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Preliminary Findings in Beluga (*Delphinapterus leucas*) Tactile Interactions

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Abstract

Contact is a common component of social interactions in mammals, including marine mammals. However, the role of contact in social interactions by white whales, or belugas (*Delphinapterus leucas*), is virtually unknown. The current study was conducted to investigate the rate of physical contact between belugas compared to the rate at which belugas contact objects based on observations of eight belugas of various ages in human care. The frequency, duration, initiator, receiver, and body parts involved were recorded using focal follows 2 to 3 d a week in three seasons: (1) summer, (2) fall, and (3) spring. When examined as a group, contact between belugas occurred rarely (0.02 contact events/min; $N = 57$ contact events). The majority of the contact events were of short duration and were exhibited during affiliative social interactions between young belugas. Only two contact events occurred between adult or juvenile belugas. No seasonal effects were observed for contact between belugas. Belugas contacted objects much more frequently than other whales at an average rate of 0.68 events/min across two seasons. These results suggest that belugas in human care seek physical contact, but perhaps not with each other, unless it is during a critical period of development such as during the development of relationships for young belugas whether it is with their mother or with another young conspecific. Additional research is needed to verify these patterns of contact in belugas across different environments.

Key Words: beluga, *Delphinapterus leucas*, calf, contact, object contact, social interactions, whale

Introduction

Contact

The skin is the largest sensory organ and touch is the first sensory system to develop in mammals (Field, 2010; Nakamura & Sakai, 2014). Yet, touch is rarely studied, particularly for its role in social interactions. Touch can be divided into three contact types that seem to correspond to a distinct range of functions: (1) social contact, (2) object contact, and (3) self-contact. *Social contact*, or inter-individual contact, is defined as "physical contact of any part of the body of one individual with a part of the body of another individual in any way" (Nakamura & Sakai, 2014, p. 357). Social touch, therefore, includes mother-infant contact, socio-sexual or copulatory contact, aggressive contact, affiliative contact, and social grooming. The majority of research on touch in humans (Montagu, 1971; Field, 2010; Gallace & Spence, 2010), primates (Harlow, 1958; Nakamura & Sakai, 2014), cetaceans (Sakai et al., 2006; Dudzinski et al., 2009, 2010, 2012), and ungulates (Green, 1992) has focused on its role in the mother-offspring relationship and infant development. The results of these studies indicate that contact between mothers and their offspring facilitates the offspring's physical, cognitive, and social growth. Special attention has been paid to social grooming by ungulates (Mooring et al., 2004; Rho et al., 2007) and primates (Romero et al., 2011) as a means of strengthening bonds or mediating post-conflict interactions. Pectoral fin rubbing in cetaceans (Norris, 1991; Dudzinski, 1998; Mann & Smuts, 1998, 1999; Sakai et al., 2006) has been proposed as a comparable social grooming behavior (see Nakamura & Sakai, 2014, for a review comparing social touch in cetaceans and primates).

Contact Behaviors in Cetaceans

Social Contact—Affiliative interactions between cetaceans are characterized by synchrony in

swimming and breathing patterns, close inter-animal proximity, and physical contact (Dudzinski, 1998; Gubbins et al., 1999; Miles & Herzing, 2003; Connor et al., 2006; Dudzinski et al., 2009, 2010). Observations of wild and captive cetaceans have indicated that contact occurs relatively frequently between conspecifics during affiliative social interactions and typically involves various fin and body contact (Herman & Tavolga, 1980; Dudzinski, 1998; Mann & Smuts, 1999; Connor et al., 2006; Dudzinski et al., 2009, 2010, 2012).

Five overlapping hypotheses have emerged to explain the function of social contact for cetaceans. Social contact is hypothesized to (1) aid in the formation and maintenance of social bonds, (2) promote hygiene through the removal of ectoparasites and old epidermal cells (reviewed by Dudzinski et al., 2009), (3) facilitate sexual interactions (Tavolga & Essapian, 1957; Norris et al., 1994), (4) reduce male harassment (Connor et al., 2006), and (5) reduce stress. These hypotheses have been tested with several wild populations of bottlenose dolphins (*Tursiops truncatus*; Connor et al., 1992, 2006), and with Indo-Pacific (*T. aduncus*) and Atlantic spotted (*Stenella frontalis*) dolphins (Dudzinski et al., 2009). Research with bottlenose dolphins has indicated that the type of social contact varied by sex and supported the hypotheses that contact facilitates the formation and maintenance of social bonds, reduces male harassment, and reduces stress (Connor et al., 1992, 2006). Females engage in contact swimming with each other and with their calves, while males display petting (pectoral fin to body contact) with each other most often (Connor et al., 2006).

Similar results were found using 12 y of data collected on Indo-Pacific bottlenose dolphins from Mikura Island in Japan, and on Atlantic spotted dolphins from Little Bahama Bank in The Bahamas in which pectoral fin contact was examined (Dudzinski et al., 2009). The results of this study supported the role of contact in the formation and maintenance of social bonds, with an indirect result of stress reduction; the use of contact as a hygienic or self-stimulating function was not supported despite very different physical environments. The similarity in contact rates between the two populations, the differences in physical topography, and the corroborating results of Sakai and colleagues (2006) argue against hygiene and, perhaps, for pleasurable stimulation (Dudzinski et al., 2009).

Object and Self-Contact—Contact with objects or object-rubbing has been observed across cetaceans. Although self-contact may serve different functions than object contact, both forms of contact need access to a substrate or object given the physical constraints of cetaceans. Self-rubbing is hypothesized to have social, hygienic, sexual, and stress-reducing functions much like inter-animal contact (Dudzinski et al., 2009). Cetaceans will actively contact free-floating objects during play (Kuczaj & Trone, 2001; Kuczaj & Highfill, 2005; Kuczaj et al., 2006; Hill & Ramirez, 2014) as well as less dynamic or stationary objects such as pool floors or ocean floors and pool sides or oceanographic geological features (Sakai et al., 2013). Self-rubbing on pool sides has been observed as a solitary behavior (Sakai et al., 2013), while object contact during play may be independent or social (Paulos et al., 2010). Based on their shared functions, it has been proposed that self-rubbing may substitute for social rubbing. As previously performed with dolphins (e.g., Dudzinski et al., 2012), the replacement hypothesis can be tested using studies that compare the behavioral topography and rates of self-rubbing to social rubbing.

