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EXPLORING TEMPERAMENT IN BELUGA WHALE CALVES
(DELPHINAPTERUS LEUCAS)

by

Beri Brown

A Dissertation
Submitted to the Graduate School,
the College of Education and Human Sciences
and the School of Psychology
at The University of Southern Mississippi
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy

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December 2018

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2018

Published by the Graduate School



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ABSTRACT

Studies of personality and temperament in humans span many disciplines, although animal research is still relatively undeveloped. Research investigating stable individual differences in marine mammals has been limited, and to date there have not been any studies with beluga whales. As an ongoing longitudinal study, seven beluga calves, housed at SeaWorld San Antonio, were videotaped throughout their first two years of life. Four videos were selected from archived video recordings for each calf from the following nine phases: newborn phase (month 1), Q1 (month 2-3), Q2 (month 4-6), Q3 (month 7-9), Q4 (month 10-12), Q5 (month 13-15), Q6 (month 16-18), Q7 (month 19-21), Q8 (month 22-24). Videos were coded for 40 behaviors: three behavioral states, including durations, and 37 behaviors for frequency. These behaviors were later consolidated to 23 behaviors for analysis. A Principal Components Analysis (PCA) of these 23 behaviors across all seven whales yielded a five-factor model for beluga calf temperament. Factors included mother-calf bond, sociability, independence, exploration-vigilance, curiosity-playfulness. A PCA for year one and a PCA from year two were compared and did not yield the same five factors. A paired-samples t-test revealed that five of 26 behaviors were significantly different between year one and year two, and 21 behaviors were significantly different between the newborn phase and year one. While there was only one behavior, orient at researcher, that was not observed in the newborn phase, the calves' behavior was significantly different during their first month of life. The orient at researcher behavior was observed for the first time around quarter three in all seven whales, signifying a potential milestone. The time the calves spent swimming with their mothers decreased with age, while the time spent swimming socially and

swimming alone increased with age. Based on the five-factor model, beluga calves each had their own distinct temperament. While temperament appears to not have stabilized by year two, distinct patterns of behavior were observable in year one and year two. Based on the behavioral patterns of the whales in the first two years of life, it can be argued that beluga calves have distinct temperaments.

ACKNOWLEDGMENTS

As I have often said, it really does take a village! I am so humbled by having the most unbelievable village! Please know that I am fully aware that my words are going to fall short of how thankful I am to each and every one of you, but I'm going to try anyway!

To my committee, thank you! Dr. Alen Hajnal: thank you for leading me through both my thesis and my dissertation and for all of your guidance and encouragement... and for always believing in me! Dr. Richard Mohn, thank you for guiding me through all things statistics and for patiently answering all of my calls, e-mails, and often silly questions. I have always appreciated your ability to bring humor and perspective to all things stats. Dr. Lawrence Patihis, thank you for all of your kind words and helpful suggestions throughout the process.

Dr. Heather Hill... I'm honestly not sure where to start. You have gone so far above and beyond and truly been my academic fairy godmother! Not everyone has the privilege of working with someone brilliant who totally gets them and supports all facets of their life... and I could not be more thankful to you for stepping into that role and giving me the opportunity to work with you! It's literally been life-changing and magical! Your ability to waive your magic wand and say exactly the right thing to encourage me, help me recover perspective and focus, make the perfect revisions, or suggest the perfect article (among a multitude of other things) is still impressive! You are an inspiring scientist, mom, person, and super human! I honestly think you have magical powers! I cannot thank you enough for all of your guidance and wisdom and for the chance to work with you and embark into the wonderful world of belugas!!

To Dr. Pepper Hanna, thank you for letting me talk through things at you. Your ability to make things work, over the phone, without saying a word doesn't really make sense, but is so appreciated! Plus Dr. Pepper and Dr. B... the non-Texas and Texas versions... same same, different name!

To my person, Dan, you have gone out of your way to be helpful in my dissertation journey and I appreciate you so much! From teaching me value of a progress tracking excel spreadsheet to pivot tables, you've always been there, in so many ways, to help whenever I needed you. Thank you so much for going on diss journey with me and being beyond supportive and encouraging!

To my Rora dog, you have spent the most time on this journey with me! I got you right before I started grad school, and you have been there through every paper, PowerPoint, lesson plan, and everything in between. Thank you for unconditionally being excited to see me...your wagging tail got me through many long days and late nights!

To Dr. Stan Kuczaj, thank you for taking a chance on the Disney girl who was interested in your lab. You believed I could, and I did!

To the beluga whales at Sea World San Antonio: I met you when I was in high school and you inspired me to work with marine mammals...little did I know you would also wind up as the subject of my dissertation! Thank you for allowing us to learn from you, inspiring us, and serving as ambassadors to your conspecifics in the wild!

And finally, to my parents: Thank you for always supporting me and encouraging me to pursue (all of) my dreams! I absolutely could not have done with without you!

As Elle Woods would say, “We did it!”

DEDICATION

I would like to dedicate this manuscript to my mom, Dr. Elene Bouhoutsos – Brown. Mom, you have been my own personal Miss Frizzle since I was little, and I cannot thank you enough for always inspiring me to be myself, “take chances, make mistakes, and get messy!” You have supported me in all of my adventures and been my best friend along the way! Not everyone has a mom who would willingly spend the time it takes to do their reliability coding, but that’s just one simple example of the amazing kind of mom you are! My dissertation touches on the importance of mother-child relationships and I will be eternally grateful to have the most amazing relationship with you! Your strength, humor, kindness, and wisdom inspire me daily and I hope that one day I can be just as amazing of a mom to my own kiddos! I love you mom!

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LIST OF ABBREVIATIONS

BORIS	Behavioral Observation Research Interactive Software
CBQ	The Children's Behavior Questionnaire
EED	Environmental Enrichment Device
EFA	Exploratory Factor Analysis
FFM	Five Factor Model
Lags	Pacific White-Sided Dolphin
PCA	Principal Component Analysis

CHAPTER I – Introduction

What is temperament?

The study of behavioral patterns in humans, often referred to as temperament or personality, has been found throughout multiple disciplines, including psychology (personality psychology, social psychology, clinical psychology, school psychology, developmental psychology), genetics, psychobiology, psychiatry, and anthropology. Likewise, the study of behavioral patterns in animals spans multiple fields including (comparative) psychology, zoo management, anthropology, and endocrinology. Since behavioral studies span so many different fields, all with different approaches and theories, there is still no general consensus on the classifications and definitions for personality and temperament, especially in the field of comparative psychology (Frick, Highfill, & Kuczaj, 2017; Gosling, 2001; Sinn, Perrin, Mather, & Anderson, 2001). Nonetheless, the overarching themes that are echoed throughout the literature have created an overall picture of how behavioral patterns should be portrayed.

Behavioral Patterns Throughout the Lifespan

Looking at the development of personality in humans, Roberts and DelVecchio (2000) conducted a meta-analysis of 152 studies investigating personality development throughout the human lifespan and predicted that developmental milestones, such as developing a sense of self, would correspond with greater personality stability. This prediction was made based on the fact that each milestone created new schemas or lenses through which the world could be seen and assessed by a child. For example, developing a sense of self allows one to differentiate himself or herself from others and realize that both individuals can have differing thoughts and opinions. Based on the results of the

meta-analysis conducted by Roberts and DelVecchio (2000) and other work performed by Caspi and Roberts (2001), personality was least consistent was the lowest from birth to 2.9 years, followed by an increase in consistency between age three and 5.9 to relative stability throughout the college years, until early adulthood where some instability occurred as different environments were experienced, and stabilizing finally between 50 and 59 years of age (Caspi & Roberts, 2001; Roberts & DelVecchio, 2000).

Despite the fact that Roberts and DelVicchio (2000) found personality to be the least consistent in early childhood, others found temperament to be stable in early childhood. Losonczy-Marshall (2014) studied temperament in one -, two -, and three-year-old children and found stability among five dimensions of temperament including intensity, mood, activity, approach, and adaptability. Similarly, Bornstein, Putnick, Gartstein, Hahn, Austead, and O'Connor (2015) examined infant temperament stability and found that temperament was stable across age, gender, birth order, term status, and socioeconomic status for a two-factor structure of positive and negative affectivity. While these two studies yielded different models for exploring at temperament in early childhood, they both suggest that temperament was present, measurable, and stable even at an early age. Bornstein and colleagues (2015) not that temperament is of interest because it shapes the behavioral patterns of young children, particularly how they interact with their environment.

Defining Temperament and Personality in Humans

McCrae et al. (2000) defined temperament as an innate predisposition that was observable in preverbal infants and humans, comprised of instinctual behavior, and independent of environmental influences. In other words, temperament was biologically

based and not learned. Personality, on the other hand, was defined as patterns of behavior and thought that were acquired through experience, found only in organisms with sophisticated cognitive systems (McCrae et al., 2000). McCrae et al. (2000) argued that temperament and personality were composed of similar traits, but from different perspectives: innate tendencies vs environmental influences.

Similarly, Rothbart (2007) argued that temperament was the foundation for personality, and the link between neural networks and individual differences. That is, temperament was the amalgamation of innate responses and the mechanisms that regulate them and when combined with experience synergistically “grow” a personality (Rothbart, 2007). More specifically, Rothbart defined temperament as “individual differences in emotional, motor, and attentional reactivity measured by latency, intensity, and recovery of response, and self-regulation processes such as effortful control that modulate activity” (Rothbart, 2007, p. 207). This definition highlights the fact that there are potentially opposing forces at play: innate behavioral reactions and the effortful control that it used to regulate them. This regulation is learned through experiences, teaching the individual which responses are appropriate as well as when they are not appropriate.

McCrae and colleagues (2000) noted the role of the environment in shaping personality. As Rothbart (2007) proposed, it is through experience that innate behaviors either get reinforced and repeated, or punished and decreased in frequency, which thereby forms behavioral patterns. McCrae et al. (2000) also illustrated the importance of the lifelong parent-child relationship. Parenting styles resulted in long-term consequences for the development of characteristic adaptations in offspring

Measuring Temperament in Humans and Human Infants

The biggest challenge in measuring temperament (and personality) is that it cannot be directly measured. There is no tool that currently exists that directly measures one's temperament. Instead, temperament must be inferred from observing behavioral patterns, and then comparing the patterns of the individual to those of a larger group, noting similarities and differences.

Measurements of temperament in humans are predominately performed through questionnaires. These questionnaires list adjectives that describe traits or behaviors, which are then ranked, often along a Likert Scale (e.g. agree, strongly agree, disagree, strongly disagree), indicating the degree to which the particular adjective describes the subject. For adult subjects, these can be self-reports or reports completed by someone who knows the individual well. In children, since they are often not capable of a self-report, someone who knows the child well provides the ratings. This approach to personality, rooted in a top-down approach, uses previous research to choose behaviors or adjectives that have already been studied. The behavior of the individual can then be compared to known groups or other participants for evaluation. Scores from these questionnaires are tested for their correlations, using a factor analysis, to determine how the items on the questionnaire relate to one another. These correlations are then interpreted by the researcher to determine the number of temperament factors needed to create the most robust model for the data and explain the most variance across the sample (Bornstein et al., 2015; Garstein & Rothbart, 2003; McCrae & John, 1992; Rothbart, 2004; Rothbart, 2007; Rothbart, Ahadi, Hershey, & Fisher, 2001).

Human Studies of Temperament in Early Childhood

Factor analysis has been used to develop all of the models for temperament in early childhood. In 1977, Thomas and Chess identified nine measures of temperament in infants, which included activity level, approach/withdrawal, intensity, threshold, adaptability, rhythmicity, mood, attention span persistence, and distractibility. While it has since been modified, the dimensions established by Thomas and Chess (1997) served as the model for The Children's Behavior Questionnaire (CBQ), which is more focused on the what and why of behaviors. The CBQ measured temperament in children between the ages of three and seven (Rothbart, 2004; Rothbart et al., 2001). Rothbart and colleagues viewed the CBQ as a theory-derived instrument, acknowledging that temperament was influenced by both experience and maturation. For the purposes of the CBQ, temperament was defined as being intrinsically based individual differences that were centered around reactions, including both self-regulation and reactivity (Rothbart et al., 2001; Rothbart, 2004). By means of the principal axis factoring, the scores from over 158 3- to 7- year-old children were analyzed using the 15 scales of the CBQ to determine the principal factors onto which the behavioral scales loaded. The scales of the CBQ loaded onto 3 factors: *Negative Affectivity*, *Extraversion/Surgency*, and *Effortful Control*. Negative affectivity included loadings from scales of sadness, fear, anger/frustration, and discomfort. Soothability loaded negatively on this scale (Rothbart et al., 2001). Extraversion included loadings from scales of activity, impulsivity, and high intensity pleasure. Shyness loaded negatively onto this factor. Smiling/laughter and positive anticipation also loaded onto this factor. Effortful control included loadings from low intensity pleasure, inhibitory control, perceptual sensitivity, attentional control, and

smiling/laughter. The CBQ dimensions of Extraversion /Positive affect and Negative affect/Neuroticism are very similar to dimensions of the Five Factor Model (FFM) of adult personality (McCrae & John, 1992; Rothbart et al., 2001).

The CBQ was then modified to evaluate temperament in infants. Due to the nonverbal limitations of infants, the question had to be adjusted to evaluate behavior under different conditions. Two questionnaires are commonly used to assess infant temperament: The Infant Behavior Questionnaire (IBQ) and the Infant Behavior Questionnaire-Revised (IBQ-R).

The IBQ is a parent report measure that consists of 94 items measuring 6 scales: *Soothability*, ability to calm after crying or being in distress; *Fear*, increased latency or distress when approaching a novel object or environment; *Activity level*, participation in gross motor activity; *Smiling and laughter*, positive affect and arousal; *Distress to limitations*, response to frustrating situations; and *Duration of orienting*, sustained attention without a change in stimulation (Bornstein et al., 2015). Factor analyses of the IBQ have resulted in these scales loading predominately onto two factors: *positive affectivity* and *negative affectivity* (Bornstein et al., 2015). Positive affectivity was comprised of orienting, soothability, smiling, and laughter. Negative affectivity was comprised of fear and distress to limitations (Bornstein et al., 2015).

The IBQ-R, a modification of the IBQ, has eight more behavioral scales than the original IBQ. The IBQ-R is a parent-report questionnaire that uses 191 questions, divided into 14 scales to measure temperament in infants between three and 12 months of age: *Approach*, *Vocal reactivity*, *High intensity pleasure*, *Smiling and laughter*, *Activity level*, *Perceptual sensitivity*, *Sadness*, *Distress to limitations*, *Fear*, *Falling*

reactivity/Rate of recovery from distress, Low intensity pleasure, Cuddliness, Duration of orienting, and Soothability. An exploratory factor analysis of the IBQ-R revealed that the subcategories loaded onto three of the temperament subscale measures: Surgency/Extroversion, Negative Affectivity, and Orientation/Regulation (Garstein & Rothbart, 2003). These three factors were also reflected in the CBQ and the FFM, allowing for more meaningful comparisons between the three scales, which measure temperament and personality at different ages. The fact that similar factors persisted from infancy to adulthood suggests that the factors of infant temperament carry through to adult personality (Rothbart, 2007).

The Five Factor Model of Adult Personality

While many of the infant models for temperament yielded a large number of factors, the most commonly used and referenced measure for personality in adult humans is a five-factor model. Originally coined by Goldberg (1981), The Big Five Factors of personality included *Surgency, Agreeableness, Conscientiousness, Emotional Stability, and Intellect.* In 1985, Costa and McCrae took three of these factors to create a personality inventory, called the NEO-PI, a personality questionnaire incorporating Likert-scale ratings of questions that clustered together to reflect the scales of *Neuroticism, Extraversion, and Openness.* In 1991, Costa, McCrae, and Dye recognized two additional scales, *Agreeableness* and *Conscientiousness*, and introduced the NEO PI-R, which contained a 240-question survey that loaded onto the five personality scales. This translation of Goldberg's Big Five are what are most often referred to as the Five Factor Model (FFM) of personality consists of a categorized list of traits on five behavioral scales: *Extraversion*; outgoing, talkative, assertive; *Agreeableness*; good

natured, agreeable, empathetic, *Conscientiousness*; careful, self-disciplined; *Neuroticism* depressed, hostile, anxious; and *Openness to Experience* creative, curious, sensitive (McCrae & John, 1992). The FFM is the most commonly used model used to inventory personality in adult humans.

Temperament and Personality in Animals

According to Stamps and Groothuis (2010), animal personality entails “individual differences in behavior that are consistent both across contexts and across time” (p. 304). Temperament and personality are often used interchangeably in animal research (Frick et al., 2017; Gosling, 2001; Stamp & Groothuis, 2010). In some instances, this is due to a fear of anthropomorphizing the behavioral patterns of animals. In other instances, it is because there is not a consensus throughout the field as to how the two should be differentiated, especially with regards to animal behavior. For example, Stamps and Groothuis (2010) comment that while temperament and coping style were originally terms with different meanings, that their definitions have now converged with that of personality. Meanwhile, others continue to treat personality and temperament as separate (usually related) entities (reviewed by Frick et al., 2017; Gosling, 2001; Stamps & Groothuis, 2010).

For the purposes of this study, temperament is defined as innate patterns of behavior that have not (yet) been altered by the individual’s environment, using definitions typically used in human studies of early childhood. Sinn, Perrin, Mather, and Anderson (2001), defined temperament as the precursor to personality, which occurs early in life and consists of behavioral styles predominately composed of innate responses. Temperamental traits are viewed as being exclusive to young individuals who

have not yet had enough life experience to have their behavioral patterns influenced by their environments. Personality, on the other hand, refers to behavioral patterns that were made more robust through life experiences.

