Florida Keys Watch

Brad Rosov, The Nature Conservancy, Sugarloaf Key, FL.

Goals

Florida Keys Watch (FKW) was a canal water quality monitoring program designed to assess levels of bacterial and human-borne viral contamination in a series of canals throughout the Florida Keys. The mission of this program was to document the status of canal water quality and to determine whether human waste was a source of contamination.

Good water quality is essential for maintaining healthy aquatic habitats such as seagrass beds, mangroves, and coral reefs. Potential threats to the condition of nearshore waters stem from natural and anthropogenic processes. Nutrients from poorly treated wastewater and stormwater runoff are potential sources of pollution in the nearshore waters in the Florida Keys. Without a centralized sewage treatment system, the Keys rely upon more than 23,000 private onsite systems and approximately 246 small wastewater treatment plants to manage their wastewater load. The onsite systems are composed of approximately 15,200 permitted septic systems, 640 Advanced Treatment Units, and 7,200 unknown systems (2,800 of which are believed to be illegal cess pits). These systems send water that is poorly treated or untreated into the porous limestone foundation just below a thin veneer of soil. Tides and heavy rains flush out this tainted groundwater and transport nutrient, bacterial, viral, and other contaminants from the groundwater into adjacent canal systems and nearshore waters. This contamination poses a potential human health risk as well as a threat to the health of the aquatic ecosystem.

FKW was a partnership established between the U.S. Environmental Protection Agency (EPA) and The Nature Conservancy (TNC), a private, non-profit conservation organization. The EPA provided funding for the analysis of viral samples. TNC provided funding and acted as the managing partner by providing staff support and coordination for the program.

This report presents data collected from the inception of the program in August 2002 through January 2003. Although viral samples were collected during this period, the results have not been determined at the time of writing this report.

Methodology

FKW was modeled from a previous canal water quality study conducted by University of South Florida (USF) researchers in 1999. In the earlier study, water samples were collected from 19 canal sites and analyzed for a suite of bacterial and viral indicators that can potentially cause disease in humans. Ten of the sampling stations in the USF study were included in FKW. Seven additional sites were identified through use of the Monroe County Sanitary Wastewater Master Plan and are recognized as “hotspots” (areas that will receive a community wastewater collection and treatment system by the year 2010). In all, FKW incorporated a total of 17 canal sampling stations at both public and private sites (Table 1). Stations were distributed between Mile Marker 105 in Key Largo and Mile Marker 10 in Boca Chica (Table 1) and included sites both bayside and oceanside. One station (#14) was changed after several sampling events and only the data from the newer station were included in this report.

Data were collected from each station by TNC staff or volunteers. Each collector was trained in sampling techniques including filling out data forms, calibrating field equipment, and handling water samples to ensure the integrity of the data. The TNC Marine Conservation Program Manager supervised a trained intern who periodically evaluated volunteers on the care and manner with which they sampled, and all data went through a quality control check to identify possible errors. All protocols and methods utilized for this projected were included in a Quality Assurance Project Plan (QAPP) submitted to and approved by the Region IV Water Management Division of the EPA. A database was maintained to track the schedule of volunteer training, as described in the QAPP.

Every two weeks, a team of two volunteers and the marine intern collected data and water samples from all 17 stations. The following information was recorded on a standardized data form: station identification number, date, time, tide, salinity, dissolved oxygen (from surface and at depth), temperature (from surface and at depth), and rainfall in the past 24 hours. Rainfall data were scored as a "0," "1," or "2." A score of "0" denoted that there was no rainfall over the previous 24 hours, "1" denoted that 0.1-0.5 inches of rain was recorded over the previous 24 hours, and "2" denoted that over 0.5 inches of rainfall was recorded over the previous 24 hours. In addition, two 100-ml water samples were collected from each station to determine levels of enterococcus bacterial contamination. Enterococcus bacteria are commonly found in association with warm-blooded animals, including raccoons, dogs, and humans.

All water samples and data sheets were collected from volunteers following each sampling and were brought to TNC's office in Sugarloaf Key. Analysis of these water samples was conducted at the TNC office through use of the Enterolert most probable number (MPN) technique. TNC staff were trained to analyze samples properly and meet the quality assurance/quality control standards as described in the QAPP. All data from the field forms and sample analysis were then checked for errors and entered into a database managed by TNC.

