
2018-2019 Kenai Beach Bacteria Monitoring Report

FY19-20 Final Report



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Conservation

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The Kenai Watershed Forum is dedicated to successfully identifying and addressing the needs of the region by providing high quality education, restoration, and research programs.



“Working together for healthy watersheds on the Kenai Peninsula”

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Executive summary

Under contracts with the City of Kenai (CoK), the Kenai Watershed Forum (KWF) has been working with the Alaska Department of Environmental Conservation (ADEC) for several summers in an ongoing initiative to monitor bacteria concentrations at public beaches and within the lower six miles of the Kenai River in Kenai, Alaska. Bacteria monitored included fecal coliform and enterococci, both of which are found in the excrement of warm-blooded animals such as gulls. Gulls are attracted to Kenai beaches by fish carcasses produced during the personal use dipnet fishery (PUF). In order to establish a baseline for bacteria, KWF began monitoring fecal coliform and enterococci concentrations from 2010-2014 at sites in the lower six miles of the Kenai River and along its beaches at the mouth. In 2015, best management practices (BMPs) were implemented by the City of Kenai, which included clearing fish carcasses from the beaches at night during the dipnet PUF to reduce the number of gulls present during the day. To assess changes in bacteria concentrations post-BMP implementation, the Kenai Watershed Forum conducted monitoring from 2018-2019 at sites located at the North and South Kenai Beaches; Warren Ames Memorial Bridge; and upstream and downstream of the gull rookery. To compliment these efforts, a 24-hour monitoring event was conducted at the beach locations in 2018 to assess tidal influence on bacteria concentrations. Microbial source tracking (MST) was also conducted prior to and during the PUF in order to identify sources of these bacteria. This document summarized bacteria results throughout the 2018-2019 monitoring seasons and makes recommendations for the continuation of successful beach monitoring efforts.

Introduction

The Kenai River is a glacially-fed river located on Alaska's Kenai Peninsula that begins at the outlet of Kenai Lake and flows into Cook Inlet, a branch of the Gulf of Alaska. This river, known internationally for its prolific fisheries, provides rearing habitat and annual migratory routes for all five species of Pacific Salmon. Each summer, thousands of recreationists participate in the Kenai River sportfishing season, which includes a resident-only dipnet PUF during much of July.

Since 1996, the Alaska Department of Fish and Game (ADFG) has managed the dipnet PUF for Alaska residents under the Kenai River Late-Run Sockeye Salmon Management Plan. The PUF is generally open from July 10th to July 31st starting from the Warren Ames Memorial Bridge between mile five and six of the Kenai River, to the mouth of the river, where the boundary extends along the North and South Kenai Beaches (Figure 1). While providing ample fishing and recreational opportunities for resident recreationists, the dipnet PUF also supports the local economy and is therefore highly valued by many throughout the state. However, the fishery has resulted in accumulation of fish carcass waste along the North and South Kenai beaches due to the waste management practices of users.

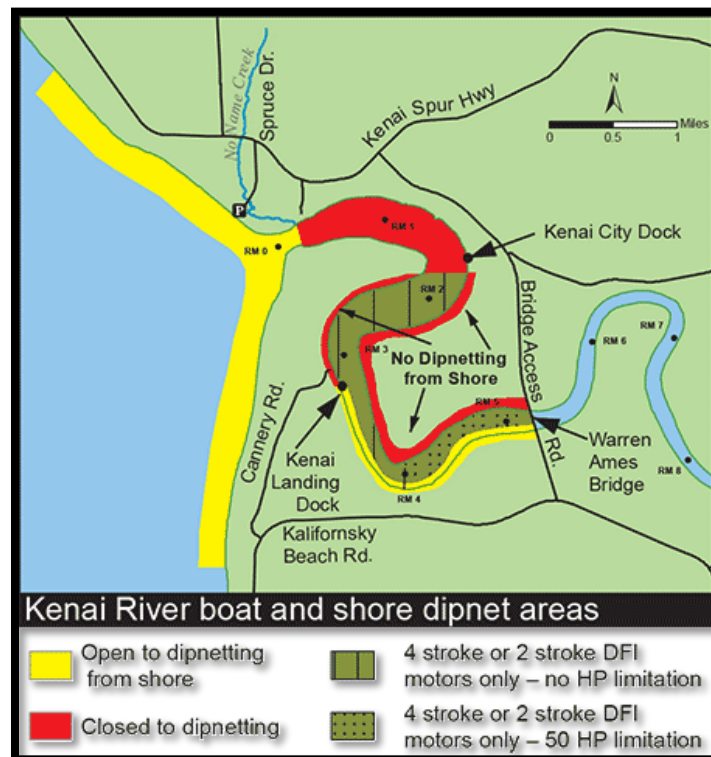


Figure 1. Kenai River and Kenai Beach dipnet PUF access locations (Alaska Department of Fish and Game, 2018).

Common practice of recreationists within the dipnet PUF involves processing fish and discarding the waste along the beaches or within nearshore ocean water. It is also common to store freshly-caught fish on the beaches before processing them. The fish and resulting waste exposed along the beaches draws thousands of gulls from an established upstream gull rookery to the area each day to feed. The excrement from these gulls carries bacteria including fecal coliform bacteria and enterococci, which are affecting water quality along the North and South Kenai Beaches. When in exceedance of ADEC water quality standards, these bacteria can be indicative of water containing concentrations of other bacteria that could induce illness.

Monitoring for fecal coliform and enterococci bacteria was initiated in 2010 in Kenai, Alaska. Throughout the 2010-2014 monitoring seasons, bacteria concentrations were found to periodically exceed the state standards throughout this timeframe and, in response, CoK implemented best management practices (BMPs) in 2014. These required the nightly clearing of fish carcasses from North and South Kenai Beaches and installing portable toilets during the PUF. Such practices were executed with the goal of reducing sources of bacteria, thereby minimizing the exposure of recreationists and fishermen.

Following three years of BMP implementation, KWF was contracted through the CoK to work with ADEC to sample for fecal coliform bacteria and enterococci concentrations throughout the summers of 2018-2019. The overarching sampling objective was to monitor changes in these bacteria concentrations post-BMP implementation. KWF conducted 13 weeks of weekly bacteria sampling from June to September 2018 at the North and South Kenai Beaches, two sites near the upriver gull rookery, and near the Warren Ames Memorial Bridge (Figure 2). A 24-hour monitoring event was employed during the 2018 monitoring season to assess a possible correlation between tide cycles and bacteria concentrations. Weekly routine sampling events took place again in 2019 for 15 weeks throughout May-September. Sampling for MST analyses was conducted once before and during the PUF in order to identify and quantify bacteria sources in the system.

Throughout the 2018-2019 monitoring period, several water quality exceedances of both fecal coliform and enterococci were identified, particularly at the North and South Kenai Beach sampling locations. In response, KWF collaborated with CoK and ADEC to conduct public outreach and education centered around the potential health risks and preventative measures the public could take in order to avoid contact with contaminated water.

Methods

Prior to monitoring in 2018 and 2019, the ADEC BEACH Water Quality Monitoring and Pathogen Detection Quality Assurance Project Plan (QAPP) was revised for sampling five predetermined sites within the lower reaches of the Kenai River as well as along the North and South Kenai Beaches. KWF employees and interns were trained in proper sampling techniques using the methods outlined in the QAPP and sampling was monitored throughout the summer for consistency and technique.

Monitoring locations

All five weekly monitoring locations are located throughout the lower six miles of the Kenai River and along the North and South Kenai Beaches at the Kenai River outlet along Cook Inlet. During peak recreation and fishing periods in July and August, this area experiences high pressure from both commercial and personal-use power boats as well as bank fisherman during the dipnet PUF from July 10th -July 31st. The upstream-most site, Warren Ames Memorial Bridge, receives little pressure from fishermen and was therefore chosen as a monitoring site for background concentrations of fecal coliform and enterococci bacteria. Further downstream near the Kenai River outlet is a large gull rookery located on river left that, at times, plays host to hundreds of gulls. The North and South Kenai Beaches located near the Kenai River outlet draw thousands of dipnetters during the PUF season. Table 1 displays monitoring locations, site descriptions and prevalent sources of bacteria; Figure 2 delineates the monitoring locations in the lower six miles of the Kenai River and along the beaches at its outlet. Sampling site photographs can be found in Appendix D.

Table 1. 2018-2019 Kenai beach bacteria monitoring site locations and descriptions.

| Site Name | Site ID | Latitude | Longitude | Site description |
|------------------------------------|---------|----------|------------|--|
| Warren Ames Memorial Bridge | BRG1 | 60.5259 | -151.20647 | Farthestmost upstream site on Kenai River, receiving little use by fishermen; provides data for background levels of bacteria in river |
| Kenai River Gull Rookery 2 | KRGR2 | 60.5518 | -151.244 | Upstream of gull rookery on the Keanai River; provides data for bacteria levels above influence of rookery |
| Kenai River Gull Rookery 1 | KRGR2 | 60.5366 | -151.254 | Downstream of gull rookery on the Keanai River; provides data for bacteria levels below rookery |
| North Kenai Beach 2* | NKB2 | 60.55057 | -151.27206 | One of two sites on North Kenai Beach, receiving high dipnetting pressure during PUF; fish carcasses from PUF attract hundreds of gulls present during certain days of PUF; provides data for bacteria levels before, during, after PUF; *used briefly as site in 2018 |
| North Kenai Beach 4 | NKB4 | 60.54978 | -151.26804 | One of two sites on North Kenai Beach, receiving high dipnetting pressure during PUF; fish carcasses from PUF attract hundreds of gulls present during certain days of PUF; provides data for bacteria levels before, during, after PUF |
| South Kenai Beach 2* | SKB2 | 60.54673 | -151.26318 | One of two sites on South Kenai Beach, receiving high dipnetting pressure during PUF; fish carcasses from PUF attract hundreds of gulls present during certain days of PUF; provides data for bacteria levels before, during, after PUF; *used briefly as site in 2018 |
| South Kenai Beach 3 | SKB3 | 60.54332 | -151.26532 | One of two sites on South Kenai Beach, receiving high dipnetting pressure during PUF; fish carcasses from PUF attract hundreds of gulls present during certain days of PUF; provides data for bacteria levels before, during, after PUF |



Figure 2. 2018-2019 Kenai River beach sampling sites used for fecal coliform and enterococci monitoring.