It is also important to note that much like with humans, although personality studies require repeated measures of the same individuals, the actual focus is on the behavior of individuals relative to one another and a group as a whole. Without the comparison to the group, or other individuals, there is no reference as to what is normal and the ranges of behaviors that should be expected. It is through the comparison of the individual to the group as a whole that the individual's behavior gains meaning (Stamps & Groothuis, 2010). As a result, temperament refers not only to the underlying characteristics that are specific to an individual, but also to those that vary across individuals.

Rating temperament or personality in animals

Although a lot of animal personality research has been based on genetics, this negates the influence of the environment on behavioral patterns. Much like the ongoing nature versus nurture debate in psychology, neither genetics nor environment alone determine personality or temperament. It is the synergy between genetics and environment that leads to behavioral patterns (Stamps & Groothuis, 2010). Thus, it is important to look at the behavioral patterns themselves, which might then lead to a greater understanding of genetic components and even the interplay between genetics and environment.

Similar to human research, there are two methods commonly used to study temperament: rating and coding (Gosling, 2001; Highfill et al., 2010; Hill et al., 2017;

Stamp & Groothuis, 2010). Ratings of animals, typically conducted through questionnaires, are completed by a trainer or caretaker who has experience with the animal. Much like questionnaires done with humans, raters are given a list of adjectives of behaviors and the asked to use a Likert Scale to determine how well each one describes the animal's typical behavior. These ratings are based on cumulative experiences with an animal, much like human ratings of children or even self-ratings. Since the rating is based on cumulative experience, it negates the need for multiple evaluations, according to Gosling (2001), making it more efficient. On the other hand, because these ratings are based on cumulative experience, they are also subject to preconceived notions or past experiences and may not always be an accurate reflection of current behavior (Highfill et al., 2010). Accordingly, ratings must be done by multiple observers in order to have a reliable measure and balance individual variation (Gosling, 2001), although Highfill et al. (2010) found that having multiple coders did not lead to interrater reliability for personality. Highfill et al. (2010) emphasized the importance of the rater's history with the animal, across multiple contexts, in order to achieve intercoder reliability.

Again, comparable to that which has been performed with humans, coding animal behavior can take place in either familiar or novel situations (Gosling, 2001). Whether the animal is given a task designed to elicit a specific behavior, or the animal is observed in his or her natural habitat, only behaviors that are observed during the set window of time are recorded and analyzed. Unlike rating, coding behavior evaluates only the current snapshot of behavior, regardless of whether the behavior was typical or atypical

for that animal, and free from the confounds of any behavior outside of that which is observed while coding (Gosling, 2001).

Challenges to Behavioral Assessments in both Animals and Humans

As Gosling (2001) reviews, one major challenge of personality research for both humans and animals is determining the reliability and validity of the data. Because temperament and personality cannot be directly observed, it is important to ensure that the measurements being used are genuinely reflective of the behavioral trends present in the subject.

First, it is imperative that the behaviors being investigated are both relevant and meaningful to the subject (Gosling, 2001). While folding one's arms might indicate frustration in humans, this metric does not translate to animals that do not have arms. Consequently, it is too species specific and would not be a relevant metric outside of humans and non-human primates. Determining the meaning of behaviors also often includes considering the context in which the behavior takes place. For example, humans can cry tears of joy or sadness. While they both actions produce tears, there are very different contexts behind them.

Second, the environment of the subject must be considered (Gosling, 2001). For example, a solitary jaguar cannot engage in social interactions with conspecifics, so sociability would be measured differently for a jaguar living alone than one living within a group setting. Likewise, a juvenile male who is becoming interested in females for the first time would have a completely different behavioral repertoire during mating season than he would outside of breeding season.

There are three ways in which reliability can easily be assessed: intercoder reliability, within-subject reliability, and test-retest reliability (Gosling, 2001). Intercoder reliability can be calculated using Cohen's (1960) kappa formula. Within-subject reliability should increase with increased data collection. Only evaluating one snapshot of behavior might paint an inaccurate picture, but multiple snapshots are likely to provide a more robust big picture of the animal or human's behavioral repertoire. The same is true of test-retest reliability. Repeated behavioral patterns suggest that the behavior is not an anomaly (Gosling, 2001).

To ensure reliability in personality assessment, Gosling (2001) suggested several guidelines. The first was to confirm that intercoder reliability was high and that independent assessments agreed (Gosling & Vazire, 2002). Next, Gosling (2001) noted that personality scales should depict a full range of behavior and the variability within the scale, without being too vague. If scales are too focused, then they do not examine the full range of behavior, and if they are too vague their factor analysis were muddled, as behaviors will load on multiple scales. Gosling and Vazire (2002) also stated that assessments should look at real-world outcomes that are relevant to and predictive of natural behaviors. Gosling (2001) also recommended having at least three to four dimensions per scale, ensuring that the items tap into the common construct or personality factor expected. Creating meaningful dimensions can be accomplished through an exploratory and confirmatory factor analyses, ensuring that the descriptions and adjectives load onto their predicted personality traits. Finally, it is also important that ratings reflect traits that are being exhibited by the animal or human of interest and not

the observer's embedded theories about personality or the subject (Gosling & Vazire, 2002).

Gosling (2001) also pointed out that some traits and behaviors are easier to detect than others, and that some animals are easier to judge than others. For example, large aquatic mammals, even under human care, are more difficult to observe, as they have both surface and underwater behaviors, than terrestrial mammals or even fish, who are much smaller and easier to house and view in a tank in a laboratory. It should also be noted that personality has been found to forecast interest in participating in research tasks (Latzman, Sauvign e, & Hopkins, 2016), and taken into consideration that certain temperaments and personalities are likely to present behaviors that are more blatantly obvious than other more discrete traits.

Another way to increase behavioral reliability and validity is to determine if the data are best suited for a top-down or a bottom-up approach (Frick et al., 2017; Hill et al., 2017). Top-down approaches use frameworks that are already established in the literature, while bottom-up approaches use species-specific traits that are measured to analyze data. Top-down approaches are advantageous because they facilitate cross-species comparisons, while bottom-down approaches are often a better representation of species-specific behavior.

One of the greatest challenges in both animal and human personality research is that variability makes it difficult to draw universal conclusions and comparative connections. Sometimes referred to as the jingle fallacy, researchers have often used the same label to refer to different constructs (Gosling, 2001), or they use different terminology to describe similar qualities (Highfill & Kuczaj, 2007). Either type of error

has made comparisons challenging, both within a species and across species. Inconsistencies in terminology have been a huge challenge for personality researchers studying both humans and animals. Consequently, agreeing upon a common metric would help create consistency within the field, although it might not encompass as many species-specific behaviors. Researchers who have made up their own framework inhibit comparisons, although they might get a more robust interpretation of behavior (Gosling, 2001; Highfill & Kuczaj, 2002). That being said, there are also some tradeoffs that must occur between comparability and comprehensiveness, as both are difficult to achieve (Freeman & Gosling, 2010; Gosling, 2001).

Studying animals, much like studying infants, has its own set of challenges. First, like infants, animals do not have language to communicate. For this same reason, neither animals nor infants are capable of conducting self-reports (Highfill & Kuczaj, 2007). Human infants and many young animals are limited in their behavioral repertoires and are codependent upon their mothers for care and protection. Nonverbal subjects make teasing apart the behaviors and personality of the infant more challenging.

Furthermore, looking for personality and temperament traits in young animals and humans is paradoxical in that one is looking for stability during an inherent time of change and development (Sinn et al., 2001). While little is agreed upon about the ontogeny of personality and temperament behavioral patterns in both humans and animals, studying development lends itself to uncovering developmental milestones and learning more about how these traits come into existence. Learning about development could also lead to insights about the evolutionary significance of these traits and how

their stability ebbs and flows along with other developmental milestones and how and why that is beneficial to survival.

Personality Studies in Animals

Animal personality studies have increased in frequency and encompass numerous disciplines (Gosling, 2001; Stamps & Groothuis, 2010). While each discipline has its own focus when exploring personality, methodologies are shared across the disciplines. Like human personality research, the behaviors of individual animals are measured repeatedly and then interpreted for reliable behavioral patterns that are derived through comparisons to others. Additionally, given the previously mentioned challenges to personality research, methodologies are intentionally selected within the tradeoff of comparability and measuring species-specific behaviors (Freeman & Gosling, 2010; Gosling, 2001).

To examine temperament in an octopus (*Octopus bimaculoides*), Sinn, et al. (2001), observed 19 behaviors during the third week of life. A Principal Component Analysis (PCA) revealed that 15 behaviors should be analyzed and an Exploratory Factor Analysis (EFA), using summed frequencies of the behaviors, yielded a 4-factor solution that explained 53% of variance. These four temperament factors included active engagement, arousal/readiness, aggression, and avoidance/disinterest. As Sinn et al. (2001) pointed out, the names of these factors are subjective, but should reflected the underlying theory and hypotheses.

To avoid the confounds of identifying the behaviors of interest a priori, Boulton, Grimmer, Rosenthal, Walling, and Wilson (2013) argued that variables should be discovered by the observed data. Instead of defining which behaviors should be

indicative of a particular trait before analyzing behavior, Boulton et al. (2013) used an exploratory bottom-up approach allowing the data to define the parameters being measured. With a multivariate approach, Boulton and colleagues (2013) used a variance covariance matrix to analyze their data from sheephead swordtails (*Xiphophorus birchmani*) and found significant correlations for a set of behavior traits, which produced a single vector interpreted as boldness.

The studies by Sinn et al. (2001) and by Bouton et al. (2013) provide support for an “emic” approach in which behavioral scales and descriptors are created for the species being studied as opposed to an “etic” approach in which a scale from another species is adapted for a species currently being studied (Freeman & Gosling, 2010). In their review of 18 studies incorporating factor analysis of primate personality, Freeman and Gosling (2010) identified 14-dimension categories that have been used to identify personality in primates. The two most commonly studied traits were Sociability and Fearfulness, followed by Playfulness, Confidence/Aggressiveness, Activity, Excitability, Curiosity, Dominance, and Agreeableness, Irritability, Intelligence, Impulsiveness, Anxiousness, and Independence (in order of frequency).

Primate personality has also been examined longitudinally. For example, von Borell, Kulik, and Widdig (2016) investigated the development of personality in macaques (*Macaca mulatta*), using consistent methods to investigate the same behaviors throughout the first seven years of life (covering most life stages into adulthood). They chose to focus on the three traits that have been reported for adult macaque personalities most consistently: fearfulness, aggression, and sociability, which have also been shown to be present in infancy and early development in macaques in previous studies (as

reviewed in von Borell et al., 2016). One of the main goals of their analysis was to determine the age at which behaviors consistently loaded onto their hypothesized personality factor. Through 20-minute focal follow (Altmann, 1974; von Borell, Kulik, & Widding, 2016) observations of 24 target animals for the first seven years of their life, von Borell and colleagues (2016) identified affiliative or aggressive interactions with other conspecifics but excluded interactions with the infant's mother to avoid maternal kin bias. Point samples were also taken every four minutes (Altmann, 1974), summarizing the behavior of the juvenile macaque and any conspecifics within 2 m (Altmann, 1974; von Borell, Kulik, & Widding, 2016). Additional behavioral descriptions were also collected. Ultimately, 11 infant-initiated behaviors were chosen to represent the three personality dimensions, which were then analyzed with a multiple factor analysis (dual-MFA). The results of this analysis indicated that only Fearfulness loaded throughout development, while Aggression and Sociability were less stable. Aggression only loaded after the age of three. The authors therefore concluded that macaques develop into their personality, instead of being born with stable traits (von Borell et al., 2016).

Personality Studies with Cetaceans

Overall, personality research with cetaceans is relatively limited. This lack of research might, in part, be due to the challenges in observing their behaviors in entirety (e.g., water clarity and availability of underwater viewing windows in human settings; the ability to observe marine mammals for an extended duration, or in some instances underwater at all, in the wild). Despite these limitations, some progress has been made on measuring personality in dolphins found in human care.

Highfill and Kuczaj (2007) were the first to research the stability of personality traits in Atlantic bottlenose dolphins (*Tursiops truncatus*). Dolphin trainers completed personality rating questionnaires about 16 dolphins housed at MarineLife Oceanarium in Gulfport, MS, using a modified version of the human Five Factor Model. This modified scale altered the original 30 behavioral dimensions to be dolphin-specific behavioral descriptions. The results of this initial study indicated that trainer ratings could be reliable. A unique opportunity arose when this dolphin population was displaced by Hurricane Katrina into the Mississippi Sound for over two weeks (Hoffland, et al., 2017). Following the rescue of these dolphins, the surviving population was relocated to the Atlantis in the Bahamas, and 15 months after the hurricane, the trainers of Atlantis also completed the same personality ratings (Highfill & Kuczaj 2007, 2010). Despite their changes in environment and experiences during Hurricane Katrina, 12 of the dolphins exhibited relatively stable personality traits (Highfill & Kuczaj 2007, 2010). This stability suggested that while environmental factors might help to shape personality, the personalities of the dolphins persevered even through their displacement into the wild during a natural disaster and their transport to a new facility.

Kuczaj, Highfill, and Byerly (2012) evaluated 20 dolphins at Dolphins Plus in Key Largo, FL in three social contexts: interactions with the physical world, interactions with conspecifics, and interactions with humans. The dolphins' trainers rated the dolphins on playfulness, timidity, curiosity, and how observant they were in each of the three settings. They also rated the dolphins on aggressiveness, gentleness, and cooperation in two social contexts: interactions with humans and interactions with conspecifics. Only four of the 20 dolphins displayed stable personality traits across each

context. These findings suggest that environment likely played a role in the stability of reactions. Additionally, three of the four dolphins that showed stable personalities were related, suggesting a potential genetic component to personality stability (Kuczaj et al., 2012).

Skrzypczak (2016) explored the personality of Atlantic spotted dolphin (*Stenella frontalis*) calves in mother-calf pairs. His behavioral ethogram focused on three components of personality: boldness, curiosity, and sociability. Boldness was a measure of the percentage of time the calf spent more than one body-length away from his or her mother. Curiosity was measured as a reflection of the amount of time the calf spent within one body length of a human. Sociability was the measure of the percentage of time the calf spent within one body length of a conspecific. A moderately strong correlation was found between boldness and curiosity in the calves, indicating the presence of a personality trait.

Across this handful of studies of cetacean personalities, there is clear evidence that marine mammal behavior can be used to determine personality traits. Nonetheless, more consistent terminology still needs to be established. For example, it is unclear whether or not personality and temperament should be used interchangeably for animal studies (Stamps & Groothuis, 2001). Furthermore, more behavioral research using coding or both coding and rating would help make the field more robust given that different results can be obtained when using one or the other (Uher & Asendorpf, 2008). To determine the universality of personality, additional cetaceans should be investigated in both human-managed and naturalistic settings.

Mother-Infant Interactions in Cetacean Species

Belugas are not unique in their dependence on maternal care for survival and development. In fact, studies have been conducted on infant behavior in several cetacean species, including, but not limited to, killer whales (*Orcinus orca*), Atlantic spotted dolphins (*Stenella frontalis*), Atlantic bottlenose dolphins (*Tursiops truncatus*), and Southern right whales (*Eubalaena australis*) (killer whales: Guarino, Hill, & Sigman, 2017; spotted dolphins: Herzing, 1997; Weinpress & Herzing, 2015; bottlenose dolphins: Gubbins, McCowan, Lynn, Hooper, & Reiss, 1999; Mann & Smuts, 1999; Hill, Greer, Solangi, & Kuczaj, 2007; right whales: Taber & Thomas, 1982; Thomas & Taber, 1984; cetacean overview: Tyack, Connor, Mann & Whitehead, 2000). Cetaceans most commonly give birth to one offspring at a time, and spend several years focusing their time and energy on the survival of that one offspring, resulting in an interbirth interval of several years and a strong bond between mother and calf (Tyack et al., 2000). Most cetaceans live in matrilineal-based fission-fusion societies. Typically, pods are formed of predominately related females and their offspring. Once males reach sexual maturity they leave the pod to either live a predominately solitary life, or to join a bachelor pod. Because of the similarities in most cetacean societies, maternal patterns are similar, although the level of maternal care and specific maternal behaviors vary among species (Hill et al., 2007; Guarino et al., 2017). Overall, it appears that cetacean calves and mothers exhibit similar behavioral patterns whether they are in their natural habitat or under human care (beluga whales: Hill, 2009; Krasnova et al., 2006; Krasnova et al., 2009; bottlenose dolphins: Gubbins et al., 1999; Mann & Smuts, 1999; Hill et al., 2007; killer whales: Guarino et al., 2017; right whales: Taber & Thomas, 1982; Thomas & Taber, 1984; spotted dolphins: Herzing, 1997; Weinpress & Herzing, 2015). These

similar behavioral patterns apply to exploratory behaviors of the calves and maternal behaviors of the mothers as well as their mother-calf interactions. It is also important to note that cetaceans under human care serve as reliable models for the behavior of their wild counterparts.

Beluga Calf Behavior

Beluga calves spend at least the first three years of their life with their mother (Krasnova, Bel'kovich, & Chernetsky, 2006, 2009). As a result, strong mother-infant attachments are fundamental for the survival of beluga calves (Hill, 2009; Krasnova et al., 2006, 2009). As with most mammals, the first few months of life are considered to be the most important for beluga calves, as these months will set the foundation and behavior basis for the rest of the calf's life (Krasnova et al., 2009). Consequently, the newborn and calf stages are when the most drastic and significant changes in behavior and development take place.

