of counts from aerial surveys and photos could be biased toward the more visible white belugas and miss the smaller darker calves and counts made from shore observation posts could be biased toward neonates because they breathe more frequently.

If the Nastapoka beluga herd were representative of the eastern Hudson Bay population, an estimate of the recruitment could be calculated from age class proportions. The percentage of neonates (19.2%) divided by the percentage of mature females (35.25%) yields a calf production of 0.54 calf per year, or one calf per female every two years. This figure is higher than the average calf production reported for western Hudson Bay belugas, which was slightly less than one calf per female every 3 years (Sergeant 1973) and which had a gross annual reproductive rate of 0.13. The discrepancy between the two estimates of calf production could indicate that the Nastapoka herd is not representative of its eastern Hudson Bay population. This is probably the case since the estimate of sex ratio indicates an unusually high proportion of females in the Nastapoka herd.

It appears that pairs of females accompanied by calves in their third year (2/3 length) are not fully represented in the estuary. However, since there is a seasonal average proportion of 2/3 length calves (11.4%) present in the estuary, females that would be their mothers are either absent, or accompanied by a neonate.

Since there are no independent estimates of age structure outside the Nastapoka estuary with which to compare this age structure, figures of calf production and recruitment presented here cannot yet be used as estimates of annual production rates.

From a management point of view, a high calf production could be maintained if eligible females mate with the available males. However, the hunters at the Nastapoka estuary harvest females accompanied by young when large unaccompanied whales cannot be found. This might indicate that the hunters have over-harvested the male proportion of the estuary stock and are now utilizing the reproductive core of the population. Strong site tenacity coupled with a high proportion of neonates are characteristics of the Nastapoka herd which makes it extremely vulnerable to over-exploitation. Fortunately, hunters have agreed to greatly reduce the harvest of these females in the future whenever possible.

Belugas at the Nastapoka were found to be very site tenacious. The same whales were seen to return to the estuary after repeated hunts and disturbances. Recovery periods of at least two days for a hunt and one day for motor disturbances were found to be necessary for whales to re-establish themselves in the estuary. Such recovery periods, however, do not allow the whales to occupy the estuary for a very long period of time, only two days on average from the time of the return of the first whale. It would be expected that continuous or frequent disturbances would eventually decrease the time whales can occupy the estuary and might eventually lead to its complete desertion. This might be what happened in the Great Whale River estuary and what is probably occurring at the Mucalic River in Ungava Bay (Smith pers. com.). The time between two sequential disturbances should not, at a minimum, exceed the time required for whale numbers to build up to their usual maximum levels. If the disturbance regime were to increase from the present level of week-end hunts and occasional boat traffic, the whales might severely reduce their occupancy of the estuary and possibly altogether abandon the Nastapoka site.

The ethogram of the beluga species compiled during the present study is incomplete since the summer estuarine occupation only represents a brief portion of the annual life cycle of the whales and there is an obvious lack of behavior associated with feeding, resting and mating. Feeding in such a small area is not likely and empty stomachs of whales harvested in the estuary support this idea. Resting or sleeping was thought to be impossible because of the strong current existing in the estuary. The reproductive season of belugas is in early spring as shown by ovarian analysis (Brodie 1971) and nothing is yet known of their behavior at that very important period in their life cycle.

Most action patterns observed for belugas of the Nastapoka were very similar to those reported in the literature for other species of free-ranging and captive odontocetes (see Appendix 1; Norris and Dohl 1980b; Wursig and Wursig 1979 and 1980; Saayman and Tayler 1979; Martinez and

Klinghammer 1978; Tayler and Saayman 1972). The present study on free-ranging belugas shows that they do possess as wide a behavioral repertoire as most odontocete species.

The two most distinctive behaviors seen relatively often in this study were the formation of a rosette and the riding. The rosette formation was not really an action pattern, but rather a consequence of several whales in social contact with their heads close together. It was reported for the first time in sperm whales in a care giving situation (Nishiwaki 1962). It has also been seen in belugas as part of social contacts in the Canadian arctic (T. G. Smith pers. com.). Sightings in which mature belugas were seen to persist in carrying inanimate objects (Smith and Sleno 1986) support the idea that small calves could just as easily be carried by their mothers or that calves could ride on the back of adults. It has been observed in only one other species of dolphin, the finless porpoise Neophocaena asiaeorientalis, (Pilleri and Peixun 1979). In the present study, the riding action pattern is not thought to be an optical illusion as discussed in Tomilin (1967).

The ordinary swimming was, by far, the dominant action pattern seen in belugas of the Nastapoka. All the other action patterns combined, only made up 10% of the total activity budget of the whales. This portion of the activity budget was found to be influenced by the following intrinsic and extrinsic factors.

A high density of whales in the estuary seemed to inhibit the display of more diverse observable action patterns. A negative relation was found between water clarity and the amount of PAP displayed. Turbid water conditions seemed to encourage the display of a greater amount of action patterns above the water surface other than ordinary swimming, perhaps helping in the communication between whales when underwater vision was limited. The time elapsed since the return of whales to the estuary after a disturbance (ET) was also found to be influential. As ET increased, the ratio of PAP decreased, indicating, perhaps, a certain period of adjustment following the return of belugas in the estuary. The amount of PAP displayed would then return to the presumed normal or average level. As the median of the herd distribution approached the downstream portion of the estuary, more of the PAP were displayed. This could indicate that the confinement or novelty aspect of the upstream quadrats could have acted as a deterrent on the display of more prominent action patterns. Decrease in water depth in the downstream quadrats, on the other hand, could also have acted to increase the amount of PAP displayed above the water surface because of the lack of vertical space. Observation periods subjectively judged as good were generally counts where a higher proportion of PAP was displayed. This suggests that when all the observation conditions were favorable, such as a low level of fatigue of the observer and a generally good visibility of the whales, a significant increase in the proportion of PAP was registered. It was also found that during periods of high winds, belugas tended to be more active above the water surface. The effect of high winds cannot be readily explained and further investigation on this topic is needed for interpretation.

Finally, a slight decrease in the display of PAP later in the day was found by the analysis. This could be an indication of a diel cycle in belugas of the estuary. Well marked diel and seasonal activity cycles are widely reported for odontocetes. Shane (1977) found significant variations of some behaviors with respect to the season and the time of day in bottlenose dolphins of the Atlantic. Saayman et al. (1973) showed that the behavior of both captive and free-ranging Indian bottlenose dolphins was significantly influenced by a diurnal rhythm. In some species however, such as in captive Amazon dolphins, Inia geoffrensis, no well-marked diel activity cycle could be found (Layne and Caldwell 1964).

The discriminant analysis used on the same set of data showed that the five activity classes could be effectively differentiated from one another using combinations of biological and environmental factors. Along each of the discriminant functions one or a few factors predominated. Age was found to be the most important factor of the first function showing that it had a more pronounced effect than any of the natural or human induced factors measured in the estuary. The importance of age was not unexpected. In other studies, age was also shown to play a role in differentiating between behavior (Saayman and Tayler 1979; Saayman et al. 1973). However, comparable quantitative information on this subject is not yet available in the cetacean literature.

It was surprising that the behavior of belugas would only be slightly influenced by human induced disturbances. I expected that the whales would show much greater variation in their behavior in response to disturbances. A possible explanation for the observed lack of variation in behavioral response in whales after their return to the estuary was that the whales recovered behaviorally from the disturbances outside the estuary and only returned when they felt secure enough or when they returned to their normal level of activity. Other factors shown to have limited discriminating power were water clarity, quadrat, and time elapsed after a hunt.

Water turbidity in coastal areas has been thought to induce side swimming in Tursiops (Leatherwood 1975). In other studies, habitat has also been found to be a very influential factor on the behavior of odontocetes.

Shane (1977) found a highly significant effect of location on both feeding and mating activities of coastal bottlenose dolphins of Texas. Saayman and Tayler (1979) observing humpback dolphins (Sousa sp.), found significant variations in moving, feeding, social activities and resting behaviors between different types of habitat such as in areas of sheltered sandy bottom and unsheltered rocky coastline areas. Wursig and Wursig (1979) report that the movements and behavior of bottlenose dolphins of the south Atlantic were influenced by tide and nearshore rocks.

There was distinct group type segregation in belugas of the Nastapoka estuary. I found groups containing calves and accompanying adults and groups of large white individuals with no calves. These groups have often been reported for belugas elsewhere (Tomilin 1967; Yablokov et al. 1974). Bel'kovich and Yablokov (1965: in Yablokov et al. 1974) demonstrated that mixed schools of belugas, females and young, consisted of genetically related specimens. Such family groups are also thought to occur in sperm whales (Best 1979) and in killer whales (Bigg 1982).

In addition to the groups with calves and the groups containing only adults, I also found groups of belugas composed only of juveniles, 1/2 or 2/3 length, and groups composed of a combination of these two age classes. I also found groups of only sub-adults, or 3/4 length, and groups of sub-adults associated with large juveniles, or 2/3 length, and groups of sub-adults in association with large adults. Such variety in group age composition is also reported in narwhals (Silverman 1979) and in sperm whales (Best 1979). It is possible that the relatively small area of the Nastapoka River is responsible for further break-up of the beluga groups usually seen during this time of year in other areas. It is also possible that the confinement of the estuary is favorable to the formation of juvenile groups which would normally stay within the safety of nursery groups, accompanied by their mothers.

Belugas in the present study demonstrated a high degree of fluidity of groups of the same type. Group membership was constantly changing in all types of grouping, although mixed age or nursery groups demonstrated greater stability. With the limited help of individual identification through natural marks, no permanent association between adults or other non-neonate calves could be discerned. However, more systematic observations of identified individuals might show otherwise. Interactions between the mixed age and same age groups were characterized by a high level of aggressive-like behaviors. The similar age groups were observed to be the instigators of most of the interactions between the groups. The impression was gained that nursery groups did not solicit any social contacts with members of the other group type.

In summary, the different groups showed variations in age-class composition, size, group stability, and behavioral repertoire. Differences were also noted in the associations between action patterns, and degree of stereotypy of sequences of action patterns between the two types of groups. MAGs were larger, more abundant, and showed greater membership stability (less group changes) than SAGs. Their behavioral repertoire, on the other hand, was smaller and showed a lesser degree of stereotypy in sequences of events than SAGs.

Several studies demonstrated a fair degree of fluidity of subgroup size and composition within larger groups in several coastal dolphins species (Wursig 1978; Norris and Dohl 1980b; Wells et al. 1980). From my observations, I found that belugas have a rather structured social organization during their occupation of the Nastapoka estuary. Group types are distinct and do not seem to easily mix with different group types without displaying agonistic behaviors. Mixing between the same types of groups, however, occurred frequently and without much disruption. Fluidity of group membership, therefore, appears to be limited in belugas of the Nastapoka estuary. The fluidity of membership appears to be only occurring within the same type of groups, where identified individuals were often seen with different identified individuals. My information on the social structure of belugas is very limited since there are no data on social organization outside the estuary or during the spring when mating takes place and the social structure would be most evident. Behavioral observations prior to, and during the period of reproduction would be the most informative but unfortunately this occurs in the open ice filled seas during late winter conditions and data from this period will probably always be scant. To further our knowledge, we would have to extend our observation season, properly mark or tag individuals of known sex, and, if possible, monitor their movements and activities using radiotelemetry.

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Table 1. Spearman rank correlation coefficients between the enviromental factors and the median position of the whale herd in the Nastapoka estuary in 1984.

Environmental factor	Correlation Coefficient (|R|)	Probability of a greater |R|	Number of Observations
Tide	-0.39845	0.0001	349
Total count	-0.33728	0.0001	351
Water surface	0.32272	0.0001	351
Estuary time	-0.23086	0.0001	272
Hunt time	-0.21195	0.0004	272
Wind speed	-0.16976	0.0014	351
Wind dir.(Sine)	-0.14865	0.0053	351
Water clarity	0.12183	0.0224	351
* Count index	-0.11870	0.0262	351
Water temp.(fresh)	-0.11371	0.0332	351
Time of day	0.06737	0.2080	351
Obs. # (season)	0.00189	0.9752	274

* Bias introduced by the observer.

Table 2. Contingency table of the age structure of the Nastapoka herd in 1983 and 1984 estimated by focal sampling. A deviation statistic Z was calculated for each cell and compared with the critical value of z (2.73) given a significance level of 0.05. None of the cells showed significant variation. Age classes 2/3 and 3/4 were combined in 1984 because these classes were already combined in the 1983 data.

Age class	1983 Obs. (percent) Z statistic	1984 Obs. (percent) Z statistic
Neonate	240 (16.3%) 1.4715	309 (19.1%) 1.3128
1/2	226 (15.3%) 0.3046	257 (15.9%) 0.2872
2/3 + 3/4	441 (29.9%) 1.7775	411 (25.4%) 1.8309
White	568 (38.5%) 0.3837	640 (39.6%) 0.3667

$X^2=9.5082$, df=3, $0.01<p<0.025$

Table 3. Contingency table of the age structure of the Nastapoka herd in different quadrats of the estuary during the 1984 season using scan sampling. A deviation statistic Z was calculated for each cell and compared with the critical value of z (3.0256) given a significance level of 0.05. Cell values which are significantly different from the expected value are marked with an asterisk.

	Q1	Q2	Q3	Q4
Age class	Obs. (percent) Z statistic	Obs. (percent) Z statistic	Obs. (percent) Z statistic	Obs. (percent) Z statistic
Neonate	1278 (20.5%) 2.8693	2486 (19.9%) 1.8354	1258 (17.6%) * 3.2546	1369 (18.2%) 2.0722
1/2	931 (15.2%) 0.4266	1992 (16.0%) 1.6207	1125 (15.8%) 0.7899	1074 (14.3%) 2.5852
2/3	649 (10.6%) 1.9505	1581 (12.7%) * 4.1051	888 (12.5%) 2.5527	671 (8.9%) * 7.2206
3/4	606 (9.9%) * 7.1721	1773 (14.2%) * 4.4626	1045 (14.7%) * 4.2657	814 (10.8%) * 5.0958
White	2663 (43.5%) 2.7609	4644 (37.2%) * 7.9141	2818 (39.5%) 2.4331	3584 (47.7%) * 8.6139

X^2=342.4939, df=12, p<0.005

Table 4. Contingency table of the age structure variation of the Nastapoka herd over the 1984 season. The dates listed are mean values of dates for blocs of equal sample size. A deviation statistic Z was calculated for each cell and compared with the critical value of z (3.0256) given a significance level of 0.05. Cell values which are significantly different from the expected value are marked with an asterisk.

Age class	17 July Obs. (percent) Z statistic	7 August Obs. (percent) Z statistic	20 August Obs. (percent) Z statistic	29 August Obs. (percent) Z statistic
Neonate	1455 (17.4%) * 3.9657	1733 (20.4%) 2.5837	1670 (20.0%) 1.6840	1542 (18.9%) 0.6223
1/2	1143 (13.7%) * 4.2544	1474 (17.4%) * 4.5117	1257 (15.1%) 0.7863	1254 (15.4%) 0.0187
2/3	1484 (17.8%) * 14.2083	736 (8.7%) * 8.4982	547 (6.6%) * 17.3304	1022 (12.5%) 3.0170
3/4	910 (10.9%) * 5.1238	1226 (14.4%) * 4.2706	1029 (12.3%) 1.0690	1077 (13.2%) 1.1922
White	3355 (40.2%) 1.6985	3310 (39.0%) * 3.5317	3844 (46.1%) * 6.7856	3259 (40.0%) 2.0206

X^2=703.7002, df=12, p<0.005

Table 5. Contingency table of age structure variation over increasing blocks of periods of time elapsed since the return of belugas to the estuary (ET) during the 1984 season. A deviation statistic Z was calculated for each cell and compared with the critical value of z (3.0256) given a significance level of 0.05. Cell values which are significantly different from the expected value are marked with an asterisk.