Sampling design

Sites selected for monitoring throughout the 2018 and 2019 sampling seasons remained consistent with those used in previous years. These included a sampling site at the Warren Ames Memorial Bridge (BRG1), above and below the gull rookery in the Kenai River (KRGR1 and KRGR2, respectively), and two different areas on both the North (NKB4) and South (SKB3) Kenai Beaches (Figure 2). Initially, the 2018 sampling design included alternating between SKB2 and SKB3 as well as NKB2 and NKB4 each week, but was later revised to only include sampling at SKB3 and NKB4 each week (Table 1).

During a typical sampling event, morning site visits were conducted around the time of high tide. Sites near the gull rookery (KRGR1, KRGR2) were accessed by boat while all other sites were accessed by land. At each site, two 100-mL grab samples of water were collected, one for fecal coliform bacteria and one for enterococci. A set of replicate samples was collected for quality control during each sampling event, typically rotating between the North and South Kenai Beach sampling sites. In-situ air and water temperatures were collected using a YSI 650 MDS multiprobe meter and local observations were made regarding the weather, tides, beach, activity noted on the beach, water, and potential sources of contamination (gulls, boats, etc...). For the purpose of quantifying and referencing observed fishermen, campers, and other beach-goers, the all-encompassing term *recreationists* will be used throughout this report. All field observations were recorded on an EPA Marine Beach Sanitary found in Appendix A.

All grab samples were carefully packaged and shipped on ice with a corresponding chain-of-custody form (see Appendix B) within six hours of sampling via commercial air carrier to an ADEC-certified laboratory in Anchorage for processing, including ARS Aleut Analytical and SGS North America Inc. As required by the project QAPP, the quantity of fecal coliform bacteria per 100-mL sample was determined using analytical method ID SM-9222D while the quantity of enterococci per 100-mL sample was determined using analytical method ID D6503-99 (Alaska Department of Environmental Conservation: Division of Water, 2018). The results of these analyses were reported by the laboratory to KWF and ADEC within 48 hours of receiving the samples. If exceedances were present, employees of KWF, ADEC, and CoK collaboratively acted to alert the public of the risks of exposure and preventative measures to take in order to avoid contact with the contaminated water body. ADEC also released press releases which can be found in Appendix C.

2018: 24-hour monitoring event

An additional 24-beach monitoring event was added to the 2018 monitoring plan in order to identify any effects of tide cycles on the concentrations of fecal coliform bacteria and enterococci along the North and South Kenai Beaches. A group of two field staff members were stationed at SKB3 and NKB4 from 9:00 AM on July 25, 2018 to 9:00 AM on July 26th, 2018.

Grab samples were taken for fecal coliform bacteria and enterococci at each site at the top of each hour. Air and water temperature, as well as all previously-mentioned observations were documented. Samples were stored on ice until they were shuttled periodically to the airport for shipment to the laboratory in Anchorage. Due to lack of flights and limited laboratory hours, samples could not be processed through the night so delayed sample analyses were preapproved by ADEC and the laboratory. Results of analyses were reported within a timely manner.

2019: Microbial source tracking

Sampling was conducted at all five Kenai River bacteria monitoring locations in 2019 for microbial source tracking (MST), a method used to identify sources of fecal contamination based on genetic markers (Table 1). Throughout this process, MST methodology was employed to test for the presence of dog, human, and gull fecal matter-all potential sources contributing to bacteria concentrations in the Kenai River system. The first sampling event occurred before the PUF on June 4th and a second event occurred on July 23rd. Because the concentrations of bacteria were not elevated enough during the second sampling event, these MST samples were not submitted for processes and ADEC requested a third sampling event, held on August 1st.

All sampling events for MST corresponded with a bacteria sampling event. Prior to each sampling event, five 500-mL sterile sampling bottles were packaged individually by wrapping them in paper towels and storing them in ziplock bags. Once in the field, hands were cleaned and new disposable gloves were used. Sample bottles remained closed until just prior to sample collection. Each bottle was labeled with sampling location, sample type (MST), date, and time. One grab sample was taken per monitoring location and subsequently packaged and shipped on ice with a corresponding chain-of-custody form (Appendix B) within six hours of sampling via commercial air carrier to the ADEC-certified laboratory, SGS North America Inc (SGS), in Anchorage. To concentrate bacteria within the samples, SGS processed all samples via a sterile, vacuum filtration method. All resulting filters were stored in a freezer until given permission by KWF to overnight the frozen samples with a temperature blank to ADEC-approved Source Molecular in Miami, Florida, where the bacteria source was identified by genetic markers using quantitative polymerase chain reaction (qPCR) and Digital PCR technologies.

Quality assurance and quality control

Data was reviewed for quality control and assurance by the ADEC Project Manager assigned to this monitoring program as well as the Grantee Project Quality Assurance Officer. In addition, a duplicate, quality control sample was taken for both fecal coliform and enterococci analyses. These samples alternated between the North and South Kenai Beaches each week. The higher of the two results for both fecal coliform and enterococci was utilized during data analysis in order to err on the side of caution.

All data was uploaded to the state Ambient Water Quality Monitoring System (AQWMS) by ADEC.

Water quality standards

Fecal coliform and enterococci results from the 2018 and 2019 monitoring periods were analyzed based on the Alaska water quality standards for marine water (18 AAC 70 (14)). Fecal coliform exceedances are determined based on standards set for secondary water recreation and harvesting raw aquatic life for consumption. Standards are described throughout Table 2 below.

Criteria for these standards required the results of a minimum of $n=5$ samples to calculate a 30-day rolling geometric mean. In instances where a 30-day period included a bacterium result of 0 CFU/100 mL, this result was not included in the geometric mean calculation because this calculation is not possible with the result of 0 CFU/100 mL. Fecal coliform exceedances were also identified when the seasonal percentage of the number of samples exceeding the standard was greater than 10%. Enterococci exceedances were identified in a similar manner; however, if fewer than 10 samples were collected in a 30-day period, single samples were compared to the 10% maximum criteria. If they exceeded the criteria, they were considered an exceedance.

During the summer monitoring period, weekly exceedances were determined based on results exceeding 130 enterococci CFU/100 mL for water recreation (contact recreation), 400 fecal coliform CFU/100 mL for water recreation (secondary recreation), and/or 31 fecal coliform CFU/100 mL for a membrane filtration test for harvesting for consumption of raw mollusks or other raw aquatic life (Table 2). When an exceedance occurred during the PUF season a public advisory was issued. Advisories were active until two consecutive weeks of bacteria concentrations below exceedance criteria were achieved.

Table 2. 2018 Alaska Department of Environment Conservation water quality standards for fecal coliform and enterococci in marine waters.

| Water Quality Standards for Bacteria: Marine Water Uses | | |
|--|--|--|
| | Fecal coliform | Enterococci |
| Water recreation: contact recreation, 18 AAC 70 (14)(B)(i) | | In a 30-day period, the geometric mean of samples may not exceed 35 enterococci CFU/100 ml, and* not more than 10% of the samples may exceed a statistical threshold value (STV) of 130 enterococci CFU/100 ml. |
| Water recreation: secondary recreation, 18 AAC 70 (14)(B)(ii) | In a 30-day period, the geometric mean of samples may not exceed 200 fecal coliform/100ml, and* not more than 10% of the samples may exceed 400 fecal coliform/100ml. | |
| Harvesting for consumption of raw mollusks or other raw aquatic life, 18 AAC 70 (14)(D) | The geometric mean of samples may not exceed 14 fecal coliform/100 ml; and* not more than 10% of the samples may exceed; - 43 MPN per 100 ml for a five-tube decimal dilution test; - 49 MPN per 100 ml for a three-tube decimal dilution test; - 28 MPN per 100 ml for a twelve-tube single dilution test; - <i>31 CFU per 100 ml for a membrane filtration test (see note 14)***</i> | |
| *For single-year analysis, "and" is replaced with "and/or". | | |
| **Standard that was referenced based on analysis methodology used by the laboratory. | | |
| ***Note 14. When fecal coliform concentrations are monitored in waters designated as state approved shellfish harvesting and growing waters, these waters are also subject to 18 AAC 34.010(19). | | |
| Bold text indicates concentrations used to determine exceedances for public notices. | | |
| Alaska Water Quality Standards for Marine Water (18 AAC 70 (14)) | | |

Public outreach

Public outreach remained a critical component of effective bacteria monitoring during the 2018-2019 monitoring seasons. ADEC partnered with Stream Watch, a program specializing in angler education and outreach, to disseminate general information regarding ways to avoid contact with bacteria, proper fish handling, etc... Brochures were given to participants of the dipnet PUF when they visited the Stream Watch booths on the North and South Kenai Beaches.

To further notify the public, ADEC issued educational radio ads that were played four times per week during the dipnet PUF. In addition, Facebook advisory posts were made regarding site-specific weekly exceedances of fecal coliform and enterococci, as well as guidelines for avoiding contact with bacteria. These posts can be found on the ADEC Facebook page at <https://www.facebook.com/AlaskaDEC/>. In response to site-specific bacteria exceedances, press releases were issued; these detailed precautionary measures the public should take to avoid bacteria-impacted marine water. Press releases can be found in Appendix C of this report and online at <https://dec.alaska.gov/water/water-quality/beach-program/>. Finally, emails were sent to local partners each week, summarizing the results from sampling event that week. Exceedances, press releases and lifted advisories were also detailed in these emails.

