

Water Quality Measures in Alaska's Ports and Shipping Lanes: 2022 Annual Report



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**Alaska Department of Environmental Conservation
Division of Water**

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Summary

The Alaska Department of Environmental Conservation (ADEC), Division of Water (DOW), Water Quality implemented a water quality assessment project beginning in 2020 and extending through 2022. The project was a continuation and expansion upon water quality monitoring that was initiated in 2015. The 2022 assessment project was conducted to provide water quality data following the Covid-19 pandemic and the return of Cruise Ships to Alaskan waters. In 2022 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 (Figure 1). 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.

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). Samples were collected from approximately 150 sampling sites located in open water shipping lanes and within 20 ports. At each shipping lane and port sampling site, water samples were collected and analyzed for fecal coliform and *Enterococci* bacteria, ammonia-N; and total and dissolved copper (Cu), nickel (Ni), and zinc (Zn), resulting in over 2,500 analyses each year. 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 5 samples within a 30-day period. Concentrations of

ammonia-N, metals, and geometric mean bacterial concentrations were compared to Alaska Water Quality Standard (WQS) numeric criteria (WQC) (18 AAC 70) (DEC 2018b) (see inset).

Geometric mean concentrations of fecal coliform bacteria exceeded the numeric criteria (14 cfu/100 ml) within the small boat harbors of Homer, Valdez, and Ketchikan.

Water Quality Criteria	
Fecal Coliforms	Geometric mean of 14 cfu/100 ml and ≤10% of the samples > 31 cfu/100 ml.
<i>Enterococci</i>	Geometric mean of samples may not exceed 31 <i>Enterococci</i> 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)	81 µg/L (chronic)

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 < 0.059 mg/L at all sampling ports and averaged 0.023 mg/L. Concentrations of ammonia-N among Shipping Lane sites was < 0.045 mg/L and averaged 0.016 mg/L.

Average port concentrations of dissolved Cu were 0.52 µg/L when high Anchorage concentrations (8.98 µg/L) were excluded. Average dissolved Cu concentrations were greater in Anchorage (8.89 µg/L), Seward (1.57 µg/L) and Valdez (1.37 µg/L) compared to other ports. Average dissolved Ni concentrations were < 0.5 µg/L and average dissolved Zn was < 0.9 µg/L (Anchorage excluded). Average dissolved

concentrations of Ni in Knik Arm near Anchorage (5.62 $\mu\text{g/L}$) approached WQS numeric criteria and were higher in Seward and Valdez than other Ports sampled. The average concentrations of metals in Shipping Lanes sites was $< 0.5 \mu\text{g/L}$ in 2022.

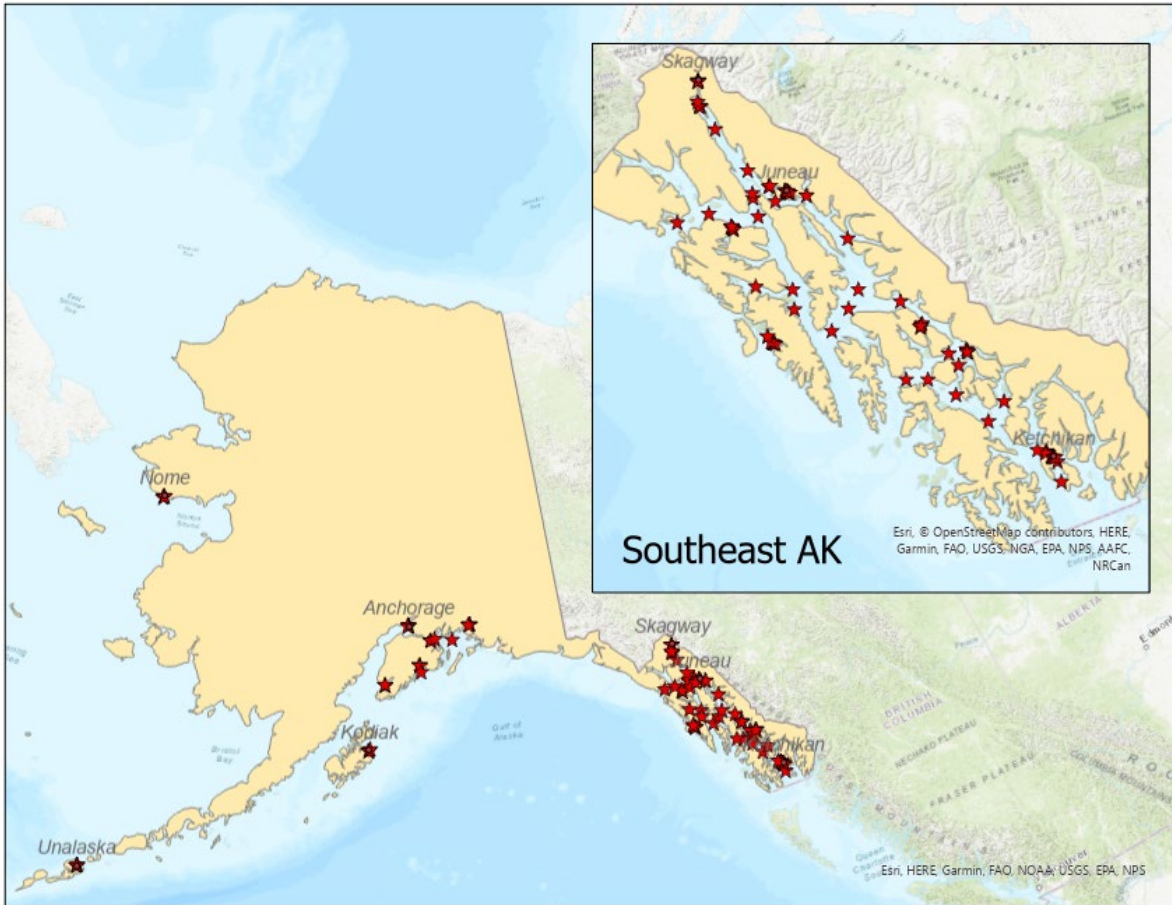


Figure 1. Locations of Alaska Ports and Shipping Lane sampling sites sampled in 2020, 2021, and 2022.

Introduction

The Alaska Department of Environmental Conservation, Division of Water, initiated a 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 2020a).

The sampling program was expanded in 2020 and 2021 in response to the cancellation of cruise ship voyages to Alaska due to the Covid-19 pandemic. Sampling 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) (ARRI 2020b and ARRI 2021).

Cruise ships returned to Alaska's waters in 2022 and sampling was conducted to measure conditions that included this additional potential source of pollutants. Sampling methods and locations were the same in 2022, 2021 and 2020.

Sampling was conducted within 20 ports throughout Alaska with sampling occurring at six or more sites within each port. Bacterial sampling (fecal coliforms and *Enterococci*) was conducted at all port sampling sites, five samples were taken within a 30-day period to ensure compliance with DEC bacteria assessment criteria. Sampling also included 29 sites located within major waterways or shipping lanes throughout Southeast and a limited number of samples in Southcentral 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 concentrations exceeded WQC at multiple sites.

Methods

The water sampling plan, sample collection, handling, and analyses was conducted following the approved Quality Assurance and Project Plan (ARRI 2022).

Sampling Locations and Dates

Water sampling was conducted from late April 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 open water Shipping Lane sites. Sampling in southcentral, western, and northern Alaska started in Seward on June 5, 2022, with the final sample collected in Valdez on August 24, 2022. Two Shipping Lanes sites were located in southcentral Alaska in Prince William Sound and Resurrection Bay.

Cruise Ships

The number of cruise ships docked within ports during the sampling period was obtained from the Cruise Line Agencies of Alaska, Cruise Ship Calendar for 2022.

Sample Collection

Water samples were collected from 1m water depth. Harbor water was pumped through Teflon tubing into laboratory-provided sample bottles (ALS Environmental) using a peristaltic pump (Solonist 410). Tubing and bottles were flushed for approximately three minutes prior to sample collection at each sampling location.

Table 1. Date ports and shipping lanes sites (abbreviated site names) were 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 bacteria samples received after the hold time.

Port	Metals/Ammonia	Fecal/EC	Fecal/EC	Fecal/EC	Fecal/EC	Fecal/EC
Juneau	5/9/2022 (1.8)	5/9/2022	5/11/2022	5/23/2022	6/6/2022	6/7/2022
Auke Bay	5/9/2022 (1.8)	5/9/2022	5/11/2022	5/23/2022	6/6/2022	6/7/2022
Haines, LC02	5/17/2022 (4.7)	5/16/2022	5/18/2022	5/24/2022	5/25/2022	5/26/2022
Skagway	5/16/2022 (4.7)	4/28/2022	5/10/2022	5/12/2022	5/16/2022	5/17/2022
Hoonah	5/12/2022 (3.2)	5/12/2022	5/13/2022	5/25/2022	5/25/2022	6/1/2022*
Shipping Lanes: IS02, NC	5/13/2022 (3.2)	5/13/2022				
Sitka	5/10/2022 (3.7)	5/10/2022	5/19/2022*	5/25/2022	6/6/2022	6/7/2022
Wrangell	5/3/2022 (11.0)	5/3/2022	5/11/2022	5/19/2022	5/25/2022	6/1/2022
Petersburg	5/2/2022 (5.0)	5/2/2022	5/9/2022	5/16/2022	5/23/2022	5/31/2022
MP, SP02, SP01, SP03, FS03	5/15/2022 (1.2)	5/15/2022				
SS01, SS02, SS03, Stikine, CS03	5/16/2022 (1.2)	5/16/2022				
FS02, FS01, WS, ChS02, PS, IS01	5/17/2022 (1.2)	5/17/2022				
ChS03, FP, LC01,	5/18/2022 (1.2)	5/18/2022				
Ketchikan	5/4/2022 (2.6)	5/4/2022	5/5/2022	5/10/2022	5/12/2022	5/17/2022
Ward Cove	5/4/2022 (2.6)	5/4/2022	5/5/2022	5/10/2022	5/12/2022	5/17/2022
NI01, NI02	5/5/2022 (2.6)	5/5/2022				
CS01, CS02, DI	5/6/2022 (2.1)	5/6/2022				
Whittier	6/21/2022 (3.6)	6/13/2022	6/14/2022	6/21/2022	6/24/2022	7/6/2022
Storey Island	8/3/2022 (5.5)	8/3/2022				
Seward and Sunny Cove	6/5/2022 (4.9)	6/3/2022	6/6/2022	6/13/2022	6/14/2022	6/15/2022
Homer	7/24/2022 (2.9)	7/18/2022	7/20/2022	7/21/2022	7/26/2022	7/27/2022
Anchorage	7/1/2022 (3.4)	6/29/2022	7/1/2022	7/5/2022	7/7/2022	7/8/2022
Valdez	8/8/22 (5.5)	8/4/2022*	8/8/2022*	8/22/2022*	8/23/2022*	8/24/2022*
Kodiak	7/12/2022 (2.7)	6/16/2022	6/20/2022	6/23/2022	7/11/2022*	7/12/2022
Dutch Harbor	6/26/2022 (2.0)	6/24/2022	6/25/2022	6/26/2022	6/27/2022	6/28/2022
Nome	7/28/2022 (2.0)	7/25/2022	7/27/2022	7/28/2022	7/29/2022	8/1/2022

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 the US Environmental Protection Agency (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 Method Detection Limit (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), SGS (Anchorage), R&M Engineering (Ketchikan), and Makushin Bay (Dutch Harbor) 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. Equipment blanks were collected by submerging the pump tubing into the liter of deionized water; therefore, metals could be introduced into the equipment 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 present in some trip blanks. Ammonia-N and total and dissolved metals were present in some equipment blanks, therefore, reported values may be biased high and true concentrations may be less than reported values. 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. Sample results above the MDL are included in tables and figures. Result values should be considered estimates

when they are above the MDL but below the RL. For those values reported by the laboratory as “Not Detected,” a value of 0.5 x MDL was used in tables and when calculating averages or geometric means. The *Enterococci* MDL was 10 MPN/100 ml for samples analyzed by Admiralty Environmental (southeast Alaska Ports) and 1 to 1.67 for samples analyzed by SGS Environmental. Therefore, if concentrations are below MDL, geometric mean concentrations will be greater for southeast ports than southcentral ports. Concentrations of *Enterococci* appear greater than concentrations of fecal coliforms when results are below the MDL for both analyses.

All raw data can be found at the EPA Water Quality Portal (<https://www.waterqualitydata.us/>).

Sample results are compared to data collected in 2020 and 2021 (ARRI 2020b, ARRI 2021).

Anchorage-Cook Inlet

Sampling locations in Knik Arm and Cook Inlet near the Port of Anchorage are shown in Figure 2. 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 1, 2022, are shown in Table 2. Salinity was low near 11 ppt. Water temperatures were warm compared to other ports averaging 16.4°C at 1m water depth. Dissolved oxygen averaged 9.3 mg/L. We were unable to measure pH due to equipment failure. 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 3), consistent with previous years.

Ammonia-N concentrations were below the MDL at all sampling stations. Total and dissolved metals concentrations exceed WQC for Cu at multiple sampling stations (Table 3). Concentrations of metals were highest at AN03.

Low concentrations of ammonia-N and high metals concentrations were consistent with 2020 and 2021 values.

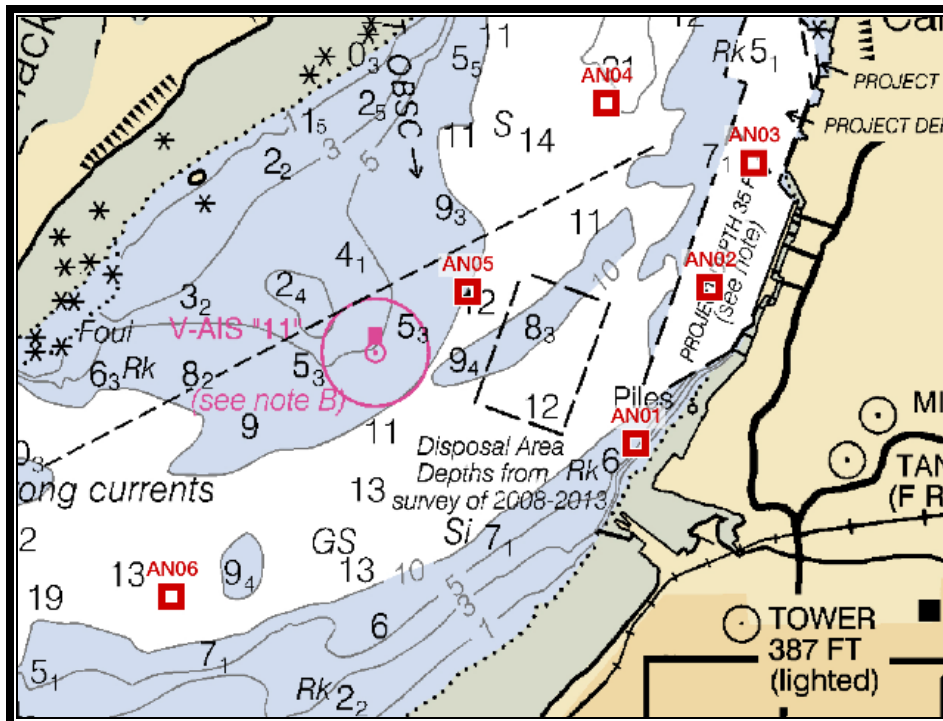


Figure 2. Chart showing Port of Anchorage sampling stations.

Table 2. Port of Anchorage water temperature (Temp), salinity, and dissolved oxygen (D.O.) on July 1, 2022, at 1, 2, 3, and 4 m water depths. Ph data were not reported in this port due to equipment failure.

Temp (C)	1m	2m	3m	4m	Salinity (ppt)	1m	2m	3m	4m
AN01	16.20	16.00	16.00	16.00	AN01	10.29	10.87	11.28	11.42
AN02	16.20	16.00	15.90	15.90	AN02	10.58	10.68	10.99	11.00
AN03	16.10	16.00	15.90	15.90	AN03	10.42	10.44	10.49	10.65
AN04	16.10	16.10	15.90	15.90	AN04	10.57	10.64	10.97	10.91
AN05	16.70	16.30	16.10	16.00	AN05	10.26	10.50	10.96	11.15
AN06	17.10	16.40	16.30	16.30	AN06	10.85	11.06	11.27	11.24
Average	16.40	16.13	16.02	16.00	Average	10.50	10.70	10.99	11.06

pH	1m	2m	3m	4m	D.O. (mg/L)	1m	2m	3m	4m
AN01					AN01	9.43	9.38	9.34	9.33
AN02					AN02	9.27	9.36	9.34	9.33
AN03					AN03	9.28	9.34	9.36	9.36
AN04					AN04	9.34	9.35	9.34	9.35
AN05					AN05	9.03	9.19	9.24	9.25
AN06					AN06	9.05	9.13	9.17	9.19
Average					Average	9.23	9.29	9.30	9.30

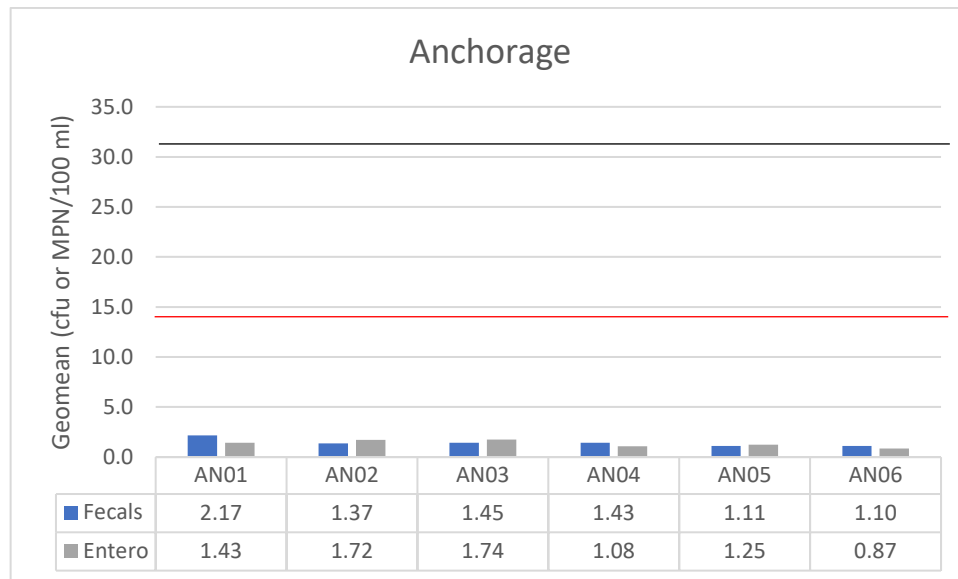


Figure 3. Port of Anchorage geometric mean (n = 5) abundance of fecal coliforms (FC) and *Enterococci* bacteria from samples taken between 6/29/22 and 7/8/22. WQC for fecal coliforms is 14 cfu/100 ml (red line) and for *Enterococci*, 31 MPN/100 ml (black line).

Table 3. Concentrations of ammonia-N, total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Anchorage sites. Values that exceed WQC are bolded.

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)
AN01	0.012	15.3	4.1	8.8	2.8	18.8	4.5
AN02	0.012	14.3	7.7	8.5	4.5	17.2	8.9
AN03	0.013	25.0	10.8	12.1	6.4	28.2	13.0
AN04	0.021	14.2	11.0	9.2	7.7	18.4	15.2
AN05	0.008	12.1	10.7	7.4	6.1	15.2	13.0
AN06	0.014	12.7	9.5	8.3	6.2	17.2	11.3
Average	0.013	15.6	9.0	9.1	5.6	19.2	11.0

Kodiak

The location of sampling sites near Kodiak are shown in Figure 4. 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 12 sampling date averaged 10.5 °C at 1m water depth (Table 4). Salinity averaged 31 ppt, pH 8.1, and dissolved oxygen 9.88 at 1m water depth. There were no consistent differences with water depth or among stations.

Geometric mean concentration of fecal coliforms and *Enterococci* were below WQC (Figure 5). The highest geometric mean was at KO01, within the small boat harbor. A high *Enterococci* value of 1730 MPN/100 ml was recorded at KO01 similar to 2021. Concentrations of fecal coliforms and *Enterococci* were similar to 2021 values and lower than values in August of 2020.

Average ammonia-N concentration was 0.05 mg/L (Table 5). Average concentrations of total and dissolved Cu, Ni were < 1.0 µg/L and Zn < 2.0 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 2022 were similar to 2021 and 2020 concentrations.

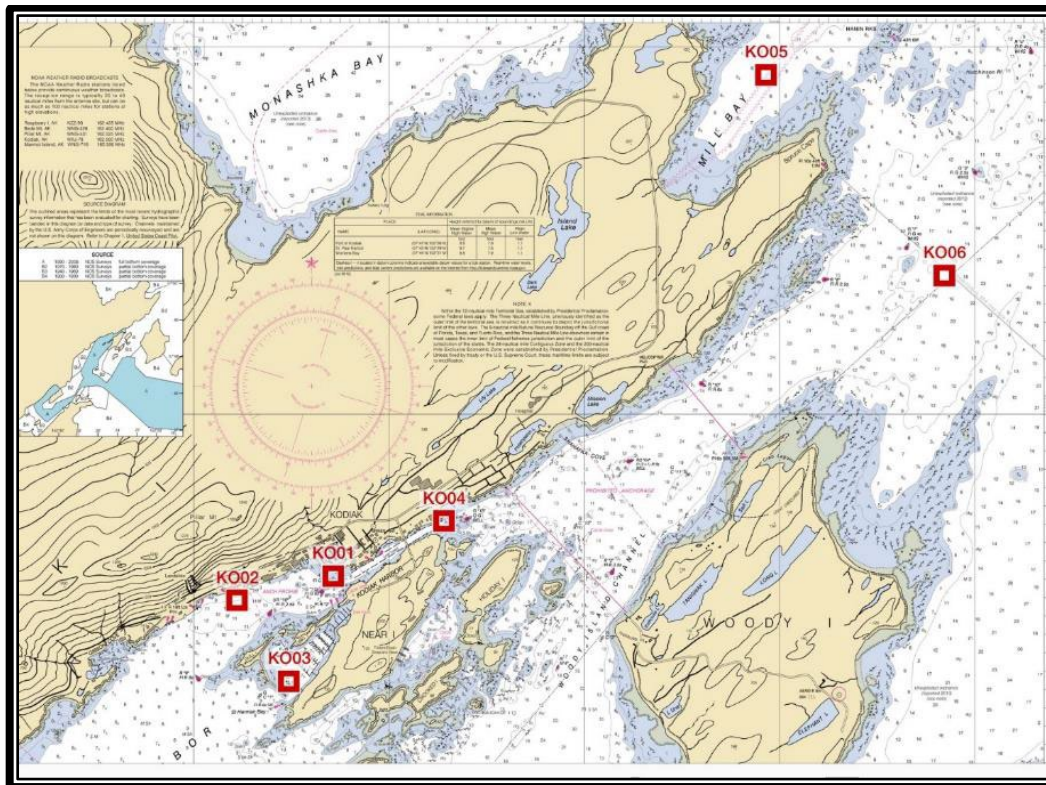


Figure 4. Port showing Port of Kodiak sampling stations. Sampling Station KO05 was not sampled in 2022.

