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Tactile Behavior in a Group of Captive Rough-Toothed Dolphins as a Function of Opportunities to Play with Objects

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The University of Southern Mississippi

TACTILE BEHAVIOR IN A GROUP OF CAPTIVE ROUGH-TOOTHED DOLPHINS AS A FUNCTION OF OPPORTUNITIES TO PLAY WITH OBJECTS

by

Kelly Ann Caffery

Abstract of a Dissertation
Submitted to the Graduate School
of The University of Southern Mississippi
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy

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ABSTRACT

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Cetaceans live in complex physical and social environments that are frequently changing. In contrast, the captive environment for marine mammals is often lacking in stimulation. As a result, enrichment is often used to increase species-typical behaviors and enhance the well-being of the animals. The purpose of this study was to compare the effects of enrichment objects on the social behavior of a group of seven captive rough-toothed dolphins (*Steno bredanensis*). Observations of this species in the wild suggest it may have a particular affinity for tactile and object play behaviors. Therefore, these behavior categories were a primary focus during this investigation. The effect of enrichment on the social behavior of the subjects was assessed by comparing two conditions, the *no enrichment condition* and the *enriched condition*. The behaviors of interest were coded and analyzed from focal follow video recordings for each dolphin collected over 28 trials. The results revealed a significant increase in the total number of behaviors engaged in by the dolphins when enrichment objects were present. Furthermore, aggressive social behaviors were significantly reduced during the enriched condition. These findings demonstrate that enrichment can increase species-typical behaviors of rough-toothed dolphins as well as minimize aggression. The implications of these results for the welfare of dolphins in human care and how they might compliment studies with wild populations are discussed.

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CHAPTER I

INTRODUCTION

Dolphins typically live in dynamic fision-fusion societies with high socio-cognitive demands (Connor, 2007). In order to maintain such a complex social structure, their level of communication and behavioral repertoire must be equally sophisticated (Marino, 2002). The predominant modes of communication amongst cetaceans are through acoustic, visual, and tactile sensory systems (Paulos, Dudzinski, & Kuczaj, 2007). Due to limited technology and the challenge of recording underwater behaviors, research conducted on aquatic mammals focused primarily on vocal communication. The popularity of studying acoustics in dolphins overshadowed the other modalities used for communication (Pryor, 1990). However, recent studies suggest that in addition to vocal communication, non-vocal communication (including tactile behavior) plays a key role in the communication of dolphins and should no longer be overlooked (Dudzinski, 1998; Kaplan & Connor, 2007; Paulos et al., 2007; Pearson, 2008; Sakai, Hishii, Takeda, & Kohshima, 2006; Tamaki, Morisaka, & Taki, 2006).

Tactile behavior may function as a common modality for communication among dolphins because their skin is highly innervated and sensitive (Denhardt, 1990; Pryor, 1990; Ridgway & Carder, 1990). Areas of particular high sensitivity include the skin around the tip of the rostrum, eyes, blowhole, melon, lower jaw, abdomen, fluke, and pectoral fins. Due to the reduction of typical mammal extremities, the rostrum is frequently used for touch, especially contact with objects, and is an area that contains a great deal of mechanoreceptors within the skin (Dehnhardt, 1990; Dudzinski et al., 2012). In addition to the rostrum, dolphins commonly use their pectoral fins to make contact

with one another. Dolphins often swim in pairs or groups while maintaining contact with at least one other group member via the pectoral fin (Connor, Mann, & Watson-Capps, 2006a; Dudzinski, Gregg, Ribic, & Kuczaj, 2009; Johnson & Moewe, 1999). However, touching is not limited to these two areas because dolphins may use their melon, chin, dorsal fin, genital area, peduncle, fluke, or the dorsal, ventral, or side of their body while engaging in tactile behavior (Kaplan & Connor, 2007; Pryor, 1990).

The type of tactile contact in which dolphins engage varies greatly. The vocabulary used to describe physical contact by dolphins includes, but is not limited to, touching, petting, rubbing, caressing, stroking, contact swimming, or tactile contact (Connor et al., 2006a; Dudzinski et al., 2009; Pryor, 1990). Although tactile behavior is not easily and consistently defined in the literature (see Table 1 in Sakai et al., 2006 for an overview), some uniformity does exist. For example, the term *rubbing* usually refers to any general tactile contact in which the *rubber* moves a body part, such as the head, fins, fluke, or rostrum along some region of the *rubbee's* body. (Bel'kovich, Ivanova, Kozarovitsky, Novikova, & Kharitonov, 1991; Paulos et al., 2007). *Petting* or *flipper rubbing* are terms generally used more specifically to describe tactile contact that occurs when one dolphin rubs its pectoral fin against another dolphin's body (Connor, Smolker, & Bejders, 2006b; Dudzinski et al., 2009; Sakai et al., 2006). A simple touch between dolphins with no rubbing movement is often categorized as *tactile contact* or *simple contact* (Paulos et al., 2007). *Contact swimming*, another commonly used tactile behavior term, is typically applied when one dolphin maintains static contact of its pectoral fin to either the side or to the pectoral fin of another dolphin. During contact swimming, the

dolphins remain in close proximity, swim synchronously, and sometimes engage in this behavior for extended periods of time (Connor et al., 2006a).

Both wild and captive dolphin populations engage in tactile behavior in a variety of contexts. Touching and rubbing behaviors may occur in affliative, sexual, or aggressive social environments (Dudzinski, 1998; Paulos et al., 2007). Dolphins engage in aggressive contact when the initiator rakes its teeth along the body of another dolphin, bites another dolphin, or forcefully hits, rams, or slams its body or body part(s) into another dolphin (Pryor, 1990; Samuels & Spradlin, 1995). Sexual contact typically involves the genital region or the presence of a male erection. While some contact may be inadvertent, the majority of other types of tactile behavior are considered to reflect some degree of affiliation (Dudzinski, 1996). The communicatory function of tactile behavior most likely depends on the social context, the location of the contact on the rubbee and the rubbers body, the type of contact, and the force of the contact (Tamaki et al., 2006).

An increase in systematic observational studies of dolphin contact behavior coupled with comparisons to terrestrial mammal tactile behavior has resulted in numerous hypotheses regarding the purpose of different forms of touch utilized by dolphins. For a variety of terrestrial species, tactile behavior may play an important role in the establishment and maintenance of the group social structure as well as promote the well-being of its group members, including humans (Derelga, Lewis, Harrison, Winstead, & Constanza, 1989; Hall, 1996; Hertenstein, 2002; Hertenstein, Verkamp, Kerestes, & Holmes, 2006; Kontos, 1978; Stack & Muir, 1990), non-human primates (Harlow & Zimmerman, 1959; Keverne, Martensz, & Tuite, 1989; Terry, 1970; for bonnet macaques: Silk, 1999; for bonobos: Paoli, Tacconi, Borgognini Tarli, & Palagi, 2007; for

chimpanzees: Newton-Fisher, 2002; Williams, Liu, & Pusey, 2002; for gorillas: Harcourt, 1979; and for vervet monkeys: Seyfarth & Cheney, 1984), elephants (Archie, Morrison, Foley, Moss, & Alberts, 2006; Langbauer, 2000; Makecha, Fad, & Kuczaj, 2012; Vidya & Sukumar, 2005), and hyenas (East & Hofer, 2001; Wahaj, Guse, & Holekamp, 2001). Purposed functions of tactile behavior include maintaining or promoting rank in a social dominance hierarchy, reducing tension among group members (i.e., as a method of post-conflict reconciliation), indicating the establishment of a close social bond or affiliation, and reducing the risk of parasite infection (Connor et al., 2006a; Dudzinski, 1996, 1998; Kaplan & Connor, 2007; Morisaka, Koshima, Yoshioka, Suzuki, & Nakahara, 2010). In dolphins, tactile behavior may be strictly sexual in nature and a type of courtship activity, or it may function in strengthening affiliative bonds including the mother-infant bond (Sakai et al., 2006). Tactile behavior could also indicate the establishment of alliances during aggressive bouts or indicate a greeting or mode of individual recognition (Dudzinski, 1998). As in terrestrial mammals, dolphin tactile behavior may function as a grooming tool and serve as a method of removing old skin from the body surface (Sakai et al., 2006). Additionally, dolphins appear to enjoy tactile contact and often engage in it during social play as well as solicit it from humans both in the wild and captivity (Perelberg, Veit, van der Woude, Donio, & Shashar, 2010). For example, care takers at captive facilities have reportedly trained some dolphins using only physical contact as reinforcement (Goldblatt, 1993; Pryor, 1990).

One species of dolphin that seems to have a particular affinity for tactile behavior is the rough-toothed dolphin (*Steno bredanensis*). Wild populations of rough-toothed dolphins have been repeatedly observed while engaged in contact swimming (Ritter,

2002). Small, tight subgroups are formed and maintained in close association (Addink & Smeenk, 2001; Kuczaj & Yeater, 2007; Mayr & Ritter, 2005; Pitman & Stinchcomb, 2002; Ritter, 2002). Individual dolphins within the subgroups swim synchronously and flank each other with such close proximity that they are commonly seen touching (Ritter, 2002).

Swimming in such tight, synchronous subgroups likely serves a social function, and it is possible that the formation of such close affiliations reflects strong social bonds in this species (Lodi, 1992; Mayr & Ritter, 2005). For example, the tendency of juveniles to remain clearly affiliated with an adult, presumably their mother, suggests an enduring mother-calf bond and that their association may be prolonged in this species (Addink & Smeenk, 2001; Lodi, 1992). In support of this assumption, a photo-identification study found that calves tended to remain closely associated with their mother even as they transitioned into adolescence (Mayr & Ritter, 2005). Results further indicated that rough-toothed dolphins form strong social bonds between individuals of different age classes, a characteristic that may be unique to this species. Mayr and Ritter (2005) concluded that the formation of such tight subgroups is potentially a species-specific way for rough-toothed dolphins to represent and strengthen their social affiliations.

In addition to forming tight subgroups, rough-toothed dolphins have displayed affiliation in the context of play behavior. Pitman and Stinchcomb (2002) documented reports of what may have been rough-toothed dolphins cooperatively *playing with their food*. During this observation, several dolphins within the same social group participated in releasing and recapturing a dead mahimahi in a playful manner. Addink and Smeenk (2001) reported a similar behavior between a mother and her calf. Based on the

interaction, the mother appeared to have encouraged the calf to engage in this play behavior. In addition to playing with fish, rough-toothed dolphins have displayed activity with a variety of other objects and as such, appear to be a species with an affinity for object play. Play interactions have involved objects from their natural environment including seaweed and seagrass. During one observation, Ritter (2002) witnessed several rough-toothed dolphins repeatedly nudging a tortoise at the surface of the water. However, reports of rough-toothed dolphins engaging in play behavior with pieces of plastic and plastic bags suggest that this species might be opportunistic in their play behavior as well (de Meirelles & do Rego Barros, 2007; Kuczaj & Yeater, 2007; Ritter, 2002). For example, Kuczaj and Highfill (2005) observed three dolphins passing a piece of plastic back and forth between each other and passing it in a gentle manner to the youngest member of the group. Despite these observations of wild populations engaging in play and social behavior, little is known about these behaviors among rough-toothed dolphins in the context of the captive environment.