Krasnova and colleagues (2006, 2009) identified 10 different interactive mother-calf positions that took place during the first year of life in wild belugas (the 11th position involved the calf being at a distance from the mother). Consequently, synchronous swimming is one of the most important skills for newborn beluga calves. Swimming near the surface of the water, calves are positioned initially predominately to the side of their mother or at their mother's tail flukes or caudal peduncle. This positioning facilitates respiration, nursing, camouflaged protection from predators, opportunities for sleep, and less effortful swimming for the calf (Hill, 2009; Krasnova et al., 2006, 2009). Due to their proximal body positioning while pair swimming, it has been hypothesized that when calves are first born, they were considered an extension of their mother

(Krasnova et al., 2006, 2009). As an extension of their mother, beluga calves initially have the same social status as their mother. The calf's role in the pod is not determined until they gain independence and start swimming and interacting on their own.

Similar to the ontogeny of other mammals, while beluga calves are very dependent on their mothers for food, protection, swimming lessons, and general behavioral guidance initially, as the calves aged and nursed less, they started to spend more time away from their mothers, exploring and experiencing new things (Herzing & Brunnick, 1997; Hill, 2009; Hill, Campbell, Dalton, & Osborn, 2013; Krasnova et al., 2006; Krasnova et al., 2009). For the first week of their lives, beluga calves at Cape Beluzhii, Solovestsky Island in the White Sea were observed interacting almost exclusively with their mother (Krasnova et al., 2009). Around one week of age, the beluga calves started to briefly seek independence from their mothers; between a week and a week and a half in age, belugas were observed leaving their mothers more frequently, for very short periods of time (Krasnova et al., 2009). By the time the calves were about two weeks old, they started initiating interactions with conspecifics on their own (Krasnova et al., 2009). While the beluga calves' initial behavioral pattern of following their mother was thought to be the result of imprinting, beluga calves quickly learned to imitate and learn from the behavior of their mother and other available conspecifics (Krasnova et al., 2009). As the calves developed, the time spent with their mothers decreased as the calves gained independence and confidence interacting with their environment (including conspecifics). This phase of independent exploration was thought to help the calves determine their role in the hierarchy of their pod (Krasnova et al., 2009).

Analogous behavioral trends in calves have been observed both with belugas in their natural habitats and with belugas under human care (Hill, 2009; Hill et al., 2013; Krasnova et al., 2006, 2009). Beluga whale calves in human care were observed spending 80-90% of their time swimming with their mothers during their first year of life (Hill, 2009; Hill et al., 2013). This long duration of dependence signifies the importance of the mother-calf relationship.

Human and Non-Human Primate Attachment and Behavioral Influences

In humans, the initial attachment of mother and child is thought to play a crucial role in the psychological well-being and development of the child (van Rosmalen, van der Horst, & van der Veer, 2016). Attachment has also been explored in non-human primates, such as rhesus monkeys that have offspring-rearing patterns similar to that of cetaceans, as well as matrilineal fission-fusion societies (Suomi, 2004, 2005). In fact, Bowlby looked to the interaction of rhesus monkey mothers and calves when formulating his attachment theory (reviewed by Suomi, 2005). Like cetaceans and humans, rhesus monkeys start their life completely dependent upon their mothers and spend all of their time in close physical contact (Hill, 2009; Hill et al., 2013; Krasnova et al., 2006, 2009; Suomi, 2004, 2005). Once rhesus monkeys have established their relationship with their mother, the mother becomes a secure base from which they can explore their environment (Suomi, 2004). Much like with human children, when a stressful situation occurred, rhesus monkeys returned back to their mother for reassurance (Suomi, 2004, 2005). Although attachment has not yet been assessed formally in cetaceans, similar behavioral trends have been seen with belugas, and other cetaceans, using their mothers

as a secure base from which they can explore, learn, and seek comfort when needed (Hill, 2009; Hill et al., 2013; Krasnova et al., 2006, 2009).

Suomi (2004) identified connections between maternal style, environment, and temperament in both rhesus monkey mothers and their offspring that were overlooked in past research. Likewise, Bray and colleagues (2017) found that canine maternal styles influenced puppy temperaments. Maternal styles have been characterized by the pattern of behavior the mother exhibits when interacting with her offspring (Bray et al., 2017; Hill et al., 2007; Suomi, 2004). Typically, the behavior of an offspring is thought to be a relatively independent variable. Measures of temperament and personality look to behavioral trends at face value. For example, an animal that is very independent and outgoing would be classified as an extrovert, while a less explorative animal would be classified as an introvert. This does not consider the fact that in order for the animal to be outgoing, the mother must permit the animal to have independence and explore away from her. Consequently, maternal behavior and environment have a significant influence on the behavior of offspring (Bray et al., 2017; Suomi, 2004).

When examining maternal styles, Suomi (2004) unearthed that low-ranking rhesus monkey mothers were more restrictive of their infant's explorations than were high-ranking mothers. It was hypothesized that low-ranking mothers were fearful of being aggressed upon, and consequently restricted the behavior of their offspring as well. It was also found that mothers became more restrictive of infant behavior when the environment became unstable, presumably to maintain an increased vigilance over their infants (Suomi, 2004). The degree to which mothers allow their offspring to explore on their own has been termed maternal permissiveness (Hill et al., 2007).

Despite the importance of maternal behavior, rhesus mothers were not the determining factor of their offspring's behavior. Highly fearful infants were not always shaped by their mother's behavior. Some infants seemed to have an innate disposition toward being fearful and started leaving their mother later than others in their cohort and explored their environment less than others (Suomi, 2004).

Infant Socialization and Maternal Styles in Cetaceans

Since cetacean calves spend the majority of their time with their mother, a meaningful metric of the ontogeny of their independence, and individual behavioral repertoire, becomes the time they spend with their mother, with conspecifics, and the time they spend being solitary. It then becomes relevant to examine the behaviors that occur outside of pair swimming, indicating the behavioral repertoire of the calf. Since the independence of the calves is dependent initially upon their mother allowing them to swim on their own, maternal styles can influence these measures. While newborns, at their most dependent, cetaceans typically spend almost all of their time with their mother. As calves become less dependent, mothers typically start to no longer follow the calves as they start to explore their independence and briefly leave and investigate their environment (Guarino et al., 2017; Gubbins et al., 1999; Hill, 2009; Hill et al., 2007; Krasnova et al., 2006, 2009; Mann & Smuts, 1999; Skrzypczak, 2016; Taber & Thomas, 1982; Thomas & Taber, 1984).

Killer whale calves followed a typical developmental trend, spending the majority of their time with their mothers across their first three years of life, gradually decreasing across each year (Guarino et al., 2017). Newborn killer whale calves were constantly in motion, likely to maintain buoyancy. Social interactions increased after the first month,

and social interactions with the calf's mother, outside of pair swimming, developed after six months. Around 24 months, the calf was socializing and swimming with her mother equally, and also becoming more independent and engaging in solitary behaviors such as play. By the end of the third year, the calf only spent about a third of her time interacting with her mother. The calf's mother was extremely protective and would often retrieve the calf to keep her within one body length, especially as a newborn (Guarino et al., 2017).

Similarly, Atlantic spotted dolphin calves were found to stay with their mothers for the first two years (Herzing, 1997). After that, older calves were often seen in juvenile groups, although calves were observed nursing for up to five years. Spotted dolphin neonates were observed being disciplined by both their mothers and alloparents (Weinpress & Herzing, 2015).

As the most studied cetacean, more has been researched about maternal behaviors and infant socialization in Atlantic bottlenose dolphins. Much like with killer whales, dolphin calves spent the majority of their first years of life interacting with their mother (Gubbins et al., 1999; Hill et al., 2007; Mann & Smuts, 1999). Behaviors were predominantly initiated by the mother, including protective actions and proximity maintenance. As calves aged, their behavioral repertoire increased and they gained more independence, initiating most mother-calf interactions. Similar to the behavior seen in positive rhesus monkey attachments (Suomi, 2004, 2005), bottlenose dolphin calves were reported to return to their mother when they are stressed or fatigued (Hill et al., 2007). Maternal behaviors developed alongside the calf's independence. As calves sought more independence, the mothers increased their maternal permissiveness allowing the calves to

learn and explore on their own, while their mothers remained readily available should they be needed. Consequently, it was hypothesized that mothers spent the first half of the calves' first year of life controlling their behavior, and the second half monitoring it (Hill et al., 2007). This behavioral flexibility is likely reflective of an ability to adapt to the present environment. It is probable that dolphins, like rhesus monkeys, evaluate the safety of their current environment and adjust their maternal permissiveness accordingly (Hill et al., 2007; Suomi 2004, 2005). Bottlenose dolphins were found to primarily engage in swimming, play, and associative social behaviors as calves (Mann & Smuts, 1999).

Right whale calves were also found to spend the majority of their time with their mothers. Like killer whale calves, newborn right whales were constantly in motion (Thomas & Taber, 1984). Calves were born into shallow waters, a few months before migration, which allowed the calves to swim (in part to maintain buoyancy) and build their strength, as well as use the shallow waters for protection before their migration (Taber & Thomas, 1982). After about six or seven weeks, right whale calves were seen engaging in mother-centered play. In fact, while it was often discouraged by their mothers, calf play was always centered around their mother. Mothers would often swim away from a play scenario so that their calves would follow or reposition their calves to get them to stop playing. The unwillingness of mothers to play was thought to be due to energy conservation (Thomas & Taber, 1984). Once the calves matured into yearlings less play was observed. Yearlings also nursed more than calves (Thomas & Taber, 1984). Taber and Thomas (1982) classified right whale development into five stages. Stage one was the newborn stage, characterized by the mother and calf almost always

being in proximity, if not physical contact, to one another. Stage two starts at about one to three months, and is denoted by decreasing amounts of time touching, although usually still within a quarter whale length of each other. Calves are the most active in this stage and approach more than they leave their mothers. Circle swimming around their mother is considered an important calf milestone of this age, as the calf is gaining strength and coordinating, as well as starting to play with defining his or her independence. Stage three occurs during the week before the whales start their migration. Activity levels are very low during this stage, and the mothers and calves regain their proximity to one another. Stage four occurs during migration, consequently little is known about spatial relations in this phase. Stage five is the pre-weaning and separation phase (12 to 14 months of age). In this stage, mothers approach their calves less and leave their calves more than they approach their calves for the first time. As a result, calves become responsible for their proximity maintenance with their mothers (Taber & Thomas, 1982). In this regard, the behavior of right whales differs from that of the aforementioned cetaceans, where mothers are seen managing the proximity maintenance with their calves.

Infant Socialization and Maternal Styles in Beluga Whales

Similar to Taber and Thomas's findings on right whales (1982), Hill (2009) discovered that beluga calves initiated significantly more separations than their mothers (Hill et al., 2013). Interestingly, the calves were also the ones to initiate significantly more (5 to 10 times more) reunions than their mothers (Hill, 2009; Hill et al., 2013). As expected, the most frequently observed behavior in beluga whale mother-calf pairs were mother-calf pair swims, which increased in the last quarter of the year. Overall, beluga

whale calves engaged in solitary swims twice as often as they swam with each other (Hill, 2009; Hill et al., 2013).

The Current Study

This study aimed to determine the behavioral repertoire of beluga whale calves during their first two years of life. Using this behavioral repertoire, temperament was then investigated across whales during the first two years of life. Whether or not the whales had similar behavioral patterns, and therefore temperaments, across their first and second years of life was also investigated. Since newborn calves spend the majority of their time with their mothers, it was predicted that there would be behavioral differences between the first month of life and the subsequent months. Furthermore, it is hypothesized that the whales would increase their level of autonomy as they matured, increasing their behavioral repertoire and allowing for temperament-based behavioral patterns to appear. Based on a bottom-up approach, the goal of this study was to determine if temperament traits in beluga calves were measurable and stable.

To date, temperament in beluga whale calves has never been systematically investigated. Methodical evaluation of the behavioral patterns of beluga whales will illustrate their temperament through their ontogeny of independence. All observable behaviors were coded, using a bottom-up, emic, approach, without a priori traits in mind. Through an exploratory principal components analysis of all behavioral frequencies, a behavioral profile for the group of beluga whales were created. Using this profile to cross-reference individuals against the group as a whole will allow both individual and group temperaments to be determined.

Learning about beluga temperaments has implications for animal management such as knowing which animals should be housed together, or possibly even which should breed (Highfill & Kuczaj, 2010). Being mindful of a whale's temperament could also have implications for the animal's willingness/desire to learn, cooperation, positioning in social hierarchies, and aggression. Evolutionarily, if beluga whales have behavioral patterns indicative of temperament traits it would add another piece to the puzzle of how unique individual behavioral patterns increase survival rates. Meanwhile, because all of the whales being studied at SeaWorld had the same environment, if their temperaments differ, then environment alone cannot shape their temperament. Examining the behavioral budget for beluga calves might also illuminate why beluga mothers are less responsible for proximity maintenance than many of their cetacean counterparts (Hill et al., 2013; Hill et al., 2007).

CHAPTER II – METHODS

Subjects

Seven mother-calf pairs of belugas whales, housed at SeaWorld San Antonio, served as the subjects for this study. The data set included four female calves and three male calves. Two male calves were born in 2007 (Oliver and Grayson), one female in 2008 (Qinu), 2009 (Bella), and 2010 (Atla), and a male and a female in 2013 (Samson and Stella). Oliver’s mother is Martina, Grayson’s mother is Martha, Qinu’s mother is Sikku, Bella and Stella are sisters and their mother is Crissy, and Atla and Samson are siblings whose mother is Luna (see Table 1).

Table 1

Beluga whale calves born at SeaWorld San Antonio

	Birthdate	Gender	Mother	Father
Oliver	6/23/2007	M	Martina	Nanuq
Grayson	6/26/2007	M	Martha	Nanuq
Qinu	7/31/2008	F	Sikku	Nanuq
Bella	6/12/2009	F	Crissy	Nanuq
Atla	6/23/2010	F	Luna	Nanuq
Samson	7/9/2013	M	Luna	Imaq
Stella	7/26/2013	F	Crissy	Imaq

In 2007 and 2013, two calves were born in the same season, allowing each calf to have access to a conspecific of the same age. These synchronized births provided opportunities for social interaction that were not present for the beluga calves in later

years, but more accurately mimics beluga whales in their natural habitat. Bella is the first known beluga twin to survive (the other calf was stillborn) (Osborn, Dalton, Dold, Robeck, 2012). Qinu's mother Sikku was visually impaired. Oliver was ill the first 10 months of his first year of life, and he and his mother were moved out of the main pool with the other beluga whales and into a medical pool with Grayson and his mother (Hill 2009; Hill et al., 2013). Luna has not always bonded quickly with her calves. When she was slow to interact with her calf Samson, Martha was given access to the calf and provided alloparenting, which has also been seen in the wild (Krasnova et al., 2006, 2009).

Facility

All beluga whales were housed at SeaWorld San Antonio, where all of the calves were born. Their habitat consisted of a series of seven pools with 3,785, 411 L (2 million gallons) of man-made salt water. The average depth of the pools was about 7 m (25 ft). Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) (lags) are also housed in the same pools. Although belugas and lags were never given full access to one another, they are able to hear and see one another.

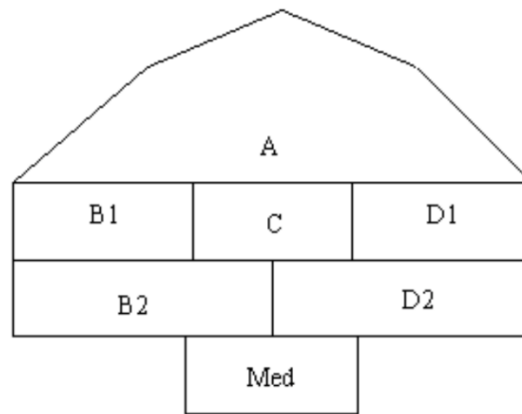


Figure 1. Schematic of the pools at the white whale and dolphin stadium at SeaWorld San Antonio.

Pools are not drawn to scale.

Mothers and calves were grouped variably with other whales throughout their first two years of life. These groupings provided varied opportunities for socialization and exploration with conspecifics. To an extent, it also mimics the fission-fusion society that is typical of belugas in their natural habitat (Krasnova et al., 2006, 2009).

Procedure

Video recordings were collected, as part of a longitudinal study, during observation sessions for later analysis. Observation sessions were conducted at least two times a week during regular, park operating hours (approximately 8:00 am to 5:00 pm). Sessions lasted at least 15 minutes, when possible, and occurred outside of feeding or training sessions to minimize the influence of confounding settings that would influence behavior.

Data were collected using a focal follow sampling method (Altmann, 1974). When the calf was away from his or her mother and they could not be captured together in the frame, the focus of the recording remained on the calf. If more than two mother-calf pairs were in the pool concurrently, there was a minimum of a 10-minute window between recordings to account for independence of observations.

Video Selection

The two-year period was divided into nine time intervals: 0-1, 1-3, 3- 6, 6-9, 9-12, 12-15, 15-18, 18-21, and 21- 24-month marks. The first month of life was referred to as the newborn (N) phase. Following the procedure of Hill, Campbell, Dalton, and Osborn (2013) subsequent measures, were broken down into quarters of the year and referred to as Q1, Q2, Q3, Q4, Q5, Q6, Q7, and Q8. Four videos were selected per quarter to yield equal sample sizes across all quarters (and the newborn phase). This also increased statistical power (Hill et al., 2013).

When possible, the videos were at least 15 minutes in duration. The minimum cutoff for the videos was 10 minutes. Videos were chosen at random, but the analysis attempted to represent a variety of scenarios, including both underwater and above water videos, videos where EEDs were available, as well as variable social pairings. Duration was the most critical variable. If focal follow videos were not available, scan samples were supplemented in their place and coded for the focal whale.

