Water Quality Measures in Alaska's Ports and Shipping Lanes: 2021 Annual Report

Prepared for:

Alaska Department of Environmental Conservation
Division of Water

By:

Jeffrey C. Davis and Gay A. Davis
The Aquatic Restoration and Research Institute
PO Box 923, Talkeetna, Alaska 99676
arri@arrialaska.org

Acknowledgements: This project was completed under contract no. CT-180000006 Amendment 2 from the Alaska Department of Environmental Conservation, Division of Water. We appreciate all of the field support and local assistance in field sampling including: Steve Wilson (Dutch Harbor, Nome and Utqiagvik), Dave Watson and Marcia Stanley (Anchorage, Seward, Homer and Kodiak), Jeff Goates (Homer and Dutch Harbor), Austin Ahmasuk (Nome), Mac Enterprises (Dutch Harbor), Alisa Abookire and ACOR (Kodiak), Patty Brown (Haines and Skagway), Chet and Hamilton Construction (Skagway), Asanti Sanborne and Mozeon Charters (Haines and Skagway), Susan Walker and Vic Walker (Juneau), Wade Panzich and Sunshine Water Taxi (Juneau), Kelly Bakos and Kupreanof Kab (Petersburg), Nordic Air (Petersburg), Jim and Alaska Charters and Adventures (Wrangell), Billy Mills and Taylour May Transport (Hoonah), Gary Downie and Gary's Sitka Adventures (Sitka), Michelle Masden and Island Wings Air Service (Ketchikan), Sean Mitchell and Weight N Sea Charters (Ketchikan), Nick Hashagen and Chasin' Tail Charters (Ketchikan), and UCI Environmental Services (Utqiagvik). Helen Wilson assisted with sample transport and data entry.

Cover Photograph: Barge in Valdez Arm

Table of Contents

Tables and Figures

Summary

The Alaska Department of Environmental Conservation (ADEC), Division of Water (DOW), Water Quality Standards, Assessment & Restoration (WQSAR), implemented a water quality assessment project from beginning in 2020 and extending through 2021. The project was a continuation and expansion upon water quality monitoring that was initiated in 2015. The 2020 and 2021 assessment projects were conducted to evaluate water quality during the period of decreased ship traffic due to the Covid-19 pandemic. In 2021 water sampling was conducted at six or more sites within 20 ports from Nome to Ketchikan, and at 30 sampling sites distributed among major shipping lanes throughout southeast and southcentral Alaska. Sampling sites within ports were selected to represent potential pollutant sources (e.g. small boat harbors, cruise ship berths, municipal stormwater, commercial shipping) and mid-channel sites. Select port sampling locations were removed from the project in 2021 where ADEC determined the site to be redundant to other sampling locations.

Sampling was conducted using methods previously established by the ADEC DOW Commercial Passenger Vessel Environmental Compliance Program (CVECP) modified to evaluate compliance with Alaska Water Quality Standards (18 AAC 70) (DEC 2018). At each shipping lane site and at sites within ports, water samples were collected and analyzed for fecal coliform and *Enterococci* bacteria, ammonia-N, copper (Cu), nickel (Ni), and zinc (Zn). Water temperature, pH, salinity, and dissolved oxygen were measured concurrent with water sampling at 1m, 2m, 3m, and 4m water depths. Water sampling for fecal coliform and *Enterococci* in ports was repeated on four subsequent dates in order to obtain five samples within a 30-day period. Concentrations of ammonia-N, metals, and geometric mean bacterial concentrations were compared to Alaska Water Quality Standards (WQS) numeric criteria (WQC) (18 AAC 70) (DEC 2018b) (see inset).

	Water Quality Criteria
Fecal Coliforms	Geometric mean of 14 cfu/100 ml and ≤10% of the samples < 31 cfu/100 ml.
Enterococci	Geometric mean of samples may not exceed 35 *Enterococci* CFU/100 ml.
Ammonia-N	0.3 mg/L (chronic criteria pH of 8.6, temperature of 15°C, and 30 ppt salinity)
Dissolved Copper (Cu)	3.1 µg/L (chronic)
Dissolved Nickel (Ni)	8.2 µg/L (chronic)
Dissolved Zinc (Zn)	86 µg/L (chronic)

Fecal coliform bacteria exceeded WQC in were above 14 cfu/100 ml (WQS for Water Use: Water Supply, Seafood Harvesting for Consumption of Raw Mollusks or other Raw Aquatic Life (18 AAC 70.020 (b)(14)(D)) at four locations in proximity to the port of Valdez. Bacteria concentrations at other sampling locations were generally similar to samples collected in 2020.

We evaluated ammonia-N concentrations for exceedances with the lowest WQS numeric criteria for the range of observed conditions. WQS numeric criteria for ammonia-N are temperature, pH, and salinity dependent and are lower for chronic than acute exposure. The lowest numeric criteria for the range of pH and salinity observed among sampling sites is 0.3 mg/L (chronic criteria pH of 8.6, temperature of 15°C, and 30 ppt salinity) (DEC 2018b, Appendix G). Average ammonia-N concentrations were < 0.033 mg/L at all sampling ports and averaged 0.017 mg/L. Concentrations of ammonia-N among Shipping Lanes sites was < 0.035 mg/L and averaged 0.013 mg/L.

Average total and dissolved concentrations of Cu, Ni, and Zn were evaluated relative to Alaska WQC. Concentrations of total Cu averaged 0.596 µg/L when elevated concentrations in Knik Arm, Anchorage

(20.79 µg/L) were excluded. Cu concentrations near WQC also occurred in Valdez (average 2.04 µg/L. Average total Ni concentrations were < 0.6 µg/L and average total Zn was < 1.2 µg/L (Anchorage excluded). Concentrations of metals in Knik Arm, Anchorage exceeded WQS numeric criteria at multiple sampling sites. Elevated concentrations of total and dissolved metals in Cook Inlet were previously documented and generally attributed to riverine loadings comprised of glacial till. As a result, DEC assigned site-specific water quality criteria for dissolved copper (3.1 µg/L (chronic)), nickel (8.2 µg/L (chronic)), and zinc (81 µg/L (chronic)) for the Point Woronzof (inc. Port of Anchorage) in 1999.[1][2] Further investigation into the relationship between total and dissolved fraction of these metals in the water column may be warranted to ascertain whether exceedances of WQC are the result of natural conditions. There were no significant differences in the concentration of metals between 2021 and 2020 at other port sampling locations; however, more Ports in 2020 had concentrations of Zn > 2 µg/L compared to 2021. The average concentrations of metals in Shipping Lanes sites was < 0.5 µg/L in 2021. High concentrations of total Cu and total Zn in samples collected in Clarence Strait (CS01) in 2020 were not present in 2021 samples.

[1] All concentrations are reported as dissolved. See 18 AAC 70.236(b)(4) for additional detail.
[2] Alaska Department of Environmental Conservation. 1999. *Site-Specific Criteria for Upper Cook Inlet Decision Document*. Watershed Management Section

Introduction

The Alaska Department of Environmental Conservation, Division of Water, initiated a marine water sampling program to determine the ambient water quality of Alaska ports and harbors beginning in 2015. Initial sampling was conducted at multiple sites during the spring and fall, prior to and following the cruise ship season, in Skagway and Juneau. Sampling in these ports continued through 2017, with a single sampling event during the cruise ship season in the Skagway Harbor (ARRI 2018). Sampling in 2018 included sites in Sitka, Hoonah, and Ketchikan (ARRI 2019) and in 2019, Ketchikan and Seward (ARRI 2020).

The sampling program was expanded in 2020 in response to the cancellation of cruise ship voyages to Alaska due to the Covid-19 pandemic. Summer samples in the absence of cruise ships provided an opportunity to evaluate potential local pollution sources (e.g. stormwater runoff, point-source discharges, and small boat and small commercial activities).

Sampling in 2020 was conducted within 16 ports throughout Alaska with sampling occurring at six or more sites within each port. Bacterial sampling (fecal coliforms and *Enterococci*) was conducted at all sampling sites and the frequency increased to five sampling dates within a 30-day period to ensure compliance with DEC bacteria assessment criteria. Sampling also was expanded to include 20 sites located within major waterways or shipping lanes throughout Southeast Alaska. In 2020, concentrations of fecal coliform bacteria exceeded WQC at one or more sites within a number of southeast and southcentral ports. Concentrations of ammonia-N were well below WQC at all sampling sites. Concentrations of metals were also low within all ports and open water sites, with the exception of the Port of Anchorage where metals concentrations (i.e., copper, nickel, and zinc) exceeded WQC at multiple sites.

With the continued absence of cruise ships in 2021, sampling was continued at 20 Ports and expanded to 30 Shipping Lanes sites. Sampling methods were the same in 2020 and 2021.

Methods

The water sampling plan, sample collection, handling, and analyses was conducted following the approved Quality Assurance and Project Plan (ARRI 2020).

Sampling Locations and Dates

2021 water sampling commenced in late April and continued through August at 20 Alaska Ports (Table 1). Southeast sampling started in Ward Cove and Ketchikan on April 20, 2021. The final southeast samples were collected in Skagway and Hoonah on June 3, 2021. Southeast sampling included 28 shipping lane sites. Sampling in southcentral, western, and northern Alaska commenced in Whittier on May 20, 2021, with the final sample collected in Utqiagvik on September 1, 2021. Two shipping lane sites were located in southcentral Alaska in Prince William Sound and Resurrection Bay. The timing of the different sampling locations was opportunistic in nature and attributed to the significant logistical challenges associated with this project.

Table 1. Date ports and shipping lanes sites (abbreviated site names) sampled for metals, ammonia-N, fecal coliforms, and *Enterococci*. Cooler temperatures when samples received at the analytical laboratory are shown in parenthesis. Asterix's indicate samples received after the hold time.

Locations	Metals/ Ammonia-N	Fecal/EC	Fecal/EC	Fecal/EC	Fecal/EC	Fecal/EC
Juneau	5/5/2021 (2.1)	5/5/2021 (3.2)	5/6/2021 (4.8)	5/11/2021 (2.9)	5/20/2021 (5.0)	5/27/2021 (6.0)
MP, SP02	5/5/2021 (2.1)	5/5/2021 (3.2)				
Auke Bay	5/4/2021 (3.2)	5/4/2021 (2.5)	5/6/2021 (4.8)	5/11/2021 (2.9)	5/20/2021 (5.0)	5/27/2021 (6.0)
LC01, FP	5/4/2021 (3.2)	5/4/2021 (2.5)				
Haines and LC02	5/12/2021 (3.5)	5/12/2021 (4.6)	5/18/2021 (5.3)	5/20/2021 (2.8)	5/24/2021 (4.0)	6/2/2021 (4.9)
Skagway	5/13/2021 (3.5)	5/13/2021 (8.5)	5/18/2021 (5.4)	5/24/2021 (4.8)	6/2/2021 (5.2)	6/3/2021 (7.7)
Hoonah	5/7/2021 (2.1)	5/7/2021 (5.6)	5/17/2021 (4.2)	5/24/2021 (8.4)	6/1/2021 (3.4)	6/3/2021 (4.0)
IS01, IS02, ChS03, NC	5/6/2021 (2.1)	5/6/2021 (5.6)*				
Sitka	5/3/2021 (3.2)	5/3/2021 (3.7)	5/11/2021 (1.9)	5/19/2021 (5.8)	5/24/2021 (3.9)	5/27/2021 (4.4)
Wrangell	4/28/2021 (5.4)	4/28/2021 (5.8)*	4/30/2021 (5.2)	5/13/2021 (0.7)	5/18/2021 (4.4)*	5/24/2021 (2.5)
SS01, SS02, SS03, Stikine	4/28/2021 (5.4)	4/28/2021 (7.2)*				
Petersburg	4/27/2021 (5.4)	4/27/2021 (3.8)	4/29/2021 (4.9)	5/13/2021 (2.1)	5/19/2021 (3.3)	5/26/2021 (4.8)
SP01, SP03, FS01, FS02, FS03	4/26/2021 (5.4)	4/26/2021 (1.4)*				
Ketchikan	4/21/2021 (2.1)	4/109/2021 (<10)	4/21/2021 (<10)	4/22/2021 (<10)	5/10/2021 (<10)	5/11/2021 (<10)
NI01, NI02	4/21/2021 (2.1)	4/21/2021 (<10)				
Ward Cove	4/20/2021 (2.1)	4/19/2021 (<10)	4/20/2021 (<10)	4/22/2021 (<10)	5/10/2021 (<10)	5/11/2021 (<10)
CS01, CS02, CS03, DI	4/20/2021 (2.1)	4/20/2021 (<10)				
Whittier	5/20/2021 (5.3)	5/24/2021 (8.4)	5/26/2021 (5.1)	5/27/2021 (4.6)	6/2/2021 (2.7)	6/15/2021 (8.2)
Storey	5/25/2021 (5.3)	5/25/21 (5.1)*				
Seward and SC	5/19/2021 (10.0)	5/19/2021 (6.6)	5/20/2021 (4.5)	5/24/2021 (9.0)	5/26/2021 (5.9)	5/27/2021 (7.6)
Homer	6/7/2021 (3.0)	6/7/2021 (1.8)*	6/9/2021 (6.5)	6/10/2021 (1.8)	6/14/2021 (3.5)	6/15/2021 (3.0)
Anchorage	7/12/2021 (11.3)	7/12/2021 (11.2)	7/15/2021 (12.5)	7/26/2021 (10.8)	7/29/2021 (14.0)	8/6/2021 (10.3)
Valdez	8/6/2021 (4.1)	8/12/2021 (4.9)*	8/16/2021 (3.7)	8/17/2021 (2.6)	8/24/2021 (5.0)*	8/26/2021 (1.9)*
Kodiak	7/7/2021 (3.9)	6/16/2021 (4.1)*	6/21/2021 (1.8)	6/28/2021 (3.2)	7/6/2021 (4.7)	7/7/2021 (5.8)
Dutch Harbor	6/21/2021 (1.7)	6/21/2021 (<10)	6/23/2021 (<10)	6/24/2021 (<10)	6/25/2021 (<10)	6/26/2021 (<10)
Nome	7/14/2021 (3.4)	7/14/2021 (1.7)	7/15/2021 (4.9)	7/20/2021 (6.0)	7/30/2021 (3.9)	8/3/2021 (5.2)
Utqiagvik	8/25/2021 (2.4)	8/25/2021 (1.0)	8/26/2021 (3.6)*	8/31/2021 (8.1)*	9/1/2021 (5.4)	

Sample Collection

Water samples were collected from 1m water depth. Harbor water was pumped through Teflon tubing into laboratory-provided sample bottles using a peristaltic pump (Solonist 410). Tubing and bottles were flushed for approximately three minutes prior to sample collection at each sampling location. Water samples were collected in sample bottles provided by the analytical laboratory. All sample bottles contained acid preservative and were sealed in two layers of plastic bags. Water samples for dissolved metals were field filtered using a pre-cleaned 0.45 µm filter. Water temperature, pH, salinity, and dissolved oxygen were measured at 1, 2, 3, and 4m depths at each sampling location. Water pH and salinity was measured with a YSI 1030 meter and dissolved oxygen and temperature with a YSI Pro ODO meter and probe. The pH meter was checked for accuracy using a 7.01 pH standard prior to field data collection. If inaccurate, the meter was recalibrated using pH 7.01 and pH 10.01 standards. The dissolved oxygen meter was calibrated using the 100% air saturation method prior to field collection in each port.

Analytical Methods

Water samples were analyzed by ALS Environmental by EPA method 200.8 following reductive precipitation reaction to obtain concentration of dissolved and total Cu, Ni, and Zn. Ammonia-N was analyzed using EPA method 350.1. The laboratory MDL and Reporting Limits (RL) are shown below.

	Reporting Limit (RL)	Method Detection Limit (MDL)	0.5 x MDL	Units
Ammonia-N	0.010	0.003	0.002	mg/L
Copper (Cu)	0.10	0.02	0.01	µg/L
Nickel (Ni)	0.20	0.03	0.02	µg/L
Zinc (Zn)	0.50	0.20	0.10	µg/L

Water samples were analyzed for total fecal coliforms and *Enterococci* by Admiralty Environmental (Juneau), ARS Aleut Analytical, LLC (Anchorage), SGS (Anchorage) and R&M Engineering (Ketchikan) using EPA method 9222D and *Enterococci* by the most probable number method. The MDL for fecal coliform bacteria was 1 cfu/100 ml and for *Enterococci* 1 MPN/100 ml (ARS Aleut), or 2 cfu/100ml and 10 MPN/100 ml (Admiralty Environmental and R&M Engineering). SGS Environmental reported results to the level of quantification (LOQ) which was 1.67 for fecal coliforms and 1.0 for *Enterococci*.

Quality Assurance

Field quality assurance measures included trip blanks, equipment blanks, and field replicates. Trip blanks were laboratory provided metals-free sealed sample bottles. Trip blanks travelled with the sample bottles and field samples and remained sealed until analyzed for total Cu, Ni, and Zn. Equipment blanks are samples of laboratory provided deionized water collected in the field using the same equipment as field sample collection. Field blanks were collected by submerging the pump tubing into the liter of deionized water; therefore, metals could be introduced into the field blank from the exterior of the tubing. Equipment blanks were collected prior to initiating field sampling. Equipment blanks were analyzed for ammonia-N and total and dissolved metals. Replicate water samples were collected at one sampling sites in most ports.

Total metals were detected in some trip blanks and ammonia-N and total and dissolved metals were detected in some equipment blanks, therefore, reported values may be biased high and true concentrations may be less than reported values. Quality objectives for precision were not met for all replicate samples, particularly ammonia-N which was often at or below the MDL. Therefore, true ammonia-N values concentrations may be slightly higher than or less than reported values by up to 0.02 mg/L. Preliminary quality assurance sample results are provided in Appendix A.

Results

Sample results are provided in the following sections for all Ports and Shipping Lanes sites sampled in 2021. Sample results are included in tables and figures if values were above the laboratory MDL. Values should be considered estimates when MDL > Value < RL. A value of 0.5 x MDL was used in tables and when calculating averages or geometric means. For southeast Alaska Ports the reported *Enterococci* results are 5 MPN/100 ml when the analyzed results were less than the MDL. The reported results for fecal coliform are 0.5 cfu/100 ml when the analyzed results were less than the MDL the value. Concentrations of *Enterococci* appear greater than concentrations of fecal coliforms when results are below the MDL for both analyses.

Sample results are compared to data collected in 2020 (ARRI 2020b).

Utqiagvik

Four sampling stations were distributed just off shore from Utqiagvik (Figure 1).

There were no spatial or vertical trends in water temperature, salinity, pH, or dissolved oxygen (Table 2). On the August 25 sampling date water temperature averaged 4°C, salinity was ~30 ppt, pH 8.0 and dissolved oxygen12 mg/L.

Fecal coliform bacteria and *Enterococci* were at or near the MDL and well below WQC (Figure 2)

Ammonia-N concentration averaged 0.026 and total and dissolved metals were < 0.6 µg/L (Table 3).

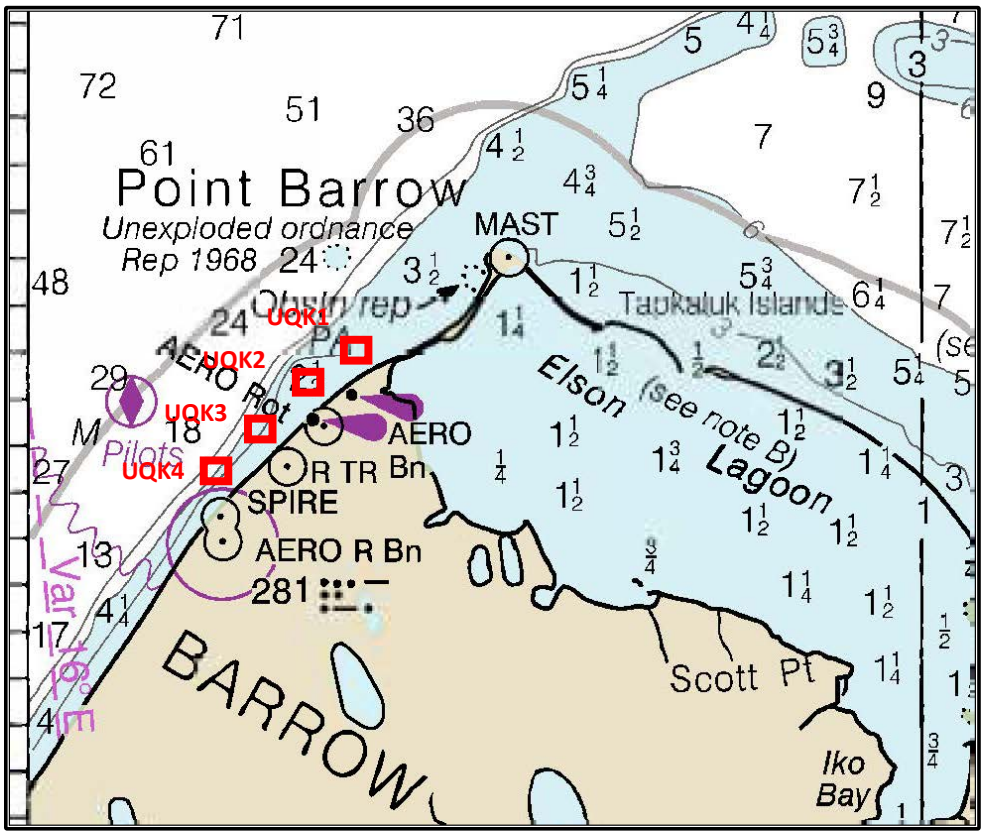


Figure 1. Chart showing Port of Utqiagvik sampling stations.

Table 2. Port of Utqiagvik water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m
UQK1	4.90	4.90	5.00	5.00
UKQ2	4.10	4.20	4.60	4.60
UQK3	4.10	4.10	4.10	4.10
UQK4	4.40	4.40	4.40	4.40
Average	4.38	4.40	4.53	4.53

Salinity (ppt)	1m	2m	3m	4m
UQK1	29.70	29.90	29.40	30.10
UKQ2	30.00	30.10	30.20	30.20
UQK3	30.10	30.10	30.10	30.10
UQK4	30.10	30.10	30.20	30.10
Average	29.98	30.05	29.98	30.13

pH	1m	2m	3m	4m
UQK1	7.99	8.04	8.04	8.05
UKQ2	8.10	8.10	8.04	8.09
UQK3	8.12	8.12	8.12	8.13
UQK4	8.12	8.12	8.12	8.12
Average	8.08	8.10	8.08	8.10

D.O. (mg/L)	1m	2m	3m	4m
UQK1	11.76	11.30	11.78	11.76
UKQ2	12.21	12.16	11.96	11.91
UQK3	12.23	12.21	12.20	12.15
UQK4	12.13	12.10	12.04	12.02
Average	12.08	11.94	12.00	11.96

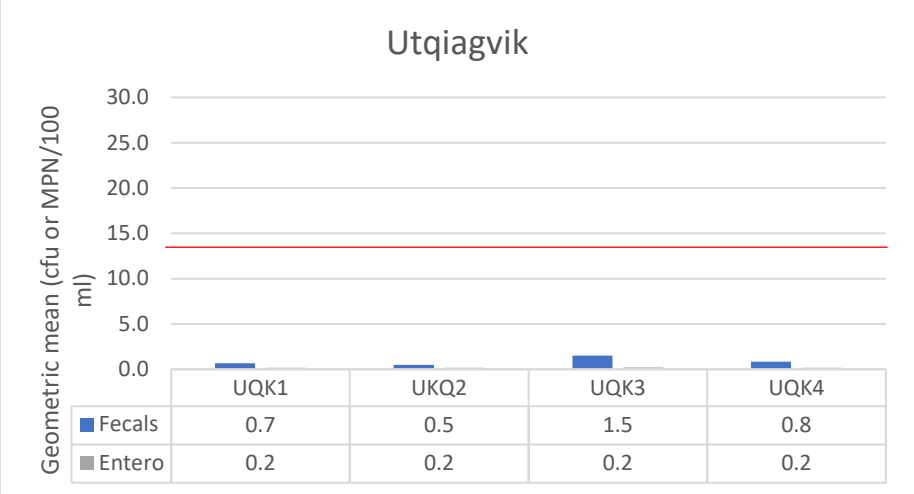


Figure 2. Port of Utqiagvik geometric mean concentrations of fecal coliforms (FC) and *Enterococci* bacteria. WQC Red line is the numeric WQC for fecal coliforms of 14 cfu/100 ml.

Table 3. Concentrations of total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Utqiagvik sampling stations. Water quality criteria (WQC) are listed for reference.

Site	Ammonia-N (mg/L)	T-Cu (µg/L)	D-Cu (µg/L)	T-Ni (µg/L)	D-Ni (µg/L)	T-Zn (µg/L)	D-Zn (µg/L)
WQC	0.3	-	3.1	-	8.2	-	86
UQK01	0.008	0.44	0.34	0.59	0.57	0.55	0.54
UQK02	0.038	0.35	0.27	0.38	0.36	0.45	0.49
UQK03	0.010	0.32	0.26	0.37	0.33	0.33	0.27
UQK04	0.047	0.34	0.27	0.40	0.36	0.35	0.27
Average	0.026	0.36	0.29	0.44	0.41	0.42	0.39

Anchorage-Cook Inlet

Six sampling locations in Knik Arm and Cook Inlet near the Port of Anchorage are shown in Figure 3. Three sampling stations were near shore adjacent to port facilities and three stations near the middle of Knik Arm.

Water temperature, salinity, pH, and dissolved oxygen measured on July 12, 2021, are shown in Table 4. Salinity was low ranging from 11 to 12 ppt and pH averaged 8.0. There were no apparent trends in these measures with depth or among sampling stations.

