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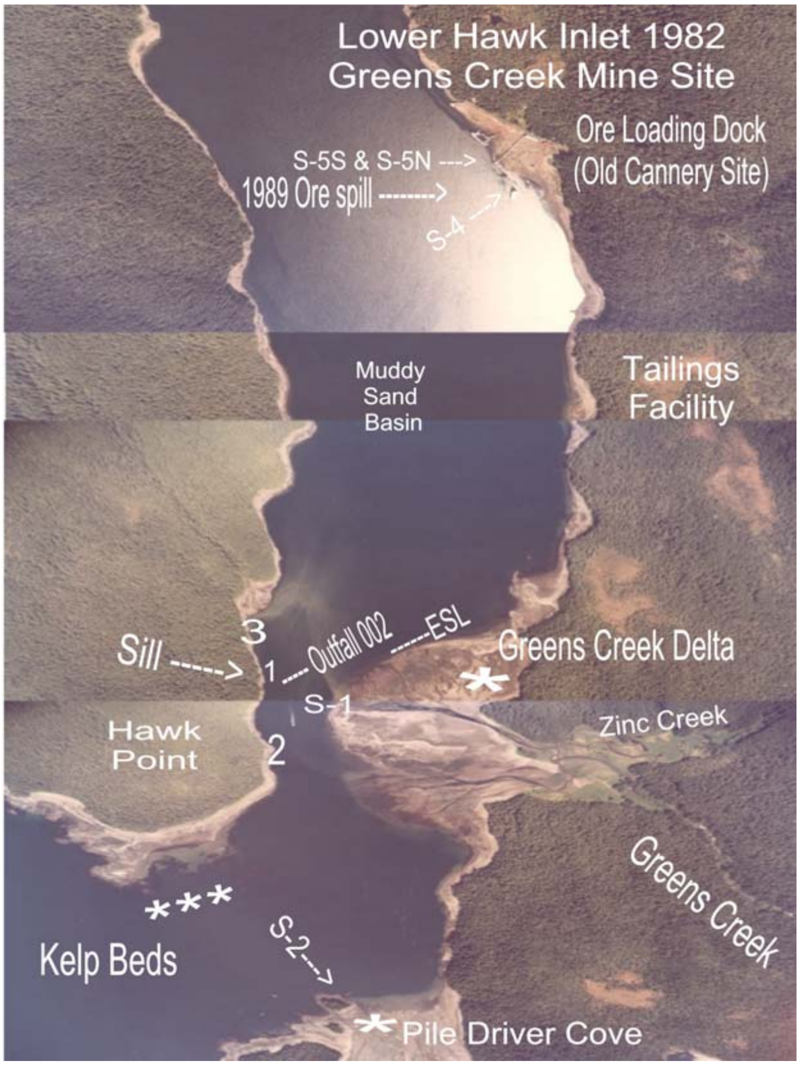
Review of Essential Fish Habitat in Hawk Inlet Subsequent to Mining Operations



Prepared for the USDA, Forest Service in connection with the Greens Creek Tailings Disposal Final Environmental Impact Statement

by
Oceanus Alaska
Juneau, Alaska

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Appendix A: Hawk Inlet Species Distributions by Habitat
Water Quality Data Report
Hawk Inlet Metal Concentrations 1984-2002

Introduction

This document provides an overview of the physical and biological marine and aquatic ecosystems in the vicinity of the Greens Creek Mine. It presents the technical information and sampling data referenced in the Kennecott Greens Creek Mine Tailings Expansion Environmental Impact Statement produced by the US Forest Service (November 2003). As such, this compendium to the EIS is a review of the status of these ecosystems in general, and is intended to characterize the status of essential fish habitat and habitat areas of particular concern subsequent to about 20 years of mining associated activities in Hawk Inlet and adjacent watersheds.

This document does not include a risk assessment analysis, and only describes observed changes in metal levels monitored without analysis of the trophic fate of metals, speciation of metals, or analysis of synergistic effects of other mining effluent constituents in the marine and aquatic environments of Hawk Inlet. However, the detail provided within may be informative in ancitipating some potential effects of further mining development such as the tailings pile expansion or other action that prolongs the life of the mine.

Research and Monitoring at Hawk Inlet Several researchers have studied marine life in Hawk Inlet, and numerous annual monitoring events have generated one of the longest time-series marine data sets in southeast Alaska. International Environmental Consultants (IEC) and the Martin Marietta Environmental Center conducted extensive quantitative surveys of Hawk Inlet intertidal and subtidal substrate and biota prior to mine construction and operations from 1979 through 1981. The Oceanographic Institute of Oregon also conducted surveys and studies prior to mine development and throughout the course of operations. Data derived from these studies on the Hawk Inlet marine ecosystem have been augmented by intermittent surveys and specialized studies by government agency researchers (USFWS, USFS, ADF&G, NMFS and UAF).

Watersheds, streams, and freshwater biota in Hawk Inlet aquatic systems have been studied since 1961 – especially the Greens Creek drainage. Buell and Associates have characterized streams and fish populations throughout the area; ADF&G has conducted spawning salmon surveys since the early 1960's; Holland *et al* conducted limited biota surveys (1981); USGS has monitored stream flows on some systems flowing into Hawk Inlet, and various academic and government researchers have studied stream ecology, fish and invertebrates in the area.

Highlights of findings from these and other studies, as well as summaries of relevant data from the 2003 EIS are included in this document.

1 Marine and Aquatic Ecosystem

The potentially affected marine and aquatic ecosystems encompassed in the project study area for the Kennecott Greens Creek Mine Tailings Expansion include watersheds indicated in Figure 1-6 and marine waters from the line between Hawk Point and Pile Driver Cove Point, immediately south of Hawk Point to the head of Hawk Inlet. Physical and oceanographic features of these habitats are first described, followed by descriptions of species, habitats and biotic communities in the study area. Finally, a review of heavy metal concentrations in Hawk Inlet seawater, sediments, halibut, several bivalve species and polychaete worms is provided.

1.0.1 Oceanography

Hawk Inlet is a marine waterway chiseled into mineral-rich rock formations on northern Admiralty Island. The physical shape of this saltwater arm (described below) off of Chatham Strait, in conjunction with large tides in the region produce strong currents which refresh nutrients within the inlet. The extent of seawater exchange together with freshwater nutrient inputs from rivers, streams and runoff support an ecosystem rich in marine life ranging from kelp forests and clam beds to groundfish schools, resident crab populations and itinerant marine mammals and birds.

This section describes the physical oceanographic characteristics of Hawk Inlet. Factors including tides, currents, and marine water quality are described using the best available information.

1.0.2 Physical Characteristics of Hawk Inlet

In order to understand the mixing and dilution of mine effluent as it enters a body of water, it is important to understand the physical characteristics of that water environment. Information on tides, depths, and other basic features are reported from National Oceanic and Atmospheric Administration nautical charts and tide records. Site-specific data are reported from scientific reports.

1.0.3 Topography and Bathymetry

Hawk Inlet extends seven miles north from Chatham Strait and ends in a tidal mudflat estuary about 0.6 miles in diameter. Hawk Inlet consists of a narrow basin, partially separated from Chatham Strait by a relatively shallow sill that includes the large delta formed by glacial activity and by riverborne sediments from Greens Creek. The narrow channel connecting the Inlet to Chatham Strait, located between the tip of the Greens Creek delta and the western shore of Hawk Inlet, has a minimum low tide depth of 35 feet. The midchannel depth ranges from 35 feet at the sill, to 250 feet in the mid-portion of the Inlet.

1.0.4 Tides, Currents and Circulation

Hawk Inlet has regular, twice-daily tides. The large tidal variation (a maximum range from high to low) of about 25 feet, the shallow Greens Creek delta, and irregularities in the rocky shoreline strongly influence circulation patterns in the Inlet. Wind may have a strong effect on surface water movement, and freshwater flowing into the inlet further influences water flow speed and vertical mixing of water between depths.

On the flood tide, the surface 35-foot layer contains the bulk of the water transport entering the Inlet at the sill and is then flushed out on the ebb tide. Current velocities in Hawk Inlet are greatest at the 1,000-foot wide Greens Creek sill -- in the vicinity of

Outfall 002, reaching a maximum of about 70 cm/sec on the flood tide. The maximum flows at ebb tide elsewhere in Hawk Inlet near the surface are in the 40-cm/sec ranges. Throughout the Inlet, current velocity decreases with depth. Polgar (1982) described that "… transport and exchange with coastal (Chatham Strait) waters are most vigorous in the surface waters, with more sluggish net circulation at depths greater than 20 meters (65 feet). At 100 feet, currents are negligible—usually less than 10 percent of those at the surface.

Differences in flood and ebb tide circulation patterns have been observed (Polgar 1982). Flooding occurs predominantly along the eastern side of the Inlet, with perceptible velocities down to a depth of 65-100 feet, while ebbing is mostly confined to the surface layer along the western shore.

A large eddy (or circular, whirlpool-like current) occurs in the broad central region of the Inlet, near the cannery. From the cannery, currents on the western shore generally move in a southward direction, and currents on the eastern shore tend to be directed northward during all phases of the tide. The effects of this gyre on entrainment or concentration of effluent are not known at the time of this writing.

1.0.5 Flushing

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. Further, the rate of flushing, or dilution of effluent toward ambient seawater concentrations, can affect speciation of metals in the environment. Since metal speciation dictates the potential toxic or other effects the effluent may impose on organisms, flushing characteristics are key in understanding potential effects in the fjord-like Hawk Inlet ecosystem.

In 1981, SEA Associates, Inc., conducted flushing studies in Hawk Inlet by observing dispersion of colored dyes in seawater. Based on these studies, it was estimated that over each tidal cycle, an average of 50 million cubic meters (or 13 billion gallons) was flushed from the Inlet. At that rate, it is estimated that the Inlet will completely flush at least once every five tidal cycles. Based on mine output up through 1995, the input of effluent from the mining operations over this flushing period represents approximately 0.009 percent of the total flushing volume (Andrews, 1996).

Another study, conducted in 1984, used dyes to examine the length of residence and the rates of flushing of conservative substances (chemicals that do not readily dissolve in seawater) released into Hawk Inlet. The results of that study also indicated that, overall, Hawk Inlet has a relatively good exchange of tidal water (Hancock, 1998).

1.0.6 Seasonal and Freshwater Effects on Seawater Mixing

While the rate of exchange between the waters of Hawk Inlet and Chatham Strait fluctuates with the amount of precipitation and with the lunar cycle, local features markedly affect tidal currents, mixing within the Inlet.

The topography and freshwater input into Hawk Inlet create a water mixing environment much like those found in estuaries. Where tidal waters meet fresh waters in estuaries, the more buoyant, fresher waters tend to move seaward along the surface, while the heavier, salty (or *saline*) tidal waters move inland below the fresher water. This slow mass exchange pattern is superimposed on the much more vigorous and rapid circulation that occurs with each change of the tide.

Although wind and geography influence mixing, the net circulation rate is affected substantially only by tidal variations and by fluctuations in the amount of fresh water coming into the Inlet.[1] Six minor tributaries enter on the western shore of Hawk Inlet. The largest tributary is Greens Creek, which, in combination with Cannery Creek, other smaller streams, runoff and direct precipitation falling on the waters of Hawk Inlet, contribute to the gross freshwater entering the system. The amount of fresh water flowing into Hawk Inlet from these tributaries peaks in September and October (because of precipitation) and again in May and June (because of melting snow).

1.0.7 Marine Water Quality

Marine water quality parameters such as temperature, salinity, total dissolved solids, and dissolved heavy metals, are monitored on a regular basis in Hawk Inlet in accordance with the KGCMC Quality Assurance Program Plan approved by ADEC for implementing sampling protocols outlined in the Mine's NPDES permit (KGCMC QAPP 1999; also see section 2.0). Analytes, method detection limits, sampling stations and frequency of sampling have been determined under the NPDES permit process and results are routinely compared to water quality for aquatic life and human health standards (George 2003). The primary objective of monitoring is to document that treated domestic waste water (Outfall 001) and mine and mill process waste water (Outfall 002), and storm water discharged from the mine and associated facilities meets NPDES effluent limitations (KGCMC QAPP, 1999). The locations of these two outfalls are:

Outfall 001 (Domestic wastewater): 58 07.30 North; 134 45.15 West

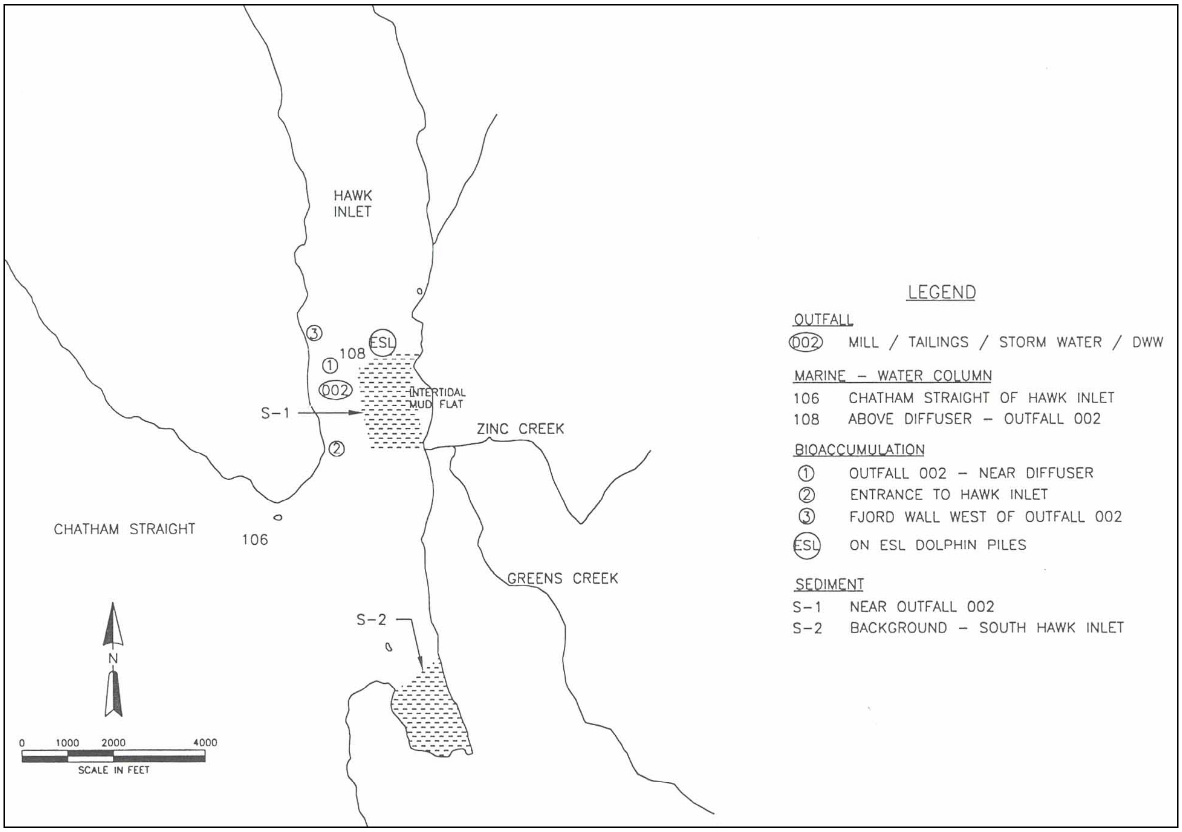
Outfall 002 (Mining effluent): 58 07.00 North; 134 45.30 West -- at 40 to 70 feet belowMLLW, about 150 feet long, with discharge vents distributed about every 10 feet

The stations for seawater sampling are as follows (Figure 1-1):

Station 104	Head of Hawk Inlet, 3 ½ miles north of the cannery (no longer required under NPDES, but still sampled)
Station 106	in Chatham Strait south and west of Hawk Point
Station 107	About mid-way East-West in Hawk Inlet, west of the ship loader facility
Station 108	Above the diffuser, in the mixing zone

1 Just over half of the fresh water entering the Inlet comes from Greens Creek, Cannery Creek, and other drainages; most of the rest comes from run-off from the surrounding land; only about five percent comes from direct precipitation over the Inlet surface. International Environmental Consultants, Inc., 1980.

Figure 1-1 Some Greens Creek Mine Seawater Sampling Stations Relative to Outfall Locations



Monitoring and baseline studies have shown that salinity increases with depth throughout Hawk Inlet and stratification is dependent on the location, volume and frequency of fresh water inflows. Salinity in the vicinity of the outfall pipe exhibited a wide range of levels: 22 to 32 parts per thousand (ppt). In the latter half of 2002, water temperatures averaged 44.6 degrees Fahrenheit at five feet below the surface. Salinity and temperature below the sea surface vary slightly over a tidal cycles, but vary widely in intertidal habitats.

Total suspended solids (TSS) averaged 56.8 mg/kg in Hawk Inlet from 1988 through 1998. Turbidity averaged 0.556 Nephelometric Turbidity Units, and with an average pH of 7.99, the water was slightly alkaline (OIO & RTI, 1998).

Hawk Inlet waters are considered "stable and well-oxygenated at all depths" (Polgar, 1982). No anoxic conditions in the deep basin of Hawk Inlet have been reported.

The results of marine receiving waters heavy metals monitoring from 1988 to present are archived in the Kennecott Greens Creek Mining Company database. All data from the most recent (2003) quarterly seawater sample analysis are provided in Tables 4-1 through 4-6.

Data from seawater samples from the Chatham Strait background site station 106 and station 108, located just outside the outfall 002 mixing zone from prior to mine operations, during the bulk of mine operations (1989-2002) and from the current year's (2003) sampling are compared in the table below.

Table 1-1 Receiving water monitoring data for the control Station 106 and outfall 002 Diffuser Station 108

Period	Parameter	Station 106 µg/L		Station 108 µg/L	
		Avg	Range	Avg	Range
Pre-Operational (1982-1986)	Lead	0.148	ND	0.059	ND
	Copper	0.783	ND	0.694	ND
	Zinc	1.669	ND	2.231	ND
Operational (1989-2002)	Arsenic	1.4577	0.0100 – 2.180	1.4418	0.9270 – 2.6000
	Cadmium	0.0826	0.0390 – 0.1200	0.0990	0.0100 – 0.2000
	Copper	0.528	0.220 – 1.600	0.5500	0.0100 – 1.5200
	Chromium	0.08	0.06 – 0.86	0.2093	0.0590 – 0.5300
	Cyanide	< 20	< 20	< 20	< 20
	Lead	0.199	0.002 – 2.600	0.1667	0.0100 – 0.8100
	Mercury	0.0008	0.0001 – 0.0110	0.0007	0.0000 – 0.0100
	Nickel	0.593	0.010 – 3.940	0.7550	0.0100 – 1.7000
	Selenium	2.904	1.0300 – 7.8700	2.152	0.0970 – 5.6200
	Silver	0.056	0.003 – 0.200	0.025	0.0000 – 0.1000
	Zinc	1.750	0.0100 – 16.700	1.516	0.0300 – 10.8000
Current (2003)	Arsenic	ND	ND	ND	ND
	Cadmium	0.1210	0.0705 – 0.1210	0.088	0.0741 – 0.1010
	Copper	0.5175	0.359 – 0.676	0.49	0.40 – 0.58
	Chromium	ND	ND	ND	ND
	Cyanide	< 20	< 20	< 20	< 20
	Lead	2.7495	0.1690 – 5.3300	0.51	0.13 – 0.90
	Mercury	0.00158	0.00071 - 0.00244	0.0012	0.00109 – 0.00120
	Nickel	ND	ND	ND	ND
	Selenium	ND	ND	ND	ND
	Silver	ND	ND	ND	ND
	Zinc	3.8050	1.500 – 6.110	1.5420	0.864 – 2.220

(Pre- Operational averages based on data from selected years as reported in OIO & RTI 1998; Operational and current year data from KCGCM laboratory report files)

1.1 Marine Biota and Habitats

Pelagic, demersal, benthic and intertidal communities exist within the Hawk Inlet marine ecosystem. Of these, benthic and intertidal habitats have been explored, while pelagic and demersal organisms have received less research. Some species inhabiting these zones are reported through harvest data, limited surveys and dive notes, but feeding strategies and ecological roles need be inferred through studies done elsewhere.

1.1.1 Phytoplankton

Both phytoplankton and zooplankton have been characterized for the water column of Hawk Inlet and vicinity (IEC 1980). Since the water column in the vicinity of the Outfall is highly turbulent, the plankton species are highly seasonal (with a spring to fall succession) and populations tend to be very patchy and transient.

The phytoplankton community of Hawk Inlet consisted of three major groups—diatoms, dinoflagellates, and miscellaneous flagellates. Baseline studies in 1978 recorded 48 species of phytoplankton. Baseline 43 zooplankton species were recorded from within Hawk Inlet, with copepods being the most common group. Zooplankton density tended to be highest at the head of the Inlet and opposite the cannery (near Outfall 001). Larval forms decreased from the head of the Inlet to the mouth (Andrews 1996).

1.1.2 Seafloor Habitats and Biotic Communities of Hawk Inlet

The major subtidal benthic (bottom) substrata that occur in Hawk Inlet are sands, muddy sands, muds, and rocks. Submerged sands primarily occur near the Greens Creek delta. This substratum contains large amounts of cobble and gravel; in areas where current velocities are high, sediments are frequently scoured to bedrock. Muddy-sand habitats occur primarily at the extreme northern end of Hawk Inlet. Submerged muddy-sand habitats also frequently contain relatively large amounts of cobble and gravel. Submerged muds occupy the central region of Hawk Inlet and contain large amounts of organic material. Submerged rocky habitats occur along the margins of the basin.

In general, in hard-bottom subtidal areas, anemones (*Metridium*), snails (*Polinices*, *Nucella*), green sea urchins, starfish, sea cucumbers, sponges, bryzoans, and a wide variety of algae are dominant. King, Tanner, and Dungeness crabs, as well as a variety of edible shrimp, are also found in the hard bottom subtidal habitats. Those habitats in Hawk Inlet and Chatham Strait are typical in species composition and relative abundance to hard-bottom habitats of the region (Holland *et al* 1981).

Annelids (worms), mussels, clams, and small crustaceans dominate soft-bottom subtidal benthic habitats; annelids are generally the most abundant. The composition of subtidal soft-bottom habitats in Hawk Inlet depends upon physical properties of the sediments. These communities in Hawk Inlet contain more species than intertidal benthic communities and are similar to subtidal benthic communities reported to occur along Northeast Pacific coasts.

The physical seafloor features (substrate, depth) and associated plants and creatures mentioned above are characteristic of several different habitat categories, or communities. Nine major marine benthic habitats are found in Hawk Inlet and the adjoining portions of Chatham Strait, making it a very diverse ecosystem. A summary of habitats and associated biota are provided in Table 1-2. A complete list of species identified in each habitat during extensive pre-mining surveys by the Martin Marietta Environmental Center, as reported in Holland, *et al* (1981) is provided in Appendix A: Hawk Inlet Species Distributions by Habitat.

Table 1-2 Features of major marine habitat types in Hawk Inlet, Admiralty Island

(Source: Holland, *et al* 1981)

Habitat Type	Area (ha)	No. of Species	Density Orgs/m^2	Dominant species	Location in Hawk Inlet

Protected (estuarine) intertidal muddy sands	226.4	36	49,480	Gastropods, bivalves, polychaetes	Head of Inlet
Protected subtidal muddy sands	147.3	41	7,596	Bivalves, polychaetes	Head of Inlet
Protected intertidal and subtidal muddy sands	48.8	52	13,776	Polychaetes, foramanifera, bivalves, copepods.	Pile Driver Cove
Unprotected intertidal sand	41.3	36	99,900	Foramaniferans (sponges)	Greens Creek Delta
Intertidal and subtidal rocky	66.3	---	---	(samples from Chatham)	Shoreline and mouth of Inlet
Deep subtidal muds	321.8	52	14,061	Polychaetes, bivalves	Basin -- Cannery
Submerged sill of sand-gravel-cobble	187.2	80	30,526	Polychaetes, gastropods, amphipods	Greens Creek Delta/002
Nereocystis kelp beds (sand)	125.4	69	67,352	Polychaetes, amphipods, bivalves	Interspersed
Transition areas	168.5	---	---	---	Interspersed

Subtidal soft-bottom muds. The major habitat type occurring throughout Hawk Inlet is deep subtidal softbottom communities. Organisms occupying this habitat feed directly on phytoplankton (filter feeders) and seaweeds (grazers), or they use carbon from primary producers after it has been incorporated into sediments (deposit feeders). These species assemblages typically serve as a forage base for juvenile and adult fishes and crab, and serve as important linkages between benthic (seafloor) and pelagic (water column) portions of the marine ecosystem. In Hawk Inlet, 52 species of invertebrates were identified in deep mud-silt-clay habitat near the Cannery. The density of organisms in five one-meter square quadrat samples averaged 13,776 individuals. Most abundant organisms included polychaete worms, foraminifers (sponges), bivalves, calenoid copepods and euphausiids.

Intertidal estuarine mudflat. The largest estuarine mudflat in Hawk Inlet lies at the head of the Inlet, and is just over 0.6 miles across. Biota surveys in 1981 revealed both high abundance and high diversity of species in this community. Five one-meter square quadrat samples averaged 49,480 individuals, composed of 36 identified invertebrate species or species groups. Dominant species included gastropods, bivalves and polychaetes.

Only the four habitats that occur near Outfall 002 are detailed further. The four habitats types, based on sediment and associated organisms, are: unprotected intertidal sands, submerged sill, kelp beds, and intertidal and subtidal rocky areas.

Intertidal Sands. Intertidal sands form a delta at the mouth of Greens and Zinc Creeks. The sands, which compose this habitat type, are coarse and contain a high proportion of gravel, some cobble, some silt and clay of glacial origin, and low amounts of organics (~2%) (Holland, *et al* 1981). Brown algae and green algae are attached to hard surfaces in this habitat along with mussels, barnacles, and snails. Amphipods and polychaetes burrow in the sands and live under the algae. The sands provide habitat for numerous pelecypod species. Little neck clams, cockles, butter clams and gaper clams are abundant in the intertidal sands in the vicinity of Outfall 002. The 1981 survey results indicated that five 1-meter square quadrats averaged 99,900 individuals each, representing 36 species or groups – 93% of individuals counted belonged to the sponge family, foramanifera. Major predators feeding in this habitat are the starry flounder, shore birds, ducks, and river otters.

Submerged Sill Habitat. The submerged sill habitat, composed of a mixture of sand, gravel, shells and cobble, occurs mainly near the entrance of Hawk Inlet and also immediately behind the Greens Creek delta This habitat is basically an extension of the Greens Creek Delta into subtidal areas. The submerged sill habitat is productive and characterized by large numbers and a diverse assemblage of polychaetes, bivalves, gastropods and amphipods. Results of pre-mining dive surveys (Holland *et al* 1981) showed that 80 species or species groups occurred at an average density of 30,526 individuals per meter square. A few scallops have been collected from the vicinity of the sill. The sill habitat is an important feeding area for benthic- feeding fish, including cod, halibut, sole, and starry flounder. Dungeness crab also forage here and some shrimp have been collected. Humpback whale have been observed feeding over this habitat. Divers observed octopus, king crab and halibut in the deep areas behind the sill.

The diffuser for outfall 002 (-40 foot depth), mixing zone and sampling stations S1, STN1, ESL, and 008 (water column station) lie within this habitat zone.

Kelp Habitat. Beds of bull kelp, extend around Hawk Point and along the shores of Chatham Strait to a depth of approximately 65 feet. Smaller kelp beds are also present along the eastern and western shores of Hawk Inlet, especially near the head of the fjord and a small bed lies above the terminus of Outfall 002. Sediments under kelp beds are rocky to provide attachment for the holdfast but also interspersed with cobbles, mud, sand and shell debris.

The benthic biota occurring under the kelp beds are extremely productive and complex. Holland *et al* conducted replicate quadrat surveys in 1981 and showed that representatives of 69 species occurred in kelp bed habitats at a density of 67,352 individual organisms per square meter. In rocky kelp habitats, large anemones, starfish, and sea cucumber are abundant under the kelp. Amphipods and polychaetes are abundant in sediments under kelp. The kelp bed and associated edge habitat is an important feeding area for small fish, shrimps, whales, seals, and sea lion.

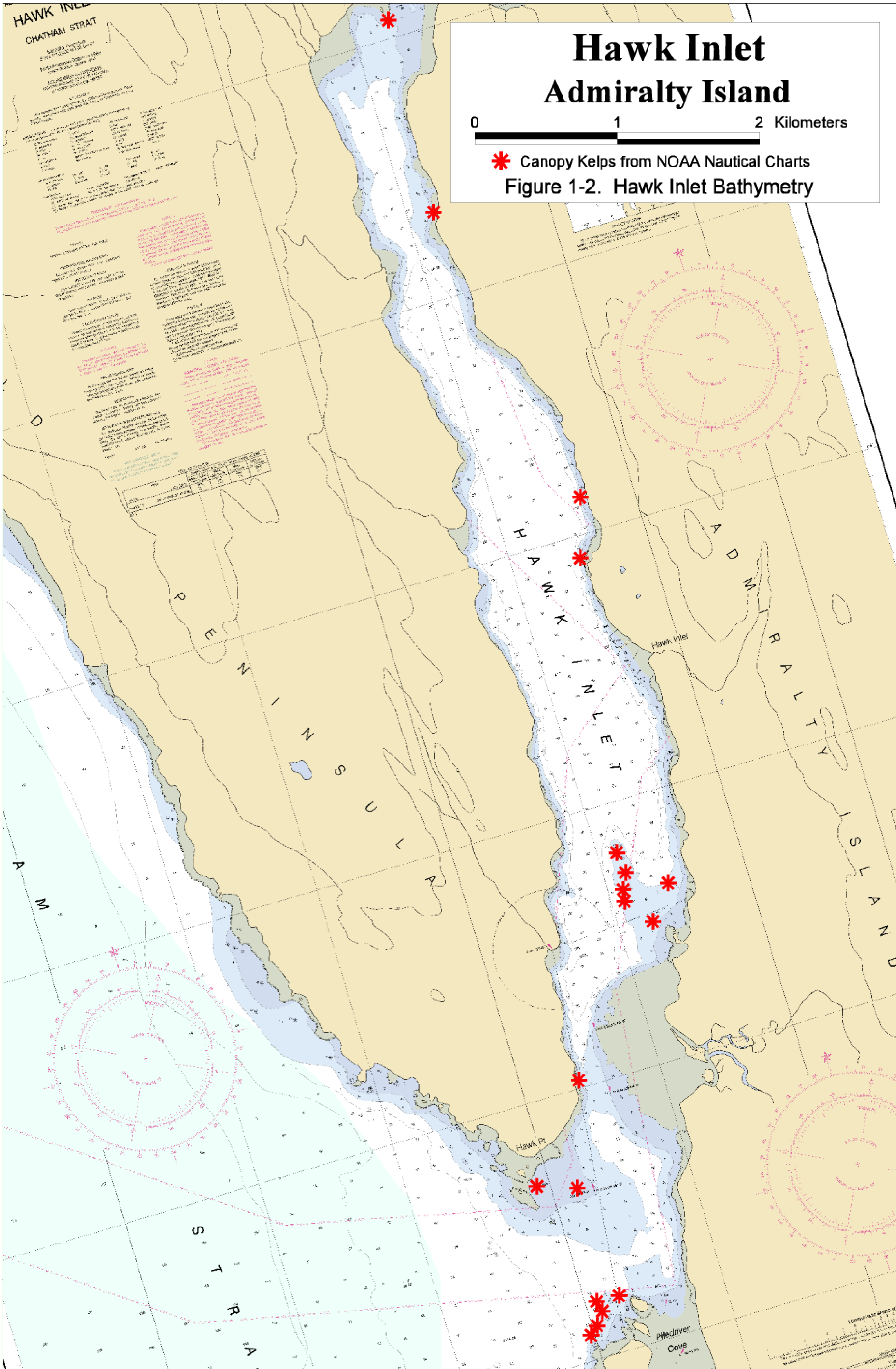


Figure 1-2. Hawk Inlet Bathymetry

Because of their protected location, kelp beds near the head of Hawk Inlet probably are important as nursery habitats for species with planktonic development stages as well as small fishes such as outmigrating juvenile salmon. Three species of brachiopods have been collected attached to rocks lying below the kelp bed at the end of the outfall pipe.

Rocky Habitats. Rocky habitats occur intertidally and subtidally throughout much of Hawk Inlet and along the shore of Chatham Strait in the vicinity of Hawk Point. Inside Hawk Inlet, the rocky habitats are steep and relatively narrow. However, along the shores of Chatham Strait, rocky habitats are gently sloping, and small, protected sand and cobble beaches occur in protected coves.

Patches of sand have been observed subtidally in protected locations. Seaweed, mussels, barnacles, limpets, and snails are abundant in intertidal rocky habitats. Anemones, sea urchins, sea stars, and numerous species of tidepool fish are abundant in the many tidal pools. No commercially or recreationally harvested species occur in this habitat in large numbers, although mussels have been monitored for bulk tissue concentration along the rocky shore west of Outfall 002.

1.1.3 Marine Fish and Shellfish

Information on Hawk Inlet fisheries is derived from numerous investigations conducted by government agencies and Greens Creek consultants. Otter trawl, gill net and public survey information has indicated the presence of several commercial and non-commercial fish and shellfish species—salmon, flathead sole, yellowfin and rock sole, arrowtooth and starry flounder, Pacific cod, white-, spotted and masked greenling, and shortfin eel pout. Halibut were also observed. Non-commercial species present included snake prickleback, sturgeon poacher, staghorn, great and spiny head sculpin, Pacific sandlance, daubed shanny, and copper rockfish. Schools of herring in spawning condition occur in the Inlet during spring (Carlson 1999).

As described above, shellfish species in Hawk Inlet include extensive clam beds, with little necks, cockles, soft-shell clam, horse clam and mussels. Tanner, Dungeness, king and hermit crabs are also abundant in shallow and deep Hawk Inlet habitats.

Federally managed fish and shellfish and their prey, as well as salmon in Hawk Inlet, are described under the Essential Fish Habitat section 1.2, below. The health of marine habitats and biota prior to operations and during the mine's production years to date is also discussed later in this section.

1.1.4 Hawk Inlet Area Fisheries

Sport, commercial and subsistence fishery data provides additional information on the species and abundance of marine life in the Hawk Inlet area. The intensity of subsistence, sport, and commercial fishing within Hawk Inlet is not well documented. Sport fishing is discussed in the recreation section, and subsistence harvests of clams, crab and fish are described under the subsistence section. Commercial fishery harvests in the vicinity of Hawk Inlet are reported under ADF&G statistical areas 345803 and 11216 (ADF&G, 2002). Pacific cod, sablefish, lingcod, and over a dozen species of rockfish are harvested annually in Hawk Inlet and in adjacent waters of Chatham Strait (Table 1-3). All species of Pacific salmon, as well as Dungeness crab, brown crab, red king crab and bairdi Tanner crab are harvested inside Hawk Inlet and in Chatham Strait. The total volume of fish (except halibut), shellfish and salmon harvested in this vicinity was 9.3 million pounds in 2001.

Halibut harvests for Hawk Inlet are reported as part of a much larger region, and do not reflect the amount of fish taken from the project area. Historical information indicates that occasional commercial halibut fishing in the area yielded some large catches during 1914 to 1976, when the cannery was open. Since that time smaller vessels fish individual fishing quotas near and occasionally inside of Hawk Inlet. Commercial fishing and tender vessels occasionally use Hawk Inlet as a mooring site.

Table 1-3 Hawk Inlet Area Fish and Shellfish Harvest Data

Harvest Data for Stat Area 112-16 & 345-803 for 2001				
Year	**Species Name**	**Number**	**Pounds**	**Permits**
2001	Pacific (gray) cod		2,819.18	11
2001	arrowtooth flounder, lingcod, bocaccio & black rockfish		2,822.85	4
2001	thornyhead rockfish		2,573.87	28
2001	yelloweye & canary rockfish		287.82	8
2001	quillback rockfish		63.1	4
2001	rougheye rockfish		4,123.36	28
2001	shortraker rockfish		5,045.38	22
2001	redbanded, dusky & silvergray rockfish		2,291.18	23
2001	king salmon	118	1915	24
2001	king salmon	45	214	5
2001	sockeye salmon	37,117	23,0733	85
2001	coho salmon	31,341	22,6931	91
2001	pink salmon	2,364,402	8,035,198	85
2001	chum salmon	86,645	689,129.5	85
2001	sablefish (blackcod)		138,414.4	18
2001	dungeness, red king, brown king & bairdi Tanner crab	4,061	9,626	4
		Total pounds	**9,352,188**	

Data source: Zephyr, Neptune & Venus Databases, Run 05/02/02
Alaska Department of Fish and Game, Division of Commercial Fisheries

1.1.5 Freshwater Aquatic Biota and Habitats

The fresh water aquatic environment in and near the project area displays a wide variety of physical and hydrological forms and conditions, and therefore a wide variety of habitat values for aquatic species. Extensive detail on physical conditions at the mining site, adjacent wetlands, stream chemistry and other information on aquatic habitats are provided in the 2003 FEIS. The results of recent efforts to characterize habitats and species diversity at Greens Creek and Tributary Creek are provided here. Further descriptions of anadromous waters are found in the following section.

The Alaska Department of Fish and Game, Kennecott Greens Creek Mining Company, and the US Forest Service, in cooperation with the US Fish and Wildlife Service initiated a freshwater biomonitoring program in two locations, currently influenced by tailings contact water – Greens Creek and Tributary Creek in 2001, and compared features with reference sites within the same drainages (ADF&G 2001). Results from the first two years indicate:

- Greens Creek and Tributary Creek continue to sustain complex, diverse aquatic communities and population levels similar to the reference site;
- Periphyton biomass and community composition appears to be robust;

- Periphyton biomass in the affected site in Greens Creek was similar to that of Greens Creek reference site and mayflies (*Ephemeroptera*) dominated both sites;
- Aquatic invertebrate communities are taxonomically rich and abundant
- Populations of many pollution-sensitive taxa remain intact;
- Mayflies were slightly dominant at Tributary Creek, where non-insect invertebrates, true flies and stoneflies were identified as important components of the aquatic community.
- Juvenile fish (Dolly Varden and coho salmon) populations with many age classes were present at both affected sites.

1.2 Essential Fish Habitat and Habitat Areas of Particular Concern

Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act requires Federal agencies to consult with NMFS on all actions that may adversely affect Essential Fish Habitat (EFH). The US Forest Service and NMFS letter of agreement regarding the EEH consultative process (Pennoyer 2000) provides guidance for USFS EFH consultations, using NEPA procedures.

Essential Fish Habitat (EFH) includes those waters and substrata necessary for fish spawning, breeding, rearing, and growth to maturity. In the context of EFH, "fish" refers to federally managed fish or shellfish species and their prey. EFH includes all segments of streams where salmon reside during any period of the year as well as the marine waters, substrates and biological communities of Hawk Inlet.

The National Marine Fisheries Service has identified Hawk Inlet as EFH for several marine and anadromous species. The NMFS queriable EFH database (www.fakr.noaa.gov\efh) and all other sources of data, including dive surveys, commercial and sport fishing data, and research data were used to develop the following list of species having EFH in Hawk Inlet. In addition to federally managed groundfish and shellfish, species listed in Hawk Inlet include major prey species, such as forage fish and shrimp (per Miller, 2003). Note that Scarlet king crab (*Lithodes couesii*) was listed on the NMFS EFH database as having EFH in Hawk Inlet. Due to the depth profile of the Inlet and life history of Scarlet king crab, its presence is implausible. This species has been removed from further EFH consideration this document. Although harvest data and very limited survey data confirm the presence of these species, data are not available on the populations of these species occupying Hawk Inlet.

Marine habitats and biotic communities within Hawk Inlet that support marine species are described above. Anadromous habitats are described in the following section. Habitat associations for some marine species with EFH in Hawk Inlet are also provided in Table 1-5, below. Habitats used by marine species during sensitive life history stages, breeding, or feeding periods provides insight for anticipating potential effects by the proposed project. The physical loss of habitat can negatively affect an organism's survival.

Table 1-4 FMP Managed Species with EFH in Hawk Inlet and adjacent watersheds.

Federally Managed Species		
Common Name	**Scientific Name**	**Life History Stage**
Walleye pollock	*Theragra chalcogramma*	eggs,juveniles,mature
Flathead sole	*Hippoglossoides elassodon*	Not specified
Yellowfin sole	*Limanda aspera*	Not specified
Arrowtooth flounder	*Atheresthes stomias*	Not specified
Sablefish	*Anoploploma fimbria*	Not specified
Pacific ocean perch	*Sebastes alutus*	Not specified
Rock sole	*Lepidopsetta bilineatus*	Not specified
Pacific cod	*Gadus macrocephalus*	Not specified
Sculpins (9 species)	Family Cottidae	Not specified
Pacific salmon	*Onchorynchus* sp.	Egg, juvenile, adult
Pink salmon	*O. gorbuscha*	Egg, juvenile, adult
Chum salmon	*O. keta*	Egg, juvenile, adult
Coho salmon	*O. kisutch*	Egg, juvenile, adult
Forage Fish Complex		
Eulachon	*Thaleichthys pacificus*	Not specified
Rainbow smelt	*Osmerus mordax*	Not specified
Pacific herring	*Clupea harengus*	Not specified
Shrimp	*Pandalidae, Crangonidae*	Not specified
Squid	*Loligo*	Not specified
Octopus	*O.dofleini/rubescens*	Not specified
Red king crab	*Paralithodes camtchatica*	Not specified
Snow crab	*Chionocetes opilio*	Not specified
Tanner crab	*Chionocetes tanneri*	Not specified

Beyond the physical structure of a habitat, the prey species and abundance the habitat supports also influence essential fish habitat quality. Chemical composition of these habitat features may directly affect fish and shellfish directly through skin and gill absorption or through consumption of chemically altered foods and sediments.

The general feeding strategies of species listed in the EFH table, above are as follows:

Walleye pollock feed throughout the water column, on pelagic crustaceans (copepods, euphausiids), and other young fish,and highly are cannibalistic on young pollock.

Sablefish feed throughout the water column, particularly in very deep (>100 fathom) waters. Early juveniles eat euphausiids. Juvenile and adults consume euphausiids, shrimp, cephalopods (octopus and squid), young sablefish, pollock, jellyfish, flatfish, capelin, herring, sandlance.

Pacific ocean perch feed throughout the water column on zooplankton, mainly euphausiids and calenoid copepods.

Pacific cod feed throughout the water column and near seafloor. Cod are omnivorous, typically feeding on euphausiids, pollock, yellowfin sole, arrowtooth flounder, polychaete worms, amphipods, crab, crangonid shrimp, bivalves (etc). Young cod feed mostly on invertebrates, and adults feed largely on fish.

Rocksole feed in sandy areas containing polychaetes, bivalves, amphipods and crustaceans.

Arrowtooth flounder feed in gravel-mud substrates near the seafloor. The diet of larvae includes phytoplankton and zooplankton. Late juveniles feed on euphausiids, crustaceans, amphipods and young pollock. Adults consume gadids, euphausiids and other groundfish.

Flathead sole larvae consume phytoplankton and zooplankton, adults and juveniles feed on polychaete worms, brittle stars, pollock and small tanner crab.

Sculpins (9 species) feed near bottom, but some species make excursions to the sea surface for catching larger fish prey. Prey items include crabs, barnacles and mussels. Fish and shrimp are targetted by larger sculpin species. Larvae consume copepods.

Pacific Salmon

Adults are primarily fish eaters. Coho and chinook prey on forage fish, pelagic crustaceans, squid and sablefish juveniles.

Juveniles consume plankton and small crustaceans: copepods, amphipods and various species of meiofauna.

Forage Fish Complex are plankton feeders, primarily feeding in the water column. Herring spend a great deal of daytime hours feeding/resting/hiding in schools on the seafloor, especially during winter months. Throughout the year, herring migrate vertically to the surface to feed at night, and into deeper waters to avoid predators by day.

Shrimp Crangon shrimps feed on seafloor dwelling crustaceans and detritus. Pandalid shrimps feed primarily in the water column on phytoplankton.

Squid feed in water column primarily on zooplankton.

Octopus feed mainly along the seafloor, on crabs, sea urchins and bivalves.

King and Tanner Crab feed exclusively on the seafloor. Their broad diet consists of polychaete worms, crabs, bivalves, starfish, brittle stars, etc.

Beyond assessing prey preferences of organisms in Hawk Inlet, understanding their feeding strategies in the context of food web connections is important for contemplating pathways for contaminant transfer and ecological shifts that may result from natural or anthropogenic influences.

The food webs for three prominent species in Hawk Inlet are provided in the following figures. Each of these species or groups -- polychaetes worms, tanner crab, and Pacific halibut, occupy different niches, feeding guilds, habitats, and trophic levels. These food webs were modeled for Taku Inlet Basin, a site in northern southeast Alaska less than 20 miles from Hawk Inlet, but interrelationships among species are appropriate for Hawk Inlet as well.

Polychaetes and bivalves are abundant, and play a major role in marine demersal food webs. Bivalves and worms are largely filter and or deposit feeders living in close association with the seafloor, and therefore would encounter heavy metals that may have adsorbed to organic particles dropping out of the water column or metals that concentrate in seafloor sediments. Both halibut and tanner crab consume polychaetes and bivalves, and live close to the seafloor as well. These and other higher trophic level organisms may be susceptible to ingesting metals potentially accumulating in worms and bivalves, through the lethal and sub lethal effects of those metals are not fully predictable.

Figure 1-3 Polychaete Worm Food Web

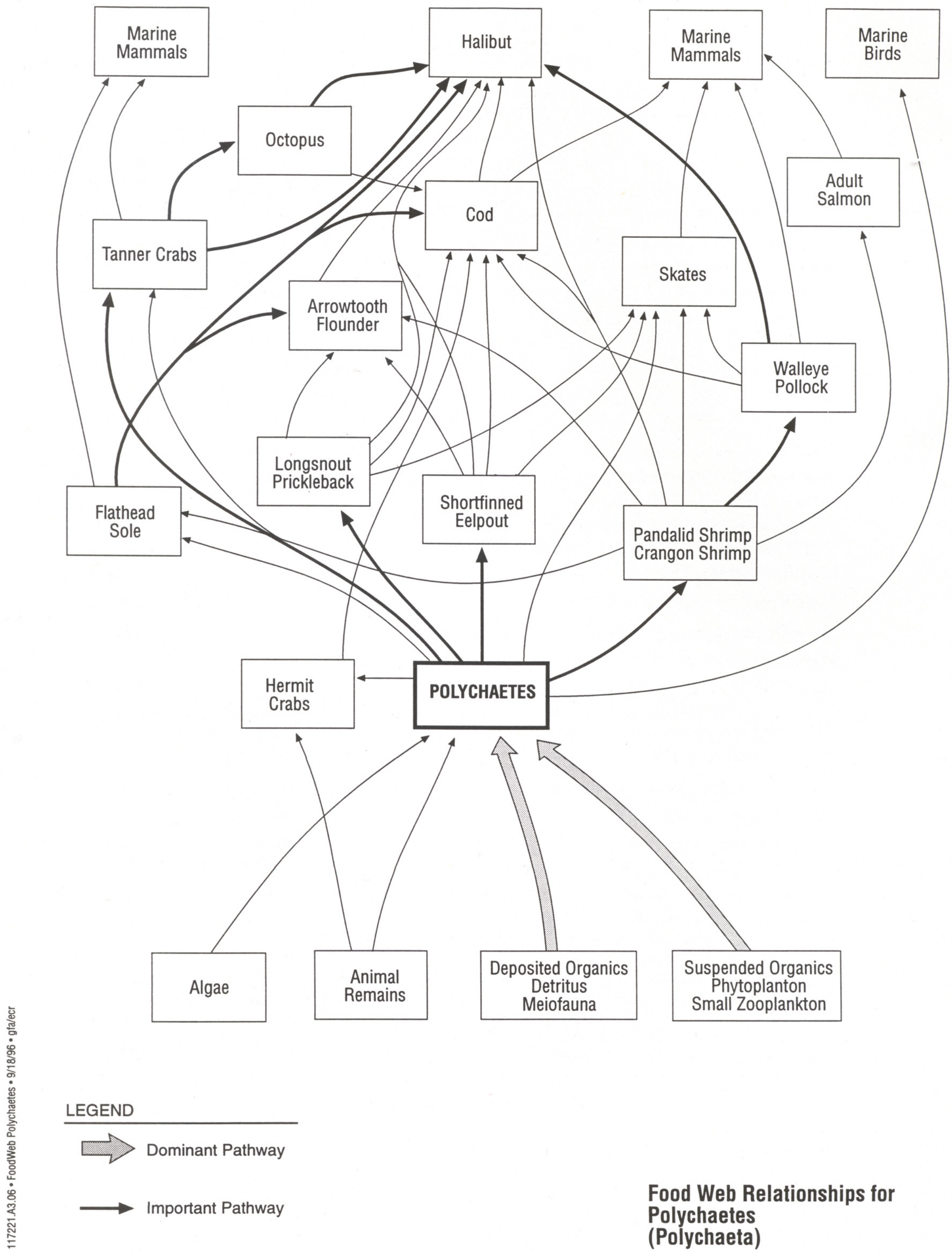


Figure 1-4 Tanner Crab Food Web

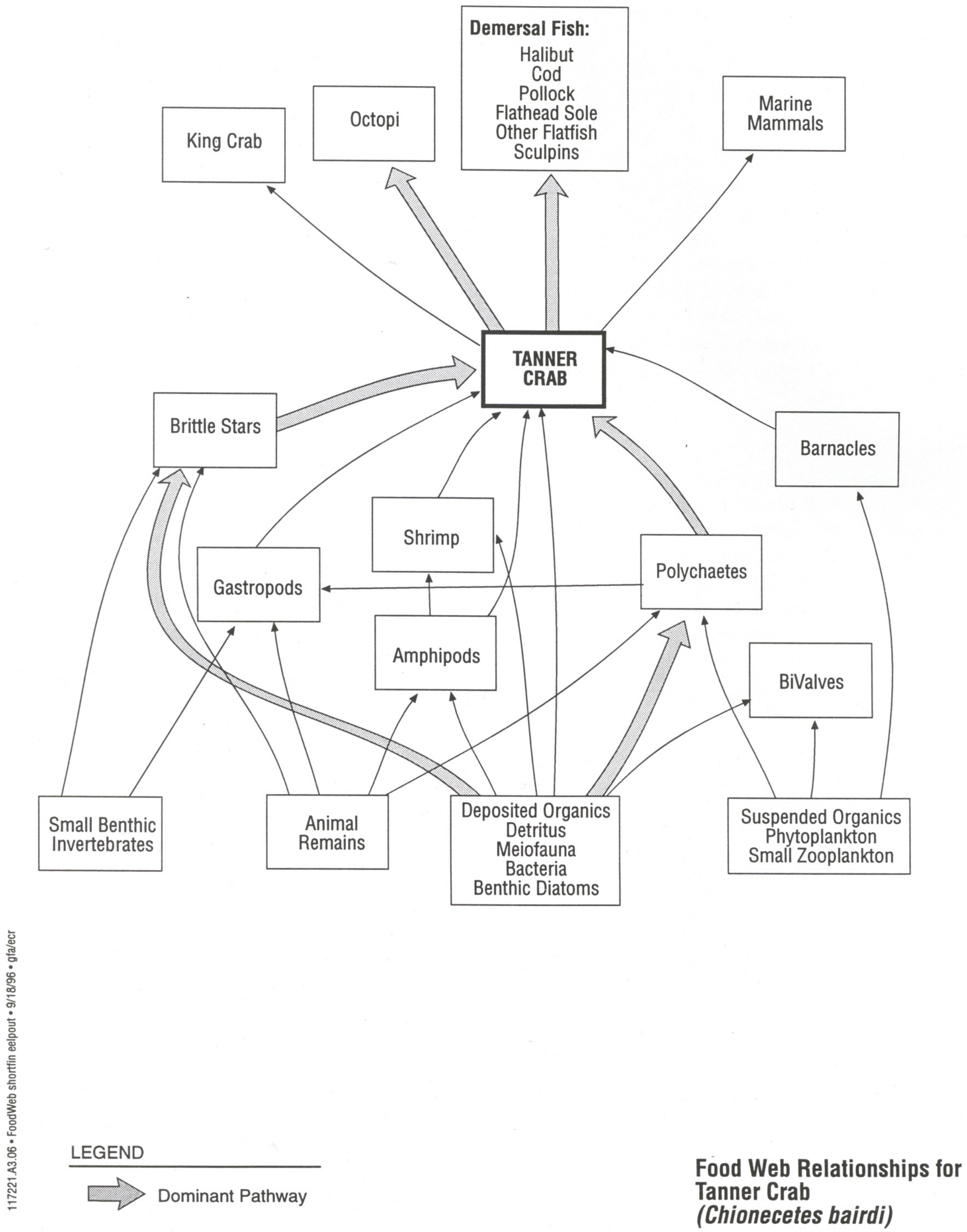


Figure 1-5 Pacific Halibut Food Web

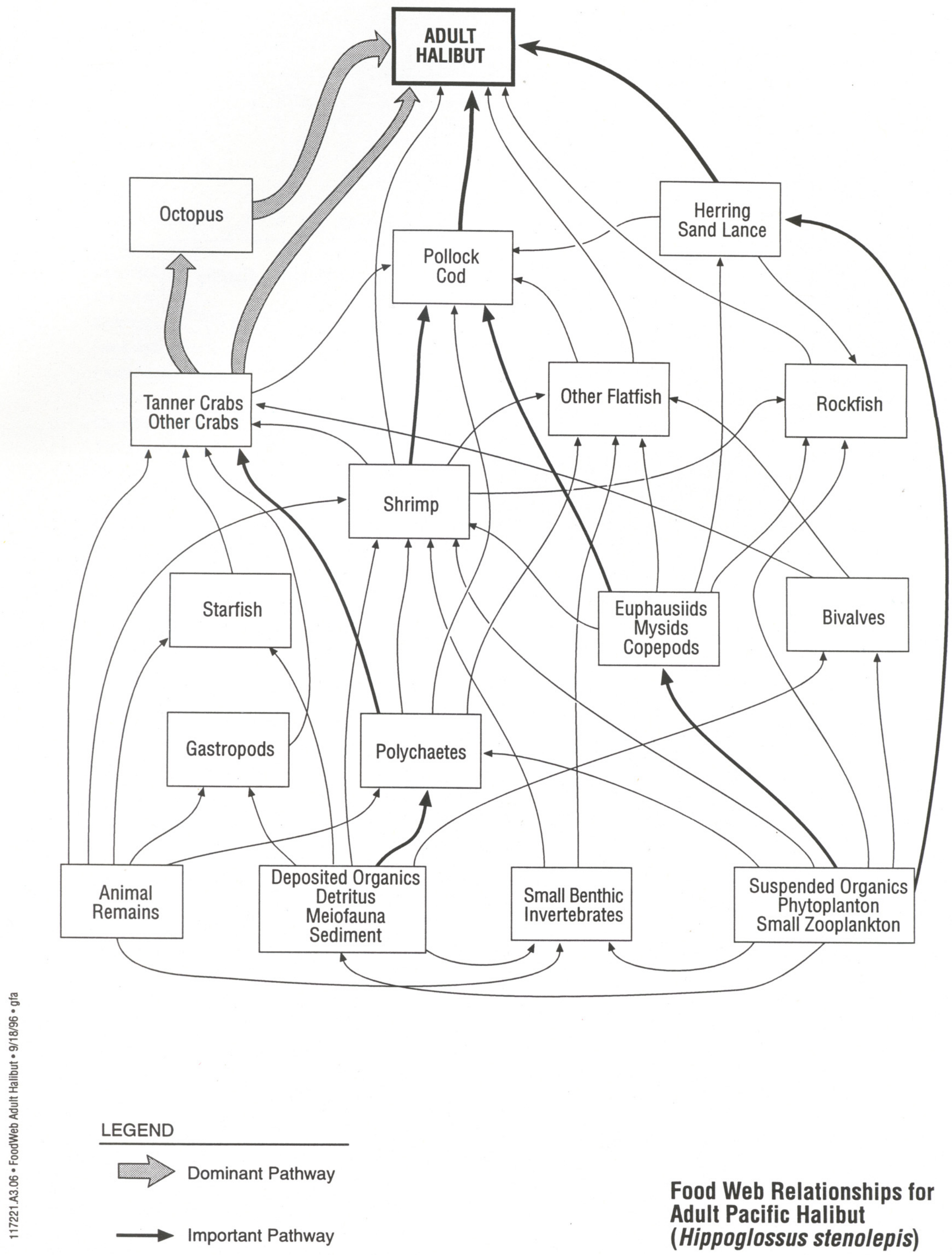


Table 1-5 Selected Federally Managed Marine Fish Habitat Associations

Habitat Associations for Selected Marine Species having Essential Fish Habitat in Hawk Inlet * = habitat occurs in Hawk Inlet

		Location										Substrate								Veg.		Pelagic Domain					Oceanography					
	Life Stage/Activity	Beach (intertidal) *	Inner Shelf (1-50 m) *	Middle Shelf (50-100)	Outer Shelf (100-200 m)	Upper Slope (200-1000 m)	Lower Slope (>1000 m)	Basin (<3000 m)	Bay/Estuarine **	Island Pass	Not Known	Mud/Clay/Silt *	Sand/Granule *	Gravel *	Pebble *	Cobble *	Boulder *	Bedrock *	Not Applicable	Kelp Forest *	Sea Grasses *	Near Surface *	Pelagic *	Semi-demersal/Semi-pelegic	Demersal *	Not Known	Upwelling Areas	Gyres		Fronts	Edges (ice, bathymetric)	Life Stage/Activity
Pacific Cod	A		x	x	x							x	x												x							A
	LJ		x	x	x							x	x												x							LJ
	EJ	x	x									x	x												x							EJ
	L										x								x			x										L
	E		x	x	x							x	x												x							E
Walleye Pollock	A				x			x															x	x			x	x		x	x	A
	J		x	x	x					x									x				x					x	x	x		J
	L				x														x				x					x		x		L
	E				x	x		x											x				x					x				E
Yellow Fin Sole	A	x	x	x	x				x				x												x						x	A
	LJ		x	x	x				x				x												x							LJ
	EJ		x	x	x				x				x												x							EJ
	L	x	x						x										x				x									L
	E	x							x										x				x									E
Flathead Sole	A		x	x	x							x	x												x						x	A
	LJ		x	x	x							x	x												x							LJ
	EJ		x	x	x							x	x												x							EJ
	L		x	x	x														x				x									L
	E		x	x	x														x				x									E
Rock Sole	A		x	x	x								x	x											x						x	A
	LJ		x	x	x				x				x	x											x							LJ
	EJ		x	x	x				x				x	x											x							EJ
	L		x	x	x																		x									L
	E				x																				x							E
Arrowtooth Flounder	A		x	x	x	x			x			x	x	x											x						x	A
	LJ		x	x	x	x						x	x	x											x							LJ
	EJ		x	x	x	x						x	x	x											x							EJ
	L		x	x	x				x														x									L
	E		x	x	x																		x									E
Sculpins	A	x	x	x	x	x						x	x	x											x							A
	J	x	x	x	x	x						x	x	x											x							J
	L		x	x	x	x													x			x	x									L
	E	x	x	x	x									x	x	x									x							E

1.2.1 Anadromous Fish Streams

Essential Fish Habitat includes those waters necessary for spawning, breeding, feeding, and growth to maturity. Although all five species of Pacific salmon are found in Hawk Inlet, it is considered EFH only for pink, chum and coho by the National Marine Fisheries Service. Habitats occupied by pink, chum, and coho salmon during various life history stages are described in Table 1-6 below. Specific habitats in the project area and in the Greens Creek-Tributary Creek drainage are detailed in the following section.

Table 1-6 Salmon EFH and HAPC – Marine Habitat and Natal Streams

		Coho, Pink and Chum Salmon Habitat Associations *Habitat Feature found in Hawk Inlet and Adjacent watersheds																																											
		Habitats					Benthic Domain										Structure, Substrate, and Vegetation																						Pelagic Domain				Oceanography		
							Shelf			Slope			Canyon				Structure										Substrate								Vegetation										
	Life Stage/Activity	Fresh water *	Estuarine *	Nearshore (50-200m) *	Offshore (>200m)	Vertical Depth (m)	Intertidal *	Subtidal (<30m) *	[break]) *	Upper (Break-500m)	Intermediate (500-1000m)	Lower (>1000m)	Head (<100m) *	500m)	Lower (>500m)	Not Known	Bars *	Banks *	Sinks	Slumps/Rockfalls/Debris Field	Channels	Ledges	Pinnacles	Reefs	Vertical Walls	Artificial	Organic Debris *	Mud/Clay/Silt *	Sand/Granule *	Gravel *	Pebble *	Cobble *	Boulder *	Bedrock *	Estuarine, e.g., algal cover *	Kelp Forest *	Marine, e.g. Sea Grasses *	Not Known	Near Surface *	Midwaters *	Near Bottom *	Not Known	Temperature (Celsius)	Salinity (ppt)	Life Stage/Activity
Coho Salmon	EI	M																												M	M														EI
	JF	M																																					M	M	M				JF
	JE		M	M																																			M						JE
	JM		M	M	M	<50M											M	M			M	M	M	M	M	M													M				<15C		JM
	AM			M	M	<200M											M	M			M	M	M	M	M	M													M	M			<15C		AM
	AF	M	M																																										AF
Pink Salmon	EL	M	M				M																							M	M														EL
	JF	M																																					M						JF
	JE		M	M																																			M						JE
	JM		M	M	M	<50M											M	M			M	M	M	M	M	M													M	M			<15C		JM
	AM			M	M	<200M											M	M			M	M	M	M	M	M													M	M			<15C		AM
	AF	M	M				M																																						AF
Chum Salmon	EL	M	M				M																							M	M														EL
	JF	M																																							M				JF
	JE		M	M																																					M				JE
	JM		M	M	M	<200M											M	M			M	M	M	M	M	M													M				<15C		JM
	AM			M	M	<200M											M	M			M	M	M	M	M	M													M	M	M		<15C		AM
	AF	M	M				M																																						AF

EL- Early Larvae JF – Juvenile Female JE – Juvenile JM – Juvenile Male AM- Adult Male AF – Adult Female

1.2.2 Freshwater and Salmon Habitat: Original Conditions

The overall project area for the proposed tailings pile project includes all or portions of three watersheds (Figure 1-6):

- Greens Creek
- Zinc Creek
- Tributary Creek (tributary to lower Zinc Creek)

General descriptions of the aquatic environments of these systems were given in the Greens Creek FEIS (USDA, 1983), along with descriptions of Cannery Creek, Piledriver Creek, and several unnamed creeks that enter the head of Hawk Inlet.

Fish surveys were conducted in the early 1980's in all of the water bodies listed above (Buell, 1981). It was found that, in general, the stream systems in and near the project area supported a varied and abundant fish fauna reflective of species in the region. Migration barriers heavily influenced distribution of anadromous species; if access was available, anadromous fish were present (other limiting factors did not appear to influence distribution). Above anadromous fish barriers, resident fish distribution appeared to be governed by perennial stream flow. The anadromous fish passage that KGCMC constructed in 1989 opened substantial additional habitat. A summary of fish survey results is given in Table 1-7.

The following descriptions of the potentially affected fresh water aquatic environment are derived from the Greens Creek FEIS (1983) and associated documents, subsequent environmental documents and direct observations. Salmon spawning in any of these streams and juveniles emerging from streams will migrate through Hawk Inlet, which does have the potential to be affected by mining activities, and associated infrastructure. Streams are part of the EFH in the area.

Table 1-7 Fish Species Found in Streams in or near the Greens Creek Mine Project Area

Creek	Juveniles / resident adults						Anadromous adults			
	Coho	Cutthroat Trout	Dolly varden	Sockeye	Sculpin	Stickleback	Pink	Chum	Dolly Varden	Coho
Greens Creek	++	++	++	0	++	+	++	++	++	++
Zinc Creek	++	+	++	0	++	+	++	++	+	+
Tributary Creek	+	+	+	0	++	0	++	0	+	+
Young Bay Trib.	++	++	+	+	++	++	0	0	?	+
Fowler Creek	++	+	++	0	++	+	++	+	++	+
Lower Fowler Trib.	++	+	++	0	?	0	0	0	?	+
Upper Fowler Trib.	0	0	0	0	0	0	0	0	0	+
Lower G.C. Trib.	0	0	0	0	0	0	0	0	0	0
Piledriver Creek	++	0	+	0	++	+	+	+	+	0
Piledriver Cr. Trib.	++	0	+	0	?	0	0	?	?	+

Upper Hawk Tribs.	+	?	+	0	++	++	+	?	?	?
Pristine Pond	0	0	0	0	0	0	0	0	0	0
Cannery Creek	0	?	?	0	0	0	0	0	0	0
Abundance indicators: ++ = abundant; + = moderate occurrence or few; 0 = not found; ? = presence strongly suspected but not confirmed. Observations were made in the early 1980's										

Greens Creek and Significant Tributaries. Greens Creek originates in glacial cirques on Admiralty Island with a maximum elevation of 4,600 ft (Eagle Peak) and flows generally westward through steep relief, draining a watershed of approximately 18 square miles. It flows into the lower end of Hawk Inlet over a significant intertidal delta, which it shares with Zinc Creek. Stream length from the headwaters to tidewater is approximately 10 miles. The average gradient of Greens Creek is 2.7 percent; the gradient is much steeper in the upper reaches above Big Sore Creek, which is tributary to Greens Creek at approximately River Mile 7.2. Middle Greens Creek, between Big Sore Creek and Greens Creek Falls at approximately River Mile (RM) 3.6, has a moderate gradient of just over 2 percent; lower Greens Creek, between the falls and tidewater has a shallow gradient between 1 percent and 2 percent (Buell, 1981).

