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Seasonal and Diurnal Behavioral Patterns of Bottlenose Dolphins, *Tursiops truncatus*, That Exhibit High Site and Low Site Fidelity to Mississippi Sound

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The University of Southern Mississippi

SEASONAL AND DIURNAL BEHAVIORAL PATTERNS OF BOTTLENOSE DOLPHINS, *TURSIOPS TRUNCATUS*, THAT EXHIBIT HIGH SITE AND LOW SITE FIDELITY TO MISSISSIPPI SOUND

by

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ABSTRACT

SEASONAL AND DIURNAL BEHAVIORAL PATTERNS OF BOTTLENOSE DOLPHINS, *TURSIOPS TRUNCATUS*, THAT EXHIBIT HIGH SITE AND LOW SITE FIDELITY TO MISSISSIPPI SOUND

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This study examined whether bottlenose dolphins (*Tursiops truncatus*) exhibit site fidelity to the Mississippi Sound and how the seasonal and diurnal behavioral patterns of dolphins that exhibit high site fidelity to the Mississippi Sound differ from those of dolphins with lower site fidelity. Opportunistic surveys conducted from July 2006 to April 2010 were analyzed. Statistical analyses consisted of nonparametric tests (Spearman's correlation, loglinear models, and Pearson's chi-square) to compare behavioral patterns of high site fidelity, mixed, and low site fidelity groups. Behavioral patterns significantly differed between site fidelity groups across seasons and diurnal periods. Feeding behavior was observed significantly more often in lower site fidelity groups, which coincides with seasonal prey species migrations. These findings suggest that lower site fidelity dolphins may migrate through the Mississippi Sound to pursue seasonal prey species. Sighting patterns of dolphins suggest the Mississippi Sound is characterized by seasonal migrations of low site fidelity dolphins during the spring and summer. Higher site fidelity dolphins that are potential seasonal residents and year round residents may also exhibit seasonal movements in the Mississippi Sound. Knowledge of the behavioral patterns of high site fidelity and low site fidelity dolphins may lead to improved conservation efforts for potential inshore and coastal stocks to ensure better

population health in an area that is highly vulnerable to anthropogenic disturbance such as commercial fishing, boat traffic, and pollution.

DEDICATION

I would like to dedicate this manuscript to my mom, Shannon McBride. I would like to thank her for encouraging me to pursue my dreams and teaching me that anything can be achieved through perseverance in following inspiration.

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I would like to thank my thesis advisor, Dr. Stan Kuczaj, and my other committee members, Dr. John Harsh and Dr. Frank Moore, for their advice throughout this project. I am very grateful to Dr. Richard Mohn for answering all my questions about statistics. Appreciation is expressed to the Institute for Marine Mammal Studies for providing a boat and boat operator to conduct surveys for the Mississippi Sound Wild Dolphin Project, which is the source of data for this project. I would like to recognize and thank all the graduate students, interns, and volunteers in the Marine Mammal Behavior and Cognition Laboratory for their assistance in processing the data collected for the Mississippi Sound Wild Dolphin Project. This thesis project would not be possible without your many long hours of hard work. I would also like to thank Tina Stone, Briana Harvey, Christina Perazio, Natalia Botero, Erin Frick, Brittany Jones, and Kelley Winship for their advice and support on the writing and defense of this project.

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CHAPTER I

INTRODUCTION

Understanding behavioral patterns of a species allows for the design and implementation of effective conservation practices that are based on that species' specific ecological needs (Miller, Solangi, & Kuczaj, 2010). Most behavioral studies to date have focused on general activity budgets for a specific geographic dolphin population (*Tursiops aduncas ehrenburg:* Saayman, Tayler, & Bower, 1973; *Tursiops truncatus*: Bearzi, 2005; Bearzi, Saylan, & Hwang, 2009; Gruber, 1981; Hanson & Defran, 1993; Miller et al., 2010; Shane, 1977, 1990; Shane & Schmidly, 1978; Sini, Canning, Stockin, & Pierce, 2005; Wursig & Wursig, 1979). Knowledge of general behavioral patterns is extremely valuable in addressing a population's conservation and management needs. However, little information is available about the behavioral patterns of individual overlapping inshore resident communities and migratory coastal dolphins within a geographical area. Behavioral pattern studies report different observations across study sites (see Tables 1 and 2 for comparison). There are many factors that may contribute to the behavioral variation that is observed across geographic populations, such as different study methodology, habitat characteristics, prey availability, and anthropogenic disturbance. The representation of inshore resident communities and migratory coastal dolphins may partially account for the intraspecific behavioral variation. Based on the different site fidelity patterns of inshore residents and coastal dolphins, each group may exploit different resources and place different ecological pressures on their habitat. The implications of utilizing different site fidelity patterns to exploit their habitat's resources include varying seasonal and diurnal behavioral patterns. This study addresses the following questions: 1) do bottlenose dolphins (*Tursiops truncatus*) exhibit site fidelity to the Mississippi Sound and why?; 2) how do the behavioral patterns of dolphins that exhibit high site fidelity differ from dolphins that exhibit low site fidelity to the Mississippi Sound across time of day and across seasons?; and 3) how do the behavioral patterns of groups consisting of both high site fidelity and low site fidelity dolphins (mixed groups) differ from high site fidelity and low site fidelity groups?

CHAPTER II

BACKGROUND INFORMATION

Delphinid Behavioral Patterns

A number of studies have been conducted to determine behavioral patterns of different species of dolphins in various locations throughout the world (Bearzi, 2005; Bearzi et al., 2009; Gruber, 1981; Hanson & Defran, 1993; Miller et al., 2010; Saayman et al., 1973; Shane, 1977; 1990; Shane & Schmidly, 1978; Sini et al., 2005; Wursig & Wursig, 1979). These studies have found that behavioral patterns change in relation to time of day, season, year, and are also influenced by environmental factors such as depth, tidal current, distance from shore, and habitat characteristics. Common trends are that dolphins spend the majority of their time traveling, a moderate amount of time feeding, and a small portion of time socializing (Hanson & Defran, 1993). However, season and time of day influence these patterns.

Seasonal Behavioral Patterns

Table 1 summarizes significant behavioral changes across seasons reported in literature.

Table 1

Summary Table of Seasonal Behavioral Pattern Studies (Findings are Significant at p<.05 Level or Lower)

Author	**Spring**	**Summer**	**Fall**	**Winter**
Gruber, 1981 Matagorda Bay, TX	Travel & Social	Travel & Social	Feed	Feed
Hanson & Defran, 1993 San Diego, CA		Social		
Miller et al., 2010 Gulfport, MS	Social		Feed	Travel

Table 1 (continued).

Author	**Spring**	**Summer**	**Fall**	**Winter**
Shane, 1977 Aransas Pass, TX	Travel & Social		Feed	Travel
Shane, 1990 Sanibel Island, FL			Social & Travel/Feed	Social & Travel/Feed
Shane & Schmidly, 1978 Aransas Pass, TX	Travel & Social		Feed	Travel
Wursig & Wursig, 1979 Golfo San Jose, Argentina	Deep-water Feed		Deep-water Feed	Deep-water Feed

Majority of the studies observed similar trends with travel and social behavior increasing during the spring and feeding behavior increasing during the fall (Gruber, 1981; Miller et al., 2010; Shane, 1977; Shane & Schmidly, 1978). Travel behavior was most often observed during winter months (Miller et al., 2010; Shane, 1977; Shane & Schmidly, 1978). Social behavior was more often observed during summer months (Gruber, 1981; Hanson & Defran, 1993).

There is still much to learn about the seasonal activities of dolphins and to what extent external variables affect these behavioral patterns. External variables such as habitat characteristics, environmental variables, degree of anthropogenic disturbance, prey species availability, and habitat utilization strategies, likely contribute to the inconsistency of findings. These studies were conducted in a diverse array of geographical areas on populations that show various levels of site fidelity to the study site. This difference in the population's site fidelity may partially account for the intraspecific variation in seasonal behavioral patterns.

For instance, Shane's (1990) study was conducted near Sanibel Island, FL, which is a small barrier island off the west coast of Florida. She observed the behavior of a small population of dolphins that were frequently resighted, suggesting that this population consisted mostly of resident dolphins that exhibit high site fidelity to Sanibel Island, FL. Shane found an increase in social and travel/feed behavior during fall and winter months. These results contrast with seasonal behavioral observations from open, rocky shore study sites (Hanson & Defran, 1993; Wursig & Wursig, 1979). Hanson and Defran (1993) conducted their study on the population in San Diego, CA, which is reported from other photo-identification projects in southern California to have very low resighting rates, suggesting this population has a large home range and exhibits low site fidelity to any particular area (Bearzi, 2005; Defran & Weller, 1999; Hwang, 2011). In Bearzi's (2005) study, behavioral patterns of dolphins in Santa Monica Bay, CA did not vary consistently across seasons; however, behavioral patterns differed significantly across study years. Studies off the coasts of Texas and Mississippi observed different trends in seasonal behavior patterns than those previously discussed (Gruber, 1981; Miller et al., 2010; Shane, 1977; Shane & Schmidly, 1978). Photo-identification studies in this region report a wide range of site fidelity patterns, including year round residents, seasonal residents, and migratory nonresidents (Gruber, 1981; Hubard, Maze-Foley, Mullin, & Schroeder, 2004; Maze & Wursig, 1999; Shane, 1977, 1980; Shane & Schmidly, 1978). These comparisons show that intraspecific variation in seasonal behavioral patterns exists between geographic populations that exhibit different site fidelity patterns. Site fidelity differences may not be causing the variance in behavioral patterns, but the observed differences indicate that ecological pressures differ between populations, resulting in different site fidelity patterns to exploit their habitat's resources.