Table 4. Port of Kodiak water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) on July 12, 2022, at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m	Salinity (ppt)	1m	2m	3m	4m
KO01	10.10	10.00	9.90	9.80	KO01	31.60	31.6	31.20	31.70
KO02	10.60	10.40	10.10	10.00	KO02	31.42	31.57	31.65	31.67
KO03	12.00	11.20	10.50	10.30	KO03	31.40	31.42	31.60	31.64
KO04	10.10	10.10	10.00	10.00	KO04	31.62	31.64	31.66	31.70
KO06	9.90	9.90	9.80	9.70	KO06	31.75	31.79	31.83	31.83
Average	10.54	10.32	10.06	9.96	Average	31.56	31.60	31.59	31.71

pH	1m	2m	3m	4m	D.O. (mg/L)	1m	2m	3m	4m
KO01	7.97	7.95	7.97	7.96	KO01	9.30	9.29	9.29	9.33
KO02	8.08	8.09	8.08	8.05	KO02	9.87	9.99	9.98	9.89
KO03	8.13	8.24	8.10	8.08	KO03	10.50	10.72	10.77	10.66
KO04	8.08	8.08	8.08	8.17	KO04	9.60	9.71	9.75	9.80
KO06	8.09	8.09	8.13	8.08	KO06	10.13	10.22	10.34	10.37
Average	8.07	8.09	8.07	8.07	Average	9.88	9.99	10.03	10.01

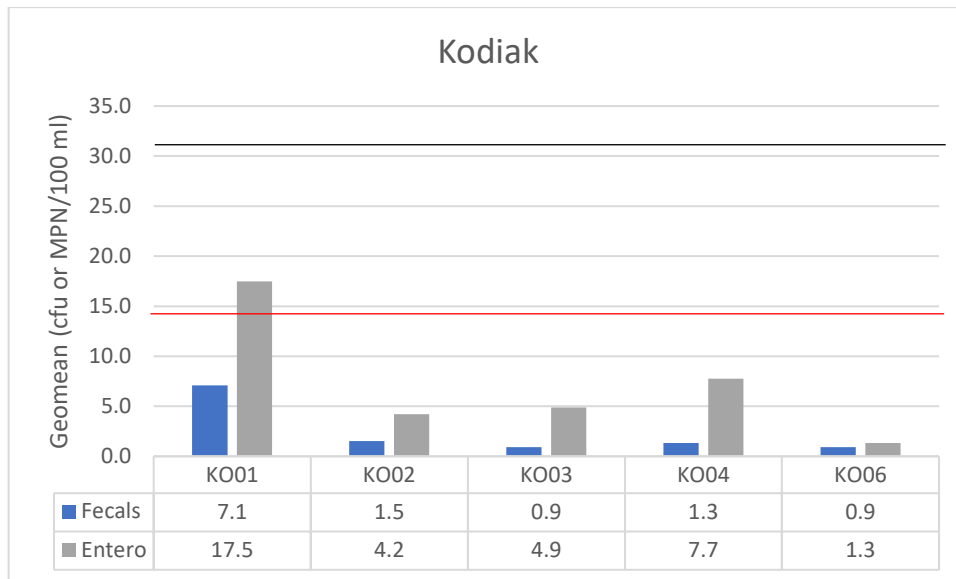


Figure 5. Port of Kodiak geometric mean (n = 5) abundance of fecal coliforms (FC) and *Enterococci* bacteria from samples collected between 6/16/22 and 7/12/22. WQC for fecal coliforms is 14 cfu/100 ml (red line) and for *Enterococci*, 31 MPN/100 ml (black line).

Table 5. Concentrations of ammonia-N, and total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Kodiak sampling stations in 2022.

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)
KO01	0.085	0.60	0.63	0.35	0.34	3.17	4.13
KO02	0.047	0.30	0.31	0.36	0.34	0.90	0.88
KO03	0.010	0.45	0.44	0.32	0.31	2.49	2.47
KO04	0.073	0.39	0.29	0.34	0.32	1.21	0.91
KO06	0.028	0.16	0.22	0.30	0.29	0.39	0.78
Average	0.049	0.38	0.38	0.33	0.32	1.63	1.83

Dutch Harbor

Sampling stations in Dutch Harbor and Iliuliuk Bay are shown in Figure 6.

Water temperatures on June 26, 2022 averaged 8.3°C at the water surface and 7.2°C at 4m water depth (Table 6). Salinity was over 30 ppt and did not vary with location or water depth. Water pH was 8.0 at all depths. Dissolved oxygen averaged near 11 mg/L at all depths but was lower at DH06 compared to other stations.

Fecal coliform bacteria and *Enterococci* were below WQC (Figure 7). A single high *Enterococci* value of 350 MPN/100 ml was recorded at DH03. Fecal coliforms and *Enterococci* abundance were similar to previous measures.

Ammonia-N and the concentration of metals were low at all sampling stations (Table 7). Ammonia-N averaged 0.06 mg/L. Cu and Ni concentrations were < 1 µg/L at all sampling stations and average Zn concentrations < 1.5 µg/L with the highest values at DH02, DH03, and DH06 as in 2021.

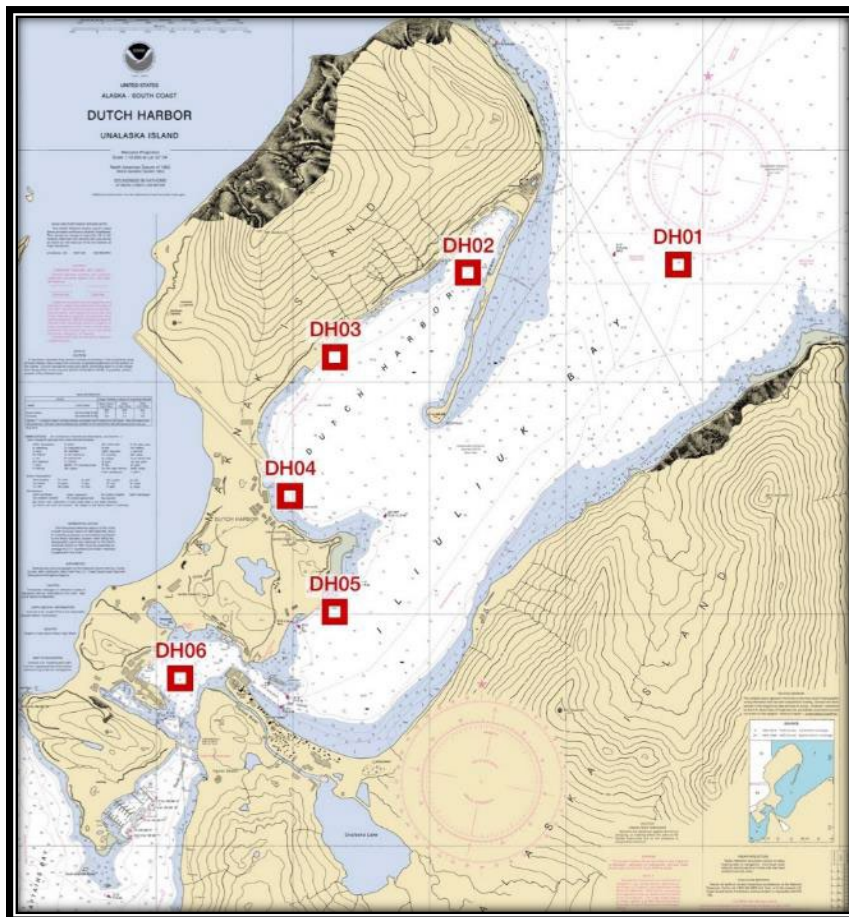


Figure 6. Chart showing Dutch Harbor sampling stations.

Table 6. Dutch Harbor water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) on June 26, 2022, at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m	Salinity (ppt)	1m	2m	3m	4m
DH01	7.20	7.10	7.10	7.10	DH01	31.70	31.70	31.70	31.80
DH02	8.20	7.40	7.10	7.00	DH02	31.50	31.80	31.70	31.80
DH03	8.40	7.40	7.60	6.80	DH03	31.60	31.70	31.70	31.80
DH04	9.00	8.80	8.70	7.70	DH04	31.10	31.30	31.30	31.60
DH05	9.00	8.90	7.50	7.40	DH05	31.20	31.40	31.70	31.60
DH06	7.90	7.60	7.50	6.80	DH06	30.30	30.80	31.00	31.60
Average	8.28	7.87	7.58	7.13	Average	31.23	31.45	31.52	31.70

pH	1m	2m	3m	4m	D.O. (mg/L)	1m	2m	3m	4m
DH01	7.56	7.65	7.66	7.63	DH01	11.59	11.66	11.72	11.73
DH02	7.68	7.53	7.52	7.51	DH02	11.80	11.99	11.30	11.41
DH03	7.76	7.74	7.75	7.77	DH03	12.98	11.50	11.78	10.98
DH04	8.10	8.12	8.12	8.12	DH04	12.88	13.04	12.63	10.87
DH05	8.45	8.47	8.54	8.56	DH05	13.81	13.69	12.18	11.92
DH06	8.40	8.36	8.37	8.31	DH06	7.72	7.42	7.26	6.82
Average	7.99	7.98	7.99	7.98	Average	11.80	11.55	11.15	10.62

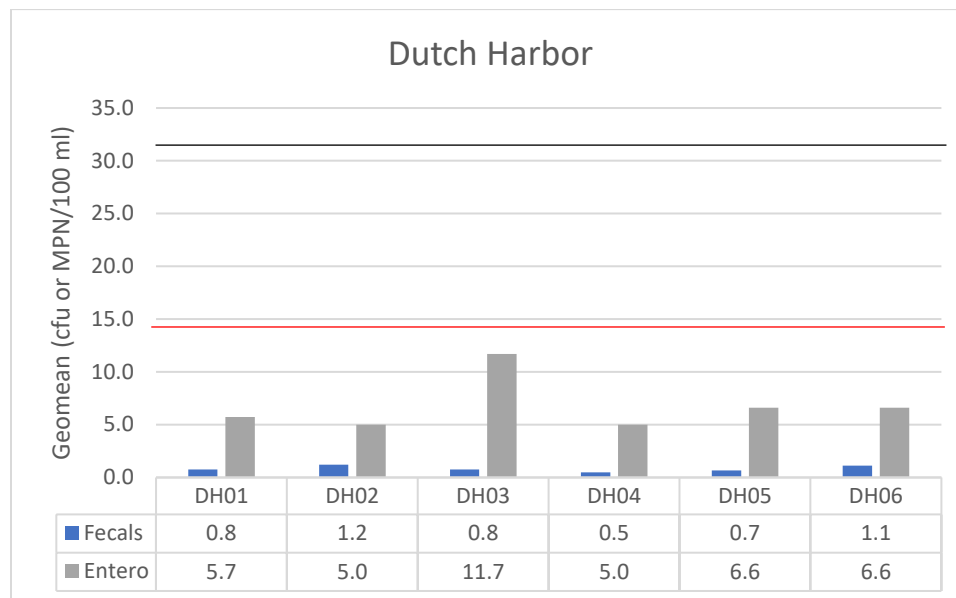


Figure 7. Dutch Harbor geometric mean (n = 6) abundance of fecal coliforms (FC) and *Enterococci* bacteria from samples collected between 6/24/22 and 6/28/22. WQC for fecal coliforms is 14 cfu/100 ml (red line) and for *Enterococci*, 31 MPN/100 ml (black line).

Table 7. Concentrations of ammonia-N, and total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Dutch Harbor sites.

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)
DH01	0.072	0.20	0.30	0.31	0.34	0.31	0.41
DH02	0.004	0.57	0.59	0.32	0.29	2.43	2.37
DH03	0.036	2.47	2.44	0.33	0.33	2.07	1.99
DH04	0.008	0.31	0.35	0.33	0.31	0.88	0.88
DH05	0.005	0.29	0.34	0.31	0.30	0.91	0.84
DH06	0.226	0.46	0.65	0.30	0.31	2.02	2.11
Average	0.059	0.72	0.78	0.32	0.31	1.44	1.43

Nome-Norton Sound

Sampling sites near Nome were located at the Cruise Ship Berth (NO01), Inner Harbor (NO02), near the beach camps (NO03), off of Front Street (NO04), and offshore (NO06) (Figure 8).

A single cruise ship was present in Nome on July 23, 2022 two days prior to the first bacteria sampling.

There were only minor differences in water temperature, salinity, pH and dissolved oxygen with water depth, and no consistent differences among sampling sites. Average water temperature on the July 28 sampling date was 11.7°C at 1m and 12.3°C at 4m water depth (Table 8). Average salinity was 22.9 ppt at 1m and 28.6 ppt at 4m, pH 8.1, and dissolved oxygen 9.3 mg/L at 1m and 8.9 mg/L at 4m water depth.

Geometric mean fecal coliforms and *Enterococci* were below WQC (Figure 9). There were no large differences among sites and no single high values. Bacteria concentrations were similar to 2021 values but < values in 2020 at NO02.

Ammonia-N concentrations were near the MDL at all sampling sites (Table 9). Metals data for NO02 were removed because dissolved concentrations were greater than total concentrations. However, in 2021 concentrations of dissolved Cu and Zn also were greater than total concentrations at NO02. Total and dissolved Cu, Ni, and Zn concentrations were <1 µg/L.

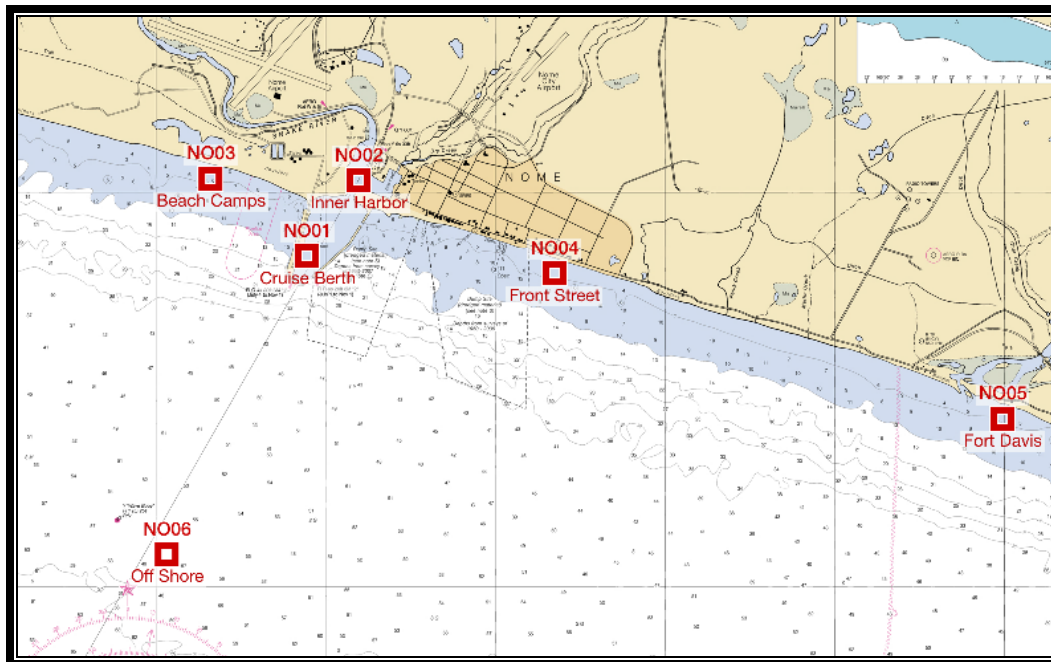


Figure 8. Chart showing Port of Nome sampling stations. NO05 was not sampled in 2021 or 2022.

Table 8. Port of Nome water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) on July 28, 2022, at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m	Salinity (ppt)	1m	2m	3m	4m
NO01	12.00	12.40	12.40	12.40	NO01	25.98	28.48	28.54	28.57
NO02	10.00	12.20	12.40		NO02	3.17	28.08	28.47	
NO03	12.00	12.20	12.20	12.20	NO03	28.30	28.62	28.30	28.63
NO04	12.10	12.10	12.10	12.10	NO04	28.44	28.44	28.43	28.42
NO06	12.20	12.30	12.40	12.60	NO06	28.66	28.77	28.86	28.95
Average	11.66	12.24	12.30	12.33	Average	22.91	28.48	28.52	28.64
pH	1m	2m	3m	4m	D.O. (mg/L)	1m	2m	3m	4m
NO01	7.91	7.92	7.92	7.92	NO01	9.08	8.96	8.94	8.93
NO02	7.68	7.83	7.83		NO02	10.22	8.80	8.57	
NO03	8.53	8.41	8.31	8.30	NO03	9.00	8.94	8.90	8.88
NO04	8.58	8.45	8.38	8.26	NO04	9.00	8.99	8.99	8.98
NO06	8.05	8.03	8.11	8.00	NO06	8.98	8.94	8.91	8.86
Average	8.15	8.13	8.11	8.12	Average	9.26	8.93	8.86	8.91

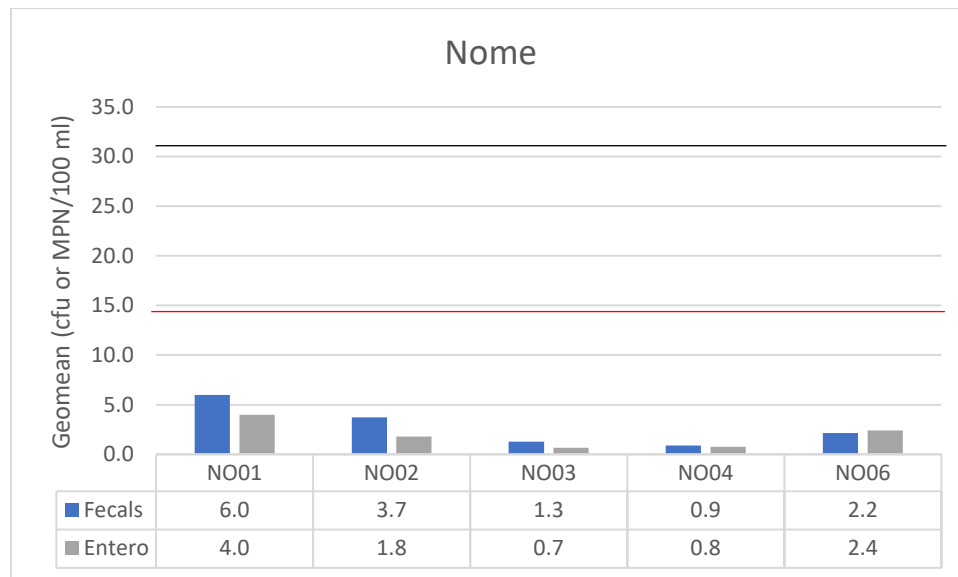


Figure 9. Port of Nome geometric mean (n = 5) abundance of fecal coliforms (FC) and *Enterococci* bacteria from samples collected between 7/25/22 and 8/1/22. WQC for fecal coliforms is 14 cfu/100 ml (red line) and for *Enterococci*, 31 MPN/100 ml (black line).

Table 9. Concentrations of ammonia-N and total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Nome sampling stations.

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)
NO1	0.017	0.62	0.56	0.74	0.68	1.53	0.91
NO2	0.013						
NO3	0.017	0.91	0.85	1.00	0.95	0.82	0.73
NO4	0.008	0.89	0.85	0.96	0.94	0.62	0.59
NO6	0.007	0.85	0.80	0.88	0.86	0.68	0.38
Average	0.012	0.82	0.77	0.90	0.86	0.91	0.65

Valdez-Valdez Arm

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 10).

A single cruise ship was docked in Valdez on August 3, 19, and 23, 2022.

Salinity, temperature, dissolved oxygen, and to a lesser extent pH, varied with water depth in Valdez Arm (Table 10). Surface waters were less saline on the August 8 sampling date averaging 2 ppt at 1m water depth and 220ppt at 4m. Water temperatures were approximately 5°C cooler, and dissolved oxygen 2 mg/L higher at 1m compared to 4m water depth. Water pH was near 8 at all sampling sites and depths.

The geometric mean of five fecal coliform bacteria samples exceeded WQC at VA04 and VA05 (Figure 11). The maximum fecal coliform count was 61 cfu/100ml. These results are less than geometric mean fecal coliform counts in 2020 and 2021 when WQC were exceeded at multiple sampling stations. Geometric mean *Enterococci* concentrations were above WQC at VA04 (geomean of 42 MPN/100ml) and had a single high value of 299 MPN/100ml.

Ammonia-N concentration averaged 0.045 mg/L (Table 11). Average total and dissolved metals were < 3 µg/L. Concentrations of metals were high relative to other ports except Anchorage and Seward, and exceeded WQC at VA05. Similar relative high metals concentrations are consistent with 2020 and 2021 results.