Table 1-8 Salmon Run Estimates for Greens Creek, Hawk Inlet

YEAR	Pink Salmon	Chum Salmon
1961	7,300	500
1962	1,250	n.s.
1963	9,000	7,000
1964	n.s	3,500
1965	2,750	n.s.
1966	1,500	5,025
1967	2,500	1,500
1968	4,100	1,800
1969	13,400	1,000
1970	7,300	200
1971	11,000	500
1972	2,500	4,100
1973	11,000	2,000
1974	1,100	200
1975	3,100	1,500
1976	400	400
1977	15,000	4,000
1978	16,300	700
1979	16,000	6,000
1980	7,800	3,200
1981	15,000	*Not Available*
1982	10,000	*Not Available*
1983	6,500	*Not Available*
1984	5,600	*Not Available*
1986	6,000	*Not Available*
1988	7,000	*Not Available*
1989	20,000	*Not Available*
1992	14,600	*Not Available*
1993	14,000	*Not Available*
1994	34,000	*Not Available*
1995	18,000	*Not Available*
1996	3,700	*Not Available*
1997	53,000	*Not Available*
1998	2,600	*Not Available*
1999	50,000	*Not Available*
2000	800	*Not Available*
2001	21,000	*Not Available*
2002	3,000	*Not Available*

In 1989 the high Greens Creek Falls were modified to allow upstream fish passage as mitigation for the mining project (see below). A series of cataracts and falls in Greens Creek above Big Sore Creek continue to constitute anadromous fish migration barriers. Stream substrate materials in Greens Creek range from bedrock in confined channel areas above Big Sore Creek and at Greens Creek Falls to deep, uncompacted sand mixed with fine gravel on the Delta. Substrate materials and channel morphology generally reflect stream gradient, with a high pool: riffle ratio in Middle Greens Creek to long gravel riffles in lower reaches near the delta.

Large woody debris significantly affects channel morphology in Lower Greens Creek but, although abundant, exerts less control in the steeper reaches of Middle Greens Creek. Lower Greens Creek upstream of the grassy delta is in deep shade. Upstream of Greens Creek Falls, the canopy is generally open. Between Greens Creek Falls and the Delta the stream channel has regions of extensive braiding, caused mostly by the abundance of large woody debris and low landform relief. This area contains an abundance of excellent juvenile salmonid rearing habitat along with abundant spawning habitat for anadromous salmonids.

Excellent coho spawning habitat is present between the braided channel area and the delta; excellent pink and chum spawning habitat is present in the delta area (Buell, 1981).

Lower Greens Creek supports significant runs of pink and chum salmon. Data are collected annually by ADF&G to produce estimates of run strength for these two species. The data presented here are ADF&G peak escapement estimates, based on one to several surveys per season. 1982 – 2002 chum salmon data are highly variable due to survey limitations. Chum counts in those years varied from 200 to 11,500 fish per year, and chum were seen in Greens Creek during all survey years (K. Monagle, pers. comm. 2003)

Greens Creek also supports anadromous runs of coho salmon, Dolly Varden char and coastal cutthroat trout, although these are not routinely enumerated. Rearing juvenile and adult island king salmon have been observed in the middle and lower reaches of Greens Creek (Buell 1981; Kaelke and Kaelke 2003).

Figure 1-6 Greens Creek Drainage Basins

Zinc Creek. Zinc Creek drains an area of about 5 square miles south of the lower Greens Creek watershed. The channel length is approximately 3.4 miles from a very steep headwater area at about 1,000 ft. elevation to the delta on Hawk Inlet that this creek shares with Greens Creek. A falls constituting a barrier to upstream anadromous fish migration is present at approximately RM 2.2. Upstream of this falls, the gradient is steep, ranging from 4 percent in lower reaches to 16 percent in the headwater area. Downstream of the falls channel gradients vary between 1-2 percent. In lower Zinc Creek the channel is braided in many areas due to abundant large woody debris and low landform relief. Excellent coho spawning and rearing habitat is present throughout. The pool: riffle ratio in this area provides an excellent mix of habitat elements for both spawning and rearing. Excellent pink and chum spawning habitat is abundant in the delta area. Coho rearing habitat is excellent in backwater areas and brackish sloughs (Buell, 1981).

Tributary Creek. Tributary Creek enters Zinc Creek from the north at approximately RM 0.8 and drains a watershed of approximately 1 square mile. At the time of writing of the FEIS, the stream channel was approximately 2.2 mi long and had a very low gradient, especially in headwater areas, which consisted of muskeg. Mine development changes have been limited to disturbance to headwater muskeg in the Tributary Creek watershed. At the time of writing of the FEIS, the lower 5,600 ft (1.06 miles) of Tributary Creek was accessible to anadromous fish. Channel geometry in this area remains narrow and incised; pools are not abundant.

Although small, this stream is governed by large woody debris and continues to provide good rearing habitat for coho salmon, Dolly Varden char and cutthroat trout, although pool depth rarely exceeds 1.5 feet. Limited spawning habitat is present, but the stream is used for spawning by pink and chum salmon to some extent. Coho spawning habitat is extremely rare, but some small gravel patches in the lower reaches are adequate for Dolly Varden and cutthroat. Because of potential impacts to the aquatic environment anticipated in the original FEIS, a special anadromous fish population and habitat study was undertaken for Tributary Creek in 1981.

Three reaches in Tributary Creek were repeatedly electro-fished and rearing juvenile salmonid populations were calculated (using Petersen tag-recapture method after Ricker 1958). The result determined that the densities of yearling and young-of-the-year coho ranged from 10-12 YOY/100 ft. and 8-9 yearlings/100 ft. Cutthroat juvenile densities ranged from 8-9-fish/100 ft.; juvenile Dolly Varden densities ranged from 6-9-fish/100 ft. (Buell, 1981). Presence of about 180 square feet of good anadromous fish spawning and 0.4 acres of rearing habitat was documented for the entire accessible length of Tributary Creek (about 7,400 feet).

Big Sore Creek. Big Sore Creek drains a watershed of approximately 1.5 square miles and is tributary to Greens Creek at RM 7.2. The stream arises in glacial cirques over 3,000 feet in elevation and flows generally northward for approximately 1.7 miles. The stream gradient is very steep over most of this length with a gradient averaging 16 percent; anadromous fish access is impossible except for the lowest extremity of this stream near its confluence with Greens Creek. The stream is unstable as are the steep slopes of its lower watershed. Debris jams incorporating large logs, smaller woody debris, and rock rubble are common throughout the stream. Between log and rock debris jams the stream has a terraced, cascading bedrock and boulder channel. Many active slope failures are present. Riparian vegetation is thin due to the unstable nature of the watershed and particularly the stream margins. In the lowest extremity of Big Sore Creek the pool: riffle ratio is 0:3 and pools rarely exceed 2 feet in depth. Distribution of resident and (potentially) anadromous fish is probably limited to this short reach. The bed load from Big Sore Creek has formed a significant deposit of rock rubble and large woody debris (Buell, 1981).

Pristine Pond. This water body is a small, perched lake with a surface area of about 7.5 acres lying at about 300 feet of elevation on the ridge separating the Greens Creek and Piledriver Creek watersheds. The natural outlet of the lake is elevated by beaver dams and drains at a rate of about 1 cubic foot per second (cfs) summer base flow to the northeast into Greens Creek. Soundings indicate a maximum depth of 55 feet. This lake receives inflow from the surrounding hills and a muskeg to the east. A fish survey consisting of experimental gillnetting, echo-sounding in the lake itself, and electro-fishing of the outlet could not confirm any fish presence, although the lake could probably support resident Dolly Varden if they were introduced (Buell, 1981).

Lower Greens Creek Tributary. This small stream drains Pristine Pond (see above) flowing about 1.0 mile from that water body at elevation 300 feet northeast into Greens Creek at about RM 1.2. Average stream gradient is about 6 percent. Impassible barriers near its confluence with Greens Creek preclude access to this stream by anadromous fish, and electro-fishing in the upper and lower reaches could not confirm any resident or anadromous fish presence. Pool: riffle ratios are consistently about 0.5, with relatively abundant large woody debris exerting significant control over channel geometry. Surface flow from the headwater lake is augmented by springs throughout most of the channel length. Valley side slopes in the lower reaches are steep (about 20 percent) and moderately unstable. Bed transport in the lower reaches is significant (Buell, 1981).

Lower Piledriver Creek. Piledriver Creek drains a watershed of approximately 4.0 square miles located southwest of the Greens Creek drainage. The stream flows generally north-northwest and enters Chatham Strait at Piledriver Cove, immediately south of the mouth of Hawk Inlet. Summer base flow is about 8 cfs. Although the extreme upper portion of the Piledriver Creek drainage is at 3,000 feet of elevation, most of the watershed is low in elevation and of low relief. The perennial portion of this stream is about 2 miles in length. The upper portion of this area has a gradient of about 2 percent; bed materials are gravel and cobble, and large woody debris exerts significant control over channel morphology. Pool: riffle ratios in the upper portion of the perennial reach are 0:6-0:8 and most provide good-to-excellent rearing areas for juvenile coho, Dolly Varden and cutthroat.

Spawning areas for coho are small but adequate, averaging about 2-3 square yards at pool outlets, with some longer riffles present. Large numbers of juvenile coho were observed rearing in this area in the early 1980's. In addition, large numbers of adult pink and chum were observed spawning in lower Piledriver Creek where it passes through a meadow area and into tidewater. In this lower area, the channel geometry is no longer significantly affected by large woody debris, the gradient is shallow (about 1 percent) and the channel geometry is characterized by long, shallow riffles (Buell, 1981).

Piledriver Tributary. A small, unnamed tributary enters Piledriver Creek at about RM 0.5, draining the valley slopes to the northeast. This stream drains a watershed of about 1.0 square miles and flows at about 1.0 cfs summer base flow for about 0.8 miles from muskegs and flats at about elevation 250 to its confluence with Piledriver Creek. Stream gradient in the upper reaches is about 4 percent, decreasing to 2 percent in lower elevations. The lower 0.5 mile of this stream is used by significant numbers of pink and chum salmon for spawning; yearling coho and Dolly Varden were observed to be abundant in the lower 0.5 mile of this stream in the early 1980's (Buell, 1981).

Cannery Creek. Cannery Creek drains a watershed of about 1.0 square mile and a maximum elevation of just over 1,000 feet, located immediately east of the old cannery site, now the KGCMC buildings. The stream had served as a water supply for the cannery, and continues to provide water for KCGCM use. Cannery Creek flows generally east directly into Hawk Inlet over a steep rock bluff about 35 feet high into a very short gravel/cobble channel and onto an intertidal delta. Upstream of the bluff the stream channel is controlled by large woody debris and has a cobble/boulder substrate with occasional bedrock outcrops. Only minimal spawning habitat for resident fish is present, but rearing habitat for small resident salmonids is adequate for this small stream. However, electro-fishing efforts in the early 1980's were unable to confirm any resident fish presence (Buell, 1981).

Unnamed Tributaries to Upper Hawk Inlet. Four small streams enter upper Hawk Inlet along the north and west shores. The three northern-most streams have formed contiguous alluvial delta areas; the fourth has formed a small independent rocky delta. The three northern-most streams have good-to-excellent spawning habitat for pink and chum salmon in their lower reaches. All three were observed to have received moderate-to-heavy use during fish surveys conducted in the early 1980s; reds and carcasses were abundant and bear scavenging had been heavy. Large numbers of stickleback and sculpin and a few rearing juvenile coho and Dolly Varden were also documented. The western-most stream has a significantly steeper gradient (3-6 percent) and spawning habitat for anadromous fish is rare. Use was found to be very low in intensity during fish surveys in the early 1980's, corresponding to the spawning habitat quality and abundance. No juvenile salmonids were documented for this stream (Buell, 1981).

1.2.3 Freshwater and Salmon Habitat: Changes Since the 1983 FEIS

One of the most significant changes in this habitat was the implementation of a dry tailings disposal strategy. The change in strategy significantly reduced the total area of disturbance from a 150-acre wet tailings impoundment area designed to store 4 million tons of tailings behind an 80-foot high dam, to a 29-acre dry tailings disposal area and a 3.5 acre surface sediment pond well within the original wet tailings disposal footprint (USDA, 1988). This change greatly reduced the administratively determined impact of tailings disposal on the aquatic environment within the Tributary Creek drainage basin as shown in Table 1-9. (USDA, 1988). The entire spawning habitat in the Tributary Creek drainage was preserved by the dry tailings strategy (50 percent would have been lost) and 88 percent of the rearing habitat was preserved (75 percent would have been lost).

Table 1-9 Comparison of Effects of Changing from Wet Tailings Disposal (FEIS) to Dry Tailings Disposal (Existing Conditions)

	Length of Stream (ft)	Drainage Area (ac)	Spawning Habitat (ft^2)	Rearing Habitat (ac)
Wet Tailings Disposal (FEIS)				
Eliminated	4,700	150	90	0.3
Remaining	2,700	150	90 (50%)	0.1 (25%)
Dry Tailings Disposal (Existing Conditions)				
Eliminated	1,600	29	0	0.05
Remaining	5,700	271	180 (100%)	0.35 (88%)

(Source: America North, 1988)

Another significant change was the implementation of the mitigation for mine development. This involved providing for anadromous fish passage over Greens Creek Falls (RM 3.6). This measure was intended to ensure passage conditions for coho salmon and provide that species with access to 3.6 miles of Middle Greens Creek (USDA, 1983). Specifically, this mitigation measure provided approximately 6.5 acres of spawning and rearing habitat for coho salmon (assuming an average channel width of 15 feet) to mitigate the loss of 0.05 acres of rearing habitat in Tributary Creek and other minor losses due to road construction and potential water quality impacts of mining activities. Passage conditions were provided by KGCMC in 1989 (USDA, 1988). Subsequent monitoring confirmed the presence of yearling coho salmon rearing in Middle Greens Creek at estimated densities of about 150 fish per mile for the lower 2/3 of that reach. In addition, young-of-the-year King salmon, previously unrecorded for any stream within the general project area, were observed at estimated densities of over half that for yearling coho. Pink and chum salmon were also confirmed to be using Middle Greens Creek for spawning (Buell, 1992).

1.2.4 Marine Life History Phases of Hawk Inlet Salmon

Five species of salmon have been observed in Hawk Inlet. Pink and chum are most abundant, but coho are prevalent as well. Adult salmon spawning in Greens and Zinc Creeks stage in the lower portion of the inlet before migrating upstream.

Juvenile fish moving from the creeks to the sea can accumulate in shallow waters in most parts of the Inlet where brackish surface waters predominate. Pink and chum salmon juveniles use Hawk Inlet during the initial marine phase of their life. No abundance or distribution data for juvenile salmon is available for the project area. However, a relatively large population can be assumed, based on known adult escapement data from streams feeding into Hawk Inlet. National Marine Fisheries Service personnel working on other studies within the inlet have noted large numbers of juveniles (Jaenicke, 1981; Buell, 2002).

Exact migratory patterns and at-sea feeding areas for juvenile salmon are unknown. Published observations show migration is not directly from freshwater streams to the open ocean. Rather, a period of about 40 days is spent in saltwater, near the stream of origin. During that time, juveniles feed on epibenthic organisms (small, marine crustaceans living in near-shore areas, close to the bottom) found in mudflat and soft sediment habitats. Accumulations of pink and chum juveniles would be expected to occupy sheltered areas such as bays and coves and other near-shore areas of the intertidal and subtidal zone that have the protective cover of kelp beds, soft bottoms, and low current velocities. This habitat type is common in Hawk Inlet, particularly in the north end.

After initial growth inside of Hawk Inlet, a generalized migratory pattern that involves the fish moving predominantly seaward can be assumed. In the case of Hawk Inlet, that would be through the sill area to Chatham Strait and onward to the Gulf of Alaska.

1.2.5 Habitat Areas of Particular Concern (HAPC)

Habitat areas of particular concern (HAPC) are subsets of EFH that may be rare, sensitive, or particularly vulnerable to human impacts. HAPCs in Alaska include eelgrass, kelp and mussel beds (NMFS, 2002). Holland et al (1981) estimated that 125 hectares of bull kelp habitat lie between Hawk Point and the head of Hawk Inlet (Figure 1-2, Figure 1-7, Section 1.1.2). Limited surveys revealed that Hawk Inlet kelp beds support about 70 species of invertebrates in very high densities. Adult and juvenile salmon use these kelp beds as protection during migration and juvenile feeding.

Two *Nereocystis* bull kelp beds occur inside of Hawk Inlet, and patches of eelgrass occur near the head of the inlet. The beds of bull kelp (*Nereocystis* sp.) occupy rock and cobble habitats at depths from 15 to 45 feet, along the western shore of the entrance to Hawk Inlet and along the shore of Chatham Strait, north of the mouth of Hawk Inlet. A second major kelp bed occurs near the head of Hawk Inlet.

Figure 1-7 Aerial mosaic of Lower Hawk Inlet, Admiralty Island.

Stations shown S-1, S-2, S-4 and S-5 are sediment and worm sampling sites. Station S-3 is in the head of Hawk Inlet. Stations 1, 2, 3 and ESL are mussel sampling sites. Photo R&M Engineering 1982

2 Status of Marine and Aquatic Habitats in Hawk Inlet

This section reviews conditions in marine and aquatic habitats prior to mining operations subsequent to years of mine production.

2.0 Pre-Mining Conditions in Hawk Inlet

New, rich ore deposits were discovered on northern Admiralty Island in the 1970s. In anticipation of the Greens Creek Mine development, government agency scientists and biological consulants carried out surveys of marine life and baseline studies of heavy metals in the environment. At that time, the main human influence on Hawk Inlet had included fishing, hunting, and a seafood plant operation.

A fish cannery operated in Hawk Inlet for several decades, processing salmon, herring and groundfish (Figure 1-7). The cannery building was set over the water on piers near the current ship loadout facilities. This structure burned in 1974, dropping most of the building contents onto the underlying ocean floor. When preparing the site for the future ship loading facilities much of this material was recovered from the area by clamshell dredge. There remains considerable residual material on the seafloor, however, especially in the deep-water area immediately West, or off-shore of the ship loading dolphins. Divers report seeing a lot of metal material as well as some batteries on the seafloor. A “reef” of can lids (2+ cubic yards) still lies on the bottom just East, or inshore of the dolphins. Beyond this material underwater, sources of influence on the environment from the cannery operation may have included human waste disposal and seafood processing effluent, boat activity, and cannery debris discarded in nearshore shallow waters.

The effects of the cannery and associated vessels shaped the pre-mining environment in Hawk Inlet to some degree. In 1979, IEC conducted studies of habitats and species in Hawk Inlet. Soon thereafter, Holland, *et al* (1981) and others characterized marine species diversity and quantified abundance of species (Section 1.1). In general, early investigators of Hawk Inlet concluded that the area was rich in marine species typical of southeast Alaska. The abundance of seafloor organisms both subtidally and intertidally were considered very high. Although cannery impacts were not explicitely analyzed, Holland *et al* concluded that species composition and abundance suggested that the system had recovered or was not impaired by the cannery.

Prior to opening of the Greens Creek Mine for full production in 1989, sediment and biota tissues were sampled for heavy metal concentrations. IEC (1980) sampled sediment, seawater, fish and invertebrate tissues in 1979. Holland *et al* (1981) sampled mussel and clam tissue; Rudis, *et al* (2001) sampled mussel tissue and eagle blood in 1987; the Oceanographic Institute of Oregon (OIO 1984-1988) sampled sediments, mussel tissue, polychaete worms (*Nereis* and *Nephthys*) and (intermittently) other bivalve tissues (brachiopods, cockles, little neck clams, and soft shell clams).

The OIO studies were the baseline phase for what would develop into long-term marine ecosystem monitoring program for the mine, which is described earlier and is further detailed in the section below. Routine sampling areas used by OIO for long-term monitoring are shown in Figure 1-7 and Figure 2-1. Note that Station S-2 in Piledriver Cove is considered a “background” site. Results of these pre-mining investigations are summarized in tables in this section, as well as in tables and graphs in section 4 showing all data available in the time series.

One of the only species that was sampled pre-mining, but has not been subsequently sampled is Pacific halibut. Holland (1981) collected halibut samples from near the Cannery site and at the Greens Creek Delta sill. Results of heavy metals analysis are provided below. Since halibut are a high-level consumer in the ecosystem, they may serve as a valuable indicator of metals accumulation or stress in Hawk Inlet.

Table 2-1 Metals in Hawk Inlet Halibut Prior to Mining

Metals in Hawk Inlet Halibut in 1981 (mg/kg dry) ppm										
Site	Ag	As	Cd	Cu	Cr	Hg	Ni	Pb	Se	Zn
Cannery	0.07	0.051	0.014	0.65	0.31	0.07	0.37	0.43	0.096	5.1
GCD Sill	0.11	0.025	0.033	0.50	0.28	0.01	0.95	0.62	0.05	4.0

All other data are presented in this section and section four by station, and graphed by metal. The linear regression lines provided in section four graphs for all species and all metals are intended to illustrate trends in metal concentration over time. As is often the case in the natural environment, there are numerous fluctuations in concentrations, but spikes in concentrations are evident following a documented ore concentrate spill event and both increases and decreases in metals in biological tissues can also be observed in some cases.

In order to better understand the results of these data and all subsequent metal concentration data in this section, national environmental standards guidelines for metals concentrations are provided for comparison with Hawk Inlet data. The standards used in this document are as follows:

National Status and Trends (NOAA 2003). These (non-regulatory) numerical sediment quality guidelines are based on many site measurements in the USA. They reflect biological effects associated with concentrations of various metals in marine sediments.

> **ERL "Effects Range Low"** = Based on the 10^{th} percentile of effects observations—ERL is indicative of concentrations below which adverse effects rarely occur.
>
> **ERM "Effects Range Median"** = Based on the 50^{th} percentile of effects observations – ERM are representative of concentrations above which effects frequently occur.

Washington State Sediment Quality Standards (WAC 173-204)-- Levels indicated correspond to sediment quality that will result in no adverse effects, including no acute or chronic adverse effects on biological resources.

NOAA Screening Quick Reference Table for Inorganics in Solids "SquiRTs"

> **Apparent Effects Threshhold (AET") –** Relate chemical concentrations in sediments to biological indicators of injury. AET levels represent the concentration above which adverse biological impacts would <u>always</u> be expected by an organism due to exposure to that contaminant alone (as determined for Puget Sound, Washington). Species groups: (I = infaunal species,

A=amphipod,B=bivalve, O=oyster larvae, E=echinoderm larvae, N-neanthes worm)

Table 2-2 NOAA Mussel Watch Levels in Alaskan Specimens

NOAA Mussel Watch Program Alaskan Metals Averages				
Metal	Average	Range		
Arsenic	11.480	6.53	-	17.00
Cadmium	2.870	1.94	-	5.00
Chromium	2.560	0.00	-	8.84
Copper	10.080	6.68	-	15.00
Lead	1.170	0.26	-	2.30
Mercury	0.070	0.00	-	0.12
Nickel	2.370	0.89	-	6.60
Selenium	3.760	2.39	-	5.49
Silver	ND	ND		ND
Zinc	87.950	67.00	-	120.0

NOAA Mussel Watch – Average and range values included in Table 2-2 represent metal levels reported from various sites across Alaska sampled for metals in mussels. These numbers are provided for comparison purposes only.

Guideline values from the NST, SQS, AET and NOAA mussel watch program are compared with Hawk Inlet sampling results in the tables in this section (see footnotes under each table), tables in Section 4. Guideline levels are also portrayed visually relative to the time series sampling data for each metal at each station in sediment, worms, and mussels in graphs in Section 4.

Table 2-3 Pre-Mining Operations (pre-1989) Metals Concentrations in Sediments
(Sources: Holland, et al. 1981 Rudis, 2001; OIO & ReTec 1998)

Metal	Station S1 Pre-Mining Period (1984-1988) Avg (ppm) ±1SD			MMEC 1981 Greens Creek Delta (Stn S1) Avg (ppm)	Station S2 Pre-Mining Period (1984 – 1988) Avg (ppm) ±1SD			MMEC 1981 Head of Inlet (Stn S3) Avg (ppm)	Station S3 Pre-Mining Period (1984 – 1988) Avg (ppm) ±1SD			MMEC 1981 Old Cannery (Stn S4/5) Avg (ppm)	Station S4 Pre-Mining Period (1984 – 1988) Avg (ppm) ±1SD			National Status & Trends		WA SQS
																ERL	ERM	
Arsenic	7.500	±	1.288	**22**	4.596	±	1.412	**17**	19.611	±	7.271	**13**	**8.700**	±	1.593	8.20	63.133	5.70
Cadmium	0.239	:	0.133	<0.15	0.434	:	0.304	0.48	0.626	±	0.293	0.22	0.451	±	0.336	1.20	8.667	5.10
Chromium	**150.22**[a]	±	26.419	57	**139.00** [a]	±	32.973	55	**86.44** [a]	±	21.732	14	**125.5**[a]	±	17.623	81.00	337.889	260.0
Copper	24.889	:	7.736	17	15.789	:	2.254	16	**39.522**	±	10.604	18	**51.675**	±	15.527	34.00	243.778	390.0
Lead	8.233	±	3.133	8.4	5.211	±	2.007	7.4	10.400	±	3.377	4.8	**59.450**	±	21.904	46.70	198.967	450.0
Mercury	0.051	:	0.021	**0.35**	0.026	:	0.007	0.034	0.075	±	0.026	**0.49**	0.131	±	0.083	0.15	0.648	0.41
Nickel	***63.856***	±	10.529	43	**37.278**	±	3.611	42	**39.611**	±	7.346	17	**37.475**	±	7.369	20.90	48.189	140.0
Selenium	1.056[b]	:	0.460	0.55	0.836	:	0.449	0.38	1.672	±	0.776	0.30	0.862	±	0.532	---	---	0.41
Silver	0.095	±	0.069	<0.2	0.034	±	0.019	<0.15	0.265	±	0.116	<0.14	0.085	±	0.039	1.00	3.400	6.10
Zinc	125.45	:	11.387	110	62.689	:	5.875	110	147.10	±	31.482	50	140.65	±	40.038	150.0	381.111	410.0

Note: For Martin Marietta Environmental Center Data, results from a single subtidal sample is reported; intertidal samples were also collected at the same site.

BOLD numbers exceed National Status & Trend Effects Range Low Levels
BOLD, ITALICIZED numbers exceed NS&T Effects Range Median levels;
UNDERLINED numbers exceed Washington Sediment Quality Standards
[Noted] values exceed Apparent Effects Threshold for Sediments (AET), see species affected:
a. Neanthes b. Amphipod

Table 2-4 Pre-Mining Metals in Hawk Inlet Worms
(Data Source Rudis, 2001; OIO & ReTec 1998; Columbia Analytical 1984-2002)

Metal	Station S1 Pre-Mining Period (1984-1988) Avg (ppm) ±1SD			Station S2 Pre-Mining Period (1984 – 1988) Avg (ppm) ±1SD			Station S3 Pre-Mining Period (1984 – 1988) Avg (ppm) ±1SD			Station S4 Pre-Mining Period (1984 – 1988) Avg (ppm) ±1SD		
Arsenic	23.878	±	5.030	36.844	±	8.859	22.689	±	7.297	26.150	±	7.000
Cadmium	4.001	±	1.704	1.701	±	0.745	4.164	±	2.465	1.205	±	0.983
Chromium	5.332	±	6.073	1.996	±	1.060	1.298	±	1.425	0.880	±	0.212
Copper	9.036	±	1.188	12.371	±	3.313	15.833	±	5.256	16.800	±	9.475
Lead	0.490	±	0.161	0.587	±	0.235	0.796	±	0.458	4.155	±	1.789
Mercury	0.049	±	0.010	0.019	±	0.009	0.126	±	0.227	0.108	±	0.088
Nickel	6.107	±	2.371	3.357	±	1.113	5.496	±	1.761	4.220	±	0.325
Selenium	4.887	±	2.021	2.940	±	1.205	3.890	±	1.401	2.645	±	0.827
Silver	0.171	±	0.142	0.111	±	0.139	0.419	±	0.324	0.065	±	0.007
Zinc	243.556	±	42.480	181.078	±	29.427	239.778	±	70.885	193.500	±	14.84

Table 2-5 Pre-Mining Concentrations in Hawk Inlet Mussels (Data Source Rudis, 2001; OIO & ReTec 1998; Columbia Analytical 1984-2002)

Metal	USFWS Hawk Inlet 10-Stations 1987 Avg (ppm)±*1SD*			Station Stn 1 Pre Mining Period (1984-1989)) Avg (ppm)±*1SD*			Station Stn2 Pre Mining Period (1984-1989) Avg (ppm) ±*1SD*			Station Stn3 Pre Mining Period (1984-1989) Avg (ppm)±*1SD*			Station ESL Pre Mining Period (1984-1989) Avg (ppm)±*1SD*		
Arsenic	---	±	---	10.131	±	2.004	10.569	±	2.812	11.321	±	3.674	8.807	±	1.911
Cadmium	---	±	---	***7.409***	±	1.911	***8.602***	±	3.288	***9.273***	±	3.240	***6.667***	±	1.697
Chromium	---	±	---	1.621	±	1.388	1.028	±	0.389	1.476	±	1.123	0.989	±	0.599
Copper	10.047	±	1.52	7.963	±	1.270	7.706	±	1.116	8.498	±	1.794	8.160	±	0.719
Lead	0.121	±	0.049	0.622	±	0.439	0.368	±	0.204	0.586	±	0.224	0.423	±	0.118
Mercury	0.022	±	0.002	**0.073**	±	0.101	0.036	±	0.013	0.039	±	0.013	0.032	±	0.011
Nickel	---	±	---	1.609	±	0.979	1.102	±	0.343	1.553	±	0.701	1.290	±	0.601
Selenium	---	±	---	2.801	±	0.811	2.761	±	0.579	3.164	±	0.871	2.862	±	0.917
Silver	---	±	---	0.121	±	0.022	0.195	±	0.202	0.139	±	0.078	0.118	±	0.042
Zinc	16.296	±	3.827	**94.922**	±	11.895	82.356	±	11.880	**94.822**	±	11.054	**91.400**	±	8.885

BOLD value exceeds Alaskan statewide mussel concentration average; ***BOLD ITALICS*** value exceeds upper end of Alaska Mussel Watch range

Pre-Mining Operations Sediment Metals average levels show some consistency across station, but the standard deviations for these data indicate high variability, typical of natural conditions. These data are useful as baseline values against which to compare metal values after mining began. Only a subset of these data were used to calculate baseline values because not all stations or samples represent natural conditions for comparison..

The values reported here from the MMEC 1981 study are for subtidal data. These values vary from the OIO intertidal data, with some metals consistently higher and some consistently lower across stations. These differences from intertidal data may be due to grain size differences, ambient water influencing metal uptake, or other factors. Subtidal stations are continually subjected only to seawater and effluent, while intertidal stations are subjected to seawater and effluent only when submerged by the tide and are otherwise influenced by precipitation, air and the different suite of marine organisms that occupy beach areas. Because the MMEC (Holland *et al*, 1981) data, represent metal levels from **subtidal** samples, are single year values with no ranges reported, and because no subsequent subtidal samples have been collected at these stations, they are not included in the baseline conditions calculation.

Stations S-4 and S5 (north and south) have likely been influenced by both the old cannery operation and mine exploration work prior to opening of the mine, and therefore are not considered suitable as pre-mining background stations. The natural background metals levels, or baseline for comparison of post-mining data is the average and range of values from stations S1, S2 and S3.

Hence, only the the multi-year, multi-station information from OIO stations S-1, S-2 and S-3 was used in calculating pre-mining baseline levels for Hawk Inlet (Table 2-5).

Table 2-6 Pre-Mining Metals in Sediment

Pre-Mining Baseline: Stations S-1, S-2 and S-3			
Metal	Average	Minimum	Maximum
Arsenic	10.57	3.30	33.50
Cadmium	0.43	0.03	1.09
Chromium	125.22	56.00	188.00
Copper	26.73	11.90	55.20
Lead	7.95	2.30	15.10
Mercury	0.05	0.01	0.12
Nickel	46.91	27.40	75.80
Selenium	1.19	0.17	3.50
Silver	0.13	0.01	0.49
Zinc	111.75	52.80	200.00

In comparing all Hawk Inlet pre-mining baseline metals to National Status and Trends levels, it appears that several Hawk Inlet values are greater than the NST ERLs. The average chromium and nickel values exceed ERL levels at every site in Hawk Inlet. Arsenic and copper are slightly above ERL levels at Station S-3 and Arsenic, Chromium, Lead and Nickel are all above ERL at Station S-4, near the old cannery site. None of the pre-mining metals levels exceeded ERM or AET levels.

Polychaete worms --Pre-mining polychaete worm (*Nephthys*) tissue concentrations indicate that only copper appears to be slightly elevated at station ESL, over the other sites S-1, S-2, and S-3.

Mussels – Pre-mining mussel tissue data indicated that cadmium and zinc at most stations are elevated above Alaskan mussel watch average levels, and mercury is slighly higher than Mussel Watch levels at station S-1. Levels of all metals are fairly consistent among stations, except that the 1997 Hawk Inlet-wide zinc average level is substantially lower (16.29 ppm) than the other stations (82 to 94 ppm).

2.0.1 Mining Start-up and 1989 Ore Spill History (Oeklaus 2003)

Exploration and construction planning continued through the mid to late 1980's. Mining "shakedown" operations began in early 1989, followed by full production. A feed conveyor design flaw led to a single spill of ore concentrate at the loading dock in this early operational phase.

2.0.2 KGCMC Ship Loadout facility

The original ship loader configuration included an open conveyor system, with three transfer points outside of the buildings. That loadout fed a canvas tube, which directed the concentrate flow toward the ship hold below. This system was initially tested with sand fed onto a barge, and all worked well.

The first ship loading, in mid-1989 found the concentrate much heavier than the test sand, resulting in a belt support failure with a resultant spill of concentrate into the ocean beneath the ship loader.

In analyzing problem areas during 1994-5 preparatory to restarting KGCMC, the ship loader was redesigned, and recovery of the spilled concentrate was planned.

The new shiploader installed in 1995 is fully contained. A telescoping pair of tubes fully encloses the conveyor from within the loadout building. A retractable, cascading chute extends from the tail of the feed conveyor in the distal telescoping tube down into the ship hold. Now concentrate flow outside of the loadout building containment is limited to the final 1-3 feet within the hold by the loadout operator standing on the deck of the ship, looking directly down into the hold being filled. With a remote control and handheld radio he governs all aspects of the conveyor tube and chute positions, in conjunction with the concentrate feed.

A suction dredge company was brought on site during the summer of 1995. Divers dredged the available concentrate off of the ocean floor. This effort was confounded somewhat by the residual debris from the 1974 cannery facility fire. About twice as much material was dredged from the site as was predicted by earlier dive assessments of the spill quantity. Dive surveys and sediment sampling for metals has been conducted annually since the spill occurred. Results are presented in

Table 2-7, below.

2.0.3 KGCMC Marine Monitoring Program

In planning for development of the Greens Creek mine, scientists experienced in Northwest US ocean environments and their monitoring developed the original marine organism and sediment program, in conjunction with NMFS personnel.

An array of sampling approaches, target materials, and sites were selected, and monitoring began in 1984, 5 years before the mine became active, and 3 years before any construction activities began. Subsequent installation of facilities resulted in additional monitoring sites to correspond to the selected outfall diffuser location.

In response to the 1989 concentrate spill, the KGCMC contractor added another monitoring site to the shiploader area (Site 5 South, 5 North is a continuation of the original Site 5). The two site 5 sampling areas now bracket the concentrate spill area.

2.1 Post-Mining Conditions in Hawk Inlet

2.1.1 Monitoring Methods: Seafloor Sediments and Biological Tissues

The Kennecott Greens Creek Mine now covers some 320 acres, employs over 270 workers produces over 600,000 tons of ore annually, and ships concentrates to smelters throughout the world (KGCMC Website 2003). On land, concentrates are transported from the 920 mine site to port facilities at Hawk Inlet and filtered tailings to the tailings impoundment in covered 50 ton haulage trucks. A mine operation of this magnitude may affect the marine environment through numerous activities. These include: Ship and tugboat traffic (prop wash, risk of fuel releases, presence in Hawk Inlet), ore ship loading and transfer operations, treated human waste entering Hawk Inlet at outfall 001, sediment-laden runoff from roads and ore facilities, on-land fuel spills, increased human presence and possible disturbance to intertidal communities, etc.

A major source of potential impact to the marine environment from mining activities in Hawk Inlet is through the introduction of mine effluents at outfall 002. Outfall 002 drains treated mill waste waters, runoff from the mine services areas, underground mine water, seepage and runoff from the dry tailings pile, and waste rock storage sites.

Outfall 002 consists of a pipe that extends across the Greens Creek Delta, and discharges to the floor of Hawk Inlet near a sandy sill formed at the narrowest point in Hawk Inlet (Figure 1-7). The outfall pipe is anchored, and descends along the seafloor. The terminal 50-foot length of the pipe extending from –40 feet to –90 feet MLLW expels effluent through a bank of 15 diffusers. Based upon modeling of the diffuser's ability to disperse treated effluent, ADEC has permitted a 300 by 100 foot "mixing zone" centered at the diffuser. Effluent within the mixing zone is diluted 170:1. Marine Alaska Water Quality Standards (AWQS) are based on a further 50:1 dilution of freshwater standards. AWQS must be met at the edge of the mixing zone. This effluent is monitored regularly, following the provisions of multiple water quality regulations and the NPDES permit requirements.

In 1984, a long-term heavy metal monitoring program was initiated to detect changes in the quality of habitat for resident and migratory organisms associated with Hawk Inlet and its freshwater tributaries. This monitoring program includes sampling of intertidal and subtidal seafloor sediments, biota such as worms and bivalves, and the water column for heavy metal concentrations.

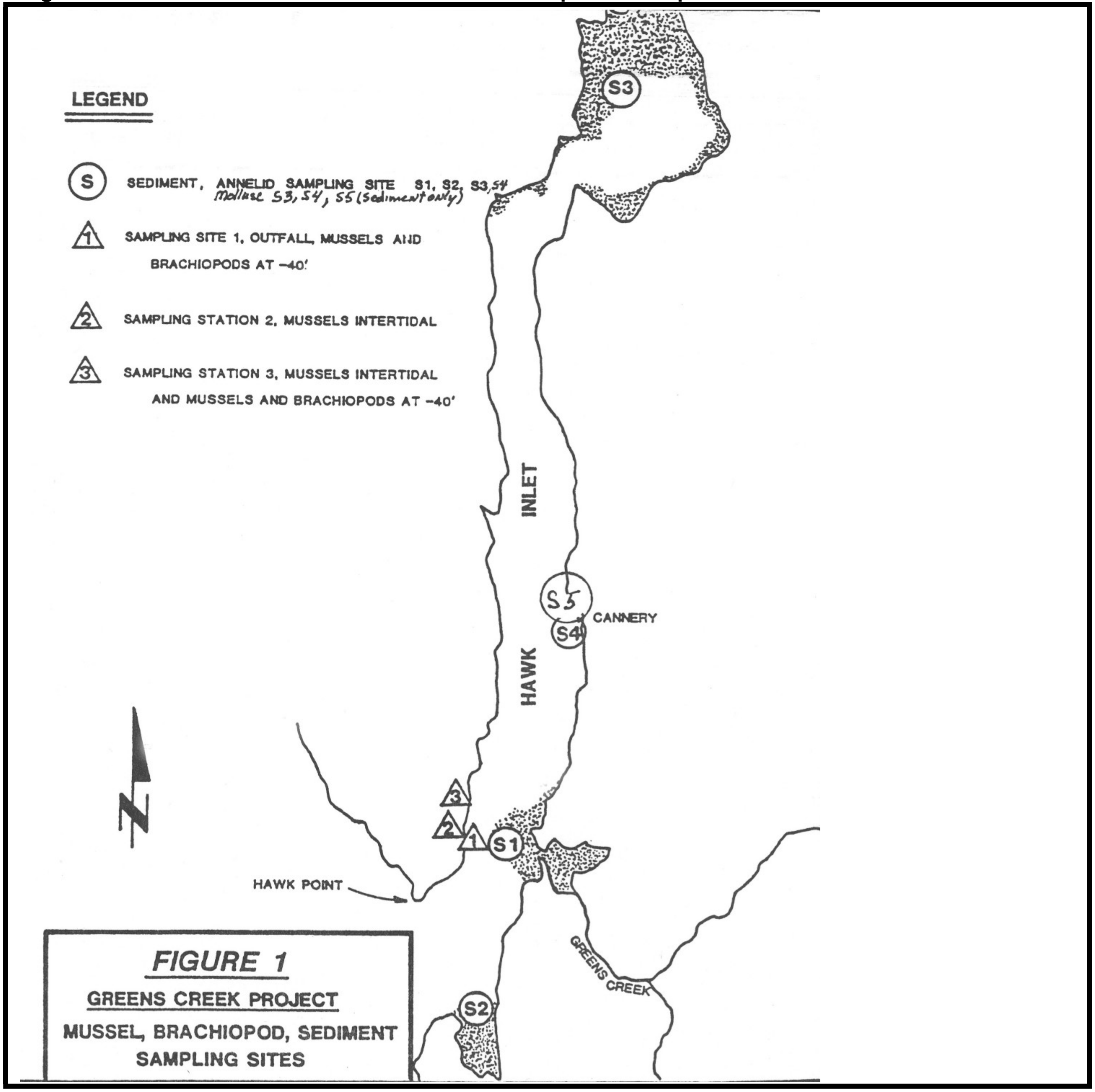
NMFS collaborated in developing protocols which were included in the marine monitoring program required under the Greens Creek NPDES permit. Over the past 20 years, sampling requirements, locations, frequency and analytes have changed somewhat, as the monitoring program became more focused on the areas of potential impact and effluent constituents of greatest concern.

The core sampling program consists of scientific consultants conducting quarterly seawater column monitoring, semi-annual sediment sampling, and semi-annual testing of sediment and tissues from *Nepthys procera*, *Nereis* spp, *Mytilus edulis* from 1984 through present. Divers collected subtidal and intertidal sediment, seawater and tissue samples at outfall 002 and background sites. Station S-1 is located closest to the outfall pipe end, S-2 is in Southern Hawk Inlet at Piledriver Cove (background site), and S-3 is an intertidal control sampling site in the head of Hawk Inlet (Figure 1-2, Figure 1-7, and Figure 2-1). Site S-4 and Sites S-5 North and S-5 South lie near the middle of the Inlet, near the ore loading dock. Sampling at the latter sites has intensified subsequent to the ore spill and cleanup.

Sediment samples are composited from each sample station. "fine" and "bulk" sediment are categorized, and total solids composition is determined in the laboratory. Most samples collected are "bulk".

Invertebrate Tissue Sampling Polychaete worms and blue mussels were selected as indicators of heavy metals accumulating in marine life in Hawk Inlet for the duration of the monitoring program. Other bivalves (cockles, clams and jingle shells) and lug worms were also sampled for metals intermittently. Polychaetes generally dwell in subtidal mud, sand and gravel. Some

Figure 2-1 Hawk Inlet Sediment and Biota Sample Site Map



species are mobile, while others are sedentary – but all are considered "benthic obligates", as their lives are spent in close association with the seafloor. For this reason, and because worms are consumed by many fish and crabs, polychaete metal levels provide some insight regarding the health of the seafloor community near the outfall and reference sites.

Mussels (*Mytilus* sp.) are an intertidal and shallow subtidal bivalve. These filter feeders strain enormous amounts of seawater for plankton, and tend to accumulate metals from the environment. Although the GCM outfall diffuser is on the seafloor, discharged effluent is comprised of freshwater – the buoyant water masses discharged therefore affect not only the seafloor, but float to the surface and bathe intertidal organisms as well. For this reason also, mussels are an appropriate interceptor organism for metals monitoring in Hawk Inlet. Additionally, metals in mussels are monitored nation-wide in the NOAA's Mussel Watch Program, so results can be compared with pristine and impaired water bodies in the coastal USA.

All sediment and tissue samples were analyzed by professional laboratories, with an ADEC and EPA approved QA/QC plan. Sampling data were synthesized in semi-annual reports submitted to KGCMC, ADEC and USEPA for NPDES permit compliance monitoring. The results of sampling are provided inTable 2-8, below, as well as in the full data tables and graphs in Section 4.

Table 2-7 Post-mine production Metals in Hawk Inlet Sediments (Data Source Rudis, 2001; OIO & ReTec 1998; Columbia Analytical 1984-2002)

Metal	USFWS Hawk Inlet 10-Stations 1997 Avg (ppm) ±1SD			Station S1 Production Period (1989-2002) Avg (ppm)±1SD			Station S2 Production Period (1989 – 2002) Avg (ppm) ±1SD			Station S3 Production Period (1989 – 2002) Avg (ppm) ±1SD			Station S4 Production Period (1989 – 2002) Avg (ppm) ±1SD		
Arsenic	5.75	±	0.91	8.77	±	6.03	3.49	±	1.58	**21.95**	±	5.39	**10.83**	±	4.09
Cadmium	0.64	±	0.04	0.29	±	0.24	0.19	±	0.08	0.76	±	0.27	**1.22**	±	1.01
Chromium	73.98	±	35.22	**114.04**	±	98.90	87.73	±	57.85	54.61	±	30.14	77.24	±	45.91
Copper	17.23	±	8.52	19.98	±	8.37	13.75	±	4.46	**38.23**	±	7.48	**71.58**	±	59.40
Lead	4.554	±	11.74	9.78	±	4.93	3.76	±	1.98	14.93	±	4.33	**171.19**	±	152.57
Mercury	<0.10	±	nd	0.06	±	0.04	0.02	±	0.02	0.09	±	0.03	0.28	±	0.72
Nickel	28.83	±	18.08	52.45	±	21.65	32.86	±	14.71	36.15	±	10.59	30.81	±	8.62
Selenium	1.01	±	0.13	2.35	±	3.33	0.91	±	0.79	2.99	±	1.79	1.48	±	1.48
Silver	------	±	-----	0.14	±	0.12	0.04	±	0.03	0.28	±	0.12	**1.12**	±	1.15
Zinc	58.93	±	33.09	113.45	±	31.78	54.49	±	16.46	144.72	±	30.48	**246.80**	±	200.75

Table 2-6, continued

Metal	Station S-5 N Production Period (1989-2002) Avg (ppm)±1SD			Station S-5 S Production Period (1994-2002) Avg (ppm)±1SD			National Status & Trends		WA SQS
							ERL	ERL	
Arsenic	**19.600**	±	16.793	**10.433**	±	4.929	8.20	63.133	57
Cadmium	***18.752***	±	49.146	**3.771**	±	3.518	1.20	8.667	5.10
Chromium	80.765	±	53.489	32.478	±	17.070	81.00	337.889	260.00
Copper	***290.403***	±	456.991	**79.913**	±	40.284	34.00	243.778	390.00
Lead	***1525.552***	±	2895.327	***282.239***	±	293.332	46.70	198.967	450.00
Mercury	***3.039***	±	6.887	**0.514**	±	0.276	0.15	0.648	0.41
Nickel	37.735	±	14.912	36.600	±	23.277	20.90	48.189	140.00
Selenium	2.234	±	1.651	1.808	±	0.745	---	---	0.41
Silver	**3.069**	±	3.734	**1.798**	±	2.747	1.00	3.400	6.10
Zinc	***2867.483***	±	6698.752	***694.944***	±	666.884	150.00	381.111	410.00

BOLD numbers exceed NST ERL levels *BOLD, ITALICIZED* numbers exceed NST ERM levels;
UNDERLINED numbers exceed Washington Sediment Quality Standards

Table 2-8 Post Mine Production Metal Concentrations in Hawk Inlet Polychaete Worms (Source: OIO & RTI 1998; Columbia Analytical 1984-2002)

Metal	Station S1 Production Period (1989-2002) Avg (ppm)±1SD			Station S2 Production Period (1989 – 2002) Avg (ppm) ±1SD			Station S3 Production Period (1989 – 2002) Avg (ppm) ±1SD			Station S4 Production Period (1989 – 2002) Avg (ppm) ±1SD		
Arsenic	**26.857**	±	7.361	32.967	±	13.549	**23.405**	±	3.390	**27.929**	±	6.098
Cadmium	3.011	±	1.303	1.408	±	1.864	2.868	±	1.727	**1.355**	±	0.741
Chromium	**8.239**	±	15.802	9.887	±	21.640	**2.330**	±	1.959	**2.994**	±	4.388
Copper	**10.369**	±	4.427	9.728	±	4.072	11.392	±	2.947	**31.582**	±	21.628
Lead	**1.332**	±	1.198	**0.821**	±	0.530	**0.891**	±	0.441	**14.887**	±	15.958
Mercury	0.045	±	0.019	**0.101**	±	0.360	0.040	±	0.016	0.035	±	0.017
Nickel	**12.164**	±	16.146	**7.323**	±	11.968	**7.498**	±	2.979	**5.400**	±	2.845
Selenium	4.668	±	2.082	2.810	±	1.159	3.877	±	1.409	**3.356**	±	1.153
Silver	0.154	±	0.113	0.082	±	0.097	0.241	±	0.117	**1.228**	±	1.120
Zinc	202.700	±	57.401	151.183	±	42.619	238.593	±	42.478	**217.379**	±	66.455

Bold values are averages that are higher than the pre-mining (1984-1989) average concentrations

Table 2-9 Post-Mine Production Metal Concentrations in Hawk Inlet Mussels (Rudis, 2001; OIO & RTI 1998; Columbia Analytical 1989-2002)

Metal	USFWS Hawk Inlet 10-Stations 1997 Avg (ppm) ±1SD			Station Stn1 Production Period (1989-2002) Avg (ppm)±1SD			Station Stn2 Production Period (1989 – 2002) Avg (ppm) ±1SD			Station Stn3 Production Period (1989 – 2002) Avg (ppm) ±1SD			Station ESL Production Period (1989 – 2002) Avg (ppm) ±1SD		
Arsenic	8.545	±	0.979	8.769	±	6.026	3.493	±	1.578	***21.948***	±	5.394	10.829	±	4.091
Cadmium	***8.535***	±	3.209	0.288	±	0.239	0.192	±	0.082	0.764	±	0.274	1.219	±	1.008
Chromium	2.494	±	0.590	***114.045***	±	98.896	***87.727***	±	57.846	***54.613***	±	30.136	77.239	±	45.911
Copper	8.142	±	1.028	***19.983***	±	8.365	**13.754**	±	4.457	***38.230***	±	7.480	***71.580***	±	59.397
Lead	3.04	±	---	***9.778***	±	4.929	***3.756***	±	1.975	***14.927***	±	4.327	***171.193***	±	152.568
Mercury	--	±	---	0.058	±	0.039	0.024	±	0.022	0.088	±	0.030	***0.283***	±	0.724
Nickel	1.474	±	0.132	***52.448***	±	21.646	***32.864***	±	14.706	***36.148***	±	10.590	***30.813***	±	8.617
Selenium	1.008	±	0.132	2.352	±	3.331	0.906	±	0.789	2.987	±	1.788	1.480	±	1.477
Silver	------	±	-----	0.139	±	0.122	0.041	±	0.031	0.284	±	0.120	1.116	±	1.154
Zinc	**117.65**	±	31.00	113.457	±	31.776	54.490	±	16.462	***144.720***	±	30.475	***246.801***	±	200.748

BOLD value exceeds Alaskan statewide mussel concentration average; ***BOLD ITALICS*** value exceeds upper end of Alaska Mussel Watch range Underline post-mining average value exceeds pre-mining average value for this metal.

This section reviews the results of mine production period metals concentrations that are summarized in the tables above. Results will be contrasted between stations, between pre and post mining time periods, and discussed relative to events in Hawk Inlet that may influence metal levels in sediment and tissues. Further, average values are compared to federal guidance levels and levels observed elsewhere.

2.1.2 Sediments

Station S-1 Average sediment sample levels for six of the ten metals measured increased slightly to substantially from pre-mining to mine production periods at this Greens Creek Delta site. Selenium and silver exhibited the greatest percent increases between periods – Se was 122% higher after mining and Ag was 45% higher. Linear regression of pre and post mining data time series indicates that the overall trend for Se is a continued increase, while Ag is decreasing slightly. Remaining elevated metals increased from 14 to 20%. Zn, Ni, Cu, Cr and As exceeded ERLs at least three times, with Cr and Ni exceeding ERM only once and 21 times, respectively.

Table 2-10 Station S-1 Metal Levels in Sediment Between Periods and NST exceedances

Sediment S-1	# Times >ERL	AVG > ERL?	# Times >ERM	Diff btwn Avgs ppm	% diff avgs
Arsenic	9	Yes	0	1.27	16.92
Cadmium	0	No	0	0.05	20.43
Chromium	21	No	1	-36.18	-24.08
Copper	3	No	0	-4.91	-19.71
Lead	0	No	0	1.54	18.76
Mercury	0	No	0	0.01	14.24
Nickel	30	Yes	21	-11.41	-17.86
Selenium			0	1.30	122.67
Silver	0	No	0	0.04	46.21
Zinc	3	No	0	-12.00	-9.56

Table 2-11 Station S-2 Metal Levels in Sediment Between Periods and NST exceedances

Sediment S-2	# Times >ERL	AVG > ERL?	# Times >ERM	Diff btwn Avgs ppm	% diff avgs
Arsenic	1	Yes	0	-1.10	-24.00
Cadmium	0	No	0	-0.24	-55.70
Chromium	21	No	0	-51.27	-36.89
Copper	0	No	0	-2.03	-12.89
Lead	0	No	0	-1.46	-27.93
Mercury	0	No	0	0.00	-7.30
Nickel	24	Yes	1	-4.41	-11.84
Selenium			0	0.07	8.38
Silver	0	No	0	0.01	23.18
Zinc	0	No	0	-8.20	-13.08

Station S-2 Average levels for 8 metals at the Piledriver Cove site sediment samples decreased between pre-mining and production periods. The average Cd level dropped 51 ppm (55.7%). Only Se and Ag, those metals which also increased at station S-1, increased at station S-2. Like station S-1, Cr and Ni exceeded ERL more than 20 times in the 38 sampling events, and As exceeded ERL once. Only Ni exceeded ERM, on a single event. At this background site there was a decline in natural metal levels over the monitored period.

Station S-3 Station S-3, located in the head of Hawk Inlet, exhibited very different trends from the other background station, S-2. Most metals at S-3 are at much higher levels than either sites S-1 or S-2. Field observations of a mass wasting event in the watershed above station S-3 led researchers to surmise that the event released metals from abandoned historic mine workings into the environment. Six of ten average metal levels increased at S-3 during production years over pre-mining years, while Zn and Cu decreased slightly and Cr, and Ni decreased more substantially, at 36.8% and 8.7%. All metals except Pb and Ag exceeded ERL, As, Ni and Cu 29+ times. Only Ni exceeded ERM on one occaison. Because of the trends observed and the possible effects of the wasting event on metal levels at S-3, it is not suitable as a background or baseline site – however, it is included in the Hawk Inlet average for both baseline and post mining comparisons. It may be appropriate to reconsider S-3 as a background monitoring station.

Table 2-12 Station S-3 Metal Levels in Sediment Between Periods and NST exceedances

Sediment S-3	# Times >ERL	AVG > ERL?	# Times >ERM	Diff btwn avgs	% diff avgs
Arsenic	31	Yes	0	2.34	11.92
Cadmium	3	No	0	0.14	22.07
Chromium	11	No	0	-31.83	-36.82
Copper	29	No	0	-1.29	-3.27
Lead	0	No	0	4.53	43.53
Mercury	1	No	0	0.01	17.57
Nickel	30	Yes	1	-3.46	-8.74
Selenium			0	1.32	78.65
Silver	0	No	0	0.02	7.32
Zinc	19	No	0	-2.38	-1.62

Table 2-13 Station S-4 Metal Levels in Sediment Between Periods and NST exceedances

Sediment S-4	# Times >ERL	AVG > ERL?	# Times >ERM	Diff btwn avgs	% diff avgs
Arsenic	19	Yes	0	2.13	24.47
Cadmium	10	No	0	0.77	170.21
Chromium	21	No	0	-48.26	-38.45
Copper	30	No	0	19.91	38.52
Lead	30	No	9	111.74	187.96
Mercury	11	No	1	0.15	115.77
Nickel	28	Yes	1	-6.66	-17.78
Selenium			0	0.62	71.76
Silver	9	No	2	1.03	1210.71
Zinc	23	No	5	106.15	75.47

Station S-4 Metal levels at Station S-4, an intertidal station near the ship loading facility in central Hawk Inlet, exhibited markedly higher metal levels than sites 1, 2 and 3. Over the course of the 1989 through 2002 time period, S-4 metals were 38 to 97% higher in average concentration than metals at background station S-2. Exceptions to this were Cr, which was 13% lower at S-4 and Ni, at about 7% lower average level than Station S-2.

Due to its proximity to mine loading operations, it is more likely influenced by those activities than by effluent from the outfall. More importantly, this site was also affected by a spill of ore concentrate in 1989. Although cleanup efforts were extensive, liter-sized pockets of concentrate are still observed throughout the area. Prop wash from ore ships continues to both resuspend these pockets and may also mix them with natural sediments. Despite the cleanup and mixing of sediments, linear regression models for metal trends at S-4 indicate continued increasing levels for As, Hg, Se, and Ag. Pb, Cd, Cu and Zn exhibit very week or no trend, but 2002 values for each of these metals is higher than the two previous years. Cr and Ni concentrations continue to reflect hotspots in sampling at S-4, but both metals exhibit steep downward trends.

All metals at S-4 increased in concentration between pre and post mining periods, except Cr and Ni, which decreased about 38% and 18%, respectively. The S-4 sediment table shows that biannual metal measurements exceeded NS&T ERL levels from 9 (Ag) to over 30 (Pb and Cu) times. As and Ni average levels over the 19 year sampling program also exceeded ERLs.

Table 2-14 Station S-5N Metal Levels in Sediment Between Periods and NST exceedances

Sediment S-5N	# Times >ERL	AVG > ERL?	# Times >ERM
Arsenic	15	Yes	0
Cadmium	22	No	9
Chromium	13	No	0
Copper	29	No	2
Lead	28	No	22
Mercury	22	No	13
Nickel	22	Yes	3
Selenium			0
Silver	17	No	3
Zinc	26	No	19

Station S-5N and **Station S-5S** were established to monitor metal levels beneath the ore shiploading berth at the Greens Creek Mine at the north and south sides of the 1989 concentrate spill. Site levels reflect spikes in metal levels resulting from that single ore concentrate spill event at the dock in 1989, as well as cleanup and any further impacts to sediments subsequent to the spill. All metal values have exceeded ERL frequently and Cd, Cu, Pb, Hg, Ni, Ag and Zn have exceeded ERM levels from 2 to 22 times since monitoring began.

Table 2-15 Station S-5S Metal Levels in Sediment Between Periods and NST exceedances

Sediment S-5S	# Times >ERL	AVG > ERL?	# Times >ERM
Arsenic	5	Yes	0
Cadmium	10	No	2
Chromium	0	No	0
Copper	13	No	0
Lead	13	No	7
Mercury	10	No	1
Nickel	8	Yes	1
Selenium			0
Silver	3	No	2
Zinc	12	No	9

2.1.3 Comparison of Pre-Mining and Production Period Metals in Sediments

A summary comparing pre-mining baseline metal levels with mining production period levels for stations S-1, S-2 and S-3 are shown in Table 2-16. The average mining period values for station S-1, the outfall monitoring intertidal station, are in the last column.

Table 2-16 Metals in Sediment: Average and Range Stations S-1, S-2, S-3 (mg/kg dry) ppm

Pre-Mining Baseline: 1884-1988				Mining Period: 1989-2002			
Metal	Average	Minimum	Maximum	Average	Minimum	Maximum	S-1 Avg
Arsenic (As)	10.57	3.30	33.50	**11.40**	1.26	33.50	8.77
Cadmium (Cd)	0.43	0.03	1.09	0.41	0.03	1.53	0.29
Chromium (Cr)	125.22	56.00	188.00	85.46	12.50	450.00	114.05
Copper (Cu)	26.73	11.90	55.20	23.99	7.80	55.20	19.98
Lead (Pb)	7.95	2.30	15.10	**9.49**	1.48	26.00	**9.78**
Mercury (Hg)	0.05	0.01	0.12	**0.06**	0.00	0.16	**0.06**
Nickel (Ni)	46.91	27.40	75.80	40.49	13.00	86.90	**52.45**
Selenium (Se)	1.19	0.17	3.50	**2.08**	0.17	14.00	**2.36**
Silver (Ag)	0.13	0.01	0.49	0.15	0.01	0.59	**0.14**
Zinc (Zn)	111.75	52.80	200.00	104.22	30.50	200.00	**113.45**

BOLD Mining production period values that are higher than the average baseline level UNDERLINED Any value that exceeds NST ERL levels, note there is no ERL for Se

This comparison shows that when averaged across all baseline stations, the average metal levels for As, Pb, Hg, and Ag have only slightly increased during the mining period. Se roughly doubled in concentration at all stations between pre-mining and mining periods. Cd, Cr, Cu, Ni, and Zn have decreased at these stations since mining began.

At Station S-1, As, Cd, Cr, and Cu have decreased slightly to substantially subsequent to mining in Hawk Inlet. Hg, Ag and Zn have increased only slighly above baseline levels. The remaining metals have increased by varying factors: Pb(1.23X), Ni (1.12X), and Se (1.98X) during the mining period.

Relative to NST levels, As, Cr, and Ni average levels are consistently higher than ERL – prior to and subsequent to mining activity. Maximum levels detected during the mining period exceeded ERL for As, Cd, Cr, Cu, Hg, Ni, and Zn. All metal levels at station 1 are well-below NST ERM levels. Overall, S-1 sample levels are lower than the combined Mining Period average sediment metal level for four metals (As, Cd, Cu and Ag), and higher for five metals (Cr, Pb, Ni, Se and Zn). The mercury level average for S-1 was the same as the combined average (0.06 ppm)

In addition to the semi-annual samples OIO collected in Hawk Inlet, the USFWS independently sampled sediment throughout Hawk Inlet in 1997 (USFWS 2003; Rudis 2001). In general, the area wide averages they reported from 10 sites were comparable for mining period metals, except Cd levels reported by USFWS were substantially higher than mining period averages. USFWS reported that marine sediments collected at the mine facility loading dock area were significantly higher than metal concentrations found in other parts of Hawk Inlet. Table 2-16 compares the USFWS Hawk Inlet-wide average sediment metal concentrations to concentrations found at OIO stations sampled during the operational period.

Stations S-4, S-5S and S-5N – located near the ore loading dock, exhibited different average metal levels, with station S-5N showing much higher concentrations than other stations (Table 2-17).

Table 2-17. Comparison of baseline and mining period average metal levels in sediment to S4 and S5 levels prior to and during mining period

Metal	Baseline Average	Mining Average	Mining S-4	Mining S-5S	Mining S-5N
Arsenic	10.57	11.40	**10.83**	**10.43**	***19.60***
Cadmium	0.43	0.41	***1.22***	***3.77***	***18.75**** [1]
Chromium	125.22	85.46	77.24 [1]	32.48	80.77 [1]
Copper	26.73	23.99	**71.58**	***79.91***	***290.40****
Lead	7.95	9.49	***171.19***	***282.24****	***1525.55**** [2]
Mercury	0.05	0.06	***0.28***	***0.51***	***3.04****
Nickel	46.91	40.49	30.81	36.60	37.73
Selenium	1.19 [3]	2.08 [3]	***1.48*** [3]	**1.81** [3]	***2.23*** [3]
Silver	0.13	0.15	***1.12***	***1.80***	***3.07**** [3]
Zinc	111.75	104.22	***246.80***	***694.94**** [4]	***2867.48**** [4]

BOLD figures are higer than the baseline average. ***BOLD ITALICIZED*** values are higher than the Mining period average. UNDERLINED values exceed NST ERLs, *values exceed NST ERMs, and noted values exceed Apparent Effects Threshold (AET) for identified species groups: 1. *Neanthes* bioassays 2. Bivalves 3. Amphipods 4. Infaunal community impacts

2.1.4 Polychaete Worms

Average metal concentrations in the indicator polychaete worm, *Nephthys* during the mining production period increased for Cr, Pb and Ni. All maximum values for stations S1, S2, and S3 exceeded the baseline levels. Some metals at station S-4 were higher than baseline average values, As, Cr, Cu, Pb, Ni, and Ag. Of these, As, Cr, and Ni are slightly higher than the baseline or production period levels. Remaining metals at S-4 are higher than baseline average values by varying degrees: Pb(24X) and Ag (5X).

Table 2-18 Metal Concentrations in *Nephthys* Prior to and During Mining

Metals in *Nephthys*: Average and Range							
Pre-Mining Baseline: S-1, S-2, S-3				Mining Prod'n Period: S-1, S-2, S-3			Station S4
Metal	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
Arsenic	27.80	8.70	47.90	27.74	9.60	**65.00**	**27.93**
Cadmium	3.29	0.53	8.45	2.43	0.24	**10.60**	1.36
Chromium	2.88	0.51	18.00	**6.82**	0.27	**84.00**	**2.99**
Copper	12.41	6.24	22.60	10.50	4.30	**27.30**	**31.58**
Lead	0.62	0.28	1.64	**1.01**	0.05	**4.76**	**14.89**
Mercury	0.06	0.01	0.73	0.06	0.01	**1.67**	0.03
Nickel	4.99	1.90	11.52	**8.99**	1.20	**72.40**	**5.40**
Selenium	3.91	1.30	8.90	3.78	1.00	**9.20**	3.36
Silver	0.23	0.01	1.05	0.16	0.02	**0.53**	**1.23**
Zinc	221.47	71.00	305.00	197.49	62.60	**357.00**	217.38

Bold values are mining production period levels which exceed pre-mining levels

2.1.5 Mussels

Concentrations for As, Cr, Cu, Pb, Hg, Ni, Se increased in mussel tissues during the mining period, but most averages increased only slightly above pre-mining levels. The maximum values reported during the mining period reflect "spikes", and all of these levels exceed baseline averages, as well as statewide NOAA Mussel Watch averages.

Table 2-19 Metal Concentrations in Mussels Prior to and During Mining

Metals in Mussels: Average and Range							Mussel
Pre-Mining Baseline: Stn1-3, ESL (1984-1988)				Mining Period: Stn1-3, ESL (1989-2002)			Watch
Metal	Average	Minimum	Maximum	Average	Minimum	Maximum	Avg
Arsenic	10.207	6.430	19.700	**10.214**	6.100	**15.000**	11.480
Cadmium	7.988	3.250	15.760	7.290	0.250	**14.500**	2.870
Chromium	1.278	0.550	5.100	**2.555**	0.400	**13.100**	2.560
Copper	8.082	5.500	12.200	**8.667**	0.500	**110.000**	10.080
Lead	0.500	0.150	1.730	**1.155**	0.100	**4.760**	1.170
Mercury	0.045	0.014	0.340	**0.049**	0.010	**0.560**	0.070
Nickel	1.389	0.450	3.400	**2.372**	0.470	**10.800**	2.370
Selenium	2.897	1.180	4.600	**3.054**	0.800	**7.430**	3.760
Silver	0.143	0.040	0.710	0.126	0.060	**0.280**	na
Zinc	90.875	71.900	120.000	78.886	2.500	**113.000**	87.95

Bold values indicate mining production levels that exceed pre-mining average metal levels. Underlined values indicate values which exceed the mussel watch Alaska statewide averages.