For example, a study of three wild dolphin populations was conducted to compare the topography, initiator, receiver, and frequency of self-rubbing to those same variables for social rubbing to determine the extent to which their functions overlapped (Dudzinski et al., 2012). Remarkably, the rate of self-rubbing was nearly identical across all three populations, and the rate of social rubbing was similar across the three populations despite the differences in environment and social groupings (Dudzinski et al., 2012). The consistency of self-rubbing across the three populations and the similar topography of self-rubbing suggested that social groupings and environmental conditions were not likely determinants. Rather, self-rubbing may be an evolutionarily conserved behavior for delphinids (Dudzinski et al., 2012). Self-rubbing most commonly involved the flukes or the rostrum, while social contact most commonly involved the dolphin's face, side, or rostrum. Dolphins used their pectoral fins equally for self- and social rubbing. Dudzinski et al. (2012) posited that self-rubbing may function exclusively for hygiene, play, sensual pleasure, and as a part of feeding or foraging behavior, while social contact likely fulfills different needs, "including maintenance of social bonds, social grooming, conflict resolution, stress reduction, assisted locomotion or pre-copulatory behavior" (p. 36).

Belugas

Research on belugas (*Delphinapterus leucas*) has focused on their biological and physiological characteristics (e.g., White et al., 1994; Wagemann & Kozlowska, 2005), population dispersals (e.g., Brodie, 1989; Harwood et al., 1996; Brown Gladden et al., 1999), echolocation (Turl, 1990), and social composition through genetics (e.g., Colbeck et al., 2013). Less emphasis has been

placed on understanding the nature of their social relationships and social interactions (exceptions: Krasnova et al., 2006, 2009; Hill, 2009; Leung et al., 2010; Hill et al., 2013). Although belugas were one of the first aquatic mammals to be maintained in human care (reviewed by Samuels & Tyack, 2000), a limited amount of research exists on captive belugas (e.g., Hill, 2009; Glabicky et al., 2013; Hill et al., 2013; Hill & Campbell, 2014; Hill & Ramirez, 2014).

Inter-Individual Contact and Social Behavior of Belugas

Many belugas live in various social groupings of mixed sex and age with various stratifications that migrate between summer and winter habitats (Sergeant, 1973; Heide-Jørgensen & Teilmann, 1994; Smith et al., 1994; Brown Gladden et al., 1997, 1999; O'Corry-Crowe et al., 1997; Moore et al., 2000; Colbeck et al., 2013). Often described as a social species given their propensity to congregate and travel in large social groupings (e.g., tens to hundreds of belugas in one geographic area), this claim has not been examined behaviorally. Using evidence from genetic-based studies and a handful of behavioral observations, females and their mixed age and mixed sex offspring will often form a pod and travel together between sites, while adult males appear to live in smaller groups that are loosely associated with the larger, related female groups (e.g., Colbeck et al., 2013).

The earliest contact events observed for belugas are between mothers and their neonate calves. Beluga calves immediately swim and begin to follow their mothers at birth, and, like many cetacean calves, young beluga calves swim at their mother's sides or the mother's flukes, which facilitate the calves' movement through the water (Krasnova et al., 2006, 2009; Hill, 2009; Noren et al., 2008; Noren & Edwards, 2011; Hill et al., 2013). As calves mature, they continue to spend the majority of their time swimming below their mother's peduncle ("infant position"; Gubbins et al., 1999; Mann & Smuts, 1999; Krasnova et al., 2006). Cetacean calves will engage in melon to mammary contact in this position (i.e., bumping) to begin nursing bouts. Calves become more independent over time, spending less time at their mother's side. Based on the limited data available, beluga mother-calf relationships (Krasnova et al., 2006, 2009; Hill, 2009; Hill et al., 2013) seem to function like dolphin mother-calf relationships (Herzing, 1997; Mann & Smuts, 1999; Connor et al., 2006; Tamaki et al., 2006), but the role of contact has not been evaluated for belugas.

Object Contact and Social Behavior of Belugas

Unlike any other cetaceans, belugas undergo a seasonal epidermal molt. Over the winter, the epidermis of beluga skin thickens and develops a yellow cast (Kleinenberg et al., 1964). This "coating" can harden and be up to 3 to 4 mm thick in the spring and is at its thinnest in the fall (St. Aubin et al., 1990; Smith et al., 1992). The belugas' fall migration into warmer waters is thought to accelerate seasonal sloughing (St. Aubin et al., 1990; Smith et al., 1992).

Based on a 4-y study of a beluga population that annually migrates to the Cunningham Inlet, 13.9% of this population's activity budget was spent rubbing on objects (Smith et al., 1992). The belugas were observed rubbing in the shallow water, on sandbars, and even diving down to rub on the deep bottom. Time spent rubbing changed seasonally and was greatest during early July. Interestingly, large white whales swimming with neonates did not rub unless the adult beluga left the neonate with a juvenile beluga to engage in solo rubbing behavior.

Research Questions

Research has shown that dolphins engage in frequent and varied inter-individual contact. This contact is hypothesized to be an important part of establishing relationships with conspecifics and within the mother-calf pair. On the other hand, rubbing against objects appears to occur less frequently in dolphins and is thought to be primarily for hygiene, play, sensual pleasure, or a part of foraging behavior. The evidence from several populations of dolphins suggests that object contact is not determined by environment or climate.

