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AERIAL STUDIES OF THE WEST INDIAN MANATEE (Trichechus manatus) ON THE WEST COAST OF FLORIDA 1990 TECHNICAL REPORT

Submitted to:

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I. INTRODUCTION AND PROBLEM STATEMENT

The West Indian manatee, Trichechus manatus, is an endangered species protected by federal, state, and even some local legislation. Yet, its survival is in jeopardy throughout its range due to high mortality (partially associated with human activity), low reproductive rate, and loss of habitat.

Manatees have attracted considerable interest from scientists, coastal managers and the public in the last decade. However, insufficient data still exist for determination of population trends and sites important to manatees on the west coast of Florida. Aerial survey projects are providing valuable data on habitat use patterns, as well as a measure of manatee abundance within the survey region. These data provide information crucial to management decisions affecting manatee habitat suitability and protection.

This report presents 1990 sighting data for manatees from Anna Maria Sound to northern Charlotte Harbor, including the Myakka River. This work is a continuation of manatee population studies conducted by Mote Marine Laboratory since 1985. The project objectives are to determine the distribution and habitat requirements for manatees in the bays between Anna Maria Sound and northern Charlotte Harbor. Specific goals are outlined as follows:

Year 1. Identify if preferred areas exist.

Years 2-5. Determine variability in preferred-site usage.

Years 6-10. Monitor variability and identify habitat preference determinants.

II. LITERATURE REVIEW

A. Natural History - Taxonomy

The West Indian manatee (Trichechus manatus) is one of four living species of an obscure order of aquatic marine mammals known as Sirenia. Living Sirenians are tropically and subtropically distributed in shallow coastal waters. Three species of manatees exist (West Indian, Trichechus manatus; Amazonian, T. inunguis; and West African, T. senegalensis), as well as the dugong (Dugong dugon). A fifth species, Steller's seacow (Hydrodamalis gigas),

a toothless, ten-meter-long (33 feet), five-ton, kelp-eater from the Bering Sea, was hunted to extinction within twenty-seven years of its discovery in 1741.

Recent studies of skull morphometrics indicate that manatees of the southern U.S. are a subspecies distinct from those of lower latitudes (Domning and Hayek, 1986). This suggests that the deep water and strong currents of the Straits of Florida are effective barriers to gene flow. Thus, while the preferred common name for the species remains the West Indian manatee, the subspecies found in Florida can also correctly be called the Florida manatee (*T. manatus latirostris*).

B. Description

The West Indian manatee is a gentle, somewhat walrus-shaped mammal with a flat, rounded tail. The highly maneuverable forelimbs are paddle-like flippers; hind limbs are absent. Adults range in color from gray to brown; calves are darker at birth and lighten in color at about one month. Adults can reach a length of 4.3 meters (14 feet) but average about 3 meters (9.8 feet) and can weigh up to 1,635 kilograms (3,800 pounds), averaging 360 to 540 kilograms (793 to 1,190 pounds). Females may tend to be larger and heavier than males.

The manatees' thick skin is finely wrinkled, and the outer layer is continually sloughing off, possibly to reduce the build-up of algal and barnacle growth. Two blubber layers are present for insulation: one under the skin and the other beneath the outer muscle layer. Hair is distributed sparsely over the body and may aid in detecting water currents. The skeleton consists of thick, heavy bones which function in buoyancy control.

The bulbous face of the manatee is covered by stiff whiskers. The muscular pads of the upper lip are used to manipulate food into the mouth. The teeth of manatees are continually replaced. The grinding molars form in the back of the jaw, move forward, wear down and eventually fall out. This is an adaptation to the diet of abrasive food which is often mixed with sand and silt. Manatees breathe through a pair of nostrils on the dorsoanterior surface of the snout. The nostrils can be sealed by valves when the animal is underwater. Ear openings, located behind the eyes, are small and lack external openings.

No substantial sexual dimorphism has been documented, although Hartman (1979) describes females as "bulkier". The gender of an animal can be

determined by observation of the ventral surface. The female genital slit is located just anterior to the anus, while the male genital aperture is located further forward, just posterior to the umbilicus.

C. Distribution

The West Indian manatee currently is found from the southern U.S. through the Caribbean Islands, eastern Central America, Colombia, Venezuela, and south to Brazil's northeast coast, as well as in all major island systems of the West Indies. Within the United States, their range is largely confined to the peninsular Florida and Georgia coasts. However, wandering manatees have been sighted as far north as Currituck Sound, Virginia, and as far west as the Rio Grande River. The rare animal found west of the Mississippi probably followed the coast north from Mexican waters.

Manatees that roam beyond Florida in summer and fail to return by winter rarely survive. The West Indian manatee is basically a tropical mammal inhabiting temperate waters and is at risk from winter cold spells. The historical winter range of manatees is thought to be centered in southern Florida, with a few refuges in northern Florida. Over the past thirty years, the construction of power plants and industrial sites has extended the manatees' winter range.

Hartman (1974) estimated a statewide manatee population of 750 to 850 animals, with 1,000 being the conceivable maximum based on limited aerial surveys and interviews with observers. A subsequent attempt (Irvine and Campbell, 1978) to survey the entire state sighted 738 manatees. A total of 853 animals identified by scar patterns is included in the 1985 Manatee Identification Catalog compiled by the USFWS. The "official" current minimum estimate stands at 1,200 manatees (Weigle, 1987). This figure is based on a winter aerial survey of power plants and counts in natural warm water refuges, plus estimates for areas not surveyed.

Thus, it is evident that the population size of manatees is not accurately known and certainly trends cannot be deduced from what is known. Furthermore, manatees are so long-lived and have such a low reproductive rate that it may take years for trends to become evident. Continued and intensified studies are desperately needed in order to assess the status of manatees in Florida.

D. Habitat

The West Indian manatee inhabits freshwater, brackish, and marine environments and can freely move between salinity extremes. They are commonly found in coastal waters, estuaries, rivers, and springs throughout their tropical and subtropical range (Husar, 1977; Hartman, 1979). Water depths of less than 5 meters (16 feet) are preferred, and shallows less than 1 meter (3 feet) are avoided (Powell and Rathbun, 1984; Hartman, 1979). Manatees are frequently sighted over seagrass beds in depths of 1-3 meters (3-9 feet), especially in areas adjacent to deeper waters. High tides are often used to reach otherwise inaccessible vegetation. Water turbidity appears to have little or no effect on manatees, as they are sighted in both clear and muddy waters (Husar, 1977; Hartman, 1979).

Manatee distribution is dependent on water temperatures and their range is limited by seasonally cold weather (Husar, 1977; Hartman, 1974, 1979). Manatees have a high thermal conductance (117 to 229% of predicted weight-specific values) and a very low metabolic rate (15-22% of weight-specific values) and are thus poorly adapted to winter water temperatures in much of Florida (Irvine, 1983). The minimum suitable water temperature appears to be about 20°C (68°F). When temperatures begin to fall below this, manatees migrate toward sources of warm water. Winter manatee aggregations center around twenty-four warm-water sources; six are natural, and the remainder are discharges from power plants and industrial sites (Hartman, 1974). On the west coast of Florida important winter aggregation sites include the headwaters of the Homosassa and Crystal Rivers, the Crystal River and the Bartow Power Plant (Florida Power Corp.), Big Bend Generating Plant (Tampa Electric Co.), and the Fort Myers Power Plant (Florida Power and Light Co.).

Apparently not all manatees take shelter in the warm-water refuges. The maximum number of manatees counted around power plants after passage of a cold front is 804 (Reynolds, 1988). The activity of manatees that do not use warm-water refuges is unknown. Some manatees may take refuge in areas where temperatures are less extreme, such as offshore waters, the center of large bays, or in rivers (Hartman, 1974). Deaths attributed to cold mainly involve late juvenile and sub-adult age classes, which may be inexperienced at utilizing thermal refuges (O'Shea et al., 1985).

Recent unpublished data from the Florida Department of Natural Resources describe two types of cold-induced mortalities. The first is sudden hypothermia with the animals becoming lethargic then dying, often with full stomachs. The second is chronic cold-stress evidenced by depleted blubber layers and empty stomachs.

E. Feeding

Manatees are essentially herbivorous, feeding on a wide variety of submerged, floating and emergent plants. Adults feed six to eight hours a day, usually in sessions of one to two hours (Hartman, 1971; Applied Biology, Inc., 1977) and may consume approximately 8% of their body weight daily (Best, 1981). Along with the vascular plants, amounts of associated algae are also consumed as well as insect larvae, amphipods, mollusks, crustaceans, and other invertebrates which may supply substantial amounts of protein (Hartman, 1971; Husar, 1974). Calves begin eating vegetation long before they are weaned, but feeding sessions are shorter (about 30 minutes) and less concentrated.

Plants are manipulated into the mouth by the heavily bristled fleshy upper lip pads. The flippers may also be used in guiding food toward the mouth. The orientation of the manatee's mouth seems to be particularly adapted to grazing on bottom vegetation (Domning, 1980). Examination of stomach contents shows that food is well chewed by the grinding molars. During feeding sessions, the chewing rate (two chews per second) is interrupted only for respiration (every 1-5 minutes). As animals become sated, short rests may be interspersed with eating, until finally feeding is halted and the animal moves away.

Manatees feed in depths of 0.5 to 4.0 meters and are often observed at the edge of grassbeds, possibly allowing a quick escape to deeper water if the animal is disturbed. Manatees are generally selective in their choice of feeding sites and reportedly return to the same areas for long periods of time, suggesting that they have preferred feeding sites (Hartman, 1979).

F. Reproduction

Hartman (1979) describes the manatee as a mildly social but essentially solitary animal. Other than the firm association between mother and calf, the

only stable grouping is that of a mating herd of manatees. These groups may remain together for periods of a week to over a month, centered around a single estrous female. The fleeing cow is relentlessly pursued by as many as seventeen courting bulls that constantly attempt to mouth and embrace her. When she is finally receptive, the cow is promiscuous, allowing several males to copulate with her in a ventral-to-ventral position (Hartman, 1971, 1979).

Manatees appear to lack a specific breeding season, as calves are born throughout the year. Manatees have a low reproductive rate; the gestation period is approximately 13 months, with one calf being produced only every three to five years (Hartman, 1971, 1979; Husar, 1977). Twins occasionally occur, although twin survival rates are unknown. It has been reported that females may at times care for orphaned calves (Hartman, 1979). Newborn calves are 1.0 to 1.4 meters in length (3.3 to 4.5 feet) and weigh about 30 kilograms (66 pounds) (Odell, 1982).

Beginning immediately after birth, the mother repeatedly assists her calf to the surface with her flippers or back, allows it to breathe, and then lowers it until a rhythm is established. Newborns swim using only their flippers, and learn to use their tail several days later (Barbour, 1937; Moore, 1957).

Calves remain dependent on their mothers for up to two years, although they may remain in contact for long periods beyond weaning. This may enhance survival rates by allowing them to learn migration routes, the locations of feeding grounds and winter refuges (O'Shea and Shane, 1985). Suckling occurs underwater when the female is suspended at the surface or lying on the bottom. Calves grasp the teat (located under each flipper) and suckle for up to two minutes. Calves begin grazing a few weeks after birth and, as they mature, alternate grazing and suckling, becoming less and less dependent on milk (Hartman, 1971, 1979; Husar, 1977).

G. Social Interactions

Manatees are not territorial or aggressive, and no social hierarchy has been recognized. With the exceptions noted above (cow-calf pairs and mating herds), groups are ephemeral, casually forming and dispersing without regard to age or sex. Animals come together to cavort, rest, migrate, or feed, and groups exhibit social facilitation (i.e., animals within a group usually partake in the

same activity). Individuals may remain with a group for periods of a few minutes to as long as a few days (Hartman, 1979). No mechanisms for social group cohesion (i.e., stereotyped greeting rituals) have been reported (USFWS, 1979 Report).

Social contacts include mouthing, nuzzling, bumping, embracing, chasing and "kissing". Hartman (1979) believes these interactions to be a type of play that both provides pleasurable tactile sensation and serves to solidify rudimentary social bonds. Play appears to occur only when the animals are fed, rested, and free of environmental pressures (i.e., human harassment). No signs of irritability have been detected even in extremely crowded conditions during cold spell congregations (Moore, 1956).

H. Mortality Factors

In 1974, a manatee carcass salvage program was initiated by the U.S. Fish and Wildlife Service to document causes of manatee deaths in Florida. The objectives for the program include collecting biological information from the carcasses, determining cause of death, noting seasonal and geographic trends in the data, and summarizing cause of death data. The Florida Department of Natural Resources (FDNR) took over the responsibility in 1985 and publishes monthly and yearly summaries of mortality data. Cause of death categories are based on probable circumstances at death (Bonde et al., 1983). The USFWS and FDNR have developed seven categories (under modification in 1990):

Boat/Barge Collision: Deaths attributed to collisions with boats or barges exhibited through massive trauma (gashes, cuts, internal damage) or resulting in a blow causing unconsciousness and subsequent drowning. Further differentiation of the boat kills as propellor- or impact-induced is the primary change for 1990.

Crushed/Drowned in Floodgate or Canal Lock: Death resulting from entrapment in gates of navigation locks or flood control dams.

Other Human Related: Miscellaneous human-caused mortalities including animals shot by vandals, poaching, entanglement (fishing

nets, crab trap lines, etc.), ingestion of or infection from monofilament fishing line and hooks, and so on.

Perinatal (<150 cm): Deaths as a result of separation from the mother, stillbirths and neonates, or young deceased animals of undetermined causes. If a positive cause of death can be determined, the calf is tallied in that category.

Other Natural: Deaths involving disease, starvation, cold-induced mortalities, or reproductive complications.

Undetermined: Cause of death cannot be determined from the necropsy often due to extreme decomposition of the carcass.

Verified, Not Recovered: Reports of dead manatees that were verified but not recovered by the necropsy team.

I. Legal Status

Concern for the fate of the manatee has been expressed since the 1700's when the English established Florida as a manatee sanctuary. Despite this concern, numbers continued to decline and imminent extinction was predicted by writers in the late 1800's (Campbell and Powell, 1976). In 1893, a Florida law was enacted to protect manatees and in 1907 a Florida statute (Ch. 370.12) was passed imposing a $500 fine and/or a six month prison sentence on anyone caught molesting or killing a manatee.

In 1969, under the Federal Endangered Species Conservation Act, the manatee was listed as an "endangered species" by the Department of the Interior. This protection was reaffirmed in the Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973. This legislation levies up to a $20,000 fine and/or a one year prison sentence upon anyone who knowingly attempts to "harass, harm, pursue, hunt, shoot, wound, kill, capture, or collect endangered species". Administration of the law is the responsibility of the U.S. Fish and Wildlife Service in cooperation with state agencies.

III. STUDY DESIGN

A. Field Methods

Figure 1 illustrates the aerial survey location on the west coast of Florida, showing the boundaries of the northern and southern regions. Flight parameters are itemized in Table 1. Each survey is designated by a letter and consists of one north and one south field survey. Flight paths are shown in Figure 2a-g and illustrate a general approach to censusing all open water areas. Typically, many overlapping circuits are required.

Flights were conducted at 80-90 knots at an altitude of 150 m, using either a Cessna 172 or a Cessna 150, both high wing aircraft. Bays were surveyed starting at the north end of the survey area and working south (Figure 2a-g).

The Gulf beaches and the Myakka River were surveyed from south to north. Flights were postponed if: 1) wind speed or gusts exceeded 15 mph; 2) Visual Flight Rules (VFR) were not in effect; 3) severe weather was forecast or encountered for the observation period; or 4) sighting conditions (combined water clarity and surface conditions) were too adverse.

A primary observer (with at least 25 hours of aerial survey experience) occupied the right front seat. Secondary observers occasionally occupied the rear seats. All sightings were logged, with appropriate notations if the primary observer did not make the initial sighting. Photographic records were made of any animals with scar patterns that might be recognizable in the future (these data are not covered in this report).

Once sighted, herds were circled until all data to be recorded could be verified. The location, number and life stage (adult or calf) were recorded on standardized map sets. Manatee locations were indicated on the maps by a "T.m." with a dot (if the herd was stationary) or a directional arrow (showing direction of movement). The number of animals in the herd was recorded next to the "T.m.", as was the initial time of the sighting and the numbers of any photos taken.

Additional data recorded for each page of the map set included: date of survey, beginning and end times, water clarity, surface conditions, number of adults, number of calves, and total number of manatees sighted. For the purpose

of this study, calves were defined as one-half the length (or less) of accompanying adults.

Water clarity was estimated from the air for each sub-region according to the following scheme:

1.	Excellent	greater than 3 meters
2.	Good	2 to 3 meters
3.	Fair	3/4 to 2 meters
4.	Poor	1/4 to 3/4 meters
5.	Bad	less than 1/4 meter

Surface conditions were classified according to the scale presented in Table 2. Incidental sightings of sea turtles (Caretta caretta) and bottlenose dolphins (Tursiops truncatus) were also noted but are not discussed in this report.

Monthly water temperatures for north Sarasota Bay were provided by the Manatee County Public Health Department in northern Sarasota Bay. Monthly temperatures for the southern survey region were supplied by the U.S. Geologic Survey in Tampa, Florida. The data used were collected at a station near Hog Island at the mouth of the Peace River.

It is important to note that each survey represents a measurement of manatee abundance for that flight only. It is assumed that many of the same manatees are recounted on subsequent flights. The total number of manatees seen in 1990 is a summation of sightings recorded for each individual survey, and does not represent an estimate of the total manatee population for the survey area.

Presumably, not all manatees are sighted on a survey due to less than optimal water clarity and surface conditions occurring in the area. However, consistent application of established and broadly-accepted methodology provides for comparison between surveys. Thus, what is presented is a relative measure of minimum manatee abundance.

B. Laboratory Methods

1. Sightings

For this report the survey area was divided into twelve sectors (Figure 3a-b) as described in Nabor and Patton (1989). The northern region was

comprised of sectors I-VII and the southern region consisted of sectors VIII-XII.

The numbers of individual manatees for each monthly flight were graphed to express abundance and seasonal distribution throughout the total survey area and they were graphed separately for the northern and southern survey areas.

Numbers of individual manatees sighted in each sector were graphed to illustrate regional distribution throughout the study period. Also, they were graphed for each sector by month to show regional distribution throughout the year.

The data regarding calves were tabulated as percent of total manatee sightings for each month and season for illustration of seasonal distribution throughout the entire survey area and separately for the northern and southern survey areas. Regional distribution of calves was described by calculating the percentage of total found in each sector and by graphing the number of calves sighted in each sector for each month.

Regional distribution for total number of manatees and for calves also is presented using the regional indices described in Nabor and Patton (1989). These indices are based on a calculation of survey effort determined by the number of "visits" made to each sector and in each month to yeild a Total Survey Effort (T.S.E.). To measure abundance and distribution with these indices, the number of manatees sighted in each sector is divided by the T.S.E. for that variable. Comparisons with data presented in previous years are made.

2. Herds

The herd, which represents one or more manatees, sizes of manatee sighting events were tabulated and the percent of animals in each size herd graphed to depict the herd-size distributions for all of the collected data. The average number of manatees per herd was determined by month and sector.

The calf-mother pairs are separated from the other adults in order to show the influence of these pair bonds on herds of more than one animal. In determining the number of calf-mother pairs, one adult from each herd was designated a "mother" for each calf in that group. This tactic assumes a 1:1 calf-mother ratio with no orphaned or adopted calves. Unless distinctly obvious as a lone adult with two calves, it was also assumed there were no twins.

3. Movements

Manatee movement trends were examined through vector analysis of the number of occurrences recorded for manatees moving in a given compass direction. Each set of observations for a given direction is plotted as the magnitude in that direction, and subsequent data are plotted as direction and magnitude vectors connected to the end point of the latest plotted data set. The result is a net displacement from the origin. A random directional distribution would produce a small (near zero) net displacement, while a skewed distribution would produce a net displacement proportionately large for the magnitudes of component vectors. In order to compare vector plots consisting of unequal numbers of directional sighting records, a directional "Factor" was calculated by dividing the net displacement by the average value for the vectors represented.

4. Behavior

Some of the manatees displayed distinct and recognizable behaviors. When a behavior was markedly noticeable, it was recorded. These behaviors included: feeding, traveling, resting/basking, milling, mating, and playing. Behaviors of both calves and adults were noted when observable.

5. Mortality

Manatee mortality factors in Sarasota County for 1982-1990 were provided by the Florida Marine Research Institute, St. Petersburg, Florida.

IV. RESULTS AND DISCUSSION

SIGHTINGS

A. Cumulative Totals

Table 1 shows and manatee counts for each flight during 1990. The January flight was not conducted due to poor weather conditions. The 1990 data collection terminated with November due to funding constraints. Both the northern and southern survey areas were flown ten times, once per month. Gasparilla Sound (Sector X) and the Myakka River (Sector XII) were flown only nine times because of poor weather conditions. The cumulative number of

sightings recorded was 315 with 587 animals for ten aerial surveys and 82.7 survey hours yielding 7.1 animals per survey hour. The largest number of manatees recorded for a single survey was 78 manatees in November. The fewest number of manatees sighted was 34 in May. [The January and December surveys were not flown when normally there would be few if any animals in the study area (Patton, 1986)]. The average number seen per survey was 59 manatees. This average is greater than that recorded for previous years (Nabor and Patton, 1989; Morgan and Patton, 1990). The number of manatees sighted in the northern survey was 203 and 384 were recorded for the southern survey (averaging 20 and 38 per survey, respectively). This proportion of sightings between the north (34%) and south (66%) survey areas is similar to that seen in 1989 (Morgan and Patton, 1990). Only seven individuals were seen in the near-shore coastal Gulf of Mexico (1.2%). Calves comprised 12.9% of the cumulative count, a somewhat higher percentage than reported for 1985-1988 (Nabor and Patton, 1989) and 1989 (Morgan and Patton, 1990). Calves are discussed in more detail in a separate section of this report.

B. Locations

Sighting locations are shown in Figure 4a-g. Manatees were well distributed over the survey area with the exception of the western shore of Sarasota Bay and the Venice Inlet area. Manatees were recorded for 50% and 70% of the flights to Anna Maria Sound and Palma Sola Bay, respectively. Manatees were seen during 80% of the flights in north Sarasota Bay (Manatee County). For all but one of the flights in this area they were seen exclusively around Sister and Jewfish Keys, and/or the Buttonwood Harbor area. Animals were present in south Sarasota Bay for every flight except February's, with the most frequent sightings in Pansy Bayou and the grass flats between City Island and St. Armands Key (50% and 60% of all flights, respectively). North and south Lemon Bay contained manatees during all of the flights, as did the Turtle Bay area and the Myakka River. These areas of consistent use support patterns described in MML's previous surveys from 1985 to 1988 (Nabor and Patton, 1989) and 1989 (Morgan and Patton, 1990). Four exceptions include a decrease in sightings in a site on the northeast side of the Manatee Avenue Bridge in Anna Maria Sound and fewer sightings in the Venice area, Midnight Pass area, and Forked Creek as compared

to the data compiled in Nabor and Patton's report (1989). Particularly noteworthy are the smaller localized areas of regular and recurring use seen in north and south Sarasota Bay. Manatees were concentrated in the Jewfish/Sister Key and Buttonwood Harbor area of Manatee County to a greater extent than in previous years. The Pansy Bayou/City Island/St. Armand's Key area continues to function as a preferred habitat for manatees in south Sarasota Bay.

C. Seasonal Distribution

Figure 5 demonstrates the seasonal distribution of manatees in the study area, shown as total numbers per month. Manatees were present in all months sampled and, described in this manner, were most abundant in June, July and November. Numbers recorded for other months varied considerably. These seasonal trends are comparable to those reported in Nabor and Patton (1989), with the exception that manatees were more abundant during February, March and April in 1990. In addition, there was some evidence of a secondary peak in November, 1990.

Figure 6a-b shows monthly sightings for the northern and southern regions of the survey. Manatees were seen infrequently in the northern region during the winter and early spring, while counts were abundant in the southern region at the same time. Sightings in the north began to increase in May and by June became fairly common. Concurrently, manatees were common throughout the year in the southern region with the exception of May, August, and October. These low counts may be largely a function of poor weather conditions resulting in limited visibility, particularly in north Charlotte Harbor and the Myakka River.

