

Seasonal Abundance and Site Fidelity of Bottlenose Dolphins (*Tursiops truncatus*) in Mississippi Sound

Carrie W. Hubbard,^{1,2,3} Kathy Maze-Foley,¹ Keith D. Mullin,¹ and William W. Schroeder²

¹National Marine Fisheries Service, Southeast Fisheries Science Center,
3209 Frederic Street, Pascagoula, MS 39567, USA

²Marine Science Program, The University of Alabama, Dauphin Island Sea Lab,
101 Bienville Boulevard, Dauphin Island, AL 36528, USA

³Present address: National Marine Fisheries Service, Office of Protected Resources,
1315 East-West Highway, Silver Spring, MD 20910, USA

Abstract

Line-transect and photo-identification methods were used to examine bottlenose dolphin (*Tursiops truncatus*) abundance and site fidelity in a 446 km² portion of the Mississippi Sound in the north-central Gulf of Mexico from May 1995 through September 1996. For estimating density and abundance, north-south transect lines were surveyed using a 6.4-m boat. The density and abundance of dolphins in the area surveyed within Mississippi Sound varied seasonally, peaking in summer 1995 with 1.3 dolphins/km² and 584 dolphins ($CV = 0.17$), and dropping to a low in fall 1995 with 0.6 dolphins/km² and 268 dolphins ($CV = 0.23$). Density estimates were comparable to previous seasonal estimates for Mississippi Sound. Dolphins were widely distributed throughout the study area during all seasons. Group sizes ranged from 1 to 50 dolphins with an overall median of 4.0 ($\bar{x} = 6.5$, $SE = 0.45$, $n = 288$). Group size varied by season, with the smallest groups in fall and winter (median = 3.0 for each), slightly larger groups in spring (median = 3.5), and largest groups during the summers (median = 5.0 and 5.5). Groups containing calves were significantly larger than groups without calves (median = 10.0 and 3.0, respectively) ($p \leq 0.001$). Five hundred fifteen individuals were photo-identified, but resighting rates were low, with a mean of 1.57 sightings/dolphin. The most frequently sighted dolphin was observed on six occasions. Evidence of site fidelity over various time scales was found, including possible long-term site fidelity. Two dolphins first photographed in 1991 and two dolphins freeze-branded in 1982-1983 were resighted during this study.

Key Words: bottlenose dolphin, *Tursiops truncatus*, line-transect, abundance, group size, photo-identification, Mississippi Sound, Gulf of Mexico

Introduction

Bottlenose dolphins (*Tursiops truncatus*) are the only cetaceans routinely present in Mississippi Sound (Sound) in the north-central Gulf of Mexico (Gulf). The Sound was once the site of the largest live-capture fishery of bottlenose dolphins in North America (Reeves & Leatherwood, 1984). Forty-one percent of all dolphins taken from the Gulf for the purpose of public display and research were removed from the Sound (Blaylock et al., 1995). Between 1973 and 1988, 202 dolphins were removed from the Sound and adjacent waters (Scott, 1990). The Sound is the site of a wide variety of human activities that include shipping, commercial and recreational fishing, oil and gas development, dredging, and recreational boating.

Previous research on Mississippi Sound bottlenose dolphins, originally spurred by the area's importance as a live-capture fishery, primarily focused on estimating abundance. A series of seasonal aerial surveys was conducted in 1980 and 1981 (Thompson, 1982). Abundances ranged from 140 ($SE = 86$) dolphins in September to 93 ($SE = 22$) dolphins in December, with corresponding densities ranging from 0.08-0.13 dolphins/km² (Table 1). No significant seasonal peaks in abundance were evident from these surveys. To gather baseline biological data and study dolphin ranging patterns, 50 bottlenose dolphins were captured from the Sound and freeze-branded with a number from June to August 1982 (Solangi & Dukes, 1983). An additional seven were branded between October 1982 and June 1983. A mark-recapture study from August 1982 to September 1985, using the freeze-branded individuals and coinciding with the capture-removal of 30 dolphins from the Sound, produced abundance estimates ranging from 2,392 to 7,051 dolphins (Lohoefer et al., 1990a).

Table 1. A summary of bottlenose dolphin density in the Mississippi Sound from various studies; density is expressed in dolphins/km². When available, coefficients of variation are in parenthesis. Years given are when fieldwork took place. Study areas included our study area, but except for Lohoefer et al., 1992b, did not cover the entire Sound.

