AERIAL STUDIES OF THE WEST INDIAN MANATEE (Trichechus manatus) FROM ANNA MARIA FLORIDA TO NORTHERN CHARLOTTE HARBOR INCLUDING THE MYAKKA RIVER: RECOMMENDED HABITAT PROTECTION AND MANATEE MANAGEMENT STRATEGIES

Submitted to :

Natural Resources Department
County of Sarasota
P.O. Box 8
Sarasota, FL 34230

Submitted by :

Peter Nabor
Geoffrey W. Patton
Mote Marine Laboratory
1600 City Island
Sarasota, FL 34236

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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.

Mote Marine Laboratory has been conducting aerial surveys and collecting manatee sighting data on the Gulf Coast since January 1985. This report presents nearly four years of sighting data for the area from Anna Maria Island (27°32.5'N) to Venice (27°03'N) and almost two years for the area south of Venice to northern Charlotte Harbor (26°43'N), including the Myakka River (Figure 1).

Manatee mortality factors are outlined in Table 1. Human activities, especially boat and barge operation, have a strong detrimental effect on manatees. Moreover, the percentage of manatees killed by boats has increased in recent years (statewide and locally), as have percentages for all other categories of human related mortalities. Recreational and commercial boat use is increasing as the human population on Florida's coast continues to expand. The number of registered boats in Florida now stands at about 650,000. The number of boats trailered into Florida by visitors represents an additional 350,000 boats. By the year 2000 these figures are expected to double. In 1987, about 100 people were killed in boating accidents and 1,000 were seriously injured. Thirty-nine manatees died as a result of boat collisions in the same period. Reynolds and Gluckman (1988) state that discounting most calves and some rare adults, virtually all manatees are

scarred from boat propellers, many with multiple scar patterns. This suggests a very high injury rate.

For Sarasota County, the only county entirely within the survey area and for which government data are readily available, boat registrations are shown in Figure 2 and manatee mortalities in Figure 3. The apparent correlation may point to a "threshold" of boat use. Above such a threshold, manatees may not be able to avoid collisions for very long. Furthermore, the unmanaged human population growth is diminishing the capacity of coastal habitat to support manatees. Seagrass habitats, essential feeding areas for manatees, have been impacted statewide by dredging, human generated pollution, organic debris, turbidity, and siltation. According to Reynolds and Gluckman (1988), habitat protection is essential to the long-term survival of the manatee, and immediate efforts should be taken to acquire a system of key habitat reserves via state and federal programs and private organizations. Further, important habitats that cannot be acquired may still be protected. Channel exempt slow speed (no wake) zones and maximum speeds should be imposed and enforced in critical areas to reduce manatee injury and mortality rates and to protect seagrass communities from excessive turbidity, siltation and direct damage.

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 are represented (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 ft), 5 ton, kelp-eater from the Bering Sea, was hunted to extinction within 27 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 seal-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 (3,600 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 west as the Rio Grande River and as far north as Currituck Sound, Virginia.

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 30 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. 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. 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 Endangered Species Act of 1973 and the Marine Mammal Protection Act of 1972. This legislation levies up to a $20,000 fine and/or a 1 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.

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 (2 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. 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 grassflats 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 fall below this, manatees migrate toward sources of warm water. Winter aggregations center around 24 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 Cow), 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).

G. 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 17 courting bulls, which 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 3 to 5 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 2 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).

H. 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).

I. 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, O'Shea and Beck, 1983). The USFWS and FDNR have developed seven categories:

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.

Crushed/Drowned in Floodsate 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 from separation from the mother, stillbirths and neonates, young deceased animals, or 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.

III. STUDY DESIGN

A. Field Methods

Hartman (1974) estimated a statewide manatee population of no more than 1,000 animals. An estimate of 40 manatees was given for the area from Cortez to Placida, although no animals were seen on a summer aerial survey. A subsequent attempt (Irvine and Campbell, 1978) to survey the entire state sighted no manatees between Anna Maria and Venice. Irvine et al. (1981) conducted aerial surveys along Florida's west coast and recorded a total of only 20 manatees sighted during three surveys between Anna Maria and Venice (Table 2).

MML began surveying the area from Anna Maria Island to Venice in January 1985. The area south of Venice to northern Charlotte Harbor, including Gasparilla Pass, Turtle Bay, and the Myakka River, was added in January 1987. Surveys have been conducted biweekly in warm months and a minimum of once a month during colder periods, as manatees typically leave the survey region during periods of low water temperatures.

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

The location, number and life stage (adult or calf) were recorded on standardized map sets. Herds were circled until all data to be recorded could be verified. Manatee locations were indicated on the maps by a "T.m." with a dot (if the herd was stationary) or a directional arrow (showing vector 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.

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 and years. Thus, what is presented is a relative measure of minimum manatee abundance, not absolute counts.

B. Laboratory Methods

1. Movements

Two graphing techniques were applied to understand manatee movement patterns. The first is a polar histogram of the number of occurrences recorded for manatees moving in a given compass direction. The second technique applies a vector analysis approach to the data from the polar histogram. 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. A directional "Factor" was then calculated by dividing the net displacement into the average value for the vectors represented. This factor presents a means of comparing vector plots.

2. Sightings

For this report the survey area was divided first into 12 sectors using major geographical landmarks or bridges as dividing points. Figure 4 demonstrates these divisions in map form, and a description of the boundaries and a calculation of square kilometers for each sector is presented in Table 3. Secondly, a survey effort calculation was made by determining the number of "visits" to each sector and in each month (= Total Survey Effort) over 3-3/4 years.

To present a measure of manatee abundance for the entire survey area, a monthly index of manatee sightings was created in which the total number of manatees sighted in a month was divided by the Total Survey Effort (TSE) for that month.

The data for each of the twelve sectors were tabulated and graphed by month to demonstrate the average number of manatees per survey over the course of a year. The data for each month were compiled and graphed by sector to show the average number per survey on a regional basis.

A regional index for the survey region was also created in which the total number of manatees sighted in a sector (over 3-3/4 years) was

divided by the TSE for that sector. To calculate manatee densities in each sector, the number of manatees per square kilometer per survey effort (Tm/km^2/TSE) was determined.

The data regarding calves were examined in a variety of ways including the regional index (i.e., calves/TSE for each sector) and the density calculation for each sector (calves/km^2/TSE) both mentioned previously. The remainder of comparisons were made on a percent calves basis (i.e., number of calves divided by the total number of manatees in that sector or month). Percent calves were determined by sector, by month, by TSE, by season, and by year for all data.

Reports of manatee sightings have been collected from concerned citizens since late 1984. Data from telephone interviews are recorded in a logbook and include information on date and time, name and phone number of caller, number and location of manatees observed, size of the animals, identifying scars seen, and behavior of animals.

3. Herds

The herd sizes of manatee sighting events were tabulated and the percent of animals and percent of sightings were graphed to depict the herd-size distributions for all of the collected data. The average number of manatees per herd was determined by month, sector, and year.

4. Locations

A one-square nautical mile grid was overlaid on a map of the survey area and the number of manatees sighted in each grid was calculated and graphed. Recommendations for manatee protection were formulated based on regular and recurring use of specific areas by manatees and known risks to the animals.

IV. RESULTS AND DISCUSSION

Table 4 presents flight dates and manatee counts for each flight since January 1985. Over the four-year study period, 1,258 herd sightings (a herd being comprised of one or more manatees) were recorded during a total of 120 flights. The cumulative number of animal sightings

was 2,695 for an average of 22.5 manatees per survey flight. Of the 2,695 animals, 295 (10.9%) were calves.

1. Movements

Manatees typically depart our survey region when water temperatures drop below 20°C (68°F) and return in the spring when water temperatures in the bays rise. Figure 5 demonstrates the low numbers of manatees sighted in January and February when water temperatures are lowest. It can also be seen from this figure that peak counts are made in September and October, with a secondary peak in May and June.

A possible scenario to explain the pattern in Figure 5 follows. As waters warm in spring, animals enter our study area and counts increase until a peak is reached in May and June. In the summer, manatees continue to disperse and may leave the boundaries of the survey area looking for food, mating herds, etc. and counts decrease (i.e., July and August). In September and October, manatee counts again peak, possibly as animals reverse the dispersal patterns. During November and December, animals may begin migrating closer to sources of warm water as air and water temperatures begin to fall. Finally, in January and February animals remain near warm water refuges outside our survey region.

Figure 6A-L demonstrates the average number of manatees per survey in each sector by month. With very few exceptions (most notably during periods of low water temperatures) manatees may be found anywhere in the study area at any time. However, a few trends are evident. In Sector I, counts are elevated in March and April but are highest in October, November and December. This sector borders on south Tampa Bay and may serve as a collecting point for manatees seeking and exiting from warm water refuges in Tampa Bay. Sectors II, IV, VI, and VII are all utilized by manatees to a greater extent during the second half of the year, peaking in September or October. Sector V shows an abrupt peak in May and high counts in November and December. Sectors III, VIII, and IX have relatively high counts throughout times of warm water. Sector XI shows a distinct peak in spring (March, April, May) with a secondary peak in September and October. This sector lies at the northern end of Charlotte

Harbor and is believed to act as a collecting area for manatees prior to seeking warm water sources in fall and as a stopover for animals exiting these refuges in spring. Counts decrease in June, July and August as animals presumably disperse to other areas. Finally, Sector XII is the Myakka River which may be a natural refuge utilized by a small number of manatees in December, January and February. Counts in this sector are high all summer, possibly coinciding with the peak of manatee exploratory activity.

Figure 7A-L demonstrates how data for each month are distributed by sector. In January and February, the low number of manatees is evident as is the occurrence of animals in the Myakka River. Graphs for March and April show the high degree of use in Sector XI as well as the appearance of animals in the northern sectors. The influx of animals into the central areas can also be seen beginning in March and continuing throughout the year. By the second half of the year, all sectors are utilized by manatees to a varying extent.

A direction of movement was recorded for 26.7% (335 of 1,258) of manatee herd sightings since 1985. These data are summarized in a series of polar histograms and vector analyses. Figure 8 shows the polar histograms for winter (December, January, February), spring (March, April, May), summer (June, July, August), fall (September, October November) and for all data recorded. Figure 9 depicts vector analyses of manatee movements for the same time periods.

The factor in the vector analyses for all data (factor = 0.05 NE) is negligible demonstrating almost no net movement. The analysis for winter shows a very strong directionality of movement to the south-southeast (factor = 2.13 SSE). The majority of the movements noted was in December (22 of 24 recorded). Thus, a strong southward migration is evident as water temperatures begin to fall. Spring movement patterns also showed a southerly trend (factor = 1.45 SW). This may be a result of manatees moving south away from warm water sources in Tampa Bay. Manatees entering our survey area from the south aggregate at Turtle Bay and may not begin moving north until late May. This migration may play a part in the slight north-northeast trend observed in summer. The factor is small (factor = 0.57 NNE) and demonstrates generally random movements

during summer. Fall movement patterns are also north-northeasterly with a small factor (factor = 0.72 NNE), again exhibiting no strong migration pattern, but possibly reflecting a return to winter refuges in Tampa Bay.

2. Sightings

Table 5 presents a summary of the Total Survey Effort (TSE), a means for adjusting manatee counts (by area or month) for unequal numbers of visits. The survey effort ranged from zero for Sector XII in November to nine visits throughout Sectors I-VII in June during the nearly four year period. The variations are the result of weather, scheduling conflicts, and the fact that the southern region has only been surveyed for the past two years.

Figure 5 illustrates the seasonality of manatee use of the study area. Manatees move into the area from wintering grounds both to the south and to the north during the spring and generally leave in winter as the water temperature falls below tolerable levels. This activity pattern can be followed for each sector in Figures 7A-L.

The monthly data were combined in Figure 10 to give a regional index of manatee sightings (number of manatees sighted in a sector/TSE for that sector). This effort depicts the gross manatee usage patterns for the entire survey region. Notable are the numbers in Sarasota Bay (Sector III), North and South Lemon Bay (VIII and IX), and especially the high numbers in the Gasparilla Sound-Cape Haze Aquatic Preserve area (XI) and the Myakka River (XII). Generally, the southern region shows greater utilization by manatees. Sector-by-sector differences for each month are shown in Figure 6A-L. Figure 11 utilizes a calculation of area (square kilometers) for each sector to generate an index of manatee densities (manatees/km^2/TSE). The importance of Lemon Bay (VIII and IX) can easily be seen as it contains high density counts. The importance of the entire south region is evident, although the dominance of Sectors XI and XII in Figure 10 are reduced in Figure 11 with the application of a square kilometer calculation. The count for Sector III is also reduced because of the size of the sector. Sectors IV and VI increase in importance due to the relatively small size of the sectors.

Manatees are believed to lack a specific breeding season, and calves are born throughout the year (Hartman, 1979; Husar, 1977). Figure 12 shows the percent of manatees sighted in each month that were calves, and Figure 13 shows a measure of calves seen per unit effort (calves/TSE). Of all manatees sighted, 10.9% were calves. This calf-to-adult ratio is within the ranges of other studies (Irvine, Caffin and Kochman, 1981; Reynolds, 1988). The low counts during periods of low water temperatures likely are a result of the females with calves remaining close to warm water refuges. A comparison of percent calves by season is shown in Figure 14. It is important to note that animals in our survey region do not belong to a closed population; immigration and emigration may greatly affect the data. Thus, it cannot be said that there is a spring calving peak, but only that the percent calves is highest in spring for the survey region.

The percent calves varied greatly between years (S.D. = 2.5). Figure 15 shows yearly variations in these data. If only the figures for the north area for 1987-1988 are used, the variability is somewhat reduced (S.D. = 1.1), as is the cumulative percent (8.1% from 10.9% for all data). The percent calves for the southern area is notably higher than that for the north, 13.0% vs. 8.1%, respectively (south area surveyed in 1987 and 1988 only).

The number of calves per Total Survey Effort (calves/TSE) by sector is shown in Figure 16. It can be seen that the highest counts are achieved in southern waters, especially Lemon Bay (Sectors VII and VIII), the Gasparilla Sound-Cape Haze Aquatic Preserve area (Sector XI), and the Myakka River (Sector XII). Figure 17 illustrates the relative calf densities per TSE in the respective sectors (calves/10km^2/TSE). Sectors IV and VII show high calf densities in the north region, while in the south, calf densities for Sectors XI and XII decrease markedly (because of their large areas). The Lemon Bay sectors (VII and IX) show the highest calf densities per TSE.

Figure 18 demonstrates the percentage of animals that were calves in each sector. Sectors IV and VIII stand well above the 8.1% average for the north region, while sectors VIII and XI are above the 13.0%

average in the south. Low calf percentages were recorded in Sectors II, V and X.

3. Herds

A total of 1,258 herd sightings produced a count of 2,695 manatees in herds of 1-21 animals (Table 6). The average herd size was 2.14 animals. Groups of four or fewer manatees accounted for 91.3% of the sightings and 70.7% of the individuals. Hartman's (1979) description of the manatee as a mildly social but essentially solitary animal seems accurate, as 75.2% of the sightings were a single animal, an adult plus one calf, or two manatees. Furthermore, only 8.7% of sightings were herds of five or more manatees. Herd size distributions for all data are given in Table 6 and are graphically depicted in Figures 19 and 20.

Data on the average number of manatees per herd were examined by sector, month, and year. Yearly data are displayed in Figure 21. The overall average herd size is 2.14 animals. Little variation was detected between years (S.D. = 0.08). Figure 22 shows a regional breakdown of these data. Sector XI demonstrates an average number per herd well above the average for all data. This sector, especially the Turtle Bay area, serves as a collection area for manatees in the spring, and herds of up to 21 animals have been sighted there. Sector VII also exhibits an above average number per herd. This sector includes the Venice Inlet area, Lyons, Dona and Robert Bays. Two of these bays also have associated creeks reaching a few miles inland (Dona Bay to Shakett Creek and Roberts Bay to Curry Creek). Verbal sighting reports indicate that manatees often use these creeks which lie beyond our study area. The lowest average number per herd was found in Sector II, with low averages also found in Sectors I, III, X, and XII.

Monthly data on average number per herd are shown in Figure 23. The lowest average occurred in January, most likely as a result of the low overall number of animals in the study area. The average herd size increases until a peak is reached in April. This April peak is a result of the clustering of manatees around Turtle Bay (Sector XI). Herd sizes then decrease through August as animals disperse, and then increase in September and October as animals presumably begin to reverse dispersal

patterns, and finally decrease in November and December as animals leave the survey area.

4. Locations

It was formerly believed that few manatees inhabited the area between Anna Maria and Charlotte Harbor. Previous aerial survey projects in this area were of short duration and were non-intensive (Table 2). Surveys by MML have shown this area to contain important non-winter habitats for manatees. As an indication of the number of manatees that may be found in the area, the five maximum counts for north and south regions were averaged separately for each year. These yearly figures were then averaged to generate an estimate of the maximum number of manatees that may be found within our survey area (Table 7). The overall average of maximum counts for the north region (over nearly four years) is 27.0 manatees, and this figure for the south region (over nearly two years) is 72.2 manatees, for a combined average of 99.2 manatees for the entire survey region. Again, these figures demonstrate values for the high end of the scale for the number of manatees found in the survey region.

Habitat protection is essential for the long-term survival of manatees. Seagrass habitats have been greatly reduced statewide, largely as a result of poorly managed human population growth. Key habitat reserves should be acquired along all of Florida's coasts and areas not acquired should be protected. Channel exempt slow speed (no wake) zones should be imposed as well as maximum speed limits for areas outside the slow speed (no wake) zones. These actions will reduce manatee mortalities caused by boat collisions and also help to reduce siltation and turbidity, thereby minimizing destruction of seagrass communities. Manatee conservation efforts, including habitat protection, must be integrated into local growth management plans if manatees are to survive.

Some of the most important information to be gained from aerial survey efforts is the distribution of sighting locations over the region. Figure 24 uses bar graph maps to summarize the sighting location data for this study. The north region (Figure 24A-B) is comprised of nearly four

years of data, while the south area represents nearly two years of data (Figure 24C-E).

V. CONCLUSIONS

Aerial survey programs are providing valuable information and serving to build a data base that will establish the basis for making sound management decisions regarding the protection of manatees and habitat critical to their survival. In 1985, Florida enacted growth management legislation which mandates that local planners develop and implement growth management plans which account for habitat conservation and endangered species protection.

Manatees in our survey area (and throughout Florida) are facing a building threat from poorly managed human population growth. Increasing levels of boating activity and habitat destruction are the greatest menace to the survival of manatees in Florida. Seagrass communities have been impacted statewide and reduced 50% in areas such as Charlotte Harbor and Tampa Bay (Estevez et al., 1986), thus reducing the capacity of coastal environments to support manatees and other wildlife.

In addition to impacts of habitat loss and degradation manatees must bear the direct pressures of man. Statewide, collisions with boats and barges have accounted for at least 26% of manatee mortalities each of the past four years, and 33% for 1987 and 1988 (Table 1). This category contributes the largest number of manatee deaths attributed to an identifiable cause. Moreover, the number of boats using Florida waterways (i.e., Florida's registered boats and transient boats) stands at 1,000,000 and is expected to exceed 2,000,000 by the year 2000. Injury and mortality rates for manatees, as well as for humans, are increasing at an alarming rate due to the expanding number and speeds of boats using Florida's waterways (speeds now may well exceed 100 mph) (Reynolds and Gluckman, 1988).

Manatee mortalities in Sarasota County have been steadily increasing since the first one recorded in 1983, to a high of 7 manatee deaths in 1988. Of deaths attributed to known causes since 1983, 33.3% are a result of boat collisions (4 of 12); 58.3% are calf mortalities (7

of 12); and 8.3% are of natural causes (1 of 12) (Figure 3). Cause of death could not be determined for eight dead manatees recorded in Sarasota County (usually due to the condition of the animal at the time of examination). A number of the mortalities in the unknown category as well as the calf category (i.e., premature births) may be a result of human pressures on the manatees within the survey area.

One of the primary goals of this program is to identify sites within the survey area that are important to manatees. A number of locations of regular or recurring manatee use have been identified over the course of these surveys. Manatees reportedly utilize specific areas over long periods of time, suggesting that they have preferred sites (Hartman, 1979). It is unfortunate that some habitats favored by manatees are also popular areas for human use (i.e., commercial netting, water skiing, jet skiing, etc.). It is critical that conflicts be reduced so that these areas remain available for manatee use and that the animals are free from harassment while utilizing these sites. Further and more detailed studies are required to obtain a more complete understanding of how manatees use our waters on a seasonal basis and from year to year.

It should be noted here that the areas described below are the minimum number which can be identified to date. Other areas will likely become apparent with further data collection efforts. Specifically, migrational patterns do not lend themselves to rapid detection through short-term, "snapshot" data collection efforts such as the present study. Continued work will yield finer resolution of areas important to manatees and permit monitoring of population trends within the study area.

A bar graph map (on a one square nautical mile grid) of manatees sighted is presented in Figure 24A-E. From this figure, areas of importance were identified and transferred to Figure 25A and B. These areas should be protected for manatees. Man's activities within these areas must be controlled to enable manatees to utilize their preferred sites so they are not pushed into marginal habitats to avoid harassment.

Reynolds and Gluckman (1988) recommend that all inland waterways in important manatee areas be designated as channel exempt slow speed (no wake) zones and that maximum speed limits be set for channels. As these

surveys have demonstrated the importance of this region to manatees, these actions should be taken as soon as possible. However, until the measures are fully implemented, the areas identified as critical habitat within the survey area should be immediately protected. Recommendations for the study area are summarized in Table 8. The following discussion of these areas corresponds to Figure 26A-K. The International Union for Conservation of Nature and Natural Resources' scheme for classification of critical habitats (Salm and Clark, 1984) is utilized to categorize some of these areas. Conservation categories provide a means for incorporating conservation goals into development plans and defining appropriate management regimes.

The area on the northeast side of the Manatee Avenue Bridge (Rt. 64) must be protected. This area should be classified and protected as a Category IV Managed Nature Reserve/Wildlife Sanctuary (Figure 26A), and signs should be posted denoting a "No Entry, Manatee Refuge Area". An exemption for a clearly marked channel to the existing marina would likely be necessary, and this should be an idle speed zone. Expansion of the marina should be limited, pending demonstration of the effectiveness of protection efforts.

The area inside (bayward) and to the south of Longboat Pass should be posted as a slow speed (no wake) zone, channel exempt (Figure 26B).

The Buttonwood Harbor area should be established as a slow speed (no wake) zone and signs posted to this effect (Figure 26C).

The Hyatt Boat Basin should be regulated as an idle speed zone with signs maintained to warn the increasing number of boaters using this facility about the possibility of manatees occurring in the area (Figure 26D).

The grassflats and channels surrounding Lido Key, City Island, St. Armands Key, Bird Key, Coon Key, and Otter Key are very critical areas for manatees (Figure 26D). This entire area should be established as a slow speed (no wake) zone, and should be well posted with appropriate caution signs. Further, the area known as Pansy Bayou should be classified and protected as a Category IV Managed Nature Reserve/Wildlife Sanctuary. The land on the west side of the bayou is presently undeveloped and exists partially as a 65-acre city park at North Lido

Beach. It is proposed that the City of Sarasota prohibit development in this area. Signs denoting a "No Entry, Manatee Refuge Area" designation for the bayou can easily be erected at the opening of the bayou, although an access (idle speed) exemption may need to be granted to waterfront property owners on this body of water.

Roberts Bay (N) should be protected as a channel exempt slow speed (no wake) zone, and again, posted with appropriate signs (Figure 26E).

The basin in Little Sarasota Bay around Midnight Pass should also be designated and posted as a slow speed (no wake) zone, channel exempt (Figure 26F).

The waters from north Blackburn Bay through the Venice Inlet area should be established as a channel exempt slow speed (no wake) zone (Figure 266). This area includes Lyons Bay, Dona Bay with Shakett Creek, Roberts Bay (S) with Curry Creek, the Venice Inlet, and all of Blackburn Bay. The aforementioned creeks lie outside of our survey area, but citizen reports are frequently received of manatees using these areas (especially Shakett Creek).

The whole of Lemon Bay is proving to be critical habitat for manatees (Figure 26H). This area is already recognized by the Department of Natural Resources as an aquatic preserve; however, a more restrictive scheme of protection is warranted due to the high concentrations of manatees utilizing these waters. It is proposed that Lemon Bay be designated as a Category IV Managed Nature Reserve/Wildlife Sanctuary or possibly as a Category VIII Managed Resource Area. In any case, channel exempt slow speed (no wake) zones need to be immediately established throughout Lemon Bay and its associated creeks. Forked Creek should be designated as an idle speed zone due to the numbers of manatees and boaters using the area.

At the south end of Lemon Bay lies the cutoff which connects Lemon Bay with Placida Harbor (Figure 261). The cutoff area is proving to be an important migratory corridor for manatees. It is proposed that a slow speed zone be established for the ICW between south Lemon Bay (marker G9) through Placida Harbor to Gasparilla Sound (marker G19). Placida Harbor should be established as a slow speed (no wake) zone along with the

grassflat areas in Gasparilla Sound near the 771 Bridge to Gasparilla Island.

At the north end of Charlotte Harbor lies one of the most critical habitats for manatees in the survey region (Figure 265). The areas around Bull and Turtle Bays are already protected by the Island Bay National Wildlife Refuge. However, because of the extreme importance of these waters to manatees, more stringent measures must be taken. It is warranted to declare Turtle Bay as a Category I: Strict Nature Reserve to ensure that the area remains free from human intrusion. Turtle Bay and the water near the mouth should be established as a No Entry Manatee Refuge during critical times of the year (Figures 27 and 28). The area near Bull Bay should be posted as a slow speed (no wake) zone.

The Myakka River is proving to be important to manatees (Figure 26K). Extensive portions of the river and the mouth of the system are poorly marked. This situation should be remedied, and the entire lower river (through the Hog Island area) should be declared a channel exempt slow speed (no wake) area with a slow to moderate upper speed limit in the channel. The upper river section should be posted as a slow speed (no wake) zone due to the number of manatees in the area and the lack of areas in which manatees can avoid boats. These areas should be well posted with the appropriate caution signs, especially near the numerous canals in the mid-section of the river to alert the public of the danger to manatees. It is possible that the Myakka River contains areas that are utilized as natural winter refuges. This postulate deserves more attention in the future.

Finally, severe boating congestion occurs at all passes within the survey region and presents a navigational hazard to humans as well as manatees. During aerial surveys, manatees have been sighted moving into and out of passes, and numerous verbal reports of the same nature have been collected indicating that manatees utilize passes as migrational corridors. All passes should be classified as slow speed (no wake) zones.

The detrimental impact of human activities on these critical areas may be illustrated by the example presently under investigation at Area 1 (Figure 26A). An abandoned marina located on the northeast side of the

Manatee Avenue Causeway (Rt. 64) was reactivated in 1987. The number of manatees sighted per visit declined from a combined 1.71 manatees per TSE for 1985 and 1986 to 1.00 per TSE for 1987 and 1988 (through October). Further, the percentage of times that manatees were sighted in or directly adjacent to the site has fallen from a combined 62.2% for 1985 and 1986 to 29.7% for 1987 and 1988 (October). These data are presented by year in Table 9. These results are preliminary, and further investigations of sites such as this are being conducted. More yearly data must be collected in order to assess this situation fully. Such examples may provide important data on the negative influence of increased boating activity on manatee distributions and may, upon further examination, be used to guide management decisions regarding manatee habitat conservation.

VI. RECOMMENDATIONS

The West Indian manatee, as an endangered species, is under the protection of federal, state, and even some municipal legislation. Yet the survival of manatees in Florida continues to be threatened by factors such as increasing human-related mortalities and habitat destruction. Manatee conservation objectives must be fully developed and integrated into state and local growth management plans.

Based on the results of this aerial survey program and a review of available literature on manatee protection, several recommendations can be made for the survey region in the following areas:

1) boating restrictions in shallow water;
2) maximum speed limits in all inland waterways;
3) more extensive channel marking;
4) designating sanctuaries or habitat reserves for manatees;
5) specifying areas for use by water skiers, jet skiers, wave-riders, etc.;
6) increasing public awareness programs;
7) increasing manatee research efforts.

If these measures are implemented, manatee injuries and mortalities from boat collisions should be reduced, human injury and mortality rates will

decline, and water turbidity and siltation will be reduced, minimizing seagrass destruction.

The first two recommendations regarding boat speed restrictions will ultimately help manatees, people, and seagrass communities. Manatees are most vulnerable to collisions with boats in shallow water, as they have little opportunity to avoid oncoming boats. Boat speeds now may well exceed 100 mph, and speeds in excess of even 30 mph allow little reaction time for manatees to avoid collisions. Thus, it is proposed that channel exempt slow speed (no wake) zones be established and maximum speed limits be fixed for all inland waterways. These restrictions would afford boaters more opportunity to see and avoid hitting manatees, allow manatees more time to avoid boats, and reduce the severity of any collisions that might still occur.

The third recommendation involves more extensive marking of channels. This effort would again benefit manatees, boaters, and seagrass communities by minimizing random boat traffic. Channels should be clearly marked leading to the ICW from all marinas and public boat ramps. Containment of boat traffic within channels of adequate depth will allow manatees an opportunity to sound to avoid collisions, reduce the chances of boaters damaging their vessels by running aground, and reduce destruction of submerged aquatic vegetation.