	< 30 Hrs.	30 to 75 Hrs.	75 to 135 Hrs.	>135 Hrs.
Age class	Obs. (percent) Z statistic	Obs. (percent) Z statistic	Obs. (percent) Z statistic	Obs. (percent) Z statistic
Neonate	1600 (19.2%) 0.0140	1687 (19.6%) 0.9267	1498 (18.7%) 1.1164	1568 (19.3%) 0.1471
1/2	1257 (15.1%) 0.7870	1275 (14.8%) 1.3992	1267 (15.8%) 0.8893	1299 (16.0%) 1.2827
2/3	814 (9.8%) * 4.8284	912 (10.6%) 2.2618	1117 (13.9%) * 6.1719	928 (11.4%) 0.0215
3/4	909 (10.9%) * 4.9056	1109 (12.9%) 0.6600	1011 (12.6%) 0.6901	1158 (14.2%) * 3.8394
White	3751 (41.3%) * 5.3700	3605 (42.0%) 1.0174	3124 (39.0%) * 3.5250	3179 (39.1%) * 3.3577

χ^2=161.6074, df=12, p<0.005

Table 6. Calendar of identification of belugas at the Nastapoka estuary during the 1984 season with reference to those identified in 1983 (*) and to the dates of the disturbances; H = Hunt, M = Motor (continued on next page).

		Whale Identification Number																						
		*	*					*	*	*				*									*	*
	DATE	1	3	4	7	8	10	11	15	17	19	20	22	23	26	28	30	31	37	39	41	42	44	45
	6-July	I	I																					
M	7- "	I	I	I	I	I																		
	8- "																							
H	9- "																							
M	10- "																							
	11- "																							
H	12- "					I	I	I																
	13- "																							
	14- "																							
2H	15- "																							
	16- "																							
	17- "	I					I	I											I					
	18- "	I					I	I		I														
	19- "						I	I	I	I														
	20- "	I					I		I	I														
	21- "						I		I	I														
	22- "		I	I			I		I	I	I													
	23- "		I	I																				
	24- "		I	I									I	I			I							
M	25- "						I				I	I			I									
	26- "													I										
	27- "			I		I	I		I	I				I										
	28- "		I				I			I														
H	29- "																							
	30- "							I						I	I									
	31- "	I	I	I	I		I	I	I	I			I	I	I	I	I							
	1-Aug.	I		I			I	I	I	I	I		I			I	I	I						
	2- "	I					I						I				I							
	3- "	I	I				I				I		I					I						
	4- "	I	I									I				I								
	5- "		I	I			I								I		I	I	I					
	6- "			I	I							I	I				I	I	I					
	7- "						I						I											
H	8- "		I																	I				
	9- "																							
	10- "																			I				
	11- "																							
	12- "			I			I		I											I				
	13- "																							

Table 6 (continued). Calendar of identification of belugas.

		Whale Identification Number																						
		*	*					*	*	*				*									*	*
	DATE	1	3	4	7	8	10	11	15	17	19	20	22	23	26	28	30	31	37	39	41	42	44	45
	14-Aug.		I				I											I		I				
	15- "		I			I	I		I			I								I				
	16- "		I				I						I	I						I				
	17- "		I				I		I											I		I		
H	18- "						I		I															
	19- "															I								
M	20- "								I					I										
	21- "																							
M	22- "																							
	23- "								I						I									
M	24- "	I	I		I																			
	25- "	I			I	I								I									I	I
	26- "	I																						I
	27- "	I																					I	
	28- "																							
	29- "	I	I									I											I	
	30- "		I			I			I			I				I			I	I	I		I	
	31- "	I			I				I	I		I							I	I	I	I	I	
	1-Sep.		I			I			I			I				I		I				I		
	2- "				I	I		I	I	I		I								I	I	I	I	

Table 7. Minimum occupation rates of the Nastapoka estuary by individually identified belugas using scars and natural markings during the 1984 season.

Whale ID #	Total observation period (days)	Number of days of occupation	Percent estuary occupation
* 1	26	10	38 %
* 3	26	14	54 %
* 4	25	7	28 %
7	25	7	28 %
8	25	6	24 %
* 10	24	11	46 %
11	23	4	15 %
12	24	2	8 %
* 15	23	11	48 %
* 17	24	8	33 %
19	21	2	10 %
20	18	8	44 %
22	19	5	26 %
* 23	19	5	26 %
26	18	2	11 %
28	12	5	42 %
30	19	3	16 %
31	13	2	15 %
37	13	3	23 %
39	11	5	45 %
41	13	3	23 %
42	10	4	40 %
* 44	7	5	71 %
* 45	6	1	17 %

* Whales identified in 1983.
Mean minimum estuary occupation = 30.46 % ± 15.89 %

Table 8. Recovery time of whales in the Nastapoka estuary as a result of hunting activities during the 1983 and 1984 seasons.

Date	Initial count	* Partial Recovery (hours)	* Total Recovery (hours)	** Recovery time of identified whales # of hours (ID no.)
23/07/83	100	35	48	-
09/07/84	88	19	50	-
12/07/84	51	36	35	380(8), 117(10,11)
15/07/84	35	2	25	-
15/07/84	25	26	48	-
29/07/84	114	4	45	-
08/08/84	31	48	58	144(3), 56(39)
18/08/84	209	11	12	48(15)

* Recovery time: Partial= return of first whale to estuary, Total= return of >70% of Initial or pre-disturbance count to estuary.

Table 9. Recovery time of whales in the Nastapoka estuary as a result of motor traffic activities during the 1983 and 1984 seasons.

Date	Initial count	* Partial Recovery (hours)	* Total Recovery (hours)	** Recovery time of identified whales # of hours (ID no.)
25/07/83	70	24	33	-
03/08/83	105	28	28	-
07/07/84	101	28	36	165(1),372(3,4) 574(7),106(8)
10/07/84	40	20	22	-
25/07/84	117	16	41	42(10),236(20) 169(19),177(26)
20/08/84	129	3	5	123(23)
22/08/84	14	2	5	-
24/08/84	207	15	27	33(1),104(3)

* Recovery time: Partial= return of first whale to estuary; Total= return of >70% of Initial or pre-disturbance count to estuary.

Table 10. Ethogram of white whales in the Nastapoka River estuary.

Class of activity	Action pattern	Description
Swimming	Ordinary	Gentle rolling of the back when surfacing to breathe.
"	Leaping	Projecting the body out of the water exposing the foward half of the body during the initial thrust and re-entering the water head/first.
"	Sounding	Diving into the water with a sharp bend of the tail stock.
"	Tail up	Lifting the flukes out of the water when sounding.
"	Skimming	Advancing through the water with the head held above the water surface.
"	Head up	Raising only the head to clear the blow hole when surfacing to breathe.
Display Swimming	Side swimming	Swimming in a foward motion on the side.
"	Back swimming	Swimming in a foward motion on the back.
Aerial	Breaching	Projecting the body out of the water in an oblique position and falling in the water on the side, front or back.
"	Aerial spin	Projecting the body out of the water in a horizontal position and spinning on the longitudinal axis before falling in the water.
"	Spy hop	Raising the body out of the water in an upright vertical position exposing the head and neck.
"	Tail stand	Raising and maintaining the body out of the water in an upright position by vigourous tail movements (very short duration).
"	Pitch polling	Maintaining the body in an upright position with the head out of the water while rotating on the longitudinal axis.
"	Tail wave	Moving the tail from side to side.

Table 10 (continued). Ethogram of white whales.

Class of activity	Action pattern	Description
Interactive	Head slap	Hitting the water surface with the chin and throat.
"	Head bob	Small up and down movements of the head at the water surface.
"	Flipper slap	Hitting the ventral part of the pectoral fin against the water surface.
"	Tail slap	Striking the water surface with the flukes of the tail.
"	Open mouth	Whales facing one another with their mouths open, thus forming a rosette formation.
"	Biting	Holding with the mouth any part of another whale.
"	Chasing	Pursuits between whales.
"	Rolling	Longitudinal turning at the water surface.
"	Tumbling	Whales rolling on top of each other and tussling.
"	Head butting	Hitting against another whale using the head.
"	Erection	Erect penis seen when a whale exposes its ventral surface above the water surface.
Epimeletic	Riding	One whale maintaining a parellel position on the back of another.
"	Cross-back	Crossing over another whale at the water surface.
"	Suckling	Young calf repeatedly diving close to the genital area of an adult.

Table 11. Total activity budget based on frequency counts of action patterns obtained from scan sampling during the summer of 1984 at the Nastapoka River estuary. Pattern counts and percentages are summed to give the class counts and percentages. The ordinary swimming is treated separately. The ordinary swimming total percentage and the class total percentages add up to 100%, or to the total activity budget (continued on next page).

Activity class Action pattern	Class count Pattern count	Class total % Pattern total %
Ordinary swimming	29,921	89.78
Swimming		
Fast	178	0.53
Leaping	92	0.28
Sounding	48	0.14
Tail up	94	0.28
Skimming	42	0.13
Head up	981	2.94
	1,435	4.31
Swim Display		
Side swimming	732	2.20
Back swimming	30	0.09
	762	2.29
Epimeletic		
Riding	194	0.58
Cross-back	16	0.05
Suckling	4	0.01
	214	0.64
Aerial		
Breaching	48	0.14
Aerial spin	14	0.04
Spy hop	40	0.12
Tail stand	9	0.03
Tail wave	38	0.11
	149	0.45

Table 11 (continued). Total activity budget.

Activity class Action pattern	Class count Pattern count	Class total % Pattern total %
Interactive		
Head slap	29	0.09
Head bob	38	0.11
Flipper slap	4	0.01
Tail slap	378	1.13
Rosette	*(194)	*0.58
Open mouth	10	0.03
Biting	1	0.00
Chasing	16	0.05
Rolling	65	0.16
Tumbling	102	0.31
Head but	2	0.01
Erection	7	0.02
	645	2.52

* 23.12% of the interactive action patterns were done in rosette formations.

Table 12. Result of the stepwise regression of the ratio of prominent action patterns (PAP) to the total number of action patterns (TBEH) on all environmental factors.

Variables added successively in the model at the 0.05 level	Estimated regression coefficient in last model	F of each variable in the last model	Prob > F	R^2 of model after the addition of each new variable
TBEH	-0.0224	25.70	0.0001	0.2273
WC	-0.0693	20.78	0.0001	0.2854
ET	-0.0076	6.65	0.0105	0.3113
MED	0.1454	9.21	0.0027	0.3295
CI	0.0506	6.57	0.0110	0.3444
WSP	-0.0054	6.34	0.0124	0.3565
TM	-0.0001	5.81	0.0167	0.3716

TBEH = Total number of action patterns counted in one observation session
WC = Water clarity
ET = Time (hrs.) elapsed since the return of whales in the estuary
MED = Median of the distribution of whales in the estuary
CI = Count index
WSP = Wind speed
TM = Time of day

Table 13. Mahalanobis distance (D) and associated probability (P) between the activity class centroids.

Activity Class		Epimeletic	Swim	Disp. Swim	Aerial	Interactive
Epimeletic	D	-	* 2.0259	* 2.0709	* 1.6089	* 2.0443
	P	-	0.0000	0.0000	0.0000	0.0000
Swim	D		-	* 0.4440	0.6530	* 0.6687
	P		-	0.0001	0.9875	0.0000
Display swim	D			-	0.6496	* 0.4756
	P			-	0.8668	0.0000
Aerial	D				-	* 0.6809
	P				-	0.0000
Interactive	D					-
	P					-

D^2 is significant (*) if $P < 0.05$.

Table 14. Coefficients of the discriminant functions based on the environmental factors, including age, recorded during each observation session in 1984. The most discriminating values are preceeded by an asterisk.

Environmental Factors	First Discriminant function $R^2= 0.1971$	2nd Discriminant function $R^2=0.0664$	3rd Discriminant function $R^2=0.0159$
Physical factors			
Tide	0.0128	-0.2682	0.1033
Water surface	0.0540	0.3297	-0.3367
Water clarity	-0.0564	0.5579	-0.0131
Water temp.	0.0098	-0.0771	0.0758
Wind direction	0.0289	0.1215	-0.1702
Wind speed	-0.0271	0.2807	-0.0398
Quadrat	* -0.1464	* -0.4378	* 0.5936
Temporal factors			
Time of day	0.0592	0.0879	0.2113
Month	0.0171	-0.3103	* -0.7588
Time in estuary	0.0054	0.0411	* -0.4510
Time from hunt	* -0.1093	* 0.4072	* 0.4113
Biological factor			
Age of whale	* 1.1215	0.0129	0.0056
Density factor			
Total # of whales	0.0384	-0.3463	0.2586
Observer bias factor			
Count index	0.0077	-0.1772	0.0440

Table 15. Activity budget of age classes based on frequency counts of action patterns obtained from scan sampling in 1984. The total budget of each age class (100%) is calculated by summing all the pattern percentages for the particular age class (continued on next page).

	Age classes				
	Neonate	1/2	2/3	3/4	White
Activity class Action pattern	Pattern percent	Pattern percent	Pattern percent	Pattern percent	Pattern percent
Ordinary swimming	94.72	91.11	88.76	87.86	87.87
Swimming					
Fast	0.56	0.56	0.24	0.38	0.67
Leaping	0.48	0.39	0.42	0.12	0.15
Sounding	0.02	0.14	0.13	0.09	0.23
Tail up	0.23	0.76	0.24	0.31	0.13
Skimming	0.02	0.10	0.11	0.17	0.18
Head up	0.75	1.05	2.16	3.32	4.76
	2.06	3.00	3.30	4.39	6.12
Swim Display					
Side swimming	0.27	2.22	2.88	2.81	2.71
Back swimming	0.02	0.00	0.16	0.17	0.12
	0.29	2.22	3.04	2.98	2.83
Epimeletic					
Riding	2.25	0.62	0.29	0.07	0.03
Cross-back	0.19	0.02	0.03	0.00	0.01
Suckling	0.03	0.02	0.03	0.00	0.00
	2.47	0.66	0.35	0.07	0.47
Aerial					
Breaching	0.05	0.31	0.24	0.09	0.12
Aerial spin	0.00	0.23	0.00	0.02	0.01
Spy hop	0.11	0.16	0.18	0.12	0.09
Tail stand	0.03	0.06	0.08	0.00	0.01
Tail wave	0.00	0.06	0.18	0.19	0.15
	0.19	0.82	0.68	0.42	0.38

Table 15 (continued). Activity budget of age classes.

