AERIAL SURVEY OF THE BOTTLENOSED DOLPHIN, *TURSIOPS TRUNCATUS*, AND THE WEST INDIAN MANATEE, *TRICHECHUS MANATUS*, IN THE INDIAN AND BANANA RIVERS, FLORIDA

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ABSTRACT

Aerial surveys were conducted of the Indian and Banana Rivers, eastern Florida, to estimate numbers of bottlenosed dolphins and West Indian manatees. Thirty-nine east-west transects, 4.63 km (2.5 n.mi.) apart, were flown on six successive days in August. Observers at inlets from the ocean inventoried dolphins and manatees entering or leaving the river during the hours of the surveys. There were 64 sightings of dolphins from aircraft, totaling 507 animals. Fifteen dolphins were seen entering or leaving the river. Direction of movement within the inlets appeared unrelated to tidal flow. The population of dolphins in the rivers during the week of the survey (10-15 August 1977) was estimated at 438 ± 127. Calves composed 8.1 to 10.1% of all animals seen. Feeding was observed at widely scattered times and locations. There were 60 sightings of manatees totaling 151 animals. No attempt is made to estimate the size of the manatee population. Calves made up 9.9 to 13.2% of all manatees seen.

The portion of the intracoastal waterway of eastern Florida between about lat. 28°47'N and 27°10'N consists of the connected waters of the Indian and Banana Rivers (Figures 1, 2, 3). Together they form a complex waterway just over 185.0 km (100 n.mi.) long and from <0.93 km (0.5 n.mi.) to >9.3 km (5.0 n.mi) wide. Below the junction of the two rivers at the southern tip of Merritt Island (approximately lat. 28°09'30"N), the Indian River is connected to the adjacent Atlantic Ocean by boating channels at Sebastian and Fort Pierce Inlets.

Like many other portions of the intracoastal waterway, the Indian-Banana River complex is home to Atlantic bottlenosed dolphin, *Tursiops truncatus*. Although the numbers of dolphins inhabiting the rivers is unknown, they have been rumored to contain as many as 5,000 individuals (Orr[2]). Whatever its actual size, however, this population is at the center of a growing controversy. Commercial fishermen in the river and the adjacent ocean report that the dolphins are a nuisance and menace, annually causing an estimated $441,000 worth of damage to longlines and trammel nets used in the Spanish and king mackerel fisheries and not infrequent injury to fishermen (Cato and Prochaska 1976). The fishermen have reportedly requested assistance from the Federal government in controlling the dolphin populations. (White[3]). Recent attempts to use sounds projected underwater to deter the dolphins from approaching fishing nets and boats have had little effect (Caldwell and Caldwell[4]). Because of restrictions imposed on the "taking" of marine mammals by the Marine Mammal Protection Act of 1972, and concerns about the dolphins' roles in the ecosystem, any attempts to reduce the alleged interference of dolphins with the fishing activity must fall under close scrutiny.

The river complex is also home, at least seasonally, to some endangered West Indian manatees, *Trichechus manatus*. The status of these and other manatees of the mainland United States has been most recently reviewed by Hartman[5] and Irvine and Campbell (1978).

During August 1977, I conducted an aerial survey of Indian and Banana Rivers to estimate the size and productivity (number of calves) of the bottlenosed dolphin population. In addition, I took

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[2]Orr, J. M. 1977. A survey of Tursiops populations in the coastal United States, Hawaii and Territorial Waters. Contract Report No. PL92-522, to the U.S. Marine Mammal Commission, Wash., D.C., 18 p.

[3]J. R. White, Doctor of Veterinary Medicine, 16501 S.W. 184th St., Miami, Fla., pers. commun. July 1977.

[4]Caldwell, D. K., and M. C. Caldwell. 1975. Dolphins and fisheries. *In* A report on the Sea Grant program, p. 28-29. State University System of Florida.

[5]Hartman, D. S. 1974. Distribution, status and conservation of the manatee in the United States. Unpubl. rep. in files of U.S. Dep. Inter., Natl. Fish Wildl. Lab., Wash., D.C., 126 p.

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advantage of the survey to count manatees and to note numbers of manatee calves.

MATERIALS AND METHODS

The survey design follows the recommendations of Leatherwood et al. (1978) for a strip census of bottlenosed dolphins. Thirty-nine east-west transects were placed 4.63 km (2.5 n.mi.) apart. Each day for six successive days (10-15 August) the replicate transects were flown in a Cessna 172 Skyhawk[6] travelling 167.0 km/h (90 kn) at an altitude of 150 m (500 ft).

The visual angle which provided 0.463 km (0.25 n.mi.) coverage on each side was determined prior to the survey and marked by tape on the wing struts and windows. One observer on each side searched for dolphins within 0.463 km of the aircraft. Sightings near the outer boundary of the survey strip were checked using an inclinometer. Sightings outside the survey strip and on connecting legs were ignored. Each time dolphins were sighted within the survey strip, the aircraft diverted to the group and circled until the following information could be obtained: location of the sighting (using landmarks and local navigational aids), number of individuals, number of apparent calves of the year, group activity, and swimming direction.

Each time manatees were sighted, both on the survey transects and on the legs connecting transects, the same procedure was followed. Adults and calves were clearly distinguishable (calves were defined as small animals in the close company of a much larger adult). A total of five individuals of a third class, intermediate-sized animals, were logged separately as possible older calves. Because manatees were secondary targets of the survey, less time was generally spent on manatee than on dolphin sightings.

As an index to through-water visibility, records were maintained on 3 days of the percentage of each transect for which the bottom within the strip was visible from the aircraft. To minimize effects of other potential variables on counts the following controls were exercised: all flights were conducted between 0725 and 1300; observers remained the same and maintained the same positions in the aircraft; altitude and speed were held constant; methods of searching and circling were the same throughout; estimates of totals and numbers of calves were agreed upon by observers before each sighting was logged and transects resumed. Surveys were only conducted when the sea surface and winds were estimated to be a Beaufort number of 1.5 or below. Because weather was generally excellent for all 6 days, this required only one 40-min suspension on 14 August to permit a rain squall and associated winds to pass. Each day, during the hours of the aerial surveys, observers stationed on shore logged numbers of dolphins and manatees entering or leaving Indian River by Sebastian and Fort Pierce Inlets and the direction of travel of these animals relative to tidal flow.

Resultant data on dolphins were analyzed following the procedures outlined by Leatherwood et al. (1978) for a strip census of bottlenosed dolphins. Inherent in the application of this method is the critical assumption that all dolphin herds within the 0.926 km (0.5 n.mi.) are observed. Resultant data on manatees are presented as incidental observations with no attempt to estimate population size.

