

CPVEC Ambient Water Quality Monitoring: Sitka, Hoonah, and Ketchikan Harbors 2018



Prepared February 2019 for:



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

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CPVEC Ambient Monitoring
2018 Annual Report

Cover Photograph. Cruise ship docked in Port Fredrick near Hoonah on August 8, 2018.

Summary

Water sampling was conducted in Port Fredrick near Hoonah, Sitka Harbor, and Tongass Narrows near Ketchikan in April, June, August, and October (Ketchikan only), 2018. Water samples were analyzed for concentrations of ammonia-N; dissolved and total copper, nickel, and zinc; and the abundance of fecal coliform and *enterococci* bacteria. Water temperature, salinity, pH, and dissolved oxygen were measured at 1, 2, 3, and 4m depths concurrently. Sampling also was conducted at sampling sites near the Sitka and Ketchikan Alaska Marine Highway (AMHS) docks, and at the entrance to the Thomas Basin, a small boat harbor in Ketchikan (bacterial analyses only).

Water temperatures were similar among sampling locations, increasing from between 6 and 8°C in April to 14 to 16°C in August. Harbor waters were more saline in April, near 30 ppt, and decreased in all harbors during June and August to 20 to 25 ppt. Measures of pH ranged from 7.9 to 8.2, were consistent among sampling dates, and sampling locations. Dissolved oxygen was above saturation at all sampling locations and on all sampling dates, with concentrations generally reflecting changing water temperatures and oxygen solubility.

Concentrations of ammonia-N were very low in April at all sampling locations often below laboratory detection limits. Ammonia-N concentrations increased during summer but remained less than 0.025 mg/L. Dissolved Cu concentrations were similar among sites and at most locations and dates < 0.5 µg/L. Average concentrations of dissolved Cu, however, were higher in the Sitka Harbor in June due to some relatively high concentrations. Similarly, dissolved Zn was < 1.0 µg/L at all sampling locations and on all sampling dates with the exception of the Sitka Harbor during June where high concentrations were present at some sampling sites. Concentrations of dissolved Ni were < 0.4 µg/L on all sampling dates, were highest in Port Fredrick, consistent among sampling dates in Port Fredrick and Sitka Harbor, but decreased in Tongass Narrows from 0.30 µg/L in April to 0.05 µg/L in October.

Fecal coliform bacteria were present at low abundances in samples collected from Port Fredrick and the Sitka Harbor in June and August but not April. Enterococci were below 10 MPN/100 ml (method detection limit) within these two harbors on all sampling dates. Fecal coliform bacteria were abundant in Tongass Narrows, at the AMHS dock, and at Thomas Basin, with values of 76, 166, and 315 cfu/100 ml, respectively, in August samples, with associated high concentrations of *enterococci*.

Introduction

The Alaska Department of Environmental Conservation (DEC), Commercial Passenger Vessel Environmental Compliance (CPVEC) program is responsible for authorizing proposed 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 general permit is based on the best available ambient water quality data; however, these data are limited.

The objective of this project is to provide more complete water quality data for the permit area. 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 2018 sampling conducted in Port Fredrick near Hoonah, Sitka Harbor, and Tongass Narrows near Ketchikan. These data augment previous water quality data from the Skagway and Juneau Harbors collected from September 2015 through October 2017.

Methods

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

Sampling Locations

Sampling sites were established within three sampling locations: Port Fredrick near Hoonah, Sitka Harbor, and Tongass Narrows near Ketchikan. Six potential sampling sites were established in Port Fredrick (Figure 1). Water sample collection for metals analyses occurred at four of the six sites selected randomly on each sampling date. A water sample was collected at one of the six locations on each sampling date for bacterial analyses.

Water samples were collected and analyzed for ammonia-N, Cu, Ni, and at 12 sampling sites within the Sitka Harbor and at a site near the AMHS Dock (57.0356, -135.3096). Water samples were collected and analyzed for fecal coliform bacteria and enterococci at 3 of the 12 sampling sites in Sitka Harbor and at the site near the AMHS Dock.

Within Tongass Narrows, water sample collection for metals and bacterial analyses occurred at a site near the AMHS Dock (55.3529, -131.6946), a site at the mouth of Thomas Basin (bacterial analyses only) (55.3386, -131.6430), and at 12 of 24 randomly selected sites for metal and bacterial analyses (Figure 3).

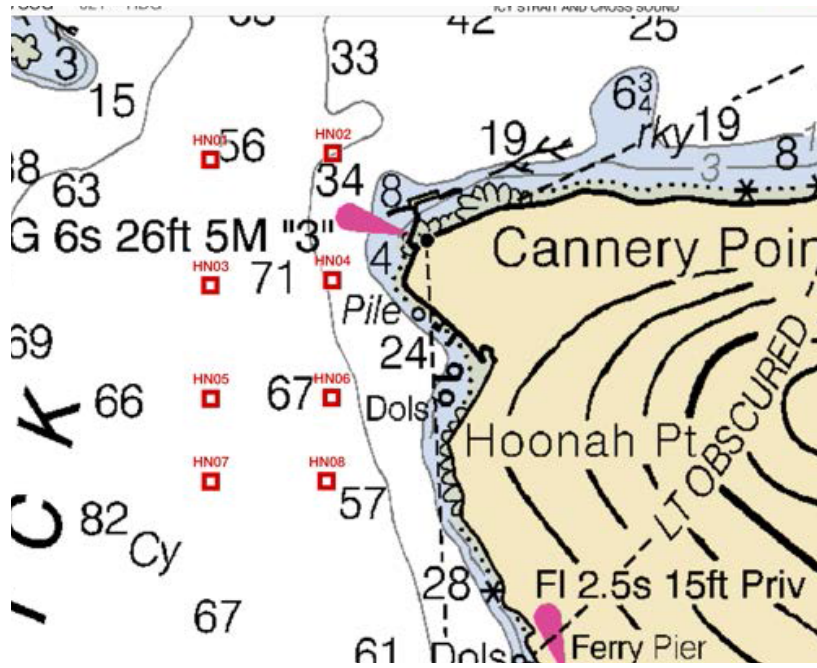
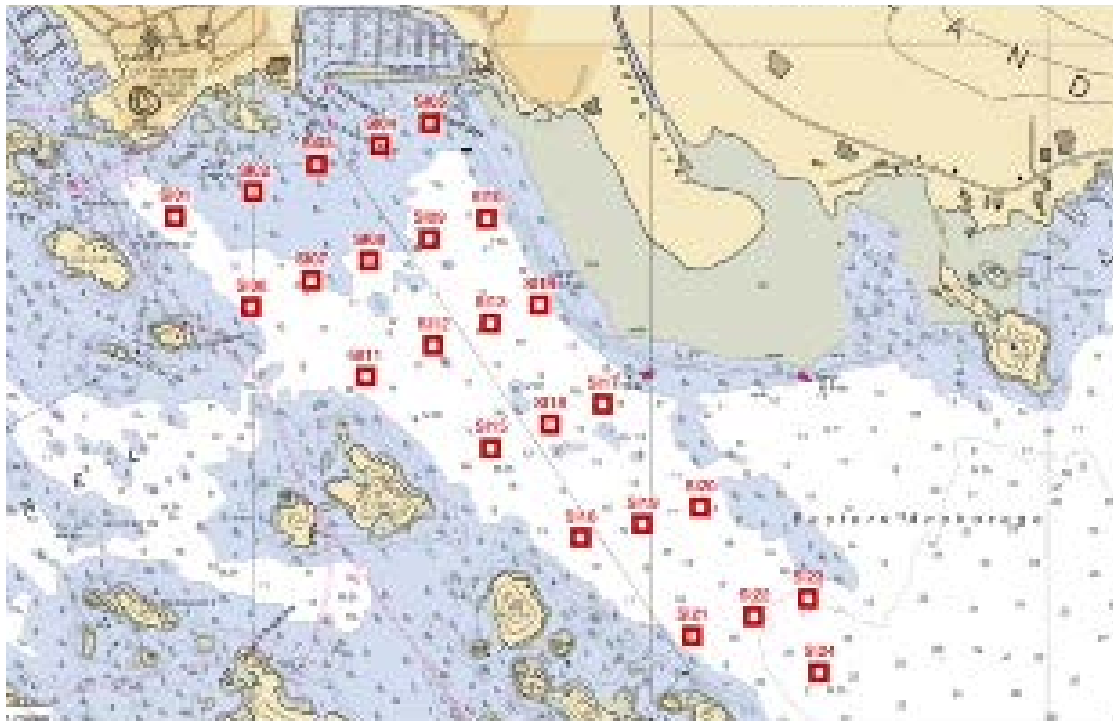


Figure 1. Locations of sampling sites in Port Fredrick adjacent to the Cruise Ship dock near Hoonah.



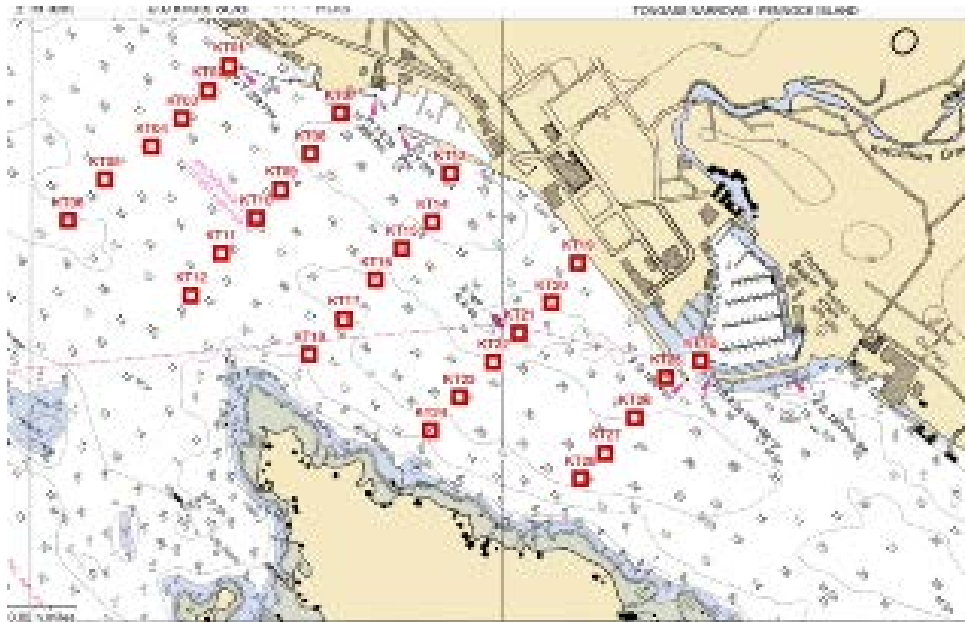


Figure 3. Sampling sites in Tongass Narrows near Ketchikan. Site near the AMH Ferry Dock is not shown.

Sampling Dates and Times

The dates and times water samples were collected are shown in Table 1.

Table 1. Dates and times sampling was conducted in Port Fredrick near Hoonah, Sitka Harbor, and Tongass Narrows near Ketchikan and times of high and low tides. C is clear, PC is partly cloudy, LR is light rain, HR is heavy rain.