Habitat protection is essential for the long-term survival of manatees. Reynolds and Gluckman (1988) indicate that an integrated system of protected areas which are as large and numerous as possible (given human-oriented constraints) need to be established immediately. Also detailed in their report are the processes by which habitat may be acquired through municipal, state, and federal programs and private organizations.

Studies confirm increases in manatee numbers where strict controls on boating and other human activities have been implemented. Manatees learn the locations of safe reserves and utilize them, and a system of refuges will have positive impacts on manatees as well as various other forms of wildlife (Reynolds and Gluckman, 1988). It is proposed that immediate actions be taken, especially by local planners, to develop site

specific plans for protection of critical manatee habitat within the survey region.

The fifth recommendation proposes that actions be taken to designate specific areas for use by water skiers, wave-riders and jet-skiers. These areas must be established in deeper waters to allow manatees to sound to avoid collisions and also to ensure that aquatic vegetation is not destroyed. During aerial surveys, manatees have been observed fleeing from their identified preferred habitat as a result of jet-skis entering these areas. It is also significant that manatees are rarely sighted during aerial surveys in areas being used by ski boats. It is unfortunate that areas preferred by manatees are often also desireable for human usage. These conflicts must be reduced if manatees are to exist in the survey area.

Public awareness is a key point in manatee conservation. The general public, if made aware of the plight of the manatee, will take action to protect the endangered species, and human-caused mortalities may decline. Primary targets of public awareness programs include boaters, skiers, commercial fishermen, and school children at various levels. If an operator's license is required for boaters, boater education courses and proficiency exams should include information on boat related manatee mortalities and means of reducing collisions with manatees, regulations regarding manatee protection, and ways to avoid disturbing these animals. Out-of-state boaters using Florida's waters must also be educated in these points. More school programs should be initiated in local school districts to develop responsibility for endangered species and increase awareness as early as possible.

The final recommendation involves increasing manatee research efforts. The knowledge gained from projects such a this is helping to build a data base to understand manatees better and to discover means of protecting them and their critical habitats. This program has brought out several questions and potential research projects which need to be investigated. An analysis of factors influencing site preference is necessary to understand why manatees utilize certain areas over others. Site-specific studies of manatees, habitat and habitat use patterns would be desirable at several locations in the survey region. A scar catalog

to identify individual manatees utilizing the survey region should be compiled to provide data on individual movements, migration patterns and site fidelity. Research should be continued on hearing thresholds in captive and wild manatees. Radio telemetric research is desired to provide data on movement and behavior patterns. Acoustic detection devices need to be developed to monitor movements remotely. Devices for remote observations should be investigated. Length/frequency analyses can be conducted to determine population trends.

VII. ACKNOWLEDGEMENTS

This study has been funded primarily by the West Coast Inland Navigation District which is comprised of Manatee, Sarasota, Charlotte and Lee Counties. Sarasota County has provided contract management and contributions have been supplied by the Florida Department of Natural Resources, Michael Saunders Realty, and private citizens. Special acknowledgements go to our dedicated pilots, particularly Paul Graybill and Scott Sorenson. Sincere thanks to Laurie Rose for typing the original manuscript and to Linda Franklin for putting up with the multitude of revisions. Thanks to all of the others who have helped along the way: survey participants, Laboratory Director Dr. Kumar Mahadevan, Laboratory staff and airport personnel. For understanding our need to do this, special thanks to our families.

F I G U R E S

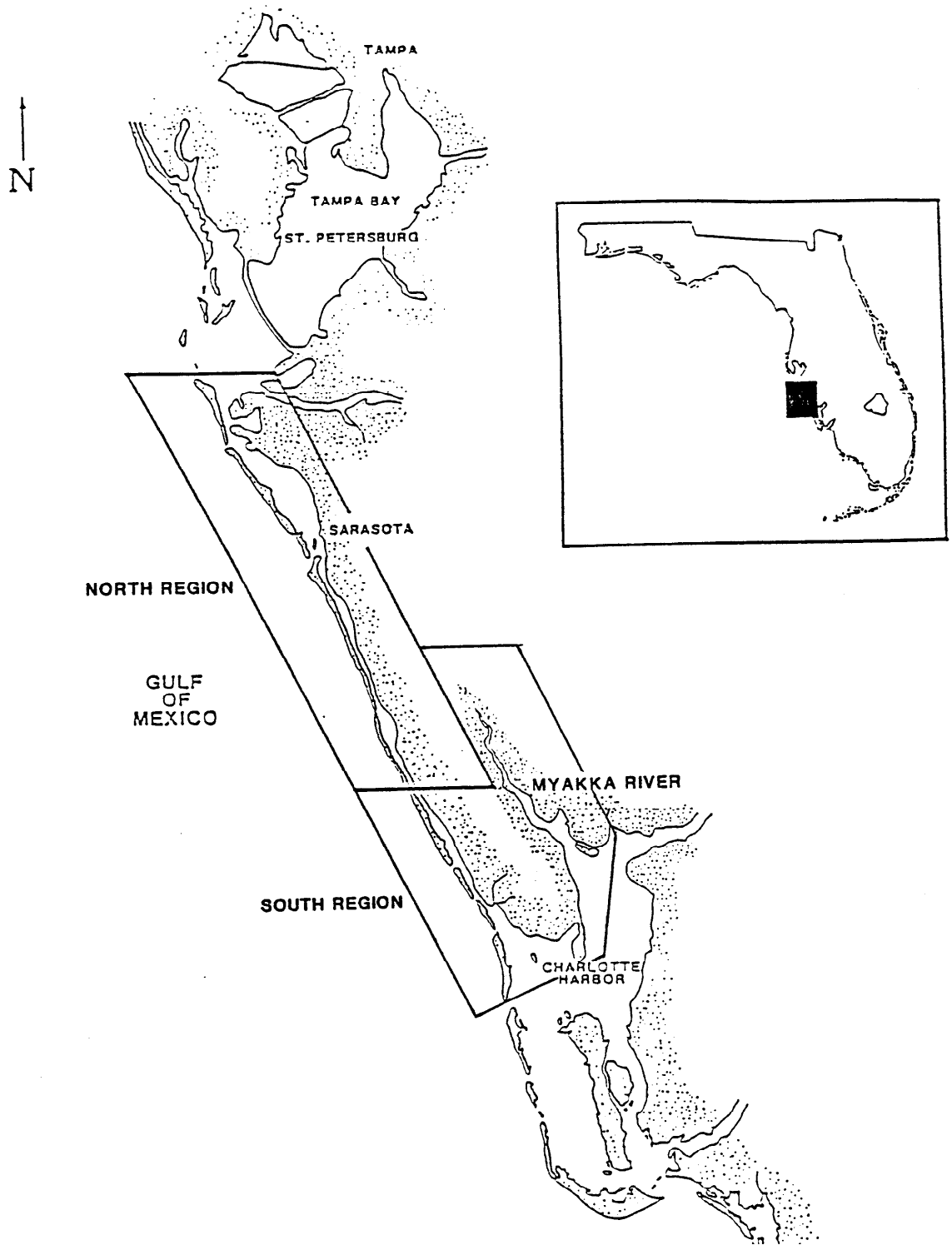


Figure 1. Location of the Study Area, Showing Division into North and South Regions.

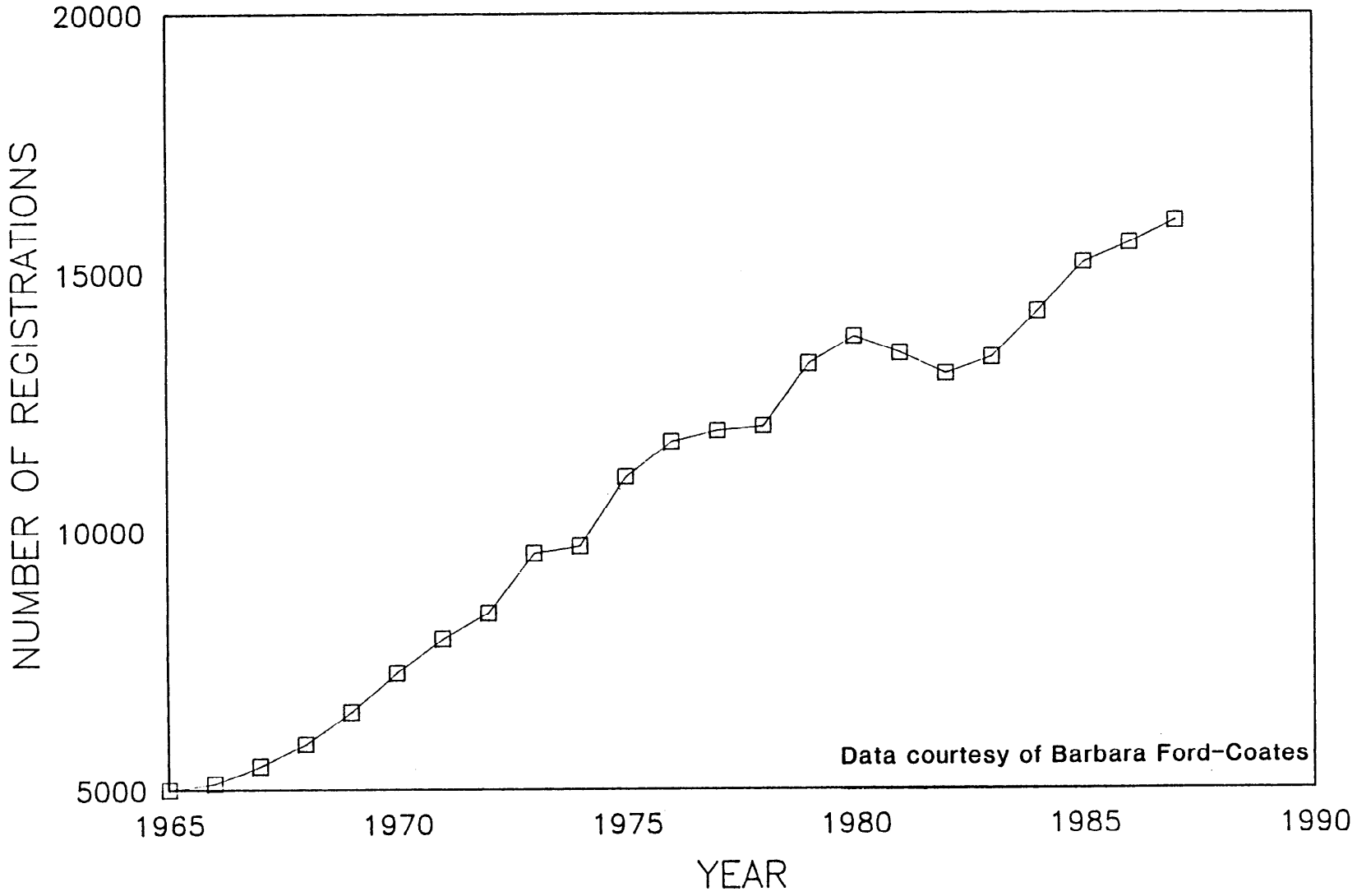


Figure 2. Sarasota County boat registrations for 1965-1987. 1982 excludes commercial registrations.

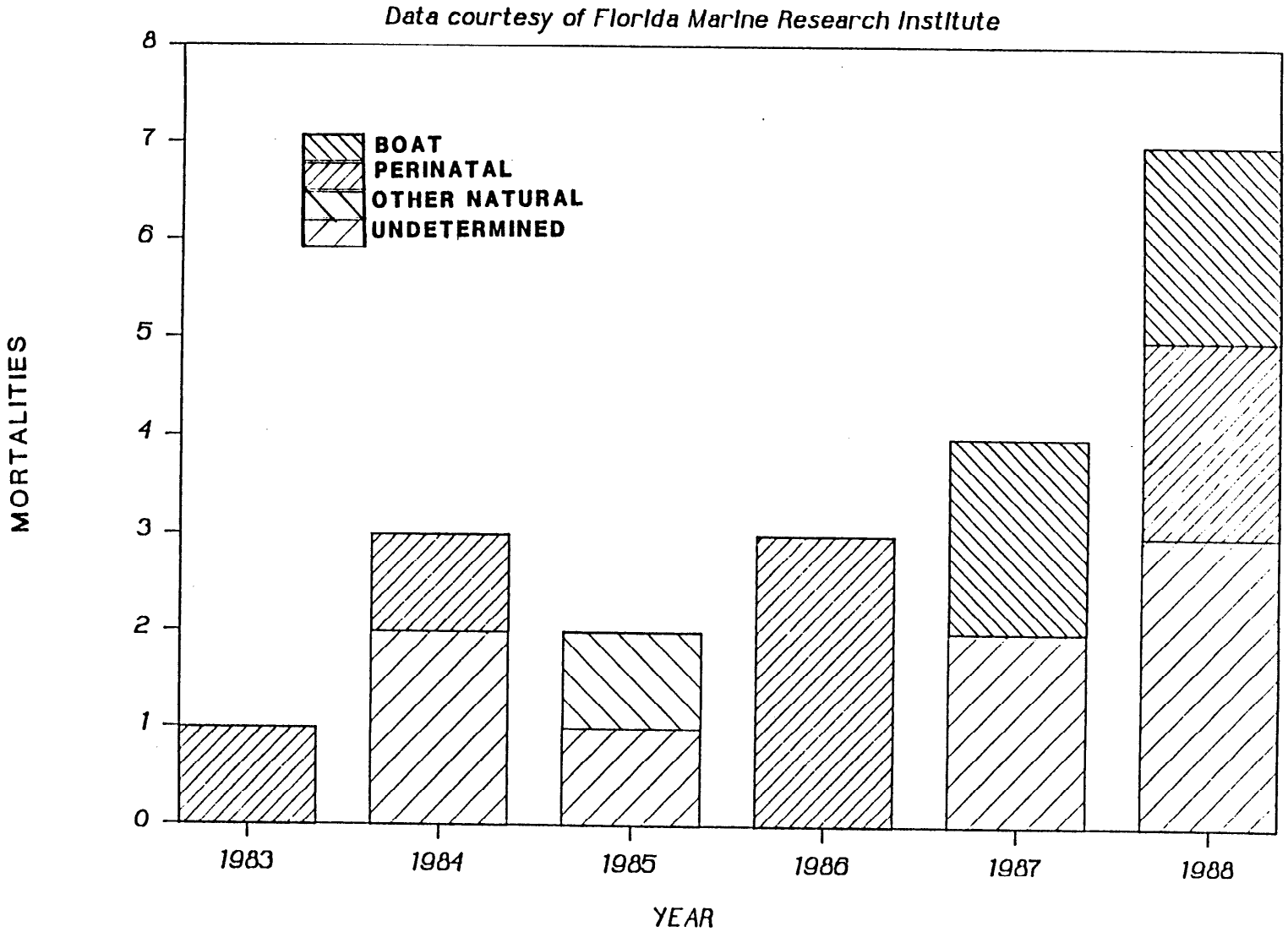


Figure 3. Manatee mortalities for Sarasota County for 1983-1988.

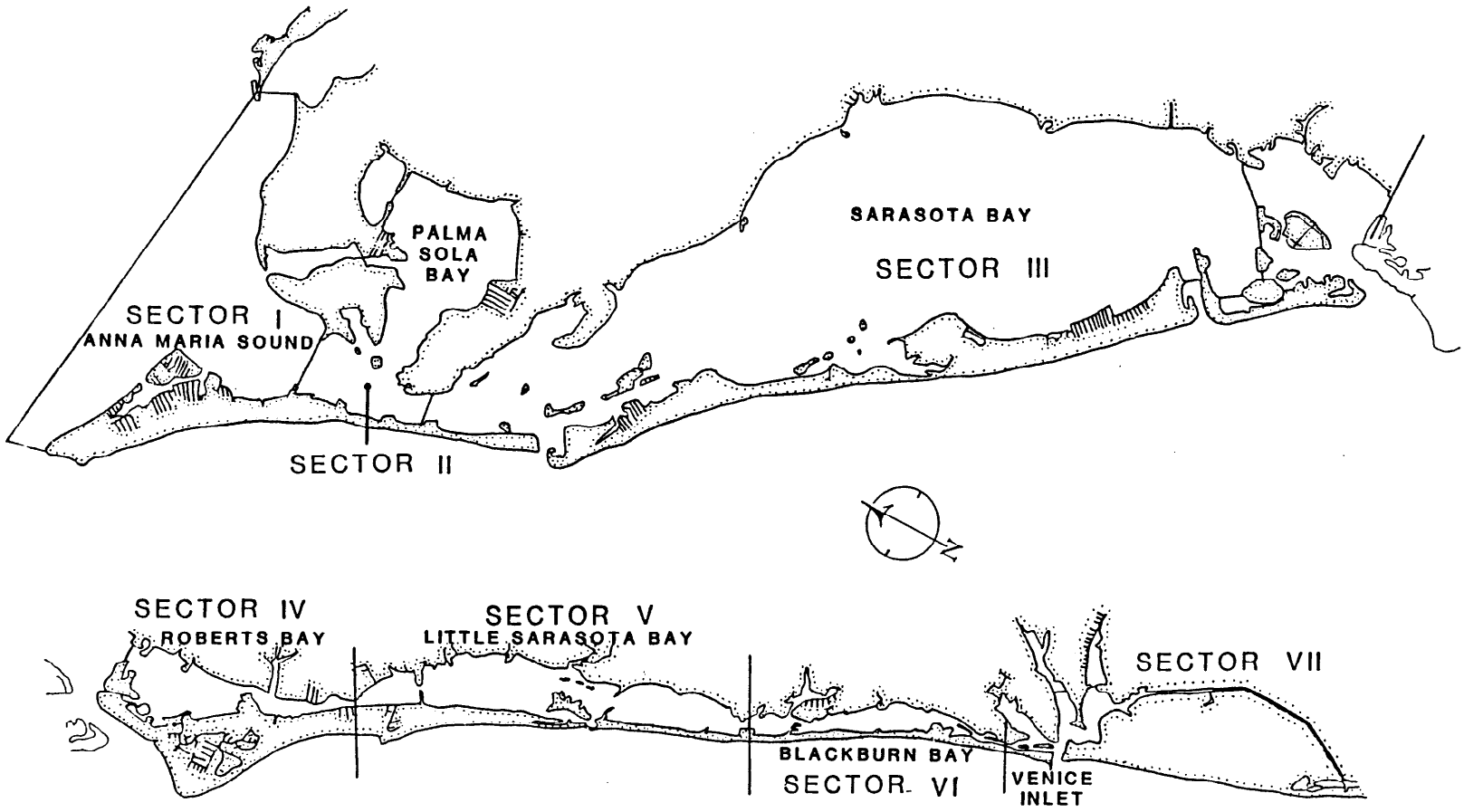


Figure 4A. Division of the survey area into twelve sectors.

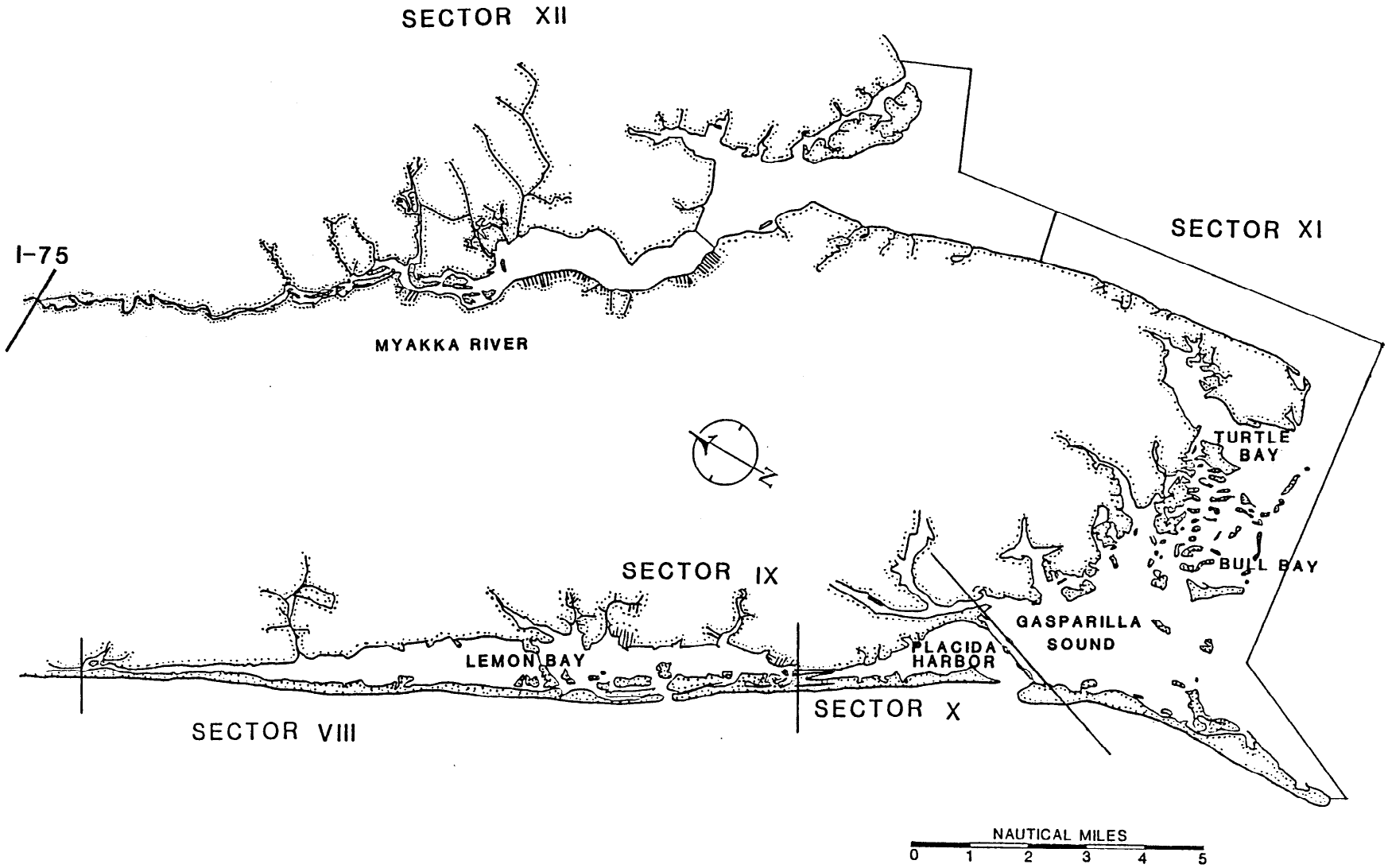


Figure 4B. Division of the survey area into twelve sectors.

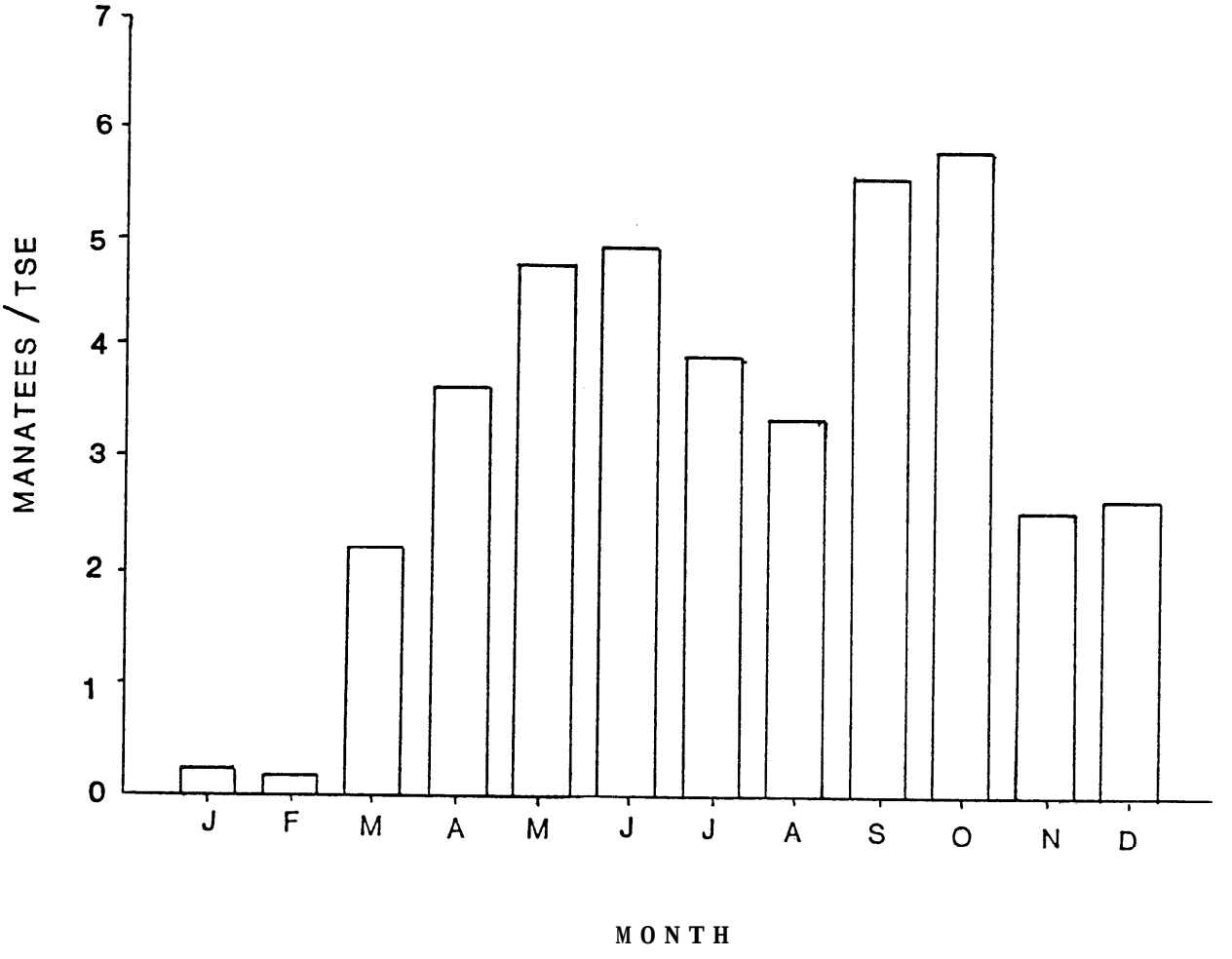


Figure 5. Monthly index of manatee sightings, as total number of manatees sighted in a month per survey effort for that month.

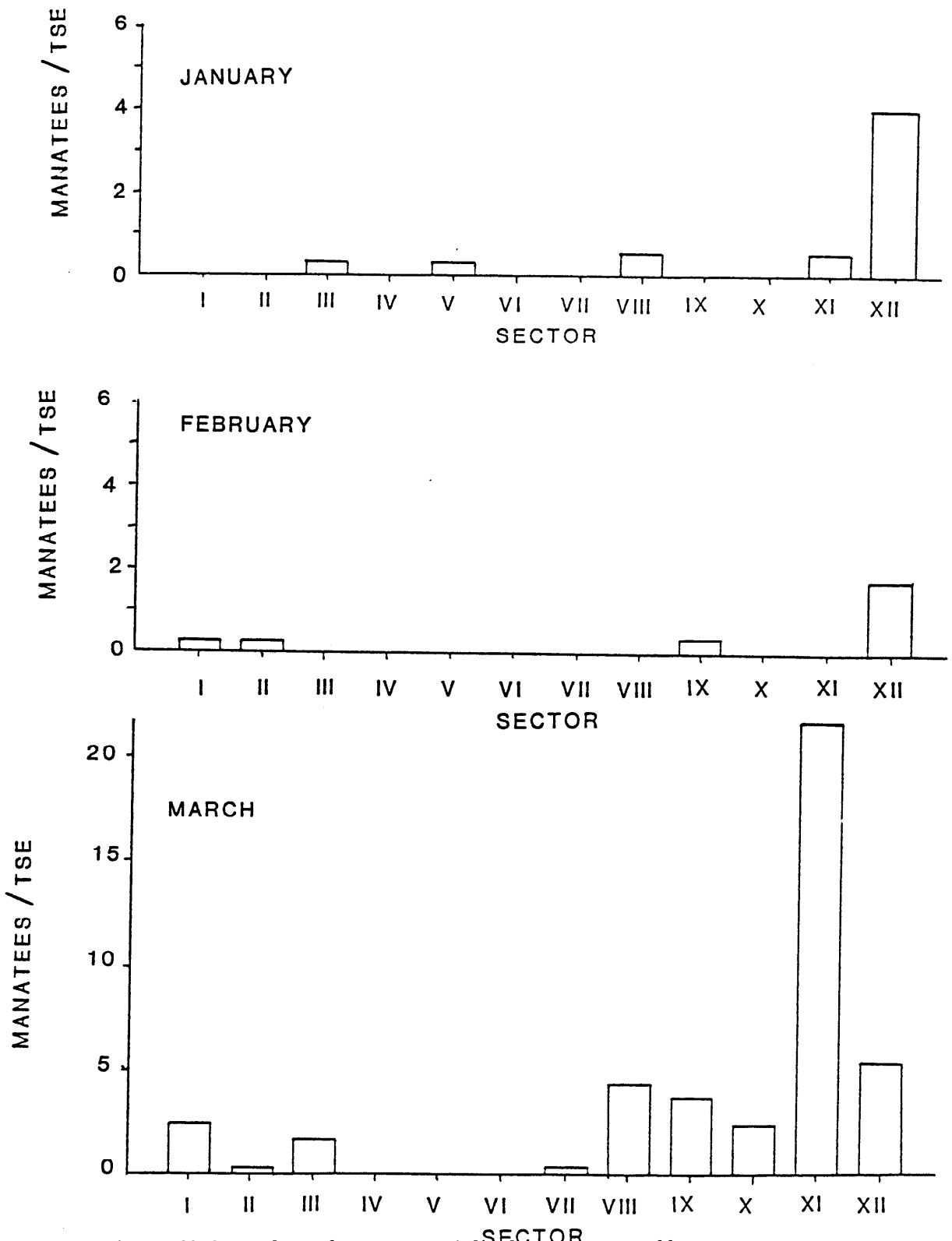


Figure 6A-C. Number of manatees sighted per survey effort in each sector, by month.

