

COMPREHENSIVE VIDEO ETHOGRAM ON BELUGA
(*DELPHINAPTERUS LEUCAS*) BEHAVIOR

A Thesis

by

CAROLYN ANN CAMPBELL

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of
MASTER OF SCIENCE

May 2011

Major Subject: Oceanography

Comprehensive Video Ethogram on Beluga (*Delphinapterus leucas*) Behavior

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Co-Chairs of Committee,	Andrew Vastano
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ABSTRACT

Comprehensive Video Ethogram on Beluga (*Delphinapterus leucas*) Behavior.

(May 2011)

Carolyn Ann Campbell, B.S., Texas A&M University

Co-Chairs of Advisory Committee: Dr. Andrew Vastano
Dr. John Wormuth

Research is limited for belugas in both the wild and in the care of humans. To address this lack of knowledge, I created a comprehensive video ethogram of beluga behavior, collected from the beluga population located at Sea World San Antonio.

The purpose of this study was to create an educational tool to train future research observers and to increase public awareness. Video recordings were taken from above water and then imported into video editing software. A total of 103 videos were reviewed, which represented 24 hours 49 minutes of video data. Each video was examined for the best examples of each behavior of interest. Clips of these behaviors were recorded and edited together into a single video paired with a voiceover commentary to explain the clip. The video ethogram comprises 82% of the behaviors in the comprehensive ethogram. A total of 268 clips of behaviors are in the video. The full running length of the video ethogram is 1 hour 5 minutes 2.03 seconds. Of all the potential behaviors, 64% were found to be frequent and 36% were found to be rare. The

video portion provides visual examples of the behavior while the voiceover commentary provides explanations.

Due to the lack of a comprehensive ethogram in the literature and time consuming process of training observers, this video ethogram is a necessary and practical addition to the study of belugas.

DEDICATION

To My Family

Thank you for always being loving, supportive, encouraging and patient with me over all these years. I could not have accomplished this, or anything, without you.

My parents, Janet and Colin, are the pillars which I lean upon through everything, and you never discouraged me from following my crazy dreams.

My sister, Sarah, has not only been the best sister a girl could ask for, but a best friend; I could not have made it without all the laughter we have shared.

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CHAPTER I

INTRODUCTION

The beluga (*Delphinapterus leucas*) or white whale, of the order Cetacea, is highly adapted to live in its aquatic environment. Cetaceans have evolved a large surface area to volume ratio to reduce heat loss because water is 25 times more conductive than air. Outside of a pair of pectoral fins and flukes for propulsion, they have no external forelimbs, pinnae or external gonads, which also helps reduce heat loss (Ridgway 1997). Cetaceans evolved from land animals, as indicated by a pair of vestigial pelvic bones. However, all other signs of hind limbs have disappeared. Beluga is in the suborder Odontoceti, or toothed whales, where animals retain the same teeth after birth, which are permanent and are not replaced if lost. This suborder is also characterized by a well-developed sternum where three pairs of ribs are attached, five fingers in the pectoral fins, and one external nasal opening (Ridgway 1997). The superfamily of the beluga is Delphinoidea, which comprises over half the cetaceans. Within this superfamily only seven of the species included are medium sized whales, the rest are porpoises or dolphins (Ridgway 1997). Beluga is in the family Monodontidea, which includes three subfamilies. Each subfamily contains only one species, and includes the subfamily of Delphinapterinae, or belugas.

This thesis follows the style of *Animal Behavior*.

The distribution of belugas is the arctic and subarctic waters, surrounding the northern parts of Alaska, Canada and Russia, with the northernmost limit being Svalbard ($>80^{\circ}\text{N}$) and the southernmost limit being the St. Lawrence River in eastern Canada ($47-49^{\circ}\text{N}$) (O’Corry-Crowe 2009). Belugas undergo small migrations, as they follow the receding ice in the spring and summer. They enter estuaries, shallow inlets and bays during the warmer months and leave these areas during colder months (O’Corry-Crowe 2009). Genetic studies on the summer populations have found they tend to return to their natal areas each year. Returning to the same natal areas suggests cultural inheritance among mothers and calves, leading to the possibility of sub-populations (Brown Gladden et al. 1997; O’Corry-Crowe et al. 1997). Several beluga populations then leave these coastal regions and travel in more open oceans where the ice coverage is up to 90%. Using diving depth data researchers have suggested that belugas are probably foraging on deeper benthic species and ice-associated species (Suydam et al. 2001).

Belugas have a number of adaptations that aid in their survival in the arctic areas. The most distinguishing feature of the beluga is its white color, allowing it to blend well with the ice. Beluga originates from a derivative of the Russian word for white, ‘beloye’. It is considered a small-to-medium sized-whale, reaching 3.5-5.5m in length and up to 1500kg in weight (Ridgway 1997; O’Corry-Crowe 2009). They lack a dorsal fin, possessing only a small dorsal ridge, and their flippers are rather small and fan shaped. They have a thick insulating layer of blubber, up to 15cm thick.

Compared to other cetaceans, belugas swim rather slowly with cruising speeds of 6-9km per hour and bursts of speed up to 20km per hour. Although belugas have slow swimming speeds, they are very agile swimmers, an ability which facilitates their foraging and access to shallow waters in some coastal areas. Also, accessing shallow waters allows belugas to escape predators like killer whales (*Orcinus orca*) as these large predators cannot follow. Finally, since water is a better conductor of heat than air, exposing some of their bodies to air can achieve some thermal advantages (Brodie 1989). Belugas are also known to swim upside down, which researchers have hypothesized may be useful for aerial orientation (Brodie 1989).

Echolocation, as in other Cetaceans, is used for communication, hunting and monitoring the environment. Echolocation is the ability to produce high-frequency clicks and to detect echoes that bounce off distant objects. The ability to navigate through heavy, ice-packed water to locate areas free of ice is extremely adaptive in the circumpolar region. Belugas are all hypothesized to use their echolocation to find pockets of air in ice covered water (Turl 1990). In shallow water, where turbidity increases, echolocation becomes more valuable when light is limited and eyesight may be unreliable (Tyack 2000).

The diet of the beluga is highly variable and depends on the season and region (i.e., estuaries or off shore). However, it has been difficult to visually determine the main prey species of belugas as they are benthic feeders. Most diet estimations have come from

analyzing stomach contents from stranded or hunted specimens. There are several species that belugas prey upon that may be still unknown to researchers.

Belugas are known as the “sea canary of the ocean” because they have a broad and diverse array of communication sounds. As many as 50 call types have been identified. Some of their sounds include groans, whistles, buzzes, trills and roars (O’Corry-Crowe 2009). Also, the beluga is capable of producing individually distinctive calls, which may be used to maintain relationships (Bel’kovich and Sh’ekotov 1990). The ability to maintain relationships can be very helpful when traveling long distances and through ice fields.

CHAPTER II

LITERATURE REVIEW: BELUGA BEHAVIOR

Introduction

Several species of cetaceans (e.g., bottlenose dolphin, killer whale, humpback whale) in the care of humans and in the wild have been studied extensively. However, little research has been conducted on belugas in either area. Studies conducted in the wild and in the care of humans were examined to achieve a full understanding of beluga behavior.

Research Conducted in the Wild

Wild research can be expensive and visually challenging, especially in the arctic where weather is not always ideal. These factors probably contributed to the limited research conducted on wild belugas. The behavioral content from the few studies that do exist on live belugas was useful.

The two major studies found on live wild beluga are on the spatial relationship of mother-calf pairs and on categorizing the vocalizations of belugas. Krasnova et al. (2006) observed the spatial relationships between mother and infant belugas under natural conditions for three different age groups: newborn, one-month-old and two-month-old. Their observations were made from an observation tower near a known pod's breeding area and they also made video recordings under water of previously established high visitation areas. Analysis was done on the frequency and durations of

11 predefined (with a diagram) spatial relations of the calf to the cow. The results showed that in all age classes the highest frequency spatial relationship was “at the cow’s side”, which is comparable to the echelon position, and “at the cow’s tail”, which is comparable to the infant position. These spatial relationships were highest when the calf was a newborn and declined as the calf became older and increased its mobility. The spatial diagram created for the study of the cow and calf was one of the initial sources used to help create an operational definition for the mother-calf relationship behaviors. The beluga was the first cetacean species to have their vocalizations recorded underwater, due to their high frequency of vocalization (Schevill and Lawrence 1949). Belikov and Bel’kovich (2006) classified the beluga vocalization into three categories: pulsed sounds (clicks and pulsed sounds), noisy calls, and whistles. They identified 12 different whistle types using frequency information to classify each whistle type. The results showed that out of all the whistles analyzed the dominant one was ‘flat whistle’ at 50 percent and the ‘rising whistle’ was second at 23 percent (Belikov and Bel’kovich 2006). This was the first study that focused on beluga communication and the importance of the different sounds.

Other areas of research involving wild populations include analysis of samples from hunted belugas. Studies have been conducted on the physical characteristics, food sources and pollutants. Brodie (1971) used data collected from captured and hunted animals to examine aspects of growth and reproduction of a single population. One behavioral observation they collected from the hunting community was that full-term

and postpartum females tended to aggregate closer to shore or in more sheltered, smaller bays away from the main herd. Seaman et al. (1982) reported that the beluga diet varied by season after examining the stomach contents of belugas collected by the Eskimo subsistence hunters in the Bering and Chukchi Seas. For example, the primary food sources during the spring included arctic cod, krill, and octopus. However, during the summer the diet included more variety with saffron cod, sculpins, herring, smelt, capelin, salmon and char. Variation in the diet was also observed based on geographic location for the fall and winter months. The northern populations seem mostly to depend on arctic and saffron cod, while the southern populations seem mostly to depend on pollock. Since the beluga is still a species hunted and consumed by several northern native populations the health of the belugas is of interest. As a result, many studies have been conducted on the biomagnification of toxins in the food web and its effects on belugas and, in turn, the effect it will have on humans. Samples are obtained from the hunted belugas which resulted in the majority of research conducted on wild belugas have been from their analysis. The samples obtained from the hunted belugas are not the only ones available, belugas in the care of human also provide samples.

