Manatees, People and Three Sisters Springs

Rae Ellen Syverson and Carl Wolfe

December, 2014 – January, 2015

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Summary

The objectives of this study were to obtain accurate counts of manatees, swimmers, and boaters using Three Sisters Springs during 30 days in December, 2014 and January, 2015 and to analyze this data to gain a better understanding of the interaction of manatees and humans in the Springs.

Three Sisters Springs was open to swimmers and boaters 22 of the 30 days; 8 days were closed due to cold temperatures.

More than 30,800 entries and exits (passages) to the Springs were recorded over the 30-day study period. Manatees made 11,116 or 36% of the passages; swimmers and boaters made up the remaining 19,700 passages.

The results show that manatees' use of the Springs are influenced by tide, water temperature, and time of day.

On six of the study days more than 300 manatees were in the Springs at one time, with a high number of 446. On six additional days more than 150 manatees were in the Springs at one time. On the other end of the spectrum, on three days of the Christmas holidays there were 6 or less manatees in the Springs at one time. The Gulf water temperatures on these holidays ranged from 66°F to 70°F.

Tide height and water temperature are strongly associated with the number of manatees in the Springs. The most manatees in the Springs at one time were seen near sunrise with a high tide and Gulf water temperature 62°F or less.

When high numbers of manatees are in the Springs the water becomes opaque and visibility may be reduced to less than 20". Opaque water is caused by sediment stirred up from the bottom of the Springs and from dispersed manatee fecal material.

Tide and temperature influences appear to play a much larger role in manatee usage of the Springs than the presence or absence of swimmers or paddlecraft. However, manatees may be slow to return to the Springs on a rising tide when high numbers of paddlecraft and swimmers are present.

When few manatees are present, and the number of boaters and swimmers are high, the number of adverse interactions increases. Manatees usually do not leave the springs when stressed by swimmers, although they may move to another area.

Tour groups of swimmers accompanied by boat captains exhibit better behavior than unaccompanied groups.

Holidays can be equated to unregulated chaos in Three Sisters Springs under current operating policy. On December 27, 2014 two thousand two hundred fifty eight (2,258) human passages were recorded, or one passage every 15.9 seconds. The maximum number of manatees in the Springs at one time this day was 20 at sunrise.

High numbers of swimmers and boaters degrade the experience for all visitors, both those in water and those viewing from the boardwalk.

Swimmers spent an average of 33 minutes in the Springs; boaters spent an average of 23 minutes in the Springs.

The Springs Run, the only water entrance to the Springs, is a frequent source of congestion with swimmers blocking the channel by swimming abreast up the channel or walking in at low tide, frequent boat jams, and a high rate of concurrent manatee, paddlecraft and swimmer passages.

In the course of the study, 5,235 manatee passages were recorded on the days the Springs were open. Of these passages, 1,942 were concurrent with one or more human passages. In other words, manatees had to swim in or out with humans 37% of the time when they sought the warmth of the Springs or when they left the Springs to feed or to avoid a low tide.

The significant number of turnarounds, and observations of manatee behavior in the absence of humans suggest that manatees exhibit different, more active behaviors when no humans are present in the waters of Three Sisters Springs

Opening the boardwalk to visitors in November, 2014 changed the economic and manatee watching paradigm. Many more people were able to view the manatees and enjoy the phenomenon that is Three Sisters Springs. Boardwalk visitors appreciate and praise the volunteer interpreters provided by Crystal River NWR.

Boardwalk visitors comment vociferously on apparent harassment and perceived rule violations by swimmers and boaters.

Three Sisters Springs has an intricate ecosystem that includes a diverse fish population, turtles, blue crabs, and a host of water birds. All of this is visible from the boardwalk. A variety of birds and flora can be seen in adjacent tree and shrub habitat. Bird songs and breathing manatees frequently fill the air with sound. This is a remarkable urban location, with abundant natural experiences available to those who choose to look at and beyond the manatees.

The aesthetics of Three Sisters Springs should guide an integrated process of addressing the holistic management needs of the Springs. The preservation and protection of these aesthetic qualities should become a priority objective for future management complementing the preservation and protection of the endangered manatee.

Introduction and Background

Three Sisters Springs is a beautiful, natural, three-lobed complex of springs, sand boils and vents. The Springs comprise about 1.5 acres and are located on 57 acres in the city of Crystal River, Florida. The clear blue water and surrounding vegetation provide an increasingly rare habitat in an area that is rapidly shifting in geographic and natural diversity. It is the only confined body of water in the United States that is open to swimmers and boaters when manatees are present.

Aerial photos from 1944 showed forested wetlands surrounding a group of springs which discharged to Kings Bay through a long, non-navigable, heavily wooded, shallow, braided and poorly defined spring run. Longtime residents recall swimming in the Springs as a favorite pastime in the early 1950's. In the 1960's, a man-made canal was constructed to allow navigable access to the Springs. Large pipes were placed in the entrance to the Springs in 1982 to restrict larger boats from entering and the Springs Run was lined with boulders. Many of these boulders were removed after 2010 when Crystal River NWR assumed management responsibility for Three Sisters Springs.

Just outside and adjacent to the channel from the Springs are several more artesian springs that are roped off specifically for manatee use and called the Sanctuary or Idiot's Delight. The Springs discharge into a dredged, residential canal which leads into Kings Bay, and eventually to the Crystal River. Crystal River flows to the Gulf of Mexico.

In the 1980's a large borrow pond was excavated near the middle of the 57 acres forming Lake Lynda . Fill was used to raise the surrounding ground elevation in preparation for development. Over the years most of the trees and other vegetation were removed from the site. At this juncture, community concern for the long-term well-being of the Springs emerged. In 2008, The Friends of Crystal River National Wildlife Refuge began efforts to save TSS from development. Through a successful partnership of state, federal and local entities, the Springs were purchased in 2010 for 10.5 million dollars. While the Springs are owned by the City of Crystal River and the Southwest Florida Water Management District, the U.S. Fish and Wildlife Service under lease agreement with the city, manages Three Sisters Springs as part of the Crystal River NWR.

A boardwalk, constructed in 2011, follows the lobes of the Springs on three sides. A concessionaire was selected after a competitive bid and the boardwalk was opened to the public in November, 2014.

Three Sisters Springs, as part of the complex of some 70 warm springs in Kings Bay, serves as one of the most important natural shelters for the Florida manatee during cold weather events. The Springs maintain a constant temperature between 72°F and 74°F degrees and are considered among the highest priority winter thermal retreats for manatees throughout its range.

Manatee use of Kings Bay has been shown to have increased since the first aerial surveys in 1967. In 1968, only 38 manatees were noted in Kings Bay. By 1988, populations totaled 158. By 2013, some 560 manatees were counted in the Bay (1). An estimated 300 manatees were observed using the warm spring waters during a cold water closure in January, 2014 (2). Because heavy tree canopy surrounds Three Sisters Springs, accurate aerial counts have not been possible within the Springs.

As we would find in this study, estimates of manatee numbers in the Springs could not be considered accurate unless they were made under low tide conditions with good visibility. Counts made during mid-to-high tides conditions were considered unreliable, and near certain to underestimate the number of manatees. No prior attempts had been made to accurately count the manatees entering and leaving the Springs since the boulders blocking the Springs Run were removed in 2010.

The objectives of this study were to obtain accurate counts of manatees, swimmers, and boaters using Three Sisters Springs during 30 days in December, 2014 and January, 2015 and to analyze this data to gain a better understanding of the interaction of manatees and humans in the Springs.

Materials and Methods

The Study Area and Data Collection

For this study, observations were made at the mouth of the Springs Run where the outflow enters the adjacent residential canal. Observations were made from a point on the boardwalk adjacent to the large pipes from sunrise to sunset. The data collection team consisted of 4 volunteers, 5 Fish and Wildlife Service interns and a high school student on an internship (see Acknowledgements).

A data collection sheet was developed for recording passages through the Springs Run (Appendix I). The time and number of manatees, swimmers, and boats passing through the pipes was recorded, both for entry and exit of the Springs. Boats were noted as kayak, canoe, or paddleboard. Boats are referred to as paddlecraft throughout this report, while the people using the paddlecraft are referred to as boaters. An environmental data sheet was also developed to record ambient air temperature and temperature of the Springs at the mouth of the Springs and in each of the three lobes (Appendix 1). Tide height was recorded on the environmental data sheet every 30 minutes at the pipes. Data was collected on 30 days from December 10, 2014 to January 31, 2015.

In order to understand the variety of human interactions with manatees, the data collection schedule took into consideration weekdays, weekend days, and holidays. It is known that manatees enter and leave the Springs as the tide rises and falls. With the above considerations in mind, thirty sampling days were selected over a seven and a half week period to encompass a full lunar cycle.

The number of manatee present in the Springs was initially recorded every two hours. When it was noted that the most accurate count of the manatees in the Springs could be obtained at low tide, emphasis was placed on obtaining accurate low tide counts and counts at other times were made at the discretion of the observer.