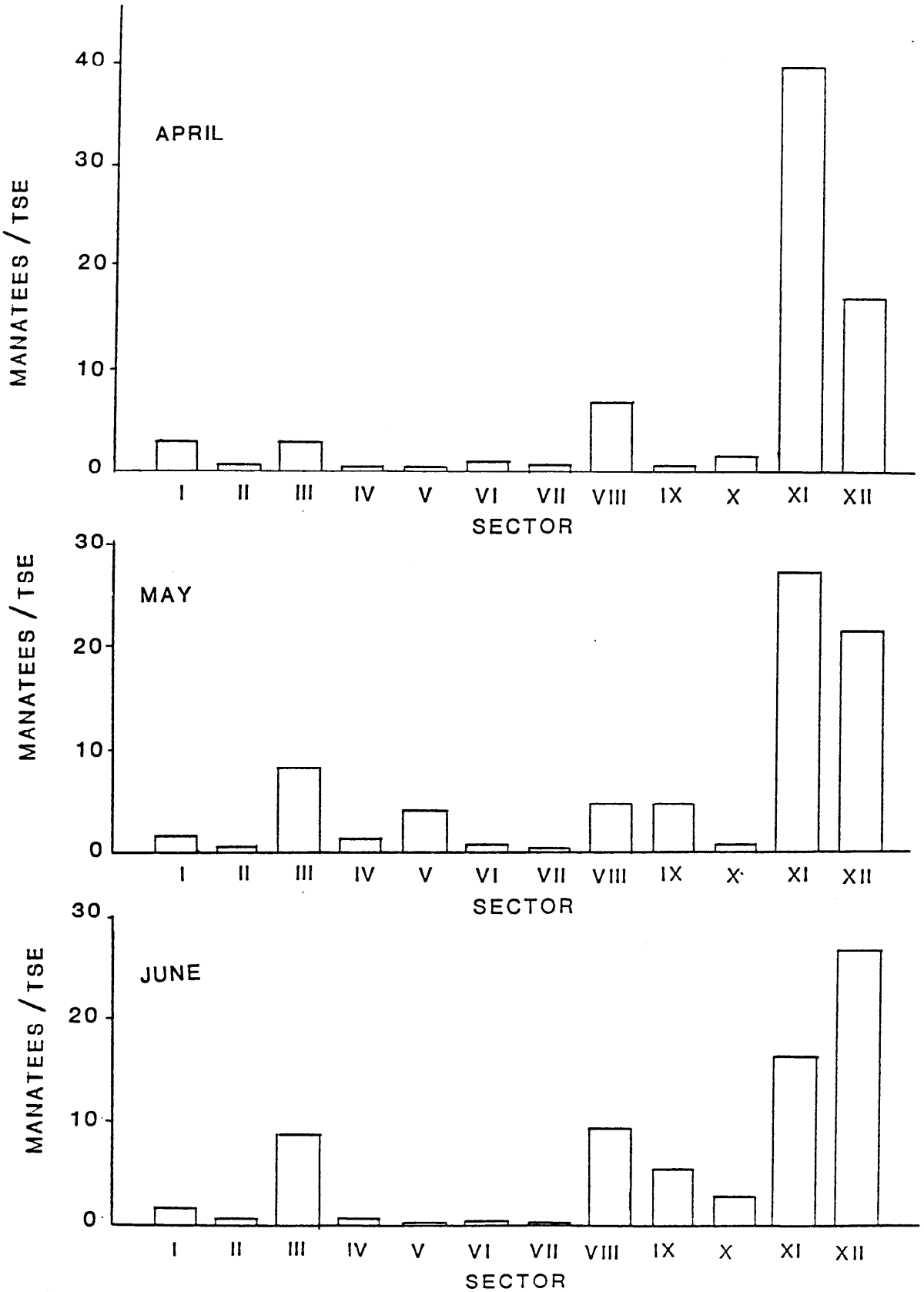


Figure 6D-F. Number of manatees sighted per survey effort in each sector, by month.

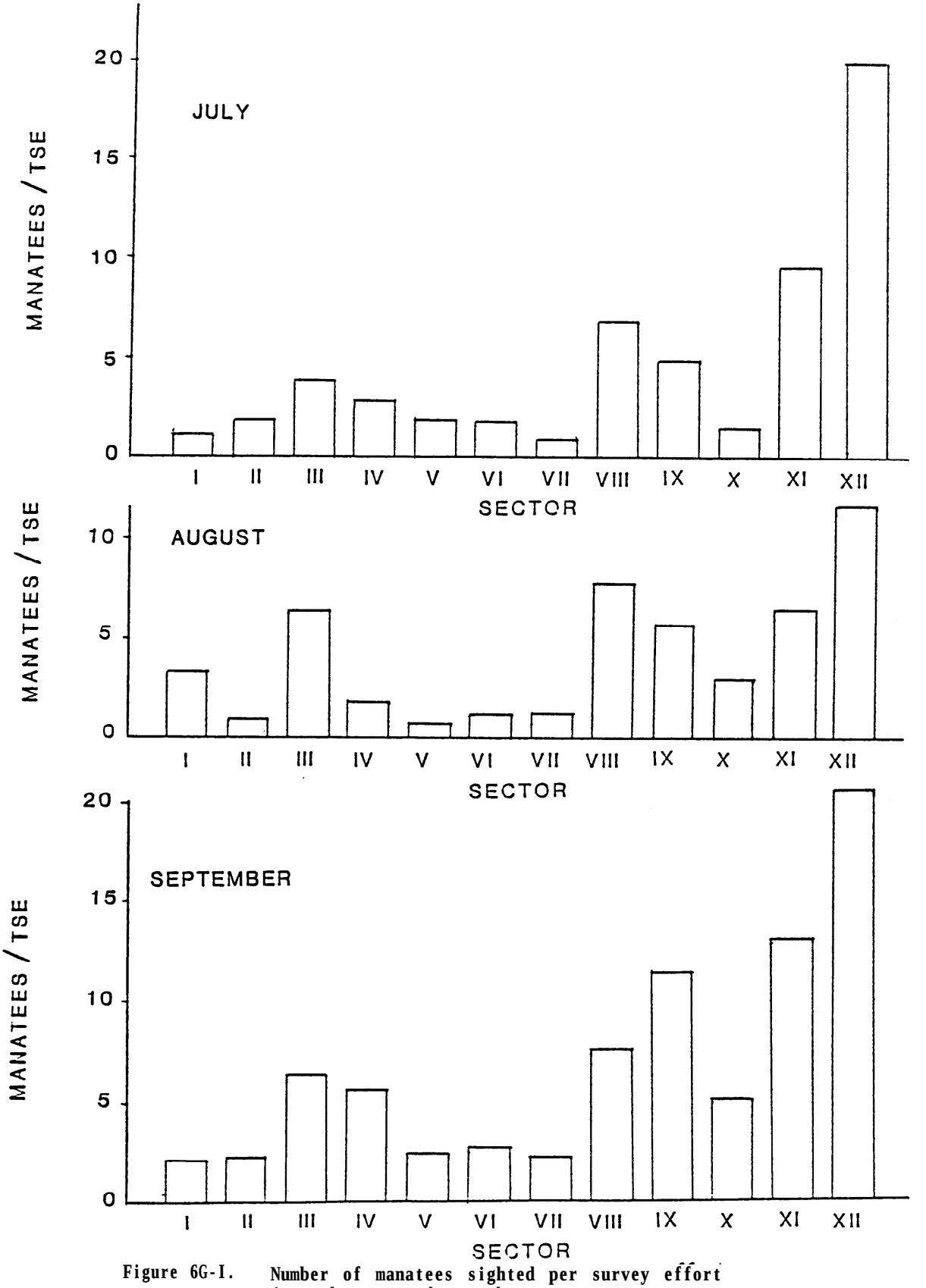


Figure 6G-I. Number of manatees sighted per survey effort in each sector, by month.

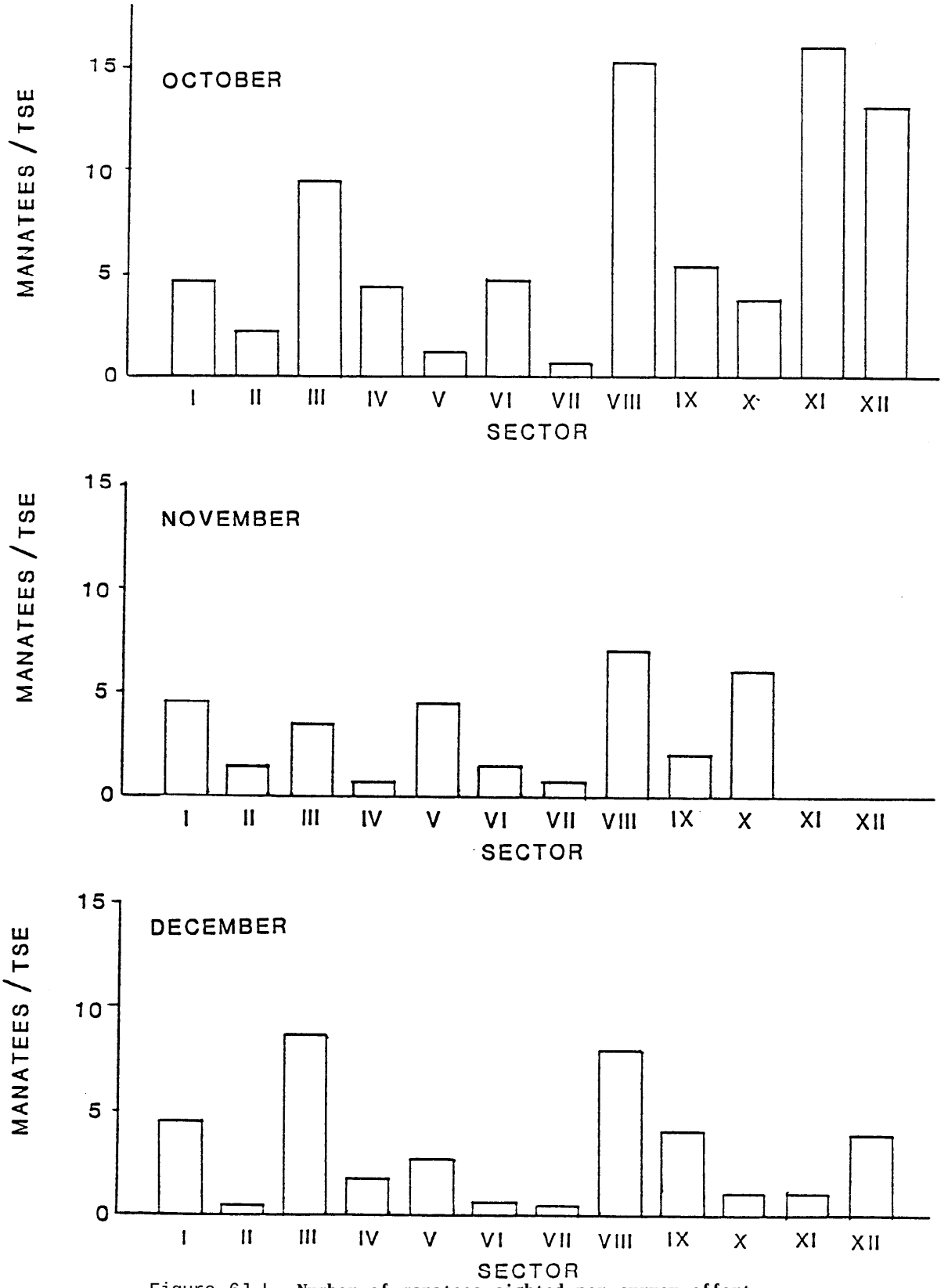


Figure 6J-L. **Number of manatees sighted per survey effort in each sector, by month.**

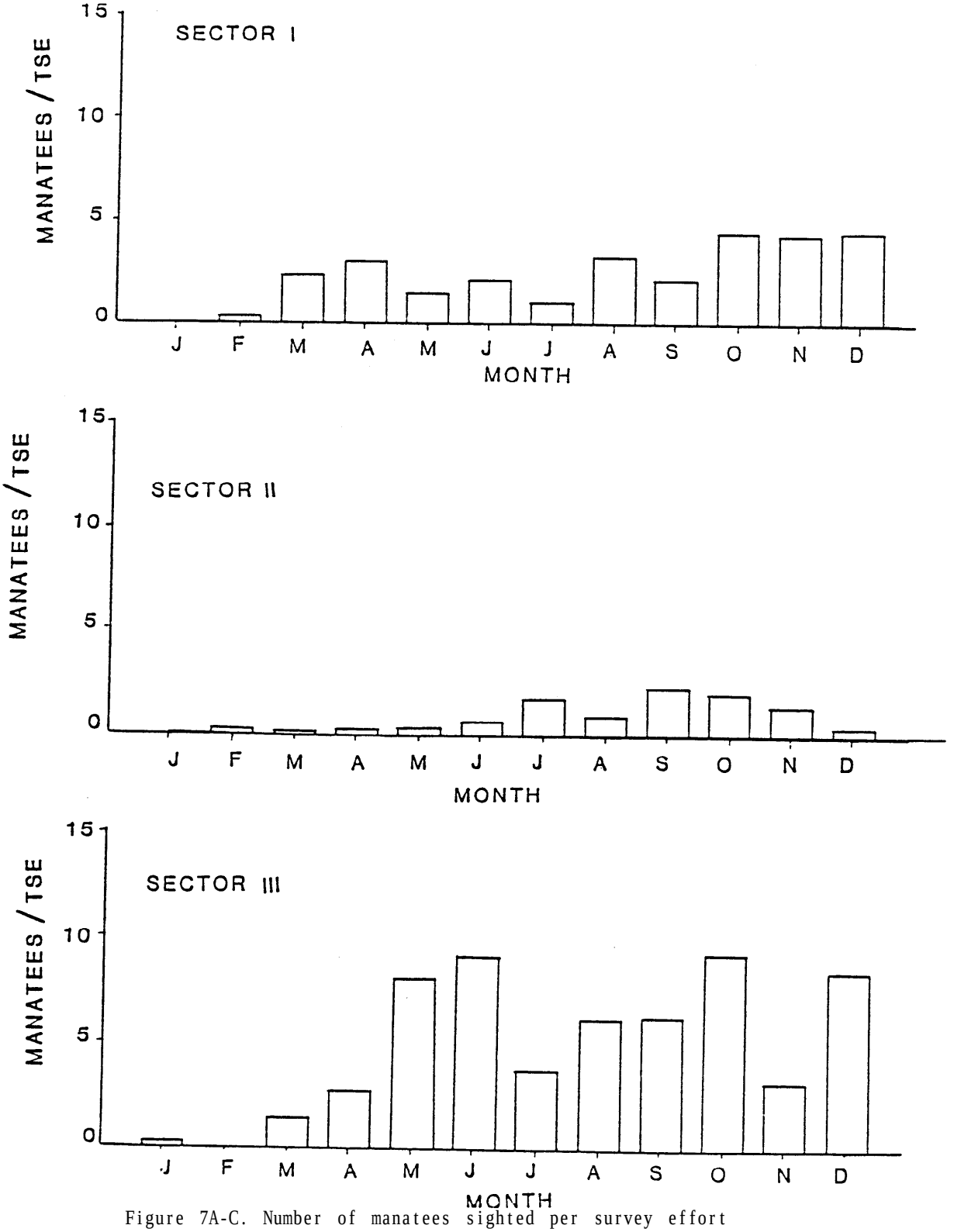


Figure 7A-C. Number of manatees sighted per survey effort in each month, by sector.

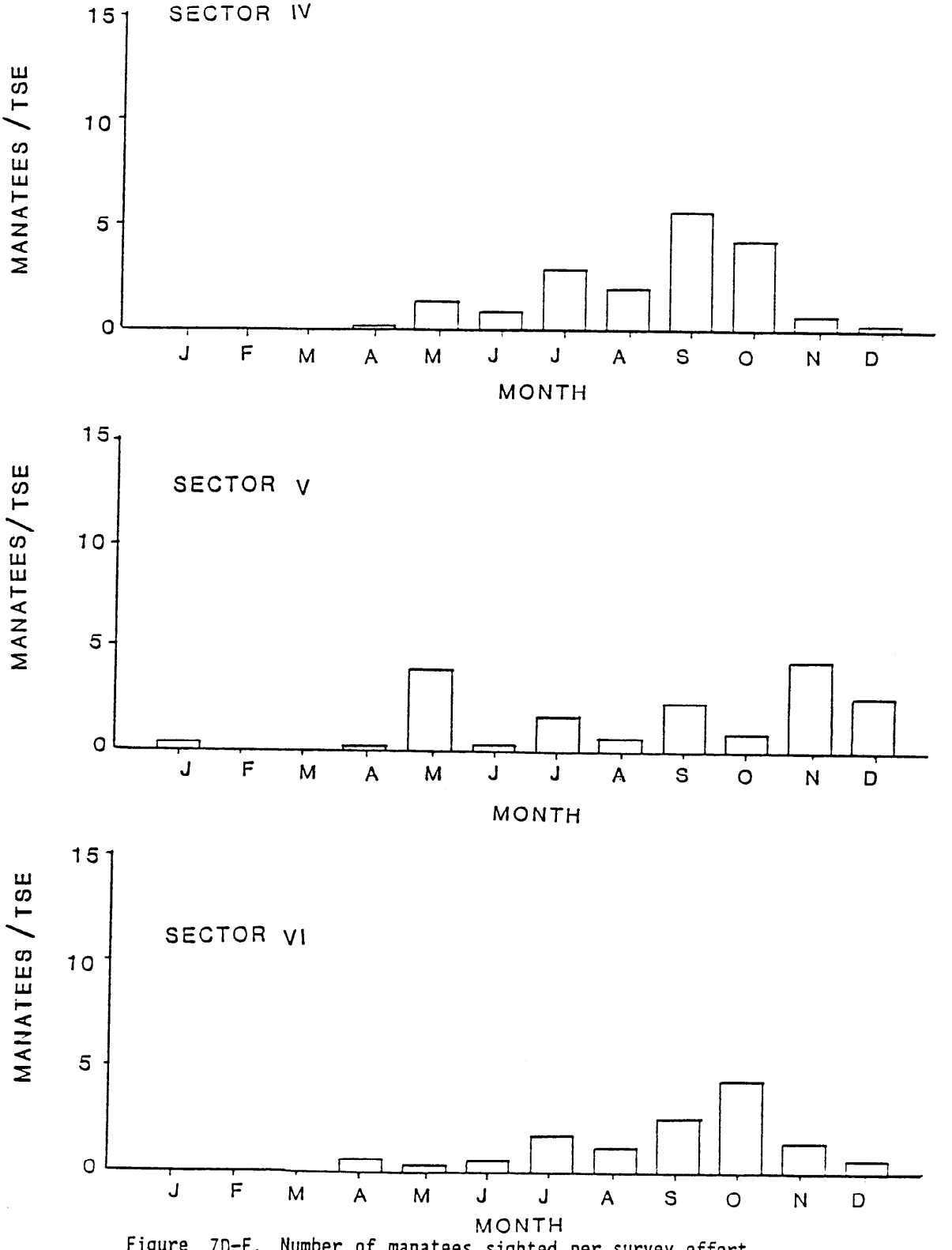


Figure 7D-F. Number of manatees sighted per survey effort in each month, by sector.

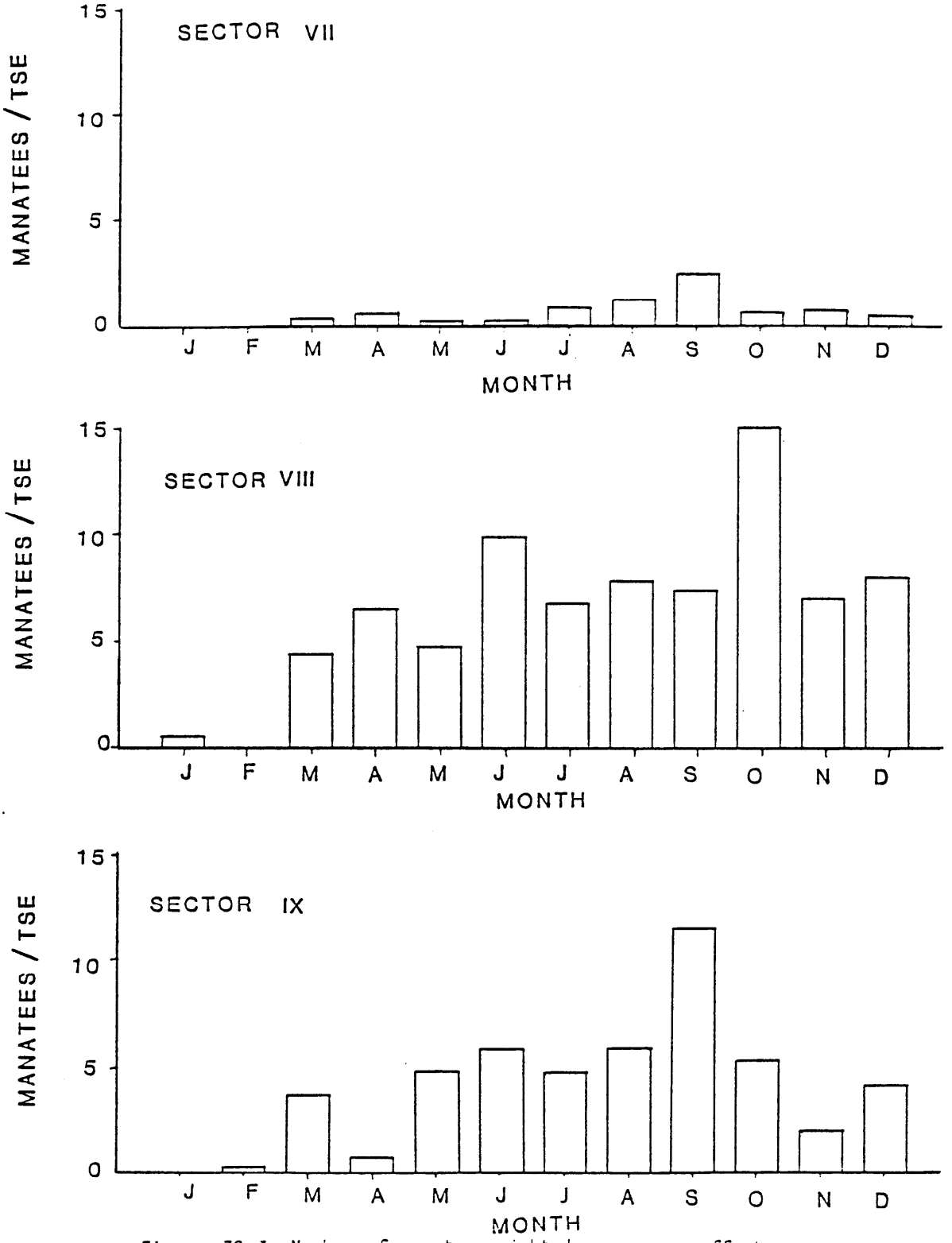


Figure 7G-I. Number of manatees sighted per survey effort in each month, by sector.

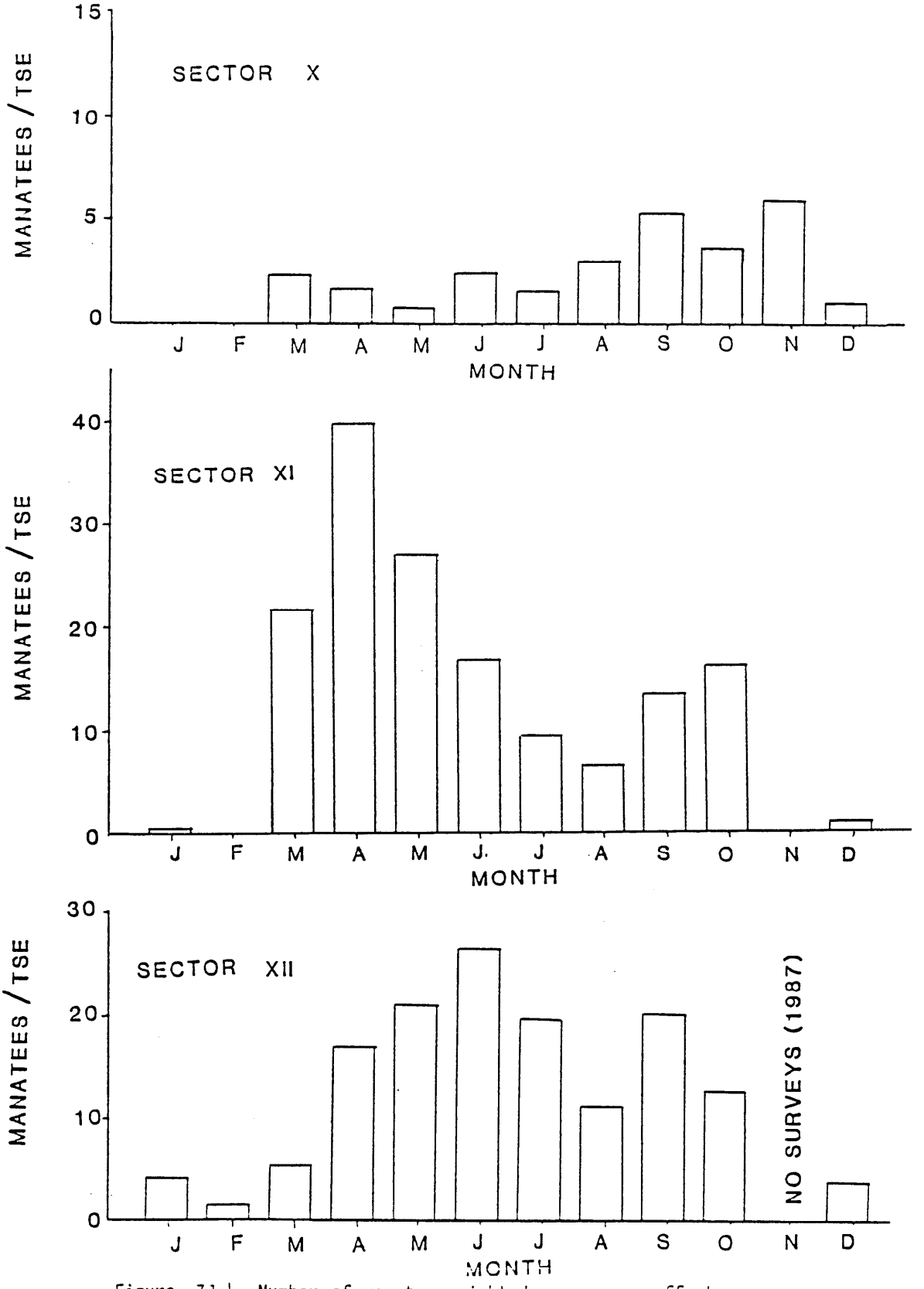


Figure 7J-L. Number of manatees sighted per survey effort in each month, by sector.