RESULTS

Dolphins

On each replicate of the transects, I surveyed approximately 174.0 linear km (94 n.mi.) or 161.2 km² (47 n.mi.²) of water, an estimated 20% of the surface area of the rivers. In all, 64 sightings of dolphins, totaling 507 animals (Table 1) were made on the transects (Figures 1, 2, 3). Sightings included from 1 to 35 individuals about a mean of 8.2 and a median of 5. The distribution of herd sizes by replicate is shown in Figure 4.

Animals clearly identifiable as calves of the year were seen with 22 groups (34.4%) and comprised 8.1% of all animals seen (Table 1). Slightly larger animals, perhaps older calves of the year,

TABLE 1.—Numbers of herds and individuals of bottlenosed dolphins observed in Indian and Banana Rivers, Fla., during aerial surveys, 10-15 August 1977.

Survey no. (replicate)	Date	Total no. of herds	Total no. of individuals	Total no. of calves of the season
1	10 Aug.	11	90	6 (6.7%)
2	11 Aug.	10	74	7 (9.5%)
3	12 Aug.	16	106	13 (12.3%)
4	13 Aug.	7	49	3 (6.1%)
5	14 Aug.	7	84	6 (7.1%)
6	15 Aug.	13	104	6 (5.8%)
Totals		64	507	41 (8.1%)

[6]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

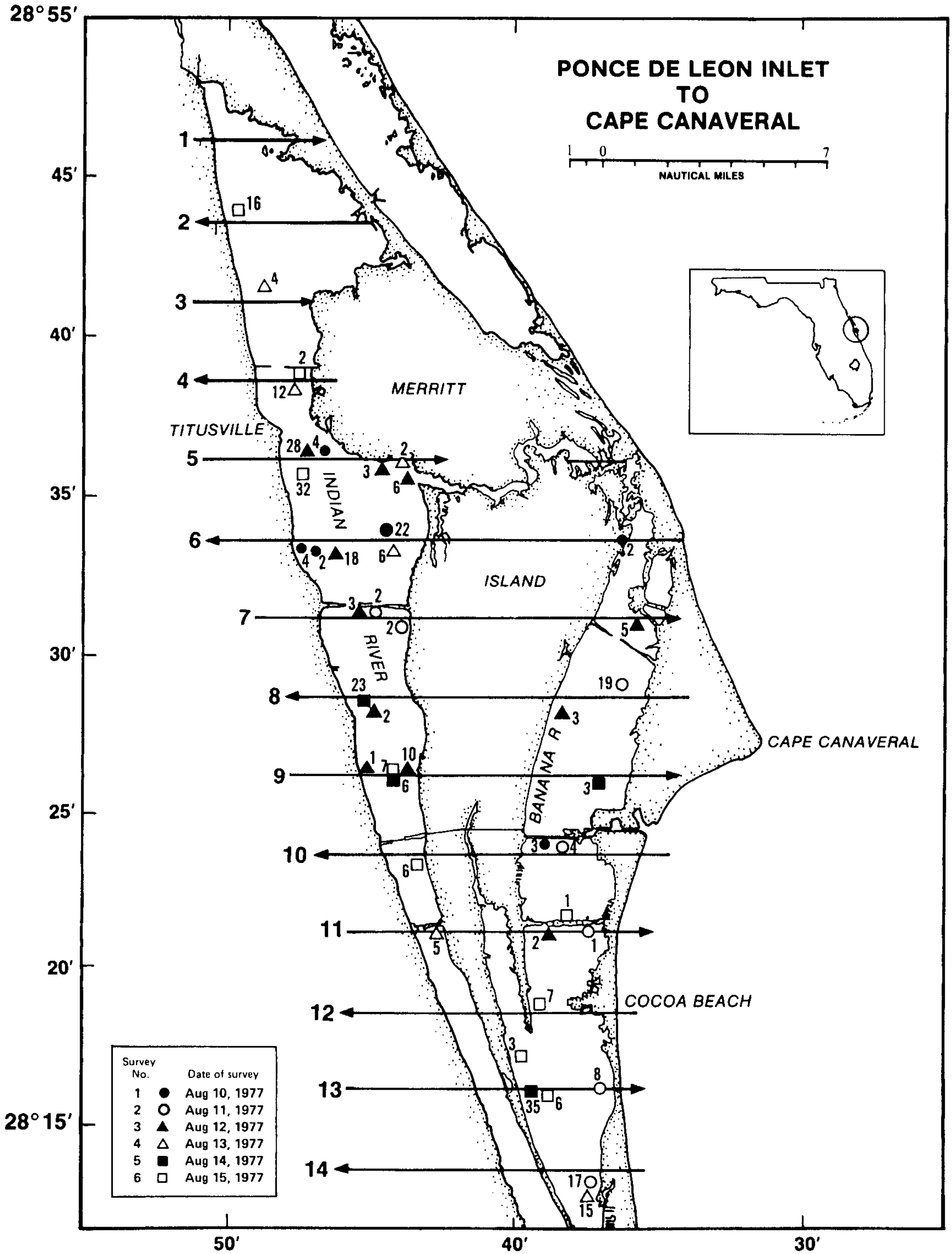

FIGURE 1.—Indian and Banana Rivers, Fla., indicating locations of transects 1-14 and sightings of herds of bottlenosed dolphins. Numbers by the symbols indicate numbers of individuals counted. The symbols indicate locales that were contained within the 0.463-km (0.25 n.mi.) strips.

