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HABITAT SELECTION BY MANATEES IN SARASOTA BAY, FLORIDA

JANET G. GANNON,
KERRI M. SCOLARDI,
JOHN E. REYNOLDS, III
Mote Marine Laboratory,
1600 Ken Thompson Parkway,
Sarasota, Florida 34236, U.S.A.
E-mail: jangann@mote.org

JESSICA K. KOELSCH
The Ocean Conservancy, 449 Central Avenue,
Suite 200, St. Petersburg, Florida 33701, U.S.A.

TERESA J. KESSENICH
Mote Marine Laboratory,
1600 Ken Thompson Parkway,
Sarasota, Florida 34236, U.S.A.

ABSTRACT

Habitat selection by Florida manatees (*Trichechus manatus latirostris*) is influenced by, among other things, availability of food, thermal, and freshwater resources. However, habitat selection by females with dependent calves may differ from that of other demographic groups with regard to the relative importance of these factors. Additional factors that may influence habitat selection for females with dependent calves include ambient noise, strong currents, or increased foraging requirements. We examined distributional data for manatees from aerial surveys of the coastal waters near Sarasota, Florida, between 1994 and 2004 to determine whether habitat selection by groups of manatees that included calves differed from that of other groups. We characterized groups according to their location within seven habitat types. Enclosed bays not traversed by the Intracoastal Waterway had the highest proportions of groups with calves. Groups with calves used a No Entry refuge (from which almost all human use is barred) to a greater extent than did other groups. Overall, groups with calves exhibited significantly different habitat selection from groups without calves ($P < 0.001$, $\chi^2 = 43.0$, df $= 6$), but this was not consistent across seasons. During the winter and spring, thermal requirements influenced manatees to such an extent that all demographic groups selected habitat similarly.

Key words: Florida manatee, *Trichechus manatus latirostris*, Sarasota County, habitat selection, calves, refuge, conservation.

INTRODUCTION

The Florida manatee (*Trichechus manatus latirostris*), a subspecies of the West Indian manatee, is found along the southeastern Atlantic and Gulf of Mexico coasts of the United States. Although individuals can occasionally be seen as far north as the Chesapeake Bay and as far west as eastern Texas (Powell and Rathbun 1984, Reeves *et al*. 1992, Reynolds and Powell 2002), the manatee's primary range is in peninsular Florida. Within Florida, manatees are found in freshwater, estuarine, and saltwater habitats (Reeves *et al*. 1992, Reynolds and Powell 2002).

Several habitat requirements influence the manatee's distribution. In summer, manatees are found near shallow seagrass beds where they feed. In winter, manatee distribution is influenced by the need for access to warm-water refugia (USFWS 2001). To avoid the effects of cold, manatees aggregate at natural and anthropogenic warm-water refugia (*i.e.*, thermal effluents) when water temperatures elsewhere drop below 18 °C–20 °C (Irvine 1983, Deutsch *et al*. 2003, Laist and Reynolds 2005). Although the distribution of manatees is most heavily influenced by the availability of suitable forage in nonwinter months and warm-water refugia in winter, other likely factors include access to freshwater in salt and brackish areas, searching for mates, and human activities (USFWS 2001).

Given the complexity of manatees' habitat selection, they may move considerable distances, extending their range in summer when their thermal requirements are easily met throughout Florida's waters, and to some extent waters farther north and west (Shane 1983, Provancha and Provancha 1988, Reid *et al*. 1991, Reynolds and Odell 1991). Shorter movements related to activities such as foraging and mating occur in both winter and summer (Deutsch *et al*. 2003, Flamm *et al*. 2005).

Demography may influence both habitat selection and movement. The number of areas visited for extended periods, and the sizes of these areas, differ according to sex and reproductive status (for females). In Tampa Bay, females without calves visited fewer places, each of a larger size, than those used by males and females with calves (Flamm *et al*. 2005). Both Deutsch *et al*. (2003) and Flamm *et al*. (2005) found that males ranged most extensively, with high rates of movement likely related to searching for estrous females.

The Florida manatee is listed as endangered by the federal government (USFWS 2001) and as threatened by the state of Florida,[1] and is further protected under the U.S. Marine Mammal Protection Act and the Florida Manatee Sanctuary Act. Several levels of government are involved in management of the subspecies and numerous nonprofit organizations have interests in management issues. The major objectives of the most recent Florida Manatee Recovery Plan are (1) minimizing causes of disturbance, harassment, injury, and mortality; (2) determining and monitoring the status of manatee populations; (3) protecting, identifying, evaluating, and monitoring manatee habitats; and (4) facilitating recovery through public awareness and education (USFWS 2001).