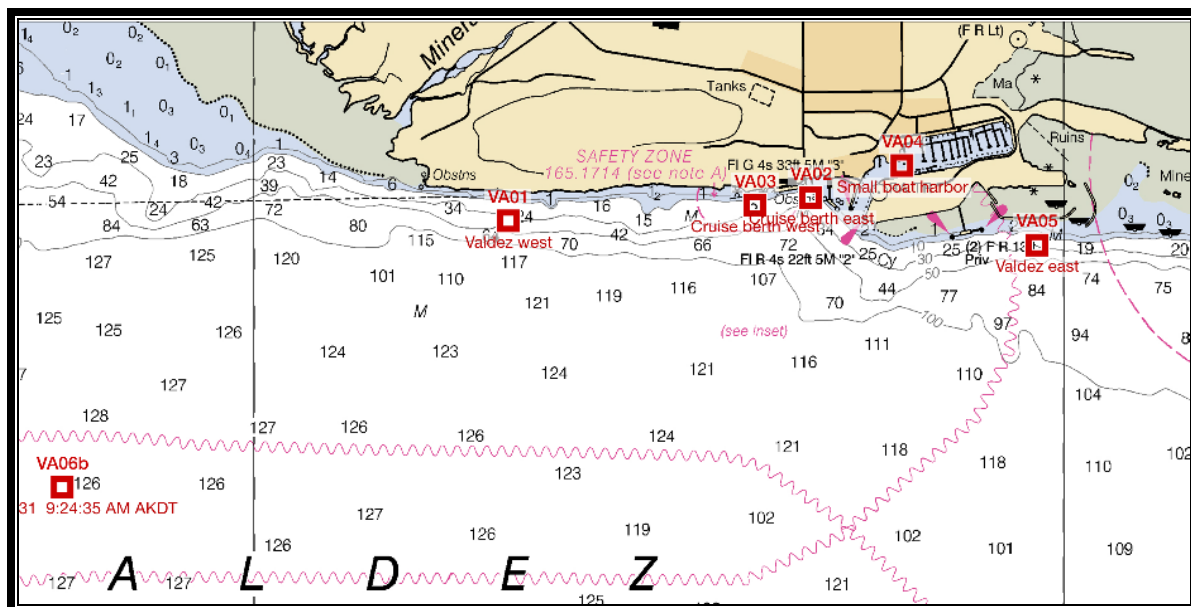


Figure 10. Port of Valdez sampling stations.

Table 10. Port of Valdez water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) on August 8, 2022, at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m	Salinity (ppt)	1m	2m	3m	4m
VA01	6.40	8.80	13.50	14.00	VA01	0.88	8.06	19.72	21.00
VA02	7.40	8.40	10.00	13.50	VA02	2.85	6.83	13.89	19.60
VA03	7.20	8.30	12.50	14.10	VA03	2.38	5.74	15.20	19.97
VA04	8.40	10.00	11.50	12.60	VA04	3.94	8.95	15.27	19.65
VA05	5.00	6.60	10.90	12.40	VA05	0.87	2.97	13.90	17.72
VA06	7.50	9.10	14.00	13.90	VA06	2.26	7.01	18.53	22.08
Average	6.98	8.53	12.07	13.42	Average	2.20	6.59	16.09	20.00

pH	1m	2m	3m	4m	D.O. (mg/L)	1m	2m	3m	4m
VA01	7.94	8.05	8.29	8.29	VA01	12.34	11.67	10.13	9.86
VA02	7.96	8.08	8.20	8.24	VA02	11.27	11.55	10.66	9.90
VA03	7.89	7.94	8.32	8.38	VA03	11.54	11.32	10.41	9.89
VA04	7.60	7.77	8.01	8.13	VA04	11.45	11.07	10.43	9.80
VA05	8.08	8.05	8.29	8.28	VA05	12.62	12.33	10.66	10.05
VA06	8.31	8.68	8.67	8.60	VA06	12.08	11.66	9.98	9.63
Average	7.96	8.10	8.30	8.32	Average	11.88	11.60	10.38	9.86

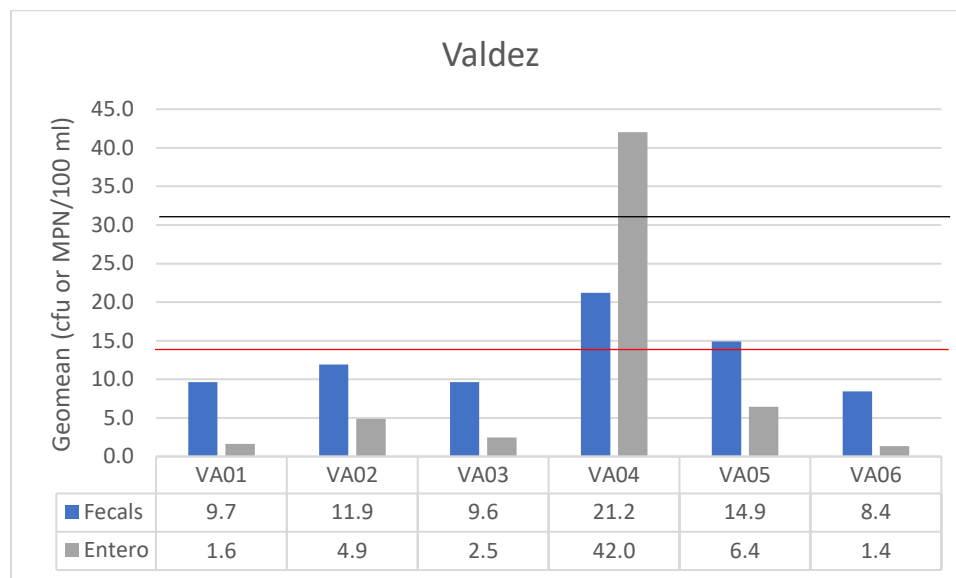


Figure 11. Port of Valdez geometric mean (n = 6) abundance of fecal coliforms (FC) and *Enterococci* bacteria from samples collected between 8/4/22 and 8/24/22. WQC for fecal coliforms is 14 cfu/100ml (red line) and for *Enterococci*, 31 MPN/100 ml (black line).

Table 11. Concentrations of ammonia-N and total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Valdez sampling stations. Values above WQC are bolded.

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)
VA01	0.049	1.04	0.55	1.26	0.90	1.71	0.99
VA02	0.047	1.37	0.64	1.65	1.03	2.16	1.04
VA03	0.057	1.80	0.83	2.03	1.21	3.03	1.42
VA04	0.036	2.19	1.09	1.87	1.15	5.63	3.80
VA05	0.047	8.92	4.64	5.90	3.80	10.50	5.64
VA06	0.033	0.97	0.44	1.14	1.31	1.26	0.48
Average	0.045	2.72	1.37	2.31	1.57	4.05	2.23

Whittier-Passage Canal

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 12).

Water sampling was conducted between June 16 and July 6, 2022. Cruise ships were docked at Whittier on 8 days during the sampling period.

Average salinity was 5 ppt lower at the 1m (19 ppt) than at 4m water depth (24 ppt) but there were no consistent differences in temperature, pH or dissolved oxygen with water depth (Table 12). Water temperature was 13.5°C on the June 21 sampling date, pH was 8.3, and dissolved oxygen 10.3 mg/L.

Geometric mean fecal coliforms and *Enterococci* bacteria were near or at the MDL at all sampling sites (Figure 13). A single high fecal coliform value of 28 cfu/100 ml occurred at WH05. The 2022 fecal coliform results are lower than in 2020 and 2021.

Average ammonia-N concentration was 0.012 mg/L (Table13). Average concentrations of total and dissolved Cu and Ni were < 0.6 µg/L, and Zn < 1.2 µg/L. Ammonia-N and metal concentrations have been similar among sampling years.

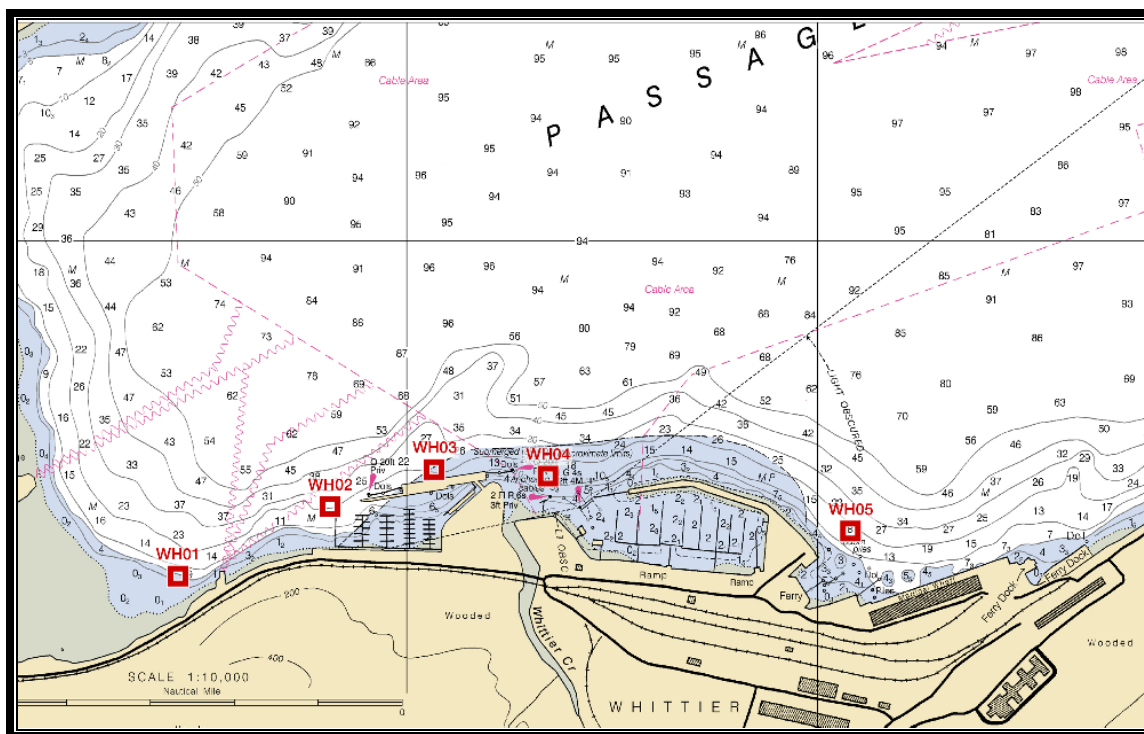


Figure 12. Port of Whittier sampling stations. Station WH06 located at Decision Point is not shown. Station WH03 was not sampled in 2021 or 2022.

Table 12. Port of Whittier water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) on July 21, 2022, at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m	Salinity (ppt)	1m	2m	3m	4m
WH01	11.70	14.20	14.10	13.40	WH01	10.60	23.03	22.95	23.99
WH02	14.10	14.00	13.60	13.40	WH02	21.30	22.49	23.30	23.95
WH04	14.40	14.10	13.60	12.60	WH04	20.31	21.88	23.72	24.90
WH05	14.40	14.30	13.60	13.50	WH05	21.38	21.42	23.82	23.82
WH06	13.20	13.90	13.80	13.70	WH06	18.57	22.39	23.49	23.71
Average	13.56	14.10	13.74	13.32	Average	18.43	22.24	23.46	24.07

pH	1m	2m	3m	4m	D.O. (mg/L)	1m	2m	3m	4m
WH01	8.31	8.28	8.29	8.42	WH01	11.41	10.05	10.35	10.53
WH02	8.29	8.27	8.29	8.42	WH02	9.67	9.91	10.15	10.45
WH04	8.15	8.21	8.24	8.35	WH04	9.75	9.87	10.16	10.45
WH05	8.29	8.29	8.30	8.20	WH05	10.16	10.17	10.17	10.45
WH06	8.32	8.32	8.31	8.40	WH06	10.43	10.33	10.35	10.45
Average	8.27	8.27	8.29	8.36	Average	10.28	10.07	10.24	10.47

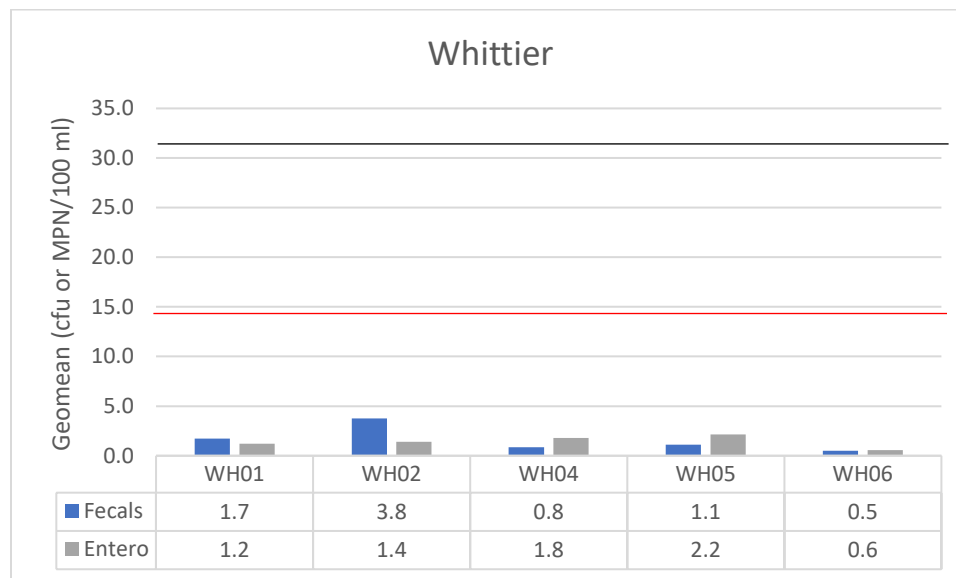


Figure 13. Port of Whittier geometric mean (n = 5) abundance of fecal coliforms (FC) and *Enterococci* bacteria from samples collected between 6/13/22 and 7/6/22. WQC for fecal coliforms is 14 cfu/100 ml (red line) and for *Enterococci*, 31 MPN/100 ml (black line).

Table 13. Concentrations of ammonia-N and total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Whittier sampling stations.

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)
WH01	0.012	0.45	0.46	0.48	0.48	0.59	0.41
WH02	0.006	0.45	0.41	0.49	0.49	0.63	0.43
WH04	0.015	1.16	0.82	0.49	0.49	4.30	2.90
WH05	0.011	0.43	0.40	0.45	0.45	0.59	0.30
WH06	0.018	0.41	0.52	0.48	0.48	0.36	0.24
Average	0.012	0.58	0.52	0.48	0.48	1.29	0.86

Seward-Resurrection Bay

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 14).

Water sampling was conducted between June 3 and June 15, 2022. A total of eight Cruise Ships were docked in Seward during this sampling period.

Average salinity was lower at 1m water depth, (average 6.4 ppt), compared to 4m depth (average 13 ppt). Salinity did not vary with depth at the open water site (SE06) (Table 14). Water temperature was similar among sampling stations and depths. There were only minor differences in pH (~8.0) and dissolved oxygen (~11 mg/L) among stations and depths.

Geometric mean fecal coliforms were below WQC ranging from 3.1 to 13.6 cfu/100 ml (Figure 15). The highest single fecal coliform count was 220 cfu/100 ml at SE03. Fecal coliforms were lower in early June of 2022 and 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 0.016 mg/L (Table 15). Average total metals were <5 µg/L and total Cu exceeded 3.1µg/L at SE01, SE03, and SE05. Concentrations of metals were higher in 2022 compared to 2020 and 2021.

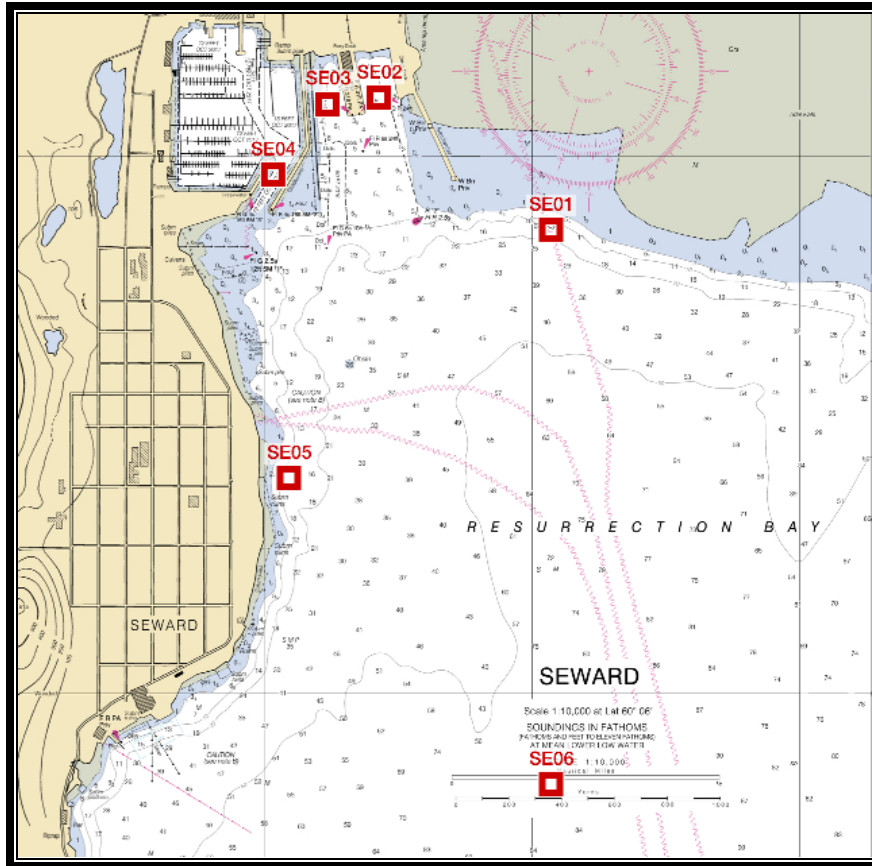


Figure 14. Chart showing Port of Seward sampling stations. SE02 was not sampled in 2021 or 2022.

Table 14. Port of Seward water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) on June 5, 2022, at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m	Salinity (ppt)	1m	2m	3m	4m
SE01	9.60	9.40	9.70	10.10	SE01	1.96	1.89	1.87	4.47
SE03	9.20				SE03	1.85			
SE04	11.80	11.50	11.60	11.90	SE04	9.93	11.16	18.79	25.77
SE05	10.10	10.40	11.00	11.50	SE05	5.02	5.08	5.08	10.07
SE06	13.20	13.20	13.50	13.50	SE06	13.48	13.52	13.57	14.68
Average	10.78	11.13	11.45	11.75	Average	6.45	7.91	9.83	13.75
pH	1m	2m	3m	4m	D.O. (mg/L)	1m	2m	3m	4m
SE01	7.90	7.90	8.03	8.29	SE01	10.89	11.20	11.38	11.33
SE03	7.84				SE03	10.85			
SE04	8.01	7.99	8.04	8.03	SE04	11.04	10.82	10.31	9.99
SE05	8.04	8.17	8.25	8.39	SE05	10.74	10.99	11.00	11.00
SE06	8.38	8.37	8.38	8.54	SE06	11.03	11.04	11.07	11.11
Average	8.03	8.11	8.18	8.31	Average	10.91	11.01	10.94	10.86

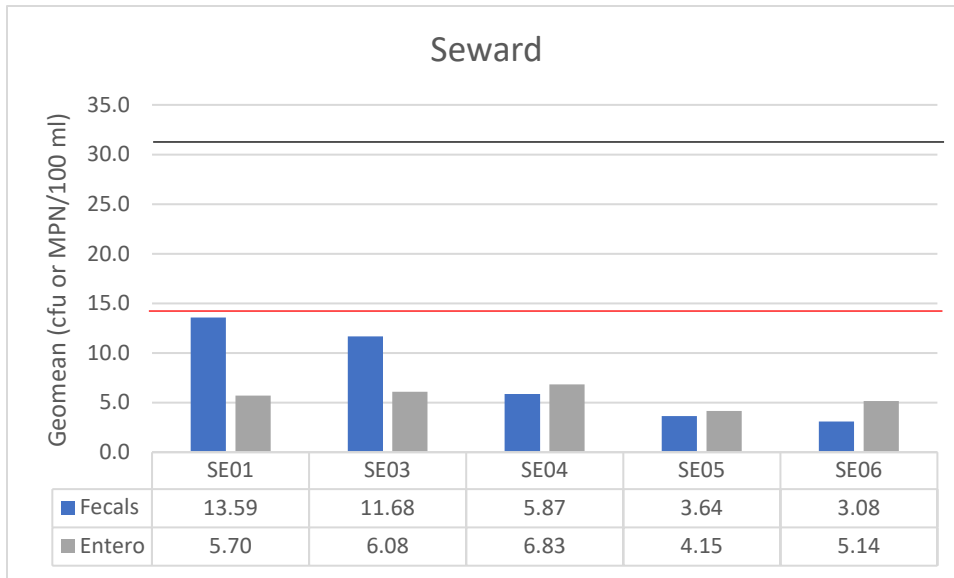


Figure 15. Port of Seward geometric (n = 5) mean abundance of fecal coliforms (FC) and *Enterococci* bacteria from samples collected between 6/3/22 and 6/15/22. WQC for fecal coliforms is 14 cfu/100 ml (red line) and for *Enterococci*, 31 MPN/100 ml (black line).

Table 15. Concentrations of ammonia-N and total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Seward sampling stations.

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)
SE01	0.017	5.76	1.66	4.54	1.76	7.27	1.93
SE03	0.010	9.06	2.79	5.65	2.03	10.10	2.72
SE04	0.040	2.39	1.54	1.07	0.69	6.49	5.34
SE05	0.006	3.57	1.21	2.76	1.00	4.19	1.28
SE06	0.009	1.63	0.65	1.33	0.63	1.82	0.39
Average	0.016	4.48	1.57	3.07	1.22	5.97	2.33

Homer-Kachemak Bay

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 16).

Sampling was conducted between July 18 and July 27, 2022. No Cruise Ships were docked in Homer during the sampling period.

There were no apparent trends in water temperature, salinity, pH, or dissolved oxygen among sampling stations or with water depth (Table 16). Water temperature averaged 10.5 °C, salinity was near 27 ppt, average pH was 8.3 and dissolved oxygen 10.2 mg/L. Dissolved oxygen was slightly lower at HO02, within the small boat harbor.

Geometric mean fecal coliform bacteria and *Enterococci* abundances were below WQC at all sampling station except HO02 where the geomean was 31.6 with single high values of 74 and 57 cfu/100ml. (Figure 17). The abundance of bacteria was similar measures in 2020 and 2021, with highest values at HR02.

Ammonia-N concentrations averaged 0.027 on July 21, 2022 (Table 17.) The average concentration of total and dissolved metals were $\leq 1 \mu\text{g/L}$ in 2022 consistent with previous years. Highest concentrations of metals were at HR02.