USFWS sampled sites throughout Hawk Inlet in 1987 and 1997, including near the old cannery site that is now the ore loading dock area. Therefore, their data incorporates metal levels at that site, whereas the OIO data do not include ore loading dock information. USFWS summarized the results of their 1987 and 1997 mussel sampling efforts in Hawk Inlet as follows:

- Lead was higher in two of ten 1997 mussel samples
- The mean zinc concentration was higher in 1997 samples

- Copper concentrations were significantly higher in 1997
- Metal sediment levels from USFWS sampling were not reflected in mussels

2.1.6 Metal Concentrations in Aquatic Organisms

Very limited data are available on heavy metals in biotic tissues from freshwater systems in Hawk Inlet drainages. Holland *et al* (1981) collected samples of juvenile coho in July 1981 from Tributary Creek (Tributary to Zinc Creek). In a joint research project led by ADF&G staff (2003) coho and dolly varden were sampled from Greens Creek and Tributary Creeks, including sites within and above stream segments receiving tailings water.

Only the *highest* values found in fish in Tributary Creek in 1981 and the 2000-2002 study are provided here Table 2-20. In comparing 1981 coho results with 2000-2002 coho and dolly varden samples from Tributary Creek, levels for most metals measured are higher. The exception is Ag, which is substantially lower in the 2000-2002 samples. Cd, Cu, Pb, Se and Zn are substantially higher than the 1981 values. It is important to note that results may be due in part to differences in study design, fish species, fish age, sampling location, tissue selection, etc.

Table 2-20 Metals in Tributary Creek Fish Prior to and During Mining

Metals in Tributary Creek Fish: Highest Levels Reported (mg/kg dry) ppm						
	Ag	Cd	Cu	Pb	Se	Zn
1981	0.86	0.14	3.8	<0.36	1.6	190
2000	0.68	0.54	16.7	1.56	3.8	189
2001	0.11	0.67	6.42	1.50	6.62	119
2002	0.10	0.96	5.13	1.83	4.42	154

2.1.7 Metal concentrations and toxicity testing in selected streams

The recently developed biomonitoring program led by ADF&G with the University of Alaska Fairbanks is summarized here. Heavy metals in juvenile fish and toxicity testing were conducted to ascertain the degree of difference between affected study sites and reference sites. The median values for mercury, lead, cadmium, selenium, copper, and zinc were similar among the two study sites. No metal levels in fish at or below affected sites were elevated above reference site levels.

Acute toxicity tests using water from each site were conducted using changes in growth of *Vibrio fishceri* at variable concentrations as an indicator of water quality. There was no toxic response from any sites at any concentration test up to undiluted stream water.

The study results to date provide an initial indication that aquatic ecosystems at sites subjected to tailings contact water continue to maintain healthy, abundant periphyton and invertebrate populations relative to control sites. When compared to the selected reference site, metals did not appear to concentrate in juvenile fish potentially exposed to contact water, relative to fish in the same stream above the possible exposure point.

2.1.8 Summary: Marine and Aquatic Habitats and Biota in Hawk Inlet

The status of the health of marine and aquatic can be viewed based on species diversity ("biodiversity"), species abundance (density of organisms in a study area), and quality of the environment (habitat integrity relative to pristine conditions).

Aquatic Environment Physical and chemical changes to aquatic habitats in the project area drainages are further detailed in the FEIS (USDA FS 2003).nThe limited aquatic data presented here suggests that the diversity and abundance of aquatic life in selected streams are comparable to sites unaffected by mining. While heavy metal levels in Tributary Creek fish appear to be substantially higher since mine operations began, surface and groundwater analyses do not show such increases (Oeklaus 2003). The recent biomonitoring study suggests that metal levels are elevated in stream sections above mining operatiobs as well, suggesting a possible area-wide increase in metals in fish tissue.

Marine Environment For the marine environment, there are no data available to numerically compare current diversity or abundance of organisms between pre-mining and post-mining years, nor with a comparable natural control site. The extensive pre-mining surveys show that Hawk Inlet harbored high densities of a diverse range of species in the various intertidal and subtidal habitats. These data could serve as a sufficient baseline for quantitatively comparing these parameters to current conditions if re-surveyed. Meanwhile, anecdotal observations by fishermen and researchers suggests that the physical features and biotic communities of Hawk Inlet appear to remain intact following nearly 12 years of operation of the mine.

Physical changes The quality of the environment subsequent to mining can also be viewed based on physical and chemical changes. Physical changes to the marine environment resulting from the mining operation include very minor alterations of the seafloor for installation of outfall pipes and diffusers at outfalls 001 and 002, piling driven for modifications to the dock and loading facility, removal of most old Cannery debris, and impacts of the ore concentrate spill on the seafloor near the dock. Vessels traveling to and from the facility may have led to infrequent disturbances to fish and wildlife, but these are considered temporary and have no effect on populations. No major fuel spills on land or water have been reported which would suggest petroleum hydrocarbon impacts to Hawk Inlet since a 1989 diesel spill near the shiploader (Oeklaus 2003).

Metals in sediments Based on the data presented here, it appears that heavy metals in sediment near the outfall 002 site have not increased substantially above the area-wide baseline levels during mining years (baseline is S1, S2 and S3 average). Although some metals remained above NST ERL levels, these metals appear to be of naturally high concentrations in the study area. When comparing pre-mining sediment levels at station S-1 to production period mining at S-1, marked increases in some metals (As, Cd, Pb, Hg, Se and Ag) are apparent. Although measurements at S-1 during the mining period have exceeded ERL levels numerous times, only Ni and Cr have reached ERM levels. It appears that some elevated metal levels in sediments at the outfall site may likely result from mining operations, some metals are at levels warranting attention, but are not likely toxic to marine life, based on National Status and Trends from nationwide studies.

Metals concentrations in sediments near the ore loading dock increased abruptly due primarily to the 1989 ore concentrate spill. Compared to the National Status and Trends data and AET levels, some heavy metals in marine sediments at stations S-4, S-5S and S-5N are present at levels that are likely toxic to bivalves, amphipods, and the infaunal community (organisms burrowed in the seafloor). Cd, Cu, Pb, Hg, Se, Ag and Zn occur at the ore loading dock sites at levels of concern for biological communities.

Metals in worms The indicator polychaete worm, *Nephthys*, had higher concentrations of Cr, Pb and Ni at stations S-1, S-2 and S-3 during the mining period than prior to mining. At station S-4, three metals were above baseline levels during the mining period: Cu (2.5X), Pb (24X), and Ni (5X). These same metals were also substantially higher than the area wide average Cu 3X), Pb (14X) and Ag (4X). This suggests that the elevated concentrations in this worm species are related to mining activities, likely the 1989 concentrate spill residual. As worms are still present at this site 14 years following the spill, these levels do not appear to be fatally toxic to worms. It is not known whether these levels are sub-lethally toxic to worms, or whether the metals in worm tissue are biologically available to species that prey on these worms.

Nephthys at station S-4 also exhibited signs of bioconcentration of Arsenic. Where sediment concentrations of As ranged from 4 to 20 ppm, As in this worm from the same site ranged from 15 to 37 ppm over the many years sampled.

Metal levels in the other polychaetes worm sampled, *Nereis*, show response increases in metals following the 1989 concentrate spill, and continued elevated concentrations of some metals in the most recent sampling years.

Metals in mussels Both the USFWS and OIO longterm monitoring study results indicate that metals in mussels are at higher levels subsequent to mining operations. The USFWS study showed that average levels for 10 stations in Hawk Inlet, Pb, and Zn were higher in 1997 than in 1987 (Rudis 2001). OIO monitoring results show that four metals are at somewhat higher concentrations at monitoring stations: Cr (2x), Pb (2.3X), Ni (1.7X), and Se (1.1X). Note that while Zn increased in the USFWS study, levels decreased in the OIO monitoring study. Whereas maximum measurements for all metals except As, Hg, and Ag exceeded Alaskan Mussel Watch average levels, the average mining production period metal levels are generally below Mussel Watch averages for Alaska. The exception to this is Cd, which was above Mussel Watch Alaska averages prior to and subsequent to mining operations. Because the USFWS Hawk Inlet-wide levels of Pb increased similarly to the outfall monitoring site levels of Pb, these increases over time may be due to natural increases in Pb in the environment.

Overall, these data suggest that mussels may be experiencing slightly elevated levels of Cr, Pb, Ni, Se and possibly Zn during the mining activity time period – similar to increases in these metals in Hawk Inlet sediments. Due to the variability in data and lack of comparison with control sites, the causes for minor metal elevations cannot be identified.

Metals in Clams and Brachiopods Brachiopods have exhibited spikes in metal levels following the ore concentrate spill, but in most cases metal concentrations in this species then decreased. Some metals in braciopods continued to exhibit increasing concentration trends. Cockles, little neck clams and soft shell clams exhibited varying concentrations. Due to the irregular sampling frequency, it is difficult to elucidate trends in these data.

Essential Fish Habitat Anadromous salmon habitat effects of the Greens Creek Mine appear to be limited to the physical and chemical changes to wetlands and drainages described in the FEIS and possibly increased metal concentrations in coho tissue in Tributary Creek. Saltwater salmon for juveniles and adults includes the water column and shallow nursery and staging areas in Hawk Inlet. Seawater data presented in section 1 indicates that only three metals are slightly elevated above the background station over a 20 year time period. Based on the comparison of average metal levels at stations 106 and 108 only, it does not appear as if the water column has been impacted – therefore neither planktonic prey nor salmon likely have been negatively effected by mining effluent. Metals in sediments and biota at stations throughout Hawk Inlet have increased in some cases, and juvenile salmon would likely encounter elevated metal levels through consumption of demersal crustaceans and other prey species.

Marine species which consume sedentary seafloor organisms such as worms and bivalves would be most susceptible to trophic transfer of some metals. Foodweb diagrams for polychaetes, tanner crab and halibut illustrate some of the pathways for potential transfer of metals among species in Hawk Inlet. Based on the suite of species listed as having Essential Fish Habitat in Hawk Inlet, the species most likely to encounter these elevated metal levels through their diet and habitat uses would include the flatfishes (*eg* yellowfin sole, arrowtooth flounder, flathead sole, and rock sole), pacific cod, sculpin, octopus and crab species. Though not an EFH species, Pacific halibut also have similar consumption patterns to these species. All of these species consume worms, bivalves, and crab.

In light of the data presented on elevated levels of metals in some invertebrates, it is likely that the EFH for some species has been degraded as a result of mining operations.

Ecosystem Effects Migratory and resident fish, mammals, and birds which consume seafloor-dwelling organisms in the limited area near the ore loading dock would also likely encounter elevated metal levels in their diet. There are no data available to evaluate whether metals are increasing at higher trophic levels in Hawk Inlet marine species such as fish, crab and mammals. The lethal, sublethal, and overall extent of any ecosystem effects of the mine operation cannot be fully quantified without further sampling and analysis.

3 Mitigation and Minimization of Mining Effects

The Kennecott Greens Creek Mining Company has undertaken numerous projects, operational design revisions, monitoring activities and research to identify, mitigate or minimize the short term and long term effects of mining on the marine and aquatic environment. Some of these efforts are reflected in the list below. A review by the Greens Creek Inter-Agency Review Team further details performance regarding environmental stewardship (February 2000).

3.0 Mitigation Measures Taken to Minimize Effects on Water Habitats

3.0.1 Operations

1. Redesigned and reconstructed shiploading facility: Ore conveyor now fully enclosed to prevent dust escapement and spillage.
2. Modified effluent treatment: treatment previously was passive, with natural settling pond; now active treatment is fully enclosed, flocculant and co-precipitant are added to precipitate metals, pH monitored and controlled
3. Haulage trucks are covered to eliminate spillage or dusting; truck tires are washed after each load prior to re-entering the site road network.
4. Collect and treat process waters and contact runoff
5. To minimize sedimentation and runoff, disturbed surface areas are reclaimed, structures removed, and sites are revegetated.
6. To minimize groundwater/ARD mobility and potential entry to aquatic and marine waters, contain, capture and treat contact water, cap, cover and monitor rock piles and tailing; divert run-on groundwater and surface waters.
7. Spill impact minimization: ADEC-approved spill prevention plans and cleanup protocols are instituted throughout the operation. All spills are immediately reported, and cleanup is accelerated to minimize spread of fuels and other contaminants.

3.0.2 Monitoring and Research

1. NPDES Program Monitoring and Reporting
2. Freshwater quality monthly monitoring and reporting
3. Freshwater withdrawals monitored and reported to USFS
4. All creek disturbances are reported to ADF&G and remediated
5. Toxicity testing and bioassays on marine organisms have been conducted to monitor potential biological effects of mining effluent on the environment.
6. Internal geo-chemical monitoring to document chemical status of surface sites.
7. Regular audits by external scientists to ensure integrity of programs and provide diverse viewpoints.

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Appendix A: Hawk Inlet Species Distributions by Habitat

Pre-Mining Baseline Intertidal and Subtidal Quadrat Sampling Results
(1981)

Tables excerpted from:

Final Results of the 1981 Summer Field Program for the Greens Creek Project

A.F. Holland, M. Hiegel and W.A. Richkus

Environmental Center

Martin Marietta Corporation

Baltimore, Maryland 1981

Table A.	Greens Creek Delta density of species observed (B-4, B-5, B-6)
Table B.	Cannery Site density of species observed (B-8, B-9, B-10)
Table C.	Head of Hawk Inlet density of species observed (B-12, B-13, B-14)

GREENS CREEK DELTA

	Intertidal							Subtidal						
	1	2	3	4	5	X̄	SD	1	2	3	4	5	X̄	SD
Foraminifera														
Unidentified forams	64935	90909	64935	1.1E5	1.4E5	93351	30340				1794	763	512	789
Cnidaria								38					8	17
Unidentified anemones														
Platyhelminthes														
Acoela sp.									229				46	102
Unidentified flatworms		130	130			52	71							
Nematoda														
Unidentified nematodes					649	130	290	38					8	17
Rhynchocoela														
Unidentified nemertean (red)	130	260	260		1169	364	463	458	992	229	611	76	473	356
Unidentified nemertean (red w/white head)	260		130	260		130	130							
Phoronida														
Phoronopsis harmeri								305	305	229	878	534	450	265
Chaetognatha														
Unidentified chaetognath														
Gastropoda														
Acmacea sp (Limpets)	1169		260			286	506							
Alvinia sp.														
Boreotrophon pacificus														
Cylichna sp.								38		38	38		23	21
Lacuna variegata								3588	4542	153	76	76	1687	2197
Littorina sitkana	909	260	260	260		338	339							
Littorina scutulata	130				130	52	71	76	229	38			69	95
Moellaria sp.								687	305	114	38	153	260	258
Natica sp.														
Nucella emarginata														
Odostomia sp.														
Polinices pallidus														
Unidentified nudibranchs											38		8	17
Bivalvia														
Clinocardium ciliatum														
Lucinoma annulata														
Nuculana hamata														
Nucula tenuis														
Macoma balthica									153				30	68
Macoma calcarea														
Macoma nasuta														
Macoma obliqua														
Macoma sp.											38		8	17
Mya arenaria														
Mya arenaria siphon														
Mysella sp.			390	130		104	169	76	76	38			38	38
Mytilus edulis			130			26	58	38	76		38	76	46	32
Pandora filosa														
Panomya ampla								38		38	229		61	96
Protothaca staminia			130			26	58	76	191	76	38	305	137	110
Psephidia lordi								1107	3130	305	191	153	980	1265
Yoldia myalis														
Oligochaeta														
Oligochaetes														
Polychaeta														
Ampharetidae sp. 1											38		8	17
Ampharetidae sp. 2														
Arabellidae					130	26	58		38				8	17
Aricidea jefreysii										1107			221	495
Armandia brevis					130	26	58	4504	5191		1908	1985	2718	2114
Capitellidae(unidentified juvenile)			130			26	58							
Capitellidae (short)														
Chaetopteridae					260	52	116	1488	3053	153	1527	534	1351	1124
Chaetozone setosa									38		38		15	21
Chone sp.								496	229	114		458	260	215
Cossura longocirrata											114		23	51
Dorvillea sp.	130					26	58							
Eteone longa								153	153	229	114	267	183	63
Eunoe uniseriata														
Euchone analis								76		153	191	420	168	159
Exogone gemmifera			130		130	52	71	38	76	153			53	64
Fabricia sabella	909	130	1299	260	1948	909	752		76		76		30	42
Glycinde sp.					130	26	58				76	38	25	34
Gyptis sp.														
Harmothoe imbricata								229	496	305	191	153	275	136
Haploscoloplos elongatus (Orbiniidae)									76				15	34
Lumbrineris sp.														
Maldanidae sp. 1														
Nephtys ciliata								76		38	38	114	53	44
Nephtys sp. 1									114				23	51

GREENS CREEK DELTA

	Intertidal							Subtidal						
	1	2	3	4	5	X̄	SD	1	2	3	4	5	X̄	SD
Nephtys sp. 2														
Nephtys sp. 3														
Nereidae										38	38		15	21
Onuphis geophiliformis								114	38	38		153	69	63
Owenia fusiformis								114	1107	153	267	191	366	413
Pectinaria sp.								382	1794	267	114	534	518	675
Pholoe minuta	390		260	130	130	182	148		76	38		76	38	38
Phyllodoce groenlandica									38		38	38	23	21
Pilargidae														
Polydora socialis				130	390	104	169		38		38		15	21
Praxillella														
Prionospio malmgreni					520	104	232	12214	5153	3168	5191	2672	5680	3826
Prionospio (filament gills)														
Prionospio sp. (large eyes)								114					23	51
Potamilla sp.														
Scolelepis sp.														
Sphaerosyllis erinaceus									38	38			15	21
Sphaerosyllis sp.								916	1221	344	534	305	664	394
Spio filicornis	1299		1169		1169	727	666	38	114	38	153	114	91	51
Spiophanes sp.			130		779	182	339	370	15458	2252	8702	5878	6532	5939
Spionidae sp. 1 (forked nose)								76	76	38		114	61	43
Spionidae sp. 2 (stubby nose)								76			114	153	67	68
Spionidae sp. 3 (large eyes)									114				23	51
Spionidae sp. 4 (black cheeks)														
Sternaspis scutata	390	390	130	260	2857	805	1152				38		8	17
Syllis adamantea														
Syllis sp.	130	390	390			182	197							
Syllidae sp. 2				260	779	208	339							
Syllidae sp. 3								38						
Tharyx secundus														
Travisia sp. 1								38					8	17
Travisia sp. 2			260	260	909	286	382	38		114			30	50
Archiannelida														
Dinophilidae														
Protodriloides sp.														
Amphipoda														
Bateidae									76			114	38	54
Caprella laeviuscula									114				23	51
Corophium sp. 1				130	390	104	169	382	458	305		2214	672	879
Corophium sp. 2			260		260	104	142		76		2214	38	466	787
Gammaridae sp.														
Hyperiidae sp.											38		8	17
Lysianassidae sp. 1					260	52	116							
Lysianassidae sp. 2								38	38	344		344	153	175
Marinogammarus sp.									38				8	17
Mesogammaridae														
Oedicerotidae sp. 1											38	76	23	34
Oedicerotidae sp. 2								153					31	68
Photis sp.					130	26	58	153	267	344			153	155
Phoxocephalidae								153	305	38	38	114	130	110
Stenothoidae											38		8	17
Talitridae								305	305	191	687	382	374	188
Unidentified amphipod sp. 2					260	52	116	229	153	496	3511	3015	1481	1641
Unidentified amphipod sp. 3								38		114	38	38	46	42
Unidentified amphipod sp. 4								76		267		38	76	111
Cumacea														
Unidentified cumacean									191	114		38	69	83
Isopoda														
Asellota										38			8	17
Gnorimosphaeroma oregonense			520	260	130	182	217				38		8	17
Idotea aculatea									38			38	15	21
Tanaidacea														
Unidentified tanaids					130	26	58	267	38	229	114		130	116
Mysidacea														
Unidentified mysids														
Caridea														
Crangon munitella								38					8	17
Sclerocrangon alata														
Euphausiacea														
Unidentified euphausids											38		8	17
Copepods														
Cyclopiod copepod														
Unidentified Calanoid sp.								38			114	153	61	69
Unidentified Harpacticoid sp.	260		520	260	130	234	193	458	3740	38	76	305	923	1589
Ostracod														
Unidentified ostracods									38				8	17

GREENS CREEK DELTA

	Intertidal							Subtidal						
	1	2	3	4	5	X̄	SD	1	2	3	4	5	X̄	SD
Cirripedia														
Unidentified barnacles			1558			312	697	76	38	382		38	107	156
Paguroidea														
Pagurus sp.									38				8	17
Brachyura														
Unidentified crab								76	38			38	30	32
Unidentified zoea														
Arachnida														
Unidentified mite														
Unidentified Pseudoscorpionida														
Insecta														
Unidentified insect larvae														
Unidentified species			390			78	174							
Echinodermata														
Unidentified sea urchins								687	1145	1336	420	458	809	412
Unidentified sand dollars														
Unidentified sea cucumbers														
Unidentified star fish								38	114				30	50
Tunicata														
Unidentified tunicates														

CANNERY

	Intertidal							Subtidal						
	1	2	3	4	5	X̄	SD	1	2	3	4	5	X̄	SD
Foraminifera														
Unidentified forams	3.0E5	2.0E5	1.1E5			1.2E5	1.2E5	2786	2176	2099	534	1374	1796	865
Cnidaria														
Unidentified anemones														
Platyhelminthes														
Acoela sp.														
Unidentified flatworms														
Nematoda														
Unidentified nematodes	654	2158	1046	1242	4837	1647	1810	305	611	382	114	305	344	179
Rhynchocoela														
Unidentified nemertean (red)	65	65	65	131	131	92	36	191	382	38	496	153	252	184
Unidentified nemertean (red w/white head)														
Phoronida														
Phoronopsis harmeri														
Chaetognatha														
Unidentified chaetognath								38	229	191	229	153	168	79
Gastropoda														
Acmaea sp. (Limpets)	196	196	654	261	65	274	224							
Alvinia sp.										38			8	17
Boreotrophon pacificus	131	65	38	196		86	78							
Cylichna sp.														
Lacuna variegata			196	65	65	65	80			229	38		53	100
Littorina sitkana	1307	458	327	392		497	486							
Littorina scutulata	588		327	2680	196	758	1095							
Moellaria sp.								38				38	8	17
Natica sp.												38	8	17
Nucella emarginata								38				38	15	21
Odostomia sp.	65					13	29					38	8	17
Polinices pallidus									38				8	17
Unidentified nudibranchs														
Bivalvia														
Clinocardium ciliatum														
Lucinoma annulata								687	649	1336	992	1450	1023	366
Nuculana hamata									38				8	17
Nucula tenuis								229	420	38	114	191	198	144
Macoma balthica	1372	1307	1569	1634	1438	1464	136							
Macoma calcarea									229	305	496	267	260	178
Macoma nasuta														
Macoma obliqua								153				38	38	66
Macoma sp.														
Mya arenaria				65		13	29							
Mya arenaria siphon				65		13	29							
Mysella sp.	65			65	65	39	36							
Mytilus edulis	1372	65	1307	327	1438	902	653							
Pandora filosa														
Panomya ampla				65		13	29							
Protothaca staminia	65		131	523	65	157	210							
Psephidia lordi								38					8	17
Yoldia myalis								76	38	38	38	38	46	17
Oligochaeta														
Oligochaetes				3006		601	1344					38	8	17
Polychaeta														
Ampharetidae sp. 1			65			13	29	38	114	76	76	114	84	32
Ampharetidae sp. 2														
Arabellidae	65					13	29							
Aricidea jefreysii								38	76	76			38	38
Armandia brevis			65			13	29		38	76		76	38	38
Capitellidae(unidentified juvenile)	131	654	588	1046	131	510	388	725	458	534	458	114	458	221
Capitellidae (short)	654		1076	1046	915	738	445							
Chaetopteridae										38			8	17
Chaetozone setosa														
Chone sp.									191	114		153	92	88
Cossura longocirrata								611	1221	1221	1107	1679	1168	381
Dorvillea sp.								38				76	23	34
Eteone longa	392	261	456	1176	523	562	357							
Eunoe uniseriata								38	76				23	34
Euchone analis														
Exogone gemmifera			196	392	65	131	167		38	38			15	21
Fabricia sabella	6601	3399	8039	10458	4902	6680	2741	76			153		46	68
Glycinde sp.					65	13	29			38	38		15	21
Gyptis sp.									76				15	34
Harmothoe imbricata			131	65		39	68	382	458	916	344	267	473	259
Haploscoloplos elongatus (Orbiniidae)								611	534	114	38	496	359	262
Lumbrineris sp.		131				26	58	878	1145	611	1260	840	947	258
Maldanidae sp. 1								267	191		38	38	107	116

CANNERY

	Intertidal							Subtidal						
	1	2	3	4	5	$\overline{X}$	SD	1	2	3	4	5	$\overline{X}$	SD
Ostracod														
Unidentified ostracods														
Cirripedia														
Unidentified barnacles				64		13	29							
Paguroidea														
Pagurus sp.	65	196	523	588	719	413	276		38				8	17
Brachyura														
Unidentified crab														
Unidentified zoea								76	38	114	38	229	99	79
Arachnida														
Unidentified mite				65		13	29							
Unidentified Pseudoscorpionida														
Insecta														
Unidentified insect larvae	65		131		1111	261	478							
Unidentified species														
Echinodermata														
Unidentified sea urchins														
Unidentified sand dollars														
Unidentified sea cucumbers														
Unidentified star fish														
Tunicata														
Unidentified tunicates														

HEAD OF INLET

	Intertidal							Subtidal						
	1	2	3	4	5	X̄	SD	1	2	3	4	5	X̄	SD
Foraminifera														
Unidentified forams														
Cnidaria														
Unidentified anemones														
Platyhelminthes														
Acoela sp.	130					26	58							
Unidentified flatworms														
Nematoda														
Unidentified nematodes	130	130	260	130		130	92	76			305	76	92	125
Rhynchocoela														
Unidentified nemertean (red)	130					26	58	76	38	76	38	114	69	32
Unidentified nemertean (red w/white head)														
Phoronida														
Phoronopsis harmeri														
Chaetognatha														
Unidentified chaetognath														
Gastropoda														
Acmaea sp. (Limpets)														
Alvinia sp.								38		76	38	38	38	27
Boreotrophon pacificus														
Cylichna sp.														
Lacuna variegata	1558	1948	1558	5844	519	2285	2059	191	38	382	153	267	206	128
Littorina sitkana														
Littorina scutulata											763	611	275	380
Moellaria sp.	1688	4545	3247	1948	1039	2493	1400							
Natica sp.														
Nucella emarginata								38		76	38	38	38	27
Odostomia sp.														
Polinices pallidus														
Unidentified nudibranchs														
Bivalvia														
Clinocardium ciliatum											38		8	17
Lucinoma annulata								153			840	4008	1000	1717
Nuculana hamata														
Nucula tenuis											76	153	46	68
Macoma balthica	390	390	519	130	130	312	174							
Macoma calcarea														
Macoma nasuta		130		130		52	71	229		38	267	649	237	258
Macoma obliqua														
Macoma sp.														
Mya arenaria														
Mya arenaria siphon														
Mysella sp.	25714	19870	10519	13766	7662	15506	7292	191		229	4008	7443	2374	3293
Mytilus edulis		130				26	58							
Pandora filosa														
Panomya ampla														
Protothaca staminia														
Psephidia lordi														
Yoldia myalis														
Oligochaeta														
Oligochaetes														
Polychaeta														
Ampharetidae sp. 1														
Ampharetidae sp. 2														
Arabellidae														
Aricidea jefreysii									38		38		15	21
Armandia brevis											38		8	17
Capitellidae(unidentified juvenile)	1558	3766	2987	3117	390	2364	1366	76	114		573	305	214	230
Capitellidae (short)														
Chaetopteridae														
Chaetozone setosa														
Chone sp.												38	8	17
Cossura longocirrata												76	15	34
Dorvillea sp.											153	76	46	68
Eteone longa	260	1039	390	260	130	416	360					76	15	34
Eunoe uniseriata														
Euchone analis														
Exogone gemmifera														
Fabricia sabella				130		26	58							
Glycinde sp.	130		130	130	390	156	142	114		38	153	191	99	79
Gyptis sp.														
Harmothoe imbricata	130	779	390	519	390	442	236	305		420	649	76	290	262
Haploscoloplos elongatus(Orbiniidae)	390	2468	390	1299	390	987	917			3511	1260		954	1530
Lumbrineris sp.										38	1069	840	389	552
Maldanidae sp. 1														

HEAD OF INLET

	Intertidal							Subtidal						
	1	2	3	4	5	$\bar{X}$	SD	1	2	3	4	5	$\bar{X}$	SD
Nephtys ciliata	3636	7662	11169	2357	2727	5610	3705			38	611	267	133	264
Nephtys sp. 1		909	519	260	260	390	343				840	382	144	372
Nephtys sp. 2														
Nephtys sp. 3														
Nereidae														
Onuphis geophiliformis														
Owenia fusiformis														
Pectinaria sp.											38		8	17
Pholoe minuta								229		38	344	267	175	149
Phyllodoce groenlandica											38		8	17
Pilargidae				130		26	58	38				420	92	184
Polydora socialis														
Praxillella sp.						26	58				726	153		
Prionospio malmgreni	130									153	153	114	84	78
Prionospio sp. (filament gills)														
Prionospio sp. (large eyes)														
Potamilla sp.	649	649	519	649	390	571	116				76		15	34
Scolelepis sp.														
Sphaerosyllis erinaceus														
Sphaerosyllis sp.														
Spio filicornis	1169	1299	2338	1039	260	1221	744							
Spiophanes sp.		130				26	58							
Spionidae sp. 1 (forked nose)	11688	7792	12987	4545	2857	7974	4385				1298	191	298	565
Spionidae sp. 2 (stubby nose)			130			26	58							
Spionidae sp. 3 (large eyes)														
Spionidae sp. 4 (black cheeks)														
Sternaspis scutata														
Syllis adamantea														
Syllis sp.											38		8	17
Syllidae sp. 2	3636	5065	5195	647		2909	2449				38	38	15	21
Syllidae sp. 3														
Tharyx secundus														
Travisia sp. 1														
Travisia sp. 2	779	1429	2468	909	130	1143	873	38			229	114	76	97
Archiannelida														
Dinophilidae														
Protodriloides sp.														
Amphipoda														
Bateidae														
Caprella laeviuscula														
Corophium sp. 1														
Corophium sp. 2											38		8	17
Gammaridae														
Hyperiidae														
Lysianassidae sp. 1														
Lysianassidae sp. 2														
Marinogammarus sp.			390		260	130	184							
Mesogammaridae														
Oedicerotidae sp. 1														
Oedicerotidae sp. 2														
Photis sp.														
Phoxocephalidae														
Stenothoidae														
Talitridae											38		8	17
Unidentified amphipod sp. 2											38		8	17
Unidentified amphipod sp. 3		130				26	58			76			15	34
Unidentified amphipod sp. 4														
Cumacea														
Unidentified cumacean	130	260	260		130	156	109				76	114	38	54
Isopoda														
Asellota														
Gnorimosphaeroma oregonense														
Idotea aculatea														
Tanaidacea														
Unidentified tanaids	130					26	58							
Mysidacea														
Unidentified mysids	130	260	1688	779	4545	1480	1819							
Caridea														
Crangon munitella				130		26	58					38	8	17
Sclerocrangon alata														
Euphausiacea														
Unidentified euphausids														
Copepods														
Cyclopiod copepod														
Unidentified Calanoid sp.														
Unidentified Harpacticoid sp.	779	2597	8831	130		2467	3705				76	38	19	38

HEAD OF INLET

	Intertidal							Subtidal						
	1	2	3	4	5	$\overline{X}$	SD	1	2	3	4	5	$\overline{X}$	SD
Ostracod														
Unidentified ostracods		130	1039			234	454							
Cirripedia														
Unidentified barnacles														
Paguroidea														
Pagurus sp.				130		26	58							
Brachyura														
Unidentified crab														
Unidentified zoea														
Arachnida														
Unidentified mite														
Unidentified Pseudoscorpionida														
Insecta														
Unidentified insect larvae														
Unidentified species			130			26	58							
Echinodermata														
Unidentified sea urchins														
Unidentified sand dollars														
Unidentified sea cucumbers														
Unidentified star fish														
Tunicata														
Unidentified tunicates	130					26	58							

Water Quality Data Report

SiteNbr	Date	DupID	Total (ug	coverable in	coverable i	ine Total re	ecoverable	overable in	, Total (ug/	otal Recove	verable in V	, Total (ug/	overable in
			As Tot	As Rec	Cd Rec		Cr Rec	Cu Rec	Cn		Pb Rec	Hg Tot	Ni Rec
104	2/23/88			1.34	0.087		0.201	5.8			0.161	0.0004	1.13
104	2/23/88			0.91	0.081		0.175	0.538			0.024	0.0003	0.622
104	5/20/88			0.69	0.113		0.443	6.33	<5		0.319	0.0147 (J)	1.56
104	5/20/88			0.98	0.081		0.192	0.561			0.056	0.0125	0.571
104	8/31/88			0.69	0.161		0.414	8.08	<5		1.57	0.0147 (J)	0.73
104	8/31/88			0.77	0.078		0.192	0.5			0.084	0.001	0.508
104	12/14/88			1.1	0.095		0.59	0.61			0.177	0.0006	0.619
104	12/14/88			0.97	0.097		0.39	0.35			0.078	0.0004	0.558
104	2/1/89			1.6	0.108		0.68	1.02			0.196	0.0004	0.711
104	2/1/89			1.16	0.103		0.59	0.45			0.103	0.0016	0.497
104	5/10/89			1.1	0.06		0.23	0.63	<5		0.107	0.0009	0.65
104	5/10/89			0.97	0.06		0.25	0.43			0.074	0.0013	0.58
104	8/27/89			0.95	0.093		0.54	3.53	<5		3.95 (J)	0.0007	1.8
104	8/27/89			1.1	0.073		0.33	0.85			0.09	0.0003	1.7
104	11/20/89			1.43	0.097		0.14	0.49	<5		0.08	0.00066	0.68
104	11/20/89			1.35	0.091		0.11	0.45			0.08	0.0007	0.51
104	2/28/90			1.05	0.084		0.3	0.57	<5		0.21	0.0003	0.59
104	2/28/90			1.37	0.082		0.19	0.42			0.52	0.00052	0.57
104	5/31/90			1.4	0.078		0.15	1.3			0.16	0.0003	0.95
104	5/31/90			0.99	0.084		0.19	0.58			0.1	0.0003	1.6
104	8/30/90			0.85			0.35				0.638	0.00042	
104	8/30/90			0.99			0.19				0.262	0.00064	
104	12/11/90			1.28	0.117		0.249	0.973			0.34	0.00188	0.492
104	12/11/90			1.27	0.1		0.187	0.541			0.15	0.0012	0.455
104	2/8/91			1.39	0.115		0.183	2.29	<5		0.22	0.00058	0.637
104	2/8/91			0.77	0.1		0.228	1.02			0.14	0.00093	0.496
104	5/20/91			0.74	0.106		0.24	1.74			0.43	0.00195	0.79
104	5/20/91	1		0.004	<2		100 (J)	<2	<5		<7	<0.01	3
104	5/20/91			0.93	0.092		0.16	1.14			0.31	0.00054	0.72
104	5/20/91	1		<5	<2		240 (R)	40 (R)			<7	<0.01	5
104	8/17/91			1	<2		<6	<2	12		2	<0.01	4
104	8/17/91			<1	<2		<6	<2			1	0.01	<4
104	11/26/91			1.58	0.103		0.43	1.15			0.257	0.00016	1.73
104	11/26/91			1.42	0.103		0.21	0.64			0.107	0.00009	0.9
104	2/27/92			1.59	0.098		0.53	0.8			0.301	0.00078	0.78
104	2/27/92	1		<1	7 (R)		9	<2	<5		<1	<0.01	<1
104	2/27/92			1.29	0.093		0.39	0.52			0.138	0.00088	0.83
104	2/27/92	1		<1	<2		8	<2			<1	<0.01	<1
104	5/29/92			1.35	0.057		1.47	0.694			0.16	0.00124	0.89
104	5/29/92	1		<4	<2		<6	<4	<5		<1	<0.01	16 (R)
104	5/29/92			1.48	0.058		0.34	0.592			0.119	0.00106	0.64
104	5/29/92	1		2	5 (R)		<6	5			<1	<0.01	5
104	9/13/92			1.43	0.08		0.511	4.1	<5		0.391	0.00106	1.91
104	9/13/92			1.24	0.075		0.2	1.3			0.069	0.00026	0.63
104	10/30/92			1.34	0.094		0.21	1.27	<5		0.383	0.00043	0.517
104	10/30/92			1.26	0.088		0.153	0.658			0.073	0.00029	0.582
104	1/29/93			1.71	0.134		0.493	5.21	<5		1.3	0.00459	1.4
104	1/29/93			1.53	0.102		0.164	0.435			0.11	0.00054	0.644
104	4/9/93			2.2	0.12		0.434	4.2	<5		0.846	0.0007	0.79
104	4/9/93			1.1	0.1		0.178	0.75			0.209	0.0005	0.41
104	7/10/93			3.2	0.066		0.19	2	<5		0.14	0.00084	0.9
104	7/10/93			2.3	0.064		0.17	0.49			0.068	0.00056	0.54
104	10/7/93			1.2	0.094		0.24	0.76	<0.005		0.12	0.00021	0.92
104	10/7/93			1	0.095		0.27	0.7			0.21	0.00034	1.6
104	1/19/94			2.31	0.102		0.13	1.52	<5		0.197	0.0004	0.495
104	1/19/94			2.05	0.099		0.63	0.789			0.234	0.0004	0.435
104	4/5/94			2.92	0.085		0.36	1.83	<5		0.363	0.00098	0.781
104	4/5/94			1.95	0.076		0.21	0.632			0.07	0.00087	0.544
104	7/14/94			0.81	0.056		0.178	0.572	<5		<0.01	0.00054	0.564
104	7/14/94			1.63	0.053		0.178	0.764	<5		<0.01	0.00057	0.778
104	10/13/94			1.7	0.0767		0.22	2.9	<5		0.299	0.00058	0.686
104	10/13/94			1.84	0.0526		0.56	0.691	<5		0.116	0.00056	0.984
104	1/6/95			1.98	0.079		0.21	0.748	<5		0.105	0.00037	0.826
104	1/6/95			1.7	0.086		0.23	0.815	<5		0.054	0.00034	0.61
104	5/2/95			1.99	0.0763		0.44	0.708	<5		0.221	0.00225	0.508
104	5/2/95			1.99	0.0821		0.26	0.461	<5		0.073	0.00151	0.561
104	8/31/95			1.49	0.0678		0.226	0.57	<5		0.0675	0.000264	0.454
104	8/31/95			1.74	0.0694		0.313	0.366			0.0539	0.000776	0.443
104	11/30/95			0.86	0.1		0.346	0.9	<5		0.3	0.000369	0.9
104	11/30/95			1.59	0.1		0.2	<0.2			<0.1	0.000347	0.8
104	3/13/96			2.11	0.0836		0.18	0.28	<5		0.0457	0.00043	0.409
104	3/13/96			1.73	0.0829		0.16	0.257			0.0057	0.000613	0.368

Water Quality Data Report

SiteNbr	Date	DupID	Total (ug	coverable in	coverable iine	Total re	coverable	overable in	, Total (ug/	otal Recov	overable in V	, Total (ug/	overable in
			As Tot	As Rec	Cd Rec		Cr Rec	Cu Rec	Cn		Pb Rec	Hg Tot	Ni Rec
104	2/23/88			1.34	0.087		0.201	5.8			0.161	0.0004	1.13
104	2/23/88			0.91	0.081		0.175	0.538			0.024	0.0003	0.622
104	6/24/96			1.05	0.0615		0.266	0.386	<5		0.0602	0.0012	0.577
104	6/24/96			1.02	0.0637		0.342	0.335			0.0601	0.00064	0.472
104	9/23/96			1.08	0.0624		0.309	0.659		<5	0.13	0.000597	0.434
104	9/23/96			1.02	0.0594		0.145	0.339			0.0621	0.000595	0.475
104	12/17/96			1.99	0.0876		0.278	0.312	<5	<5	0.0445	0.00274	0.44
104	12/17/96			0.0303	<0.25		<2.93	0.311			0.0609	<0.000047	0.389
104	3/4/97			2.05	0.0866		0.18	0.283	<5	<5	0.0714	0.00147	0.411
104	3/4/97			1.88	0.0996		0.22	0.536			0.12	0.0041	0.404
104	6/11/97			2.44	0.0773		0.2	0.574		<5	0.642	0.00124	0.565
104	6/11/97			2.12	0.0756		0.15	0.363			0.0994	0.000612	0.409
104	8/25/97		0.697		0.0564		0.127	0.43	<5		0.124	0.000684	0.344
104	8/25/97		0.775		0.0591		0.368	0.413			0.129	0.00119	0.407
104	12/8/97		1.3		0.0961		0.181	0.954		<5	0.0519	0.00129	1.02
104	12/8/97		1.53		0.0896		0.154	0.348			0.0397	0.00169	0.58
104	3/17/98		1.55		0.0707		0.277	0.455	<5		0.1	0.000917	0.418
104	3/17/98		1.64		0.071		0.341	0.332			0.21	0.000456	0.45
104	6/2/98		0.846		0.0624		0.216	0.516	<20		0.12	0.000925	0.638
104	6/2/98		1		0.0631		0.175	0.365			0.0419	0.000929	0.431
104	9/10/98		0.972		0.054		0.26	3.31	<20		0.17	0.000743	0.504
104	9/10/98		0.957		0.0557		0.158	0.341			0.0482	0.00136	0.521
104	11/12/98		1.66		0.0844		0.242	1.08	<20		0.264	0.0117 (J)	0.602
104	11/12/98		1.7		0.0871		0.235	0.652			0.143	0.0103	0.512
104	3/10/99				0.0805			0.757	<5		0.0903	0.000813	
104	6/17/99				0.0631			0.561	<5		0.166	0.00078	
104	8/17/99				0.0532			1.75	<5		0.186	0.00122	
104	10/28/99				0.0766			0.623	<5		0.54	0.00182	
104	2/24/00				0.0874			1.16	<5		0.358	0.000972	
104	6/7/00				0.0672			0.661	<5		0.211	0.00117	
104	9/19/00				0.0688			1.16			0.24	0.00135	
104	12/20/00				0.0842			0.47	<10		0.0565	0.000858	
104	3/5/01				0.0794			0.388	<8		0.0519	0.000641	
104	6/12/01				0.0666			0.471	<5		0.0517	0.000974	
104	8/23/01				0.0558			0.33	<5		0.0329	0.000429 (H	
104	12/20/01				0.0876			1.95	<4		0.0722	0.00118 (H)	
104	3/21/02				0.093			0.331	<4		0.0756	0.000636	
104	6/12/02				0.0749			0.395	<4		0.0857	0.000716	
104	8/15/02				0.0615			0.413	<4		0.0795	0.000686	
104	12/26/02				0.0826			0.549	<4		0.457	0.000762	
104	3/26/03				0.279			1.99	0		7.13	0.00558	
104	6/18/03				0.0748			0.425			0.1	0.421	
			#DIV/0!										
105	2/9/88			0.97	0.102		0.338	1.24			0.124	0.0004	0.766
105	2/9/88			1.47	0.089		0.138	0.373			0.048	0.0003	0.526
105	5/20/88			0.62	0.087		0.207	0.717	<5		0.075	0.0101	0.54
105	5/20/88			0.001	0.086		0.177	0.392			0.028	0.0099	0.444
105	8/31/88			0.94	0.089		0.488	6.18 (R)	5		0.591	0.001	0.857
105	8/31/88			0.62	0.076		0.177	0.372			0.047	0.0005	0.063
105	12/14/88			1.1	0.093		0.68	0.44			0.146	0.0006	0.604
105	12/14/88			1.08	0.089		0.29	0.28			0.057	0.0003	0.611
105	2/1/89			1.35	0.126		0.2	0.46	<5		0.113	0.0006	0.374
105	2/1/89			1.57	0.097		0.29	0.25			0.098	0.0004	0.39
105	5/10/89			1.1	0.05		0.34	0.94	<5		0.163	0.0004	0.61
105	5/10/89			1.08	0.065		0.19	0.31			0.048	0.0003	0.48
105	8/27/89			1.05	0.091		0.3	1.43	<5		0.2	0.0008	1.2
105	8/27/89			1.12	0.065		0.19	0.63			0.08	0.0004	1.6
105	11/20/89			1.5	0.094		0.19	0.59			0.24	0.0011	0.85
105	11/20/89			1.54	0.086		0.19	0.36			0.13	0.00033	0.65
105	2/28/90			1.23	0.085		0.31	2.26	<5		0.35	0.0005	0.62
105	2/28/90			1.21	0.08		0.12	0.46			0.15	0.00021	0.48
105	5/31/90			1.4	0.085		0.15	0.36			0.08	0.0012	0.51
105	5/31/90			1.1	0.083		0.15	0.33			0.08	0.0002	0.81
105	8/30/90			0.9			0.12				0.206	0.00045	
105	8/30/90			0.99			0.074				0.081	0.00032	
105	12/11/90			1.29	0.096		0.187	0.987			0.2	0.00072	0.53
105	12/11/90			0.88	0.094		0.187	0.353			0.15	0.00096	0.492
105	2/8/91			1.58	0.105		0.161	0.6	<5		0.17	0.0003	0.496

Water Quality Data Report

SiteNbr	Date	DupID	Total (ug As Tot	coverable in As Rec	coverable i Cd Rec	ine Total re	ecoverable Cr Rec	overable in Cu Rec	, Total (ug/ Cn	otal Recov	overable in Pb Rec	y, Total (ug/ Hg Tot	overable in Ni Rec
104	2/23/88			1.34	0.087		0.201	5.8			0.161	0.0004	1.13
104	2/23/88			0.91	0.081		0.175	0.538			0.024	0.0003	0.622
105	2/8/91			1.59	0.099		0.138	0.4			0.087	0.0003	0.496
105	5/20/91			1.02	0.089		0.18	0.68			0.29	0.00049	0.57
105	5/20/91	1		<5	<2		<6	<2	<5		<7	<0.01	<1
105	5/20/91			1.1	0.09		0.1	0.59			0.14	0.00025	0.58
105	5/20/91	1		<5	<2		<6	<2			<7	<0.01	<1
105	8/17/91			<1	<2		<6	<2	17		1	0.01	<4
105	8/17/91			1	<2		<6	<2			18 (R)	<0.01	<4
105	11/26/91			1.56	0.096		0.19	0.78			0.061	0.00011	0.79
105	11/26/91			1.48	0.093		0.15	0.48			0.081	0.00009	0.99
105	2/27/92			1.4	0.096		0.29	0.57			0.262	0.00096	0.94
105	2/27/92	1		<1	<2		9 (R)	<2	<5		<1	<0.01	<1
105	2/27/92			1.43	0.094		0.24	0.56			0.294	0.00101	0.97
105	2/27/92	1		<1	<2		<6	<2			<1	<0.01	<1
105	5/29/92			0.95	0.057		0.59	0.755			0.212	0.00102	0.84
105	5/29/92	1		<4	<4		7 (J)	<2	<5		<1	<0.01	11 (R)
105	5/29/92			1.3	0.048		0.29	0.469			0.094	0.00115	0.87
105	5/29/92	1		<4	5 (R)		7 (J)	<4			<1	<0.01	3
105	9/13/92			1.38	0.089		0.378	0.92	<5		0.06	0.00081	1.01
105	9/13/92			1.2	0.088		0.422	1.13			0.043	0.00134	1.61
105	10/30/92			1.35	0.088		0.115	0.388	<5		0.074	0.00032	0.338
105	10/30/92			1.62	0.088		0.096	0.406			0.053	0.00036	0.378
105	1/29/93			1.37	0.106		0.164	0.663	<5		0.19	0.00047	0.602
105	1/29/93			1.47	0.102		0.105	0.222			0.029	0.00018	0.392
105	4/9/93			<1	0.11		0.197	0.79	<5		0.417	0.00035	0.47
105	4/9/93			1.3	0.1		0.178	0.53			0.121	0.003	0.76
105	7/10/93			2.1	0.055		0.21	0.42	<5		0.057	0.00067	0.38
105	7/10/93			2.1	0.063		0.19	0.31			0.037	0.0005	0.41
105	10/7/93			1.8	0.092		0.21	0.45	<5		0.16	0.00025	0.4
105	10/7/93			1	0.086		0.21	0.37			0.061	0.00014	0.66
105	1/19/94			2.18	0.097		0.32	0.326	<5		0.09	0.00022	0.394
105	1/19/94			2.44	0.096		0.42	0.314			0.078	0.0001	0.405
105	4/5/94			0.97	0.082		0.42	0.828	<5		0.176	0.00053	2.56
105	4/5/94			1.25	0.077		0.17	0.373			0.031	0.0004	0.419
105	7/14/94			1.63	0.053		0.245	0.473	<5		<0.01	0.00027	1.1
105	7/14/94			1.14	0.49		0.267	0.412	<5		<0.01	0.00056	0.374
105	10/13/94			1.7	0.0633		0.13	0.398	<5		0.201	0.00042	0.431
105	10/13/94			1.41	0.0541		0.13	0.41	<5		0.061	0.00038	0.427
105	1/6/95			1.7	0.081		0.172	0.394	<5		0.029	0.00026	0.472
105	1/6/95			1.84	0.087		0.153	0.432	<5		0.045	0.0003	0.515
105	5/2/95			1.7	0.081		0.18	0.832	<5		0.22	0.00222	0.511
105	5/2/95			2.13	0.0831		0.26	0.358	<5		0.047	0.00229	0.484
105	8/31/95			1.86	0.0653		0.174	0.358	<5		0.0244	0.000545	0.508
105	8/31/95			1.61	0.0639		0.209	0.455			0.0233	0.000192	0.366
105	11/30/95			<0.37	<0.1		0.4	0.6	<5		0.1	0.000318	1.1
105	11/30/95			1.35	<0.1		<0.167	1.3			0.2	0.000247	1.5
105	3/13/96			1.49	0.0868		0.11	0.272	<5		0.0108	0.000422	0.416
105	3/13/96			1.73	0.0836		<0.11	0.261			0.0107	0.000531	0.37
105	6/24/96			1.17	0.0663		0.261	0.272	<5		0.0336	0.000524	0.366
105	6/24/96			1.23	0.0649		0.283	0.23			0.0111	0.000704	0.386
105	9/23/96			1.05	0.069		0.118	0.314		<5	0.117	0.000909	0.366
105	9/23/96			1	0.0662		0.0949	0.232			0.0317	0.00224	0.34
105	12/17/96			1.99	0.298		0.382	0.412		<5	0.621	0.001	0.418
105	12/17/96			1.99	0.0722		0.174	0.223			0.0265	0.000378	0.328
105	3/4/97			1.37	0.0842		0.32	0.256	<5	<5	0.0734	0.000461	0.465
105	3/4/97			1.71	0.0849		0.15	0.254			0.0637	0.000352	0.379
105	6/11/97			1.79	0.0831		0.14	0.294		<5	0.0747	0.000397	0.4
105	6/11/97			2.12	0.0729		0.18	0.271			0.0688	0.000315	0.353
105	8/25/97		0.698		0.0593		0.14	0.278	<5		0.0615	0.000751	0.33
105	8/25/97		0.722		0.0557		0.0901	0.217			0.0254	0.000254	0.33
105	12/8/97		1.59		0.086		0.115	0.405		<5	0.0692	0.000442	0.55
105	12/8/97		1.46		0.0853		0.272	0.285			0.0249	0.000347	0.51
105	3/17/98		1.63		0.0752		0.237	0.303	<5		0.0429	0.000413	0.409
105	3/17/98		1.58		0.076		0.222	0.261			0.0205	0.000526	0.39
105	6/2/98		0.95		0.064		0.11	0.291	<20		0.0483	0.000492	0.358
105	6/2/98		0.95		0.0659		0.11	0.234			0.0263	0.000392	0.351
105	9/10/98		0.798		0.052		0.146	0.321	<20		0.0502	0.00262	0.392
105	9/10/98		1.06		0.0518		0.176	0.257			0.0285	0.000377	0.456
105	11/12/98		1.8		0.0779		0.336	0.701	<20		0.213	0.0104	0.515
105	11/12/98		1.82		0.0802		0.31	0.499			0.063	0.0103	0.495
106	2/9/88			0.92	0.07		0.138	0.476			0.09	0.0002	0.622

Water Quality Data Report

SiteNbr	Date	DupID	Total (ug	coverable in	coverable i	ine Total re	ecoverable	overable in	, Total (ug/	otal Recov	verable in	, Total (ug/	overable in
			As Tot	As Rec	Cd Rec		Cr Rec	Cu Rec	Cn		Pb Rec	Hg Tot	Ni Rec
104	2/23/88			1.34	0.087		0.201	5.8			0.161	0.0004	1.13
104	2/23/88			0.91	0.081		0.175	0.538			0.024	0.0003	0.622
106	2/9/88			1.24	0.069		0.15	0.352			0.161	0.0002	0.469
106	5/20/88			0.87	0.075		0.118	0.392	<5		0.056	0.0064	0.317
106	5/20/88			0.87	0.074		0.118	0.257			0.056	0.0115	0.635
106	8/31/88			0.86	0.088		0.488	3.93 (R)	<5		0.235	0.0008	0.571
106	8/31/88			0.95	0.083		0.192	0.338			0.056	0.0008	0.667
106	12/14/88			1.28	0.091		0.39	0.33			0.177	0.0006	0.42
106	12/14/88			1.2	0.09		0.88	0.26			0.047	0.0003	0.573
106	2/1/89			1.7	0.098		0.39	0.45	<5		0.167	0.0004	0.367
106	2/1/89			1.75	0.095		0.2	0.22			0.123	0.0002	0.306
106	5/10/89			1.28	0.088		0.17	0.89	<5		0.111	0.0018	0.72
106	5/10/89			1.2	0.068		0.17	0.57			0.096	0.0028	0.63
106	8/27/89			0.92	0.076		0.19	0.75	<5		0.07	0.0003	1.5
106	8/27/89			1.07	0.074		0.14	0.83			0.05	0.0002	1.2
106	11/20/89			1.46	0.086		0.12	0.37			0.26	0.00024	0.5
106	11/20/89			1.4	0.094		0.11	0.31			0.2	0.00062	0.56
106	2/28/90			1.04	0.082		0.14	0.66			0.18	0.00044	0.39
106	2/28/90			1.46	0.09		0.07	0.29			0.097	0.00021	0.37
106	5/31/90			1.4	0.076		0.21	0.67			0.15	0.0003	1.9
106	5/31/90			1.3	0.082		0.14	0.27			0.03	0.0001	0.51
106	8/30/90			0.94			0.074				0.041	0.00038	
106	8/30/90			1.12			0.089				0.036	0.0003	
106	12/11/90			0.87	0.09		0.125	0.484			0.19	0.00103	0.379
106	12/11/90			0.88	0.093		0.062	0.417			0.043	0.00059	0.455
106	2/8/91			1.17	0.099		0.161	0.46	<5		0.13	0.0005	0.402
106	2/8/91			1.43	0.095		0.138	0.32			0.054	0.00026	0.396
106	5/20/91			1.1	0.082		0.12	0.44			0.07	0.00021	0.45
106	5/20/91	1		<5	<2		<6	<2			<7	<0.01	23 (R)
106	5/20/91			1.34	0.082		0.18	0.31			0.07	0.00029	0.43
106	5/20/91	1		<5	<2		<6	<2			<7	<0.01	<1
106	8/17/91			<1	<2		<6	<2			1	<0.01	<4
106	8/17/91			5 (J)	<2		<6	<2			1	<0.01	<4
106	11/26/91			1.52	0.086		0.49	0.86			0.096	0.00009	3.94
106	11/26/91			1.36	0.088		0.19	0.51			0.054	0.00005	0.81
106	2/27/92			1.53	0.103		0.16	0.89			0.623	0.00094	0.64
106	2/27/92	1		<1	7 (R)		7 (J)	<2			<1	<0.01	<1
106	2/27/92			1.58	0.093		0.24	0.44			0.113	0.00059	0.55
106	2/27/92	1		<1	7 (R)		8 (J)	<2			<1	<0.01	<1
106	5/29/92			1.29	0.042		0.17	0.439			0.05	0.00055	0.4
106	5/29/92	1		<4	5 (J)		9 (R)	<2			<1	<10	5
106	5/29/92			1.26	0.039		0.17	0.327			0.032	0.00081	0.4
106	5/29/92	1		<4	5 (J)		<6	<2			<1	<10	4
106	9/13/92			1.21	0.093		0.178	0.4			0.06	0.0003	0.57
106	9/13/92			1.17	0.091		0.466	0.95			0.069	0.00116	1
106	10/30/92			1.34	0.087		0.096	0.399			0.062	0.0002	0.356
106	10/30/92			1.44	0.088		0.306	0.345			0.061	0.00013	0.354
106	1/29/93			1.39	0.089		0.149	0.522			0.26	0.0004	0.465
106	1/29/93			1.37	0.081		0.105	0.258			0.11	0.00018	0.386
106	4/9/93			1.1	0.12		0.178	0.67			0.916	0.00065	0.43
106	4/9/93			1.3	0.1		0.237	0.27			0.199	0.00019	0.39
106	7/10/93			2.1	0.056		0.17	0.4			0.04	0.0002	0.33
106	7/10/93			2.1	0.06		0.19	0.37			0.034	0.00017	0.39
106	10/7/93			1.6	0.085		0.46	0.4			0.034	0.00009	0.43
106	10/7/93			1	0.09		0.64	0.31			0.026	0.00009	0.38
106	1/19/94			2.18	0.101		0.16	0.418			0.123	0.00023	0.405
106	1/19/94			2.18	0.101		0.16	0.418			0.123	0.00023	0.405
106	4/5/94			0.97	0.081		0.34	0.604	<5		0.086	0.00178	0.703
106	4/5/94			2.09	0.08		0.17	0.385	<5		0.079	0.00114	0.403
106	7/14/94			1.3	0.047		0.133	0.267	<5		<0.01	0.00019	0.394
106	7/14/94			1.63	0.047		0.133	0.367	<5		<0.01	0.0002	0.398
106	10/13/94			2.12	0.0573		0.26	0.399	<5		0.046	0.00032	0.417
106	10/13/94			1.55	0.072		0.15	0.341	<5		0.01	0.00034	0.436
106	1/6/95			1.84	0.083		0.191	0.481	<5		0.055	0.00016	0.507
106	1/6/95			1.41	0.078		0.172	0.429	<5		0.018	0.00019	0.475
106	5/2/95			1.99	0.0871		0.2	0.876	<5		0.366	0.00279	0.25
106	5/2/95			1.99	0.0799		0.2	0.395	<5		0.038	0.00099	0.456
106	8/31/95			1.86	0.0696		0.104	0.34	<5		0.0875	0.000593	0.367
106	8/31/95			1.98	0.0708		0.174	0.28			0.0132	0.00118	0.355
106	11/30/95			1.22	0.1		0.855	1.6	<5		2.6	0.0735 (R)	14.5 (R)
106	11/30/95			1.59	0.1		0.419	0.3			0.4	0.00967	1
106	3/13/96			1.49	0.0829		0.14	0.262	<5		0.002	0.00122	0.348

Water Quality Data Report

SiteNbr	Date	DupID	Total (ug	overable in	coverable i	ine Total re	ecoverable	overable in	, Total (ug/	otal Recove	overable in	/, Total (ug/	overable in
			As Tot	As Rec	Cd Rec		Cr Rec	Cu Rec	Cn		Pb Rec	Hg Tot	Ni Rec
104	2/23/88			1.34	0.087		0.201	5.8			0.161	0.0004	1.13
104	2/23/88			0.91	0.081		0.175	0.538			0.024	0.0003	0.622
106	3/13/96			1.98	0.0826		0.14	0.242			0.002	0.000263	0.346
106	6/24/96			1.11	0.0633		0.251	0.246	<5		0.0027	0.000297	0.335
106	6/24/96			1.13	0.0598		0.247	0.229			0.0032	0.000282	0.315
106	9/23/96			1	0.0584		0.0909	0.215		<5	0.0185	0.000987	0.297
106	9/23/96			1.05	0.064		0.0889	0.235		<5	0.0257	0.000397	0.307
106	12/17/96			2.17	0.057		0.122	0.168			0.0599	0.00164	0.252
106	12/17/96			2.17	0.0817		0.104	0.219			0.0248	0.000423	0.357
106	3/4/97			1.71	0.0763		0.22	0.234	<5		0.0555	0.000266	0.368
106	3/4/97			1.88	0.0845		0.18	0.227			0.0281	0.000359	0.344
106	6/11/97			1.63	0.0703		0.18	0.234			0.0383	0.000404	0.324
106	6/11/97			1.79	0.0729		0.2	0.264			0.0274	0.00022	0.362
106	8/25/97		0.706		0.0541		0.0951	0.245			0.0919	0.000389	0.239
106	8/25/97		0.711		0.0596		0.204	0.196			0.096	0.000385	0.311
106	12/8/97		1.49		0.079		0.101	0.312			0.0831	0.000418	0.57
106	12/8/97		1.51		0.0807		0.122	0.306			0.0124	0.0003	0.526
106	3/17/98		1.64		0.0704		0.305	0.255			0.0825	0.000444	0.38
106	3/17/98		1.6		0.0722		0.218	0.244			0.0134	0.000158	0.377
106	6/2/98		0.967		0.0619		0.112	0.214			0.0211	0.000313	0.321
106	6/2/98		0.982		0.0668		0.095	0.199			0.00911	0.00019	0.318
106	9/10/98		1.07		0.0582		0.169	0.507			0.186	0.000679	0.394
106	9/10/98		1.07		0.0573		0.184	0.219			0.0109	0.000885	0.353
106	11/12/98		1.85		0.0796		0.241	0.352	<20		0.0834	0.011	0.464
106	11/12/98		1.78		0.076		0.216	0.239			0.0322	0.0104	0.461
106	3/10/99				0.0668			0.299	<5		0.093	0.000595	
106	6/17/99				0.0647			0.386	<5		0.0701	0.00052	
106	7/1/99					<20 (H)							
106	8/17/99				0.0571			0.419	<5		0.0635	0.00123	
106	10/28/99				0.0705			0.571	<5		0.584	0.00108	
106	2/24/00				0.0918			0.443	<5		0.273	0.00253	
106	6/7/00				0.071			0.451	<5		0.135	0.000794	
106	9/19/00				0.0707			0.397			0.09	0.000739	
106	12/20/00				0.0806			0.47	<10		0.288	0.000883	
106	3/5/01				0.0814			0.33	<8		0.0477	<0.00058	
106	6/12/01				0.0624			0.334	<5		0.0209	0.000479	
106	8/23/01				0.0615			0.308	<5		0.0172	0.000302 (H	
106	12/20/01				0.0839			0.248	<4		<0.055	0.000319 (H	
106	3/21/02				0.1			0.274	<4		0.133	0.000413	
106	6/12/02				0.0658			0.276	<4		<0.052	0.000443	
106	8/15/02				0.0696			1.05	<4		0.0608	0.00042	
106	12/26/02				0.0827			0.404	<4		0.152	0.00069	
106	3/26/03				0.121			0.676	<0.004		5.33	0.00244	
106	6/18/03				0.0705			0.359			0.169	0.000713	
107	2/9/88			1.2	0.084		0.163	0.496			0.042	0.0002	0.651
107	2/9/88			0.9	0.068		0.238	0.455			0.042	0.0002	0.488
107	5/20/88			0.76	0.081		0.384	0.913	<5		0.131	0.0085	0.635
107	5/20/88			0.82	0.079		0.148	0.352			0.047	0.0102	0.54
107	8/31/88			0.76	0.086		0.31	1.6	<5		0.084	0.0007	0.825
107	8/31/88			0.79	0.089		0.222	0.44			0.075	0.0008	0.444
107	12/14/88			1.35	0.093		0.39	0.29			0.063	0.0005	0.512
107	12/14/88			1.37	0.1		0.2	0.37			0.104	0.0004	0.657
107	2/1/89			1.39	0.097		0.78	0.43	<5		0.132	0.0007	0.917
107	2/1/89			1.54	0.105		0.39	1.03			0.152	0.0011	0.52
107	5/10/89			1.35	0.074		0.23	0.9	<5		0.13	0.0043	0.92
107	5/10/89			1.37	0.07		0.19	0.33			0.078	0.0028	0.51
107	8/27/89			1.16	0.096		0.63	2.15	<5		0.24	0.0002	1.9
107	8/27/89			1.2	0.07		0.23	0.79			0.11	0.0006	1.8
107	11/20/89			1.55	0.103		0.16	0.78			0.79	0.00036999	0.93
107	11/20/89			1.5	0.094		0.11	0.38			0.19	0.00115000	0.62
107	2/28/90			1.38	0.107		0.17	0.81	<5		0.77	0.00115	0.5
107	2/28/90			1.34	0.085		0.14	0.4			0.24	0.00019	0.45
107	5/31/90			1.5	0.08		0.15	0.48			0.13	0.0008	0.62
107	5/31/90			1.3	0.079		0.17	0.34			0.06	0.0005	0.58
107	8/30/90			0.76			0.074				0.096	0.00027	
107	8/30/90			0.66			0.103				0.026	0.00016	
107	12/11/90			0.77	0.104		0.187	0.849			0.55	0.00468	0.492
107	12/11/90			1.34	0.095		0.125	0.378			0.16	0.0011	0.455
107	2/8/91			1.56	0.1		0.406	0.81	<5		0.17	0.00051	0.51
107	2/8/91			1.64	0.097		0.161	0.38			0.08	0.00026	0.496
107	5/20/91			1.1	0.099		0.16	1.08			0.57	0.0009	0.65
107	5/20/91	1		<5	<2		<6	<2	<5		<7	<0.01	10 (R)