This paper presents an analysis of 11 yr of aerial survey data in Sarasota Bay, Florida, with the purpose of determining if female manatees with dependent calves select habitat differently from other demographic groups. Females with dependent

[1] In June 2006, the Florida Fish and Wildlife Conservation Commission voted to downlist the Florida manatee to "threatened" status. The species' official status on the state's list of protected species will continue to be "endangered" until a new management plan has been developed and approved.

calves are particularly important in manatee management. As is common in long-lived marine species (Heppel *et al*. 1999), population modeling suggests that adult (especially reproductive female) survival has the most significant effect on the finite rate of increase (λ) in the Florida manatee population (Eberhardt and O'Shea 1995, Marmontel *et al*. 1997, Runge *et al*. 2004). This may be especially important in southwestern Florida (including Sarasota Bay), where the population appears to be declining at a rate of about 1.1% per year (Runge *et al*. 2004). Furthermore, a significant source of mortality is categorized as "perinatal," that is, deaths of small (<150 cm) manatees that cannot be attributed to human-related causes (Ackerman *et al*. 1995). Perinatal mortalities accounted for 19.8% of all manatee mortalities in the continental United States between 2001 and 2004 (MMC 2005). Managers should be concerned with factors that may influence perinatal mortality, including distribution and habitat selection of females with calves. Furthermore, the most recent Manatee Recovery Plan identified protection of essential manatee habitat as a necessary recovery action (USFWS 2001). The plan cited the need to better understand and monitor the interactions that take place between manatees, habitat, and people.

In this paper we specifically assess whether Pansy Bayou, a No Entry Zone created as a manatee refuge, is disproportionately selected by female manatees with dependent calves. Given the heated debate in Florida regarding manatee protection zones (Reynolds 1999, Aipanijiguly *et al*. 2003), this assessment may provide valuable information for managers regarding the success and value of protected areas throughout the state of Florida.

Materials and Methods

Study Area

The study was conducted in the coastal waters of Sarasota, Manatee, and Charlotte counties, on the central west coast of the Florida peninsula (Fig. 1). The region contains important foraging areas and travel corridors for manatees and is used year-round (Nabor and Patton 1988). Coastal waters average less than 2 m deep (Alderson 2000), and extensive seagrass beds are found in the area. Sarasota Bay, the largest embayment in the study area, contains approximately 50 km^2 of seagrass beds, and Lemon Bay possesses approximately 10 km^2. The study area is located between two major manatee warm-water refugia (Ft. Myers Power Plant to the south and Big Bend Power Plant to the north) and near several secondary warm-water refugia (*e.g.,* Warm Mineral Springs in the Myakka River). Most of the shoreline is developed (Gorzelany 2003) and the region's human population is consistently increasing (in 2000 reaching approximately 340,000 persons residing in Sarasota County, the primary area of the study; Gorzaleny 2003).

Sarasota Bay is a popular boating area, with one registered vessel for every 16 residents in Sarasota County (Gorzaleny 2003), and is traversed by the Intracoastal Waterway (ICW). The bay contains a No Entry Zone manatee refuge (Pansy Bayou), a small, shallow bay with extensive grass beds and a single deep channel (Fig. 2). Almost all forms of human use are prohibited in Pansy Bayou, including boating of any sort (except by the few residents with houses adjacent to the bayou), fishing, and swimming.

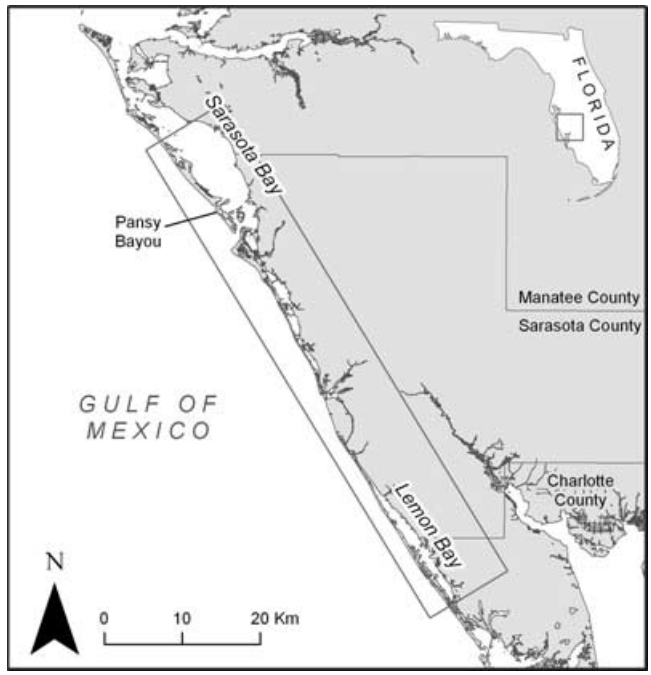

Figure 1. Study area.