Port Fredrick near Hoonah					
Sample Date	Sample Time	Weather	Low Tide	High Tide	
04/13/2018	12:00 to 13:00	LR	06:29	12:35	
06/04/2018	14:00 to 15:00	LR	11:40	18:07	
08/08/2018	11:00 to 12:00	HR	11:46	05:17	
Sitka Harbor					
Sample Date	Sample Time	Weather	Low Tide	High Tide	
04/12/2018	12:00 to 14:30	PC	17:42	11:20	
06/06/2018	08:30 to 12:30	PC	13:03	06:20	
08/07/2018	08:00 to 12:00	PC	15:41	10:32	
Tongass Narrows					
Sample Date	Sample Time	Weather	Low Tide	High Tide	
04/09/2018	10:00 to 12:00	PC	08:04	15:05	
06/05/2018	10:30 to 13:00	PC	12:00	05:25	
08/09/2018	11:00 to 13:30	HR	05:46	12:10	
10/17/2018	09:30 to 12:30	LR	14:04	08:23	

Sample Collection

Water samples were collected from ~1 meter depth. Harbor water was pumped water through Teflon tubing into laboratory-provided sample bottles using a peristaltic pump (Solonist 410). Tubing and bottles were flushed for approximately 3 minutes prior to sample collection at each sampling location. Water samples for dissolved metals were field filtered.

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.

Three 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 twelve 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 by Admiralty Environmental (Hoonah), City of Sitka, and R&M Engineering (Ketchikan) using EPA method 9222D and *E. coli* by the most probable number method.

Results

Quality Assurance

All of the analyses met the laboratory data quality objectives for accuracy and precision. Copper, zinc, and ammonia-N were present in trip blanks and field blanks (Table x). Trip blanks are sample bottles prepared and sealed by the analytical laboratory and transported with all other samples. 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 metals were below method reporting limits with the exception of dissolved and total copper. Copper also was present at the method detection limit in trip blanks. Therefore, reported concentrations of metals 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%. Eight of the 69 analyses did not meet data quality objectives for precision. Four samples were analyzed for ammonia-N and were collected during the April (2) and June (2) sampling dates. Two samples were analyzed for zinc, and one for dissolved nickel. All sample values were below method reporting limits.

Bacterial samples collected in Sitka Harbor and analyzed for enterococci and samples collected in Port Fredrick near Hoonah exceeded hold times prior to analyses. Therefore, reported numbers could be higher than true values.

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Table 2. Average concentration of metals in field and trip blanks. Three field blanks were collected within the Sitka and Ketchikan Harbors on all sampling dates. MDL is the methods detection limit, and MRL is the method reporting limit.

	Field Blank	Trip Blank	MDL	MRL
Ammonia-N (mg/L)	0.007		0.003	0.01
Dissolved Cu (µg/L)	0.14		0.02	0.10
Total Cu (µg/L)	0.10	0.02	0.02	0.10
Dissolved Ni (µg/L)	0.00		0.03	0.20
Total Ni (µg/L)	0.00	0.00	0.03	0.20
Dissolved Zn (µg/L)	0.26		0.20	0.50
Total Zn (µg/L)	0.30	0.00	0.20	0.50

Hoonah

Fecal Coliforms and *Enterococci*

The numbers of fecal coliforms and enterococci within water samples collected from Port Fredrick near Hoonah are shown in Table 2. Fecal coliform bacteria counts were highest in June. *Enterococci* were below method detection limits on all sampling dates.

Water Temperature, Salinity, pH, and Dissolved Oxygen

Basic water physical and chemical characteristics measured at four sample depths at each sampling site and date are shown in Figures 4 through 7. The physical and chemical characteristics measured were similar among the four sampling locations. Water temperature varied from 5°C in April to over 13°C in August. Water temperature decreased slightly with sampling depth. Salinity decreased from near 30 ppt in April to approximately 25 ppt in June and August. Salinity was lower (<1 to 2 ppt) near the water surface. The pH was near 8.0 units on all sampling dates and did not vary consistently with water depth. Dissolved oxygen was at or above saturation on all sampling dates. Concentrations of dissolved oxygen were inversely related to water temperatures.

Table 3. Numbers of bacteria within a single sample collected on each sampling date from Port Fredrick adjacent to the ship dock near Hoonah.

Fecal Coliforms (cfu/100 ml)	Port Fredrick
April 2018	<2
June 2018	22
August 2018	8
<i>Enterococci</i> <i>i</i> (MPN/100 ml)	
April 2018	<10
June 2018	<10
August 2018	<10

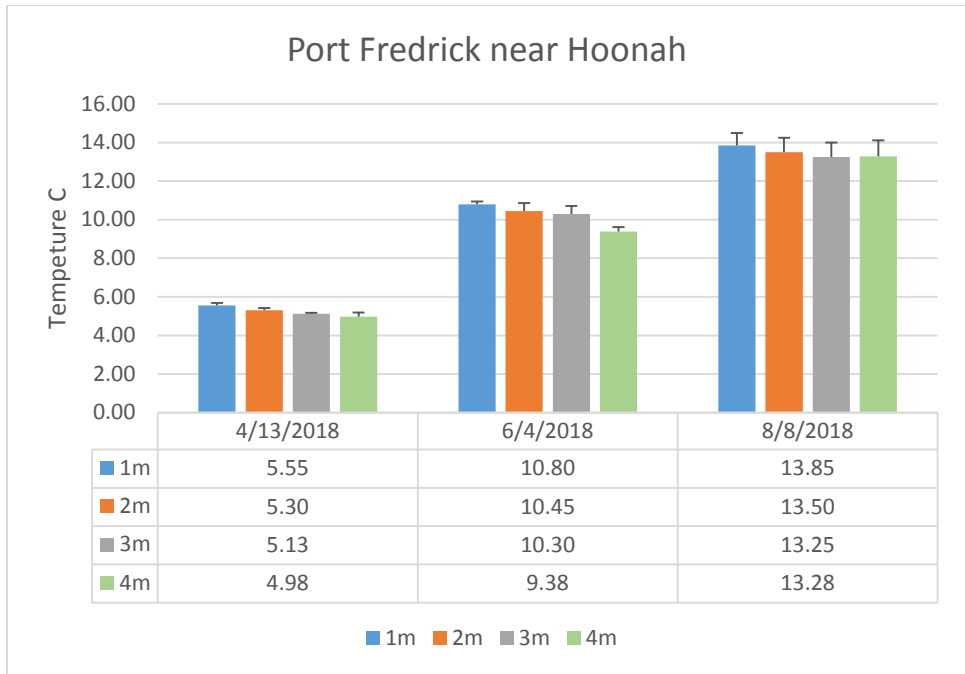


Figure 4. Average water temperature among the four sampling locations in Port Fredrick near Hoonah at 1 to 4 m water depth. Error bars are one standard deviation.

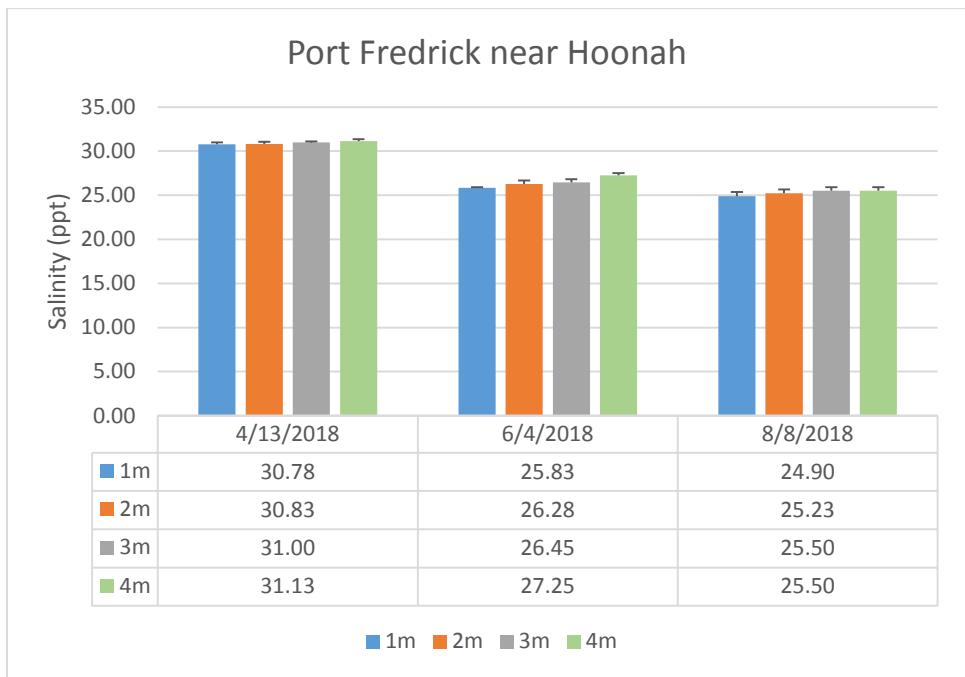


Figure 5. Average salinity among the four sampling locations in Port Fredrick near Hoonah at 1 to 4 m water depth. Error bars are one standard deviation.

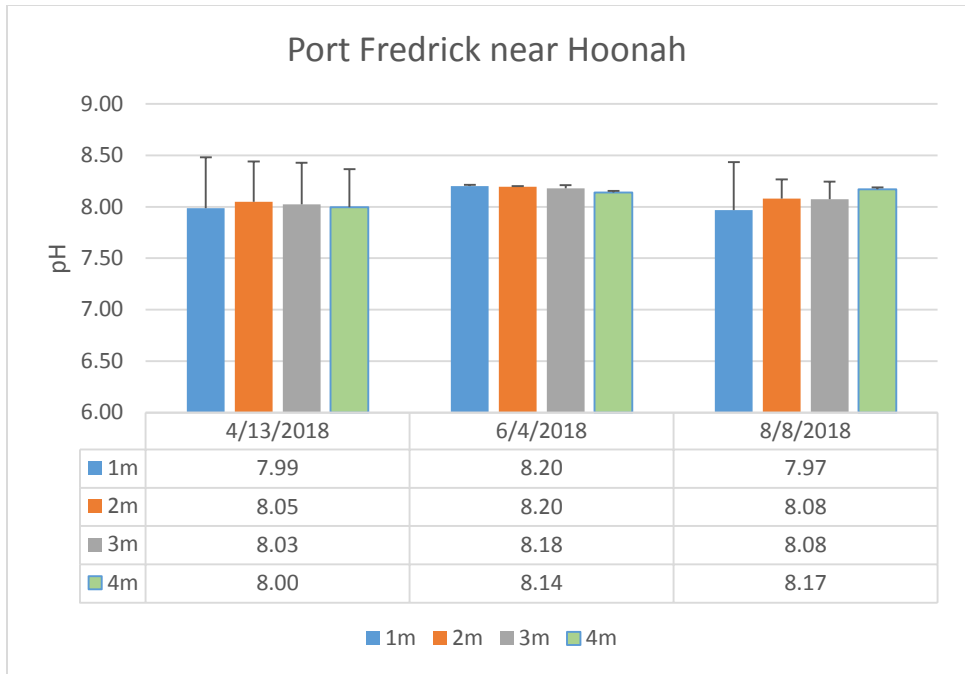


Figure 6. Average pH among the four sampling locations in Port Fredrick near Hoonah at 1 to 4 m water depths. Error bars are one standard deviation.