To date, a limited number of studies have documented the role of inter-individual contact and object contact for belugas. Currently, what is known about belugas and the role of contact during their social interactions involves a specific socio-sexual behavior and mother-calf swims. Additionally, rubbing on objects may take on a special function for belugas during the apex of their seasonal molt. It is likely that object rubbing, seasonal molt, breeding, and the annual migration to warmer waters are interconnected.

Given this limited knowledge, the purpose of the present study was to investigate the nature of object contact and inter-individual contact for belugas by observing a population in human care. The present study followed a group of adult and juvenile/infant belugas for three seasons, recording the frequency, duration, initiator, receiver, and body parts used or touched as contact occurred during focal follows. As a preliminary study, the following questions guided the research:

- What are the characteristics of beluga contact events?
- In which context is contact most likely to occur?
- Does inter-individual contact differ from beluga contact with objects?

Methods

Subjects

The subjects included eight belugas housed in a multi-pool interconnected habitat at a single facility. The habitat consisted of seven pools with a total water volume of 2,000,000 gallons or 7,570 m^3. Different configurations of pools and social groupings were determined randomly by the training staff each day. Social groupings, which ranged between two and eight belugas, included combinations such as multiple mother-calf pairs, all adults, or a larger combination of those two types of groups. All subjects were either born at the facility or had been in human care for more than 20 y. Relevant demographic information for each subject is provided in Table 1.

Measures

Using a stopwatch and an ethogram, the following information was recorded for focal belugas: the observed beluga, the pool in which the belugas were located during the observation, time of observations, companions in pool, the beluga that initiated or received contact, the type of contact (e.g., rub or touch), the body part used to contact another animal or object (e.g., touch/rub with body, touch/rub with head, touch/rub with pectoral fin, and touch/rub with fluke), and the type of social interaction in which the contact occurred (e.g., affiliative, agonistic, or socio-sexual). Definitions are provided in Table 2. The frequency and duration of all observed contact behaviors were recorded. To ensure consistent recording of the body part used to initiate or receive contact, the beluga body was divided into four areas: (1) head, (2) body (part of the body or full body), (3) pectoral fins, and (4) flukes.

Observations were conducted across three seasons: Summer 2011, Fall 2011, and Spring 2012. Observations during Summer 2011 focused only on inter-individual contact between belugas. The ethogram was modified to include object contact variables for Fall 2011 and Spring 2012. Type of object contact (e.g., rub or touch), its duration, and frequency were recorded (Table 2). Objects consisted of pool sides and floors, and free-floating enrichment devices (EEDs) such as buoy balls, car wash straps, plastic flower pots, and plastic slides (Table 2).

Procedure

The data were collected 3 d a week between 0800 and 1200 h. A 10-min focal follow of individual belugas was used to collect the data. Several parameters were set to control for potential biases, including lack of independent observations, unequal observation time, and the influence of people passing by the pool. The order of beluga observations was randomly determined each day. Several procedures were also instituted to control for carry-over effects between observations. If belugas were housed in separate social groupings, observations were alternated between each social grouping when possible. If belugas were housed in the same social grouping, a beluga not involved in any interactions with the observed animal was selected as the next focal follow animal. Additionally, a 5-min interval of no observation time was conducted if the same social grouping was to be observed. Contact events occurring between non-focal belugas during the observation session were not recorded. All observations were conducted outside of training sessions and at times when a minimal number of people (guests or trainers) were present.

Two observers collected the data for the current study. The primary observer (C. Alvarez) trained the second observer and conducted reliability sessions with the second observer during the Fall 2011 observations until a 95% agreement criterion was obtained. C. Alvarez conducted Summer

Table 1. Demographic information for each beluga

Animal	Sex	Age classification	Age (y)		
			Summer 2011	Fall 2011	Spring 2012
ATL	Female	Calf	1	1	1.5
BEL	Female	Calf	2	2	2.5
OLI	Male	Juvenile	4	4	4.5
LUN	Female	Adult	10	11	12
IMA	Male	Adult	~23	~23	~23
CRI	Female	Adult	~26	~26	~26
MAR	Female	Adult	~26	~26	~26
NAT	Female	Adult	~29	~29	~29

and Fall 2011 observations. The second observer, C. Wall, collected Spring 2012 data. Opportunities for reliability sessions were not available during the Spring 2012 observations.

Timing Protocols

Two rules were used to time contact bouts. First, timing for the duration of a contact event started when contact by the focal beluga was initiated and stopped as soon as contact between the beluga and the object of interest (a second beluga or an object) was terminated. Second, if multiple contacts occurred during an interaction, the stopwatch was stopped each time contact was disrupted and a separation between the focal beluga and its recipient occurred. Thus, if the focal beluga was making contact with a ball, the stopwatch was started and stopped each time contact and separation of contact occurred, and the total time accrued by the end of a bout was recorded. The contact bout ended if the beluga transitioned to a new activity or more than 5 s had elapsed in which no contact with the object or other beluga had occurred.

Data Analyses

All data were transferred into *Excel* spreadsheets. Data were analyzed at an individual event level, a session level, and an aggregated level for each animal. Two types of contact were assessed: (1) social contact or inter-individual contact, which involved contact between belugas; and (2) object contact, which involved contact between a beluga and an inanimate object. The data were entered as individual events for every observation session conducted for each animal. The data were then collapsed across each session for each animal so that if multiple contact events occurred within the same data session, they were summarized into one line of data. Using the summarized data, a series of mixed model ANOVAs were conducted. Chi square tests of independence were conducted with individual data.

Results

Observation Sessions

During each season (i.e., summer, fall, and spring), each beluga was observed 15 times, which resulted in a total of 360 independent observation sessions. The total observation time was 60 h. Across the three seasons, individual belugas were observed for a total of 7.5 h each.