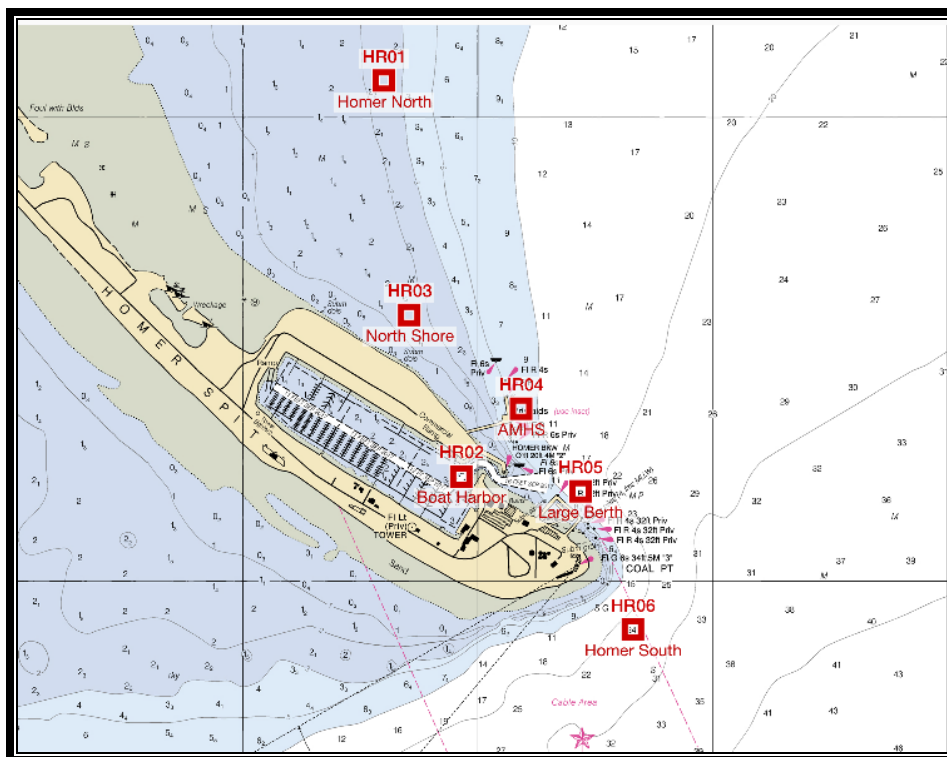


Figure 16. Chart showing Port of Homer sampling stations. HR04 was not sampled on 2021 or 2022.

Table 16. Port of Homer water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) on July 21, 2022, at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m	Salinity (ppt)	1m	2m	3m	4m
HR01	10.40	10.30	10.10	10.00	HR01	27.53	28.02	28.38	28.91
HR02	10.90	10.70	10.60	10.50	HR02	27.71	27.90	27.90	28.44
HR03	10.40	10.20	10.10	10.10	HR03	28.45	28.79	28.86	28.87
HR05	11.40	10.60	10.50	10.40	HR05	26.95	27.49	27.61	27.70
HR06	10.90	10.80	10.70	10.70	HR06	26.00	26.68	26.80	27.21
Average	10.80	10.52	10.40	10.34	Average	27.33	27.78	27.91	28.23

pH	1m	2m	3m	4m	D.O. (mg/L)	1m	2m	3m	4m
HR01	8.30	8.29	8.55	8.50	HR01	10.15	10.32	10.37	10.35
HR02	8.15	8.17	8.21	8.53	HR02	9.85	9.30	9.96	9.91
HR03	8.24	8.21	8.71	8.55	HR03	10.14	10.21	10.21	10.21
HR05	8.42	8.35	8.25	8.14	HR05	10.55	10.68	10.74	10.76
HR06	8.25	8.27	8.33	8.82	HR06	10.52	10.62	10.69	10.71
Average	8.27	8.26	8.41	8.51	Average	10.24	10.23	10.39	10.39

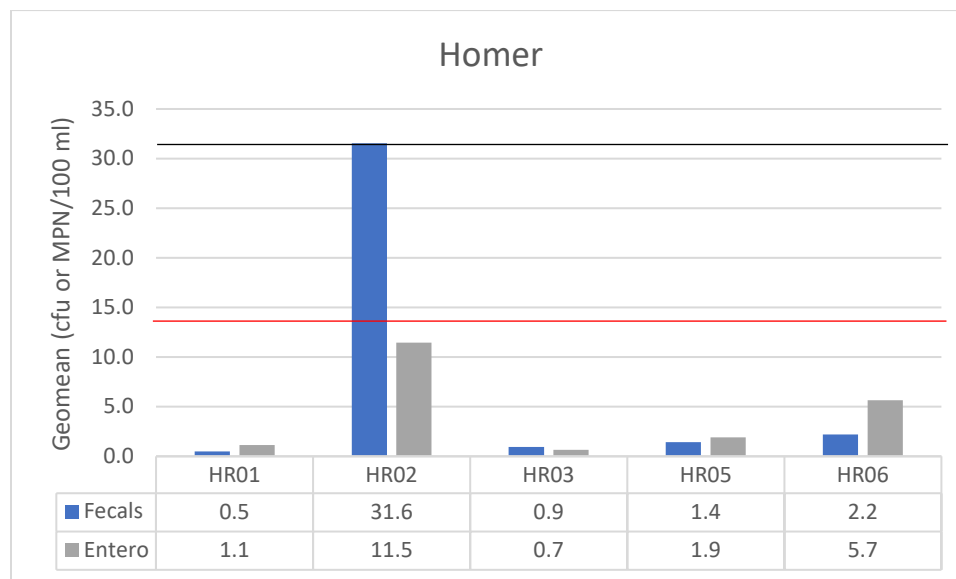


Figure 17. Port of Homer geometric mean (n = 5) abundance of fecal coliforms (FC) and *Enterococci* bacteria from samples collected between 7/18/22 and 7/27/22. WQC for fecal coliforms is 14 cfu/100 ml (red line) for *Enterococci*, 31 MPN/100 ml (black line).

Table 17. Concentrations of ammonia-N and total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Homer sampling stations

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)
HR01	0.032	0.46	0.37	0.47	0.38	0.35	0.10
HR02	0.027	1.00	0.57	0.53	0.39	2.34	1.98
HR03	0.022	0.44	0.33	0.44	0.36	0.35	0.10
HR05	0.037	0.59	0.35	0.54	0.38	0.86	0.10
HR06	0.016	0.48	0.37	0.47	0.40	0.36	0.10
Average	0.027	0.59	0.40	0.49	0.38	0.85	0.48

Haines-Chilkoot Inlet

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 18).

Sampling was conducted between May 16 and May 26, 2022. A total of eight Cruise Ships were docked in Haines during this sampling period.

Water temperatures among Haines sampling stations (Table 18) on the May 17 sampling date averaged 8.7 at 1m and 7.8 at 4m water depth (Table 18). There were no apparent trends in salinity, pH, or dissolved oxygen with water depth. Waters were saline at ~28 ppt, pH averaged 8.7, and dissolved oxygen at 12.6 mg/L.

Geometric mean fecal coliforms and *Enterococci* abundances were below WQC and near the MDL on all sampling dates (Figure 19). The maximum fecal coliform count was 2 cfu/100 ml and the maximum *Enterococci* count was 10. Results were consistent with those obtained in 2020 and 2021.

Ammonia-N concentration averaged 0.01 and average concentrations of all metals were < 0.5 µg/L (Table 19). Concentrations of ammonia-N, Cu, Ni, and Zn were similar to 2020 and 2021 values.

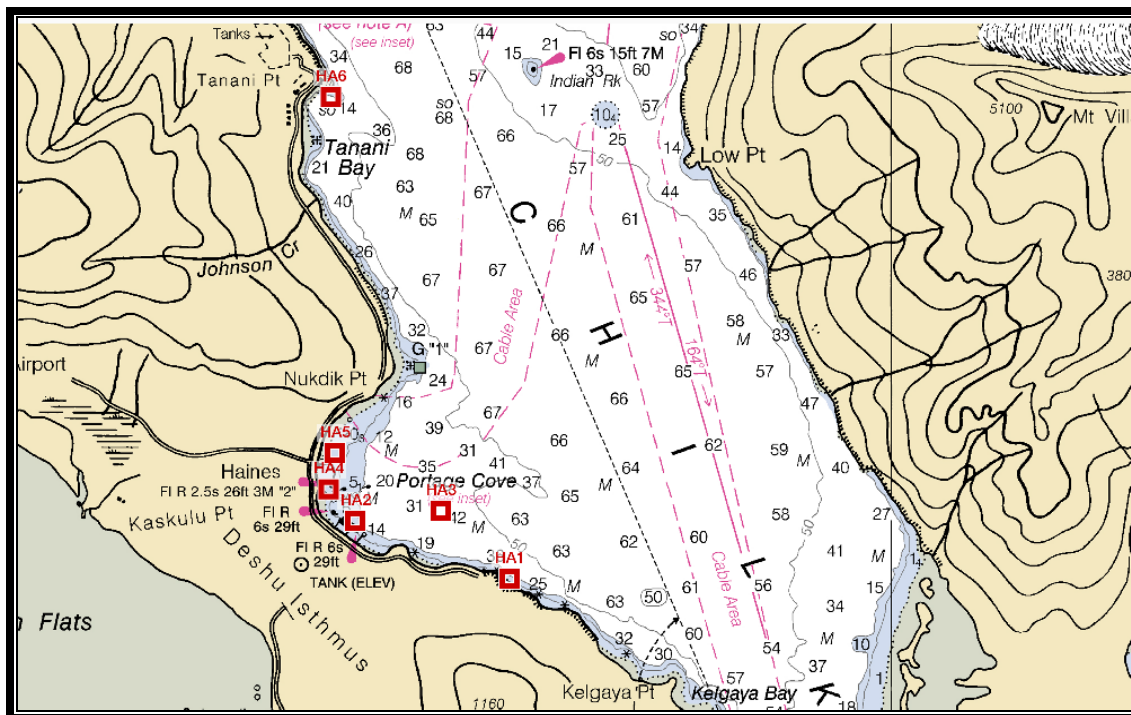


Figure 18. Chart showing Port of Haines sampling stations. HA05 was not sampled in 2021 or 2022

Table 18. Port of Haines water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) on June 17, 2022, at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m	Salinity (ppt)	1m	2m	3m	4m
HA01	8.10	8.00	8.00	8.00	HA01	28.62	28.62	28.63	28.65
HA02	9.10	8.60	8.50	8.30	HA02	27.90	28.20	28.50	28.63
HA03	8.50	8.40	7.80	7.50	HA03	28.26	28.28	28.47	28.77
HA04	9.30	8.50	8.10	7.90	HA04	26.87	27.55	28.50	28.83
HA06	8.60	8.10	7.60	7.40	HA06	28.03	28.16	28.59	28.83
Average	8.72	8.32	8.00	7.82	Average	27.94	28.16	28.54	28.74

pH	1m	2m	3m	4m	D.O. (mg/L)	1m	2m	3m	4m
HA01	8.64	8.64	8.64	8.72	HA01	13.00	13.02	13.08	13.03
HA02	8.61	8.61	8.60	8.66	HA02	12.20	12.20	12.50	12.71
HA03	8.60	8.65	8.61	8.67	HA03	13.06	13.08	13.10	13.19
HA04	8.58	8.60	8.64	8.60	HA04	11.45	11.55	12.16	12.72
HA06	8.63	8.61	8.60	8.70	HA06	13.04	13.10	13.27	13.43
Average	8.61	8.62	8.62	8.67	Average	12.55	12.59	12.82	13.02

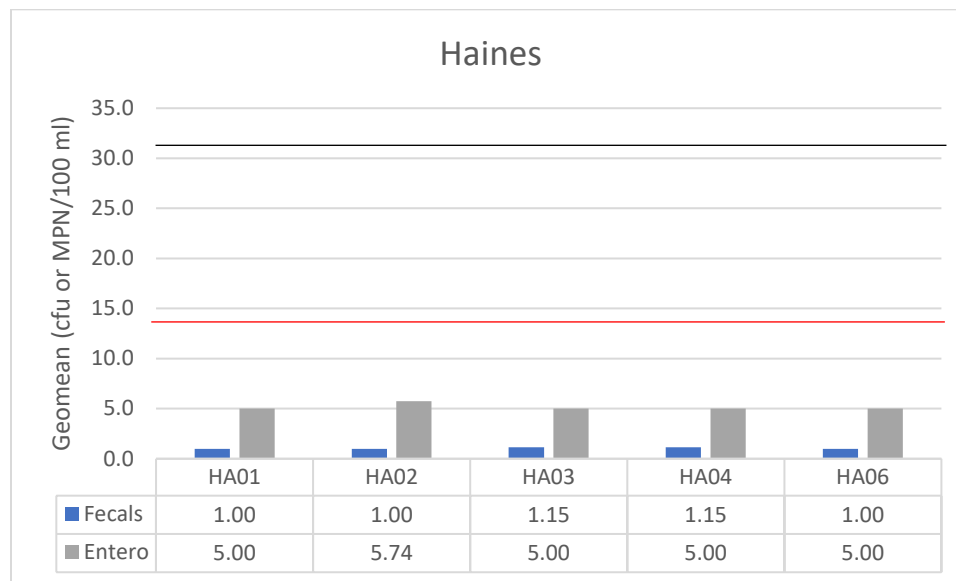


Figure 19. Port of Haines geometric mean (n = 5) abundance of fecal coliforms (FC) and *Enterococci* bacteria from samples collected between 5/16/22 and 5/26/22. WQC for fecal coliforms is 14 cfu/100 ml (red line) and for *Enterococci*, 31 MPN/100 ml (black line).

Table 19. Concentrations of total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Haines sampling stations.

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)
HA01	0.006	0.25	0.20	0.36	0.36	0.10	0.10
HA02	0.008	0.27	0.24	0.38	0.36	0.32	0.39
HA03	0.002	0.28	0.19	0.39	0.34	0.27	0.10
HA04	0.018	0.42	0.32	0.42	0.34	1.16	0.87
HA06	0.012	0.34	0.27	0.40	0.34	0.23	0.10
Average	0.009	0.31	0.24	0.39	0.35	0.42	0.31

Skagway-Taiya Inlet

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 20).

Sampling was conducted between April 28 and May 17, 2022. A total of 35 Cruise Ships were docked in Skagway during this sampling period.

Unlike previous years, salinity was consistent among sampling stations and depths with an average of near 28 ppt on the May 17 sampling date (Table 20). These values are greater than those obtained on May 13, 2021 or June 29, 2020. In 2021 salinity ranged from 14 ppt at 1m water depth to 24 ppt at 4, and in 2020, salinity was 5 ppt or less at all sites and depths. Water temperature in 2022 was ~7.5°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 21). Concentrations of fecal coliforms in 2022 were similar to results from 2020 and 2021 sampling.

Average ammonia-N concentration was 0.014 mg/L. Average total and dissolved Cu and Ni concentrations were < 0.5 µg/L. Concentrations of Zn were higher than in previous years, particularly at SK02 and SK03 (Table 21).

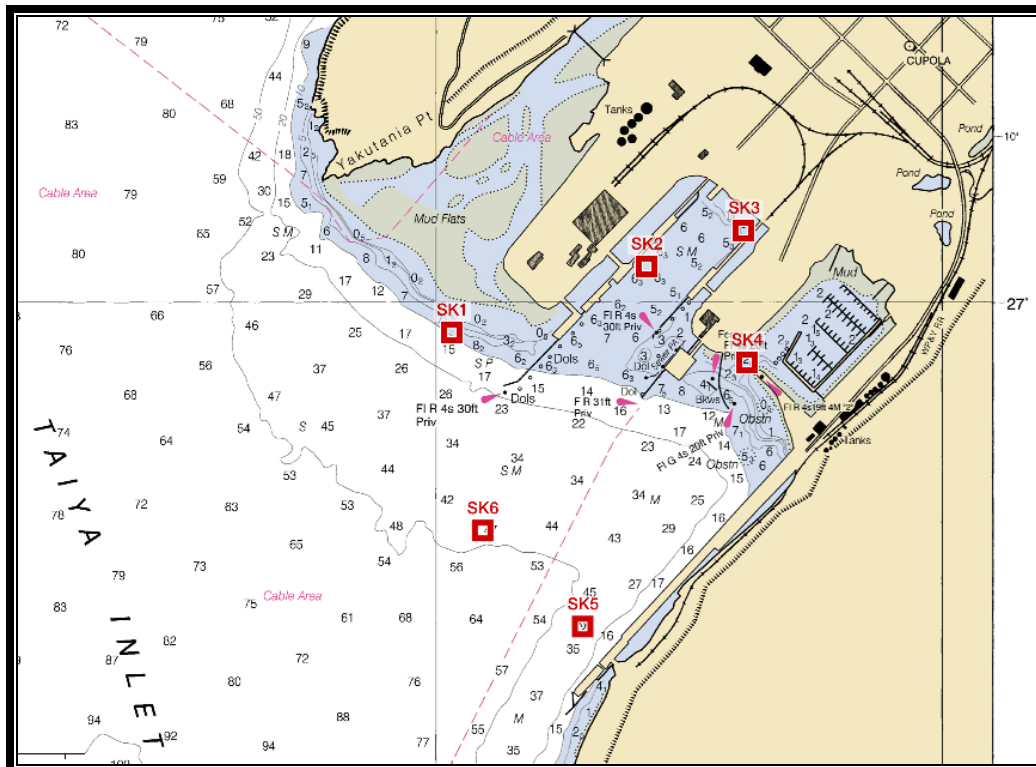


Figure 20. Chart showing the Port of Skagway sampling stations. Station SK07 is within Taiya Inlet to the southwest of this figure. SK06 was not sampled in 2021 or 2022.

Table 20. Port of Skagway water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) on May 17, 2022, at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m	Salinity (ppt)	1m	2m	3m	4m
SK01	7.60	7.60	7.60	7.70	SK01	28.49	27.38	27.72	28.03
SK02	7.60	7.90	7.70	7.70	SK02	25.84	27.40	27.86	28.03
SK03	7.30	7.60	7.70	7.70	SK03	22.28	27.64	27.75	27.90
SK04	7.60	7.60	7.70	7.70	SK04	26.19	26.74	27.39	27.96
SK05	7.70	7.70	7.70	7.70	SK05	28.36	28.37	28.38	28.40
SK07	7.50	7.60	7.60	7.60	SK07	25.82	26.74	27.09	27.54
Average	7.55	7.67	7.67	7.68	Average	26.16	27.38	27.70	27.98
pH	1m	2m	3m	4m	D.O. (mg/L)	1m	2m	3m	4m
SK01	8.60	8.59	8.73	8.66	SK01	12.27	12.14	11.87	11.81
SK02	8.57	8.58	8.71	8.67	SK02	12.11	12.04	11.97	11.91
SK03	8.53	8.58	8.66	8.65	SK03	11.58	11.30	11.74	11.91
SK04	8.59	8.56	8.72	8.65	SK04	10.74	11.15	11.45	11.59
SK05	8.60	8.63	8.67	8.68	SK05	11.33	11.67	12.03	12.18
SK07	8.65	8.62	8.62	8.71	SK07	12.13	12.11	11.98	11.86
Average	8.59	8.59	8.69	8.67	Average	11.69	11.74	11.84	11.88

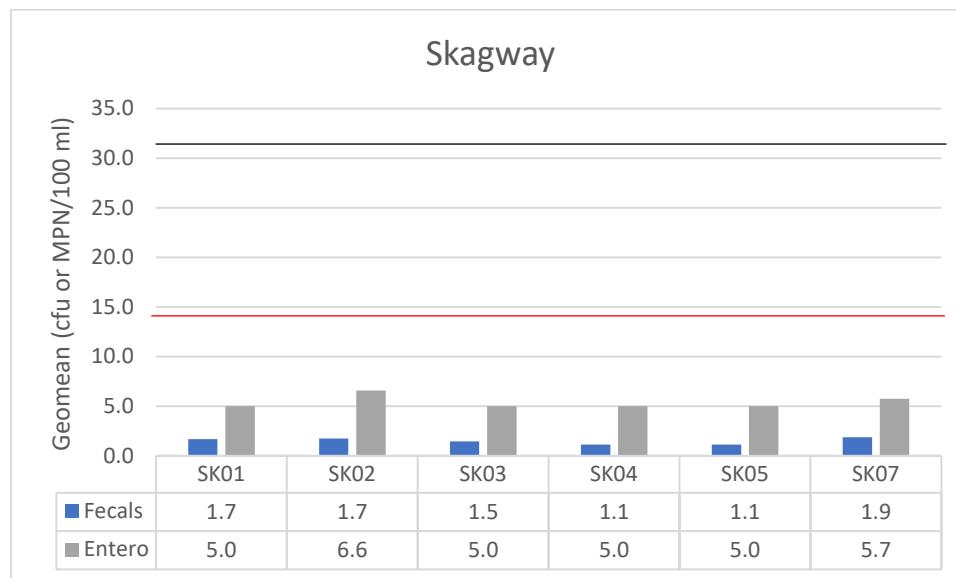


Figure 21. Port of Skagway geometric mean (n = 6) abundance of fecal coliforms (FC) and *Enterococci* bacteria from samples collected between 4/28/22 and 5/17/22. WQC for fecal coliforms is 14 cfu/100 ml (red line) and for *Enterococci*, 31 MPN/100 ml (black line).

Table 21. Concentrations of ammonia-N and total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Skagway sampling stations.

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)
SK01	0.015	0.39	0.26	0.34	0.29	1.55	0.46
SK02	0.017	0.79	0.23	0.48	0.34	13.80	0.78
SK03	0.021	0.78	0.24	0.48	0.32	11.60	1.90
SK04	0.009	0.45	0.29	0.39	0.33	3.94	0.84
SK05	0.006	0.30	0.26	0.38	0.34	0.90	0.28
SK07	0.018	0.27	0.22	0.35	0.33	0.28	0.10
Average	0.014	0.50	0.25	0.40	0.33	5.35	0.73

Juneau-Auke Bay-Gastineau Channel

Sampling sites in Gastineau Channel were located close to downtown and near two tie-ups (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 22). Auke Bay sampling sites were at the entrance to the small boat harbor and at the berth used by the Alaska Marine Highway.

Water sampling in Auke Bay and Gastineau Channel was conducted from May 9 to June 7, 2022. A total of 110 Cruise Ships docked in the Port of Juneau during this sampling period. Four or more ships were present on each sampling date.

Water temperature, salinity, pH and dissolved oxygen were greater in Auke Bay compared to Gastineau Channel (Table 22). Water temperature in Auke Bay on the May 9 sampling date was near 9°C in Auke Bay and 8°C in Gastineau Channel. Salinity was near 27 ppt in Auke Bay and increased slightly with depth. Salinity in Gastineau Channel averaged 23.6 ppt at 1m water depth and 28.3 ppt at 4m water depth. In Auke Bay pH averaged 8.5 and in Gastineau Channel 8.2 and dissolved oxygen 14.2 mg/L and 12.2 mg/L, respectively.

