

Assessment Of Occurrences Of Magnificent Frigatebirds In Northwest Florida:

The Influence of Weather And Roosts

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ABSTRACT

Magnificent Frigatebirds *Fregata magnificens* have been reported along the coast of northwest Florida since 1915. Most of the 150 counts ranged up to 20 birds; eight higher counts ranged from 26–250 birds. All high counts were associated with storms (seven with tropical cyclones, one with a lesser storm). Several high counts associated with tropical cyclones suggested that large roosts of frigatebirds on the Chandeleur Islands of Louisiana influenced their abundance in northwest Florida. Excluding high counts, frigatebirds were more abundant in northwest Florida during tropical cyclones than during more typical weather (mean of 7 versus 1.8 birds). The proximity of northwest Florida to larger populations of frigatebirds on the Gulf Coast rather than the Atlantic Coast influenced counts, especially during tropical cyclones. Most occurrences (64%), however, were associated with more typical weather, which have a different seasonal distribution (primarily April to June) than occurrences associated with tropical cyclones (primarily August to October). Most occurrences during more typical weather were associated with southerly or across windsurface wind flows that were not stronger (mean of 15.6 km/h) than average monthly wind speeds. Disregarding occurrences associated with tropical cyclones because these birds are vagrants, the most probable proximate cause for annual movements of non-breeding Magnificent Frigatebirds during more typical weather to northwest Florida and other regions in southeastern North America is best explained by an increase in sea-surface temperatures coupled with an asymmetric interaction of southerly surface wind flows.

INTRODUCTION

Magnificent Frigatebirds *Fregata magnificens* as non-breeding visitors to coastal and offshore environments of the southeastern United States are much more abundant in the Gulf of Mexico than in the Atlantic Ocean (Eisenmann 1962, Harrington et al. 1972, Clapp et al. 1982, Robertson and Woolfenden 1992, Stevenson and Anderson 1994, Robertson and Wilmers 1996). Frigatebirds are most numerous from April through October in Florida, where they form large roosts on the Gulf Coast north to Cedar Key (Seahorse Key in Levy County) (Stevenson and Anderson 1994). Stevenson and Anderson (1994), based on West (1991), stated that the Seahorse Key roost routinely held more than 1000 birds, but no data have been published to substantiate this claim. The largest estimate has been 700 birds (Edscorn 1974), although high counts of 300–400 have been the norm. Along the southwest Gulf Coast frigatebirds once formed roosts of 1000 or more (Howell 1932, Harrington et al. 1972, Clapp et al. 1982, Robertson and Woolfenden 1992), although they have become less numerous since the 1980s, at least around Tampa Bay (Robertson and Woolfenden 1992). Birds at roosts increase during April and reach a maximum from June to August (possibly also September) (Eisenmann 1962, Harrington et al. 1972, Clapp et al. 1982, Stevenson and Anderson 1994).

A distributional anomaly, however, occurs in the northern Gulf of Mexico. A large isolated summer roost of Magnificent Frigatebirds forms offshore in southeast Louisiana, where birds are concentrated in the Chandeleur Islands (Oberholser 1938, Lowery 1955, Clapp et al. 1982). The origin of these birds is unknown

(Robertson and Wilmers 1996), although McNair (2000) suggested they fly directly across the Gulf from the Yucatán. Oberholser (1938) stated that frigatebirds in the Chandeleur Islands may gather into a flock of many thousands. Lowery (1955) stated that 5000–10,000 frigatebirds in early June were not unusual. The highest count listed by either source, however, was 1100 birds on 4 June 1933 (Oberholser 1938). Numbers have declined at roosts in the Chandeleurs since the 1980s. The largest count has been 1000 birds at North Island in summer 1994 (J. Harris, pers. comm.) and 700 on 3 October 1984 (Purrrington 1985). Frigatebirds do not form roosts in the northeast Gulf of Mexico between southeast Louisiana and Cedar Key, Florida.

