

Warm Effluent Outlets and the Mortality of Perinatal  
Florida Manatees (*Tricheus manatus latirostris*)

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Power plants discharge warm exhaust into waters occupied by Florida Manatees (*Tricheus manatus latirostris*) and have affected manatees' natural migration pattern.

When water temperatures decrease seasonally manatees normally migrate south, but some manatees now winter at artificial warm water outlets.

Manatees quickly deplete seagrass beds by the outlet and must forage for food in colder waters. Since babies always accompany their mothers, on the trips to forage for food in colder waters they don't fare as well as their adult counterparts because they have less blubber to keep them warm. It has been hypothesized that Brevard County has the most perinatal deaths in Florida because many of these babies succumb to cold stress.

## Review of Literature

The West Indian Manatee (*Tricheus manatus*) is a member of the Trichechidae or manatee family and belongs to the order Sirenia, which has two families Dugongidae and Trichechidae. The family Dugongidae contains only one live living species, Dugong dugon (The Red Book 1993). The family Trichechidae includes three species: the Amazonian manatee (*Tricheus inunguis*), the West African manatee (*T. senegalensis*), and the West Indian manatee (*T. manatus*). The West Indian manatee has two subspecies, the Florida manatee (*T. manatus latirostris*) and the Antillean manatee (*T. manatus manatus*). The reason for the sub classification is that the Antillean manatee lives in the greater Caribbean and northeast South America and the Florida manatee lives around Florida and these two populations have almost no interaction (USFWS 1987). The four living sirenian species are all geographically isolated, and listed as threatened or endangered. The closest, living terrestrial mammalian relative to the manatee is the elephant.

The West Indian Manatee is a large gray or brown aquatic mammal. They have no hind limbs, and their forelimbs are modified as flippers. Manatee tails are flattened horizontally and rounded. Their body is covered with sparse hairs, called vibrissae, and their muzzles with stiff whiskers (Marshall 2000). Their sexes are distinguished by the position of the genital openings and presence or absence of mammary glands. Generally, manatees have a mean mass of 410-545 kg (900-1200 lb), and mean length of 2.7-3 m (9-10 ft), with maximums of 3.6 m and 1775 kg seen (the females tend to be larger and heavier). When born, baby manatees have an average mass of 30 kg (USFWS 1993). Manatees can live up to 60 years (Marmontel 1995). Female manatees have a 12-month

gestation period and reach reproductive age after 4 to 5 years, while males reach reproductive maturity at about 9 to 10 years of age (Massicot 1999).

They have a large flexible prehensile upper lip that acts in many ways like a shortened trunk, somewhat similar to an elephant's. They use the lip to gather food and eat, as well as using it for social interactions and communications (Marshall 2000). They have small, widely spaced eyes with eyelids that close in a circular manner. Manatees are also believed to have the ability to see in color. They are mainly herbivores, spending most of their time grazing in shallow waters and at depths of 1-2 m (3-7 ft). Manatees will consume almost any aquatic vegetation available to them and sometimes even shoreline vegetation. They mainly eat manatee grass (*Syringodium filiforme*) a species of sea grass (Florida Museum of Natural History). Manatees may spend about 5 hours a day feeding, and may consume 4 to 9 percent of their body weight a day. Half a manatee's day is spent sleeping in the water, surfacing for air regularly at intervals no greater than 20 minutes.

On average, most manatees swim about 3 to 5 miles per hour. However, they have been known to swim up to 21 miles per hour in short bursts (Harvey 2007). Manatees inhabit shallow, marshy coastal areas and rivers. Florida is usually the northernmost range of the West Indian manatee as their low metabolic rate makes cold weather endurance difficult. They may on occasion stray up the mid-Atlantic coast in summer.

Florida manatees (*T. manatus*) have been known to live up to 60 years, and they can move freely between salinity extremes; however, Amazonian manatees (*T. inunguis*) never venture out into salt water. They emit a wide range of sounds used in communication, especially between cows and their calves, yet also between adults to maintain contact and during sexual and play behaviors (O'Shea 2006). They may use taste and smell, in addition to sight, sound, and touch, to communicate. Manatees are

capable of understanding discrimination tasks, and show signs of complex associated learning and advanced long term memory (Gerstein 1994). They demonstrate complex discrimination and task-learning similar to dolphins and pinnipeds in acoustic and visual studies (Gerstein 1994).