Water temperatures in the Gulf of Mexico at Shell Island (near the mouth of Crystal River) and the mouth of Kings Bay were obtained from the USGS National Water Information System website. The data and web addresses for these sites are noted in Appendix II. Weather conditions were noted by the observers on the environmental data page and wind strength and direction were obtained from the Intellicast website for Crystal River.

Water temperature in the lobes of Three Sisters Springs (Springs) was measured using a standard Taylor pool thermometer attached to a spinning rod. The rod enabled the temperature to be taken from the boardwalk. Ambient air temperature was recorded from a standard outdoor thermometer placed at the end of the boardwalk adjacent to the exit from the Springs Run. Tide height was measured in inches using metal yard sticks. The first yard stick was placed on the bottom of the Run and attached to a 3" PVC pipe with zip ties. The 3" pipe was permanently attached to a second 8" piling visible from the boardwalk. The second yardstick was place on top of the first and attached in a similar manner. This enabled tide height to be measured over a 72" range. Two portable storage clipboards , a digital clock, binoculars, and a stool completed the field equipment used in the study. Two three-ring binders were used for storage of the completed original data sheets, and a backup copy. The data was also stored electronically with Microsoft Excel on multiple hard drive devices.

Data Handling

The raw data was entered into Excel spreadsheets using a format similar to the field data collection sheets. Data from each day of the study was collated and graphed. Daily observations were separated into thirty-minute intervals and the number of boats, swimmers, and manatees determined for each time interval. The number of manatee passages (a passage is one pass through the pipes) and the number of swimmer and boat passages was also determined.

The number of manatees was calculated from the count at low tide. On 19 days during this study no manatees were in the Springs at low tide. On nine additional days there were less than 10 manatees in the Springs at low tide. and on 2 colder days there were more than 10 manatees in the Springs at low tide. By adding and subtracting the manatees entering and leaving the Springs, the number of manatees in the Springs at any time was calculated. From these calculations we determined the maximum number of manatees in the springs at one time.

To determine the number of concurrent passages, that is, a manatee passage through the Springs Run at the same time as a boat or swimmer passage, we used the criteria shown in Table I.

To evaluate the frequently observed phenomenon when a manatee enters the Springs Run and turns and exits the Springs Run in a minute or less we defined a "turnaround" as one or more manatees entering the Springs Run channel through the pipes and then turning and exiting the Springs back through the pipes within one minute. More information on this analysis is in the Results section.

Table I. Criteria for determining a concurrent passage

A concurrent passage when a manatee swims in is defined as:

- Swimmer(s) swims in 1' earlier or at the same minute
- Swimmer(s) swims out 1' later or at the same minute
- Boater(s) paddles in 1' later or at the same minute
- Boater(s) paddles out at the same minute

A concurrent passage when a manatee swims out is defined as:

- Swimmer(s) swims in 1' earlier or at the same minute
- Swimmer(s) swims out 1' later or at the same minute
- Boater(s) paddles in 1' later earlier or at the same minute
- Boater(s) paddles out at the same minute

The length of stay of swimmers and boaters in the Springs was calculated from the entry and exit times recorded on the data collection sheets. Standard statistical tests were used as appropriate.

Manatee and human usage of Three Sisters Springs were recorded for 10 weekdays (non-holidays), 9 weekend days (non-holidays), and 11 holidays for a total of 30 days. The study was designed to include holidays as these are the days when the Springs get the most usage by swimmers and boaters. The Springs were closed due to cold temperature on 8 study days and closed until 10:00 AM on two additional days.

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the U.S. Fish and Wildlife Service.

Results

The data collectors recorded more than 31,000 passages (manatees, swimmers, and boaters) through the Springs Run. On the busiest day this usage equated to one passage every 15.4 seconds or one human passage every 15.9 seconds.

Tide height and water temperature in the Gulf were strongly associated with the number of manatees in the Springs. Tide height and lunar cycle for each day of the study are shown in Appendix III. Water temperature in the Springs was monitored daily and was consistently between 72°F and 74°F. The water temperature at the exit of the Springs Run was 71°F to 74°F eighty-six percent of the time. On four days the temperature was less than or equal to 70°F with a low reading of 67°F.

The rise and fall of the tide for each day is shown on the graphs and charts in Appendix IV. Tide height ranged from a low of 19 inches on January 7th to over 80" on January 24th. January 24th was the stormiest day of the study with 2.06 inches of rain on January 23rd and 24th and winds gusting to 37 mph from the west.

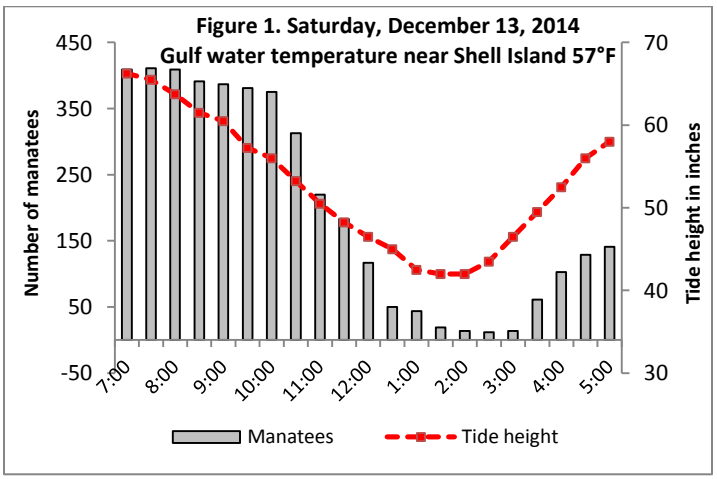


Figure 1 shows the distribution of manatees and tide height for Saturday, December 13, 2014 and is a typical pattern for the days with a high tide near sunrise and cold water temperatures.

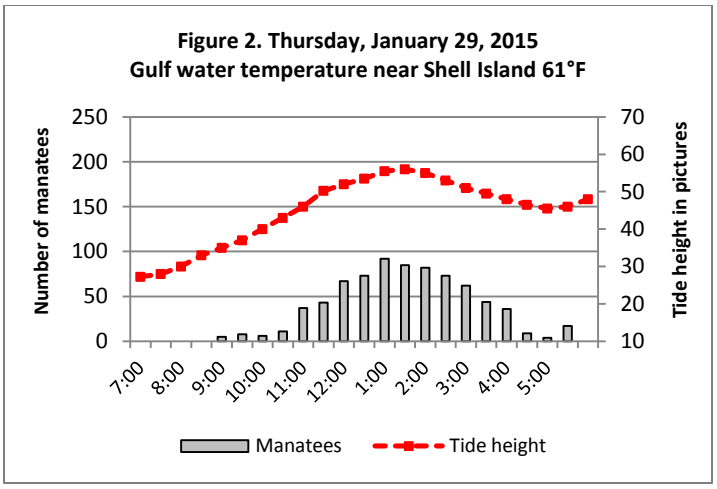
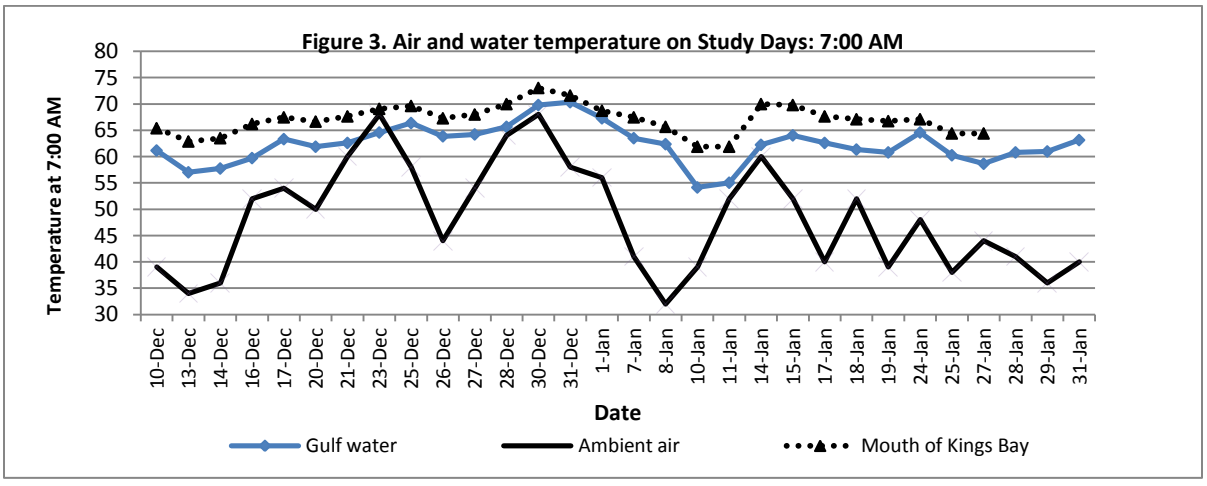


Figure 2 shows the distribution of manatees and tide height for Thursday, January 29, 2015 and is a typical pattern for the days with a high tide during the day and cold water temperatures.