In order to provide captive rough-toothed dolphins the best care, it is necessary to have a greater understanding of their behavior. Studies have shown that keeping animals in captivity can adversely affect their behavior due to stress and lack of environmental stimulation (McPhee, 2002). Stressed-induced animals or animals with little environmental stimulation may have impaired reproductive function, impaired immune response, and engage in stereotypic behaviors (Morgan & Tromborg, 2007). Stereotypic behaviors encompass a broad category of behaviors, but the term generally refers to abnormal, invariant, repetitive, and functionless behavior patterns (Mason, Clubb, Latham, & Vickery, 2007; Shyne, 2006; Swaisgood & Shepherdson, 2005). Examples of

common stereotypic behaviors observed in captive populations include pica, over-grooming, pacing, plucking hair or feathers (Mason et al., 2007; Shyne, 2006), and swimming in circles (Grindrod & Cleaver, 2001) and head-pressing behavior (repetitively pressing head against the sides of the pool) for marine mammals (Greenwood, 1977). Captive facilities often attempt to minimize abnormal behaviors and thereby elicit functional and species-typical behaviors by providing their animals with enrichment (Altman, Gross, & Lowry, 2005).

Environmental enrichment can be defined as the use of environmental stimuli to improve the biological well-being of captive animals (de Azevedo, Cipreste, & Young, 2007; Delfour & Beyer, 2012; Goldblatt, 1993; Swaisgood & Shepherdson, 2005; Wells, 2009). Most often the goals of enrichment strategies are to "encourage more in the way of species-typical patterns of behavior, increase the ability to cope with challenges, enhance behavioral repertoire, increase positive use of the environment, and/or reduce or eliminate aberrant patterns of behavior, e.g. stereotypies" (Wells, 2009, p. 2). Although these goals may be the overall objective of enrichment programs, the types of environmental enrichment a captive facility may provide can be quite versatile. However, in an analysis of the environmental enrichment literature, de Azevedo et al. (2007) found that the different types of enrichment could be organized into five broad categories including food-related enrichment (i.e., rhesus macaques given daily monkey biscuits in puzzle feeders; Reinhardt, 1993), structural enrichment (i.e., hollow plastic drums added to a polar bear exhibit; Altman, 1999), cognitive enrichment (i.e., orcas taught to associate underwater tones with specific behaviors; Kuczaj, Lacinak, & Turner, 1998), social enrichment (i.e., social partner(s) added to the cages of laboratory-housed

rhesus monkeys; Schapiro, Bloomsmith, Porter, & Suarez, 1996), and sensory enrichment (i.e. the introduction of mirrors, colors, music, or scents into the enclosures of non-human primates; Wells, 2009).

As predominately social animals, it is essential for captive dolphins, in particular, to be provided the opportunity to engage in social interactions (Kuczaj et al., 1998). Captive dolphins kept in isolation or in unstable social groups show an increased risk of mortality, higher incidence of disease, and difficulty in rearing young (Waples & Gales, 2002). In addition to social stimulation, employees at captive dolphin facilities can attempt to improve their animals' quality of life by introducing environmental enrichment, including novel objects and toys, into their environment (Goldblatt, 1993; Kuczaj et al., 1998). However, enrichment can cost time and money for captive facilities, so it is important to maximize the animals' benefits by using enrichment items efficiently (Tarou & Bashaw, 2007). To date, the effect of environmental enrichment on dolphin social behavior has not been systematically studied and, therefore, was the focus of this current investigation.

The purpose of this study was to compare the effects of inanimate enrichment items on the social behavior of a group of seven captive rough-toothed dolphins (*Steno bredanensis*) at Gulf World Marine Park. Specifically, this study assessed the effect of the enrichment items on the dolphins' tactile behavior and other types of social behavior. The goals of this study addressed the following questions with regard to environmental enrichment and its potential benefits: (a) Does it affect non-aggressive social behavior? (b) Does it affect affiliative tactile behavior? (c) Does it affect aggressive behavior? (d) Does it affect solitary tactile behavior? (e) Do the dolphins differ in the amount of

social behaviors they engage in? (f) Do the dolphins differ in the amount of object play behaviors they engage in? (g) Is there a relationship between tactile behavior and object play behavior?

According to a study conducted by Delfour and Beyer (2012), enrichment objects introduced to the environment of captive dolphins did not affect their social behavior or social associations. Similarly, Paquette and Prescott (1988) found the presence of novel objects had no affect on the number of overall social interactions between chimpanzees. The chimpanzees did decrease in their self-grooming and slightly decreased in their social grooming. Therefore, in this study the overall non-aggressive social behavior of the dolphins was not predicted to significantly differ between the no enrichment and the enriched conditions. Some specific types of non-aggressive social behavior were expected to decrease during the enriched condition due to the potential to engage in object play behaviors as an alternative. For example, dolphin-to-dolphin tactile behavior was estimated to be significantly higher in the no enrichment condition compared to the enriched condition as a result of the lack of environmental stimulation in the pool. Pool rubbing (categorized under solitary tactile behavior) was also expected to be higher in the no enrichment condition for the same reason. Furthermore, displays of aggression among the rough-toothed dolphins were anticipated to decline when enrichment was added to the environment based on studies conducted with captive otters (Ross, 2002). Results from several studies conducted with other captive mammals suggest that individual differences play a major role in how an animal will respond to provided enrichment (Bacon, Ripsky, Hawk, & Battershill; 2000; Hunter, Bay, Martin, & Hatfield, 2002; Powell & Svoke,

2008). In view of that, individual differences were expected to factor into the frequency of behaviors exhibited by each dolphin.

CHAPTER II

METHODS

Subjects

The subjects were seven rough-toothed dolphins (*Steno bredanensis)* at the Gulf World Marine Park in Panama City, Florida. The dolphins were housed together in one pool and consisted of three males and four females (see Table 1). All of the animals were stranded and deemed unfit to be released into the wild.

Table 1

Captive Rough-toothed Dolphins at Gulf World Marine Park

Dolphin	Sex	Age at stranding	Strand date	Date arrived at Gulf World
Astro	Male	Calf (2-2.5 years)	04/18/05	07/16/05
Dancer	Female	Juvenile	03/24/07	05/06/07
Doris	Female	Adult	09/27/04	09/27/04
Ivan	Male	Calf (<1 year)	09/27/04	09/27/04
Largo	Female	Calf (<1 year)	03/02/05	08/15/05
Noah	Male	Adult (17-22 years)	08/26/04	07/14/05
Vixen	Female	Juvenile	12/25/02	07/17/05

Procedure

Enrichment Conditions

The effect of structured environmental enrichment on the social behavior of the subjects was assessed across two conditions, the *no enrichment condition* and the *enriched condition*. In the no enrichment condition, no enrichment items were in the pool. During the enriched condition, 11 enrichment items could be in the pool including: four different rope toys, one oblong smooth-textured buoy, one oblong ridged-textured buoy,

one ball buoy, one hula hoop, one boogie board, one cone, and one large, hollow plastic tube strung across the length of the pool. If a dolphin tossed a toy out of the pool, it was not replaced in order to minimize human interaction during such sessions. Each condition counted as one trial, and the order of the trials was semi-randomized with no more than three of the same condition in a row.

Focal Follows

During a trial, five-minute focal follows were video recorded for each dolphin. Since there were seven rough-toothed dolphins in the social group and the focal follows were consecutive, the total time for video recording was 35 minutes per trial. An additional five minutes were recorded at the beginning of each trial to allow the dolphins time to habituate to the enrichment condition and to allow the experimenter or trainer time to move away from the pool after adding or removing toys. A Latin Square design was used to determine the order in which the subjects were video recorded for their focal follow. Each dolphin was assigned a letter in the following order:

A = Astro B = Doris C = Noah D = Vixen E = Largo F = Ivan G = Dancer

The letters were organized in a Latin Square:

A	B	C	D	E	F	G
B	C	D	E	F	G	A
C	D	E	F	G	A	B

A total of 28 trials were sporadically conducted (14 trials per condition) throughout the months of January - March, 2010. Approximately 140 minutes of video were recorded for each dolphin (70 minutes per condition) for a total of 980 minutes of overall video recording. In order to minimize confounding variables, sessions were conducted when human interaction was minimal. Therefore, trials were conducted around

training sessions, feeding sessions, human encounters, and shows. Environmental data was collected to assess possible effects of extraneous variables. Environmental data that was noted included time of day, weather, and any unexpected distractions that sometimes occur at captive facilities (e.g., a group of trainers passed by the pool with feeding buckets during a session).

Behavioral Analysis

All behavioral analysis was conducted entirely from recorded video as an effort to maximize the accuracy in the assessment of behaviors. The video tapes were analyzed using all occurrence sampling of the behaviors of interest (Altmann, 1974). To test for inter-observer reliability, one observer coded every trial, and a second observer coded approximately 25% of the trials (trial numbers were selected at random). Inter-observer reliability was determined using Cohen's kappa and the overall value of kappa was .87 indicating a high level of agreement between observers.

An ethogram comprised of a list of behavioral characteristics observed in captive bottlenose dolphins and wild rough-toothed dolphin populations was used to assess the behaviors of interest (see Appendix A and B). The frequency of dolphin-to-dolphin tactile behaviors, non-tactile social behaviors, sexual behaviors, aggressive social behaviors, solitary tactile behaviors, solitary object play behaviors, and social object play behaviors were recorded. In addition, the initiator, and recipient of all social behaviors, the type of social or object play behaviors, and the type of objects interacted with were recorded (see Table 2).

Table 2

Behaviors of Interest for Video Analysis

Behavior category	Type of behavior	Additional information	
Non-tactile social behavior	Chase, Follow, Pair swim, Group swim, Pair rest, & Group rest	Dolphins involved	Initiator of behavior
Affiliative tactile behavior	Touch, Rub, Contact swim, & Sexual contact	Dolphins involved	Initiator of behavior
Aggressive tactile behavior	Hit & Rake/ Bite	Dolphins involved	Initiator of behavior
Solitary tactile behavior	Rub pool & Masturbate		
Solitary object play behavior	Rub toy, Static toy, Toss toy, Touch toy, & Travel with toy	Type of object	
Social object play behavior	Mutual toy play & Steal toy	Type of object	Dolphins involved

CHAPTER III

RESULTS

Descriptive and inferential statistics were conducted on the variables of interest using the statistical package for the Social Sciences (SPSS). The frequencies of behaviors in both the no enrichment and the enriched conditions were analyzed via paired *t*-test, Pearson's product-moment correlation, and chi-square goodness-of-fit test. Cohen's d was used to indicate effect sizes and an alpha level of .05 was used for all statistical analyses. The total frequency of behavior in the no enrichment condition versus the enriched condition was compared as well as the categories of non-aggressive social behaviors, aggressive social behaviors, solitary tactile behaviors and object play behaviors. More specifically, non-tactile social behaviors, affiliative tactile behaviors, aggressive tactile behaviors, chase behavior, solitary object play behaviors, and social object play behaviors were examined. Toy preference and object play behaviors as they related to other social behaviors were also investigated. Since tactile behavior was of particular interest for this study, it was explored in further detail by comparing how often the dolphins engaged in the behavior with their conspecifics and by analyzing the frequency each dolphin initiated the behavior.