Location and study	Summer	Fall	Winter	Spring
<i>Boat surveys</i>				
Present study	1.3 (0.17) 1995	0.6 (0.23) 1995	0.6 (0.28) 1995-	0.8 (0.29) 1996
	1.2 (0.29) 1996		1996	
Mullin & Hoggard, 1992a, 1992b	1.1 (0.20) 1991		0.5 (0.25) 1991	
	1.1 (0.16) 1992		0.6 (0.26) 1992	
Lohoefer et al., 1990b	1.3 (0.31) 1985	1.0 (0.18) 1985	0.3 (0.13) 1985	0.7 (0.18) 1985
	1.5 (0.37) 1986	1.0 (0.28) 1986	0.4 (0.13) 1986	1.0 (0.21) 1986
<i>Aerial surveys</i>				
Blaylock & Hoggard, 1994		0.2 (0.49) 1992		
Scott et al., 1989	0.5 (0.16) 1984	0.1 (0.18) 1984	0.1 (0.13) 1984	
Thompson, 1982	0.1 (0.47) 1980	0.1 (0.61) 1980	0.1 (0.24) 1980	0.1 (0.32) 1980

Unlike previous studies, a boat-based, line-transect survey conducted from October 1984 to September 1986 suggested that the number of bottlenose dolphins in the Sound fluctuated between approximately 2,400 in summer and 500 in winter, yielding densities of 1.5 and 0.3 dolphins/km², respectively (Lohoefer et al., 1990b; Table 1). Boat-based, line-transect surveys also were conducted in the Sound during 1991-1992 (Mullin & Hoggard, 1992a, 1992b). Mean group size in both summers (June-August), 1991 and 1992, was 5.7 dolphins/group; dolphin density was 1.1 dolphins/km² during both summers. Densities and group sizes were lower in winter (January-March): for 1991, mean group size was 3.1 dolphins/group and density was 0.5 dolphins/km²; and for 1992, mean group size was 3.5 dolphins/group and density was 0.6 dolphins/km² (Mullin & Hoggard, 1992b).

While estimating abundance remains a critical element of the management strategy of the National Marine Fisheries Service (NMFS), defining stock structure is equally important. The U.S. Marine Mammal Protection Act (1972) requires that species be managed via subunits called stocks (see Wade & Angliss, 1997). It was assumed that for the inshore bottlenose dolphins in the Gulf (i.e., 33 bay, sound, and estuary stocks), communities of dolphins potentially inhabit each northern Gulf embayment (Blaylock et al., 1995). For a number of reasons, inshore Gulf stock structure is complex and has been the subject of two review panels (Hansen & Hohn, 1997; Hubard & Swartz, 2002). The panels recommended that the current stock structure be maintained unless substantial evidence is gathered to form the basis for revision. The panels also recommended that genetic, satellite and radio-tracking, photo-identification (photo-ID), and long-term site specific studies be

completed towards elucidating bottlenose dolphin stock structure in the Gulf.

Because of the behavioral plasticity demonstrated by this species (e.g., Shane et al., 1986), assumptions cannot be made about the ecology of Mississippi Sound dolphins based solely on studies from other areas. To better understand the seasonal changes in abundance and stock structure of Mississippi Sound bottlenose dolphins, we initiated a research project with the following objectives: (1) estimate the density and abundance of bottlenose dolphins using line-transect methods; (2) examine the relationships between season and abundance, group size, and group composition; (3) create a foundation for long-term research by establishing a photo-ID catalog; and (4) examine occurrence patterns, site fidelity, and ranging patterns of individual dolphins.

Materials and Methods

Study Area

The Sound, encompassing approximately 1,578 km² (Lohoefer et al., 1990a), is located in the north-central Gulf of Mexico (Figure 1). To the north, the Sound is bordered by the Alabama, Mississippi, and Louisiana coasts, and to the south, it is separated from the Gulf by six barrier islands. Christmas (1973) summarized some of the physical and hydrological characteristics of the Sound. The average depth at mean low tide is 3.6 m. Tides are diurnal and range only 0.46 m, but strong seasonal winds (N/NE in winter, S/SE in summer) can have a dramatic effect on tidal fluctuations. The bottom is composed almost entirely of soft substrate, typically sand and/or mud. Sea surface temperatures commonly range from 32° C in summer to 9° C in winter, and salinities typically range from 0 to 33 ppt.

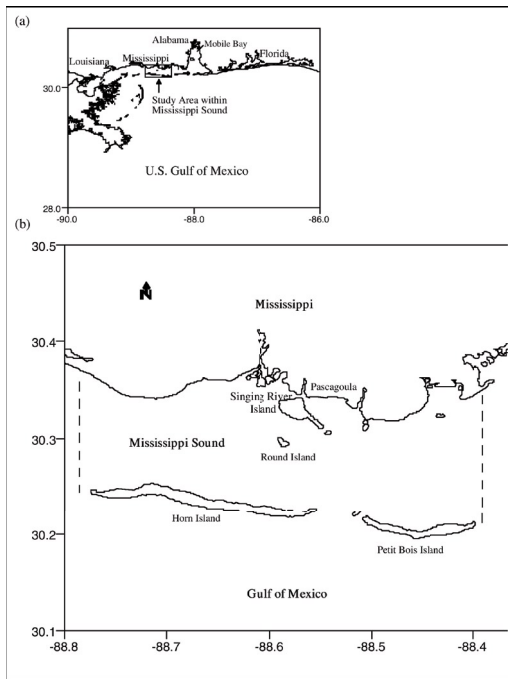


Figure 1. The Mississippi Sound study area is shown in both (a) and (b). The top chart (a) indicates the position of the study area within the Sound and the surrounding Gulf of Mexico, and the positions of nearby coastal states. Dashed lines in (b) indicate the east and west boundaries of the study area.

