Cannon Beach Microbial Source Tracking Study

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Executive Summary

This document reports results from a Microbial Source Tracking study to better understand the potential sources of fecal contamination at Cannon Beach and Tolovana Beach. The work supplements previous sampling and investigations at these beaches where public use is high and fecal bacteria sample results have also been consistently high. Sample collection occurred between June and November of 2022 at both marine and freshwater sites. The Oregon Department of Environmental Quality analyzed for fecal indicator bacteria concentrations in all samples. The samples that met or exceeded the Beach Action Value or water quality standards for marine or freshwater would be analyzed using quantitative Polymerase Chain Reaction, also referred to as qPCR, by the U.S. Environmental Protection Agency's Region 10 lab in Manchester, Washington to determine possible sources of fecal contamination.

Out of 100 samples collected over the entire study area, 21 exceeded the water quality criteria for *Enterococcus* (marine) or the water quality criteria for *E. coli* (freshwater). Samples analyzed by EPA's lab looked for the presence of human, ruminant and dog markers to determine whether those sources of fecal pollution may be present in the three watersheds adjacent to Cannon and Tolovana beaches. Results from the qPCR study showed consistent detection of ruminant and human markers. The number of human markers detected was higher than anticipated. DEQ recommends further investigation to confirm the contamination types in the study area.

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Introduction

Public health agencies, including Oregon's Department of Environmental Quality, regularly test water samples collected from rivers, streams and marine sites across Oregon to measure the level of fecal bacteria, *E. coli* and *Enterococcus sp*. The Oregon Health Authority partners with DEQ to monitor the Oregon Coast for bacteria levels at priority public beaches through the Oregon Beach Monitoring Program, also known as OBMP. OBMP prioritizes beaches with high use and those where OBMP has measured greater concentrations of fecal bacteria. OHA uses data collected by the OBMP to advise beach visitors about the risk of illness associated with exposure to high levels of fecal bacteria. The OBMP has monitored Oregon's beaches for fecal contamination since 2002 and has collected and analyzed more than 20,000 fecal bacteria water samples since then. Elevated fecal bacteria can come from humans (i.e., combined sewer overflows, leaking septic systems and people camping), pets, livestock or wildlife. Understanding contamination types can help resource managers better target contamination sources to mitigate or stop contamination from entering the water. Knowing the contamination sources and developing control measures would decrease the risk of people being exposed to fecal pollution.

Every two years, OBMP conducts a site list assessment to select priority beaches to monitor based on public use and available fecal indicator bacteria results. This assessment process uses data collected from 91 beaches to rank beaches by recreational water contact and bacterial contamination. The 2022 assessment listed Cannon Beach as the highest use beach in Oregon and Tolovana Beach as the fourth highest used. Bacterial contamination scores are based on geometric mean and percent exceedance results for each beach. Geometric mean and percent exceedance results are ranked and assigned scores. The bacteria scores are combined, and the combined bacteria rank is then weighted by the use score to calculate an overall risk. Using this methodology, Cannon Beach was the highest ranked score and Tolovana Beach was the third highest rank score for bacteria (figure 1).