Diurnal Behavioral Patterns

Table 2 presents a summary of significant changes in diurnal behavioral patterns reported in literature.

Table 2

Summary Table of Diurnal Behavioral Pattern Studies (Findings are Significant at p<.05 Level or Lower)

Author	Morning	Midday	Afternoon	Evening
Gruber, 1981 Matagorda Bay, TX	Feed		Travel & Social	
Hanson & Defran, 1993 San Diego, CA	Feed	Travel		Feed
Miller et al., 2010 Gulfport, MS	Feed		Social	
Saayman et al., 1973 Eastern Cape, South Africa	Feed	Social	Feed	
Shane, 1977 Aransas Pass, TX	Feed	Social	Feed	
Shane, 1990 Sanibel Island, FL	Feed & Travel/Feed			Social
Sine et al., 2005 Aberdeen, Scotland	Travel			Mill
Wursig & Wursig, 1979 Golfo San Jose, Argentina	Rest	Feed	Aerial*	

*Aerial behaviors are hypothesized to be associated with feeding and socializing (Wursig & Wursig, 1979).

Nearly all studies observed feeding behaviors in the morning hours (Gruber, 1981; Hanson & Defran, 1993; Miller et al., 2010; Saayman et al., 1973; Shane, 1977; 1990). Several studies reported a second feeding peak later in the afternoon or evening (Hanson & Defran, 1993; Saayman et al., 1973; Shane, 1977; Wursig & Wursig, 1979). Social behavior was observed later throughout the day, but observations varied greatly across study sites (Gruber, 1981; Miller et al., 2010; Saayman et al., 1973; Shane, 1977; 1990; Wursig & Wursig, 1977). Travel and milling behaviors also differed across time of day in different study sites (Gruber, 1981; Hanson & Defran, 1993; Sine et al., 2005). This comparison of diurnal behavioral patterns emphasizes the plasticity of bottlenose dolphin behavior across geographical areas. Habitat characteristics and prey distribution differ greatly between these study sites and undoubtedly affect diurnal behavioral patterns (Shane, Wells, & Wursig, 1986). However, there is little understanding of how site fidelity patterns of a population are related to diurnal behavioral patterns. Differences in site fidelity patterns may indicate that different ecological pressures affect the population and may alter overall diurnal behavioral patterns.

Free-Ranging Behavioral Patterns

To date, few studies have looked at behavioral patterns of populations of different dolphin species that have been determined to be largely free-ranging and migratory (Bearzi, Politi, & Di Sciara, 1999; Bearzi et al., 2009; Neumann, 2001). In Neumann (2001) the behavioral patterns of free ranging common dolphins (*Delphinus delphis*) in the northwestern Bay of Plenty, New Zealand were studied. Neumann found that common dolphins spent 54.8% of their time traveling, 20.5% milling, 17% feeding, 7.3% socializing, and 0.4% resting, although the exact proportion of these activities varied from month to month. However, no statistically significant changes were observed across seasons. Bearzi and colleagues (1999) studied behavioral patterns of free-ranging bottlenose dolphins (*Tursiops truncatus*) in the North Adriatic Sea and found that behavioral patterns did not consistently change across seasons but differed across years in which long dive behavior increased and dive/following-trawler and travel behavior decreased across study years. A study conducted by Bearzi and colleagues (2009) compared behavioral patterns of coastal (<1km from shore) and offshore (1-65 km from shore) populations of bottlenose dolphins in Santa Monica Bay, CA. The authors found that both populations spent most of their time in travel and travel-dive states and that the offshore population socialized more often than the coastal population. This study documented very low sighting frequencies in both coastal and offshore populations, suggesting that both populations have a large home range and low site fidelity to the study site. A small percentage (4.8%) of individuals were observed in both coastal and offshore population areas indicating that dolphins cross designated population boundaries and potentially interact together.

In comparison, the behavioral patterns of offshore free ranging coastal dolphins did not vary consistently across seasons but varied significantly across study years. Inshore populations of dolphins show significant behavioral pattern changes with time of day and across seasons. These comparisons show that free-ranging dolphins potentially have different behavioral patterns relative to inshore dolphins. However, conclusions about these behavioral differences cannot be made until the inshore populations have been systematically investigated to determine the overlap between inshore resident dolphins and coastal nonresident dolphins, since both groups have been observed interacting close to shore (Fazioli, Hofmann, & Wells, 2006; Maze & Würsig, 1999; Quintana-Rizzo & Wells, 2001; Shane, 2004; Wells, Scott, & Irvine, 1987). Therefore, behavioral pattern results of inshore populations may potentially be represented by both inshore residents and coastal nonresidents migrating through the area at the time of study.

Recognition, Distribution, and Population Estimates of Bottlenose Dolphin Stocks in the Northern Gulf of Mexico

According to the Marine Mammal Protection Act [16 U.S.C. 1362A], a stock is defined as a group of marine mammals within the same species or subspecies that inhabit a common area and interbreed when mature. The term stock is based on "communities" described by Wells, Scott, and Irvine (1987), which refer to resident dolphins that exhibit high site fidelity to the same location, overlap in their home ranges, interact regularly, and exhibit similar genetic profiles to a much greater extent than dolphins in adjacent waters. At this time, scientists are uncertain of the exact geographic boundaries between communities. Therefore, certain locations that have shown evidence of being inhabited by potential communities have been designated as stocks for management purposes until more empirical evidence is available to establish the exact home range of these communities. There are four bottlenose dolphin stock types recognized in the Gulf of Mexico population: (1) oceanic stock, (2) continental shelf stock, (3) coastal stock, and (4) inshore (bay, estuarine, and sound) stock. For the purposes of this study, only coastal and inshore stocks will be discussed since the other stocks do not inhabit the study area.

Coastal stock refers to bottlenose dolphins that inhabit waters between bay boundaries and barrier islands to the 20-m isobath, which represents a management boundary rather than an ecological boundary (Blaylock & Hoggard, 1994; Fulling, Mullin, & Hubard, 2003; Scott, Wells, & Irvine, 1990). Three coastal stocks are recognized at this time based on climatic and oceanographic differences across the Gulf of Mexico coastline: eastern, northern, and western. The northern stock resides in waters between 84° W and the Mississippi River Delta, including the Mississippi Sound. The northern coastal stock may have a home range that overlaps with the continental shelf stock as well as bay, estuarine, and sound stocks in the northern Gulf of Mexico (Hersh & Duffield, 1990; LeDuc & Curry, 1998). The best abundance estimate for the northern stock is 2,473 (CV = 0.25), and the minimum population estimate, which was obtained by using the lower limit of the two-tailed 60% confidence interval of the log-normally distributed abundance estimate, is 2,004 dolphins. This estimate was obtained from aerial surveys conducted in summer of 2007 (Waring, Josephson, Maze-Foley, & Rosel, 2010).

Evidence has shown that there are genetic differences between inshore and offshore stocks. In Hoelzel, Potter, and Best (1998), two genetically divergent ecotypes, which are genetically distinct populations within a species adapted to specific environmental conditions, were found between inshore and offshore dolphin populations through mitochondrial DNA and nuclear genetic marker analysis. Torres, Rosel, D'Agrosa, and Read (2003) found that a significant separation of these two ecotypes in the northwestern Atlantic occurs between inshore dolphins that inhabit waters closer than 7.5 km from shore and offshore dolphins that inhabit deeper waters beyond 34 km from shore. Both of these ecotypes were found between 7.5 km and 34 km. These results show that there is a distinct biological separation between inshore and offshore stock dolphins, which interact in intermediate distances from shore.

Bay, estuarine, and sound stocks are difficult to distinguish due to the limited amount of information about both the northern Gulf of Mexico region and possible biological differences between inshore stocks. Sellas, Wells, and Rosel (2005) found a significant genetic separation of mitochondrial DNA and nuclear microsatellite samples between neighboring inshore resident stocks of dolphins in the Gulf of Mexico as well as between coastal dolphins and inshore stocks. Several other studies have further supported the genetic separation between neighboring inshore resident stocks in the Gulf of Mexico (Duffield & Wells, 1986; 1991; 2002). These studies show that biologically distinct resident stocks exist despite the fact that these stocks inhabit small geographic areas that are adjacent to each other. In 2010, thirty-two inshore stocks were recognized in the Gulf of Mexico. The most recent population abundance estimate for the Mississippi Sound ranges from 1,413 dolphins (CV=0.25) in the winter to 2,255 dolphins (CV=0.22) in the summer (Miller, Mackey, Solangi, & Kuczaj, 2012). Hubard and colleagues (2004) estimated that population abundance ranged from 268 dolphins (CV=0.23) in the winter to 584 dolphins (CV=0.17) in the summer for a smaller area within the Mississippi Sound.