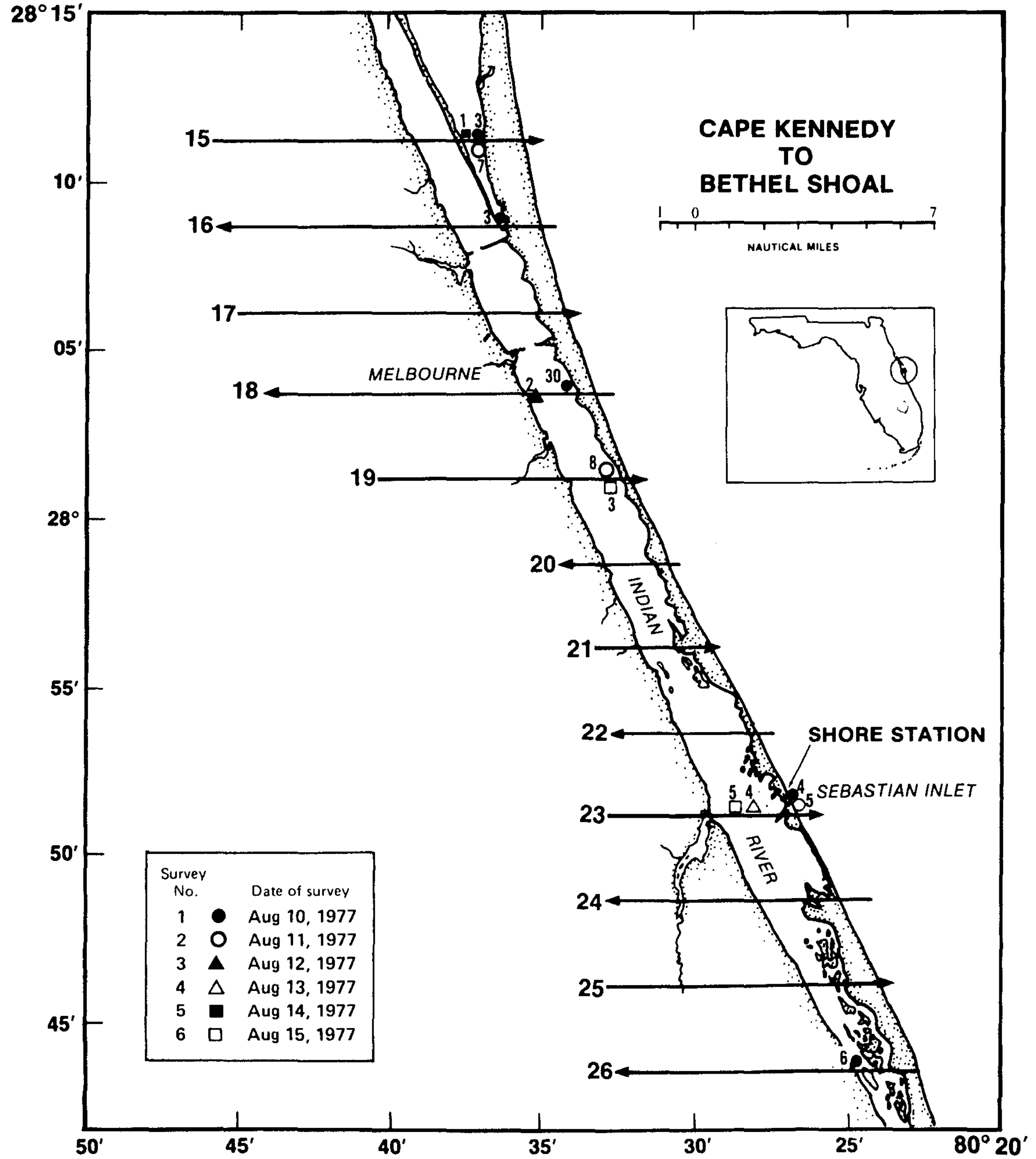

FIGURE 2.—Indian and Banana Rivers, Fla., indicating locations of transects 15-26 and sightings of herds of bottlenosed dolphins. Numbers by the symbols indicate numbers of individuals counted. The symbols indicate locales that were contained within the 0.463-km (0.25 n.mi.) strips.

were seen with seven groups (10.9%) and composed 2% of all animals seen. Depending on the correct classification of these larger animals, total calves of the year surviving at the time of survey appeared to range from 8.1 to 10.1%. The herd densities (number of herds per square kilometer) and mean herd sizes (mean number of animals per herd) for each replicate and the variances of both values are summarized in Table 2. The estimated densities of dolphins were calculated from:

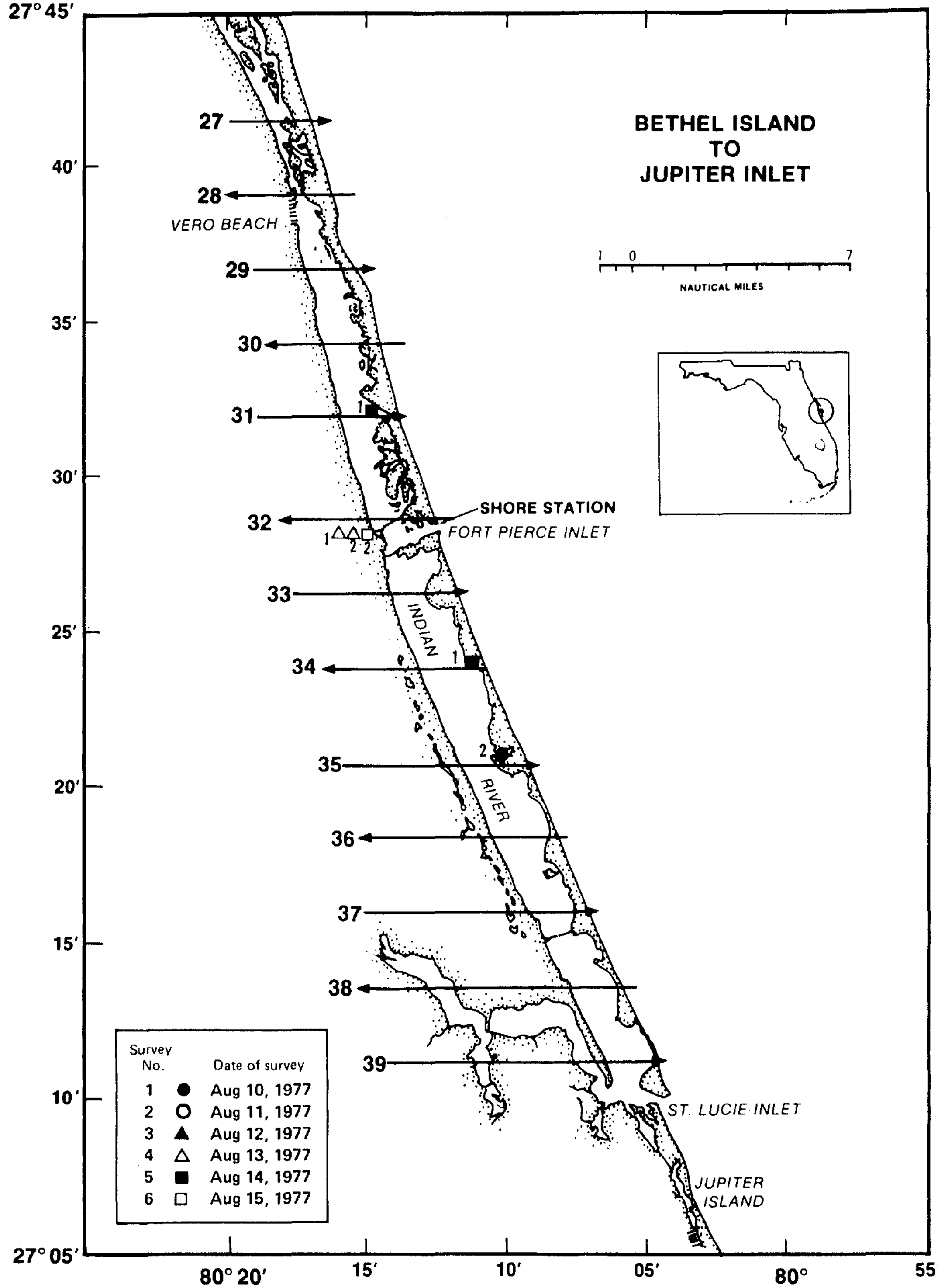

FIGURE 3.—Indian and Banana Rivers, Fla., indicating locations of transects 27-39 and sightings of herds of bottlenosed dolphins. Numbers by the symbols indicate numbers of individuals counted. The symbols indicate locales that were contained within the 0.463-km (0.25 n.mi.) strips.

