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The Behavioral Development of Two Beluga Calves During the First Year of Life

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Currently, very little formal research exists regarding the behavioral development of beluga calves (*Delphinapterus leucas*). The behaviors and interactions of two beluga calves born into the care of humans were observed consistently from birth to 12 months. Changes in behavior were recorded continuously for 20 minutes for each mother-calf pair 2 to 4 times a week. As expected, the primary calf activity involved swimming with mother, which gradually decreased over the first year of life. Calves initiated the majority of their separations from and reunions with their mothers. Unexpectedly, the calves demonstrated an early independence and primary responsibility for proximity maintenance to their mothers. The calves also engaged in more solitary swims, object play, and interactions with each other across the year. In summary, the two calves followed developmental trends that were similar to each other and to other cetaceans in the care of humans.

Native to Arctic and sub-Arctic waters, belugas (*Delphinapterus leucas)* have been in the care of humans over 30 years (Samuels & Tyack, 2000). Despite our considerable knowledge of some cetaceans, including bottlenose dolphins (*Tursiops truncatus*) and killer whales (*Orcinus orca*), little attention has been directed towards the behavior of belugas in the care of humans. The majority of studies examining belugas have focused almost exclusively on their biological and physiological characteristics (Brodie, 1971, 1989; Lyamin, Pryaslova, Lance, & Siegel, 2005; O'Brien, Steinman, Schmitt, & Robeck, 2008; Robeck et al., 1995; Russell, Simongoff, & Nightengale, 1997), population distribution (Brown Gladden, Ferguson, Friesen, & Clayton, 1999; Hobbs, Rugh, & DeMaster, 2000), and sound production and reception (Erbe, 2000; Ridgway et al., 2001). Very few studies have examined their social and behavioral characteristics (Delfour & Aulagnier, 1997; Kilborn, 1994; Krasnova, Bel'kovich, & Chernetsky, 2006).

Like many cetaceans, belugas are considered to be highly affiliative and social by nature (Brodie, 1989; Defran & Pryor, 1980; Nowak, 1991). In their natural habitat, belugas form large herds composed of smaller, intact groups that are generally segregated by sex and age and may change rapidly over short time periods. One of the principal social groups within these beluga herds consist of mothers and their calves. To better understand the beluga mother-calf relationship and the development of calf behavior with only one such study to date, behavioral

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research conducted with other cetaceans (e.g., bottlenose dolphins, killer whales, and spotted dolphins, *Stenella frontalis*) is summarized.

Many studies have focused on different aspects of the mother-calf relationship, including mother-calf spatial relations, nursing patterns, proximity maintenance, play, maternal care behaviors, mother-calf synchrony and sleeping patterns (Asper, Young, & Walsh, 1988; Cockcroft & Ross, 1990; Dudzinski, 1998; Gubbins, McCowan, Lynn, Hooper, & Reiss, 1999; Hill, Greer, Solangi, & Kuczaj, 2007; Krasnova et al., 2006; Mann & Smuts, 1998, 1999; Mann, Connor, Barre, & Heithaus, 2000; Mann & Watson-Capps, 2005; Miles & Herzing, 2003; Reid, Mann, Weiner, & Hecker, 1995; Smolker, Mann, & Smuts, 1993). One of the most important components of the mother-calf relationship is the mother-calf pair swim. Mother-calf pair swims are characterized by close synchronous swims in which contact may occur (Brodie, 1989; Gubbins et al., 1999; Krasnova et al., 2006; Lyamin et al., 2005; Mann & Smuts, 1999). Mother-calf pair swims may include echelon swims in which the calf is positioned just above and slightly to the side of the mother's dorsal fin or ridge (Gubbins et al., 1999; Mann & Smuts, 1999), infant swims in which the calf is positioned under and slightly to the side of the mother's genital and mammary region, or pair swims which are characterized by close proximity (within five meters) and synchrony (Gubbins et al., 1999; Mann & Smuts, 1999). The close synchronous swims regulate the calf's swim and respiration patterns, provide consistent access to the mammary slits for milk, give protection from predators (e.g., proximity and camouflage shading), and offer opportunities for sleep.

Bottlenose dolphin neonates rarely and briefly separate from their mothers during the first few weeks of life (Cockcroft & Ross, 1990; Hill et al., 2007; Mann & Smuts, 1999; Mann & Watson-Capps, 2005). Many of these very early separations involve unintentional departures by the calf, such as times in which neonates do not follow their mothers' direction changes. Mothers typically retrieve their calves under these circumstances and are generally responsible for maintaining proximity the first few months of life (Mann & Smuts, 1999; Miles & Herzing, 2003; Reid et al., 1995). As the calves become more proficient swimmers (as early as two to three months), they become more responsible for proximity maintenance as the number of intentional calf separations and reunions increase over time (Cockcroft & Ross, 1990; Gibson & Mann, 2008; Krasnova et al., 2006; Mann & Smuts, 1999; Mann & Watson-Capps, 2005; Reid et al., 1995). In additiaon, the average distance between mothers and their calves increase as the calves mature (Gibson & Mann, 2008; Krasnova et al., 2006; Mann & Smuts, 1999; Mann & Watson-Capps, 2005).

Calves explore their environment through independent swims, object and motor play, and social interactions when separated from their mothers (Dudzinski, 1998; Gibson & Mann, 2008; Kuczaj, Makecha, Trone, Paulos, & Ramos, 2006; Mann & Smuts, 1999; Miles & Herzing, 2003; Reid et al., 1995). Object play may include investigating objects found within their environment (e.g., fish, seaweed, or environmental enrichment devices -- EEDs) and manipulating water by creating bubble rings and vortices. Motor play activities, in turn, involve the repetition or “practice” of a particular motor behavior, such as a vertical spin at the water surface. Finally, social interactions often entail calves swimming with other adults and other calves, initiating affiliative contact (e.g., rubbing), or playing chase games. As expected, these activities increase in frequency as calves mature and spend more time away from their mothers (Dudzinski, 1998; Gibson & Mann, 2008; Kuczaj et al., 2006; Mann & Smuts, 1999; Miles & Herzing, 2003; Reid et al., 1995). Belugas have been observed engaging in many of these activities, but their developmental trajectories have not been formally examined.

