



Bacterial source tracking guides management of boat head waste in a coastal resort area

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ABSTRACT

Fecal contamination of water bodies causes a public health problem and economic loss. To control such contamination management actions need to be guided by sound science. From 2007–2009 a study was undertaken to determine the sources of fecal bacteria contamination to the marine waters adjoining the Town of Wrightsville Beach, North Carolina, USA. The research effort included sampling for fecal coliform and *Enterococcus* bacteria, sampling for optical brighteners, dye studies, and use of molecular bacterial source tracking techniques including polymerase chain reaction (PCR) and terminal restriction fragment polymorphism (T-RFLP) fingerprinting of the *Bacteroides*–*Prevotella* group. Of the 96 samples collected from nine locations during the study, the water contact standard for *Enterococcus* was exceeded on 13 occasions. The T-RFLP fingerprint analyses demonstrated that the most widespread source of fecal contamination was human, occurring in 38% of the samples, with secondary ruminant and avian sources also detected. Optical brightener concentrations were low, reflecting a lack of sewage line leakage or spills. A lack of sewer leaks and lack of septic systems in the town pointed toward discharge from boat heads into the marine waters as the major cause of fecal contamination; this was supported by dye studies. Based on these data, the Town initiated action to have the U.S. Environmental Protection Agency declare the coastal waters (out to 3 nautical miles), the nearby Atlantic Intracoastal Waterway and its tributaries a no-discharge zone (NDZ) to alleviate the human fecal pollution. The Town garnered supporting resolutions from other local communities who jointly petitioned the North Carolina Department of Environmental and Natural Resources. This State regulatory agency supported the local government resolutions and sent an application for an NDZ to the EPA in April 2009. The EPA concurred, and in February 2010 the coastal waters of New Hanover County, NC, became the first marine area on the U.S. eastern seaboard between Delaware and the Florida Keys to be declared a no-discharge zone.

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1. Introduction

Environmental degradation of a recreational area can lead not only to ecological impacts, but can cause economic loss as well. This is especially true when public health is involved; for example, contaminated beach water can cause a significantly increased incidence of illness among beachgoers including vomiting, diarrhea, fever, etc. (Alexander et al., 1992). Gastrointestinal illness and eye, ear and respiratory infections contracted from beach waters can also lead to a significant economic burden (Dwight et al., 2005). Eating shellfish contaminated with fecal microbes causes various

illnesses to consumers (Wittman and Flick, 1995), and closures of shellfishing beds to harvest from fecal contamination leads to significant economic losses (Mallin, 2009). In resort areas, people recreate on and within local water bodies in multiple ways, such as swimming, surfing, diving, water skiing, boating, kayaking, fishing, wildlife tours, etc. One such area is Wrightsville Beach, North Carolina, USA, which has been considered a resort area since 1899, and has had an operational yacht club since 1856. In recent years waters within town limits have had an increasing number of water contact warnings posted by the North Carolina Division of Environmental Health's Shellfish Sanitation and Recreational Water Quality Office, based on excessive fecal bacteria indicator (*Enterococcus*) counts. Because these postings are distributed not only locally but also to news organizations within inland cities (where many visitors of

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Wrightsville Beach reside) this has led to concern from town administrators and business owners about potential loss of visitor revenues. Because of these concerns the Town of Wrightsville Beach partnered with the University of North Carolina Wilmington in an effort to determine the source(s) of the fecal contamination in order to properly direct management efforts designed to reduce the microbial contamination and subsequent postings.

The Town of Wrightsville Beach is located on a barrier island complex in New Hanover County, adjacent to the City of Wilmington (Fig. 1). It is fronted by the Atlantic Ocean with a series of sounds, including Banks Channel, Motts Channel and the Atlantic Intra-coastal Waterway (ICW) lying adjacent to and within the town (Fig. 1). Land use within the town is primarily residential, including second homes, seasonal and weekend rentals, hotels and commercial establishments. Land within the town is fully developed, although large salt marsh areas occur both within town limits and nearby on the mainland and spoil islands in the ICW. While some shellfishing areas within town limits are open to harvest, others are closed due to excessive fecal coliform bacteria counts. The town has a year-round population of 2600 and a summer population of approximately 15,000, with elevated visitor populations on holidays as well. The town hosts five marinas, with numerous boats at semi-permanent mooring. Harbors and marinas in general have been shown to be focal points of fecal contamination, with concentrations

of fecal contamination indicator microbes increasing during the higher occupancy of holiday weekends (Guillon-Cotard et al., 1998; Sobsey et al., 2003); increases in boat usage in general in relatively confined estuarine areas have also increased the microbiological contamination of the water (Faust, 1982). Wrightsville Beach is a popular stopping point in autumn for boaters passing south on the ICW to winter in warmer climes (often referred to as snowbirds) and those returning boaters in the spring. Sewage is piped onshore and treated at the Lower Cape Fear Public Utility Authority's Southside Wastewater Treatment Plant, located along the shores of the Cape Fear River within the City of Wilmington. There are no active septic systems on the island, causeway, and mainland areas within the town limits.