Manatees have a very low metabolism and don't have the amount of blubber that other marine mammals do. Because of these factors manatees get sick when the water temperature falls below 68° Fahrenheit (Walsh 2004). When the waters get too cold manatees suffer from cold stress or hypothermia, get too sluggish to eat, and die. Cold stress syndrome is a combination of diseases initiated by cold water and manatees' limited ability to adapt to low temperature extremes. Studies show that the animal's metabolism slows, leading to digestion problems, decreased appetite, and associated weight loss. Those factors, along with the possible release of certain hormones, weaken manatees' immune systems, which make them vulnerable to environmental toxins as well as a variety of diseases, including pneumonia, intestinal infections, and perhaps even a manatee virus similar to one that causes human cervical cancer (Harbor Branch Oceanographic Institute 2006).

During the winter when the Florida waters get cold, manatees normally migrate to southern Florida and the Keys. They also seek out natural warm springs in Florida's coastal springs (Laist 2005). In recent years manatees have started to congregate at warm effluent outlets discharged by power plants (King 2003). These warm outlets have altered the manatees natural migration pattern. They have begun to stay at the warm outlets all winter (King 2003). One of the main power plants is the Florida Power and Light Cape Canaveral Plant.

When the manatees graze they rip out the sea grass by the roots and it doesn't grow back (Soloman 1994). Normally, they then move on to other areas. But when they gather by the warm effluent outlets during the cold winter months they quickly devour the sea grass by the outlet, and then must travel out to colder waters for food (Soloman 1994). Being mammals, manatees are warm-blooded but are also unable to regulate their body temperature. A temperature drop of a few degrees can cause cold stress, a form of hypothermia in manatees, and can be fatal for manatees (USFWS 1993). However, most manatees are able to survive the winter treks for nourishment, provided they make it back to the warm effluent outlet quickly enough (USFWS 1993). Since babies always accompany their mothers, on the trips to forage for food in colder waters they don't fare as well as their adult counterparts because they have less blubber to keep them warm (Frisch 1988).

Perinatal manatees, baby manatees, are classified as a manatee with a length of 150 cm or less (USFWS 1993). They are very susceptible to cold stress because they lack the body mass and blubber that older and larger manatees have. As a result of all these combined factors it seems likely that there is a correlation between the number of perinatal mortalities in Brevard County and the FPL warm effluent outlet.

### Research Question and Hypothesis

The purpose of this research is to determine whether artificial warm water outlets have caused an increase in the deaths of perinatal Florida manatees (*Tricheus manatus latirostris*). Power plants shoot out their warm exhaust into waters that are occupied by manatees and have altered the manatees' natural migration pattern. Regularly, in the winter, when the waters get colder, manatees migrate south to warmer waters. Some

manatees have stopped migrating and simply stay at the artificial warm outlets. However, once the manatees have eaten all the food in the area they have no choices but to leave the warm outlet to forage for food in the colder waters. Perinatal manatees, lacking the amount of blubber that adults have, would have be challenged by the cold waters and would be subject to cold stress. The research hypothesis is that there has been an increase in the amount of perinatal manatee deaths due to the change in the manatees' migration pattern.

### Methods and Materials

The researcher has analyzed the Florida Fish and Wildlife Research Institute database of manatee mortalities in Brevard County. The Florida Fish and Wildlife Conservation Commission gathers manatee carcasses and keeps records which include the location, time of death, and cause of death in a database. When all of those factors cannot be readily identified the most probable cause or time of death is listed. The database is kept to determine what causes manatee deaths and what can be done to decrease the manatee mortality rates. The data is collected by the Florida Fish and Wildlife Conservation Commission through its dedicated carcass salvage program. By having quick response teams to sightings of carcasses and regular sweeps over areas populated by manatees most manatee mortalities are noted quickly.

