Maine Healthy Beaches: Beach Action Value Justification

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In 2017, MHB will use 70 MPN as the threshold for a retest, 104 MPN for posting contamination advisories, and will continue preemptive rainfall advisories.

I. Background

A. The value of healthy beaches

Coastal beaches are a valued resource, as coastal tourism and recreation contributes approximately $2.5 billion annually to Maine's economy (1). In York County alone, visitor numbers to coastal beaches exceeded 11.5 million in 2014, contributing over $1.6 billion to local economies (2, 3). Clean coastal waters are a major priority. When asked to prioritize coastal management issues in a survey, beach users (residents and visitors) ranked reducing coastal pollution as the first of 13 possible priority actions, and clean waters and sandy beaches were ranked the two most important factors when planning visits to coastal areas. The public values programs that protect public health and provide beach advisories (4). Coastal tourism and recreation, as well as the environment they depend on, are vulnerable to a number of factors including pollution and climate change.

B. Maine Healthy Beaches (MHB) Program

MHB plays a critical role in sustaining coastal tourism and recreation, providing the state's only unified, quality-assured structure for monitoring water quality and protecting public health on coastal beaches (5). MHB is fully supported by grant funding acquired annually from the United States Environmental Protection Agency (EPA), is managed by the Maine Department of Environmental Protection (ME DEP), and coordinated by UMaine Extension. MHB successfully works with 28 local management entities to conduct routine monitoring, assessment, and public notification of water quality conditions for 60 beach management areas (more than 29 miles of public-access beaches) from Kittery to Mount Desert Island. Program participation is voluntary and beaches must have a management entity and a feasible plan for meeting MHB protocols and policies. This includes designating a local beach manager, field monitors, and providing timely notification of local beach status. Additionally, MHB builds local capacity to address pollution issues by bringing together diverse partners focused on sharing resources and solving problems.

Since the program's inception in 2002, MHB has used the EPA-recommended single sample maximum of 104 Most Probable Number (MPN) of enterococci (ENT) bacteria per 100 ml as the safety limit (6). When levels exceed this limit, a public contamination advisory is recommended and sites are retested as soon as possible. The monitoring frequency may increase until results are within acceptable limits. In 2012, EPA published a draft *National Beach Guidance and Required Performance Criteria for Grants* including updated water quality standards relating to the overall health of a water body (i.e., impairment status). EPA also provided two new "optional" beach action value (BAV) scenarios to allow states to provide more timely public notification (i.e., bad beach day). In 2014, the final Beach Guidance was published requiring states to adopt a new or alternative BAV in order to receive program funding (6). MHB acknowledges the challenges of providing new Beach Guidance and appreciates EPA's efforts in forming the new requirements, including their consideration of public concerns as well as public health and environmental research.

C. Stakeholder engagement and feedback

Given the potential impact a change in the BAV would have on public health, local coastal economies largely based on tourism, public perceptions, and the limited resources and scope of the program, MHB engaged diverse partners in the BAV selection process. Since the draft Beach Guidance was released in December 2012, MHB coordinators have shared it with experts and resource managers within and outside of Maine, local beach managers, field monitors, and the public. For example, BAV-related data summaries and information were presented at the Maine Beaches Conference in 2015 and at the Maine Sustainability and Water Conference in 2016. Additionally, MHB brought together a technical advisory committee (TAC) comprised of approximately 20 experts and professionals in the fields of public health, microbiology, marine science, economics, and resource management. Meetings were held in 2015 to discuss EPA's Beach Guidance, MHB's current policies, key considerations, and potential scenarios moving forward. After extensive consideration of multiple factors, the TAC recommended to continue with the current BAV of 104 MPN. Following the TAC meetings, a BAV sub-committee was formed to follow up on the TAC's recommendations, delve further into the science and studies behind the EPA Beach Guidance, conduct data analyses, etc.

II. Key Considerations

The following items represent the primary considerations for adopting the EPA-recommended criteria.

A. Limitations of fecal indicator bacteria and uncertain health effects

Measuring fecal indicator bacteria (FIB) levels is a useful tool for assessing water quality, but FIBs are also limited in their ability to provide timely results that adequately represent the risk of illness in all bathing waters. Due to collection, transport, and analysis requirements, there is a 28-36 hour lag-time in obtaining results. In highly dynamic systems like the coastal zone, much can change during this time and recorded FIB levels are often extremely variable across spatial and temporal scales (7). Beaches are often open on Day 1 when next-day results indicate conditions were unsafe; beach advisories are then posted on Day 2 even though retest results available on the third day indicate levels were in fact acceptable.[1] Moreover, FIBs do not differentiate the source(s) of fecal contamination. When assessing the public health risk, research indicates that sources do matter, with human-sourced fecal contamination is of greatest risk to human health. Fecal contamination from various non-human animal sources is more variable and has lower health risks. Because the source of fecal contamination determines the degree of health risk, FIB levels alone cannot indicate the likelihood of contracting illness in recreational waters (8, 9).

Studies in Maine and elsewhere have demonstrated little to no association between recorded FIB levels and human markers of contamination (10, 11, 12, 13), further complicating our understanding of human health risk associated with FIB contributions from non-human sources. Likewise, FIBs can persist and regrow in favorable conditions (14) which is recognized by EPA in the 2014 Beach Guidance:

> "*FIB are not exclusively of fecal origin, and they can be part of the natural microflora in the environment. FIB can persist and even grow in sand, sediments, and soils; on plant surfaces; and within algal mats and biofilms. FIB from these non-fecal sources have not been demonstrated to be related to the potential for human illnes*s" (15, 16, 17, 18).

[1] See Section C, resample cleanliness.

Naturalized (non-enteric) FIB contributions do not indicate the degree of human or animal fecal contamination, as human pathogens do not multiply outside of the intestinal tract. Recent studies conducted on Maine beaches assessed the impact of cast and warmed seaweed mounds on beach water quality and indicated ENT levels as high as 98,040 MPN in the interior of the seaweed mounds per gram of wet seaweed, and as high as >24,196[2] MPN in adjacent beach water. Decomposition inside the seaweed mounds provided favorable warm and moist conditions for non-enteric FIB growth (19).

EPA's epidemiological studies are limited in scope and do not include alternative sewage markers, human enteric pathogens, or include beaches impacted by non-point sources (NPS) of pollution. Studies using the same or a similar study design to EPA have not demonstrated a correlation between FIB levels and gastrointestinal illness for NPS impacted beaches (20, 21, 22). Nationally, NPS pollution is the leading cause of impairment to water bodies compared to only 10% that are impacted by point source pollution alone (23); therefore, the health effects associated with EPA's criteria may not be directly applicable to the majority of recreational waters (8). NPS pollution is the primary contributor of FIB data for greater than 60% of coastal beaches monitored through MHB,[3] creating further uncertainty between the relationship of FIB levels and human illness at these beaches.

In addition to the uncertain health effects associated with NPS pollution, two EPA epidemiological studies conducted in 2009 in Puerto Rico and South Carolina did not establish a consistent relationship between FIB levels and swimming associated illness (24). It is unclear how the limited marine data collected in tropical/temperate regions combined with freshwater study data used to establish the new criteria relates to Maine's cold-water, dynamic coastal beaches. Currently, no funding is available in Maine for waterborne disease surveillance to allow researchers to determine if illnesses are related to beach recreation. Although individual illness reporting is limited and there are many other exposures by which a beach goer can get sick (e.g. shellfish), under the current threshold of 104 MPN, there have been no known illnesses tied directly to fecal contamination.

Furthermore, the explanation regarding the calculation of the EPA criteria values raises numerous questions. According to EPA, ENT values using molecular qPCR methods were significantly associated with illness, whereas ENT values using culture-based methods were not. Also, a single sample exceedance was not quantitatively related to illness, but a relationship was observed when established geometric mean values were exceeded (25). Therefore, fully adopting a conservative BAV is challenging given the tools and resources currently available in states like Maine. Unless states have the funding and capacity to calculate a daily geometric mean using qPCR methods, it is difficult to understand the risk of illness. Given all the uncertainties and obstacles, we determined it is reasonable to continue with a BAV of 104 MPN (approx. 85^{th} percentile), as this intermediate value falls in between the conservative BAV of 70 (75^{th} percentile) and the STV of 130 (95^{th} percentile) on the EPA 36/1000-illness distribution. This reasoning is underscored in the 2012 EPA Guidance indicating the adoption of the proposed BAV is at the discretion of states to be used as a conservative tool and the STV value may be used as a BAV:

[2] This is beyond the method detection limit for the dilution.
[3] See Section E, Sources of FIB

"The BAV is not a component of EPA's recommended criteria, but a tool that states may choose to use, without adopting it into their WQS as a "do not exceed value" for beach notification purposes (i.e., advisories). While the GM and STV would be the applicable WQS, a BAV could be used at the state's discretion as a more conservative, precautionary tool for beach management decisions. Similarly, states could also choose to use the STV as a "do not exceed value" for the purposes of their beach notification program, without adopting it as a "do not exceed value" in their WQS"(6).

In summary, the limitations of FIBs and the uncertain health effects associated with recorded FIB levels are substantial concerns and as a result, we believe the EPA Beach Guidance contains insufficient information for effective implementation in Maine. More information would allow us to demonstrate to stakeholders and the public a defensible change that will confer improved public health protection. For these reasons, MHB has investigated possible alternatives to adopting the EPA-recommended BAV scenarios.

B. MHB program capacity and effectiveness

Since the MHB program's inception in 2002, funding has essentially remained flat, while costs and needs have risen. To address this problem, MHB has significantly reduced special studies, source identification and remediation efforts, and has not added beaches into the program. Given the financial limitations and the cost-saving measures already taken, MHB will need to begin reducing the number of testing locations and monitoring frequency, and lowering the BAV will increase the extent of these reductions. Additionally, MHB and partners are concerned that lowering the BAV will increase costs and staff time, further diminishing the program's capacity to grow and improve as well as meet the needs of participating communities/parks and underserved populations. Moreover, many of the recommendations outlined in the recent Beach Guidance are not feasible given current funding and resource limitations. More real-time, source-specific data is needed to better protect public health, yet the molecular methods are highly technical and expensive. Maine is not alone with this challenge, as many states will require additional resources and funding to train personnel and upgrade facilities in order to apply molecular methods (8).

Over a third of participating towns/parks have communicated they will not participate in the MHB program if the BAV level is lowered. MHB participation is voluntary and program retention is a constant challenge. In some cases, beach managers are already reluctant to post beaches at the current 104 MPN. This reluctance stems in part from the lag time in results, how often retest results indicate clean/false postings, the lack of source identification, FIB contributions from non-enteric sources, uncertain health effects, limited funding, and how beach advisories negatively impact local economies and public perceptions of those resources. With these uncertainties and complexities surrounding the Beach Guidance, MHB has struggled with communicating and justifying the EPA-preferred BAV to diverse audiences. Overall, feedback from stakeholders regarding the proposed changes has been negative. For example, beach managers have shared that in their experience, people are not getting sick at the current 104/MPN limit and without strong evidence demonstrating that a drop in the BAV will confer better health protection, changes to current policy are not warranted. Without additional resources and staff to respond to increased efforts, retesting/posting the beach and addressing public concern/inquires will be challenging. Additionally, fully adopting an EPA-preferred BAV will likely be a cause of concern and confusion, as clear justification for change is lacking and the current limit is something that is widely accepted, recognized, and understood by the public.

C. Analysis of routine data[4]

With extensive support from Walker Environmental Research (Appendix A), we analyzed 10 years (2006-2015) of beach data to address the most relevant questions identified by MHB and partners. By consulting with stakeholders and conducting extensive data analysis, MHB gained considerable feedback and insight concerning the selection of the most appropriate BAV for Maine moving forward.

Over the last 10 years, **8.8%** of all samples exceeded the 104 MPN safety limit, **12.5%** exceeded the EPA-preferred BAV of 70 MPN, and **3.7%** of samples fell between the 70 and 104 thresholds (Table B1, Appendix B). Lowering the BAV from 104 to 70 would increase the exceedance rate by **25-67%** (annual variation) with an average annual increase of **42%** for this time period (Figure 1). Therefore, it is expected that resampling and associated costs could increase by as much as nearly 70% over the course of a grant year, reinforcing concerns regarding whether or not the benefits of lowering the BAV outweigh the negative consequences (Figure B1, Appendix B).

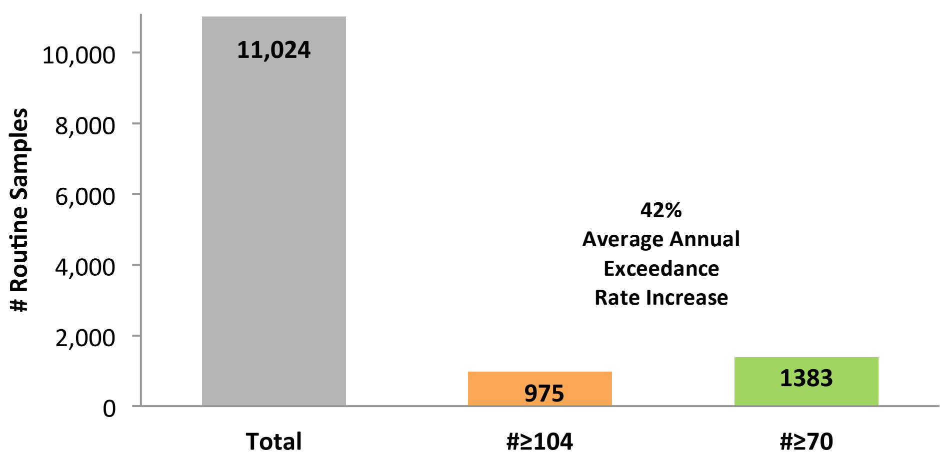

Figure 1. Total routine samples, number ≥ 104 MPN, and number ≥ 70 collected at 60 beaches (85 sites) from 2006 to 2015.