In order to avoid biased coding, a Latin square paradigm was used to code the videos in the following order:

Newborn = 1234567

Q1 = 2345671

Q2 = 3456712

Q3 = 4567123

Q4 = 5671234

Q5 = 6712345

Q6 = 7123456

Q7 = 7654321

Q8 = 6543217

This coding method prevented the coders from acclimating to one specific whale. This method also helped to counterbalance the learning curve that naturally occurred as coders became more familiar with the whales and their behavior. It was assumed that starting at the newborn phase would allow the coding to start with less complex videos and finish the coding with more complex videos, allowing researchers time to improve their behavior identification across the coding.

Coding Beluga Behavior

Behavioral events of the calves were recorded using all-occurrence sampling (Altman, 1974; Hill et al., 2007). This method provided a frequency count of each behavior. Using DiPaola and Kraus's (2007) beluga behavior definitions as a guide, the behaviors coded are summarized in Table 2.

Table 2

Beluga Whale Behavior

Behavior	Description
Affiliative Rub	Calf rubs his or her body on the exhibit, another whale, or an object
Back Slap	Calf clears his or her upper body from the water and forcefully slaps the water with his or her back upon return to the water
Being Herded	Calf's movements are being directed by another whale, such that the calf is made to swim where the other beluga wants the calf to go
Bite	Calf contacts another whale or object with his or her teeth
Bow	Calf clears the water with the majority of or entire body and returns to the water with a head first entry and little water displacement
Breach	Calf clears the water with the majority of or the entire body and forcefully returns to the water with a large splash
Bubble Burst	A very large exhalation by the blowhole, underwater, producing a pocket of air that expands as it moves to the surface

Bubble Ring	Calf blows a bubble in the shape of a circular ring
Bubble Streams	A line of small to medium sized bubbles, often produced with whistles, but not necessarily
Calf Initiates Swim	Calf initiates a reunion (within one body length) with another whale and synchronizes action
Calf Leaves Swim	Calf initiates a separation (more than one body length) from another whale
Chase	The calf swims rapidly behind another animal, who subsequently swims away at a rapid pace with the actor following
Chest Slap	Calf clears his or her upper body from the water and forcefully slaps the water with his or her chest upon return to the water
Chin Slap	Calf clears his or her upper body from the water and forcefully slaps the water with his or her chin upon return to the water
Chin Up	Calf rests his or her chin on the slideout often orienting to the edge of the pool
Chuff	Calf exhales sharply through blowhole, producing a sharp puff sound

Displacing other whale	Calf causes another whale to leave a location, either with an aggressive action or rapid swimming toward the whale
Environmental Enrichment Device (EED) Play	Calf interacts with an object, not typically found in their exhibit, provided by the training team
Erection	Calf's penis is visible
Fluke Out Dive	Calf dives down underwater, head first, and his or her tail flukes leave the surface of the water as he or she dives
Fluke Slap	Calf hits his or her flukes against the surface of the water, creating a loud slap sound
Head Jerk	Quick head movement, usually in a lateral or vertical direction
Herding	Calf uses his or her body to guide the movements of another whale, often blocking that whale's path as a means of getting the whale to move in a different direction
Hula	Calf is in a spy hop position, with head out of the water and vertical body orientation, and spins around himself or herself

Jaw Clap	Beluga opens mouth sharply, in an aggressive fashion, often resulting in a popping sound
Motor Play	Calf engages in activities that support motor development, moving parts of his or her body
Orients	The calf looks at the environment, a whale, or an object by moving his or her head for more than 1 second
Other Initiates Swim	Adult initiates a reunion (within one body length) with the calf and synchronizes action
Other Leaves Swim	Adult initiates a separation (more than one body length) from the calf and pursues its own action
Pectoral Flipper Slap	Calf hits his or her pectoral flipper against the surface of the water, creating a loud slap sound
S Posture	Calf positions his body in an S shape, with his pelvis toward another whale
Sexual Play	Calf interacts with another whale, often rubbing their bodies together or making sexual contact
Side Slap	Calf clears his or her upper body from the water and forcefully slaps the water with its side upon return to the water
Social Play	Whale interacts with another whale in a playful fashion, often engaging in motor play
Solo Swim	Calf swims independently of other available whales

Spit Water	Calf spits a stream of water
Spy Hop	Calf becomes vertical with its head above water, while bobbing up and down and orienting at its environment, people, or other animals
Startle Response/ Flee	The calf rapidly swims away from a situation or whale. The calf might also startle with a jerky body movement before swimming away
Surfing on Slideout	Calf glides (not actively swimming) his or her body across the slideout, often in a playful fashion
Swim with Mother	Calf swims within a body length of his or her mother
Swim with Other	Calf swims in synchronization, within a body length of a whale(s) other than his or her mother, matching their speed and direction and maintaining their relative position
Underwater Spin/Barrel Roll	Calf spins his or her body below the surface of the water
Water Fountain	Calf squirts water out the sides of his or her mouth in a water fountain arc shape
Water Play	Calf manipulates water into bubbles, rings, water fountains, or spits water

Keeping in mind that many of these behaviors are context specific (see Gosling, 2001; Stamp & Groothuis, 2010), modifiers were added to certain behaviors. The context in which behaviors took place often changed their overall meaning. For example, biting could take place in an aggressive context or a playful context.

Affiliative rubs were coded along with the modifier of the recipient of the rubbing. This could range from part of the exhibit (e.g., wall, slideout, gate) to the whale's mother, another whale, or an EED. It was also noted if the rubbing was taking place with a mouth to mouth or melon to melon body positioning. Head jerks were given the modifiers playful, aggressive, or exploratory. Open mouth behaviors were given the modifiers play, aggression, or water play. Bites were classified as playful or aggressive, as well as recording the recipient of the bite: EED, exhibit, another whale, or bubbles. Orients were classified as the whale looking at the wall/exhibit, a trainer, the researcher, another whale, a lag, an EED, bubbles, or the environment (anything aside from humans outside of the whales' underwater environment).

Additionally, durations of swims and who the calves are swimming with were analyzed. Mother-calf swims, solitary swims, social swims (with a conspecific other than the calf's mother), and social swims with the calf's mother (and a conspecific) were also recorded. A calf swimming within a full body length of his or her mother was considered to be engaging in a pair swim with his or her mother. The calf was considered to no longer be with his or her mother when the calf is more than a body length away from his or her mother. A calf swimming within a body length of another whale (not his or her mother), was considered a social swim. If the calf was swimming within a body length of both a conspecific and his or her mother, the duration was denoted as a social swim with

the calf's mother. It was also noted whether the calf or the mother initiated both the separation and the reunion of their pair swims.

Behaviors were coded using BORIS software, developed by Friard and Gamba (2016). BORIS (Behavioral Observation Research Interactive Software), is an open-source event-logging software for behavioral observation, which allows for real-time coding while watching behavioral videos and integrated playback. In addition to coding, this software also calculates activity budgets, allows the identification of variables and subjects while coding, and exports data to excel. Statistical analysis was performed using SPSS.

Determining Temperament Scales

There is currently no literature on temperament in beluga whales. This study utilized a bottom-up approach allowing the data to shape the focal temperament traits (Frick et al., 2017; Hill et al., 2017). An exploratory factor analysis (EFA) was conducted to determine how many factors the beluga calf behaviors load onto. Behaviors were condensed into groupings since some behaviors were very similar (e.g. bubble ring, bubble burst, bubble stream) and were likely characteristic of the same temperamental traits. If there were not enough (or any) occurrences of a behavior, and the behavior could not be grouped with other similar behaviors, then the behavior was removed from the analysis. As a means of making swim durations standardized (since videos varied slightly in duration), measurements were converted into percentages of the total video time. Consequently, swim durations, across all three swim scenarios, totaled 100 for each video.

Once the factors were determined, z-scores were calculated for each factor in SPSS to normalize all measurements to the same scales for comparisons. Since both frequencies and durations were being measured, it was necessary to normalize the measurements for each factor in order for comparisons to be done between whales. The z-scores for each factor were compared across all seven whales.

Paired-samples t-tests were used to compare durations of time spent engaging in mother-calf swims, solitary swims, and social swims. These comparisons were made between the newborn phase and year one, as well as between year one and year two. Since there were only four videos for the newborn phase, but 16 for year one, z-scores were used for the t-test to compare year one and the newborn phase. Z-scores were calculated relative to the timeframe they represented (not over the two years total). This allowed the t-test to compare the score distribution for year one and the newborn phase exclusively, as opposed to the two timeframes relative to the overall score distribution.

While the PCA and t-tests allowed for an investigation of the scores of the whales overall, graphing the data allowed for a visual representation of the calves' individual differences. Graphs were created for both the calves' z-scores on each of the five temperament factors as well as their swim states over time. The figures created a visual representation of the ontogeny of the behavioral patterns for each whale.

Reliability

Intercoder reliability was determined using 20% of the data, roughly one video per month for each calf were randomly selected. Videos were coded with regard to the frequency and duration of set behaviors. Cohen's kappa (1960) wherein $(\kappa) = (p_o - p_e) / (1 - p_e)$, wherein p_o = observer agreement and p_e = agreement expected by chance, was

used to calculate reliability, which was set for 80% agreement, between two independent coders. A built-in Cohen's kappa function in BORIS was used to determine agreement between coders for each selected video. Agreement was then averaged across 52 videos that were coded for reliability.

CHAPTER III - RESULTS

Patterns of Behavior in a Beluga Calf Population

The original behaviors that were coded were consolidated into 23 behaviors and three swim states for analysis, due to the context specific nature of some of the behaviors. Social play included mouth to mouth interactions, sexual play, s postures, erections, and social play. Water play included spit water, water play, bubble streams, bubble bursts, bubble rings, biting bubbles, orienting at bubbles, open mouths for bubble and water play, and water fountains. Motor play included beaching on the slide out, playful biting, hula-ing, bowing, underwater spins/ barrel rolls, motor play, surfing on the slide out, fluke out dives, playful head jerks, and chasing. EED play included orienting at the EED, object play (both EED and non EED), bite EED, orient at EED, and affiliative rubs on the EED. Display behaviors included breach, chest slap, pectoral flipper slap, chin slap, fluke slap, back slap, aggressive head jerks, exploratory head herks, chuffing, and unspecified head jerks. Exploratory behaviors included chin ups and spy hops. All other behaviors were coded in the same fashion that they were analyzed.

The PCA revealed that several behaviors did not occur frequently enough to correlate with other behaviors and were consequently removed. One of the behaviors removed from the PCA was the “startle/flee” behavior. This behavior was characterized by a sharp reaction by the calf, followed by rapid swimming away from where the whale was. The startle/flee behaviors would naturally be classified as submissive, but were not observed enough to load onto the temperament model. Consequently, while included in the t-tests, submissive behaviors were not represented in the temperament model. The startle/flee behavioral category included both the startle/flee response and being herded.

Other initiate swim and other leave swim behaviors were also excluded from the PCA, as they were not a reflection of the calves' behavior and therefore did not influence the temperament of the calves. Overall, three behaviors were excluded from the PCA, but still used in the t-test. This resulted in 20 behavioral frequencies for the PCA and 23 for the T-tests. Both t-tests and the PCA had three swim states.

Other behaviors, such as displace other whale, were only coded several times across the observations. As a result, they did not occur frequently enough to make them meaningful metrics for additional analysis. Since these behaviors also did not fit with any of the behaviors used for the PCA they were completely removed from the data analysis. Likewise, aggressive behaviors were not seen very frequently. Some aggressive behaviors like jaw claps, which were in the original ethogram, were never observed. Consequently, aggressive behaviors (jaw clap, herding) were excluded from analysis completely.

From the seven observed calves, a general picture can be formulated of the most frequently occurring behaviors and swim states in beluga calves during their first two years of life as a whole (see Figure 3). Comparisons of each whale and each time frame back to the overall activity budget allowed for a more elaborate representation of each whale's individual behavioral patterns and the patterns of the calves as a whole throughout their development.

Table 3

Beluga Whale Behavior the First Two Years of Life

Behavior:	Mean	Min	Max	N
Other initiate swim	1.40 +/- 2.35	0.00	15.00	252.00
Other leave swim	1.14 +/- 1.93	0.00	11.00	252.00
Swim with mother (f)	4.02 +/- 4.42	0.00	42.00	252.00
Swim solo (f)	5.11 +/- 4.62	0.00	21.00	252.00
Swim social (f)	2.08 +/- 3.18	0.00	15.00	252.00
Display	0.33 +/- 0.81	0.00	6.00	252.00
Startle	2.10 +/- 3.86	0.00	27.00	252.00
Orient trainer	0.94 +/- 3.61	0.00	39.00	252.00
Orient researcher	2.29 +/- 8.70	0.00	80.00	252.00
Orient environment	3.13 +/- 6.31	0.00	42.00	252.00
Orient wall	1.65 +/- 2.85	0.00	17.00	252.00
Orient whale	1.00 +/- 1.90	0.00	16.00	252.00
Orient lag	0.12 +/- 0.63	0.00	8.00	252.00
Exploratory behavior	3.58 +/- 8.54	0.00	73.00	252.00
Play social	0.74 +/- 2.50	0.00	21.00	252.00
Water play	6.84 +/- 11.90	0.00	127.00	252.00
Motor play	3.49 +/- 6.90	0.00	56.00	252.00
EED play	3.40 +/- 15.70	0.00	156.00	252.00
Affiliative rub mother	1.16 +/- 2.71	0.00	22.00	252.00
Affiliative rub other	0.54 +/- 1.69	0.00	18.00	252.00
Affiliative rub exhibit	1.81 +/- 3.98	0.00	28.00	252.00
Calf initiate swim	2.87 +/- 3.41	0.00	19.00	252.00
Calf leave swim	3.09 +/- 3.58	0.00	21.00	252.00
Swim with mother percentage	47.35 +/- 38.42	0.00	100.00	252.00
Swim solo percentage	46.34 +/- 36.27	0.00	100.00	252.00
Swim social percentage	6.31 +/- 12.43	0.00	95.96	252.00

In order to determine reliability, two independent coders analyzed video data.

The second coder observed 52 videos, approximately 20% of the videos. Both coders were over 80% reliable for the videos that were coded for reliability. The average agreement was 90.81% and agreement ranged from 65.4 % to 100%.

An initial Principal Component Analysis (PCA) revealed that there were at least two factors with significant relationships. The KMO score was greater than .5, meaning that the sample size was adequate. The Bartlett's Test of Sphericity was highly

significant, meaning that at least two behaviors are highly correlated. The matrix table of the initial PCA suggested a six-factor model. When comparing the five- and six- factor solutions, with a Varimax orthogonal rotation, there were fewer double loadings and stronger loadings on the five-factor model. The five-factor solution was still in agreement with the scree plot (see Figure 2) and yielded only factors with eigenvalues greater than one (Costello & Osborne, 2005).

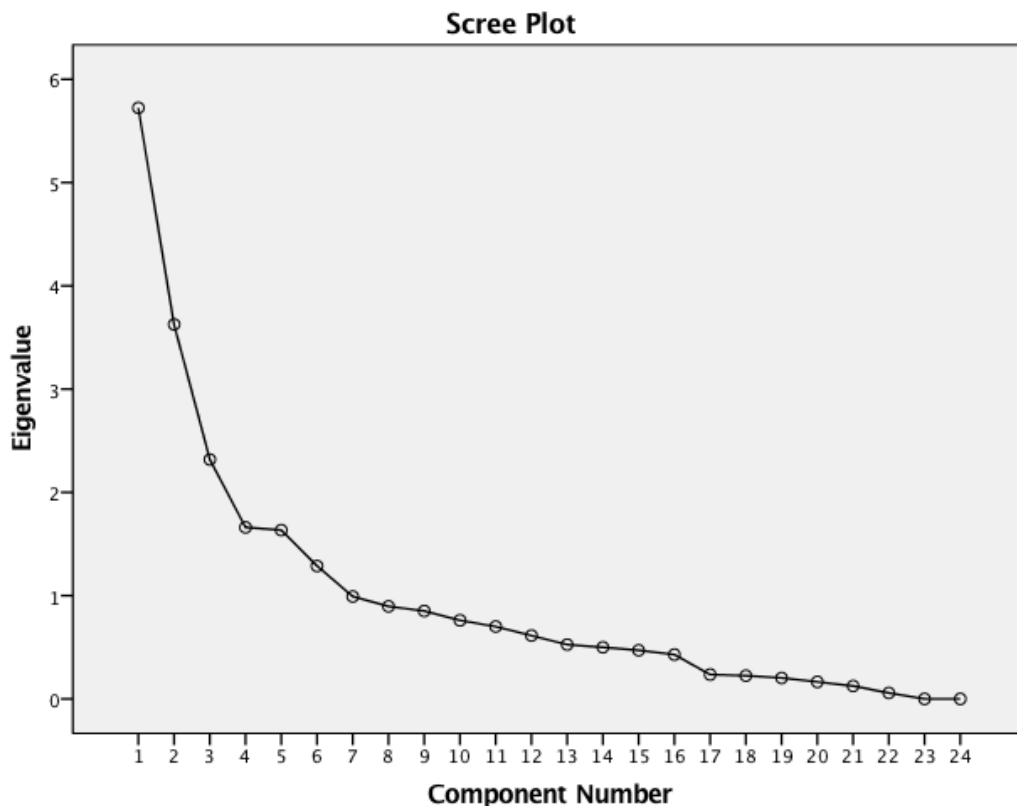


Figure 2. PCA Scree Plot of Beluga Behavior During the First Two Years of Life

Although several items had double loadings in the rotated five-factor solution, the behaviors were more evenly distributed among the factors and the groupings made theoretical sense. In instances where there were double loadings (see Table 4), the stronger loading was used (Schumacker & Lomax, 2010). Affiliative rub mother was

barely past the .3 cutoff. It was also double loaded. While this would normally cause a factor to be excluded, it made theoretical sense where it did load and was thought to be an important behavior contributing to temperament. As a result, the affiliative rub on mom behavior remained as part of the model (Costello & Osborne, 2005; Schumacker & Lomax, 2010). The double loading of the affiliative rub on mom behavior onto both the mother-calf bond and the independence factor is likely the result of the calves' inability to rub their mother unless they were swimming with her. Consequently, affiliative rub mother loaded along with the swim with mother frequency and the swim with mother percentage, which loaded onto different factors. EED play was also just above the .3 threshold, but was also considered to be an important behavior and remained in the analysis. Despite this fact, the five-factor model was still the most robust model of beluga temperament.