Through analysis of individual necropsy reports of all perinatal manatee deaths in Brevard, Broward, Duval, and Martin County the hypothesis's validity can be examined. The four counties have been chosen because they all have similar manatee populations. Additionally, two of the counties have power plants, while the others do not and there are two northern and southern counties. Brevard and Duval are in northern Florida and

Broward and Martin are in southern Florida. Brevard and Broward County both have a Florida Power and Light power plant that create warm effluent outlets. Duval and Martin will act as controls to Brevard and Broward, respectively, as they are without any artificial warm outlets. Broward will also be a control to Brevard because, although it does have a power plant it is in southern Florida, where the water stays warmer in the winter. The water is warm enough, so that even when the manatees have to forage for food away from the power plant the slight decrease in temperature doesn't have much of an impact on them.

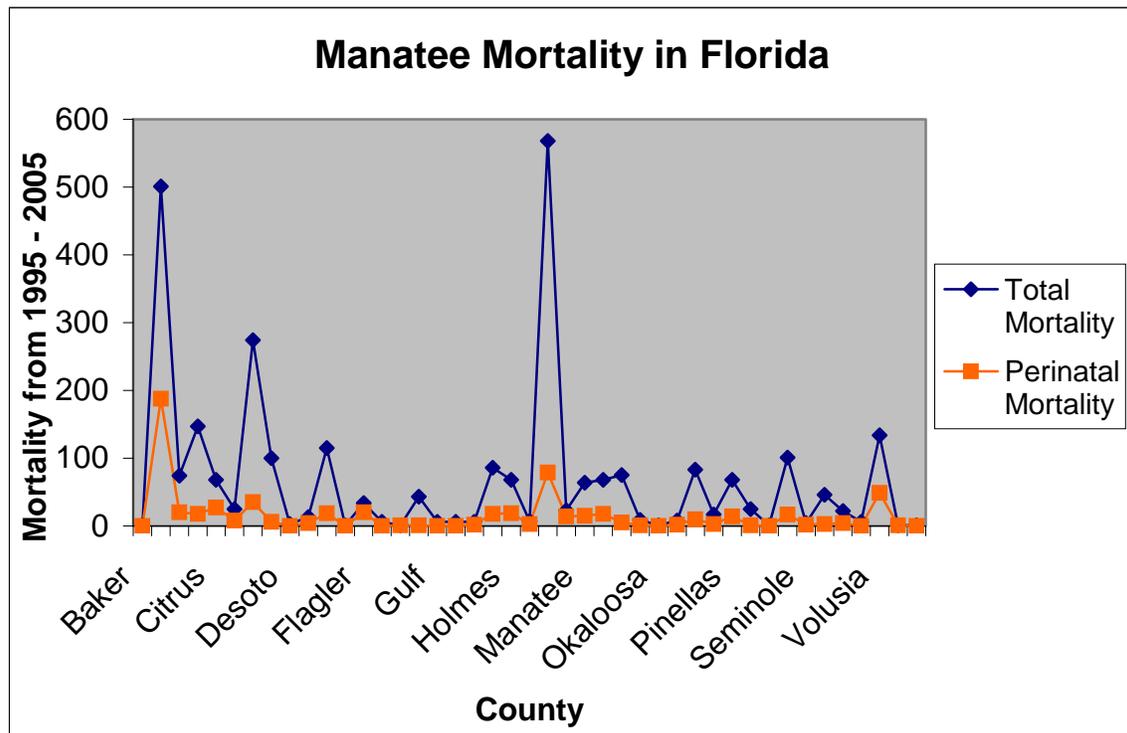
The power plant in the Brevard County vicinity is the Florida Power and Light (FPL) Cape Canaveral Plant. It is an oil and coal plant, or a natural fuels plant. In the winter it attracts just under 1000 manatees to its warm effluent outlet. It is one of the largest power plants in all of Florida, and the largest in the northern Florida region. The power plant in Broward County is the FPL Fort Lauderdale Plant. It, too, is a natural fuels plant. Its warm effluent outlet attracts approximately 300 manatees.

