HAWK INLET MONITORING PROGRAM 2018 ANNUAL REPORT

Hecla Greens Creek Mining Company

1 March 2019

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HAWK INLET MONITORING PROGRAM 2018 ANNUAL REPORT

1. INTRODUCTION

1.1 Site Description

The Greens Creek Mine on Admiralty Island is located 18 miles southwest of the city of Juneau, Alaska. Dense forests cover the mountain slopes up to an elevation of 2,500 feet, above which the vegetation is alpine. The climate is maritime, with precipitation averaging 60 to 70 inches per year at the mine site, and 45 to 55 inches per year near the port facilities. The mine and mill facilities (920 area) are located over 6 miles from Hawk Inlet tidewater.

Zinc, lead, silver, and gold are the target recovery metals. The Greens Creek Mine production of ore concentrate began in February 1989 and operated approximately four years before production was suspended in April 1993. The mine and mill were recommissioned, and operations restarted in mid-1996. A milling facility and appurtenant support facilities are in place at the 920 area. Filter pressed tailings from the milling process are backfilled in the mine and also deposited at a surface dry-stack tailings pile. Ore concentrate (concentrate) is transported from the mill to the Hawk Inlet port facilities area (Port), where it is stored until it is shipped offsite. Support facilities to the mining and milling operation at the Port include rock core storage, concentrate storage, shipping port, and shift housing. A domestic waste water treatment plant is also located at the Port.

One wastewater discharge outfall and 10 stormwater discharge sites are authorized by the HGCMC Alaska Pollutant Discharge Elimination System (APDES) Permit Number AK-0043206. Sewage treatment effluent, previously discharged through Outfall 001, is combined with area surface runoff and pumped to Pond 7. At Pond 7, the water is combined with effluent streams from the 920 and the Tailings Facility, treated, and discharged through the submarine APDES Outfall 002 to the ocean at the mouth of Hawk Inlet. Authority over the federal permitting, compliance and enforcement of the NPDES program transferred to the State in November of 2010 for the mining industry. This report fulfills the requirements of APDES Permit Number AK-0043206, effective October 1st, 2015.

Hawk Inlet is a marine inlet formed during the late Holocene glaciation and is underlain by a series of late-Paleozoic to Mesozoic phyllitic-schist and greenstone formations. Hawk

Inlet extends seven miles north from Chatham Strait to a tidal mudflat estuary about 0.6 miles in diameter. The narrow channel connecting the Inlet to Chatham Strait, located between the top of the Greens Creek delta and the western shore of Hawk Inlet, has a minimum low tide depth of 35 feet. The mid-channel depth ranges from 35 feet to 250 feet. The Inlet has regular, twice-daily tides, with a maximum tidal variation of 25 feet. On the flood tide, the surface 35-foot layer contains the bulk of the water transport entering the Inlet and is then flushed out on the ebb tide. Flushing describes the rate and extent to which a body of water is replenished by tidal or other currents. Flushing rates are also indicative of the length of time that mining effluent may remain in a water body and become incorporated into the physical and biological ecosystem through ingestion, adsorption or other means. In 1983, dispersion dye testing in Hawk Inlet determined that over each tidal cycle, an average of 13 billion gallons of water is flushed from the Inlet (SEA 1983). At that rate, it is estimated that the Inlet completely flushes once every five tidal cycles. Based on the average daily output in 2018, the input of effluent from the mining operations over a day represents approximately 0.007% of the total volume flushed daily.

Greens Creek geology exploration began in 1973, which led to predevelopment of mining operations in 1986. Prior to this the Hawk Inlet cannery was constructed in 1910 and operated until it burned in 1976. It is estimated the summer population at Hawk Inlet during cannery operation was 500. Additionally, up until 1946, gold was being mined near Hawk Inlet beginning in 1919 at the Alaska Empire Mine (Forest Service 2013). “In September 2014, the Forest Service conducted a Preliminary Assessment/Site Inspection of the Alaska Empire Mine site. Elevated concentrations of metals were found in the soil, sediment, surface water and groundwater at the Upper Camp as well as soil stained by petroleum hydrocarbons. Tailings piles with elevated concentrations remain adjacent to the creek and continue to erode tailings into the creek.” (Palmieri 2016)

Factor in the historical and current use of Hawk Inlet’s commercial fishing industry and there is a substantial amount of anthropogenic effects which cannot all be attributable to the Greens Creek mining operation.

1.2 Hawk Inlet Monitoring Program

In anticipation of the Greens Creek Mine development, government agencies, scientists and biological consultants carried out surveys of marine life and baseline studies of heavy metals in the environment beginning in the early 1980s. Several researchers have studied marine life in Hawk Inlet, and the on-going quarterly, semi-annual, and annual monitoring events have generated an extensive time-series data set of coincident metal levels in water, sediment, and marine tissue samples.

The primary objective of the Hawk Inlet monitoring program is to document the water quality, sediment chemistry, and biological conditions in receiving waters and marine environments that may be impacted by the mine’s operations. Sea water is sampled quarterly at three locations in Hawk Inlet. Sediment and invertebrate samples are

collected annually at three (five locations every three years) and seven locations, respectively (Figure 1-1). Table 1-1 summarizes the requirements of the permit for sample parameters, sample preservation and holding time, sampling frequency, analytical method and required method detection limits (MDL). Specific quality assurance/quality control (QA/QC) requirements (i.e., sampling procedures, documentation, chain of custody processes, calibration procedures and frequency, data validation, corrective actions, etc.) are outlined in the APDES Quality Assurance Project Plan: Project Monitoring Manual (HGCMC 2018).

Table 1-1. Summary of Permit Sampling Requirements for Hawk Inlet

APDES Requirement	Parameter	Required Sampling Frequency	Sample Type	Sample Container	Sample Preservation	Laboratory	Holding Time	Analytical Method(s)	Minimum Required Method Detection Limit	Units	Comments
RECEIVING WATER COLUMN MONITORING											
1.6.1.1.3 Table 5	Dissolved Cadmium	Quarterly	Grab (1 sample for Cd, Cu, Pb, Zn)	1 ea. 500 ml Teflon bottle (1 bottle for Cd, Cu, Pb, Zn)	HNO_3 to pH <2 by lab	Battelle Marine Sciences	6 months	EPA 213.2/ 1638	0.10	µg/L	MDLs set by APDES permit Section 1.6.1.1.3, Table 5
1.6.1.1.3 Table 5	Dissolved Copper	Quarterly						EPA 220.2/ 1638	0.03	µg/L	
1.6.1.1.3 Table 5	Dissolved Lead	Quarterly						EPA 239.2/ 1638	0.05	µg/L	
1.6.1.1.3 Table 5	Dissolved Zinc	Quarterly					6 months	EPA 289.2/ 1638	0.200	µg/L	
1.6.1.1.3 Table 5	Total Mercury	Quarterly	Grab	1 ea. 250 ml Teflon bottle			28 days	EPA 245.1/ 1631	0.002	µg/L	
1.6.1.1.3 Table 5	Total Suspended Solids	Quarterly	Grab	1 ea. 1 liter plastic bottle	Cool to 4°C	ACZ Labs	7 days	EPA 160.2/ SM 2540D	--	mg/L	
1.6.1.1.3 Table 5	Turbidity	Quarterly	Grab	1 ea. 1 liter plastic bottle	Cool to 4°C	Field measurement	48 hours	EPA 180.1	--	NTU	
1.6.1.1.3 Table 5	WAD Cyanide	Quarterly	Grab	1 ea 1 liter plastic bottle	NaOH to pH >12, cool to 4°C	ACZ Labs	14 days	EPA 335.2/ SM 4500-CN-E	5.00	µg/L	Add 0.6g ascorbic acid, if chlorine is present.
1.6.1.1.3 Table 5	pH	Quarterly	Grab	NA	NA	Field measurement	15 min	EPA 150.1/ SM 4500-H, B	--	SU	
1.6.1.1.3 Table 5	Conductivity	Quarterly	Grab	NA	NA	Field measurement	20 days	EPA 120.1	--	µmhos/cm	
1.6.1.1.3 Table 5	Temperature	Quarterly	Grab	NA	NA	Field measurement	15 min	NA	--	°C	
BIOACCUMULATION WATER SEDIMENT MONITORING											
1.6.1.2.3 Table 6	Total Cadmium	Annual	Grab	6 ea. 8 oz. plastic or glass jar	Chill and ice sample (not frozen)	ALS Environmental		PSEP/GFAA	0.30	mg/Kg	MDLs set by APDES permit Section 1.6.1.2.3, Table 6
1.6.1.2.3 Table 6	Total Copper	Annual	Grab			ALS		PSEP/ICP	15.00	mg/Kg	
1.6.1.2.3 Table 6	Total Lead	Annual	Grab			ALS		PSEP/ICP	0.50	mg/Kg	NMFS request dupilicate sampling
1.6.1.2.3 Table 6	Total Mercury	Annual	Grab			ALS		PSEP/ EPA 7471A	0.02	mg/Kg	
1.6.1.2.3 Table 6	Total Zinc	Annual	Grab			ALS		PSEP/ICP	15.00	mg/Kg	
BIOACCUMULATION WATER IN-SITU BIOASSAY MONITORING											
1.6.1.3.2 Table 7	Total Cadmium	Annual	Grab	6 ea. 8 oz. plastic or glass jar	Chill and ice sample (not frozen)	ALS		EPA 200.8/ 6020	not specified	mg/Kg	NMFS request dupilicate sampling since Fall 2004
1.6.1.3.2 Table 7	Total Copper	Annual	Grab			ALS		EPA 200.8/ 6020	not specified	mg/Kg	
1.6.1.3.2 Table 7	Total Lead	Annual	Grab			ALS		EPA 200.8/ 6020	not specified	mg/Kg	
1.6.1.3.2 Table 7	Total Mercury	Annual	Grab			ALS		EPA 7471A	not specified	mg/Kg	
1.6.1.3.2 Table 7	Total Zinc	Annual	Grab			ALS		EPA 200.8/ 6020	not specified	mg/Kg	

In September 2018, Global Diving & Salvage, Inc. surveyed the 002 Outfall pipeline for corrosion and damage. A CD of the survey footage can be found as Appendix B. The following points summarize the major findings of the inspection:

Diffuser:

- All anodes on the type 4 anchors were inspected and found to be in good shape, all anodes were noted with 70 to 80% of the anode remaining. All stainless-steel hardware is in good condition and remains tight and true to design.

- On the type 2 anchors, anode nuts were replaced as needed and all hardware was in good working order and tight.

- On the diffuser pipe no damage was found and outside of light marine growth, the pipeline appears to be in very good condition.

- The "duckbill" valves were inspected and found to be flowing freely with the exception of two. Light to moderate marine growth was found on the duckbill's, with 2 completely encased in growth not allowing for the flow of product. The diver was able to remove the growth off these diffusers and others to insure proper operation.

- The diver found that there was light scouring on the East side of the diffuser, and on the West side the natural bottom came half way up the pipe. This is a sign that the inflow of sediment is slowly covering the pipe from the Chatham straights side. The scouring that has occurred on the hawk inlet side is from the back eddies as the current is disrupted by the diffuser. All scouring and back filling is minimal at this time, but it could potentially become an issue in the future.

Outfall pipeline:

- The pipe line was inspected throughout its length and found to be in very good overall condition. The anchor blocks were typical throughout the length and all the stainless hardware was intact and remained tight. The anodes were replaced as needed and at the time of this survey completion no anode was below 95% intact on the entire pipeline. There were 3 flanges noted and the corresponding videos show the condition and make up of these. No damage was noted, and all the hardware was intact and tight. The pipeline lays on natural bottom and all the anchors appear to be evenly spaced and secured as intended. For all practical purposes this pipeline remains true to its design.

This report presents information on each of the three media sampled in Hawk Inlet: water column, sediment, and in-situ bioassay. Results for the samples collected are presented, along with the associated QA/QC data. Statistical evaluation of the data showing averages, variations, and changes over time are also included. The next section describes any deviations from the monitoring program that occurred, and the reasons for the deviations.

1.3 Deviation(s) from Monitoring Program and Incidents

There were no reportable deviations associated with the annual Hawk Inlet monitoring program.

2. WATER COLUMN MONITORING

The receiving water column monitoring requirements originate from Part 1.6.1.1 and Table 5 of the APDES permit. The objective of the receiving water column monitoring element of the sampling program is to provide scientifically valid data on specific physical and chemical parameters for Hawk Inlet water quality. These data are used to evaluate potential changes in the Hawk Inlet marine environment.

In fulfillment of the first EPA issued NPDES permit in 1987, Greens Creek Mining Company sampled quarterly at five locations (104, 105, 106, 107, and 108) for ten total recoverable metals (Ag, As, Ni, Zn, Cd, Cr, Cu, Hg, Pb, and Se) at depths of five feet and 20 feet. In 1998 the NPDES permit was reissued, with the number of sample locations reduced to three (106, 107, and 108) and a reduction in the metals analyzed to five metals (Cd, Cu, Pb, Hg, and Zn), collected at a depth of five feet on a quarterly basis. With the 2005 reissuance of the NPDES permit, the water column monitoring program was changed to require the analyses of Cd, Cu, Pb, and Zn as dissolved concentrations rather than total recoverable. The requirement for effluent toxicity testing was also discontinued in 2005.

The current Hawk Inlet water column monitoring program is essentially the same as was put in effect in 2005. Seawater samples are collected quarterly from the sites on an outgoing tide, with the Chatham Strait sample (Site 106) collected just after low slack water. The two other sites are Station 107, located about mid-way east-west in Hawk Inlet and west of the ship loader facility, and Station 108, located proximal to the 002 diffuser at the edge of the mixing zone. Samples at all three locations are taken at a depth of five feet. Sample timing in each quarter is tide and weather dependent. As required by Permit Part 1.6.3.2, quarterly receiving water sample collection occurs on the same day as effluent sample collection.

Water samples are sent to Battelle Marine Science Lab in Sequim, Washington for low level mercury and dissolved trace metals analyses (Cd, Cu, Pb, and Zn), and ACZ Laboratories in Steamboat Springs, Colorado for WAD CN and total suspended solids analyses. Temperature, pH, turbidity and conductivity are measured in the field by the Environmental staff.

2.1 Analytical Results

The tables in this section summarize the results for the quarterly water column monitoring conducted.

Table 2-1. Hawk Inlet Field Parameters (sample depth 5')

Quarter	Sample date	Site Number	Sample Time	Water Temperature (°C)	pH (s.u.)	Conductivity (umhos/cm @ 25°C)	Turbidity (NTU)
1	28-Mar-18	106	10:15	4.1	7.82	49,200	0.68
		107	09:40	3.8	7.81	49,200	0.63
		108	10:00	3.9	7.81	49,200	0.79
2	29-May-18	106	08:02	8.3	8.12	48,420	0.5
		107	08:37	7.7	8.02	47,410	0.65
		108	08:20	7.8	8.07	47,240	0.52
3	28-Aug-18	106	09:00	12.7	8.03	45,970	1.36
		107	09:35	11.7	7.88	43,900	0.81
		108	09:18	12	7.9	43,160	1.12
4	27-Nov-18	106	10:39	6.7	7.81	49,000	0.5
		107	11:18	6.6	7.78	49,400	0.7
		108	09:49	6.6	7.74	48,700	0.4

Table 2-2. Hawk Inlet Water Column Monitoring: Nonmetal Parameters (ACZ Laboratories) (sample depth 5')

Site	Sample Quarter	TSS (mg/L)	WAD CN (µg/L)
	Lab MDL	*(5.0)*	*(3.0)*
	Req. MDL		*(5.0)*
106	1	10	-3
	2	18	-3
	3	15	-3
	4	39	-3
107	1	26	-3
	2	21	-3
	3	12	-3
	4	36	-3
108	1	40	-3
	2	22	-3
	3	18	-3
	4	36	-3

Note: "-" denotes the sample was analyzed for but was not detected above the level of the method detection limit.

Table 2-3. Hawk Inlet Water Column Monitoring Results: Metals (Battelle Marine Sciences Laboratory) (sample depth 5')

Site	Sample Quarter	Cd (µg/L) Dissolved	Cu (µg/L) Dissolved	Hg (µg/L) Total	Pb (µg/L) Dissolved	Zn (µg/L) Dissolved
	Lab MDL	*(0.002)*	*(0.023)*	*(0.0001)*	*(0.001)*	*(0.042)*
	Req. MDL	*(0.10)*	*(0.03)*	*(0.002)*	*(0.05)*	*(0.20)*
106	1	0.087	0.253	0.0002	0.003	0.42
	2	0.071	0.195	0.0001	0.002	0.11
	3	0.044	0.219	0.0002	0.023	2.48
	4	0.077	0.259	0.0002	0.002	0.33
107	1	0.090	0.253	0.0003	0.007	0.55
	2	0.079	0.259	0.0002	0.007	0.36
	3	0.056	0.280	0.0004	0.008	0.27
	4	0.081	0.276	0.0003	0.006	0.52
108	1	0.092	0.247	0.0002	0.015	0.53
	2	0.078	0.280	0.0002	0.006	0.26
	3	0.054	0.489	0.0003	0.013	0.93
	4	0.082	0.263	0.0003	0.041	0.79

Note: "-" denotes the sample was analyzed for but was not detected above the level of the method detection limit.

Table 2-4 Site 35 APDES Outfall 002 and Water Column Site 108 Results

Site	Analyte	Units	Quarter 1	*MDL*	Quarter 2	*MDL*	Quarter 3	*MDL*	Quarter 4	*MDL*
APDES Outfall 002 Site 35	Cd Total	µg/L	0.3	0.1	0.2	0.1	-0.1	0.1	0.39	0.1
	Cu Total	µg/L	1.2	0.5	0.8	0.5	0.7	0.4	1.4	0.4
	Hg Total	µg/L	-0.2	0.2	-0.2	0.2	-0.2	0.2	-0.2	0.2
	Pb Total	µg/L	33.6	0.1	19.9	0.1	23.8	0.1	16.9	0.1
	Zn Total	µg/L	56.0	2	35.0	2	19.0	2	128.0	2
	TSS	mg/L	-5.0	5	-5.0	5	-5.0	5	-5.0	5
	WAD CN	µg/L	-3.0	3	-3.0	3	-3.0	3	-3.0	3
	pH	s.u.	8.13	--	8.35	--	7.25	--	7.62	--
Water Column Site 108	Cd Dissolved	µg/L	0.0916	0.002	0.0775	0.002	0.0535	0.002	0.0821	0.002
	Cu Dissolved	µg/L	0.247	0.023	0.280	0.023	0.489	0.023	0.263	0.023
	Hg Total	µg/L	0.0002	0.0001	0.0002	0.0001	0.0003	0.0001	0.0003	0.0001
	Pb Dissolved	µg/L	0.0147	0.001	0.0059	0.001	0.0127	0.001	0.0410	0.001
	Zn Dissolved	µg/L	0.532	0.042	0.260	0.042	0.926	0.042	0.786	0.042
	TSS	mg/L	40.0	5	22.0	5	18.0	5	36.0	5
	WAD CN	µg/L	-3.0	3	-3.0	3	-3.0	3	-3.0	3
	pH	s.u.	7.81	--	8.07	--	7.90	--	7.74	--

Notes: "-" denotes the sample was analyzed for, but was not detected above the level of the method detection limit.
Samples for Site 108 were collected on the same day as Outfall 002.

2.2 Data Evaluation

Figures 2-1a, b, c through 2-7a, b, c show the time series plots of field pH, conductivity, cadmium, copper, lead, mercury and zinc for stations 106 (2-1a through 2-7a), 107 (2-1b through 2-7b) and 108 (2-1c through 2-7c). The Alaska Water Quality Standards (AWQS) for marine aquatic life – chronic levels, are shown or noted on the graphs where applicable. The graphs show that Hawk Inlet water quality has remained within or below AWQS standards in all historical and 2018 samples.

WAD cyanide results were below the laboratory minimum detection limit (MDL) in 2018 (Table 2-2). In prior reports, it was noted that the laboratory failed to meet the required MDL of 1.0 µg/L. The WAD cyanide MDL was revised in the APDES Permit Number AK0043206 from 1.0 µg/L to 5.0 µg/L effective October 1st, 2015.

Table 2-4 summarizes the 2018 quarterly site 35 APDES outfall 002 and water column seawater station 108 results. The outfall 002 results remain significantly below the permitted effluent limits for total cadmium (100 µg/L daily max and 50 µg/L monthly average), total copper (99 µg/L daily

max and 39 µg/L monthly average), total mercury (1.9 µg/L daily max and 1.0 µg/L monthly average), total lead (327 µg/L daily max and 123 µg/L monthly average), and total zinc (1,000 µg/L daily max and 500 µg/L monthly average). The pH remained within the permitted range (not less than 6.0 or greater than 9.0 standard units). Outfall 002 results ranged from 8 to 250 times less than the daily effluent maximum limits for all five metals. Similarly, station 108 data remain significantly below AWQS for marine life for dissolved cadmium (8.8 µg/L), dissolved copper (3.1 µg/L), dissolved mercury (0.9401 µg/L), dissolved lead (8.054 µg/L), and dissolved zinc (81.488 µg/L). Station 108 results ranged from 6 to 2700 times less than the AWQS for all five metals. The sampling requirements for outfall 002 and station 108 differ in multiple respects. Comparison requires looking at the above permit effluent limits and AWQS while factoring in dissolved metals concentrations (lower MDLs) vs. total metals concentrations (higher MDLs).

Figures 2-8a through 2-8f show comparative time series plots of field pH, cadmium, copper, lead, mercury, and zinc from 2012 through 2018 for station 108 and Outfall 002. The graphs demonstrate that the mixing zone authorized by the APDES permit is protective of the AWQS for all measured parameters.

Table 2-5 is a comparison of metal values averaged from 2013 through 2017 (n=20) and the 2018 (n=4) results at the three seawater monitoring locations. Except for dissolved zinc values at site 106, the 2018 results remained near or below the previous five-year average. The 3rd quarter dissolved zinc value was 2.48 µg/L. Though this was one of the higher values recorded in the past 14 years, it was within the historical range and is well below the 81.5 µg/L chronic dissolved zinc AWQS for marine life.

Table 2-5. Hawk Inlet Water Column Average Dissolved Metal Concentrations

	Cd (µg/L)		Cu (µg/L)		Pb (µg/L)		Hg (Total - µg/L)		Zn (µg/L)	
Site	**2013 through 2017**	**2018**	**2013 through 2017**	**2018**	**2013 through 2017**	**2018**	**2013 through 2017**	**2018**	**2013 through 2017**	**2018**
106	0.072	0.070	0.243	0.232	0.008	0.008	0.0003	0.0002	0.439	0.833
107	0.073	0.076	0.301	0.267	0.014	0.007	0.0005	0.0003	0.588	0.425
108	0.075	0.076	0.301	0.320	0.017	0.019	0.0003	0.0003	0.733	0.626

2.3 QA/QC Results

Battelle Marine Sciences Laboratory and ACZ Laboratories analyzed the required parameters (refer to Table 1-1) in the sea water samples. Complete QA plans and reports are kept on file in each lab's office and are available upon request. The remainder of this section summarizes the relevant QA/QC results from each laboratory for the quarterly 2018 sea water samples. Elevated levels of zinc in the field blanks, often at levels higher than all the other sea water samples, have been noted consistently by Battelle for this sampling program.

Battelle Marine Science (low level dissolved trace metals analyses in salt water matrices):
1Q: The analytes of interest were found at detectable levels in all field samples. Concentrations in the method blank were less than the MDL for all metals. Concentrations in the field blank were less than the MDL for all metals with the exception of Pb, which was detected at 1.50 times the MDL. The above detection field blanks are not a concern considering field samples were 8.61 times higher than the MDL on average for Pb, and within the expected range, thus no corrective action was taken. Target detection limits (TDLs) were met for all metals. Standard reference material (SRM), matrix spike and duplicate results were within our default criteria of ±25%.

2Q: The analytes of interest were found at detectable levels in all field samples. Concentrations in the method blank were less than the MDL for all metals. Concentrations in the field blank were less than the MDL for all metals with the exception of Cu, Zn, Cd, and Pb, which were detected at 7.65, 43.1, 1.23, 77.5 times the MDL, respectively. On average, field samples were 10.8, 8.04, 38.2, and 6.46 times the MDL for Cu, Zn, Cd, and Pb, respectively. Target detection limits (TDLs) were met for all metals. Standard reference material (SRM), matrix spike and duplicate results were within our default criteria of ±25%.

3Q: The analytes of interest were found at detectable levels in all field samples. Concentrations in the method blank were less than the MDL for all metals. Concentrations in the field blank were less than the MDL for all metals with the exception of Zn, Pb, and Hg which were detected at 49.5, 4.65, and 1.56 times the MDL, respectively. On average, field samples were 12.5, 11.7, and 3.59 times the MDL for Zn, Pb, and Hg, respectively. Target detection limits (TDLs) were met for all metals. Standard reference material (SRM), matrix spike and duplicate results were within our default criteria of ±25%.

4Q: The analytes of interest were found at detectable levels in all field samples. Concentrations in the method blank were less than the MDL for all metals. Concentrations in the field blank were less than the MDL for all metals with the exception of Zn, which was detected at 5.85 times the MDL, respectively. Trip blank results were below the MDL for all metals with the exception of Zn and Pb, which were detected at 1.59 and 1.06 times the MDL, respectively. No corrective action was taken considering field samples were 16.4 and 11.7 times the MDL on average for Zn and Pb, respectively, and within the expected range. Target detection limits (TDLs) were met for all metals. Standard reference material (SRM), matrix spike and duplicate results were within our default criteria of ±25% with the exception of duplicate results for Zn, which had an RPD of 38%. This is not a concern considering Zn was only detected at 7.76 times the MDL in 803-785 r1.

ACZ Laboratories (WAD cyanide analyses):
1Q: No certification qualifiers associated with this analysis.
2Q: No certification qualifiers associated with this analysis.
3Q: No certification qualifiers associated with this analysis.
4Q: No certification qualifiers associated with this analysis.

3. SEDIMENT MONITORING

The requirements for the sediment monitoring originate from Section 1.6.1.2, Sediment Monitoring, and Table 6 of the APDES permit. The objective of this element of the monitoring program is to provide scientifically valid data on five specific trace metal parameters analyzed at dry weight (dw) from sediments at four locations in Hawk Inlet (see Figure 1-1 for locations). These data are used to evaluate potential changes in the Hawk Inlet marine environment over time.

Sediment samples were collected semi-annually through 2015, with the reissuance of the permit the sampling frequency was changed to annual. Samples are collected at the Greens Creek delta (Site S-1), Pile Driver Cove near the mouth of the inlet (Site S-2), ~400 feet south of the concentrate loading facility (Site S-4), and under the loading facility (Sites S-5N and S-5S which bracket the area where concentrate was spilled in 1989). Samples are analyzed at ALS Environmental (formerly Columbia Analytical Services, Inc.) in Kelso, Washington for total concentrations of five trace metals (cadmium [Cd], copper [Cu], lead [Pb], mercury [Hg], and zinc [Zn]).