Research Conducted in the Care of Humans

As with the limited research on belugas in the wild, there is little research on belugas in the care of humans. There are several studies focused on different aspects of beluga behavior, including nursing behaviors of calves. There are also a few studies on general

physiological characteristics of belugas conducted in the care of humans, focused on growth and development.

One major advantage of studying animals in the care of humans is being able to obtain physiological data. For belugas there are a few studies on general growth and development. Robeck et al. (2005) pooled data from 23 females, 12 males and 21 calves in the care of humans from several facilities achieve a sufficient overview of beluga reproduction, calf growth and development. They found that the average age when males sired their first calves was 13.3 ± 2.6 years and a fivefold increase in testosterone occurred during the months of January through April, which corresponds to the mating season. The average age for first conception was 9.1 ± 2.8 years and the mean gestation length was 475.0 ± 20.4 days. They then modeled the predicted growth of the calves in relation to age. The predicted birth weight for both sexes was 88.9kg and the length for males was 154cm while the female length was 160cm. The model also predicted that the males would grow faster in length and weight than females. Their model estimates were relatively accurate in predicting growth rates and sexual dimorphism in the calves. The results from Robeck et al. (2005) advanced the knowledge of beluga reproduction, which is necessary to maintain a healthy diverse population in the care of humans.

Two studies have focused on specific behaviors observed in belugas: bubble blows and the occurrence of S-posturing. Delfour and Aulagnier (1997) observed five captive adult belugas to examine the bubble blow. Results indicated the bubble blow seemed to be a

solitary play activity with no immediate benefit to the animal. The animals varied their actions after creating the bubble blow. They looked, followed, or ruptured the bubbles with their flukes or mouth. These behaviors were interpreted as play-like. They also found a diurnal pattern. The bubble blows occurrence was higher in early morning and early afternoon, which is consistent with other play actions (Delfour and Aulagnier 1997). Since the action was never done in coordination with another animal, therefore it was considered a non-interactive behavior. The bubble blow is a solitary play behavior because it fulfills the conditions of variation in actions, diurnal pattern, and not in coordination with another animal (Harcourt 1991). The second study, conducted by Horback et al. (2009) investigated the occurrence of S-posturing in the care of humans at Sea World San Diego. They defined S-posturing as an animal positioning its body with the neck flexed downward, pectoral fins extend upward, peduncle arching forward and the flukes flexed outward. The results indicated that this behavior occurrence increased when the animals were aggravated, such as when harbor seals (*Phoca vitulina*) that occasionally share their enclosure, were present. Both studies, bubble blows and S-posturing are vital for understanding the role individual behaviors play.

There are two main studies on calf nursing behavior. Drinnan and Sadleir (1981) conducted the first quantitative study of the suckling behavior of a beluga calf. Successful suckling was defined by the tail flexing 1-6 times to insure attachment. Lack of tail flexing while attempting to suckle was considered unsuccessful suckling. Also, suckling was considered unsuccessful when the calf attempted to suckle an immature

female. Unfortunately, the beluga calf died at 111 days of age, which compromised the results. The nursing behaviors of two beluga calves were also documented for the first 55 days of life, with a focus on the length and frequency of nursing (Russell et al. 1997). They used the operational definitions for 'lockon', which refers to the calf suckling from the mammary gland, and 'bouts', which is a group of one or more lockons during a five minute interval (Drinnan and Sadleir 1981). Russell et al. (1997) found that the patterns were similar between the two calves even though they occurred at different frequencies. The general patterns indicated that by 7-10 days of life, nursing frequency peaked and was followed by a decline. They also found that nursing was predictable; shorter nursing sessions were usually followed by longer sessions. Nursing studies like these are necessary for insuring the longevity of life for calves in the care of humans.

One extensive study of beluga behavior was performed at the Vancouver Aquarium where there is an interactive beluga exhibit of virtual 'wild' belugas using a realistic three-dimensional simulation system (DiPaola et al. 2007). The exhibit allowed visitors to alter the behavior of the belugas by changing the contextual information of environment. The purpose of the 3D simulation was to engage the visitors by giving them a more in-depth perspective of wild beluga behavior and to highlight their current advances in beluga behavior research. To create the simulation, a multi-layered model was created to achieve an entire pod's reaction to a variety of situations. The model simulates the initial action of every individual down to the position of each fluke and continues for several behaviors following the change in context (DiPaola et al. 2007).

This complex project incorporated a list of behaviors and an ethogram which at the time was the most comprehensive collection of behaviors, but not completely encompassing. Some examples of categories used in this ethogram included Adult-Calf, Affiliative, Play, Neutral, and Courting/Mating.

The study that was extensively used to help develop the mother-calf relation aspects of the comprehensive ethogram was conducted on two beluga mother calf pairs in the care of humans in Sea World San Antonio. Hill (2009) observed the behavioral relationship between the mother and calf for the first year of life for the calves. The ethogram used in this study provided additional information to develop the comprehensive ethogram. For example, some of the definitions used were the mother-calf swims, leaves, returns, and discipline. Frequency calculations of mother-calf swims, leaves and returns, solo swim and social activities were also conducted. The frequencies of these behaviors are similar to the trends of other cetacean species. The mother-calf swim was the primary activity throughout the calves entire first year but decreases as the calf became older. Also, the amount of solo swims and social activity increased as the calves became older. The separations and reunions of mother-calf swims were mostly conducted by the calves. The frequency of behavior trends conducted by Hill (2009) was useful when the examination of behavior frequencies was determined for the video aspect of the ethogram.

Purpose

The purpose of this project was to compose a comprehensive ethogram of beluga behavior and create an educational DVD of beluga behavior. Little is known about beluga behavior in the wild and in the care of humans, and this is a needed resource because of a lack of a comprehensive ethogram on beluga behavior in the literature. A comprehensive ethogram would facilitate several goals. First, a list of behaviors with a video representation allows researchers to be trained faster and more consistently while also creating a record of documented beluga behavior. Second, the ethogram could be used as an education tool for the public by displaying it at aquariums to raise awareness by engaging the public in cetacean behavior.

CHAPTER III

METHODS

Subjects and Facility

The facility for this study was Sea World San Antonio, Texas. The White Whale and Dolphin stadium that houses the belugas has seven connecting pools A, B1, B2, C, D1, D2 and medical (Figure 1). The stadium houses eight pacific white-sided dolphins (*Lagenorhynchus obliquidens*) in addition to the belugas. This study included 11 belugas over the two and half year period. Four mother-calf pairs, MAR and GRA (Male), TIN and OLI (Male), SIK and QIN (Female), CRI and BEL (Female), three adult females, LUN, WHI, and NAT were recorded throughout the study.

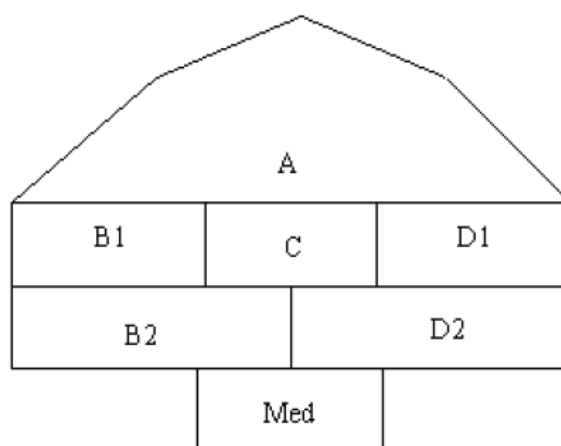


Figure 1. White Whale and Dolphin stadium (not drawn to scale). Pool A is about 38.1m by 15.2m with an average depth of 7.6m. Pools B-D are about 4.9m deep and the med pool is about 2.1m deep. All the pools are connected by gates.

Materials

The materials for this study included a Sony Handycam hand-held video recorder for behavior documentation. Video editing software program (Windows Movie Maker) was used to edit and compile the video clips into an ethogram video. Also, a DVD formatting program (Windows Creator Premier) was used to create the DVD of the ethogram videos.

Procedure

Each animal was video recorded for 15 minutes two to three times a week. All video sessions were conducted when the animals were not involved in interactions with trainers, educational groups, or other people. The goal was to capture spontaneous, natural behavior, which was free from human influences. A focal animal or pair was followed for each session. However, other animals were also housed with the focal animals. Their actions were only recorded during interactions involving the focal pair. The recorder narrated the video while recording to help identify the current context when the video recording is watched. All video recordings were conducted from a vantage point above water except when the animals were in pool A. The walls in pool A are transparent allowing for the video recordings to have the vantage point of below water through the walls. Research trips to San Antonio were made once a month and lasted several days. Two to three trips to Sea World were made for data collection each trip. Volunteers in San Antonio helped collect data during the week and weeks between trips.

This data collection process created an archival data set of videos of the mother calf-pairs at the facility.