Geometric mean concentrations of fecal coliforms and *Enterococci* were near the LOQ on most sampling dates at most sampling sites and well below WQC (Figure 4). A single sample collected on July 29 at ANO1 of 17 cfu/100 ml exceeded WQC. Fecal coliforms concentrations were lower in 2021 compared to samples collected in 2020.

Ammonia-N concentrations were below the MDL at all sampling stations. Total and dissolved metals concentrations exceed WQC for Cu and Ni at multiple sampling stations (Table 5). Concentrations of metals were highest at AN01 and tended to be higher at the sampling stations near port facilities. However, high concentrations of metals also were measured at AN06.

2021 Samples for Ammonia-N concentrations were lower while metals slightly higher than those samples collected in 2020.

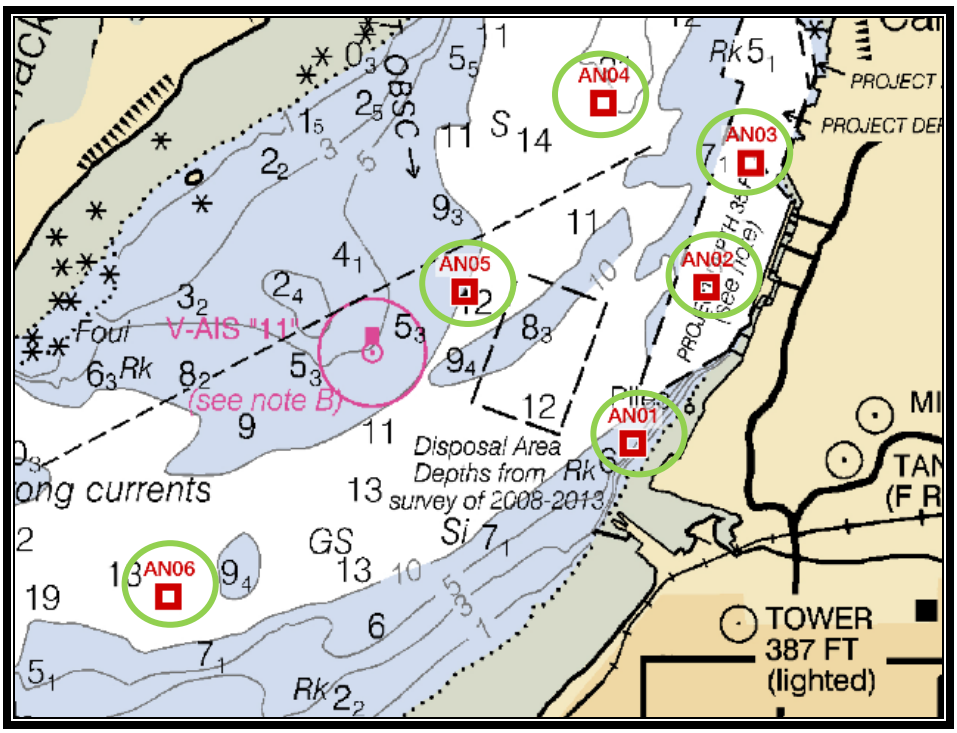


Figure 3. Chart showing Port of Anchorage sampling stations. Stations where WQC for metals or ammonia-N are exceeded are circled with green.

Table 4. Port of Anchorage water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m
AN01	13.20	13.10	13.10	13.10
AN02	13.20	13.10	13.10	13.10
AN03	13.10	13.10	13.10	13.10
AN04	13.20	13.20	13.20	13.20
AN05	13.30	13.20	13.20	13.20
AN06	13.20	13.20	13.20	13.10
Average	13.20	13.15	13.15	13.13

Salinity (ppt)	1m	2m	3m	4m
AN01	11.30	11.60	11.60	11.70
AN02	11.10	11.10	11.10	11.10
AN03	11.10	11.30	11.00	11.00
AN04	11.40	11.50	11.70	11.80
AN05	11.40	11.50	12.30	12.50
AN06	12.00	12.00	12.10	12.20
Average	11.38	11.50	11.63	11.72

pH	1m	2m	3m	4m
AN01	8.01	7.99	8.00	7.99
AN02	8.01	8.01	8.00	8.01
AN03	7.99	7.99	8.00	7.99
AN04	8.00	7.98	7.98	7.98
AN05	7.96	7.96	7.96	7.96
AN06	7.95	7.95	7.95	7.96
Average	7.99	7.98	7.98	7.98

D.O. (mg/L)	1m	2m	3m	4m
AN01	9.67	9.67	9.67	9.65
AN02	9.69	9.71	9.69	9.69
AN03	9.70	9.70	9.66	9.66
AN04	9.64	9.65	9.65	9.63
AN05	9.57	9.60	9.65	9.65
AN06	9.62	9.64	9.66	9.65
Average	9.65	9.66	9.66	9.66

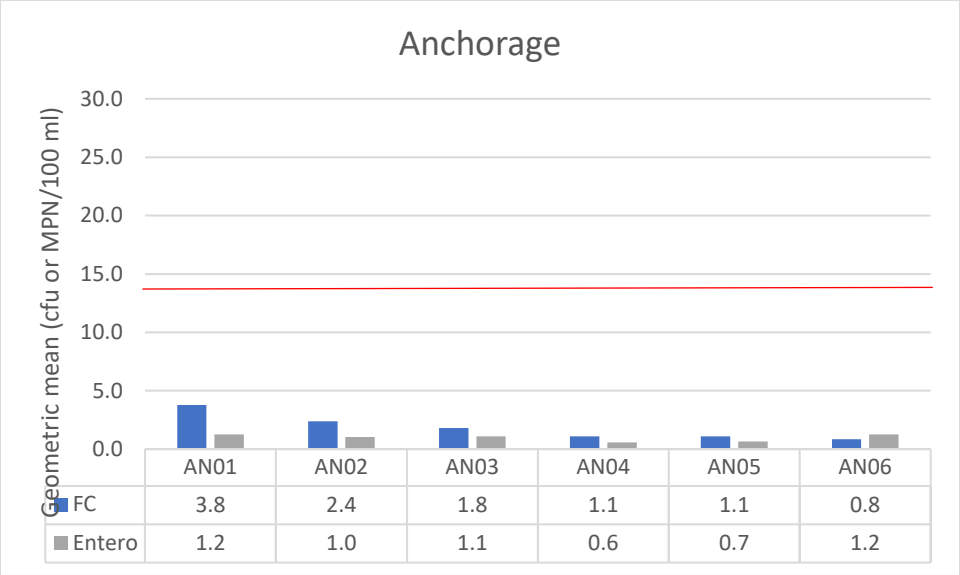


Figure 4. Port of Anchorage geometric mean concentrations of fecal coliforms (FC) and *Enterococci* bacteria. WQC Red line is the numeric WQC for fecal coliforms.

Table 5. Concentrations of total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Anchorage sites. Concentrations above numeric WQC are bolded. Water quality criteria (WQC) are listed for reference.

Site	Ammonia-N (mg/L)	T-Cu (µg/L)	D-Cu (µg/L)	T-Ni (ug/L)	D-Ni (µg/L)	T-Zn (µg/L)	D-Zn (µg/L)
WQC	0.3	-	3.1	-	8.2	-	81
AN01	0.005	**28.6**	**17.1**	18.0	**13.1**	42.1	27.0
AN02	0.005	**14.8**	**6.6**	10.7	6.6	23.6	13.1
AN03	0.005	**30.9**	**7.7**	19.1	7.3	44.7	14.2
AN04	0.005	**8.5**	**5.2**	7.1	4.8	14.0	8.4
AN05	0.005	**16.1**	**6.8**	12.5	**8.7**	26.0	11.9
AN06	0.005	**25.8**	**8.2**	16.6	7.2	39.0	13.3
Average	0.005	20.8	8.6	14.0	7.9	31.6	14.7

Kodiak

The location of five sampling sites near Kodiak are shown in Figure 5. KO01 was located within the Inner small boat harbor, KO02 was near the cruise ship berths, and KO03 was in Dog Bay small boat harbor. KO04 was near the end of East Marine Way, and KO06 was off shore.

Water temperature on the July 7 sampling date averaged 8.7 °C at 1m and 8.0 °C at 4m water depth (Table 6). Salinity averaged 31 ppt, pH 8.5, and dissolved oxygen 10.6 at 1m water depth. Water pH and dissolved oxygen declined slightly with water depth.

Geometric mean concentration of fecal coliforms and *Enterococci* were below WQC (Figure 6). However, high single fecal coliform concentrations were measured in the small boat harbors KO01 (123 cfu/100 ml) and KO03 (104 cfu/100 ml). A high *Enterococci* value of 727 MPN/100 ml was recorded at KO01. Geometric mean concentrations were lower in 2021 than 2020. In 2020 high single sample concentrations of fecal coliforms also were measured in the small boat harbors.

Average ammonia-N concentration was 0.03 mg/L (Table 7). Average concentrations of total and dissolved Cu, Ni, and Zn were < 1.0 µg/L. Cu and Ni did not vary among sampling sites, but concentrations of Zn were slightly higher within the small boat harbors. Average Cu and Ni concentration in 2021 were similar to 2020 concentrations, and concentrations of Zn were slightly lower.

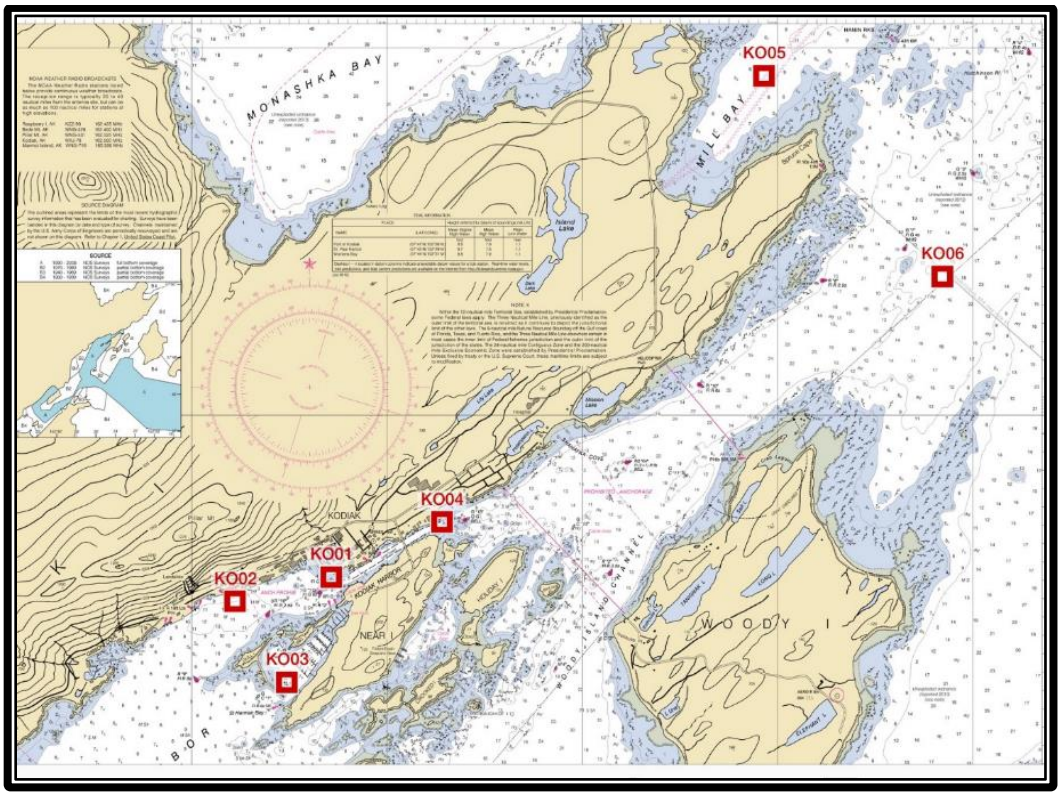


Figure 5. Port showing Port of Kodiak sampling stations. Sampling Station KO05 was not sampled in 2021.

Table 6. Port of Kodiak water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m
KO01	9.30	8.60	8.00	7.90
KO02	8.70	8.50	8.30	8.20
KO03	9.70	8.80	8.70	8.50
KO04	7.80	7.70	7.60	7.60
KO06	8.10	8.00	8.00	8.00
Average	8.72	8.32	8.12	8.04

Salinity (ppt)	1m	2m	3m	4m
KO01	29.20	30.2	31.40	31.50
KO02	31.50	31.50	31.60	31.60
KO03	31.03	31.40	31.49	31.60
KO04	31.80	31.80	31.90	31.90
KO06	31.90	31.90	31.90	31.90
Average	31.09	31.36	31.66	31.70

pH	1m	2m	3m	4m
KO01	8.14	8.11	8.09	8.08
KO02	8.64	8.50	8.40	8.30
KO03	8.34	8.31	8.28	8.26
KO04	8.10	8.10	8.10	8.10
KO06	9.20	9.04	8.80	8.70
Average	8.48	8.41	8.33	8.29

D.O. (mg/L)	1m	2m	3m	4m
KO01	10.50	10.10	9.70	9.60
KO02	10.40	10.40	10.20	9.90
KO03	12.39	12.47	12.42	12.12
KO04	9.58	9.59	9.50	9.60
KO06	10.60	10.70	10.60	10.70
Average	10.69	10.65	10.48	10.38

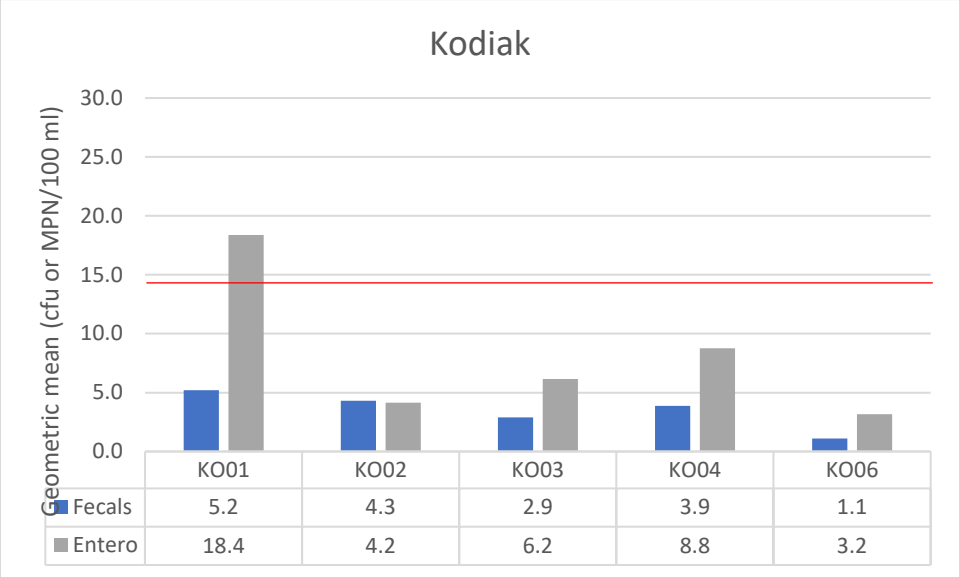


Figure 6. Port of Kodiak geometric mean concentrations of fecal coliforms (FC) and *Enterococci* bacteria. WQC Red line is the numeric WQC for fecal coliforms. WQC for *Enterococci* is 35 MPN/100 ml.

Table 7. Concentrations of total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Kodiak sampling stations. Water quality criteria (WQC) are listed for reference.

Site	Ammonia-N (mg/L)	T-Cu (µg/L)	D-Cu (µg/L)	T-Ni (µg/L)	D-Ni (µg/L)	T-Zn (µg/L)	D-Zn (µg/L)
WQC	0.3	-	3.1	-	8.2	-	86
KO01	0.043	0.39	0.28	0.37	0.34	1.10	0.43
KO02	0.020	0.30	0.25	0.36	0.31	0.76	0.51
KO03	0.041	0.30	0.30	0.36	0.32	1.35	0.74
KO04	0.046	0.23	0.23	0.32	0.31	0.23	0.28
KO06	0.016	0.17	0.22	0.30	0.30	0.10	0.10
Average	0.033	0.28	0.26	0.34	0.32	0.71	0.41

Dutch Harbor

Six sampling stations in Dutch Harbor and Iliuliuk Bay are shown in Figure 7.

Water temperatures on June 21, 2021 averaged 9°C at the water surface and 7°C at 4m water depth (Table 8). Salinity was over 30 ppt and did not vary with location or water depth. Water pH decreased from 8.4 to 8.2 with depth. Dissolved oxygen was supersaturated and averaged 15 mg/L at 1m and 14 mg/L at 4m water depth.

Fecal coliform bacteria and *Enterococci* were below WQC (Figure 8). A single high fecal coliform value of 40 cfu/100 ml was recorded at DH03 and higher *Enterococci* counts, up to 189 MPN/100 ml were recorded at DH06. Fecal coliforms and *Enterococci* concentrations were similar, though slightly lower, in 2021 compared to 2020.

Ammonia-N and the concentration of metals were low at all sampling stations (Table 9). Ammonia-N averaged 0.02 mg/L. Cu and Ni concentrations were < 1 µg/L at all sampling stations and average Zn concentrations < 2.5 µg/L with the highest values at DH02, DH03, and DH06.

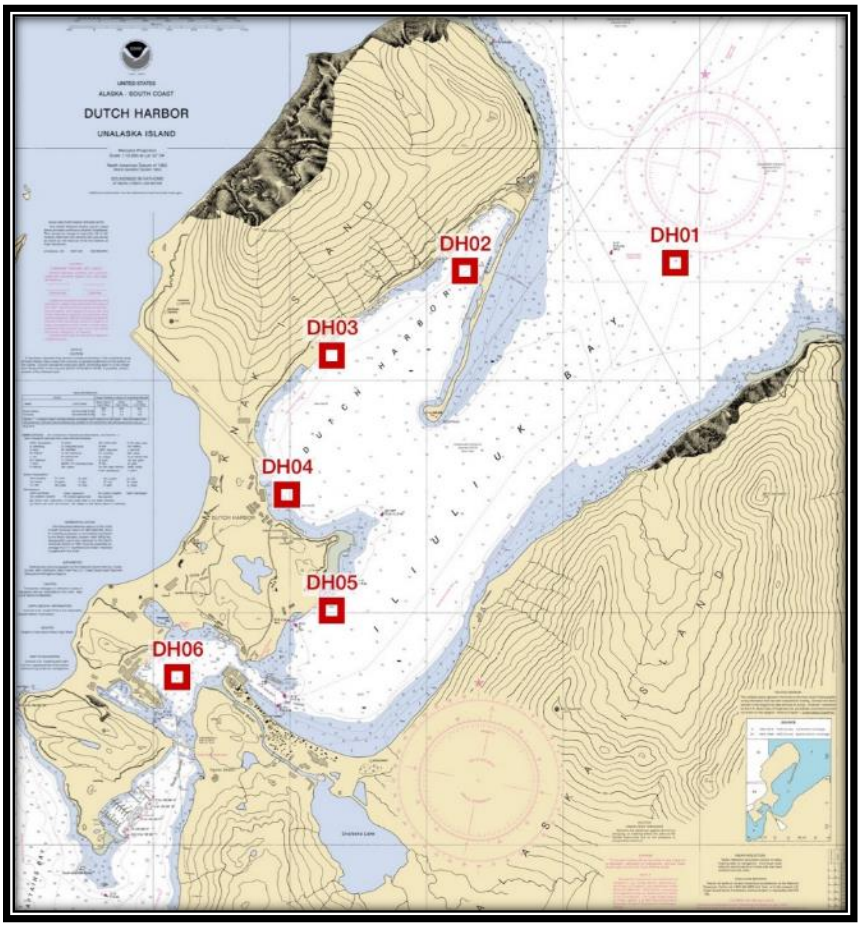


Figure 7. Chart showing Dutch Harbor sampling stations.

Table 8. Dutch Harbor water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m
DH01	8.10	8.00	7.80	6.70
DH02	10.10	9.50	8.60	7.40
DH03	9.70	8.40	8.50	7.90
DH04	9.10	9.10	9.10	7.80
DH05	9.00	8.80	8.00	7.00
DH06	8.30	7.40	6.80	6.70
DH06	8.40	8.00	7.20	6.70
Average	8.96	8.46	8.00	7.17

Salinity (ppt)	1m	2m	3m	4m
DH01	32.10	32.10	32.20	32.40
DH02	31.40	31.60	31.90	32.30
DH03	30.70	31.80	31.80	31.90
DH04	30.50	30.60	30.70	30.19
DH05	30.50	31.30	32.10	32.30
DH06	31.60	31.80	32.20	32.30
DH06	30.40	31.60	32.00	32.30
Average	31.03	31.54	31.84	31.96

pH	1m	2m	3m	4m
DH01	8.41	8.40	8.38	8.21
DH02	8.45	8.43	8.41	8.31
DH03	8.35	8.30	8.30	8.23
DH04	8.42	8.42	8.42	8.20
DH05	8.41	8.43	8.41	8.23
DH06	8.27	8.16	8.07	8.01
DH06	8.31	8.30	8.23	8.13
Average	8.37	8.35	8.32	8.19

D.O. (mg/L)	1m	2m	3m	4m
DH01	17.00	16.83	16.37	14.65
DH02	15.92	16.15	16.55	14.83
DH03	14.52	14.89	14.79	14.33
DH04	15.68	15.79	15.85	13.16
DH05	15.47	17.00	17.63	15.70
DH06	14.01	12.75	12.12	11.49
DH06	13.65	14.53	14.51	13.21
Average	15.18	15.42	15.40	13.91

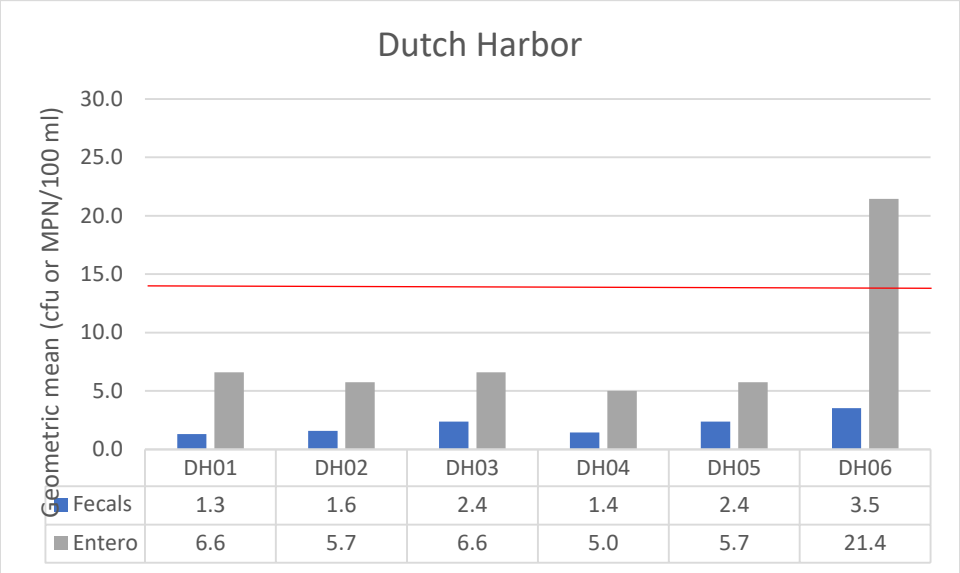


Figure 8. Dutch Harbor geometric mean concentrations of fecal coliforms (FC) and *Enterococci* bacteria. WQC Red line is the numeric WQC for fecal coliforms.

Table 9. Concentrations of total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Dutch Harbor sites. Water quality criteria (WQC) are listed for reference.

Site	Ammonia-N (mg/L)	T-Cu (µg/L)	D-Cu (µg/L)	T-Ni (ug/L)	D-Ni (µg/L)	T-Zn (µg/L)	D-Zn (µg/L)
WQC	0.3	-	3.1	-	8.2	-	86
DH01	0.006	0.21	0.21	0.26	0.22	0.59	0.36
DH02	0.026	0.67	0.41	0.26	0.22	5.11	1.14
DH03	0.020	0.85	0.72	0.21	0.27	3.92	3.19
DH04	0.009	0.25	0.38	0.14	0.22	0.66	0.89
DH05	0.009	0.28	0.42	0.21	0.14	0.98	0.91
DH06	0.058	0.47	0.62	0.23	0.15	2.67	2.20
Average	0.021	0.46	0.46	0.22	0.20	2.32	1.45

Nome-Norton Sound

Six sampling sites near Nome were located at the Cruise Ship Berth (NO01), Inner Harbor (NO)2, near the beach camps (NO03), off of Front Street (NO04), and offshore (NO06) (Figure 9).

There were only minor differences in water temperature, salinity, pH and dissolved oxygen with water depth, and no consistent differences were present among sampling sites. Average water temperature on the July 15 sampling date was 12.3 °C at 1m and 11.6 at 4m water depth (Table 10). Salinity was 27 ppt, pH 8.0, and dissolved oxygen 9.5 mg/L at 1m and 9.3 mg/L at 4m water depth.

Geometric mean fecal coliforms and *Enterococci* were below WQC (Figure 10). Geometric mean fecal coliforms were highest at sites NO01 and NO02. These two sites also had the highest single values of 82 and 69 cfu/100 ml. The highest *Enterococci* value was 11 MPN/100 ml also occurred at site NO01. These results are consistent with 2020; however, in 2020 the Geometric mean of fecal coliforms exceeded state WQS.

Ammonia-N concentrations were below the MDL at all sampling sites (Table 11). Total and dissolved Cu concentrations were near 1.0 µg/L with one high dissolved Cu value of 2.45, which was greater than the total value at NO02. Total and dissolved Zn concentrations were <1 µg/L.