Results

2018 Kenai beach bacteria monitoring

Throughout the 2018 monitoring period, several consecutive exceedances occurred for the consumption of raw mollusks and seafood as well as secondary water recreation for fecal coliform. These exceedances occurred primarily on the North and South Kenai Beaches as well as the upstream Kenai Gull Rookery sites (Table 3). In response, a press release was issued for these waters impacted by high enterococci and fecal coliform bacteria concentrations at both the North and South Kenai Beaches on July 17, 2018 encouraging recreationists to take precautions to avoid exposure.

Several exceedances occurred throughout the 2018 monitoring season for both enterococci and fecal coliform based on the Alaska water quality standards for contact and water recreation as well as the harvest for consumption of raw mollusks or other raw seafood (see Table 2). North and South Kenai Beaches were the only sites to experience enterococci exceedances based on water quality standards for water recreation (contact). In combination, results from rolling 30-day geometric means as well as results compared to the STV for enterococci showed nearly consistent exceedances for enterococci at South Kenai Beach, while most exceedances at North Kenai Beach occurred based on high geometric means throughout August (Table 4). At South Kenai Beach, the range in geometric means was 125.11-309.26 CFU/100 mL (Table 4).

Geometric means for enterococci concentrations at the North Kenai Beach ranged from 16.2-66.58 CFU/100 mL and resulted in continuous exceedances for contact water recreation from August 10th to September 7th (Table 4).

Fecal coliform exceedances based on standards for harvest for consumption of raw mollusks or other raw seafood occurred at least once at all five sampling locations throughout the 2018 monitoring season based on either geometric means or 10% seasonal percentage comparison. Beginning July 25th, North and South Kenai Beaches experienced continuous exceedances based on geometric means. During this time period, geometric means ranged from 81.71-188.97 CFU/100 mL at the South Kenai Beach and 32.66-70.74 CFU/100 mL for North Kenai Beach (Table 5). Uniquely, results from samples taken at South Kenai Beach led to a seasonal exceedance based on 10% seasonal percentage of samples for water recreation (secondary) (Table 5).

Table 3. 2018 Kenai beach monitoring data for enterococci and fecal coliform. Individual exceedances used to determine public notice issuance are color coded by exceedance type. Public notices were retracted following two consecutive weeks of exceedances.

| 2018 Kenai BEACH Monitoring Data | | | | | | | | | | |
|--|--|-----------------|--------------------------|-----------------|------------------------------------|-----------------|-----------------------------|-----------------|-----------------------------|-----------------|
| | South Kenai Beach (SKB3) | | North Kenai Beach (NKB4) | | Warren Ames Memorial Bridge (BRG1) | | Kenai Gull Rookery 1 (KRG1) | | Kenai Gull Rookery 2 (KRG2) | |
| Sample Date | Entero ¹ | FC ² | Entero ¹ | FC ² | Entero ¹ | FC ² | Entero ¹ | FC ² | Entero ¹ | FC ² |
| 6/14/2018 | [860] | [6100] | [100 (640)] | [310 (240)] | 2 | 990 | 31 | 230 | 23 | 130 |
| 6/29/2018 | [154] | [275] | [6 (4)] | [8 (18)] | NR | 15 | NR | 3 | 2 | NR |
| 7/3/2018 | 15 (15) | 200 (100) | 11 | 88 | NR | 1 | 1 | 91 | 10 | 147 |
| 7/10/2019 | Personal use dipnet fishery opens | | | | | | | | | |
| 7/13/2018 | 1990 | 1010 | 21 (38) | 36 (42) | 19 | 43 | 15 | 54 | 50 | 26 |
| 7/18/2018 | 67 (8) | 18 (10) | 5 | NR | NR | 12 | 11 | 52 | 13 | 2 |
| 7/25/18-7/26/18 | 200 AV | 241 AV | 89 AV | 121 AV | NS | NS | NS | NS | NS | NS |
| 7/30/2018 | Personal use dipnet fishery closes by emergency order | | | | | | | | | |
| 8/2/2018 | 82 (130) | 22 (32) | 75 | 56 | 1 | 8 | 15 | 50 | 37 | 82 |
| 8/10/2018 | 816 | 820 | 73 (67) | 27 (54) | 5 | 56 | 23 | 50 | 47 | 60 |
| 8/15/2018 | 39 (55) | 32 (12) | 61 | 8 | 2 | 5 | 50 | 80 | 12 | 12 |
| 8/24/2018 | 173 | 280 | 44 (24) | 58 (86) | 4 | 56 | 1 | 35 | 32 | 108 |
| 8/29/2018 | 81 (84) | 48 (37) | 29 | 25 | 2 | 12 | 66 | 72 | 34 | 28 |
| 9/7/2018 | 41 (47) | 58 (52) | 21 | 40 | 17 | 32 | NS | NS | NS | NS |
| 18 AAC 70 Alaska Water Quality Standards (amended as of April 6, 2018)-(14) Bacteria, for Marine Water Uses | | | | | | | | | | |
| Water recreation, contact | Single-sample threshold for weekly exceedance during the monitoring season is 130 enterococci CFU/100 mL³ . | | | | | | | | | |
| Water recreation, secondary | Single-sample threshold for weekly exceedance during the monitoring season is 400 fecal coliform CFU/100 mL³ . | | | | | | | | | |
| Harvest for consumption of raw mollusks or other raw seafood | Single-sample threshold for weekly exceedance during the monitoring season is 31 fecal coliform CFU/100 mL³ . | | | | | | | | | |
| ¹ Enterococci (CFU/100 mL) | NR = sample taken, no result | | | | | | | | | |
| ² Fecal coliform bacteria (CFU/100 mL) | NS = no sample taken | | | | | | | | | |
| ³ Values used as daily standards for public advisory issuance | U = Indicates that the analyte was analyzed for but not detected | | | | | | | | | |
| [] = sample was taken at SKB2 or NKB2 | AV = average result from 24-hour sampling event | | | | | | | | | |
| () = duplicate result | | | | | | | | | | |

Table 4. 2018 rolling 30-day geometric means and comparison of results to statistical threshold value for enterococci at Kenai beach monitoring locations. Exceedances are color-coded by exceedance type.

| 2018 Kenai BEACH Monitoring Data: Enterococci Exceedances | | | | | | | | | | |
|---|---|--|--------------------------|-----------------------------|------------------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| | South Kenai Beach (SKB3) | | North Kenai Beach (NKB4) | | Warren Ames Memorial Bridge (BRG1) | | Kenai Gull Rookery 1 (KRG1) | | Kenai Gull Rookery 2 (KRG2) | |
| Sample Date | GM ⁴ | STV comparison ⁵ | GM ⁴ | STV comparison ⁵ | GM ⁴ | STV comparison ⁵ | GM ⁴ | STV comparison ⁵ | GM ⁴ | STV comparison ⁵ |
| 6/14/2018 | | 860.00 | | 640.00 | | 2.00 | | 31.00 | | 23.00 |
| 6/29/2018 | | 154.00 | | 6.00 | | NR | | NR | | 2.00 |
| 7/3/2018 | | 15.00 | | 11.00 | | NR | | 1.00 | | 10.00 |
| 7/10/2018 | Personal use dipnet fishery opens | | | | | | | | | |
| 7/13/2018 | | 1990.00 | | 38.00 | | 19.00 | | 15.00 | | 50.00 |
| 7/18/2018 | | 67.00 | | 5.00 | | NR | | 11.00 | | 13.00 |
| 7/25/18-7/26/18 | 143.85 | 200 AV | 16.20 | 89 AV | | NS | | NS | | NS |
| 7/30/2018 | Personal use dipnet fishery closes by emergency order | | | | | | | | | |
| 8/2/2018 | 139.06 | 130.00 | 26.85 | 75.00 | | 1.00 | | 15.00 | | 37.00 |
| 8/10/2018 | 309.26 | 816.00 | 39.20 | 73.00 | | 5.00 | | 23.00 | | 47.00 |
| 8/15/2018 | 150.88 | 55.00 | 43.09 | 61.00 | | 2.00 | | 50.00 | | 12.00 |
| 8/24/2018 | 182.40 | 173.00 | 66.58 | 44.00 | | 4.00 | | 1.00 | | 32.00 |
| 8/29/2018 | 153.34 | 84.00 | 53.20 | 29.00 | 2.40 | 2.00 | 16.27 | 66.00 | 29.60 | 34.00 |
| 9/7/2018 | 125.11 | 47.00 | 41.24 | 21.00 | 4.23 | 17.00 | | NS | | NS |
| 18 AAC 70 Alaska Water Quality Standards (amended as of April 6, 2018)-(14) Bacteria, for Marine Water Uses | | | | | | | | | | |
| Water recreation, contact | | In a 30-day period, the geometric mean of samples may not exceed 35 enterococci CFU/100 mL, and not more than 10% of the samples may exceed a statistical threshold value (STV) of 130 CFU/100 mL. | | | | | | | | |
| ⁴ Rolling 30-day geometric mean (CFU/100mL) | | | | | | | | | | |
| ⁵ Samples individually compared to STV of 130 CFU/100 mL | | | | | | | | | | |

Table 5. 2018 rolling 30-day geometric means and total sample exceedance percentages for fecal coliform results at Kenai beach monitoring locations. Exceedances are color-coded by exceedance type.

