SEDIMENT AND BENTHIC COMMUNITY CHARACTERIZATION BELOW AGRICULTURE AND AQUACULTURE WASTE LOADINGS IN THE MIDDLE SNAKE RIVER, SOUTH-CENTRAL IDAHO

Prepared by: C. Michael Falter
Dustin R. Hinson

Idaho Water Resources Research Institute
Department of Fish & Wildlife Resources
University of Idaho
Moscow, ID 83844

Prepared for: U.S. Environmental Protection Agency
Region 10, Idaho Office
1435 North Orchard Street
Boise, ID 83706
Carla Fromm, Project Officer

U.S. Fish & Wildlife Service
Snake River Fish and Wildlife Office
1387 S. Vinnell Way, Room 368
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April, 2005

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ABSTRACT

In 2000-01, sediments, benthic macroinvertebrates (BMI), and aquatic macrophytes (AM) were sampled with a Petite Ponar Dredge downstream of a subset of existing aquaculture and agriculture discharges to the middle Snake River from Twin Falls, Idaho (RK 984.6) to Upper Salmon Falls Dam (RK 935.5). Control samples were collected upstream of the aquaculture and agriculture discharges for comparison. Analyses were limited to 2001 samples due to the improved sampling design.

Results indicate that the dominant particle sampled upstream and downstream of all sampled discharges (3 aquaculture and 3 agriculture) in 2001 was sand (43-95 %), followed by silt (4-48 %) and clay (0.5-5.0 %), respectively. In 2001, sand content was generally greater in agriculture deposition zones than aquaculture deposition zones. Overall, nutrient levels from sediment sampled in 2001 (P and N) were greater downstream of aquaculture discharges than below agriculture discharges. Sediment P averaged 758.7 $\mu g \cdot g^{-1}$ upstream of agriculture discharges and 688.1 $\mu g \cdot g^{-1}$ downstream of agriculture discharges. Sediment P averaged 734.9 $\mu g \cdot g^{-1}$ upstream of aquaculture discharges and1473.9 $\mu g \cdot g^{-1}$ downstream of aquaculture discharges in 2001. Sediment P was significantly greater ($p < 0.05$) in deposition zone sediments than control zone sediments throughout the five sampling months for all three aquaculture study sites. Sediment organic matter content averaged 1.11 % upstream of agriculture discharges and 0.91 % downstream of agriculture discharges. Sediment organic matter content averaged 1.57 % upstream of aquaculture discharges and 1.78 % downstream of aquaculture discharges. Sediment lead, chromium, cadmium, and nickel concentrations exceeded benthic community threshold effects levels (per Buchman 1999) at some point during the 2001 study, while benthic community probable effects levels (per Buchman 1999) were exceeded by cadmium and nickel.

Dominant BMI sampled from the middle Snake River in 2001 were pollution-tolerant taxa, including *Potamopyrgus antipodarum* (non-native), Oligochaeta, Chironomidae, and *Hyalella azteca* (Amphipoda). BMI density, biomass, and richness were generally greater downstream of aquaculture discharges than below agriculture discharges in 2001. The density of *Potamopyrgus antipodarum* was greater downstream of aquaculture discharges than below agriculture discharges.

Seven vascular AM taxa were sampled from five different families throughout the five-month sampling period in the middle Snake River in 2001. AM were dominated by *Potamogeton crispus* (non-native), *Ceratophyllum demersum* (native), and *Elodea Canadensis* (native), all taxa considered tolerant of organic pollution and eutrophic conditions. AM densities found during the 2001 middle Snake River sampling effort were greater than the 200 $g \cdot m^{-2}$ nuisance level (nuisance level per EPA 2002) downstream of all three aquaculture study sites and one agriculture study site. AM biomass averaged 5.9 $g \cdot m^{-2}$ upstream of agriculture discharges and 6.2 $g \cdot m^{-2}$ downstream of agriculture discharges. AM biomass averaged 33.5 $g \cdot m^{-2}$ upstream of aquaculture discharges and 73.1 $g \cdot m^{-2}$ downstream of aquaculture discharges.

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TABLE OF CONTENTS

Glossary of Acronyms and Abbreviations

AM	Aquatic Macrophyte
ANOVA	Analysis of Variance
BL	Background Level
BMI	Benthic Macroinvertebrate
CON	Control Zone
DEP	Deposition Zone
GLM	General Linear Model
H_2S	Hydrogen Sulfide
MANOVA	Multivariate Analysis of Variance
ODW	Oven Dry Weight
PEL	Probable Effects Level
PVC	Polyvinyl Chloride
RK	River Kilometer
SIG	Significant
SQuiRTs	Screening Quick Reference Tables
SOP	Standard Operating Procedure
Spp	Species (plural)
TEL	Threshold Effects Level

Study Sites

AD3	Agriculture Drain 3; Pigeon Cove LQ, LS Drain
AD2	Agriculture Drain 2; Southside LS2/39A Drain
AD1	Agriculture Drain 1; Southside 39 Drain
BC	Box Canyon Hatchery
CS	Crystal Springs Hatchery
RV	Rim View Hatchery

Sampled Elements

Ba	Barium
Be	Beryllium
C	Carbon
Ca	Calcium
Cd	Cadmium
Co	Cobalt
Cr	Chromium
Cu	Copper
Fe	Iron
K	Potassium
Mg	Magnesium
Mn	Manganese
Mo	Molybdenum
N	Nitrogen

Na	Sodium
Ni	Nickel
P	Phosphorus
Pb	Lead
S	Sulfur
Zn	Zinc

Measured Units

$\mu g \cdot g^{-1}$	Micrograms per gram
$\mu g \cdot L^{-1}$	Micrograms per liter
$\# \cdot m^{-2}$	Number per square meter
# taxa·dredge^{-1}	Number of taxa per dredge
$\delta^{13}C$	$Carbon^{13}$ to $Carbon^{12}$ ratio
$\delta^{15}N$	$Nitrogen^{15}$ to $Nitrogen^{14}$ ratio
%	Percent
BMI·m^{-2}	Benthic Macroinvertebrates per square meter
cm^2	Square centimeters
$g \cdot m^{-2}$	Grams per square meter
individuals·dredge^{-1}	Individuals per dredge
individuals·m^{-2}	Individuals per square meter
kg	Kilograms
kg·day^{-1}	Kilograms per day
km	Kilometers
mV	MilliVolts
snails·dredge^{-1}	Snails per dredge
snails·m^{-2}	Snails pre square meter

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Background

The addition of wastewaters containing unnatural amounts of nutrients (for Middle Snake region: >42.5 $\mu g \cdot l^{-1}$ total phosphorus and >0.3 $mg \cdot l^{-1}$ nitrate+nitrite), sediment, and organic matter from various effluents and discharges has been impacting riverbed environments for many years. These waste loadings often modify the natural species diversity, density, and biomass of plants and animals in rivers (Thiebaut and Muller 1998, Parkhill and Gulliver 2002). Hence, plants and animals have been increasingly used as indicators of water quality in running waters. In particular, benthic macroinvertebrates (BMI) (Linke et al. 1999, Timm et al. 2001, Rueda et al. 2002) and aquatic macrophytes (AM) (Grasmuck et al. 1995, Tremp and Kohler 1995) have been useful as bioindicators of overall aquatic ecosystem health. These organisms are useful because they are relatively sedentary in nature (and thereby exposed to environmental conditions over a period of time), are abundant and diverse in aquatic systems, are relatively easy and economical to sample, and cover a wide range of pollution tolerances (Gopal and Chamanlal 1991, Linke et al. 1999, Rueda et al. 2002).

The agriculture and aquaculture industries have been known to play a major role in the contribution of nutrients and sediments to lotic environments (Brown et al. 1974, Omernik et al. 1981, Doupe et al. 1999, Varadi 2001, Owens and Walling 2002). Waste discharges from agriculture may include both irrigation return flows and overland flows from non-irrigated agriculture, both which contribute elevated sediment and associated nutrients from runoff (Robison et al. 2002). Aquaculture wastewater typically includes particulate organic material from unconsumed feed and fecal matter (Pawar et al. 2001) as well as soluble organics (IDEQ 1995). Organic matter is considered the primary pollutant causing benthic enrichment below experimental marine aquaculture net cages (Tlusty et al. 2000) and aquaculture net cages in Japan (Pawar et al. 2001). Organic matter is also a primary pollutant downstream of inland aquaculture operations in Australia (Doupe et al. 1999) and Europe (Varadi 2001). Large inputs of particulate organic matter from aquaculture sites can settle to the sediments and create enriched conditions from two to 20 times background values that will impact the chemistry and ecology of the benthos (Tlusty et al. 2000). With accrual, these sediments may become reducing sediments and create an anaerobic environment that will enhance mobilization of nutrients and contaminants from the sediments, such as hydrogen sulfide, ammonium, methane, carbon dioxide, and metals.

The Idaho Department of Environmental Quality (IDEQ) has listed the middle Snake River in south-central Idaho as water quality-limited under the Clean Water Act since 1990 (Clark and Ott 1996, Falter and Burris 1996). Specific stream segments not meeting water quality standards are listed under *Section 303(d)* of the Clean Water Act. These listings have been the result of decades of point and non-point discharges. Studies in the 1990's (Brockway and Robison 1992, Falter and Carlson 1994, Falter et al. 1995, Falter and Burris 1996) have demonstrated the extent of the water quality problem in the middle Snake River. Sampling 55 sites along the middle Snake River (1990-1991), Brockway and Robison (1992) concluded that a 151-km stretch of river from Milner Dam (River Kilometer (RK) 1029.8) to King Hill (RK 878.5) accumulated and transported up to 27,216 $kg \cdot day^{-1}$ of nitrate+nitrite, 1,814 $kg \cdot day^{-1}$ of phosphate, and 317,515 $kg \cdot day^{-1}$ of suspended solids. Further study of the middle Snake River from Twin Falls (RK 989.7) downstream to Upper Salmon Falls Dam (RK 935) in 1992 (Falter and Carlson 1994), 1993 (Falter et al. 1995), and 1994 (Falter and Burris 1996) concluded that biomass levels for the plant community reached densities exceeding 3,000 $g \cdot m^{-2}$, while chlorophyll *a* concentrations, dissolved nutrient concentrations, and sediment nutrient levels were all indicative of a eutrophic system.

Purpose and Objectives

The goal of this study was to characterize the sediment and associated aquatic communities (BMI and AM) upstream and downstream of waste loadings from agriculture and aquaculture operations to the middle Snake River in south-central Idaho. Specific objectives were to:

(1) Spatially define sediment deposition zones directly downstream of three agriculture drains and three aquaculture discharges to the middle Snake River in 2000;

(2) Compare sediment composition upstream (control zone) and downstream (deposition zone) of three agriculture drains and three aquaculture discharges to the middle Snake River in 2000 and 2001;

(3) Compare BMI density, biomass, and taxa richness upstream (control zone) and downstream (deposition zone) of three agriculture drains and three aquaculture discharges to the middle Snake River in 2001; and

(4) Compare AM biomass and species composition upstream (control zone) and downstream (deposition zone) of three agriculture drains and three aquaculture discharges to the middle Snake River in 2001.

Study Area

The middle Snake River, located in south-central Idaho, lies in the northwestern edge of the Great Basin and occupies part of the former range of Pliocene Lake Idaho (Cazier and Myers 1996). The river carves a canyon through the basalt layers of south-central Idaho, in the center of the resulting Snake River Plain. The Snake River Plain extends 80 to 200 km north to south, from the southern edge of the central Idaho mountains to the Great Basin uplift in southern Idaho, and 645 km east to west, from the Owyhee mountains to the western edge of the Rocky Mountains (USFWS 1995). The middle Snake River collects the cold, clear waters of the Snake River Plain Aquifer that flow as springs from the north basalt canyon walls, having originated from the Lost River and Birch Creek sinks into the basalt layers some 195 miles to the northeast. These coldwater springs, contributing approximate year-round flows of 142 to 170 $m^3 \cdot s^{-1}$ to the river (Robison et al. 2002), provide optimal temperatures (14-17 °C) for culturing rainbow trout (Oncorhynchus mykiss) and other coldwater fish species. As a result, there are approximately 144 permitted fish rearing facilities adjacent to the middle Snake River that are responsible for producing approximately 70% of the nation's cultured rainbow trout (IDEQ 1995).

The middle Snake River is highly regulated by dams and diversions, primarily for irrigation and hydroelectric power generation (Clark and Ott 1996). During the irrigation season (April-October) much of the river is diverted out-of-channel to supply canals at Milner Dam (RK 1029.8) for irrigating approximately 145,700 hectares of land by sprinkler and traditional gravity methods (Robison et al. 2002). Most of the summer flow of the middle Snake River downstream of Milner Dam is as a result of irrigation return flows, agriculturally impacted tributaries, and spring flows.

Numerous point and non-point source waste loadings occur throughout the middle Snake River from irrigation returns, aquaculture effluents, confined animal feeding operations, and wastewater treatment plant returns (Brockway and Robison 1992, Falter and Burris 1996, EPA 2002). Waste loadings to the middle Snake River peak in a short stretch from Twin Falls, Idaho

(RK 984.6) to Upper Salmon Falls Dam (RK 935.5). This present study focuses on the middle Snake River between Twin Falls, Idaho and Upper Salmon Falls Dam (Figure 1).

METHODS

Study Sites

This study was conducted on a subset of existing aquaculture and agriculture discharges to the middle Snake River, selected both for their relatively large volumes and discharge to rapids-free river reaches likely to be deposition zones. A total of three irrigation return flows (Ag Drains) and three aquaculture facility discharges were sampled for sediment in 2000 and sediment, BMI, and AM in 2001 (Figure 1). The three agriculture drains selected for study all flow from the south, or left bank of the Snake River, and were located at RK 970.9 (Pigeon Cove LQ & LS Drain), 969.0 (Southside LS2/39A Drain), and 967.1 (Southside 39 Drain) (Brockway and Robison 1992, EPA 2002). In the remainder of this document, these Ag Drains will be referred to as AD3, AD2 and AD1, respectively. The three aquaculture discharges selected for study were those from Crystal Springs Hatchery (RK 966.4), Rim View Hatchery (RK 963.5), and Box Canyon Hatchery (RK 946.8), which use spring waters from Crystal Springs, Niagara Springs, and Box Canyon Springs, respectively.

Sample Collection

The deposition zone, within the first 150 meters downstream of each discharge, was defined by using a 1.83-meter calibrated metal rod. The rod was pushed down vertically through the sediments to determine the depth and substrate composition (*i.e.*, fine sediments, sand, gravel, or cobble) of the river bottom by feel and sound. PVC attachments were connected to the rod for probing in water depths up to 5.5 meters. However, because the rod itself was only 1.83 meters in length, we were limited to recording a maximum sediment depth of 1.83 meters, even if the actual sediment depth exceeded this maximum. Rod instability was already an issue with the 1.83-meter rod length; longer rod lengths would have resulted in an increased occurrence of rod bending. The rod was used from an anchored boat at 42 different point locations per site using a systematic grid design (Figure 2). The design allowed probing of the sediments from three different distances from the shoreline (5, 10, and 15 meters) and from 14 different distances from the discharge (10-150 meters). We conducted this sediment probing technique one time for each site during June, 2000.

In 2000, we collected sediment samples monthly from August to October. In each month, 16 samples were collected at each of the six study sites. At each site, we collected eight control samples upstream of the discharge (control zone) for comparison with eight samples collected downstream of the discharge (deposition zone). Samples were collected at systematic random distances from the discharge along a virtual line parallel to the shore (Figure 3).

Due to replication discrepancies, the sample design was changed for 2001 (Figure 4). In 2001, sediment, BMI, and AM samples were collected monthly from June to October, where 12 samples were collected monthly at each of the six study sites. The irrigation return flows are typically active from June to October, which led us to use these months as the bounds of our sampling period. At each site, a cluster of four replicate samples were collected at least 200 meters upstream of each discharge (control zone) for comparison with eight samples collected downstream of the discharge (deposition zone). We separated these eight deposition zone samples into two clusters of four replicates, with the first cluster of four randomly sampled between 100 and 200 meters downstream from the discharge and the second cluster randomly sampled between 1 and 100 meters downstream from the discharge. Due to differences in sampling strategy for each year, the sampled sediment could not be compared between years and statistical analysis of 2000 data could not be completed.

All sediment samples were collected with a Petite Ponar Dredge (225 cm^2). In 2000, all BMI and AM were removed from the sediment and returned to the river. In 2001, sediment, BMI, and AM were each separated, preserved, and transported for laboratory analysis. All sample collection techniques followed standard operating procedures (SOP's) detailed in Appendix A.

Immediately following collection of each sample, BMI were sorted in the field to quantify and return any listed species to the river. Dustin Hinson was the only qualified individual in the field to identify listed species. Mr. Hinson was sufficiently trained in the identification of the five listed species by Scott Lindstrom, a BMI taxonomist from EcoAnalysts in Moscow, Idaho. Mr. Lindstrom is a qualified expert in the identification of Snake River listed snail species. Due to the extreme densities of BMI in some samples, some specimens of the endangered snail, *Valvata utahensis*, went unnoticed and were not returned to the river in the field. These *Valvata utahensis* specimens were identified during laboratory processing and verified as the endangered snail by Scott Lindstrom. All preserved Valvata utahensis identified in the laboratory were sent to Bill Clark, Assistant Director of the Orma J. Smith Museum of Natural History, at Albertson College of Idaho, Caldwell, Idaho for permanent housing.

Laboratory Analysis

Sediment

Sediment samples were transported and processed at the University of Idaho Analytical Sciences Laboratory in Moscow, Idaho. Physical sediment analysis included particle size composition of sand, silt, and clay [Bouyoncos Hydrometer Method (Appendix A)]. Settling tube particle size analysis (*i.e.* Bouyoncos Hydrometer Method) is described as being superior to other methods (Le Roux 1998). Chemical sediment analysis included percent carbon and nitrogen [LECO® Combustion Analyzer CNS-2000 (Appendix A)], as well as the trace elements phosphorus, calcium, magnesium, potassium, sodium, zinc, manganese, copper, iron, sulfur, lead, chromium, cadmium, barium, nickel, cobalt, beryllium, and molybdenum [EPA 3050 screen (Appendix A)]. Sediment organic matter content (percent by dry weight) was not measured in 2001 middle Snake River sediments. As a result, organic matter measurements from 2000 middle Snake River sediments were used for inferential analysis.

Stable isotope analysis was used as an exploratory technique for determining the source of middle Snake River sediments. The objective of this analysis was to determine whether sediment stable isotopes ($\delta^{13}C$ and $\delta^{15}N$) could be used to differentiate agriculture or aquaculture sources of sediment. Stable Isotope sediments were processed and analyzed at the University of Idaho Stable Isotope Laboratory using an Elemental Analyzer online with a Delta Plus Isotope Ratio mass spectrometer. The results of this analysis are detailed in Appendix B.

Benthic Macroinvertebrates

BMI samples were preserved in 70% Ethanol with Rose Bengal Dye until processing. The high numbers of BMI in each sample warranted the use of a laboratory subsampling apparatus to make processing more efficient. The subsampling apparatus was a horizontal, rotating circular chamber that was equally divided into ten sub-chambers. Each sample, after being uniformly mixed in water, was slowly poured from a fixed point into the rotating chamber, thus equally divided between the ten sub-chambers. Subsamples were randomly chosen and sequentially processed until a cumulative count of at least 100 individuals was reached (Wrona et al. 1982). The total number of subsamples it took to reach at least 100 individuals was used as a multiplier to estimate the total number of BMI in the full sample. This method was used by Hickley (1975) to achieve a ±20% precision at 95% confidence level. These estimated counts were used to calculate total BMI density ($\#\cdot m^{-2}$) and the density of selected BMI taxa, including *Valvata* *utahensis*, *Potamopyrgus antipodarum*, and Chironomidae spp. The standard procedure for BMI oven dry weight (ODW) (Benke 1996) was used to estimate total biomass ($g \cdot m^{-2}$) for each grab sample. BMI were identified to the lowest practical taxonomic level following the manuals *An Introduction to the Aquatic Insects of North America* (Merritt and Cummins 1984), *Freshwater Snails of North America* (Burch 1982), and *Freshwater Invertebrates of the United States* (Pennak 1978). Taxa richness was determined by counting the total number of different taxa identified in each grab sample. BMI were typically identified to the family level, with selected taxonomic groups only identified to the Phylum or Class level (*i.e.* Phylum Nematoda, Class Oligochaeta) due to their difficult distinction. This potential undercounting of taxa could be a source of error in the BMI richness metric.

Aquatic Macrophytes

AM were frozen in plastic bags until processing. Each thawed sample was washed to remove detritus, sediment, and epiphytic algae before identification (Wagner and Falter 2002). All vascular submergent AM were identified to species using the manuals *The Aquatic Plants* (Prescott 1969) and *Flora of the Pacific Northwest* (Hitchcock and Cronquist 1973). The Standard Methods Procedure (10400 D.3) for AM ODW or biomass ($g \cdot m^{-2}$) was used to estimate percent species composition by weight for each grab sample (APHA 1992). All mean AM biomass values include grab samples with an AM biomass of zero. Algae were excluded from all analyses.

Statistical Analysis

Sediment

The sediment samples collected in 2000 were later deemed pseudo-replicates so we could not compare data collected in 2000 with data collected in 2001. Statistical analyses herein were only applied to sediment data collected in 2001. Multivariate analysis of variance (MANOVA) methods were used to test whether any of the 23 measured sediment variables differed ($p < 0.05$) between the five sampling months (June-October) and the six study sites (AD3, AD2, AD1, Crystal Springs, Rim View, and Box Canyon) using the general linear model (GLM) procedure in The SAS System for Windows (version 8.02). The multivariate normal assumption was checked prior to running the MANOVA using the principal components procedure in The SAS System for Windows (version 8.02).

After checking for significant differences in the data using all variables combined, analysis of variance (ANOVA) methods were used to test for significant differences ($p < 0.05$) between the deposition zone (downstream of discharge) sediments of pooled agriculture sites and pooled aquaculture sites for each of the 23 variables and for each of the five sampling months. However, comparisons of deposition zones for each variable and for each month were only made if the differences between agriculture and aquaculture control zones (upstream of discharge) for that same variable and month were determined to be statistically similar (no significant difference, $p > 0.05$).

ANOVA methods were also used to test for significant differences ($p < 0.05$) between control (upstream of discharge) and deposition (downstream of discharge) grab samples for each of the 23 variables independently. To facilitate comparison between control and deposition zones, grab samples from both deposition zone clusters were pooled prior to running the ANOVA tests. The GLM procedure in The SAS System for Windows (version 8.02) was used for all ANOVA tests with an *a priori* significance level of $\alpha = 0.05$. The univariate normal assumption was checked prior to running the ANOVA tests using the univariate procedure in The SAS System for Windows (version 8.02).

Benthic Macroinvertebrates

Multivariate analysis of variance (MANOVA) methods were used to test whether any of the three measured BMI variables (abundance, biomass, and taxa richness) differed ($p < 0.05$) between month or site using the general linear model (GLM) procedure in The SAS System for Windows (version 8.02). The multivariate normal assumption was checked prior to running the MANOVA using the principal components procedure in The SAS System for Windows (version 8.02).

After checking for significant differences in the data using all variables combined, analysis of variance (ANOVA) methods were used to test for significant differences ($p < 0.05$) between the deposition zone (downstream of discharge) BMI populations of pooled agriculture sites and pooled aquaculture sites for each of the three variables and for each of the five sampling months. However, comparisons of deposition zones for each variable and for each month were only made if the agriculture and aquaculture control zones (upstream of discharge) for that same variable and month were determined to be statistically similar (no significant difference, $p > 0.05$).

ANOVA methods were also used to test for significant differences ($p < 0.2$) between control (upstream of discharge) and deposition (downstream of discharge) grab samples for each of the three BMI variables independently. To facilitate comparison between control and deposition zones, grab samples from both deposition zone clusters were pooled prior to running the ANOVA tests. The GLM procedure in The SAS System for Windows (version 8.02) was used for all ANOVA tests with an *a priori* significance level of $\alpha = 0.05$. *Post hoc* significance levels were increased to $\alpha = 0.2$ for the control and deposition zone grab sample comparisons for all three variables. This increased significance level was selected because of the inherently variable nature of biological populations. The univariate normal assumption was checked prior to running the ANOVA tests using the univariate procedure in The SAS System for Windows (version 8.02).

Aquatic Macrophytes

Analysis of variance (ANOVA) methods were used to test whether overall AM biomass differed ($p < 0.05$) between month or site using the general linear model (GLM) procedure in The SAS System for Windows (version 8.02). ANOVA methods were also used to test for significant differences ($p < 0.05$) between deposition zone (downstream of discharge) AM biomass of pooled agriculture sites and pooled aquaculture sites for each of the five sampling months. However, industry comparisons of deposition zone AM biomass for each month were only made if AM biomass in agriculture and aquaculture control zones (upstream of discharge) for that same month were determined to be statistically similar (no significant difference, $p > 0.05$).

ANOVA methods were also used to test for significant differences between control (upstream of discharge) and deposition (downstream of discharge) grab samples according to AM biomass. To facilitate comparison between control and deposition zones, grab samples from both deposition zone clusters were pooled prior to running the ANOVA tests. The GLM procedure in The SAS System for Windows (version 8.02) was used for the ANOVA tests with an *a priori* significance level of $\alpha = 0.5$. *Post hoc* significance levels were increased to $\alpha = 0.2$ for the control and deposition zone AM biomass comparison. As with BMI, this increased significance level was selected because of the inherently variable nature of biological populations. The univariate normal assumption was checked prior to running the ANOVA tests using the univariate procedure in The SAS System for Windows (version 8.02).

RESULTS

Sediment Depth

Substrate probing was conducted in an attempt to define sediment depth downstream of the six study site discharges and to understand how sediment depth changed with distance downstream from the discharge. Sediment depths were not measured upstream of discharges because the purpose was not to compare results upstream and downstream of the discharge as with the other measured variables. However, comparisons can be made between agriculture and aquaculture sediment depths.

Sediment depth, including clay, silt, sand, and pea gravel substrates (< 5 mm diameter), in the middle Snake River ranged from zero meters downstream of AD3 (Agriculture Drain 3) to the maximum measurable depth of 1.83 meters downstream of Box Canyon, Rim View, Crystal Springs, AD1 (Agriculture Drain 1), AD2 (Agriculture Drain 2), and AD3 discharges (Figures 5 and 6). At agriculture sites, sediment depth did not show any general trends with increasing distance downstream from the discharge. However, agriculture sediment probing locations reached maximum measurable sediment depth (1.83 meters) more frequently than below aquaculture discharges. Specifically, the maximum measurable depth was reached at 51 of 123 (41 %) agriculture probing locations below agriculture discharges. These maximum depth sediment probing locations were evenly located along the entire 150 meters downstream of the agriculture discharge and for all three distances from the shoreline (5, 10, and 15 meters). The greatest occurrence of the maximum depth probing locations (*i.e.*, fine sediment), 29 of 51 (57 %), were located downstream of AD2.

Below aquaculture discharges, sediment depth generally increased as the distance downstream from the discharge increased. The maximum measurable depth (1.83 meters) was reached at 16 of 122 (13 %) aquaculture probing locations. The majority of these maximum depth sediment probing locations were located between 100 and 150 meters downstream of the aquaculture discharges and 10 meters from the shoreline.

Sediment Characterization

A difference between sediment organic matter downstream of agriculture and aquaculture industries was apparent in 2000 middle Snake River sediments. Maximum sediment organic matter (5.0 %) was sampled downstream of the Crystal Springs study site in October. Minimum sediment organic matter (0.23 %) was sampled downstream of the AD3 study site in September. Sediment organic matter downstream of aquaculture discharges averaged 1.30, 2.20, and 1.85 % for CS, RV, and BC, respectively. Sediment organic matter downstream of agriculture discharges averaged 0.75, 0.88, and 1.12 % for AD3, AD2, and AD1, respectively. Average organic content of sediments downstream of aquaculture discharges (1.78 %) was nearly twice that of average sediment organic content downstream of agriculture discharges (0.91 %). This distinct difference in organic matter composition is likely caused by the increase in aquatic vegetation downstream of aquaculture facilities coupled with the sustained organic input from aquaculture discharges.

Samples from June-October, 2001 were used to assess the mean, standard deviation and range of physical and chemical sediment characteristics over all study sites (Table 1). Physical and chemical sediment characteristics showed high variability throughout the reach for all measured variables. For example, sediment sand content ranged from 33.2-98.6 % throughout the sampling period, while sediment phosphorus ranged from 340-2,200 $\mu g \cdot g^{-1}$.

We compared the mean physical and chemical makeup of the substrate in the control and deposition zones between pooled agriculture sites and pooled aquaculture sites for all months combined (Table 2). Trends begin to appear with this further breakdown of mean sediment values. For example, mean sediment nitrogen, phosphorus, and sulfur were greater in aquaculture deposition zones (N = 0.1%, P = 1,473.93 $\mu g \cdot g^{-1}$, and S = 2,177.0 $\mu g \cdot g^{-1}$) than aquaculture control zones, agriculture control zones, or agriculture deposition zones. However, the sediment metrics, Sodium, Manganese, Iron, Barium, and Nickel were greater in agriculture control zones (Na = 823.67 $\mu g \cdot g^{-1}$, Mn = 207.93 $\mu g \cdot g^{-1}$, Fe = 13,808.33 $\mu g \cdot g^{-1}$, Ba = 113.7 $\mu g \cdot g^{-1}$, and Ni = 1,819.0 $\mu g \cdot g^{-1}$) than agriculture deposition zones, aquaculture control zones, or aquaculture deposition zones.

Statistical Comparisons

Statistical tests were performed on sampled middle Snake River sediment for two primary purposes. First, it was critical to determine whether various measured sediment parameters were statistically different between agriculture deposition zones and aquaculture deposition zones. Secondly, we attempted to decipher statistical differences between these sediment parameters in the control and deposition zones of each individual site. Principal components analysis showed that sediment data were approximately multivariate normal because each principal component was approximately univariate normal (Johnson 1998). The principal components analysis also pointed out a few outliers in the data. It was determined that these outliers couldn't be removed because the values were reasonable and were consistent between replicates. The MANOVA tests showed that there was a significant month difference for at least one of the 23 measured sediment variables (Wilks' Lambda, $p<0.0001$), indicating that there is a temporal pattern in the physical and chemical characteristics of the sediment. The MANOVA tests also showed that there was a significant site difference for at least one of the 23 measured variables (Wilks' Lambda, $p<0.0001$), indicating that there is a spatial pattern in the physical and chemical characteristics of the sediment. Due to multivariate differences by month and site, ANOVA tests comparing control and deposition zones were run on each month and site separately. Data used in all sediment ANOVA tests were not transformed because the univariate procedure showed all variables were approximately normal.

Tables 3 through 7 show mean sediment values for each month, site, and zone independently as well as indicate whether significant differences occurred between the mean sediment values. A consistent pattern became evident when analyzing these results. The pattern indicates that a significantly greater proportion of fine material (silt and clay) in a sediment sample was typically associated with a significantly greater concentration of trace elements in a sample. For example, sediment sampled from the AD3 study site in August had significantly greater proportions of silt and clay in the control zone (silt = 48.0 % and clay = 3.8 %) than the deposition zone (silt = 8.4 % and clay = 1.7 %) (Table5). Likewise, significantly greater concentrations of all 20 trace elements occurred in the control zone sediments of AD3 than the deposition zone sediments of AD3 in August. This positive relationship between the proportion of fine material and the concentration of trace elements remained consistent for all other sites and months. The high proportion of sand in the AD3 deposition zone sediments in August also contributed to the low trace element concentrations downstream of the discharge.

Figures 7-52 not only illustrate the data presented in Tables 3-7 but also provide a comparison between the aquaculture and agriculture industry deposition zone sediments based on the 23 measured sediment variables. Significant differences between agriculture and aquaculture deposition zones are illustrated in Figures 7-52, as well as significant differences between the control and deposition zones of each site. Descriptions of these results are detailed in Appendix C.

Benthic Macroinvertebrates

Benthic macroinvertebrates (BMI) were collected from the middle Snake River in 2001 to assess the changes in benthic community structure as a result of agriculture and aquaculture discharges. BMI abundance, biomass, and taxa richness were measured to quantitatively assess in-stream differences in benthic community structure.

The BMI community sampled from the middle Snake River in 2001 consisted of a variety of taxonomic categories, including insects, crustaceans, turbellarians, oligochaetes, hirudineans, nematodes, gastropods, and pelecypods. A full list of middle Snake River sampled taxa, including the sites and zones (control and deposition) from which they were collected are shown in Table 8. Gastropods, oligochaetes, and amphipods were the most frequent taxonomic groups collected, occupying all sites and zones of collection. Four different gastropod taxa, *Potamopyrgus antipodarum*, *Gyraulus parvus*, *Physella* spp., and *Pisidium* spp., occupied all sites and all zones of collection. Chironomids were sampled in all sites and zones except for the Box Canyon control zone.

BMI were also used to assess the benthic community structure in the control and deposition zones of pooled agriculture sites and pooled aquaculture sites for all months combined (Table 9). Results indicate that both BMI abundance ($\#\cdot m^{-2}$) and biomass ($g\cdot m^{-2}$) were about ten times greater downstream of aquaculture discharges (32,600 and 34.2, respectively) than downstream of agriculture discharges (3,111 and 3.3, respectively). The number of distinct BMI taxa sampled (richness) was also greater downstream of aquaculture discharges (6.0) than downstream of agriculture discharges (4.0).

BMI abundance, biomass, and richness varied within each type of discharge (Table 9). At agriculture study sites, an average of 10 % more $BMI\cdot m^{-2}$ were collected upstream of the discharge (3,415) than downstream (3,111). However, average BMI biomass ($g\cdot m^{-2}$) sampled from agriculture sites was 10 % greater downstream of the discharge (3.3) than upstream (3.0). These resulting abundance and biomass averages from agriculture sites indicate that the average weight of BMI individuals was greater downstream of the discharges than upstream. The average number of distinct taxa (richness) sampled upstream of agriculture discharges (4.6) was greater than the average number of distinct taxa sampled downstream of agriculture discharges (4.0).

At aquaculture sites, an average of 19 % more BMI·m^{-2} were sampled downstream of discharges (32,610) than upstream (27,383) (Table 9). Alternately, average biomass (g·m^{-2}) at aquaculture sites was 13 % greater upstream of discharges (38.6) than downstream (34.2). Unlike agriculture sites, average abundance and biomass values at aquaculture sites indicate that the average weight of BMI individuals was greater upstream of the discharges than downstream. Table 9 also shows that the average number of distinct taxa sampled downstream of aquaculture sites (6.0) was greater than the average number of distinct taxa sampled upstream of aquaculture sites (5.5).

Tables 10-14 show average BMI abundance, biomass, and taxa richness values for each month, site, and zone independently. Average BMI abundance was approximately 9x greater downstream of aquaculture discharges than downstream of agriculture discharges in June, August, and October of 2001 (Figure 53). Average monthly BMI abundance was consistently high downstream of the RV discharge and upstream of the BC discharge (Figure 54). Average monthly BMI abundance was greatest downstream of the RV discharge in June, where the total number of organisms exceeded 231,000 individuals·m^{-2}, 73% of which were *P. antipodarum*. Minimum monthly BMI abundance occurred upstream of the AD3 discharge in September, where the total number of organisms was less than 870 individuals·m^{-2}. Species-specific BMI abundances are shown in Figures 55-58 and are described in the section below.

Average BMI biomass was 14x greater downstream of aquaculture discharges than agriculture discharges in August and 6x greater in October, 2001 (Figure 59). As with average monthly BMI abundance, average monthly BMI biomass was consistently high downstream of the RV discharge and upstream of the BC discharge (Figure 60). The greatest monthly BMI biomass was sampled upstream of the BC discharge, exceeding 287.0 g·m^{-2}. The minimum monthly BMI biomass value of 0.4 g·m^{-2} was sampled upstream of the AD2 discharge in September.

Average BMI taxa richness was at least 25% greater downstream of aquaculture discharges than downstream of agriculture discharges for all months sampled (Figure 61). Average monthly BMI taxa richness was consistently high upstream of the RV discharge during the entire five month study, and reached a maximum of 10.3 in September (Figure 62). Consistently low monthly BMI taxa richness was evident upstream of the BC discharge, with minimum values falling to 1.7 in August. The generally low monthly taxa richness upstream of the BC discharge coincides with high densities of the exotic snail, *Potamopyrgus antipodarum*, and low densities of all other aquatic organisms. .

Species Specific Abundance

Valvata utahensis

Valvata utahensis (Utah Valvata) was the only listed species encountered throughout the 2001 benthic macroinvertebrate sampling effort. During the study, we found a single population of *V. utahensis* along the south bank of the river, about 200 meters downstream of Box Canyon aquaculture facility (RK 946.8). *V. utahensis* were found in 15 of the 20 dredge samples (75 %) collected at this location (June-October, 2001). Live *V. utahensis* from these 15 dredges ranged in number from 1-13 individuals per dredge, with an average density of 2.67 snails·dredge^{-1} (118.5 snails·m^{-2}). They inhabited very fine, black, organically enriched sediments with very heavy macrophyte communities and associated filamentous algae.

Potamopyrgus antipodarum

The exotic *Potamopyrgus antipodarum* (New Zealand mudsnail) was sampled at all six study sites during the 2001 benthic macroinvertebrate sampling effort. *P. antopodarum* were found in 179 of the 359 total dredge samples (49.9 %) at all six sites (June-October, 2001). Live *P. antipodarum* from the 359 total dredges ranged in number from 0-12,770 individuals, with an average density of 258 snails·dredge^{-1} (11,457 snails·m^{-2}). Average *P. antipodarum* abundance was greater downstream of aquaculture discharges than agriculture discharges by 4500x in June, 100x in August, and 500x in October, 2001 (Figure 55). The greatest *P. antipodarum* densities occurred 200 meters upstream of Box Canyon aquaculture facility (RK 946.8, south bank), and between 100 and 200 meters downstream of Rim View aquaculture facility (RK 964.0, north bank) (Figure 56). Densities at these particular Box Canyon and Rim View locations averaged 66,131 individuals·m^{-2} and 98,764 individuals·m^{-2}, respectively, over 20 dredge samples at each site. Overall, maximum *P. antipodarum* density occurred in a grab sample between 100 and 200 meters downstream of the Rim View aquaculture facility in June, 2001. This sample had 12,770 individuals, equivalent to 567,556 *P. antipodarum*·m^{-2}. Many of the *P. antipodarum* sampled in this particular grab were attached to the dense aquatic macrophyte and filamentous algae growth. The sediments in this area were very fine, black, and organically enriched. The distinct odor of reducing sediments (H_2S) was also evident.

Chironomidae spp.

Chironomidae spp. were sampled at each of the six study sites during the 2001 benthic macroinvertebrate sampling effort. Chironomidae spp. were found in 274 of the 359 total dredge samples (76.3 %) at all six sites (June-October, 2001). Live Chironomidae from the 359 total dredges ranged in number from 0-160 individuals, with an average density of 6.39 individuals·dredge^{-1} (284 individuals·m^{-2}). Average Chironomidae abundance was greater downstream of agriculture discharges than aquaculture discharges by 300% in June and 60% in September, 2001 (Figure 57). Greatest Chironomidae densities occurred in the deposition zone of the Crystal Springs study site in July (Figure 58). Densities at this particular location averaged 4,006 individuals·m^{-2} over eight dredge samples. Overall, maximum Chironomidae density occurred in a July grab sample 2.5 meters in depth and between 100 and 200 meters downstream of the Crystal Springs aquaculture facility. This sample had 160 individuals, equivalent to 7,111 Chironomidae·m^{-2}. The Chironomidae sampled in this particular grab were burrowed into the fine sediment. The sediments in this sample were classified as loamy sand and lacked the black, gelatinous consistency and H_2S odor typically associated with reducing sediments. There was very little aquatic macrophyte biomass sampled at this location and mats of filamentous algae were absent.

Statistical Comparisons

Statistical tests were performed on sampled BMI populations for two primary purposes. First, it was critical to determine whether BMI metrics (abundance, biomass, and taxa richness) were statistically different downstream of agriculture sites and aquaculture sites. Secondly, we attempted to decipher statistical differences between these BMI parameters in the control and deposition zones of each individual site. The principal components analysis showed that the BMI data (abundance, biomass, and taxa richness) were approximately multivariate normal because each principal component was approximately univariate normal. There were a few outliers indicated by the principal components analysis but these were not removed because the values were reasonable and were consistent between replicates. The MANOVA tests showed that there was a significant month difference for at least one of the three measured variables (Wilks' Lambda, $p<0.0001$), meaning that BMI populations showed a temporal variability. The MANOVA tests also showed that there was a significant site difference for at least one of the three measured variables (Wilks' Lambda, $p<0.0001$), meaning that the BMI populations showed a spatial variability. Because of the multivariate differences by month and site, the ANOVA tests comparing BMI population metrics between control and deposition zones were run on each month and site separately. Data used in all BMI ANOVA tests were not transformed because the univariate procedure showed all variables to be approximately normal.

Tables 10-14 indicate whether significant differences occurred between the average BMI values upstream and downstream of each discharge by site and month. At agriculture sites, general trends show that BMI taxa richness was significantly greater upstream of the discharges about five times more often than downstream of the discharges. At aquaculture sites, general trends show that BMI abundance and biomass were significantly greater downstream of the discharge about two times more often than upstream of the discharge. Figures 53-62 provide a comparison between the aquaculture and agriculture industry deposition zone sediment BMI variables (abundance, biomass, taxa richness, *P. antipodarum* abundance, and *Chironomidae* spp. abundance). Significant differences between agriculture and aquaculture deposition zones are illustrated in Figures 53-62, as well as significant differences between the control and deposition zones of each site. Descriptions of these results are detailed in Appendix C.

Aquatic Macrophytes

Seven vascular AM taxa were sampled from five different families throughout the five-month sampling period on the middle Snake River (Table 15). *Potamogeton crispus*, *Elodea canadensis*, and *Ceratophyllum demersum* were the most abundant species sampled at the aquaculture study sites (Tables 16,17, and 18). *Potamogeton crispus* and *Ceratophyllum demersum* were the most abundant species sampled at the agriculture study sites (Tables 19,20, and 21). *P. crispus* dominated both control (54.3 %) and deposition (54.9 %) zones of the Box Canyon study site. *P. crispus* also dominated the control zone (62.9 %) of AD2 and both the control (51.6 %) and deposition (75.6%) zone of AD3. *E. canadensis* dominated both the control (86.8 %) and deposition (84.5 %) zone of the Rim View study site, and the control zone (69.8 %) of the Crystal Springs study site. *C. demersum* was not only dominant in the deposition zone (47.0 %) of the Crystal Springs study site, but it was also the most dominant species in the control (93.7 %) and deposition (93.9 %) zone of AD1 and the deposition zone (95.0 %) of AD2.

Statistical Considerations

Statistical tests were performed on sampled AM populations for two primary purposes. First, it was critical to determine whether AM biomass was statistically different downstream of agriculture sites and aquaculture sites. Secondly, we attempted to decipher statistical differences between AM biomass in the control and deposition zones of each individual site. ANOVA results indicate that there was a significant month difference in overall AM biomass ($p = 0.0242$), meaning that AM populations showed temporal variability. There was also a significant site difference in overall AM biomass ($p < 0.0001$), meaning that AM populations showed spatial variability. As a result, data from each month and site were kept separate when analyzing for significant differences between AM biomass in the control and deposition zones.

Tables 10-14 indicate whether significant differences occurred between the average AM biomass upstream and downstream of each discharge across each different site and month. Distinct trends became evident and were unique to each industry. At agriculture sites, AM biomass was never significantly greater downstream of the discharge than upstream. In fact, 4 of 15 sampling occurrences (3 agriculture sites x 5 sampling months = 15 sampling occurrences) resulted in significantly greater AM biomass upstream of the discharge than downstream. At aquaculture sites, on the other hand, AM biomass was never significantly greater upstream of the discharge than downstream. Seven of 15 sampling occurrences (3 aquaculture sites x 5 sampling months = 15 sampling occurrences) resulted in significantly greater AM biomass downstream of the discharge than upstream.

Figure 63 provides a comparison between the AM biomass in the deposition zones of pooled aquaculture study sites and pooled agriculture study sites. Significant differences between the control and deposition zones of each site for each of the five sampling months are illustrated in Figure 64. Further description of AM biomass results is detailed in Appendix C. Average AM biomass was greater downstream of aquaculture discharges than agriculture discharges by 40x in June and 5x in September, 2001 (Figure 63). The greatest AM biomass sampled from the middle Snake River in 2001 occurred within 200 meters downstream of Rim View aquaculture facility in June (RK 964.0, north bank) (Figure 64). Densities at this particular Rim View location averaged 316.01 $g \cdot m^{-2}$ for eight dredge samples in June, with a maximum biomass of 677.71 $g \cdot m^{-2}$ approximately 100 meters downstream of the discharge.

DISCUSSION

Sediment Depth

As stated in the results, sediment probing was not conducted upstream of the discharges because the purpose was not to compare upstream and downstream differences in sediment depth. We simply wanted to attempt to understand the three dimensional dynamics of the deposition zones downstream of the six study site discharges. Mainly, we wanted to answer the question of how sediment depth might change with distance downstream of the discharge.

Inorganic sediments, eroded from adjacent farmlands, were transported to the river via irrigation return flows. Sediment transport was evident from the distinct brown color of the discharge water and the reduced water transparency downstream of agriculture discharges. These in-field observations led us to believe that sediment depth at agriculture sites was primarily a result of inorganic particles dropping out of suspension and settling to the river substrate. However, no trends were evident between the three agriculture study sites when we studied the relationship between sediment depth and distance from the discharge (Figure 6). We noticed pockets of very deep sediment as well as pockets of shallow sediment throughout the entire sampling distance downstream of the agriculture discharges. Each agriculture study site was different. AD1 displayed no distinguishable sediment depth pattern. Sediment depth at AD2 was consistently very deep throughout the entire 150 meters downstream of the discharge. At AD3, sediment depth increased with distance downstream of the discharge.

At aquaculture study sites, general increases in sediment depth occurred as the distance downstream from the discharge increased, to the maximum sampled distance of 150 meters (Figure 5). For all three aquaculture sites combined, a two-fold increase in average sediment depth occurred from 10 meters downstream of the discharge (0.8 m sediment depth) to 150 meters downstream of the discharge (1.5 m sediment depth). Although sediments depth measurements were limited to a maximum of 150 meters downstream of each study site discharge, sediments were dredged as far downstream as 200 meters from each study site discharge. Sediments dredged between 150 and 200 meters downstream of aquaculture discharges were generally fine-textured, leading us to assume that sediment depth was continuing to increase beyond the maximum sampled distance of 150 meters.

Different patterns of sediment depth between agriculture and aquaculture study sites complicate our understanding of deposition zones. Variations in water velocity and suspended sediment particle size can dramatically alter the sediment depth at any given location (Thomas et al 2001). These results reiterate the fact that sediment patterns in the middle Snake River are very dynamic and constantly changing.

Sediment Characterization

Particle Size

Sand was the dominant particle sampled at the middle Snake River study sites in 2001, followed by silt and clay, respectively. Comparisons were made between 2000 sediment depth results and 1994 sediment depth results from the middle Snake River study of the Crystal Springs reach (Falter and Burris 1996). While sediment depth did not appear to differ between 1994 and 2000, the composition of particle sizes differed greatly between 1994 and 2001. Specifically, sands averaged 46-59% of the dredged sediment from the Crystal Springs study site in 1994 but averaged 59-95% of the dredged sediment from the same site in 2001. Likewise, clay content averaged 37-46% of the dredged sediment from the Crystal Springs study site in 1994 but only 0.5-2.0% of the dredged sediment from the same site in 2001. Particle size values were determined using the Buoyoncos hydrometer method for both years. Larger particle size in 2001 is likely the result of high flows in 1997 that flushed fines from the surficial sediment, leaving a higher proportion of larger sand particles behind.

The 2001 middle Snake River study indicated that large amounts of silt and clay-sized particles were not being deposited within the study reach. In contrast, studies by Brockway and Robison in 1992 estimate that while only 3.1 million kg of fine solids entered the study reach from sources upstream of Milner Dam (RK 1,028) during the period from June 1990 to July 1991, approximately 63.5 million kg of fine-grained sediment left the study reach at King Hill (RK 877.6) (EPA 2002). This means that approximately 59.9 million kg of sediment entered the middle Snake River downstream of Milner Dam and remained in suspension to King Hill (150.4 kilometers downstream) during this 12-month period. The finer particles, namely silts and clays, likely made up a significant portion of the suspended sediments making it downstream to King Hill. However, Brockway and Robison (1992) also estimated that over 26.4 million kg of sediment was deposited in this same study reach during this period. Extremely high flows during 1997 likely flushed some of the deposited fines out of the reach, meaning that sediments sampled in 2001 were recent deposits.

Nutrients

Phosphorus and nitrogen are the nutrients that most often regulate eutrophic conditions in aquatic ecosystems. Phosphorus is often the limiting nutrient in aquatic systems and is found in both organic and inorganic forms (IDEQ 1995). Sediment phosphorus levels can become extremely high, even to levels >12,000 $\mu g{\cdot}g^{-1}$ as reported in the industrialized rivers of England (Owens and Walling 2002) and 2,600 $\mu g{\cdot}g^{-1}$ in the middle Snake River (Falter and Carlson 1994). Alternatively, nitrogen is less a limiting nutrient in aquatic systems, but can become limiting in systems saturated with phosphorus (Falter and Carlson 1994). Natural nitrogen levels include a significant proportion of atmospheric nitrogen that is transferred to the aquatic system via microbial processes (IDEQ 1995). Sediment Kjeldahl nitrogen was reported as high as 39,573 $\mu g{\cdot}g^{-1}$ in the middle Snake River in July, 1992 (Falter and Carlson 1994).

Between-Industry Comparison

Overall, 2001 sediment nutrient levels (P and N) were greater immediately downstream of aquaculture discharges than agriculture discharges to the middle Snake River. This result should not be misinterpreted to indicate that agriculture discharges do not contribute high nutrient loads to the study reach. For example, sediment P from every 2001 middle Snake River sediment sample (including agriculture sites) exceeded the 311.8 $\mu g{\cdot}g^{-1}$ maximum sediment P sampled in the Crystal Springs Reach in 1992 (Falter and Carlson 1994) (Table 1). In fact, sediment P concentrations sampled downstream of agriculture discharges in 2001 averaged 688.07 $\mu g{\cdot}g^{-1}$ (Table 2), a concentration more than two times the 1992 maximum sediment P concentration (311.8 $\mu g{\cdot}g^{-1}$).

Most nutrients leaving croplands are associated with sediment transport (Omernik et al. 1981). Studies by Brockway and Robison (1992) clearly documented the high nutrient loads associated with suspended sediment from agriculture return flows. They estimated that 33,566 kg of total phosphorus loadings entered the middle Snake River from 18-measured agriculture return flows (including AD1, AD2, and AD3) during the 12-month sampling period from June 1990 to July 1991.. Likewise, findings by Brockway and Robison (1992) show that AD1, AD2, and AD3 all contributed P over the 42.5 $\mu g{\cdot}l^{-1}$ total phosphorus water quality criterion (statistically based on 25th percentile of subregional waters) recommended by Flemer in 2002 (EPA personal communication) throughout the May through September, 1991 irrigation season.