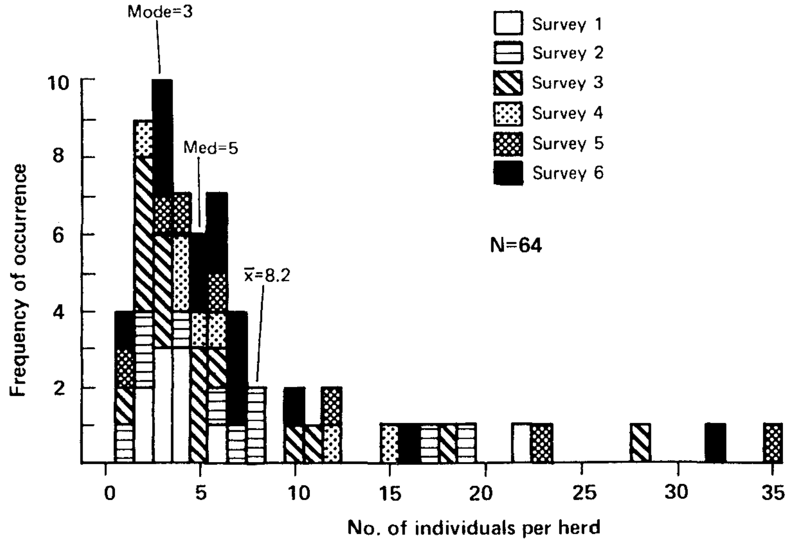

FIGURE 4.—Distribution of herd sizes of bottlenosed dolphins for each of the six replicates.

$$\bar{d} = \bar{h}\bar{a} \quad (1)$$

where $\bar{h}$ = mean herd size
$\bar{a}$ = mean herd density, described as $(\frac{1}{2}L)(n/w)$ where L = total length of transects, n = total sightings, and w = the one-sided strip width of 0.463 km (0.25 n.mi.).

The estimated variance of this product ($S^2(\bar{d})$) was calculated from Goodman (1960):

$$S^2(\bar{d}) = \bar{h}^2 S^2(\bar{a}) + \bar{a}^2 S^2(\bar{h}) - S^2(\bar{a}) S^2(\bar{h}). \quad (2)$$

where $\bar{h}$ = mean herd size
$\bar{a}$ = mean herd density
$S^2(\bar{h})$ = estimated variance of mean herd size
$S^2(\bar{a})$ = estimated variance of mean herd density.

Feeding was observed in portions of 36% (23 of 64) of the groups encountered and was observed in all survey periods and areas. Feeding behaviors were similar to those previously reported for *Tursiops* sp. (Leatherwood 1975).

There was no correlation between the visibility index and the number of sightings on any given transect or set of transects regardless of how data were grouped (rank correlation with Kendall's Tau (Conover 1971) at α = 0.05, indicating that significantly larger numbers of animals probably were not missed in the most turbid water).

TABLE 2.—Herd density (number of herds per square kilometer), mean herd size (mean number of dolphins per herd), and dolphin densities (numbers of dolphins per square kilometer) on each replicate. Except where noted means and their variances were calculated over replicates.

Survey no. (replicate)	Date (1977)	Herd density	Mean herd size	Dolphin densities
1	10 Aug.	0.068	8.18	0.556
2	11 Aug.	0.062	7.40	0.459
3	12 Aug.	0.099	6.63	0.656
4	13 Aug.	0.043	7.00	0.301
5	14 Aug.	0.043	12.00	0.516
6	15 Aug.	0.080	8.00	0.640
Means		0.066	8.20	0.521
Variance of means		9.204×10^{-4}	6.35×10^{-1}	0.1837

Using alternate method described in text: Density estimate of dolphins: $\bar{a}\bar{h}$ = 0.542 (from Equation (1)). Variance of density estimate of dolphins: $S^2(\bar{d})$ = 0.094 (from Equation (2)).

Manatees

In all I made 60 sightings of manatees, totaling 151 animals (Figures 5, 6, 7). Sightings ranged from individuals to concentrations of as many as 22 animals with a mean of 2.5. Animals clearly identifiable as calves were part of 14 of the 60 sightings (23.3%) and made up 9.9% (15 of 151) of all manatees seen (Tables 3, 4). Intermediate-sized animals, possibly yearlings or older calves, were part of 5 of the 60 sightings (8.3%) and composed 3.3% (5 of 151) of all manatees seen. If these intermediate-sized animals were also part of this year's crop, total number of calves of the year surviving at the time of the survey may be 13.2%.

No attempt was made to estimate numbers of manatees because all manatees were recorded whether on transects or connecting legs and whether within or outside the transect strip.

