

# CPVEC Ambient Water Quality Monitoring: Ketchikan (2018-2019) and Seward Harbors (2019)



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**Alaska Department of Environmental Conservation  
Division of Water  
Commercial Passenger Vessel Environmental  
Compliance Program**

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2019 Annual Report

Cover Photograph. Cruise ships in Tongass Narrows near Ketchikan June 25, 2019.

## Summary

Water sampling was conducted in Tongass Narrows near Ketchikan in Resurrection Bay near Seward in June of 2019. Water samples were analyzed for concentrations of ammonia-N; dissolved and total copper (Cu), nickel (Ni), and zinc (Zn); and the abundance of fecal coliform and *enterococci* bacteria. In Tongass Narrows, samples for bacterial analyses were also collected near the Alaska Marine Highway (AMHS) dock, near the city outfall, and at the entrance to the Thomas Basin, a small boat harbor in Ketchikan. Water temperature, salinity, pH, and dissolved oxygen were measured at 1, 2, 3, and 4m depths concurrently.

Water physical and chemical characteristics in Tongass Narrows were consistent with previous measures. Values did not vary to a large degree with water depth or among sampling sites. Water temperatures in the Tongass Narrows near Ketchikan were approximately 14°C on the June 25, 2019, sampling date. Average water temperatures were 0.4°C warmer at 1m than at 4m water depth. Dissolved oxygen concentrations ranged from 10.24 to 10.28 mg/L with water depth. The pH averaged 8.28, approximately 0.2 units higher than the lowest previous measured values. At 1m water depth, average salinity was 25.5 ppt and 25.9 at 4 m.

Fecal coliform bacteria near Ketchikan averaged 11 cfu/100 ml. Point measures in Thomas Basin, near the Alaska Marine Highway System (AMHS), and near the City outfall (between Carlanna Creek and the Airport) ranged from 5 to 11 cfu/100 ml. Ammonia-N concentrations were higher than previous measures, but dissolved and total concentrations of copper (Cu), nickel (Ni), and zinc (Zn) were similar to average 2018 values.

Water physical and chemical characteristics in Resurrection Bay near Seward, particularly salinity, varied considerably from the 1 m to 4m water depth. Salinity in Resurrection Bay near Seward increased from an average of 12.3 ppt at 1m, to 28.5 ppt at 4m. Average pH increased from 8.1 at 1m to 8.2 at 4m water depth. Water temperatures at 1m water depth averaged 12.2°C and 11.9°C at 4m water depth. Changes in dissolved oxygen (11.2 at 1m and 13.1 at 4m) were consistent with differences in water temperature.

Based on a single sampling event (n=6), ammonia-N concentrations in Resurrection Bay were similar to other harbors, but concentrations of metals tended to be higher. Average ammonia-N concentration (0.019 mg/L) was similar to averages in other harbors (0.022 mg/L). Average concentrations of dissolved Cu, Ni, and Zn (0.62 µg/L, 0.60 µg/L, and 1.39 µg/L, respectively) were higher than average values for all other harbors. Additional sampling should be conducted to determine if these June 2019 values accurately represent metals concentrations in Seward Harbor.

## Introduction

The Alaska Department of Environmental Conservation (DEC), Commercial Passenger Vessel Environmental Compliance (CPVEC) program is responsible for authorizing proposed wastewater discharges from cruise ships to marine waters. The DEC has issued a general permit (GP) for these discharges that requires compliance with water quality standard criteria at the point of discharge or submitting a request for a mixing zone. In order to authorize a mixing zone and determine the mixing zone size, the concentration of elements and physical properties of the receiving water, or ambient water quality, must be known. The current 2014 general permit is based on the best ambient water quality data available at the time of issuance; however, these data are limited.

The objective of this project is to provide more complete water quality data for future permits. More specifically, those water quality constituents that have the most likely potential to result in water quality exceedances due to cruise ship discharge: ammonia-N, copper, nickel, zinc, and fecal coliform bacteria. This report summarizes results from 2019 sampling conducted in Tongass Narrows near Ketchikan and in Resurrection Bay near Seward. These data augment previous water quality data from the Skagway, Juneau, Sitka, Ketchikan and Hoonah Harbors collected from September 2015 through October 2018.

## Methods

Field sampling and laboratory methods were implemented as described within the approved Quality Assurance Project Plan (QAPP) (ARRI 2018a).

### Sampling Locations

Within Tongass Narrows, water samples collected for ammonia-N and metals analyses from eight sampling sites randomly from 24 potential sampling sites (Figure 1, Figure 2, and Appendix B) and at the AMHS Dock (55.3529, -131.6946). Sampling in 2018 was at 12 sampling sites but reduced to eight in order to increase the number of water samples for bacterial analyses. Water samples from all sampling sites were analyzed for ammonia-N, dissolved and total Cu, Ni, and Zn. In 2018 water samples for bacterial analyses were collected at 3 of the 12 sampling sites, at the AMHS Dock site and at the mouth of Thomas Basin. In 2019 water samples for bacterial analyses were collected at 7 of the 8 sampling sites, the AMHS Dock site, near the City outfall (55.3550, -131.7028), and at the mouth of Thomas Basin (55.3386, -131.6430).

Within Resurrection Bay water samples were collected from six sampling locations (Figure 3). Three sampling locations were randomly selected from six potential sampling sites in Area A and three of six potential sampling sites from Area B. Water samples from all sampling sites were analyzed for ammonia-N, dissolved and total Cu, Ni, and Zn. Water samples was collected at one of these six sites and analyzed for fecal coliform bacteria and enterococci.

### Sampling Dates and Times

The dates and times water samples were collected are shown in Table 1. Sampling was conducted during the Cruise Ship season, but dates were selected to avoid times when ships with discharge permits were in port.

### Sample Collection

Water samples were collected from ~1 meter depth. Harbor water was pumped through Teflon tubing into laboratory-provided sample bottles using a peristaltic pump (Solonist 410). Tubing and bottles were

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flushed for approximately 3 minutes prior to sample collection at each sampling location. Water samples for dissolved metals were field filtered and the filter was flushed prior to sample collection.

Table 1. Dates and times sampling was conducted in Resurrection Bay near Seward and Tongass Narrows near Ketchikan, weather, and times of high and low tides. C is clear, and PC is partly cloudy.

<b>Resurrection Bay near Seward</b>				
Sample Date	Sample Time	Weather	Low Tide	High Tide
6/17/2019	10:30 to 11:30	PC	08:19	14:28
<b>Tongass Narrows near Ketchikan</b>				
Sample Date	Sample Time	Weather	Low Tide	High Tide
6/25/2019	07:30 to 11:30	C	13:06	06:49

Water temperature, pH, salinity, and dissolved oxygen were measured at 1, 2, 3, and 4 meter 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.

Two combined field/equipment blanks were collected from each harbor on each sampling date. Field/equipment blanks were collected using the same field methods as those for sample collection; however, water was pumped from laboratory-provided deionized water bottles. Replicate samples were collected at one of the sampling locations within each harbor.

### Analytical Methods

Water samples were analyzed by ALS Environmental by EPA method 200.8 following reductive precipitation reaction to obtain concentration of dissolved and total metals. Ammonia-N was analyzed using EPA method 350.1.

Water samples were analyzed for total fecal coliforms using EPA method 9222D and *Enterococci* by the most probable number method (ASTM D6503); conducted by ARS Aleut Analytical (Seward) and R&M Engineering (Ketchikan).

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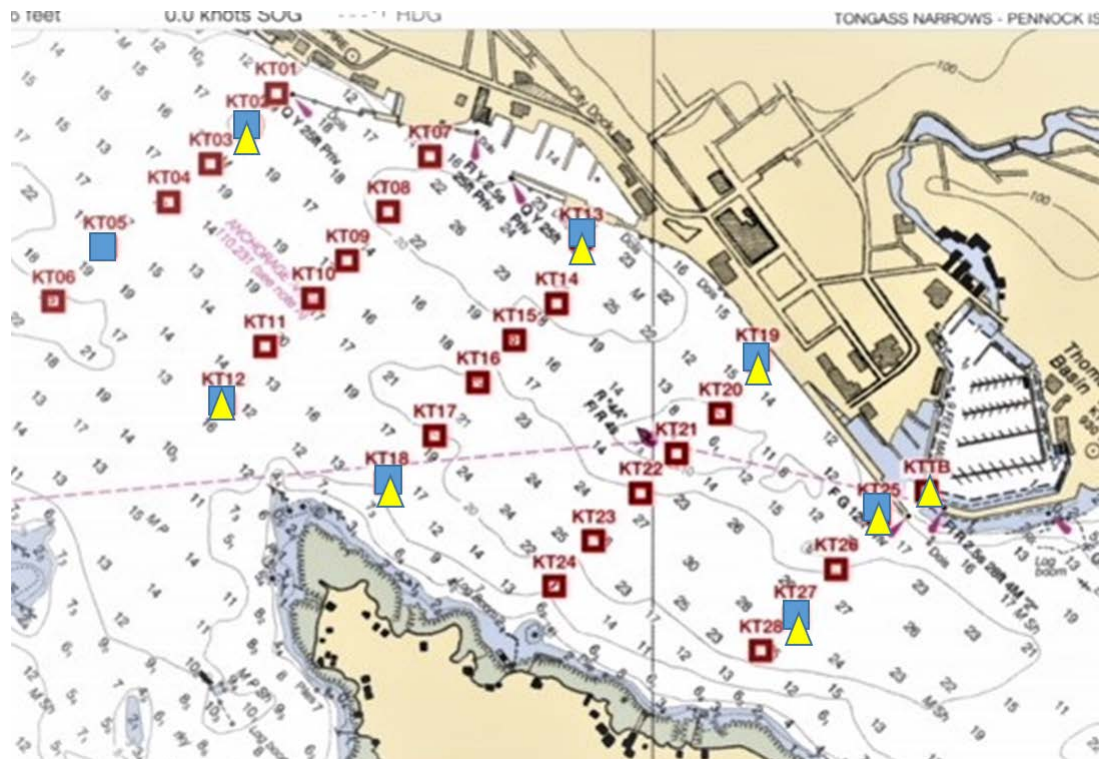


Figure 1. Potential sampling locations in Tongass Narrows near Ketchikan and at the mouth of Thomas Basin (KTTB). Blue squares indicate 2019 sampling sites. Yellow triangles indicate biological sampling sites. The AMHS Dock and City outfall sites are not shown but are located to the northwest.