Nitrate+nitrite loads from agriculture return flows were estimated at 172,365 kg over the 12 months for the 18-measured study sites in 1990-91. The 0.3 $mg \cdot l^{-1}$ nitrate+nitrite water quality criterion used by Idaho DEQ was then exceeded by AD1, AD2, and AD3 over nearly the entire 12-month period.

Although many studies, such as those mentioned above, have indicated high nutrient loads to the middle Snake River from agriculture sources, 2001 middle Snake River sediments sampled downstream of agriculture discharges contained low nutrient concentrations relative to sediments downstream of aquaculture discharges. Sediment P averaged 688.07 $\mu g \cdot g^{-1}$ downstream of agriculture discharges and 1473.93 $\mu g \cdot g^{-1}$ downstream of aquaculture discharges. Sediment N averaged 0.03 % downstream of agriculture discharges and 0.10 % downstream of aquaculture discharges.

Within-Industry Comparison

Nutrient levels (N and P) of sediments sampled upstream and downstream of agriculture discharges varied between the three agriculture study sites. Average nutrient levels were greater upstream of the AD3 discharge than downstream for all five sampling months (Tables 3-7). Conversely, average nutrient levels were greater downstream of the AD2 (3 of 5 months) and AD1 (4 of 5 months) discharges than upstream of their respective discharges. In 60 % of agriculture samples, high nutrient levels were correlated with high proportions of fine sediments. We found nutrient levels were the highest in areas where river morphology allowed the most deposition of fine material (*i.e.* backwater area, inside bend, downstream of sandbar). For example, when sampling sediment from the AD1 study site, a large sand bar was observed just downstream of the discharge. This sandbar was positioned perpendicular to the shoreline and likely blocked much of the downstream flow, creating calm conditions downstream of the sandbar where fine sediment was more likely to be deposited. As a result, AD1 deposition zone sediments contained higher nutrient concentrations than AD1 control zone sediments.

If agriculture discharge water to the middle Snake River is high in nutrients (Brockway and Robison 1992), why did we not find the 2001 sampled sediments downstream of agriculture discharges to be significantly higher in nutrients than the sampled sediments upstream of agriculture discharges? A likely explanation is that we sampled sediment only within the first 200 meters downstream of agriculture discharges. Phosphorus adheres to finer clay and silt particles more readily than to coarse sand particles. Sampling within the first 200 meters downstream of the agriculture discharges likely missed sampling much of the clay and silt particles and associated nutrients because they settled out further downstream. Studying the influence of particle size on deposition rates, Thomas et al. (2001) concluded, "smaller particles deposited more slowly, and thus traveled farther, than larger size classes". It has also been established that a small, but significant amount of nutrients from agriculture watersheds reach rivers in soluble forms not associated with the sediment (Omernik et al. 1981). As a result, dissolved nutrient loads entering the middle Snake River from agriculture discharges could easily be transported great distances before being assimilated by biota and eventually cycled to the surface sediment. Therefore, it is not surprising to find that 2001 sediment P levels directly upstream of agriculture discharges (control zones) are higher or similar to downstream levels, as a result of upstream agriculture loading.

Before aquaculture facilities were built in the Hagerman Valley, the cool springs gushing from the north canyon walls flowed unimpeded into middle Snake River. As seen downstream of aquaculture facilities today, the springs created plumes of cool, highly transparent water for several hundred meters downstream before gradually mixing with mainstem waters. These clear plumes in the mainstem Snake River likely supported healthy, diverse populations of native aquatic vegetation that found growth advantageous in the highly developed photic environment, as in the alcove springs today. The limited supply of phosphorus and nitrogen concentrations and natural flows that seasonally scoured out bed sediments probably kept the vegetation growth at an acceptable level (<200 $g{\cdot}m^{-2}$) (IDEQ 1995). Today, evidence of this historical growth can be found in Blue Heart Springs (RK 946.5), adjacent to, but minimally impacted by middle Snake River flows.

As aquaculture facilities were introduced to the Hagerman Valley, they began utilizing the constant spring flows to raise coldwater fish species. Spring waters are first diverted through hatchery raceways before discharge to the middle Snake River. These plumes maintained their cool, highly transparent nature. However, additions to the discharge water from aquaculture operations were introduced in the form of organic solids, fecal matter, and unconsumed food. These organic particles were transported to the river in aquaculture discharges, albeit in low concentrations but high annual loading rates. The natural, background levels of vegetation downstream of these discharges began trapping the organic material and depositing it in the sediments near their roots (Barko et al. 1991, Petticrew and Kalff 1992, Chambers and Prepas 1994). The trapping of organic material is further enhanced by the decrease in water velocity created by AM growth. Gradually these deposits built up in the sediments downstream of aquaculture discharges, providing high concentrations of organic matter, carbon, nitrogen, phosphorus, and trace elements in the rooting medium (Sand-jensen 1998) for greater plant densities and more widespread establishment of plant beds. Sand-jensen (1998) concluded that the sediment surface was "markedly raised and enriched with fine particles" in a dense patch of *Elodea Canadensis*. Over a sequence of low flow years such as 1986-93, these mats of vegetation utilize the nutrients trapped in the sediment to grow larger and denser. In the fall, the dense mats of vegetation would senesce and settle to the substrate, recycling some contained nutrients to the sediments for next year's growth (Chambers and Prepas 1994). Such nutrients and organic matter intermittently bound in the biota and sediments will be transported downstream at a much slower rate (IDEQ 1995) and eventually create anoxic sediment conditions in deeper deposits. Anoxic sediments were inferred by color change from pale gray to near black in New Zealand streams (Broekhuizen et al. 2001) and in the middle Snake in 1992-94 (Falter and Burris 1996). Similar black sediments were sampled downstream of aquaculture discharges to the middle Snake River in 2001, indicating anoxic sediments. Sediment redox potentials downstream of aquaculture discharges dropped below -200 millivolts (mV) during the early summer (June and July) of 2001 sampling. This result is also a strong indicator of low sediment dissolved oxygen concentrations.

Although better aquaculture practices have been put in place, such as settling ponds and screens (EPA 2002) reducing overall nutrient loading, the nutrient sink already established in the sediments downstream of aquaculture facilities continues to supply the nutrients needed for dense mats of vegetation to grow each spring. Again, these high nutrient concentrations were evident in sediments sampled downstream of aquaculture discharges to the middle Snake River in 2001, averaging 1473.93 $\mu g \cdot g^{-1}$ P and 0.10 %N. Even if aquaculture operations could eliminate additional organic nutrient inputs, it is likely that the steady supply of nutrients provided by the sediments would be enough to support several more years of nuisance level aquatic growth. This cycling of nutrients downstream of aquaculture facilities would continue until high water year's scoured sediments out of the reach.

Chambers and Prepas (1994) indicate the difficulty in distinguishing nutrient enrichment sources to the Saskatchewan River, Saskatchewan between effluent loading and nutrient enrichment from indirect effects caused by enhanced growth of AM. Regardless of which has the greatest effect, the combination of AM growth and effluent loading can create nutrient-enriched sediments at a rate superseding that of AM growth or effluent loading alone. The Saskatchewan River AM study, and the 1992-94 middle Snake River studies (Falter and Carlson 1994; Falter et al. 1995; Falter and Burris 1996) concluded that riverbed nutrient concentrations were higher in vegetated areas receiving loading from anthropogenic sources than non-vegetated areas receiving loading from anthropogenic sources. These findings agreed with those found in the middle Snake River in 2001, where sediment nutrient concentrations were higher downstream of aquaculture discharges (vegetated area) than downstream of agriculture discharges (minimally vegetated area). The capacity of AM to continuously trap suspended solids and nutrients from anthropogenic sources may lead to this result.

Very high densities of vascular aquatic macrophytes downstream of aquaculture facilities provide the surface area necessary for epiphytic algae to attach and grow. Excellent correlations have been reported between algal growths and phosphate concentrations in waters (Fox et al. 1989). Through much of June, July, and August 2001 algae covered the entire surface of the water within 10-20 meters from the shoreline and several hundred meters downstream of the three-aquaculture facilities. Because epiphytes gain much of their nutrients from the water column, it has been suggested that senescing algae cells may provide a route for the transfer of nutrients absorbed from the water (by algae) to the sediments (Barko et al. 1991). Decomposing filamentous algal growths then contribute to sediment nutrient concentrations. Therefore, the high epiphyte levels found in the middle Snake River provide yet another mechanism for the accumulation of nutrients in sediments downstream of aquaculture facilities.

Organic matter content (percent by weight) of sediment was measured in August-October, 2000. A difference between sediment organic matter downstream of agriculture and aquaculture industries was apparent. Maximum sediment organic matter (5.0 %) was sampled downstream of the Crystal Springs study site in October. Minimum sediment organic matter (0.23 %) was sampled downstream of the AD3 study site in September. Sediment organic matter downstream of aquaculture discharges averaged 1.30, 2.20, and 1.85 % for CS, RV, and BC, respectively. Sediment organic matter downstream of agriculture discharges averaged 0.75, 0.88, and 1.12 %

for AD3, AD2, and AD1, respectively. Average organic content of sediments downstream of aquaculture discharges (1.78 %) was nearly twice that of average sediment organic content downstream of agriculture discharges (0.91 %). This distinct difference in organic matter composition is likely caused by the increase in aquatic vegetation cycling downstream of aquaculture facilities coupled with the slow, steady organic loading from aquaculture discharge.

Sediment nutrient levels (N and P) were typically greater downstream of aquaculture discharges (0.10 %N, 1473.93 $\mu g \cdot g^{-1}$ P) than upstream of aquaculture discharges (0.06 %N, 734.87 $\mu g \cdot g^{-1}$ P) throughout 2001 sampling (Table 2). However, the Box Canyon study site showed greater sediment nitrogen upstream in June, 2001. Loading of silt and clay-sized particles and associated nitrogen from upstream sources apparently settled out in the Box Canyon control zone during June, raising nitrogen content in the sediments. These silt and clay-sized particles and associated nutrients did not readily settle in the Box Canyon deposition zone only a few hundred meters downstream, the colder spring waters discharged by the aquaculture facility apparently diluting mainstem middle Snake River water and the suspended sediment and nutrient load from upstream sources.

Selected Trace Elements

Between-Industry Comparison

Of the 17 selected trace elements (other than N and P) measured in the middle Snake River in 2001, 14 (Ca, Mg, K, Zn, Cu, Fe, S, Pb, Cr, Cd, Ba, Ni, Co, and Be) were found in significantly higher concentrations downstream of aquaculture discharges than agriculture discharges for at least one sampling month (i.e., sampling event; see Figures 13-52). Of the remaining three selected trace elements (Mo, Na, and Mn), only Mo was found in significantly higher concentrations downstream of agriculture discharges than aquaculture discharges for at least one sampling month.

Within-Industry Comparison

When comparing trace element concentrations upstream of aquaculture discharges with concentrations downstream of aquaculture discharges, and when comparing the trace element concentrations upstream of agriculture discharges with concentrations downstream of agriculture areas, we noticed that trends in one element typically matched trends in the other elements (Tables 3-7). For example, when Ca concentrations were significantly greater downstream of the Crystal Springs discharge than upstream in June (Table 3), 14 of the remaining 17 selected trace element concentrations (C, Mg, K, Na, Zn, Cu, Fe, S, Pb, Cr, Cd, Ba, Ni, and Be) were also significantly greater downstream of the Crystal Springs discharge than upstream of the discharge.

In general, greater concentrations of the selected trace elements were found upstream of the AD3 and BC discharges than downstream of their respective discharges. For example, June Pb concentrations upstream of the AD3 and BC discharges averaged 27.8 and 31.0 $\mu g \cdot g^{-1}$, respectively, compared to 16.4 and 20.3 $\mu g \cdot g^{-1}$ Pb downstream of their respective discharges (Table 3). Alternatively, greater concentrations of the selected trace elements were found downstream of the AD1 and CS discharges than upstream of their respective discharges. For example, July Fe concentrations downstream of the AD1 and CS discharges averaged 12,000 and 9,786 $\mu g \cdot g^{-1}$, respectively, compared to 9,500 and 7,950 $\mu g \cdot g^{-1}$ Fe upstream of their respective discharges (Table 4). Results were mixed at AD2 and RV, meaning that selected trace element concentrations were greater upstream of the discharge in some months and greater downstream of the discharge in other months.

Of further interest were the extremely high levels of Mg, Na, Mn, Fe, Pb, Cr, Cd, Ba, Ni, Co, and Mo that were sampled upstream of the AD3 discharge in July and September, 2001 (Tables 4 and 6, respectively). The concentrations of these selected trace elements were typically over two times greater than the concentrations of their respective trace elements in any other site or month. It is unknown why the sediments upstream of AD3 contained such high amounts of these trace elements. However, these high trace element levels were not associated with significantly different BMI or AM communities. Phosphorus levels were also high upstream of the AD3 discharge for July and September compared to the zones upstream of the other agriculture sites. However, the phosphorus levels upstream of the AD3 discharge did not exceed levels found in the deposition zones of the three-aquaculture sites.

Sediment Guidelines Comparison

Screening concentrations for Background Level (BL), Threshold Effects Level (TEL), and Probable Effects Level (PEL) have been determined for a few of the 18 selected trace elements measured in the middle Snake River (Table 22). BLs for trace elements are the lowest screening concentrations in freshwater sediment. Sediments with trace element concentrations found below BLs would be considered healthy, natural sediment communities. The TEL represents the concentration below which adverse effects of the trace element on the benthic community are expected to occur only rarely. The PEL represents the level above which adverse effects of the trace element on the benthic community are frequently expected. TELs and PELs are based on benthic community metrics and toxicity testing. The BLs, TELs, and PELs used for comparison were derived from the Screening Quick Reference Tables (SQuiRTs) provided by the National Oceanic and Atmospheric Administration's Coastal Protection and Restoration Division (Buchman 1999). Further comparisons were made with the 1994 Florida Sediment Quality Assessment Guidelines (FDEP) covering 6 of the 18 selected trace elements measured in the 2001 middle Snake River study.

Major sources of zinc (Zn) to aquatic systems include municipal wastewater effluents, zinc mining, smelting, refining activities, wood combustion, waste incineration, iron and steel production, and other atmospheric emissions (FDEP 1994). In fine-grained sediments, like those found in the middle Snake River, Zn readily adsorbs to organic matter and generally forms insoluble sulfides under reducing conditions. BL of Zn occurs in the range of 7-38 $\mu g \cdot g^{-1}$, with a TEL and PEL of 123.1 and 315 $\mu g \cdot g^{-1}$, respectively (Buchman 1999). Zn concentrations in the middle Snake River averaged 29-76 $\mu g \cdot g^{-1}$ in 2001 samples. The upper BL Zn concentration (38 $\mu g \cdot g^{-1}$) was exceeded both upstream and downstream of all six middle Snake River study sites in at least one 2001 sampling month.

The natural BL of manganese (Mn) in freshwater sediment is approximately 400 $\mu g \cdot g^{-1}$ (Buchman 1999). The lowest TEL for Mn based on *Hyalella azteca* bioassays is 630 $\mu g \cdot g^{-1}$. This is the concentration where the amphipod, *H. azteca,* begins to show adverse affects from Mn. Mn concentrations in the middle Snake River averaged 113-485 $\mu g \cdot g^{-1}$ in 2001 samples. Most concentrations in the middle Snake River are well below BL for freshwater sediment. The Mn concentrations that exceeded BL were sampled upstream of the AD3 discharge in July and September.

Copper (Cu) in aquatic systems occurs naturally from the weathering or solution of copper minerals and copper sulfides (FDEP 1994). Unnatural levels of Cu result from anthropogenic sources including brass and Cu pipe waste, Cu compounds used as algaecides, sewage treatment plant effluents, agriculture and aquaculture uses of Cu as pesticides and fungicides, and from atmospheric fallout. Copper can occur in aquatic environments in association with organic matter, the typical attachment form in sediments. Aquatic macrophytes readily accumulate Cu, an essential micronutrient in plants. The BL of Cu occurs in the range of 10-25 $\mu g \cdot g^{-1}$, with a

TEL and PEL of 35.7 and 197 $\mu g \cdot g^{-1}$, respectively (Buchman 1999). Cu concentrations in the middle Snake River averaged 7.5-33.0 $\mu g \cdot g^{-1}$ in 2001 samples. Average concentrations greater than the upper BL concentration (25 $\mu g \cdot g^{-1}$) occurred upstream of the AD3 discharge in July and September and downstream of the BC discharge in September.

In aquatic sediment, lead (Pb) is primarily found in association with iron and manganese hydroxides (FDEP 1994). Pb can also adsorb to clays and organic matter and can be released into the water column under reducing conditions from lead sulfide. While aquatic organisms tend to have a wide range of sensitivities to Pb, gastropods tend to be particularly vulnerable to high Pb concentrations. BL of Pb occurs in the range of 4-17 $\mu g \cdot g^{-1}$, with a TEL and PEL of 35 and 91.3 $\mu g \cdot g^{-1}$, respectively (Buchman 1999). Pb concentrations in the middle Snake River averaged 14.5-50.75 $\mu g \cdot g^{-1}$ in 2001 samples. Average Pb concentrations greater than BL (4-17 $\mu g \cdot g^{-1}$) were sampled upstream and downstream of all six study site discharges at some point during June-October, 2001. Average Pb concentrations greater than TEL (35 $\mu g \cdot g^{-1}$) were sampled upstream of the AD3 discharge in July and September, downstream of the CS discharge in September, and upstream of the RV discharge in October.

Chromium (Cr) is a trace element widely used in industrial processes (FDEP 1994). Chromium compounds are used in the production of paints, dyes, explosives, ceramics, and paper and are emitted to the environment from the metal plating industry, coal and oil burning, cement manufacturing, and the production of chromium steels. Cr adsorbs to organic material in aquatic systems and is generally more toxic to vegetation than fish. Cr will also bioaccumulate in the tissues of aquatic plants, especially algae. BL of Cr occurs in the range of 7-13 $\mu g \cdot g^{-1}$, with a TEL and PEL of 37.3 and 90 $\mu g \cdot g^{-1}$, respectively (Buchman 1999). Cr concentrations in the middle Snake River averaged 12.5-67.75 $\mu g \cdot g^{-1}$ in 2001 samples. Almost all samples at every site and month contained Cr concentrations greater than the BL (7-13 $\mu g \cdot g^{-1}$). Average Cr concentrations exceeded the TEL (37.3 $\mu g \cdot g^{-1}$) upstream of the AD3 discharge in July and September and downstream of the BC discharge in August and September.

Anthropogenic cadmium (Cd) sources include mining, metals smelting, the manufacturing of alloys, paints, batteries, and plastics, agriculture uses of sludge, fertilizers, and pesticides, and the burning of fossil fuels (FDEP 1994). Cd is found adsorbed to organic matter in sediments and can significantly accumulate in biological tissues. This trace element is known to reduce growth and inhibit the reproduction of various aquatic organisms. BL of Cd occurs in the range of 0.1-0.3 $\mu g \cdot g^{-1}$, with a TEL and PEL of 0.6 and 3.5 $\mu g \cdot g^{-1}$, respectively (Buchman 1999). Cd concentrations in the middle Snake River averaged 0.44-3.55 $\mu g \cdot g^{-1}$ in 2001 samples. All samples at every site and month contained Cd concentrations greater than the BL (0.1-0.3 $\mu g \cdot g^{-1}$). Average Cd concentrations exceeded the TEL (0.6 $\mu g \cdot g^{-1}$) at all sites at some time during the June-October study. Average Cd concentrations exceeded the PEL (3.5 $\mu g \cdot g^{-1}$) upstream of the AD3 discharge in July.

Anthropogenic sources of nickel (Ni) include fossil fuel combustion, nickel ore mining, smelting, electroplating, and nuclear power plants (FDEP 1994). Ni adsorbs to organic matter and tends to combine with iron and manganese in sediments. In anaerobic conditions, Ni can form insoluble complexes with sulfides and become toxic to organisms in the presence of copper. Screening concentrations for Ni are 9.9, 18, and 35.9 $\mu g \cdot g^{-1}$ for BL, TEL, and PEL, respectively (Buchman 1999). Ni concentrations in the middle Snake River averaged 8.95-43.75 $\mu g \cdot g^{-1}$ in 2001 samples. Background Ni concentrations (9.9 $\mu g \cdot g^{-1}$) were exceeded in nearly all middle Snake River sediment samples in 2001. Average Ni concentrations exceeded the TEL (18 $\mu g \cdot g^{-1}$) upstream of the BC discharge in June and exceeded the PEL (35.9 $\mu g \cdot g^{-1}$) upstream of the AD3 discharge in July and September.

Background cobalt (Co) levels occur in freshwater sediments at about 10 $\mu g \cdot g^{-1}$ (Buchman 1999). Co concentrations in the middle Snake River sediments averaged 6.3-26.0 $\mu g \cdot g^{-1}$. Although the Co TEL and PEL were not given, the average Co concentration in middle Snake River sediments exceeded the BL upstream and downstream of the BC and RV discharges, downstream of the AD1 and AD2 discharges, and upstream of the AD3 discharge. Maximum Co concentrations occurred upstream of the AD3 discharge and were 200 % of Co BL (10 $\mu g \cdot g^{-1}$) in July and September.

Benthic Macroinvertebrates

Benthic macroinvertebrates (BMI) are the most commonly sampled group used to assess the health of aquatic systems (Timm et al. 2001). BMI communities are used as biological indicators because they are relatively sessile in nature (thereby integrating biological responses to the ambient over time), ubiquitous, diverse with individual taxon responses to the environment, and found in a wide range of aquatic habitat types (Linke et al. 1999). Studies by Voelz et al. (2000) indicate that BMI assemblages have low resistance to disturbance, but high resilience. This means that slight changes in water quality can alter BMI communities, but not enough to extirpate all BMI groups. In addition, BMI sampling is a quick and economical way to detect changes in water quality and aquatic ecosystem health (Rueda et al. 2002). However, BMI communities can also undergo large spatial and temporal variations in structure, thus stressing the importance of a spatially and temporally representative sampling strategy (Linke et al. 1999).

Biological indices, such as BMI density, biomass, and richness are among the most commonly used methods for biological monitoring of rivers (Sandin and Johnson 2000). Studies by Sandin and Johnson (2000) indicate that BMI taxa richness is one of the most useful indices in monitoring aquatic habitats, while total density appears least useful. Because of their density and sensitivity, Chironomidae density has also been used as an indicator of water quality (Rabeni and Wang 2001).

In general, the majority of BMI sampled from the middle Snake River in 2001 were determined to be pollution-tolerant taxa (Merrit and Cummins 1996, EPA 2002). The most abundant taxa sampled in 2001 were *P. antipodarum*, Oligochaeta, Chironomidae, and Amphipoda (*Hyalella azteca*). Evidence from field surveys (EPA 2002) indicates that middle Snake River conditions do not meet standards set for cold-water biota. For instance, 1994 temperature monitoring of the middle Snake River at RK 949.5 (near Crystal Springs) resulted in 35 consecutive days with mean daily water temperatures exceeding 20°C. Furthermore, the middle Snake River does not meet the State of Idaho water quality criteria for excess nutrients (EPA 2002):

> "Surface waters of the state shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses."

The reduced density of native snail populations indicates further evidence of changing river conditions. The 1992 threatened or endangered listing of native middle Snake River snails suggested that present temperature, dissolved oxygen, and flow conditions were often not suitable for native benthic communities (USFWS FR 59244). *Valvata utahensis* (Utah Valvata) was the only listed species encountered throughout the 2001 benthic macroinvertebrate sampling effort. Averaging 2.67 snails·dredge^{-1} (118.5 snails·m^{-2}), *V. utahensis* inhabited very fine, black, organically enriched sediments with very heavy macrophyte and associated filamentous algae communities.

Only a few insect taxa other than Chironomidae were sampled from the middle Snake River in 2001. Insects intolerant of eutrophic conditions were very rare in 2001 samples. No insects from the Plecoptera (stonefly) order were sampled from the middle Snake River in 2001. Additionally, insects from only one Ephemeropteran (mayfly) family and one Trichopteran (caddis fly) family were sampled in 2001, Ephemeridae and Polycentropodidae, respectively. Similar results were evident from middle Snake River samples collected by Idaho State University (ISU) in 1992-94 (EPA 2002), where no Plecopterans were found in the middle Snake River.

Total BMI density in the middle Snake River averaged 844-231,222 individuals·m^{-2} throughout June-October, 2001. This range is comparable to the mean density of BMI sampled in the middle Snake River from 1992-1994 by Idaho State University (EPA 2002). These studies found densities often exceeding 75,000 and occasionally exceeding 200,000 individuals·m^{-2}. Although BMI densities in the middle Snake River are high, taxa richness remains relatively low. Taxa richness in 2001 middle Snake River samples averaged 1.25-10.25 distinct BMI taxa over all study sites and months. Thirty-one distinct taxa were sampled from the middle Snake River in 2001. These overall richness values for the middle Snake River are low compared to the total taxa richness of other large rivers. For example, 55 and 48 total taxa were recently sampled from the Fraser and Thompson Rivers in British Columbia, respectively (Reece and Richardson 2000). Furthermore, 54 total taxa have been collected from the Willamette River, a degraded large river in western Oregon (Altman et al. 1997).

Between-Industry Comparison

BMI density, biomass, and richness were generally greater downstream of aquaculture discharges than downstream of agriculture discharges. This could be due to the productive growth of aquatic vegetation downstream of aquaculture discharges. A study of BMI density in relation to aquatic vegetation (van den Berg et al. 1997) concluded that plant biomass is more important in determining the characteristics of the BMI community than the dominant macrophyte species. A similar study comparing BMI density, relative density, and diversity upstream and downstream of pulp mill effluents on the Athabasca River, Alberta, Canada in the late 1990's observed that density was higher downstream of the mill discharges (Culp et al. 2000). These results suggest that nutrients from the mills' enhanced primary productivity downstream, thus enriching BMI populations.

It is likely that the high sand content below agriculture discharges reduced BMI density, biomass, and richness downstream of agriculture discharges. For instance, 2001 average sand content downstream of agriculture discharges (77.87 %) was greater than downstream of aquaculture discharges (71.85 %). This difference was only statistically significant in September, 2001. The increase in substrate sand content could impact BMI communities by smothering interstitial habitat that is important BMI refuge from flow and predators. The increase in suspended sediment downstream of agriculture discharges, as indicated by secchi depths as low as 0.5 meters in June, may also create abrasive substrate conditions that are not suitable to many BMI taxa.

Potamopyrgus antipodarum densities were greater downstream of aquaculture discharges than downstream of agriculture discharges. Observations during the 2001 middle Snake study indicate that the majority of *P. antipodarum* sampled downstream of aquaculture discharges were attached to aquatic vegetation. For many snails in general, food availability is a very important determinate of snail distribution patterns (Aldridge 1983). Because these exotic snails seem to prefer algae and diatoms (Lysne 2002), it is very likely that *P. antipodarum* are found downstream of aquaculture discharges because they are utilizing the rich periphytic food source associated with AM. The tolerance of *P. antipodarum* to high organic sediments has allowed them to inhabit sediments downstream of aquaculture operations, where organic matter content reached levels as high as 5.0 % in 2000 middle Snake River sediments.

Chironomidae larvae were generally found in greater densities downstream of agriculture discharges than aquaculture discharges. Because of the relatively low number of other BMI taxa found downstream of agriculture discharges, Chironomidae were able to utilize what little production was available on the low organic matter substrates. Chironomidae are known to tolerate and even prefer sand substrates. Relyea et al. (2000) indicate that Chironomidae "significantly increase in abundance, and therefore density, immediately after an anthropogenic disturbance that may have the potential to increase inputs of fine sediment". Therefore, the increased sand content downstream of agriculture discharges relative to aquaculture discharges (77.87 % at agriculture sites, 71.85 % at aquaculture sites) provided more suitable habitat for chironomid larvae.

The average number of distinct BMI taxa sampled (richness) from the middle Snake River in 2001 was greater downstream of aquaculture discharges (6.0) than downstream of agriculture discharges (4.0) (Table 9). In rivers with cumulative water quality limitations and reduced taxa richness, like the middle Snake, the presence of cooler water temperatures and macrophyte growth, like that downstream of aquaculture discharges, can provide the additional niches necessary for a more diverse assemblage of taxonomic groups. For example, amphipod crustaceans were more frequently sampled downstream of aquaculture discharges (54% of samples) than downstream of agriculture discharges (34%). Amphipods utilize macrophyte growth downstream of aquaculture discharges for food resources and refuge.

Within-Industry Comparison

General differences in BMI density, BMI biomass, *P. antipodarum* density, and Chironomidae density between the control and deposition zones of the three agriculture study sites were not consistent over the five sampling months. Drawing any conclusions from BMI metrics measured in agriculture control and deposition zones would be very difficult because consistent trends are lacking. Overall, we would contend that BMI communities near agriculture discharges are very sporadic, and may be associated with the patchy AM communities.

BMI density, BMI biomass, and *Potamopyrgus antipodarum* density were greater downstream of the CS and RV discharges than upstream of their respective discharges. Alternately, BMI density and biomass and *P. antipodarum* density were greater upstream of the BC discharge than downstream of the BC discharge. It is important to point out that the BC control zone (upstream of discharge) is generally enriched from upstream loading more so than any other site because it is located the furthest downstream. Increased BMI and *Potomopyrgus* density followed comparable site-to-site patterns, as did elevated trace elements. Generally, where greater trace element concentrations were found, greater BMI density, BMI biomass, and *P. antipodarum* density were also found. However, the simple presence of *P. antipodarum* could be the driving force behind these results. Because *P. antipodarum* were proportionately one of the most abundant taxa found in the river, and because they had a high biomass per individual, the presence or absence of *P. antipodarum* explains much of the high biomass variability. Specifically, when *P. antipodarum* were found in a sample, they were usually found in great numbers, resulting in a high snail biomass for these samples that would overshadow the biomass contributed by other taxa in the sample.

An inverse relationship exists between the BMI density found in an aquaculture sample and the BMI taxa richness from that same sample. For example, when BMI density was greater in the CS deposition zone than the control zone, BMI taxa richness was usually greater in the CS control zone than the deposition zone. These results are also likely driven by the presence of the exotic *P. antipodarum*. As noted above, areas where the exotic snails were sampled ultimately had fewer other taxa present. This could have been the direct result of competition for the food resources or space between *P. antipodarum* and other benthic taxa. Similar studies on the Athabasca River in the late 1990's found that pulp mill effluents increased BMI biomass and density, while showing no measurable change in taxa richness (Culp et al. 2000).

Chironomidae density trends differed from BMI density, BMI biomass, and *P. antipodarum* density trends at aquaculture sites. Chironomidae density was generally greater downstream of the BC discharge than upstream of the BC discharge. However, Chironomidae density was greater upstream of the RV discharge than downstream of the RV discharge.

Aquatic Macrophytes

Aquatic macrophytes are a good indicator of the quality of running waters (Grasmuck et al. 1995), as AM biomass and species composition are influenced by the quality of the water and sediment from which they obtain their nutrients. Generally, it is the phosphorus content of the sediments and the water column that most strongly influences the productivity of AM and their associated epiphytic algae. Rooted AM obtain much of their phosphorus from the sediments (Barko et al. 1991, Falter and Carlson 1994) but many species also take up nutrients through their leaves from the water column if sediment nutrients are in short supply (Madsen and Cedergreen 2002). Epiphytic algae and non-rooted AM must utilize phosphorus only from the water column.

Chambers and Prepas (1994) noted that broad, shallow rivers of the Canadian prairies that are nutrient-enriched by sewage effluent can achieve AM biomasses >1,000 g·m^{-2}. However, they also indicate that AM densities in the Saskatchewan River, Saskatchewan, Canada were considered high at 200 g·m^{-2} in a 1989 study. This 200 g·m^{-2} density was also determined to be a reasonable lower bound for nuisance growth of AM in the middle Snake River in the 1990's (EPA 2002). Average macrophyte biomass in the middle Snake River in the 1990's measured >3,000 g·m^{-2} in the Crystal Springs Reach (RK 965.4) and averaged >200 g·m^{-2} in all sampled sites <2.0 meters in depth (Falter and Carlson 1994; Falter et al. 1995; Falter and Burris 1996). Densities found during the 2001 middle Snake River sampling effort were >200 g·m^{-2} in the RV deposition zone in June, the RV and BC deposition zones in July, the CS deposition zone in August, the RV deposition zone in September, and the AD2 deposition zone in October. Maximum AM biomass was sampled approximately 100 meters downstream of the RV discharge, totaling 677.71 g·m^{-2}.

Average sediment TP levels were higher in the middle Snake River in 2001 (490-1800 μg·g^{-1}) compared to the Saskatchewan River (215-770 μg·g^{-1}) (Chambers and Prepas 1994). The fact that the 1989 Canada study had higher AM levels (>1000 g·m^{-2}) and lower sediment TP than the middle Snake River in 2001 is notable but was also apparent in studies of freshwaters receiving organic pollution in India (Gopal and Chamanlal 1991). Falter and Burris (1996) conclude that it is more likely that factors associated with high TP (i.e. high sediment organic content, low sediment oxygen, low redox potential, high sediment ammonia, and organic acids) together limit AM growth. Other studies have shown that nutrient enrichment (N and P) in receiving waters stimulate an increase in phytoplankton, thereby limiting light penetration to macrophytes and decreasing macrophyte growth (Eminson and Phillips 1978).

The species composition of AM communities in a waterbody can often influence trophic status (Grasmuck et al. 1995). Total AM biomass in the middle Snake River in 2001 was dominated by *Potamogeton crispus*, *Ceratophyllum demersum*, and *Elodea canadensis*. Nichols and Shaw (1986) describe two of these species, *E. canadensis* and *P. crispus*, as "serious aquatic nuisances in many regions of the world". The ability of these macrophytes to reproduce vegetatively and to grow in reduced light conditions have allowed them to proliferate in conditions unsuitable for many other macrophyte species. Other studies have concluded that *P. crispus* can tolerate "strong organic pollution" (Grasmuck et al. 1995) and "eutrophication"

(Tremp and Kohler 1995). However, Gopal and Chamanlal (1991) indicated that maximum *P. crispus* growth is "obtained in waters relatively free from pollution".

While *P. crispus* and *C. demersum* have been dominant components of the middle Snake River for some time (Falter and Carlson 1994, Falter et al. 1995, Falter and Burris 1996), it is apparent that a shift in AM dominance has occurred from *Potamogeton pectinatus* to *E. Canadensis* over the last decade. *P. pectinatus* was found to be a dominant AM species in the 1990 studies but was sparsely found in 2001 samples. *P. pectinatus* are highly competitive and are a strong indicator of eutrophic conditions in flowing waters (Grasmuck et al. 1995, IDEQ 1995). The species thrives in high water velocities better than other AM species because of their long, leathery leaves and extensive root systems (EPA 2002). As a result, *P. pectinatus* typically grows quickly in the spring when water velocities are greatest, to form stable beds of vegetation. Once these macrophyte beds are firmly in place, they can slow water velocities and accumulate sediments, providing conditions more suitable for non-rooted vascular macrophytes, like *C. demersum* and *E. canadensis*. These non-rooted forms typically float higher in this newly quiescent water column, taking advantage of better light conditions, eventually shading out rooted AM like *P. pectinatus*. The dominance of *E. canadensis* growths rather than *P. pectinatus* in 2001 samples could also be due to the lack of spring sampling (March-May) during that year.

Between-Industry Comparison

Aquatic macrophyte (AM) biomass was generally greater downstream of aquaculture discharges than downstream of agriculture discharges. The deep, organically enriched fine sediment downstream of nutrient loading discharges to the middle Snake River favors aquatic plant growth (EPA 2002). Chambers and Prepas (1994) acknowledge that AM growth was greatest in the Saskatchewan River, Canada where sediment "concentrations of both exchangeable and total phosporus and nitrogen were greatest". In the middle Snake River, the aquatic plant growth likely responds to the decrease in TSS downstream of aquaculture discharges (hatchery outflows diluting TSS of the river), allowing increased light levels to reach the substrate. Deeper photic zones would also allow AM colonization to develop in greater water depths at the aquaculture study sites. Studies on Florida streams in the mid-1980's (Canfield and Hoyer 1988) concluded that light availability was the primary factor limiting growth of AM. While its uncertain whether light is the limiting factor of AM growth in the middle Snake River, the combination of increased light transparencies and sediment nutrients in the middle Snake River provide conditions favoring plant growth downstream of aquaculture discharges.

Falter and Carlson (1994) and the Idaho Department of Environmental Quality (1995) concluded that the majority of plant biomass in the middle Snake River was found in waters less than 2.0 meters in depth. The majority of AM samples collected in the deposition zones of the six study sites were collected in waters less than 2.0 meters deep (Figure 65). Similar AM sampling depths at agriculture and aquaculture study sites in 2001 justified comparison between AM metrics from the two industries (*i.e.*, if deeper sampling occurred at agriculture sites than aquaculture sites, we could not have legitimately compared plant growth from the two industries).

Within-Industry Comparison

At the three agriculture study sites, a trend in AM biomass between areas upstream and areas downstream of the discharges was not evident. AM biomass levels in the upstream and downstream areas at agriculture study sites were limited by reduced light penetration and increased sediment sand content, a direct result of high TSS levels in those river reaches.

Madsen et al. (2001) conclude that reduced turbidity increases AM growth. The greater AM production found in aquaculture deposition zones than aquaculture control zones occurs with the decrease in TSS downstream of the discharges and higher sediment nutrient concentrations. These high growths of aquatic vegetation downstream of aquaculture discharges senesce each year and cycle nutrients back to the sediments through decomposition (Jacoby et al. 1982). This decomposition, combined with nutrient enrichment from the aquaculture discharges themselves (EPA 2002), provides sufficient nutrient concentrations for sustained aquatic vegetation production.

SUMMARY

Sediment Characterization

Particle Size

1. No obvious trends were apparent between sediment depth and distance from the discharge over the three agriculture study sites. We found pockets of very deep sediment (> 1.83 m) as well as pockets of shallow sediment throughout the entire sampling distance downstream of the three agriculture discharges.
2. At aquaculture study sites, fine sediment depth increased to > 1.83 meters as distance downstream from the discharge increased, to the maximum sampled downstream distance of 150 meters.
3. Sand was the dominant particle sampled throughout the middle Snake River study reach in 2001, averaging 43-95 % of total dredged sediments over all sites, control and deposition.
4. Sand content was greater in agriculture deposition zones than aquaculture deposition zones in June, July, August, and September, 2001. Statistically significant differences ($p < 0.05$) between the sand content of agriculture deposition zones and aquaculture deposition zones only occurred in September.
5. Differences in sand content between the control and deposition zone of Agriculture Drain 3 (AD3) were not apparent. Sand content was significantly greater in the deposition zone of Agriculture Drain 2 (AD2) than in the control zone in all months but October. At Agriculture Drain 1 (AD1), sand content was significantly greater in the control zone than the deposition zone in all 5 sampling months.
6. CS and Rim View (RV) aquaculture sites each had significantly greater sand content in control zones than deposition zones for 4 of 5 sampling months but Box Canyon (BC) aquaculture site had significantly greater sand content in deposition zones for 4 of 5 months.
7. Silt content, averaged 4-48% of total dredged sediment in 2001 and was greater in agriculture deposition zones than aquaculture deposition zones in June, July, August, and September. Statistically significant differences ($p < 0.05$) between the silt content of agriculture deposition zones and aquaculture deposition zones only occurred in June and September.

8. AD3 showed no significant trends in silt content between control and deposition zones. AD2 had significantly greater silt content in control zones than deposition zones for 4 of 5 months whereas AD1 had significantly greater silt content in deposition zones than in control zones for all months.
9. While CS and RV each had significantly greater silt content in deposition zones than control zones for 4 of 5 sampling months, BC had significantly greater silt content in control zones for 4 of 5 months.
10. Clays were the least dominant sediment type sampled in the middle Snake River in 2001, averaging 0.5-5.0 % of the total dredged sediment by volume. Clay content was significantly greater in aquaculture deposition zones than agriculture deposition zones in both July and October.
11. At AD3 and AD1, no significant trends were seen in clay content between deposition and control zone sediments. Clay content in the AD2 control zone was significantly greater than clay content in the AD2 deposition zone for four of five months.
12. CS and RV had significantly greater clay content in deposition zones than control zones in 2 of 5 months, whereas BC had significantly greater clay content in the control zone than the deposition zone in 4 of 5 months.
13. At the Crystal Springs (CS) aquaculture site (the one site overlapping 1992-94 and 2000-01 studies), a substantial decrease in clay content occurred from 1992-94 (37-46 %) (Falter and Burris 1996) and 2001 (0.5-2.0 %). High flows of 1997 likely flushed out the fine clay content in surficial sediments, leaving behind a higher proportion of sand.

Nitrogen, Phosphorus, and Carbon

1. Overall, 2001 sediment nutrient levels (P and N) were greater downstream of aquaculture discharges than below agriculture discharges in the middle Snake River. Nitrogen content was significantly greater in aquaculture deposition zones than below agriculture deposition zones in both July and August. Phosphorus content was significantly greater in aquaculture deposition zones than in agriculture deposition zones in June, September, and October.
2. Sediment P averaged 758.7 $\mu g \cdot g^{-1}$ upstream of agriculture discharges and 688.1 $\mu g \cdot g^{-1}$ downstream of agriculture discharges. Sediment P averaged 734.9 $\mu g \cdot g^{-1}$ upstream of aquaculture discharges and 1473.9 $\mu g \cdot g^{-1}$ downstream of aquaculture discharges.

Sediment P was significantly greater in deposition zone sediments than control zone sediments throughout the 5 sampling months for all three aquaculture study sites.

3. Sediment P concentrations sampled downstream of agriculture discharges in 2001 averaged 688.07 $\mu g{\cdot}g^{-1}$ (Table 2), a concentration more than two times the 1992 maximum sediment P concentration (311.8 $\mu g{\cdot}g^{-1}$) (Falter and Carlson 1994).
4. Sediment N averaged 0.04 % upstream of agriculture discharges and 0.03 % downstream of agriculture discharges. Sediment N averaged 0.06 % upstream of aquaculture discharges and 0.10 % downstream of aquaculture discharges.
5. Sediment sampled from the six study sites in the middle Snake River averaged 0.7-3.1 %C throughout the five sampling months in 2001. Sediment C was significantly greater in aquaculture deposition zones than agriculture deposition zones in June (1.2 % at agriculture sites and 2.3 % at aquaculture sites). Sediment sampled from the AD1 deposition zone had significantly greater carbon content than the AD1 control zone for all five months sampled.
6. Sampling only within the first 200 m downstream of discharges likely missed sampling much of the clay and silt particles and associated nutrients because they were likely deposited further downstream in more quiescent river reaches.
7. Nutrient content at agriculture study sites coincided with increased silt and clay content of the sediment, resulting in highest nutrient concentrations being sampled wherever river morphology allowed the deposition of fines.
8. Even without further organic input by aquaculture facilities, nutrients created by macrophyte beds will likely continue to support nuisance growths of macrophytes and epiphytic algae until flows are high enough to flush the fine organic sediments downstream.

Other Trace Elements

1. Of the 17 selected trace elements (other than N and P) measured in the middle Snake River sediment in 2001, 14 (Ca, Mg, K, Zn, Cu, Fe, S, Pb, Cr, Cd, Ba, Ni, Co, and Be) were found in significantly higher concentrations downstream of aquaculture discharges than below agriculture discharges for at least one sampling month; 3 were not (Mo, Na, and Mn).

2. The Background Level Zn concentration (38 $\mu g \cdot g^{-1}$) was exceeded both upstream and downstream of all six middle Snake River study sites for at least one 2001 sampling month.
3. Mn concentrations that exceeded Background Levels (400 $\mu g \cdot g^{-1}$) were sampled upstream of the AD3 discharge in July and September.
4. Mean Cu concentrations greater than the upper Background Levels (25 $\mu g \cdot g^{-1}$) occurred upstream of the AD3 discharge in July and September and downstream of the BC discharge in September.
5. Mean Pb concentrations greater than Background Levels (4-17 $\mu g \cdot g^{-1}$) were sampled upstream and downstream of all six study site discharges at some point during June-October, 2001. Mean Pb concentrations greater than the Threshold Effects Level (35 $\mu g \cdot g^{-1}$) were sampled upstream of the AD3 discharge in July and September, downstream of the CS discharge in September, and upstream of the RV discharge in October.
6. Almost all samples at every site and month contained Cr concentrations greater than the Background Levels (7-13 $\mu g \cdot g^{-1}$). Mean Cr concentrations exceeded the Threshold Effects Level (37.3 $\mu g \cdot g^{-1}$) upstream of the AD3 discharge in July and September and downstream of the BC discharge in August and September.
7. All samples at every site and month contained Cd concentrations greater than Background Levels (0.1-0.3 $\mu g \cdot g^{-1}$). Mean Cd concentrations exceeded the Threshold Effects Level (0.6 $\mu g \cdot g^{-1}$) at all sites at some time during the June-October study. Mean Cd concentrations exceeded the Probable Effects Level (3.5 $\mu g \cdot g^{-1}$) upstream of the AD3 discharge in July.
8. Background Level Ni concentrations (9.9 $\mu g \cdot g^{-1}$) were exceeded in nearly all middle Snake River sediment samples in 2001. Mean Ni concentrations exceeded the Threshold Effects Level (18 $\mu g \cdot g^{-1}$) upstream of the BC discharge in June and exceeded the Probable Effects Level (35.9 $\mu g \cdot g^{-1}$) upstream of the AD3 discharge in July and September.
9. Maximum Co concentrations occurred upstream of the AD3 discharge and exceeded Co Background Levels (10 $\mu g \cdot g^{-1}$) by 2X in July and September.

Benthic Macroinvertebrates

1. The majority of BMI sampled from the middle Snake River in 2001 were soft-substrate, pollution-tolerant taxa (*e.g. P. antipodarum*, Oligochaeta, Chironomidae, and *Hyalella azteca*).
2. Mean BMI density was highest in the deposition zones of pooled aquaculture sites (32,610 BMI·m^{-2}) and lowest in the deposition zones of pooled agriculture sites (3,111 BMI·m^{-2}). Average BMI density was approximately 9x greater downstream of aquaculture discharges than downstream of agriculture discharges in June, August, and October of 2001.
3. Average monthly BMI density was greatest downstream of the RV discharge in June, where the total number of organisms exceeded 231,000 BMI·m^{-2}, 73% of which were *P. antipodarum*. Minimum monthly BMI density occurred upstream of the AD3 discharge in September, where the total number of organisms was less than 870 individuals·m^{-2}.
4. *Valvata utahensis* (Utah Valvata) was the only listed species encountered throughout the 2001 benthic macroinvertebrate sampling effort. Averaging 2.67 snails·dredge^{-1} (118.5 snails·m^{-2}), *V. utahensis* inhabited very fine, black, organically enriched sediments with very heavy macrophyte communities and associated filamentous algae.
5. The exotic *P. antopodarum* were found in 49.9 % of all grab samples (June-October, 2001), averaging 258 snails·dredge^{-1} (11,457 snails·m^{-2}). Average *P. antipodarum* density was significantly greater downstream of aquaculture discharges than agriculture discharges by 4500x in June, 100x in August, and 500x in October, 2001. Maximum *P. antipodarum* density (567,556 *P. antipodarum*·m^{-2}) occurred in a grab sample between 100 and 200 m downstream of the Rim View aquaculture facility in June, 2001. Because these exotic snails seem to prefer algae and diatoms (Lysne 2002), it is very likely that *P. antipodarum* are found downstream of aquaculture discharges because they are utilizing the rich periphytic food source associated with AM.
6. Chironomidae spp. were found in 274 (76.3 %) dredge samples at the six sites sampled in 2001, averaging 6.39 individuals·dredge^{-1} (284 individuals·m^{-2}). Average Chironomidae density was significantly greater downstream of agriculture discharges than downstream of aquaculture discharges by 300% in June, 2001. Maximum Chironomidae densities,

averaging 4,006 individuals·m^{-2} over eight dredge samples, occurred in the deposition zone of the Crystal Springs study site in July.

7. Mean BMI biomass was highest in the control zones of pooled aquaculture sites (38.6 g·m^{-2}) and lowest in the control zones of pooled agriculture sites (3.0 g·m^{-2}). Average BMI biomass was 14x greater downstream of aquaculture discharges than agriculture discharges in August and 6x greater in October, 2001.
8. Mean BMI richness in the middle Snake River in 2001 was greater downstream of aquaculture discharges (6.0) than downstream of agriculture discharges (4.0). Mean BMI richness was at least 25% greater downstream of aquaculture discharges than downstream of agriculture discharges for all months sampled.
9. BMI density, biomass, and community richness were generally greater downstream of aquaculture discharges than downstream of agriculture discharges. The increase in BMI density, biomass, and community richness downstream of aquaculture discharges could be due to the productive growth of aquatic vegetation in these areas. Conversely, the sporadic densities of BMI downstream of agriculture discharges may be associated with the patchy AM community composition found at those sites.

   Note: BMI were typically identified to the family level, with selected taxonomic groups only identified to the Phylum or Class level (*i.e.* Phylum Nematoda, Class Oligochaeta) due to their difficult distinction. This potential undercounting of taxa could be a source of error in the BMI richness metric.

Aquatic Macrophytes

1. Seven vascular AM taxa were sampled from five different families throughout the 5-month sampling period in the middle Snake River in 2001. AM biomass in the middle Snake River in 2001 was dominated by *Potamogeton crispus*, *Ceratophyllum demersum*, and *Elodea canadensis*, all taxa considered tolerant of organic pollution and eutrophic conditions.
2. AM Densities found during the 2001 middle Snake River sampling effort were greater than the 200 g·m^{-2} nuisance level (nuisance level per EPA 2002) in the RV deposition zone in June, the RV and BC deposition zones in July, the CS deposition zone in August, the RV deposition zone in September, and the AD2 deposition zone in October.

Maximum AM biomass (677.7 $g{\cdot}m^{-2}$) was sampled approximately 100 m downstream of the RV discharge.