Finally, while the calves are away from their mothers, many mothers appear to monitor their calves’ activities. For example, mothers retrieve their calves from dangerous situations, such as at the appearance of a shark (Mann & Watson-Capps, 2005), the approach towards a pool wall (Cockcoft & Ross, 1990; McBride & Kritzler, 1951; Reid et al., 1995), or from a play interaction that has become too exuberant (Hill et al., 2007). While all mothers swim with their calves, nurse them, initiate reunions, monitor their activities by following them or orienting at them from afar, intervene when necessary and discipline on occasion (Cockcroft & Ross, 1990; Dudzinski, 1998; Gubbins et al., 1999; Hill et al., 2007; Mann & Smuts, 1998, 1999; Mann & Watson-Capps, 2005; Miles & Herzing, 2003; Reid et al., 1995), each mother does so to varying degrees (Hill et al., 2007). For example, some mothers engage in discipline (e.g., a maternal behavior that is directed toward a calf to reduce a particular behavior) more often and throughout the first year of life while other mothers rarely engage in discipline and seem to limit it to the first few months of life.

Although a large body of information exists for calf development in many cetaceans, there is a lack of data concerning beluga calves, their mothers, and their environment. Currently, veterinary, animal care and training staffs have only their years of experience (anecdotal evidence) and a handful of studies (Recchia, 1992; Russell et al., 1997; Schneider, Schamel, & Noonan, 2003) to guide them in the care and socialization of these animals. In an effort to better understand calf development and maternal behaviors in belugas, the current study documented the development of two beluga calves and maternal care behaviors during the first year of life. Using the previous research with other cetaceans, the following developmental trends were expected:

1) Calves should engage in less swimming with their mothers over time.
2) Calves should separate from their mothers more frequently over time.
    a. Mothers should initiate more reunions than the calves during the first month of life.
    b. Calves should initiate more reunions as they mature.
3) Calves should engage in more solitary swimming over time.
4) Calves should engage in more social interactions over time.
5) Calves should also engage in object play, which should increase over time.
6) Finally, the two mothers should display similar maternal behaviors.

Method

Subjects

Two beluga (*Delphinapterus leucas*) mother-calf pairs located at Sea World San Antonio were the subjects for the current study. TIN was approximately 25 years old at the time of the birth of her fifth calf, OLI. OLI was born June 23, 2007. OLI was approximately 63.6 kg (about 140 lbs) and 1.5 m (4.8 ft) shortly after birth. By the end of the first year, he weighed approximately 136.4 kg (about 300 lbs) and was 1.8 m (5.8 ft) long.

The other mother-to-be, MAR, was present at the time of OLI's birth and remained with TIN and OLI. MAR, also approximately 25 years old, gave birth to her second calf, GRA, June 26, 2007 in the presence of TIN and OLI. GRA weighed approximately 50.9 kg (about 112 lbs) and was about 1.6 m long (approximately 5.2 ft) within a few days of birth. He weighed 198.2 kg (436 lbs) and was 1.9 m (6.2 ft) long by the end of the first year. The calves were sired by the same male.

Both calves and their mothers experienced some bouts of illness during the first year of life (approximately 3 months – both calves, 6 months – OLI only, and 10 months – TIN & OLI). These time frames are indicated in Table 1. It is not unusual for beluga calves or their mothers to contract respiratory illnesses, which are managed with fluids and antibiotics (Cook, Calle, McClave, & Palma, 1992; Robeck et al., 1995: Russell et al., 1997). Behavioral symptoms of these illnesses included lethargy and suppression of diet. Both calves and their mothers received such therapy and successfully rebounded within weeks of diagnosis each time.

Table 1
Distribution of Observation Sessions across the First Year of Life for Each Mother-Calf Pair.

TIN-OLI				***MAR-GRA***			
Month	*# of Sessions*	*Quarter*	*# of Sessions*	*Month*	*# of Sessions*	*Quarter*	*# of Sessions*
1[a]	10	1	28	1[a]	5	1	25
2	8			2	7		
3[b]	10			3[b]	13		
4	18	2	49	4	21	2	52
5	17			5	16		
6[b]	14			6	15		
7	5	3	36	7	8	3	33
8	22			8	17		
9	9			9	8		
10[b, c]	6	4	29	10	9	4	28
11[a]	6			11[a]	3		
12	17			12	16		

Note: The number of sessions varied across the months due to observer availability. For example, Month 7 coincided with the end of the academic year. In contrast, Month 8 and Month 12 corresponded to the addition of two new observers, respectively. Due to the variability across sessions, the data were collapsed into quarters to allow for more equal sampling. All sessions were 20 minutes in length.
[a]Housing change. [b]Calf illness. [c]Mother illness.

Facility

Both calves were born in a triangular-shaped pool that held approximately 2 million gallons and was about 38.1 m (125 ft) by 15.2 m (50 ft) with an average depth of 7.6 m (about 25 ft). See Figure 1 for a schematic of the pool layout. During their second week of life, the two mother-calf pairs were re-located to a zoological pool with the following approximate dimensions, 17.1 m x 10.7 m x 6.1 m (56 ft x 35 ft x 20 ft), within Sea World San Antonio. This move was made to better monitor the health and behavior of the mother-calf pairs. The mother-calf pairs remained in this pool until May 2008 (11 months) when they returned to their original birthing habitat to be integrated with the remaining beluga population (four adult females).

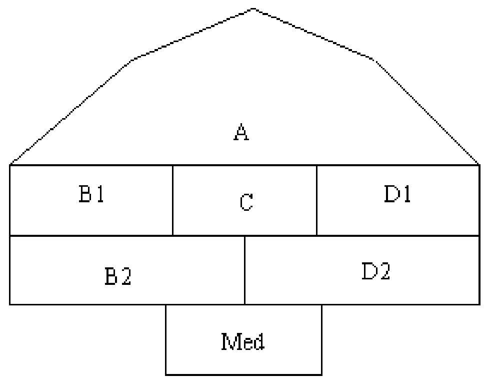

Figure 1. Schematic of pool layout of Viva! Stadium Sea World San Antonio. Pools are not drawn to scale. Gates connect all pools together.

After returning to the original location, the mother-calf pairs were housed together for approximately one week. The mothers and calves were then grouped with different animals throughout the day and night, three weeks before their year birthday. These social groupings allowed the mother-calf pairs to interact with other adult beluga females besides themselves. The changes in housing are indicated in Table 1.