Due to the large size of the Sound, a smaller region therein was selected for study. The study area (approximately 446 km²) encompassed waters between the eastern tip of Petit Bois Island (88° 23' W) and the western tip of Horn Island (88° 46.75' W), and northward to the mainland (Figure 1). This reduction in size allowed all parts of the study area to be accessed relatively quickly, thus minimizing transit time and increasing sampling effort. This area was chosen for logistical reasons based on its proximity to the NMFS laboratory in Pascagoula, Mississippi.

Data Collection

Data were collected for 16 months, from 25 May 1995 to 25 September 1996. The survey platform was a 6.4-m Wellcraft boat equipped with a 150-hp Evinrude outboard motor. Surveys were conducted when the sea state was calm (Beaufort 0-2) and usually lasted 4-6 hours between 0800 and 1600 h. A LoRAN-C navigation system was used to determine latitude and longitude.

Similar to previous studies conducted in this area (Lohofener et al., 1990b; Mullin & Hoggard, 1992a, 1992b), line-transect methods were used

to estimate seasonal abundance and density (Buckland et al., 1993). To create a systematic search pattern with a random start, the study area was divided into eight zones of equal width. Each zone contained 12 transect lines that ran along lines of longitude every 25 seconds of a degree. Prior to a survey, a starting transect number was selected randomly, and the corresponding transect line was surveyed in as many zones as possible on that day. In an effort to ensure that all animals between land and the boat were accounted for, transect lines began and ended as close to the shoreline as possible. A goal of 24 lines/month, comprised of three lines in each zone, was set at the beginning of the project.

Two observers conducted line-transect sampling by scanning the waters from abeam of the boat (90°) to directly in front of the vessel and over 10-15° on the other observer's side. The right-side observer had the additional duty of driving the boat. In an effort to maintain constant speed, all transect lines were driven with the engine running at approximately the same rpm (2,800-3,100) (~16 knots).

When a dolphin group was sighted, the divert location on the transect line was stored on the LoRAN-C navigation system. The boat was then driven to the location where the dolphins were originally seen. This sighting location also was recorded so that the group's "perpendicular sighting distance" from the transect line could be calculated as the difference between longitudes and converted to meters. For density purposes, group size was considered to be the number of dolphins seen within the first 2 to 3 min of sighting the group (i.e., any loss or gain of animals during prolonged contact did not alter the original estimate). On most days, photo-ID research was conducted in conjunction with line-transect surveys. Once photography and data collection were completed, the boat was driven to the divert location and the transect was continued. Average sea state and weather for the entire line were assessed and recorded at the end of each transect line.

In addition to location information, the following data were recorded for each dolphin sighting: time, group size (total number), group composition (number of adults, number of calves), environmental conditions, and photography information. A group was considered an aggregation of dolphins in the same general vicinity, seemingly associating with each other and exhibiting similar behavior (Shane, 1990). Following Shane's description, animals whose length was two-thirds or less than an adult's length were classified as calves. This determination was made by eye while in the field.

The decision to leave a group of dolphins during photo-ID efforts was made for any of several reasons: all animals had been photographed, the dolphins were exhibiting boat avoidance or some other behavior that precluded photography, or due to time constraints (e.g., attempt to strike a balance between time spent photographing and time spent surveying transect lines, day length).

Several motor-driven cameras were used during the study: a Nikon 8008 with a databack and a 60-300 mm zoom lens; a Nikon N90 with a 400 mm Tokina AT-X fixed lens; and a Canon EOS ElanII with a 75-300 mm USM zoom lens. Kodak 100 Ektachrome Elite II slide film or Sensia 100 Fujichrome slide film was used. Roll number and frames shot were recorded on data sheets for each sighting.

Data Analysis

Dolphin density was estimated using line lengths, perpendicular sighting distances, and group size estimates with the program *Distance* (Laake et al., 1993). Examining a histogram of the complete dataset by perpendicular sighting distance revealed several outliers. Sightings beyond a perpendicular distance of 600 m were eliminated. This resulted in the loss of only seven observations (2.6% of all sightings), falling under the 5-10% truncation level recommended by Buckland et al. (1993). The histogram of perpendicular sighting distances for the entire dataset also showed a spiked pattern of sightings close to the transect line. Separate histograms were generated for each season, and all showed a similar spiked pattern. This suggested that the spike was not related to the search pattern of a specific observer but rather a function of the entire survey (CWH participated in every survey, but the second observer changed throughout the 16 months). Perpendicular distances were then grouped into a variety of interval combinations until a set (0, 75, 150, 300, 450, 600 m) was found that minimized the spike.

To reduce bias in mean group size estimates due to the potential of a positive relationship between group size and perpendicular sighting distance (x), a regression was performed showing the relationship between the probability detection function, $g(x)$, and observed group size (Buckland et al., 1993). From this regression, an expected group size was estimated for each season. A Student's t -test was performed to test for a difference between the actual mean group size and the expected mean group size ($p < 0.15$).