An additional station S-3 located near the head of Hawk Inlet, established as a background site, has also been sampled for sediment and biota since the 1980s. Though dropped from the official sampling program in the early 2000s, HGCMC continued to monitor the site yearly and has included the data in this report.

3.1 Sediment Analytical Results

All sediment samples were collected by Marine Taxonomic Services, LTD. The sample locations, dates, times, weather conditions, and tides are shown in Table 3-1. Tables 3-2 and 3-3 in this section summarize the total metals results for the semi-annual sediment monitoring events. Sample repetitions (reps) 1 through 6 denote replicate samples taken at each sample site.

Table 3-1. Hawk Inlet Sediment Monitoring Field Parameters

Locations	Date Sampled	Time Sampled (24 hour)	Air Temperature (°F)	Weather Conditions	Tide (ft MLLW)
S-1	4/28/2018	06:20	39	Overcast	-0.9
S-2	4/27/2018	06:00	37	Overcast	0.3
S-3	4/26/2018	17:30	45	Overcast	0.3
S-4	4/26/2018	16:00	43	Overcast	2.0

Table 3-2. Hawk Inlet Sediment Results (ALS Environmental)

Site	Rep	Sample Date	Cd (mg/kg dw)	Cu (mg/kg dw)	Pb (mg/kg dw)	Hg (mg/kg dw)	Zn (mg/kg dw)
S-1 Sediments	1	4/28/2018	0.119	15.9	6.34	<0.021	114.0
	2		0.124	15.9	6.57	0.024	98.1
	3		0.115	15.5	6.69	0.028	106.0
	4		0.143	19.7	7.33	0.027	126.0
	5		0.148	16.2	6.79	0.028	109.0
	6		0.134	15.1	6.69	0.025	101.0
S-2 Sediments	1	4/27/2018	0.039	11	1.78	<0.19	40.8
	2		0.048	9.02	2.02	<0.02	43.2
	3		0.045	9.29	2.07	<0.021	47.9
	4		0.048	10.4	2.04	<0.02	49.6
	5		0.055	10	1.77	<0.02	43.5
	6		0.051	10.7	1.72	<0.021	44.6
S-3 Sediments	1	4/26/2018	1.530	65.1	23.00	0.074	241.0
	2		0.889	51.5	16.90	0.066	187.0
	3		0.923	49.4	16.30	0.059	195.0
	4		1.340	61.5	21.10	0.075	206.0
	5		1.310	62.2	17.30	0.093	216.0
	6		0.922	46.7	15.00	0.062	159.0
S-4 Sediments	1	4/26/2018	0.431	20.2	26.60	0.035	73.2
	2		0.372	19.2	15.80	0.033	64.1
	3		0.354	23.6	17.20	0.030	66.0
	4		0.403	21.1	23.00	0.030	72.4
	5		0.392	25.1	25.00	0.029	93.8
	6		0.410	22	22.10	0.033	76.9

Notes: Method Reporting Limit (MRL) – Define by ALS Environmental as being times the MDL (or greater).
Method Reporting Limit (MRL) – Listed in the Appendix.
"<" denotes the sample was analyzed for, but was not detected above the MRL/MDL.

3.2 Data Evaluation

Prior to opening the Greens Creek Mine for full production in 1989, sediment and biota tissues were sampled for heavy metal concentrations. Sampling sites S-1, S-2, and S-3 were chosen to represent natural conditions; therefore, results from these sites from September of 1984 until January of 1989 were used to calculate baseline, pre-production values. These data are useful as

baseline values against which to compare metal values after mining began, and the results for the current year's sampling. Sampling sites S-4, and S-5 are thought to have been influenced by the old industrial cannery operation and are not used for background comparisons.

Table 3-3. Sediment Data: Pre-Production Baseline, Production Period and Current Year Comparison using a compilation of results from Stations S-1, S-2, (and S-3 for Pre-Production only)

Period	Statistic	Cd	Cu	Pb	Hg	Zn
		mg/kg dw	mg/kg dw	mg/kg dw	mg/kg dw	mg/kg dw
Pre-Production (9/1984-1/1989) (n = 27)	Avg	0.37	24.6	7.7	0.046	104
	Min	0.03	11.9	2.2	0.011	11
	Max	1.09	55.2	15.1	0.102	200
Production (2/1989-9/2017) (n = 234)	Avg	0.17	13.6	4.9	0.023	72
	Min	0.06	6.0	1.3	0.002	26
	Max	0.90	39.5	23.7	0.140	188
Current Year 2018 (n=12)	Avg	0.09	13.2	4.3	0.017	77
	Min	0.04	9.0	1.7	0.010	41
	Max	0.15	19.7	7.3	0.028	126

Note: non-detects are averaged using half of the MRL value.

The comparison of pre-production and production sediment metal values in Table 3-3 shows that across Stations S-1 and S-2, the average metal levels are lower during the production/mining period than they were during pre-production. The current year's results show the average metals levels to be equal or below the production period's average values for all metals except for zinc. Based on these data, it appears that heavy metals in sediment continue to vary from year to year, and there are no apparent trends in metals concentrations when concentrations from production years are compared to pre-production concentrations.

Figures 3-1 through 3-5 show the time series plots for cadmium, copper, lead, mercury and zinc including replicate samples for sample site S-1. Figures 3-6 through 3-10 show the time series plots for cadmium, copper, lead, mercury and zinc including replicate samples for sample site S-2. Replicate samples are plotted with a single point, representing the mean value of the data, and error bars represent the overall distribution of the data.

Sampling sites S-4 and S-5N and S-5S are located near the ore concentrate loading facility. In May 1989, the first attempt to load a barge with bulk ore concentrate resulted in a spill of approximately 1,000 pounds of bulk ore concentrate into Hawk Inlet. During the re-commissioning of the mine (mid-nineties) State and Federal agencies provided oversight as Greens Creek Mine cleaned up the spilled concentrate. A suction dredge contractor removed approximately 550 cubic yards of concentrate and sediment from the spill site in 1994. This effort

was confounded by the residual debris from the 1976 cannery facility fire. Metal scrap was removed from the area along with inert debris. Although clean-up efforts were extensive, annual sediment monitoring indicates that there may still be some concentrate present at the spill site.

Following the 1994 clean-up effort at the concentrate spill site, the sampling methodology at S-5 was expanded. The site was sub-divided into two separate locations. Sampling site S-5S was added on the south side of the spill area. This station complements S-5N located on the north side of the spill area (site S-5N is a continuation of the original site 5). Average concentrations of heavy metals at S-4 and S-5N remain below or equal to average concentrations reported since production began. However, following the spill, metal concentrations in the sediment at S-5S have been elevated and variable. Sites S-5N and S-5S are sampled every three years and will be sampled again in 2019. See the 2016 Hawk Inlet Monitoring report for a discussion of heavy metals at sites S-5N and S-5S. Figures 3-11 through 3-15 show the metal time series graphs for site S-4. Figures 3-16 through 3-20 show the metal time series graphs for site S-5N. Figures 3-21 through 3-25 show the metal time series graphs for site S-5S. Since 2004 replicate samples have been taken at each site and all replicates were included; plotted by the mean and include the standard error bars, unless otherwise noted.

Table 3-4 shows the average metal concentrations and the associated standard deviations for each sediment sampling site during pre-production, production, and the current year. At site S-1, located at the Greens Creek delta and closest to Outfall 002, the 2018 average concentrations for cadmium, copper, lead, and mercury were all less than or equal to both the production and pre-production period averages. The average zinc concentration was higher than the production period but lower than the pre-production period. At site S-2, the background site in Pile Driver Cove, the 2018 average concentrations for cadmium, copper, and lead were lower than both the production and pre-production period averages. The average mercury and zinc concentrations were higher than the production period but lower than the pre-production period. At site S-4, near the historic cannery facilities, the 2018 average cadmium concentration was slightly higher than the pre-production average but lower than the production period average. Average concentrations of copper, lead, mercury, and zinc were lower than both the production and pre-production periods.

Site S-3 is located near the head of Hawk Inlet and approximately four miles north of the Greens Creek Mine port facilities. The 2018 average concentrations for all metals were greater than or equal to both the pre-production and production averages at this location. Further, the 2018 average concentrations of cadmium, copper, mercury, and zinc were significantly higher than those at the other sediment monitoring locations. Given these data and the spatial distance between the monitoring locations, it is evident that there are inputs of metals to Hawk Inlet that are not associated with the Greens Creek Mine.

Table 3-4. Sediment Data Comparison of Pre-Production, Production, and Current Year Values for Sites S-1, S-2, S-3, S-4, S-5N, and S-5S

Station	Period	Cd (mg/kg)		Cu (mg/kg)		Pb (mg/kg)		Hg (mg/kg)		Zn (mg/kg)	
		Avg	*Stdev*	*Avg*	*Stdev*	*Avg*	*Stdev*	*Avg*	*Stdev*	*Avg*	*Stdev*
S-1	**Pre-Production (9/1984 - 1/1989) (n=9)**	0.22	0.11	21.8	3.8	7.8	2.1	0.04	0.01	125.0	7.7
	Production (1989 - 2017) (n=118)	0.20	0.15	16.4	6.0	7.5	3.3	0.03	0.02	99.8	27.5
	Reporting Year 2018 (n=6)	0.13	0.01	16.4	1.5	6.7	0.3	0.02	0.01	109.0	9.2
S-2	**Pre-Production (9/1984 - 1/1989) (n=9)**	0.27	0.11	14.9	2.6	5.3	2.4	0.03	0.01	60.5	5.4
	Production (1989 - 2017) (n=114)	0.15	0.09	10.6	3.9	2.3	1.3	0.01	0.01	43.5	12.3
	Reporting Year 2018 (n=6)	0.05	0.00	10.1	0.7	1.9	0.1	0.02	0.03	44.9	3.0
S-3	**Pre-Production (9/1984 - 1/1989) (n=9)**	0.62	0.28	37.0	9.1	10.0	3.3	0.07	0.02	127.0	49.8
	Production (1989 - 2017) (n=117)	0.74	0.35	36.1	12.8	14.2	5.0	0.07	0.03	131.9	40.9
	Reporting Year 2018 (n=6)	1.15	0.25	56.1	7.1	18.3	2.8	0.07	0.01	200.7	25.3
S-4	**Pre-Production (9/1984 - 1/1989) (n=6)**	0.34	0.17	46.2	12.1	53.8	20.2	0.11	0.06	136.5	41.6
	Production (1989 - 2017) (n=118)	0.53	0.68	33.6	39.2	61.1	100.2	0.10	0.36	112.3	131.4
	Reporting Year 2018 (n=6)	0.39	0.03	21.9	2.0	21.6	3.9	0.03	0.00	74.4	9.7
S-5N	**Production (2/1989 - 5/2016)**	7.04	25.93	178.5	263.8	751.4	1659.9	1.00	3.59	1,194	3,551
S-5S	**Production (2/1989 - 5/2016)**	3.72	3.43	106.5	78.9	341.9	360.1	0.32	0.26	812	712

Notes: Underlined concentrations are higher than pre-production averages. Non-detects are averaged using half of the MRL/MDL value.

3.3 QA/QC Results

ALS Environmental analyzed the required parameters (see Table 1-1) in the sediment samples. Complete QA plans and reports are kept on file at the ALS Environmental office and are available upon request. The remainder of this section summarizes any relevant QA/QC results that were exceptions for the 2018 sampling event.

Beginning in the fall of 2004, duplicate samples have been collected from each site, where possible, to address a National Marine Fisheries Service request. Precision can be calculated from the results of duplicate samples. In this case, the Relative Standard Deviation (RSD) is calculated as follows:

$$RSD = \frac{\text{standard deviation} * 100}{\text{sample mean}}$$

The RSD is shown for the duplicate samples from 2018 in Table 3-5.

The data quality objective for the RSD is that it is less than or equal to 30 percent, when the values are at least four times the detection limit. All RSDs calculated for the 2018 dataset were within this data quality objective.

Table 3-5. Relative Standard Deviation for Replicate Sediment Samples

Site	Rep	Sample Date	Cd (mg/kg dw)	Cu (mg/kg dw)	Pb (mg/kg dw)	Hg (mg/kg dw)	Zn (mg/kg dw)
S-1 Sediments	1	4/28/2018	0.119	15.9	6.3	<0.021	114.0
	2		0.124	15.9	6.6	0.024	98.1
	3		0.115	15.5	6.7	0.028	106.0
	4		0.143	19.7	7.3	0.027	126.0
	5		0.148	16.2	6.8	0.028	109.0
	6		0.134	15.1	6.7	0.025	101.0
		RSD (%)	***10.22***	***10.2***	***4.9***	***6.88***	***9.2***
S-2 Sediments	1	4/27/2018	0.039	11	1.8	<0.190	40.8
	2		0.048	9.02	2.0	<0.020	43.2
	3		0.045	9.29	2.1	<0.021	47.9
	4		0.048	10.4	2.0	<0.020	49.6
	5		0.055	10	1.8	<0.020	43.5
	6		0.051	10.7	1.7	<0.021	44.6
		RSD (%)	***11.39***	***7.8***	***8.4***	--	***7.2***
S-3 Sediments	1	4/26/2018	1.530	65.1	23.0	0.074	241.0
	2		0.889	51.5	16.9	0.066	187.0
	3		0.923	49.4	16.3	0.059	195.0
	4		1.340	61.5	21.1	0.075	206.0
	5		1.310	62.2	17.3	0.093	216.0
	6		0.922	46.7	15.0	0.062	159.0
		RSD (%)	***23.85***	***13.9***	***16.9***	***17.21***	***13.8***
S-4 Sediments	1	4/26/2018	0.431	20.2	26.6	0.035	73.2
	2		0.372	19.2	15.8	0.033	64.1
	3		0.354	23.6	17.2	0.030	66.0
	4		0.403	21.1	23.0	0.030	72.4
	5		0.392	25.1	25.0	0.029	93.8
	6		0.410	22	22.1	0.033	76.9
		RSD (%)	***7.00***	***10.0***	***19.8***	***7.38***	***14.3***

"--" indicates RSD was not calculated because three or more of the values were less than 4 times the MRL.

"<" denotes the sample was analyzed for, but was not detected above the MRL/MDL.

4. IN-SITU BIOASSAYS

The requirements for the bioassay monitoring originate from Section 1.6.1.3, In-situ Bioassays, and Table 7 of the APDES permit. The objective of this monitoring element is to provide scientifically valid data on five specific trace metal parameters analyzed at dry weight from the tissues of polychaete worms (*Nephtys*) and bay mussels (*Mytilus edulis*) at seven locations in Hawk Inlet. These data are used to evaluate potential changes in the Hawk Inlet marine environment.

Bioaccumulation in-situ bioassay sampling in Hawk Inlet consists of annual testing of trace metal tissue burdens of selected species of invertebrate organisms with different feeding guilds. In the Hawk Inlet sill area, where no fine-grained sediments occur, four sites (Stations STN-1, STN-2, STN-3 and East Shoal Light (ESL)) are used for in-situ bioassay monitoring of trace metals in bay mussels. Data gathered from this area measures the response in organisms in the immediate vicinity of the 002 Outfall discharge. In most other areas of Hawk Inlet, the bottom is covered with sediment. Consequently, samples of sediment dwelling polychaete worms (*Nephtys procera and Nereis sp.*) are collected at three additional sites (S-1, S-2, and S-4). *Nereis sp*. were not encountered in sufficient numbers for analysis in 2018 and so only *Nephtys* were collected.

4.1 Analytical Results

All tissue samples were collected by Marine Taxonomic Services, LTD. The sample locations, types, dates, times, weather conditions, and tides are shown in Table 4-1. Table 4-2 summarizes the total metals results for the annual bioassays. Sample repetitions (reps) 1 through 6 denote replicate samples taken at each site.

Table 4-1. Hawk Inlet Tissue Sampling Field Data

Locations	Sample Type	Date Sampled	Time Sampled (24 hour)	Air Temperature (°F)	Weather Conditions	Tide (ft MLLW)
S-1	*Nephtys*	4/28/2018	06:20	39	Overcast	-0.9
S-2	*Nephtys*	4/27/2018	06:00	37	Overcast	0.3
S-3	*Nephtys*	4/26/2018	17:30	45	Overcast	0.3
S-4	*Nephtys*	4/26/2018	16:00	43	Overcast	2.0
STN-1	Mussels	4/29/2018	07:30	38	Ptly Cloudy	-1.6
STN-2	Mussels	4/29/2018	09:30	41	Ptly Cloudy	2.0
STN-3	Mussels	4/29/2018	18:40	45	Ptly Cloudy	2.0
ESL	Mussels	4/29/2018	20:00	43	Ptly Cloudy	0.6

Table 4-2. Hawk Inlet Tissue Bioassay Results (ALS Environmental)

Site	Rep	Sample Date	Cd (mg/kg dw)	Cu (mg/kg dw)	Pb (mg/kg dw)	Hg (mg/kg dw)	Zn (mg/kg dw)
S-1 *Nephtys*	1	4/28/2018	3.38	10.1	2.08	0.062	246.0
	2		3.26	10.0	1.78	0.069	235.0
	3		3.19	10.1	1.39	0.066	233.0
	4		3.10	9.89	1.31	0.055	226.0
	5		3.11	11.3	1.28	0.063	220.0
	6		2.82	11.8	2.29	0.064	203.0
S-2 *Nephtys*	1	4/27/2018	0.82	9.55	1.04	<0.02	179.0
	2		0.87	8.17	1.06	<0.02	187.0
	3		0.86	8.59	1.13	<0.02	190.0
	4		0.87	8.78	1.10	<0.02	189.0
	5		0.85	8.41	1.48	<0.02	178.0
	6		0.81	8.96	1.09	<0.02	174.0
S-4 *Nephtys*	1	4/26/2018	0.84	20.4	3.71	<0.02	179.0
	2		0.82	17.3	3.64	0.028	184.0
	3		0.83	29.5	3.88	0.033	182.0
	4		0.79	20.4	3.60	0.029	175.0
	5		0.77	25.2	3.49	0.030	168.0
	6		0.78	19.7	3.57	0.034	170.0
STN-1 Mussels	1	4/29/2018	13.20	11.0	0.70	0.057	117.0
	2		12.70	10.7	0.62	0.059	114.0
	3		12.90	10.6	0.63	0.059	114.0
	4		12.80	11.5	0.66	0.059	113.0
	5		12.40	10.3	0.65	0.052	111.0
	6		12.70	10.2	0.61	0.057	110.0
STN-2 Mussels	1	4/29/2018	12.10	11.2	0.83	0.057	96.0
	2		11.80	11.2	0.44	0.047	95.6
	3		12.00	11.4	0.42	0.054	97.7
	4		12.00	11.1	0.41	0.051	95.9
	5		11.80	10.9	0.39	0.049	95.7
	6		11.90	11.1	0.41	0.057	95.8
STN-3 Mussels	1	4/29/2018	12.30	11.4	0.62	0.050	106.0
	2		12.30	11.2	0.60	0.049	106.0
	3		12.30	11.2	0.59	0.058	106.0
	4		12.00	11.3	0.62	0.050	107.0
	5		12.40	11.4	0.66	0.050	108.0
	6		12.20	10.9	0.69	0.062	105.0
ESL Mussels	1	4/29/2018	6.76	15.1	0.39	0.041	80.4
	2		6.74	15.7	0.39	0.052	83.0
	3		6.56	15.0	0.38	<0.02	80.1
	4		6.46	14.6	0.37	<0.02	79.0
	5		6.72	15.3	0.38	0.056	82.1
	6		6.52	14.9	0.38	0.057	81.0

"<" denotes the sample was analyzed for, but was not detected above the MRL/MDL

4.2 Data Evaluation

Prior to opening the Greens Creek Mine for full production in 1989, sediment and biota tissues were sampled for heavy metal concentrations. Results for mussels from sites STN-1, STN-2, STN-3 and ESL, and for *Nephtys* from sites S-1, S-2, and S-3 from September of 1984 until January of 1989 were used to calculate baseline, pre-production values. These data are useful as baseline values against which to compare metal values after mining began and the results for the current year's sampling.

As noted by Oceanographic Institute of Oregon in the 1998 Kennecott Greens Creek Mine Risk Assessment (p 4-3),

> "Sampling stations were selected to demonstrate a range of potential exposures including "worst case" exposure to Outfall discharges. Some of the test organisms placed in cages directly on the Outfall diffuser ports lived for six months. These results indicate that even maximum exposure to the Outfall discharge result in no acute effects."

Average lead concentrations in mussel tissues were approximately 2.5 times higher during the production period than the pre-production period (Table 4-3). Average 2018 lead values (0.53 mg/kg dw) were approximately equal to the pre-production (0.50 mg/kg dw) and 0.8 mg/kg lower than production average values (1.33 mg/kg dw). Average zinc values (99.1 mg/kg dw) were slightly higher in concentration to pre-production values (91.1 mg/kg dw) and production values (91.1 mg/kg dw). Average cadmium values (10.90 mg/kg dw) were higher than pre-production values (7.99 mg/kg dw) and production values (8.48 mg/kg dw). Average copper concentration (12.05 mg/kg dw) was greater than both pre-production concentration (8.08 mg/kg dw) and production concentration (8.43 mg/kg dw). Average concentration for mercury was comparable to pre-production average concentration. Figures 4-1 through 4-20 show the time series plots for cadmium, copper, lead, mercury and zinc in mussel samples for sample sites STN-1, STN-2, STN-3, and ESL. Error bars were included for the replicate samples taken in 2016, 2017, and 2018. Prior to the reissued 2015 APDES permit, replicate mussel tissue samples were not collected.

Table 4-3. Mussels Tissue Data: Pre-Production, Production, and Current Year - Sites STN-1, STN-2, STN-3, and ESL.

Period	Statistic	Cd	Cu	Pb	Hg	Zn
		mg/kg dw	mg/kg dw	mg/kg dw	mg/kg dw	mg/kg dw
Pre-Production (9/1984-1/1989) (n = 36)	Avg	7.99	8.08	0.50	0.05	91.1
	Min	3.25	5.5	0.15	0.014	71.9
	Max	15.76	12.2	1.73	0.34	142.0
Production (2/1989-9/2017) (n = 272)	Avg	8.48	8.43	1.33	0.05	91.1
	Min	3.01	0.82	0.32	0.01	49.0
	Max	15.9	110	9.41	0.56	167.0
Current Year 2018 (n=24)	Avg	10.90	12.05	0.53	0.05	99.1
	Min	6.46	10.2	0.369	0.041	79.0
	Max	13.2	15.7	0.834	0.062	117.0

Notes: Non-detects are averaged using half of the MDL value; underlined average values higher than baseline.

Trace metal concentrations averaged for *Nephtys* sampled in 2018 are varied when compared to pre-production and production stages of monitoring (Table 4-4). Cadmium (1.60 mg/kg dw), mercury (0.03 mg/kg dw) and zinc (195 mg/kg dw) were reported at concentrations below or equal to both the pre-production and production stages of monitoring. Average lead and copper concentrations for 2018 were 2.2 mg/kg dw and 13.8 mg/kg dw respectively. These values were above the pre-production measurements, but similar to production averages.

Table 4-4. Hawk Inlet *Nephtys* Tissue Data: Pre-Production Baseline, Production Period and Current Year Comparison using a compilation of results from Stations S-1, S-2, and S-4.

Period	Statistic	Cd	Cu	Pb	Hg	Zn
		mg/kg dw	mg/kg dw	mg/kg dw	mg/kg dw	mg/kg dw
Pre-Production (9/1984-1/1989) (n = 20)	Avg	2.69	11.3	0.9	0.04	210
	Min	0.51	6.2	0.3	0.01	143
	Max	6.91	23.5	5.4	0.17	303
Production (2/1989-9/2017) (n = 354)	Avg	1.62	12.5	2.9	0.03	194
	Min	0.24	3.9	0.1	0.01	63
	Max	8.33	104.7	89.3	0.10	482
Current Year 2018 (n=18)	Avg	1.60	13.8	2.2	0.03	195
	Min	0.77	8.2	1.0	0.01	168
	Max	3.38	29.5	3.9	0.07	246

Notes: Non-detects are averaged using half of the MDL value; underlined average values higher than baseline.

The average and standard deviation results for pre-production, production and current year periods for the individual sites for mussels is provided in Table 4-5. Table 4-5 shows larger standard deviations in production levels of zinc concentrations in mussels at all sites, except for STN-3. Larger standard deviations were also noticed for lead at STN-2 and STN-3, as well as copper at ESL. In 2018, metals at all sites were higher than the pre-production period, except for cadmium, lead, and zinc at ESL, and mercury at STN-1.

Table 4-5. Average and Standard Deviation Values for Pre-Production, Production, and Current Year Mussel Data – Sites STN-1, STN-2, STN-3, and ESL.

Station	Period	Cd (mg/kg)		Cu (mg/kg)		Pb (mg/kg)		Hg (mg/kg)		Zn (mg/kg)	
		Avg	*Stdev*	*Avg*	*Stdev*	*Avg*	*Stdev*	*Avg*	*Stdev*	*Avg*	*Stdev*
ESL	Pre-Production (9/1984 - 1/1989) (n=9)	6.67	1.60	8.16	0.68	0.42	0.11	0.03	0.01	91.4	8.4
	Production (2/1989 - 5/2017) (n=68)	6.63	1.77	10.04	13.05	1.22	0.76	0.03	0.02	85.3	18.8
	Reporting Year 2018 (n=6)	6.63	0.12	15.10	0.34	0.38	0.01	0.05	0.01	80.9	1.3
STN-1	Pre-Production (9/1984 - 1/1989) (n=9)	7.41	1.80	7.96	1.20	0.62	0.41	0.07	0.09	94.9	11.2
	Production (2/1989 - 5/2017) (n=68)	8.83	2.29	7.80	2.16	1.36	0.87	0.05	0.05	93.4	25.0
	Reporting Year 2018 (n=6)	12.78	0.24	10.72	0.44	0.64	0.03	0.06	0.00	113.2	2.3
STN-2	Pre-Production (9/1984 - 1/1989) (n=9)	8.60	3.10	7.71	1.05	0.37	0.19	0.04	0.01	82.4	11.2
	Production (2/1989 - 5/2017) (n=68)	9.18	2.43	8.22	3.70	3.26	15.06	0.04	0.02	92.7	26.1
	Reporting Year 2018 (n=6)	11.93	0.11	11.15	0.15	0.48	0.16	0.05	0.004	96.1	0.7
STN-3	Pre-Production (9/1984 - 1/1989) (n=9)	9.27	3.05	8.50	1.69	0.59	0.21	0.04	0.01	95.7	17.8
	Production (2/1989 - 5/2017) (n=68)	9.14	2.16	7.55	1.99	2.65	11.05	0.05	0.06	91.6	17.6
	Reporting Year 2018 (n=6)	12.25	0.13	11.23	0.17	0.63	0.03	0.05	0.00	106.3	0.9

Notes: Underlined concentrations are higher than pre-production averages. Non-detects are averaged using half of the MRL/MDL value.