Water Quality Data Report

SiteNbr	Date	DupID	Total (ug	coverable in	coverable i	ine Total re	ecoverable	overable in	, Total (ug/	otal Recov	verable in	, Total (ug/	overable in
			As Tot	As Rec	Cd Rec		Cr Rec	Cu Rec	Cn		Pb Rec	Hg Tot	Ni Rec
104	2/23/88			1.34	0.087		0.201	5.8			0.161	0.0004	1.13
104	2/23/88			0.91	0.081		0.175	0.538			0.024	0.0003	0.622
107	5/20/91			1.09	0.088		0.18	0.62			0.14	0.00059	0.55
107	5/20/91	1		<5	<2		<6	<2			<7	<0.01	<1
107	8/17/91			<1	<2		<6	<2	<5		<1	0.016 (R)	<4
107	8/17/91			<1	<2		<6	<2			<1	<0.01	<4
107	11/26/91			1.58	0.098		0.17	0.53			0.077	0.00006	0.74
107	11/26/91			1.47	0.103		0.19	0.58			0.073	0.00005	0.87
107	2/27/92			1.47	0.096		0.26	0.6			0.361	0.00083	0.87
107	2/27/92	1		<1	6		9 (J)	<2	<5		<1	<0.01	<1
107	2/27/92			1.57	0.098		0.18	0.67			0.23	0.00087	0.65
107	2/27/92	1		<1	<2		8 (J)	<2			<1	<0.01	<1
107	5/29/92			1.15	0.054		0.31	0.582			0.169	0.00093	0.67
107	5/29/92	1		1	6		<12	<2	<5		<1	<0.01	4
107	5/29/92			1.29	0.052		0.19	0.531			0.097	0.00086	0.61
107	5/29/92	1		<2	43 (R)		<6				<1	<0.01	9 (R)
107	9/13/92			1.58	0.079		0.289	1.65	<5		0.129	0.0008	0.75
107	9/13/92			1.1	0.085		0.178	0.52			0.069	0.00046	1.13
107	10/30/92			1.5	0.087		0.172	0.429	<5		0.107	0.00021	0.367
107	10/30/92			1.27	0.087		0.191	0.706			0.157	0.00027	0.733
107	1/29/93			1.35	0.098		0.194	0.565	<5		0.19	0.00041	0.667
107	1/29/93			1.46	0.203		0.523	0.33			0.11	0.00014	0.475
107	4/9/93			1.7	0.11		0.197	0.39	<5		0.137	0.00042	0.45
107	4/9/93			1.7	0.11		0.158	1.15			0.189	0.00043	0.41
107	7/10/93			1.8	0.06		0.15	0.5	<5		0.09	0.0005	0.44
107	7/10/93			1.2	0.063		0.15	0.35			0.047	0.00028	0.39
107	10/7/93			1	0.088		0.24	1	<0.005		0.1	0.00031	0.41
107	10/7/93			0.6	0.09		0.38	0.39			0.073	0.00017	0.41
107	1/19/94			1.54	0.119		0.18	0.33	<5		0.117	0.00017	0.471
107	1/19/94			1.8	0.098		0.11	0.362			0.137	0.0003	2.97
107	4/5/94			0.97	0.079		0.34	1.28	<5		0.336	0.00052	0.627
107	4/5/94			0.84	0.082		0.3	0.57			0.081	0.00036	0.448
107	7/14/94			1.63	0.061		0.267	0.467	<5		<0.01	0.00056	0.887
107	7/14/94			2.44	0.049		0.111	0.371	<5		<0.01	0.00058	0.423
107	10/13/94			1.41	0.0708		0.21	0.959	<5		0.149	0.00043	0.505
107	10/13/94			1.84	0.0746		0.22	0.556	<5		0.097	0.00055	0.473
107	1/6/95			1.7	0.093		0.23	0.582	<5		0.068	0.00024	0.612
107	1/6/95			1.41	0.086		0.191	0.465	<5		0.049	0.00025	0.692
107	5/2/95			1.7	0.0789		0.26	0.69	<5		0.1	0.00186	0.651
107	5/2/95			1.56	0.0768		0.22	0.723	<5		0.151	0.00365	0.48
107	8/31/95			1.61	0.0654		0.278	0.422	<5		0.0758	0.000197	0.376
107	8/31/95			1.36	0.0626		0.104	0.312			0.0296	0.000275	0.378
107	11/30/95			1.59	<0.1		<0.167	0.8	<5		<0.1	0.000367	0.7
107	11/30/95			1.35	0.1		0.167	1.5			0.1	0.000405	1.2
107	3/13/96			1.73	0.0745		0.16	0.25	<5		0.0169	0.000521	0.336
107	3/13/96			1.98	0.0851		0.19	0.25			0.0059	0.000333	0.366
107	6/24/96			1.08	0.064		0.305	0.283	<5		0.0323	0.000481	0.605
107	6/24/96			1.12	0.0677		0.264	0.255			0.0235	0.000486	0.342
107	9/23/96			1.06	0.0586		0.111	0.269		<5	0.0443	0.000357	0.344
107	9/23/96			1.09	0.063		0.114	0.244			0.0241	0.000251	0.334
107	12/17/96			1.99	0.0571		0.174	0.215		<5	0.0989	0.00157	0.293
107	12/17/96			1.99	0.0567		0.191	0.228			0.0277	0.00135	0.296
107	3/4/97			1.37	0.0838		0.18	0.246	<5	<5	0.0415	0.000334	0.371
107	3/4/97			1.71	0.0879		0.17	0.235			0.0379	0.000307	0.361
107	6/11/97			1.79	0.0704		0.12	0.329		<5	0.292	0.000608	0.376
107	6/11/97			1.95	0.0589		0.11	0.245			0.175	0.000395	0.291
107	8/25/97		0.692		0.0541		0.0891	0.223	<5		0.0182	0.000402	0.283
107	8/25/97		0.66		0.056		0.0891	0.228			0.0283	0.000599	0.277
107	12/8/97		1.6		0.0853		0.134	0.442		<5	0.0763	0.00048	0.693
107	12/8/97		1.5		0.0912		0.108	0.322			0.0497	0.000346	0.478
107	3/17/98		1.69		0.0759		0.343	0.338	<5		0.0732	0.000191	0.414
107	3/17/98		1.57		0.0736		0.321	0.28			0.0188	0.000467	0.378
107	6/2/98		0.945		0.0643		0.115	0.359	<20		0.0803	0.000579	0.367
107	6/2/98		1.07		0.0653		0.115	0.273			0.0551	0.000376	0.369
107	9/10/98		1.07		0.0497		0.256	0.353	<20		0.0473	0.000596	0.426
107	9/10/98		0.966		0.0551		0.144	0.543			0.0965	0.00046	0.429
107	11/12/98		1.7		0.0799		0.227	0.562	<20		0.18	0.00958	0.484
107	11/12/98		1.71		0.0762		0.201	0.251			0.0504	0.0101	0.463
107	3/10/99				0.0712			0.533	<5		0.301	0.000892	
107	6/17/99				0.06			0.415	<5		0.123	0.000784	
107	7/1/99					<20 (H)							
107	8/17/99				0.054			0.423	<5		0.0563	0.000587	

Water Quality Data Report

SiteNbr	Date	DupID	Total (ug	coverable in	coverable i	ine Total re	ecoverable	overable in	, Total (ug/	otal Recov	overable in	y, Total (ug/	overable in
			As Tot	As Rec	Cd Rec		Cr Rec	Cu Rec	Cn		Pb Rec	Hg Tot	Ni Rec
104	2/23/88			1.34	0.087		0.201	5.8			0.161	0.0004	1.13
104	2/23/88			0.91	0.081		0.175	0.538			0.024	0.0003	0.622
107	10/28/99				0.0736			0.361	<5		0.314	0.00143	
107	2/24/00				0.0961			0.886	<5		0.722	0.00196	
107	6/7/00				0.0754			0.826	<5		0.416	0.004	
107	9/19/00				0.0715			0.675			0.271	0.00115	
107	12/20/00				0.0786			0.457	<10		<0.046	0.000784	
107	3/5/01				0.0825			0.355	<8		0.0469	0.00079	
107	6/12/01				0.0668			0.437	<5		0.0479	0.000842	
107	8/23/01				0.0574			0.334	<5		0.0215	0.000428 (H	
107	12/20/01				0.0847			0.303	<4		0.0657	0.000449 (H	
107	3/21/02				0.0876			0.316	<4		0.151	0.00132	
107	6/12/02				0.0756			0.348	<4		0.0903	0.000702	
107	8/15/02				0.0655			0.428	<4		0.0566	0.000938	
107	12/26/02				0.0831			0.458	<4		0.152	0.00093	
107	3/26/03				0.148			0.603	<0.004		0.5	0.0016	
107	6/18/03				0.0729			0.385			0.11	0.0188	
108	2/9/88			1.58	0.08		0.175	0.559			0.077	0.0004	0.699
108	2/9/88			1.09	0.08		0.15	0.518			0.029	0.0002	0.546
108	5/20/88			0.58	0.068		0.34	0.582		<5	0.094	0.0109	0.54
108	5/20/88			0.79	0.08		0.118	0.412			0.047	0.0098	0.413
108	8/31/88			0.69	0.091		0.296	1.22		<5	0.122	0.0007	0.889
108	8/31/88			0.91	0.076		0.163	0.338			0.066	0.0004	0.444
108	12/14/88			1.11	0.098		0.39	0.4			0.13	0.0004	0.581
108	12/14/88			1.01	0.092		0.39	0.29			0.047	0.0004	0.481
108	2/1/89			1.46	1		0.1	0.26		<5	0.064	0.0005	0.29
108	2/1/89			1.51	0.112		0.2	0.81			0.373	0.0016	0.474
108	5/10/89			1.11	0.381		0.32	3.67 (R)		<5	5.305 (R)	0.0113	0.32
108	5/10/89			1.01	0.072		0.34	0.63			0.1	0.0007	0.99
108	8/27/89			1.05	0.081		0.28	1.52		<5	0.18	0.0006	1.7
108	8/27/89			0.91	0.065		0.19	0.66			0.08	0.0002	1.3
108	11/20/89			1.25	0.094		0.21	0.52			0.17	0.00079000	0.79
108	11/20/89			1.5	0.096		0.18	0.63			0.42	0.00050999	0.82
108	2/28/90			1.52	0.09		0.28	0.7		<5	0.22	0.00061	0.66
108	2/28/90			1.41	0.079		0.14	0.38			0.16	0.00013	0.48
108	5/31/90			1.3	0.083		0.15	0.42			0.09	0.0003	1.7
108	5/31/90			1.5	0.083		0.17	0.27			0.05	0.0001	0.62
108	8/30/90			0.79			<0.052				0.076	0.00038	
108	8/30/90			0.94			0.059				0.026	0.00038	
108	12/11/90			0.72	0.09		0.187	0.396			0.14	0.00058	0.455
108	12/11/90			1.41	0.094		0.125	0.385			0.091	0.00057	0.455
108	2/8/91			1.57	0.102		0.161	0.44		<5	0.13	0.00024	0.49
108	2/8/91			1.87	0.1		0.138	0.56			0.13	0.00031	0.503
108	5/20/91			1.11	0.096		0.16	0.86			0.43	0.00065	0.95
108	5/20/91	1		<5	<2		<6	<2		<5	<7	<0.01	<1
108	5/20/91			0.94	0.09		0.16	0.48			0.16	0.00033	0.61
108	5/20/91	1		<5	<2		<6	<2			<7	<0.01	<1
108	8/17/91			<1	<2		<6	<2		<5	1	0.034 (R)	<4
108	8/17/91			<1	<2		<6	<2			2	0.01	4 (R)
108	11/26/91			1.4	0.098		0.21	0.65			0.138	0.00004	0.79
108	11/26/91			1.35	0.096		0.17	0.54			0.115	0.00005	0.84
108	2/27/92			1.21	0.101		0.24	0.85			0.464	0.00092	0.93
108	2/27/92	1		<1	<2		8 (J)	<2		<5	<1	<0.01	<1
108	2/27/92			1.5	0.095		0.2	0.6			0.308	0.00085	0.82
108	2/27/92	1		6 (R)	<2		<6	<2			<1	<0.01	<1
108	5/29/92			1.31	0.054		0.48	0.806			0.324	0.00345	1.03
108	5/29/92	1		<4	5 (R)		12 (R)	<2		<5	<1	<0.01	4 (R)
108	5/29/92			0.96	0.049		0.29	0.459			0.101	0.00132	0.64
108	5/29/92	1		<4	5 (R)		7	<2			<1	<0.01	1
108	9/13/92			1.06	0.102		0.311	0.48		<5	0.155	0.00107	1.24
108	9/13/92			1.01	0.088		0.466	1.05			0.078	0.00094	1.06
108	10/30/92			1.18	0.079		0.096	0.388		<5	0.086	0.00026	0.42
108	10/30/92			1.44	0.106		0.153	0.493			0.229	0.00027	0.34
108	1/29/93			1.29	0.085		0.179	0.686		<5	0.26	0.00098	0.762
108	1/29/93			0.67	0.093		0.134	0.311			0.076	0.00022	0.683
108	4/9/93			<1	0.11		0.257	0.37		<5	0.202	0.00046	0.4
108	4/9/93			<1	0.11		0.197	0.3			0.091	0.00028	0.4
108	7/10/93			1.8	0.059		0.19	0.63		<5	0.079	0.00081	0.38
108	7/10/93			1.1	0.064		0.19	0.28			0.026	0.0004	0.38
108	10/7/93			1.4	0.088		<0.05	0.44		<5	0.079	0.00016	0.77
108	10/7/93			1.2	0.09		0.27	0.65			0.13	0.00018	1.5
108	1/19/94			1.92	0.096		0.26	0.467		<5	0.069	0.00015	0.4

Water Quality Data Report

SiteNbr	Date	DupID	Total (ug	coverable in	coverable i	ine Total re	ecoverable	overable in	, Total (ug/	otal Recov	overable in	, Total (ug/	overable in
			As Tot	As Rec	Cd Rec		Cr Rec	Cu Rec	Cn		Pb Rec	Hg Tot	Ni Rec
104	2/23/88			1.34	0.087		0.201	5.8			0.161	0.0004	1.13
104	2/23/88			0.91	0.081		0.175	0.538			0.024	0.0003	0.622
108	1/19/94			1.92	0.097		0.53	0.279			0.119	0.00023	0.396
108	4/5/94			1.39	0.078		0.25	0.516		<5	0.085	0.00043	0.575
108	4/5/94			2.23	0.084		0.15	0.415			0.023	0.00042	0.763
108	7/14/94			1.3	0.052		0.156	0.318		<5	<0.01	0.00032	0.671
108	7/14/94			2.6	0.052		0.222	0.502		<5	<0.01	0.00032	0.671
108	10/13/94			1.13	0.0592		0.41	0.367		<5	0.033	0.00032	0.587
108	10/13/94			1.41	0.0662		0.39	0.331		<5	0.039	0.00069	0.484
108	1/6/95			1.56	0.084		0.172	0.455		<5	0.096	0.00021	0.569
108	1/6/95			1.84	0.092		0.172	0.474		<5	0.038	0.00027	0.524
108	5/2/95			1.99	0.0749		0.13	0.539		<5	0.072	0.00072	0.514
108	5/2/95			2.13	0.0781		0.15	0.341		<5	0.061	0.00092	0.457
108	8/31/95			1.61	0.0676		0.296	0.328		<5	0.0208	0.000164	0.408
108	8/31/95			1.49	0.0657		0.244	0.358			0.0208	0.000295	0.408
108	11/30/95			1.22	0.1		0.167	1.3		<5	0.1	0.00058	0.9
108	11/30/95			1.22	0.2		<0.167	1			<0.1	0.000409	0.7
108	3/13/96			1.98	0.0712		0.12	0.209		<5	0.0042	0.000291	0.299
108	3/13/96			1.61	0.0851		0.12	0.253			0.02	0.000463	0.352
108	6/24/96			0.927	0.0643		0.223	0.444		<5	0.0267	0.000492	0.373
108	6/24/96			1.32	0.0677		0.292	0.23			0.0205	0.000664	0.344
108	9/23/96			1.14	0.0593		0.122	0.238		<5	0.041	0.000168	0.356
108	9/23/96			1.03	0.0572		0.0929	0.223			0.0238	0.000308	0.319
108	12/17/96			1.99	0.0747		0.174	0.243		<5	0.08	0.00165	0.361
108	12/17/96			1.81	0.0819		0.139	0.257			0.0525	0.00168	0.394
108	3/4/97			1.88	0.0904		0.22	0.256		<5	0.051	0.00207	0.385
108	3/4/97			2.05	0.0832		0.17	0.234			0.0432	0.000574	0.376
108	6/11/97			2.12	0.0626		0.12	0.268		<5	0.0878	0.000334	0.312
108	6/11/97			1.79	0.0663		0.11	0.382			0.0517	0.000327	0.314
108	8/25/97		0.639		0.0558		0.123	0.228	<5		0.0421	0.000428	0.296
108	8/25/97		0.513		0.0459		0.0511	0.161			0.0169	0.000516	0.203
108	12/8/97			1.44	0.0526		0.1	0.292		<5	0.0401	0.00052	0.835
108	12/8/97		1.54		0.0879		0.128	0.3			0.0566	0.000481	0.488
108	3/17/98		1.66		0.0719		0.236	0.312	<5		0.0401	0.000764	0.421
108	3/17/98		1.63		0.0738		0.355	0.318			0.0443	0.000451	0.455
108	6/2/98		0.977		0.0669		0.116	0.264	<20		0.0425	0.00062	0.382
108	6/2/98		0.934		0.0653		0.118	0.221			0.0153	0.000234	0.348
108	9/10/98		1.12		0.0557		0.451	0.639	<20		0.0783	0.000406	0.536
108	9/10/98		0.925		0.0523		0.271	0.278			0.0324	0.000513	0.458
108	11/12/98		1.71		0.0804		0.212	0.24	<20		0.0548	0.00977	0.468
108	11/12/98		1.72		0.0805		0.214	0.263			0.0762	0.00956	0.495
108	3/10/99				0.0737			0.499	<5		0.286	0.000913	
108	6/17/99				0.0771			0.934	<5		0.485	0.00185	
108	7/1/99					<20 (H)							
108	8/17/99				0.0635			0.698	<5		0.251	0.00185	
108	10/28/99				0.0664			0.882	<5		0.647	0.00418	
108	2/24/00				0.0945			0.652	<5		0.81	0.00153	
108	6/7/00				0.0785			0.943	<5		0.623	0.00212	
108	9/19/00				0.0731			0.518			0.194	0.00115	
108	12/20/00				0.0853			0.446	<10		0.0483	0.000647	
108	3/5/01				0.0826			0.347	<8		0.052	<0.00058	
108	6/12/01				0.0705			0.348	<5		0.0295	0.000468	
108	8/23/01				0.0557			0.321	<5		0.0458	0.00037 (H)	
108	12/20/01				0.0843			0.299	<4		0.0652	0.000695 (H	
108	3/21/02				0.0885			0.32	<4		<0.068	0.00351	
108	6/12/02				0.0775			0.32	<4		<0.052	0.000711	
108	8/15/02				0.0613			0.363	<4		0.0517	0.000598	
108	12/26/02				0.0815			0.516	<4		0.0879	0.000844	
108	3/26/03				0.101			0.575	<0.004		0.902	0.0012	
108	6/18/03				0.0741			0.391			0.125	0.00109	

Water Quality Data Report

SiteNbr	Lab, Standard Pb SLU	standard u pH	Recoverable Se Rec	Recoverable in Si	Conductance, Field (Conductance)	Air (Degree	Air (Degree	Water (Degr	Water (Degr	Tot_	Nonfil	Turbidity, NT	Telometric T
104			<1.25	0.002	28200			2.3					
104			<1.25	0.003	28000			2.9					
104			<0.46	0.005	30000	50		7.5					
104			<0.46	0.001	30100			7.2					
104			<0.46	0.009	31800		55	11.3					
104			<0.46	0.002	31300			11.1					
104			<2.1	0.002	27800		30	4.5					
104			<2.1	0.001	27800		30	5.1					
104			<2.1	0.002									
104			<2.1	0.003									
104			<2.1	0.002	29200			7					
104			<2.1	0.002	29900			6.8					
104			<0.52	0.005	22900			13					
104			<0.52		30000			11.8					
104			<6.3	<0.0003	24000		35	3.5					
104			<6.3	<0.0003	25500			4					
104			<1.96	0.002	20900		35	2.5					
104			<1.96	0.001	27600		35	3					
104			<1.5	0.009	310		50	9					
104			<1.5	0.002	311		50	8					
104				0.004			65						
104				0.002			65						
104			<2.2	0.006	25200		20	2.5					
104			<2.2	0.004	26500		20	3					
104			<2.2	0.004	25000		25	1					
104			<2.2	0.003	25500		25	2					
104			<1.96	0.004									
104			<7	1.9 (R)	28000		50	7					
104			<1.96	0.002									
104			<7	1 (J)	28300		50	6.5					
104			<1	<0.3									
104			<1	<0.3									
104			<2.74	0.003	25100		38						
104			<2.74	0.071	26800								
104			<1.8	0.005									
104			<5	<0.07	258			5					
104			<1.8	0.004									
104			<5	<0.07	268			4					
104			<3.5	0.004									
104			<2	0.8	282		50	7.5					
104			<3.5	0.002									
104			<1	0.96 (J)	290		50	7					
104			<1.39	0.005			38						
104			<1.39	0.002			38						
104			<5.8	0.004	275		35	5					
104			<5.8	0.002	271		35	5.1					
104			2.5	0.0203	23000		40	8					
104			<2.3	0.0046	230		40	9.5					
104			5.5	0.008	25800		38	4.2					
104			4.8	0.001	25900		38	3.9					
104			3.2	<0.003	29800		55	13.1					
104			1.9	0.006	29900		55	12.9					
104			<2.1	0.002			38						
104			<2.1	0.004			38						
104			2.6	0.012	23000		30	3					
104			2.6	0.009	24000		30	3					
104			<2.2	0.003	23700		45	4.9					
104			<2.2	0.008	24100		45	4					
104			<2.5	<0.006	27500			12					
104			<2.5	<0.006	25000			11.5					
104			<2.9	0.0014	23000		45	8.6					
104			<2.9	0.00903	23000		45	8.3					
104			3.7	<0.003	21500		18	1.9					
104			<3.7	<0.003	22000		18	2.1					
104			<1.3	0.004	19100		50	7					
104			<1.3	<0.003	21400		50	5.9					
104			1.2	0.00185									
104			1.2	0.00233	23300	11		11.5					
104			1.2	0.2									
104			<1.2	0.1									
104			3.5	0.003									
104			<3.5	<0.003									

Water Quality Data Report

SiteNbr	b, Standarc Pb SLU	standard u pH	coverable i Se Rec	overable in Si	nce,Field (onductance	Air (Degree	Air (Degree	Vater (Degr	Vater (Degr	(Tot_ Nonfil	urbidity, NT	elometric T
104			<1.25	0.002	28200			2.3				
104			<1.25	0.003	28000			2.9				
104			1.8	0.004	33000	18		5				
104			<1.8	0.0086								
104			<0.3	<0.25	30500	5		7.2				
104			<0.3	<0.25	31010	5		8.6				
104			<2.93	<0.25	28000	0		3.9				
104			1.99	0.217	28200	0		3.8				
104			3.02	0.0609	49100	-5		2.4				
104			3.02	0.265	49000	-5		2.4				
104			2.25	0.0131	32930	12.4		9.9				
104			4.5	0.386	32350	12.4		8.8				
104			<0.097	<0.01	32470	13.44		12.2				
104			<0.097	<0.01	32590	13.44		11.8				
104			0.097	0.005	29300	3		6				
104			0.097	0.005	29670	3		6.2				
104			0.815	0.005	28800	3		4.7				
104			1.11	0.005	28920	3		4.7				
104			0.33	0.181	42490	12		11.7				
104			0.61	0.265	45180	12		9.6				
104			0.277	0.0805	43980			10.2	50.4			
104			0.262	0.201	44140			10.2	53.6			
104		7.92	0.675	0.147	29830			6.3	43.3		0.58	
104			0.495	0.221	29860			6.2	43.2			
104		7.9 (H)			27810			1.8	35.2	29	0.55	
104		8.1 (H)			30060	11	51.8	7.9	46.2	26	1.2	
104		8 (H)			29650	13	55.4	12	53.6	27	0.7	
104		7.8 (H)			29310	4	39.2	7.3	45.1	66 (J)	0.59	
104		7.9 (H)			28640	1.52	34.7	3.7	38.7	65	0.27	
104		8.1 (H)			31250	9.47	49	7.9	46.2	83	1.3	
104					30850	8.44	47.2	9.8	49.6			
104					30010	1.1	34	4	39.2			
104					29860			4	39.2			
104	8.1				49000	16	60.8	9.5	49.1	44	1.4	
104		8.06			35430	13	55.4	12	53.6	30.4		0.5
104		7.76			47920			2.8	37	44	0.33	
104		7.82			49350	5.96	42.7	2.1	35.8	27.7	0.24	
104		8.19			30130			9.2	48.6	27.5	1.6	
104		8.03			43510	13.65	56.6	11.4	52.5	37.6	0.56	
104		7.86			45220	0.95	33.7	6.8	44.2	39	0.49	
104	7.84	7.84			47070	7.2	45	4.9	40.8	25.6	0.7	0.7
104					46050	10.16	50.3	9.4	48.9			
105			<1.25	0.001	29000		24	3.3				
105			<1.25	0.001	29000			4				
105			<0.46	0.002	30600	50		8				
105			<0.46	0.001	30800			7.8				
105			<0.46	0.001	31900		55	11				
105			<0.46	0.001	31900			11.1				
105			<2.1	0.002	28000		30	4.5				
105			<2.1	0.001	28000		30	5				
105			<2.1	0.002								
105			<2.1	0.002								
105			<2.1	0.001	30000			7				
105			<2.1	0.001	30600			6.8				
105			<0.52	0.001	33000			13.9				
105			<0.52	0.009	32900			12.9				
105			<6.3	0.002	29000		35	3.5				
105			<6.3	<0.003	29000		35	4				
105			<1.96	0.003	27900		35	3				
105			<1.96	0.001	28000		35	3.1				
105			<1.5	0.001	31000		50	9				
105			<1.5	<0.001	31000		50	8				
105				0.001			65					
105				0.001			65					
105			<2.2	0.004	26500		20	3.3				
105			<2.2	0.003	26500		20	3.8				
105			<2.2	0.003	25000		25	1.7				

Water Quality Data Report

SiteNbr	b, Standarc Pb SLU	standard u pH	coverable i Se Rec	overable in Si	nce,Field (onductance	Air (Degree	Air (Degree	Vater (Degr	Vater (Degr	(Tot_	Nonfil	urbidity, NT	elometric T
104			<1.25	0.002	28200			2.3					
104			<1.25	0.003	28000			2.9					
105			<2.2	0.002	26000		25	2					
105			<1.96	0.003									
105			<7	1.4 (R)	28800		50	7.2					
105			<1.96	0.002									
105			<7	0.7 (J)	29000		50	6.8					
105			<1	<0.3									
105			<1	<0.3									
105			<2.74	<0.001									
105			<2.74	<0.001									
105			<1.8	0.005									
105			<5	<0.07	25500			5					
105			<1.8	0.009									
105			<5	<0.07	25500			4.8					
105			<3.5	0.003	25200		50	9.9					
105			<2	0.5									
105			<3.5	0.002	26000		50	7.2					
105			<2	<0.1									
105			<1.39	0.001			38						
105			<1.39	0.001			38						
105			<5.8	0.001	28000		38	6					
105			<5.8	0.003	28100		38	6					
105			2.5	0.0043	23500		40	3.2					
105			<2.3	0.003	24000		40	3.2					
105			3.4	0.002	25600		38	4.1					
105			2.8	0.05	24200		38	5					
105			1.9	<0.003	30200		55	13					
105			1.3	<0.003	30100		55	11.8					
105			<2.1	0.003			40						
105			<2.1	0.4			40						
105			2.6	0.007	23000		30	3.5					
105			2.6	0.007	24000		30	4					
105			<2.2	<0.003	23900		35	5					
105			<2.2	<0.003	24100		35	4.5					
105			<2.5	<0.006	27200			11					
105			<2.5	<0.006	27000			10.1					
105			<2.9	0.00643	23800		45	8.1					
105			<2.9	0.00465	23900		45	8.5					
105			<3.7	<0.003	23200		19	2.8					
105			<3.7	0.008	23200		19	3.2					
105			<1.3	0.004	23900		50	5.9					
105			<1.3	<0.003	24000		50	5.5					
105			1.3	0.00199	24700	11		11.9					
105			1.3	0.094									
105			1.34	<0.1									
105			<1.2	<0.1									
105			3.5	0.003									
105			<3.5	<0.003									
105			<1.8	0.012									
105			<1.8	0.3487									
105			<0.3	<0.25	30800	5		9.9					
105			<0.3	<0.25	31000	5		9.5					
105			<2.93	<0.25	29000	0		4					
105			<2.93	<0.25	29000	0		4.2					
105			2.27	0.0225	48800	-5		3.1					
105			1.51	0.0627	48800	-5		3.1					
105			5.62	0.0401	32010	13		9.4					
105			5.62	0.00532	32490	13		8.8					
105			<0.097	<0.01	32910	13.36		12.4					
105			<0.097	<0.01	32830	13.36		11.6					
105			0.097	0.005	29350	3		6					
105			0.097	0.005	29990	3		6.4					
105			0.88	0.005	29120	3.5		4.7					
105			0.8	0.005	29150	3.5		4.7					
105			0.601	0.181	46300	12.4		8.7					
105			0.442	0.265	46750	12.4		8.1					
105			0.169	0.0805	44230			10.1	50.2				
105			0.297	0.282	44340			10.1	50.2				
105		7.86	0.734	0.221	30030			6.7	44.1			0.36	
105			0.616	0.294	30120			6.7	44.1				
106			<1.25	0.001	29600		24	3.9					

Water Quality Data Report

SiteNbr	Lab, Standard Pb SLU	standard u pH	Recoverable Se Rec	Recoverable in Si	Conductance, Field (Conductance	Air (Degree	Air (Degree	Water (Degr	Water (Degr	(Tot_	Nonfil	Turbidity, NT	Telometric T
104			<1.25	0.002	28200			2.3					
104			<1.25	0.003	28000			2.9					
106			<1.25	0.001	29300			4.2					
106			<0.46	0.003	31300	50		8.1					
106			<0.46	0.001	31200			8					
106			<0.46	0.001	32100		55	10.8					
106			<0.46	0.001	32000			10.3					
106			<2.1	0.001	28100		30	4.6					
106			<2.1	0.005	28200		30	5.2					
106			<2.1	0.002									
106			<2.1	0.002									
106			<2.1	0.001	31000			7.9					
106			<2.1	0.001	31100			7.6					
106			<0.52	<0.0003	33000			13.9					
106			<0.52	<0.0003	33100			11.1					
106			<6.3	0.002			35						
106			<6.3	0.001			35						
106			<1.96	0.001	28100		35	3.1					
106			<1.96	<0.001	28100		35	3.4					
106			<1.5	<0.001	33000			9					
106			<1.5	<0.001	32500			8					
106				<0.001			65						
106				0.001			65						
106			<2.2	0.003	27500		20	5					
106			<2.2	0.002	27700		20	4.5					
106			<2.2	0.002	27500		25	2					
106			<2.2	0.002	27500		25	2.7					
106			<1.96	<0.001									
106			<7	<0.6	29800		50	7.7					
106			<1.96	<0.001									
106			<7	<0.6	29600		50	7.5					
106			<1	<0.3									
106			<1	<0.3									
106			<2.74	0.001	27700								
106			<2.74	<0.001	27700								
106			<1.8	0.032	26800			5.5					
106			<5	<0.07									
106			<1.8	0.001	27200			5.1					
106			<5	<0.07									
106			<3.5	0.002	30700		50	10					
106			<5	0.2									
106			<3.5	<0.001	30200		50	8.2					
106			<6	<0.1									
106			<1.39	<0.001			38						
106			<1.39	0.007			38						
106			<5.8	0.002	28500		38	6					
106			<5.8	<0.001	28500		38	6.5					
106			2.5	0.0047	24000		40	4					
106			<2.3	0.0034	25500		40	4.5					
106			3.4	0.006	25900		38	4.9					
106			3.4	<0.001	25300		38	4.9					
106			1.9	<0.003	29200		55	12.5					
106			3.2	<0.003	298		55	10.5					
106			<2.1	0.003			40						
106			<2.1	<0.001			40						
106			2.6	0.007	20000		30	5					
106			2.6	0.007	21900		30	5					
106			<2.2	<0.003	24900		40	5.5					
106			<2.2	<0.003	24900		40	5.1					
106			<2.5	<0.006	27200			11.5					
106			<2.5	<0.006	27200			10.2					
106			<2.9	0.00266	24500		45	8.1					
106			<2.9	0.00793	24700		45	8					
106			<3.7	<0.003	24000		19	3.6					
106			<3.7	<0.003	24000		19	4					
106			<1.3	0.004	24200		50	6.2					
106			<1.3	<0.003	24200		50	5.6					
106			1.2	0.0104	25100	11		11.5					
106			<1.2	0.001	25400	11		11					
106			<1.2	<0.1									
106			1.34	0.1									
106			3.5	0.003									

Water Quality Data Report

SiteNbr	b, Standarc Pb SLU	standard u pH	coverable i Se Rec	overable in Si	nce,Field (onductance	Air (Degree	Air (Degree	Vater (Degr	Vater (Degr	(Tot_ Nonfi	urbidity, NT	elometric T
104			<1.25	0.002	28200			2.3				
104			<1.25	0.003	28000			2.9				
106			3.5	0.003								
106			<1.8	0.0927								
106			<1.8	<0.004								
106			<0.3	<0.25	30500			9.6				
106			<0.3	<0.25	32900			9.2				
106			<2.93	<0.25	29800	0		5				
106			<2.93	<0.25	30100	0		20 (J)				
106			3.02	0.131	49100	-5		3.4				
106			3.78	0.0116	49400	-5		3.6				
106			7.87	0.0756	32840	13.25		8.9				
106			3.37	0.0147	32340	13.25		8				
106			<0.097	<0.01	33000	13.16		11.8				
106			<0.097	<0.01	33240	13.16		11.1				
106			0.097	0.005	30130	3		6.4				
106			0.097	0.005	30310	3		6.5				
106			1.16	0.005	29530	3.8		5				
106			0.992	0.005	29520	3.8		5				
106			0.352	0.265	46480	12.9		8.9				
106			0.326	0.307	47120	12.9		8				
106			0.338	0.282	45250			9.7	49.5			
106			0.269	0.604 (J)	45730			9.5	49.1			
106		7.89	1.03	0.0735	30090			6.6	43.9		0.38	
106			0.557	0.368	30200			6.7	44.1			
106		7.8 (H)			29740	1	33.8	4.1	39.4	28	0.58	
106		8.3 (H)			31100	11	51.8	8.5	47.3	37	0.68	
106						16	60.8					
106		8.1 (H)			21400	13	55.4	11.4	52.5	24	0.45	
106	7.8 (H)				30620	4	39.2	7.4	45.3	100 (J)	0.38	
106		7.9 (H)			28490	1.9	35.4	4.1	39.4	84	0.24	
106	8.1 (H)				31090	10.02	50	7.2	45	110	0.78	
106					31740	8.87	48	9.4	48.9			
106					30090 (J)	1.03	33.9	4.7	40.5			
106					30400			4.5	40.1			
106		8.2			35300	15	59	8.7	47.7	41	0.94	
106		8.04			35190	13	55.4	10.6	51.1	45	0.63	
106		7.77			47600			5.7	42.3	41.1	0.28	
106		7.74			48760	6.63	43.9	3.2	37.8	82.7	0.14	
106		8.23			31860			9.7	49.5	51.5	0.48	
106		8.06			44420	13.65	56.6	11.5	52.7	19.2	0.34	
106		7.89			45730	1.05	33.9	7	44.6	34	0.33	
106	7.84	7.84			47730	7.2	45	5	41	46.7	0.43	0.43
106					46940	9.7	49.5	9.7	49.5			
107			<1.25	0.001	29000		24	3.9				
107			<1.25	0.001	29000			4.2				
107			<0.46	0.001	30100	50		7.6				
107			<0.46	0.001	30500			7.5				
107			<0.46	0.001	31900		55	12				
107			<0.46	0.001	31900			12				
107			<2.1	0.002	27900		30	4.9				
107			<2.1	0.001	28000		30	5.1				
107			<2.1	0.002								
107			<2.1	0.002								
107			<2.1	0.002	29700			7.1				
107			<2.1	0.002	30100			6.5				
107			<0.52	0.002	33100			14.5				
107			<0.52	0.001	33000			12.4				
107			<6.3	0.004			35					
107			<6.3	<0.0003								
107			<1.96	0.005	27200		35	2.2				
107			<1.96	0.002	28000		35	3.1				
107			<1.5	0.001	32500		50	7.5				
107			<1.5	<0.001	32000		50	7				
107				<0.001			65					
107				0.002			65					
107			<2.2	0.003	26000		20	3.5				
107			<2.2	0.003	26200		20	3.5				
107			<2.2	0.003	24000		25	1.5				
107			<2.2	0.002	24000		25	1.9				
107			<1.96	0.004	28300			6.8				
107			<7	<0.6			50					

Water Quality Data Report

SiteNbr	ıb, Standarc Pb SLU	standard u pH	coverable i Se Rec	overable in Si	ınce,Field (ı Conductance	Air (Degree	Air (Degree	Vater (Degr	Vater (Degr	(Tot_ Nonfil	urbidity, NT	elometric T
104			<1.25	0.002	28200			2.3				
104			<1.25	0.003	28000			2.9				
107			<1.96	0.002	28800		50	6.8				
107			<7	<0.6								
107			<1	<0.3								
107			<1	11 (R)								
107			<2.74	0.003	27500		38					
107			<2.74	0.001	27200							
107			<1.8	0.004	24700			5				
107			<5	<0.07								
107			<1.8	0.003	25500			5.4				
107			<5	<0.07								
107			<3.5	0.002	28200		50	8				
107			<4	0.1								
107			<3.5	0.002	29000		50	7				
107			<2	<0.1								
107			<1.39	0.005			38					
107			<1.39	0.001			38					
107			<5.8	0.001	28000		35	6				
107			<5.8	0.003	28000		35	6				
107			<2.3	0.0052	24000		40	3				
107			<2.3	0.0044	24500		40	3				
107			2.1	0.001	25500		38	3.9				
107			2.8	0.001	26100		38	3.6				
107			2.5	<0.003	30500		55	13.6				
107			3.2	<0.003	29800		55	11.5				
107			<2.1	0.002			40					
107			<2.1	0.001			40					
107			2.6	0.007	24000		30	3.4				
107			2.6	0.01	24000		30	3.4				
107			<2.2	0.007	21500		40	5.1				
107			<2.2	0.008	22100		40	4.5				
107			<2.5	<0.006	27800			12.2				
107			<2.5	<0.006	27000			10.5				
107			<2.9	0.00293	23500		45	8.2				
107			<2.9	0.00071	23800		45	8.1				
107			<3.7	<0.003	22900		19	2.9				
107			<3.7	<0.003	23000		19	3.5				
107			<1.3	<0.003	22900		50	6.1				
107			<1.3	0.004	23400		50	6				
107			1.3	0.00138	24100	11		11.5				
107			1.2	0.00328	24800	11		11.5				
107			2.01	<0.1								
107			1.2	0.1								
107			<3.5	<0.003								
107			3.5	0.003								
107			<1.8	0.0768								
107			<1.8	<0.004								
107			<0.3	<0.25	29100	5		9.4				
107			<0.3	<0.25	30100	5		9.2				
107			<2.93	<0.25	28000	0		4				
107			<2.93	<0.25	29000	0		4.2				
107			3.02	0.0219	48900	-5		3.4				
107			2.27	0.0626	48900	-5		3.4				
107			5.62	0.00926	32820	12.8		9.4				
107			7.87 (J)	0.00667	32350	12.8		8.7				
107			0.097	<0.01	32650	13.39		12.1				
107			<0.097	<0.01	32730	13.39		11.8				
107			0.097	0.005	29860	3		6.3				
107			0.097	0.005	30080	3		6.5				
107			1.09	0.005	28990	3.3		4.7				
107			0.849	0.005	29170	3.3		4.8				
107			0.503	0.223	44690	12.6		9.9				
107			0.885	0.223	46500	12.6		8.4				
107			0.439	0.241	44150			10.2	50.4			
107			0.293	0.282	44590			10	50			
107		7.93	0.517	0.294	30080			6.6	43.9			
107			0.531	0.221	30190			6.7	44.1			
107		7.8 (H)			29290	1	33.8	3.6	38.5	27	0.54	
107		8.1 (H)			29980	11	51.8	8.1	46.6	37	0.88	
107						16	60.8					
107		8 (H)			26930	13	55.4	11.9	53.4	26	0.4	

Water Quality Data Report

SiteNbr	ıb, Standarc Pb SLU	standard u pH	coverable i Se Rec	overable in Si	ınce,Field (ı onductance	Air (Degree	Air (Degree	Vater (Degr	Vater (Degr	(Tot_ Nonfil	urbidity, NT	elometric T
104			<1.25	0.002	28200			2.3				
104			<1.25	0.003	28000			2.9				
107		7.8 (H)			29330	4	39.2	7.3	45.1	98 (J)	0.39	
107		7.9 (H)			28950	1.9	35.4	3.8	38.8	180	0.28	
107		8.1 (H)			30700	9.47	49	8.2	46.8	99	1.1	
107					30350	8.44	47.2	9.8	49.6			
107					30080	1.03	33.9	4	39.2			
107					30060			4.3	39.7			
107		8.2			48000	13	55.4	9.3	48.7	55	1.3	
107		8.07			35350	13	55.4	11.9	53.4	35.9	0.3	
107		7.78			47430			4.9	40.8	37.5	0.49	
107		7.75			49120	6.63	43.9	3.1	37.6	35.6	0.17	
107		8.17			30770			8.9	48	40.3	1.3	
107		8.03			42360	13.65	56.6	12.3	54.1	31	0.7	
107		7.88			45230	0.95	33.7	7.1	44.8	28	0.5	
107	7.83	7.83			47740	7.2	45	4.7	40.5	20.5	0.59	0.59
107					46270	9.7	49.5	9.3	48.7			
108			<1.25	0.001	29000		24	3.4				
108			<1.25	<0.001	29000			4				
108			<0.46	0.001	30300	50		7.9				
108			<0.46	0.001	30800			7.8				
108			<0.46	0.002	31800		55	11.1				
108			<0.46	0.001	31900			11.1				
108			<2.1	0.001	27900		30	4.5				
108			<2.1	0.003	28100		30	5.1				
108			<2.1	0.001								
108			<2.1	0.002								
108			<2.1	0.003	30000			7.1				
108			<2.1	0.002	30600			7				
108			<0.52	0.002	32900			14				
108			<0.52	0.001	32900			12.7				
108			<6.3	0.004	12000			15				
108			<6.3	0.002								
108			<1.96	0.003	28000		35	2.9				
108			<1.96	0.001	28100		35	3.1				
108			<1.5	0.002	31100		50	9				
108			<1.5	0.001	31000		50	7.5				
108				0.001			65					
108				0.001			65					
108			<2.2	0.002	26500			3.2				
108			<2.2	0.002	26800			3.8				
108			<2.2	0.002	26500		25	2				
108			<2.2	0.002	26500		20	2				
108			<1.96	0.007	29000		50	7.2				
108			<7	<0.6								
108			<1.96	0.002	29000			6.8				
108			<7	<0.6								
108			<1	<0.3								
108			<1	26 (R)								
108			<2.74	0.001	27500							
108			<2.74	<0.001	27700							
108			<1.8	0.009	24500			5				
108			<5	<0.07								
108			<1.8	0.007	24800			4.6				
108			<5	<0.07								
108			<3.5	0.005	27200		50	10				
108			<4	<1								
108			<3.5	0.002	29000		50	7.2				
108			<2	0.1								
108			<1.39	0.003			38					
108			<1.39	0.001			38					
108			<5.8	0.001	28300		38	6.1				
108			<5.8	0.002	28200		38	6.1				
108			<2.3	0.0053	23000		40	2.8				
108			<2.3	0.0032	24800		40	2.5				
108			2.1	0.002	25800		38	5.3				
108			2.1	0.002	25700		38	4.2				
108			1.9	<0.003	30500		58	12.8				
108			1.9	<0.003	30100		58	11.1				
108			<2.1	0.001			40					
108			<2.1	0.003			40					
108			2.6	0.007	24000		30	3.8				

Water Quality Data Report

SiteNbr	b, Standarc Pb SLU	standard u pH	coverable i Se Rec	overable in Si	nce,Field (: onductance	Air (Degree	Air (Degree	Vater (Degr	Vater (Degr	(Tot_ Nonfi	urbidity, NT	elometric T
104			<1.25	0.002	28200			2.3				
104			<1.25	0.003	28000			2.9				
108			2.6	0.007	24500		30	4				
108			<2.2	0.032	24000			5				
108			<2.2	<0.003	24800			4.8				
108			<2.5	<0.006	27200			10.6				
108			<2.5	<0.006	27000			10				
108			<2.9	0.00004	23900		45	8.1				
108			<2.9	0.00953	24000		45	8.5				
108			<3.7	<0.003	23200		19	3.1				
108			<3.7	<0.003	23500		19	3.6				
108			<1.3	<0.003	24000		50	6				
108			<1.3	<0.003	24100		50	5.8				
108			1.2	0.00176	25400	11		11.5				
108			<1.2	0.00275	25800	11		11.5				
108			1.2	0.1								
108			<1.2	<0.1								
108			<3.5	<0.003								
108			<3.5	<0.003								
108			<1.8	0.0065								
108			1.8	0.0168								
108			<0.3	<0.25	30000			8.8				
108			<0.3	<0.25	31200	5		9.6				
108			<2.93	<0.25	28900	0		4				
108			<2.93	<0.25	29000	0		4.2				
108			2.27	0.047	48800	-5		3.2				
108			3.78	0.0147	48800	-5		3.2				
108			5.62	0.0285	32900	13.25		9.7				
108			5.62	0.0147	32500	13.25		8.8				
108			0.097	<0.01	32880	13.35		12.3				
108			<0.097	<0.01	32630	13.35		12.1				
108			0.4	0.005	29910	3		6.4				
108			0.097	0.005	30240	3		6.6				
108			1.05	0.005	29150	3.5		4.7				
108			0.883	0.005	29180	3.5		4.7				
108			0.595	0.265	46630	12.6		8.5				
108			0.372	0.223	47000	12.6		7.9				
108			0.34	0.121	44220			10.1	50.2			
108			0.289	0.161	44800			10	50			
108		7.88	0.532	0.294	30160			6.7	44.1		0.47	
108			0.437	0.331	30240			6.7	44.1			
108		7.8 (H)			29280	1	33.8	3.6	38.5	27	0.48	
108		8.2 (H)			29820	11	51.8	8.5	47.3	33	2.6	
108						16	60.8					
108		8 (H)			26470	13	55.4	12	53.6	26	0.83	
108		7.9 (H)			29230	4	39.2	7.3	45.1	89 (J)	0.56	
108		7.9 (H)			28930	1.9	35.4	3.8	38.8	65	0.24	
108		8.1 (H)			31250	10.02	50	7.5	45.5	110	1.1	
108					30650	8.44	47.2	9.8	49.6			
108					30160 (J)	1.03	33.9	4	39.2			
108					30030			4.3	39.7			
108		8.1			51600	14	57.2	8.4	47.1	44	0.76	
108		8.08			34490	13		11.8	53.2	29.3	0.3	
108		7.76			48830			4.8	40.6	35.6	0.38	
108		7.77			48710	7.33	45.2	3.6	38.5	21.8	0.32	
108		8.15			31070			8.7	47.7	28.7	1.3	
108		8.02			42600	14.21	57.6	12.2	54	38	0.75	
108		7.89			45120	1.05	33.9	7	44.6	30	0.67	
108	7.83	7.83			47630	7.2	45	4.8	40.6	24	0.41	0.41
108					46350	9.7	49.5	9.4	48.9			

Water Quality Data Report

SiteNbr	ling Locati	city (Miles	verable in Water as Zn ug/l
104	5		0.882
104	20		0.529
104	5	0	2.44
104	20		1.02
104	5	5	7.12
104	20		1.02
104	5		1.8
104	20		1.03
104	5		7.25
104	20		3.06
104	5		8.5
104	20		2.4
104	5		1.95
104	20		<0.68
104	5		0.28
104	20		0.79
104	5		0.49
104	20		0.41
104	5		1.1
104	20		0.37
104	5	15 (J)	0.853
104	20	15 (J)	0.683
104	5	10	3.19
104	20	10	3.01
104	5	5	2.11
104	20	5	1.32
104	5		2.37
104	5	0	<2
104	20		0.74
104	20	0	<2
104	5		<2
104	20		<2
104	5	0	1.62
104	20		1.12
104	5		1.89
104	5		19
104	20		1.44
104	20		29
104	5		2.45
104	5	0	5
104	20		1.16
104	20	0	8
104	5	0	5.87
104	20	0	0.46
104	5	5	4.21
104	20	5	<0.44
104	5	0	2.93
104	20	0	<0.52
104	5	0	0.79
104	20	0	<0.3
104	5	3	0.67
104	20	3	7.3
104	5	0	0.58
104	20	0	1.1
104	5	3	1.39
104	20	3	0.3
104	5	0	3.31
104	20	0	1.79
104	5	3	0.4
104	20	3	0.72
104	5		3.41
104	20		1.46
104	5	5	<0.85
104	20	5	0.77
104	5	0	0.63
104	20	0	1.03
104	5		0.36
104	20		0.45
104	5		0.4
104	20		0.16
104	5		0.66
104	20		0.75

Water Quality Data Report

SiteNbr	ıling Locati	ocity (Miles	ıverable in Water as Zn ug/l
104	5		0.882
104	20		0.529
104	5		0.42
104	20		0.85
104	5		1.8
104	20		1.59
104	5		1.5
104	20		0.139
104	5		1.25
104	20		3.6
104	5		2.69
104	20		0.78
104	5		3.24
104	20		2.88
104	5		5.08
104	20		0.722
104	5		0.792
104	20		1.74
104	5		0.852
104	20		0.617
104	5		1.26
104	20		0.514
104	5		0.745
104	20		1.45
104	5		3.08
104	5		1.09
104	5		3.56
104	5		1.48
104	5		1.58
104	5		1.15
104	5		1.9
104	5		0.624
104	5		0.628
104	5		0.566
104	5		0.346
104	5		0.572
104	5		0.648
104	5		0.411
104	5		0.862
104	5		4.78
104	5		9.98
104	5		1.07
105	5	15	3.7
105	20		0.706
105	5	1	0.813
105	20		0.813
105	5	10	4.27
105	20		2.03
105	5		0.771
105	20		0.642
105	5		2.38
105	20		1.59
105	5		2
105	20		1.3
105	5		0.76
105	20		2.05
105	5		0.79
105	20		0.31
105	5		0.96
105	20		0.38
105	5		0.4
105	20		0.32
105	5	10	<0.588
105	20	10	<0.588
105	5	15	2.1
105	20	15	1.47
105	5	20	<0.67

Water Quality Data Report

SiteNbr	ıling Locatio	ıcity (Miles	ıverable in Water as Zn ug/l
104	5		0.882
104	20		0.529
105	20	20	0.93
105	5		1.06
105	5	5	<2
105	20		1.15
105	20	5	<2
105	5		<2
105	20		<2
105	5		0.87
105	20		1.25
105	5		2.22
105	5		11
105	20		2.77
105	20		13 (J)
105	5	0	1.03
105	5		16 (R)
105	20	0	0.64
105	20		25 (R)
105	5	0	0.58
105	20	0	0.58
105	5	15	<0.44
105	20	15	0.89
105	5	0	0.82
105	20	0	<0.52
105	5	10	0.35
105	20	10	<0.3
105	5	3	0.48
105	20	3	0.19
105	5	5	<0.44
105	20	5	0.49
105	5	3	0.3
105	20	3	0.4
105	5	3	2.86
105	20	3	1.16
105	5	3	0.88
105	20	3	2.24
105	5		0.88
105	20		<0.61
105	5		0.7
105	20		0.85
105	5	0	2.54
105	20	0	<0.24
105	5		0.27
105	20		<0.16
105	5		0.24
105	20		0.16
105	5		0.33
105	20		0.42
105	5		0.34
105	20		0.51
105	5		1.73
105	20		1.18
105	5		2.84
105	20		0.67
105	5		0.55
105	20		0.7
105	5		1.74
105	20		0.61
105	5		12.3 (J)
105	20		2.28
105	5		1.69
105	20		0.677
105	5		2.2
105	20		0.392
105	5		0.746
105	20		0.509
105	5		0.522
105	20		0.386
105	5		1.15
105	20		0.622
106	5	15	0.706

Water Quality Data Report

SiteNbr	ıling Locatio	ıcity (Miles	ıverable in Water as Zn ug/l
104	5		0.882
104	20		0.529
106	20		0.363
106	5	5	0.813
106	20		0.61
106	5	10	2.24
106	20		0.813
106	5	3	0.385
106	20	3	0.514
106	5		1.59
106	20		2.61
106	5		2.3
106	20		1.6
106	5		<0.68
106	20		<0.68
106	5		0.35
106	20		1.93
106	5		0.49
106	20		1.7
106	5		0.89
106	20		0.26
106	5	25	<0.588
106	20	25	<0.588
106	5	0	1.83
106	20	0	1.11
106	5	25	<0.67
106	20	25	1.09
106	5		<0.14
106	5	0	<2
106	20		0.66
106	20	0	<2
106	5		<2
106	20		<2
106	5	10	1
106	20		<0.56
106	5		2.11
106	5		12
106	20		0.67
106	20		13
106	5	0	<0.44
106	5		5
106	20	0	0.51
106	20		10
106	5	0	0.81
106	20	0	1.27
106	5	10	<0.44
106	20	10	<0.44
106	5	0	0.82
106	20	0	<0.52
106	5	10	0.97
106	20	10	<0.3
106	5	10	<0.17
106	20	10	1.2
106	5	0	<0.44
106	20	0	<0.44
106	5	3	0.99
106	20	3	1.39
106	5	3	1.16
106	20	3	1.07
106	5	3	0.88
106	20	3	1.84
106	5	20	0.68
106	20	20	<0.61
106	5		<0.54
106	20		0.62
106	5	0	16.7
106	20	0	<0.24
106	5		0.54
106	20		<0.16
106	5		7.7
106	20		52.9 (R)
106	5		0.42

Water Quality Data Report

SiteNbr	ıling Locati	ıcity (Miles	ıverable in Water as Zn ug/l
104	5		0.882
104	20		0.529
106			0.33
106	5		0.17
106	20		0.17
106	5		1.22
106	20		1.02
106	5		1.17
106	20		0.58
106	5		0.86
106	20		0.55
106	5		0.96
106	20		13.9
106	5		8.11
106	20		68.1 (R)
106	5		0.814
106	20		0.52
106	5		0.522
106	20		0.391
106	5		0.389
106	20		0.398
106	5		0.684
106	20		0.371
106	5		0.354
106	20		1.19
106	5		0.736
106	5		0.547
106	5		
106	5		1.82
106	5		2.22
106	5		1.27
106	5		0.854
106	5		0.773
106	5		1.28
106	5		2.72
106	5		0.317
106	5		0.356
106	5		0.348
106	5		0.597
106	5		<0.179
106	5		0.979
106	5		2.03
106	5		6.11
106	5		1.5
107	5	12	1.71
107	20		0.823
107	5	0	1.42
107	20		0.407
107	5	10	2.64
107	20		1.22
107	5	3	0.771
107	20	3	0.642
107	5		4.42
107	20		2.95
107	5		3.1
107	20		1.9
107	5		0.97
107	20		<0.68
107	5		0.86
107	20		<0.27
107	5		1.7
107	20		0.71
107	5		0.32
107	20		0.49
107	5	20	<0.588
107	20	20	<0.588
107	5	15	2.1
107	20	15	2.01
107	5	25 (J)	1.17
107	20	15	1.09
107	5	0	1.31
107	5		<2

Water Quality Data Report

SiteNbr	pling Locati	ocity (Miles	verable in Water as Zn ug/l
104	5		0.882
104	20		0.529
107	20	0	0.49
107	20		<2
107	5		<2
107	20		<2
107	5	3	0.62
107	20		1.37
107	5		3.22
107	5		11 (J)
107	20		1.89
107	20		9
107	5	0	1.03
107	5		11 (J)
107	20	0	1.16
107	20		10 (J)
107	5	0	0.81
107	20	0	0.81
107	5	10	0.64
107	20	10	1.02
107	5	0	0.94
107	20	0	<0.52
107	5	5	<0.3
107	20	5	<0.3
107	5	3	0.48
107	20	3	14 (R)
107	5	5	0.87
107	20	5	0.78
107	5	3	0.2
107	20	3	0.17
107	5	0	2.41
107	20	0	1.61
107	5	3	1.76
107	20	3	3.85
107	5		1.46
107	20		5.06
107	5		0.93
107	20		0.85
107	5	0	3.01
107	20	0	2.06
107	5		<0.16
107	20		0.18
107	5		<0.14
107	20		0.16
107	5		0.5
107	20		1.25
107	5		0.51
107	20		0.51
107	5		1.44
107	20		1.37
107	5		1.34
107	20		1.09
107	5		0.31
107	20		0.24
107	5		1.65
107	20		4.69
107	5		2.08
107	20		4.29
107	5		2.95
107	20		8.63
107	5		1.91
107	20		0.378
107	5		0.59
107	20		0.57
107	5		0.574
107	20		0.627
107	5		0.951
107	20		0.197
107	5		1.34
107	5		1.02
107	5		
107	5		3.36

Water Quality Data Report

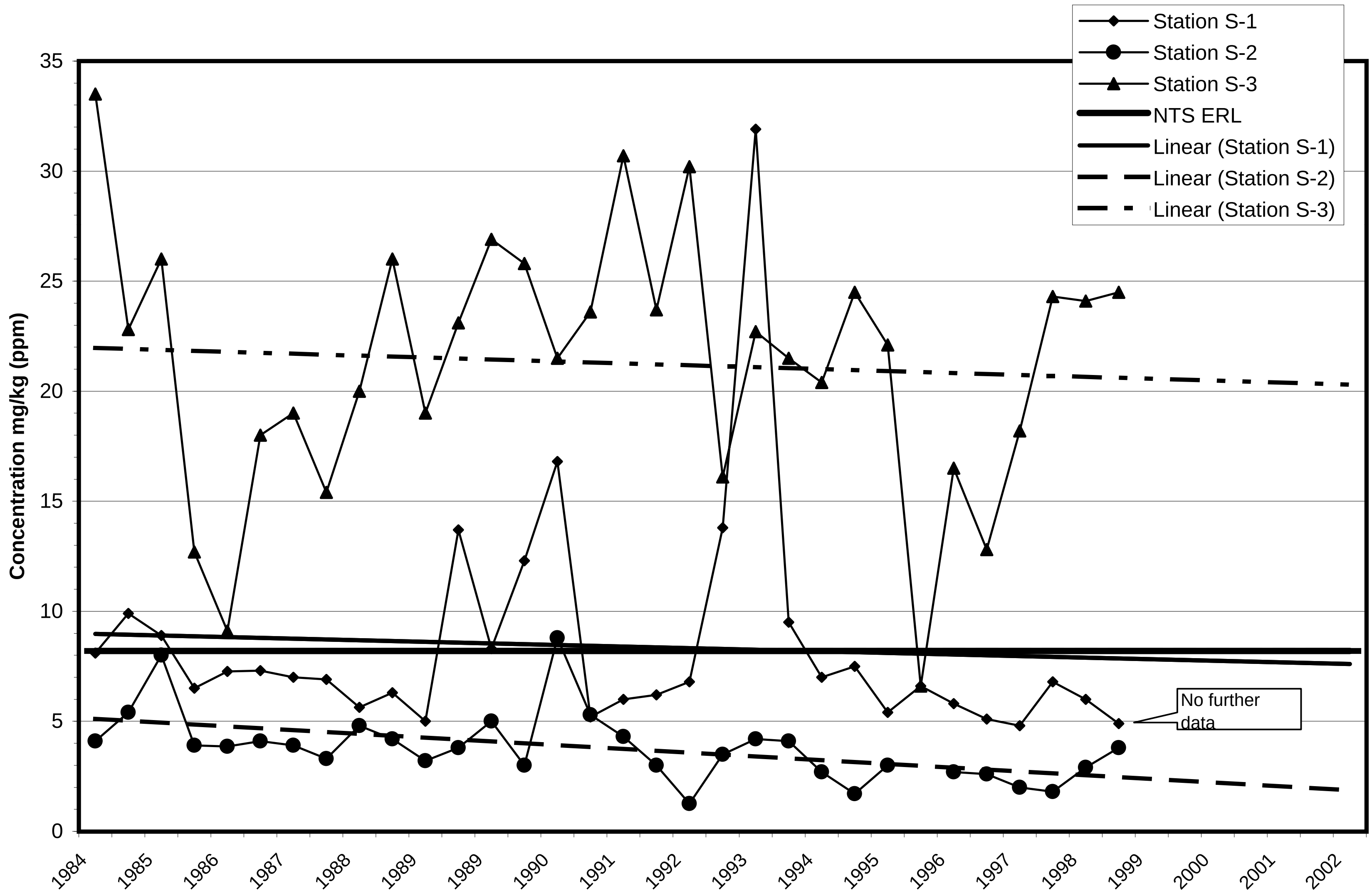
SiteNbr	ling Locati	ocity (Miles	verable in Water as Zn ug/l
104	5		0.882
104	20		0.529
107	5		1.69
107	5		3.1
107	5		2.41
107	5		0.875
107	5		0.559
107	5		0.682
107	5		0.561
107	5		0.298
107	5		0.562
107	5		0.759
107	5		0.354
107	5		0.687
107	5		2.59
107	5		2.42
107	5		1.34
108	5	18	1.12
108	20		0.941
108	5	4	1.02
108	20		1.02
108	5	10	1.42
108	20		2.64
108	5	3	0.514
108	20	3	0.385
108	5		1.93
108	20		2.15
108	5		2.6
108	20		2.3
108	5		<0.68
108	20		<0.68
108	5		0.28
108	20		0.45
108	5		0.74
108	20		0.63
108	5		0.55
108	20		0.43
108	5	15	<0.588
108	20	15	<0.588
108	5	15	1.74
108	20	15	1.65
108	5	25	1.01
108	20	25	<0.67
108	5		1.06
108	5		<2
108	20		0.82
108	20		<2
108	5		<2
108	20		<2
108	5	5	1.12
108	20		1.12
108	5		3.66
108	5		13 (J)
108	20		3
108	20		17 (R)
108	5	0	0.51
108	5		19 (R)
108	20	0	0.77
108	20		4
108	5	0	1.84
108	20	0	1.04
108	5	15	<0.44
108	20	15	1.66
108	5	5	1.05
108	20	5	<0.52
108	5	10	3.7
108	20	10	<0.3
108	5	0	5.4
108	20	0	0.19
108	5	10	0.58
108	20	10	0.49
108	5	3	0.3

Water Quality Data Report

SiteNbr	ıling Locati	ıcity (Miles	ıverable in Water as Zn ug/l
104	5		0.882
104	20		0.529
108	20	3	0.4
108	5		2.59
108	20		1.34
108	5	3	0.4
108	20	3	0.4
108	5	20	0.88
108	20	20	1.95
108	5	10	1.39
108	20	10	1.7
108	5	0	0.39
108	20	0	0.55
108	5		0.18
108	20		<0.16
108	5		0.14
108	20		0.16
108	5		0.75
108	20		0.91
108	5		0.25
108	20		0.68
108	5		1.07
108	20		1.36
108	5		1.09
108	20		0.92
108	5		1.41
108	20		1.8
108	5		10.8
108	20		1.04
108	5		17.8 (R)
108	20		1.89
108	5		2.37
108	20		1.03
108	5		0.555
108	20		0.752
108	5		0.472
108	20		0.334
108	5		2.3
108	20		0.531
108	5		0.296
108	20		0.21
108	5		2.89
108	5		2.69
108	5		
108	5		4.07
108	5		2.13
108	5		2.61
108	5		3.3
108	5		1.56
108	5		0.512
108	5		0.759
108	5		0.403
108	5		0.331
108	5		0.623
108	5		0.551
108	5		0.238
108	5		0.655
108	5		4.14
108	5		2.22
108	5		0.864