The geometric mean of fecal coliforms and *Enterococci* were near the MDL in May of 2022 (Figure 23). The highest single measure of fecal coliforms was 15 cfu/100 ml at JU12. The geometric mean of fecal coliforms was similar in 2022 and 2021, but lower than values in July of 2020 when concentrations exceeded WQC at JU11.

Ammonia-N and metals concentrations were low in 2020, 2021, and 2022. Average ammonia-N concentration in 2022 was 0.020 mg/L (Table 25). Average total and dissolved Cu, Ni, and Zn concentrations were <1.0 µg/L.

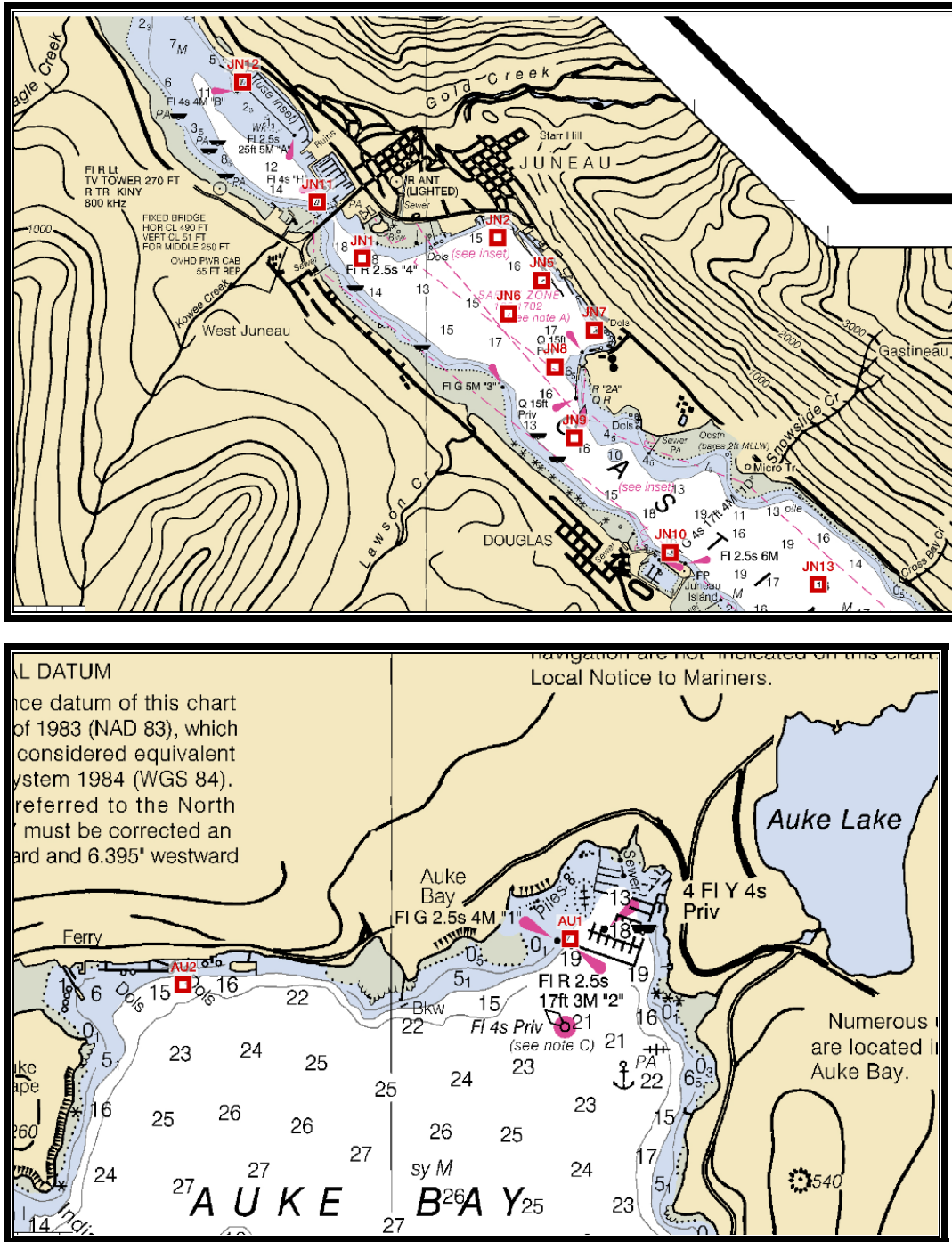


Figure 22. Chart showing Port of Auke Bay and Juneau sampling stations. JU01 and JU05 were not sampled in 2021 or 2022.

Table 22. Port of Juneau (JU) and Auke Bay (AU) water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) on May 9, 2022, at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m	Salinity (ppt)	1m	2m	3m	4m
AU01	8.80	8.40	8.10	7.00	AU01	27.28	27.90	28.59	29.23
AU02	8.90	8.00	6.80	6.40	AU02	26.55	27.99	29.26	29.62
JU02	7.20	6.80	6.60	6.20	JU02	24.99	27.80	27.99	28.50
JU05	7.90	7.30	7.00	6.80	JU05	25.40	26.25	26.90	27.26
JU06	7.80	7.10	6.50	5.80	JU06	23.87	26.40	27.77	28.76
JU07	7.40	7.10	7.10	6.60	JU07	21.31	26.80	27.90	28.66
JU08	7.80	7.20	6.80	6.20	JU08	23.79	25.20	27.20	28.50
JU09	7.70	6.60	6.50	6.10	JU09	23.81	25.52	27.50	27.99
JU10	8.30	7.30	7.20	6.60	JU10	22.50	25.77	26.44	27.95
JU11	7.80	7.30	6.60	6.30	JU11	22.40	24.70	27.45	28.40
JU12	8.40	7.60	6.70	5.90	JU12	25.16	25.85	27.37	29.20
JU13	9.60	7.80	6.80	6.10	JU13	23.27	25.50	28.22	28.16
Average	8.13	7.38	6.89	6.33	Average	24.19	26.31	27.72	28.52
pH	1m	2m	3m	4m	D.O. (mg/L)	1m	2m	3m	4m
AU01	8.58	8.56	8.54	8.56	AU01	13.53	13.56	13.97	14.57
AU02	8.43	8.46	8.49	8.44	AU02	14.81	14.81	14.67	14.23
JU02	8.19	8.16	8.26	8.48	JU02	12.29	12.14	12.50	12.85
JU05	8.20	8.21	8.23	8.45	JU05	12.63	12.53	12.58	12.62
JU06	8.22	8.20	8.22	8.35	JU06	12.00	12.01	12.23	12.36
JU07	8.28	8.22	8.55	8.49	JU07	12.17	11.95	12.84	13.20
JU08	8.26	8.24	8.42	8.27	JU08	12.64	12.53	12.29	12.11
JU09	8.27	8.28	8.28	8.56	JU09	12.62	12.70	12.65	12.35
JU10	8.40	8.27	8.22	8.36	JU10	12.54	12.27	12.34	13.20
JU11	8.15	8.13	8.15	8.17	JU11	11.57	11.57	11.80	12.17
JU12	7.95	7.98	8.13	8.11	JU12	11.28	11.17	11.81	12.07
JU13	8.42	8.37	8.42	8.45	JU13	12.57	12.69	13.63	14.05
Average	8.28	8.26	8.33	8.39	Average	12.55	12.49	12.78	12.98

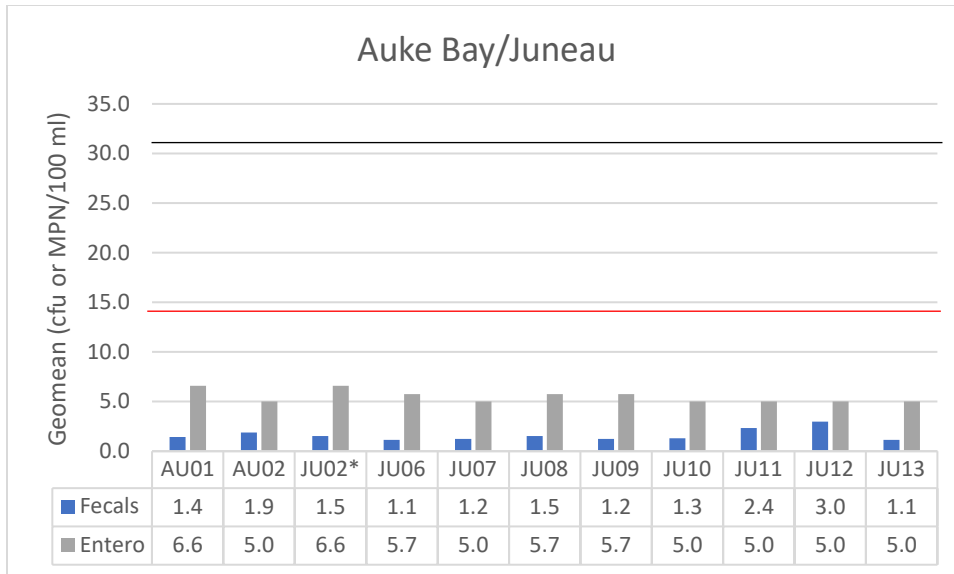


Figure 23. Port of Juneau and Auke Bay geometric mean (n = 12) abundance of fecal coliforms (FC) and *Enterococci* bacteria from samples collected between 5/9/22 and 6/7/22. WQC for fecal coliforms is 14 cfu/100 ml (red line) and for *Enterococci*, 31 MPN/100 ml (black line).

Table 23. Concentrations of ammonia-N, and total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Ports of Auke Bay and Juneau sampling stations.

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)
AU01	0.010	0.36	0.37	0.44	0.43	0.52	0.40
AU02	0.026	0.45	0.51	0.44	0.43	0.87	0.95
JU02	0.021	0.49	0.52	0.54	0.53	0.75	0.71
JU05	0.017	0.68	0.42	0.53	0.51	0.83	0.65
JU06	0.017	0.46	0.42	0.55	0.53	0.87	0.72
JU07	0.031	0.52	0.50	0.57	0.54	1.11	1.06
JU08	0.018	0.48	0.44	0.54	0.52	0.80	0.70
JU09	0.016	0.48	0.45	0.55	0.53	0.74	0.65
JU10	0.012	0.56	0.49	0.57	0.53	0.54	0.42
JU11	0.027	0.49	0.46	0.59	0.57	0.69	0.64
JU12	0.037	0.92	0.85	0.56	0.54	2.50	2.75
JU13	0.008	0.56	0.54	0.60	0.54	0.56	0.56
Average	0.020	0.54	0.50	0.54	0.52	0.90	0.85

Hoonah-Icy Strait

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 24).

Water sampling was conducted on 5 days beginning on May 12 and ending on June 1, 2022. Cruise Ships were docked at Icy Point on 31 days during that sampling period.

Average water temperature was slightly warmer and salinity lower at 1m compared to 4m water depth (Table 24). Average water temperature was ~1.3°C cooler at 1m water depth than at 4m, and average salinity was 27.4 ppt at 1m water depth and 29.7 at 4m. Average water pH was ~8.6 and dissolved oxygen ~14.4 mg/L.

Fecal coliform bacteria and *Enterococci* were present at concentrations well below WQC, with geometric mean fecal coliforms ranging from 1.1 to 2.9 cfu/100 ml (Figure 25). The abundance of these bacteria in water samples collected were slightly lower than those collected in 2020 and 2021.

Concentrations of ammonia-N and metals were low in water samples collected in Icy Strait near Hoonah. Average ammonia-N was 0.004 mg/L and average total and dissolved metals were < 0.5 µg/L (Table 25). Concentrations of ammonia-N and metals also were low in 2020 and 2021 samples.

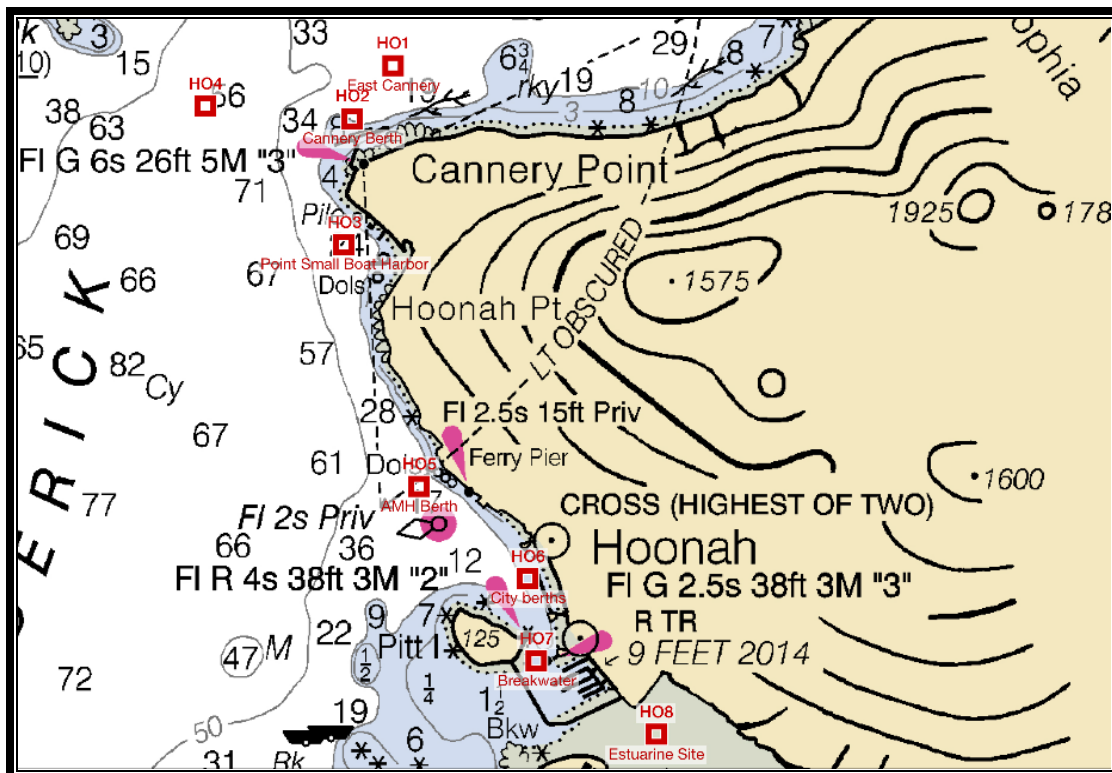


Figure 24. Chart showing Port of Hoonah sampling stations.

Table 24. Port of Hoonah water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) on May 12, 2022, at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m	Salinity (ppt)	1m	2m	3m	4m
HO01	9.10	8.60	8.20	8.10	HO01	27.46	27.90	28.47	29.11
HO02	9.10	8.50	8.30	7.40	HO02	26.71	27.94	28.45	29.78
HO03	8.90	8.00	7.50	7.30	HO03	27.08	28.47	29.25	30.04
HO04	9.00	8.60	7.60	7.60	HO04	27.00	27.85	29.70	29.82
HO05	9.10	8.40	8.10	7.90	HO05	27.56	29.20	29.62	29.74
HO06	8.90	8.80	8.70	8.20	HO06	27.95	28.59	28.87	29.38
HO07	9.20	8.90	8.20	7.50	HO07	27.19	28.14	28.99	29.75
HO08	9.80	8.90	8.60	8.20	HO08	28.60	28.72	29.37	29.65
Average	9.14	8.59	8.15	7.78	Average	27.44	28.35	29.09	29.66
pH	1m	2m	3m	4m	D.O. (mg/L)	1m	2m	3m	4m
HO01	8.70	8.67	8.67	8.68	HO01	14.63	14.76	14.50	14.20
HO02	8.64	8.63	8.54	8.57	HO02	14.40	14.82	15.03	14.34
HO03	8.58	8.57	8.57	8.64	HO03	13.96	14.50	14.90	15.37
HO04	8.67	8.66	8.61	8.68	HO04	14.14	14.33	14.95	15.32
HO05	8.67	8.64	8.64	8.75	HO05	14.03	14.98	15.65	15.87
HO06	8.56	8.61	8.60	8.69	HO06	14.32	14.44	14.96	15.24
HO07	8.65	8.63	8.57	8.67	HO07	14.11	14.07	14.34	14.80
HO08	8.64	8.61	8.66	8.75	HO08	15.35	15.32	15.57	16.15
Average	8.64	8.63	8.61	8.68	Average	14.37	14.65	14.99	15.16

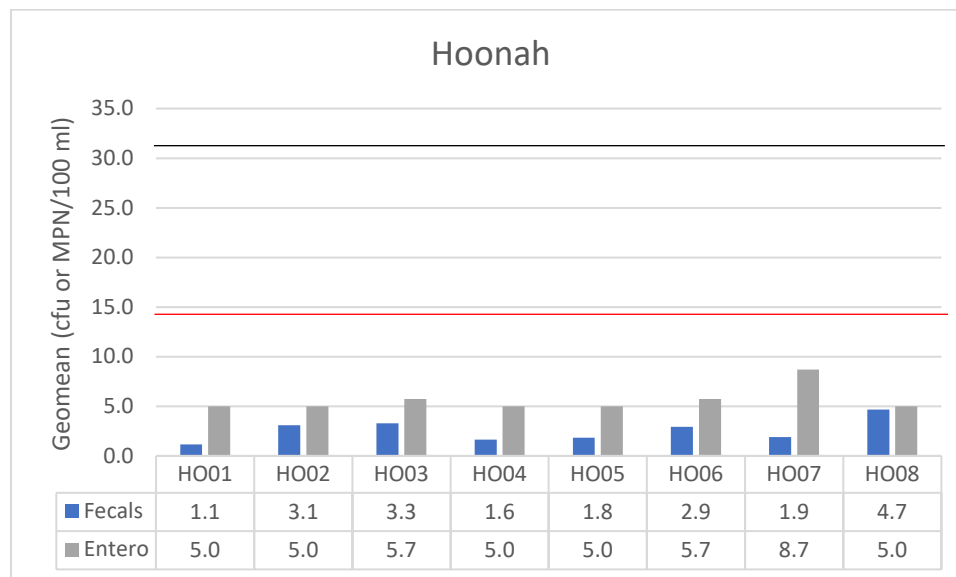


Figure 25. Port of Hoonah geometric mean (n = 8) abundance of fecal coliforms (FC) and *Enterococci* bacteria from samples collected between 5/12/22 and 6/1/22. WQC for fecal coliforms is 14 cfu/100 ml (red line) and for *Enterococci*, 31 MPN/100 ml (black line).

Table 25. Concentrations of ammonia-N, and total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Hoonah sampling stations

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)
HO01	0.002	0.24	0.25	0.37	0.37	0.10	0.10
HO02	0.002	0.27	0.25	0.37	0.36	0.10	0.10
HO03	0.004	0.26	0.26	0.35	0.36	0.10	0.10
HO04	0.002	0.25	0.23	0.38	0.34	0.10	0.10
HO05	0.002	0.24	0.24	0.39	0.37	0.10	0.10
HO06	0.021	0.35	0.30	0.36	0.35	0.99	0.66
HO07	0.002	0.26	0.25	0.38	0.36	0.32	0.21
HO08	0.002	0.22	0.24	0.40	0.36	0.10	0.10
Average	0.004	0.26	0.25	0.38	0.36	0.24	0.18

Sitka-Sitka Sound

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

Sampling was conducted on 5 days beginning on May 10, and ending on June 7, 2022. A total of 41 Cruise Ships docked near Sitka during the sampling period.

There were minor differences in average water temperatures and salinity with water depth or among stations on May 10, 2022 (Table 26). Average water temperature was 9°C and salinity 29 – 30 ppt. The pH measured at the majority of sites and depths was near 8.4. The average concentration of dissolved oxygen was 11 – 12 mg/L.

Fecal coliform and *Enterococci* bacteria abundances in water samples were close to the MDL and well below WQC (Figure 27). Results from May 2022 were similar to May 2021 and July 2020 results.

Average concentrations of ammonia-N and metals were low in samples collected in Sitka Sound (Table 27). Average ammonia-N concentration was 0.018 mg/L. Average total and dissolved Cu and Ni concentrations were ≤ 0.3 $\mu\text{g/L}$, and total and dissolved Zn ≤ 1.0 $\mu\text{g/L}$. Zn concentrations were highest at SI01, SI06, SI07, and SI08.

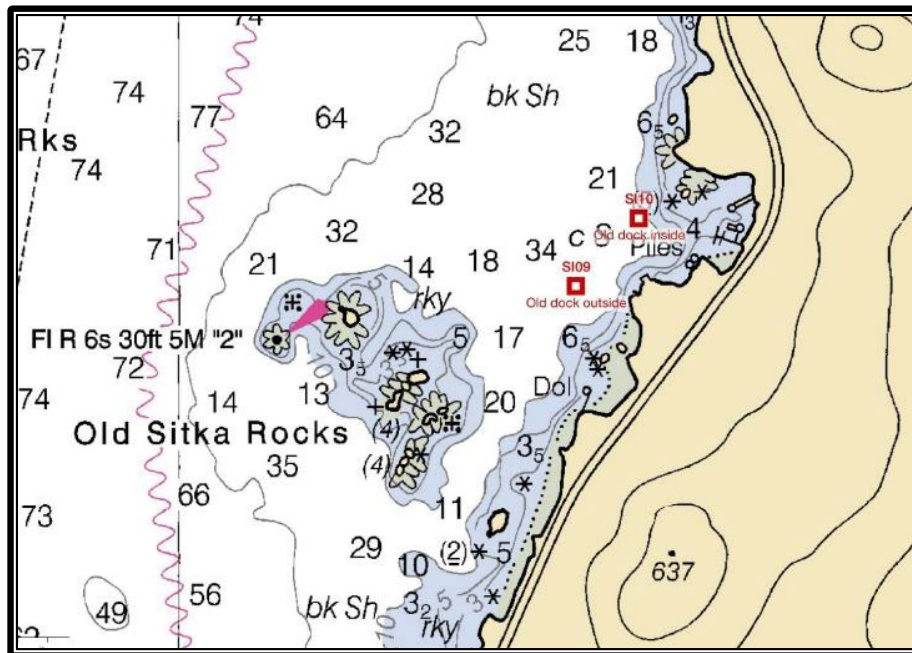
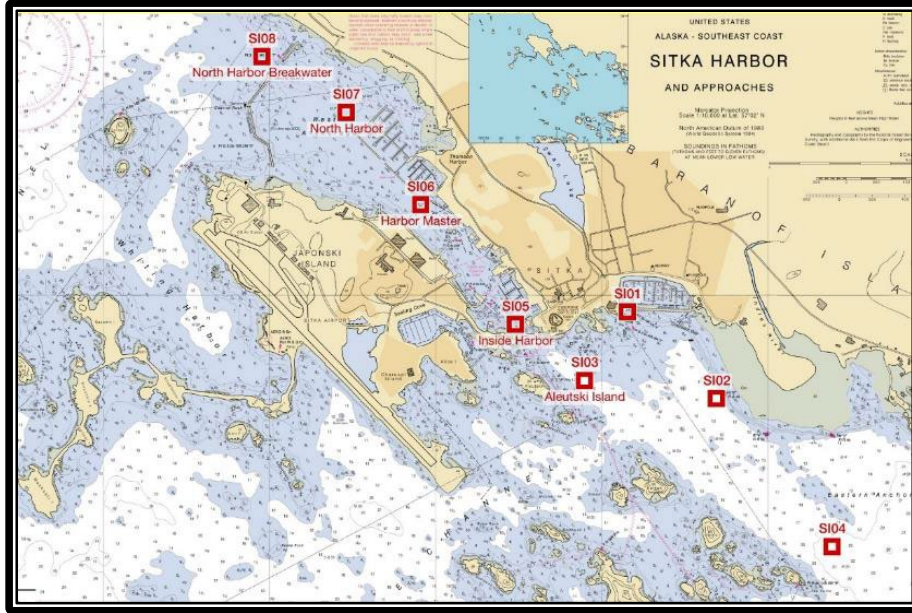


Figure 26. Charts showing Port of Sitka sampling stations near the small boat harbors (top) and the Alaska Marine Highway berth (bottom).