To better understand the similarities between the two BAVs specifically at Maine's beaches, routine ENT results were examined to assess how likely it was that a sample exceeding 70 MPN also exceeded 104 MPN. Out of the 1,383 historical samples greater than 70 MPN, the majority (70.5%) were also greater than 104 MPN. In other words, **if a sample is over 70 MPN it is also likely to be over 104 MPN**, further demonstrating that lowering current BAV to 70 will not likely confer improved public health protection in Maine.

[4] This does not include retest results following an exceedance. There were **12,051** total samples (routine and resamples) collected from 2006-2015.

Additionally, MHB utilizes the IDEXX Enterolert® Quanti-Tray 2000, an EPA-approved method for ambient water testing. This method uses a nutrient indicator that fluoresces when metabolized by ENT, and results are enumerated by counting the number of fluorescing wells and referring to an MPN reference table (26). In addition to a point estimate of the MPN, 95% confidence limits (CLs) provide a range in which the actual value of a given MPN could fall. IDEXX published CLs demonstrate a large overlap between 70 MPN and 104 MPN ranging from 52-137 MPN (Figure 1). The overlap in these two CLs includes both the 70 and 104 limits raising the question of whether the sensitivity of this method is sufficient to reliably distinguish between the two. This limited sensitivity thus underscores the high uncertainty of improved health protection conferred by dropping the current BAV to an EPA-preferred level.

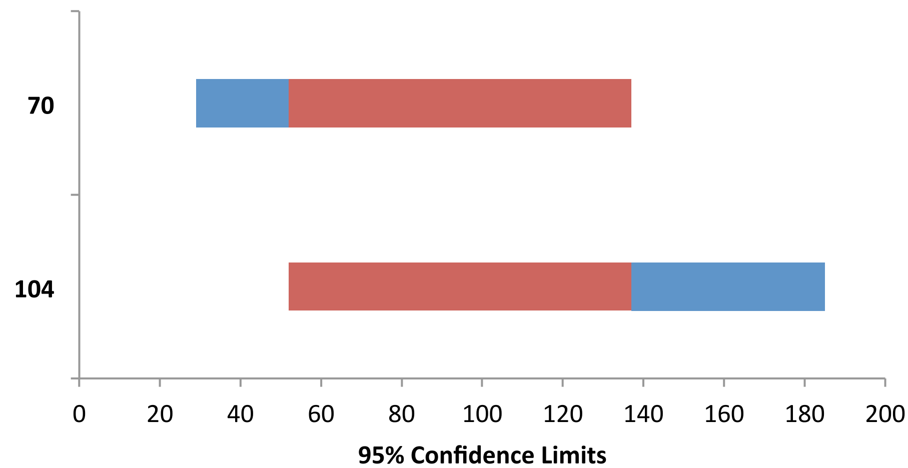

Figure 2. IDEXX Quanti-Tray®/2000 MPN 95% confidence limits for concentrations of 70 and 104 MPN. Red areas indicate the range of overlap, and blue areas indicate no overlap.

Resamples are collected as soon as possible following an exceedance of a routine sample, typically the same day that the routine sample result is available. From 2006-2015, 903 resamples were collected with 837 representing the initial retest and 66 representing additional retests due to consecutive exceedances. Beaches are often posted under an advisory the day retests are collected, and these results represent the actual beach conditions on the initial day of posting. Out of the 837 initial resamples, only 15.5% (130 resamples) exceeded 104 MPN and 21.4% (179 resamples) exceeded 70 MPN. These data indicate that under the 104 threshold, 84.5% of the time beaches were considered unsafe and posted under an advisory when results were actually within acceptable limits, underscoring concerns about the lag time in obtaining results and false postings. If the threshold were lowered to 70 MPN, beaches would have been posted incorrectly 78.6% of the time.

Given the limitations of FIBs and the gaps in understanding regarding health risks, the increase in exceedances and small reduction in false postings associated with lowering the BAV to 70 MPN is likely not worth the impact on already limited resources, staff and volunteer time, as well as the negative effects on local economies and public perceptions.

D. Problematic versus clean beaches

Problematic beaches

Each beach varies in its system dynamics, pollution sources, sensitivity to local rain events, and how long it takes contamination events to flush out of the system. Assessment of exceedance rates over the past 10 years indicates that the top 10% (6 beaches) have had >18% of samples exceed the 104-safety limit. Collectively, these **six** beaches accounted for nearly **30%** of the total exceedances, and three (Laite, Cape Neddick, and Goochs) are impacted by point sources[5] of fecal pollution (Figure 3).

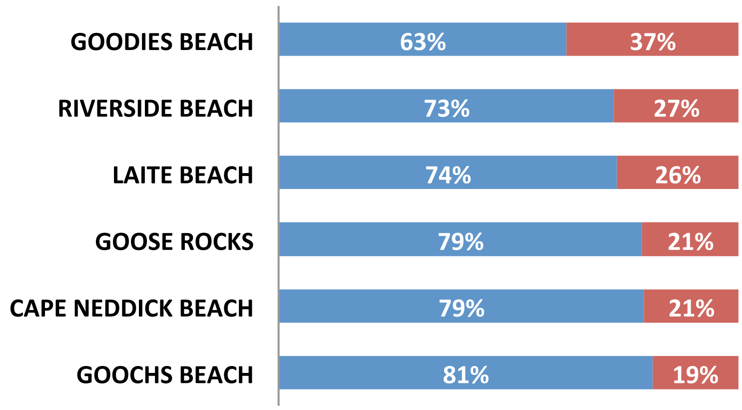

Figure 3. Beaches with the greatest exceedance rates (% samples ≥ 104) program-wide during 2006-2015. Blue bars indicate the % of routine samples that were acceptable and red bars the % of samples that exceeded 104 MPN.

Based on the percentage of historical samples between the 70 and 104 thresholds, the greatest resampling burdens would occur at the top 10% (6 beaches), which would all see a >7% increase in exceedance rate associated with 70 MPN (Figure 4). The beaches that would be affected most by dropping the BAV are considered "high-risk" due to the impact of freshwater inputs and the potential for human-sourced fecal contamination.[6] Given that the beaches with the greatest amount of historical samples between 70 and 104 MPN are also considered "high-risk," MHB has decided to integrate the 70 MPN limit as the trigger for resampling. This will confer more testing in these areas, allowing MHB to better track potential contamination events.

[5] Point sources can include sewage treatment plant outfalls, overboard discharges units, combined sewer overflows, etc. located within a mile of the beach.

[6] Riverside and Wells Harbor beaches are not impacted by point sources.

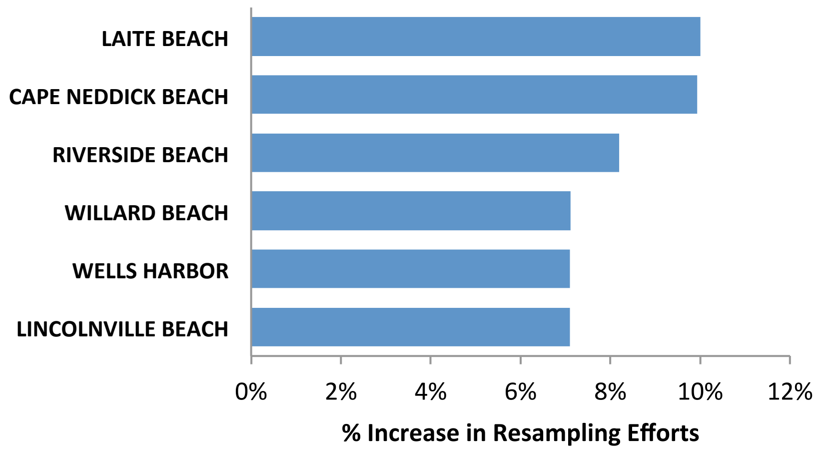

Figure 4. The beaches[7] with the greatest number of historical data points between 70 and 104 MPN during 2006-2015. With the adoption of 70 MPN as the trigger for a retest, it is expected that these beaches will exceed limits more frequently in the future.

Two of these beaches (Lincolnville and Laite) as well as Goodies, Colony, East End, and Short Sands also represent those with the lowest resample cleanliness rate[8] program-wide (less than 75%), comprising over **32%** of all historical initial resamples (Figure 5). How often resamples are clean can indicate the nature and extent of a contamination event, and/or how quickly the event flushes out of the system (typically one day for most beaches; Table A2).[9] MHB has supported ongoing efforts to address pollution sources and increase monitoring frequency at these beaches and lowering the BAV to 70 would not alter this focus.

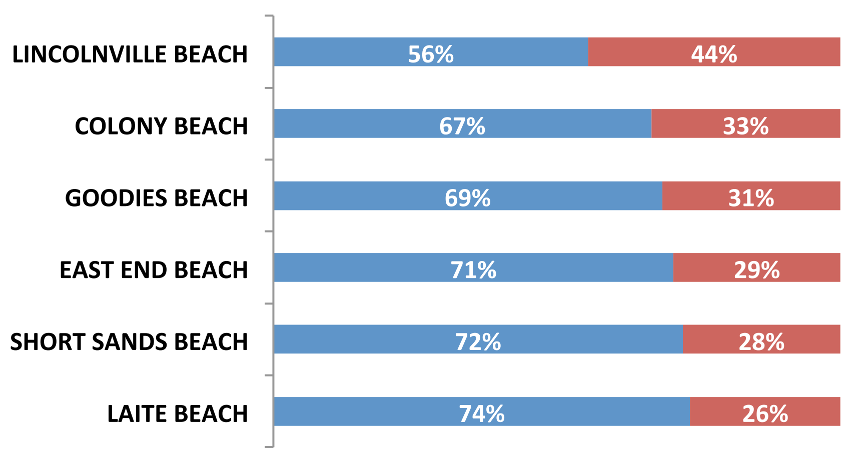

Figure 5. Beaches with the lowest resample cleanliness rate (less than 75%) program-wide. Blue bars indicate the percentage of initial resamples that are clean. Red bars indicate the percentage of resamples that exceed the safety limit (104 MPN).

Clean beaches

[7] For more details on impacts per beach see appendices A and B.
[8] A percentage indicating how often initial resamples following an exceedance are clean.
[9] Includes only those beaches with at least 10 resamples. Calculations use current EPA 104 MPN/100ml threshold.

Excluding the six beaches that exceed most frequently, the program-wide exceedance rate (≥104 MPN) from 2006-2015 was **6.2%** (690 exceedances out of 11,024 routine samples). Overall, the majority of Maine's coastal beaches are clean with only temporary increases in bacteria levels as retest results are acceptable most of the time. For example, over the ten-year analysis period:[10]

- **Half** of Maine's monitored coastal beaches (30) had a **<7%** exceedance rate and 27% (16 beaches) had <**5%** exceedance rate. The majority of beaches with low exceedance rates (21) also had a resample cleanliness rate of 100%,[11] and are primarily impacted by non-point source pollution (e.g. runoff, wildlife).[12]
- **52%** of monitored coastal beaches (31) had resample cleanliness rates of **≥90%**.
- Half-Mile Beach had **zero** exceedances over the analysis period. Fort Foster Pier Beach and Sand Beach each had **one** exceedance (**<1%** exceedance rate) and **zero** exceedances have occurred at Fort Foster-Pier Beach since 2011.
- Mile Beach, Fort Foster-Scuba Beach, and Gil Bouche Park Beach had **two** exceedances (**<2%** exceedance rate). Mile Beach has had **zero** exceedances since 2009.
- **Three** beaches (OOB-North End, Fortunes Rocks, and Middle) have had just **four** exceedances (**2.9-3.5%** exceedance rate).
- Popham's East and West Beaches had exceedance rates of **<3.6%** and have had **zero** exceedances since 2012 and 2013 respectively.
- Scarborough Beach State Park had **seven** exceedances (**1.7%** exceedance rate) over the 10-year study period but has had **zero** exceedances since 2009.

E. Sources of FIB

MHB has supported extensive, ongoing efforts to identify and address pollution sources, especially for beaches with frequent exceedances. The MHB risk assessment matrix, an evaluation of water quality trends and potential sources of fecal bacteria within one mile of the beach, has been conducted for all participating beaches and is currently being updated. Overall, **62%** of Maine's beaches are predominately impacted by non-point pollution, whereas 38% are impacted by point sources. Although point sources exist at 23 out of 60 of beaches, many are also impacted by freshwater inputs (rivers, streams, storm drains). Therefore, non-point source pollution is also a major contributor to FIB loading at these locations.