Survey Methods

We conducted aerial surveys between 1994 and 2004. Surveys generally occurred twice a month, with variation according to weather and funding. Although coverage occasionally varied, surveys followed a standardized route. In most years we alternated starting at the northernmost point and the southernmost point to reduce bias due to observer fatigue, diurnal survey conditions, and manatee distribution patterns.

We conducted surveys in a single engine, high winged Cessna 172 aircraft traveling at an altitude of 150–230 m and a speed of 150–160 km/h. Surveys were postponed if winds rose above 30 km/h or if the modified Beaufort scale reached three or greater in local waters. The primary observer (with at least 30 h of experience surveying for manatees) sat in the front right seat of the plane, and a secondary observer, when available, sat in the rear right seat. The primary observer was responsible for sighting manatees and all counts and data collection; secondary observers confirmed counts and helped search for manatees when the primary observer was recording data. We reduced the effects of glare by wearing polarized sunglasses and surveying through an open window. Employing the extended area survey technique (Packard 1985), the aircraft followed a predetermined route designed to cover the habitats in which manatees were most likely to be found. When we sighted manatees or signs that suggested manatees were in an area, such as mud plumes or disturbances in the water, the plane slowed and circled the area until the primary observer obtained a count of manatees. We collected data on the total number of manatees in a sighting, the number of calves (defined as individuals less than or equal to one-half the size

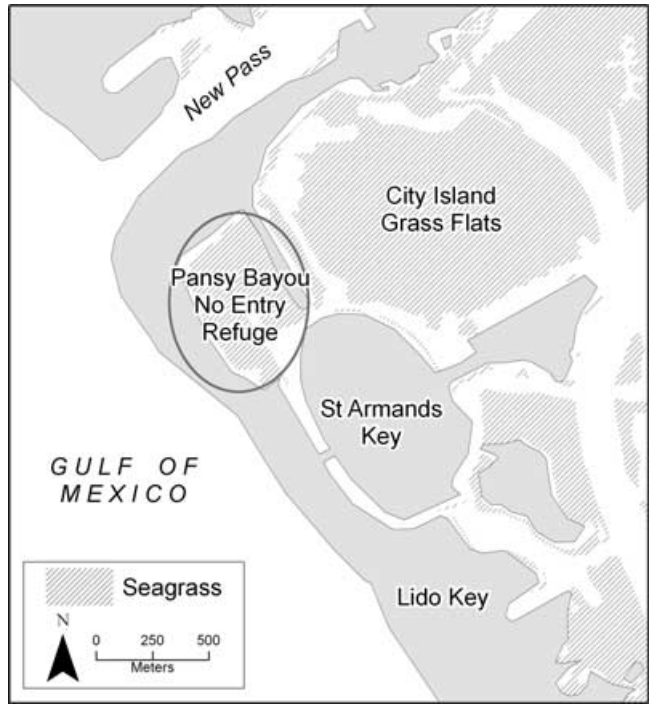

Figure 2. Location of Pansy Bayou No Entry manatee refuge in Sarasota County, Florida.

of a closely associated adult; Irvine 1982, Reynolds and Wilcox 1994), habitat type, behavior, location (drawn on custom printed maps), and survey conditions.

Data Treatment and Statistics

The locations of sightings were digitized into a Geographic Information System (GIS) from hard-copy survey maps and related data entered into a linked database. We divided sightings into two types: those in which at least one calf was sighted and those in which no calves were sighted. We used aerial photos and ancillary geographic data such as a GIS coverage of the ICW to designate seven habitat types within the study area (Table 1). Habitat types were determined on the basis of several attributes, including bottom type (*i.e.*, areas typically containing seagrass regardless of minor temporal changes), bathymetry, level of protection from boating traffic, and size of water body (small bay, large bay, or Gulf of Mexico). Each sighting was categorized as being in one of these habitat types.