Figure 2. Aerial view of Tongass Narrows showing the location of the sampling site near the Ketchikan Airport (KT AIR) and the Alaska Marine Highway Service (AMHS) relative to the main sampling area (KT 01 – KT 28) near the cruise ship docks and Thomas Basin (TB).



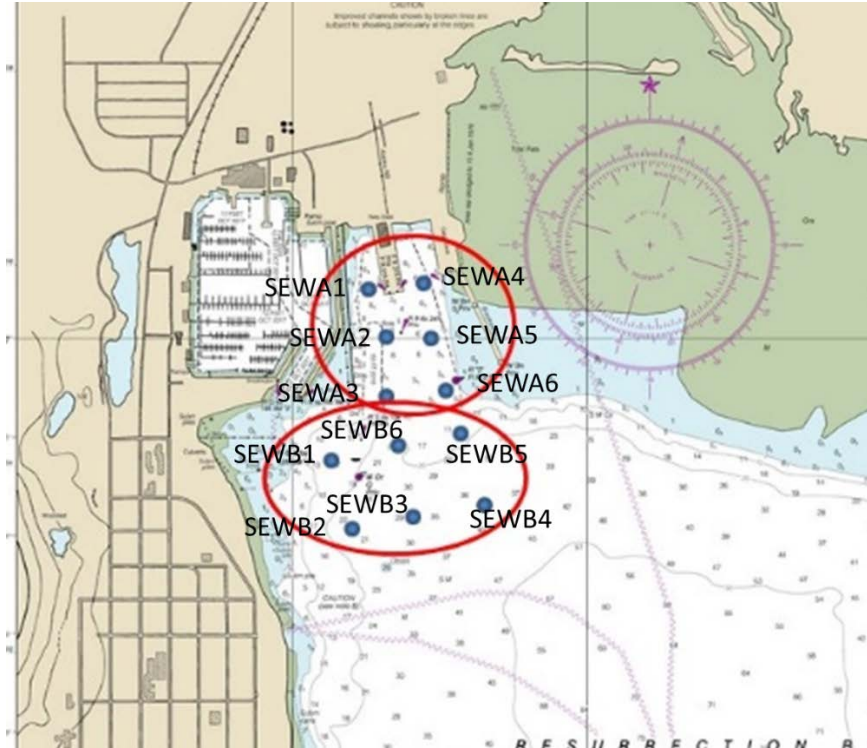


Figure 3. Potential sampling sites within two sampling areas in Resurrection Bay near the Seward Boat Harbor.

## Results

### Quality Assurance

All of the analyses met the laboratory data quality objectives for accuracy and precision. No metals or ammonia-N were found within trip blanks. All total metal concentrations in field/equipment blanks were below method detection limits (MDLs). Dissolved copper, nickel, zinc, and ammonia-N were present in field/equipment blanks at low concentrations (see Appendix C). Dissolved Nickel and Zinc were non-detect in the Seward equipment blank samples. Equipment/Field blanks are samples of laboratory-prepared deionized water collected at the same location and using the same methods as field samples. Average concentrations of dissolved metals in field/equipment blanks were above MDLs but below method reporting limits (MRLs). Ammonia-N concentrations were above method reporting limits therefore reported concentrations may be biased high.

Field replicate samples were collected at all harbors and on all sampling dates to test for precision (difference between replicates concentrations divided by the average concentration). The data quality objective for precision was established at 20%. One sample for total zinc in the Ketchikan Harbor did not meet the quality objective for precision.

### Resurrection Bay near Seward Harbor

#### Fecal Coliforms and *Enterococci*

One water sample collected in Resurrection Bay at site SEW A3 was analyzed for fecal coliform bacteria and *Enterococci* (Table 3). The abundance of 15 cfu/100 ml exceeds part of numeric criteria for

“Harvesting for Consumption of Raw Mollusks or Other Raw Aquatic Life” (14 cfu/100 ml) (18 AAC 70.020 (14)(D)). However, water quality criteria are based on a geometric mean of multiple samples within a 30-day period and require that a single sample exceed 31 cfu/100 ml (ADEC 2018)

Table 2. Abundance of fecal coliforms and *Enterococci* in a water sample collected from Resurrection Bay near the Seward Boat Harbor.

Date	Site	Measurement	Result	Unit
6/17/2019	SEW A3	Fecal Coliforms	15	CFU/100 ml
6/17/2019	SEW A3	Enterococci	1	MPN/100 ml

#### Water Temperature, Salinity, pH, and Dissolved Oxygen

Water physical and chemical characteristics measured at four sample depths at each sampling site are shown in Figures 3 through 6. There were differences in water characteristics with sample depth but only small differences among sampling sites. The differences in water physical and chemical characteristics are consistent with fresh, less saline, water near the water surface.

Water temperatures ranged from approximately 12° to 13°C with warmer waters near the surface at most sampling sites (Figure 4). Salinity was 10.0 ppt at 1 m water depth, increasing to 26 to 28 ppt at 4m water depth. (Figure 5). The pH of surface waters was 8.1 at 1m depth and increased slightly to 8.2 at 4m water depth (Figure 6). Concentrations of dissolved oxygen were lower in the warmer surface waters consistent with differences in water temperature and dissolved oxygen solubility (Figure 7).

#### Ammonia-N, Copper, Nickel, and Zinc

Concentrations of ammonia-N and dissolved and total Cu, Ni, and Zn in Resurrection Bay near the Seward Harbor are shown in Figures 8 through 11. Concentrations of ammonia-N ranged from 0.1 to 0.3 mg/L and averaged 0.2 mg/L (Figure 8). Dissolved Cu concentrations ranged from 0.4 to 0.9 µg/L and averaged 0.62 µg/L. Total Cu concentrations averaged 1.39 µg/L and ranged from 1.0 to 1.9 µg/L (Figure 8). Concentrations of dissolved Ni averaged 0.6 µg/L with a range from 0.5 to 0.8 µg/L. Concentrations of total Ni were nearly two times higher than dissolved concentrations with an average of 1.12 µg/L and a range from 0.9 to 1.5 µg/L (Figure 10). Dissolved Zn concentrations averaged 1.39 µg/L and total Zn averaged 2.58 µg/L (Figure 11).



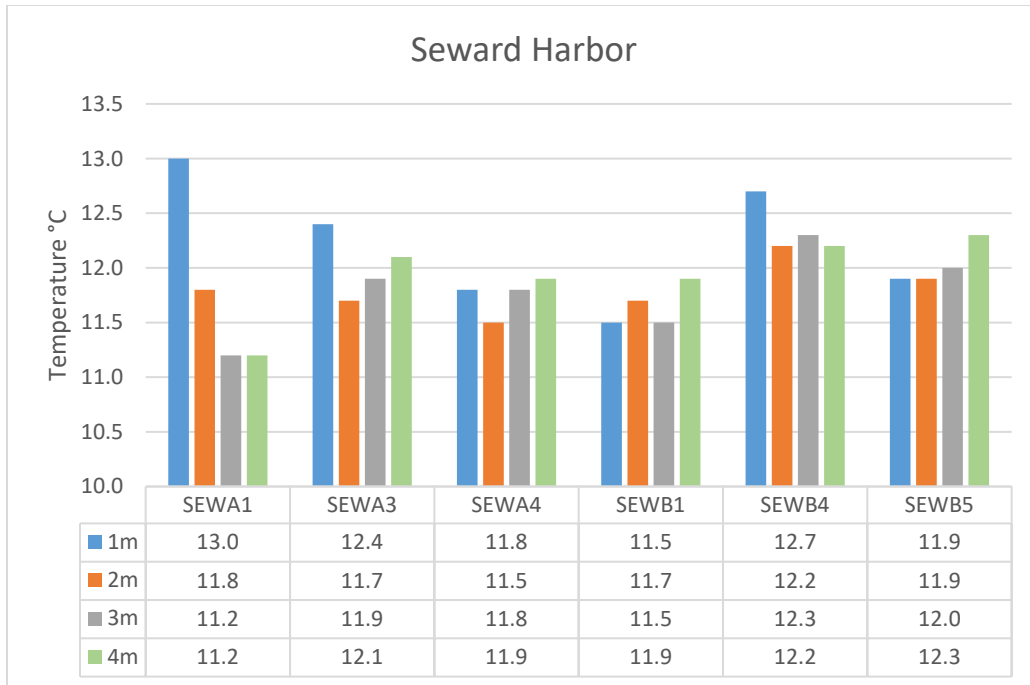


Figure 4. Water temperature at Seward Harbor sampling sites on 17 June 2019 at 1m to 4m water depth.