Located between these two roost sites lies the Florida Panhandle, where Magnificent Frigatebirds along the immediate coast are rare to uncommon from April to October, decreasing in winter to rare and irregular (Robertson and Woolfenden 1992, Stevenson and Anderson 1994). Each end of the Florida Panhandle (Escambia County in the west, Wakulla and Franklin Counties in the east) is approximately 165 km away from the Chandeleur Islands, Louisiana, and Cedar Key, Florida, respectively. This distance is probably outside the normal foraging range from the roost of most frigatebirds (Eisenmann 1962, Harrington et al. 1972, Robertson and Wilmers 1996).

This hiatus (large gap between roosts, birds outside normal foraging range) in northwest Florida presents an unusual opportunity to examine how tropical cyclones, surface wind flows during more typical weather, and roosting populations of frigatebirds in southeast Louisiana and peninsular Florida may contribute to patterns of occurrence (frequency, abundance, seasonality) of Magnificent Frigatebirds. These birds are highly specialized land-based aerial feeders that are responsive to the effects of storms and wind, both on the coast (Harrington et al. 1972) and inland, where most occurrences in Florida followed storms (McNair 2000).

METHODS

I obtained published and unpublished data on coastal occurrences of Magnificent Frigatebirds in the Florida Panhandle (as defined by Robertson and Woolfenden 1992), from Howell (1932), Weston (1965), Stevenson and Anderson (1994), *Audubon Field Notes* and its successors *American Birds* (cf. Loftin et al. 1991), *Field Notes*, and *North American Birds*, the field observations section of the *Florida Field Naturalist*, archives at Tall Timbers Research Station (TTRS), and observers in northwest Florida (see Acknowledgments). I assumed all frigatebirds were correctly identified. I did not assume that reporting rates or observer effort were even over time and space. To facilitate analyses, I categorized each observation into one of three geographic regions in northwest Florida: west (Escambia, Santa Rosa, and Okaloosa Counties), central (Walton, Bay, and Gulf Counties), and east (Franklin and Wakulla Counties [no observations from Jefferson County]). Except for one juvenile that probably lingered for 20 days (3–22 October 1995) at Gulf Breeze, Santa Rosa County, following Hurricane *Opal*, frigatebirds apparently remained continuously at the same locality for five days or less. Thus, my operational definition of a single observation is that birds must occur at least 6 days apart at the same locality. When multiple observations occurred at the same locality within five days, I chose the observation with the largest number of frigatebirds. These procedures reduced pseudo-replication of observations. Occurrences at multiple localities during the same weather event were scarce along the coast of northwest Florida and their resolution did not contribute toward the analyses except during Hurricane *George* in 1998, so unlike observations in the

interior of Florida (McNair 2000), I made no adjustment for this factor. I classified weather events into two categories, tropical cyclones (including tropical depressions and subtropical cyclones with winds equal to or greater than 63 km/h) and more typical weather.

I examined the tracks of tropical cyclones in the North Atlantic Ocean using several sources (Neumann et al. 1981, annual reports in *Monthly Weather Review* for data from 1981–1995 and in *Weatherwise* from 1996–1998) to determine which occurrences were associated with tropical cyclones (cf. McNair 2000). For additional clarifications, I also examined hurricane season summaries of North Atlantic tropical cyclones in *Monthly Weather Review*, weather data in *Storm Data* (since 1959), and *Daily Weather Maps* (since 1969).

Two first-order weather stations that provide data on wind speed and direction are located along the immediate coast of the Florida Panhandle (courtesy of the Southeast Regional Climate Center [SERCC]), in Pensacola (Escambia County) and Panama City (Bay County). For all occurrences of frigatebirds since 1993 that were not associated with tropical cyclones, I chose the weather station closest to each observation in northwest Florida for an approximation of associated information on mean daily wind speed (mph converted to km/h) and prevailing wind direction (to the nearest eighth quadrant, i.e., NE, SW, etc.). For additional clarifications, I examined weather data in northwest Florida on and near each day of observation since 1993 in *Local Climatological Data Florida*, *Storm Data*, and *Daily Weather Maps*. I also obtained mean monthly wind speeds for the Pensacola and Panama City weather stations from SERCC for months represented by observations. I then compared the associated mean daily wind speed for each observation since 1993 to the mean monthly wind speed of the closest weather station. Since more than one observation may occur within a month, I randomly chose one observation per month that was closest to each weather station to avoid repeated comparisons of two or more observations per month with the same mean monthly wind speed value, although inclusion of all observations yielded similar results.