In addition to freshwater inputs, beaches in close proximity to marsh systems can display higher FIB levels and non-enteric FIB can persist and regrowth under these favorable conditions.[13] In Maine, **55%** (33 beaches) are located in close proximity to marshes; therefore, non-enteric FIBs are likely contributing to bacteria loading and confounding our understanding of human risk at these locations. Moreover, several beaches that tend to exceed frequently (Lincolnville, Cape Neddick, Riverside, and Wells Harbor), also represent those impacted by FIB loading from nearby marsh systems.

III. Actions to Improve Water Quality

[10] See Appendix B, Table 1 for the number of years each BMA has participated in program.
[11] Long Sands South (95.2%), Popham East (85.7%), Lagoon Beach (83.3%), and Gil Bouche (50%).
[12] Moody Beach and Pemaquid Beach are impacted by point sources.
[13] See Limitations of FIBs and uncertain health effects, Section A

In addition to routine risk assessment, MHB has concentrated efforts on beaches with consistently elevated FIB levels, focusing on human sources of fecal contamination (Tables 1-2). With the uncertainty regarding how lowering the BAV will confer increased public health benefits, MHB is confident that these are effective strategies for improving water quality and protecting public health on Maine's coastal beaches, and represent the best return on investment of limited resources. Since the program's inception, MHB has provided extensive support to communities and partners including circulation studies, bacteria and microbial source tracking, sanitary surveys, GIS risk analyses, education/outreach initiatives, and more. Efforts beyond routine monitoring have been supported for **20** coastal communities including **68**% (41 out of 60) of Maine's beaches.

In partnership with MHB, communities have initiated actions to improve water quality and ecosystem health emphasizing problematic areas. Many have augmented MHB support by securing grants and other local funding, including ME DEP 319 watershed restoration grants and Maine Coastal Program coastal community grants. Towns have hired consultants and some have created municipal positions focused on shoreline protection. MHB has supported multi-year efforts and brought together diverse partners to share resources and solve problems. Examples include[14]:

- York: bacteria and microbial source tracking studies, GIS risk assessments, septic mapping, and investigations of and improvements to sewer/stormwater infrastructure. York created and retained a Shoreland and Environmental Resource Officer and hired consultants to conduct intensified rainfall monitoring and assess FIB levels in cast seaweed resulting in a site-specific, weather-based model in support of precautionary rainfall advisories and a beach management and cleaning plan.
- Ogunquit: efforts have focused primarily on improving water quality and ecosystem health within the Ogunquit River Watershed and include intensified monitoring, a circulation study, sanitary surveys, canine detection, GIS watershed risk analyses, education/outreach initiatives, a septic system database, protective ordinances, stormwater best management practices, and investigations of and improvements to storm/sewer infrastructure. The town has acquired several grants to fund their continued efforts to identify and remediate pollution sources.
- Saco and Old Orchard Beach: are divided by the Goosefare Brook, an impaired water body with chronic bacterial pollution issues. Efforts include bacteria and microbial source tracking, pharmaceutical and personal care product testing, canine detection, and monitoring of multiple watershed health parameters. The towns collaborated on 319-watershed restoration grant to develop and implement a Watershed Management Plan and implement stormwater retrofits and erosion control projects. Both towns have conducted extensive investigations of and improvements to stormwater/sewer infrastructure including removal of illicit discharges and malfunctioning septic systems.
- South Portland: efforts have focused on improving water quality in the Willard Beach watershed, including intensive monitoring, education/outreach campaigns, sanitary surveys, canine detection, and infrastructure investigations and improvements such as upgrades and the removal of illicit cross-connections.

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[14] Additional details/reports provided upon request.

- Midcoast: this region is home to beaches (Goodies, Laite, and Lincolnville) with some of the greatest historical exceedance rates. Goodies and Laite are nested within a larger harbor with freshwater inputs and other potential sources. Lincolnville, Camden and Rockport have acquired supplemental funding to augment continued efforts to improve water quality, including intensified monitoring studies, boater's education campaigns, installation of pump out facilities, sanitary surveys, watershed modeling, and infrastructure improvements such as removal of illicit cross connections and malfunctioning septic systems. As a result, Rock Brook was removed from the state's list of impaired waters and Lincolnville is installing a new wastewater treatment facility.

NPS pollution is the number one contributor to impaired water quality in Maine and nation-wide (22). The lag time in obtaining FIB results can present a window of exposure to potentially harmful pathogens. In response, MHB has conducted intensified monitoring and analysis of the bacteria-rainfall relationship in support of precautionary rainfall advisories (PRAs). It is recommended that beaches are posted when local rainfall levels exceed one inch in 24 hours, and remain posted for at least 24 hours or two tidal cycles after the rainfall ceases.[15] In 2015, **13** communities implemented PRAs, conferring increased protection to the public at **28** beaches, including many with frequent exceedances and/or point sources of pollution. Consistently posting PRAs at more beaches is ongoing effort. MHB and partners agree that given the lag-time in obtaining FIB results and the likelihood of wet-weather induced contamination events, posting PRAs are an integral component of public health protection on coastal beaches.

IV. Summary and Conclusions

EPA has recommended that states adopt a BAV of either 60 MPN or 70 MPN. Feedback from experts and other stakeholders has prompted the need for Maine to seek an alternative BAV scenario. Despite our current resource limitations, MHB has decided to use the 70 MPN as the trigger for resampling in order to better monitor the potential public health risks and persistence of contamination events, especially at "high-risk" beaches. However, the current 104 MPN limit will continue to be used for posting contamination advisories, and heavy rainfall will trigger preemptive rainfall advisories.

The following summarizes the primary components of this justification and why MHB has not chosen to fully adopt an EPA-preferred BAV:

- Due to the limitations of FIB sampling methodologies and epidemiological studies and the high rate of false postings, not enough information or evidence exists to warrant changing the existing BAV.
- Overall, Maine's beaches are considered clean with only temporary increases in FIB levels, with acceptable retest results occurring 84.5% of the time.
- The overlapping confidence limits of the IDEXX enumeration method suggest a low sensitivity in its ability to accurately distinguish between 70 and 104 MPN.
- Analysis of historical data show that a sample above 70 MPN was also above 104 MPN more than 70% of the time.

[15] The local threshold and duration of posting may vary

- MHB is voluntary with limited funding and capacity to meet current and emerging needs of the program. Reducing the BAV will increase exceedance rates, beach advisories, costs and efforts. Without demonstrated improved public health protection, changing the BAV will diminish MHB's scope and effectiveness, and negatively affect program retention, public perceptions, and local economies.
- With insufficient information, communicating the complexities and reasoning behind EPA's preferred BAVs to diverse audiences has been difficult. The current BAV is understood and widely accepted by state agencies, municipalities, and the public. Changes are expected to cause confusion.
- Using the conservative BAV value of 70 MPN for resampling efforts will allow MHB to track potential contamination events, especially at "high-risk" beaches. Combining current budget constraints and no foreseeable increase in project funding, MHB is currently investigating how to allocate resources to problem beaches, while decreasing efforts at clean beaches.

After careful consideration of the potential benefits and drawbacks to fully adopting an EPA-preferred BAV, it is our opinion that integrating the proposed 70 MPN for resampling efforts represents a reasonable approach that will contribute to maintaining successful public health protection in Maine. We appreciate efforts by EPA and the research community to advance this work and look forward to future research and tools that will augment our efforts to improve water quality and protect public health on Maine's valued coastal beaches.

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Maine Healthy Beaches: Data Exploration

Jeffrey D Walker, PhD

August 25, 2016

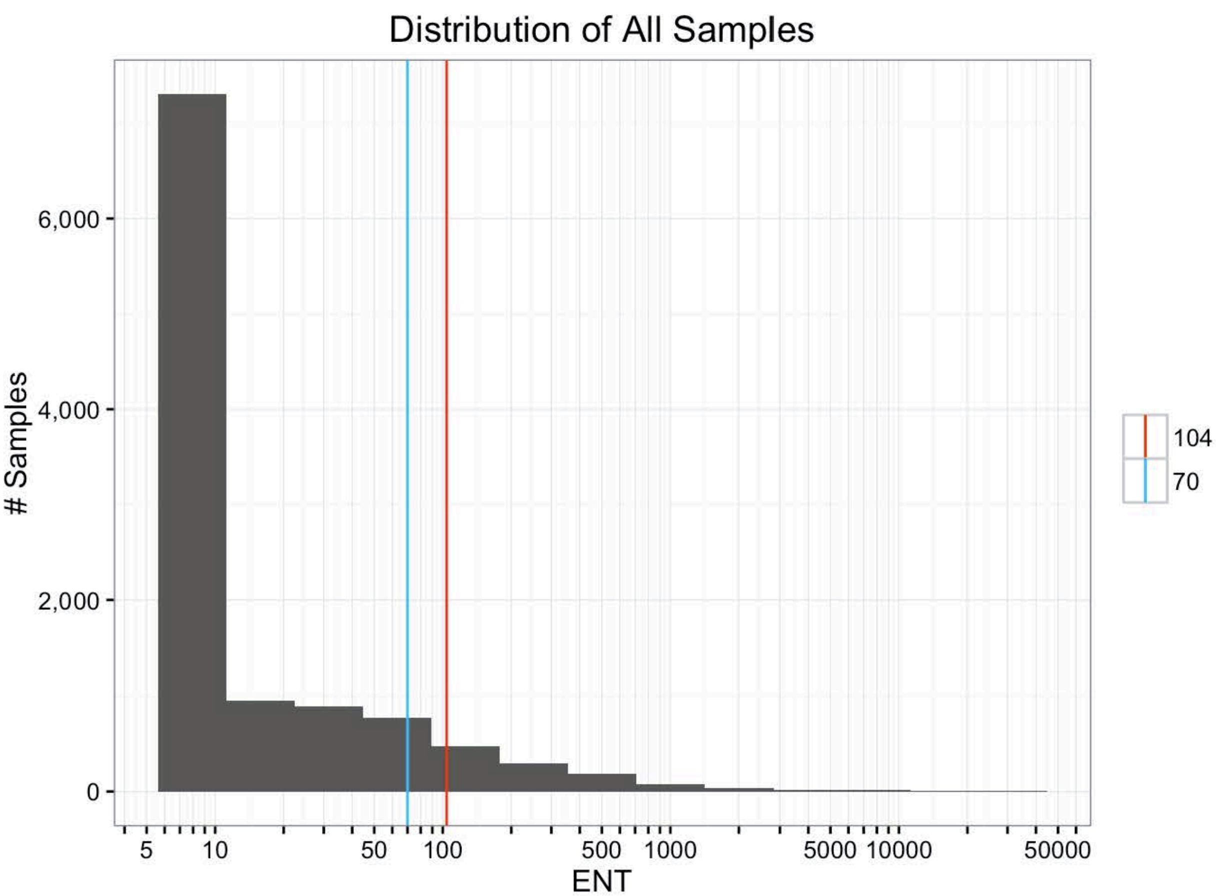
- 1 Distribution of Enterococcus Concentrations
  - 1.1 All Samples
  - 1.2 By Beach
  - 1.3 By Site
- 2 Sampling Frequency and Resampling

1 Distribution of Enterococcus Concentrations

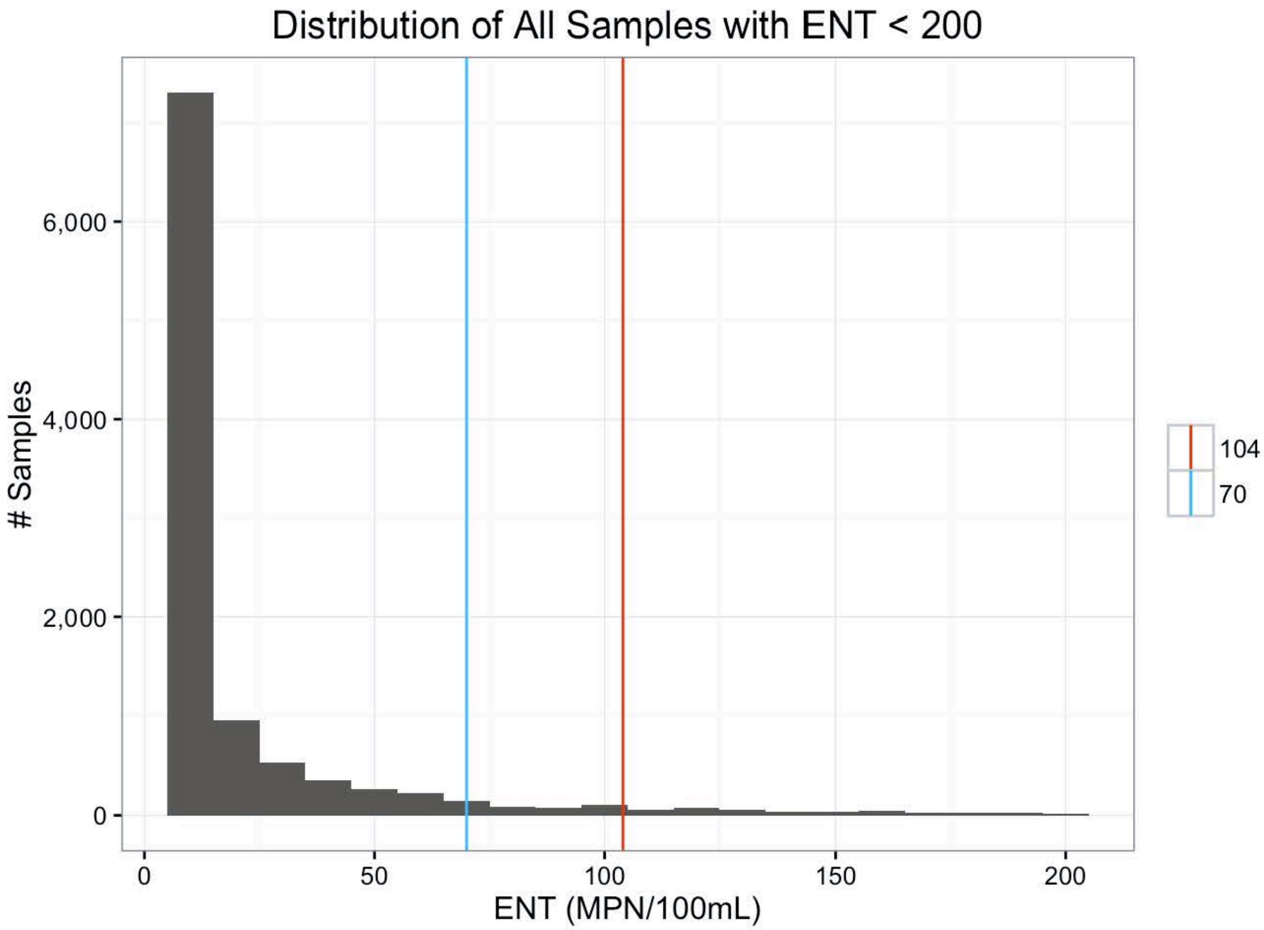
1.1 All Samples

This section summarizes the distribution of all enterococcus samples. It only includes routine samples and thus excludes all resamples.