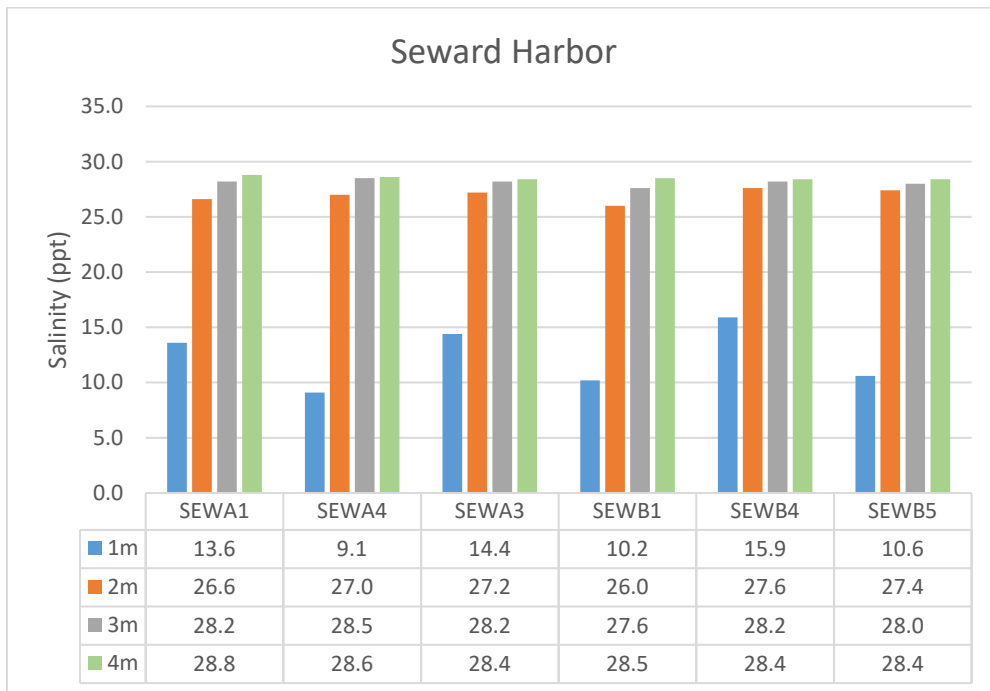


Figure 5. Salinity at Seward Harbor sampling sites on 17 June 2019 at 1m to 4m water depth.



Figure 6. Water pH at Seward Harbor sampling sites on 17 June 2019 at 1m to 4m water depth.

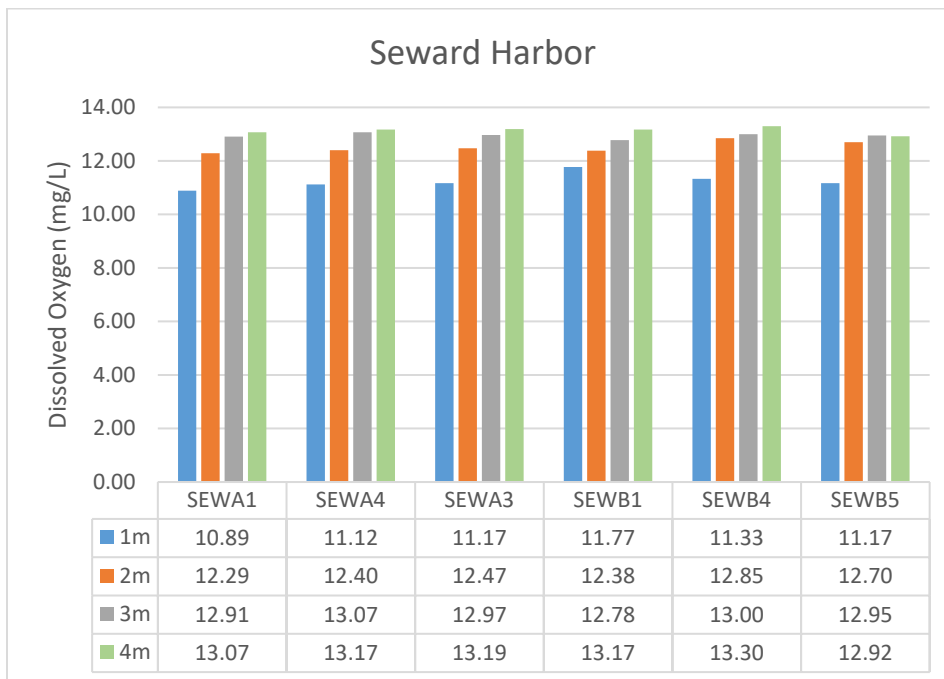


Figure 7. Dissolved oxygen concentration at Seward Harbor sampling sites on 17 June 2019 at 1m to 4m water depth.

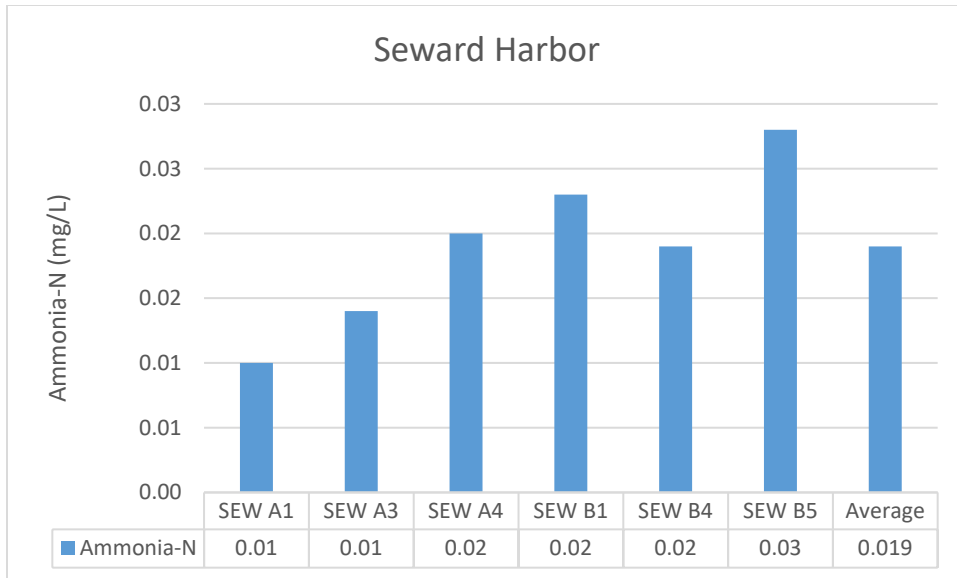


Figure 8. Ammonia-N concentrations at Seward Harbor sampling sites on 17 June 2019.

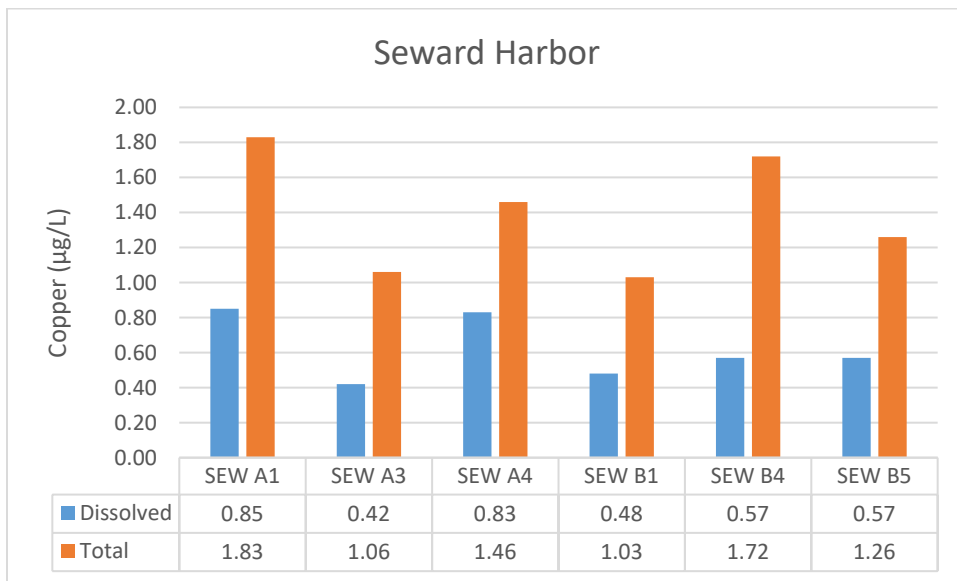


Figure 9. Dissolved and total Cu concentrations at Seward Harbor sampling sites on 17 June 2019.

