TIME-ACTIVITY BUDGETS AND DISPLACEMENT RATES IN FLORIDA MANATEES (TRICHECHUS MANATUS) IN THE ABSENCE AND PRESENCE OF HUMANS

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Time-Activity budgets and Displacement Rates in Florida Manatees

(*Trichechus manatus*) in the Absence and Presence of Humans

by

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This thesis was prepared under the direction of the candidate's thesis advisor, Dr. Ralph M. Adams, Department of Biology and has been approved by the members of his supervisory committee. It was submitted to the faculty of The College of Science and was accepted in partial fulfillment for the degree of Master of Science.

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Abstract

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The effects of human presence on displacement behavior and time-activity budgets of free-ranging manatees (*Trichechus manatus*) are poorly known. The congregation of manatees and human tourists in the warm waters of Crystal River, Florida, during the winter months offered a unique opportunity to study these effects. Focal animal sampling was used to gather behavioral data on manatees during randomly selected daylight sampling periods. Frequencies of displacement were correlated with numbers of humans to determine if incidences of displacement were increased. Displacement increased with human presence. Maintenance and sexual behaviors decreased as human presence increased.

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Introduction

Florida manatees (Trichechus manatus), especially juveniles, are stenothermal and prone to cold-water (<20°C) induced deaths (Hartman, 1979; O'Shea et al., 1985a) because they have high thermal conductance and unusually low metabolic rates (Irvine, 1983; Miculka and Worthy, 1994). Behavioral thermoregulation is therefore very important (Packard et al, 1989). Manatees congregate at Kings Spring, Crystal River, Citrus County, Florida, when surrounding water temperatures fall below 20°C, because of the warm water effluent created by the natural spring.

Kings Spring is the only area open to large scale tourist activities where swimming with manatees is allowed. Dramatic increase in ecotourism activities during the past decade (Buckingham, 1990) may affect the time-activity budgets of manatees in the Spring area (Hartman 1979; Powell 1981; Buckingham, 1990). Several researchers have reported that divers cause manatees to be displaced into the sanctuary zones - areas that have been set aside for manatees only, with human intrusion prohibited. Research also indicates that the manatees are displaced out of the warm water refuges, and remain out of the warm water for long periods (Hartman, 1979; Powell, 1981; Kochman et al., 1985). Manatees' avoidance of human contact may cause them to spend more time in the sanctuary zones and lose forage time as sufficient food is unavailable in the sanctuaries (Powell, 1981; Kochman et al., 1985). Avoidance of divers may also increase transit time to forage zones where fewer people are present, increase total forage time because of human disturbance, or cause manatees to feed at night when surrounding waters are colder (Buckingham, 1990). Increased forage time or cold exposure would place additional energy requirements on animals that are at their tolerance threshold (Hartman, 1979; Packard et al, 1989).

Despite these concerns, there have been no prior studies of the effects of human activity on the displacement of manatees. Rationale for this research is the need to determine the time-activity budgets of Kings Spring manatees as relates to human presence, and to determine whether manatees are displaced from their warm water refuge or from forage areas by snorkelers and divers that visit the area. If divers' activities are causing manatees to change their activity patterns or leave the Spring area, the result could be counterproductive to protection measures.

The purpose of this research was to identify the time-activity budgets of manatees at Kings Spring before, during, and after human contact. The research was designed to address four major questions: 1. What are the time-activity budgets of individual, non-interacting manatees, at Kings Spring? 2. How do the time-activity budgets differ when manatees interact with other manatees? 3. Do the time-activity budgets change when manatees interact with humans? 4. Are manatees displaced by snorkelers and divers?

Materials and Methods

Study Site and Animals

Kings Spring is a warm water effluent located at Crystal River, Citrus County, Florida (Fig. I). It serves as a refuge for manatees that congregate there during winter months and attracts large numbers of human visitors who hope to interact with these animals (Dietz, 1992; O'Shea, 1994). This creates an excellent setting in which to observe the influence of human activity on manatee behavior. Manatees are free-ranging throughout the site except when air temperatures drop below 5°C or water temperatures drop below 18°C, when they will not normally leave the warm water effluent of the spring. The population is composed of adults, as well as juveniles, of both genders. These sex and size classes, together with scar and tail characteristics, were used to identify individuals and groups of animals.