The data were run on *Distance* to estimate density, abundance, and average group size. For each seasonal estimate, a transect line was considered a separate replicate. The equation for dolphin density was as follows:

$$D_i = \frac{n_i \cdot f(0) \cdot S}{2 \cdot l_i}$$

where, D_i is the dolphin density for a single transect line i , n_i is the number of dolphin groups detected on the line, $f(0)$ is the probability density function of distances evaluated at zero distance (pooled from all seasons), S is the average seasonal group size, and l_i is the length of the transect line i . The overall seasonal density (D) was estimated by averaging all the individual transect line densities weighted by line length. The variance of D was estimated for replicate lines following Buckland et al. (1993). To determine seasonal abundance (N), D was multiplied by 446 km², the size of the study area. Log-normal 95% confidence intervals of N also were estimated.

For data analyses, seasons were defined as summer—June through August; fall—September through November; winter—December through February; and spring—March through May (Fertl, 1994; Hanson & Defran, 1993; Maze & Würsig, 1999; Shane, 1990). To analyze group size by season, we excluded groups sighted during May 1995 and September 1996, and analyzed data only from five complete seasons (June 1995–August 1996). All group size datasets were found to be highly skewed and failed normality and equal variance tests; therefore, Mann-Whitney Rank Sum tests were performed when two samples were compared. A Kruskal-Wallis one-way ANOVA was used to examine relationships between three or more samples. If an ANOVA found statistical significance ($p < 0.05$), a *post hoc* all pairwise multiple comparison test (Dunn's method) was performed. These statistical tests compare median values; however, we also report means and standard errors to facilitate comparisons with other studies.

The techniques for examining and cataloging dorsal fin photographs were based on the protocol described by Defran et al. (1990). Animals that lacked natural notches or markings were considered unidentifiable and were not included in analyses. All new slides were compared to the catalog twice to determine if the animal had been sighted previously. If a match was not found, a new ID number was assigned, and the animal was added to the catalog.

Results

Survey Effort

Eighty-eight surveys resulted in the completion of 336 transect lines (Table 2). Two hundred ninety groups were sighted, and 101 of these groups were photographed.

Density and Abundance

To estimate density and abundance, a total of 312 transect lines, equaling 3,666 km of effort and yielding 265 group sightings, were analyzed (Table 2). The 24 transect lines surveyed during fall 1996 (September) were not included in the analyses because only one month of this season was surveyed. Based on a minimum Akaike's Information Criterion (AIC) score, *Distance* selected a hazard-rate key with two cosine adjustments as a model for the perpendicular sighting distance curve. The estimate of $f(0)$ for the entire study was 0.00578/m (se = 0.00053).

In summer 1995, fall 1995, and summer 1996, the expected group sizes were smaller than the observed group sizes, and these differences were significant ($p = 0.012, 0.035, \text{ and } 0.064$, respectively). For winter 1995-1996, the expected group size was smaller than the observed group size but not significant ($p = 0.258$). Because a significant difference between expected and observed group sizes was present for several seasons, the expected group size was used also for winter 1995-1996. Spring 1996 was unusual since the expected group size estimated by *Distance* actually was higher than the mean observed group size. Because this is counterintuitive, the mean observed group size was used to estimate density.

Estimated group sizes ranged from 3.2 dolphins/group in fall 1995 to 6.7 in summer 1996. Densities and abundances also peaked in the summer and were lowest in the fall and winter. Densities ranged from 1.3 dolphins/km² to 0.6 dolphins/km², and abundances ranged from 268 to 584 (Table 2).

Group Size and Composition

Group size ranged from 1 to 50 dolphins, with an overall median group size of 4.0 ($\bar{x} = 6.5, SE = 0.45, n = 288$). The frequency of different group sizes was examined by dividing sizes into increments of five animals. The majority of groups (62%) contained one to five animals. Groups with 15 or fewer dolphins comprised 91% of all sightings.

Examining group size by season resulted in the smallest groups in fall (median = 3.0, $\bar{x} = 4.1, SE = 0.62, n = 56$) and winter (median = 3.0, $\bar{x} = 5.2, SE = 1.52, n = 35$), slightly larger groups in spring (median = 3.5, $\bar{x} = 5.4, SE = 0.98, n = 36$), and largest groups in summers (median = 5.0, $\bar{x} = 6.0, SE = 0.51, n = 94$ for 1995; median = 5.5, $\bar{x} = 9.1, SE = 1.52, n = 48$ for 1996). Seasonal group sizes were significantly different (Kruskal-Wallis, $H = 14.228, df = 4, p = 0.007, n = 269$), but an all pairwise multiple comparison (Dunn's method) did not detect a difference between any two seasons. The size of groups with and without calves was also examined. Groups containing one or more calves (median = 10.0, $\bar{x} = 13.0, SE = 1.34, n = 58$) were significantly larger in size (calves included) than groups without calves (median = 3.0, $\bar{x} = 4.9, SE = 0.39, n = 230$) ($p \leq 0.001$, Mann-Whitney U). Overall, calves comprised 5.8% of dolphins observed, and calves were sighted year-round.