Overall Behaviors

The dolphins displayed significantly more total behaviors in the enriched condition than in the no enrichment condition, $t(6) = -3.88$, $p = .008$, $d = 1.47$, as shown in Figure 1. All dolphins, except Doris, engaged in significantly more overall behaviors in the no enrichment condition than in the enriched condition (χ^2, $p < .05$ for each pairwise comparison). There were also significant individual differences in the number of

total behaviors produced by each dolphin during both the no enrichment condition, $\chi^2(6, N = 989) = 174.88$, $p < .001$, and the enriched condition, $\chi^2(6, N = 2{,}335) = 403.53$, $p < .001$. In the no enrichment condition, Astro engaged in the highest number of total behaviors and Vixen engaged in the lowest number of total behaviors. In the enriched condition, Largo engaged in the highest number of total behaviors and Doris engaged in the lowest number of total behaviors.

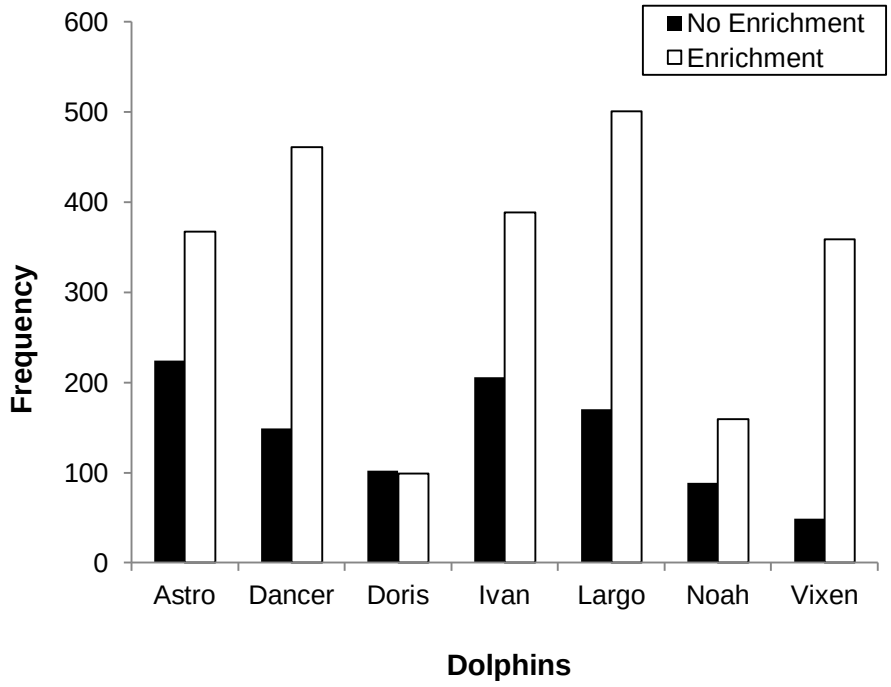

Figure 1. Frequency of overall behaviors engaged in by each dolphin in the no enrichment condition and the enriched condition.

Non-Aggressive Social Behaviors

When social object play behaviors were excluded from the analysis, the dolphins engaged in significantly more non-aggressive social behaviors in the no enrichment condition than in the enriched condition, $t(6) = 3.39$, $p = .015$, $d = 1.28$ (see Figure 2). Furthermore, all seven dolphins differed significantly between the two conditions when the same analysis was conduct individually (χ^2, $p < .05$ for each pairwise comparison).

Vixen was the only dolphin that engaged in more non-aggressive social behaviors during the enriched condition, $\chi^2(1, N = 80) = 4.05, p < .05$, instead of the no enrichment condition . However, when social object play behaviors were included in the analysis, there was no difference in non-aggressive social interactions between the two conditions, $t(6) = -1.064, p > .05$. Significant individual differences were found between the dolphins in their frequency of non-aggressive social behaviors, regardless if social object play behaviors were included in the analysis, in both the no enrichment condition, $\chi^2(6, N = 876) = 174.85, p < .001$, and the enriched condition, $\chi^2(6, N = 570) = 76.75, p < .001$ (no social object play behaviors) and $\chi^2(6, N = 1{,}012) = 176.38, p < .001$ (social object play behaviors included). Additionally, the frequencies of non-aggressive social behaviors showed a positive correlation, $r(5) = .91, p = .005$, between the two conditions but only when social object play behaviors were omitted from the analysis. Thus, dolphins who engaged in more non-aggressive social behaviors in the no enrichment condition also engaged in more during the enriched condition. For example, Astro and Vixen engaged in the highest and least amount of non-aggressive social behaviors, respectively, for both conditions.

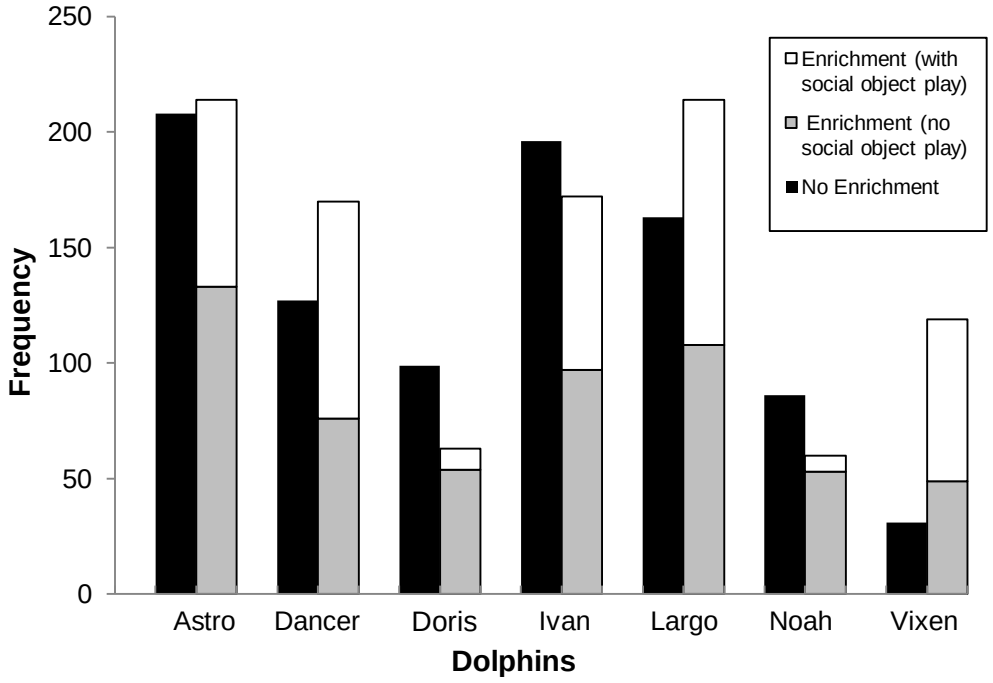

Figure 2. Frequency of non-aggressive social behaviors engaged in by each dolphin in the no enrichment condition and the enriched condition. The enriched condition is shown with and without social object play behaviors.

Non-tactile Social Behaviors

Non-tactile social behaviors were significantly more frequent in the no enrichment condition than the enriched condition, $t(6) = 3.75$, $p = .01$, $d = 1.42$. Individually, non-tactile social behaviors were significantly higher in the no enrichment condition for five of the seven dolphins (χ^2, $p < .05$ for each pairwise comparison). Noah and Vixen engaged in more non-tactile social behaviors in the no enrichment condition as well but their frequencies were not significantly different between the two conditions. Significant differences were found in the frequency of non-tactile social behaviors between the dolphins in both the no enrichment, $\chi^2(6, N = 546) = 124.46$, $p < .001$, and enriched conditions, $\chi^2(6, N = 228) = 50.65$, $p < .001$. Ivan engaged in the highest frequency of non-tactile social behaviors in the no enrichment condition, whereas Astro and Noah were tied for the highest frequency in the enriched condition (see Figure 3).

Vixen engaged in the lowest frequency in both conditions and, in fact, was substantially lower than her conspecifics with less than 10 occurrences of non-tactile social behaviors in either one. All of the other dolphins engaged in more than 60 non-tactile social behaviors in the no enrichment condition and more than 20 in the enriched condition.

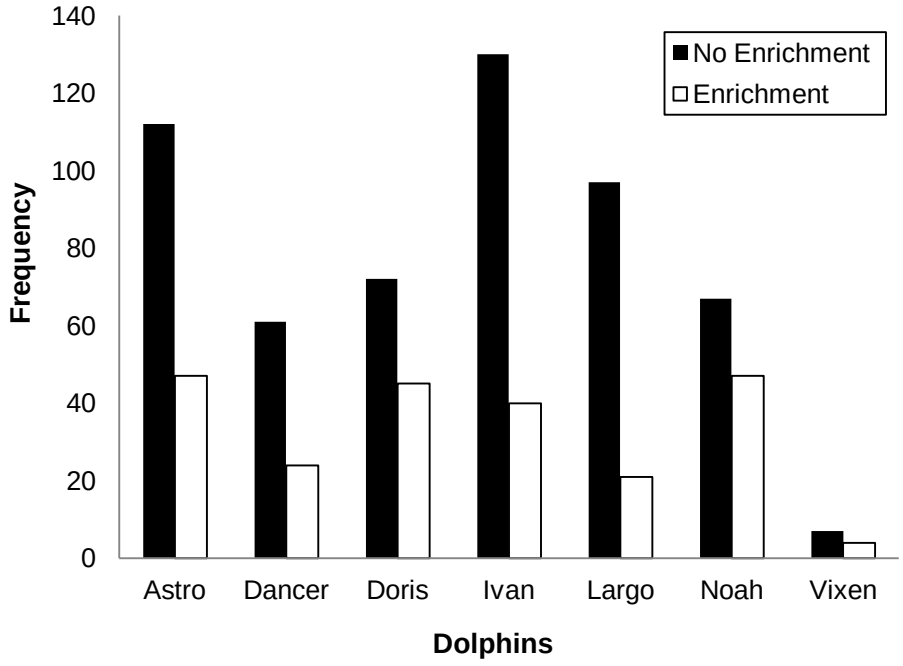

Figure 3. Frequency of non-tactile social behaviors engaged in by each dolphin in the no enrichment condition and the enriched condition.

Affiliative Tactile Behaviors

The frequency of affiliative tactile behaviors in the no enrichment condition compared to the frequency of affiliative tactile behaviors in the enriched condition were not significantly different, $t(6) = 0.50$, $p > .05$. However, affiliative tactile behaviors when compared between the dolphins significantly differed in the no enrichment condition, $\chi^2(6, N = 364) = 96.58$, $p < .001$, as well as in the enriched condition, $\chi^2(6, N = 342) = 129.99$, $p < .001$. The frequencies of affiliative tactile behaviors were also positively correlated between the two conditions, $r(5) = .86$, $p = .014$. Therefore, if the

dolphins engaged in a high, moderate, or low frequency of affiliative tactile behaviors in one condition, they tended to maintain that trend in the other condition (see Figure 4). In the no enrichment condition, Astro engaged in the highest frequency of affiliative tactile behaviors, whereas Noah engaged in the lowest frequency. Likewise, Noah engaged in the least number of affiliative tactile behaviors in the enriched condition. Astro maintained a high number of affiliative tactile behaviors in the enriched condition as well but dropped to second highest with one less occurrence of that behavior type than Largo.