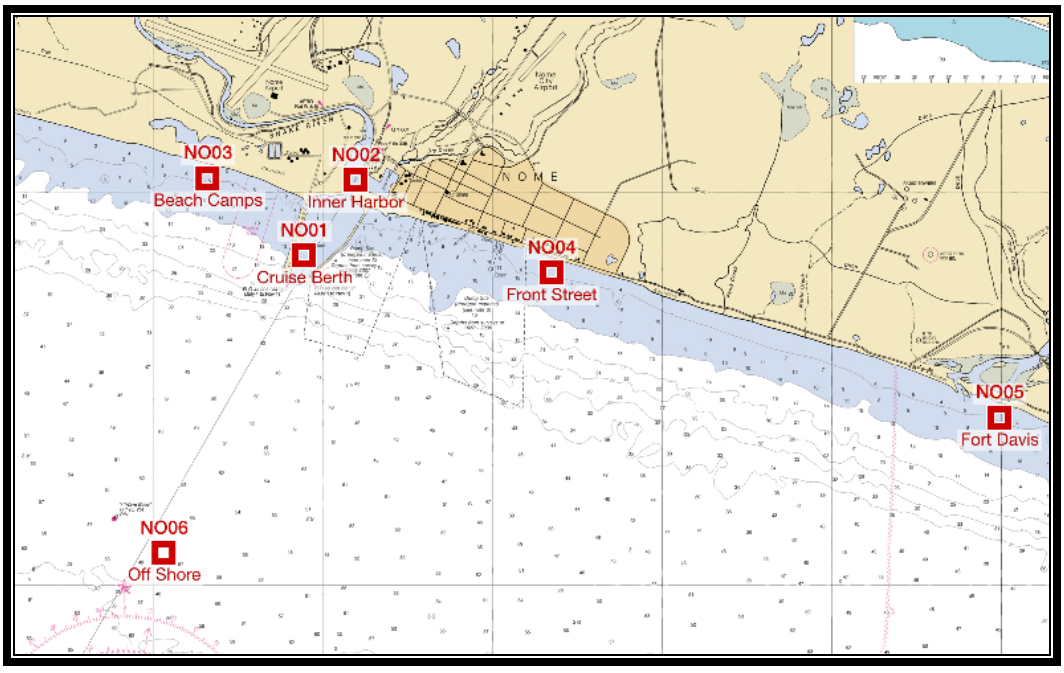


Figure 9. Chart showing Port of Nome sampling stations. NO05 was not sampled in 2021.

Table 10. Port of Nome water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m
NO01	12.60	11.60	11.40	11.30
NO02	13.20	12.80	12.40	12.50
NO03	12.00	11.80	11.30	11.00
NO04	11.50	11.40	11.30	11.20
NO06	12.20	12.20	12.20	12.20
Average	12.30	11.96	11.72	11.64

Salinity (ppt)	1m	2m	3m	4m
NO01	25.30	26.90	27.10	27.30
NO02	25.00	25.70	20.10	25.90
NO03	26.40	26.60	27.30	27.60
NO04	27.00	27.00	27.20	27.40
NO06	26.10	26.10	26.10	26.10
Average	25.96	26.46	25.56	26.86

pH	1m	2m	3m	4m
NO01	8.00	7.99	8.00	8.00
NO02	8.00	7.99	7.88	7.85
NO03	8.04	8.05	8.02	8.02
NO04	8.05	8.05	8.04	8.04
NO06	8.06	8.06	8.06	8.07
Average	8.03	8.03	8.00	8.00

D.O. (mg/L)	1m	2m	3m	4m
NO01	9.60	9.49	9.47	9.36
NO02	9.00	8.91	8.50	8.22
NO03	9.73	9.61	9.46	9.43
NO04	9.66	9.61	9.55	9.53
NO06	9.80	9.74	9.72	9.70
Average	9.56	9.47	9.34	9.25

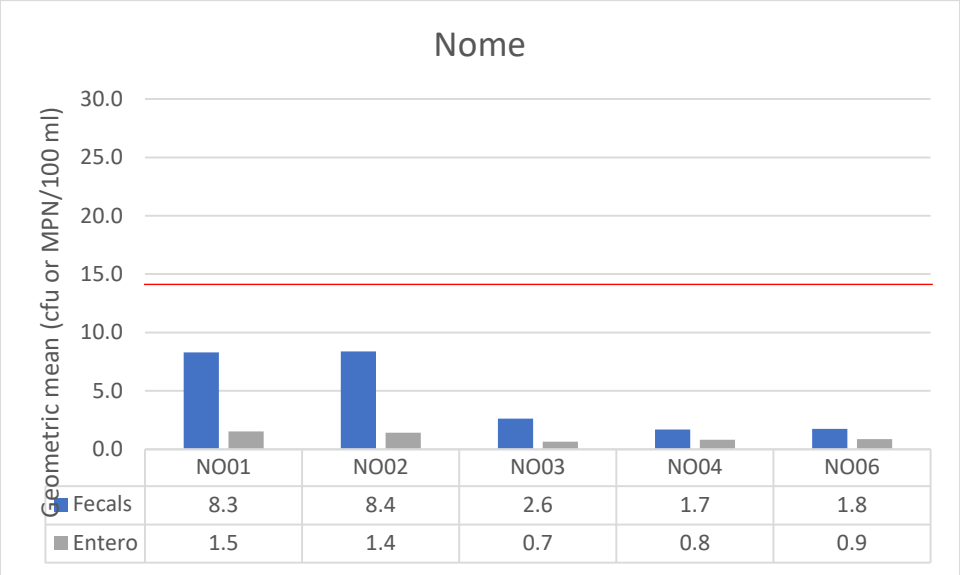


Figure 10. Port of Nome geometric mean concentrations of fecal coliforms (FC) and *Enterococci* bacteria. WQC Red line is the numeric WQC for fecal coliforms.

Table 11. Concentrations of total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Nome sampling stations. Water quality criteria (WQC) are listed for reference.

Site	Ammonia-N (mg/L)	T-Cu (µg/L)	D-Cu (µg/L)	T-Ni (µg/L)	D-Ni (µg/L)	T-Zn (µg/L)	D-Zn (µg/L)
WQC	0.3	-	3.1	-	8.2	-	86
NO01	0.002	1.04	1.32	0.99	0.92	0.40	0.39
NO02	0.002	1.01	2.45	0.99	0.84	0.87	1.79
NO03	0.002	1.03	1.09	0.99	0.94	0.33	0.21
NO04	0.002	0.96	1.05	0.97	0.88	0.45	0.39
NO06	0.002	1.02	1.34	0.91	0.91	0.10	0.26
Average	0.002	1.01	1.45	0.97	0.90	0.43	0.61

Valdez-Valdez Arm

Six sampling sites in Valdez Arm near the City of Valdez were located nearshore west of town (VA01), adjacent to the cruise ship and Alaska Marine Highway berth (VA03), between the berth and the small boat harbor breakwater (VA02), within the old small boat harbor (VA04), just outside of the new small boat harbor (VA05), and in the middle of Valdez Arm (VA06) (Figure 11).

Salinity, temperature, dissolved oxygen, and to a lesser extent pH, varied with water depth in Valdez Arm (Table 12). Surface waters were less saline on the August 16 sampling date averaging 2 ppt at 1m water depth and 22 ppt at 4m. Water temperatures were approximately 2°C cooler, and dissolved oxygen 2 mg/L higher at 1m compared to 4m water depth. Water temperatures were also slightly warmer within the small boat harbor (VA04) compared to the other sites. Water pH was slightly below 8 at all sampling sites and depths.

Geometric mean fecal coliform bacteria exceeded WQC at VA01, VA02, and VA04 (Figure 12). The maximum fecal coliform count at these sites was 46, 104, and 37 cfu/100ml, respectively. These results are consistent with geometric mean fecal coliform counts in 2020 when WQC were exceeded at VA02, VA03, VA04, and VA05. Geometric mean *Enterococci* concentrations were below WQC with the highest single value of 16 MPN/100 ml at VA05. The source of the bacteria could not be determined by this study and further investigation is warranted to determine the bacteria is anthropogenic in nature.

Ammonia-N concentration averaged 0.028 mg/L (Table 13). Average total and dissolved metals were < 3 µg/L. Concentrations of metals were high relative to other ports except those collected at the Port of Anchorage, but were below WQC. Total metals were approximately twice the concentration of dissolved metals. The highest metals concentrations were recorded at VA05. Elevated metals concentrations are consistent with samples collected in 2020.

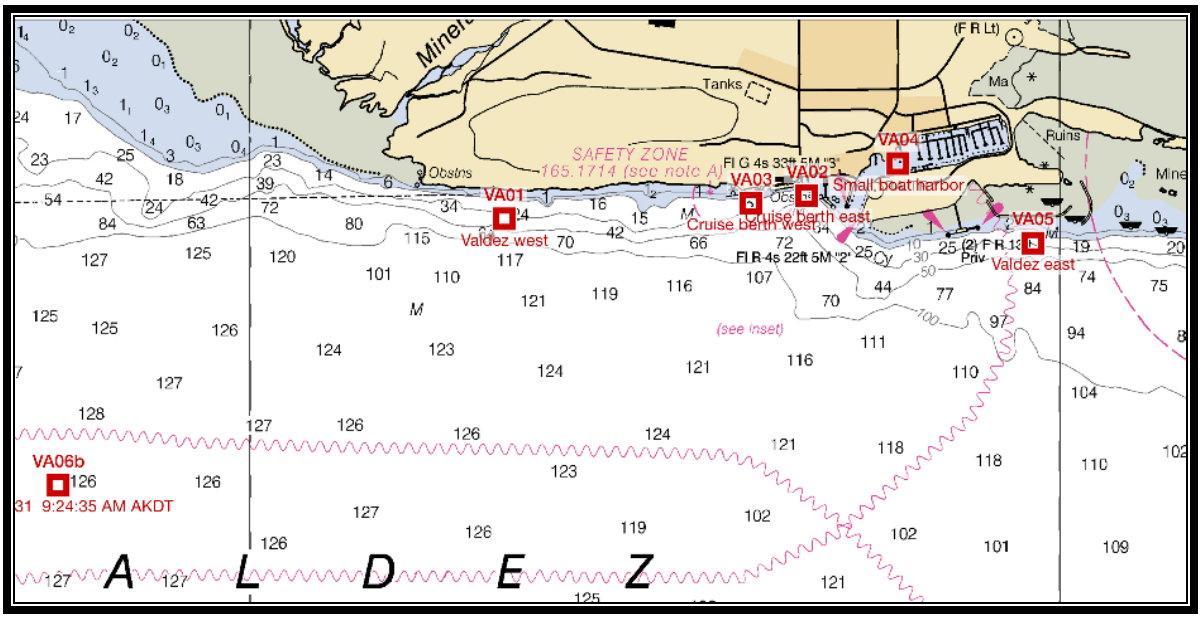


Figure 11. Port of Valdez sampling stations.

Table 12. Port of Valdez water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m
VA01	9.10	9.60	10.90	11.70
VA02	9.50	9.40	11.10	11.20
VA03	9.60	9.50	10.60	11.20
VA04	10.30	10.70	11.00	11.10
VA05	8.80	9.10	11.20	11.00
VA06	9.90	12.70	12.90	12.10
Average	9.53	10.17	11.28	11.38

Salinity (ppt)	1m	2m	3m	4m
VA01	2.01	3.31	9.90	23.63
VA02	1.31	2.23	20.34	23.19
VA03	1.99	3.53	17.30	22.50
VA04	3.38	4.54	10.31	18.01
VA05	1.04	1.81	21.15	23.15
VA06	3.45	12.06	15.03	18.97
Average	2.20	4.58	15.67	21.58

pH	1m	2m	3m	4m
VA01	7.71	7.71	7.80	7.92
VA02	7.75	7.67	7.82	7.91
VA03	7.76	7.72	7.85	7.93
VA04	7.36	7.34	7.67	7.95
VA05	7.68	7.72	7.82	7.92
VA06	7.91	8.02	8.05	8.06
Average	7.70	7.70	7.84	7.95

D.O. (mg/L)	1m	2m	3m	4m
VA01	11.81	11.87	11.11	10.04
VA02	11.83	11.77	10.35	9.96
VA03	11.86	11.78	10.45	9.96
VA04	11.32	11.23	10.71	10.11
VA05	11.85	11.71	10.09	9.92
VA06	11.76	10.90	10.60	10.58
Average	11.74	11.54	10.55	10.10

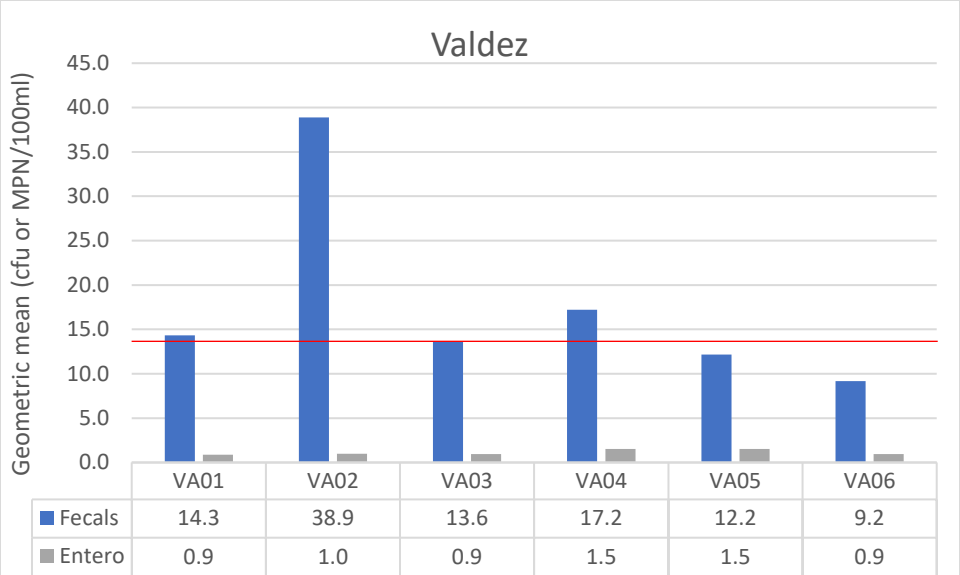


Figure 12. Port of Valdez geometric mean concentrations of fecal coliforms (FC) and *Enterococci* bacteria. WQC Red line is the numeric WQC for fecal coliforms.

Table 13. Concentrations of total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Valdez sampling stations. Water quality criteria (WQC) are listed for reference.

Site	Ammonia-N (mg/L)	T-Cu (µg/L)	D-Cu (µg/L)	T-Ni (µg /L)	D-Ni (µg/L)	T-Zn (µg/L)	D-Zn (µg/L)
WQC	0.3	-	3.1	-	8.2	-	86
VA01	0.019	1.53	0.35	1.83	0.76	2.00	0.41
VA02	0.028	1.94	0.40	1.99	0.90	2.91	0.61
VA03	0.021	1.62	0.35	1.85	0.91	2.48	0.46
VA04	0.034	1.91	0.76	1.73	0.88	5.61	3.32
VA05	0.053	4.18	1.11	3.45	1.50	5.86	1.72
VA06	0.015	1.04	0.36	1.42	0.87	1.56	0.41
Average	0.028	2.04	0.56	2.05	0.97	3.40	1.16

Whittier-Passage Canal

Five sampling sites in Passage Canal were distributed from the head of Passage Canal (WH01), at the entrances to both small boat harbors (WH02 and WH04), near the Alaska Marine Highway System(AMHS) dock (WH05) and in the middle of the canal near Decision Point (WH06) (Figure 13).

Average salinity was 2 ppt lower at the 1m (26 ppt) than at 4m water depth (28 ppt) but there were no consistent differences in temperature, pH or dissolved oxygen with water depth (Table 15). Water temperature was 10°C on the May 26 sampling date, pH was 8.3, and dissolved oxygen 10.9 mg/L.

Geometric mean fecal coliforms and *Enterococci* bacteria were near or at the MDL at all sampling sites (Figure 14). A single high value of 25 cfu/100 ml occurred at WH04, within the small boat harbor. The 2021 results are similar to 2020 results when geometric mean fecal coliforms ranged from 4.3 to 8.5 cfu/100 ml.

Average ammonia-N concentration was 0.005 mg/L (Table15). Average concentrations of total and dissolved metals concentrations were < 0.6 µg/L. Ammonia-N and metal concentrations in 2021 and 2020 were similar but concentrations of Zn were slightly higher in 2020 (total Zn 0.62 µg/L in 2021 compared to 2.41 µg/L in 2020).

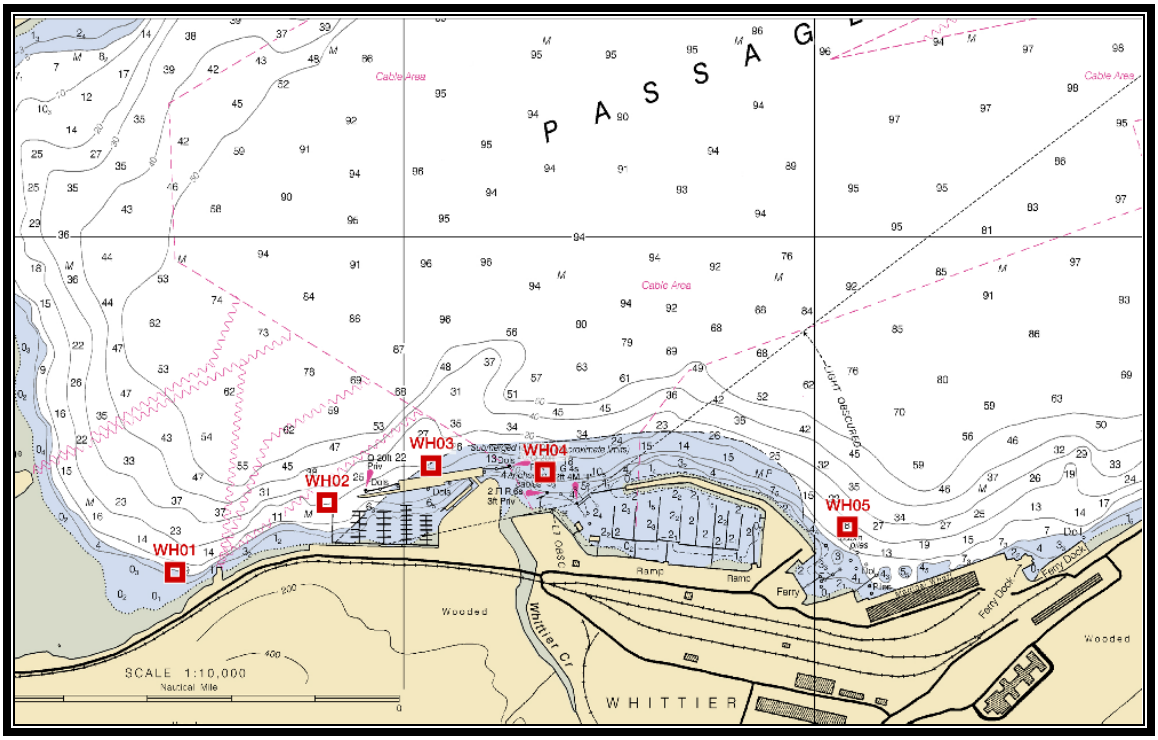


Figure 13. Port of Whittier sampling stations. Station WH06 located at Deception Point is not shown. Station WH03 was not sampled in 2021.

Table 14. Port of Whittier water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m
WH01	9.50	10.40	10.00	9.70
WH02	8.60	10.30	10.40	9.80
WH04	9.60	9.90	9.60	9.30
WH05	9.90	9.80	9.80	9.70
WH06	10.70	10.70	10.70	9.90
Average	9.66	10.22	10.10	9.68

Salinity (ppt)	1m	2m	3m	4m
WH01	28.16	28.18	28.24	28.33
WH02	22.65	28.40	28.21	28.28
WH04	25.14	27.80	27.94	28.00
WH05	26.41	27.75	27.98	28.32
WH06	27.12	27.12	27.16	27.96
Average	25.90	27.85	27.91	28.18

pH	1m	2m	3m	4m
WH01	8.28	8.31	8.31	8.29
WH02	8.36	8.32	8.32	8.34
WH04	8.17	8.25	8.19	8.07
WH05	8.29	8.32	8.32	8.34
WH06	8.16	8.31	8.34	8.34
Average	8.25	8.30	8.30	8.28

D.O. (mg/L)	1m	2m	3m	4m
WH01	10.99	10.99	11.07	11.11
WH02	11.23	10.89	10.90	10.98
WH04	10.44	10.55	10.77	10.77
WH05	11.11	11.05	11.14	11.18
WH06	10.75	10.68	10.65	10.76
Average	10.90	10.83	10.91	10.96

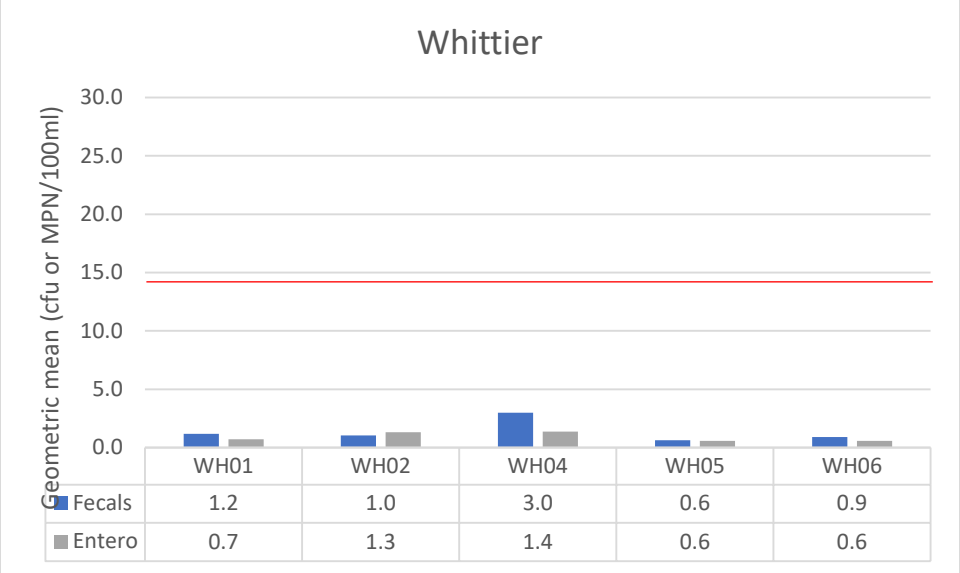


Figure 14. Port of Whittier geometric mean concentrations of fecal coliforms (FC) and *Enterococci* bacteria. WQC Red line is the numeric WQC for fecal coliforms.

Table 15. Concentrations of total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Whittier sampling stations. Water quality criteria (WQC) are listed for reference.

Site	Ammonia-N (mg/L)	T-Cu (µg/L)	D-Cu (µg/L)	T-Ni (µg/L)	D-Ni (µg/L)	T-Zn (µg/L)	D-Zn (µg/L)
WQC	0.3	-	3.1	-	8.2	-	86
WH01	0.010	0.40	0.36	0.42	0.41	0.23	0.10
WH02	0.002	0.45	0.40	0.44	0.38	0.48	0.25
WH04	0.008	0.66	0.53	0.52	0.49	1.82	1.79
WH05	0.002	0.48	0.42	0.45	0.37	0.33	0.10
WH06	0.003	0.46	0.35	0.46	0.42	0.25	0.10
Average	0.005	0.49	0.41	0.46	0.41	0.62	0.47

Seward-Resurrection Bay

Five sampling sites in Resurrection Bay near Seward were selected to be representative of the nearshore zone east of the harbor (SE01), the off-shore open water (SE06), commercial docks (SE02 and SE03), the small boat harbor (SE04) and potential urban runoff (SE05) (Figure 15).

Salinity was lower at 1m water depth, (average 13 ppt), compared to 4m depth (average 26 ppt). Salinity did not vary with depth at the open water site (SE06) (Table 16). Water temperature was 6 to 7°C at 1m water depth at sites SE01 and SE02 and from 9 to 10°C at the remaining sites and depths. There were only minor differences in pH (~8.7) and dissolved oxygen (~11 mg/L) among sites and depths.

Geometric mean fecal coliforms were below WQC ranging from 3.9 to 9.2 cfu/100 ml (Figure 16). The highest single fecal coliform count was 24 cfu/100 ml at SE01. Fecal coliforms were lower in May of 2021 compared to July of 2020. In 2020 fecal coliforms, but not *Enterococci*, exceeded WQC at sites SE01, SE02, and SE03.

Average ammonia-N concentration was 0.033 mg/L (Table 17). Average total metals were <3 µg/L. Concentrations of ammonia-N and metals were similar in 2021 and 2020.

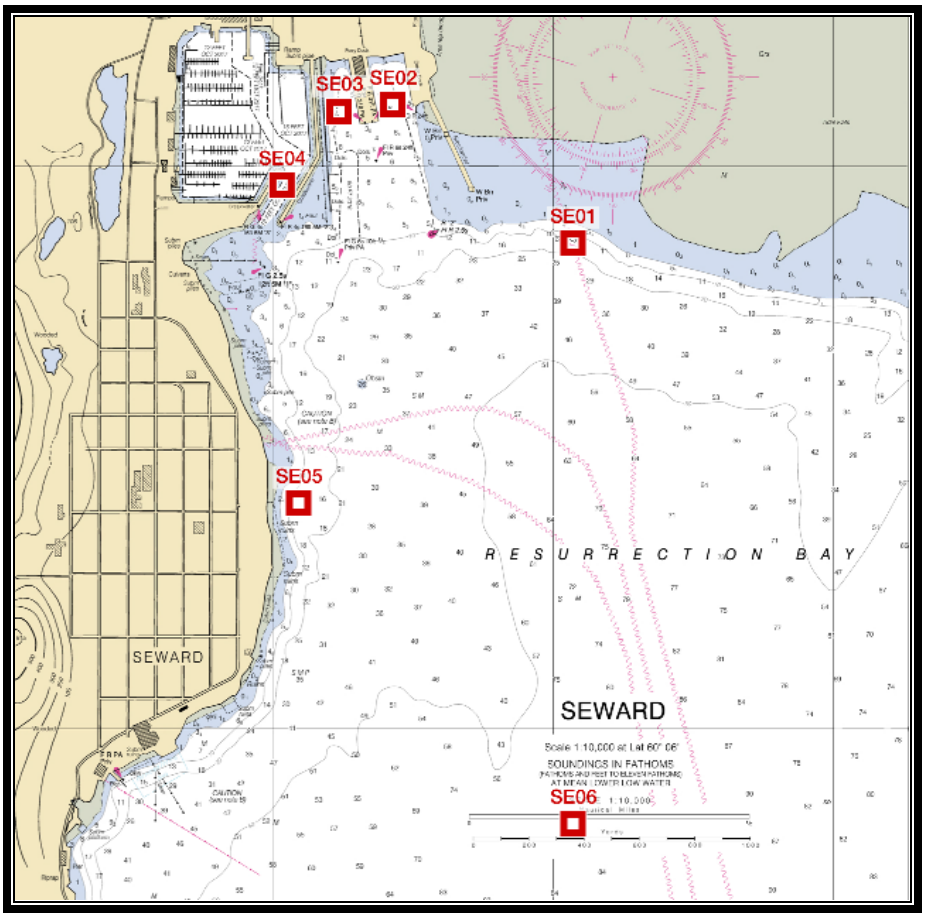


Figure 15. Chart showing Port of Seward sampling stations. SE02 was not sampled in 2021.