Depth of the site varies from < 1 m to > 4 m, which allowed in-water observations. In addition, a 7.7m high observation platform was erected on Banana Island, adjoining the site which surrounds Kings Spring. The platform allowed observations of manatee behavior (some with binoculars) within the sanctuary area which is free from human disturbance. The majority of these platform observations served as a control for individual and conspecifically interacting manatees. From the platform a unique area called the keyhole was also visible. This is a swim corridor through the sanctuary for divers to access the main spring. This allowed observations of manatees swimming from the sanctuary (no humans) into the keyhole (human interaction took place), and back into the sanctuary.

Sampling Techniques

I have observed and video-taped manatee behavior for the past ten winters in the Kings Spring area. These preliminary observations have provided me with the skill to identify specific behavioral repertoires that were analyzed in this report. Observations analyzed in this report were collected from early November 1994 to early March 1995. During these months water temperatures in the Gulf of Mexico are generally lower than 20^{o}C and manatees congregate in the spring area. All observations took place during a range of daylight hours, from 0700 to 1800 h EST, to account for the possibility of changing activity cycles. Observations were made every 30 s in periods of 30 min, and continued for blocks of 1-3 h. Observations were conducted at least 2 days a week from the water (3,886 observations) and from the observation platform (1,357 observations). A total of 43.7 h of data were collected for statistical analysis.

For each 30 min sampling period, a sample group of animals was identified from which a focal animal was randomly chosen (Altmann, 1974). Specific behaviors (defined below) of this focal animal were recorded every 30 s for the entire 30 min sampling period. A different focal animal was chosen for each 30 min sampling period. The behaviors were recorded on custom waterproof slates, designed and produced specifically for this project. A sketch was drawn of each focal animal, including scars, algal patterns, skin irregularities, and unique tail characteristics (Hartman, 1971, 1979). Gender (if known) and body length were also noted. As each behavior was recorded, the numbers of manatees and divers were noted.

In-water data were collected using mask, fins, and snorkel only, since use of SCUBA gear appears to disturb the animals (Reynolds, 1981a). During all observations, the researchers worked in teams of two to ensure accuracy. This method mimicked the normal interactions between humans and manatees which already occurred at this site, and allowed observations of the focal animal's typical response to uncontrolled interactions. When an observer was within the defined interaction range of 1.5 m, they were counted among the total number of humans interacting. Following the focal animal while swimming also mimicked normal interactions of snorkelers at the site who were often observed to engage in this type of behavior.

Seventeen trained undergraduate volunteers from the University of Central Florida and Florida Atlantic University assisted in the data collection. These volunteers were selected after completion of 16 hours of formal training including lecture, slides, and scoring of manatee behavior utilizing video tape. In addition to formal training, daily on-site briefings were conducted prior to commencing data collection.

Additionally, the date, time of day, weather conditions, air and water temperatures, and barometric pressure were recorded. If a manatee left the area before the 30 min sampling period had elapsed, the time was noted.

Recorded Behaviors

The following behaviors were recorded: **Maintenance Behaviors**--1. feeding--grasping, ingesting, and chewing vegetation (Moore, 1956); 2. breathing--inhaling air at the surface (Moore, 1956); 3. swimming--animal is leisurely to moderately moving (Moore, 1956); 4. resting--lying motionless in the water column or on the bottom (Moore, 1956; Hartman, 1979); **Social Behavior**--5. follow-the-leader--two or more animals swimming head-to-tail with the lead animal setting the course and speed (Hartman, 1979); **Flight Behaviors**--6. fast swimming--animal is engaged in flight or intense mating activity (Hartman, 1979); 7. diving--quickly descending to the bottom (Buckingham, 1990); **Sexual Behaviors**--8. ventral rubbing--rubbing the ventral region against another object (Moore, 1956); 9. mouthing--taking an object or body part into the mouth (Moore, 1956); 10. nuzzling--placing the muzzle against the body of another manatee, or a human (Moore, 1956; Hartman, 1979); 11. hugging--embracing another individual's body or body part with the flippers (Hartman, 1979); 12. rolling--rolling over repeatedly (Hartman, 1979); **Agonistic Behaviors**--13. butting--striking another animal or human (Hartman, 1979); 14. tail slapping--slapping the tail on the water surface (Hartman, 1971); 15. interference--moving, and remaining, between one animal and another (Hartman, 1971).

Time-Activity Budgets and Displacement

1. What are the time-activity budgets of individual, non-interacting, manatees at Kings Spring? To determine the time-activity budgets of non-interacting manatees, I used the focal animal sampling procedure previously described. A total of 24 focal animals (3848 observations) were chosen to determine the time-activity budgets of individual, non-interacting manatees.