Measure

An ethogram, adapted from previous research (Hill et al., 2007), was used to document behaviors of interest. Information collected included the focal animal pair, location, date and time of observation, observer, any environmental stimuli (e.g., objects in and around the pool, presence of people), broad behavioral categories (e.g., mother-calf activities, solitary activities, and social interactions), and specific behaviors of interest (e.g., motor activities, object play). Table 2 lists all the behaviors of interest and their operational definitions. Frequency data were collected for all behaviors of interest.

Procedure

Both mother-calf pairs were observed from July 2007 to July 2008. Sessions were conducted two to four times per week during park operating hours (generally between 8:00am and 5:00pm). To control for time of day of effects, sessions were alternated between the morning (62.5% of the sessions) and afternoon (37.5% of the sessions). These sessions were conducted at standardized times around feeding and training sessions to minimize the influence of the trainers' presence on the mother-calf pairs.

Table 2
Operational Definitions for Specific Calf and Maternal Behaviors.

Target Behavior	Operational Definition
Mother-calf swim	Mother and calf swim within 1m of each other and are synchronous
Contact	Mother or calf touches some part of the other's body with a body part
Left calf/mother	Mother/calf swims beyond 1m of calf/mother
Return to calf/mother	Mother/calf swims within 1m of calf/mother after being more than 1m away, an active maternal care behavior
Follow calf	Mother trails behind calf no more than 2m away as calf swims or interacts independently or with another animal other than mother, a passive maternal care behavior
Herd calf	Mother physically guides calf in specific direction using some part of her body, an active maternal care behavior
Intervention	Mother intercedes between calf and another dolphin or object by returning to calf and swimming between the calf and object of concern and/or removing the calf from the situation, an active maternal care behavior
Discipline	Behavior mother directs toward calf in response to calf's behavior, an active maternal care behavior
Pins down to bottom	Mother holds calf down against bottom of pool
Holds just under water	Mother holds calf under water with her body
Holds up above water	Mother holds calf partially out of water with either her rostrum or her belly if she is in a ventral position
Swim with other	Mother/calf swims with animal other than each other
Orients	Animal's eyes and head are directed at a person, object, or dolphin within or near enclosure, a passive maternal care behavior
Object play	Mother/calf interacts with or manipulates an available object (e.g., toy)
Social interactions	Mother/calf engages in pleasurable activities, aggressive activities, or sexual activities with other animals
Affiliative	Interactions with other animals in which rubbing, petting, contact swimming, playful chases, or positive actions between two animals
Agonistic	Interactions with other animals in which aggressive actions occur, including open mouth threats, head jerks, bubble bursts directed toward an animal, biting, ramming
Sexual	Interactions with other animals in which contact is made to or by the genitalia, erections may or may not be present in males

A focal sampling rule (Altmann, 1974/1996; Martin & Bateson, 1993) was followed for 20 minute observation sessions for each mother-calf pair[1]. Two recording rules were used to collect data: instantaneous sampling at one minute intervals and continuous sampling in which every change in behavior was recorded during each interval for both the mother and the calf, after the initial sampling point was recorded. Data from the continuous sampling procedure were examined to allow for a better representation of less frequent or discrete events (e.g., discipline, separations, or reunions). Behaviors that were long-lasting in duration and crossed across multiple intervals were recorded as a new instance for each interval and were included in the overall frequency count. Thus, an observation that began with a mother-calf swim that lasted the entire session resulted in a frequency count of 21 mother-calf swims even though it was technically only one mother-calf swim. However, as duration was not recorded and the same method was used for all behaviors of interest whether they were sustained behaviors or discrete events, these data may be interpreted in relation to each other.

Table 1 summarizes the number of sessions for each mother-calf pair per month. TIN and OLI were observed for a total of 142 sessions, which represents 47.3 hrs of observation. MAR and GRA were observed for a total of 138 sessions, which represents 46 hrs of observation. Each mother-calf pair was observed independently from one another for a total of 93.3 hrs. Thus, one mother-calf was observed for 20 minutes followed by the other mother-calf pair. The first pair observed was alternated each day to control for time of day or animal effects. A 5-15 min break was observed between contiguous sessions to ensure independence of observations. Five observers, including the author, collected data throughout the year.[2]

To ensure consistency across sessions and observers, reliability sessions were conducted and multiple observation sessions were videotaped and later coded. Three percent of the real-time sessions (*n* = 4 sessions) were conducted for reliability purposes. While more reliability sessions are ideal, constraints in observer schedules and the number of available observers restricted the number of reliability sessions possible for the current study.[3]

The four reliability sessions consisted of two observers independently recording the mother-calf behaviors from the same vantage point. Due to the low frequencies of certain behaviors (in fact, some behaviors never occurred during these sessions), the following concordance rate equation was used (Martin & Bateson, 1993): agreements / (agreements + disagreements). Rates ranged from 56.3% to 87.5% for the following variables: mother-calf swim (62.5%), mother-calf swim with other (81.3%), swim with other (87.5%), solitary swim (68.8%), mother left calf (81.3%), calf left mother (56.3%), mother returned to calf (75.0%), calf returned to mother (62.5%), and total object play (87.5%). The average concordance rate across the nine basic behavioral categories was 73.6%.[4]

[1] Previous research conducted by the author (Hill et al., 2007, personal observation) had indicated that accurate information regarding the behavior of mothers and their calves could be obtained in 20 min sessions. The frequency of sessions, the standardized collection procedure, the conduct of reliability sessions, and the length of the study were considered adequate controls for the goal of obtaining the most accurate data possible.

[2] All observers were trained by the author. Training consisted of intensive review of the behaviors to be observed, animal identification, and training reliability sessions using the instantaneous sampling data. Observers were considered trained once they were in agreement with the author approximately 85% of the time.

[3] The videotaped data corroborated the real-time data and are in preparation for a separate manuscript regarding attachments in belugas.

[4] Many of the reliability measures were lower than the typical standard of 80%. The current deviation from the accepted level is likely related to the small number of available sessions and a function of the recording method utilized by the session observers. Better reliability and similar results were attained for data analyzed from videotaped sessions to be reported in an upcoming manuscript.