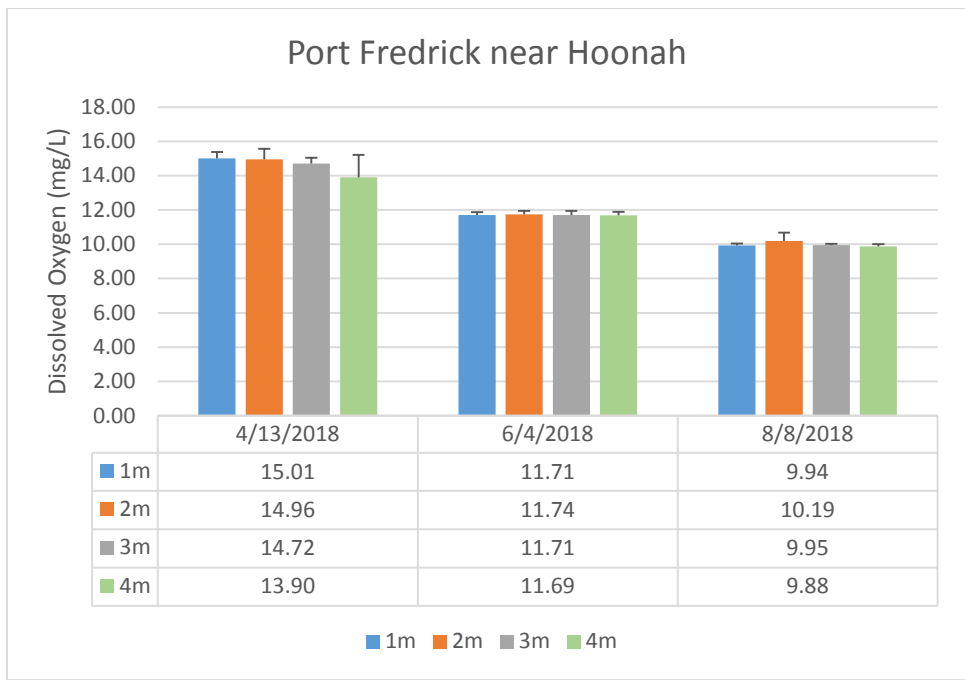


Figure 7. Average dissolved oxygen concentration among the four sampling locations in Port Fredrick near Hoonah at 1 to 4 m water depth. Error bars are one standard deviation.

Ammonia-N, Copper, Nickel, and Zinc

Average concentrations of ammonia-N and dissolved and total copper, nickel, and zinc are shown in Figures 8 through 11. Average Port Fredrick ammonia-N concentrations were below method detection limits (MDL) in April and below 0.015 mg/L on all other sampling dates. Dissolved copper concentrations were highest in April samples and were < 0.3 µg/L on all sampling dates. Concentrations of zinc also were highest in the April samples, but < 1.0 µg/L. Zinc concentrations were below the MDL of 0.2 µg/L in the majority of samples collected in June and August. Concentrations of Nickel were consistent among sampling dates with dissolved concentrations < 0.4 µg/L and total concentrations < 0.5 µg/L.

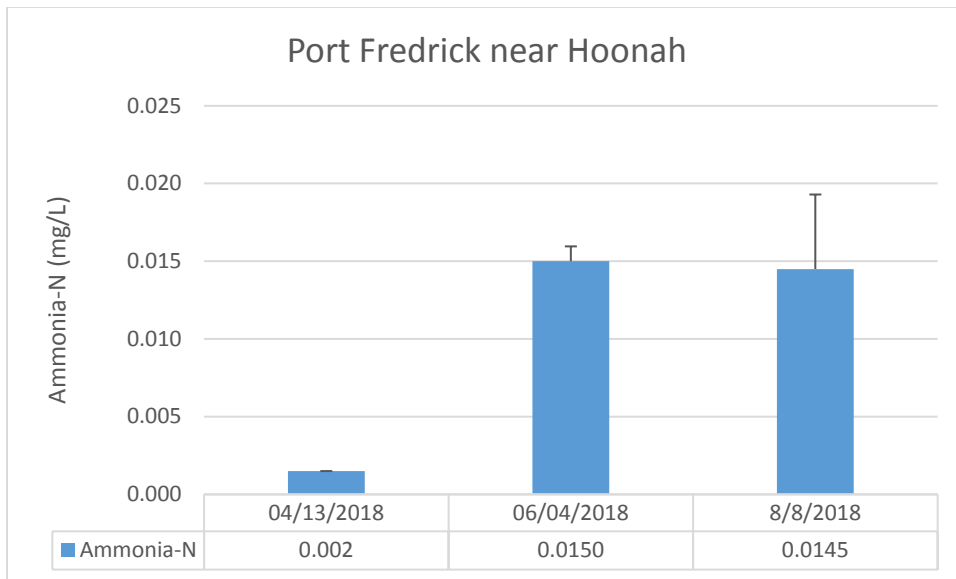


Figure 8. Average Port Fredrick ammonia-N concentrations (N = 4) for each 2018 sampling date. Concentrations in April were below the MDL of 0.003 mg/L and average concentrations were calculated using 0.5 x MDL. Error bars are one standard deviation.

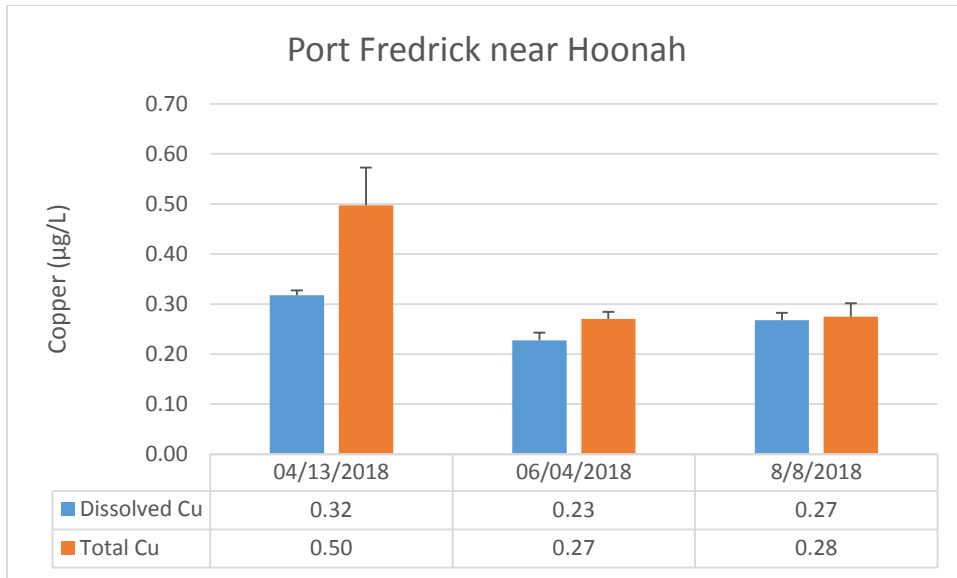


Figure 9. Average Port Fredrick dissolved and total copper concentrations (N = 4) for each 2018 sampling date. Error bars are one standard deviation.

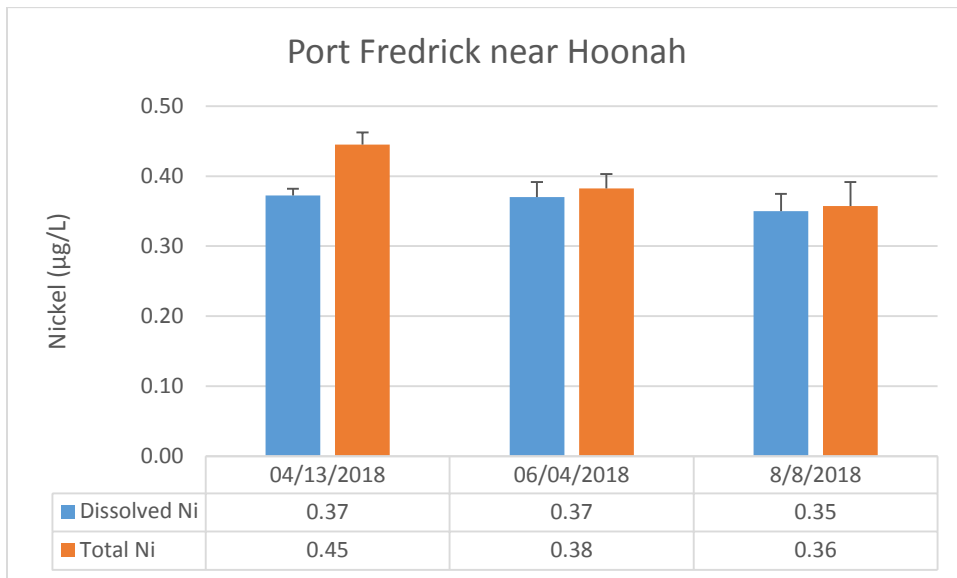


Figure 10. Average Port Fredrick dissolved and total nickel concentrations (N = 4) for each 2018 sampling date. Error bars are one standard deviation.

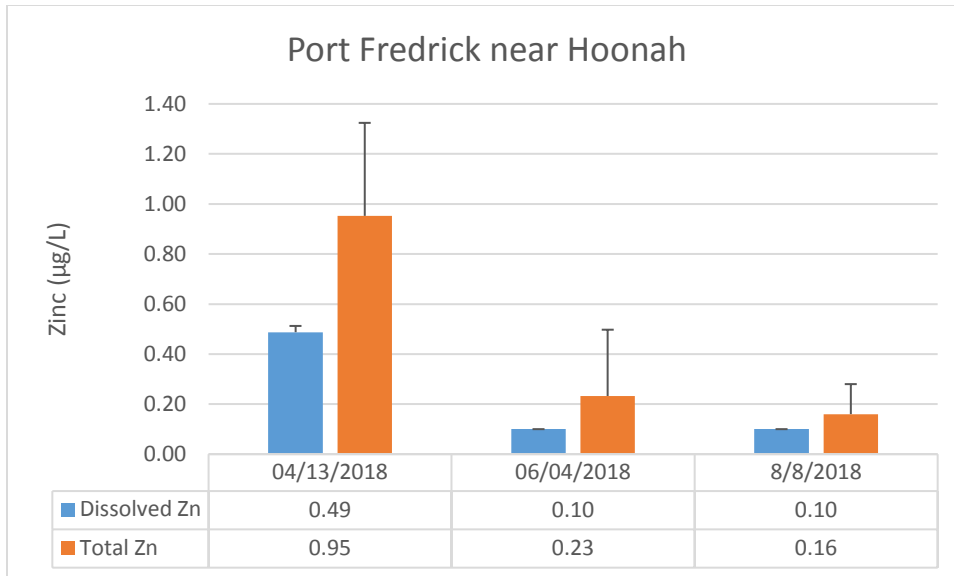


Figure 11. Average Port Fredrick dissolved and total zinc concentrations (N = 4) for each 2018 sampling date. Average concentrations of total and dissolved zinc were calculated using 0.5 x MDL for values that were below the detection limit of 0.2 µg/L. The MRL is 0.5 µg/L. Error bars are one standard deviation.

Sitka Harbor

Fecal Coliforms and Enterococci

Fecal coliform bacteria were generally absent from water samples collected within the harbor near Sitka and north of Sitka near the AMFS dock (Table 3). The highest fecal coliform count was 6 cfu/100 ml in a single sample collected in August. *Enterococci* were below MDL on all sampling dates and sites.

Table 4. Average fecal coliforms and enterococci within 100 ml samples collected in the Sitka Harbor and near the AMHS Dock north of Sitka. Three samples were collected on each sampling date within the Sitka Harbor and reported values are averages rounded to the nearest whole number. A single sample was collected on each sampling date at the AMHS Dock.

Fecal Coliforms	Sitka Harbor	Sitka AMHS Dock
April 2018	0	0
June 2018	1	0
August 2018	2	0
<i>Enterococci</i>	Sitka Harbor	Sitka AMHS Dock
April 2018	<10	<10
June 2018	<10	<10
August 2018	<10	<10

Water Temperature, Salinity, pH, and Dissolved Oxygen

Water temperature, salinity, pH, and dissolved oxygen are reported for the single sample collected north of Sitka near the AMFS dock and as the average of 12 samples collected just south of town in Sitka Harbor (Figures 12 through 15). There were no apparent differences in these parameters between these two locations. There was also little variability among sampling locations in the Sitka Harbor. Water temperatures were cooler in April (7°C) and warmest in August (14°C) and declined < 1.3°C with depth. Salinity ranged from 31 ppt in April to 26 to 27 ppt in June and August. Salinity also decreased with depth in June and August. The pH was near 8.2 on all sampling dates and depths. Dissolved oxygen ranged from 10 to 13 mg/L and was well above saturation on all sampling dates.