Table 4

PCA Loadings for Beluga Behavior During the First Two Years of Life

Rotated Component Matrix

Behavior	Component				
	1	2	3	4	5
Swim with mother (<i>f</i>)	0.84				
Swim solo (<i>f</i>)	0.84	0.33			
Swim social (<i>f</i>)	0.46	0.64			
Display				0.77	0.39
Orient trainer				0.81	
Orient researcher					0.69
Orient environment				0.65	
Orient wall			0.62	0.35	
Orient whale					0.56
Orient lag		0.45			
Exploratory behavior				0.80	
Play social		0.77			

Table 4 (continued).

Water play			0.66
Motor play			0.71
EED play			0.37
Affiliative rub mother	0.32		-0.31
Affiliative rub other		0.83	
Affiliative rub exhibit			0.64
Calf initiate swim	0.89		
Calf leave swim	0.83		
Swim with mother percentage*			-0.83
Swim solo percentage			0.85
Swim social percentage		0.88	

*scores reversed

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

The behavior swim with mother (percentage) loaded negatively on factor three. Accordingly, the scores for this behavior were reversed to calculate Cronbach's alpha. All five factors had relatively reliable alpha values. Factor one had a Cronbach's alpha of .841, factor two had a Cronbach's alpha of .562, factor three had a Cronbach's alpha of .692, factor four had a Cronbach's alpha of .752, and factor five had a Cronbach's alpha of .476.

Table 5 demonstrates which behaviors loaded on each of the five factors. Factor one was thought to demonstrate the mother-calf bond, factor two sociability, factor three independence, factor four exploration and vigilance, and factor five curiosity and playfulness. Overall, the five-factor model explained 61.54% of the variance.

Table 5

Five Factor Model for Beluga Temperament Over the First Two Years of Life

Factor 1: Mother-calf bond	Factor 2: Sociability	Factor 3: Independence	Factor 4: Exportation – vigilance	Factor 5: Curiosity - playfulness
Swim with mother frequency	Swim social frequency	Orient at wall	Orient at trainer	Orient at researcher
Swim solo frequency	Orient lag	Affiliative rub exhibit	Orient environment	Orient at whale
Affiliative rub on mother	Play social	Swim with mother* (percentage)	Exploratory behavior	Water play
Calf initiate swim	Affiliative rub other whale	Swim solo (percentage)	Display behavior	Motor play
Calf leave swim	Swim Social (percentage)			EED play

*loaded negatively

Table 6 shows the loadings for a PCA looking at only the first year of the beluga calves' lives. A varimax orthogonal rotation was used to create a five-factor model for the purposes of comparison with the five-factor model that represented the first two years of the calves' lives. This model explained 62.8 % of variance, making it a comparably strong model to that of the first two years. Meanwhile, behaviors during the first year of life loaded differently than those over the first two years.

Table 6

PCA Loadings for Beluga Behavior During the First Year of Life

Behavior	Component				
	1	2	3	4	5
Swim with mother (<i>f</i>)			.89		
Swim solo (<i>f</i>)		.53	.70		
Swim social (<i>f</i>)	.34	.76			
Display	.69				.33
Orient trainer			.32		.62
Orient researcher	.83				
Orient environment	.45				.74
Orient wall				.73	
Orient whale	.75				
Orient lag		.30			
Exploratory behavior				.31	.74
Play social		.71			
Water play	.82				
Motor play	.71				.40
EED play					
Affiliative rub mother			.64		
Affiliative rub other		.67			
Affiliative rub exhibit				.72	
Calf initiate swim		.43	.76		
Calf leave swim		.38	.79		
Swim with mother percentage		-.33		-.84	
Swim solo percentage				.88	
Swim social percentage		.83			

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

Table 7 shows the loadings for a PCA looking at only the second year of the beluga calves' lives. A varimax orthogonal rotation was used to create a five-factor model for the purposes of comparison with the five-factor model that represented the first two years of the calves' lives and the five-factor model that represented the calves' first year of life. This model explained 64.8 % of variance, making it a comparably strong model to that of the first two years cumulatively and the first year on its own. Behaviors

loaded during the second year of life loaded differently than those over the first two years together, as well as the first year alone.

Table 7

PCA Loadings for Beluga Behavior During the Second Year of Life

Behavior	Component				
	1	2	3	4	5
Swim with mother (<i>f</i>)	0.797				
Swim solo (<i>f</i>)	0.903				
Swim social (<i>f</i>)	0.598	0.535		0.347	
Display			0.799		
Orient trainer			0.789		
Orient researcher					0.46
Orient environment			0.741		
Orient wall			0.496	0.39	
Orient whale	0.461	0.387			
Orient lag		0.698			
Exploratory behavior			0.744		0.486
Play social		0.856			
Water play				0.4	
Motor play					0.7
EED play					0.796
Affiliative rub mother				-0.496	
Affiliative rub other		0.894			
Affiliative rub exhibit				0.449	
Calf initiate swim	0.92				
Calf leave swim	0.885				
Swim with mother percentage				-0.849	
Swim solo percentage				0.832	
Swim social percentage		0.872			

Extraction Method: Principal Component Analysis.
 Rotation Method: Varimax with Kaiser Normalization.

Despite accounting for quite a bit of the variance, 62.8 % and 64.8 %, the same factors did not emerge from the analysis of year one and year two independently. Consequently, while the beluga calves were showing distinct patterns of behavior in both

the first and second years of their lives, there appeared to still be some fluidity in these patterns between the two years.

Since the PCAs revealed that there were differences between the year one and year two, a paired-samples t-test was conducted to further explore where those differences occurred. There were not enough videos during the newborn phase to run a PCA, but a t-test, using Z-scores, was used to compare year one and the newborn phase.

The paired samples t-test revealed significant differences for 10 behaviors between year one and year two. These behaviors included display, startle, orient trainer, orient environment, exploratory behavior, motor play, EED play, affiliative rub exhibit, swim with mom percentage and swim solo percentage (see Figure 8). Both the frequency of rubs on the exhibit and the percentage of time the calves spent swimming with their mothers significantly decreased between year one and year two. All of the other significant behaviors increased between year one and year two.

The paired samples t-test revealed significant differences for 15 behaviors between the newborn phase and year one (see Table 8). These behaviors included other leave swim, swim with mom frequency, swim solo frequency, swim social frequency, display, startle, orient trainer, orient researcher, orient wall, play social, water play, calf initiate swim, swim with mom percentage, swim solo percentage, and swim social percentage. The only behavior that significantly decreased between the newborn phase and year one was the percentage of time engaged in the swim with mom behavior. Orient researcher behavior was the only behavior that was not observed during the newborn phase. These results demonstrate that the beluga calves' behavior was significantly different between the newborn phase and year one.

Table 8

Descriptive Statistics for Beluga Behavior

Behavior:	Year Two			Year 2 vs. Year 1		Year One		Year 1 vs. Newborn		Newborn	
	Mean	Z-Score		p value	t value	Mean	Z-Score	p value	t value	Mean	Z-Score
Other initiate swim	1.28 +/- 2.11	-0.05		0.59	0.54	1.43 +/- 2.15	0.01	0.63	0.49	1.82 +/- 3.73	0.18
Other leave swim	1.08 +/- 1.90	-0.03		0.28	1.08	1.36 +/- 2.08	0.11	0.00*	-3.15	0.50 +/- 1.07	-0.33
Swim with mother (f)	3.59 +/- 3.63	-0.10		0.06	1.90	4.71 +/- 5.29	0.16	0.01*	-2.79	3.00 +/- 2.97	-0.23
Swim solo (f)	5.36 +/- 4.51	0.05		0.79	0.27	5.51 +/- 4.89	0.09	0.00*	-4.86	2.54 +/- 2.90	-0.56
Swim social (f)	2.30 +/- 3.22	0.07		1.00	0.00	2.3 +/- 3.40	0.07	0.00*	-5.27	0.32 +/- 0.77	-0.55
Display	0.54 +/- 1.08	0.27		0.00*	-3.11	0.19 +/- 0.46	-0.18	0.02*	-2.50	0.04 +/- 0.19	-0.36
Startle	3.25 +/- 4.78	0.30		0.00*	-3.51	1.37 +/- 2.83	-0.19	0.03*	-2.37	0.46 +/- 1.17	-0.42
Orient trainer	1.68 +/- 5.15	0.20		0.02*	-2.45	0.43 +/- 1.39	-0.14	0.04*	-2.21	0.07 +/- 0.38	-0.24
Orient researcher	3.26 +/- 10.54	0.11		0.28	-1.09	1.89 +/- 7.61	-0.05	0.01*	-2.62	0.00 +/- 0.00	NA
Orient environment	4.31 +/- 7.46	0.18		0.01*	-2.72	2.09 +/- 3.90	-0.17	0.74	0.34	2.61 +/- 8.28	-0.09
Orient wall	1.89 +/- 3.18	0.08		0.42	-0.81	1.64 +/- 2.74	0.00	0.01*	-2.64	0.75 +/- 1.48	-0.32
Orient whale	1.04 +/- 1.67	0.02		0.85	0.19	1.08 +/- 2.20	0.04	0.17	-1.42	0.57 +/- 1.45	-0.23
Orient lag	0.13 +/- 0.47	0.02		0.91	-0.12	0.13 +/- 0.82	0.01	0.31	-1.04	0.04 +/- 0.19	-0.13
Exploratory behavior	6.04 +/- 11.80	0.29		0.00*	-3.56	1.82 +/- 3.59	-0.21	0.10	-1.71	0.82 +/- 2.48	-0.32
Play social	0.88 +/- 2.60	0.06		0.75	-0.33	0.77 +/- 2.69	0.01	0.01*	-2.97	0.04 +/- 0.19	-0.28
Water play	7.70 +/- 9.19	0.07		0.70	-0.38	7.14 +/- 15.00	0.03	0.01*	-2.77	2.21 +/- 4.28	-0.39
Motor play	4.71 +/- 8.13	0.18		0.04*	-2.12	2.69 +/- 6.07	-0.12	0.30	-1.06	1.79 +/- 2.74	-0.25
EED play	6.54 +/- 22.77	0.20		0.01*	-2.50	1.05 +/- 4.47	-0.15	0.11	-1.65	0.25 +/- 1.32	-0.20
Affiliative rub mother	0.90 +/- 2.01	-0.10		0.52	0.65	1.07 +/- 2.10	-0.03	0.15	1.50	2.57 +/- 5.58	0.52
Affiliative rub other	0.63 +/- 2.10	0.05		0.70	-0.39	0.54 +/- 1.39	0.00	0.08	-1.83	0.18 +/- 0.61	-0.21
Affiliative rub exhibit	1.08 +/- 1.95	-0.18		0.00*	2.99	2.57 +/- 5.30	0.19	0.30	-1.06	1.68 +/- 3.48	-0.03
Calf initiate swim	3.00 +/- 3.27	0.04		0.60	0.53	3.22 +/- 3.71	0.10	0.00*	-5.69	0.96 +/- 1.82	-0.56
Calf leave swim	3.13 +/- 3.33	0.01		0.88	0.15	3.2 +/- 3.75	0.03	0.36	-0.93	2.50 +/- 3.90	-0.17
Swim with mother percentage	39.43 +/- 35.53	-0.21		0.00*	2.90	50.87 +/- 38.52	0.09	0.02*	2.56	65.00 +/- 42.41	0.46
Swim solo percentage	52.98 +/- 34.35	0.18		0.01*	-2.68	42.97 +/- 35.95	-0.09	0.05*	-2.05	33.24 +/- 40.71	-0.36
Swim social percentage	7.59 +/- 14.35	0.10		0.40	-0.85	6.164 +/- 11.37	-0.01	0.02*	-2.54	1.76 +/- 5.55	-0.37

*denotes significant values, $p \leq 0.05$

Since there appeared to be overarching trends in swim states across time, swim states were graphed across all whales over time. Atla was an outlier among the other whales (see Figure 3). Consequently, she was excluded from subsequent analyses of the calves' swim states over the first two years of life. Figures 4-6 show the ontogeny of the other six calves' swims states across the newborn phase, year one and year two.

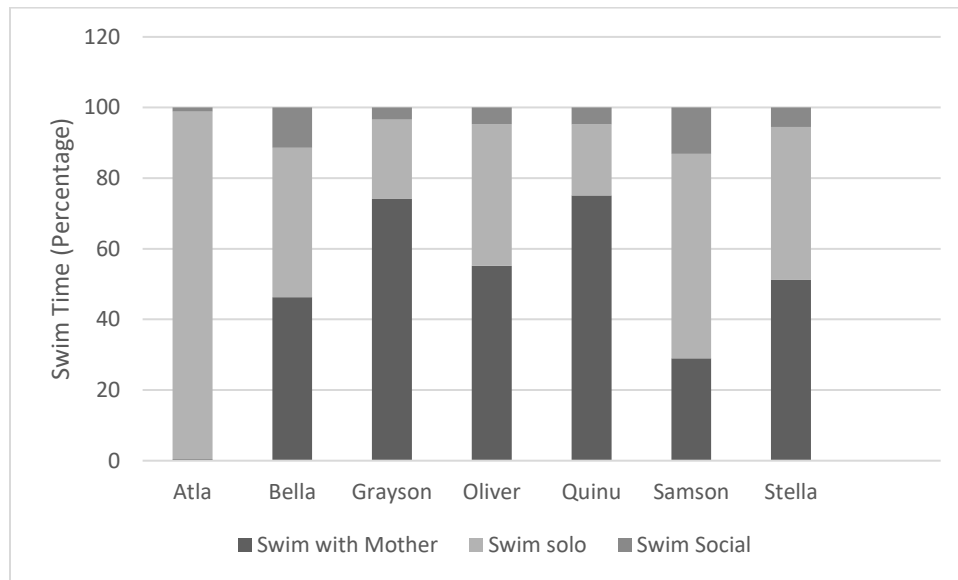


Figure 3. Average Swim State Percentages During the First Two Years of Life

Figure 4 demonstrates that, overall, beluga calves swam the most with their mother during the newborn phase. The calves decreased the amount of time they spent with their mother as they got older. T-tests revealed that the calves spent significantly more time swimming with their mothers in the newborn phase than year one. The t-test also exhibited that the calves spent significantly less time swimming with their mother in year two than they did in year one (see Table 8).

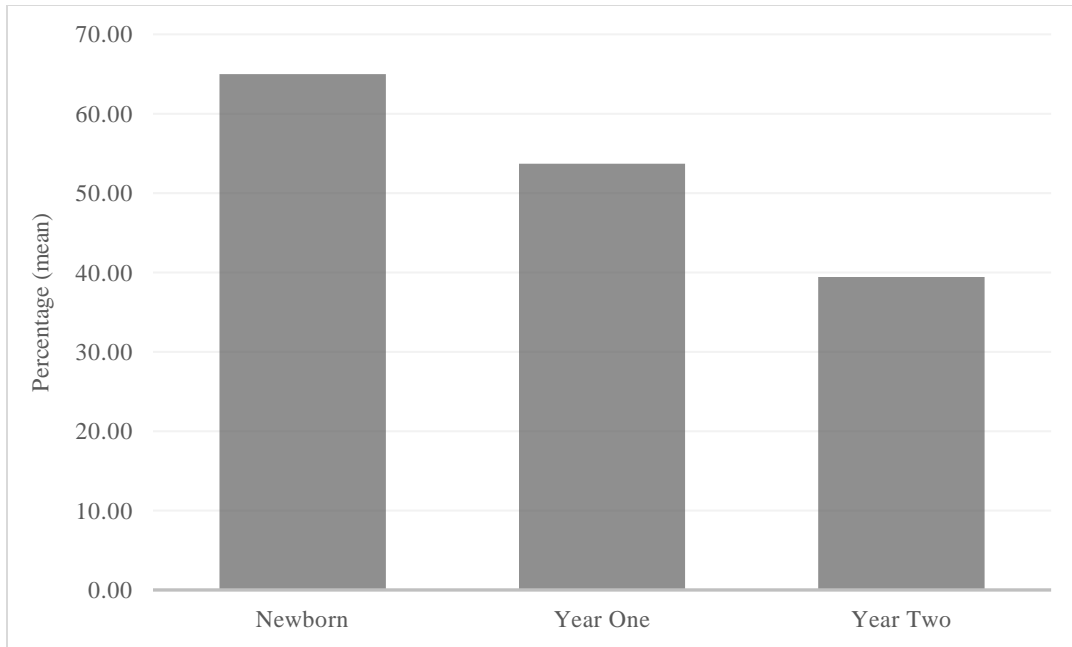


Figure 4. Average Swim with Mother Behavior During the First Two Years of Life

Figure 5 demonstrates that, overall, the calves increased the amount of time they spent swimming socially, with whales other than their mother, as they got older. The t-test revealed that there was a significant increase in the percentage of time spent engaging in social swims between the newborn phase and year one. A significant difference was not found between year one and year two (see Table 8).