Residents and Nonresidents

Long-term, year-round resident dolphins have been identified in many different geographic locations, including the Mississippi Sound (Hubard et al., 2004). Five generations of residents are documented in Sarasota Bay, Florida and a maximum immigration and emigration rate of 2-3% was estimated by Wells and Scott (1990). Studies show that residents differ behaviorally from coastal nonresidents in their use of habitat, prey type, and seasonal distribution. Residents utilize the bay, sound, and estuary waters much more frequently than nonresidents, and residents rarely use the passes to the Gulf waters (Fazioli et al., 2006; Gruber, 1981; Irvine, Scott, Wells, & Kaufman, 1981; Lynn & Würsig, 2002; Maze & Würsig, 1999; Shane, 1977, 1990). Barros and Wells (1998) reported that the residents of Sarasota Bay, Florida lack squid in their diet, which is a main staple for nonresidents that have stranded along neighboring Gulf of Mexico beaches. This difference in diet may reflect potential differences in availability of prey species for residents and nonresidents and may suggest that these stocks employ different feeding behaviors that are more successful and efficient for different prey types.

Interactions and genetic exchange do occur between residents from different communities as well as between residents and nonresidents (Duffield & Wells, 2002). Residents and nonresidents are often sighted together. A range of 14-17% of Sarasota resident group sightings involved at least one nonresident (Fazioli et al., 2006; Wells et al., 1987). Similar findings have been reported for inshore resident communities in San Luis Pass, Texas (Maze & Würsig, 1999), Pine Island Sound, Florida (Shane, 2004), and 20% of resident sightings included at least one nonresident dolphin in Cedar Keys, Florida (Quintana-Rizzo & Wells, 2001).

Nonresident dolphins vary greatly in their movement patterns (Shane et al., 1986). These animals often mix with resident communities in passes and at the mouths of large estuaries (Bräger, 1993; Henningsen, 1991; Weller, 1998; Wells, 1986). Additionally, seasonal residents have been recognized in multiple locations. Seasonal residents inhabit an area for one or two seasons out of the year and then migrate to another area for the rest of the year (Gubbins, 2002; Maze & Wursig, 1999; Shane, 1980).

Seasonal Distributions

Residents from inshore stocks exhibit seasonal changes in distribution across different geographical areas. Residents in small bay systems, like Sarasota Bay, FL, and San Luis Pass, TX, have been reported to move offshore into Gulf waters during winter months after spending spring and summer inshore (Irvine et al., 1981; Maze & Würsig, 1999). In St. Joseph's Bay, Florida, increases in abundance occur during spring and fall. Based on photo-identification and satellite tagging results, dolphins with low site-fidelity indices were sighted more often during the fall and spring, and dolphins with higher site-fidelity indices were also sighted during the summer and winter. These results indicate that a potential resident community resides in St. Joseph's Bay, FL during the summer and winter months and that this area is frequented by nonresident dolphins during the spring and fall (Balmer et al., 2008). Also, seasonal changes in abundance for larger bay systems indicate that migrations to northern bays during the summer and southern bays during the winter may occur (Bräger, 1993; Fertl, 1994; Gruber, 1981; Henningsen, 1991; Lynn & Würsig, 2002; Scott, Burn, Hansen, & Owen, 1989; Shane, 1977; Thompson, 1981; Weller, 1998).

The Mississippi Sound is characterized by spring and summer increases in abundance. It is possible that dolphins move offshore during fall and winter in addition to an influx of coastal dolphins during the spring and summer (Hubard et al., 2004). These seasonal distributions may create more opportunities for genetic exchange between stocks and/or to follow prey migrations offshore. Seasonal movements of residents and nonresidents further complicate the recognition of distinct stocks and must be taken into account when analyzing sighting history and ranging patterns of potential inshore and coastal dolphins that overlap in a location.

Current Study

Based on current literature, inshore resident dolphins differ from coastal migratory dolphins in their genetic profiles, diet, habitat utilization strategies, and movement patterns. However, knowledge about the seasonal and diurnal behavioral pattern differences of residents and coastal dolphins is very limited. This study examined the site fidelity patterns of dolphins in the Mississippi Sound and possible differences in the seasonal and diurnal behavioral patterns of dolphins that exhibit high site fidelity and low site fidelity to the Mississippi Sound. This study also assessed how behavioral patterns of mixed groups composed of both high site fidelity and low site fidelity groups differ from behavioral patterns of high site fidelity and low site fidelity groups.

CHAPTER III

METHODS

Study Area

The Mississippi Sound is approximately 1,578 km^2 and located in the north central Gulf of Mexico (Lohoefener, Hoggard, Ford, & Benigno, 1990). It spreads across Alabama, Mississippi, and Louisiana shorelines and is separated from the Gulf waters by several barrier islands: Cat, Ship, Horn, Petit Bois and Dauphin Islands. These islands range from 15 km to 20 km from shore. The average depth at mean low tide is 3.6 m. Tides are diurnal and range from 0.46 m, but winds cause a high degree of variance in tide. The bottom substrate of the study area consists of sand and/or mud (Christmas, 1973). The study area has been surveyed by the Mississippi Sound Wild Dolphin Project starting in July 2003 to August 2012. Opportunistic boat surveys conducted from July 2006 to April 2010 around Cat, Ship, and Horn Islands were chosen for analysis. During the study period, sea surface temperatures ranged from 7° C to 35° C. Salinity was observed between 5 ppt to 30 ppt with an average of 24 ppt. Observations were made from a 7-m vessel with a 225 Ram injection Evinrude outboard motor. The order in which islands were surveyed was randomly determined and the vessel launched from Gulfport Harbor. Surveys began at approximately 8:30 hours and typically ended about 14:00 hours after the circumference of the island was surveyed. A total of 176 trips were made during this study period providing approximately 1000 hours of surveying the field. A total of 710 encounters with dolphins occurred during the study period yielding 160 hours of observation.

Data Collection

Once dolphins were sighted, the research vessel followed the dolphins at a suitable distance for obtaining data. A group of dolphins was defined as all dolphins within 100 meters of each other. Once observations began, one researcher collected at least fifteen minutes of behavioral data, one researcher took photographs of dorsal fins for identification, one researcher collected environmental data, and another researcher videotaped behavior. Behavioral data was collected using a modified instantaneous method described in Mann (1999) for behavioral states. For this method, behavioral state, which was determined by the behavior of the majority of the group, was recorded every minute. If dolphins were submerged at the time of behavioral state recording, then a one minute delay was allowed for the dolphins to resurface. If the behavioral state was the same as the previous minute's behavioral state, then the behavioral state did not change and was thus recorded as the same behavioral state for the elapsed minute. However, if the dolphins did not surface during the one minute delay or resurfaced engaged in a different behavioral state, then the dolphins were recorded as not found for that elapsed minute and the change in behavioral state was noted for the next minute. Behavioral state definitions were adapted from Shane (1990) and descriptions for each behavioral state are listed in Table 3 below.

Table 3

Description of Behavioral States Adapted from Shane (1990)

State	**Description**
Feed	Majority of group engages in foraging behaviors such as repeated fluke-in/out dives in one location, feeding circles/splashes, fish kicks/toss, etc.

Table 3 (continued).

State	Description
Social	Majority of group in almost constant physical contact with one another, engaging in group social balls and often displaying surface behaviors
Traveling	Majority of group moving steadily in one direction (slow or fast)
Mill	Majority of the group is moving in various directions in one location, with no apparent physical contact between individuals
With Boat	Majority of the group approaches or travels alongside a boat
Rest	Majority of the group drifting at surface
Other	Majority of the group is engaging in a state not listed
Underwater	Majority of the group is not visible (i.e., underwater), but their location is known
Not Found	Majority of the group is not located at/during interval

Data Analysis

Photos from field observations were processed using standard photo identification methods to identify individuals with distinctive markings on their dorsal fins (Wursig & Jefferson, 1990; Wursig & Wursig, 1977). A total of 862 dolphins were identified between July 2006 and April 2010. The entire sighting history of these dolphins were analyzed for site fidelity assessment, which extended from July 2004 to Spring 2011 at the time of analysis. Sighting history of these dolphins ranged from 1 sighting to 21 sightings over the seven year project period, with an average of 3 sightings. Of the 710 encounters conducted during the study period, 320 encounters were used for data analysis because the observers collected at least 15 minutes of behavioral data and the majority of group members were identified using high quality photos manually rated using the catalog and database computer program, FinBase (Marine Mammals Program, Center for Coastal Environmental Health and Biomolecular Research, NOAA). Additionally, a group of dolphins was defined as two or more animals within 100 meters of each other for this study; therefore, single dolphin observations were excluded from data analysis as well. These 320 encounters yielded a total of 4800 minutes of behavioral data that were used for nonparametric data analysis. The frequency of minutes in each behavioral state was calculated for all dolphin groups for behavioral pattern comparisons. See Figure 1 below for the proportion of time dolphins spent in each behavioral state across the survey period.