Ammonia-N, Copper, Nickel, and Zinc

Ammonia-N concentrations in the Sitka Harbor and near the AMHS dock were below MDL in April and < 0.02 mg/L on all other sampling dates (Figure 16).

Copper concentrations were generally < 0.3 µg/L (Figure 17) on all sampling dates. However, June dissolved and total concentrations of copper were higher and variable. Dissolved concentrations at four sampling locations (SI 14, SI 18, SI 23, and SI 24) ranged from 3.5 to 6.9 µg/L resulting in a Sitka Harbor average of 1.75 µg/L. The Sitka Harbor average dissolved Cu concentration was 0.3 µg/L when these sites are not included. Total copper concentrations were extremely high at two locations: 791 µg/L at SI 02 and 16.3 µg/L at SI 18. The Sitka Harbor average total Cu concentration (0.91 µg/L) was calculated excluding these two high values.

Concentrations of total and dissolved Ni were consistent within the Sitka Harbor and among sampling dates, generally < 0.35 µg/L (Figure 18).

Concentrations of zinc were < 5.0 µg/L in April and August, but, similar to Cu, were higher and variable in June (Figure 19). The average dissolved Zn concentration in June was 2.32 µg/L which included three sites (SI 14, SI 18, and SI 24) where concentrations ranged from 6.0 to 7.9 µg/L. The average Sitka Harbor total Zn concentration was 2.18 µg/L which was calculated including two sites with high concentrations: SI 15 (9.57 µg/L) and SI 18 (5.96 µg/L), but did not include a measure of 1400 µg/L from SI 02.

Six Sitka sampling locations in June had relatively high Cu or Zn concentrations (Table 4). Sampling sites SI 02 and SI 15 had high concentrations of total Cu and Zn but not dissolved Cu or Zn. Site SI 18 had high concentrations of total and dissolved Cu and Zn. SI 14 and SI 24 had high dissolved concentrations of both elements and SI 14 had high concentrations of dissolved Cu. High concentrations of total but not dissolved metals are possible when the boat is drifting and samples for total metals are collected first followed by samples for dissolved metals.

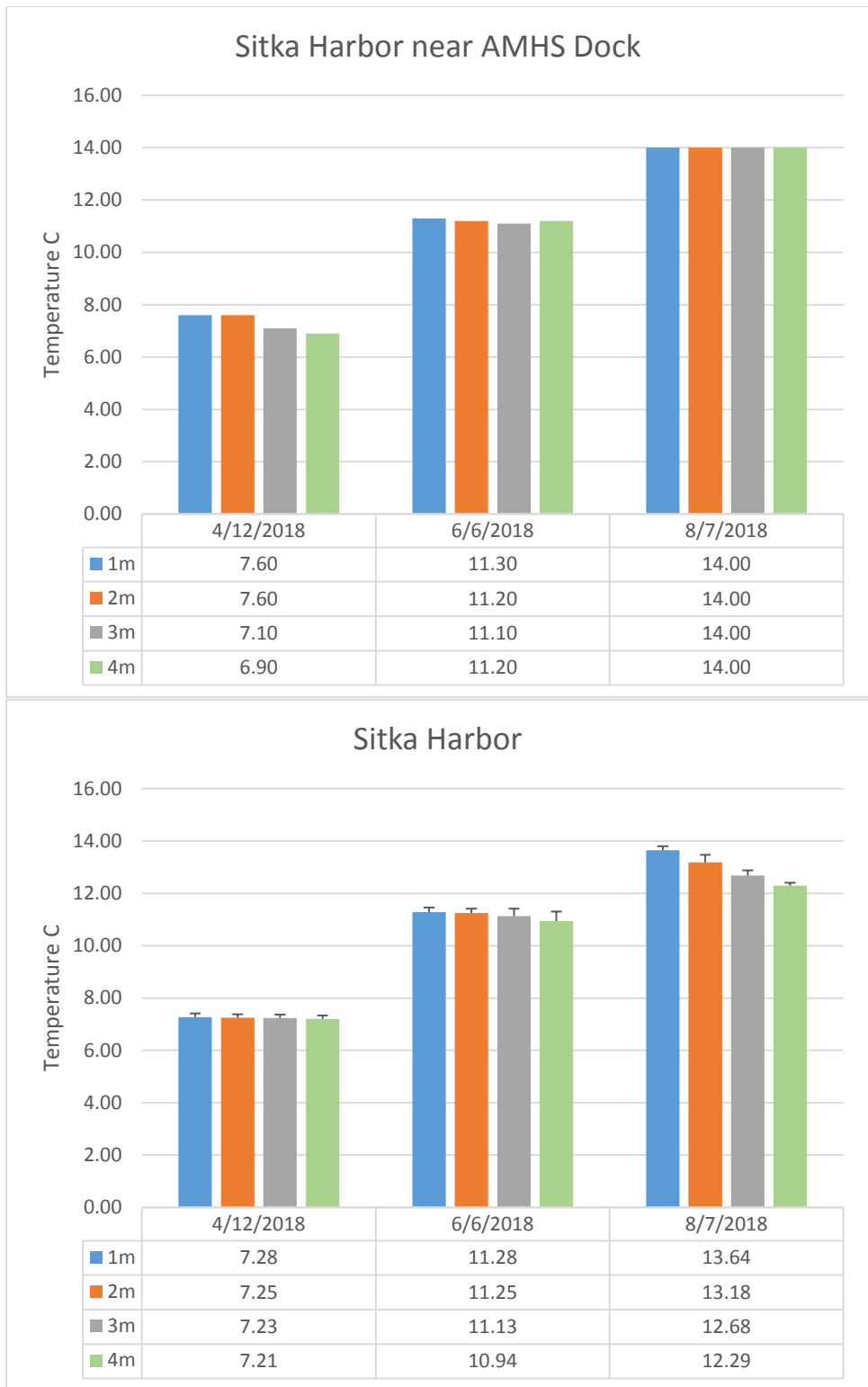


Figure 12. Water temperature at a single location in the Sitka Harbor near the AMHS dock and average (N = 12) water temperature in the Sitka Harbor. Error bars are one standard deviation.

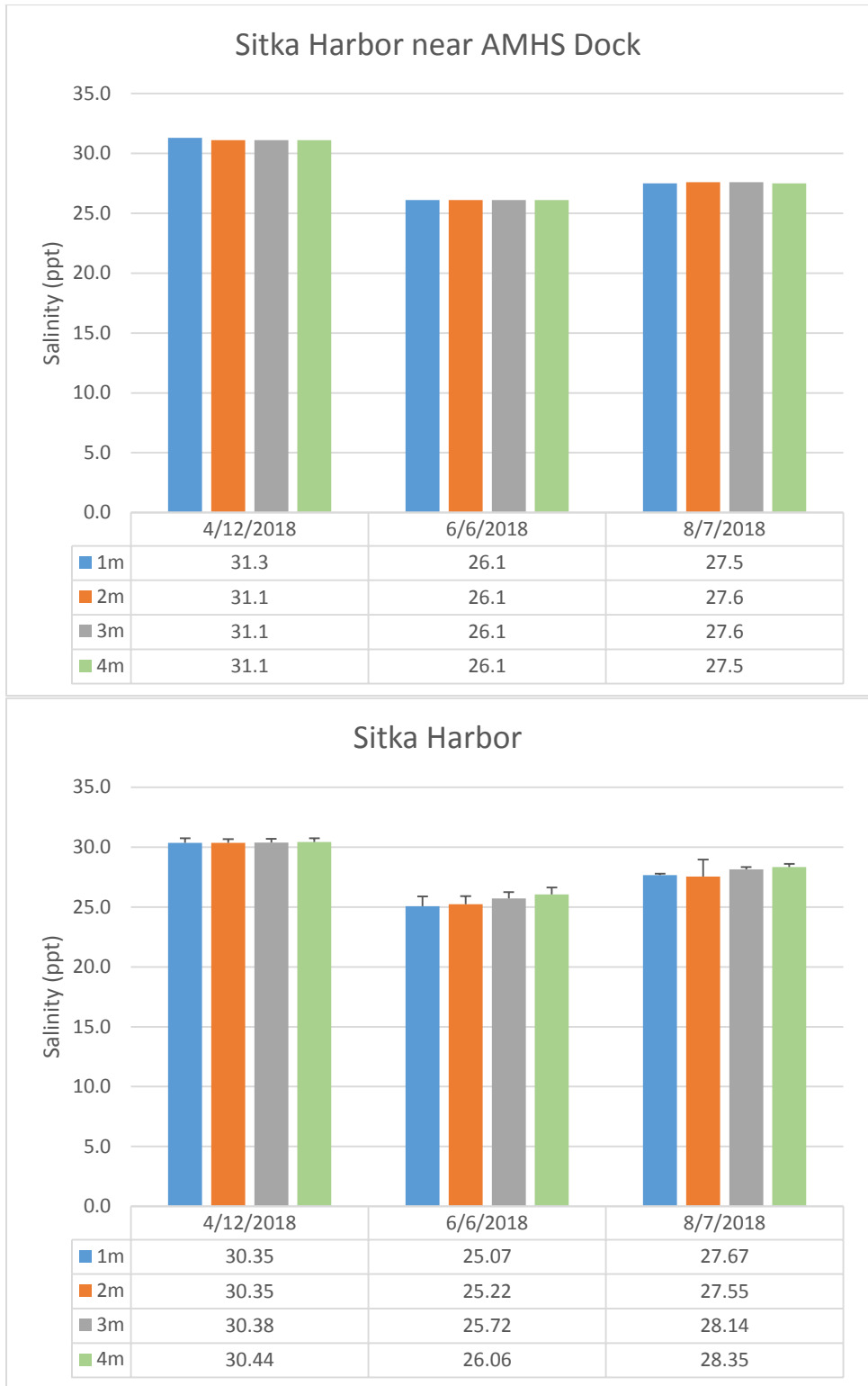


Figure 13. Water salinity at a single location in the Sitka Harbor near the AMHS dock and average (N = 12) water temperature in the Sitka Harbor. Error bars are one standard deviation.



Figure 14. Water pH at a single location in the Sitka Harbor near the AMHS dock and average (N = 12) water temperature in the Sitka Harbor. Error bars are one standard deviation.