A possible scenario to explain the seasonal trends during 1990 involves comparison to water temperature patterns (Figure 7). Water temperatures were lower in the northern survey region for January and February than they were in the southern region. During February, manatee abundance in the north was very low, yet it was high in the southern region, at which time temperatures there remained favorable. However, although water temperatures were similar in both survey areas during April, manatee abundance in the north remained low during that month. During the rest of the year (except September) water temperatures were higher in the southern survey area than those in the north, although the water was sufficiently warm enough to support manatees, as evidenced by

sightings in both northern and southern regions. There may have been an earlier temperature drop in the fall for the southern survey area as compared to the north, which could explain the greater number of manatees sighted in November and October in the north than in the south. However, the temperature data are insufficient to solidify such a conclusion. Other factors such as rainfall and vegetation or a weak understanding of migration could be affecting seasonal distribution.

D. Regional Distribution

Figure 8a-j illustrates the number of manatees sighted in each sector for each month. Manatee sightings were at a minimum in the north (Sectors I-VII) during February, March and April, the majority occurring in the southern region, particularly sectors XI and XII (Turtle Bay and the Myakka River) and to a lesser extent in sectors VIII and IX (Lemon Bay). In May, manatees began moving back into the northern region, and were fairly well dispersed throughout the entire area. At this time water temperatures became comparable between the survey areas, and there appeared to be movement between, and in and out of the northern and southern regions for the rest of the year.

Areas of highest abundance during the colder months of February, March, and April included Lemon Bay (sectors XIII and IX), Turtle Bay and upper Charlotte Harbor (sector XI), and the Myakka River (sector XII). These areas also tended to experience high counts throughout the warmer months of the year except in May, August, and October. Manatees were sighted throughout the northern region during the warm months, particularly in sectors III, IV, and V, which include Jewfish and Sister Keys, Buttonwood Harbor, and the seagrass beds around City Island, Lido Key, and St. Armand's Key, as well as Pansy Bayou. Manatees were well represented in Anna Maria Sound and Palma Sola Bay (sectors I and II) from August through November. However, there appears to be a lot of movement within the northern region, as well as between the northern and southern regions.

The monthly data were combined in Figure 9 to give a regional index of manatee sightings (number of manatees sighted in a sector per total survey effort for that sector). This presentation depicts the gross usage patterns for the entire survey area. Notable are the numbers in south Sarasota Bay,

which includes City Island/Lido/St. Armands seagrass beds and Pansy Bayou (sector V), north and south Lemon Bay (sectors VIII and IX) and especially the Gasparilla Sound-Cape Haze Aquatic Preserve area (XI) and Myakka River (XII). This repeats the findings in Morgan and Patton (1990) with slightly fewer manatees/TSE in Sector XI, and in Nabor and Patton (1989) with less emphasis on north Sarasota Bay (sector III). More frequent usage of sector V was apparent in 1990, as well as in 1989 (Morgan and Patton, 1990) than in previous years (Nabor and Patton 1989).

E. Calves

Manatees are believed to lack a specific breeding season, and manatees are born at any time of the year (Hartman, 1979; Husar, 1977). Of all manatees sighted, 12.9% were calves. In the northern region, 15.3% of manatees sighted were calves, and 11.7% of sightings in the southern region were calves. These percentages are higher than those tabulated in previous years (Nabor and Patton, 1989; Morgan and Patton, 1990).

Figure 10 shows the percentage of calves sighted in each month. Fluctuations between most months are fairly small with the greatest percentage present in May and November. The least number of calves was recorded in February. At this level of analysis, no obvious breeding season can be detected. These results are similar to previous reports (Nabor and Patton, 1989; Morgan and Patton, 1990) but the spring elevation in calf numbers is not nearly as strong. The exact timing of the appearance of calves, as well as adults, presumably will vary year to year, depending on water temperature patterns and other environmental factors not yet understood.

When the data are separated for the northern and southern regions (Figure 11a-b), greater fluctuations in monthly calf percentages are evident. In February and March, there were no calves sighted in the north. The largest percentage of calves occurred in May, followed closely by July, October and November. In the southern region, no calves were sighted in October. The greatest percentages of calves occurred in March and June.

A comparison of calf percentages by season is demonstrated in Figure 12. Seasons were defined as follows: winter consists of February and March; spring

comprises April, May, and June; summer comprises July, August, and September; fall consists of October and November. The largest percentage of calves for 1990 were seen in the spring and fall. This supports the trend reported in Nabor and Patton (1989). However, it is important to note that, along with possible sighting discrepancies between observers, immigration and emigration may also be affecting the data. Therefore, it cannot be concluded that a breeding period peak exists in the spring but only that the percentage of calves sighted appears to be highest in spring for manatees within the boundaries of the survey area.

Figure 13a-b shows the calf percentages by season for the northern and southern survey regions. These trends may provide further evidence that immigration and emigration movements influence the percentage of calves by season. In the northern survey area, the largest percentage of calves was sighted in the fall, and no spring percentage peak occurred. Conversely, the percentage of calves in fall for the southern survey was lower than that for both summer and spring. It appears that the spring and fall peaks occurring for the overall survey area may be a function of seasonal distribution rather than indicative of a definite calving period.

The number of calves per total survey effort by sector (regional index) is demonstrated by Figure 14. By far, the greatest number of calf sightings occurred in the Gasparilla Sound-Cape Haze (sector XI) and the Myakka River (sector XII), and to a lesser degree in the City Island/Pansy Bayou area of Sarasota Bay (sector V) and in north Lemon Bay (sector VIII). These areas may be functioning as nursery grounds for manatees within the survey area. These results are comparable to those reported in previous years (Nabor and Patton, 1989; Morgan and Patton, 1990) except that there were more calf sightings in the Myakka River. In addition, more calves were recorded in sectors II, III, and IV than in previous years (Nabor and Patton, 1989; Morgan and Patton, 1990).

Figure 15a-j illustrates the number of calves seen in each sector for each month. In the winter months of February and March, calves were present only in the southern survey area sectors VIII, XI, and XII. Calves appeared in the northern survey area in April and May (exclusively in sector V), after which they were dispersed over the entire survey area for the rest of the year with the exception of October when none were spotted in the south. The highest

numbers of calves occurred in sector V in May and in sector XII in June and July. (It should be noted that sector XII was aborted in August due to an afternoon thunderstorm).

HERDS

In 1990, 315 herds (one or more manatees) were sighted. Herd size ranged from 1-13 individuals. The average herd size was 1.86 animals. This value is smaller than that calculated in previous years (Nabor and Patton, 1989; Morgan and Patton, 1990). If the mother-calf pairs are considered as one individual rather than two, the average herd size is 1.62 individuals. Of all the herds, 35.2% were seen in the northern region of the surveys, while 64.8% were sighted in the southern region. This proportion between the north and south survey area herd sightings is comparable to that reported in 1989 (Morgan and Patton, 1990). Herd size distribution as percent of total herds for each size herd is illustrated by Figure 16. Groups of four or fewer manatees accounted for 93.0% of the sightings and 74.8% of the individuals. Herds of solitary manatees comprised 58.4% of the herds sighted and 31.3% of the individuals. A fairly large percentage of the animals was spotted in groups of two (27.6%). Mother and calf associations comprised 55.5% of these pairs. Therefore, only 12.3% of the individuals were interacting in herds of two for reasons other than calf-mother associations. A herd size of five or more accounted for only 7.0% of all herd sightings. These results are comparable to those reported in various studies (Hartman, 1979; Odell, 1979; Irvine et al., 1981; Patton, 1980, 1987, and Patton et al., 1987).

Average herd size for each month is shown in Figure 17. Above average values for February and April indicate that migratory aggregations may have occurred during these months. The higher values in June and July are evidence of increased local manatee usage during the summer season and a subsequent increase in the number of mating herds.

Data on average herd size per sector (Figure 18) show that quite a bit of variation occurred on a regional basis. In the north, sectors III and IV are above the average for all data. The greatest number of manatees per herd occurred in sector VII, where the small number of sightings there tended to represent large herds. Sector V had many sightings, but the manatees were

primarily in small groups of one or two animals rather than large herds. In the southern survey section, sectors VIII, XI, and XII experienced herd sizes greater than average.

MOVEMENTS

A direction of movement was recorded for 29% of the manatee sightings. The data are summarized in a series of vector analysis diagrams (Figure 19). The factor in the vector analyses for all data is slightly greater than one, indicating strong movement to the east-northeast which may be a result of the manatees moving toward fresh water sources. When the data are analyzed separately by season, no substantial seasonal component is revealed.

BEHAVIOR

When behaviors of the manatees were markedly noticeable, they were recorded. These behaviors were plotted on pie graphs to show the proportion of time spent in various activities (Figure 20). The most common identifiable behavior in all animals is traveling with 44% of all observations. Other frequent behaviors include a large number of animals (35%) observed feeding and a smaller number (13%) were resting. The observed behaviors of mother-calf pairs are similar to that of other adult manatees.

MORTALITY

Recent manatee mortality data for Sarasota County are depicted by Figure 21. Human activities, especially boat and barge operation, have a strong detrimental effect on manatees. Thirty-eight percent of manatee deaths between 1987 and September of 1990 were attributed directly to boat collisions. Recreational and commercial boat use is increasing as the human population on Florida's coast continues to expand. Reynolds and Gluckman (1988) relate that essentially all manatees are scarred from boat propellers (except for calves and some rare adults), many with multiple scar patterns. This suggests a very high injury rate.

Florida's human population growth is also diminishing the capacity of the coastal habitat to support manatees. Seagrass habitats, essential feeding area for manatees, have been impacted statewide by dredging, pollution, debris, turbidity, and siltation. Data provided by this report reiterate and strengthen the recommendations outlined by MML in 1989 for stringent management of the identified prime habitats of Florida's west coast manatees.

V. ACKNOWLEDGEMENTS

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Special acknowledgements go to our dedicated pilots. Sincere thanks to Francesann Logan and Victoria Devine for typing the tables and revising the manuscript. Additional thanks to all of the others who have helped along the way: survey participants, laboratory staff and interns, (especially Angie Dukeman), and personnel at both Sarasota and Venice airports.

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VII. LIST OF PARTICIPANTS

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Chris Stone
Lori Olives
Con Halton
Dawn Bobbit
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Jenny Sahagen

PILOTS

Rolland Freeman
Ron Gilbert
Greg Huffman
Bill Saxleby
Scott Sorenson
John Martens
Don Hatton

APPENDIX 1: FIGURES

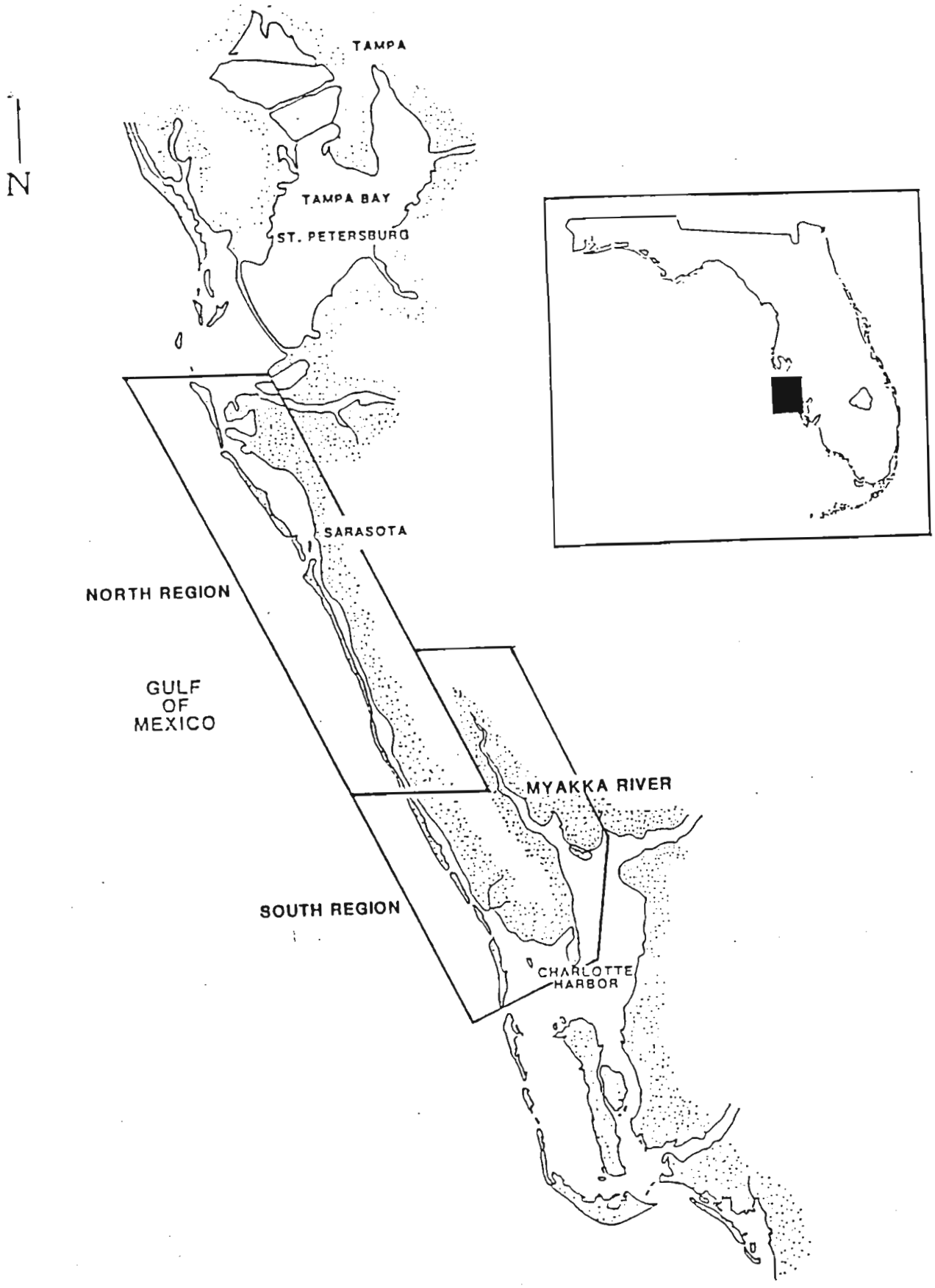

Figure 1. Location of the Study Area, Showing Division into North and South Regions.

Figure 2a. Aerial survey flight patterns.

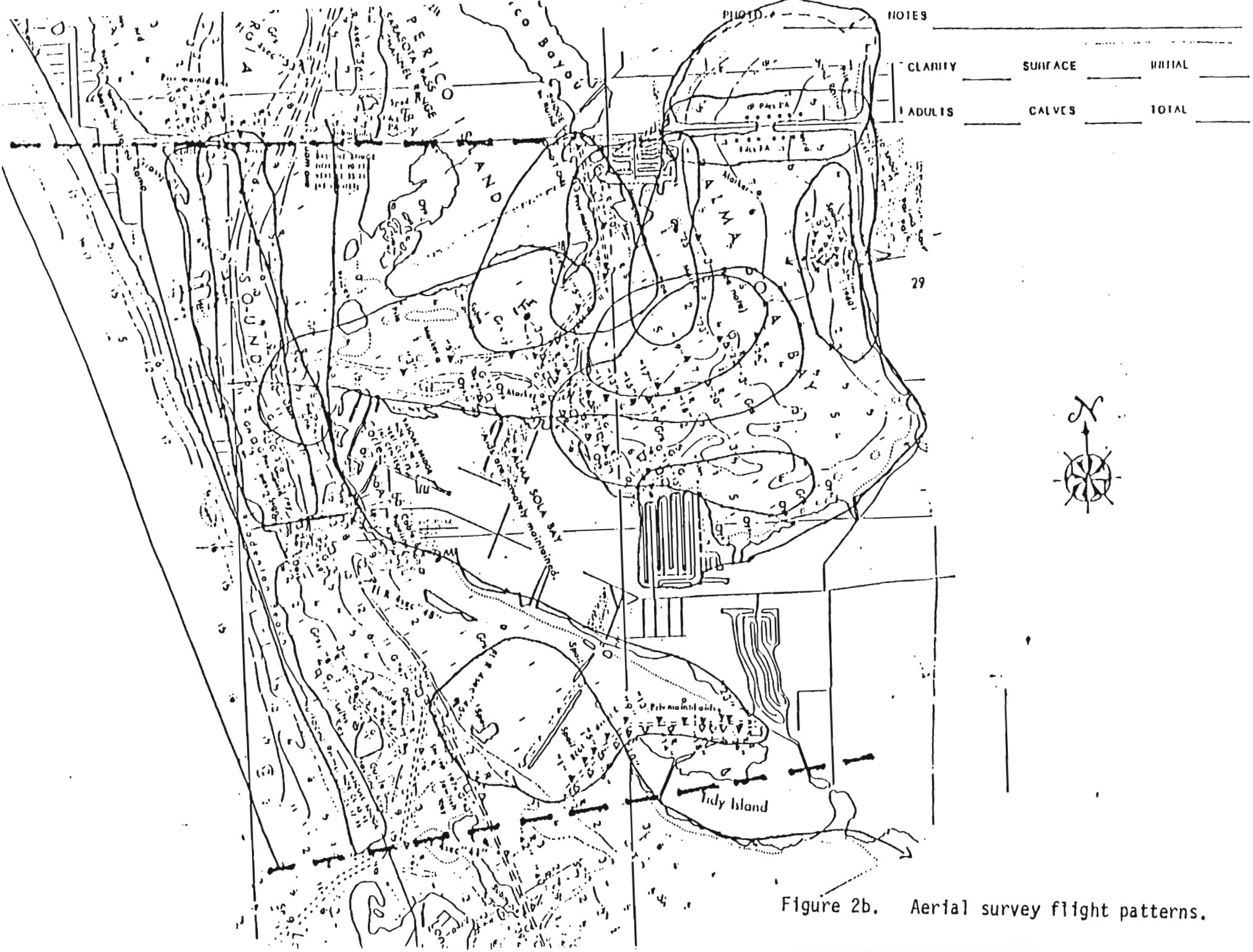

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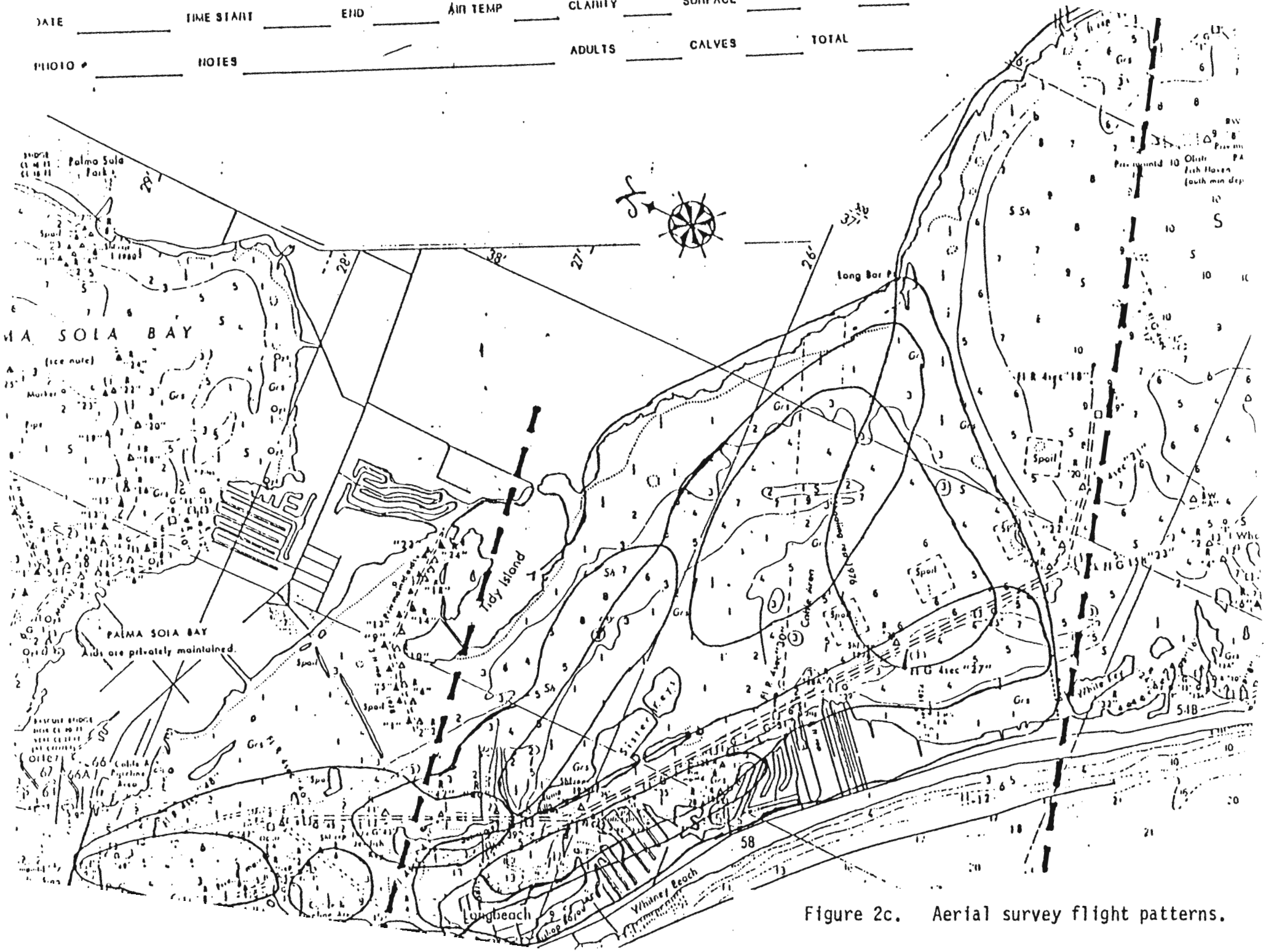
PHOTO # _____ NOTES _____ ADULTS _____ CALVES _____ TOTAL _____



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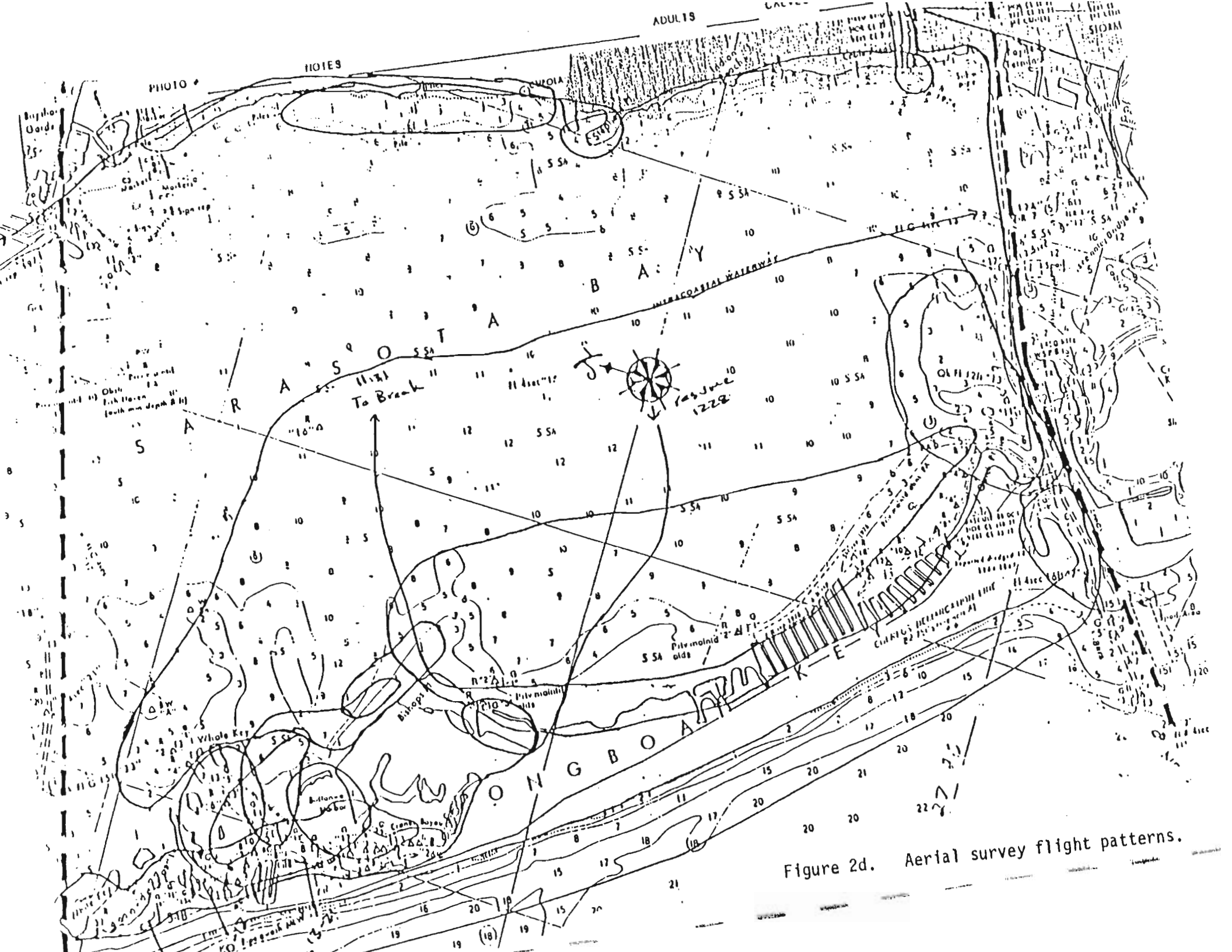