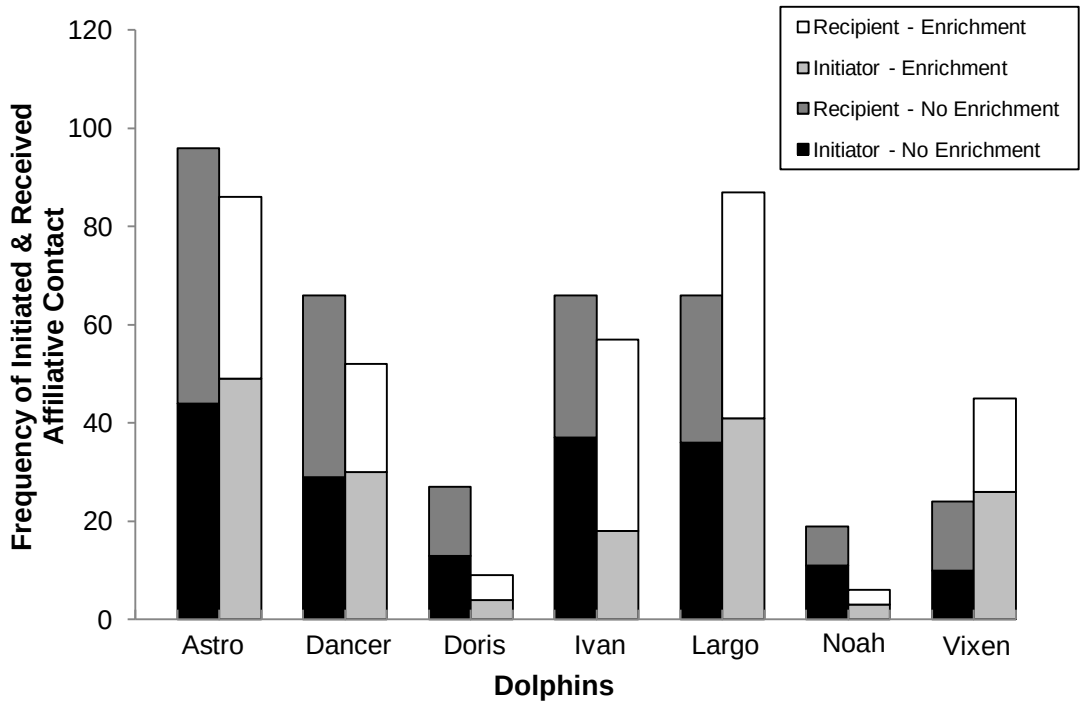

Figure 4. Frequency of initiated and received affiliative tactile behaviors for each dolphin in the no enrichment condition and the enriched condition.

As a central focus of the study, affiliative tactile behaviors were examined more specifically and included the analysis of contact swim, rub, and touch behaviors. Sexual contact was the one affiliative tactile behavior excluded since it was only observed twice during the course of the study (see Table 3). No significant differences were found between the no enrichment and the enriched conditions for contact swim, rub, or touch

behaviors. However, the frequencies of rub behaviors were positively correlated between the no enrichment and enriched conditions, $r(5) = .82$, $p = .025$, as well as the frequencies of touch behaviors, $r(5) = .80$, $p = .029$. Although no significant differences were found between the two conditions, there were significant differences in the type of affiliative tactile behavior used by the dolphins during both the no enrichment condition, $\chi^2(3, N = 364) = 241.36$, $p < .001$, and the enriched condition, $\chi^2(2, N = 342) = 129.75$, $p < .001$. The highest frequency and second highest frequency type of affiliative tactile behavior observed during either condition were touch and rub, respectively.

Table 3

Frequency of Affiliative Tactile Behavior in the No Enrichment Condition and the Enriched Condition

Type of behavior	Astro		Dancer		Doris		Ivan		Largo		Noah		Vixen		Total	
	No	E	No	E	No	E	No	E	No	E	No	E	No	E	No	E
Contact swim	9	9	4	0	3	1	2	3	12	5	7	0	1	0	38	18
Rub	40	33	28	21	7	3	28	23	26	41	2	3	7	16	138	140
Sexual contact	1	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0
Touch	46	44	34	31	17	5	35	31	28	41	10	3	16	29	186	184

Note. No = No enrichment condition; E = Enriched condition.

Affiliative Tactile Behavior Initiations

The frequency that each dolphin initiated affiliative tactile behavior was also investigated and compared (see Figure 4). The amount the dolphins initiated affiliative tactile behavior was not significantly different, $t(6) = 0.29$, $p > .05$, between the no enrichment condition and the enriched condition. Nevertheless, a positive and almost significant correlation was found between the two conditions for the frequency that each

dolphin initiated affiliative tactile behavior, $r(5) = .75$, $p = .051$. Table 4 shows the percentage that the individual dolphins initiated each type of affiliative tactile behavior out of the total frequency they engaged in the behavior for both the no enrichment and enriched conditions. For example, Ivan initiated 100% of the contact swim behaviors he engaged in during the no enrichment condition but in the enriched condition, he initiated just two-thirds of his contact swims at 67%. In contrast, Largo remained stable by initiating 0% of the contact swims that she engaged in during either condition. Significant individual differences were revealed among the dolphins in the no enrichment condition, $\chi^2(6, N = 180) = 46.8$, $p < .001$, as well as in the enriched condition, $\chi^2(6, N = 171) = 74.9$, $p < .001$. Astro initiated the most affiliative tactile behaviors in both conditions, whereas Vixen initiated the least in the no enrichment condition, and Noah initiated the least in the enriched condition.

Table 4

Percentage Dolphins Initiated Affiliative Tactile Behavior in the No Enrichment Condition and the Enriched Condition

Type of behavior	_Astro_		_Dancer_		_Doris_		_Ivan_		_Largo_		_Noah_		_Vixen_	
	No	E	No	E	No	E	No	E	No	E	No	E	No	E
Contact swim	100%	78%	25%	0	33%	0%	100%	67%	0%	0%	57%	0	0%	0
Rub	35%	45%	46%	52%	43%	67%	64%	30%	65%	66%	50%	33%	43%	44%
Sexual contact	100%	0	0	0	0	0	0%	0	0	0	0	0	0	0
Touch	43%	61%	44%	61%	53%	40%	49%	29%	68%	34%	60%	67%	44%	66%

Note. No = No enrichment condition; E = Enriched condition. Percentage determined by the frequency the dolphin initiated the behavior divided by the total frequency the dolphin engaged in the behavior.

Aggressive Social Behaviors

Aggressive social behaviors for this study included all aggressive tactile behaviors and chase behavior. Chase behavior may be considered both a play behavior and an aggressive behavior (Dudzinski, 2010). However, for the duration of this study with this specific group of captive rough-toothed dolphins, chase appeared to be used in a predominately aggressive manner. For the no enrichment condition, in all but two occurrences of aggressive tactile behavior, the hit, rake, or bite behavior was preceded by a chase behavior. Furthermore if chase was used in the form of play, it would more than likely occur in relatively equal amounts for both conditions, especially in the case of the enriched condition where the dolphins would be predicted to chase each other for the toys. However, no occurrence of chase behavior was observed during the enriched condition in which the number of aggressive tactile behaviors was also reduced (see Table 5). Therefore, for the purposes of this study, chase behavior was categorized as an aggressive action and included in the analysis of overall aggressive social behavior.

Table 5

Frequency of Aggressive Social Behavior in the No Enrichment Condition and the Enriched Condition

Type of behavior	Astro		Dancer		Doris		Ivan		Largo		Noah		Vixen	
	No	E	No	E	No	E	No	E	No	E	No	E	No	E
Hit	3	2	5	0	0	0	1	2	3	0	0	0	2	0
Rake/ Bite	1	0	2	0	0	0	0	0	0	0	0	0	1	0
Aggressive tactile total	4	2	7	0	0	0	1	2	3	0	0	0	3	0
Chase	10	0	11	0	0	0	6	0	6	0	0	0	1	0

Note. No = No enrichment condition; E = Enriched condition.

For overall aggressive social behavior, the dolphins displayed significantly more aggressive social behavior in the no enrichment condition than in the enriched condition, $t(6) = 2.75$, $p = .033$, $d = 1.47$ (see Figure 5). However, the frequencies of aggressive social behavior were too low to determine if the dolphins significantly differed between the two conditions at the individual level. Astro was the one exception since it could be determined that he engaged in significantly more aggressive behavior in the no enrichment condition, $\chi^2(1, N = 16) = 9.00$, $p = .003$. Additionally, a significant difference was found between the dolphins in their frequency of aggressive social behavior during the no enrichment condition, $\chi^2(4, N = 52) = 12.04$, $p = .017$. Doris and Noah were excluded from the chi-square analysis because they were not involved in any aggressive social behavior (see Figure 5). A chi-square analysis could not be conducted for the enriched condition because all expected frequencies of aggressive social behavior in that condition were less than five. When tested for correlation, no significant relationship was found between the frequency of aggressive social behavior displayed in the no enrichment condition and the frequency it was displayed in the enriched condition.

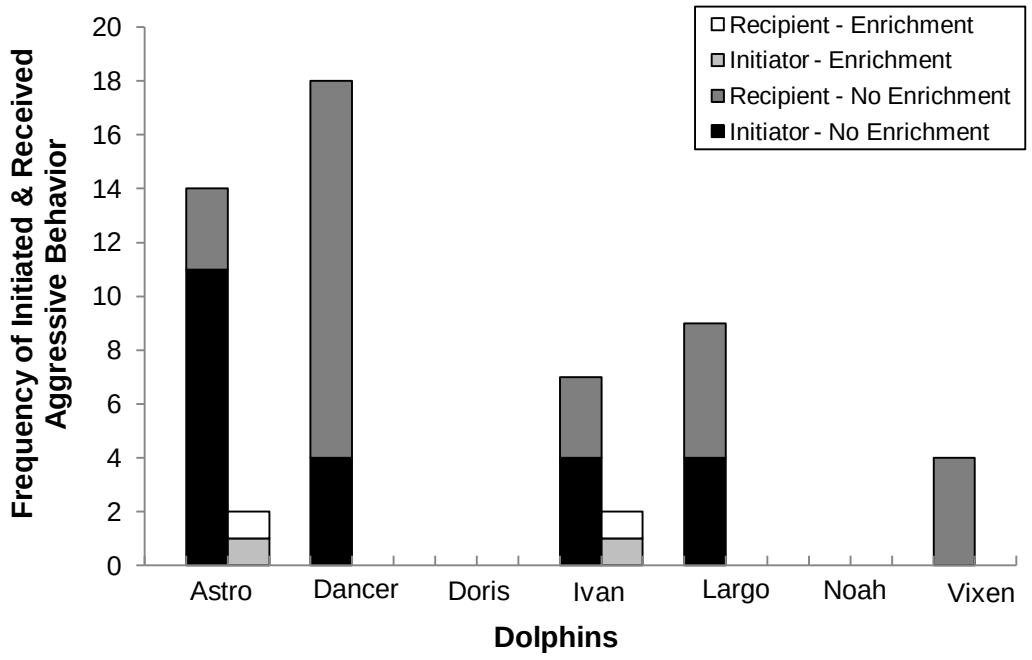

Figure 5. Frequency of initiated and received aggressive behaviors for each dolphin in the no enrichment condition and the enriched condition.

