NOAA Technical Memorandum NMFS-SEFSC-435

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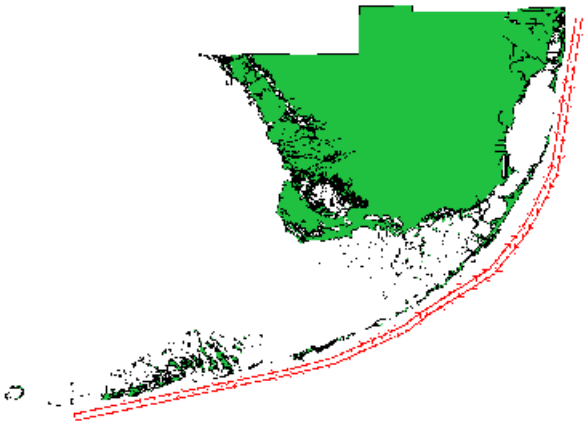

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ABSTRACT

The bottlenose dolphin, *Tursiops truncatus*, is the most common cetacean species found in nearshore waters of the Florida Keys and in Florida Bay. Opportunistic sightings from aerial surveys provide rough estimates of the relative abundance of bottlenose dolphin in these waters. These surveys have been conducted along the southeast Florida coast since September 1992 to document vessel usage in the Keys and since March 1995 to census bird populations in the Florida Bay. Sightings of 1,851 bottlenose dolphins occurred in 109 surveys from inception through December 1997. Herd sizes, seasonality, and encounter rates were compared between the two areas, as well as with previous studies in nearby areas. The total number of bottlenose dolphins per survey was 18.57 (range 0 - 116) in Florida Keys nearshore waters and 13.47 (range 0 - 49) in Florida Bay. Mean herd size was 6.06 dolphins (range 1 -36) in Florida Keys nearshore waters versus 3.03 dolphins (range 1 - 18) in Florida Bay. Seasonality had no effect on numbers observed in either area. Encounter rates were higher in Florida Keys nearshore waters (0.12 per nautical mile) than in Florida Bay (0.04 per nautical mile), suggesting that bottlenose dolphins may be more abundant in nearshore waters of the Florida Keys than in Florida Bay.

Keywords: aerial survey, bottlenose dolphins, Florida Bay, Florida Keys, *Tursiops truncatus*

INTRODUCTION

The National Marine Fisheries Service (NMFS) Miami Laboratory and the United States Coast Guard Miami Air Station established a cooperative agreement in September 1992 to monitor marine animals and vessel activity in the Florida Keys (McClellan 1996). The primary objectives of the study were to document sea turtle and marine mammal occurrence, seasonality, and distribution along the southeast Florida coast and to describe vessel usage patterns in Biscayne National Park (BNP) and the Florida Keys National Marine Sanctuary (FKNMS). A separate survey, in collaboration with Everglades National Park (ENP), was initiated in March 1995 (Browder *et al.* 1995, 1997) to census the large fish-eating water birds in Florida Bay. Sightings of marine mammals and reptiles were also recorded.

Bottlenose dolphins (*Tursiops truncatus*) are managed by the NMFS under the authority of the Marine Mammal Protection Act of 1972, as amended, and are the most common cetacean in this region (Fritts *et al.* 1983, Hansen 1986). Stock assessments and descriptions of the stocks have been reported for the groups described in this study, but the structure is still uncertain (Blaylock *et al.* 1995, Hansen and Hohn 1997, Waring *et al.* 1997, 1999). Current understanding of stock structure of bottlenose dolphins in both the Atlantic and Gulf of Mexico (bays, coastal waters, and outer continental shelf waters) is based primarily on sampling strata and/or geography and may not be accurate biologically (Hansen and Hohn 1997). Of the two distinct bottlenose dolphin ecotypes that probably occur in this area, these animals are more likely the shallow, warm-water type, and probably include resident and migratory animals.

Few population data exist for the south Florida area before 1972, although marine mammal observations were recorded during the 1969-1971 Portuguese man-of-war survey by the Florida Department of Natural Resources (Hansen 1986). Aerial surveys to determine the status of bottlenose dolphin stocks were conducted in Biscayne Bay and in the Whitewater Bay area of Everglades National Park from June 1974 to June 1975 (Odell 1979) and in the southeastern United States from 1979 to1983 (Hansen and Scott 1989). Litz *et al.* (1996) documented bottlenose dolphin occurrences in Biscayne Bay with a boat-based photo-identification project that began in 1990, and Contillo *et al.* (1997) have continued this survey.

Bottlenose dolphin sightings from aerial surveys over Atlantic waters along the reef tract between Miami and Key West (September 28, 1992 through December 12, 1997) and surveys of Florida Bay waters (March 24, 1995 through December 12, 1997) are presented. In the 109 surveys conducted, 1,851 bottlenose dolphins were sighted. The purpose of this report is to summarize these opportunistic sightings and discuss them in relation to previously reported levels of abundance. This was not intended to be a directed survey directed at assessing the population of bottlenose dolphin, nor their relationship with the Atlantic coastal populations. The results of this opportunistic work points out the need for dedicated dolphin studies in this region.

METHODS

Aerial surveys conducted along the southeast Florida coast from Ft. Pierce to Key West were described in McClellan (1996). All 75 flights summarized here were aboard United States Coast Guard aircraft based at the Miami Air Station, Opalocka, Florida. A RG-8 fixed wing, single engine airplane was

used for two flights and the other 73 flights utilized the HH-65 Dolphin helicopter. The helicopter, preferred because it could carry more observers and hover as required for species identification, was flown south along the reef tract to Sand Key and then back to Miami over Hawk Channel (Figure 1). Each flight varied in time and distance because of weather, Search and Rescue (SAR) missions, and other factors. Each flight carried between 3 and 5 observers (including the flight crew), lasted one to four hours of flight time between 8:30 A.M. and 4:00 P.M., and varied in starting and ending points. A viewing strip width of approximately 0.5 nautical mile (nmi) was estimated. The helicopters flew at air speeds between 80 and 120 knots (kn) at an altitude of 150 to 300 feet (ft) {50 to 100 meters (m)}. Transects varied but, in general, were aligned with the reef tract, using lighthouses as reference points. Departures from this path were made to adequately view vessels, therefore each flight transect was slightly different from the others.

The 34 Florida Bay surveys also were conducted from the HH-65 Dolphin helicopter. One to three flight days (between 8:00 A.M. and 2:00 P.M.) were needed to completely cover the Bay monthly. An altitude of 150-200 ft (50 m) was maintained, with the survey track recorded from geographic coordinates obtained from the helicopter's Global Positioning System (GPS) unit. To maximize the observations on feeding birds on mud banks and island and mainland intertidal areas, flights were generally scheduled to coincide with low tide in the part of the Bay surveyed. Tidal stage is relevant only in the western and southern parts of the Bay, because tidal amplitude is damped to near zero moving eastward. Bay coverage extends westward to about 80° 03' W and southward to about 24° 54' N (Figure 1).