	Age classes				
	Neonate	1/2	2/3	3/4	White
Activity class Action pattern	Pattern percent	Pattern percent	Pattern percent	Pattern percent	Pattern percent
Interactive					
Head slap	0.02	0.06	0.13	0.02	0.14
Head bob	0.08	0.12	0.11	0.19	0.11
Flipper slap	0.00	0.00	0.05	0.02	0.01
Tail slap	0.13	1.25	1.66	1.91	1.18
Rosette *	0.00	0.00	0.48	1.06	0.95
Open mouth	0.00	0.02	0.05	0.12	0.01
Biting	0.00	0.00	0.00	0.00	0.01
Chasing	0.00	0.08	0.08	0.01	0.04
Rolling	0.03	0.08	0.29	0.35	0.15
Tumbling	0.03	0.64	0.84	0.40	0.13
Head but	0.00	0.00	0.00	0.02	0.02
Erection	0.00	0.00	0.03	0.05	0.03
	0.23	2.25	3.72	4.15	2.75
	100.00	100.00	100.00	100.00	100.00

---

* 23.12% of the interactive action patterns were done in rosette formations.

Table 16. Activity budget in quadrats based on frequency counts of action patterns obtained from scan sampling in 1984. The total budget in each quadrat (100%) is calculated by summing all the pattern percentages for the particular quadrat (continued on next page).

	Quadrats			
	1	2	3	4
Activity class Action pattern	Pattern percent	Pattern percent	Pattern percent	Pattern percent
Ordinary swimming	96.21	93.94	87.41	80.21
Swimming				
Fast	0.03	0.14	0.35	0.20
Leaping	0.10	0.20	0.46	0.37
Sounding	0.70	0.04	0.00	0.00
Tail up	0.33	0.30	0.21	0.29
Skimming	0.02	0.03	0.14	0.32
Head up	0.47	0.95	3.49	7.59
	1.65	1.66	4.65	8.77
Swim Display				
Side swimming	0.72	1.67	3.04	3.43
Back swimming	0.07	0.0[illegible]	0.21	0.11
	0.77	1.69	3.25	3.54
Epimeletic				
Riding	0.08	0.44	0.74	1.08
Cross-back	0.02	0.06	0.03	0.07
Suckling	0.00	0.00	0.06	0.00
	0.01	0.05	0.83	1.15
Aerial				
Breaching	0.13	0.06	0.07	0.33
Aerial spin	0.02	0.10	0.01	0.00
Spy hop	0.03	0.03	0.22	0.24
Tail stand	0.33	0.30	0.21	0.29
Tail wave	0.05	0.03	0.25	0.17
	0.56	0.52	0.76	1.03

Table 16 (continued). Activity budget in quadrats.

	Quadrats			
	1	2	3	4
Activity class Action pattern	Pattern percent	Pattern percent	Pattern percent	Pattern percent
Interactive				
Head slap	0.20	0.01	0.04	0.16
Head bob	0.02	0.02	0.24	0.23
Flipper slap	0.00	0.01	0.25	0.17
Tail slap	0.69	0.86	1.05	2.00
Rosette *	0.00	0.64	0.32	1.21
Open mouth	0.00	0.03	0.08	0.00
Biting	0.00	0.00	0.01	0.00
Chasing	0.03	0.02	0.07	0.08
Rolling	0.05	0.15	0.19	0.39
Tumbling	0.05	0.22	0.62	0.36
Head but	0.00	0.02	0.00	0.00
Erection	0.00	0.00	0.04	0.05
	1.04	1.98	2.91	4.65
Total	100.00	100.00	100.00	100.00

* 20.51% of the interactive action patterns were done in rosette formations.

Table 17. Activity budget of activity classes in different degrees of water clarity based on frequency counts from scan samples in 1984.

Activity class	1 (opaque)	2	3	4 (clear)	Total
	Frequency Column %	Frequency Column %	Frequency Column %	Frequency Column %	Mean row percent.
Ordinary Swim	865	2498	17651	8125	29139
	85.56	88.71	90.12	89.79	89.82
Swim	73	134	878	308	1393
	7.22	4.76	4.48	3.41	4.29
Display swim	31	78	418	201	728
	3.07	2.77	2.13	2.23	2.24
Epimeletic	8	21	125	56	210
	0.79	0.75	0.64	0.62	0.65
Aerial	4	21	72	47	144
	0.40	0.75	0.37	0.52	0.44
Interactive	30	64	443	292	829
	2.97	2.27	2.26	3.23	2.56

Table 18. Activity budget of activity classes in increasing periods of time elapsed after a hunt based on frequency counts from scan samples in 1984.

Activity class	≤ 125hrs.	125 to 190	190 to 279	> 279hrs.	Total
	Frequency Column %	Frequency Column %	Frequency Column %	Frequency Column %	Mean row percent
Ordinary swim	7302	7747	7276	7284	29609
	98.08	90.83	89.44	89.94	89.84
Epimeletic	45	65	49	54	213
	0.55	0.76	0.60	0.67	0.65
Swim	396	351	327	338	1412
	4.83	4.12	4.02	4.17	4.28
Display swim	174	182	213	176	745
	2.12	2.13	2.62	2.17	2.26
Aerial	47	35	34	30	146
	0.57	0.41	0.42	0.37	0.44
Interactive	232	149	236	217	834
	2.83	1.75	2.90	2.68	2.53

Table 19. Activity budget of activity classes by month based on frequency counts from scan samples in 1984.

Activity class	July	August	September	Total
	Frequency Column %	Frequency Column %	Frequency Column %	Mean row percent
Ordinary swim	8750	17882	2507	29139
	88.35	90.47	90.41	89.82
Epimeletic	66	130	14	210
	0.67	0.66	0.50	0.65
Swim	460	805	128	1393
	4.64	4.07	4.62	4.29
Display swim	212	444	72	728
	2.14	2.25	2.60	2.24
Aerial	56	79	9	144
	0.57	0.40	0.32	0.44
Interactive	360	426	43	829
	3.63	2.16	1.55	2.56

Table 20. Activity budget of activity classes by increasing periods of time spent in the estuary based on frequency counts from scan sampling in 1984.

Activity class	≤ 30hrs.	30 to 75	75 to 135	> 135hrs.	Total
	Frequency Column %	Frequency Column %	Frequency Column %	Frequency Column %	Mean row percent
Ordinary swim	7211	7800	7299	7299	29609
	87.63	90.86	91.06	89.79	89.84
Epimeletic	51	63	39	60	213
	0.62	0.73	0.49	0.74	0.65
Swim	487	277	294	354	1412
	5.92	3.23	3.67	4.35	4.28
Display swim	219	157	147	222	745
	2.66	1.83	1.83	2.73	2.26
Aerial	48	29	40	29	146
	0.58	0.34	0.50	0.36	0.44
Interactive	213	259	197	165	834
	2.59	3.02	2.46	2.03	2.53

Table 21. Age class inventory of 272 groups of belugas in the Nastapoka estuary during the 1984 season.

Group type	Description	Age classes					Total number of groups
		Neonate	1/2	2/3	3/4	White	
Similar age	Singleton	-	-	1	1	10	12
"	> 1 whale	-	P	-	-	-	12
"	"	-	P	P	-	-	8
"	"	-	-	P	-	-	6
"	"	-	-	P	P	-	2
"	"	-	-	-	P	-	6
"	"	-	-	-	P	P	35
"	"	-	-	-	-	P	16
							97
Mixed age	Couples	P	-	-	-	P	14
"	"	-	P	-	-	P	8
"	"	-	-	P	-	P	2
"	"	P	-	-	P	-	5
"	"	-	P	-	P	-	2
"	Triads	P	-	P	-	P	3
"	"	-	P	-	P	P	1
"	>3 whales combinations	P	P	P	P	P	140
							175

P = presence of the age class.

Table 22. Number of focal samples at the Nastapoka estuary in which action patterns were present for the two types of groups.

Action patterns	Group Contexts				
	MAG (n=45)	MAG+MAG (n=9)	MAG+SAG (n=20)	SAG+SAG (n=10)	SAG (n=37)
Head up	15	2	1	1	5
Spy hop	4	0	0	0	2
Skim	4	0	1	0	4
Ride	8	2	2	0	2
Suckling	4	1	0	0	0
Stirring	4	0	0	0	0
Leap	0	0	4	0	0
Bubbles	8	2	3	1	5
Back swim	3	2	3	2	1
Side swim	8	2	8	5	18
Tail wave	1	1	1	1	1
Tail kick	2	1	5	3	10
Chasing	1	0	4	2	2
Bite	1	0	0	1	1
Head-out	0	0	1	1	4
Head bob	0	0	1	2	7
Tumble	0	0	0	1	7
Flipper slap	0	0	0	0	1
Rolling	0	0	3	2	13
Head but	0	0	0	0	1
Open mouth	0	0	0	1	4
Rosette	0	0	0	3	5
Head slap	0	0	0	0	1
Erection	0	0	0	0	2
Arial spin	0	0	0	0	1

n = number of focal samples.

Glossary of abreviations of action patterns and group encounters used in Figures 10 and 11, and in Tables 23 and 24.

Mixed Age Groups

TWA : Tail wave
STI : Stirring
TKI : Tail kick
BUB : Bubbles
SOR : Splitting of original group
SOU : Sounding
BIT : Biting
SKI : Skimming
ROL : Rolling
CHA : Chasing
SSA : Split from SAG
JSA : Join with SAG
LEP : Leaping
BSW : Back swimming
HUP : Head up to breathe
RID : Riding
HOU : Head out
SSW : Side swimming
SUC : Suckling
SMA : Split from MAG
JMA : Join with MAG

Similar Age Groups

CHA : Chasing
LEP : Leaping
BUB : Bubbles
HSL : Head slap
JMA : Join with MAG
SMA : Split from MAG
SEX : Erection
HBO : Head bobbing
SSW : Side swimming
JSA : Join with SAG
SKI : Skimming
HUP : Head up
SOR : Splitting of original group
RID : Riding
ASP : Aerial spin
BIT : Biting
SSA : Split from SAG
TUM : Tumbling
ROS : Rosette formation
OPM : Open mouth
HOU : Head out
BSW : Back swimming
ROL : Rolling
TWA : Tail wave
TKI : Tail kick
FSL : Flipper slap
SOU : Sounding

Table 23. Transition matrix of the preceding and following action patterns from the Mixed Age Groups in the 1984 season.

Preceding action pattern	Following action pattern																						
	JMA	SMA	JSA	SSA	SOR	* HUP	* SOU	SPH	* SKI	* RID	SUC	* STI	BUB	* BSW	* SSW	TWA	TKI	CHA	BIT	HOU	ROL	LEP	Row total
JMA		1				1				1			1										4
SMA	1									1													2
JSA				1								1	1	1	1		1	2					8
SSA			1			1					1				1								4
SOR								1															1
HUP	1						3		3	4	2		4	4			1						22
SOU			1			2							1										4
SPH						1									2								3
SKI													1	1	1			1					4
RID	2		1			1						1	2	3	3		1			1			15
SUC	2					3							1	2									8
STI				1				1		1				4									7
BUB	2	1	1	3		4	1		2	2	1			2	3							2	24
BSW			1			4				1	1	4	2		2	1				1			17
SSW	2		1		1	2				2	1			2			1	1			1		14
TWA	1									1													2
TKI				1	2								1										4
CHA										1			4						1			1	7
BIT													1										1
HOU	1					1								1									3
ROL																		1					1
LEP			1	1	1													1					4
Column total	12	2	7	7	4	20	4	2	5	14	6	6	1	20	1	1	4	6	1	2	1	3	159

* dependent on the preceding action pattern (p<0.05)

Table 24. Transition matrix of the preceding and following action patterns from the Similar Age Groups in the 1984 season.

Preceding action pattern	Following action pattern																													Row total
	*	*	*			*			*	*	*	*	*	*	*	*	*	*	*	*	*		*	*		*		*		
	JMA	SMA	JSA	SSA	SOR	HUP	SOU	SPH	SKI	RID	BUB	SSW	TWA	TKI	CHA	BIT	HOU	HBO	TUM	FSL	ROL	HBU	OPM	ROS	HSL	SEX	ASP	BSW	LEP	
JMA		5										4	1		1														1	12
SMA			2									5			5									1						13
JSA				1		1				1		3		1	1			1					1							10
SSA												1		1							1									3
SOR				1		1							2																	4
HUP									3		1	4		1			2	2			1									14
SOU																														0
SPH																					2									2
SKI					1	2												2						1						6
RID							1		1			2																		4
BUB	1		1		1	1								1							1									6
SSW	8	1	1			4				1	1		3	13	1		6	2	4		11			5				2	2	65
TWA	1		1			1						2		4	1			1			2									13
TKI			4								3	8	1		1			2	4	1	7			3	1	2		1		38
CHA		1			1							2							1		1								8	14
BIT												3							1				1							5
HOU			1							1		4							1		2		1	2						12
HBO					1	3						3		3			1				1							3		15
TUM			2									4	1	3			1				3			1		3				18
FSL														1																1
ROL			2								2	6	2	6			2		6					5				4		35
HBU														2									1							3
OPM				1						1		2				4			1									1		10
ROS								1				4	2	2		1					3	1	5					1		20
HSL												1																		1
SEX	2											3																		5
ASP																												1		1
BSW		1							1			7		1			1	3			2	1	1							18
LEP		2	1									1			2													1		7
Column total	12	10	15	3	4	13	1	1	5	4	7	69	12	39	12	5	13	13	18	1	37	2	10	18	1	5	0	14	11	355

* dependent on the preceding action pattern ($p<0.05$)

Figure 1. Location of the study site in Hudson Bay.

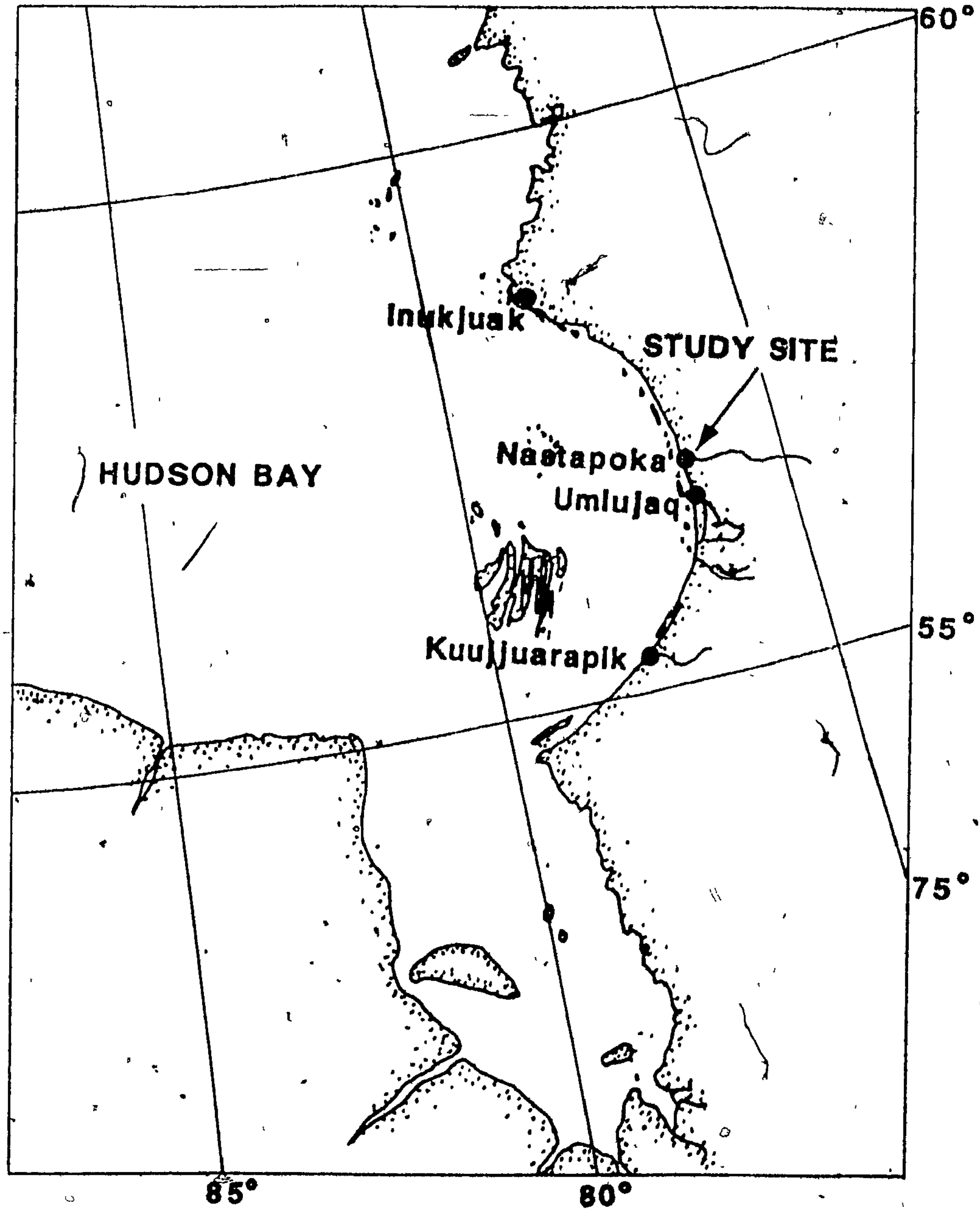

60°
Inukjuak
STUDY SITE
Nastapoka
Umiujaq
HUDSON BAY
55°
Kuujjuarapik
75°
85°
80°

Figure 2. Map of the study site, the Nastapoka River estuary, showing the location of the observation tower, the quadrats and the water sampling stations.