This figure shows the histogram of all routine samples on a log-scale. The vertical lines show the 70 and 104 limits. The distribution is uni-modal, the large change at 10 MPN/100mL is due to the detection limits.



This figure shows the same data, but on a linear scale and only including samples with ENT < 200 to focus on the lower range. Again, the majority of routine samples are at or below the detection limit of 10 MPN/100mL.



Question: What fraction of all routine samples are between 70 and 104?

Answer: 3.71%

This table shows the fraction of routine samples <70, between 70-104, and >104.

Range	Percent
<=70	87.5%
70-104	3.7%
>104	8.8%

Question: If a routine sample is greater than 70 MPN/100mL, what is the probability it is also > 104?

Answer: 70.4%

This table shows the fraction of samples between 70-104 and >104 based only on samples with concentrations <70. This shows that out of all samples greater than 70 MPN/100mL, about 70% are also above 104, and 30% are between 70 and 104.

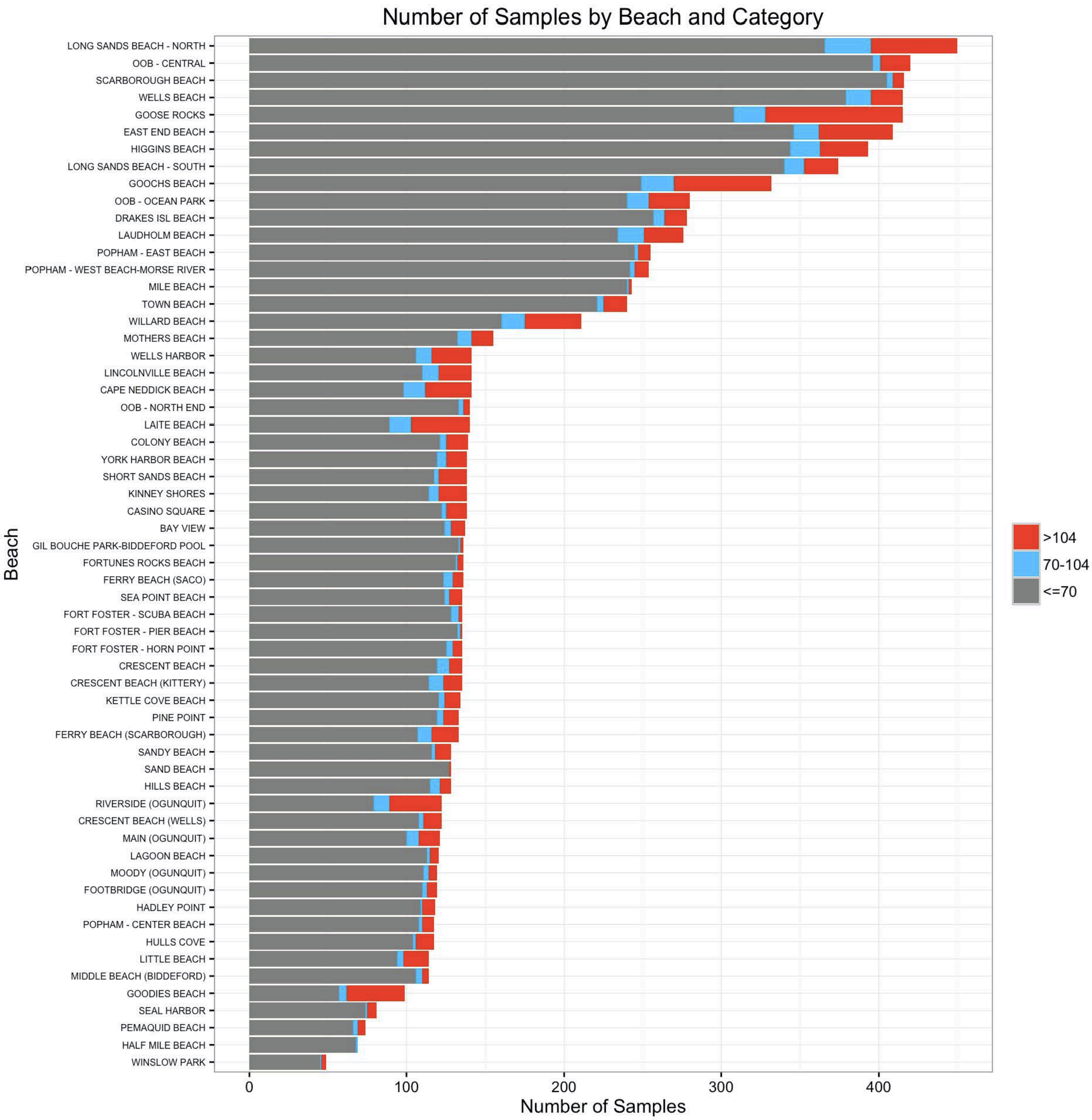
Range	Percent
70-104	29.6%

Range	Percent
>104	70.4%

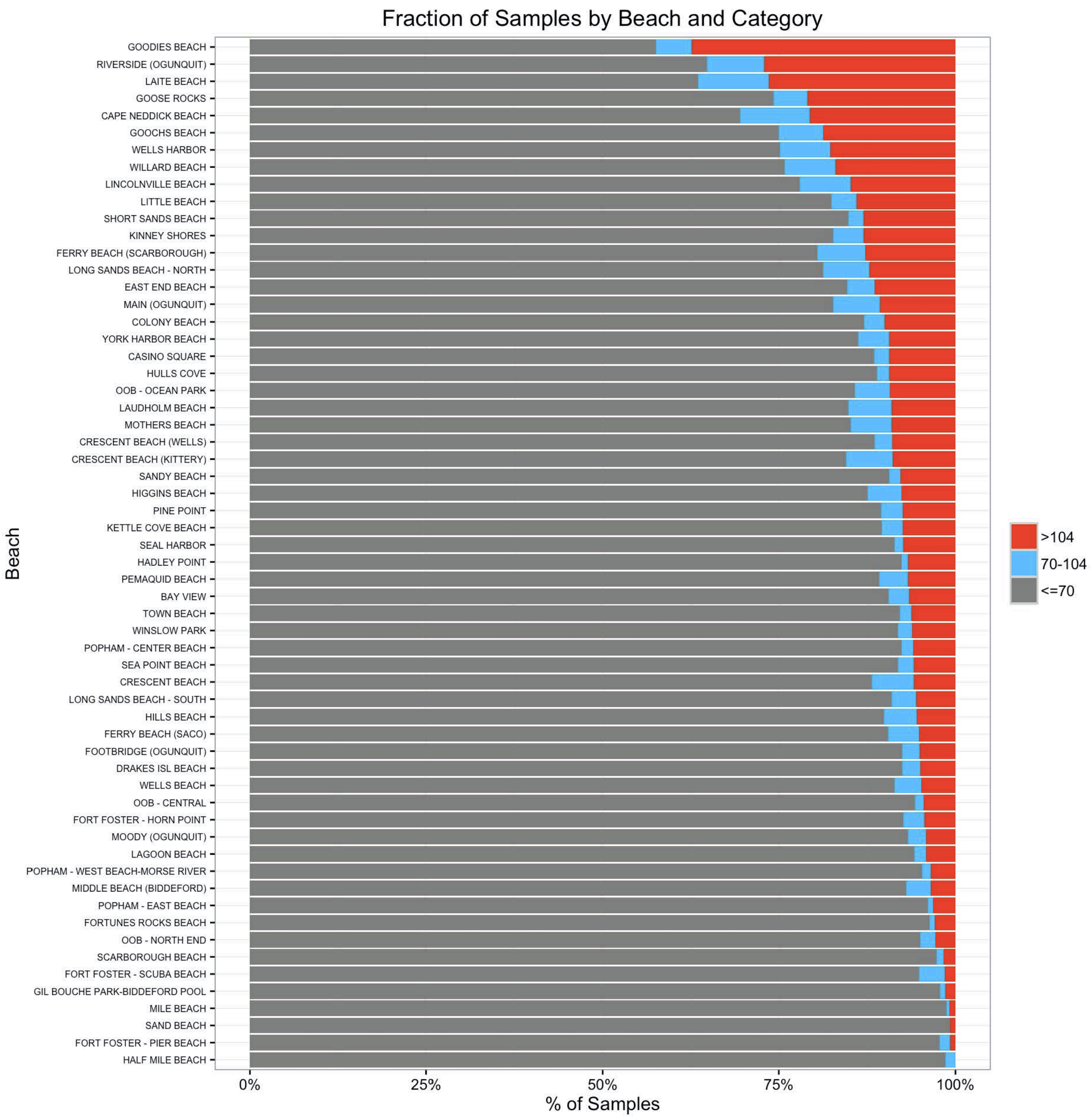
1.2 By Beach

In this section, the data are grouped by beach and thus may include more than one sampling site.

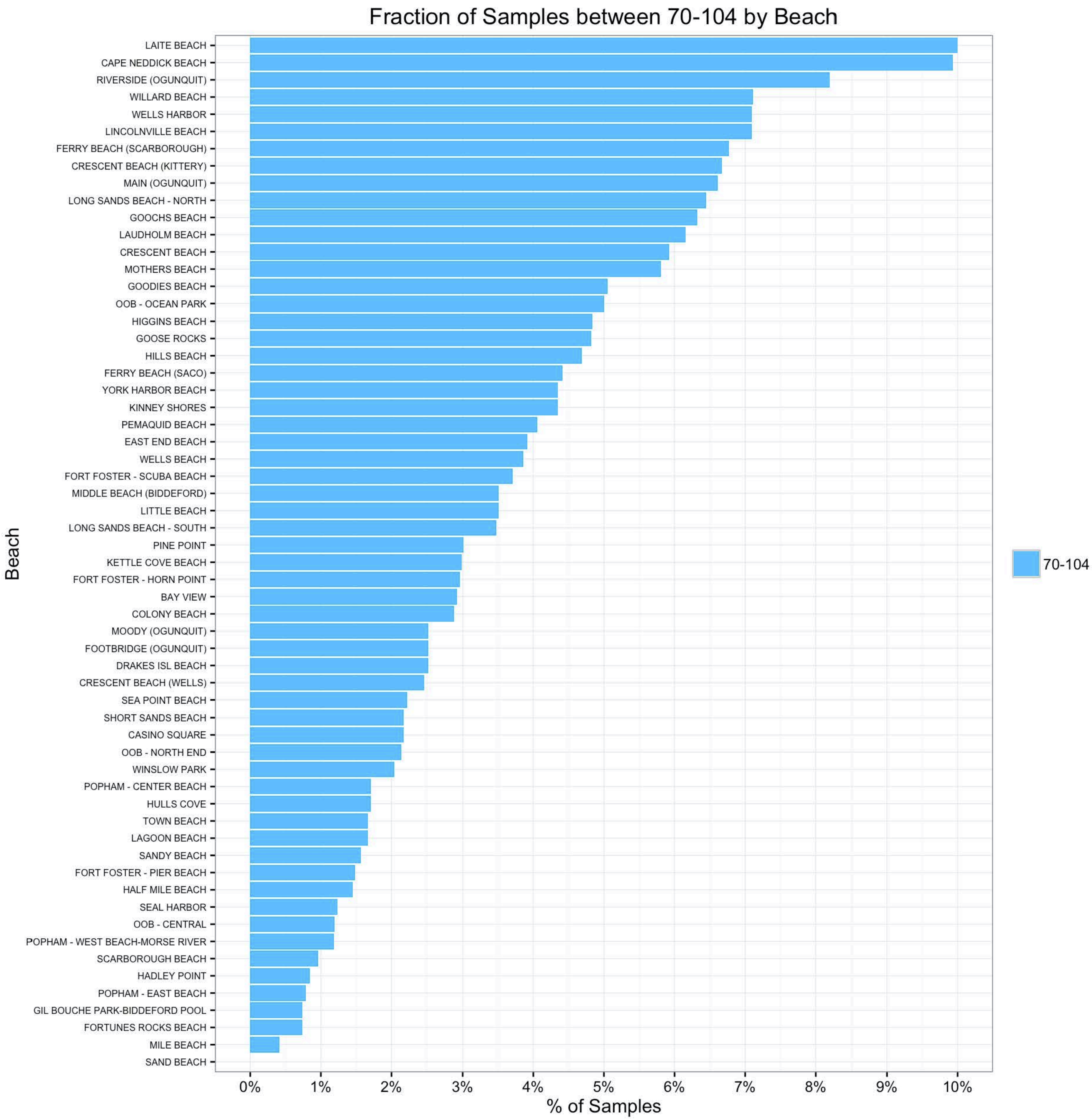
This figure shows the total number of routine samples in each category (<70, 70-104, >104).