Habitat selection is defined as usage of particular habitats disproportionate to the availability of those habitats (Johnson 1980). A comparison of measures of habitat use by manatees with dependent calves to that of other manatee groups was used to infer differences in habitat selection. We used a chi-square test to compare the proportions of groups that included calves to those that did not include calves within each habitat. Season played an important role in the use of Sarasota Bay by manatees; therefore, we tested subsets of data based on seasons (Table 2). We also wished to determine

Table 1. Criteria for classifying sightings by habitat and percentage of sightings, by season, that included at least one calf.

Classification	Habitat characteristics	Percentage sightings with ≥ 1 calf			
		Summer	Autumn	Winter	Spring
Open bay	Sarasota bay proper, includes seagrass beds in shallow areas	19.9%	18.7%	8.6%	13.0%
Enclosed bay, no ICW	Small bays, shallow waters, extensive seagrass beds	20.7%	19.9%	20.0%	23.5%
Enclosed bay, with ICW	Same as above, traversed by ICW and heavily traveled by boats	15.5%	16.8%	12.8%	21.5%
Narrow waterway	Narrow portion of the ICW, heavily traveled by boats	12.2%	10.8%	16.7%	21.4%
Pass	Inlets between estuarine bays and Gulf of Mexico	2.9%	0%	0%	11.1%
Gulf	Gulf of Mexico	1.7%	0%	11.1%	4.2%
Creek, canal, or basin	Small creeks, canals, or basins off the main bodies of water, not heavily traveled by boats, no extensive seagrass beds, freshwater often available	14.5%	22.0%	21.7%	22.7%

if mother–calf pairs of manatees exhibited habitat selection with regard to Pansy Bayou, the No Entry refuge. We used a chi-square test (with Yates' correction; Zar 1999) to compare the proportion of groups containing calves in the refuge to those using all other shallow embayments (other than those traversed by the ICW).

RESULTS

We conducted 235 surveys, yielding 4,435 sightings of manatees. Seasonal effort was relatively constant, but manatee sightings were fewest in winter (Table 2). Overall, 18.4% of sightings included at least one calf. There was no seasonal difference in the proportion of sightings with calves ($P = 0.07$, $\chi^2 = 7.05$, df = 3), although low power (0.59) likely affected the significance of this result.

The proportion of sightings with one or more calves varied with habitat ($P < 0.001$, $\chi^2 = 43.0$, df = 6, Table 1 and Fig. 3), with the lowest proportions in the

Table 2. Survey effort, sightings, and percentage sightings that included at least one calf, by season.

Season	Months	No. of surveys	No. of manatee sightings	% Sightings with ≥ 1 Calf
Winter	Dec Jan Feb	51	390	17.4
Spring	Mar Apr May	63	1,118	20.9
Summer	Jun Jul Aug	65	1,562	17.0
Autumn	Sep Oct Nov	56	1,365	18.1
Totals		235	4,435	Average = 18.4

