Using Strip-transect Aerial Surveys to Estimate Manatee Abundance in the Ten Thousand Islands Region of Southwest Florida

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INTRODUCTION

Strip-transect aerial surveys have been used extensively in Australia to estimate trends in offshore dugong populations (Marsh and Sinclair 1989; Marsh 1995). The use of strip-transect methods in estimating manatee population size and trend, however, has been limited (Miller *et al.* 1998). Manatee surveys have typically not been designed to sample quantified survey areas, or to produce estimates of abundance. While useful in obtaining minimum manatee counts and distribution information, the latter surveys do not permit statistical comparison of survey results over time (Lefebvre *et al.* 1995).

OBJECTIVES

Our ultimate objective is to determine if manatee density and distribution in the nearshore waters of the Ten Thousand Islands and farther south into the Everglades National Park change in response to restoration of natural hydrologic patterns in southwestern Florida. The northern Ten Thousand Islands region is of particular interest because of proposed changes to the Southern Golden Gate Estates and Faka Union Canal drainage. We want to statistically compare pre- and post-restoration indices of manatee abundance. We also believe that strip-transect methods will be a successful tool for determining manatee population trends in the Ten Thousand Islands region, unlike many other regions of Florida, in which manatees may be highly aggregated at winter sites or their density may be too low and distribution too linear to permit this approach.

METHODS

Transects flown during a pilot study in July – October 2000 were oriented perpendicular to shore, between Palm Bay and the Ferguson River (Fig. 1A). Based on results from these surveys, we omitted 5 transects (26 – 30, Fig. 1A) and established 5 new transects (31 – 35, Fig. 1B) near Cape Romano prior to the 2001 surveys. Eight surveys were conducted between 15 July and 30 August 2001 and eight surveys were conducted between 20 June and 17 September 2002. We established parallel transects, 1 km apart, with a survey strip width of approximately 250 m. Transect lengths ranged from 3.4 to 8.4 km; water area surveyed ranged from 0.79 to 1.53 km_ per transect (Table 1). Two of the transects, number 31 and 32, were completely over water (Fig. 1B). During the 2002 surveys, a subsample of transects were reflown in an attempt to estimate detectability bias and identify plumes sighted on initial flights.

Manatee locations were plotted on navigational charts, and flight paths were recorded on a Garmin GPS III in 2002. Surveys were conducted from a Cessna 172 at an altitude of 153 m, traveling at approximately 120-140 km per hour. Perception bias, which occurs when some of the manatees visible within a strip transect are missed by an observer, was estimated by applying a Petersen mark-recapture model to counts made by two observers (Pollock and Kendall 1987; Marsh and Sinclair 1989).

RESULTS

Manatee group locations for all survey dates are shown in Figure 3. The corrected number of manatee groups (a group = 1 or more individuals in the same location) sighted on transects ranged from 12.9 to 27.1 and 15.0 to 20.4 per survey during 2001 and 2002, respectively (Table 1). The corrected number of individuals counted ranged from 15.1 to 61.7 in 2001, and from 26.5 to 54.1 per survey in 2002 (Table 1). Mean group size per survey ranged from 1.1 to 2.3 during 2001 and 1.4 to 2.7 during 2002. Survey-specific population estimates in this study ranged from 58 to 237, or 1.62 to 6.64 per km_ during 2001 and 102 to 208, or 2.85 to 5.81 per km_ in 2002. Annual population estimates from these surveys were 126 ± 19.5 (0 ± S.E.) in 2001and 137 ± 11.3 in 2002 (Table 3). Reflights of transects on 7 surveys in 2002 yielded higher number of groups on six of the seven surveys. Of the 51 observations made during reflights:

± 13 groups (25%) were seen on both flights.
± 14 groups (27%) were identified on reflights that were initially recorded as plumes.
± 9 plumes (18%) recorded on initial flights were identified as non-manatee on reflight.
± 1 group (2%) was not seen on the reflight.
± 14 groups (27%) were seen on the reflight that were not seen on the initial flight.