| 2018 Kenai BEACH Monitoring Data: Fecal Coliform Exceedances | | | | | | | | | | | | | | | |
|---|---|--|--|--------------------------|---|--|------------------------------------|---|--|-----------------------------|---|--|-----------------------------|---|--|
| | South Kenai Beach (SKB3) | | | North Kenai Beach (NKB4) | | | Warren Ames Memorial Bridge (BRG1) | | | Kenai Gull Rookery 1 (KRG1) | | | Kenai Gull Rookery 2 (KRG2) | | |
| Sample Date | GM ⁴ | % samples exceeding 31 CFU/100mL ⁶ | % samples exceeding 400 CFU/100mL ⁶ | GM ⁴ | % samples exceeding 31 CFU/100mL ⁶ | % samples exceeding 400 CFU/100mL ⁶ | GM ⁴ | % samples exceeding 31 CFU/100mL ⁶ | % samples exceeding 400 CFU/100mL ⁶ | GM ⁴ | % samples exceeding 31 CFU/100mL ⁶ | % samples exceeding 400 CFU/100mL ⁶ | GM ⁴ | % samples exceeding 31 CFU/100mL ⁶ | % samples exceeding 400 CFU/100mL ⁶ |
| 7/10/2018 | Personal use dipnet fishery opens | | | | | | | | | | | | | | |
| 7/25/18-7/26/18 | 188.97 | | | 53.27 | | | | | | | | | | | |
| 7/30/2018 | Personal use dipnet fishery closes by emergency order | | | | | | | | | | | | | | |
| 8/2/2018 | 122.90 | | | 70.74 | | | | | | | | | | | |
| 8/10/2018 | 162.97 | | | 62.61 | | | | | | | | | | | |
| 8/15/2018 | 81.71 | | | 41.36 | | | | | | | | | | | |
| 8/24/2018 | 141.47 | | | 47.88 | | | | | | | | | | | |
| 8/29/2018 | 102.45 | | | 34.93 | | | 17.20 | | | 55.02 | | | 44.70 | | |
| 9/7/2018 | 115.39 | 91.67% | 25.00% | 32.66 | 70.00% | 0.00% | 22.70 | 45.45% | 9.09% | | 90.00% | 0.00% | | 55.56% | 0.00% |
| 18 AAC 70 Alaska Water Quality Standards (amended as of April 6, 2018)-(14) Bacteria, for Marine Water Uses | | | | | | | | | | | | | | | |
| Water recreation, secondary | | In a 30-day period, the geometric mean of samples may not exceed 200 fecal coliform/100 mL, and not more than 10% of the samples may exceed 400 fecal coliform/100 mL. | | | | | | | | | | | | | |
| Harvest for consumption of raw mollusks or other raw seafood | | The geometric mean of samples may not exceed 14 fecal coliform/100 ml; and not more than 10% of the samples may exceed 31 CFU/100 mL for a membrane filtration test. | | | | | | | | | | | | | |
| ⁶ Percent of total samples in exceedance | | | | | | | | | | | | | | | |

2018 24-hour monitoring event

During the 2018 24-hour monitoring event for enterococci and fecal coliform concentrations, 24 samples were taken for both bacteria types at North and South Kenai beaches beginning at 9 am on July 25th, ending on July 26th at 8 am (Table 6). Tidal fluctuation data was summarized and can be found in Table 6. Exceedances are also highlighted based on criteria used as daily standards for public advisory issuance detailed in Table 3.

During the 24-hour sampling period, enterococci concentrations at South Kenai Beach ranged from 16-770 CFU/100 mL (Table 6). There were 15 samples whose enterococci results exceeded the threshold of 130 CFU/100 mL (contact water recreation) and occurred primarily during and just after outgoing tides. Fecal coliform samples taken at South Kenai Beach reported results ranging from 22-680 CFU/100 mL, at which the maximum concentrations were observed in samples taken at or before low tide (Table 6). The analysis of 19 of 24 samples showed exceedances for fecal coliform based on criteria for harvest for consumption of raw mollusks or other raw seafood while two of 24 samples lead to results that exceeded the standards used for secondary water recreation. The minimum results for fecal coliform at South Kenai Beach were taken at or just before high tide.

In contrast, samples analyzed for enterococci at North Kenai Beach ranged from 9-283 CFU/100 mL and resulted in only six concentrations that exceed the contact water recreation threshold value for public notices (Table 6). The highest concentration occurred one hour after high tide. Fecal coliform results at North Kenai Beach ranged from 2-290 CFU/100 mL; the maximum result was reported from a sample taken during an outgoing tide (Table 6). 20 of 24 fecal coliform samples taken at this site resulted in concentrations that exceeded the threshold for consumption of raw mollusks or other raw seafood. Those that did not were reported from samples taken at or just before high tide.

Notably, there were no results at high tide (18.3') for either enterococci or fecal coliform at either North or South Kenai Beach that exceeded thresholds for contact water recreation, secondary water recreation, or harvest for consumption of raw mollusks or other raw seafood.

Table 6. 2018 Kenai beach monitoring data for enterococci and fecal coliform as well as tidal swing information during the 24-hour sampling event. Exceedances used to determine public notice issuance are color coded by exceedance type.

| | | South Kenai Beach (SKB3) | | North Kenai Beach (NKB4) | | | |
|--|-------|--|-----------------|--------------------------|-----------------|----------|--------------|
| Date | Time | Entero ¹ | FC ² | Entero ¹ | FC ² | Tides | Gauge height |
| 7/25/2018 | 9:00 | 150 | 200 | 34 | 84 | Outgoing | |
| 7/25/2018 | 10:00 | 236 | 250 | 69 | 138 | | |
| 7/25/2018 | 11:00 | 167 | 280 | 84 | 96 | Low | 0.5' |
| 7/25/2018 | 12:00 | 113 | 179 | 59 | 148 | Incoming | |
| 7/25/2018 | 13:00 | 16 | 44 | 140 (72) | 113 (134) | | |
| 7/25/2018 | 14:00 | 93 (201) | 230 (350) | 55 | 40 | | |
| 7/25/2018 | 15:00 | 157 | 108 | 27 | 34 | | |
| 7/25/2018 | 16:00 | 26 | 30 | 12 | 18 | High | 18.3' |
| 7/25/2018 | 17:00 | 56 | 44 | 238 | 260 | Outgoing | |
| 7/25/2018 | 18:00 | 78 | 37 | 66 | 179 | | |
| 7/25/2018 | 19:00 | 110 | 86 | 157 | 143 | | |
| 7/25/2018 | 20:00 | 201 | 250 | 109 | 290 | | |
| 7/25/2018 | 21:00 | 435 (345) | 660 (470) | 86 (88) | 166 (116) | | |
| 7/25/2018 | 22:00 | 770 | 680 | 153 | 112 | Low | 5.1' |
| 7/25/2018 | 23:00 | 133 | 290 | 36 | 64 | Incoming | |
| 7/26/2018 | 0:00 | 228 | 380 | 122 | 143 | | |
| 7/26/2018 | 1:00 | 326 | 270 | 108 | 62 | | |
| 7/26/2018 | 2:00 | 35 | 22 | 22 | 10 | | |
| 7/26/2018 | 3:00 | 24 | 23 | 9 | 2 | Outgoing | |
| 7/26/2018 | 4:00 | 308 | 158 | 10 | 4 | | |
| 7/26/2018 | 5:00 | 148 (167) | 202 (300) | 93 (172) | 237 (185) | | |
| 7/26/2018 | 6:00 | 276 | 330 | 187 | 119 | | |
| 7/26/2018 | 7:00 | 344 | 320 | 78 | 99 | | |
| 7/26/2018 | 8:00 | 248 | 310 | 128 | 260 | | |
| Water recreation, contact | | Single-sample threshold for weekly exceedance during the monitoring season is 130 enterococci CFU/100 mL³ . | | | | | |
| Water recreation, secondary | | Single-sample threshold for weekly exceedance during the monitoring season is 400 fecal coliform CFU/100 mL³ . | | | | | |
| Harvest for consumption of raw mollusks or other raw seafood | | Single-sample threshold for weekly exceedance during the monitoring season is 31 fecal coliform CFU/100 mL³ . | | | | | |

2019 Kenai beach bacteria monitoring

Analytical tests for enterococci throughout the 2019 Kenai beach bacteria monitoring season revealed exceedances for contact water recreation at South Kenai Beach following the closure of the dipnet PUF season. Several consecutive exceedances occurred for fecal coliform at the North and South Kenai Beaches while fewer were noted at the Warren Ames Memorial Bridge and both Kenai Gull Rookery sampling sites. In response, ADEC issued a press release on June 6, 2019 for the North Kenai Beach for water impacted by elevated concentrations of enterococci and fecal coliform. Later that month, a press release was issued on June 20, 2019, lifting the advisory for enterococci on the North Kenai Beach while implementing one for water impacted by elevated concentrations of fecal coliform at both North and South Kenai Beaches and the upstream Kenai Gull Rookery sampling site for consumption of raw seafood. The final press release was issued on July 5, 2019 for waters impacted by elevated concentrations of fecal coliform and enterococci at both North and South Kenai Beaches as well as both Kenai Gull Rookery sampling sites. These exceedances occurred for both contact water recreation and consumption of seafood. All press releases can be found in Appendix C and supporting results can be found in Table 7.

Several exceedances occurred throughout the 2019 monitoring season for both enterococci and fecal coliform based on the Alaska Water Quality Standards for contact water recreation as well as the harvest for consumption of raw mollusks or other raw seafood. Exceedances related to geometric means for enterococci at South Kenai Beach ranged from 10.10-131.52 CFU/100 mL, and those related to individual sample exceedances occurred five out of 8 times beginning July 2, 2019 (Table 8). The geometric means for enterococci at North Kenai Beach ranged from 7.86-67.03 CFU/100 mL throughout the 2019 monitoring season and those related to individual sample exceedances occurred sporadically beginning June 4, 2019 (Table 8).