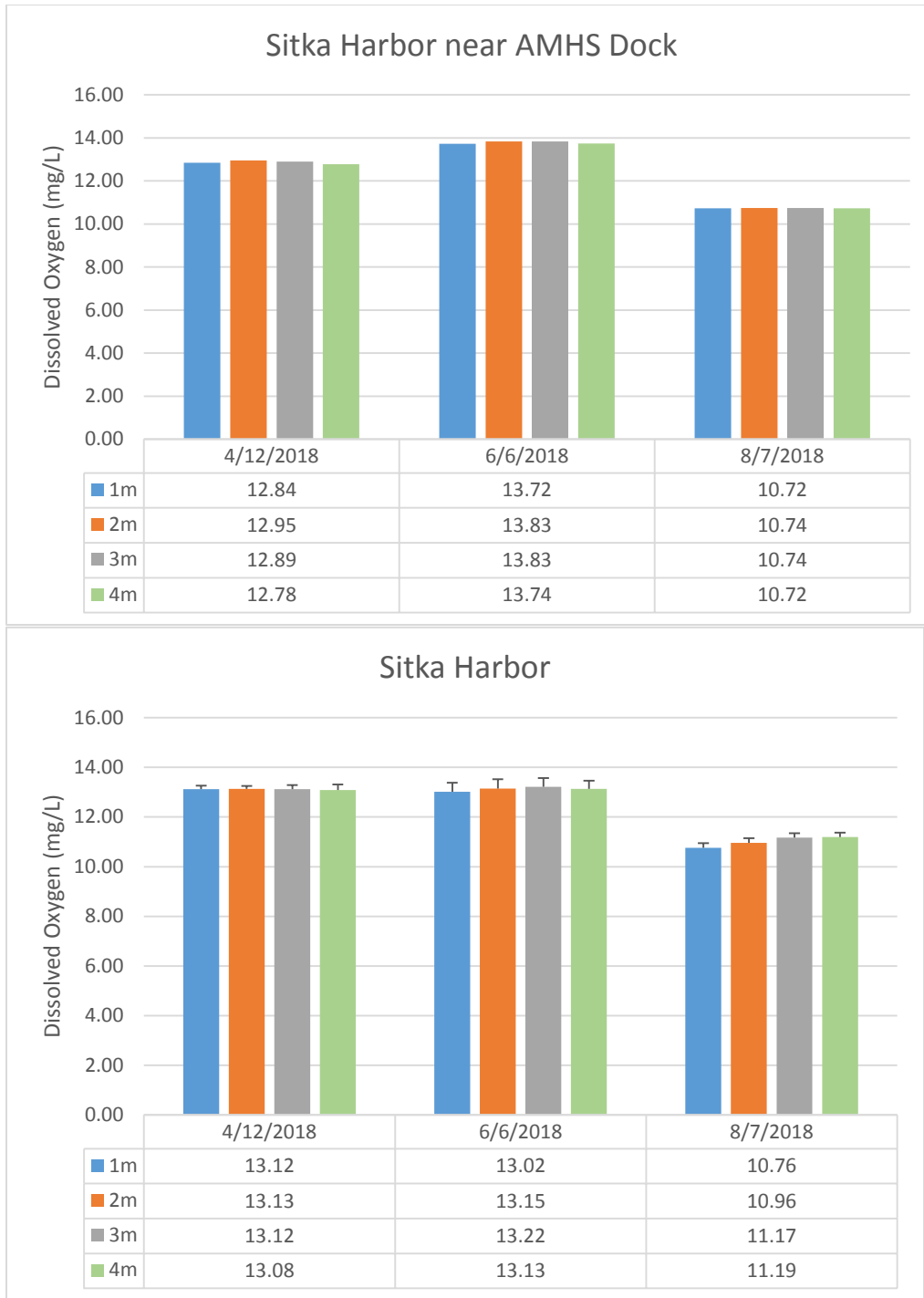


Figure 15. Dissolved oxygen concentrations at a single location in the Sitka Harbor near the AMHS dock and average (N = 12) water temperature in the Sitka Harbor. Error bars are one standard deviation.

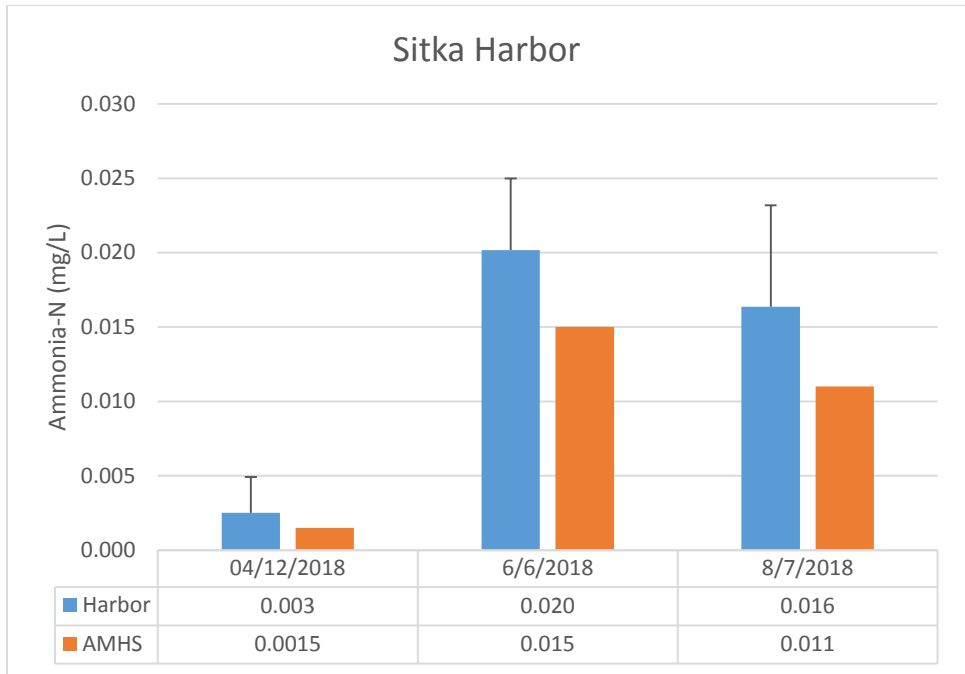


Figure 16. Average Sitka Harbor (N = 12), and AMHS point measure of ammonia concentrations on each 2018 sampling date. Concentrations were below MDL (0.003) and MRL (0.10) in April. Error bars are one standard deviation.

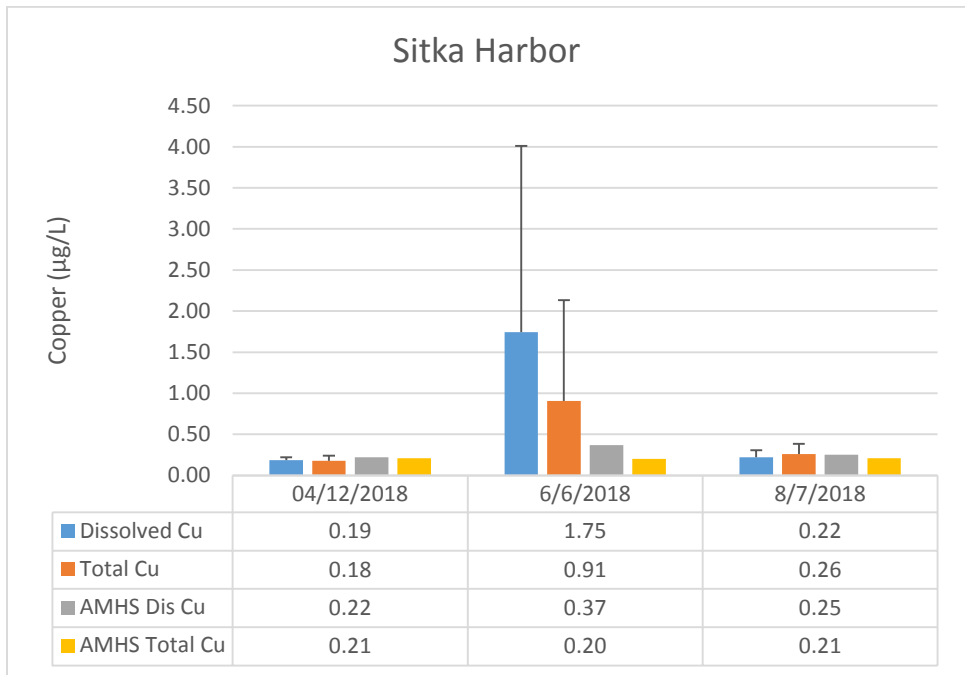


Figure 17. Average Sitka Harbor (N = 12), and AMHS point measure of dissolved and total copper concentrations on each 2018 sampling date. Error bars are one standard deviation.

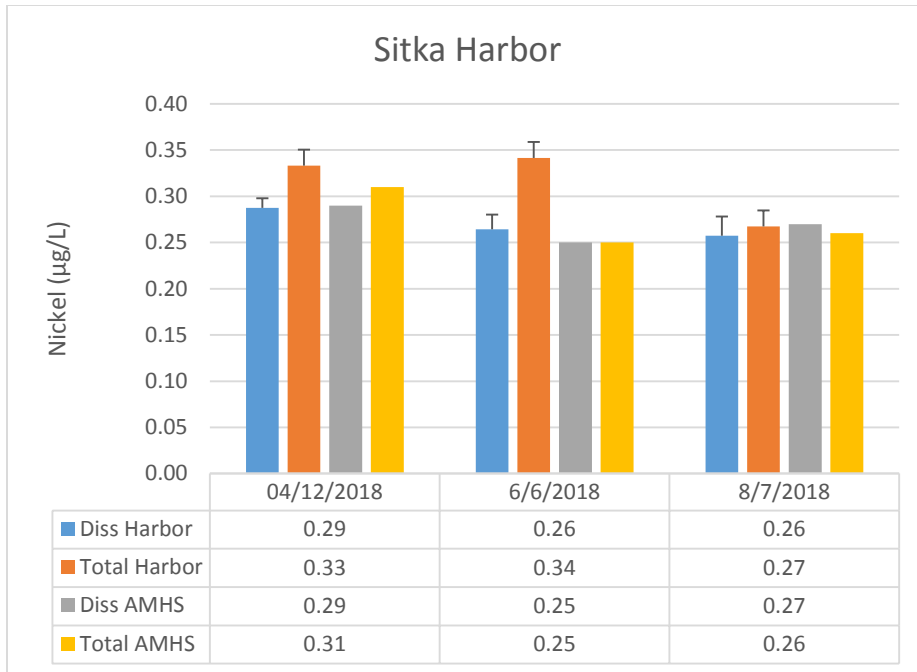


Figure 18. Average Sitka Harbor (N = 12), and AMHS point measure of dissolved and total nickel concentrations on each 2018 sampling date. Error bars are one standard deviation.

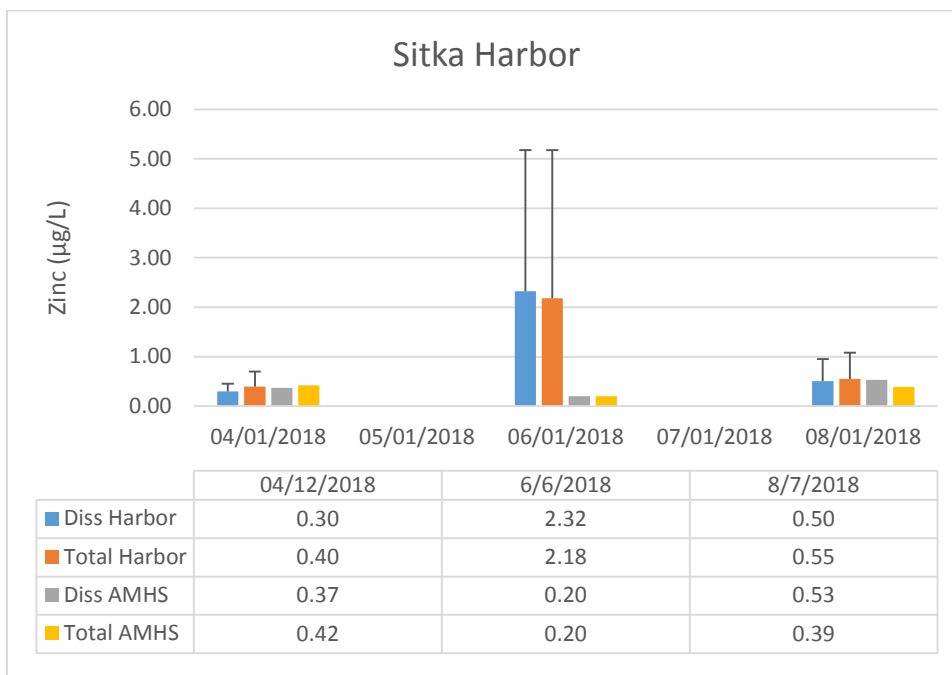


Figure 19. Average Sitka Harbor (N = 12), and AMHS point measure of dissolved and total zinc concentrations on each 2018 sampling date. Error bars are one standard deviation.