2. How do the time-activity budgets differ when a manatee is interacting with other manatees? I defined interaction with other manatees as remaining within 1.5 m of another individual for 30 s or longer. A total of 16 focal animals (956 observations) were used to determine the time-activity budgets of conspecifically-interacting manatees.

3. How do the time-activity budgets change when manatees interact with humans? I defined interaction with humans as remaining within 1.5 m of a human or group of humans for 30 s or longer. A total of 23 focal animals (1396 observations) were used to determine the time-activity budgets of manatees that interacted with humans.

4. Are manatees displaced by snorkelers and divers? During the time-activity studies, I recorded the frequencies with which displacement occurred. I defined displacement as: a) The animal displaced at least 15 m from where it had been for more than 3 min; the animal terminated an interaction by swimming into the sanctuary, or at least 15 m from where it had been interacting: and, b) the animal stayed away from it's previous position for the remainder of the 30 min reporting period. The number of humans that were present preceding displacement was noted to determine if human group size

was significantly correlated. A total of 23 focal animals (1396 observations) were used to determine the frequency of displacement of manatees away from interacting humans.

Statistical Analysis

Pearson Product-Moment Correlation was used to determine statistical significance of manatee group size to behavior, as well as human group size to manatee behavior. Linear Regression analysis was used to determine significance of human presence and group size to manatee displacement.

Results

Individual and Conspecific Time-Activity Budgets

Individual, non-interacting manatees comprised 63% of all data collected. Non-interacting adults spent a total of 77% of their time performing the maintenance behaviors of: resting (32%), swimming (18%), breathing (16%), and feeding (11%). Conspecific interactions resulted in behaviors that differed in frequency from behaviors of non-interacting manatees (Table 1). A Pearson Product-Moment Correlation Matrix indicates the effects of manatee group size on behavior (Table 2). As group size increased, so did social and sexual behaviors. Agonistic behaviors (fast swim, diving, butting, tail slap, interference) occurred rarely with no correlation to group size. Nevertheless, the maintenance behaviors of feeding and resting decreased as group size increased. Negative numbers depict a negative correlation.

Groups of two to three manatees consisted of either a female with calves or several males. Groups of more than four manatees were almost always (99%) males that were exhibiting homosexual behaviors (defined sexual behaviors presented to individuals of the same gender), or were males pursuing a cow in a mating herd. I never recorded two or more adult females together.

Of the manatees for whom gender was recorded, gender was not related to maintenance behavior. Males displayed a higher rate of social and sexual behaviors. This is consistent with results of Hartman (1971) which indicated that males initiate pre-copulatory activities and engage in homosexual and mastubatory behavior.

Time-Activity Budgets during Human Interaction

The time-activity budgets of manatees interacting with humans were different from those of non-interacting or conspecifically-interacting manatees. Table 3 shows the percentage of time spent per behavior per group. The table indicates that breathing (up to 5 people present), swimming, fast swimming, rolling, and diving increased as human presence increased. Conversely, feeding, breathing (when 6 or more humans were present), follow-the leader, nuzzling, mouthing, and ventral rubbing decreased as human presence increased.

The primary categories of behavior - maintenance, social, and sexual - were all impacted by human presence. The degree of impact was related to the number of humans. Table 4 illustrates the correlation between the numbers of humans and the frequencies of manatee behaviors.

Displacement Frequencies

Manatees displayed considerable variation in displacement (Table 5). A linear regression was performed to show the relationship of conspecific interactions on displacement (Fig. II). The numbers of manatees present did not affect displacement (p=0.731, r=0.037, DF=1).

Of the 29 manatee displacements, 9 (31%) occurred in the absence of humans and 20 (69%) occurred in the presence of humans. A linear regression was performed to show relationship between number of displacements and the number of interacting humans (Fig. III). Presence of interacting humans was significantly associated to displacement ($p<.001$, $r=.693$, $F=80.241$, $df=1$).

Observations took place in, and displacements began within, the observation area outlined in fig I. Of the 20 manatee displacements recorded involving human interaction, 12 (60%) displaced into the main sanctuary, and 8 (40%) displaced towards foraging areas to the west of the Spring. Manatees that moved <15 m were not recorded as being displaced. Manatees that displaced westerly may have stopped after traveling >15 m. Manatees that displaced remained away from their original position for the remainder of the 30 min observation period. Recorded water temperature in the western foraging area was 18^oC during most of the study.

Environmental Conditions and Activity Cycles

Manatees left the spring area daily from 0900 to 1100. Many were observed feeding on the western side of Banana Island. Manatees returned in the early afternoon. Air and water temperature extremes (5^oC air, 18^oC water) caused congregations at the springs effluent. These observations were consistent with findings of others (Moore, 1956; Hartman, 1971; Powell, 1981; Buckingham, 1990; Rathbun et al, 1990).