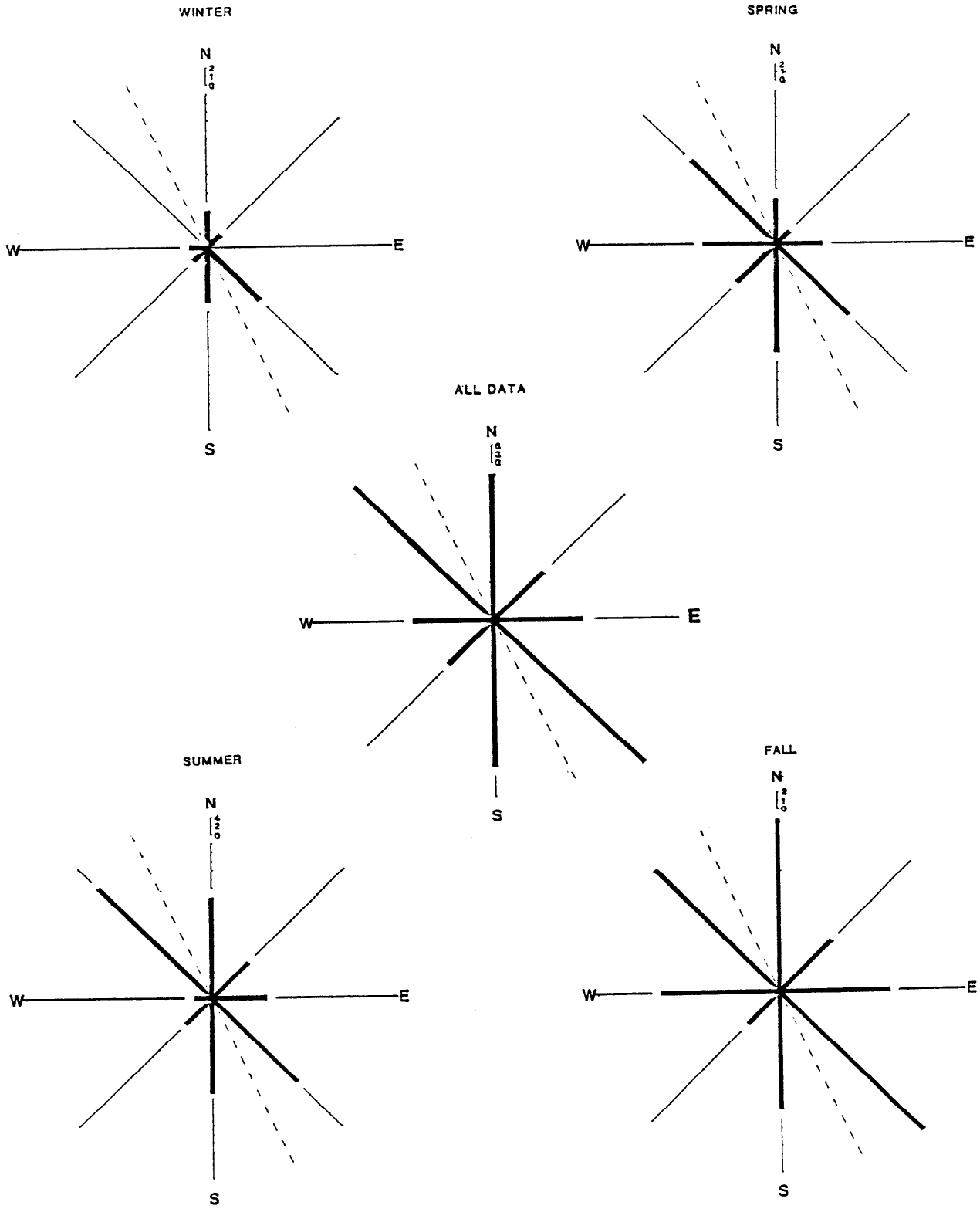


Figure 8. Polar histograms depicting manatee movements for all data and for each season. Dotted line indicates approximate direction of ICW.

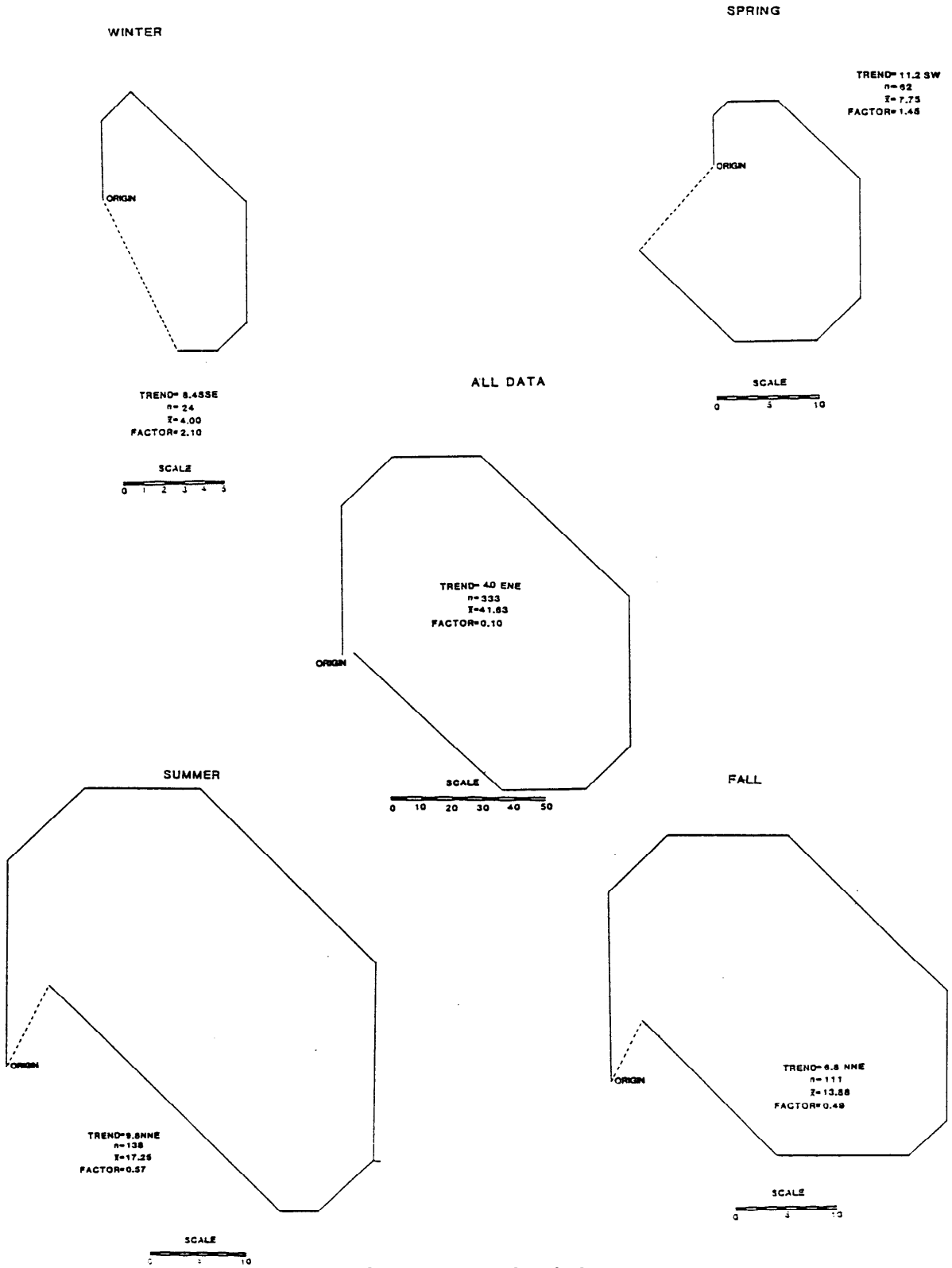


Figure 9. Vector analysis approach of depicting manatee movements for all data and for each season.

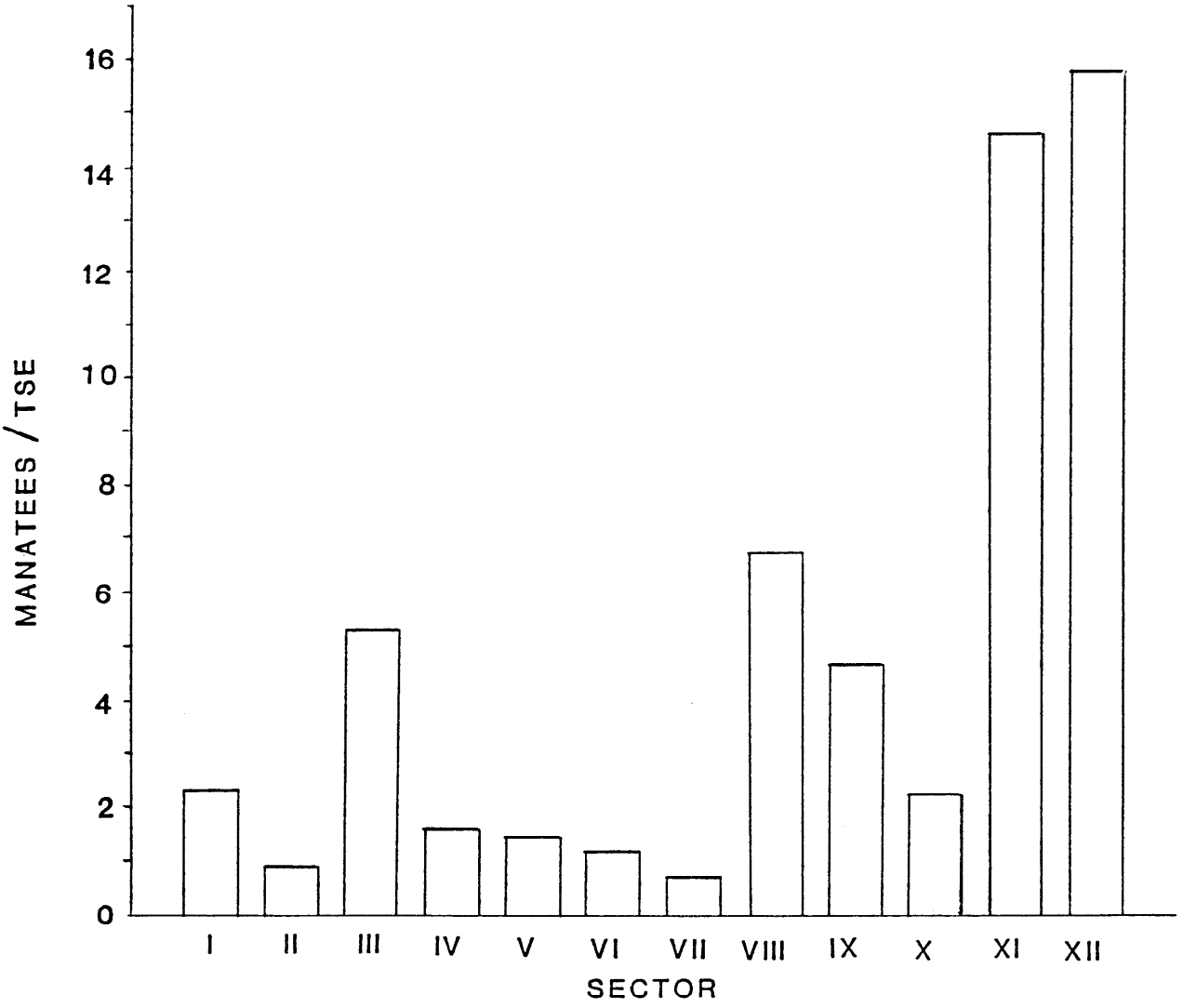


Figure 10. Regional index of manatee sightings as total number of manatees sighted in a sector per survey effort for that sector.

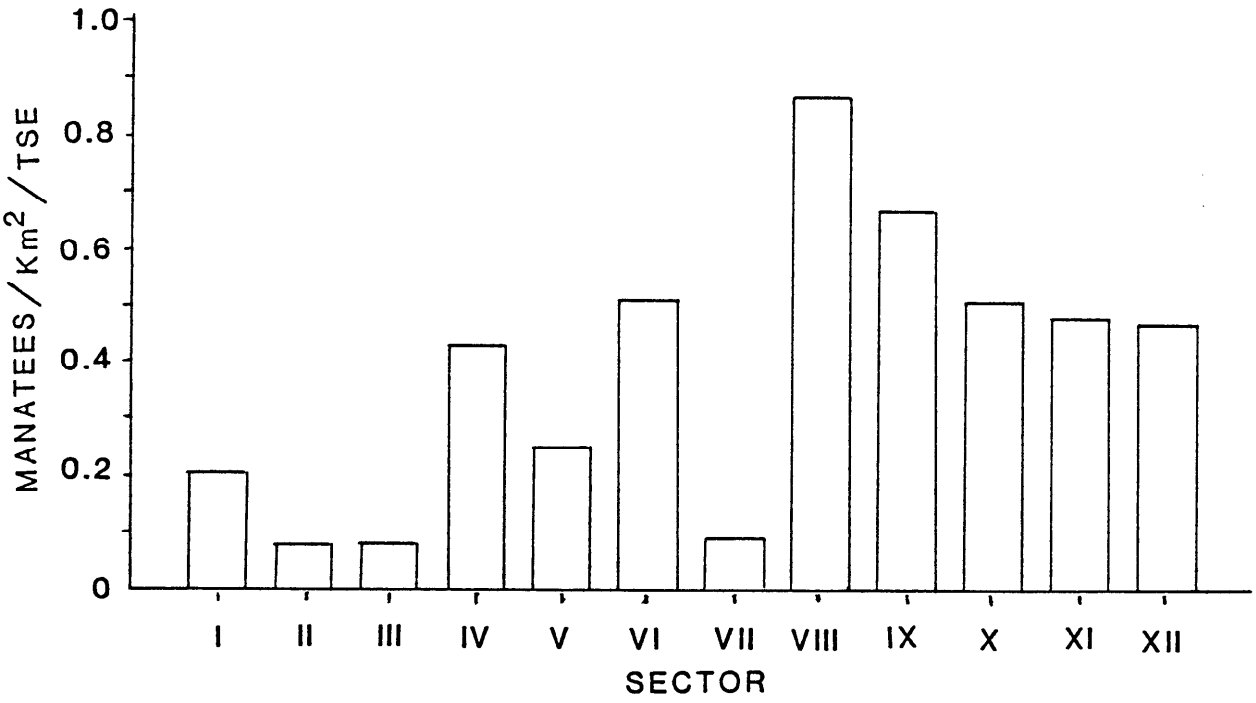


Figure 11. Calculated manatee densities by survey effort.

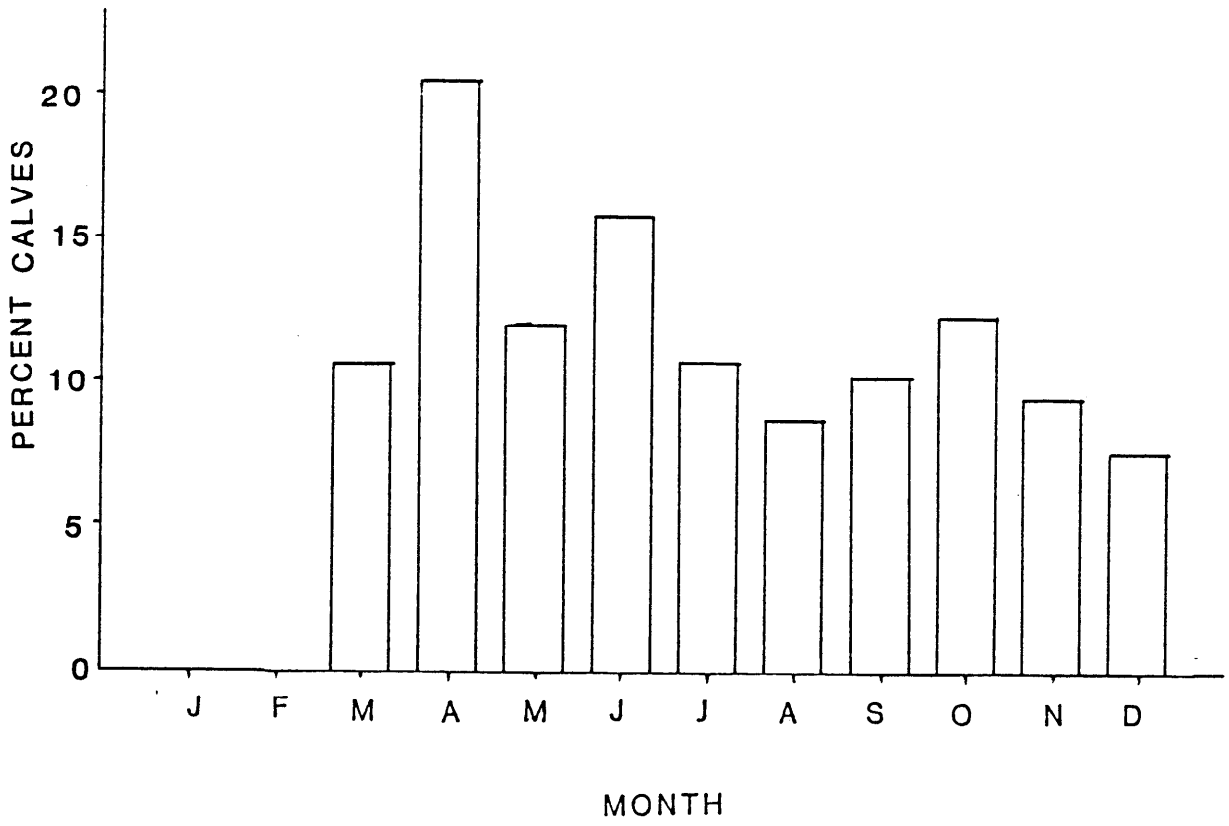


Figure 12. Percentage of manatee calves by month.

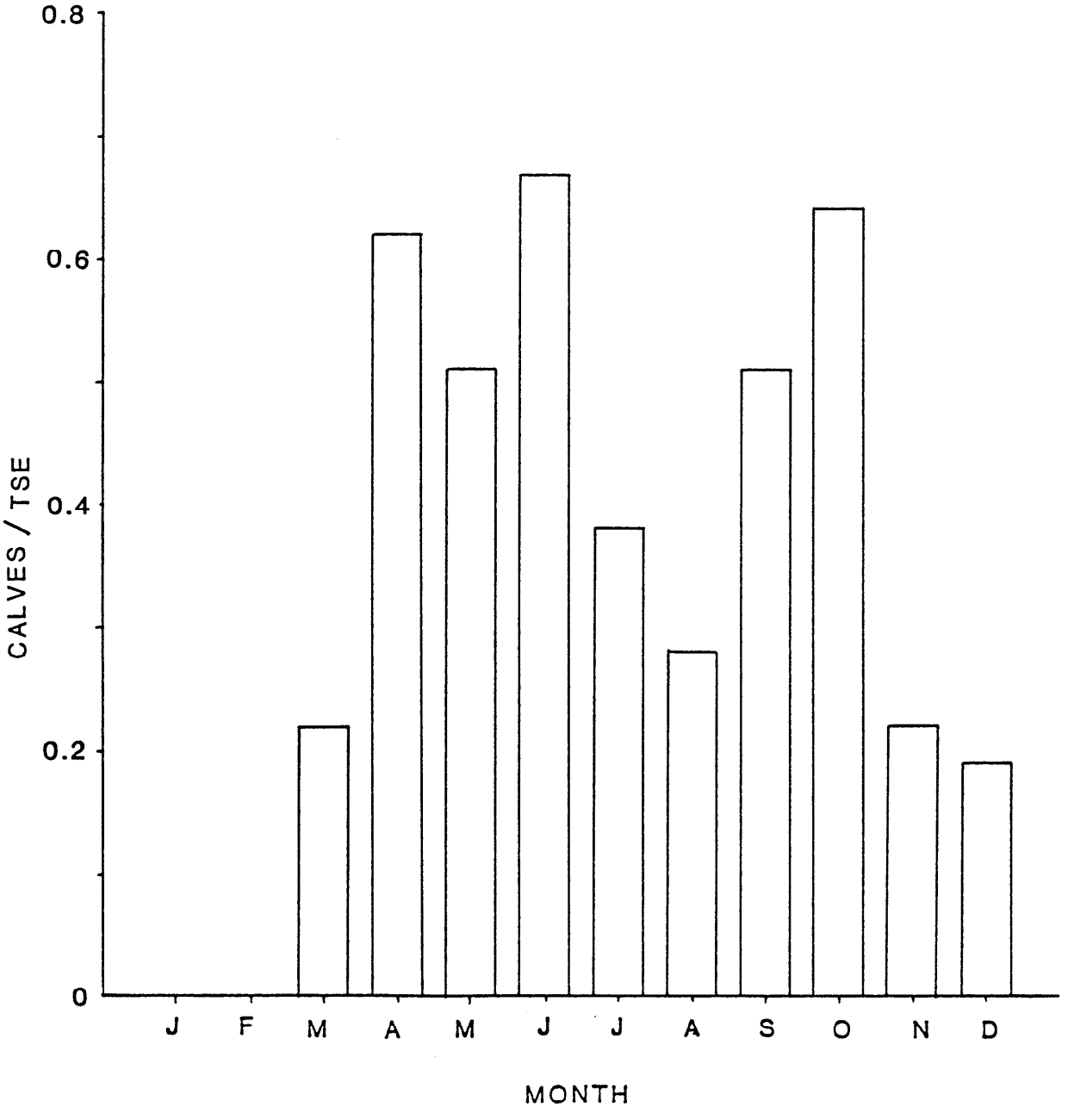


Figure 13. Monthly index of calf sightings.

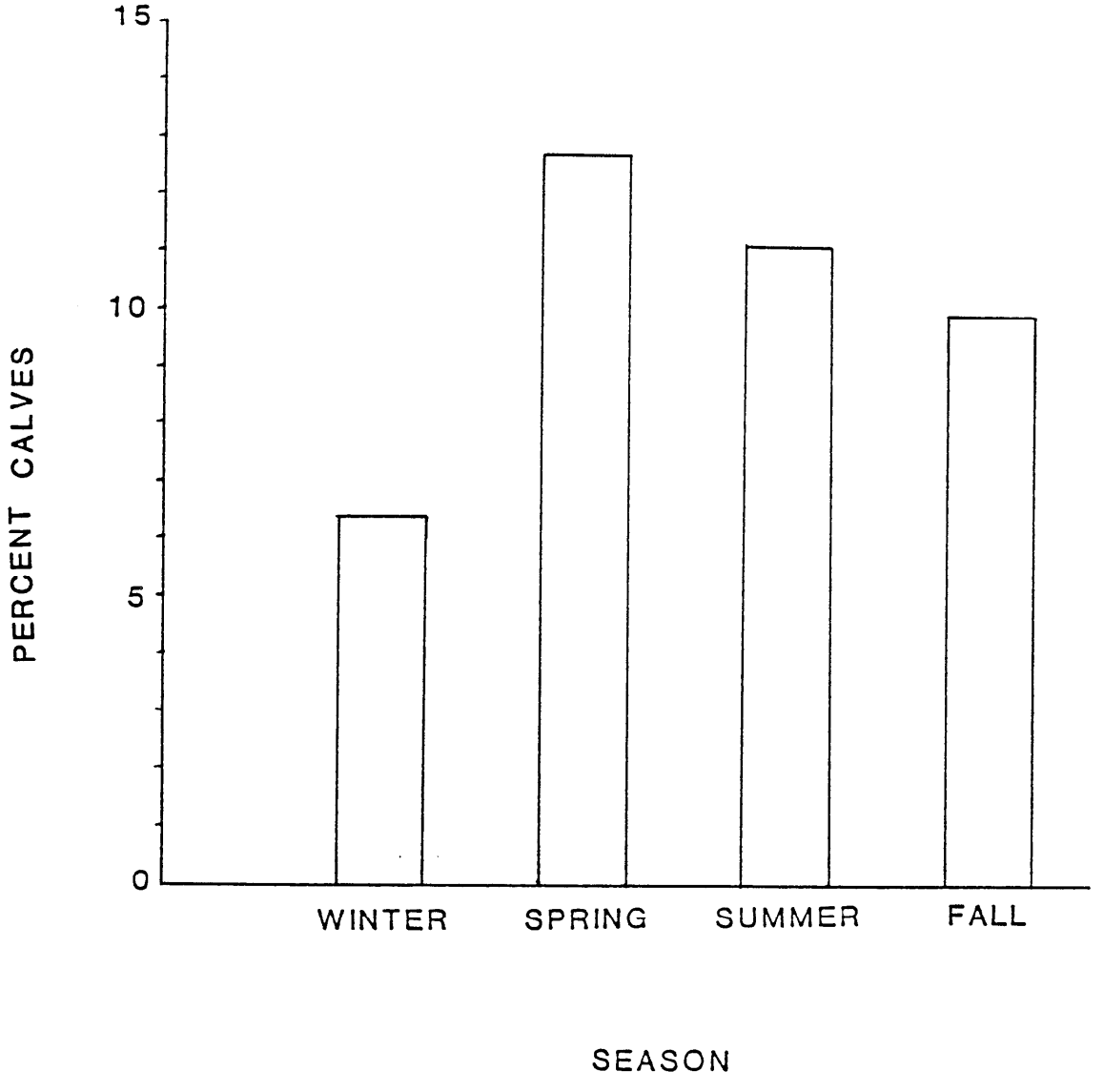


Figure 14. Percentage of manatee calves by season.

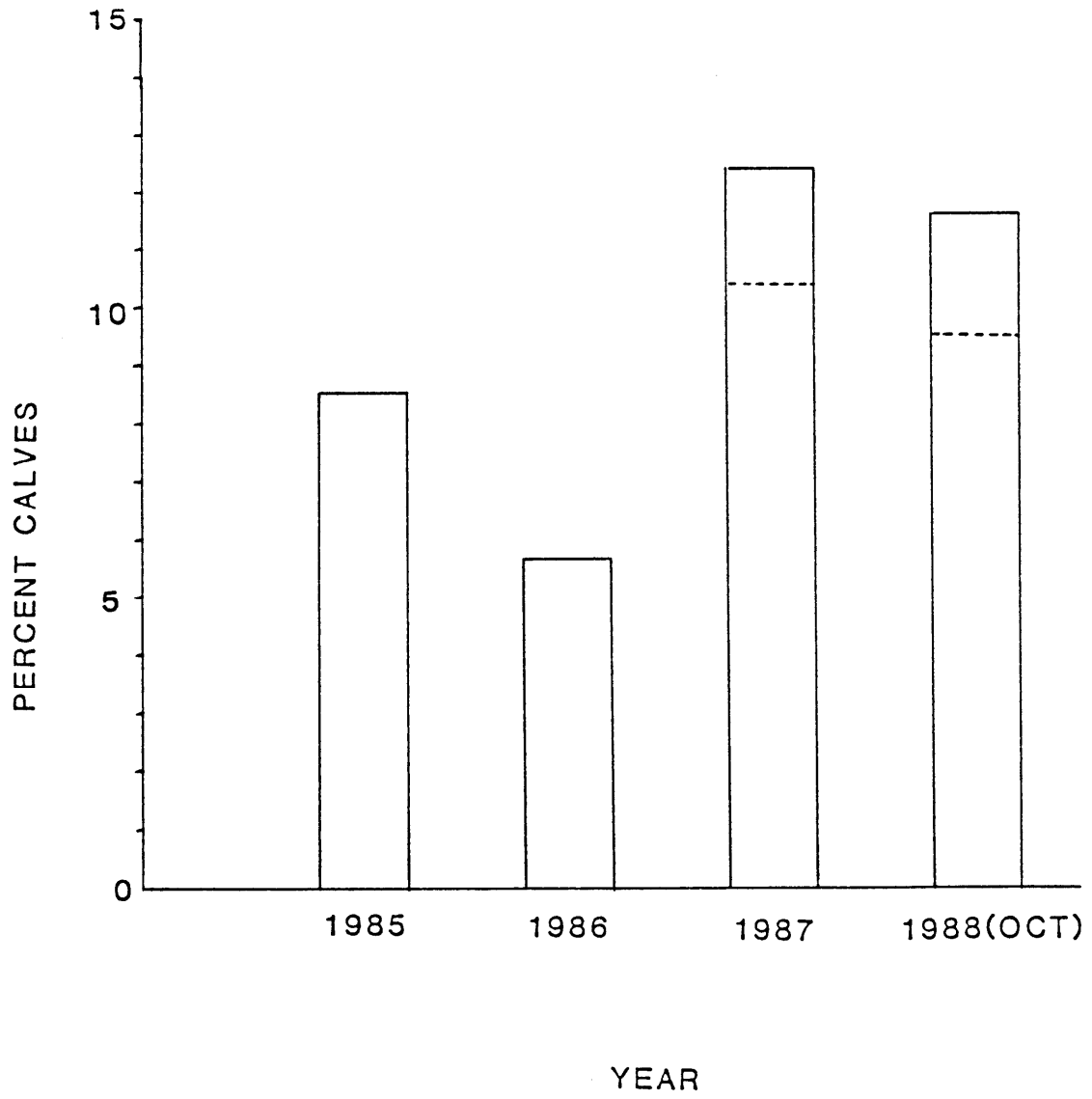


Figure 15. **Percentage of calf sightings by year. Data for 1985 and 1986 represent North region only, while data for 1987 and 1988 include the South region. Percentages for North region are shown as a dotted line for 1987 and 1988.**

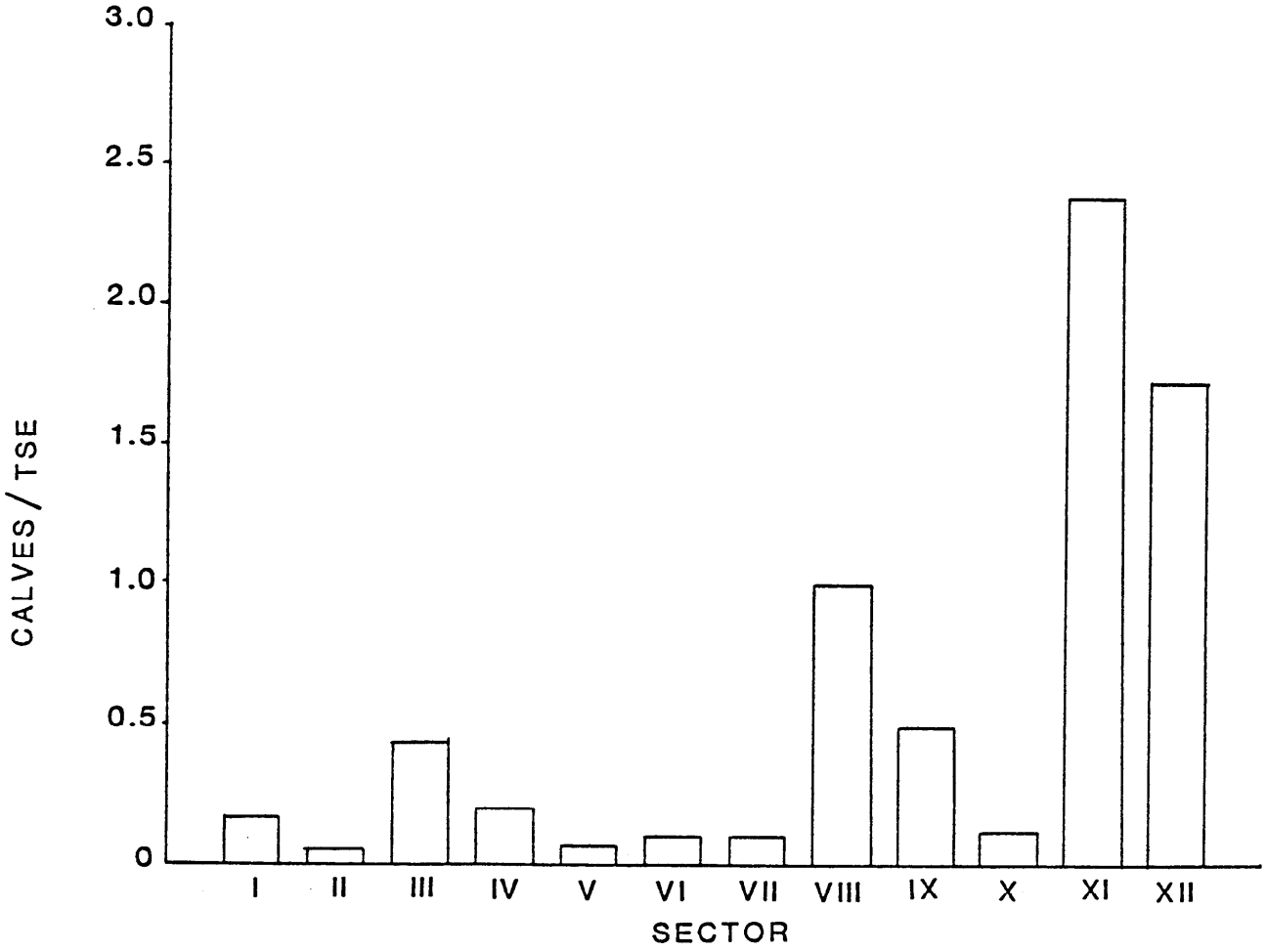


Figure 16. Regional index of calf sightings.