The historical and year 2018 metals concentration in *Nephtys* is shown in Table 4-6. Concentrations of cadmium and mercury in *Nephtys* show general decline over time. Cadmium and mercury (except S-1) average concentrations were lower at all four sampled stations for both production relative to pre-production and 2018 relative to pre-production. Moreover, in 2018 cadmium and mercury levels were similar to, or lower than the production average. Zinc concentrations in 2018 were similar to, or slightly higher than the pre-production and production levels. Various trends in copper were reported at all three stations; increase at S-1, almost no change at S-2, and an increase at S-3 and S-4. Lead concentrations at S-1 and S-2 have been higher on average since production began relative to pre-production; however, 2018 concentrations were higher than the average for the other production years. At S-4, lead concentrations were much lower in 2018 than the production average and lower than pre-production average concentration. Beginning in the fall of 2004 replicate sampling of *Nephtys* was initiated. The replicate samples are averaged in Table 4-6. Figures 4-21 through 4-35 show the time series plots for cadmium, copper, lead, mercury and zinc including replicate samples in *Nephtys* for sample sites S-1, S-2, and S-4. Replicate samples are plotted by the mean and include standard error bars.

Table 4-6. Average and Standard Deviation Values for Pre-Production, Production, and Current Year *Nephtys* Data – Sites S-1, S-2, S-3, and S-4

Station	Period	Cd (mg/kg)		Cu (mg/kg)		Pb (mg/kg)		Hg (mg/kg)		Zn (mg/kg)	
		Avg	*Stdev*	*Avg*	*Stdev*	*Avg*	*Stdev*	*Avg*	*Stdev*	*Avg*	*Stdev*
S-1	Pre-Production (9/1984 - 1/1989) (n=9)	4.00	1.61	9.04	1.12	0.49	0.15	0.05	0.01	243.6	40.1
	Production (2/1989 - 5/2017) (n=116)	2.96	0.99	9.93	5.32	0.93	0.77	0.04	0.02	213.9	34.6
	Reporting Year 2018 (n=6)	3.14	0.17	10.53	0.74	1.69	0.39	0.06	0.00	227.2	13.5
S-2	Pre-Production (9/1984 - 1/1989) (n=9)	1.70	0.70	12.37	3.12	0.59	0.22	0.02	0.01	181.1	27.7
	Production (2/1989 - 5/2017) (n=116)	1.09	0.47	8.57	4.64	0.69	0.34	0.02	0.01	172.2	34.0
	Reporting Year 2018 (n=6)	0.85	0.02	8.74	0.44	1.15	0.15	0.01	0.00	182.8	6.1
S-3	Pre-Production (9/1984 - 1/1989) (n=8)	4.08	2.45	16.45	4.92	0.82	0.45	0.14	0.22	241.4	70.7
	Production (2/1989 - 5/2017) (n=114)	2.05	1.15	13.51	14.90	0.85	0.68	0.04	0.02	237.0	43.3
	Reporting Year 2018 (n=6)	1.90	0.12	26.05	1.40	2.05	0.56	0.05	0.00	257.3	14.2
S-4	Pre-Production (9/1984 - 1/1989) (n=2)	1.21	0.70	16.80	6.70	4.16	1.27	0.11	0.06	193.5	10.5
	Production (2/1989 - 5/2017) (n=116)	0.81	0.54	18.96	16.10	7.21	8.92	0.02	0.02	195.8	42.8
	Reporting Year 2018 (n=6)	0.80	0.03	22.08	4.06	3.65	0.12	0.03	0.00	176.3	5.9

Notes: Underlined concentrations are higher than pre-production averages. Non-detects are averaged using half of the MRL/MDL value.

4.3 QA/QC Results

5. CONCLUSIONS

Water quality, sediments, and invertebrate tissue monitoring began in Hawk Inlet prior to production to establish a baseline against which future monitoring (during production) could be evaluated within the context of potential natural changes over time. Greens Creek Mine has established a 30+ year monitoring database for many of the sites used to establish the original baseline. This monitoring program has been modified as needed (e.g. splitting of S-5 into S-5N and S-5S and dropping of S-3) to account for changes at the site and to facilitate compliances with the APDES permit.

Long-term water column monitoring for cadmium, copper, lead, mercury, and zinc indicates no impairment (exceedance of marine water quality standards) of the Hawk Inlet water column.

Sediment monitoring has been occurring annually for 30+ years. The 2018 average concentrations for cadmium, copper, lead, mercury, and zinc at sites S-1, S-2, and S-4 were similar or less than the averages established during the pre-production and production periods at each site. Time series graphs for each site show an overall decrease in concentrations for most metals over time, with less variability in recent years compared to the earlier years of the monitoring program. Conversely, sediment samples collected in 2018 at site S-3, a former background location at the head of Hawk Inlet, showed higher cadmium, copper, mercury, and zinc concentrations than those measured at S-1, S-2, and S-4, and higher average concentrations for all metals compared to the pre-production and production period averages at that location. With the variation in metal concentrations between S-3 and the other locations, it is evident that there are sources of metals, likely natural, at the head of Hawk Inlet that are not associated with the Greens Creek Mine.

Site S-1 is located at the Greens Creek delta near the vicinity of Outfall 002. Site S-2 is a background site located over 1.5 miles to the south of S-1, and S-3 is located approximately 6 miles to the north. Comparing the average concentrations of metals for the three sites during the pre-production period, production period, and 2018, S-3 had the highest concentrations of all metals during each period whereas S-2 had the lowest. Given that S-1 is geographically located between the two sites, it is evident that metals concentrations at S-1 are within the range of natural conditions.

Metals results from tissue monitoring of *Nephtys* show that concentrations are variable from year to year. While annual average concentrations at site S-1 are consistently higher than those observed at S-2, there are typically similar variations among the sites. If the temporal variation in the *Nephtys* tissue concentrations at S-1 was a result of discharge from the 002 Outfall, the similar variation observed at S-2 would not be expected. In addition, the 2018 average concentrations for copper, lead, and zinc in *Nephtys* tissue at S-3 were greater than those measured at S-1. Based on this, HGCMC believes that the variation in concentration monitored in organisms near the 002 Outfall is natural and that the monitoring program is sufficient for detecting changes.

The effectiveness of the sediment monitoring system for detecting change can be evaluated by examining metal concentrations at sites near the ship loader (S-4 and S-5 (N and S)). These sites are influenced from the original activities of the cannery, the burning down of the cannery in 1976, and concentrate spillage associated with the ship loader spill in 1989. For example, prior to the spill, pre-production lead levels at S-4 were approximately 50 mg/kg dw. Post concentrate spillage, between 1989-1994, resulted in drastic increase of lead concentration (around 200 mg/kg dw) at S-4. During re-commissioning (mid 1990s) sediments were dredged in the vicinity of the ship loader. Following dredging, the average lead level returned to pre-productions levels. Since the early 2000's lead levels at S-4 have routinely been less than 30 mg/kg, attributed to natural process (e.g. sedimentation) and repeated debris cleanup efforts of dive crews that have removed contaminated materials associated with pre-mine site users (e.g. batteries).

As discussed in the report, there have been some elevated metal concentrations in the invertebrate and sediment samples. However, the recent *Nephtys* tissue and sediment samples exhibit similar variation despite their spatial distances. These results indicate that there is natural variability, the relatively low trophic level organisms studied are not greatly impacted, and that the APDES monitoring program is effective for measuring potential impacts associated with the Greens Creek Mine.

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FIGURES

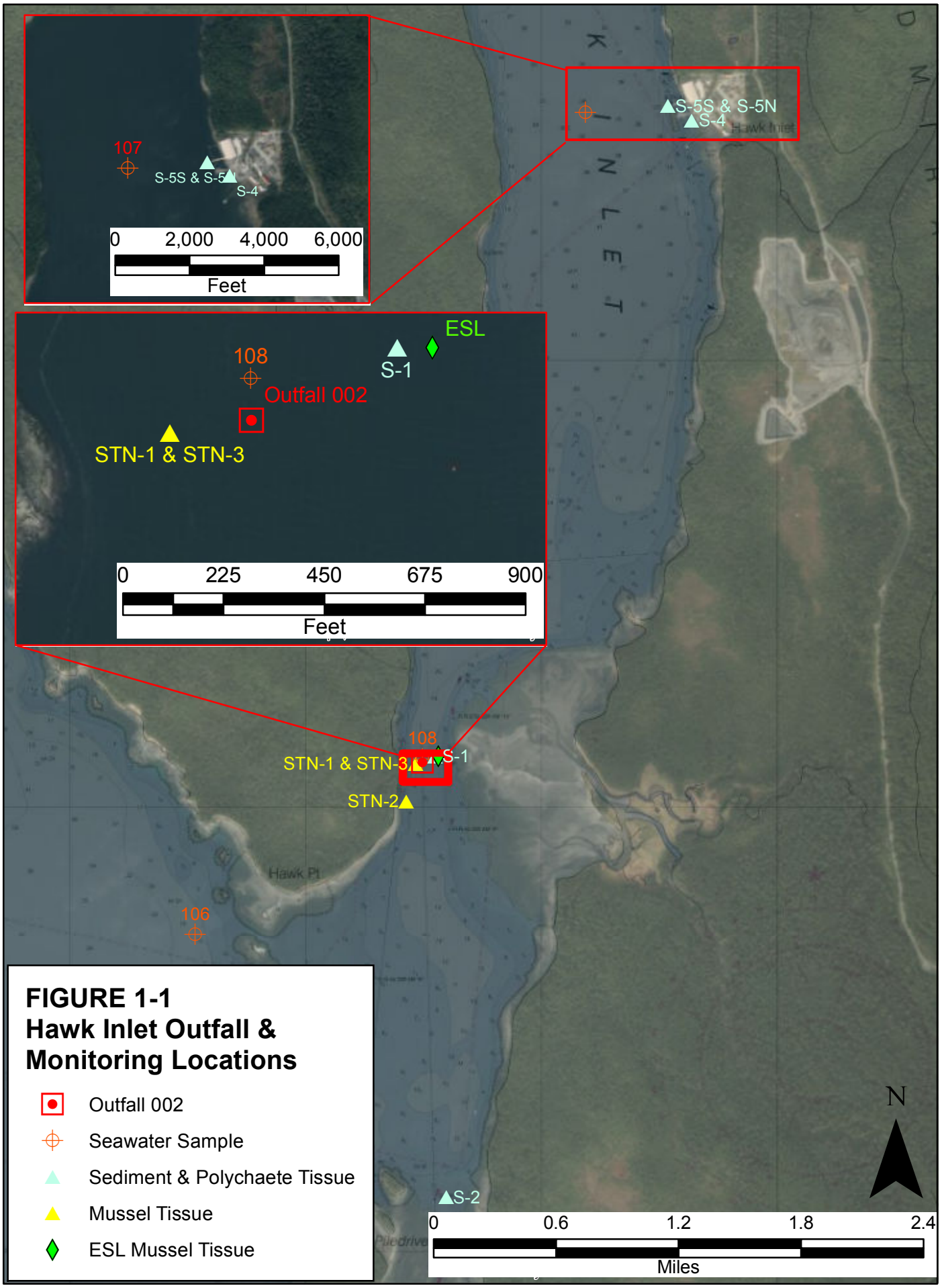


FIGURE 1-1
Hawk Inlet Outfall & Monitoring Locations

- Outfall 002
- Seawater Sample
- Sediment & Polychaete Tissue
- Mussel Tissue
- ESL Mussel Tissue

Figure 2-1a. Site 106 - Field pH

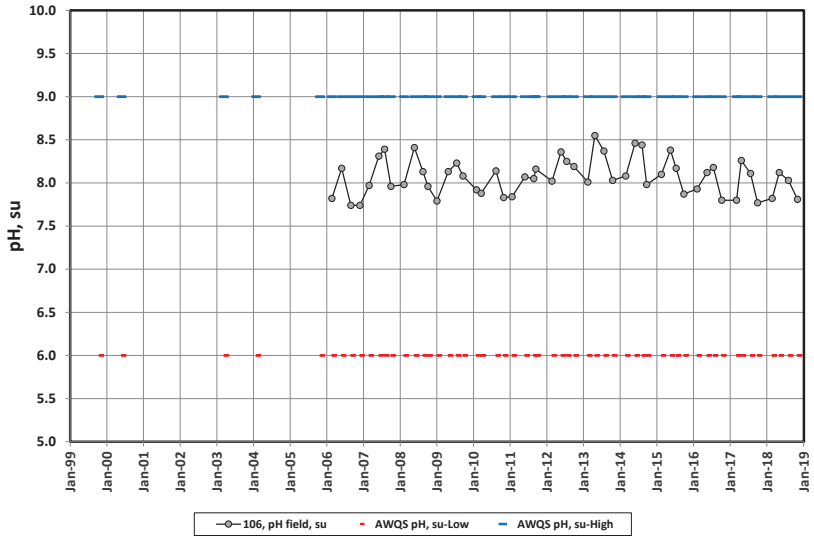


Figure 2-1b. Site 107 - Field pH

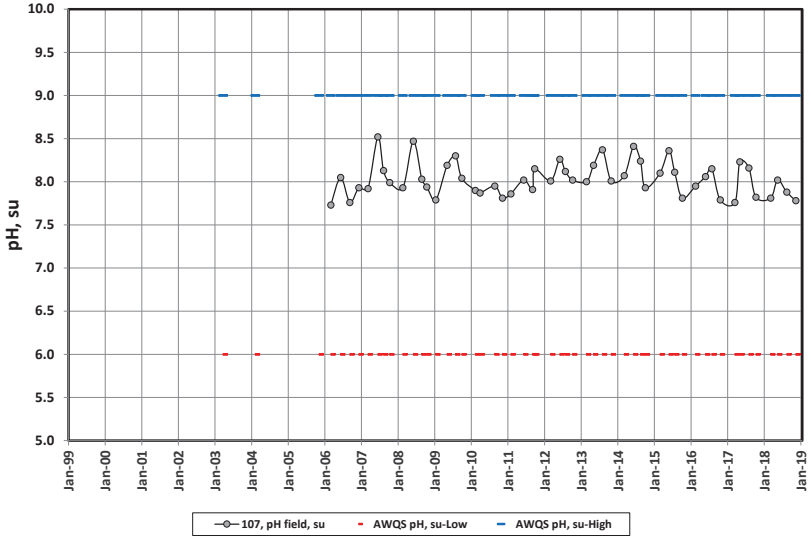


Figure 2-1c. Site 108 - Field pH

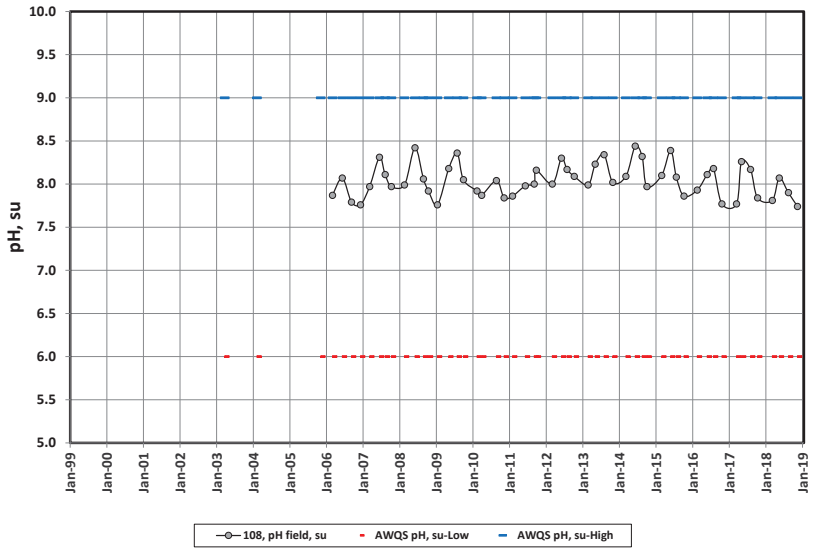


Figure 2-2a. Site 106 - Field Conductivity

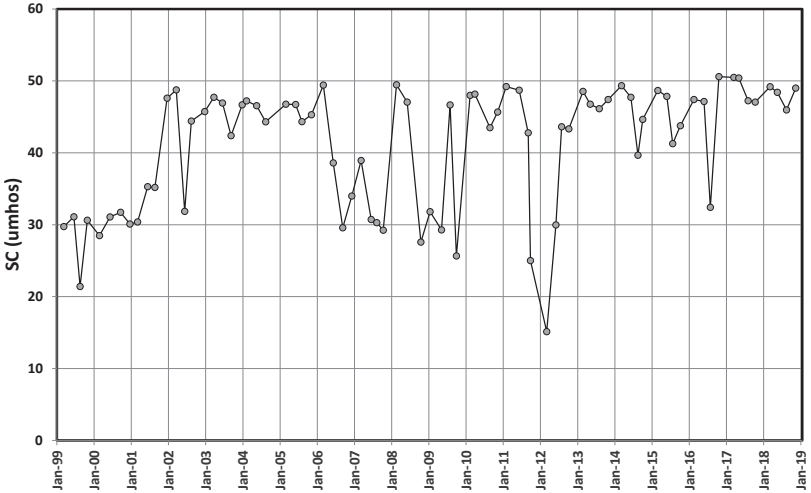


Figure 2-2b. Site 107 - Field Conductivity

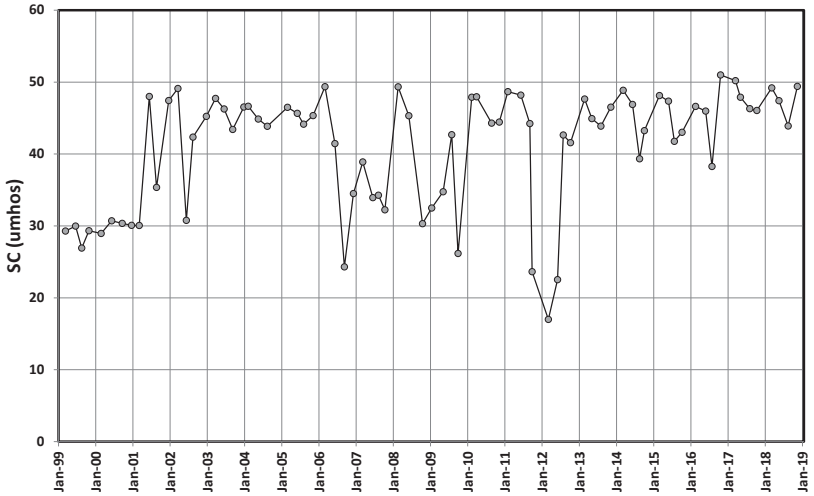


Figure 2-2c. Site 108 - Field Conductivity

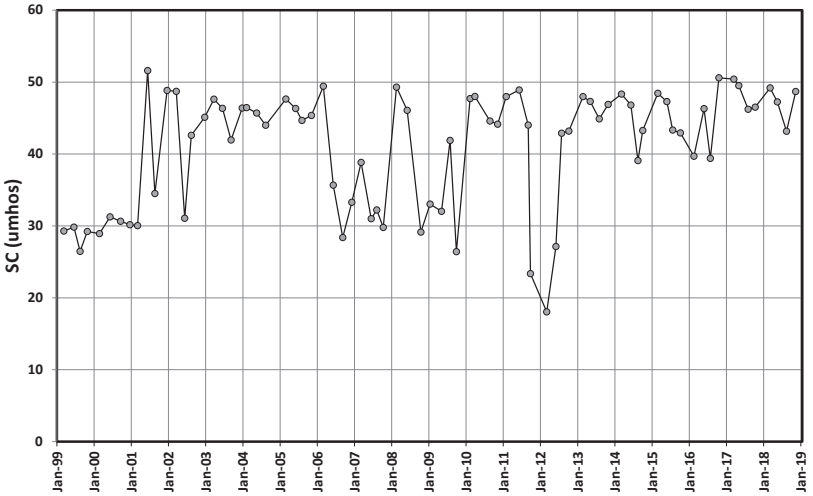
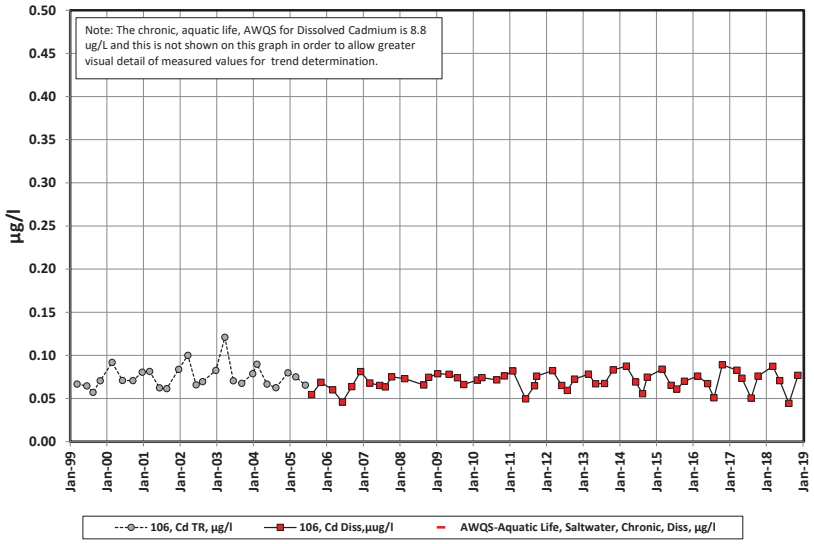


Figure 2-3a. Site 106 - Cadmium



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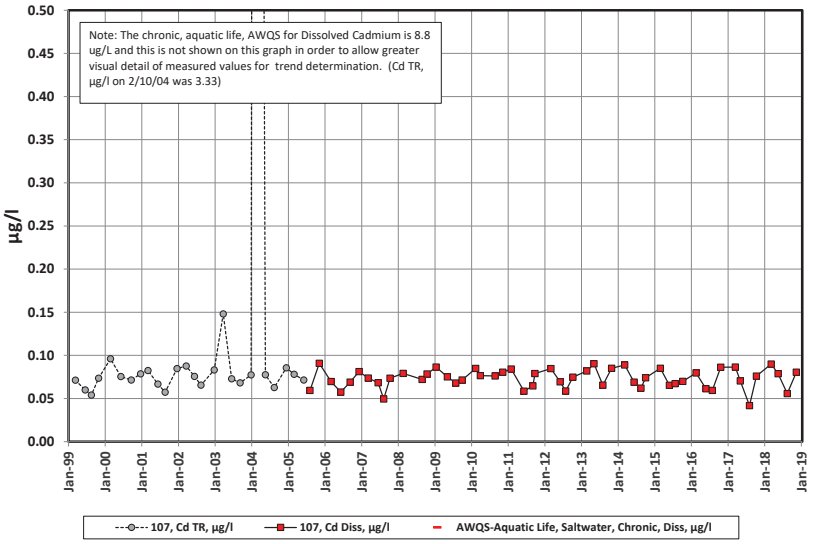

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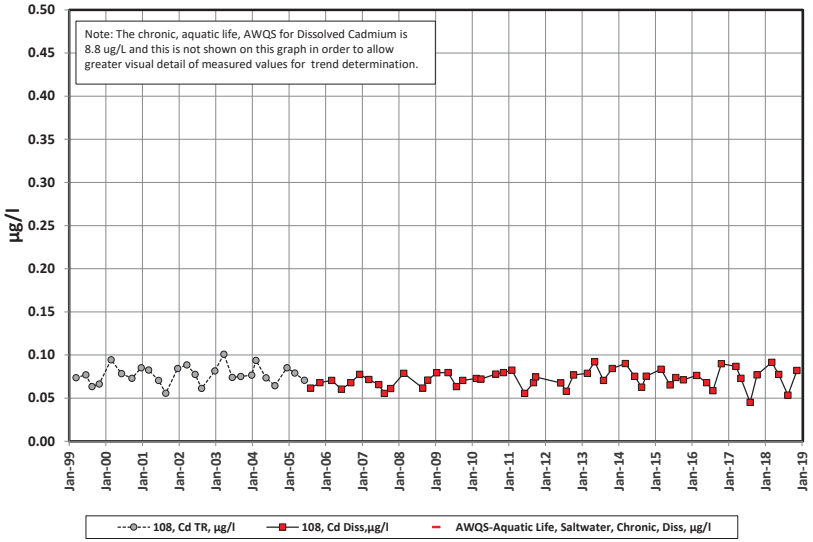
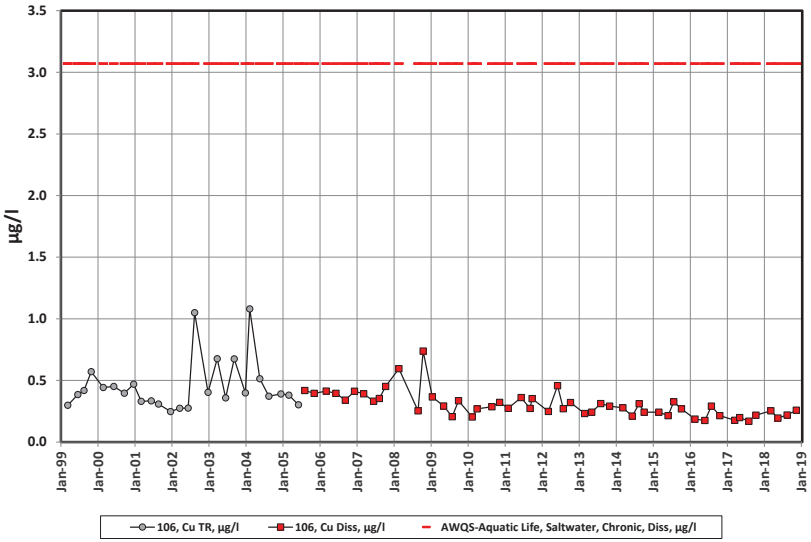


Figure 2-4a. Site 106 - Copper



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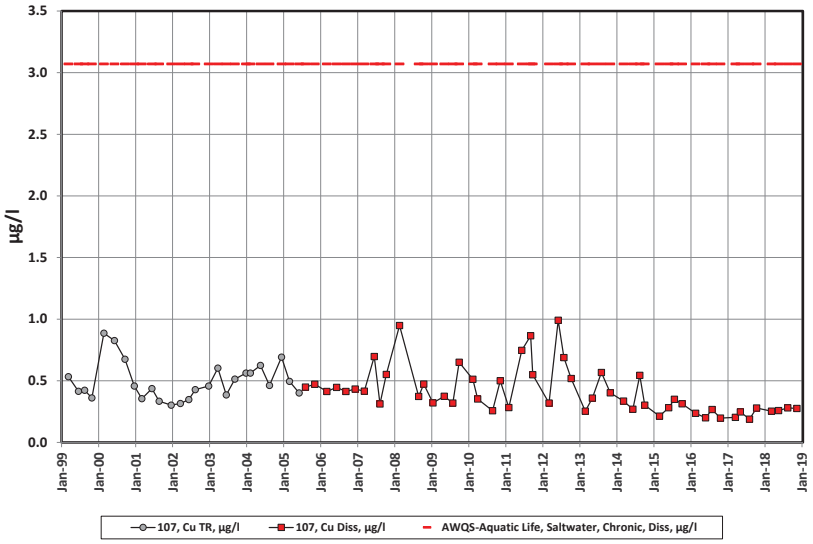