3. AM biomass averaged 5.9 $g{\cdot}m^{-2}$ upstream of agriculture discharges and 6.2 $g{\cdot}m^{-2}$ downstream of agriculture discharges. AM biomass averaged 33.5 $g{\cdot}m^{-2}$ upstream of aquaculture discharges and 73.1 $g{\cdot}m^{-2}$ downstream of aquaculture discharges.
4. AM biomass averaged 11.1 $g{\cdot}m^{-2}$ upstream of the AD3 discharge and 6.2 $g{\cdot}m^{-2}$ downstream of the AD3 discharge. AM biomass averaged 5.6 $g{\cdot}m^{-2}$ upstream of the AD2 discharge and 8.0 $g{\cdot}m^{-2}$ downstream of the AD2 discharge. AM biomass averaged 1.8 $g{\cdot}m^{-2}$ upstream of the AD1 discharge and 4.4 $g{\cdot}m^{-2}$ downstream of the AD1 discharge.
5. AM biomass averaged 10.5 $g{\cdot}m^{-2}$ upstream of the CS discharge and 33.0 $g{\cdot}m^{-2}$ downstream of the CS discharge. AM biomass averaged 54.8 $g{\cdot}m^{-2}$ upstream of the RV discharge and 145.0 $g{\cdot}m^{-2}$ downstream of the RV discharge. AM biomass averaged 35.3 $g{\cdot}m^{-2}$ upstream of the BC discharge and 41.2 $g{\cdot}m^{-2}$ downstream of the BC discharge.
6. AM biomass levels in the upstream and downstream areas at agriculture study sites were limited by reduced light penetration, a direct result of high TSS levels.
7. The greater AM production found in aquaculture deposition zones than aquaculture control zones occurred with the decrease in TSS and higher nutrient concentrations in the sediments downstream of the discharges.
8. Aquatic macrophyte decomposition, combined with nutrient enrichment from the aquaculture discharges themselves (EPA 2002), provides sufficient nutrient concentrations for sustained aquatic vegetation production.

CONCLUSIONS

It is difficult to generalize river processing of effluents over a large reach of divergent conditions. This study showed that the processing and fate of materials entering the middle Snake River from each discharge are unique depending on water quality, ecological, and temporal characteristics of each site. For example, nutrients or organic matter entering the middle Snake River in June are processed differently from materials entering in October. June nutrient or organic additions to the Middle Snake River are rapidly utilized by growing plant communities, whereas more of the October additions are stored in sediments until subsequent year's high plant growth. Likewise, materials entering the middle Snake River at an aquaculture site in a hydrologically constrained reach are processed differently from materials entering at an aquaculture site in a hydrologically unconstrained reach. Particulate additions in constrained reaches remain in suspension longer than particulate additions in unconstrained reaches due to the higher gradient and velocities typically associated with constrained reaches. This distinction between discharge/receiving sites requires that each site's potential impacts be assessed on a site-by-site basis.

At the AD3 study site (Pigeon Cove LQ and LS Drain), sand content was higher downstream of the discharge than upstream, whereas silt and clay content was higher upstream of the discharge than downstream. In all months combined (June-October 2001) average sediment nitrogen and phosphorus content, and average trace element concentrations (17 selected elements) were higher upstream of the AD3 discharge than downstream. Similarly, 5-month average BMI density, BMI biomass, BMI richness, and AM biomass were higher upstream of the AD3 discharge than downstream.

At the AD2 study site (Southside LS2/39A Drain), sand content was higher downstream of the discharge than upstream, whereas silt and clay content was higher upstream of the discharge than downstream. In all months combined (June-October 2001) average sediment nitrogen and all trace elements except Ca, Na, Ni, Co, and Mo had higher concentrations upstream of the AD2 discharge than downstream. However, average sediment phosphorus concentrations for the 5 sampling months were higher downstream of the AD2 discharge than upstream. Average BMI density and BMI richness for the 5 sampling months were higher upstream of the AD2 discharge than downstream. However, average BMI and AM biomass were higher downstream of the AD2 discharge than upstream.

At the AD1 study site (Southside 39 Drain), sand content was higher upstream of the discharge than downstream, whereas silt and clay content was higher downstream of the discharge than upstream. Average sediment nitrogen and phosphorus content for the 5 sampling months was higher downstream of the AD1 discharge than upstream. Similarly, all trace elements but Na had higher average concentrations downstream of the AD1 discharge than upstream. Average BMI density and AM biomass were higher downstream of the AD1 discharge than upstream. No differences were apparent when comparing BMI biomass and BMI richness between the AD1 control and deposition zones.

At the CS study site (Crystal Springs hatchery), sand content was higher upstream of the discharge than downstream, whereas silt and clay content was higher downstream of the discharge than upstream. Average sediment nitrogen and phosphorus content for the 5 sampling months was higher downstream of the CS discharge than upstream. Similarly, all 17 other trace elements had higher average concentrations downstream of the CS discharge than upstream. Average BMI density, BMI biomass, and AM biomass were higher downstream of the CS discharge than upstream. Average BMI richness upstream of the CS discharge was identical to average BMI richness downstream of the CS discharge.

At the RV study site (Rim View hatchery), sand content was higher upstream of the discharge than downstream, whereas silt and clay content was higher downstream of the discharge than upstream. Average sediment nitrogen and phosphorus content for the 5 sampling months was higher downstream of the RV discharge than upstream. Similarly, all trace elements but Na and Mn had higher average concentrations downstream of the AD1 discharge than upstream. Average BMI density, BMI biomass, and AM biomass were higher downstream of the RV discharge than upstream. Average BMI richness was higher upstream of the RV discharge than downstream.

At the BC study site (Box Canyon hatchery), sand content was higher upstream of the discharge than downstream, whereas silt and clay content was higher downstream of the discharge than upstream. Average sediment nitrogen for the 5 sampling months was higher upstream of the BC discharge than downstream, whereas average sediment phosphorus was higher downstream of the BC discharge than upstream. Trace element concentrations between the BC control and deposition zones showed variable trends depending on the element. Average concentrations of C, Ca, Mg, K, Mn, Fe, Pb, Cd, Ba, Ni, Be, and Mo were higher upstream of the

BC discharge than downstream, whereas average concentrations of Na, Zn, Cu, S, Cr, and Co were higher downstream of the BC discharge than upstream. Average BMI density and BMI biomass were higher upstream of the BC discharge than downstream, whereas average BMI richness and AM biomass were higher downstream of the BC discharge than upstream.

IMPLICATIONS AND RECOMMENDATIONS

The intent of our 2001 middle Snake River study was not to compare the magnitude of different industry effluents but instead to assess the condition of sediment and benthic biota downstream of industry effluents. Regardless of effluent magnitude, comparing the benthic environment upstream and downstream of individual discharges provides a more clear understanding of the relationship between an impact and the potential source of the impact. Understanding the relationship between a discharge and its ecological impact on the benthic environment will provide opportunities to measure the success of point source management by measuring changes in the benthic environment. Validation of point source discharge management decisions with benthic impact analysis will allow managers to relate positive ecological changes to changes in industry practices (*i.e.* best management practices).

Results of this 2001 middle Snake River benthic study will play an important role in assessing effluent impacts on the five ESA threatened and endangered snails found in the study reach. *Valvata utahensis* was the only listed snail species encountered during our 2001 study. The small *V. utahensis* population was sampled in the deposition zone directly downstream of Box Canyon hatchery and was found in no other locations during the five-month study. *V. utahensis* presence downstream of the Box Canyon aquaculture facility indicates it's tolerance of the benthic environment associated with the Box Canyon deposition zone (*i.e.* dense aquatic macrophytes, organically enriched sediments).

Future benthic research in middle Snake River basin could include the comparison of aquaculture deposition zones (treatment) with deposition zones downstream of unaltered spring discharges (control). However, comparisons should only be made if the compared zones are located in geomorphically similar river reaches (e.g. Box Canyon hatchery and Box Canyon springs).

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Table 1. Mean, standard deviation, and range of measured sediment metrics across all study sites and sampling months (June-October) in the middle Snake River, 2001.

	mean	std dev	range
Sand (%)	74.93	14.39	33.2 - 98.6
Silt (%)	23.12	13.34	0.6 - 61.2
Clay (%)	1.94	1.48	0.0 - 7.6
C (%)	1.54	0.66	0.4 - 3.9
N (%)	0.06	0.06	0.0 - 0.4
Ca ($\mu g \cdot g^{-1}$)	29,211.70	8,309.30	12,000 -.52,000
Mg ($\mu g \cdot g^{-1}$)	5,526.74	1,979.65	1,600 - 20,000
K ($\mu g \cdot g^{-1}$)	2,176.43	718.17	130 - 4,500
Na ($\mu g \cdot g^{-1}$)	533.3	375.69	210 - 3,900
Zn ($\mu g \cdot g^{-1}$)	49.67	15.15	22 - 150
Mn ($\mu g \cdot g^{-1}$)	184.38	61.45	100 - 590
Cu ($\mu g \cdot g^{-1}$)	14.9	6.46	7.1 - 64
Fe ($\mu g \cdot g^{-1}$)	11,693.87	3,619.33	5,700 - 40,000
P ($\mu g \cdot g^{-1}$)	968.08	426.04	340 - 2,200
S ($\mu g \cdot g^{-1}$)	1,489.36	703.03	260 - 3,500
Pb ($\mu g \cdot g^{-1}$)	25.22	8.59	12.0 - 80.0
Cr ($\mu g \cdot g^{-1}$)	23.25	9.64	11.0 - 84.0
Cd ($\mu g \cdot g^{-1}$)	1.13	0.76	0.2 - 12.0
Ba ($\mu g \cdot g^{-1}$)	96.66	30.12	47.0 - 340
Ni ($\mu g \cdot g^{-1}$)	14.69	4.95	8.3 - 53.0
Co ($\mu g \cdot g^{-1}$)	9.51	2.67	6.1 - 31.0
Be ($\mu g \cdot g^{-1}$)	0.53	0.3	0.3 - 5.0
Mo ($\mu g \cdot g^{-1}$)	6.12	1.86	1.6 - 18.0

Table 2. Average values for sediment metrics across all sites and months for agriculture and aquaculture deposition and control zones. DEP = deposition zone, CON = control zone.

	Agriculture		Aquaculture	
	DEP	CON	DEP	CON
Sand (%)	77.87	76.53	71.85	73.69
Silt (%)	20.39	21.40	26.13	24.36
Clay (%)	1.77	2.08	2.06	2.01
C (%)	1.19	1.26	1.99	1.69
N (%)	0.03	0.04	0.10	0.06
Ca (μg·g^{-1})	25500.00	26516.67	33089.73	31600.00
Mg (μg·g^{-1})	5210.93	6286.67	5531.47	5381.67
K (μg·g^{-1})	2075.20	2250.00	2245.53	2160.20
Na (μg·g^{-1})	477.33	823.67	474.93	469.80
Zn (μg·g^{-1})	42.31	48.57	59.55	45.87
Mn (μg·g^{-1})	183.00	207.93	172.47	187.80
Cu (μg·g^{-1})	12.34	15.59	17.72	13.72
Fe (μg·g^{-1})	11090.93	13808.33	11583.33	10975.00
P (μg·g^{-1})	688.07	758.73	1473.93	734.87
S (μg·g^{-1})	925.80	1200.13	2177.00	1539.20
Pb (μg·g^{-1})	24.26	28.11	25.44	23.85
Cr (μg·g^{-1})	19.99	25.14	26.63	21.14
Cd (μg·g^{-1})	1.07	1.27	1.12	0.98
Ba (μg·g^{-1})	89.43	113.07	96.82	94.61
Ni (μg·g^{-1})	13.73	18.19	14.95	13.91
Co (μg·g^{-1})	8.96	10.66	9.69	9.15
Be (μg·g^{-1})	0.49	0.52	0.54	0.50
Mo (μg·g^{-1})	6.07	6.89	5.95	5.89

Table 3. Average June values for each sediment metric in the deposition zone and control zone of each study site. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$). DEP = deposition zone, CON = control zone, SIG = significant, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

	AD3			AD2			AD1			CS			RV			BC		
	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG
Sand (%)	78.1	49.3	*	86.7	61.3	*	66.6	85.7	*	65.7	80.5	*	61	89	*	85.3	51.3	*
Silt (%)	18.9	45.7	*	12.4	35.1	*	31	12.5	*	33.2	18.8	*	36	9.3	*	14	44.9	*
Clay (%)	3	5		0.9	3.6	*	2.4	1.8		1.2	0.8		3	1.8	*	0.7	3.9	*
C (%)	1.1	2.1	*	1	1.9	*	1.4	1.1	*	2.4	1.3	*	3.1	1.3	*	1.4	3.1	*
N (%)	0.07	0.13	*	0.03	0.12	*	0.06	0.04	*	0.17	0.08	*	0.22	0.06	*	0.13	0.25	*
Ca ($\mu g \cdot g^{-1}$)	21375	34500	*	24375	31750	*	28375	24000	*	37375	25250	*	45875	24000	*	22875	43500	*
Mg ($\mu g \cdot g^{-1}$)	4187	6450	*	4187	5525	*	5962	4225	*	5875	4475	*	5462	2625	*	4350	8175	*
K ($\mu g \cdot g^{-1}$)	1388	2625	*	1400	1875	*	2188	1550	*	2188	1650	*	2213	1053	*	1304	3775	*
Na ($\mu g \cdot g^{-1}$)	371	595	*	425	393		521	480		440	388	*	491	398		464	510	*
Zn ($\mu g \cdot g^{-1}$)	38.6	55	*	35.1	46.3	*	43.4	36.8	*	59.1	39.8	*	60.9	29.3	*	58.3	67.8	
Mn ($\mu g \cdot g^{-1}$)	155	235	*	155	195	*	235	150	*	178	175		169	123	*	163	373	*
Cu ($\mu g \cdot g^{-1}$)	10.1	18.5	*	10.1	14.5	*	13.5	10.7	*	17.4	12	*	15.9	9.6	*	18	24.8	*
Fe ($\mu g \cdot g^{-1}$)	9938	13250	*	9238	10750	*	12125	9575	*	10813	9700	*	10375	7075	*	11750	14750	*
P ($\mu g \cdot g^{-1}$)	599	823	*	634	720	*	733	630	*	1425	648	*	1588	573	*	1613	893	*
S ($\mu g \cdot g^{-1}$)	909	1300	*	734	1350	*	688	998	*	2188	940	*	2388	1400	*	1800	2400	*
Pb ($\mu g \cdot g^{-1}$)	16.4	27.8	*	16.4	17.5		23.8	17.5	*	23.4	15.8	*	23	15.8	*	20.3	31	*
Cr ($\mu g \cdot g^{-1}$)	15.9	22.5	*	14.6	18.3	*	21.9	16.8	*	19	16.3	*	22	13.8	*	36.1	26	*
Cd ($\mu g \cdot g^{-1}$)	0.48	1.04	*	0.57	0.66		0.83	0.69		1.11	0.84	*	0.97	0.61	*	0.89	1.35	*
Ba ($\mu g \cdot g^{-1}$)	76.8	127.5	*	79.9	104	*	99.6	75.5	*	101.9	85	*	99	72	*	88.8	147.5	
Ni ($\mu g \cdot g^{-1}$)	10.9	16.3	*	12.1	11.8		16.9	14	*	15.1	12	*	15.4	11.3	*	13.8	18.3	
Co ($\mu g \cdot g^{-1}$)	8	10	*	8.9	7.9		10.8	9.4	*	9	8.7		9.6	8.1	*	9.7	10.3	
Be ($\mu g \cdot g^{-1}$)	0.4	0.66	*	0.39	0.49	*	0.56	0.43	*	0.57	0.44	*	0.57	0.32	*	0.4	0.87	*
Mo ($\mu g \cdot g^{-1}$)	4.8	6.2	*	4.6	4.6		5.8	4.9		5	4.6		5.1	4.4		4.8	7	

Table 4. Average July values for each sediment metric in the deposition zone and control zone of each study site. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$). DEP = deposition zone, CON = control zone, SIG = significant, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

	AD3			AD2			AD1			CS			RV			BC		
	DEP	**CON**	**SIG**	**DEP**	**CON**	**SIG**	**DEP**	**CON**	**SIG**	**DEP**	**CON**	**SIG**	**DEP**	**CON**	**SIG**	**DEP**	**CON**	**SIG**
Sand (%)	81	85		86.8	64.2	*	58.4	85.3	*	73.5	85.5	*	69.9	80.5	*	80.3	53.4	*
Silt (%)	17.8	13.5		12.3	33.3	*	38.8	14		24.6	13.8	*	27.2	18.2	*	17.6	42	*
Clay (%)	1.3	1.4		0.9	2.5	*	2.9	0.75	*	2	0.8	*	3	1.4	*	2.1	4.6	*
C (%)	1	0.89		1.1	1.6	*	1.5	0.89	*	1.9	0.86	*	2.5	1.6	*	1.7	2.1	
N (%)	0.04	0.05		0.03	0.07	*	0.06	0.02	*	0.12	0.06	*	0.17	0.07	*	0.15	0.13	
Ca ($\mu g \cdot g^{-1}$)	22125	33750	*	26375	31750	*	28625	21000	*	31571	19500	*	41875	35500	*	27625	35750	*
Mg ($\mu g \cdot g^{-1}$)	4838	16500	*	4988	6400	*	6363	4300	*	5071	3250	*	5375	4925		5025	5925	
K ($\mu g \cdot g^{-1}$)	1975	3400	*	1963	2800	*	2225	1375	*	1700	1100	*	1913	1575		1675	2250	
Na ($\mu g \cdot g^{-1}$)	561	2875	*	511	588	*	426	395	*	391	318	*	418	418		506	500	
Zn ($\mu g \cdot g^{-1}$)	40.8	71.5	*	38.6	48.3	*	43.8	36.8		51.7	31.3	*	51.5	39	*	64.9	48.3	*
Mn ($\mu g \cdot g^{-1}$)	160	485	*	168	195	*	218	140	*	166	113	*	164	148		175	200	
Cu ($\mu g \cdot g^{-1}$)	12.1	29	*	10.6	15	*	13.9	10.4	*	13.4	9.1	*	15	12.3	*	19.5	15	
Fe ($\mu g \cdot g^{-1}$)	10613	32250	*	9825	11750	*	12000	9500	*	9786	7950	*	9625	9075		12000	11500	
P ($\mu g \cdot g^{-1}$)	649	1275	*	655	746	*	709	648	*	1457	538	*	1336	698	*	1800	783	*
S ($\mu g \cdot g^{-1}$)	920	1650	*	784	1250	*	898	855		1943	740	*	2238	1500	*	2050	1325	*
Pb ($\mu g \cdot g^{-1}$)	27.4	50.8	*	26	33.3	*	29.4	24.8		22.9	19		29.6	23.5	*	22.5	21	
Cr ($\mu g \cdot g^{-1}$)	21.4	67.8	*	19.3	24.8	*	20.8	17.3	*	17.6	12.5	*	21.3	18.8	*	35.9	22	*
Cd ($\mu g \cdot g^{-1}$)	1.8	3.6	*	1.4	2	*	1.2	0.74	*	0.81	0.86		1.3	0.93	*	0.85	0.65	
Ba ($\mu g \cdot g^{-1}$)	76.6	235	*	80.8	102	*	97.4	65.3	*	91.4	61.3	*	82.6	81.5		90.6	104.3	
Ni ($\mu g \cdot g^{-1}$)	14.3	43.8	*	12.8	15.5	*	14.8	11.5	*	13.3	9.9	*	14.8	12.3	*	15.5	14.8	
Co ($\mu g \cdot g^{-1}$)	9.1	26	*	9.2	9.8	*	8.8	7.8	*	9.1	7.5	*	9	8.2	*	10.6	9.4	*
Be ($\mu g \cdot g^{-1}$)	0.48	0.68	*	0.46	0.59	*	0.54	0.38	*	0.49	0.33	*	0.5	0.42	*	0.46	0.55	
Mo ($\mu g \cdot g^{-1}$)	6	14.3	*	5.5	7.9	*	6.8	5.6		5.4	4.6		5.9	5.6		6	5.7	

Table 5. Average August values for each sediment metric in the deposition zone and control zone of each study site. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$). DEP = deposition zone, CON = control zone, SIG = significant, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

	AD3			AD2			AD1			CS			RV			BC		
	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG
Sand (%)	90	48.2	*	88	74.1	*	64.7	88	*	73.5	78.2		69.8	81	*	81.6	64.2	*
Silt (%)	8.4	48	*	11.1	23.3	*	32.9	11.3		25.6	21.4		27.8	17.8		17.1	33.7	*
Clay (%)	1.7	3.8	*	0.98	2.7	*	2.4	0.8	*	0.95	0.5		2.4	1.3	*	1.3	2.1	*
C (%)	0.85	1.9	*	1.2	1.3		1.4	0.89	*	2	1.5		2.4	1.7	*	1.4	2	*
N (%)	0.01	0.05	*	0.02	0.03		0.02	0.01		0.04	0.01		0.1	0.02	*	0.03	0.03	
Ca ($\mu g \cdot g^{-1}$)	19125	33000	*	30500	24500	*	30125	25250	*	32000	28000		39500	38500		24375	32750	*
Mg ($\mu g \cdot g^{-1}$)	3625	6850	*	5625	4675	*	6888	4775	*	5200	4700		5600	5600		5238	6525	
K ($\mu g \cdot g^{-1}$)	1500	3675	*	2238	2125		2800	1900	*	2325	2175		2463	2075	*	2063	2850	*
Na ($\mu g \cdot g^{-1}$)	411	575	*	553	495	*	544	625	*	431	433		479	525	*	555	523	*
Zn ($\mu g \cdot g^{-1}$)	37.6	59	*	43.4	45.5		45.6	39.8		55.5	42.3		58.9	39.3	*	61.4	56.5	
Mn ($\mu g \cdot g^{-1}$)	146	225	*	188	185		216	153	*	166	150	*	161	155		184	233	*
Cu ($\mu g \cdot g^{-1}$)	8.8	20.3	*	12.1	13.8		13.6	10.3	*	13.6	11.3		13.1	11.4		20	16.8	
Fe ($\mu g \cdot g^{-1}$)	10450	15000	*	11875	12000		13000	11250		10638	10750		11225	10000	*	14000	14000	
P ($\mu g \cdot g^{-1}$)	585	745	*	791	673	*	724	770		1713	685	*	1713	833	*	1550	1000	*
S ($\mu g \cdot g^{-1}$)	834	1650	*	973	1400	*	1076	1175		2350	1700		2613	1600	*	2438	2275	
Pb ($\mu g \cdot g^{-1}$)	19.1	34.3	*	28.1	24.3		28.1	22.3	*	22.5	23		21.1	22		23.9	23.3	
Cr ($\mu g \cdot g^{-1}$)	15.3	24	*	20.3	17.8	*	23.8	20		19	18.3		23.5	21.5		42.9	33.5	*
Cd ($\mu g \cdot g^{-1}$)	0.64	1.3	*	1.3	1.1		1.4	0.96	*	1.1	1.1		1.1	1		1.3	1.3	
Ba ($\mu g \cdot g^{-1}$)	78.4	137.5	*	97.9	106.5		103.4	91.8		93.6	85.8		93.8	86.3		100.3	114	*
Ni ($\mu g \cdot g^{-1}$)	10.2	16.8	*	14.9	11.8	*	16.4	13	*	13.5	13.8		15.1	14		15.5	16.3	
Co ($\mu g \cdot g^{-1}$)	7.4	9.5	*	10.5	7.4	*	9.9	9.4		9	9.8	*	10.1	9.6		11.1	10.7	*
Be ($\mu g \cdot g^{-1}$)	0.37	0.75	*	0.51	0.48		0.6	0.45	*	0.55	0.53		0.57	0.45	*	0.5	0.63	
Mo ($\mu g \cdot g^{-1}$)	5.3	9.5	*	7.3	5.8		7.7	6.1		6.3	5.7		6.8	6		6	7.2	

Table 6. Average September values for each sediment metric in the deposition zone and control zone of each study site. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$). DEP = deposition zone, CON = control zone, SIG = significant, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

	AD3			AD2			AD1			CS			RV			BC		
	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG
Sand (%)	71.4	74.1		88.7	75.7	*	71.6	94.6	*	59.3	95	*	70.8	59.8		69.8	53.5	
Silt (%)	25.5	22.6		10.4	22.7	*	27.1	4.6	*	39	4		27.4	38.2		26.3	42.9	
Clay (%)	3.1	3.3		0.9	1.6	*	1.4	0.8	*	1.7	1.1	*	1.8	2.1		4	3.6	
C (%)	1.3	1.2		1.1	1.4	*	1.2	0.7	*	2.2	0.6	*	2.1	2.2		1.9	2.2	
N (%)	0.03	0.01		0.01	0.02		0.02	0.01		0.1	0.03	*	0.1	0.09		0.12	0.08	
Ca ($\mu g \cdot g^{-1}$)	23750	33750		25750	24000		24750	17250	*	36250	15250	*	36275	40250		32375	40500	
Mg ($\mu g \cdot g^{-1}$)	5138	13500	*	4500	4600		5650	3525	*	6575	3050	*	5600	6825	*	6388	7850	
K ($\mu g \cdot g^{-1}$)	2575	3525		1863	2100	*	2325	1400	*	2750	1250	*	2613	2800		2850	3150	
Na ($\mu g \cdot g^{-1}$)	444	2825	*	466	465		483	508		441	368	*	458	473		528	495	
Zn ($\mu g \cdot g^{-1}$)	46.8	73	*	39.5	45.5		46.9	31.8	*	71.9	34.8		52.1	48		76.1	61.8	
Mn ($\mu g \cdot g^{-1}$)	189	425	*	154	168	*	226	123	*	199	125	*	151	185	*	229	258	
Cu ($\mu g \cdot g^{-1}$)	14.6	28	*	13.6	12.5		13.9	7.5	*	24.6	8.5		12.8	14.8		33	20	
Fe ($\mu g \cdot g^{-1}$)	11600	30000	*	9575	11750	*	12625	9100	*	11750	9475	*	10713	11500		16000	14750	
P ($\mu g \cdot g^{-1}$)	815	1225	*	651	640		726	605	*	1375	528	*	1338	885	*	1738	943	*
S ($\mu g \cdot g^{-1}$)	1119	1775	*	801	1200	*	836	643		2238	700	*	2163	1800	*	2563	1575	*
Pb ($\mu g \cdot g^{-1}$)	24.5	49.5	*	18.5	19.8		26.5	14.5	*	38	15	*	23.1	22.8		32.8	33.8	
Cr ($\mu g \cdot g^{-1}$)	19	57.3	*	16	20.5	*	31	15	*	22.4	14.3	*	22.6	25.8		38.6	29.3	*
Cd ($\mu g \cdot g^{-1}$)	0.97	2.3	*	0.84	1.3		1.1	0.53	*	1.2	0.44	*	1.1	1		1.5	1.5	
Ba ($\mu g \cdot g^{-1}$)	99.8	250	*	85.1	96.5	*	92.9	71.3	*	105	60.5	*	92.5	104		113	128	
Ni ($\mu g \cdot g^{-1}$)	13.6	40.3	*	11.3	13.8	*	16.9	9	*	15.4	10	*	14.1	16.3	*	17.6	17.5	
Co ($\mu g \cdot g^{-1}$)	7.8	22.8	*	7.6	8		9.8	6.3	*	9.2	7	*	8.7	9.1		11.4	10.6	
Be ($\mu g \cdot g^{-1}$)	0.52	0.7		0.46	0.56		0.53	0.33	*	0.6	0.3	*	0.67	0.56		0.63	0.7	
Mo ($\mu g \cdot g^{-1}$)	5.5	12	*	5.6	5.5		7.9	4.8	*	6.6	4.9		6.7	7.4		8.4	8.7	

Table 7. Average October values for each sediment metric in the deposition zone and control zone of each study site. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$). DEP = deposition zone, CON = control zone, SIG = significant, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

	AD3			AD2			AD1			CS			RV			BC		
	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG
Sand (%)	84.6	85.5		87	89.8		64.5	87.2	*	73.6	93.3	*	58.4	75.7	*	85.3	64.5	*
Silt (%)	14.6	13.5		12	9		32.7	11.9		24.5	6.3	*	38.8	22.6		12.8	31.5	*
Clay (%)	0.81	1		0.99	1.2		2.8	1	*	1.9	0.5	*	2.8	1.7	*	2	4	*
C (%)	1.05	1.2		1.2	0.83	*	1.5	0.97	*	1.6	0.78	*	2	1.9		1.3	2.2	*
N (%)	0.01	0.01		0.01	0.01		0.01	0.01		0.02	0.01		0.04	0.02		0.03	0.03	
Ca ($\mu g \cdot g^{-1}$)	20375	24250		27125	17000	*	29750	22000	*	30750	13250	*	32375	43750	*	25250	38250	*
Mg ($\mu g \cdot g^{-1}$)	4188	5050	*	5050	3350	*	6975	4575	*	5925	2800	*	6113	7275	*	5175	6725	*
K ($\mu g \cdot g^{-1}$)	1850	2125		1913	1500	*	2925	1775	*	2738	1225	*	2600	2225	*	2288	3250	*
Na ($\mu g \cdot g^{-1}$)	457	535		471	478		516	523		478	353	*	420	790	*	624	555	*
Zn ($\mu g \cdot g^{-1}$)	48	45.3		37.5	55.5		49	38.5		50.9	53		57.9	39.5		62.1	57.3	
Mn ($\mu g \cdot g^{-1}$)	140	150		160	135	*	235	155	*	151	138		150	223	*	181	218	
Cu ($\mu g \cdot g^{-1}$)	12.6	15.5		11.3	14.8		14.3	13		13.9	8.9	*	14.5	13.5		21.1	17.8	
Fe ($\mu g \cdot g^{-1}$)	9850	10225		10150	10475		13500	10250	*	10325	8600	*	11375	12750	*	13375	12750	
P ($\mu g \cdot g^{-1}$)	586	685	*	699	513	*	765	683	*	1035	490	*	903	768	*	1525	758	*
S ($\mu g \cdot g^{-1}$)	833	988		1078	783	*	1404	985		1438	683	*	2120	2950		2125	1500	*
Pb ($\mu g \cdot g^{-1}$)	23.7	32		24.6	26.8		31.4	26.5		25	28.8		27.5	35		26	28	
Cr ($\mu g \cdot g^{-1}$)	17.4	21.5	*	18.5	14.5	*	24.6	19	*	19.8	13	*	22.3	27	*	36.5	25	*
Cd ($\mu g \cdot g^{-1}$)	0.89	1.1		1.3	0.77		1.3	1		1.1	0.69	*	1.3	1.3		1.1	1.1	
Ba ($\mu g \cdot g^{-1}$)	85.4	80.5		81.4	77.3		106	75.3	*	94.5	64	*	98.3	104		107	121	
Ni ($\mu g \cdot g^{-1}$)	11.3	13.8	*	13.5	9.8	*	16.1	12.8	*	14.8	10.1	*	13.4	15		17	17	
Co ($\mu g \cdot g^{-1}$)	7.6	9	*	9.1	7.5	*	9.9	9.1		9.4	7.5	*	8.2	10.5	*	11.2	10.2	
Be ($\mu g \cdot g^{-1}$)	0.44	0.47		0.49	0.39		0.59	0.44		0.52	0.29	*	0.54	0.49		0.48	0.62	*
Mo ($\mu g \cdot g^{-1}$)	5	5.7		6.4	4.9	*	6.9	5.6		4.9	4.6		5.6	5.9		5.8	6	

Table 8. Benthic macroinvertebrate (BMI) taxa sampled from the middle Snake River, Idaho, June-October, 2001. Study sites and zones where BMI were sampled are listed. c = control zone, d = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

Scientific Name	Study sites and zones sampled
Phylum Arthropoda	
Class Insecta	
Diptera	
Chironomidae	BC(d); RV(c,d); CS(c,d); AD1(c,d); AD2(c,d); AD3(c,d)
Ephydridae	CS(c); AD1(c,d); AD2(c,d); AD3(c,d)
Stratiomyiidae	CS(c)
Ceratopogonidae	RV(c); CS(c,d); AD1(d); AD2(c)
Tipulidae	AD3(c)
Collembola	
Podura aquatica	CS(d)
Odonata	
Anisoptera	BC(d); RV(c,d)
Zygoptera	BC(d); RV(c,d); CS(c,d); AD1(d); AD2(d); AD3(c,d)
Coleoptera	
Corixidae	BC(d); CS(d); AD1(c); AD3(d)
Haliplidae	
Haliplus spp.	BC(c); CS(c); AD1(c,d); AD2(c,d); AD3(c,d)
Megaloptera	
Sialidae	
Sialis spp.	CS(c)
Trichoptera	
Polycentropodidae	AD1(d)
Ephemeroptera	
Ephemeridae	CS(c); AD1(c,d); AD2(c,d); AD3(c,d)
Class Crustacea	
Amphipoda	BC(c,d); RV(c,d); CS(c,d); AD1(c,d); AD2(c,d); AD3(c,d)
Isopoda	BC(c,d); RV(c,d); CS(c,d); AD2(d); AD3(c)
Phylum Platyhelminthes	
Class Turbellaria	BC(c,d); CS(d); AD1(d); AD3(d)
Phylum Annelida	
Class Oligochaeta	BC(c,d); RV(c,d); CS(c,d); AD1(c,d); AD2(c,d); AD3(c,d)
Class Hirudinea	BC(c,d); RV(c,d); CS(c,d); AD1(c,d); AD2(c,d); AD3(d)
Phylum Nematoda	BC(d); RV(c); CS(c,d); AD1(c,d); AD2(c,d); AD3(c,d)

Table 8 (cont). Benthic macroinvertebrate (BMI) taxa sampled from the middle Snake River, Idaho, June-October, 2001. Study sites and zones where BMI were sampled are listed. c = control zone, d = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery

Scientific Name	Study sites and zones sampled
Phylum Mollusca	
Class Gastropoda	
Hydrobiidae	
Potamopyrgus antipodarum	BC(c,d); RV(c,d); CS(c,d); AD1(c,d); AD2(c,d); AD3(c,d)
Ancylidae	
Ferrissia spp.	CS(d)
Physidae	
Physella spp.	BC(c,d); RV(c,d); CS(c,d); AD1(c,d); AD2(c,d); AD3(c,d)
Planorbidae	
Gyraulus parvus	BC(c,d); RV(c,d); CS(c,d); AD1(c,d); AD2(c,d); AD3(c,d)
Vorticifex effusus	BC(c,d); RV(c,d); CS(c,d); AD1(d); AD2(d); AD3(c)
Valvatidae	
Valvata humeralis	RV(d); CS(c); AD3(d)
Valvata utahensis	BC(d)
Lymnaeidae	BC(d); RV(c); CS(d); AD1(c,d)
Class Pelecypoda	
Sphaeriidae	
Musculium spp.	AD1(c); AD2(c)
Pisidium spp.	BC(c,d); RV(c,d); CS(c,d); AD1(c,d); AD2(c,d); AD3(c,d)

Table 9. Average values for BMI and AM metrics across all sites and months for agriculture and aquaculture deposition and control zones. DEP = deposition zone, CON = control zone.

	Agriculture		Aquaculture	
	DEP	CON	DEP	CON
BMI ($\# \cdot m^{-2}$)	3,111	3,415	32,610	27,383
BMI ($g \cdot m^{-2}$)	3.3	3.0	34.2	38.6
BMI taxa richness	4.0	4.6	6.0	5.5
AM ($g \cdot m^{-2}$)	6.2	5.9	73.1	33.5

Table 10. Average June values for BMI and AM metrics in the deposition zone and control zone of each study site. Asterisks indicate a significant difference between control and deposition zones ($p < 0.2$). DEP = deposition zone, CON = control zone, SIG = significant, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

	AD3			AD2			AD1			CS			RV			BC		
	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG
BMI ($\# \cdot m^{-2}$)	6,520	12,239	*	4,011	6,919	*	9,973	8,832		9,168	8,921		231,222	17,425	*	12,707	206,333	*
BMI ($g \cdot m^{-2}$)	5.1	14.4	*	3.5	3.3		9.2	5.4	*	18.0	14.8		213.3	40.4	*	24.3	287.1	*
BMI taxa richness	3.9	6.0	*	4.4	6.3	*	3.1	4.3	*	5.8	4.8		6.0	9.8	*	6.4	4.3	
AM ($g \cdot m^{-2}$)	13.1	13.2		0.5	6.6	*	0.2	0.0		9.4	2.4		325.3	107.3	*	51.5	56.6	

Table 11. Average July values for BMI and AM metrics in the deposition zone and control zone of each study site. Asterisks indicate a significant difference between control and deposition zones ($p < 0.2$). DEP = deposition zone, CON = control zone, SIG = significant, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

	AD3			AD2			AD1			CS			RV			BC		
	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG
BMI ($\#\cdot m^{-2}$)	3,858	5,539	*	3,539	4,884	*	4,427	2,589	*	9,253	4,022		37,694	3,400	*	43,986	58,444	
BMI ($g\cdot m^{-2}$)	4.0	1.9		10.4	4.2	*	1.9	7.9	*	9.8	3.4	*	50.1	1.1	*	59.2	110.6	*
BMI taxa richness	3.9	4.8		4.1	5.0		3.5	3.5		5.8	5.0		6.3	6.5		7.1	3.0	*
AM ($g\cdot m^{-2}$)	1.8	1.2		0.1	16.7	*	0.0	0.0		16.0	1.5		121.3	12.3	*	104.3	73.5	

Table 12. Average August values for BMI and AM metrics in the deposition zone and control zone of each study site. Asterisks indicate a significant difference between control and deposition zones ($p < 0.2$). DEP = deposition zone, CON = control zone, SIG = significant, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

	AD3			AD2			AD1			CS			RV			BC		
	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG
BMI ($\#\cdot m^{-2}$)	1,139	1,022		878	956		1,772	1,289		7,608	5,822		20,356	3,732	*	2,394	44,593	*
BMI ($g\cdot m^{-2}$)	0.7	1.0		0.9	0.6		1.5	1.4		5.8	2.6		31.7	2.2	*	4.1	58.6	*
BMI taxa richness	2.9	5.5	*	3.4	4.0		4.8	4.5		6.0	8.8	*	5.8	8.7		5.3	1.7	
AM ($g\cdot m^{-2}$)	3.8	15.4	*	0.9	1.9		5.5	2.8		49.5	45.6		48.2	12.2	*	20.0	13.8	

Table 13. Average September values for BMI and AM metrics in the deposition zone and control zone of each study site. Asterisks indicate a significant difference between control and deposition zones ($p < 0.2$). DEP = deposition zone, CON = control zone, SIG = significant, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

	AD3			AD2			AD1			CS			RV			BC		
	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG
BMI (#·m^{-2})	972	867		1,050	867		2,294	1,200	*	6,399	2,189	*	44,639	32,389		10,894	4,178	*
BMI (g·m^{-2})	6.0	0.8		0.6	0.4		1.5	0.9	*	7.7	1.5		40.0	19.6	*	11.2	7.7	
BMI taxa richness	4.8	4.8		4.0	3.5		6.1	5.3		7.0	6.5		7.0	10.3	*	6.9	2.0	*
AM (g·m^{-2})	12.2	21.1		2.3	1.8		15.8	3.2		28.8	2.9	*	109.5	135.1		10.3	1.1	*

Table 14. Average October values for BMI and AM metrics in the deposition zone and control zone of each study site. Asterisks indicate a significant difference between control and deposition zones ($p < 0.2$). DEP = deposition zone, CON = control zone, SIG = significant, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

	AD3			AD2			AD1			CS			RV			BC		
	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG	DEP	CON	SIG
BMI (#·m^{-2})	1,089	1,544		1,953	844		3,185	1,633	*	3,597	1,456	*	42,241	1,178	*	6,985	16,667	*
BMI (g·m^{-2})	0.5	0.8		1.6	0.5	*	2.2	1.7		2.5	1.0	*	31.3	1.1	*	4.4	27.3	*
BMI taxa richness	2.5	3.5	*	5.3	3.5	*	3.6	4.0		4.8	4.3		6.0	5.0		3.9	1.3	*
AM (g·m^{-2})	0.2	4.4	*	36.4	0.9		0.5	0.0		61.1	0.0	*	120.6	6.9	*	20.1	31.6	

Table 15. Vascular aquatic macrophyte species sampled from the six study sites, middle Snake River, Idaho, June-October, 2001.

Species	Abbreviation
Ceratophyllaceae (Hornwort Family)	
Ceratophyllum demersum L.	Cdem
Hydrocharitaceae (Frog's-bit Family)	
Elodea canadensis Rich. In Michx.	Ecan
Potamogetonaceae (Pond Weed Family)	
Potamogeton berchtoldii Fieb.	Pber
P. crispus L.	Pcri
P. pectinatus L.	Ppec
Ranunculaceae (Buttercup Family)	
Ranunculus aquatilis L.	Raqu
Zannichelliacaea (Horned Pondweed Family)	
Zannichellia palustris L.	Zpal

Table 16. Aquatic macrophyte abundance (%) for each species collected from the Box Canyon Hatchery study site in the middle Snake River, Idaho, June-October, 2001. Percent abundance is based on dry weight biomass. CON = control zone upstream of discharge, DEP = deposition zone downstream of discharge.

	JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		**TOTAL**	
	CON	DEP	CON	DEP	CON	DEP	CON	DEP	CON	DEP	**CON**	**DEP**
Ceratophyllum demersum	15.3	2.0	10.5	43.8	38.3	25.3	0.0	8.3	19.7	2.8	**15.7**	**24.0**
Elodea canadensis	40.9	23.3	19.3	7.8	52.8	17.2	0.0	9.1	19.0	9.7	**28.6**	**13.9**
Potamogeton berchtoldii	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.5**
Potamogeton crispus	42.3	67.8	68.3	38.9	8.9	57.5	100.0	81.2	60.9	87.4	**54.3**	**54.9**
Potamogeton pectinatus	1.5	5.2	1.9	8.9	0.0	0.0	0.0	1.4	0.4	0.1	**1.4**	**6.3**
Ranunculus aquatilis	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.3**
Zannichellia palustris	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.1**
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table 17. Aquatic macrophyte abundance (%) for each species collected from the Rim View Hatchery study site in the middle Snake River, Idaho, June-October, 2001. Percent abundance is based on dry weight biomass. CON = control zone upstream of discharge, DEP = deposition zone downstream of discharge.

	JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		TOTAL	
	CON	DEP	CON	DEP	CON	DEP	CON	DEP	CON	DEP	**CON**	**DEP**
Ceratophyllum demersum	1.3	4.5	41.4	3.2	0.5	9.9	5.2	5.5	0.0	10.1	**3.1**	**5.2**
Elodea canadensis	81.4	91.7	0.0	69.9	91.0	56.2	94.2	86.4	99.0	84.2	**86.8**	**84.5**
Potamogeton berchtoldii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**
Potamogeton crispus	17.3	3.2	58.6	26.7	8.5	33.9	0.6	8.1	0.8	4.8	**10.1**	**9.9**
Potamogeton pectinatus	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.2	0.9	**0.0**	**0.1**
Ranunculus aquatilis	0.0	0.6	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.3**
Zannichellia palustris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table 18. Aquatic macrophyte abundance (%) for each species collected from the Crystal Springs Hatchery study site in the middle Snake River, Idaho, June-October, 2001. Percent abundance is based on dry weight biomass. CON = control zone upstream of discharge, DEP = deposition zone downstream of discharge.

	JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		**TOTAL**	
	CON	DEP	CON	DEP	CON	DEP	CON	DEP	CON	DEP	**CON**	**DEP**
Ceratophyllum demersum	13.3	10.1	0.0	3.8	16.0	78.7	0.0	36.5	0.0	44.2	**15.5**	**47.0**
Elodea canadensis	0.0	4.8	5.7	7.5	75.6	1.2	0.0	18.7	0.0	53.0	**69.8**	**24.7**
Potamogeton berchtoldii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**
Potamogeton crispus	86.7	85.1	92.7	88.7	8.4	20.1	0.0	44.8	0.0	2.8	**14.7**	**28.3**
Potamogeton pectinatus	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**
Ranunculus aquatilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**
Zannichellia palustris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**NP**	**100.0**	**NP**	**100.0**	**100.0**	**100.0**

Table 19. Aquatic macrophyte abundance (%) for each species collected from the AD1 (Southside 39 Drain) study site in the middle Snake River, Idaho, June-October, 2001. Percent abundance is based on dry weight biomass. CON = control zone upstream of discharge, DEP = deposition zone downstream of discharge.

	JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		**TOTAL**	
	CON	DEP	CON	DEP	CON	DEP	CON	DEP	CON	DEP	**CON**	**DEP**
Ceratophyllum demersum	0.0	0.0	0.0	0.0	91.5	91.2	100.0	99.3	0.0	0.5	**93.7**	**93.9**
Elodea canadensis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	85.4	**0.0**	**2.5**
Potamogeton berchtoldii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**
Potamogeton crispus	0.0	100.0	0.0	0.0	8.5	0.0	0.0	0.0	0.0	14.1	**6.3**	**1.4**
Potamogeton pectinatus	0.0	0.0	0.0	0.0	0.0	8.8	0.0	0.0	0.0	0.0	**0.0**	**2.2**
Ranunculus aquatilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**
Zannichellia palustris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**
TOTAL	**NP**	**100.0**	**NP**	**NP**	**100.0**	**100.0**	**100.0**	**100.0**	**NP**	**100.0**	**100.0**	**100.0**

Table 20. Aquatic macrophyte abundance (%) for each species collected from the AD2 (Southside LS2/39A Drain) study site in the middle Snake River, Idaho, June-October, 2001. Percent abundance is based on dry weight biomass. CON = control zone upstream of discharge, DEP = deposition zone downstream of discharge.

	JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		TOTAL	
	CON	DEP	CON	DEP	CON	DEP	CON	DEP	CON	DEP	**CON**	**DEP**
Ceratophyllum demersum	0.0	62.8	47.8	100.0	80.7	5.6	21.1	90.8	0.0	97.9	**35.3**	**95.0**
Elodea canadensis	2.3	0.0	0.6	0.0	3.3	0.0	10.3	8.9	0.0	1.8	**1.8**	**2.2**
Potamogeton berchtoldii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**
Potamogeton crispus	97.7	37.2	51.6	0.0	16.0	94.4	68.6	0.0	100.0	0.3	**62.9**	**2.8**
Potamogeton pectinatus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	**0.0**	**0.0**
Ranunculus aquatilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**
Zannichellia palustris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table 21. Aquatic macrophyte abundance (%) for each species collected from the AD3 (Pigeon Cove LS & LQ Drain) study site in the middle Snake River, Idaho, June-October, 2001. Percent abundance is based on dry weight biomass. CON = control zone upstream of discharge, DEP = deposition zone downstream of discharge.

	JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		**TOTAL**	
	CON	DEP	CON	DEP	CON	DEP	CON	DEP	CON	DEP	**CON**	**DEP**
Ceratophyllum demersum	46.2	1.0	20.6	2.9	69.8	56.9	21.1	30.4	0.0	100.0	**39.0**	**20.0**
Elodea canadensis	7.3	0.0	0.0	21.4	18.7	1.1	6.5	0.0	0.0	0.0	**9.4**	**1.4**
Potamogeton berchtoldii	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.1**
Potamogeton crispus	46.5	98.8	79.4	75.7	11.5	18.3	72.4	69.6	100.0	0.0	**51.6**	**75.6**
Potamogeton pectinatus	0.0	0.0	0.0	0.0	0.0	23.7	0.0	0.0	0.0	0.0	**0.0**	**2.9**
Ranunculus aquatilis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**
Zannichellia palustris	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0.0**
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table 22. Screening concentrations for trace element contaminants in freshwater sediment derived from NOAA Screening Quick Reference Tables (Buchman 1999).

	Background Level (BL)	Threshold Effects Level (TEL)	Probable Effects Level (PEL)
Zn (ug/g)	7-38	123.1	315
Mn (ug/g)	400	630	N/A
Cu (ug/g)	10-25	35.7	197
Pb (ug/g)	4-17	35	91.3
Cr (ug/g)	7-13	37.3	90
Cd (ug/g)	0.1-0.3	0.6	3.5
Ni (ug/g)	9.9	18	35.9
Co (ug/g)	10	N/A	N/A

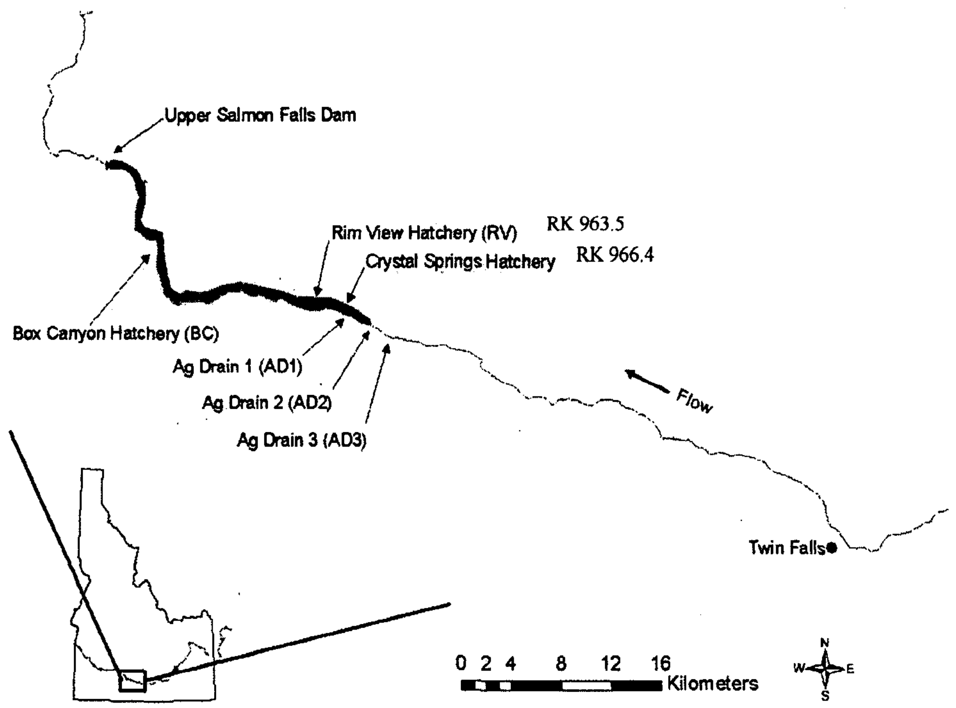

Figure 1. Sample sites located on the middle Snake River. Arrows indicate the flow direction of each of the six discharges. Discharge locations are located at RK 970.9 (AD3), RK 969.0 (AD2), RK 967.1 (AD1), RK 966.4 (CS), RK 9963.5 (RV), and RK 946.8 (BC).