Distribution

Dolphins were widely distributed throughout the study area during all seasons (Figure 2); however, there were several regions where dolphins were absent during surveys. Areas of few or no sightings included waters in the very easternmost section of the study area (north of Petit Bois Island),

Table 2. Seasonal line-transect effort and seasonal density and abundance results as estimated by *Distance* for the Mississippi Sound study area; also included is the number of groups photographed during each season. An additional 16 groups were photographed (1 in May 1995 and 15 in September 1996).

	Summer 1995	Fall 1995	Winter 1995-1996	Spring 1996	Summer 1996
Transect lines completed	87	67	49	47	62
Effort (km)	1,039.5	788.3	563.7	560.2	714.2
No. of groups observed	96	54	35	32	48
Mean group size, S	5.0	3.2	3.6	4.9*	6.7
Density (D), dolphins/km ²	1.3	0.6	0.6	0.8	1.2
Abundance (N)	584	268	286	364	555
CV(N)	0.2	0.2	0.3	0.3	0.3
95% confidence interval	419-815	173-415	167-490	205-644	316-974
No. of groups photographed	19	16	14	12	24

*The observed mean group size was used instead of expected mean group size for spring 1996 (see text; CV = coefficient of variation).

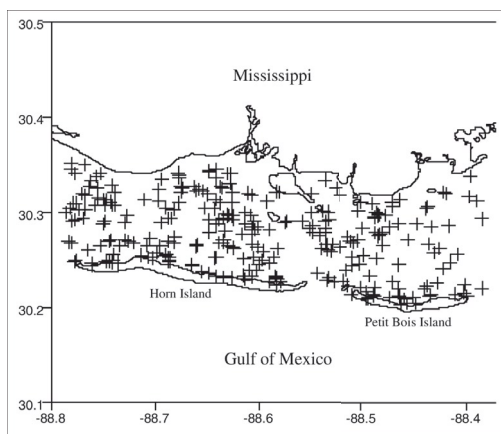


Figure 2. Locations of dolphin sightings for the entire study period; each "+" represents one sighting of a group of dolphins.

immediately south of Round Island, and small areas midway in the Sound north of Horn Island.

Photo-ID

A total of 515 dolphins were identified. New animals continued to be identified throughout the study at a high rate, suggesting that many more animals use the study area and were not identified. The frequency with which dolphins were resighted was low. The majority of dolphins (336, 65.2%) were sighted one time, and 489 (95.0%) were sighted three or fewer times. The two most frequently sighted dolphins were observed six times.

One animal, #35, was sighted during all four seasons. All animals first sighted in winter were also sighted the following spring or summer, or both. Also of interest is that some individuals

were sighted during the same season one year after their original sighting. For example, dolphin #84 was sighted on 16 August 1995 and again on 16 August 1996 only 2.4 km from the original sighting.

By comparing the catalog to previous photographs taken in the Sound during prior surveys (Mullin & Hoggard, 1992a), we found evidence suggesting long-term site fidelity. Dolphin #63 was photographed in June 1991 and resighted in July 1995. Also, dolphin #153 was photographed in June 1991 and then in September 1995 and April 1996. As previously mentioned, 57 dolphins were freeze-branded in the Sound in 1982 and 1983 (Lohoefer et al., 1990a; Solangi & Dukes, 1983). Two of the branded animals were resighted during this study (Figure 3). In both cases, the branded numbers were still on the dorsal fins in the form of scarring/raised skin, but the white coloration had disappeared so that the brands blended in with the rest of the fin. These dolphins were not recognized as branded while in the field, but the brands were apparent when the slides were examined in the laboratory. Dolphin #626 was sighted on 27 August 1996. Prior to this study, it had been sighted five times in 1982 and 1983, including its original capture date. When captured, this female dolphin was approximately 2 years old and 193 cm (Solangi & Dukes, 1983). Additional surveys during 1997 (by the authors using the same methodology) yielded another sighting of #626 on 18 August 1997. Another female dolphin, #649, which was 3 years old at the time of capture, was sighted on 11 September 1996 off Horn Island; previously, she was sighted in August and September 1982.