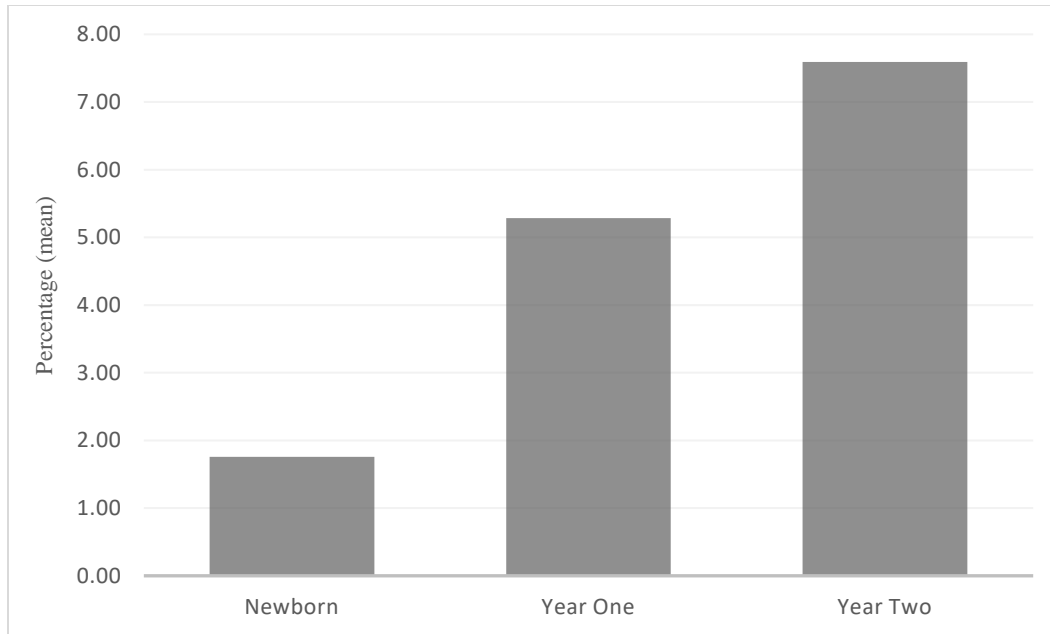


Figure 5. Average Social Swim Behavior During the First Two Years of Life

Figure 6 demonstrates that, overall, the calves increased the amount of time they spent swimming alone as they got older. T-test revealed that there was a significant increase in the percentage of time spent engaging in social swims between the newborn phase and year one. A significant difference was also found in the percentage of time engaging in solitary swims between year one and year two (see Table 8).

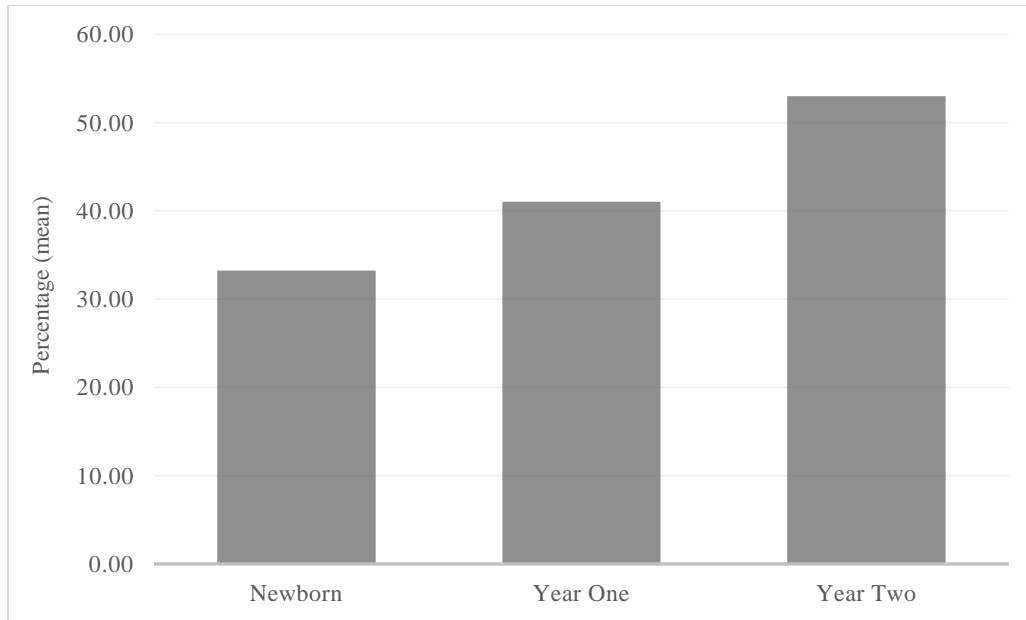


Figure 6. Average Solo Swim Behavior During the First Two Years of Life

Individual Patterns of Behavior in Beluga Whale Calves

After discovering the behavioral trends for the calves all together, it became relevant to look at the behavioral patterns and swim trends of each individual whale. Since frequencies and swim duration percentages loaded onto factors together, average z-scores used for this analysis. These z-scores reflected each individual whale's ranking for the behaviors for each temperament trait. The percentage of time each individual whale spent in each of the three swim states was also graphed to investigate the ontogeny of their independence from their mother. The swim states and temperament trait rankings together provide a robust depiction of each whale's unique behavioral patterns throughout the first two years of life.

As was previously mentioned, Atla was an outlier from the other whales. Atla, was the least bonded to her mother, and consequently the most independent whale (see Figure 7). She almost exclusively swam by herself and very rarely was engaged in social

swims of swims with her mother (see Figure 8). This is reflected in her low mother-calf bond score and low sociability score, paired with her high independence score. Atla was very vigilant of her environment, and was a little lower than average with regards to curiosity and playfulness.

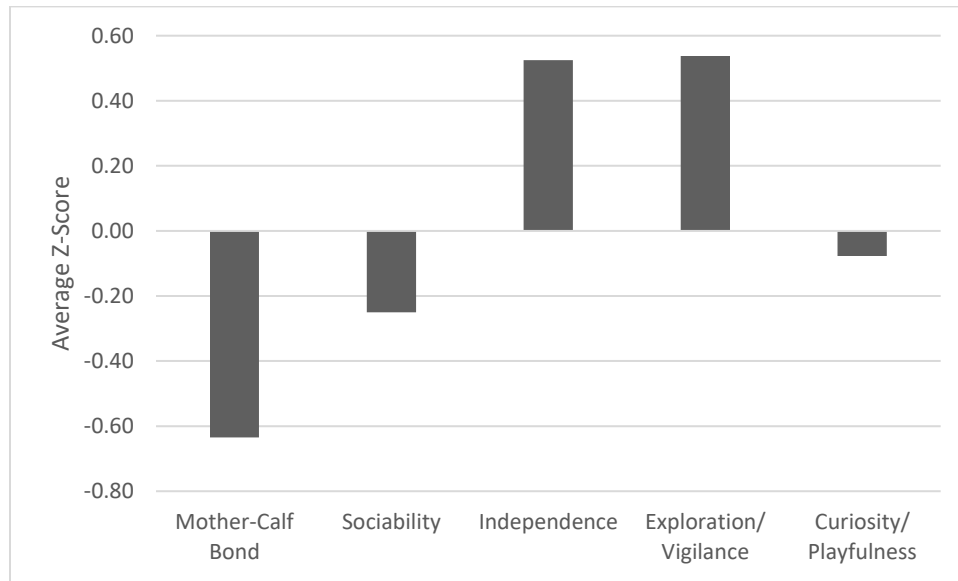


Figure 7. Atla Temperament Scores During the First Two Years of Life

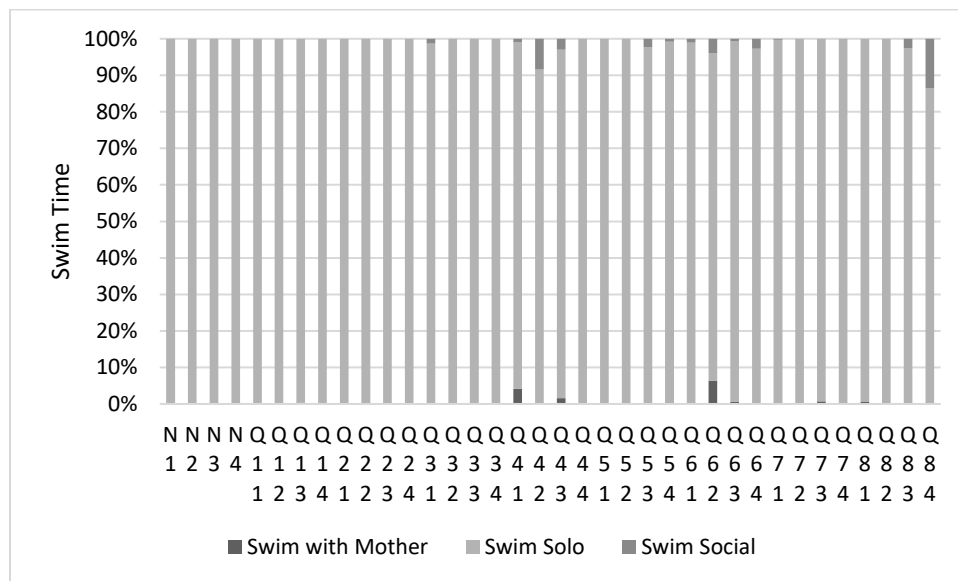


Figure 8. Atla Swim States for the First Two Years of Life

Bella had the highest sociability score (see Figure 9). Unlike Atla, Bella engaged in multiple types of swims. Bella had the second strongest bond with her mother (just below Grayson). Initially she spent more time swimming with her mother and did not spend as much time engaged in social swims (See Figure 10). Around the start of quarter three she began to have more social interactions. After that around year one she had a spike in swimming with her mother again, and then became increasingly independent. Bella was the second most independent whale (second to Atla). She was not overly vigilant of things outside of her environment, but she was curious and playful with object within her environment, such as EEDs and engaged in a lot of water play.

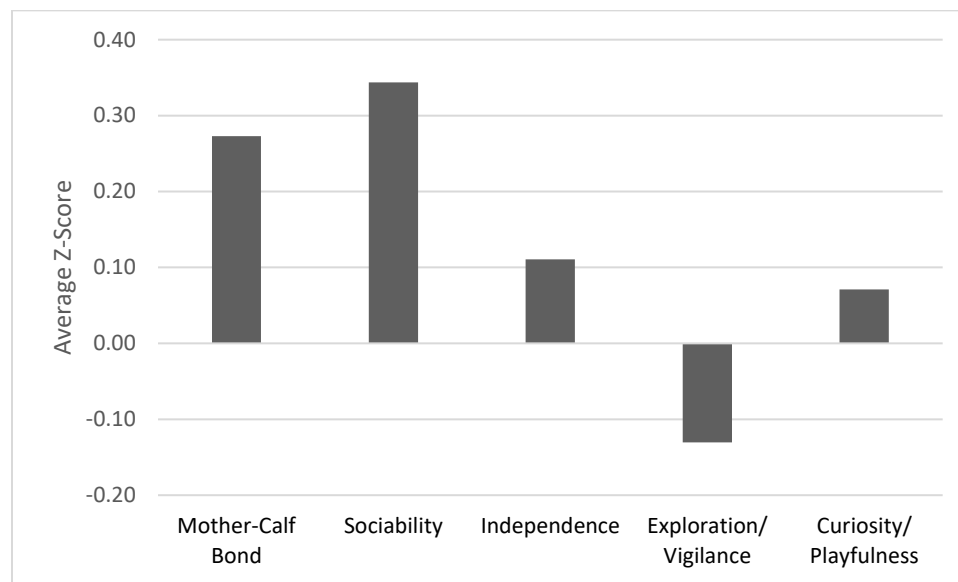


Figure 9. Bella Temperament Scores During the First Two Years of Life

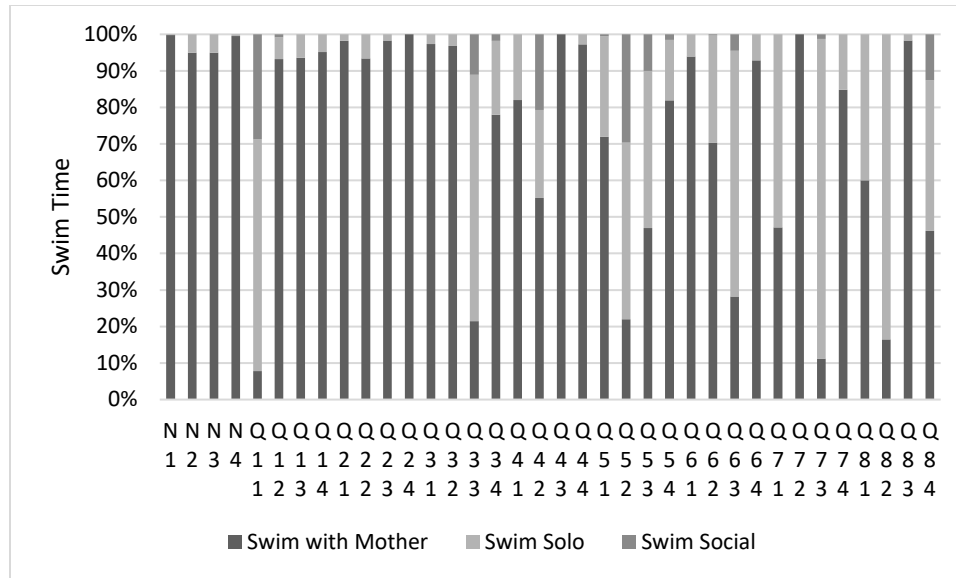


Figure 12. Grayson Swim States for the First Two Years of Life

Oliver initially spent all of his time with his mother, and then became increasingly independent (see Figure 14). Although Oliver initially swam with his mother a lot, he almost exclusively engaged in solo swims during his second year of life. This resulted in a weak mother-calf bond being portrayed (second to Atla), and low sociability (see Figure 13). On the other hand, Oliver was not ranked as being highly independent like Atla. Oliver ranked just below average for exploration and just above average for curiosity and playfulness.

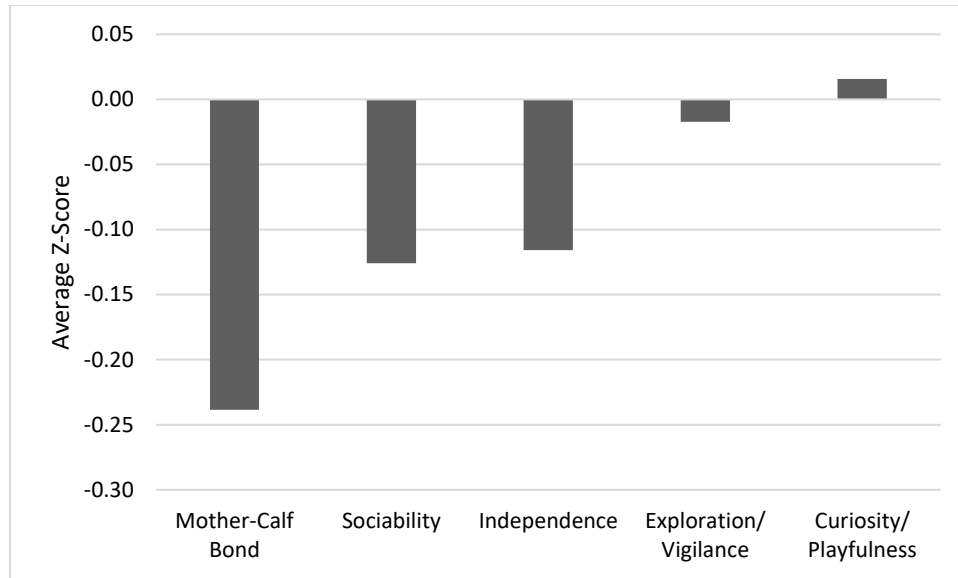


Figure 13. Oliver Temperament Scores During the First Two Years of Life

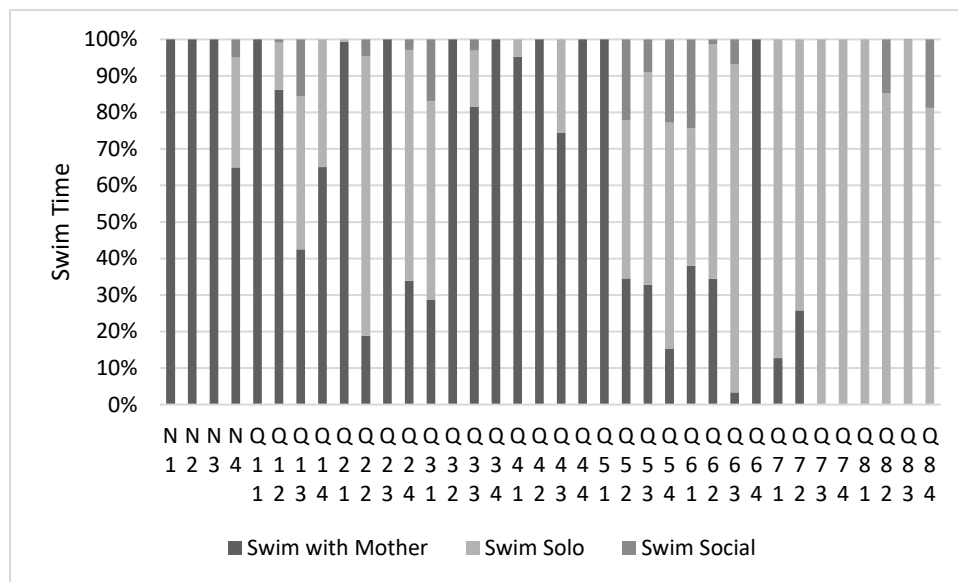


Figure 14. Oliver Swim States for the First Two Years of Life

Qinu spent the majority of her time engaged in mother calf swims (see Figure 15). Unlike most of the other whales, Qinu does not have a noticeable shift to more solitary swimming as she got older. This pattern is reflected in her positive mother-calf bond (see