Figure 2-4c. Site 108 - Copper

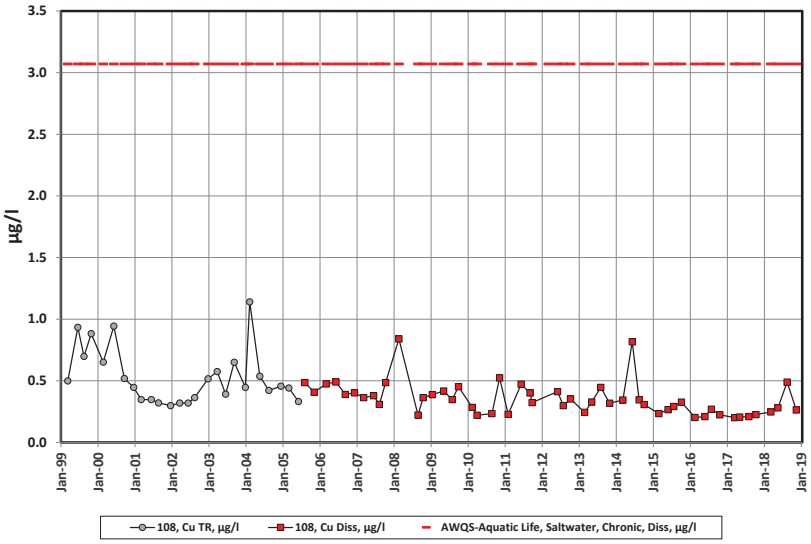


Figure 2-5a. Site 106 - Mercury

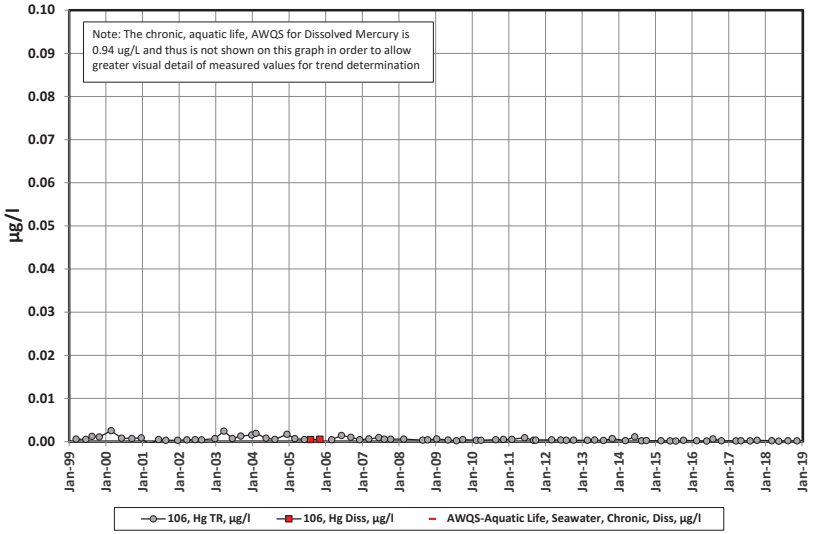
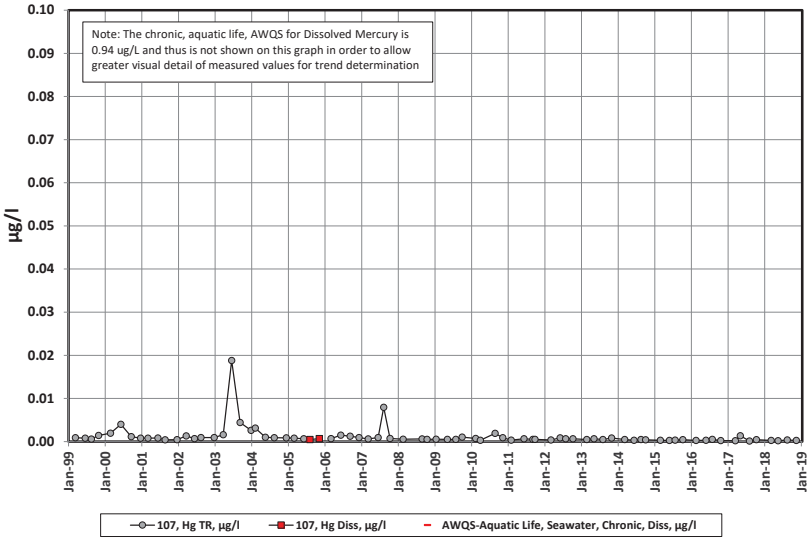


Figure 2-5b. Site 107 - Mercury



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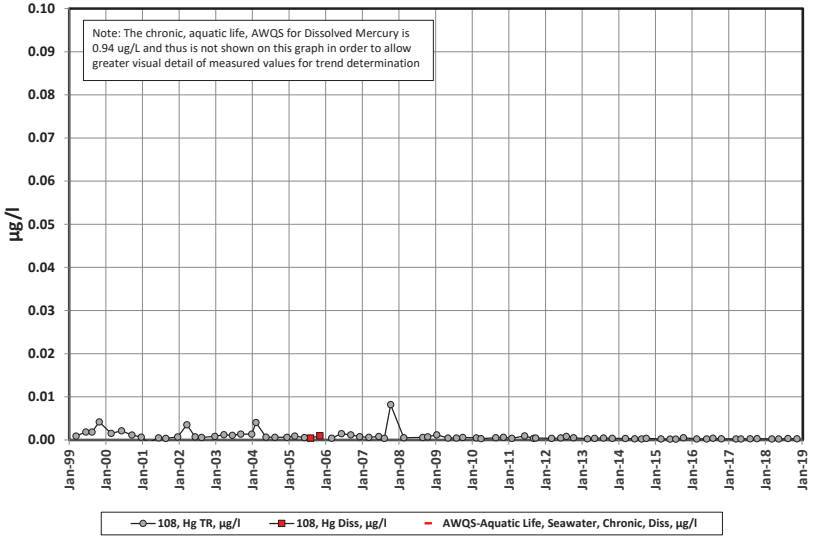


Figure 2-6a. Site 106 - Lead

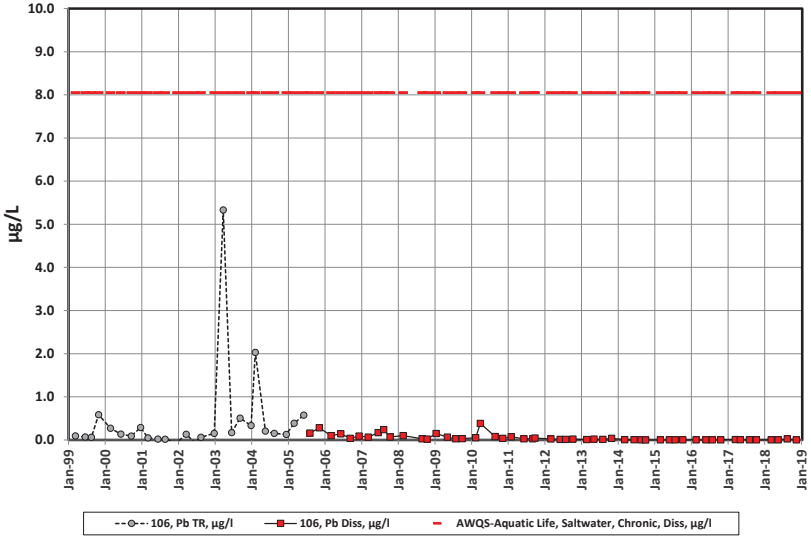
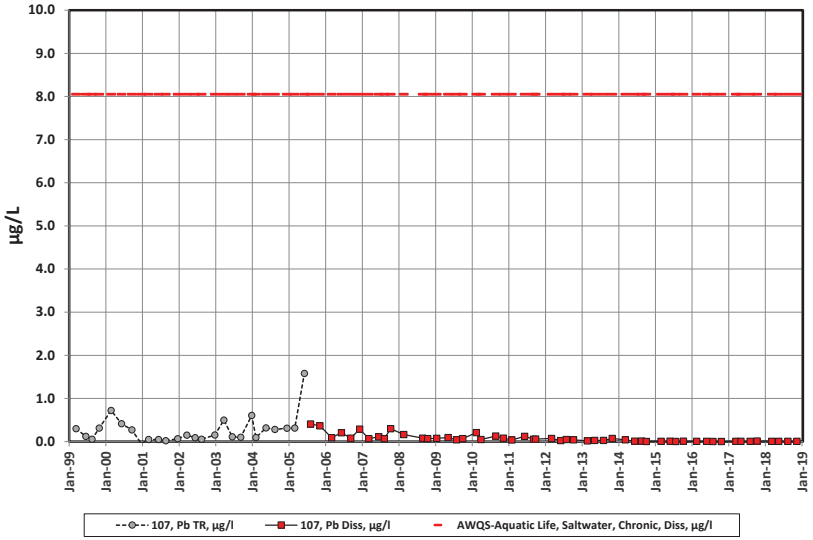


figure 2-6b. Site 107 - Lead



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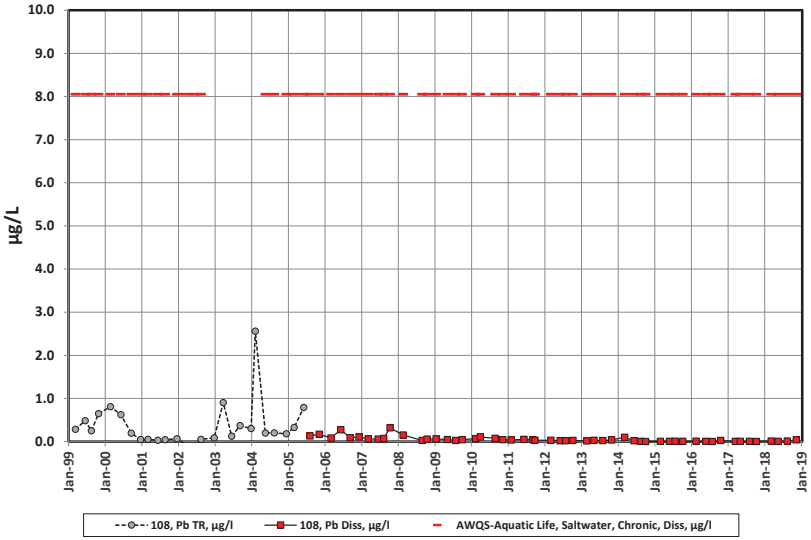