The low number of resightings precluded an adequate examination of ranging patterns; however, by plotting the sighting locations of

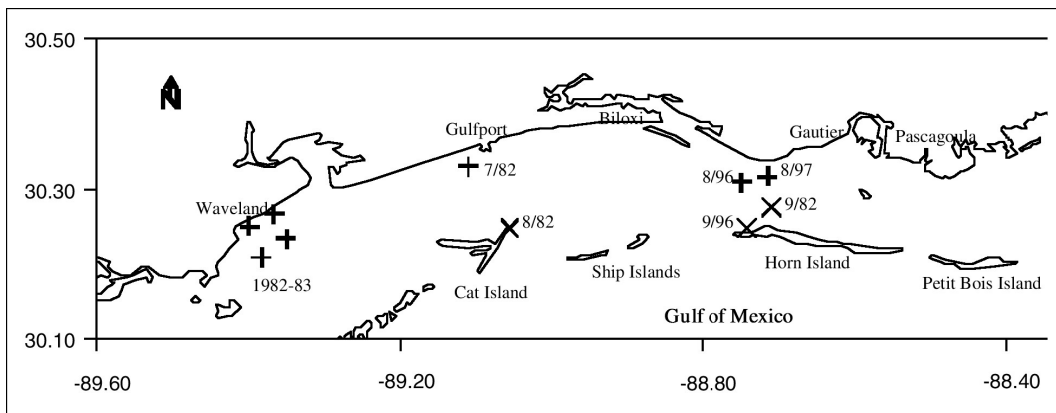


Figure 3. Sighting locations and dates (month/year) of freeze-branded dolphins #626 (+) and #649 (x); sightings from 1982-1983 were obtained from Solangi & Dukes (1983).

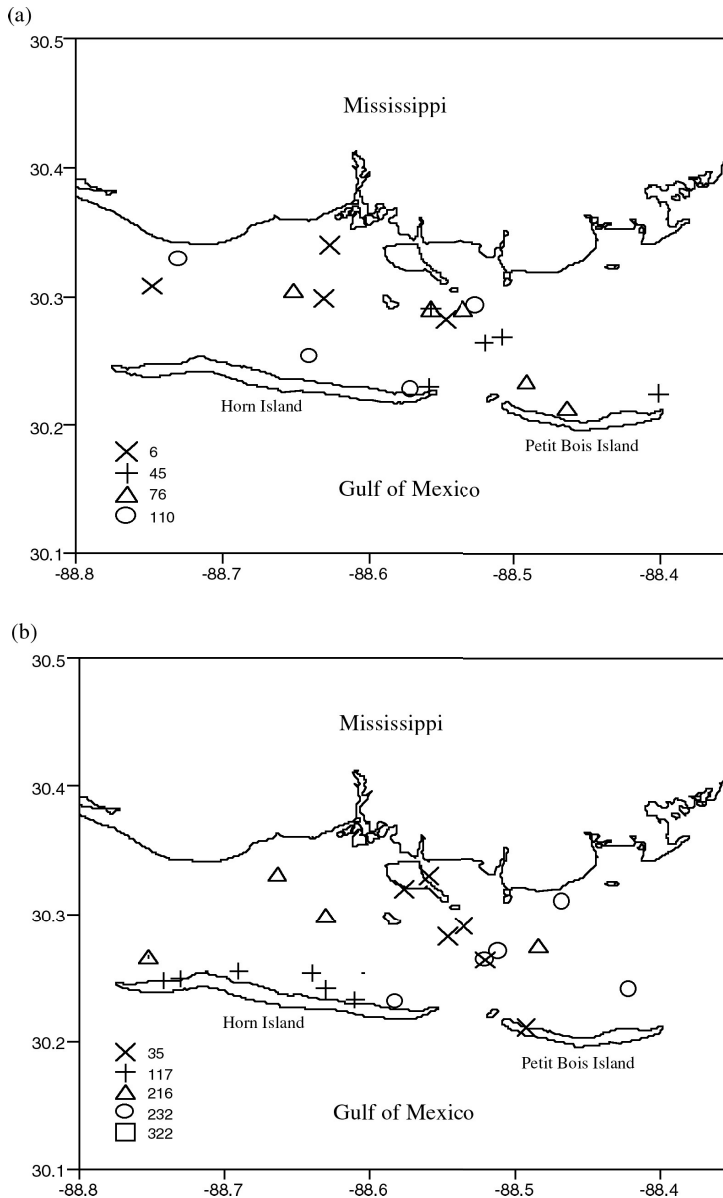


Figure 4. Sighting locations of dolphins observed ≥ 4 times; each symbol represents one sighting. All sightings of a given individual occurred on separate survey days.

several dolphins with four or more sightings, some patterns of geographic fidelity arose (Figures 4a & 4b). The sightings of #6 were widely distributed across the study area from east to west, but almost all sightings occurred north of Round Island and none were near the barrier islands. Dolphin #35 was found from the mainland south to Petit Bois Island, but was only sighted in a narrow band that corresponded fairly well to shipping

channels. Dolphin #45 was observed from the easternmost point of Petit Bois Island to just south of the Pascagoula River, but not further to the west. Sightings of #110 were expansive and incorporated both the northern shoreline and the islands, but did not extend east to any of the waters north of Petit Bois Island. All sightings of #117 and #322 occurred along the north shore of Horn Island. The sightings of other dolphins (e.g., #76,

#216, and #232) were widely distributed throughout the study area.

