A Comprehensive Water Quality Analysis Along the Toms River and Dillon's Creek, New Jersey

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Abstract

The Toms River, which is a main tributary of the Barnegat Bay Watershed, is an important system for numerous species of plants and animals. However, the water body has faced several water quality issues, mainly the watershed's eutrophic conditions. Organizations such as the New Jersey Department of Environmental Protection and Save Barnegat Bay (SBB) advocate for monitoring its water quality. The SBB Student Program has conducted a four-year study testing several water quality parameters along the Toms River. Dillon's Creek, a section of the river, has faced some of the highest bacteria levels in past years. In this research, the water quality along Dillon's Creek and Toms River was analyzed to determine its implications for the greater Toms River system and the Barnegat Bay Watershed. Dillon's Creek, while receiving freshwater from Toms River, demonstrates stronger saltwater influences and poor flushing. Almost every Dillon's Creek sampling site exceeded safe swimming levels set by the Environmental Protection Agency, and there were decreases in dissolved oxygen over a four-year period in four Toms River sites. Furthermore, residential and recreational areas remain susceptible to variable bacterial changes as winter levels had lower geometric means with large ranges. The northern sampling location displayed the greatest geometric mean while nitrate means ranged from 29.0 to 33.4 ppm. Future research should focus on determining nonpoint and point sources for bacteria and nutrient presence, along with further understanding the relationship between Dillon's Creek's input to the Toms River system.

Introduction

- The Toms River, one of the largest subwatersheds of the Barnegat Bay, sustains various ecosystems, including birds, finfish, submerged aquatic vegetation, and tree species (Save Barnegat Bay, 2023a).
- The Toms River has a history of compromised water quality: issues date back to Ciba-Geigy's groundwater pollution, leading to the site's declaration as a Superfund site in 1982 and Toms River Chemical's dye-laden wastewater dumping in the 1960s (National Oceanic and Atmospheric Administration [NOAA], 2021). In an effort to mitigate water quality issues in the Barnegat Bay, the New Jersey Department of Environmental Protection (NJDEP) instituted water quality monitoring programs at two sites near the mouth of the Toms River, mapping stormwater drainage and collecting long-term water quality (NJDEP, 2017).
- The presence of bacteria in water bodies can impact human and animal health, and there are several bacteria classifications to understand the wellbeing of a water system. Total coliform refers to gram-negative bacteria that are not always associated with warm-blooded animals but is still used to identify unclean waters (United States Geological Survey [USGS], 2018). Fecal coliform, a subgroup of total coliform bacteria, can group at 44.5°C, differentiating them from other total coliforms, acting as an indicator for fecal matter from warm-blooded animals (USGS, 2018).
- *Escherichia coli* and *Enterococcus* are bacteria that are found in the gastrointestinal tract of warm-blooded animals. *E. coli* is a common human bacteria and is found in high numbers in human sewage (Dungan & Bjorneberg, 2021).
- Dillon's Creek is a main tributary of the Toms River, located in Island Heights and at the mouth of the estuarine system. It is surrounded by its corresponding marina, where 216 docks line the water body (Dillon's Creek Marina, 2023).
- An ongoing three-year study between Clean Ocean Action and Save Barnegat Bay (SBB) focuses on pinpointing sanitary pollution sites and hot-spot areas; through the initiative, Dillon's Creek consistently yielded the greatest mean bacterial levels among sample sites (SBB, 2023b).
- Analyzing the presence of various human signatures and water quality parameters, both physical and bacterial, may lead to an increased understanding of anthropogenic influences in the greater Toms River and Barnegat Bay system.

Figure 1: Water sampling and bacterial testing. Water samples were retrieved using a sampling pole (left). Samples were stored and refrigerated until tested *ex situ* for bacteria (right).

Methodology

Data Collection

Water sampling was conducted on Wednesdays and Saturdays at 1700 GMT from November 16 to December 27, 2022, at five sites along Dillon's Creek in Island Heights, New Jersey. Samples were collected in sterile plastic bags. *E. coli* was measured using 2 mL of a water sample that was pipetted into a Coliscan Easygel® medium and poured into a pretreated plate (**Figure 1**). After the plates were incubated at 37±2°C for 24 hours, colonies were counted. Nitrates were quantified using Nitrate TesTabs®. Historical data of water quality at Dillon's Creek and the Toms River was retrieved from SBB's 2019–2022 Student Grant Program. Water sampling and bacterial methods were the same as above.

Data Analysis and Geographic Information Systems (GIS) Applications

E. coli geometric means were calculated for both the SBB data and the collected water samples from November and December, 2022. ArcGIS Pro was used to display the data from SBB and the collected water samples. GeoTIFF satellite images of the sampling areas were retrieved from the New Jersey Geographic Information Network, and a "New Jersey Water Bodies" shapefile from the NJDEP was used to display the water bodies in the satellite images. Coordinate points of each sampling location were used to display findings (**Figures 2 & 3**).