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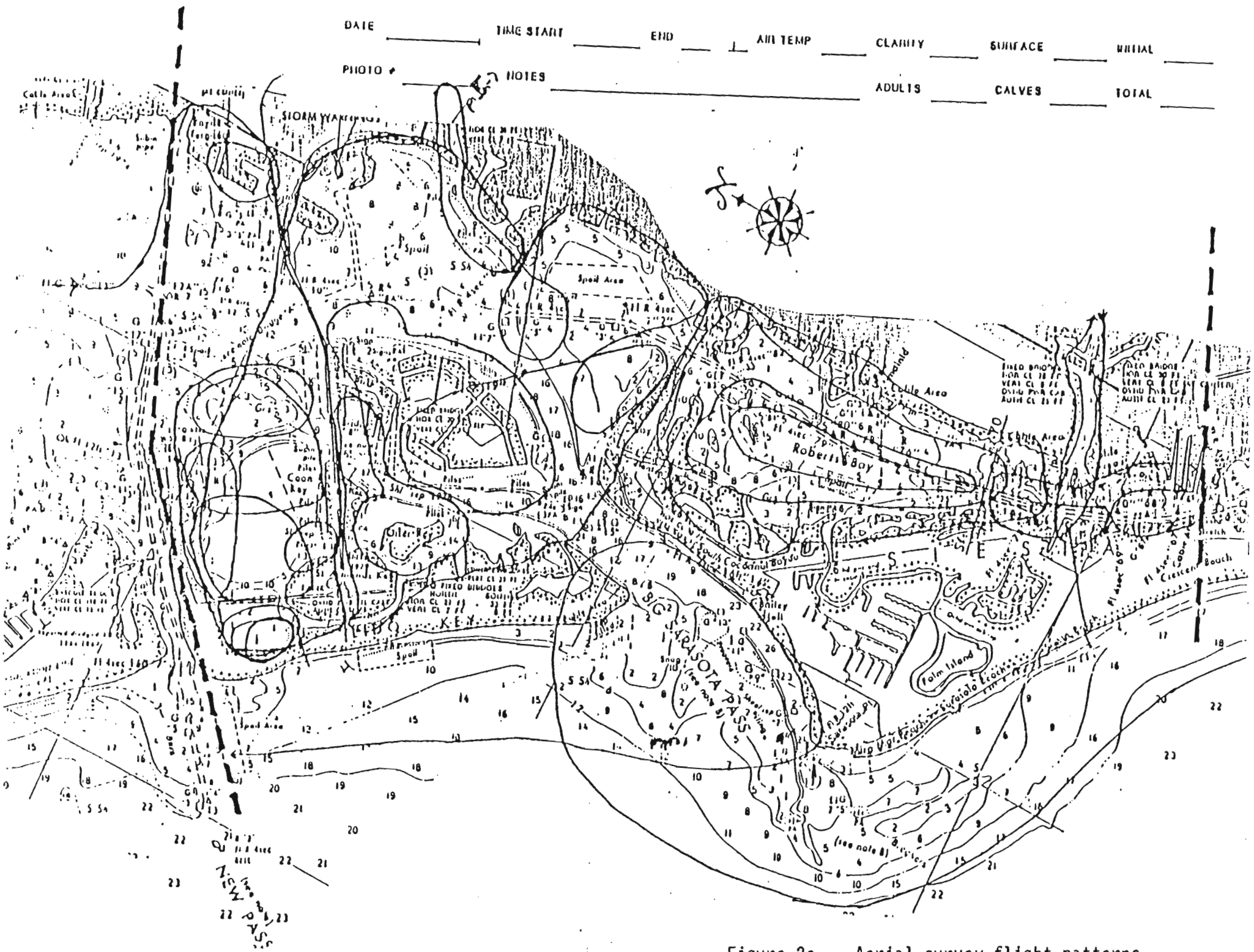
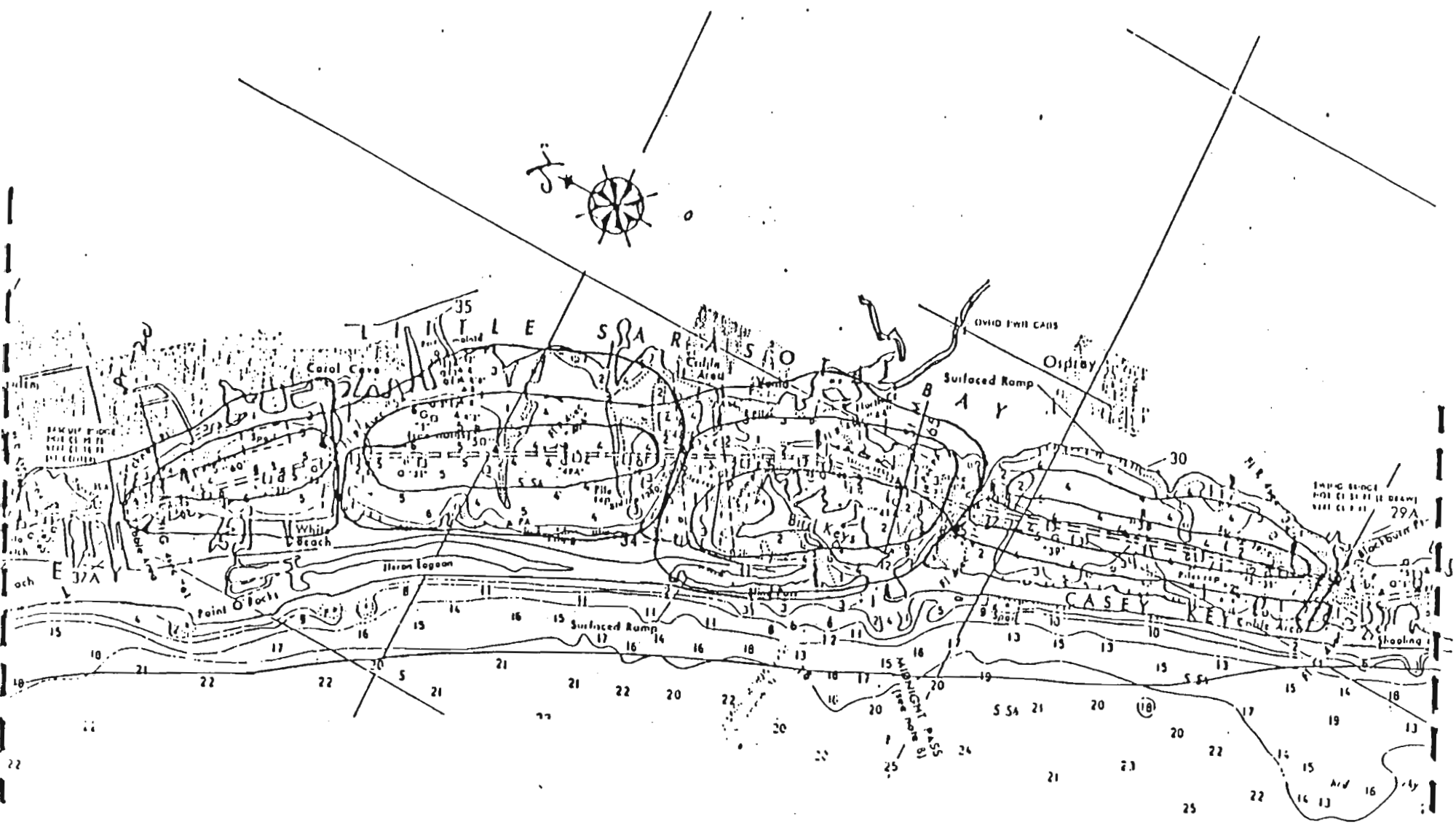


Figure 2e. Aerial survey flight patterns.

NOTES ADULTS CALVES TOTAL



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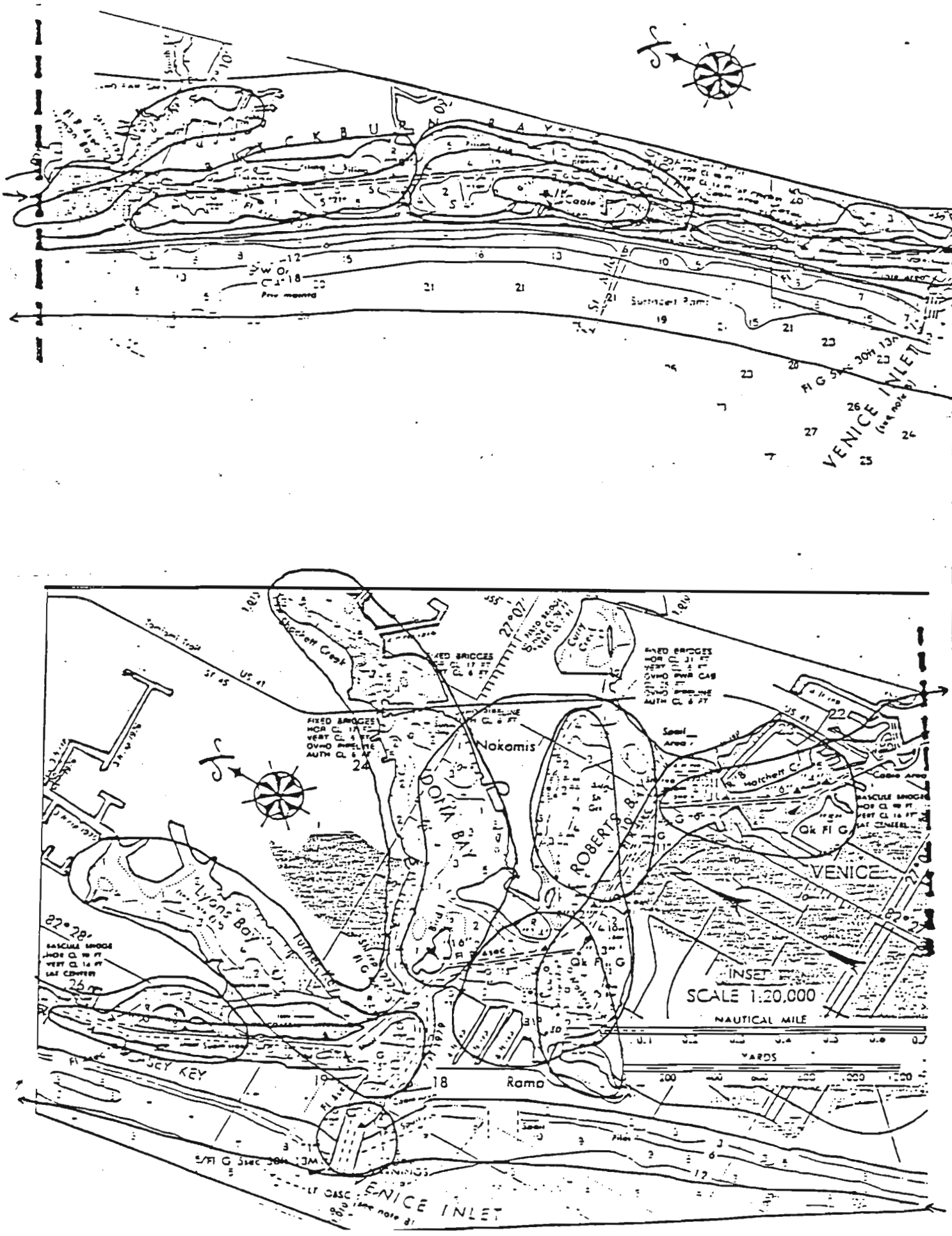

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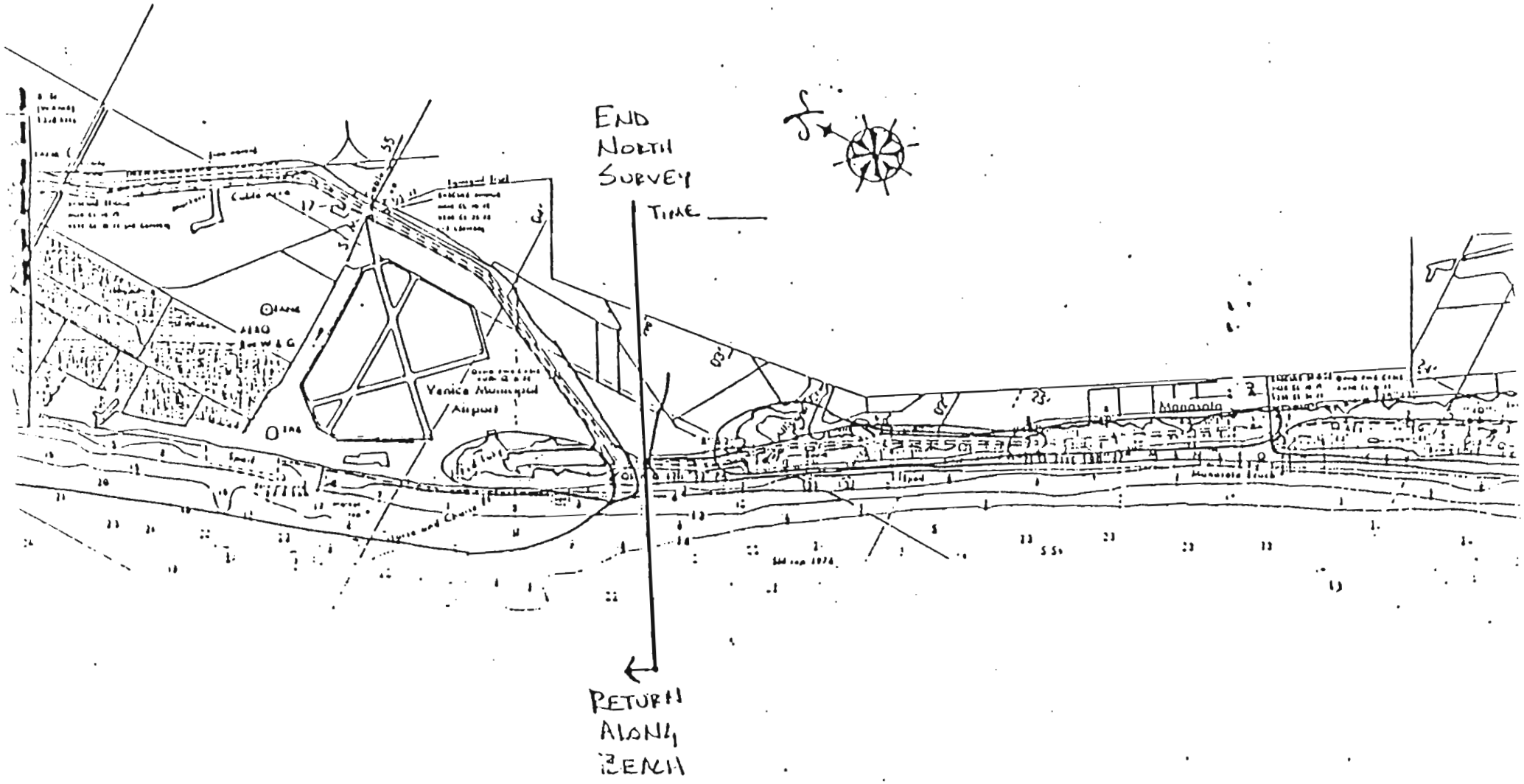
CLARITY _____ SURFACE _____ INITIAL _____

ADULTS _____ CALVES _____ TOTAL _____



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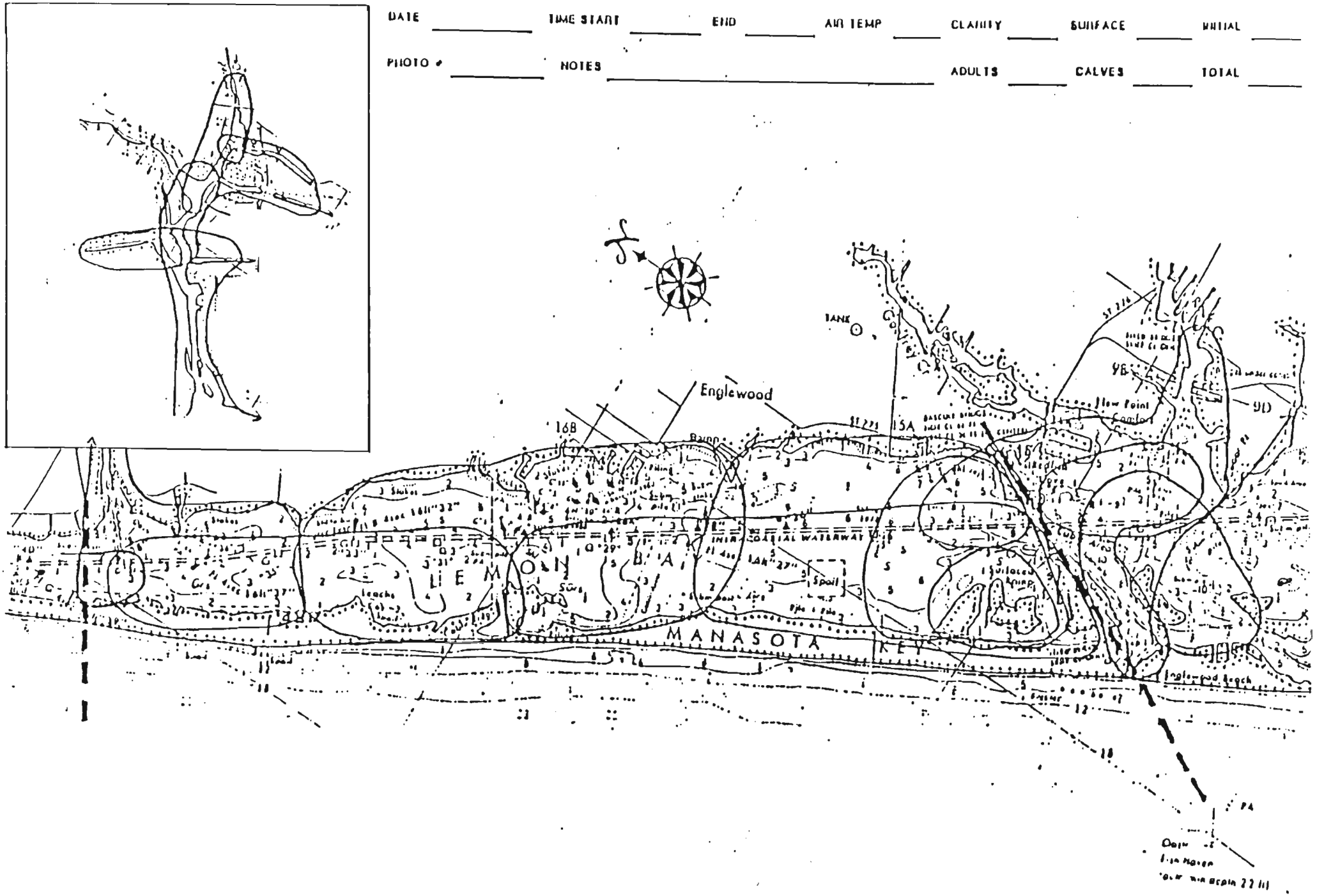

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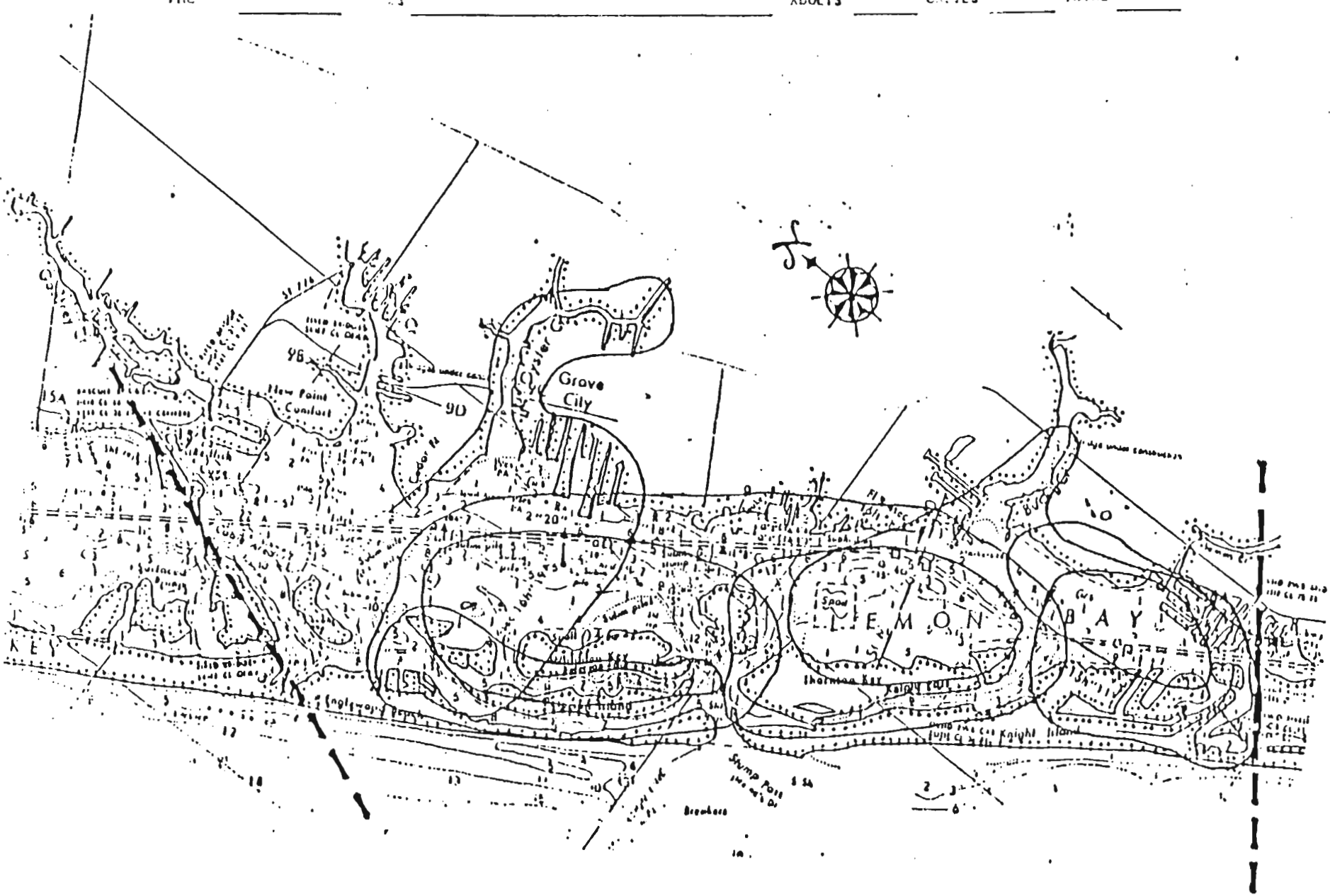