Discussion

Density and Abundance

The seasonal trends for abundances and densities, which peaked in summer and were lowest in fall and winter, closely resembled some estimates made previously in this area (Table 1). The precision (*CV*) of these estimates was also similar. Expected group size and density estimates were similar to those made by Mullin & Hoggard (1992a, 1992b). Densities were extrapolated to abundance for the 1,578 km² area determined by Lohofener et al. (1990a) to represent the entire Sound. Summer abundances (2,051 dolphins for 1995; 1,963 dolphins for 1996) were very similar to the estimates of 2,036 and 2,399 dolphins in the Sound made by Lohofener et al. (1990b); however, the winter estimate from this study, 1,010 dolphins, was larger than the previous winter estimates of 520 and 679 dolphins. Of course, dolphin densities found in this study area may not apply elsewhere in the Sound.

Upon examination of all density estimates for the Sound (Table 1), it is obvious that densities from all three boat-based surveys are very similar, whereas aerial surveys repeatedly produced much lower density estimates. This suggests that some aspect of aerial surveys, such as high speed (~100 knots) through the study area, may cause negative bias. Wells et al. (1995) reported that for Sarasota Bay, Florida, boat-based population estimates were much larger than those from aerial surveys and suggested that high turbidity (also a factor in the Sound) may contribute to underestimations from aerial surveys.

Our estimates suggest that twice the number of dolphins are present in the study area in summer than in fall and winter. In the colder months, dolphins probably move offshore into the Gulf. Similar behavior has been observed in other locations within the Gulf such as Sarasota Bay (Irvine et al., 1981; Wells et al., 1980) and San Luis Pass, Texas (Maze & Würsig, 1999). Several species identified by Barros & Odell (1990) as common prey of bottlenose dolphins (silver perch, *Bairdiella chrysoura*; Atlantic croaker, *Micropogonias undulatus*; sand seatrout, *Cynoscion arenarius*; mullet, *Mugil* sp.; and spot, *Leiostomus xanthurus*) are considered highly abundant in the Sound and are known to migrate to warmer, deeper waters during fall and winter (Pattillo et al., 1997). We hypothesize that the Sound may not support as many bottlenose dolphins during winter due to the migration of many fish species. Calving requirements may also play a role in shifts in abundance. Along the

Mississippi coast, as well as along neighboring Alabama and Louisiana coasts, neonate strandings occurred most frequently in April and March (SER Stranding Network, unpub. data), suggesting a spring peak in calving. It is possible that offshore animals are moving into the Sound during warmer months to give birth to calves. Shallow areas along the barrier islands and coast may serve as nursery areas as has been suggested for other study sites, such as Sarasota Bay and Virginia Beach, Virginia (Barco et al., 1999; Scott et al., 1990). Finally, it is possible that seasonal shifts in abundance are due to east-west movements, but we consider this very unlikely. We can see no advantage to lateral movements as conditions to the east and west of our study site, both within the Sound and along the Alabama and Louisiana coasts, are likely very similar to our study site in terms of temperature and distribution of predators and prey.

Group Size and Composition

The factors considered to influence group size, such as predation, prey distribution, geography, and environmental conditions, are complex. Group sizes are variable for bottlenose dolphins, but they are commonly found in relatively small groups of 15 or fewer animals. Generally, group size increases with increased water depth or openness of the habitat (Shane et al., 1986). With the presence of barrier islands, the Sound's geography is not completely open like regions on the coast of California; however, it is less protected than semi-enclosed bays. The group sizes for the Mississippi Sound were similar to those for bottlenose dolphins in many semi-enclosed bays, such as Sarasota Bay ($\bar{x} = 7.0$; Wells et al., 1987), and other study areas, like Shark Bay, Australia ($\bar{x} = 4.8$; Smolker et al., 1992) and the northern Adriatic Sea ($\bar{x} = 7.4$; Bearzi et al., 1997). In addition, the mean group sizes for this study were very similar to those found by Goodwin (1985) for the nearby waters of Mobile Bay, Alabama, where the mean group size was 6.7 for the Gulf and 8.0 for the passage connecting Mobile Bay to the Gulf. The distribution of group sizes we found, with the majority of groups containing one to five dolphins and nearly all containing less than 15 dolphins, was similar to other studies as well (e.g., Bearzi et al., 1997; dos Santos & Lacerda, 1987; Maze-Foley & Würsig, 2002).

In this study, groups containing at least one calf were significantly larger than groups without calves. This tendency has been observed in many other locations as well, including the Gulf de Guayaquil, Ecuador (Félix, 1997); the Galveston Ship Channel, Texas (Fertl, 1994); San Luis Pass, Texas (Maze-Foley & Würsig, 2002); San Diego,

California (Weller, 1991); Sarasota Bay, Florida (Wells et al., 1987); and Turneffe Atoll, Belize (Campbell et al., 2002).