RESULTS

Magnificent Frigatebirds have been documented to occur along the northwest coast of Florida on 150 occasions since 1915. The geographic distribution of observations is non-random: 68 (45.3%) occurrences each are from the west (mainly Escambia County) and east (mainly Franklin County), and 14 (9.3%) are from the central region ($\chi^2 = 37$, $P < 0.01$). The number of frigatebird occurrences (grouped by decade) along the northwest coast has increased significantly over the years (Spearman's $r = 0.83$, $n = 9$, $P = 0.006$), especially since the 1980s ($n = 117$, 78% of total). Fifty-four (36%) observations were associated with tropical cyclones, 96 (64%) with more typical weather. Earlier decades (before the 1980s) had a higher proportion of observations associated with tropical cyclones compared to more typical weather (19 of 33, 58%) than during recent decades (1980s–1990s; 35 of 117, 30%) ($\chi^2 = 6.60$, $P < 0.01$).

The number of frigatebirds per occurrence along the coast of northwest Florida ranged up to 250 birds; just more than half (52%) of all counts were of one bird. All counts greater than 14 birds only occurred once each. The first gap in flock size occurred after 20 birds; only eight counts were higher (26, 50, 52, 55, 66, 150, 200, 250). Excluding the eight high counts, the mean number of birds that occurred during tropical cyclones was significantly higher than during more typical weather (cyclones: $7 + 5.6$ SD, $n = 47$; typical weather: $1.8 + 1.7$, $n = 95$; t -test on log-transformed numbers $t = 8.23$, $df = 140$, $P < 0.001$; also see Table 1). Excluding high counts, further analyses (unpubl.) for each weather category showed that the

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Table 1. The number and frequency of observations of Magnificent Frigatebirds along the northwest coast of Florida for four count categories that compare observations associated with tropical cyclones to more typical weather^a.

Count Category	Tropical Cyclones	Typical Weather
1	9 (17%)	69 (72%)
2-4	13 (24%)	19 (20%)
5-14	19 (35%)	7 (7%) ^b
≥ 15	13 (24%)	1 (1%) ^c

^a G-test=55.39, df=3, P<0.001.
^b The highest count was 10 in this category.
^c The only count in this category was questionable; see text.

mean number of birds did not differ among years, regions, or monthly dates of observation.

Six high counts were in the western Panhandle before the 1980s, and all were associated with tropical cyclones. Observations from these storms occurred on 8 July and from 16 September to 4 October. The eyes of two storms (Hurricane 1 in 1916, Hurricane *Ethel* in 1960) passed through the Chandeleur Islands; neither storm moved over land until reaching the Mississippi coast. Hurricane 1 originated from the western Caribbean Sea, Hurricane *Ethel* from the central Gulf of Mexico. The latter storm was associated with the highest count of birds (250) in the Florida Panhandle. The eyes of the other storms passed to the west of the Chandeleur Islands before landing on the central Louisiana coast, except for the storm associated with the count of 26 birds which passed just to the east of the Chandeleurs before landing on the Mississippi-Alabama coast. These storms originated in the western Caribbean Sea or western Atlantic Ocean and passed over land before final landfall. The path of one storm (Hurricane *Hilda* in 1964) was unusual. After landfall on the Louisiana coast, the track of the storm took an abrupt 90° turn to the east and passed along the northern Gulf coast into the Florida Panhandle, where flocks of 50 and 200 birds were observed. The only other tropical cyclone that has taken a similar path along the northern Gulf coast since 1915 was Hurricane *George* in 1998, whose eye passed through the Chandeleur Islands before landfall on the Mississippi coast. Multiple occurrences of frigatebirds in the Florida Panhandle were associated with *George*; at least 88 birds were observed. Both *Hilda* and *George* took a path that "corralled" birds.