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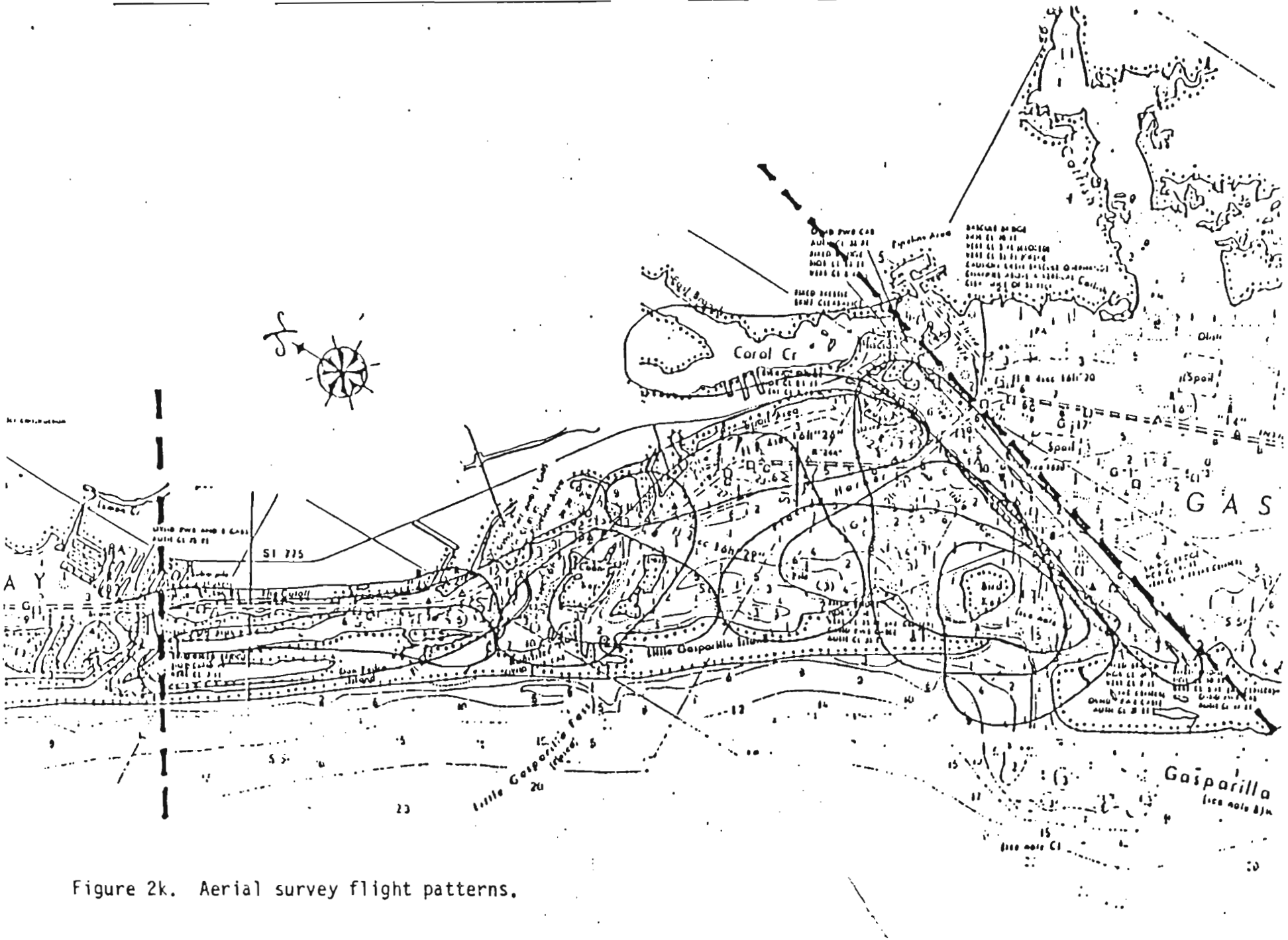
PHOTO # _____ NOTES _____ ADULTS _____ CALVES _____ TOTAL _____



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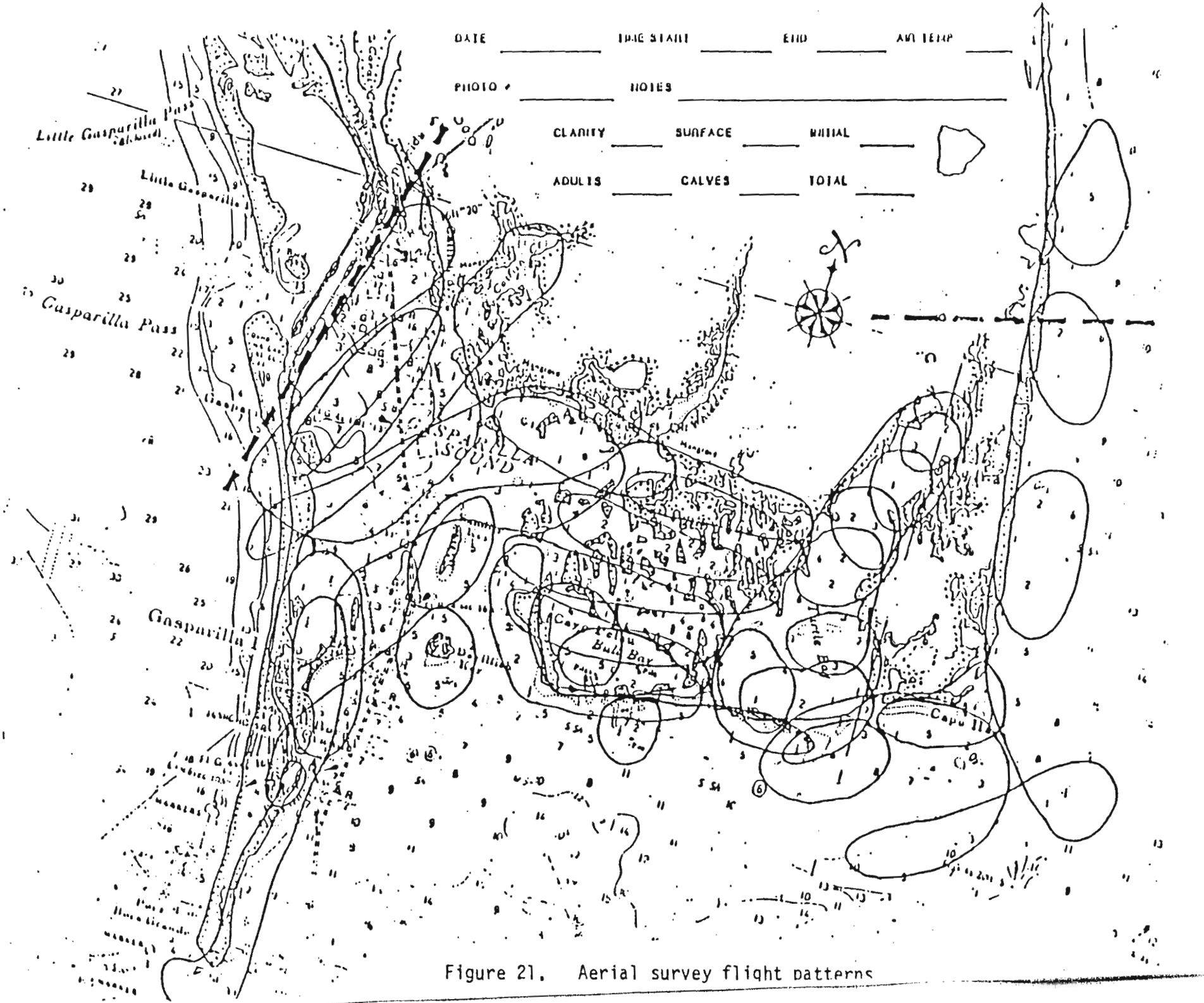
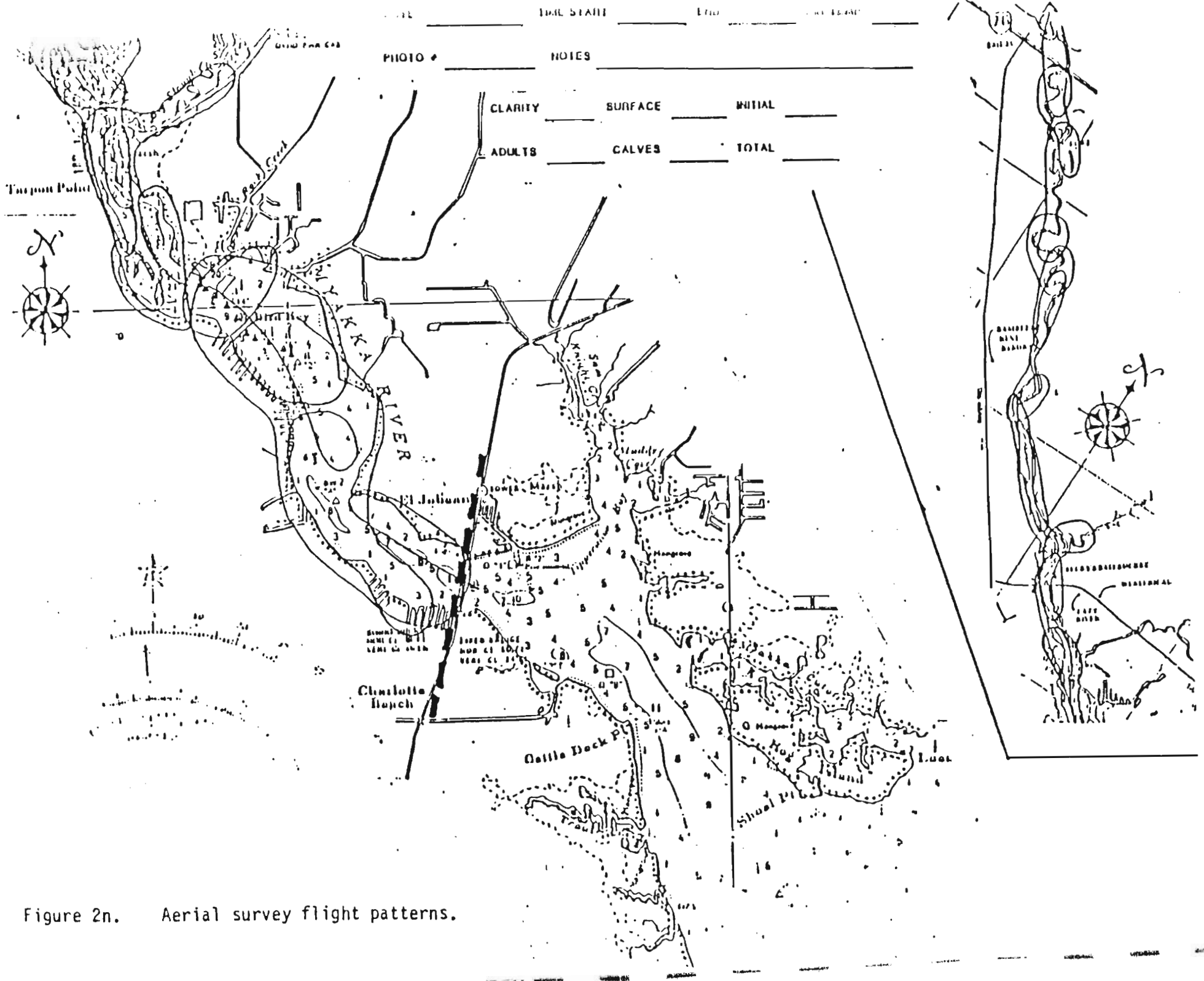


Figure 21. Aerial survey flight patterns

DATE _____ TIME START _____ END _____ AIR TEMP _____ CLARITY _____ SURFACE _____

PHOTO # _____ NOTES _____ ADULTS _____ CALVES _____ TO

Figure 2m. Aerial survey flight patterns.



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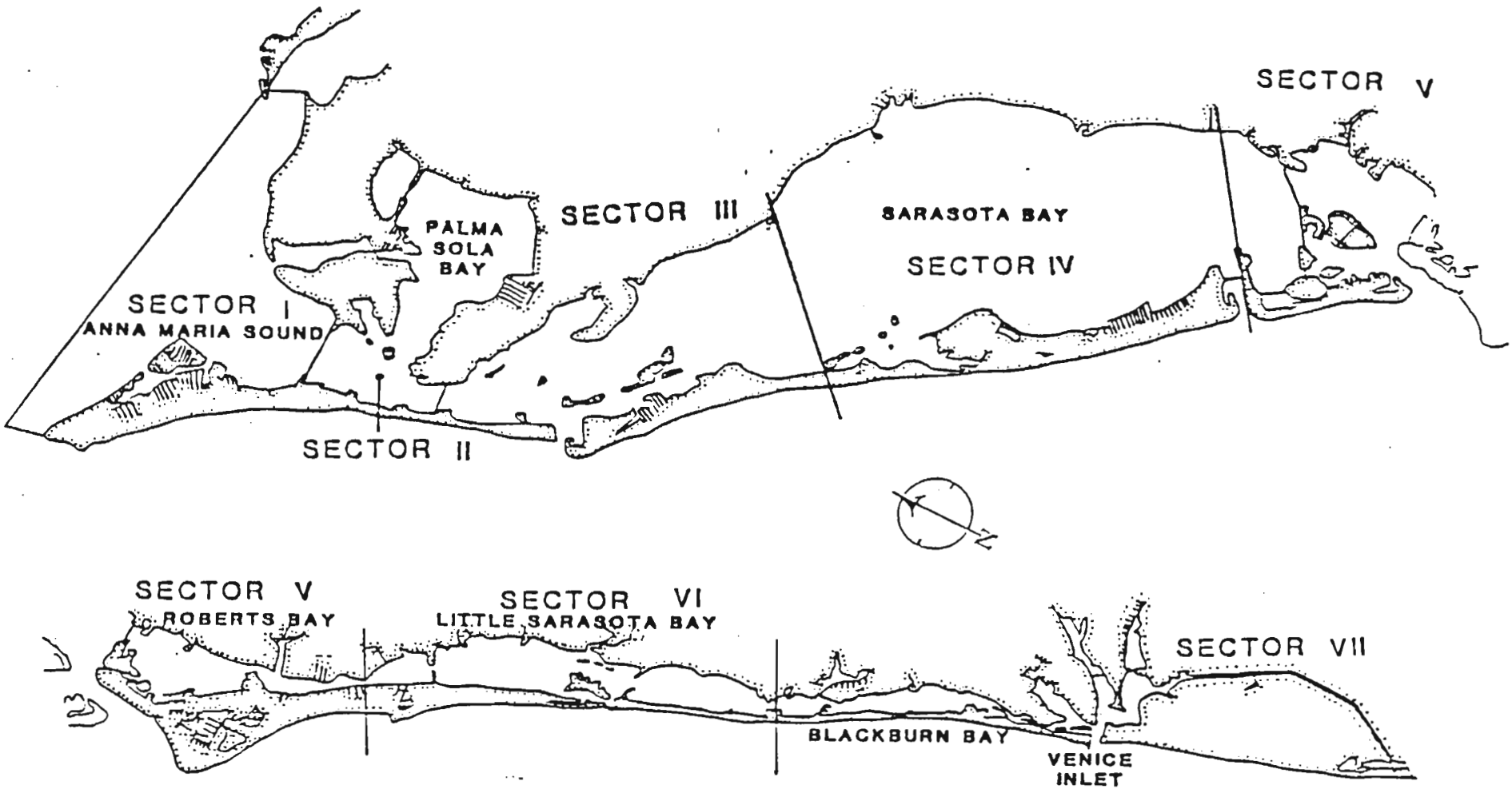
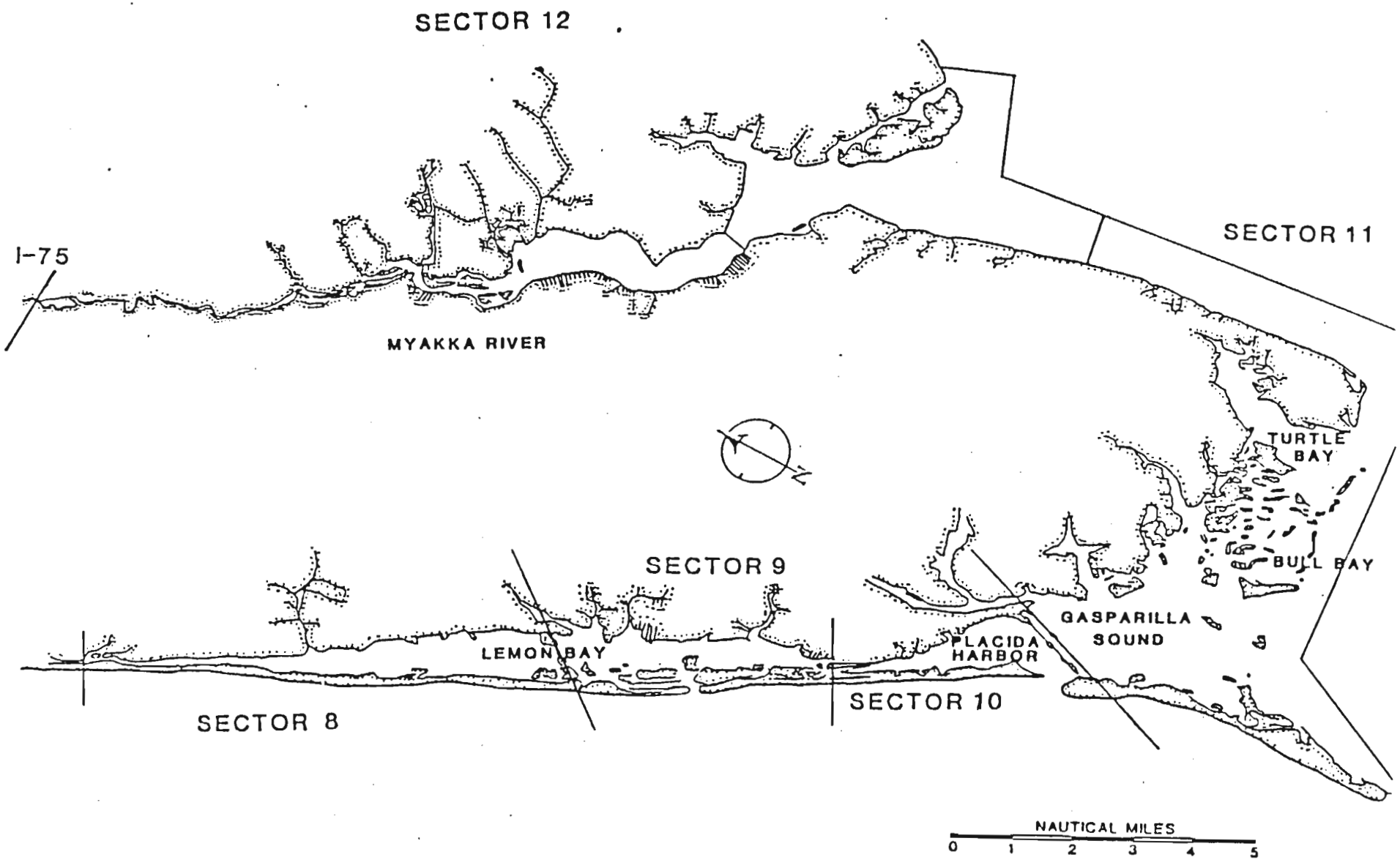


Figure 3a Division of the survey area into twelve sectors.



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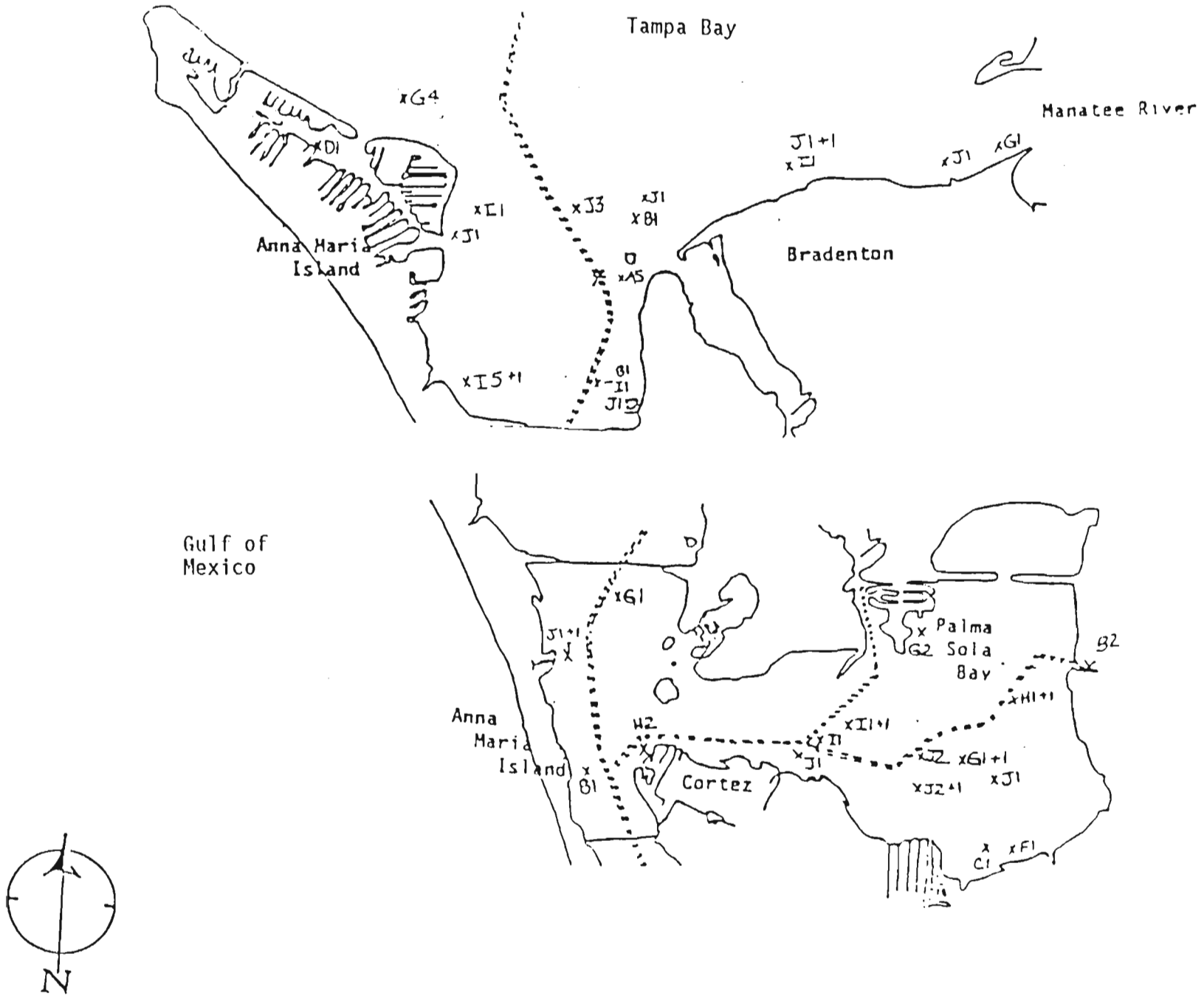

Fig. 4a. Manatee Herd Sightings Locations: Mouth of the Manatee River and Anna Maria Sound.

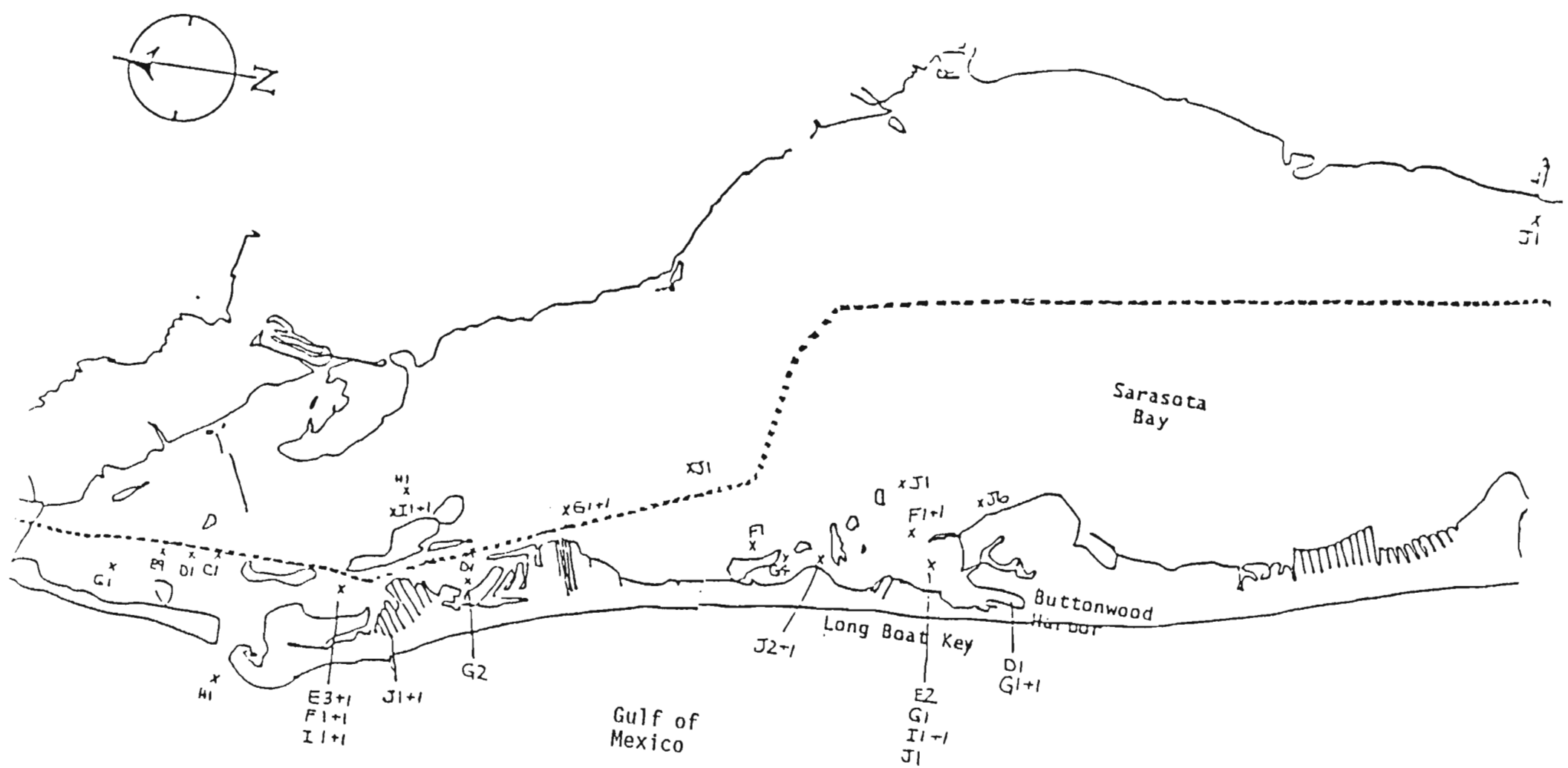

Fig. 4b. Manatee Herd Sightings Locations: Sarasota Bay.