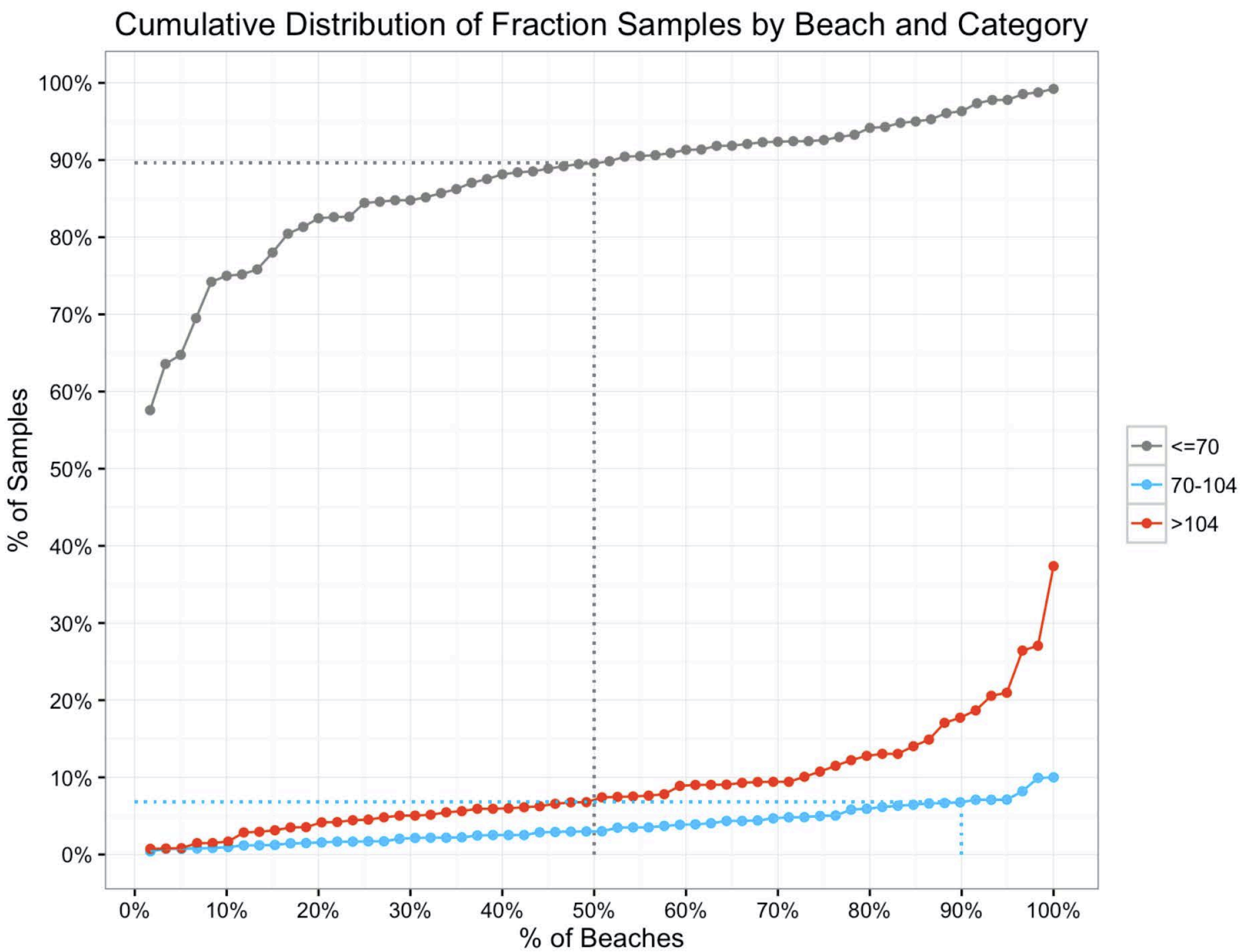
This figure shows the same data, but instead of the number of routine samples, it shows the fraction of routine samples in each category by beach ordered by the fraction >104 (dirtiest beaches at the top, cleanest at the bottom).



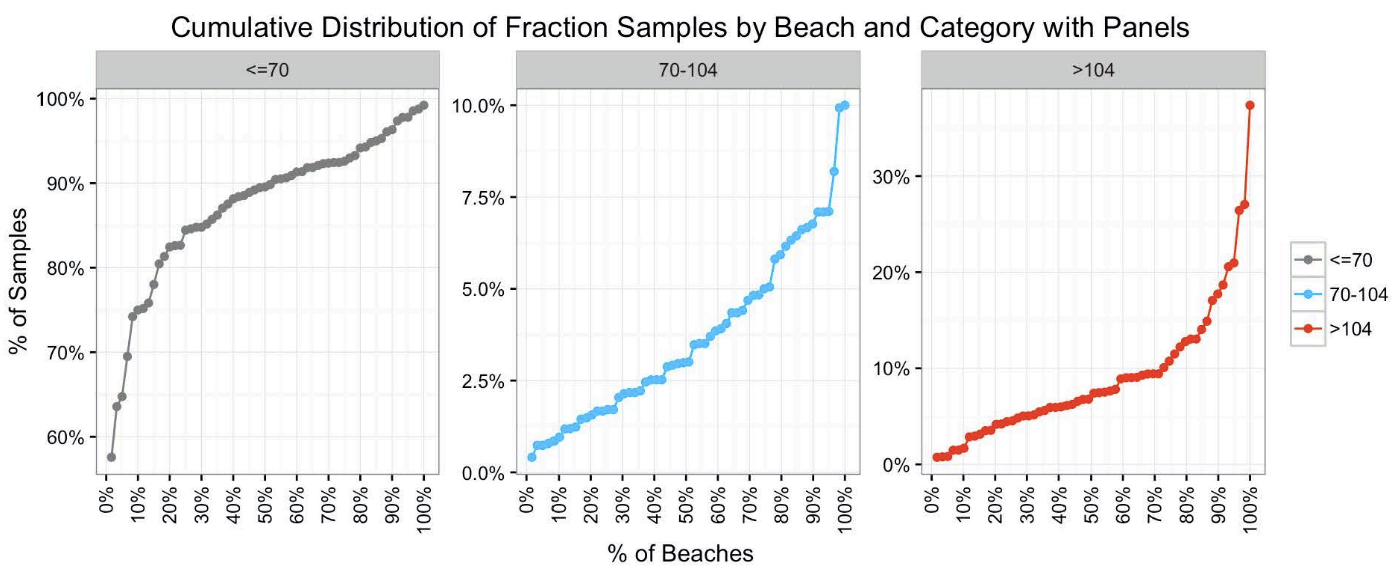
This figure shows only the fraction of routine samples between 70-104 (the blue bars of the previous figure) and ordered from highest to lowest.



This figure shows the cumulative distribution of % routine samples for each category across beaches. It shows, for example, that 50% of the beaches have 90% or less of samples <70 (dotted gray line), and that 90% of beaches have 7% or less of samples between 70-104 (dotted blue line).



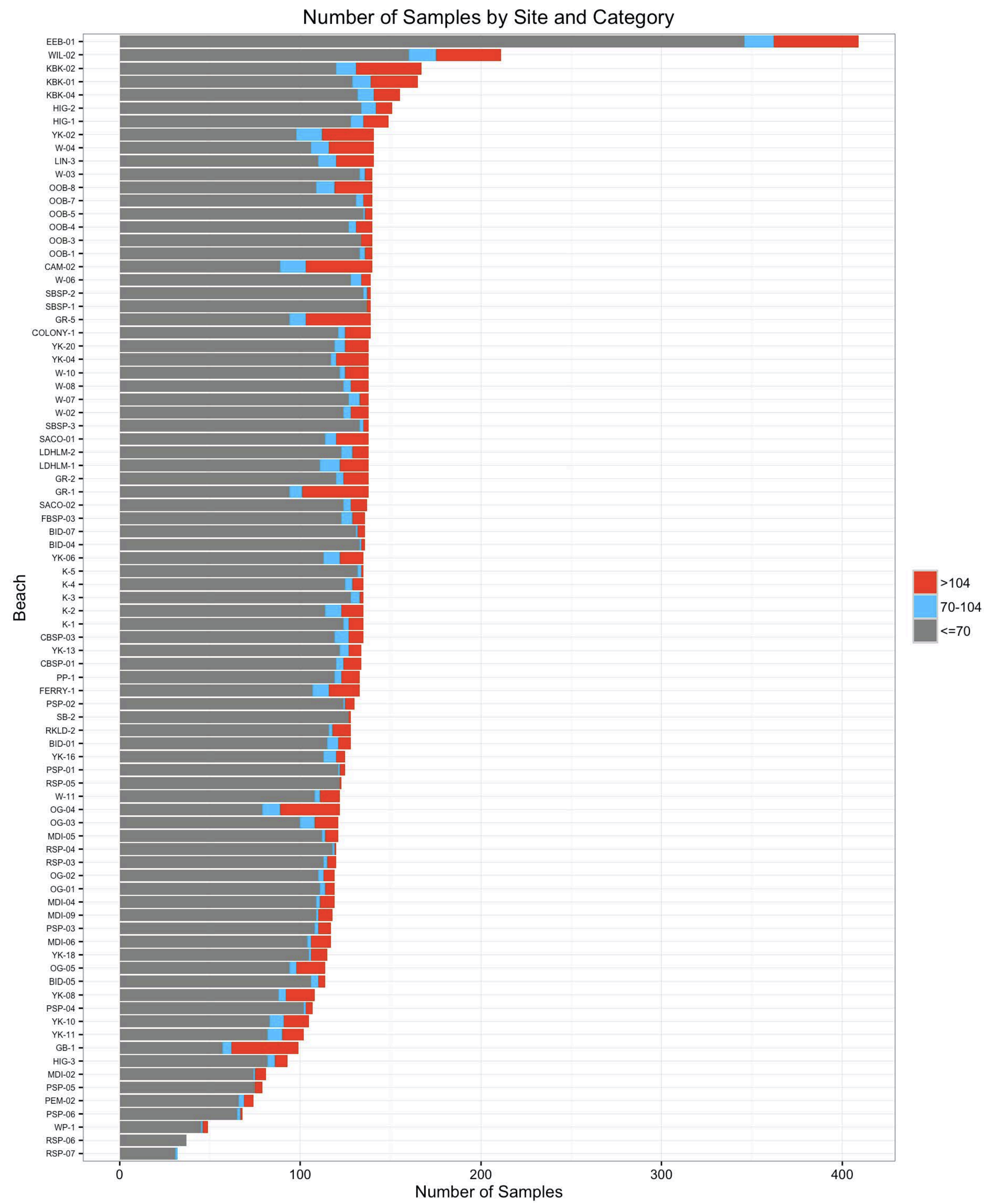
This figure shows the same data, but separates each category into separate panels with different y-axis scales.