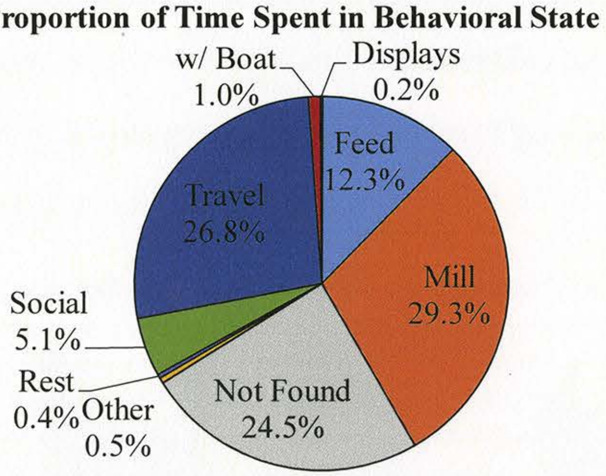


Figure 1. Chart of the proportion of time spent in each behavioral state for all dolphin groups during the survey period. The proportion of time spent in each behavioral state is expressed as the percentage value under the behavioral state.

Additional information included for each encounter was group size, season, time of day, geographic location, salinity, tide, and depth. Seasons were defined by identifying the months with the lowest average sea surface temperatures, which were December, January, and February and were used to define the winter season. Based on this distinction, spring was defined as March – May, summer was June – August, and fall was September – November. Time of day was defined as early morning (8:00-9:30), late morning (9:30-11:30), and afternoon (11:30-14:00) which is similar to the methods described in Miller et al., 2010. See Table 4 below for a summary of survey effort for analyzed data.

Table 4

Summary of Survey Effort for Seasonal and Diurnal Time Periods for Analyzed Data

Period	Number of Trips	Number of Sightings	Number of Minutes
Spring	34	76	1140
Summer	37	123	1845
Fall	36	91	1365
Winter	19	30	450
Early Morning	61	67	1005
Late Morning	101	165	2475
Afternoon	61	88	1320

The frequency of minutes in each behavioral state was calculated for each season and diurnal time period for all dolphin groups. See Figure 2 and Figure 3 for seasonal and diurnal behavioral patterns for all dolphin groups.

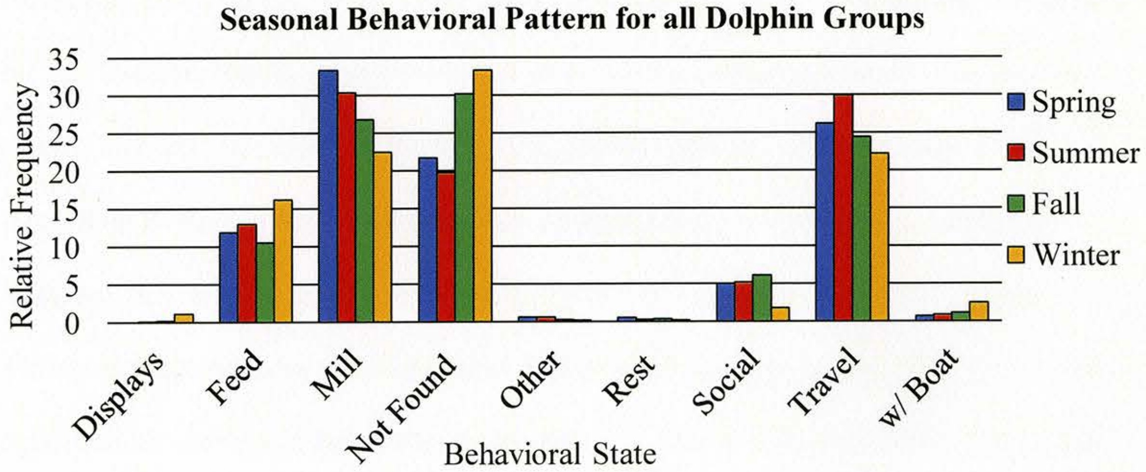


Figure 2. Relative frequency of the time spent in each behavioral state for each season for all dolphin groups. The relative frequency is the amount of time dolphin groups were observed in a specific behavioral state during a season controlled by the total amount of observation time for that season.

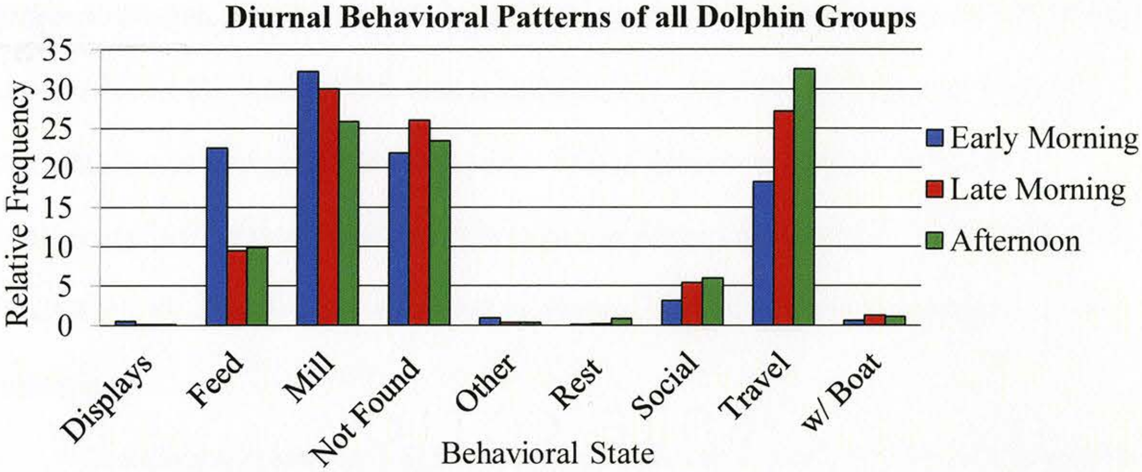


Figure 3. Relative frequency of the time spent in each behavioral state for each diurnal period for all dolphin groups. The relative frequency is the amount of time dolphin groups were observed in a specific behavioral state during a diurnal period controlled by the total amount of observation time for that diurnal period.

Statistical Analysis

Based on previous studies, nonparametric analyses were most commonly used to analyze behavioral patterns (Bearzi, 2005; Bearzi et al, 1999; Miller et al., 2010; Neumann, 2001; Shane, 1977, 1990; Shane & Schmidly, 1978). Operational definitions for site fidelity classification were based on residency definitions reported in smaller estuary and bay communities (Balmer et al., 2008; Gubbins, 2002; Zolman, 2002). According to these studies, residents and seasonal residents have a high number of sightings that are consistent across multiple years to a specific geographic location. Taking into account that the Mississippi Sound is a large open area and the limitations of opportunistic surveys in being able to accurately collect a complete sighting history for all identified dolphins, these previously reported residency definitions were modified to yield more flexible criteria to classify individuals that exhibit high or low site fidelity to the Mississippi Sound. In order to be classified as a high site fidelity individual, a dolphin averaged at least one sighting per study year and was sighted during multiple years and in different seasons. Based on this definition, a high site fidelity dolphin was sighted at least seven times in different seasons across multiple years since the current overall photo identification project period is seven years. This definition reflects the dolphin's consistency in returning to the survey area across a long period of time but also allows for flexibility with sighting error attributed by survey bias and photographic identification limitations.

Transient dolphins are migratory nonresidents and exhibit very low site fidelity to any particular location; therefore, they have a very low frequency of sightings (Gubbins, 2002; Zolman, 2002). In order to be classified as a low site fidelity individual, a dolphin was sighted only once across the seven year project period. Dolphins that did not meet high site fidelity criteria but were sighted more than once were classified as intermediate dolphins.

Based on the operational site fidelity classification, 94 (10.9%) identified dolphins were sighted seven or more times in different seasons over multiple years and were classified as high site fidelity dolphins. Forty-two percent (n = 364) of sighted individuals were sighted only once, showing that a large portion of the surveyed population are individuals that show low site fidelity to the Mississippi Sound (see Figure 4 below).