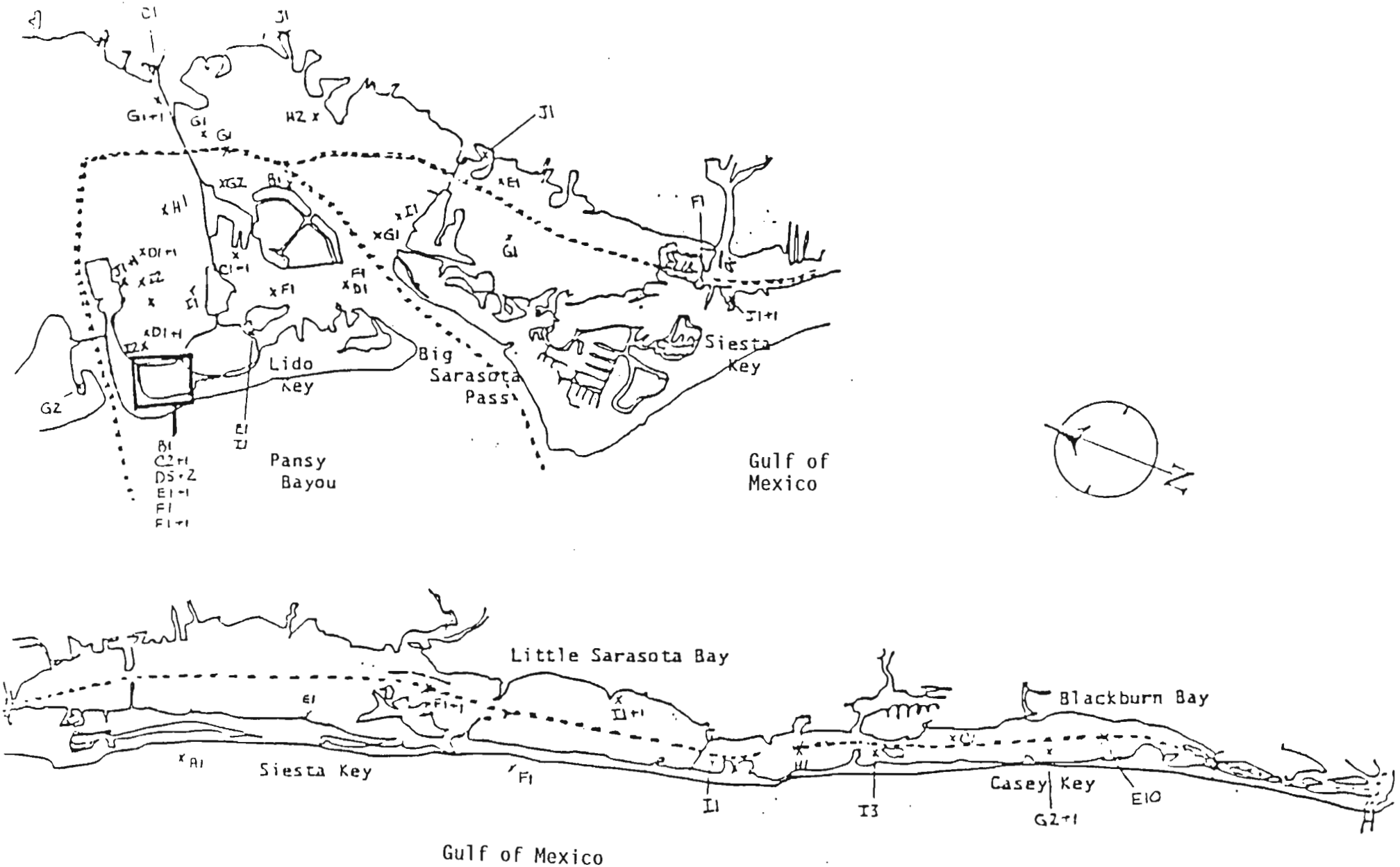

Fig. 4c. Manatee Herd Sightings Locations: Sarasota area, Little Sarasota Bay, and Blackburn Bay.

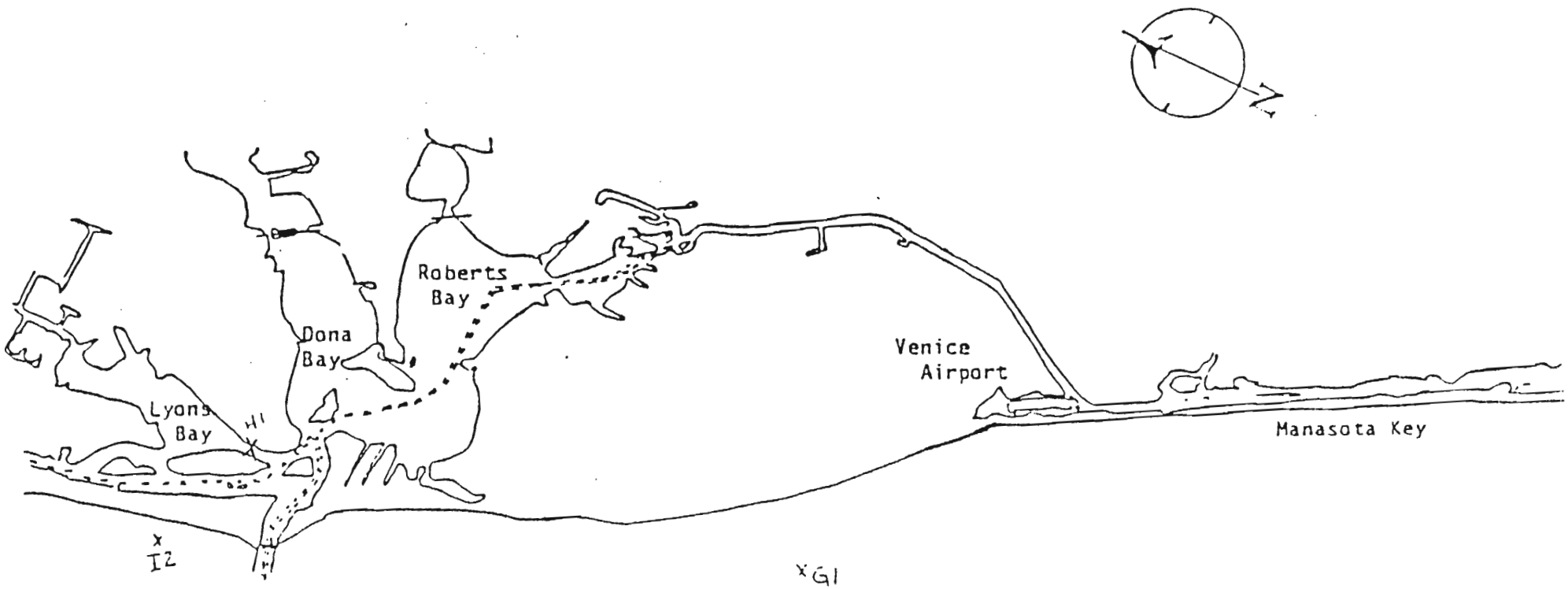

Fig. 4d. Manatee Herd Sightings Locations: Venice area.

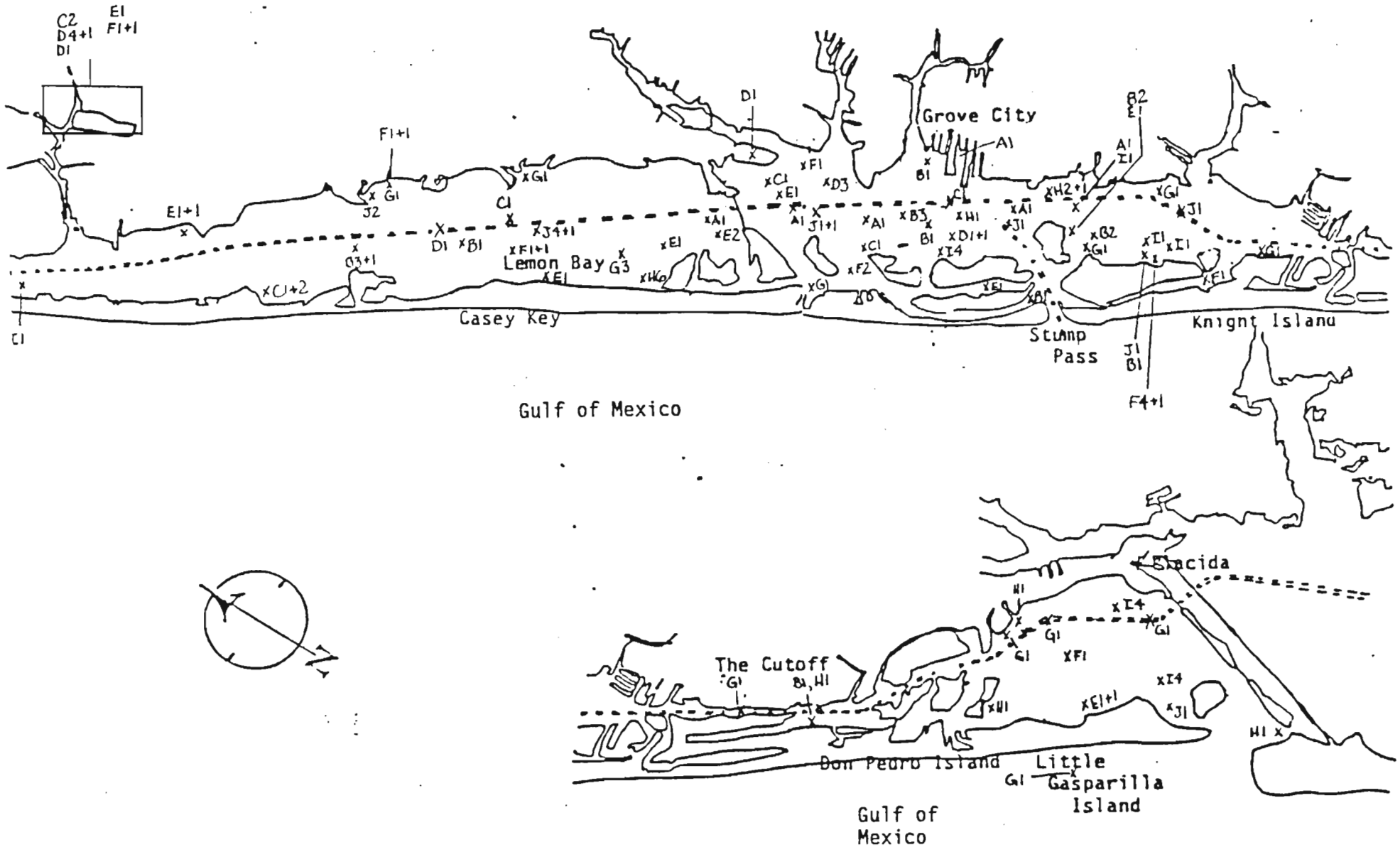

Fig. 4e. Manatee Herd Sighting Locations: Lemon Bay and Placida Harbor.

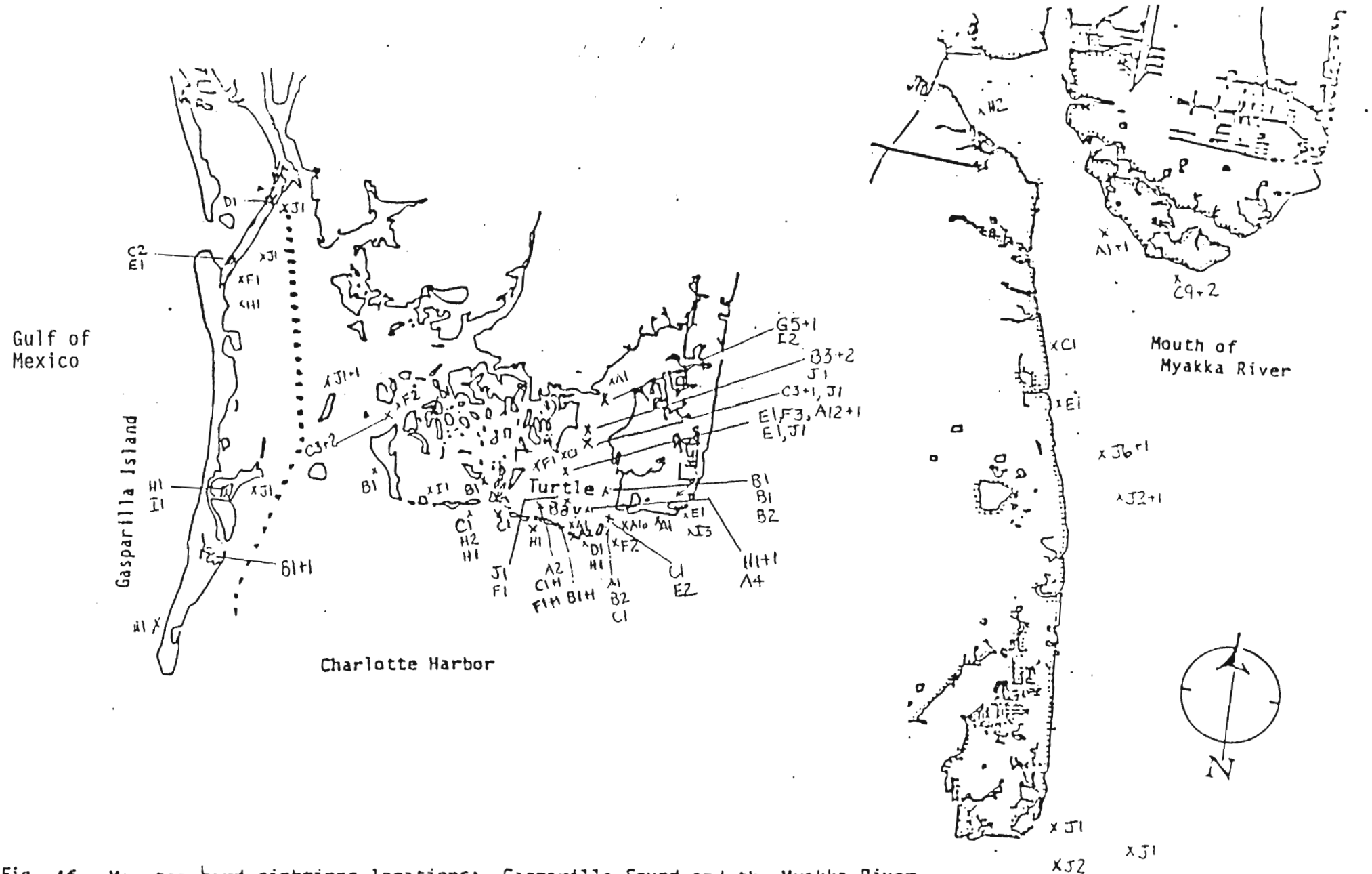

Fig. 4f. Manatee herd sightings locations: Gasparilla Sound and the Myakka River.

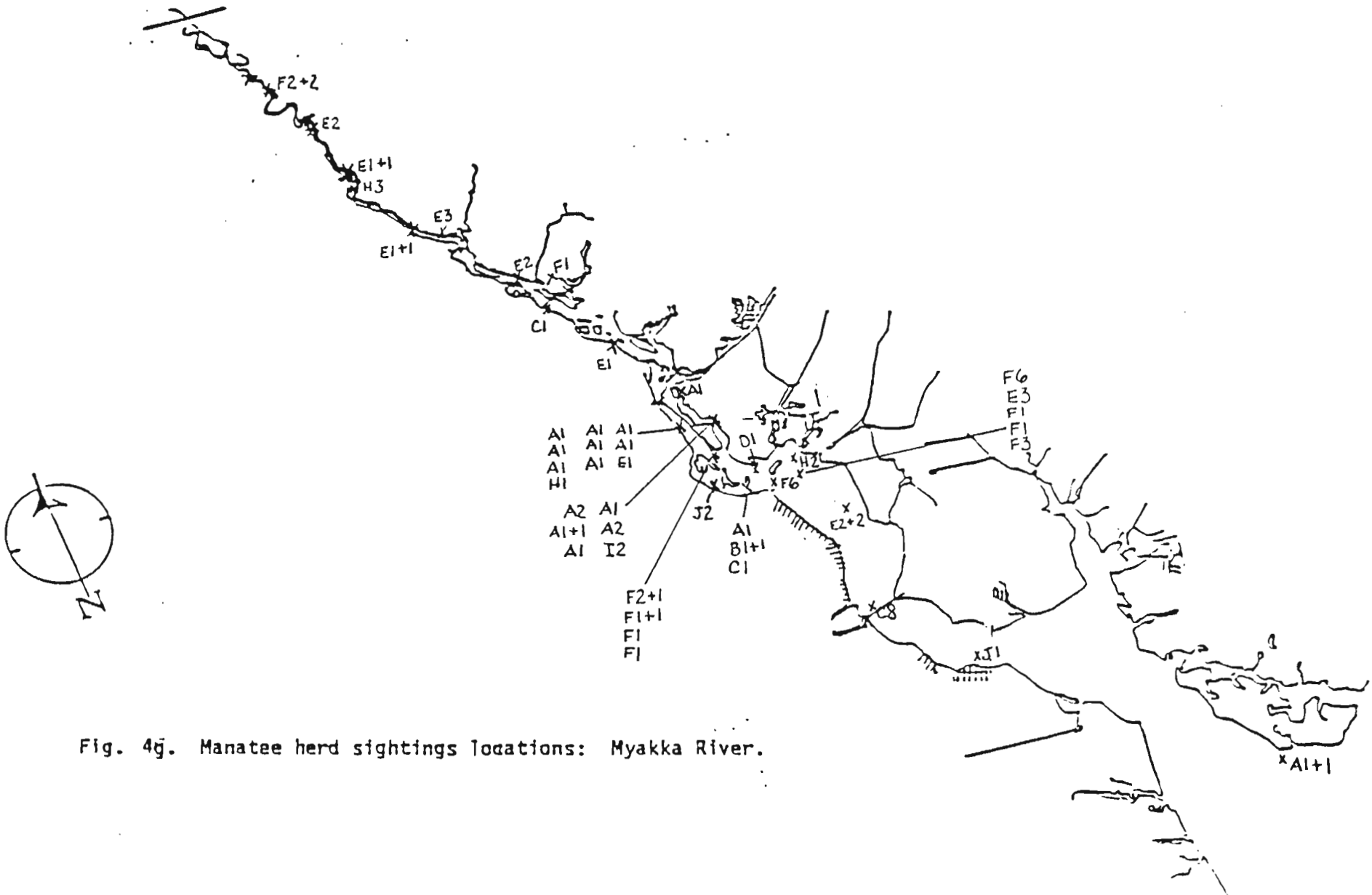

Fig. 4g. Manatee herd sightings locations: Myakka River.

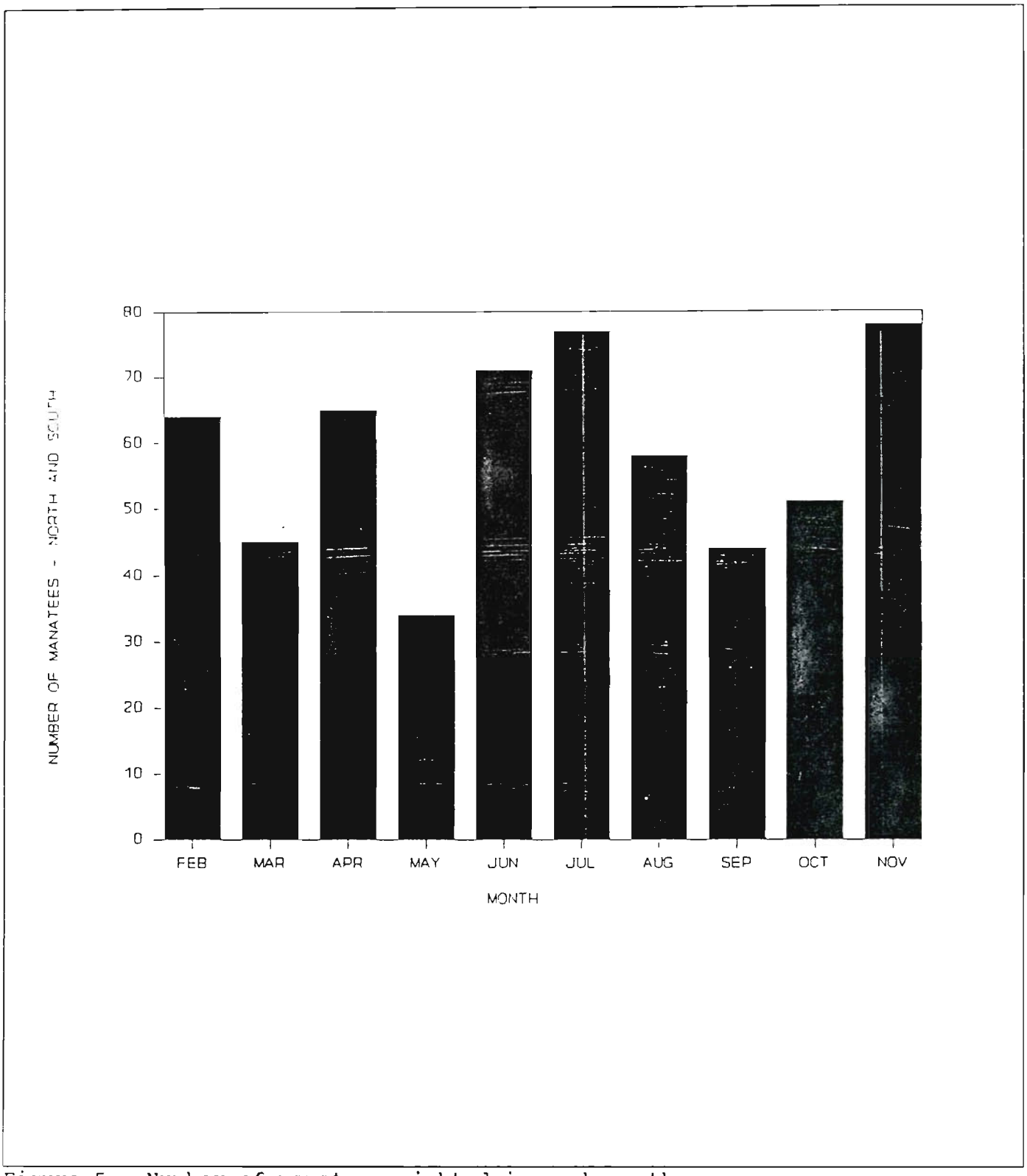

Figure 5. Number of manatees sighted in each month.

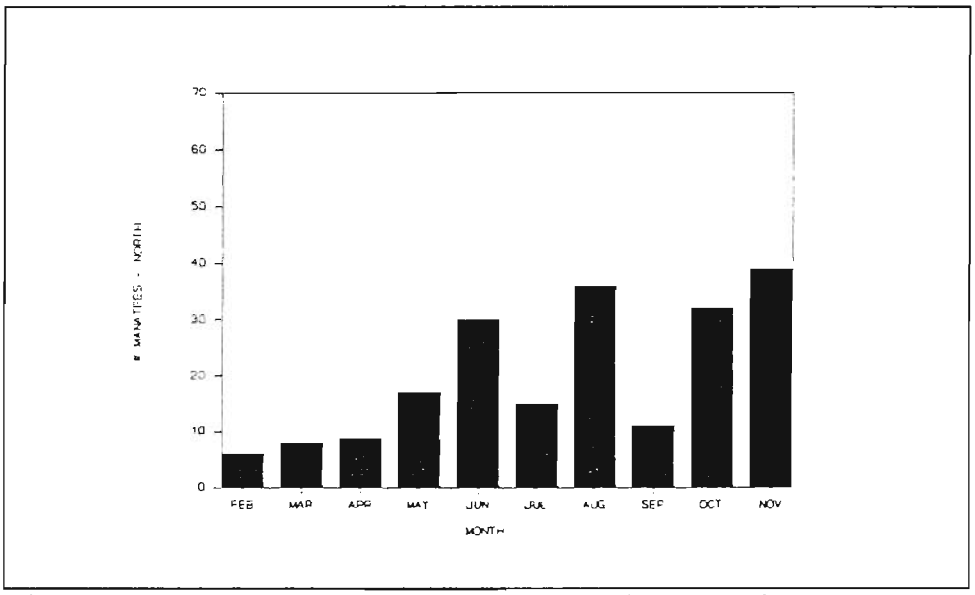

Figure 6a. Number of manatees sighted in each month for the northern survey area.