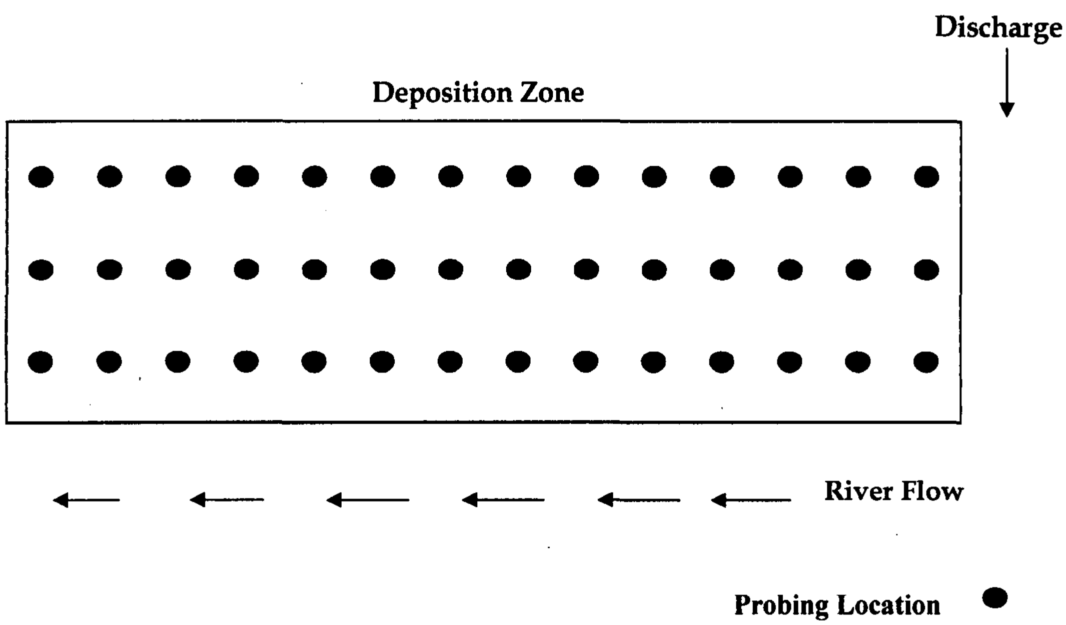

Figure 2. Diagram of systematic sediment probing locations at each site. The three transects of 14 probing locations were 5, 10, and 15 meters from the shoreline and spanned a distance of 150 meters downstream from the discharge.

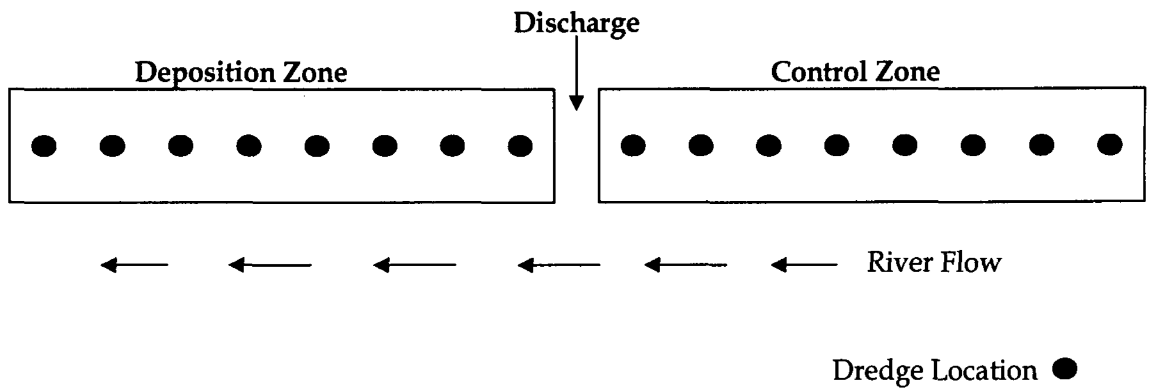

Figure 3. Diagram of dredge locations at each site for year 2000 dredging. The dredge samples were taken randomly between 2 and 15 meters from the shoreline, spanning a distance of 200 meters upstream and downstream from the discharge.

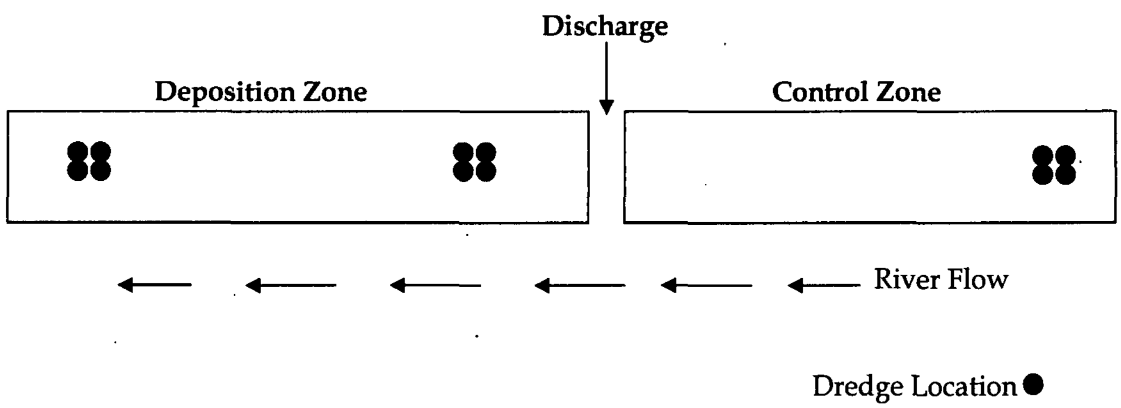

Figure 4. Diagram of dredge locations at each site for year 2001 dredging. The dredge "clusters" were taken randomly between 2 and 15 meters from the shoreline. The control zone dredges were sampled at least 200 meters upstream from the discharge. The upstream-most dredges in the deposition zone were sampled between 1 and 100 meters downstream from the discharge and the downstream-most dredges in the deposition zone were sampled between 100 and 200 meters downstream.

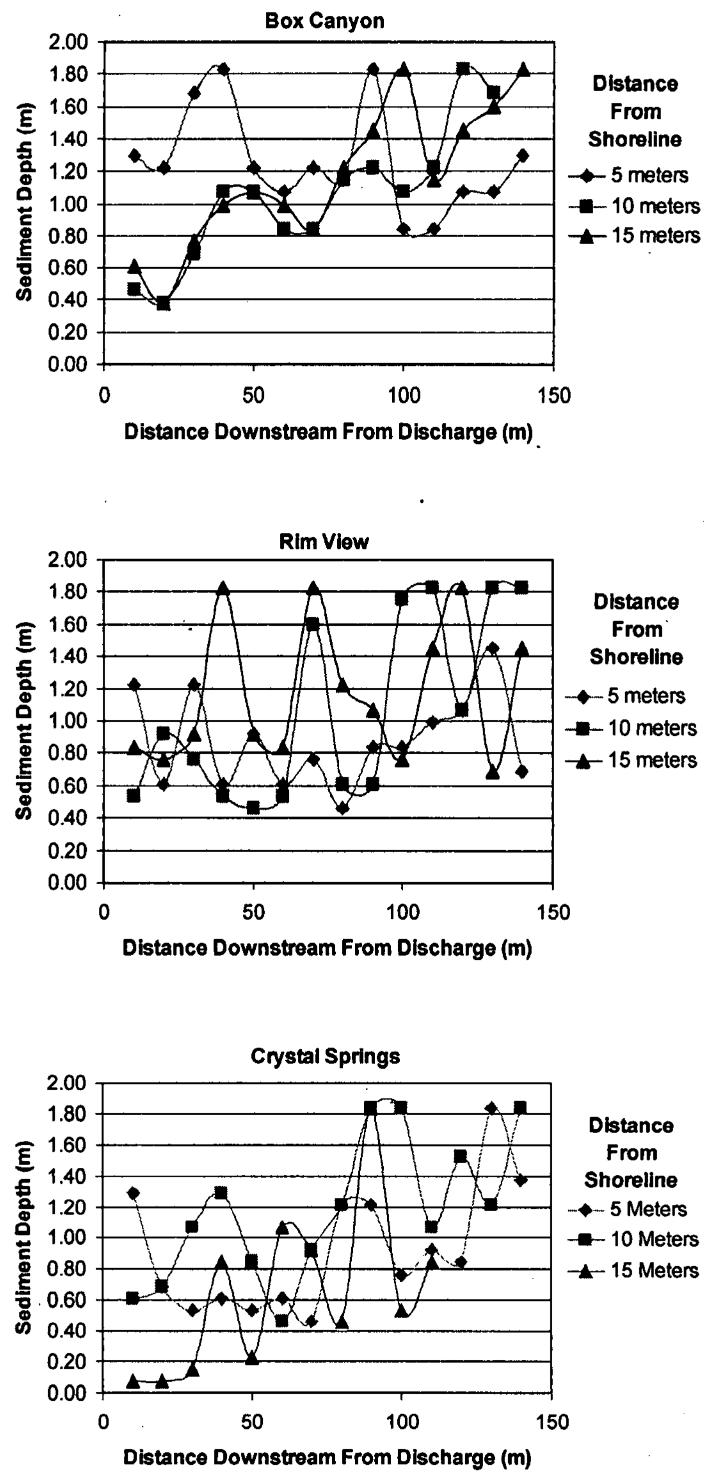

Figure 5. Sediment depth (m) for three distances from the shoreline (5, 10, and 15 m) within 150 meters downstream of the 3 selected aquaculture discharges to the middle Snake River June, 2000.

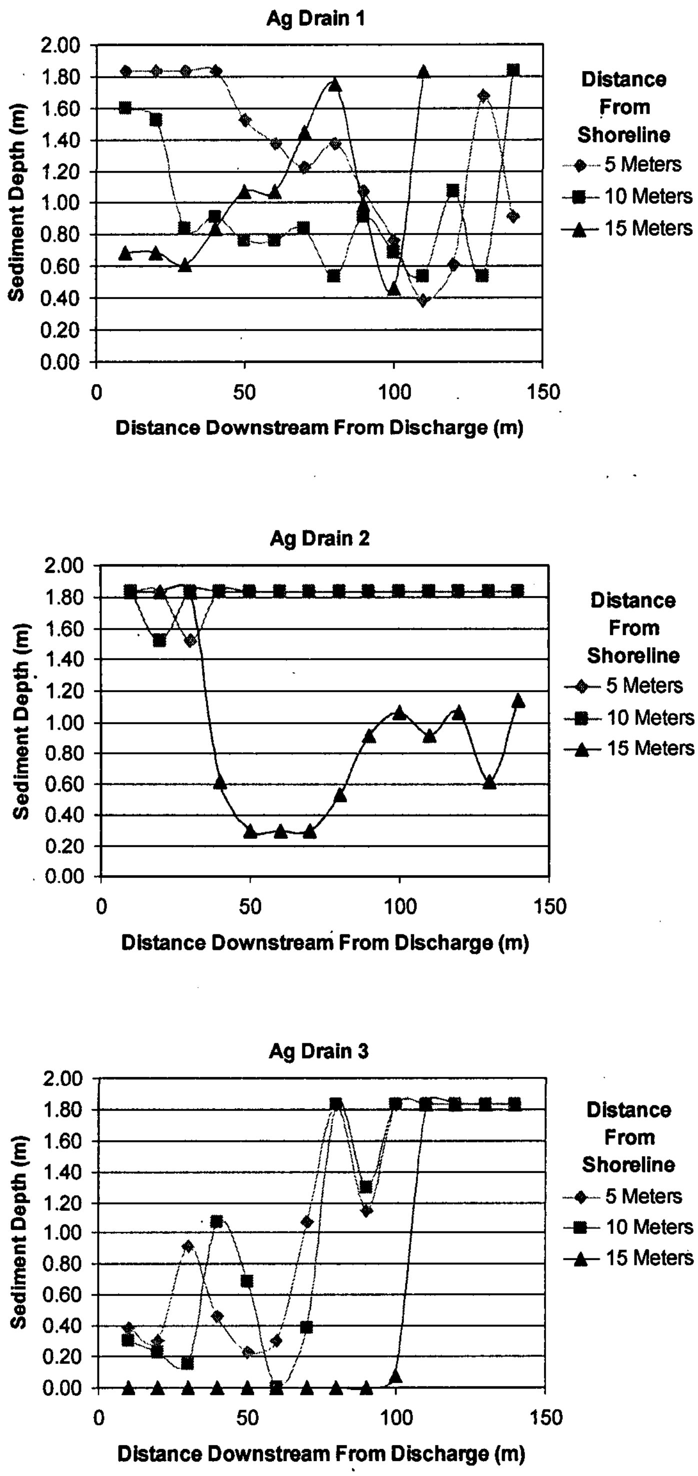

Figure 6. Sediment depth (m) for three distances from the shoreline (5, 10, and 15 m) within 150 meters downstream of the 3 selected agriculture discharges to the middle Snake River June, 2000. Ag Drain 1 = Southside 39 Drain, Ag Drain 2 = Southside LS2/39A Drain, Ag Drain 3 = Pigeon Cove LQ & LS Drain.

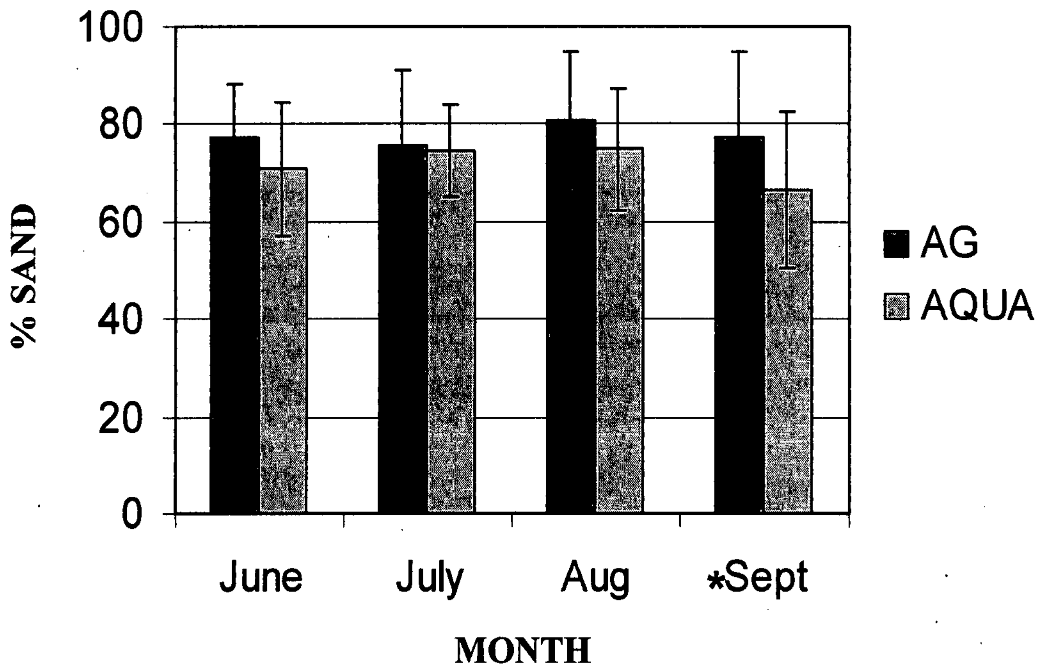

Figure 7. Sand content (%) of sediment sampled from agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the sand content (%) of sediment sampled from aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

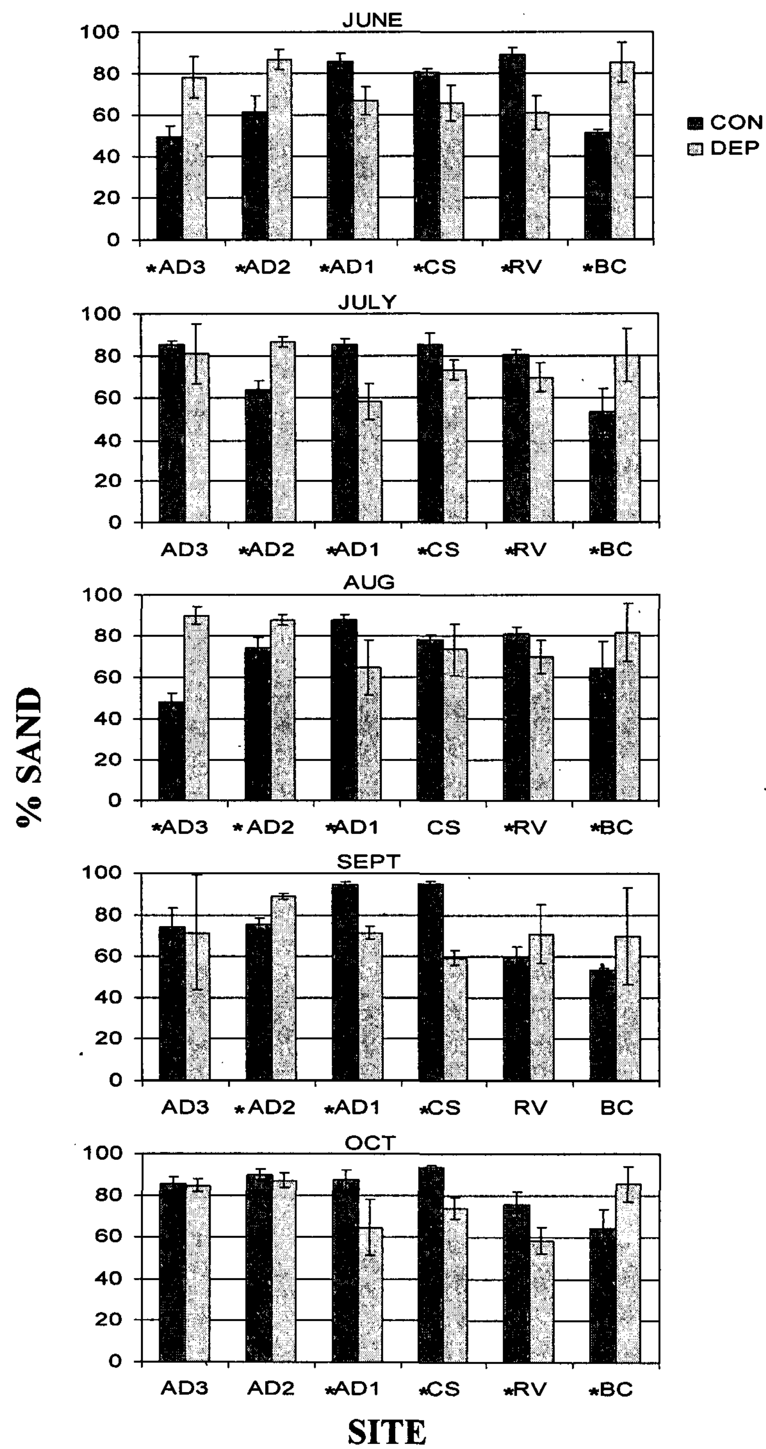

Figure 8. Sand content (%) of sediment sampled at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

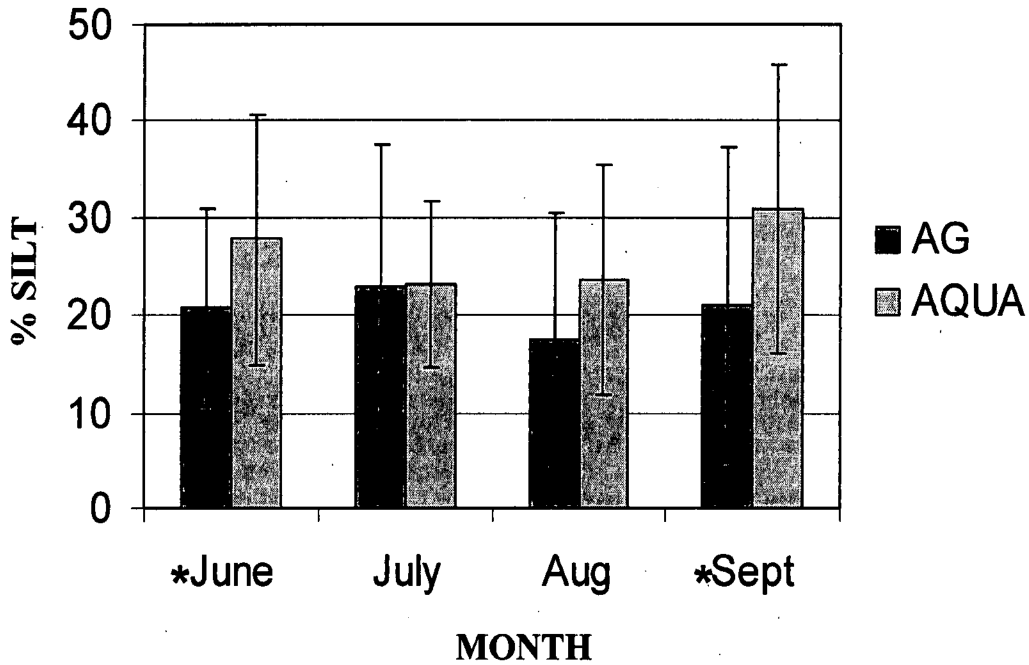

Figure 9. Silt content (%) of sediment sampled from agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the silt content (%) of sediment sampled from aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

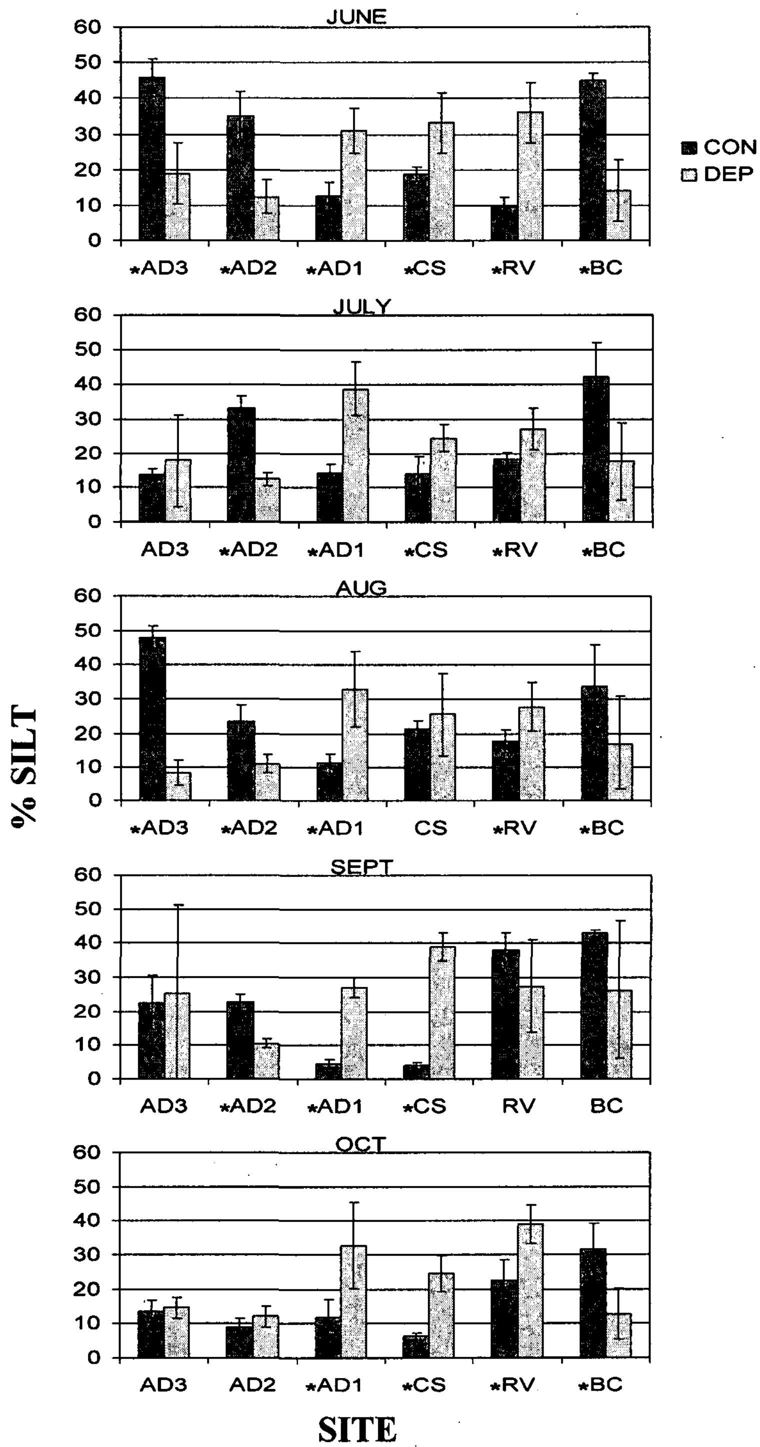

Figure 10. Silt content (%) of sediment sampled at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

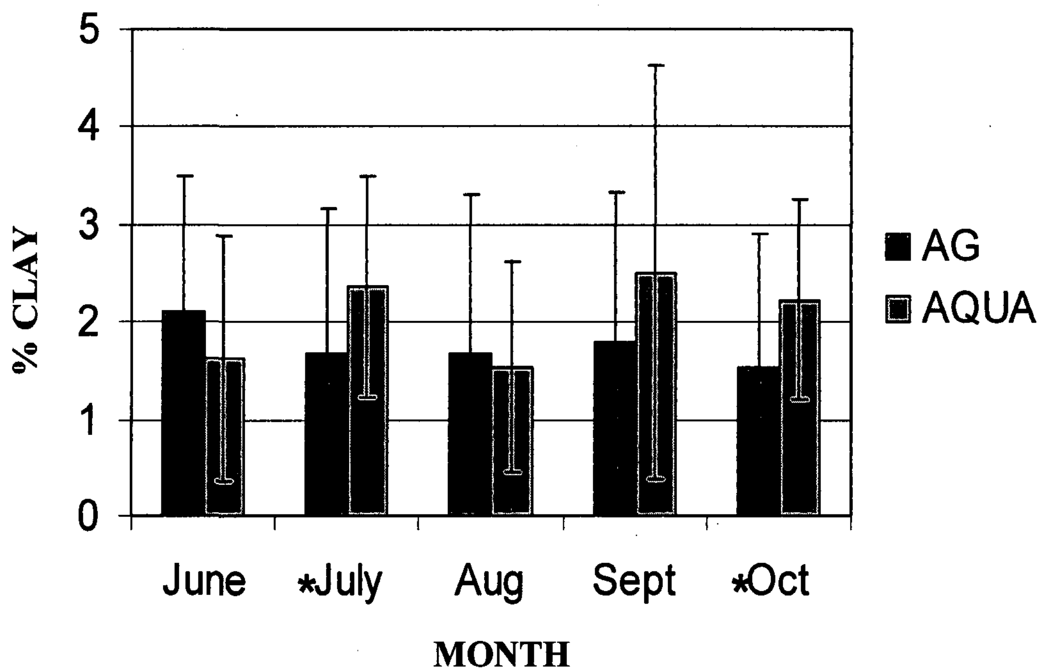

Figure 11. Clay content (%) of sediment sampled from agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the clay content (%) of sediment sampled from aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

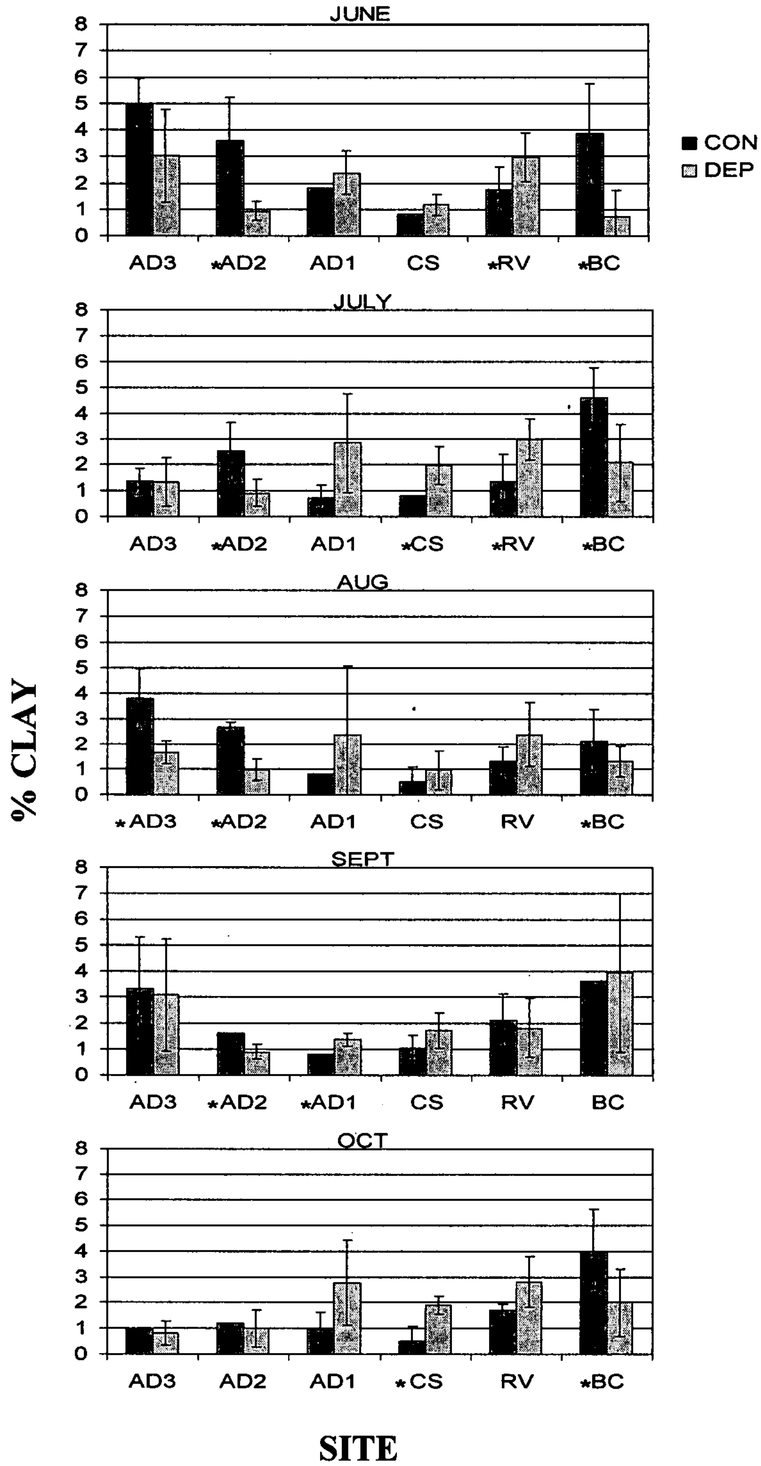

Figure 12. Clay content (%) of sediment sampled at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

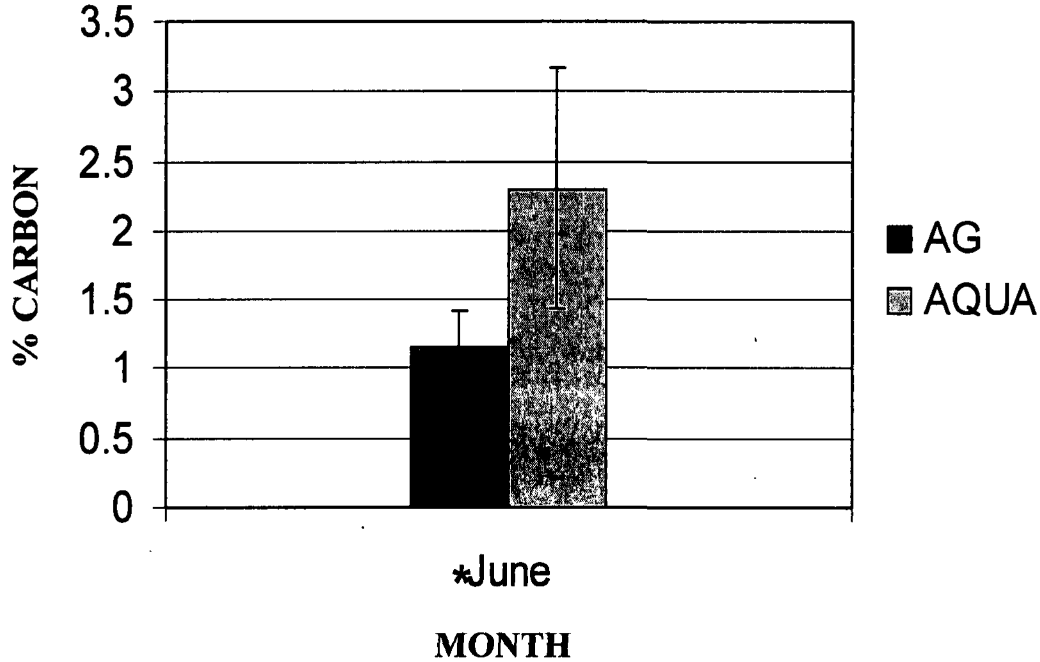

Figure 13. Carbon content (%) of sediment sampled from agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the carbon content (%) of sediment sampled from aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

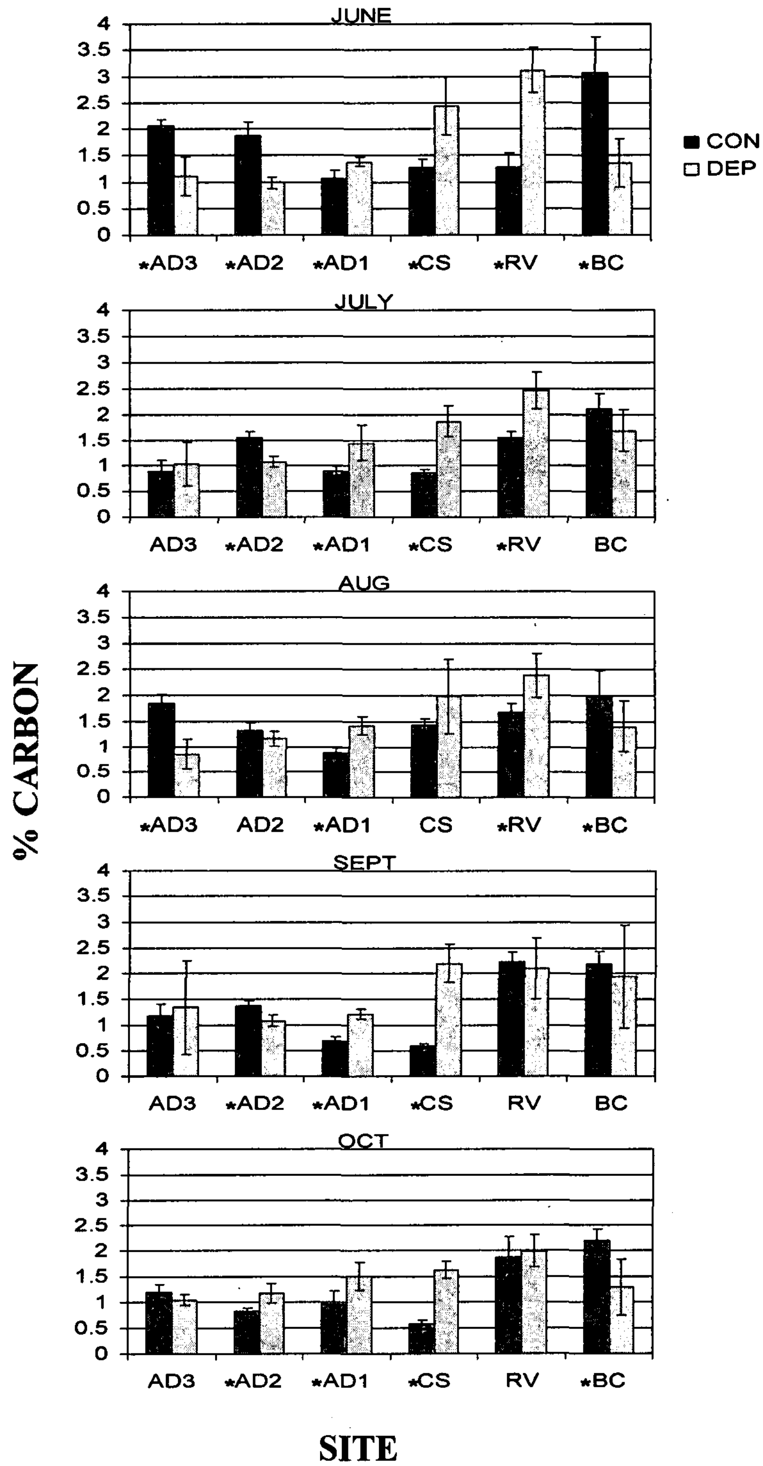

Figure 14. Carbon content (%) of sediment sampled at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

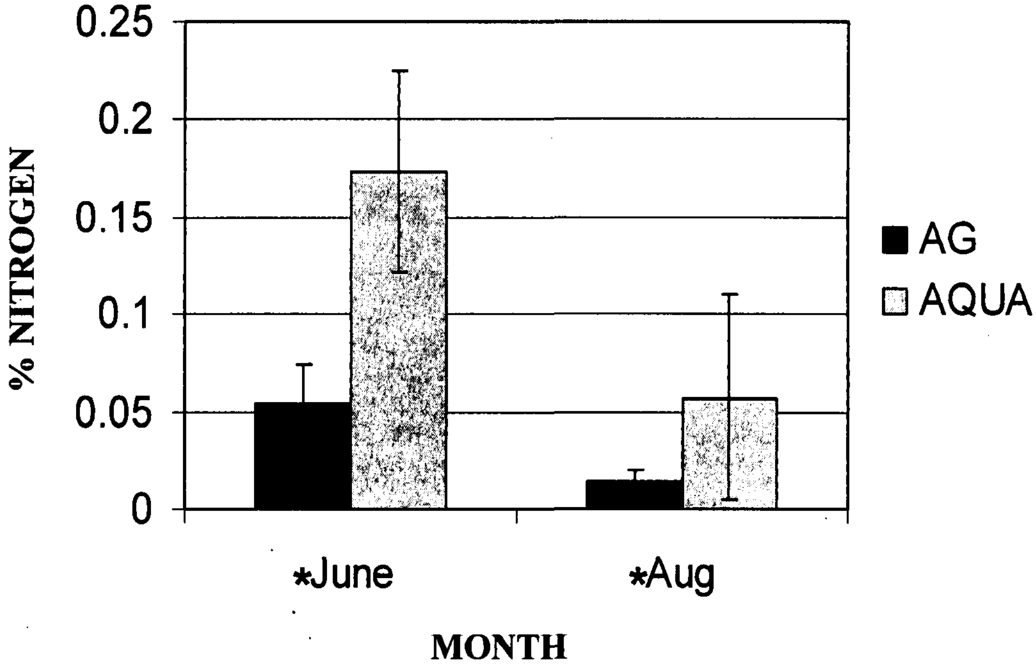

Figure 15. Nitrogen content (%) of sediment sampled from agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the nitrogen content (%) of sediment sampled from aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

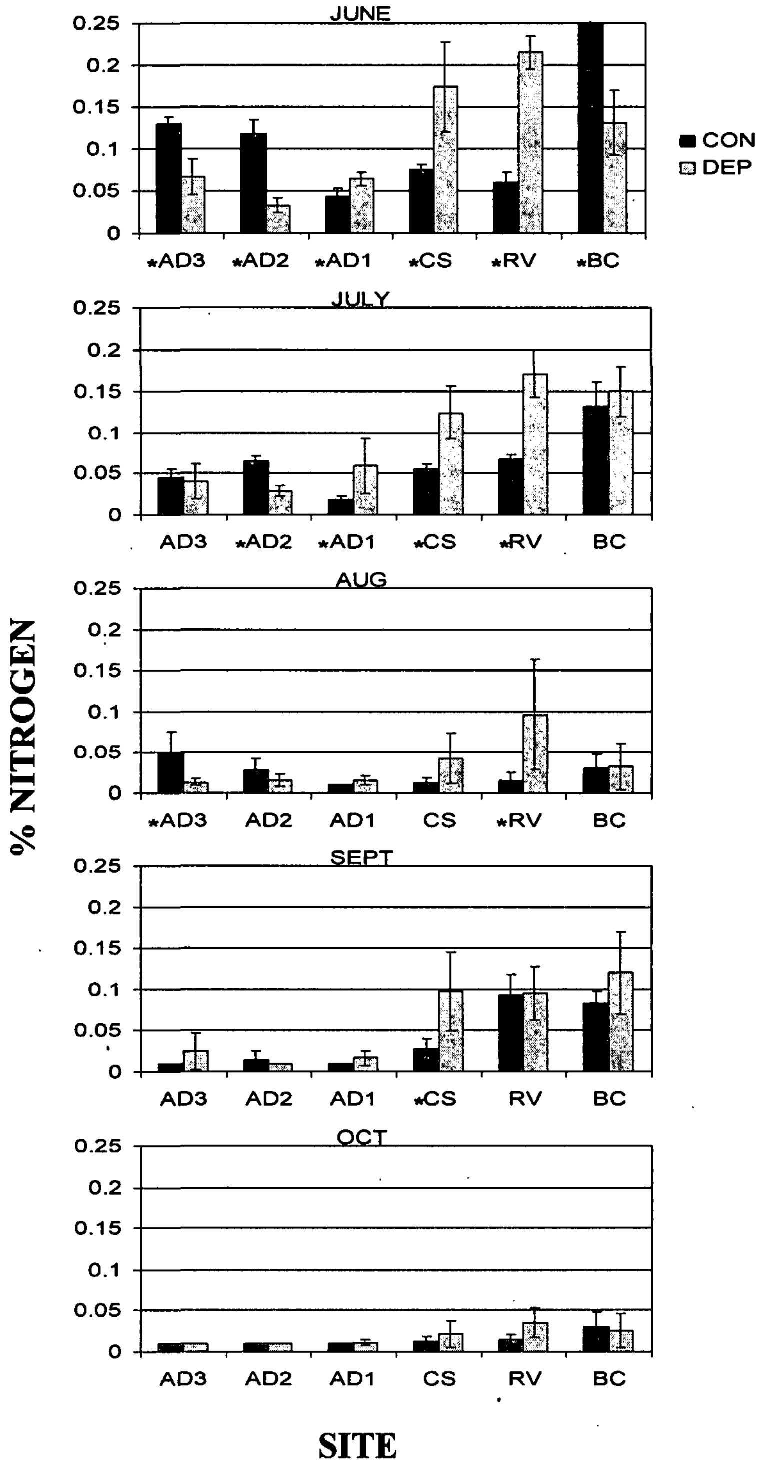

Figure 16. Nitrogen content (%) of sediment sampled at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

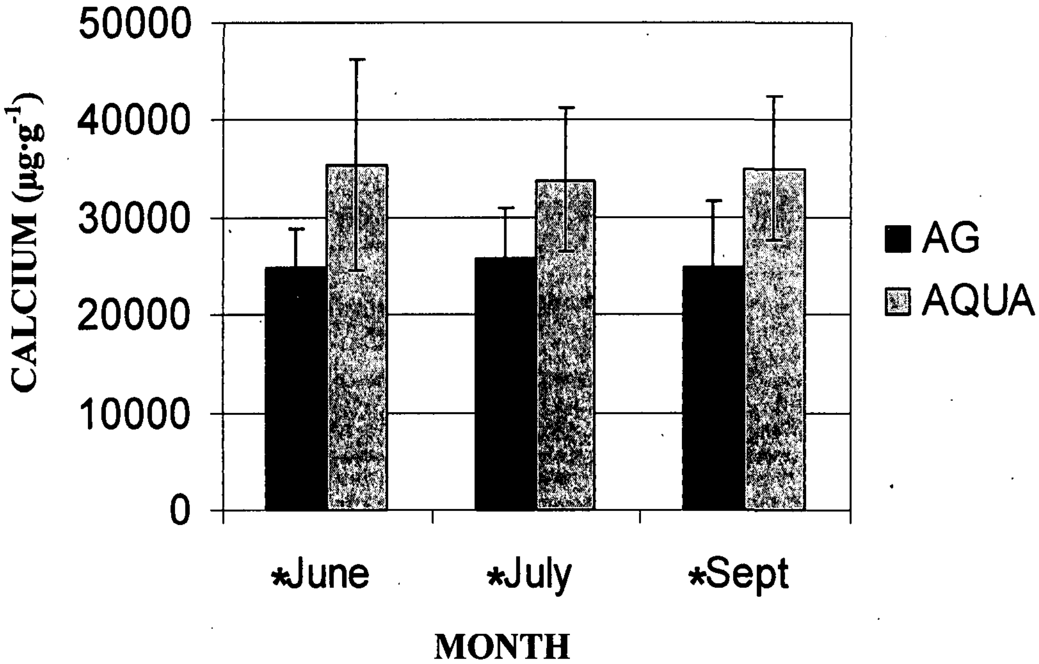

Figure 17. Calcium content (µg·g^{-1}) of sediment sampled from agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the calcium content (µg·g^{-1}) of sediment sampled from aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

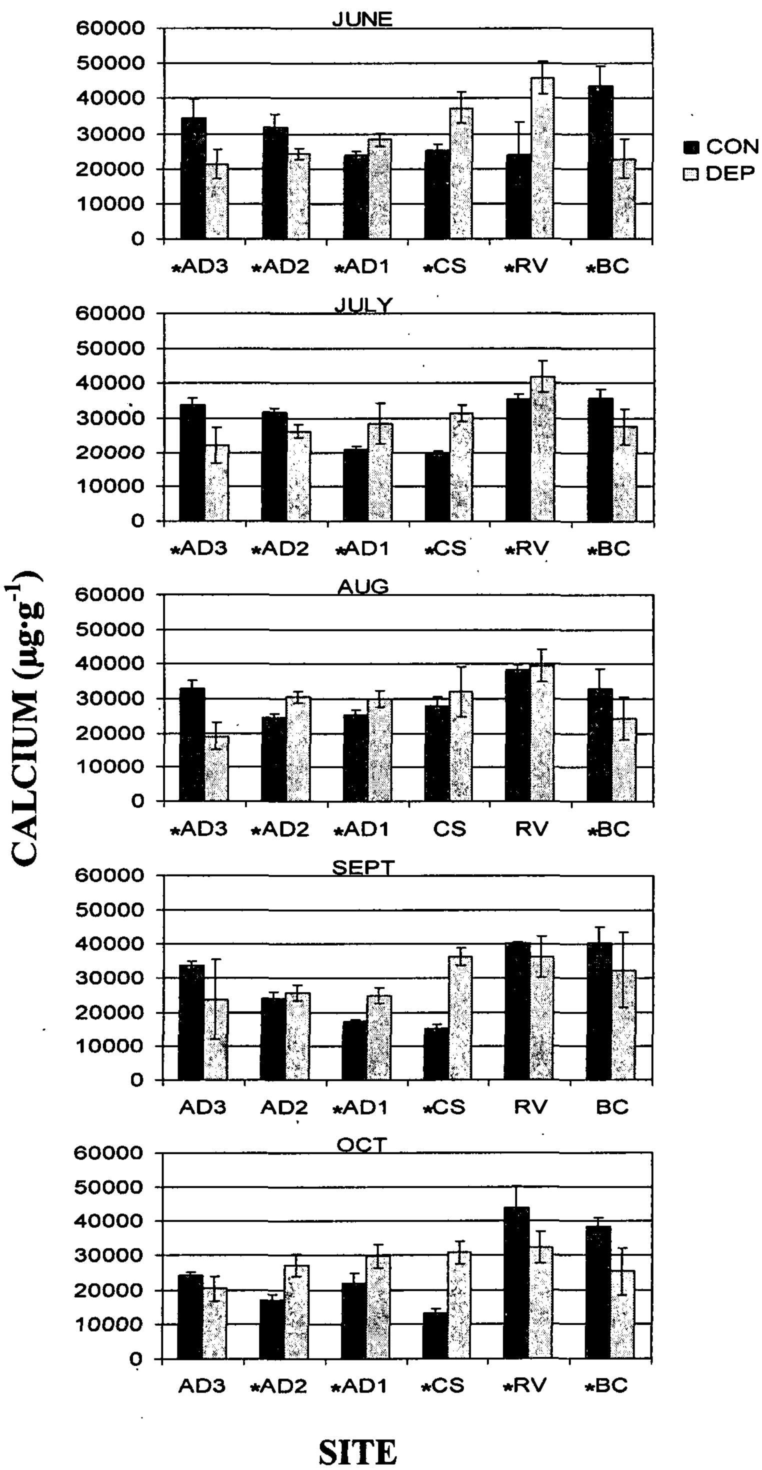

Figure 18. Calcium content ($\mu g \cdot g^{-1}$) of sediment sampled at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

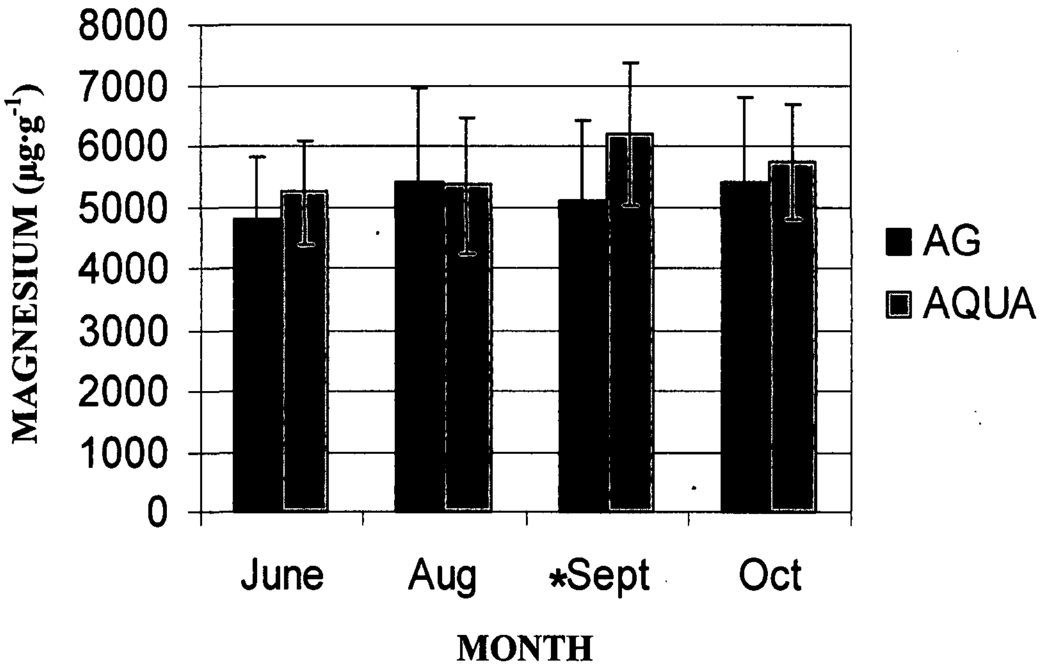

Figure 19. Magnesium content ($\mu g \cdot g^{-1}$) of sediment sampled from agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the magnesium content ($\mu g \cdot g^{-1}$) of sediment sampled from aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