Table 16. Port of Seward water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m
SE01	5.60	9.90	9.90	9.90
SE03	7.10	10.10	10.10	9.80
SE04	9.20	10.30	10.10	9.00
SE05	8.80	9.70	9.80	9.80
SE06	9.60	9.80	9.90	9.90
Average	8.06	9.96	9.96	9.68

Salinity (ppt)	1m	2m	3m	4m
SE01	1.75	24.63	24.44	24.51
SE03	10.08	27.61	28.56	28.89
SE04	16.90	19.52	25.95	28.94
SE05	16.92	17.87	19.76	23.35
SE06	21.22	21.73	21.74	23.90
Average	13.37	22.27	24.09	25.92

pH	1m	2m	3m	4m
SE01	8.33	8.34	8.46	8.35
SE03	9.42	9.24	9.08	9.00
SE04	8.19	8.12	8.20	8.24
SE05	8.42	8.41	8.50	8.42
SE06	9.81	9.62	9.49	9.37
Average	8.83	8.75	8.75	8.68

D.O. (mg/L)	1m	2m	3m	4m
SE01	12.35	10.53	10.63	10.70
SE03	11.27	10.59	10.64	10.08
SE04	10.59	10.23	10.54	11.40
SE05	11.19	11.15	11.09	10.92
SE06	10.99	10.96	11.01	10.90
Average	11.28	10.69	10.78	10.80

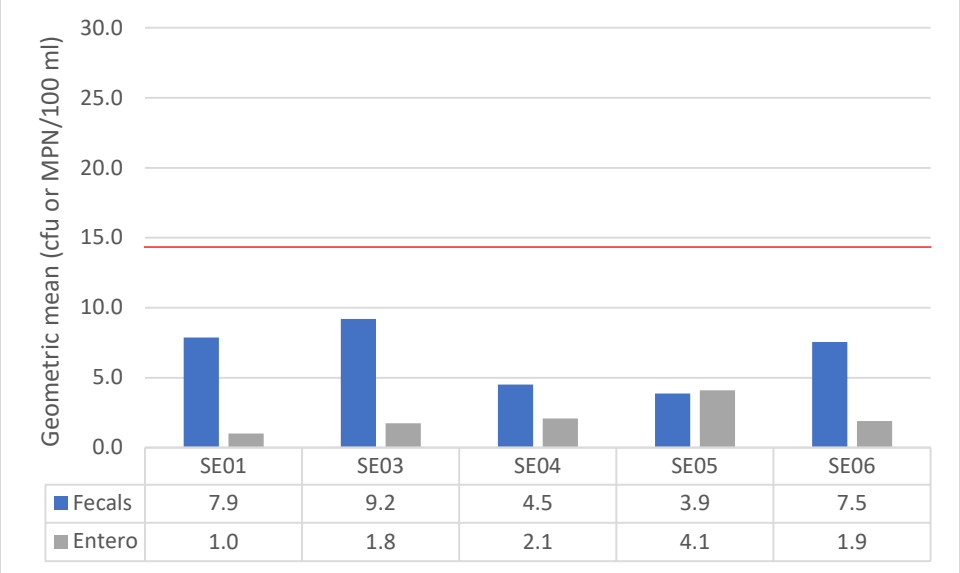


Figure 16. Port of Seward geometric mean concentrations of fecal coliforms (FC) and *Enterococci* bacteria. WQC Red line is the numeric WQC for fecal coliforms.

Table 17. Concentrations of total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Seward sampling stations. Water quality criteria (WQC) are listed for reference.

Site	Ammonia-N (mg/L)	T-Cu (µg/L)	D-Cu (µg/L)	T-Ni (µg/L)	D-Ni (µg/L)	T-Zn (µg/L)	D-Zn (µg/L)
WQC	0.3	-	3.1	-	8.2	-	86
SE01	0.015	1.79	0.77	1.62	0.78	2.36	0.82
SE03	0.015	2.45	0.94	2.24	0.90	3.38	1.09
SE04	0.102	2.32	1.85	0.65	0.52	8.51	7.24
SE05	0.012	0.85	0.51	0.78	0.51	1.02	0.45
SE06	0.019	0.77	0.50	0.67	0.49	0.87	0.41
Average	0.033	1.64	0.91	1.19	0.64	3.23	2.00

Homer-Kachemak Bay

Five sampling sites in Kachemak Bay near the Homer Spit were located slightly off-shore north (HR01) and south (HR06) of the Homer Spit, within the small boat harbor (HR02), north of the harbor breakwater (HR03), at the AMHS dock (HR04), and at the larger cruise ship berth (HR05) (Figure 17).

There were no apparent trends in water temperature, salinity, pH, or dissolved oxygen among sampling stations or with water depth (Table 18). Water temperature averaged 8.6 °C, salinity was near 30 ppt, average pH was 8.3 and dissolved oxygen 11.3 mg/L.

Geometric mean fecal coliform bacteria and *Enterococci* concentrations were well below WQC (Figure 18). A single high value of 20 cfu/100 ml fecal coliforms was found at HR02. HR02 also had the highest *Enterococci* count of 34 MPN/100 ml. concentrations In general the bacteria concentrations in 2021 were slightly lower than 2020 results.

Ammonia-N concentrations averaged 0.02 on June 7, 2021 and 0.002 on July 23, 2020 (Table 19. The concentration of total and dissolved metals were ≤ 1 µg/L in 2021 consistent with 2020 results.

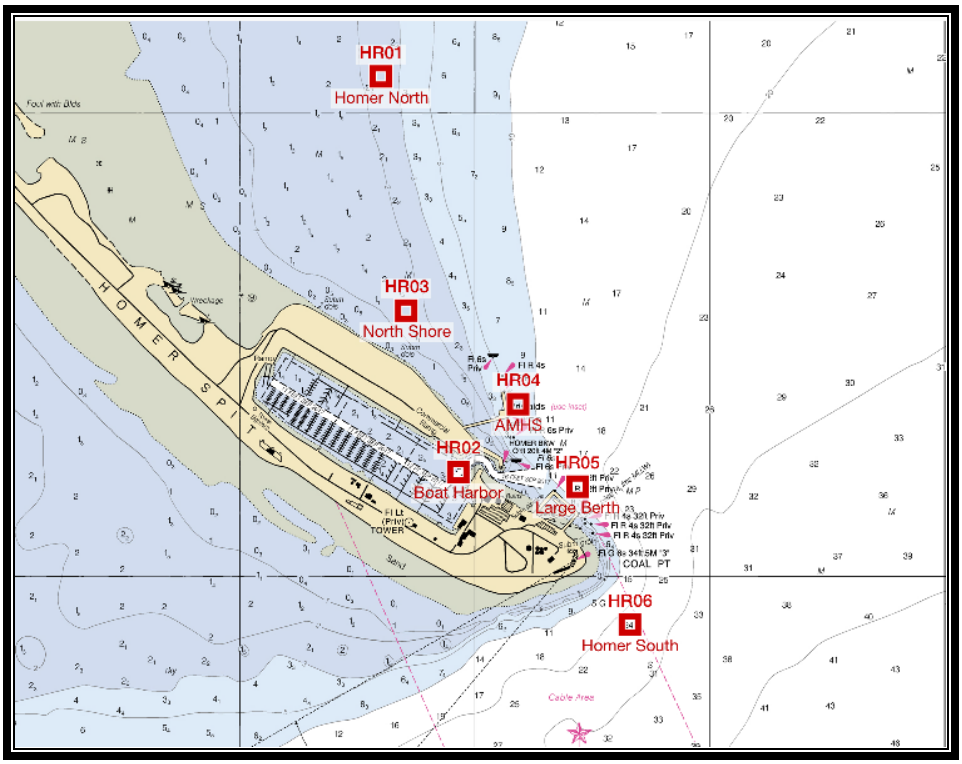


Figure 17. Chart showing Port of Homer sampling stations.

Table 18. Port of Homer water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m
HR01	8.70	7.50	7.50	7.50
HR02	9.00	8.80	8.50	8.40
HR03	9.10	8.70	8.60	8.60
HR05	8.80	8.50	8.20	8.00
HR06	9.60	9.60	9.50	9.50
Average	9.04	8.62	8.46	8.40

Salinity (ppt)	1m	2m	3m	4m
HR01	29.19	30.36	30.50	30.50
HR02	29.80	30.04	30.16	30.14
HR03	29.84	29.93	29.94	29.95
HR05	29.80	29.96	30.05	30.18
HR06	29.72	29.80	29.83	29.83
Average	29.67	30.02	30.10	30.12

pH	1m	2m	3m	4m
HR01	8.34	8.23	8.24	8.30
HR02	8.24	8.28	8.28	8.32
HR03	8.29	8.31	8.35	8.31
HR05	8.29	8.28	8.26	8.30
HR06	8.45	8.46	8.45	8.42
Average	8.32	8.31	8.32	8.33

D.O. (mg/L)	1m	2m	3m	4m
HR01	10.80	11.05	11.02	11.00
HR02	11.21	11.17	11.18	11.20
HR03	11.57	11.54	11.53	11.52
HR05	11.38	11.38	11.42	11.42
HR06	11.34	11.38	11.41	11.42
Average	11.26	11.30	11.31	11.31

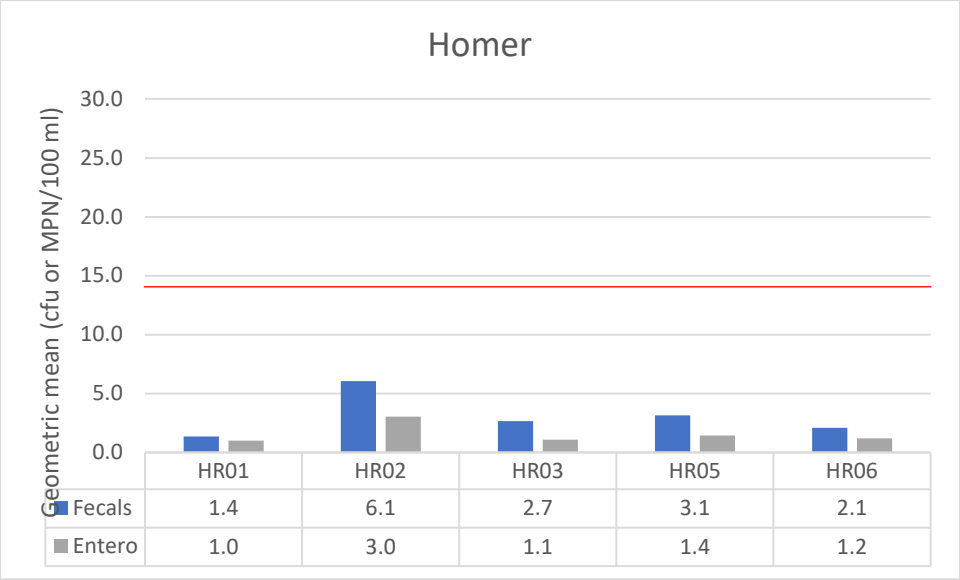


Figure 18. Port of Homer geometric mean concentrations of fecal coliforms (FC) and *Enterococci* bacteria. WQC Red line is the numeric WQC for fecal coliforms.

Table 19. Concentrations of total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Homer sampling stations. Water quality criteria (WQC) are listed for reference.

Site	Ammonia-N (mg/L)	T-Cu (µg/L)	D-Cu (µg/L)	T-Ni (ug/L)	D-Ni (µg/L)	T-Zn (µg/L)	D-Zn (µg/L)
WQC	0.3	-	3.1	-	8.2	-	86
HR01	0.021	0.71	1.01	0.51	0.40	0.75	0.52
HR02	0.017	0.85	1.38	0.61	0.65	1.59	1.54
HR03	0.030	0.64	0.81	0.50	0.33	0.56	0.36
HR05	0.014	0.77	0.85	0.52	0.40	0.77	0.53
HR06	0.018	0.94	0.87	0.86	0.42	1.70	0.54
Average	0.020	0.78	0.98	0.60	0.44	1.07	0.70

Haines-Chilkoot Inlet

Five sampling sites in Chilkoot Inlet were located near-shore north (HA06) and south (HA01) of Haines, slightly off-shore (HA03), within the small boat harbor (HA04) and adjacent to the cruise ship berth (HA02) (Figure 19).

Water temperatures among Haines sampling stations (Figure 5) on the May 12 sampling date were low averaging 6.7 at 1m and 6.5 at 4m water depth (Table 20). There were no apparent trends in salinity, pH, or dissolved oxygen with water depth. Waters were saline at ~25 ppt, pH averaged 8.7, and dissolved oxygen was supersaturated at 15 mg/L.

Geometric mean fecal coliforms and *Enterococci* concentrationss were below WQC and near the MDL on all sampling dates (Figure 20). The maximum fecal coliform count was 8 cfu/100 ml at HA04 and the maximum *Enterococci* count was 96 at HA06. Results were consistent with those obtained in 2020.

Ammonia-N concentration averaged 0.01 and average concentrations of all metals were < 0.5 µg/L (Table 21). Concentrations of ammonia-N, Cu, Ni, and Zn were similar to 2020 results.

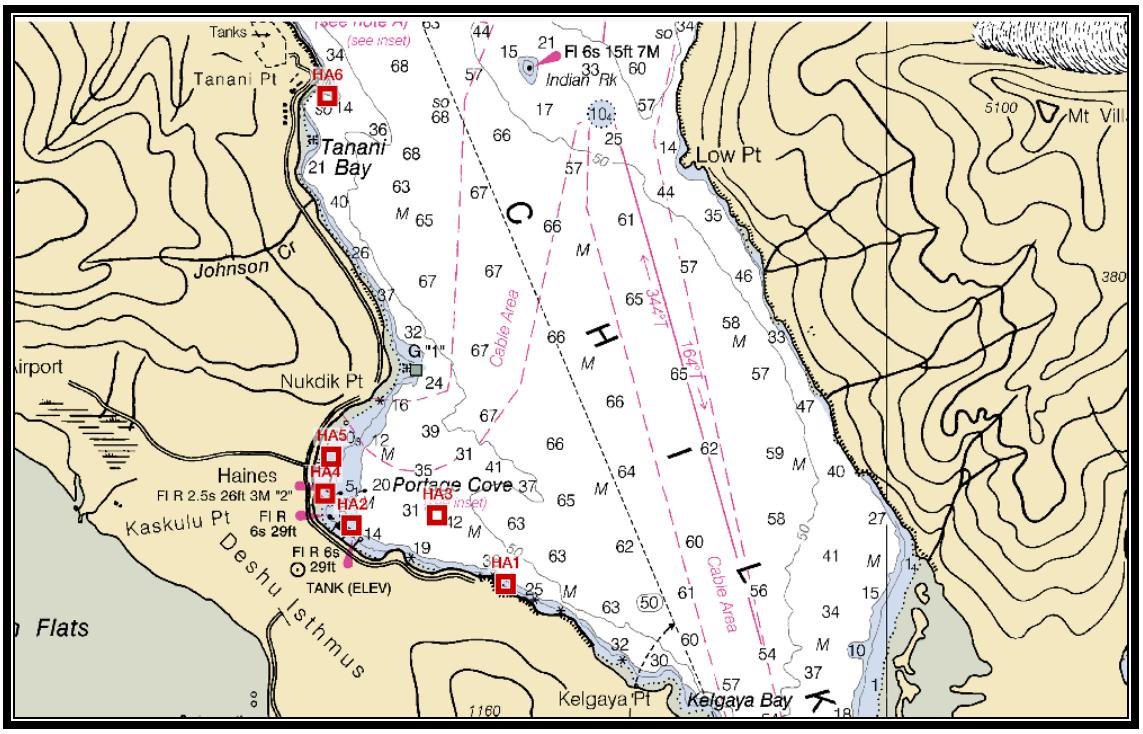


Figure 19. Chart showing Port of Haines sampling stations. HA05 was not sampled in 2021

Table 20. Port of Haines water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) at 1, 2, 3, and 4 m water depths.

Temp C	1m	2m	3m	4m
HA01	6.40	6.30	6.30	6.30
HA02	6.80	6.60	6.60	6.60
HA03	6.70	6.60	6.50	6.30
HA04	6.80	6.70	6.60	6.60
HA06	6.70	6.50	6.50	6.50
Average	6.68	6.54	6.50	6.46

Salinity (ppt)	1m	2m	3m	4m
HA01	23.34	28.68	28.97	29.07
HA02	24.29	27.37	27.84	27.93
HA03	27.75	27.82	28.12	28.28
HA04	23.95	25.27	26.80	28.40
HA06	23.31	24.03	24.44	14.80
Average	24.53	26.63	27.23	25.70

pH	1m	2m	3m	4m
HA01	8.61	8.59	8.63	8.59
HA02	8.69	8.69	8.72	8.66
HA03	8.64	8.62	8.64	8.72
HA04	8.62	8.62	8.57	8.69
HA06	8.67	8.66	8.74	8.65
Average	8.65	8.64	8.66	8.66

D.O. (mg/L)	1m	2m	3m	4m
HA01	15.19	15.18	15.25	15.25
HA02	14.82	14.74	15.34	15.59
HA03	15.22	15.25	15.42	15.58
HA04	13.95	14.07	14.51	14.69
HA06	14.50	14.60	15.00	15.03
Average	14.74	14.77	15.10	15.23

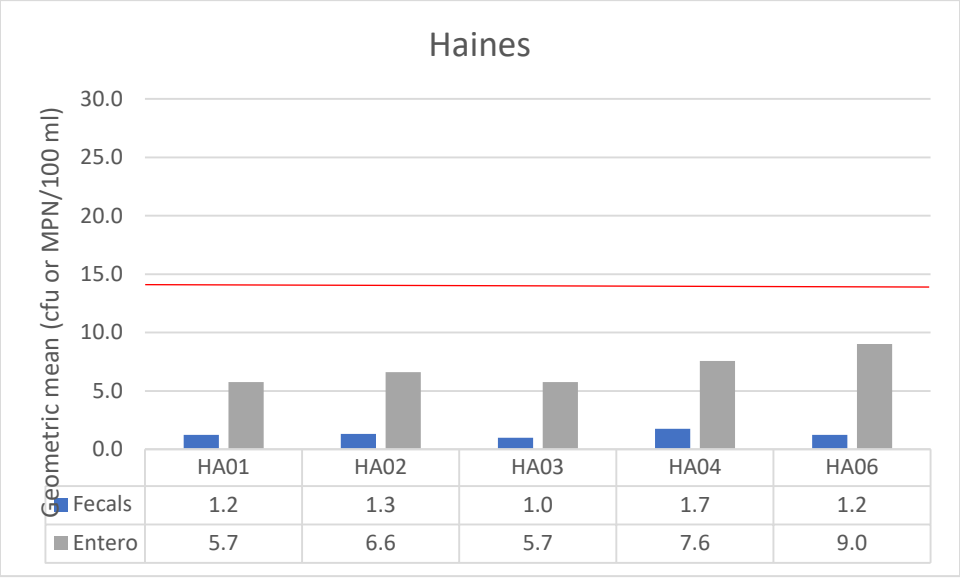


Figure 20. Port of Haines geometric mean concentrations of fecal coliforms (FC) and *Enterococci* bacteria. WQC Red line is the numeric WQC for fecal coliforms.

Table 21. Concentrations of total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Haines sampling stations. Water quality criteria (WQC) are listed for reference.

Site	Ammonia-N (mg/L)	T-Cu (µg/L)	D-Cu (µg/L)	T-Ni (ug/L)	D-Ni (µg/L)	T-Zn (µg/L)	D-Zn (µg/L)
WQC	0.3	-	3.1	-	8.2	-	86
HA01	0.007	0.36	0.32	0.38	0.34	0.32	0.10
HA02	0.007	0.36	0.33	0.33	0.32	0.32	0.10
HA03	0.007	0.33	0.28	0.39	0.34	0.31	0.10
HA04	0.021	0.48	0.39	0.37	0.35	0.64	0.38
HA06	0.009	0.35	0.33	0.38	0.32	0.72	0.10
Average	0.010	0.38	0.33	0.37	0.33	0.46	0.16

Skagway-Taiya Inlet

Five Skagway sampling sites were located near the mouth of the Skagway River (SK01), the commercial Ore Dock (SK02), adjacent to the cruise ship berth and near the mouth of Pullen Creek (SK03), in the small boat harbor (SK04), near the cruise ship berths (SK05) and off-shore in the middle of Taiya Inlet (SK07) (Figure 21).

Salinity varied with water depth on the May 13 sampling date with an average of 14 ppt at 1m and 25 ppt at 4m water depth (Table 22). These values are higher than those obtained on June 29, 2020, when salinity was 5 ppt or less at all sites and depths. Water temperature in 2021 was ~7°C, pH 8.6, and dissolved oxygen 12 mg/L.

Geometric mean fecal coliforms and *Enterococci* were low at all sites and near the MDL (Figure 22). Concentrations of fecal coliforms in 2021 were similar to results from 2020 sampling.

Average ammonia-N concentration was 0.025 mg/L. Average total and dissolved Cu and Ni concentrations were < 0.4 µg/L, and Zn < 1.3 µg/L (Table 23).

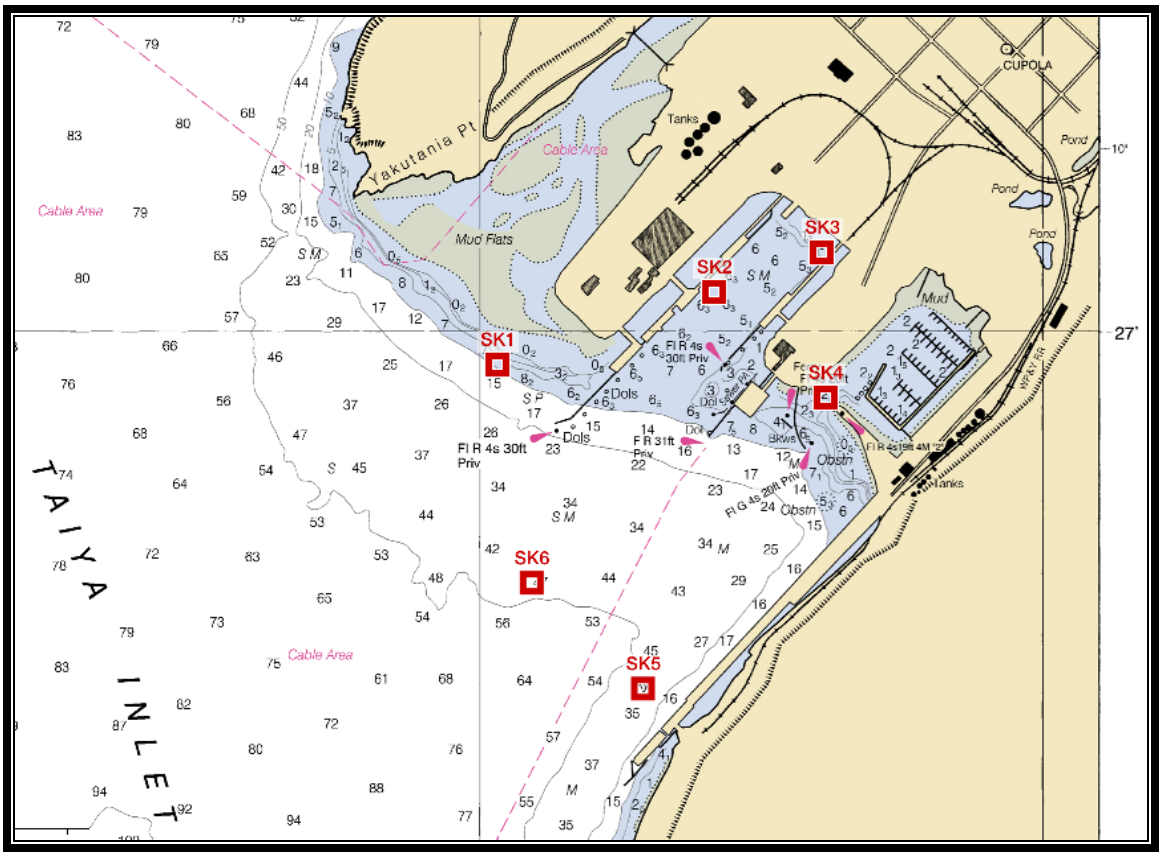


Figure 21. Chart showing the Port of Skagway sampling stations. Station SK07 is within Taiya Inlet to the southwest of this figure. SK06 was not sampled in 2021.