Hawk Inlet Metal Concentrations 1984-2002

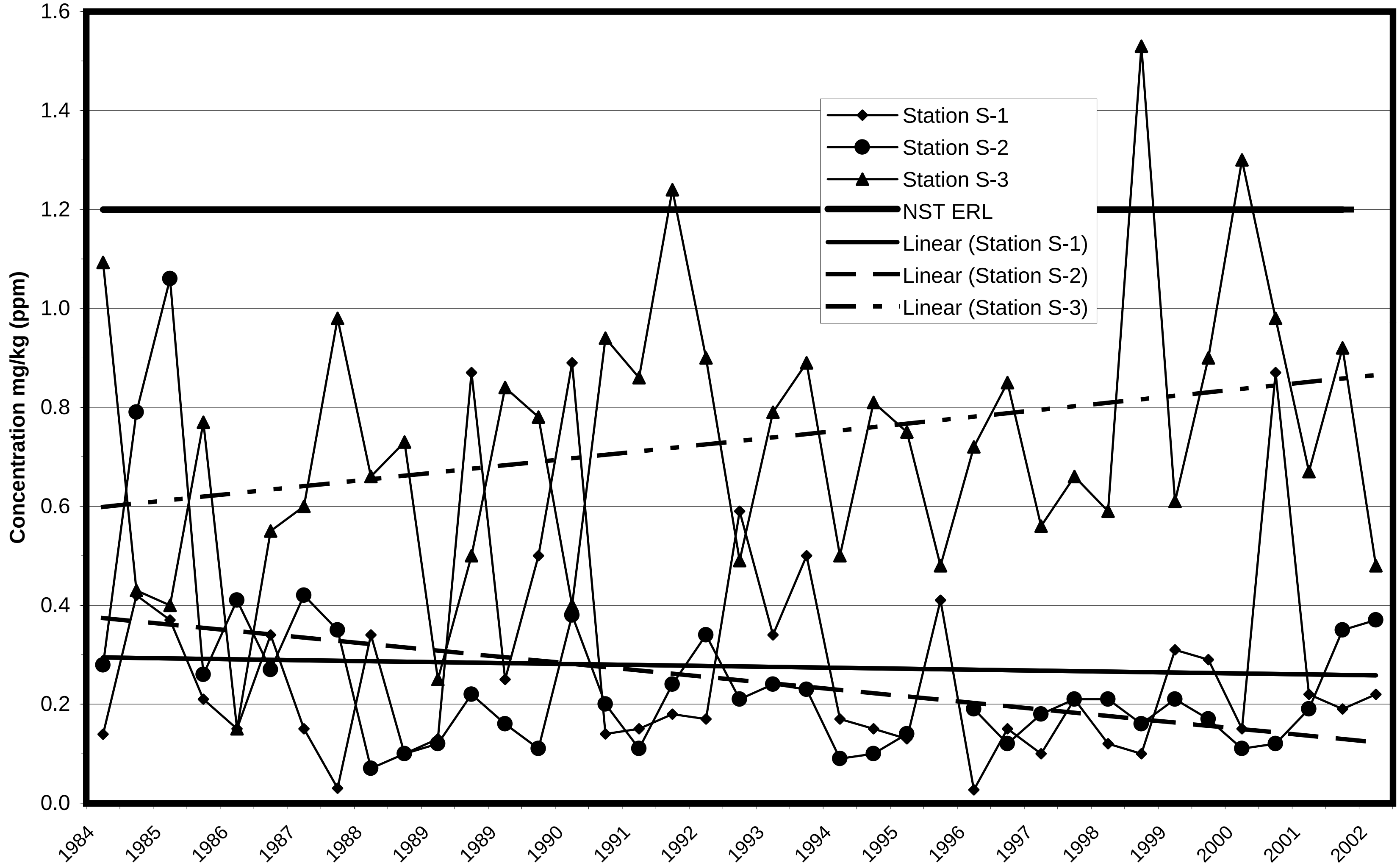
Figure 4-1. S-1, S-2, S-3 Sediment Arsenic (As)



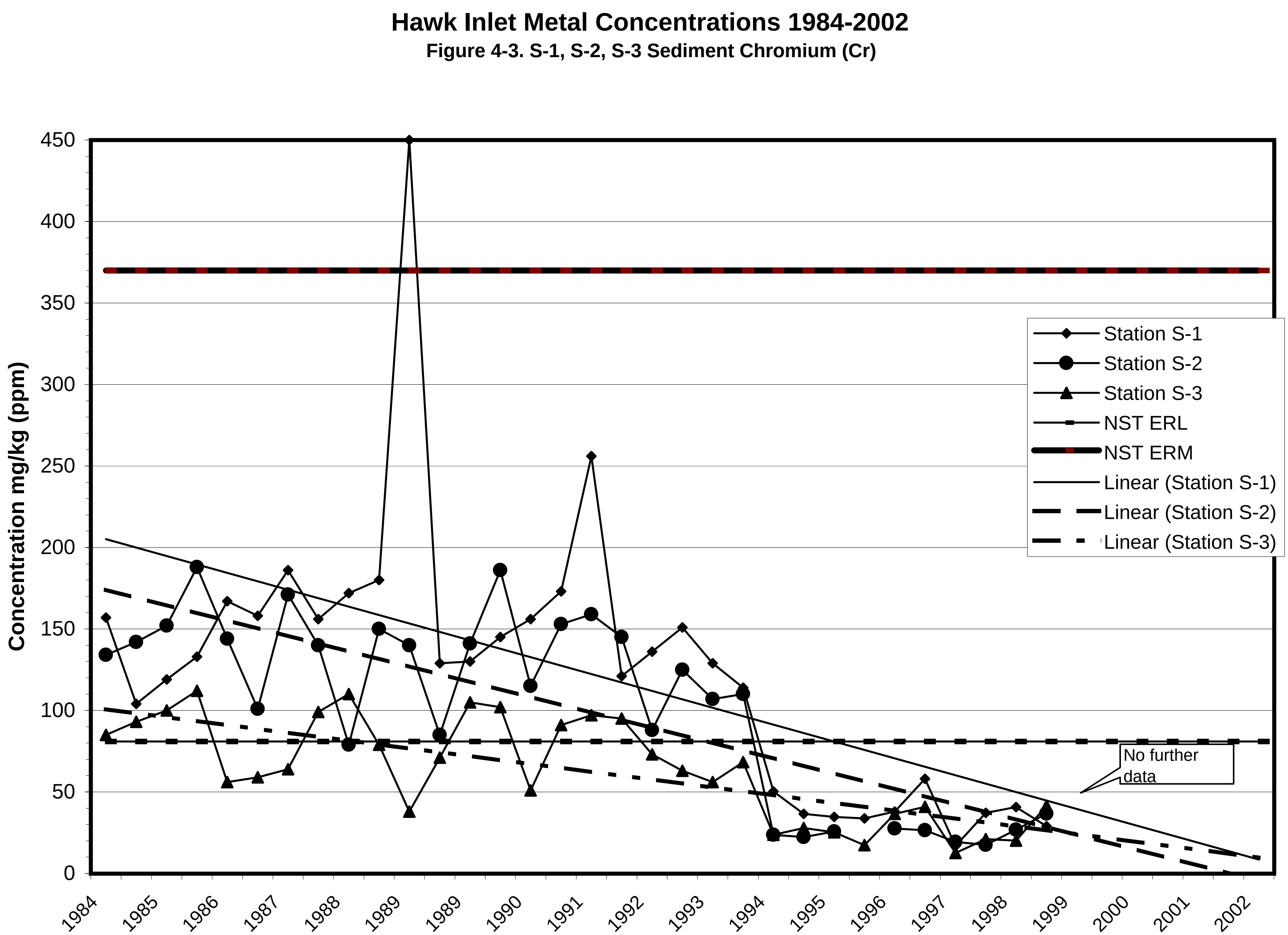
Oceanus Alaska, KGCMC Data,Sed As

Hawk Inlet Metal Concentrations 1984-2002

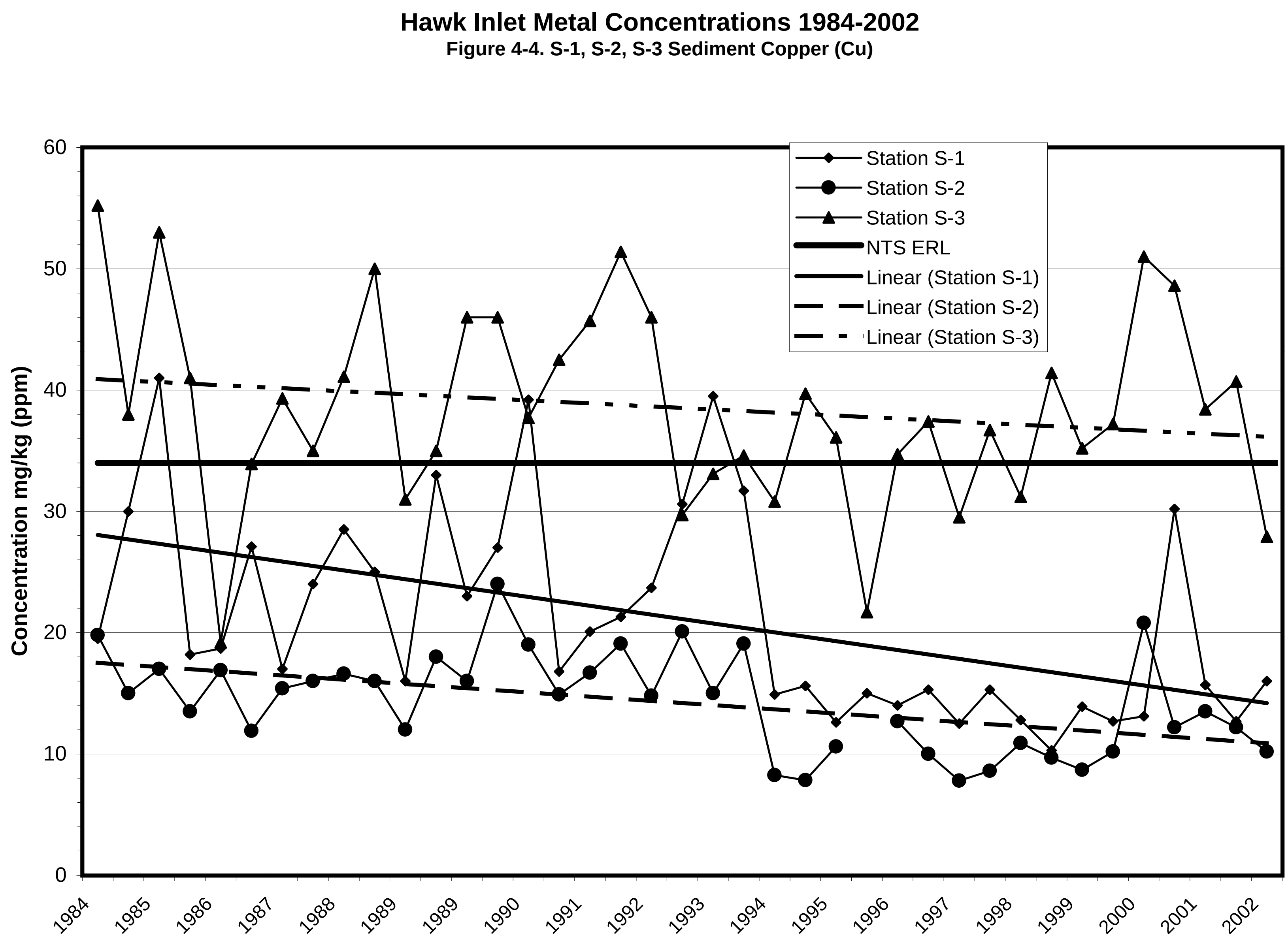
Figure 4-2. S-1, S-2, S-3 Sediment Cadmium (Cd)



Oceanus Alaska, KGCMC Data,Sed Cd



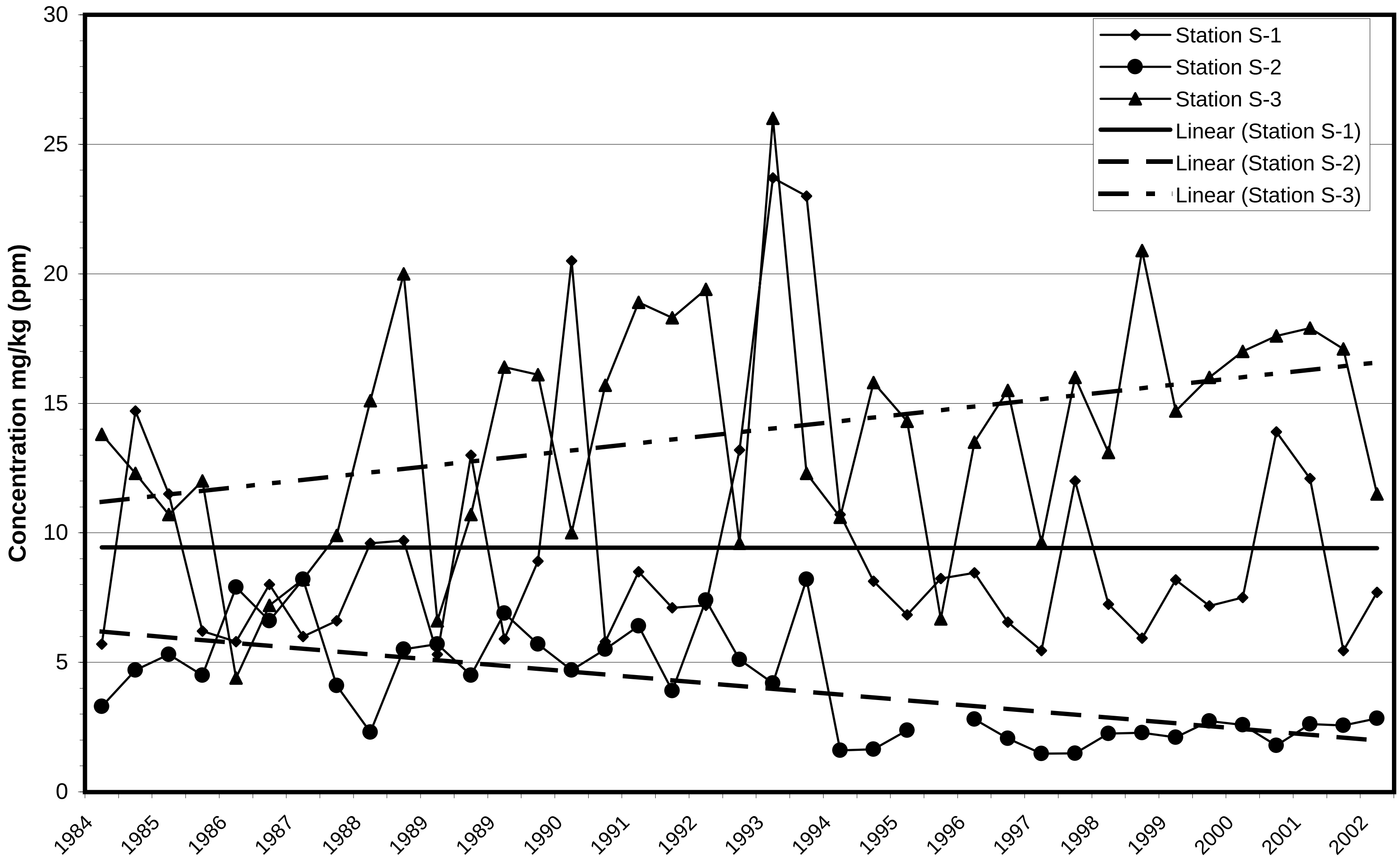
Oceanus Alaska, KGCMC Data,Sed Cr



Oceanus Alaska, KGCMC Data,Sed cu

Hawk Inlet Metal Concentrations 1984-2002

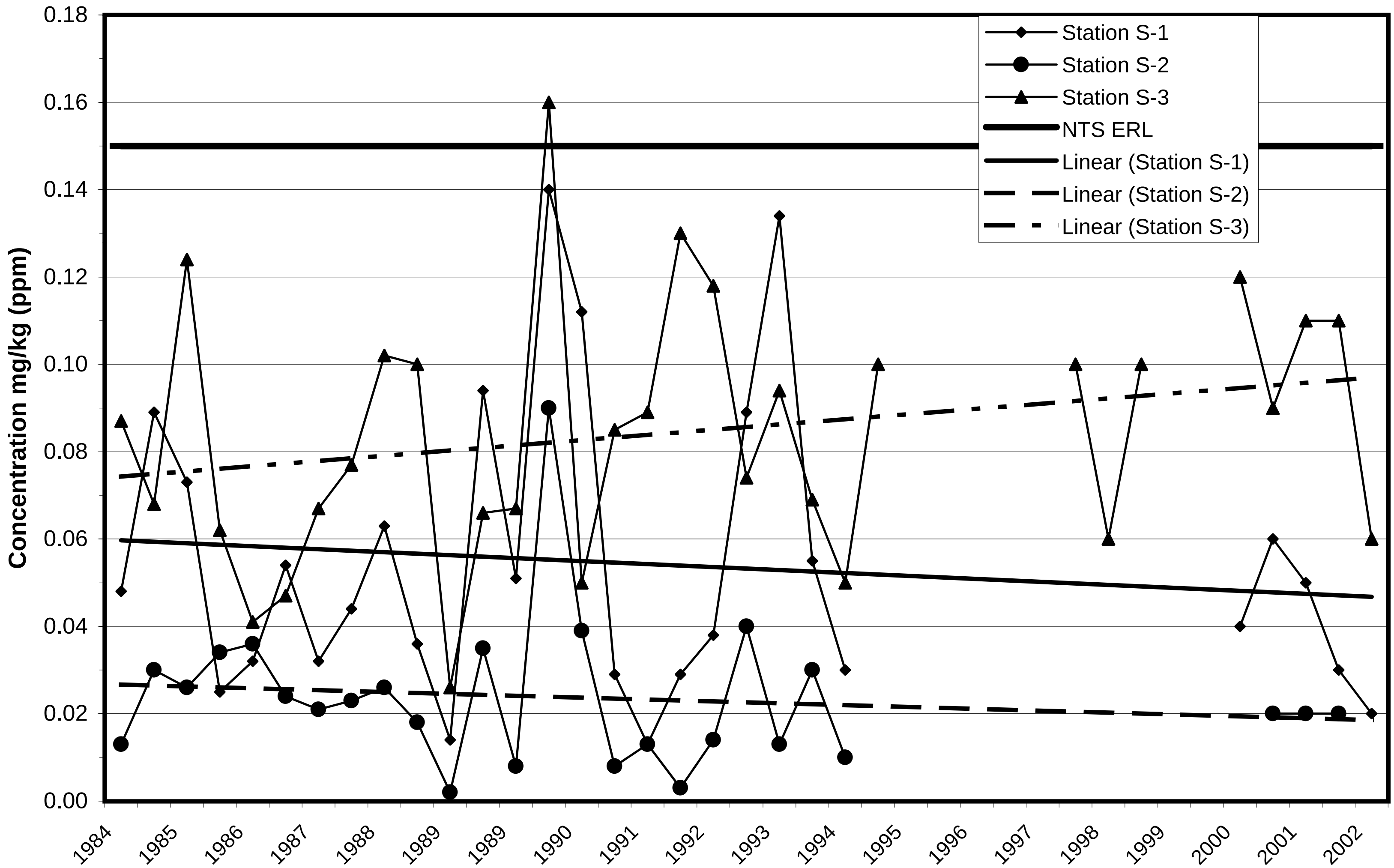
Figure 4-5. Station S-1, S-2, S-3 Sediment Lead (Pb)



Oceanus Alaska, KGCMC Data,Sed Pb

Hawk Inlet Metal Concentrations 1984-2002

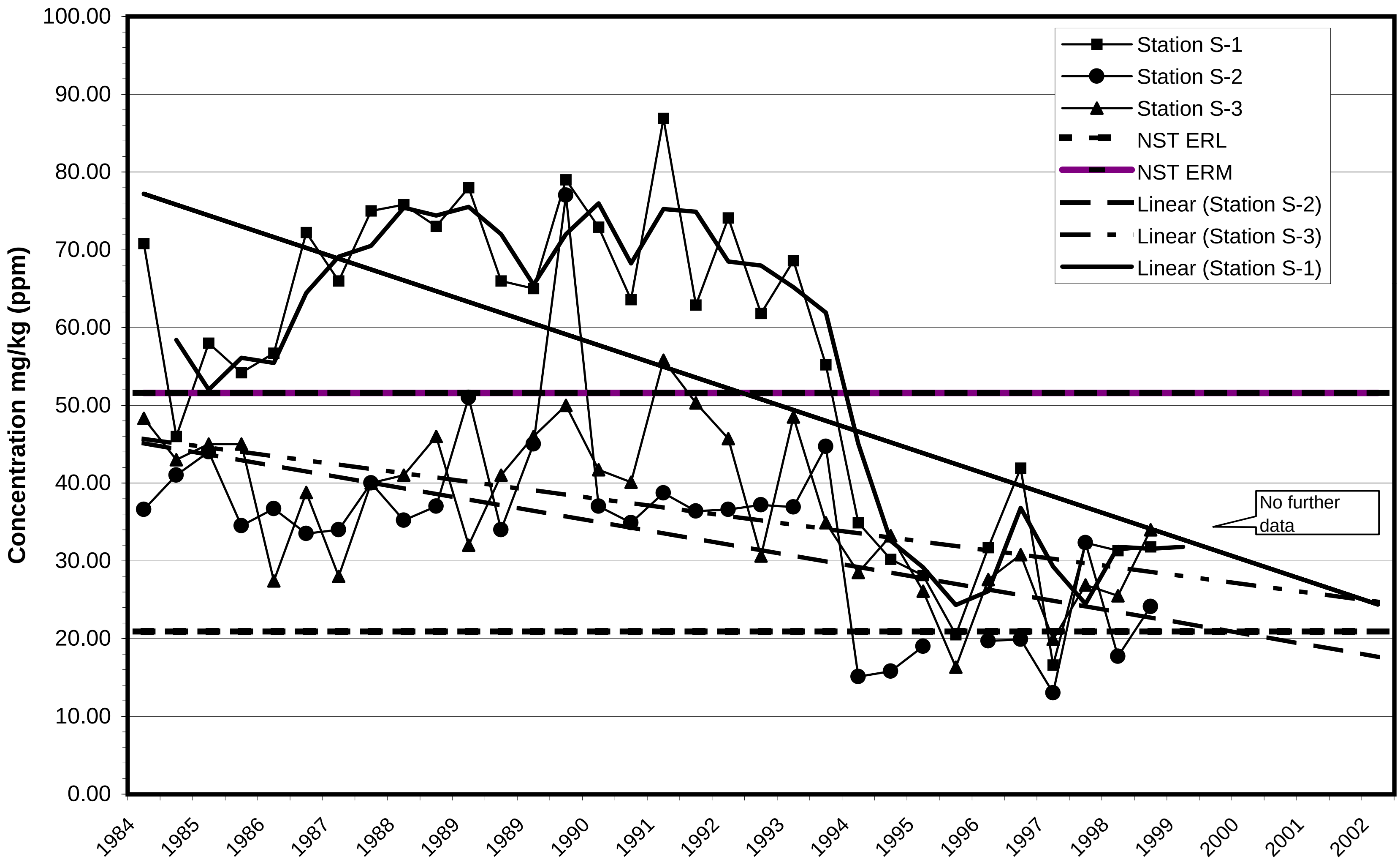
Figure 4-6. Station S-1, S-2, S-3 Sediment Mercury (Hg)



Oceanus Alaska, KGCMC Data,Sed Hg

Hawk Inlet Metal Concentrations 1984-2002

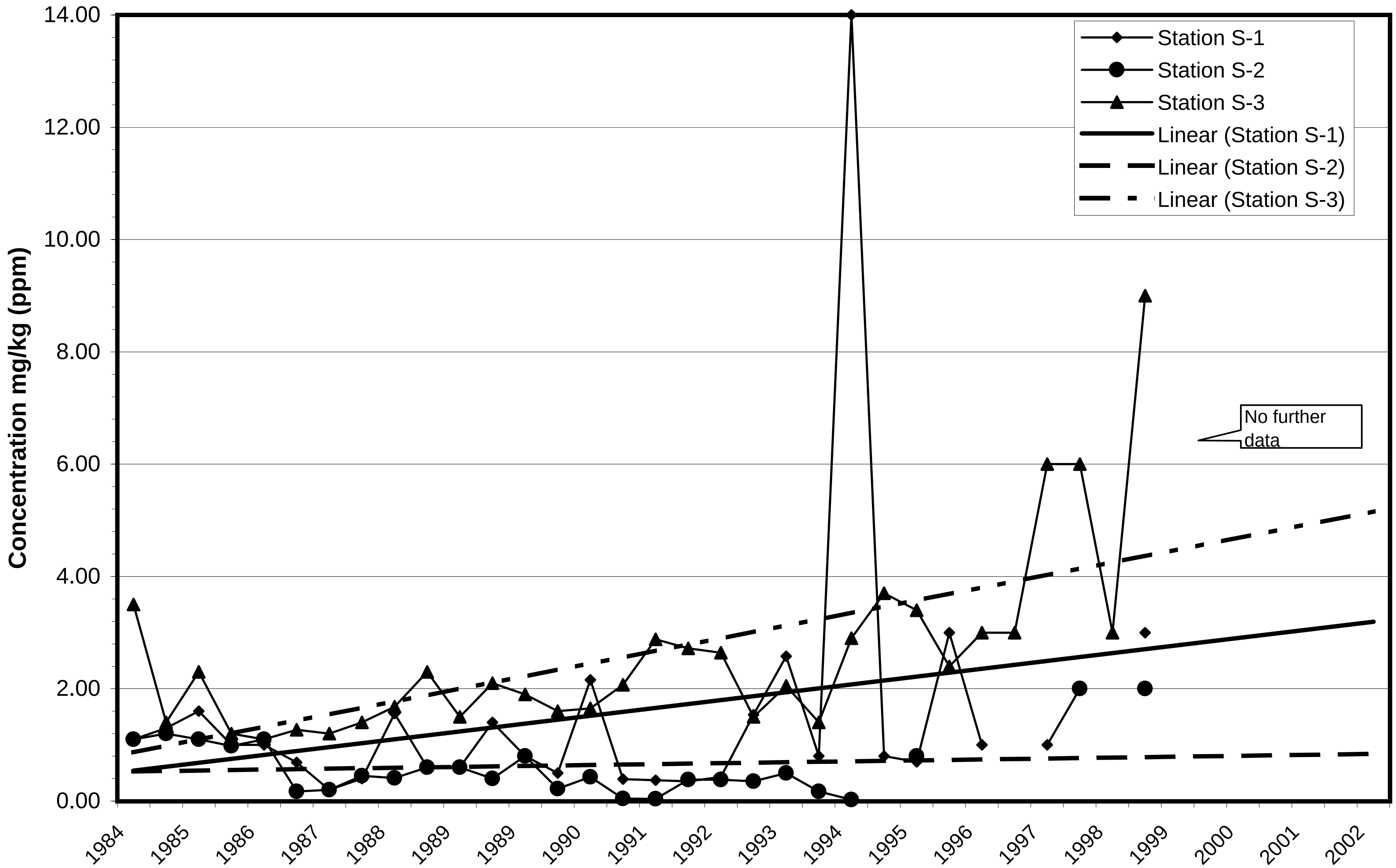
Figure 4-7. Station S-1, S-2, S-3 Sediment Nickel (Ni)



Oceanus Alaska, KGCMC Data,Sed Ni

Hawk Inlet Metal Concentrations 1984-2002

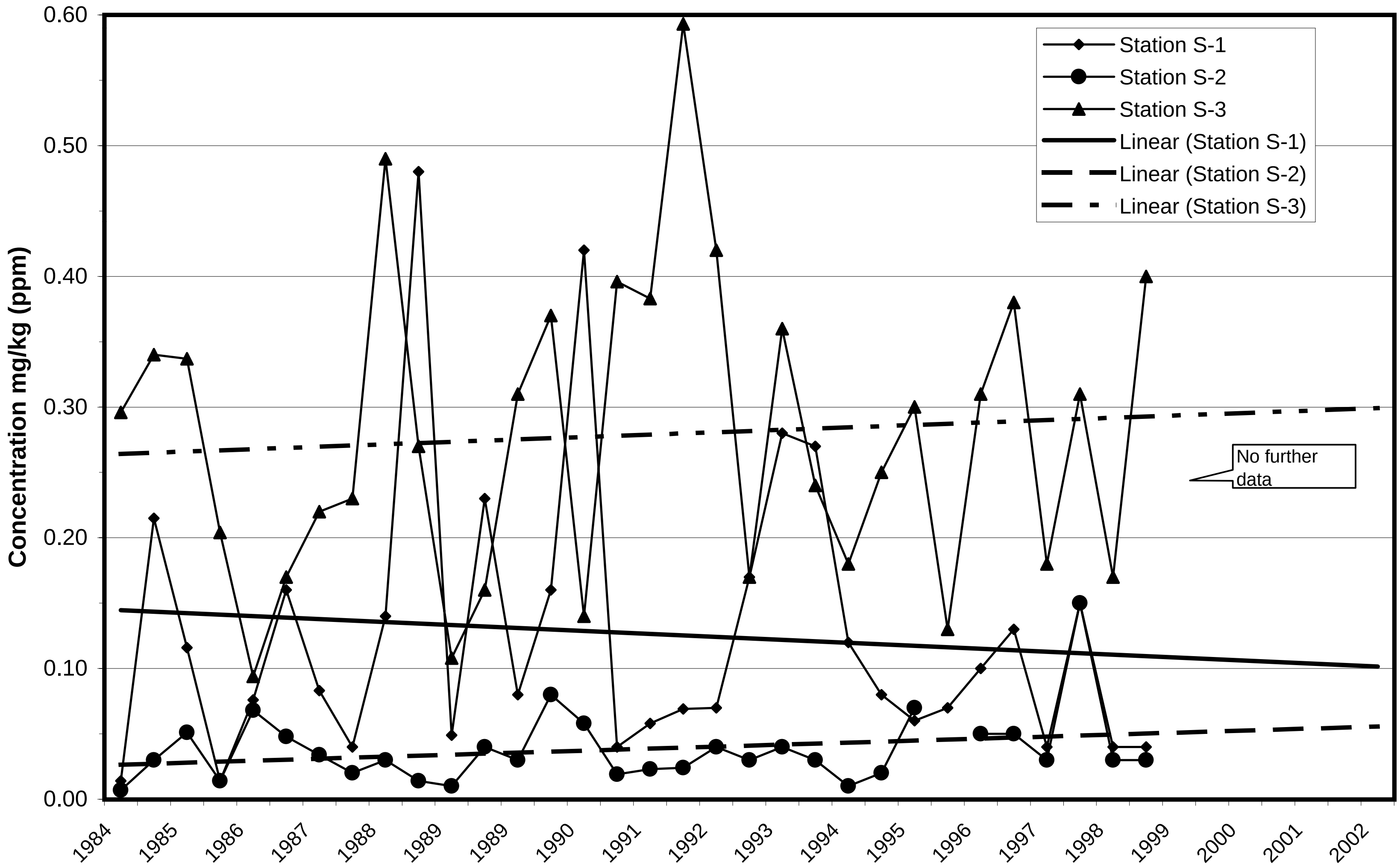
Figure 4-8. Station S-1, S-2, S-3 Sediment Selenium (Se)



Oceanus Alaska, KGCMC Data,Sed Se

Hawk Inlet Metal Concentrations 1984-2002

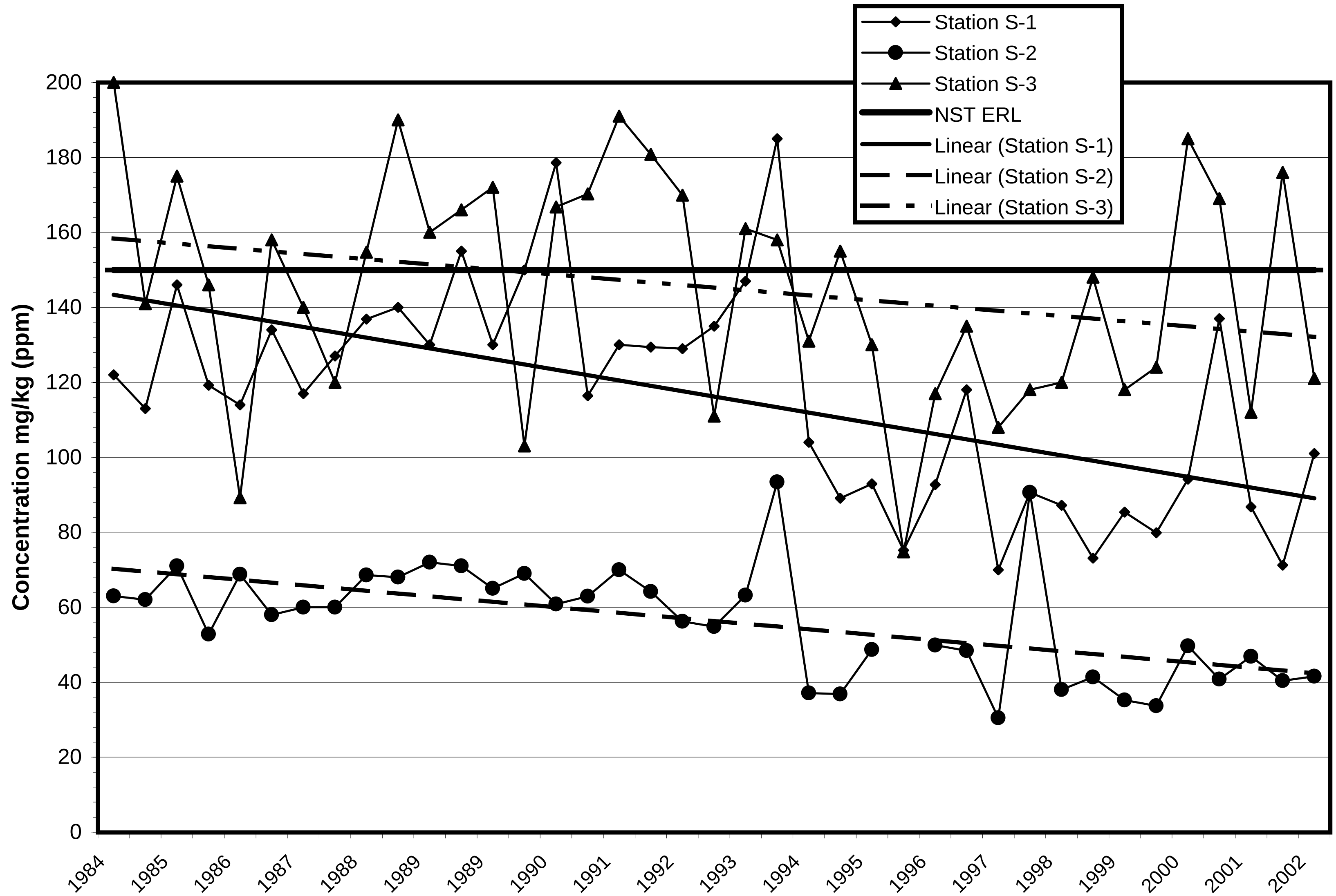
Figure 4-9. Station S-1, S-2, S-3 Sediment Silver (Ag)



Oceanus Alaska, KGCMC Data,Sed Ag

Hawk Inlet Metal Concentrations 1984-2002

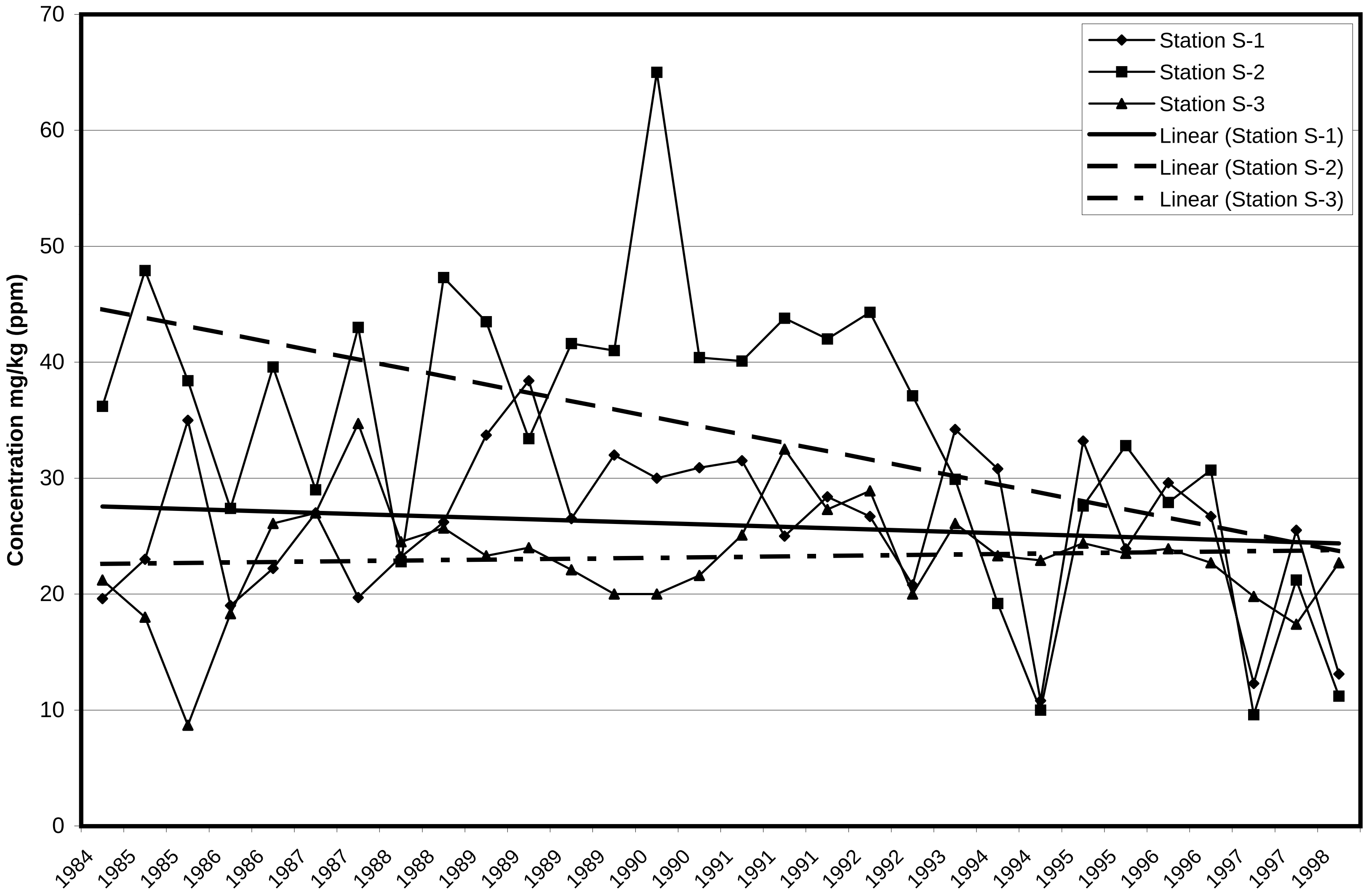
Figure 4-10. Station S-1, S-2, S-3 Sediment Zinc (Zn)



Oceanus Alaska, KGCMC Data,Sed Zn

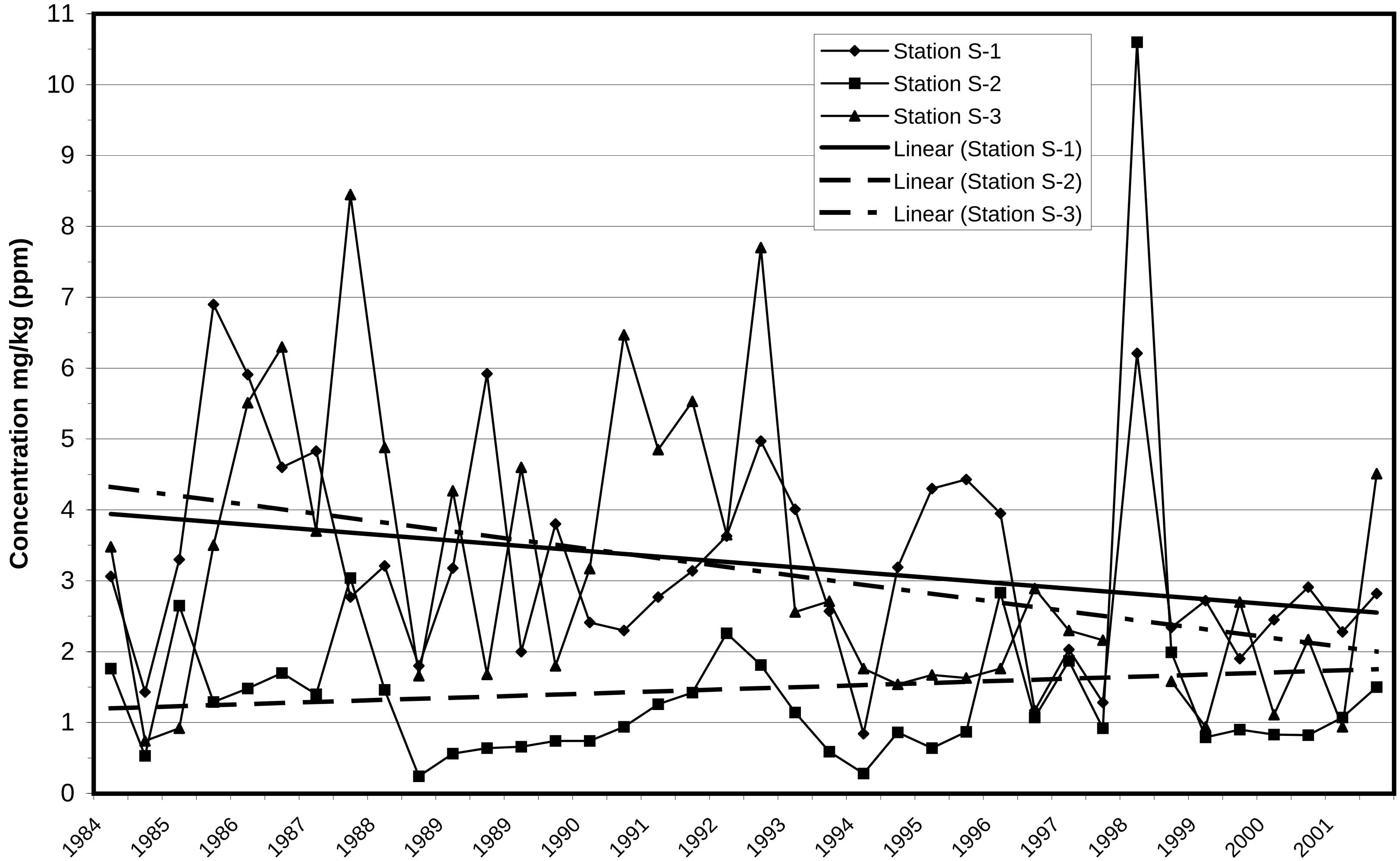
Hawk Inlet Metal Concentrations 1984-2002

Figure 4-31. S-1, S-2, S-3 Nephthys Arsenic (As)



Oceanus Alaska, KGCMC Data,Worm As

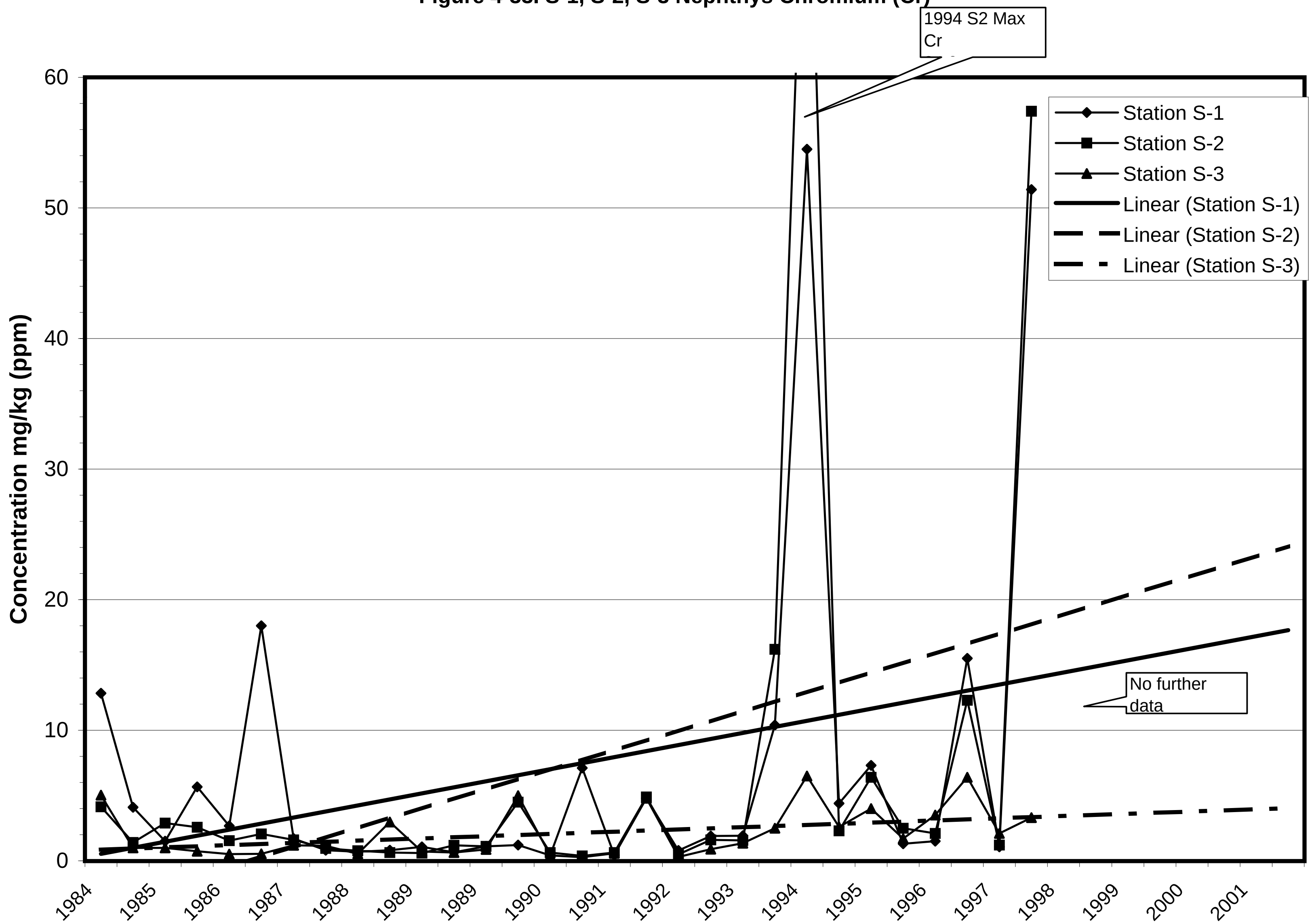
Hawk Inlet Metal Concentrations 1984-2002
Figure 4-32. S-1, S-2, S-3 Nephthys Cadmium (Cd)



Oceanus Alaska, KGCMC Data,Worm Cd

Hawk Inlet Metal Concentrations 1984-2002

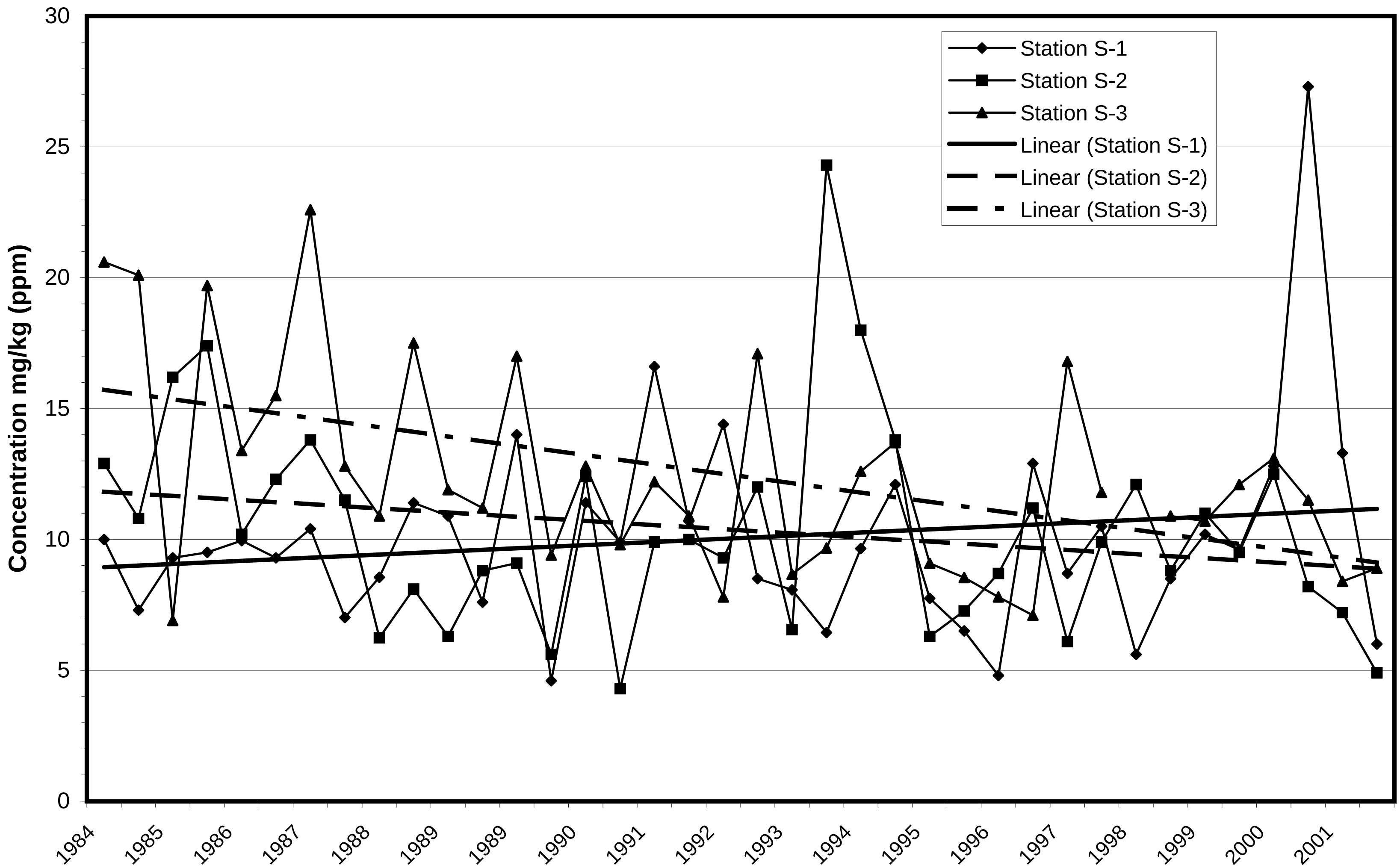
Figure 4-33. S-1, S-2, S-3 Nephthys Chromium (Cr)



Oceanus Alaska, KGCMC Data,Worm Cr

Hawk Inlet Metal Concentrations 1984-2002

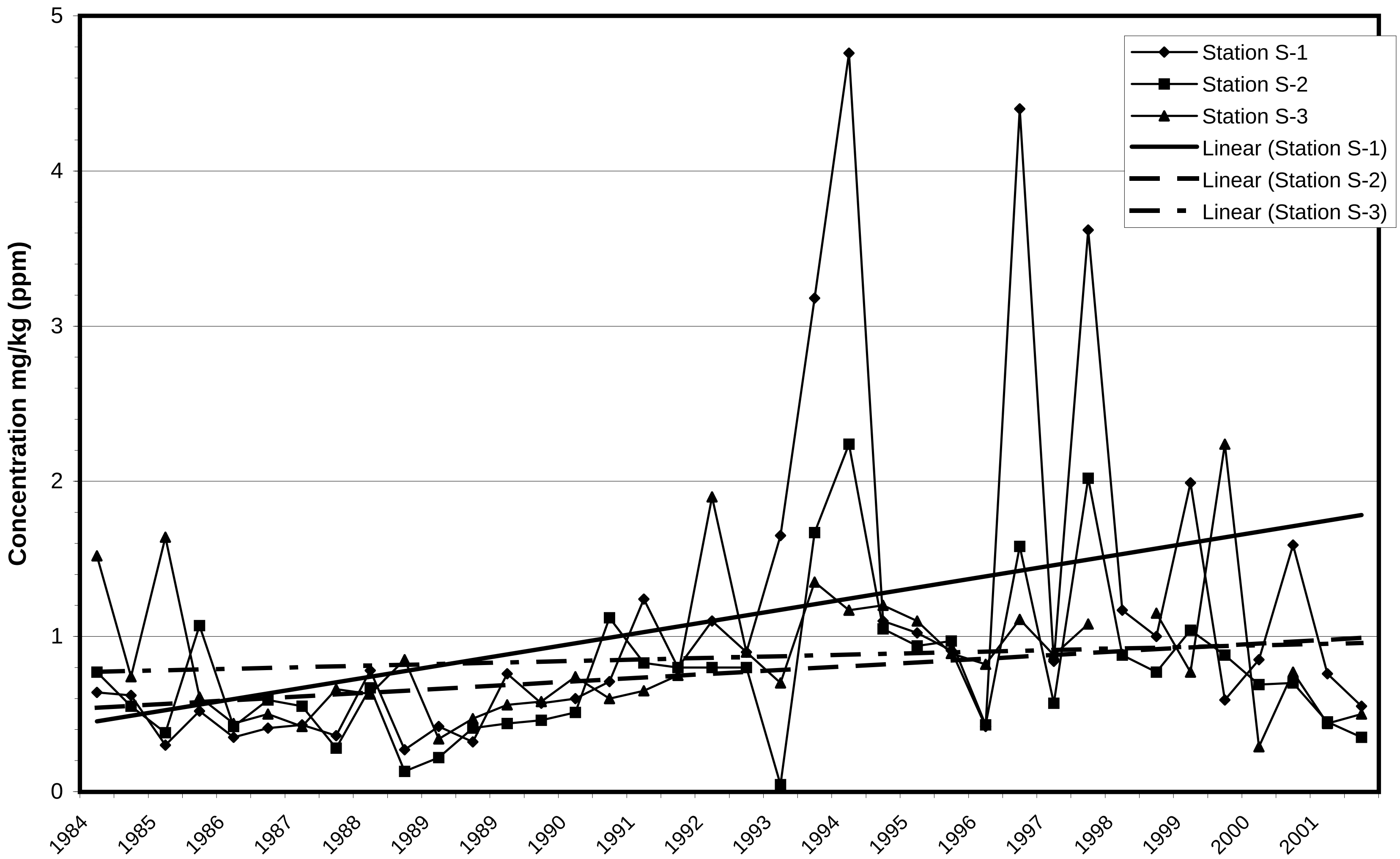
Figure 4-34. S-1, S-2, S-3 Nephthys Copper (Cu)



Oceanus Alaska, KGCMC Data,Worm Cu

Hawk Inlet Metal Concentrations 1984-2002

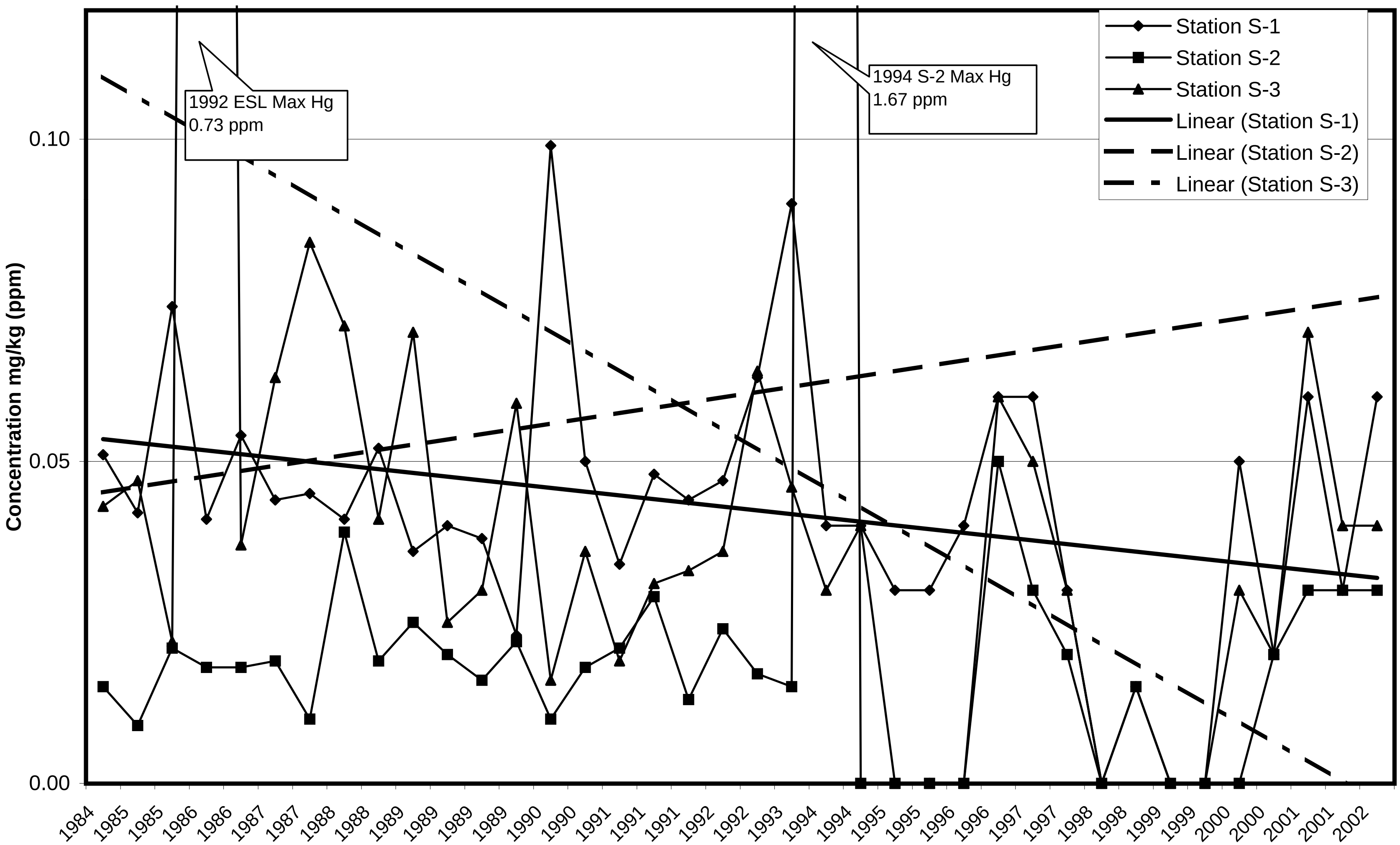
Figure 4-35. S-1, S-2, S-3 Nephthys Lead (Pb)



Oceanus Alaska, KGCMC Data,Worm Pb

Hawk Inlet Metal Concentrations 1984-2002

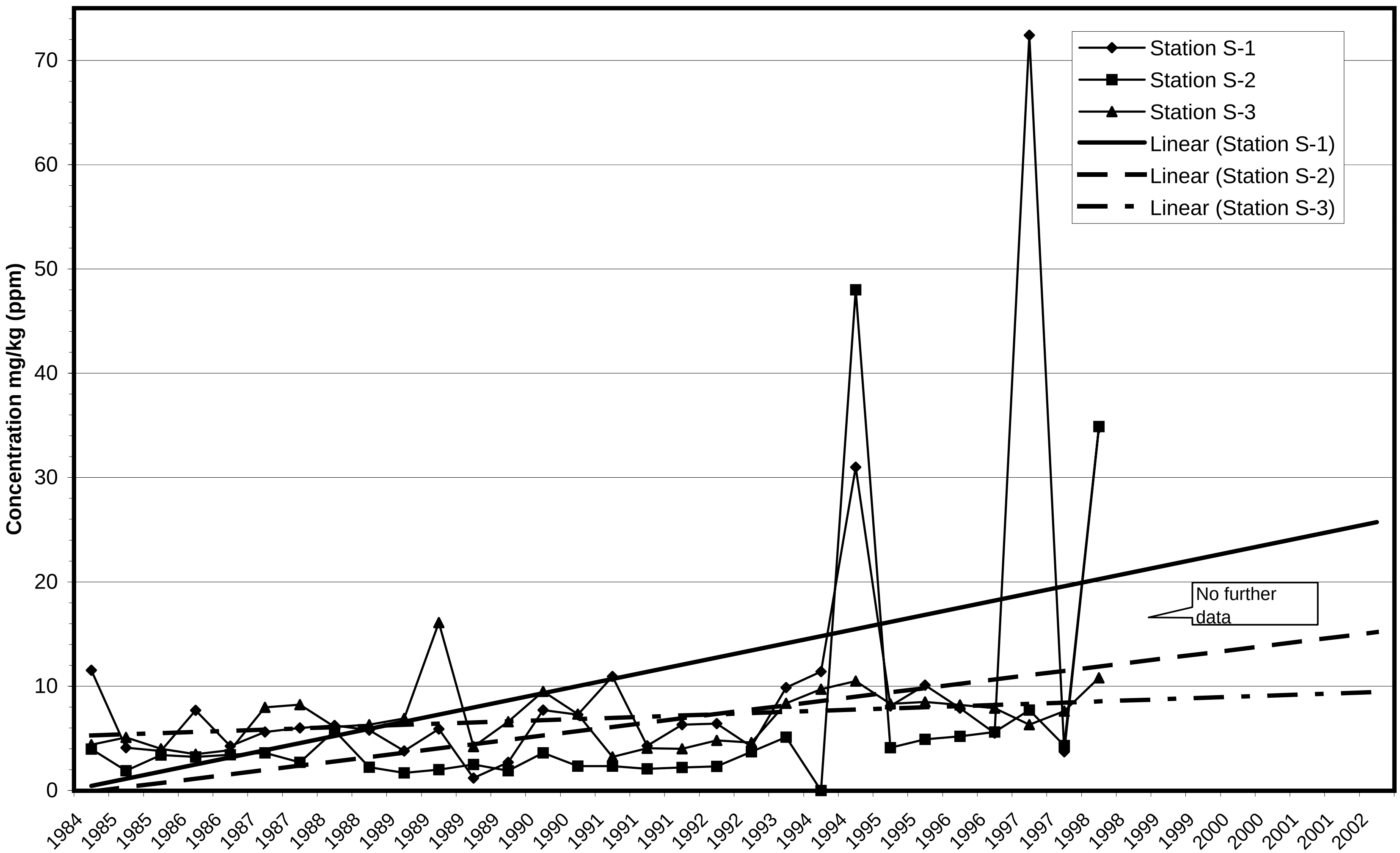
Figure 4-36. S-1, S-2, S-3 Nephthys Mercury (Hg)



Oceanus Alaska, KGCMC Data,Worm Hg

Hawk Inlet Metal Concentrations 1984-2002

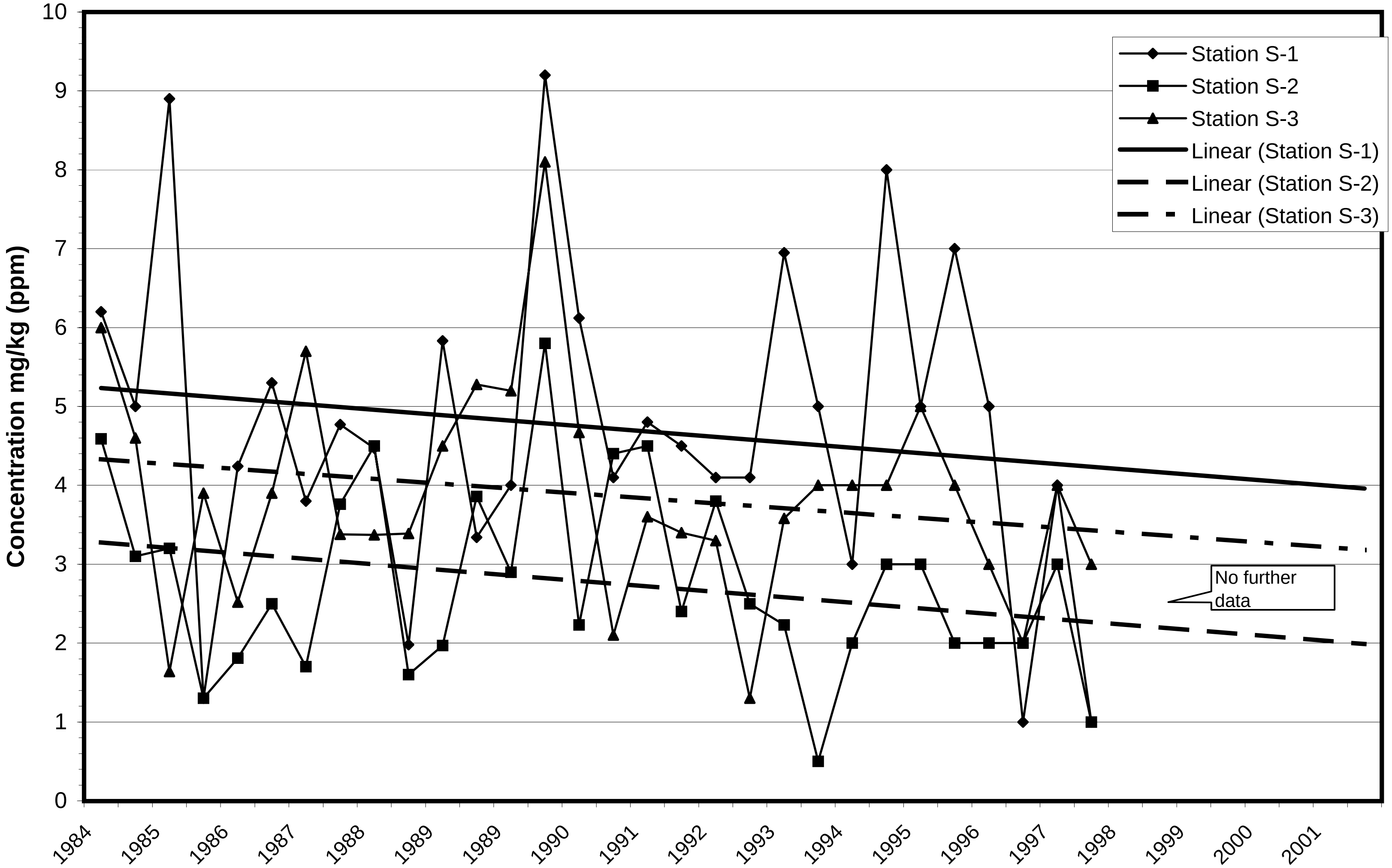
Figure 4-37. S-1, S-2, S-3 Nephthys Nickel (Ni)