In contrast to enterococci, exceedances based on fecal coliform standards (harvesting raw mollusks or other raw seafood for consumption) occurred at all five sampling sites in 2019. Fecal coliform sampling results from the South Kenai Beach resulted in a range in geometric means of 10.1-131.52 CFU/100 mL as well as a seasonal exceedance (Table 9). Geometric means at North Kenai Beach ranged from 7.86-67.03 CFU/100 mL; this beach also experienced a seasonal exceedance for fecal coliform (Table 9). Exceedances based on geometric means and seasonal data for fecal coliform results at the Warren Ames Memorial Bridge and the Kenai Gull Rookery sampling sites are summarized in Table 9.

Table 7. 2019 Kenai beach monitoring data for enterococci and fecal coliform. Individual exceedances used to determine public notice issuance are color coded by exceedance type. Public notices were retracted following two consecutive weeks of exceedances.

| 2019 Kenai BEACH Monitoring Data | | | | | | | | | | |
|--|--|-----------------|---------------------------|-----------------|------------------------------------|-----------------|-----------------------------|-----------------|-----------------------------|-----------------|
| | South Kenai Beach (SKB3) | | North Kenai Beach (NKB4) | | Warren Ames Memorial Bridge (BRG1) | | Kenai Gull Rookery 1 (KRG1) | | Kenai Gull Rookery 2 (KRG2) | |
| Sample Date | Enterococcus ¹ | FC ² | Enterococcus ¹ | FC ² | Enterococcus ¹ | FC ² | Enterococcus ¹ | FC ² | Enterococcus ¹ | FC ² |
| 5/21/2019 | 5 (4) | 8 (5) | 1 | 1 | 1 | NR | 1 | 5 | 1 | 1 |
| 5/29/2019 | 6 | 25 | 5 (6) | 25 (35) | 1 U | 7 | NR | 5 | 2 | 10 |
| 6/4/2019 | 2 (10) | 9 (6) | 139 | 102 | 3 | 10 | 6 | 8 | 1 U | 5 |
| 6/11/2019 | 7 | 5 | 1 U (1) | 2 (1 U) | 1 U | 11 | 20 | 46 | 1 U | 4 |
| 6/18/2019 | 50 (36) | 84 (76) | 36 | 41 | 1 | 17 | 23 | 25 | 17 | 29 |
| 6/25/2019 | 71 | 26 | 15 (14) | 44 (50) | 8 | 24 | 1 U | 7 | 3 | 25 |
| 7/2/2019 | 231 (411) | 141 (93) | 46 | 57 | 1 | 3 | 34 | 49 | 50 | 78 |
| 7/9/2019 | 23 | 90 | 3 (2) | 7 (5) | 2 | 12 | 13 | 49 | 16 | 45 |
| 7/10/2019 | Personal use dipnet fishery opens | | | | | | | | | |
| 7/17/2019 | 727 (387) | 380 (400) | 365 | 346 | 7 | 62 | 1 | 16 | 17 | 80 |
| 7/23/2019 | 23 | 80 | 72 (43) | 83 (82) | 2 | 42 | 2 | 4.5 | 6 | 56 |
| 7/27/2019 | Personal use dipnet fishery hours are extended to 24 hours/day through 7/31/19 | | | | | | | | | |
| 7/31/2019 | Personal use dipnet fishery closes | | | | | | | | | |
| 8/1/2019 | 249 (243) | 324 (382) | 291 | 158 | 18 | 47 | 5 | 4 | 30 | 41 |
| 8/6/2019 | 155 | 7 | 27 (59) | 2 (2) | 2 | 11 | 10 | 65 | 5 | 2 |
| 8/20/2019 | 285 (152) | 76 (60) | 16 | 39 | 1 | 7 | 6 | 12 | 22 | 74 |
| 9/4/2019 | 28 | 4 | 20 (18) | 2 (2) | 5 | 5 | 73 | 225 | 8 | 2 |
| 18 AAC 70 Alaska Water Quality Standards (amended as of April 6, 2018)-(14) Bacteria, for Marine Water Uses | | | | | | | | | | |
| Water recreation, contact | Single-sample threshold for weekly exceedance during the monitoring season is 130 enterococci CFU/100 mL³ . | | | | | | | | | |
| Water recreation, secondary | Single-sample threshold for weekly exceedance during the monitoring season is 400 fecal coliform CFU/100 mL³ . | | | | | | | | | |
| Harvest for consumption of raw mollusks or other raw seafood | Single-sample threshold for weekly exceedance during the monitoring season is 31 fecal coliform CFU/100 mL³ . | | | | | | | | | |

Table 8. 2019 rolling 30-day geometric means and comparison of results to statistical threshold value for enterococci at Kenai beach monitoring locations. Exceedances are color-coded by exceedance type.

| 2019 Kenai BEACH Monitoring Data: Enterococci Exceedances | | | | | | | | | | |
|---|--|-----------------------------|--------------------------|-----------------------------|------------------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| | South Kenai Beach (SKB3) | | North Kenai Beach (NKB4) | | Warren Ames Memorial Bridge (BRG1) | | Kenai Gull Rookery 1 (KRG1) | | Kenai Gull Rookery 2 (KRG2) | |
| Sample Date | GM ⁴ | STV comparison ⁵ | GM ⁴ | STV comparison ⁵ | GM ⁴ | STV comparison ⁵ | GM ⁴ | STV comparison ⁵ | GM ⁴ | STV comparison ⁵ |
| 5/21/2019 | | 5.00 | | 1.00 | | 1.00 | | 1.00 | | 1.00 |
| 5/29/2019 | | 6.00 | | 6.00 | | 1 U | | NR | | 2.00 |
| 6/4/2019 | | 10.00 | | 139.00 | | 3.00 | | 6.00 | | 1 U |
| 6/11/2019 | | 7.00 | | 1.00 | | 1 U | | 20.00 | | 1 U |
| 6/18/2019 | 10.10 | 50.00 | 7.86 | 36.00 | 1.44 | 1.00 | | 23.00 | 3.24 | 17.00 |
| 6/25/2019 | 17.17 | 71.00 | 13.51 | 15.00 | 2.88 | 8.00 | | 1 U | 4.67 | 3.00 |
| 7/2/2019 | 39.98 | 411.00 | 20.31 | 46.00 | 2.21 | 1.00 | 17.50 | 34.00 | 13.66 | 50.00 |
| 7/9/2019 | 47.23 | 23.00 | 9.43 | 3.00 | 2.00 | 2.00 | 21.23 | 13.00 | 14.21 | 16.00 |
| 7/10/2019 | Personal use dipnet fishery opens | | | | | | | | | |
| 7/17/2019 | 119.53 | 727.00 | 30.68 | 365.00 | 2.57 | 7.00 | 10.04 | 1.00 | 14.73 | 17.00 |
| 7/23/2019 | 102.33 | 23.00 | 35.25 | 72.00 | 2.95 | 2.00 | 5.45 | 2.00 | 11.96 | 6.00 |
| 7/27/2019 | Personal use dipnet fishery hours are extended to 24 hours/day through 7/31/19 | | | | | | | | | |
| 7/31/2019 | Personal use dipnet fishery closes | | | | | | | | | |
| 8/1/2019 | 131.52 | 249.00 | 63.78 | 291.00 | 3.47 | 18.00 | 5.36 | 5.00 | 18.96 | 30.00 |
| 8/6/2019 | 108.22 | 155.00 | 67.03 | 59.00 | 3.99 | 2.00 | 4.20 | 10.00 | 11.96 | 5.00 |
| 8/20/2019 | | 285.00 | | 16.00 | | 1.00 | | 6.00 | | 22.00 |
| 9/4/2019 | | 28.00 | | 20.00 | | 5.00 | | 73.00 | | 8.00 |
| 18 AAC 70 Alaska Water Quality Standards (amended as of April 6, 2018)-(14) Bacteria, for Marine Water Uses | | | | | | | | | | |
| Water recreation, contact | In a 30-day period, the geometric mean of samples may not exceed 35 enterococci CFU/100 mL, and not more than 10% of the samples may exceed a statistical threshold value (STV) of 130 CFU/100 mL. | | | | | | | | | |

Table 9. 2019 rolling 30-day geometric means and total sample exceedance percentages for fecal coliform results at Kenai beach monitoring locations. Exceedances are color-coded by exceedance type.