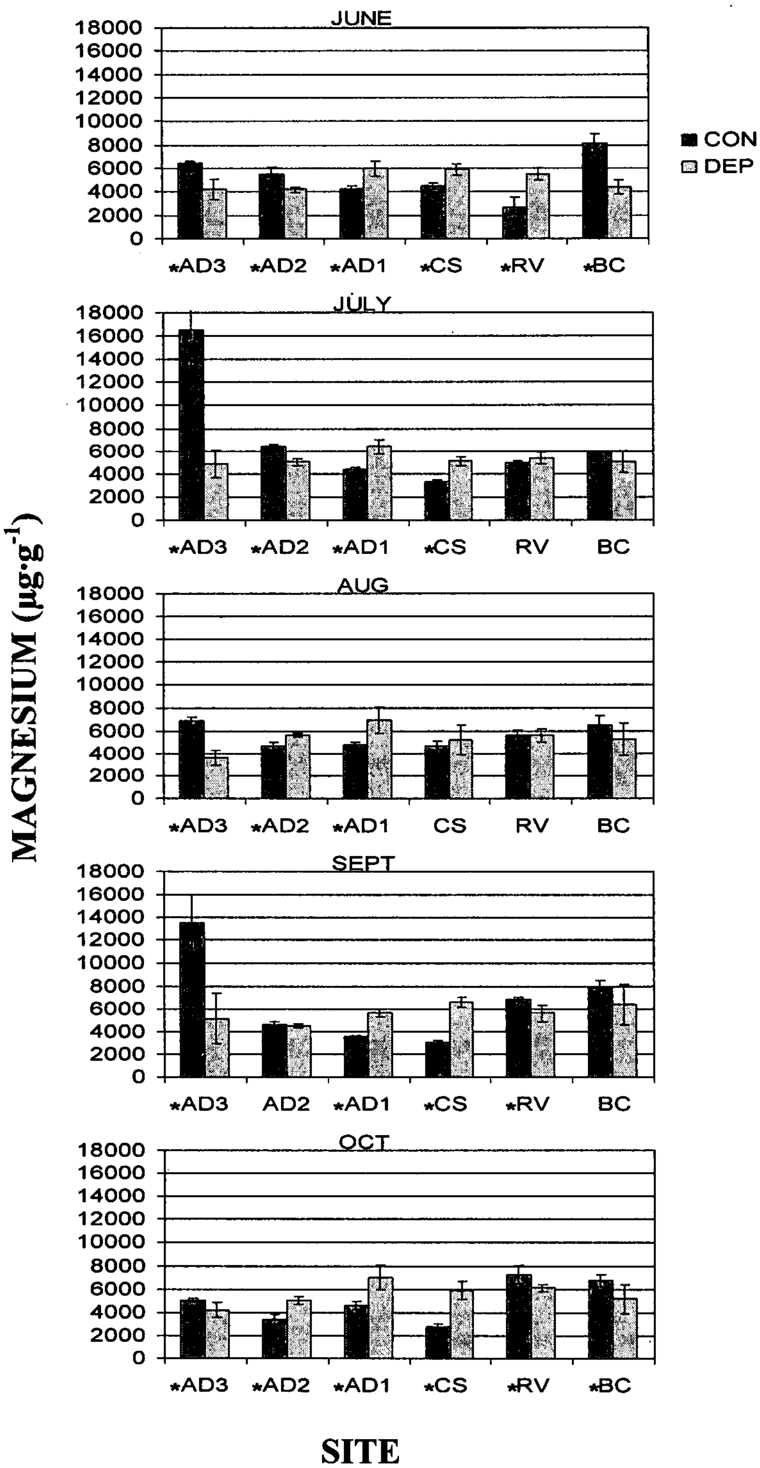

Figure 20. Magnesium content ($\mu g \cdot g^{-1}$) of sediment sampled at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

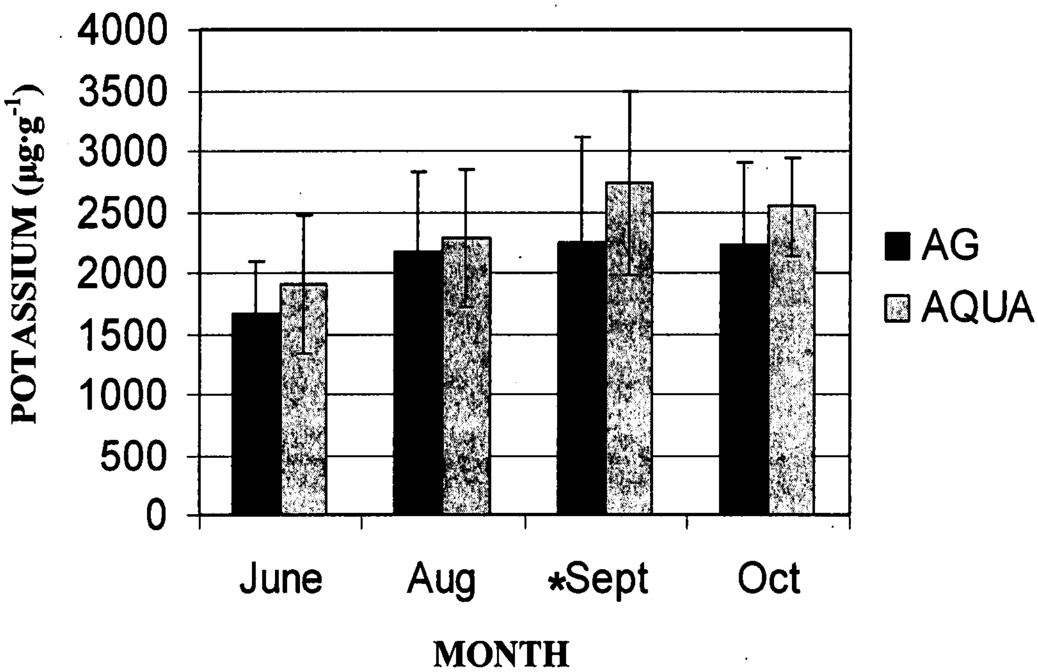

Figure 21. Potassium content ($\mu g{\cdot}g^{-1}$) of sediment sampled from agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the potassium content ($\mu g{\cdot}g^{-1}$) of sediment sampled from aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

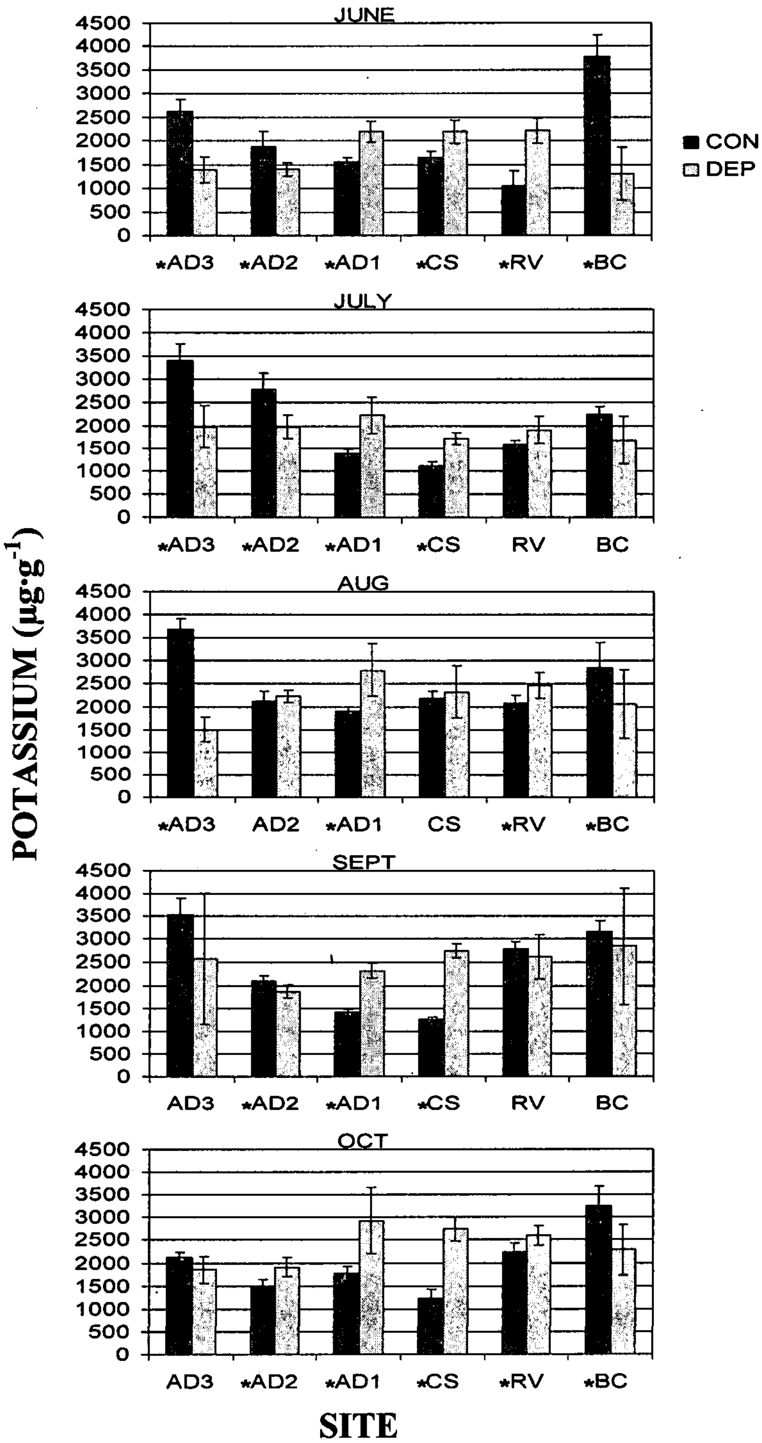

Figure 22. Potassium content (µg·g^{-1}) of sediment sampled at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

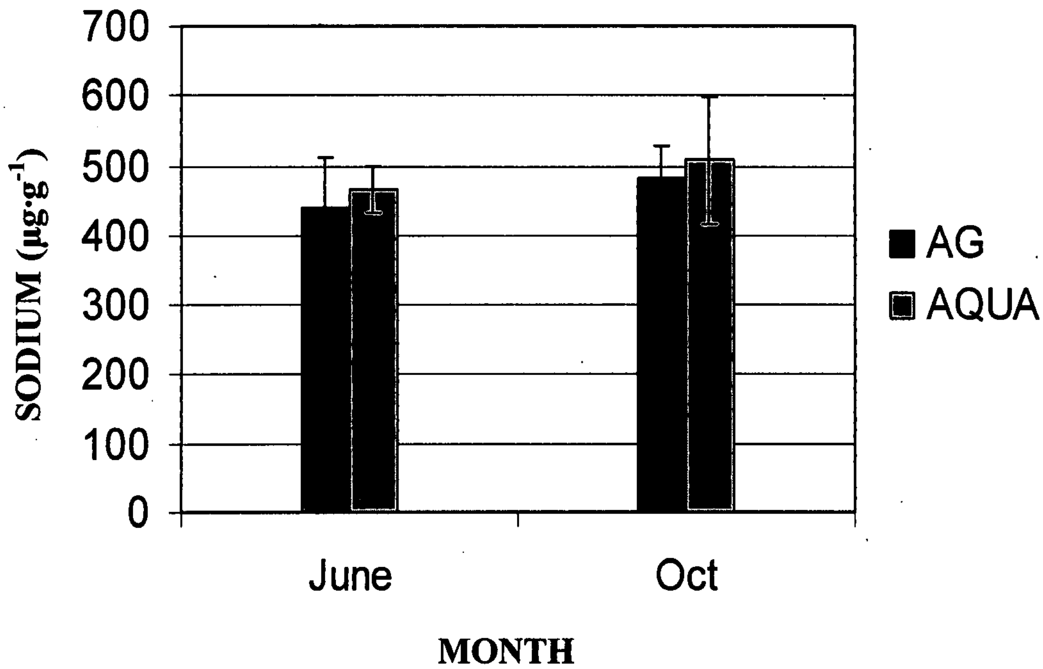

Figure 23. Sodium content ($\mu g \cdot g^{-1}$) of sediment sampled from agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the sodium content ($\mu g \cdot g^{-1}$) of sediment sampled from aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

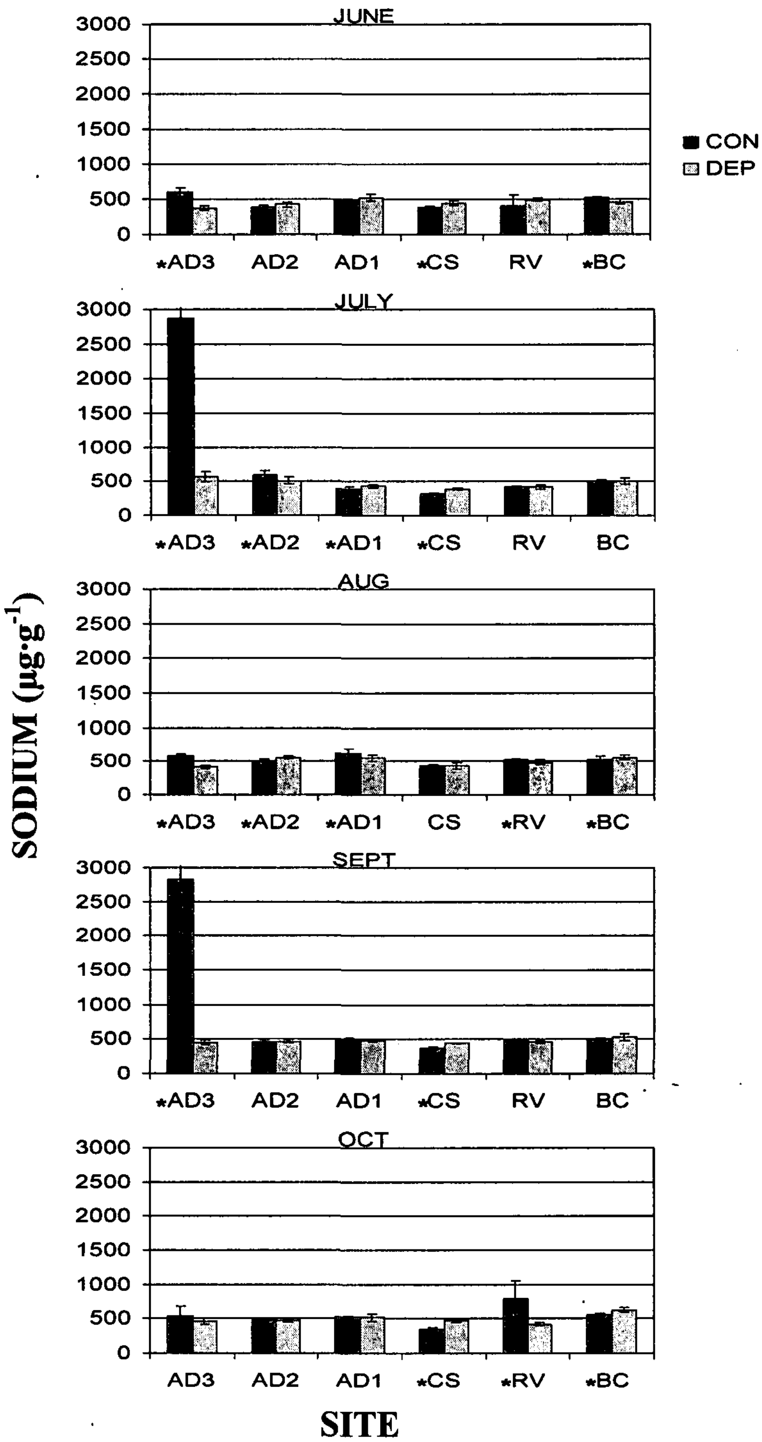

Figure 24. Sodium content ($\mu g \cdot g^{-1}$) of sediment sampled at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$).CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

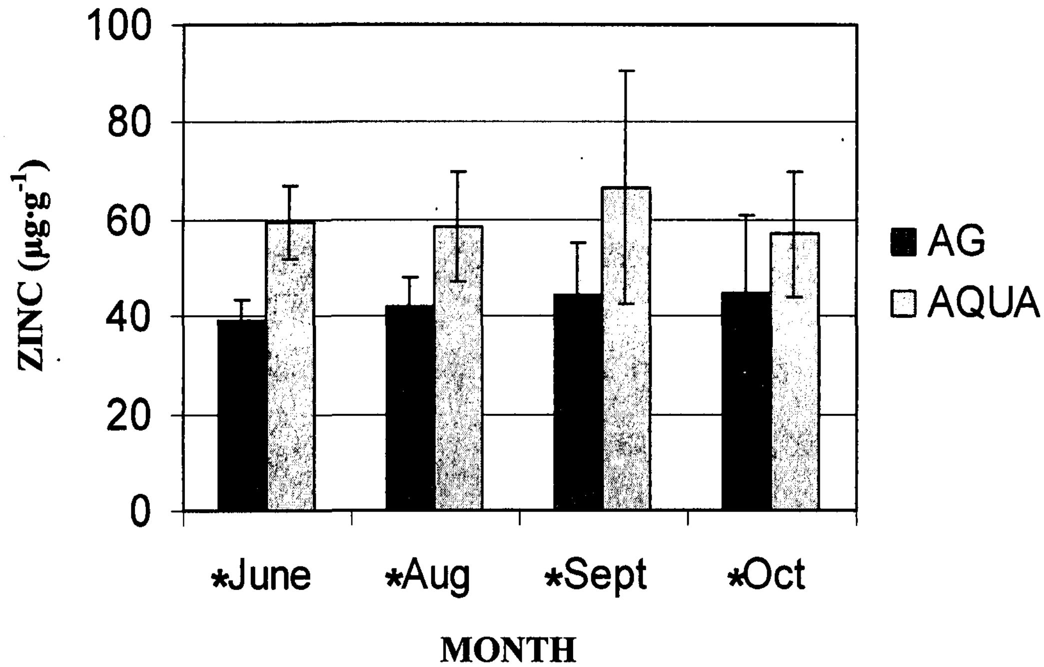

Figure 25. Zinc content (µg·g^{-1}) of sediment sampled from agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the zinc content (µg·g^{-1}) of sediment sampled from aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

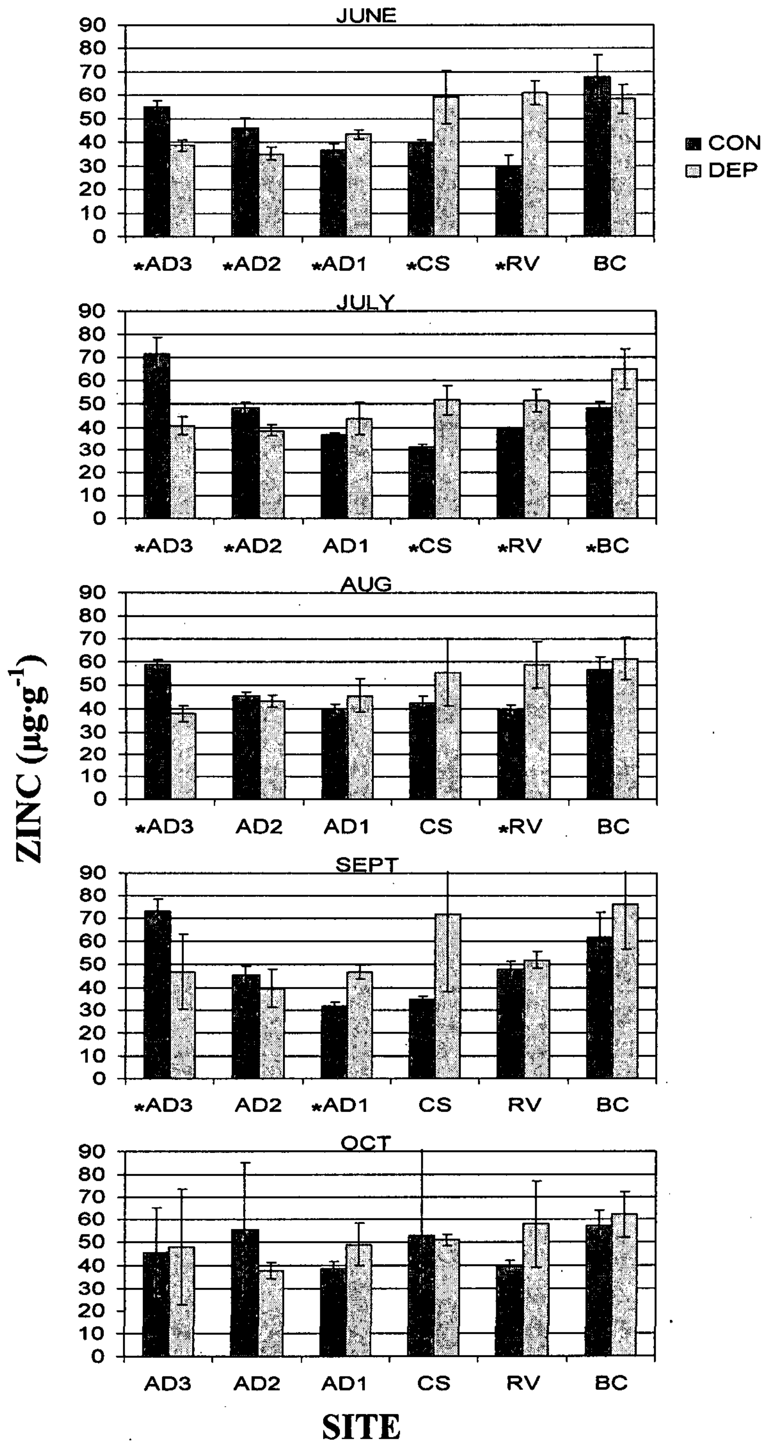

Figure 26. Zinc content ($\mu g \cdot g^{-1}$) of sediment sampled at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

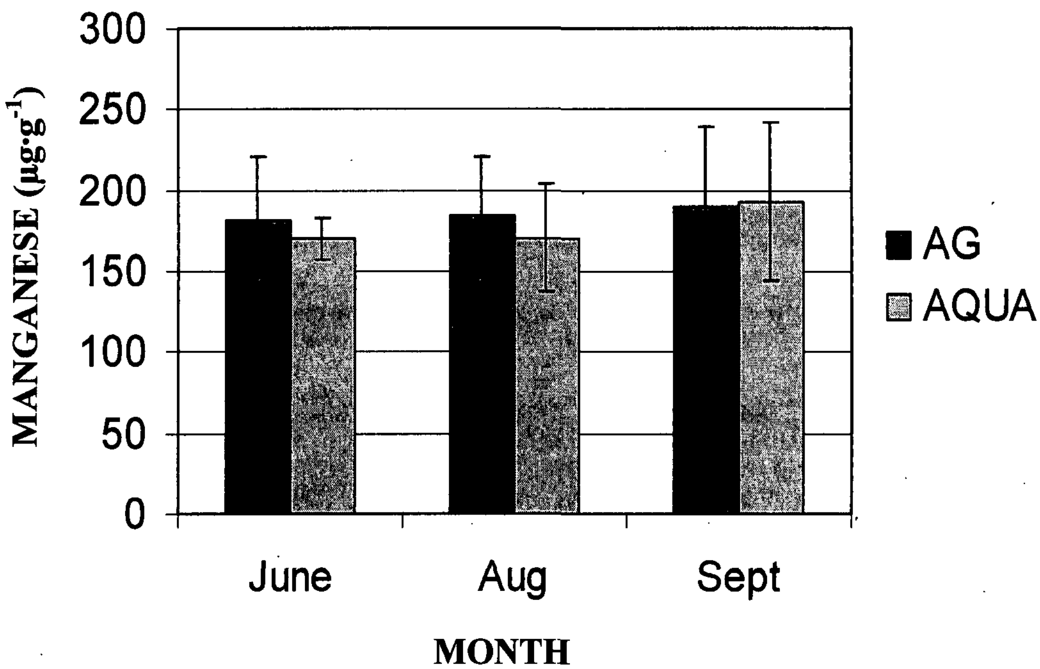

Figure 27. Manganese content (µg·g^{-1}) of sediment sampled from agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the manganese content (µg·g^{-1}) of sediment sampled from aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

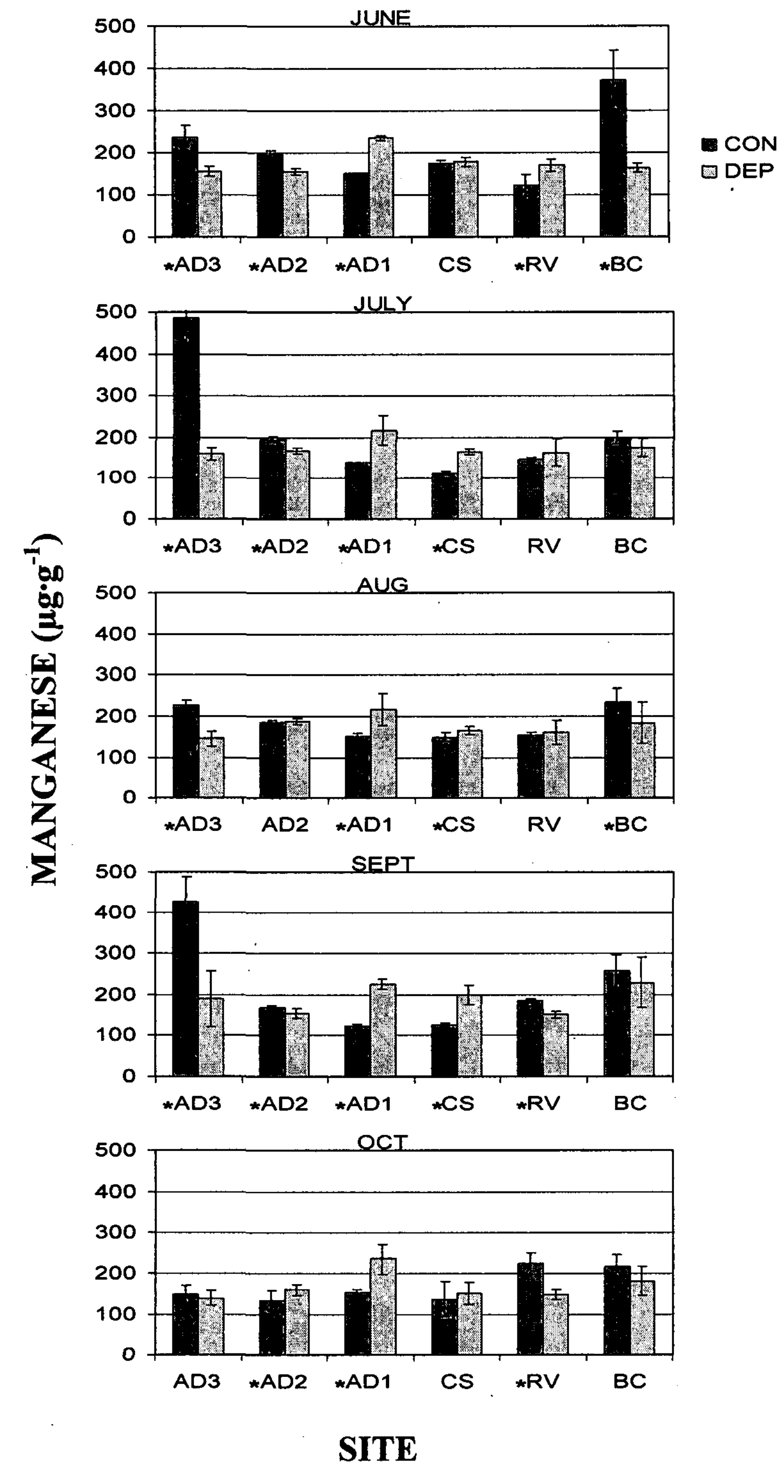

Figure 28. Manganese content ($\mu g \cdot g^{-1}$) of sediment sampled at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

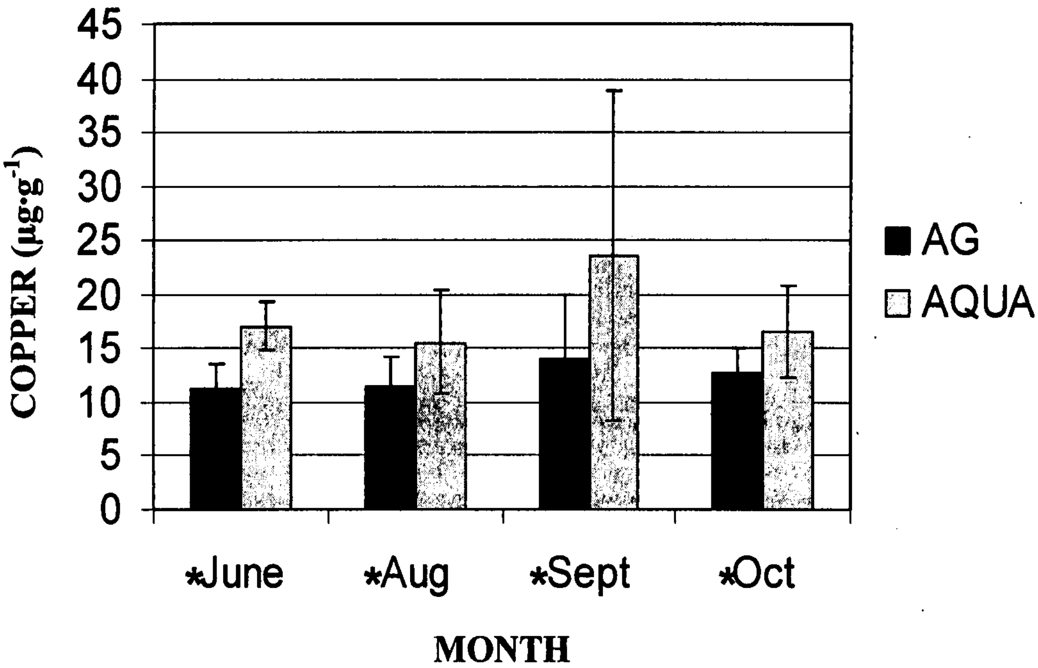

Figure 29. Copper content ($\mu g{\cdot}g^{-1}$) of sediment sampled from agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the copper content ($\mu g{\cdot}g^{-1}$) of sediment sampled from aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

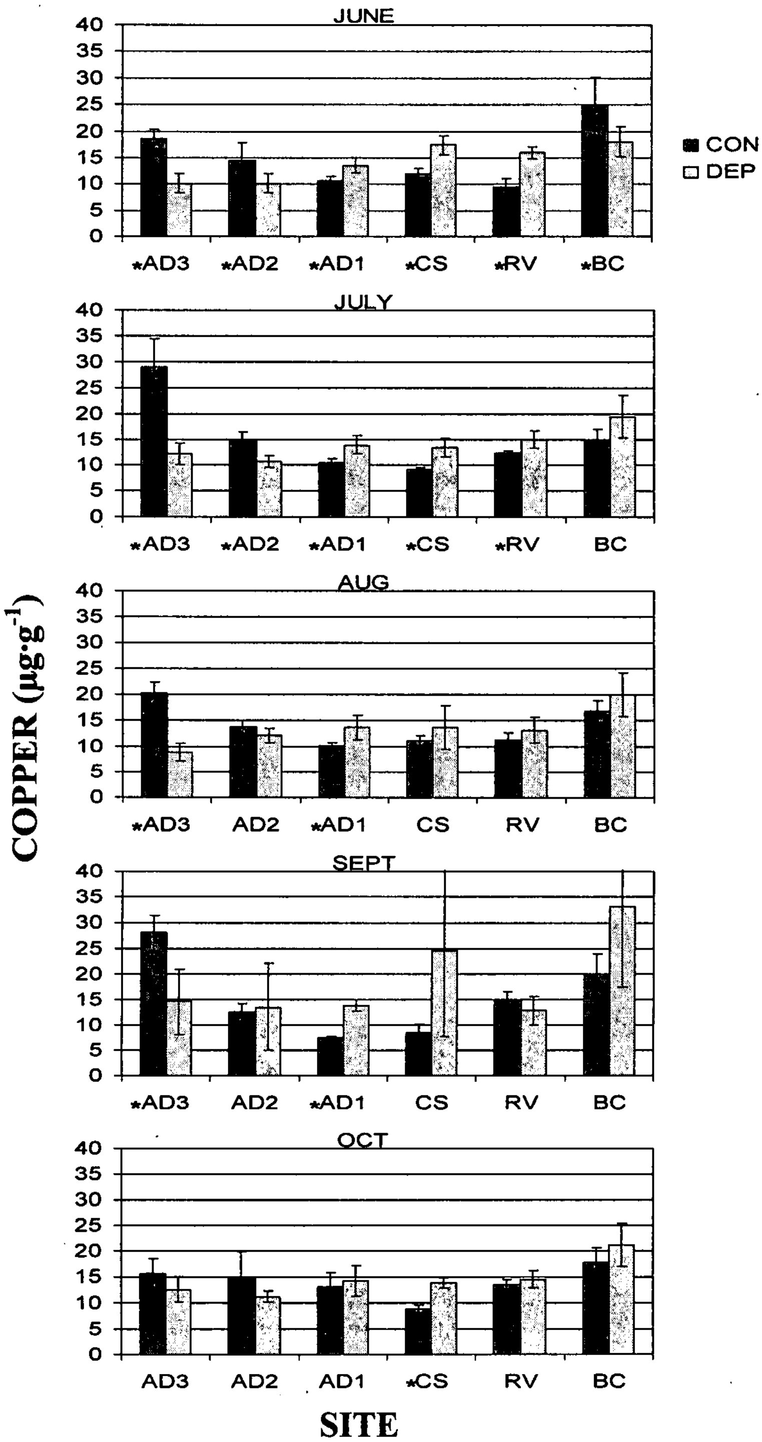

Figure 30. Copper content ($\mu g \cdot g^{-1}$) of sediment sampled at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

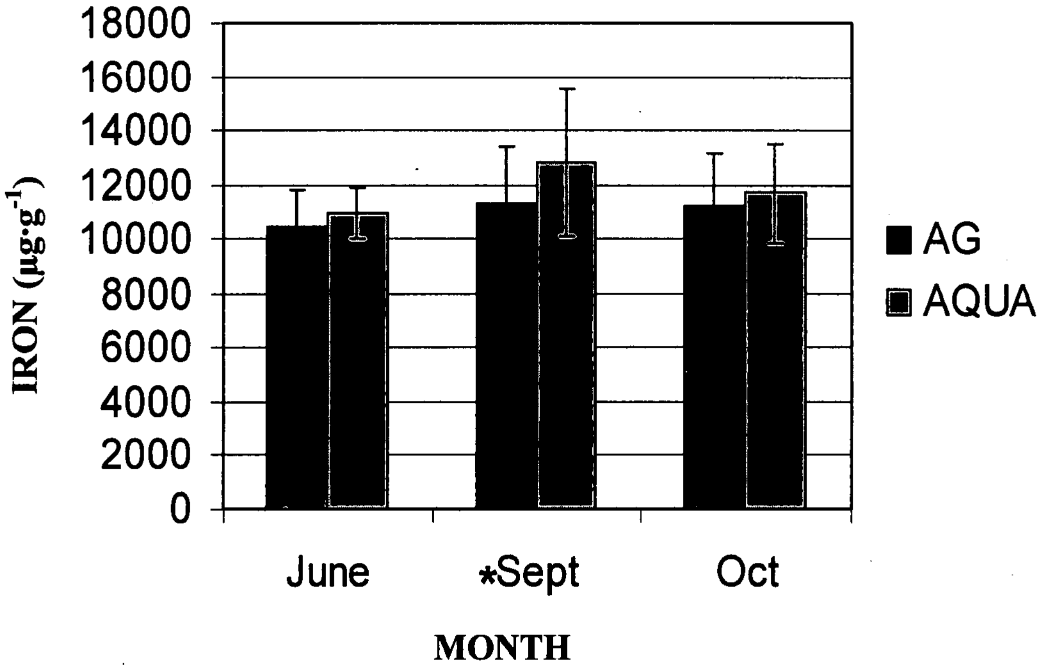

Figure 31. Iron content (µg·g^{-1}) of sediment sampled from agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the iron content (µg·g^{-1}) of sediment sampled from aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

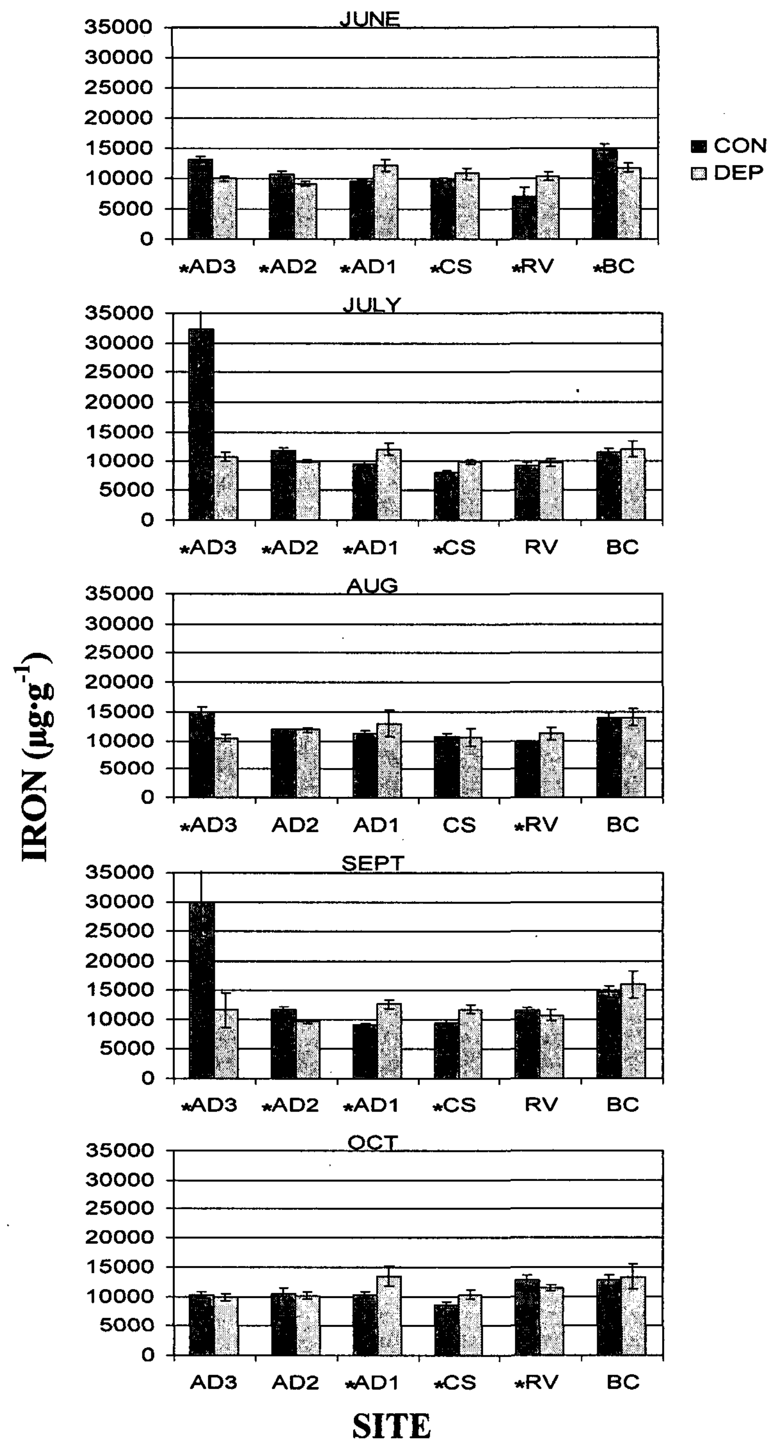

Figure 32. Iron content ($\mu g \cdot g^{-1}$) of sediment sampled at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones.($p < 0.05$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

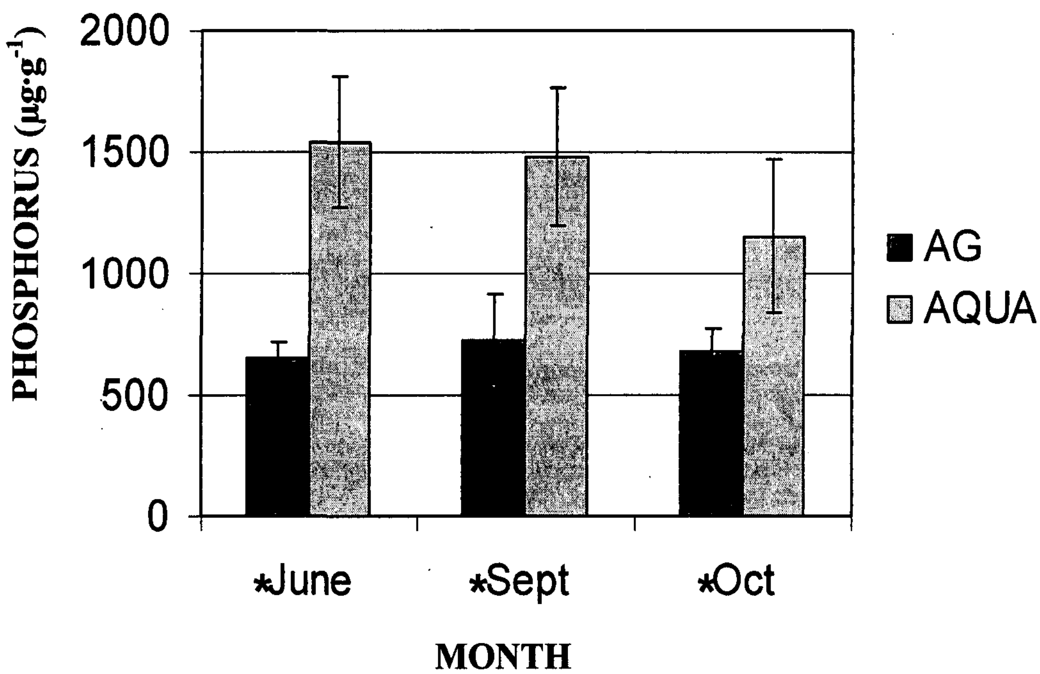

Figure 33. Phosphorus content ($\mu g \cdot g^{-1}$) of sediment sampled from agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the phosphorus content ($\mu g \cdot g^{-1}$) of sediment sampled from aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

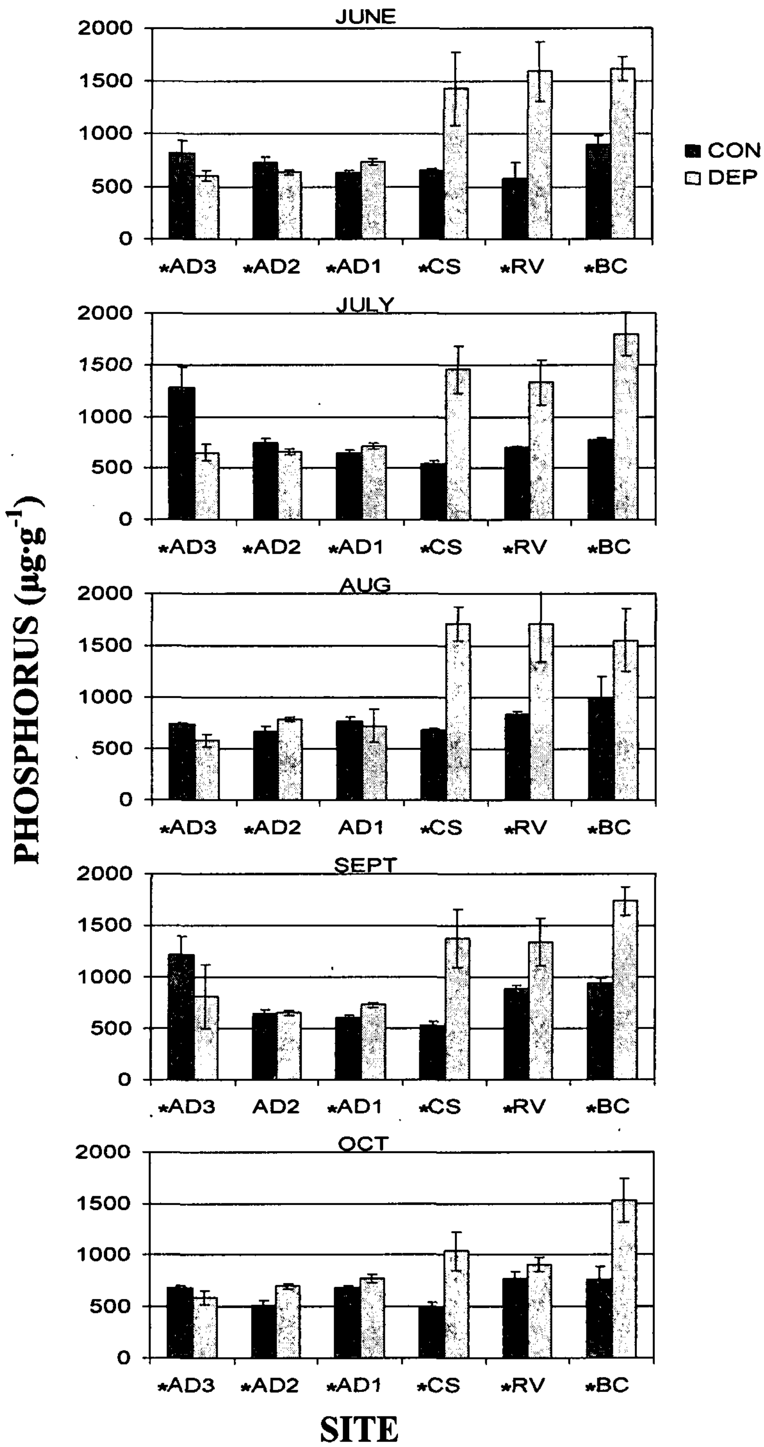

Figure 34. Phosphorus content ($\mu g \cdot g^{-1}$) of sediment sampled at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

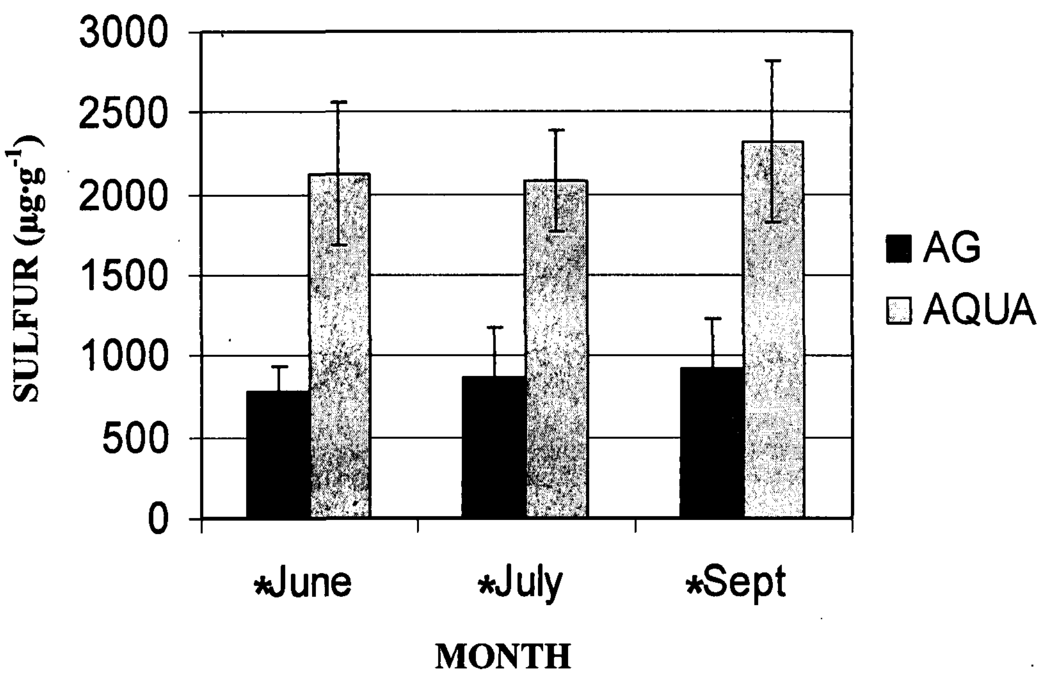

Figure 35. Sulfur content (µg·g^{-1}) of sediment sampled from agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the sulfur content (µg·g^{-1}) of sediment sampled from aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

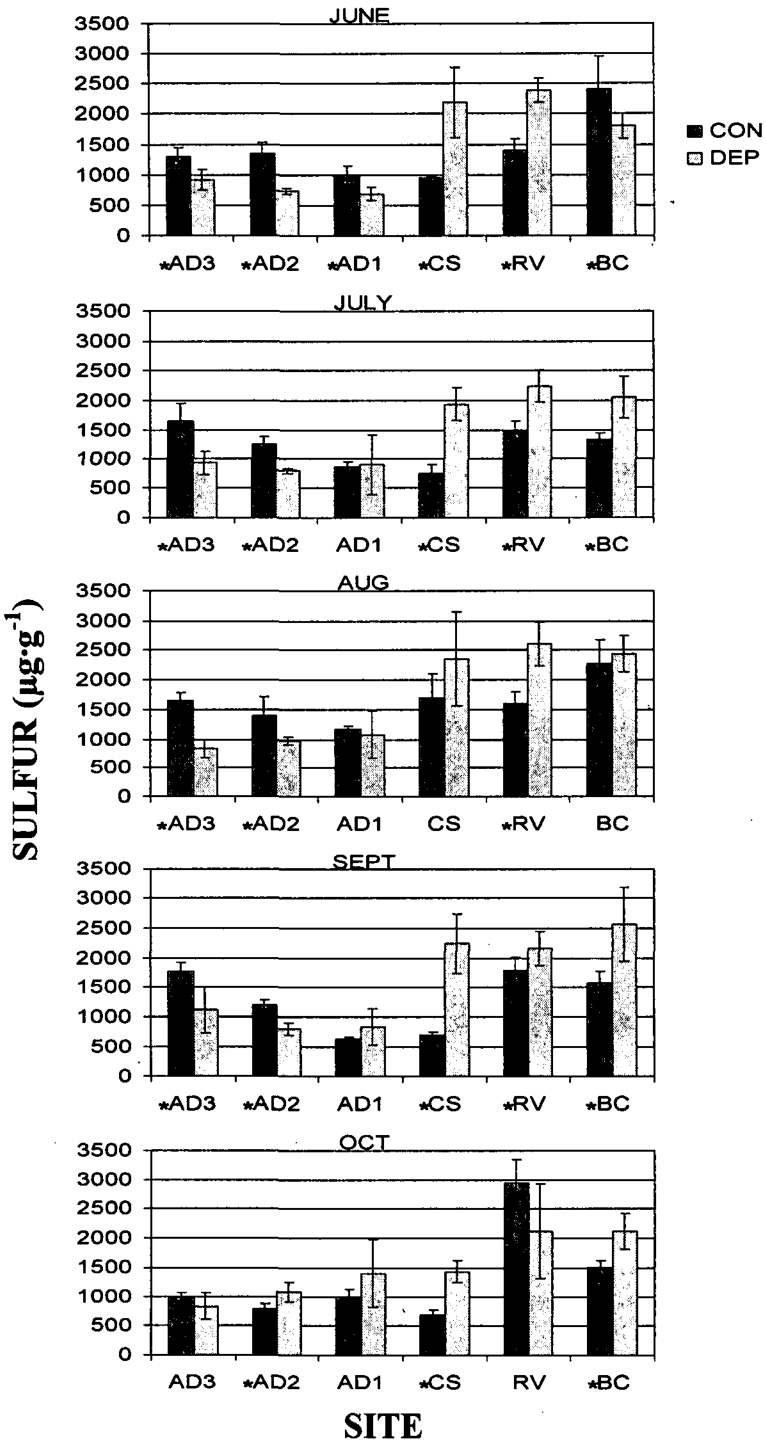

Figure 36. Sulfur content ($\mu g \cdot g^{-1}$) of sediment sampled at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$).CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