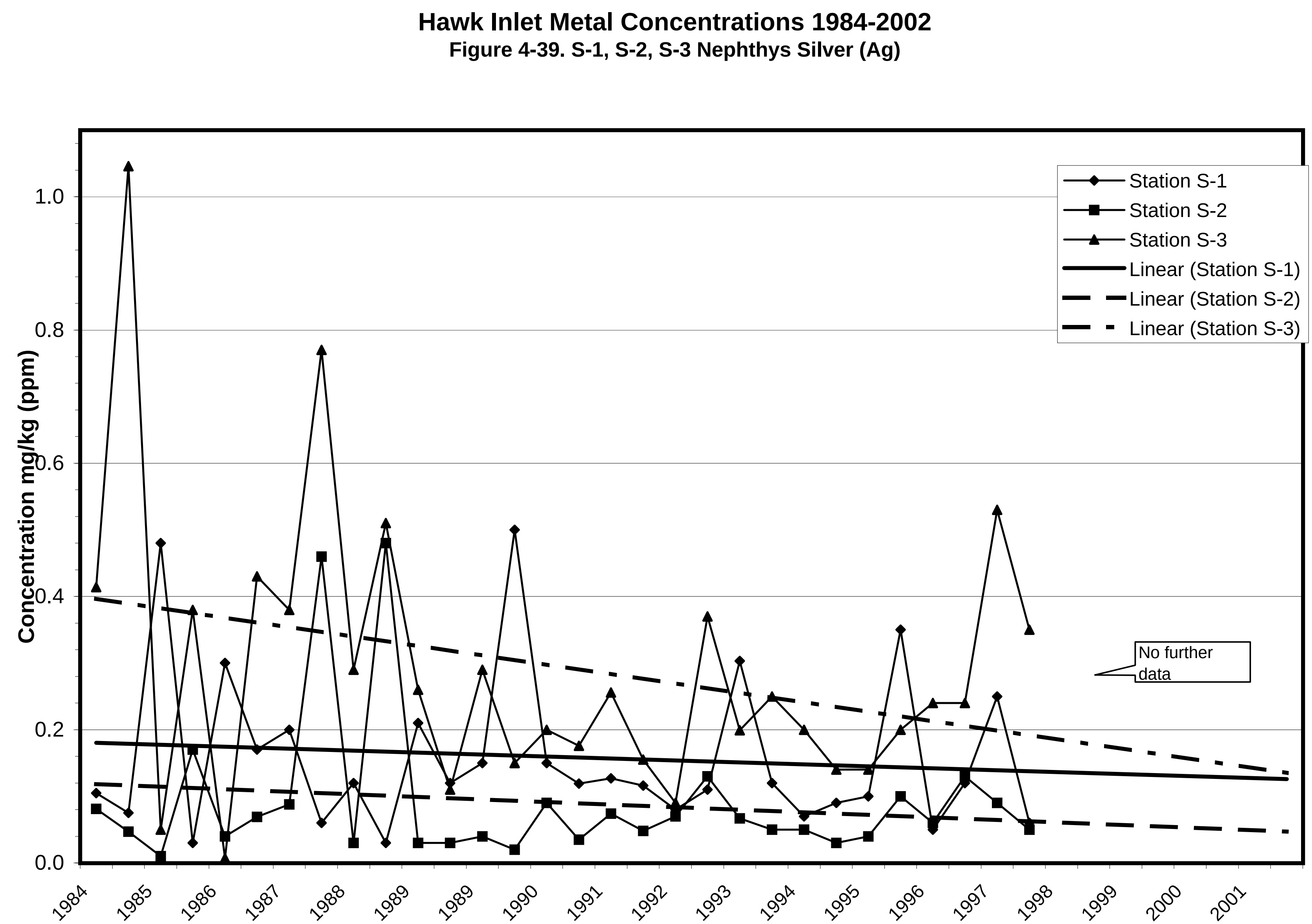
Oceanus Alaska, KGCMC Data,Worm Ni

Hawk Inlet Metal Concentrations 1984-2002

Figure 4-38. S-1, S-2, S-3 Nephthys Selenium (Se)



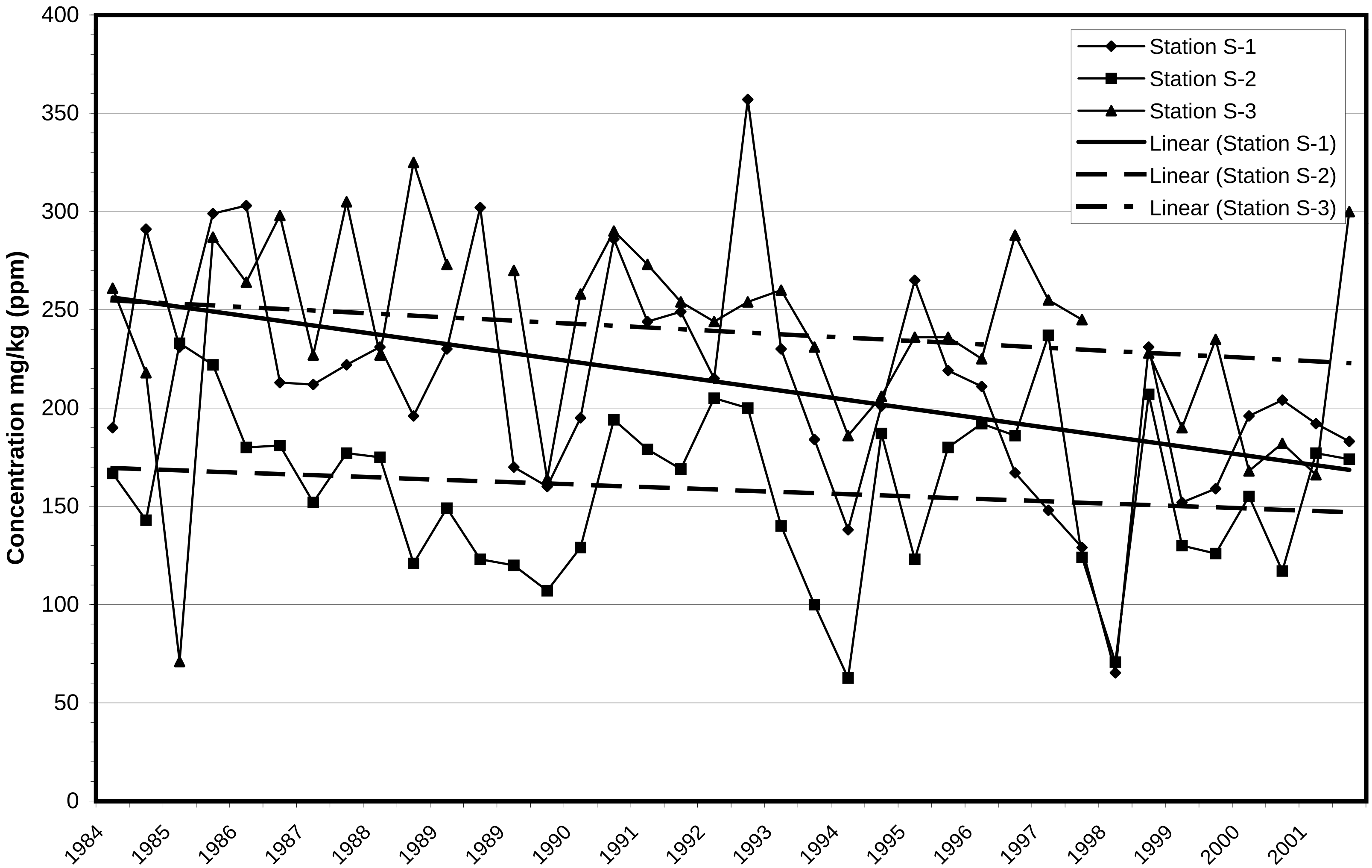
Oceanus Alaska, KGCMC Data,Worm Se



Oceanus Alaska, KGCMC Data,Worm Ag

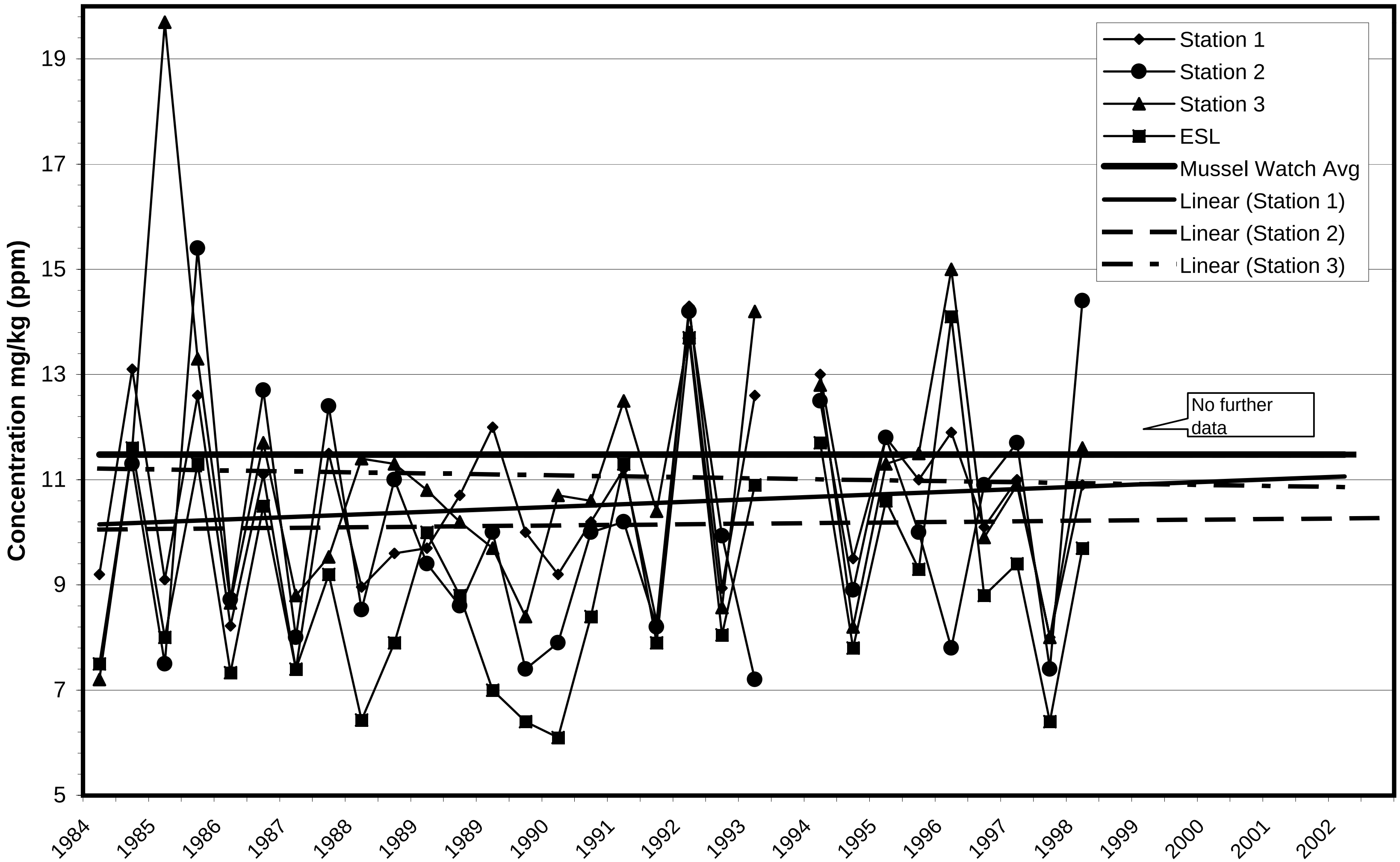
Hawk Inlet Metal Concentrations 1984-2002

Figure 40.S-1, S-2, S-3 Nephthys Zinc (Zn)



Oceanus Alaska, KGCMC Data,Worm Zn

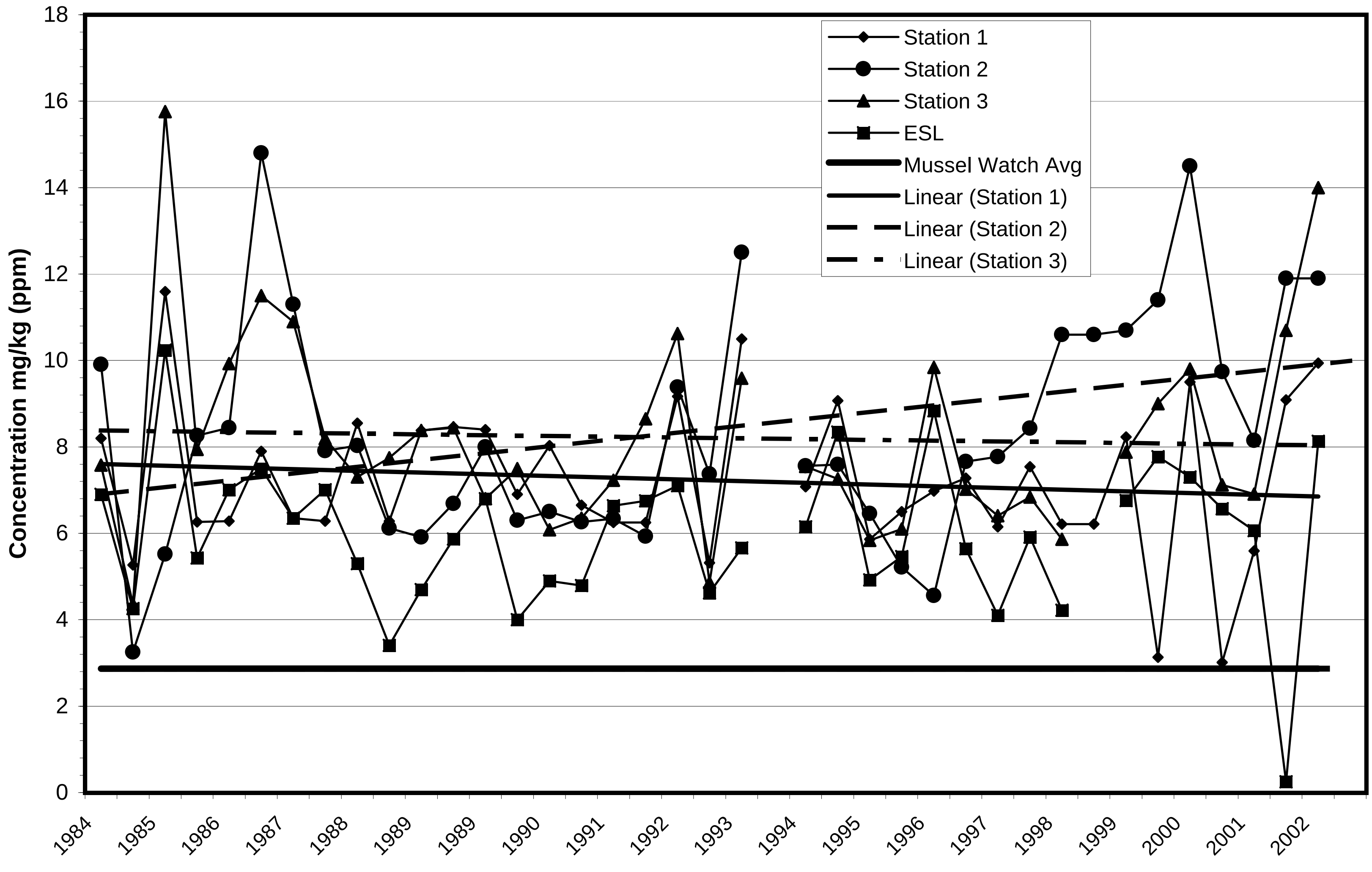
Hawk Inlet Metal Concentrations 1984-2002
Figure 50.S-1, S-2, S-3 Mussel Arsenic (As)



Oceanus Alaska, KGCMC Data,Mussel As

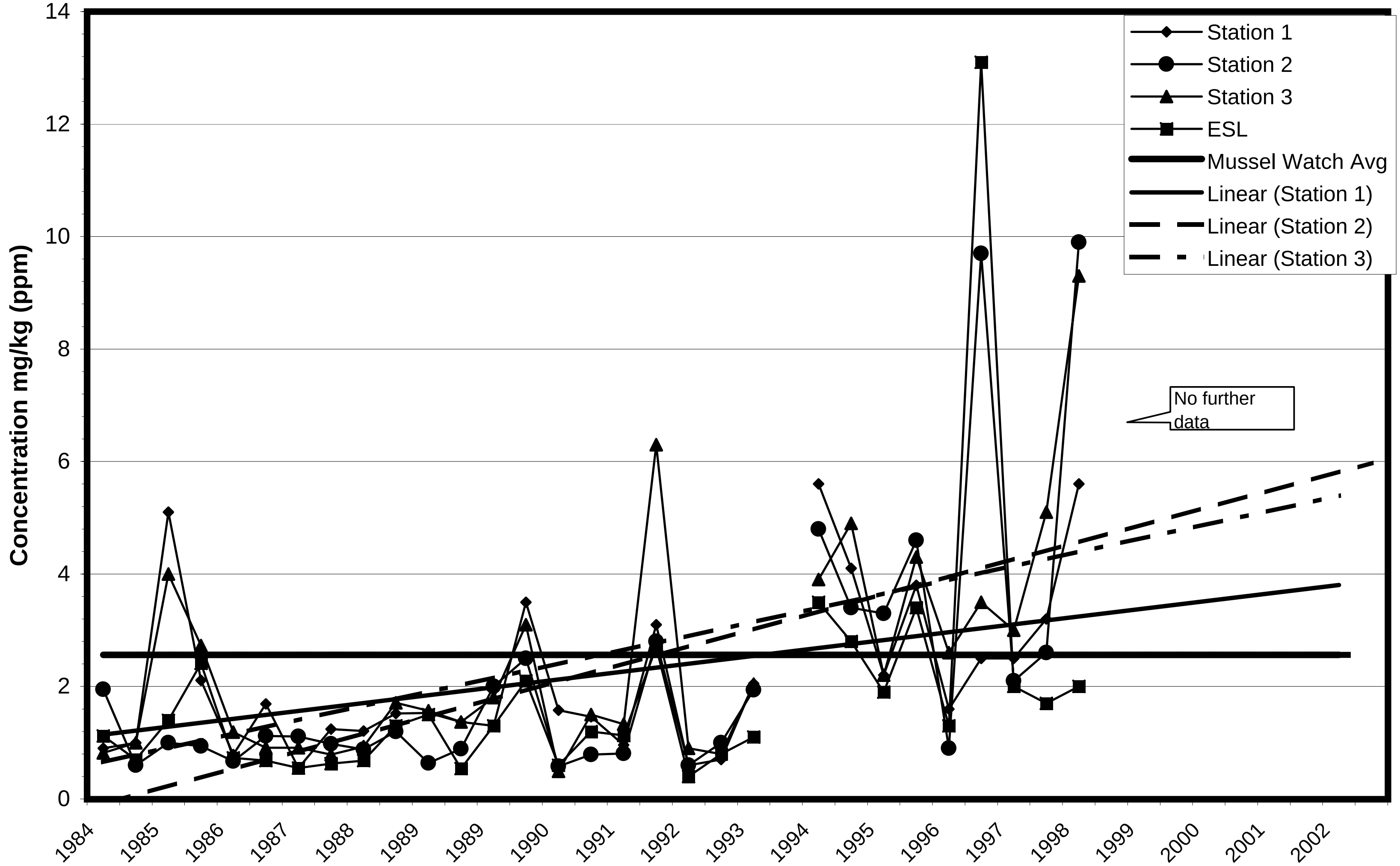
Hawk Inlet Metal Concentrations 1984-2002

Figure 51. S-1, S-2, S-3 Mussel Cadmium (Cd)



Oceanus Alaska, KGCMC Data,Mussel Cd

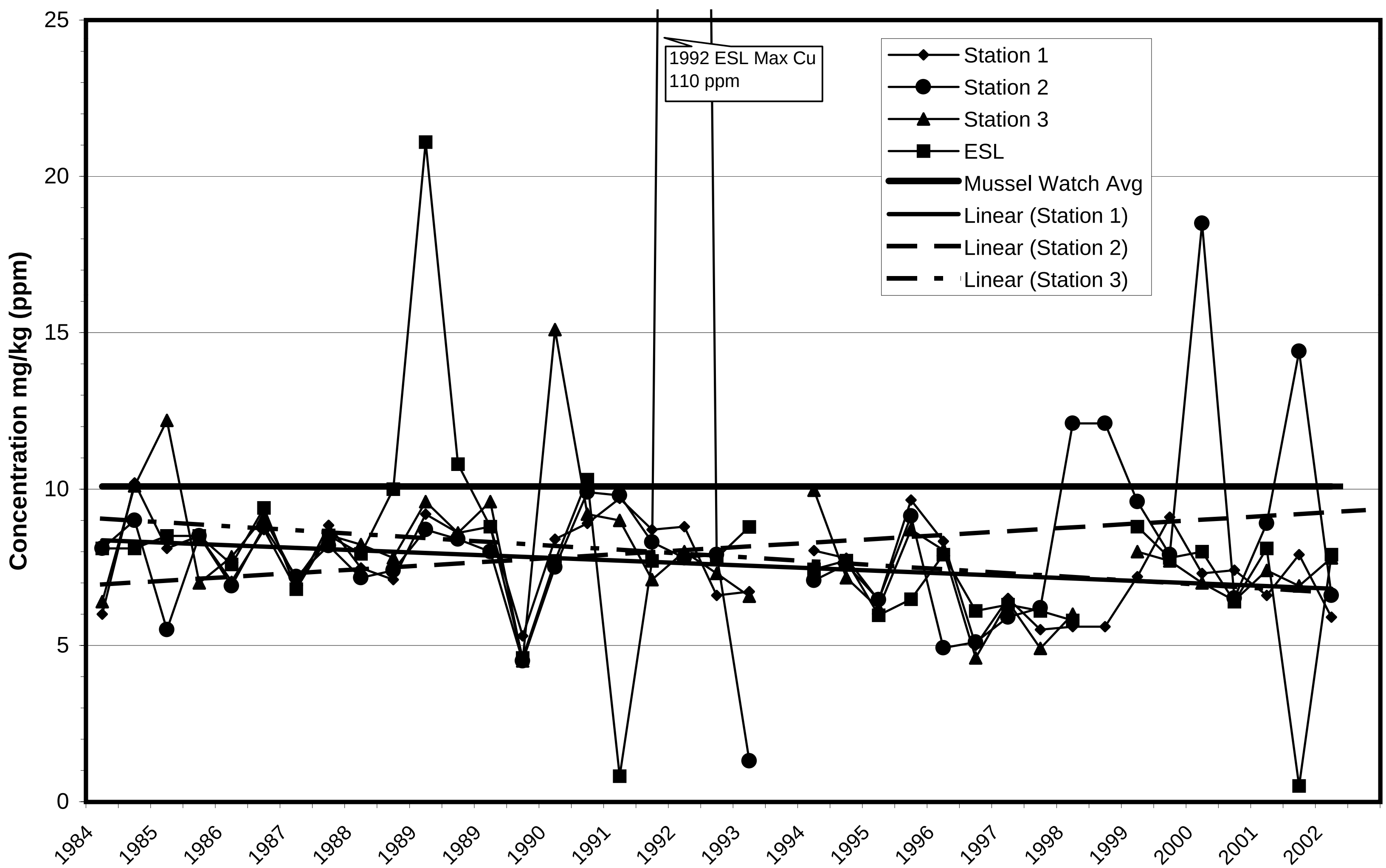
Hawk Inlet Metal Concentrations 1984-2002
Figure 52. S-1, S-2, S-3 Mussel Chromium (Cr)



Oceanus Alaska, KGCMC Data,Mussel Cr

Hawk Inlet Metal Concentrations 1984-2002

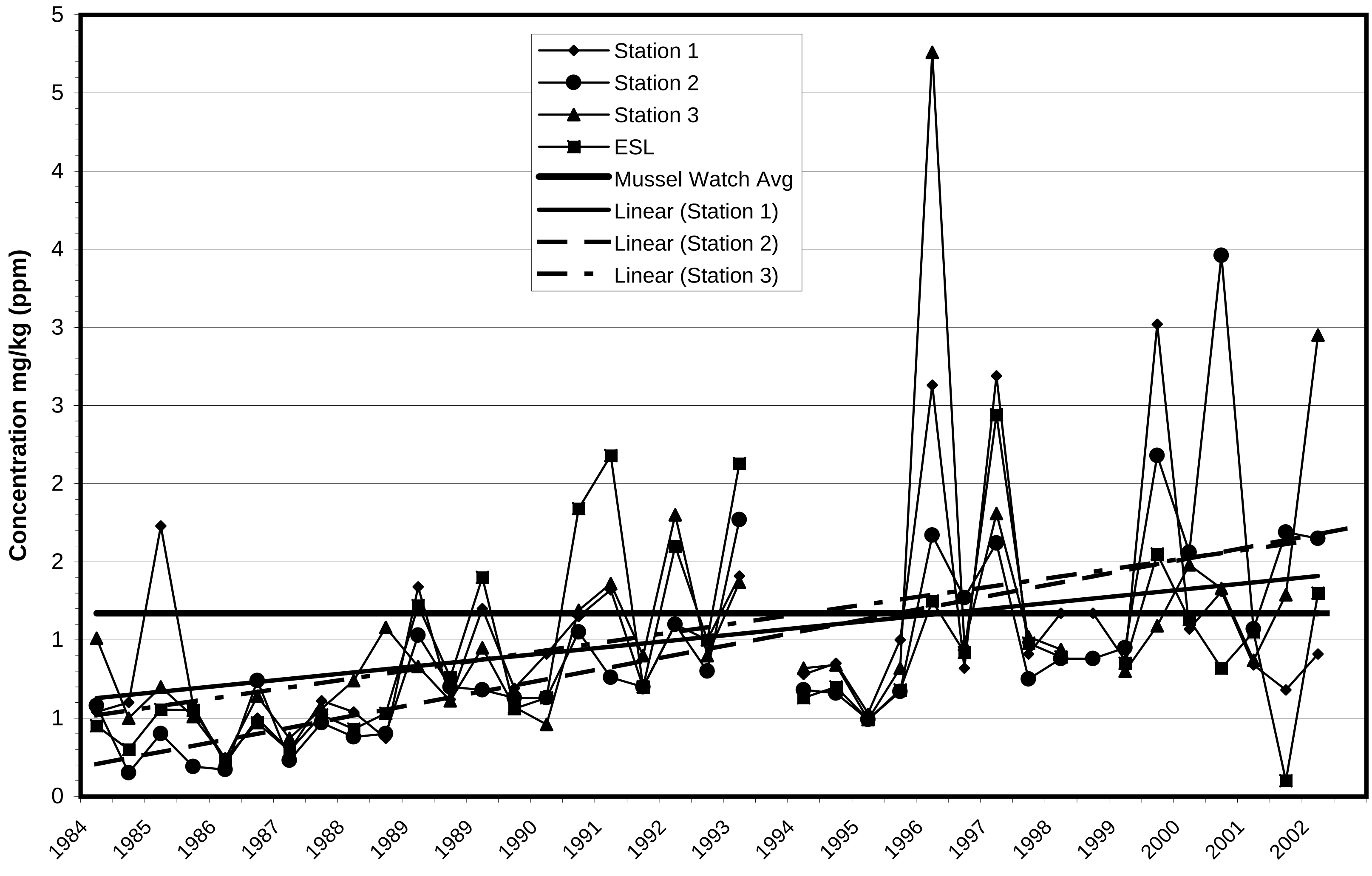
Figure 53.S-1, S-2, S-3 Mussel Copper (Cu)



Oceanus Alaska, KGCMC Data,Mussel Cu

Hawk Inlet Metal Concentrations 1984-2002

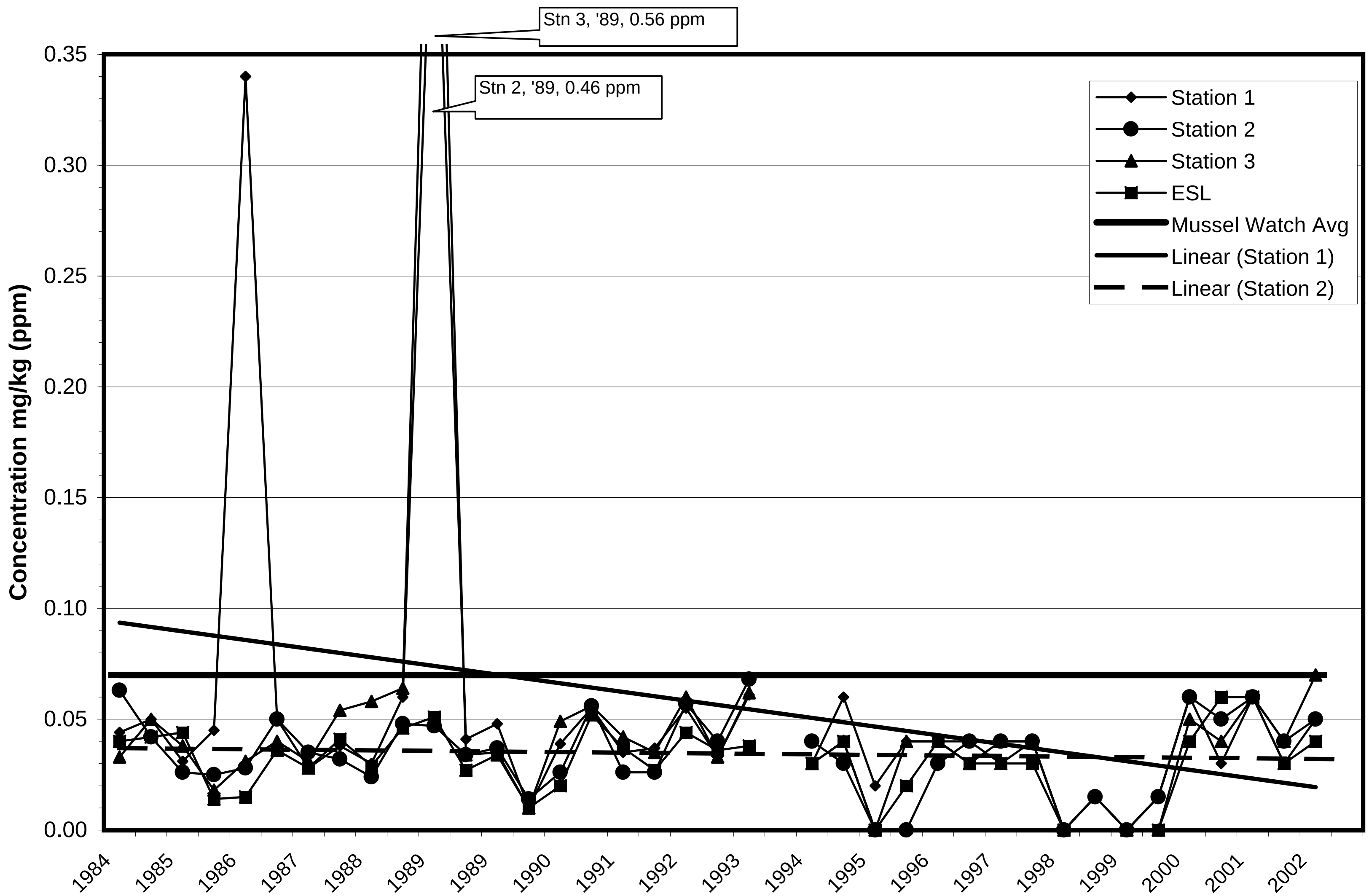
Figure 54. S-1, S-2, S-3 Mussel Lead (Pb)



Oceanus Alaska, KGCMC Data,Mussel Pb

Hawk Inlet Metal Concentrations 1984-2002

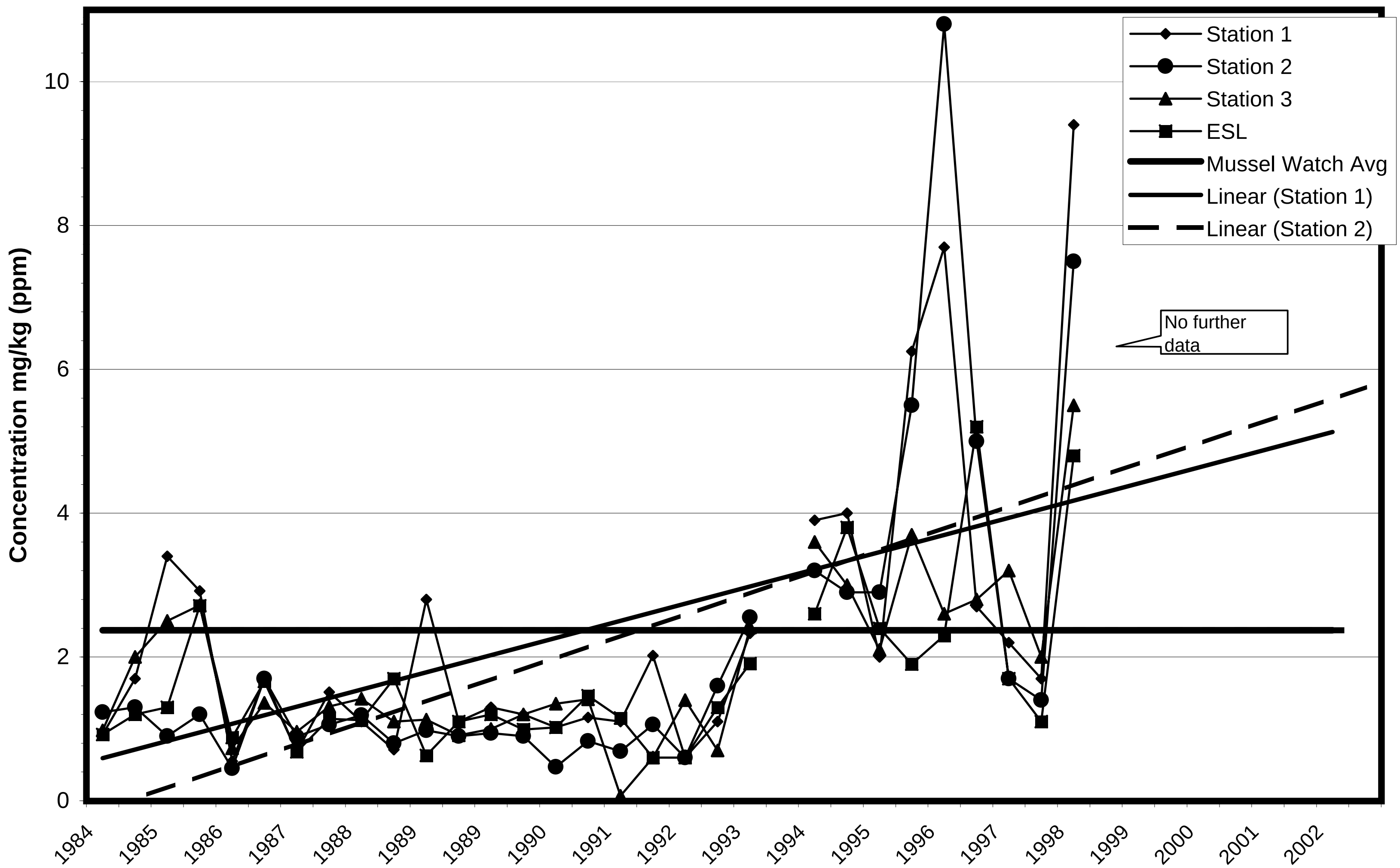
Figure 55.S-1, S-2, S-3 Mussel Mercury (Hg)



Oceanus Alaska, KGCMC Data,Mussel Hg

Hawk Inlet Metal Concentrations 1984-2002

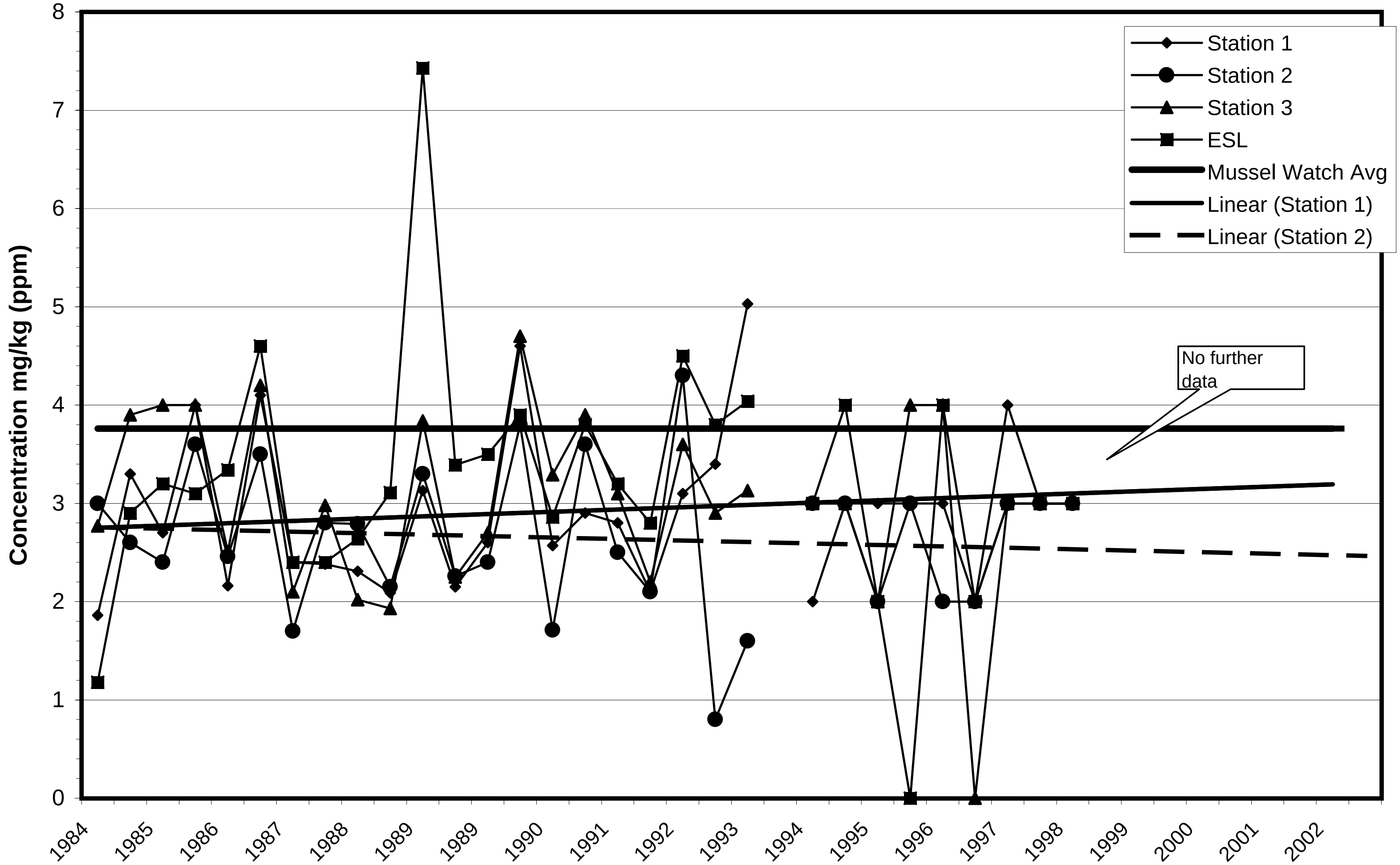
Figure 56.S-1, S-2, S-3 Mussel Nickel (Ni)



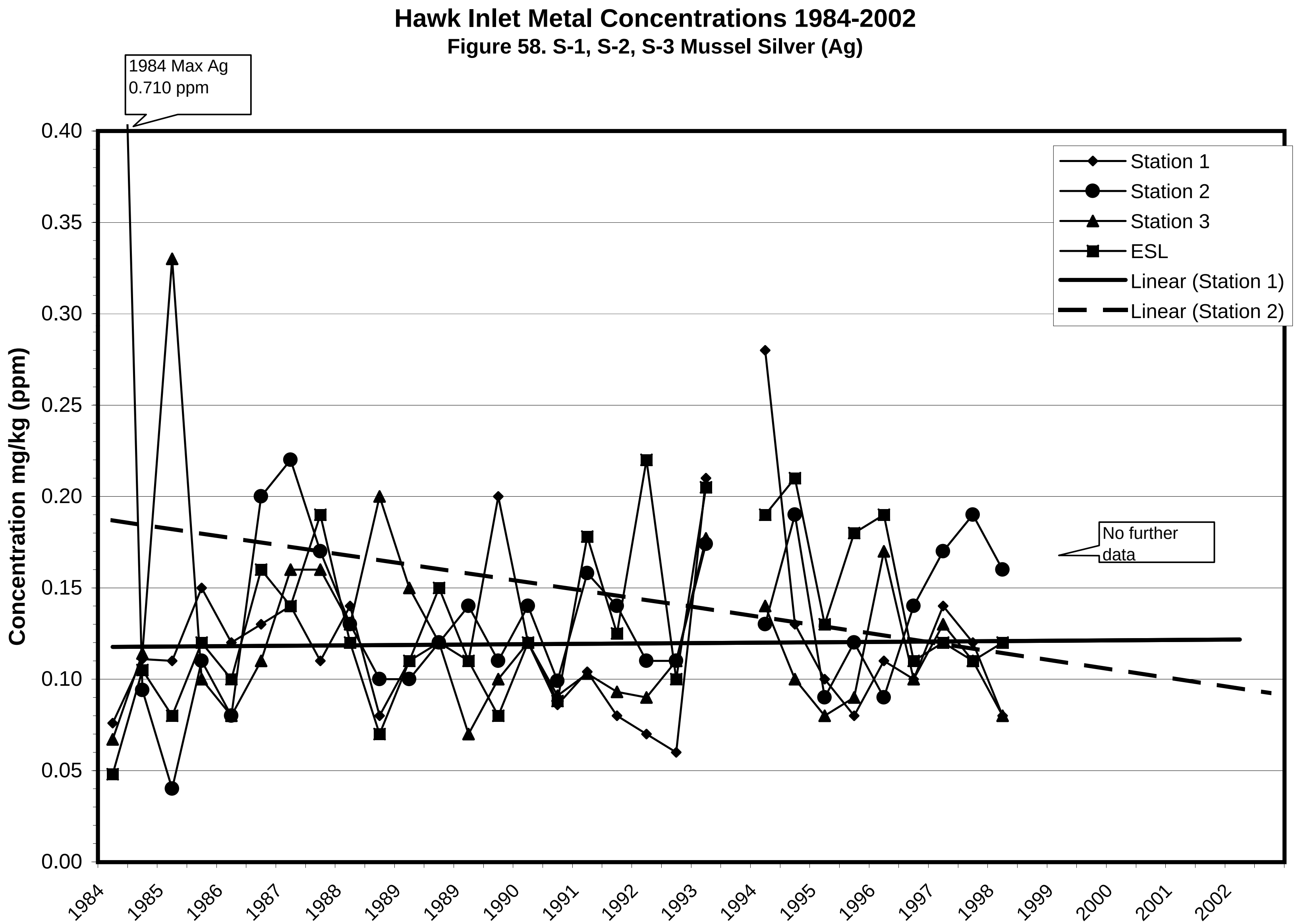
Oceanus Alaska, KGCMC Data,Mussel Ni

Hawk Inlet Metal Concentrations 1984-2002

Figure 57. S-1, S-2, S-3 Mussel Selenium (Se)



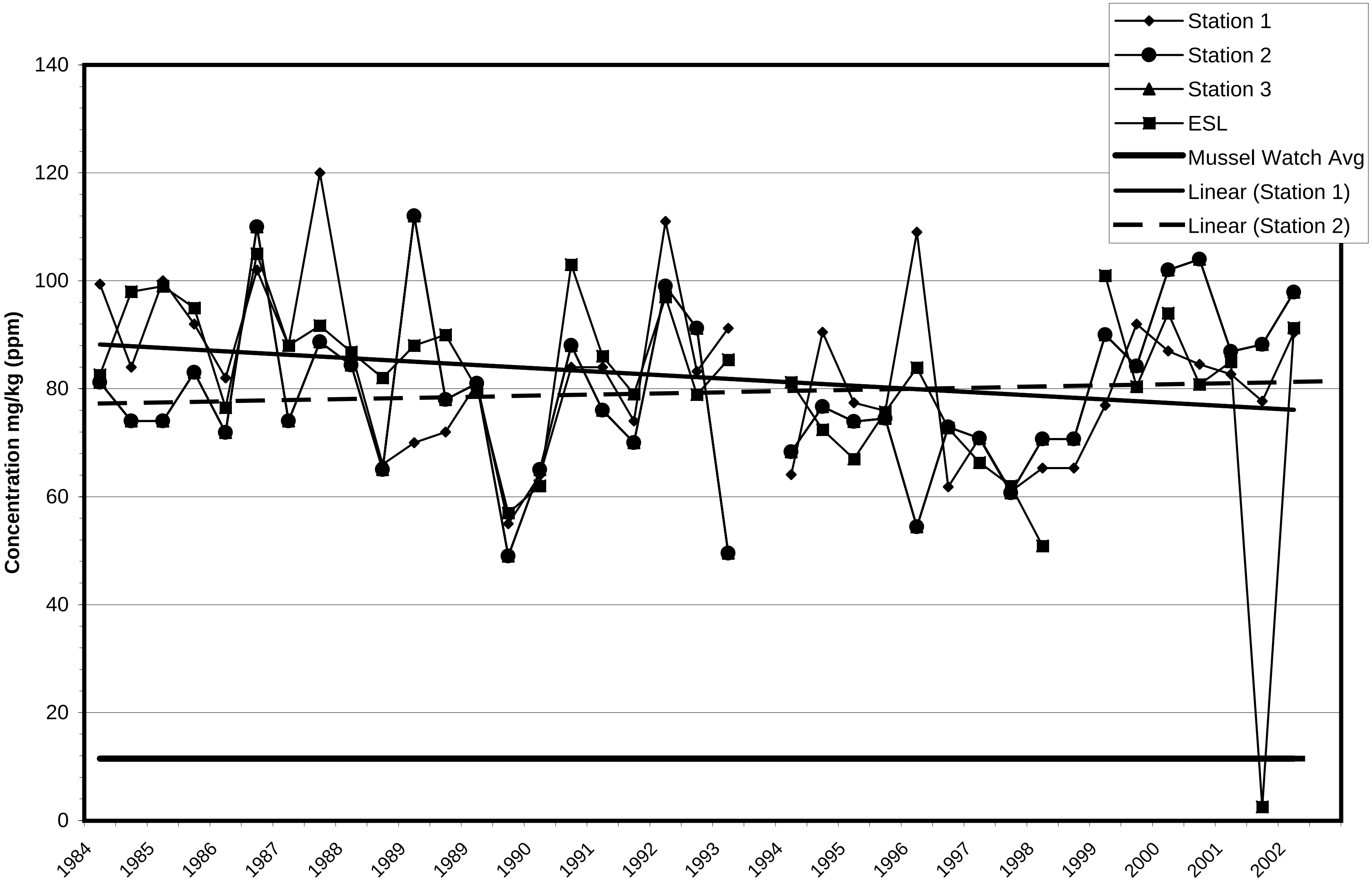
Oceanus Alaska, KGCMC Data,Mussel Se



Oceanus Alaska, KGCMC Data,Mussel Ag

Hawk Inlet Metal Concentrations 1984-2002

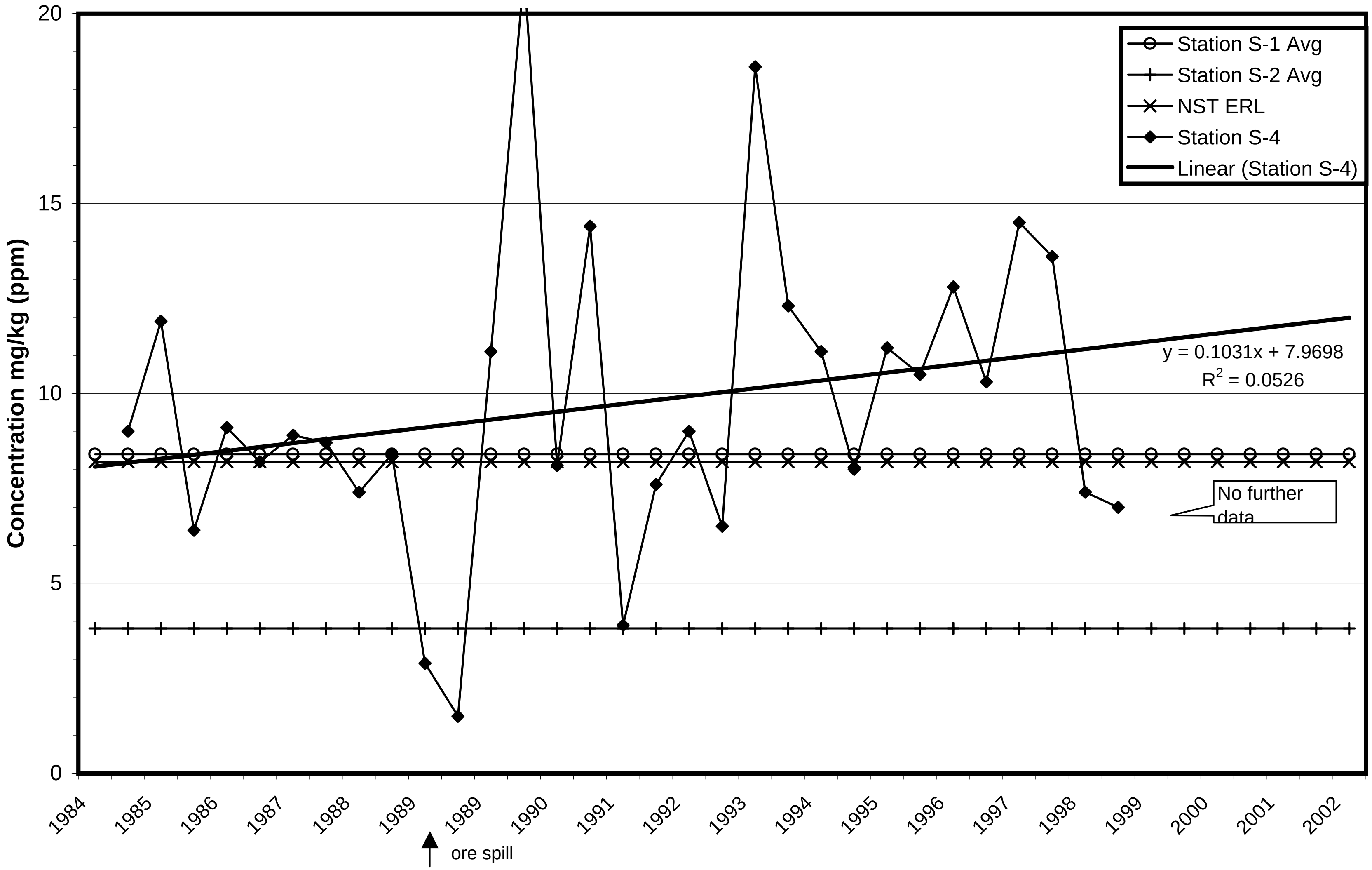
Figure 59. S-1, S-2, S-3 Mussel Zinc (Zn)



Oceanus Alaska, KGCMC Data,Mussel Zn

Hawk Inlet Metal Concentrations 1984-2002

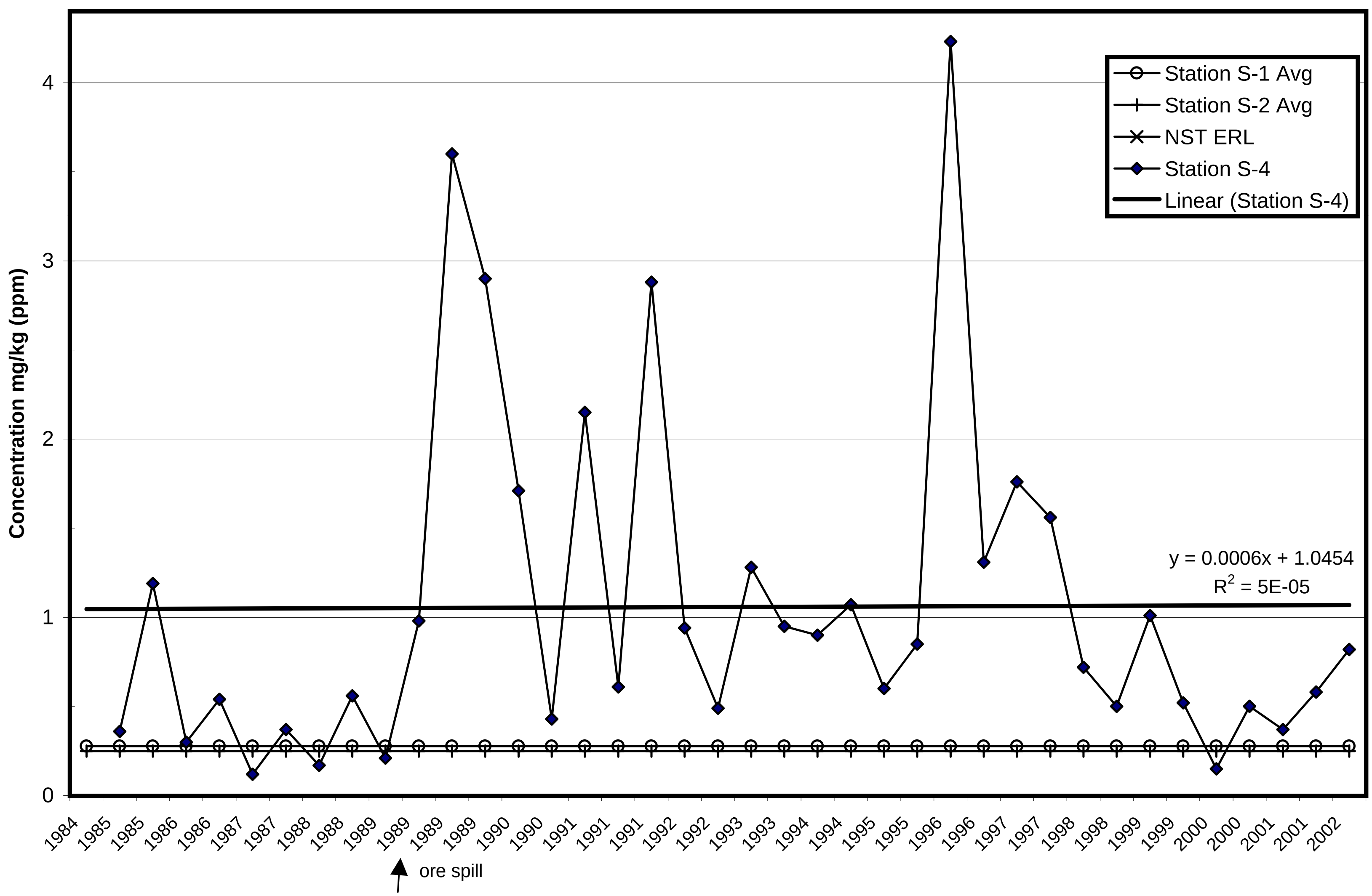
Figure 11. Station S-4 Sediment Arsenic (As)



Oceanus Alaska, KGCMC Data,S-4Sed As

Hawk Inlet Metal Concentrations 1984-2002

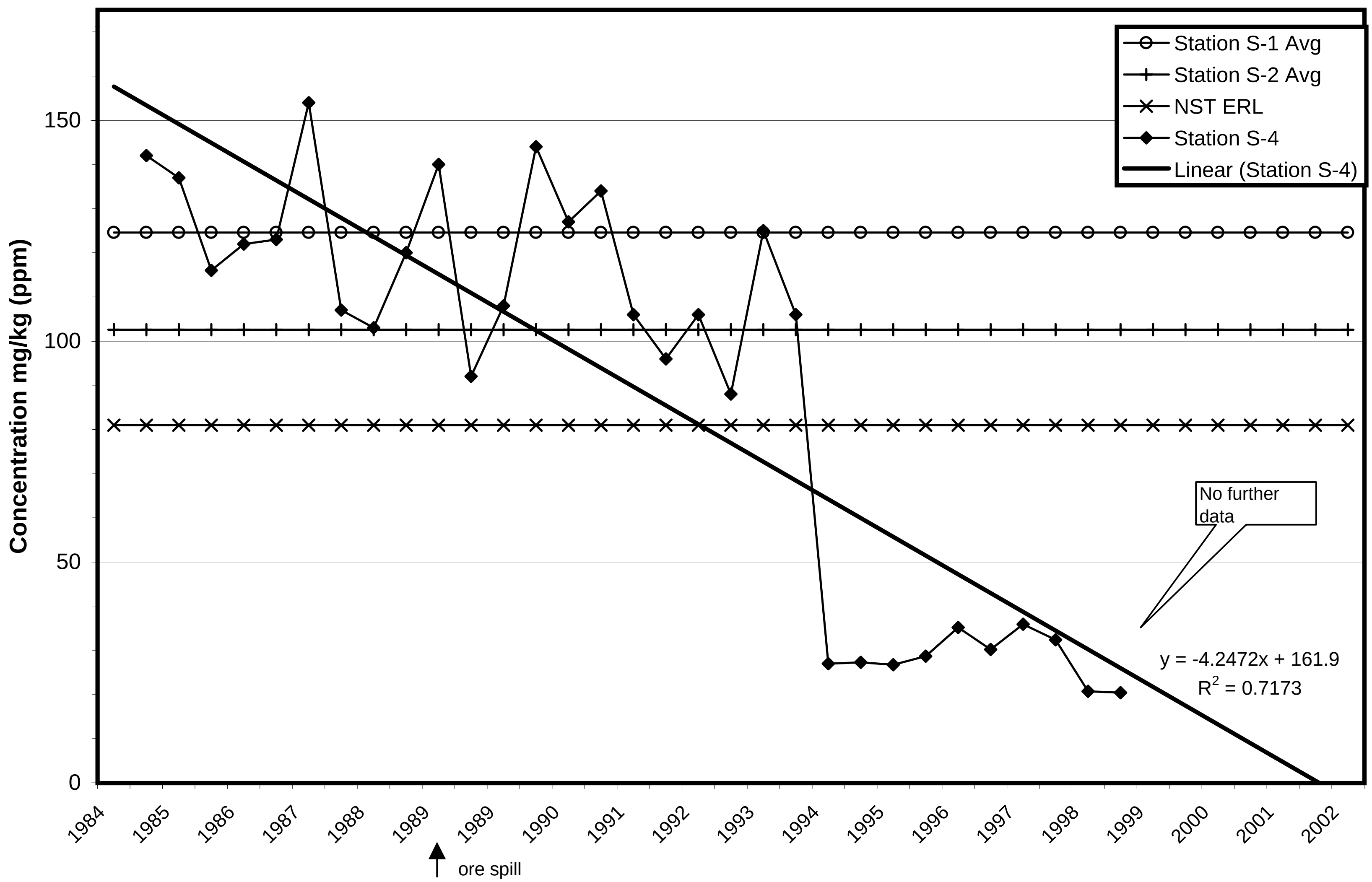
Figure 12. Station S-4 Sediment Cadimium (Cd)



Oceanus Alaska, KGCMC Data,S-4Sed Cd

Hawk Inlet Metal Concentrations 1984-2002

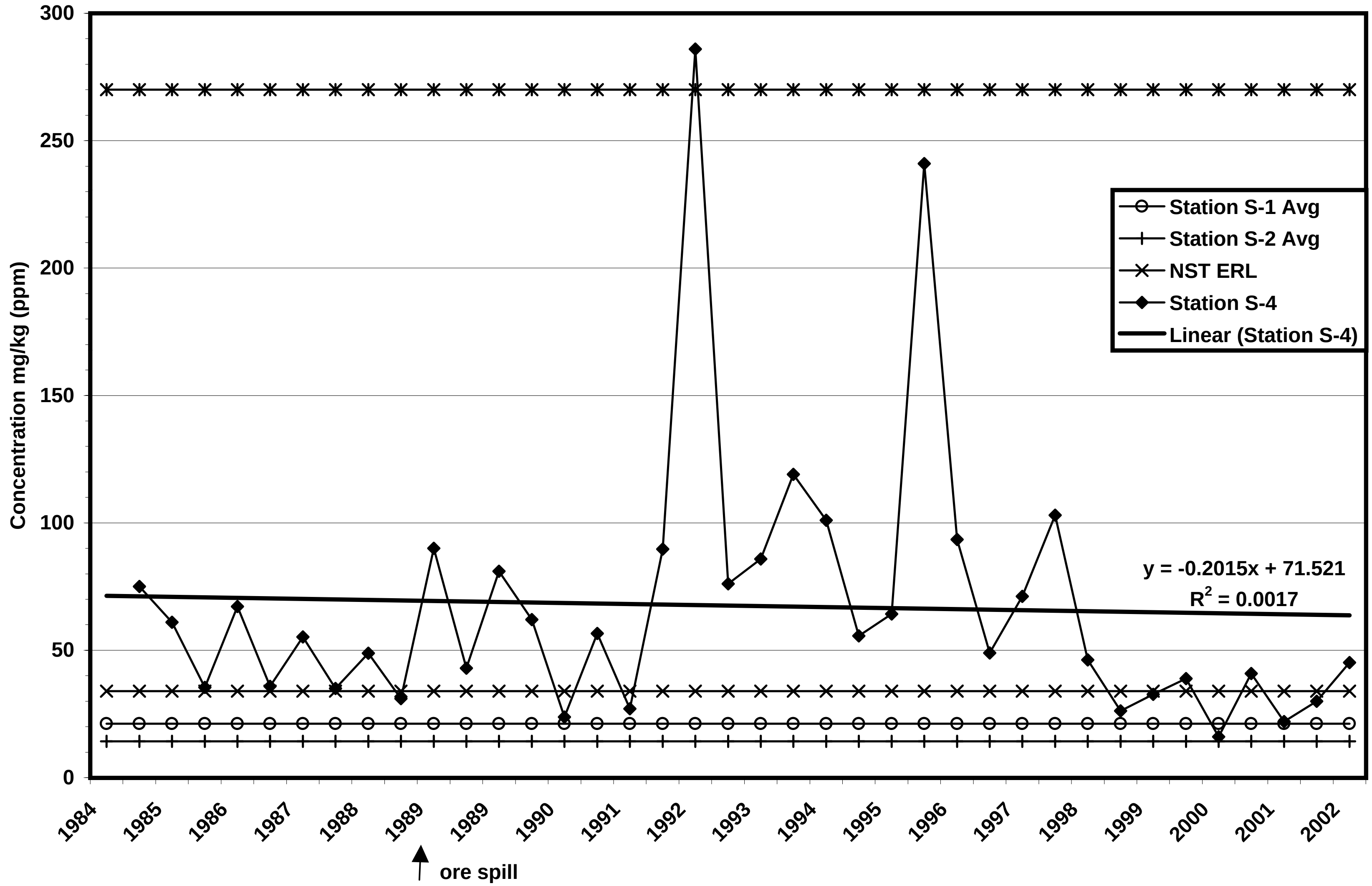
Figure 13. Station S-4 Sediment Chromium (Cr)



Oceanus Alaska, KGCMC Data,S4Sed Cr

Hawk Inlet Metal Concentrations 1984-2002

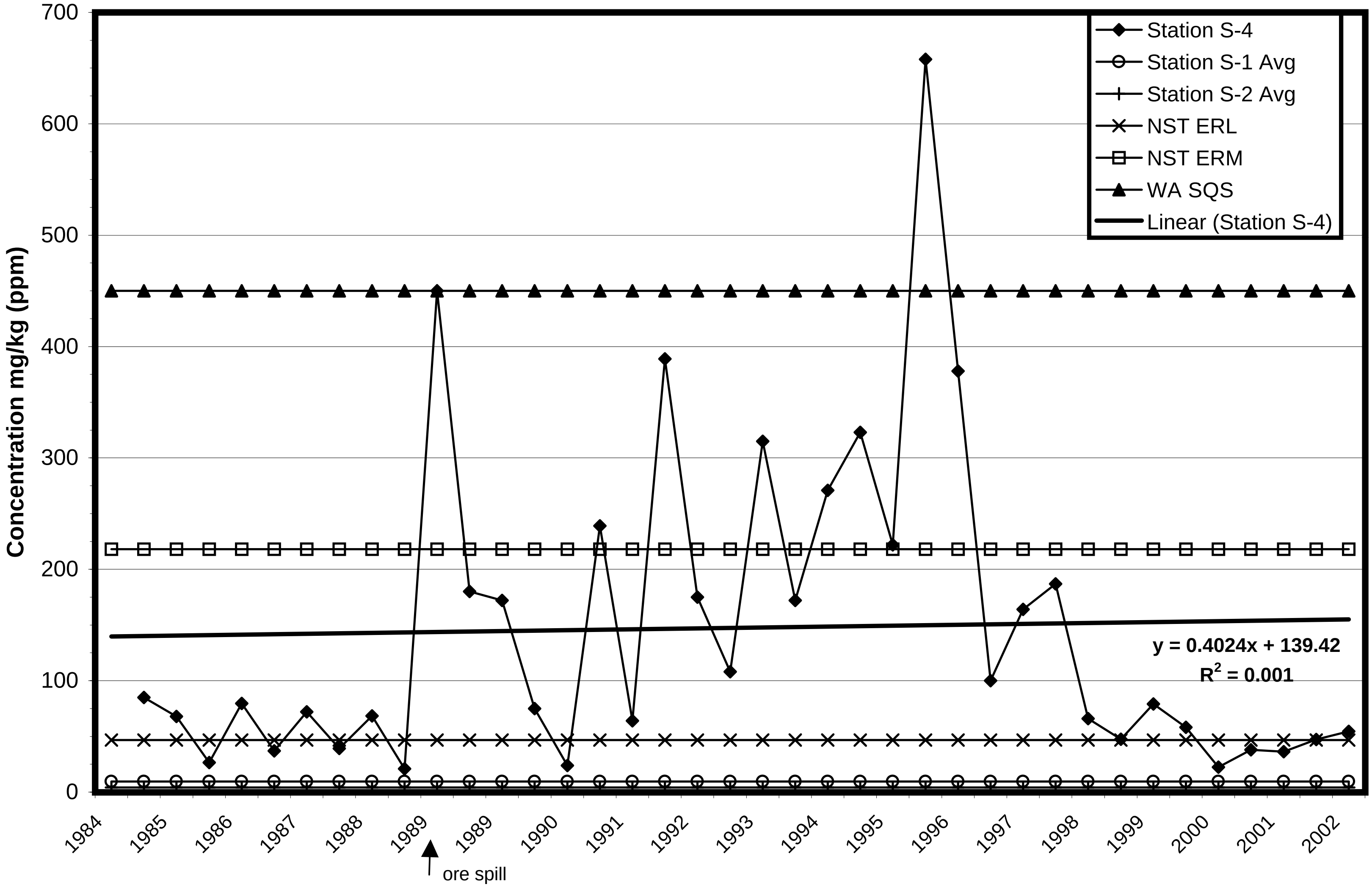
Figure 14. Station S-4 Sediment Copper (Cu)