Data Analyses

All analyses were performed separately for each individual animal so that individual differences across behavioral patterns could be observed. All data were assessed for normality. Data that exceeded an absolute skew value of 3.5 were transformed using a square root function with .5 added to the relevant data (Martin & Bateson, 1993). To account for the uneven sample sizes at the month level, data were collapsed into quarters. Each hypothesis examining changes in behavior over time was tested using repeated measures Analysis of Variance (ANOVA) tests. A Greenhouse-Geisser correction was applied when the sphericity assumption was violated. All hypotheses were examined using an alpha level of 0.05. Table 3 summarizes the means (frequency per 20 min session) and standard deviations for all variables of interest per quarter.

Table 3
Frequency Means and Standard Deviations for Variables of Interest per Quarter.

	Q1	**Q2**	**Q3**	**Q4**
	M ± *SD*	*M* ± *SD*	*M* ± *SD*	*M* ± *SD*
OLI (*n* = 28)				
Mother-calf swim*	20.32 ± 3.89	18.36 ± 5.14	16.96 ± 6.19	19.89 ± 3.75
Mother-calf swim with other[a]	0.93 ± 0.43	0.80 ± 0.28	0.95 ± 0.49	0.95 ± 0.42
Swim with other[†]*	0.84 ± 0.30	0.83 ± 0.38	1.23 ± 0.63	1.35 ± 0.85
Initiated separations	2.14 ± 2.76	0.79 ± 1.29	1.64 ± 1.85	1.93 ± 2.72
Initiated reunions*	3.75 ± 3.31	1.39 ± 2.10	1.64 ± 2.08	2.71 ± 4.28
Solitary swim*	2.36 ± 3.69	3.43 ± 6.00	7.29 ± 6.77	4.04 ± 5.16
Object play	0.96 ± 2.40	1.68 ± 3.89	1.93 ± 3.55	1.00 ± 2.89
TIN (*n* = 28)				
Initiated separations*	0.96 ± 1.45	0.61 ± 1.03	0.14 ± 0.45	0.43 ± 0.79
Initiated reunions	1.04 ± 1.79	0.25 ± 0.80	0.29 ± 0.53	0.54 ± 0.88
GRA (*n* = 25)				
Mother-calf swim*	21.60 ± 4.44	18.20 ± 5.18	16.12 ± 7.10	19.00 ± 5.64
Mother-calf swim with other[a]	0.77 ± 0.17	0.73 ± 0.10	0.71 ± 0.00	0.89 ± 0.37
Swim with other[a]*	0.81 ± 0.30	0.75 ± 0.14	1.18 ± 0.73	1.51 ± 0.89
Initiated separations	3.44 ± 3.54	2.72 ± 2.48	3.84 ± 3.14	3.64 ± 3.25
Initiated reunions*	6.96 ± 3.70	4.24 ± 3.76	3.88 ± 3.31	4.08 ± 3.11
Solitary swim*	3.44 ± 4.14	5.36 ± 7.63	8.80 ± 7.68	7.32 ± 7.09
Object play	0.64 ± 1.78	0.92 ± 3.41	3.48 ± 5.85	1.56 ± 3.04
MAR (*n* = 25)				
Initiated separations*	2.40 ± 2.45	1.48 ± 2.26	0.24 ± 0.52	0.56 ± 1.00
Initiated reunions	0.52 ± 0.92	0.44 ± 1.16	0.40 ± 1.29	0.36 ± 0.64

Note: The means and standard deviations represent the data used to perform all repeated measures analyses. The means represent the average number of times the behavior was observed across 20-minute sessions during each quarter. Mother-calf swims must be interpreted with caution as they represent overestimations of the actual mother-calf swims. See text for additional explanation.
[a] The data represent the square root transformation.
* $p < 0.05$

Results

As determined from previous research, the calves were expected to decrease the frequency with which they swam with their mothers over time. The results of repeated measures ANOVA indicated that significant changes in mother-calf swims occurred for both calves: OLI, $F(3, 81) = 2.75$, $p = 0.048$, $\eta_p^2 = 0.092$ and GRA, $F(3, 72) = 4.11$, $p = 0.009$, $\eta_p^2 = 0.146$. As Figure 2 displays, this hypothesis was partially supported as a quadratic trend best described the data for both calves: OLI, $F(1, 27) = 6.93$, $p = 0.014$, $\eta_p^2 = 0.204$ and GRA, $F(1, 24) = 15.58$, $p = .001$, $\eta_p^2 = 0.394$. The frequency of mother-calf swims decreased from the first to the second quarter (OLI) and across the first three quarters (GRA) and then increased the last half of the year. The average number of mother-calf swims increased almost to first quarter levels for OLI and slightly for the other calf, GRA, during the last quarter. Visual analyses indicated that the increase in mother-calf swims during the last quarter was due to an increase in mother-calf swims at 10 months (OLI: $M = 21.50$, $SD = 2.34$; GRA: $M = 22.67$, $SD = 1.64$) and 11 months (OLI: $M = 21.33$, $SD = 0.42$; GRA: $M = 22.00$, $SD = 0.58$) before decreasing at 12 months (OLI: $M = 18.55$, $SD = 0.78$; GRA: $M = 16.75$, $SD = 1.21$). Mother-calf swims with others rarely occurred and did not significantly change over the first year of life, as indicated by a repeated measures ANOVA.

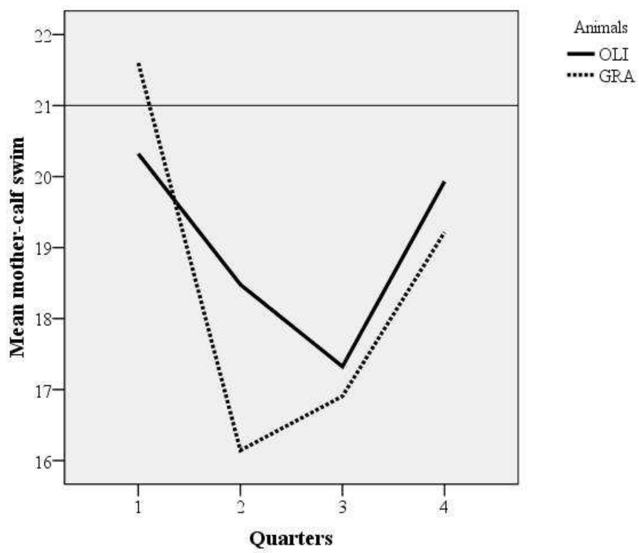

Figure 2. Quarterly trend for mother-calf swims for each calf. The reference line indicates the number of events that would occur if the animal engaged in that behavior for the entire session. Any number over the reference line would indicate the animal engaged in the behavior for most of the session but engaged in other types of behaviors at times as well. Any number below the reference line would indicate the animal did not engage in the same behavior the entire observation.