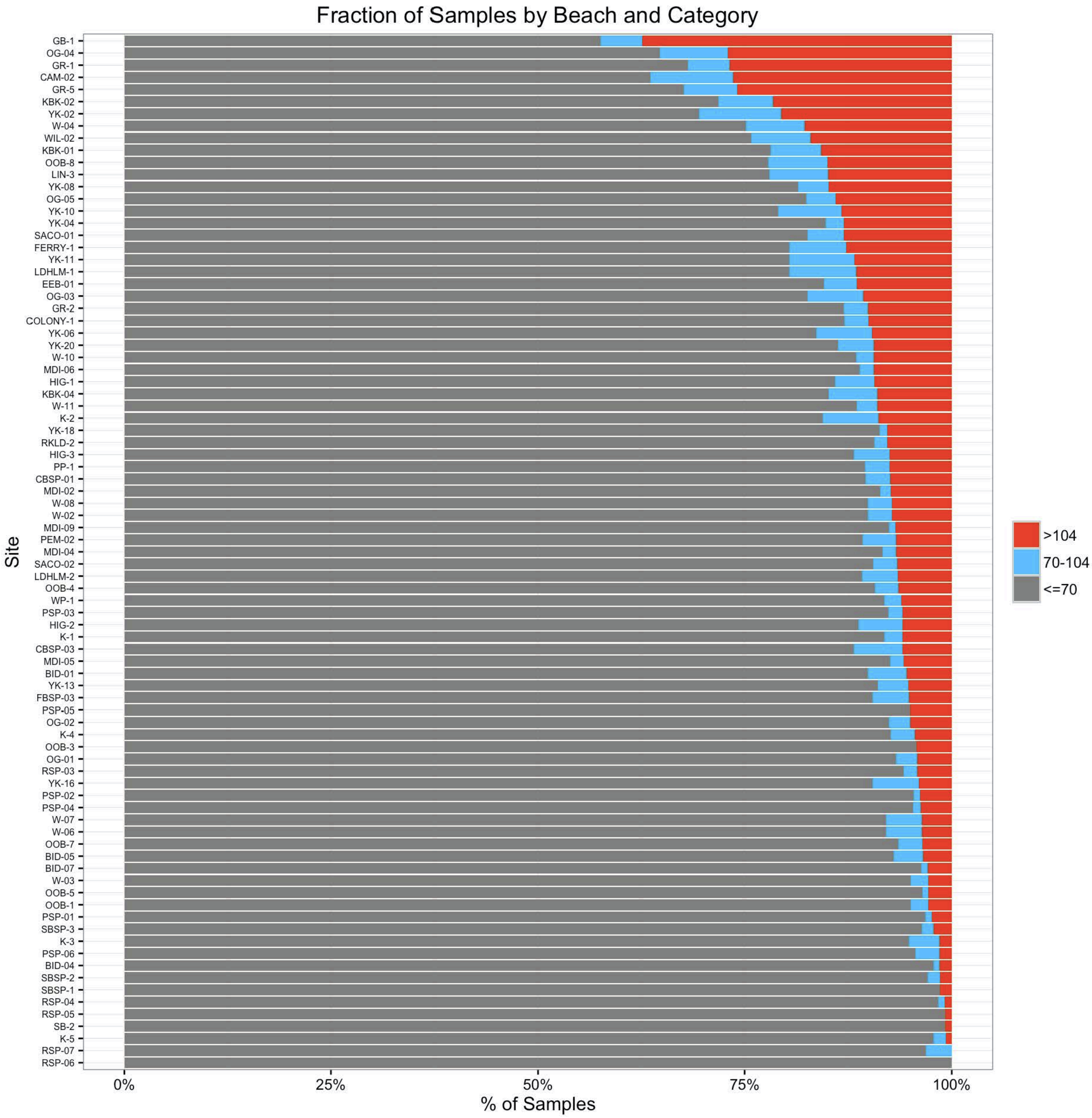
1.3 By Site

In this section, the data are grouped by site instead of beach.

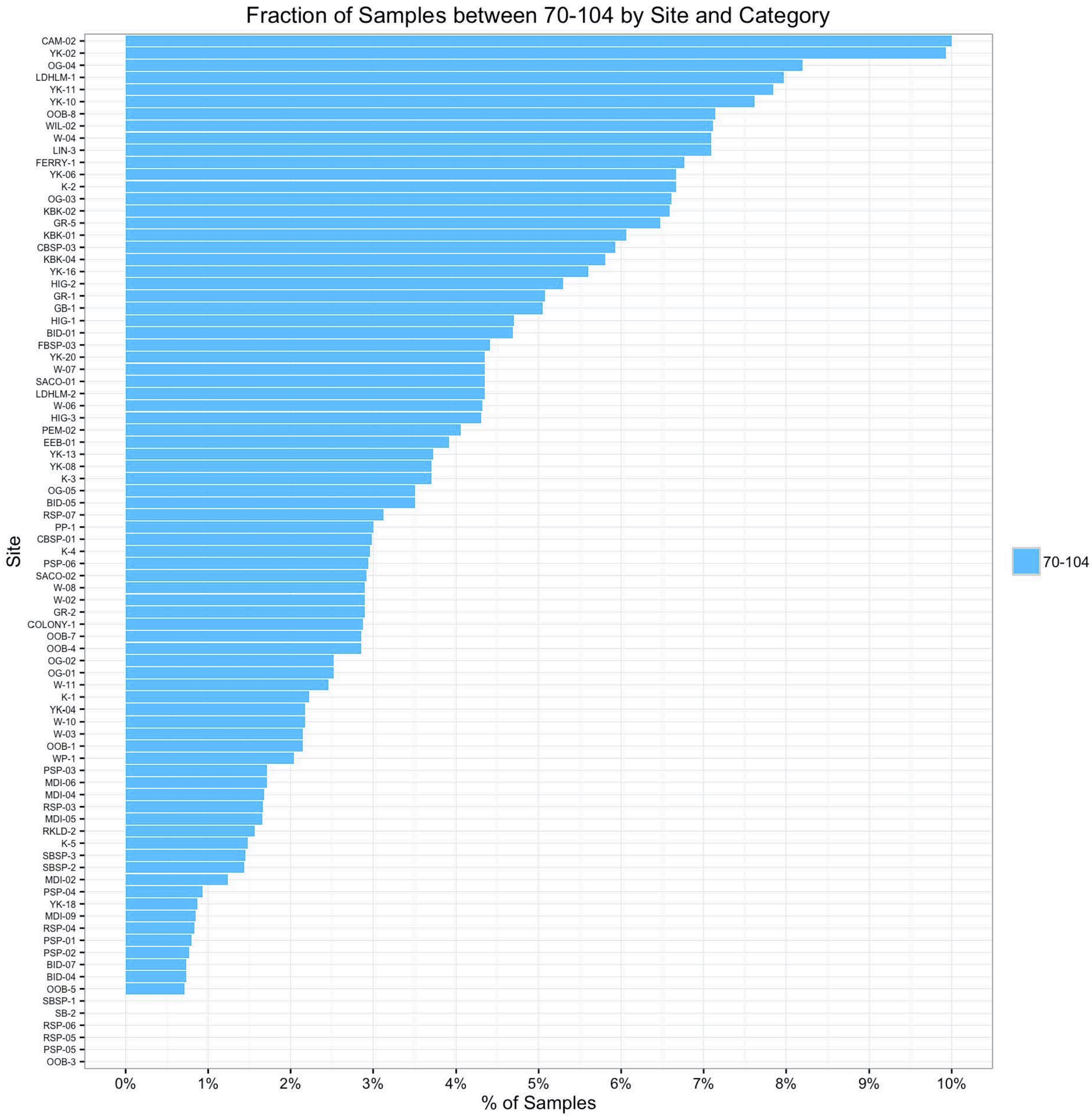
This figure shows the total number of samples in each category (<70, 70-104, >104), ordered by the total number of samples.



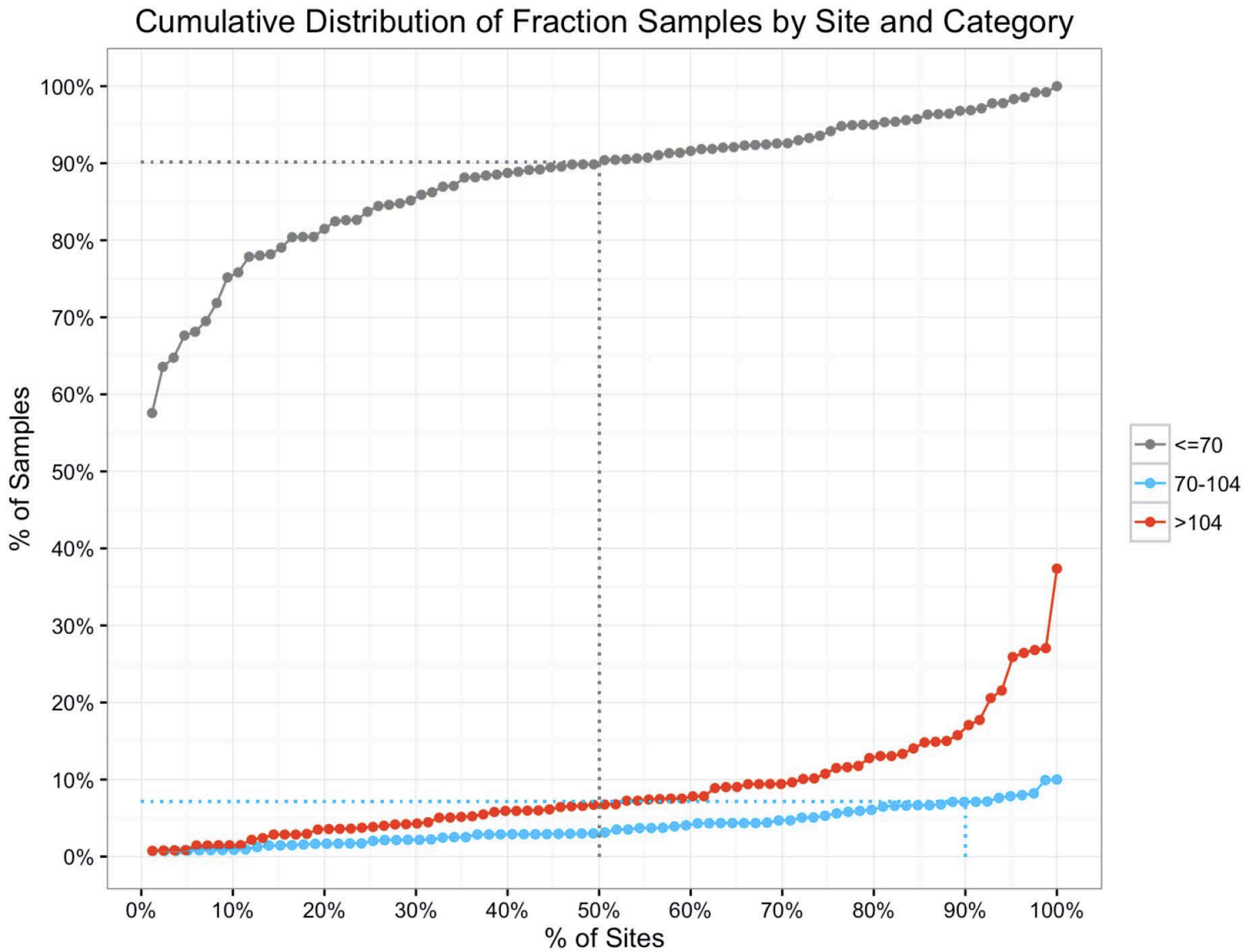
This figure shows the same data, but instead of the number of samples, it shows the fraction of samples in each category by beach ordered by the fraction >104 (dirtiest beaches at the top, cleanest at the bottom).



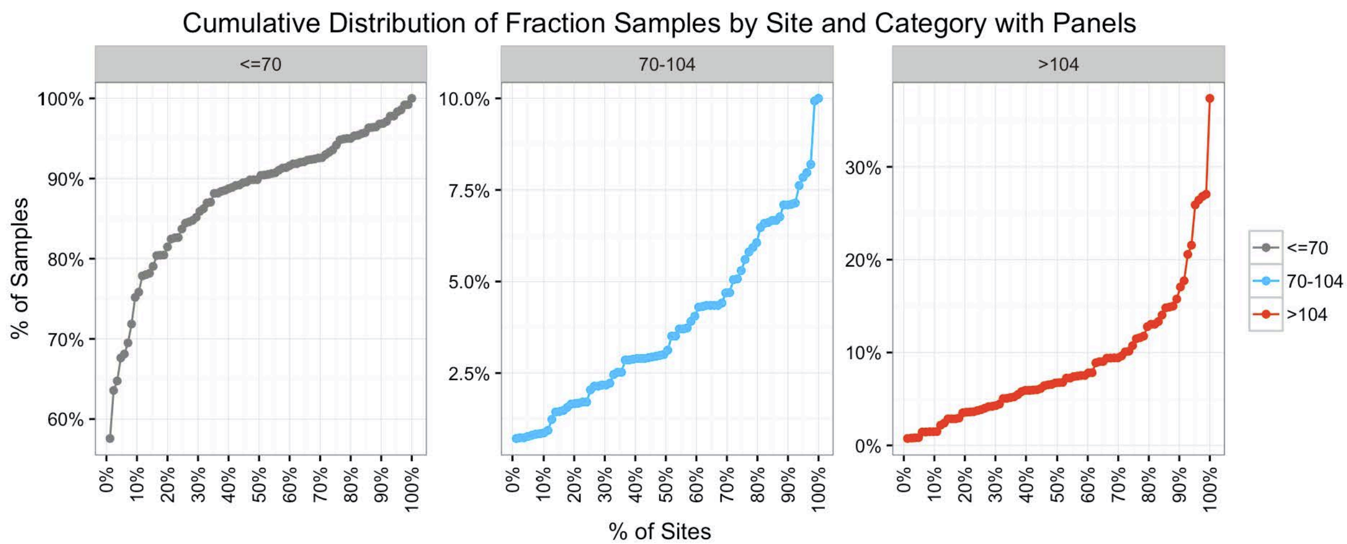
This figure shows only the fraction of total samples between 70-104 (the blue bars of the previous figure) and ordered from highest to lowest.