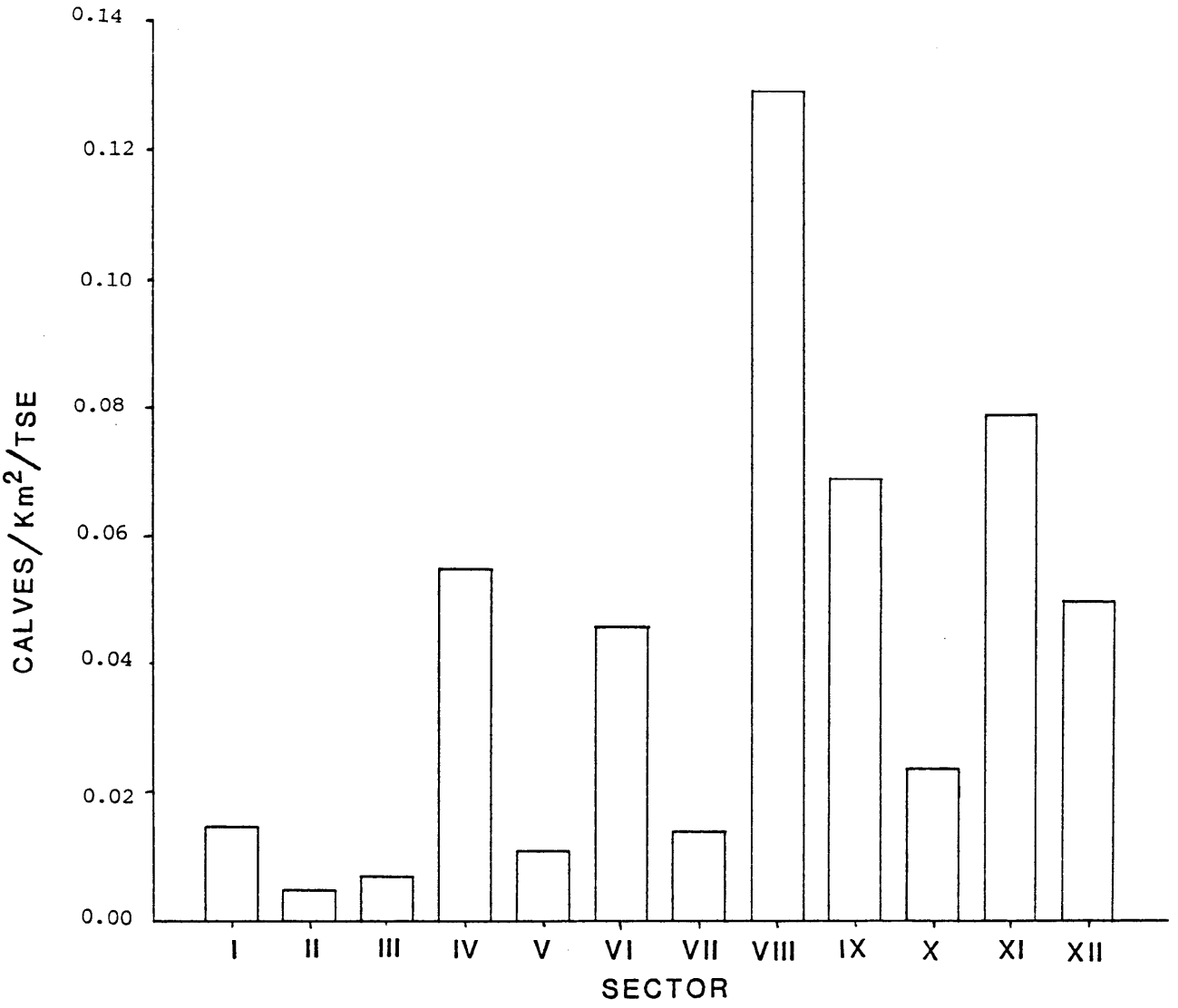


Figure 17. Index of calf densities for the survey region.

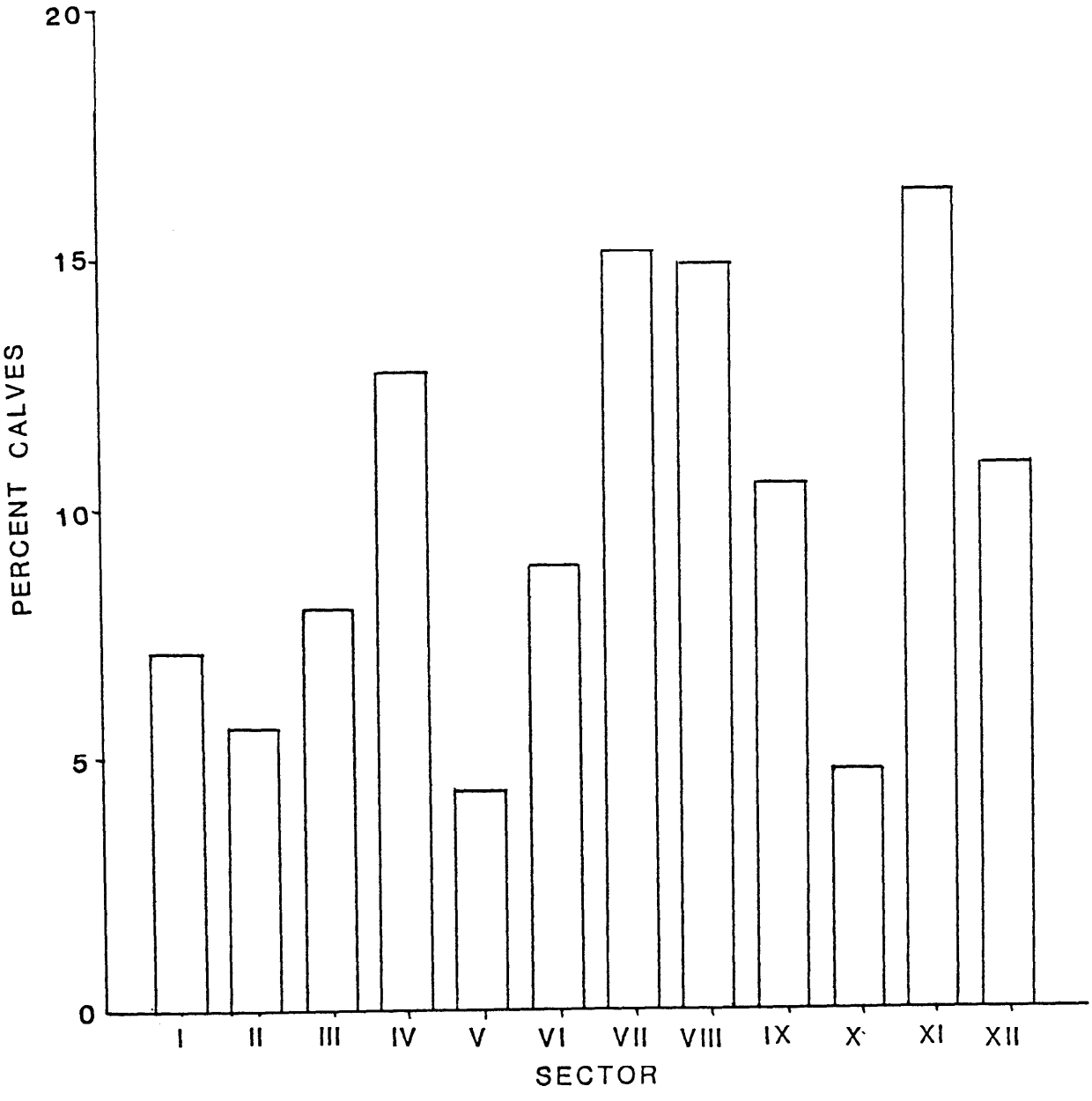


Figure 18. Percentage of manatee calves by sector.

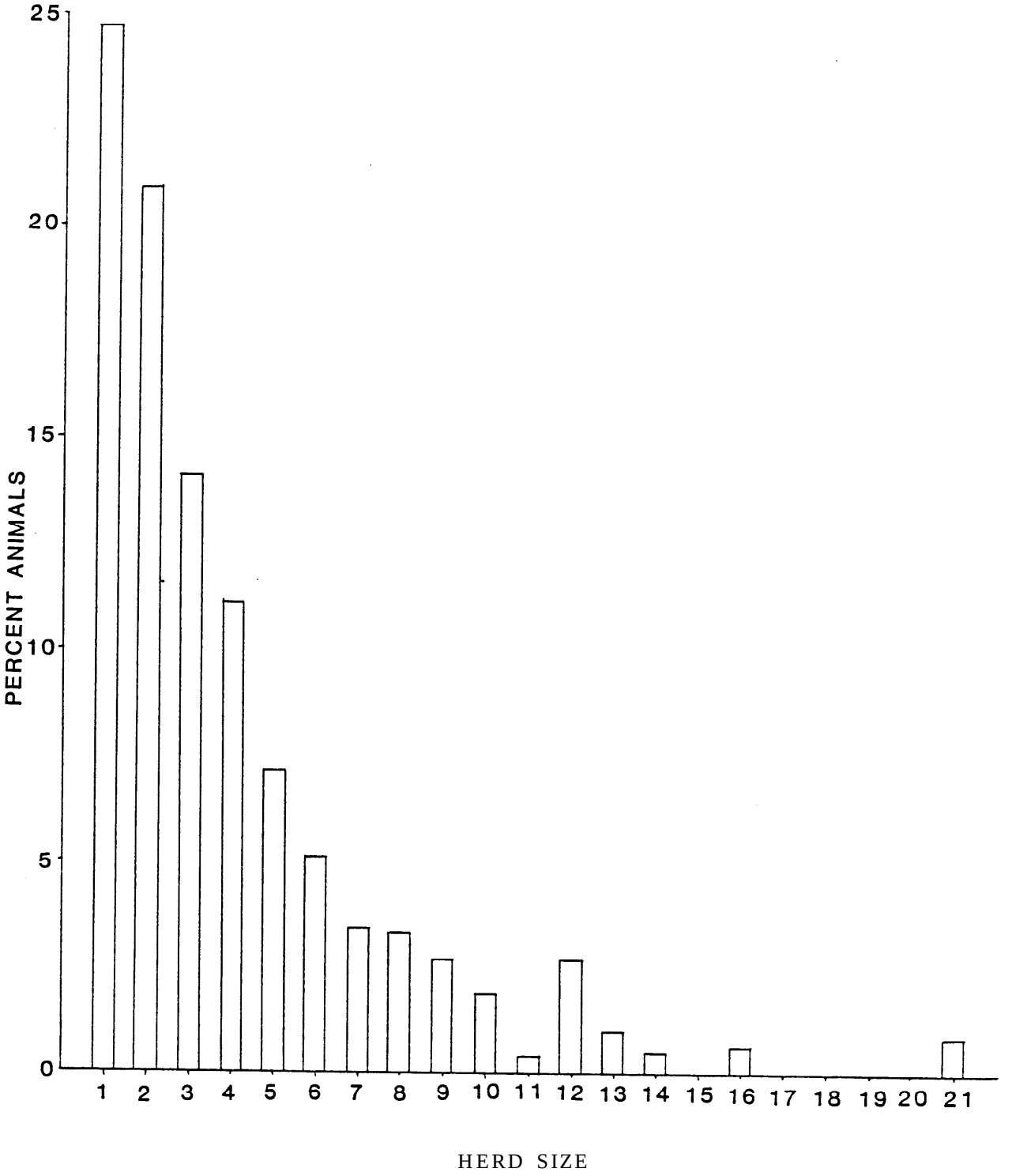


Figure 19. Herd size distribution as percent of animals sighted.

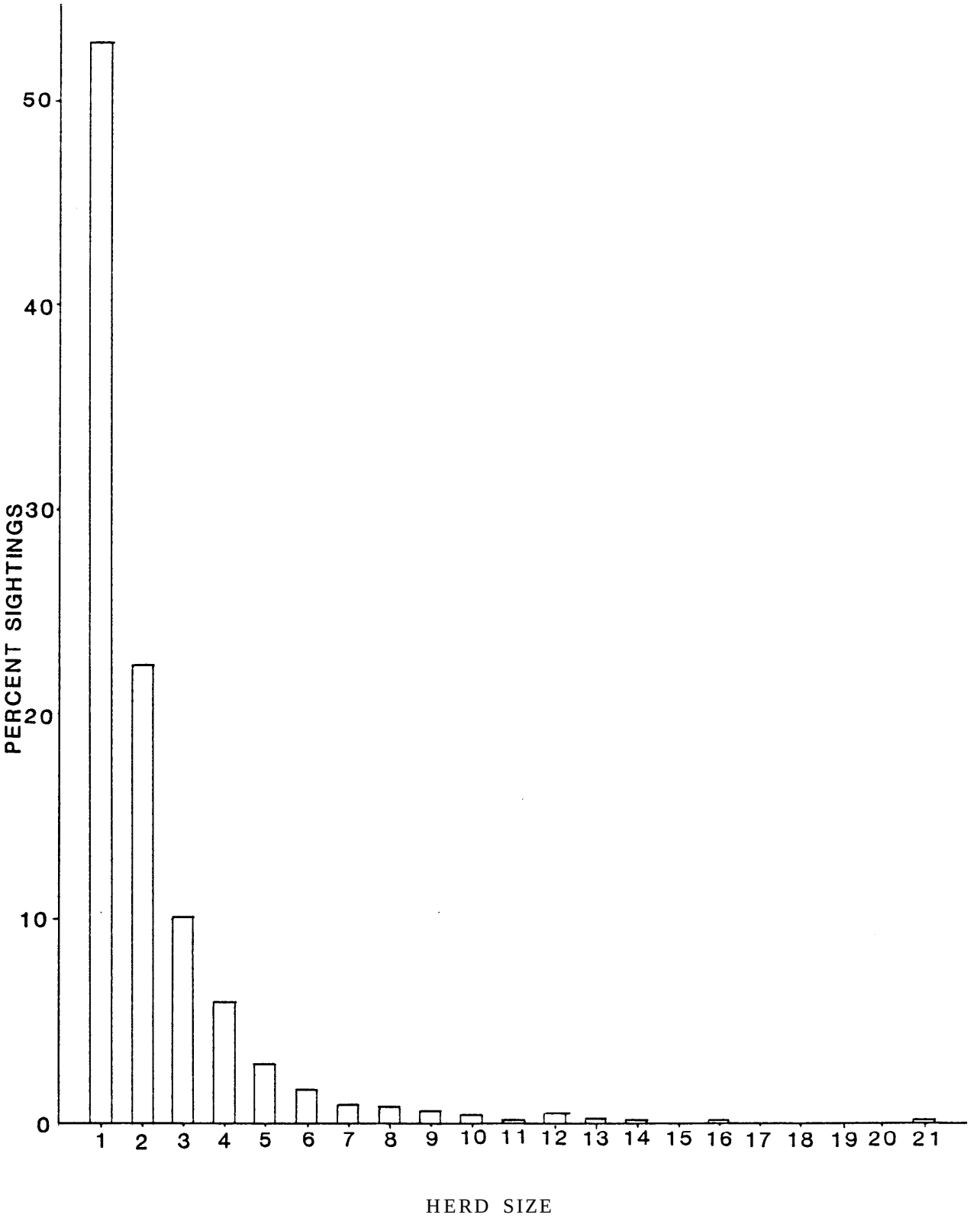


Figure 20. Herd size distribution as percent of sightings.

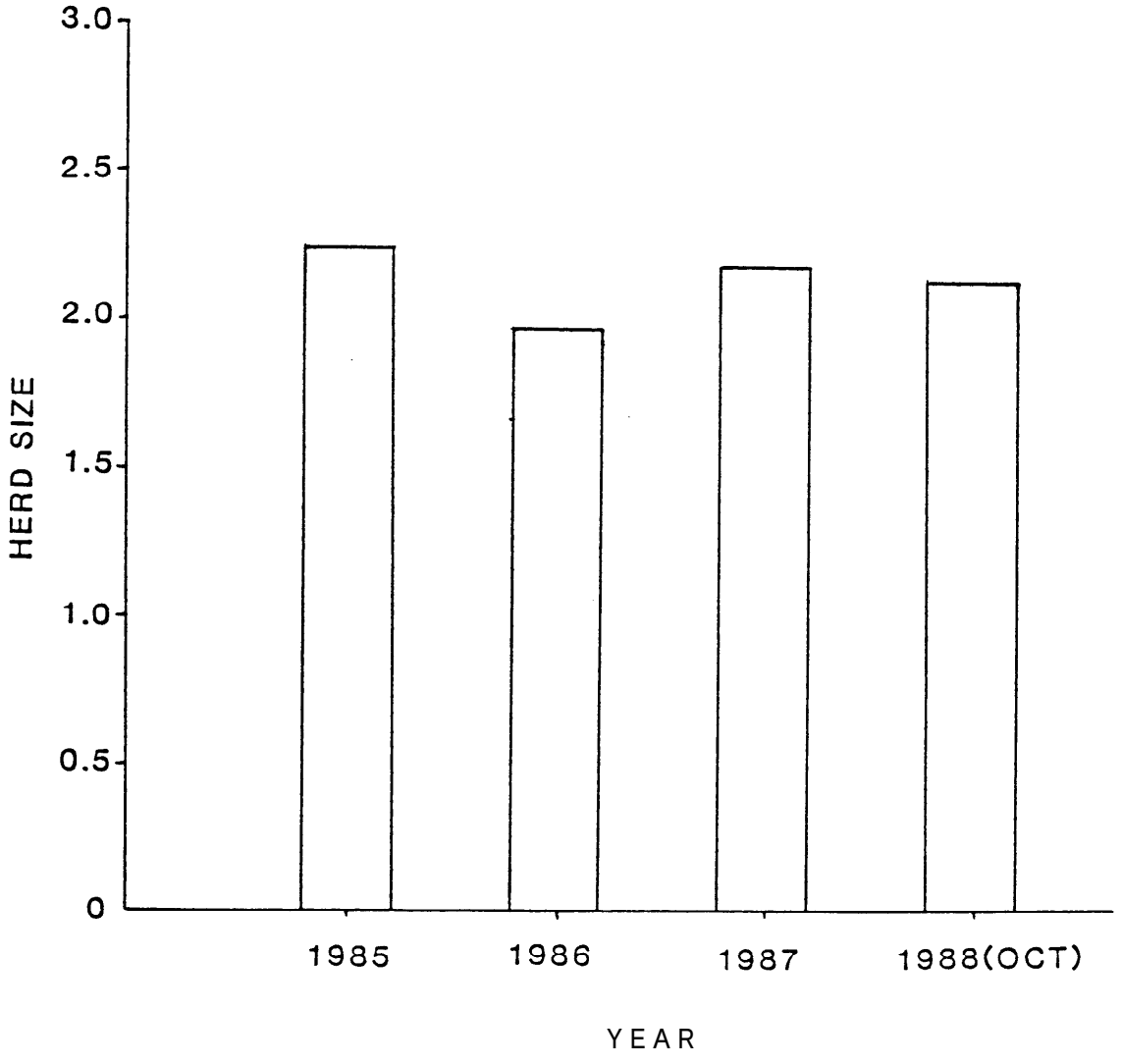


Figure 21. Average herd size by year.

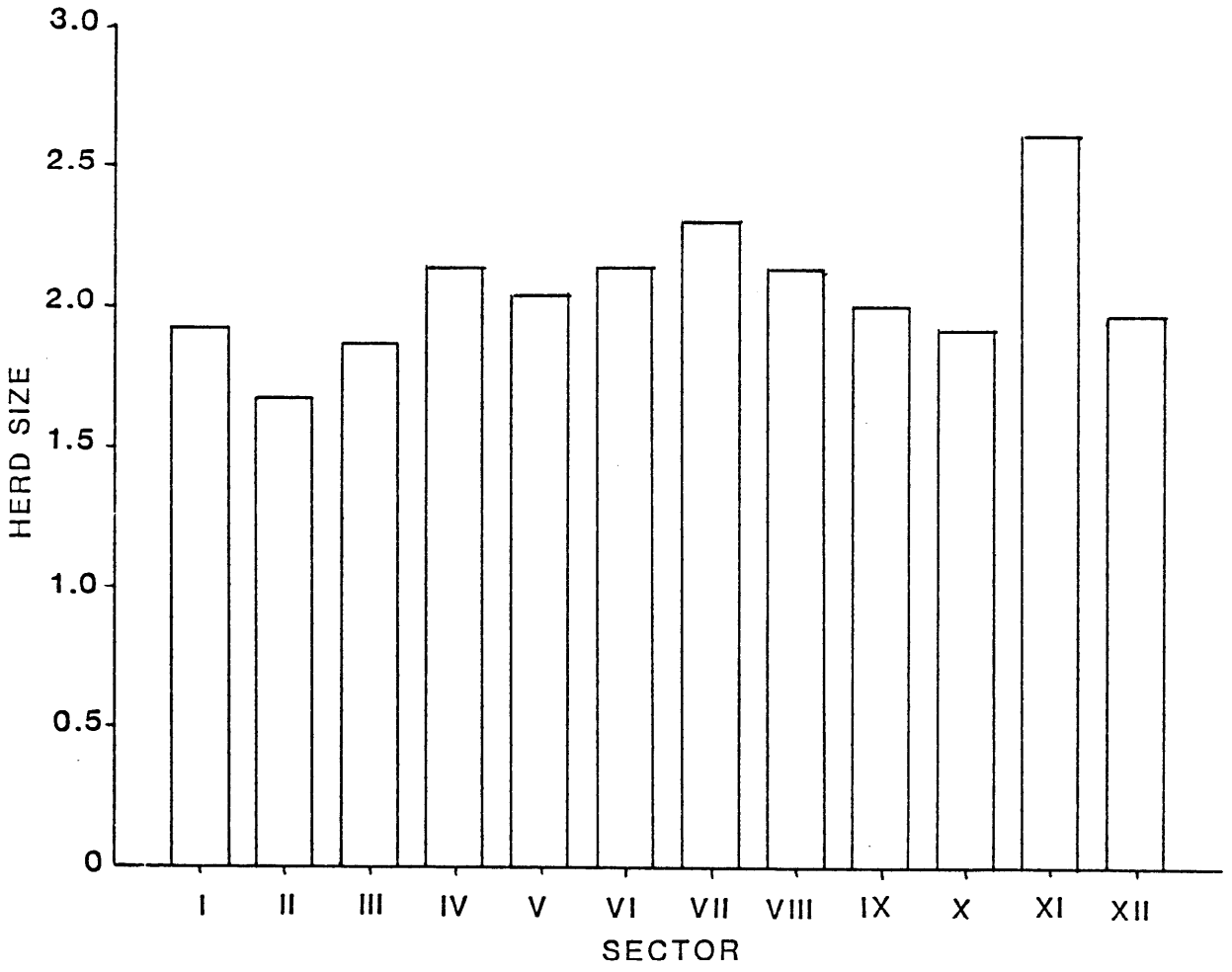


Figure 22. Average herd size by sector.

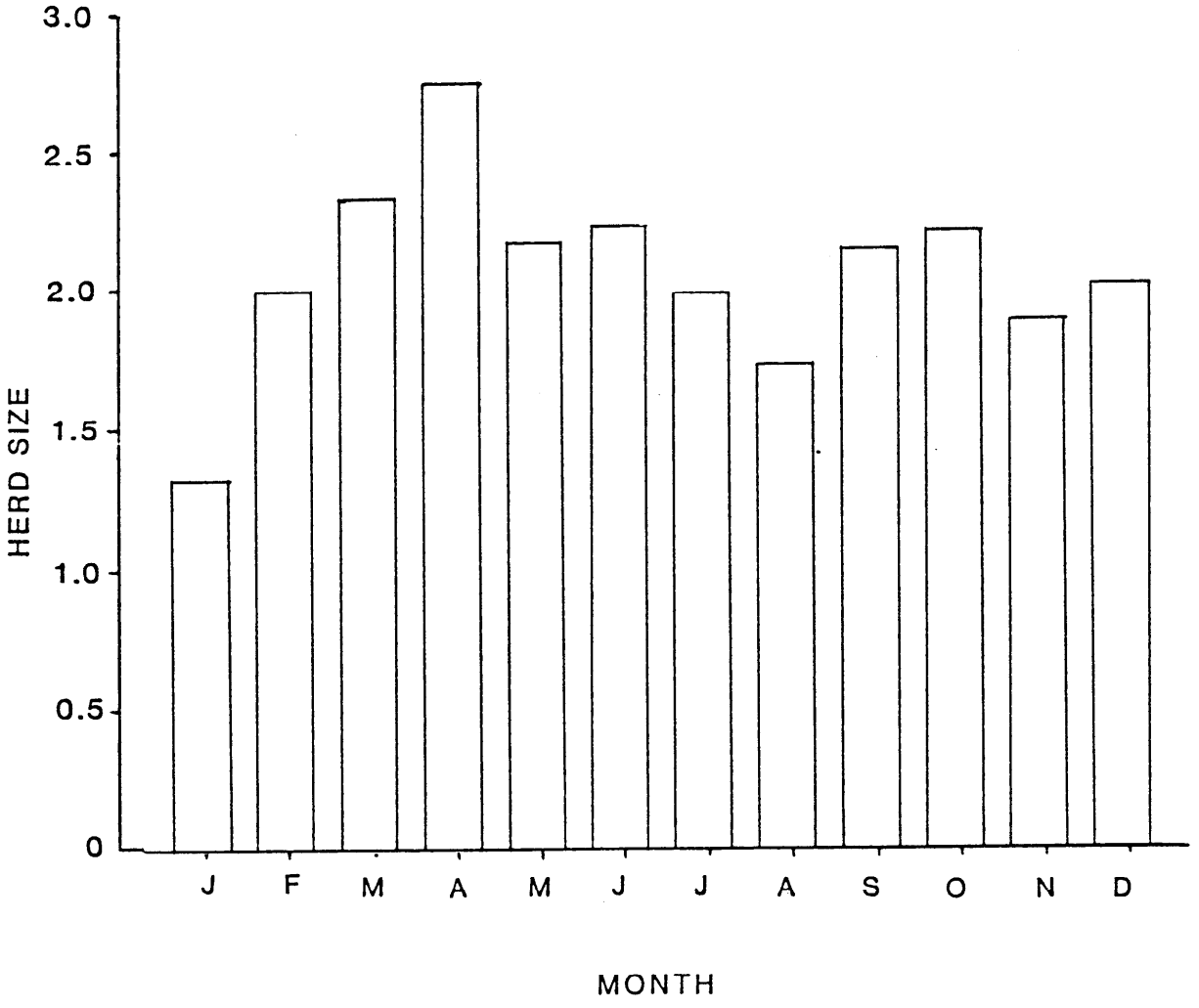


Figure 23. Average herd size by month.