Aggressive Tactile Behaviors

There was no significant difference for aggressive tactile behaviors between the no enrichment condition and the enriched condition, $t(6) = 1.95$, $p > .05$. Additionally, there was no significant correlation found between the frequency of aggressive tactile behaviors engaged in during the no enrichment condition and in the enriched condition. A chi-square analysis could not be conducted for either condition because all expected frequencies of aggressive tactile behavior were less than five.

Chase Behavior

There was a significant difference in the frequency of chase behavior between the no enrichment condition and the enriched condition, $t(6) = 2.77$, $p = .032$, $d = 1.05$. However, no significant individual differences were found between the dolphins for chase behavior in the no enrichment condition. Based on the fact that a zero occurrence

of chase behavior was observed in the enriched condition, no chi-square analysis of the enriched condition or test for correlation between the two conditions could be conducted. Interestingly, the frequency of aggressive tactile behaviors and the frequency of chase behavior was positively correlated for the no enrichment condition, $r(5) = .81$, $p = .027$. Dancer was involved in the most aggressive tactile behaviors and the most chase behaviors followed by Astro for both of those behavior categories.

Aggressive Social Behavior Initiations

The frequency that each dolphin initiated aggressive social behavior was also analyzed (see Figure 5). The amount the dolphins initiated aggressive social behavior was not significantly different, $t(6) = 2.11$, $p > .05$, between the no enrichment condition and the enriched condition. Furthermore, no significant correlation was found between the two conditions for the frequency that each dolphin initiated aggressive social behavior. Table 6 shows the percentage that each type of aggressive social behavior was initiated by the individual dolphins out of the total frequency they engaged in the behavior for both the no enrichment and enriched conditions. In the case of aggressive tactile behavior initiations, Ivan initiated 0% of the aggressive tactile behaviors he engaged in during the no enrichment condition, but he increased his frequency of initiations to 50% during the enriched condition. Conversely, Astro decreased from initiating 75% of his aggressive tactile behaviors in the no enrichment condition to initiating just 50% in the enriched condition. Figure 5 shows that in the no enrichment condition, Astro initiated the most aggressive social behaviors compared to his conspecifics, but Dancer was involved in the most, primarily as the recipient. Only Ivan and Astro engaged in aggressive social behaviors during the enriched condition with each dolphin initiating 50% of their

interactions. As stated previously, Doris and Noah were not involved in any aggressive social behaviors during either condition so they did not initiate any aggression. Vixen was the only dolphin entirely a recipient of aggressive social behavior.

Table 6

Percentage Dolphins Initiated Aggressive Social Behavior in the No Enrichment Condition and the Enriched Condition

Type of behavior	Astro		Dancer		Doris		Ivan		Largo		Noah		Vixen	
	No	E	No	E	No	E	No	E	No	E	No	E	No	E
Hit	67%	50%	20%	0	0	0	0%	50%	100%	0	0	0	0%	0
Rake/ Bite	100%	0	0%	0	0	0	0	0	0	0	0	0	0%	0
Aggressive tactile total	75%	50%	14%	0	0	0	0%	50%	100%	0	0	0	0%	0
Chase	80%	0	27%	0	0	0	67%	0	17%	0	0	0	0%	0

Note. No = No enrichment condition; E = Enriched condition. Percentage determined by the frequency the dolphin initiated the behavior divided by the total frequency the dolphin engaged in the behavior.

Once similarities were observed between the primary initiators for affiliative tactile behavior and for aggressive social behavior, a correlation was conducted to determine if the behaviors were significantly related. Based on the low frequency of aggressive behavior initiations in the enriched condition, only the no enrichment condition was used in the analysis. The frequency of aggressive behavior initiations in the no enrichment condition was positively correlated to the frequency of affiliative tactile initiations in both the enriched condition, $r(5) = .80$, $p = .031$, and the no enrichment condition, $r(5) = .88$, $p = .009$. Astro initiated the most affiliative tactile behaviors and the most aggressive behaviors. Noah initiated the least affiliative tactile behaviors and initiated zero aggressive behaviors, although both Doris and Vixen initiated zero aggressive behaviors as well.

Solitary Tactile Behaviors

Solitary tactile behaviors included rub pool and masturbation. During the course of the study, no instance of masturbation was observed among any of the dolphins; therefore, only instances of rub pool behaviors were included in the statistical analyses. The frequency of solitary tactile behavior (rub pool) was significantly more in the no enrichment condition compared to the enriched condition, $t(6) = 4.13$, $p = .006$, $d = 1.56$. Individually, Astro and Ivan engaged in significantly more solitary tactile behavior in the no enrichment condition (χ^2, $p < .05$ for each pairwise comparison). However, an analysis could not be conducted for the remaining dolphins due to the low frequency they engaged in the behavior. When a comparison was conducted between the dolphins, the individuals significantly differed in the amount of solitary tactile behavior they engaged in during the no enrichment condition, $\chi^2(6, N = 61) = 20.36$, $p = .002$. No chi-square analysis was conducted for the enriched condition since all expected frequencies were less than five for that condition. Dancer and Vixen engaged in the highest amount of solitary tactile behavior in the no enrichment condition and Doris and Noah engaged in the least amount (see Figure 6).

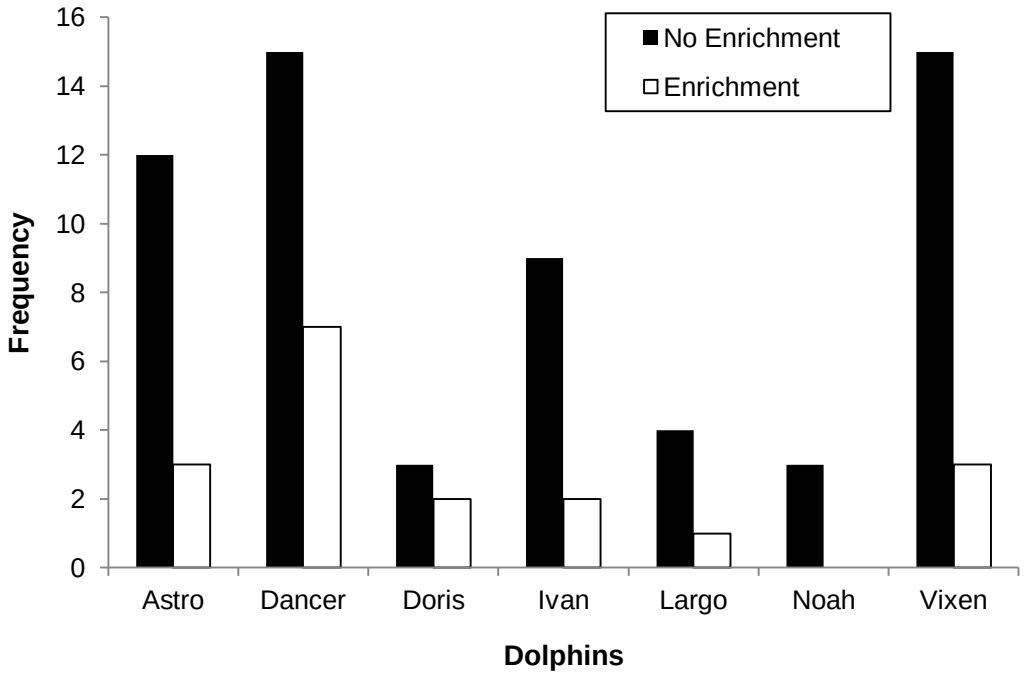

Figure 6. Frequency of solitary tactile behavior engaged in by each dolphin in the no enrichment condition and the enriched condition.

A significant positive correlation was found between the frequency the dolphins engaged in solitary tactile behavior in the no enrichment condition and the frequency they engaged in the behavior during the enriched condition, $r(5) = .79$, $p = .036$. As previously stated, Dancer was one of two dolphins that engaged in the highest amount of solitary tactile behavior in the no enrichment condition and Noah was one of two dolphins that engaged in the least amount. Both Dancer and Noah remained in their positions for highest and lowest frequency of solitary tactile behavior in the enriched condition. Several correlation tests were subsequently conducted to determine if any predictable relationship could be found between the frequency the dolphins engaged in solitary tactile behavior and the frequency they engaged in other types of tactile behaviors and object play behaviors. Since so few solitary tactile behaviors were engaged in during the enriched condition, only the frequencies for the no enrichment condition were used in the

succeeding correlation analyses. No significant correlation was found between the frequency of solitary tactile behavior (in the no enrichment condition) and the frequency of affiliative tactile behavior during either the enriched or no enrichment conditions. Furthermore, no significant correlation was found between the frequency of solitary tactile behavior and the frequency of overall object play behaviors. A significant positive correlation was found, however, between the frequency of solitary tactile behavior and the frequency of aggressive tactile behavior in the no enrichment condition, $r(5) = .76$, $p = .048$. To explore this relationship further, a correlation analysis was conducted between the frequency of solitary tactile behavior and the frequency of aggressive tactile behavior initiations as well as the frequency the dolphins were recipients of aggressive tactile behavior. Interestingly, no significant correlation was found between the frequency of solitary tactile behavior and the frequency of aggressive tactile behavior initiations. On the other hand, there was a significant positive correlation found between the frequency of solitary tactile behavior and the frequency the dolphins were recipients of aggressive tactile behavior, $r(5) = .83$, $p = .021$. The dolphins that engaged in the highest frequency of solitary tactile behavior in the no enrichment condition, Dancer and Vixen, were also the highest and second highest recipients of aggressive tactile behavior, respectively.

Object Play Behaviors

The dolphins displayed significant individual differences in their frequency of total object play behaviors, $\chi^2(6, N = 1{,}301) = 296.2$, $p < .001$. Largo engaged in the highest frequency of object play behaviors overall, whereas Doris engaged in the least amount of object play behaviors (see Figure 7). Significant differences were also found among the type of object play behaviors the dolphins used, $\chi^2(6, N = 1{,}046) = 547.561$, p

< .001. The highest frequency and second highest frequency type of object play behaviors observed were travel with toy and touch toy, respectively. For further statistical analysis of object play behaviors, they were collapsed into three main categories: object touch behaviors lasting longer than or equal to two seconds (OTB $\geq$ 2 seconds), object touch behaviors lasting less than or equal to two seconds (OTB $\leq$ 2 seconds), and social object play behaviors (see Table 7). OTB $\geq$ 2 seconds included rub toy, static toy, and travel with toy behaviors. OTB $\leq$ 2 seconds included toss toy and touch toy. Social object play behaviors included mutual toy play and steal toy.