Table 26. Port of Sitka water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) on May 10, 2022, at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m	Salinity (ppt)	1m	2m	3m	4m
SI01	9.20	9.20	9.20	9.10	SI01	27.70	27.61	28.47	29.55
SI02	9.50	9.50	9.40	9.40	SI02	27.78	27.85	28.03	28.16
SI03	9.00	9.10	9.10	9.10	SI03	26.98	27.35	28.56	28.59
SI04	9.60	9.40	9.20	9.20	SI04	27.53	28.07	28.88	29.41
SI05	9.10	9.20	9.30	9.40	SI05	27.08	29.20	29.65	29.00
SI06	9.10	9.20	9.20	9.00	SI06	27.98	28.92	30.65	30.77
SI07	9.20	9.20	9.10	8.60	SI07	29.42	30.20	30.58	30.83
SI08	8.90	8.80	8.80	8.40	SI08	30.31	30.58	30.72	30.89
SI09	8.50	8.40	8.40	8.30	SI09	30.57	30.60	30.62	30.64
SI10	8.50	8.40	8.30	8.20	SI10	30.37	30.42	30.53	30.59
Average	9.06	9.04	9.00	8.87	Average	28.57	29.08	29.67	29.84
pH	1m	2m	3m	4m	D.O. (mg/L)	1m	2m	3m	4m
SI01	8.40	8.40	8.43	8.44	SI01	11.22	11.65	11.24	11.13
SI02	8.41	8.37	8.41	8.36	SI02	11.49	11.51	11.52	11.56
SI03	8.36	8.41	8.42	8.43	SI03	11.13	11.23	11.38	11.52
SI04	8.34	8.38	8.47	8.41	SI04	11.46	11.44	11.50	11.65
SI05	8.40	8.40	8.47	8.43	SI05	11.26	11.33	11.66	11.91
SI06	8.44	8.44	8.47	8.47	SI06	11.37	11.55	11.72	11.90
SI07	8.54	8.53	8.53	8.51	SI07	11.68	11.65	11.74	11.85
SI08					SI08	11.73	11.84	12.10	12.19
SI09	8.36	8.39	8.36	8.37	SI09	11.65	11.68	11.74	11.75
SI10	8.30	8.32	8.32	8.35	SI10	11.33	11.40	11.50	11.60
Average	8.39	8.40	8.43	8.42	Average	11.43	11.53	11.61	11.71

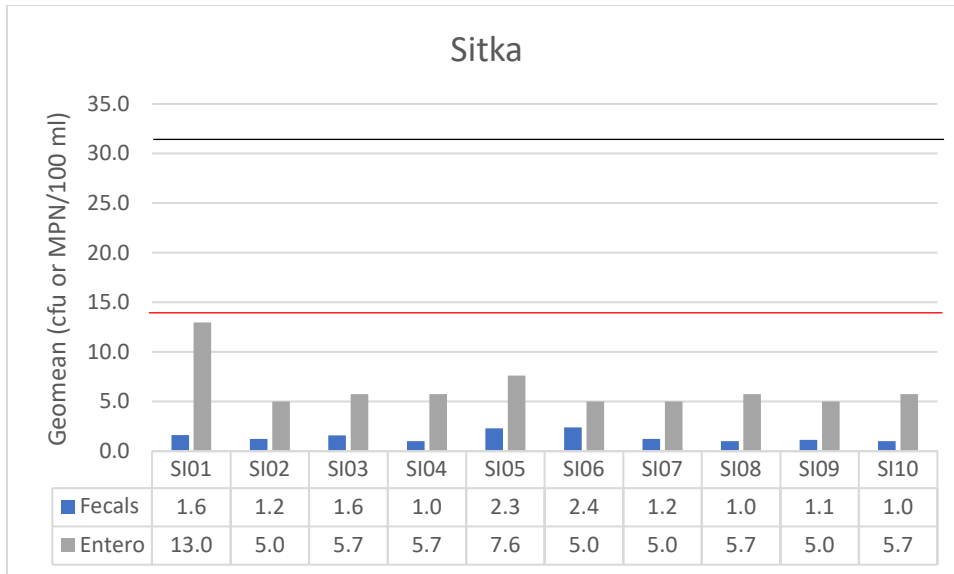


Figure 27. Port of Sitka geometric mean (n = 10) abundance of fecal coliforms (FC) and *Enterococci* bacteria from samples collected between 5/10/22 and 6/7/22. WQC for fecal coliforms is 14 cfu/100 ml (red line) and for *Enterococci*, 31 MPN/100 ml (black line).

Table 27. Concentrations of ammonia-N, total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Sitka sampling stations.

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)
SI01	0.019	0.51	0.49	0.30	0.28	1.69	1.70
SI02	0.023	0.21	0.20	0.30	0.29	0.41	0.45
SI03	0.020	0.20	0.21	0.29	0.28	0.52	0.47
SI04	0.019	0.16	0.17	0.30	0.30	0.27	0.25
SI05	0.017	0.22	0.22	0.28	0.31	0.57	0.54
SI06	0.020	0.27	0.24	0.30	0.29	1.56	0.73
SI07	0.009	0.41	0.45	0.32	0.29	1.72	1.44
SI08	0.017	0.28	0.26	0.30	0.29	1.04	0.80
SI09	0.012	0.14	0.15	0.30	0.30	0.10	0.10
SI10	0.026	0.27	0.27	0.31	0.29	0.53	0.48
Average	0.018	0.27	0.27	0.30	0.29	0.84	0.70

Petersburg-Wrangell Narrows

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 28).

Water samples were collected between May 2 and May 31, 2022. A total of 12 Cruise Ships docked in Petersburg during the sampling period.

On the May 2, 2022 sampling date, average water temperature was 6.6 °C and was consistent with water depth and among sampling sites (Table 28). Salinity was near 30 ppt at all sites and depths. The pH was lower than other ports at 8.0 and dissolved oxygen was near saturation between 10.4 mg/L.

Geometric mean concentrations of fecal coliforms and *Enterococci* were low at or near the MDL (Figure 29). The maximum fecal coliform count was 8 cfu/100 ml at PE01 and PE02. Bacterial abundance was lower in 2022 compare to July, 2020 when concentrations exceeded 15 cfu/100 ml at PE02 and PE03.

Average ammonia-N concentration was 0.038 mg/L and total and dissolved metals were < 0.5 µg/L. Table 29). Water samples collected in 2021 and 2020 had similar low concentrations of ammonia and metals.

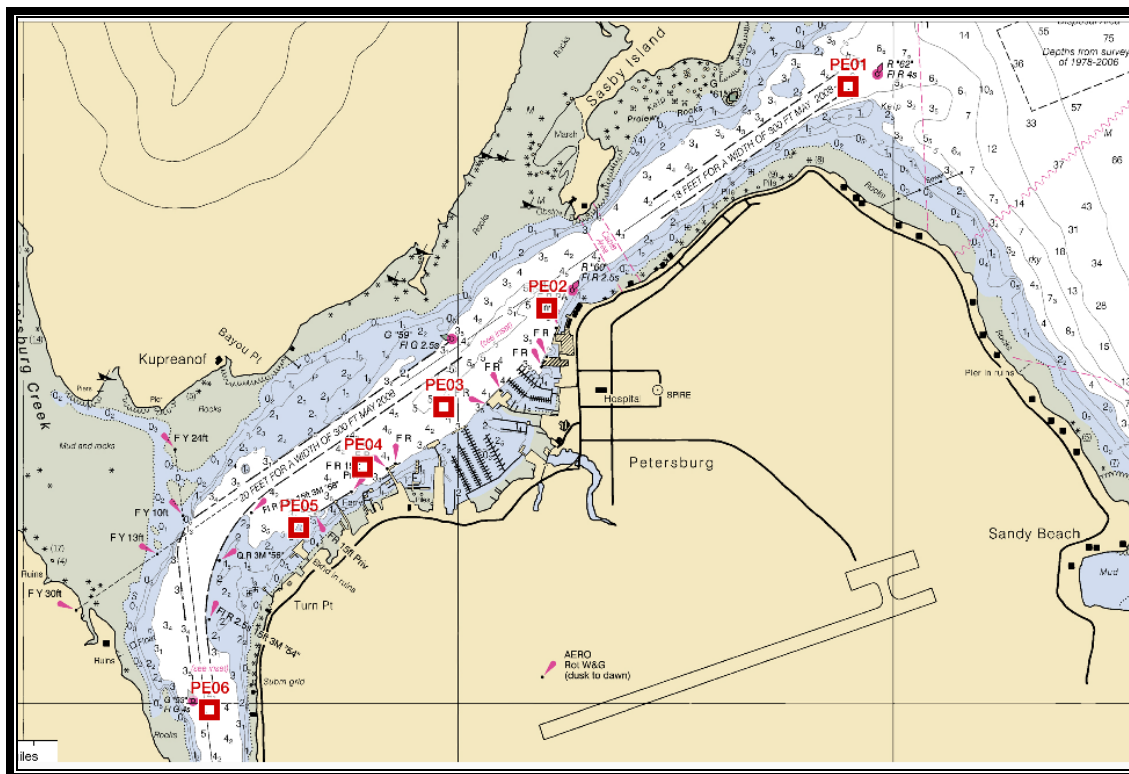


Figure 28. Chart showing Port of Petersburg sampling stations. PE05 was not sampled in 2021 or 2022.

Table 28. Port of Petersburg water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) on May 2, 2022, at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m	Salinity (ppt)	1m	2m	3m	4m
PE01	6.50	6.20	6.20	6.10	PE01	29.64	29.71	29.88	30.00
PE02	6.40	6.50	6.50	6.50	PE02	29.02	29.26	29.53	29.81
PE03	6.70	6.70	6.70	6.70	PE03	29.97	30.09	30.12	30.12
PE04	6.70	6.70	6.60	6.60	PE04	29.55	29.95	30.09	30.09
PE06	6.80	6.70	6.60	6.60	PE06	29.65	29.82	30.08	30.10
Average	6.62	6.56	6.52	6.50	Average	29.57	29.77	29.94	30.02
pH	1m	2m	3m	4m	D.O. (mg/L)	1m	2m	3m	4m
PE01	8.04	8.04	8.05	8.22	PE01	10.13	10.13	10.10	10.06
PE02	8.06	8.07	8.06	8.06	PE02	10.20	10.23	10.24	10.24
PE03	8.00	8.01	8.02	8.01	PE03	9.93	10.12	10.27	10.30
PE04	8.09	8.08	8.06	8.15	PE04	10.14	10.23	10.25	10.25
PE06	8.04	8.04	8.06	8.12	PE06	10.26	10.37	10.37	10.38
Average	8.05	8.05	8.05	8.11	Average	10.13	10.22	10.25	10.25

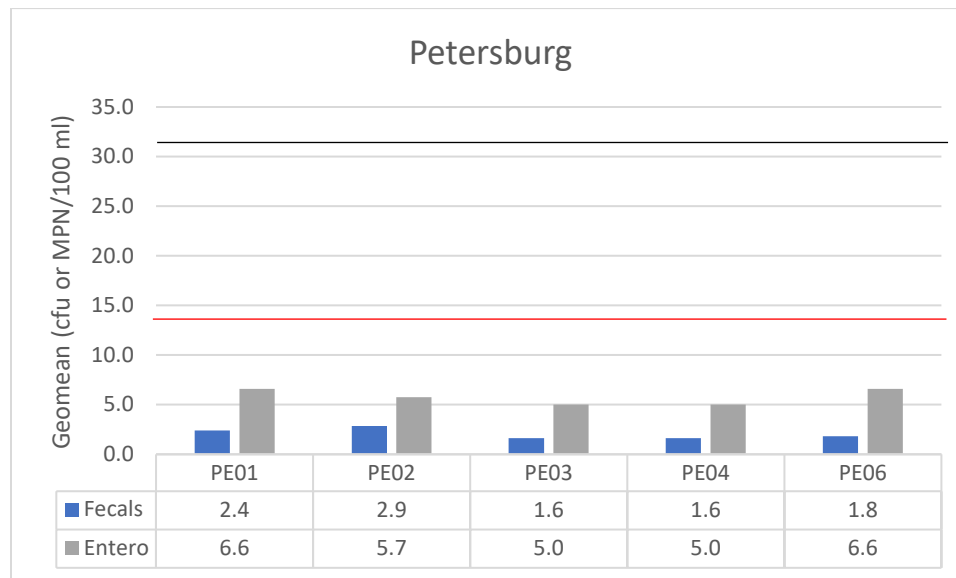


Figure 29. Port of Petersburg geometric mean (n = 5) abundance of fecal coliforms (FC) and *Enterococci* bacteria from samples collected between 5/2/22 and 5/31/22. WQC for fecal coliforms is 14 cfu/100 ml (red line) and for *Enterococci*, 31 MPN/100 ml (black line).

Table 29. Concentrations of ammonia-N, total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Petersburg sampling stations.

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)
PE01	0.032	0.24	0.23	0.36	0.36	0.36	0.26
PE02	0.034	0.25	0.24	0.39	0.31	0.34	0.30
PE03	0.041	0.26	0.22	0.36	0.33	0.39	0.25
PE04	0.038	0.24	0.53	0.39	0.37	0.31	0.68
PE06	0.043	0.24	0.22	0.37	0.36	0.29	0.23
Average	0.038	0.25	0.29	0.37	0.35	0.34	0.34

Wrangell-Sumner Strait

Wrangell sampling sites were distributed from near the airport runway (WR01) along the shoreline to the southern small boat harbor (WR05). WR03 was at the city dock and WR04 was in the northern small boat harbor. WR06 was located offshore (Figure 30).

Average water temperature was near 8°C on May 3, 2022 (8.3°C in late April of 2021 and 12.6°C in July of 2020) and was similar at 1m and 4m water depths and sampling stations (Table 30). Salinity was ~28 ppt at all stations and depths. During previous sampling years salinity has been lower at 1m water depths. The pH averaged 8.5 and dissolved oxygen 12 mg/L, similar to 2021 and 2020 values.

Geometric mean fecal coliforms ranged from 1.0 to 3.1 cfu/100 ml and *Enterococci* were < the MDL of 10 MPN/100 ml on all sampling dates (Figure 31). Bacteria abundances have been low in all sampling years (2020 and 2021).

Average ammonia-N concentration was 0.023 mg/L and total and dissolved metals < 0.5µg/L (Table 31). Total metal concentrations were greatest in 2020 ranging from 2 µg/L (Ni) to 3 µg/L (Zn).

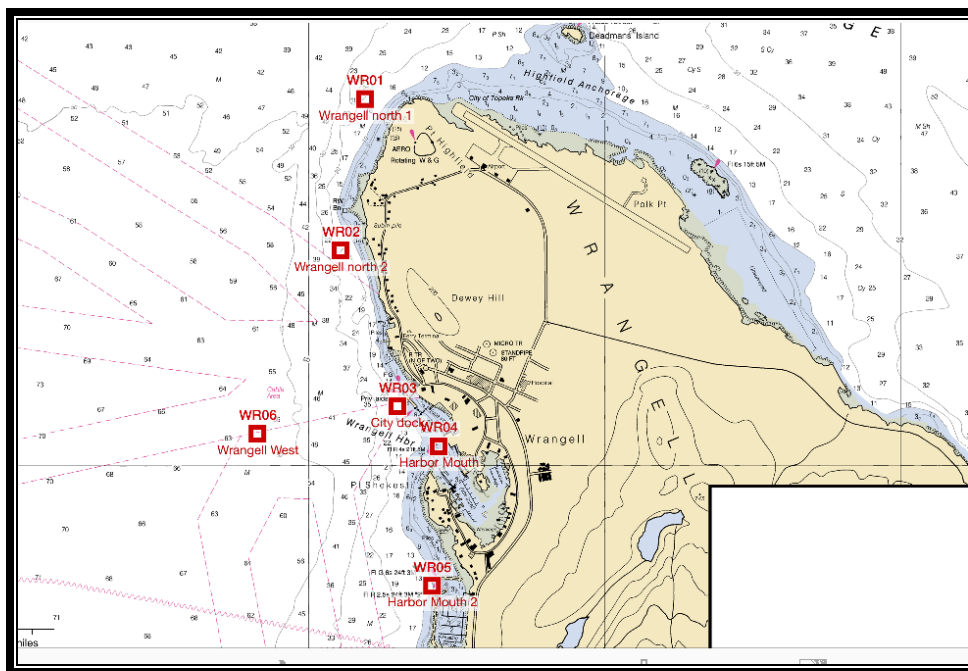


Figure 30. Chart showing Port of Wrangell sampling stations.

Table 30. Port of Wrangell water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) on the May 3, 2022, sampling date at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m	Salinity (ppt)	1m	2m	3m	4m
WR01	7.90	7.90	7.90	7.90	WR01	28.25	28.28	28.27	28.28
WR02	8.00	8.00	8.00	8.00	WR02	28.19	28.21	28.21	28.21
WR03	8.50	8.00	8.00	8.00	WR03	27.72	28.20	28.23	28.24
WR04	8.40	8.00	7.90	7.90	WR04	27.69	28.20	28.31	28.37
WR05	8.20	8.10	8.00	7.90	WR05	28.38	28.40	28.47	28.52
WR06	8.00	8.00	8.00	8.00	WR06	28.56	28.59	28.60	28.60
Average	8.17	8.00	7.97	7.95	Average	28.13	28.31	28.35	28.37
pH	1m	2m	3m	4m	D.O. (mg/L)	1m	2m	3m	4m
WR01	8.83	8.79	8.73	8.77	WR01	11.73	11.93	12.02	12.08
WR02	8.42	8.43	8.53	8.37	WR02	11.85	12.11	12.24	12.31
WR03	8.42	8.39	8.47	8.33	WR03	12.52	12.60	12.58	12.55
WR04	8.76	8.69	8.52	8.64	WR04	12.16	12.37	12.50	12.54
WR05	8.44	8.43	8.45	8.35	WR05	12.03	12.30	12.45	12.52
WR06	8.47	8.46	8.49	8.45	WR06	12.08	12.18	12.26	12.29
Average	8.56	8.53	8.53	8.49	Average	12.06	12.25	12.34	12.38

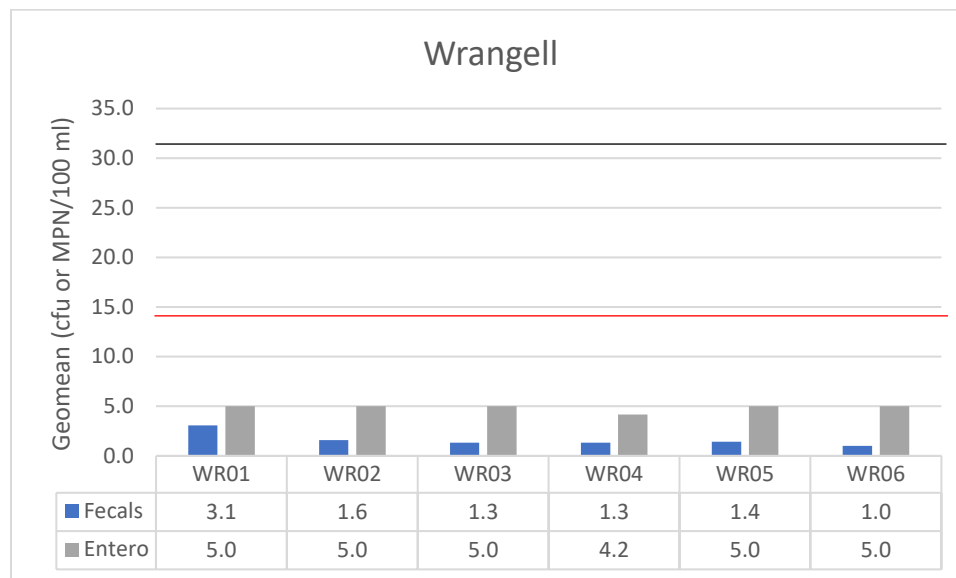


Figure 31. Port of Wrangell geometric mean (n = 6) abundance of fecal coliforms (FC) and *Enterococci* bacteria from samples collected from 5/2/22 to 6/1/22. WQC for fecal coliforms is 14 cfu/100 ml (red line) and for *Enterococci*, 31 MPN/100 ml (black line).

Table 31. Concentrations of ammonia-N, total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Wrangell sampling stations.

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)
WR01	0.036	0.22	0.19	0.34	0.28	0.21	0.10
WR02	0.010	0.26	0.21	0.37	0.32	0.32	0.10
WR03	0.071	0.37	0.19	0.37	0.34	0.57	0.27
WR04	0.010	0.33	0.20	0.38	0.34	0.70	0.35
WR05	0.003	0.22	0.17	0.33	0.29	0.39	0.24
WR06	0.010	0.21	0.15	0.33	0.28	0.27	0.10
Average	0.023	0.27	0.19	0.35	0.31	0.41	0.19

Ward Cove

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 32).