Manatees leave the Springs on a falling tide and return on a rising tide. Appendix V shows the low tide height and the number of manatees in the Springs for those 18 days when all manatees left the Springs. On January 31st when the Gulf water temperature was 63°F, one manatee remained in the Springs at a low tide of 27 inches. This was the lowest tide that a manatee was seen in the Springs. When the Gulf water temperature was 65°F or higher all the manatees left the springs when the tide height was as high as 46 inches.

Water temperatures at Shell Island near the mouth of Crystal River varied from a high of 71.4°F at 5:00 PM on December 30, 2014 to a low of 54.1°F at 7:00 AM on January 10, 2015. At the mouth of Kings Bay the temperature varied from a high of 73.8°F at 5:00 PM on December 30, 2014 to a low of 61.9°F at 7:00 AM on January 11, 2015. Ambient air temperature varied from a high of 70°F on December 25, 2014 to a low of 30°F at 7:00 AM on January 14, 2015. Figure 3 shows that ambient air temperature changes precede changes in the water temperatures.



A look at water temperature on the days when high tide was near 7:00 AM shows that as the water temperature decreased from 70°F to 54°F, the number of manatees in the Springs increased (Figure 4). Of the two temperature measures, the number of manatees most closely follows the water temperature in the Gulf at Shell Island.

Figure 4. Comparison of tide height, temperature, and number of manatees

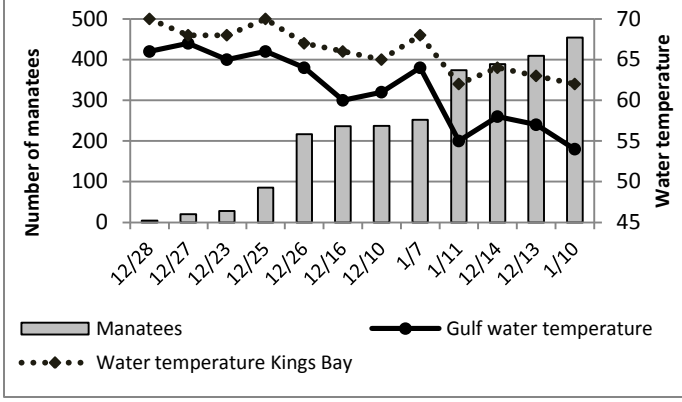
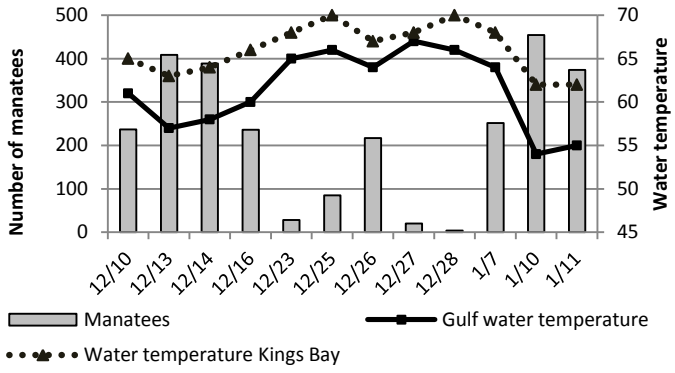
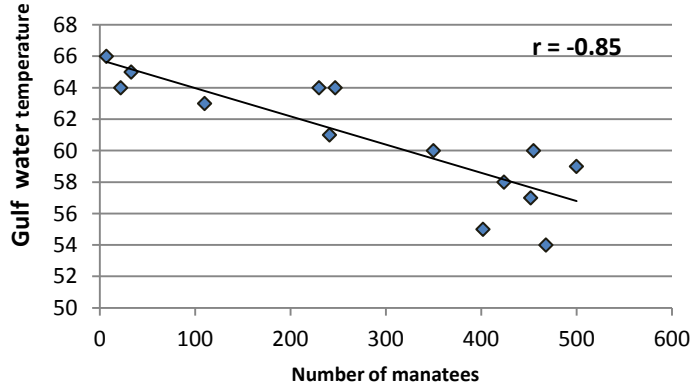


Figure 5. Manatees, Water Temperature, and High Tide at 7:00 AM



The same data arranged sequentially (Figure 5), shows that as the air and water temperatures warmed over Christmas week, the number of manatees in the Springs at 7:00 AM (high tide on all these days) decreased. When the Gulf water temperature was near 66°F few manatees were in the Springs. When the temperature decreased to 54°F on January 10th, the number of manatees in the Springs at sunrise was highest.

Figure 6. Gulf Temperature, Manatees and High Tide near Sunrise



A strong correlation (r=-0.85) exists between the number of manatees in the Springs at 7:00 AM on days with a high tide at the same time and the Gulf water temperature near Shell Island. When the water temperature was 60°F or lower, the manatee numbers in the Springs exceeded 300 at sunrise.

Does the time of day influence the number of manatees in the Springs?

On the days when high tide was late morning or in the afternoon, fewer manatees entered the Springs at high tide when compared to the manatees found in the Springs at similar temperature and a high tide first thing in the morning. For example, see December 17, 2014, January 14th and 15th, 2015 in Appendix IV.

Figure 7

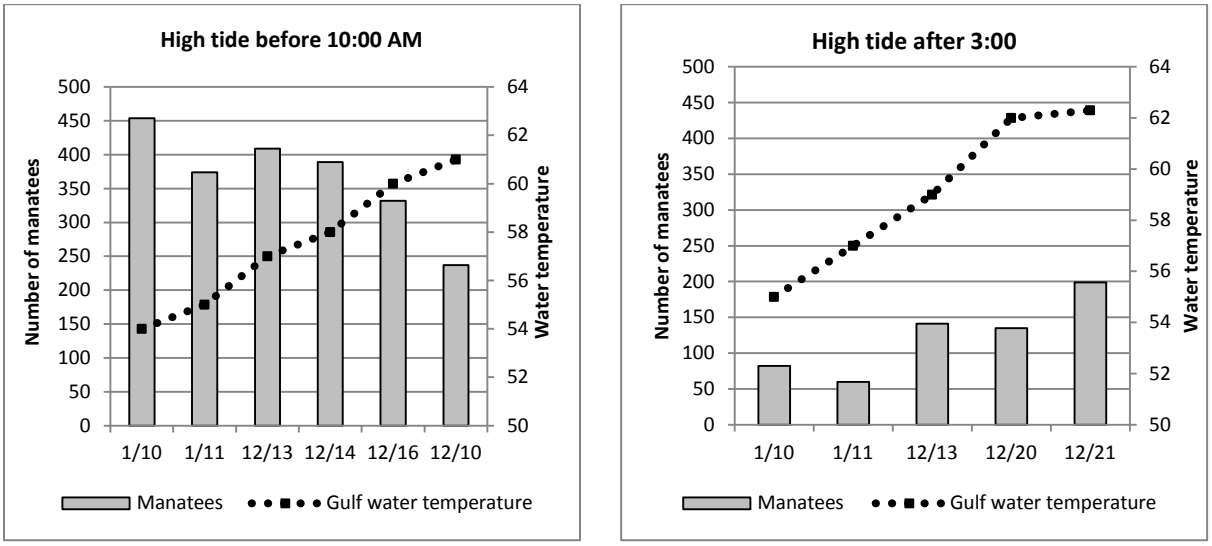
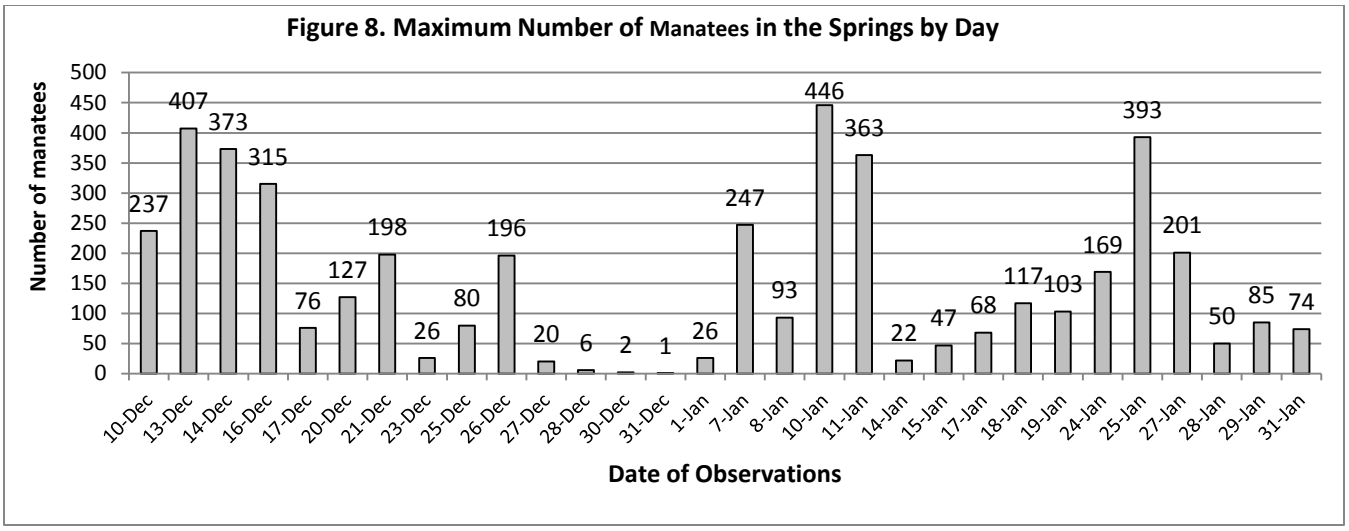


Figure 7 compares the number of manatees in the Springs at comparable temperatures and tide heights (not shown) with the difference that the graph on the left shows days with a high tide before 10:00 AM and the graph on the right shows days with a high tide after 3:00 PM. Some days, like December 10th, had two high tides, one at sunrise, and the other near sunset.