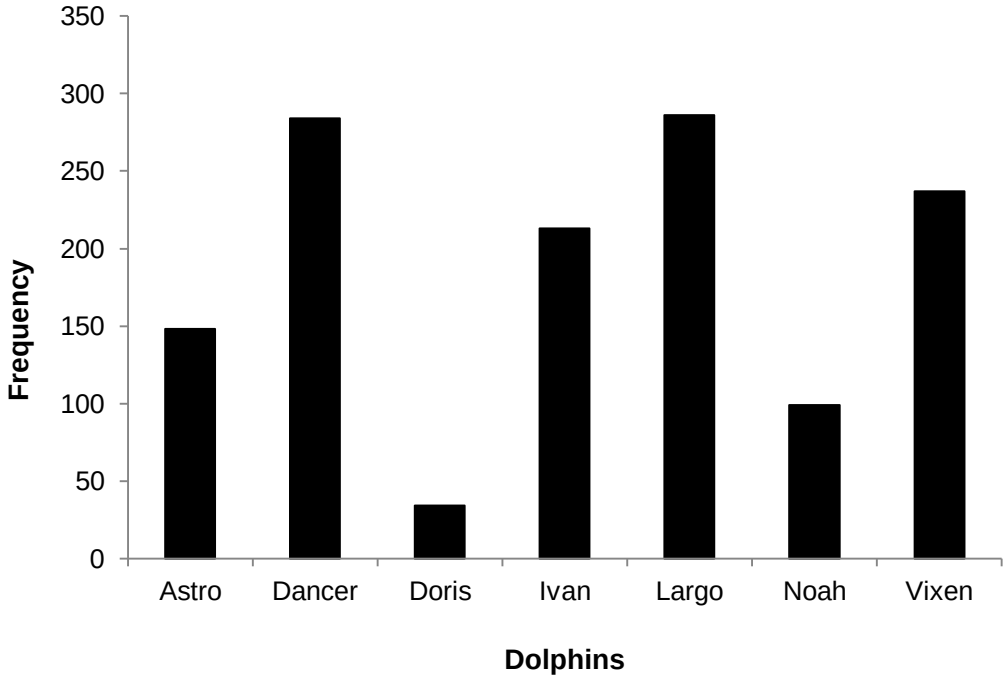

Figure 7. Frequency of overall object play behaviors engaged in by each dolphin during the enriched condition.

Table 7

Frequency of Object Play Behaviors in the Enriched Condition

Type of behavior	Astro	Dancer	Doris	Ivan	Largo	Noah	Vixen
Rub toy	13	4	4	4	9	4	22
Static toy	8	9	4	17	9	33	16
Travel toy	19	94	15	62	87	20	40
Touch ≥ 2sec	40	107	23	83	105	57	78
Toss toy	5	22	0	20	13	0	27
Touch toy	22	61	2	35	62	35	62
Touch ≤ 2sec	27	83	2	55	75	35	89
Mutual play	71	88	8	65	91	5	58
Steal toy	10	6	1	10	15	2	12
Social toy	81	94	9	75	106	7	70

Note. Touch ≥ 2 sec = Object play behaviors lasting greater than or equal to two seconds; Touch ≤ 2 sec = Object play behaviors lasting less than or equal to two seconds

Solitary Object Play Behaviors

Solitary object play behaviors included both OTB $\geq$ 2 seconds and OTB $\leq$ 2 seconds behavior categories. The frequency of OTB $\geq$ 2 seconds significantly differed between the individual dolphins, $\chi^2(6, N = 493) = 86.67$, $p < .001$. Additionally, there was a significant difference in the frequency of OTB $\leq$ 2 seconds that each dolphin engaged in, $\chi^2(6, N = 366) = 120.14$, $p < .001$. There was also a highly significant positive correlation between the dolphins' frequencies of OTB $\geq$ 2 seconds and OTB $\leq$ 2 seconds, $r(5) = .91$, $p = .005$. Therefore, the dolphins tended to be consistent in the amount of solitary object play behaviors they engaged in regardless of the length of time spent interacting with the objects. For example, Doris engaged in the least amount of OTB $\geq$ 2 seconds and OTB $\leq$ 2 seconds, whereas Dancer and Largo engaged in the most and

second most frequency of OTB $\geq$ 2 seconds, respectively (see Table 7). Dancer and Largo also engaged in the second-highest and third-highest number of OTB $\leq$ 2 seconds, respectively, but were both surpassed by Vixen for that behavior category. Due to the particular interest of this study in affiliative tactile behavior and how it relates to object play behavior, the dolphins' frequencies for the two behavior categories were tested for correlation. However, no significant correlation was found between affiliative tactile behavior and any solitary object play behaviors.

Social Object Play Behaviors

A significant difference was also found in the frequency of social object play behaviors that each dolphin engaged in, $\chi^2(6, N = 442) = 148.53$, $p < .001$. Largo had the highest frequency of social object play behaviors and Noah had the lowest (see Table 7). Social object play behavior was further investigated to determine if any predictable relationship could be found between the frequency the dolphins engaged in social object play behavior and the frequency of affiliative tactile behaviors. Although no correlation was found between social object play behaviors and affiliative tactile behaviors in the no enrichment condition, there was a significant positive correlation between them in the enriched condition, $r(5) = .91$, $p = .004$. Subsequently, the frequencies of social object play and the specific types of affiliative tactile behavior were tested for correlation in the categories of contact swim, rub, and touch behaviors (sexual contact was excluded from analysis due to the low frequency of the behavior). There was no correlation found between the frequency of social object play behavior and contact swim in either the enriched or no enrichment conditions. However, a significant positive correlation was found between the frequency of social object play behavior and the frequency of rub

affiliative tactile behavior in both the no enrichment condition, $r(5) = .76$, $p = .047$, and the enriched condition, $r(5) = .91$, $p = .005$. In addition, a significant positive correlation was found between the frequency of social object play behavior and the frequency of touch affiliative tactile behavior but only in the enriched condition, $r(5) = .94$, $p = .001$. As previously stated, Largo engaged in the most social object play behavior as well as the most affiliative tactile behavior in the enriched condition. Likewise, Noah maintained his position in both behavior categories by engaging in the lowest frequency of social object play behavior and affiliative tactile behavior during the enriched condition.

Object Preference

The overall frequency of object play behaviors significantly differed between the various types of toys, $\chi^2(10, N = 1{,}046) = 1{,}278.83$, $p < .001$. Even when the four versions of the rope toy were collapsed into one category, Figure 8 clearly shows the dolphins preferred to interact with one toy in particular, the boogie board. Furthermore, the boogie board scored the highest frequency of interaction for every category of object play behavior including: static toy, toss toy, touch toy, travel with toy, mutual toy play, and steal toy (see Table 8). However, the rub toy object play behavior was the one exception because the big tube ranked first as the preferred toy for that type of behavior. Compared to the other toy types with frequencies of less than 10, the big tube was substantially higher with a frequency of interaction greater than 40 for the rub toy behavior. The smooth buoy toy acquired the least number of object play behaviors.

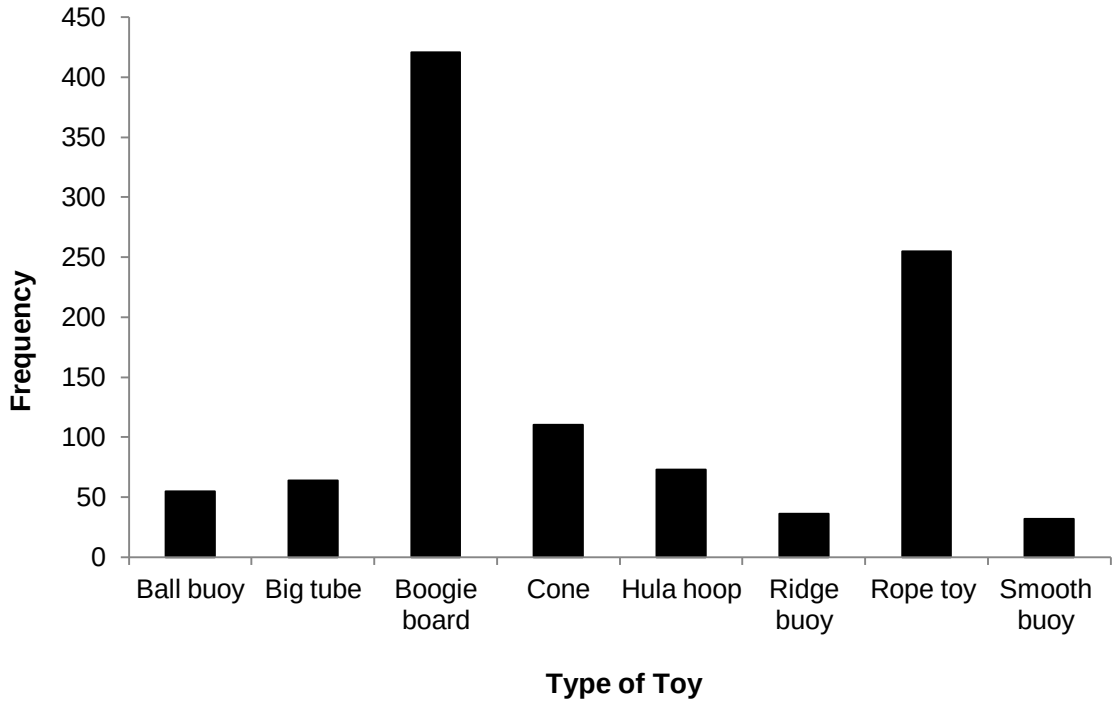

Figure 8. The total number of dolphin interactions with each object type during the enriched condition. Rope toys 1-4 were collapsed into one main rope toy category.

Table 8

Toy Preference by Object Play Behavior in the Enriched Condition

Toy type	Rub toy	Static toy	Toss toy	Touch toy	Travel toy	Mutual play	Steal toy
Ball buoy	2	0	22	20	9	2	0
Big tube	42	1	2	18	0	1	0
Boogie board	6	20	29	103	168	79	16
Cone	5	17	2	29	10	47	0
Hula hoop	3	15	0	26	27	2	0
Ridge buoy	0	1	18	11	5	1	0
Rope toy 1	0	16	4	18	21	7	3
Rope toy 2	0	10	0	22	35	10	6
Rope toy 3	0	9	0	7	29	4	1
Rope toy 4	0	7	4	10	27	4	1
Smooth buoy	2	0	6	15	6	3	0

CHAPTER IV

DISCUSSION

Overall, the rough-toothed dolphins significantly increased their total number of behaviors when enrichment objects were added to the pool. They also displayed significant individual differences between each other in the amount of behaviors they engaged in for both the enriched and no enrichment conditions. As a combined social group, however, the dolphins did display some general tendencies to engage in certain social and object play behaviors over others. For example, collectively, the dolphins displayed more touch and rub affiliative tactile behaviors than contact swimming or sexual contact. In the case of object play behaviors, they were more likely to touch or travel with the toys. As the most preferred toy, the boogie board was well suited for these types of object play behaviors due to its light weight, easy maneuverability, and buoyancy. This preference for a relatively simplistic object concurs with a study conducted by Delfour and Beyer (2012) in which they found that captive bottlenose dolphins displayed the greatest interest in simple stimuli that was easily manipulated. In conclusion to their study, Delfour and Beyer emphasized the need to analyze the effect of enrichment on captive dolphins in the context of their social environment as well as how it relates to individual differences and that is exactly what this study intended to achieve.