Figure 16). Qinu was not highly social, resulting in the second lowest sociability score (second to Atla). She also had the second lowest score for exploration (second to Grayson). She also was not as playful or independent as some of the other whales

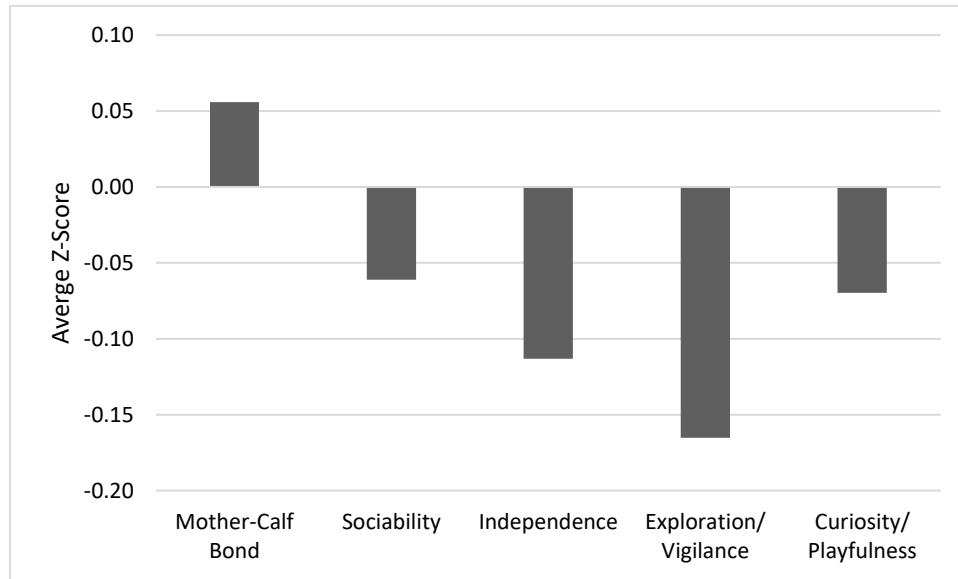


Figure 15. Qinu Temperament Scores During the First Two Years of Life



Figure 16. Qinu Swim States for the First Two Years of Life

Samson engaged in more solitary swimming than all of the other whales, except his sister Atla (see Figure 18). While he did spend some time swimming with his mother, as is reflected in his positive mother-calf bond (see Figure 17), as a young calf he did not engage in a lot of mother calf swims. This suggested that it took him a longer time to bond with his mother. Samson went through a highly social bout around Quarter 6 (1.5 years), and ranked high on sociability (second to Bella). Because he was highly social, Samson was also the second least independent (second to Grayson). Like Atla, Samson employed in the second most explorative behaviors (second to Atla). Samson was just above average in his level of curiosity and playfulness.

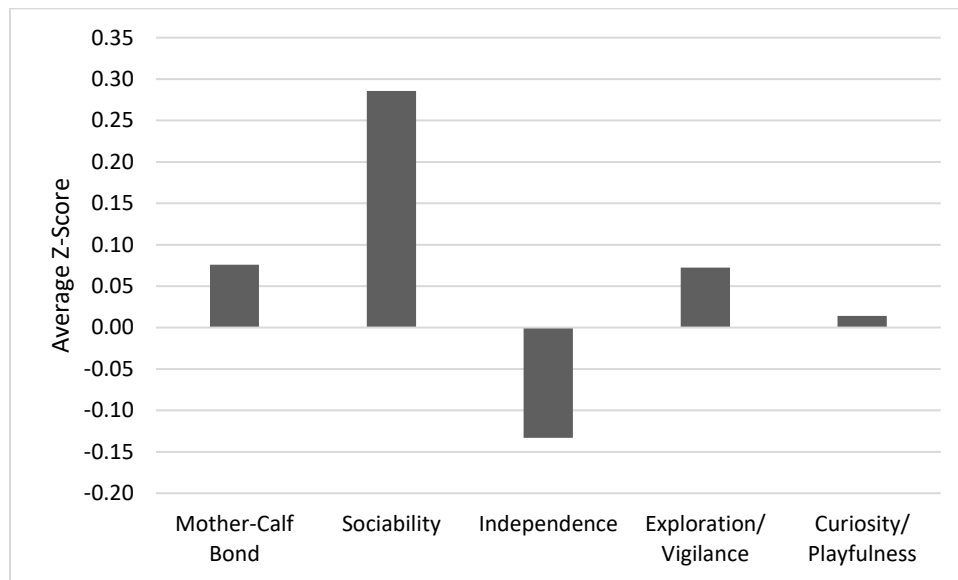


Figure 17. Samson Temperament Scores During the First Two Years of Life

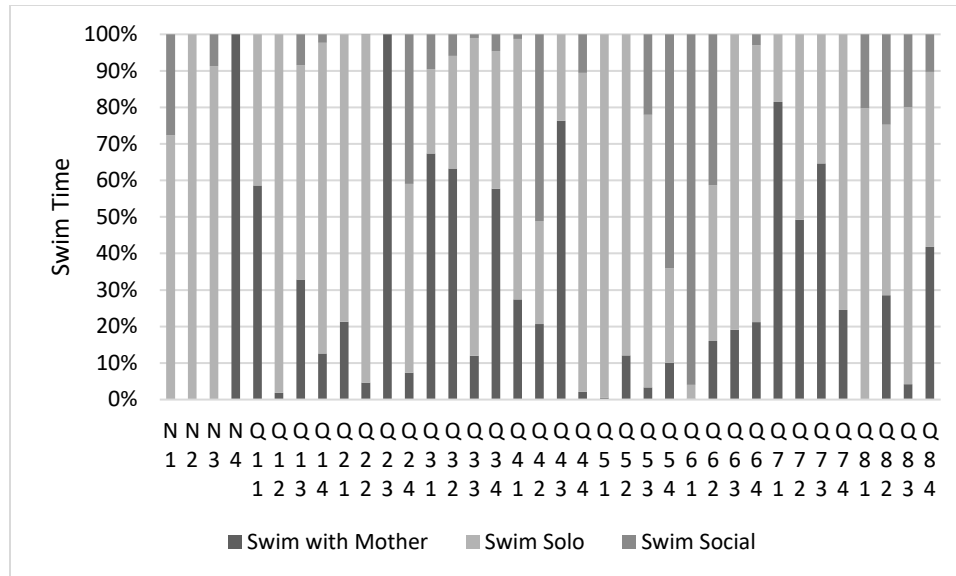


Figure 18. Samson Swim States for the First Two Years of Life

Stella maintained a high level of mother calf swimming throughout her first two years of life (see Figure 20). This was reflected in her positive bond with her mother (see Figure 19). Stella was not highly social with other whales, and had a low sociability rank. Stella is unique in that her independence almost has an inverse bell curve, while many of the other whales got increasingly independent as they got older. Stella did not rank high on independence for this reason. Stella did not exhibit a lot of vigilant behaviors, but she was the most playful and curious whale. She often engaged in bubble and water play, EED play, motor play, and oriented to the researcher.

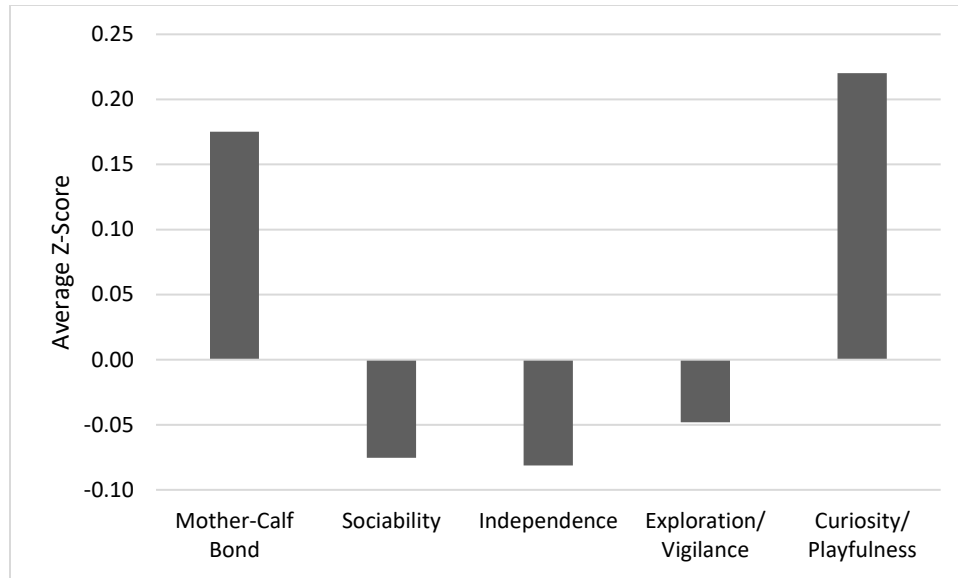


Figure 19. Stella Temperament Scores During the First Two Years of Life

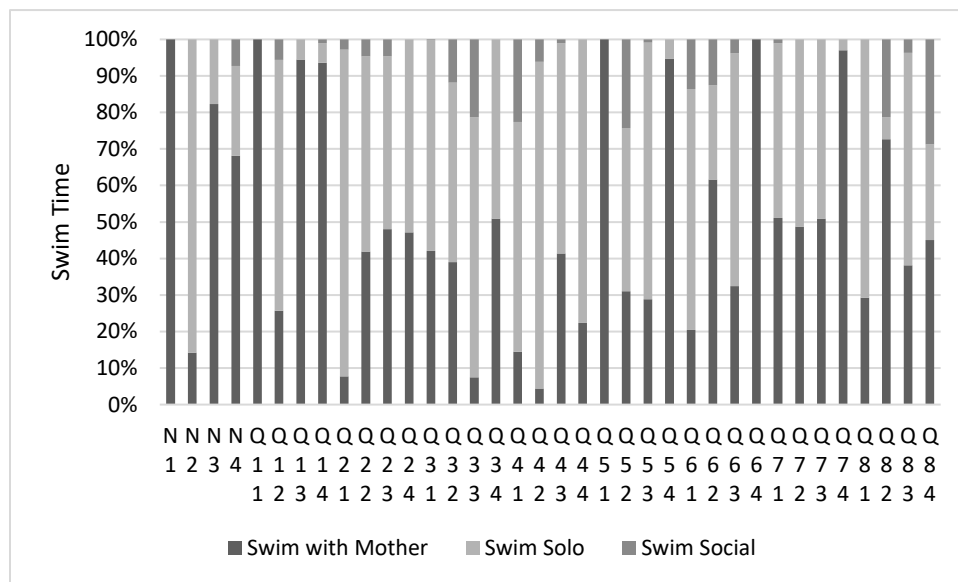


Figure 20. Stella Swim States for the First Two Years of Life

These graphical representations of the five-factor model, depict the varying degree to which each whale’s behavior represented these five factors. The variability of these measures across the whales indicates that each whale had his or her own unique

temperament composition. This suggests that the five-factor model was a robust interpretation for the behavioral patterns of the whales in their first two years of life.

CHAPTER IV – Discussion

A PCA of 23 behaviors across seven beluga whale calves yielded a five-factor model for beluga calf temperament. Factors included mother-calf bond, sociability, independence, exploration-vigilance, curiosity-playfulness. These results suggest that temperament is present in beluga whale calves within their first two years of life. Variability between the whales indicated that each whale had his or her own distinct behavioral pattern which lead to differing levels on the temperament scales. This pattern indicates that a five-factor model is a fitting model to represent temperament in beluga whale calves.

As McCrae et al. (2000) noted, mother-child bonds are an essential component to development and the ontogeny of behavioral patterns in humans. The same appears to be true for belugas. From an evolutionary standpoint, belugas have an intercalf interval of several years, indicating the importance of the mother-calf bond during the first few years of the calf's life (Tyack et al., 2000). Nonetheless, research has indicated that mothers provide varying degrees of maternal care and maternal behaviors (Guarino et al., 2017; Hill, 2009; Hill et al., 2007; Krasnova et al., 2006; Krasnova et al., 2009). Accordingly, it is fitting that that mother-calf bond presented itself as an integral factor for determining calf temperament.

Atla had the least strong bond with her mother and was an outlier in comparison to the other whales on most of the temperament scales and the swim states (see Figure 6 & 7). This suggests that her lack of strong maternal bonding influenced other temperament scales as well. Atla appeared to be more interested in human attention than

that of her mother, which often resulted in her swimming alone because no humans were around. Her mother, Luna, also exhibited very human-focused behavior. Luna's focus on seeking human attention likely impacted the amount of time and energy she spent bonding with her calf. Additionally, Atla was Luna's first calf. Samson, Atla's younger brother, exhibited a more positive relationship with his mother. Potentially, this could demonstrate that mothers learn more about parenting with each subsequent offspring. Another potential explanation is that the environment was different for Samson than for Atla. Stella was born right around the same time as Samson, which presented both Luna and Samson the opportunity to mirror the behavior of a conspecific mother and calf relationship. Beluga mothers often engage in alloparenting, which could have kept Luna more engaged and allowed Luna to let Samson socialize more than she let Atla socialize (Hill, 2009; Hill et al., 2014).

Other similarities between siblings were seen as well. In addition to Atla and Samson having the weakest association with their mother, they also engaged in the most explorative behaviors. Meanwhile, Bella and Stella had two of the highest levels of attachment to their mother, Crissy. Stella and Bella were the two most curious and playful whales and Samson and Atla were the two most explorative whales. Yet on the other factors, the siblings differed in their rankings. Again, these patterns support future research on genetic components and the influence of maternal styles and environment on the temperament of beluga whale calves.

While differing parenting styles in beluga whale calves have been explored from the maternal behavior perspective (Hill, 2009; Hill et al., 2013), further research is needed to look at the impact of calf behavior on maternal styles. Although Luna's

maternal style did not equally impact both Atla and Samson, she showed less interest in her calves and being with them than other beluga mothers.

Oliver also ranked as having a negative association with his mother, but likely for a different set of reasons. When Oliver was a year and a half old, his mother passed away, after being sick. While Oliver's mother, Martina, was ill she spent some time in a medical pool that separated her from the other whales so that she could more easily receive medical attention from the SeaWorld staff. This limited Oliver's ability to be with his mother during the second year of his life, which resulted in a noticeable difference in his swim state behavioral patterns (see Figure 14). Nonetheless, Oliver spent time associating with his mother while she was still alive and healthy, which explains why he shows a stronger affiliation to his mother than Atla, who never bonded with her mother. It also explains why he does not show a lot of independent behaviors. He was likely not independent by nature, and then had to readjust his behavior once his mother was no longer available.

These findings also shed light on the importance of looking at multiple facets of behavior and the advantages of doing research with animals under human care. Skrzypczak (2016), conducted a field study of Atlantic spotted dolphin calves, measuring sociability by looking at the amount of time calves spent within one body length of a conspecific. In the current study, a similar measure was used (social swim percentage), in addition to the frequency of social swims, social play, affiliative rubs with whales other than the calf's mother and orients and interactions with the lags. This painted a more robust portrait of the calves' behavioral patterns. Furthermore, doing research with animals under human care allowed the researchers to have access to more information

about outside variables (such as the whale's history and health as well as his or her mother's history and health). Consequently, the current model supports previous cetacean research, with a more detailed lens of sociability.

The second temperament factor examined the calves' sociability. More specifically, the calves' willingness to be outgoing and affiliative with other whales, as well as orienting at and interacting with lags in neighboring pools. Several factors influenced the sociability of the whales, in addition to the whales' temperaments. For example, the availability of conspecifics and more importantly, the age and gender of other conspecifics. Belugas differ from other cetaceans in their sociability. A killer whale calf in human care did not engage in social interactions until six months of age (Guarino et al., 2017). The belugas at SeaWorld, on the other hand, mirrored those in the wild, who have been seen engaging in social interaction as early as two weeks of age (Krasnova et al., 2009).

Although Samson and Stella were born the same year, the majority of Samson's social interactions happened with Oliver, who was six years older than him. While Samson was a calf, Oliver was approaching sexual maturity, which may have been related to him to being more socially interactive. Similar to primates and spinner dolphins, beluga whales typically use social and sexual play to establish their sexual behaviors and dominance, as well as to create bonds (Glabicky et al., 2010). As a young inquisitive playful calf, Samson served as a younger male companion and playmate for Oliver, as well as providing a target for Oliver to practice his dominance and sexual behaviors, while also creating affiliative bonds. Bella, the most social whale, was social with Qinu and Grayson (and Oliver), who were a year and two years older than she was.

Oliver and Grayson, on the other hand, did not have access to older calves to interact with when they were calves. In fact, for almost the entire first year of their lives, they did not have access to any whales other than each other and their mothers. They also did not have access to lags. Consequently, while Oliver and Grayson interacted with one another and their mothers, they initially had fewer social interaction opportunities than any of the other calves. These social constraints likely explain why their sociability and independence levels were so similar.