One of two high counts (52 birds) in the eastern Panhandle occurred on 3 October 1992 during a tropical depression that was then centered in the eastern Gulf of Mexico. Heavy rains (over 10 cm), strong winds (gusts up to 108 km/h), and local tornadoes accompanied this storm that landed on the Gulf/Franklin County border. The other high count (66 birds) on 7 October 1976 was not associated with a tropical cyclone, but its validity is questionable (possible falsified data). This count did occur during a prolonged storm (6-8 October), a large stationary front that on 7 October produced heavy rains (over 5 cm), moderate windspeeds (< 32 km/h), and a wind direction from the southeast.

The mean daily wind speed associated with all occurrences of frigatebirds since 1993 during more typical weather was 15.6 + 4.5 km/h (range: 8-29 km/h, n = 45), which was not different from the mean of the randomly chosen subset which was restricted to one observation per month closest to each weather station (15.8 + 5.6 km/h, n = 20). Both values are highly similar to the mean monthly

wind speed (15.4 + 2.4 km/h, n = 20) recorded at the two weather stations in Pensacola and Panama City. The prevailing wind direction on the days of occurrence of frigatebirds was from the south (SW-SE = 23, W = 5, E = 12, NW-NE = 5).

Magnificent Frigatebirds have occurred along the coast of northwest Florida from 26 March to 6 January, with most observations (89%) from April through October (Fig. 1). Their frequency of occurrence early, however, is from a distinctly different cause than their later occurrence. The number and proportion of frigatebirds during more typical weather was highest from April through June, compared to lower numbers later in the year. In contrast, most observations from August through October (peaking in September) have been associated with tropical cyclones.

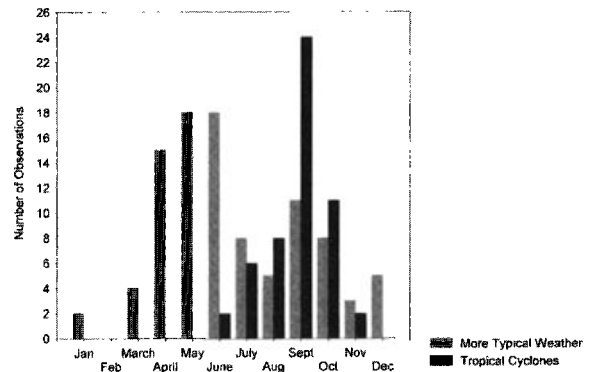


Figure 1. Seasonal distribution by month that compares observations associated with tropical cyclones to more typical weather for Magnificent Frigatebirds that have occurred along the northwest coast of Florida (n=150).

DISCUSSION

An increase in observer effort and reporting rates, not an increase in the number of Magnificent Frigatebirds, is responsible for the increase in the number of observations of frigatebirds in northwest Florida since the 1980s (Robertson and Woolfenden 1992, Robertson and Wilmers 1996; cf. McNair 2000). Recent sampling (which include contributions of solicited observations) is probably fairly representative except in the central region where birds are undersampled (i.e., observers occurred more frequently in the eastern and western Panhandle), although the central region is farther away from large sources of frigatebirds in southeast Louisiana and peninsular Florida. Before the 1980s, documented occurrences were biased toward observations associated with tropical cyclones. Weston (1965) stated that single frigatebirds and small groups not associated with tropical cyclones appeared several times every summer in the western Panhandle, but few of these observations were published. Frigatebirds during more typical weather were badly under-reported before the 1980s in northwest Florida, especially from April to June.