Enrichment Affect on Non-Aggressive Social Behavior

As a whole, non-aggressive social behavior was predicted to decrease during the enriched condition due to the opportunity to engage in object related behaviors. When social object play behaviors were excluded from the analysis, enrichment did affect the non-aggressive social behavior of the rough-toothed dolphins. The dolphins engaged in

significantly more non-aggressive social behavior, especially non-tactile social behaviors, without enrichment objects in the pool. However, when social object play behaviors were included in the analysis, no significant difference was found between the enriched and the no enrichment conditions. This suggests the dolphins engaged in less non-aggressive social behaviors, such as pair swims and follows, in the enriched condition because they were able to engage in other forms of social behavior involving the enrichment items, such as mutual play and steal toy, that were not available to them in the no enrichment condition.

Enrichment Affect on Affiliative Tactile Behavior

Affiliative tactile behavior was also predicted to decrease during the enriched condition. Nevertheless, no significant difference was found between the two conditions for this behavior. This result suggests that regardless of all dolphins having interacted with the enrichment (albeit some more than others), the contact with the inanimate objects could not supplement the tactile behavior engaged in with conspecifics. Furthermore, the positive correlation between the no enrichment and enriched conditions indicates the dolphins maintained a similar level of affiliative tactile behavior across the two conditions. For example, the juvenile dolphins, Astro, Dancer, Ivan, and Largo, engaged in affiliative tactile behavior more frequently than the adults, Doris, Noah, and Vixen, in both conditions.

In a study conducted by Dudzinski (1998), the majority of contact was observed between dolphins of the same sex, in a similar age class, and was especially prevalent among juveniles. In this study, age did appear to play a role in how often the dolphins contacted each other in an affiliative manner. During the no enrichment condition, three

of the juvenile dolphins (Dancer, Ivan, and Largo) engaged in the exact same amount of this type of behavior. In contrast, no obvious gender differences were found. For either sex in both conditions, touch was the affiliative tactile behavior engaged in most frequently followed by rub. Contact swimming may be uniquely sex specific across some delphinid species since the behavior is primarily engaged in by female Indian Ocean bottlenose dolphins (Connor et al., 2006a) and primarily engaged in by male Commerson's dolphins (Johnson & Moewe, 1999) However, this group of rough-toothed dolphins were analogous to spotted dolphins in that no sex bias was observed (Dudzinski, 1998).

Sexual contact was solely observed during the no enrichment condition between Astro and Ivan. According to Mann (2006), juvenile dolphins engage in higher levels of all socio-sexual behavior including homosexual behavior. Therefore, the sexual contact observed during this study between the two juvenile males was consistent with these results. Homosexual behavior is suggested to function in alliance formation leading to the long-term stable bonds observed between male dolphins. However, this behavior may also play a role in the formation of dominance status as well as provide an opportunity to practice mating (Mann, 2006).

The results did not reveal a definitive dolphin consistently in the role of the initiator or consistently the recipient of affiliative tactile behavior. During the enriched condition, Astro, Dancer, Largo, and Vixen all increased their number of affiliative tactile behavior initiations, whereas Doris, Ivan, and Noah all decreased in their initiations. When grouped according to age, however, the juveniles initiated more affiliative tactile behavior than the adults in both conditions. This increased level of juvenile initiated

affiliative tactile behavior is consistent with other studies of both wild and captive populations (Dudzinski, 1998; Johnson & Moewe, 1999; Kaplan & Connor, 2007; Tamaki et al., 2006). Consequently, researchers have inferred that the foundation for long-term social affiliations commonly seen among dolphins is established during this prepubescent stage of their life (Kaplan & Connor, 2007). Vixen, the youngest adult, was the one exception because she initiated the least number of affiliative tactile behaviors compared to her conspecifics in the no enrichment condition but moved to fourth place during the enriched condition. For Vixen, specifically, the presence of the enrichment objects may have facilitated her to engage in more pro-social behaviors with the other dolphins in the pool.

Enrichment Affect on Aggressive Behavior

As predicted, the number of aggressive social behaviors was significantly reduced when the enrichment objects were present in the pool. Interestingly, only the four juvenile dolphins, Astro, Dancer, Ivan, and Largo, initiated aggressive behavior. The two oldest dolphins, Doris and Noah, in the social group were not involved in any aggressive behaviors, and Vixen, the youngest adult, was solely the recipient of aggressive behavior. Only Astro and Ivan, the two juvenile males, engaged in aggressive behavior during the enriched condition and were equally the initiator and recipient of aggression. Dancer, the newest member to the social group and possibly the youngest member, was involved in the most aggressive behaviors primarily as the recipient.

The increased level of aggressive behaviors exhibited by the juvenile dolphins concurs with other captive dolphin studies (Holobinko & Waring, 2010; Samuels & Gifford, 1997; Weaver, 2003). One possible explanation for the heightened aggression

observed among this age class is an attempt to establish their place in the social hierarchy. The two oldest dolphins in the pool, Doris and Noah, were neither the initiator nor recipient of aggressive behavior. More than likely, Doris and Noah have established their place in the dominance hierarchy and since no aggressive behavior was directed toward them, it was unnecessary from them to instigate an agnostic encounter. Primarily, Doris and Noah engage in social activity with each other, whereas Vixen is relatively solitary (personal observation, 2009). As the youngest adult and without a clear social alliance, Vixen may have been a target for the boisterous juvenile dolphins as they attempt to establish their dominance.

Enrichment Affect on Solitary Tactile Behavior

The enrichment objects may not have been sufficient tactile stimulation to compensate for affiliative dolphin-to-dolphin contact but they did affect how often the dolphins rubbed against the sides and steps of the pool. During the enriched condition, solitary tactile behavior was significantly reduced compared to the no enrichment condition. The *big tube*, strung across the length of the pool elicited the majority of the rub object behaviors, which likely played a role in decreasing the number of rub pool behaviors.

Further investigation of solitary tactile behavior and its relationship to other types of tactile behavior and object play behavior, proved interesting in its result. A significant positive correlation was found between the frequency the dolphins engaged in solitary tactile behavior and the frequency the dolphins were recipients of aggressive tactile behavior. Thus, dolphins that engaged in the most solitary tactile behavior also received the most aggressive contact.

Individual Differences for Social Behaviors

According to Highfill and Kuczaj (2010), some captive dolphins are more likely to initiate certain social behaviors possibly as a reflection of individual differences and underlying personality traits. Personality, as it relates to this study, can be defined as "an individual dolphin's distinguishing patterns of behavior that remain consistent over time and across situations" (Highfill & Kuczaj, 2007, p. 380). Furthermore, personality and consistent individual differences have been used interchangeably in the literature when referring to non-human animal populations (Highfill & Kuczaj, 2010). In this study, the dolphins did display significant individual differences in the amount of social behaviors they engaged in. Results indicated significant individual differences in non-aggressive social behaviors in both the enriched and no enrichment conditions. More specifically, individual differences among non-tactile social behaviors and affiliative tactile behaviors were observed during both conditions. Furthermore, in the no enrichment condition, the dolphins displayed significant individual differences for aggressive social behavior and solitary tactile behavior as well. The frequencies of these behaviors, however, were too low during the enriched condition to determine significant differences.

Individual Differences for Object Play Behaviors

Significant individual differences were also observed in the frequency of object play behaviors the dolphins engaged in. The dolphins displayed significant individual differences for both categories of solitary object play behaviors, those lasting less than two seconds and those lasting longer than two seconds. The dolphins also showed

significant individual differences in the frequency of social object play behaviors they engaged in.

The juvenile female dolphins, Dancer and Largo, engaged in the highest frequency of object play behaviors. Astro and Ivan engaged in a high number of object play behaviors as well but Vixen engaged in more. When compared to the other adult dolphins, Vixen's high level of toy interactions could be inferred as her having a particular affinity for solitary object play. Due to the small sample size, however, it remains unclear if Vixen's increased object play behavior is simply a reflection of her age as a relatively younger (compared to Doris and Noah) adult. When looking specifically at social object play behaviors, the four juveniles engaged in the highest frequency and surpass all three adult dolphins. The results of this study are consistent with Dudzinski's (2010) findings that juvenile dolphins display more play and inquisitive behaviors in both wild and captive populations. In a study conducted by Herzing, Delfour, and Pack (2012), sexually immature wild Atlantic spotted dolphins, particularly juvenile females, were more likely to engage in object play activities and interactions with humans. The dolphins' willingness to engage with humans and interact with objects was attributed to individual differences and personality factors.

Relationship between Tactile Behavior and Object Play Behavior

No significant correlation was found between affiliative tactile behavior and solitary object play behaviors. However, a significant positive correlation was observed between social object play behaviors and affiliative tactile behaviors during the enriched condition. Therefore, the dolphins that engaged in social object play behaviors more often also engaged in affiliative tactile behaviors more frequently. These results may reflect

personality differences in that the more *social* dolphins engage in more pro-social behaviors regardless of the context. For these extroverted individuals, objects may be used as just another modality to facilitate social interactions.

CHAPTER V

SUMMARY

Samuels et al. (1989) observed an increased level of object rubbing in a dolphin that received a low level of dolphin-to-dolphin contact and hypothesized that social tactile behavior may serve a hygienic purpose (as cited in Dudzinski et al., 2012, p. 23). In comparison, affiliative tactile behavior did decrease for some dolphins in the presence of enrichment during this study but the difference was not significant. Furthermore, the amount of affiliative tactile behavior was correlated between the two conditions. These results suggest that inanimate objects do not fulfill the purpose that dolphin-to-dolphin tactile serves but rather some dolphins show a greater affinity for affiliative tactile behavior compared to others. Similar to studies conducted with other species (Dudzinski et al., 2012; Herzing et al., 2012; Highfill & Kuczaj, 2010; Kuczaj, Yeater, & Highfill, 2012), the rough-toothed dolphins in this study demonstrated significant individual differences in their preference for affiliative contact. Therefore, the decrease in level of affiliative tactile behavior during the enriched condition may simply be a consequence of the increased opportunity to engage in other object related behaviors and as such, the differences between the two conditions were not significant.

Tactile contact with an object may not be a preferred substitute for affiliative dolphin-to-dolphin contact but it may function as a compromise to avoid an aggressive reaction. In a study conducted by Dudzinski et al. (2012), dolphin calves and juveniles were much more likely to seek contact from their conspecifics at their captive facility study site compared to the dolphins of the same age classes at their wild populations study sites. In addition, females among one population of wild dolphins engaged in 94%

of the observed self-rubbing events compared to males. Although not conclusively proven by their results, Dudzinski and colleagues suggested that self-rubbing may be a measure taken to avoid agnostic encounters with conspecific males. Therefore, females would engage in more self-rubbing behavior and in the human controlled environment, calves and juveniles could solicit affilitiave contact with less fear of an aggressive response compared to their wild counterparts.