Figure 2-7a. Site 106 - Zinc

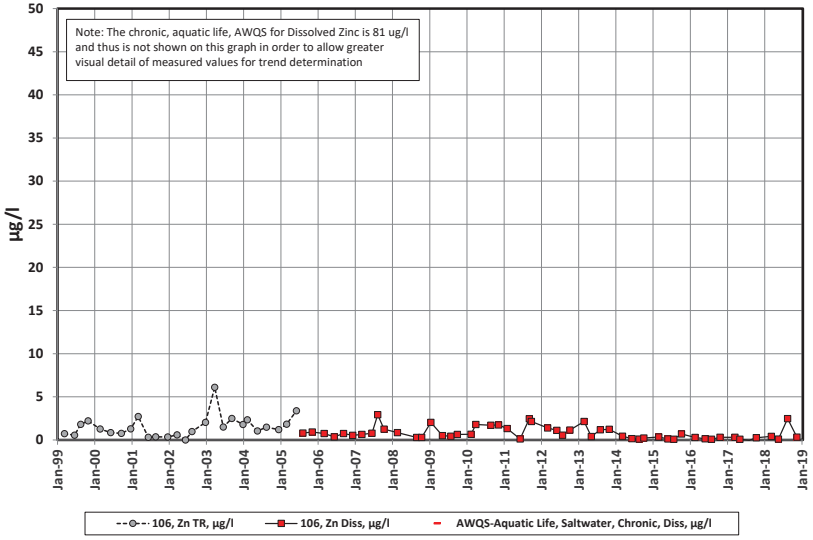


Figure 2-7b. Site 107 - Zinc

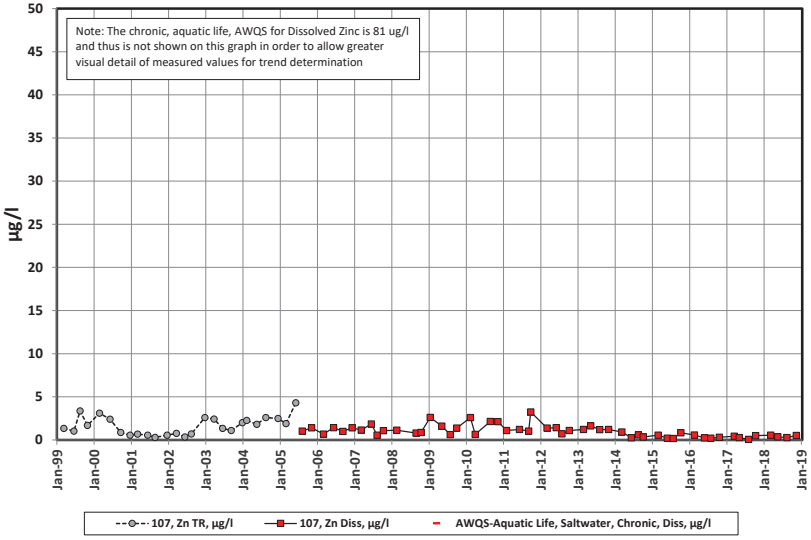


Figure 2-7c. Site 108 - Zinc

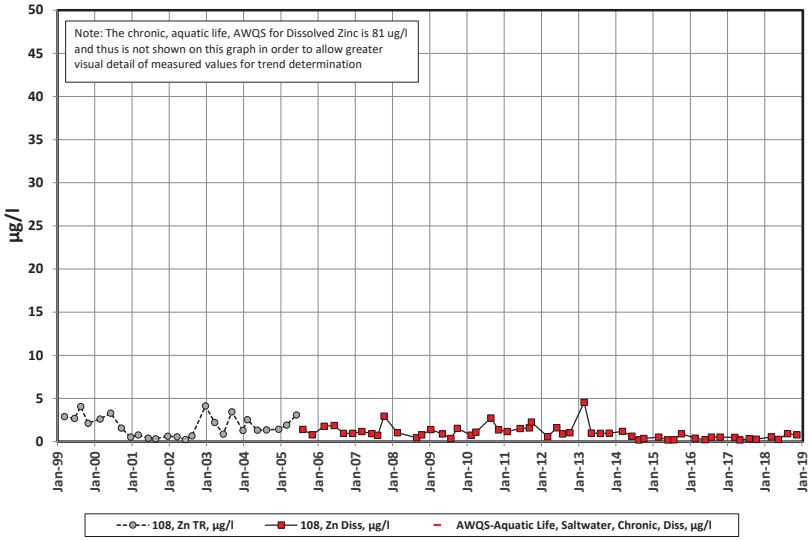


Figure 2-8a. Site 108 and Outfall 002 - Field pH

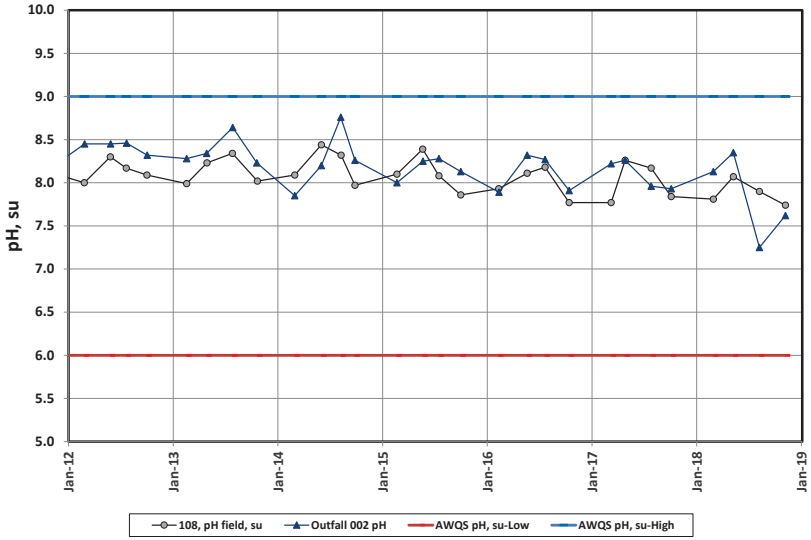


Figure 2-8b. Site 108 and Outfall 002 - Cadmium

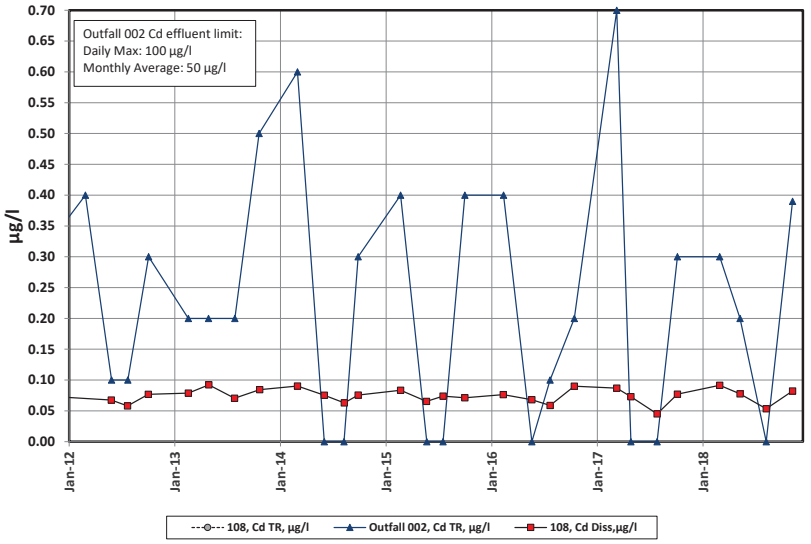


Figure 2-8c. Site 108 and Outfall 002 - Copper

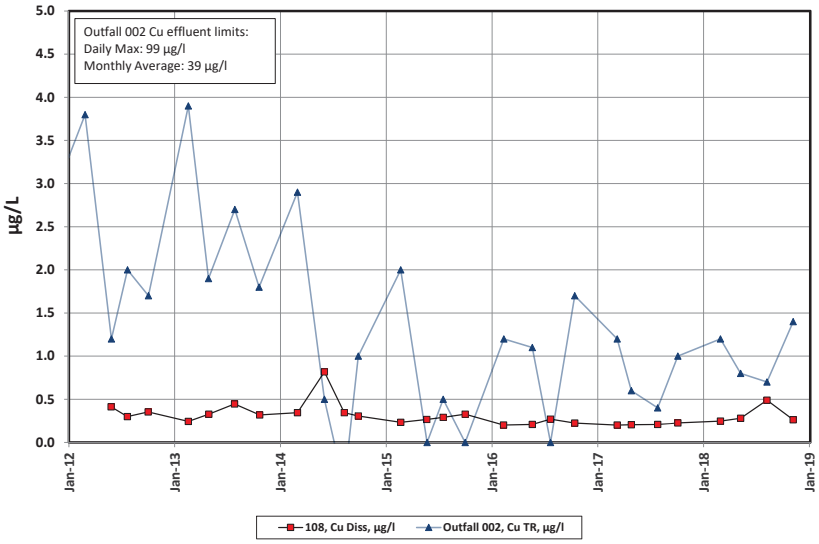


Figure 2-8d. Site 108 and Outfall 002 - Mercury

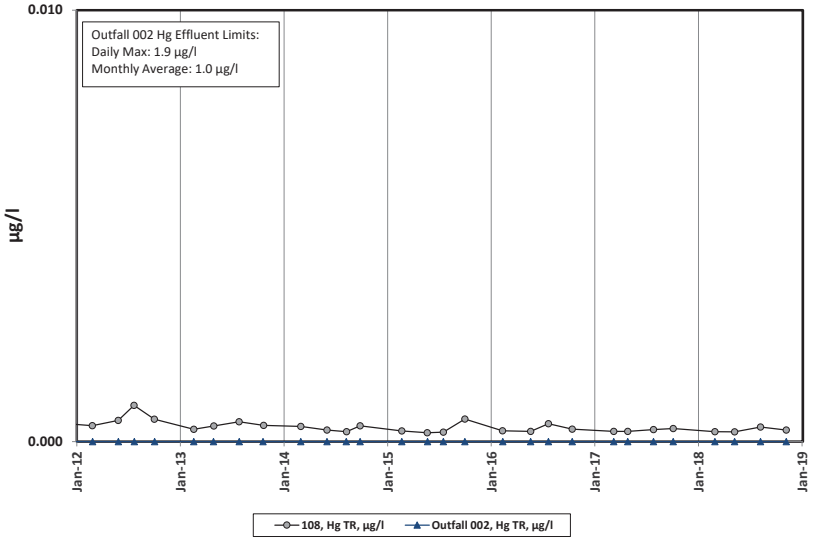


Figure 2-8e. Site 108 and Outfall 002 - Lead

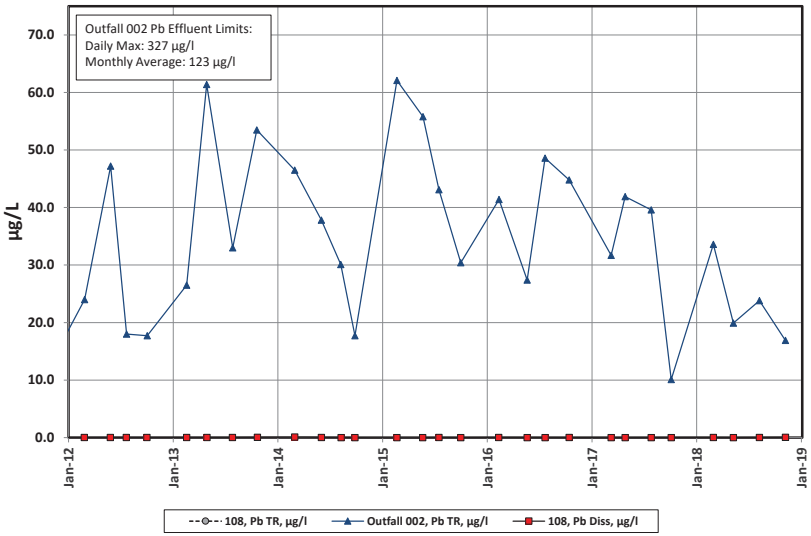


Figure 2-8f. Site 108 and Outfall 002 - Zinc

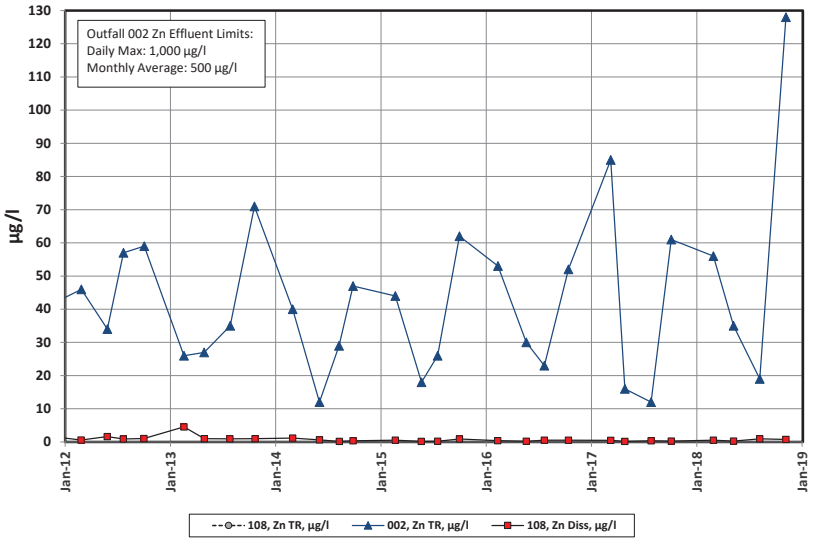


Figure 3-1. Cadmium in Sediment at Site S-1

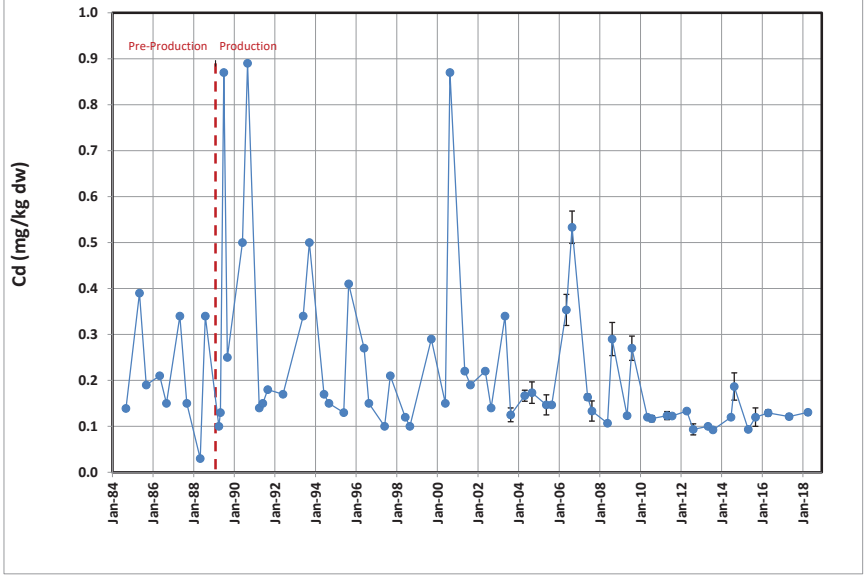


Figure 3-2. Copper in Sediment at Site S-1

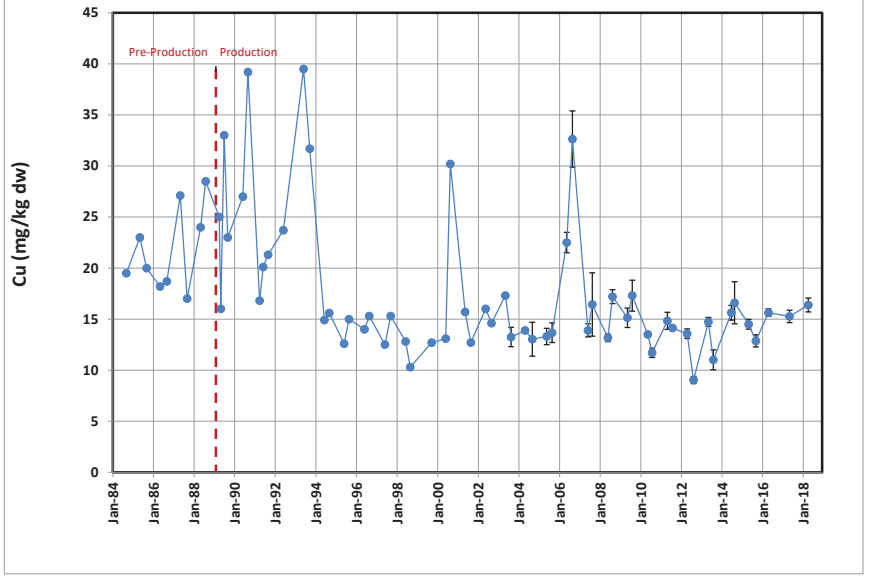


Figure 3-3. Lead in Sediment at Site S-1

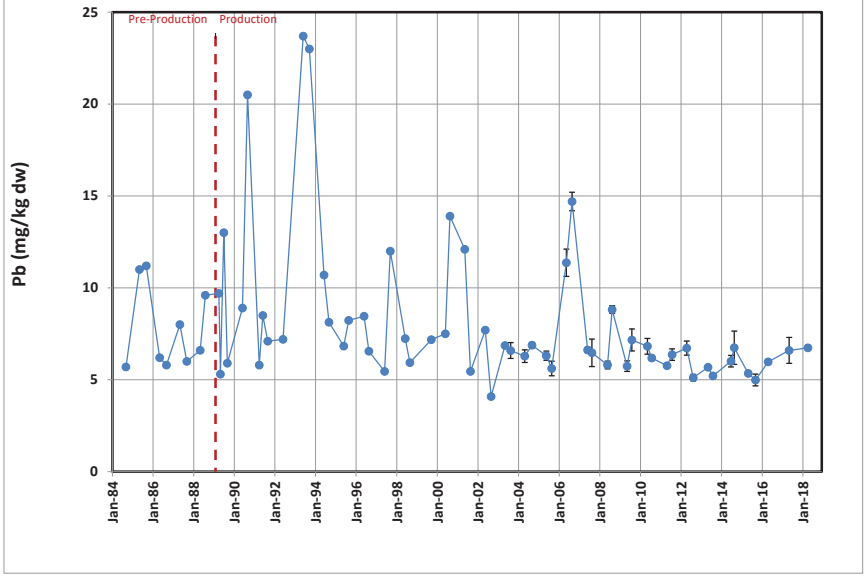


Figure 3-4. Mercury in Sediment at Site S-1

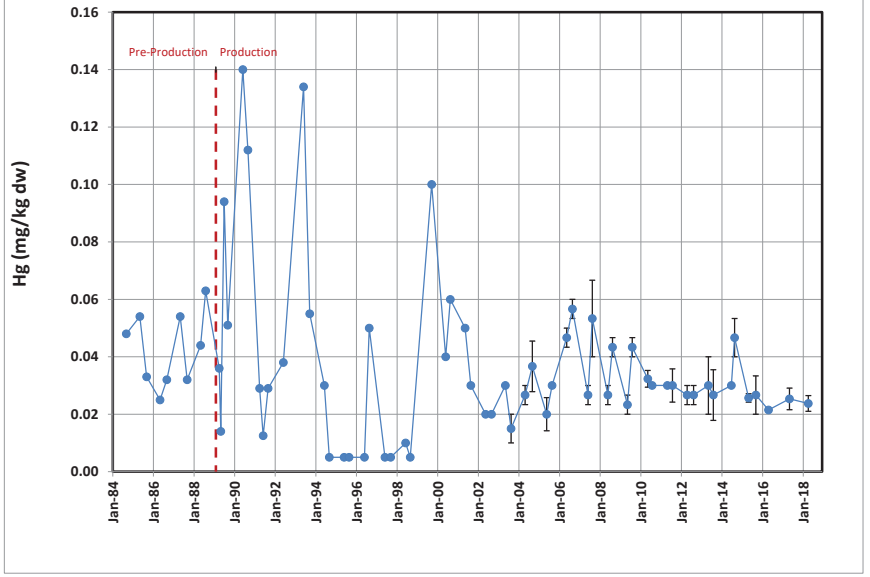


Figure 3-5. Zinc in Sediment at Site S-1

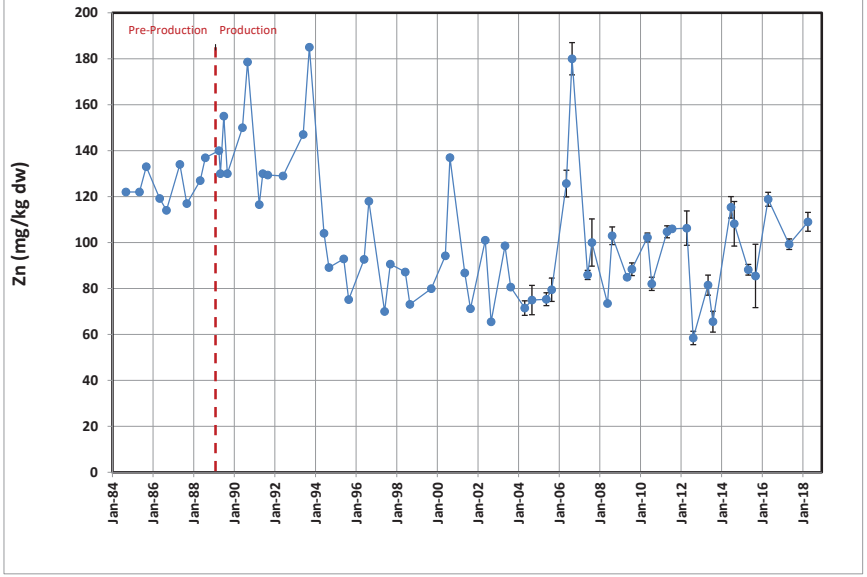


Figure 3-6. Cadmium in Sediment at Site S-2

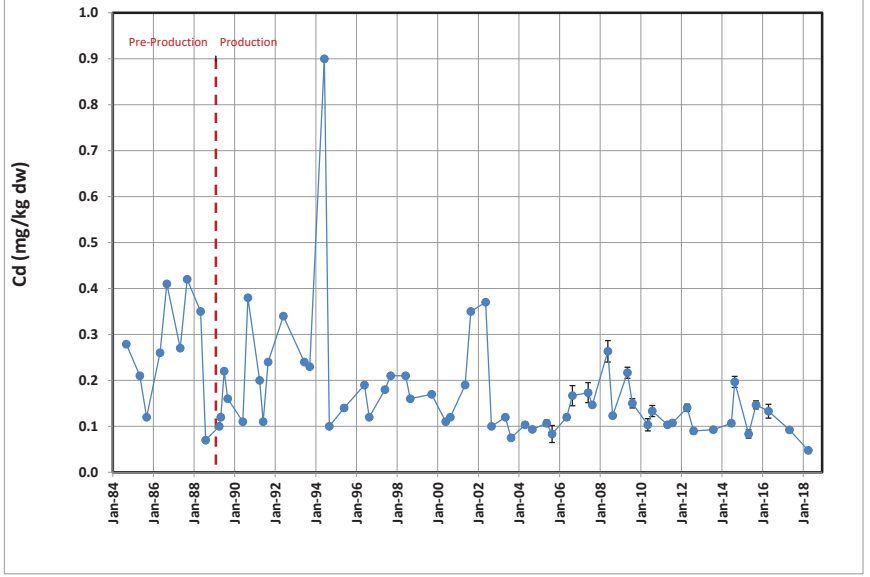


Figure 3-7. Copper in Sediment at Site S-2

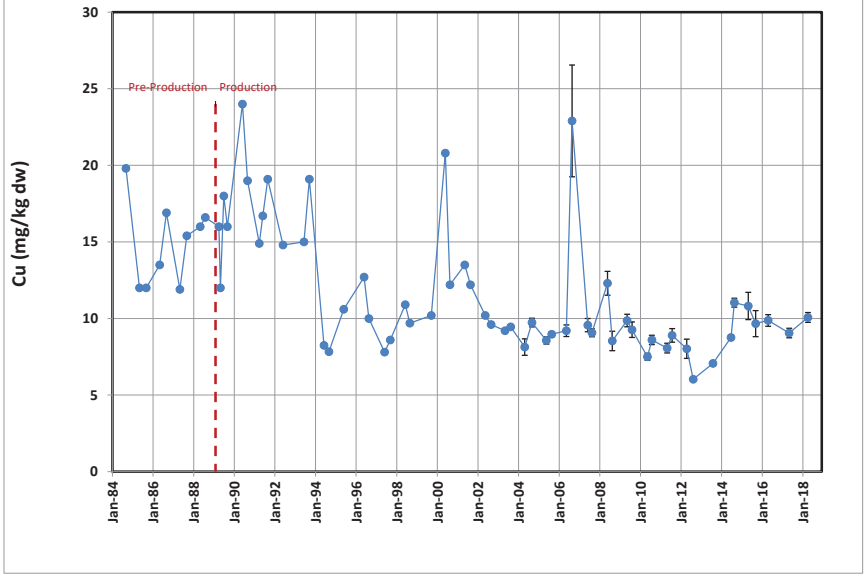


Figure 3-8. Lead in Sediment at Site S-2

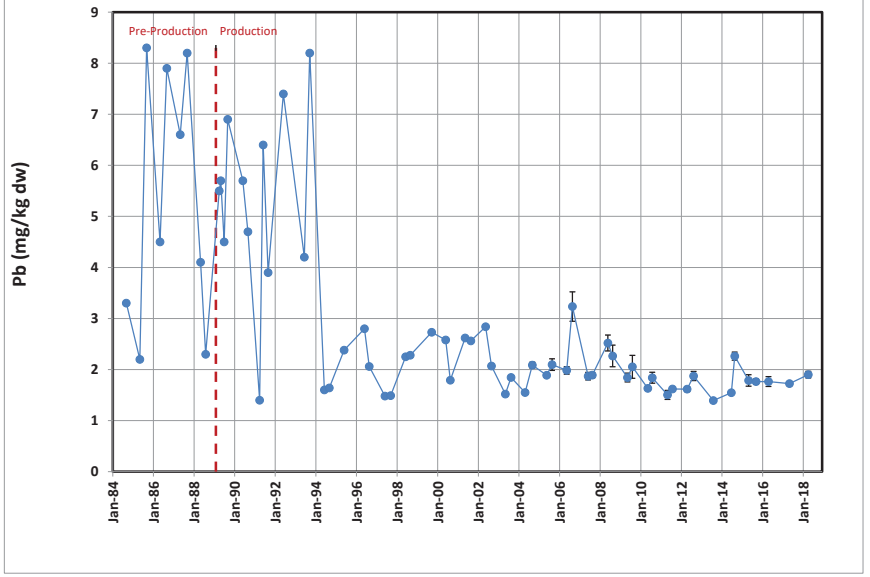


Figure 3-9. Mercury in Sediment at Site S-2

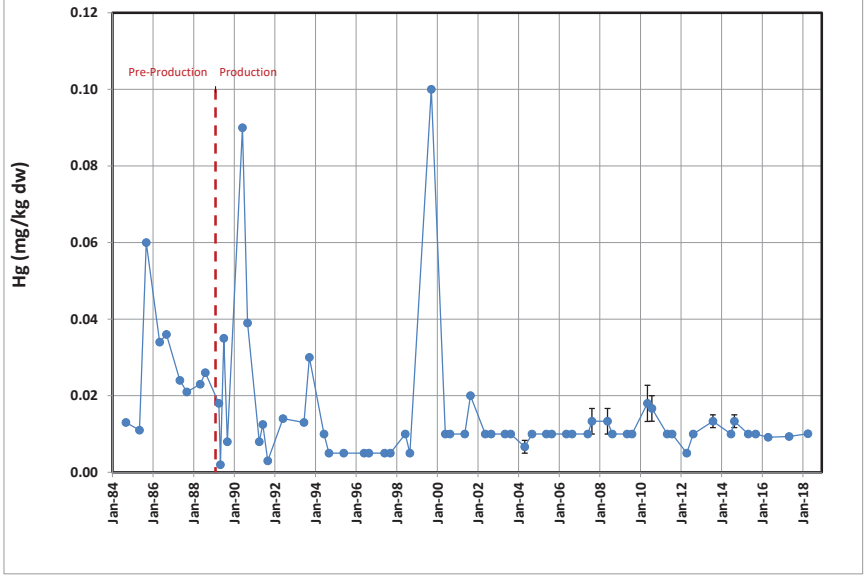


Figure 3-10. Zinc in Sediment at Site S-2

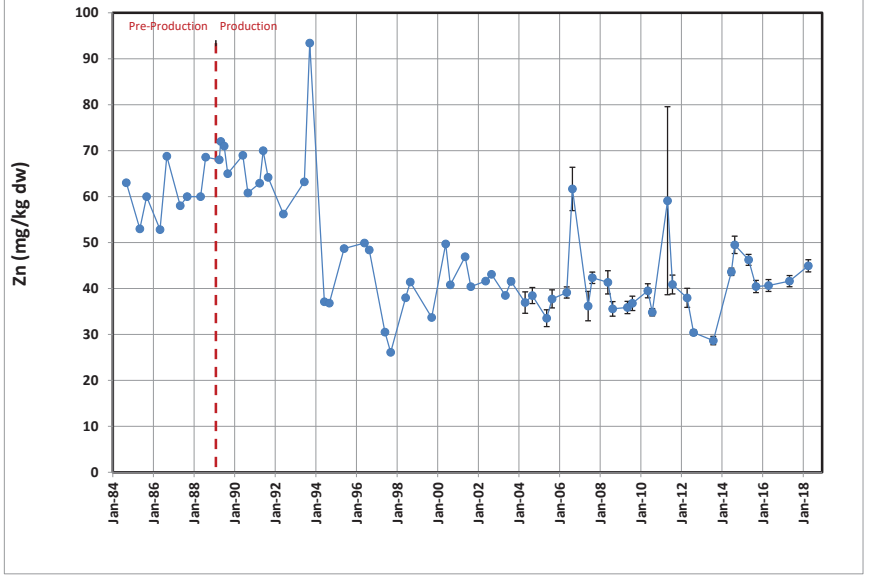


Figure 3-11. Cadmium in Sediment at Site S-4

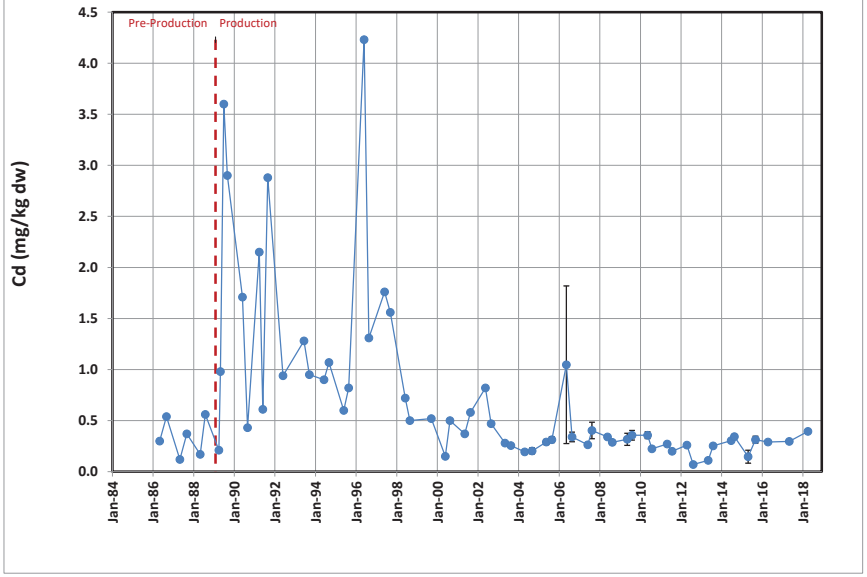


Figure 3-12. Copper in Sediment at Site S-4

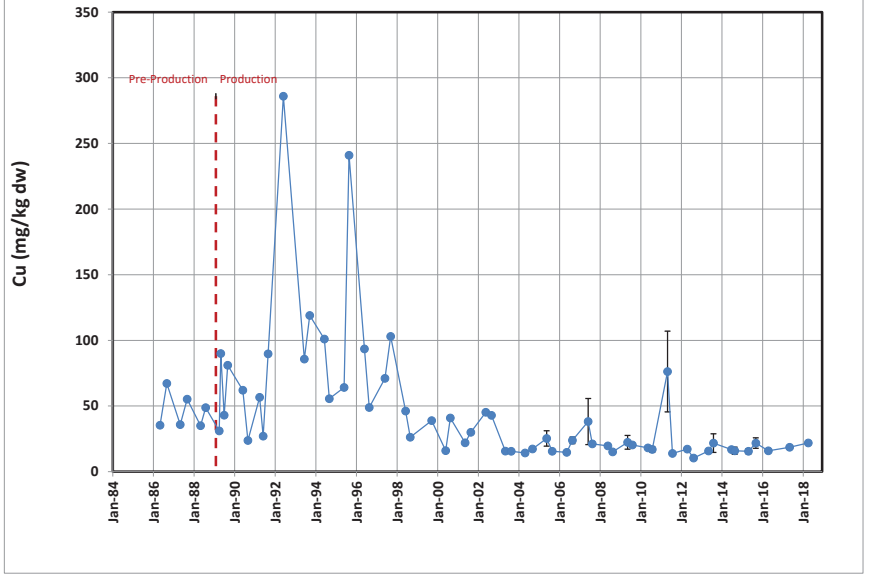


Figure 3-13. Lead in Sediment at Site S-4

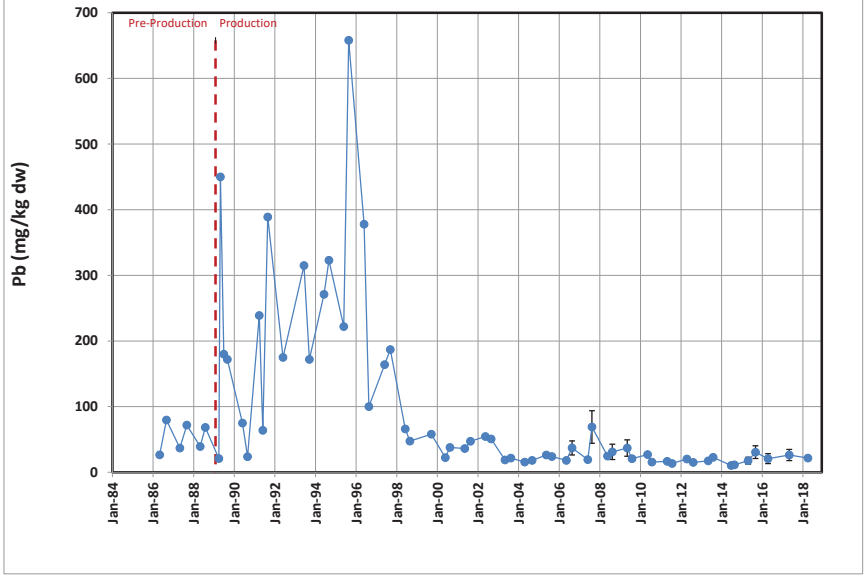


Figure 3-14. Mercury in Sediment at Site S-4

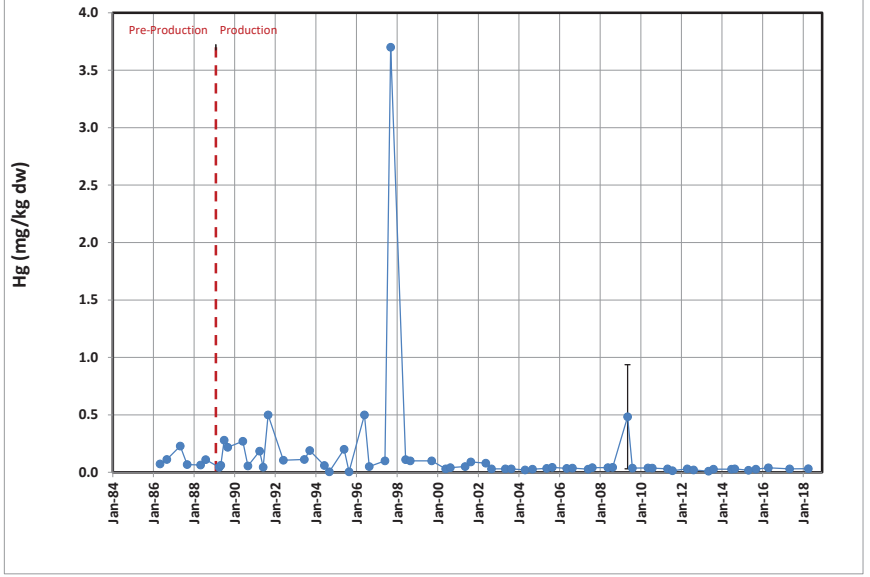


Figure 3-15. Zinc in Sediment at Site S-4

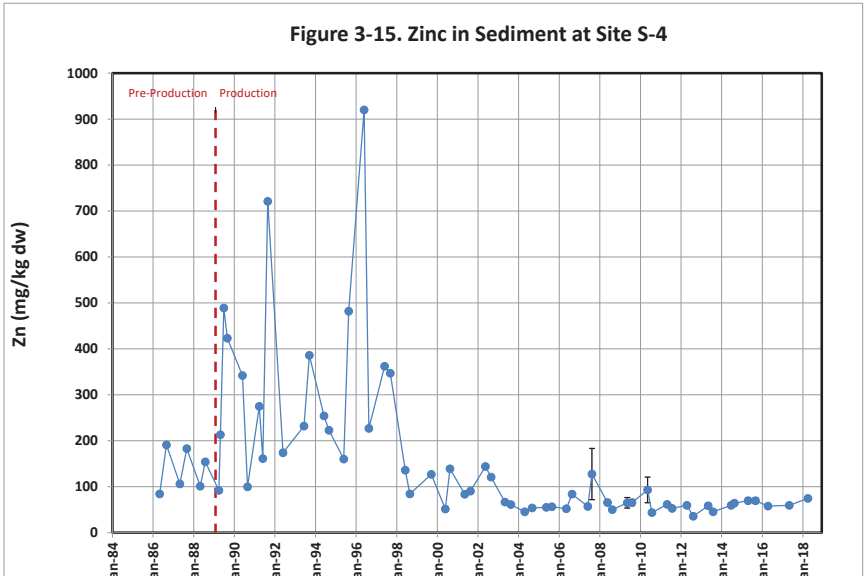


Figure 3-16. Cadmium in Sediment at Site S-5N

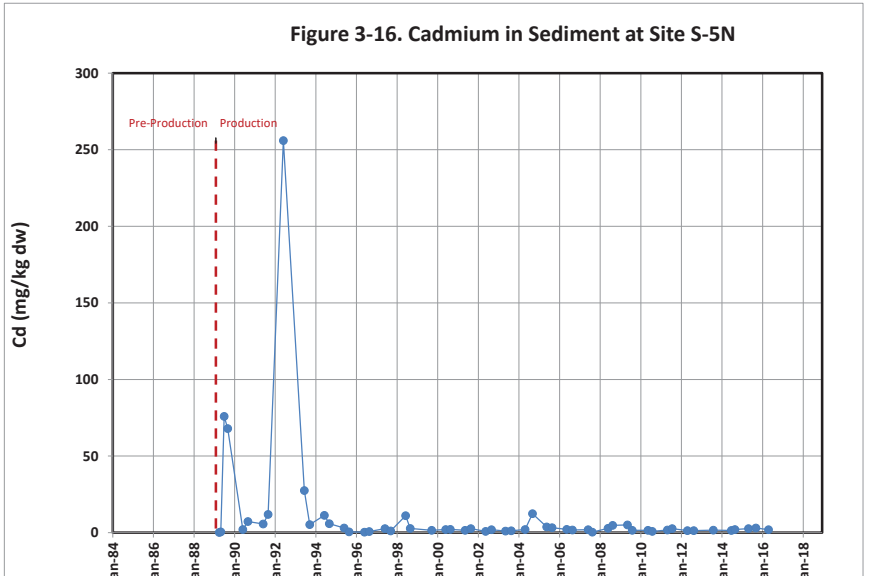


Figure 3-17. Copper in Sediment at Site S-5N

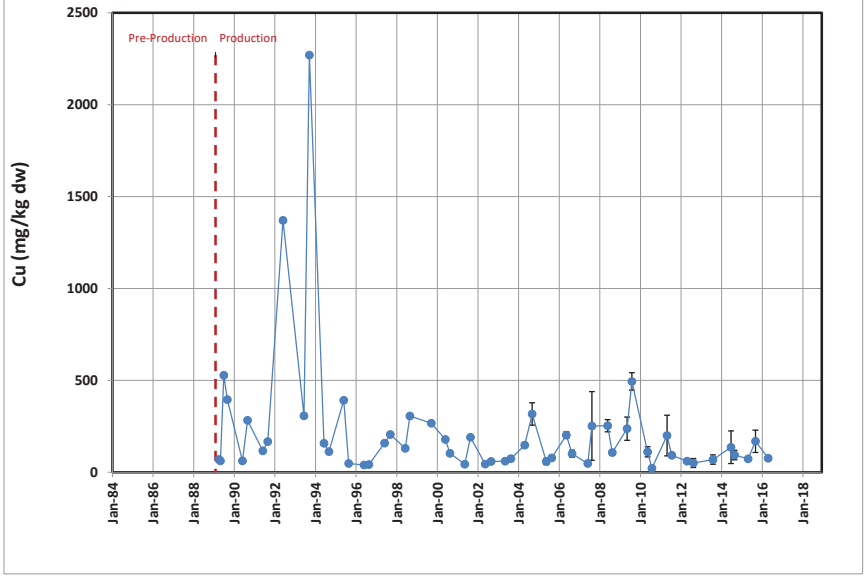


Figure 3-18. Lead in Sediment at Site S-5N

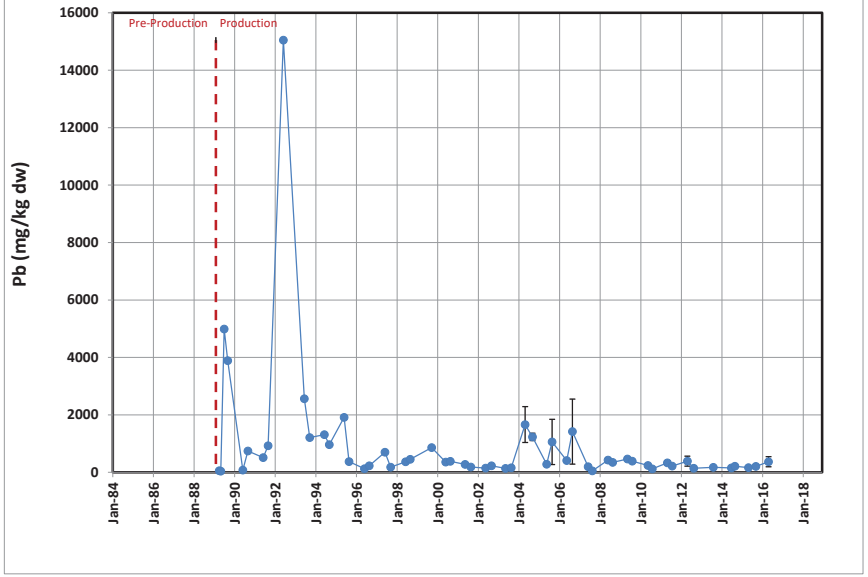


Figure 3-19. Mercury in Sediment at Site S-5N

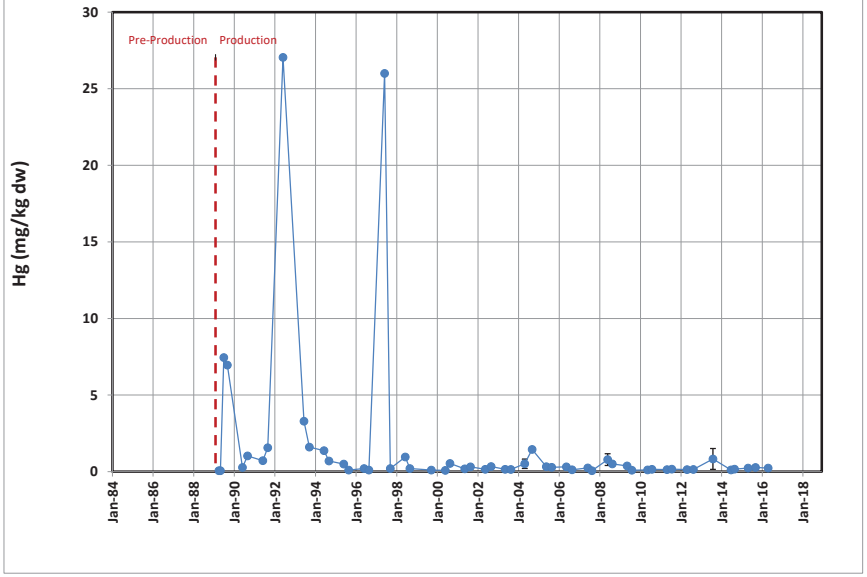


Figure 3-20. Zinc in Sediment at Site S-5N

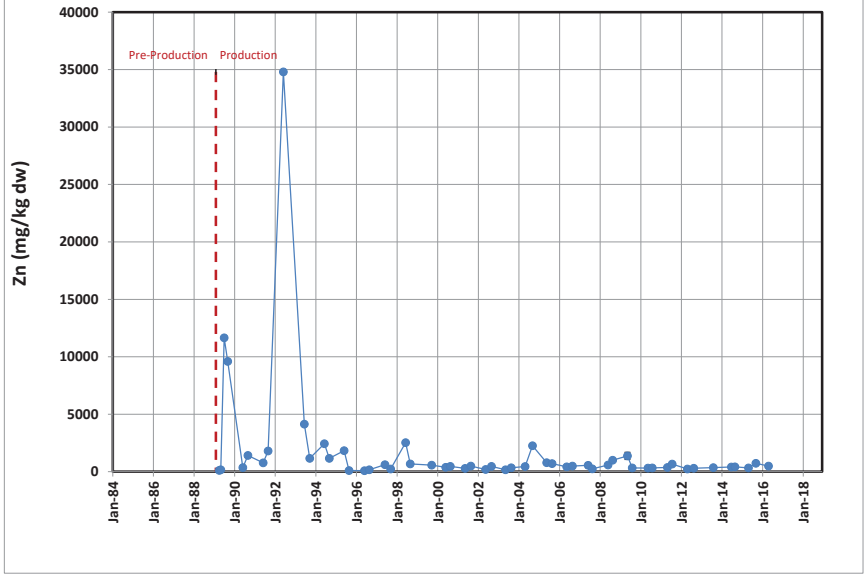


Figure 3-21. Cadmium in Sediment at Site S-5S

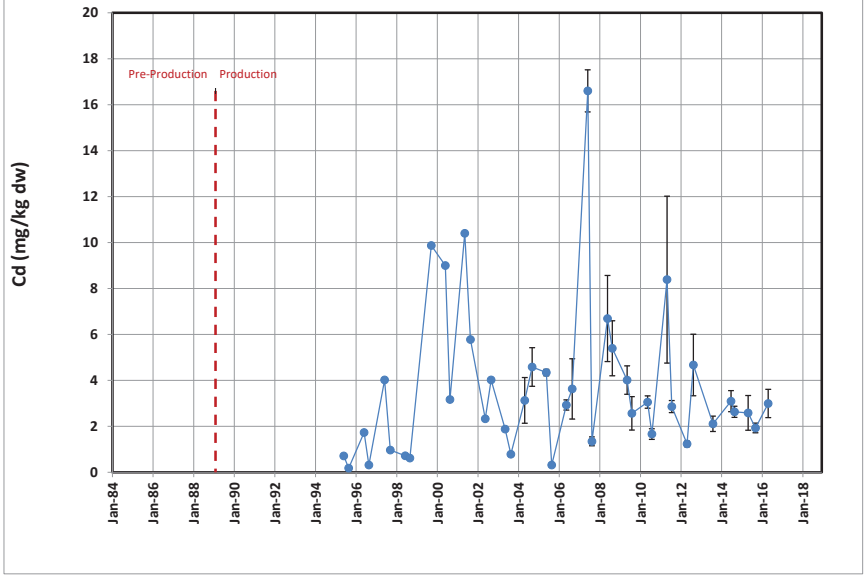


Figure 3-22. Copper in Sediment at Site S-5S

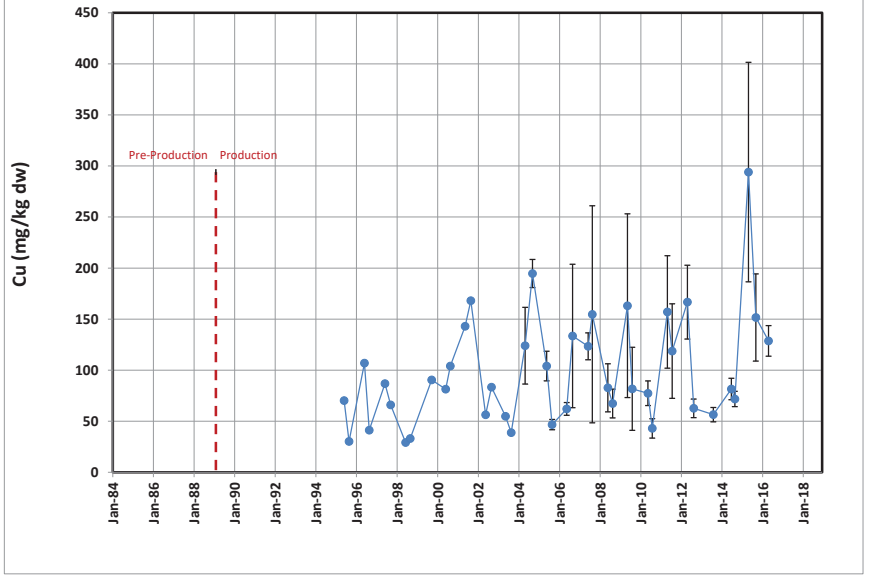


Figure 3-23. Lead in Sediment at Site S-5S

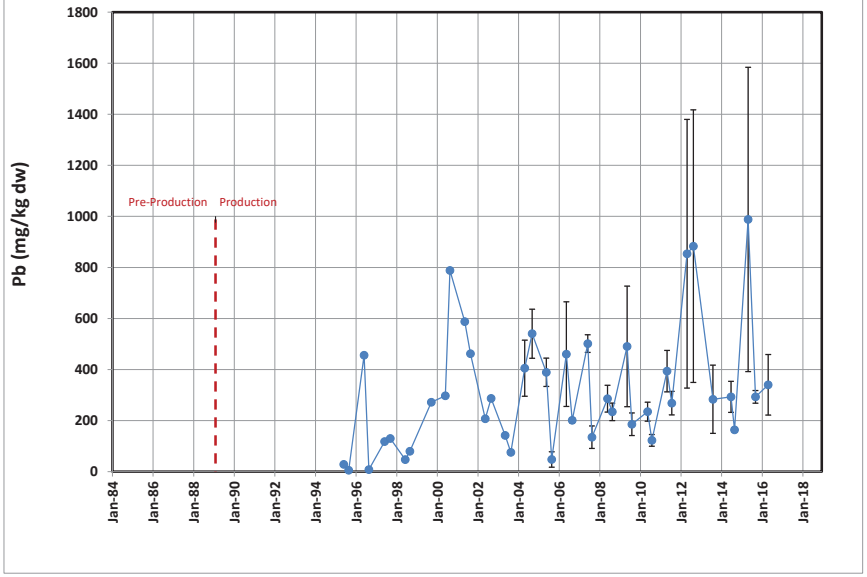


Figure 3-24. Mercury in Sediment at Site S-5S

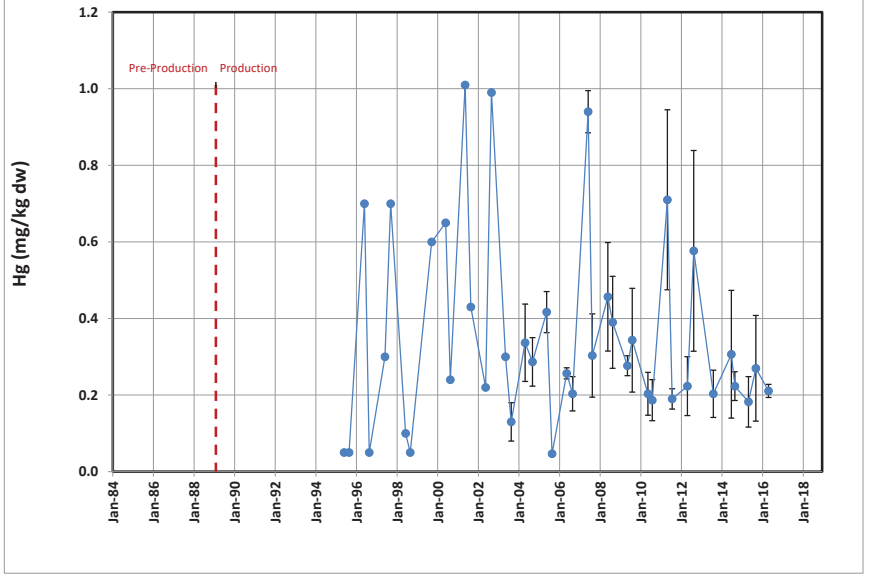


Figure 3-25. Zinc in Sediment at Site S-5S

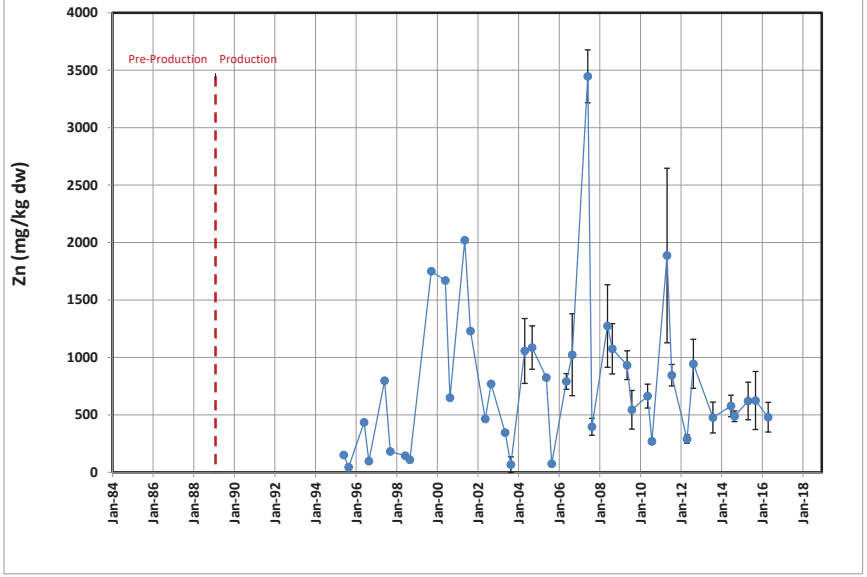


Figure 4-1. Cadmium in Mussels at Site STN-1

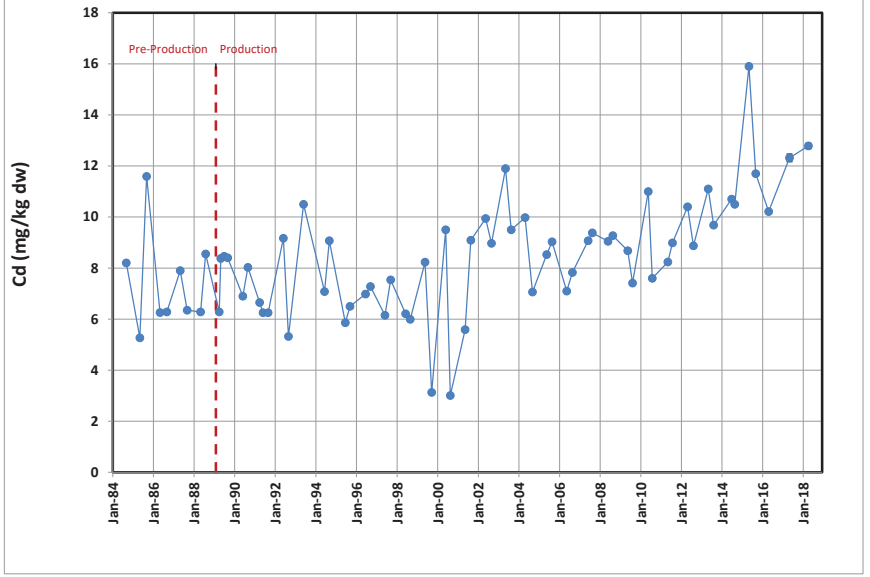


Figure 4-2. Copper in Mussels at Site STN-1

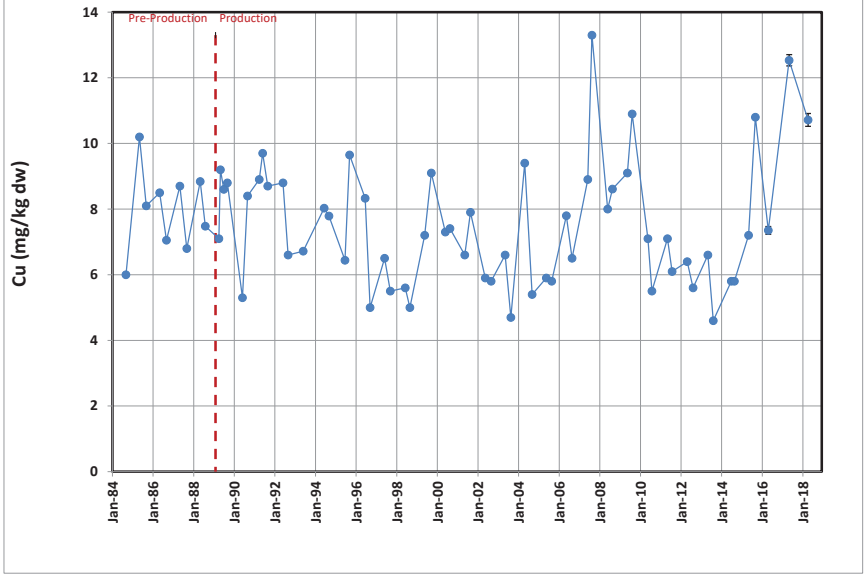


Figure 4-3. Lead in Mussels at Site STN-1

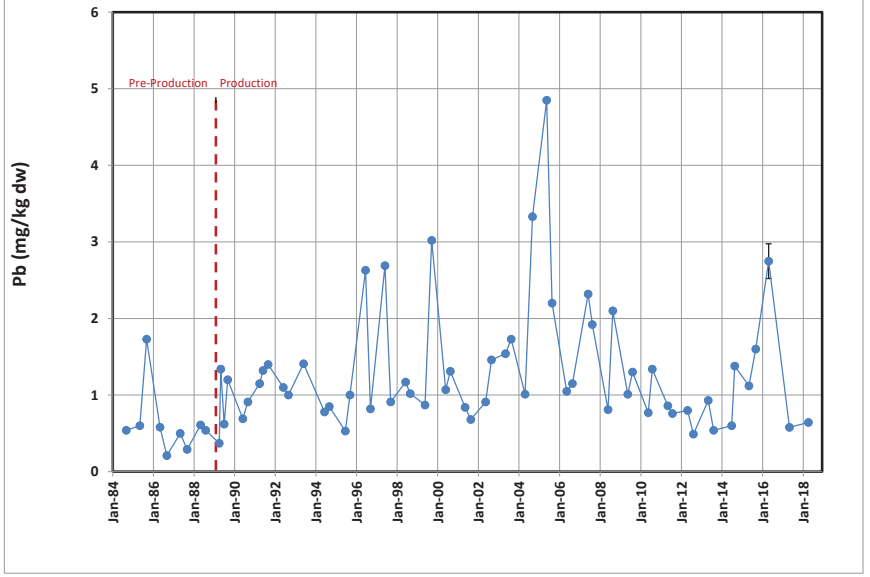


Figure 4-4. Mercury in Mussels at Site STN-1

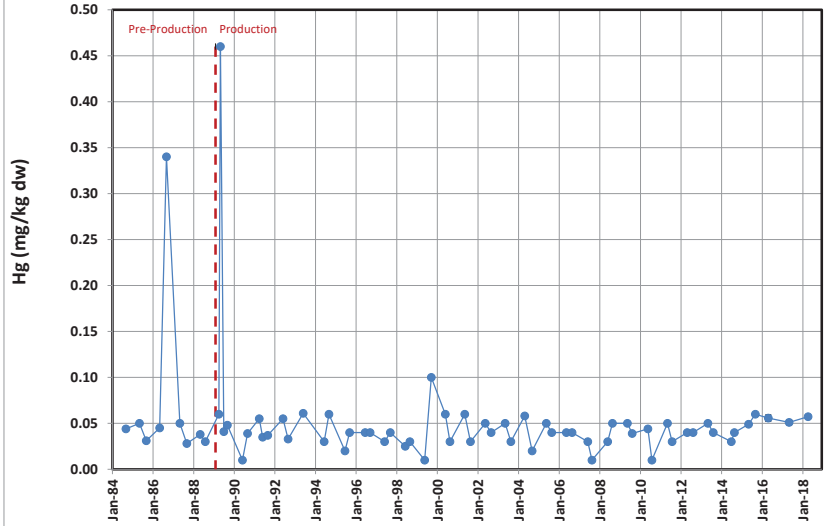


Figure 4-5. Zinc in Mussels at Site STN-1

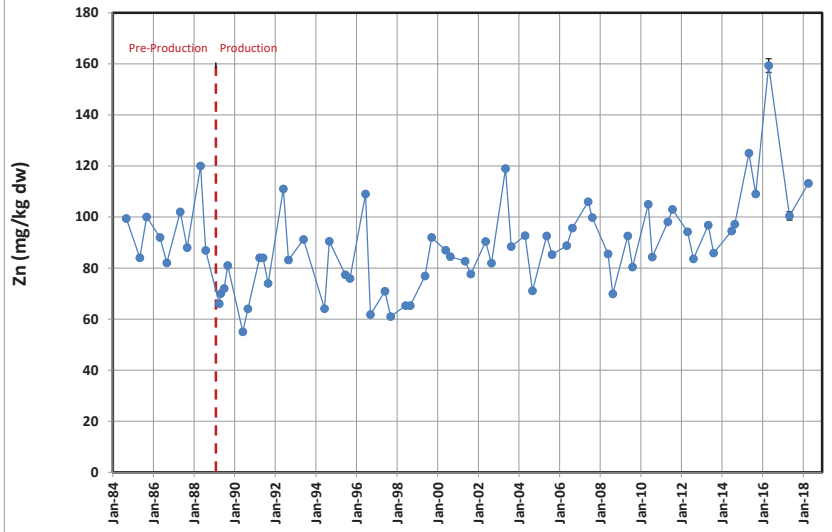


Figure 4-6. Cadmium in Mussels at Site STN-2

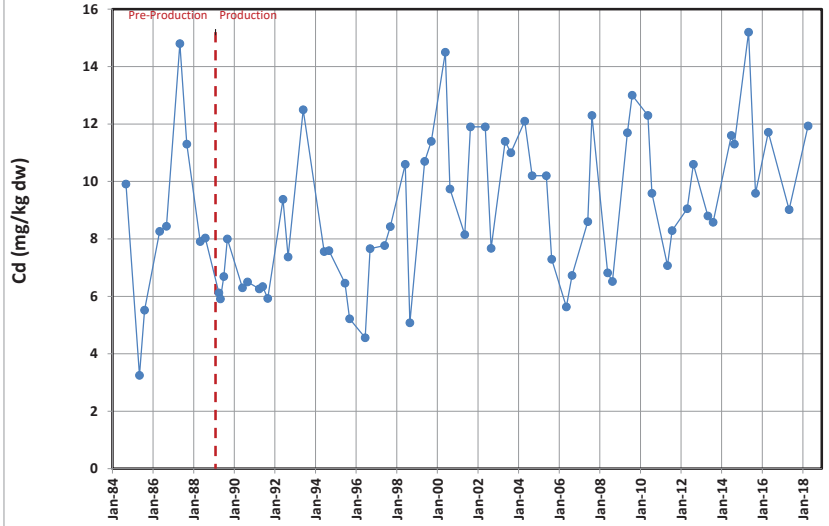


Figure 4-7. Copper in Mussels at Site STN-2

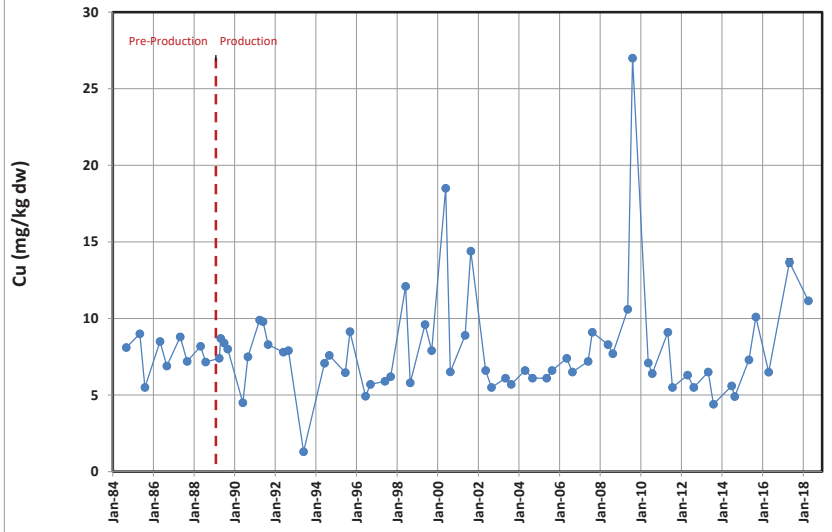


Figure 4-8. Lead in Mussels at Site STN-2

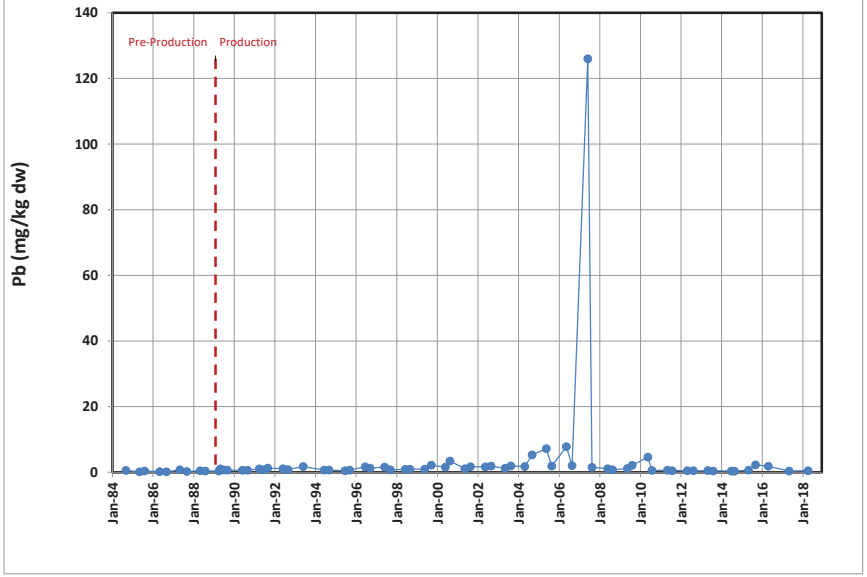


Figure 4-9. Mercury in Mussels at Site STN-2