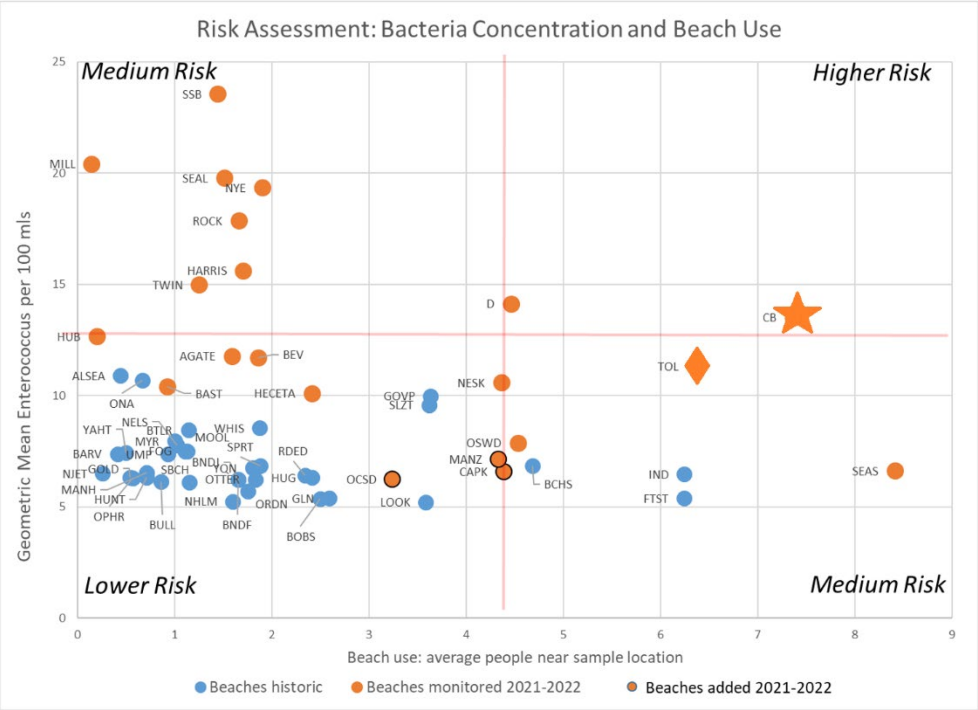

Figure 1: A quadrant scatter plot of the OBMP's site list assessment, used to select priority beaches for monitoring. The assessment plots the beach site based on the geometric mean of *Enterococcus* and average number of people near sample location on the beach. Cannon Beach (CB) is represented by a star, Tolovana Beach (TOL) is represented by a diamond.

The OBMP investigated the tributaries upstream of the marine Cannon Beach sites to better understand the locations for sources of fecal bacteria in 2012. DEQ sampled eighteen sites in the Ecola Creek, Gower Street Creek and Chisana Creek watersheds five times. The purpose of the 2012 investigation was to provide information and guide actions to reduce bacteria at Cannon Beach. The 2012 investigation was successful in identifying areas upstream of beaches with elevated *E. coli* or *Enterococcus* detections; however, due to technological limitations, DEQ was not able to differentiate the type of fecal contamination.

In recent years, technology has advanced, and researchers have developed tools and methodologies to identify specific sources of bacterial contamination (contamination type). Quantitative Polymerase Chain Reaction is a technology used for Microbial Source Tracking. This method uses genetic markers associated with different host species to identify some of the potential sources of fecal bacteria present in water samples with high counts of *E. coli* and *Enterococcus*. Having the ability to identify sources of fecal contamination allows resource managers and city planners to introduce best management practices that target sources to mitigate or eliminate fecal bacteria contamination in water.

As a follow up to the 2012 Cannon Beach Study, DEQ worked with the U.S. Environmental Protection Agency's Manchester lab to investigate the potential source of fecal contamination in the watersheds adjacent to Cannon and Tolovana beaches. The work supplemented the previous sampling at these beaches, where public use and fecal bacteria sample results continue to be high. Sample collection occurred between June and November of 2022 at 10

marine and freshwater sites that are connected to Cannon and Tolovana beaches. DEQ analyzed for fecal indicator bacteria concentrations in all samples. As per the DEQ Sample Analysis Plan, only those samples that met or exceeded the marine or freshwater standards would be analyzed by qPCR at the EPA Region 10 lab to look for potential sources of fecal contamination type.

Methods

Study area

Cannon and Tolovana beaches make up one contiguous beach located along Oregon's north coast. Both beaches fall within the city of Cannon Beach's jurisdiction. The small coastal town stretches nearly four miles long with the beach to the west and Highway 101 near the eastern boundary, which is almost entirely within one mile of the beach. East of town is primarily coast range forestland (figure 2). Three drainages enter the beach:

- **Ecola Creek** is the largest drainage entering the beach. It flows onto the beach near the northern boundary of town. The majority of the Ecola Creek watershed is forestland, but the lower portion of the watershed captures surface water and groundwater flow from the northern part of town. The upstream portion of the basin is a drinking water supply area for the City of Cannon Beach. The wastewater treatment plant for town is located just south of Ecola Creek in the lower watershed.
- **Gower Street Creek** is a small intermittent drainage just south of the Ecola Creek watershed. Gower Street Creek's watershed is primarily within the urban Cannon Beach area with some forestland in the headwaters. Gower Street Creek empties onto Cannon Beach near Ecola Court, a popular beach access point near the center of town.
- **Chisana Creek** is the southernmost drainage and empties onto Tolovana Beach at the Tolovana Beach State Recreation Area access point. The Chisana Creek watershed is similar in size to the Gower Street Creek watershed, but its watershed is more evenly split between forestlands in the upper watershed and urban area in the lower watershed.