During the first nine months in 1995, four to five flights were made each month for the Florida Bay survey, and fixed north-south transects were flown about one nmi apart. Diversions from the straight flight path were made to circle each island within 0.5 nmi distance of the transect. Experience gained during the 9-month period of fixed-transect flights allowed the researchers to design a more efficient coverage method that focused on islands and near-exposed banks and their immediate surroundings. This change was necessary to retain geographic coverage of the Bay when the number of flight days was reduced, first to three (beginning October 1995), and later to two (beginning July 1996), per month. Data within each month were pooled to constitute a full Bay survey for that month.

Mean number of bottlenose dolphins observed per survey, mean encounter rate, and mean herd size (number/herd) were calculated for each survey area. The reliability of these first two variables as estimates of abundance and density, respectively, is influenced by the ratio of the standard deviation to the mean, reported as the coefficient of variation (CV). CV was computed for the mean number of dolphins per herd and for density (dolphin per nmi) for both the Florida Keys and Florida Bay. CV, standard deviation (SD), and standard error (SE) are provided for previous studies and, when possible, were calculated directly from the data. Statistical comparisons of mean number of observations per survey, mean encounter rates, and mean herd sizes were made using Students t tests. Comparisons of seasonal and monthly data within survey areas were made with ANOVAs.

A number of factors other than animal distributions and abundance can affect both the mean and variance of bottlenose dolphin

observations and might account for differences between surveys. Bottlenose dolphin observations were dependent on environmental and solar factors. Observer experience and fatigue, sun reflection, contrast, water turbidity, wind and sea conditions, time of day, animal behavior, and flight altitude and air speed could all affect dolphin sightings and numbers. Under turbid or rough conditions, only animals at the water surface could be seen, so the total numbers could be negatively biased. For a thorough discussion of availability and perception bias, see Marsh and Sinclair (1989). The survey designs used in the historical surveys differ from each other and the present surveys in platforms, altitudes, air speeds, and other factors; and effects of these differences could not be analyzed.

RESULTS

The data summarized here for bottlenose dolphins were collected incidentally during surveys designed primarily to assess vessel activity in the Florida Keys and to monitor bird populations in Florida Bay, and were not collected for bottlenose dolphin population estimates. Bottlenose dolphins were the only identified cetacean species observed during the surveys. Tables 1 and 2 present bottlenose dolphin sightings from our two surveys, previous survey results from other surveys in southern Florida waters are given in Table 3 for comparison, and Table 4 presents seasonality data for our surveys.

Abundance

Sightings of bottlenose dolphins were reported on 97 of the 109 surveys; 1,851 individuals were counted. Sightings occurred on 65 of the 75 surveys of Florida Keys nearshore Atlantic waters; the count was 1,393 dolphins {mean [$\bar{0}$] = 18.57 ± 21.08 per survey, range = 0 - 116 individuals, CV = 1.14, 95% confidence limits [ci] = 16.81 - 20.03} (Tables 1 and 3). Monthly coverages of Florida Bay waters resulted in 458 bottlenose dolphins ($\bar{0}$ = 13.47 ± 11.92 per survey, range = 0 - 49 individuals, CV = 0.88, 95% ci = 12.85 - 14.89) sighted in 32 of the 34 surveys (Tables 2 and 3). The difference in the total mean number per survey of bottlenose dolphins between the two areas was significant (95% t-test, p = 0.0556).

Hansen (1986) analyzed opportunistic bottlenose dolphin sightings ($\bar{0}$ = 5.14 ± 12.06, 95% ci = 3.77 - 6.51) in waters off the Florida Keys (Table 3) collected during Portugese man-of-war (*Physalia physalia*) surveys by the Florida Department of Natural Resources (FDNR). Hansen's (1986) mean counts per survey were significantly lower than our results for Florida Keys Atlantic waters (95% t-test analysis, p = 0). This difference may have been due to differences in distance from shore because the FDNR surveys were up to 30-50 nmi offshore, while this survey was conducted along the reef tract and nearshore waters. McClellan (1996) reported sightings ($\bar{0}$ = 10.75 ± 12.06, 95% ci = 8.38 - 13.12) from nearshore waters from Ft. Pierce to Miami (Table 3). A significantly higher mean number of bottlenose dolphins (95% t-test, p = 0.0378) was found in Florida Keys nearshore Atlantic waters. These two comparisons suggest that a greater density of bottlenose dolphins occurs along the nearshore and reef tract waters of the Florida Keys than in either the offshore waters of the Florida Keys or the nearshore waters of central Florida.

Comparison of total numbers from our opportunistic Florida Bay (1995 - 1997) data with the Odell (1979) study in Whitewater Bay 20 years ago ($\bar{0}$ = 34.43 ± 27.95, 95% ci = 31.68 - 37.18, Table 3), shows a significant

difference in mean numbers (95% t-test, p = 0). The Odell study was directed at bottlenose dolphins, which may partly explain why Odell's numbers were higher. The differences between the mean numbers from the Indian and Banana Rivers (Leatherwood 1979), both considered bay and estuarine type habitats (mean = 84.5 ± 19.34, 95% ci = 79.17 - 89.83, Table 3), and this Florida Bay survey also are significant (95% t-test, p = 0.0001). Whether the much larger mean numbers in the previous surveys are due to changes in abundance between surveys (over 20 years), site suitability differences, or differences in stock density preferences is not known.

Herd Size

A bottlenose dolphin herd is described as one or more animals in "relatively" close proximity, and may contain several subunits (Odell 1979). The Florida Bay survey ($\bar{0}$ = 3.03 ± 2.59 bottlenose dolphins/herd, range 1 to 18, 95% ci = 5.55 - 6.57, survey CV = 1.01) and the Florida Keys nearshore Atlantic and reef tract survey ($\bar{0}$ = 6.06 ± 6.15 bottlenose dolphins/herd, range 1 to 36, 95% ci = 2.72 - 3.34, survey CV = 0.85) suggest a significant difference (95% t-test, p = 0.0005) in mean herd sizes (Tables 1 - 3). Leatherwood (1979), who discussed differences in herd sizes between offshore and inshore waters, said groups tend to be larger in coastal waters than in shallow embayments (such as Florida Bay).

Hansen (1986), in an opportunistic survey of Atlantic waters offshore of the Florida Keys, reported the mean herd size from 28 sightings over 35 surveys at 6.43 ± 7.60 animals/herd (range 1 - 55, 95% ci = 5.46 - 7.4, Table 3). McClellan (1996) saw an average herd size of 4.77 ± 2.59 (range 2 - 43, 95% ci = 3.61 - 5.93) from 12 surveys between Miami and Ft. Pierce, Florida (Table 3). There is no statistical difference (95% t-test, p = 0.4105 and 0.2487, respectively) in the mean herd size between these two surveys and the Florida Keys nearshore Atlantic waters survey presented here. Mean herd sizes observed in other southeastern United States surveys have been reported (Table 3) at 4.15 to 5.18 bottlenose dolphin/herd (Blaylock and Hoggard 1994) and for bay and nearshore waters off Key West, Florida, at 3.8 animals/herd (Hansen and Scott 1989). T-test analysis was not conducted because CV's and data for these previous surveys were not reported.