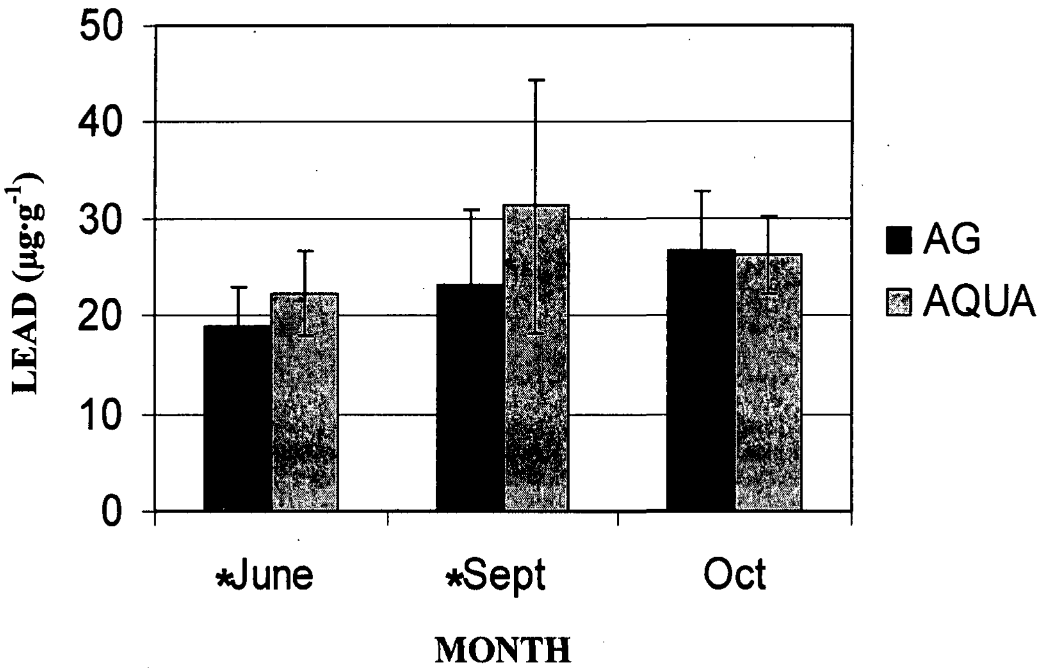

Figure 37. Lead content ($\mu g \cdot g^{-1}$) of sediment sampled from agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the lead content ($\mu g \cdot g^{-1}$) of sediment sampled from aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

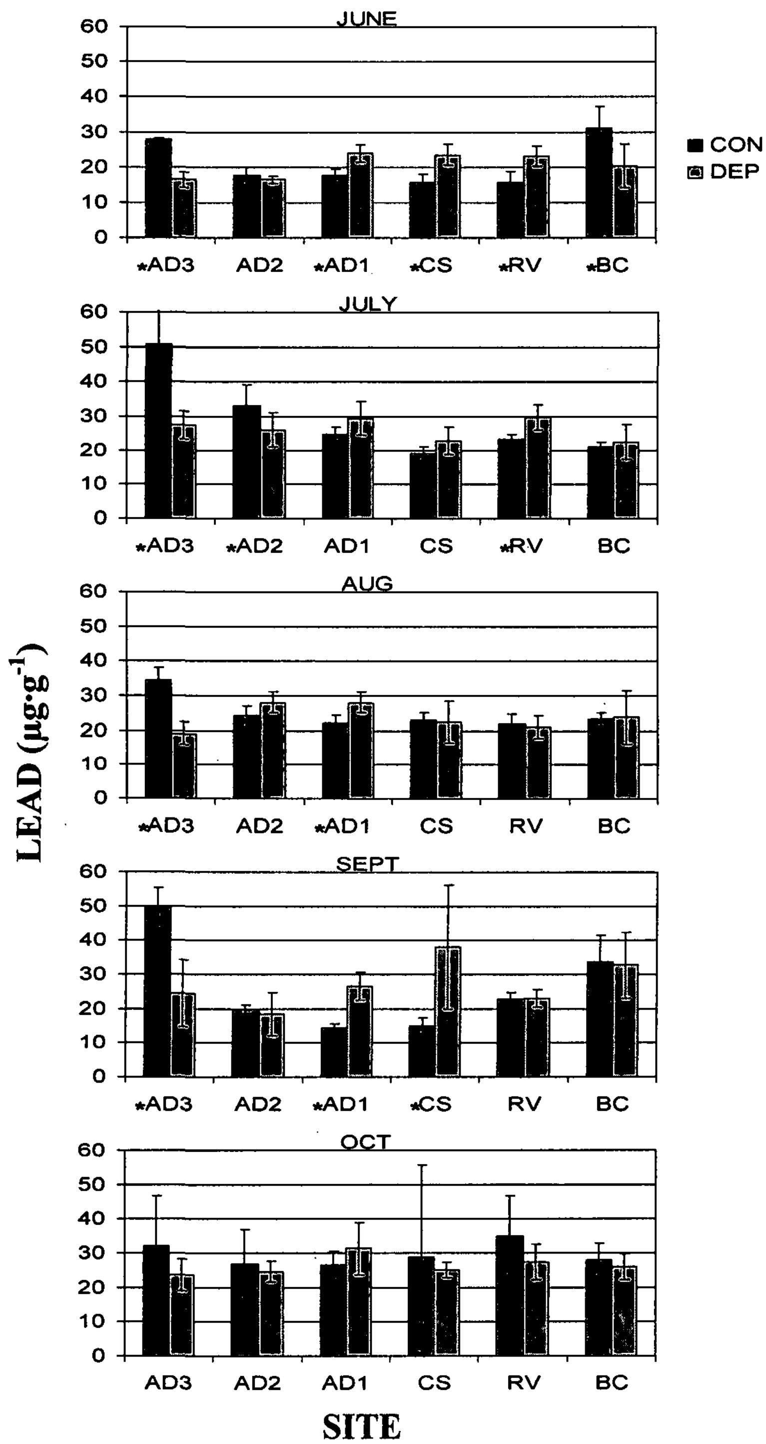

Figure 38. Lead content (µg·g^{-1}) of sediment sampled at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

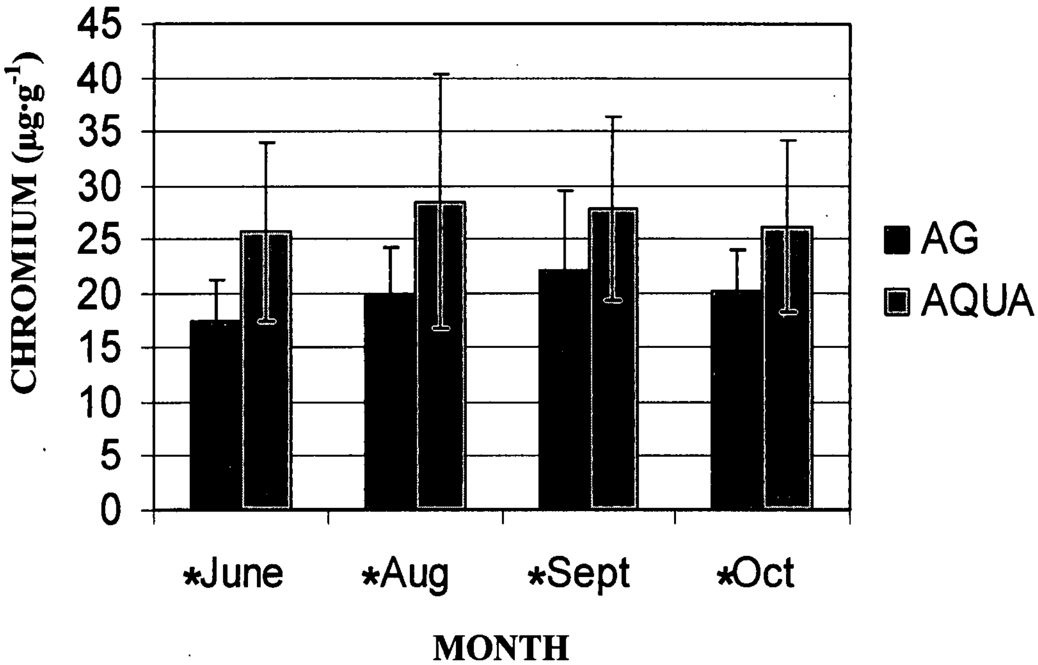

Figure 39. Chromium content ($\mu g \cdot g^{-1}$) of sediment sampled from agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the chromium content ($\mu g \cdot g^{-1}$) of sediment sampled from aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

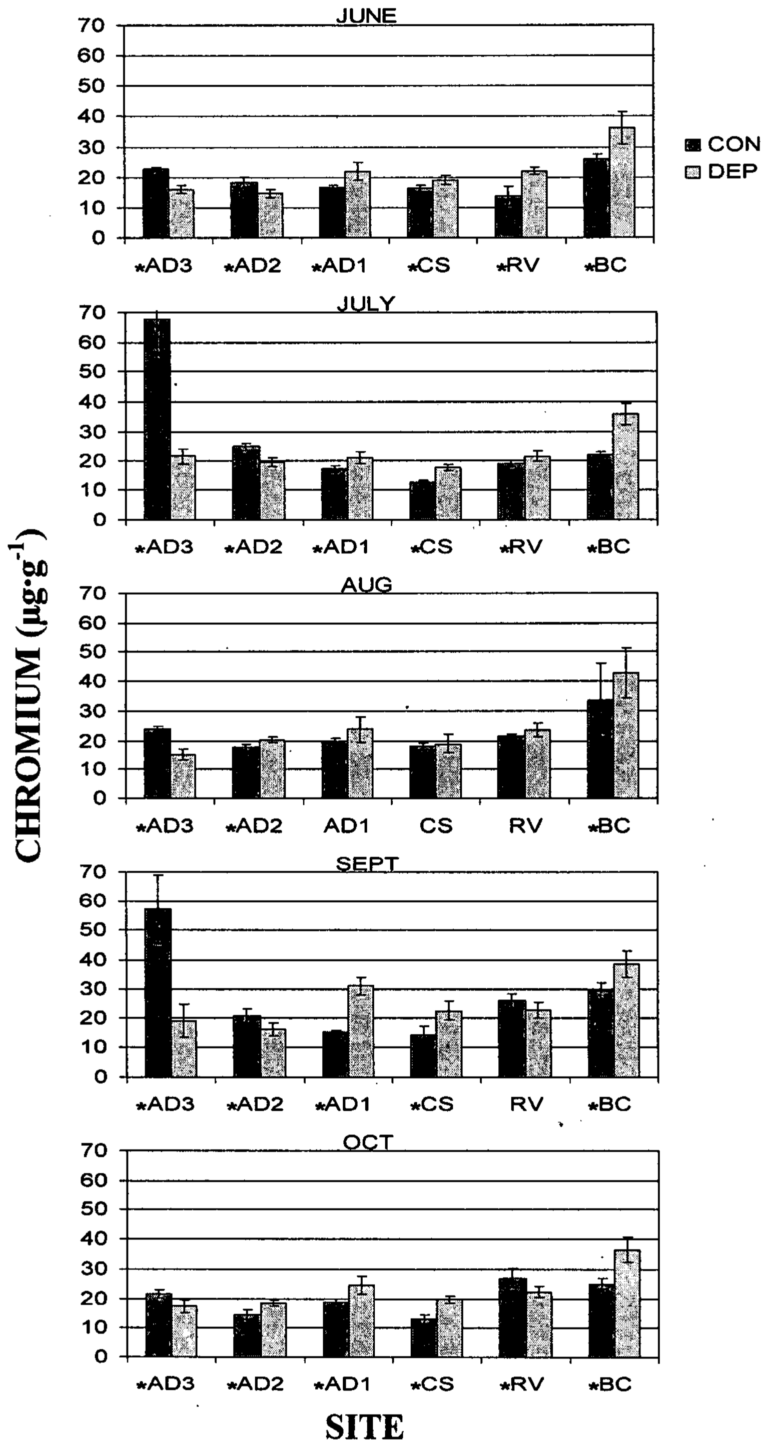

Figure 40. Chromium content (µg·g^{-1}) of sediment sampled at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

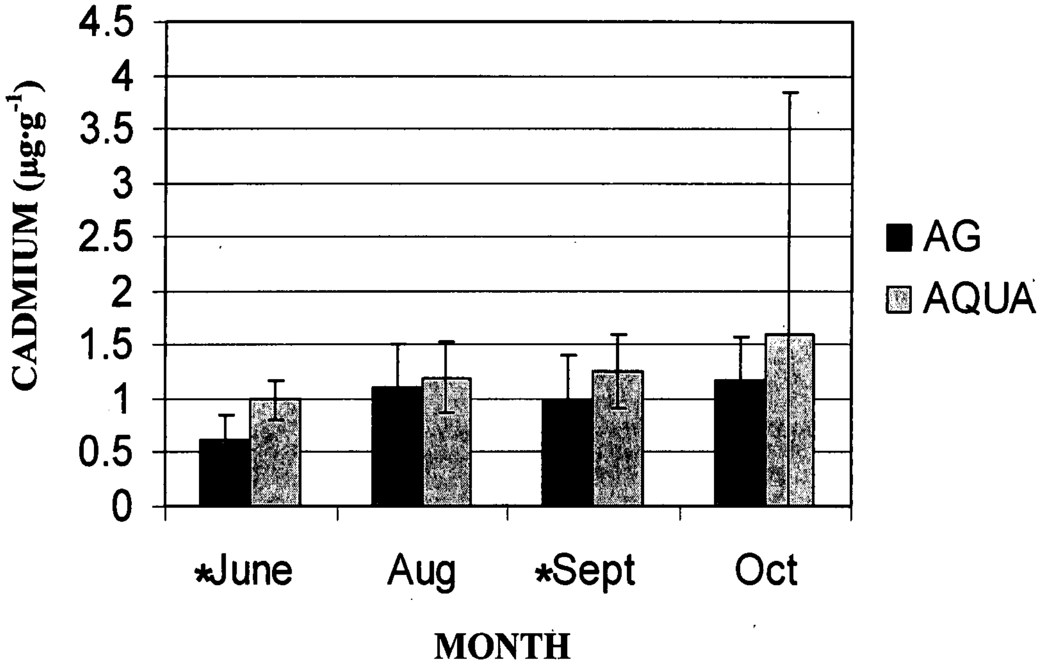

Figure 41. Cadmium content ($\mu g \cdot g^{-1}$) of sediment sampled from agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the cadmium content ($\mu g \cdot g^{-1}$) of sediment sampled from aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

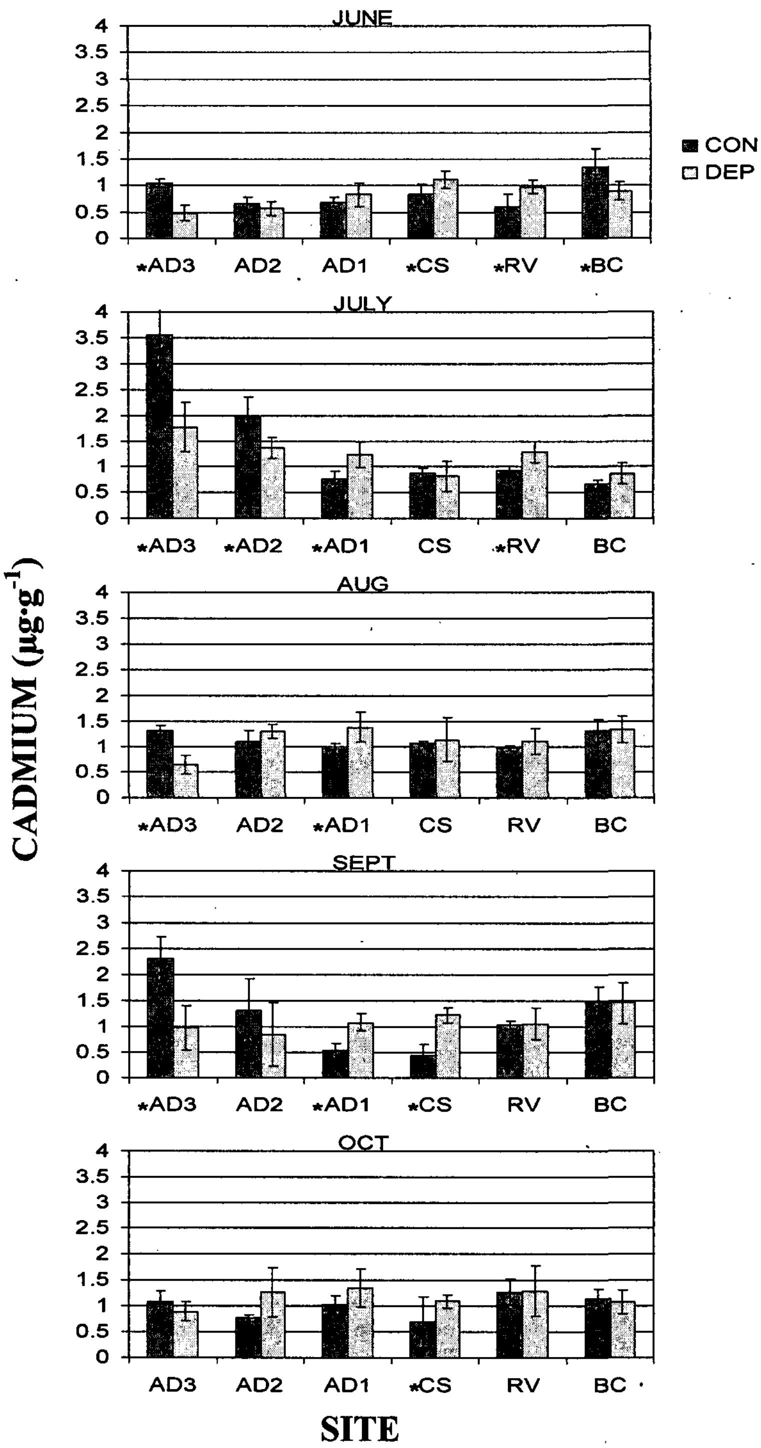

Figure 42. Cadmium content (µg·g^{-1}) of sediment sampled at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

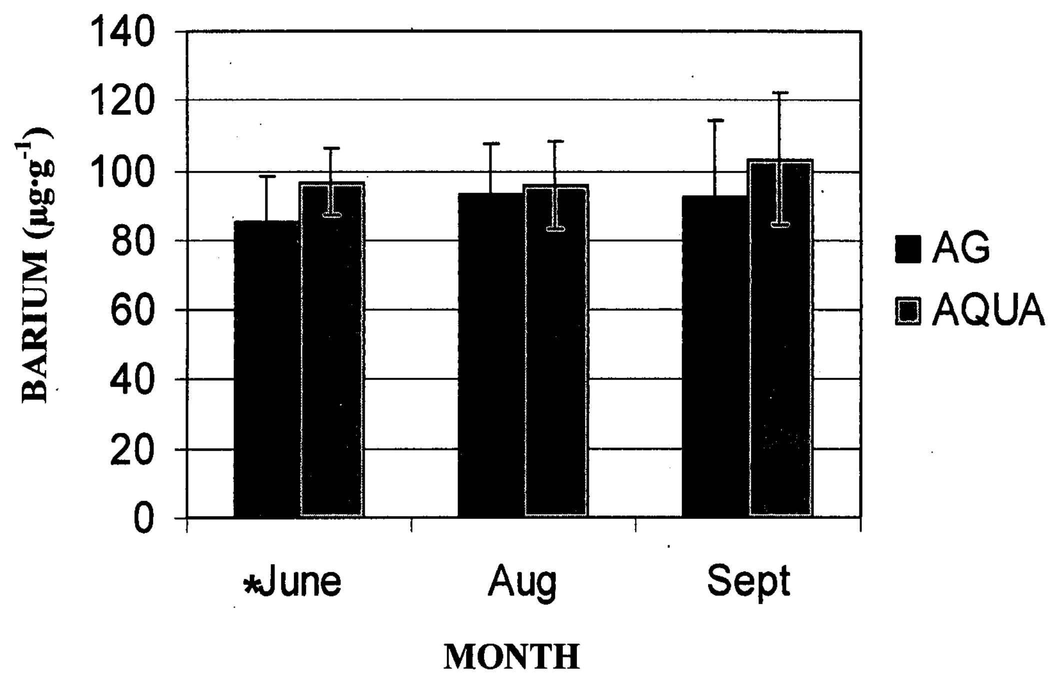

Figure 43. Barium content (µg·g^{-1}) of sediment sampled from agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the barium content (µg·g^{-1}) of sediment sampled from aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

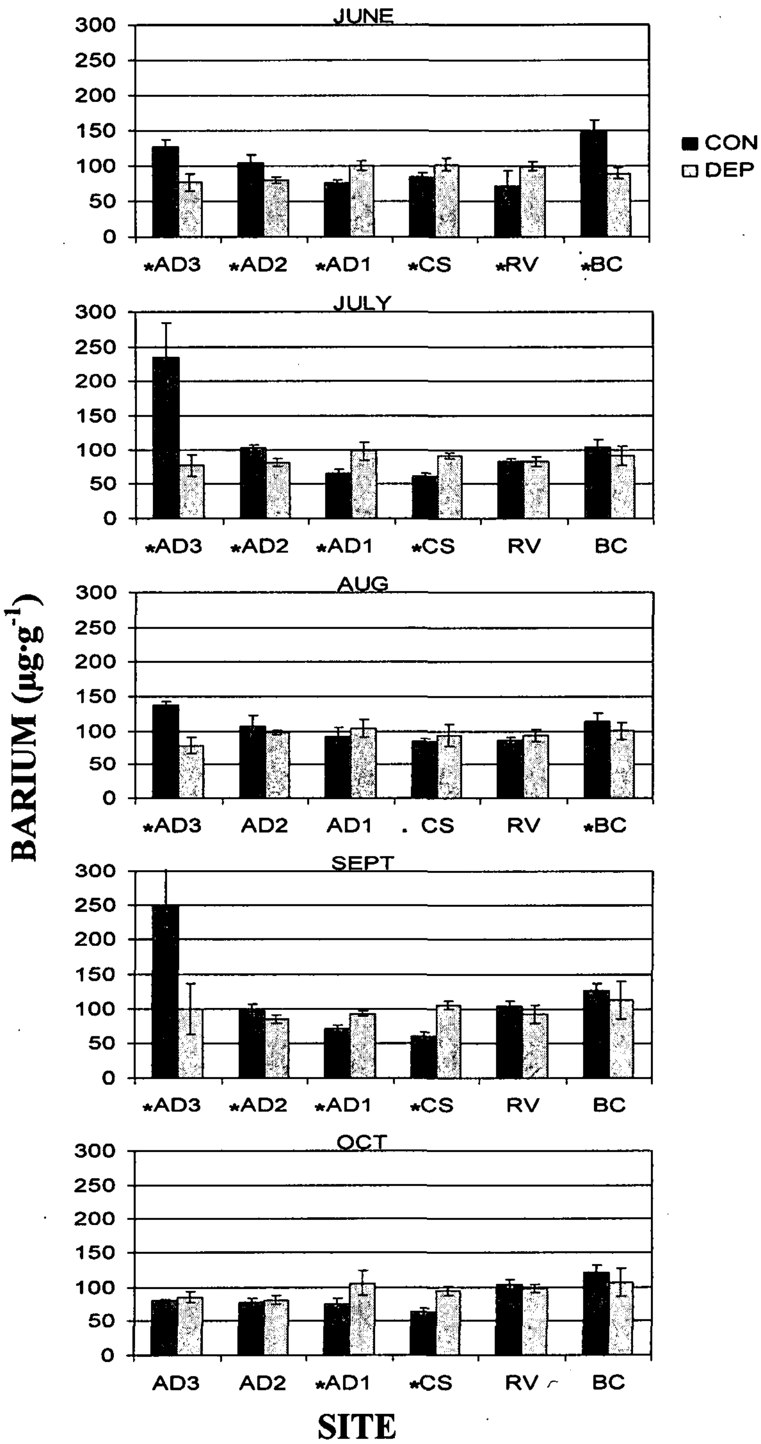

Figure 44. Barium content (µg·g^{-1}) of sediment sampled at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

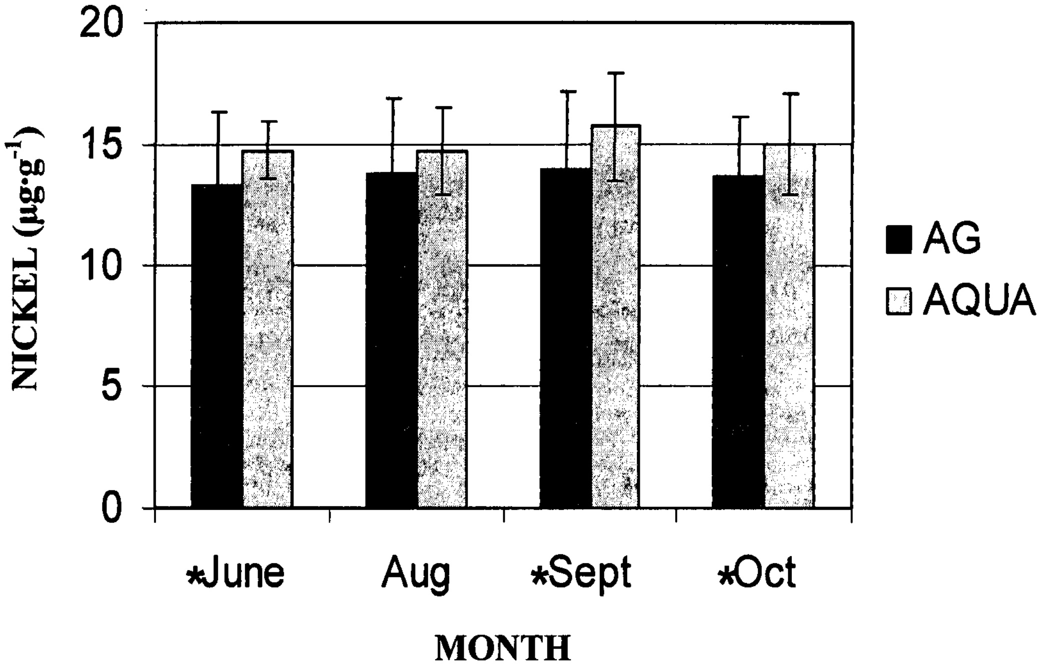

Figure 45. Nickel content ($\mu g \cdot g^{-1}$) of sediment sampled from agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the nickel content ($\mu g \cdot g^{-1}$) of sediment sampled from aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

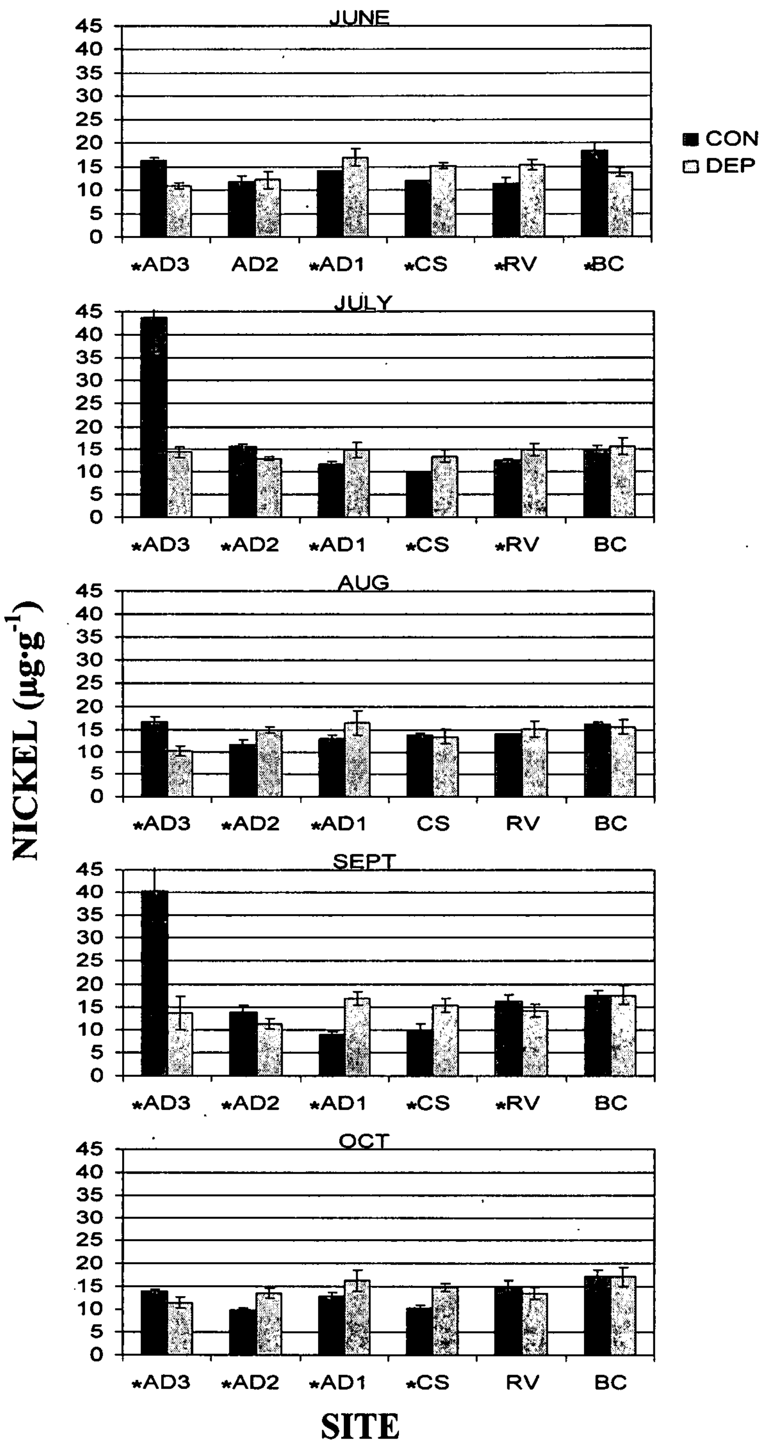

Figure 46. Nickel content (µg·g^{-1}) of sediment sampled at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

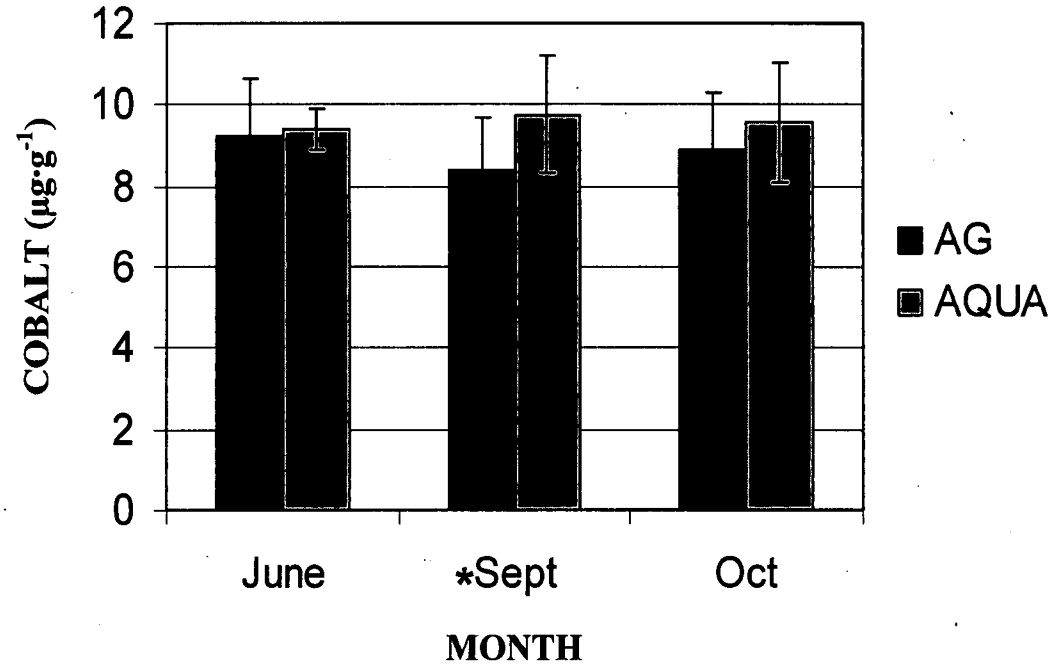

Figure 47. Cobalt content ($\mu g \cdot g^{-1}$) of sediment sampled from agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the cobalt content ($\mu g \cdot g^{-1}$) of sediment sampled from aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

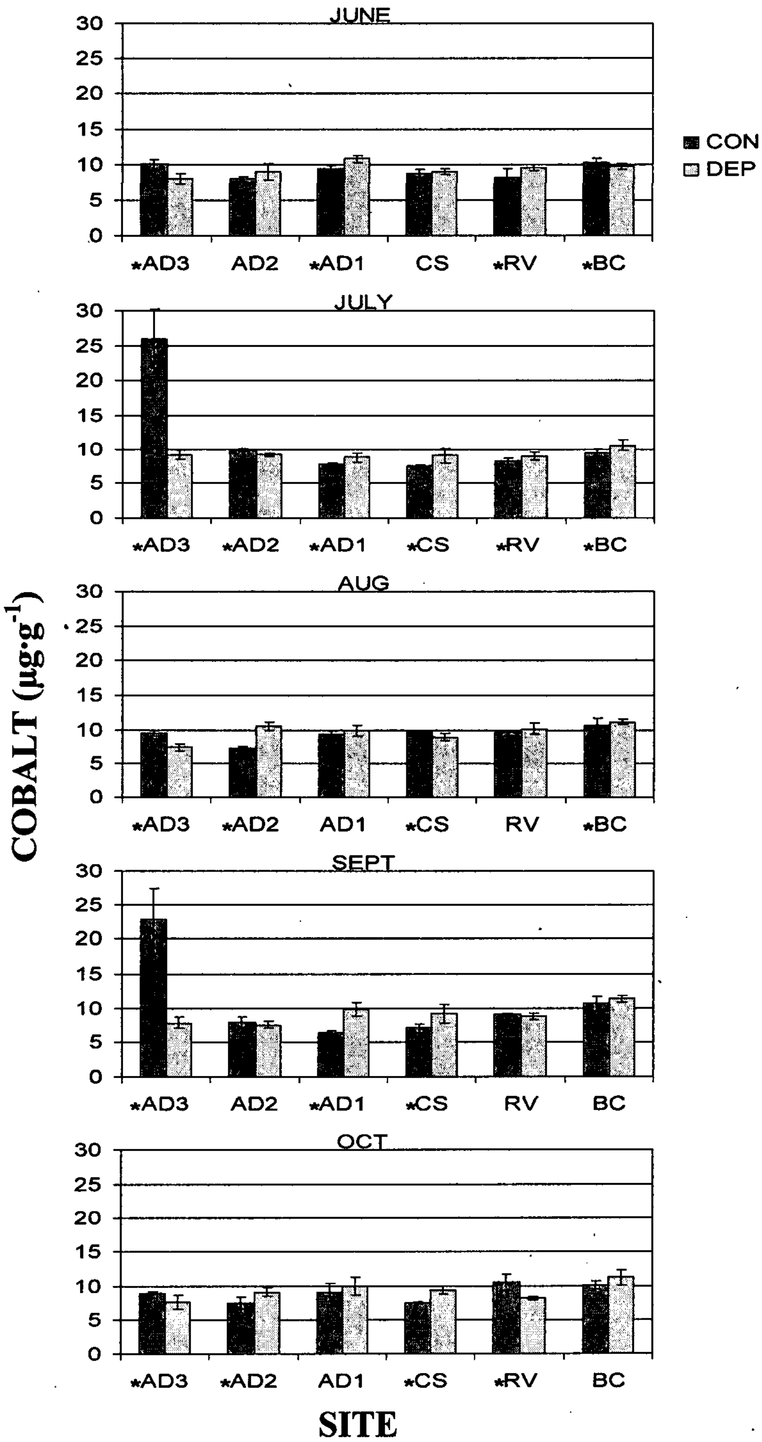

Figure 48. Cobalt content ($\mu g \cdot g^{-1}$) of sediment sampled at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

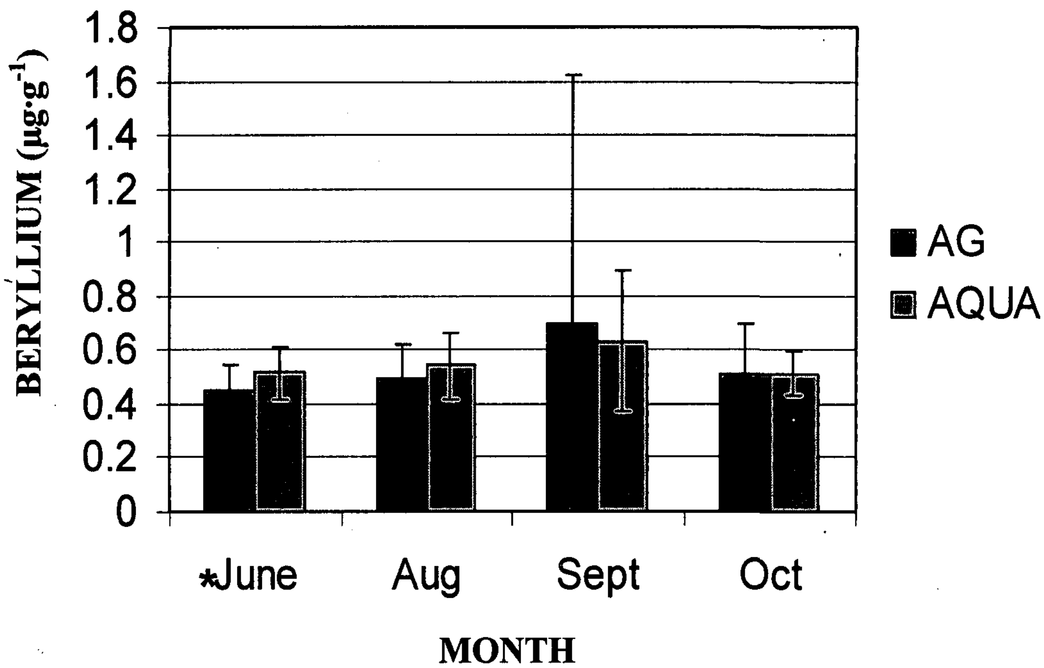

Figure 49. Beryllium content ($\mu g{\cdot}g^{-1}$) of sediment sampled from agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the beryllium content ($\mu g{\cdot}g^{-1}$) of sediment sampled from aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

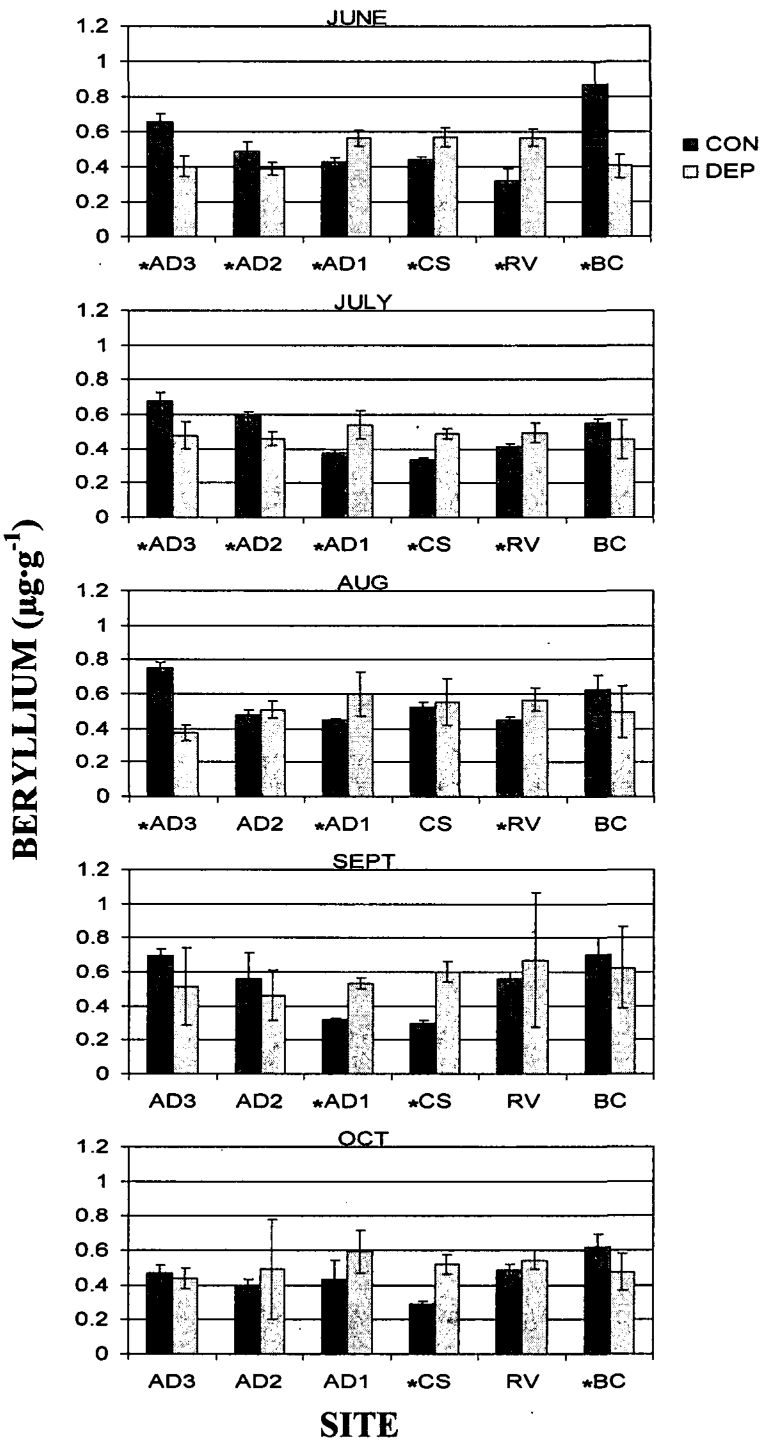

Figure 50. Beryllium content (µg·g^{-1}) of sediment sampled at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

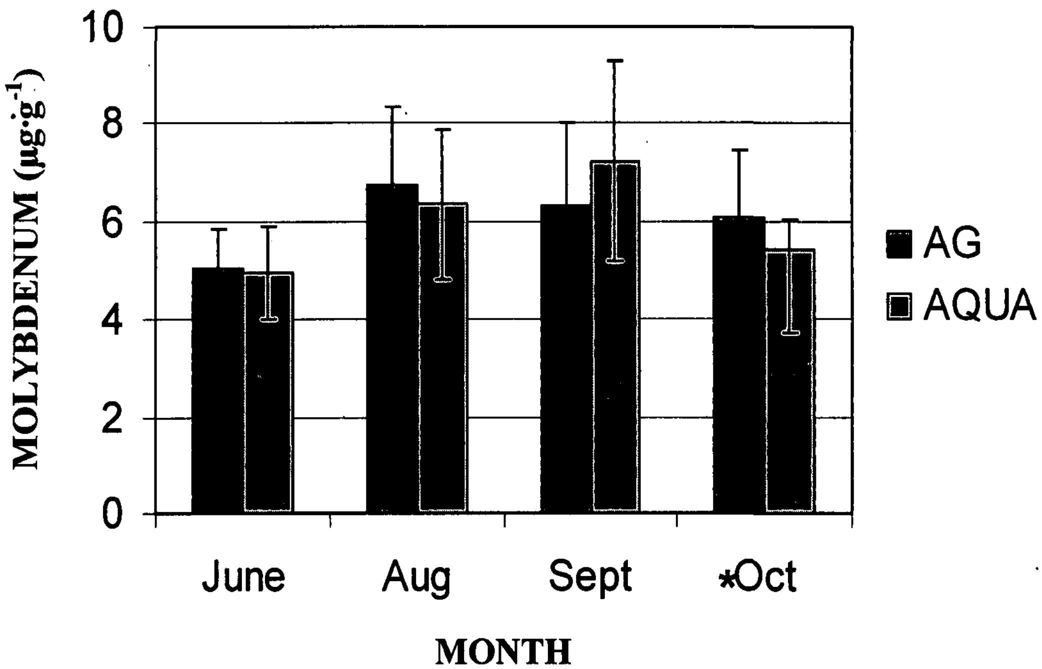

Figure 51. Molybdenum content (µg·g^{-1}) of sediment sampled from agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the molybdenum content (µg·g^{-1}) of sediment sampled from aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

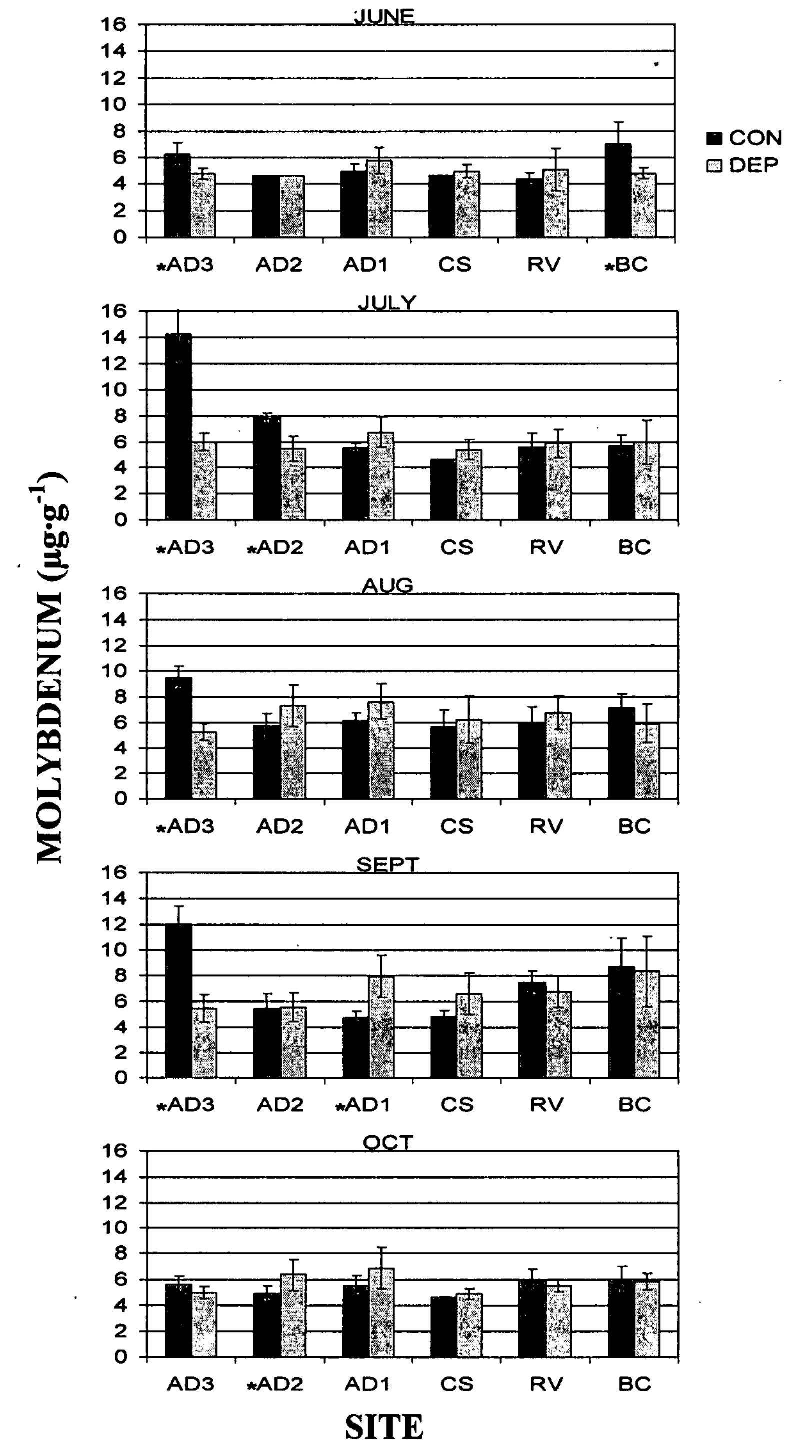

Figure 52. Molybdenum content ($\mu g \cdot g^{-1}$) of sediment sampled at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.05$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

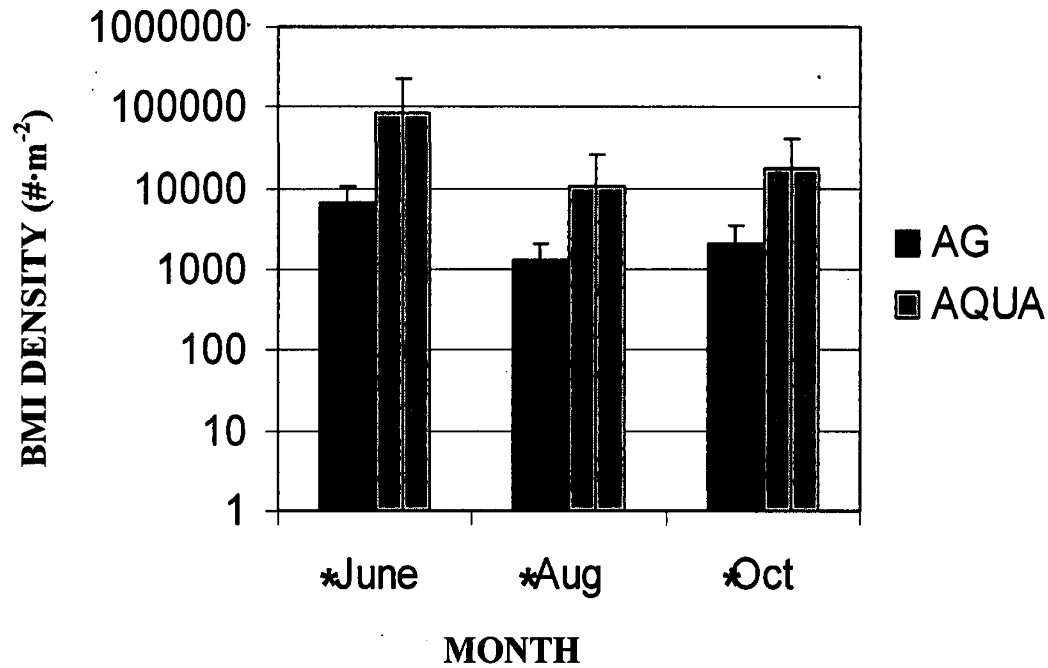

Figure 53. Benthic macroinvertebrate density (#·m^{-2}) of agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the benthic macroinvertebrate density (#·m^{-2}) of aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