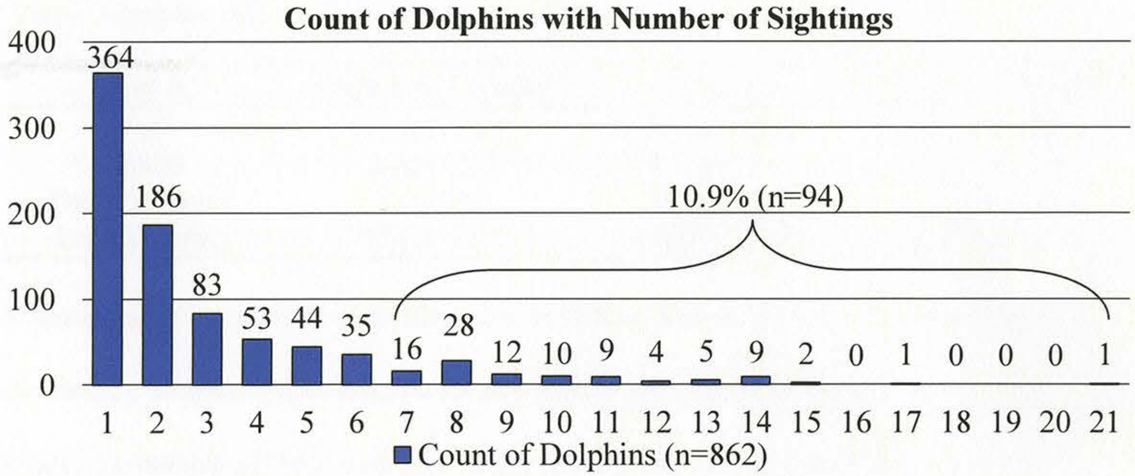


Figure 4. Distribution of the entire sighting history for identified dolphins from July 2006 to April 2010. The brackets indicate high site fidelity individuals that average one or more sightings per year and are sighted during multiple years and in different seasons.

The remaining identified dolphins were classified as intermediate dolphins (n=404, 46.9%). After classifying individuals, a group composition ratio of each site fidelity class was calculated for each group. Groups consisting of at least 70% of either high site fidelity or low site fidelity individuals were classified as that type of site fidelity group. If the percentage for each site fidelity group was below 70%, then the group was classified as a mixed site fidelity group. Of the 320 encounters used for behavioral analysis, 43 sightings (n=645 minutes) were classified as high site fidelity groups, 63 sightings (n=945 minutes) were classified as low site fidelity groups, and 214 sightings (n=3210 minutes) were classified as mixed groups. See Table 5 below for summary of data representing each seasonal and diurnal period for nonparametric analysis.

Table 5

Summary of Data for Nonparametric Statistical Analysis (Parentheses Refer to Minutes of Behavioral Data Collected for Seasonal or Diurnal Period)

Period	**High Site Fidelity**	**Mixed**	**Low Site Fidelity**
Spring	6 (n=90)	44 (n=660)	26 (n=390)
Summer	13 (n=195)	93 (n=1395)	17 (n=255)

Table 5 (continued).

Period	High Site Fidelity	Mixed	Low Site Fidelity
Fall	16 (n=240)	60 (n=900)	15 (n=225)
Winter	8 (n=120)	17 (n=255)	5 (n=75)
Early Morning	2 (n=30)	46 (n=690)	19 (n=285)
Late Morning	27 (n=405)	109 (n=1635)	29 (n=435)

A Spearman's correlation was calculated to compare ranked behavioral states between site fidelity classes. Behavioral states in which dolphin groups were observed spending a greater proportion of their time were assigned higher ranking (see Table 6 below).

Table 6

Spearman's Ranking of Behavioral States and Associated Percentage of Time and Frequency of Minutes Spent in each Behavioral State for each Site Fidelity Class

	High Site Fidelity		**Mixed**		**Low Site Fidelity**	
Behavior State	Rank	% of Time (n=mins)	Rank	% of Time (n=mins)	Rank	% of Time (n=mins)
With Boat	1	0.6% (n=4)	1	1.2% (n=40)	1	0.6% (n=6)
Social	2	4.7% (n=30)	2	5.2% (n=168)	2	4.9% (n=46)
Feed	3	10.7% (n=69)	3	12.1% (n=390)	3	14.0% (n=132)
Mill	4	21.7% (n=140)	5	31.7% (n=1016)	4	26.6% (n=251)
Travel	5	29.8% (n=192)	4	26.2% (n=841)	5	26.7% (n=252)

A Pearson's chi-square test was conducted in order to examine significant differences in the overall proportion of time spent in each behavioral state between site fidelity classes. The standardized residuals between observed and expected frequencies were used to determine where significant differences occurred. For significant results, a loglinear model was conducted to identify significant main effects and interactions between site fidelity class, behavioral state, and season or diurnal period. Follow-up layered Pearson's chi-square tests were conducted in order to determine which combinations of variables contribute to the significant findings in the loglinear model. The layered Pearson's chi-square test was organized so that the season or diurnal period in which the sighting occurred was the layered variable, and the frequency of each behavioral state was compared across site fidelity classes.

A separate analysis was conducted for the recording of not found. A Pearson's chi-square analysis was implemented to compare the frequency of time spent in all behavior states to the frequency of time recorded as not found for each site fidelity class. As mentioned previously, environmental variables such as tide, depth, sea surface temperature, and salinity have been found to correlate with behavioral patterns (Gruber, 1981; Hanson & Defran, 1993; Saayman et al., 1973; Shane, 1977, 1990; Shane & Schmidly, 1978; Sini et. al., 2005; Wursig & Wursig, 1979). These environmental variables were collected for each sighting and analyzed using a multiple linear regression model for each behavioral state to determine whether environmental variables potentially influenced dolphin behavior.

CHAPTER IV

RESULTS

Behavioral Pattern Results

Spearman's correlation showed there was a significant relationship between behavioral states of low site fidelity groups and mixed groups ($r_{s=}$ .900, p<.05). This result shows that low site fidelity groups and mixed groups differed only slightly in the ranking of their behavioral states. Ranking of behavioral states between low site and high site fidelity groups did not differ. A Pearson's chi-square analysis showed that there were significant differences in mill and travel behavioral states across site fidelity classes (χ^2=26.58, df=8, p<.01). High site fidelity dolphin groups spent significantly less time milling and spent significantly more time traveling compared to mixed and low site fidelity groups. There was a significant effect size between behavioral states and site fidelity classes (Cramer's V=.061, p<.01). See Figure 5 below to compare overall time budgets for each site fidelity class.

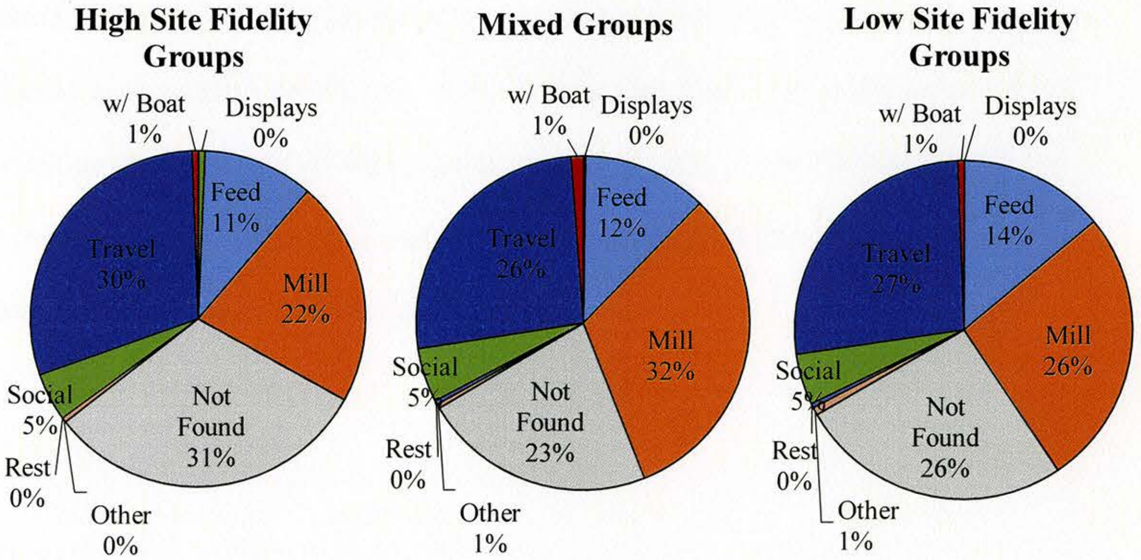


Figure 5. Proportion of time spent in each behavioral state for each site fidelity class across the entire survey period. The proportion of time spent in each behavioral state is expressed as the percentage value under the behavioral state.

A seasonal three-way loglinear model found all effects between site fidelity class, season, and behavioral state variables to be significant. The likelihood ratio of the model was $\chi^2(0)=0$, p=1 and showed that the model would be significantly changed if the three-way interaction variable between site fidelity class, season, and behavioral state was removed ($\chi^2(24)=87.44$, $p<.001$). A layered Pearson's chi-square analysis across seasons revealed significant differences in behavioral states between site fidelity classes during the spring ($\chi^2=15.49$, df=8, p=.05), summer ($\chi^2=59.12$, df=8, $p<.01$) and fall ($\chi^2=28.50$, df=8, $p<.01$). There were no significant differences in behavioral states between site fidelity classes for winter months ($\chi^2=5.98$, df=8, $p>.05$). Cramer's V was significant for spring (Cramer's V=.09, p=.05), summer (Cramer's V=.14, $p<.01$), fall (Cramer's V=.12, $p<.01$), and nonsignificant for winter (Cramer's V=.10, $p>.05$).