Table 1. Behavior frequencies of single and multiple adult manatees expressed as a percentage of the total number of observations. (N=Total number of observations)

Behavior	# Manatees 1	2	3-5	>6
Maintenance Behaviors				
Feeding	10.6	10.2	9.0	0.0
Breathing	16.4	16.9	15.1	36.1
Resting	32.0	17.8	8.3	7.8
Swimming	17.8	18.3	22.5	32.8
Social Behavior				
F-the-Lead	0.2	0.9	7.8	0.0
Flight Behaviors				
Fast swim	0.9	2.5	0.2	0.0
Diving	0.4	1.2	0.5	0.0
Sexual Behaviors				
Vent Rub	0.3	0.8	10.4	1.9
Mouthing	0.8	0.1	0.5	0.0
Nuzzling	2.2	2.2	5.4	11.7
Hugging	0.4	0.4	3.3	5.9
Rolling	3.0	3.0	1.4	1.9
Agonistic Behaviors				
Butting	0.0	0.0	0.0	0.0
Tail Slap	0.1	0.0	0.1	2.9
Interference	0.1	0.0	0.2	0.0
Other	14.9	25.7	15.3	0.0
	N=3848	N=904	N=423	N=68

Table 2. Pearson product-moment correlation between manatee group size and its effect on behavior. (N=5,243)

Behavior	# Manatees 1	2	3-5	>5	P
Maintenance behaviors					
Feeding	0.1	0.1	0.1	0.0	<0.001
Breathing	0.1	0.1	0.0	0.3	<0.001
Resting	0.3	0.1	0.0	0.0	<0.001
Swimming	0.0	0.0	0.1	0.2	<0.001
Social behavior					
Follow-the-Leader	0.0	0.0	0.1	0.0	<0.001
Flight behavior					
Fast Swim	0.0	0.0	0.0	0.0	<0.001
Diving	0.0	0.0	0.0	0.0	<0.001
Sexual behavior					
Ventral Rubbing	-0.2	0.2	-0.1	-0.2	<0.001
Mouthing	0.0	0.0	0.0	0.0	<0.001
Nuzzling	-0.0	0.0	0.3	0.1	<0.001
Hugging	-0.2	0.0	-0.2	-0.1	<0.001
Rolling	-0.0	-0.0	-0.0	-0.0	<0.001
Agonistic behavior					
Butting	0.0	0.0	0.0	0.0	n/a
Tail Slap	0.0	0.0	0.0	0.1	0.1
Interference	0.0	0.0	0.0	0.1	0.7

Table 3. Behavior frequencies of single and multiple adult manatees in the presence of humans expressed as percentages of the total numbers of observations. (N=Total number of observations.)

	# Humans				
Behavior	1	2	3-5	6-9	>9
Maintenance behaviors					
Feeding	18.3	11.8	7.4	0.5	0.0
Breathing	12.1	13.3	12.3	11.9	4.2
Resting	7.4	13.9	15.3	15.0	5.6
Swimming	17.9	22.4	24.8	38.1	34.2
Social behavior					
F-the-Lead	1.8	0.5	0.6	0.0	0.0
Flight behavior					
Fast swim	1.6	1.2	0.8	5.2	5.6
Diving	0.4	1.4	0.9	1.0	1.4
Sexual behavior					
Vent Rub	2.7	0.6	0.3	0.0	0.0
Mouthing	1.1	1.2	1.2	0.0	0.0
Nuzzling	4.2	2.2	0.5	0.0	0.0
Hugging	0.5	1.0	1.2	0.0	0.0
Rolling	2.7	4.4	5.5	4.6	0.0
Agonistic behavior					
Butting	0.0	0.1	0.0	0.0	0.0
Tail Slap	0.0	0.0	0.1	0.0	0.0
Interference	0.0	0.3	0.2	0.0	0.0
	n=552	n=813	n=1025	n=194	n=72

Table 4. Pearson product-moment correlation between the number of humans and frequencies of manatee behavior. (N=Total number of observations.)