The number of manatees in the Springs on days with a water temperature $\leq$62°F exceeded previously estimated numbers. Figure 8 shows the maximum number of manatees in the Springs at any one time. High numbers of manatees in the Springs were associated with reduced visibility in the water due to sediment stirred up from the bottom of the Springs and dispersed fecal matter. At times horizontal and vertical visibility was reduced to less than 20 inches (3). At sunrise, on dark mornings, it was difficult to see the bottom of the Springs Run at the pipes; manatees entering and exiting the Springs at this time may have been undercounted. The number of manatees in the Springs at one time surpassed 150 on 12 study days. On six of those days the number exceeded 300. These numbers were much higher than the number seen in previous years and 446 manatees in the Springs the morning of January 10, 2015 was a record for Three Sisters Springs.



People entering the Springs by water included swimmers and boaters. The Springs were open 22 of the 30 days in the study. Swimmers totaled 7,385 and boaters 3,867 during the 22 open days. The maximum number of people on one day was 1,252 on December 27, 2014. While 3,867 people viewed manatees in the Springs from boats, only 2,924 paddlecraft entered the Springs. Nine hundred forty-three of the boaters were in boats with more than one person.

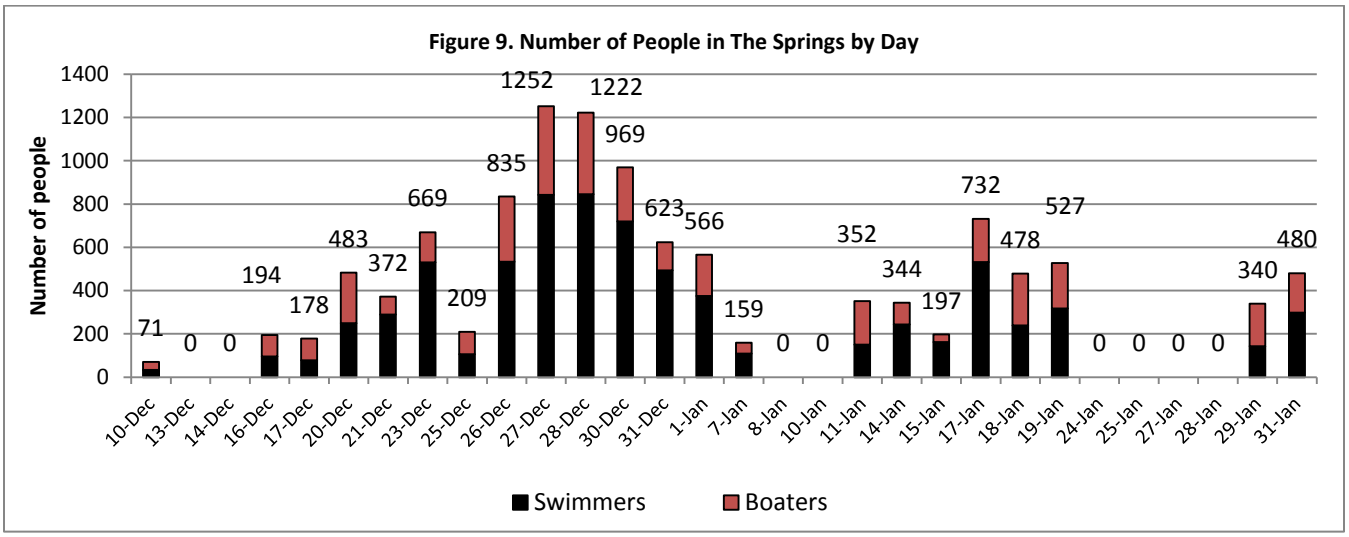
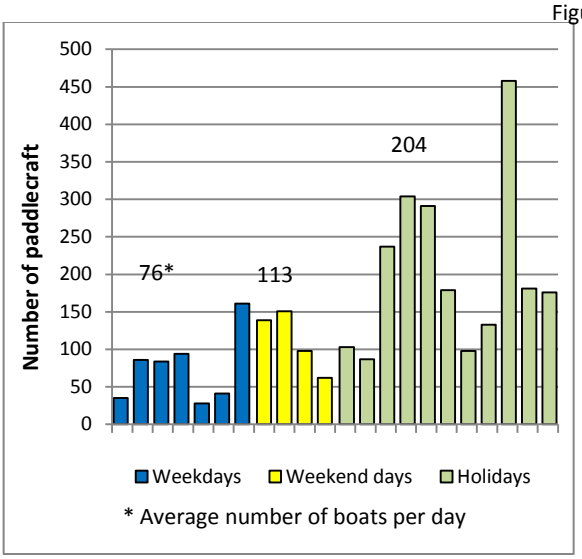
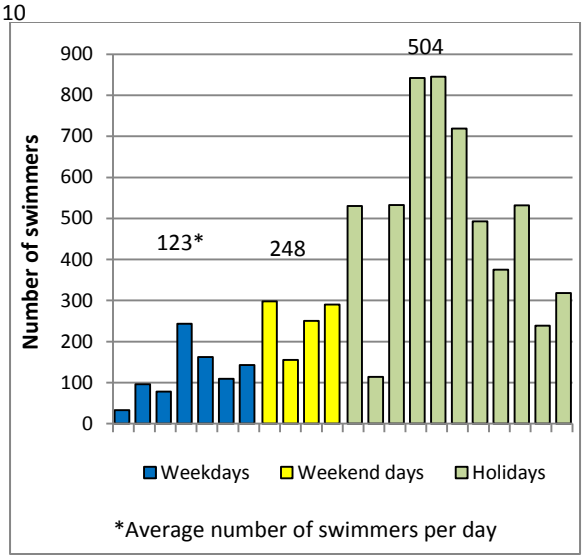


Figure 10 shows the number of paddlecraft and swimmers per day. On weekdays there was an average of 76 paddlecraft entering per day. This number doubled on weekend days and doubled again on holidays. The number of swimmers showed a similar progression from weekdays (123) to weekend days (248) to holidays (504).

Figure 10





What is the effect of paddlecraft on manatees?

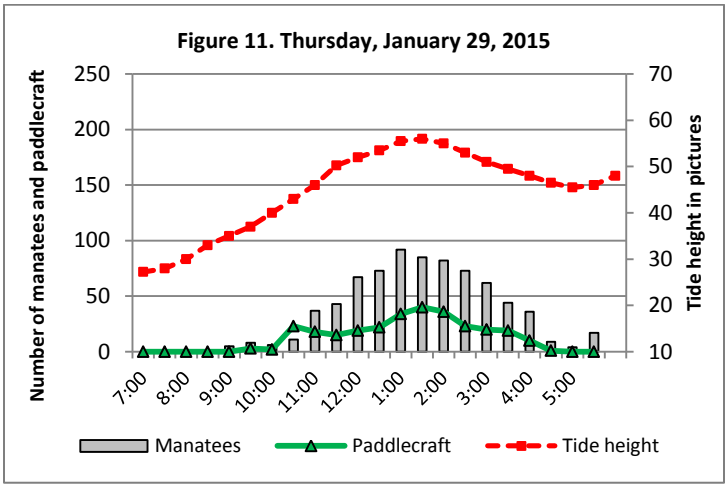


Figure 11 is the graph of the same day as shown in Figure 2 (relationship of manatees returning to the Springs on a rising tide). In Figure 11 the number and distribution of paddlecraft in the Springs is shown. Incoming paddlecraft appear to have little effect on the number of manatees during each half hour time interval. A review of the 22 days the Springs were open shows little effect of paddlecraft on the number of manatees in the Springs.

What is the effect of swimmers on manatees?