Table 2. Operational definitions for variables of interest

Target behavior	Operational definition
Contact classifications	
Inter-individual contact	Contact between two or more belugas.
Object contact	Contact exclusively between a beluga and an object.
Contact variables	
Touch	Contact is statically maintained at a single location for less than 2 s.
Rub	Contact is continuously maintained as the initiating body part moves dynamically across the receiver's surface for more than 2 s.
Body part	The body part contacted is classified as head, pectoral fins, body, or flukes.
Initiator/receiver	The initiator is the animal that began the contact event, while the receiver is the animal that was the recipient of the contact event.
Object type	Pool walls, buoy balls, car wash straps, plastic flower pots, plastic slides, and naturally occurring material (e.g., leaves).
Social interaction classifications	Any type of event between two or more belugas that involved an initiation of interaction and elicited a response from the receiving animal.
Infant swim	A pair swim between a mother and her calf in which the calf is positioned below the mother's body with the calf's head at the mammary/genital slits.
Affiliative	Any type of interaction between two belugas that is non-aggressive and/or non-sexual in nature.
Socio-sexual	Any type of interaction between two belugas that involves the genitalia or genital region of one or both belugas.
Agonistic	Any type of interaction between two belugas that is produced to threaten or displace another beluga (e.g., chases that involve bite attempts, biting, or raking).

Characteristics and Contexts of Inter-Individual Contact Events

Out of 360 observation sessions, 32 sessions (9%) contained inter-individual contact events. These 32 sessions produced 57 discrete inter-individual contact events for a rate of 0.02 contact events/min across all three seasons. Only a single contact event (1.8%) occurred between adult belugas, while significantly more contact events (n = 26, 45.6%) occurred between the younger belugas (ATL, OLI, and BEL) and a mother-calf pair (n = 30; 52.6%): $\chi^2(2, N = 57) = 26.00$, $p < 0.001$. The single contact event between adults occurred when NAT initiated a fluke-to-body touch with the adult male, IMA (Table 3). This contact event occurred during an affiliative interaction accounting for less than 1% of her total observation time.

Contexts of Contact During Social Interactions—Of the 57 total contact events, the majority of contact events occurred during various social interactions: 70.2% during affiliative interactions, 24.6% during mother-calf infant swims, 1.8% during agonistic interactions, and 3.5% during sexual interactions (Table 3). Significantly more contact events (n = 30; 53% of all observed events) occurred between a bonded mother-calf pair than other beluga pairs: $\chi^2(3, N = 57) = 46.93, p < 0.001$. Fourteen of these contact events, slightly less than half of the mother-calf contact events, occurred while the calf was in infant swim position. Contact events during the mother-calf infant swim position were longer in duration on average than any other type of contact event: $F_{(3,27)} = 7.77, p = 0.001, \eta_p^2 = 0.46$, LSD post hocs, ps < 0.05 (Table 3).

Types of Contact During Social Interactions—Belugas that engaged in contact assumed one of two roles: (1) initiator or (2) receiver. As displayed in Table 4, the majority (n = 51; 89.5%) of initiations were made by two of the immature belugas (OLI and BEL). The majority of contact received was by the mother (n = 26; 45.6%) and her calf (n = 16; 28.1%) (see Table 4 for individual results). As noted in Table 4, these initiated contacts showed a seasonal effect for one calf, BEL, which is likely related to her age. During inter-individual contact, initiating animals used their bodies (n = 29; 50.9%), heads (n = 25; 43.9%), pectoral fins (n = 2; 3.5%), and flukes (n = 1; 1.8%). Significantly more contact events were initiated using the body and the head: $\chi^2(3, N = 57) = 46.23$, $p < 0.001$. Receiving animals were contacted on their bodies (n = 47; 82.5%), heads (n = 5; 8.8%), and flukes (n = 5; 8.8%). Significantly more contact events were received on the body than any other location: $\chi^2(2, N = 57) = 61.90, p < 0.001$.

Rubs and Touches—Contact was classified as a *touch* if it was static and a *rub* if it was dynamic. The rubber and rubbee relationship (see Dudzinski et al., 2012) is frequently studied in dolphins, but static touches between animals are rarely examined. Overall, the belugas exhibited more touches (n = 42; 73.7%) than rubs (n = 15; 26.3%), binomial test, $p = 0.001$, when contacting each other. To examine the relationship between type of contact and type of social interaction, a Chi square test of independence was conducted. Touches occurred significantly more often than expected by chance during mother-calf infant swims (n = 14; 24.6%), while rubs occurred significantly more often than chance during all social interactions combined (n = 15; 26.3%): $\chi^2(1, N = 57) = 6.63, p = 0.01$, V = 0.34. Out of the 42 touch contact events, animals that initiated touches did so most frequently with their head (n = 25; 59.5%): $\chi^2(3, N = 42) = 36.67$, $p < 0.001$; and receivers of touches tended to be touched on their body (n = 32: 76.2%): $\chi^2(2, N = 42) = 34.71, p < 0.001$. Animals that initiated and received rubs used only their body (i.e., part of the body or full body) in some capacity (initiators: n = 15; receivers: n = 15, 100%).

Head-to-Body Contact—Infant position is a unique swim position that provides biological benefits such as access to nursing and resting opportunities (Gubbins et al., 1999; Mann & Smuts, 1999; Krasnova et al., 2006, 2009). During the infant position, the calf swims slightly below the mother's flukes at the mammary slits leading to contact between the calf's head and the mother's body. As Table 3 shows, head-to-body contact occurred in two contexts: (1) between the mother-calf pair while swimming in infant position and (2) during a single agonistic interaction between a juvenile male and his adult sister. In both contexts, the head-to-body contact was a static touch.