A number of sources of fecal microbial contamination to other regional waterways have been identified in previous research. These include urban and suburban stormwater runoff (Mallin et al., 2000, 2009), poorly-functioning or improperly placed septic systems (Cahoon et al., 2006), large-scale sewage spills (Mallin et al., 2007), and smaller sewage spills and leaks (Tavares et al., 2008). Human fecal contamination has been found at several mainland tidal creek locations using molecular methods detecting host specific *Bacteroides–Prevotella* groups (Spivey, 2008). Thus, one objective of the research portion of this study was to assess the microbiological water quality at a variety of locations in town waters, looking for any particular loci of elevated pollutant activity (“hot spots”) and assess fecal contamination in light of various environmental parameters. The second objective was to use DNA-based techniques to determine the source or sources of the fecal contamination causing the regulatory postings. The objectives were pursued by sampling the waters for two commonly-used fecal contamination indicators, fecal coliform bacteria and *Enterococcus* bacteria; sampling for optical brighteners; and sampling for accompanying field parameters including water temperature, salinity and turbidity. Molecular microbial source tracking was conducted using polymerase chain reaction (PCR) and T-RFLP fingerprinting of *Bacteroides–Prevotella* group. The overall goal of these two objectives was to provide management guidance for town administrators and regulatory agencies to reduce fecal contamination of the waters of the Town of Wrightsville Beach.

2. Methods

2.1. Sampling design

Nine sites were sampled throughout the course of the study (Table 1). Some stations were chosen based on previous standard violations as determined by State agencies, while other stations were chosen based on human boating activity or dockages. Station WB-CM was located in a commercial marina off Motts Channel, Station WB-WP was at a public-access boat dock in a small town park on Banks Channel near the commercial district where boaters can tie up temporarily, Station WB-CYC was from the dock of the Carolina Yacht Club on Banks Channel, Station WB-JPB was at the U.S. Coast Guard dock on Banks Channel, Station WB-WR was at the boat launch ramp operated by the North Carolina Wildlife Resources Commission on the ICW, Station WB-JM was in the surf on the ocean beach near a popular pier, Station WB-SB was from a private multi-boat dock along the northern reaches of Banks Channel, Station WB-LB was a small private dock on Lollipop Bay, a relatively enclosed bay near the northern portion of Wrightsville Beach, and Station WB-MS was on a dock located at the Wrightsville Yacht Club on the ICW. The beach water station WB-JM was only sampled for seven months; owing to its consistently low fecal indicator counts sampling for the remaining five trips was conducted at WB-MS.

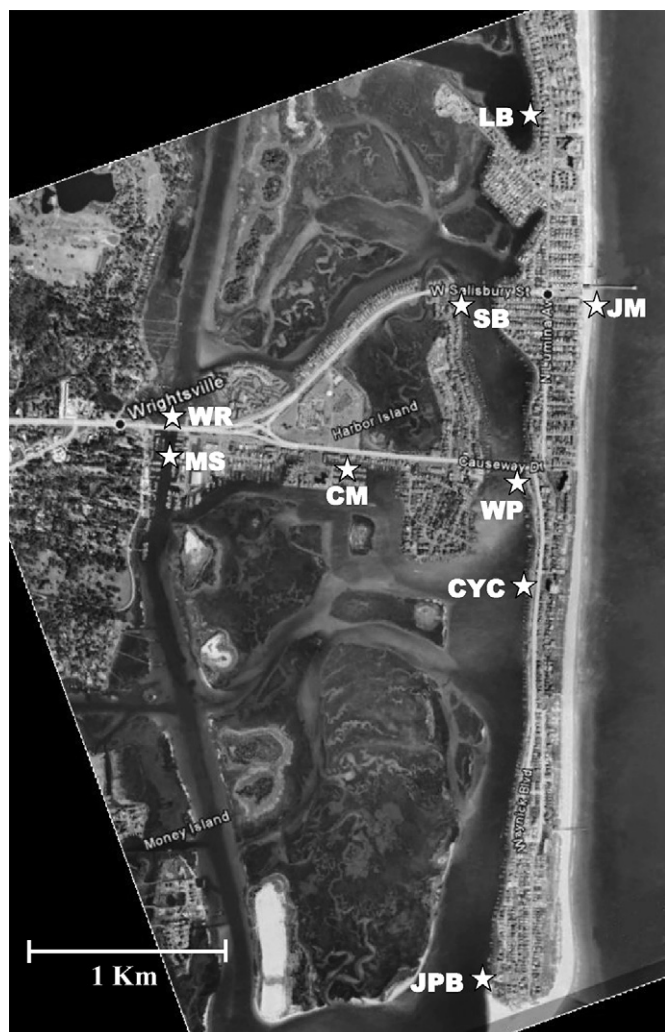


Fig. 1. Map of Wrightsville Beach and surrounding waterways showing sampling stations.

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