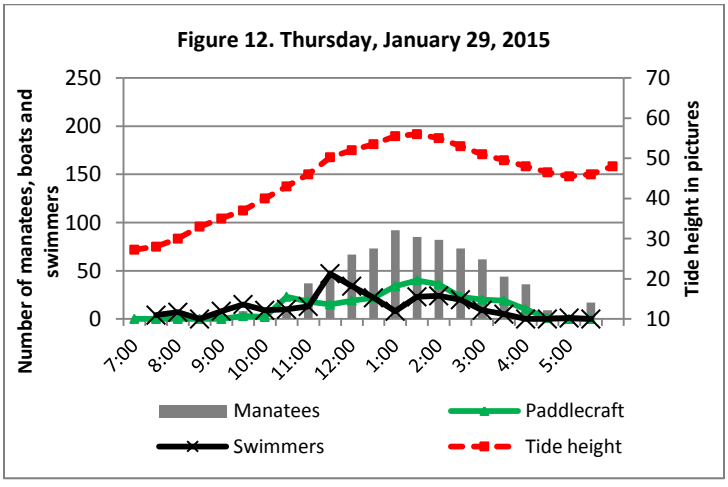
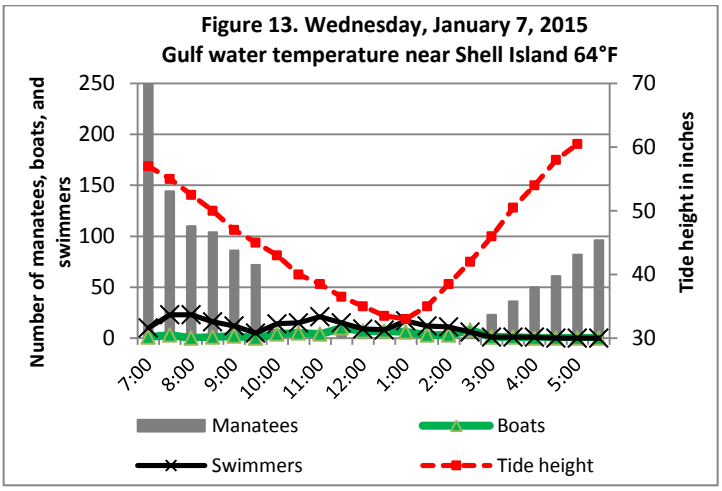


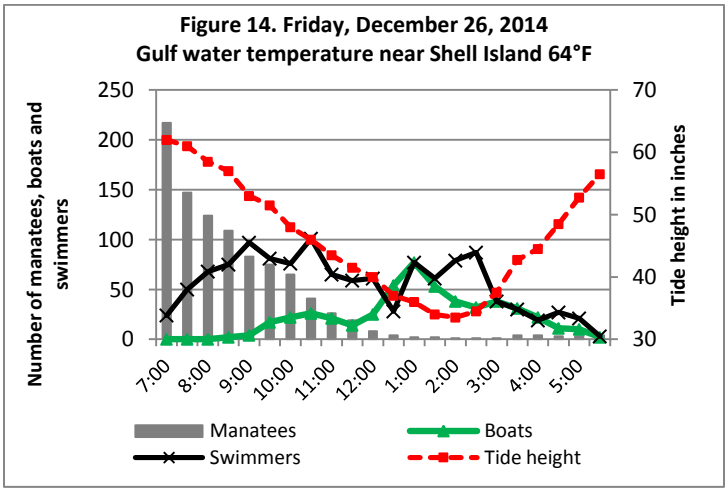
Figure 12 shows the same day as Figure 2 and includes the swimmers in the Springs on this day. As with the paddlecraft, the swimmers appear to have little effect on the number of manatees, even when there is a peak of swimmers around 11:30 AM. A review of the other open days, with the possible exception of the busier Christmas holidays, shows similar results.

Throughout the study we noted that manatees usually did not leave the Springs when crowded by swimmers, although they may move to another lobe. Disturbance of the manatees by swimmers, such as pursuing and surrounding, was frequently observed. However, positive manatee and swimmer interaction was also observed. In general, accompanied groups of swimmers showed better behavior than unaccompanied groups.

During the holidays, congestion and crowd control seemed to play a more important role than swimming or boating with the manatees. The air and water temperatures warmed the last week of December and few to no manatees were in the springs. The greatest use of the Springs by humans was during this time period.

Figure 13, January 7, 2015 is shown for a comparison to Figure 14, December 26, 2014. On both days the Gulf water temperature was 64°F and the tide pattern and height is similar.





One hundred nine swimmers and forty one paddlecraft visited the Springs on January 7th. In contrast, 533 swimmers and 237 paddlecraft visited the Springs on December 26th.

On January 7th manatees returned to the Springs on the afternoon rising tide. On December 26th, few manatees returned to the Springs on the afternoon rising tide following a day with high numbers of swimmers and paddlecraft.

The Springs Run

The Springs Run, the manmade channel between the Springs and the residential canal, is the only access to the Springs for manatees, paddlecraft, and swimmers wanting to swim with the manatees in the Springs. The amount of usage of the Springs Run had not been previously documented. General guidelines for usage of the Springs suggest that swimmers stay to the right and swim, rather than walk into the Springs.

In this study passages through the Springs Run pipes were recorded for each manatee, swimmer, and boater. A passage was recorded when the pipes were completely passed in either direction. The direction (into or out of the Springs) and time of passage was noted.

The total number of passages per day is shown in Table 2. The number of passages ranged from 507 to 2,278 on days the Springs were open and from 105 to 1,144 on the days the Springs were closed due to weather conditions. The days with most passages recorded were holidays and holiday weekends. On December 27, 2014 two thousand two hundred seventy-eight passages were recorded, or one passage every 15.8 seconds.

The number of manatee passages ranged from 3 to 475 on days the Springs were open and from 105 to 1,144 the days the Springs were closed. The most manatee passages (1,144) were recorded on Tuesday, January 27, 2015. On this day low tide was 45" in height, the water temperature at the mouth of Kings Bay ranged from 64°F to 67°F between 7:00 AM and 5:00 PM and the wind blew out of the west at 15 miles per hour. Ambient air temperature was 44°F at 7:00 AM and climbed to 65°F during the day. The reason for the high number of passages is unknown but may be related to the flat tide. On this day, the minimum number of manatees in the Springs at one time was estimated to be 45 and the maximum number at one time 201.

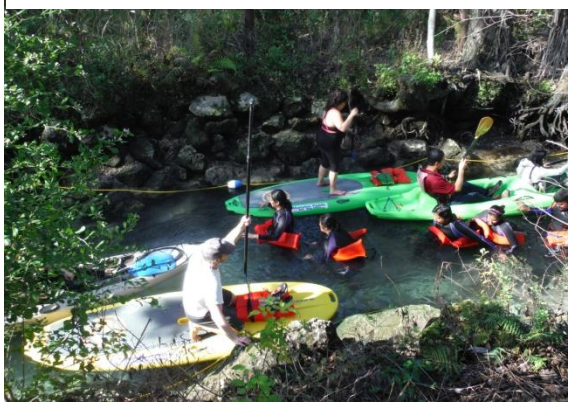
With the high number of passages of manatees, swimmers, and boaters it was not unexpected that many of the passages were concurrent. Numerous photographs verify the conflicts occurring during concurrent passages.

Table 2

Date	All passages	Manatee passages
Days Springs open		
10-Dec	507	370
17-Dec	650	326
20-Dec	1171	475
21-Dec	1084	380
23-Dec	1347	135
25-Dec	585	185
26-Dec	1830	290
27-Dec	1215	33
28-Dec	2278	10
30-Dec	1799	3
31-Dec	1186	4
1-Jan	1090	74
7-Jan	700	400
14-Jan	741	70
15-Jan	509	173
17-Jan	1600	220
18-Jan	1195	355
19-Jan	1267	279
29-Jan	692	334
31-Jan	1129	255
Days Springs closed		
24-Jan	619	619
25-Jan	820	820
27-Jan	1144	1144
28-Jan	356	356
8-Jan	105	105
10-Jan	661	661
13-Dec	714	714
14-Dec	711	711
Days Springs opened at 10:00 AM		
16-Dec	1334	970
11-Jan	1278	649

Data collectors noted many instances when there were multiple boat jams in the Springs Run and numerous swimmers proceeding abreast in the Run at the same time either by swimming or walking (at low tide). The Springs Run is the only way the manatees can reach the warm waters of Three Sisters Springs.

- Swimmers and boaters in and out of the water in the entrance to the Springs Run (pipes area) blocking any manatees from entering or exiting.



Swimmers from a tour group walk their way through boat traffic entering the Springs Run, occupying the entire channel.

Swimmers and kayakers watch and pass over entering manatees. The rear paddler on the right is totally unaware of the manatee.

To gain some perspective on frequency of concurrent passages we posed this question: How many times did humans and manatees encounter one another in the Springs Run?

The criteria for determining a concurrent passage is shown in Table I in the Data Handling Section. The number of concurrent passages ranged from 2 to 254 on days the Springs were open including the two days the Springs opened at 10:00 AM (Table 3). This represented 11% to 100% of the manatees entering or leaving the Springs Run depending on the day.

In the course of the entire study, 5,235 manatee passages were recorded during the hours the Springs were open. Of these passages, 1,942 were concurrent with one or more human passages. In other words, manatees had to swim in or out with humans 37% of the time when they sought the warmth of the Springs or when they left the Springs to feed or to avoid a low tide.