| 2019 Kenai BEACH Monitoring Data: Fecal Coliform Exceedances | | | | | | | | | | | | | | | |
|--|--|--|--|--------------------------|---|--|-----------------------------|---|--|-----------------------------|---|--|-----------------------------|---|--|
| Sample Date | South Kenai Beach (SKB3) | | | North Kenai Beach (NKB4) | | | Warren Ames Memorial Bridge | | | Kenai Gull Rookery 1 (KRG1) | | | Kenai Gull Rookery 2 (KRG2) | | |
| | GM ⁴ | % samples exceeding 31 CFU/100mL ⁶ | % samples exceeding 400 CFU/100mL ⁶ | GM ⁴ | % samples exceeding 31 CFU/100mL ⁶ | % samples exceeding 400 CFU/100mL ⁶ | GM ⁴ | % samples exceeding 31 CFU/100mL ⁶ | % samples exceeding 400 CFU/100mL ⁶ | GM ⁴ | % samples exceeding 31 CFU/100mL ⁶ | % samples exceeding 400 CFU/100mL ⁶ | GM ⁴ | % samples exceeding 31 CFU/100mL ⁶ | % samples exceeding 400 CFU/100mL ⁶ |
| 6/18/2019 | 17.53 | | | 23.26 | | | | | | 14.65 | | | 8.73 | | |
| 6/25/2019 | 18.97 | | | 27.11 | | | 12.57 | | | 12.63 | | | 10.77 | | |
| 7/2/2019 | 26.81 | | | 29.88 | | | 10.61 | | | 19.94 | | | 16.24 | | |
| 7/9/2019 | 69.10 | | | 27.12 | | | 9.52 | | | 25.62 | | | 44.44 | | |
| 7/10/2019 | Personal use dipnet fishery opens | | | | | | | | | | | | | | |
| 7/17/2019 | 107.18 | | | 51.26 | | | 15.21 | | | 22.77 | | | 51.47 | | |
| 7/23/2019 | 142.28 | | | 58.58 | | | 31.50 | | | 15.22 | | | 58.64 | | |
| 7/27/2019 | Personal use dipnet fishery hours are extended to 24 hours/day through 7/31/19 | | | | | | | | | | | | | | |
| 7/31/2019 | Personal use dipnet fishery closes | | | | | | | | | | | | | | |
| 8/1/2019 | 182.12 | | | 75.07 | | | 34.81 | | | 10.90 | | | 53.62 | | |
| 8/6/2019 | 94.91 | | | 36.36 | | | 27.65 | | | 15.58 | | | 27.78 | | |
| 9/4/2019 | | 50.00% | 0.00% | | 64.29% | 0.00% | | 21.43% | 0.00% | | 35.71% | 0.00% | | 42.86% | 0.00% |
| 18 AAC 70 Alaska Water Quality Standards (amended as of April 6, 2018)-(14) Bacteria, for Marine Water Uses | | | | | | | | | | | | | | | |
| Water recreation, secondary | | In a 30-day period, the geometric mean of samples may not exceed 200 fecal coliform/100 mL, and not more than 10% of the samples may exceed 400 fecal coliform/100 mL. | | | | | | | | | | | | | |
| Harvest for consumption of raw mollusks or other raw seafood | | The geometric mean of samples may not exceed 14 fecal coliform/100 mL; and not more than 10% of the samples may exceed 31 CFU/100 mL for a membrane filtration test. | | | | | | | | | | | | | |

2019 Microbial source tracking

Sampling for microbial source tracking (MST) was conducted in June and August of the 2019 monitoring season. MST results from the June sampling event reported quantifiable gull fecal marker copies at all five sampling sites, ranging from 938-3610 marker copies/100 mL (Table 10). Marker copies for human feces were either not detected or detected but not quantifiable at any of the five sites at which samples were collected. Evidence of dog feces was noted at only North and South Kenai Beaches, whose quantified presence of markers were 4660 marker copies/100 mL and 1210 marker copies/100 mL, respective (Table 10).

During the August MST sampling event, the presence of dog feces was either not detected or not quantifiable at any of the five sites at which sampling was conducted. With the exception of the upstream Kenai Gull Rookery sampling site, human fecal matter was detected by not quantifiable at sampling locations. In contrast, gull feces were detected at all five sampling locations in August. Results varied from 2920-28200 marker copies/100 mL for gull feces (Table 10).

Table 10. 2019 microbial source tracking results from June and August sampling events on the Kenai River and its beaches.

| Sampling date | Sampling site | Biomarker gene type (copies/100 mL) | | |
|------------------------------------|---------------|-------------------------------------|------------|--------------|
| | | Dog feces | Gull feces | Human feces |
| 6/4/2019 | SKB3 | 1210.00 | 1330.00 | not detected |
| | NKB4 | 4660.00 | 938.00 | not detected |
| | BRG1 | not detected | 1680.00 | DNQ |
| | KRG1 | not detected | 3610.00 | DNQ |
| | KRG2 | not detected | 2140.00 | not detected |
| 8/1/2019 | SKB3 | not detected | 28200.00 | DNQ |
| | NKB4 | not detected | 11600.00 | DNQ |
| | BRG1 | DNQ | 2920.00 | DNQ |
| | KRG1 | not detected | 3040.00 | 525.00 |
| | KRG2 | DNQ | 9010.00 | DNQ |
| DNQ= detected but not quantifiable | | | | |

Discussion

2018-2019 Kenai beach bacteria monitoring

Throughout the 2018 bacteria monitoring season, enterococci exceedances occurred consistently at the South Kenai Beach, while most exceedances at North Kenai Beach were detected in the latter half of the sampling season. The higher concentrations of enterococci at North Kenai Beach can likely be explained by the increase in fish carcasses and therefore gulls during the dipnet PUF in July. In addition, it has been hypothesized that patterns in outgoing river water and tidal currents result in a north-to-south movement at the mouth of the Kenai River. This would explain the consistency in exceedances at the South Kenai Beach for enterococci, though it is highly recommended that this is researched in greater depth. Similar patterns in exceedance timing for enterococci were also observed in 2019, though exceedances at South Kenai Beach began at the beginning of July.

Seasonal exceedances for fecal coliform occurred at all five sampling locations during both the 2018 and 2019 monitoring seasons. Notably, the percentage of samples exceeding the 10% provision (harvesting raw mollusks or other seafood for consumption) in 2018 exceeded the percentages in 2019. While the 2019 dipnet PUF report submitted by the City of Kenai did not address changes in attendance, it did state that overall revenue was down from 2018 (Ostrander, 2019). Assuming there is a correlation between attendance and revenue, lower attendance in 2019 may have led to fewer carcasses and gulls present at the beach, and therefore lower bacteria concentrations.

The expansion in the number of sampling weeks throughout the 2019 monitoring season was intended to provide further insight into bacteria concentrations before and after the dipnet PUF season.

It is important to note that, due to limited sampling events conducted on a weekly basis, geometric means could not be calculated until at least five samples were collected in a 30-day period. Therefore, geometric means could not be calculated until late-July in 2018 and mid-June in 2019. However, exceedances based on the 10% provision of water quality standards for bacteria in marine settings could be implemented for each sampling season. In response, the number of sampling weeks throughout the 2019 monitoring season was expanded with the intension of providing further insight into bacteria concentrations before and after the dipnet PUF season.

While the data collected during the 2018 and 2019 monitoring seasons was not sufficient to implement the Environmental Protection Agency's (EPA) Virtual Beach Model, they provided insight into bacteria concentrations before and after the dipnet PUF. Moving forward, it is recommended that sufficient data is collected in coming years in order to implement this model. In doing so, it can be determined if extended sampling similar to that conducted in 2019 should be continued or if fewer sampling events would be sufficient in order to "spot check" bacteria concentrations throughout the summer.

Emergency orders for sport fishing were issued by ADFG throughout the 2018 and 2019 monitoring seasons. Due to failure to meet the sustainable escapement goal for sockeye, an emergency closure was issued for the dipnet PUF on July 30, 2018, cutting the season back by two days. In contrast, ADFG extended the dipnet PUF hours to 24 hours/day through the 2019 dipnet PUF season closure on July 31, 2019. It remains unclear if these emergency orders directly or indirectly affected bacteria concentrations along the Kenai Beaches but the dipnet PUF experienced a 30% decrease in attendance throughout the 2018 season (Ostrander, 2018). An additional change made in 2019 was the reduction in the frequency that North and South Kenai Beaches were raked by the CoK; this decision was based on observations from previous years (Ostrander, 2019). As stated previously, overall revenue in 2019 was down from 2018, which may be an indication that attendance was down as well (Ostrander, 2019). Due to this potential decrease in attendance (and likely the number of carcasses on beaches), it cannot be determined if the reduction in raking had a direct effect on bacteria concentrations at North and South Kenai Beaches. As a result, it is recommended that ADEC work closely with CoK to effectively implement BMPs based on dipnet PUF attendance, carcass concentrations along beaches, etc... for each year. A modification of BMPs to include disposal or compost of carcasses could be a more permanent, effective way to mitigate the effects on bacteria concentrations.

Finally, a continuation in open communication with local stakeholders will remain a critical component of successful and meaningful bacteria monitoring. Emails to stakeholders summarizing weekly sampling results have shown to be effective for conveying data in a transparent manner. Public education and outreach events have also been proven effective, and should continue during future monitoring seasons. Public advisories have reached thousands of radio listeners, Facebook viewers, etc... That being said, it is highly recommended that protocol is developed to increase consistency in when advisories are issued and subsequently removed after two weeks of bacteria concentrations below exceedance threshold.

2018 24-hour monitoring event

The establishment of a baseline dataset for hourly fluctuation of bacteria concentrations was accelerated by the implementation of a 24-hour monitoring event in 2018. While there did not appear to be a consistent relationship between tidal changes and bacteria concentrations, much was gained from this monitoring period. There were concentrations of enterococci and fecal

coliform that exceeded the water quality standard thresholds during low, incoming, high, and outgoing tides. The single exception to the observation occurred at North Kenai Beach, at which enterococci concentrations remained below the threshold during an incoming tide, and both enterococci and fecal coliform concentrations remained below their thresholds during a high tide event. A single high tide event (18.3') resulted in no exceedances in bacteria thresholds at either North or South Kenai Beaches. As ocean water floods the Kenai River during high tides, the water concentrations at the outlet of the river rise considerably. While this water is still impacted by bacteria, it is likely that bacteria concentrations are reduced at this time due to dilution by incoming tidal water, only to be flushed back out during an outgoing tide.

Uniquely, this 24-hour monitoring period also resulted in the highest fecal coliform concentrations detected during both the 2018 and 2019 monitoring seasons. These concentrations ranging from 470-680 CFU/100 mL were detected in samples collected at South Kenai Beach immediately before and during low tide (1.5') (Table 6). These concentrations exceeded the fecal coliform water quality standard threshold of 400 CFU/100 mL for secondary water recreation. This is likely due river water flushing out during an outgoing tide, at which point bacteria concentrations may increase. It is critical to note that these are results from single-sample collection events and additional monitoring at low tides would be necessary to confirm whether bacteria concentrations remain elevated during low tides.