The second hypothesis examined whether the calves initiated separations from their mothers more frequently over time, as expected from previous studies with other cetaceans. As seen in Figure 3, no significant developmental trend was observed for the calves, which failed to support the hypothesis. However, the mothers did initiate significantly fewer separations over time: TIN, $F(2.43, 65.61) = 3.52$, $p = 0.027$, $\eta_p^2 = 0.115$, linear trend, $F(1, 27) = 5.04$, $p = 0.033$, $\eta_p^2 = 0.157$ and MAR, $F(2.20, 52.71) = 7.47$, $p = 0.001$, $\eta_p^2 = 0.237$, linear trend, $F(1, 24) = 12.68$, $p = 0.002$, $\eta_p^2 = 0.346$. Figure 3 suggested that a difference existed in the frequency with which mothers and calves initiated separations. To examine this relationship, paired sample t-tests were conducted for each mother-calf pair per quarter. The results indicated that the calves initiated significantly more separations than their mothers across all four quarters, except for GRA's first quarter: OLI, Q1 - $t(27) = 2.23$, $p = 0.03$, Q2 - $t(47) = 2.43$, $p = 0.019$, Q3 - $t(33) = 4.33$, $p < 0.001$, Q4 - $t(28) = 2.87$, $p = 0.008$; GRA, Q1 - $t(24) = 1.20$, $p > 0.05$, Q2 - $t(47) = 4.35$, $p < 0.001$, Q3 - $t(31) = 5.82$, $p < 0.001$, Q4 - $t(27) = 4.36$, $p < 0.001$. Finally, GRA initiated significantly more separations from his mother, MAR, during the second and third quarters, than OLI initiated from his mother, TIN, Q3 - $t(89.27) = -3.59$, $p = 0.001$; Q4 - $t(47.40) = -3.26$, $p = 0.002$. As Table 3 summarizes, each calf initiated more than twice as many separations as his mother, on average. These results indirectly supported the hypothesis.

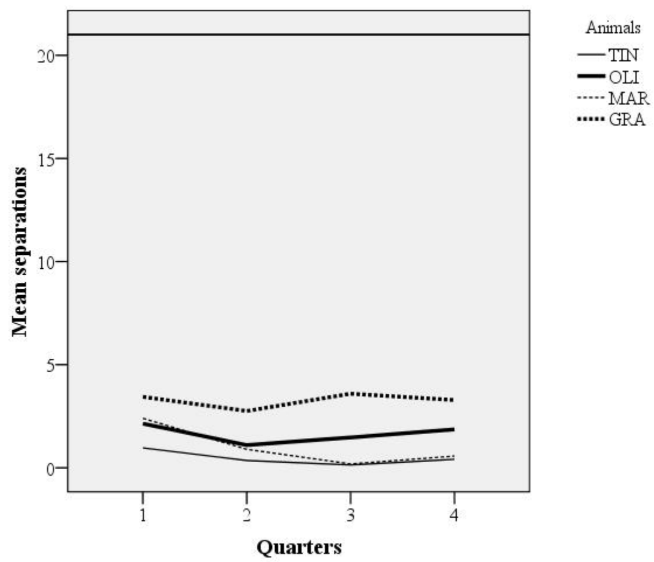

Figure 3. Quarterly trends for separations initiated by each mother-calf pair. The reference line indicates the number of events that would occur if the animal engaged in that behavior for the entire session. Any number over the reference line would indicate the animal engaged in the behavior for most of the session but engaged in other types of behaviors at times as well. Any number below the reference line would indicate the animal did not engage in the same behavior the entire observation.

The third developmental pattern examined were the initiation of reunions. The mothers were expected to initiate the majority of their reunions with their calves early during the first year of life, as found in previous studies. The calves were then expected to initiate more reunions with their mothers as they matured. While no significant trend was observed for the mothers, the calves demonstrated changes in their initiations of reunions with their mothers over time: OLI, $F(2.27, 61.18) = 3.32$, $p = 0.037$, $\eta_p^2 = 0.110$ and GRA, $F(3, 72) = 4.07$, $p = 0.01$, $\eta_p^2 = 0.145$. In partial support of the hypothesis, significant U-shaped quadratic trends were observed for both calves: OLI, $F(1, 27) = 8.97$, $p = 0.006$, $\eta_p^2 = 0.249$ and GRA, $F(1, 26) = 7.92$, $p = 0.01$, $\eta_p^2 = 0.248$. Both calves generally initiated more reunions during the first quarter and during the last quarter as seen in Figure 4. The calves also initiated significantly more reunions than their mothers across each quarter, as indicated by a series of paired sample t-tests, OLI, Q1 - $t(27) = 3.89$, $p = 0.001$, Q2 - $t(47) = 3.79$, $p = 0.001$, Q3 - $t(33) = 3.66$, $p = 0.001$, Q4 - $t(28) = 2.57$, $p = 0.016$; GRA, Q1 - $t(24) = 9.02$, $p < 0.001$, Q2 - $t(47) = 6.23$, $p < 0.001$, Q3 - $t(31) = 5.50$, $p < 0.001$, Q4 - $t(27) = 5.90$, $p < 0.001$. A review of Table 3 again suggests that, on average, each calf initiated five to ten times more reunions than his mother.

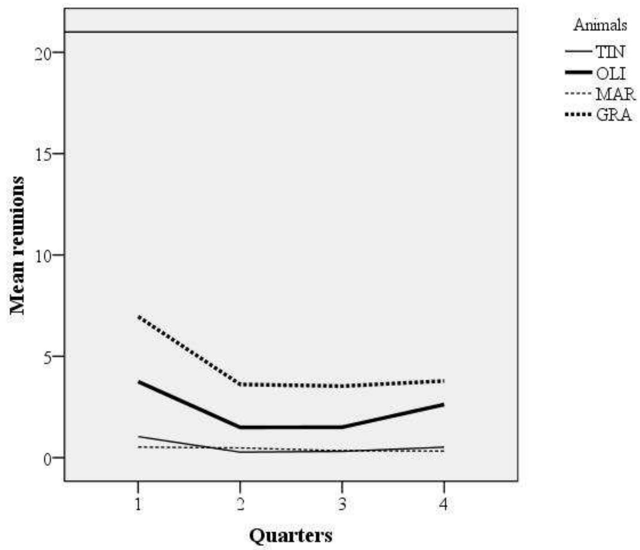

Figure 4. Quarterly trends for reunions initiated by each mother-calf pair. The reference line indicates the number of events that would occur if the animal engaged in that behavior for the entire session. Any number over the reference line would indicate the animal engaged in the behavior for most of the session but engaged in other types of behaviors at times as well. Any number below the reference line would indicate the animal did not engage in the same behavior the entire observation.