Water sampling was conducted from May 4 through May 17, 2022. A total of 41 Cruise Ships were docked at the Ketchikan Port during the sampling period. We do not know how many of those ships docked in Ward Cove.

Salinity in Ward Cove was lower at 1m than 2m to 4m, but there were no large differences in other parameters among sites or depths (Table 32). Average salinity was 24 ppt at 1 m and 29 ppt at 2m, 3m, and 4m. Water temperature was $\sim 7.4^{\circ}\text{C}$ on the May 4 sampling date at all sites and depths. The pH was near 8.4 was consistent among sites, depths and previous years (average 8.4 in May 2021 and 8.6 in July 2020). Dissolved oxygen ranged from 10.2 to 11.57 mg/L.

Geometric mean fecal coliforms ranged from 3.8 to 12.8 cfu/100ml and the maximum single value was 23 cfu/100ml (Figure 33). The Geometric mean of *Enterococci* ranged from 5 to 6 MPN/100ml as most of the results were below the MDL of 10 MPN/100ml. These results are greater than May 2021 values but less than July 2020 when fecal coliforms exceeded 14 cfu/100 ml at three Ward Cove sites.

Ammonia-N concentrations averaged 0.023 mg/L (Table 33). Total and dissolved Cu and Ni in water samples were $< 0.5 \mu\text{g/L}$ and total and dissolved Zn $< 1.5 \mu\text{g/L}$. Concentrations of ammonia-N and metals were similar to 2021 and 2020 values.

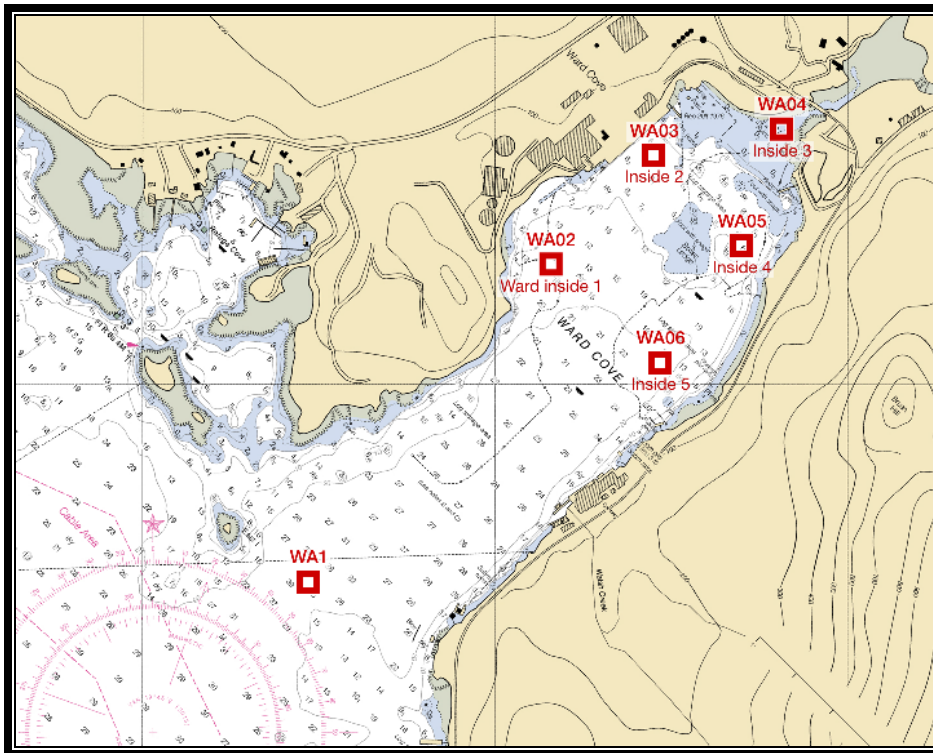


Figure 32. Port of Ward Cove showing sampling stations. WA02 was not sampled in 2021.

Table 32. Port of Ward Cove water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) on May 4, 2022, at 1, 2, 3, and 4 m water depths on 4/20/2021.

Temp (C)	1m	2m	3m	4m	Salinity (ppt)	1m	2m	3m	4m
WA01	7.40	7.40	7.40	7.30	WA01	22.23	28.72	29.34	29.41
WA03	7.20	7.40	7.40	7.30	WA03	29.05	29.65	29.73	29.76
WA04	7.40	7.40	7.40	7.40	WA04	24.92	29.51	29.64	29.74
WA05	7.40	7.40	7.40	7.40	WA05	23.26	28.93	29.19	29.98
WA06	7.40	7.40	7.40	7.40	WA06	22.27	29.31	27.49	29.67
Average	7.36	7.40	7.40	7.36	Average	24.35	29.22	29.08	29.71
pH	1m	2m	3m	4m	D.O. (mg/L)	1m	2m	3m	4m
WA01	8.14	8.15	8.15	8.12	WA01	10.98	10.53	10.35	10.19
WA03	8.17	8.16	8.19	8.18	WA03	11.57	10.30	10.45	10.50
WA04	8.17	8.19	8.22	8.16	WA04	10.20	10.29	10.41	10.45
WA05	8.17	8.18	8.25	8.20	WA05	10.40	10.31	10.48	10.53
WA06	8.07	8.07	8.18	8.18	WA06	10.75	10.38	10.43	10.47
Average	8.14	8.15	8.30	8.17	Average	10.78	10.36	10.42	10.43

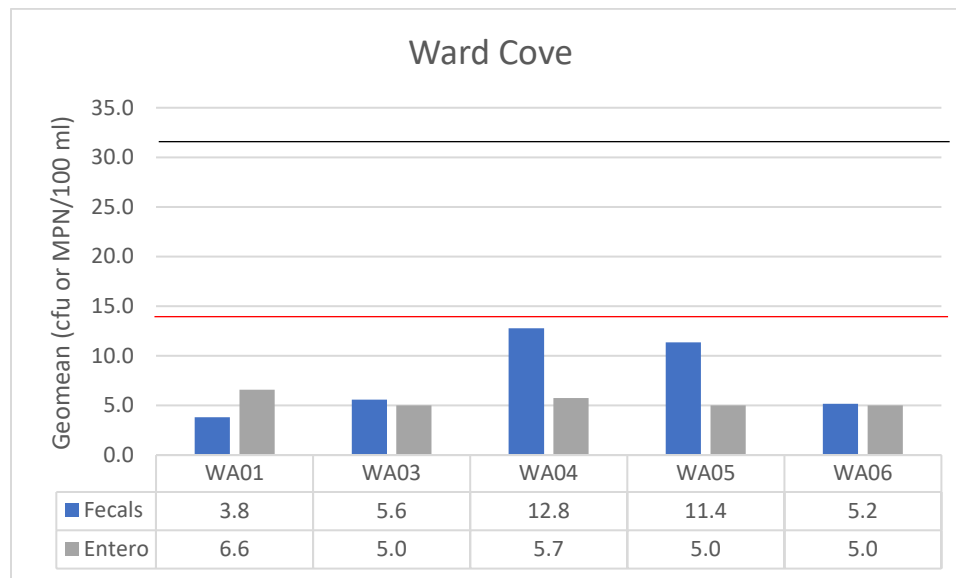


Figure 33. Ward Cove geometric mean (n = 5) abundance of fecal coliforms (FC) and *Enterococci* bacteria from samples collected between 5/3/22 and 6/1/22. WQC for fecal coliforms is 14 cfu/100 ml (red line) and for *Enterococci*, 31 MPN/100 ml (black line).

Table 33. Concentrations of ammonia-N, total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Ward Cove sampling stations.

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)
WA01	0.015	0.28	0.43	0.30	0.29	0.65	0.76
WA03	0.019	0.40	0.38	0.43	0.43	1.79	1.60
WA04	0.014	0.57	0.28	0.32	0.31	1.51	1.06
WA05	0.041	0.27	0.31	0.32	0.31	1.40	1.30
WA06	0.025	0.31	0.36	0.35	0.35	1.14	1.16
Average	0.023	0.37	0.35	0.34	0.34	1.30	1.18

Ketchikan-Tongass Narrows

Sampling sites 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 34).

Water sampling was conducted between May 4 and May 17, 2022. A total of 41 Cruise Ships docked in the Port of Ketchikan during the sampling period.

Water temperature, salinity, pH, and dissolved oxygen in Tongass Narrows were similar among sampling sites and water depths, with the exception of water temperature and salinity in the upper meter of KE01 near the mouth of Ketchikan Creek (Table 34). Average water temperature was $\sim 7.5^{\circ}\text{C}$ in May of 2022 but at KE01 was 6.8°C at 1m depth. Average salinity ranged from 28 to 30 ppt and was 24 ppt in the surface water at the KE01 sampling station. Average pH ranged from 8.2 to 8.4 and dissolved oxygen 10.3 to 10.4 mg/L.

Geometric mean fecal coliforms ranged from 2.5 to 18.1 cfu/100ml and *Enterococci* from 5.0 (0.5 x the MDL) to 7.6 MPN/100 ml (Figure 35). Geometric mean fecal coliform concentration exceeded WQC at KE01 and the maximum value was 44 cfu/100 ml. Bacterial abundances in May of 2022 and April 2021 water samples were less than in water samples collected in July of 2020.

Average ammonia-N concentration was 0.021 mg/L. Total and dissolved metals were $<1 \mu\text{g/L}$ (Table 35). Concentrations of metals were similar among sampling years 2020, 2021, and 2022.

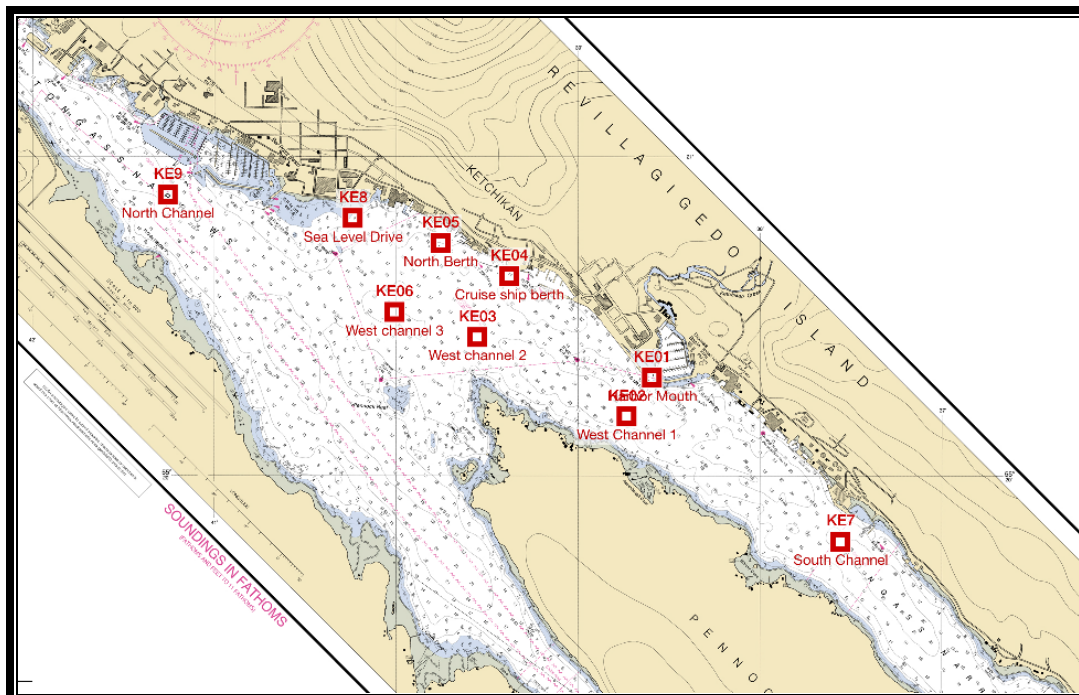


Figure 34. Chart showing Port of Ketchikan sampling stations. KE03 was not sampled in 2021 or 2022.

Table 34. Port of Ketchikan water temperature (Temp), salinity, pH and dissolved oxygen (D.O.) on May 4, 2022, at 1, 2, 3, and 4 m water depths.

Temp (C)	1m	2m	3m	4m	Salinity (ppt)	1m	2m	3m	4m
KE01	6.80	7.30	7.60	7.60	KE01	25.25	29.47	29.63	29.88
KE02	7.70	7.70	7.70	7.60	KE02	29.51	29.60	29.63	29.67
KE04	7.60	7.50	7.50	7.50	KE04	27.65	28.15	28.90	29.94
KE05	7.50	7.50	7.50	7.50	KE05	27.21	29.25	29.50	29.58
KE06	7.60	7.60	7.60	7.50	KE06	29.36	29.44	29.53	29.60
KE07	7.70	7.70	7.70	7.70	KE07	29.91	29.93	29.94	29.95
KE08	7.60	7.50	7.50	7.60	KE08	28.25	28.61	28.61	28.82
KE09	7.50	7.50	7.50	7.50	KE09	29.78	29.81	29.87	29.85
Average	7.50	7.54	7.58	7.56	Average	28.37	29.28	29.45	29.66
pH	1m	2m	3m	4m	D.O. (mg/L)	1m	2m	3m	4m
KE01	8.16	8.16	8.37	8.26	KE01	10.79	10.42	10.35	10.34
KE02	8.17	8.18	8.58	8.23	KE02	10.33	10.30	10.23	10.18
KE04	8.15	8.14	8.21	8.19	KE04	10.35	10.29	10.19	10.17
KE05	8.21	8.20	8.36	8.23	KE05	10.47	10.40	10.40	10.26
KE06	8.18	8.18	8.46	8.24	KE06	10.37	10.35	10.31	10.28
KE07	8.21	8.24	8.16	8.30	KE07	10.56	10.54	10.51	10.49
KE08	8.19	8.20	8.42	8.21	KE08	10.42	10.40	10.36	10.32
KE09	8.17	8.22	8.24	8.19	KE09	10.22	10.29	10.33	10.35
Average	8.18	8.19	8.35	8.23	Average	10.44	10.37	10.34	10.30

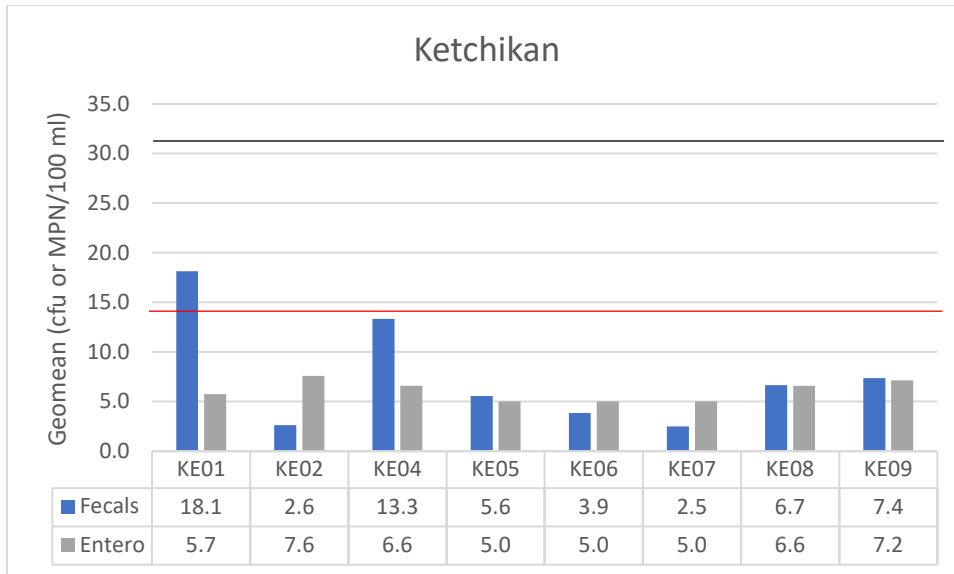


Figure 35. Port of Ketchikan geometric mean (n = 8) abundance of fecal coliforms (FC) and *Enterococci* bacteria from samples collected between 5/4/22 and 5/17/22. WQC for fecal coliforms is 14 cfu/100 ml (red line) and for *Enterococci*, 31 MPN/100 ml (black line).

Table 35. Concentrations of ammonia-N, total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Port of Ketchikan sampling stations.

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)
KE01	0.020	0.78	0.43	0.29	0.29	1.63	0.90
KE02	0.018	0.22	0.20	0.31	0.29	0.36	0.30
KE04	0.017	0.48	0.40	0.29	0.29	0.81	0.75
KE05	0.015	0.50	0.41	0.30	0.28	0.88	0.73
KE06	0.029	0.23	0.21	0.29	0.29	0.40	0.41
KE07	0.018	0.24	0.17	0.31	0.29	0.36	0.31
KE08	0.021	0.40	0.32	0.31	0.31	0.61	0.54
KE09	0.030	0.19	0.20	0.28	0.29	0.35	0.41
Average	0.021	0.38	0.29	0.30	0.29	0.68	0.54

Shipping Lanes

Water samples were collected within all major channels (canals, straights, sounds, and passages) in Southeast Alaska (Figure 36 and 37). Two additional Shipping Lanes sites were located in Southcentral Alaska near Storey Island in Prince William Sound and at Sunny Cove in Resurrection Bay. A table of Shipping Lanes site names and coordinates is in Appendix B.

The water temperature and salinity at 1m to 4m water depths for Shipping Lanes sites are in Table 36 and pH and dissolved oxygen concentrations in Table 37. Water Temperatures at 1m water depth ranged from 6.3°C to 15.7°C. Cooler water sites were in Sumner Strait, Fredrick Sound, North Cove and Pelican Strait. Warmer sites were in Southcentral Alaska (Storey Island and Sunny Cove); however, these sites were sampled later in the summer. When all sites were considered, there was no significant difference in water temperature between 1m and 4m water depth (t-test, $p = 0.49$).

Average salinity ranged from 29.3 ppt at 1 m water depth to 29.5 ppt at 4 m water depth. Among sites salinity ranged from 20.7 ppt at SP02 to 32.0 ppt in North Cove. Other sites with lower salinity included Sunny Cove, Storey Island, Stikine, and Sumner Strait.

The pH ranged from 7.8 to 8.8 at 1m water depth and averaged 8.23. Sites with lower pH (<8.0) were in Fredrick Sound and Sumner Strait. Dissolved oxygen concentration ranged from 8.9 to 17.4 mg/L and averaged 12.55 mg/L. Sites where dissolved oxygen was < 10 mg/L also were located in Sumner Strait. Sumner Strait also had relatively low pH and dissolved oxygen in 2020 and 2021.

Concentrations of fecal coliform bacteria were below the MDL at all sampling sites except Nichols Passage at 3 cfu/100 ml. *Enterococci* bacteria were below the MDL at all Shipping Lane sampling sites with the exception Nichols Passage and Lynn Canal where concentrations were at the MDL of 10 MPN/100m ml.

Ammonia-N and total and dissolved metals were low at all Shipping Lanes sites (Table 38). Ammonia-N ranged from 0.002 mg/L to 0.045 mg/L and averaged 0.016 mg/L. Average total and dissolved Cu, Ni, and Zn were < 0.5 µg/L (Figure 37). Results from 2020, 2021, and 2022 samples analyzed for ammonia-N and metals were similar among years.

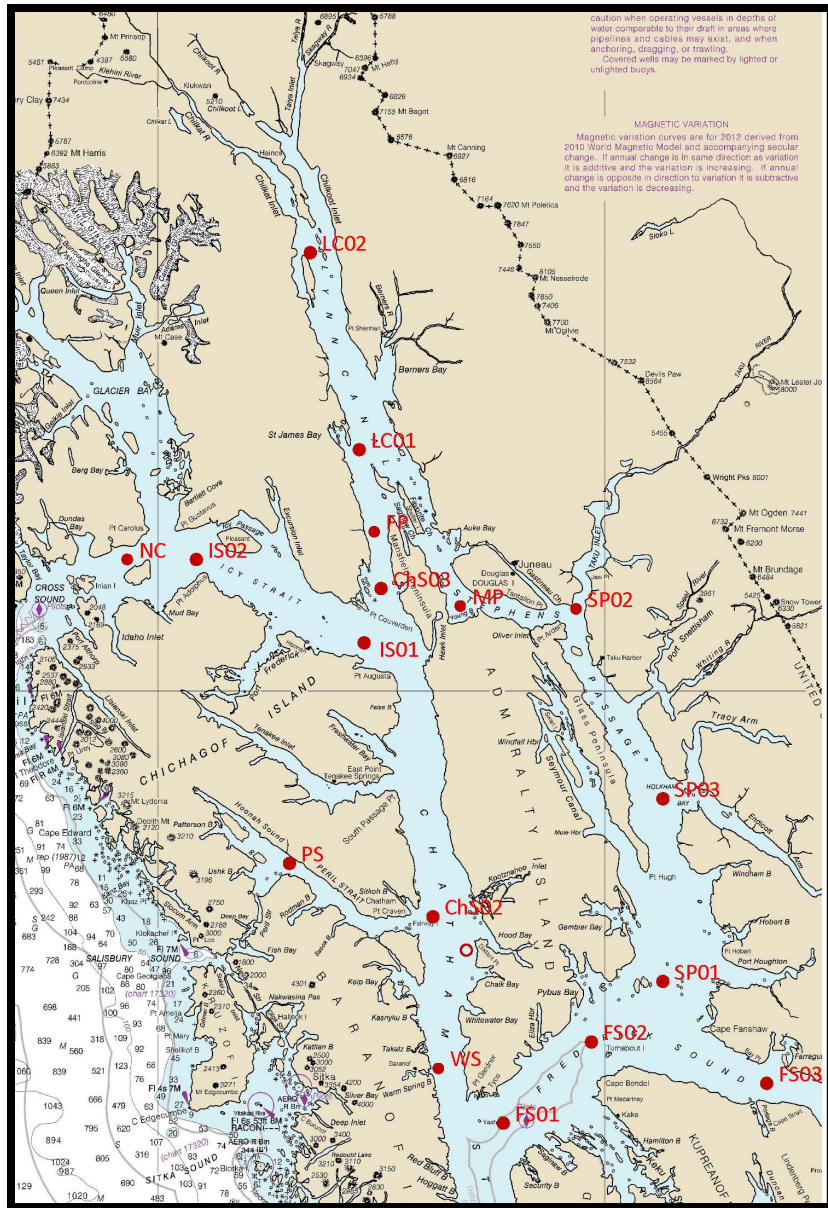


Figure 36. Locations of Shipping Lanes sites from upper Lynn Canal near Haines to Fredrick Sound.