All videos were converted into DVD format for analysis and were reviewed in full to find the best representation of each behavior. As the videos were reviewed, the length of each video, the animal in each clip, and the video from which the example originated, was documented. An ethogram video was compiled using the five best examples of each behavior. A good example is defined by a clear visual of the animals, good water clarity, little object obstruction, and the performance of the behavior was in different contexts. A voiceover commentary explains the behavior and possible context for each behavior set. All video clips and voiceover commentary were compiled on a DVD and organized by the following categories: Social, Displays and Communication, Object Play, Mother-Calf Relations, and Monitor Environment.

CHAPTER IV

RESULTS

Video Ethogram

The comprehensive ethogram is organized by five major categories: Social, Displays and Communication, Object Play, Mother-Calf Relations, and Monitor Environment. The categories are further organized into sections and behaviors. There are a total of 17 sections and 81 behaviors. For example, the Social category includes the section Swims, which includes the behavior Solo swim. Appendix A lists each behavior and the operational definitions used in the comprehensive ethogram.

A total of 103 videos were reviewed, which represented 24 hours 49 minutes of video data. Each video was examined for the five best examples of each behavior of interest. Some behaviors had many possible options, so five examples were selected to display a variety of contexts in which the behavior was observed. Examples were selected for their representation of the behavior with consideration for context, age of animal, angle of recording, and behavioral topography. For the 25 behaviors in which five examples could not be located, the number of samples varied depending on the total number of clips demonstrating that behavior. A screen presenting the operational definition of the upcoming behavior precedes each set of samples. A voice commentary explaining the behavior is provided for each example. For clips with multiple animals present, a picture of the behavior precedes the clip to facilitate understanding of the behavior and to establish the context.

The DVD is constructed so that the video may be viewed in its entirety, in categories, or in sections of categories. The main menu has the following options: Play All, Category Selection and Practice. Play All plays all the categories consecutively. Category Selection leads to a sub menu which lists all five categories. Selecting one of the categories leads to another sub menu with a Play Category, which plays the entire category, and a list of all the sections in the category to watch individually. For example, in the category for Social Behaviors, the sub menu has the option of playing the Swims, Affiliative, Aggressive, Submission, and Courting/Mating sections. Practice leads to a sub menu with six short videos, five minutes in length, which trainees will practice. Three of the six videos consist of video recordings paired with a voice-over commentary regarding the progression of behaviors within each video. The other three videos simply play the behaviors so the trainees may practice documenting the behaviors as they occur. Also, the practice videos provide examples of how behaviors may follow one another and create a series of behaviors.

Table Explanations

An index of summary information for each of the behavioral categories of Social, Displays and Communication, Object Play, Mother-Calf Relations and Monitor Environment is listed in Tables 1 through 5, respectively. Each table includes the time length of each operational definition, the animal or animals in each clip, a description of each clip, the time length of each clip, and the video from which the clip originated. A summary of the total number of behaviors represented, the number of clips, the time

length, and the number of videos reviewed may be found at the end of each table. The full running length of the video ethogram is 1 hour 5 minutes 2.03 seconds. The running length for behavior categories is as follows: Social-21 minutes 50.07 seconds, Displays and Communication-11 minutes 35.24 seconds, Object Play-10 minutes 6.15 seconds, Mother-Calf Relations-17 minutes 37.50 seconds, and Monitor Environment-3 minutes 53.07 seconds.

Table 6 summarizes the level of effort necessary to produce the current training video. It includes the number of behaviors, the number of desired example clips, the number of acquired example clips, and the percent of success in each category. The number of desired clips was determined by multiplying the number of behaviors by five, the standard number. The percent of success was determined by dividing the number of acquired clips by the number of desired clips. At the bottom of the table are the totals for the entire video. In summary, the video contains the operational definitions for 81 behaviors and presents 268 behavior example clips, or 66.17% of the desired number of clips for the video which was 405 examples.

Each behavior was grouped based on how many example clips were obtained for the video. Frequency groups were created ranging from five to zero clips. For example, for every behavior that had five clips, these clips were grouped together. Behaviors with three or more clips were considered frequent and the behaviors with two or less clips were considered rare. The behaviors in each group are displayed in Table 7, along with

the category, section, and the behavior total out of the section total. Table 7 shows each individual behavior as frequent or rare. Due to the fact that some behaviors were rarely seen, example clips could not be obtained and the video ethogram is not fully comprehensive. For example, the mating behavior section was not included due to a lack of video representation. Also, Table 7 compares the individual behaviors to others in the same category section. For example, in the category Social, section Swims, the Solo Swim is a frequent behavior and there are four other behaviors in that section out of six that are in that frequency group of five example clips. However, in the category Social, section Aggressive, the Open Mouth Threat is a frequent behavior but it is the only behavior in that section in that frequency group of five example clips.

The information displayed in Table 8 consists of the total behaviors in each frequency group, the totals of frequent and rare behaviors and the percent of each. The percent of each group was determined by dividing the number of behaviors in the group by the total number of behaviors in the ethogram. The results showed that 81.48% of the behaviors had at least one example clip. Also, the results showed that 64.20% of the behaviors occurred frequently and 35.80% of the behaviors were rare occurrences. The information displayed in Table 9 consists of the sections totals grouped into frequent or rare. It includes the category, section, the total number of behaviors out of the section totals in each group, and the percent of each group. The frequency of the section was determined by if the majority of the behaviors in the section had three or more behaviors clips. The percent was determined by dividing the total number of frequent or rare

sections by the total number of sections. The results showed that 82.35% of the sections were frequent and 17.65% of the sections were rare.

CHAPTER V

CONCLUSION

Introduction

The purpose of this project was to compose a comprehensive ethogram and create an educational DVD of beluga behavior. To date, specific aspects of beluga behavior have been examined previously, including mother-calf swimming positions and calf development. In addition, another study created a simple ethogram to develop a virtual simulation program of belugas interacting with one another in a natural environment. However, a comprehensive ethogram for belugas is lacking in the current literature and this project attempts to improve upon this deficiency. The educational DVD of beluga behavior serves two purposes: to train researchers and educate the public. First, having a list of behaviors with a video representation improves efficiency and consistency in training researchers. The video allows researchers to have access to a source with all the behavioral definitions and visual examples. The video also creates a record of documented beluga behavior. Second, aquariums can create educational displays for the public using the ethogram. The display will hopefully raise awareness by engaging the public in cetacean behavior.

Training Research Observers

Currently observers are trained by watching past videos or shadowing a senior observer at the facility. This training method leads to several opportunities for inconsistency. For example, most trainees will not observe the full range of behaviors during their training.

Also, the frequent behaviors can be executed in multiple ways and possibilities may be missed during training. Training observers with the video provides examples of the rare behaviors and a spectrum of different types of the frequent behaviors. The example clips vary in animals performing the behavior, point of observation and variation in execution of the behavior. The future trainee will be able to see multiple examples of the behaviors and in different contexts, resulting in a better understanding of beluga behavior. The rare behaviors that were captured are valuable learning examples because a trainee could potentially never have seen them during their training. A few visual examples of a rare behavior can be very beneficial in being able to recognize the behavior while in the field. For example, the head jerk and head thrust are both rare behaviors. Only two example clips were located for each behavior. However, these four clips allow a trainee an opportunity to distinguish between the two behaviors. In addition to the inconsistency of behaviors possibly observed; the time needed for training is also a limitation.

Currently the time invested in training is extensive, lasting several months resulting in multiple research trips to the facility to spend hours watching the animals. The video displays the behaviors in concise organized manner. Furthermore, the video is set up so the trainee can watch the video in its entirety, in individual chapters or sections of the chapters. This set up allows someone to become familiar with all the behaviors or focus on certain behaviors they may be confused about. The video has condensed 24 hours 49 minutes of video data into 1 hour and 5 minutes. Another added benefit is that the video

contains several practice videos which allows the trainee to practice and be corrected if mistakes occur. It is expected that this video will lead to a more efficient and timely training of observers without multiple research trips.

Process of Creating Video

The processes of creating the video started with reviewing 24 hours 49 minutes of archival video data of mother-calf focal pair recordings. The archival data was composed of four mother-calf pairs at the facility. The other three adult females at the facility were only filmed when they interacted with the focal pair. Not filming the other adults limited the possibility of gathering example clips that were not associated with mother-calf pairs. For example, the aggression and submission sections were limited. The social grouping or lack of grouping of the animals presented a challenge for gathering clips of all the behaviors. Video recordings conducted while the mother and calf were in a pool by themselves also limited range of possible behaviors. If the mother and calf are by themselves the social context is restricted and behaviors requiring social interaction with other animals were not possible. The limitation presented challenge. However, many of the future observers trained with this video will be focusing on mother-calf pairs.

The next step was to gather five good examples of each behavior and pair them with voice commentary describing the clip. Good clips had a clear view of the animals, good water clarity, little object obstruction, and the performance of the behavior in different

contexts. Working within the confines of the facility presented some limitations for gathering good examples. The facility area was occasionally not optimal for video recording due to poor lighting conditions and opaque glass. All video recordings were conducted from a vantage point above water except when the animals were in pool A. If lighting was poor with the above water vantage point, the video recordings did not capture behaviors that occurred towards the bottom of the pool. The walls in pool A are transparent allowing for the video recordings to have the vantage point of below water through the walls. However, condensation occasionally turned the glass opaque, resulting in diminished video quality. The unfavorable conditions made collecting good visual examples challenging. Behaviors may have been captured on video but were unusable due to poor visibility. The voice over commentary paired with each clip assisted in clarifying the behavior when visualization was less than optimal. The video recordings were conducted around the schedule of the facility staff performing their required duties. This schedule limited the amount of time available to collect video recordings. Working with the limitations of poor visibility and time constraints was an obstacle. However, a sufficient number of quality clips were gathered and compiled to produce the video ethogram.