Time of Year—The time of year was also examined to determine if the nature or frequency of contact events changed across seasons (Table 3). The results of a Chi square test of independence indicated that there was a significant relationship between season and type of interaction in which contact was observed at the group level: $\chi^2(8, N = 57) = 24.20, p = 0.002, V = 0.46$. During the summer observations, mother-calf infant position accounted for more of the contact events than expected by chance as compared to any other type of interaction (n = 9; 33.3%). These results are accounted for by the bonded mother-calf pair as indicated by the individual analyses presented in Table 4. In contrast, no mother-calf infant position swims were observed during the spring, which was less than expected by chance. Rather, contact was observed during a variety of social interactions. Affiliative interactions were represented significantly more often than expected by chance during the spring than during any other season (n = 10; 76.9%) (Table 3). These

Table 3. Summary of inter-individual contact events per season across all sessions

Season	Type of contact events	Body part	*N*	Mean duration (s)	*SEM*
Summer 2011					
	Mother-Calf		*18*		
	Infant swim			79.46	34.37
		Head-to-body	9		
	Affiliative			1.84	0.56
		Body-to-body	9		
	Total Social		9		
	Affiliative			1.96	0.34
		Body-to-body	2		
		Head-to-head	1		
		Head-to-flukes	5		
		Pec fin-to-body	1		
Fall 2011					
	Mother-Calf		7		
	Infant swim			41.42	24.26
		Head-to-body	5		
	Affiliative			23.02	17.89
		Body-to-body	1		
		Body-to-head	4		
	Total Social		5		
	Affiliative			4.07	0.21
		Body-to-body	3		
		Head-to-body	2		
Spring 2012					
	Mother-Calf		--		
	Total Social		13		
	Affiliative			1.75	0.41
		Body-to-body	3		
		Body-to-flukes	1		
		Body-to-full body	5		
		Body-to-pec fin	1		
	Agonistic			1.78	0.00
		Head-to-body	1		
	Sexual			7.05	3.17
		Body-to-body	1		
		Full body-to-body	1		
Total					
	Mother-Calf Infant		14	60.44	20.65
	Mother-Calf Affiliative		16	13.94	10.48
	Affiliative		24	2.26	0.31
	Agonistic		1	1.78	—
	Sexual		2	7.05	3.17

Note: *SEM* = Standard Error of the Mean

Table 4. Frequency of initiation of inter-individual contact per beluga for each season

	Initiators				Receivers			
Beluga	SU 2011	FA 2011	SP 2012	Total	SU 2011	FA 2011	SP 2012	Total
ATL	--	--	--	--	2	2	--	4
BEL	18	12	2	32	3	5	8	16
OLI	7	3	9	19	--	--	3	3
LUN	--	--	1	1	6	--	1	7
IMA	--	--	--	--	--	--	1	1
CRI	2	2	--	4	16	10	--	26
MAR	--	--	--	--	--	--	--	--
NAT	--	--	1	1	--	--	--	--
Total	27	17	13	57	27	17	13	57

Note: Both BEL and OLI initiated significantly more interactions than any other beluga overall: Chi square goodness of fit, $\chi^2(4, N = 57) = 66.07$, $p < 0.001$. Both CRI and BEL received more interactions than any other beluga overall: Chi square goodness of fit, $\chi^2(5, N = 56) = 56.22$, $p < 0.001$. Only BEL's distribution as an initiator per season was statistically significant, $\chi^2(2, N = 32) = 12.25$, $p < 0.002$, indicating she initiated significantly more contact interactions during the summer than any other season.

trends were likely influenced by the maturation of the bonded calf as she became increasingly more independent across the observation period.

Characteristics and Contexts of Object Contact Events

Out of 240 observation sessions, 217 sessions (90.4%) contained object contact events. These 217 sessions produced 1,632 discrete object contact events. All of the belugas engaged in object contact events. One beluga (NAT) displayed significantly more object contact across the two seasons than any other beluga (mixed model ANOVA with beluga as a between subjects variable and season as a within subjects variable: Huynh Feldt correction, $F_{(7,112)} = 95.14$, $p = 0.04$, $\eta_p^2 = 0.12$ with LSD post hoc tests, $p < 0.05$) (Table 5; Figure 1).

Types of Contact—Belugas contacted pool walls (n =1,547; 95%) and EEDs (n = 85; 5%). Contact with the pool walls occurred significantly more than contact with other objects: $\chi^2(1, N = 1{,}632) = 1{,}309.70$, $p < 0.001$. Moreover, contact with pool walls involved a rub (n = 1,485; 96%) significantly more often than a touch (n = 62; 4%): $\chi^2(1, N = 1{,}547) = 1{,}308.94$, $p < 0.001$. Contact with pool walls was made significantly more frequently with the body (n = 1,505; 97.5%) than the head (n = 24; 1.6%), pectoral fins (n = 9; 0.6%), or flukes (n = 9; 0.6%): $\chi^2(3, N = 1{,}544 = 4{,}319.85$, $p < 0.001$. Wall rubs occurred about 0.62 times/min during an observation.

Contact with EEDs occurred as both rubs (n = 5; 6%) and touches (n = 80; 94%). The belugas contacted EEDs with their heads (n = 62; 72.9%), bodies (n = 19; 22.4%), or flukes (n = 4; 4.7%): $\chi^2(2, N = 85) = 64.63$, $p < 0.01$. Contact with EEDs occurred about 0.04 times/min.

Time of Year and Sex of Beluga—A mixed model ANOVA with sex of beluga as a between subjects variable and season as a within subjects variable was conducted. No significant effects were observed for season, sex of beluga, or the interaction between season and sex of the beluga (Figure 2). On average, the belugas contacted objects 6.8 times/10-min session (Table 5; Figure 1).

Comparison of Inter-Individual Contact and Object Contact

Three variables—frequency, body part used, and if it was a rub or a touch—were examined to assess if contact differed if performed with another beluga or with an object. To account for the change in recording protocol from the summer to the fall, the following comparisons were based on the Fall 2011 observations (240 sessions; 2,400 min) and Spring 2012 observations (240 sessions; 2,400 min).

Comparison of Types of Contact and Season—The frequency of object contact occurred more often (n = 1,632; 98%) than the frequency of inter-individual contact (n = 30; 2%). Through the use of aggregated data per session, a series of mixed ANOVAs was conducted to compare object contact to inter-individual contact when considering types of object (e.g., wall vs EED), touches only, rubs only, and all types of contact and the influence of season. The results of these analyses are summarized in Figure 3 and Table 6. Object contact occurred significantly more often in all analyses than inter-individual contact, with some seasonal interactions. Specifically, wall touches occurred significantly more often during the spring observations than inter-individual touches in either observation period or wall touches during the fall.