Excluding the Cape Romano transects, the overall distribution of sightings was slightly bimodal, with average (= 0.44 groups per transect) or higher than average number of groups sighted on transects 1-5 and 17-21 during both years (Fig. 3). Transect 6 starts near the mouth of the Barron River, and Transects 19 and 20 start near the mouth of the Faka Union Canal. Transects 31 and 32 off Cape Romano have consistently yielded the highest number of groups, averaging 3.1 and 2.3 groups respectively for both years (Fig. 3). The average number of groups was also higher (0.62 groups per transect) in 2001.

The Faka Union Canal is known to attract large numbers of manatees (Fig. 4), particularly in the winter, presumably because of the availability of freshwater at its head and thermal buffering provided by its depth. In this study, we considered the canal to be a separate, high-density stratum, analogous to the "hot spots" described by Miller *et al.* (1998). When manatee counts from this stratum were added to the transect-based estimates, estimates for the whole study area on all dates ranged from 59 to 247 in 2001 (0 =132±20) and 108 to 207 in 2002 (0 =141±11.2). High-density stratum counts accounted for 28 and 30 percent of the total estimated population in 2001 and 2002, respectively .

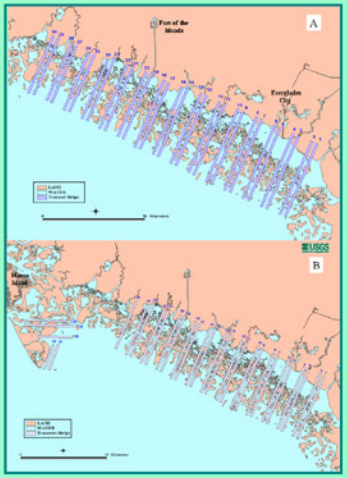

Figure 1. Spatial arrangement of 30 manatee aerial survey strip-transect polygons in the Ten Thousand Islands during flights July-October 2000 (top) and July 2001-August 2002 (bottom).

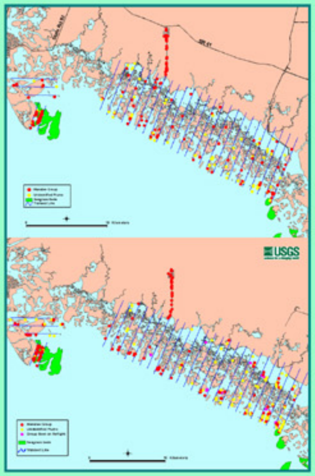

Figure 2. Locations of manatee groups on 30 strip transects during 8 aerial surveys in 2001 (top) and 8 surveys in 2002 (bottom) within the northern Ten Thousand Islands region of southwest Florida.

Date	Survey Conditions	Number Groups	Corrected Number Groups	Number Unidentified Plumes	Total Number Manatees	Corrected Number Manatees	Mean Group Size (SE)	Total # manatees in Faka Union Canal	Estimated Number Manatees	Manatee Density
[illegible]	Fair	[illegible]	12.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Good	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Good	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Good	[illegible]	20.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Very Good	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Very Good	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Very Good	[illegible]	27.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Good	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Date	Survey Conditions	Number Groups	Corrected Number Groups	Number Unidentified Plumes	Total Number Manatees	Corrected Number Manatees	Mean Group Size	Total # manatees in Faka Union Canal	Estimated Number Manatees	Manatee Density
[illegible]	Fair	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Very Good	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Good	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Good	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Good	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Good	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Fair	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Good	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

a) Area treated as separate high density strata.
b) Manatees per km² of water within study area.
c) No reflights conducted during this survey.
d) Numbers in parentheses are from reflights.

Table 1. Manatee counts corrected for perception bias and multiplied by mean group size to obtain population estimates in the northern Ten Thousand Islands during 2 survey years, July through August 2001 and June through September 2002.