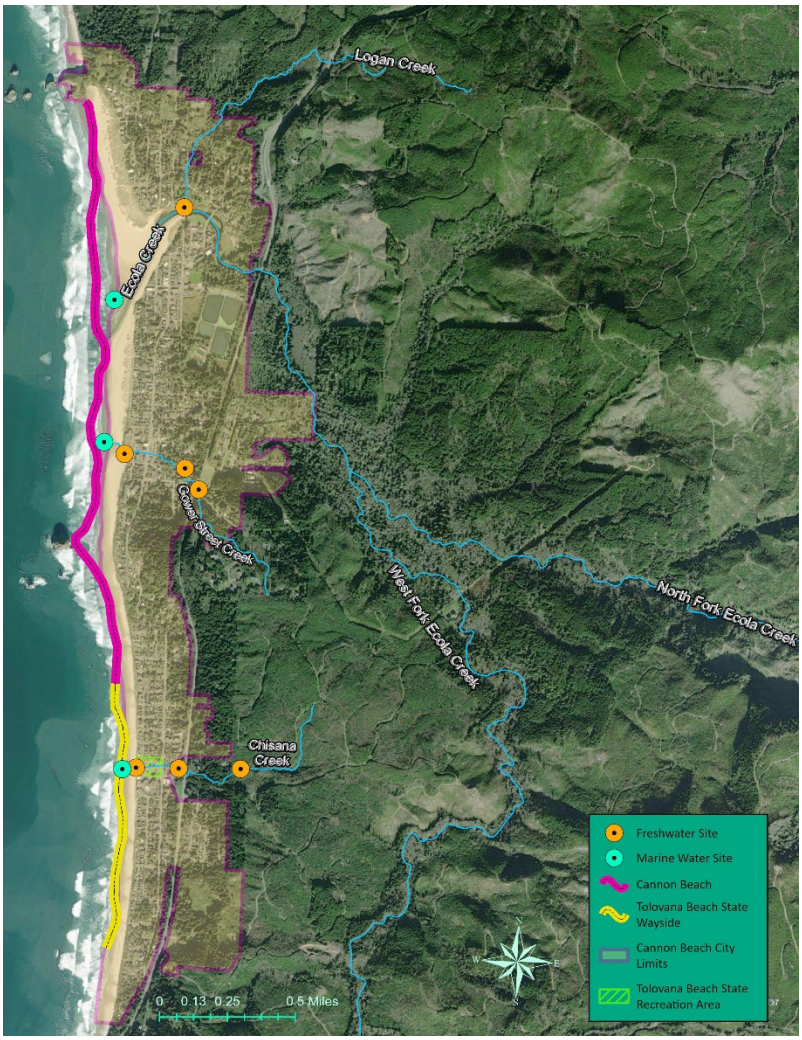

Figure 2: Cannon Beach MST Project Study Area and Sites Map

Study design

This study was built on the 2012 investigation by selecting a subset of the same sites with an emphasis on the drainages that showed the highest fecal indicator bacteria concentrations, also referred to as FIB concentrations. This study extended the timing of the previous study, conducting 10 sampling events between June and November of 2022. DEQ sampled both marine and freshwater sites. DEQ collected the samples in individual sampling vessels as described in the project's sampling and analysis plan (DEQ, 2020). DEQ recorded field measurements of temperature, conductivity and salinity at the time of sampling. Sample location information is summarized in Table 1 and mapped in Figure 2.

Site ID	Name	Latitude	Longitude	Sample Media	Sample Count
29395	Cannon Beach at mouth of Ecola Creek	45.8974	-123.9537	Marine water	10
31536	Ecola Creek at mouth of Logan Creek	45.9025	-123.9599	Fresh water	10

29396	Cannon Beach near Ecola court storm out fall	45.8898	-123.9651	Marine water	10
34608	Gower Street Creek at Ecola Court	45.8893	-123.9638	Fresh water	10
37262	Gower Street Creek from culvert to ditch at E. Dawes Street and Cypress Court	45.8887	-123.9590	Fresh water	10
37260	Gower Street Creek SE of Highway 101, upstream of secondary drainage pipe	45.8876	-123.9581	Fresh water	10
30503	Tolovana State Park Beach at mouth of Chisana Creek	45.8727	-123.9629	Marine water	10
36221	Chisana Creek at Tolovana State Park pipe outflow	45.8726	-123.9623	Fresh water	10
37257	Chisana Creek 40 meters west of Highway 101 upstream of Wayside Inn	45.8727	-123.9586	Fresh water	10
37266	Chisana Creek tributary ditch upstream of residences at E. Warren Way and unnamed road junction at clear cut	45.8728	-123.9539	Fresh water	10

Table 11: Cannon Beach MST Project Site Information.

Recreational water criteria

Bacteria water quality criteria rely on fecal indicator bacteria to establish the risk of illness-causing organisms in the water. FIB are not necessarily illness causing, but their presence does indicate an increased likelihood of a myriad of other illness-causing organisms known to be present in feces.

Enterococcus is the FIB used for the marine water recreational contact criterion, while *E. coli* is used for the freshwater recreational contact FIB. EPA notes that "EPA based its 1986 criteria for recreational marine and fresh waters on observed illness levels in swimmers and corresponding levels of bacterial indicators of fecal contamination, specifically *Enterococcus* and *E. coli* for fresh water and *Enterococcus* for marine water", and "two microorganisms that have consistently performed well as indicators of illness in sewage-contaminated waters during epidemiological studies are *Enterococcus* in both marine and freshwater, and *E. coli* in fresh water measured by culture" (EPA, 2012). EPA also mentions that *E. coli* is viable but nonculturable in marine water.