In spring, high site fidelity groups spent significantly more time traveling. In summer, high site fidelity groups spent significantly less time feeding, while low site fidelity groups spent significantly more time feeding. High site fidelity groups spent significantly more time traveling during summer. In fall, low site fidelity groups spent significantly less time feeding and more time traveling (see Figure 6 for seasonal behavioral patterns of each site fidelity class).

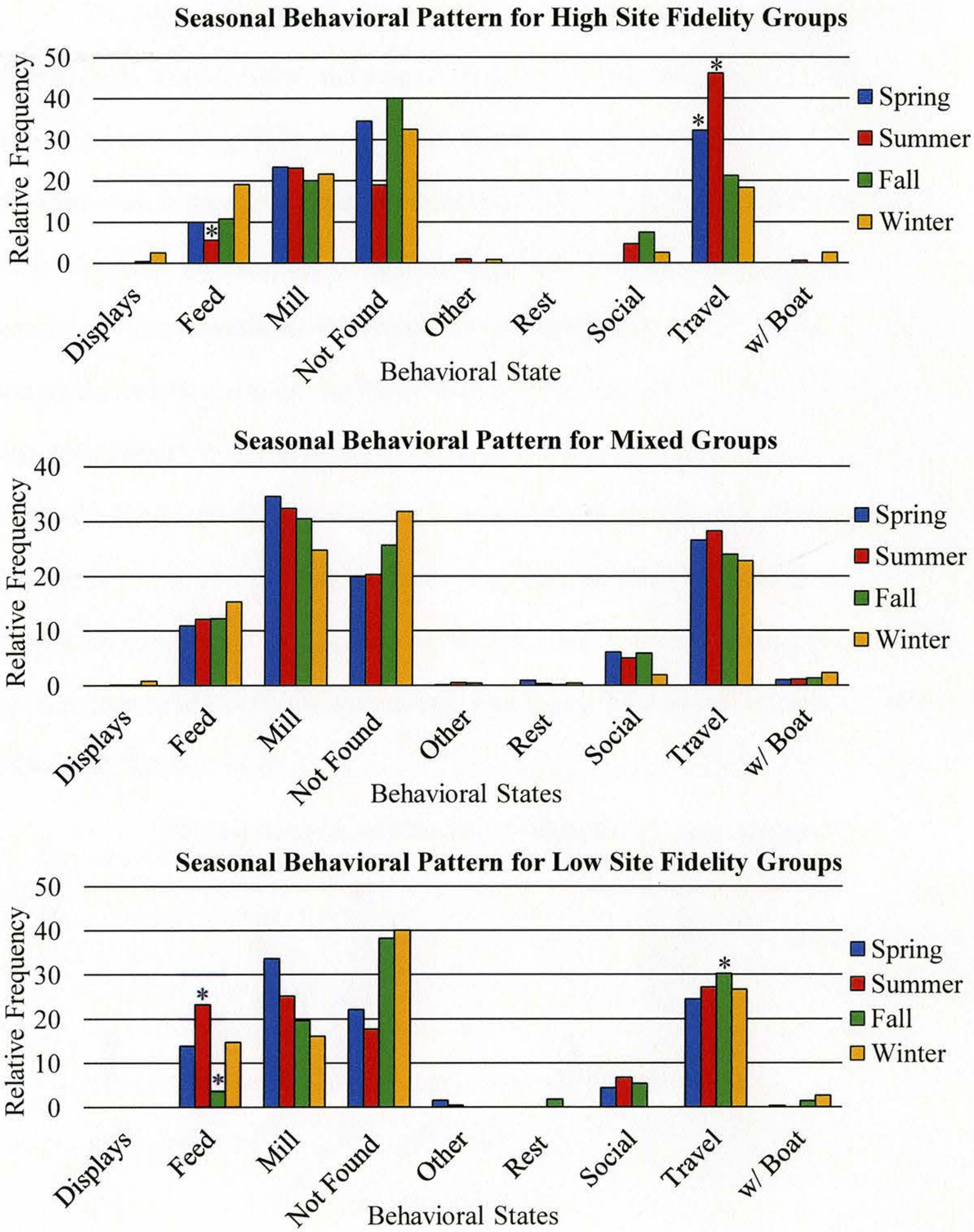
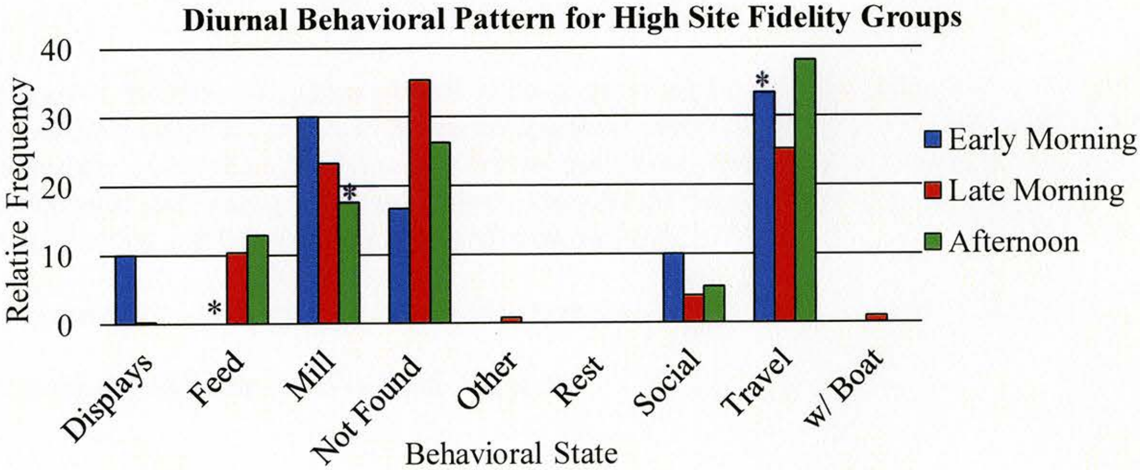
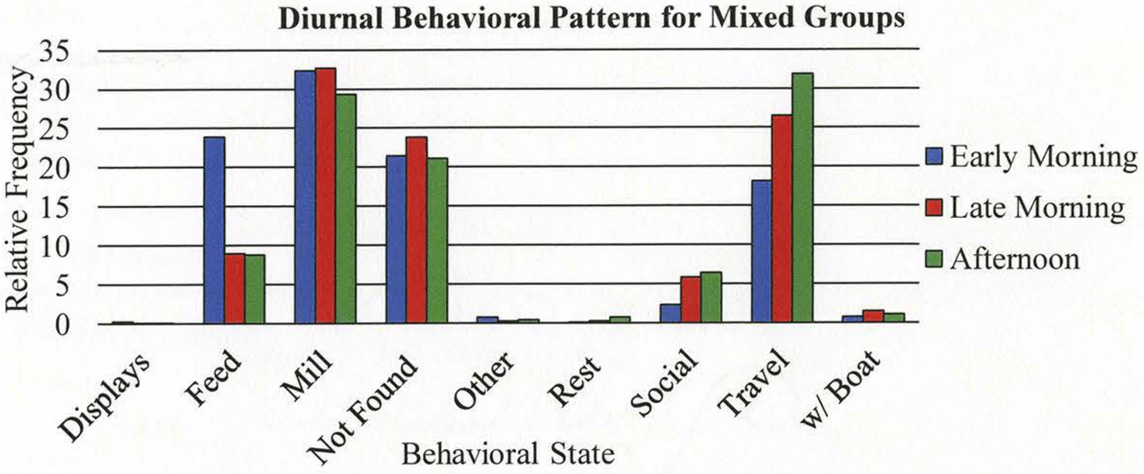


Figure 6. Relative frequency of time spent in each behavioral state for each site fidelity class across seasons (* refers to significant results at p<.05 level). The relative frequency is the amount of time site fidelity groups were observed in a specific behavioral state during a season controlled by the total amount of observation time for that site fidelity class in that season.

The diurnal three-way loglinear model also reported that all effects between site fidelity class, diurnal period, and behavioral state variables were significant. The likelihood ratio was $\chi^2(0)=0$, $p=1$, and the fit of the model was significantly impacted if the three-way interaction variable between site fidelity class, diurnal period, and behavioral state was removed ($\chi^2(16)=44.56$, $p<.001$). A layered Pearson's chi-square analysis revealed significant differences in behavioral states between site fidelity classes during the early morning ($\chi^2=19.94$, df=8, $p<.05$), late morning ($\chi^2=18.23$, df=8, $p<.05$), and afternoon ($\chi^2=20.80$, df=8, $p<.01$). Cramer's V was significant for early morning (Cramer's V=.11, $p<.05$), late morning (Cramer's V=.07, $p<.05$), and afternoon (Cramer's V=.10, $p<.01$). In the early morning, high site fidelity groups spent significantly less time feeding and more time traveling. In the afternoon, high site fidelity groups spent significantly less milling (see Figure 7 for diurnal behavioral patterns of each site fidelity class).