The clips were then organized into the same categories and sections as the comprehensive ethogram. To assist in the visual organization of the behaviors, a screen with the category and section names begins each section. The next screen displayed shows the operational definition and a picture of the behavior to precede each set of

behavioral examples clips. Where an example clip of a behavior could not be found, the operational definition screen was still displayed to keep the ethogram comprehensive. To be fully comprehensive all the behaviors are included. Behaviors were considered rare when example clips could not be gathered.

Due to the nature of rare behaviors, they were difficult to capture on video and compile five examples. One behavior section not included in the video was mating because of the rarity of the behavior being observed and the facility lacked adult males. When an adult male was present at the facility, only the behavior of swimming together, which is associated with mating, was observed and unfortunately never captured on video. The limited social grouping combinations in which mating could arise resulted in no mating behavior examples for the video ethogram. Despite the fact that video recordings focused on mother-calf pairs, no discipline between mother and calf was observed enforcing the rarity of the behavior. For most of the rare behaviors only a few examples were captured. Thus, the goal of five clips was not obtained. Examples of behaviors in which a few clips were found included head thrust, bow and bubble play. For these rare behaviors, all examples captured on video were used to provide the maximum number of clips. The video ethogram is not fully comprehensive because the absence of several rare behaviors.

The limitations of the project, constraints with the facility, poor visibility and infrequent behaviors resulted in the video portion of the ethogram not being fully comprehensive.

The written portion of the fully comprehensive ethogram was included for the missing behaviors to provide explanations. The explanations are still educational because it will familiarize one with the behavior. The knowledge will increase the reorganization of the behavior in the field. Also, since the majority of the behaviors are included in the video, an observer may be able to identify a rare behavior using a process of elimination. The video has created a single resource that contains a comprehensive ethogram and visual examples. The fragmented ethograms published in several sources created a challenge in understanding the full range of behaviors. This project was designed to correct the problem of fragmented ethograms and provide visual examples. The last step of the project was to publish the video in a DVD format to insure highest compatibility to be viewed.

Future Research

This project created a comprehensive compilation of beluga behavior. Potentially, the basic documentation of behavior could be the base line for future research. Research on individual behaviors could be conducted on their frequencies or contextual information. Also, the video ethogram has several aspects that could be expanded upon. Rare behaviors can always be added to the video. Adding acoustical data and synchronizing the sounds with the behaviors would be an important addition. A follow up to this project would include a study comparing the two methods of training observers: 1) with the video and 2) without the video. The data from this research study would help support the usefulness of this project for training observers.

The current project is not limited to the behaviors of the belugas at Sea World San Antonio. The base line of behaviors observed is adaptable to belugas at other facilities. Facility specific behaviors should be added. For example, the S-posturing behavior research found with the belugas at the Sea World San Diego was not observed at Sea World San Antonio. The addition of the S-posturing behavior to the video could be important for the Sea World San Diego facility. Also, the project may be useful for studies with other species too. Literature searches have shown that many behaviors between cetacean species are similar.

Public Outreach

This project is not restricted to educating cetacean researchers, as it could also be beneficial to the public. Like the virtual simulation program of belugas displayed at the Vancouver Aquarium, this project could be displayed for the public to view and explore. The video could be an addition to the education programs of the facilities. An interactive station could be established in a public area where the visitors could view the ethogram. The station would require equipment to play the DVD and a way for the visitors to make their selections. The visitor could then watch the video, select specific behaviors sections that might interest them and even practice what they have learned. The operational definitions and voiceover commentary were designed to be simple. The wording and the phrasing in the definitions are basic enough for the public to

understand. Previous knowledge of cetacean behavior is not a requirement to benefit from the video.

Viewing the video ethogram could engage the public and increase awareness of beluga researchers. Public awareness could lead to higher levels of conservation and more people conducting research in the next generation. The video can be used by any facility with belugas to expand public outreach. Facilities that choose to incorporate this video into their education program should ensure the behaviors are consistent with the belugas at that facility. Since some behaviors can be unique to certain facilities, facilities would add behaviors or remove behaviors as needed.

Summary

A comprehensive ethogram on belugas was composed and a video ethogram was created. The video ethogram has condensed 24 hours 49:21 minutes of video data, or 103 videos, into 1 hour 5 minutes 2.03 seconds of behavior example clips. The behaviors were organized into the categories of: Social, Displays and Communication, Object Play, Mother-Calf Relations and Monitor Environment. Due to some behaviors being rare, not every behavior has a video example and future research could be conducted to add those behaviors. This project has created one source with a comprehensive ethogram and visual examples. The DVD is adaptable to other facilities with belugas and even to other cetacean species. It is the hope of this researcher that this project will be utilized and help lead to future research.

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APPENDIX A

COMPREHENSIVE ETHOGRAM

1. Social
 - a. Swims
 - i. Solo swim – An animal swims independently of other available animals
 - ii. Floating – An animal remains motionless in one location, usually at the surface, or drifts very slowly across the water for 3 or more sec
 - iii. Parallel Floating – Two or more animals floating or drifting slowly and positioned parallel to one another, within 3 meters
 - iv. Swim with other – animals swim in synchronization, within 3 meters of one another, matching their speed and direction and maintaining their relative position, for at least one lap (in captivity)
 - v. Speed swim – an animal or a group of animals swim very rapidly in circles with vigorous movement of the tails. This swimming is visibly faster than normal, so the animal's skin looks wrinkled due to the friction with the water.
 - vi. Ventral Swim – An animal swims with its belly side toward the surface and its dorsal side towards the bottom
 - b. Affiliative
 - i. Rub – An extended form of contact in which one animal rubs part of its body against the other. (e.g., the animal approaches the recipient, and contacts most of the length of its body against the back or side of the recipient)
 - ii. Nuzzle – Contact in which an animal slowly and gently brings its head into contact with another animal's body
 - iii. Join – One animal leaves its current action and moves within 1m of another animal and either mimics the recipient's actions or engages in play
 - c. Aggressive
 - i. Chase – The actor swims rapidly behind another animal, who subsequently swims away at a rapid pace with the actor following. The recipient of the action does not reciprocate a chase action. Often, an aggressive chase is related to defense of a particular spatial area, calf, or object.
 - ii. Jaw Clap – The actor, while facing another animal, rapidly opens and then closes its mouth, producing a sharp sound which resembles a gunshot. Sometimes the jaw clap is mutual. Can be produced in rapid series.

- iii. Head thrust – The actor, while facing another animal, moves its body quickly in the vertical plane, producing either an up and down or a down and up motion. Can be produced in rapid series.
 - iv. Head jerk – The actor, while facing away from another animal, moves its head quickly in a lateral direction towards the threatening animal or recipient
 - v. Open mouth threat – The actor, while facing another animal, rapidly opens its mouth fully and holds it open for at least 1 second. Mutual open mouth threats do occur.
 - vi. Directed look – The actor swings its head laterally to point the rostrum at the recipient. This behavior often involves a rapid reorientation of the actor's whole body towards the recipient.
 - vii. Melon extension – The actor, while facing the recipient, markedly changes the shape of its melon, forming it into a ball and pushing it forward
 - viii. Hit – Contact in which the actor rapidly and forcefully strikes (with tail, side body or rostrum) the recipient's body
 - ix. Bite – A particular type of contact in which the actor opens its mouth fully and closes its mouth on the recipient, often leaving indentations or marks
 - x. Bite threat – The actor opens its mouth fully while facing the recipient and moves its head quickly towards the recipient but without making contact
 - xi. Charge – The actor swims at full speed directly at the recipient, traveling at least 3 meters, but no contact is made.
 - xii. Raking – One or more animal scrape the length of the recipient's body with their teeth
 - xiii. S-posture – The actor positions its body with the neck flexed downward, pectoral fins extend upward, peduncle arching forward and the flukes flexed outward. This behavior is often associated with aggressive or threatening behavior.
- d. Submission
- i. Flinch – An animal rapidly lowers its head and moves its whole body to face away from an aggressor animal
 - ii. Flee – The recipient of an aggressive act rapidly swims away from the aggressor
 - iii. Look away – An animal turns its head to look away from another
 - iv. Avoid – An animal moves the whole or part of its body to avoid upcoming contact with another animal
- e. Courting/Mating
- i. Presenting- An animal turns on its side and presents its ventral side to another animal. It may be reciprocal. Often accompanied by bubble streams from the blowhole.