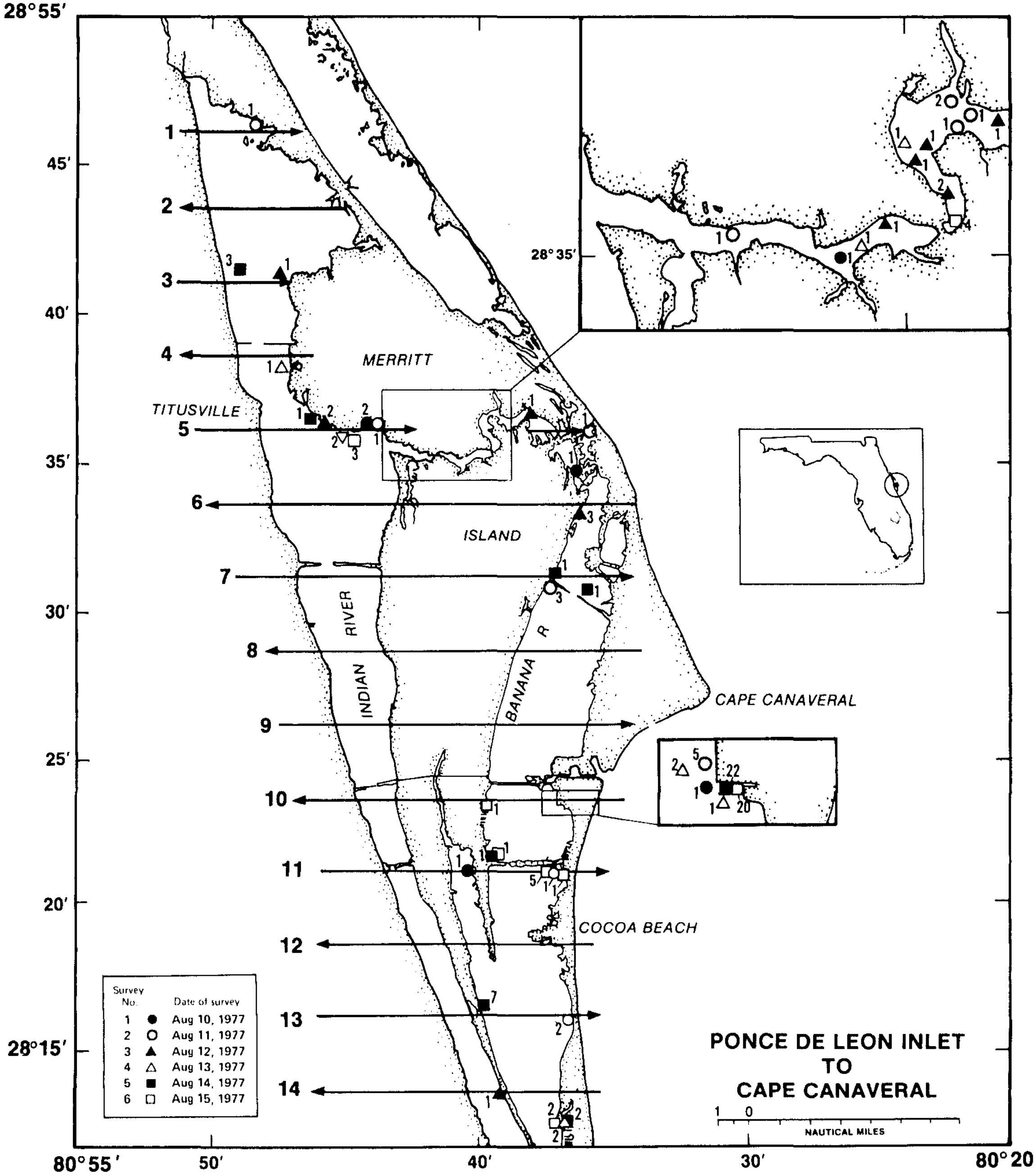

FIGURE 5.—Indian and Banana Rivers, Fla., indication locations of transects 1-14 and sightings of West Indian manatees. Numbers by the symbols indicate estimated numbers of individuals.

Manatees were often observed in several locations (Figures 5, 6, 7) though the numbers counted in each location varied among days.

A single dark adult manatee with a diagonal yellowish slash (perhaps a scar) across the back, seen 12 August near the east end of transect 3 was again observed 13 August, 200 yd from the east end of transect 4.

Manatees were sighted in the inlets on four occasions during the survey (Table 3), a group of two

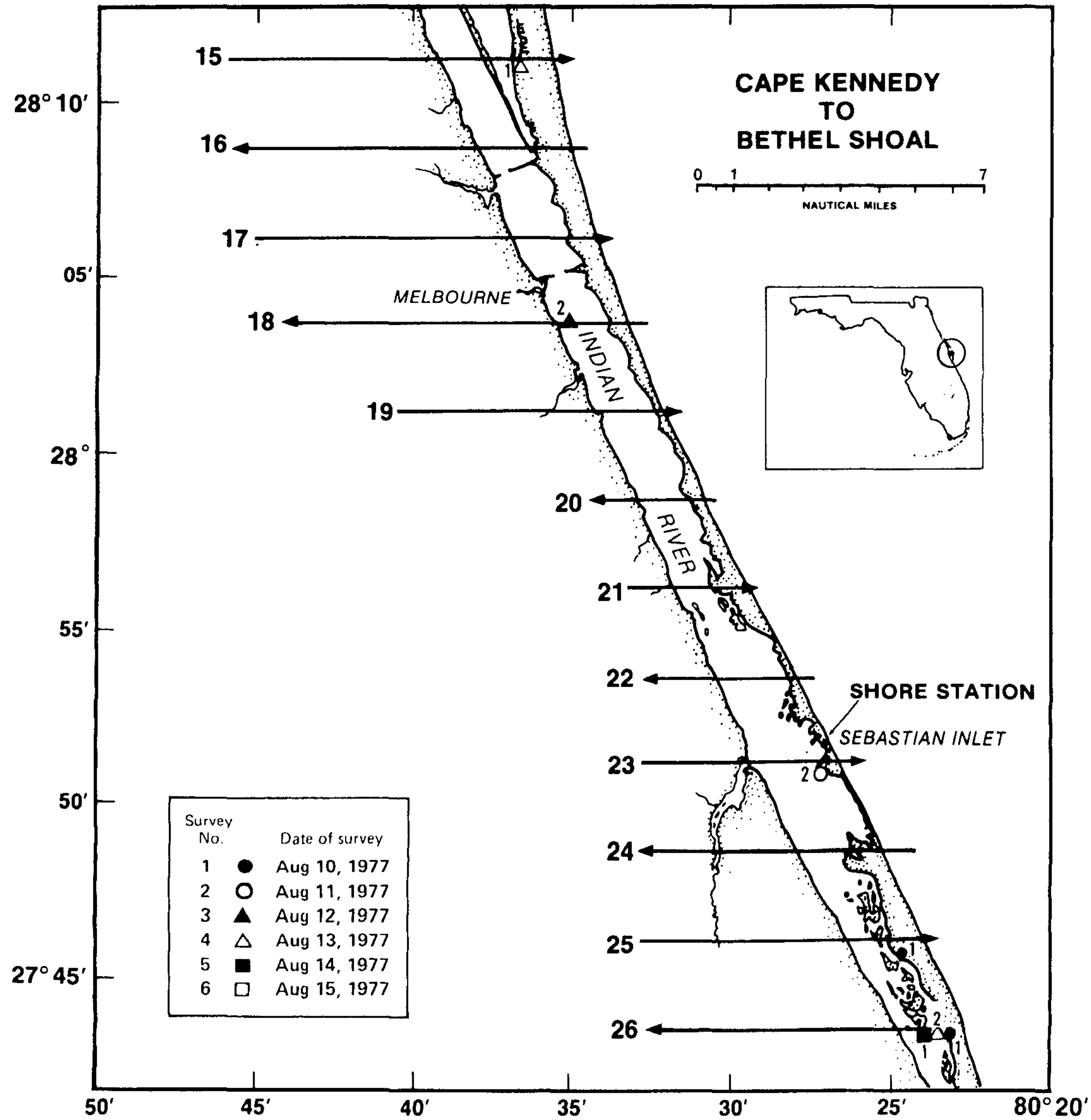

FIGURE 6.—Indian and Banana Rivers, Fla., indication locations of transects 15-26 and sightings of West Indian manatees. Numbers by the symbols indicate estimated numbers of individuals.

animals milling within Fort Pierce Inlet, a group of two adults moving against the tide, and two separate individuals moving with the tide.