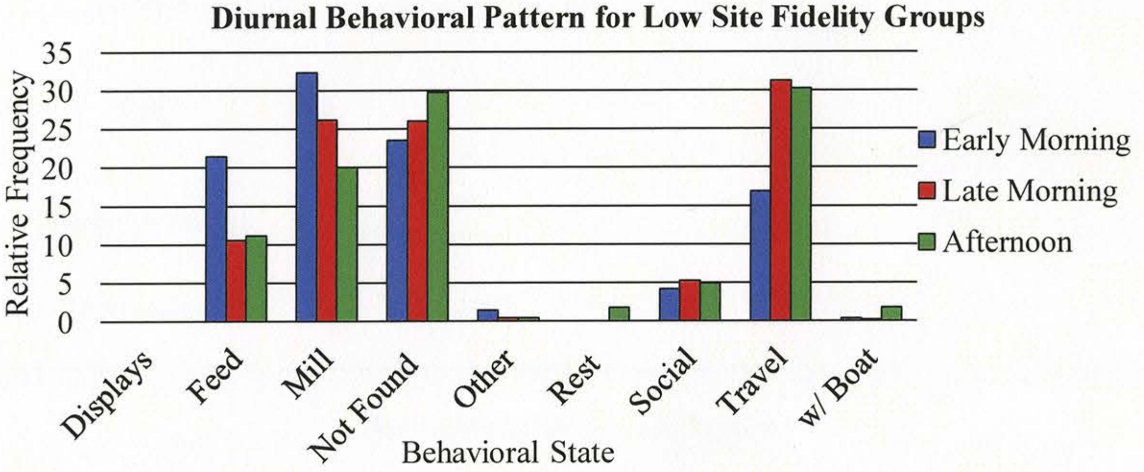


Figure 7. Relative frequency of time spent in each behavioral state for each site fidelity class across diurnal periods (* refers to significant results at p<.05 level). The relative frequency is the amount of time site fidelity groups were observed in a specific behavioral state during a diurnal period controlled by the total amount of observation time for that site fidelity class in that diurnal period.

A summary of all behavioral pattern results that were significant at p<.05 level for each site fidelity class are listed in Table 7 below.

Table 7

Summary Table of Significant Nonparametric Results at p<.05 Level for each Site Fidelity Class. Symbol (-) represents negative relationships and symbol (+) represents positive relationships

Variables	**High Site Fidelity Groups**	**Mixed Groups**	**Low Site Fidelity Groups**
Site Fidelity Groups	(-) Mill (+) Travel		
Spring	(+) Travel		
Summer	(-) Feed (+) Travel		(+) Feed
Fall			(-) Feed (+) Travel
Early Morning	(-) Feed (+) Travel		
Afternoon	(-) Mill		

Recording of Not Found Results

A Pearson's chi-square analysis showed there were significant differences between frequency of time spent in behavioral states and frequency of time spent in not found across site fidelity classes (χ^2=24.92, df=2, p<.01). High site fidelity groups spent significantly less time engaging in behavioral states and were recorded as not found significantly more. Mixed groups were recorded as not found significantly less. Figure 8 shows the proportion of time each site fidelity class spent in surface behaviors compared to their recording of not found.

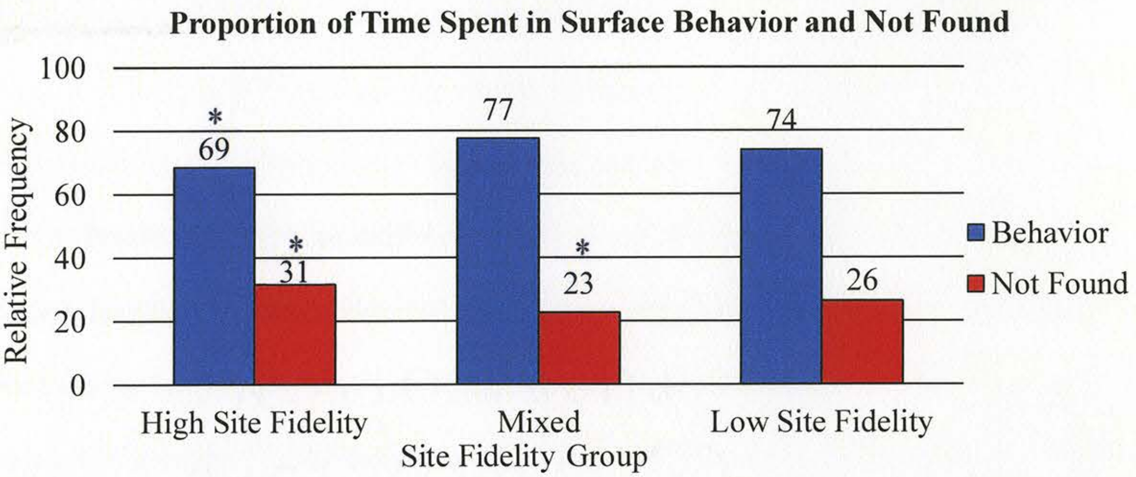


Figure 8. Proportion of time each site fidelity class was observed spending in surface behaviors and recorded as not found (* refers to significant results at p<.05 level). Surface behavior represents all behavioral states with the exception of not found.

Environmental Influence on Behavior

Multiple linear regression results revealed that environmental variables significantly predicted not found and with boat behavior. Not found behavior was significantly predicted by environmental variables (R^2=.039, p<.05); however, no specific environmental variable significantly predicted not found behavior. Depth significantly predicted with boat behavior (β=-.179, R^2=.038, p<.05). The few statistically significant results show that environmental variables did not account for the behavioral changes observed across site fidelity classes and are not potential confounds.

CHAPTER V

DISCUSSION

Site Fidelity Patterns

Bottlenose dolphins exhibited various levels of site fidelity to the Mississippi Sound. Based on results in Figure 4, 42% of the identified dolphins (n=364) were sighted once during the project period, showing that a large portion of the surveyed population consists of low site fidelity individuals. However, 10.9% of identified dolphins (n=94) met high site fidelity criteria, which suggests that the Mississippi Sound supports a small population of potential residents. More extensive observations of these individuals are needed in order to determine whether they are year round residents. Intermediate dolphins comprised 47% (n=404) of the surveyed population. Majority of intermediate dolphin sightings occurred during the summer (n=384, 52%), which suggests that these dolphins are seasonal residents that return to the Mississippi Sound periodically to spend warmer months in the survey area. Seasonal residents have been hypothesized to inhabit the Mississippi Sound based on increases in dolphin abundance during spring and summer (Hubard et al., 2004; Miller et al., 2012).

In order to better understand which site fidelity class contributes to the seasonal abundance changes in the Mississippi Sound, a seasonal breakdown of sightings was analyzed across site fidelity classes. A Pearson's chi-square analysis showed that there was a significant difference in the proportion of sightings in each season between site fidelity classes ($\chi^2=48.82$, df=6, $p<.01$). In the spring, low site fidelity dolphins were sighted significantly more during the spring (36% of spring sightings), and intermediate dolphins were sighted significantly less (39% of spring sightings). Low site fidelity dolphins were sighted significantly less during the summer (19% of summer sightings). High site fidelity dolphins were sighted significantly more during the fall (36% of fall sightings). Figure 9 shows the proportion of sightings for each season contributed by each site fidelity class.

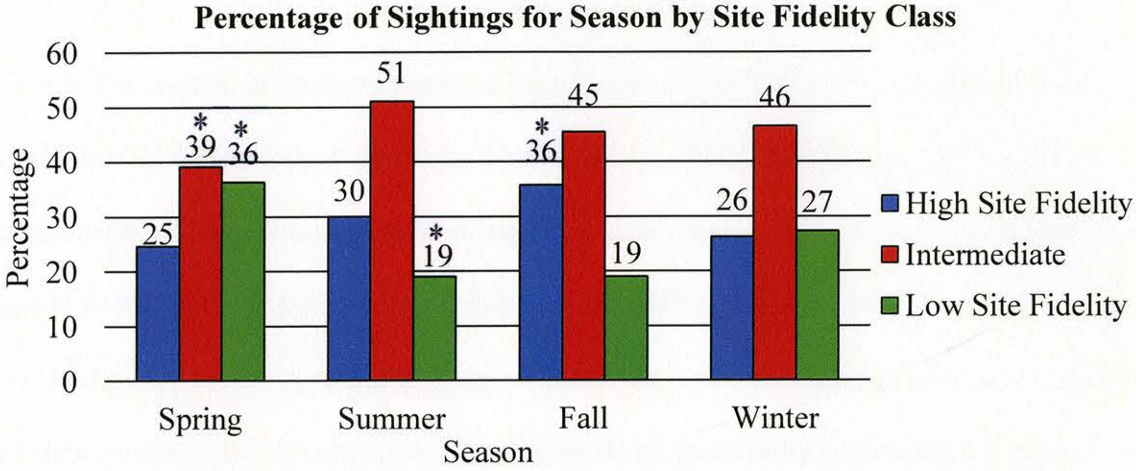


Figure 9. Percentage of sightings for each season contributed by each site fidelity class (* refers to significant results at p<.05 level). The percentage is the number of individual sightings for each site fidelity class in each season controlled by the total number of individual sightings during each season.