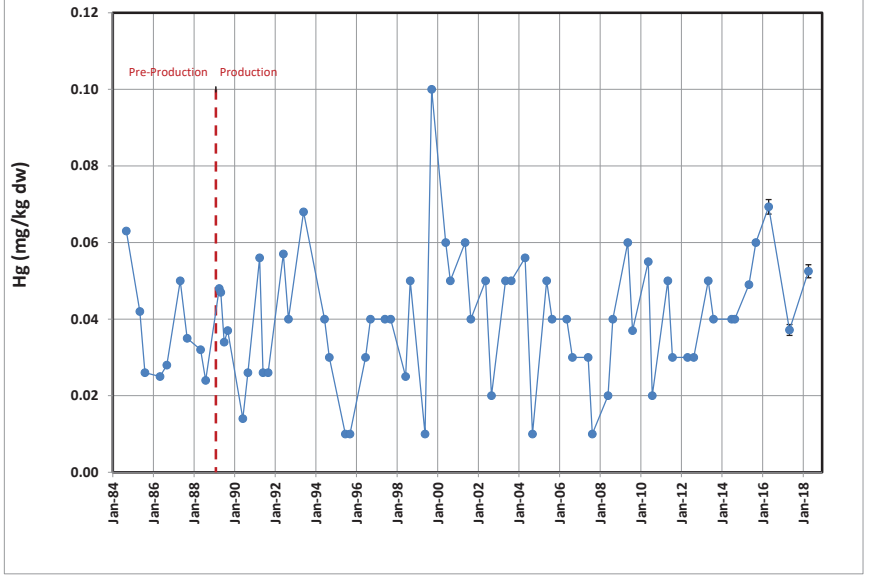


Figure 4-10. Zinc in Mussels at Site STN-2

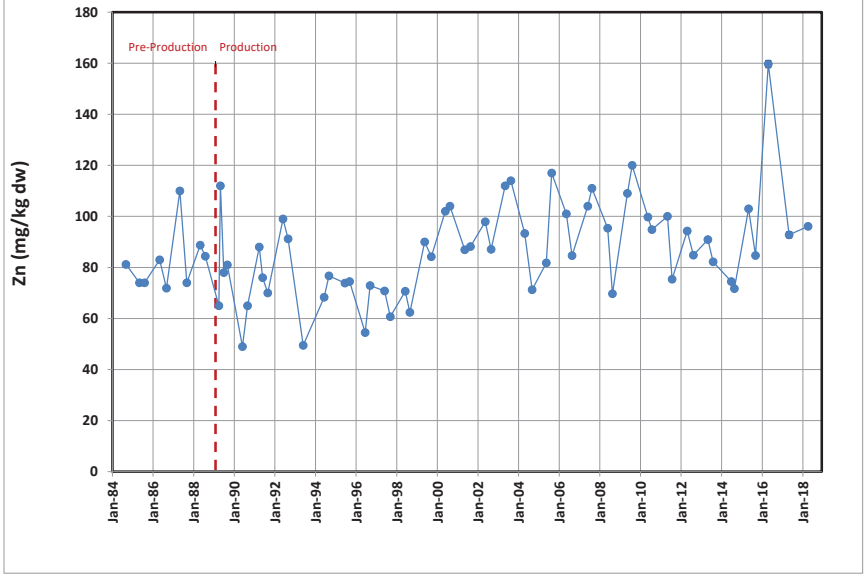


Figure 4-11. Cadmium in Mussels at Site STN-3

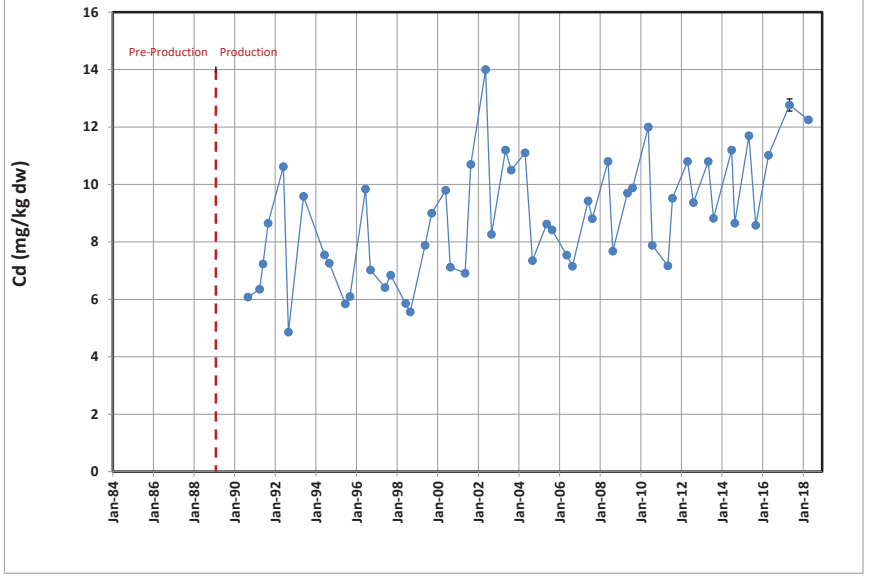


Figure 4-12. Copper in Mussels at Site STN-3

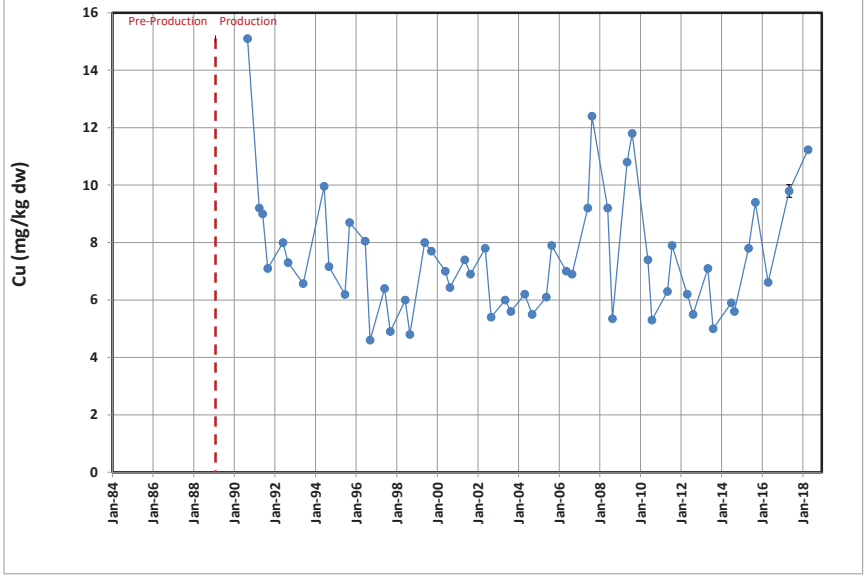


Figure 4-13. Lead in Mussels at Site STN-3

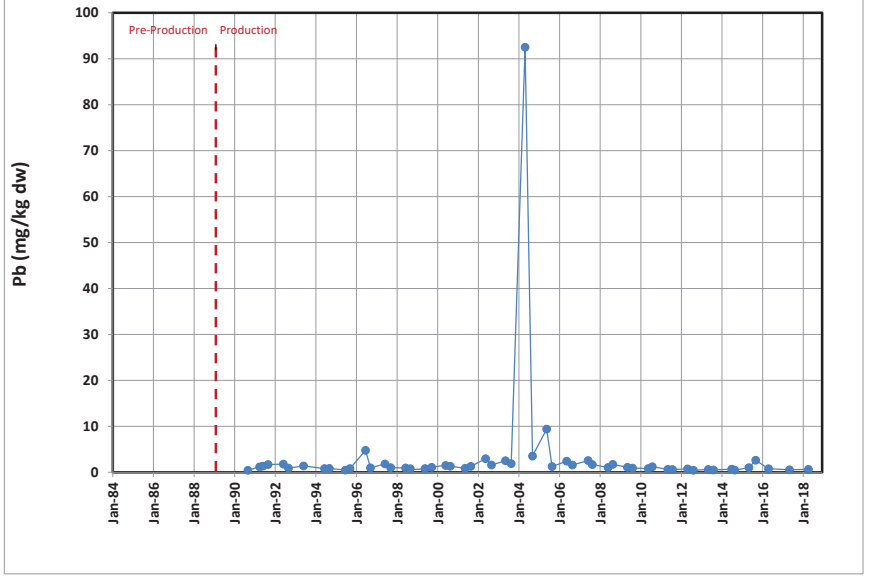


Figure 4-14. Mercury in Mussels at Site STN-3

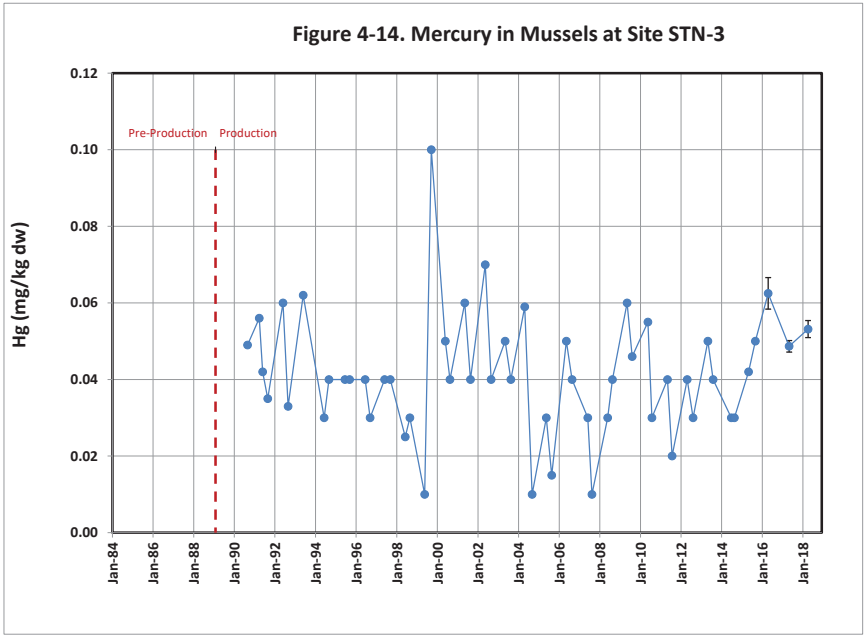


Figure 4-15. Zinc in Mussels at Site STN-3

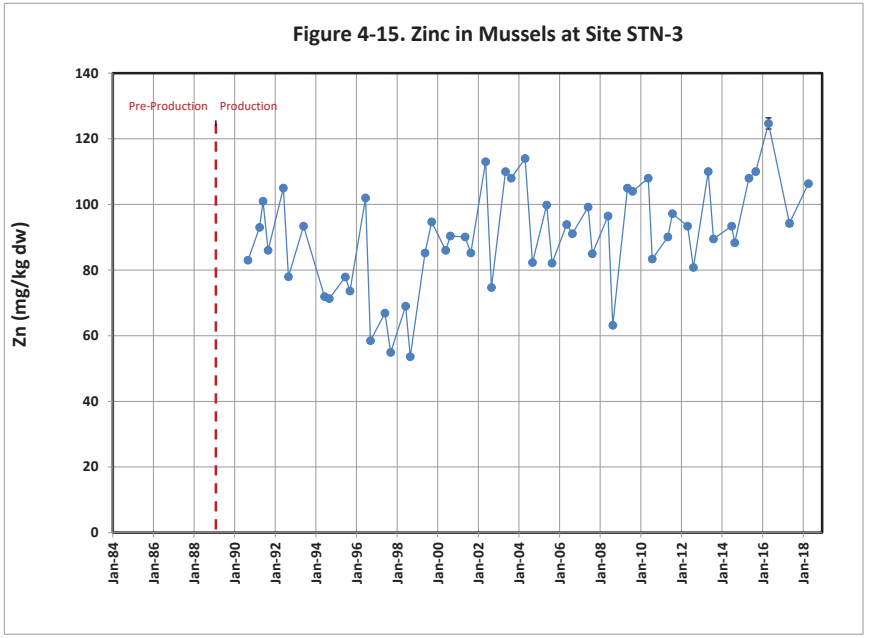


Figure 4-16. Cadmium in Mussels at Site ESL

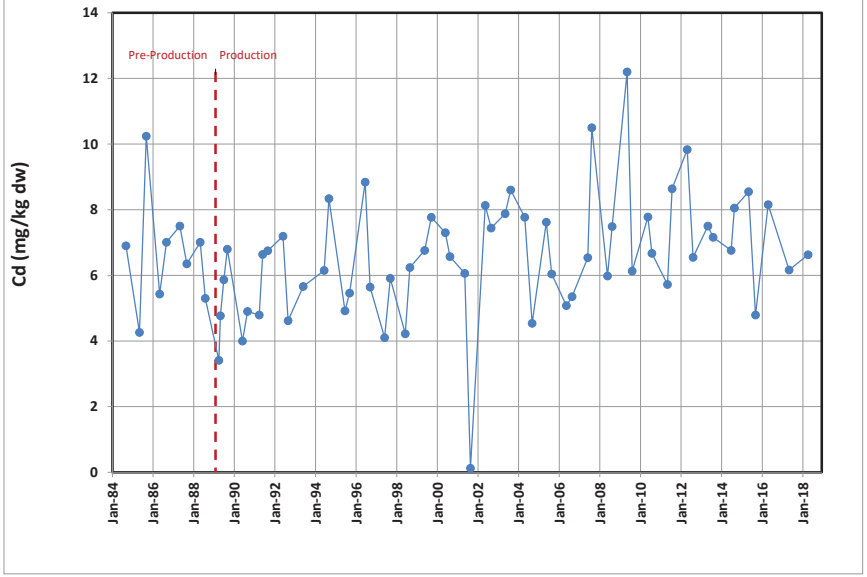


Figure 4-17. Copper in Mussels at Site ESL

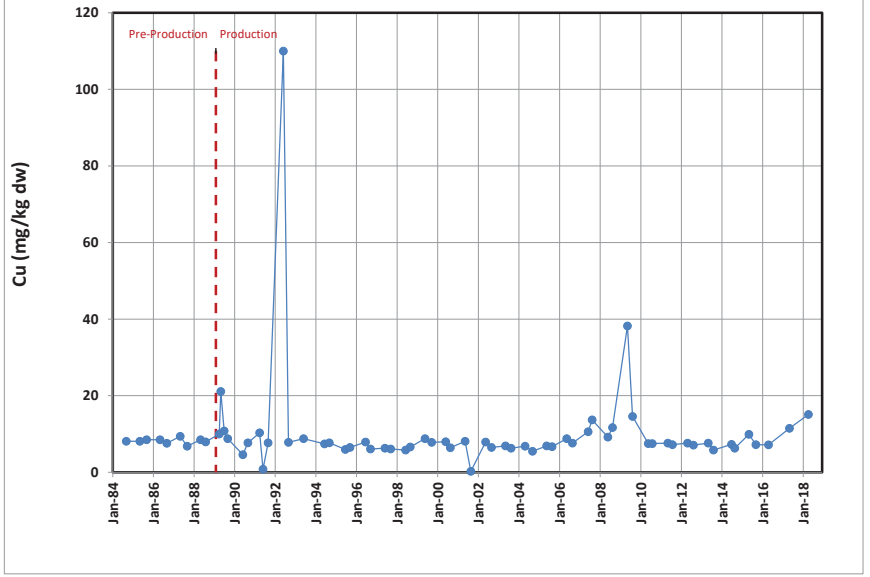


Figure 4-18. Lead in Mussels at Site ESL

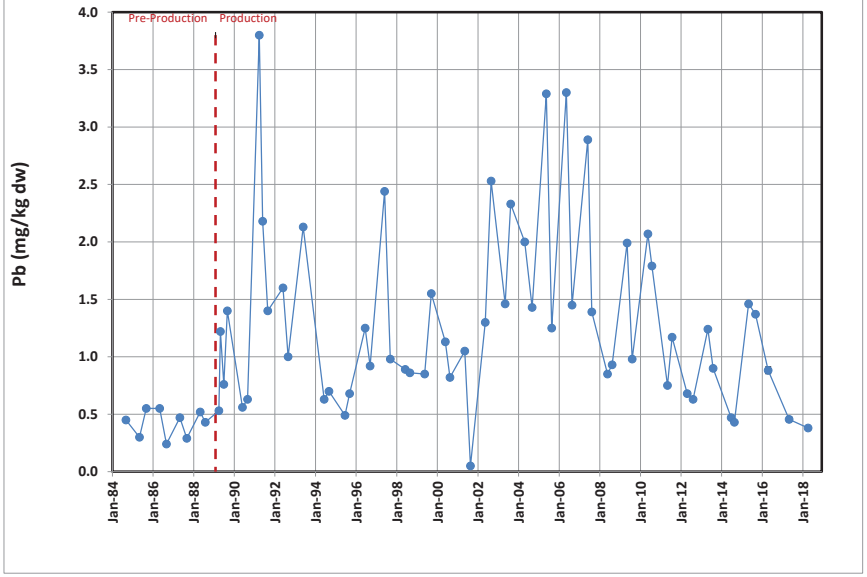


Figure 4-19. Mercury in Mussels at Site ESL

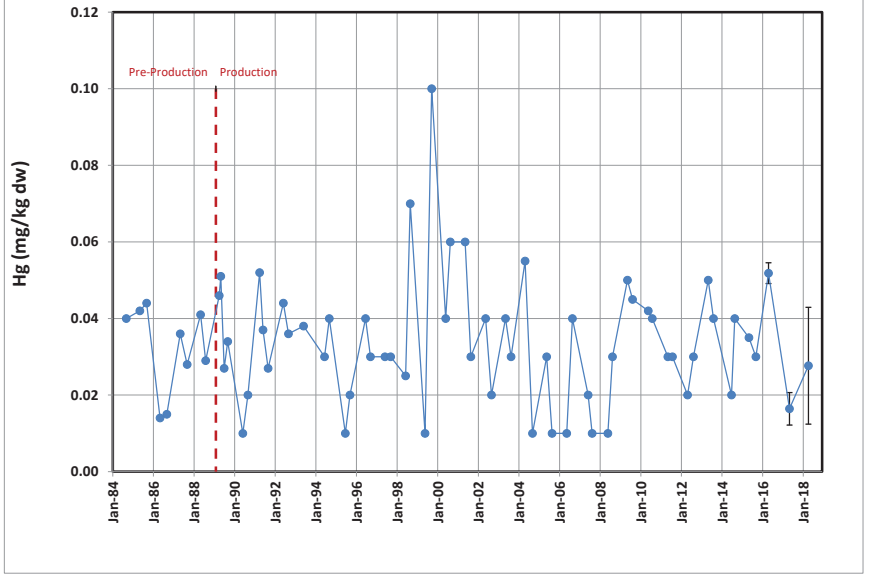


Figure 4-20. Zinc in Mussels at Site ESL

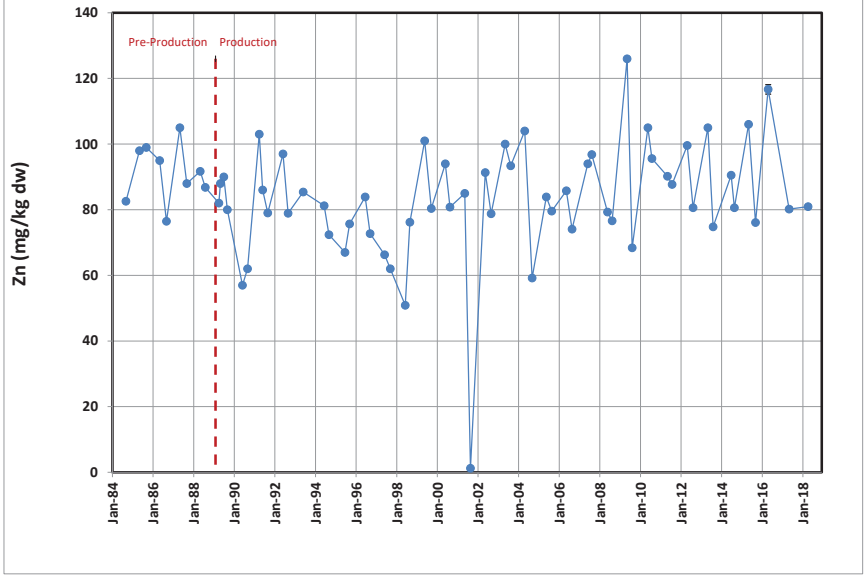


Figure 4-21. Cadmium in Nephtys at Site S-1

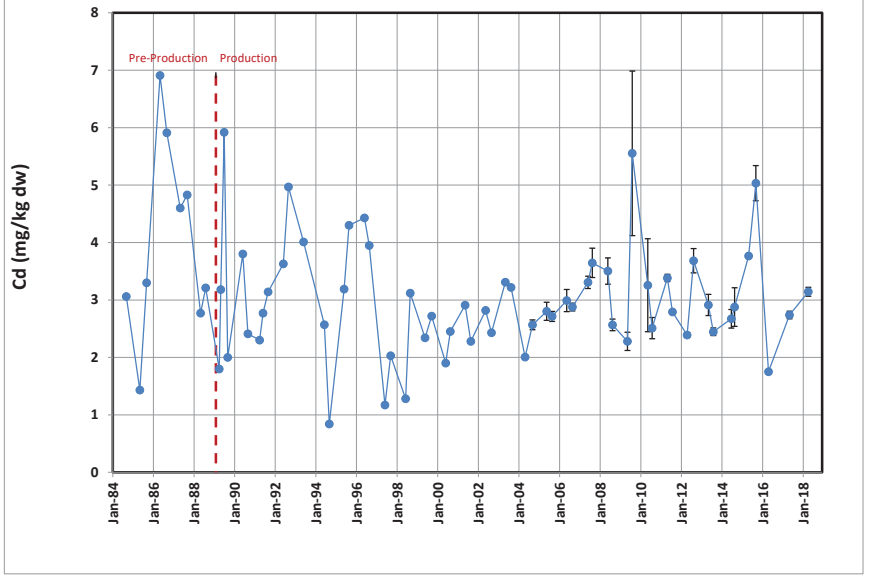


Figure 4-22. Copper in Nephtys at Site S-1

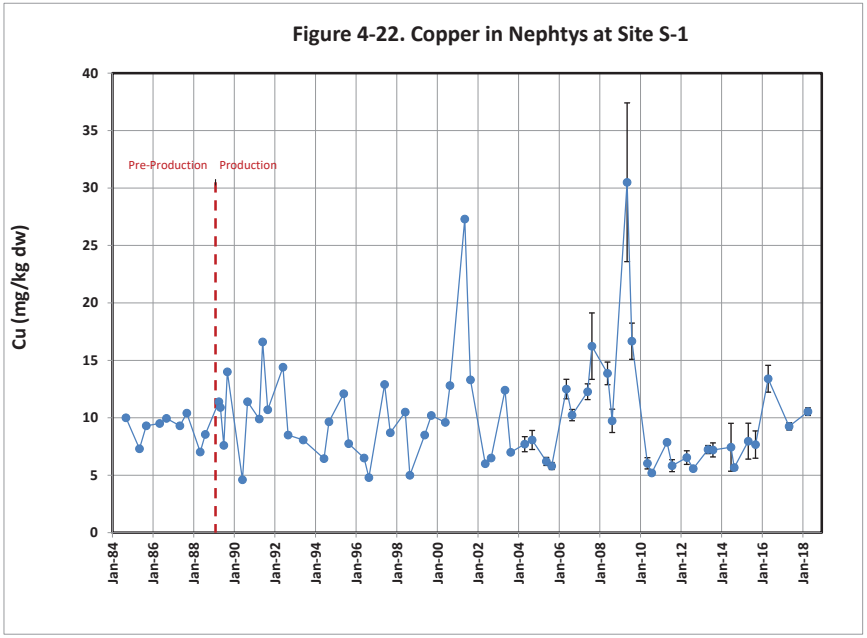


Figure 4-23. Lead in Nephtys at Site S-1

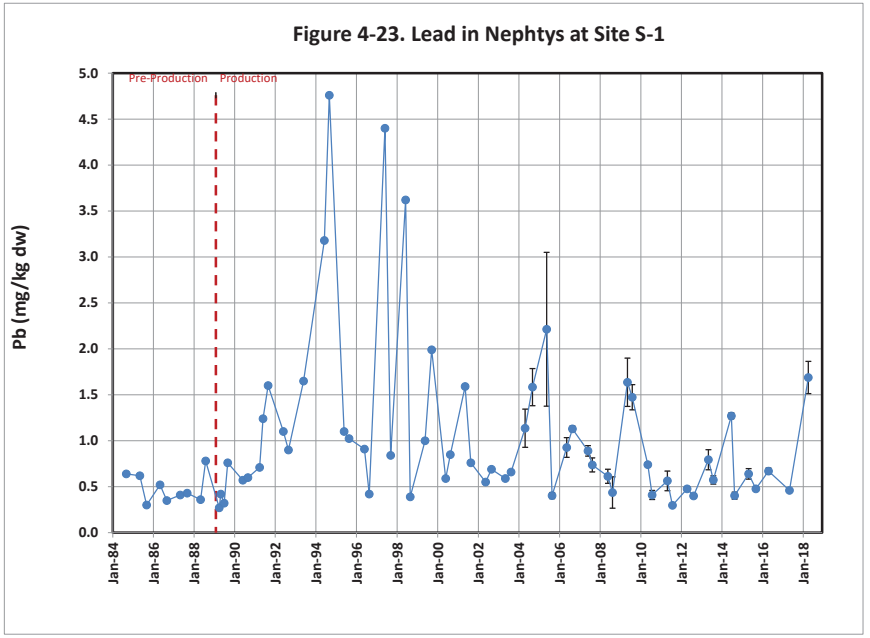


Figure 4-24. Mercury in Nephtys at Site S-1

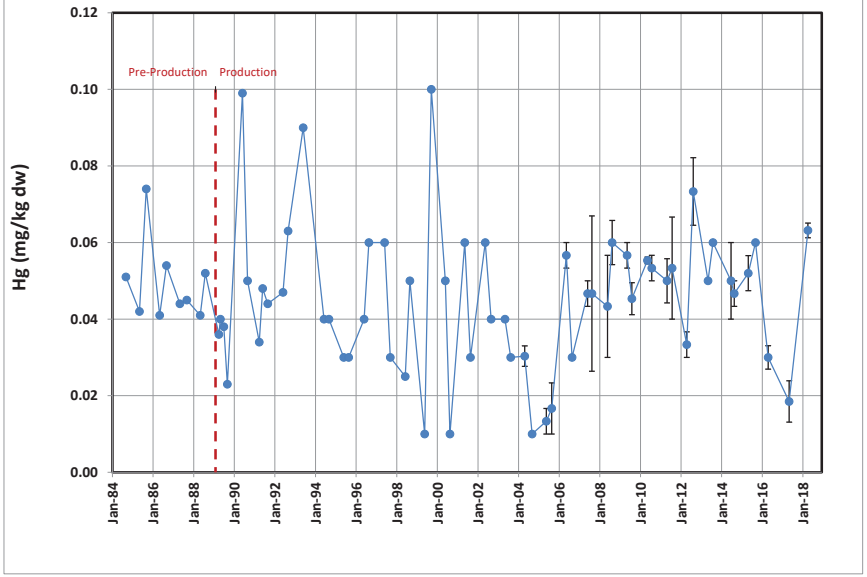


Figure 4-25. Zinc in Nephtys at Site S-1

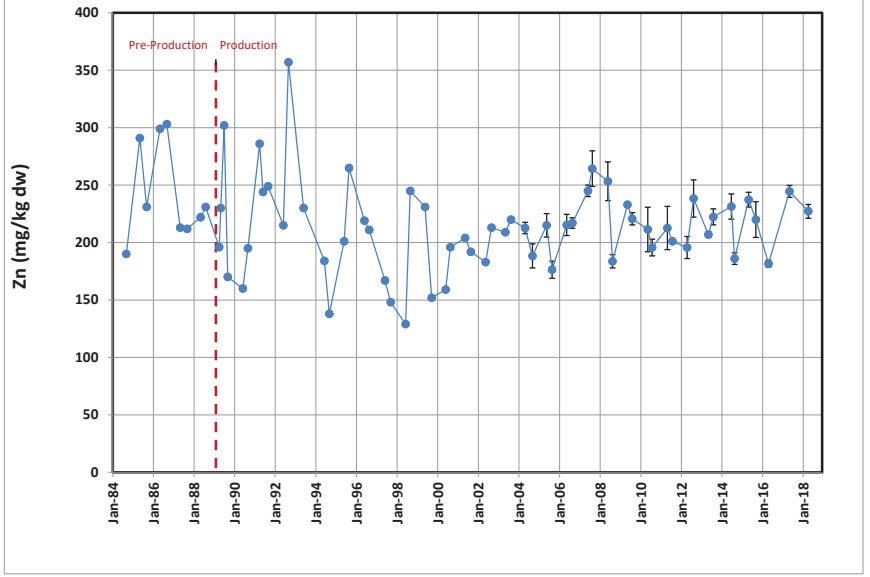


Figure 4-26. Cadmium in Nephtys at Site S-2

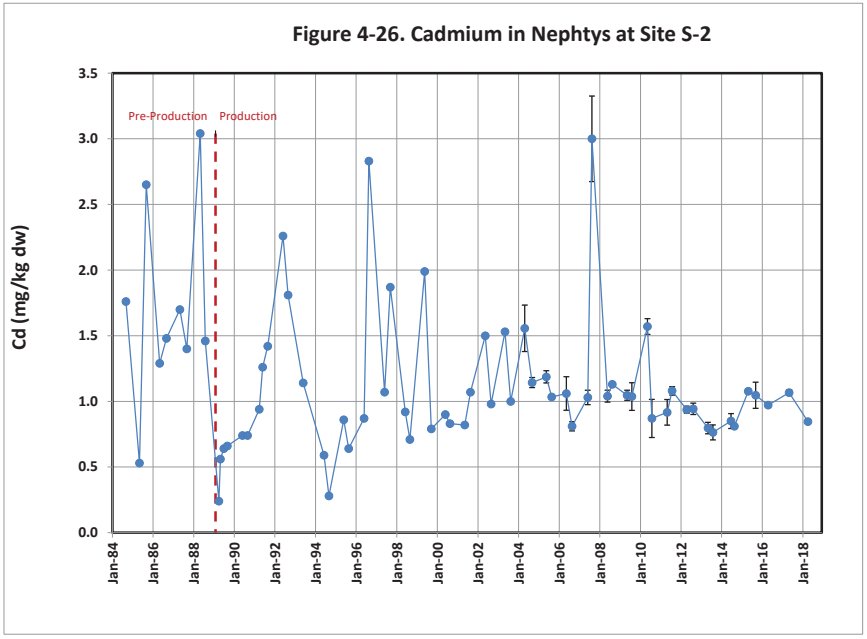


Figure 4-27. Copper in Nephtys at Site S-2

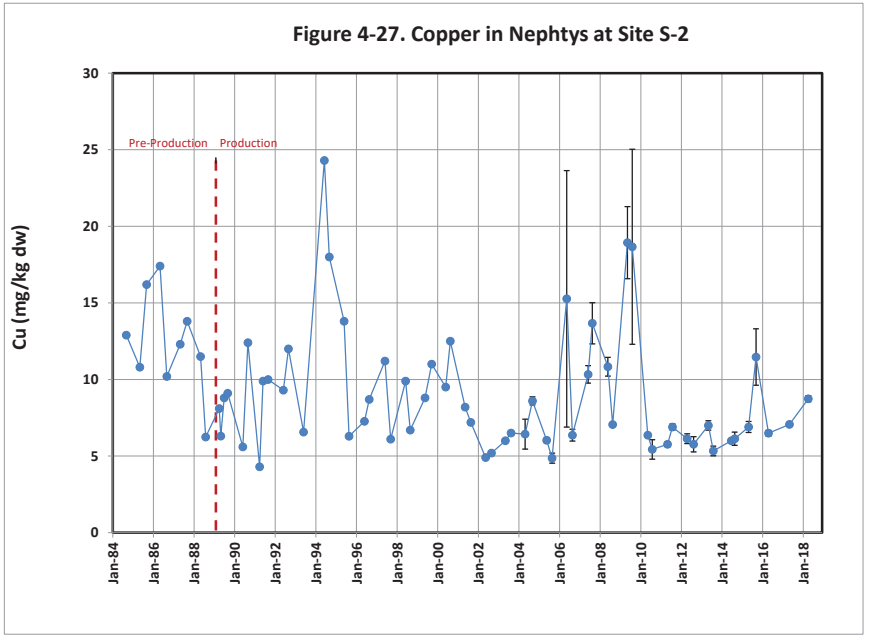


Figure 4-28. Lead in Nephtys at Site S-2

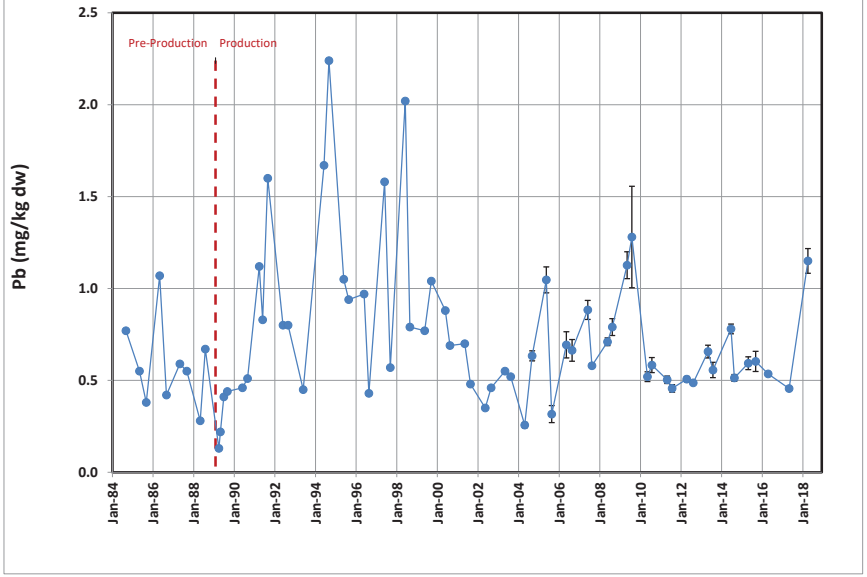


Figure 4-29. Mercury in Nephtys at Site S-2

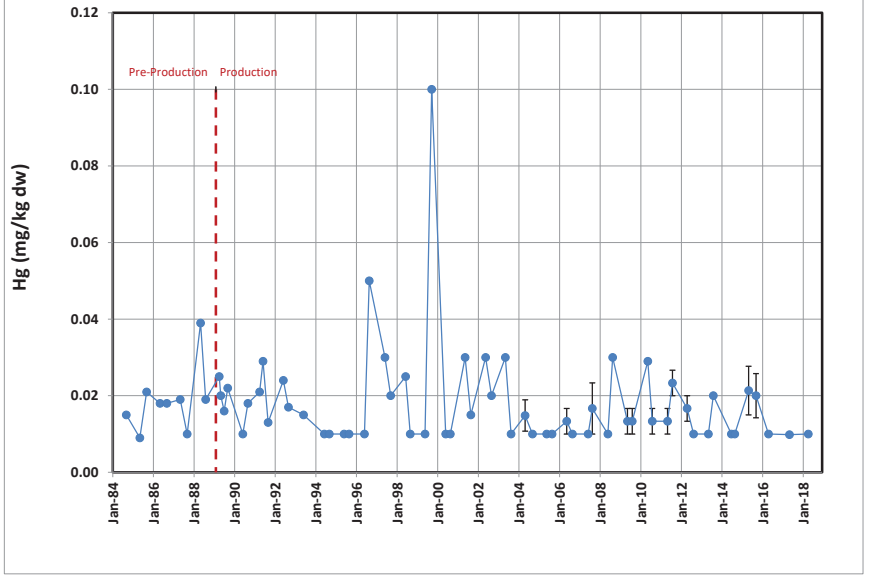


Figure 4-30. Zinc in Nephtys at Site S-2

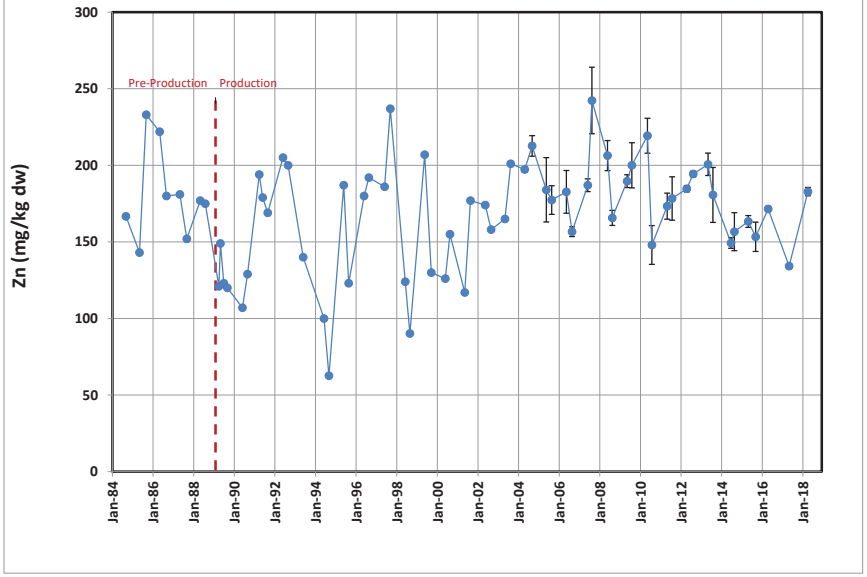


Figure 4-31. Cadmium in Nephtys at Site S-4

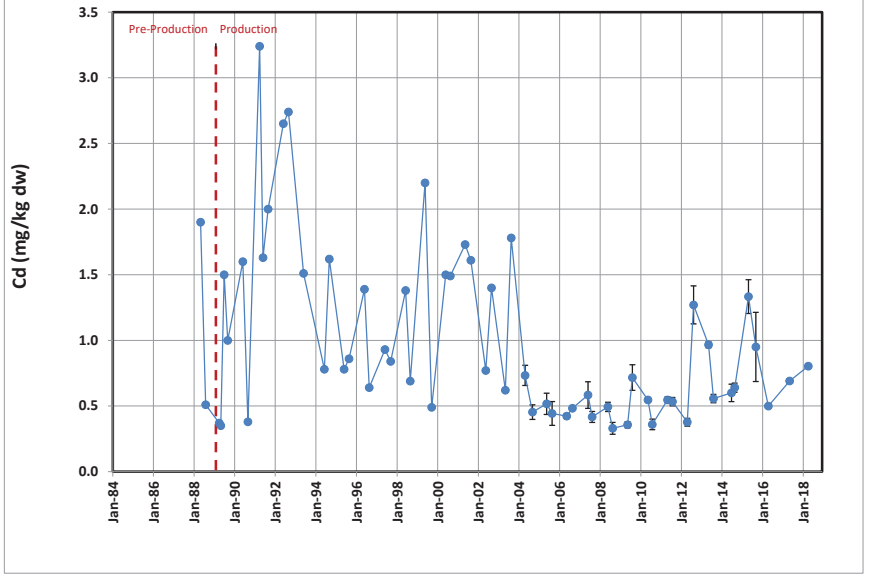


Figure 4-32. Copper in Nephtys at Site S-4

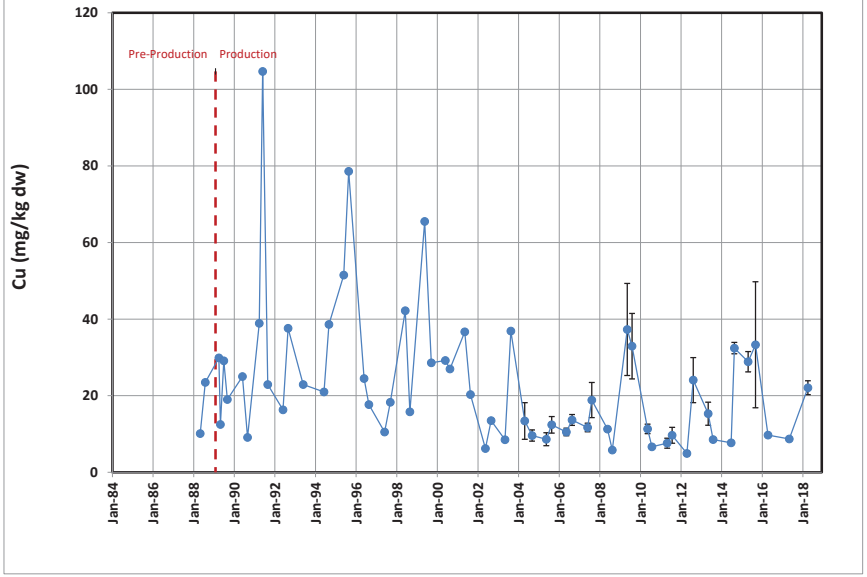


Figure 4-33. Lead in Nephtys at Site S-4

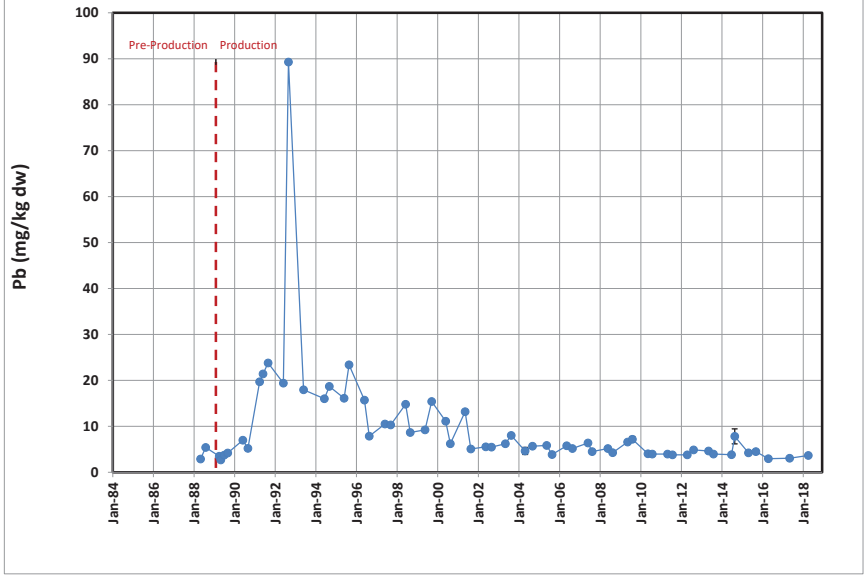


Figure 4-34. Mercury in Nephtys at Site S-4

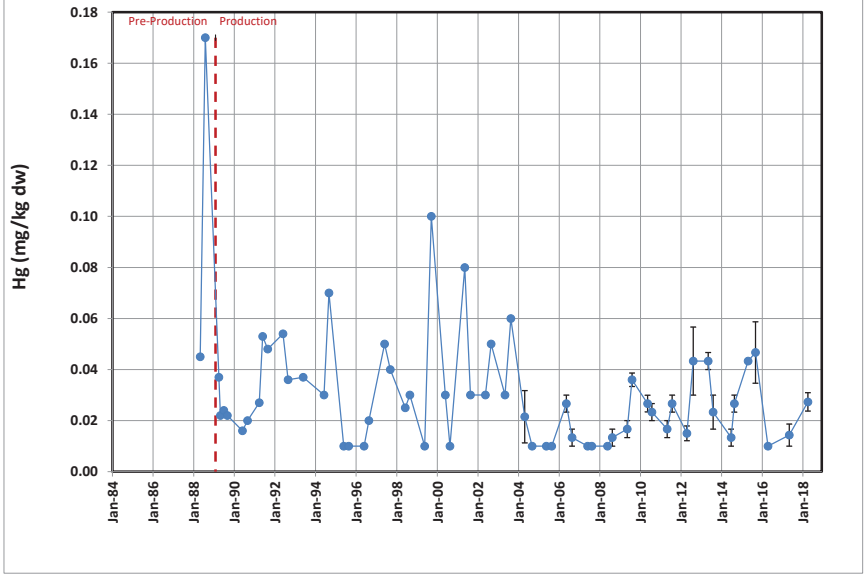
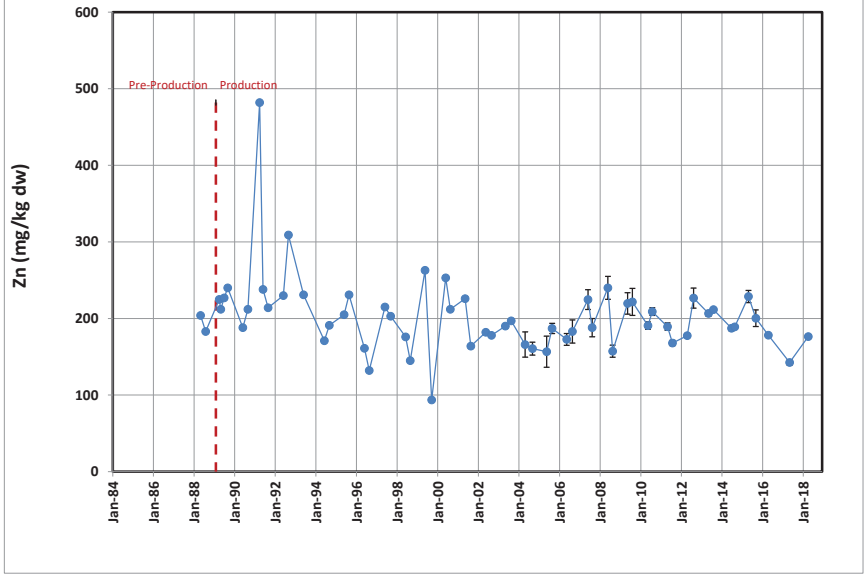


Figure 4-35. Zinc in Nephtys at Site S-4



APPENDIX A

Sediment and Organism Method Reporting Limits

Laboratory Detection Limits for Mussels Analysis		
Sample ID	**Metal (mg/Kg/dw)**	**2018 MRL**
ESL Mussel Rep. I	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
ESL Mussel Rep. II	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
ESL Mussel Rep. III	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
ESL Mussel Rep. IV	Cadmium, Total	0.02
	Copper, Total	0.099
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
ESL Mussel Rep. V	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.04
	Zinc, Total	0.5
ESL Mussel Rep. VI	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.04
	Zinc, Total	0.5
STN-1 Mussel Rep. I	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
STN-1 Mussel Rep. II	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5

Laboratory Detection Limits for Mussels Analysis		
Sample ID	**Metal (mg/Kg/dw)**	**2018 MRL**
STN-1 Mussel Rep. III	Cadmium, Total	0.02
	Copper, Total	0.099
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
STN-1 Mussel Rep. IV	Cadmium, Total	0.02
	Copper, Total	0.099
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
STN-1 Mussel Rep. V	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
STN-1 Mussel Rep. VI	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
STN-2 Mussel Rep. I	Cadmium, Total	0.02
	Copper, Total	0.099
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