Table 5. Descriptive statistics for total object contact

	Fall 2011		Spring 2012		Total	
Beluga	F	*M* ± SD	F	*M* ± SD	F	*M* ± SD
ATL	39	2.60 ± 5.07	79	5.27 ± 7.51	118	3.93 ± 6.44
BEL	78	5.20 ± 4.38	117	7.80 ± 7.66	195	6.50 ± 6.27
OLI	93	6.20 ± 9.87	108	7.20 ± 6.52	201	6.70 ± 8.23
LUN	129	8.60 ± 5.65	74	4.93 ± 2.46	203	6.77 ± 4.67
IMA	136	9.07 ± 6.92	82	5.47 ± 5.00	218	7.27 ± 6.21
CRI	88	5.87 ± 5.37	96	6.40 ± 4.17	184	6.13 ± 4.73
MAR	123	8.20 ± 9.03	77	5.13 ± 4.19	200	6.67 ± 7.09
NAT	205	13.67 ± 12.11	108	7.20 ± 6.78	313	10.43 ± 10.19
Total	891	7.49 ± 8.12	741	6.18 ± 5.73	1,632	6.80 ± 6.42

Note: No seasonal effects were observed other than for LUN (dependent *t* test, $t[14] = 2.60$, $p = 0.021$). Individual means represent number of contact events per 10-min session for each beluga. Total means represent the grand means. Belugas did not differ from one another in the frequency of object contact, with the exception of NAT. See text for details.

Additionally, inter-individual rubs occurred significantly more often during the spring observations than inter-individual rubs during the fall observations and EED rubs during the spring observations. Overall, object contact was observed 0.68 times/min while inter-individual contact was observed 0.01 times/min for the fall and spring observation periods. No other seasonal effects were detected.

As described earlier, inter-individual contact was represented almost dichotomously with adults not contacting or contacting only once, while the mother, juveniles, and calves contacted more frequently. Mean frequency of object contact was not significantly different between non-socially contacting animals ($M = 7.08$; SD = 7.90) and socially contacting animals ($M = 6.52$; SD = 6.08): independent *t* test, $p > 0.05$. Object contact had more rubs ($n = 1{,}487$; 99.5%) than inter-individual contact ($n = 8$; 0.5%). Belugas almost always initiated inter-individual contact with their bodies ($n = 15$; 83.3%) and received inter-individual contact with their bodies ($n = 22$; 88%). When contacting the pool walls, they almost always preferred to use their bodies ($n = 1{,}505$; 97.3%). In contrast, when EEDs were contacted, the belugas were more likely to use their heads than their bodies and flukes.

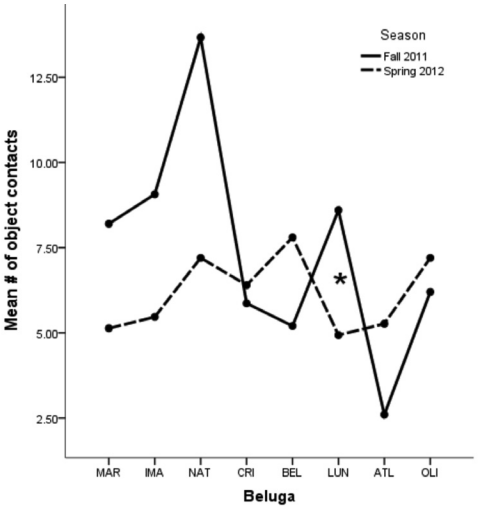

Figure 1. Mean frequency of object contact for each beluga per season. * indicates a significant difference between seasons for LUN. NAT exhibited significantly more object contact overall than all other belugas except IMA, though NAT did not show a significant seasonal effect.

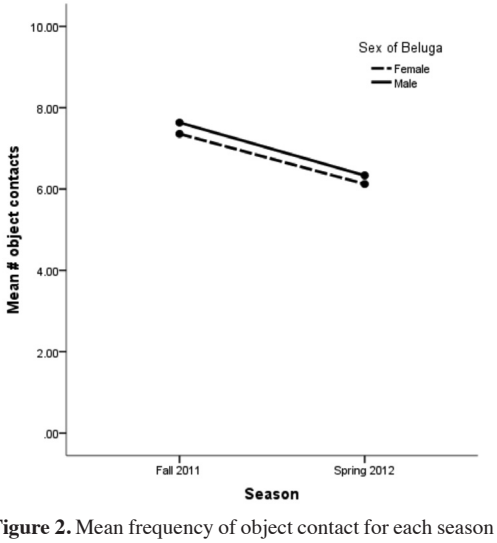

Figure 2. Mean frequency of object contact for each season by sex of beluga (6 females, 2 males)

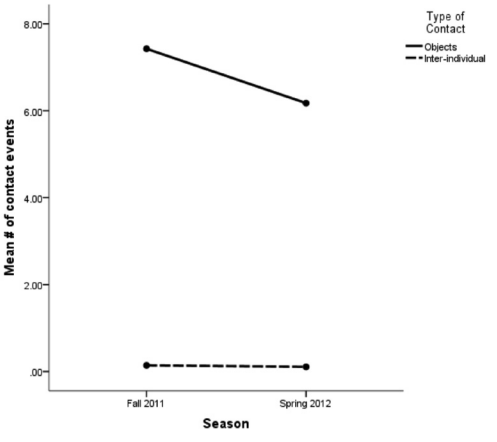

Figure 3. Mean frequency of total object contact and total inter-individual contact for each season. All types of object contact were significantly greater than inter-individual contact.