Solitary swimming, the fourth behavior investigated, was expected to increase as the calves matured and spent less time with their mothers. The results of the repeated measures ANOVA indicated that significant changes in solitary swimming occurred across quarters: OLI, $F(3, 81) = 4.04$, $p = 0.010$, $\eta_p^2 = 0.130$ and GRA, $F(3, 72) = 2.78$, $p = 0.047$, $\eta_p^2 = 0.104$. As seen in Figure 5, OLI demonstrated a significant quadratic trend (an inverse U shape) over time, $F(1, 27) = 4.64$, $p = 0.040$, $\eta_p^2 = 0.147$. In contrast, GRA exhibited a significant linear trend over time, $F(1, 24) = 5.49$, $p = 0.028$, $\eta_p^2 = 0.186$. These trends generally support the hypothesis that solitary swims increased as the calves matured and the individual means can be found in Table 3.

In an effort to understand the appearance of social behavior, the calves' swims with others were examined (Figure 6). A repeated measures ANOVA indicated that significant changes occurred over time for swims with others. Using the transformed variable and Greenhouse-Geisser correction, OLI was more likely to engage in swims with others as he matured, $F(2.02, 54.54) = 5.85$, $p = 0.005$, $\eta_p^2 = 0.178$, linear trend, $F(1, 27) = 12.46$, $p = 0.002$, $\eta_p^2 = 0.216$. GRA also showed a similar trend, $F(1.91, 45.78) = 8.88$, $p = 0.001$, $\eta_p^2 = 0.270$, linear trend, $F(1, 24) = 16.63$, $p = 0.001$, $\eta_p^2 = 0.409$.

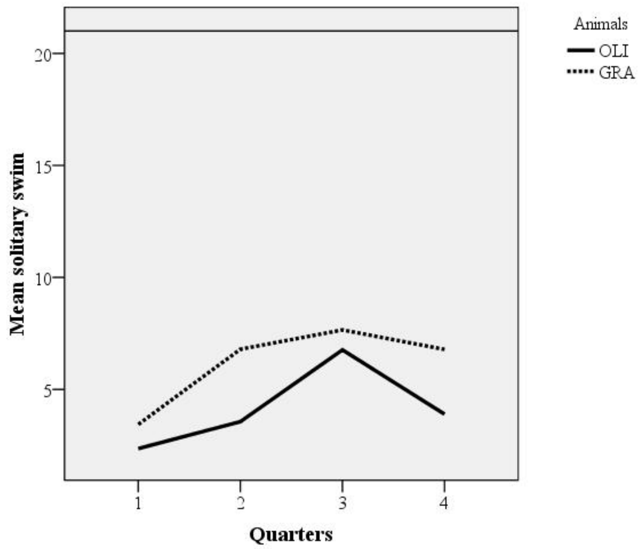

Figure 5. Quarterly trend for solitary swims for each calf. The reference line indicates the number of events that would occur if the animal engaged in that behavior for the entire session. Any number over the reference line would indicate the animal engaged in the behavior for most of the session but engaged in other types of behaviors at times as well. Any number below the reference line would indicate the animal did not engage in the same behavior the entire observation.

The last developmental hypothesis examined was the appearance of object play. No significant developmental trends were observed for either calf. Object play emerged during the first month of life for both calves and remained fairly consistent across the first year of life, as indicated by the means in Table 3. The mothers also engaged in some object play throughout the year. A preliminary analysis of the types of play exhibited by the calves and their mothers suggested that the calves generally played with fish, water, and the slide outs and gates that were part of their environment. Mothers occasionally engaged in similar types of play and were likely to interact with environmental enrichment devices (EEDs) when present. The calves were also interested in the EEDs but did not have many opportunities to interact with the EEDs as their mothers tended to control the EEDs.

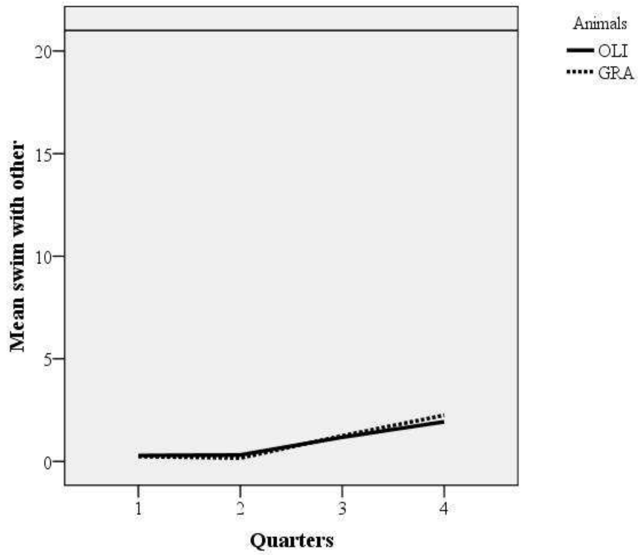

Figure 6. Quarterly trend for swims with others for each calf. The reference line indicates the number of events that would occur if the animal engaged in that behavior for the entire session. Any number over the reference line would indicate the animal engaged in the behavior for most of the session but engaged in other types of behaviors at times as well. Any number below the reference line would indicate the animal did not engage in the same behavior the entire observation.

The final hypothesis investigated the presence of maternal behavior in the two mothers. The two mothers were expected to engage in similar behaviors when caring for their calves. As expected and portrayed in Figures 2 and 4, both mothers swam with their calves the majority of the observation sessions and initiated reunions with them. TIN and MAR also intervened on their calves' behalf and herded them occasionally as seen in Figure 7. Interestingly, TIN engaged in a variety of maternal care behaviors including acting aggressively towards individuals approaching her and OLI as they swam, following OLI as he swam independently, and disciplining OLI. MAR did not exhibit the same variety of maternal care behaviors.