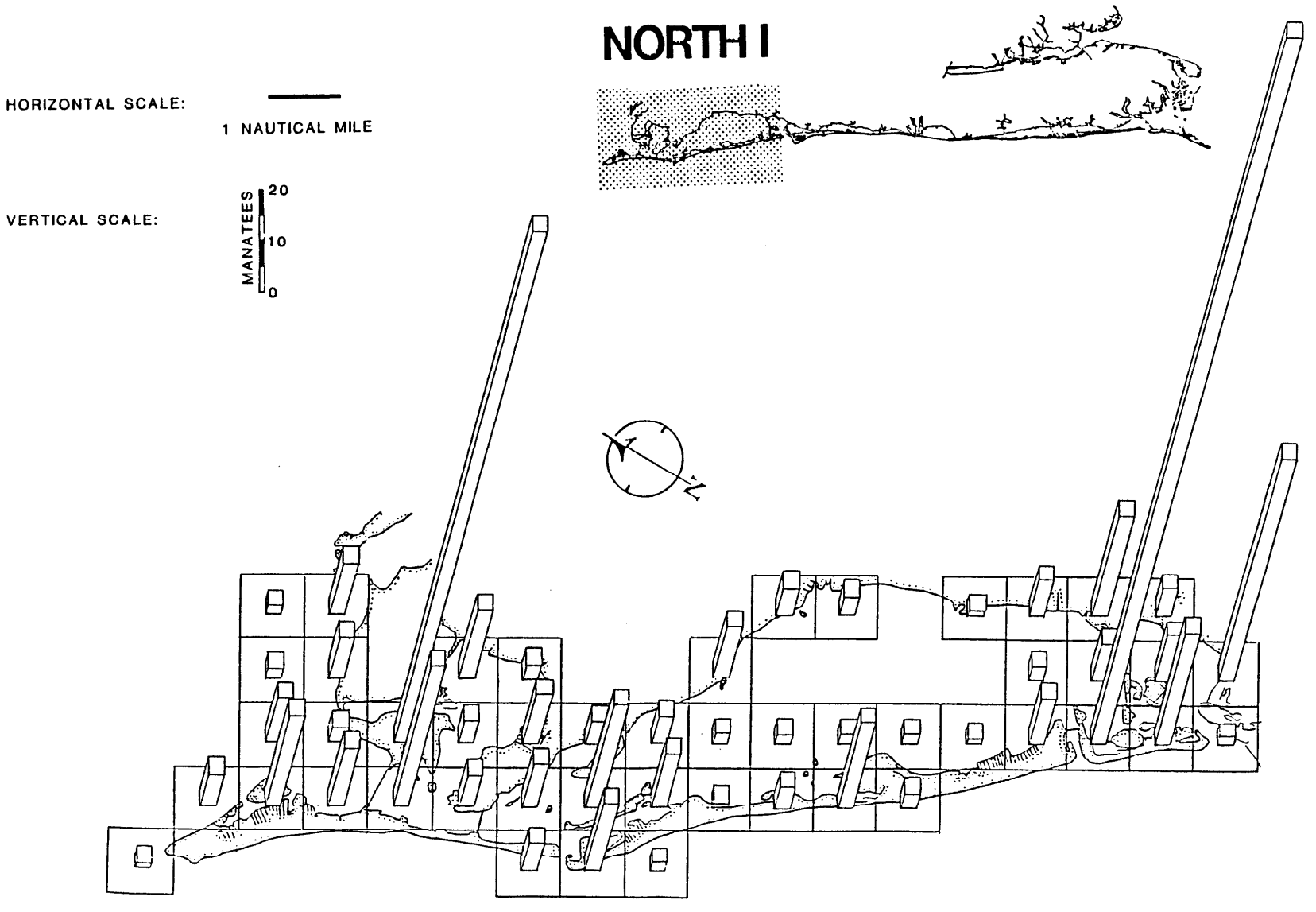


Figure 24A. **Bar graph map for the number of manatees sighted on a one square nautical mile grid. The north area is comprised of nearly four years of data.**

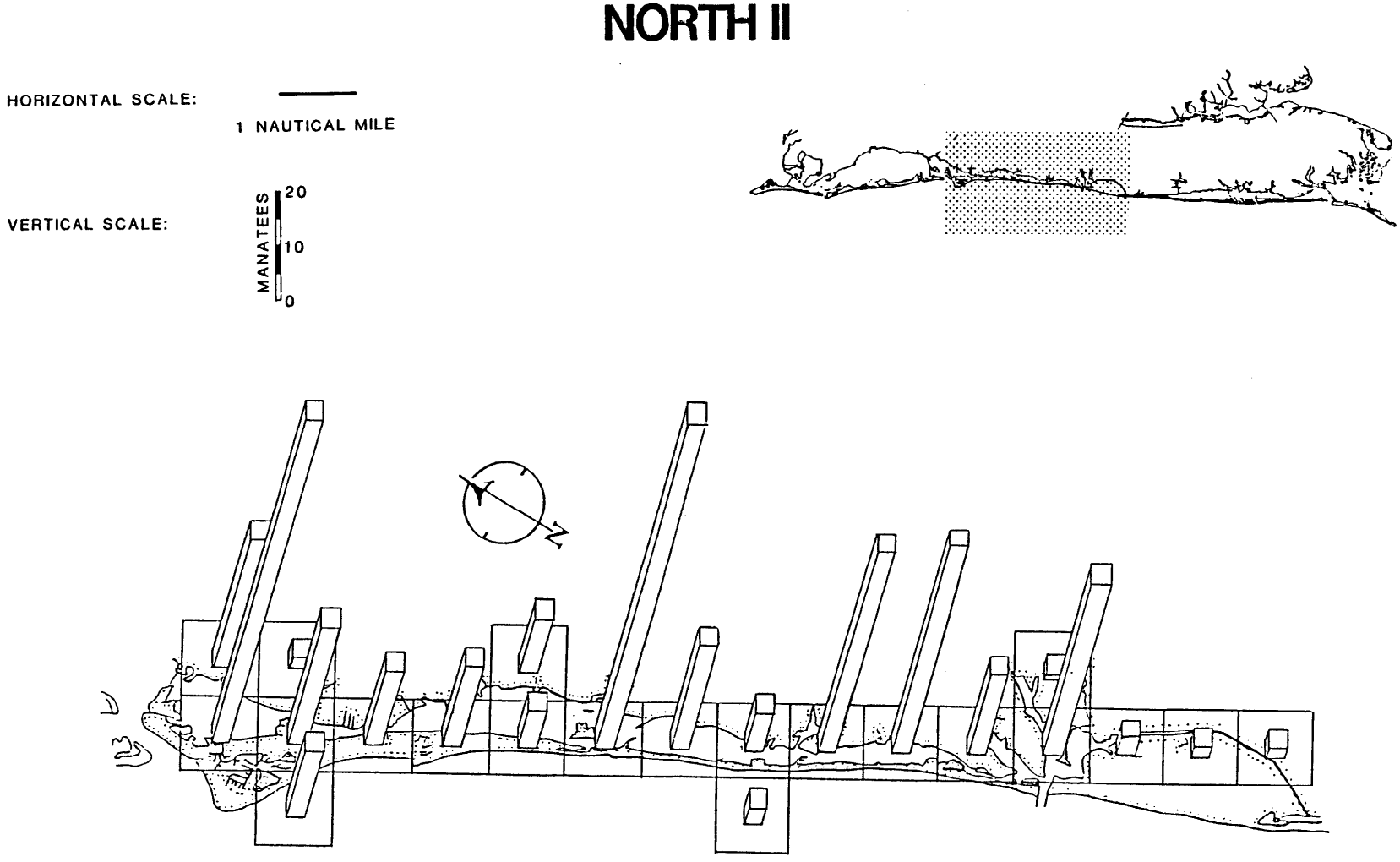


Figure 24B. **Bar graph map for the number of manatees sighted on a one square nautical mile grid. The north area is comprised of nearly four years of data.**

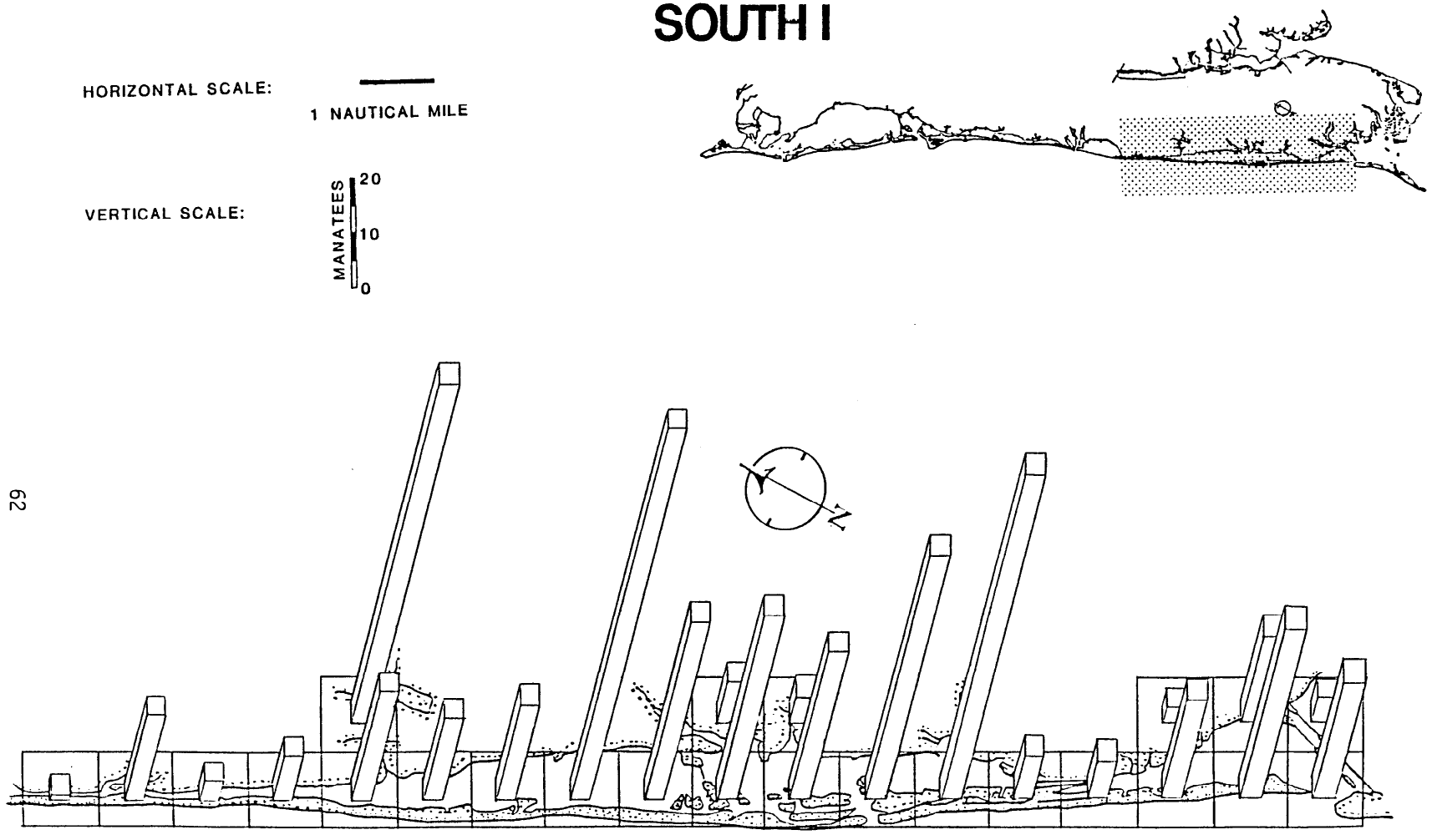


Figure 24C. **Bar graph map for the number of manatees sighted on a one square nautical mile grid. The south area is comprised of nearly two years of data.**

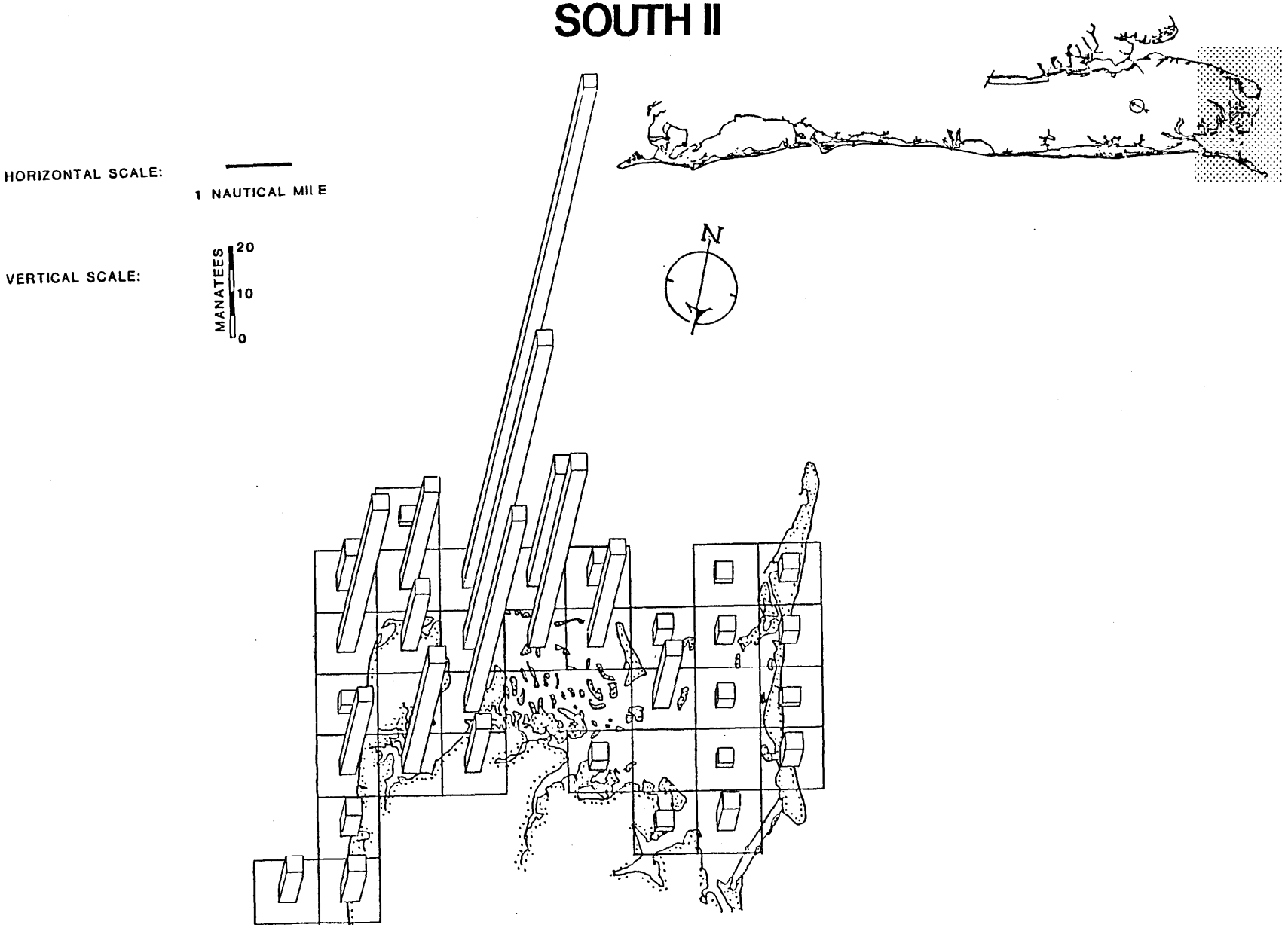


Figure 24D. Bar graph map for the number of manatees sighted on a one square nautical mile grid. The south area is comprised of nearly two years of data.

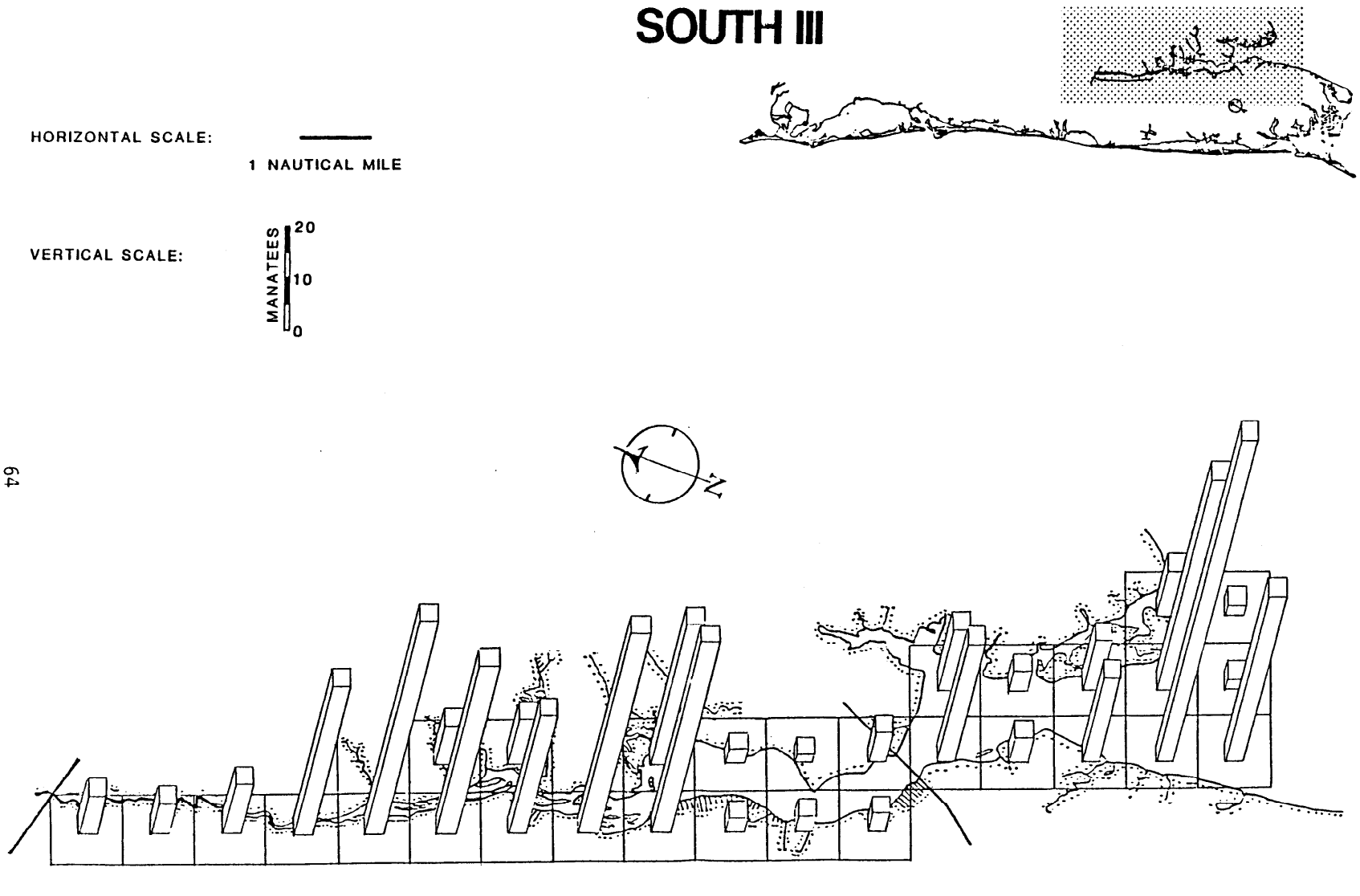


Figure 24E. **Bar graph map for the number of manatees sighted on a one square nautical mile grid.** The **south area is comprised of nearly two** years of data.

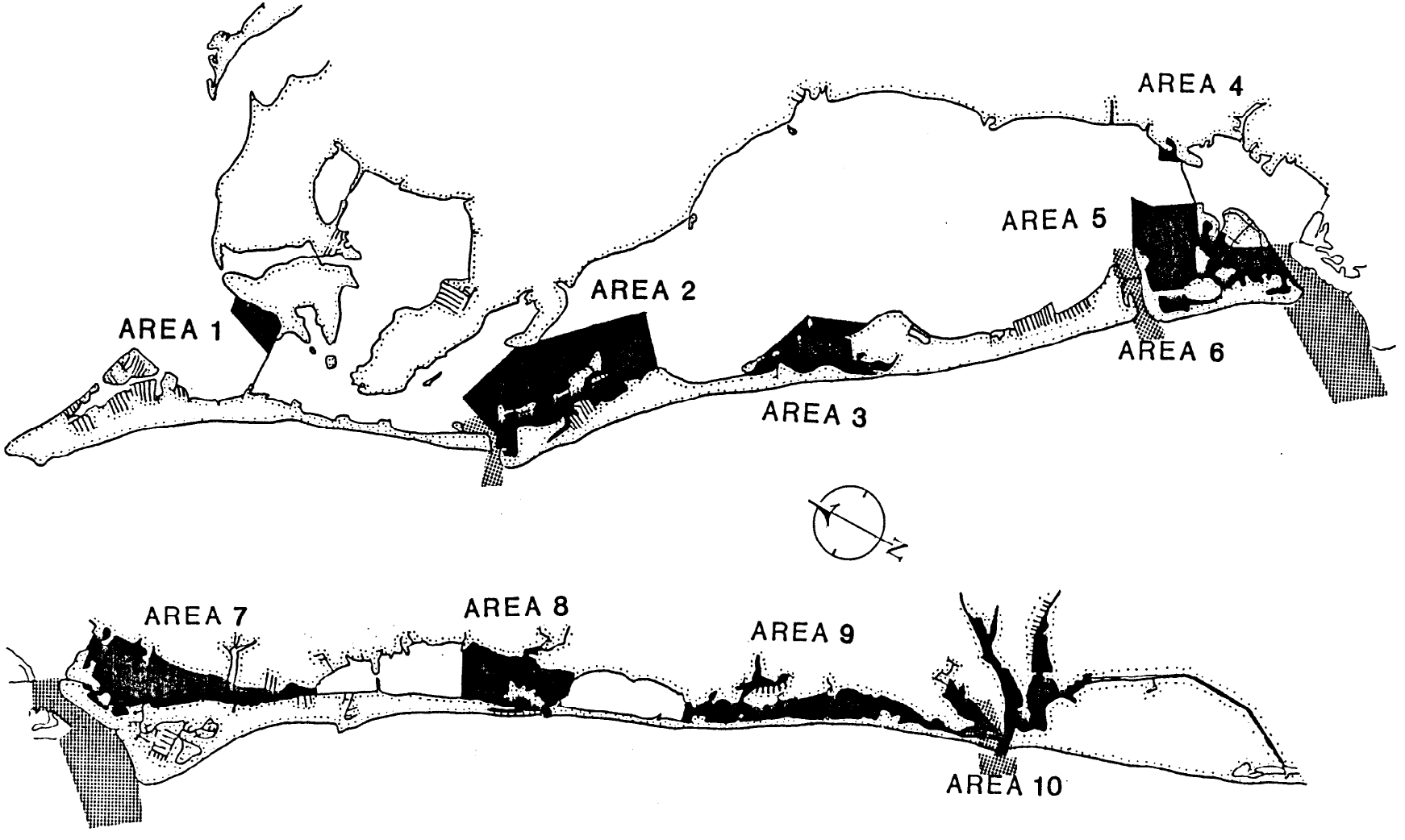


Figure 25A. Areas of importance to manatees in the survey region.

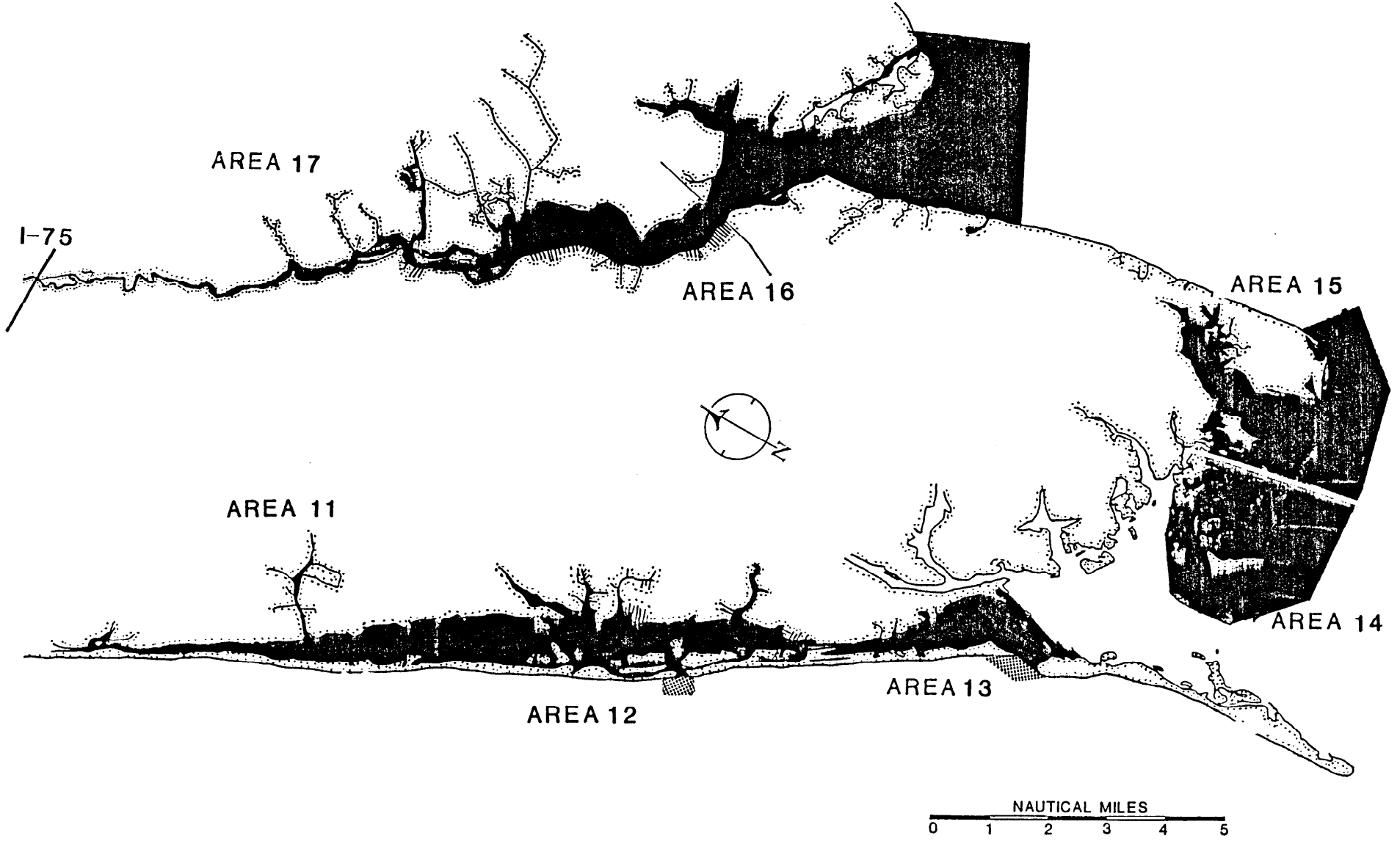


Figure 25B. Areas of importance to manatees in the survey region,

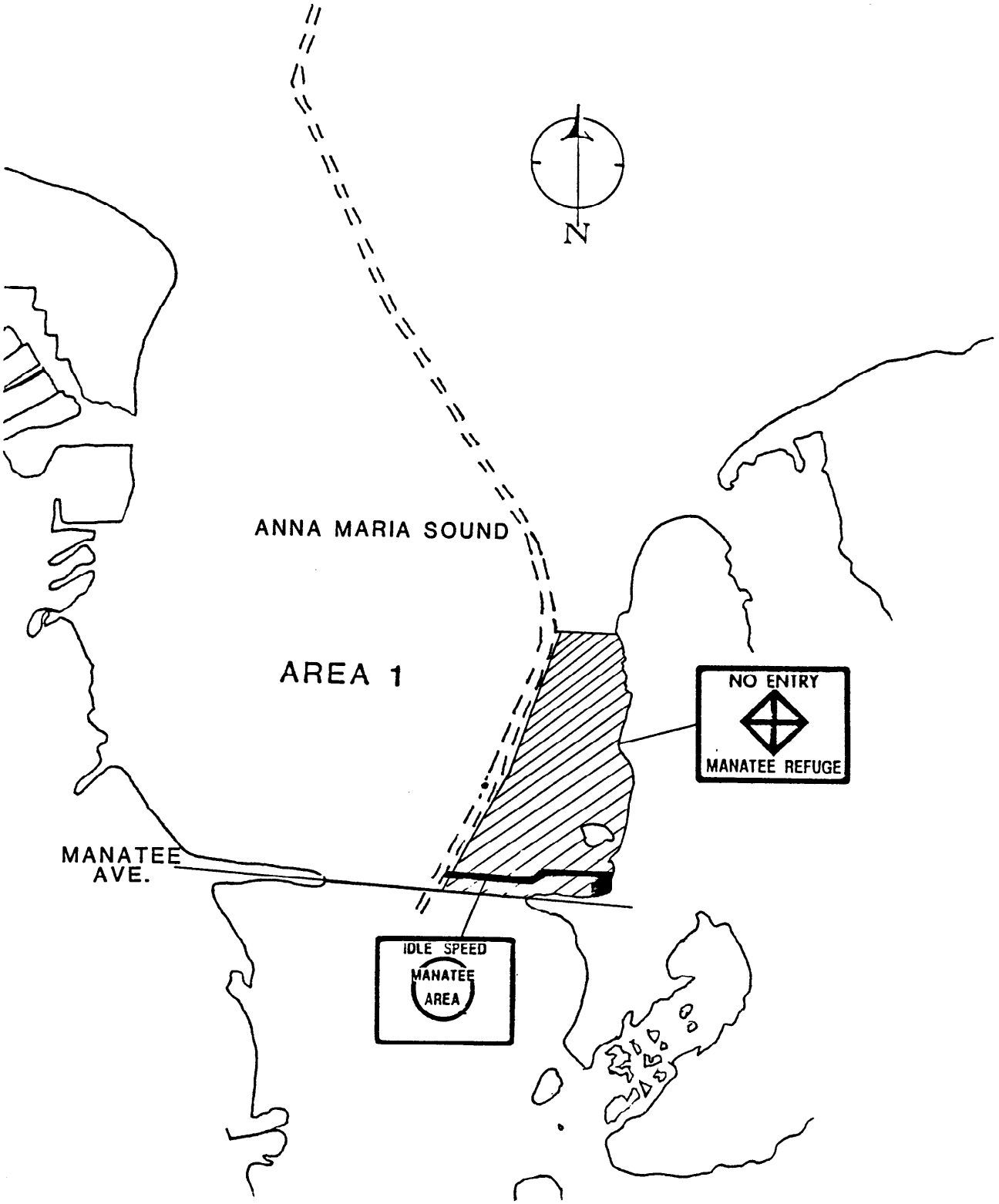


Figure 26A. Detail of critical areas and recommended means of protecting these habitats.