Following four months of data collection (mid-January 2003), samples were collected from six of the canals with the highest levels of bacterial contamination. These samples were sent to Biological Consulting Services, Inc. (BCS) for laboratory analysis for the presence of viral contamination associated with humans. Although not available for this report, the results from this portion of the project will determine if human sewage is a source for viral contamination in these canals.

Sampling also occurred following episodic events, such as a heavy rainfall. It is theorized that heavy rainfalls promote higher rates of flushing of groundwater into canal waters. Due to logistical reasons, only 6-8 stations were sampled following episodic events. A total of five viral samples were collected following an episodic event through the course of this study.

Results

Between 8 August 2002 and 28 January 2003, water quality sampling took place every two weeks for a total of 13 times at the FKW canal stations. Due to logistical reasons, data could not be obtained from several stations during these sampling dates. Additionally, four episodic sampling events occurred at six lower Keys stations.

Enterococcus
Enterococcus is a common class of bacteria that thrives in the guts of warm-blooded animals. This suite of bacteria is considered to be the best indicator of bacterial contamination because it has the ability to survive longer in warm marine waters. In 1986, the EPA set the guideline with the maximum density of 104 Colony Forming Units (CFU) of enterococcus per 100 ml of marine water to be considered safe for swimming. The state-sponsored Florida Healthy Beaches program utilizes the following standards when evaluating the condition of swimming beaches:

- 0-34 CFU/100 ml - acceptable
- 35-103 CFU/100 ml - moderate
- 104 CFU and above - poor

Enterococcus bacteria levels in canal water samples were calculated for each station (Table 2). Because it became evident that rainfall significantly affected enterococcus levels, the data were broken down into four categories: "Total Samples from Station," "No Rain Samples," "Total Rain Samples," and "Heavy Rain Samples Only" (Table 2). "Total Samples from Station" refers to the average MPN of enterococcus for all samples collected at the station. "No Rain Samples" refers to the average MPN for all samples that received a rainfall score of "0". "Total Rain Samples" refers to the average MPN for all samples that received a rainfall score of "1" and "2." "Heavy Rain Samples Only" refers to the average MPN of enterococcus for all samples that received a rainfall score of "2." It should be noted that a very heavy rainfall occurred on 12/8/02 and the subsequent enterococcus data collected was extremely high for many of the stations (CFU's were recorded in the thousands). Despite this, the results of this anomaly have been incorporated into the following analysis. No stations exceeded the EPA's recommended enterococcus maximum (104 CFU/100 ml) for samples collected following "no rainfall," while 59% of these stations exceeded the limit following a rainfall (see bottom of Table 2). Graph 1 illustrates the percentage of samples that exceeded the recommended enterococcus maximum. A similar trend was shown - only 7% of samples following no rain exceeded the limit, while 44% of the samples following a heavy rain exceeded the limit.

Using Florida Healthy Beaches standards, four stations were deemed acceptable, six stations were moderate, and seven stations were poor when analyzing "Total Samples Taken from Station." Analysis of "No Rain Samples" revealed that 12 stations were deemed acceptable, five stations were moderate, and no station was poor. "Heavy Rain Samples" revealed that only three stations were deemed acceptable, four stations were moderate, and 10 stations were poor. There was high variability for enterococcus density within individual stations as reflected in high standard errors (not presented in this report).

Dissolved Oxygen, Temperature, and Salinity
Most fish, crustaceans, and other marine organisms require oxygen. When dissolved oxygen falls below certain levels, these organisms become stressed or die. When waters are enriched with high levels of nutrients, benthic algae and phytoplankton may grow at high rates. As these organisms die, bacteria take up oxygen as they decompose organic matter. Canal systems with contaminants such as high nutrient, bacterial, or viral levels often demonstrate diminished dissolved oxygen levels that stress aquatic organisms. Florida State Statute 62-302.530 states that dissolved oxygen levels in marine waters "shall never be less than 4.0 mg/l."

Table 3 illustrates the average canal dissolved oxygen levels recorded from the surface and at depth in each canal station. All readings were conducted with a YSI Dissolved Oxygen meter in the early to late morning (7:30 AM-12:00 PM). Dissolved oxygen levels are often lower near the bottom, where most of the decomposition occurs. After averaging the two values from each site, it was determined that the average of four stations fell below the acceptable limit of 4.0 mg/l. The lowest value was 2.18 mg/l (station #17); the highest was 5.91 mg/l (station #11). The average dissolved oxygen level in the series of canals was determined to be 3.52 mg/l, which fell below the acceptable limit. The standard error within and between stations was low.