Table 5. Copper (Cu) and zinc (Zn) concentrations from samples collected within the Sitka Harbor in June, 2018 with extreme high values in one or more of the analyses.

	Dissolved Cu	Total Cu	Dissolved Zn	Total Zn
SI 02	0.32	791.00	0.99	1400.00
SI 14	6.95	0.38	7.10	0.90
SI 15	0.49	3.72	0.69	9.57
SI 18	4.02	16.30	7.85	5.96
SI 23	3.45	0.23	0.81	0.42
SI 24	3.96	0.21	6.04	0.36

Ketchikan Harbor

Fecal Coliforms and Enterococci

The abundance of fecal coliform and *enterococci* bacteria are shown in Table 5. The concentration of fecal coliforms exceeded water quality standard numeric criteria for aquatic life (20 cfu/100 ml) in Tongass Narrows in August, Thomas Basin in August and October, and at the AMHS Dock in June, August and October. Numeric criteria for contact recreation (100 cfu/100 ml) were exceeded in August samples collected at Thomas Basin and at the AMHS Dock. 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 6. Fecal coliform and enterococci results for samples collected in Tongass Narrows 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 samples rounded to the nearest whole number.

Fecal Coliforms	Tongass Narrows	Thomas Basin	AMHS Dock
4/9/2018	6	11	6
6/5/2018	18	19	22
8/9/2018	76	315	166
10/17/2018	7	58	28
<i>Enterococci</i>	Tongass Narrows	Thomas Basin	AMHS Dock
4/9/2018	8	5	2
6/5/2018	5	<10	52
8/9/2018	96	1553	192
10/17/2018	7	11	14

Water Temperature, Salinity, pH and Dissolved Oxygen

Water temperatures in Tongass Narrows were similar between sampling locations near Ketchikan and near the AMHS Dock (Figure 20) and among sites within Tongass Narrows. Water temperatures ranged from 6.4°C in April to 15.7°C in August. Water temperatures decreased < 1°C with depth to 4m. Salinity was near 30 ppt in April and decreased to ~20 ppt near the surface in June and near 24 ppt in August and October (Figure 21). Salinity increased with water depth up to 3 ppt. The pH ranged from near 8.0 in

April to 8.2 in June and August (Figure 22). The pH did not vary with water depth. 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.

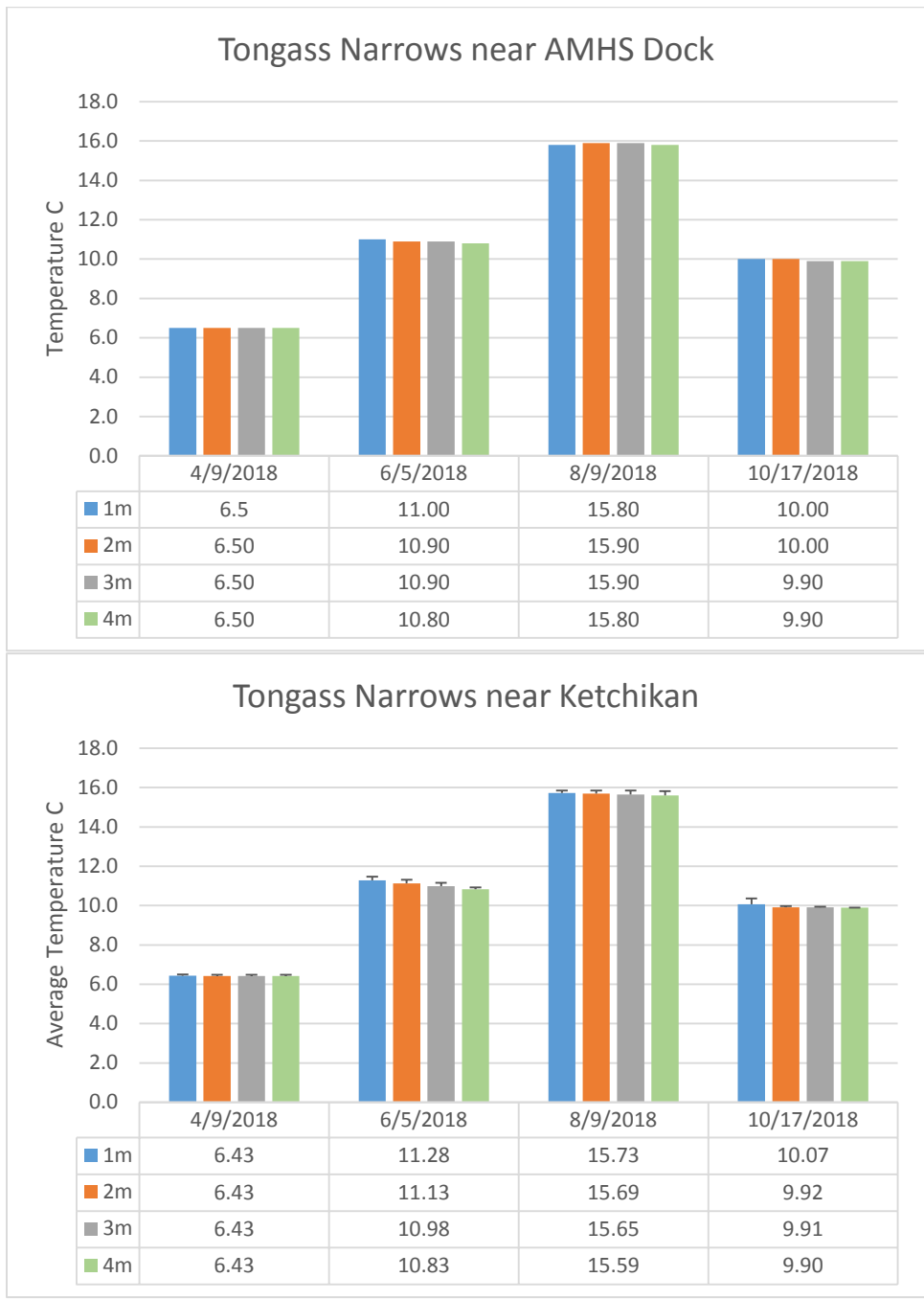


Figure 20. Water temperature at a single location in Tongass Narrows near the AMHS dock and average (N = 12) water temperature in the Tongass Narrows. Error bars are one standard deviation.



Figure 21. Water salinity at a single location in Tongass Narrows near the AMHS dock and average (N = 12) water temperature in the Tongass Narrows. Error bars are one standard deviation.

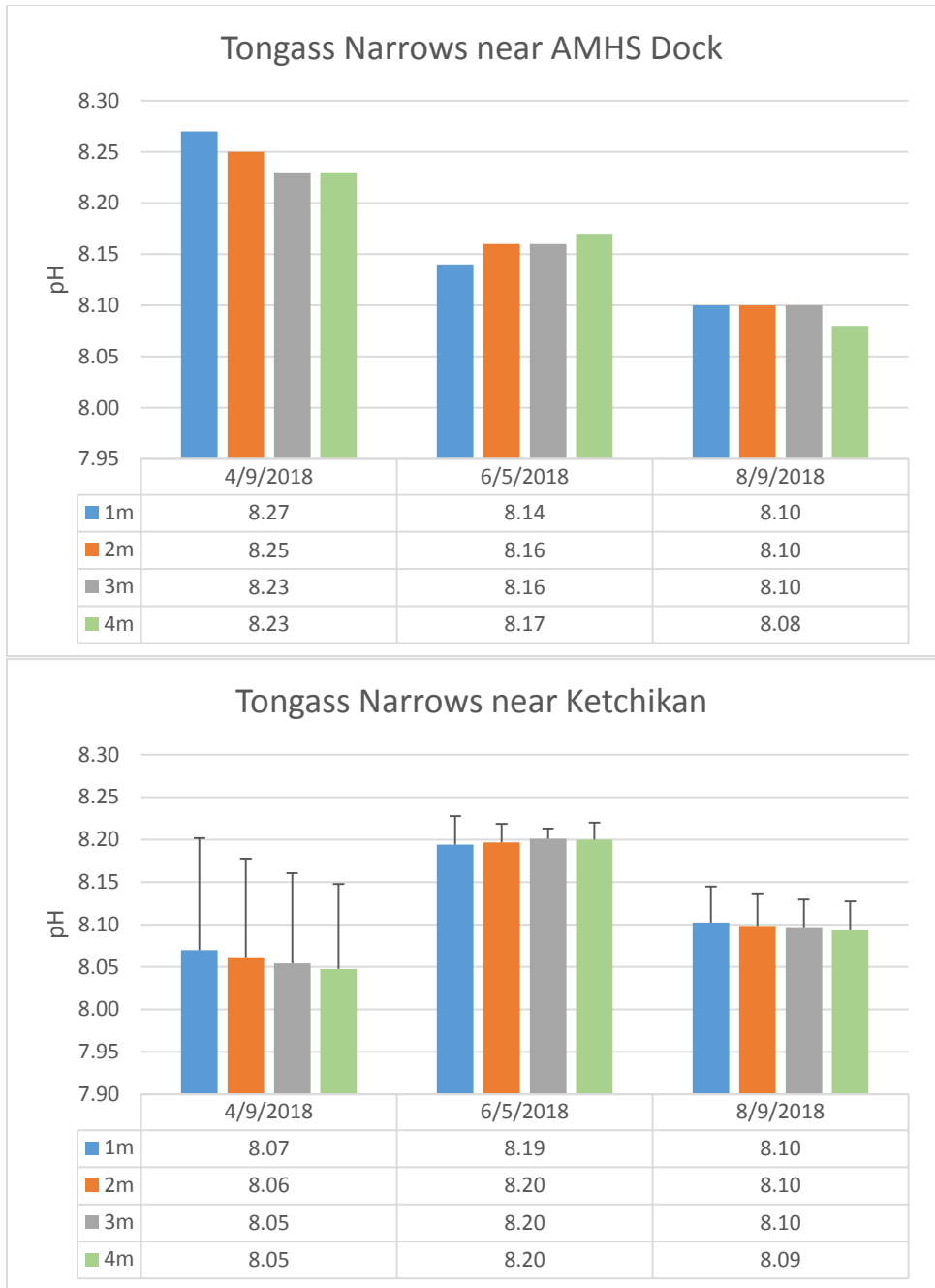


Figure 22. Water pH at a single location in Tongass Narrows near the AMHS dock and average (N = 12) water temperature in the Tongass Narrows. Error bars are one standard deviation.