DEQ and OHA use different water quality criteria for bacteria when administering their respective responsibilities to protect recreational water contact under the Clean Water Act and the BEACH Act. Under the CWA, DEQ uses water quality criteria to assess whether Oregon's waters support beneficial uses like water contact recreation. DEQ develops CWA criteria with guidance from EPA and those criteria must be approved by EPA before being used to designate which water bodies are supporting beneficial uses. For marine waters, DEQ applies a geometric mean criterion and a "Statistical Threshold Value" which is a value that may not be exceeded more than 10% of the time (DEQ, 2016). In freshwater, DEQ uses a similar geometric mean and a single sample threshold.

Under the BEACH Act, recipients of EPA funds to conduct beach monitoring are expected to establish Beach Action Values to protect recreational water contact on ocean beaches. The Beach Action Values are based on guidance from EPA's Recreational Water Quality Criteria for bacterial indicators (EPA, 2012). The Beach Action Value criteria is a single sample threshold that when exceeded, a water contact advisory is triggered until subsequent samples are below the Beach Action Value threshold. Table 2 summarizes the bacteria water quality criteria for both CWA and BEACH Act purposes.

Water Type	DEQ CWA Water Quality Criteria		OHA Beach Action Value
	Geometric Mean Criteria Not to Exceed	Statistical Threshold or Single Sample Not to Exceed	
Coastal Marine	A 90-day geometric mean of 35 *Enterococcus* organisms/100 mL	Not more than 10% samples may exceed 130 *Enterococcus* organisms/100 mL	No single marine sample may exceed 130 *Enterococcus* organisms/100 mL
Non-Coastal Freshwater	A 90-day geometric mean of 126 *E. coli* organisms/100 mL	No single sample may exceed 406 *E. coli* organisms/100 mL	N/A
A minimum of five samples in a 90-day period is required to calculate DEQ's CWA criteria except for the single sample freshwater criterion.			

Table 2: Relevant water quality criteria under Oregon Administrative Rules 340-041-0009 (Oregon Secretary of State, 2016).

Bacteria

This project used EPA-approved methods for quantifying the fecal indicator bacteria *Enterococcus* sp. and *E. coli*. Enterolert and Colilert methods use nutrient indicators that fluoresce when metabolized by fecal indicator bacteria (Idexx, 2024). Results from these methods are quantified using a probability table and are reported as a most probable number.

EPA recommends *Enterococcus* as the best indicator of health risk in recreational marine water (EPA, 2014). The OBMP samples freshwater streams and other established discharges onto public beaches and analyzes these samples for *Enterococcus*. Freshwater sample results inform the OBMP about potential sources of high marine *Enterococcus* results.

qPCR

In recent years, researchers have developed tools to identify specific sources of bacterial contamination. Quantitative Polymerase Chain Reaction, also referred to as qPCR, is a technology that can be used for Microbial Source Tracking. It can detect genetic markers associated with different host species, potentially identifying sources of fecal pollution. The qPCR approach amplifies host specific genetic markers and provides a measure of concentration of the DNA containing these markers. The DNA concentration is related to, but not directly proportional to, the number of target bacteria cells present in the original water sample (EPA, 2011).

The EPA Region 10 lab used the following established markers for this study:

- Human markers: HF 183 and HumM2
- Dog marker: DG3
- Ruminant marker: Rum2Bac

EPA performed qPCR analysis on just a subset of samples because DEQ elected to focus on only the samples that exceeded water quality standards since it considers control of microbial pollutant sources most important when fecal indicator bacteria concentrations exceed water quality criteria. Therefore, DEQ used the geometric mean water quality criteria for both marine (≥35 *Enterococcus* organisms/100mL) and the water quality criteria for freshwater (≥126 *E. coli* organisms/100 mL) as a threshold to determine when a sample qualified for qPCR analysis. EPA did not analyze collected samples with results below the relevant criteria for microbial sources using qPCR.

All qPCR water samples exceeding the criteria were analyzed using four different primer/probe sets (two human, one ruminant and one dog). In addition, DEQ collected reference samples to verify the effectiveness of the markers. For the reference samples, only the expected markers were run. For example, wastewater effluent from the Cannon Beach Sewage Treatment Plant was analyzed with HF 183 and HumM2 markers, dog scat was analyzed with the DG3 marker and ruminant (elk) scat was analyzed with the Rum2Bac marker. Although the ruminant marker tests for a marker present in ruminants (animals that ruminate include but are not limited to cattle, deer, goats and sheep), elk are commonly found roaming in the study area and are suspected to be a contributor of fecal bacteria contamination. In addition to standard duplicate and blank samples, EPA spiked samples with a Sample Processing Control, a known segment of genetic material, to verify efficient DNA extraction, screen for substances that could interfere with DNA purification and amplification and identify potential laboratory errors (Bailey, 2023).