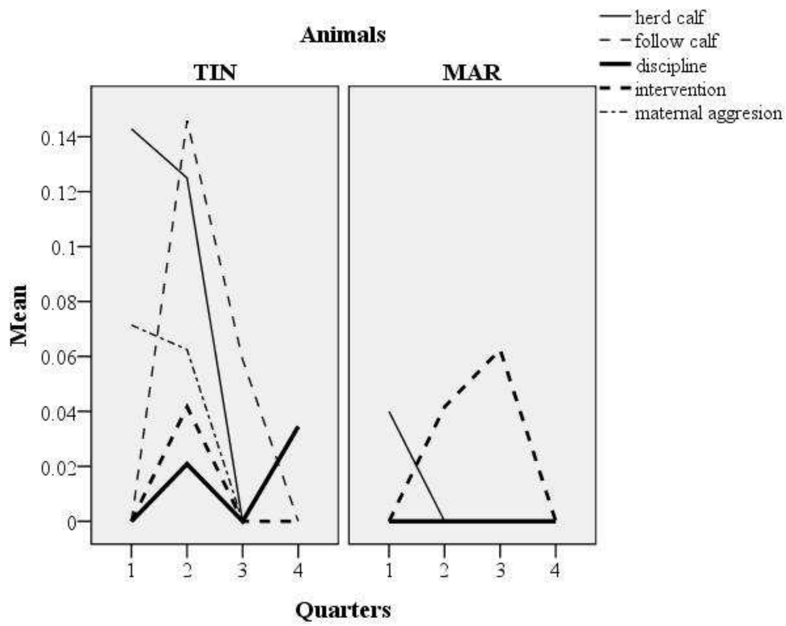

Figure 7. Quarterly trends for select maternal care behaviors for each mother. No trend analysis was performed due to variability of maternal care behaviors.

Discussion

Little research has examined the behavioral development of beluga calves (Brodie, 1989; Krasnova et al., 2006; Russell et al., 1997). The current study presents the first empirical evidence concerning the development of calf behavior in two belugas in the care of humans from birth through the first year of life. Despite the limited sample, this study emphasizes the importance of understanding beluga behavior and its development as belugas around the world have encountered increasing threats to their natural habitats (e.g., pollution, exploitation, or environmental changes affecting their calving grounds or prey distribution) (Brodie, 1989).

In general, the behavioral development across the first year of life of two beluga calves born within three days of each other appears to be similar to the development of many cetaceans previously observed. As expected, the most frequently observed behavior was mother-calf swims. Based on previous research (Cockcroft & Ross, 1990; Dudzinski, 1998; Gubbins et al., 1999; Hill et al., 2007; Krasnova et al., 2006; Kuczaj et al., 2006; Mann & Smuts, 1998, 1999; Miles & Herzing, 2003; Reid et al., 1995), mother-calf swims were expected to generally decrease over time. This trend was observed across the majority of the year for both calves. However, during the last quarter of the year mother-calf swims increased for both calves, noticeably for OLI and slightly for GRA.

This increase in mother-calf swims at the end of the first year of life may be related to several factors. At 10 months, OLI and his mother experienced a bout of illness. Previous research had indicated that calves experiencing illness may compensate for their lack of nutrition or energy by swimming more often with their mothers and nursing more frequently (as reviewed by Russell et al., 1997). Another factor accounting for the increased mother-calf swims is imitation. Although the two mother-calf pairs rarely coordinated their behaviors with each other, they likely influenced one another. Thus, if TIN and OLI increased their time together in mother-calf swims due to their illness, MAR and GRA may have also increased their mother-calf swims as a form of contagion. These two explanations may account for the increase in mother-calf swims at 10 months. Finally, the integration of the two mother-calf pairs with the rest of the Sea World beluga social group at 11 months may have sustained the increased mother-calf swims. This explanation seems to be supported by a drop in mother-calf swims during the last month of the study, which occurred shortly after their re-integration and more animals were available with which to interact. However, this last explanation must be interpreted with caution as the number of observation sessions decreased dramatically at 11 months and may not be representative of their actual behavior.

While mother-calf swims were the primary behavior during the first year of life, they did exhibit independence at very early ages. One of the most surprising results of this study involved the early emergence of separations initiated by the calves and the frequency with which they did so. Dolphin calves in their natural environment initiate more separations from their mothers, between four and six months, with mothers rarely initiating separations from their calves (Dudzinski, 1998; Mann & Smuts, 1998, 1999; Mann & Watson-Capps, 2005; Miles & Herzing, 2003). For cetaceans in the care of humans, calf-initiated separations are relatively infrequent and very brief during the first few months of life (killer whales, Asper et al., 1988; bottlenose dolphins, Cockcroft & Ross, 1990; Reid et al., 1995).

Unlike all other studies, the beluga calves initiated separations from their mothers almost immediately after birth and maintained stable rates across the first year that were 2 to 11 times their mothers' rates. Moreover, the calves' early separations often involved distances from their mothers between 1 and 5 m and beyond and durations that lasted for minutes at a time (personal observation). In contrast, the mothers exhibited significantly fewer separations over the course of the first year of life due to the calves' increasing independence and control over proximity to their mothers. The variation in the beluga calf development regarding separations from their mothers may be explained by a variety of factors, including the environmental setting, a species difference in behavior, variations in personality for mothers and calves, different maternal styles, or interactions between these variables (Highfill & Kuczaj, 2007; Hill et al., 2007).[5] Additional research is necessary to better understand this unexpected developmental finding.

Perhaps even more surprising than the number of calf-initiated separations was the lack of maternal response by both mothers to their calves' separations. Although the two beluga mothers in this sample initiated reunions with their calves, they did so at much reduced frequencies. Previous research had found that dolphin mothers initiate the majority of the reunions during the first few months of life and then shift the responsibility to the calves (Asper et al., 1988; Cockcroft & Ross, 1990; Mann & Smuts, 1999; Mann & Watson-Capps, 2005; Miles & Herzing, 2003; Reid et al., 1995). Unexpectedly, the beluga mothers did not alter the frequency with which they initiated reunions across the year. Rather, the calves were responsible for initiating reunions with their mothers within weeks of their birth and did so at rates 5 to 10 times more than their mothers across the first year.