The correlation found during this study between recipient of aggressive tactile behavior and the frequency of pool rubbing behavior further supports the theory of Dudzinski et al. (2012). Dolphins that received the highest frequency of hits, body slams, bites, and rakes, engaged in the highest frequency of solitary pool rubbing behavior during the no enrichment condition. Rather than try to solicit affiliative dolphin-to-dolphin contact from unpredictable conspecifics, this increased level of pool rubbing may be a necessary consequence to avoid potential aggressive attacks.

Several case studies conducted by Waples and Gales (2002), revealed how changes to the social environment can have severe consequences to captive bottlenose dolphins. Persistent aggressive attacks and shifts in the dominance hierarchy can cause prolonged stress, which can be further exacerbated by the captive environment. Ultimately, a dolphin's health could become compromised and can even result in death. Therefore, it is imperative that social stress and especially agnostic behavior be minimized among delphinid species in order to maintain their well-being in captive facilities (Waples & Gales, 2002). Larger pool size has been suggested as a method to enhance the welfare of captive marine mammals (Bassos & Wells, 1996; Greenwood, 1977; Waples & Gales, 2002), but for many facilities this would not be economical or

feasible. Based on the results of this study, however, a more cost effective option to help reduce aggressive behavior among captive dolphins would be to provide environmental enrichment. While the implementation of enrichment items into the pool did not completely eliminate aggressive behavior, the amount was significantly reduced between the no enrichment and enriched conditions as well as limited to just the two juvenile males.

Reduced aggression was not the only benefit the enrichment items provided. Goldblatt (1993) considers marine mammal pools to often be "the most sterile captive environment" (p. 150). Therefore, the use of enrichment items can provide stimulation to a physically impoverished environment (Grindrod & Cleaver, 2001). A number of studies have shown that enrichment can reduce stress and stereotyped behavior (Goldblatt, 1993; Grindrod & Cleaver, 2001; Hunter et al., 2002; Mason et al., 2007; Ross, 2002; Shyne, 2006; Swaisgood & Shepherdson, 2005). Although not the primary focus of this study, no conspicuous stereotypic behaviors were observed so it is unknown if the enrichment objects were effective in reducing them. However, all of the behaviors of interest in this study could be considered *species-typical* behaviors including object play and social object play since both have been observed among wild rough-toothed dolphins (Kuczaj & Yeater, 2007). The significant increase in overall behaviors during the enriched condition suggests that the enrichment objects facilitated a greater number of species-typical behaviors in comparison to when no items were in the pool. Furthermore, the only behaviors of interest that could cause potential stress, the aggressive social behaviors, were significantly reduced.

The main limitation of this study was the possibility that the data may not meet the assumptions of the paired t-test such as possible non-normality and violation of the assumption of independence. Consequently, caution in the interpretation of the results of the paired t-test is necessitated. Another limitation of this study, the small sample size, prohibits the generalizability of the results to wild rough-toothed dolphins, or even to other species of captive dolphins. However, systematic behavioral observations of captive animals have become increasingly important to help fill in the "gaps" when combined with wild population studies (Dudzinski, 2010; Dudzinski et al., 2012; Morisaka et al., 2010). By having intimate knowledge about the captive dolphins in their study, such as age, sex, medical history, genetic relatedness, etc., researchers may gain valuable information not attainable from wild dolphins. For instance, Kuczaj and Yeater (2007) while studying a population of wild rough-toothed dolphins saw the dolphins engaging in a variety of types of tactile behavior on multiple occasions. They also observed rough-toothed dolphins playing with objects and engaging in cooperative play that suggests this species may possess a "natural curiosity" and a "playful nature" (Kuczaj & Yeater, 2007, p. 146). During this study, although there were clear individual differences in the frequency of affiliative tactile behavior and object play behavior, the fact that all seven captive rough-toothed dolphins engaged in both types of behaviors supports Kuczaj and Yeater's findings for wild populations. Moreover, because the relative ages of the captive dolphins were known, it was possible during this study to establish that the juveniles participated in the majority of affiliative tactile behaviors and object play behaviors.

Future studies should evaluate the captive dolphin personality traits either by coding video or through trainer questionnaires or both. Furthermore, the dolphins should

be ranked according to their status in the dominance hierarchy. Based on this information, the researcher could have a broader understanding of the individual dolphins' response to the enrichment objects as well as their involvement in the social dynamic of the group. As a result of acquiring a greater knowledge of their dolphins' personalities, position in the social structure, and preference for enrichment items, the caretakers at captive facilities could better customize their enrichment programs to fit the needs of their individual animals. More importantly, caretakers need to have a deeper understanding of their particular species social behavior and indicators of stress and aggression. According to Highfill and Kuczaj (2010), "knowing the idiosyncrasies of individual animals enables human caretakers to better predict the behavior of group members" (p. 274). Finally, the development of individual profiles for each animal could help caretakers avoid inadvertently adding stress when their goal is to reduce it (Delfour & Beyer, 2012).

Multiple studies suggest that enrichment can reduce stereotypic behavior and increase species-specific behaviors, but the results of this study suggest it could also reduce agnostic behavior among social marine mammals. Based on this information, it should be a precedent for captive facilities to provide enrichment for the psychological, and even physical, health of the animals in their care. In addition, increasing play behaviors, both social and object oriented, has been suggested to promote developmental and cognitive functions (Herzing et al., 2012). Therefore, cognitively advanced species, such as the rough-toothed dolphin, may benefit the most from enrichment involving objects since it facilitates play and thereby, enhances the well-being of the animals (Kuczaj et al., 2002).

Overall, this study demonstrated that enrichment can increase species-typical behaviors including social and object play. Enrichment was also shown to minimize aggressive behaviors and possibly reduce stress as a byproduct. Enrichment was not found to be a supplement to affiliative tactile contact between the dolphins but does appear to function as a suitable alternative to rubbing against the bottom, sides, and steps of the pool. Whether pool rubbing behavior or object contact behaviors, serves a hygienic purpose for the dolphins or simply provides a pleasurable tactile sensation remains unclear. Regardless of the function, this group of rough-toothed dolphins appeared to display an affinity for engaging in affiliative dolphin-to-dolphin tactile behavior and object play behaviors consistent with observations of wild populations. Finally, due to the sterile nature of the captive marine mammal environment, caretakers should continue to provide stimulation for their dolphins through environmental enrichment. Future studies should look to establish behavioral and personality profiles for their individual animals in order to customize enrichment programs to fit the specific needs of the animals in their care.

APPENDIX A

GENERAL BEHAVIOR CODES AND DESCRIPTIONS

Name of behavior	Type	Description
Non-tactile social behaviors		
Pair swim	State	two dolphins swim in close proximity (approximately 2 feet) and in the same direction for 5 seconds or more
Group swim	State	three or more dolphins swim together in close proximity (approximately 2 feet) and in the same direction for 5 seconds or more
Follow	State	one dolphin follows in close proximity (approximately 2 feet) behind one or more dolphins for 5 seconds or more
Pair/ Group rest	State	two or more dolphins resting motionless or almost motionless at the surface of the water in close proximity (approximately 1-2 feet) to each other often touching or nearly touching for 10 seconds or more facing the same direction
Chase	State	rapid and persistent pursuit of another dolphin occurring for 5 seconds or more, considered as an aggressive behavior
Affiliative tactile behaviors		
Touch	Event	a simple touch between dolphins with no rubbing movement, occurring for 1 second or more
Rub	State	any general tactile contact in which the rubber is moving a body part, such as the head, fins, fluke or rostrum along some region of the rubbee's body, occurring for 2 seconds or more
Contact swimming	State	one dolphin maintains static contact of its pectoral fin to either the side or the pectoral fin of another dolphin while swimming for 3 seconds or more
Sexual contact	State	any contact behaviors that involve a male erection either touching another dolphin or being touched or a direct contact with one dolphin's genital slit by another dolphin
Aggressive tactile behaviors		
Hit	Event	abrupt and forceful contact with another dolphin that causes the hit dolphin to be moved due to the force of the contact
Rake/ Bite	Event	abrupt, forceful contact with another dolphin using the teeth (bite) including rubbing/sliding its jaws on the other dolphin (rake)
Solitary tactile behaviors		
Rub pool	State	the dolphin rubs some part of its body in a non-sexual manner against the wall or step of the pool for 2 seconds or more
Masturbation	State	the dolphin engages in self-stimulation by rubbing its genitals against an inanimate object (must be clear genital contact with object) for 2 seconds or more

APPENDIX B

OBJECT PLAY BEHAVIOR CODES AND DESCRIPTIONS

Name of behavior	Type	Description
Solitary object play behaviors		
Touch object	Event	solitary interaction with an object where the dolphin touches the object with some part of its body for at least 1 second but less than 5 seconds
Toss object	Event	interacting with an object in such a way that the object is flung from one location to another such as using the rostrum to flick a ball into the air
Travel with object	State	swimming with an object including carrying the object in the mouth, on the rostrum, or on the pectoral or dorsal fin for at least 2 seconds or longer
Static object contact	State	resting or engaging in little activity while remaining in contact with an object for 5 seconds or more
Rub object	State	the dolphin moves its body or body part against an inanimate object for 2 seconds or more
Social object play behaviors		
Steal object	Event	one dolphin takes an object that another dolphin was interacting with and travels with the stolen object
Mutual object play	State	two or more dolphins mutually interacting with the same object

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INSTITUTIONAL ANIMAL CARE AND USE COMMITTEE NOTICE OF COMMITTEE ACTION

The proposal noted below was reviewed and approved by The University of Southern Mississippi Institutional Animal Care and Use Committee (IACUC) in accordance with regulations by the United States Department of Agriculture and the Public Health Service Office of Laboratory Animal Welfare. The project expiration date is noted below. If for some reason the project is not completed by the end of the three year approval period, your protocol must be reactivated (a new protocol must be submitted and approved) before further work involving the use of animals can be done.

Any significant changes (see attached) should be brought to the attention of the committee at the earliest possible time. If you should have any questions, please contact me.

PROTOCOL NUMBER:	**10042701**
PROJECT TITLE:	**Tactile Behavior in a Group of Captive Rough-toothed Dolphins as a Function of Opportunities to Play with Objects**
PROPOSED PROJECT DATES:	**March 2010 – September 2012**
PROJECT TYPE:	**New**
PRINCIPAL INVESTIGATOR(S):	**Stan Kuczaj**
DEPARTMENT:	**Coastal Science – USM GCRL**
FUNDING AGENCY/SPONSOR:	
IACUC COMMITTEE ACTION:	**Full Committee Approval**
PROTOCOL EXPIRATON DATE:	**September 30, 2012**

Jodie M. Jawor, Ph.D.
IACUC Chair

4/15/2013
Date

*Replacement letter (original has been misplaced)