2019 Microbial source tracking

While it is widely accepted that the bacteria derived from local gull populations and those that flock to the North and South Kenai Beaches, limited MST data has been gathered during previous Kenai bacteria monitoring events. Historically, sample analysis for MST was conducted in 2011 and 2014; results can be found here: <https://dec.alaska.gov/water/water-quality/beach-program/>.

MST samples analyzed from the 2019 sampling events in June and August reported gull feces at all five sampling sites. The highest concentration of marker copies associated with gull fecal matter were detected at both Kenai Gull Rookery sites in June, while the concentration of gull marker copies was an order of magnitude higher at North and South Kenai Beaches than all other sites during the August sampling event. This is very likely due to the increase in the number of carcasses (and therefore gulls) along the beaches.

It is critical to note that each MST result is a snapshot of conditions, and not necessarily representative of the water in an area as a whole. The mouth of the Kenai is a dynamic and ever-changing zone. Influenced by river discharge, tides, wind, and boat traffic, patterns in water flow can vary by the minute. To better assess any spatial and/or temporal variation in bacteria sources throughout the monitoring period, additional sampling for MST analysis is recommended.

Conclusions and recommendations

Data collected throughout 2018 and 2019 provided insight into some of the factors involved in the fluctuation of bacteria concentrations at the Kenai Beaches and the sources of these bacteria throughout the summer months. Moving forward, the following recommendations should be taken into consideration:

1. While North Kenai Beach continues to experience bacteria exceedances each year, South Kenai Beach is shown to have more frequent exceedances. Both beaches are impacted by an increase in carcasses and therefore gulls during the dipnet PUF.
 - a. Additional research surrounding patterns in tidal currents and river outflow at the mouth of the Kenai River is highly recommended, as these patterns may inform the discrepancy in bacteria concentrations between beaches.
 - b. It is recommended that ADEC work with the CoK to assess the effectiveness of current BMPs and modify if necessary. One possible modification could include requiring the immediate disposal or composting of carcasses on the beach.
2. Consistent communication with stakeholders and user groups will remain critical to effective beach monitoring. Protocol should be established to ensure consistency in when public advisories are issued and for what sites they are necessary.
3. Because MST analyses provide results for single-sample events, the results from 2019 provide a snapshot of bacteria marker copy concentrations at the time of sampling. Due to extremely dynamic patterns in current at the mouth of the Kenai, more consistent sampling for MST is recommended in order to assess spatiotemporal variation in bacteria sources.
4. Data collection for additional parameters including wave height is recommended in future years in order to effectively implement EPA's Virtual Beach Model. In the future, this modeling could inform the amount of sampling required to effectively issue public advisories for bacteria.
 - a. Using the results of the Virtual Beach Model, it is advised that a monitoring program be established in perpetuity in order to issue public advisories when necessary.

These four actions would support educated management decisions, encourage preservation of environmental habitat, mitigate potential public health issues, and ensure transparency of the beach monitoring process.

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Appendix A: EPA Marine Beach Sanitary Survey

Name of Beach _____ Date _____

Nearest Town _____

Describe Sampling Location (Note location on map and attach) _____

Latitude N _____ Longitude _____

SAMPLES

Sample(s) ID: _____ Time: _____

Replicate ID: _____ Time: _____

Field Blank ID: _____ Time: _____

Weather Conditions:

Sunny & Clear _____ Rain _____
Cloudy / Overcast _____ Fog _____

☐ Other (describe): _____

Water Temperature: _____ °C

Air Temperature: _____ °F _____ °C

Wind Speed (approx): _____ Mph

Wind Direction: _____ ☐ On Shore ☐ Off Shore

Precipitation in the last 24 hours: _____ in

Tidal Conditions:

☐ Low Tide ☐ Ebbing
☐ High Tide ☐ Flooding

Tide **Height** **Time**

Low: _____ ☐ ft ☐ m (am/pm)

High: _____ ☐ ft ☐ m (am/pm)

Condition of the beach:

| | Debris (Describe) | Vegetation (% Coverage) |
|----------|----------------------|----------------------------|
| On shore | | |
| In water | | |

Activity on the Beach

Adults _____ Dogs _____

Children _____

Other _____

(describe): _____

Type of Activity

Swimmers _____ Walkers _____ Fishermen _____ Boaters _____

Other _____

(describe): _____

Condition of the Water

☐ Clear ☐ Cloudy & Murky ☐ Oily Film

☐ Other _____

(describe): _____

Potential Sources of Pollution

☐ Water Fowl (approx #): _____ ☐ Boats (approx #): _____

☐ Other _____

(describe): _____

☐ Sanitary Facilities (describe): _____

☐ Sewage odor/presence (describe): _____

☐ Presence of stormwater pipes or other flow across the beach (describe): _____

Appendix B: Chain-of-custody



SGS North America Inc.
CHAIN OF CUSTODY RECORD

Locations Nationwide
Alaska Maryland
New Jersey New York
North Carolina Indiana
West Virginia Kentucky
www.us.sgs.com

| Section 1 | | Section 2 | | Section 3 | | Section 4 | | Section 5 | |
|-----------------------|--|-----------|--|---------------|--|-----------------|--|-------------|--|
| CLIENT: | | PHONE NO: | | PROJECT NAME: | | PROJECT PERMIT: | | REPORTS TO: | |
| CONTACT: | | DATE | | TIME | | DATE | | TIME | |
| INVOICE TO: | | DATE | | TIME | | DATE | | TIME | |
| RESERVED for lab use | | DATE | | TIME | | DATE | | TIME | |
| SAMPLE IDENTIFICATION | | DATE | | TIME | | DATE | | TIME | |
| MATRUX CODE | | DATE | | TIME | | DATE | | TIME | |
| Type | | DATE | | TIME | | DATE | | TIME | |
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Appendix C: Press releases

DEC FIND ELEVATED BACTERIA LEVELS ON KENAI RIVER BEACHES

Fecal Coliform and Enterococci bacteria may indicate a health risk

FOR IMMEDIATE RELEASE — July 17, 2018

CONTACT: Nancy Sonafrank, Division of Air Quality, 907-451-2726, nancy.sonafrank@alaska.gov

KENAI, AK — The Alaska Department of Environmental Conservation (DEC) has been collecting water quality samples along coastal beach areas in Kenai, Alaska periodically since 2010. This year DEC has planned monitoring and sampling from June through early September, 2018. Recently collected samples indicated elevated levels of enterococci bacteria in the marine water at the following locations:

- South Kenai River Beach
- North Kenai River Beach

Contact with water impacted by enterococci or fecal coliform bacteria may cause stomach aches, diarrhea, or ear, eye, and skin infections. DEC recommends beach users take normal precautions to avoid exposure, such as avoiding swimming in the water, washing after contact with the water, and rinsing fish with clean water after they have been harvested from the area. As always, people should cook seafood to a minimum internal temperature of 145 degrees Fahrenheit to destroy pathogens.

Water quality samples collected on July 3 and 13, 2018 contained levels above Alaska's enterococci and fecal coliform bacteria limit for recreation and harvesting for consumption of raw fish and shellfish. Until sample results meet water quality standards and DEC lifts this advisory, people should take precautionary measures when recreating. The next sampling is scheduled for this week with results available on July 23.

The beach sampling program is being funded by the Environmental Protection Agency's Beaches Environmental Assessment and Coastal Health (BEACH) Act grant program and is being implemented by DEC. It is part of a nationwide effort to decrease the incidence of water-borne illness at public beaches. For more information about the Alaska beach monitoring program, visit the [Alaska BEACH Grant Program Website](#).

2018 RECREATIONAL SEASON MONITORING COMPLETE FOR KENAI BEACHES**FOR IMMEDIATE RELEASE — September 19, 2018**CONTACT: Nancy Sonafrank, Division of Water, 907-451-2726, nancy.sonafrank@alaska.gov

KENAI, AK — The Department of Environmental Conservation (DEC) has completed the 2018 Kenai BEACH Monitoring Program for coastal areas in Kenai, Alaska. Bacteria monitoring is planned for 2019 to help further determine bacteria sources, and to understand the natural background levels of bacteria. Further sampling will continue during the recreation season in summer, 2019. Beaches monitored this season include:

- South Kenai River Beach
- North Kenai River Beach

Enterococci levels were found to be below the state standards for recreational uses at both beaches listed above.

Fecal coliform bacteria levels were above state limits protecting consumption of raw fish and shellfish at both beaches listed above. DEC recommends that when fishing in these areas people should rinse fish/marine foods with clean water and cook seafood to a minimum internal temperature of 145 degrees Fahrenheit to destroy pathogens.

As part of a statewide recreational beach monitoring program, marine water samples have been collected weekly from June 12 to September 7 at the recreational beach locations listed below. The 2018 monitoring location maps and an analytical data results table are available on the [Alaska BEACH Grant Program Website](#); the 2018 monitoring report will be posted on the website in late 2018.

The purpose of DEC's 2018-2019 monitoring on the Kenai River coastal beach areas is to evaluate background levels of bacteria before, during and after the fishery season to determine progress towards meeting water quality standards. The City of Kenai has implemented Best Management Practices (BMPs) to remove fish carcasses discarded on the recreational beaches during the July Personal Use Fishery (PUF). The BMPs were undertaken to discourage the presence of seabirds and therefore reduce the bacteria from seabird waste. Previous bacteria monitoring was done during 2010 to 2014; primarily during the fishery seasons.