Odell (1979) recorded a mean of 2.98 animals/herd from 46 of 47 surveys (range 5 - 98, 95% ci = 2.88 - 3.08) from nearby waters of Whitewater Bay, which is located in Everglades National Park (Table 3). There was no significant difference between the the Florida Bay survey (3.03 bottlenose dolphins/herd) and Odell (1979) (95% t-test, p = 0.4587). Even though the Florida Bay survey was opportunistic and Odell (1979) was a dedicated bottlenose dolphin survey, the mean herd sizes are comparable.

Comparisons of mean herd sizes to other surveys showed that Florida Bay herd sizes (3.03 bottlenose dolphins/herd) were significantly smaller. Odell (1979) recorded a mean herd size of 9.57 animals (range 3 - 13, 95% ci = 8.78 - 10.36) from 7 herds seen in 22 aerial surveys in Biscayne Bay; this was significantly higher than Florida Bay mean herd size (95% t-test, p = 0). Leatherwood (1979) recorded 8.2 bottlenose dolphins/herd (range 1 - 35, 95% ci = 7.71 - 8.69) in the Indian and Banana Rivers (Table 3), and his survey also showed significant differences in mean herd sizes (95% t-test, p = 0.0001) from the Florida Bay survey. Odell (1979) suggested that differences between regions may be due to isolation or differences in

environmental complexity, food abundance, or pollution.

Herd sizes are reported in the literature for additional surveys from southeast Florida waters (Table 3). A mean herd size was recorded at 5.15 (range 1 - 21 individuals) from Biscayne Bay boat surveys (Litz *et al.* 1996). Contillo *et al.* (1997) reported a mean herd size of 5.0 (1 - 27 animals, Contillo *et al.* 1997) for Biscayne Bay. Since CV's and data were not reported, statistical comparison could not be made, but Biscayne Bay herd sizes appear to be larger.

Seasonality

Bottlenose dolphins were sighted during all months in nearshore waters off the Florida Keys and Florida Bay (Figures 2 - 5). In these figures, winter refers to the months of January through March, spring is considered to be April through June, summer is July through September, and fall is October through December. There were no significant differences among seasons in either the mean number observed or mean encounter rates (number per nmi) in Florida Keys nearshore Atlantic waters (one-way ANOVA, $p = 0.158$ and 0.293, respectively) or Florida Bay (one-way ANOVA, $p = 0.226$ and 0.247, respectively) (Table 4).

No individual monthly differences in encounter rates (one-way ANOVA, $p = 0.698$), group sizes (one-way ANOVA, $p = 0.271$), or total number (one-way ANOVA, $p = 0.697$) among the Florida Keys Atlantic group bottlenose dolphins, were indicated. There also were no individual monthly differences in encounter rates (one-way ANOVA, $p = 0.844$), group sizes (one-way ANOVA, $p = 0.596$), or total number (one-way ANOVA, $p = 0.926$) among seasons in the Florida Bay group.

Information about seasonality was presented in Hansen (1986) and Hansen and Scott (1989) for Atlantic waters. Statistical comparisons could not be made with the surveys presented here, but variation in density by season in the Key West area does not appear significant (Hansen and Scott 1989).

Encounter rates

Overall bottlenose dolphins sighting rates averaged 0.12 dolphins/nmi (CV = 1.12) for the Florida Keys surveys, with a total of 14,938 nmi of transect lines flown (Tables 1 and 3). Encounter rates for selected historical surveys are shown in Table 3, but no statistical comparisons are made since data and CV's for the estimates were not reported. For Florida Bay waters, 12,842 nmi were flown with an estimated 0.04 bottlenose dolphins/nmi (CV = 0.81) observed (Tables 2 and 3). These rates appear less than the 0.12 bottlenose dolphins/nmi seen by Odell (1979) in the nearby waters of Whitewater Bay, but no statistical comparisons could be made. Differences in sighting rates in the two separate geographic areas of ENP could be explained by habitat differences, particularly complexity and water depth.

DISCUSSION

It has been suggested that opportunistic surveys are suboptimal and cannot be expected to provide true abundance estimates (Blaylock 1995). The large variances associated with these surveys may be due not only to the fact that the data were opportunistic, may be because the distribution of dolphin stocks is highly variable, or because viewing conditions vary considerably from one survey to the next. These projects were not intended to be dedicated surveys directed at assessing the population of bottlenose dolphin, nor their relationship to

the Atlantic coast populations.

Our surveys do suggest that bottlenose dolphin range throughout the southeast Florida area. Despite the large variances, statistical tests suggested that herd sizes were larger and densities were greater in Florida Keys Atlantic nearshore than in Florida Bay or Biscayne Bay. Florida Bay populations were higher than Biscayne Bay populations in the 1970's, and this trend appears to be the same today. Although bottlenose dolphins were sighted throughout the south Florida area, from the estuarine and bay areas to the reef tract, they were most common in nearshore Atlantic waters off the Florida Keys. Season does not appear to have influenced the number sighted, suggesting that these bottlenose dolphins are residents, not migrants. Scott *et al.* (1988) proposed that the coastal bottlenose dolphin groups are local, resident stocks in certain embayments, and that transient stocks migrate seasonally. We did not see evidence of this in these surveys. Future dedicated studies are necessary to determine stock structure and population sizes in this region.

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LITERATURE CITED

Blaylock, R.A. 1995. A pilot study to estimate abundance of the U.S. Atlantic coastal migratory bottlenose dolphin. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SEFSC-362. 9 pp.

Blaylock, R.A. and W. Hoggard. 1994. Preliminary estimates of bottlenose dolphin abundance in southern U.S. Atlantic and Gulf of Mexico continental shelf waters. NOAA Technical Memorandum NMFS-SEFSC-356. 10 pp.

Blaylock, R.A., J.W. Hain, L.J. Hansen, D.L. Palka, and G.T. Waring. 1995. U.S. Atlantic and gulf of Mexico marine mammal stock assessments. NOAA Technical Memorandum NMFS-SEFSC-363. 211 pp.

Browder, J.A., O. Bass, J. Gebelein, and H. Huang. 1995. Spatial analysis of Florida Bay. (*Abstract*). **In**: Conference of Florida Bay Investigators, 17-18 October 1995.

Browder, J.A., O. Bass, J. Gebelein, and H. Huang. 1997. Water bird usage of Florida Bay. *(Abstract*). Page 37 **In**: First Annual Conference of the Walt Denein Society. 22-24 May, 1997. Miami, FL.