Table 1 (see text for explanation)

Florida Keys Watch Stations	Site #	Mile Marker	Public/Private
Boca Chica, Boca Chica Ocean Shores	1	10	Public
Big Coppitt, Porpoise Point	2	10	Private
Saddlebunch Keys, Bay Point	3	15	Public
Sugarloaf Key, Sugarloaf Shores	4	17	Private
Cudjoe Key, Cudjoe Gardens	5	21	Public
Cudjoe Key, Cutthroat Estates	6	22	Private
Big Pine Key, Eden Pines	7	30	Private
Big Pine Key, Whispering Pines	8	31	Public
Marathon, 27th Ave	9	48.5	Private
Marathon, Dolphin Dr.	10	51	Public
Duck Key	11	61	Private
Conch Key	12	63	Public
Islamorada, Port Antigua	13	74.5	Private
Tavernier, Banyan Lane	14	92	Private
Key Largo, Rock Harbour	15	98.5	Private
Key Largo, Pimlico Lane	16	103	Private
Key Largo, Sexton Cove Estates	17	105.5	Private

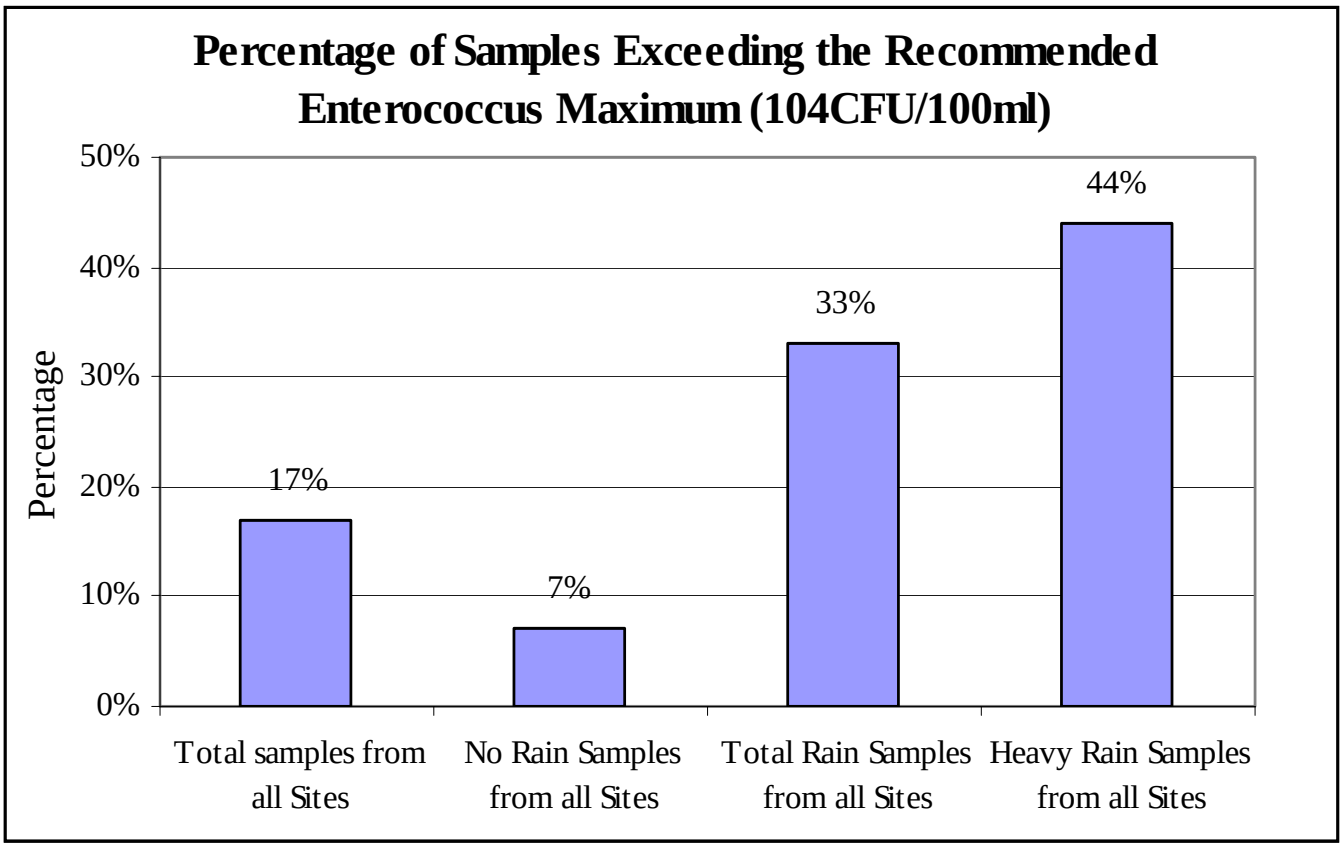
Table 2 (see text for explanation)