Table 22. Port of Skagway water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m
SK01	6.90	6.90	5.80	6.90
SK02	6.90	6.90	6.30	6.50
SK03	6.90	6.90	6.10	6.00
SK04	6.50	6.30	6.00	6.80
SK05	6.90	6.60	6.60	6.90
SK07	6.90	6.80	6.60	6.90
Average	6.83	6.73	6.23	6.67

Salinity (ppt)	1m	2m	3m	4m
SK01	11.06	22.58	23.34	27.59
SK02	14.53	17.29	22.18	22.74
SK03	12.46	16.74	21.90	22.58
SK04	11.51	21.00	21.57	22.30
SK05	16.74	21.41	23.39	23.50
SK07	16.09	21.89	24.25	24.54
Average	13.73	20.15	22.77	23.88

pH	1m	2m	3m	4m
SK01	8.63	8.61	8.60	8.61
SK02	8.64	8.74	8.64	8.63
SK03	8.67	8.67	8.59	8.61
SK04	8.49	8.35	8.69	8.66
SK05	8.64	8.54	8.65	8.65
SK07	8.67	8.68	8.69	8.66
Average	8.62	8.60	8.64	8.64

D.O. (mg/L)	1m	2m	3m	4m
SK01	12.08	11.86	12.20	12.17
SK02	11.87	11.89	11.77	12.00
SK03	12.01	11.95	11.90	12.18
SK04	12.87	12.13	12.31	12.59
SK05	11.80	11.71	12.09	12.30
SK07	12.18	12.05	12.33	12.65
Average	12.14	11.93	12.10	12.32

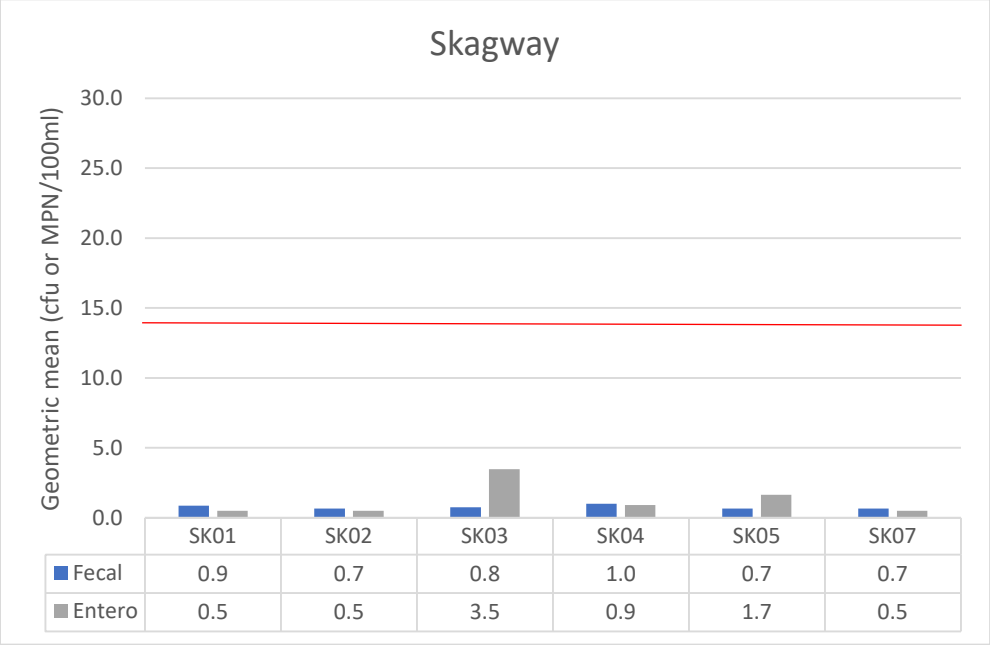


Figure 22. Port of Skagway geometric mean concentrations of fecal coliforms (FC) and *Enterococci* bacteria. WQC Red line is the numeric WQC for fecal coliforms.

Table 23. Concentrations of total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Skagway sampling stations. Water quality criteria (WQC) are listed for reference.

Site	Ammonia-N (mg/L)	T-Cu (µg/L)	D-Cu (µg/L)	T-Ni (µg/L)	D-Ni (µg/L)	T-Zn (µg/L)	D-Zn (µg/L)
WQC	0.3	-	3.1	-	8.2	-	86
SK01	0.009	0.46	0.37	0.28	0.20	1.12	0.54
SK02	0.021	0.43	0.50	0.27	0.33	1.52	1.10
SK03	0.067	0.32	0.34	0.27	0.19	2.04	0.78
SK04	0.014	0.36	0.31	0.31	0.22	1.06	0.62
SK05	0.010	0.39	0.29	0.32	0.24	1.06	0.30
SK07	0.026	0.35	0.30	0.34	0.23	0.75	0.20
Average	0.025	0.39	0.35	0.30	0.24	1.26	0.59

Juneau-Auke Bay-Gastineau Channel

Nine sampling sites in Gastineau Channel were located adjacent to the City and Borough of Juneau Downtown Cruise Ship berth (JU02), at the Princess Cruise Lines private berth (JN07), mid-inlet (JN06), Carnival Cruise Lines private berth (JU08), mid-channel (JU09), City of Juneau Harris (JU11) and Aurora (JU12) small boat harbors, outside the Douglas small boat harbor (JU10) and south of the rock dump and Alaska Marine Lines tie-ups (JU13) (Figure 23). Two Auke Bay sampling sites were at the entrance to the small boat harbor and at the berth used by the Alaska Marine Highway.

Water temperature, salinity, pH and dissolved oxygen were greater in Auke Bay compared to Gastineau Channel (Table 24). Water temperature in Auke Bay on the May 5 sampling date was near 7°C in Auke Bay and 6°C in Gastineau Channel. Salinity was near 28 ppt in Auke Bay and did not vary with depth. Salinity in Gastineau Channel averaged 17 ppt at 1m water depth and 24 ppt at 4m water depth. In Auke Bay pH averaged 8.4 and in Gastineau Channel 8.0 and dissolved oxygen 13 mg/L and 10 mg/L, respectively.

In general geometric mean fecal coliforms and *Enterococci* at different sampling locations were near the MDL (0.5 cfu/MPM) in May of 2021 (Figure 24). The highest single measure of fecal coliforms was 18 cfu/100 ml at JU11. Bacteria concentrations in 2020 were generally higher than those collected in 2021.

Ammonia-N and metals concentrations were low in 2020 and 2021. Average ammonia-N concentration in 2021 was 0.031 mg/L (Table 25). Average total and dissolved Cu and Ni concentrations were <0.7 µg/L and Zn <1.5 µg/L.

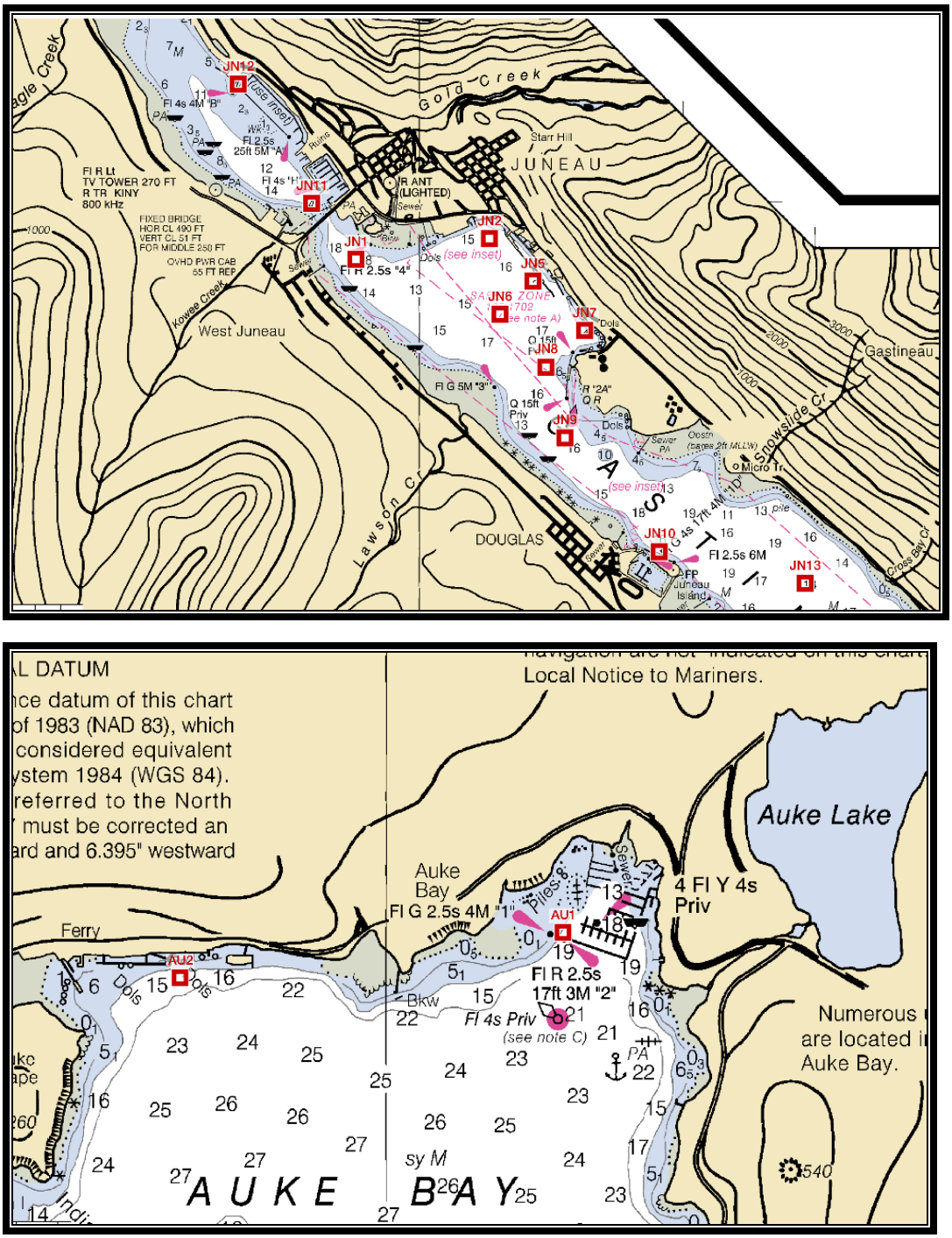


Figure 23. Chart showing Port of Auke Bay and Juneau sampling stations. JU01 and JU05 were not sampled in 2021

Table 24. Port of Juneau and Auke Bay water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m
AU01	7.20	7.20	7.20	7.10
AU02	7.10	7.10	7.00	6.90
JU02	6.60	6.30	5.80	5.30
JU06	6.50	6.40	6.30	6.10
JU07	6.40	6.40	6.30	5.60
JU08	6.50	6.40	6.40	5.40
JU09	6.40	6.40	6.30	5.90
JU10	5.80	6.30	5.90	5.50
JU11	6.60	6.40	6.30	5.80
JU12	6.60	6.40	6.20	5.80
JU13	6.60	6.60	6.50	6.30
Average	6.57	6.54	6.38	5.97

Salinity (ppt)	1m	2m	3m	4m
AU01	26.73	27.91	28.09	28.23
AU02	27.30	27.50	27.75	27.86
JU02	22.16	22.50	23.90	27.77
JU06	19.32	21.82	22.08	22.76
JU07	13.59	21.09	21.55	24.47
JU08	19.93	21.54	21.80	24.94
JU09	17.80	21.43	22.63	23.14
JU10	13.03	22.49	23.70	26.39
JU11	16.42	16.69	16.79	24.44
JU12	18.59	19.84	20.69	24.42
JU13	19.66	20.59	21.82	22.34
Average	19.50	22.13	22.80	25.16

pH	1m	2m	3m	4m
AU01	8.44	8.49	8.48	8.42
AU02	8.43	8.47	8.42	8.39
JU02	7.88	7.90	7.81	7.88
JU06	7.94	7.92	7.90	7.90
JU07	7.90	7.92	7.90	7.81
JU08	8.13	8.09	8.07	8.00
JU09	7.92	7.91	7.88	7.95
JU10	7.90	7.87	7.82	7.88
JU11	7.89	7.87	7.83	7.85
JU12	7.88	7.87	7.87	7.77
JU13	8.56	8.51	8.49	8.35
Average	8.08	8.07	8.04	8.02

D.O. (mg/L)	1m	2m	3m	4m
AU01	12.74	13.33	13.49	13.66
AU02	12.81	12.79	12.76	12.74
JU02	10.30	10.24	9.88	9.34
JU06	10.68	10.53	10.45	10.35
JU07	10.80	10.44	10.39	10.08
JU08	10.88	10.64	10.54	10.12
JU09	11.01	10.74	10.54	10.44
JU10	11.71	10.85	10.32	9.78
JU11	11.00	10.99	10.99	10.30
JU12	10.71	10.60	10.52	10.11
JU13	10.83	10.76	10.63	10.57
Average	11.22	11.08	10.96	10.68

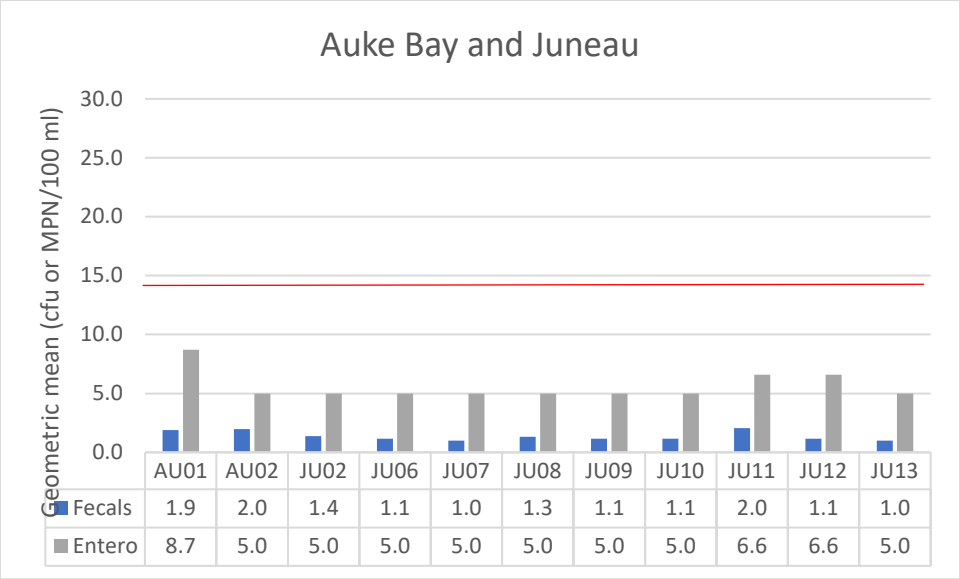


Figure 24. Port of Juneau and Auke Bay geometric mean concentrations of fecal coliforms (FC) and *Enterococci* bacteria. WQC Red line is the numeric WQC for fecal coliforms.

Table 25. Concentrations of total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Ports of Auke Bay and Juneau sampling stations. Water quality criteria (WQC) are listed for reference.

Site	Ammonia-N (mg/L)	T-Cu (µg/L)	D-Cu (µg/L)	T-Ni (µg/L)	D-Ni (µg/L)	T-Zn (µg/L)	D-Zn (µg/L)
WQC	0.3	-	3.1	-	8.2	-	86
AU01	0.008	0.45	0.39	0.47	0.47	0.77	0.58
AU02	0.013	0.42	0.36	0.47	0.42	0.76	0.52
JU02	0.022	0.64	0.56	0.73	0.70	1.13	0.80
JU06	0.026	0.65	0.57	0.75	0.63	1.28	1.17
JU07	0.027	0.66	0.56	0.68	0.64	1.43	1.23
JU08	0.024	0.65	0.56	0.75	0.65	1.33	1.06
JU09	0.029	0.64	0.55	0.75	0.65	1.29	1.16
JU10	0.046	0.66	0.55	0.70	0.62	1.13	1.00
JU11	0.041	0.69	0.56	0.67	0.77	1.22	1.29
JU12	0.039	0.85	0.68	0.70	0.70	2.49	1.97
JU13	0.022	0.65	0.55	0.79	0.68	1.15	0.99
Average	0.031	0.68	0.57	0.72	0.67	1.38	1.19

Hoonah-Icy Strait

Eight sampling stations in Hoonah were located near the Cannery Point cruise ship berth (HO01 through HO03) in the open water of Icy Strait (HO04), near the AMHS berth (HO05) at the entrance to the small boat harbor (HO07) and in the shallow water estuary (HO08) (Figure 25).

Average water temperature was slightly warmer and salinity lower at 1m compared to 4m water depth, but not at all sites (Table 26). Average water temperature was ~1.3°C cooler and salinity, at 29.77 ppt, 1.43 ppt lower at 1m, than 4m water depth. However, these differences were not apparent at HO03 and HO05. Average water pH was ~8.3 and dissolved oxygen ~13.5 mg/L.

Fecal coliform bacteria and *Enterococci* were present at concentrations above the MDL at all sites with geometric mean fecal coliforms ranging from 1.8 to 9.4 cfu/100 ml (Figure 26). Single high fecal coliform counts of 160, 220, and 130 occurred at sites HO03, HO06, and HO07, respectively. High *Enterococci* counts of 61 and 110 MPN/100 ml occurred on a single sampling date at HO06 and HO07. The concentrations of these bacteria in water samples collected in May and June of 2021 were similar to their concentrations in samples collected in July of 2020 with the exception of site HO08. Geometric mean fecal coliforms exceeded WQC at HO08 in 2020 but not in 2021.

Concentrations of ammonia-N and metals were low in water samples collected in Icy Strait near Hoonah. Average ammonia-N was 0.008 mg/L and average total and dissolved metals were < 0.6 µg/L (Table 27). Concentrations of ammonia-N and metals also were low in 2020 samples.

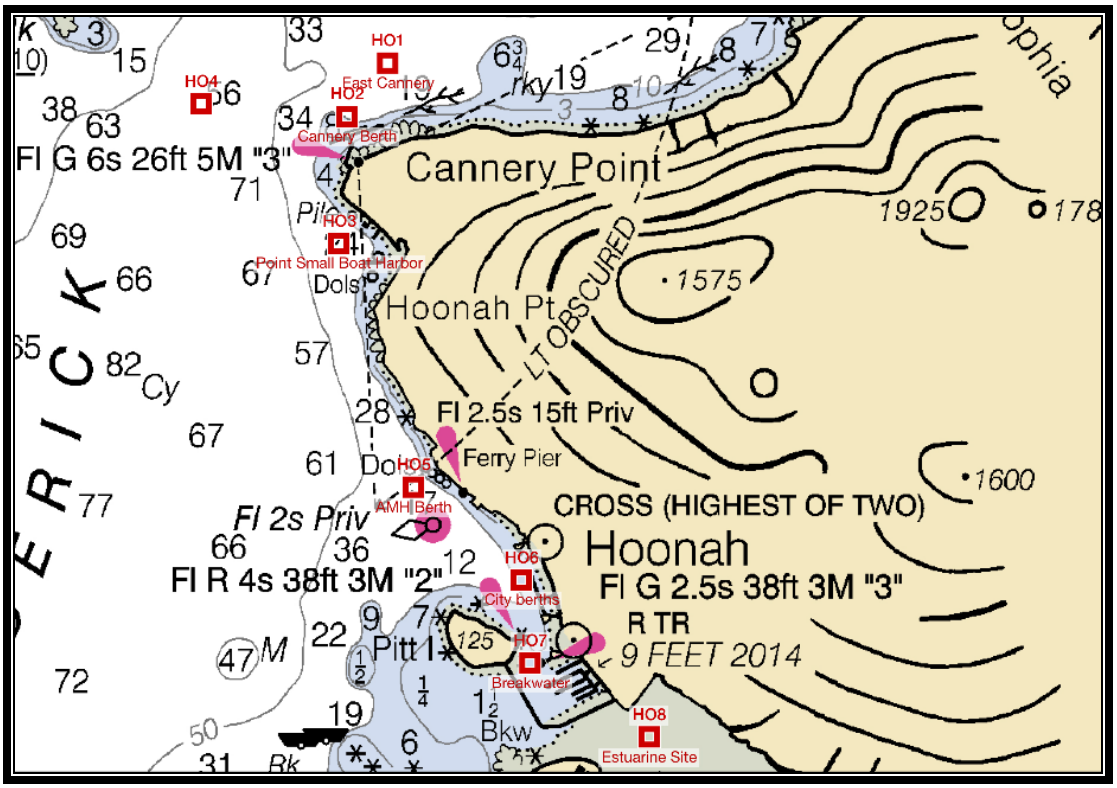


Figure 25. Chart showing Port of Hoonah sampling stations.

Table 26. Port of Hoonah water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m
HO01	7.80	6.70	6.30	5.70
HO02	7.40	6.50	6.40	6.00
HO03	5.80	5.60	5.30	5.20
HO04	7.80	6.80	5.80	5.70
HO05	5.70	5.30	5.20	5.20
HO06	7.10	6.10	5.50	5.40
HO07	7.20	5.90	5.90	5.90
HO08	6.10	5.70	5.40	5.40
Average	6.86	6.08	5.73	5.56

Salinity (ppt)	1m	2m	3m	4m
HO01	29.35	30.30	30.60	30.95
HO02	29.67	30.15	30.60	30.95
HO03	31.22	31.36	31.49	31.51
HO04	27.79	29.40	30.96	31.15
HO05	31.20	31.33	31.42	31.45
HO06	29.91	30.50	31.23	31.27
HO07	27.82	30.39	30.91	30.92
HO08	31.17	30.78	31.24	31.37
Average	29.77	30.53	31.06	31.20

pH	1m	2m	3m	4m
HO01	8.38	8.32	8.35	8.17
HO02	8.43	8.34	8.36	8.30
HO03	8.12	8.10	8.14	8.09
HO04	8.49	8.33	8.23	8.35
HO05	8.17	8.03	8.16	8.15
HO06	8.32	8.18	8.24	8.19
HO07	8.28	8.20	8.19	8.20
HO08	8.20	8.16	8.11	8.17
Average	8.30	8.21	8.22	8.20

D.O. (mg/L)	1m	2m	3m	4m
HO01	14.86	14.83	15.01	14.23
HO02	14.48	14.41	14.37	13.90
HO03	11.83	11.82	11.57	11.57
HO04	14.32	14.07	13.91	13.65
HO05	12.93	12.90	12.19	11.81
HO06	14.47	14.26	13.50	13.20
HO07	13.26	13.17	13.35	13.45
HO08	14.03	13.95	13.64	12.44
Average	13.77	13.68	13.44	13.03

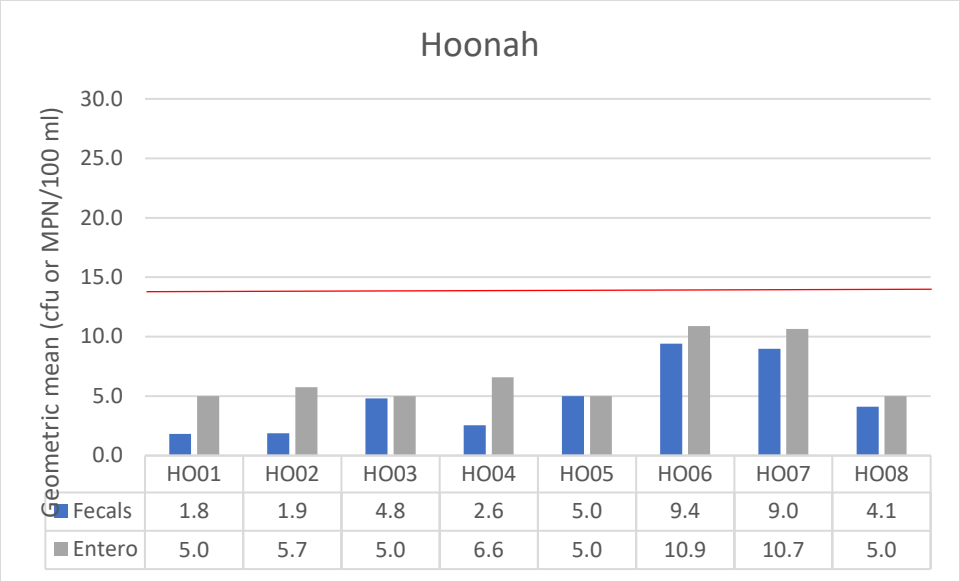


Figure 26. Port of Hoonah geometric mean concentrations of fecal coliforms (FC) and *Enterococci* bacteria. WQC Red line is the numeric WQC for fecal coliforms.

Table 27. Concentrations of total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Hoonah sampling stations. Water quality criteria (WQC) are listed for reference.