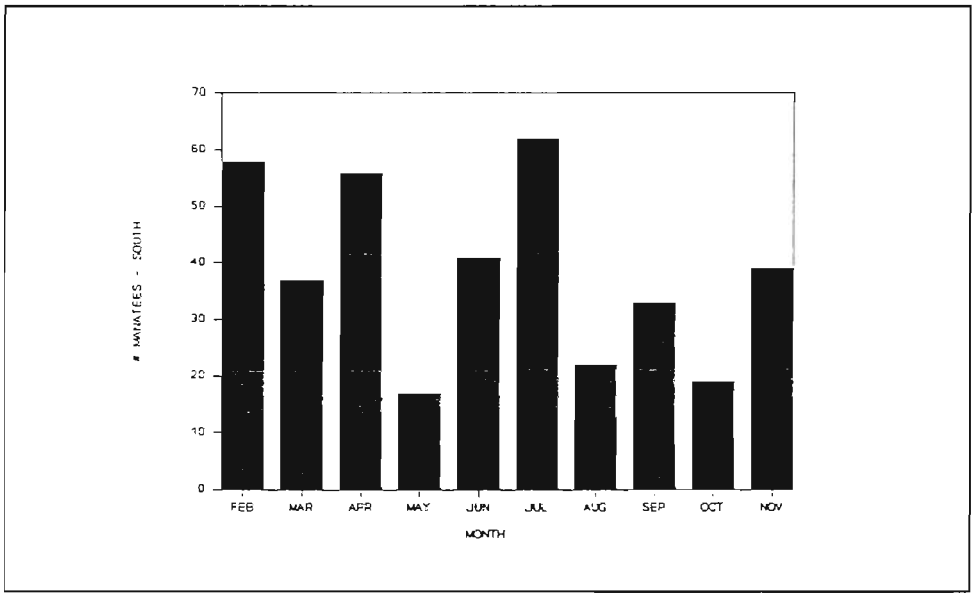

Figure 6b. Number of manatee sighted in each month for the southern survey area.

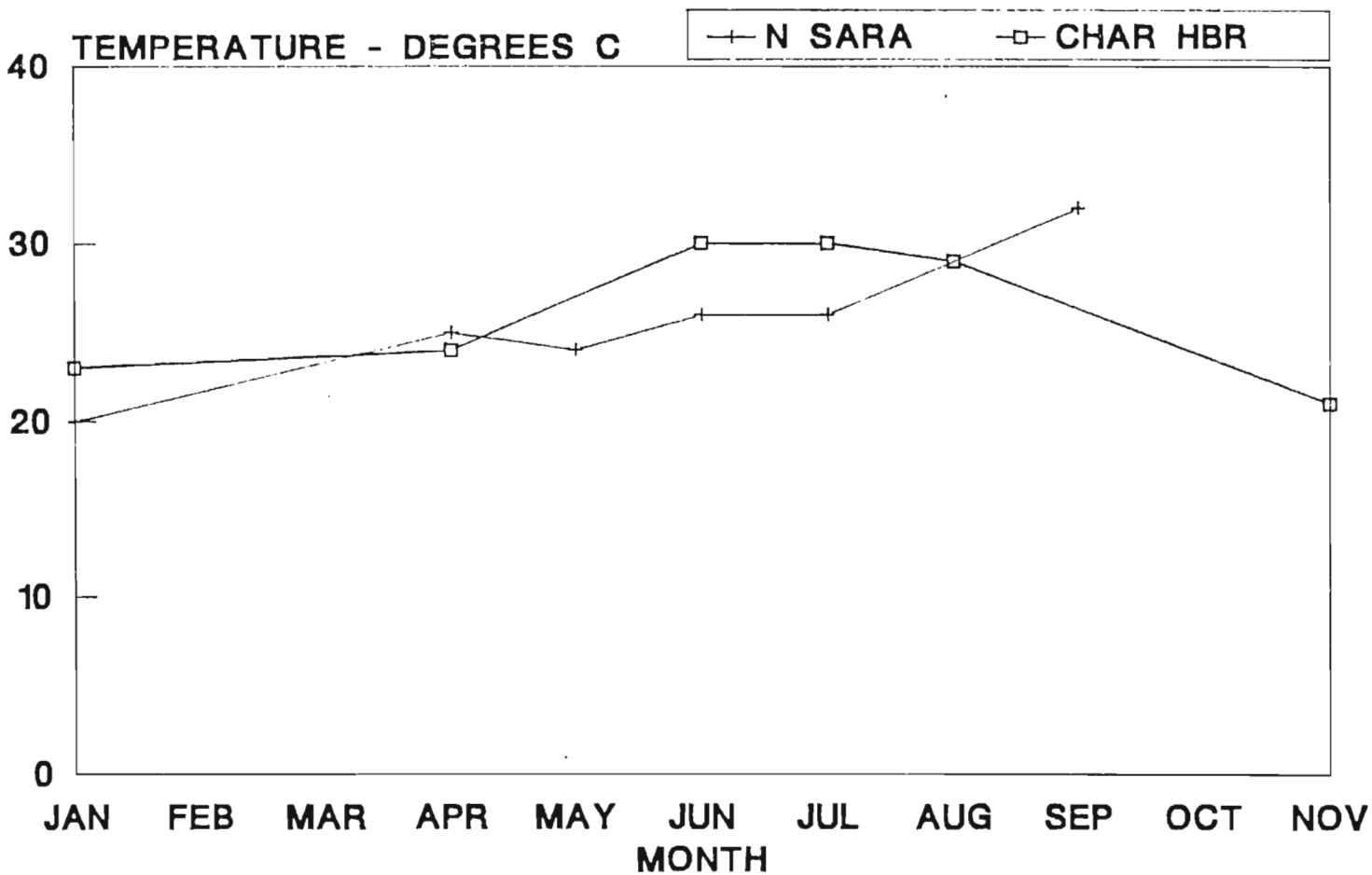

Figure 7. Water temperatures for north Sarasota Bay and northen Charlotte Harbor.

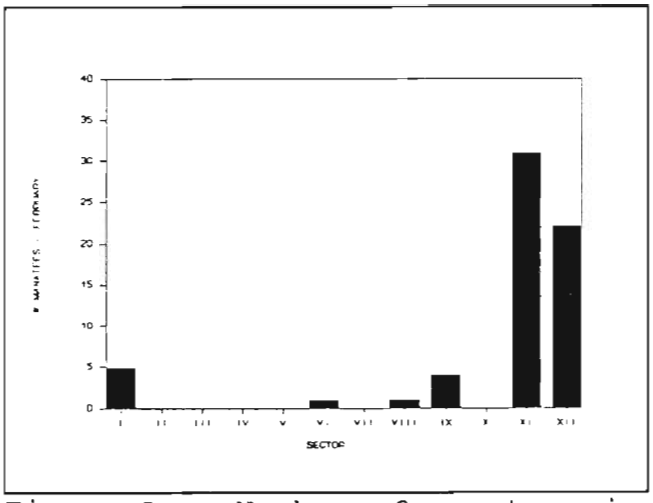

Figure 8a. Number of manatees in each sector, February.

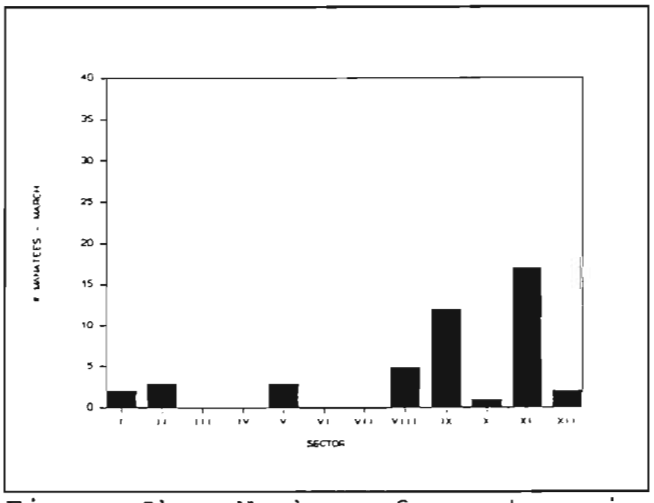

Figure 8b. Number of manatees in each sector, March.

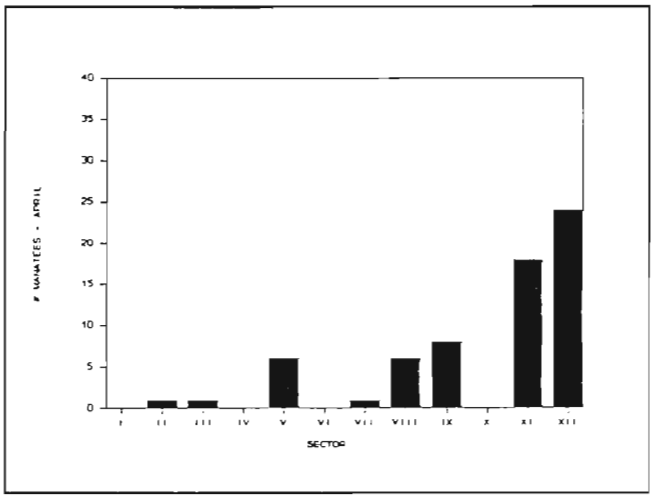

Figure 8c. Number of manatees in each sector, April.

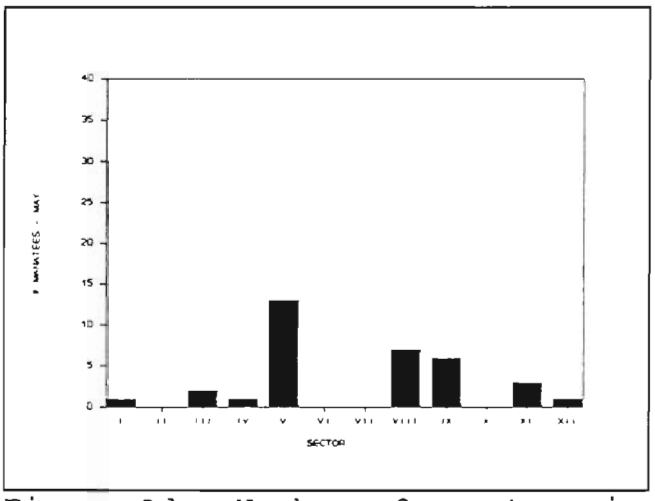

Figure 8d. Number of manatees in each sector, May.

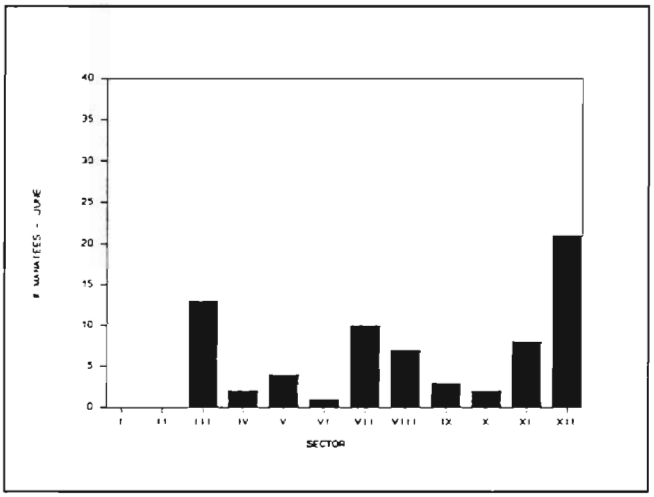

Figure 8e. Number of manatees in each sector, June.

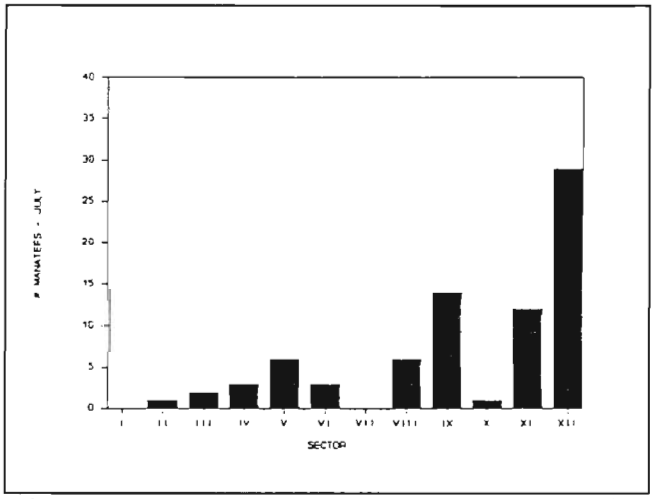

Figure 8f. Number of manatees in each sector. July.

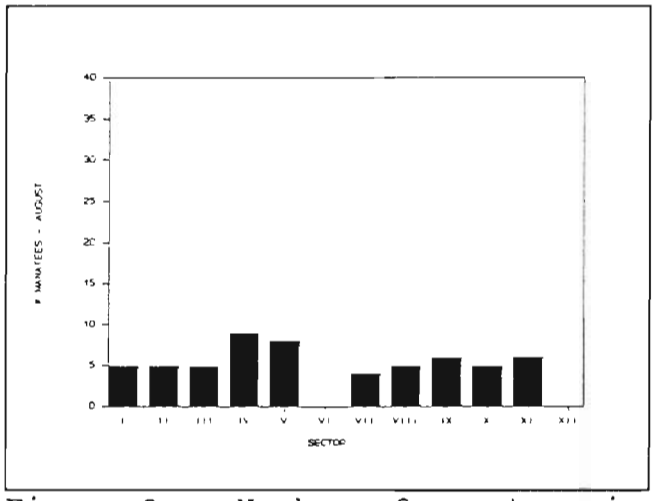

Figure 8g. Number of manatees in each sector, August.

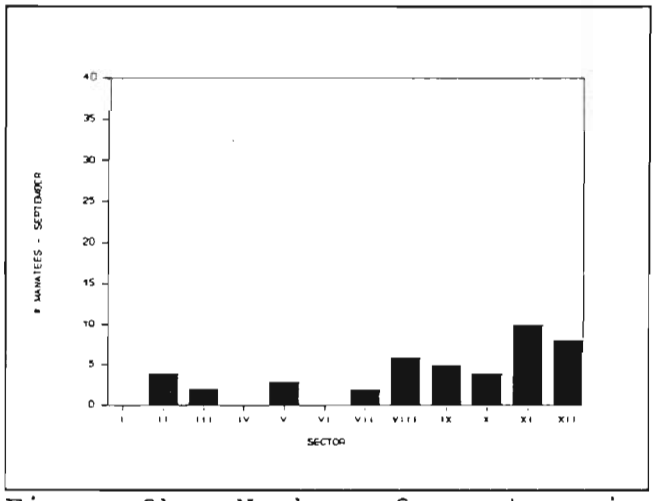

Figure 8h. Number of manatees in each sector, September.

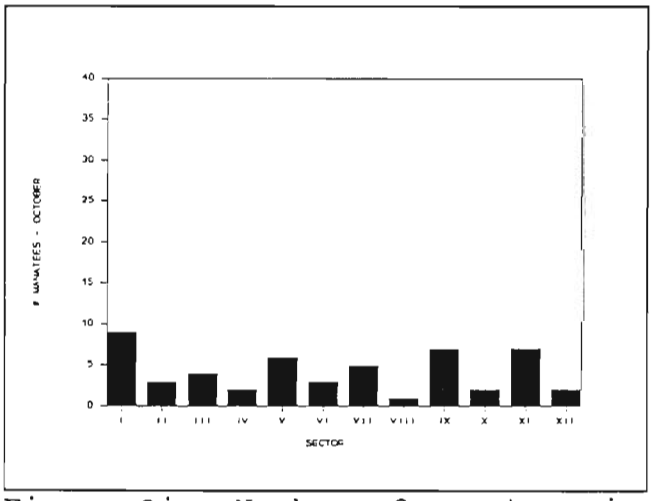

Figure 8i. Number of manatees in each sector, October.

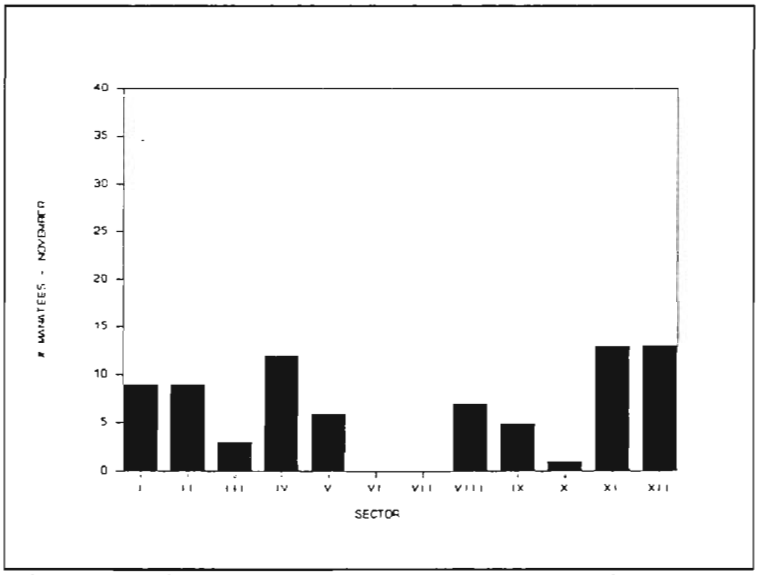

Figure 8j. Number of manatees in each sector, November.

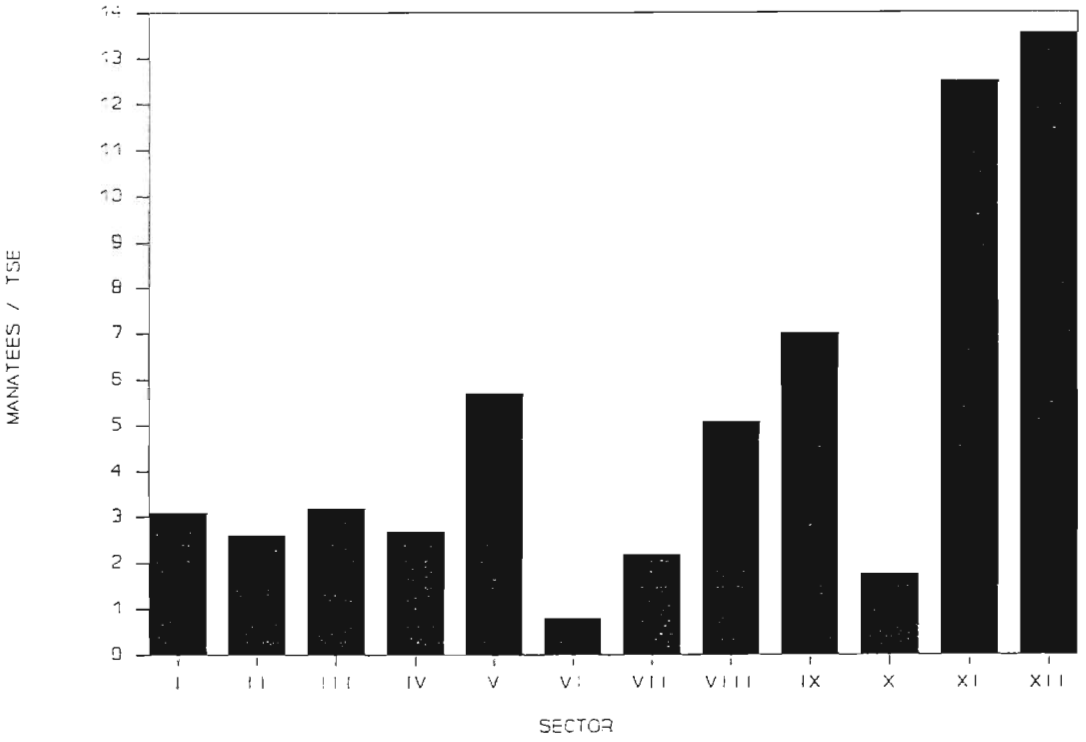

Figure 9. Regional index of manatee sightings as number per survey effort for each sector.

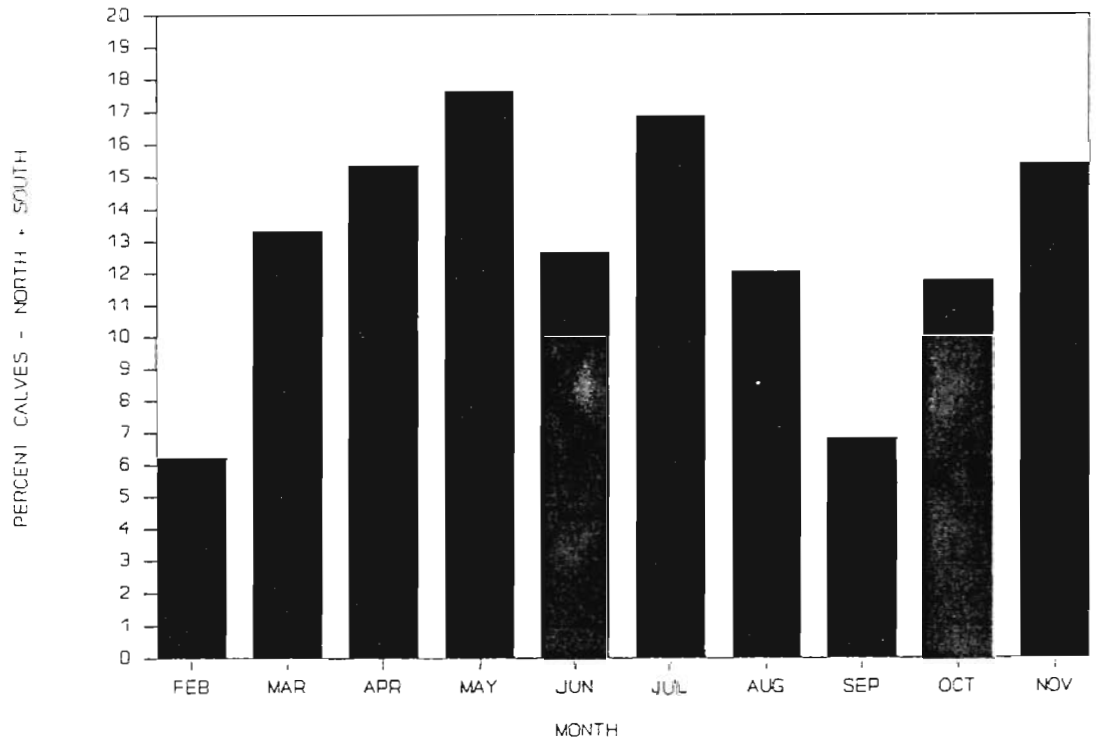

Figure 10. Calf percentages per month for the total survey area.