Enterococcus Averages (CFU/100 ml)

Station Identification	Total Samples from Station	No Rain Samples	Total Rain Samples	Heavy Rain Samples Only
#1, Boca Chica, Ocean Shores	**687.9**	9.4	**1477.3**	**3585.4**
#2, Big Coppitt, Porpoise Point	**447.7**	22.0	**944.3**	**2759.0**
#3, Saddlebunch Keys, Bay Point	**753.4**	65.3	**1441.4**	**2826.1**
#4, Sugarloaf Key, Sugarloaf Shores	**262.1**	10.7	**513.5**	**1154.7**
#5, Cudjoe Key, Cudjoe Gardens	59.1	13.0	99.4	**133.0**
#6, Cudjoe Key, Cutthroat Estates	**231.7**	15.1	**447.6**	**865.3**
#7, Big Pine Key, Eden Pines	**151.8**	6.3	**297.4**	**378.0**
#8, Big Pine Key, Whispering Pines	61.9	48.4	89.7	45.1
#9, Marathon, 27th Ave	7.4	5.6	13.5	10.0
#10, Marathon, Dolphin Dr.	61.8	21.6	**152.4**	52.0
#11, Duck Key	5.8	5.6	6.7	10.0
#12, Conch Key	58.9	65.1	36.3	52.0
#13, Islamorada, Port Antigua	5.8	2.8	12.6	30.5
#14, Tavernier, Banyan Lane	98.5	38.7	**189.5**	**412.0**
#15, Key Largo, Rock Harbour	26.7	26.8	26.4	85.5
#16, Key Largo, Pimlico Lane	77.2	40.1	**170.1**	**335.0**
#17, Key Largo, Sexton Cove Estates	**228.0**	11.7	**876.8**	**2459.5**
Ave. enterococcus levels for all stations	**189.7**	24.0	**399.7**	**893.7**
% Stations exceeding 104 CFU/100 ml	41%	0%	59%	59%

Note: bold values represent enterococcus averages that exceeded 104 CFU/100 ml.

Graph 1 *(see text for explanation)*



	Total samples from all Sites	No Rain Samples from all Sites	Total Rain Samples from all Sites	Heavy Rain Samples from all Sites
Number of Samples	231	144	89	36
# of Samples Exceeding 104 CFU	39	10	29	16
% of Samples Exceeding 104 CFU	17%	7%	33%	44%

Table 3 (see text for explanation)

Dissolved Oxygen, Temperature, and Salinity Averages

Station Identification	Dissolved Oxygen (mg/l)	Temperature (C)	Salinity (ppt)
#1, Boca Chica, Ocean Shores	4.77	27.2	36.2
#2, Big Coppitt, Porpoise Point	5.34	26.2	36.2
#3, Saddlebunch Keys, Bay Point	4.38	26.0	36.9
#4, Sugarloaf Key, Sugarloaf Shores	5.55	26.1	36.2
#5, Cudjoe Key, Cudjoe Gardens	5.08	26.3	36.2
#6, Cudjoe Key, Cutthroat Estates	**3.64**	26.6	35.6
#7, Big Pine Key, Eden Pines	4.13	26.8	32.8
#8, Big Pine Key, Whispering Pines	**2.25**	26.1	34.9
#9, Marathon, 27th Ave	4.59	26.7	36.6
#10, Marathon, Dolphin Dr.	4.22	26.4	37.2
#11, Duck Key	5.91	26.0	37.1
#12, Conch Key	5.21	25.7	36.6
#13, Islamorada, Port Antigua	5.23	27.1	36.8
#14, Tavernier, Banyan Lane	4.31	23.4	35.5
#15, Key Largo, Rock Harbour	4.37	26.3	29.2
#16, Key Largo, Pimlico Lane	**3.39**	26.5	26.2
#17, Key Largo, Sexton Cove Estates	**2.18**	26.9	28.2
Ave. DO, Temp, and Salinity	4.39	26.3	34.6

Note: bold values represent dissolved oxygen averages that were below the 4.0 mg/l standard.