Behavior	# Humans 1	2	3-5	6-9	>9	P
Maintenance behaviors						
Feeding	0.1	0.0	-0.4	-0.6	0.0	0.001
Breathing	0.0	-0.4	-0.1	0.0	-0.1	0.002
Resting	-0.2	-0.1	-0.1	-0.1	-0.1	0.001
Swimming	0.0	0.0	0.1	0.1	-0.1	0.002
Social behavior						
F-the-Lead	0.0	0.0	0.0	0.0	0.0	0.003
Flight behavior						
Fast swim	0.0	0.0	0.0	0.1	0.1	0.003
Diving	0.0	0.1	0.0	0.0	0.0	0.003
Sexual behavior						
Vent Rub	0.0	0.0	-0.1	0.0	0.0	0.002
Mouthing	0.0	0.0	0.0	0.0	0.0	0.002
Nuzzling	0.1	0.0	-0.1	0.0	0.0	0.001
Hugging	0.0	0.0	0.0	0.0	0.0	0.001
Rolling	0.0	0.0	0.1	0.0	0.0	0.001
Agonistic behavior						
Butting	0.0	0.0	0.0	0.0	0.0	0.910
Tail Slap	0.0	0.0	0.0	0.0	0.0	0.530
Interference	0.0	0.0	0.0	0.0	0.0	0.610
	n=552	n=813	n=1025	n=194	n=72	

Table 5. Percentage of observation time that the 23 observed focal animals displaced away from interacting humans. (N=Total number of observations).

Manatee	N	Percentage of observation time
1	240	36.3
2	240	64.2
3	240	2.90
4	180	28.3
5	120	0.0
6	120	0.0
7	120	69.2
8	120	0.0
10	300	60.7
11	180	0.0
12	180	32.2
13	120	0.0
14	240	30.8
15	60	0.0
16	240	21.3
17	300	27.7
18	180	23.3
19	240	0.0
20	60	0.0
21	180	43.3
22	60	35.0
24	60	0.0
26	60	0.0

Figure I. Map of the Research Site.