Discussion

Existing research with humans suggested that touch has many therapeutic benefits on the immune system, growth, breathing, heart rate, and levels of stress and anxiety (Field, 2010). Previous research with dolphins and primates has suggested that touch may decrease aggressive behaviors, increase female bonding, mend relationships, and provide positive developmental and social effects on infants (Mann & Smuts, 1999; Connor et al., 2006; Tamaki et al., 2006; Dudzinski et al., 2009; Nakamura & Sakai, 2014). The purpose of this study was to investigate the degree and nature of physical contact between belugas and with objects in a diverse group of belugas in human care that ranged in age, sex, and social composition.

Nature of Contact Events

Frequency of Contact—Out of 60 h of observation time for eight belugas grouped in various social compositions (e.g., all adults, only mother-calf pairs, and mixed groups), contact between belugas was observed primarily between the bonded mother-calf pairs (n = 38) and between immature belugas (n = 17). Only one contact event occurred between adults, and one contact event occurred between a juvenile male and his adult sister. When compared to two previously studied populations of dolphins, the belugas contacted each other at much lower rates (0.02 events/min vs 0.37 events/min, Mikura Island; and 0.27 events/min, The Bahamas; Dudzinski et al., 2009). The lack of contact between adults suggests that inter-individual contact may not be a critical component to maintaining adult social relationships. Anecdotal reports of belugas housed at other facilities across North America support both the minimal amount of contact between adult belugas and the more frequent contact between beluga mother-calf pairs and young belugas (S. Dietrich, K. Dudzinski, H. Hill, M. Noonan, and

Table 6. Statistics for object contact vs inter-individual contact

		Fall 2011			Spring 2012			Total					
Type of object	Type of contact	F	*M*	SD	F	*M*	SD	F	*M*	SD	F	*p*	η_p^2
Wall													
	Touches	17	0.13	0.61	46	0.38	0.80	63	0.26	0.72	M: 9.41	**	0.04
											I: 9.41	**	0.04
	Rubs	821	6.84	7.75	664	5.53	5.86	1485	6.19	6.89	M: 191.61	***	0.45
EED													
	Touches	48	0.41	2.03	11	0.26	1.40	59	0.38	1.74	M: 4.56	*	0.02
	Rubs	5	0.04	0.27	0	0.00	0.00	5	0.02	0.19	I: 4.91	*	0.02
All objects													
	Touches	65	0.54	2.09	57	0.64	1.60	122	0.59	0.86	M: 16.92	***	0.07
	Rubs	826	6.89	7.73	664	5.53	5.86	1490	6.21	6.88	M: 193.69	***	0.45
Inter-individual													
	Touches	16	0.13	0.53	6	0.05	0.22	22	0.09	0.41			
	Rubs	1	0.01	0.09	7	0.06	0.35	8	0.03	0.26			

Note: All analyses contrasted the mean frequency of type of object contact to the mean frequency of inter-individual contact events. Analyses were conducted using data collapsed across each session. All analyses had the same $df_{(1, 238)}$. M = Main effect; I = Interaction. No seasonal main effects were found. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

D. Yeater, pers. obs.). Moreover, when photographs of white, larger, and assumed older, free-ranging belugas are examined, the belugas do not appear to be in contact with one another (e.g., see www.arkive.org/beluga-whale/delphinapterus-leucas/image-G112776.html). Some anecdotal reports, however, suggest that belugas in their natural habitat are observed to contact each other frequently (V. Vergara, pers. comm.), which necessitates additional empirical studies examining contact between belugas housed at other facilities or in their natural habitat. It is unclear if the limited contact observed was specific to this beluga population or is a characteristic of belugas as a species that may be related to social structure and/or ecology of the habitat.

Contrasted to the minimal amount of inter-individual contact, the belugas contacted objects more frequently (0.68 events/min or about seven contacts per observation session). Although individuals showed some variation in the number of object contacts displayed, all of the belugas were more likely to touch or rub against inanimate objects (usually the side of a pool) than another beluga. Previous research with free-ranging belugas had suggested that during the summer months, belugas, with the exception of mothers with neonates, spent up to 14% of their time rubbing the shallow substrate, presumably to slough their skin (Smith et al., 1992). The results of the current study support the importance of self-rubbing in belugas (adults without neonates and, to a lesser degree, adults with older calves, juveniles, and calves) across seasons in an environment with a controlled water temperature (i.e., 16° to 19° C) year round, which represents the upper end of summer water temperatures in sub-arctic waters (e.g., Churchill, Manitoba: 5° to 14° C). While the frequency of object contact in the current study could be related to sloughing, the belugas' resting swim patterns and housing arrangements may better explain the current results. More information from additional facilities is needed to interpret the frequency with which object contact is made by belugas in human care as well as the frequency with which adult females with neonates rub against objects.

Contexts and Nature of Contact—More than half of the observed contact events between belugas occurred during mother-calf interactions. Two females had calves 2 y or younger at the time of the study. The pair that was bonded and spent the majority of their time together (Hill et al., 2013; Hill & Campbell, 2014) displayed the majority of the contact events during social interactions with each other or with other young belugas. No contact occurred between the second mother-calf pair, which had not bonded, and the calf did not initiate any inter-animal contact.

Two immature belugas initiated all inter-animal contact except for a single contact event between an adult female and adult male. Almost 75% of the contact events were static touches between two belugas. However, during social interactions, excluding mother-calf infant swims, the belugas were more likely to use rubs than touches. The belugas also initiated contact with each other during social interactions using a variety of body parts. Contact events during social interactions not involving the mother-calf pair (n = 27) included body-to-body contact, head-to-flukes contact, head-to-body contact, and a variety of other combinations such as pectoral fin to body or reverse. This difference in body parts depended on the context and likely reflected the nature of social interactions. The majority of the contact events observed during social interactions occurred during affiliative play and games involving the immature belugas. Affiliative interactions between immature belugas were characterized by approaches from many different angles as these belugas often chased, head butted, swam over or under, or circled around one another.