Table 3. The total number of concurrent passages per day.

Date	All passages	Manatee passages	Concurrent passages	Percent concurrent
Days Springs open				
10-Dec	507	370	42	11%
17-Dec	650	326	90	28%
20-Dec	1171	475	176	37%
21-Dec	1084	380	87	23%
23-Dec	1347	135	71	53%
25-Dec	585	185	46	25%
26-Dec	1830	290	94	32%
27-Dec	1215	33	18	55%
28-Dec	2278	10	7	70%
30-Dec	1799	3	2	67%
31-Dec	1186	4	4	100%
1-Jan	1090	74	36	49%
7-Jan	700	400	23	6%
14-Jan	741	70	28	40%
15-Jan	509	173	52	30%
17-Jan	1600	220	177	80%
18-Jan	1195	355	219	62%
19-Jan	1267	279	141	51%
29-Jan	692	334	143	43%
31-Jan	1129	255	133	52%
Days Springs opened at 10:00 AM				
16-Dec	1334	571*	254	44%
11-Jan	1278	293*	99	34%

*manatee passages after Springs opened at 10:00 AM

Another question which begged answers was: How often do concurrent passages lead to a turnaround of the manatee(s)?

In the initial days of watching and recording data at the pipes we identified a problem we felt was associated with the presence of swimmers and boaters in the Springs Run: manatees, which entered the Run only to turn around and come back out, apparently due to contact with humans. When we looked at this in more detail we realized that observation alone was insufficient to document turnarounds due to inadequate staffing to follow each manatee through the Springs Run until it entered the Springs.

An initial attempt to document turnarounds on the written data sheets showed that real time documentation was time consuming and interfered with accurate data collection. We also noted that "turnarounds" occurred both in the presence and absence of humans.

In order to look more closely at the turnaround phenomenon we defined a turnaround as *one or more manatees entering into the Springs Run channel through the pipes and then turning and exiting the Springs back through the pipes within one minute.* A turnaround associated with humans met the following criteria:

- More than one swimmer enters the Springs Run heading into the Springs one minute earlier or during the same minute the manatee(s) enters the Run heading into the Springs
- More than one swimmer exits the Springs and the Springs Run at the same minute or one minute later than the manatee exits
- Three or more boats enter the Springs Run heading into the Springs during the same minute as the manatee enters the Springs Run heading into the Springs
- More than one boat exits the Springs and Springs Run at the same minute the manatee exits the Springs and the Springs Run, or
- A combination of the above four stipulations.

Twenty-two study days when the Springs were open were examined for human manatee interactions resulting in a turnaround of a manatee. Seventy-nine turnarounds affecting 98 manatees appear to be directly related to human/manatee interactions in the Springs Run. For example, on Dec 20 one manatee entering the Springs Run met 8 swimmers coming out of the Springs. The manatee turned and exited the same minute. Later the same day, four manatees entered the Springs Run and were met by 5 swimmers coming out. All four manatees turned and exited. On January 19th, four manatees entered the Springs Run and ran into 7 kayaks exiting the Springs Run. One of the four manatees turned and exited the Springs Run.

The number of turnaround incidents associated with people ranged from 1 to 10 per day. The number of manatees turned in one incident was usually one, but ranged from 1 to 5. The percentage of manatees turned by swimmers and boaters was calculated as a percentage of the manatees swimming in that same day. One to 10.4% of the manatees swimming in were turned by people. Four open days were excluded from this analysis because the number of manatees swimming in was less than 15 and no manatees turned around resulting in no meaningful data.

This data demonstrates that the presence of swimmers and boaters in the Springs Run has an effect on manatees seeking to enter the Springs via the only channel into the Springs. While the numbers of manatees turned back is small, the manatees do enter the Springs for warmth essential to survival.

Analysis of the data for the 18 open days considered above showed that there were more turnarounds in the absence of humans than in the presence of humans. Consequently we analyzed the raw data for 7 additional days when the Springs were not open to the public due to cold weather. One closed day was excluded for the same reason indicated above, only 6 manatees swam in that day. The two days that the Springs opened at 10:00 AM were divided into before and after opening and analyzed accordingly.

Table 4. Manatee turnaround one minute after entering the Springs Run to the Springs.

Springs open (18 days)	No people involved in turnaround	People involved in turnaround
Manatees swimming in (2,321)		
Turnaround incidents	238	79
Number of manatees involved	338	98
Number of manatees turning around as percent of manatees swimming in	14.6%	4.2%
Springs closed (7 days)		
Manatees swimming in (2,139)		
Turnaround incidents	400	None
Number of manatees involved	595	None
Number of manatees turning around as percent of manatees swimming in	33.3%	None

Table 4 shows that there were more turnarounds on the days the Springs were closed. If we exclude the turnarounds caused by people on open days, $P < 0.0007$. (If we compare all the turnarounds on open days to those on closed days, $P < 0.01$). In either case, manatees are significantly more active on days the Springs are closed to humans.

Are the manatees more active in the absence of swimmers and boaters? This study cannot answer the question. However, our observations and comments from the boardwalk interpreters led us to believe they were. Manatees exhibited different behaviors when the springs were closed. Mother and calf interactions were more relaxed and playful, nursing on or near the surface was evident. The manatees displayed more interactions with each other. Active mating herd behavior was observed in all three lobes, something rarely seen when people were present in the water.

We asked Anne-Marie and Al Tauses, two boardwalk volunteers to share their observations. Anne-Marie wrote:

> "Per your request, below please find our observations of recent manatee activity when TSS is open to snorkelers, swimmers, paddlers, etc. compared to activity when the Springs are closed to human traffic:

First and foremost, we generally observe that the manatees are "relaxed" when they have the Springs to themselves. Our definition of a relaxed manatee is strictly our own based on a combined +/-400 hours of observation over the last few months. We believe that the manatees do not become relaxed until they have been in the Springs undisturbed for 24-hours or more. Closing the Springs for short periods of time, although valuable, seems not to have an immediate effect on behavior.

Relaxed manatees tend to rest closer to the surface of the water for long periods of time. Mothers nurse their babies at the surface as well as resting on the bottom. Babies wander farther away from their mothers to interact with other youngsters. Some adults rest upside down with their flippers crossed over them for long periods interspersed with leisurely rolling and casual surfacing for air. If breaching is the correct term for backs coming way out of the water followed by the tail straight up, that happens frequently as well.

Now, the more surprising and delightful observations:

Resting, sleeping manatees occupy the area close to the embankment while groups of frolicking, cavorting animals use the interior space to roll with their flippers wrapped around each other. Their entire heads come out of the water as they splash and "play" sending waves of water outward. Some very loud interesting noises come from these groups during this period of interaction. Although we understand this shares similar characteristic with a mating herd, mothers and babies are participating in this activity, so it seems unlikely. Mating herds have developed in the Springs during periods of closure, but the level of intensity quite clearly sets it apart from "play."

The most unusual observation we made was 6-8 manatees forming a circle on the surface of the water with their noses all pointing to the center. They appeared to be participating in some synchronized swimming event!

Well, there you have it--the decidedly unscientific observations of casual bystanders enthralled by the behavior of magnificent wild manatees! Feel free to use the above information as you wish, or tell us we are blissfully ignorant of the meaning of what we observed."

Additional Observations

Ten study days were analyzed for the length of stay of swimmers and boaters. The number of swimmers totaled 3,052. The average length of stay of the swimmers was 33 $\pm$ 3 minutes. Sixty-three percent of swimmers spent 11 to 40 minutes in the Springs. The number of paddle-craft on these 10 days totaled 1,142. The average length of stay of paddlecraft was 23 $\pm$ 5 minutes. Seventy-seven percent of boats spent less than 30 minutes in the Springs (Appendix VI).

In developing this study protocol and methodology, we considered measuring noise level at certain points at the Springs. We concluded we had neither time, money nor expertise to accurately measure

noise levels. We did, however, note several instances where noise levels had an effect on manatees in the Springs.

On the morning of January 24, 2015 a blower was used to clear the boardwalk of debris following the storm of the previous night. The blower engine noise caused the manatees to rapidly depart the Springs. The departure slowed when the blower was turned off and increased when it was turned back on.

On January 27, 2015 a low-flying helicopter hovered over the Springs around 12:50 PM. Manatees immediately began exiting the Springs. The graph and table for January 27th shows the adverse affect of this extremely loud motor noise on the manatees (Appendix IV).

We noted that manatees often exited the Springs at sunrise. Two possible explanations relate to noise. The first is that each morning tour boats arrived before sunrise with swimmers. Does the motor noise or human voices cause some of the manatees to flee? An alternative explanation is that early morning footsteps on the boardwalk alarm them.

We also noted that when the water temperatures were taken early in the morning in the Springs and the thermometer happened to land within a foot or so of a resting manatee, the manatee would often move slowly away from the point where the thermometer entered the water. Whether the noise or vibrations of the thermometer hitting the water, or the thermometer falling to the bottom caused manatee movement was unknown.