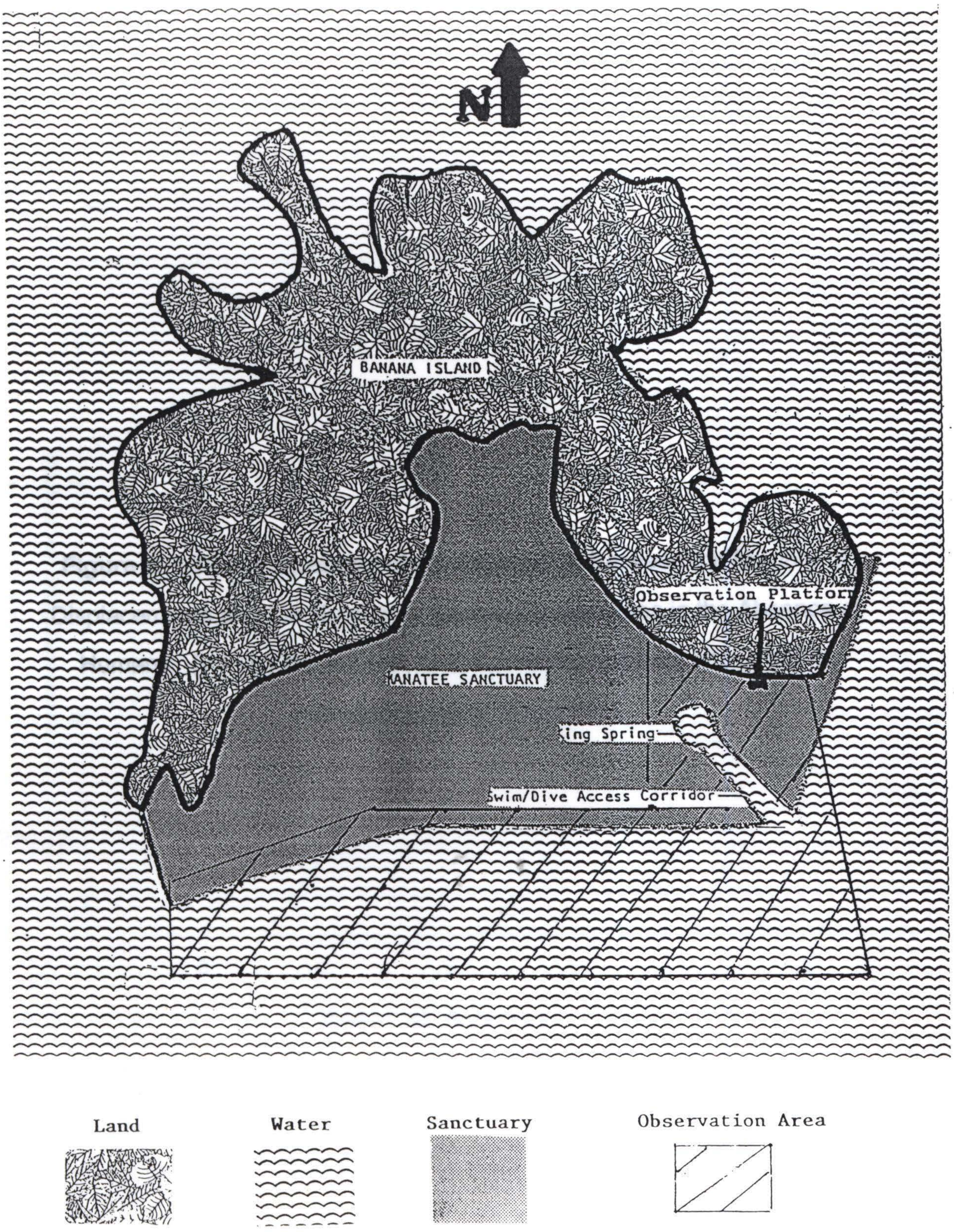

N
BANANA ISLAND
ANATEE SANCTUARY
ing Spring
Observation Platfor
wim/Dive Access Corridor
Land
Water
Sanctuary
Observation Area

Figure II. Linear Regression of the Association Between the Number of Displacements and the Number of Interacting Manatees in the Absence of Humans. (y = 0.001x + 0.445; n=9; C.I.=95%; numbers above points represent number of animals)