Site	Ammonia-N (mg/L)	T-Cu (µg/L)	D-Cu (µg/L)	T-Ni (µg/L)	D-Ni (µg/L)	T-Zn (µg/L)	D-Zn (µg/L)
WQC	0.3	-	3.1	-	8.2	-	86
HO01	0.013	0.29	0.21	0.41	0.38	0.27	0.10
HO02	0.002	0.26	0.26	0.38	0.37	0.31	0.24
HO03	0.019	0.27	0.22	0.43	0.40	0.33	0.22
HO04	0.006	0.25	0.22	0.41	0.38	0.22	0.10
HO05	0.009	0.33	0.26	0.44	0.41	0.52	0.37
HO06	0.006	0.31	0.25	0.40	0.40	0.85	0.67
HO07	0.004	0.55	0.42	0.40	0.38	1.75	1.13
HO08	0.005	0.29	0.22	0.44	0.39	0.51	0.40
Average	0.008	0.32	0.26	0.41	0.39	0.60	0.40

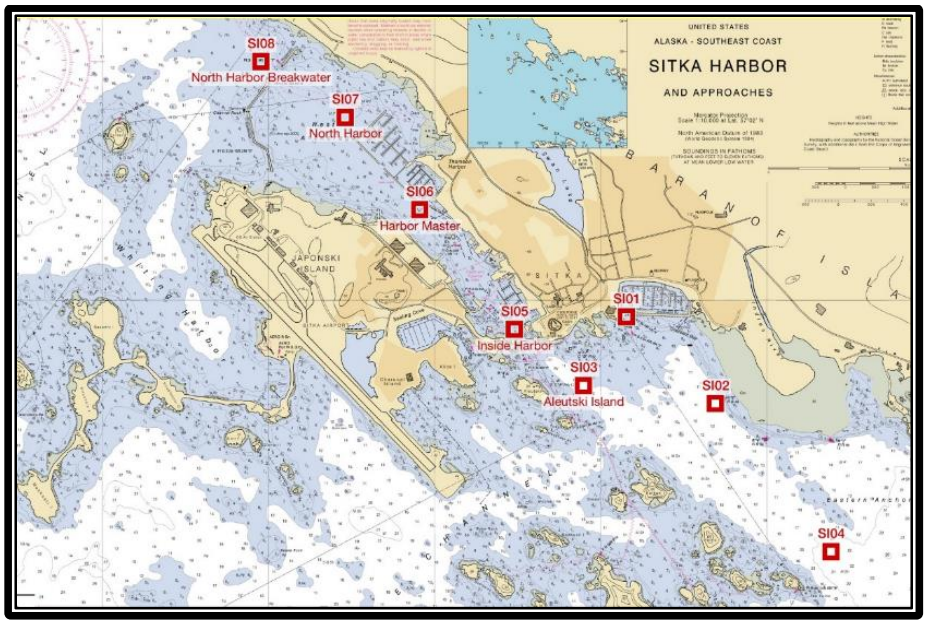
Sitka-Sitka Sound

Ten sampling sites near Sitka were selected to represent small boat harbors (SI01, SI05, SI06, SI07), outside the harbor breakwater (SI08 an SI03), cruise ship anchorages (SI02 and SI04) (Figure 26), and near the AMHS dock (SI09 and SI10) (Figure 27).

Average water temperatures were warmer and less saline at 1m than at 4m water depth on May 3, 2021 (Table 28). Water temperatures were 0.5°C warmer and ~4 ppt less saline. The pH measured at the majority of sites and depths was near 8.5. The average concentration of dissolved oxygen was slightly lower in the warmer surface waters than at 4m water depth.

Fecal coliform and *Enterococci* bacteria concentrations in water samples were close to the MDL and well below WQC (Figure 28). Results from May 2021 were similar to, but slightly lower than, results from July 2020.

Similar to 2020, concentrations of ammonia-N and metals were low in samples collected in Sitka Sound (Table 29). Average ammonia-N concentration was 0.016 mg/L. Total and dissolved Cu concentrations were ≤ 1 µg/L, total and dissolved Ni ≤ 0.3 µg/L, and total and dissolved Zn ≤ 1.5 µg/L. Concentrations of dissolved Cu and Zn were much higher than total concentrations at site SI03, suggesting possible contamination of dissolved samples. Cu and Zn tended to be higher at SI01, within the small boat harbor.



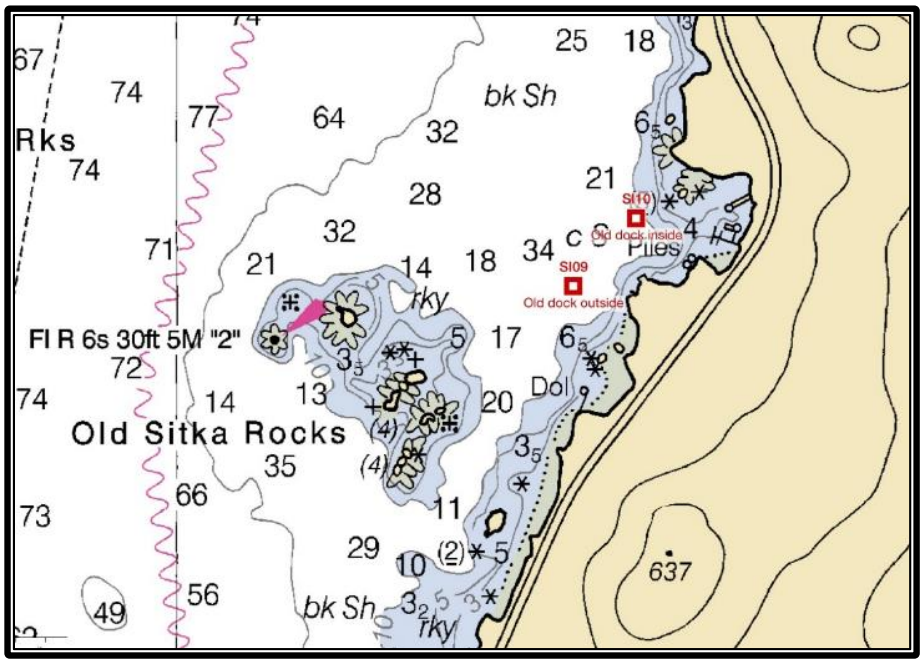


Figure 27. Charts showing Port of Sitka sampling stations near the small boat harbors (top) and the Alaska Marine Highway berth (bottom).

Table 28. Port of Sitka water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m
SI01	8.70	8.50	7.80	7.60
SI02	8.50	8.50	8.70	7.70
SI03	8.40	8.40	7.90	7.70
SI04	8.40	8.40	7.90	7.80
SI05	8.50	8.50	8.30	8.20
SI06	8.40	8.40	8.30	8.10
SI07	8.60	8.60	8.30	8.10
SI08	8.50	8.20	8.30	8.30
SI09	8.40	8.30	8.30	8.10
SI10	8.50	8.40	8.20	8.10
Average	8.49	8.42	8.20	7.97

Salinity (ppt)	1m	2m	3m	4m
SI01	24.58	24.85	30.76	31.20
SI02	25.12	25.46	30.04	30.83
SI03	24.67	25.96	30.40	30.89
SI04	25.40	27.61	30.58	30.85
SI05	25.54	27.88	29.36	29.59
SI06	25.44	27.85	28.99	29.85
SI07	26.83	27.19	28.34	29.98
SI08	25.80	28.83	29.10	29.29
SI09	29.70	29.80	29.89	30.19
SI10	28.10	29.30	29.85	29.90
Average	26.12	27.17	29.73	30.26

pH	1m	2m	3m	4m
SI01	8.36	8.38	8.29	8.29
SI02	8.56	8.54	8.43	8.44
SI03	8.46	8.46	8.41	8.38
SI04	8.43	8.43	8.40	8.40
SI05	9.01	8.92	8.84	8.77
SI06	8.42	8.42	8.41	8.45
SI07	8.44	8.45	8.43	8.41
SI08	8.44	8.47	8.46	8.56
SI09	8.46	8.46	8.45	8.48
SI10	8.46	8.43	8.42	8.49
Average	8.50	8.50	8.45	8.47

D.O. (mg/L)	1m	2m	3m	4m
SI01	11.44	11.82	11.70	11.98
SI02	11.85	11.92	11.74	12.59
SI03	11.39	11.75	12.16	12.51
SI04	10.85	11.94	12.55	12.96
SI05	11.96	12.07	12.29	12.56
SI06	11.91	11.82	12.10	12.36
SI07	12.15	12.22	12.34	12.57
SI08	12.10	11.97	12.19	12.35
SI09	13.14	13.14	13.22	13.14
SI10	13.30	13.13	13.13	13.33
Average	12.01	12.18	12.34	12.64

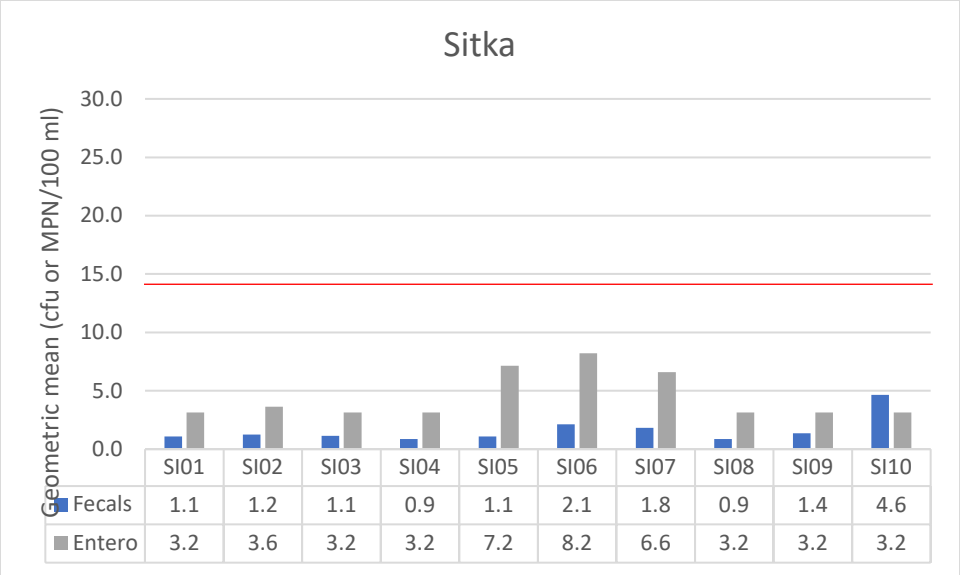


Figure 28. Port of Sitka geometric mean concentrations of fecal coliforms (FC) and *Enterococci* bacteria. WQC Red line is the numeric WQC for fecal coliforms.

Table 29. Concentrations of total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Sitka sampling stations. Water quality criteria (WQC) are listed for reference.

Site	Ammonia-N (mg/L)	T-Cu (µg/L)	D-Cu (µg/L)	T-Ni (µg/L)	D-Ni (µg/L)	T-Zn (µg/L)	D-Zn (µg/L)
WQC	0.3	-	3.1	-	8.2	-	86
SI01	0.031	1.16	1.02	0.31	0.29	5.02	4.88
SI02	0.016	0.32	0.30	0.30	0.27	0.86	0.59
SI03	0.010	0.38	3.98	0.30	0.28	1.23	3.43
SI04	0.011	0.21	0.21	0.27	0.29	0.56	0.48
SI05	0.024	0.23	0.26	0.30	0.27	0.47	0.54
SI06	0.026	0.31	0.39	0.29	0.29	1.27	1.63
SI07	0.007	0.65	0.61	0.29	0.29	2.69	2.69
SI08	0.014	0.43	0.40	0.31	0.28	2.25	1.77
SI09	0.010	0.23	0.28	0.25	0.28	0.67	0.61
SI10	0.008	0.14	0.14	0.28	0.28	0.28	0.25
Average	0.016	0.41	0.76	0.29	0.28	1.53	1.69

Petersburg-Wrangell Narrows

Five sampling sites near Petersburg were located in Wrangell Narrows bracketing the berths and harbors (PE01 and PE06), at the north end of the small boat harbor (PE02), at the small boat harbor entrance (PE03), and near the fuel dock (PE04) (Figure 29).

On the April 27 sampling date, average water temperature was 6.8 °C and was consistent with water depth and among sampling sites (Table 30). Average salinity was slightly lower at 1m water depth than at 4m. The pH was more acidic than other ports at 7.8 and dissolved oxygen was near saturation at 10.4 mg/L. Salinity was higher in the spring of 2021 (~29 ppt) compared to July of 2020 (26 ppt).

Geometric mean concentrations of fecal coliforms and *Enterococci* were low at or near the MDL (Figure 30). The maximum fecal coliform count was 12 cfu/100 ml at PE02. Bacterial concentrations were lower in samples collected in May of 2021 compared to July or 2020 when concentrations exceeded WQC at PE02 and PE03.

Average ammonia-N concentration was 0.025 mg/L and total and dissolved metals were < 0.5 µg/L. Water samples collected in 2020 had similar low concentrations of ammonia and metals.

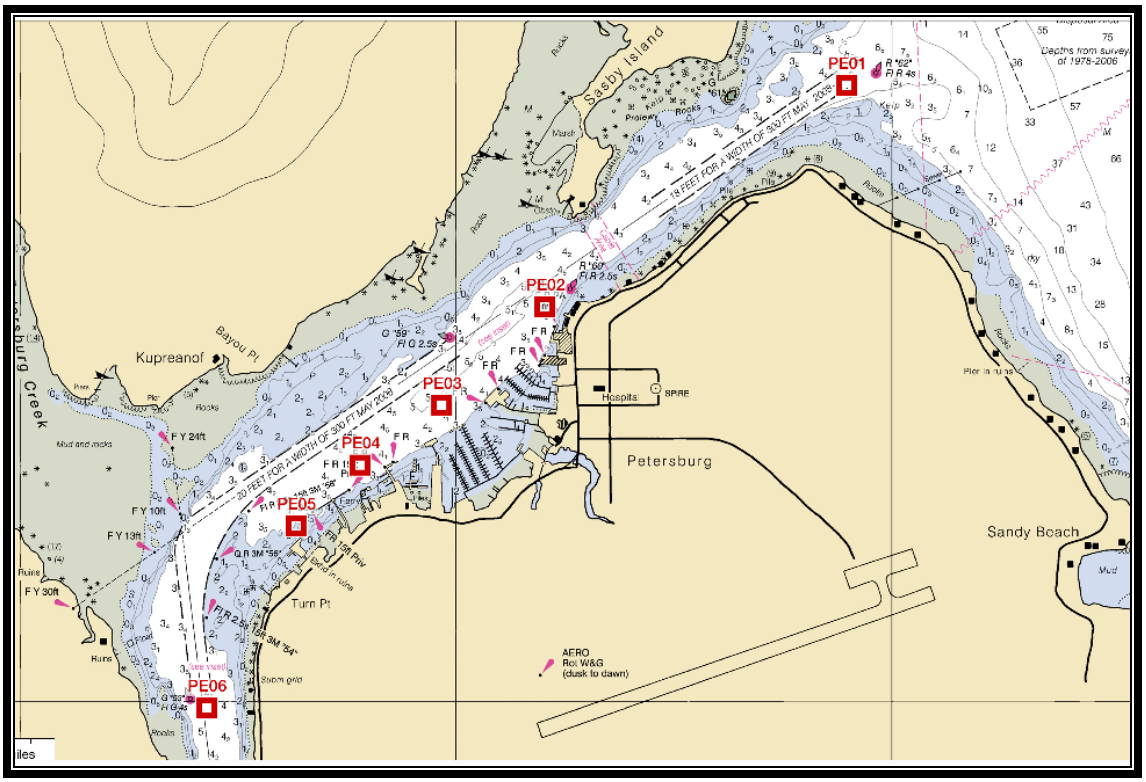


Figure 29. Chart showing Port of Petersburg sampling stations. PE05 was not sampled in 2021.

Table 30. Port of Petersburg water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m
PE01	6.5	6.50	6.30	6.30
PE02	7.00	7.00	7.00	7.00
PE03	6.90	7.00	6.90	6.90
PE04	6.90	6.90	6.90	6.90
PE06	6.80	6.80	6.80	6.80
Average	6.82	6.84	6.78	6.78

Salinity (ppt)	1m	2m	3m	4m
PE01	28.8	29.29	29.45	29.69
PE02	29.53	29.54	29.55	29.56
PE03	28.61	28.86	29.37	29.63
PE04	29.12	29.32	29.66	29.68
PE06	29.65	29.63	29.64	29.64
Average	29.14	29.33	29.53	29.64

pH	1m	2m	3m	4m
PE01	7.84	7.82	7.81	7.79
PE02	7.84	7.85	7.56	8.04
PE03	7.84	7.83	7.85	7.80
PE04	7.84	7.83	7.82	7.83
PE06	7.89	7.85	7.85	7.82
Average	7.85	7.84	7.78	7.86

D.O. (mg/L)	1m	2m	3m	4m
PE01	10.22	10.35	10.23	10.20
PE02	10.40	10.56	10.61	10.63
PE03	10.20	10.54	10.51	10.60
PE04	10.28	10.51	10.56	10.55
PE06	10.44	10.51	10.53	10.54
Average	10.31	10.49	10.49	10.50

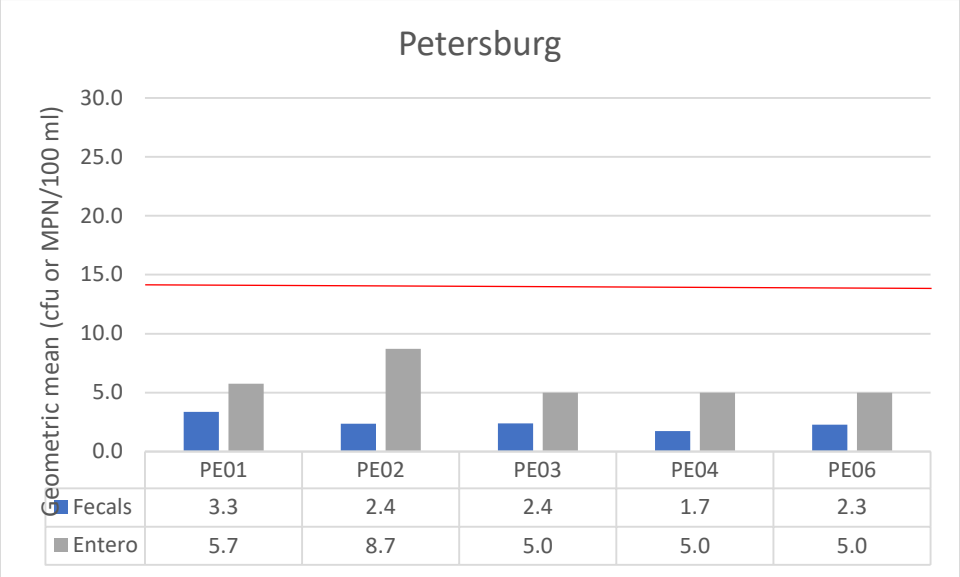


Figure 30. Port of Petersburg geometric mean concentrations of fecal coliforms (FC) and *Enterococci* bacteria. WQC Red line is the numeric WQC for fecal coliforms.

Table 31. Concentrations of total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Petersburg sampling stations. Water quality criteria (WQC) are listed for reference.

Site	Ammonia-N (mg/L)	T-Cu (µg/L)	D-Cu (µg/L)	T-Ni (µg/L)	D-Ni (µg/L)	T-Zn (µg/L)	D-Zn (µg/L)
WQC	0.3	-	3.1	-	8.2	-	86
PE01	0.030	0.26	0.33	0.45	0.37	0.44	0.48
PE02	0.017	0.27	0.28	0.44	0.38	0.51	0.37
PE03	0.028	0.25	0.29	0.42	0.37	0.42	0.39
PE04	0.024	0.26	0.30	0.42	0.37	0.51	0.44
PE06	0.026	0.24	0.40	0.43	0.41	0.43	0.48
Average	0.025	0.26	0.32	0.43	0.38	0.46	0.43

Wrangell-Sumner Strait

Six Wrangell sampling sites were located near the airport runway (WR01), the southern small boat harbor (WR05), the city dock (WR03) and the northern small boat harbor (WR04). WR06 was located to the west of the community (Figure 31) outside of the anticipated area of anthropogenic influence.

Average water temperature was 8.3°C in late April of 2021 (12.6°C in July of 2020) and was similar at 1m and 4m water depths (Table 32). Temperatures at 1m water depth ranged from 9.2 (WR05) to 7.1°C (WR03). Salinity was lower at 1m (24 ppt) than at 4m (27 ppt) water depth. Salinity in April of 2021 was greater than salinity measured in July of 2020 (14 ppt at 1m water depth). The pH averaged 8.4 and dissolved oxygen 12.1 mg/L in 2021, similar to 2020 values.

Geometric mean fecal coliforms ranged from 0.7 to 1.4 cfu/100 ml and *Enterococci* from 0.5 to 1.3 MPN/100 ml (Figure 32). Bacteria concentrations in samples collected in May of 2021 were lower than those collected in July of 2021 and did not exceed WQC at any sampling site in either year.

Average ammonia-N concentration was 0.009 mg/L and total and dissolved metals < 0.5µg/L (Table 33). Total metal concentrations were greater in 2020 ranging from 2 to 3 µg/L.

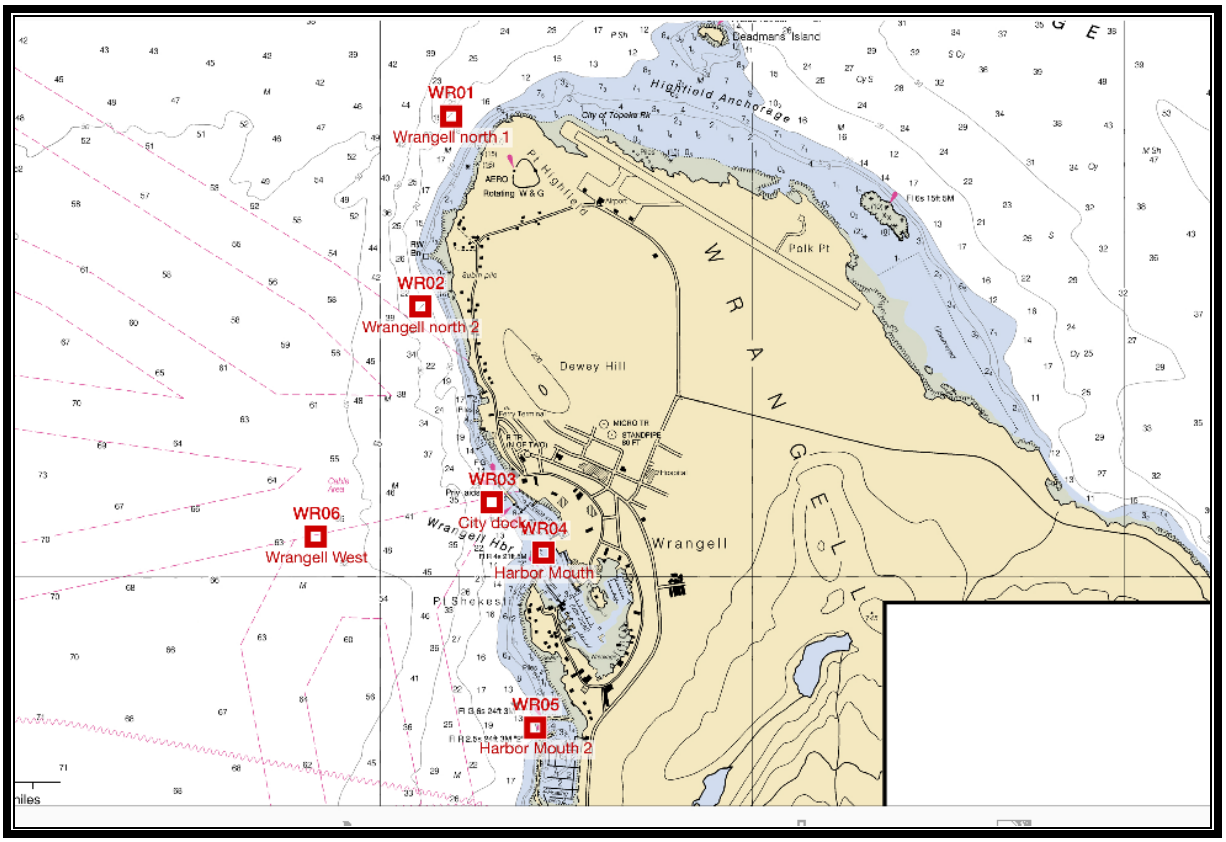


Figure 31. Chart showing Port of Wrangell sampling stations.

Table 32. Port of Wrangell water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) at 1, 2, 3, and 4 m water depths on 4/28/2021.

Temp (C)	1m	2m	3m	4m
WR01	8.30	7.10	7.10	7.10
WR02	7.50	8.50	8.00	7.90
WR03	7.10	9.10	9.00	8.90
WR04	8.80	8.70	8.70	8.60
WR05	9.20	8.70	8.50	8.40
WR06	8.70	8.50	8.00	7.90
Average	8.27	8.43	8.22	8.13

Salinity (ppt)	1m	2m	3m	4m
WR01	26.92	28.50	28.58	28.58
WR02	21.96	27.07	27.58	27.70
WR03	20.09	26.23	26.44	26.57
WR04	26.08	26.23	26.56	26.80
WR05	25.90	26.55	26.79	26.95
WR06	24.07	26.82	27.23	27.40
Average	24.17	26.90	27.20	27.33

pH	1m	2m	3m	4m
WR01	8.34	8.13	8.04	8.02
WR02	8.20	8.42	8.36	8.26
WR03	8.12	8.47	8.50	8.43
WR04	8.44	8.45	8.42	8.44
WR05	8.52	8.48	8.46	8.42
WR06	8.65	8.59	8.50	8.44
Average	8.38	8.42	8.38	8.34

D.O. (mg/L)	1m	2m	3m	4m
WR01	11.45	11.17	10.72	10.47
WR02	12.08	12.09	12.50	12.44
WR03	10.65	11.69	12.39	12.82
WR04	11.75	12.36	12.66	12.77
WR05	12.50	12.86	12.93	12.97
WR06	11.96	12.20	12.44	12.27
Average	11.73	12.06	12.27	12.29

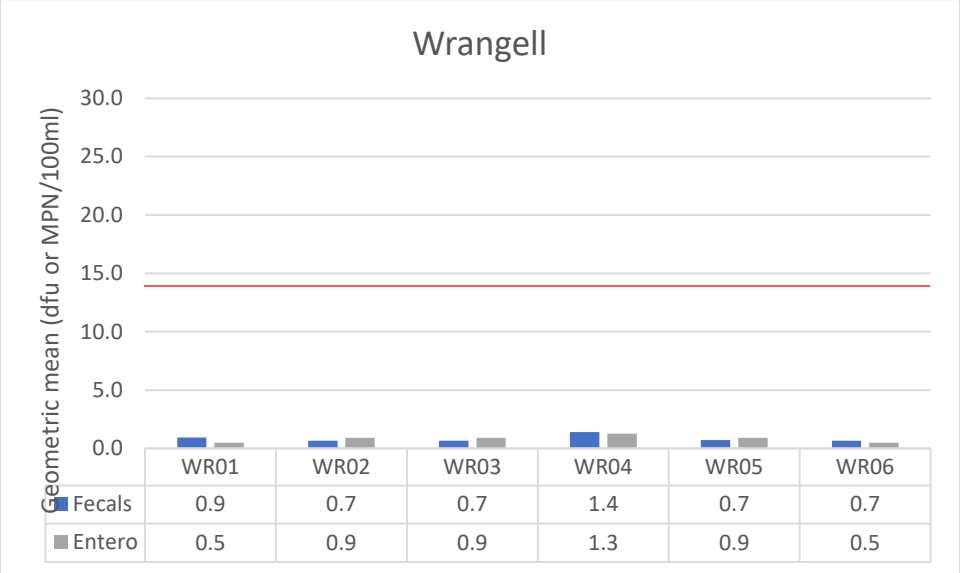


Figure 32. Port of Wrangell geometric mean concentrations of fecal coliforms (FC) and *Enterococci* bacteria. WQC Red line is the numeric WQC for fecal coliforms.