Like the dolphins', manatees' movements appeared unrelated to tidal flow within the channels.

DISCUSSION

Dolphins

The estimated number of dolphins in the river at the time of the survey (438 ± 127) was considerably smaller than one would have expected for the area based on the accounts of Cato and Prochaska (1976) and Orr (see footnote 2) and on discussions with fishermen and other residents of the area. However, the densities of dolphins observed were generally much higher than those reported from aerial surveys of the waters of Alabama, Mississippi, and Louisiana (Leatherwood et al. 1978) and the west coast of Florida (Odell and

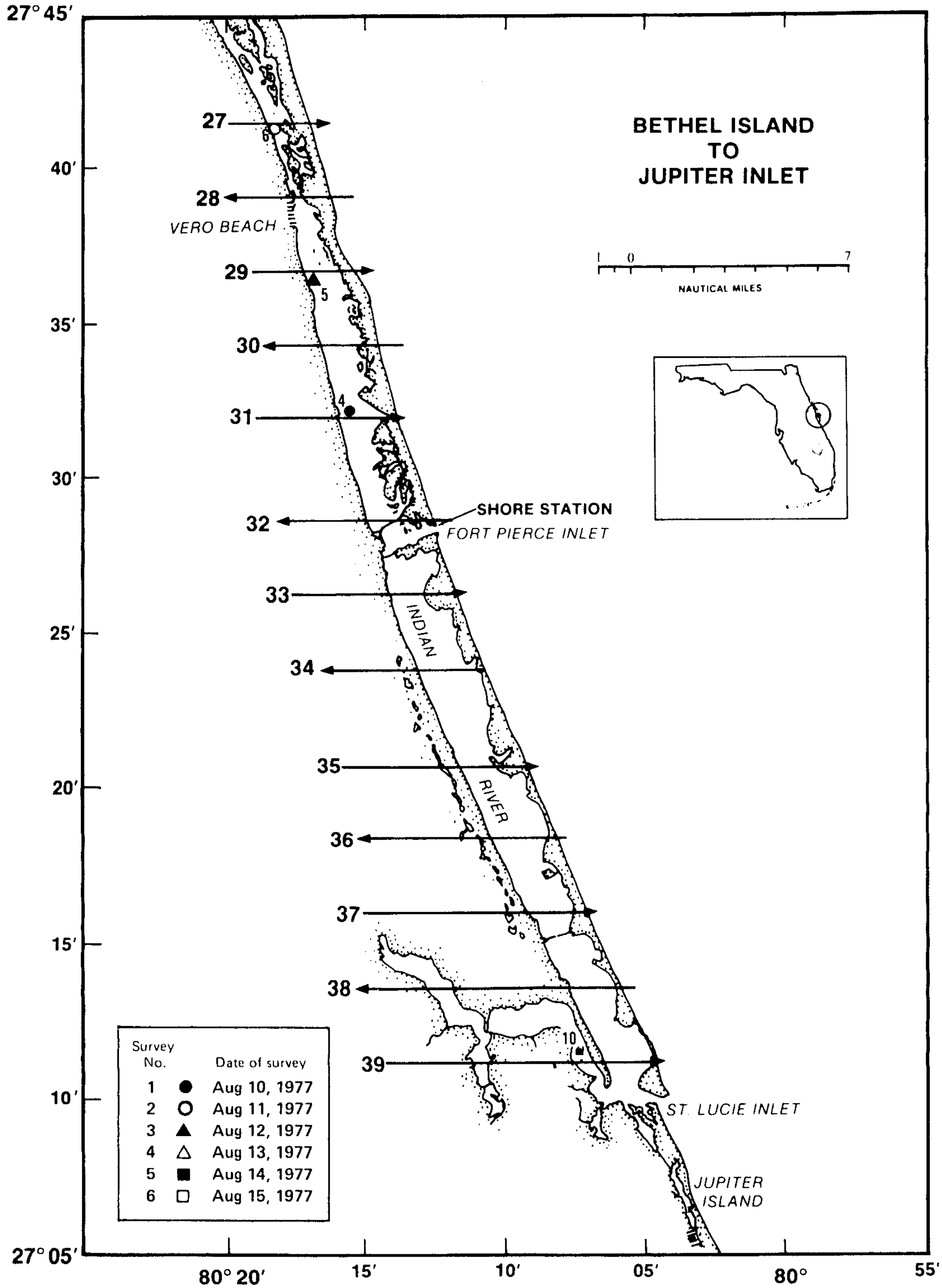

FIGURE 7.—Indian and Banana Rivers, Fla., indicating locations of transects 27-39 and sightings of West Indian manatees. Numbers by the symbols indicate estimated numbers of individuals.

TABLE 3.—Numbers of bottlenosed dolphins and West Indian manatees entering or leaving the Indian River during the time of the aerial surveys, indicating direction of travel relative to tidal flow.

Date (1977)	Bottlenosed dolphins	West Indian manatees
10 Aug.	4 adults moving against tide into river through Sebastian Inlet 7 adults, 2 calves moving with tide from river into Sebastian Inlet thence against tide back into river	0
11 Aug.	1 adult moving against tide into river through Sebastian Inlet	2 adults milling within Fort Pierce Inlet
12 Aug.	0	0
13 Aug.	0	2 adults moving against tide into river through Fort Pierce Inlet
14 Aug.	0	0
15 Aug.	1 "juvenile" milling within Sebastian Inlet at slack tide	1 adult moving with tide from river to ocean through Sebastian Inlet 1 adult moving with tide from river to ocean through Sebastian Inlet
Total	15 individuals, consisting of 5 moving against tide, 9 moving both with and against tide, and 1 milling within inlet	6 individuals, consisting of 2 milling within inlet, 2 moving against tide, and 2 moving with tide

TABLE 4.—Summary of West Indian manatee sightings by day during the six 1-day aerial surveys, August 1977.