- ii. Coupling- this may follow after presenting. The two animals rub their ventral sides together for a few seconds.
 - iii. Posturing- similar to presenting, but not directed at any particular individual. Often accompanied by up-down movements of the head, bubbling, and graded vocalizations
 - iv. Swim together- when two animals swim closely together, but not necessarily in synchrony, in between presenting and/or coupling bouts.
 - v. Intromission- genital contact in which an erect penis is inserted into the genital slit of the female
2. Displays and Communications
- a. Aerial
 - i. Breach – An animal completely clears the water with the majority of or the entire body and forcefully returns to the water with a large splash
 - ii. Chin slap – An animal clears its upper body from the water and forcefully slaps the water with its chin upon return to the water
 - iii. Chest slap – An animal clears its upper body from the water and forcefully slaps the water with its chest upon return to the water
 - iv. Side slap - An animal clears its upper body from the water and forcefully slaps the water with its side upon return to the water
 - v. Bow – An animal clears the water with the majority of or entire body and returns to the water with a head first entry and little water displacement
 - b. Water
 - i. Head stand – An animal becomes vertical with its head oriented to the bottom and stays for at least a few seconds, fluke can be above water but rest of the body is under water, animal bobs up and down
 - ii. Fluke stand – An animal becomes vertical with its fluke oriented to the bottom and stays for at least a few seconds, animal usually completely under water, animal bobs up and down
 - iii. Bubble streams – a line of small to medium sized bubbles, often produced with whistles, but not necessarily
 - iv. Bubble burst - a very large exhalation by the blowhole, underwater, producing a pocket of air that expands as it moves to the surface
 - v. Water fountain – a large exhalation by the blowhole at the water surface producing a rapid succession of splashes
 - c. Vocalization – Any sound produced
 - i. Whistles – up sweeps, down sweeps, loops, single tones/frequencies
 - ii. Chirps – short, pure-tone, with a possible short, sharp upsweep
 - iii. Clicks – rapid bursts of short broad band sounds

- iv. Squeaks/squeals – long, narrow-band sounds
 - v. Squawks – short, loud, discordant sounds (e.g., Luna)
3. Object play
- a. Water
 - i. Water spit – An animal ejects water up into the air by the mouth
 - ii. Water toss – An animal moves its head in an upward direction which displaces a mouthful of water. The animal may try to catch the water again as it returns to the surface.
 - iii. Bubbleplay – An animal blows bubbles and chases after them. Bubbles may be round or donut-shaped
 - b. Holds
 - i. Rostrum hold – An animal traps an object in place with its rostrum
 - ii. Fluke Hold – An animal traps an object in place with its fluke
 - iii. Chest Hold – An animal traps an object under water with its chest
 - c. Push
 - i. Rostrum Push – An animal actively displaces an object with its rostrum
 - ii. Fluke push/Hit – An animal actively displaces an object with its flukes
 - d. Rub
 - i. Wall rub – An animal rubs its body along the wall
 - ii. Object rub – An animal rubs its body along an object
 - e. Carry
 - i. Rostrum Carry – an animal travels with an object resting on its head
 - ii. Fluke Carry – an animal travels with an object resting on its fluke
 - iii. Pectoral Carry - an animal travels with an object resting on its pectoral fins
 - iv. Body Carry - an animal travels with an object resting on some part of its body
4. Mother-calf Relations
- a. Swims
 - i. Echelon swim – Calf swims parallel to the adult, positioned near the dorsal ridge region and slightly staggered, and maintains its relative position to adult for at least 3 seconds. There is often contact, with the calf touching the adult's flank.
 - ii. Infant swim – Calf swims directly below an adult, positioned near the mammary slits or genital slit. This swim is usually accompanied by bumping or nuzzling.
 - iii. Follow swim – Calf/Adult swims directly behind the adult/calf, maintaining relative position for at least 3 seconds. The actions of the following animal are dictated by the lead animal.

- iv. Swims in front – Calf swims in front of adult, maintaining relative position for at least 3 seconds.
 - v. Side by side swim – Calf swims to the side of the adult, maintaining relative position for at least 3 seconds.
 - vi. Piggiback swim – A particular form of echelon swim in which the calf swims directly above and often slightly behind the adult, with its head right above the adult's dorsal mid-line or on dorsal ridge
 - vii. Allocare – Care of calf that is performed by an adult other than the mother
- b. Leaves and Returns
- i. Leave – Adult or calf initiates a separation from the other participant and pursues its own action
 - ii. Return – Adult or calf initiates a reunion with the other and synchronizes action
 - 1. Return initially - left but return again within 3 seconds
 - 2. Return delayed – left and did not return again until after 3 seconds or more
- c. Contact
- i. Brief contact – Adult-calf contact for 3 seconds or less
 - ii. Sustained contact – Adult-calf contact for more than 3 seconds
- d. Bumping – Calf swims under adult, repeatedly raising and lowering its head, contacting mammary region
- e. Nursing – The calf takes a teat in its mouth, and holds on. There is a reduction of swimming movements by the mother and distinctive rapid short tail motions by the calf, maintaining relative position to the mother.
- f. Herd calf – Adult maneuvers the calf away from its current activity and directs the calf to a new activity, usually swimming together. This action usually involves contact initiated by the adult.
- g. Intervene – Adult will prevent the calf from entering an activity or association with another animal or will end a current activity or association. The adult will maneuver herself between the calf and the activity, which disrupts the calf's actions. It may result in a pair swim.
- h. Discipline – Adult will do an aggressive behavior toward the calf in response to the calf's ongoing actions. Discipline includes all of the aggressive behaviors seen between non-mother-calf animals and can include holding the calf at the bottom of the pool and preventing it from surfacing.
5. Monitor environment
- a. Orients – An animal looks at environment, head turns or eye turns to different area of its environment
 - i. At Animal – An animal orients at another animal
 - ii. At Environment – An animal orients around at its environment, above water or under water
 - iii. At people – An animal orients at a trainer or person around

- iv. Spy hop – An animal becomes vertical with its head above water, while bobbing up and down and orienting at its environment, people, or other animals.

APPENDIX B

TABLES

Table 1
Video Index for Social Category

Category	Behavior	Animal	Clip Description	Video Number
Social Swims	Solo Swim 7.60 seconds	QIN	QIN solo swim 11.33 seconds	M2U00041
		GRA	GRA solo swim 10.53 seconds	M2U00049
		GRA	GRA solo swim 11.03 seconds	M2U00053
		QIN	QIN solo swim 10.00 seconds	M2U00074
		GRA	GRA solo swim 10.00 seconds	M2U00067
		GRA	GRA floating/gliding 9.61 seconds	M2U00042
	Floating 13.23 seconds	TIN	TIN floating 10.30 seconds	M2U00046
		WHI	WHI floating at the gate 7.83 seconds	M2U00173
		GRA	GRA floating/gliding 11.53 seconds	M2U00042
		OLI	OLI floating at the fence 10.73 seconds	M2U00022
		TIN, OLI	TIN and OLI parallel floating 10.86 seconds	M2U00072
		OLI, GRA	OLI and GRA parallel floating at the gate 10.18 seconds	VTS_01_1(2)
		OLI, GRA	OLI and GRA parallel floating in the water column by the gate 9.81 seconds	VTS_01_1(1)
		OLI, GRA	OLI and GRA parallel floating at the fence 10.63 seconds	VTS_02_1

Table 1 (continued)

Category	Behavior	Animal	Clip Description	Video Number
		TIN, OLI	TIN and OLI parallel floating 9.79 seconds	M2U00072
	Swim with other 15.50 seconds	TIN, OLI, LUN	TIN and OLI swim with LUN 34.60 seconds	M2U00054
		GRA, OLI	GRA and OLI swim together 10.50 seconds	VTS_01_1(1)
		TIN, OLI, GRA	TIN and OLI swim with GRA 36.40 seconds	M2U00054
	Speed swim 17.00 seconds	MAR, GRA	MRA and GRA speed swim together 13.50 seconds	M2U00051
		LUN, QIN	LUN and QIN speed swim together 12.33 seconds	M2U00087
		MAR, GRA	MRA and GRA speed swim together 22.09 seconds	M2U00049
		OLI, GRA	OLI and GRA speed swim/chase each other 10.36 seconds	M2U00039
	Ventral Swim 9.71 seconds	SIK	SIK ventral swim 7.37 seconds	M2U00076
		MAR, GRA	MAR and GRA ventral swim 10.13 seconds	M2U00091
		SIK	SIK ventral swim 11.00 seconds	M2U00082
		SIK	SIK ventral swim 8.83 seconds	M2U00082
		SIK	SIK ventral swim 6.73 seconds	M2U00082
Affiliative	Rub 16.80 seconds	WHI, WHIc	WHIc rubs WHI 10.57 seconds	M2U00043
		WHI, WHIc	WHIc rubs WHI 15.07 seconds	M2U00043
		QIN, LUN	QIN rubs LUN 12.73 seconds	M2U00090
		OLI, TIN	OLI rubs TIN 9.90 seconds	M2U00017

Table 1 (continued)

Category	Behavior	Animal	Clip Description	Video Number
		GRA, LUN	GRA rubs LUN 14.57 seconds	M2U00045
	Nuzzle 10.80 seconds	OLI, TIN	OLI nuzzles TIN 15.20 seconds	M2U00077
		OLI, TIN	OLI nuzzles TIN 10.30 seconds	M2U00077
	Join 12.70 seconds	QIN, WHI	QIN join WHI 12.27 seconds	M2U00041
		GRA, OLI	GRA join OLI 16.00 seconds	M2U00045
		OLI, LUN	OLI join LUN 9.63 seconds	M2U00050
		GRA, WHI	GRA join WHI 18.87 seconds	M2U00058
		QIN, LUN	QIN join LUN 12.40 seconds	M2U00087
Aggressive	Chase 22.83 seconds	MAR, WHI	MRA chase WHI 12.57 seconds	M2U00053
	Jaw Clap 20.04 seconds		Videos not available.	
	Head Thrust 15.66 seconds	WHI, QIN	WHI head thrust to QIN 10.70 seconds	M2U00043
		GRA, QIN	GRA head thrust to QIN 6.93 seconds	121109-MG
	Head Jerk 11.00 seconds	WHI, QIN	WHI head jerk to QIN 7.70 seconds	M2U00043
		WHI, LUN	WHI head jerk to LUN 6.36 seconds	M2U00050
	Open Mouth Threat 15.20 seconds	WHI, QIN	WHI open mouth threat to QIN 8.00 seconds	M2U00043
		WHI, QIN	WHI open mouth threat to QIN 11.60 seconds	M2U00043
		WHI, GRA	WHI open mouth threat to GRA 10.96 seconds	M2U00058
		LUN, OLI	LUN open mouth threat to OLI 7.87 seconds	M2U00059