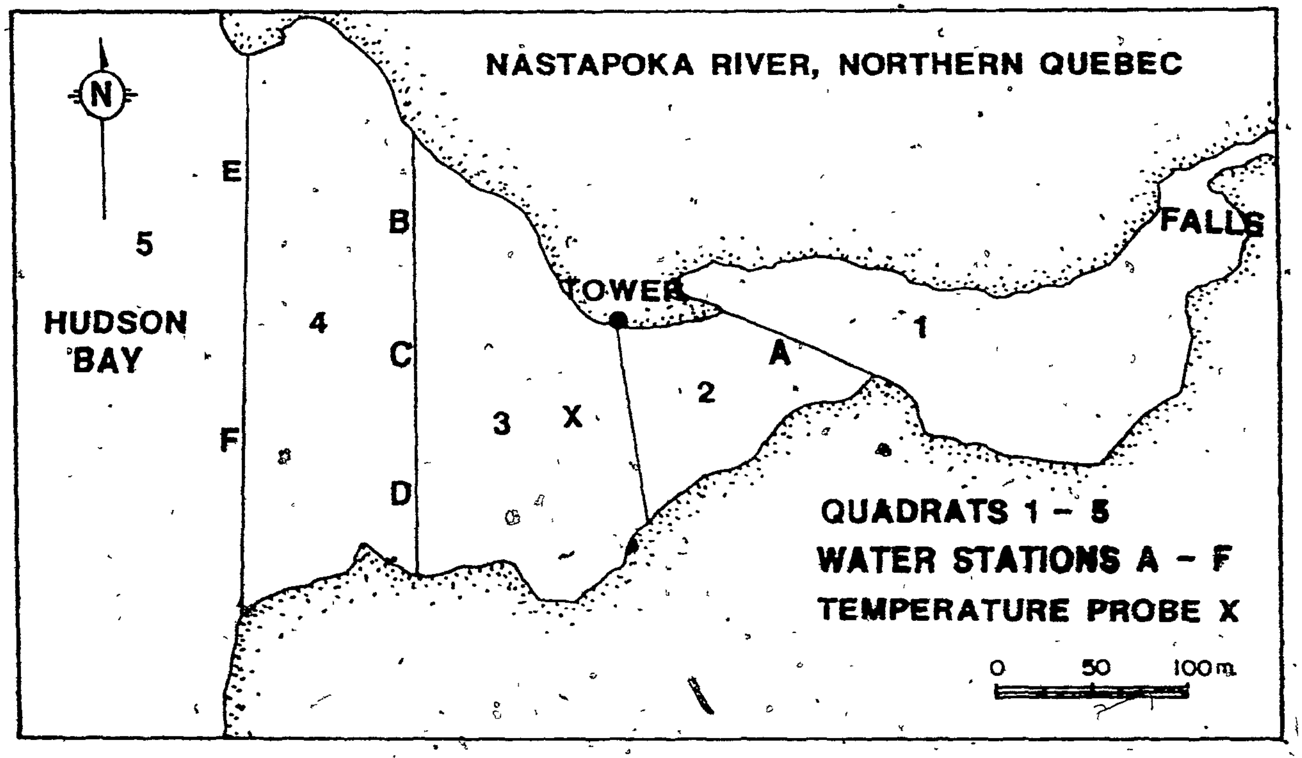
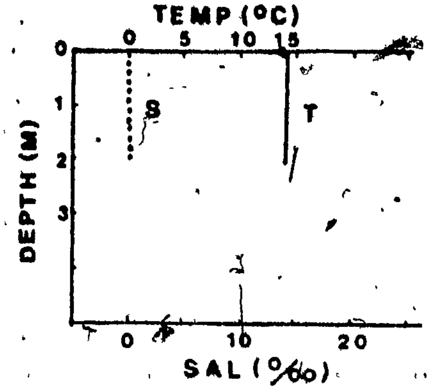
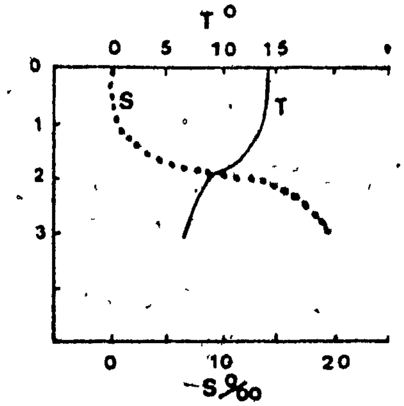

NASTAPOKA RIVER, NORTHERN QUEBEC
N
E
B
5
FALLS
TOWER
HUDSON BAY
4
C
A
1
2
3
X
F
D
QUADRATS 1 - 5
WATER STATIONS A - F
TEMPERATURE PROBE X
0
50
100 m

Figure 3. Salinity and temperature/depth profiles of the different water sampling stations in the Nastapoka River estuary.

STATION A



STATION C



STATION F

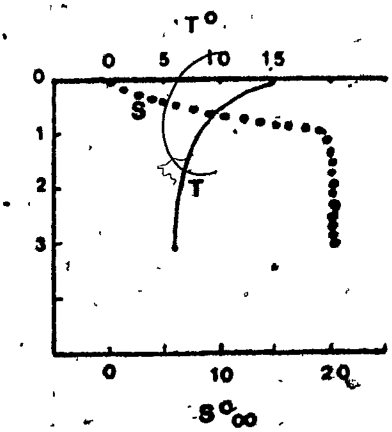
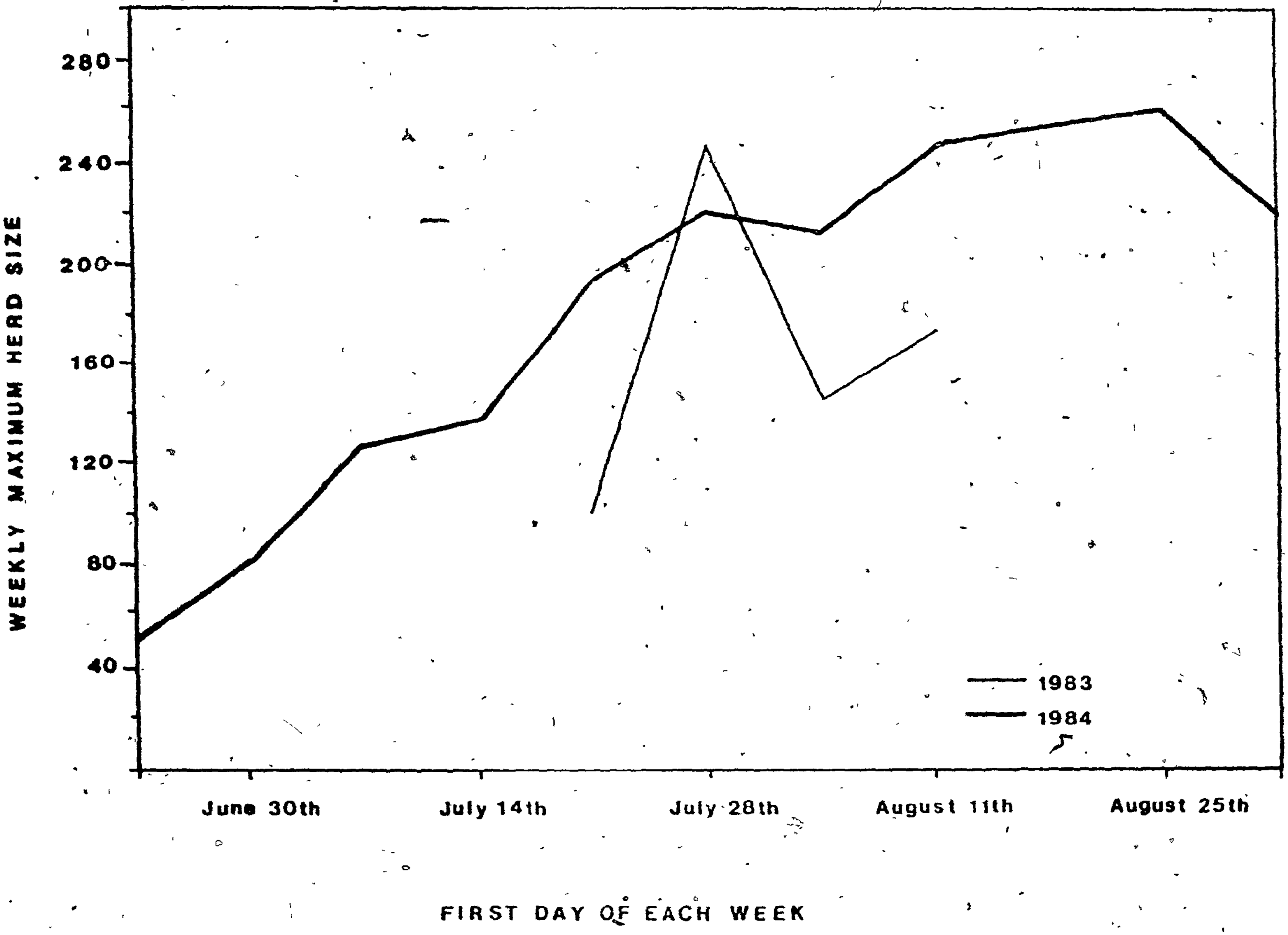


Figure 4. Maximum weekly count of belugas in the Nastapoka River estuary.



WEEKLY MAXIMUM HERD SIZE
280
240
200
160
120
80
40
1983
1984
June 30th
July 14th
July 28th
August 11th
August 25th
FIRST DAY OF EACH WEEK

Figure 5. Drawings of the five age classes of belugas recognized in the Nastapoka River estuary.

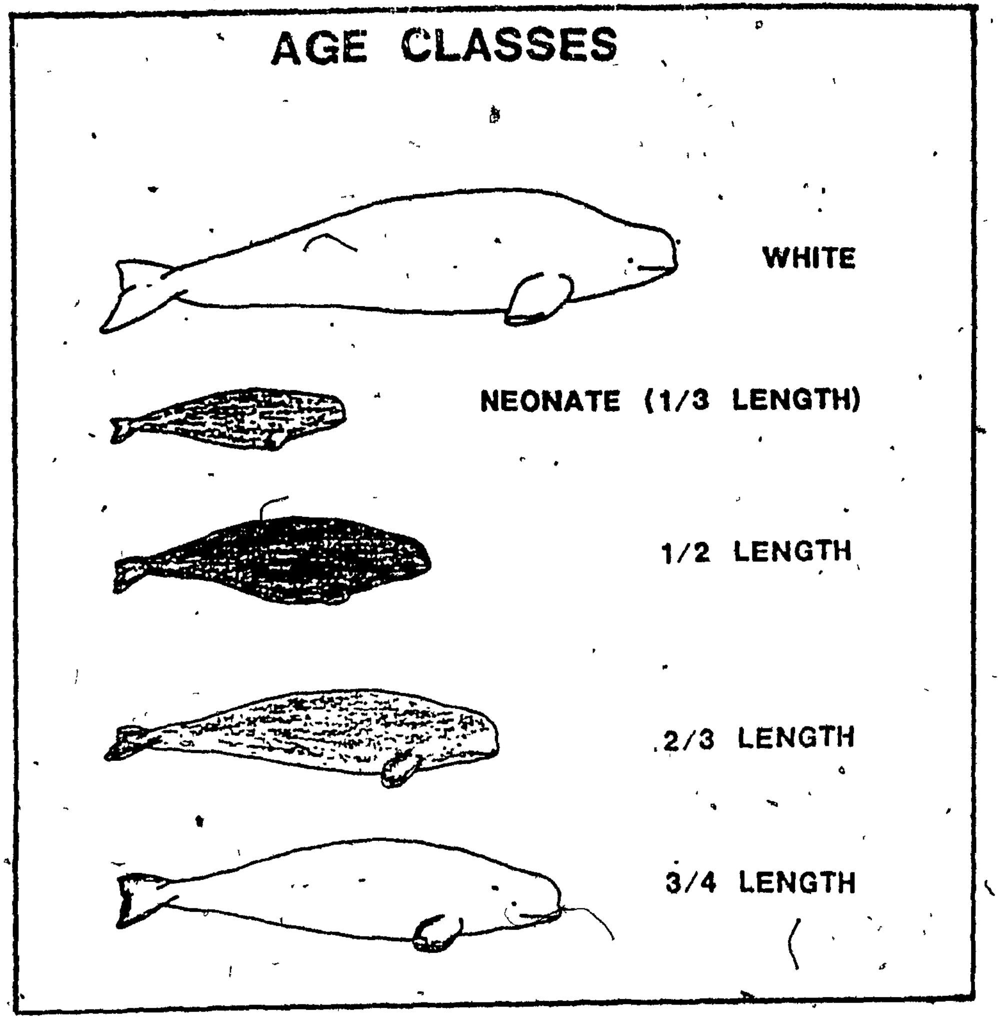
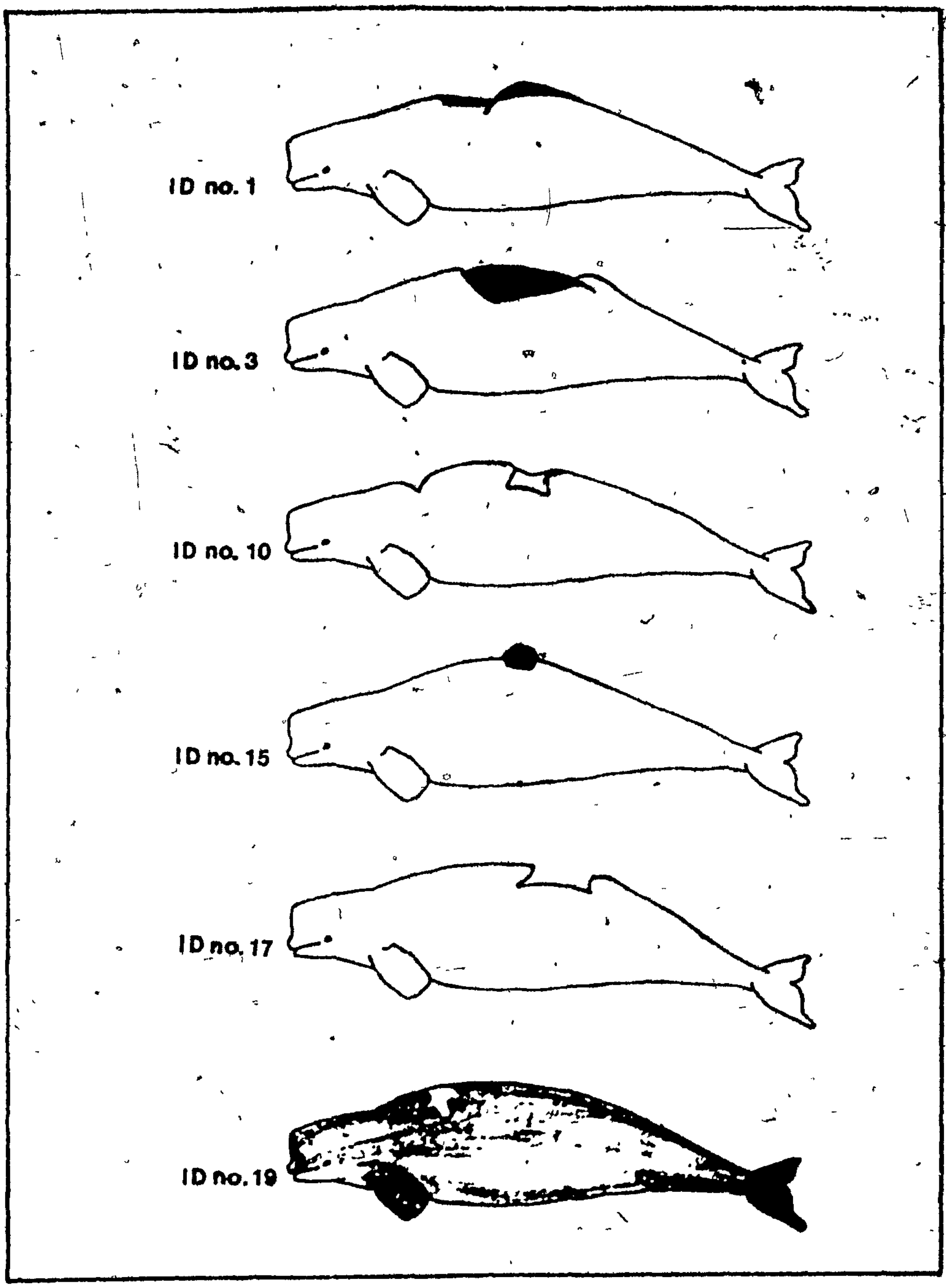
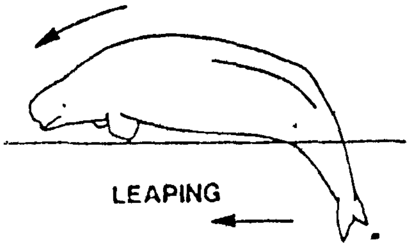