This figure shows the cumulative distribution of % samples for each category across beaches. It shows, for example, that 50% of the beaches have 90% or less of samples <70 (dotted gray line), and that 90% of beaches have 7% or less of samples between 70-104 (dotted blue line).

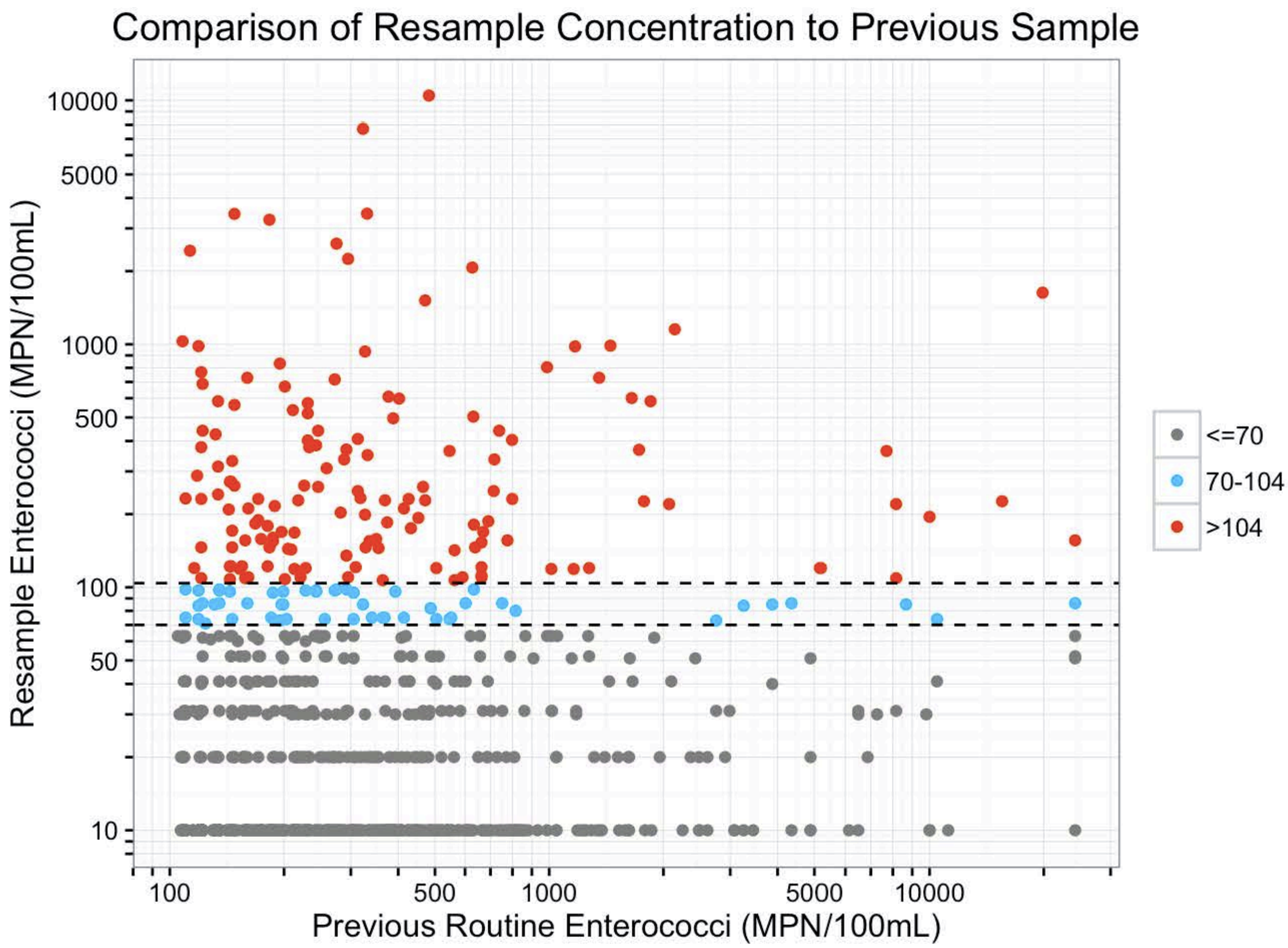


This figure shows the same data, but separates each category into separate panels with different y-axis scales.



2 Sampling Frequency and Resampling

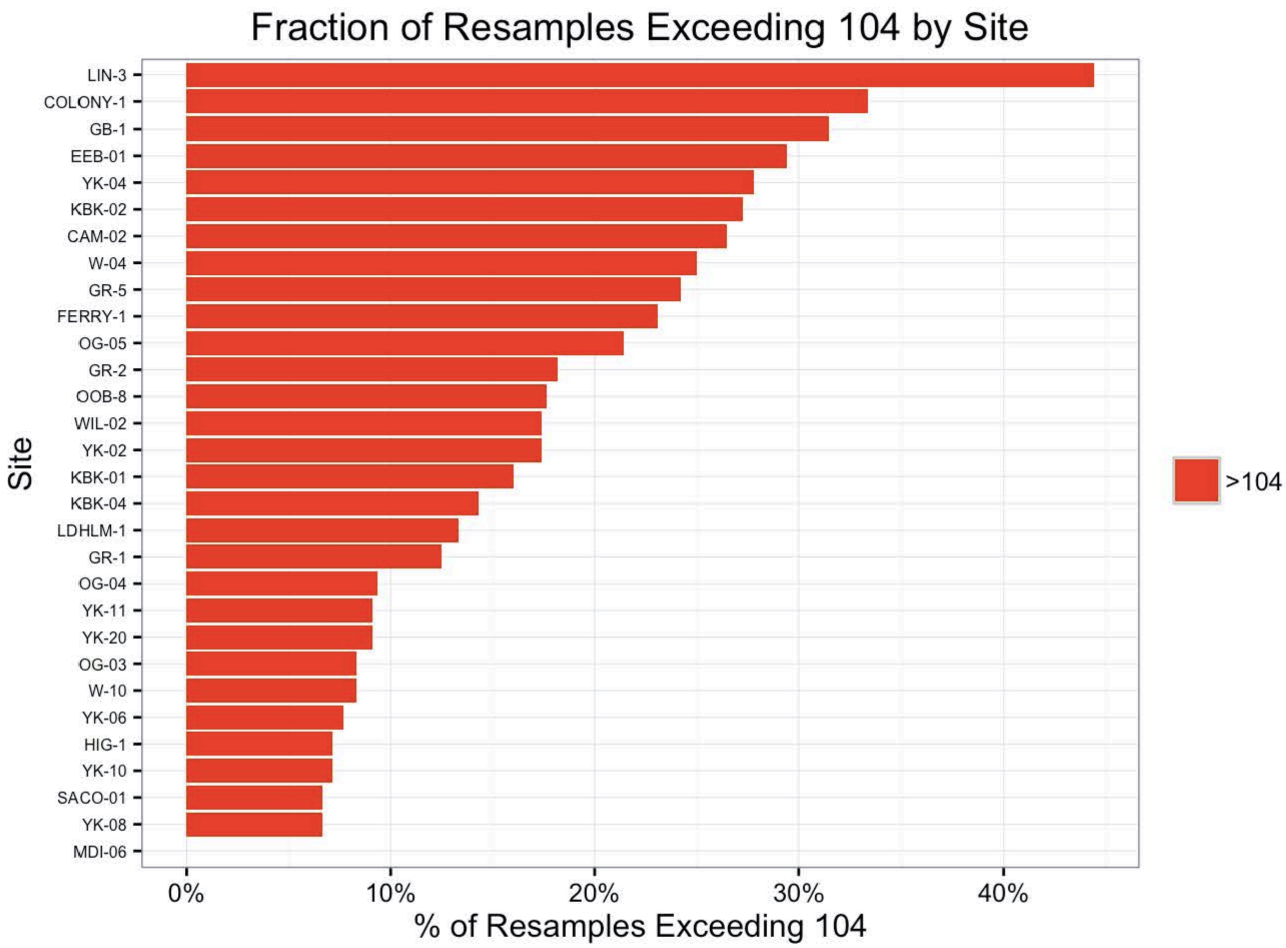
This section looks at how often resamples come back above or below the current limit of 104. This figure plots the each resample concentration against the concentration of the previous (routine) sample.



Question: What percent of all resamples have concentrations exceeding 104?

Answer: There were 130 resamples that exceed 104 MPN/100mL out of 837 total resamples, and thus 15.5% of all resamples continue to exceed 104 MPN/100mL.

This figure shows the percent of all resamples that come back above the current limit of 104 by site. This only includes initial resamples (i.e. resamples that follow a routine sample, but not resamples that are the second or third resample in a row). This also only includes sites that have at least 10 resamples total over the entire period (to exclude sites with only a couple resamples). This shows that at LIN-3, more than 40% of the resamples following a routine sample continued to exceed the 104 MPN/100mL.



Fraction of Resamples Exceeding 104 by Site
Site
LIN-3
COLONY-1
GB-1
EEB-01
YK-04
KBK-02
CAM-02
W-04
GR-5
FERRY-1
OG-05
GR-2
OOB-8
WIL-02
YK-02
KBK-01
KBK-04
LDHLM-1
GR-1
OG-04
YK-11
YK-20
OG-03
W-10
YK-06
HIG-1
YK-10
SACO-01
YK-08
MDI-06
0%
10%
20%
30%
40%
% of Resamples Exceeding 104
>104

Appendix B: Supplementary Data and Figures

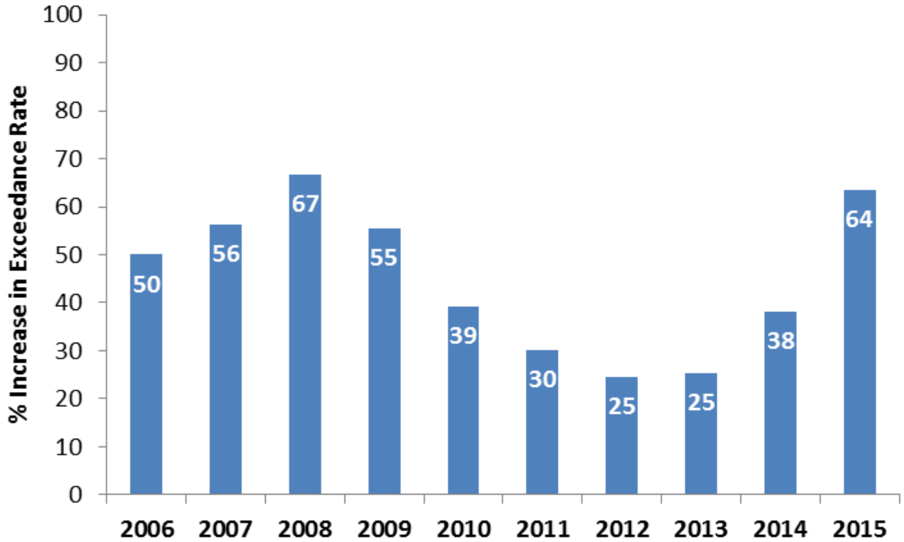


Figure B1. Percent increase in program-wide exceedance rate per year (2006-2015) resulting from lowering the BAV threshold from 104 to 70 MPN.

Table B1. Summary of MHB routine data (2006-2015) including beach name and sites , # of samples, # and % of samples exceeding each threshold (104 and 70 MPN), predominant pollution source, and years participating in MHB program.