Looking at swim percentages, it can be seen that overall the calves spent more time engaging in social swims as they became more independent (see Figures 8, 10, 12, 14, 16). That being said, social swims were less frequent than any other type of swim. There were significantly more social swims in year one than in the newborn phase (see Table 8). Consequently, beluga calves were social, but in a relative way, due to the fact that they spent more time engaging in solitary swims and swims with their mothers. In the newborn phase, the whales spent on average 1.76% of their time engaging in social swims. In year one it went up to 6.16 % and by year two it increased to 7.59% (see Table 8). This increased independence with age in calves mirrors that which has been observed in beluga whales in the wild (Krasnova et al., 2009). Further research is needed to see if belugas become more social beyond their second year of life, or if they spend a large portion of their time alone.

The third factor examined independence and introversion. The behaviors seen in this category included affiliative rubbing with the exhibit, orienting to the wall, and amount of time spent swimming alone. Swimming with the calf's mother was inversely related on this factor. This pattern makes sense from a theoretical standpoint because

being social other whales and being social with one's mother are different. Furthermore, since beluga calves are typically dependent upon their mothers, especially while they are young, it makes sense that the opposite of being independent would be dependently swimming with one's mother. Wall, gate, and exhibit rubbing behaviors that were exhibited by the whales were also most frequently done when the whales were alone. These behaviors were exhibited the most by Atla and Bella.

The amount of time the whales spent swimming with their mothers decreased as the calves got older (see Figure 4). This was the inverse of (social and) solo swims (see Figure 5 and Figure 6). As the calves got older, they increased their number of solo swims, increasing their independence. During the newborn phase, whales swam with their mothers on average 65% of the time. By year one this decreased to 50.87%, and by year two it was at 39.43% (see Table 8). For solitary swims, newborns spent an average of 33.29% of their time swimming alone, this increased to 42.97% by year one and 52.98% of their time year two. This pattern reflects the literature that calves get more independent as they get older, even though they are initially more dependent upon their mothers (Hill, 2009; Hill et al., 2013; Hill et al., 2017; Krasnova et al., 2006, 2009).

Maternal parenting style likely had an impact on swim states, and consequently temperament. More permissive mothers were more likely to allow their calves to engage in solo swims than were more protective and present mothers (Hill, 2009). Atla, who was not bonded with her mother, had the greatest independence and spent the majority of her time swimming on her own (see Figure 3 and Figure 7).

Grayson, who was strongly bonded with his mother had the least amount of independence (see Figures 11, 12). As Figure 12 demonstrates, Grayson spent the

majority of his time swimming with his mother and very little time swimming on his own. Additional research would be needed to know if this was predominantly a reflection of Grayson's temperament or his mother's parenting, or more likely, a combination of the two. Grayson also was not overly vigilant of the environment outside of his pool, and he also did not engage in a lot of behavior exploring objects within the pool. Again, these behavioral patterns could be the result of the amount of time he spent swimming with his mother limiting the amount of time he had available for engaging in other more playful activities.

It is noteworthy that behavioral patterns reported reflect the calves' behavior only in the videos observed and could potentially present a snapshot that is not indicative of their overall behavior. Furthermore, because the behaviors are based on frequencies, it is possible that a whale that engaged in a behavior frequently in a few videos would rank higher than a whale that consistently engaged in a behavior in multiple videos, but with less frequency. This is a potential limitation to behavioral coding. Likewise, only behaviors that were observable have been reported. Since only one of the pools had an underwater viewing window, it is possible that a greater behavioral diversity was present than what could be observed due to visibility limitations (which were also impacted by things like glare and whales swimming into pools that were farther away).

Factor four pertained to exploration and vigilance. This temperament trait primarily involved the whales focusing their attention on things outside of their habitat. The behaviors coded as exploration included the whales lifting their head out of the water to orient to be vigilant of things outside of their pool, orienting toward their trainer, performing exploratory behaviors such as spy hopping and chin ups, which required the

whales to orient of their pool, and even display behaviors, such as bow jumps, which also allowed them to monitor their environment.

Atla was extremely vigilant about monitoring her environment. If trainers were near the exhibit she was almost always right by them and often engaging in display behaviors to try and elicit their attention. When the trainers were not present, Atla was often spy hopping to look for them. Luna, Atla's mother also spent a large portion of her time spy hopping and vocalizing at the edges of the pools looking for her trainers. Siblings Atla and Samson had the highest levels of environmental vigilance. One possible explanation is that these behaviors were learned from their mother, who also engaged in a lot of exploratory behaviors. Luna was very bonded to her trainers and often spent time engaged in behaviors both to seek the trainers' attention and to monitor her environment for the presence of a trainer. Similar behaviors were seen in both Samson and Atla. The calves often mimicked their mother's behavior. Atla would also use display behaviors, such as pectoral slaps to try and elicit attention from any trainers who were around. Since the trainers would eventually walk by the pools or engage the whales in a feeding session throughout the day, spy hopping and exploring the environment outside of their pool was variably reinforced, making it highly probable that the whales would repeat the behavior.

Furthermore, because Luna was such a permissive mother, this allowed her calves to explore their environment more. Both Samson and Atla spent a large amount of time engaging in solo swims, which allowed them to explore and be more vigilant of their environment. Again, this begs the question as to whether Atla and Samson were innately born with more exploratory temperaments, or if Luna's lack of intervention resulted in

their increased observations of their surroundings. Additional research would be needed to fully address this question.

Interestingly, Grayson, showed the least amount of vigilance of his environment. Again, this could potentially be explained by the amount of time he spent swimming with his mother. Since Grayson could not simultaneously swim with his mother and orient toward the environment beyond his pool, his lack of independence kept him from spending time exploring his environment. Again, suggests that more research should be done to investigate how attachment and maternal style influence the behavior of calves.

Qinu, whose mother Sikku was visually impaired, also was not very vigilant of stimuli outside of the pool. It is probable that Sikku was more dependent on echolocation to see things than most of the other whales. Consequently, it would follow logically that Qinu, mimicking her mother, would not learn to have her eyes oriented out of the water as much as other whales, especially since echolocation is not used above the water. It is likely that Sikku's behavioral patterns influenced the amount of time Qinu spent orienting out of the water.

Factor five included curiosity and playfulness. Stella, who was the most playful, engaged in a lot of water and bubble play behaviors. Bubble bursts, bubble streams, bubble rings, and general bubble play, in calves, have been hypothesized as a form of play (Hill, Kahn, Brilliot, Roberts, Gutierrez, & Artz, 2011). Interestingly, Bella, Stella's sister, was the only other whale who displayed a lot of these behaviors.

While there are confounds of visibility, it appeared that belugas engaged in water play more often when they were in the main show pool with the underwater viewing area. If the whales can see their reflections in the exhibit glass, this could explain why water

play is so prevalent in the show pool, as it might be more interesting to them to be able to see the bubbles they are producing. Additionally, the whales are able to be at eye level with researchers and trainers, who often reacted when they saw the whales engaged in bubble and water play, likely making it more reinforcing and interesting for the whales when they were in the show pool.

Beluga calves were interested in EEDs whenever they were available. Some of the whales would even orient to EEDs in the next pool, even though they could not gain access to the object(s). Calves would stop swimming and float while watching another whale play with an EED that was inaccessible to the calf. Meanwhile, other whales had considerably less interest in playing with EEDs. Time spent interacting with EEDs varied from whale to whale. Grayson and Oliver were not recorded as interacting with EEDs until quarter five. Other whales interacted with EEDs much earlier.

Orient at researcher likely loaded onto this factor because researchers served as a novel stimulus, much like the EEDs. While the whales were used to seeing their trainers and employees in SeaWorld attire, researchers were something new that they did not see daily. Furthermore, orienting to the researcher is of interest because all of the belugas started to engage in the orient at researcher behavior around the same time, between six and nine months of age (quarter three). This trend suggests a potential developmental milestone for the belugas. Much like in human infants, it is possible that as the calves develop a sense of self they also become more interested in objects and people outside of their underwater environment (Case, 1991). Orients to the trainers did not show the same pattern. Since the researchers did not offer any kind of reinforcement to the whales, as they did not feed or touch them, unlike the trainers, this suggests that something about

orienting to the trainers was intrinsically interesting and reinforcing to the whales. Furthermore, this was the only behavior that seemed to emerge in all seven whales right around the same time, as well as being the only behavior that was not seen during the newborn phase.

Table 9

Video Belugas Engaged in at Least Three Orient to Researcher Behaviors

Calf	Video
Atla	Q 3 3
Bella	Q 3 3
Grayson	Q 3 2
Oliver	Q 2 4
Qinu	Q 3 1
Samson	Q 4 3
Stella	Q 3 4

While it was initially predicated that newborn beluga calves would behave differently in their first month of life and have less behavioral diversity than they did when they were older, this was not supported. Young beluga whales engaged in a wide variety of behaviors (see Table 7). In fact, the only behavior that was not seen at least once during the infants' first month (other than sexual behaviors) was the orient at researcher behavior. This behavioral analysis provides the first methodically coded glimpse into the behavioral diversity of the Newborn Phase, as well as a comparison from the Newborn Phase to the first two years of life.

While aggression and submission were two major components in primate temperament studies (von Borell et al., 2016), neither of those behavioral categories were frequently observed in beluga calves and were not represented in the beluga temperament traits. Von Borell and colleagues (2016) found that aggressive behaviors were not

observed in macaques until age three and suggested that aggressive behaviors were developed, not innate, making them more of a personality scale than a temperament scale (von Borell, et al., 2016). Aggressive behaviors were observed before the age of three in beluga calves, they just were not frequently observed. Furthermore, while the adults were not the focal follow of the study, they rarely engaged in aggressive behaviors with each other or the calves. Belugas overall are likely less aggressive than primate species (Hill, 2009; Krasnova et al., 2006, 2009).

In fact, of the 14 dimensions that resulted in the meta-analysis of primate behavior conducted by Freeman and Gosling (2010), beluga calves exhibited four of the traits: sociability, playfulness, curiosity, and independence. While similarities between species lend themselves to comparisons and evolutionary congruencies, differences in the key temperament components between species illuminate the necessity for bottom-up emic approaches that are specific to the species being studied (Freeman & Gosling, 2010; Frick et al., 2017; Hill et al., 2017).

Stamps and Groothuis (2010) denoted that the majority of animal personality research has focused predominantly genetic components of personality, assuming that traits are stable across ontogeny. The presenting findings that different behavioral patterns were found for year one and year two suggests that in the first two years of beluga calves' lives their temperament traits are not yet stable. Furthermore, while siblings were found to have some temperament traits that were similar, they also had others that were different. Consequently, genetics alone cannot accurately account for the differing temperament traits found in the beluga whales. The observed behavioral

diversity highlights the importance of looking at factors beyond genetics to account for temperament traits in beluga whales.

The PCA for the first year of life did not have loadings for EED play (see Table 6). This follows logically since the EEDs were typically not available to the calves for the first few quarters (for the safety of the whales), making them present more often during the second year of life.

Orient at lag was the least frequently occurring behavior. Cumulatively, the whales only oriented to the lags 30 times (that were visible) during the first two years. Knowing when the whales were watching a lag was challenging. While whales and lags were never in the same pool, the whales would often orient to the net walls or gates between pools and watch other animals. Depending on the angle from which the video was taken and the glare, it was often difficult to see exactly what the whale was watching, so orient at lag was only coded when the observer could distinctly tell that the calves were watching the lags. Coding orients at the lags in this fashion was likely a conservative approach to coding this behavior.

While the behaviors did not cluster the same way for the PCAs for year one and year two, it was still significant that behavioral patterns could be seen for both years. A challenge in studying the development of temperament is that ontogeny is centered around change, while one of the defining characteristics of temperament is stability (Groothuis & Maestirpari, 2013; Sinn et al., 2001; Stamps & Groothuis, 2010). Nonetheless, the fact that behavioral patterns can be seen within the year suggests that while the behavioral patterns of the belugas still have plasticity, there are still patterns

present and temperament can be discerned. Additional research is needed to determine if/when temperament traits stabilize during beluga whale development.

Previous studies have shown that much like right whales, beluga calves were more responsible for their proximity maintenance with their mothers than were other cetaceans (Hill et al., 2013; Hill et al., 2007; Taber & Thomas, 1982). The behavioral budget provided by this study supports this expectation. Cumulatively, the seven beluga calves initiated 724 swims with other whales, and left swims with other whales 779 times. On the other hand, other whales initiated swims with the calves 354 times and left swims with the calves 287 times. This means that calves were twice as likely to initiate or leave a swim than other whales.

One major limitation to doing an observational study was the researcher's inability to manipulate the environment of the whales. Ideally, researchers would be able to control and choose the environment, conspecifics, and external objects (such as EEDs) that were available to the whales. Due to social dynamics, guest interactions, sicknesses, training schedules, performance times, weather, trainer availability, and myriad other factors, this was not the case. Data were collected when the researchers were present, and the whales were observed as they were, without any manipulation to their social groups or the availability of objects. A lack of control over contextual variables results from observational data collection. As a result, this study focused more on behavioral patterns across time and less across contexts. Stamps and Groothuis (2010) emphasize that both are important for personality research. Consequently, future research could aim to look more at consistency in behavior across contexts, although this is often challenging

to do with animals in human care facilities. Context has been found to influence trait stability in other cetaceans such as dolphins (Kuczaj et al., 2012).

Visibility of the animals also presented a major challenge. At times, visibility was limited because the whales had access to multiple pools or due to glare or the whales being underwater. Even in the show pool, which is the only pool with underwater viewing, there were places where the whales could go and no longer be visible. In an ideal setting the whales would always be visible during recording sessions.

Future research should continue to investigate the relationship between genetics, environment, maternal style, birth order, and availability of conspecifics to explore how each variable influenced temperament. Since the environment for all seven whales was predominantly the same pools at SeaWorld, it is unlikely that the exhibit itself has a large impact on temperament. Consequently, other environmental factors, such as seasons, presence of trainers, time of day, and presence and age of conspecifics might prove to be more valuable future pursuits.

Overall, it seems that maternal behavior and parenting styles influenced beluga calf behavior. Not only did the amount of time spent with the calf's mother determine the time available for other activities and socialization, calves were also seen mimicking their mothers' behaviors. These patterns provide preliminary support that much like rhesus monkeys (Suomi, 2004) and dogs (Bray et al., 2017), beluga temperaments are likely shaped both by maternal behavior and their environment, and are not just a genetic trait. Bray and colleagues (2017) noted that with their dog population, increased maternal behavior was actually positively correlated with less desirable temperament traits such as impulsivity and poor problem-solving skills. Bray and colleagues (2017)

suggest that a moderate level of maternal care is ideal because it presents challenges that the pups most overcome, leaving them more well-balanced. Similarly, Suomi (2004) argued that the outcome of an infant whose mother falls at one of the extremes of the personality spectrum does not inevitably mean that the outcome of the infant would be the same. Suomi argued that there was a balance of nature and nurture at play, and that with a stable social environment, an infant was able to overcome extreme parenting and have a positive social outcome and development. Maternal attachment is quintessential to normal development in humans and primates (Suomi, 2004, 2005; van Rosmalen, et al, 2016) and appears to have a similarly crucial role in cetaceans (Guarino et al., 2017; Hill, 2009; Hill et al., 2013; Hill et al., 2007; Krasnova et al., 2006, 2009), providing a secure base from which offspring can explore and learn. As was seen in the videos, as well as by Hill (2009), calves with a secure attachment were able to leave to explore, but then returned to their mother when something startled them (Hill et al., 2013). Future research should address the relationship between maternal style and temperament in calves. Other similar variables such as maternal care over subsequent offspring, and the availability of other mother-calf pairs to model should also be considered.

Researching temperament sheds light as to the evolutionary significance of behavioral patterns, as well as their ontogeny (Sinn et al., 2001). While it is often challenging to find stability during a developmental period that is marked by change, the presence of behavioral patterns and a potential developmental milestone in the beluga whale calves helps shed light as to why these behavioral patterns exist. Comparative studies facilitate comparisons between species. Temperament traits have been found from cephalopods (Sinn et al, 2001) to cetaceans (Highfill & Kuczaj, 2007; Kuczaj et al.,

2012; Skrzypczak, 2016). Looking at developmental trends and similarities between, this helps illuminate the significance of temperament traits in humans and animals alike.

Learning about temperaments has practical implications for animal management (Highfill & Kuczaj, 2010). Knowing which temperaments will work well together can help facilities to better predict social pairings and even breeding pairs of whales. It can also help facilitate care of the calves. If calves are not highly social, then offering the opportunity to interact with other whales would not be reinforcing to that particular calf. Similarly, if an animal is not playful, offering an EED will not be reinforcing to that calf. Approaching both training and enrichment programs, knowing the temperament of the animals would potentially allow the care team to improve their care and understand of the calves.

Working together with human care facilities to learn more about the animals they house, allows these animals to serve as ambassadors to their conspecifics in the wild. The better understanding that is developed of beluga whales, the more readily we can help protect their environment in the wild and keep them safe for future generations.

APPENDIX A – IACUC Approval Letter



THE UNIVERSITY OF
SOUTHERN MISSISSIPPI.

School of Biological Environmental and Earth Sciences
College Dr. # | Hattiesburg MS,
Phone | Dr. Jake Schaefer, Interim Executive Director

September ,

Beri Brown
PhD Graduate Student
Marine Mammal Behavior and Cognition Laboratory

Dear Beri,

Because your dissertation work involves viewing of archival video data, and not the creation of any new footage, you do not need an approved IACUC protocol. An approved protocol would only be needed if you were observing animals directly, or shooting new video as part of your research.

Good luck with your research,



Jake Schaefer
Interim Executive Director, School of Biological Environmental and Earth Sciences
Chair, USM IACUC Committee

College Dr. #, Hattiesburg, MS
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