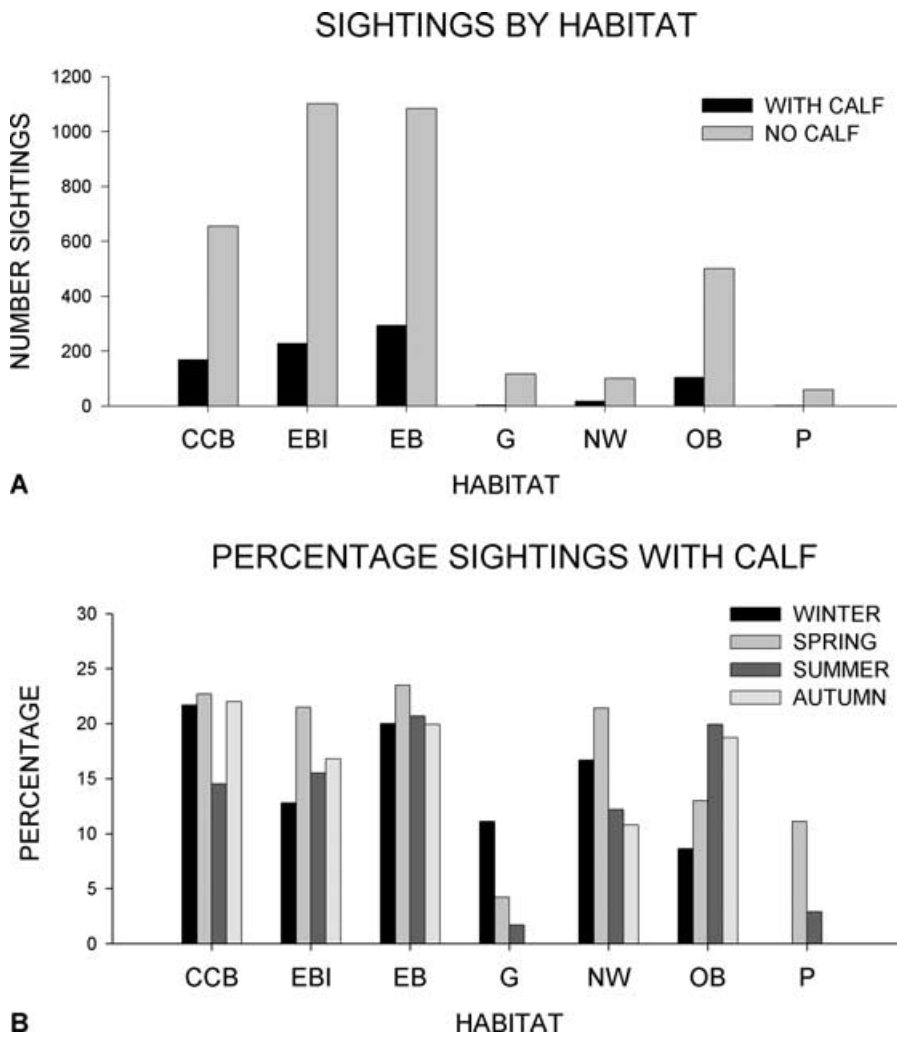

Figure 3. (A) Number of manatee sightings per habitat. (B) Percentage of sightings with calves, by season. Habitat abbreviations: CCB = Creek, Canal, Basin; EBI = Enclosed Bay (with ICW); EB = Enclosed Bay (no ICW); G = Gulf; NW = Narrow Waterway; OB = Open Bay; P = Pass.

Gulf (2.5%) and Pass (3.2%) and the highest in Enclosed Bay (no ICW) (21.3%). Gulf and Pass likely represent marginal habitat for manatees given the very low numbers of individuals found there. Therefore, we tested a subset of the data excluding sightings from these habitats and again found significant differences in the proportion of sightings with one or more calves in different habitats ($P = 0.02$, $\chi^2 = 11.52$, $df = 4$).

Although there was a significant difference in the proportion of sightings with calves among habitat types, this was not consistent when data were assessed by season

(Fig. 3 and Table 1). Differences were significant in summer ($P < 0.001$, $\chi^2 = 23.8$, df = 6) and autumn ($P = 0.019$, $\chi^2 = 15.13$, df = 6), but not in winter ($P = 0.36$, $\chi^2 = 6.6$, df = 6, power = 0.43). Significance was not detected in spring ($P = 0.064$, $\chi^2 = 11.9$, df = 6), but in this case low power (0.73) could have played a role in the outcome. The proportion of sightings that included calves was consistently high in Enclosed Bay (no ICW) and Creek, Canal, Basin; and seasonally high in Enclosed Bay (with ICW). The proportion of sightings with calves was consistently low in Gulf and Pass.

Groups containing at least one calf exhibited habitat selection toward the No Entry refuge, Pansy Bayou, when compared with other groups of manatees ($P = 0.005$, $\chi^2 = 7.83$, df = 1). However, when this was tested by season, only summer was significant ($P = 0.015$, $\chi^2 = 5.9$, df = 1). Sightings within Pansy Bayou that included calves were proportional to other sightings in autumn ($P = 0.3$, $\chi^2 = 1.08$, df = 1, power = 0.17), winter ($P = 0.56$, $\chi^2 = 0.35$, df = 1, power = 0.08), and spring ($P = 0.34$, $\chi^2 = 0.93$, df = 1, power = 0.15), although low power in these seasons may preclude finding significance.

Discussion

There are several factors that may affect likelihood of a calf being noted in a survey, such as changes in survey methods or personnel, inadvertent changes in criteria for designating an animal a calf, or changes in sighting conditions that might make calves less apparent (Reynolds and Wilcox 1994). Effects of these issues were minimized wherever possible by using experienced observers with little change in personnel over time and by limiting surveys to times with the best of weather conditions.