Date	Survey no.	Total no. of sightings	Number of animals: Total	Calves of season	Other possible calves
10 Aug.	1	9	13	1(7.6%)	1(0.7%)
11 Aug.	2	12	21	2(9.5%)	1(0.7%)
12 Aug.	3	8	18	2(11.1%)	0(—)
13 Aug.	4	11	18	1(5.6%)	0(—)
14 Aug.	5	11	41	5(12.2%)	0(—)
15 Aug.	6	9	40	4(10.0%)	3(2.0%)
Total		60	151	15(9.9%)	5(3.3%)

TABLE 5.—Some estimates of density of bottlenosed dophins, *Tursiops* sp., in coastal waters of the southeastern United States.

Location	Reference	Dolphin per km²	Dolphins per n.mi.²
Mississippi gulf coast	Leatherwood et al. (1978)	0.23	0.57
Louisiana gulf coast	Leatherwood et al. (1978)	0.44	1.08
Florida[1] West Coast	Odell and Reynolds (see footnote 7)	0.23	0.57
Texas gulf coast	Barham et al. (see footnote 8)	0.65	1.61
Florida Indian River	This paper	0.68	1.77

[1]Derived from their Table 10 by computing the product of mean herd size (5.43) and mean herd density (0.0497).

Reynolds[7]), and were consistent with those reported from aerial surveys conducted in Texas using similar methodology (Barham et al.[8]) (Table 5). This consistency and the relatively low variance estimates are evidence that this was a realistic estimate of the numbers of dolphins in the rivers during the time of the survey.

Bottlenosed dolphins have been observed to occur as individuals and in groups of over 200 animals (Leatherwood and Platter[9]). Mean herd sizes of bottlenosed dolphins off eastern Florida and in the Gulf of Mexico vary considerably from one area to another. Groups apparently decrease in size with distance from shore (Odell and Reynolds see footnote 7); tend in coastal waters to be larger in deeper and in open water areas than in shallow embayments, lagoons, and marshlands (Leatherwood and Platter see footnote 9; Leatherwood et al. 1978; Shane and Schmidley[10]); and tend to fluctuate in size seasonally with little pattern discernible (Shane and Schmidley see footnote 10). The mean group size observed during this study (8.2) was well within the limits reported by all authors for eastern Florida and gulf coast waters. This and the lack of correlation between herd size and herd density further support the reasonableness of this population estimate (only if the distribution of herd sizes were normal could the inference technically be made that the two variables were independent (Figure 4)).

Because the estimation of variance in total numbers of animals assumes that herd size and

[7]Odell, D. K., and J. E. Reynolds III. In press. Distribution and abundance of the bottlenosed dolphin, *Tursiops truncatus*, on the west coast of Florida. Contract Report to the U.S. Marine Mammal Commission, Wash., D.C., 55 p. National Technical Information Service, Wash., D.C.

[8]Barham, E. G., J. C. Sweeny, S. Leatherwood, R. K. Beggs, and C. L. Barham. 1978. Aerial census of bottlenosed dolphins (*Tursiops truncatus*) in a region of the Texas coast. Unpubl. manuscr., 34 p. Southwest Fisheries Center, National Marine Fisheries Service, NOAA, P.O. Box 271, La Jolla, CA 92038.

[9]Leatherwood, S., and M. F. Platter. 1975. Aerial assessment of bottlenosed dolphins off Alabama, Mississippi, and Louisiana. *In* D. K. Odell, D. B. Siniff, and G. H. Waring (editors), *Tursiops truncatus* assessment workshop, p. 49-86. Final Report, U.S. Marine Mammal Commission, Contract MM5AC021.

[10]Shane, S. H., and D. J. Schmidley. In press. Population biology of Atlantic bottlenosed dolphins, *Tursiops truncatus*, in the Aransas Pass area of Texas. Contract Report to the U.S. Marine Mammal Commission, Wash., D.C., 238 p. National Technical Information Service, Wash., D.C.

herd density are mutually independent, the data by day were examined for correlation. Using Kendall's rank correlation coefficient (Conover 1971) at $\alpha = 0.05$, mean herd size and mean herd density were demonstrated to be uncorrelated within the area surveyed.

The dolphin densities per square kilometer were then multiplied by the area surveyed and a factor of 5 (since the survey covered 20% of the total area) and the 95% confidence limits calculated for the estimate. The figures support an estimate of 438 ± 127 dolphins for the Indian and Banana Rivers during the time of the survey.

As an alternate method for estimating dolphin densities, I took the average density over replicates from column 3, Table 2. This procedure results in a density estimate of 0.40 dolphin/km^2 (1.36 dolphins/n.mi.^{2}), a value very close to the estimate obtained using the method described above (0.41 dolphin/km^2, 1.41 dolphins/n.mi.^{2}), but having a variance twice as large (0.1837 vs. 0.094). Because of the higher variance, it can be argued that the first method used, because it takes into account both average herd size and average herd density, is preferable in this case.

The numbers of dolphins entering or leaving the river at Sebastian (4 groups totaling 15 animals) and Fort Pierce Inlets (none sighted) were negligible and were judged as insignificant to the total population size. Two of those groups were entering the river against an outgoing tide, one moved from the river into the inlet on an ebbing tide, then turned around and reentered the river, and one was milling within the inlet (Table 3).

The surprisingly low estimate does, of course, raise an important question. Is the population of bottlenosed dolphins in the river complex always this small (and only appears larger because of periodic concentrations of animals in limited areas) or is it augmented seasonally by influxes of animals from other areas migrating into the rivers in response to the movement of fishes?

Caldwell (1955) and others have suggested limited home ranges for bottlenosed dolphins. Wells et al.,[11] Irvine et al.,[12] and Shane and Schmidley (see footnote 10) have all clearly demonstrated limited home ranges for portions of the populations in their study areas; Wells et al. (see footnote 11) have shown differences in size and locations of home ranges based on age and sex classes, and all these authors have reported some movements of animals into and out of their study areas.

Caldwell and Caldwell (1972) summarize the views of the fishermen from eastern Florida that there are "river" and "ocean" *T. truncatus* populations. Caldwell et al. (1975) presented evidence from the distribution of cases of "Lobos" disease (lobomycosis) in bottlenosed dolphins that indicate greatest susceptibility to the disease in riverine-estuarine stocks and suggest isolation of river from ocean stocks.

Shane[13] reported that the offshore population of bottlenosed dolphins off Texas rarely interacted with the bay population but that the winter population in the Port Aransas area was at least twice as large as that in summer, because the bay population was augmented by "large numbers" of dolphins entering that area for the winter either from the adjacent gulf or from adjacent bay systems. Whether or not a similar influx occurs in the Indian River is unclear. Additional surveys during the peak seasons of the most important midwinter fisheries (king and Spanish mackerel, bluefish, spots, and pompano) might provide answers.