In addition to listing positive detections, EPA notes markers below the limit of quantification as BLOQ. If neither positive nor BLOQ, EPA reports the results as non-detects. Non-detects can indicate that a target marker was not present in the sample or was in too low of concentration to be detected. BLOQ results indicate that the target fecal matter was potentially present, but at too low of concentration to be quantified with suitable precision and accuracy. While BLOQ results cannot be quantified, they can be a useful tool by indicating the presence of target sources when a sampling location has repeated BLOQ results over the course of the project, or when a sampling location has a mix of results and BLOQs. In these cases, further investigation is recommended (Bailey, 2023). In this report, DEQ considered BLOQ results for any of the four markers as a detection due to the frequency of BLOQs at the same sites in the study area.

Results

MST Results

Out of 100 samples collected over the entire study area, 21 exceeded the criteria for *E. coli* (freshwater) or the water quality criteria for *Enterococcus* (marine). Out of the 43 total marine samples, three exceeded the *Enterococcus* water quality criteria of 35 MPN (7%), while 18 of the 73 freshwater samples exceeded the *E. coli* criteria of 126 MPN (25%).

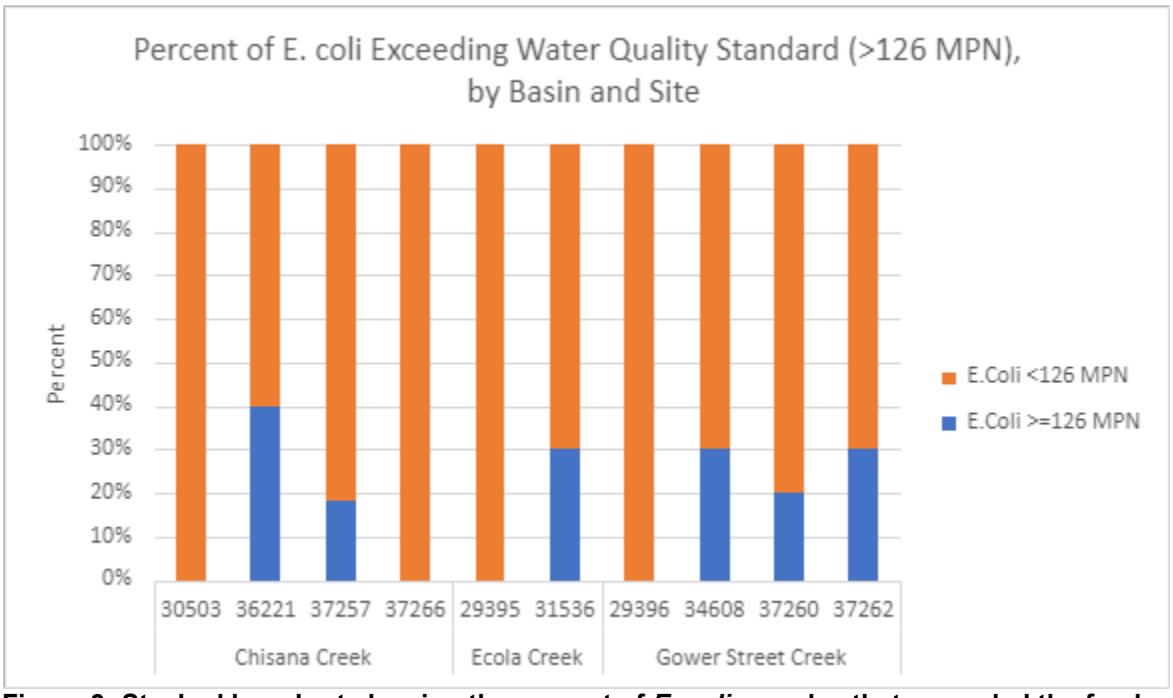

Figure 3: Stacked bar chart showing the percent of *E. coli* samples that exceeded the freshwater water quality criteria (≥126 MPN).

Both ruminant and human markers were detected in all three watersheds. Chisana Creek had the highest number of human markers detected (six total detections) and had human markers detected more frequently than ruminant markers (six times human compared to four times ruminant). The dog marker was present in each basin but was only detected in four of the 10 sites in the study area (Figure 5). The dog marker was most consistently detected at Site 37262 in the Gower Street Creek Basin. The Gower Street Creek watershed had the highest rate of exceedances at 33%, followed by Chisana Creek watershed with 29% and Ecola Creek watershed with 19%.

Months with highest percentage of *E. coli* exceeding the criteria were October (50%) and November (40%). 16 of the 21 samples sent to the EPA lab were collected in October or November (76%), and no samples exceeded the criteria in September (Figure 4). Precipitation data for the City of Seaside, just north of Cannon Beach, showed that November 7, 2022, was the only date during this study with a substantial amount of precipitation. There were a high number of detections on that date; however, the data are insufficient to confirm a correlation between the amount of precipitation and high FIB or positive detections of markers.