Group sizes varied significantly across the seasons. Although the multiple comparison (Dunn's method) did not find a pairwise difference, we believe the significance of the Kruskal-Wallis test resulted from larger group sizes in summers compared to fall and winter. The *Distance* results also support this. The group size results mirror the density and abundance results; density and abundance were higher in summer and lower in fall and winter as well. Group sizes were larger for socializing groups than for groups engaged in any other behavior, and social behavior was observed more often during summer than during other seasons (Hubard, 1998). This seasonal increase in social behavior may be due to increased mating activity or formation of nursery groups composed of mothers and young calves. It is also possible the shrimp and menhaden fisheries play a role in aggregating dolphins during summer. The brown shrimp (*Penaeus aztecus*) fishery, which composes ~85% of Mississippi's shrimp harvest, is most active from May to October (NMFS, Fisheries Statistics and Economics Division, pers. comm.). The Gulf menhaden (*Brevoortia patronus*) fishery is active from mid-April through 1 November (Vaughan et al., 2000). Both fisheries are active during the summer months, and dolphins in the Sound feed in association with these fisheries.

Undoubtedly, abundance, density, and group size fluctuate seasonally, but some differences could be an artifact of the way we defined our seasons. We used four seasons to compare our findings to previous studies; however, two seasonal weather patterns with intermediary periods between them more accurately reflect the climatology of the central and western Gulf (Gore, 1992).

Distribution

With the exception of a few small regions, dolphin groups were observed throughout the study area during each season. The lack of sightings south-southeast of Singing River Island, where the western branch of the Pascagoula River enters the Sound, may be explained by survey procedures. This particular region is extremely shallow (< 1 m) and covered with seagrass beds. Often, the boat could not be driven as close to shore as in other areas hence dolphins may have been missed. There is no obvious explanation for the lack of sightings in the other small areas. Dolphins probably do occupy these regions at times, but for whatever reason, none were observed during this study.

Photo-ID

Despite large numbers of dolphins and low resighting rates, we obtained evidence of site fidelity over various temporal and spatial scales. Identified individuals were observed across multiple seasons within our study area. Resightings of animals during multiple seasons indicated some degree of short-term site fidelity to our study area, but site fidelity was complicated by what we believe were seasonal inshore and offshore movements. There was a winter gap where few dolphins were resighted, and then an increase in April when many dolphins last sighted in summer and fall were resighted. Some animals may be year-round residents, whereas others may only enter the Sound during the warmer months. Similar to bottlenose dolphins from other locales, such as Sarasota Bay, Florida (Barros & Wells, 1998; Irvine et al., 1981; Scott et al., 1990; Wells et al., 1987), and San Luis Pass, Texas (Maze & Würsig, 1999), the dolphins of the Sound may move into the warmer, deeper waters of the Gulf during winter. As Scott et al. (1990) suggested, these movements could be due to a variety of constraints, including changes in prey distribution, predation, and reproductive needs; however, assumptions cannot be made about the ecology of the Sound dolphins based solely on studies from other areas. Bottlenose dolphins have demonstrated behavioral plasticity (e.g., Shane et al., 1986), and differences between areas (e.g., physiography) could affect important aspects of their ecology. Further study is needed to address patterns of seasonal residency and movements.

Identified individuals also were observed across many years within the Sound. Long-term site fidelity was suggested by animals photographed in 1991 that were resighted during 1995 and 1996, and also by the resightings of dolphins freeze-branded during 1982-1983. At present, the evidence for long-term site fidelity is insufficient to draw any conclusions.

The extent of individual dolphin movements within the Sound is uncertain for those animals that may reside there all or part of the year. The distribution of sightings for several frequently sighted dolphins during this study and previous studies (Lohoefer et al., 1990a; Solangi & Dukes, 1983) suggested that some dolphins may range within smaller geographic areas or particular habitats such as waters adjacent to barrier islands or shipping channels. It is important to know if individual dolphins use the entire Sound, if there are separate home ranges within the Sound, or a combination of both. We suggest that dolphins are moving inshore and offshore on a seasonal basis, but we have limited evidence to suggest to what

extent animals are moving on a short-term (daily, weekly) basis.

Additional study is needed to more adequately define individual residency and ranging behavior, including movements within the Sound and inshore and offshore movements. Future studies could incorporate a tagging (radio or satellite) component to address these topics. Conducting intense seasonal, multivessel surveys of the entire Sound and adjacent offshore waters is another option that may further elucidate residency and movements. Either option would be expensive and logistically challenging due to the large size of the Sound and the sea conditions offshore of the barrier islands; however, expanding the study area to include the entire Sound and offshore waters and/or tagging individuals will be necessary to better define residency and ranging hence, to have a better understanding of stock structure. Genetic studies could also help elucidate stock structure. Another complementary option may be to intensively survey small areas within the Sound to better assess whether some individuals display site fidelity to particular habitats.

Current pressures on the bottlenose dolphins in the Sound include human interactions such as shootings and net entanglements (Southeast U.S. Marine Mammal Stranding Network, unpub. data), disease such as morbillivirus (Duignan et al., 1996; Krafft et al., 1995; Lipscomb et al., 1996), and possibly biotoxin poisoning from red tide events (Geraci et al., 1999). More accurate abundance estimates and an improved understanding of residency and ranging behavior will allow for a better assessment of how these or other threats contribute to changes in population size.

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