AGE CLASSES
WHITE
NEONATE (1/3 LENGTH)
1/2 LENGTH
2/3 LENGTH
3/4 LENGTH

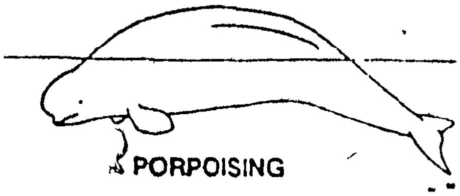
Figure 6. Drawings of some of the marks used to identify belugas of the Nastapoka estuary during the 1983 and 1984 seasons.


ID no. 1
ID no. 3
ID no. 10
ID no. 15
ID no. 17
ID no. 19

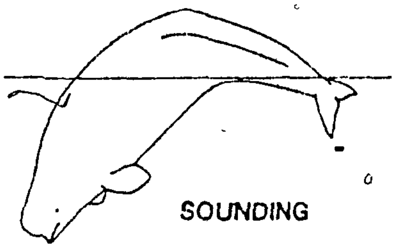
Figures 7a and 7b. Drawings of action patterns observed in belugas of the Nastapoka River estuary.



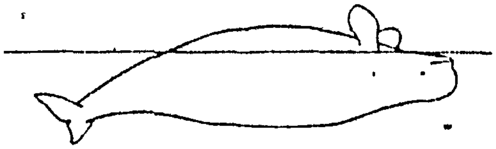
LEAPING



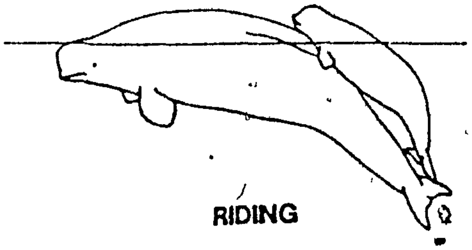
PORPOISING



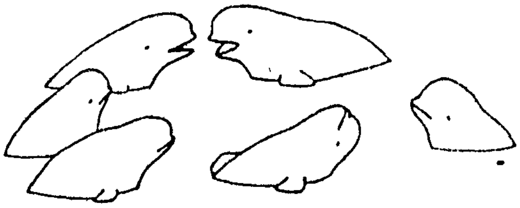
SOUNDING



BACK SWIMMING

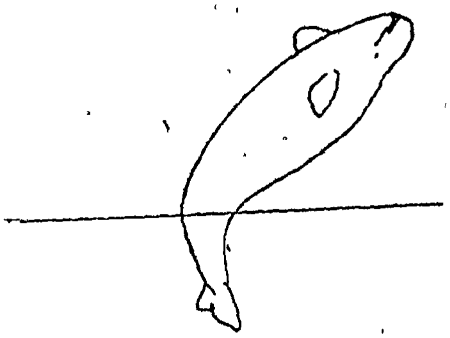


RIDING

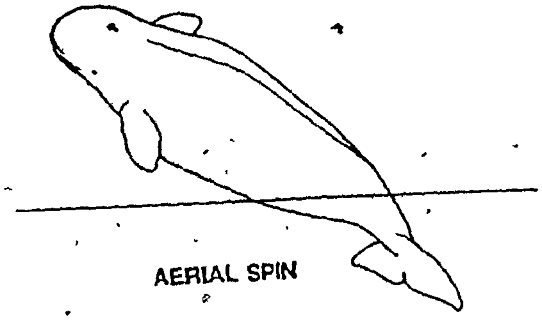


ROSETTE

SPY HOPPING



BREACHING



AERIAL SPIN

Figure 8. Representation of the centroids of the activity classes in a three dimensional graph corresponding to the three significant discriminant axes.

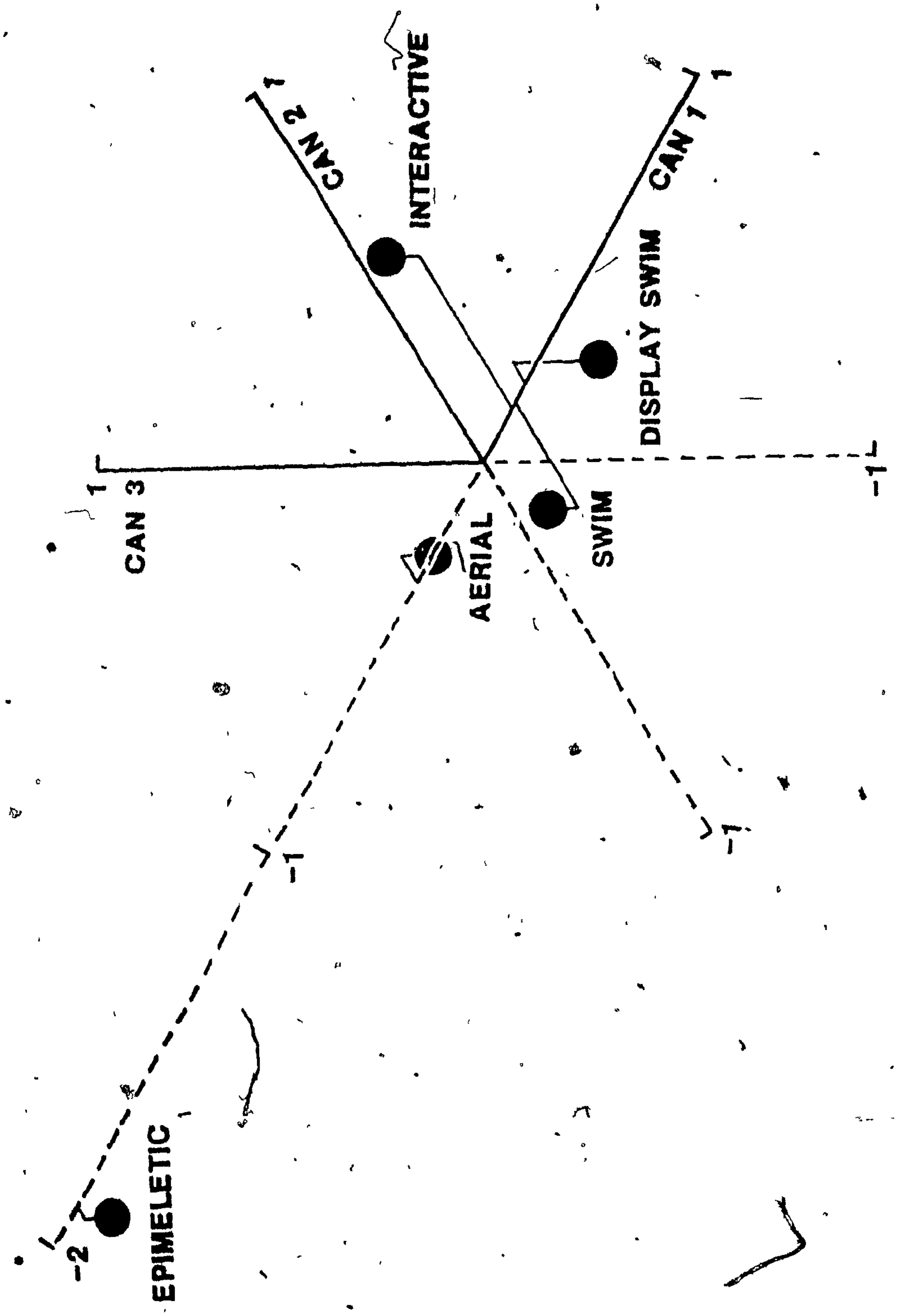

CAN 1
1
CAN 2
1
CAN 3
1
-1
-1
-1
-2
INTERACTIVE
DISPLAY SWIM
SWIM
AERIAL
EPIMELETIC

Figure 9. Size frequency of 272 groups of belugas in the Nastapoka River estuary. A distinction was made between mixed-age and similar-age groups.

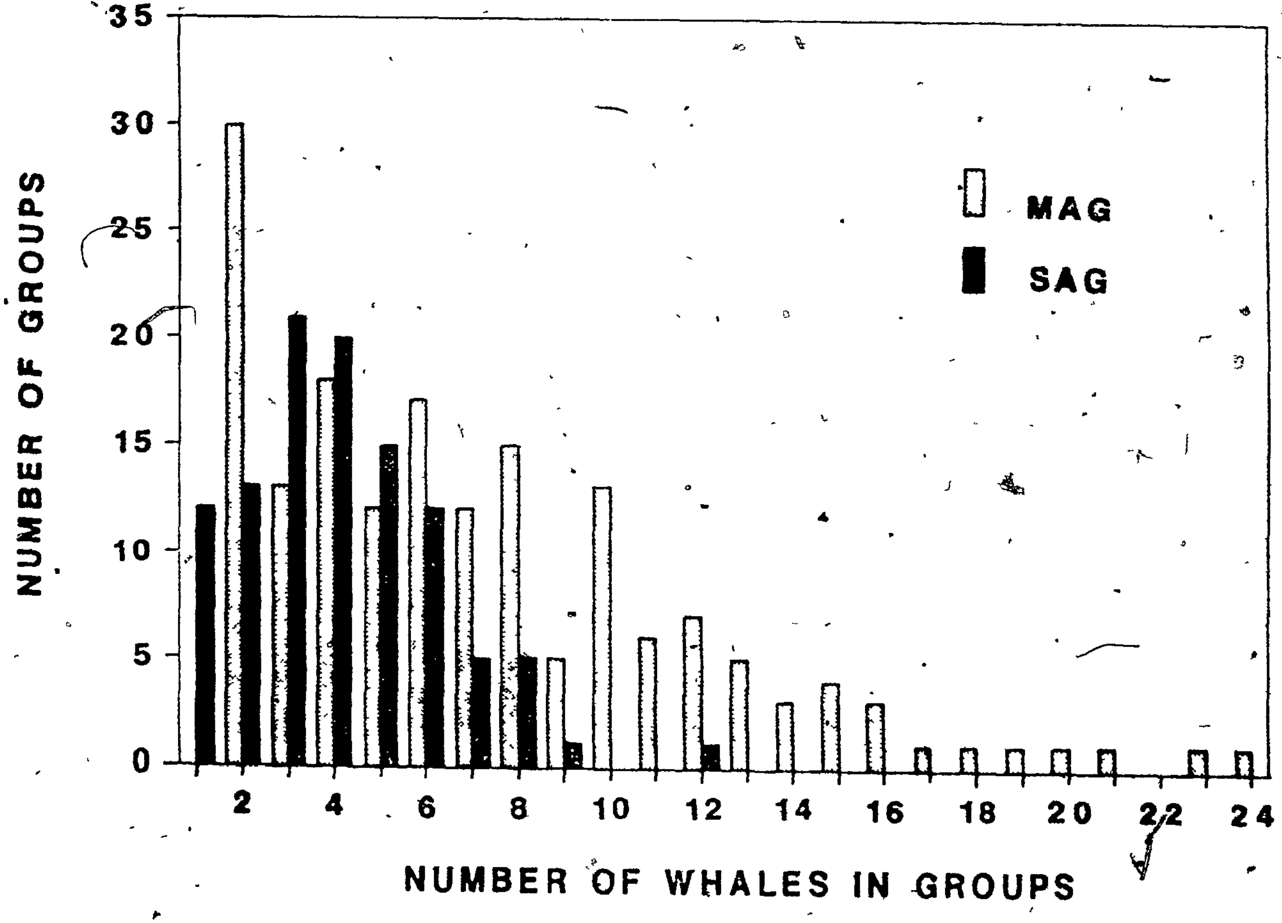

35
30
25
20
15
10
5
0
NUMBER OF GROUPS
▯ MAG
▮ SAG
2
4
6
8
10
12
14
16
18
20
22
24
NUMBER OF WHALES IN GROUPS

Figure 10. Cluster analysis of action patterns and group encounters based on the nonparametric (Spearman) correlations of frequencies recorded during group focal samples (n=37) from mixed age groups in the Nastapoka estuary. Horizontal lines indicate inter-cluster correlations.