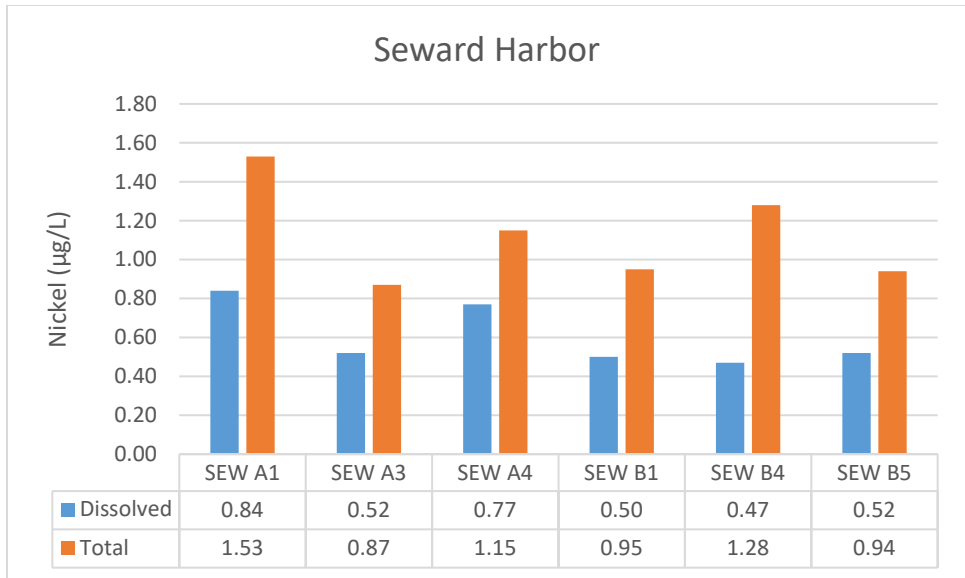


Figure 10. Dissolved and total Ni concentrations at Seward Harbor sampling sites on 17 June 2019.

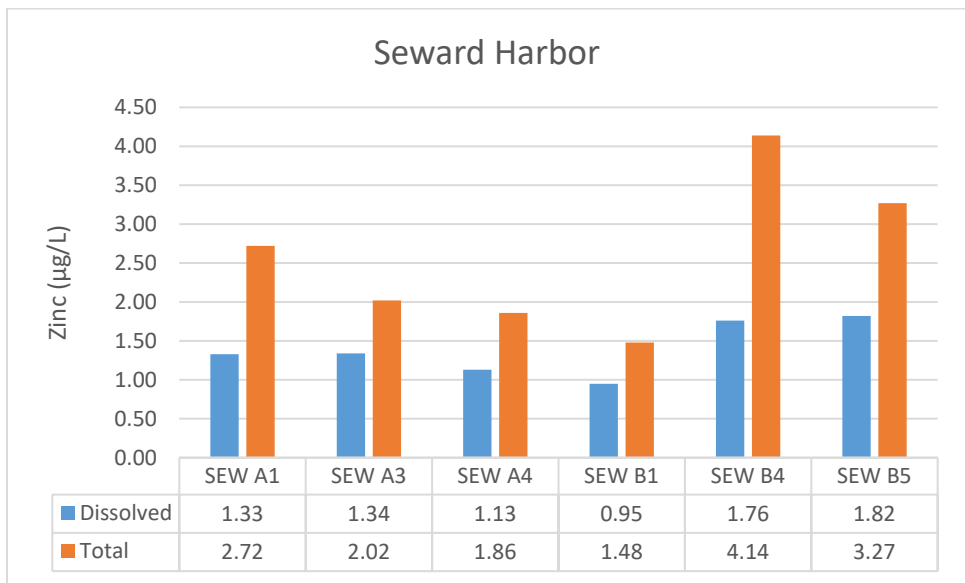


Figure 11. Dissolved and total Zn concentrations at Seward Harbor sampling sites on 17 June 2019.

## Ketchikan Harbor

### Fecal Coliforms and Enterococci

The abundance of fecal coliform and *enterococci* bacteria from all sampling dates and sites are shown in Table 3. Tongass Narrows values for the main cruise ship area are an average of samples three samples in 2018 and seven samples in 2019. Thomas Basin, AMHS Dock and City Outfall are reported individually. Bacterial results for Thomas Basin and the City Outfall are informational and outside of the original scope of this project. The concentration of fecal coliforms previously exceeded water quality standard numeric criteria for some uses; however, fecal coliform abundance on 25 June 2019 were lower than previous measures, ranged from 5 to 14, and averaged 11 cfu/100 ml. Water quality criteria are based on the geometric mean of multiple samples collected within 30 days; therefore, sample results reported here cannot be used to evaluate potential exceedances. However, concentrations of fecal coliforms in samples exceeded numeric criteria for “Harvesting for Consumption of Raw Mollusks or Other Raw Aquatic Life” (14 cfu/100 ml) (18 AAC 70.020 (14)(D)) in Tongass Narrows in June and August, and at Thomas Basin and AMHS Dock in June, August and October. Numeric criteria for contact recreation (35 *enterococci* cfu/100 ml) were exceeded in August samples collected at all sampling sites in August and at the AMHS Dock in June and August. High fecal coliform counts were generally associated with high counts of *enterococci*, with the exception of the fecal coliform in the October sample in Thomas Basin.

Table 3. Fecal coliform and enterococci results for samples collected in Tongass Narrows (Main cruise ship area sample size n=3 unless otherwise noted in table) near Ketchikan, the entrance to the Thomas Basin small boat harbor, and in Tongass Narrows near the AMHS Dock. Values for Tongass Narrows are the average of three (2018) to seven (2019) samples rounded to the nearest whole number.

Fecal Coliforms				
(cfu/100 ml)	Tongass Narrows	Thomas Basin	AMHS Dock	City Outfall
4/9/2018	6	11	6	
6/5/2018	18	19	22	
8/9/2018	76	315	166	
10/17/2018	7	58	28	
6/25/2019	11	5	6	11
Enterococci				
(cfu/100 ml)	Tongass Narrows	Thomas Basin	AMHS Dock	City Outfall
4/9/2018	8	5	2	
6/5/2018	5	<10	52	
8/9/2018	96	1553	192	
10/17/2018	7	11	14	
6/25/2019	<10	<10	<10	10

### Water Temperature, Salinity, pH and Dissolved Oxygen

Water physical and chemical characteristics for all sampling dates are shown in Figures 12 through 15. There are no apparent differences in water quality characteristics between Tongass Narrows near Ketchikan and near the AMHS Dock. In 2018, water temperatures ranged from 6.4°C in April to 15.7°C in August. Water temperatures decreased < 1°C with depth to 4m. Water temperatures in June of 2019 were 14°C (Figure 12). Salinity was near 30 ppt in April. In June, salinity at the water surface decreased

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to ~22 ppt and near 24 ppt in August and October. Salinity on 25 June 2019 ranged from 25.4 to 25.7 ppt (Figure 13). The largest difference in salinity with water depth was an increase of 1.8 ppt in August 2018.

The pH ranged from near 8.0 in April to 8.2 in June and August (Figure 14). In June 2019, pH was 8.26 at all depths. Dissolved oxygen was above saturation on all sampling dates with concentrations ranging from over 11 mg/L to a low of 8.6 mg/L in August 2018, and 10.2 on 25 June 2019 (Figure 15).



Figure 12. Average water temperature in Tongass Narrows near Ketchikan (top) near the AMHS dock (bottom). Error bars are one standard deviation.





Figure 13. Average salinity in Tongass Narrows near Ketchikan (top) and the AMHS dock (bottom). Error bars are one standard deviation.



Figure 14. Average pH in Tongass Narrows near Ketchikan (top) and the AMHS dock (bottom). Error bars are one standard deviation.

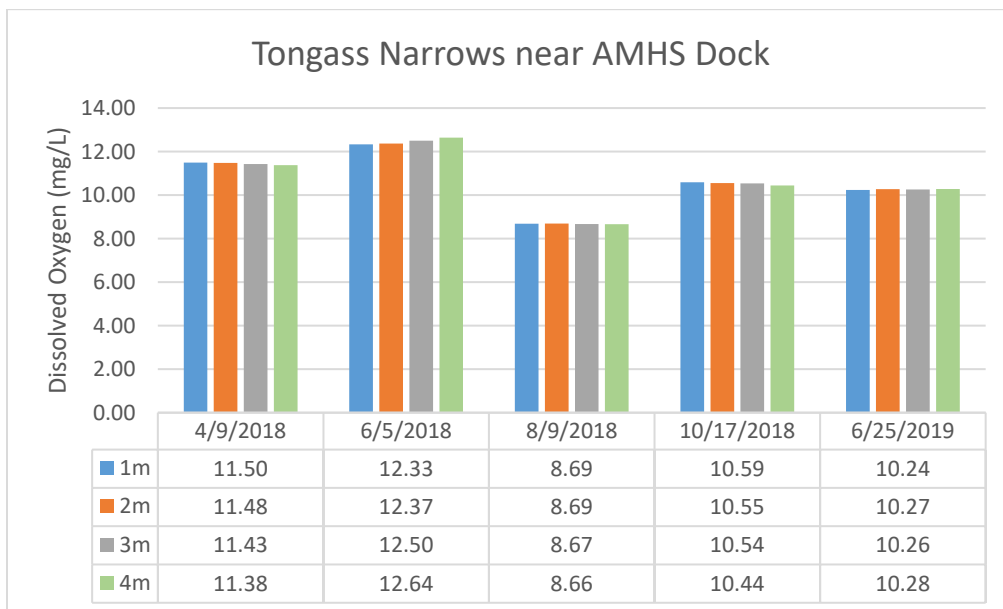
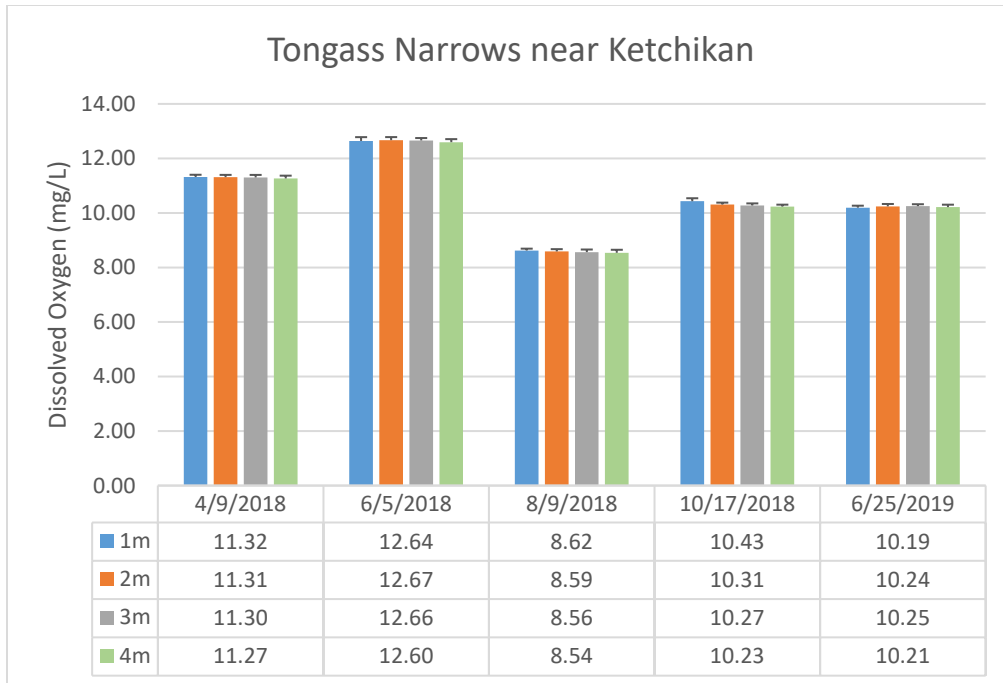