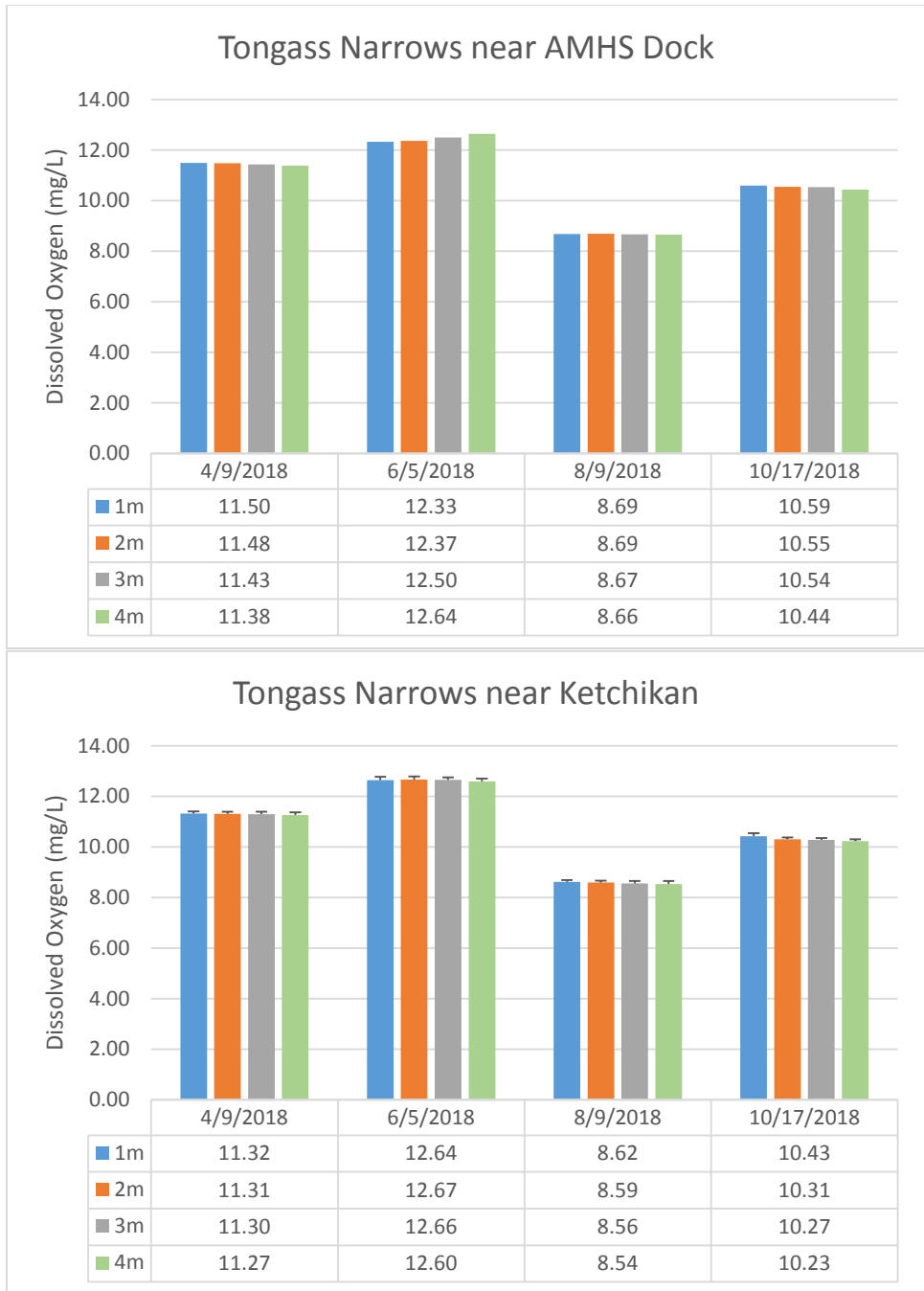


Figure 23. Concentrations of dissolved oxygen at a single location in Tongass Narrows near the AMHS dock and average (N = 12) water temperature in the Tongass Narrows. Error bars are one standard deviation.

Ammonia-N, Copper, Nickel, and Zinc

Ammonia-N concentrations in Tongass Narrows were near MDL limits and average concentrations below MRL in April (Figure 24). Ammonia-N concentrations in June and August tended to be higher in samples collected near the AMHS Dock compare to average concentrations in Tongass Narrows, which did not exceed 0.025 mg/L.

Dissolved Cu concentrations were similar among sampling dates (< 0.5 µg/L) (Figure 25). Total Cu concentrations were generally < 0.6 µg/L and similar among sampling dates. Concentrations of Cu near the AMHS Dock appeared similar to average concentrations in Tongass Narrows.

Dissolved and total Ni concentrations decreased in Tongass Narrows from 0.39 µg/L April to 0.06 µg/L October (Figure 26).

Average concentrations of dissolve Zn were similar among sampling dates an generally < 1.0 µg/L. Total Zn was relatively high in April samples (2.1 µg/L) but closer to dissolved concentrations on all other sampling dates (Figure 27).

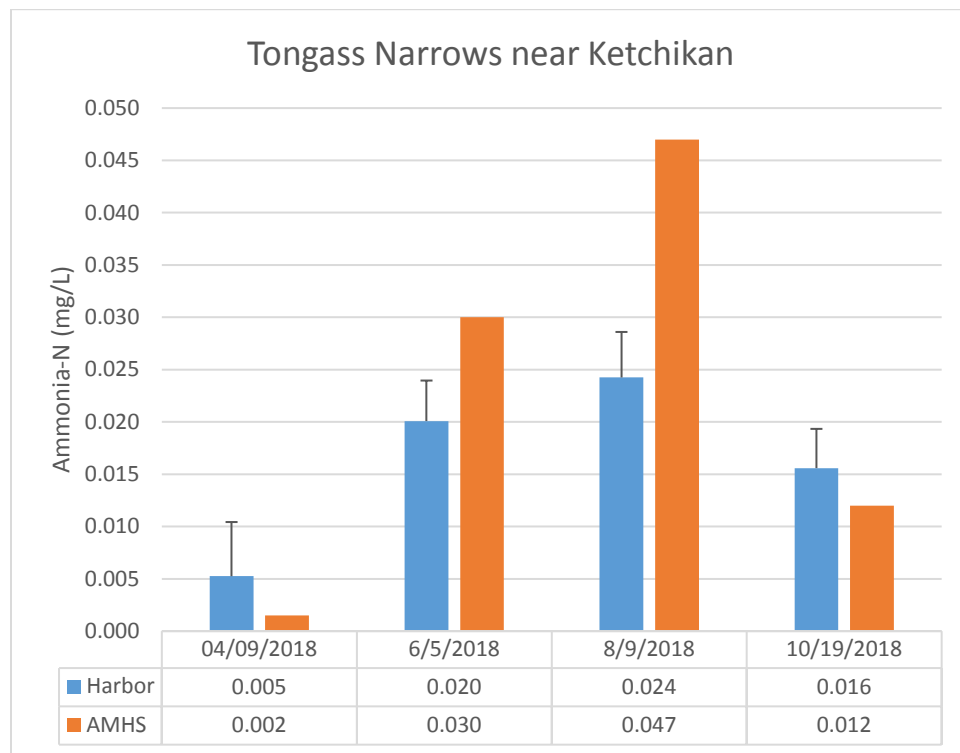


Figure 24. Average Ketchikan Harbor (N = 12), and AMHS point measure of ammonia-N concentrations on each 2018 sampling date. Error bars are one standard deviation.

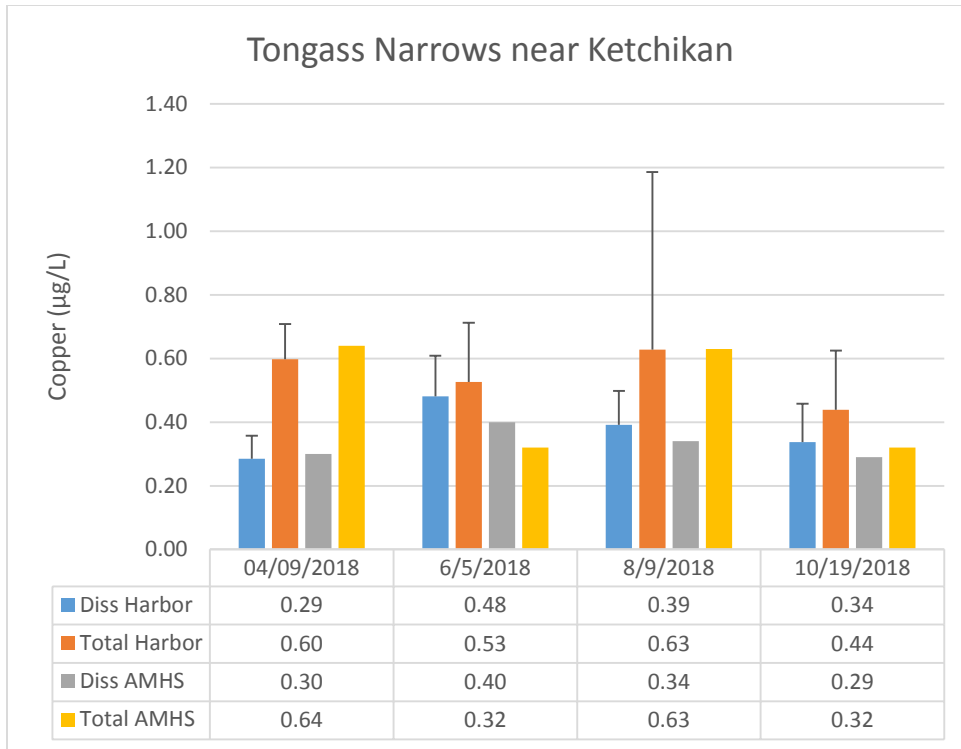


Figure 25. Average Ketchikan Harbor (N = 12), and AMHS point measure of dissolved and total copper concentrations on each 2018 sampling date. Error bars are one standard deviation.

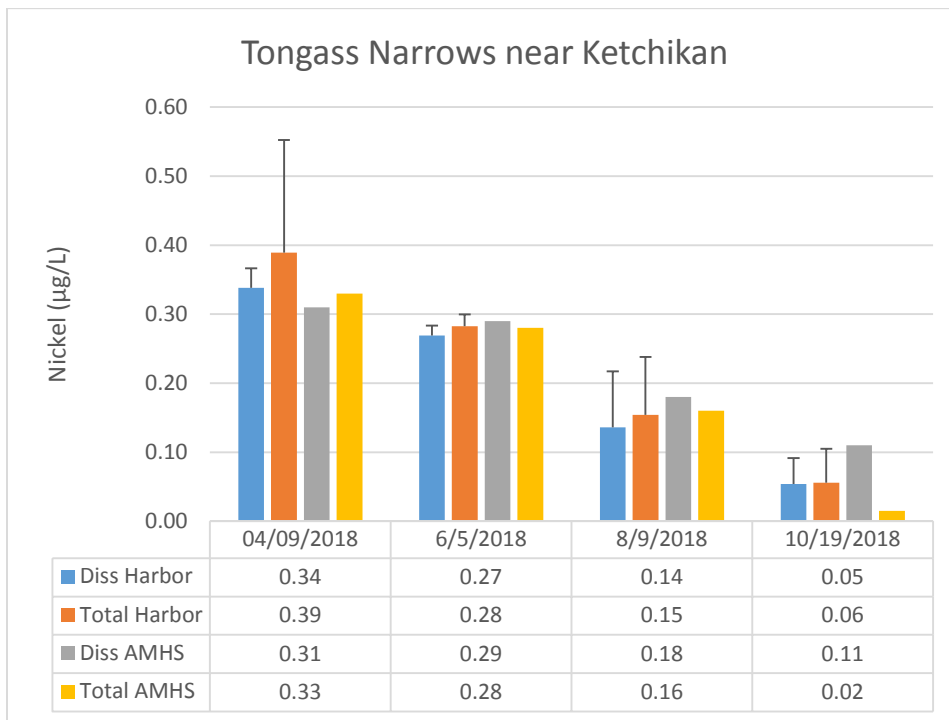


Figure 26. Average Ketchikan Harbor (N = 12), and AMHS point measure of dissolved and total nickel concentrations on each 2018 sampling date. Error bars are one standard deviation.