The researcher has analyzed necropsy reports of perinatal manatees in the chosen counties that died between the years of 1995-2005. The time frame starts in 1995 because that is when Florida's dedicated salvage program was started. Although the database was started in 1974, prior to 1995 recovery and necropsy efforts were inconsistent. Mortalities during the winter months, November through March, have been focused on. Additionally, deaths from the other months and Florida as a whole have been studied, to be used as a standard.

## Data and Analysis

Data analysis was carried out in three steps: (1) tallying the mortalities for each county, (2) breaking down the mortalities month by month over the ten-year period, and (3) determining the cause for each perinatal mortality.

**Figure 1: Manatee Mortality in Florida**

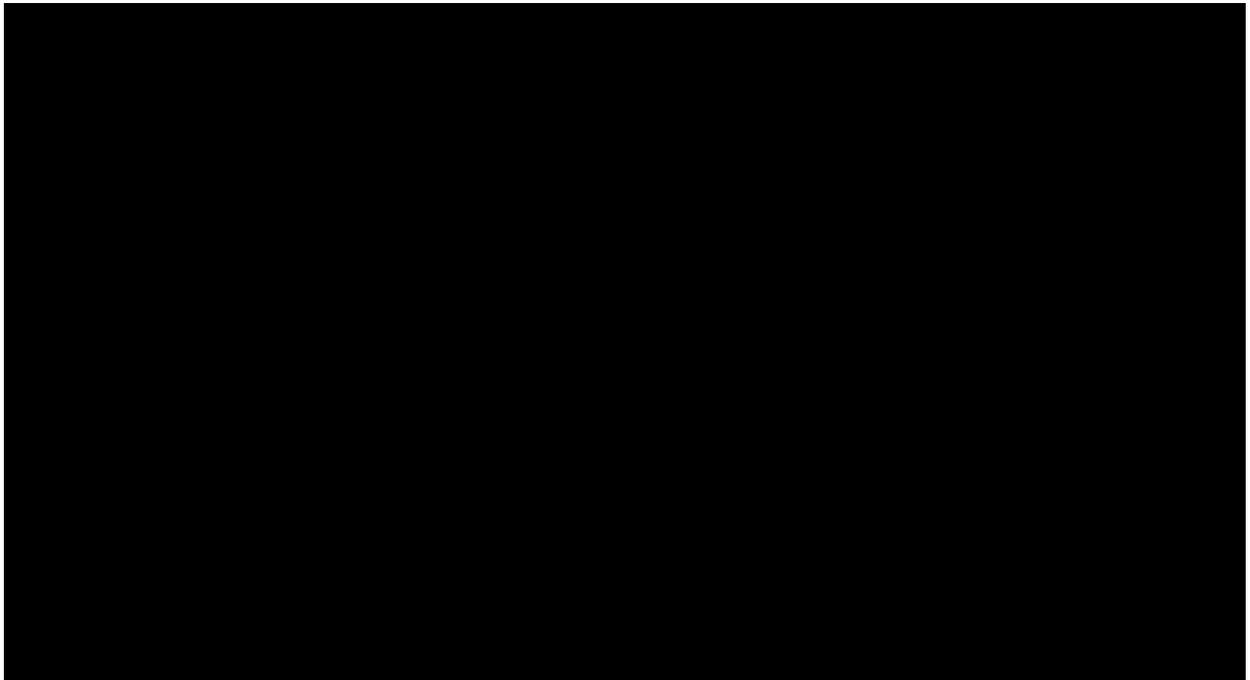


Through use of the Fish and Wildlife Research Institute's database the total mortalities and perinatal mortalities could be seen for each county. Figure 1, above, depicts the 44 counties that are inhabited by manatees and the total mortality and perinatal mortality in the corresponding counties. After calculating the mortalities for all of the counties in Florida it was determined that Brevard, Broward, Duval, and Martin County would be used in the research. The number of mortalities throughout the Florida counties was very erratic, with some as high as 187 mortalities and others as low as just

one mortality over the ten-year time period. These four counties were chosen because they have similar manatee populations and they would be able to act as controls for each other.