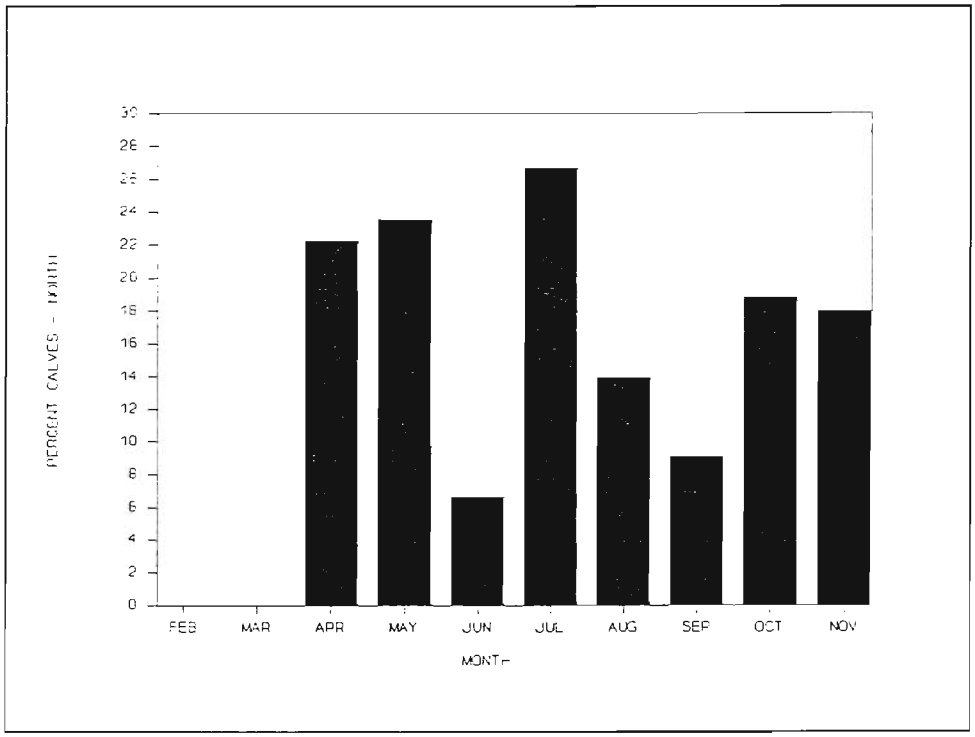

Figure 11a. Calf percentages per month for the northern survey area.

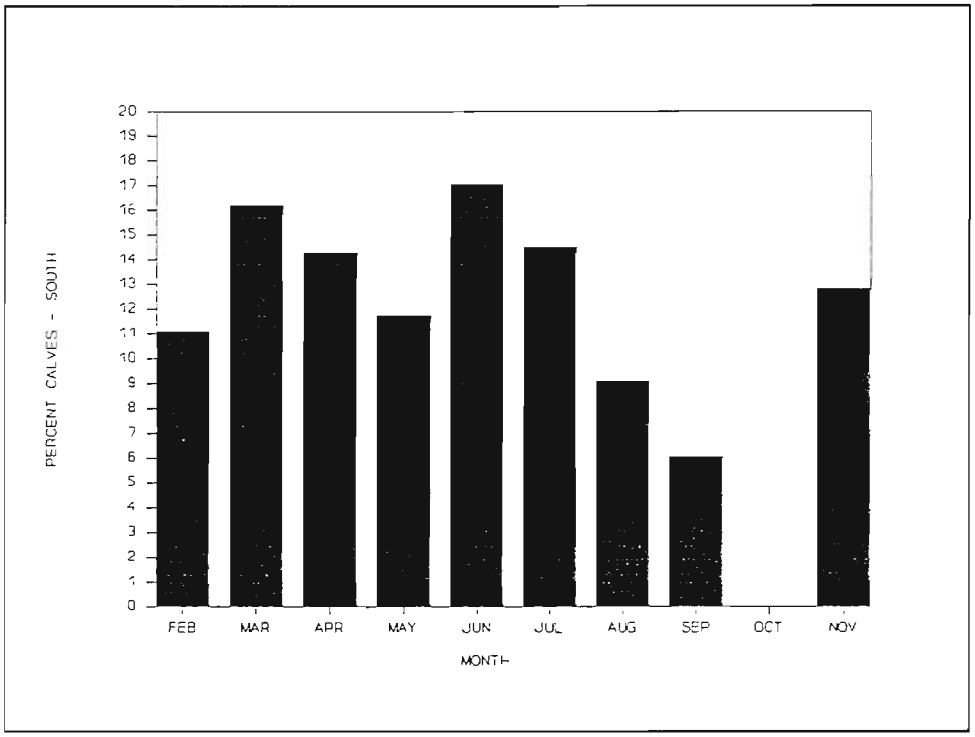

Figure 11b. Calf percentages per month for the southern survey area.

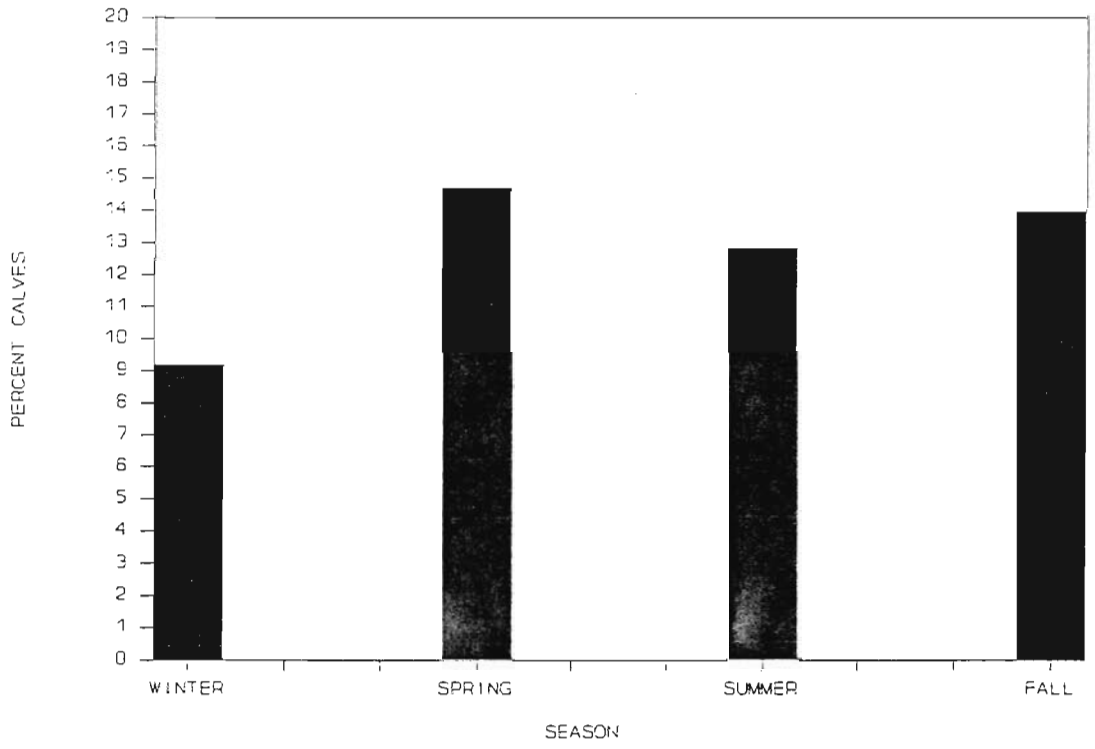

Figure 12. Calf percentages per season for the total survey area.

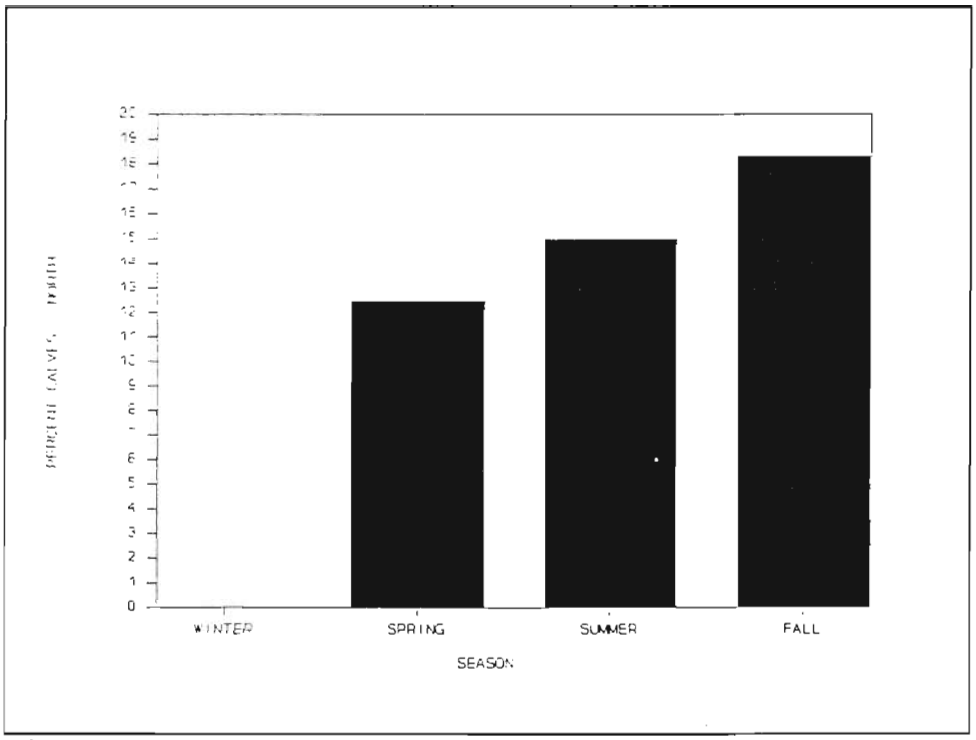

Figure 13a. Calf percentages per season for the norhtern survey area.

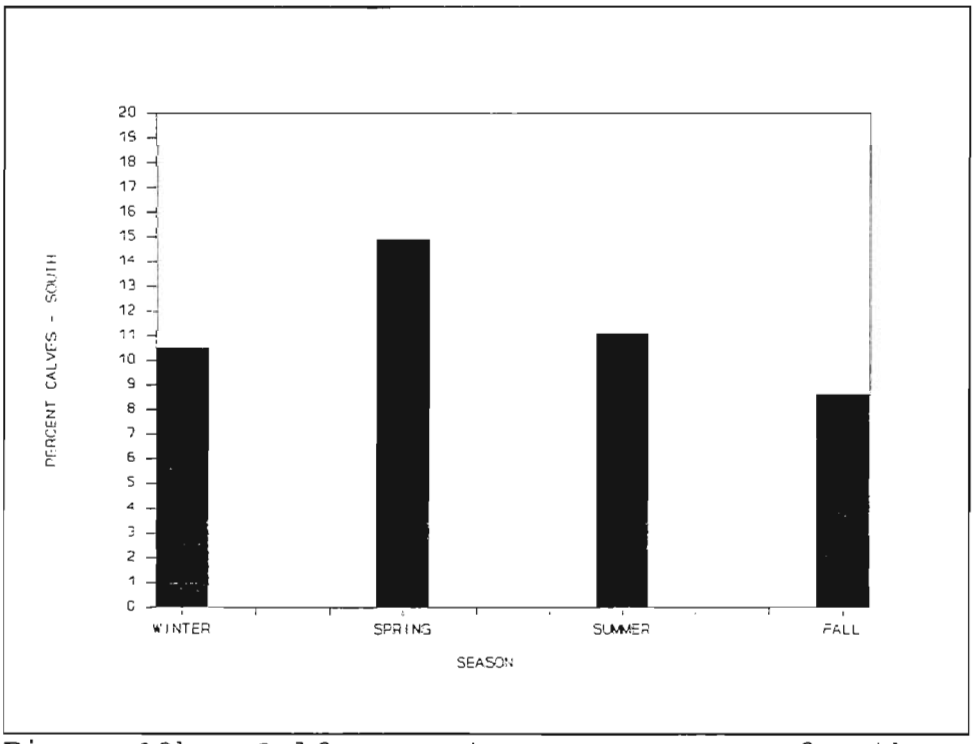

Figure 13b. Calf percentages per season for the southern survey area.

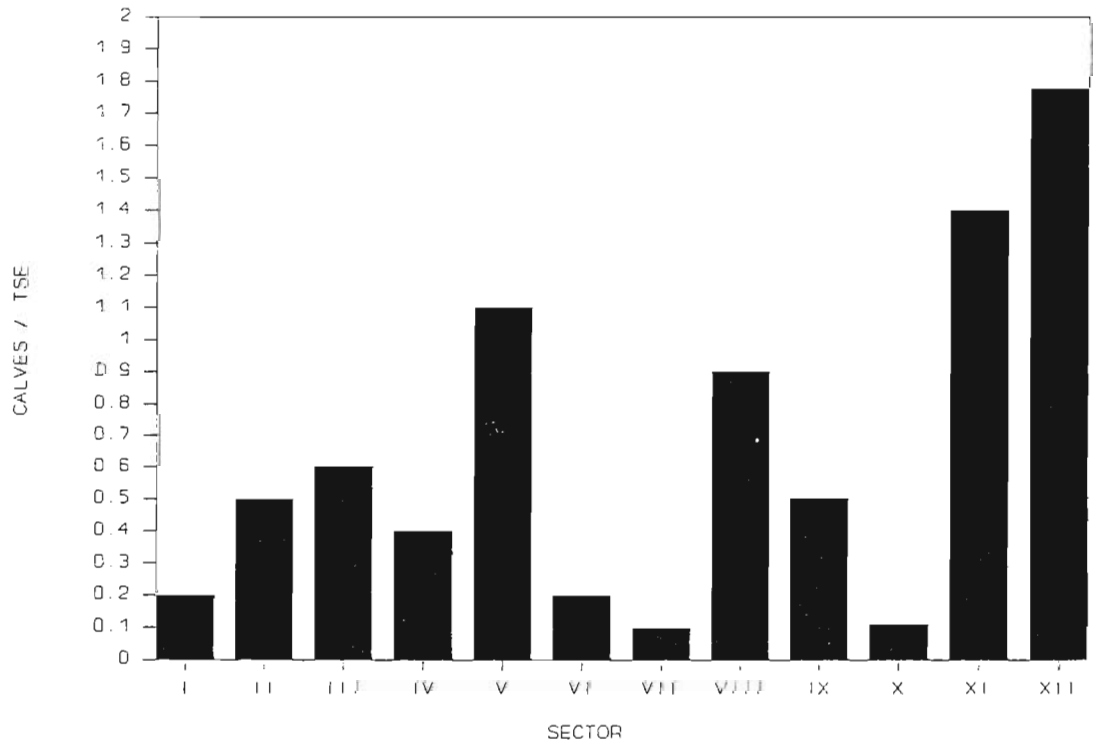

Figure 14. Regional index of calf sightings as number per survey effort for each region.

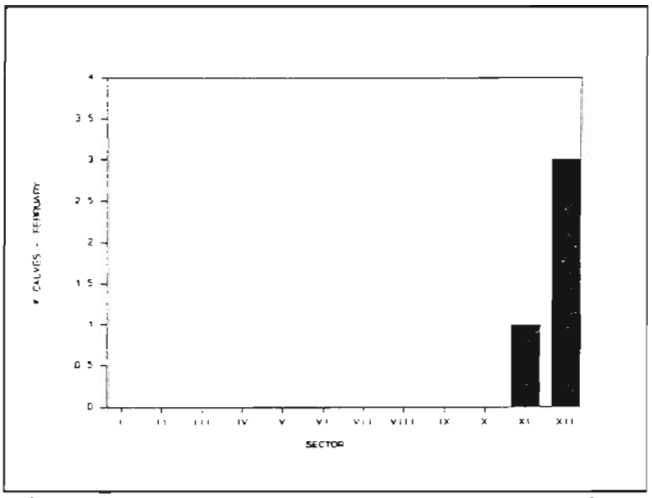

Figure 15a. Number of calves in each sector, February.

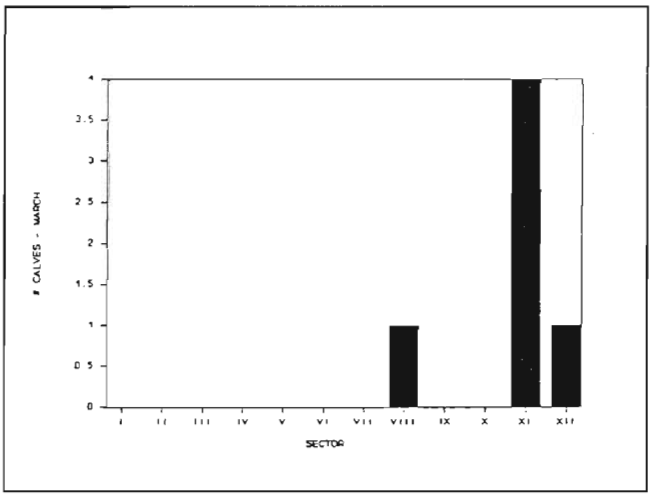

Figure 15b. Number of calves in each sector, March.

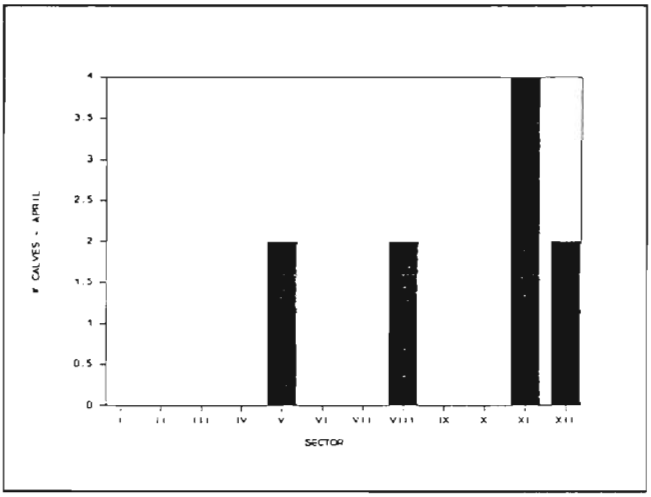

Figure 15c. Number of calves in each sector, April.

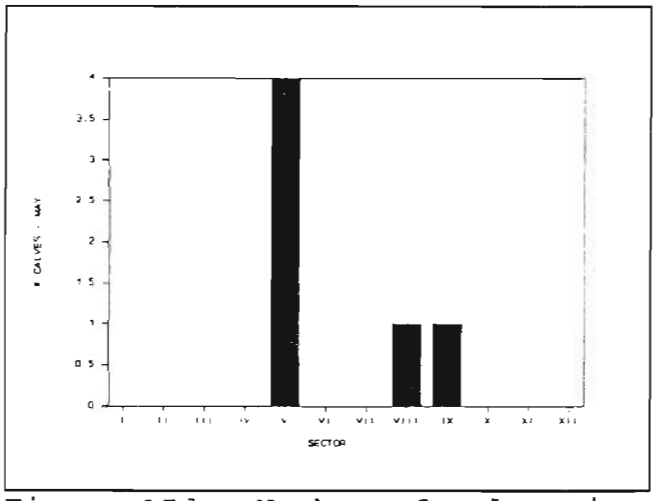

Figure 15d. Number of calves in each sector, May.

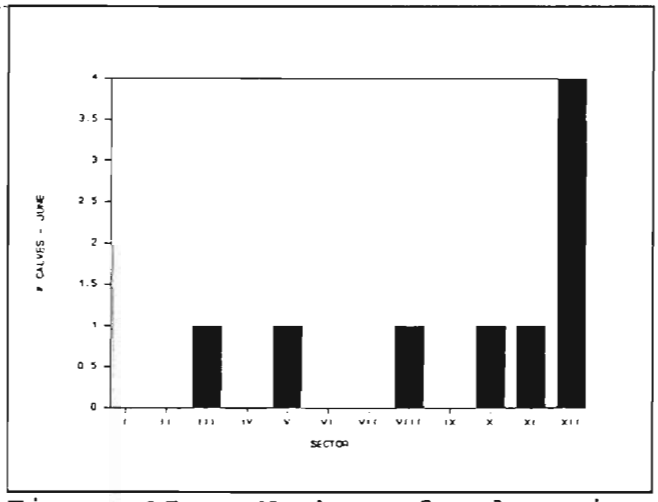

Figure 15e. Number of calves in each sector, June.

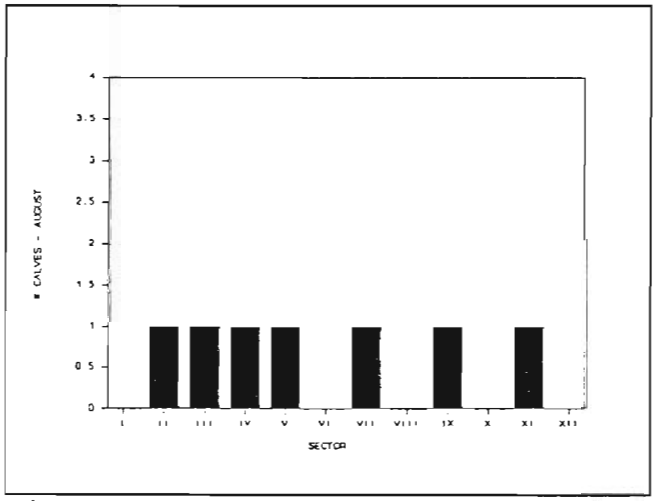

Figure 15f. Number of calves in each sector, July.

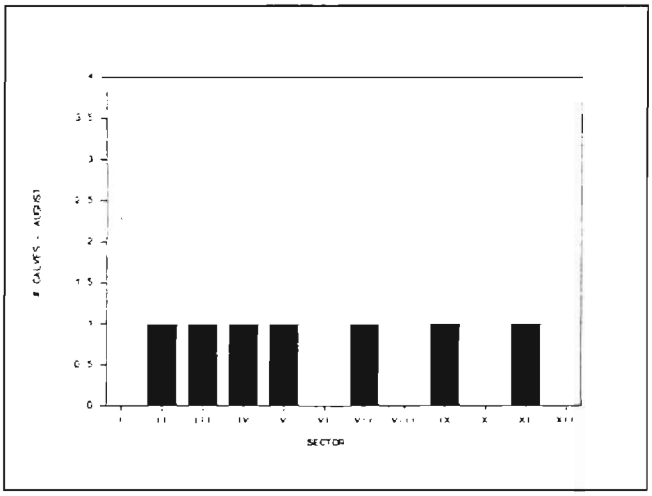

Figure 15g. Number of calves per sector, August.

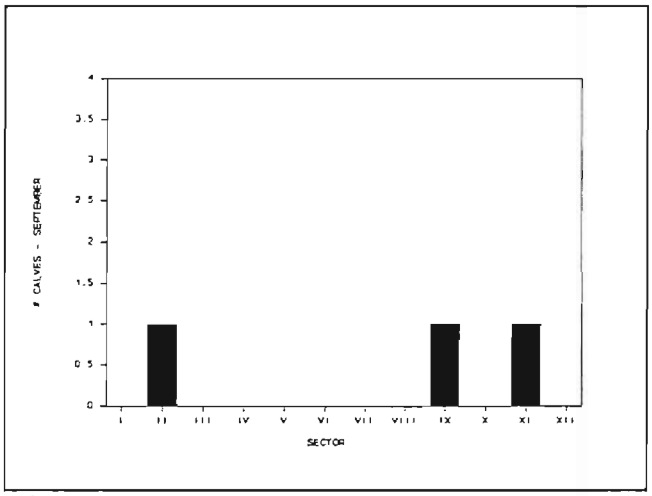

Figure 15h. Number of calves in each sector, September.

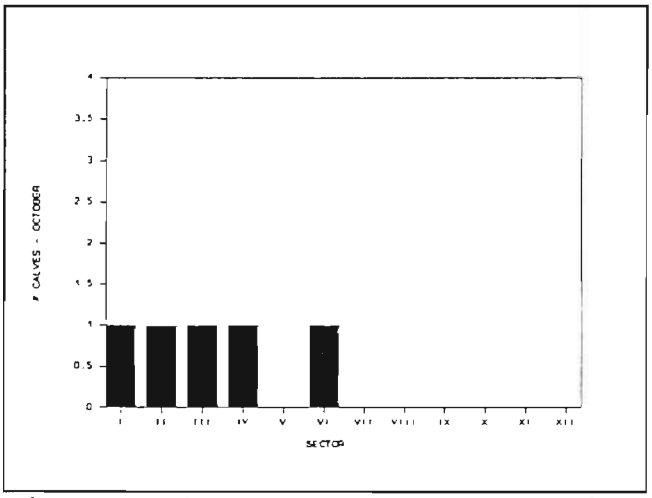

Figure 15i. Number of calves in each sector, October.

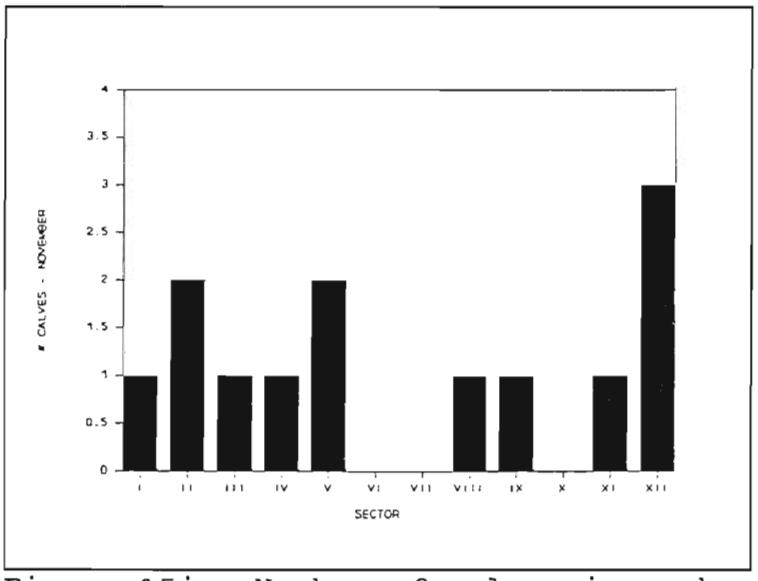

Figure 15j. Number of calves in each sector, November.