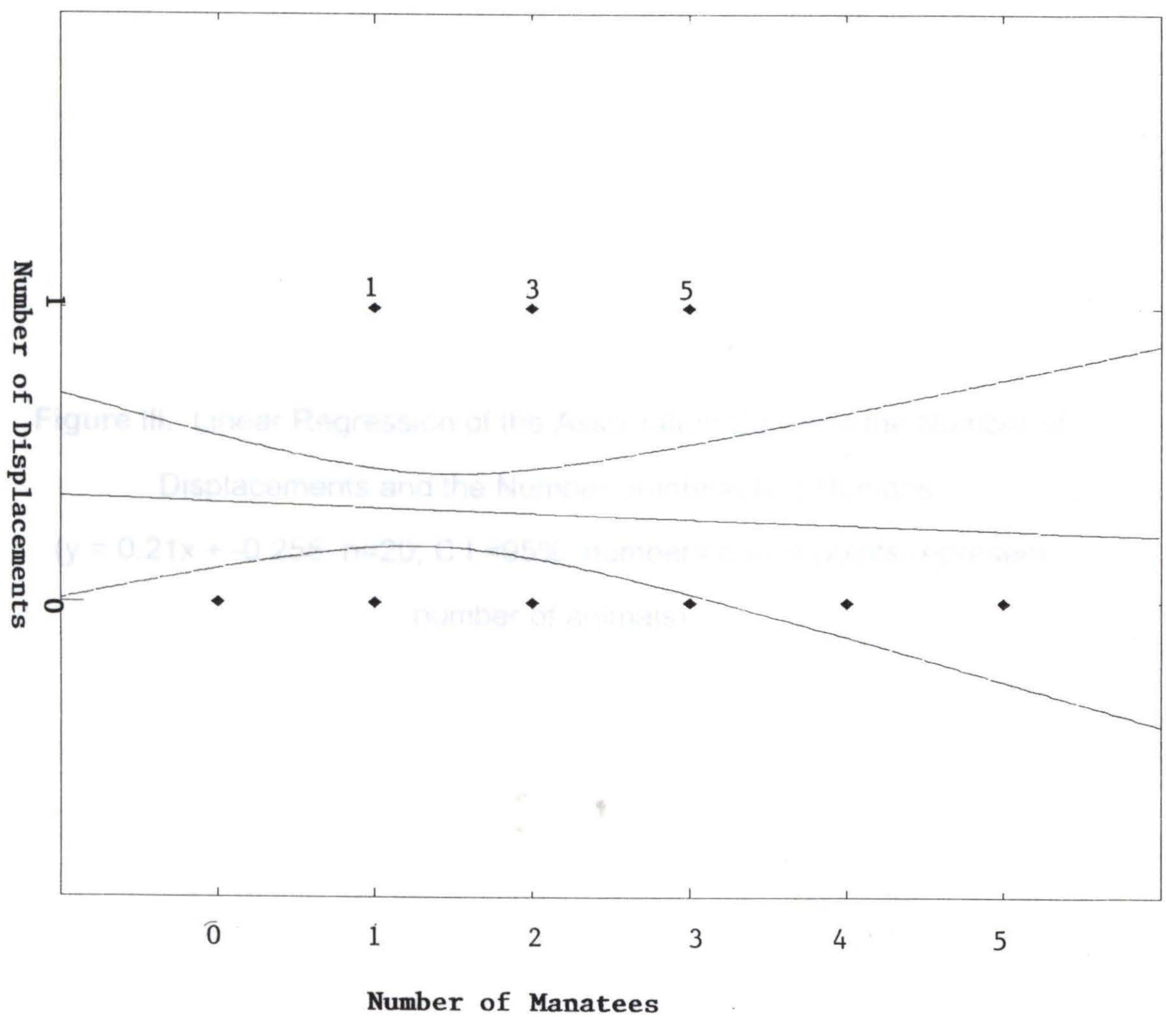
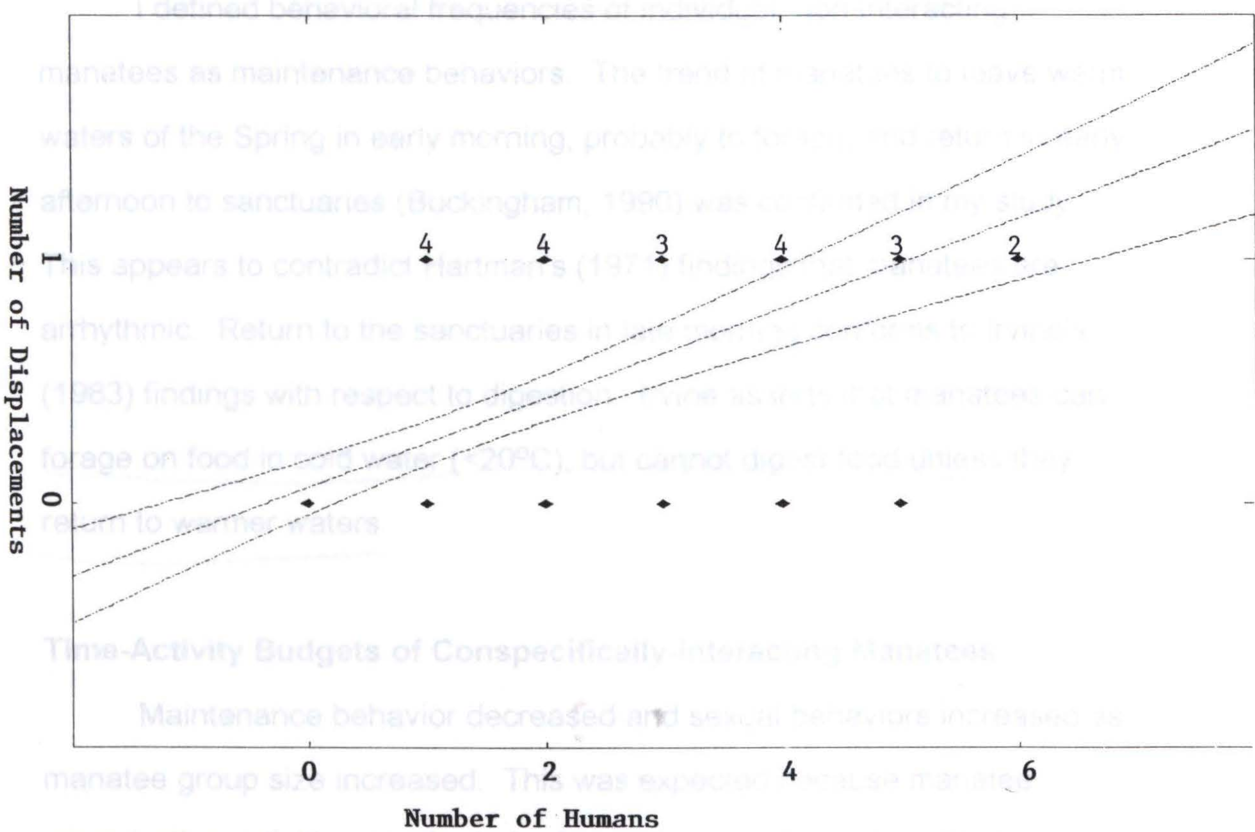

Number of Displacements
1
0
1
3
5
0
1
2
3
4
5
Number of Manatees

Figure III. Linear Regression of the Association Between the Number of Displacements and the Number of Interacting Humans.
(y = 0.21x + -0.255; n=20; C.I.=95%; numbers above points represent number of animals)


Number of Displacements
Number of Humans
0
1
0
2
4
6
4
4
3
4
3
2

Discussion

Non-Interacting Manatee Time-Activity Budgets

I defined behavioral frequencies of individual, non interacting, manatees as maintenance behaviors. The trend of manatees to leave warm waters of the Spring in early morning, probably to forage, and return in early afternoon to sanctuaries (Buckingham, 1990) was confirmed in my study. This appears to contradict Hartman's (1971) findings that manatees are arrhythmic. Return to the sanctuaries in late morning conforms to Irvine's (1983) findings with respect to digestion. Irvine asserts that manatees can forage on food in cold water (<20ºC), but cannot digest food unless they return to warmer waters.