Figure 15. Average concentration of dissolved oxygen in Tongass Narrows near Ketchikan at water depths from 1 m to 4m (top) and at the AMHS dock (bottom). Error bars are one standard deviation.

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Ammonia-N, Copper, Nickel, and Zinc

Concentrations of ammonia-N, Cu, Ni, and Zn are shown in figures 16 through 19. Results are provided separately for samples collected near the AMHS Dock and average values for Tongass Narrows. However, there were no statistically significant differences between these two locations for concentrations of ammonia-N, or dissolved and total Cu, Ni, and Zn (t-test,  $p > 0.5$  for all test).

Average ammonia-N concentrations on 25 June 2019 were 0.045 mg/L which were higher than the overall average (all sampling dates) of 0.022 mg/L (Figure 16).

Dissolved Cu concentrations were similar among sampling dates ( $< 0.5 \mu\text{g/L}$ ) and have ranged from 0.3 to 0.5  $\mu\text{g/L}$  (Figure 17). Total Cu concentrations are only slightly higher and have been generally  $< 0.6 \mu\text{g/L}$ , and similar among sampling dates.

Dissolved Ni concentrations decreased in Tongass Narrows from 0.1  $\mu\text{g/L}$  to 0.3  $\mu\text{g/L}$ , and total concentrations from 0.1 to 0.4  $\mu\text{g/L}$  (Figure 18).

Average concentrations of dissolve Zn were similar among sampling dates an generally  $< 1.0 \mu\text{g/L}$ . Total Zn was relatively high in April samples (2.1  $\mu\text{g/L}$ ) but closer to dissolved concentrations on all other sampling dates (Figure 19).

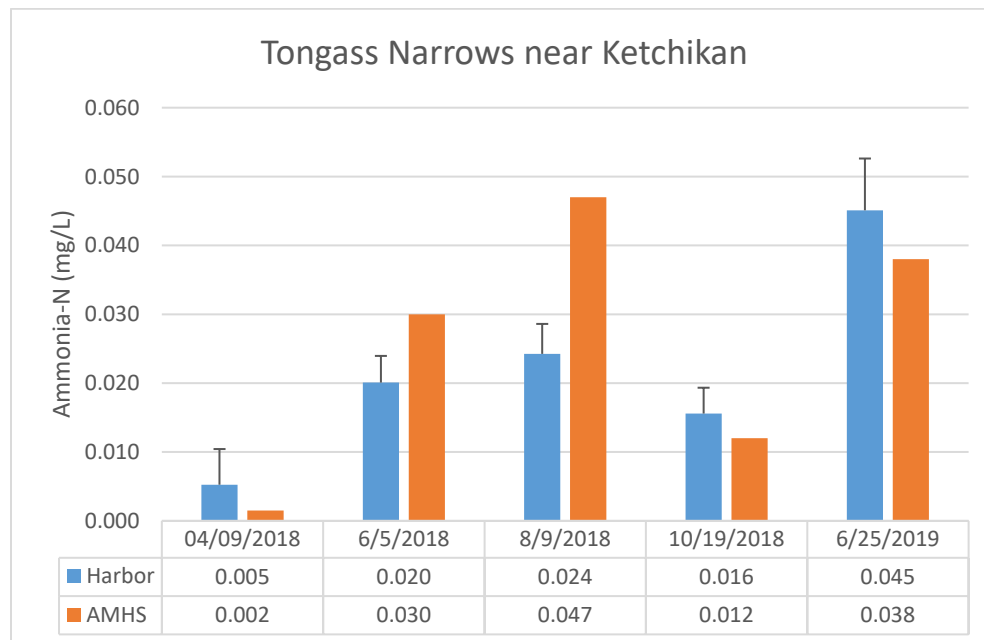


Figure 16. Average Ketchikan Harbor and AMHS point measure of ammonia-N concentrations on each 2018 and June 2019 sampling date. Error bars are one standard deviation.

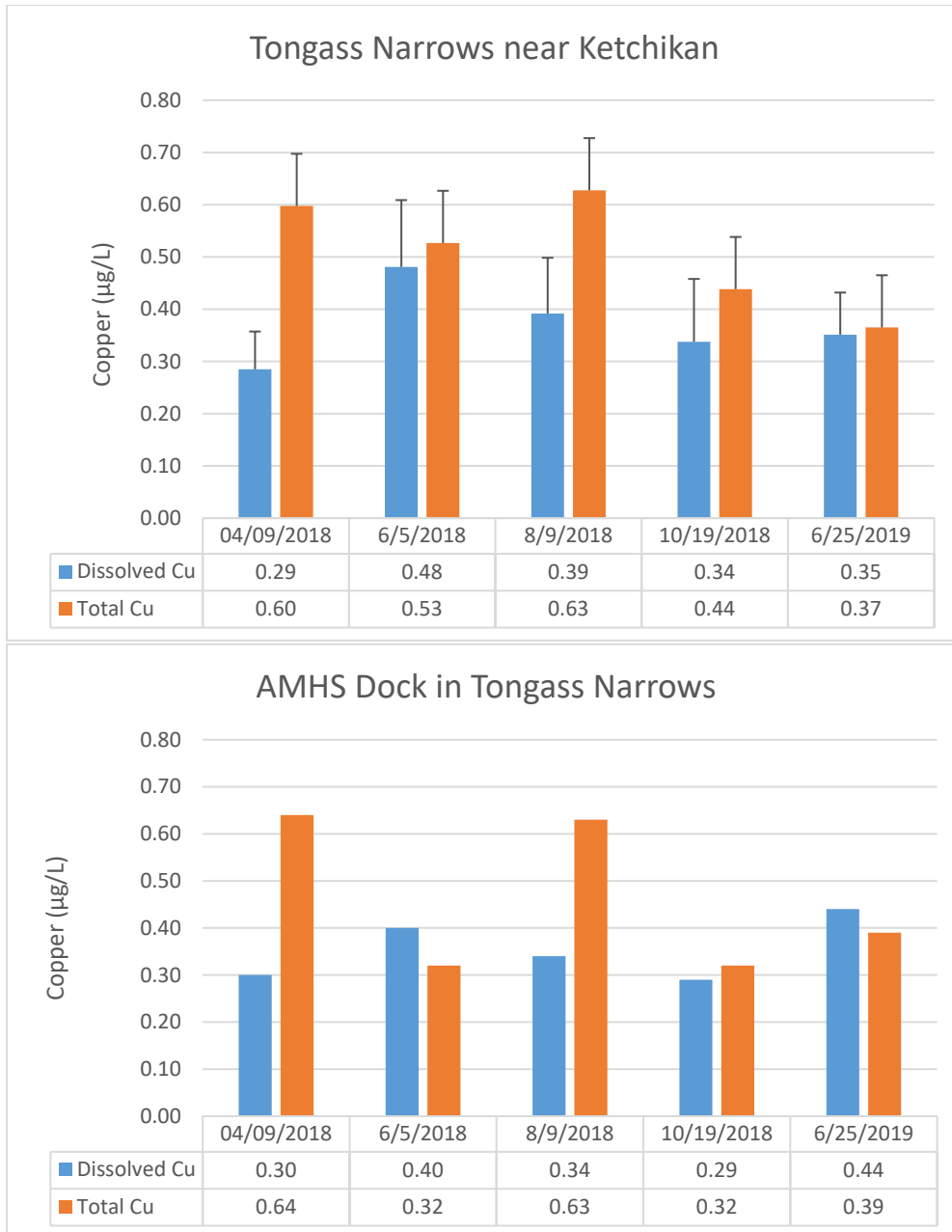


Figure 17. Average Ketchikan Harbor and AMHS point measure of dissolved and total copper concentrations on each 2018 and June 2019 sampling dates. Error bars are one standard deviation.