These results show that seasonal changes in abundance may be attributed to by the migration of both low site fidelity and intermediate dolphins during spring and summer as well as changes in the movement patterns of higher site fidelity dolphins. It is possible that high site fidelity dolphins utilize different areas of the Mississippi Sound that were not surveyed or extend their home range offshore during the winter to account for seasonal variation in their sighting history. This finding is supported by observations of year round residents exhibiting seasonal distribution changes in multiple study areas (Balmer et al., 2008; Bräger, 1993; Fertl, 1994; Gruber, 1981; Henningsen, 1991; Irvine et al., 1981; Lynn & Würsig, 2002; Maze & Würsig, 1999; Scott et al., 1989; Shane, 1977; Thompson, 1981; Weller, 1998). Additionally, different habitat utilization strategies have been observed in year round resident dolphins in Sarasota, FL and San Luis Pass, TX. Residents utilized shallow inshore bays during spring and summer and spent the majority of their time in deeper channels, passes, and coastal waters during the fall and winter (Barros & Wells, 1998; Irvine et al, 1981; Maze & Würsig, 1999).

Seasonal Behavioral Patterns

The overall behavioral pattern analyses found significant relationships between mill and travel behaviors in high site fidelity groups. When behavior of site fidelity classes was compared across seasons, significant relationships between travel behavior and high site fidelity groups remained. High site fidelity groups were observed traveling more often during the spring and summer. Based on previous seasonal behavioral pattern studies, researchers reported significant increases in travel behavior during spring and summer (Gruber, 1981; Shane, 1977; Shane & Schmidly, 1978). These studies were conducted in different locations along the Texas coastline and report a variety of site fidelity levels, including high site fidelity dolphins (Maze & Wursig, 1999; Shane 1980; Shane et al., 1986). This increase in travel behavior during the summer coincides with the highest dolphin abundance estimates in the Mississippi Sound (Hubard et al., 2004; Miller et al., 2012). Additionally, high site fidelity groups were observed feeding significantly less often during the summer. It is possible that high site fidelity groups search for less exploited habitat locations to reduce competition for prey resources, which explains the increased observance of traveling behavior and decreased observance of feeding behavior. More evidence is needed to examine the seasonal availability of prey in relation to dolphin abundance to support this conclusion.

Alternatively, the increased travel behavior and decreased feeding behavior during summer may also be a result of boat avoidance behavior. Dolphins in the Mississippi Sound have been observed to engage in longer dives, increase traveling behavior, and cease foraging when approached by high-speed recreational watercraft (Miller, Solangi, & Kuczaj, 2008). The most common recreational activities for the Mississippi coast are fishing, boating, and ecotourism of local wildlife, which are pursued by both residents and tourists (Grado, Jones, Earles, & Jones, 2003). These activities most likely occur during warmer months. High site fidelity groups are more likely to be exposed to seasonal fluctuations in boat traffic and may exhibit boat avoidance behavior when boat traffic is at its highest levels in the Mississippi Sound. This increase in travel and decrease in feeding may reflect the response of high site fidelity groups to either reduce competition and/or avoid boat traffic.

In the summer, low site fidelity groups were observed feeding more often. The increase in feeding behavior during the summer coincides with the seasonal migrations of common prey species, such as crevalle jack (*Caranx hippos*), Gulf menhaden *(Brevoortia patronus*), pinfish (*Lagodon rhomboides*), spot (*Leiostomus xanthurus*), and striped mullet (*Mugil cephalus*). These species inhabit inshore areas in the northern Gulf of Mexico during the summer and migrate offshore during the fall and winter (Barros & Wells, 1998; Benson, 1982; Irvine et al., 1981; Leatherwood, 1975). The seasonal migration of prey species in the Mississippi Sound may explain the seasonal increase of dolphin abundance and increased observances of feeding behavior during the summer. This conclusion is strengthened by findings from a foraging hotspot analysis conducted by Smith, Hurley, Toms, Mackey, Solangi, & Kuczaj (2013) in the Mississippi Sound, which showed multiple foraging hotspots were found prior to and immediately after Hurricane Katrina. The authors suggested that the Mississippi Sound serves as a transit location for migratory and/or seasonal dolphins, specifically for feeding behaviors. Previous behavioral pattern studies did not find increases in feeding behavior during summer months, so this finding may be unique to Mississippi Sound.

In the fall, low site fidelity groups spent significantly less time feeding and more time traveling. Previous behavioral pattern studies reported the opposite result of observing increased feeding behavior during the fall (Gruber, 1981; Miller et al., 2010; Shane, 1977, 1990; Shane & Schmidly, 1978). Also, previous studies did not report observing increased travel behavior during the fall. Since seasonal prey species are migrating offshore during the fall and winter, it is likely that low site fidelity groups are migrating out of the Mississippi Sound to find other prey resources. Dolphin abundance estimates have been reported to decline in the Mississippi Sound during the fall and winter (Hubard et al., 2004; Millet et al., 2012). These results would further support the conclusion that the Mississippi Sound serves as a seasonal feeding area for lower site fidelity dolphins, such as migratory coastal dolphins and/or seasonal residents during spring and summer.

No significant changes in behavior were observed in mixed groups across seasons. This finding suggests that the seasonal behavioral pattern of mixed groups differs from high site fidelity and low site fidelity groups since they did not exhibit similar patterns.

Diurnal Behavioral Patterns

Pearson's chi-square results showed that feeding behavior was observed less and travel behavior was observed more in high site fidelity groups during the early morning period. Only two groups of high site fidelity dolphins were recorded during the early morning period, so more data is needed to support this finding. In the afternoon, high site fidelity groups were observed milling significantly less. Milling behavior has been hypothesized to be associated with feeding behavior as well as socializing (Shane et al., 1986). This decrease in milling behavior suggests that high site fidelity groups are not engaging in either subsurface foraging or social behaviors very often during this time period. This result contrasts with several diurnal behavioral pattern studies, which report increased feeding and social behavior in the afternoon (Gruber, 1981; Miller et al., 2010; Saayman et al., 1973; Shane, 1977). Based on the diurnal behavioral pattern in Figure 7, high site fidelity groups spend a greater proportion of their time traveling in the afternoon, but this result was not statistically significant. No significant changes in behavior across diurnal periods were observed for low site fidelity groups and mixed groups.

Potential Conclusions about Not Found

High site fidelity groups were recorded as not found significantly more. Since not found was recoded when majority of the group was not at the surface during the one minute interval, this finding suggests that high site fidelity groups are staying submerged for longer periods of time compared to mixed groups and low site fidelity groups. Increased dive duration is a characteristic described in boat avoidance behavior (Miller et al., 2008). High site fidelity groups are more exposed to boat traffic in the Mississippi

Sound because of their consistent presence in the area. As a result, high site fidelity groups may be more sensitive to changes in boat traffic levels compared to low site fidelity groups and mixed groups. It is possible that when high site fidelity groups are approached by the research vessel and potentially other boats, they are more likely to increase dive duration and engage in boat avoidance behavior because of their chronic exposure to boat traffic in Mississippi Sound.

Mixed groups were recorded as not found significantly less. In these groups, dolphins are interacting with conspecifics that exhibit different levels of site fidelity and are potentially from different stocks. It is likely these individuals are engaging in social interactions or competing for prey resources. These behaviors offer ecological benefits, such as access to mates, food, and opportunities for social bond formation. These benefits may exert pressure for mixed groups to continue engaging in these behaviors despite being approached by the research vessel and potentially other boats. This pressure to continue interacting with conspecifics may not be as strong in high site fidelity groups since these individuals are likely familiar with each other and from the same stock. These different ecological pressures explain the pattern of increased recording of not found in high site fidelity groups and decreased recording of not found in mixed groups.

Implications

In conclusion, low site and high site fidelity groups exhibit different seasonal and diurnal behavioral patterns. Low site fidelity dolphins are observed feeding more often during the summer and high site fidelity groups are observed traveling more often during spring and summer. These behavioral patterns are not present in mixed groups, which shows that behavioral patterns of high site fidelity and low site fidelity groups are altered when these individuals interact together. Knowledge of the behavioral patterns between high site and low site fidelity dolphins may help scientists better understand differences between inshore and coastal stocks and create more effective conservation policies. For example, low site fidelity dolphins are observed feeding more often during the summer when boat traffic is at its highest levels. Policies to restrict boat traffic around areas where dolphins often forage may need to be implemented during summer to reduce anthropogenic disturbance for these animals. Also, stock management strategies are focusing on the identification and protection of long-term stable resident communities, which are considered at greatest risk from geographically localized events (Waring et al., 2010). Knowing the behavioral patterns of high site fidelity dolphins, which are potential residents, will provide baseline information to determine whether localized events have disrupted the behavioral patterns of potential residents. Ultimately, this knowledge leads to improved conservation and management practices that address the specific ecological demands of high site and low site fidelity dolphins that potentially represent different stocks.

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