Table 1 (continued)

Category	Behavior	Animal	Clip Description	Video Number
		LUN	LUN open mouth threat 10.10 seconds	M2U00090
	Directed Look 15.30 seconds	LUN, GRA	LUN directed look at GRA 12.27 seconds	M2U00045
		LUN, OLI	LUN directed look at OLI 9.60 seconds	M2U00137
	Melon Extension 13.57 seconds		Videos not available.	
	Hit 11.90 seconds	MAR, WHI	MRA hitting WHI with rostrum 10:60 seconds	M2U00067
	Bite 15.80 seconds		Videos not available.	
	Bite Threat 13.87 seconds		Videos not available.	
	Charge 12.17 seconds	MAR, WHI	MRA charge WHI 10.03 seconds	M2U00053
		MAR, WHI	MRA charge WHI 17.80 seconds	M2U00054
	Raking 9.73 seconds		Videos not available.	
	S-Posture 20.03 seconds		Videos not available.	
Submission	Flinch 11.17 seconds		Videos not available.	
	Flee 10.03 seconds	QIN, WHI	QIN flee from WHI 8.17 seconds	M2U00043
		WHI, MAR	WHI flee from MRA 14.27 seconds	M2U00053
		OLI, LUN	OLI flee from LUN 10.47 seconds	M2U00137
		WHI, MAR	WHI flee from MRA 11.53 seconds	M2U00053
		WHI, MAR	WHI flee from MRA 10.37 seconds	M2U00054
	Look Away 10.27 seconds	QIN, GRA	QIN looks away from GRA 6.93 seconds	121109-MG

Table 1 (continued)

Category	Behavior	Animal	Clip Description	Video Number
	Avoid 10.33 seconds	LUN, WHI	LUN avoid WHI 12.73 seconds	M2U00050
		OLI, LUN	OLI avoid LUN 8.77 seconds	M2U00059
Courting/ Mating	Presenting 14.30 seconds		Videos not available.	
	Coupling 11.67 seconds		Videos not available.	
	Posturing 16.33 seconds		Videos not available.	
	Swim Together 12.47 seconds		Videos not available.	
	Intromission 10.30 seconds		Videos not available.	
Category Totals	31 Behaviors	62 clips	21 minutes 50.07 seconds	30 Videos

Table 2
Video Index for Displays and Communication Category

Category	Behavior	Animal	Clip Description	Video Number	
Displays and Communication					
Aerial	Breach 11.00 seconds	OLI	OLI breach 10.63 seconds	M2U00065	
		OLI	OLI breach 8.70 seconds	M2U00073	
		OLI	OLI breach 9.16 seconds	M2U00065	
		BEL	BEL breach 6.87 seconds	121509-CB	
	Chin Slap 12.00 seconds	SIK	SIK chin slap 9.83 seconds	M2U00047	
		OLI	OLI chin slap 9.75 seconds	M2U00046	
		GRA	GRA chin slap 7.81 seconds	M2U00049	
		OLI	OLI chin slap 6.30 seconds	M2U00073	
		SIK	SIK chin slap 8.74 seconds	M2U00064	
		Chest Slap 10.10 seconds	OLI	OLI chest slap 10.47 seconds	M2U00065
			GRA	GRA chest slap 9.00 seconds	M2U00049
	LUN, GRA		LUN and GRA chest slap 9.60 seconds	M2U00045	
	LUN		LUN chest slap 7.76 seconds	M2U00048	
	GRA		GRA chest slap 10.63 seconds	M2U00045	
	Side Slap 12.63 seconds	LUN	LUN side slap 9.76 seconds	M2U00045	
		OLI	OLI side slap 7.02 seconds	M2U00073	
		QIN	QIN side slap 7.59 seconds	M2U00149	
		OLI	OLI side slap 6.37 seconds	M2U00048	

Table 2 (continued)

Category	Behavior	Animal	Clip Description	Video Number
		OLI	OLI side slap 6.95 seconds	M2U00048
	Bow 12.31 seconds	OLI	OLI bow 8.73 seconds	M2U00046
		OLI	OLI bow 6.37 seconds	M2U00039
Water	Head Stand 16.63 seconds	GRA	GRA head stand 9.37 seconds	M2U00049
		OLI	OLI head stand 10.27 seconds	M2U00043
		GRA	GRA head stand 6.37 seconds	M2U00049
	Fluke Stand 13.37 seconds	OLI	OLI fluke stand with hula 20.93 seconds	M2U00140
		OLI	OLI fluke stand with hula 20.97 seconds	M2U00140
		OLI	OLI fluke stand 9.03 seconds	M2U00076
		WHI	WHI fluke stand 13.63 seconds	M2U00041
	Bubble Stream 10.20 seconds	QIN	QIN bubble stream 6.23 seconds	M2U00043
		QIN	QIN bubble stream 7.00 seconds	M2U00061
		WHI	WHI bubble stream 7.50 seconds	M2U00043
		WHIc	WHIc bubble stream 7.67 seconds	M2U00043
		WHI	WHI bubble stream 6.23 seconds	M2U00043
	Bubble Burst 13.00 seconds	TIN	TIN bubble burst 6.00 seconds	M2U00077
		MAR	MAR bubble burst 5.00 seconds	M2U00066
		LUN	LUN bubble burst 5.43 seconds	M2U00046
		WHI	WHI bubble burst 5.60 seconds	M2U00043

Table 2 (continued)

Category	Behavior	Animal	Clip Description	Video Number
		WHI	WHI bubble burst 5.00 seconds	M2U00043
	Water Fountain 7.97 seconds	GRA	GRA water fountain 7.27 seconds	M2U00022
		CHR	CHR water fountain 5.83 seconds	121109-MG
		OLI	OLI water fountain 5.77 seconds	M2U00065
		WHI	WHI water fountain 5.73 seconds	M2U00063
		MAR	MRA water fountain series 14.90 seconds	M2U00071
Vocalization	Whistles 8.57 seconds	OLI	OLI whistles 4.30 seconds	M2U00089
	Chirps 8.39 seconds	WHI	WHI chirps 2.77 seconds	M2U00059
		TIN	TIN chirps 2.73 seconds	M2U00046
		LUN	LUN chirps 3.30 seconds	M2U00050
		WHI	WHI chirps 3.17 seconds	M2U00091
		LUN	LUN chirps 3.30 seconds	M2U00046
	Clicks 6.77 seconds	MAR	MRA clicks 4.30 seconds	M2U00173
		WHI, CHR	WHI and CHR clicks 6.17 seconds	M2U00173
		CHR	CHR clicks 4.50 seconds	M2U00091
		TIN	TIN clicks 4.08 seconds	M2U00059
		CHR	CHR clicks 3.15 seconds	M2U00046
	Squeaks/squeals 5.80 seconds	OLI	OLI squeaks/squeals 2.67 seconds	M2U00162
		TIN, OLI	TIN and OLI squeaks squeals 1.17 seconds	M2U00140

Table 2 (continued)

Category	Behavior	Animal	Clip Description	Video Number
		SIK	SIK squeak squeals 2.60 seconds	M2U00047
		LUN	LUN squeaks squeals 1.27 seconds	M2U00030
	Squawks 5.57 seconds	LUN	LUN squawks 2.93 seconds	M2U00059
		LUN	LUN squawks 3.27 seconds	M2U00069
		OLI	OLI squawks 9.00 seconds	M2U00140
		LUN	LUN squawks 3.16 seconds	M2U00147
		LUN, CHR	LUN and CHR squawks 5.77 seconds	M2U00147
Category Totals	15 Behaviors	63 Clips	11 minutes 35.24 seconds	32 Videos

Table 3
Video Index for Object Play Category

Category	Behavior	Animal	Clip Description	Video Number
Object Play	Water	Water Spit 5.94 seconds	SIK SIK water spit 5.53 seconds	M2U00041
			MAR MRA water spit 4.33 seconds	M2U00042
		SIK SIK water spit 4.27 seconds	M2U00057	
		OLI OLI water spit 5.37 seconds	M2U00172	
		OLI OLI water spit 3.37 seconds	M2U00048	
		Water Toss 12.06 seconds	SIK SIK water toss 8.63 seconds	M2U00064
	Holds	Bubble Play 10.00 seconds	SIK SIK water toss 7.55 seconds	M2U00064
			SIK SIK water toss 5.45 seconds	M2U00147
			SIK SIK water toss 7.53 seconds	M2U00147
		Rostrum Hold 6.07 seconds	SIK SIK water toss 7.30 seconds	M2U00147
			GRA GRA bubble play 11.27 seconds	VTS_01_1(1)- MG
			OLI OLI bubble play 9.22 seconds	3209 O
			OLI OLI rostrum hold strap 7.18 seconds	M2U00138
			MAR MRA rostrum hold buoy ball 6.93 seconds	M2U00058
			MAR MRA rostrum hold buoy ball 7.80 seconds	M2U00058
Fluke Hold 6.77 seconds	GRA GRA rostrum hold pot 10.26 seconds	121109-MG		
	MAR MRA fluke hold buoy ball 4.18 seconds	M2U00058		

Table 3 (continued)