Oceanus Alaska, KGCMC Data,S4Sed Cu

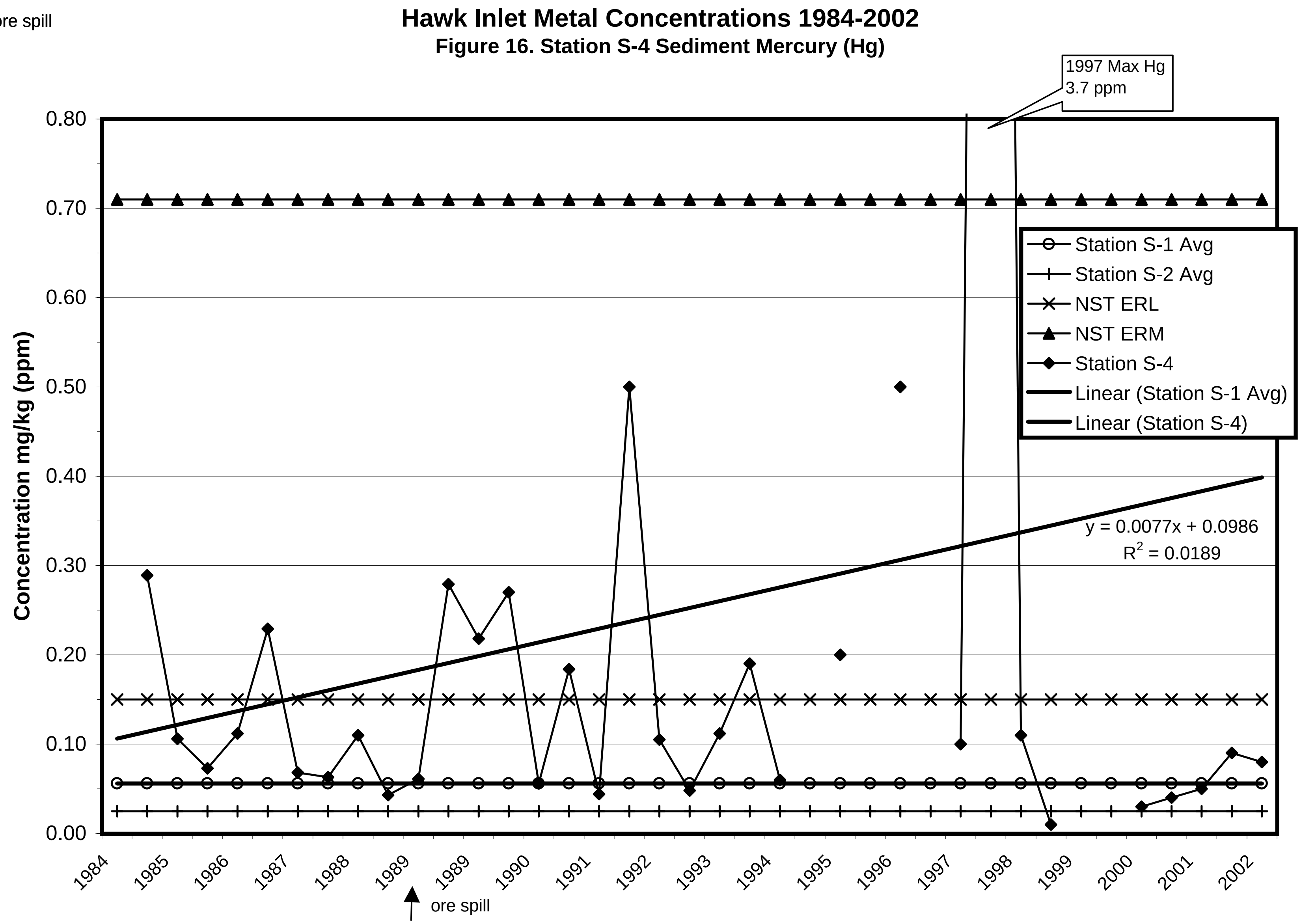
Hawk Inlet Metal Concentrations 1984-2002

Figure 15. Station S-4 Sediment Lead (Pb)

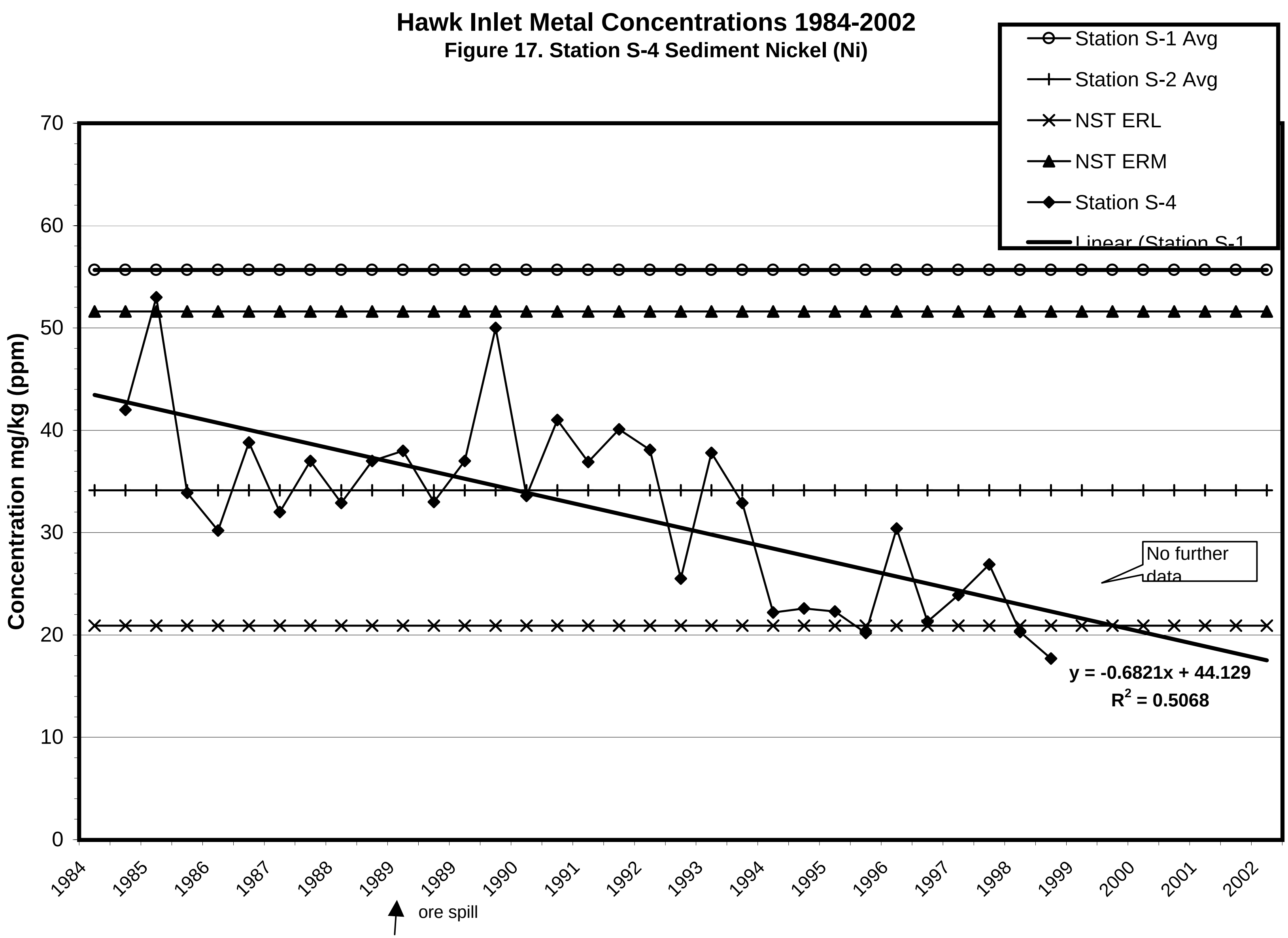


Oceanus Alaska, KGCMC Data,S4 Sed Pb

ore spill

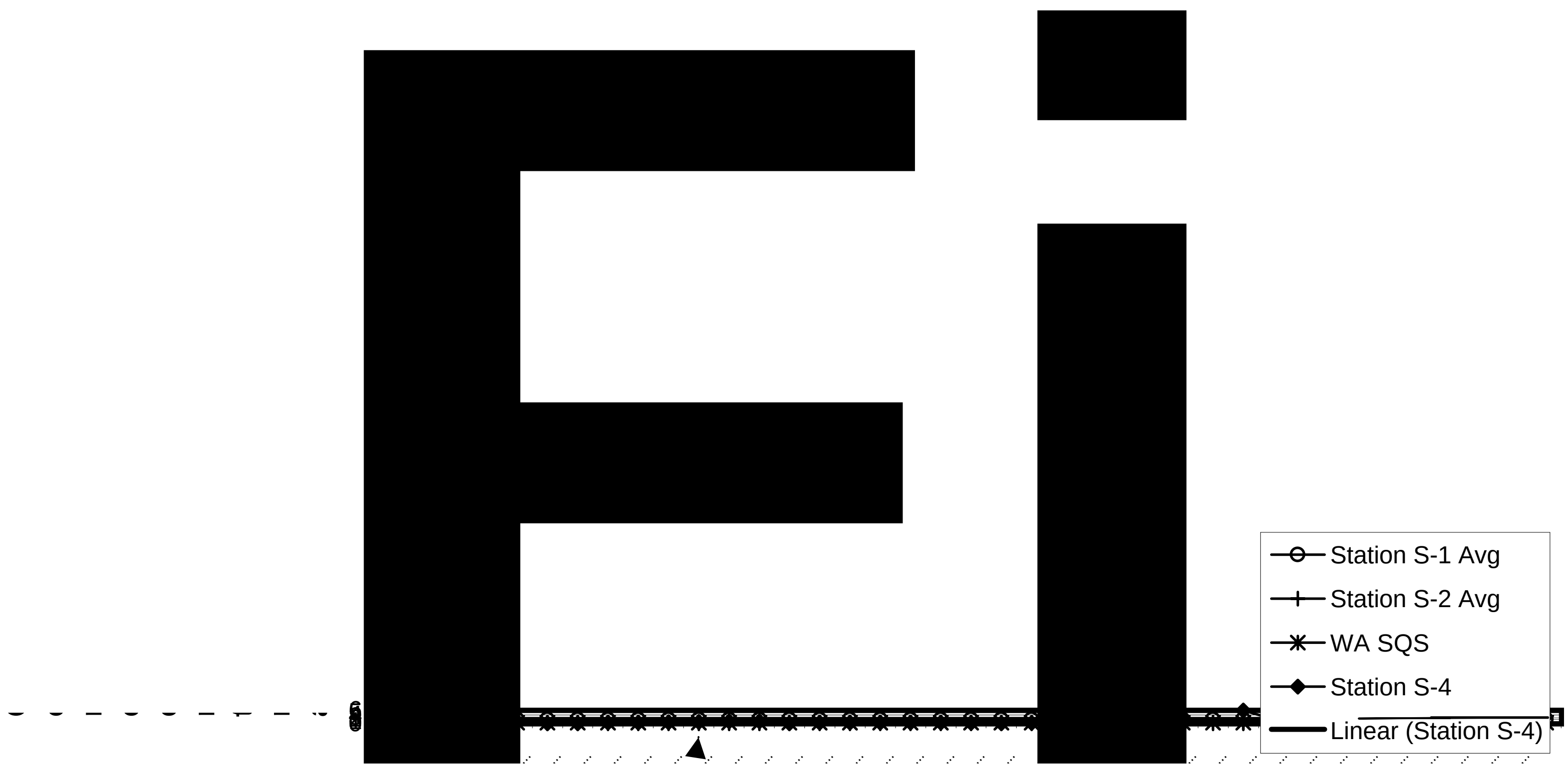


Oceanus Alaska, KGCMC Data,S-4Sed Hg



Oceanus Alaska, KGCMC Data,S-4Sed Ni

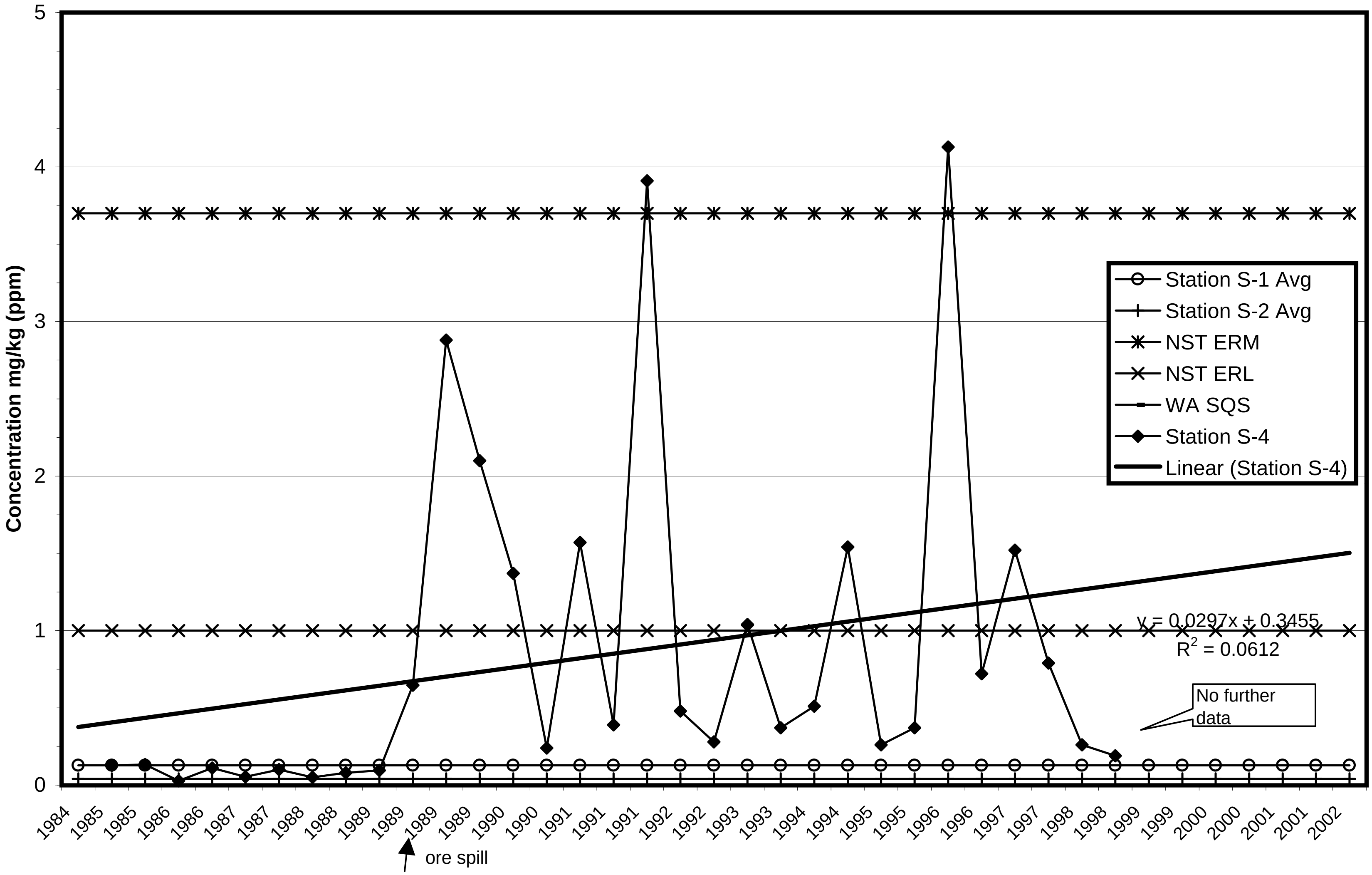
Hawk Inlet Metal Concentrations 1984-2002



Oceanus Alaska, KGCMC Data,S4Sed Se

Hawk Inlet Metal Concentrations 1984-2002

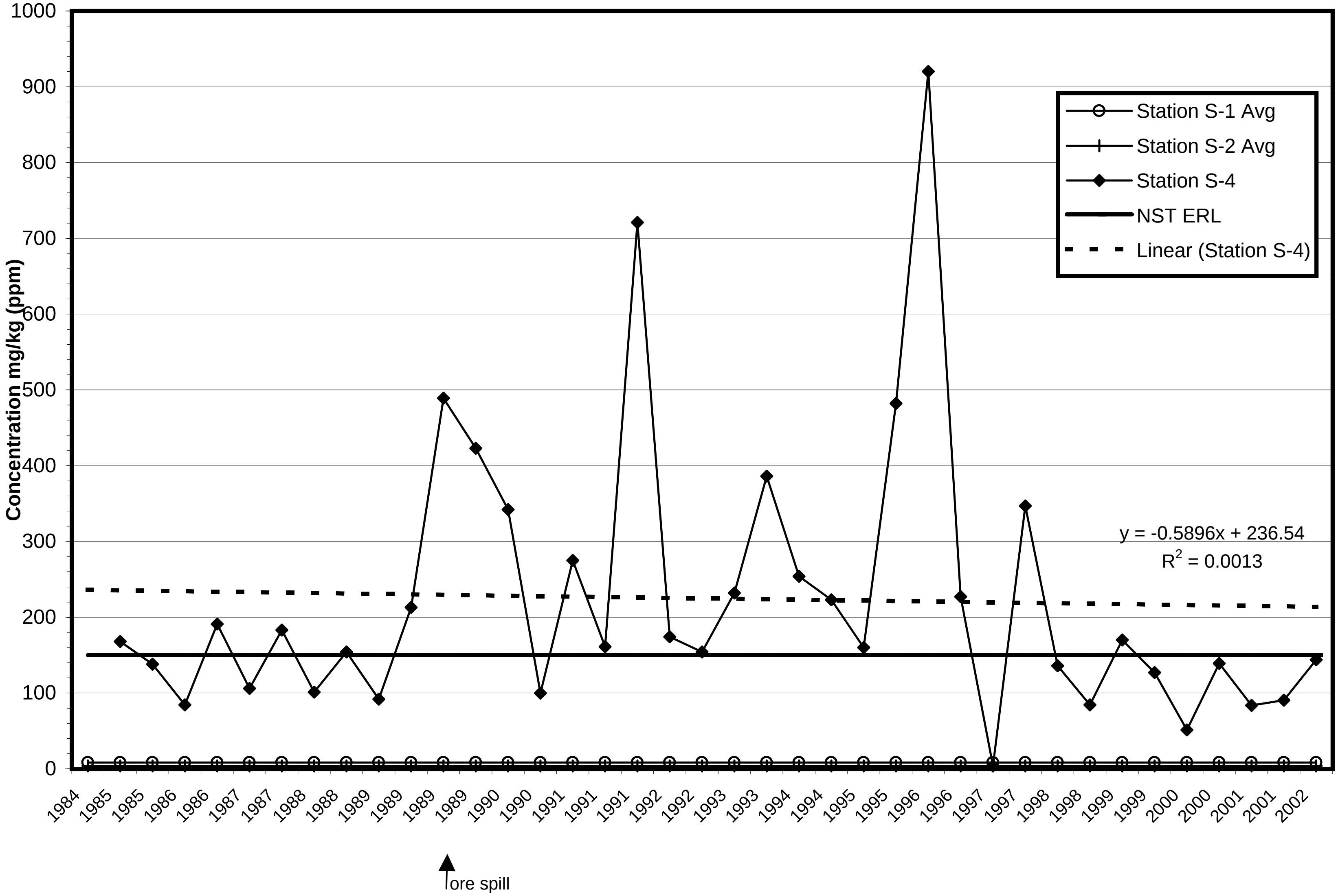
Figure 19. Stations S-4 Sediment Silver (Ag)



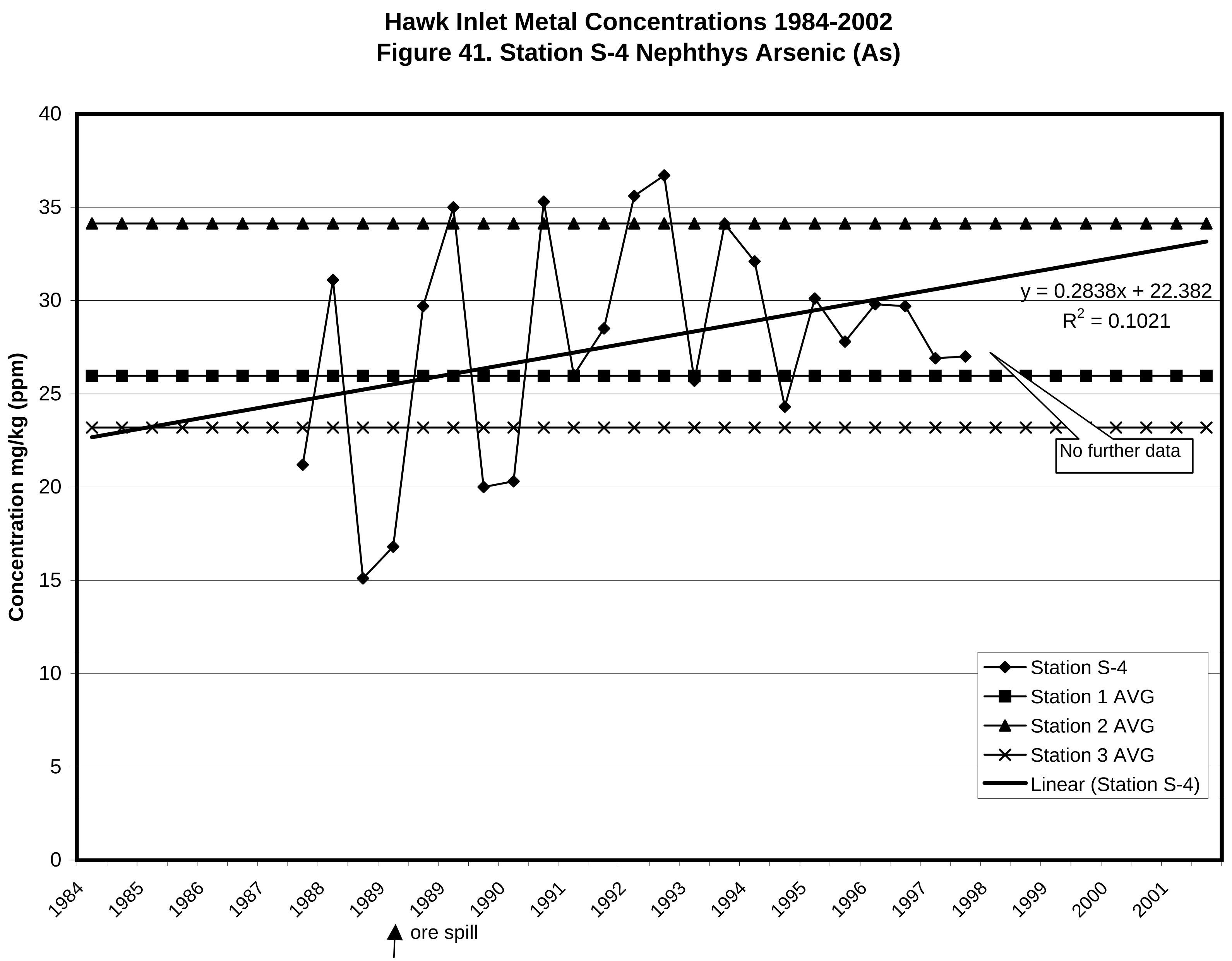
Oceanus Alaska, KGCMC Data,S4 Sed Ag

Hawk Inlet Metal Concentrations 1984-2002

Figure 20. Station S-4 Sediment Zinc (Zn)

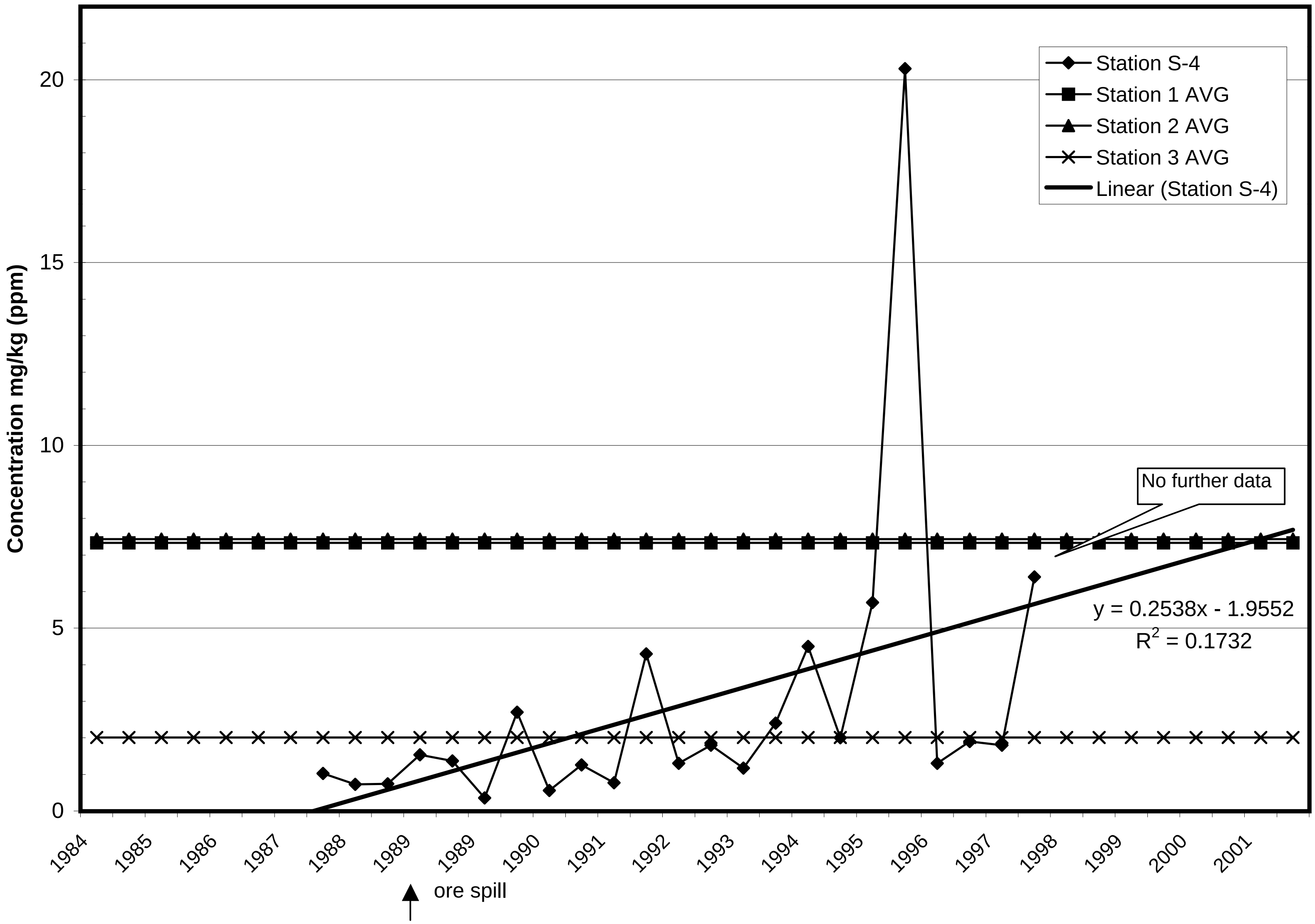


Oceanus Alaska, KGCMC Data,S4Sed Zn



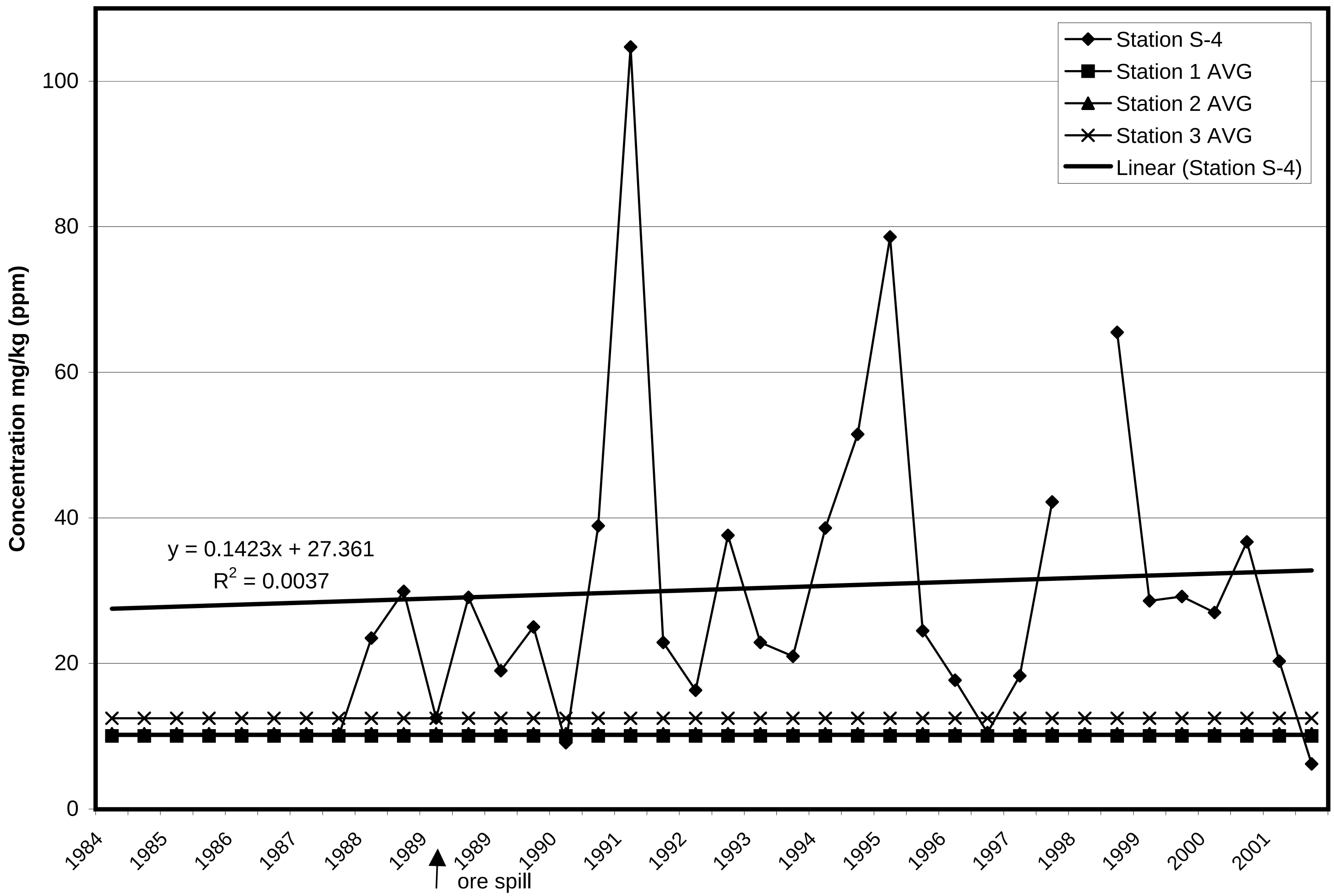
Oceanus Alaska, KGCMC Data,S4Worm As

Hawk Inlet Metal Concentrations 1984-2002
Figure 42. Station S-4 Nephthys Chromium (Cr)

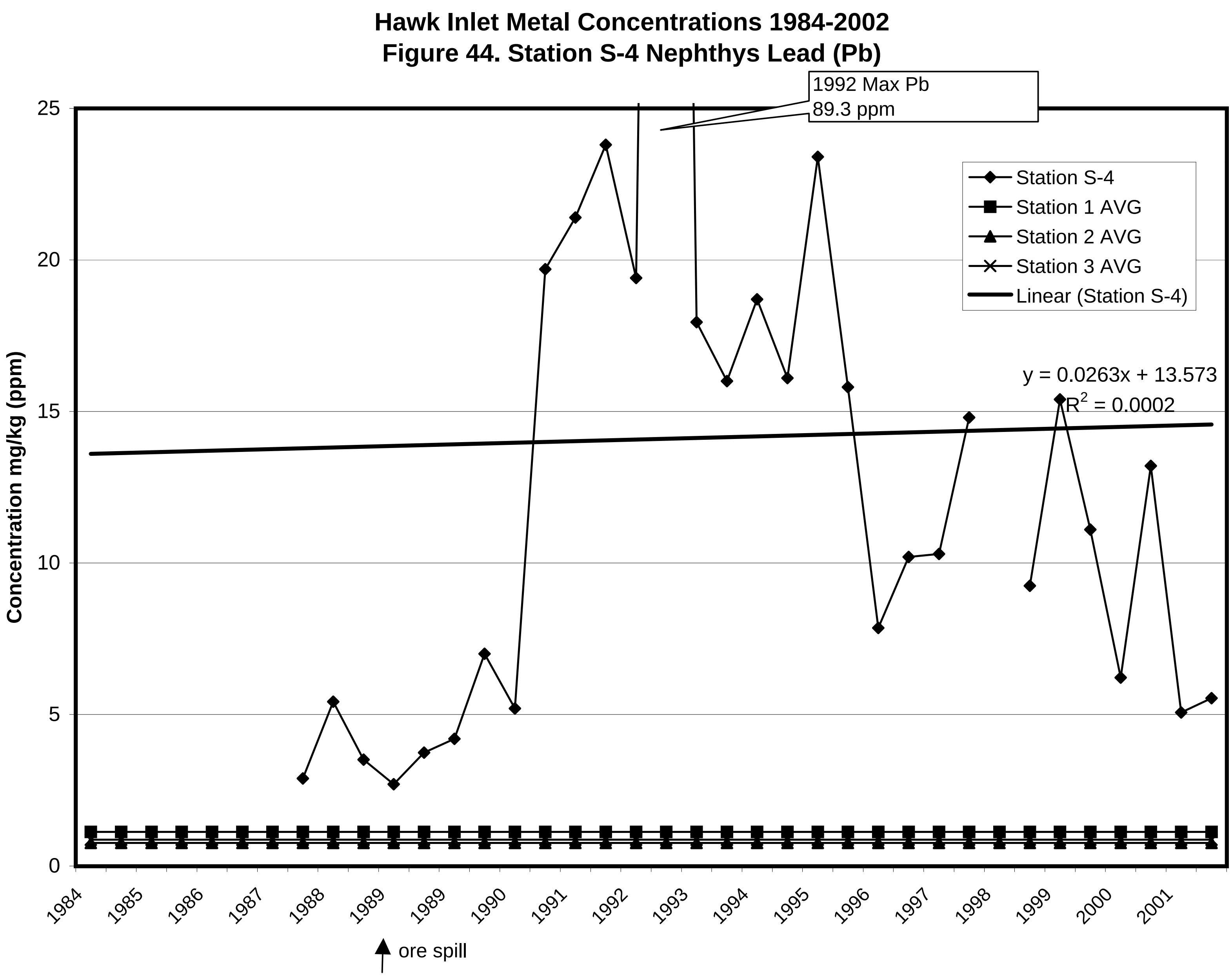


Oceanus Alaska, KGCMC Data,S4Worm Cr

Hawk Inlet Metal Concentrations 1984-2002
Figure 43. Station S-4 Nephthys Copper (Cu)

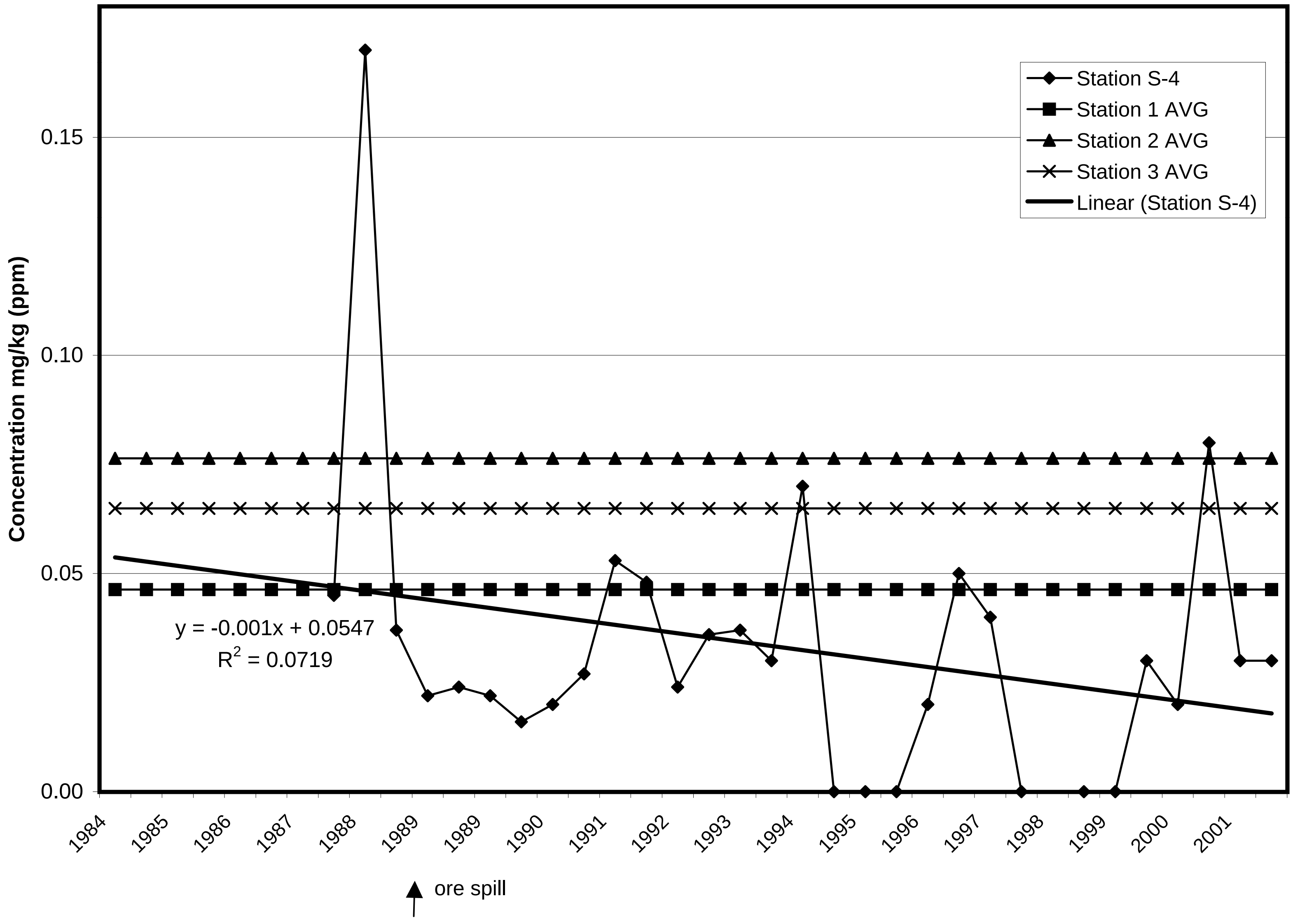


Oceanus Alaska, KGCMC Data,S4Worm Cu



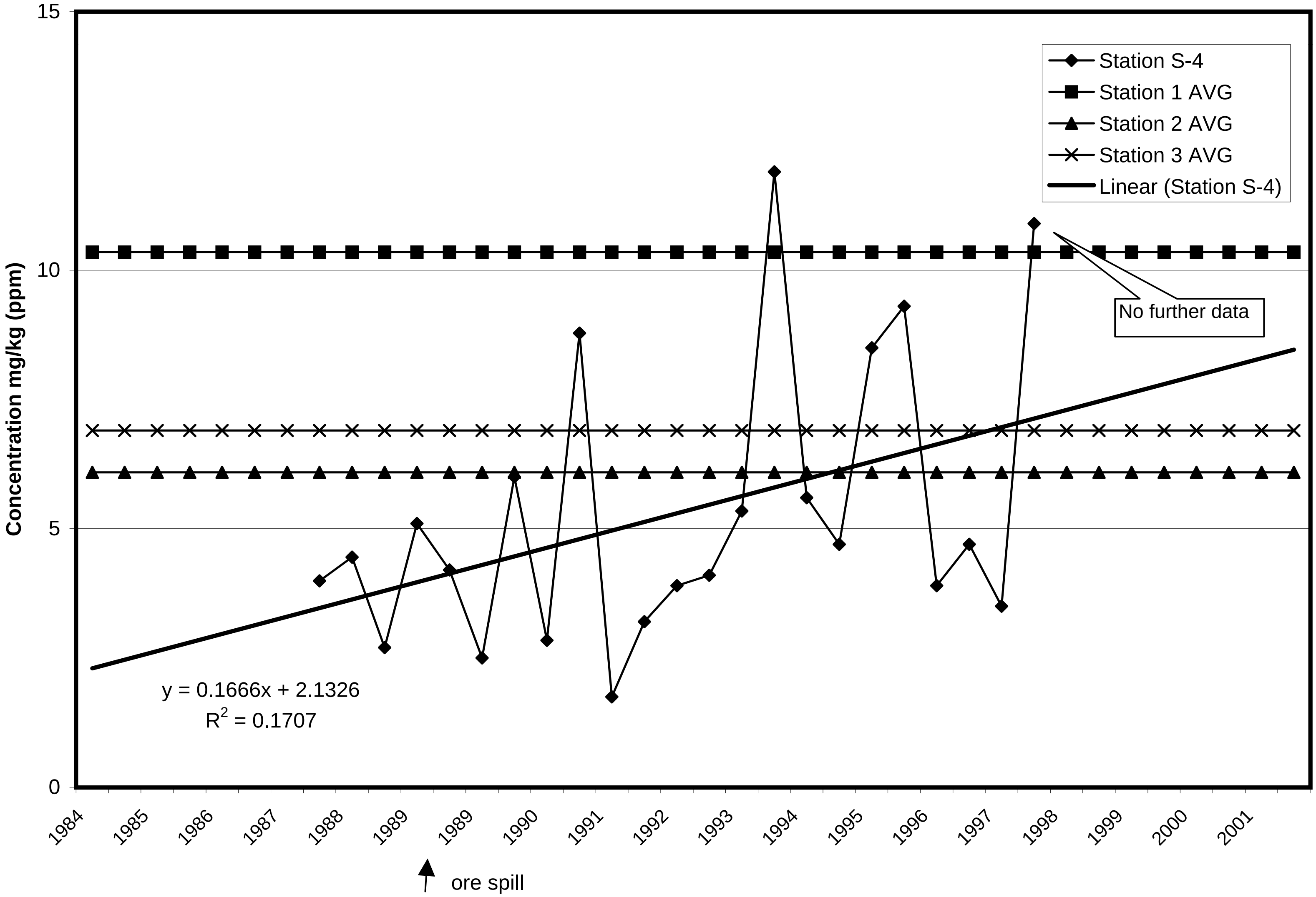
Oceanus Alaska, KGCMC Data,S4Worm Pb

Hawk Inlet Metal Concentrations 1984-2002
Figure 45. Station S-4 Nephthys Mercury (Hg)



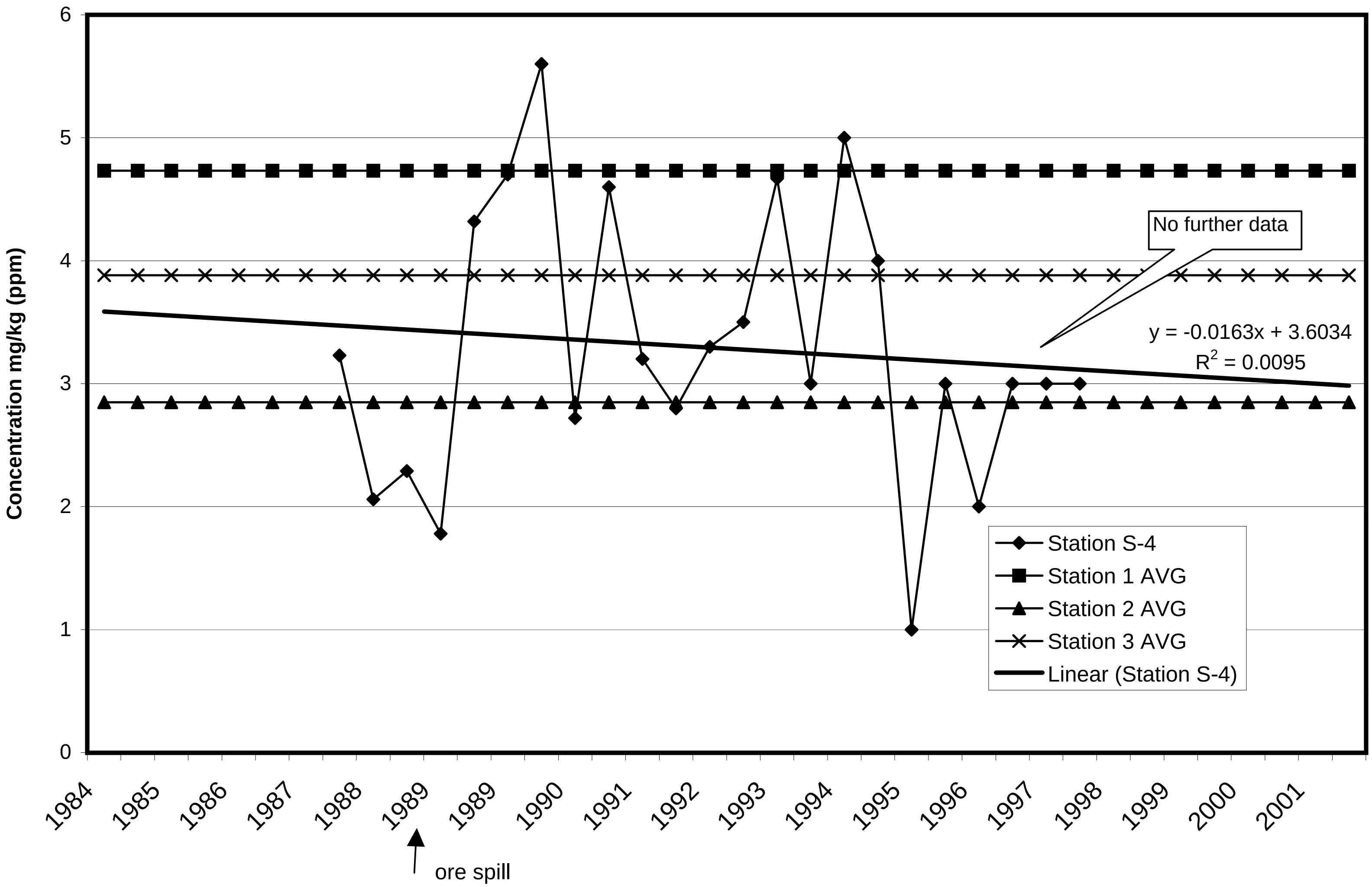
Oceanus Alaska, KGCMC Data,S4Worm Hg

Hawk Inlet Metal Concentrations 1984-2002
Figure 46. Station S-4 Nephthys Nickel (Ni)



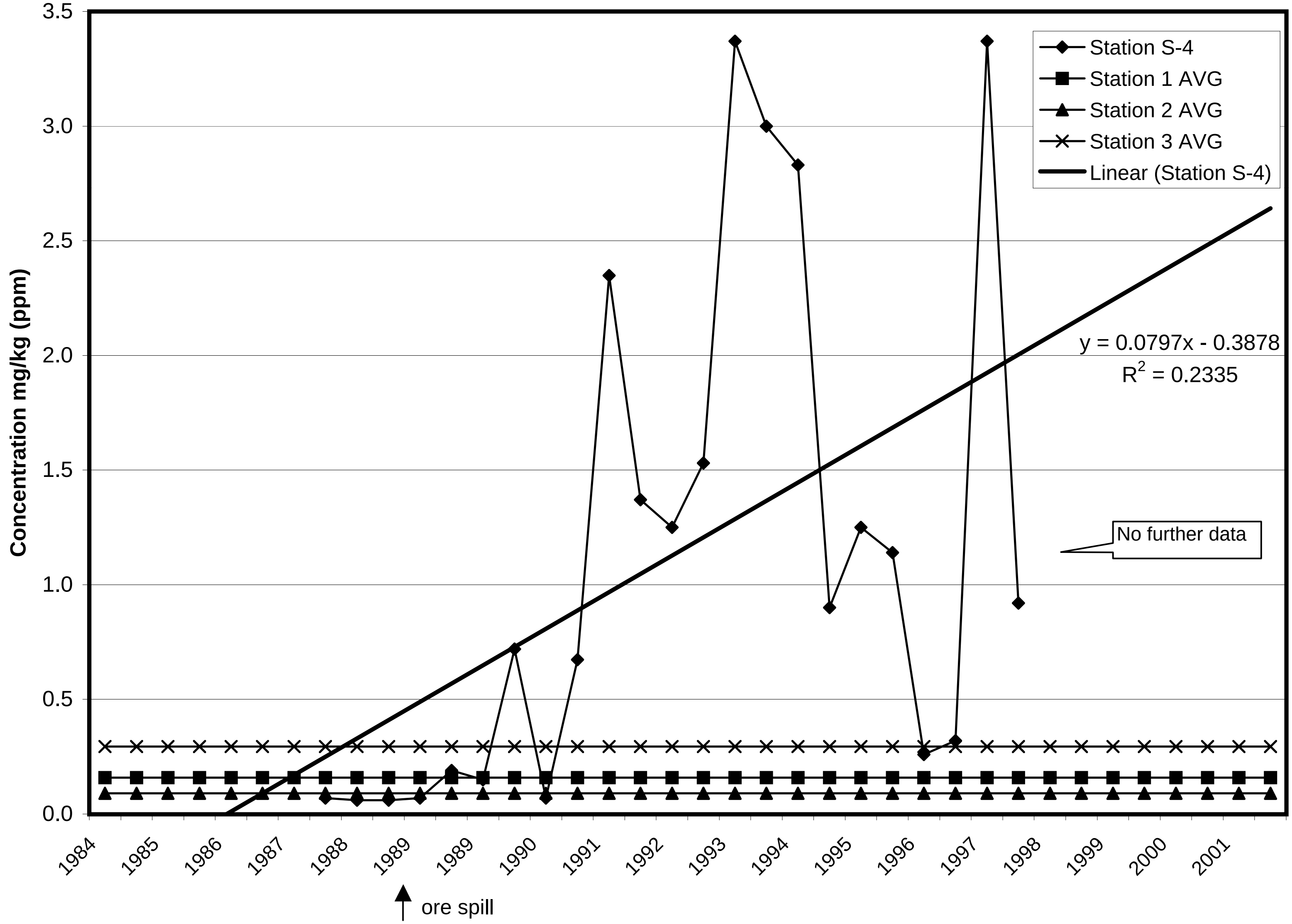
Oceanus Alaska, KGCMC Data,S4Worm Ni

Hawk Inlet Metal Concentrations 1984-2002
Figure 47. Station S-4 Nephthys Selenium (Se)



Oceanus Alaska, KGCMC Data,S4Worm Se

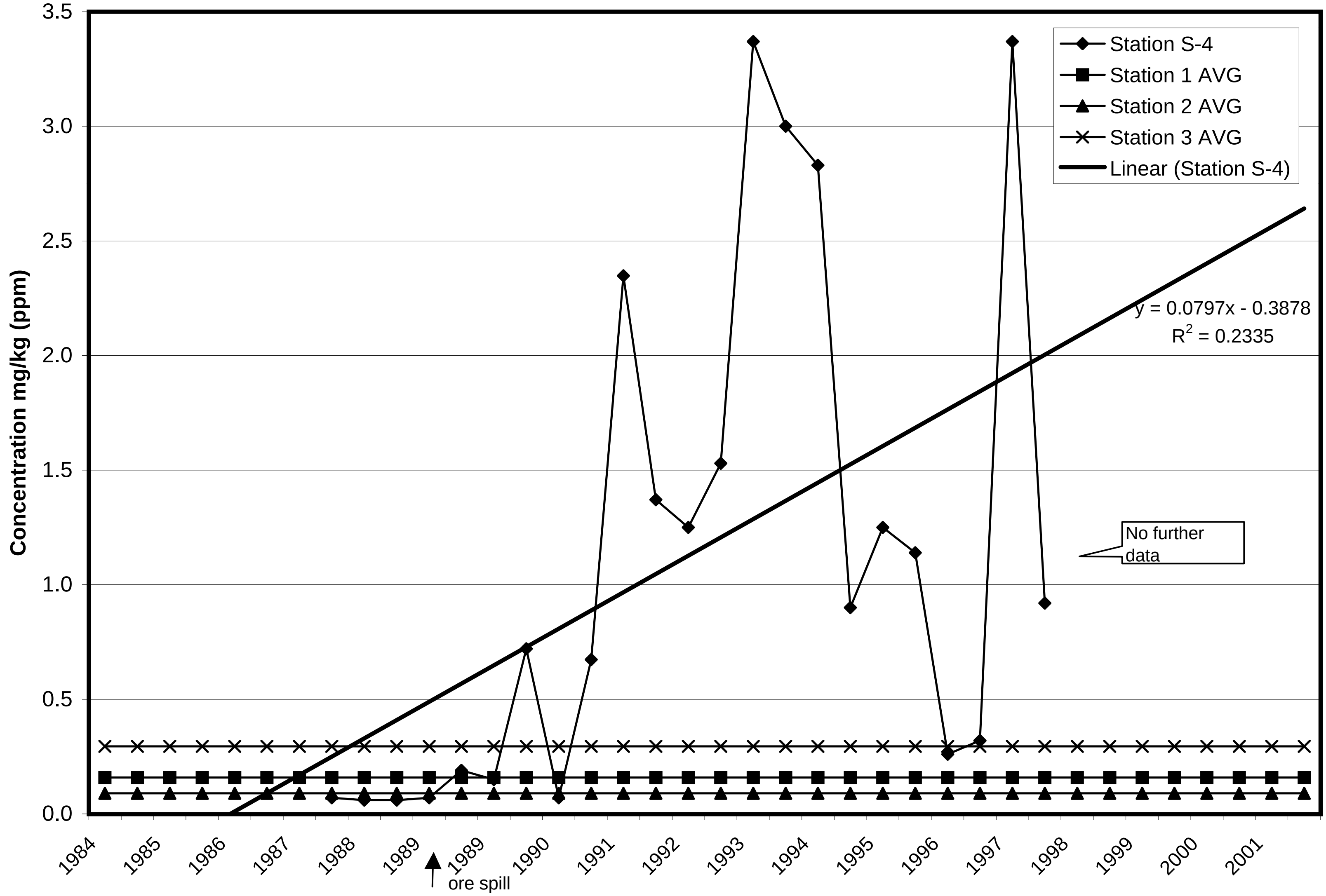
Hawk Inlet Metal Concentrations 1984-2002
Figure 48. Station S-4 Nephthys Silver (Ag)



Oceanus Alaska, KGCMC Data,S4Worm Ag

Hawk Inlet Metal Concentrations 1984-2002

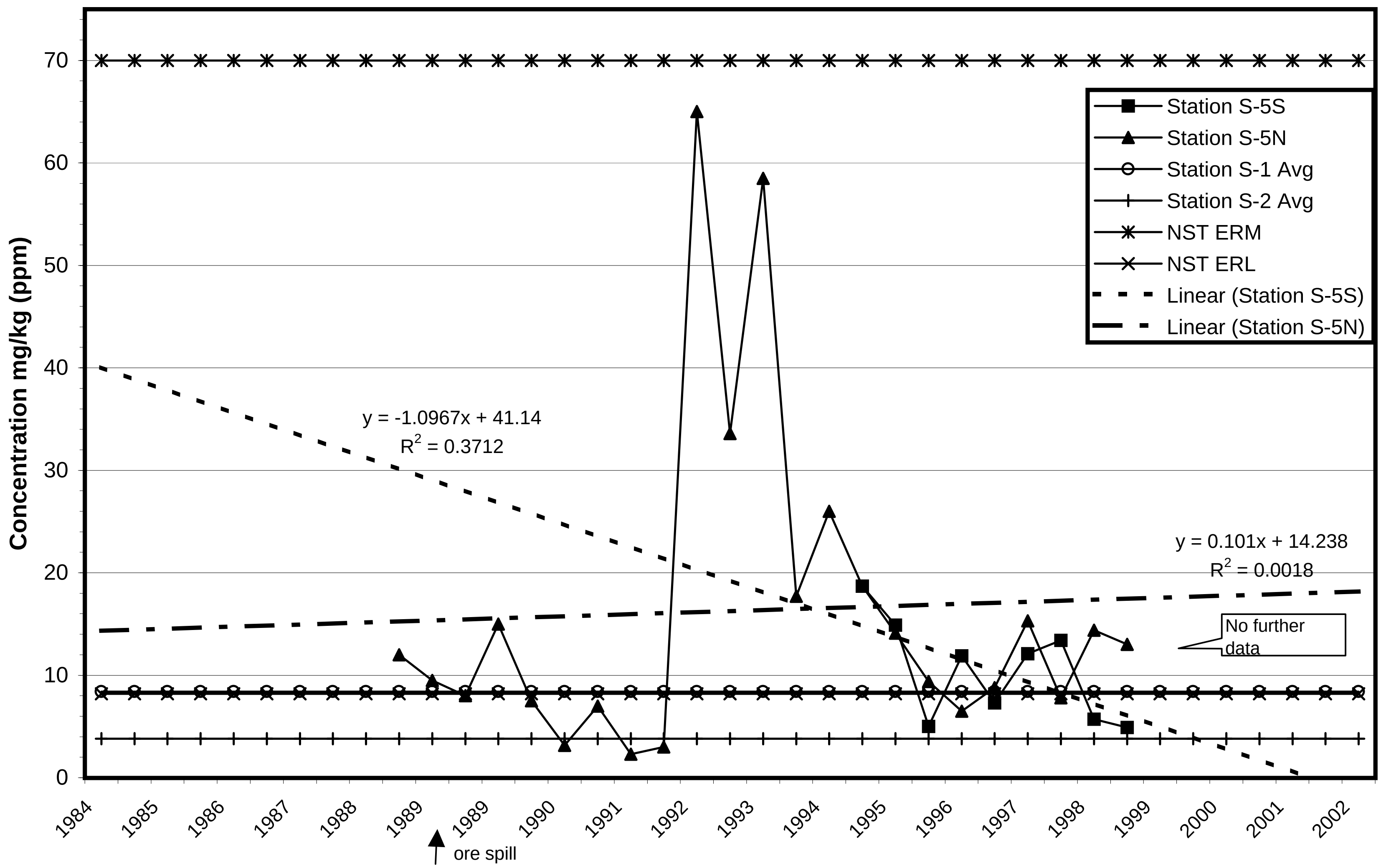
Figure 49. Station S-4 Nephthys Zinc (Zn)



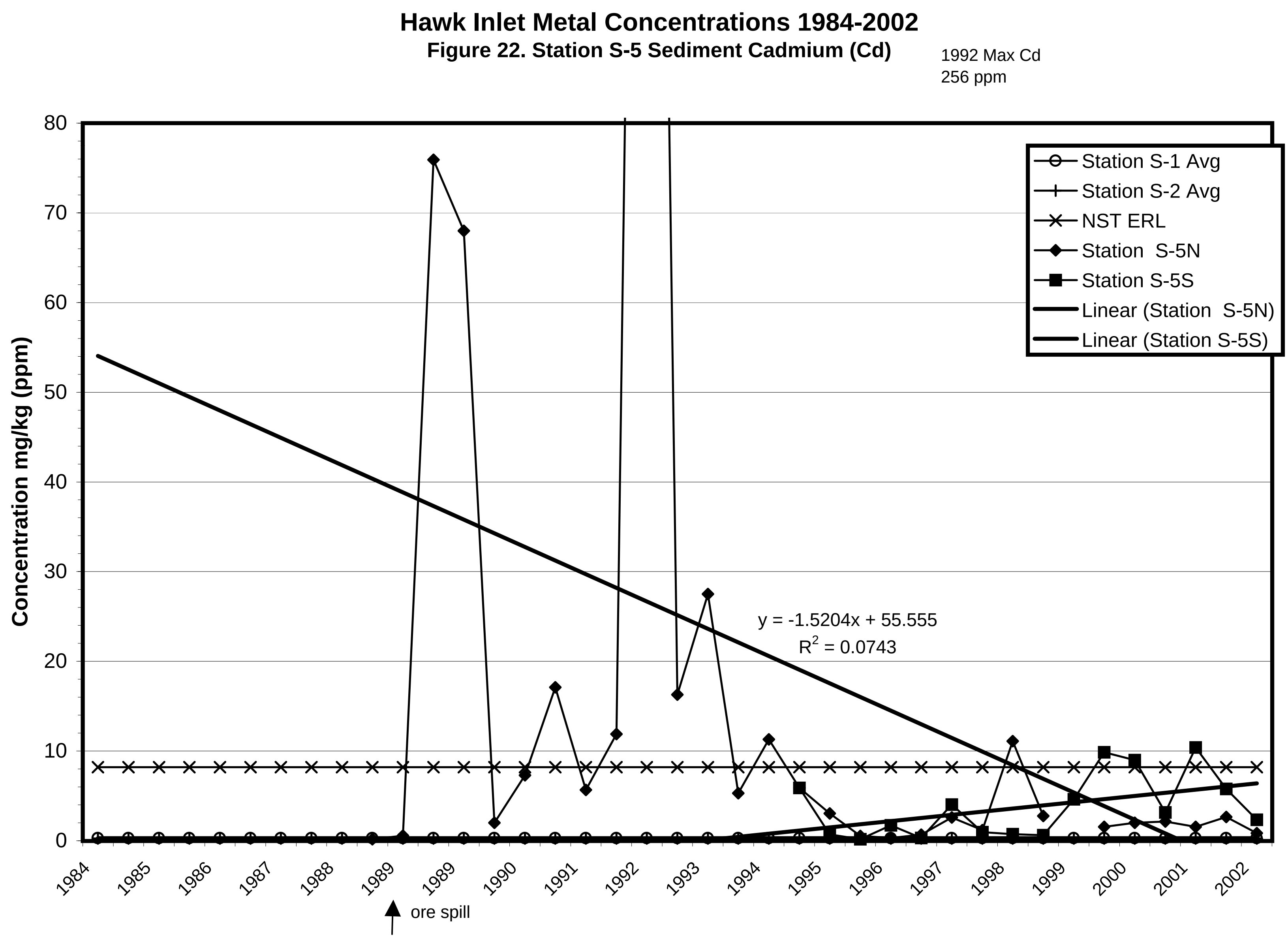
Oceanus Alaska, KGCMC Data,S4Worm Zn

Hawk Inlet Metal Concentrations 1984-2002

Figure 21. Station S-5 Sediment Arsenic (As)



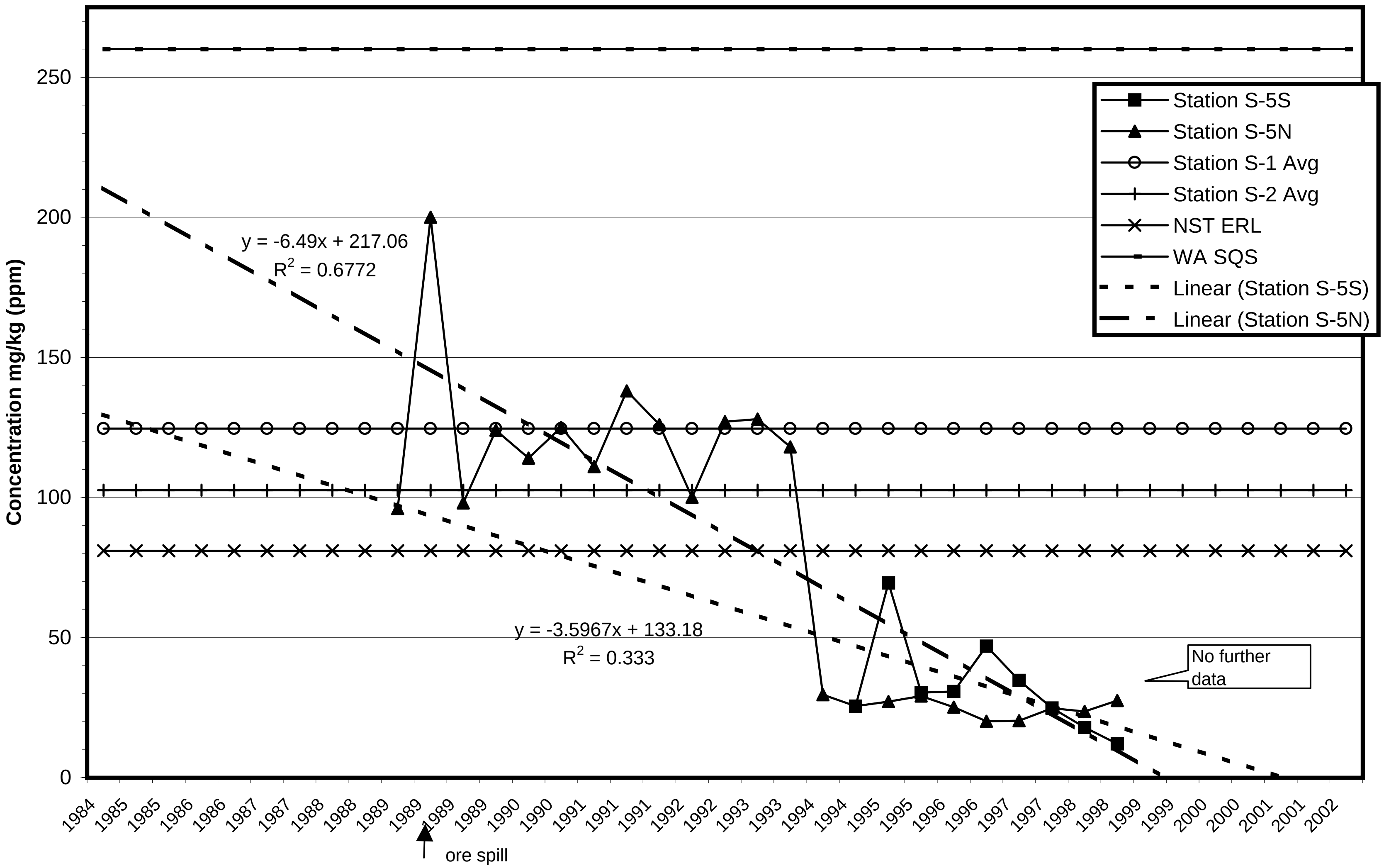
Oceanus Alaska, KGCMC Data,S-5 Sed As



Oceanus Alaska, KGCMC Data,S-5Sed Cd

Hawk Inlet Metal Concentrations 1984-2002

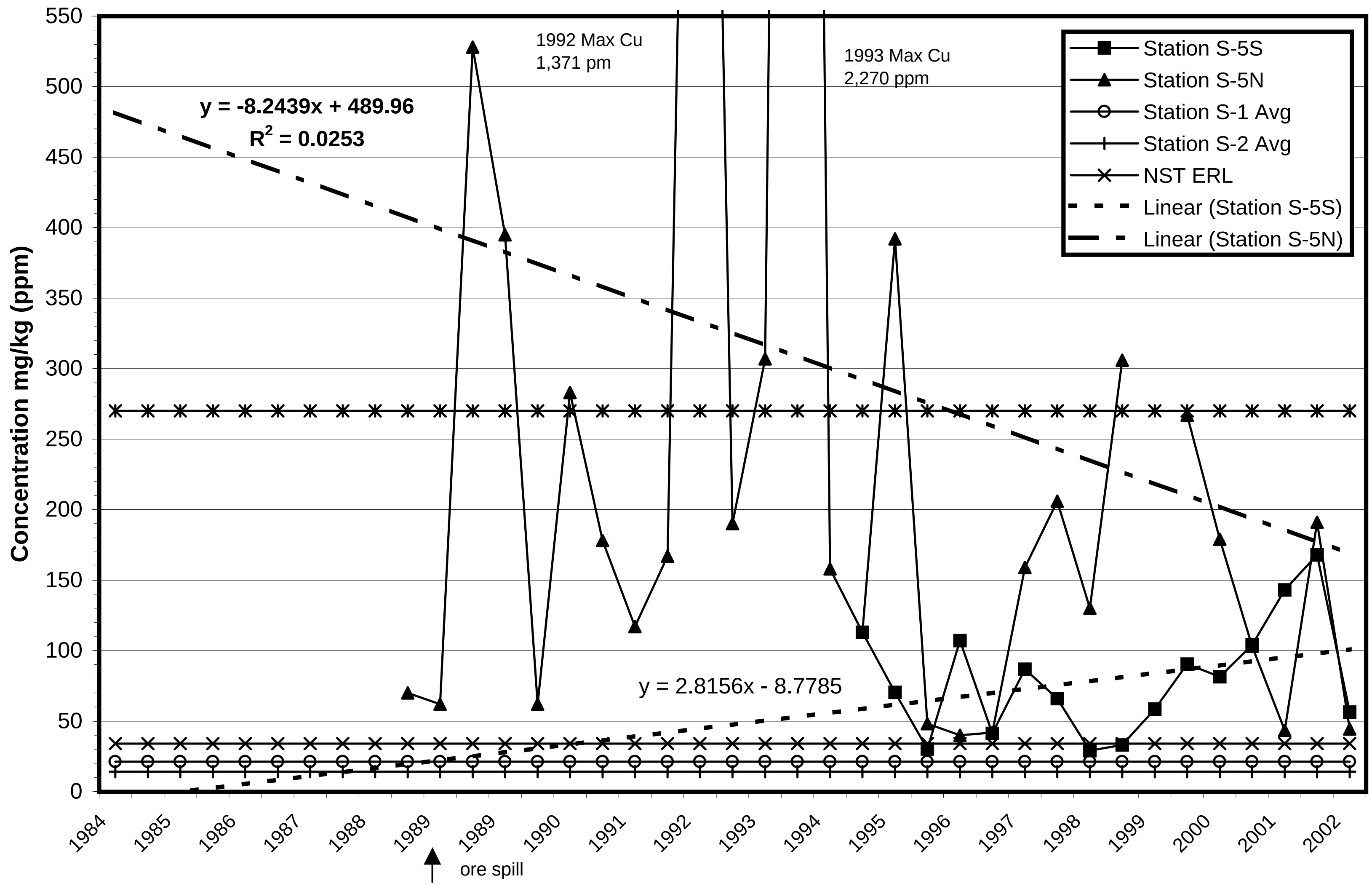
Figure 23. Station S-5 Sediment Chromium (Cr)