After it was determined that Brevard, Broward, Duval, and Martin County would be used in the research, necropsy reports for those counties were gathered from 1995 to 2005. The necropsy reports were gone through by hand to find when the manatee had died and what the cause of death was. The hypothesis suggested that most deaths for northern Florida would be during the winter months when the water was colder and that the leading cause of death would be cold stress. The southern counties would establish a control for the number of mortalities in warm water. Figure 2, shown below, depicts the percentage of perinatal mortalities per county and statewide.

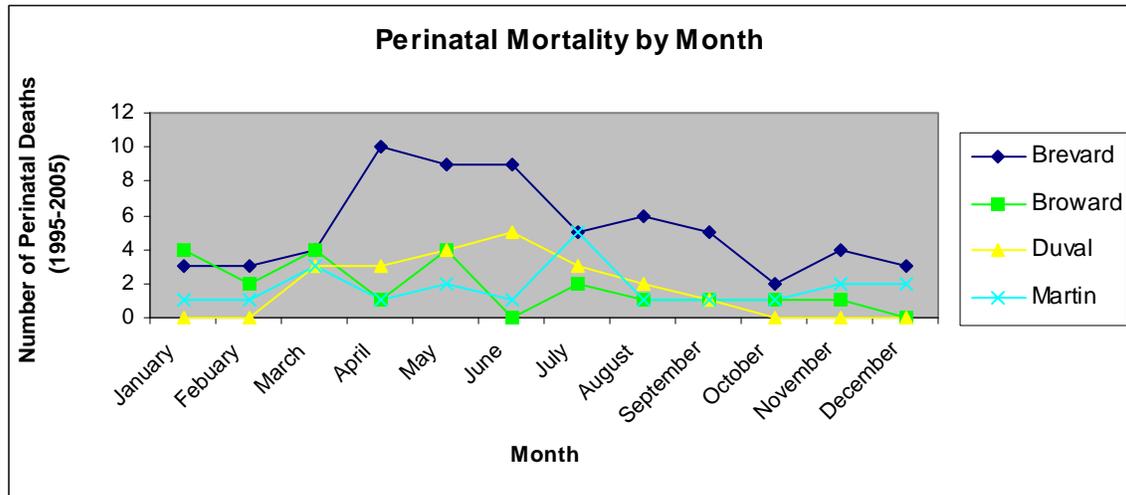
### **Figure 2: Percentage of Perinatal Mortalities**



For the state of Florida perinatal mortalities represent approximately 21% of all mortalities. Perinatal mortalities account for 36% of mortalities in Brevard County. In

Broward County perinatal deaths were 28% of all mortalities in the county. 18% of all manatee deaths in Duval County were perinatal. In Martin County perinatal deaths were 31% of all mortalities in the county.