Contillo, J., J. Tobias, and B. Mase. 1997. Photo-identification of bottlenose dolphins in Biscayne Bay, Florida 1990-1997. NOAA/NMFS/SEFSC/Miami Lab. Contr. MIA-97/98-13. 28 pp. Available from SEFSC, 75 Virginia Beach Drive, Miami, FL 33149.

Fritts, T.H., A.B. Irvine, R.D. Jennings, L.A. Collum, W. Hoffman, and M.A. McGehee.. 1983. Turtles, birds, and mammals in the northern Gulf of

Mexico and nearby Atlantic waters. U.S. Fish and Wildlife Service FWS/OBS-82/65. 445 pp.

Hansen, L.J. 1986. Dolphin aerial survey data from Florida waters April 1969-February 1971. NOAA/NMFS/SEFC/Miami Lab, CRD ML-86-52. 28 pp. Available from SEFSC, 75 Virginia Beach Drive, Miami, FL 33149.

Hansen, L.J. and A.A. Hohn. 1997. Report from the scientific peer review of the SEFSC marine Mammal Research Program, December 11 - 13, 1996. NOAA Technical Memorandum NMFS-SEFSC-406, 68pp.

Hansen, L.J. and G.P. Scott. 1989. Bottlenose dolphin densities in five selected southeastern United States areas during 1981-1983. NMFS/SEFC, Miami Laboratory, Coastal Resources Division, Contribution ML-CRD-88/89-08. 20 pp. Available from SEFSC, 75 Virginia Beach Drive, Miami, FL 33149.

Leatherwood, S. 1979. Aerial survey of the bottlenose dolphin, Tursiops truncatus, and the West Indian manatee, Trichechus manatus, in the Indian and Banana Rivers, Florida. Fishery Bulletin, U.S. 77(1):47-59.

Litz, J., J. Contillo, J. Tobias, and B. Mase. 1996. Low-level monitoring of bottlenose dolphins (Tursiops truncatus) in Biscayne Bay, Florida. April, 26, 1996. Unpubl. report. 26 pp. Available from SEFSC, 75 Virginia Beach Drive, Miami, FL 33149.

Marsh, H. and D.F. Sinclair. 1989. Correcting for visibility bias in strip transect aerial surveys of aquatic fauna. Journal of Wildlife Management 61:1017-1024.

McClellan, D.B. 1996. Aerial surveys for sea turtles, marine mammals, and vessel activity along the southeast Florida coast, 1992-1996. NOAA Technical Memorandum NMFS-SEFSC-390. 42 pp.

Odell, D.K. 1979. A preliminary study of the ecology and population biology of the bottlenose dolphin in southeast Florida. U.S. Department of Commerce, National Technical Information Service Publication PB-294336. 26 pp.

Scott, G.P, D.M. Burn, and L.J. Hansen. 1988. The dolphin die off: Long term effects and recovery of the population. Proceedings: Ocean '88, IEEE Cat. 88-CH2585-8. Vol. 3:819-823.

Waring, G.T., D.L. Palka, K.D. Mullin, J.H.W. Hain, L.J. Hansen, and K.D. Bisack. 1997. U.S. Atlantic and Gulf of Mexico Marine mammal stock assessments - 1996. NOAA Technical Memorandum NMFS-NE-114. 250 pp.

Waring, G.T., D.L. Palka, P.J. Clapham, S. Swartz, M.C. Rossman, T.V.N. Cole, K.D. Bisack, and L.J. Hansen. 1999. U.S. Atlantic marine mammal stock assessments - 1998. NOAA Technical Memorandum NMFS-NE-116. 182 pp.

Table 1. Summary of southeast Florida Atlantic waters aerial surveys, September 28, 1992 through December 12, 1997.

Survey No.	Dates	No. of Observers	Dolphin survey Time (min.)	miles (nm)	Total # of dolphins	Min # per herd	Max # per herd	Total herds	# Dolphins per mile (nm	Mean # per herd
SUR001	28-Sep-92	5	69	87	10	10	10	1	0.11	10.00
SUR002	18-Dec-92	2	50	61	0					
SUR003	29-Jan-93	4	67	114	0					
SUR004	05-Mar-93	4	67	116	6	2	4	2	0.05	3.00
SUR005	23-Apr-93	2	77	141	0					
SUR006	17-May-93	4	66	109	26	1	15	6	0.24	4.33
SUR007	04-Jun-93	3	103	148	8	8	8	1	0.05	8.00
SUR008	01-Jul-93	3	88	183	7	1	5	3	0.04	2.33
SUR009	11-Aug-93	4	123	244	14	2	4	5	0.06	2.80
SUR010	27-Aug-93	4	118	208	26	1	25	2	0.125	13.00
SUR011	10-Sep-93	3	78	153	3	3	3	1	0.02	3.00
SUR012	24-Sep-93	3	55	86	10	10	10	1	0.12	10.00
SUR013	08-Oct-93	3	107	178	8	8	8	1	0.04	8.00
SUR014	22-Oct-93	4	78	202	0					
SUR015	19-Nov-93	5	27	41	0					
SUR016	10-Dec-93	3	128	213	10	1	9	2	0.05	5.00
SUR017	11-Mar-94	3	127	150	10	1	4	5	0.07	2.00
SUR018	25-Mar-94	4	151	213	32	3	15	4	0.15	8.00
SUR019	02-Apr-94	3	135	245	0					
SUR020	06-May-94	4	77	178	4	4	4	1	0.02	4.00
SUR021	27-May-94	5	91	135	1	1	1	1	0.01	1.00
SUR022	24-Jun-94	4	105	175	9	1	5	3	0.05	3.00
SUR023	15-Jul-94	4	99	99	19	4	10	3	0.19	6.33
SUR024	27-Jul-94	3	74	150	0					
SUR025	28-Jul-94	3	111	264	3	3	3	1	0.01	3.00
SUR026	19-Aug-94	4	123	238	16	1	8	5	0.07	3.20
SUR027	26-Aug-94	4	105	119	1	1	1	1	0.01	1.00
SUR028	16-Sep-94	3	116	130	8	8	8	1	0.06	8.00
SUR029	23-Sep-94	5	144	225	10	10	10	1	0.04	10.00
SUR030	14-Oct-94	4	88	112	116	1	36	8	1.04	14.50
SUR031	21-Oct-94	4	81	130	0					
SUR032	27-Oct-94	4	90	155	8	1	3	4	0.05	2.00
SUR033	18-Nov-94	3	95	161	54	8	25	4	0.34	13.50
SUR034	09-Dec-94	3	87	130	0					
SUR035	30-Dec-94	3	192	253	42	1	22	5	0.17	8.40
SUR036	20-Jan-95	3	163	232	15	6	9	2	0.06	7.50
SUR037	27-Jan-95	4	103	177	0					
SUR038	03-Feb-95	3	131	248	34	1	11	8	0.14	4.25

Table 1 (cont.)