Enterococci and fecal coliform bacteria can come from any warm blooded animal, including birds, seals, and dogs, as well as humans. Microbial source tracking tests were performed during the 2014 Kenai BEACH monitoring season. Results from this testing indicated that seagulls and other birds from the nearby bird colony were responsible for most of the bacteria analyzed. Other potential sources of bacteria in Kenai may include wildlife and pet feces, human waste from private and municipal treatment systems, sewer line leakage, campers and/or large boats with toilets in harbor areas. Contact with water impacted by enterococci or fecal coliform bacteria may cause stomach aches, diarrhea, or ear, eye, and skin infections.

The beach sampling program has completed one year of monitoring, and is funded by the Environmental Protection Agency's Beaches Environmental Assessment and Coastal Health (BEACH) Act grant program and implemented by DEC. It is part of a nationwide effort to decrease the incidence of water-borne illness at public beaches.

Since 2002, the Alaska's BEACH Program has been monitoring recreational beaches throughout the state, including other communities in Alaska. For more information about the Alaska beach monitoring program, visit the [Alaska BEACH Grant Program Website](#).

DEC ISSUES ADVISORY FOR KENAI NORTH BEACH
FOR IMMEDIATE RELEASE — June 6, 2019
CONTACT: Nancy Sonafrank, Division of Water, 907-451-2726

SOLDOTNA, AK — The Alaska Department of Environmental Conservation (DEC) has announced an advisory for the Kenai North Beach due to elevated levels of enterococci bacteria and fecal coliform found in recent samples of the marine water at this location.

Until sample results consistently meet water quality standards and DEC lifts this advisory, people should take precautionary measures when visiting the Kenai North Beach. DEC recommends beach users take normal precautions to avoid exposure, such as avoid swimming in the water, wash with clean fresh water after contact with marine water, and rinse fish with clean water after harvesting from the area. As always, people should cook seafood to a minimum internal temperature of 145 degrees Fahrenheit to destroy pathogens.

Water samples were collected on June 4. All of the other tested locations meet water quality criteria for enterococci bacteria and fecal coliform at this time. Water quality samples were collected at the following locations:

- North Kenai Beach
- South Kenai Beach
- Kenai River Gull Rookery 1 (60.53660N, 151.25400W)
- Kenai River Gull Rookery 2 (60.55180N, 151.24400W)
- Warren Ames Bridge

As part of a statewide recreational beach monitoring program, marine water samples will be collected at the listed coastal areas to evaluate fecal coliform and enterococci bacteria levels weekly from May to September 2019. Monitoring locations maps and sampling information are shown on the [Alaska BEACH Grant Program website](#).

Enterococci bacteria can come from any warm blooded animal, including birds, seals, and dogs, as well as humans. Potential sources of this bacteria on Kenai beaches are likely birds, but may include other wildlife, pets, and humans. Contact with water impacted by enterococci bacteria may cause stomach aches, diarrhea, or ear, eye, and skin infections.

The BEACH sampling program is funded and implemented by DEC. It is part of a nationwide effort to decrease the incidence of water-borne illness at public beaches under the federal Beaches Environmental Assessment and Coastal Health (BEACH) Act. Water samples have been collected periodically at Kenai River beaches since 2010.

For more information about the Alaska BEACH monitoring program, visit the [Alaska BEACH Grant Program website](#).

FOR IMMEDIATE RELEASE — June 20, 2019**CONTACT: Nancy Sonafrank, Division of Water, 907-451-2726**

SOLDOTNA, AK — The Alaska Department of Environmental Conservation (DEC) has lifted the beach advisory issued on June 6 for the Kenai North Beach due to elevated levels of enterococci found in the marine water. Two consecutive weekly samples have shown enterococci levels at safe levels.

Water samples were collected on June 11 and 18. All five of the monitoring locations met water quality criteria for enterococci bacteria. These levels indicate that contact recreation, such as wading and swimming are safe.

Fecal coliform bacteria results were above state limits of 31 cfu/100ml set to protect humans from consumption of raw fish and shellfish at three monitoring locations (North Kenai Beach, South Kenai Beach and Kenai River Gull Rookery 1) with levels ranging from 46 to 84 cfu/100ml. DEC continues to advise that people take precautionary measures when fishing along the Kenai River Beaches by rinsing fish with clean water after harvesting from the area. As always, people should cook seafood to a minimum internal temperature of 145 degrees Fahrenheit to destroy pathogens.

Water quality samples were collected at the following locations:

- North Kenai Beach
- South Kenai Beach
- Kenai River Gull Rookery 1 (60.53660N, -151.25400W)
- Kenai River Gull Rookery 2 (60.55180N, -151.24400W)
- Warren Ames Bridge

As part of a statewide recreational beach monitoring program, marine water samples will be collected at the listed coastal areas to evaluate enterococci bacteria and fecal coliform levels weekly from May to September 2019. Monitoring locations maps and sampling information are shown on the [Alaska BEACH Grant Program website](#).

Enterococci bacteria can come from any warm blooded animal, including birds, seals, and dogs, as well as humans. Based on microbial source testing for bacteria genetic identification, the primary source of this bacteria on Kenai beaches is gulls. Contact with water impacted by enterococci bacteria may cause stomach aches, diarrhea, or ear, eye, and skin infections.

The BEACH sampling program is funded and implemented by DEC. It is part of a nationwide effort to decrease the incidence of water-borne illness at public beaches under the federal Beaches Environmental Assessment and Coastal Health (BEACH) Act. Water samples have been collected periodically at Kenai River beaches since 2010. For more information about the Alaska BEACH monitoring program, visit the [Alaska BEACH Grant Program website](#).

DEC ISSUES ADVISORY FOR KENAI RIVER**FOR IMMEDIATE RELEASE — July 5, 2019****CONTACT: Gretchen Pikul, Division of Water, 907-465-5023**

SOLDOTNA, AK — The Alaska Department of Environmental Conservation (DEC) has issued a recreational beach advisory for the Kenai River mouth due to elevated levels of enterococci found in the marine water. This recreational advisory will remain in effect for personal use fishery (July 10-31). Following the personal use fishery, the advisory will be lifted when two consecutive weekly samples have shown enterococci levels at safe levels.

Water samples were collected on July 2. One of the five monitoring locations (South Kenai Beach) exceeded the water quality criteria for enterococci bacteria. To protect beach users, the other monitoring locations within the Kenai River mouth area (North Kenai River beach and Gull Rookery areas) are included in this recreational advisory. DEC recommends beach users take precautions to avoid exposure, such as avoiding swimming in the water, and washing after contact with the water. DEC advises that people take precautionary measures when fishing along the Kenai River Beaches by rinsing fish with clean water after harvesting from the area. As always, people should cook seafood to a minimum internal temperature of 145 degrees Fahrenheit to destroy pathogens.

Fecal coliform bacteria results were above state limits of 31 cfu/100ml set to protect humans from consumption of raw fish and shellfish at three monitoring locations (North Kenai Beach, South Kenai Beach and Kenai River Gull Rookery 1 and 2) with levels ranging from 49 to 141 cfu/100ml.

Water quality samples were collected at the following locations:

- North Kenai Beach
- South Kenai Beach
- Kenai River Gull Rookery 1 (60.53660N, -151.25400W)
- Kenai River Gull Rookery 2 (60.55180N, -151.24400W)
- Warren Ames Bridge

As part of a statewide recreational beach monitoring program, marine water samples will be collected at the listed coastal areas to evaluate enterococci bacteria and fecal coliform levels weekly from May to September 2019. Monitoring locations maps and sampling information are shown on the [Alaska BEACH Grant Program website](#).

Enterococci bacteria can come from any warm blooded animal, including birds, seals, and dogs, as well as humans. Based on microbial source testing for bacteria genetic identification, the primary source of this bacteria on Kenai beaches is gulls. Contact with water impacted by enterococci bacteria may cause stomach aches, diarrhea, or ear, eye, and skin infections.

The BEACH sampling program is funded and implemented by DEC. It is part of a nationwide effort to decrease the incidence of water-borne illness at public beaches under the federal Beaches Environmental Assessment and Coastal Health (BEACH) Act. Water samples have been collected periodically at Kenai River beaches since 2010. For more information about the Alaska BEACH monitoring program, visit the Alaska BEACH monitoring program, visit the [Alaska BEACH Grant Program website](#).

Appendix D: Site photographs



South Kenai Beach 3 sampling location looking toward the Kenai River outlet. North Kenai Beach can be seen in the background. Photo taken on July 23, 2019 during the personal dipnet fishery season.



South Kenai Beach 3 sampling location. Photo taken on July 23, 2019 during the personal dipnet fishery season.



North Kenai Beach 4 sampling location. Photo taken on July 23, 2019 during the personal dipnet fishery season.



North Kenai Beach 4 sampling location looking away from the Kenai River outlet. Photo taken on July 23, 2019 during the personal dipnet fishery season.



Warren Ames Memorial Bridge 1 sampling location. Photo taken on July 23, 2019 during the personal dipnet fishery season.



Warren Ames Memorial Bridge 1 sampling location looking downstream. Photo taken on July 23, 2019 during the personal dipnet fishery season.



Kenai Gull Rookery 1 sampling location. Fish processing plant can be seen in background. Photo taken on July 23, 2019 during the personal dipnet fishery season.



Kenai Gull Rookery 1 sampling location looking downstream. Gull rookery can be seen on river left. Photo taken on July 23, 2019 during the personal dipnet fishery season.



Kenai Gull Rookery 2 sampling location looking at river right bank. Photo taken on July 23, 2019 during the personal dipnet fishery season.



Kenai Gull Rookery 2 sampling location looking downstream toward Kenai River outlet. Photo taken on July 23, 2019 during the personal dipnet fishery season.