Table 33. Concentrations of total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Wrangell sampling stations. Water quality criteria (WQC) are listed for reference.

Site	Ammonia-N (mg/L)	T-Cu (µg/L)	D-Cu (µg/L)	T-Ni (µg/L)	D-Ni (µg/L)	T-Zn (µg/L)	D-Zn (µg/L)
WQC	0.3	-	3.1	-	8.2	-	86
WR01	0.005	0.42	0.33	0.50	0.38	0.39	0.29
WR02	0.010	0.33	0.29	0.38	0.32	0.26	0.10
WR03	0.017	0.37	0.29	0.45	0.33	0.30	0.10
WR04	0.007	0.34	0.29	0.41	0.35	0.33	0.10
WR05	0.013	0.25	0.32	0.43	0.35	0.33	0.10
WR06	0.003	0.30	0.28	0.40	0.32	0.33	0.10
Average	0.009	0.34	0.30	0.43	0.34	0.32	0.13

Ward Cove

Five Ward Cove sampling sites were distributed along northwest (WA03) and southeast shores (WA05 and WA06), with one site located at the mouth of Ward Creek (WA04) and one site at the mouth of the cove (WA01) (Figure 33).

Water temperatures and dissolved oxygen concentration were greater at 1m less than at 4m water depth (Table 34). Water temperatures were ~ 1°C warmer at sites WA05 and WA06 on the south side of Ward Cove compared to the other sites. Average salinity was less at 1m (17 ppt) than at 4m (29 ppt), and less in April of 2021 than in July of 2020 (25 ppt at 1m water depth). The pH was 8.4 in 2021 and was consistent among sites and depths and with 2020 measures (average 8.6 in July 2020).

Geometric mean fecal coliforms concentrations ranged from 1.1 to 3.2 cfu/100ml and the maximum single value was 12 cfu/100ml. The Geometric mean of *Enterococci* concentrations ranged from 5 to 6 MPN/100ml as most of the results were below the MDL of 10 MPN/100ml. These results are much less than July 2020 when fecal coliforms exceeded WQC at three Ward Cove sampling sites.

Ammonia-N concentrations averaged 0.005 mg/L (Table 35). Total and dissolved metals in water samples were < 1.0 µg/L. Concentrations of ammonia-N and metals in 2021 were consistent with 2020 values.

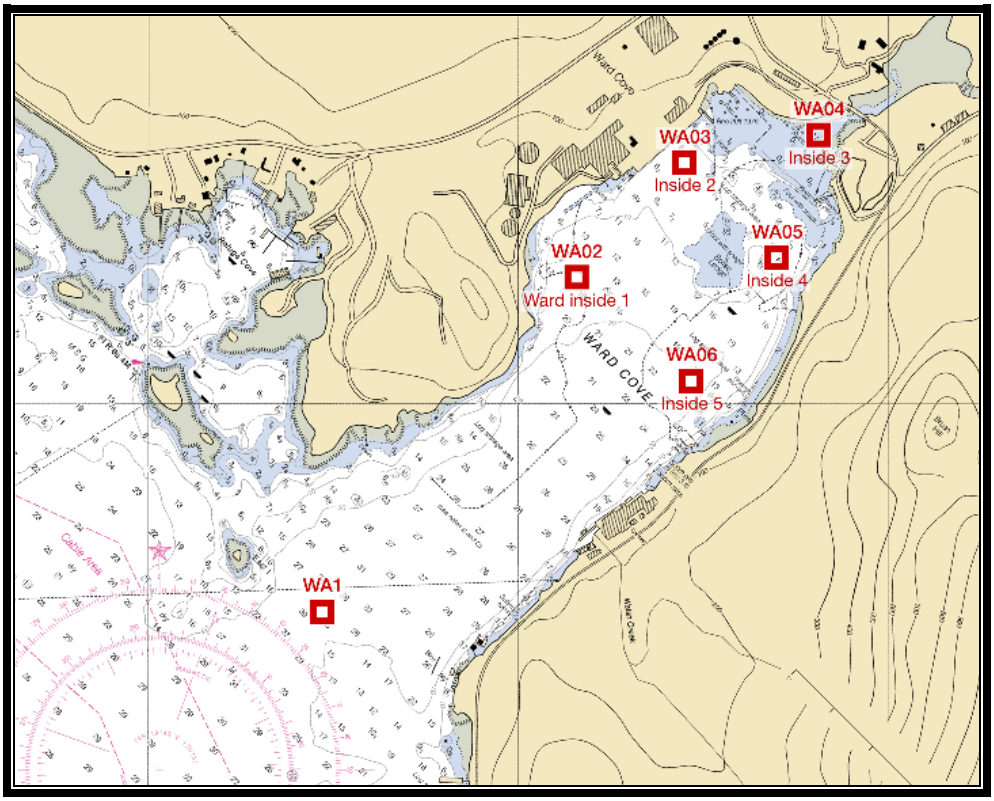


Figure 33. Port of Ward Cove showing sampling stations. WA02 was not sampled in 2021.

Table 34. Port of Ward Cove water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) at 1, 2, 3, and 4 m water depths on 4/20/2021.

Temp (C)	1m	2m	3m	4m
WA01	9.50	9.20	9.20	8.40
WA03	9.40	8.70	8.10	7.50
WA04	9.20	9.00	8.10	7.50
WA05	10.50	9.00	7.90	7.40
WA06	10.30	8.50	8.10	7.90
Average	9.78	8.88	8.28	7.74

Salinity (ppt)	1m	2m	3m	4m
WA01	28.00	28.20	28.25	28.39
WA03	9.50	27.99	28.72	28.99
WA04	6.85	28.49	29.15	29.52
WA05	27.53	28.17	27.20	29.43
WA06	10.91	28.37	28.80	29.08
Average	16.56	28.24	28.42	29.08

pH	1m	2m	3m	4m
WA01	8.42	8.42	8.42	8.45
WA03	8.43	8.42	8.48	8.43
WA04	8.33	8.32	8.59	8.43
WA05	8.43	8.38	8.37	8.21
WA06	8.46	8.42	8.36	8.30
Average	8.41	8.39	8.44	8.36

D.O. (mg/L)	1m	2m	3m	4m
WA01	12.86	13.30	14.04	14.29
WA03	12.70	13.74	15.60	16.22
WA04	11.89	13.25	14.90	15.45
WA05	13.18	14.20	15.15	15.49
WA06	12.25	13.83	14.49	14.67
Average	12.58	13.66	14.84	15.22

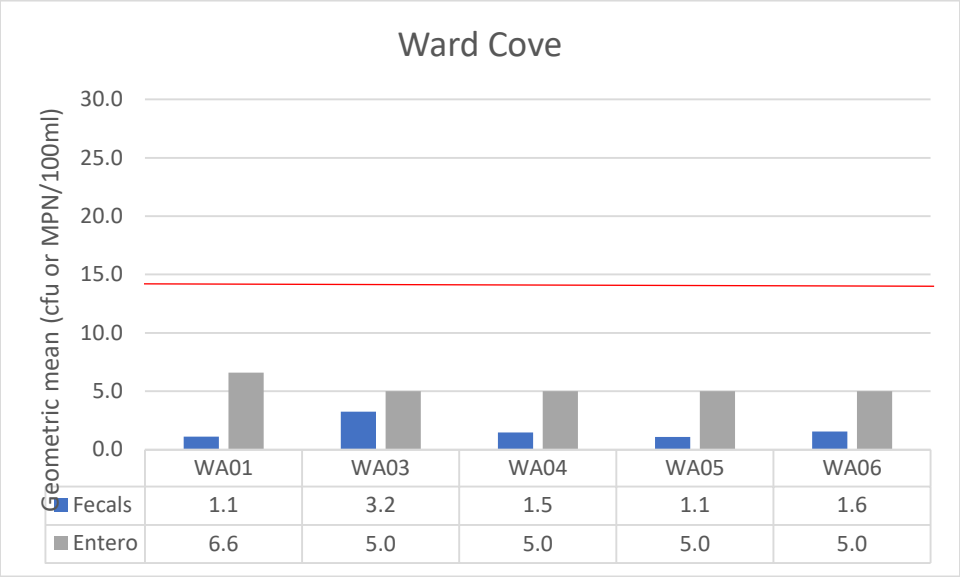


Figure 34. Ward Cove geometric mean concentrations of fecal coliforms (FC) and *Enterococci* bacteria. WQC Red line is the numeric WQC for fecal coliforms.

Table 35. Concentrations of total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Ward Cove sampling stations. Water quality criteria (WQC) are listed for reference.

Site	Ammonia-N (mg/L)	T-Cu (µg/L)	D-Cu (µg/L)	T-Ni (µg/L)	D-Ni (µg/L)	T-Zn (µg/L)	D-Zn (µg/L)
WQC	0.3	-	3.1	-	8.2	-	86
WA01	0.010	0.23	0.21	0.30	0.29	0.51	0.38
WA03	0.010	0.27	0.25	0.30	0.31	1.12	0.78
WA04	0.000	0.22	0.25	0.30	0.30	0.66	0.92
WA05	0.002	0.24	0.26	0.32	0.32	0.86	0.65
WA06	0.002	0.32	0.28	0.32	0.30	0.83	0.86
Average	0.005	0.26	0.25	0.31	0.30	0.80	0.72

Ketchikan-Tongass Narrows

Eight sampling site in Tongass Narrows near Ketchikan were representative of the north and south channel (KE07 and KE09), near cruise ship berths (KE04, KE05, KE08), Thomas Basin (a small boat harbor), the mouth of Ketchikan Creek (KE01), and within the middle of the channel (KE02, KE03, and KE06) (Figure 35).

Water temperature, salinity, pH, and dissolved oxygen in Tongass Narrows were similar among sampling sites and water depths (Table 36), although water temperature was ~1°C and dissolved oxygen ~1mg/L greater than the averages at KE09. Average water temperature was ~8°C in April of 2021 and 14°C in July of 2020. Salinity was 28 ppt in April 2021 compared to 24 ppt in July of 2020. The pH was 8.3 in April 2021 and 8.6 in July of 2020.

Geometric mean fecal coliforms ranged from 1.0 to 5.8 cfu/100ml and *Enterococci* from 5.0 (0.5 x the MDL) to 8.7 MPN/100 ml (Figure 36). The maximum fecal coliform value in 2021 was 46 cfu/100 ml at KE05. Bacterial concentrations in April 2021 water samples were much less than in water samples collected in July of 2020.

Average ammonia-N concentration was 0.016 mg/L just over the laboratory reporting limit of 0.010 mg/L. Total and dissolved metals were <1 µg/L (Table 37). The 2021 and 2020 results were similar.

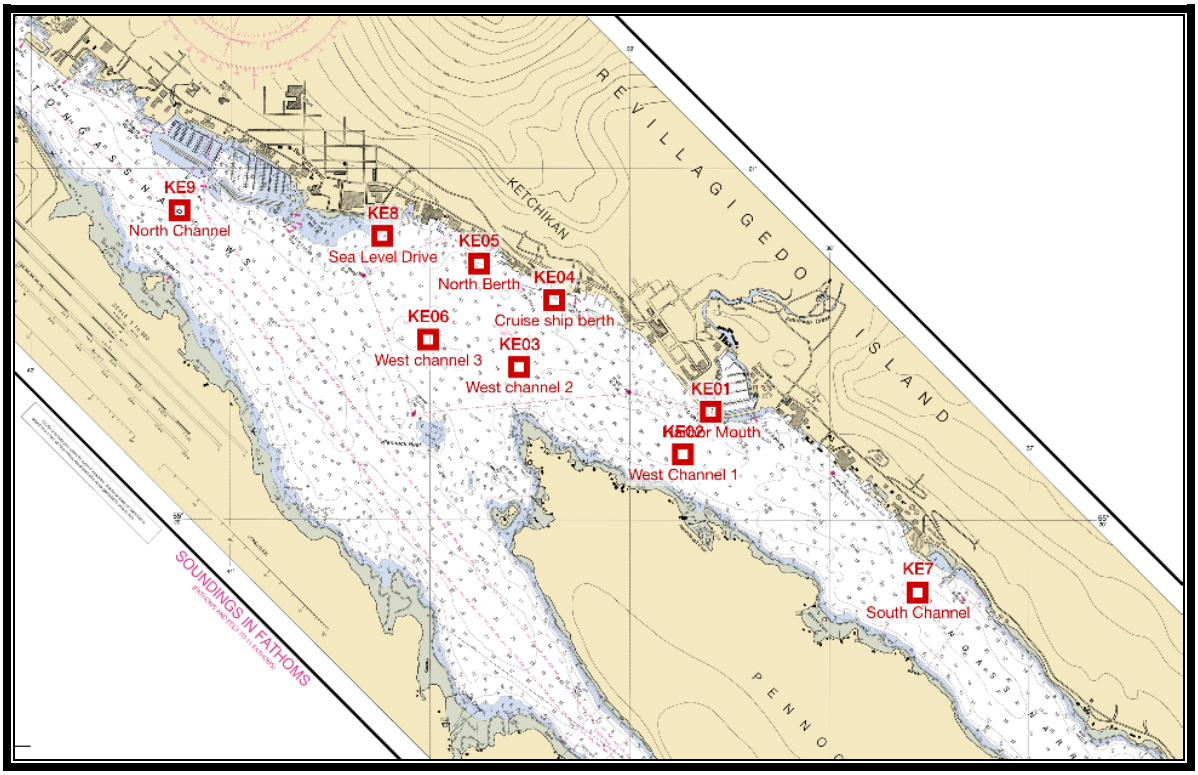


Figure 35. Chart showing Port of Ketchikan sampling stations. KE03 was not sampled in 2021.

Table 36. Port of Ketchikan water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m
KE01	8.10	8.30	8.10	8.00
KE02	8.30	8.30	8.20	8.20
KE04	7.80	7.80	7.80	7.80
KE05	8.10	7.90	7.10	6.90
KE06	8.20	8.10	7.70	7.80
KE07	8.40	8.40	8.30	8.30
KE08	7.50	7.40	7.20	6.90
KE09	9.50	9.50	8.70	8.70
Average	8.24	8.21	7.89	7.83

Salinity (ppt)	1m	2m	3m	4m
KE01	22.68	28.92	29.09	29.20
KE02	29.09	29.17	29.24	29.27
KE04	29.28	29.38	29.45	29.51
KE05	28.83	29.10	29.84	30.10
KE06	28.95	29.24	29.44	29.56
KE07	28.02	28.36	28.87	28.92
KE08	29.72	29.85	30.05	30.12
KE09	27.56	27.07	28.20	29.44
Average	28.02	28.89	29.27	29.52

pH	1m	2m	3m	4m
KE01	8.42	8.39	8.50	8.30
KE02	8.32	8.30	8.34	8.31
KE04	8.29	8.26	8.32	8.26
KE05	8.24	8.25	8.18	8.17
KE06	8.33	8.25	8.43	8.21
KE07	8.36	8.33	8.39	8.36
KE08	8.16	8.14	8.14	8.10
KE09	8.49	8.47	8.41	8.43
Average	8.33	8.30	8.34	8.27

D.O. (mg/L)	1m	2m	3m	4m
KE01	13.42	12.85	12.86	12.89
KE02	11.40	11.97	12.21	12.33
KE04	11.40	11.85	12.05	12.09
KE05	11.70	11.96	11.93	11.96
KE06	11.60	11.77	11.79	11.75
KE07	12.77	12.79	12.87	13.01
KE08	10.98	11.15	11.22	11.20
KE09	13.10	13.90	14.10	14.22
Average	12.05	12.28	12.38	12.43

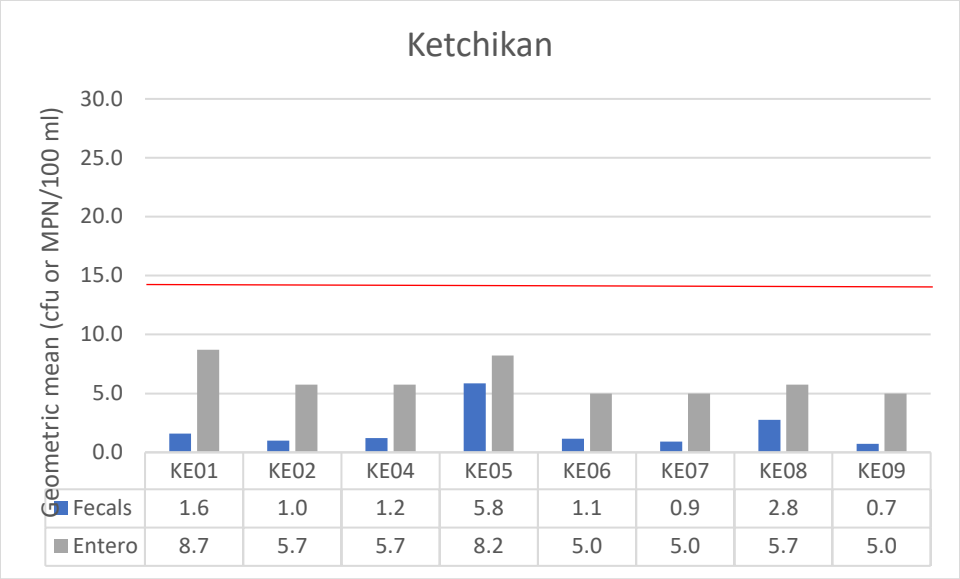


Figure 36. Port of Ketchikan geometric mean concentrations of fecal coliforms (FC) and *Enterococci* bacteria. WQC Red line is the numeric WQC for fecal coliforms.

Table 37. Concentrations of total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Ketchikan sampling stations. Water quality criteria (WQC) are listed for reference.

Site	Ammonia-N (mg/L)	T-Cu (µg/L)	D-Cu (µg/L)	T-Ni (ug/L)	D-Ni (µg/L)	T-Zn (µg/L)	D-Zn (µg/L)
WQC	0.3	-	3.1	-	8.2	-	86
KE01	0.026	0.37	0.34	0.29	0.26	3.01	2.60
KE02	0.007	0.21	0.21	0.31	0.29	0.35	0.34
KE04	0.004	0.23	0.22	0.29	0.29	0.81	0.77
KE05	0.003	0.23	0.19	0.29	0.29	1.08	0.80
KE06	0.009	0.20	0.21	0.31	0.31	0.51	0.46
KE07	0.053	0.21	0.27	0.29	0.30	0.60	0.53
KE08	0.016	0.20	0.20	0.32	0.31	0.53	0.54
KE09	0.007	0.19	0.20	0.29	0.30	0.39	0.27
Average	0.016	0.23	0.23	0.30	0.29	0.91	0.79

Shipping Lanes

Water samples were collected within several major channels (canals, straights, sounds, and passages) in Southeast Alaska (Figure 37 and 38). Two additional Shipping Lanes sites were located in Southcentral Alaska near Storey Island, Prince William Sound and at Sunny Cove, Resurrection Bay. A table of Shipping Lanes site names and coordinates is in Appendix B.

The pH and salinity at 1m to 4m water depths for Shipping Lanes sites are in Table 38 and pH and dissolved oxygen concentrations in Table 39. Water Temperatures at 1m water depth ranged from 5.3°C to 9.5°C. Cooler water sites with water temperatures <6°C were in Lynn Canal (LC01, FP), Stephens Passage (SP01, SP02, MP), and Icy Strait (IS02, NC). When all sites were considered, there was no consistent difference in water temperature between 1m and 4m water depth (t-test, $p = 0.14$).

Salinity was near 30 ppt at all Shipping Lanes sampling sites with the exception of SP02 (16.3 ppt), located in Taku Inlet off of Stephens Passage, Middle Point (24.0 ppt), located in Stephens Passage, and at the northern end of Lynn Canal (LC02) at 24.8 ppt. Each of these sites is located near a substantial source of fresh water (i.e., Taku and Chilkat Rivers respectively).

The pH ranged from 7.7 to 8.6 at 1m water depth and averaged 8.22. Sites with lower pH (<8.0) were in Fredrick Sound and Sumner Strait. Dissolved oxygen concentration ranged from 8.28 to 16.71 mg/L and averaged 12.42 mg/L. Sites where dissolved oxygen was < 10 mg/L also were located in Fredrick Sound and Sumner Strait. Sumner Strait also had relatively low pH and dissolved oxygen in September 2020.

Fecal coliform and *Enterococci* bacteria concentrations were below the MDL at all Shipping Lanes sampling sites with the exception of the site located in Sunny Cove. Sunny Cove fecal coliform concentrations were 15 cfu/100 ml. These results are consistent with 2020 Shipping Lane samples.

Ammonia-N and total and dissolved metals low at Shipping Lanes sites (Table 39). Ammonia-N ranged from 0.002 mg/L to 0.035 mg/L and averaged 0.013 mg/L. Samples from Tebnekof Bay had dissolved Cu, Ni, and Zn concentrations that exceeded total concentrations and are likely to be erroneous values. Excluding these values average total and dissolved Cu, Ni, and Zn were < 0.5 µg/L (Figure 39). Results from 2020 and 2021 samples analyzed for ammonia-N and metals were similar between years.

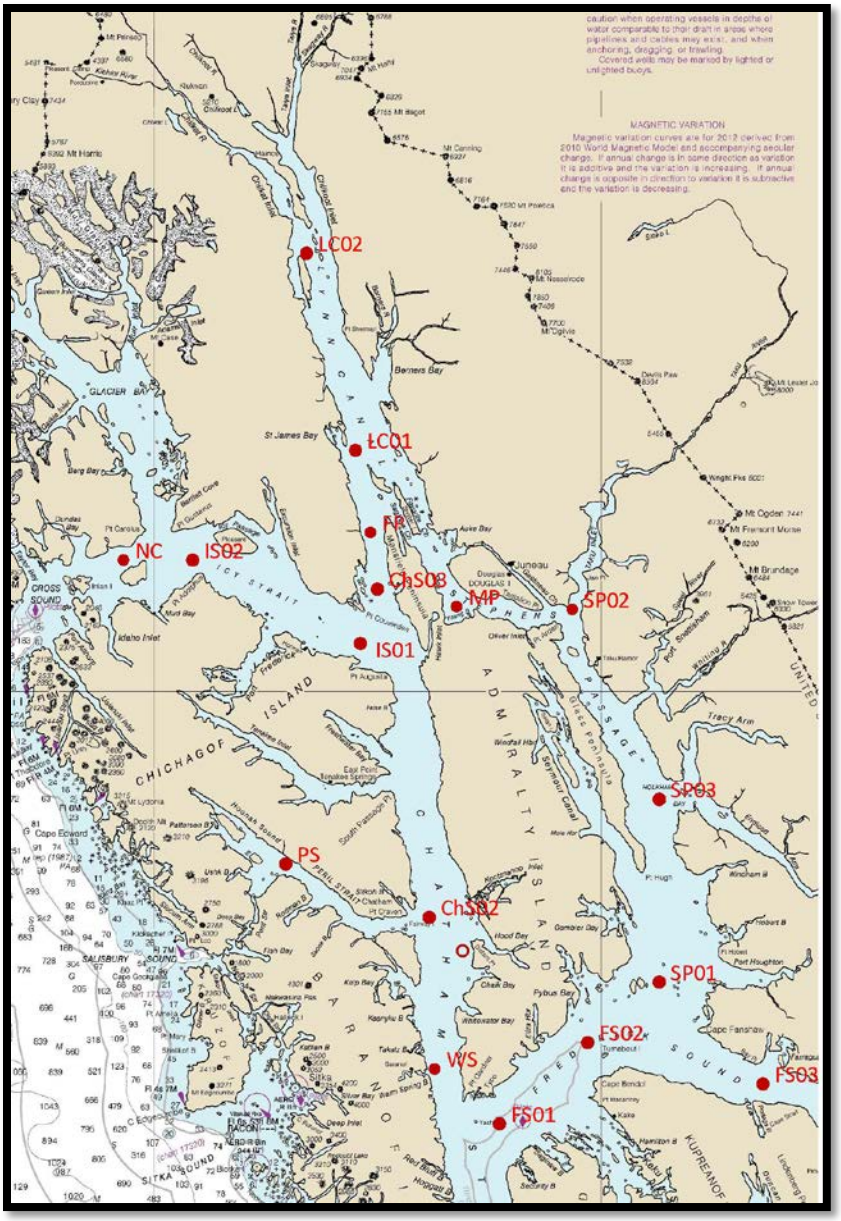


Figure 37. Locations of Shipping Lanes sites from upper Lynn Canal near Haines to Fredrick Sound.