In contrast, mother-calf interactions tended to only involve the calf's head and the mother's body. Specifically, all contact events during mother-calf swims involved head-to-body touches, presumably related to the hydrodynamic benefits and nursing access provided to calves when in this position (Gubbins et al., 1999; Mann & Smuts, 1999; Weihs, 2001; Krasnova et al., 2006, 2009; Noren et al., 2008; Hill, 2009; Noren & Edwards, 2011; Hill et al., 2013). In the current study, the frequency of mother-calf contact decreased as the bonded calf aged. This trend was likely due to the drop in mother-calf infant swim position during the spring observations, which corresponds to previous studies documenting that calves spend less time with their mothers and more time independently swimming and playing (Krasnova et al., 2006, 2009; Hill, 2009; Hill et al., 2013; Hill & Campbell, 2014). In terms of contact during other types of mother-calf social interactions, the calf generally used her head or body to rub along her mother's body. These contact events remained relatively stable across the seasons. Additional research with more bonded mother-calf pairs in larger social groupings would aid in our understanding of the role of contact in bond formation between belugas.

Ninety-five percent of all object contacts involved the side of the pool, with the remaining 5% involving free-floating objects (e.g., EEDs). Belugas rubbed the side of the pool most often with their bodies, whereas they touched the wall with their bodies and heads almost equally. When rubbing an EED, belugas only used their bodies. In contrast, belugas touched EEDs most

frequently with both their heads and bodies. Neither season nor sex of the beluga appeared to influence the frequency with which they contacted objects within their environment or the nature of that contact. Although there was variation in the frequency with which individual belugas contacted objects, only one beluga exhibited significantly more object contact than any other animal. The oldest female was more likely to contact the pool side than any other type of object, which was most likely related to her tendency to rest swim (H. Hill, pers. obs.).

Functions of Inter-Individual and Object Contact in Cetaceans

Unlike dolphins (Mann & Smuts, 1999; Connor et al., 2006; Tamaki et al., 2006; Dudzinski et al., 2009), contact between belugas is rare. When contact did occur, it primarily occurred between young animals involved in playful social interactions or contact between a mother-calf pair, primarily during an infant position swim. Despite the frequency with which it occurred, the nature of contact between the young belugas was very similar to previous research conducted with dolphins, including calves (Mann & Smuts, 1999; Dudzinski et al., 2009). Bottlenose dolphin calves appear to use contact in their development and maintenance of these early relationships and perhaps as an opportunity for determining physical ability (Tamaki et al., 2006). Similarly, the contact events between immature belugas were brief and diverse in topography. Younger belugas were more likely to initiate contact with their older peers. These contact activities may allow immature belugas to test each other's strength, which is a critical component for relationship development in young animals (Burghardt, 2005).

In contrast to the immature belugas, adult belugas were almost never observed to touch one another. Considering their large social groupings and similarities to dolphins in behavioral development and maternal care (Krasnova et al., 2006, 2009; Hill, 2009; Hill et al., 2013), some degree of contact between adult belugas would be expected as is often seen in other cetaceans (Mann & Smuts, 1999; Connor et al., 2006; Tamaki et al., 2006; Dudzinski et al., 2009, 2012; Sakai et al., 2013). It is, therefore, unclear why adult belugas did not engage in physical contact with one another during social interactions. Perhaps contact is not used as a bond formation or maintenance method for adult belugas, nor does contact appear to be used as a way to soothe or reduce aggressive tendencies as in the case of some primates and maybe dolphins (Mann & Smuts, 1999; Connor et al., 2006; Tamaki et al., 2006; Dudzinski et al., 2009, 2012; Sakai et al., 2013).

Although contact is expected during sexual interactions between males and females, none of these events occurred between adults during this study. The two socio-sexual contact events were initiated by a female calf toward a male juvenile, which corresponds to observations of socio-sexual behavior in another population of belugas in human care (Glabicky et al., 2010). Additional studies are needed to characterize the nature of other types of contact between male and female adult belugas during socio-sexual interactions.

Beyond socio-sexual interactions, no other social interactions were observed to involve contact between adults. Unlike dolphins, in which females are often in contact (Dudzinski et al., 2009, 2012), the adult female belugas were never observed to contact one another, much less socialize with one another. With the exception of the bonded mother-calf pair, the adult females engaged in independent swimming throughout the sessions.

Dudzinski et al. (2012) argued against self-rubbing as a replacement for social contact for dolphins. It is unclear if belugas use self-rubbing as a social contact replacement. Although the frequency of object contact was significantly higher than the frequency of inter-individual contact, the behavioral topography of self-rubbing did not differ significantly between belugas considered social and belugas considered less social. While the current study did not directly assess the frequency with which different types of social interactions occurred between belugas of different ages and sexes, the interactions between adult belugas, particularly the females in this population were not as frequent as in dolphins.

Before we can assess the role of contact in adult beluga interactions fully, perhaps the first question that must be addressed is how frequently do adult belugas socialize? It seems possible from the current study that contact plays a role in the development of beluga relationships, particularly for intact mother-calf pairs and between young belugas. However, given the results of this study with belugas of different ages and sex, it does not appear that contact is a significant contributor to the maintenance of adult associations (but see Glabicky et al., 2010, for a discussion of socio-sexual behavior between beluga adult males). Perhaps there are sex differences in the type of inter-individual contact belugas display that is dependent on reproductive status or developmental age. Additional research on the social interactions and the different types of contact is necessary to better understand the role of contact in beluga social interactions and associations.

Future research should also examine the relationship between contact with objects and the degree of sloughing exhibited by the animals

as this relationship may explain the frequency of contact with objects exhibited by this group of belugas. Given the difficulties of conducting such research in the wild, research in controlled environments could provide a base from which to better understand beluga social interactions and physiological-based behaviors such as sloughing. For example, recent studies of beluga social displays has revealed that belugas often use body postures to communicate with other belugas such as vertical S-postures during agonistic interactions (Horback et al., 2010; Hill et al., 2015) or bubble burst displays during threatening contexts (Hill et al., 2011).

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