Objective

To gain a basic understanding of historical water quality along the Toms River and Dillon's Creek by analyzing various parameters. To understand implications for the greater Toms River system and Barnegat Bay Watershed for future management strategies.

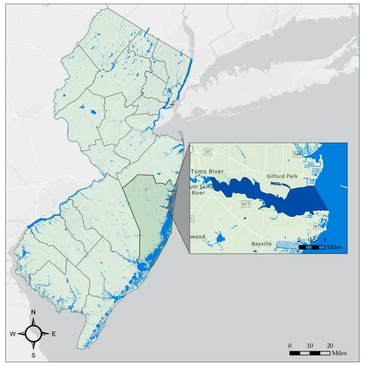

Figure 2: Relative location of Toms River, New Jersey. The Toms River, which is 41.7 miles long and 124 square miles, is a main tributary and subwatershed of the Barnegat Bay, which is a main watershed of Ocean County, New Jersey.

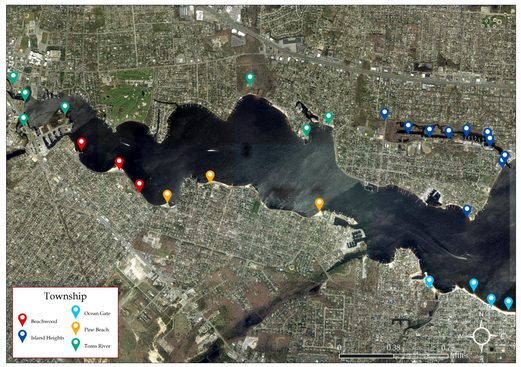

Figure 3: Sample sites used during the Save Barnegat Bay Student Grant Program, 2019–2022. Five townships were represented throughout the project: Toms River, Beachwood, Island Heights, Pine Beach, and Ocean Gate (*n* = 546).

Figure 4: *E. coli* and total coliform findings using the Coliscan Easygel® method on December 17, 2022 at Lake Avenue (L). Total coliform was valued 500 CFU/100 mL. The ubiquitous red coloring may be compounded by a modified reagent and setting time.

Figure 5: Salinity mean gradient (ppt) throughout the Toms River. The values increase from west to east towards the Barnegat Bay. Dillon's Creek, while receiving freshwater influence, maintains higher salinity means than other freshwater-affected areas (*n* = 546).

Figure 6: *E. coli* geometric means (CFU/100 mL) at Dillon's Creek historical sample sites. The tributary was tested from 2020–2022. The radii of the buffers (0.125 mi) extend to the residential areas lining the area and designate the sites of most immediate concern (*n* = 123).

Figure 7: *E. coli* geometric means (CFU/100 mL) along the Toms River, New Jersey. Locations were analyzed according to the Environmental Protection Agency's bacterial level regulations for freshwater swimming beaches (*n* = 466).

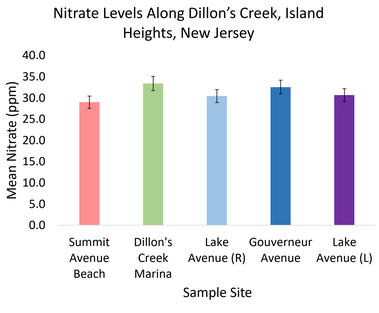

Figure 8: Nitrate means (ppm) along Dillon's Creek winter 2022 sample sites. No significant difference was found among sample sites, but their elevated presence suggests poor flushing along Dillon's Creek and exacerbated influence on *E. coli* growth (ANOVA, $p = 0.159$, $\alpha \leq 0.05$, $n = 180$).

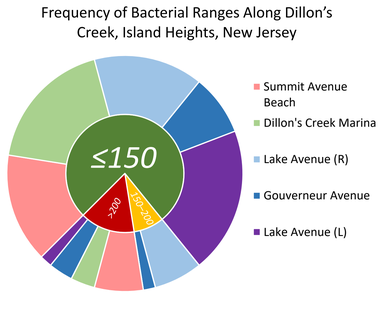

Figure 9: Frequency of bacterial count (CFU/100mL) along Dillon's Creek 2022 winter sample sites. Findings were categorized into three categories, the red ">200" signifying unsafe swimming conditions. Four of the five sample sites yielded unsafe bacterial levels throughout the study (*n* = 60).

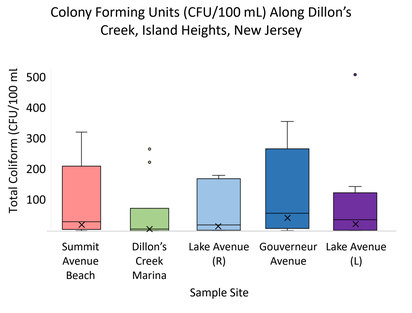

Figure 10: Bacterial presence (CFU/100 mL) along Dillon's Creek 2022 winter sample sites. Gouverneur Avenue yielded the greatest geometric mean of 32.5, suggesting further investigation into the northern end of the Creek along with its impacts on surrounding residential areas (*n* = 60).