Survey No.	Dates	No. of Observers	Dolphin survey Time (min.)	miles (nm)	Total # of dolphins	Min # per herd	Max # per herd	Total herds	# Dolphins per mile (nm	Mean # per herd
SUR039	10-Feb-95	4	112	239	0					
SUR040	17-Feb-95	5	165	254	14	2	6	5	0.06	2.80
SUR041	24-Feb-95	3	190	285	37	2	20	5	0.13	7.40
SUR042	03-Mar-95	3	132	265	34	1	18	6	0.13	5.67
SUR043	17-Mar-95	4	90	177	0					
SUR044	07-Apr-95	4	79	109	25	2	15	3	0.23	8.33
SUR046	05-May-95	3	111	260	46	1	20	6	0.18	7.67
SUR048	19-May-95	3	201	280	39	1	13	5	0.14	7.80
SUR050	02-Jun-95	3	47	15	0					
SUR051	09-Jun-95	4	176	274	47	2	18	6	0.17	7.83
SUR052	16-Jun-95	3	146	272	5	1	4	2	0.02	2.50
SUR054	07-Jul-95	3	154	243	23	1	20	3	0.09	7.67
SUR056	21-Jul-95	3	127	174	22	1	12	5	0.13	4.40
SUR057	11-Aug-95	3	52	89	10	2	4	3	0.11	3.33
SUR059	01-Sep-95	3	231	300	8	2	6	2	0.03	4.00
SUR061	29-Sep-95	4	158	300	5	5	5	1	0.02	5.00
SUR063	27-Oct-95	3	198	269	29	2	25	3	0.11	9.67
SUR065	17-Nov-95	3	90	150	0					
SUR067	15-Dec-95	3	175	290	46	2	22	5	0.16	9.20
SUR069	23-Feb-96	3	147	250	65	3	23	7	0.26	9.29
SUR071	21-Mar-96	3	181	300	24	6	10	3	0.08	8.00
SUR072	12-Jul-96	3	163	285	83	4	25	5	0.29	16.60
SUR074	02-Aug-96	3	120	175	8	2	6	2	0.05	4.00
SUR076	01-Nov-96	4	186	280	18	1	6	5	0.06	3.60
SUR079	10-Mar-97	4	190	270	45	1	16	14	0.17	3.21
SUR080	28-Mar-97	3	152	275	49	1	11	10	0.18	4.90
SUR081	25-Apr-97	4	143	280	36	1	15	6	0.13	6.00
SUR083	27-Jun-97	4	80	150	24	1	7	8	0.16	3.00
SUR084	10-Jul-97	4	209	300	39	1	17	5	0.13	7.80
SUR085	25-Jul-97	3	222	300	21	1	10	5	0.07	4.20
SUR086	08-Aug-97	3	179	300	14	1	4	6	0.05	2.33
SUR087	19-Sep-97	3	160	300	2	2	2	1	0.01	2.00
SUR088	10-Oct-97	3	63	150	0					
SUR089	24-Oct-97	4	189	300	31	2	15	5	0.10	6.20
SUR090	07-Nov-97	3	176	275	10	1	6	3	0.04	3.33
SUR091	21-Nov-97	3	119	150	24	2	17	3	0.16	8.00
SUR092	12-Dec-97	3	154	150	0					
Total			9,256	14,938	1,393	1	36	230		
Mean		3.47	123.41	199.17	18.57	2.69	11.42	3.90	0.12	6.06
std		0.66	46.86	74.08	21.08	2.58	7.62	2.56	0.14	6.15
cv		0.19	0.38	0.37	1.14	0.96	0.67	0.66	1.19	1.01

Table 2. Summary of Florida Bay aerial surveys, March 25, 1995 through December 12, 1997.

Survey No.	Dates	No. of Observers	Dolphin survey Time (min.)	miles (nm)	Total # of dolphins	Min # per herd	Max # per herd	Total herds	# Dolphins per mile (nm)	Mean # per herd
FLABAY001	24-Mar-95	4		686	6	6	6	1	0.01	6.00
FLABAY002	17,27-Apr-95	4		412	49	2	18	8	0.12	6.13
FLABAY003	04,11,18,25-May-95	4		581	9	1	5	3	0.02	3.00
FLABAY004	12,26,29-Jun-95	4		476	19	8	11	2	0.04	9.50
FLABAY005	05,10,25,27-Jul-95	4		588	15	1	4	7	0.03	2.14
FLABAY006	22,23,29,31-Aug-95	4		519	36	1	12	9	0.07	4.00
FLABAY007	18,27-Sep-95	4		320	20	1	10	6	0.06	3.33
FLABAY008	04,05,06,20-Oct-95	4		483	17	1	5	6	0.04	2.83
FLABAY009	06,08,21-Nov-95	4		422	16	1	9	5	0.04	3.20
FLABAY010	04,08-Dec-95	4		399	32	1	5	14	0.08	2.29
FLABAY011	12,29,31-Jan-96	4		478	23	1	7	9	0.05	2.56
FLABAY012	16,22,26-Feb-96	4		383	7	1	3	5	0.02	1.40
FLABAY013	18-Mar-96	4		296	6	2	4	2	0.02	3.00
FLABAY014	11-Apr-96	4		309	1	1	1	1	0.00	1.00
FLABAY015	15-May-96	4		478	2	1	1	2	0.004	1.00
FLABAY016	10-Jun-96	4		157	11	1	2	5	0.07	2.20
FLABAY017	29-Jul-96	4		383	9	1	4	5	0.02	1.80
FLABAY018	26-Aug-96	4		263	3	3	3	1	0.01	3.00
FLABAY019	11-Sep-96	4		360	7	3	4	2	0.02	3.50
FLABAY020	10,23-Oct-96	4		336	0					
FLABAY021	08-Nov-96	4		352	27	1	8	7	0.08	3.86
FLABAY022	06-Dec-96	4		321	2	2	2	1	0.01	2.00
FLABAY023	15,22-Jan-97	4		281	5	2	3	2	0.02	2.50
FLABAY024	20-Feb-97	4		359	3	1	2	2	0.01	1.50
FLABAY025	06,07-Mar-97	4		375	15	1	3	6	0.04	2.50
FLABAY026	17,18-Apr-97	4		318	4	2	2	2	0.01	2.00
FLABAY027	19,20-May-97	4		311	8	2	6	2	0.03	4.00
FLABAY028	17,19-Jun-97	4		306	17	1	4	8	0.06	2.13
FLABAY029	17,18-Jul-97	4		345	31	1	11	6	0.09	5.17
FLABAY030	13,14-Aug-97	4		328	24	1	7	9	0.07	2.67
FLABAY031	11,12-Sep-97	4		285	29	1	8	10	0.10	2.90
FLABAY032	31-Oct-97	4		255	2	2	2	1	0.01	2.00
FLABAY033	10,12-Nov-97	4		349	0					
FLABAY034	10,12-Dec-97	4		329	3	1	2	2	0.01	1.50
Total				12,842	458	1	18	151		
Mean		4.00		377.70	13.47	1.72	5.44	4.72	0.04	3.03
std		0.00		105.84	11.92	1.50	3.79	3.29	0.03	2.59
cv		0.00		0.28	0.88	0.88	0.70	0.70	0.81	0.85

Table 3. Mean herd size, number per survey, and encounter rates of bottlenose dolphin from selected surveys from southeast Florida and Florida Bay. Numbers in parenthesis indicate number of surveys and sd = +/- 1 standard deviation.