This study did not follow the boats and swimmers on the residential canal side of the Springs Run. There were many days when boats and swimmers hovered around manatees exiting the Springs or exiting Idiot's Delight to return to the Bay to feed.

Boardwalk Visitor Comment Card Study

A long, easily-accessed boardwalk was constructed around the Springs after acquisition in 2010 by USFWS. In order to provide public access to the Springs, the FWS, by bid, selected a concessionaire to provide land-based transportation to the Springs via the gate on King's Bay Drive. River Ventures, a Crystal River based Tour Company, was selected and currently provides bus transport on a schedule which allows regular visitation every day through manatee season.

Methods

Concurrent with the initiation of the swimmer-boater studies, a simple questionnaire was developed for gathering information from those visitors using the boardwalk . It was felt that input from these users would provide supplemental information which could be used in the overall management decisions for TSS. Visitors were free to complete this survey if they were so inclined. Some volunteer boardwalk interpreters encouraged visitors to complete the survey, some did not. Therefore, the sampling process was random and not systematic. Statistical treatment of the data was not considered necessary.

Three Sisters Springs Boardwalk Tour

Thank you for joining us today on this unique opportunity to view the beautiful Three Sisters Springs. We hope that your comments will help us improve future tours. Please take a moment to fill out this card and return it to River Ventures Staff.

Date_____

Where are you from?_____
How did you learn about the boardwalk?_____
What did you like best?_____
What did you like least?_____
Do you have suggestions to improve the experience?_____
Would you recommend this experience to others? Yes ☐ No ☐

To leave a review, visit TripAdvisor at Three Sisters Springs

Initially, a questionnaire return box was made available to returning boardwalk visitors at the River Ventures center. With the high amount of visitor traffic at the center, it soon became apparent that there was not sufficient time or space for visitors to easily complete a questionnaire. Subsequently, an evaluation return box was moved to a bench along the boardwalk where visitors waiting to return to the center could more conveniently complete the questionnaire. Survey forms were provided during most of the sampling period. There were high-use days when there were insufficient numbers of forms to meet demand. Therefore some potential data was lost.

In the analysis of survey returns, we grouped responses by categories, which surprisingly fell into discrete and logical groups. For the questions regarding what visitors liked most or least, we used key words to categorize these responses. Again, these responses fell into relatively narrow groupings. In asking for suggestions which would improve the boardwalk experience, we received replies which ranged from comical to practical. Those with meaningful value to management appear in the Appendix VII.

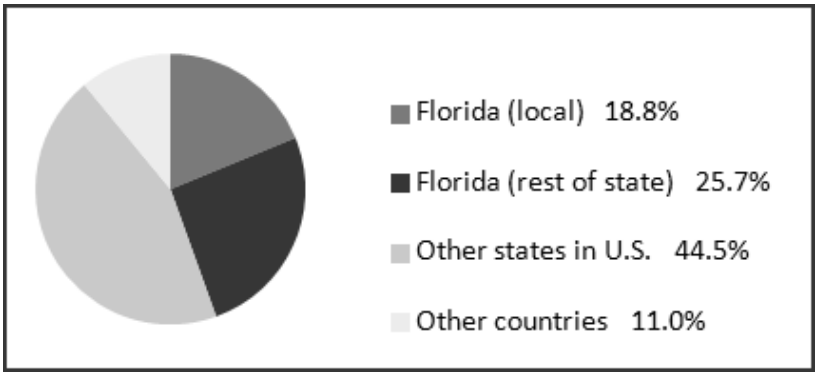
While the question of how visitors learned of TSS may appear to be more of a marketing need than a management need, answers to this were considered of worth in how education about manatees could be better tailored to specific user groups, i.e. language needs, age group needs, etc. Over 75% of the respondents found out about the Springs from a friend, the newspaper, or an online source.

Survey results are based on 564 returns from December 8, 2014 through January 31, 2015. An enhanced questionnaire program was continued after this date and subsequent data should be available through Crystal River NWR.

Results

Visitors from Florida made up 44.5 percent of the visitors to the Springs. A surprisingly high percentage of those were local residents (within 20 miles of Crystal River). Visitors from other states comprised 44.5 percent of the total. Foreign visitors made up 11.0 percent of the visitors, with strong representation from Canada and a number of European countries

The origin of visitors to the Springs is shown in Figure 15.



In looking at the answer to the question ”What did you like best”, the majority of responses fell into four distinct groups: manatees, the springs, the boardwalk and the volunteer interpreters present on the boardwalk to answer questions and provide additional information about manatees and the history of Three Sisters Springs.

	Springs Open	Springs Closed
Manatees	42.5%	43.7%
The Springs	19.6%	17.2%
Boardwalk	15.2%	11.1%
Interpreters	18.4%	25.7%
Other	1.6%	2.3%

We divided the responses to “What did you like best” into two groupings to see if there were different responses when the Springs were closed to swimmers and boaters as opposed to times when boaters and swimmers were present. Surprisingly, there was little difference in the response on open and closed days.

There was a noticeable difference in apparent interaction with boardwalk interpreters on those days the springs were closed with visitors appreciating the knowledgeable and friendly interpreters.

The opportunity to see manatees was the obvious highlight of a boardwalk visitor’s trip to the Springs. Responses were relatively similar whether the Springs were open to swimmers and boaters or not. However, many additional comments by boardwalk visitors were directed toward the quality of the experience without the presence of swimmers or boaters.

When the Springs were closed, we concluded that the high percentage of visitors who liked the volunteer interpreters on the boardwalk (25.7 percent) may have had more time to ask questions or listen than when swimmers or boaters were present. Whatever interpretations are made for this category, the importance of having trained and friendly volunteer staff present cannot be overlooked. Their presence is a contributing and significant factor in the enhancement of a boardwalk experience for visitors.

It is important to note also that words and comments in the "Liked "category form a picture of the Springs which management needs to consider in future planning . Visitors come to the Springs most certainly to see manatees, but the intrinsic values of the Springs are also important to the visitors as evidenced as words the visitors used to describe Three Sisters Springs: beautiful , quiet, tranquil, serene, and peaceful.

Visitors' response to what they liked least fell into three categories as shown in the following table.

	Springs Open
Facilities	8.4%
Seeing rules broken	9.9%
Too many people/boats	15.2%

By a large margin, boardwalk visitors did not like viewing the large number of swimmers and boaters interacting with the manatees (81.7 %). Comments ranged from "why is this allowed?" to simply "too many people!" Almost 10 % noted rule infractions or what they considered rule infractions.

This would indicate to us that these visitors had either viewed the FWS video on manatee manners or had read manatee literature.

Where 8.4 % of the visitors commented on facilities, most comments were directed toward the porta potties. Visitors were not pleased with their sanitary condition for the most part, suggested other amenities be provided such as hand sanitizer, and requested their location be changed so that they were not in a prominent, open area or moved to a location that would not appear in a photo background.

When queried as to whether they would recommend the boardwalk trip to others, 98.9% indicated that they would.

Discussion

The objective of this study, to record entry to and exit from Three Sisters Springs, enabled evaluation of the interaction of manatees and humans in the Springs.

The maximum number of manatees recorded in the Springs varied from a high of 446 to a low of one. The maximum number observed reflects only what we recorded from sunrise to sunset. This is likely an underestimate because of the opaque water when many manatees are present and because of the frequently observed departure of manatees just before sunrise from the Springs. The number closely paralleled the water temperature in Kings Bay and the Gulf. Manatees seek out warm water because they are subject to life-threatening cold stress when the water temperature falls below 68°F for an extended period of time or below 54°F for short periods of time (4). Kings Bay water temperature fell below 68°F sixty-eight percent of the time encompassed by this study including 13 days in December, a 7 day stretch in early January and the last 16 days of January. Manatees need free access to Three Sisters Springs to counter cold water temperatures in winter.

A synoptic study of manatee winter habitat showed that 88.6% of the northwest Florida manatee population used natural springs (1999-2011) with 6.5% using thermal waters released from power plants (5). However, only 3 manatees were counted in the March, 2015 aerial survey in the warm water stream from the Duke Energy's Crystal River Energy Complex (6). The nuclear plant has been shut down since 2009 and is currently being decommissioned. A record 706 manatees were counted in the February 20, 2015 aerial survey of Kings Bay (7). Four hundred six manatees, more than half of the population in Kings Bay, were reported in Three Sisters Springs one morning in January. Free and unrestricted access to the Springs is unequivocally important to protect these manatees from cold stress.

This study raised a number of questions related to manatee movement in and out of the Springs. Manatees leave Three Sisters Springs on a falling tide. It has been assumed that they do this so they won't be trapped in the Springs by a low tide Why on January 10th (Gulf water temperature 54°F) did all the manatees leave the Springs by 11:00 AM? The Springs were closed to humans this day and the tide height was 38 inches when the last one left. This is 11 inches above the lowest tide (27 inches) when manatees were in the Springs. They did not return to the Springs for 5 hours or until the tide height returned to 35 inches. Many of the manatees remained in the Sanctuary just outside the Springs Run, others left and went where? perhaps to Magnolia Spring? Why do manatees leave the Springs on a falling tide when the water depth is still well above their minimum level? What causes the early exit from the Springs around sunrise? Is it a response to motor noise and human voices as tour boats arrive outside the Springs? or footsteps on the boardwalk? or sunrise?