Discussion

- Salinity values along the Toms River generally increase towards Barnegat Bay (**Figure 5**). However, Dillon's Creek demonstrates salinity values greater than the rest of the Toms River, advancing the poor flushing of the water value regardless of inland freshwater influence (Hall, 2020). As *Enterococcus* demonstrates a higher survivability in saline waters, further investigation should be made to investigate its presence in this water body (Dorman & Bjorneberg, 2021).
- Marinas can contribute to exacerbated bacterial levels via poorly maintained sanitary waste systems and pump-out stations (NOAA, 2023). However, as displayed in **Figure 6**, the two sites in the marina did not yield the greatest bacterial levels in the creek, as they are the areas of lowest concern relative to the rest of the sample sites.
- Bacterial findings along Dillon's Creek appear different during the summer, as the historical sample sites along Dillon's Creek demonstrate that the area is unsafe for recreational swimming (**Figure 7**).
- Mean nitrate levels ranged from 15.7 to 48.0 ppm throughout the study. Summit Avenue Beach yielded the lowest mean nitrate of 29.0 ppm, while Dillon's Creek Marina yielded the greatest of 33.4 ppm (**Figure 8**).
- A study conducted by the USGS and Barnegat Bay Partnership (BBP) found that the Toms RIver had the highest total nitrogen concentrations in the watershed, the majority being nitrates. These nitrates' isotopes were consistent with those found in fertilizer sources and waste (USGS & BBP, 2013). Another Barnegat Bay study found that total nitrogen loads, when omitting atmospheric deposition, is almost five times higher than widespread development, suggesting that elevated levels of nitrates are due to urbanization and fertilizer use (Kennish et al., 2012).
- Bacterial analysis along Dillon's Creek suggests variability, specifically among seasons: during winter sampling, it was found that the geometric means of the sample sites did not exceed 40.0 CFU/100 mL, while **Figure 9** demonstrates that all sites except Lake Avenue (L) had separate accounts of bacterial measures exceeding the Environmental Protection Agency (EPA)'s 200 CFU/100 mL standard for freshwater (EPA, 1986). This suggests that these sites are susceptible to closures should it be considered a public swimming area.
- The magnitude and variability in bacterial levels along Dillon's Creek poses threats to the safety of surrounding residential areas, specifically regarding the bacterial presence at Gouverneur Avenue. The site yielded the greatest geometric mean of 32.5 CFU/100 mL (**Figures 10 & 11**). Furthermore, the Summit Avenue beach is located east of the creek's mouth. While open to the public for swimming, the geometric means of the two sample sites were 299.5 and 372.7 CFU/100 mL, both exceeding the EPA standard (**Figure 7**).
- The most westward sample site—Central Avenue—contained an *E. coli* mean greater than 2000 CFU/100 mL. Central Avenue is located on a freshwater tributary of Dillon's Creek, extending further inland into Island Heights. These magnified bacterial levels may indicate a high presence of waterborne pathogens; contaminated recreational waters were linked to gastrointestinal illnesses caused by species such as *Shigella* spp. (Pandey et al., 2014).

Figure 11: Gouverneur Avenue and Dillon's Creek Marina (right) sampling sites, 2020–2022. Gouverneur Avenue had higher bacterial geometric mean values than the marina in this study, although it was predicted that the marina would have higher bacterial values.

Conclusion

The Toms River provides economic outlets for surrounding municipalities: yacht clubs, recreational fishing, and tourism contribute to the success of the area. While the greater Toms River demonstrates water quality parameters, certain areas, specifically Dillon's Creek, require further water quality studies. Data from the SBB Student Grant Program suggests susceptibility for bacterial infestation and threats to residential and recreational areas. Investigations should be conducted along Dillon's Creek to determine the nonpoint and point sources relating to both the bacterial and nutrient loads present in the water. The potential for qPCRs for bacterial testing may be beneficial for long-term studies and monitoring at waterside communities. While qPCR testing was initially planned for this study, collaboration with a laboratory posed both financial and liability concerns. Environmental, legislative, residential, and government groups may become obligated to further investigation into the area, limiting accessibility towards amendments towards these phenomena. Furthermore, surrounding wastewater systems and residential fertilizer use may provide information regarding contribution to the current water quality. Long-term and seasonal studies, especially on the northern side of Dillon's Creek, may also suggest the impact of waterfowl and anthropogenic activities. Case studies should also be implemented along Toms River to investigate the implication of poor water quality areas towards the greater Barnegat Bay system.

Selected References

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