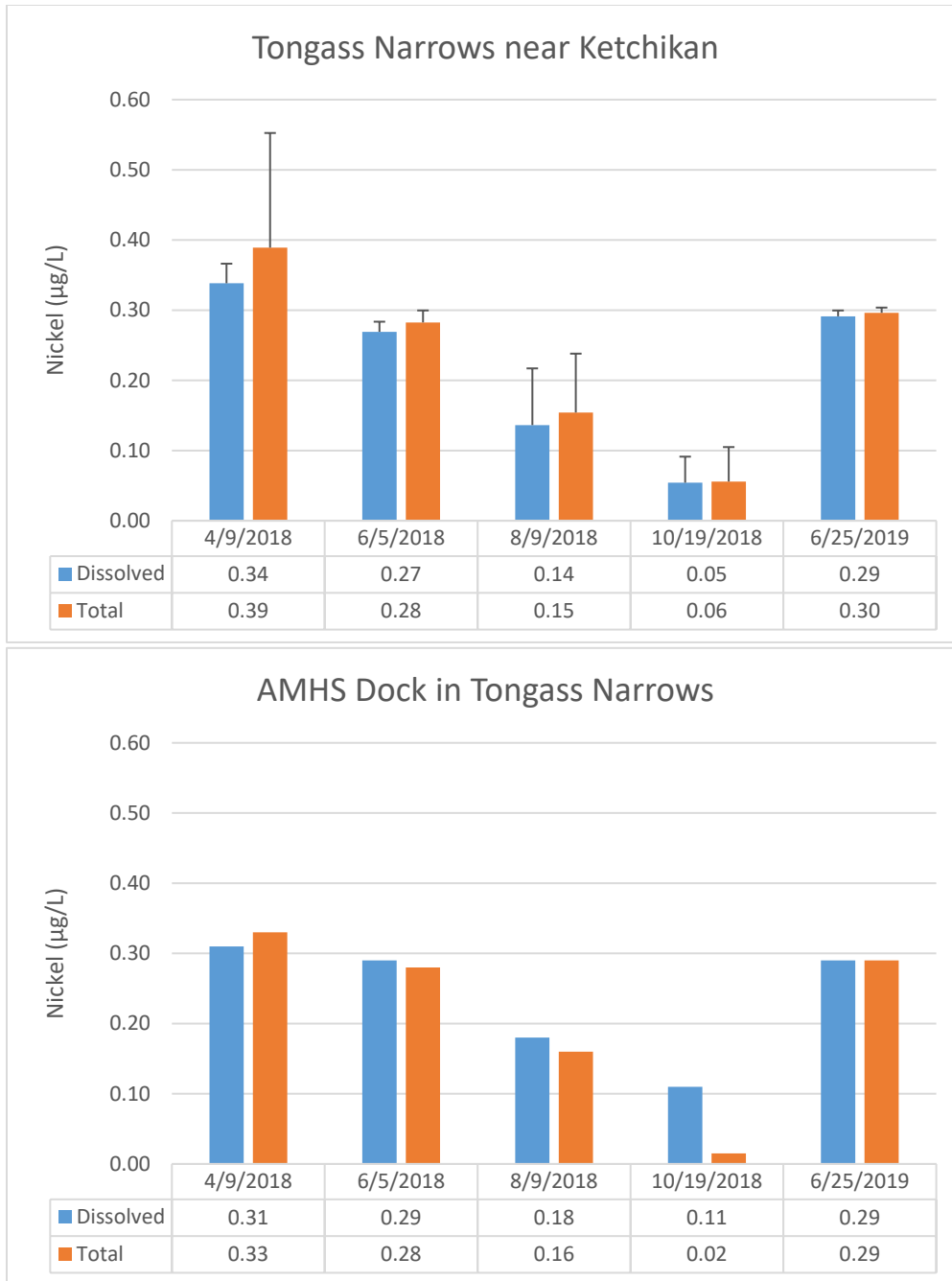


Figure 18. Average Ketchikan Harbor (N = 12), and AMHS point measure of dissolved and total nickel concentrations on each 2018 and June 2019 sampling dates. Error bars are one standard deviation.



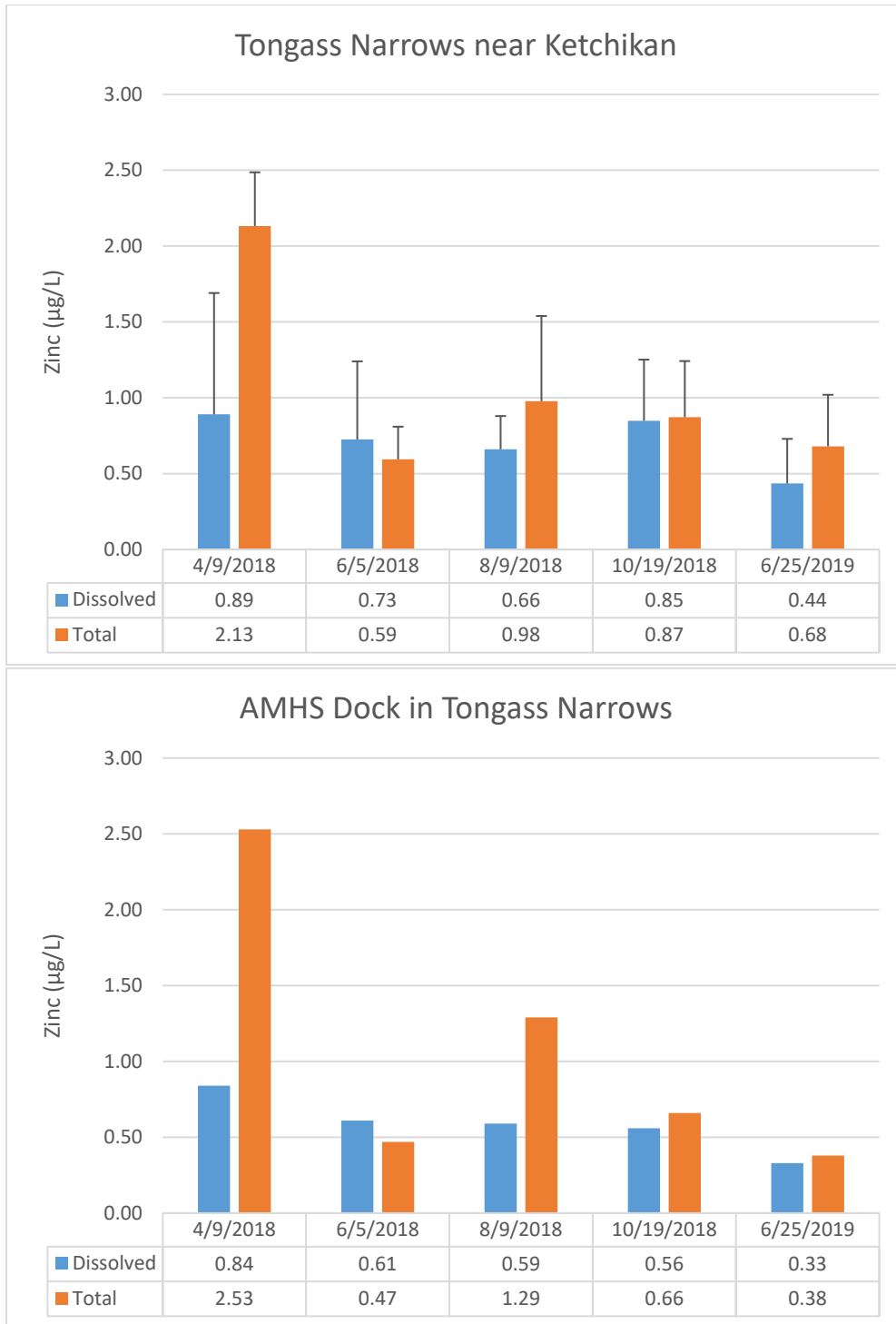


Figure 19. Average Ketchikan Harbor and AMHS point measure of dissolved and total zinc concentrations on each 2018 and June 2019 sampling dates. Error bars are one standard deviation.

## Summary of Ambient Water Quality Monitoring

Ambient water quality sampling was conducted in the spring and fall from September of 2015 through October of 2017 in the Skagway and Juneau Harbors. The Skagway Harbor also was sampled in June of 2017 (ARRI 2018b). Results for those Harbors are summarized in ARRI's 2018 report (ARRI 2019). In 2018 sampling was conducted in the Sitka and Hoonah Harbors on three sampling dates (April, June, and August) and in the Ketchikan Harbor on four sampling dates (April, June, August, October). Sampling in 2019 was conducted in June providing additional data for the Ketchikan Harbor and initial data for the Seward Harbor.

Salinity was most variable in the Skagway and Seward Harbors due to adjacent rivers. Salinity in the Skagway Harbor has been measured at over 30 ppt (April 2017) and less than 15 ppt (Sept 2016, June and Oct 2017). In June of 2016, salinity in the Skagway Harbor was 8.4 ppt at 1m water depth and 14.3 ppt at 4m water depth. Low salinity was associated with high flows from the Dyea and Skagway Rivers. Salinity in the Seward Harbor averaged 12.3 ppt at 1m water depth and 27 ppt at 4m. This is consistent with a surface layer of freshwater from the adjacent Resurrection River, Sheffler Creek, and Salmon River. Salinity in the Juneau, Ketchikan, Sitka, and Hoonah Harbors was between approximately 20 to 25 ppt and 30 ppt, with higher salinity during April sampling.