Although these two beluga calves demonstrated early independence, they did exhibit behaviors similar to other cetaceans (Asper et al., 1988; Cockcroft & Ross, 1990; Gibson & Mann, 2008; Kuczaj et al., 2006; Mann & Smuts, 1999; Miles & Herzing, 2003; Reid et al., 1995). While away from their mothers, OLI and GRA engaged in solitary swims, swims and interactions with each other and interactions with objects within their environment. However, each calf followed a different developmental course.

As the most frequent independent behavior exhibited by the calves, solitary swims occurred twice as often as swims with each other. GRA steadily increased the number of solitary swims across the first year and in fact, engaged in more swims than OLI in every quarter. Like GRA, OLI showed an increase in solitary swims during the first three quarters. However, when OLI became ill his behavior became less independent and he returned to swim with his mother. This significant decrease in solitary swims the last quarter of the year may have been further suppressed by the illness of his mother, TIN, and the belugas' relocation.

As expected when other calves are present (Kuczaj et al., 2006; Mann & Smuts, 1999), both calves initiated swims with each other within the first few months of birth. These swims and interactions steadily increased during the second half of the year, corroborating earlier research with bottlenose dolphin calves (Gibson & Mann, 2008; Mann & Smuts, 1999; Mann & Watson-Capps, 2005; Reid et al., 1995). Compared to interactions with each other, the calves engaged in object play sporadically across the first year. Object play observed in the belugas included water play (e.g., spitting and tossing water, making bubbles), motor play (e.g., sliding out on the underwater shelf, floating, spin swims), and manipulation of environmental enrichment devices (EEDs, e.g., fish and buoy balls). The belugas' object play and its emergence were similar to that observed in bottlenose dolphins (Kuczaj et al., 2006; Mann & Smuts, 1999). However, object play was not a very frequent activity. Additional research is necessary to replicate and clarify this difference in object play. Possible factors to examine include a species

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[5] Calculated reliabilities indicated that observers did not attain the standard level of agreement on calf-initiated separations. However, video recordings collected twice a week for each calf throughout their first year corroborated the findings of this study and are in preparation for publication.

difference, the effect of illness, the influence of maternal care behaviors, and the availability of objects to be manipulated.

The last category of behavior examined was maternal care behaviors. As expected, both beluga mothers generally exhibited similar maternal care behaviors (Hill et al., 2007; Mann & Smuts, 1998; 1999). Both mothers swam with their calves, rarely separated from them, and retrieved them. They also disciplined their calves and intervened for them when a “dangerous” situation occurred. However, the two mothers differed in the variability of maternal care behaviors they displayed. TIN, a multiparous mother, showed a greater variety of maternal care behaviors across the year than MAR, a less experienced mother. Although no formal comparisons were made between the two mothers due to the limited number of maternal care behaviors observed, several interesting behavioral patterns occurred.

Anecdotal evidence initially suggested that TIN was going to allow OLI a greater freedom to swim and explore as she rarely retrieved OLI from his very early independent and distant swims. In fact, before GRA was born, MAR retrieved and swam with OLI when he was stranded or disoriented. These observations suggested that MAR was going to be more protective of her calf than TIN. Unexpectedly, after the animals were relocated to their primary housing facility during the study, the maternal care roles reversed between TIN and MAR. TIN became much more controlling and vigilant of OLI’s activities than MAR was of GRA’s activities. For example, TIN intervened for OLI on multiple occasions and frequently aggressed towards GRA when he approached TIN and OLI as they swam together. MAR, however, did not regulate GRA’s behavior and never intervened between him and another animal. These intriguing results set the stage for examining the individual differences in maternal style, personality factors in belugas, and the influence of calves on their mothers’ behaviors (Hill et al., 2007; Kuczaj et al., 2006).

The results of the current study are both exciting and informative. They offer the first empirical view of beluga calf behavioral development for the first year of life. They also provide the first documentation of maternal care behaviors in beluga mothers. Despite the limitation of two mother-calf pairs within a controlled environment, the observed developmental trends of these beluga calves generally appear to follow previously observed patterns in various cetaceans both in their natural environments and in the care of humans.

Although the controlled environment and the presence of illness may be viewed as limitations, they also provide some very interesting baseline information. For example, the early independence of the calves was present in two different types of environment (e.g., a varied social and housing arrangement vs. a more controlled and simple housing). In contrast, the maternal care behaviors of each mother were apparently affected by the change in environment. The return to the more social setting also demonstrated the impact of a major event on beluga behavior as both mother-calf pairs responded similarly to the environmental change (e.g., increased mother-calf swims, decreased solitary activities).

It is possible that the presence of illness may have confounded the changes in behavior observed with the re-location, but similar changes in behavior were also observed during the bouts of illness experienced by both calves while they were housed in the primary study facility. Like many cetaceans, illness in belugas is not uncommon (Cook et al., 1992; Robeck et al., 1995; Russell et al., 1997) and may alter the expression of behavior or change activity levels. The bouts of illness experienced by the calves in this study corresponded with various behavioral changes, such as decreases in solitary swims and increases in mother-calf swims. Thus, human caregivers may be able to detect changes in health status of their calves by monitoring specific behaviors, such as reduced solitary swims and social interactions and increased time in infant position. Unfortunately, the impact of illness on the developmental trajectories and behaviors observed cannot be assessed until additional research is conducted on mother-calf pairs not experiencing illness in a similar environment.

Future research should examine the developmental trajectories of other belugas in the care of humans and in their natural habitats to corroborate the current findings. Furthermore, the development of beluga behavior should be observed within the context of a larger beluga community. While a natural control existed with the animals in this study housed only with each other for 11 months, it is possible that the two mother-calf pairs influenced each other's behaviors and developmental trajectories. Opportunities for interactions with other belugas may produce different types and frequencies of social interactions, maternal care, and perhaps solitary activities. Thus, studies with a different social context are necessary to assess these outcomes.

In summary, the current study is significant for several reasons. First, it represents the first longitudinal study of the behavioral development of beluga calves in the care of humans. Second, it documented the maternal care of beluga mothers. Third, it indirectly documented the influence of illness on beluga behavior. Finally, many of the behaviors observed were in accordance with previous research performed with other cetaceans. While the beluga development of behaviors was similar to other cetaceans, there do appear to be some differences, such as an early independence by beluga calves and infrequent object play. Future research should continue to examine the behavioral development of belugas to better understand their behavioral biology and welfare within controlled and natural environments.

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