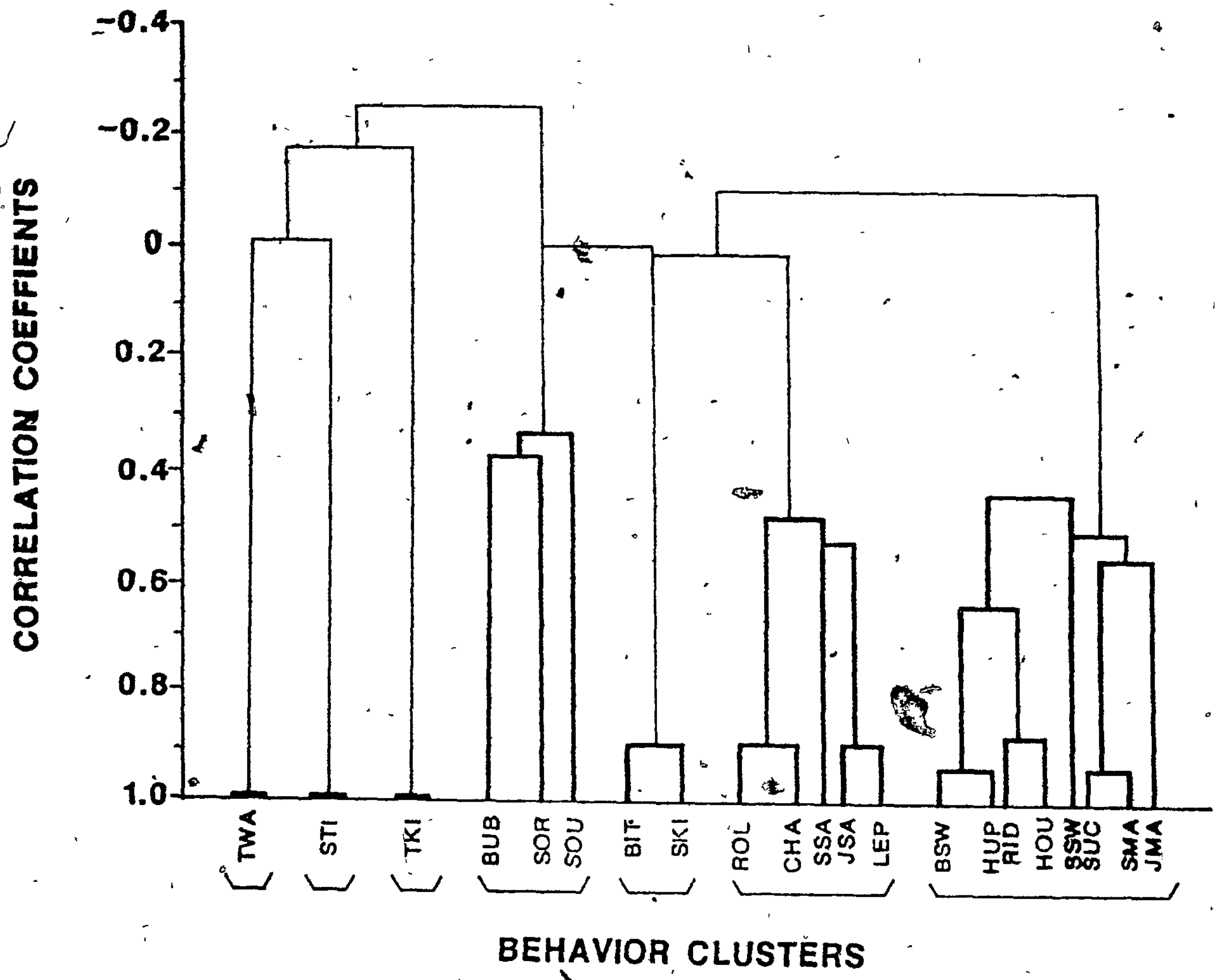
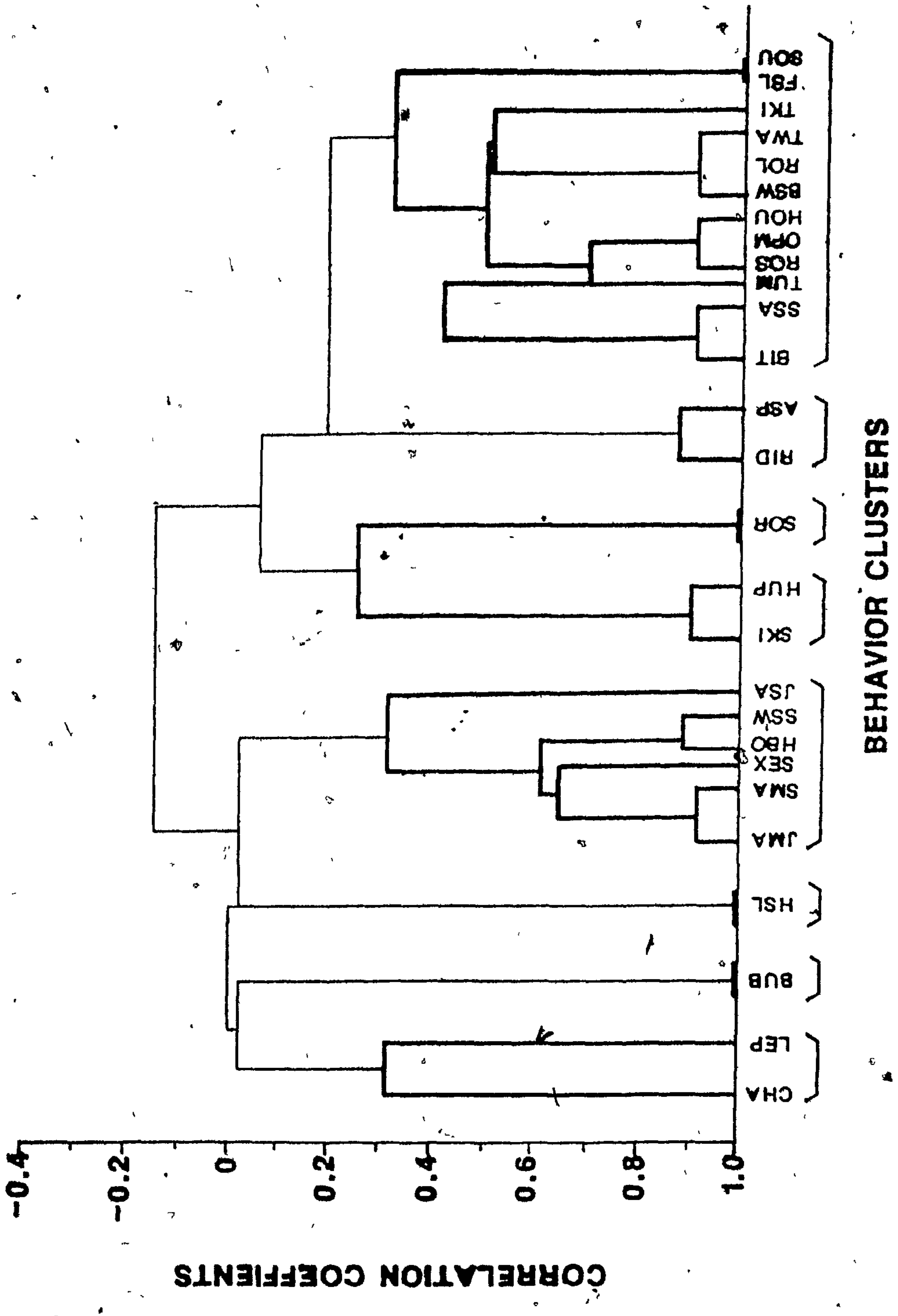

CORRELATION COEFFIENTS
−0.4
−0.2
0
0.2
0.4
0.6
0.8
1.0
TWA
STI
TKI
BUB
SOR
SOU
BIT
SKI
ROL
CHA
SSA
JSA
LEP
BSW
HUP
RID
HOU
SSW
SUC
SMA
JMA
BEHAVIOR CLUSTERS

Figure 11. Cluster analysis of action patterns and group encounters based on the nonparametric (Spearman) correlations of frequencies recorded during group focal samples (n=45) from similar age groups in the Nastapoka estuary. Horizontal lines indicate inter-cluster correlations.


CORRELATION COEFFIENTS
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1.0
CHA
LEP
BUB
HSL
JMA
SMA
SEX
HBO
SSW
JSA
SKI
HUP
SOR
RID
ASP
BIT
SSA
TUM
ROS
OPM
HOU
BSW
ROL
TWA
TKI
FBL
SOU
BEHAVIOR CLUSTERS

Appendix 1. Literature review of action patterns observed in odontocetes.

Action pattern	Context or function	Species	Source
ordinary swimming	-	Physester catodon	Caldwell et al.(1966)
"	-	Phocoena phocoena	Parry(1948)
"	-	Tursiops truncatus	Parry(1949)
slow swimming	-	Inia geoffrensis	Layne & Caldwell(1964)
typical cetacean swim	inactivity	Phocoenoides dalli	Morejohn(1979)
swimming	captive	Delphinapterus leucas	Norris & Prescott(1961)
head held above water	rapid swimming	Physester catodon	Caldwell et al.(1966)
blowhole out to breathe	slow moving herds	Lissodelphis borealis	Leatherwood & Walker(1979)
blowhole clearing water	typical breathing pattern	Inia geoffrensis	Layne & Caldwell(1964)
side swimming	play in adults (captivity)	Tursiops truncatus	Townsend(1914)
"	play in immatures (captivity)	"	Tayler & Saayman(1972)
listing	agonistic	Phocoenoides dalli	Morejohn(1979)
side swimming	sexual	Steno	Hamilton(1944)
"	sexual	Tursiops truncatus	Yablokov et al.(1974)
"	muddy coastal waters	"	Leatherwood(1975)
"	nursing females	"	McBride & Kritzler(1951); Tavolga(1966)

Appendix 1 (cont'd). Literature review of action patterns observed in odontocetes.

Action pattern	Context or function	Species	Source
side swimming	nursing females (captivity)	Steno bredanensis	Norris & Dohl(1980a)
side swimming	"	Stenella longirostris	Norris & Dohl(1980b)
side position	"	Physester catodon	Caldwell et al.(1966)
side swimming	captivity	Orcinus orca	Martinez & Klinghammer(1978)
belly presentation	sexual (captivity)	Tursiops aduncus	Saayman et al.(1973)
side swimming	normal swimming pattern (captiv.)	Platanista gangetica	Herald et al.(1969)
back swimming	locomotor play (captivity)	Platanista indi	Pilleri et al.(1980)
"	high speed chases	Tursiops aduncus	Saayman et al.(1973)
"	sexual (males)	Inia geoffrensis	Layne & Caldwell(1964)
"	sexual	Tursiops aduncus	Tayler & Saayman(1972)
"	" (females)	"	Saayman et al.(1973)
back swimming	"	Stenella longirostris	Norris & Dohl (1980b)
"	lateral action of the flukes	Tursiops truncatus, Inia geoffrensis	Townsend(1914); Layne & Caldwell(1964)
belly-up swimming	captive & wild	Orcinus orca	Martinez & Klinghammer(1978); Salden(1979)
upside down swim	-	Monodon monoceros	Silverman(1979)
back swimming	social interactions	Tursiops truncatus	Wursig & Wursig(1979)

Appendix 1 (cont'd). Literature review of action patterns observed in odontocetes.

Action pattern	Context or function	Species	Source
back swimming	social behavior	<u>Sousa</u>	Saayman & Tayler(1979)
"	feeding	<u>Tursiops truncatus</u>	Leatherwood(1975)
" (with jaws agape)	agonistic	<u>Physeter catodon</u>	Caldwell et al.(1966)
"	-	<u>Tursiops truncatus</u>	Townsend(1914)
leaping	jump with head first reentry	<u>Tursiops</u>	McBride & Hebb(1948); Townsend (1914); Tayler & Saayman(1972); Saayman et al.(1973); Wursig & Wursig(1979)
"	captive and wild	<u>Orcinus orca</u>	Martinez & Klinghammer(1978); Salden(1979)
low angle leaps	fast moving groups	<u>Lissodelphis borealis</u>	Leatherwood & Walker(1979)
leaping	-	<u>Sousa</u>	Saayman & Tayler(1979)
"	in front of vessels	<u>Phocoenoides dalli</u>	Morejohn(1979)
"	-	<u>Delphinus delphis</u>	Saayman et al.(1972)
"	feeding (fish herding)	<u>Tursiops aduncus</u>	Tayler & Saayman(1972)
lunging leap	-	<u>Physeter catodon</u>	Caldwell et al.(1966)
sounding	flight reaction	"	" "
sounding	captivity	<u>Orcinus orca</u>	Martinez & Klinghammer(1978)
sounding	escape behavior	<u>Lissodelphis borealis</u>	Norris & Prescott(1961); Leatherwood & Walker(1979)
breaching	-	<u>Physeter catodon</u>	Caldwell et al.(1966)
breaching	captivity	<u>Orcinus orca</u>	Martinez & Klinghammer(1978)

Appendix 1 (cont'd). Literature review of action patterns observed in odontocetes.

Action pattern	Context or function	Species	Source
backward jump	captivity	Orcinus orca	Martinez & Klinghammer(1978)
breaching	-	"	Ford & Ford(1981)
spiral leap	-	Delphinus delphis	Pilleri & Knuckey(1968)
noisy leap	-	Tursiops truncatus	Wursig & Wursig(1979)
variation of leaping	-	Tursiops aduncus	Saayman et al.(1973)
chest slapping	-	"	" "
leap and twist	high-speed chases	Sousa	Saayman & Tayler(1979)
jumping	moderate speed	Stenella longirostris	Hester et al.(1963)
spinning	slowly swimming groups	"	" " Norris & Dohl(1980b)
breaching	rare	Monodon monoceros	Silverman(1979)
belly flop	-	Lissodelphis borealis	Leatherwood & Walker(1979)
side slap	-	"	" "
spy hop	captivity	Orcinus orca	Martinez & Klinghammer(1978)
"	-	"	Ford & Ford(1981)
pitch poling	alerted to danger	Physeter catodon	Caldwell et al.(1966)
"	"	Globicephala sacmmoni	" "
rotating in the upright position	captivity	Orcinus orca	Martinez & Klinghammer(1978)
head up position	-	Monodon monoceros	Silverman(1979)

Appendix 1 (cont'd). Literature review of action patterns observed in odontocetes.

Action pattern	Context or function	Species	Source
lobtailing	feeding & play	Physester catodon	Caldwell et al.(1966)
lobtailing	feeding, alarm, prior to extended dive	Tursiops gilli	Norris & Prescott(1961)
lobtailing	associated with escape or sounding	Tursiops aduncus	" "
strike with tail	mock-battles (captivity)	dolphins sp.	Yablokov et al.(1974)
stand on their head and strike water	play (captivity)	dolphin sp.	Yablokov et al.(1974)
striking water with tail	between short dives(captivity)	Tursiops truncatus	Townsend(1914)
tailslap (normal or inverted)	sound emission	Stenella longirostris	Norris & Dohl(1980b)
back slap	slowly moving schools	"	" "
head slap	most common in moving schools	"	" "
tailslap	most frequent during disturbances	Tursiops truncatus	Wursig & Wursig(1979)
headslap	-	"	" "
tailslaps while on back position	initiating social interactions	Sousa	Saayman & Tayler(1979)
tailslaps in head down position	"	"	" "
fluke beating	directed at chasing partner (captivity)	Tursiops truncatus	Saayman et al.(1973)
"	cows refusing mating attempt (captivity)	"	" "

Appendix 1 (cont'd). Literature review of action patterns observed in odontocetes.