Beach Name	Site	# samples	# ≥104	% ≥104	# ≥70	% ≥70	# 70-104	% 70-104	Pollution Source (Point/Nonpoint)	Years Participating
GOODIES BEACH	GB-1	99	37	37.37	42	42.42	5	5.05	NONPOINT	2009-2015
RIVERSIDE (OGUNQUIT)	OG-04	122	33	27.05	43	35.25	10	8.20	NONPOINT	2003-2012;2014-2015
LAITE BEACH	CAM-02	140	37	26.43	51	36.43	14	10.00	POINT	2003-2015
GOOSE ROCKS	GR-1, GR-2, GR-5	415	87	20.96	107	25.78	20	4.82	NONPOINT	2004-2015
CAPE NEDDICK BEACH	YK-02	141	29	20.57	43	30.50	14	9.93	POINT	2003-2015
GOOCHS BEACH	KBK-01,KBK-02	332	62	18.67	83	25.00	21	6.33	POINT	2003-2015
WELLS HARBOR	W-04	141	25	17.73	35	24.82	10	7.09	NONPOINT	2003-2015
WILLARD BEACH	WIL-02	211	36	17.06	51	24.17	15	7.11	POINT	2003-2010;2012-2015
LINCOLNVILLE BEACH	LIN-3	141	21	14.89	31	21.99	10	7.09	POINT	2004-2015
LITTLE BEACH	OG-05	114	16	14.04	20	17.54	4	3.51	NONPOINT	2006-2012,2014-2015
KINNEY SHORES	SACO-01	138	18	13.04	24	17.39	6	4.35	POINT	2003-2015
SHORT SANDS BEACH	YK-04	138	18	13.04	21	15.22	3	2.17	POINT	2003-2015
FERRY BEACH (SCARBOROUGH)	FERRY-1	133	17	12.78	26	19.55	9	6.77	NONPOINT	2005-2015
LONG SANDS BEACH - NORTH	YK-6,YK-08,YK-10,YK-11	450	55	12.22	84	18.67	29	6.44	NONPOINT	2003-2015
EAST END BEACH	EEB-01	409	47	11.49	63	15.40	16	3.91	POINT	2000-2015
MAIN (OGUNQUIT)	OG-03	121	13	10.74	21	17.36	8	6.61	POINT	2003-2012,2014-2015
COLONY BEACH	COLONY-1	139	14	10.07	18	12.95	4	2.88	POINT	2005-2015
YORK HARBOR BEACH	YK-20	138	13	9.42	19	13.77	6	4.35	NONPOINT	2003-2015
CASINO SQUARE	W-10	138	13	9.42	16	11.59	3	2.17	POINT	2003-2015
HULLS COVE	MDI-06	117	11	9.40	13	11.11	2	1.71	POINT	2003-2005,2007-2015
OOB - OCEAN PARK	OOB-7,OOB-8	280	26	9.29	40	14.29	14	5.00	POINT	2003-2015
LAUDHOLM BEACH	LDHLM-1,LDHLM-2	276	25	9.06	42	15.22	17	6.16	NONPOINT	2006-2015
MOTHERS BEACH	KBK-04	155	14	9.03	23	14.84	9	5.81	POINT	2003-2015
CRESCENT BEACH (WELLS)	W-11	122	11	9.02	14	11.48	3	2.46	POINT	2007-2015
CRESCENT BEACH (KITTERY)	K-2	135	12	8.89	21	15.56	9	6.67	NONPOINT	2005-2014
SANDY BEACH	RKLD-2	128	10	7.81	12	9.38	2	1.56	POINT	2007-2015
HIGGINS BEACH	HIG-1,HIG-2,HIG-3	393	30	7.63	50	12.72	20	5.09	NONPOINT	2004-2015;2012-2015 (Hig 3)
PINE POINT	PP-1	133	10	7.52	14	10.53	4	3.01	NONPOINT	2004-2015
KETTLE COVE BEACH	CBSP-01	134	10	7.46	14	10.45	4	2.99	NONPOINT	2003-2015
SEAL HARBOR	MDI-02	81	6	7.41	7	8.64	1	1.23	POINT	2003-2005,2010-2015
HADLEY POINT	MDI-09	118	8	6.78	9	7.63	1	0.85	NONPOINT	2007-2015
PEMAQUID BEACH	PEM-02	74	5	6.76	8	10.81	3	4.05	POINT	2003-2015
BAY VIEW	SACO-02	137	9	6.57	13	9.49	4	2.92	POINT	2003-2015
TOWN BEACH	MDI-04,MDI-05	240	15	6.25	19	7.92	4	1.67	POINT	2003-2005,2007-2015;2004-2005,2007-2015
WINSLOW PARK	WP-1	49	3	6.12	4	8.16	1	2.04	NONPOINT	2008-2015
POPHAM - CENTER BEACH	PSP-03	117	7	5.98	9	7.69	2	1.71	NONPOINT	2003-2015
CRESCENT BEACH	CBSP-03	135	8	5.93	16	11.85	8	5.93	NONPOINT	2003-2015
SEA POINT BEACH	K-1	135	8	5.93	11	8.15	3	2.22	NONPOINT	2005-2015
LONG SANDS BEACH - SOUTH	YK-13,YK-16,YK-18	374	22	5.88	34	9.09	13	3.48	NONPOINT	2003-2015
HILLS BEACH	BID-01	128	7	5.47	13	10.16	6	4.69	POINT	2003-2015
FORT FOSTER - HORN POINT	K-4	135	7	5.19	10	7.41	4	2.96	NONPOINT	2005-2015
FERRY BEACH (SACO)	FBSP-03	136	7	5.15	13	9.56	6	4.41	NONPOINT	2003-2015
FOOTBRIDGE (OGUNQUIT)	OG-02	119	6	5.04	9	7.56	3	2.52	POINT	2003-2012,2014-2015
DRAKES ISL BEACH	W-02, W-03	278	14	5.04	21	7.55	7	2.52	NONPOINT	2003-2015
WELLS BEACH	W-06,W-07,W-08	415	20	4.82	36	8.67	16	3.86	NONPOINT	2003-2015
OOB - CENTRAL	OOB-3, OOB-4, OOB-5	420	19	4.52	24	5.71	5	1.19	NONPOINT	2003-2015
MOODY (OGUNQUIT)	OG-01	119	5	4.20	8	6.72	3	2.52	POINT	2003-2012,2014-2015
LAGOON BEACH	RSP-03	120	5	4.17	7	5.83	2	1.67	NONPOINT	2003-2015
POPHAM - WEST-MORSE RIVER	PSP-04,PSP-05,PSP-06	254	9	3.54	12	4.72	3	1.18	NONPOINT	2015;2003-2006,2009-
MIDDLE BEACH (BIDDEFORD)	BID-05	114	4	3.51	8	7.02	4	3.51	NONPOINT	2003-2015
POPHAM - EAST BEACH	PSP-01,PSP-02	255	8	3.14	10	3.92	2	0.78	NONPOINT	2003-2015
FORTUNES ROCKS BEACH	BID-07	136	4	2.94	5	3.68	1	0.74	NONPOINT	2003-2015
OOB - NORTH END	OOB-1	140	4	2.86	7	5.00	3	2.14	NONPOINT	2003-2015
SCARBOROUGH BEACH	SBSP-1,SPSP-2,SBSP-3	416	7	1.68	11	2.64	4	0.96	NONPOINT	2006-2015
FORT FOSTER - SCUBA BEACH	K-3	135	2	1.48	7	5.19	5	3.70	NONPOINT	2005-2015
GIL BOUCHE PARK-BIDDEFORD POOL	BID-04	136	2	1.47	3	2.21	1	0.74	NONPOINT	2003-2015
MILE BEACH	RSP-04,RSP-05	243	2	0.82	3	1.23	1	0.41	NONPOINT	2003-2015
SAND BEACH	SB-2	128	1	0.78	1	0.78	0	0.00	NONPOINT	2007-2015
FORT FOSTER - PIER BEACH	K-5	135	1	0.74	3	2.22	2	1.48	NONPOINT	2005-2015
HALF MILE BEACH	RSP-06,RSP-07	69	0	0.00	1	1.45	1	1.45	NONPOINT	2003-2015

Table B2. Summary of MHB resample data (2006-2015) including beach name and sites, # of resamples, # and % of samples exceeding each threshold (104 and 70 MPN) and between the two, and resample cleanliness rate.

Beach Name	Site	# Resamples	# ≥104	% ≥104	# ≥70	% ≥70	# 70-104	% 70-104	Resample Cleanliness Rate
HALF MILE BEACH	RSP-06,RSP-07	0	NA	NA	NA	NA	NA	NA	NA
GIL BOUCHE PARK-BIDDEFORD POOL	BID-04	2	1	50.00	1	50.00	0	0.00	50.0
LINCOLNVILLE BEACH	LIN-3	18	8	44.44	9	50.00	1	5.56	55.6
COLONY BEACH	COLONY-1	12	4	33.33	5	41.67	1	8.33	66.7
GOODIES BEACH	GB-1	35	11	31.43	15	42.86	4	11.43	68.6
EAST END BEACH	EEB-01	17	5	29.41	7	41.18	2	11.76	70.6
SHORT SANDS BEACH	YK-04	18	5	27.78	5	27.78	0	0.00	72.2
LAITE BEACH	CAM-02	34	9	26.47	12	35.29	3	8.82	73.5
SEA POINT BEACH	K-1	8	2	25.00	2	25.00	0	0.00	75.0
WELLS HARBOR	W-04	20	5	25.00	5	25.00	0	0.00	75.0
FERRY BEACH (SCARBOROUGH)	FERRY-1	13	3	23.08	4	30.77	1	7.69	76.9
GOOCHS BEACH	KBK-01,KBK-02	58	13	22.41	20	34.48	7	12.07	77.6
LITTLE BEACH	OG-05	14	3	21.43	4	28.57	1	7.14	78.6
FOOTBRIDGE (OGUNQUIT)	OG-02	5	1	20.00	1	20.00	0	0.00	80.0
LAGOON BEACH	RSP-03	5	1	20.00	1	20.00	0	0.00	80.0
TOWN BEACH	MDI-04,MDI-05	16	3	18.75	5	31.25	2	12.50	81.3
GOOSE ROCKS	GR-1, GR-2, GR-5	76	14	18.42	22	28.95	8	10.53	81.6
WILLARD BEACH	WIL-02	23	4	17.39	5	21.74	1	4.35	82.6
CAPE NEDDICK BEACH	YK-02	23	4	17.39	5	21.74	1	4.35	82.6
LAUDHOLM BEACH	LDHLM-1,LDHLM-2	24	4	16.67	5	20.83	1	4.17	83.3
HILLS BEACH	BID-01	6	1	16.67	1	16.67	0	0.00	83.3
SEAL HARBOR	MDI-02	6	1	16.67	1	16.67	0	0.00	83.3
MOTHERS BEACH	KBK-04	14	2	14.29	4	28.57	2	14.29	85.7
OOB - OCEAN PARK	OOB-7,OOB-8	21	3	14.29	5	23.81	2	9.52	85.7
CRESCENT BEACH	CBSP-03	7	1	14.29	1	14.29	0	0.00	85.7
POPHAM - EAST BEACH	PSP-01,PSP-02	7	1	14.29	1	14.29	0	0.00	85.7
BAY VIEW	SACO-02	7	1	14.29	1	14.29	0	0.00	85.7
PINE POINT	PP-1	9	1	11.11	3	33.33	2	22.22	88.9
SANDY BEACH	RKLD-2	9	1	11.11	1	11.11	0	0.00	88.9
HIGGINS BEACH	HIG-1,HIG-2,HIG-3	29	3	10.34	4	13.79	1	3.45	89.7
DRAKES ISL BEACH	W-02, W-03	10	1	10.00	1	10.00	0	0.00	90.0
CRESCENT BEACH (WELLS)	W-11	10	1	10.00	1	10.00	0	0.00	90.0
RIVERSIDE (OGUNQUIT)	OG-04	32	3	9.38	5	15.63	2	6.25	90.6
YORK HARBOR BEACH	YK-20	11	1	9.09	1	9.09	0	0.00	90.9
MAIN (OGUNQUIT)	OG-03	12	1	8.33	1	8.33	0	0.00	91.7
CASINO SQUARE	W-10	12	1	8.33	1	8.33	0	0.00	91.7
LONG SANDS BEACH - NORTH	YK-6,YK-08,YK-10,YK-11	53	4	7.55	7	13.21	3	5.66	92.5
KINNEY SHORES	SACO-01	15	1	6.67	1	6.67	0	0.00	93.3
OOB - CENTRAL	OOB-3, OOB-4, OOB-5	17	1	5.88	2	11.76	1	5.88	94.1
LONG SANDS BEACH - SOUTH	YK-13,YK-16,YK-18	21	1	4.76	1	4.76	0	0.00	95.2
PEMAQUID BEACH	PEM-02	4	0	0.00	1	25.00	1	25.00	100.0
FERRY BEACH (SACO)	FBSP-03	6	0	0.00	1	16.67	1	16.67	100.0
POPHAM - WEST BEACH-MORSE RIVEI	PSP-04,PSP-05,PSP-06	7	0	0.00	1	14.29	1	14.29	100.0
MIDDLE BEACH (BIDDEFORD)	BID-05	4	0	0.00	0	0.00	0	0.00	100.0
FORTUNES ROCKS BEACH	BID-07	4	0	0.00	0	0.00	0	0.00	100.0
KETTLE COVE BEACH	CBSP-01	8	0	0.00	0	0.00	0	0.00	100.0
CRESCENT BEACH (KITTERY)	K-2	9	0	0.00	0	0.00	0	0.00	100.0
FORT FOSTER - SCUBA BEACH	K-3	1	0	0.00	0	0.00	0	0.00	100.0
FORT FOSTER - HORN POINT	K-4	6	0	0.00	0	0.00	0	0.00	100.0
FORT FOSTER - PIER BEACH	K-5	1	0	0.00	0	0.00	0	0.00	100.0
HULLS COVE	MDI-06	11	0	0.00	0	0.00	0	0.00	100.0
HADLEY POINT	MDI-09	7	0	0.00	0	0.00	0	0.00	100.0
MOODY (OGUNQUIT)	OG-01	4	0	0.00	0	0.00	0	0.00	100.0
OOB - NORTH END	OOB-1	3	0	0.00	0	0.00	0	0.00	100.0
POPHAM - CENTER BEACH	PSP-03	7	0	0.00	0	0.00	0	0.00	100.0
MILE BEACH	RSP-04,RSP-05	2	0	0.00	0	0.00	0	0.00	100.0
SAND BEACH	SB-2	1	0	0.00	0	0.00	0	0.00	100.0
SCARBOROUGH BEACH	SBSP-1,SPSP-2,SBSP-3	5	0	0.00	0	0.00	0	0.00	100.0
WELLS BEACH	W-06,W-07,W-08	15	0	0.00	0	0.00	0	0.00	100.0
WINSLOW PARK	WP-1	3	0	0.00	0	0.00	0	0.00	100.0