Tropical cyclones strongly influence occurrences in northwest Florida, where frigatebirds are usually three-four times more abundant than during more typical weather. Frigatebirds are relatively frequent in the Panhandle from August to October (especially September), which are the peak months for tropical cyclones in Florida (Artusa 1988, Williams and Duedall 1995; see McNair 2000). The difference in abundance between occurrences associated with

tropical cyclones compared to more typical weather is somewhat greater along the northwest coast than in the interior of Florida, even though frigatebirds are regular visitors along the northwest coast during more typical weather. Frigatebirds are reluctant to fly over land, so fewer birds occur in the interior of Florida during tropical cyclones (McNair 2000).

Magnificent Frigatebirds are most frequent in northwest Florida during more typical weather when surface wind flows influence their occurrence. Excluding occurrences associated with tropical cyclones, most frigatebirds occur on days with prevailing southerly winds or crosswinds that are not stronger than average monthly wind speeds. Frigatebirds may occur more frequently on days with higher winds (Harrington et al. 1972), but direction rather than wind speed appears to more strongly influence their occurrence in northwest Florida. This is not surprising since frigatebirds are adapted for gliding in light to moderate winds, especially with tail winds (Schnell 1974, Pennycuick 1983, 1987; cf. large gadfly petrels, Spear and Ainley 1997b), unlike most other seabirds (Spear and Ainley 1997a). Furthermore, this downwind flight is more energy-efficient, per distance flown (Pennycuick 1975, 1989, Spear and Ainley 1997a,b). Gliding or even flapping into head winds would be difficult above moderate wind speeds because frigatebirds have 40% lower wing loadings than any other seabird (Nelson 1975, Pennycuick 1983, Spear and Ainley 1997b). Magnificent Frigatebirds are most numerous in spring (April to June), when northward movement is coupled with favorable southerly winds (Baldwin 1968). Many of these birds have probably overshot their intended destinations. The lower number of frigatebirds in northwest Florida during more typical weather from July into September, when the number of birds along the Gulf Coast farther south is greatest (Harrington et al. 1972, Stevenson and Anderson 1994) and southerly wind flows continue, suggests that wind direction has less of an influence after northward movement diminishes. Beginning in September, the prevailing wind direction shifts to the north, and frigatebirds become increasingly scarce during more typical weather in northwest Florida. Nonetheless, all frigatebird occurrences associated with more typical weather at the tail-end of the season (November to January) were accompanied by southerly surface wind flows on the warmest or one of the warmest days of the month for each observation. These reverse migrants were oriented downwind.

Roosts of Magnificent Frigatebirds in the Chandeleur Islands of Louisiana appear to have directly influenced frigatebird occurrences in northwest Florida, but only during a limited number of tropical cyclones. These cyclones passed over the Chandeleur Islands before coming ashore west of Pensacola or "corralled" large numbers of frigatebirds along the northern Gulf coast. The lack of high counts in the western Panhandle since the 1980s, other than large numbers associated with Hurricane *George* in 1998, also coincides with the decline in numbers roosting at the Chandeleur Islands (and farther south along the Gulf Coast of Florida). The lower frequency of occurrences during more typical weather from July to September when southerly winds and crosswinds are favorable and frigatebirds are most numerous, however, strongly suggests that northwest Florida is beyond the daily foraging range from their roosts of most frigatebirds. Magnificent Frigatebirds in Franklin and Escambia Counties in northwest Florida would require approximately 6.2–7.2 hours to fly from and return to roosts at Cedar Key and the Chandeleur Islands, based on mean ground speeds with tailwinds (53 km/h) or acrosswinds (46 km/h) under the condition of a 16.1 km/h mean wind speed on a typical day (Schnell 1974).