Oceanus Alaska, KGCMC Data,S5 Sed Cr

Hawk Inlet Metal Concentrations 1984-2002

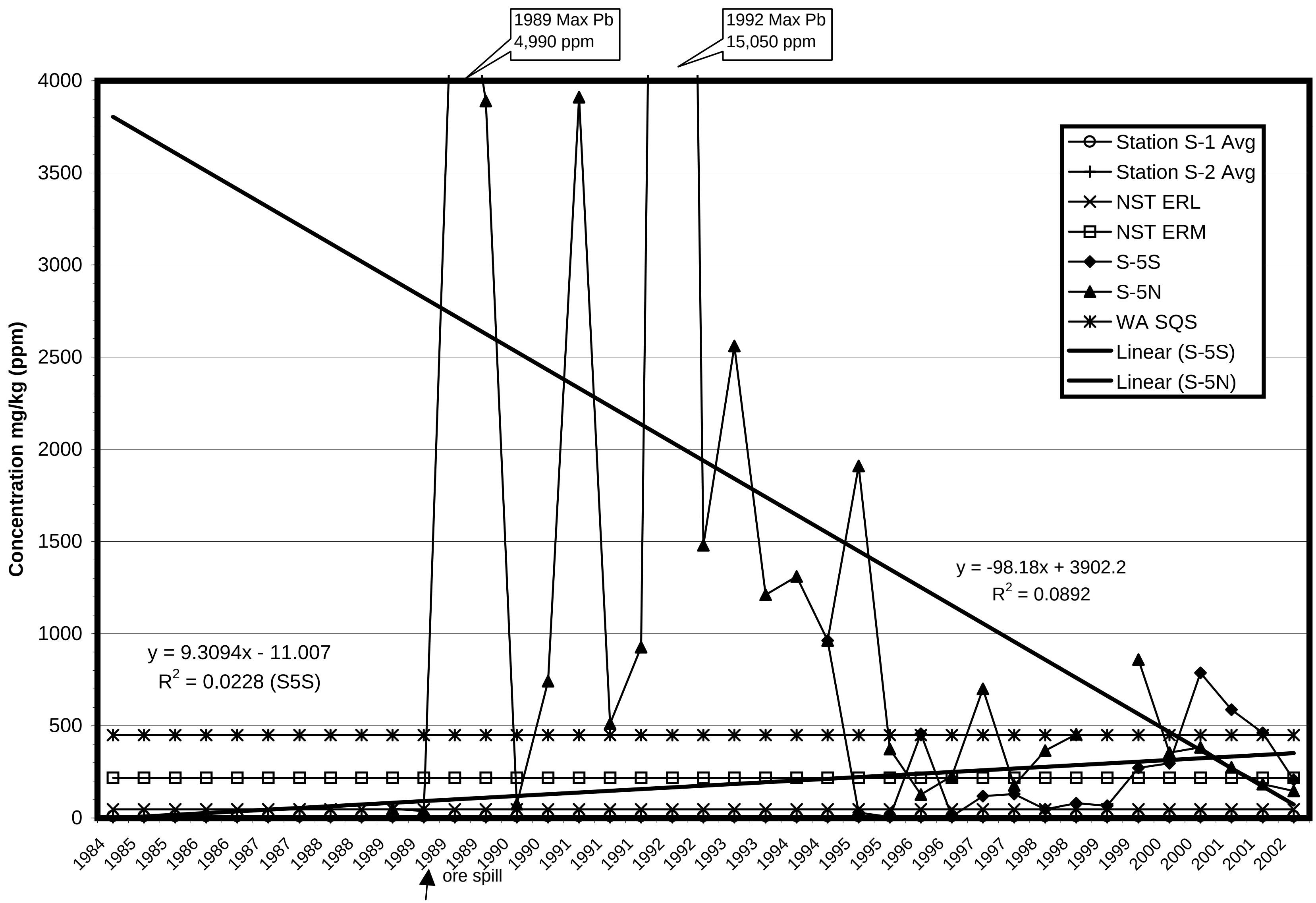
Figure 24. Station S-5 Sediment Copper (Cu)



Oceanus Alaska, KGCMC Data,S5 Sed Cu

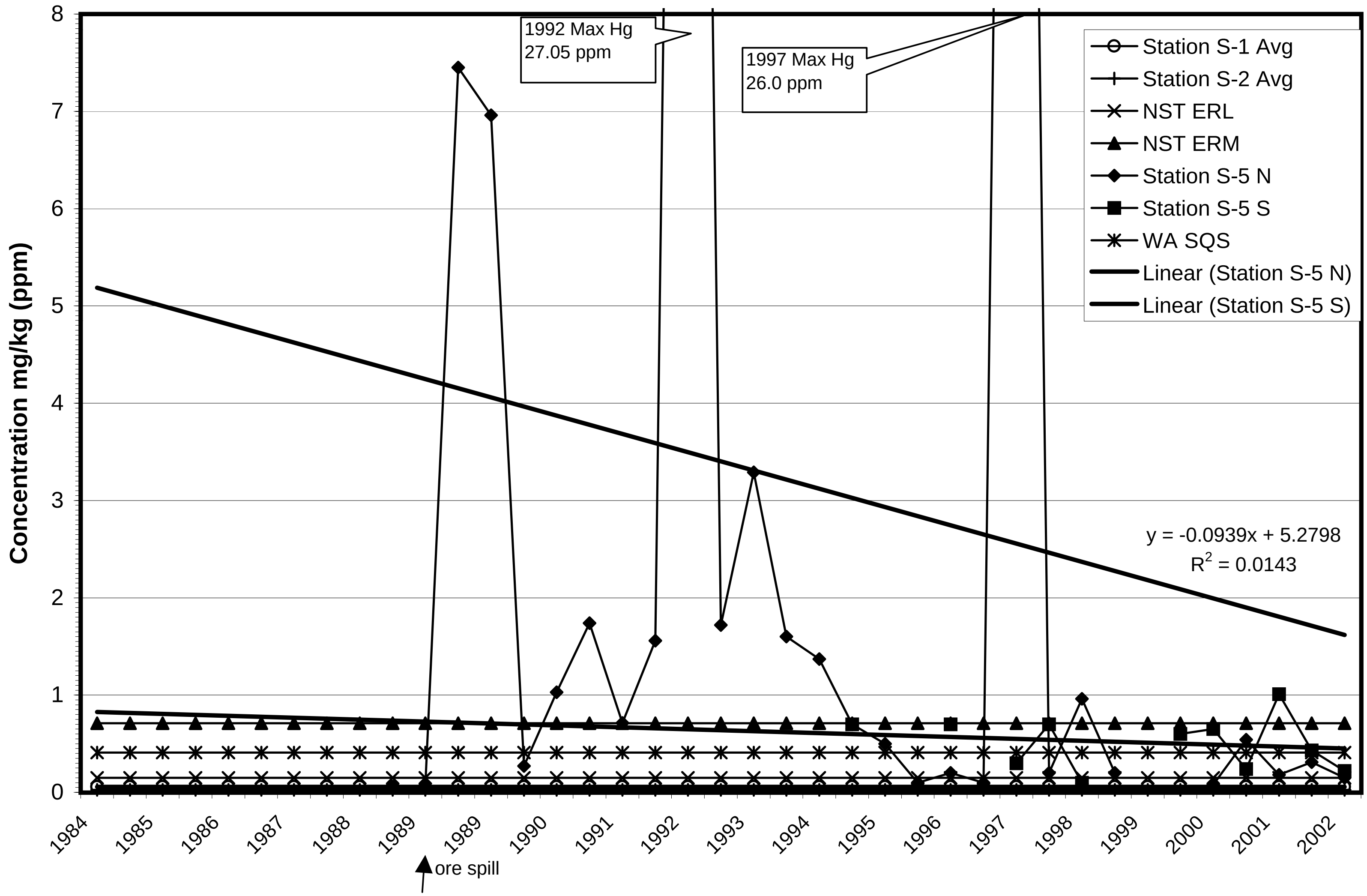
Hawk Inlet Metal Concentrations 1984-2002

Figure 25. Station S-5 Sediment Lead (Pb)

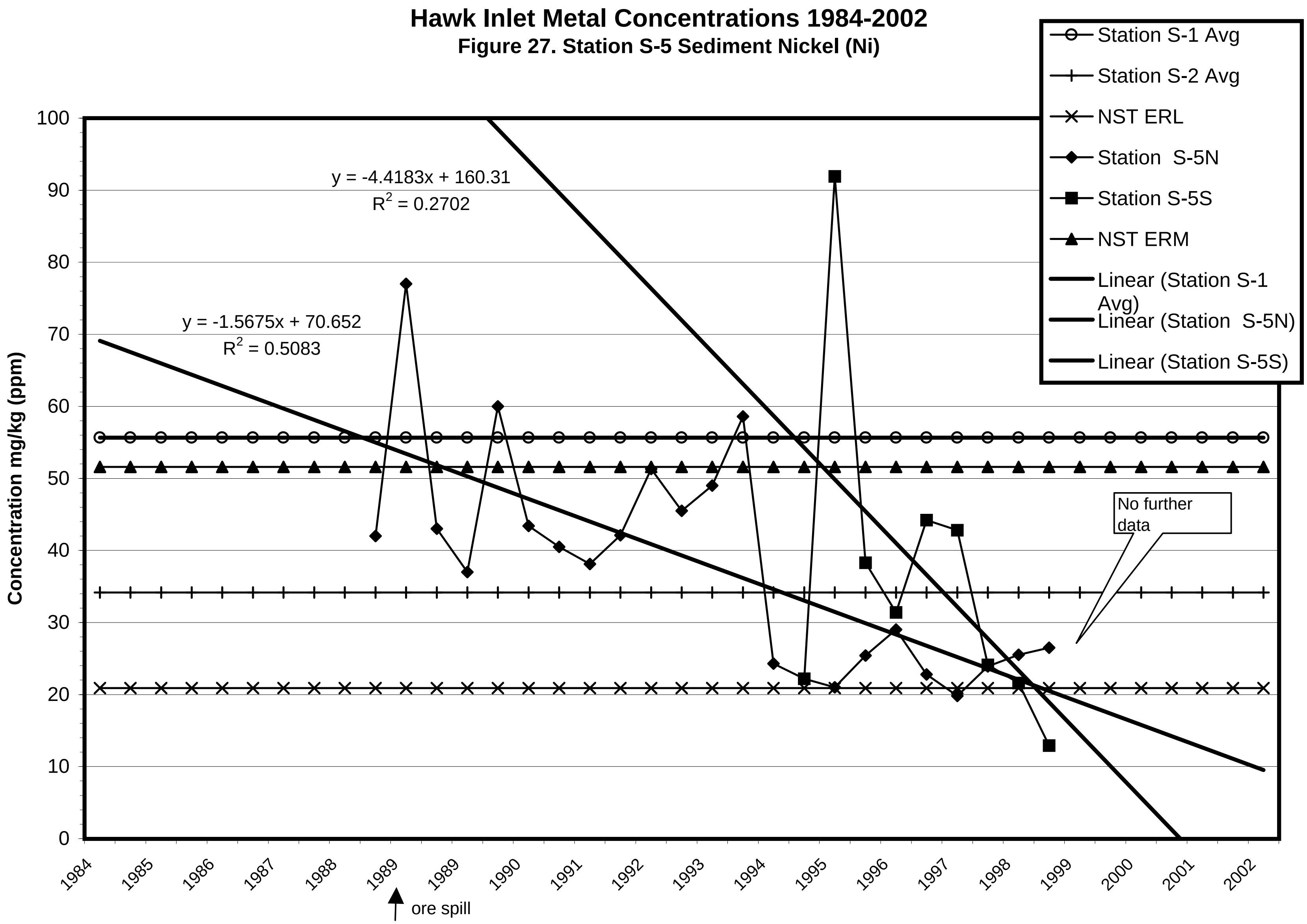


Oceanus Alaska, KGCMC Data,S5 Sed Pb

Hawk Inlet Metal Concentrations 1984-2002
Figure 26. Station S-5 Sediment Mercury (Hg)



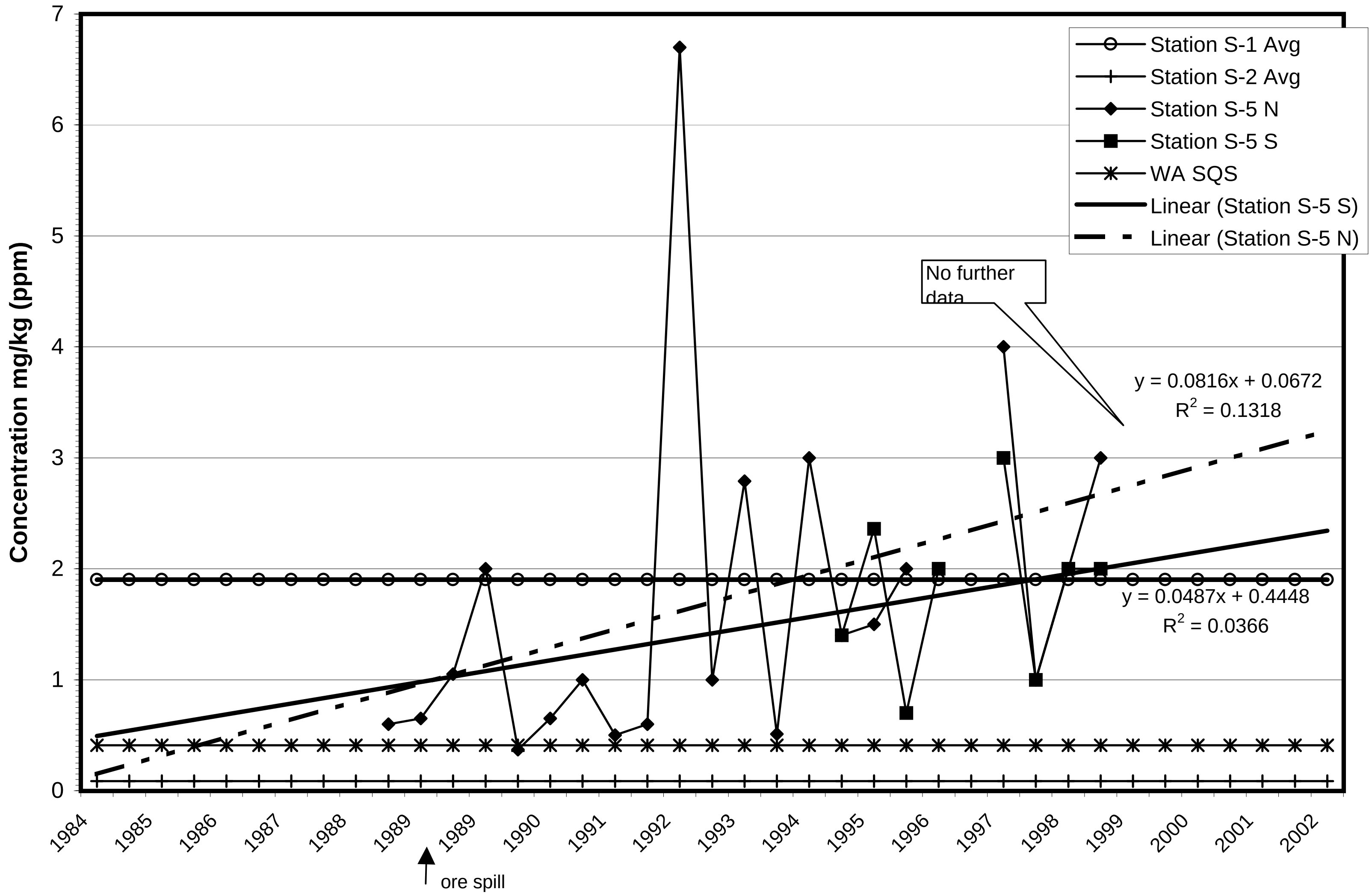
Oceanus Alaska, KGCMC Data,S-5Sed Hg



Oceanus Alaska, KGCMC Data,S-5Sed Ni

Hawk Inlet Metal Concentrations 1984-2002

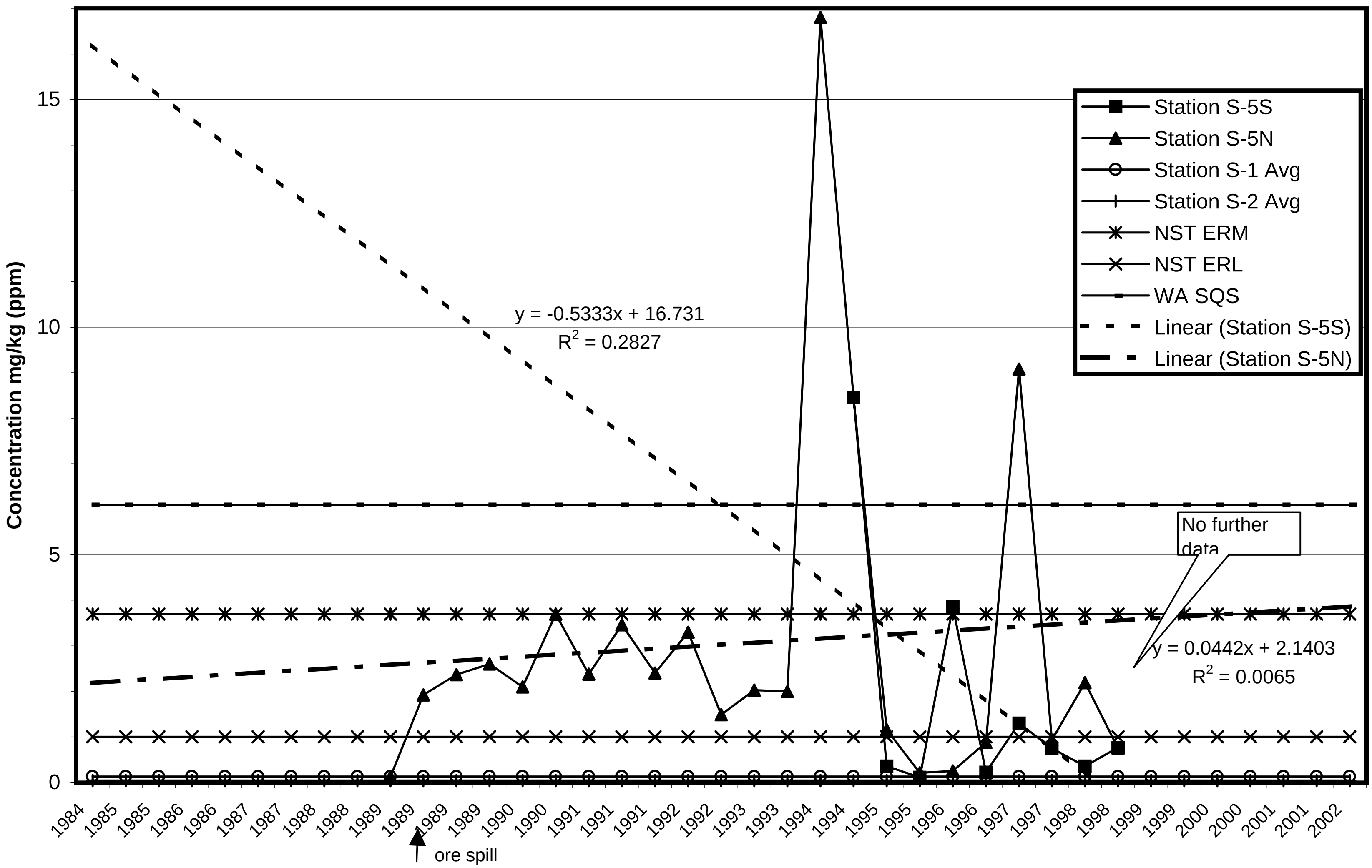
Figure 28. Station S-5 Sediment Selenium (Se)



Oceanus Alaska, KGCMC Data,S-5Sed Se

Hawk Inlet Metal Concentrations 1984-2002

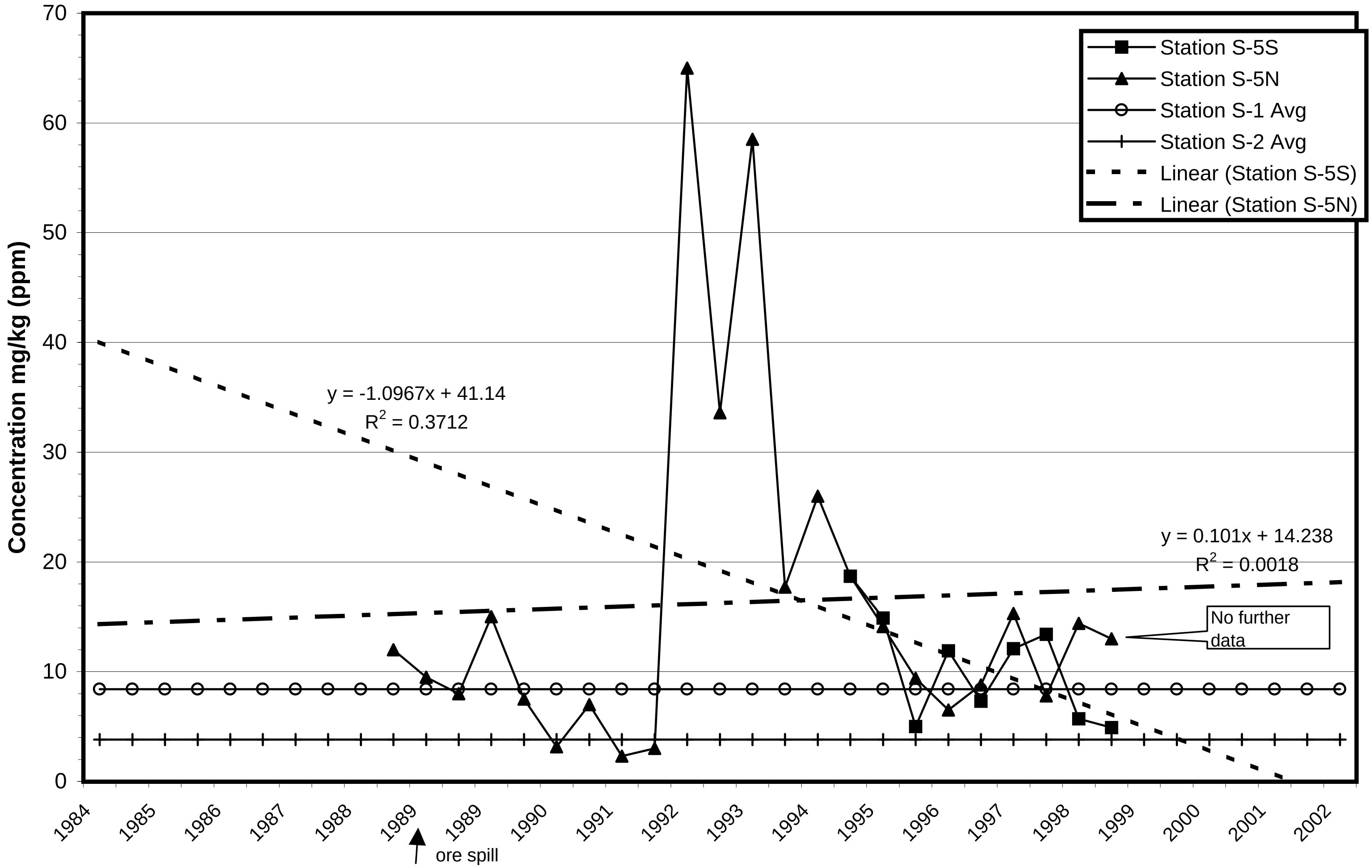
Figure 29. Station S-5 Sediment Silver (Ag)



Oceanus Alaska, KGCMC Data,S5 Sed Ag

Hawk Inlet Metal Concentrations 1984-2002

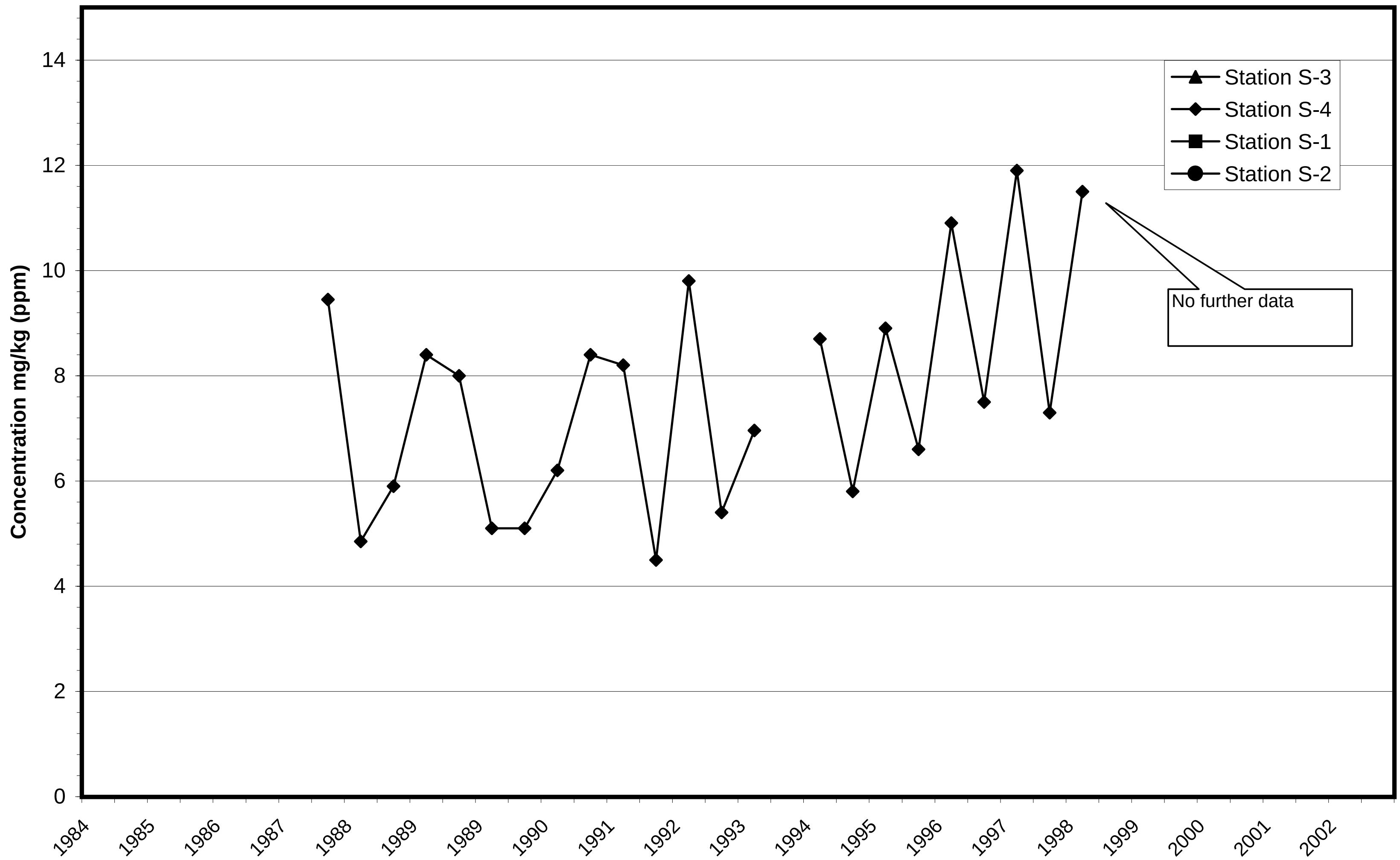
Figure 30. Station S-5 Sediment Zinc (Zn)



Oceanus Alaska, KGCMC Data,S5Sed Zn

Hawk Inlet Metal Concentrations 1984-2002

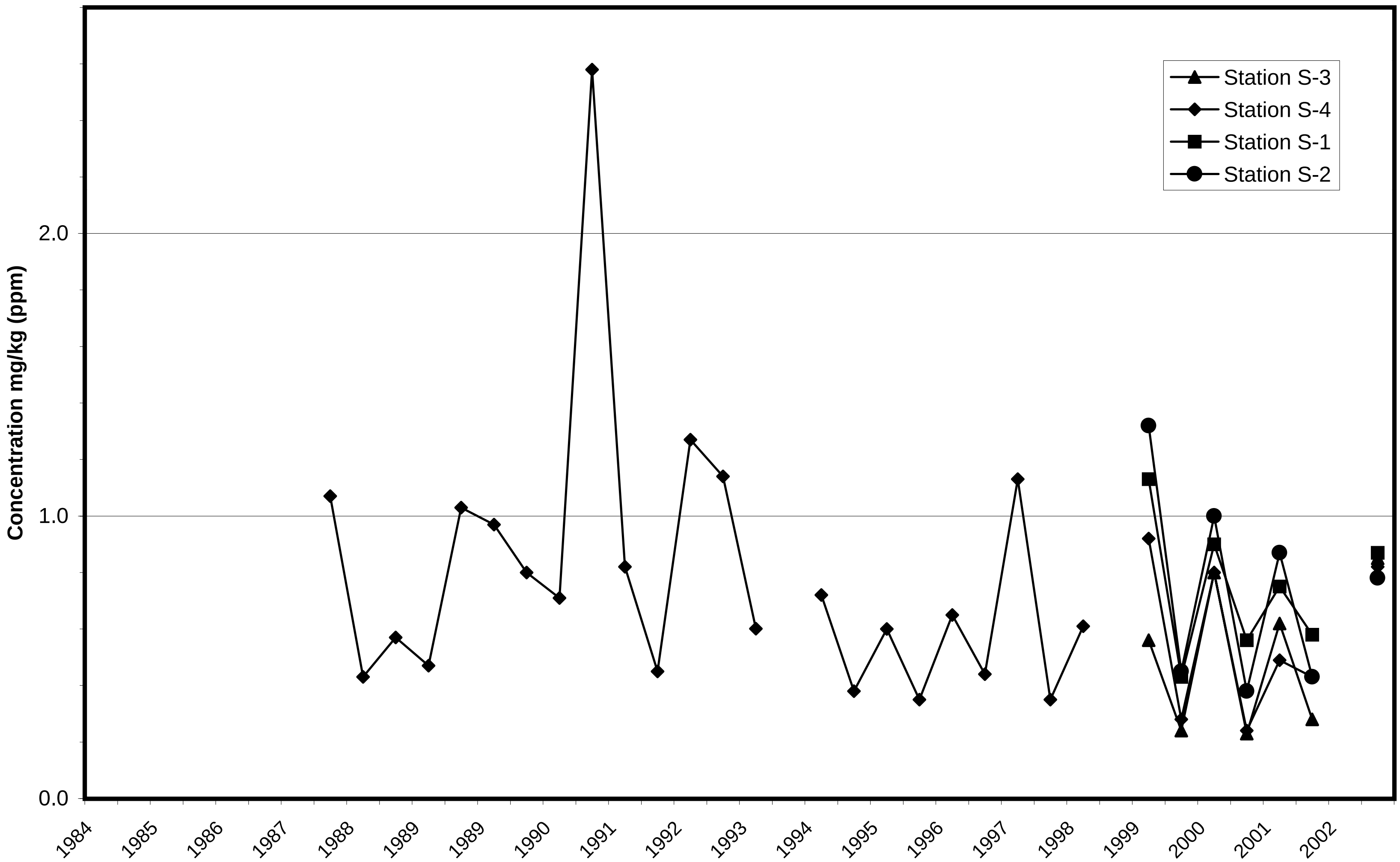
Figure 4-100. Station S-1, S-2, S-3 and S-4 Cockles Arsenic (As)



Oceanus Alaska, KGCMC Data,Cockles As

Hawk Inlet Metal Concentrations 1984-2002

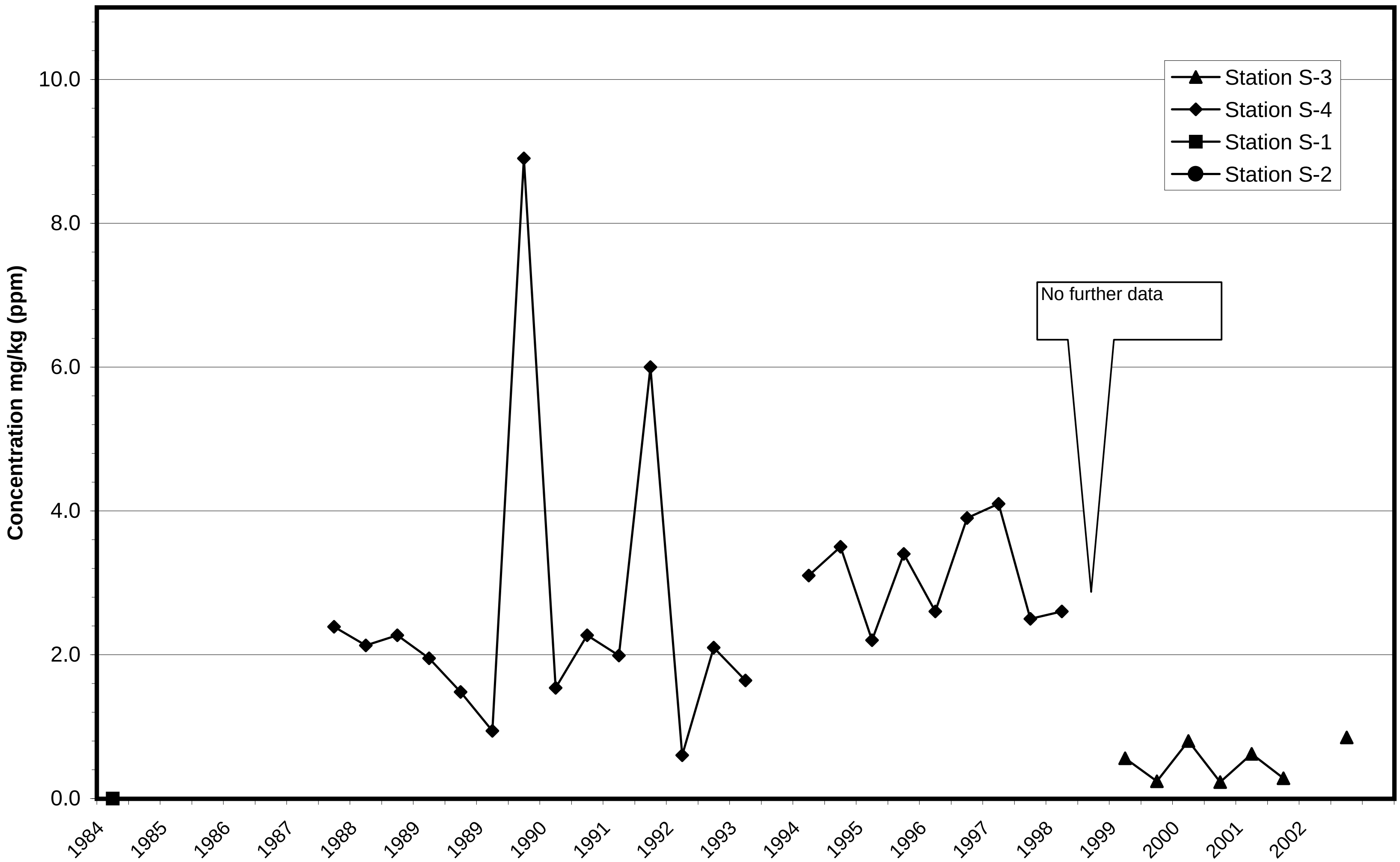
Figure 4-101. Station S-1, S-2, S-3 and S-4 Cockles Cadmium (Cd)



Oceanus Alaska, KGCMC Data,Cockles Cd

Hawk Inlet Metal Concentrations 1984-2002

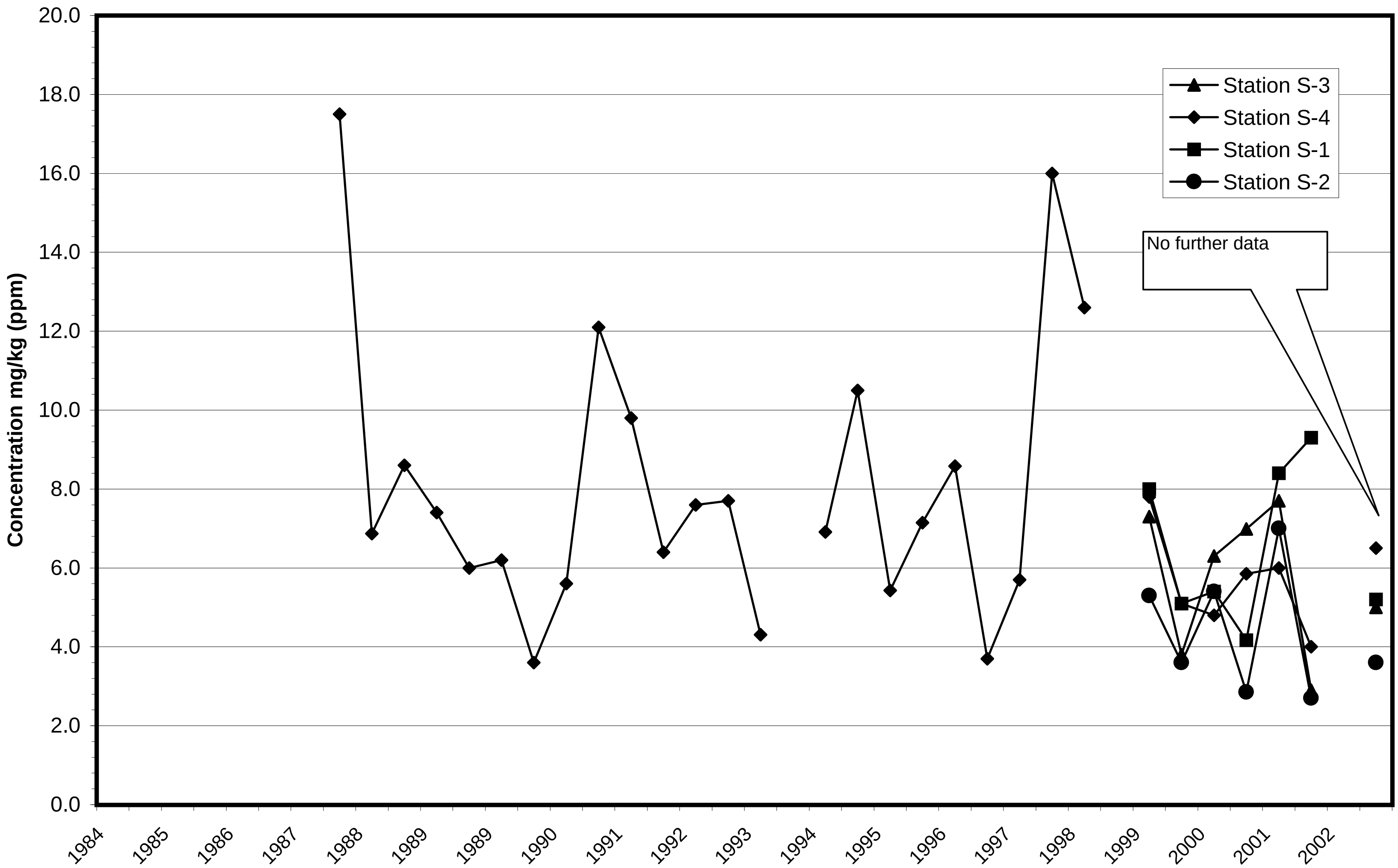
Figure 4-102. Station S-1, S-2, S-3 and S-4 Cockles Chromium (Cr)



Oceanus Alaska, KGCMC Data,Cockles Cr

Hawk Inlet Metal Concentrations 1984-2002

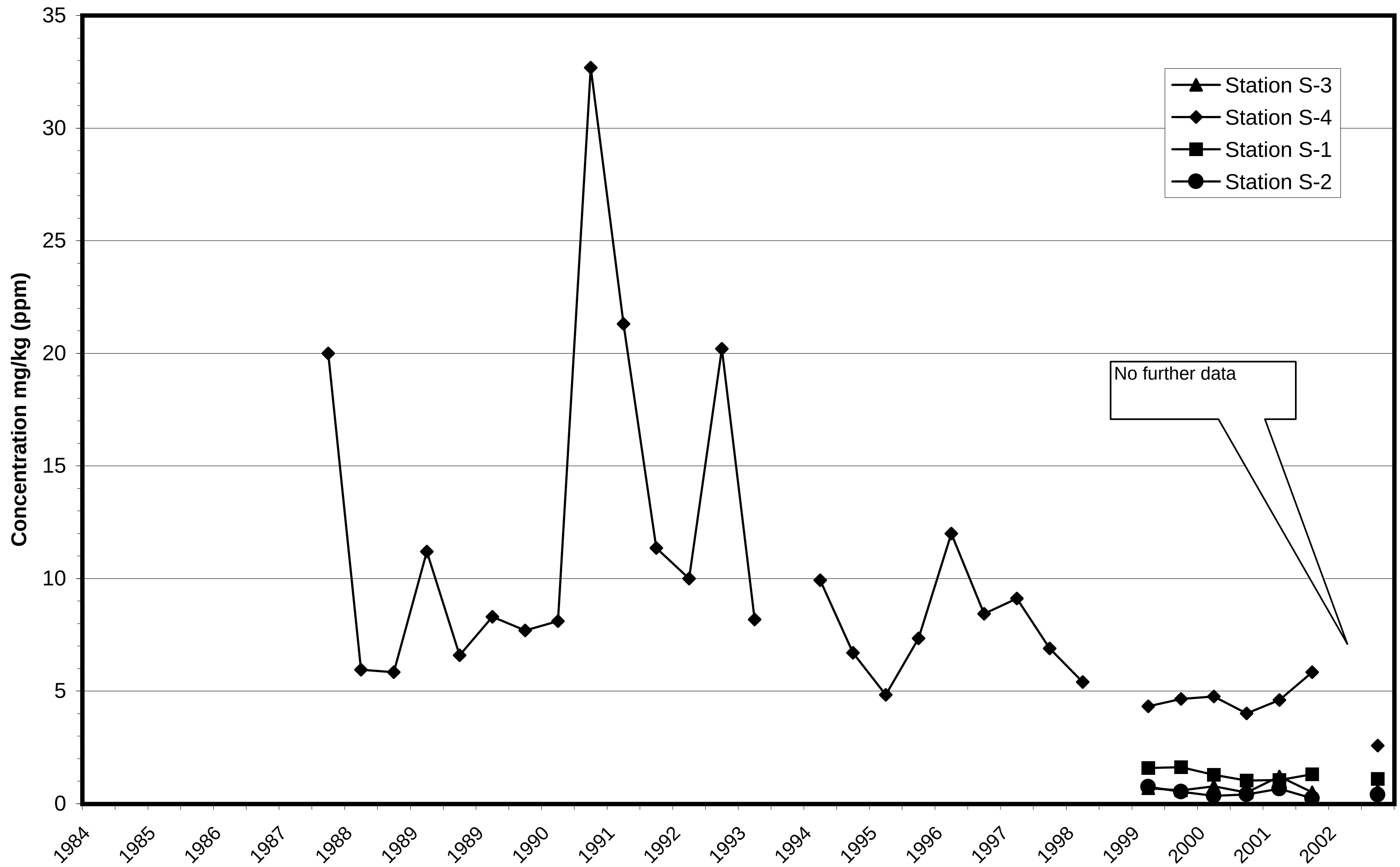
Figure 4-103. Station S-1, S-2, S-3 and S-4 Cockles Copper (Cu)



Oceanus Alaska, KGCMC Data,Cockles Cu

Hawk Inlet Metal Concentrations 1984-2002

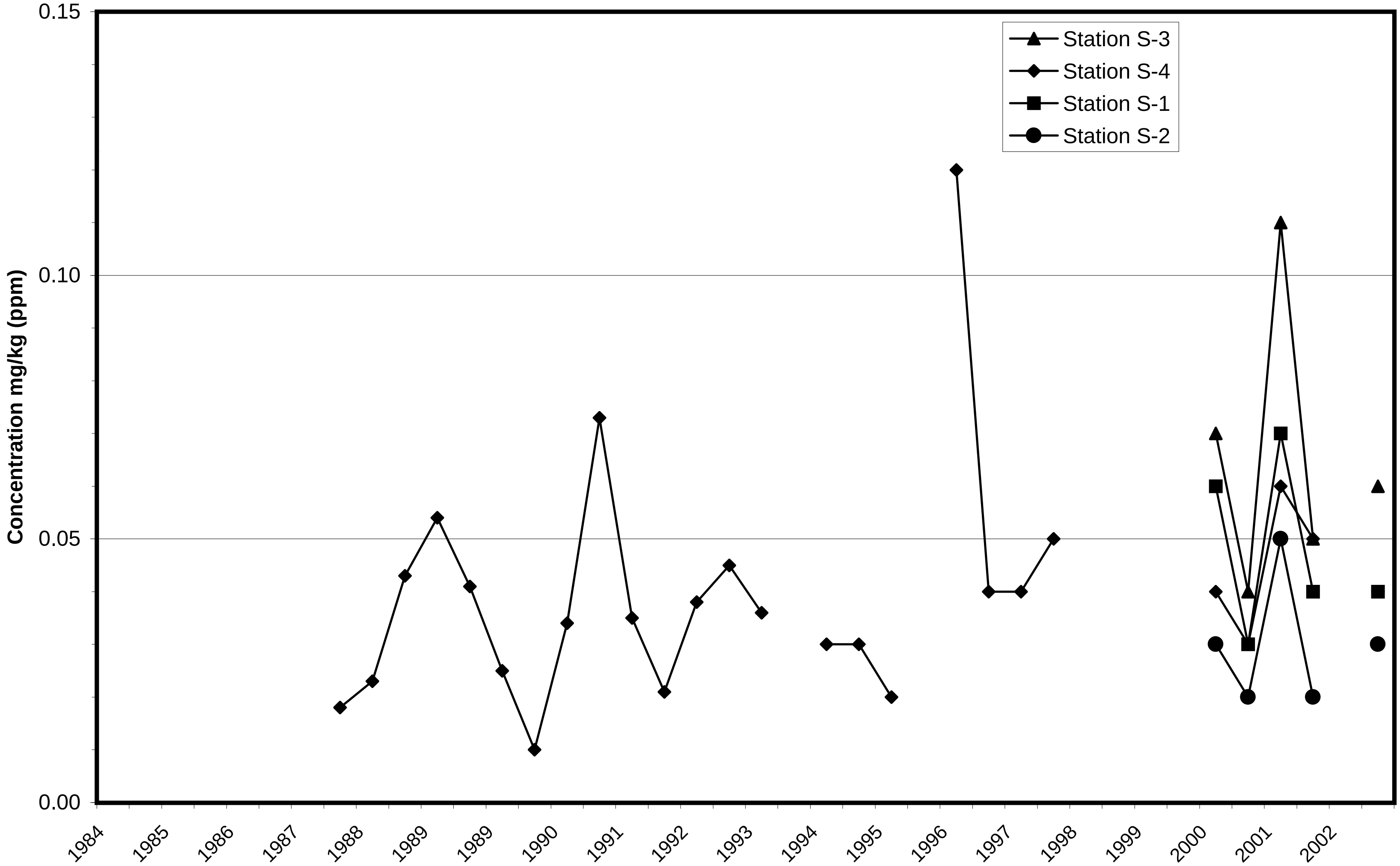
Figure 4-104. Station S-1, S-2, S-3 and S-4 Cockles Lead (Pb)



Oceanus Alaska, KGCMC Data,Cockles Pb

Hawk Inlet Metal Concentrations 1984-2002

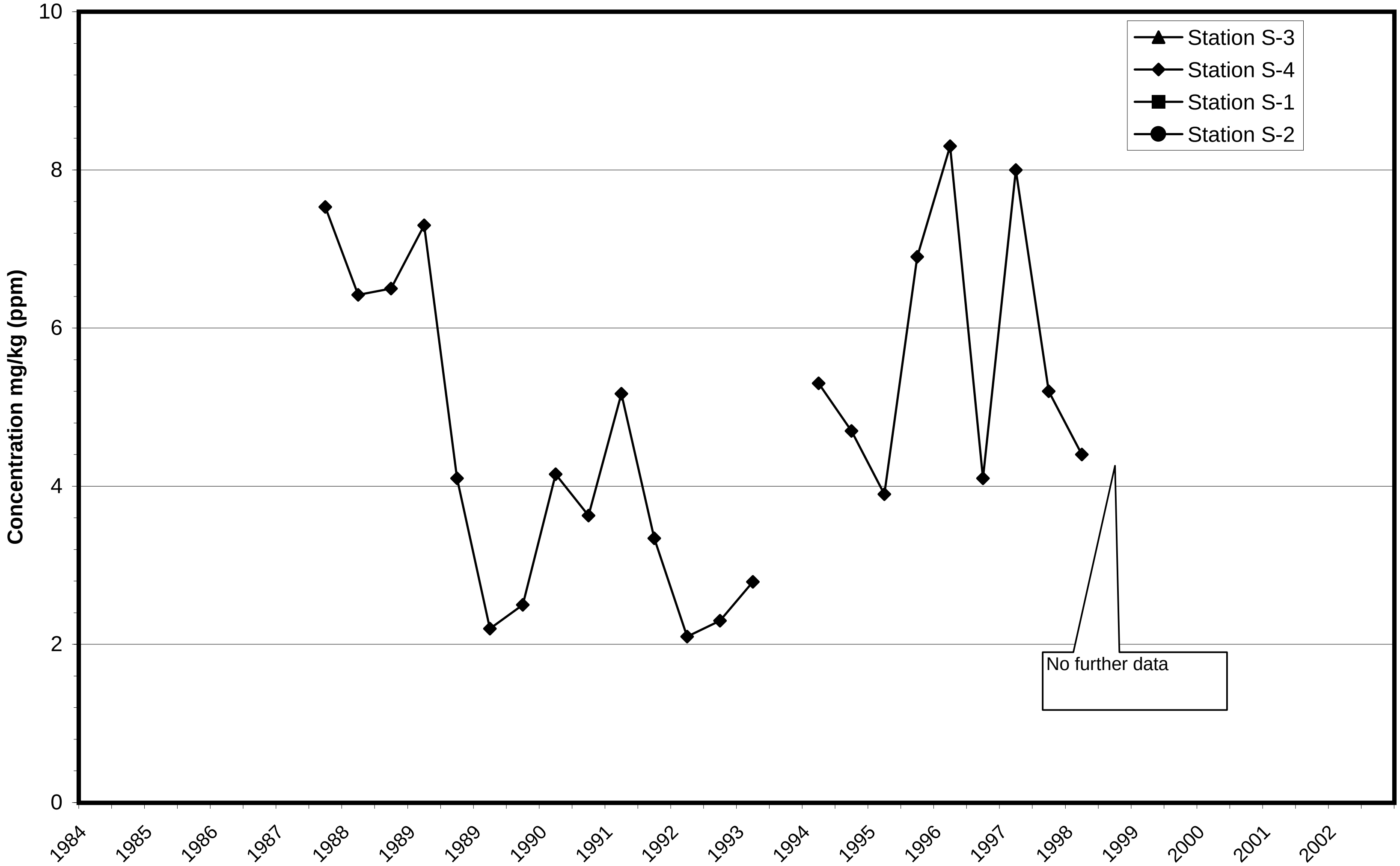
Figure 4-105. Station S-1, S-2, S-3 and S-4 Cockles Mercury (Hg)



Oceanus Alaska, KGCMC Data,Cockles Hg

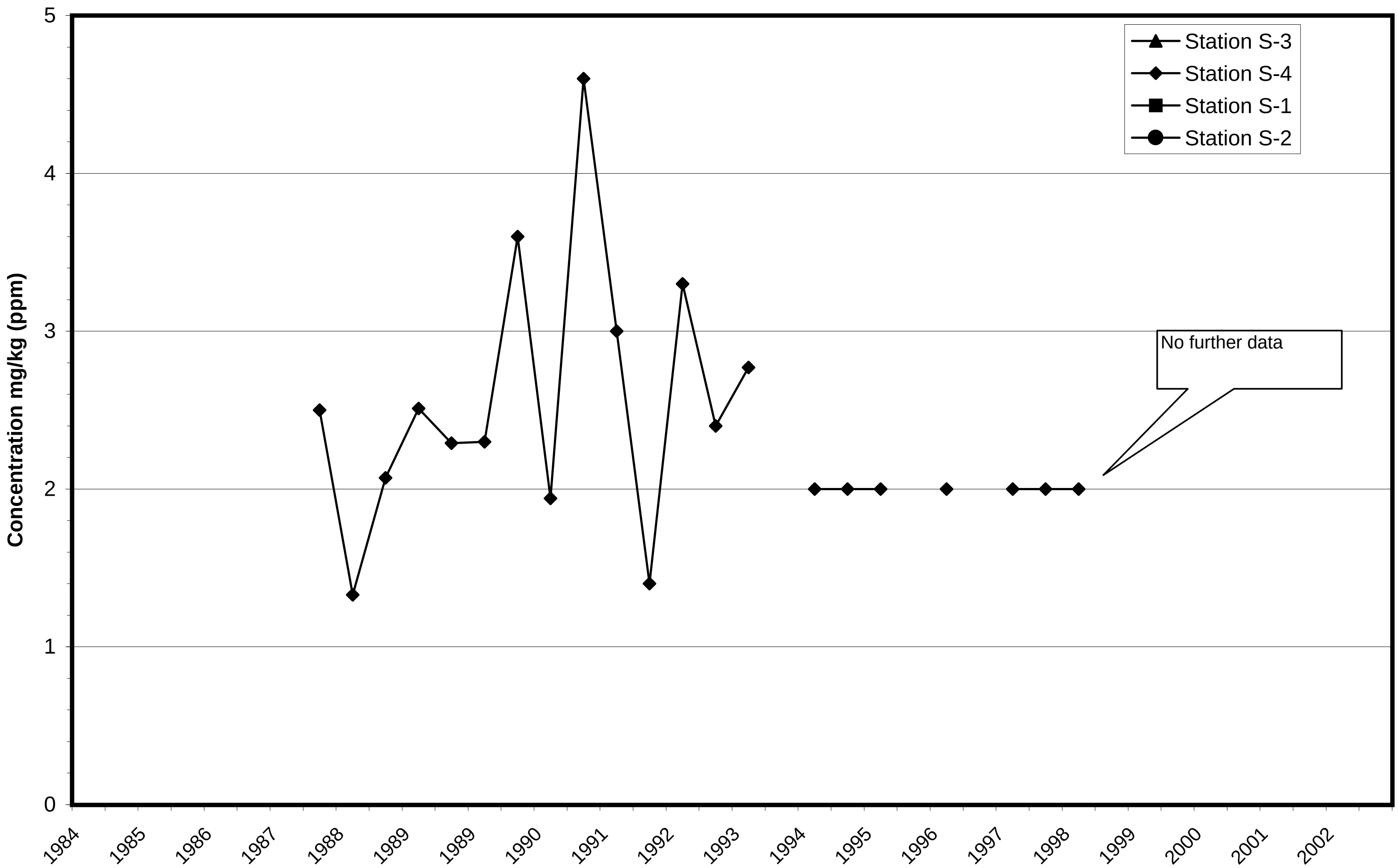
Hawk Inlet Metal Concentrations 1984-2002

Figure 4-106. Station S-1, S-2, S-3 and S-4 Cockles Nickel (Ni)



Hawk Inlet Metal Concentrations 1984-2002

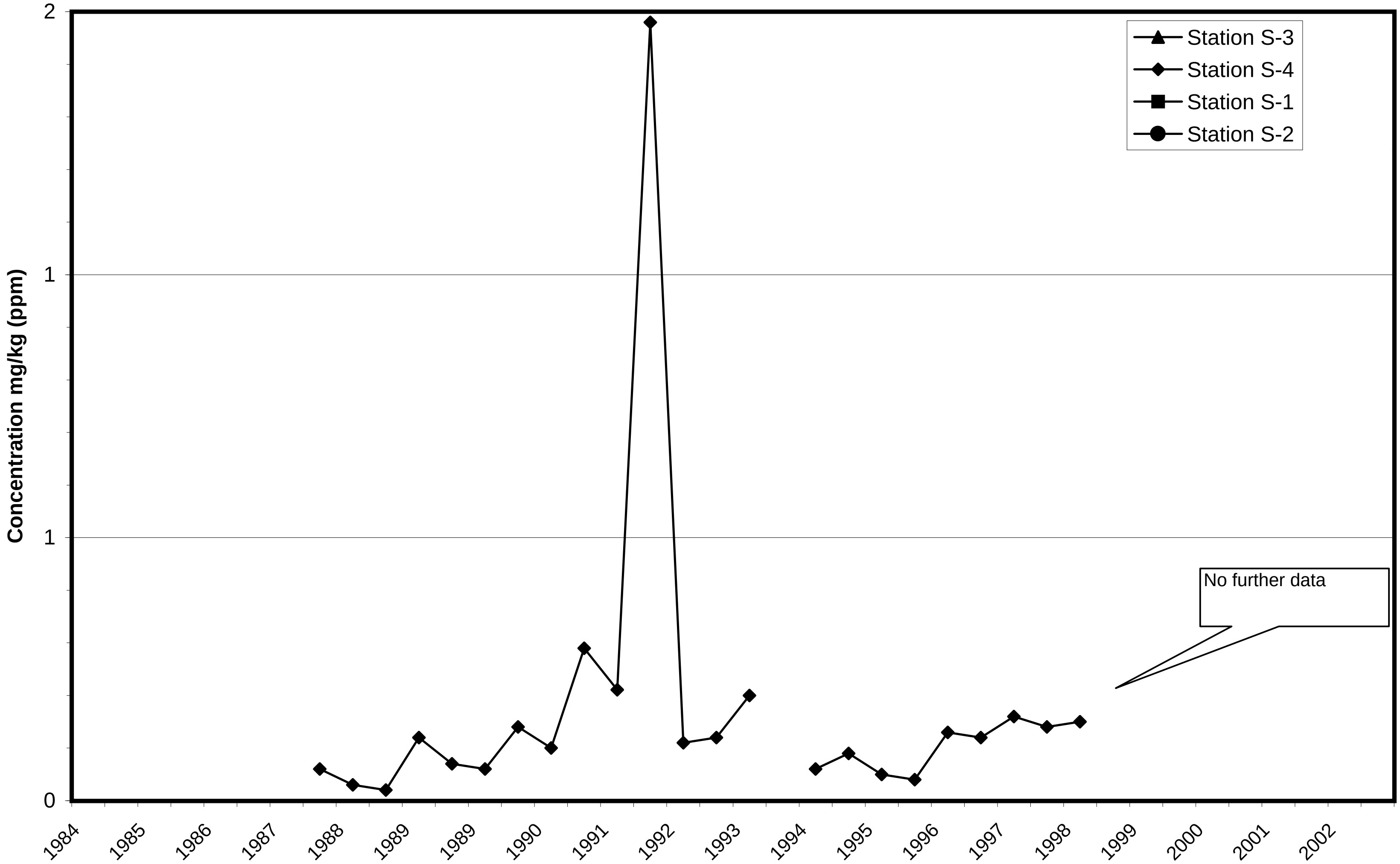
Figure 4-107. Station S-1, S-2, S-3 and S-4 Cockles Selenium (Se)



Oceanus Alaska, KGCMC Data,Cockles Se

Hawk Inlet Metal Concentrations 1984-2002

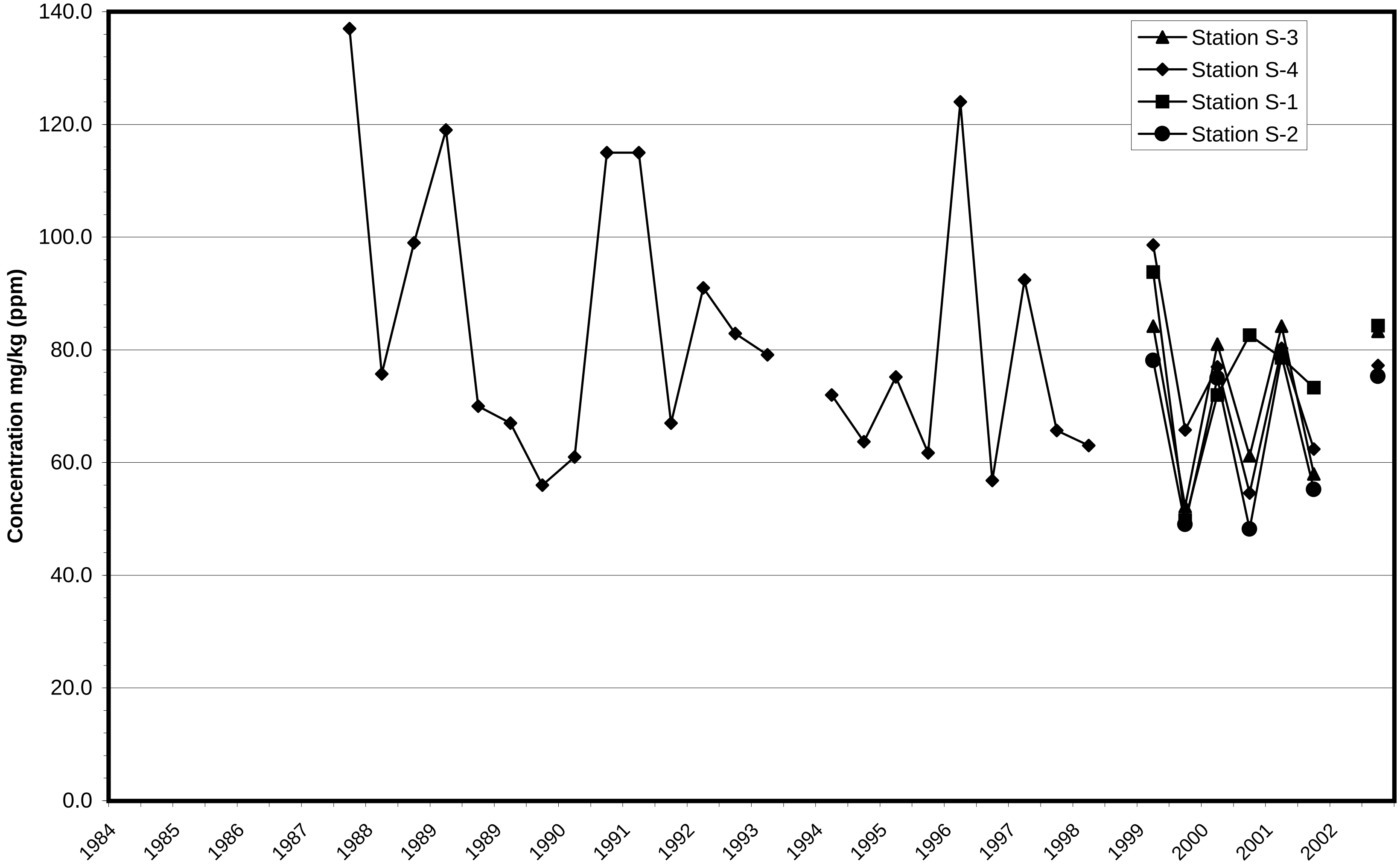
Figure 4-108. Station S-1, S-2, S-3 and S-4 Cockles Silver (Ag)



Oceanus Alaska, KGCMC Data,Cockles Ag

Hawk Inlet Metal Concentrations 1984-2002

Figure 4-109. Station S-1, S-2, S-3 and S-4 Cockles Zinc (Zn)



Oceanus Alaska, KGCMC Data,Cockles Zn