High tides shortly before or at sunrise combined with low temperatures repeatedly yielded the highest manatee counts. This led us to conclude that on days when the Gulf water temperature is expected to be 62°F or less with a high tide near sunrise, consideration should be given to closing the Springs until an hour before low tide to allow the majority of manatees to leave the Springs unimpeded.

The time of day also influences the number of manatees in the Springs. Higher numbers were always seen when high tide was near sunrise on a cold morning. When water temperatures were equivalent, and high tide was after 3:00 PM, fewer manatees were in the Springs than at comparable tide heights in the morning before 10:00 AM. As this pattern was seen on both open and closed days it cannot be attributed solely to the presence of humans. It is not clear from our limited number of data collection days whether this drop off in expected manatee numbers in the afternoon is due to feeding patterns, a diurnal behavioral pattern of the manatees, or on some open days, people in the Springs in greater numbers and for a longer duration later in the day,

The number of swimmers per day varied from 33 to 845. High numbers of swimmers were often associated with poor manatee manners. Surrounding, touching, and pursuing behaviors were noted by the data collectors and commented on by Crystal River NWR volunteers and the many boardwalk visitors.

The number of paddlecraft per day varied from 28 to 304. While the boaters we observed were generally patient and respectful of the manatees there were a number of problems. The large number of inexperienced paddlers, especially during the Christmas holidays, created numerous "boat jams" in the Springs Run. Kayak tours of 6 to 8 boats or more also tended to cause greater congestion in the Springs Run. Boat jams in the Springs persisted throughout the 2014-2015 season and ultimately led to a banning of paddlecraft in the Springs in early March, after this study was concluded.

Do swimmers and boaters cause the manatees to leave the Springs? An evaluation of the open days did not show that swimmers and boaters caused the manatees to leave the Springs. There were occasions when a manatee(s) was chased out of the Springs by a swimmer or paddlecraft, but these were rare incidents and usually monitored/corrected by USWFS Manatee Watch volunteers who were on the water in a kayak or on the boardwalk. In general, the manatees ignored the swimmers unless they were surrounded and touched once too often when they rose to breathe or unless they were cornered against a bank by overeager swimmers. Then the usual response to crowding by humans was for the manatee to swim to another area of the Springs. Tide and temperature influences appear to play a much larger role in manatee usage of the Springs than the presence or absence of swimmers or paddlecraft.

During this study we observed that manatees in the presence of humans were for the most part quiet, moving only when pursued or followed. A few manatees were acclimated to humans and actively sought human interaction. Much of the relevant published literature focuses on management of the harassment of manatees. Sorice et al (8) stated "that manatee responses to encounters with humans are hard to detect, making defining human behaviors as "harassment" problematic". We came to the same conclusion.

In contrast, we observed a markedly different behavior of the manatees in the absence of humans. Manatees entered and left the Springs more frequently and interacted with each other more often. Are manatees more active on colder days? Are the manatees more active, exhibiting a wider range of interactions, in the absence of humans? We cannot answer these questions from this study, only relate our observations. A closer look at manatee behavior and activity in Three Sisters Springs in the presence and absence of humans may illuminate the effect humans have on manatees.

The Springs Run is a major bottleneck and hazardous for manatees, boaters, and swimmers. Numerous boat jams with swimmers threading their way through boats caught perpendicular to the channel create potential collisions. It was not unusual to see paddlecraft run up on swimmers, with the occasional solid head impact. Swimmers and boaters entering or exiting the Springs can prevent manatees from entering the Springs Run or cause them to turnaround shortly after entering on their way into the Springs. This study found, using stringent criteria, that over 4% of manatees swimming into the Springs were unintentionally turned back by boaters and swimmers.

Manatees encountered humans on their way into or out of the Springs 37% of the time. This rate of concurrency in the Springs Run is felt to be unacceptable for good management practices. Manatees use the Springs to help thermoregulate their bodies on cold winter days and they need to leave the Springs at low tide and to feed. To do so, they often must run a human gauntlet. We felt that a concurrent passage could be considered an infringement or interference with normal manatee behavior and also increased opportunity for a violation to occur. Elimination of this kind of human/manatee interaction is a key in managing the Springs for maximum manatee protection. The solution to this problem seems obvious. Close the Springs Run to humans, both swimmers and boaters. Allowing restricted and controlled access to the Springs at a land-based point would eliminate use of the Run by swimmers and boaters, leaving this channel for manatees.

What happens when the manatees want to leave the Springs or cannot return to the Springs when swimmers and boaters block the entrance to the Springs Run? While our study focused on the Springs and the Springs Run, our observation post had a clear view of Idiot's Delight. When the Springs were open and on some of the first days it was closed this season, swimmers and kayakers crowded the area

between Idiot's Delight and the entrance to the Springs preventing manatees from entering the Springs Run or hindering their movement from the Springs Run into Idiot's Delight. Management reconfigured the entrance area with buoy lines on closed days in January with the result that the manatees had free access into and out of the Springs. On open days, particularly when the tide was low, swimmers and boaters clustered around the buoy line demarcating Idiot's Delight. Any manatee brave enough to exit the sanctuary swam through a gauntlet of hands, legs, and swimmers. Any manatee leaving the sanctuary to go to Magnolia Springs or to Kings Bay to feed had the same problem.

For Three Sisters Springs, carrying capacity can be defined as the number of people and manatees the area can support without environmental or aesthetic degradation. Regulatory issues concerning the endangered manatees are also a consideration when the carrying capacity of the springs is evaluated. King and Heinen (9) commented a decade ago that "tourist numbers and/or activities may detract from the natural amenities that tourists come to enjoy". It is our belief, supported by the boardwalk questionnaire and subsequent surveys of swimmers and boaters, that few people enjoyed watching, paddling or snorkeling with the high numbers of people in the Springs over the holidays.

The solution is obvious. Crystal River City Council placed a temporary ban on paddlecraft in the Springs from March10 to March 23, 2015. It is our opinion that the number of swimmers should be strictly limited. Currently, swimmers and tour groups do not use the full ten hours (sunrise to sunset) the Springs are open, but they could. The observed length of stay for swimmers in this study was 33 minutes. This included the time swimmers used to swim upstream into the Springs. By limiting the number of swimmers to no more than 25 an hour, including tour guides who enforce manatee manners guidelines, the experience of swimming with the manatees should be more enjoyable for participants and boardwalk visitors and also lessen harassment of the manatees. One method of allotting spots to tour operators is outlined in Appendix VIII as a potential entry portal to discussion and development by META (Manatee Ecotourism Association) and USFWS of an equitable allotment system for in water participants at Three Sisters Springs.

Laist et al (5) listed six actions that would ensure better access to warm water refuges for manatees during cold weather. One of these steps, "improving measures to limit human activities that disrupt manatee use of springs during the winter season", should be given a close and careful appraisal for Three Sisters Springs, Idiot's Delight, and the adjacent residential canal. The first measures would be to close the Springs Run. The next measure would limit the number of people in the water at the Springs. A third measure would be to monitor and evaluate manatees interaction with humans around Idiot's Delight and the canal (corridor to the Bay).

Boardwalk visitors commented on the tranquil and serene setting and the enjoyment derived from walking the boardwalk and observing the manatees and the surroundings. The number of people visiting the boardwalk in its first year in addition to the positive response of boardwalk visitors should serve as an indicator to both FWS and all tour operators that the Springs' boardwalk has become an established land-based amenity in the manatee watching network of Crystal River and the Crystal River NWR.

Three Sisters Springs has an intricate ecosystem that includes a diverse fish population (snook, mullet, needlefish, largemouth bass and other species), turtles, blue crabs, a host of water birds (cormorants, pelicans, egrets, heron, anhinga). All of this is visible from the boardwalk. A variety of birds and flora can be seen in adjacent tree and shrub habitat. Bird songs and breathing manatees frequently fill the air with sound. This is a remarkable urban location, with abundant natural experiences available to those who choose to look at and beyond the manatees.

It is our belief that the aesthetics of Three Sisters Springs should guide an integrated process of addressing the holistic management needs of the Springs. The preservation and protection of these aesthetic qualities should become a priority objective for future management complementing the preservation and protection of the endangered manatee.

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Appendices

I. Data Collection Sheets

II. Environmental Data: Water Temperature and Wind Speed and Direction

III. Tide height at the Entrance to Three Sisters Springs and Lunar Phase

IV. Day by day Graphs and Tables

V. Day by Day Graphs Showing Tide Height When No Manatees Are in the Springs

VI. Paddlecraft and Swimmers: Length of Stay in Springs

VII. Suggestions to Improve the Boardwalk Experience

VIII. Proposed Allotment/Reservation Program for Three Sisters Springs