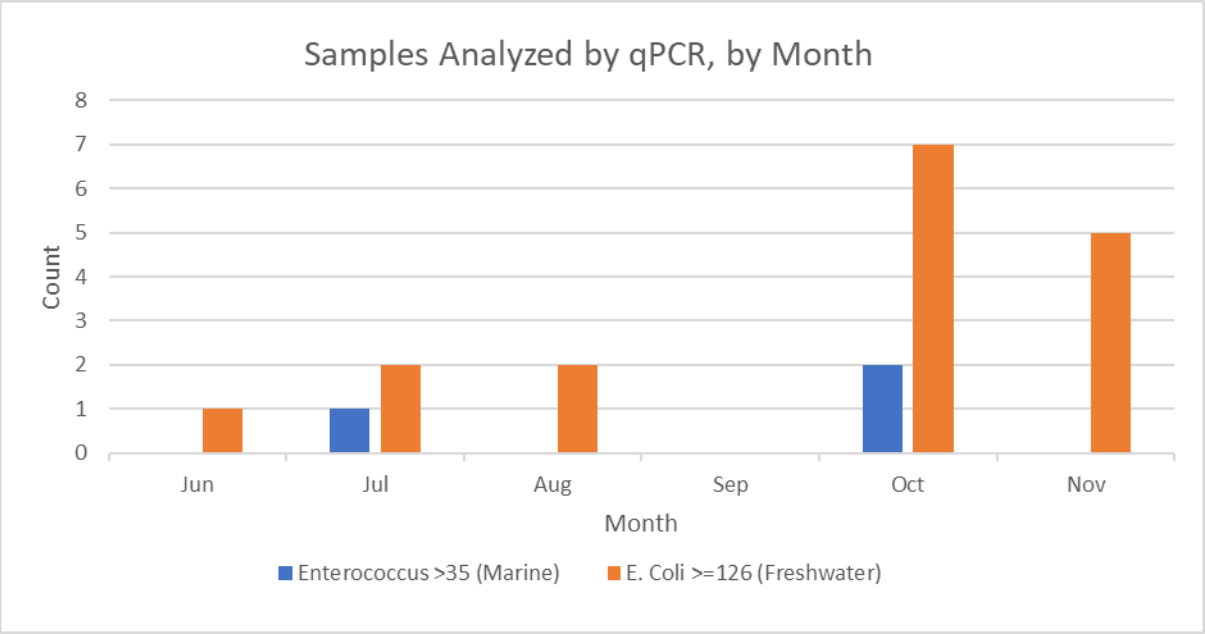

Figure 4: The number of samples analyzed for MST by month. Bars indicate marine (*Enterococcus*) and freshwater (*E. coli*) samples.