Category	Behavior	Animal	Clip Description	Video Number
		TIN	TIN fluke hold buoy ball 6.25 seconds	M2U00022
		MAR	MRA fluke hold buoy ball 5.43 seconds	VTS_04_1-MG
		MAR	MRA fluke hold buoy ball 4.48 seconds	M2U00058
		CHR	CHR fluke hold buoy ball 5.32 seconds	M2U00028
	Chest Hold 7.03 seconds	OLI	OLI chest hold buoy ball 6.50 seconds	M2U00138
		OLI	OLI chest hold buoy ball 6.30 seconds	M2U00138
		TIN	TIN chest hold buoy ball 9.10 seconds	M2U00028
		OLI	OLI chest hold buoy ball 6.14 seconds	M2U00138
		OLI	OLI chest hold buoy ball 6.06 seconds	M2U00138
Push	Rostrum Push 7.00 seconds	OLI	OLI rostrum push buoy ball 8.08 seconds	M2U00138
		WHI	WHI rostrum push buoy ball 10.85 seconds	M2U00059
		QIN	QIN rostrum push buoy ball 8.64 seconds	M2U00137
		GRA	GRA rostrum push red ball 10.77 seconds	VTS_04_1-MG

Table 3 (continued)

Category	Behavior	Animal	Clip Description	Video Number
		OLI	OLI rostrum push buoy ball 15.60 seconds	M2U00138
	Fluke Push/Hit 6.83 seconds		Videos not available.	
Rub	Wall Rub 5.43 seconds	SIK	SIK dorsal side wall rub 8.57 seconds	M2U00047
		OLI	OLI side ledge rub 5.93 seconds	M2U00144
		MAR, GRA	MRA and GRA dorsal side wall rub 6.47 seconds	M2U00049
		OLI	OLI dorsal side wall rub 7.27 seconds	M2U00140
		QIN	QIN dorsal and ventral wall rub 6.42 seconds	M2U00047
	Object rub 5.92 seconds	QIN	QIN rubs strap 7.20 seconds	M2U00137
		LUN	LUN rubs strap 9.43 seconds	M2U00137
		TIN	TIN rubs buoy ball 4.30 seconds	M2U00028
		OLI	OLI rubs and surfs buoy ball 8.40 seconds	M2U00138
		GRA	GRA rubs pot 8.27 seconds	121109-MG
Carry	Rostrum Carry 6.30 seconds	OLI	OLI rostrum carry strap 6.23 seconds	M2U00137
		OLI	OLI rostrum carry strap 7.17 seconds	M2U00138
		OLI	OLI rostrum carry strap 11.20 seconds	M2U00137
		GRA	GRA rostrum carry pot 6.53 seconds	121109-MG
		TIN	TIN melon carry strap 10.30 seconds	M2U00017

Table 3 (continued)

Category	Behavior	Animal	Clip Description	Video Number
	Fluke Carry 6.90 seconds	OLI	OLI fluke carry strap 12.10 seconds	M2U00138
		MAR	MRA fluke carry strap 8.93 seconds	M2U00017
		OLI	OLI fluke carry strap 13.10 seconds	M2U00137
		LUN	LUN fluke carry strap 5.76 seconds	M2U00137
	Pectoral Carry 6.97 seconds	OLI	OLI pectoral carry strap 9.07 seconds	M2U00137
	Body Carry 8.00 seconds	OLI	OLI body carry strap 6.63 seconds	M2U00138
		GRA	GRA body carry pot 9.60 seconds	121109-MG
		LUN	LUN body carry strap 7.53 seconds	M2U00138
		GRA	GRA body carry pot 12.00 seconds	121109-MG
Category Totals	14 behaviors	55 clips	9 minutes 56.93 seconds	21 Videos

Table 4
Video Index for Mother-Calf Relations Category

Category	Behavior	Animal	Clip Description	Video Number
Mother-Calf Relations				
Swims	Echelon Swim 16.73 seconds	QIN, LUN	QIN echelon swim with LUN 8.90 seconds	M2U00087
		GRA, MAR	GRA echelon swim with MRA 8.23 seconds	M2U00017
		QIN, SIK	QIN echelon swim with SIK 7.87 seconds	M2U00061
		QIN, SIK	QIN echelon swim with SIK 10.77 seconds	M2U00068
	Infant Swim 14.03 seconds	GRA, MAR	GRA echelon swim with MRA 11.97 seconds	M2U00014
		QIN, SIK	QIN infant swim with SIK 7.93 seconds	M2U00044
		OLI, TIN	OLI infant swim with TIN 10.73 seconds	M2U00077
		GRA, MAR	GRA infant swim with MRA 12.73 seconds	M2U00045
		GRA, MAR	GRA infant swim with MRA 9.27 seconds	M2U00049
	Follow Swim 14.90 seconds	GRA, MAR	GRA infant swim with MRA 8.67 seconds	M2U00066
		MAR, GRA	MRA follows GRA 13.47 seconds	121109-MG
		TIN, OLI	TIN follows OLI 18.47 seconds	M2U00039
		SIK, QIN	SIK follows QIN 10.83 seconds	M2U00057

Table 4 (continued)

Category	Behavior	Animal	Clip Description	Video Number
		MAR, GRA	MRA follows GRA 19.50 seconds	M2U00058
		CHR, BEL	CHR follows BEL 20.16 seconds	121109-MG
	Swims in Front 8.94 seconds		Videos not available.	
	Side by Side Swim 8.80 seconds	SIK, QIN	SIK and QIN side by side swim 9.96 seconds	M2U00070
		TIN, OLI	TIN and OLI side by side swim 10.60 seconds	VTS_02_1- TO
		MAR, GRA	MRA and GRA side by side swim 10.43 seconds	M2U00080
		MAR, GRA	MRA and GRA side by side swim 18.03 seconds	M2U00080
		MAR, GRA	MRA and GRA side by side swim 14.87 seconds	M2U00071
	Piggiback swim 16.80 seconds	QIN, SIK	QIN piggiback swim with SIK 9.00 seconds	M2U00044
		OLI, TIN	OLI piggiback swim with TIN 16.96 seconds	M2U00054
		QIN, SIK	QIN piggiback swim with TIN 9.37 seconds	M2U00070
		GRA, MAR	GRA piggiback swim with MRA 14.67 seconds	M2U00026
		QIN, SIK	QIN piggiback swim with SIK 8.00 seconds	M2U00047
	Allocare 8.77 seconds	WHI, QIN	WHI performs allocare to QIN 17.43 seconds	M2U00041

Table 4 (continued)

Category	Behavior	Animal	Clip Description	Video Number
		LUN, QIN	LUN performs allocare to QIN 12.40 seconds	M2U00087
		LUN, QIN	LUN performs allocare to QIN 12.27 seconds	M2U00071
		LUN, QIN	LUN performs allocare to QIN 17.40 seconds	M2U00074
		LUN, QIN	LUN performs allocare to QIN 11.00 seconds	M2U00077
Leaves and Returns	Leave 13.00 seconds	GRA, MAR	GRA leaves MRA 9.53 seconds	M2U00053
		GRA, MAR	GRA leaves MRA 10.70 seconds	M2U00049
		OLI, TIN	OLI leaves TIN 10.30 seconds	M2U00050
		OLI, TIN	OLI leaves TIN 10.83 seconds	M2U00030
		WHIc, WHI	WHIc leaves WHI 11.37 seconds	M2U00043
	Returns 8.50 seconds Return initially 7.63 seconds	OLI, TIN	OLI return initially to TIN 10.33 seconds	M2U00077
		GRA, MAR	GRA return initially to MRA 14.07 seconds	M2U00026
		OLI, TIN	OLI return initially to TIN 10.93 seconds	M2U00148
		QIN, SIK	QIN returns delayed to SIK 10.27 seconds	M2U00044
		GRA, MAR	GRA returns delayed to MRA 11.00 seconds	M2U00049
	Return delayed 10.07 seconds			

Table 4 (continued)

Category	Behavior	Animal	Clip Description	Video Number	
		GRA, MAR	GRA returns delayed to MRA 11.03 seconds	M2U00049	
		QIN, SIK	QIN returns delayed to SIK 11.80 seconds	M2U00057	
		OLI, TIN	OLI returns delayed to TIN 11.40 seconds	M2U00063	
Contact	Brief Contact 9.73 seconds	WHIc, WHI	WHIc brief contact WHI 7.10 seconds	M2U00043	
		OLI, TIN	OLI brief contact TIN 9.67 seconds	M2U00148	
		QIN, SIK	QIN brief contact SIK 9.60 seconds	M2U00047	
			QIN, SIK	QIN brief contact SIK 7.30 seconds	M2U00057
			GRA, MAR	GRA brief contact MRA 10.37 seconds	M2U00026
	Sustained contact 6.60 seconds	OLI, TIN	OLI sustained contact with TIN 10.50 seconds	M2U00077	
		OLI, TIN	OLI sustained contact with TIN 11.97 seconds	M2U00054	
		QIN, SIK	QIN sustained contact with SIK 10.20 seconds	M2U00044	
		GRA, MAR	GRA sustained contact with MRA 11.97 seconds	M2U00053	
			QIN, SIK	QIN sustained contact with SIK 8.57 seconds	M2U00044
	Bumping 9.30 seconds	OLI, TIN	OLI bumping TIN 13.77 seconds	M2U00089	
		OLI, TIN	OLI bumping TIN 13.00 seconds	M2U00077	
		OLI, TIN	OLI bumping TIN 12.53 seconds	M2U00077	

Table 4 (continued)