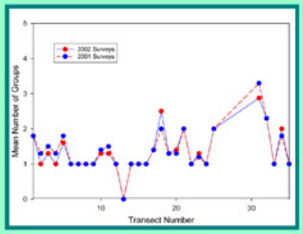

Figure 3. Mean number of manatee groups observed on each transect during 2001 and 2002 aerial surveys in the Ten Thousand Islands.

Figure 4. Manatees aggregated in a canal at Port of the Islands, January 2001.

		Low-density stratum [a]	High-density stratum [b]	Total study area
Year	n	_[c]	Count	_est[d]
2001	8	126.3 (0.19)	50	176.3 (0.09)
2002	8	137.4[d] (0.17)	57	183.4[d] (0.09)

[a] Population estimate derived from transects
[b] Counts obtained at Port of the Islands and Faka Union canal
[c] Mean (CV).
[d] Calculated from surveys without reflight groups included.

Table 2. Annual manatee population estimates using low and combined low-high density strata, Ten Thousand Islands, Florida

Figure 5. Feeding manatees, such as the one above photographed in Biscayne Bay, create a plume of sediment. In the turbid waters of our study area, sediment plumes may often be caused by feeding manatees.

TREND ANALYSIS

To assess the potential for detecting statistically significant trends in the Ten Thousand Islands population, we used TRENDS software (Gerrodette 1993). We used a CV of 0.09 based on results from the surveys in 2001 and 2002 (Table 3).

The following parameters were also selected: _ = 0.05; 1-tailed test; linear model of rate of change; CV proportional to the square root of the abundance estimate; standard normal distribution.

If number of sampling periods is 6 per year, sampling is continued for a minimum of 4 years, and CV = 0.09, then power = 0.99.

If number of sampling periods is 8 per year, sampling is continued for a minimum of 4 years, and CV = 0.09, then power = 1.0.

Thus, we should be able to adequately detect an annual rate of change of 10% per year with a minimum of 6 surveys per year if weather and logistics prevent the completion of 8 surveys during the summer survey window (June-September).

DISCUSSION AND CONCLUSIONS

Population estimates and densities in this study were similar to those for the Banana River, an important area for manatees on the Atlantic coast in the warm season. The latter estimates ranged from 112 to 209, or approximately 0.67 to 1.26 per km_ (Miller *et al.* 1998). Mean group size per survey in Ten Thousand Islands (1.41) was lower than in Banana River surveys (2.19). Mean group size was ≤ 2.00 in all of the 16 Ten Thousand Island surveys and ≥ 2.00 in 13 of 15 Banana River surveys (Miller *et al.* 1998). These findings suggest that poorer water clarity in the Ten Thousand Islands than in the Banana River, where the bottom can be seen in most of the survey area, may contribute to greater variability and smaller observed group size in our surveys.

The number of sediment plumes observed during the Ten Thousand Island surveys (72 in 2001 and 102 in 2002; Table 2 & Fig. 5) suggests that many manatees may not be directly observable. Observations from transect reflights suggest that more than 25 percent of plumes may represent an actual manatee group. Reflights of selected transects may be useful to develop survey-specific correction factors and for incorporating observed plumes in a total population estimate.

Variation in group size and population estimates is a reflection of the challenging survey conditions presented by the Ten Thousand Islands, as well as additional variability caused by weather and glare. Nevertheless, the strip-transect approach shows promise for monitoring the manatee population using this region during the warm season, if environmental variability can be minimized by selecting survey dates with optimal environmental conditions.

RECOMMENDATIONS

- A minimum of 6 surveys should be conducted every year.
- Survey conditions must be good to excellent to minimize variation among surveys.
- Surveys should be repeated every year for a minimum of 4-5 years.
- Correction for availability bias (manatees present but invisible) should be explored.
- Similar strip-transect surveys should be designed for other areas of the southwest coast.
- Reflights of transects appear to be useful for identifying manatee groups from plumes and detecting missed groups.

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