**Figure 3: Perinatal Mortality by Month**

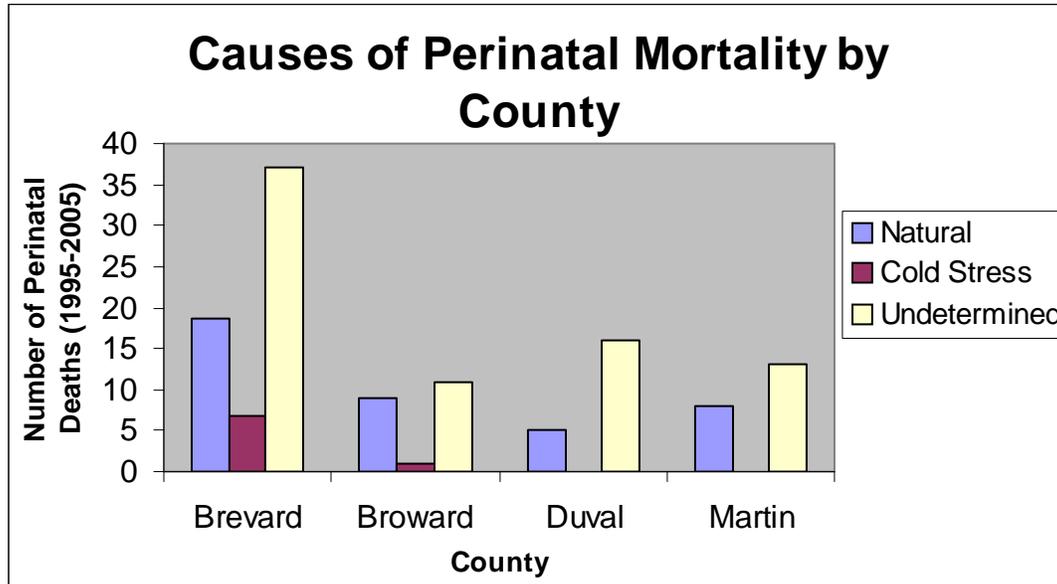


However, the data did not support the hypothesis that there would be a greater number of deaths during the winter months or that cold stress was a leading cause of death. Surprisingly, the highest number of perinatal mortalities fell between the months of April and June, rather than the winter months.

The researcher also extrapolated the causes of perinatal deaths for each county. The three classifiable causes for perinatal mortalities were natural, cold stress, and undetermined and decomposed. Natural mortalities consist of stillbirths, aborted fetuses, abandoned calves, predation, death due to deformities, and death to diseases. Cold stress is death due to manatees' limited ability to adjust to low water temperature, which causes the animal's metabolism to slow, leading to digestion problems, decreased appetite, and associated weight loss. Undetermined deaths are any mortality in which the cause of death could not be identified. Due to the difficult nature of recovering carcasses in the wild the carcass is usually too decomposed for any casual cause of death to be

determined. Occasionally there are mortalities in which a manatee dies and its carcass is fresh, yet a cause of death still cannot be determined.

**Figure 4: Causes of Perinatal Mortality by County**



The most common form of death for perinatal manatees during the ten-year span was Undetermined. There was a large fluctuation between counties for undetermined mortalities. Brevard had most of the mortalities due to cold stress; Broward had a single cold stress mortality; and Duval and Martin had no cold stress-related mortalities. Natural mortalities were similar for Broward, Duval, and Martin counties, but Brevard mortalities more than doubled the other three counties. Brevard has the largest manatee population, so it is logical that the numbers would be a little larger. However, the amount of undetermined mortalities was significantly higher than the three other counties.

### Discussion and Conclusions

The data was not conclusive in supporting the hypothesis. There weren't a greater number of deaths in Brevard County during the colder months when the manatees were

wintering at warm effluent outlets instead of migrating. Additionally, cold stress was not identified in the reports as representing a sizable percentage of deaths in Brevard County.

Duval County, the most northern county, had no cold stress related deaths over the ten-year period. In fact, it had no perinatal mortalities at all for the months of October through February. This is most likely due to the fact that the manatees in that county migrated to warmer, southern waters, seeing as they had no warm effluent outlet to retreat to. Also, the two southern counties had just one cold stress mortality between the two of them. The water temperatures in southern Florida don't usually drop below 68 degrees; cold stress is virtually nonexistent in those warmer waters.

If the manatees in Brevard County migrated to southern waters, like they had in the past, instead of wintering at the warm effluent outlet, evidence suggests that there would be significantly fewer cold stress related deaths in the county. Duval County, which is further north than Brevard, had no perinatal cold stress related deaths, or even any deaths in the winter months because they had all migrated to southern Florida. The southern counties, where the Brevard manatees would have migrated to, had next to no cold stress mortalities as well. Based on the three other counties in the study if the manatees in Brevard still followed their migration pattern there would most likely be less cold stress mortalities.

Additionally, previous to 2003, cold stress wasn't really understood and identified. Several key symptoms of cold stress are lesions on the skin, loss of blubber and mesenteric fat, an empty stomach, and dry feces. In all the later necropsy reports cold stress is identified as a cause of death, but since it was only identified recently all the early years don't have any official cold stress related deaths. However, there were many reports that described cold stress-like symptoms, and as a cause of death would be classified as undetermined. The Fish and Wildlife Research Institute should review its

database and possibly revise some older reports that don't have the clarity as more recent reports due to the advances in the understanding of manatees and cold stress.