A comparison of average ammonia-N and concentrations of dissolved and total metals is provided in Table 4 and Figure 20 through Figure 23. Concentrations varied seasonally at all sampling locations. There were, however, no consistent differences in concentrations within a harbor that would indicate potential point sources. Ammonia-N tended to be lower in the Sitka and Hoonah Harbors. Average concentrations of Zn in Hoonah also were lower than other sampling sites. Concentrations of metals appear to be higher in Seward than other harbors; however, results are based on a single sampling event, the number and timing of samples varies among harbors, and apparent differences have not been tested statistically.

Table 4. Average harbor concentrations of ammonia-N and dissolved and total metals from ambient water quality sampling. Number (n) of sampling dates vary among locations. Averages for each sampling date are from 12 samples within each major harbor (Skagway, Juneau, Sitka, and Ketchikan), four samples in Hoonah, and six samples in Seward. With the exception of eight samples in the Ketchikan Harbor on the 2019 sampling date.

	Skagway (n= 5)	Juneau (n= 4)	Sitka (n = 3)	Ketchikan (n = 5)	Hoonah (n = 3)	Seward (n = 1)
Ammonia-N (mg/L)	0.025	0.022	0.010	0.022	0.013	0.019
Dissolved Cu (µg/L)	0.29	0.44	0.20	0.35	0.27	0.62
Total Cu (µg/L)	0.39	0.54	0.45	0.46	0.35	1.39
Dissolved Ni (µg/L)	0.31	0.50	0.27	0.22	0.36	0.60
Total Ni (µg/L)	0.33	0.56	0.31	0.24	0.40	1.12
Dissolved Zn (µg/L)	1.15	0.98	1.04	0.71	0.23	1.39
Total Zn (µg/L)	1.42	1.21	1.04	1.05	0.45	2.58

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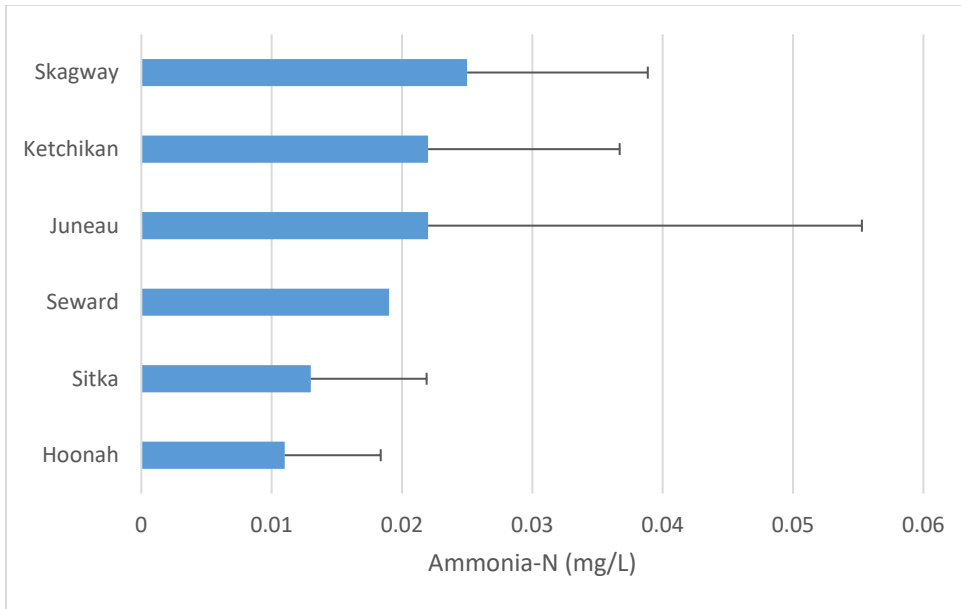


Figure 20. Average harbor ammonia-N concentrations. Error bars are one standard deviation.

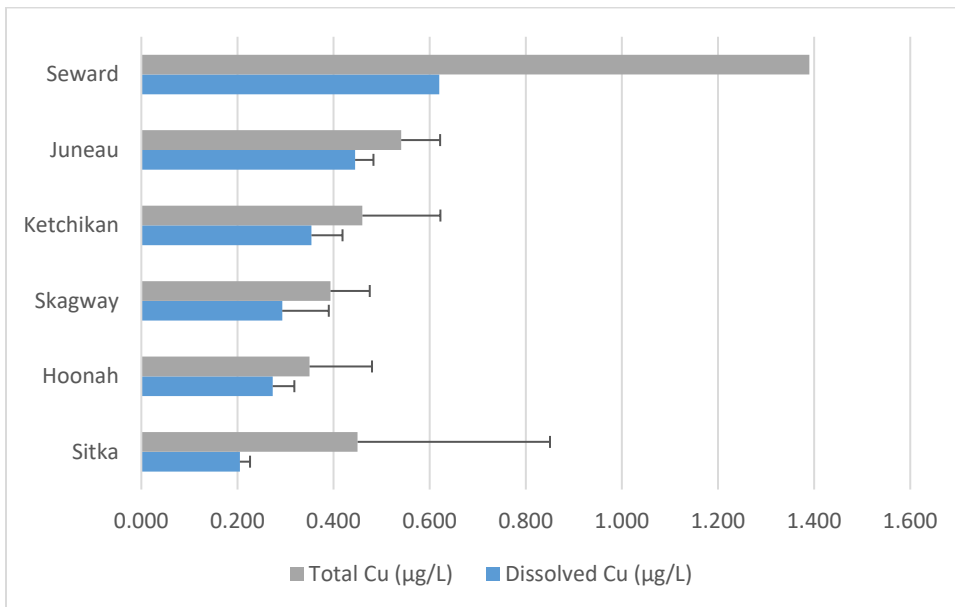


Figure 21. Average harbor total and dissolved Cu concentrations. Error bars are one standard deviation.

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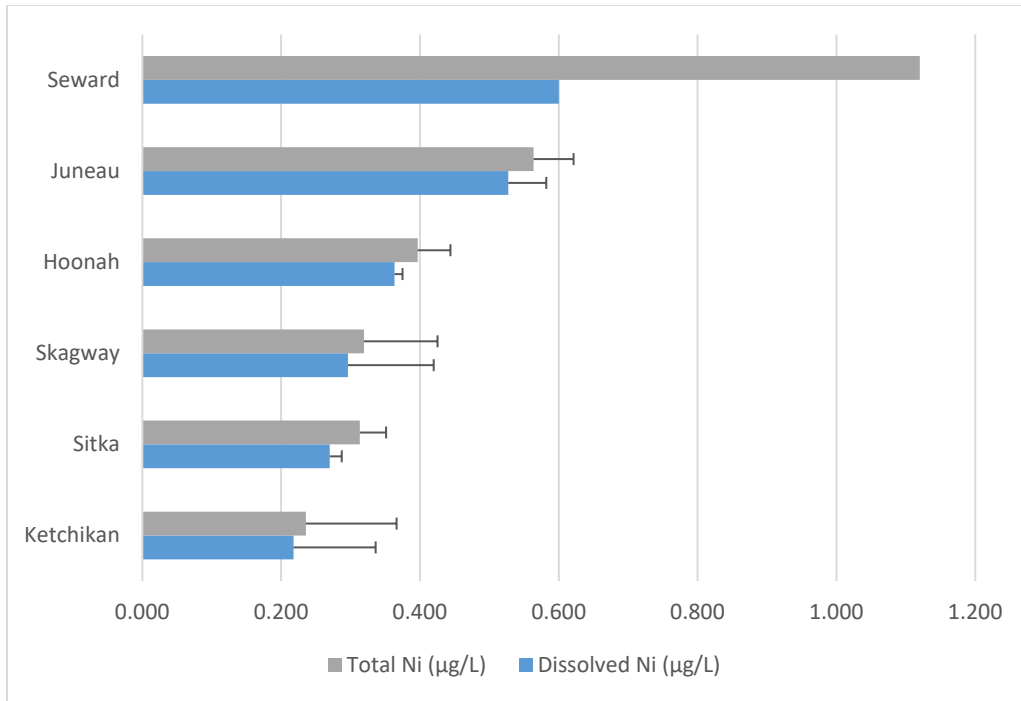


Figure 22. Average harbor total and dissolved Ni concentrations. Error bars are one standard deviation.

