Water Quality Assessment for the Town of Caswell Beach, 2008

UNCW-CMS Report 08-02

Report to:

Town of Caswell Beach
1100 Caswell Beach Rd.
c/o Mr. Jim Carter, Town Administrator
Caswell Beach, N.C. 28465

By

Michael A. Mallin, Ph.D., and Matthew R. McIver
Center for Marine Science
University of North Carolina Wilmington
5600 Marvin K. Moss Lane
Wilmington, N.C. 28409
910 962-2358
mallinm@uncw.edu

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Background

The Town of Caswell beach has recently had a master stormwater management plan developed. Part of this plan was to have the town's surface water quality tested for common pollutants at three locations. As such, the Town contracted with the University of North Carolina Wilmington's Center for Marine Science to perform this water quality analysis. The research was carried out by Dr. Michael Mallin's laboratory, the Aquatic Ecology Laboratory.

Sampling Locations

The investigation involved sampling three locations on three occasions in Tiny Piney Creek during 2008 (Figure 1). Samples were collected January 15, July 23, and October 27, 2008. Station CAS-YW is a system inflow site and was collected in the creek at Yaupon Way where the water leaves a golf course pond (Plate 1). The second site, CAS-PD, was in the middle of a developed area on Pinehurst Drive where the creek passes under a bridge near a spray aerator (Plate 2). The third site, CAS-AA, was accessed from residential yards along Alyssum Avenue and located in the salt marsh in the creek where it leaves the development to enter the estuary, but before it enters Piney Point Creek (Plate 3). GPS coordinates of the stations are in Table 1.

Table 1. GPS coordinates for UNCW sampling stations in Caswell Beach.

CAS-YW	N 33 54.305	W 78 04.070
CAS-PD	N 33 54.290	W 78 03.832
CAS-AA	N 33 54.517	W 78 03.674

Methods

Water samples were collected and then analyzed at the UNC Wilmington Center for Marine Science for total nitrogen, nitrate, total phosphorus, orthophosphate, and fecal coliform bacteria. On site, physical parameters including water temperature, conductivity, salinity, dissolved oxygen, pH and turbidity were analyzed using YSI multi-parameter instrumentation. Nitrogen and phosphorus samples were processed using an Auto Analyzer following USEPA protocols. Samples of fecal coliform bacteria were collected on site and analyzed in the laboratory within six hours of collection. Laboratory analyses were by Standard Methods (APHA 1995). The State of North Carolina has standards for human health in swimming waters that include 200 colony forming units (CFU) per 100 ml of water for fecal coliform bacteria. Additionally, the U.S. Public Health Service standard for shellfishing waters is 14 CFU/100 ml of fecal coliform bacteria.

Results

Water temperature – There was a notable increase in water temperature as the creek passed through the golf course and the community and entered the salt marsh. Presumably the lower temperatures were due to groundwater inputs, and the temperature increases were due to warming by sunlight. Although samples were taken in January and July, extremes of cold or hot temperature were not found in our sampling (Table 2).

Salinity – Sites CAS-YW and CAS-PD were essentially fresh water, ranging from 0.2 to 0.4 ppt (parts per thousand) salinity. The salt marsh site, CAS-AA, had deep enough water in January and July that there was a freshwater lens sitting atop of salty water: this situation is called salinity stratification in the scientific literature. In January the surface water was 1.4 ppt and the bottom water was 28.8 ppt, while in July the surface water was at 2.0 ppt and the bottom water was at 33.4 ppt. In October the water was too shallow to show salinity stratification. Surface water salinities are reported in Table 2.

Dissolved oxygen – Fish and other aquatic organisms require sufficient dissolved oxygen (DO) in the water to survive and stay healthy. Dissolved oxygen concentrations at CAS-YW were low on all three occasions sampled, ranging from 2.2 – 4.8 mg/L (mg/L are milligrams per liter, which is the same as ppm or parts per million). The North Carolina standard for brackish water and fresh, non-swamp waters is 5.0 mg/L. Since there was obvious plant growth in the stream and subsequent oxygen-producing photosynthesis (Plates 1 and 4), we suspect that DO is low due to groundwater inputs, which are often low in DO in coastal North Carolina. DO was still low in general as the waters reached CAS-PD, although somewhat higher possibly due to mechanical aeration as well as photosynthesis by plants in the water. At CAS-AA the DO was highest of the three sites (Table 2). We note that the salinity stratification mentioned above affected DO concentrations. In January the fresher surface water had a DO reading of 8.5 mg/L while the saltier bottom water had a DO reading of 6.7 mg/L. In July the fresher surface water had a DO reading of 4.4 mg/L while the saltier bottom water had a DO reading of 3.4 mg/L. Thus, this creek system is characterized by generally low dissolved oxygen concentrations.