	Herd Size		Number per survey		Overall encounter Rates	
This Study	Mean (± sd)	Range # animals	Total	Mean (± sd)	Number per Hour	Number per Nautical Mile (± sd)
Florida Bay (1995-1997)						
Everglades National Park (34)	3.03 ± 2.59	1-18	458	13.47 ± 11.92		0.04 ± 0.03
Southeast Florida (1992-1997)						
Florida Keys (75)	6.06 ± 6.15	1-36	1,393	18.57 ± 21.08	0.002	0.12 ± 0.14
Historical Surveys						
Leatherwood, 1979						
Indian and Banana Rivers, Central Florida (6)	8.20 ± 1.78	1-35	507	84.54 ± 19.34		1.17
Odell, 1979						
Biscayne Bay (22)	9.57 ± 3.11	3-13	67	3.05 ± 4.79	1.68	0.01
Everglades National Park (47)	2.98 ± 0.96	5-98	1,584	34.43 ± 27.95	13.04	0.12
Hansen, 1986						
Offshore Florida Keys (35)	6.43 ± 7.60	1-55	180	5.14 ± 12.06	1.78	
Hansen and Scott, 1989						
Florida Keys (Bays and nearshore)	3.8	1-19	273	2.9		0.09
SE U.S.(84)	4.15 (at 152m altitude) 5.17 (at 229m altitude)					
McClellan, 1996						
Central Florida (12)	4.77 ± 5.94	1-43	129	10.75 ± 12.19		0.06
Contillo et al., 1998						
Boat Survey Biscayne Bay (114)	5.1	1-27	180	1.58	0.32	
Offshore surveys (8)	3.0	1 -14	24	3	0.99	

Table 4. Number of sightings, number of dolphins, mean herd size (+/- sd), distance sampled, and dolphin density per nautical mile (D +/- sd) by season and area surveyed.

Area	Season (# of Surveys)	Herds (# Sightings)	# of Dolphins (N)	Mean Herd Size (± sd)	Distance (nm) Sampled	# Dolphin (per nm D (± sd)	cv N (N per survey	cv D nm per survey)
Florida Keys	Winter (16)	71	365	5.14 ± 4.99	3,565	0.12 ± 0.06	0.97	0.49
	Spring (15)	48	270	5.63 ± 4.96	2,771	0.12 ± 0.08	0.88	0.68
	Summer (24)	63	362	5.75 ± 5.99	4,952	0.08 ± 0.07	1.04	0.83
	Fall (20)	48	396	8.25 ± 8.12	3,650	0.19 ± 0.27	0.98	1.38
	Total (75)	230	1,393		14,938			
	Mean	3.90	18.57	6.06	199.17	0.12		
	SD	2.56	21.08	6.15	74.08	0.14		
	cv	0.66	1.14	1.01	0.37	1.19		

Area	Season (# of Surveys)	Herds (# Sightings)	# of Dolphins (N)	Mean Herd Size (± sd)	Distance (nm) Sampled	# Dolphin (per nm D (± sd)	cv N (N per survey	cv D nm per survey)
Florida Bay	Winter (7)	27	65	2.41 ± 1.57	2,859	0.02 ± 0.02	0.65	0.51
	Spring (9)	33	120	3.64 ± 3.53	3,347	0.04 ± 0.04	0.97	0.76
	Summer (9)	55	174	3.16 ± 2.59	3,390	0.05 ± 0.03	0.82	0.30
	Fall (9)	36	99	2.75 ± 1.95	3,246	0.03 ± 0.03	0.71	0.81
	Total (34)	151	458		12,842			
	Mean	4.72	13.47	3.03	377.70	0.04		
	SD	3.29	11.92	2.59	105.84	0.03		
	cv	0.70	0.88	0.85	0.28	0.81		

Figure 1. Generalized aerial survey effort tracts for a) Florida Keys b) Florida Bay surveys, 1992 - 1997.