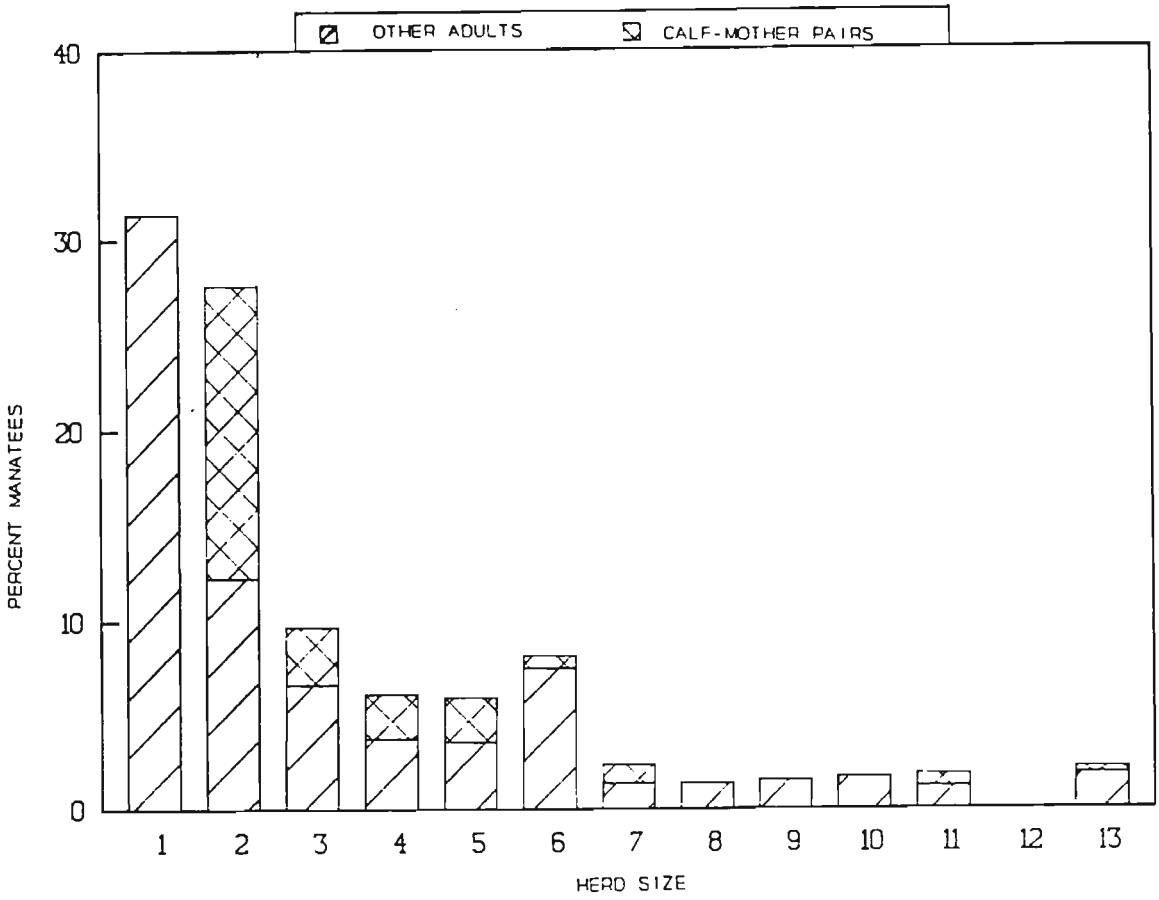

Figure 16. Herd size distribution as percent of total herds.

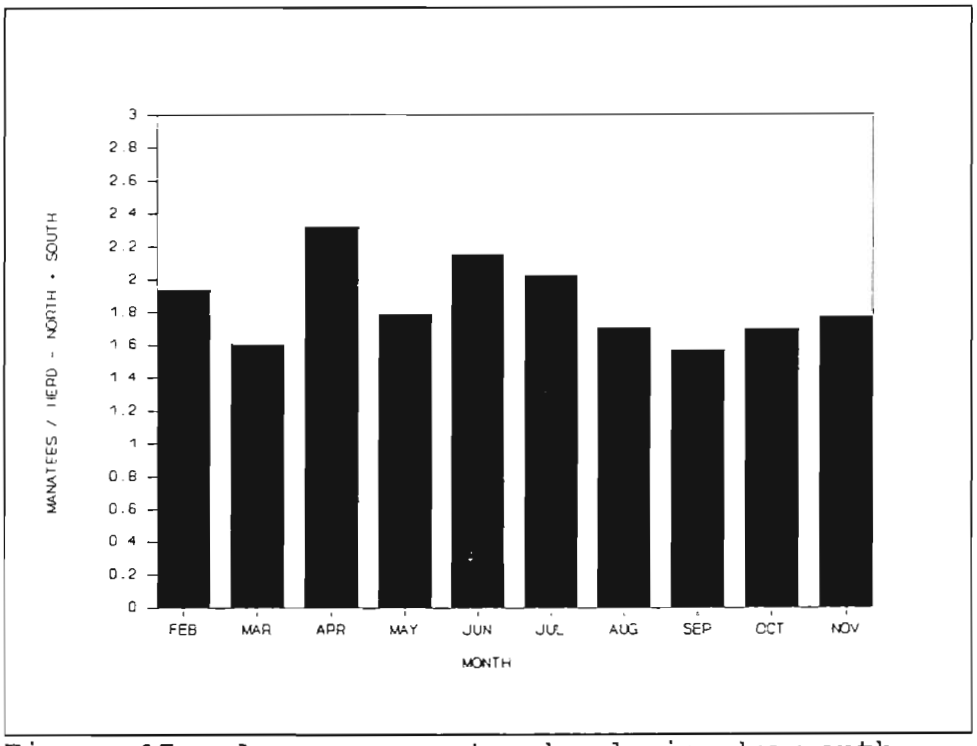

Figure 17. Average manatee herd size by month.

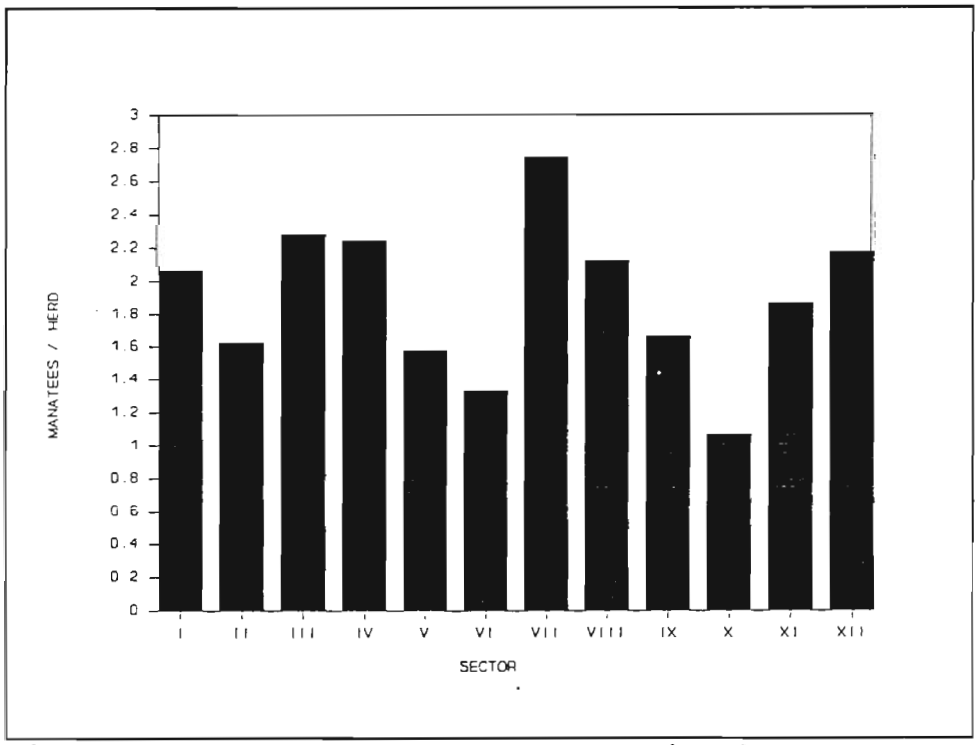

Figure 18. Average manatee herd size by sector.

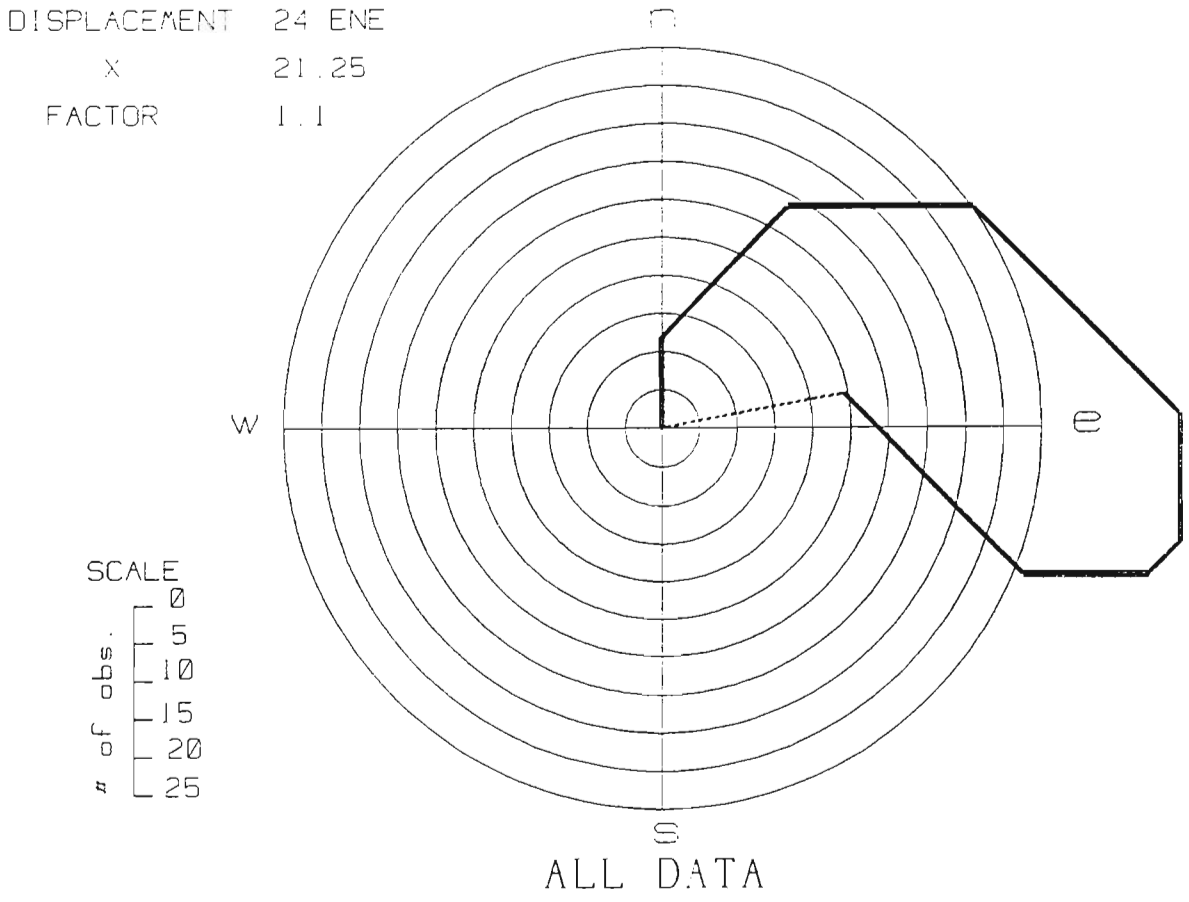

Figure 19. Vector analysis of directional movement for all sightings.

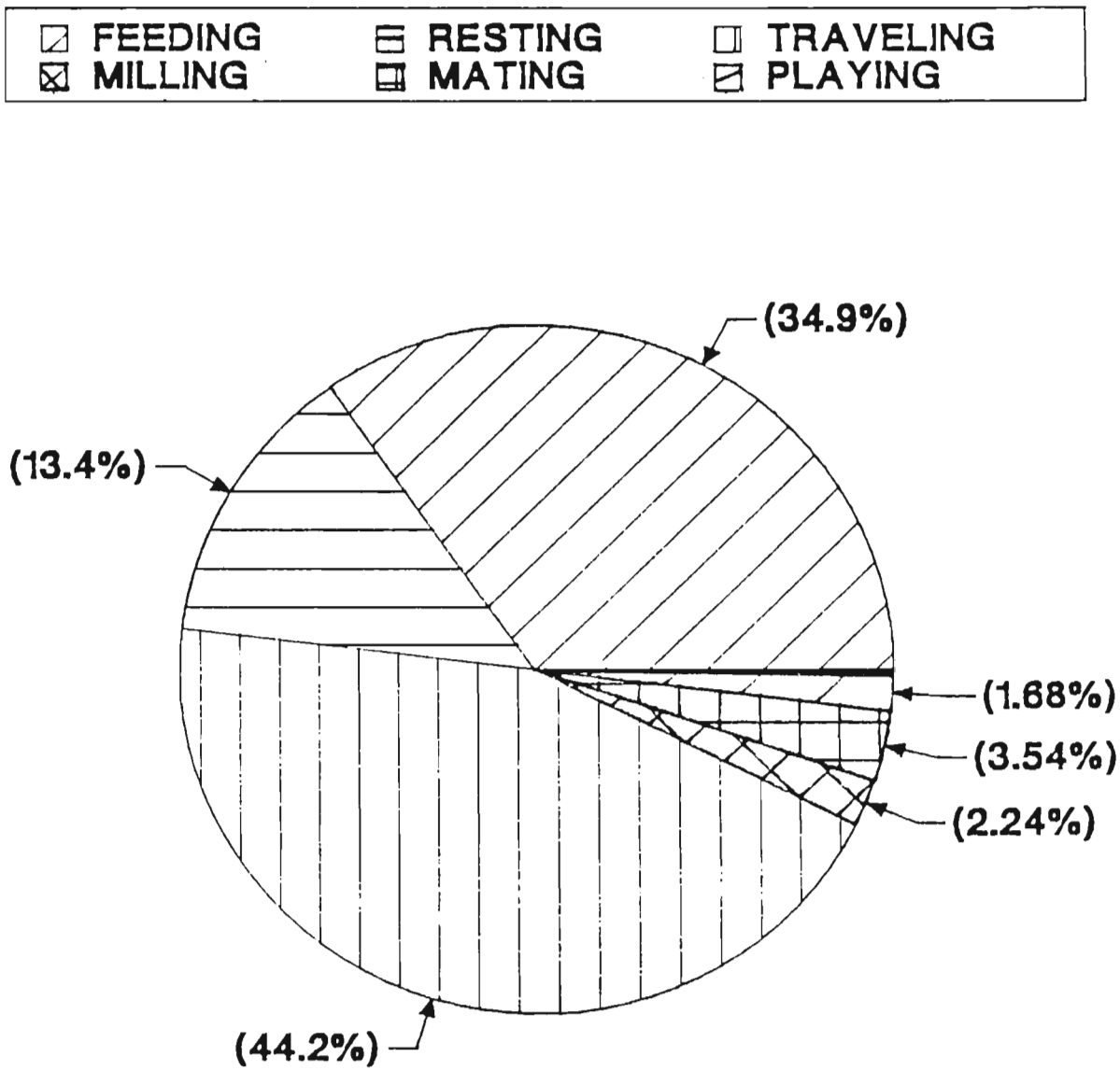

Figure 20. Behaviors of manatee adults and calves.

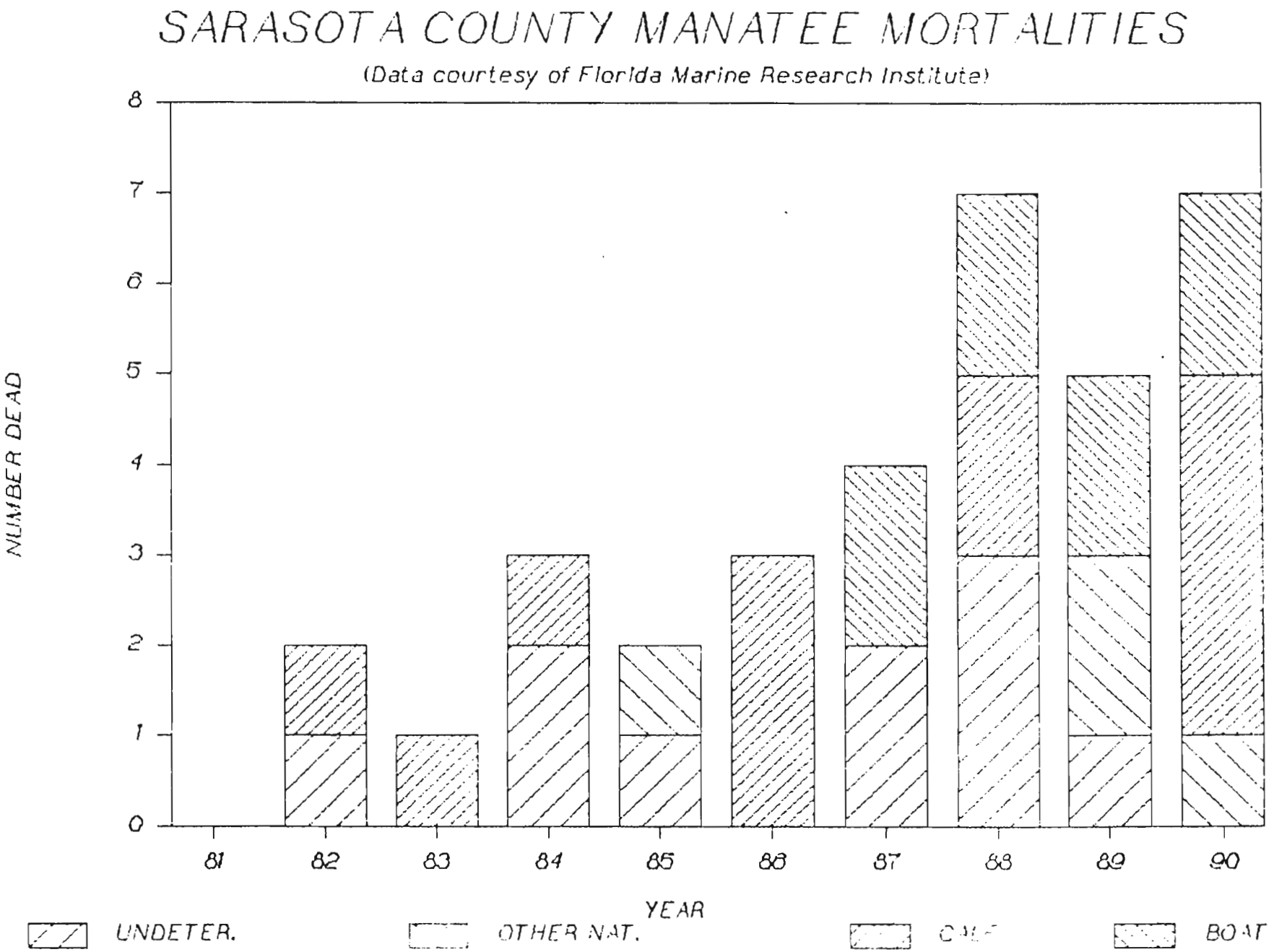

Figure 21. Manatee mortalities in Sarasota County for 1982-1990.

APPENDIX 2: TABLES

TABLE 1. Flight parameters.

FLIGHT	DATE	BEGIN	FINISH	BREAK	MANATEE COUNTS	PRIMARY OBSERVER	SECONDARY OBSERVER	PILOT	WATER CLARITY	SURFACE	WIND DIRECTION/SPEED	COMMENTS
A	N: 2/8	0919	1343	0 MIN	6+0	MAM	EH	SS	E-G	0-1	130 @8	DELAYED DUE TO HAZE
	S: 2/13	1003	1559	0 MIN	52+3	TB		BF	F	1-2	NOT AVAIL.	
B	N: 3/27	0844	1549	61 MIN	8+0	MAM	DS/DF	BF	E-F	1-3	320 @9 (1030) 310 @15 (1400) 330 @9 (1545)	SUSPICIOUS GAS LEAKAGE AFTER BREAK (1244). SWITCH PLANE TO N64168, CESSNA 150
	S: 4/9	0844	1505	64 MIN	30+6	MAM	LO	RG	F-P	2-3	100 @12 (1455)	86 MIN ADDITIONALBREAK TO TRANSPORT PASSENGER FROM ENGLEWOOD TO FT. MYERS.
C	N: 4/19	0932	1345	24 MIN	8+1	MAM		RG	G-F	1-2	NOT AVAIL.	BEACH NORTH TO BIG PASS NOT SURVEYED
	S: 4/24	0846	1312	0 MIN	48+8	MAM		SS	G-P	0-3	060 @5/10 (0900)	
D	N: 5/18	0813	1320	20 MIN	13+4	MAM		RG	E-F	1-2	190 @7 (1315)	BEACH NOT SURVEYED
	S: 5/25	0814	1211	0 MIN	15+2	MAM		RG	G-P	1-3	100 @8 (0845)	SECTOR 10 NOT SURVEYED DUE TO HEAVY RAIN
E	N: 6/11	0943	1525	73 MIN	28+2	MAM	DB	JM	G-P	1-2	NW @16 (1200)	
	S: 6/14	0809	1447	53 MIN	34+7	MAM		BF	E-F	0-1	060 @4 (0900)	
F	N: 7/17	0817	1423	26 MIN	12+3	MAM	BG	BF	G-P	1-3	070 @7 (0820) 090 @10 (1015)	
	S: 7/19	0848	1511	16 MIN	54+8	MAM	BG	BF	E-P	1-3	080 @6 (0900)	
G	N: 8/23	0809	1448	48 MIN	31+5	MAM		BF	G-P	0-2	250 @8 (1047) 210 @10 (1214)	
	S: 8/28	0811	1514	30 MIN	20+2	MAM	LP/RP	BF	G-P	0-2	NOT AVAIL.	SECTOR 11 BAD CONDITIONS/RAIN SECTOR 12 ABORTED DUE TO THUNDERSTORM 13 MIN ADDITIONAL BREAK TO DROP OFF AIRSICK PASSENGER
H	N: 9/19	0949	1647	54 MIN	8+1	MAM		BF	G-B	1-2	060 @8 (0954) 040 @14 (1632)	FLIGHT ATTEMPTED 9/18 BUT ABORTED DUE TO HEAVY GROUND HAZE 9/19 FLIGHT DELAYED DUE TO HAZE
	S: 9/26	0826	1521	57 MIN	32+2	MAM	SC	BF	G-P	0-1	NOT AVAIL.	
I	N: 10/23	0843	1559	63 MIN	26+6	MAM		BF	G-P	0-2	100 @6 (0846) 240 @5 (1156) 290 @8 (1309) 270 @10 (1412)	
	S: 10/30	0925	1606	42 MIN	18+0	MAM	JS	DH	G-B	1-3	050 @5 (0925) 050 @10 (1000) 090 @10 (1350)	ADDITION OFF-SURVEY 30 MIN. TO DROP OFF AIRSICK PASSENGER
J	N: 11/6	0946	1643	64 MIN	32+7	MAM		BF	G-P	0-2	310 @3 (0959) 260 @5 (1130) 280 @8 (1358) 290 @11 (1444)	DELAYED DUE TO HEAVY CLOUD COVER
	S: 11/8	0841	1535	41 MIN	34+5	MAM		BF	G-B	0-2	080 @8 (0843) 100 @8 (1241) 070 @7 (1533)	

Table 2. Surface conditions scale.

Scale	Effects Observed at Sea
0	Sea-like mirror
1	Ripples with appearance of scales
2	Small wavelets; crests begin to break; scattered whitecaps
3	Large wavelets; crests begin to break; scattered whitecaps
4	Moderate waves, taking a longer form; many whitecaps; some spray

(Adapted from the Beaufort Scale, which is not suited for nearshore use.)