STN-2 Mussel Rep. II	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
STN-2 Mussel Rep. III	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
STN-2 Mussel Rep. IV	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5

Method Reporting Limit (MRL) - Defined by ALS Environmental as being 3 times the MDL (or greater)

Laboratory Detection Limits for Mussels Analysis		
Sample ID	**Metal (mg/Kg/dw)**	**2018 MRL**
STN-2 Mussel Rep. V	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
STN-2 Mussel Rep. VI	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
STN-3 Mussel Rep. I	Cadmium, Total	0.02
	Copper, Total	0.099
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
STN-3 Mussel Rep. II	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
STN-3 Mussel Rep. III	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
STN-3 Mussel Rep. IV	Cadmium, Total	0.02
	Copper, Total	0.099
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
STN-3 Mussel Rep. V	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
STN-3 Mussel Rep. VI	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5

Method Reporting Limit (MRL) - Defined by ALS Environmental as being 3 times the MDL (or greater)

Laboratory Detection Limits for Sediment Analysis		
Sample ID	**Metal (mg/Kg/dw)**	**2018 MRL**
S-1 Sediment Rep. I	Cadmium, Total	0.021
	Copper, Total	0.1
	Lead, Total	0.052
	Mercury, Total	0.021
	Zinc, Total	0.52
S-1 Sediment Rep. II	Cadmium, Total	0.02
	Copper, Total	0.098
	Lead, Total	0.049
	Mercury, Total	0.021
	Zinc, Total	0.49
S-1 Sediment Rep. III	Cadmium, Total	0.021
	Copper, Total	0.1
	Lead, Total	0.052
	Mercury, Total	0.021
	Zinc, Total	0.52
S-1 Sediment Rep. IV	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.051
	Mercury, Total	0.021
	Zinc, Total	0.51
S-1 Sediment Rep. V	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.051
	Mercury, Total	0.021
	Zinc, Total	0.51
S-1 Sediment Rep. VI	Cadmium, Total	0.021
	Copper, Total	0.1
	Lead, Total	0.051
	Mercury, Total	0.02
	Zinc, Total	0.51
S-2 Sediment Rep. I	Cadmium, Total	0.021
	Copper, Total	0.1
	Lead, Total	0.052
	Mercury, Total	0.02
	Zinc, Total	0.52
S-2 Sediment Rep. II	Cadmium, Total	0.017
	Copper, Total	0.085
	Lead, Total	0.042
	Mercury, Total	0.021
	Zinc, Total	0.42

Laboratory Detection Limits for Sediment Analysis		
Sample ID	**Metal (mg/Kg/dw)**	**2018 MRL**
S-2 Sediment Rep. III	Cadmium, Total	0.019
	Copper, Total	0.097
	Lead, Total	0.049
	Mercury, Total	0.02
	Zinc, Total	0.49
S-2 Sediment Rep. IV	Cadmium, Total	0.019
	Copper, Total	0.093
	Lead, Total	0.047
	Mercury, Total	0.02
	Zinc, Total	0.47
S-2 Sediment Rep. V	Cadmium, Total	0.018
	Copper, Total	0.09
	Lead, Total	0.045
	Mercury, Total	0.019
	Zinc, Total	0.45
S-2 Sediment Rep. VI	Cadmium, Total	0.02
	Copper, Total	0.099
	Lead, Total	0.049
	Mercury, Total	0.021
	Zinc, Total	0.49
S-3 Sediment Rep. I	Cadmium, Total	0.025
	Copper, Total	0.12
	Lead, Total	0.062
	Mercury, Total	0.03
	Zinc, Total	0.62
S-3 Sediment Rep. II	Cadmium, Total	0.021
	Copper, Total	0.1
	Lead, Total	0.052
	Mercury, Total	0.026
	Zinc, Total	0.52
S-3 Sediment Rep. III	Cadmium, Total	0.023
	Copper, Total	0.11
	Lead, Total	0.057
	Mercury, Total	0.023
	Zinc, Total	0.57
S-3 Sediment Rep. IV	Cadmium, Total	0.031
	Copper, Total	0.16
	Lead, Total	0.078
	Mercury, Total	0.032
	Zinc, Total	0.78

Method Reporting Limit (MRL) - Defined by ALS Environmental as being 3 times the MDL (or greater)

Laboratory Detection Limits for Sediment Analysis		
Sample ID	**Metal (mg/Kg/dw)**	**2018 MRL**
S-3 Sediment Rep. V	Cadmium, Total	0.026
	Copper, Total	0.13
	Lead, Total	0.066
	Mercury, Total	0.027
	Zinc, Total	0.66
S-3 Sediment Rep. VI	Cadmium, Total	0.023
	Copper, Total	0.11