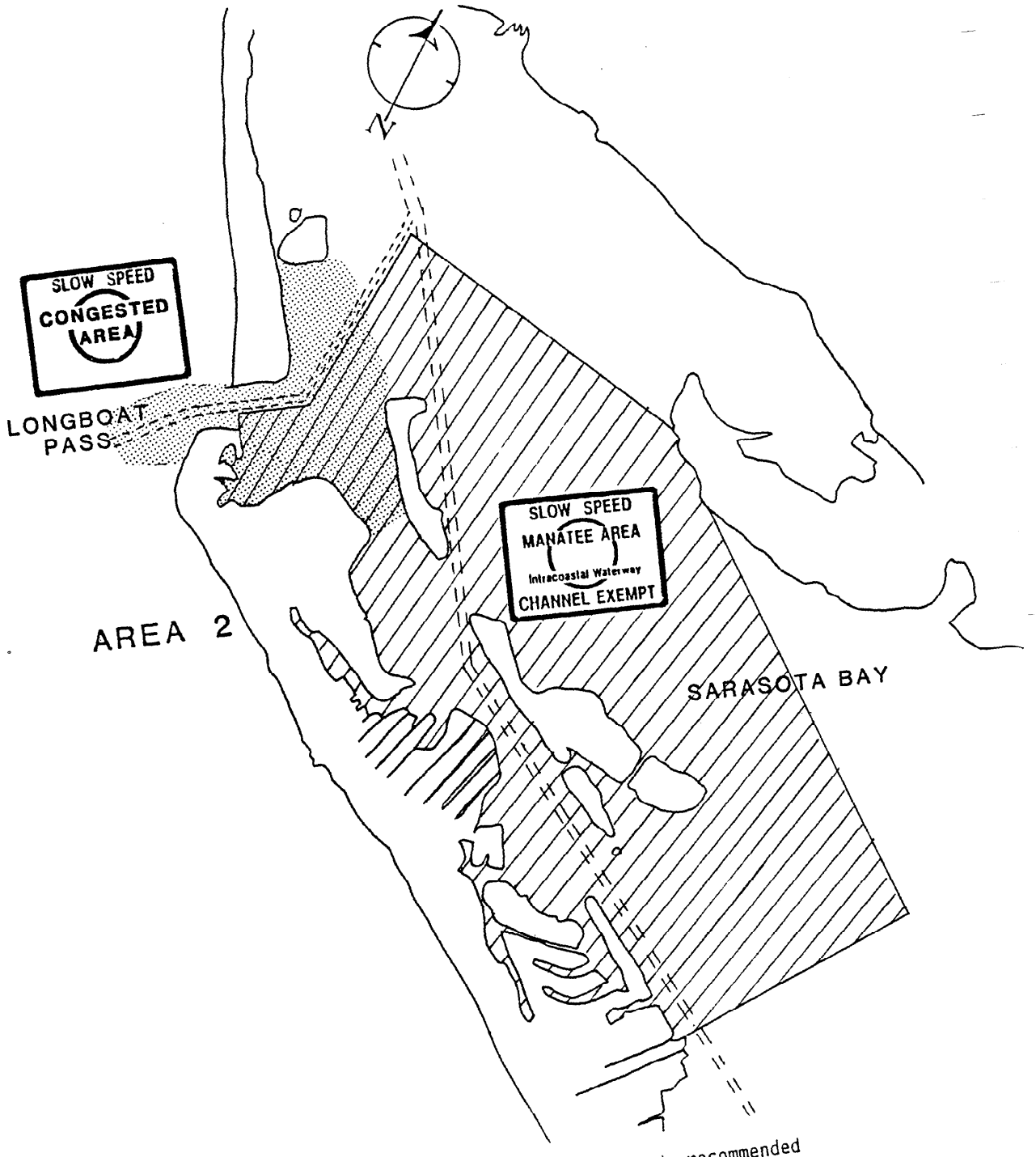
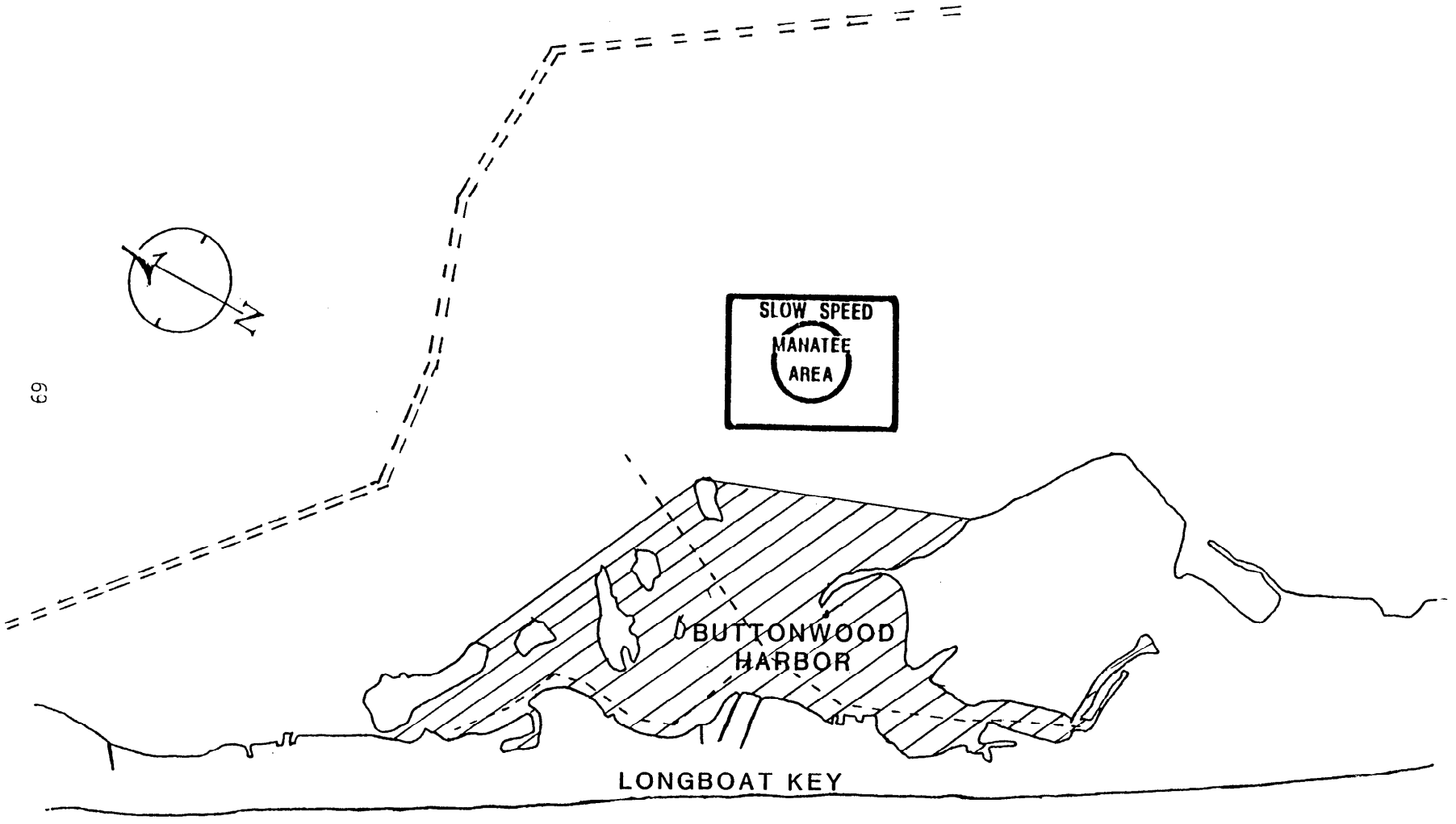


Figure 26B. Detail of critical areas and recommended means of protecting these habitats.



AREA 3

Figure 26C. **Detail of critical areas and recommended means of protecting these habitats.**

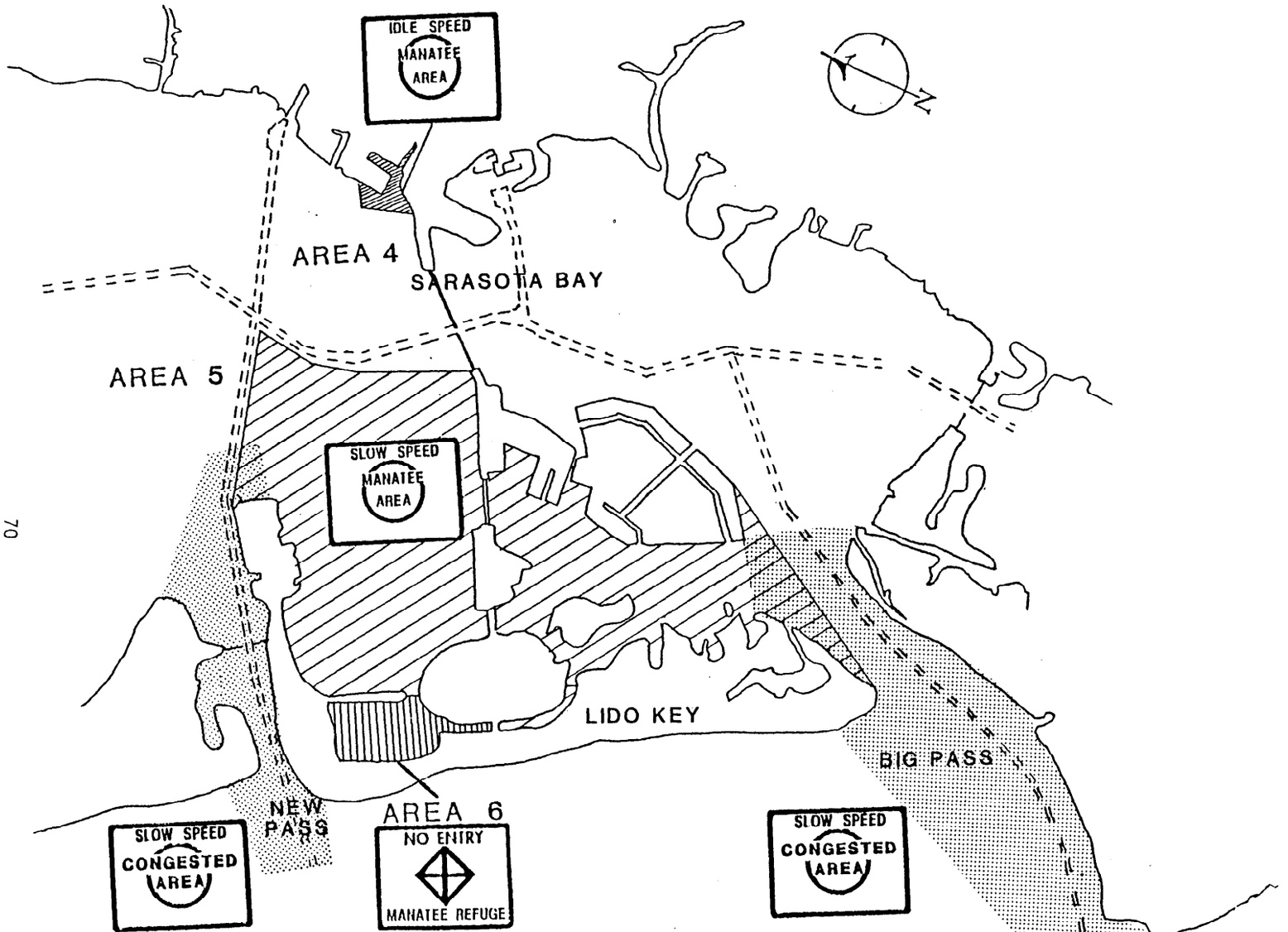


Figure 26D. Detail of critical areas and recommended means of protecting these habitats.

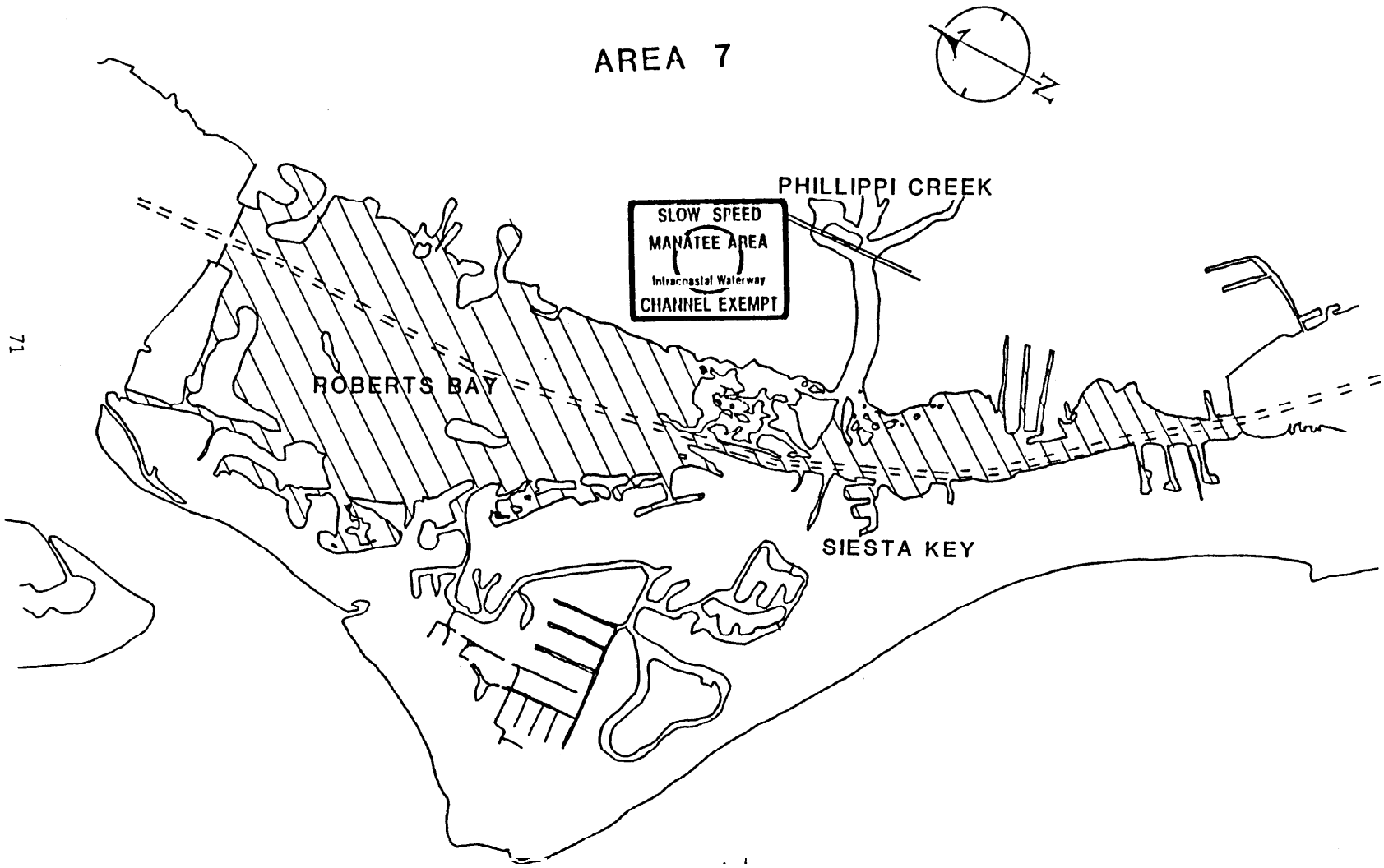


Figure 26E. Detail of critical areas and recommended means of protecting these habitats.

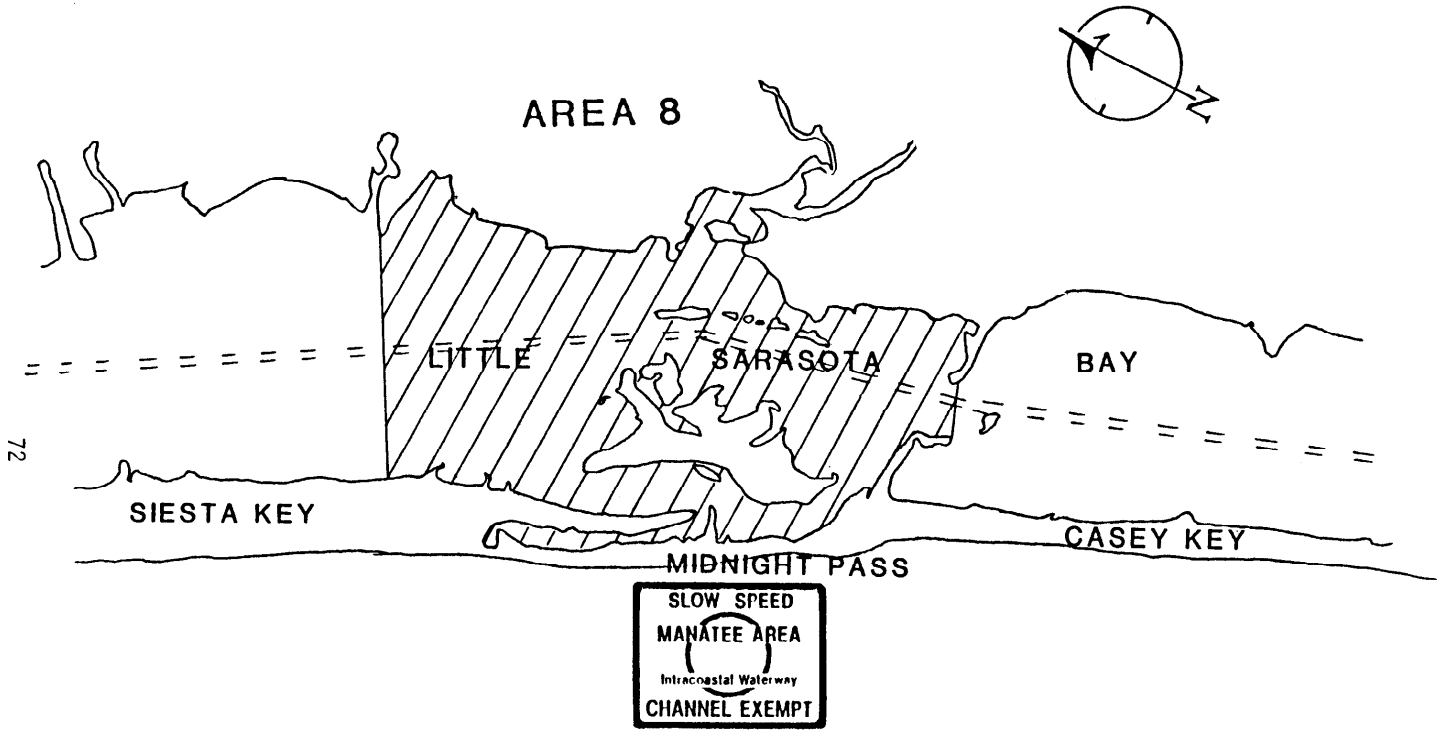


Figure 26. Detail of critical areas and recommended means of protecting these habitats.

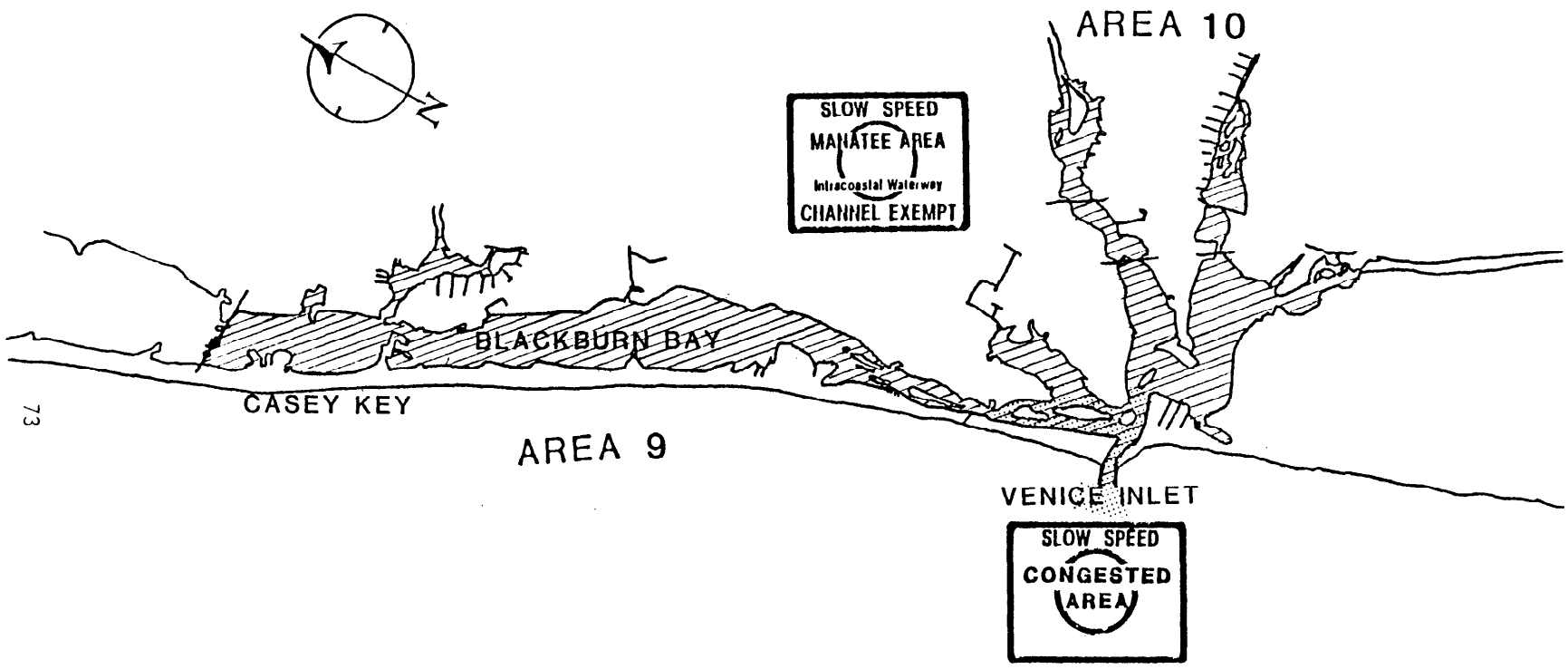


Figure 26G. Detail of critical areas and recommended means of protecting these habitats.

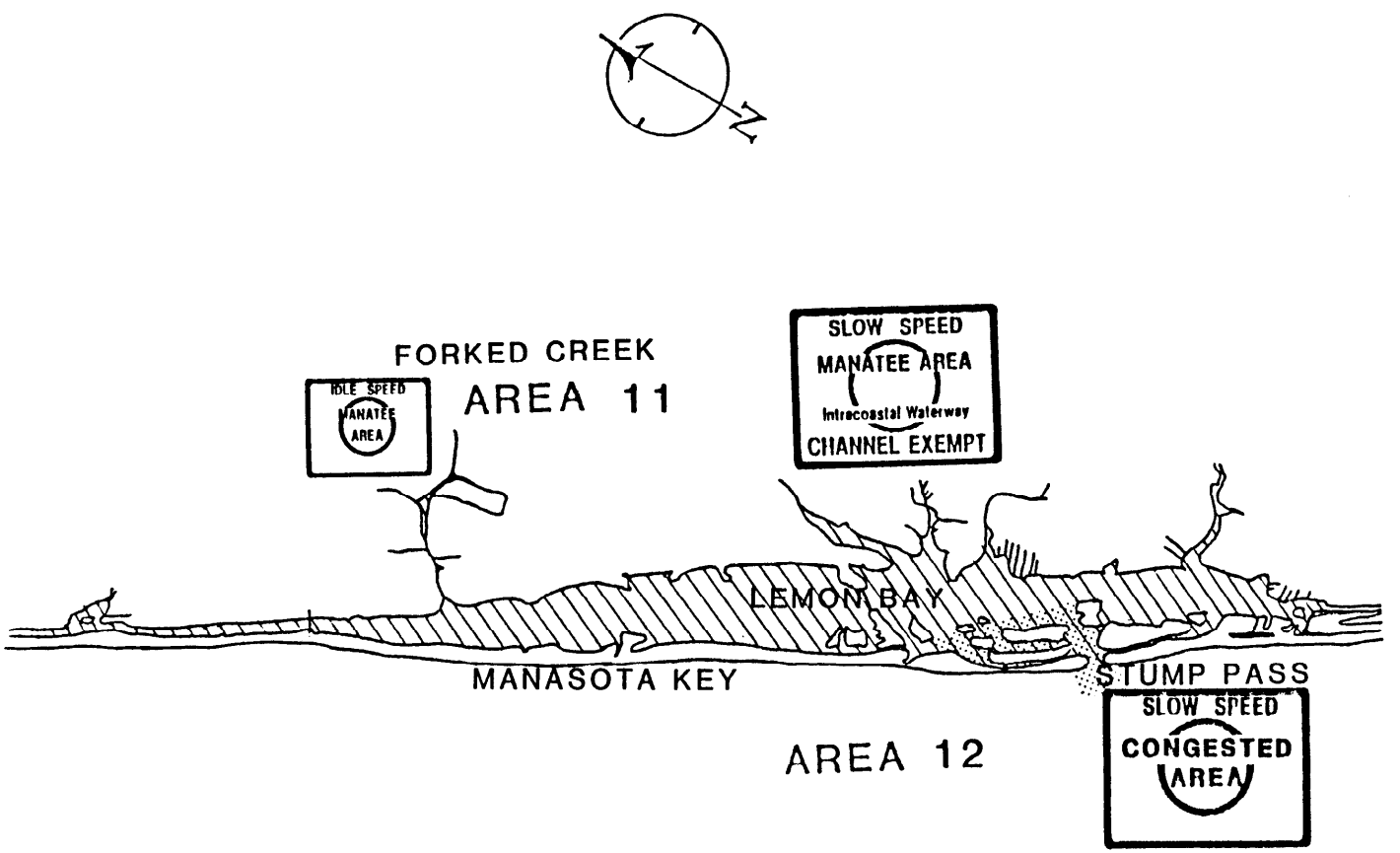


Figure 26H. Detail of critical areas and recommended means of protecting these habitats.