The overall number of sightings was low in winter, but the proportion of sightings with calves was not significantly different in winter from that of other seasons. Manatees use the study area extensively in warm seasons, but during winter, when manatees aggregate at warm-water refugia in nearby waters, use of the study area is limited to travel or feeding excursions during warm spells (Gorzaleny 2003). Groups with calves appear to exhibit behavior similar to that of other manatees in this regard, given the consistent proportion of sightings with at least one calf, regardless of season.

The proportion of sightings that included calves was significantly different when classified by habitat, suggesting that the relative importance of resources correlated with habitat use is different for females with calves than for other manatees. This may reflect habitat requirements specific to this social unit or demographic group. Several mechanisms driving habitat selection for manatees with calves may exist, but their influences and interactions are uncertain.

Increased selection may reflect greater need for access to foraging areas due to the increased metabolism associated with nursing a calf (Young 1976) or preference for waters less exposed to watercraft (Miksis-Olds 2006), conditions present in the habitats with high proportions of groups with calves (namely, Enclosed Bay (no ICW) and Creek, Canal, Basin). Sound also may play a role. Manatees communicate with relatively high-frequency calls of 2.5–5 kHz (Schevill and Watkins 1965, Nowacek *et al*. 2003). High frequency sounds normally cannot travel as far as low-frequency sounds, but in shallow seagrass beds, the opposite is the case (Miksis-Olds 2006). Manatee distribution appears to be correlated with environmental noise levels, with higher-use grassbeds being "quieter" than lower use grassbeds of similar species composition and density (Miksis-Olds 2006). The effects of sound on mothers and calves may be

more profound than for other animals, in that manatees increase vocalization rate, duration, and source level when calves are present (Miksis-Olds 2006). Call duration increases when environmental noise levels are elevated and calves are present during feeding and milling episodes (Miksis-Olds 2006). Increased use of embayments that are not traversed by the ICW would be consistent with the idea that female manatees prefer habitats that offer quiet waters with ready access to foraging.

The habitats with the lowest proportion of sightings with at least one calf, Gulf and Pass, were also the habitats with the lowest proportion of total sightings (2.5% and 3.2%, respectively). These habitats are probably marginal for manatees, given the low proportion of animals sighted in them and the relative lack of available seagrass habitat and freshwater. They appear even less attractive to manatees with calves. Lower use of Gulf and Pass areas may be attributed to several factors. Separation of calves from mothers can lead to death of the former (Ackerman *et al*. 1995); given the stronger currents and wave energy in Gulf and Pass waters, mothers may avoid these areas. As there is no evidence of predation of manatees, including calves (Ackerman *et al*. 1995), predator avoidance is an unlikely factor in habitat selection. Wave noise also may be greater in the Gulf, diminishing the ability of mothers to maintain auditory contact with calves. It is possible; however, that mother–calf pairs are not often found in Gulf and Pass waters simply due to the distance of these areas to foraging grounds.

Season appears to influence habitat selection in manatees with dependent calves. Considering the disparity of needs for manatees depending on season, this is not surprising. Habitat selection by manatees with calves was different from that of other manatees only during summer and autumn, although low statistical power of analyses in winter and particularly in spring may have influenced results. When thermal needs are easily met, other factors seem to influence manatees with dependent calves and cause them to select habitat differently. However, winter represents a time of elevated thermal stress for manatees, which likely outstrips all other considerations for every demographic group of manatees in the study area. Winter habitat selection of mothers with calves may be different from other manatees, but this may not be apparent in the study area, which contains no warm-water refugia. For example, Reynolds and Wilcox (1994) noted that the Ft. Myers power plant has a higher prevalence of calves than do other power plants.

Manatees with calves were more likely to use the No Entry refuge, Pansy Bayou, than other areas, although this is seasonally dependent. This area may represent the "ideal" habitat, with extensive seagrass, shallow waters, and near exclusion of watercraft traffic and the noise it produces (Richardson *et al*. 1995). The increased proportion of manatees with calves in this area suggests the refuge is successful in protecting habitat for this important demographic group. This provides a successful model for other manatee protection zones that may be created in the future.

CONCLUSION

Manatees with dependent calves appear to select habitat differently from other demographic groups of manatees, specifically in warm-weather months when thermal needs do not strongly influence behavior. Female manatees and their calves are important demographically due to the strong influence of adult survival on population growth rate and high levels of perinatal mortality. Managers wishing to protect manatees with calves should assess the specific needs of this demographic group in their jurisdictions. Pansy Bayou, a No Entry manatee refuge, had higher proportions

of sightings with one or more calf than other areas. The increased use of the area by groups including calves should be considered in assessing the success of this refuge and others like it.

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