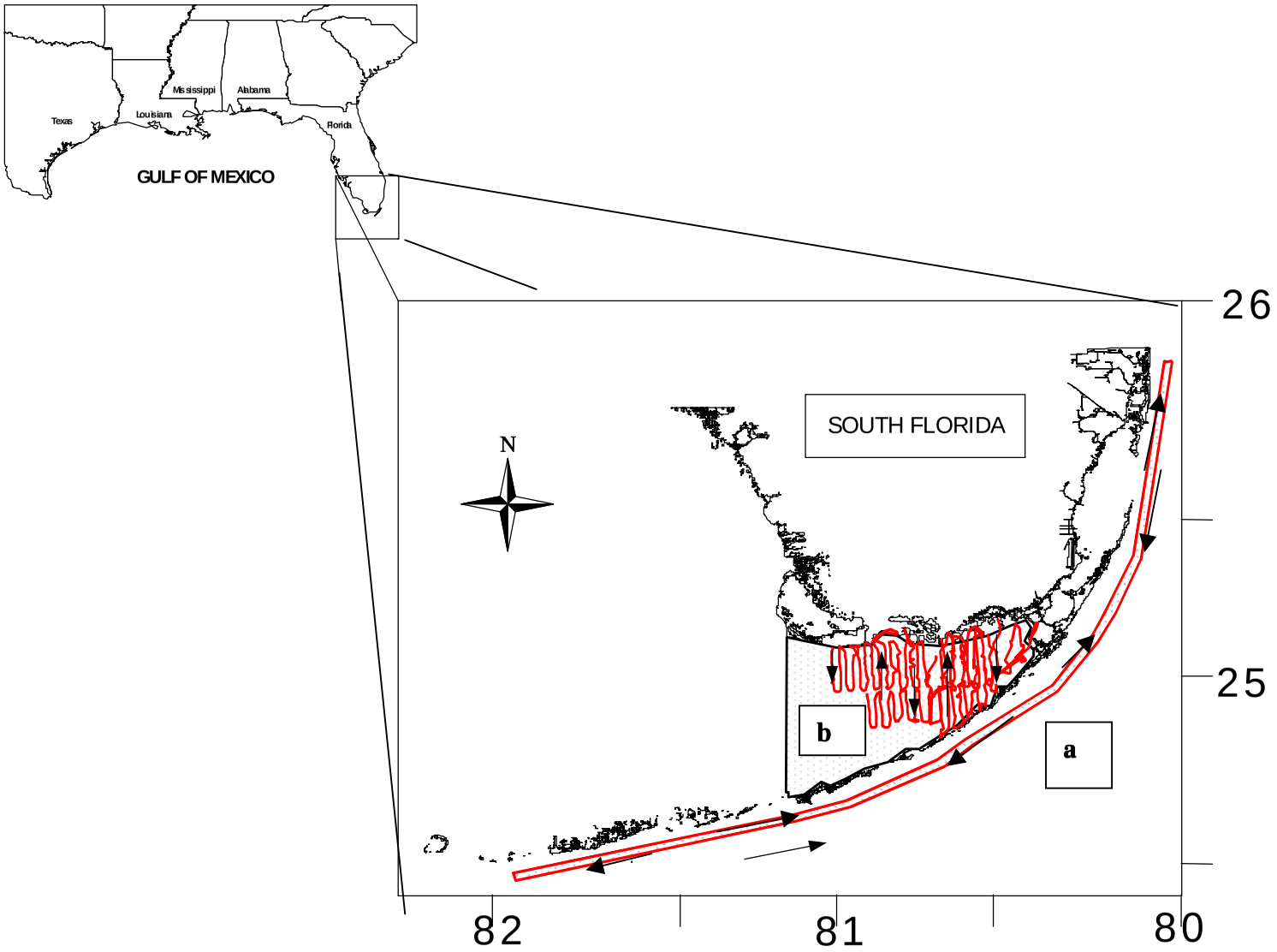

Figure 2. Opportunistic bottlenose dolphin sightings observed during 23 aerial surveys during the Winter months (October through December) in the Florida Keys and Florida Bay. All flights were aboard U.S. Coast Guard aircraft between September 1992 and December 1997.

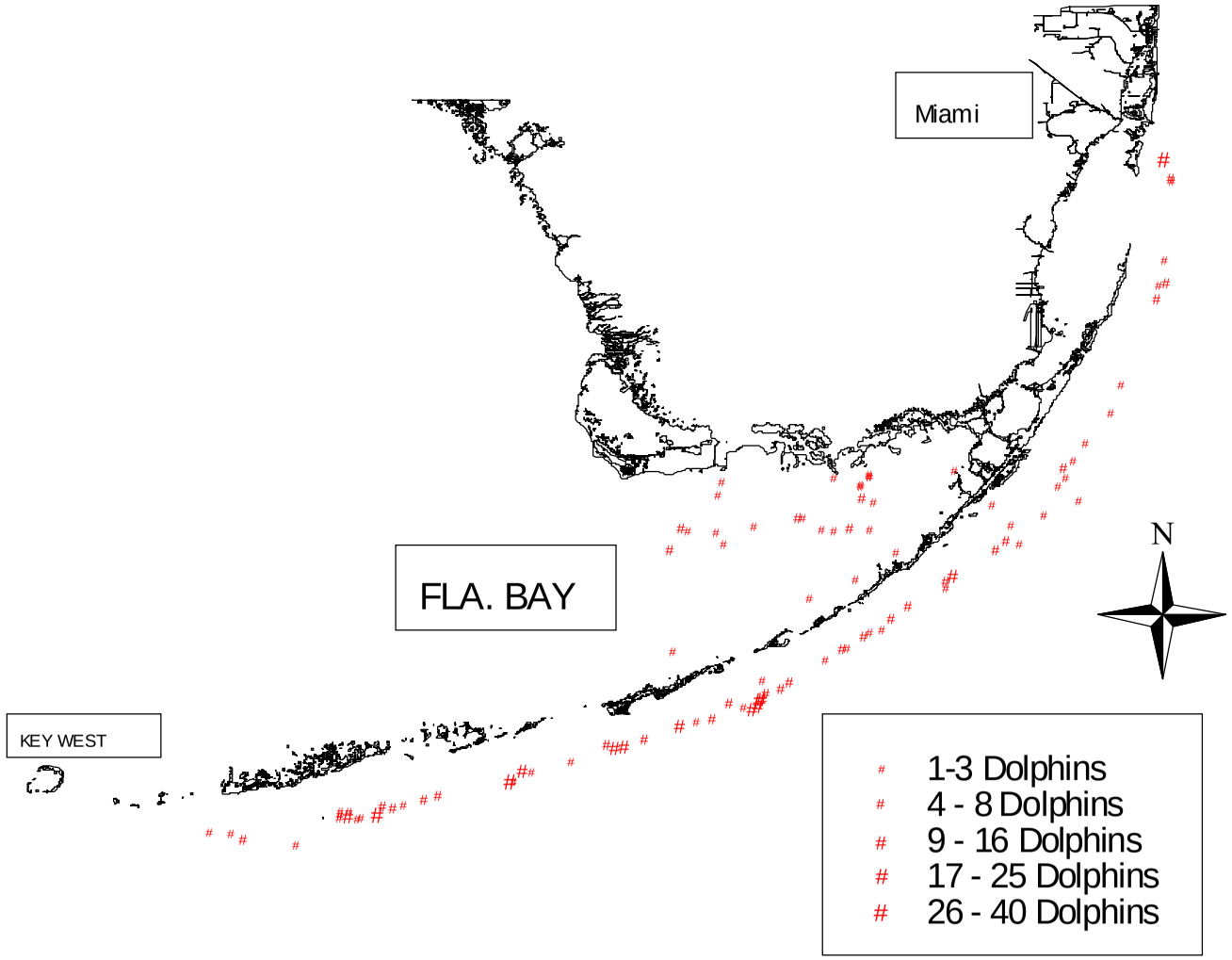

Figure 3. Opportunistic bottlenose dolphin sightings observed during 24 aerial surveys during the Spring months (April through June) in the Florida Keys and Florida Bay. All flights were aboard U.S. Coast Guard aircraft between September 1992 and December 1997.