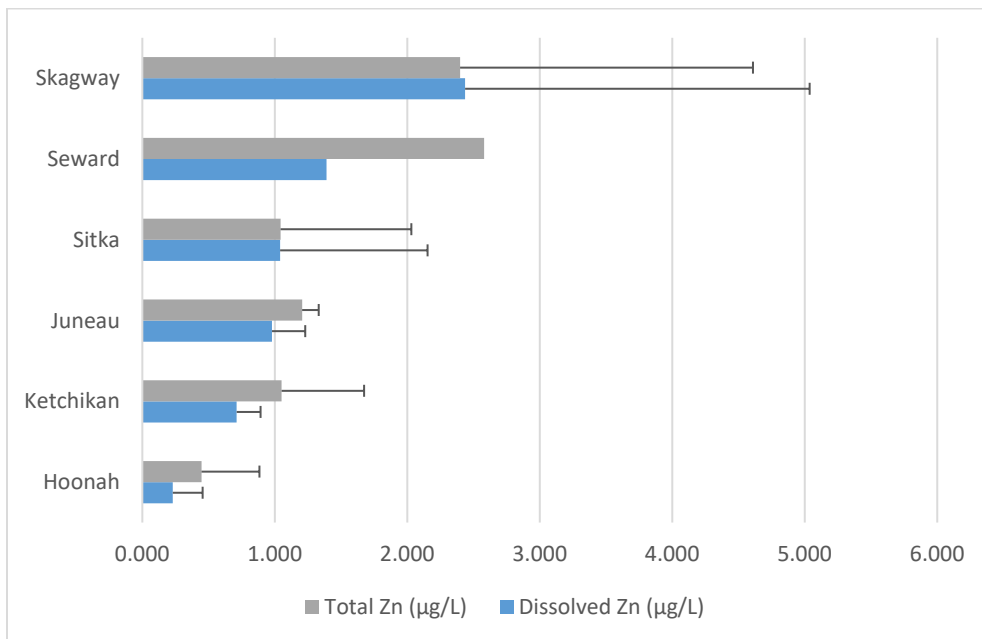


Figure 23 Average harbor total and dissolved Zn concentrations. Error bars are one standard deviation.

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ARRI. 2018a. CPVEC Ambient Water Quality Monitoring: Quality Assurance and Project Plan for Water Quality Monitoring Sampling and Analysis Activities: Version 2. Prepared for the Alaska Department of Environmental Conservation Division of Water. Aquatic Restoration and Research Institute, Talkeetna, AK.

ARRI. 2018b. CPVEC Ambient Water Quality Monitoring: Juneau and Skagway Harbors September 2015 through October 2017. Prepared for the Alaska Department of Environmental Conservation Division of Water. Aquatic Restoration and Research Institute, Talkeetna, AK.

ARRI. 2019. CPVEC Ambient Water Quality Monitoring: Sitka, Hoonah, and Ketchikan Harbors 2018. Prepared for the Alaska Department of Environmental Conservation Division of Water. Aquatic Restoration and Research Institute, Talkeetna, AK.

## Appendix A. Project Photographs



Photograph A1. Cruise ship in the Seward Harbor (June 16, 2019).



Photograph A2. Seward small boat harbor (June 16, 2019).





Photograph A3. Cruise ships in Tongass Narrows near Ketchikan (June 24, 2019).



Photograph A4. Sampling Tongass Narrows on June 25, 2019.

## Appendix B. Sampling Sites – Locations and Samples by Date

Table B1. Coordinates of Tongass Narrows, Ketchikan Harbor, sampling locations showing types of sample measures or analyses on each sampling date. 4D is water temperature, turbidity, salinity, and dissolved oxygen measured at 4 depths, M is for samples analyzed for dissolved and total Cu, Ni, Zn, and Ammonia-N, and B is a samples analyzed for fecal coliform and *enterococci* bacteria.

Name	Latitude	Longitude	4/9/2018	6/5/2018	8/9/2018	10/19/2018	6/25/2019
KT01	55.3445	-131.6596					
KT02	55.3441	-131.6604	4D, M		4D, M, B	4D, M, B	4D, M, B
KT03	55.3435	-131.6613			4D, M		
KT04	55.3429	-131.6624	4D, M	4D, M	4D, M	4D, M	
KT05	55.3422	-131.6640					4D, M
KT06	55.3414	-131.6654					
KT07	55.3436	-131.6557	4D, M			4D, M	
KT08	55.3428	-131.6568		4D, M, B			
KT09	55.3420	-131.6578					
KT10	55.3415	-131.6587	4D, M			4D, M	
KT11	55.3408	-131.6599		4D, M	4D, M		
KT12	55.3399	-131.6610	4D, M		4D, M, B	4D, M, B	4D, M, B
KT13	55.3424	-131.6518	4D, M, B			4D, M	4D, M, B
KT14	55.3414	-131.6525	4D, M	4D, M		4D, M	
KT15	55.3409	-131.6535			4D, M		
KT16	55.3402	-131.6545	4D, M		4D, M	4D, M	
KT17	55.3394	-131.6556	4D, M	4D, M	4D, M	4D, M, B	
KT18	55.3387	-131.6568		4D, M, B	4D, M, B		4D, M, B
KT19	55.3406	-131.6473	4D, M, B			4D, M	4D, M, B
KT20	55.3398	-131.6483		4D, M	4D, M		
KT21	55.3392	-131.6494					
KT22	55.3386	-131.6503	4D, M	4D, M, B		4D, M	
KT23	55.3379	-131.6515	4D, M, B		4D, M	4D, M	
KT24	55.3372	-131.6525		4D, M	4D, M		
KT25	55.3383	-131.6442		4D, M			4D, M, B
KT26	55.3374	-131.6453		4D, M			
KT27	55.3367	-131.6463					4D, M, B
KT28	55.3362	-131.6472		4D, M			
KTAMHS	55.3529	-131.6946	4D, M, B	4D, M, B	4D, M, B	4D, M, B	4D, M, B
KTTB	55.3386	-131.6430	B	B	B	B	B
KTAIR	55.3550	-131.7028					B

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Table B2. Coordinates of Resurrection Bay, Seward Harbor, sampling locations showing types of sample measures or analyses. 4D is water temperature, turbidity, salinity, and dissolved oxygen measured at 4 depths, M is dissolved and total Cu, Ni, Zn, and Ammonia-N, and B is biological.

<b>SITE</b>	<b>Latitude</b>	<b>Longitude</b>	<b>6/17/2019</b>
SEW A1	60.1177	-149.4292	4D, M
SEW A2	60.1165	-149.4287	
SEW A3	60.1153	-149.4279	4D, M, B
SEW A4	60.1181	-149.4256	4D, M
SEW A5	60.1169	-149.4251	
SEW A6	60.1156	-149.4243	
SEW B1	60.1132	-149.4330	4D, M
SEW B2	60.1115	-149.4319	
SEW B3	60.1119	-149.4257	
SEW B4	60.1127	-149.4219	4D, M
SEW B5	60.1145	-149.4228	4D, M
SEW B6	60.1139	-149.4274	

## Appendix C. Table of Quality Assurance Field/Equipment Blanks and Trip Blanks

Table B2. Analytical results of field/equipment and trip blanks for the Ketchikan and Seward Harbors in June 2019. EB is equipment blank, and DUP is laboratory duplicate.

Harbor	Blank	Measurement	Value	Units
Ketchikan Harbor	KTEB1	Ammonia as Nitrogen	0.028	mg/L
Ketchikan Harbor	KTEB1DUP	Ammonia as Nitrogen	0.027	mg/L
Ketchikan Harbor	KTEB1	Copper, Dissolved	0.05	µg/L
Ketchikan Harbor	KTEB2	Copper, Dissolved	0.07	µg/L
Ketchikan Harbor	KTEB1	Copper, Total	ND	µg/L
Ketchikan Harbor	KTEB2	Copper, Total	ND	µg/L
Ketchikan Harbor	TRIP BLANK	Copper, Total	ND	µg/L
Ketchikan Harbor	KTEB1	Nickel, Dissolved	ND	µg/L
Ketchikan Harbor	KTEB2	Nickel, Dissolved	0.04	µg/L
Ketchikan Harbor	KTEB1	Nickel, Total	ND	µg/L
Ketchikan Harbor	KTEB2	Nickel, Total	ND	µg/L
Ketchikan Harbor	TRIP BLANK	Nickel, Total	ND	µg/L
Ketchikan Harbor	KTEB1	Zinc, Dissolved	0.23	µg/L
Ketchikan Harbor	KTEB2	Zinc, Dissolved	0.45	µg/L
Ketchikan Harbor	KTEB1	Zinc, Total	ND	µg/L
Ketchikan Harbor	KTEB2	Zinc, Total	ND	µg/L
Ketchikan Harbor	TRIP BLANK	Zinc, Total	ND	µg/L
Seward Harbor	SEW EB1	Ammonia as Nitrogen	0.016	mg/L
Seward Harbor	SEW EB1	Copper, Dissolved	0.03	µg/L
Seward Harbor	SEW EB2	Copper, Dissolved	0.04	µg/L
Seward Harbor	SEW EB1	Copper, Total	ND	µg/L
Seward Harbor	SEW EB2	Copper, Total	ND	µg/L
Seward Harbor	TRIP BLANK	Copper, Total	ND	µg/L
Seward Harbor	SEW EB1	Nickel, Dissolved	ND	µg/L
Seward Harbor	SEW EB2	Nickel, Dissolved	ND	µg/L
Seward Harbor	SEW EB1	Nickel, Total	ND	µg/L
Seward Harbor	SEW EB2	Nickel, Total	ND	µg/L
Seward Harbor	TRIP BLANK	Nickel, Total	ND	µg/L
Seward Harbor	SEW EB1	Zinc, Dissolved	ND	µg/L
Seward Harbor	SEW EB2	Zinc, Dissolved	ND	µg/L
Seward Harbor	SEW EB1	Zinc, Total	ND	µg/L
Seward Harbor	SEW EB2	Zinc, Total	ND	µg/L
Seward Harbor	TRIP BLANK	Zinc, Total	ND	µg/L