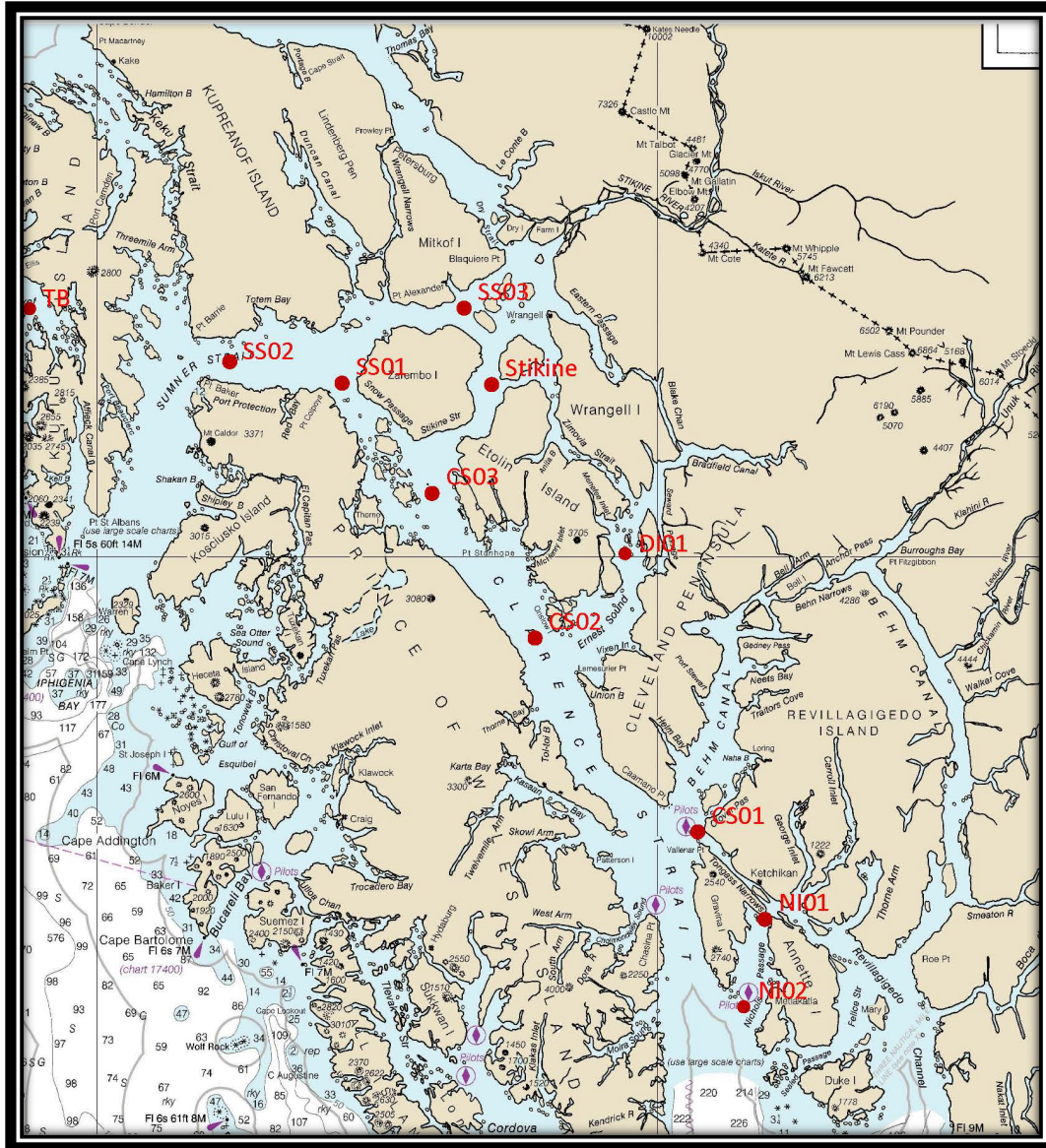


Figure 37. Sampling sites from Tebnkof in the northwest and Sumner Strait near Wrangell in the northeast to Nichols Passage south of Ketchikan.

Table 36. 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	Salinity (ppt)	1m	2m	3m	4m
ChS02	7.40	7.00	6.70	6.40	ChS02	30.51	30.59	30.64	30.69
CHS03	7.50	7.30	7.20	7.20	CHS03	29.92	29.97	30.03	30.12
CS01	8.80	8.00	7.90	7.70	CS01	29.93	29.85	29.93	30.00
CS02	7.90	7.90	7.90	7.60	CS02	30.08	30.04	30.04	30.14
CS03	8.20	8.20	8.20	8.20	CS03	29.74	29.74	29.74	29.75
FP	7.80	7.80	7.40	7.40	FP	30.00	30.08	30.09	30.12
FS01	7.30	7.10	7.10	6.90	FS01	31.03	31.03	31.05	31.03
FS02	6.50	6.50	6.40	6.40	FS02	31.00	30.99	30.99	31.00
FS03	6.50	6.50	6.50	6.50	FS03	30.32	30.32	30.33	30.33
IS01	7.70	7.50	7.50	7.30	IS01	30.19	30.16	30.16	30.14
IS02	6.30	6.30	6.20	6.20	IS02	31.41	31.39	31.35	31.37
LC01	8.70	8.70	8.60	8.30	LC01	28.83	28.83	28.85	29.18
LC02	8.10	8.10	8.10	8.10	LC02	27.71	28.01	28.01	28.08
MP	9.20	8.60	8.10	8.10	MP	27.54	27.67	27.82	28.03
NIO1	7.80	7.70	7.70	7.70	NIO1	29.91	29.96	29.98	30.01
NIO2	8.10	8.10	8.00	8.00	NIO2	30.14	30.16	30.16	30.24
North Cove	6.30	6.30	6.30	6.30	North Cove	31.96	31.94	31.99	32.00
PS	6.80	6.40	6.20	6.10	PS	30.07	30.24	30.28	30.30
SP01	7.30	7.20	7.20	7.20	SP01	30.39	30.40	30.40	30.41
SP01	7.30	7.20	7.20	7.20	SP01	30.39	30.40	30.40	30.41
SP02	7.50	7.50	7.50	7.30	SP02	20.71	20.62	21.13	22.01
SP03	7.20	7.10	7.00	6.70	SP03	30.03	30.07	30.17	30.25
SS01	6.90	6.90	6.90	6.90	SS01	30.74	30.75	36.75	30.77
SS02	6.80	6.80	6.80	6.80	SS02	30.77	30.87	30.86	30.87
SS03	7.50	7.50	7.50	7.50	SS03	25.75	25.97	26.00	26.12
Stikine	8.10	8.10	8.10	8.10	Stikine	27.61	27.85	27.95	28.04
Storey Island	15.70	15.40	15.20	15.30	Storey Island	25.10	25.24	25.41	25.49
Sunny Cove	13.60	12.50	12.50	11.40	Sunny Cove	26.51	26.58	27.15	28.60
WS	6.70	6.70	6.70	6.70	WS	31.05	31.06	31.05	31.06
Average	7.98	7.82	7.74	7.64	Average	29.29	29.34	29.61	29.54

Table 37. Shipping lanes water pH and dissolved oxygen (D.O.) at 1, 2, 3, and 4 m water depths.

pH	1m	2m	3m	4m	D.O. (mg/L)	1m	2m	3m	4m
ChS02	8.18	8.19	8.20	8.20	ChS02	11.99	12.18	12.42	12.80
CHS03	8.23	8.34	8.39	8.41	CHS03	15.29	15.40	15.54	15.52
CS01	8.05	8.07	8.07	8.07	CS01	11.29	11.27	11.25	11.23
CS02	8.12	8.15	8.15	8.07	CS02	11.92	11.84	11.84	11.84
CS03	8.20	8.20	8.20	8.20	CS03	11.37	11.43	11.56	11.64
FP	8.47	8.48	8.48	8.49	FP	14.60	14.81	14.86	14.81
FS01	8.19	8.20	8.21	8.21	FS01	12.03	12.19	12.33	12.53
FS02	7.99	8.04	8.05	8.06	FS02	11.30	11.35	11.32	11.35
FS03					FS03	14.75	14.94	15.41	16.44
IS01	8.33	8.38	8.40	8.41	IS01	15.30	15.48	15.41	15.48
IS02	8.78	8.75	8.72	8.79	IS02	10.21	10.20	10.19	10.18
LC01	8.53	8.53	8.53	8.55	LC01	14.27	14.29	14.32	14.68
LC02	8.67	8.65	8.69	8.76	LC02	13.23	13.29	13.27	13.31
MP	8.50	8.52	8.52	8.52	MP	15.09	15.86	15.71	15.65
NI01	8.23	8.25	8.23	8.21	NI01	10.67	10.66	10.65	10.65
NI02	8.44	8.44	8.47	8.40	NI02	11.69	11.67	11.65	11.63
North Cove	8.06	7.91	7.91	8.01	North Cove	8.94	8.90	8.85	8.79
PS	8.23	8.24	8.23	8.23	PS	13.16	13.13	13.23	13.60
SP01					SP01	16.43	16.49	16.50	16.91
SP01					SP01	16.43	16.49	16.50	16.91
SP02					SP02	13.62	13.67	13.79	13.78
SP03					SP03	17.39	17.55	17.25	17.11
SS01	7.93	7.92	7.92	7.92	SS01	9.00	9.04	9.18	9.25
SS02	7.91	7.91	7.91	7.91	SS02	9.41	9.48	9.62	9.78
SS03	7.80	7.96	7.99	8.01	SS03	11.93	11.02	11.22	11.41
Stikine	8.15	8.16	8.16	8.16	Stikine	11.11	11.17	11.23	11.33
Storey Island	8.17	8.15	8.21	8.16	Storey Island	9.13	9.14	9.19	9.22
Sunny Cove	8.33	8.33	8.34	8.46	Sunny Cove	10.66	10.69	10.85	11.45
WS	8.14	8.14	8.14	8.15	WS	11.87	12.24	12.60	13.04
Average	8.23	8.25	8.26	8.27	Average	12.55	12.62	12.68	12.84

Table 38. Concentrations of ammonia-N, total (T) and dissolved (D), copper (Cu), nickel (Ni), and zinc (Zn) at Shipping Lanes sampling stations.

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)
ChS02	0.014	0.16	0.14	0.35	0.37	0.10	0.10
ChS03	0.006	0.18	0.21	0.37	0.36	0.10	0.10
CS01	0.045	0.15	1.13	0.30	0.28	0.10	0.10
CS02	0.017	0.13	0.14	0.28	0.28	0.10	0.10
CS03	0.020	0.10	0.12	0.29	0.28	0.10	0.10
DI01	0.009	0.13	0.13	0.27	0.28	0.10	0.10
FP	0.004	0.17	0.19	0.37	0.36	0.10	0.10
FS01	0.014	0.13	0.18	0.35	0.35	0.23	0.10
FS02	0.027	0.14	0.30	0.35	0.36	0.10	0.10
FS03	0.008	0.20	0.20	0.40	0.37	3.02	1.06
IS01	0.002	0.14	0.21	0.35	0.34	0.10	0.10
IS02	0.030	0.25	0.25	0.45	0.42	0.24	0.10
LC01	0.004	0.23	0.22	0.41	0.39	0.10	0.10
LC02	0.008	0.25	0.24	0.38	0.33	0.27	0.10
MP	0.012	0.33	0.33	0.49	0.44	0.23	0.10
NI01	0.026	0.14	0.17	0.29	0.27	0.10	0.10
NI02	0.015	0.13	0.22	0.26	0.28	0.10	0.10
North Cove	0.022	0.20	0.23	0.38	0.36	1.26	0.20
PS	0.006	0.15	0.15	0.37	0.35	0.10	0.10
SP01	0.020	0.15	0.19	0.36	0.35	0.10	0.10
SP02	0.025	1.40	0.91	1.70	1.05	1.69	0.72
SP03	0.004	0.19	0.20	0.39	0.39	0.10	0.10
SS01	0.028	0.18	0.16	0.35	0.33	0.28	0.10
SS02	0.043	0.15	0.17	0.33	0.33	0.25	0.10
SS03	0.019	0.54	0.37	0.55	0.39	0.47	0.10
Stikine	0.011	0.19	0.19	0.33	0.30	0.10	0.10
Storey Island	0.011	0.48	0.49	0.43	0.42	0.10	0.10
Sunny Cove	0.007	0.39	0.76	0.48	0.42	0.10	0.10
WS	0.014	0.14	0.15	0.37	0.36	0.10	0.10
Averages*	0.016	0.25	0.29	0.41	0.37	0.34	0.16

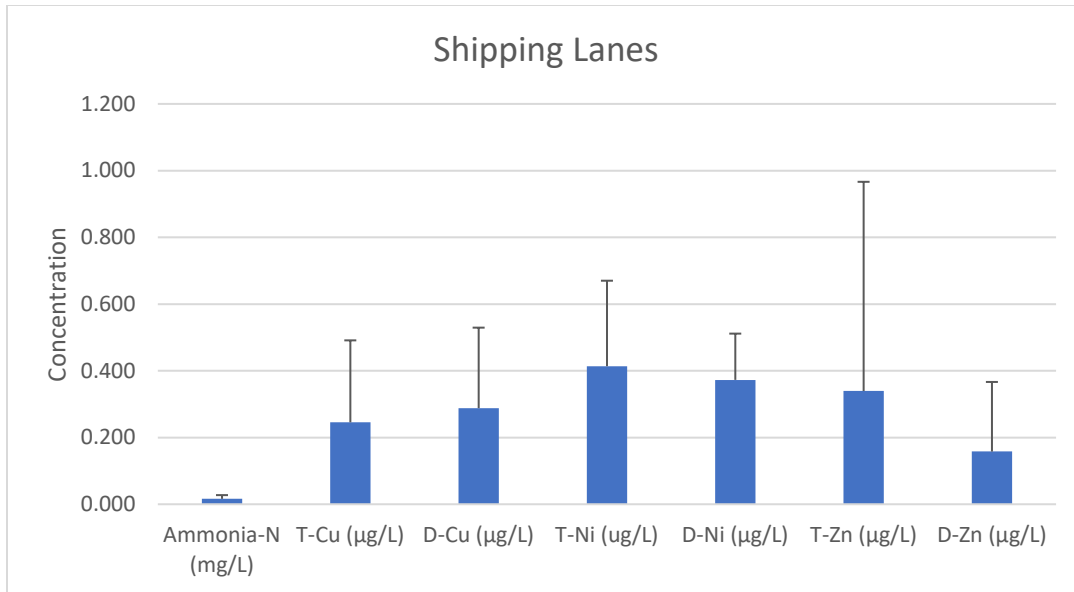


Figure 38. Mean concentrations (n = 29) of ammonia-N and total (T) and dissolved (D) copper, nickel, and zinc among the Shipping Lanes sites. Error bars are one standard deviation.

Annual Port Comparisons

Average concentrations of ammonia-N and total Cu, Ni, and Zn from 2020, 2021, and 2022 samples are provided in Table 39. Ammonia-N concentrations were low at all ports in all years, well below the WQC of 0.3 mg/L. Average ammonia-N concentration ranged from 0.01 to 0.06 mg/L in 2022, 0.01 mg/L to 0.03 mg/L in 2021, and 0.01 to 0.04 mg/L in 2020 samples. Ports with greater than the average 2022 concentration were Dutch Harbor, Valdez, Kodiak, Homer, and Petersburg.

Average concentrations of total Cu ranged from 1.6 (2022) to 1.7 µg/L (2021 and 2020). Total Ni ranged from 1.2 (2022, and 2020) to 1.3 (2021) and total Zn from 2.6 (2022) to 3.0 (2020). Every year concentrations were above average in the Southcentral Ports of Anchorage, Seward, and Valdez. Excluding these ports average Cu and Ni concentrations were < 0.7 µg/L and Zn < 1.5 µg/L. Average metal concentrations were not significantly different among sampling years (ANOVA $p > 0.05$).

Geomean fecal coliform bacteria concentrations exceeded 14 cfu/100 ml at more sampling sites in 2020 compared to 2021 and 2022. In 2020 concentrations were greater than WQC at 20 sites located in Kodiak (2 sites), Nome (1), Valdez (4 sites), Seward (3), Homer (1) Petersburg (2), Juneau (1), Hoonah (1), Ward Cove (3), and Ketchikan (2). In 2021 geomean concentrations were greater than WQC at five sites located in Anchorage (1), Dutch Harbor (1), and Valdez (3); and in 2022 at 4 sites located in Homer (1), Valdez (2), and Ketchikan (1).

Table 39. Average concentrations of ammonia-N and total Cu, Ni, and Zn from 2020, 2021, and 2022 samples collected in Alaska's Ports. Most ports had 5 or 6 sites. Hoonah had 8 sites, Juneau/Auke Bay 12, Ketchikan 8, and Sitka 10.

Port	Ammonia-N (mg/L)			T-Cu (µg/L)			T-Ni (µg/L)			T-Zn (µg/L)		
	2022	2021	2020	2022	2021	2020	2022	2021	2020	2022	2021	2020
Anchorage	0.013	0.005	0.009	15.60	20.79	15.25	9.06	14.00	9.90	19.17	31.57	23.37
Auke Bay	0.018	0.011	0.014	0.41	0.44	0.98	0.44	0.47	0.58	0.70	0.77	1.66
Dutch Harbor	0.059	0.021		0.72	0.46		0.32	0.22		1.44	2.32	
Haines	0.009	0.010	0.006	0.31	0.38	0.45	0.39	0.37	0.26	0.42	0.46	0.93
Homer	0.027	0.020	0.002	0.59	0.78	0.76	0.49	0.60	0.64	0.85	1.07	1.12
Hoonah	0.004	0.008	0.002	0.26	0.32	0.30	0.38	0.41	0.37	0.24	0.60	0.22
Juneau	0.020	0.031	0.002	0.56	0.68	0.68	0.56	0.72	0.66	0.94	1.38	1.30
Ketchikan	0.021	0.016	0.004	0.38	0.23	0.33	0.30	0.30	0.28	0.68	0.91	0.67
Kodiak	0.049	0.033	0.023	0.38	0.28	0.58	0.33	0.34	0.36	1.63	0.71	2.51
Nome	0.012	0.002		0.82	1.01		0.90	0.97		0.91	0.43	
Petersburg	0.038	0.025	0.043	0.25	0.26	0.41	0.37	0.43	0.39	0.34	0.46	0.58
Seward	0.016	0.033	0.015	4.48	1.64	2.06	3.07	1.19	1.76	5.97	3.23	3.13
Sitka	0.018	0.016	0.002	0.27	0.41	0.39	0.30	0.29	0.27	0.84	1.53	0.93
Skagway	0.014	0.025	0.014	0.50	0.39	0.42	0.40	0.30	0.24	5.35	1.26	2.62
Utqiagvik		0.026			0.36			0.44			0.42	
Valdez	0.045	0.028	0.009	2.72	2.04	1.26	2.31	2.05	1.36	4.05	3.40	2.18
Ward Cove	0.023	0.005	0.002	0.37	0.26	0.51	0.34	0.31	0.33	1.30	0.80	1.76
Whittier	0.012	0.005	0.005	0.58	0.49	0.79	0.48	0.46	0.66	1.29	0.62	2.41
Wrangell	0.023	0.009	0.002	0.27	0.34	2.58	0.35	0.43	1.78	0.41	0.32	3.27
Average	0.023	0.017	0.009	1.64	1.66	1.73	1.15	1.28	1.24	2.58	2.75	3.04

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- 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 2018.

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).

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. Hold time exceedances were due to remote sampling locations for some Shipping Lanes sites or because of cancelled or delayed flights.

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. Precision results for ammonia-N and metals samples are shown in Table 40 and Table 41 are the precision results for in situ measures of water temperature, pH, salinity and dissolved oxygen. For ammonia-N, 67% of replicate samples met data quality objectives. For metals, 89% to 100% of replicates met precision quality objectives. For field measures, 72% to 100% of the replicate samples met data quality objectives.

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 seven of 19 trip blanks and total Ni in one of the 19 trip blanks. (Table 42).

Ammonia-N and total and dissolved metals also were present at low concentrations in some field blanks. Field blanks are ionized water taken into the field and exposed to the same sample collecting procedures as routine samples. (Table 43). Ammonia-N was present at a maximum concentration of 0.02 mg/L. Dissolved Cu was above MRL in 10 of the 18 samples at a maximum concentration of 0.34 µg/L. Total Cu was present at concentrations above MRL in 4 of the 18 samples. Ni was not found in concentrations above MRL and Zn was found in two samples.

Table 40. Number of sample replicates, and number that did not meet sample quality objectives. Max Difference is the greatest difference between replicates.

	Samples	Number not meeting Objective	Percent Meeting Objective	Max Difference
Ammonia-N	18	6	66.67	0.026
Dissolved Cu	18	1	94.44	0.25
Total Cu	18	0	100.00	0.10
Dissolved Ni	18	0	100.00	0.03
Total Ni	18	1	94.44	0.15
Dissolved Zn	18	1	94.44	1.24
Total Zn	18	2	88.89	0.20

Table 41. The number of replicate field measures, number of replicates that did not meet data quality objectives and the percent of samples that met data quality objectives.

	Replicate Measures	No. not Meeting Objective	Percent Meeting Objective
Temperature	60	10	83.33
pH	60	17	71.67
Salinity	59	3	94.92
DO	59	0	100.00

Table 42. Number of trip blanks with concentrations of total metals present.

Measure	Total Number	No. > than MDL	Percent Meeting Criteria	No. > than MRL	Percent Meeting Criteria
Copper	19	7	63.16	2	96.83
Nickel	19	1	94.74	0	100.00
Zinc	19	0	100.00	0	100.00

Table 43. Number of equipment blanks with concentrations above the MDL and the MRL. The percent of samples that met the criteria ranged from 44.4 for dissolved Cu to 100% for Ni.

Field Blanks	Total Number	No. > MDL	Percent Meeting Criteria	NO. > MRL	Percent Meeting Criteria	Max Value
Ammonia-N	18	14	22.22	6	66.67	0.02
Dissolved Cu	18	16	11.11	10	44.44	0.34
Total Cu	18	13	27.78	4	77.78	0.67
Dissolved Ni	18	4	77.78	0	100.00	0.10
Total Ni	18	2	88.89	0	100.00	0.14
Dissolved Zn	18	8	55.56	2	88.89	2.48
Total Zn	18	7	61.11	2	88.89	2.01

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