Action pattern	Context or function	Species	Source
fluke beating	directed at calf interupting sexual activity (captivity)	<u>Tursiops truncatus</u>	Saayman et al.(1973)
rythmic beating of the flukes	sexual behavior	<u>Tursiops aduncus</u>	Tayler & Saayman(1972)
"	aggressive incidents prior to a chase	"	" "
tail slaps	feeding, schooling prey fish	<u>Lagenorhynchus obscurus</u>	Wursig & Wursig(1980)
pectoral fin slap, fluke slap (dorsal & ventral)	captivity	<u>Orcinus</u> <u>orca</u>	Martinez & Klinghammer(1978)
tail lobbing, flipper lobbing	sequential	"	Ford & Ford(1981)
head bobbing	agonistic behavior	"	" "
head jerking	play behavior	<u>Tursiops aduncus</u>	Tayler & Saayman(1972)
lobtail	upon reentry of belly flops and side slaps	<u>Lissodelphis borealis</u>	Leatherwood & Walker(1979)
smacking tail on water	prior to a dive (captivity)	<u>Tursiops truncatus</u>	Lawrence & Schevill(1954)
fluke slaps	extremely rare	<u>Inia geoffrensis</u>	Layne & Caldwell(1964)
tail slap, flipper slap	-	<u>Monodon monoceros</u>	Silverman(1979)
tusk slap	-		" "
arching	resembling head bob	"	" "
poised vertically head down...smaking flukes on water	-	<u>Globicephala scammoni</u>	Brown(1960)

Appendix 1 (cont'd). Literature review of action patterns observed in odontocetes.

Action pattern	Context or function	Species	Source
marguerite formation	around a wounded individual	Physeter catodon	Nishiwaki(1962)
pushing up reaction	epimeletic or care giving behavior	several whale species	Yablokov et al.(1974)
orient their heads together	captivity	Orcinus orca	Martinez & Klinghammer(1978)
mouth open	threat display (captivity)	"	" "
mouthing	sparring and mock-threats (captivity)	Tursiops adundus	Saayman et al.(1973)
biting	sexual sequences leaving rake marks	"	" "
open mouth	agonistic situation (with listing)	Phocoenoides dalli	Morejohn(1979)
open mouth	aggressive behavior	Physeter catodon	Caldwell et al.(1966)
mouthing	precopulatory (captivity)	Tursiops truncatus	Tavolga & Essapian(1957)
open mouth	threat display to SCUBA divers	Tursiops aduncus	Tayler & Saayman(1972)
rolling over	captivity	Platanista indi	Pilleri et al.(1980)
barrel-roll	captivity	Inia geoffrensis	Layne & Caldwell(1964)
rolling	"	Tursiops truncatus	McBride & Hebb(1948)
"	during tussling (see below)	"	Townsend(1914)
"	used by cows refuse mating (captivity)	Tursiops aduncus	Saayman et al.(1973)
"	captivity	Orcinus orca	Martinez & Klinghammer(1978)

Appendix 1 (cont'd). Literature review of action patterns observed in odontocetes.

Action pattern	Context or function	Species	Source
tussling	play behavior	Tursiops truncatus	Townsend(1914)
chasing	-	Monodon monoceros	Silverman(1979)
"	courtship sequences feeding activities, (wild and captive)	Tursiops truncatus	Saayman et al.(1973)
"	captivity	Orcinus orca	Martinez & Klinghammer(1978)
head butting	"	"	" "
ramming	attack situation	Physeter catodon	Caldwell et al.(1966)
echelon formation	small individual using larger one during locomotion	Lagenorhynchus obliquidens	Norris & Prescott(1961)
calf riding on back of adult	at considerable speed	Neophocaena asiaeorientalis	Pilleri & Peixun(1979)
penile erection	sexual, manipulative tool	Tursiops truncatus	McBride & Hebb(1948); Tavolga & Essapian(1957); Caldwell & Caldwell(1972); Tayler & Saayman(1972); Pillery et al.(1980)
suckling	captivity	"	McBride & Kritzler(1951); Tavolga & Essapian(1957)
"	wild	Physeter catodon	Caldwell et al.(1966)
"	captivity	Delphinapterus Leucas	Hewlett (1978)

Appendix 2. Catalogue of beluga whales identified during the 1983 and 1984 summer seasons at the Nastapoka estuary.

ID number (size)	Date	Time	Quadrat	Calf	Group type: age structure and other ID (#) in same group
1 (w)	19-07-83	1444	3	Neo	-
''(w)	06-07-84	0724	2	.	SAG
''	''	1200	3	1/2	-
''	''	1305	2	1/2	-
''	07-07-84	1505	3	1/2	MAG: 1/2 w 3/4 3/4 2/3 1/2 neo w 1/2 w w+1/2
''	17-07-84	1916	3	1/2	MAG: w+1/2 w w 1/2 2/3
''	18-07-84	1149	3	Neo?	-
''	''	1717	2	1/2	MAG: 3/4/1/2
''	20-07-84	1102	4	Neo	MAG+SAG?:w w (17) w+neo w 1/2
''	31-97-84	1319	2	-	MAG
''	02-08-84	1230	4	1/2	MAG: (10) (42)
''	03-08-84	1100	3	1/2	MAG
''	''	1352	3	1/2	MAG: (31)+1/2 (22)+neo
''	04-08-84	1610	3	1/2	MAG
''	24-08-84	0855	-	1/2	-
''	25-08-84	1746	2	1/2	MAG
''	''	1910	2	1/2	MAG?
''	26-08-84	1455	3	1/2	MAG
''	27-08-84	1305	3	1/2	MAG
''	29-08-84	0929	1	1/2	-
''	31-08-84	1602	2	1/2	-
3 (L3/4)	19-07-83	1518	3	.	-
''	08-08-83	0852	3	.	-

Appendix 2 (cont'd). Catalogue of beluga whales identified during the 1983 and 1984 ~~summer seasons~~ at the Nastapoka estuary.

ID number (size)	Date	Time	Quadrat	Calf	Group type: age structure and other ID (#) in same group
3	10-08-83	1037	2	.	-
''(w)	06-07-84	1236	-	Neo	MAG: w+2/3 w+neo w+neo
''	07-07-84	1022	2	.	Alone
''	''	1433	3	Neo	MAG: w+neo 3/4 1/2 w+neo+2/3
3 (w)	07-07-84	1505	3	1/2	MAG: w+neo w+1/2
''	22-07-84	1016	1	-	MAG
''	23-07-84	0918	2	-	MAG
''	24-07-84	1904	-	1/2	-
''	28-07-84	1730	3	-	MAG: (10)+neo
''	31-07-84	1302	2	1/2	MAG
''	03-08-84	1851	2	-	MAG
''	04-08-84	1610	2	1/2	MAG
''	05-08-84	1500	2	1/2	MAG
''	08-08-84	0931	3	-	MAG: 3/4 w+neo w+neo
''	14-08-84	0920	4	-	MAG
''	''	0935	3	-	MAG: 1/2 w 2/3
''	''	1312	4	1/2	MAG
''	''	1356	2	.	Alone?
''	''	1501	2	.	Alone?
''	''	1938	3	.	Alone?
''	''	2000	4	.	Alone?
''	15-08-84	1135	2	-	-
''	''	1758	2	1/2	MAG: 2/3 w
''	''	1900	1	-	MAG

Appendix 2 (cont'd). Catalogue of beluga whales identified during the 1983 and 1984 summer seasons at the Nastapoka estuary.

ID number (size)	Date	Time	Quadrat	Calf	Group type: age structure and other ID (#) in same group
3	16-08-84	1356	2	.	Alone?
''	17-08-84	1244	4	1/2	-
''	24-08-84	0855	-	1/2	-
'' (w)	29-08-84	1729	2	1/2	-
''	30-08-84	1202	2	-	-
''	''	1213	2	-	-
''	''	1451	4	1/2	-
''	''	1726	3	-	MAG?
''	01-09-84	1110	2	-	-
4 (w)	19-07-83	-	-	-	-
''	20-07-83	-	-	-	-
''	21-07-83	0915	-	-	-
''	27-07-83	-	2	-	-
''	''	2100	3	-	-
''	30-07-83	1008	3	-	-
''	''	1655	2	-	-
''	06-08-83	1755	3	-	-
''	13-08-83	1300	3	-	-
'' (w)	07-07-84	1034	2	.	SAG: (6) w 3/4
''	22-07-84	1023	2	Neo	MAG: w 3/4 w 2/3
''	''	1737	1	Neo	MAG
''	23-07084	1925	2	Neo	MAG+SAG?: 3/4 3/4 2/3 2/3 2/3
''	24-07-84	1441	1	N+2/3	MAG

Appendix 2 (cont'd). Catalogue of beluga whales identified during the 1983 and 1984 summer seasons at the Nastapoka estuary.

ID number (size)	Date	Time	Quadrat	Calf	Group type: age structure and other ID (#) in same group
4	24-07-84	1452	1	-	MAG: (22)+neo
"	27-07-84	1122	3	.	SAG: w w w w w
"	31-07-84	1013	3	N+2/3	MAG+SAG: (15)in sag
"	01-08-84	1329	2	neo	MAG
"	05-08-84	1500	2	-	MAG
"	06-08-84	0830	2	-	MAG?
"	12-08-84	1058	3	.	MAG: w+neo
5 (w)	05-07-84	1332	3	Neo	MAG
"	"	1726	4	Neo	-
"	12-07-84	0742	3	Neo	MAG: w+neo 3/4 2/3 w
6 (w)	07-07-84	1034	2	.	SAG: (4) w 3/4
"	07-07-84	1100	2	.	SAG: w w w w w w (8)
"	18-07-84	1800	3	.	SAG+MAG:(10) (11) (4) neos 1/2s
7 (3/4)	07-07-84	1034	3	.	SAG: w w w w w w
"	31-07-84	1952	3	.	SAG: 3/4 3/4
"	06-08-84	1751	3	.	SAG: w w w w w w 3/4
"	24-08-84	0854	4	.	SAG: 3/4 w
"	25-08-84	0914	3	.	SAG: w w w
"	31-08-84	1259	3	.	SAG: 3/4 w
"	02-09-84	0846	3	.	SAG: 3/4 3/4
8 (3/4)	07-07-84	1100	2	.	SAG: w w w w w w (6)
"	12-07-84	0821	3	.	SAG: (21) w

Appendix 2 (cont'd). Catalogue of beluga whales identified during the 1983 and 1984 summer seasons at the Nastapoka estuary.

ID number (size)	Date	Time	Quadrat	Calf	Group type: age structure and other ID (#) in same group
8	12-07-84	0739	3	.	SAG+MAG: w neo 2/3 w neo w 1/2
''	27-07-84	1711	2	.	MAG?: w 1/2 2/3
''	15-08-84	1758	2	.	SAG: w w
''	25-08-84	0914	3	-	-
''	30-08-84	1441	3	-	-
''	''	1530	2	.	SAG: w
''	01-09-84	1600	2	.	SAG: w w w w w
''	02-09-84	1700	2	.	SAG: w
9 (w)	07-07-84	1505	3	.	SAG: w w w w
10 (w)	19-07-83	-	3	-	-
''	20-07-83	-	3	-	-
''	21-07-83	0941	2	-	-
''	22-07-83	1956	2	-	MAG: w+neo w+neo 2/3 2/3
''	27-07-83	1921	4	-	-
''	30-07-83	1008	3	-	-
''	31-07-83	0904	4	-	-
''	''	1210	2	-	-
''	01-08-83	1037	4	-	-
''	''	1124	4	-	-
''	''	1335	2	-	-
''	02-08-83	1441	3	-	-
''	''	1751	2	-	-
''	06-08-83	1755	3	-	MAG: (4)

Appendix 2 (cont'd). Catalogue of beluga whales identified during the 1983 and 1984 summer seasons at the Nastapoka estuary.

ID number (size)	Date	Time	Quadrat	Calf	Group type: age structure and other ID (#) in same group
10	08-08-83	1905	3	-	-
''	10-08-83	1145	3	-	-
''	13-08-83	1030	3	-	-
'' (w)	12-07-84	0800	3	-	MAG: w 3/4 2/3 1/2 neo neo w 1/2 1/2 1/2
''	12-07-84	0821	3	Neo	MAG: w+neo w+neo 2/3 2/3
''	''	0842	3	Neo	MAG: w+neo 1/2 3/4 neo w+neo
''	''	0846	2	1/2	MAG: (11)+neo w+neo
''	17-07-84	0936	2	Neo	MAG: (11)+neo 3/4+neo (16)+neo 1/2 2/3
''	''	0954	2	Neo	MAG: 3/4+neo 2/3 (11)+neo (12)+neo (16)+neo
''	18-07-84	1146	3	Neo	MAG: w w neo 3/4 1/2 w 1/2 w w
''	''	1717	3	Neo	MAG: 1/2 1/2 2/3 3/4+neo (4) (11)+neo w+neo
''	19-07-84	1857	2	Neo	MAG
''	20-07-84	1506	2	-	-
''	21-07-84	1532	1	1/2	MAG+SAG: w w 3/4 1/2 w w3/4 w 3/4
''	22-07-84	0908	2	Neo	MAG: w+neo w+neo w+neo
''	25-07-84	1500	3	-	-
''	27-07-84	1040	3	Neo	MAG
''	28-07-84	1704	1	-	MAG: (3) in sag?
''	31-07-84	1100	3	-	MAG+SAG?: (29)mag (17) sag: w w w w
''	01-08-84	1449	1	-	Alone?
''	''	1721	2	-	MAG?
''	02-08-84	1230	4	-	MAG: (42) (1)+1/2
''	03-08-84	1326	2	-	MAG

Appendix 2 (cont'd). Catalogue of beluga whales identified during the 1983 and 1984 summer seasons at the Nastapoka estuary.

ID number (size)	Date	Time	Quadrat	Calf	Group type: age structure and other ID (#) in same group
10	03-08-84	1659	2	Neo	MAG: (22)
''	05-08-84	1600	3	-	MAG: (31)+1/2
''	07-08-85	1055	2	-	MAG
''	12-08-84	1116	3	-	MAG?
''	''	1214	2	-	-
''	''	2038	2	-	MAG
''	14-08-84	0935	2	-	MAG: (31)+1/2
''	15-08-84	1758	2	.	?:w
''	16-08-84	1504	1	.	-
''	17-08-84	1000	3	.	SAG: w
''	''	1759	2	.	SAG?: w w w
11 (w)	12-07-84	0845	2	Neo	MAG: w+neo (10)+neo
''	17-07-84	0954	2	Neo	MAG: 3/4+neo 2/3 (12)+neo (10)+neo (16)+neo
''	''	1500	1	Neo	MAG: 3/4+neo w+neo w+neo
''	18-07-84	1318	2	Neo	MAG+SAG: w+neo w+neo+2/3 3/4 w w w w
''	''	1800	3	-	MAG: (6) (10) (11)
''	19-07-84	1310	1	-	MAG
''	30-07-84	1046	4	Neo	MAG
''	''	1547	4	Neo	MAG+SAG: w w w w w
''	31-07-84	1100	3	_	MAG+SAG: w w w w (10) (29)
''	''	1959	3	1/2	MAG: (28)+1/2 (22)+neo
''	01-08-84	1233	3	Neo	MAG: (30)+1/2
''	11-08-84	0900	5	.	SAG: w w w w w w

Appendix 2 (cont'd). Catalogue of beluga whales identified during the 1983 and 1984 summer seasons at the Nastapoka estuary.