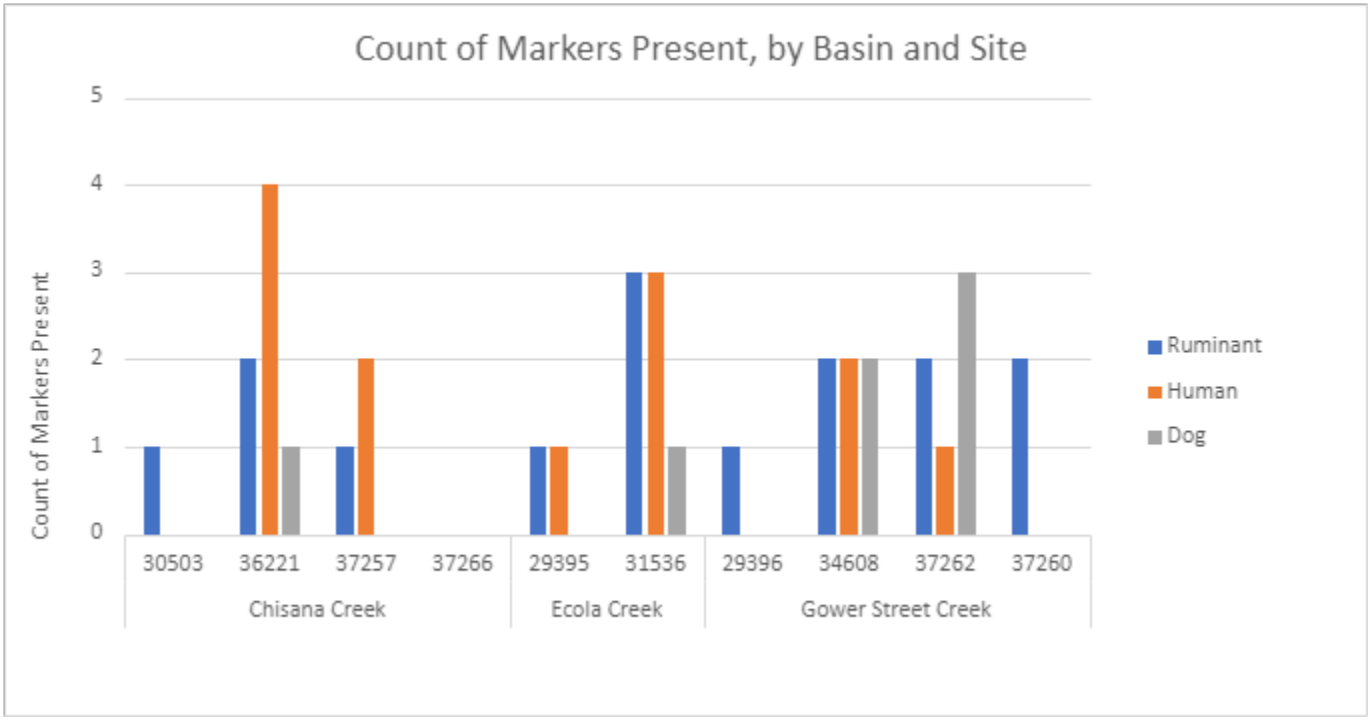

Figure 5: Count of MST markers present at each site, by basin. Sites organized downstream (left) to upstream (right) by basin.

When both human markers were combined and BLOQs were included, there were 13 total detections out of 21 samples (62%). Ruminant markers were detected in 15 out of 21 samples (71%). Ruminant markers were detected at every site, except for Site 37266 in the Chisana Creek Basin. Site 37266 is the most upstream site in the Chisana Creek Basin and was the only

site in the entire study area that did not have any samples exceed the *E. coli* criteria. Dog markers were only detected at four locations in the study area and there were seven total detections out of 21 samples sent for analysis (33%) (Figure 5).

Ecola Creek Basin

Figure 6: Ecola Creek Basin with monitoring locations, Cannon Beach city limits, and the boundary for Cannon Beach.

Ruminant and human markers were detected once at Site 29395 and three times at Site 31536. Ruminant and human markers were detected most often in this watershed at Site 31536, which is located at the confluence of Logan Creek and Ecola Creek. There is a wastewater treatment plant in this basin, just south of Ecola Creek and upstream of Site 31536 (Figure 6). Discharge from wastewater treatment plants are regulated by permits issued by DEQ, which prevent the discharging of water with bacteria levels above the water quality criteria.

Site 29395 is a marine site and only had one sample that exceeded the water quality standard for *Enterococcus*, collected on July 6, 2022. This sample had both ruminant and human markers present (Figure 5).

Gower Street Creek Basin

Figure 7: Gower Street Creek Basin with monitoring locations, Cannon Beach City Limits, and the boundary for Cannon Beach.

Dog markers were consistently detected at Site 37262, with 3 of the 10 samples (30%) showing the presence of the dog marker. Ruminant markers were consistently detected in this watershed and were present at all 4 sites in the watershed (7 total ruminant detections in the Gower Street Creek Basin). Human markers were only present at Sites 34608 and 37262. Site 37260, which is the most upstream site in the basin, and Site 29396, which is on the beach, only had ruminant markers detected in the samples (Figure 5).

Chisana Creek Basin

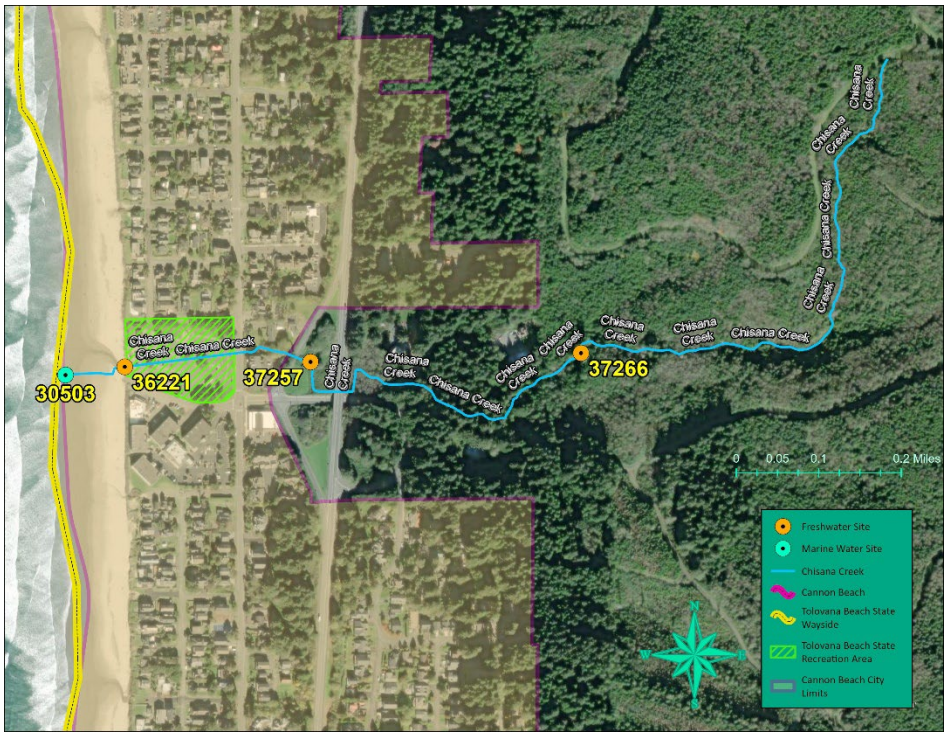

Figure 8: Chisana Creek Basin with monitoring locations, Cannon Beach City Limits, and the boundary for Tolovana Beach.