Turbidity – Turbidity is a measure of the cloudiness of the water, and is usually caused by dirt running into the stream following a storm. It is often most elevated near construction sites where the trees and other vegetation has been removed and erosion of the land occurs. North Carolina has a freshwater standard of 50 NTU (Nephelometric turbidity units) and a salt and brackish water standard of 25 NTUs. All three sites maintained turbidity levels well below the state standard (Table 2). The highest recorded was 13 NTU at CAS-YW in July.

Nitrate – Nitrate is a form of inorganic nitrogen that is often associated with fertilizer runoff from golf courses and urban situations. Nitrate concentrations were highest at our upper station CAS-YD, and approximately equal to each other at the two other sites farther downstream (Table 2). It is notable that nitrate concentrations in Tiny Piney Creek are high in general, compared with the upper portions of urban tidal creeks in the Wilmington area (Mallin et al. 2004) and some urban freshwater streams in the city of Wilmington (Mallin et al. 2002). Locally, the nitrate concentrations in this creek were exceeded only by certain golf course streams in New Hanover and Brunswick Counties (Mallin and Wheeler 2000).

Total nitrogen – Total nitrogen is the sum of organic nitrogen plus inorganic nitrogen (which consists of nitrate and ammonia). Nitrogen can come from fertilizer, sewage, septic leachate, stormwater runoff, atmospheric deposition (i.e. acid rain) or may come from groundwater. Table 2 shows a pattern of decreasing nitrogen concentrations from upper Tiny Piney Creek downstream toward the estuary. The source(s) near the upper end are probably either golf course fertilizer or groundwater inputs, and nitrogen is used up (taken up) by the vegetation and algae in the creek as it flows through the golf course and housing development to the estuary. The concentrations are not excessive in any of the areas, however.

Orthophosphate – Orthophosphate is the main inorganic form of phosphorus. Concentrations increased as Tiny Piney Creek passed through the golf course and housing development; however, concentrations in general were low at all sites (Table 2).

Total phosphorus – Total phosphorus is the sum of organic phosphorus and inorganic phosphorus (which is largely orthophosphate). Its sources are sewage, septic leachate, domestic or wild animal manure on the landscape that enters the creek during stormwater runoff, and soils, where it is subject to erosion. The concentrations are lowest at the upper end of the creek, peak in the middle and decrease at the headwaters of the estuary (Table 2). It is likely that some phosphorus enters the stream from stormwater runoff, but concentrations are low in all areas.

Fecal coliform bacteria – Fecal coliform bacteria are commonly used as indicators of the amount of fecal microbial contamination in a water body. The United States Public Health Service has a standard of 14 CFU (colony forming units) of fecal coliforms per 100 mL of water for shellfishing waters. The State of North Carolina has a standard of 200 CFU/100 mL for human contact in fresh waters (beach waters currently use a different organism, *Enterococcus*, as an indictor organism). Based on our data, this creek has a significant problem with high fecal coliform bacteria counts. Counts were well above the standard at CAS-AA on all three occasions sampled (Table 2). At CAS-YW they were next highest, exceeding the NC standard twice, while at CAS-PD they were lowest, although also exceeding the standard twice (Table 2).

Discussion and Conclusions

Based on limited data (three sampling periods) Tiny Piney Creek has substandard water quality in terms of low dissolved oxygen. The low dissolved oxygen may be a matter of groundwater inputs that are naturally low in DO entering the creek – this can be investigated if the Town chooses to. If it is a natural occurrence the Town may be able to alleviate this situation by aeration near the upper portions of Tiny Piney Creek.

As mentioned, nitrate concentrations are relatively high in Tiny Piney Creek, higher than in nearby tidal creeks or urban streams, but on a par with some golf course streams. Thus, it is likely that golf course fertilizers contribute to the elevated nitrate in this creek. Orthophosphate, as well as total phosphorus, was in low concentrations throughout Tiny Piney Creek

Researchers often use a nitrogen-to-phosphorus ratio to determine which nutrient (N or P) will likely stimulate algal blooms in an aquatic system. Algae have an N/P ratio of 16. The overall N/P ratio in Tiny Piney Creek in our limited sampling was 60, which means that nitrogen is in abundance over phosphorus, so phosphorus inputs are likely to stimulate algae growth. However, since phosphorus is in low concentrations, algal blooms should not normally be a problem. We ran several tests to check the algae biomass (as chlorophyll *a*) in the creek. The results ranged from 1 to10 µg/L, which are low concentrations and do not represent an algal bloom problem. Thus, the low phosphorus inputs are probably helping to keep algal growth low. Continued efforts to clean up pet waste would help to keep phosphorus runoff out of the water.