Most reports of Magnificent Frigatebirds in northwest Florida do

not include the age or sex of the birds (Lee 1995, this study) as is the case for the rest of the Gulf of Mexico and southeast Atlantic Coasts, except at roosts along the southwest and central Gulf Coast of Florida and in southeast Louisiana. However, most birds in Franklin County since 1995 have been adult males (pers. obs.). Counts at roosts in Tampa Bay are predominantly of adults, usually males (about 83%, Harrington et al. 1972, Robertson and Wilmers 1996), although relatively large roosts at Dry Tortugas were mostly females (Harrington et al. 1972). Oberholser (1938) and Lowery (1955) suggested that immatures were the predominant age class at roosts in southeast Louisiana. Age- and sex-ratio data for most observations could have illuminated the basis for the pattern of occurrences of Magnificent Frigatebirds in northwest Florida (and other regions in southeastern North America), including implications of wind speed on sex-biased dispersal (Harrington et al. 1972) and revealed information about the possible origins of these birds.

Other than tropical cyclones, surface wind flows, and large roosts, the proximity of northwest Florida to larger populations on the Gulf Coast rather than the Atlantic Coast of Florida also influences counts of Magnificent Frigatebirds during tropical cyclones and more typical weather (cf. McNair 2000). Disregarding an unlikely count of 210 at Vero Beach on 2 January 1967 (Clapp et al. 1982), the largest and most northern roost on the Atlantic Coast is in Brevard County (Indian River and Mosquito Lagoon area), where as many as 86 birds have been reported from July to September (Cruikshank 1980, Clapp et al. 1982). Large flocks of frigatebirds have rarely been reported farther north along the northeast coast of Florida, even during tropical cyclones, and never from Georgia to North Carolina (Clapp et al. 1982, Lee 1995, Tove et al. 1998), where the maximum count of 5 was associated with a hurricane (pers. exam. of Clapp et al. 1982). The most frequent number reported from Georgia to North Carolina is one (e.g., 60 of 72 observations [83%], Clapp et al. 1982), where frigatebirds are less numerous than along the coast of northwest Florida during more typical weather (almost 2 birds per occurrence), despite similarly favorable southerly winds and similar sea surface temperatures (data from SERCC) during spring and summer. Unlike northwest Florida, few occurrences from Georgia to North Carolina are clearly associated with tropical cyclones (pers. exam. of Clapp et al. 1982; E. S. Brinkley, in litt.). Nonetheless, many observations also have occurred later (June to September), compared to most occurrences in northwest Florida during more typical weather.

Frigatebirds have a somewhat anomalous distribution along the coast of northwest Florida during more typical weather, when they are most frequent in spring, not summer in contrast to the rest of southeastern North America (e.g., peninsular Florida, Harrington et al. 1972, Stevenson and Anderson 1994; Georgia to North Carolina, Clapp et al. 1982) where the highest sea surface temperatures (data from SERCC) coincide with the largest number of occurrences of frigatebirds (cf. Patten and Minnich 1997). The larger number of occurrences during spring in northwest Florida probably can be ascribed to its unusual position as a hiatus between, yet proximity to, source populations moving north to roosts in the Chandeleur Islands and Cedar Key. These roosts are relatively close and at similar latitudes to northwest Florida, yet northwest Florida is outside the normal foraging range of these individuals, unlike birds in coastal Mississippi (Toups and Jackson 1987). In contrast, frigatebirds must fly much greater distances from source populations located farther south to reach Georgia to North Carolina. The somewhat anomalous distributional pattern of frigatebirds in northwest Florida during more typical weather with favorable surface wind flows would have gone undetected if separate analyses of the influence of tropical

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cyclones had not been conducted. Nonetheless, most frigatebirds begin moving north to the Florida Panhandle and the rest of southeastern North America with the sharp increase of sea surface temperatures in spring (data from SERCC), after prevailing southerly surface wind flows begin in February. Most birds cease moving north when sea-surface temperatures sharply decrease in October (when temperatures are nonetheless warmer than in April), one month after the prevailing surface wind direction shifts to the north (Baldwin 1968). The increase in sea-surface temperatures is controlled by global climate and movements of this warm-water pantropical species into southeastern North America are presumably associated with increases in suitable food that allow it to survive.