ID number (size)	Date	Time	Quadrat	Calf	Group type: age structure and other ID (#) in same group
11	02-09-84	0846	2	Neo	MAG: (12)+neo
12 (w)	17-07-84	0954	2	Neo	MAG: 3/4+neo 2/3 (10)+neo (11)+neo (16)+neo
''	18-07-84	1318	3	Neo	MAG: 2/3 2/3 1/2 w+neo 1/2 neo 2/3
''	''	1822	2	-	MAG: w+neo
''	03-08-84	1002	3	Neo	MAG
''	''	1651	2	Neo	MAG
''	02-09-84	0846	2	Neo	MAG: (11)
14 (3/4)	17-07-84	1916	3	.	SAG: 3/4 w w w w
''	22-07-84	1737	2	-	-
15 (w)	19-07-84	1857	2	.	SAG: w w
''	20-07-84	1120	2	-	-
''	21-07-84	1101	2	.	SAG: w w w w
''	''	1245	1	-	-
''	''	1532	1	.	SAG: w w
''	22-07-84	0908	2	.	SAG: w w
''	''	1737	2	.	SAG: w w w
''	27-07-84	1122	3	.	SAG: w w
''	''	1725	1	.	SAG: w w
''	31-07-84	1013	3	.	SAG: 3/4 w
''	''	1319	2	.	SAG: w w
''	''	1935	2	.	SAG+MAG: w w+neo
''	01-08-84	-	-	-	-

Appendix 2 (cont'd). Catalogue of beluga whales identified during the 1983 and 1984 summer seasons at the Nastapoka estuary.

ID number (size)	Date	Time	Quadrat	Calf	Group type: age structure and other ID (#) in same group
15	12-08-84	1214	2	.	SAG: w w w
"	"	1322	3	.	SAG: w w
"	17-08-84	1233	2	.	SAG: w w
"	"	1900	1	.	SAG: w
"	18-08-84	0831	1	.	SAG: w w
"	"	1159	1	-	-
"	"	1444	1	-	-
"	20-08-84	1504	1	.	SAG: w w
"	23-08-84	0900	3	.	SAG: w w
"	30-08-84	0938	3	.	SAG: w w w w
"	"	0957	2	.	SAG: w w w w
"	"	1020	2	.	SAG: w w
"	31-08-84	1045	2	.	SAG: w
"	"	1400	2	.	SAG: w w w w
"	"	1530	3	.	SAG: w
"	01-09-84	1218	2	.	SAG: 3/4
"	"	1531	2	.	SAG: w w
"	02-09-84	1320	2	.	SAG: w
"	"	1801	2	-	-
16 (w)	20-07-83	-	-	-	-
"	27-07-83	1145	3	-	
"	08-08-83	0852	3	Neo	-

Appendix 2 (cont'd). Catalogue of beluga whales identified during the 1983 and 1984 summer seasons at the Nastapoka estuary.

ID number (size)	Date	Time	Quadrat	Calf	Group type: age structure and other ID (#) in same group
16 (w)	17-07-84	0954	2	Neo	MAG: 3/4+1/2 2/3 (10)+neo (11)+neo (12)+neo
''	''	0955	2	Neo	MAG: 2/3
''	19-07-84	1857	2	Neo	MAG: w+neo w+neo
''	24-07-84	1904	-	-	SAG: w w
17 (w)	02-08-83	1751	2	-	-
''	12-08-83	1307	4	-	-
''	13-08-83	0958	2	-	-
'' (w)	18-07-84	1559	1	.	SAG: (18)
''	''	2110	4	.	MAG
''	20-07-84	1826	1	.	SAG: w w w w w
''	21-07-84	1532	1	.	SAG: w w w w w w w
''	22-07-84	0908	3	.	SAG: w
''	28-07-84	1715	3	.	SAG: w w w (25)
''	31-07-84	1107	4	.	SAG: w
''	''	1956	3	.	SAG: w w w w
''	01-08-84	1329	2	.	SAG: w w
''	''	1449	1	.	SAG: w
''	''	1758	3	.	SAG: 3/4 3/4 w w w w
''	31-08-84	0950	2	-	-
''	''	1259	2	.	SAG: w w
''	02-09-84	1320	1	.	SAG: w w w
18 (w)	18-07-84	1559	1	.	SAG: (17)

Appendix 2 (cont'd). Catalogue of beluga whales identified during the 1983 and 1984 summer seasons at the Nastapoka estuary.

ID number (size)	Date	Time	Quadrat	Calf	Group type: age structure and other ID (#) in same group
18	20-07-84	1457	2	-	SAG?
19 (3/4)	22-07-84	1737	2	-	-
''	25-07-84	1627	2	-	MAG
''	01-08-84	1721	2	-	-
''	03-08-84	1437	3	-	SAG: 1/2 1/2 1/2
20 (3/4)	25-07-84	1510	3	.	SAG: 3/4 3/4 3/4
''	04-08-84	1233	3	.	SAG: w w 3/4 3/4
''	06-08-84	0830	3	.	SAG: 3/4 3/4 3/4
''	''	1810	4	.	SAG: 3/4 3/4 w w w
''	15-08-85	1505	2	.	SAG: 3/4 3/4 3/4
''	''	1758	4	.	SAG: 3/4 3/4 3/4
''	''	1900	3	-	-
''	29-08-84	1428	3	.	SAG: 3/4 3/4 3/4
''	30-08-84	1200	2	.	SAG: w w w w 3/4
''	''	1441	3	-	-
''	''	1459	2	.	SAG: 3/4 w w
''	''	1726	4	.	SAG: w w
''	31-08-84	1501	3	-	-
''	''	1602	3	.	SAG: w w w 2/3 3/4
''	02-09-84	0846	2	.	SAG: 3/4 3/4 w w
21 (3/4)	12-07-84	0821	3	.	SAG: w w
''	24-07-84	1515	3	-	-

Appendix 2 (cont'd). Catalogue of beluga whales identified during the 1983 and 1984 summer seasons at the Nastapoka estuary.

ID number (size)	Date	Time	Quadrat	Calf	Group type: age structure and other ID (#) in same group
22 (3/4)	24--07-84	1452	1	Neo	MAG: (4)
''	31-07-84	1506	3	Neo	COUPLE
''	''	1643	3	Neo	MAG: (30)+1/2
''	''	1959	3	Neo	MAG: (11) (28)
''	01-08-84	1329	3	Neo	MAG: (31)
''	''	1449	2	Neo	MAG: w+neo
''	''	1512	3	Neo	MAG: (30)+1/2
''	02-08-84	1036	2	Neo	MAG: w+neo
''	''	1130	3	Neo	MAG: (30)+1/2
''	''	1244	4	Neo	MAG: (32)+1/2
''	03-08-84	1352	3	Neo	MAG: (1)+1/2 (31)+1/2
''	''	1659	3	-	MAG: (10)+neo
''	06-08-84	0959	3	Neo	MAG
''	07-08-84	1055	2	Neo	COUPLE
''	16-08-84	0928	3	Neo	MAG
23 (w)	24-07-84	1555	3	-	MAG?
''	''	1834	3	Neo	MAG: 3/4
''	26-07-84	1238	4	-	-
''	27-07-84	1711	4	-	MAG: w+1/2 w+1/2
''	30-07-84	1026	4	Neo	MAG
''	''	1033	3	-	MAG: (11)
''	31-07-84	1100	3	Neo	MAG
''	''	1935	3	Neo	MAG

Appendix 2 (cont'd). Catalogue of beluga whales identified during the 1983 and 1984 summer seasons at the Nastapoka estuary.

ID number (size)	Date	Time	Quadrat	Calf	Group type: age structure and other ID (#) in same group
23	16-08-84	1504	2	Neo	MAG
''	20-08-84	0908	3	Neo	MAG: 2/3
''	25-08-84	1254	3	Neo	MAG: 2/3
24 (w)	06-08-83	1743	3	-	-
''	08-08-83	0745	3	Neo	MAG: 1/2 3/4
''	12-08-83	1000	3	Neo	-
''	''	1325	2	Neo	-
''	13-08-83	1013	3	Neo	-
''	''	1715	3	-	-
'' (w)	12-07-84	0831	4	-	MAG: neo w w neo w 3/4 2/3
''	24-07-84	1515	1	-	-
''	''	1545	3	1/2	MAG: (30)+1/2
25 (w)	17-07-84	1916	3	.	Alone
''	25-07-84	1510	3	.	SAG: w w w
''	28-07-84	1715	3	.	SAG:L w w w w
26 (w)	24-07-84	1521	1	-	-
''	25-07-84	1120	3	-	MAG?
''	''	1306	3	Neo	MAG? 1/2 w+neo 2/3 1/2 w+neo
''	30-07-84	1340	4	Neo	MAG
''	''	1345	4	-	MAG
''	31-07-84	0935	2	-	MAG
''	05-08-84	1500	3	-	SAG: 3/4 3/4 2/3

Appendix 2 (cont'd). Catalogue of beluga whales identified during the 1983 and 1984 summer seasons at the Nastapoka estuary.

ID number (size)	Date	Time	Quadrat	Calf	Group type: age structure and other ID (#) in same group
26	22-08-84	1854	3	.	SAG: w w
27 (2/3)	31-07-84	0935	3	.	MAG
28 (3/4)	31-07-84	0935	3	-	MAG
''	''	1959	3	1/2	MAG: (11)+1/2 (22)
''	''	20-07-84	3	1/2	MAG: w+1/2 3/4
''	01-08-84	1721	3	Neo	MAG
''	04-08-84	1226	-	-	-
''	19-08-84	0709	3	Neo	MAG
''	30-08-84	1300	3	Neo	MAG
''	01-09-84	1700	2	-	-
29 (3/4)	24-07-84	1521	1	-	-
''	31-07-84	1100	3	-	MAG: (10)+neo (11)+neo
''	31-08-84	1315	3	Neo	MAG?
''	01-09-84	1100	2	1/2	MAG?
30 (w)	24-07-84	1549	3	1/2	MAG: (24)+1/2
''	31-07-84	1643	3	1/2	MAG: (22)+neo
''	01-08-84	1233	3	1/2	COUPLE
''	''	1552	3	-	MAG: (32) (33)+1/2
''	02-08-84	1130	2	1/2	MAG: (22)+neo
''	05-08-84	1311	2	Neo	MAG: (35)+neo
''	06-08-84	1231	2	Neo	-

Appendix 2 (cont'd). Catalogue of beluga whales identified during the 1983 and 1984 summer seasons at the Nastapoka estuary.

ID number (size)	Date	Time	Quadrat	Calf	Group type: age structure and other ID (#) in same group
31 (w)	01-08-84	1329	3	-	MAG: (22)+neo
''	03-08-84	1352	3	1/2	MAG: (1)+1/2 (22)+neo
''	''	1445	3	1/2	MAG: w+1/2
''	05-08-84	1600	3	1/2	MAG: (10)
''	06-08-84	1518	2	1/2	MAG?
''	14-08-84	1458	2	1/2	MAG
''	01-09-84	1305	2	1/2	-
32 (w)	01-08-84	1552	3	-	MAG: (30)+1/2 (33)+1/2
''	02-08-84	1114	3	-	MAG: (33)+1/2
''	''	1230	3	1/2	MAG
''	''	1244	4	1/2	MAG: (22)+1/2
33 (w)	01-08-84	1503	3	-	-
''	02-08-84	1114	3	1/2	MAG: (32)
35 (w)	05-08-84	1311	2	Neo	MAG: (30)+neo
''	''	1602	2	1/2	MAG
''	''	1923	3	-	MAG?
''	06-08-84	0904	2	Neo	MAG
''	18-08-84	0825	3	Neo	MAG
''	31-08-84	1315	3	Neo	-
36 (3/4)	06-08-84	1017	3	-	MAG
37 (w)	17-07-84	2115	2	-	MAG: (32)+neo w 2/3

Appendix 2 (cont'd). Catalogue of beluga whales identified during the 1983 and 1984 summer seasons at the Nastapoka estuary.

ID number (size)	Date	Time	Quadrat	Calf	Group type: age structure and other ID (#) in same group
37	05-08-84	1923	3	Neo	MAG
"	06-08-84	1116	2	Neo	MAG: w+neo
"	"	1353	2	Neo	MAG: 3/4 2/3
"	30-08-84	1517	3	Neo	MAG
"	31-08-84	1259	3	-	-
"	02-09-84	1100	3	Neo	Mag
38 (3/4)	03-08-84	1651	2	.	SAG: w w w 3/4 3/4
"	12-08-84	1043	4	-	-
"	"	1130	2	-	MAG?: (4)
39 (3/4)	08-08-84	0947	2	-	MAG?
"	10-08-84	1717	3	.	SAG?: w
"	12-08-84	1043	2	.	SAG: w w w 3/4 3/4
"	"	1240	3	.	SAG?: (40)
"	"	2038	3	-	-
"	14-08-84	0935	3	-	-
"	15-08-84	0833	-	.	SAG?: w w
"	"	1014	-	-	-
"	16-08-84	0928	-	-	MAG
"	"	1025		-	MAG
"	17-08-84	1000	3	.	SAG: 3/4/ 3/4 3/4
"	26-08-84	1701	4	Neo	MAG?
"	30-08-84	1300	2	.	SAG: w w w 3/4

Appendix 2 (cont'd). Catalogue of beluga whales identified during the 1983 and 1984 summer seasons at the Nastapoka estuary.

ID number (size)	Date	Time	Quadrat	Calf	Group type: age structure and other ID (#) in same group
39	31-08-84	0950	3	.	SAG: 3/4 w
''	''	1913	2	.	SAG: w
''	02-09-84	0931	3	-	MAG
40 (w)	12-08-84	1240	3	-	SAG: (39)
41 (1/2)	30-08-84	1441	3	.	MAG?
''	31-08-84	1045	3	.	MAG?
''	''	1913	3	.	MAG?: w
''	02-09-84	0846	2	.	MAG
42 (1/2)	31-07-84	1302	2	.	MAG
''	''	1314	4	.	MAG: w
''	01-08-84	1329	3	.	MAG: w
''	02-08	1230	4	.	MAG: (10) (1)+1/2
''	17-08-84	1230	3	.	-
43 (neo)	03-08-84	1336	3	.	MAG: w
''	06-08-84	0830	2	.	MAG: w
44 (w)	24-08-84	0854	4	.	SAG
''	27-08-84	1824	3	-	-
''	29-08-84	0813	4	.	SAG: 3/4
''	''	1300	2	-	-
''	30-08-84	1020	2	1/2	MAG?
''	''	1300	2	Neo?	MAG?

Appendix 2 (cont'd). Catalogue of beluga whales identified during the 1983 and 1984 summer seasons at the Nastapoka estuary.

ID number (size)	Date	Time	Quadrat	Calf	Group type: age structure and other ID (#) in same group
44	31-08-84	1501	2	-	-
''	''	1530	3	.	SAG:w w w
''	''	1602	4	-	-
''	''	1913	4	-	-
''	02-09-84	1610	2	-	MAG
45 (3/4)	12-08-83	1010	3	Neo	-
''	''	1310	-	Neo	-
'' (L3/4)	25-08-84	1500	-	-	-
''	26-08-84	1448	2	-	-
46 (w)	02-09-84	1702	2	-	MAG