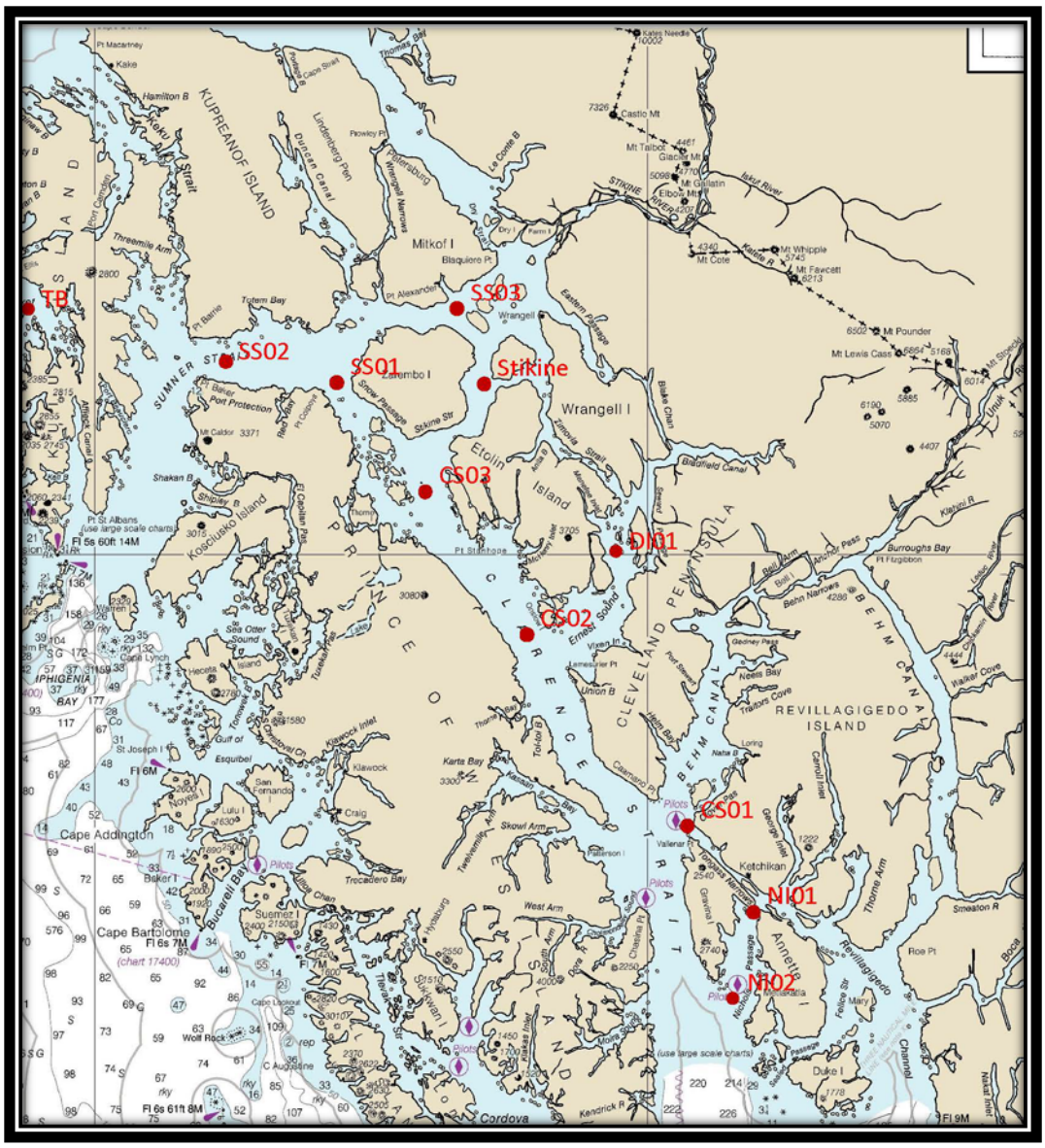


Figure 38. Sampling sites from Tebnekof in the northwest and Sumner Strait near Wrangell in the northeast to Nichols Passage south of Ketchikan.

Table 38. Shipping lanes water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m
CS01	9.50	9.20	8.90	7.40
CS02	7.90	7.70	7.60	7.60
CS03	8.50	8.40	8.30	7.30
DI01	8.30	8.20	7.60	7.50
NI01	7.90	7.90	7.70	7.40
NI02	7.60	7.60	7.60	7.50
FS01	7.40	6.50	6.10	6.00
FS02	5.40	5.30	5.20	5.20
FS03	8.40	8.10	8.00	7.30
SP01	5.70	5.50	5.50	5.50
SP02	5.60	5.90	6.20	6.00
SP03	6.60	5.20	4.80	4.80
SS01	6.50	6.50	6.50	6.50
SS02	6.40	6.40	6.40	6.40
SS03	6.70	6.70	6.70	6.70
Stikine	7.20	7.20	7.20	7.20
FP	5.50	5.50	5.50	5.50
LC01	5.30	5.30	5.30	5.30
LC02	6.40	6.80	6.80	6.80
MP	5.90	5.90	5.90	5.80
IS01	6.60	6.60	6.50	6.40
IS02	5.70	5.70	5.70	5.70
CHS02	7.80	7.40	7.10	7.20
CHS03	6.20	6.10	6.10	5.90
NC	5.90	5.80	5.90	5.90
PS	8.70	8.50	8.40	8.00
TB	8.70	7.70	7.30	7.10
WS	8.10	7.80	7.60	7.50
Storey	9.30	9.30	8.90	8.90
SC	9.10	9.00	8.90	8.80
Average	7.16	6.99	6.87	6.70

Salinity (ppt)	1m	2m	3m	4m
CS01	27.56	28.20	28.32	28.66
CS02	28.90	29.27	29.38	29.41
CS03	29.68	29.85	29.98	30.04
DI01	26.96	27.13	27.66	27.92
NI01	29.34	27.36	29.55	29.78
NI02	30.32	30.32	30.33	30.34
FS01	31.35	31.28	31.26	31.20
FS02	31.57	31.52	31.53	31.54
FS03	31.15	31.11	31.10	31.13
SP01	30.87	30.86	30.97	30.98
SP02	16.26	23.42	26.87	27.54
SP03	31.22	31.25	31.25	31.30
SS01	31.57	31.64	31.74	31.75
SS02	31.72	31.75	31.78	31.81
SS03	28.13	28.20	28.21	28.22
Stikine	29.84	29.84	29.84	29.84
FP	30.88	30.90	30.91	30.92
LC01	30.83	30.82	30.82	30.82
LC02	24.79	28.25	28.46	28.56
MP	23.95	23.99	24.37	25.04
IS01	31.06	31.08	31.09	31.10
IS02	31.55	31.54	31.55	31.55
CHS02	29.70	30.10	29.90	30.10
CHS03	30.52	30.54	30.62	30.67
NC	31.74	31.81	31.85	31.85
PS	28.20	28.60	28.70	29.00
TB	30.70	30.90	31.10	31.20
WS	30.50	30.60	30.60	30.70
Storey	30.58	30.66	30.69	30.82
SC	30.04	30.43	30.69	30.76
Average	29.38	29.77	30.04	30.15

Table 39. Shipping lanes water pH and dissolved oxygen (D.O.) at 1, 2, 3, and 4 m water depths.

pH	1m	2m	3m	4m
CS01	8.23	8.30	8.31	8.23
CS02	8.41	8.44	8.45	8.46
CS03	8.20	8.19	8.23	8.10
DI01	8.39	8.41	8.43	8.47
NI01	8.27	8.26	8.19	8.16
NI02	8.16	8.16	8.20	8.19
FS01	8.15	8.18	8.16	8.09
FS02	7.94	7.94	7.89	7.89
FS03	8.00	8.00	8.00	8.00
SP01	8.09	8.09	8.13	8.11
SP02	8.22	8.42	8.48	8.39
SP03	8.13	7.87	7.76	7.81
SS01	7.88	7.89	7.87	7.85
SS02	7.83	7.84	7.83	7.85
SS03	8.35	8.28	8.25	8.18
Stikine	8.39	8.39	8.42	8.38
FP	8.29	8.26	8.29	8.26
LC01	8.38	8.40	8.41	8.37
LC02	8.60	8.60	8.72	8.63
MP	8.08	8.07	8.10	8.08
IS01	8.55	8.54	8.59	8.60
IS02	8.12	8.12	8.43	8.21
CHS02	8.31	8.30	8.32	8.32
CHS03	8.56	8.55	8.46	8.54
NC	8.03	8.04	8.02	8.01
PS	8.40	8.42	8.43	8.43
TB	7.70	7.88	7.98	8.02
WS	8.44	8.44	8.44	8.43
Storey	8.24	8.31	8.28	8.36
SC	8.33	8.32	8.34	8.27
Average	8.22	8.23	8.25	8.22

D.O. (mg/L)	1m	2m	3m	4m
CS01	12.40	12.92	13.22	13.33
CS02	13.69	14.57	14.92	15.09
CS03	13.36	13.29	13.22	12.91
DI01	13.53	14.28	15.13	15.20
NI01	12.22	12.21	12.16	11.94
NI02	11.99	12.09	12.14	12.18
FS01	13.45	13.49	13.50	13.22
FS02	9.77	9.77	9.72	9.67
FS03	10.65	10.64	10.69	10.71
SP01	12.80	12.72	12.34	12.20
SP02	12.12	12.12	12.39	12.53
SP03	12.34	11.01	10.20	9.59
SS01	8.28	8.26	8.24	8.23
SS02	8.57	8.49	8.46	8.45
SS03	9.81	9.68	9.63	9.59
Stikine	13.14	13.15	13.15	13.15
FP	12.11	13.01	13.52	13.94
LC01	13.26	13.27	13.28	13.28
LC02	13.68	13.95	14.45	14.67
MP	11.15	11.22	11.28	11.25
IS01	16.71	16.73	16.76	16.82
IS02	11.53	11.52	11.52	11.54
CHS02	13.54	13.50	13.37	13.46
CHS03	16.65	16.65	16.65	16.65
NC	10.03	9.94	9.86	9.80
PS	13.34	13.51	13.70	13.92
TB	15.66	15.68	19.99	14.30
WS	15.09	15.31	15.26	15.17
Storey	10.69	10.75	10.86	11.01
SC	11.04	10.95	11.07	11.11
Average	12.42	12.49	12.69	12.50

Table 40. Concentrations of total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Shipping Lanes sampling stations. Water quality criteria (WQC) are listed for reference.

Site	Ammonia-N (mg/L)	T-Cu (µg/L)	D-Cu (µg/L)	T-Ni (µg/L)	D-Ni (µg/L)	T-Zn (µg/L)	D-Zn (µg/L)
WQC	0.3	-	3.1	-	8.2	-	86
CS01	0.010	0.19	0.19	0.30	0.31	0.21	0.10
CS02	0.030	0.14	0.14	0.29	0.29	0.10	0.10
CS03	0.002	0.14	0.15	0.33	0.33	0.25	0.10
DI01	0.002	0.17	0.16	0.29	0.29	0.10	0.10
NI01	0.012	0.17	0.14	0.29	0.28	0.27	0.22
NI02	0.002	0.16	0.13	0.30	0.30	0.10	0.26
FS01	0.008	0.19	0.30	0.40	0.36	0.43	0.35
FS02	0.002	0.16	0.28	0.39	0.36	0.31	0.39
FS03	0.010	0.17	0.25	0.39	0.36	0.35	0.34
SP01	0.012	0.23	0.44	0.39	0.37	0.32	0.33
SP02	0.017	1.39	0.78	1.65	0.86	1.56	0.45
SP03	0.010	0.17	0.59	0.39	0.39	0.25	0.35
SS01	0.018	0.19	0.26	0.39	0.34	0.32	0.33
SS02	0.007	0.15	0.20	0.36	0.32	0.24	0.26
SS03	0.024	0.66	0.38	0.69	0.47	0.62	0.36
Stikine	0.010	0.21	0.25	0.38	0.31	0.23	0.10
FP	0.004	0.21	0.18	0.37	0.35	0.30	0.25
LC01	0.009	0.25	0.22	0.39	0.38	0.36	0.10
LC02	0.014	0.48	0.33	0.53	0.36	0.76	0.10
MP	0.014	1.16	0.49	0.76	0.60	0.95	0.32
IS01	0.004	0.22	0.18	0.38	0.35	0.10	0.10
IS02	0.010	0.29	0.22	0.42	0.37	0.39	0.10
CHS02	0.034	0.20	0.51	0.35	0.33	0.24	0.37
CHS03	0.002	0.22	0.18	0.38	0.34	0.23	0.10
NC	0.012	0.24	0.19	0.41	0.37	0.28	0.21
PS	0.011	0.29	0.57	0.32	0.33	0.24	0.39
TB	0.022	0.14	**10.10**	0.29	0.38	0.10	**11.70**
WS	0.035	0.19	0.83	0.32	0.35	0.26	1.07
Story	0.035	0.41	0.39	0.35	0.33	0.10	0.10
SC	0.009	0.32	0.32	0.30	0.33	0.10	0.10

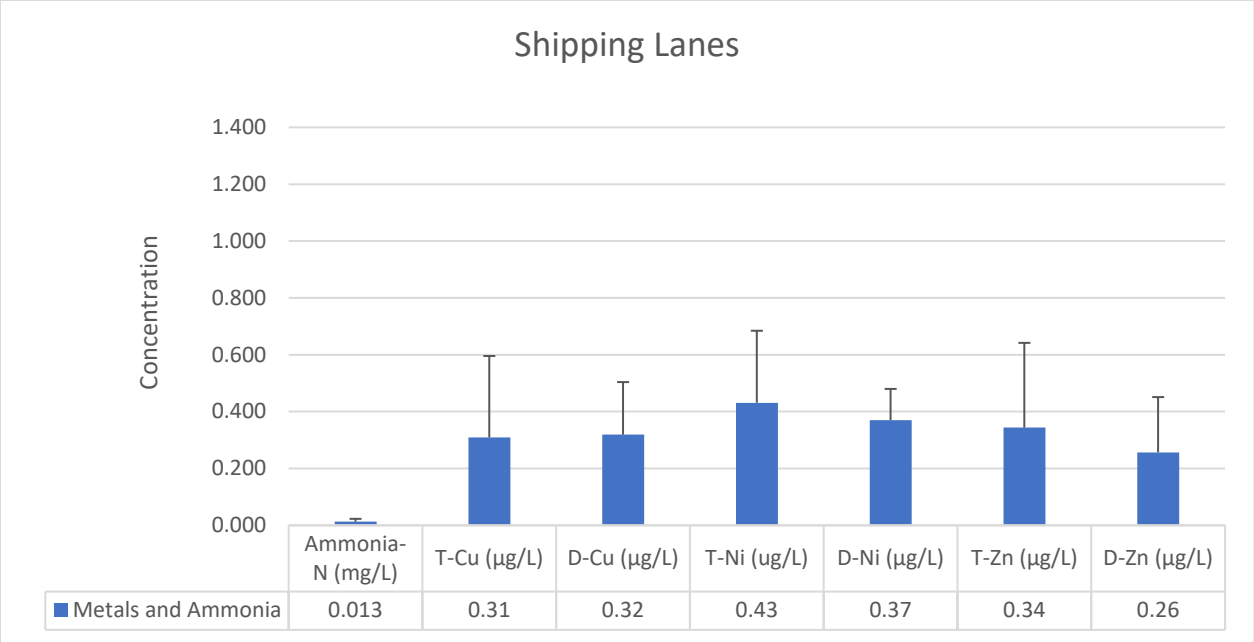


Figure 39. Mean concentrations of ammonia-N and total (T) and dissolved (D) copper, nickel, and zinc among the 28 Shipping Lanes sites. Values from Tebnekof (TB) excluded. Error bars are one standard deviation.

Site Comparisons

Average Port concentrations of ammonia-N and total Cu, Ni, and Zn from 2021 and 2020 samples are provided in Table 41. Ammonia-N concentrations were low at all Ports in both years, well below the WQC of 0.3 mg/L. Average ammonia-N concentration ranged from 0.01 mg/L to 0.03 mg/L in 2021 samples. Ammonia-N concentrations were greater in 2021 (0.017 mg/L average) than in 2020 (0.009 mg/L average) (Paired t-test, p = 0.01). Ammonia-N concentrations in samples from Shipping Lanes sites also were greater in 2021 (0.012 mg/L) than in 2020 (0.006 mg/L) (Paired t-test, p = 0.04). These differences may reflect reduced biological uptake in the cooler spring 2021 sampling compared to the warmer summer sampling in 2020.

Metals concentrations were much higher in samples collected in the vicinity of the Port of Anchorage compared to other ports in 2021 and in 2020. Total Cu concentrations were < 1.0 µg/L at all Ports except Anchorage, Nome, Seward and Valdez in 2021 and 2020. Average concentrations of total Ni were < 1.0 µg/L in samples from all Ports except Anchorage, Seward, and Valdez. Average concentrations of Zn were < 2 µg/L except for samples collected from Anchorage, Dutch Harbor, Seward, and Valdez in 2021 and Anchorage, Kodiak, Seward, Skagway, Valdez, Whittier, and Wrangell in 2020. Higher concentrations of Zn tended to occur in samples collected in or near small boat harbors and could be related to sacrificial zinc anodes used by many boats used to reduce corrosion.

Table 41. Average concentrations of ammonia-N and dissolved Cu, Ni, and Zn from 2021 and 2020 samples collected in Alaska's Ports.

Port	Ammonia-N (mg/L)		D-Cu (µg/L)		D-Ni (ug/L)		D-Zn (µg/L)	
	2021	2020	2021	2020	2021	2020	2021	2020
WQC	0.3		3.1		8.2		86	
Anchorage	0.005	0.009	8.6	8.62	7.9	5.91	14.7[3]	12.90
Auke Bay	0.011	0.014	0.38	0.87	0.45	0.52	0.55	1.13
Dutch Harbor	0.021		0.46		0.20		1.45	
Haines	0.010	0.006	0.33	0.39	0.33	0.31	0.16	0.52
Homer	0.020	0.002	0.98	0.51	0.44	0.45	0.70	0.63
Hoonah	0.008	0.002	0.26	0.28	0.39	0.34	0.40	0.17
Juneau	0.031	0.002	0.57	0.58	0.67	0.58	1.19	0.66
Ketchikan	0.016	0.004	0.23	0.29	0.29	0.27	0.79	0.59
Kodiak	0.033	0.023	0.26	0.46	0.32	0.34	0.41	2.03
Nome	0.002		1.45		0.90		0.61	
Petersburg	0.025	0.043	0.32	0.41	0.38	0.39	0.43	0.93
Seward	0.033	0.015	0.91	0.81	0.64	0.75	2.00	1.50
Sitka	0.016	0.002	0.76	0.40	0.28	0.24	1.69	0.76
Skagway	0.025	0.014	0.35	0.47	0.24	0.27	0.59	2.38
Utqiagvik	0.026		0.29		0.41		0.39	
Valdez	0.028	0.009	0.56	0.30	0.97	0.65	1.16	0.79
Ward Cove	0.005	0.002	0.25	0.52	0.30	0.32	0.72	1.56
Whittier	0.005	0.005	0.41	0.57	0.41	0.51	0.47	1.58

[3] Applicable site-specific criteria for zinc at the Anchorage port is 81 ug/L per 18 AAC 70.236(b)(4).

Wrangell	0.009	0.002	0.30	1.83	0.34	0.88	0.13	2.10

References

ARRI. 2018. CPVEC Ambient Water Quality Monitoring: Juneau and Skagway Harbors September 2015 through October 2017. Final Report for the Alaska Department of Environmental Conservation, Division of Water, Commercial Passenger Vessel Environmental Compliance Program. Aquatic Restoration and Research Institute, Talkeetna, AK.

ARRI 2019. CPVEC Ambient Water Quality Monitoring: Sitka, Hoonah, and Ketchikan Harbors 2018. Final Report for the Alaska Department of Environmental Conservation, Division of Water, Commercial Passenger Vessel Environmental Compliance Program. Aquatic Restoration and Research Institute, Talkeetna, AK.

ARRI 2020a. CPVEC Ambient Water Quality Monitoring: Ketchikan (2018-2019) and Seward Harbors (2019). Final Report for the Alaska Department of Environmental Conservation, Division of Water, Commercial Passenger Vessel Environmental Compliance Program. Aquatic Restoration and Research Institute, Talkeetna, AK.

ARRI 2020b. Water Quality Measures in Alaska's Ports and Shipping Lanes: 2020 Annual Report. Final report for the Alaska Department of Environmental Conservation Division of Water. Aquatic Restoration and Research Institute, Talkeetna, AK.

DEC. 2018a. Department of Environmental Conservation 18 AAC 70 Water Quality Standards as Amended as of April 6 2018.

DEC 2018b. State of Alaska Department of Environmental Conservation. Alaska Water Quality Criteria for Toxic and Other Deleterious Organic and Inorganic Substances Amended as of April 6 2108.

Appendix A. Quality Assurance

All water samples to be analyzed for ammonia-N, Cu, Ni, and Zn arrived at the analytical laboratory within the prescribed holding time. Water samples to be analyzed for ammonia-N are preserved by maintaining sample temperatures < 4°C until analyzed. Some sample coolers were warmer than this preservation criteria (see Table 1). Samples from Petersburg, Wrangell, Whittier, and adjacent Shipping Lanes sites arrived at the laboratory with cooler temperatures of 5.3 or 5.4°. Water samples collected from Seward and Anchorage arrived at the laboratory with cooler temperatures of 10°C and 11°C, respectively.

All water samples to be analyzed for fecal coliform and *Enterococci* bacteria arrived at analytical laboratories with sample temperatures below the preservation temperature of 10°C. Some samples did not meet the 6-hour hold time (see Table 1). Hold time exceedances were due to remove sampling locations for some Shipping Lanes sites or to cancelled or delayed flights. All samples were analyzed within 24 hours of collection.

Data quality objectives for precision from replicate samples were not always met. Precision is calculated from the difference between two replicate samples. At low concentrations precision objectives are more difficult to obtain. The number of replicate samples that did not meet precision objectives is shown in Table 41. There were seven ammonia-N replicates that did not meet precision quality objectives. However, at least one value from four of these seven replicates estimates with concentrations < RL.

Trip blanks are sealed sample bottles provided by the laboratory that accompany the sample bottles from the time they leave the laboratory until they return. They are never opened. Total Cu was present in four of 15 trip blanks and total Ni and Zn in one of the 14 trip blanks. (Table 42).

Ammonia-N and total and dissolved metals also were present at low concentrations in some of the field blanks (Table 43). Ammonia-N was above method RL in nine of the 14 field blanks. Average ammonia-N concentration in these nine samples was 0.022 mg/L and the maximum concentration was 0.027 mg/L. Total Cu and Zn, and dissolved Cu, Ni, and Zn were present at concentrations above RL in some of the blank samples. The average concentration of dissolved Cu in field blanks was 0.28 µg/L, 0.08 µg/L above the MDL. The average concentration of dissolved Ni in equipment blanks was 0.02 µg/L, the MDL, and the average concentration of dissolved Zn in equipment blanks was 0.54 µg/L 0.34 µg/L above the MDL.

The concentrations of ammonia-N and metals within this report may be biased high and true values may be less than reported values.

Table 42. Number of sample replicates that did not meet sample quality objectives from 12 pairs of replicate samples. Ave. Diff. is the average difference between replicates that did not meet quality objectives and Max. Diff. is the maximum difference between sample replicates.

	No. > QC Objective	**Ave. Diff.**	**Max. Diff.**
Ammonia-N (mg/L)	7	0.008	0.022
Dissolved Cu (µg/L)	2	0.19	0.63
Total Cu (µg/L)	2	0.14	0.14
Dissolved Ni (µg/L)	0	0.13	N/A
Total Ni (µg/L)	1	0.03	0.07
Dissolved Zn (µg/L)	2	0.29	0.54
Total Zn (µg/L)	2	0.20	0.63

Table 43. Number of trip blanks with concentrations of total metals present.

Trip Blank	Value < MDL	MDL >Value< RL	Value > RL
Total Cu	11	4	0
Total Ni	14	1	0
Total Zn	14	1	0

Table 44. Number of equipment blanks with concentrations below the MDL, greater than the MDL but less than the RL, and greater than the RL.

Equipment Blanks	Value < MDL	MDL >Value< RL	Value > RL
Ammonia-N	4	1	9
Total Cu	4	9	1
Total Ni	13	1	0
Total Zn	6	6	2
Dissolved Cu	0	10	4
Dissolved Ni	12	1	1
Dissolved Zn	3	6	5

Appendix B. Coordinates of Shipping Lanes Sites

Site Name	Latitude	Longitude	Location
CHS02	57.4523	-134.7857	Chatham Strait
CHS03	58.3227	-134.9862	Chatham Strait
CS01	55.4427	-131.8494	Clarence Strait
CS02	55.8235	-132.4272	Clarence Strait
CS03	56.1348	-132.7785	Clarence Strait
DI01	55.9466	-132.0928	Dear Island in Ernest Sound
FP	58.3658	-134.9726	False Point in Chatham Strait
FS01	57.0028	-134.3698	Fredrick Sound
FS02	57.1485	-134.0020	Fredrick Sound
FS03	57.0712	-133.1610	Fredrick Sound
IS01	58.1545	-134.9898	Icy Strait
IS02	58.2983	-135.7742	Icy Strait
LC01	58.5702	-134.9415	Lynn Canal
LC02	58.9982	-135.2790	Lynn Canal
MP	58.2408	-134.6421	Middle Point in Stephens Passage
NC	58.2960	-136.3306	North Cove near Hoonah
NI01	55.2897	-131.6105	Nichols Passage
NI02	55.1093	-131.6578	Nichols Passage
PS	57.5693	-135.3549	Peril Strait
SP01	57.2848	-133.7560	Stephens Passage
SP02	58.2102	-134.1140	Stephens Passage
SP03	57.7398	-133.6705	Stephens Passage
SS01	56.3403	-133.1292	Sumner Strait
SS02	56.3990	-133.4593	Sumner Strait
SS03	56.5020	-132.6827	Sumner Strait
SC	59.9177	-149.3639	Sunny Cove in Resurrection Bay
Stikine	56.3755	-132.5915	Stikine Strait
Storey	60.7474	-147.4580	Storey Island
TB	56.4912	-134.1920	Tebnekof Bay
WS	57.2803	-134.8513	Warm Springs in Chatham Strait