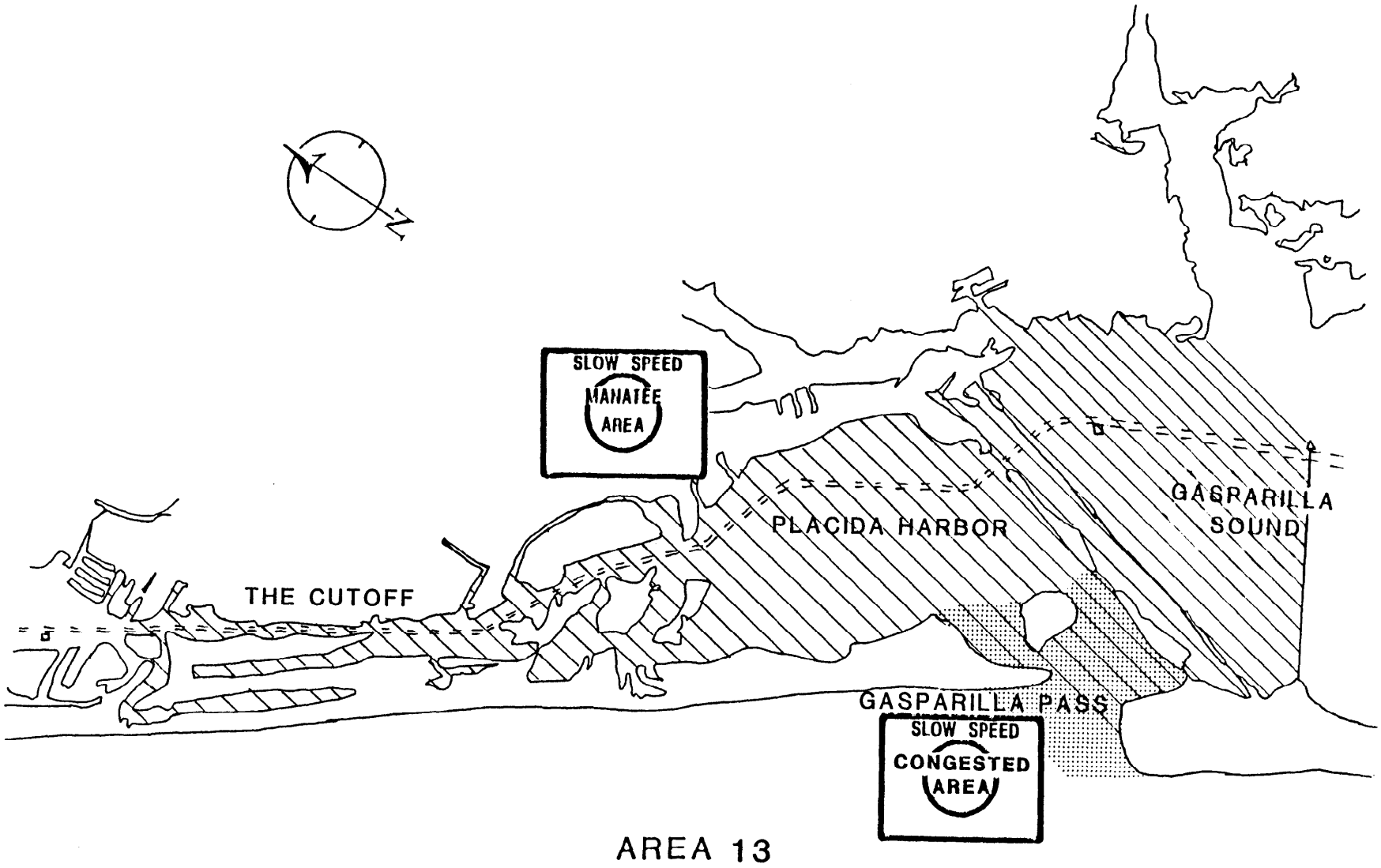


Figure 26I. Detail of critical areas and recommended means of protecting these habitats,

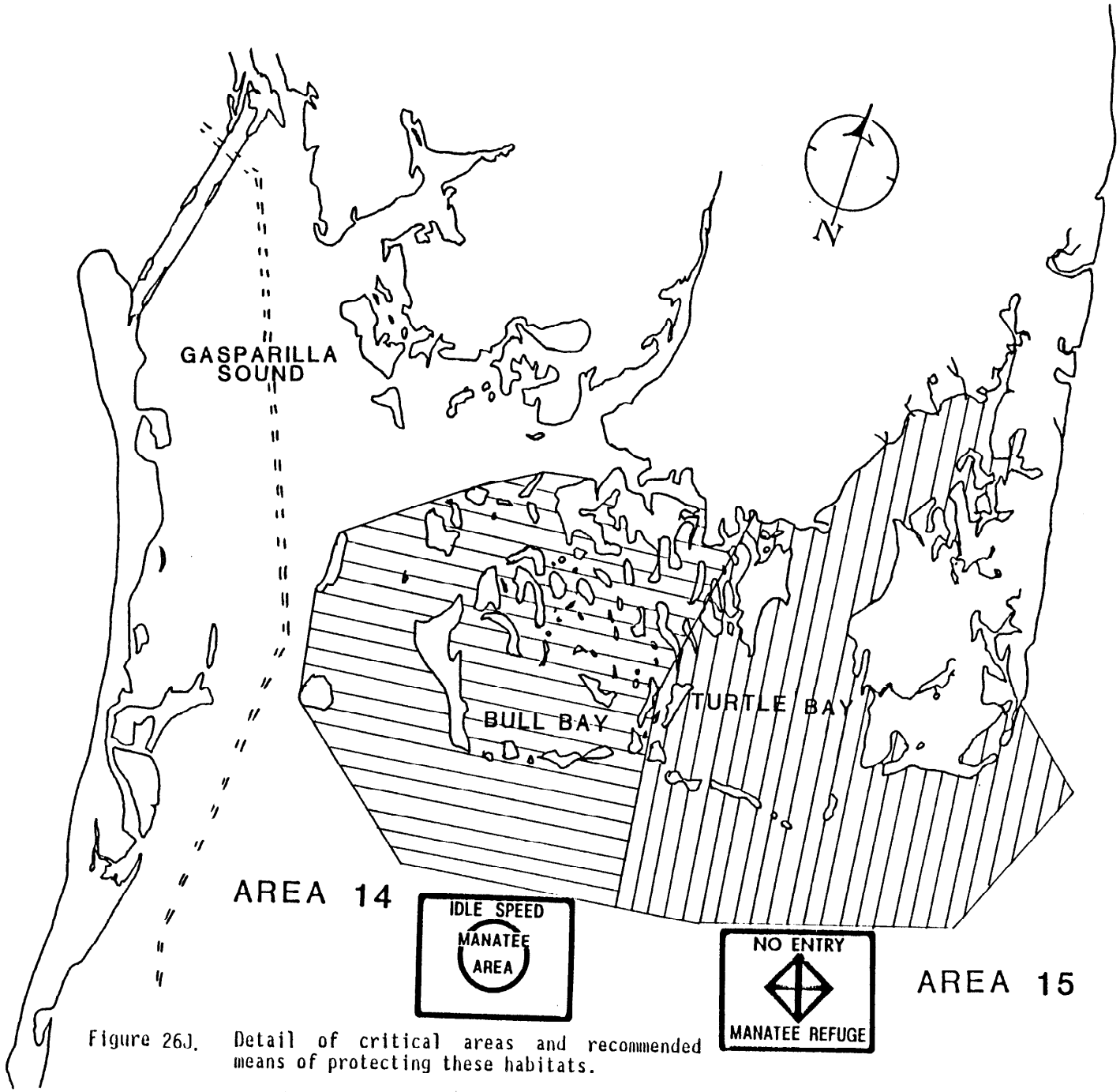


Figure 26J. Detail of critical areas and recommended means of protecting these habitats.

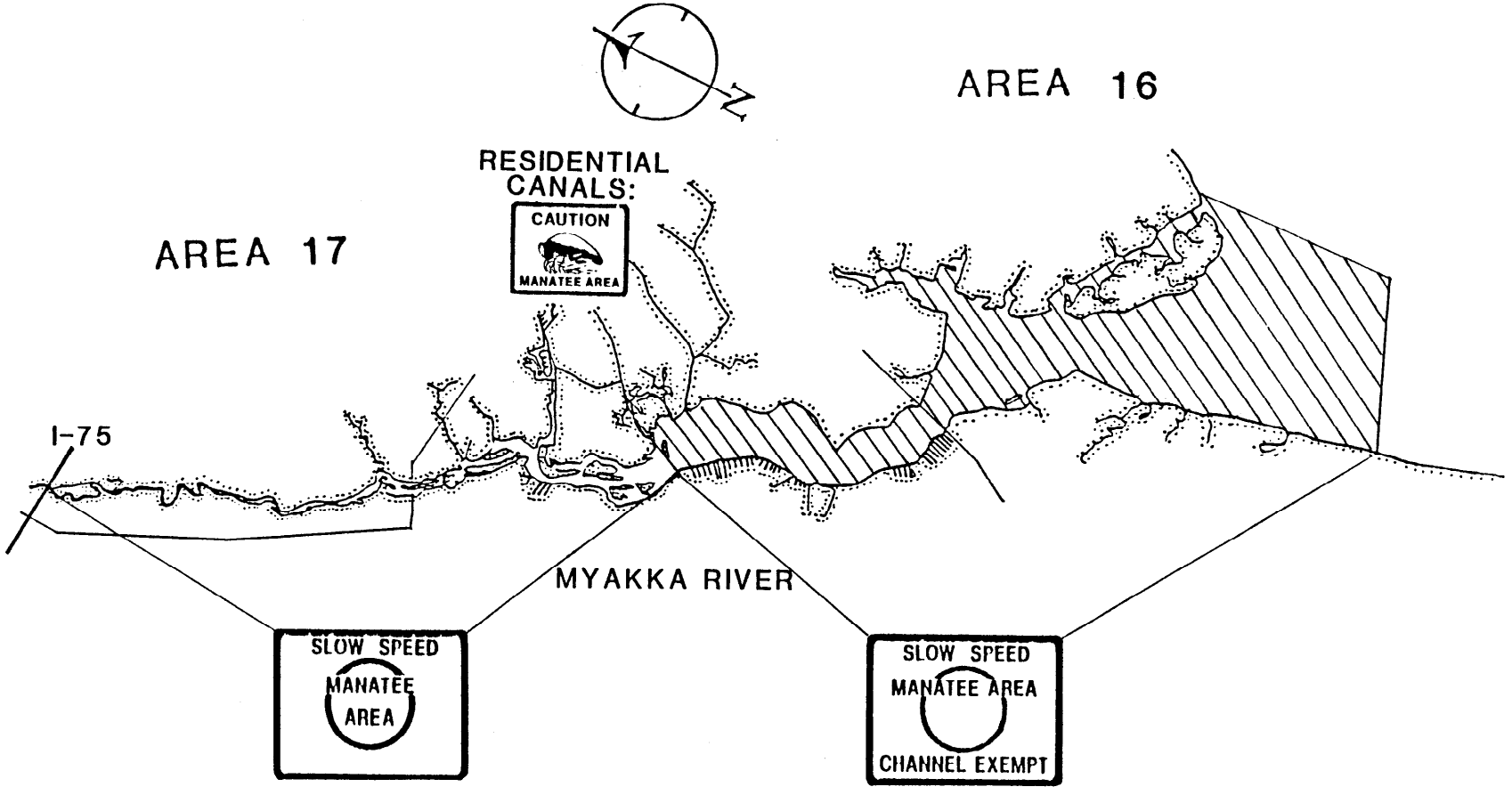


Figure 26K. **Detail of critical areas and recommended means of protecting these habitats.**

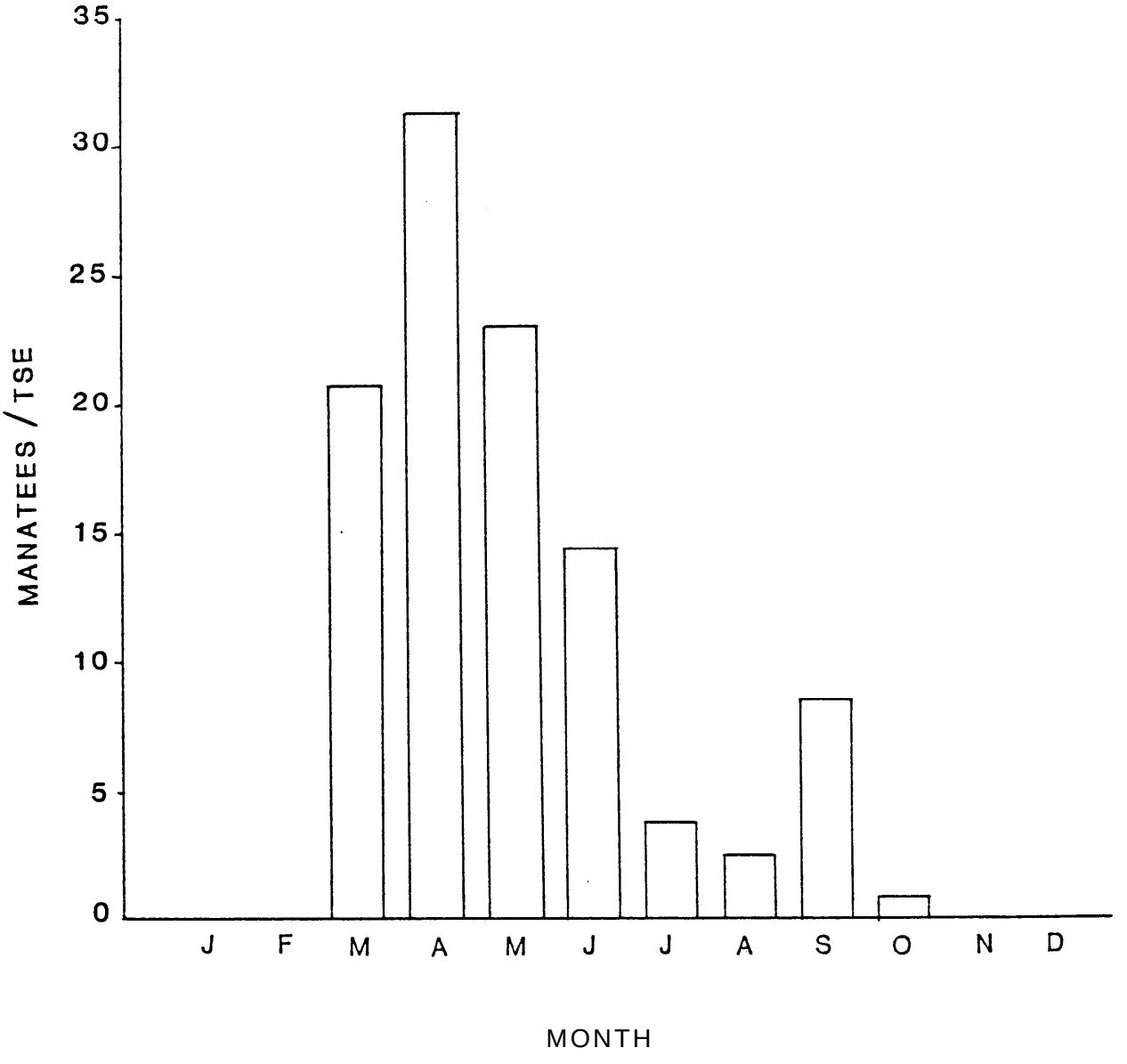


Figure 27. Number of manatees sighted per survey effort in the Turtle Bay area by month.

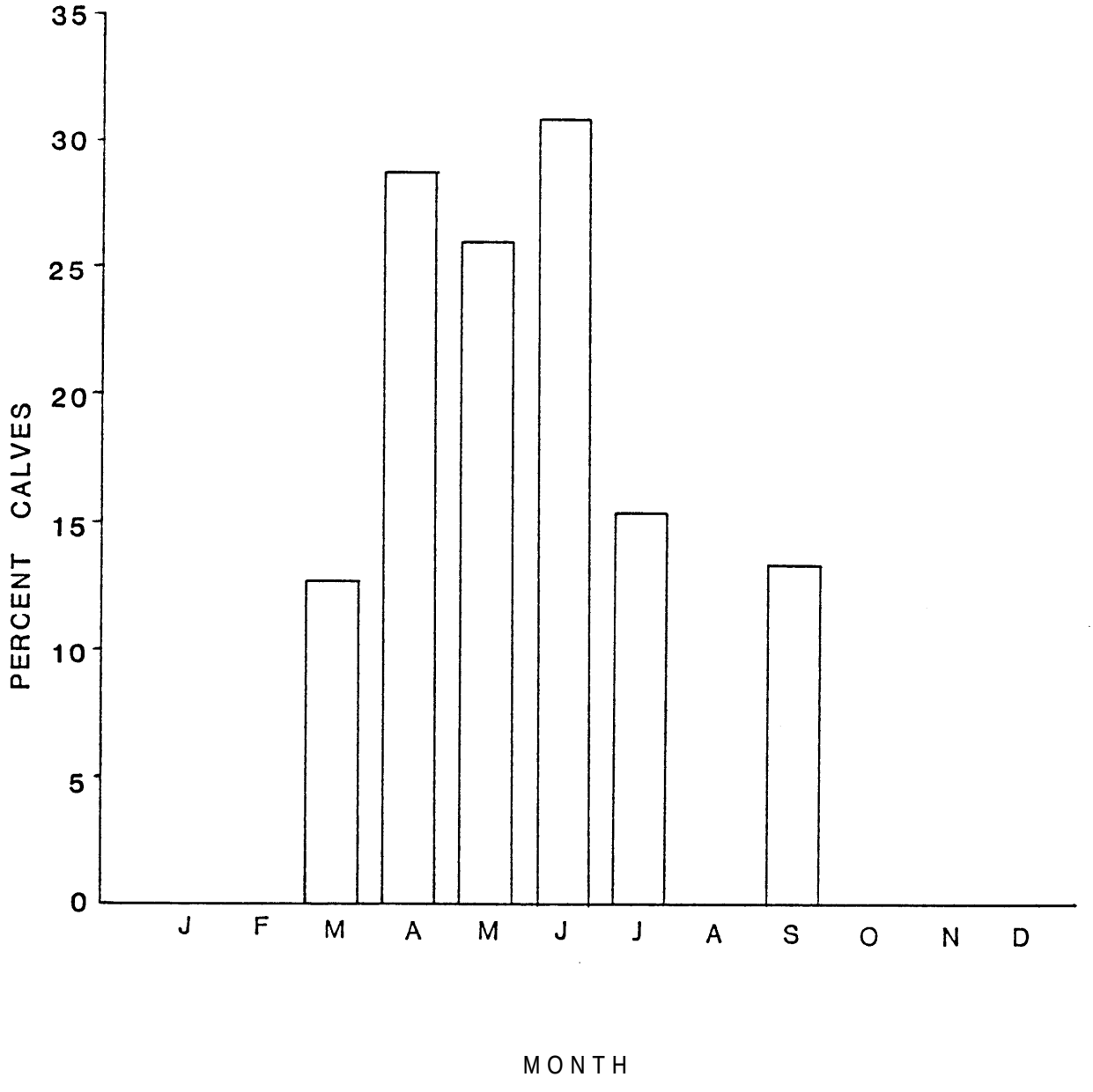


Figure 28. **Percentage of manatee calves in the Turtle Bay area by month.**

T A B L E S

Table 1. **Summary of Manatee Fatalities for** 1985-1988 **(from the Florida Marine Research** Institute, **Manatee Recovery Program).**

	1985	1986	**1987**	1988
Boat/Barge Collision	35 (27.1%)	33 (26.4%)	39 (33.3%)	43 (32.3%)
Flood Gate/Canal Lock	3 (2.3%)	3 (2.4%)	5 (4.3%)	7 (5.3%)
Other Human Related	5 (3.9%)	1 (0.8%)	4 (3.4%)	4 (3.0%)
Perinatal	25 (19.4%)	27 (21.6%)	30 (25.6%)	30 (22.6%)
Other Natural	20 (15.5%)	13 (10.4%)	16 (13.7%)	24 (18.0%)
Undetermined	35 (27.1%)	42 (33.6%)	22 (18.8%)	23 (17.3%)
Verified, not recovered	6 (4.7%)	6 (4.8%)	1 (0.9%)	2 (1.5%)
TOTAL	129	125	117	133

Table 2. **Previous non-winter manatee aerial surveys covering the survey area.**

PERIOD	NO. OF SURVEYS	MANATEES SIGHTED	REFERENCE
1973	4	0	Hartman (1974)
1976	1	0	Irvine and Campbell (1978)
1979	5	20	Irvine, Caffin and Kochman (1981)
1985	25	314	Patton (1986)
1986	20	269	Patton, Kreckman and Sprinkel (1987)
1987	20	947	Nabor and Patton (1988)

Table 3. Description of the twelve sectors and square kilometer calculations for each.

AREA	DESCRIPTION	km^2
I	Study area north of Manatee Ave. Bridge	11.52
II	Area between Manatee Avenue and Cortez Road Bridges	10.06
III	Sarasota Bay to Siesta Bridge	61.75
IV	Roberts Bay (N) (to Stickney Point Bridge)	3.60
V	Little Sarasota Bay (to Blackburn Point Bridge)	5.81
VI	Blackburn Bay (to South Casey Key Bridge)	2.22
VII	Venice Inlet area (including 3 bays) to Alligator Creek	7.30
VIII	North Lemon Bay (Alligator Creek to SR 776 Bridge)	7.78
IX	South Lemon Bay [to Marker 67 (=North end of "The Cutoff")]	7.06
X	Placida Harbor	4.45
XI	Gasparilla Sound and Cape Haze Aquatic Preserve areas	30.27
XII	Myakka River (including Hog Island area)	33.80

Table 4. **Summary of flight dates and manatee counts for each survey** (1985-1988 Oct.).

	1985		1986		1987		1988	
					Dates	**Tm**	**Dates**	**Tm**
Mon.	**Date**	**Tm**	**Date**	**Tm**	**N:S**	**N&S***	**N:S**	**N&S***
Jan	7	1 + 0	--	--	29:30	3+ 0	15:16	4 + 0
	22	0	--	--	--	--	--	--
Feb	9	0	--	--	4:12	2+ 0	22:18	5 + 0
	18	0	--	--	21:26	1+ 0	--	--
Mar	3	3+ 1	12	0+ 0	11:12	18+ 0	31**	51+ 3
	20	4+ 0	24	1+ 1	25:23	51+ 9	--	--
Apr	1	1+ 0	7	9+ 0	6: 8	42+11	27:29	85+15
	17	6+ 0	24	13+ 0	20:22	52+16	--	--
	29	6+ 1	--	--	--	--	--	--
May	13	19+ 1	5	16+ 1	17:16	49+ 5	10:11	53+11
	28	18+ 1	22	9+ 0	27:28	91+17	23:26	66+ 3
Jun	10	23+ 1	2	14+ 0	9:11	81+ 8	2: 3	72+12
	24	12+ 2	16	5+ 1	23:24	70+16	16:17	64+12
							27:28	35+ 7
Jul	9	17+ 1	7	19+ 2	9,10:13	40+ 4	11:13	55+ 9
	--	--	14	7+1	22:24	40+ 0	25:26	70+13
	--	--	26	18+ 0	--	--	--	--
Aug	6	10+ 0	8	18+ 2	5:7	33+ 2	11:17	36+ 2
	20	20+ 2	22	5+ 3	19:21	55+ 4	25:9/1	48+ 6
Sep	6	22+ 4	4	16+ 1	9:11	66+ 9	20:27	97+ 7
	23	24+ 2	18	9+ 0	28:10/3	53+ 6	28:10/4	98+ 8
Oct	7	1+ 0	2	24+ 1	20:24	37+ 3	11:12	101+12
	14	15+ 1	--	--	--	--	24:25	93+16
Nov	12	26+ 4	11	18+ 0	16,23:24	23+ 4		
	25	5+ 0	26	11+ 0	--	--		
Dec	4	25+ 2	10	31+ 2	11:10	23+ 3		
	10	18+ 3	26	12+ 0				
	23	0						

*** Combined totals for north and south surveys shown as adults + calves.**
**** North and south surveys flown on same date.**

Table 5. **Summary of Total Survey Effort (TSE) for each sector and each month, for** 1985-1988 (Oct.)..

SECTOR	MONTH												
	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
I	4	5	7	8	8	9	8	8	8	6	5	6	82
II	4	5	7	8	8	9	8	8	8	6	5	6	82
III	4	5	7	8	8	9	8	8	8	6	5	6	82
IV	4	5	7	8	8	9	8	8	8	5	5	6	81
V	4	5	7	8	8	9	8	7	8	5	4	6	79
VI	4	5	7	8	8	9	8	7	8	5	4	6	79
VII	4	5	7	8	8	9	8	7	8	5	4	6	79
VIII	2	3	3	3	4	5	4	4	4	3	1	1	37
IX	2	3	3	3	4	5	4	4	4	3	1	1	37
X	2	3	3	3	4	5	4	4	4	3	1	1	37
XI	2	3	3	3	4	5	4	4	4	3	1	1	37
XII	1	3	3	3	4	5	4	3	4	3	0	1	34
TOTAL	37	50	64	71	76	88	76	72	76	53	36	47	

Table 6. Breakdown of sightings by herd size, showing number and percent of sightings and the number and percent of animals represented.

# Tm in Herd	# Sightings	% Sightings	# Animals	% Animals
1	665	**52.9**	665	24.7
2	281	22.3	562	20.9
3	127	10.1	381	14.1
4	75	6.0	300	11.1
5	38	3.0	190	7.1
6	23	1.8	138	5.1
7	13	1.0	91	3.4
8	11	0.9	88	3.3
9	8	0.6	72	2.7
10	5	0.4	50	1.9
11	1	0.1	11	0.4
12	6	0.5	72	2.7
13	2	0.2	26	1.0
14	1	0.1	14	0.5
15	0	0.0	0	0.0
16	1	0.1	16	0.6
21	1	0.1	21	0.8
Total	1,258		2,695	

Table 7. Maximum manatee counts for the north and south survey regions by year.

	Maximum Manatee Counts					
	North Region				South Region	
	1985	1986	1987	1988	1987	1988
	30	33	32	38	84	81
	27	25	27	38	73	74
	26	21	27	29	63	75
	26	20	25	28	62	75
	24	18	24	21	56	75
Yearly Average	26.6	23.4	27.0	30.8	67.6	76.8
Overall Average	**North** = 27.0				**South** = 72.2	

Table 8. Summary of recommended measures to safeguard critical manatee habitat within the survey region. Category classifications are from the International Union for Conservation of Nature and Natural Resources (Salm and Clark, 1984).

LOCATION/DESCRIPTION	COUNTY	TYPE OF RESTRICTION	SEASON	APPROX. LENGTH (naut. mi)
Anna Maria Sound: area at the northeast corner of Manatee Avenue Bridge	Manatee	Category IV: No Entry Refuge	All Year	0.5
Longboat Pass area - inside and to the south	Manatee	Slow Speed Zone, Channel Exempt	March-Dec	2.0
Buttonwood Harbor area	Manatee-Sarasota	Slow Speed Zone	March-Dec	2.0
Hyatt Basin	Sarasota	Idle Speed Zone	March-Dec	0.5
Lido grassflats	Sarasota	Slow Speed	March-Dec	2.0
Pansy Bayou	Sarasota	Category IV: No Entry Refuge	All Year	0.5
Roberts Bay (N)	Sarasota	Slow Speed Zone, Channel Exempt	April-Nov	3.0
Midnight Pass area (Little Sarasota Bay)	Sarasota	Slow Speed Zone, Channel Exempt	April-Dec	1.0
Blackburn Bay	Sarasota	Slow Speed Zone, Channel Exempt	April-Nov	3.0
Venice Inlet Area	Sarasota	Slow Speed Zone, Channel Exempt	March-Dec	2.0
Lemon Bay	Sarasota-Charlotte	Slow Speed Zone, Channel Exempt, Category IV or VIII	March-Dec	12.0

Table 8. Continued.

Forked Creek (off of Lemon Bay)	Sarasota	Idle Speed Zone	March-Dec	1.5
The Cutoff area, Placida Harbor and Gasparilla Sound (Marker G9 to G19)	Charlotte	Slow Speed Zone	March-Dec	5.0
Bull Bay area/north Charlotte Harbor	Charlotte-Lee	Idle Speed Zone	All Year	2.5
Turtle Bay area	Charlotte-Lee	Category I: No Entry Refuge	All Year	2.5
Lower Myakka River	Charlotte	Slow Speed Zone, Channel Exempt	All Year	9.0
Upper Myakka River	Sarasota	Slow Speed Zone	All Year	8.0

Table 9. Example of decreasing frequency of use by manatees of a site in Anna Maria Sound.

	ANNA MARIA SOUND SITE			
	1985	1986	1987	1988 (Oct)
Counts (as adults t calves)	37+3	36+1	14+3	16+4
Total	40	37	17	20
Visits	25	20	20	17
Manatees/ Visit	1.60	1.85	0.85	1.18
Manatees/ Visit Over Two Years	1.71		1.00	
% of Surveys Animals were Present	64.0	60.0	35.0	23.5
% of Surveys Animals were Present Over Two Years	62.2		29.7	

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PARTICIPANTS

MML STAFF

Primary Observers:

Jay Gorzelany
Sue Hofmann
Pete Nabor
Geoffrey Patton
Jay Sprinkel
Brad Weigle

Secondary Observers:

Tracey Beecher
Paul Dufault
Mary Jo Kehl
Wes Maluk

Interns:

Jennifer Crawford
Todd Kreckman
Owen Smith
Jennifer Gerow

PILOTS

Rolland Freeman
Paul Graybill
A. Lemka
S. Pitcher
Scott Sorenson