Surprisingly, the highest number of perinatal mortalities for all of the counties fell between the months of April and June, rather than the winter months. This is most likely due to the fact that most manatees give birth in the spring and the perinatals are most vulnerable right after they are born. Most of the deaths in the spring are probably naturally occurring, but what can and should be done is a thorough study on what manatees die from most often throughout the year, in all counties.

The highest cause of perinatal deaths was undetermined. This is most likely due to the fact that most manatee carcasses are badly decomposed by the time a research team locates and necropsies a carcass. The Florida Fish and Wildlife Research Institute needs more manpower and quicker response teams. In numerous necropsy reports, carcasses are not collected until the day after they are reported. Since there is a delay in retrieving the carcasses, they decompose and make the necropsy reports less accurate. Then it is harder to identify a cause of death and understand what manatees are dying from.

In summary much research still needs to be done to increase our understanding of manatee ecology and the human impact on the manatee population. Currently, manatees are listed as an endangered species. At the very least, further research should be done on perinatal manatee mortality in the state of Florida, as well as manatee populations throughout Florida in general. Perhaps future research will provide us with an understanding that will allow us to balance the needs of manatees with those of humans.

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## References

- Deutsch, Charles. 2000. Winter Movements and Use of Warm-Water Refugia by Radio-tagged West Indian Manatees Along the Atlantic Coast of the United States. Final Report prepared for the Florida Power and Light Company and U.S. Geological Survey. 133 pp.
- Frisch, Katherine. "Can Technological Solutions Prevent Manatee/ Boat Collisions." Florida Fish and Wildlife Conservation Commission. 13 Nov 2003.
- Gerstein, Edmund, Gerstein, Forsythe, Blue. "The Underwater Audiogram of the West Indian Manatee." 1999.
- Harvey, John. "Clinical Biochemistry in Healthy Manatees (*Tricheus Manatus Latirostris*)." Journal of Zoo and Wildlife Medicine. 6 Jun 2007. BioOne.
- King, Jill. "An Assessment of the Behaviors of Overwintering Manatees as Influenced by Interactions with Tourists at Two Central Sites in Florida." Biological Conservation. 15 Jan 2003. Science Direct.
- Laist, David, Reynolds. "Florida Manatees, Warm-Water Refuges, and an Uncertain Future." Coastal Management. 1 Jun 2004.
- O'Shea, Thomas. "Aspects of Underwater Sound Communication in Florida Manatees (*Tricheus Manatus Latirostris*)." Journal of Mammalogy. 12 Dec 2006. BioOne.
- Marshall, Christopher. "Food-Handling Ability and Feeding-Cycle Length of Manatees Feeding on Several Species of Aquatic Plants." Journal of Mammalogy. 30Apr 1999. BioOne.
- Reynolds, John. "Distribution and Abundance of Florida Manatees (*Tricheus Manatus Latirostris*) Around Selected Power Plants Following Winter Cold Fronts: 2006-2007." 20 Apr 2007.

Soloman, Barry. "The Florida Manatee and Eco-Tourism: Toward a Safe Minimum Standard." Ecological Economics. 22 Mar 2004. Science Direct.

"Summary of Manatee Avoidance Technology Session." Florida Marine Mammal Conference. 10 Apr 2005.

U.S. Fish and Wildlife Service. "Biological Information on the West Indian Manatee (*Trichechus Manatus*)." May 1999.

U.S. Fish and Wildlife Service. 2000. Florida Manatees and Warm Water: Proceedings of the Warm-Water Workshop, Jupiter, Florida, August 24-25, 1999. XXX pp.

Walsh, Cathy. "Effects of Environmental Stressors on Lymphocyte Proliferation in Florida Manatees, *Trichechus manatus latirostris*." Vetinary Immunology and Immunopathology. 18 Mar 2004. Science Direct.