In considering the questions of the dolphins' population size and alleged damage to nets, it should be remembered that bottlenosed dolphins, at least in some areas, are not uniformly distributed but tend to concentrate in areas of high fish productivity (Leatherwood and Platter see footnote 9) which are often areas of highest human use (Leatherwood 1975). Irvine et al. (see footnote 12), for example, reported that short-term movements of bottlenosed dolphins near Tampa Bay appear to correlate with movements of mullet. Frequent joint use of resources by dolphins and humans make the dolphins highly visible and could result in inflated estimates of their numbers.

Even if not augmented seasonally by immigration from other areas, the relatively small dolphin population in Indian and Banana Rivers could be responsible for net damage of the types reported by Cato and Prochaska (1976). Feeding by dolphins near seine and gill net fisheries is well known

[11]Wells, R. S., A. B. Irvine, and M. D. Scott. 1977. Home range characteristics and group composition of the Atlantic bottlenosed dolphin *Tursiops truncatus* on the west coast of Florida. *In* Proceedings (Abstr.) of the Second Conference on the Biology of Marine Mammals, San Diego, Calif., 12-15 Dec. 1977, p. 15.

[12]Irvine, A. B., M. D. Scott, and R. S. Wells. 1977. Movements and activities of Atlantic bottlenosed dolphins. *In* Proceedings (Abstr.) of the Second Conference on the Biology of Marine Mammals, San Diego, Calif., 12-15 Dec. 1977, p. 16.

[13]Shane, S. H. 1977. Population biology of *Tursiops truncatus* in Texas. *In* Proceedings (Abstr.) of the Second Conference on the Biology of Marine Mammals, San Diego, Calif., 12-15 Dec. 1977, p. 57.

(Leatherwood 1975), and dolphins sometimes become entangled as a consequence (Mitchell 1975). An entangled adult dolphin, struggling for escape, is certainly capable of ripping a small-mesh net apart. Further, bottlenosed dolphins have been documented stealing fish from longlines (Iverson[14]). Even so, dolphins may not actually be responsible for all or even the majority of the damage in Indian River. Cato and Prochaska (1976) refer to damage to nets by sharks and cite the need for deterrents. D. K. Caldwell[15] reviewed the evidence and concluded that the majority of damage to nets in the Indian River was probably caused by sharks and not by dolphins, citing as support numerous reports by fishermen and others working the area of sharks around nets. He also concluded, however, that dolphins were stealing fish and damaging gear in the king mackerel fishery in the nearby Atlantic Ocean. During the aerial surveys, I observed huge concentrations of sharks on the sand bars at the entrance of St. Lucie Channel. Therefore, the question of what causes the damage to nets is still open and regulation of the dolphin population based on its supposed size and levels of damage to the fisheries would be premature.

Irvine et al. (see footnote 12) reported that in spring calves composed as much as 14% of the bottlenosed dolphin population near Tampa Bay. Shane (see footnote 13) reported that calves constituted from 3.65% (February) to 12.92% (May) of the dolphins in the Port Aransas area ($\bar{x}$ = 7.61); Leatherwood et al. (1978) reported summer figures from 7.7 to 7.9% calves for coastal Alabama, Mississippi, and Louisiana. The 8.1-10.1% calves observed during this survey therefore are well within the reported ranges of percentages of calves in local bottlenosed dolphin populations.

It has been noted that in areas where tidal flow is negligible, as is the case within these rivers, dolphin movements appear to be related to some factor other than tide (Shane and Schmidley see footnote 10). Shane and Schmidley found that the dolphins in areas of swiftest current moved against tidal flow. The inability to ascertain a relationship between swimming direction of groups and tidal flow in the river inlets in this study is perhaps related to our small sample size.

Manatees

Hartman (see footnote 5) and Irvine and Campbell (1978) reported that Florida manatees concentrated near warmwater refugia during winter months but dispersed during the remainder of the year. The 151 manatees (some no doubt repeats on successive days) sighted during this survey were distributed throughout the nearshore waters of the Indian-Banana River complex, including several less saline canals, and animals were not concentrated near the St. Lucie power station or other potential warmwater areas where winter concentrations have been reported (Irvine and Campbell 1978). No manatees were observed in the deeper open water of the rivers. All were in shallower coastal waters, marinas, creek mouths, bayous, and canals. The number of calves observed, composing from 9.9 to 13.2%, depending on the correct classification of the intermediate-sized animals observed, falls within the ranges of 9.6% calves (winter) and 13.4% calves (summer) reported by Irvine and Campbell (1978).

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LITERATURE CITED

CALDWELL, D. K.
1955. Evidence of home range of an Atlantic bottlenose dolphin. J. Mammal. 36:304-305.

CALDWELL, D. K., AND M. C. CALDWELL.
1972. The world of the bottlenosed dolphin. J. B. Lippincott Co., Phila., 157 p.

[14]Iverson, R. T. B. 1975. Bottlenosed dolphins stealing fish from Hawaiian fishermen's lines. Unpubl. manuscr., 12 p. Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, P.O. Box 3830, Honolulu, HI 96812.

[15]D. K. Caldwell, University of Florida, Biocommunication and Marine Mammal Research Facility. Rt. 1, Box 121, St. Augustine, FL 32084, pers. commun. September 1977.

CALDWELL, D. K., M. C. CALDWELL, J. C. WOODARD, L. AJELLO, W. KAPLAN, AND H. M. MCCLURE.
1975. Lobomycosis as a disease of the Atlantic bottlenosed dolphin (*Tursiops truncatus* Montagu, 1821). Am. J. Trop. Med. Hygiene 24:105-114.

CATO, J. C., AND F. J. PROCHASKA.
1976. Porpoise attacking hooked fish irk and injure Florida fishermen. Natl. Fisherman 56(9):3B, 16B.

CONOVER, W. J.
1971. Practical nonparametric statistics. John Wiley and Sons, Inc., N.Y., 462 p.

GOODMAN, L. A.
1960. On the exact variance of products. J. Am. Stat. Assoc. 55:708-713.

IRVINE, A. B., AND H. W. CAMPBELL.
1978. Aerial census of the West Indian manatee, *Trichechus manatus*, in the southeastern United States. J. Mammal. 59:613-617.

LEATHERWOOD, S.
1975. Some observations of feeding behavior of bottlenosed dolphins (*Tursiops truncatus*) in the northern Gulf of Mexico and (*Tursiops* cf *T. gilli*) off southern California, Baja California, and Nayarit, Mexico. Mar. Fish. Rev. 37(9):10-16.

LEATHERWOOD, S., J. R. GILBERT, AND D. G. CHAPMAN.
1978. An evaluation of some techniques for aerial censuses of bottlenosed dolphins. J. Wildl. Manage. 42:239-250.

MITCHELL, E.
1975. Porpoise, dolphin and small whale fisheries of the world: status and problems. Int. Union Conserv. Nat., Monogr. 3, 129 p.