Time-Activity Budgets of Conspecifically-Interacting Manatees

Maintenance behavior decreased and sexual behaviors increased as manatee group size increased. This was expected because manatee reproductive activities are the hub of manatee social structure (Hartman, 1971; Reynolds, 1981a). The only exception was breathing, which increased significantly when manatees were in groups of more than six individuals.

There is evidence that breathing rates in manatees increase during high activity periods (O'Shea et al, 1985b). In this study, groups of six or more manatees were always found in mating herds, or herds of males just separated from a mating herd. Mating herds characteristically increase their activity as males pursue the female and vie for position (Hartman, 1971, 1979). These data are consistent with results reported by Reynolds (1981b).

Swimming, hugging, ventral rubbing, and nuzzling also increased as group size increased. This is consistent with mating herd dynamics. During the precopulation phase of mating, there is considerable physical contact and swimming.

Time-Activity Budgets During Human Interaction

The most striking difference between conspecific and human interactions was resting frequencies. Manatees rested from 8% to 32% of the time in the presence of conspecifics. In the presence of humans, however, they only rested 6% to 15% of the time. This represents a decrease of almost 50%. Buckingham (1990) suggested that presence of boats and human visitors (divers and snorkelers) in the area might increase the manatees' energy needs by causing the animals to move farther away from the Spring to avoid human contact.

Swimming frequencies increased as human presence increased. The data demonstrate a significant positive correlation between human presence and increased manatee activity. This suggests that manatees' energy requirements will also increase. Buckingham (1990) indicated that this was a concern in the Kings Bay population because more foraging means more travel from the warm water spring, which exposes manatees to greater boat traffic and colder waters. In my study manatees foraged in areas to the north and west of Banana Island. Water temperature in this area varied from 18^{o}C - 20^{o}C. This is very close to the thermal tolerance of manatees (Irvine,1983). These temperatures are also below temperature required by manatees for digestion (Irvine, 1983). I have documented considerable use of extended sanctuary zones, especially in late morning when human densities are at a peak. This may be a behavioral response of manatees to reduce their energy requirements, but this behavior results in diminished foraging opportunities. Buckingham (1990) found that night feeding (to avoid humans) appeared to be more frequent in this population. This exposes the manatees to colder water temperatures that exist at night. Irvine (1983) states that avoidance of boat traffic and large numbers of humans may require additional foraging in cold water areas, which would necessitate additional resting time in warm waters. My results support these hypotheses.

All behaviors, except fast swimming and diving (both of which increased), showed dramatic decreases when more than six people were present. Large numbers of people interact with manatees, and these interactions were correlated with changes in manatee behavior. Energy requirements will increase as resting decreases, and flight behaviors increase. As previously mentioned, it is believed that manatees are presently maintaining optimum energy balance, and that higher energy requirements may not be sustainable. This is an indication that management measures need to be developed that will limit the number of people interacting with manatees.

Frequency of Manatee Displacement in the Presence of Humans

Manatee displacement increased in the presence of humans. Displacements occurred when humans intruded while the animal was resting, feeding, or engaged in sexual behavior. Detrimental effects of feeding and resting interruptions were discussed earlier. Interruptions in sexual activities might reduce the reproductive capacity of the population. Manatee displacements in the absence of humans comprised 31% of total observed displacements. This occurred only when females were eluding males, or when males left homosexual interactions. The data demonstrate that normal patterns of behavior are being greatly affected by human presence.

Individual variation was great. This variation confirms similar reports by other researchers (Hartman, 1974; 1979; Buckingham, 1990; Rathbun et al,1990). Nevertheless, several authors have suggested that Crystal River manatees seem to have acclimatized to divers and snorkelers (Hartman, 1974, 1979; Buckingham, 1991; Rathbun et al,1990).

Conclusions

1. Maintenance behavior decreased and socio-sexual behavior increased as manatee group size increased.

2. Manatee activity increased in the presence of humans; resting decreased while swimming increased.

3. Frequency of manatee displacement varied greatly, but was significantly associated with human presence.

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