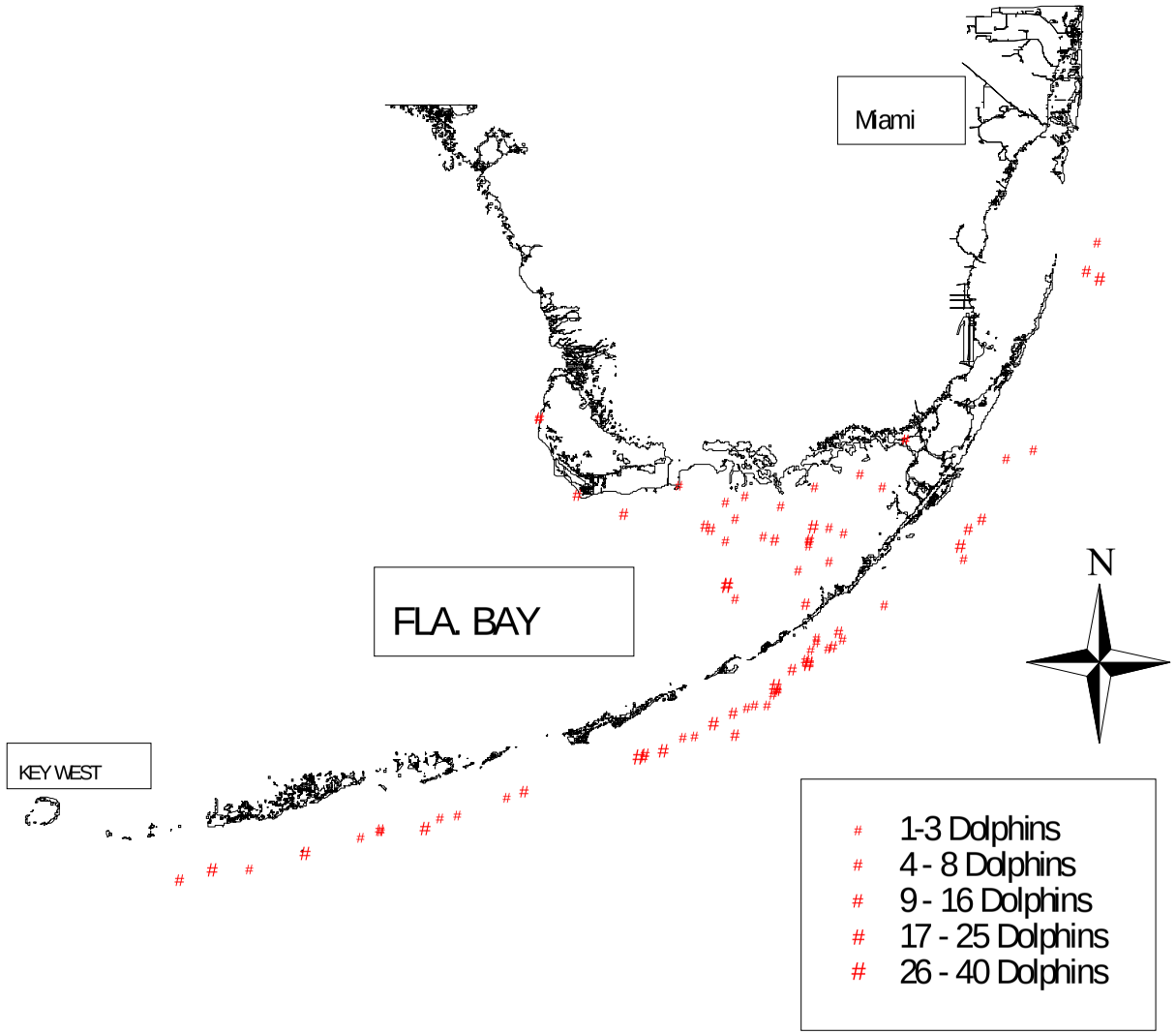

Figure 4. Opportunistic bottlenose dolphin sightings observed during 32 aerial surveys during the Summer months (July through September) in the Florida Keys and Florida Bay. All flights were aboard U.S. Coast Guard aircraft between September 1992 and December 1997.

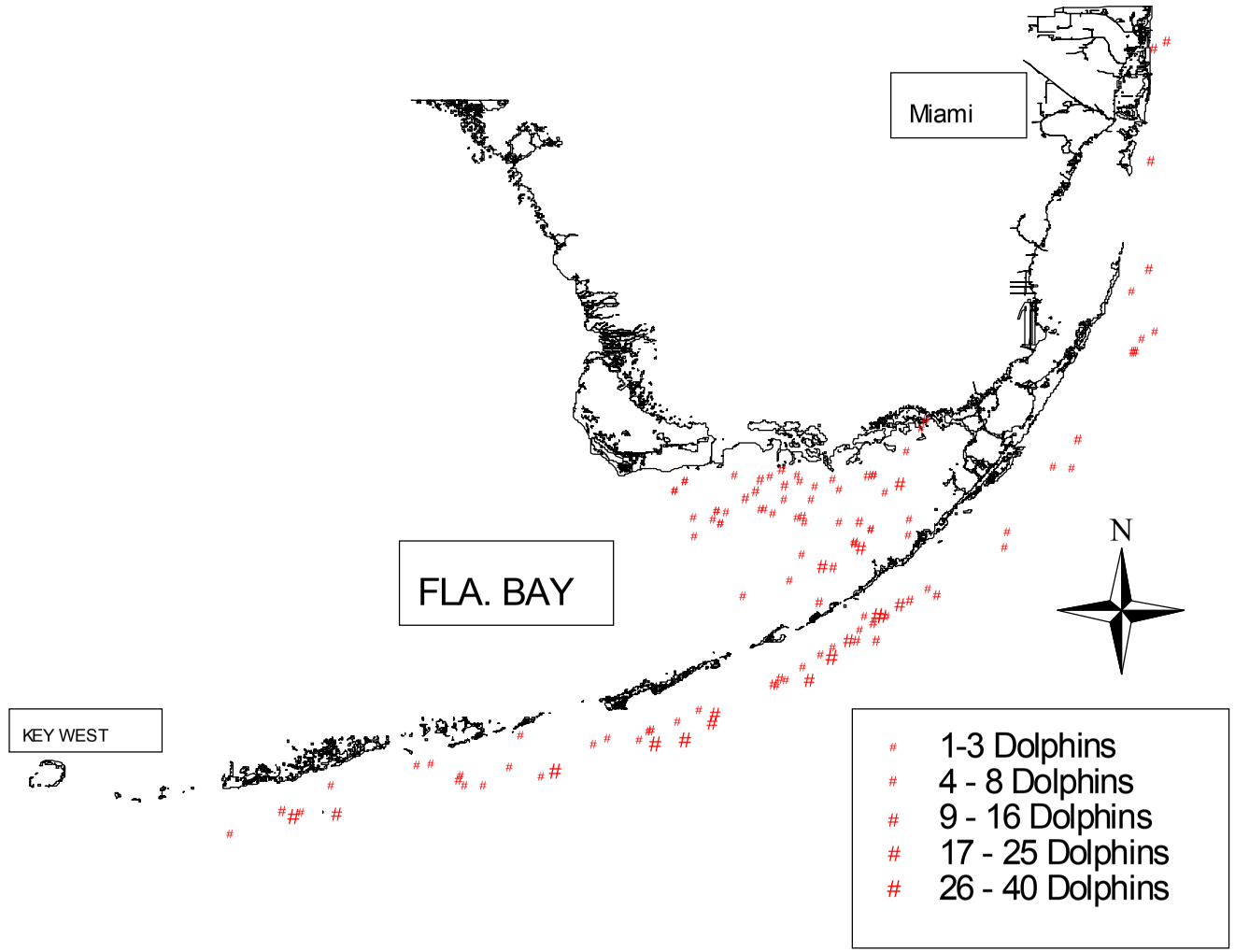

Figure 5. Opportunistic bottlenose dolphin sightings observed during 30 aerial surveys during the Fall months (October through December) in the Florida Keys and Florida Bay. All flights were aboard U.S. Coast Guard aircraft between September 1992 and December 1997.