Several other hypotheses have been invoked to account for the occurrence of non-breeding Magnificent Frigatebirds in southeastern North America. Eisenmann (1962), Harrington et al. (1972), Clapp et al. (1982), and Robertson and Wilmers (1996) stated the annual occurrence of frigatebirds is associated with the timing of breeding at large seabird colonies, implying that frigatebirds feed on eggs and young of other seabirds (Nelson 1975). Although kleptoparasitism may be a fairly frequent foraging strategy under certain conditions (Gochfeld and Burger 1981) and has differing age and sexual patterns in frigatebirds (cf. Gilardi 1994), most frigatebirds subsist on food they catch for themselves (Eisenmann 1962, Harrington et al. 1972, Nelson 1975). The occurrence of most frigatebirds in northwest Florida during more typical weather does coincide with the timing of breeding of other seabirds in this region (primarily April to July; Robertson and Woolfenden 1992, Stevenson and Anderson 1994). Frigatebirds also are concentrated at isolated roosts in the Chandeleur Islands that contain huge colonies of other seabirds (Clapp and Buckley 1984). The large isolated roost at Cedar Key, however, is not near large seabird colonies, which are generally scarce between Tampa Bay and Mobile Bay, Alabama (Clapp and Buckley 1984, Cooley 1987, Stevenson and Anderson 1994). Nor do frigatebirds roost in coastal Alabama (Imhof 1976), which contains a very large seabird colony (Cooley 1987; R. Clay, pers. comm.). Furthermore, frigatebirds remain numerous in southeastern North America through September, after other seabirds have ceased breeding.

Another hypothesis states the annual occurrence of frigatebirds is related to the timing of their breeding in the Bahamas and the Caribbean (Eisenmann 1962). This hypothesis requires that frigatebirds are more numerous in southeastern North America during their non-breeding season. However, Magnificent Frigatebirds have an unusual reproductive cycle (Diamond 1972, 1973). Females are biennial breeders and the breeding season is prolonged (about 9 months), primarily because nestlings have slow growth rates (Nelson 1975). Alternate-year breeding would not coincide with annual movements of females to southeastern North America. Males do not provision young, depart long before females, and may be annual breeders (Diamond 1973, Nelson 1975), so males may possibly make annual movements. The expected adult male-biased dispersal is in general agreement with data from Florida (except Dry Tortugas), but not from Louisiana. Furthermore, the breeding season of Magnificent Frigatebirds is highly variable between sites (Eisenmann 1962, Nelson 1975) and breeding in colonies closest to the mainland of southeastern North America, at Key West, the Bahamas, and the Yucatán (Eisenmann 1962, Boswall 1978, Gochfeld and Burger 1981, Clapp et al. 1982, Howell 1989, Robertson and Wilmers 1996) frequently occurs from April to October, when numbers of non-breeding frigatebirds along the coast of southeastern North America should be reduced, not increased. Reconciling this hypothesis with the timing of movements of the different age and sex classes of

frigatebirds in southeastern North America is difficult.

This study has examined two main proximate causes of dispersal (tropical cyclones, surface wind flows) of Magnificent Frigatebirds to a hiatus zone in the northeast Gulf of Mexico (northwest Florida), located about 165 km at each end from two traditional large isolated roosts. Investigation at this local scale also has illuminated processes of dispersal of Magnificent Frigatebirds at a regional scale, in southeastern North America. Two hypotheses previously invoked to account for patterns of dispersal of Magnificent Frigatebirds to southeastern North America probably are inadequate. The timing of the breeding season of Magnificent Frigatebirds in the Bahamas and the Caribbean only addresses the timing of the availability of birds to disperse to southeastern North America, not any underlying process of dispersal. The timing of the breeding season of other large seabird colonies also does not address any underlying process of dispersal, but does focus on the availability of food, which would ultimately ensure the survival of non-breeding Magnificent Frigatebirds in southeastern North America. Excluding birds associated with tropical cyclones because they are vagrants, an increase in sea-surface temperatures coupled with an asymmetric interaction with southerly surface wind flows probably is the best hypothesis for the proximate cause most responsible for the annual movements of frigatebirds during more typical weather to southeastern North America.

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