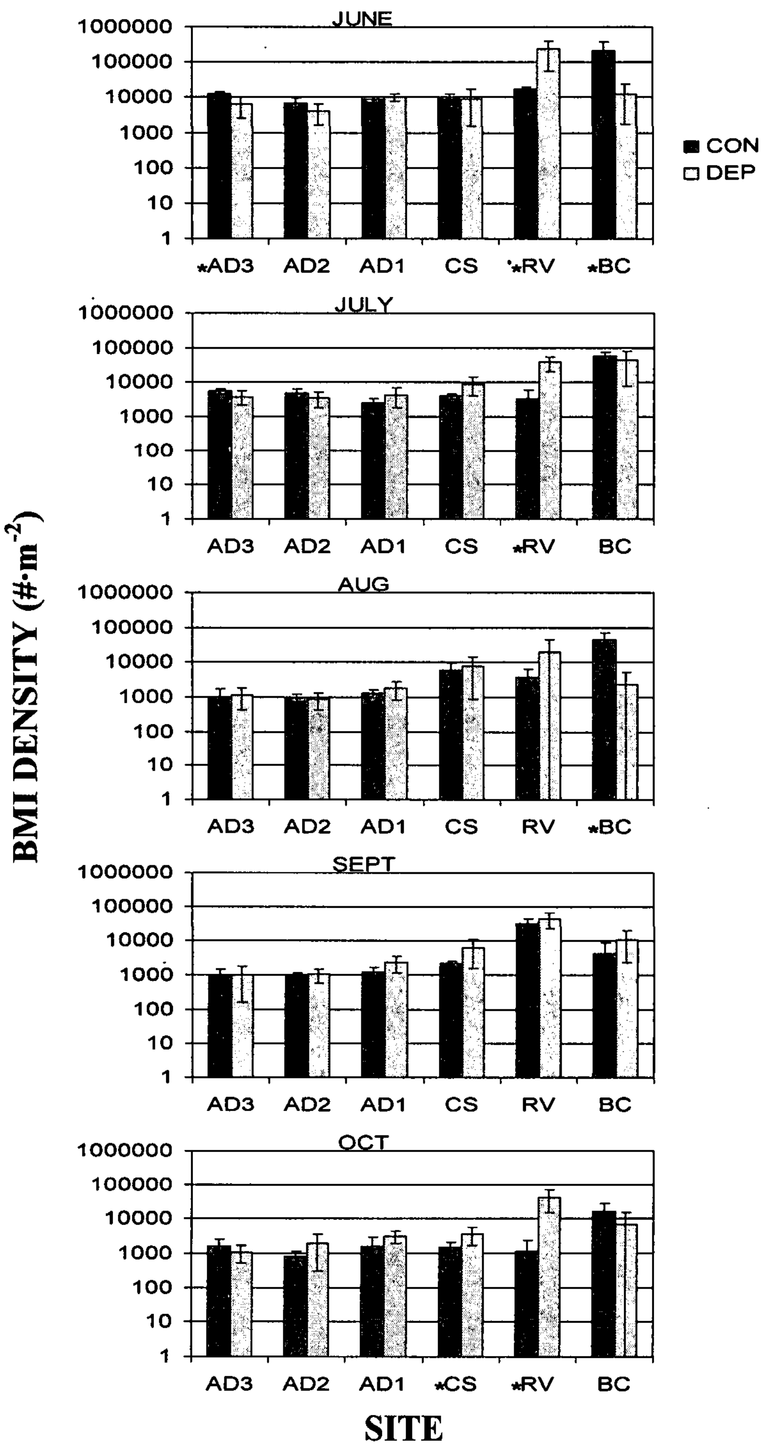

Figure 54. Benthic macroinvertebrate density (#·m^{-2}) at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.2$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

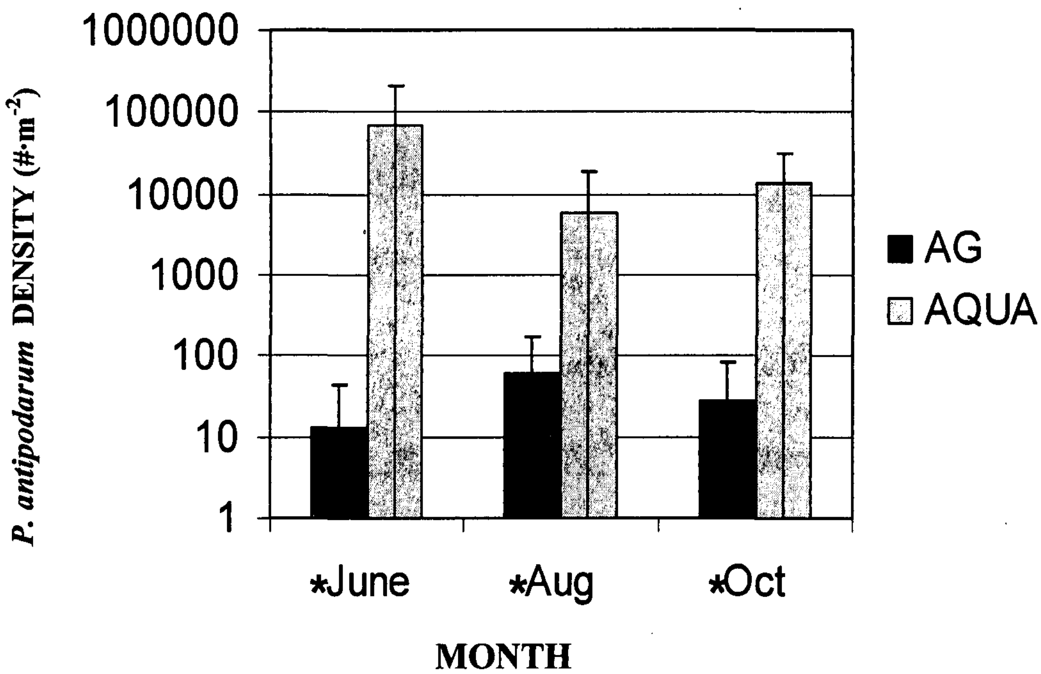

Figure 55. *Potamopyrgus antipodarum* (New Zealand mudsnail) density (#·m^{-2}) in agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the *P. antipodarum* density (#·m^{-2}) in aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

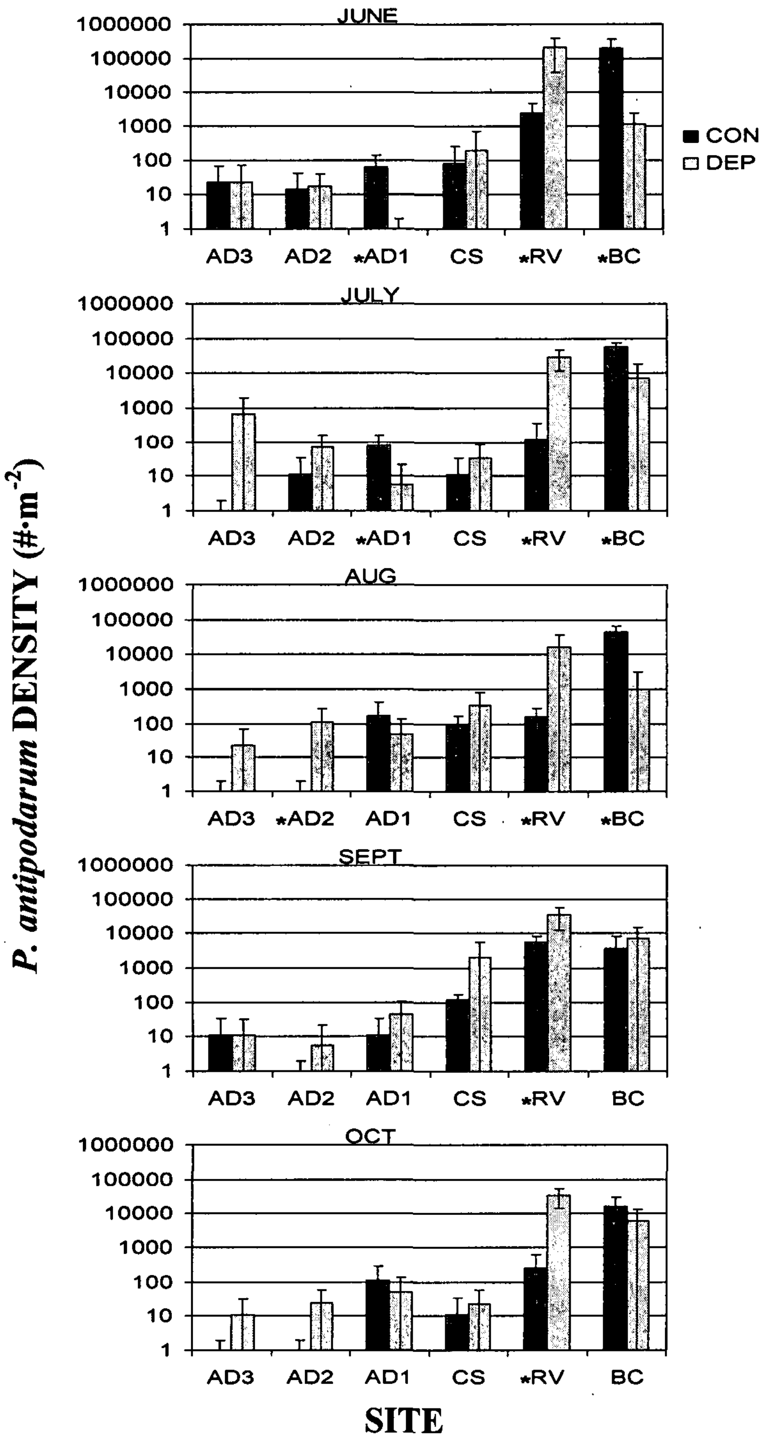

Figure 56. *Potamopyrgus antipodarum* (New Zealand mudsnail) density ($\#\cdot m^{-2}$) at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.2$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

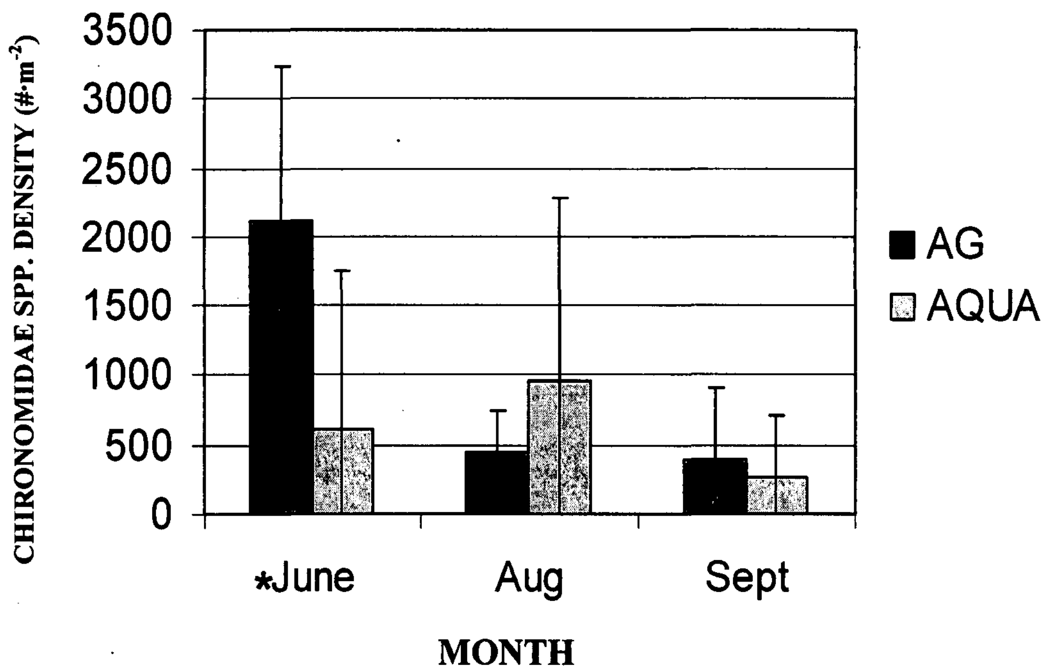

Figure 57. Chironomidae spp. density (#·m^{-2}) in agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between Chironomidae spp. density (#·m^{-2}) in aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

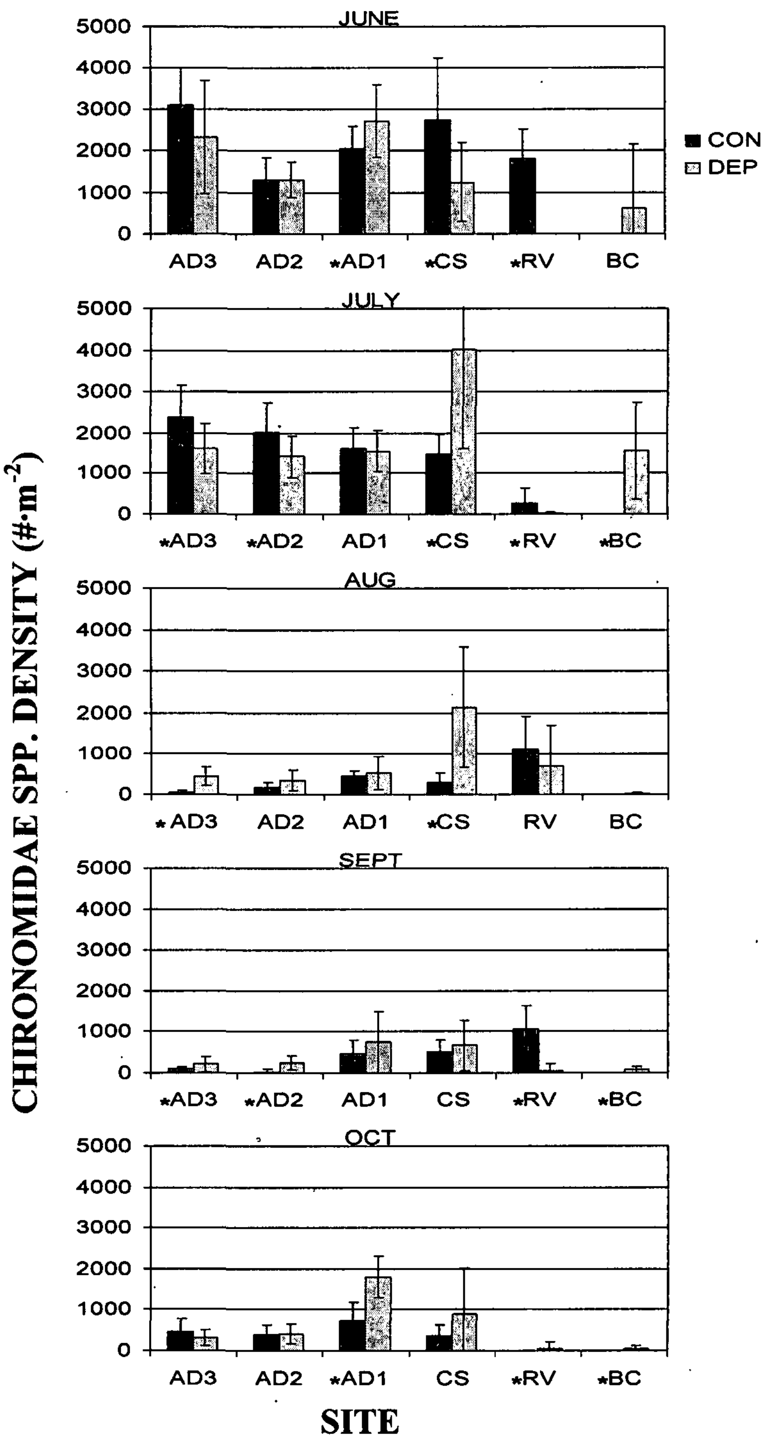

Figure 58. Chironomidae spp. density (#·m^{-2}) at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.2$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

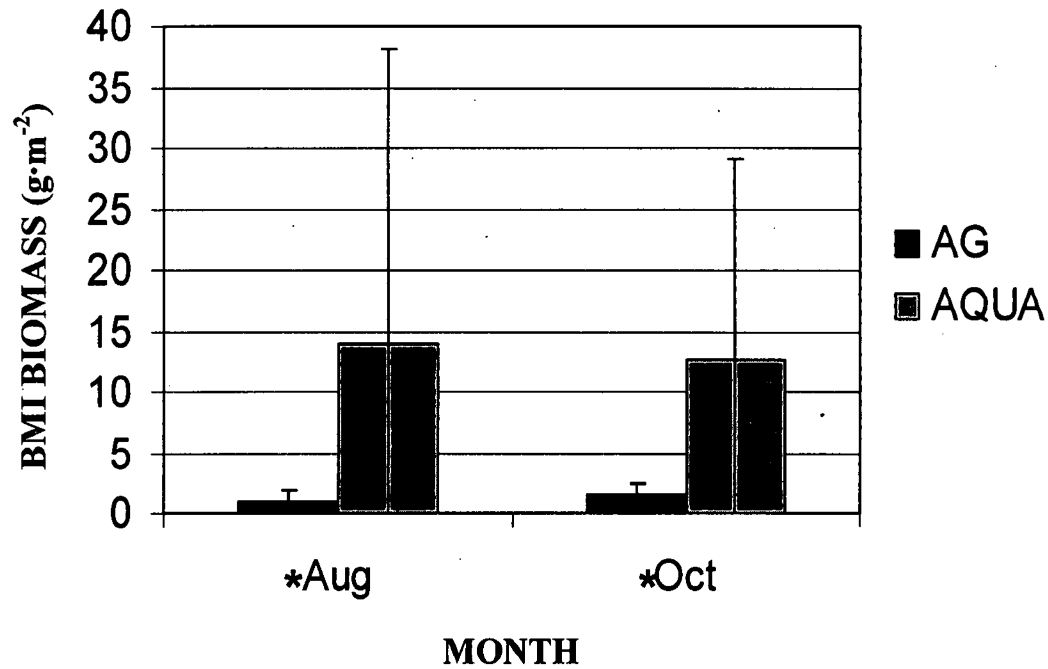

Figure 59. Benthic macroinvertebrate dry weight biomass ($g \cdot m^{-2}$) of agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the benthic macroinvertebrate dry weight biomass ($g \cdot m^{-2}$) of aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

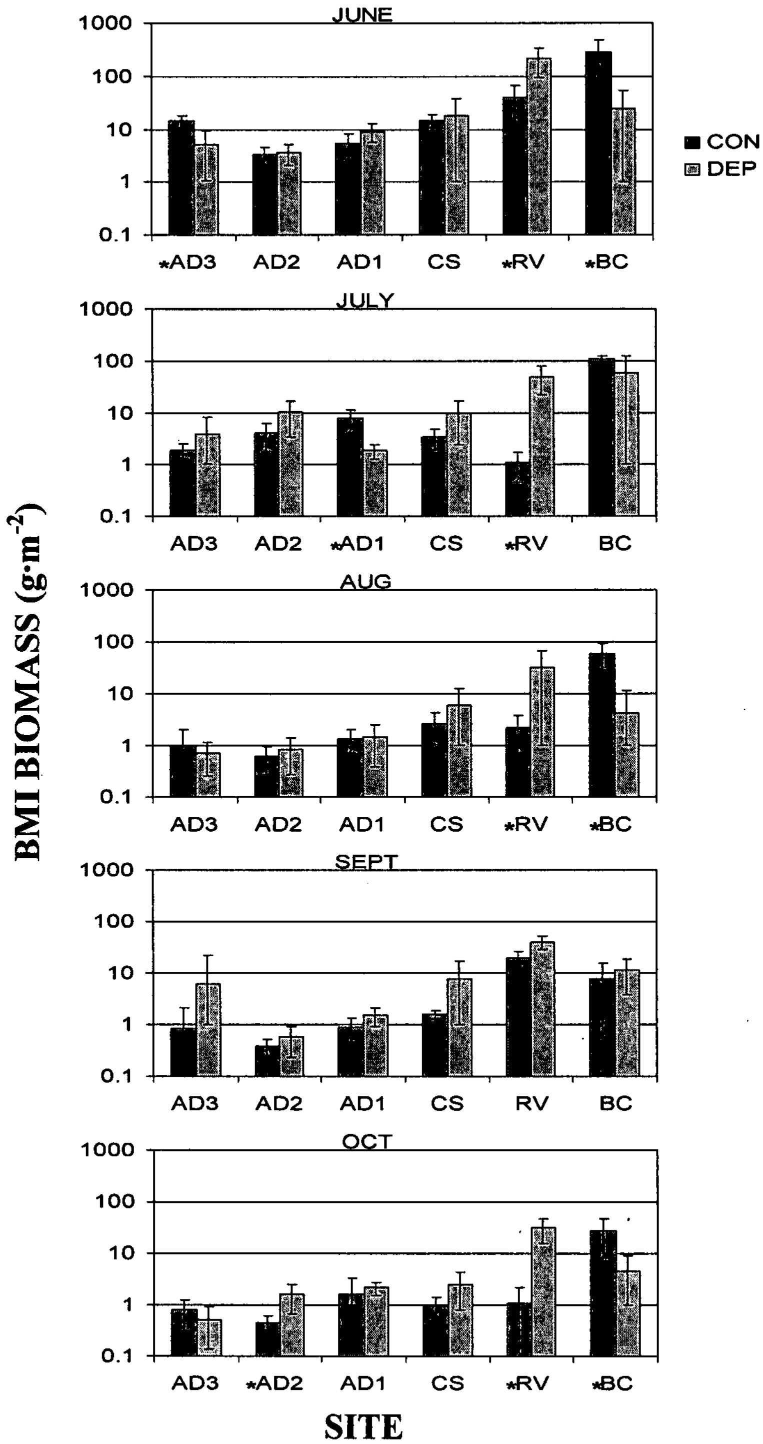

Figure 60. Benthic macroinvertebrate dry weight biomass ($g \cdot m^{-2}$) at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.2$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

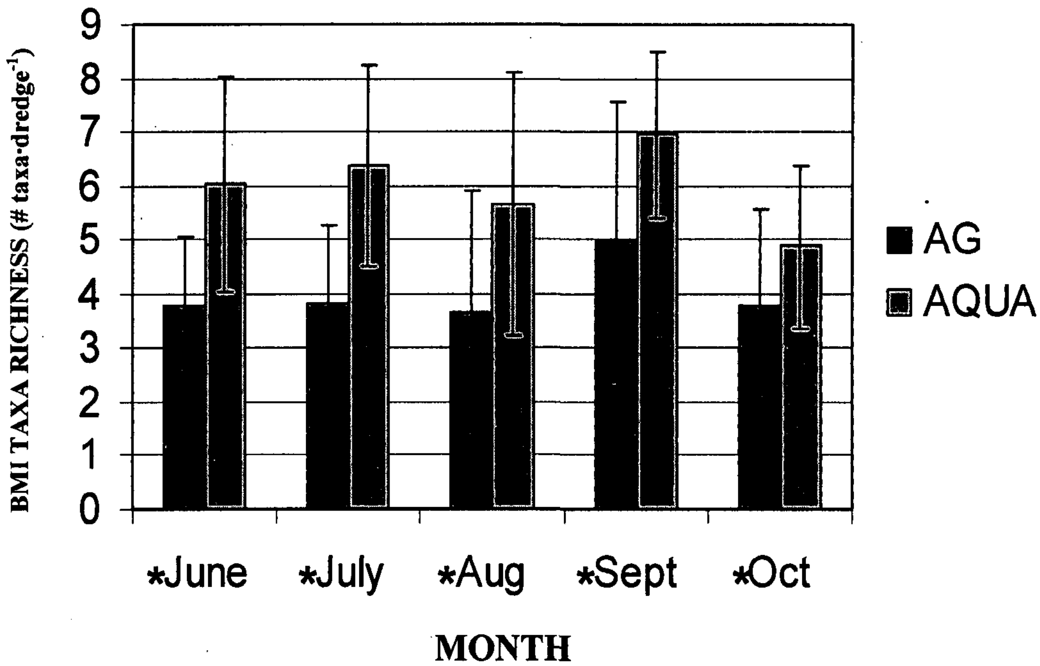

Figure 61. Benthic macroinvertebrate taxa richness (# taxa·dredge^{-1}) of agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the benthic macroinvertebrate taxa richness (# taxa·dredge^{-1}) of aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

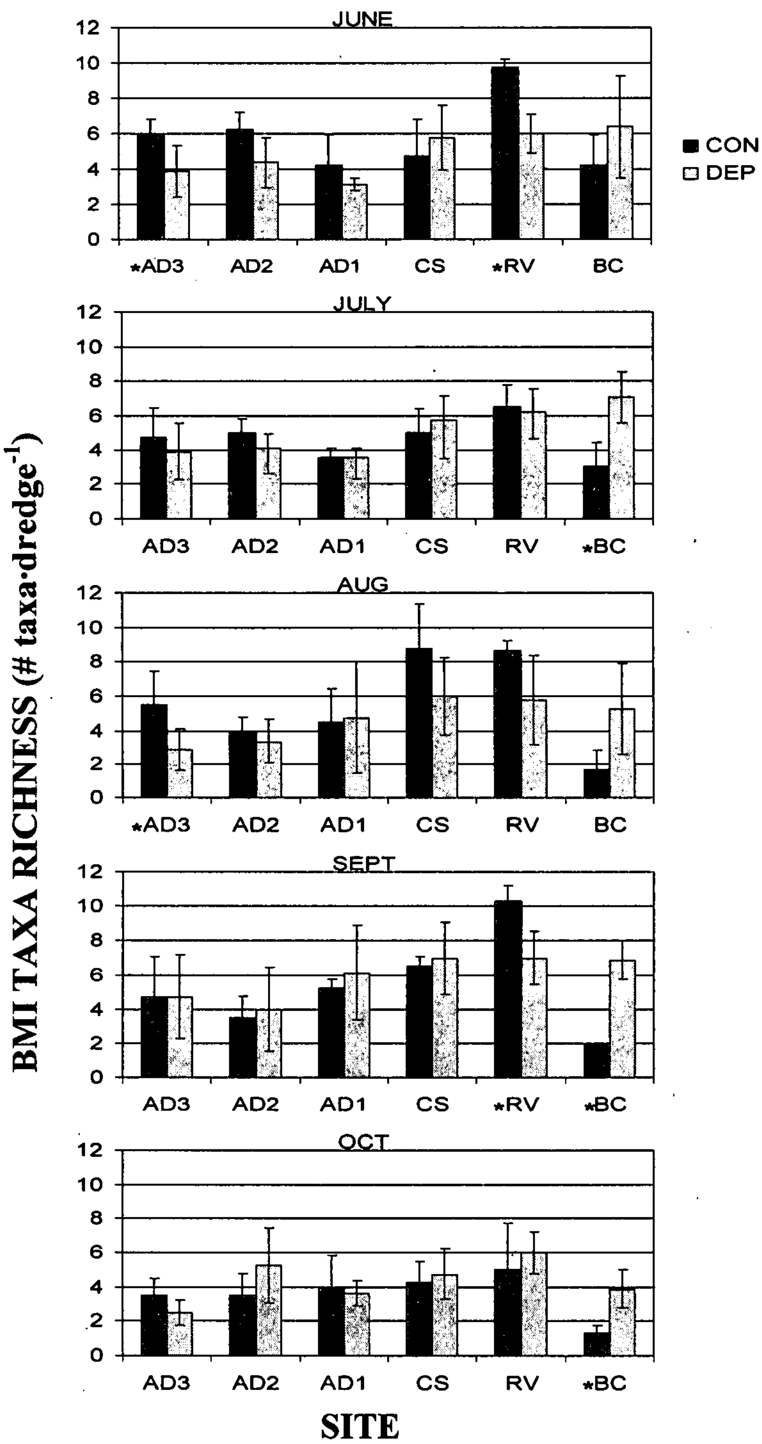

Figure 62. Benthic macroinvertebrate taxa richness (# taxa·dredge^{-1}) at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from mean. Asterisks indicate significant difference between control and deposition zones ($p < 0.2$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

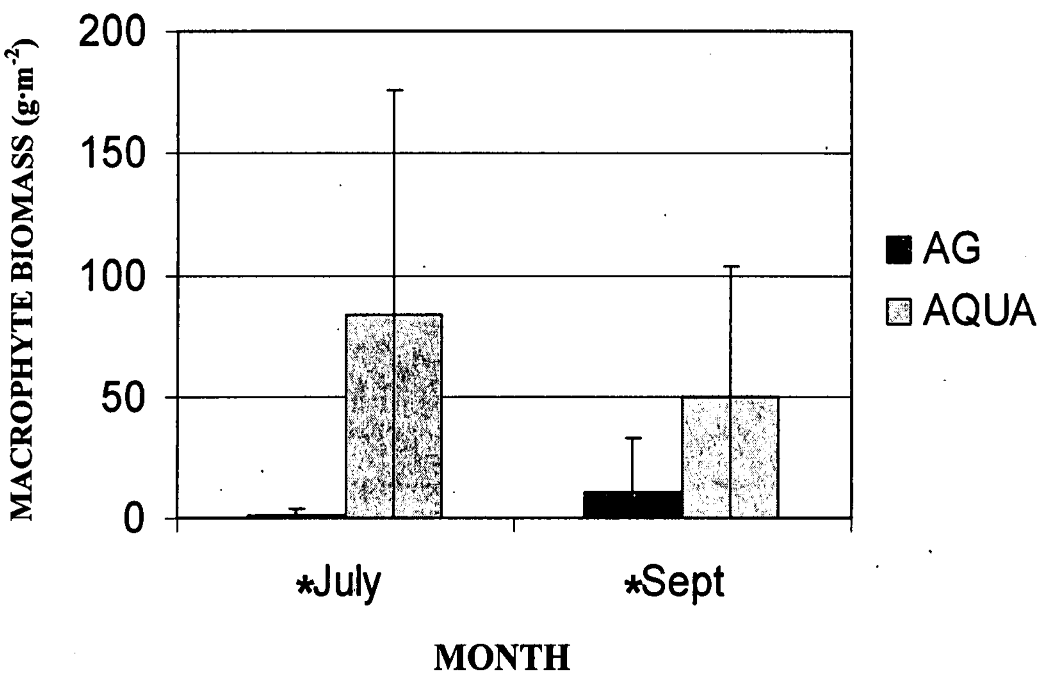

Figure 63. Aquatic macrophyte dry weight biomass ($g \cdot m^{-2}$) of agriculture and aquaculture deposition zones. Months shown are those that had no significant difference ($p > 0.05$) between the aquatic macrophyte dry weight biomass ($g \cdot m^{-2}$) of aquaculture and agriculture control zones. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between agriculture and aquaculture deposition zones ($p < 0.05$). AG = agriculture deposition zone, AQUA = aquaculture deposition zone.

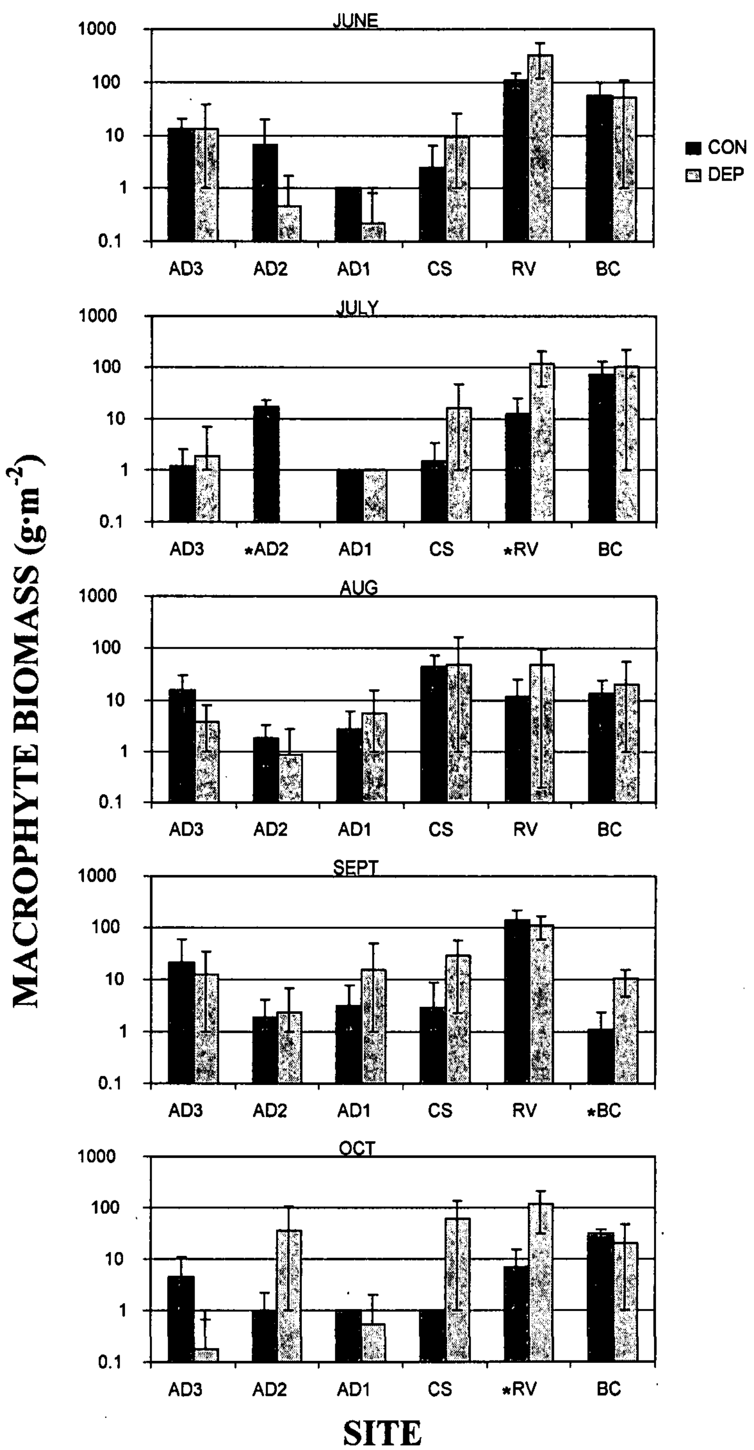

Figure 64. Aquatic macrophyte dry weight biomass (g·m^{-2}) at the six study sites in the middle Snake River June-October, 2001. Error bars represent ± 1 standard deviation from the mean. Asterisks indicate a significant difference between control and deposition zones ($p < 0.2$). CON = control zone, DEP = deposition zone, AD3 = Pigeon Cove LQ, LS Drain, AD2 = Southside LS2/39A Drain, AD1 = Southside 39 Drain, CS = Crystal Springs Hatchery, RV = Rim View Hatchery, BC = Box Canyon Hatchery.

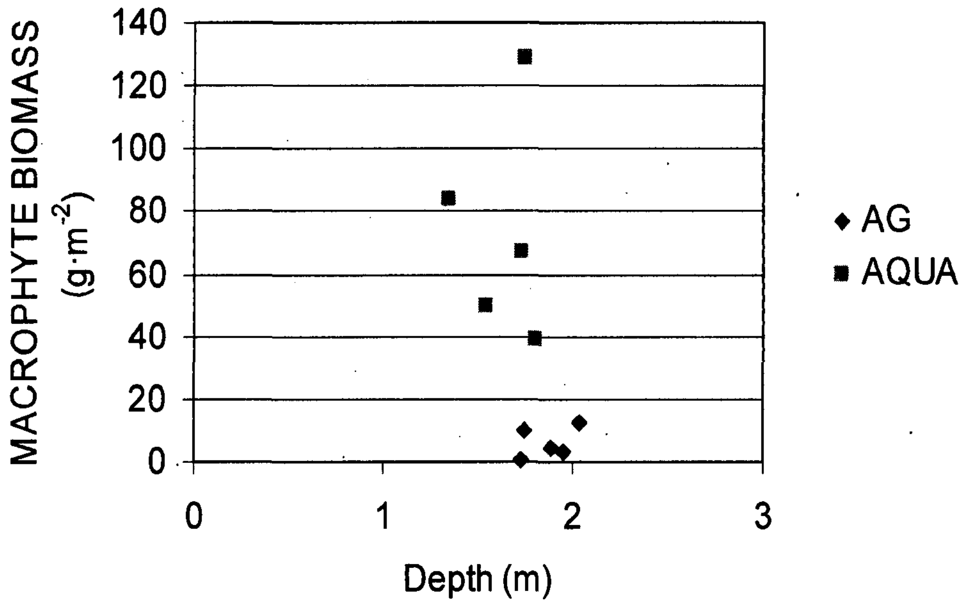

Figure 65. Monthly aquatic macrophyte dry weight biomass (g·m^{-2}) by depth (m) of agriculture (AG) and aquaculture (AQUA) deposition zones

APPENDIX A:

STANDARD OPERATING PROCEDURES

A. In-Field SOP

A.1. *Current Meter (University of Idaho, Aquatic Ecology Lab, standard protocol)*

1. Use a Marsh-McBirney water current meter.
2. Take current readings at each dredge location prior to dredging.
3. Attach electrode to aluminum rod.
4. Place rod in water so that the large part of electrode is facing into the current.
5. Turn meter on and take flow readings in ft/sec within 20 cm of substrate
6. Record on data sheet

A.2. *Secchi Disk (University of Idaho, Aquatic Ecology Lab, standard protocol)*

1. Use a standard 20cm secchi disk.
1. Sufficient weight should be added so that the line will remain vertical in the water.
3. Remove sunglasses.
4. Lower the disk on the shady side of the boat.
5. Record the depth - in meters - at which the disk disappears from sight.
6. Lower the disk further and then raise slowly.
7. Record the depth at which the disk reappears.

A.3. *GPS (University of Idaho, Aquatic Ecology Lab, standard protocol)*

1. Use a Trimble GeoExplorer II or GeoExplorer III GPS unit.
2. Plug battery pack into bottom of unit so green light appears.
3. Push on/off button.
4. When Main menu comes up, choose Data Capture.
5. When Data Capture menu comes up, choose Open Rov. File.
6. Allow 100 satellite readings to occur.
7. Once 100 readings have been taken, choose Close File.
8. When asked if you want to close file, choose Yes.
9. Push on/off button for 5 seconds to turn off.
10. Unplug battery pack to conserve power.
11. Upon return to laboratory, download files.

A.4. *Dredging (University of Idaho, Aquatic Ecology Lab, standard protocol)*

1. Use a stainless steel petite Ponar Dredge
2. At each sampling location be sure the boat is securely anchored.
3. Open the dredge and place the set pin. Lower the dredge into the water at a slow and steady rate to ensure that the dredge remains upright in the water column.
4. Once the dredge reaches the substrate, release the set pin by releasing

the tension in the rope. Activate the dredge by pulling up on the rope and continue to pull at a constant rate until the dredge can be lifted from the water and gently placed in the boat.

5. Before opening dredge, evaluate for degree of disturbance, penetration depth, and amount of leakage. If the grab is unacceptable, repeat steps 3-5.
6. If dredge is acceptable, proceed with sediment, benthic macroinvertebrate, and aquatic macrophyte sampling processing.

A.5. ***Redox Probe (University of Idaho, Aquatic Ecology Lab, standard protocol)***

1. Use an Orion combination redox electrode with an Orion Research meter, model SA 210.
2. Calibrate before any readings are taken (refer to manual).
3. Remove cap from probe surface, rinse the probe with de-ionized water and dry with a chem-wipe.
4. Carefully push probe 5 centimeters into sediment.
5. Turn meter on and start the stopwatch.
6. Record reading each minute, for 10 consecutive minutes, as long as there is at least a 2 mV change from one minute to the next.
7. Once readings are taken, rinse probe with de-ionized water and dry with a chem-wipe.
8. Place cap back on probe surface and store in a dry place out of the sun until next use.

A.6. ***Temperature Probe (University of Idaho, Aquatic Ecology Lab, standard protocol)***

1. Use a temp/pH electrode with BNC connector attached to an Orion model SA 720 meter.
2. Wash probe with de-ionized water and dry with a Chem-wipe.
3. Carefully push probe 5 centimeters into the sediment.
4. Turn meter on and start the stopwatch.
5. Record reading at 5 minutes.
6. Once readings are taken, rinse probe with de-ionized water and dry with a Chem-wipe.
7. Store in a dry place out of the sun until next use.

B. Laboratory SOP

B.1. ***Sediment Particle Size (Analytical Sciences Lab, University of Idaho)***

1. Equipment and Apparatus
   - A. Analytical Balance
   - B. 400 mL Nalgene Cups
     Polypropylene Beakers order from Fisher catalog # 02-586-6F.
   - C. Soil mixer
     Barnant General Purpose Mixer order from VWR

catalog # BR700-5400.

D. Hydrometer
Soil Analysis Hydrometer (ASTM 152 H) order from VWR catalog # 34792-001.

E. Hydrometer Cylinder
KIMAX T.C. Soil Testing Cylinder (1130 and 1205 mL) order from VWR catalog # 34794-007.

F. Thermometer (32 - 85 F)

G. Stop Watch

H. Metal Stirring Rod

I. 400 mL Beakers

J. Steam Table or Bath

2. Instrument Operating Parameters
There are no instruments used in this analysis.

3. Reagents
   A. Sodium hypochlorite, 5-6% - stock (household bleach)
   Purchase from local store.
   B. Sodium chloride, 1N - Dissolve 58.5 g NaCl in 800 mL Millipore water. Make to 1 liter volume.
   Sodium chloride USP/FCC grade order from VWR Catalog # JT3628-9.
   C. Sodium hexametaphosphate, 5% - Dissolve 50 g sodium hexametaphosphate in 800 mL Millipore water. Make to 1 liter volume. Sodium hexametaphosphate order from VWR catalog # JTV030-9.

4. Standards
Standards are not used in this procedure.

5. Sample Preparation
   A. Weigh 100 g for sandy soils, 50 g for other soils of air dried (30 - 40° C), ground, and sieved (2 mm sieve) soil into 4000 mL nalgene cups.
   B. Pretreat soil if necessary. (See "Interferences" below.)
   C. Add approximately 200 to 250 mL distilled water.
   D. Add 5 mL 5% sodium hexametaphosphate.
   E. Stir and allow to set a minimum of 15 minutes.
   F. Stir with a mixer 5 minutes for sandy soils and 10 minutes for all other soils.
   G. Transfer soil into hydrometer cylinder.
   H. Place hydrometer into cylinder and make to proper volume with distilled water: 1205 mL for sandy soils, 1130 mL for all other soils.

6. Interferences
   A. The dispersion process is the single most important step and the dispersion is dependent on the paddle. Therefore the paddle should be replaced as soon as it shows sings of wear.
   B. The hexametaphosphate loses its dispersing efficiency after 1 month; make it fresh every time for best results.
   C. Organic matter (< 4-5%) may cause erroneous readings. If the sample warrants removal of organic matter, do the following:
      1. Add 100 mL of sodium hypochlorite (household bleach) to 50 g of soil in a beaker.
      2. Steam heat for 15 minutes.
      3. Let soil settle, decant.
      4. Wash into hydrometer cup.
      5. If a fine-textured soil (clay) is suspected, add 5 mL of sodium hexametaphosphate.
         Continue the normal procedure from this step.
   D. If the soil will not disperse, add additional sodium hexametaphosphate.
   E. If the soil is salt-affected and flocculates because of too much sodium, vacuum filter and wash the soil with 1N NaCl after letting it set overnight in 1N NaCl. Wash the soil off the filter with water into the hydrometer cylinder. Proceed normally.
   F. It is now accepted that calcium carbonate removal disrupts particle size estimation more than helps it, so unless requested, do not remove $CaCO_3$.

7. Sample Analysis
   A. Remove hydrometer and stir sample thoroughly.
   B. Start stopwatch immediately after stirring is completed, replace hydrometer, and read scale at exactly 40 seconds. Note beginning time. (When stopwatch is first started. See steps E and F below).
   C. Remove hydrometer, clean and dry.
   D. Record temperature of suspension in degrees F.
   E. Allow suspension to settle undisturbed for 2 hours from starting point noted in step B.
   F. Replace hydrometer carefully and record reading.
   G. Record a second temperature in degrees F.

   Notes:
   A. When doing several samples, note beginning time and allow a certain period of time to elapse between each sample. (Allow enough time to record temperature, reading, and stir the next sample.) Then at the end of two hours, read each sample that same time period

apart.

B. The settling process is temperature dependent, so the analysis should be done in as constant a temperature area as is available.

8. Calculations

A. Temperature correction:

1. For each degree above 68°F, add 0.2 units to the reading.
2. For each degree below 68°F, subtract 0.2 units from the reading.

B. % Sand:

g of soil weighed – corrected 40 sec. reading * = g sand settled

$$\frac{\text{g sand settled}}{\text{g soil weighed}} \times 100 = \%\ \text{sand}$$

*The hydrometer is calibrated in grams of soil in suspension at the time the reading is taken. It only takes 40 sec. for the sands to settle out and leave the silt and clay in suspension.

C. % Clay:

$$\frac{\text{corrected 2 hr reading}}{\text{g soil weighed}} \times 100 = \%\ \text{clay}$$

D. % Silt:

100% – % sand – % clay = % silt

9. Quality Control and Reference Material

The accepted limits are two standard deviations from the averages of our in house references for particle size distribution.

10: Documentation Requirements

The in house reference material results are recorded on the PSD QC sheet and the PSD benchsheet. The sample PSD values are recorded onto the PSD benchsheet. The PSD benchsheet can be found at P:\bench\inorgan\soil\psdbench.xls and the PSD QC sheet can be found at P:\qcsheets\inorgan\soil\soiltext.xls.

11. Safety and Health

Consult Material Data Safety Sheets for information on reagents.

12. References

Bouyoncos, George. 1951. A recalibration of the hydrometer method for making mechanical analysis of soils. Agron. J. 43:434-438.

Bouyoncos, George. 1962. Hydrometer method improved for making particle size analysis of soils. Agron. J. 54:464-465.

Day, P.R. 1956. Report of the committee on physical

analysis. 1954-55. Soil Sci. Soc. Am. Proc. 20:167-169.
Anderson, J.V. 1963. An improved pretreatment for mineralogical analysis of samples containing organic matter. Clays Caly Min. 10:380-388.
Omueti, I.A.I. 1980. Sodium hypochlorite treatment for organic matter destruction in tropical soils of Nigeria. Soil Sci. Soc. Am. J. 44:878-880.

13. Validation
The particle size distribution values have a long history of in house reference quality control.

B.2. ***Sediment Organic Carbon (Year 2000 sediment only, Analytical Sciences Lab, University of Idaho)***

1. Equipment and Apparatus

   A. *Analytical Balance*

   B. 500 mL Erlenmeyer flasks
   KIMAX brand titration flasks order from Fisher catalog # 10-091C.
   C. Thermometer (needs to be able to read at least 150 C)
   D. Hot Plate
   E. 50 mL Buret

2. Instrument Operating Parameters
This is a titration and no instruments are used for this procedure.

3. Reagents
   A. 1 N Potassium Dichromate ($K_2Cr_2O_7$) - Accurately weigh 98.08 grams of potassium dichromate into approximately 600 mL Millipore water in a 2 L volumetric flask. Make to volume with Millipore water.
   Note: This is a primary standard and must be made with extreme care to assure a normality of 1.
   Potassium Dichromate reagent grade from VWR catalog # JT3090-5.
   B. Sulfuric Acid (H_2SO_4), concentrated. (It may be necessary to add 15 g of silver sulfate (Ag_2SO_4) per liter of sulfuric acid to remove the chloride from the soil.)
   Sulfuric acid reagent grade order from Fisher catalog # A300-212.
   Silver sulfate reagent grade order from Fisher catalog #'s190-100.
   C. Ferrous sulfate, 0.5 N - Dissolve 140 grams reagent grade

$FeSO_4 \bullet 7H_2O$ in Millipore water. Add 15 mL concentrated H_2SO_4. Make to 1 liter. Standardize against 10 mL 1N $K_2Cr_2O_7$. Store in a dark bottle.
Sulfuric acid reagent grade order from Fisher catalog # A300-212.
Iron sulfate reagent grade order from Fisher catalog # I146-3.

D. Ferroin indicator — dissolve 1.485 grams 1, 10-Phenanthroline and 0.695 grams $FeSO_4 \bullet 7H_2O$ in Millipore water and dilute to 100 mL. Iron sulfate reagent grade order from Fisher catalog # I146-3.
1, 10-phenanthroline certified ACS grade order from Fisher catalog # p70-5.

4. Standards

   A blank sample using 10 mL of potassium dichromate should be titrated to determine the normality of the iron sulfate.

5. Sample Preparation
   A. Weigh between 0.10 and 10.00 (± 1%) of dried (30 - 40 C), ground, and sieved (2 mm sieve) soil into 500 mL Erlenmeyer flask.
   B. Add 10 mL 1N $K_2Cr_2O_7$, and swirl.
   C. Rapidly add 20 mL concentrated H_2SO_4 and heat to 150°C in a hood.
   D. Allow to cool 30 minutes and then add 200 mL distilled water.

6. Sample Analysis
   A. Add 3-4 drops ferroin indicator and titrate from a dark green to red endpoint using $FeSO_4$.
   B. Titrate a blank to standardize $K_2Cr_2O_7$.
   C. Repeat with less soil if over 75% of the dichromate is reduced or with more soil if under 20% of the dichromate is reduced.

7. Calculations
   A.

$$O.C.\% = \frac{[(mL\ K_2Cr_2O_7 * N\ K_2Cr_2O_7) - (mL\ FeSO_4 * N\ FeSO_4)](0.003)(100)}{g\ soil} \times f$$

f = An average correction factor (Use 1.12 unless otherwise requested.)

8. Quality Control and Reference Material

   The accepted limits are two standard deviations from the averages of our in house references for the titrimetric organic carbon test. The QC charts for the titrimetric organic carbon test are located at: P:\qccharts\inorgan\soils\titr\oc\oc.xls, poc.xlc, and soc.xlc.

9. Documentation Requirements

The in house reference material results are recorded on the titrimetric organic carbon QC sheet and the titrimetric organic carbon benchsheet. The sample organic carbon values are recorded onto the titrimetric organic carbon benchsheet. The titrimetric organic carbon benchsheet can be found at P:\bench\inorgan\soil\omhbench.xls and the titrimetric organic carbon QC sheets can be found at P:\qcsheets\inorgan\soil\orgmatti.xls.

10. Safety and Health
    A. Handle the potassium dichromate with care. Read the MSDS before using the potassium dichromate.
    B. Acids are corrosive.

11. Reference

Allison, L.E. 1965. Organic Carbon. In: C.A. Black (Ed.) Methods of soil analysis, Part 2. Agronomy 9:1346-1365.

12. Validation

The organic carbon values are checked quarterly by the Western States Agricultural Exchange Program.

B.3 ***Sediment Carbon & Nitrogen (Analytical Sciences Lab, University of Idaho)***

1. Equipment and Apparatus

A. Instrument
   1. LECO® Combustion Analyzer CNS-2000
   2. Denver Instrument Company Analytical Balance

B. Miscellaneous
   1. Weigh boats
   2. Combustion Aid for Liquids
   3. Combustion Aid for Solids

2. Instrument Operating Parameters

A. External gas tanks: Nitrogen 40 psi; Helium 40 psi; Oxygen 40 psi.
B. System and analysis parameters will be determined by the particular CNS method.

3. Reagents

A. Anhydrone
B. Lecosorb
C. Copper Turnings and Copper Sticks
D. N-Catalyst

4. Standards

A. Sulfa-methazine (CNS)
B. House Reference Grass
C. House Reference Soil
D. EDTA (CN)

5. Blank Correction

A. Before the analysis of samples, 6 blank weigh boats are analyzed to determine the background carbon, nitrogen, and sulfur levels present in the combustion gases and the CNS system.
B. Add six blanks to the weight list by selecting the blanks ID code from the analyze menu. The manual weight icon will allow the operator to change the weight, 0.2g is used as a blank weight and is the default weight. The sample ID and weight can be repeatedly entered into the weight table by pressing the enter key.
C. After the six blank analyses have been completed, touch the calibrate menu, touch the blanks icon and select "Carbon, Sulfur, and Nitrogen" from the pop-up window. Touch the ↑ or the ↓ key to move the cursor and locate the blanks just analyzed. Touch the "Include Results" to highlight the six blanks. Touch "Process Results" to calculate new blank values for carbon, nitrogen, and sulfur.