	Lead, Total	0.057
	Mercury, Total	0.025
	Zinc, Total	0.57
S-4 Sediment Rep. I	Cadmium, Total	0.022
	Copper, Total	0.11
	Lead, Total	0.055
	Mercury, Total	0.017
	Zinc, Total	0.55
S-4 Sediment Rep. II	Cadmium, Total	0.019
	Copper, Total	0.096
	Lead, Total	0.048
	Mercury, Total	0.021
	Zinc, Total	0.48
S-4 Sediment Rep. III	Cadmium, Total	0.021
	Copper, Total	0.11
	Lead, Total	0.053
	Mercury, Total	0.022
	Zinc, Total	0.53
S-4 Sediment Rep. IV	Cadmium, Total	0.022
	Copper, Total	0.11
	Lead, Total	0.055
	Mercury, Total	0.02
	Zinc, Total	0.55
S-4 Sediment Rep. V	Cadmium, Total	0.024
	Copper, Total	0.12
	Lead, Total	0.059
	Mercury, Total	0.025
	Zinc, Total	0.59
S-4 Sediment Rep. VI	Cadmium, Total	0.02
	Copper, Total	0.098
	Lead, Total	0.049
	Mercury, Total	0.021
	Zinc, Total	0.49

Method Reporting Limit (MRL) - Defined by ALS Environmental as being 3 times the MDL (or greater)

Laboratory Detection Limits for *Nephtys* Analysis		
Sample ID	**Metal (mg/Kg/dw)**	**2018 MRL**
S-1 Nephtys Rep. I	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
S-1 Nephtys Rep. II	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
S-1 Nephtys Rep. III	Cadmium, Total	0.02
	Copper, Total	0.099
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
S-1 Nephtys Rep. IV	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
S-1 Nephtys Rep. V	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
S-1 Nephtys Rep. VI	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
S-2 Nephtys Rep. I	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
S-2 Nephtys Rep. II	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5

Laboratory Detection Limits for *Nephtys* Analysis		
Sample ID	**Metal (mg/Kg/dw)**	**2018 MRL**
S-2 Nephtys Rep. III	Cadmium, Total	0.02
	Copper, Total	0.099
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
S-2 Nephtys Rep. IV	Cadmium, Total	0.02
	Copper, Total	0.099
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
S-2 Nephtys Rep. V	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
S-2 Nephtys Rep. VI	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
S-3 Nephtys Rep. I	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
S-3 Nephtys Rep. II	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
S-3 Nephtys Rep. III	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
S-3 Nephtys Rep. IV	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5

Method Reporting Limit (MRL) - Defined by ALS Environmental as being 3 times the MDL (or greater)

Laboratory Detection Limits for *Nephtys* Analysis		
Sample ID	**Metal (mg/Kg/dw)**	**2018 MRL**
S-3 Nephtys Rep. V	Cadmium, Total	0.02
	Copper, Total	0.099
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
S-3 Nephtys Rep. VI	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
S-4 Nephtys Rep. I	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
S-4 Nephtys Rep. II	Cadmium, Total	0.02
	Copper, Total	0.099
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
S-4 Nephtys Rep. III	Cadmium, Total	0.02
	Copper, Total	0.099
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
S-4 Nephtys Rep. IV	Cadmium, Total	0.02
	Copper, Total	0.099
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
S-4 Nephtys Rep. V	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5
S-4 Nephtys Rep. VI	Cadmium, Total	0.02
	Copper, Total	0.1
	Lead, Total	0.02
	Mercury, Total	0.02
	Zinc, Total	0.5

Method Reporting Limit (MRL) - Defined by ALS Environmental as being 3 times the MDL (or greater)

APPENDIX B

Outfall Survey Footage

Provided electronically to the Alaska Department of Environmental Conservation

APPENDIX C

Historical Hawk Inlet Data

Provided electronically to the Alaska Department of Environmental Conservation