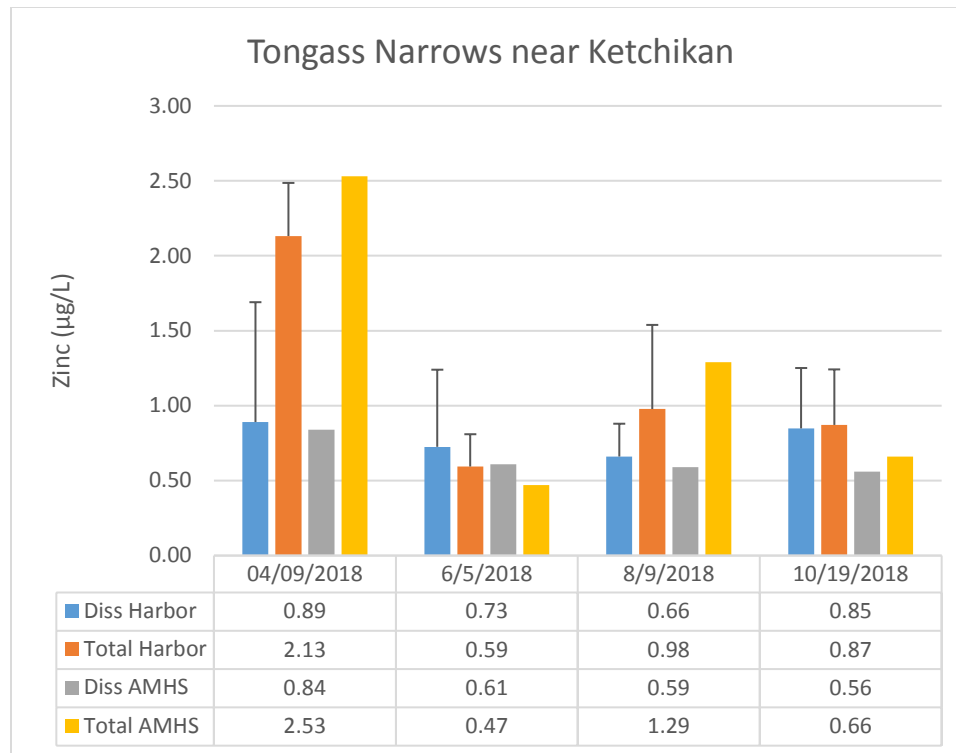


Figure 27. Average Ketchikan Harbor (N = 12), and AMHS point measure of dissolved and total zinc concentrations on each 2018 sampling date. Error bars are one standard deviation.

Site Comparisons

Measures of water characteristics among the three sampling locations at 1 m water depth are shown in Figure 28. Water temperatures were similar among sampling locations, increasing from April through August, with maximum average water temperature near 16°C in Tongass Narrows. Harbor waters were more saline in April and decreased in all harbors during the summer months. Measures of pH were near 8.2, consistent among sampling dates, and similar among sampling locations. Dissolve oxygen was above saturation at all sampling locations and on all sampling dates, with concentrations generally reflecting changing water temperatures and oxygen solubility.

Ammonia-N and dissolved metals concentrations at all sampling locations are shown in Figure 29. Concentrations of ammonia-N were very low in April at all sampling locations often below MDL and MRL. Concentrations increased during summer but remained less than 0.025 mg/L. Dissolved Cu concentrations were similar among sites and at most locations and dates < 0.5 µg/L. Average concentrations of dissolved Cu, however, were higher in the Sitka Harbor in June due to some relatively high concentrations. Similarly, dissolved Zn was < 1.0 µg/L at all sampling locations and on all sampling dates with the exception of the Sitka Harbor during June where extreme high concentrations were present at some sampling locations.

Concentrations of dissolved Ni were < 0.4 µg/L on all sampling dates, were highest in Port Fredrick, consistent among sampling dates in Port Fredrick and Sitka Harbor, but decreased in Tongass Narrows from 0.3 µg/L in April to 0.05 µg/L in October.

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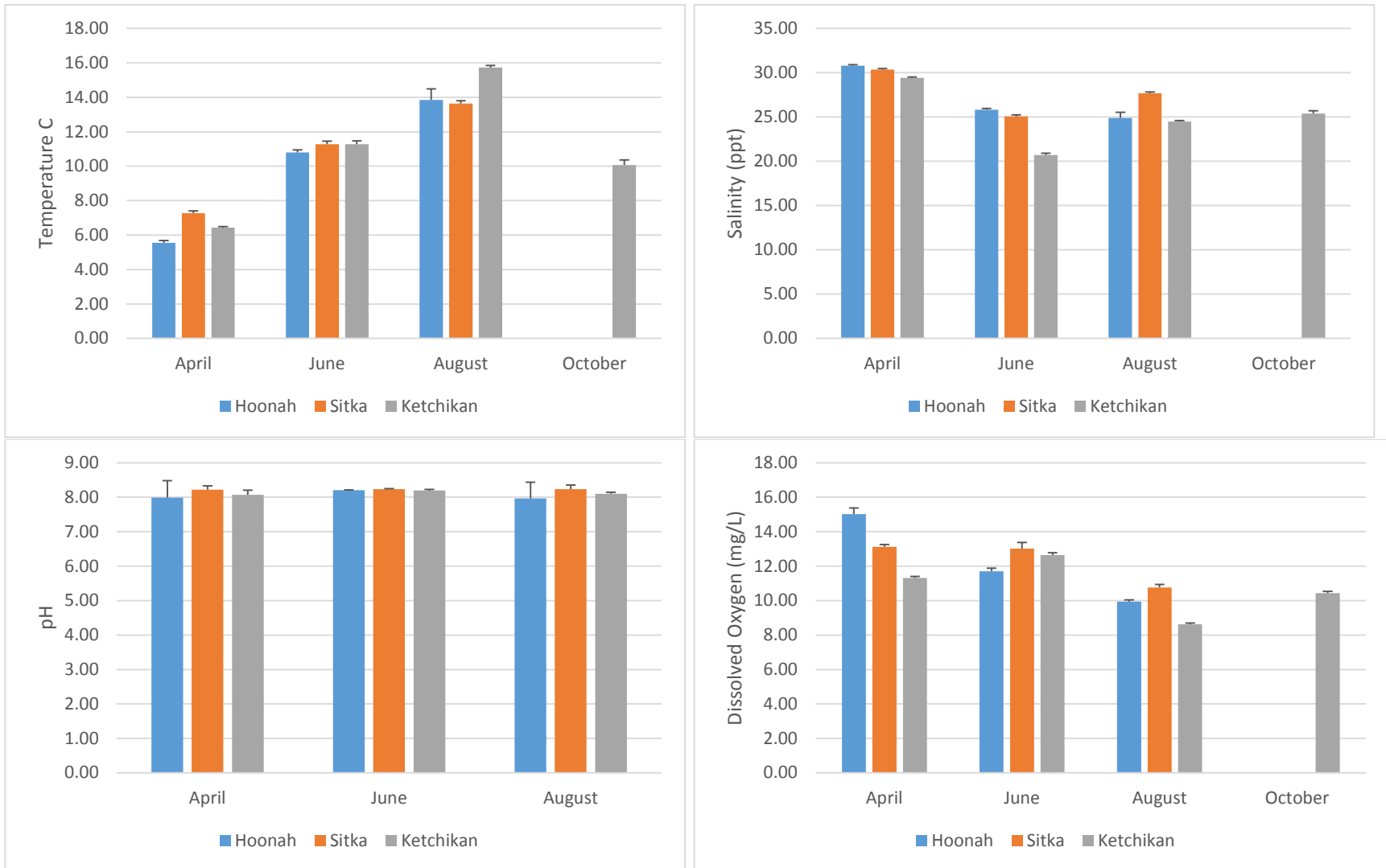


Figure 28. Comparison of water temperature, salinity, pH and dissolved oxygen among sampling locations in 2018.

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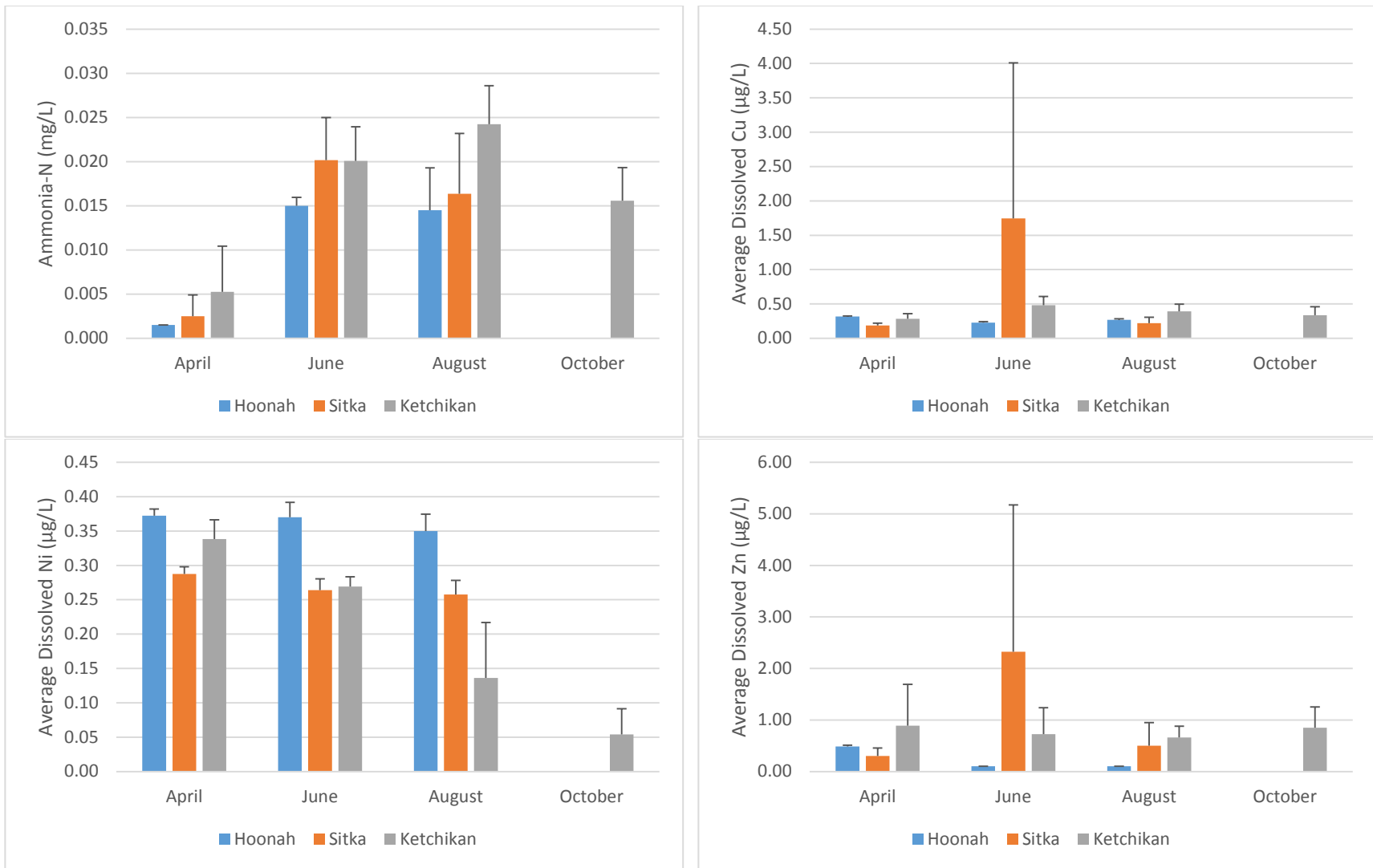


Figure 29. Comparison of ammonia-N and dissolved metals among 2018 sampling locations.