The highest percentage of *E. coli* values that exceeded criteria in the entire study were at Site 36221 in the Chisana Creek Basin. Ruminant, human and dog markers were present at all the sites in this watershed, except Site 37266. Dog markers were detected once at Site 36221. Human markers were detected more often (six detections) than ruminant markers (four detections) in this basin. Human markers were present most frequently at Site 36221, which was the highest occurrence of any marker in the study. Site 36221 is located below the parking lot for Tolovana Beach State Recreation Area, near a culvert style outfall (Figure 9). There are restrooms with flush toilets located near the northern boundary of the parking lot.

Figure 9: Photo of outfall at Site 36621 that connects Chisana Creek to Tolovana State Beach.

Site 30503 is a marine site, located at Tolovana State Beach, just west of the pipe outflow and Site 36221. Site 30503 had one detection of the ruminant marker, and the human and dog markers were not present. Site 37266 did not have any samples collected exceed the criteria for *E. coli*, so no samples from this location were analyzed using the qPCR method. Site 37266 is located in forested land upstream of the City of Cannon Beach (Figure 8). Human markers were also present at Site 37257, which is located just outside of the Cannon Beach city limits.

Conclusion

Fecal contamination and exceedances of recreational water quality criteria are not a new problem within the study area. During the 2012 study, DEQ field staff collected and analyzed 82 samples for *Enterococcus* in both dry and rainy weather. The timing of the sampling targeted the first substantial rain following the 2012 summer season. The 2012 study found that bacteria concentrations were lowest at the six Ecola Creek watershed sites and higher at the Chisana Creek and Gower Street Creek watershed sites. Bacteria concentrations increased in all streams from upstream to downstream in the watersheds and were highest at all sites during heavy rains. Overall, 23% of the *Entercocccus* samples exceeded recreational water quality criteria of 130 bacteria/100 mL. In both the 2012 and 2022 studies, the Ecola Creek watershed had the lowest rate of exceedance with 17% in 2012 and 19% in 2022. Sites in the Gower Street Creek watershed again had the highest rate of exceedance in the study area, with 34% in 2012, and 43% in 2022.

Exceedances of the geometric mean water quality criteria for *Enterococcus* are not limited to the 2012 and 2022 studies, as routine OBMP monitoring shows persistent high FIB results at the

same sites in the study area. The OBMP tests for *Enterococcus* during routine monitoring between Memorial Day and Labor Day, and sites located near Cannon Beach and Tolovana Beach are sampled every three weeks during this time period. In 2023, Cannon Beach had four samples exceed the water quality criteria on three of the 10 dates that samples were collected. All the exceeding samples were at freshwater sites, so no beach advisories were issued. Tolovana Beach had a total of 10 samples exceed the water quality criteria in 2023. Three of these were coastal samples that resulted in water contact advisories on two different dates. Tolovana was sampled on the same 10 dates as Cannon Beach, plus two resample dates in response to the advisories. While sites in the Ecola Creek Basin have less frequent high results, samples collected at the Gower Street pipe or Chisana Creek pipe at Tolovana Beach consistently have high results for *Enterococcus*. The OBMP only collects samples for *E. coli* during special investigations, so there are no *E. coli* results available for 2023.

Possible contributing factors of fecal contamination in these areas include but are not limited to busy beach parking lots with flush toilets, failure to pick up dog scat from public areas, stormwater runoff, nearby wastewater treatment plants and elk freely roaming on the beach and upstream in all three watersheds. Given the large population of elk around Cannon Beach, DEQ anticipated detection of the ruminant markers at most sites; however, DEQ did not expect the detection of human markers at six of the 10 sites because there are no apparent sources directly contributing human fecal bacteria in the study area. Similarly, DEQ did not expect similar frequency of ruminant and human markers detections. The presence of human markers in the samples is of concern because fecal bacteria from human sources carry a higher risk of illness than fecal bacteria from dog or ruminant sources. The frequency of human marker detection may warrant further investigation to identify pollution sources.

DEQ expected up to 40% of samples collected for this investigation would exceed the water quality criteria and be subsequently analyzed by qPCR. Yet only 21% of samples were above the criteria, meaning fewer samples than expected were analyzed by qPCR. The small sample size did not allow DEQ to analyze data with more robust statistical tests. Although samples for this study were collected between June through November, 76% of the samples that exceeded the criteria for *E. coli* or *Enterococcus* were collected during the rainy season, in October and November, suggesting that stormwater runoff into streams may contribute bacterial contamination. DEQ recommends investigation of bacterial contamination and associated hydrologic conditions to refine the understanding of contaminant sources and potential mitigations.

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