Category	Behavior	Animal	Clip Description	Video Number
		QIN, LUN	QIN bumping LUN 15.79 seconds	M2U00077
		QIN, LUN	QIN bumping LUN 14.23 seconds	M2U00087
	Nursing 15.81 seconds	QIN, SIK	QIN nursing with SIK 11.47 seconds	M2U00041
		QIN, SIK	QIN nursing with SIK 12.05 seconds	M2U00160
		QIN, SIK	QIN nursing with SIK 10.90 seconds	M2U00044
		GRA, MAR	GRA nursing with MRA 10.23 seconds	VTS_01_1- MG
		QIN, SIK	QIN nursing with SIK 10.30 seconds	M2U00040
	Herd Calf 14.55 seconds	WHI, WHIc	WHI herd WHIc 12.00 seconds	M2U00033
		WHI, WHIc	WHI herd WHIc 12.50 seconds	M2U00033
		WHI, WHIc	WHI herd WHIc 12.50 seconds	M2U00033
	Intervene 22.23 seconds	TIN, OLI	TIN intervene OLI from playing with the strap 17.20 seconds	M2U00017
	Discipline 20.57 seconds		Videos not available.	
Category Totals	17 behaviors	67 clips	17 minutes 37.50 seconds	35 Videos

Table 5
Video Index for Monitor Environment Category

Category	Behavior	Animal	Clip Description	Video Number
Monitor Environment	Orients		Orients 7.27 seconds	
			Orients at animal 6.00 seconds	
		MAR, GRA, BEL	MRA orients at GRA and BEL 7.23 seconds	121109-MG
		QIN, OLI	QIN orients at OLI 9.07 seconds	M2U00137
		OLI, QIN	OLI and QIN orienting at each other through the fence 10.10 seconds	M2U00063
		GRA, TIN, OLI	GRA orients at TIN and OLI 6.37 seconds	M2U00054
		LUN, QIN	LUN orients at QIN 8.27 seconds	M2U00074
		GRA	GRA orients at environment 9.50 seconds	M2U00067
		OLI	OLI orients at environment 6.70 seconds	M2U00089
		LUN	LUN orients at environment 8.37 seconds	M2U00087
		TIN	TIN orients at environment 7.83 seconds	M2U00073
		MAR	MRA orients at environment 7.27 seconds	M2U00067
		Orients at people 8.33 seconds	OLI	OLI orients at people 9.33 seconds
	MAR	MRA orients at trainer 10.50 seconds	M2U00058	

Table 5 (continued)

Category	Behavior	Animal	Clip Description	Video Number
		OLI	OLI orients at people 10.07 seconds	M2U00079
		TIN, OLI	TIN and OLI orients at people 10.03 seconds	M2U00077
		MAR	MRA orients at people 7.27 seconds	M2U00045
	Spy Hop 11.30 seconds	OLI	OLI spy hop 12.13 seconds	M2U00079
		WHI	WHI spy hop 7.50 seconds	M2U00141
		SIK	SIK spy hop 11.99 seconds	M2U00064
		MAR	MRA spy hop 13.01 seconds	M2U00042
		OLI	OLI spy hop 9.70 seconds	M2U00059
Category Totals	4 behaviors	20 clips	3 minutes 53.07 seconds	18 videos

Table 6
Category Totals

Behavior Category	Number of Behaviors	Number of Desired Example Clips	Number of Acquired Example Clips	Percent of Success (Acquired/Desired)
Social	31	155	62	40%
Displays and Communication	15	75	63	84%
Object Play	14	70	55	78.57%
Mother-Calf Relations	17	85	67	78.82%
Monitor Environment	4	20	20	100%
Total	81	405	267	65.93%

Table 7
Behaviors Grouped by Frequencies

Number of examples for behaviors	Category of Behavior-Section	Behavior	Behavior total out of Section total
Five examples – Frequent	Social - Swims	Solo Swim	
		Floating Parallel Floating Ventral Swim	4 out of 6
		Social - Affiliative	Rub Join
	Social – Aggressive	Open Mouth	1 out of 13
	Social – Submission	Flee	1 out of 4
	Displays and Communication – Aerial	Chin Slap	
		Chest Slap Side Slap	3 out of 5
	Displays and Communication – Water	Bubble Stream	
		Bubble Burst Water Fountain	3 out of 5
	Displays and Communication - Vocalizations	Chirps	
		Clicks Squawks	3 out of 5
	Object Play – Water	Water Spit Water Toss	
		Object Play – Holds	Fluke Hold Chest Hold
	Object Play – Push	Rostrum Push	2 out of 3

Table 7 (continued)

Number of examples for behaviors	Category of Behavior-Section	Behavior	Behavior total out of Section total
	Object Play – Rub	Wall Rub Object Rub	1 out of 2
	Object Play – Carry	Rostrum Carry	2 out of 2
	Mother-Calf Relations – Swims	Echelon Swim Infant Swim Follow Swim Side by Side Swim Piggiback Swim Allocare	1 out of 4 6 out of 7
	Mother-Calf Relations – Leaves and Returns	Leave Return delayed	2 out of 3
	Mother-Calf Relations – Contact	Brief Contact Sustained Contact Bumping Nursing	4 out of 7
	Monitor Environment	Orients at Animal Orients at Environment Orients at People Spy Hop	4 out of 4
Four examples – Frequent	Social – Swims	Speed Swim	1 out of 6

Table 7 (continued)

Number of examples for behaviors	Category of Behavior-Section	Behavior	Behavior total out of Section total
	Displays and Communication – Aerial	Breach	1 out of 5
	Displays and Communication – Water	Fluke Stand	1 out of 5
	Displays and Communication – Vocalizations	Squeaks/Squeals	1 out of 5
	Object Play – Holds	Rostrum Hold	1 out of 3
	Object Play – Carry	Fluke Carry Body Carry	2 out of 4
Three examples – Frequent	Social – Swims	Swim with Other	1 out of 6
	Displays and Communication – Water	Head Stand	1 out of 5
	Mother-Calf Relations – Leaves and Returns	Return Initially	1 out of 3
	Mother-Calf Relations – Contact	Herd Calf	1 out of 7
Two examples – Rare	Social – Affiliative	Nuzzle	1 out of 3
	Social – Aggressive	Head Thrust Head Jerk Directed Look Charge	4 out of 13
	Social – Submission	Avoid	1 out of 4

Table 7 (continued)

Number of examples for behaviors	Category of Behavior-Section	Behavior	Behavior total out of Section total
One example –Rare	Displays and Communication – Aerial	Bow	1 out of 5
	Object Play – Water	Bubble Play	1 out of 3
	Social – Aggressive	Chase	2 out of 13
	Social – Submission	Hit	1 out of 4
	Displays and Communication – Vocalizations	Look Away	1 out of 4
	Whistles		1 out of 5
	Object Play – Carry	Pectoral Carry	1 out of 4
Zero examples –Rare	Mother-Calf Relations – Contact	Intervene	1 out of 7
	Social – Aggressive	Jaw Clap Melon Extension Bite Bite Threat Raking S-Posture	6 out of 13
	Social – Submission	Flinch	1 out of 4
	Social – Mating	Presenting Coupling Posturing Swim Together Intromission	5 out of 5
	Object Play – Push	Fluke Push Hit	1 out of 2
	Mother-Calf Relations – Swims	Swims in Front	1 out of 7

Table 7 (continued)

Number of examples for behaviors	Category of Behavior-Section	Behavior	Behavior total out of Section total
	Mother-Calf Relations – Contact	Discipline	1 out of 7

Table 8
Group Totals and Frequencies

Group	Total number of behavior in group	Total number of behaviors	Percentage
Five examples	41	81	50.62%
Four examples	7	81	8.64%
Three examples	4	81	4.94%
Two examples	8	81	9.88%
One example	6	81	7.41%
Total			81.48%
Zero example	15	81	18.52%
Frequent (3 or more examples)	52	81	64.20%
Rare (2 or less examples)	29	81	35.80%

Table 9
Sections Grouped by Frequency

	Behavior Category- Section	Behavior total out of Category- Section total	Percentage
Frequent (3 or more examples) - Majority of Behavior Category- Sections has 3 or more examples	Social – Swims	6 out of 6	82.35%
	Social – Affiliative	2 out of 3	
	Displays and Communication – Aerial	4 out of 5	
	Displays and Communication – Water	5 out of 5	
	Displays and Communication – Vocalizations	4 out of 5	
	Object Play – Water	2 out of 3	
	Object Play – Holds	3 out of 3	
	Object Play – Push	1 out of 2	
	Object Play – Rub	2 out of 2	
	Object Play – Carry	3 out of 4	
	Mother-Calf Relations – Swims	6 out of 7	
	Mother-Calf Relations – Leaves and Returns	3 out of 3	
	Mother-Calf Relations – Contact Monitor Environment	5 out of 7	
		4 out of 4	
	Rare (2 or less examples) - Majority of Behavior Category- Sections has 2 or less examples	Social – Aggressive	
Social – Submission		3 out of 4	
Social – Mating		5 out of 5	
Total	17		100%

VITA

Carolyn Ann Campbell received her Bachelor of Science degree in biology from Texas A&M University in 2008. She entered the Oceanography graduate program at Texas A&M University in August 2008 with a concentration in biological oceanography. Her research has focused on beluga (*Delphinapterus leucas*) behavior. She received her Master of Science in May 2011. Interests include all cetacean behavior and ecology.

Ms. Campbell has been a member of the Society for Marine Mammology since 2009 and was a co-author on a poster presentation at the 18th Biannual Conference for the society titled, “The Relationship Between Beluga (*Delphinapterus leucas*) Mothers and their Calves in Captivity during the First Year of Life.” She also gave a talk at the South Central Regional IMATA workshop, May 2010, titled “Comprehensive video ethogram on beluga (*Delphinapterus leucas*) behavior.”

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