The creek has a problem with high fecal bacteria counts, and solutions to such a problem may be complex. High fecal bacteria counts can be caused by incomplete treatment in septic systems, which is a common problem in coastal areas that have sandy soils and a high water table. If there are any remaining septic systems near the upper creek this could be an issue. We understand the golf course is hooked up to the Oak Island system and their sewage is piped away. The development adjoining the golf course has its sewage treated by a package plant. If the plant malfunctions on occasion high fecal counts can result. Otherwise, leaking sewer lines and pump stations can be problematic in areas where waste is piped elsewhere for treatment (this has been a frequent recent occurrence in Wilmington). In situations where septic or sewer problems are not occurring, elevated fecal bacteria counts in water bodies can result from stormwater runoff. Potential stormwater drainages were observed and photographed along the upper golf course pond above Yaupon Way (Plate 4) and in the pond just downstream of Yaupon Way (Plate 5). Pet manure on the landscape, as well as manure deposited by urban wildlife can create reservoirs for fecal bacteria that are released into nearby streams when rainfall occurs. Dog manure and manure from bird flocks was observed along the pond downstream of Yaupon Way (Plate 5) and wild animal feces near the creek in the estuary by CAS-AA.

Recommendations

The upper end of Tiny Piney Creek (Figure 1) should be sampled for dissolved oxygen concentrations to see if there are groundwater springs contributing water with low dissolved oxygen to the creek and estuary. The Town can then decide what action, if any, can or should be taken. Since nitrate concentrations are high, the Town can determine if it originates from groundwater sources in the upper creek or is solely from golf course runoff; the answer to this can guide any further action. Since phosphate concentrations are low in the creek, continued efforts to pick up pet waste will help ensure that algal blooms in the creek are kept to a minimum.

The most pressing issue is the high fecal bacteria counts in Tiny Piney Creek, throughout its length. We do recommend that the town investigate the sources of this contamination. The UNCW Center for Marine Science is currently performing fecal bacteria source tracking for New Hanover County and the Town of Wrightsville Beach, and would be pleased to assist the Town of Caswell Beach in such an endeavor.

References

APHA. 1995. Standard Methods for the Examination of Water and Wastewater, 19th ed. American Public Health Association, Washington, D.C.

Mallin, M.A. and T.L. Wheeler. 2000. Nutrient and fecal coliform discharge from coastal North Carolina golf courses. *Journal of Environmental Quality* 29:979-986.

Mallin, M.A., S.H. Ensign, T.L.Wheeler and D.B. Mayes. 2002. Pollutant removal efficacy of three wet detention ponds. *Journal of Environmental Quality* 31:654-660.

Mallin, M.A., D.C. Parsons, V.L. Johnson, M.R. McIver and H.A. CoVan. 2004. Nutrient limitation and algal blooms in urbanizing tidal creeks. *Journal of Experimental Marine Biology and Ecology* 298:211-231.

Table 2. Water quality summary data for the Town of Caswell Beach, 2008, presented as average + one standard deviation / range. For fecal coliforms the geometric mean / range is presented.

Station	CAS-YW	CAS-PD	CAS-AA
Water temperature (degrees C)	17.8+9.5 8.1-27.1	19.4+9.5 10.0-29.0	20.3+11.3 8.8-31.4
Salinity (ppt)	0.3+0.1 0.2-0.4	0.4+0.1 0.3-0.4	2.0+0.6 1.4-2.6
Dissolved oxygen (mg/L)	3.1+1.5 2.2-4.8	3.9+2.2 2.1-6.3	6.4+2.1 4.4-8.5
Turbidity (NTU)	6.3+5.8 3.0-13.0	3.0+1.0 2.0-4.0	5.3+3.3 3.0-9.0
Nitrate (µg/L)	676.4+563.0 329.0-1,326.0	404.6+438.6 13.7-879.0	460.6+200.6 324.0-691.0
Total nitrogen (µg/L)	1,319.6+37.4 1,293.1-1,346.0	957.1+336.1 719.5-1,194.8	788.1+266.8 599.5+976.8
Orthophosphate (µg/L)	4.8+2.4 2.1-6.5	13.2+4.5 9.0-18.0	20.6+12.5 10.7-34.6
Total phosphorus (µg/L)	28.4+16.8 16.5-40.2	46.8+29.0 26.3-67.3	37.4+12.4 28.6-46.2
Fecal coliform bacteria (CFU/100 mL)	517 190-1,040	197 88-415	1,266 830-2,360

Figure 1. Location of UNCW sampling stations along Tiny Piney Creek in Caswell Beach (path of the stream is enhanced by darkened line).

Plate 1. Left – Pond and stream leading into station CAS-YW (right).

Plate 2. Left - Tiny Piney Creek leading into Station CAS-PD (right).

Plate 3. Left -Dock near Station CAS-AA, in upper estuary (right).

Plate 4. Golf course pond upstream of CAS-YW (left), intermittent stream entering pond upstream of CAS-YW (middle), stormwater drain entering pond upstream of CAS-YW (right).

Plate 5. Drainage pipe entering pond below CAS-YW (left), Ibis (and ibis manure) along pond below CAS-YW (middle), dog manure along shore of pond below CAS-YW (right).