6. Sample Preparation

A. Solid Samples

1. Dry plant and soil samples in the drying ovens located in room #7.
2. Grind samples.
3. Weigh sample into weigh boats, approximately 100 mg for plants, 200 mg for standards and soil samples. Weigh boats are recycled after CNS analysis. Boats are scraped out with a spatula and stored in a dessicator located in the inorganic laboratory.
4. Record the UIASL Sample Number, and sample weight on the bench sheet.
5. Duplicate every tenth sample.
6. The autoloader tray contains 49 spaces for weigh boats: 5 for standards and references and 44 for samples.
7. When weigh boats are placed in the autoloader, carefully move weigh boats to disperse sample material throughout the bottom of the weigh boat. Sample material should be distributed evenly on the bottom of the boats to facilitate complete combustion. The weigh boats are placed with the round end facing towards the front to the autosampler. (The front of the autosampler is labeled "FRONT" with permanent marker.)

B. Liquid Samples
   1. Use "Com-Aid for solids" for all liquid samples.
   2. Before analyzing liquids, the weigh boats must be lined with an aluminum liner that can be purchased from LECO®.

7. *Sample Analysis*

A. To record sample identification and weights to be analyzed, touch the "Analyze" menu icon. Sample identifications and weights are added by touching the Login-sample window. A keyboard window will pop-up and the sample identification can be entered. The manual weight icon is then selected and a numerical keypad is displayed for entry of the sample weight.

B. Sulfamethazine, EDTA, references, and blanks already have identification codes assigned to them. To add one of these samples to the weight list, touch the ID code icon. Select the appropriate standard or reference from the alphabetical list. Exit the ID-code window, and change the weight using the manual weight icon.

C. All samples are analyzed in the order they are placed in the sample weights list.

D. After sample Identification's, weights, references and sulfamethazine are recorded in the weight list. Touch the analyze icon. The autoloader window will appear and the cursor can be moved to the first position of the auto loader and the analysis will start.

8. *Sample Weight List*

A. From the reports menu, touch "Sample Weights" to view, modify, or print the list of samples, standards, and references entered and ready for analysis. Sulfamethazine will have a STANDARD designation in the third column of the ID code column.

B. A standard ID code must be used in order to use the results for calibration. Check the weight list to confirm that sulfamethazine is specified as a standard in the run list.

9. *Drift Correction*

A. Drift correction should be performed on a daily basis. The calibration of the instrument was performed during the manufacturing process, unless the CNS was serviced or major parts have been changed - only drift correction is necessary. Drift correction is used to compensate for changes in the analyzer's environment that takes place during normal operation.

B. Touch "Drift Correction" from the Calibrate menu. Then select "Carbon, Sulfur, and Nitrogen" from the pop-up window. Touch the ↑ or the ↓ key to move the cursor, once the appropriate sulfamethazine standards have been located for that particular run, touch the "Include Results" key to highlight.

C. Touch the "Process Results" key to calculate the new calibration values.

10. Result Recalculation
    A. The results are reprocessed with the new calibration values. From the Calibrate menu, touch the "Recalculate Results". Select "Carbon, Sulfur, and Nitrogen" from the pop-up window. Touch "Include Results" to highlight the samples that need to be recalculated. Touch "Process Results" to have the results recalculated and printed out.

11. Quality Control and Reference Material
    A. QC Data
        1. Fill out QC data sheets for sulfamethazine and reference samples.
        2. House reference material: grass, soil, and oil. If results are within 2 standard deviations of in-house averages of all elements, analysis has passed QC.
    B. Quality Assurance
        1. All quality control samples, duplicates, etc. are recorded on the QC report.

12. Safety and Health
    A. Reagents are strongly basic, use appropriate techniques.
    B. Consult MSDS file for information on reagents.

13. Documentation Requirements
    A. Routine and non-routine maintenance entries should be recorded at the time of performance in the "LECO® CNS-2000 Maintenance Logbook" which is stored near the instrument in room 24. Refer to SOP.52.030, LECO® CNS-2000 Operation, Calibration and Maintenance for routine and non-routine procedures.
    B. Bench sheet is located at P:\BENCH\CNS\BENCH.XLS.MATRIX.
    C. QC report is located at P:\QCREPORT\CNSQC.DOC.
    D. CNS equipment SOP is at P:\SOP\EQUIP\INORGAN\CNSLECO.DOC.

14. References

A. LECO® Corporation, 1998. *CNS-2000 Instrumentation for :Characterization of Organic/Inorganic Materials and Microstructural Analysis*. *CNS-2000 Instructional Manual*. LECO® Corporation, 3000 Lakeview Ave. St. Joseph, Michigan 49085.

B.4. ***Sediment Trace Elements (Analytical Sciences Lab, University of Idaho)***

Element	**Line**	**Wavelength**	**Method Detection limit µg/g**
Aluminum	Al3	308.215 nm	19
Barium	Ba1	455.403 nm	0.16
Beryllium	Be1	313.042 nm	0.017
Cadmium	Cd1	214.438 nm	0.35
Calcium	Ca3	317.933 nm	28
Chromium	Cr3	206.149 nm	1.1
Cobalt	Co1	228.616 nm	1.1
Copper	Cu1	324.754 nm	1.0
Iron	Fe2	259.940 nm	10
Lead	Pb1	220.353 nm	5.5
Magnesium	Mg1	279.553 nm	5.2
Manganese	Mn1	257.610 nm	0.52
Molybdenum	Mo1	202.030 nm	3.9
Nickel	Ni3	231.604 nm	.45
Phosphorus	P1	213.618 nm	8.3
Potassium	K1	766.490 nm	120
Sodium	Na2	589.592 nm	30
Sulfur	S1	180.669 nm	48
Zinc	Zn1	213.856 nm	0.74

A representative 1 g to 2 g (wet weight) sample of sludge or waste or 1.00 g (dry weight) of soil is digested in nitric acid and hydrogen peroxide at 150 C. The digestate is then refluxed at 150 C with hydrochloric acid, filtered if necessary and analyzed for Al, Ba, Be, Ca, Cd, Cr, Co, Cu, Fe, Mg, Mn, Mo, Ni, Pb, K, Na, S, P, and Zn by ICPES. A separate sample can be dried for a total solids determination of sludges and other wastes.

Interferences:
Sludge samples can contain diverse matrix types, each of which may present its own analytical challenge. Spiked samples and any relevant standard reference material should be processed to aid in determining whether Method 3050 is applicable to a given waste.

1. Equipment and Apparatus
   A. Tecator Digestion Tubes: Volumetric, 75 mL
   B. Tecator Model 1040 Digestor block and controller
   C. Thermometer: That covers range of 1 to 200°C.
   D. Whatman No. 41 filter paper (or equivalent)

E. Drying oven: Maintained at 30°C.
F. Glass or Polyethylene funnels
G. Whatman No. 934-AH Glass Microfibre Filters -11.0 cm diameter. Order from Fisher Catalog # 1827-110.

2. Instrumental Parameters
A. ICP Operating Parameters

POWER	1.0 KW
COOLANT	13 LPM
NEBULIZER	40 PSI
AUXILIARY	0.4 LPM
PUMP RATE	1.3 mL/min
AUTOSTART COOLANT	11 LPM

B. Further Operating Parameters

Number of integrations	2
Uptake Time	35 sec
Scan integration time	2 sec
Weight correction	Y
Dilution correction	Y
Interelement correction	N
Peaking Line	S1
Backround integration = peak	Y
Line Integration	3 sec
Uv PMT Gain	3
Visible PMT Gain	3

C. Standards and Check Standards

ELEMENT	STANDARD-CHECK STANDARD #1 * μg/mL	STANDARD-CHECK STANDARD #2 * μg/mL	STANDARD-CHECK STANDARD #3 * μg/mL
Ca	0.0000±1.0000	100.00±20%	
Mg	0.0000±1.0000	100.00±20%	
K	0.0000±1.0000	100.00±20%	

Na	0.0000±1.0000	100.00±20%	
Zn	0.0000±1.0000	5.0000±20%	
Mn	0.0000±1.0000	5.0000±20%	
Cu	0.0000±1.0000	5.0000±20%	
Fe	0.0000±1.0000	100.00±20%	
P	0.0000±1.0000	10.000±20%	
S	0.0000±1.0000	10.000±20%	
Pb	0.0000±1.0000	10.000±20%	
Al	0.0000±1.0000	100.00±20%	
Cr	0.0000±1.0000	1.0000±20%	
Cd	0.0000±1.0000	1.0000±20%	
Ba	0.0000±1.0000		5.0000±20%
Ni	0.0000±1.0000		1.0000±20%
Co	0.0000±1.0000		1.0000±20%
Be	0.0000±1.0000		1.0000±20%
Mo	0.0000±1.0000		1.0000±20%

**Limits only apply to check standards (standard #2 for Ca is 100 ppm, while checkstandard #2 for Ca should read within 20% of 100 ppm), blanks should be within 1.000 ppm of being zero.*
Check Standard #1 is run every 14 samples
Check standards #2 and #3 are run every 7 samples

3. Reagents
   A. 18 M Ohm Water
   B. Concentrated nitric acid, Trace Metal grade (HNO_3)
   C. Concentrated hydrochloric acid, Trace Metal grade (HCl)
   D. Hydrogen peroxide (30%) (H_2O_2)

4. Standards
   Use AESAR ICP grade standards from the list above in part B of section 2.

5. Sample Preparation and Analysis
   A. Sample Collection, Preservation, and Handling
   1. All samples must have been collected using a sampling plan that addresses the considerations discussed in
   chapter 9 of EPA Test Methods.
   2. All sample containers and glassware used in the analysis must be prewashed with detergents, acids and Type II water. The 75 mL digestion tubes should be washed, acid rinsed and acid refluxed. (See SOP 30.300.10.) Plastic and glass containers are both suitable for sample collection and storage.

3. Nonaqeuous samples shall be refrigerated in the cold room upon receipt and analyzed as soon as possible. Soil samples should be dried at 40°C for at least 8 hours and then ground and passed through a 20 mesh screen. Samples that have been digested should be stored in the cold room at 4°C.

B. Procedure

1. Sample Preparation
   a. Mix the sample thoroughly to achieve homogeneity. For each digestion procedure, weigh to the nearest 0.003 g and transfer to a digestion tube a 1.00-g to 2.00-g portion of sample. (1.00 g of oven dried and ground soil).
   b. Add 7.5 mL of HNO_3, mix the slurry, and place the tube in the digester block. Heat the sample to 150°C and reflux until NO_2 (brown-orange) fumes are no longer evolving from the digestion tubes. Note: Samples with high organic matter should sit overnight (covered) before heating.
   c. After digestion has been completed, slowly add 1 mL of 30% H_2O_2. Care must be taken to ensure that losses do not occur due to excessively vigorous effervescence.
   d. Continue to add 30% H_2O_2 in 1-mL aliquots with warming until the effervescence is minimal or until the general sample appearance is unchanged. NOTE: Do not add more than a total of 7.5 mL 30% H_2O_2.
   e. If the sample is being prepared for the ICP analysis of Al, Ba, Be, Ca, Cd, Cr, Co, Cu, Fe, Pb, Mg, Mn, Mo, Ni, K, Na,S,P, and Zn, add 7.5 mL of concentrated HCl, return the digestion tubes to the heating block and reflux for an additional 2 hours. After cooling, dilute to 75 mL with 18 MOhm water and invert to mix. Particulates in the digestate that may clog the nebulizer should be removed by filtration, by centrifugation or by allowing the sample to settle.
   f. Filtration: Filter through Whatman No. 934-AH Glass Microfibre filters (or equivalent).
   g. The diluted sample has an approximate acid concentration of 10.0% (v/v) HNO_3 and 10.0% (v/v) HCl. The sample is now ready for analysis by optical emission ICP spectroscopy.

6. Calculations

A. The concentrations determined for soils are on a dry weight basis since the samples have been dried and ground.

B. The concentrations determined for sludges and other waste materials are to be reported on the basis of the actual weight of the sample. If a dry weight analysis is desired, then the percent solids of the sample must also be provided.
C. If percent solids is desired, a separate determination of percent solids must be performed on a homogeneous aliquot of the sample.
D. All numbers output by the ICP will have been adjusted for weight and dilutions by the software.

7. Quality Control and Reference Material
   A. Quality Control to be used
      1. For each group of samples processed, preparation blanks (reagents) should be carried throughout the entire sample preparation and analytical process. These blanks will be useful in determining if samples are being contaminated.
      2. Duplicate samples should be processed on a routine basis. Duplicate samples will be used to determine precision. The sample load will dictate the frequency, but 10% is recommended.
      3. Spiked samples or standard reference materials must be employed to determine accuracy. A spike sample should be included with each group of samples processed and whenever a new sample matrix is being analyzed. Standard reference materials and in house QC should be included. SRM 2704 Buffalo River Sediment,SRM 2709 San Joaquin Baseline reference, SRM 2710 Montana Soil Highly Elevated, SRM 2711 Montana Soil Moderately Elevated are recommended for soils digests and other appropriate SRM materials should be selected which correspond to the matrix of the samples digested.
      4. The concentration of all calibration standards should be verified against a quality control check sample obtained from an outside source.
      5. Quarterly QC charts can be found for the 3050 method at P:\qccharts\inorg\soils\icp\3050*.

8. Documentation Requirements

   Instrument calibrations for 3050 screen are recorded in the ICP log book which is located next to the ICP in the ICP room. The reference material results are recorded on the 3050 QC sheet and are also on the ICP print out. The sample 3050 values are printed on the ICP print out. The 3050 bench sheet can be found at P:\bench\inorg\soil\3050.xls and the 3050 QC sheet can be found at P:\qcreport\soil\3050.doc.

9. Safety and Health

A. Consult Material Safety Data Sheets for information on reagents.
B. The heating block and the tubes are very hot during the digestion.
C. Acids are very corrosive.
D. Hydrogen Peroxide is a very strong oxidizing agent and is very reactive when first added to the sample tubes.

10. Method Performance
    A. University of Idaho Analytical Laboratory Instrument Limit of Detection

Element	µg/mL	Element	µg/mL
P	0.11	Cr	0.015
K	1.6	Pb	0.074
Cu	0.013	Ca	0.37
Zn	0.0099	Mg	0.069
Mn	0.0069	Cd	0.0047
Fe	0.14	S	0.64
Na	0.41	Ni	0.0060
Al	0.26	Co	0.015
Mo	0.052	Ba	0.0022
Be	0.0002	As	0.18

11. References
    A. Test Methods for Evaluating Solid Waste, Volume 1A: Laboratory Manual, Physical/Chemical Methods, PB88-239223, Part 1 of 4, Nov 86, USEPA
12. Validation
    The 3050 method uses certified soil references and in house references for quality control.

B.5. ***Sediment Isotope Analysis (University of Idaho, Stable Isotope Lab)***
1. Use Elemental Analyzer online with a Delta Plus Isotope Ratio mass Spec.
2. Follow standard protocol unique to the operating machine for determining ratios of $^{13}C/^{12}C$ and $^{15}N/^{14}N$

B.6. ***Aquatic Macrophyte Identification (University of Idaho, Aquatic Ecology Lab, standard protocol)***
1. **Remove aquatic macrophyte samples from freezer, place in a large tray, and allow to thaw in the refrigerator for twenty-four hours.**
2. Using a dissecting microscope, identify samples to the lowest possible taxon according to Hitchcock's, The Flora of the Pacific Northwest.
3. Sort identified samples by taxon to species.
4. Remove any additional woody debris in the sample.

B.7. ***Aquatic Macrophyte Oven Dry Weight (University of Idaho, Aquatic Ecology Lab, standard protocol)***

1. Record all taxon weights to 0.01 g
2. Record weight of a clean aluminum tare and tare number in Aquatic Macrophyte Biomass Notebook.
3. Place sorted aquatic macrophyte sample into spinner.
4. Spin each sorted sample for 45 seconds to remove excess water.
5. Remove aquatic macrophyte sample from spinner and put into an appropriate pre – weighed aluminum tare.
6. Weigh the tare & sample and record in the Wet Weight Column of data sheet.
7. Place tares into drying oven at 105° C for twenty – four hours.
8. After twenty – four hours, turn off oven. (Do not open oven while it is on, the opening of the oven will cause a draft and you may lose some of the samples.)
9. Remove tares and place in desiccator and allow to cool for one hour.
10. Weigh each sample to 0.01 and record in the Oven Dry Weight (ODW) Column of data sheet.

B.8. ***Aquatic Macrophyte Ash Free-Oven Dry Weight (University of Idaho, Aquatic Ecology Lab, standard protocol)***

1. Place weighed ODW samples into furnace for 6 hours at 550 °C.
2. Turn off oven.
3. Remove samples from oven and allow to cool.
4. Wet samples with dd ionized water to reconstitute sublimated carbonates.
5. Place in drying oven at 105° C for 24 hours.
6. Allow samples to cool in desiccator for ten minutes.
7. Record weight of sample under Ash Free Oven Dry Weight Column (AFODW) of data sheet.

B.9. ***Benthic Macroinvertebrate Sorting (University of Idaho, Aquatic Ecology Lab, standard protocol)***

1. Rinse sample of Ethyl alcohol + glycerin preservative with double de-ionized water in a No 20 Sieve (0.25 mm).
2. Excess alcohol should be collected in a glass bottle for proper wasted disposal.
3. Place rinsed organisms on a Pyrex watch glass.

B.10. ***Benthic Macroinvertebrate Identification (University of Idaho, Aquatic Ecology Lab, standard protocol)***

1. Using a dissecting scope, identify invertebrates to the lowest possible taxon according to Merritt and Cummins, <u>Aquatic Insects of North America</u>.
2. Do not count exuvia.
3. If organism is fragmented, only count the head parts.

4. Separate each taxonomic group and place in a correctly marked vial that contains sufficient amount of Ethyl alcohol + glycerin.
5. Record the number of organisms in each group on data sheet.
6. Place vials in finished box. Use a rubber band or masking tape to ensure that vials from one sampling location are kept together.
8. Return data sheet to Macroinvertebrate Project Notebook.

APPENDIX B:

SEDIMENT STABLE ISOTOPE ANALYSIS

BACKGROUND AND PURPOSE

Isotopes are atoms of the same element that differ in atomic mass (specifically, number of neutrons). Stable carbon ($^{13}C/^{12}C$) and nitrogen ($^{15}N/^{14}N$) isotope ratios have been used as indicators of paleoproductivity (Schelske and Hodell 1991; Schelske and Hodell 1995), primary production in lentic environments (Gu et al. 1996; Owen et al. 1999), fish migration (Kline et al. 1998), and food web relationships or food sources (Hesslein et al. 1991). Stable isotope ratios can be very useful in labeling biological material due to the natural isotope gradients that exist in nature (Kline et al. 1998).

Of particular interest is the use of stable isotope ratios to separate biological material from terrestrial and marine origins. Stable isotopes can be used to differentiate marine-derived nutrients from terrestrial nutrients because heavier isotopes (^{13}C and ^{15}N) are more common in marine environments. Winter et al. (2000) described the use of stable isotopes in assessing the effects of anadromous salmonids on the incorporation of marine-derived nutrients to rivers and streams. Nutrients from anadromous salmonids are marine-derived, allowing their contribution to be traced within the terrestrial environment. Many aquaculture operations in the middle Snake River utilize marine-derived nutrients in their food resources. As a result, heavier isotopes of carbon and nitrogen (marine-derived), transported to the river in aquaculture discharges, could provide a stable isotope ratio that is distinguishable from agricultural (terrestrially-derived) carbon and nitrogen.

Ratios of stable isotopes are often expressed relative to international standards (air for nitrogen and Peedee belemnite limestone (PDB) for carbon) and are reported in standard delta notation. For example, carbon stable isotope ratios are reported using the following expression:

$$\delta^{13}C = \left[\frac{{}^{13}C/{}^{12}C_{sample}}{{}^{13}C/{}^{12}C_{PDB}}\right] - 1 \times 1{,}000$$

Our purpose in using stable isotope ratios in the middle Snake River study was twofold. First, we wanted to determine whether distinct isotope signatures were evident between sediment organic matter sampled upstream and sediment organic matter sampled downstream of industry discharges (agriculture and aquaculture separately). Second, we wanted to determine whether distinct signatures were evident between sediment organic matter sampled downstream of aquaculture discharges and sediment organic matter sampled downstream of agriculture discharges. If distinguishable differences were found, stable isotopes might be used to assess the organic contribution of each industry to the middle Snake River.

METHODS

Sediment sampled upstream and downstream of six discharges to the middle Snake River (three agriculture, three aquaculture) in 2000 and 2001 were processed at the University of Idaho Stable Isotope Laboratory using an Elemental Analyzer online with a Delta Plus Isotope Ratio mass spectrometer. Only sediment containing greater than 0.04 % nitrogen could be processed due to laboratory equipment requirements. Processed data in raw form are shown in Tables 23 and 24 for 2000 and 2001, respectively.

First, deposition zone sediments below industry discharges were compared to control zone sediments of industry discharges (agriculture and aquaculture kept separate). Processed carbon isotope ratios ($\delta^{13}C$) of each sample were plotted against the respective nitrogen isotope ratios ($\delta^{15}N$) of each sample. Resulting relationships were analyzed for distinct signatures, or groups of plotted points based on zone of sampling (control vs. deposition).

Second, deposition zone sediments of agriculture discharges were compared to deposition zone sediments of aquaculture discharges by plotting processed carbon isotope ratios ($\delta^{13}C$) of each sample against their respective nitrogen isotope ratios ($\delta^{15}N$). Resulting relationships were analyzed for distinct signatures, or groups of plotted points, based on industry type (agriculture or aquaculture).

RESULTS & CONCLUSIONS

Distinct signatures, or distinct groups of plotted points, were not apparent when comparing control zone sediment to deposition zone sediment for either industry in 2000 (Figures 66 and 67) or 2001 (Figures 68 and 69). Distinct signatures, or groups of plotted points, were not apparent when comparing deposition zone sediment of agriculture discharges to deposition zone sediment of aquaculture discharges in 2000 or 2001 (Figures 70 and 71).

We conclude that carbon and nitrogen stable isotope ratios of middle Snake River sediment were similar upstream and downstream of the six discharges.

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Table 23. $\delta^{13}C$ and $\delta^{15}N$ stable isotope analysis of middle Snake River sediments, 2000.

Date	Site	Dredge #	Location	$d^{15}N_{AIR}$	%N	$d^{13}C_{PDB}$, ($^{17}O_{corrected}$)	%C
07/25/00	AD1	5	CON	6.23	0.139	-16.44	2.33
07/25/00	AD1	6	CON	5.85	0.121	-15.95	2.12
07/25/00	AD1	10	DEP	5.98	0.092	-14.88	1.84
07/25/00	AD1	12	DEP	5.83	0.075	-13.80	1.36
07/25/00	AD1	13	DEP	4.91	0.081	-14.03	1.44
07/25/00	AD1	14	DEP	4.44	0.091	-15.05	1.47
07/25/00	AD1	15	DEP	4.92	0.100	-15.30	1.54
07/25/00	AD1	16	DEP	4.18	0.103	-16.18	1.62
09/21/00	AD1	1	CON	5.77	0.069	-13.10	1.43
09/21/00	AD1	2	CON	5.77	0.103	-13.56	1.88
09/21/00	AD1	4	CON	6.50	0.078	-13.72	1.28
09/21/00	AD1	8	CON	4.49	0.067	-13.59	1.39
09/21/00	AD1	9	DEP	5.26	0.088	-13.98	1.56
10/26/00	AD1	2	CON	5.57	0.061	-14.61	1.28
10/26/00	AD1	6	CON	5.55	0.056	-12.74	1.29
07/26/00	AD2	2	CON	5.95	0.075	-12.38	1.67
07/26/00	AD2	3	CON	5.98	0.082	-12.98	1.61
07/26/00	AD2	5	CON	5.91	0.095	-14.18	1.73
07/26/00	AD2	6	CON	6.14	0.102	-15.58	1.74
07/26/00	AD2	13	DEP	4.15	0.063	-13.27	1.45
07/26/00	AD2	16	DEP	4.91	0.066	-13.20	1.55
09/22/00	AD2	1	CON	6.23	0.061	-11.43	1.30
09/22/00	AD2	3	CON	5.29	0.084	-11.93	1.62
09/22/00	AD2	5	CON	6.06	0.074	-11.86	1.45
09/22/00	AD2	6	CON	5.83	0.069	-11.59	1.47
09/22/00	AD2	10	DEP	6.25	0.062	-12.05	1.46
10/26/00	AD2	4	CON	6.27	0.133	-14.67	2.28
10/26/00	AD2	5	CON	6.19	0.110	-13.42	1.93
07/27/00	AD3	2	CON	5.73	0.094	-15.84	1.80
07/27/00	AD3	3	CON	5.80	0.076	-14.27	1.42
07/27/00	AD3	5	CON	5.14	0.070	-14.51	1.36
07/27/00	AD3	7	CON	5.57	0.084	-16.13	1.62
07/27/00	AD3	11	DEP	4.41	0.064	-15.95	1.19
07/27/00	AD3	14	DEP	5.39	0.059	-10.51	1.34
09/21/00	AD3	2	CON	5.32	0.100	-14.06	2.29
09/21/00	AD3	4	CON	5.61	0.071	-14.82	1.40
09/21/00	AD3	7	CON	5.92	0.066	-14.26	1.24
10/26/00	AD3	1	CON	5.86	0.138	-15.10	2.12
10/26/00	AD3	2	CON	5.85	0.088	-15.19	1.57
10/26/00	AD3	3	CON	5.65	0.064	-14.88	1.21
10/26/00	AD3	4	CON	5.16	0.076	-15.08	1.46
10/26/00	AD3	7	CON	6.16	0.066	-12.07	1.38
07/23/00	BC	3	CON	6.10	0.144	-15.28	2.40
07/23/00	BC	4	CON	5.81	0.134	-15.27	2.19
07/23/00	BC	5	CON	5.87	0.164	-15.57	2.47
07/23/00	BC	6	CON	5.02	0.137	-15.65	2.32
07/23/00	BC	7	CON	5.02	0.138	-15.69	2.39
07/23/00	BC	8	DEP	6.37	0.142	-16.52	2.33

Table 23 (continued). $\delta^{13}C$ and $\delta^{15}N$ stable isotope analysis of middle Snake River sediment, 2000.

Date	Site	Dredge #	Location	$d^{15}N_{AIR}$	%N	$d^{13}C_{PDB}$, (^{17}O corrected)	%C
07/23/00	BC	10	DEP	5.02	0.273	-17.44	3.34
07/23/00	BC	11	DEP	5.39	0.128	-15.01	1.91
07/23/00	BC	12	DEP	3.63	0.047	-11.79	0.73
07/23/00	BC	13	DEP	4.70	0.067	-13.29	0.89
07/23/00	BC	14	DEP	6.29	0.177	-15.95	2.37
09/21/00	BC	1	CON	5.37	0.094	-13.10	1.95
09/21/00	BC	2	CON	6.23	0.107	-15.36	1.73
09/21/00	BC	3	CON	5.84	0.113	-13.98	2.24
09/21/00	BC	4	CON	5.98	0.170	-15.99	2.61
09/21/00	BC	5	CON	4.86	0.139	-14.99	2.42
09/21/00	BC	6	CON	5.61	0.104	-14.57	1.86
09/21/00	BC	9	DEP	4.04	0.130	-15.17	1.51
09/21/00	BC	10	DEP	5.46	0.072	-12.52	0.95
10/26/00	BC	1	CON	5.56	0.103	-12.77	2.01
10/26/00	BC	2	CON	6.39	0.118	-14.85	1.93
10/26/00	BC	3	CON	6.28	0.131	-15.81	2.03
10/26/00	BC	4	CON	5.87	0.144	-15.87	2.25
10/26/00	BC	5	CON	6.02	0.162	-16.05	2.48
10/26/00	BC	6	CON	5.99	0.243	-16.56	3.12
10/26/00	BC	7	CON	5.47	0.183	-15.93	2.36
10/26/00	BC	9	DEP	3.11	0.133	-15.41	1.45
10/26/00	BC	10	DEP	5.33	0.142	-16.46	1.73
07/24/00	CS	1	CON	5.86	0.083	-14.13	1.40
07/24/00	CS	10	DEP	6.20	0.000	-11.15	1.11
07/24/00	CS	13	DEP	4.47	0.075	-13.14	1.37
07/24/00	CS	14	DEP	4.46	0.052	-13.12	0.76
09/20/00	CS	1	CON	5.42	0.060	-13.46	1.10
09/20/00	CS	2	CON	6.04	0.051	-13.18	0.83
09/20/00	CS	6	CON	6.17	0.092	-14.85	1.25
09/20/00	CS	7	CON	5.52	0.040	-9.27	0.87
09/20/00	CS	10	DEP	5.50	0.058	-13.87	0.74
10/26/00	CS	3	CON	6.38	0.065	-13.29	1.21
10/26/00	CS	6	CON	6.05	0.099	-16.51	1.48
07/28/00	RV	2	CON	5.04	0.075	-13.18	1.47
07/28/00	RV	3	CON	5.02	0.055	-11.92	1.14
07/28/00	RV	10	DEP	4.01	0.232	-17.50	3.11
07/28/00	RV	11	DEP	5.21	0.200	-16.67	2.41
07/28/00	RV	12	DEP	5.27	0.164	-14.60	2.19
07/28/00	RV	13	DEP	4.81	0.136	-16.81	2.14
07/28/00	RV	14	DEP	4.51	0.170	-13.94	2.91
07/28/00	RV	15	DEP	6.12	0.088	-13.61	1.30
07/28/00	RV	16	DEP	4.49	0.127	-14.98	1.95

Table 23 (continued). $\delta^{13}C$ and $\delta^{15}N$ stable isotope analysis of middle Snake River sediment, 2000.

Date	Site	Dredge #	Location	$d^{15}N_{AIR}$	%N	$d^{13}C_{PDB}$, ($^{17}O_{corrected}$)	%C
09/21/00	RV	1	CON	5.81	0.113	-13.96	1.97
09/21/00	RV	2	CON	5.99	0.123	-13.97	1.98
09/21/00	RV	3	CON	5.15	0.055	-10.56	1.09
09/21/00	RV	4	CON	4.49	0.031	-8.37	0.77
09/21/00	RV	6	CON	4.15	0.130	-15.49	1.99
09/21/00	RV	7	CON	4.77	0.235	-17.82	3.38
09/21/00	RV	8	CON	4.76	0.202	-15.18	2.82
09/21/00	RV	9	DEP	4.28	0.188	-15.86	2.58
09/21/00	RV	10	DEP	5.23	0.068	-11.59	1.01
10/26/00	RV	1	CON	6.29	0.245	-15.87	3.84
10/26/00	RV	3	CON	6.14	0.262	-15.64	3.71
10/26/00	RV	4	CON	4.68	0.143	-14.80	2.48
10/26/00	RV	5	CON	5.67	0.098	-12.75	1.90
10/26/00	RV	6	CON	5.41	0.212	-16.45	3.08
10/26/00	RV	7	CON	4.85	0.166	-15.20	2.58
10/26/00	RV	8	CON	5.11	0.267	-16.62	3.49
10/26/00	RV	9	DEP	4.81	0.138	-14.00	2.42

Table 24. $\delta^{13}C$ and $\delta^{15}N$ stable isotope analysis of middle Snake River sediment, 2001.

Date	Site	Dredge #	Location	$d^{15}N_{AIR}$	%N	$d^{13}C_{PDB}$, (^{17}O corrected)	%C
06/11/01	AD1	3	DEP	5.65	0.057	-11.97	1.31
06/11/01	AD1	4	DEP	5.67	0.074	-13.59	1.53
06/11/01	AD1	6	DEP	4.67	0.059	-13.14	1.24
06/11/01	AD1	7	DEP	5.13	0.079	-14.05	1.45
06/11/01	AD1	8	DEP	3.89	0.056	-11.32	1.09
06/11/01	AD1	12	CON	4.69	0.048	-12.76	1.02
06/30/01	AD1	1	DEP	5.60	0.048	-12.40	1.09
06/30/01	AD1	2	DEP	5.63	0.081	-14.09	1.58
06/30/01	AD1	3	DEP	5.82	0.053	-12.48	1.12
06/11/01	AD2	6	DEP	4.66	0.050	-11.14	1.16
06/12/01	AD2	9	DEP	5.48	0.116	-13.75	1.88
06/12/01	AD2	10	CON	6.20	0.131	-15.01	2.08
06/12/01	AD2	11	CON	5.89	0.151	-14.61	2.46
06/12/01	AD2	12	CON	5.32	0.079	-13.72	1.38
07/02/01	AD2	11	CON	5.90	0.096	-13.46	1.75
07/02/01	AD2	12	CON	5.87	0.068	-12.61	1.34
06/12/01	AD3	1	DEP	5.34	0.055	-15.17	1.18
06/13/01	AD3	3	DEP	5.54	0.077	-13.63	1.51
06/13/01	AD3	4	DEP	5.82	0.134	-15.58	2.35
06/13/01	AD3	8	DEP	4.93	0.036	-11.77	0.65
06/13/01	AD3	10	CON	5.63	0.126	-15.92	2.18
06/13/01	AD3	11	CON	5.84	0.125	-15.53	2.03
06/13/01	AD3	12	CON	5.59	0.124	-15.18	1.99
07/03/01	AD3	1	DEP	6.01	0.131	-16.94	2.46
07/03/01	AD3	4	DEP	5.76	0.060	-13.32	1.26
08/24/01	AD3	9	CON	5.51	0.105	-15.04	1.82
08/24/01	AD3	11	CON	5.31	0.109	-15.12	1.92
09/15/01	AD3	3	DEP	5.22	0.206	-15.30	2.90
06/06/01	BC	1	DEP	4.18	0.106	-15.58	1.22
06/06/01	BC	2	DEP	4.75	0.186	-16.15	2.24
06/06/01	BC	3	DEP	4.69	0.131	-16.04	1.56
06/06/01	BC	4	DEP	5.02	0.153	-16.73	1.83
06/06/01	BC	6	DEP	3.38	0.075	-14.30	0.84
06/07/01	BC	7	DEP	4.63	0.123	-15.51	1.35
06/07/01	BC	8	DEP	4.93	0.080	-13.81	0.92
06/07/01	BC	10	CON	5.95	0.159	-15.47	2.50
06/07/01	BC	11	CON	5.58	0.217	-16.38	2.92
06/07/01	BC	12	CON	6.34	0.215	-16.04	3.25

Table 24 (continued). $\delta^{13}C$ and $\delta^{15}N$ stable isotope analysis of middle Snake River sediment, 2001.

Date	Site	Dredge #	Location	$d^{15}N_{AIR}$	%N	$d^{13}C_{PDB}$, (^{17}O corrected)	%C
06/28/01	BC	1	DEP	4.39	0.121	-15.36	1.37
06/28/01	BC	2	DEP	4.72	0.137	-16.79	1.80
06/28/01	BC	3	DEP	4.00	0.154	-15.62	1.73
06/28/01	BC	4	DEP	4.69	0.169	-15.80	1.91
06/28/01	BC	5	DEP	4.93	0.119	-16.36	1.42
06/28/01	BC	6	DEP	4.91	0.075	-16.60	0.89
06/28/01	BC	7	DEP	4.69	0.102	-15.99	1.25
06/28/01	BC	8	DEP	5.06	0.160	-16.13	1.74
06/28/01	BC	11	CON	7.55	0.189	-19.06	2.98
06/28/01	BC	12	CON	6.33	0.127	-16.80	2.07
08/20/01	BC	1	DEP	5.06	0.155	-17.37	1.58
09/09/01	BC	4	DEP	5.15	0.228	-16.84	2.73
09/09/01	BC	8	DEP	4.65	0.083	-13.37	0.97
09/09/01	BC	9	CON	5.05	0.085	-15.22	0.93
09/09/01	BC	10	CON	5.10	0.135	-15.44	2.02
09/09/01	BC	11	CON	6.15	0.108	-15.29	1.81
09/09/01	BC	12	CON	5.96	0.128	-14.09	2.17
10/08/01	BC	2	DEP	5.59	0.174	-15.26	2.12
06/10/01	CS	1	DEP	5.82	0.117	-13.28	2.03
06/10/01	CS	2	DEP	5.78	0.092	-13.22	1.66
06/10/01	CS	3	DEP	5.28	0.134	-15.96	2.34
06/10/01	CS	4	DEP	5.52	0.143	-15.13	2.43
06/10/01	CS	6	DEP	5.47	0.261	-17.10	3.34
06/10/01	CS	8	DEP	5.38	0.215	-17.34	2.82
06/10/01	CS	12	CON	5.63	0.063	-14.22	1.27
07/01/01	CS	2	DEP	5.35	0.066	-14.01	1.12
07/01/01	CS	5	DEP	5.55	0.152	-15.39	2.11
07/01/01	CS	7	DEP	5.77	0.118	-15.00	1.78
07/01/01	CS	11	CON	5.93	0.031	-9.41	0.77
07/01/01	CS	12	CON	5.00	0.036	-10.00	0.77
08/21/01	CS	6	DEP	5.19	0.225	-16.57	3.01
08/21/01	CS	7	DEP	5.54	0.202	-15.91	2.94
08/21/01	CS	8	DEP	4.63	0.146	-14.75	1.99
09/12/01	CS	1	DEP	5.82	0.063	-14.03	1.20
09/12/01	CS	4	DEP	5.55	0.078	-13.87	1.37
09/12/01	CS	5	DEP	5.35	0.168	-15.84	2.35
09/12/01	CS	7	DEP	5.18	0.199	-17.81	2.79
09/12/01	CS	8	DEP	5.62	0.192	-16.97	2.64
10/10/01	CS	7	DEP	5.75	0.064	-12.60	1.19

Table 24 (continued). $\delta^{13}C$ and $\delta^{15}N$ stable isotope analysis of middle Snake River sediment, 2001.

Date	Site	Dredge #	Location	$d^{15}N_{AIR}$	%N	$d^{13}C_{PDB}$, ($^{17}O_{corrected}$)	%C
06/07/01	RV	2	DEP	4.98	0.219	-17.80	3.46
06/08/01	RV	4	DEP	3.93	0.205	-16.42	3.13
06/09/01	RV	6	DEP	4.59	0.231	-16.53	3.10
06/09/01	RV	7	DEP	5.17	0.176	-16.15	2.27
06/09/01	RV	8	DEP	5.38	0.202	-16.63	2.56
06/09/01	RV	10	CON	6.39	0.087	-13.08	1.85
06/09/01	RV	12	CON	4.71	0.044	-11.83	0.92
06/29/01	RV	1	DEP	4.91	0.104	-13.43	2.17
06/29/01	RV	2	DEP	5.24	0.171	-17.09	2.59
06/29/01	RV	3	DEP	5.19	0.193	-15.38	2.88
06/29/01	RV	4	DEP	6.36	0.097	-13.68	1.69
06/29/01	RV	7	DEP	5.32	0.179	-16.03	2.78
06/29/01	RV	8	DEP	4.52	0.121	-14.03	1.93
06/29/01	RV	10	CON	5.96	0.054	-10.74	1.46
06/29/01	RV	12	CON	6.05	0.071	-11.68	1.64
08/19/01	RV	2	DEP	5.52	0.150	-14.39	2.48
08/19/01	RV	3	DEP	5.14	0.089	-13.12	1.47
08/19/01	RV	5	DEP	5.25	0.134	-14.90	2.05
08/19/01	RV	6	DEP	4.17	0.187	-16.13	2.44
08/19/01	RV	7	DEP	5.59	0.247	-17.87	3.03
08/19/01	RV	8	DEP	5.44	0.140	-16.12	1.84
09/11/01	RV	1	DEP	5.72	0.186	-15.63	3.01
09/11/01	RV	2	DEP	5.63	0.132	-14.27	2.25
09/11/01	RV	3	DEP	5.66	0.115	-14.34	1.96
09/11/01	RV	4	DEP	4.68	0.133	-14.14	2.28
09/11/01	RV	6	DEP	5.27	0.070	-12.85	1.27
09/11/01	RV	7	DEP	5.44	0.100	-14.89	1.75
09/11/01	RV	8	DEP	5.18	0.098	-14.60	1.56
09/11/01	RV	9	CON	6.09	0.155	-14.62	2.10
09/11/01	RV	10	CON	5.81	0.098	-12.44	1.89
09/11/01	RV	12	CON	6.28	0.132	-14.72	2.31
10/09/01	RV	1	DEP	5.47	0.121	-15.35	2.21

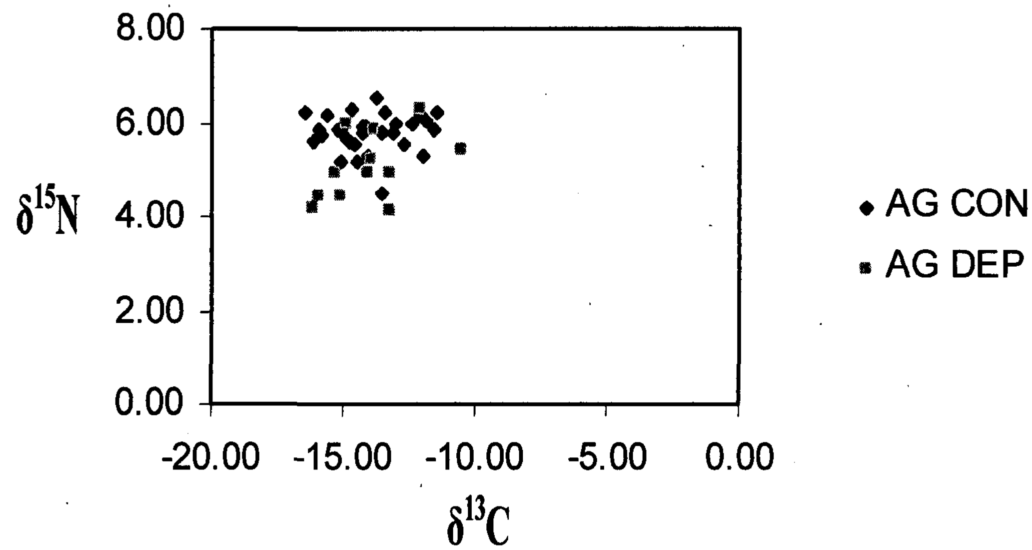

Figure 66. Comparison of the stable isotope ratios ($\delta^{13}C$ and $\delta^{15}N$) between sediments sampled upstream of agriculture discharges (AG CON) and sediments sampled downstream of agriculture discharges (AG DEP) in the middle Snake River, 2000.

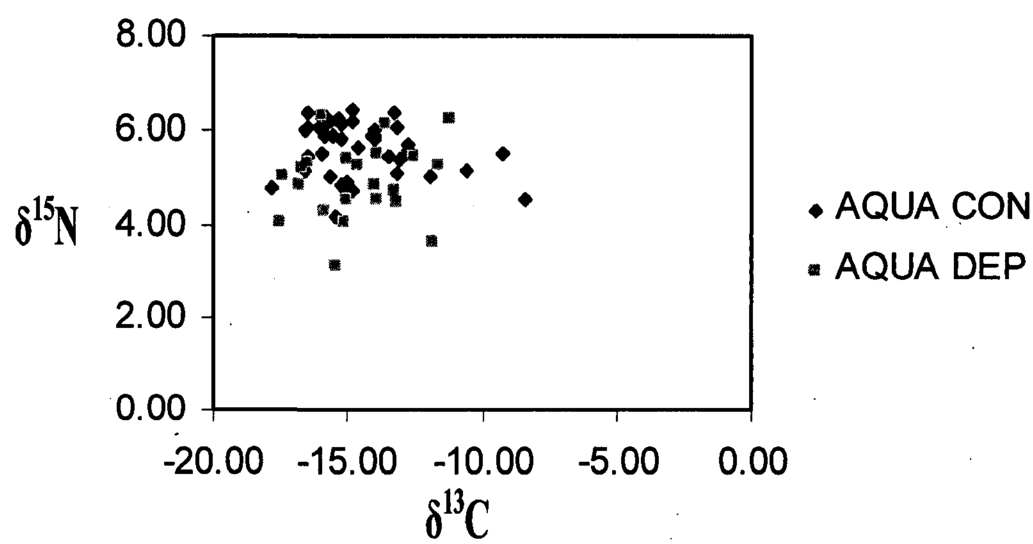

Figure 67. Comparison of the stable isotope ratios ($\delta^{13}C$ and $\delta^{15}N$) between sediments sampled upstream of aquaculture discharges (AQUA CON) and sediments sampled downstream of aquaculture discharges (AQUA DEP) in the middle Snake River, 2000.

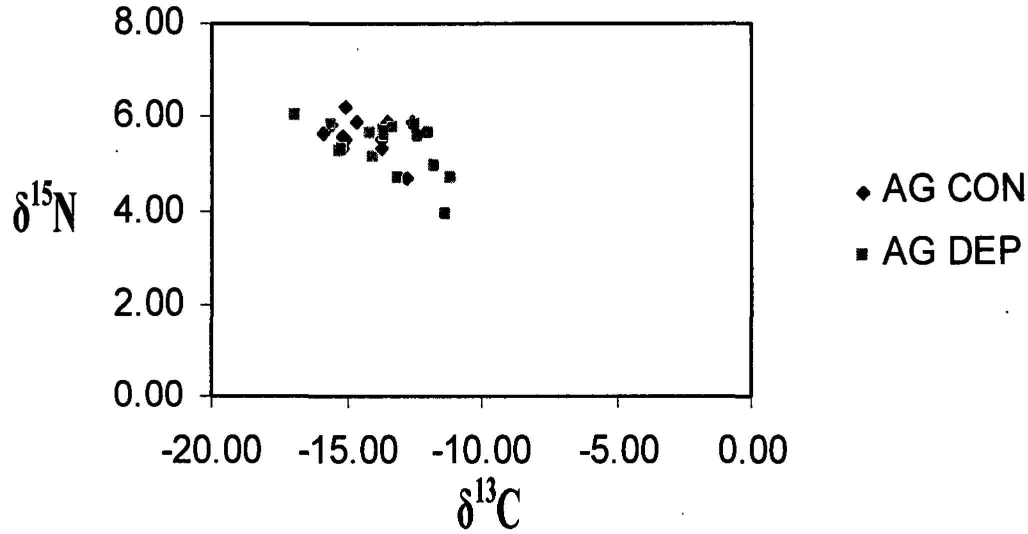

Figure 68. Comparison of the stable isotope ratios ($\delta^{13}C$ and $\delta^{15}N$) between sediments sampled upstream of agriculture discharges (AG CON) and sediments sampled downstream of agriculture discharges (AG DEP) in the middle Snake River, 2001.

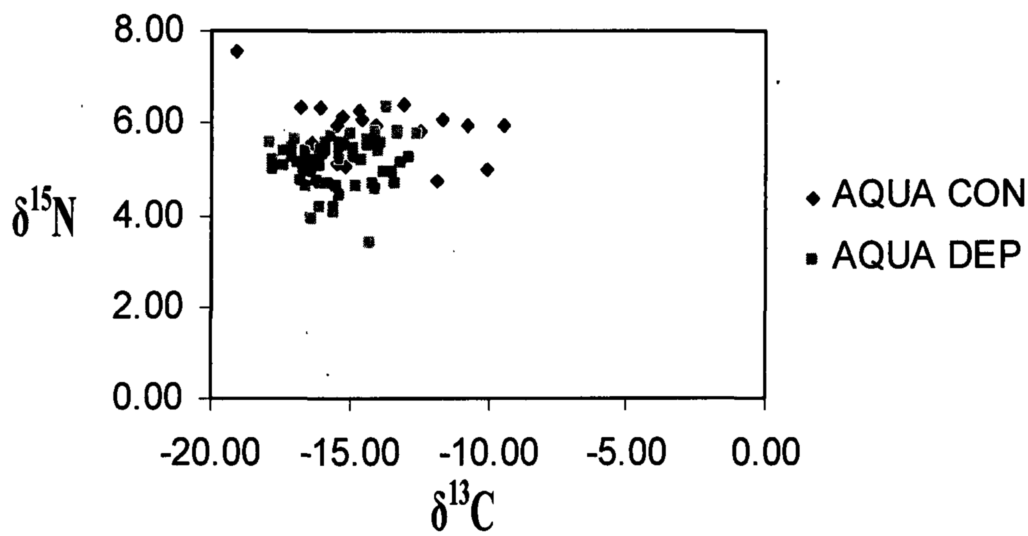

Figure 69. Comparison of the stable isotope ratios ($\delta^{13}C$ and $\delta^{15}N$) between sediments sampled upstream of aquaculture discharges (AQUA CON) and sediments sampled downstream of aquaculture discharges (AQUA DEP) in the middle Snake River, 2001.

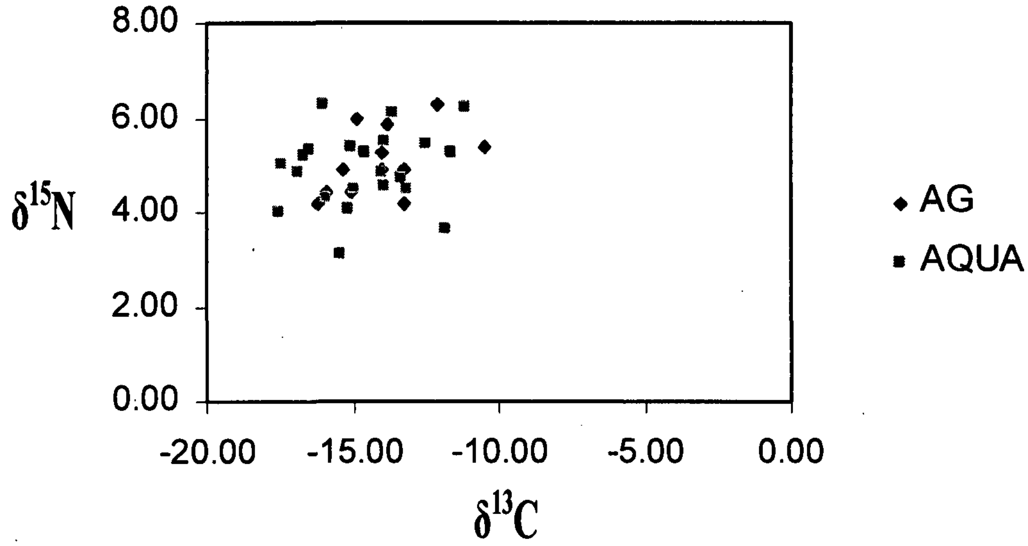

Figure 70. Comparison of the stable isotope ratios ($\delta^{13}C$ and $\delta^{15}N$) between sediments sampled downstream of agriculture discharges (AG) and sediments sampled downstream of aquaculture discharges (AQUA) in the middle Snake River, 2000.

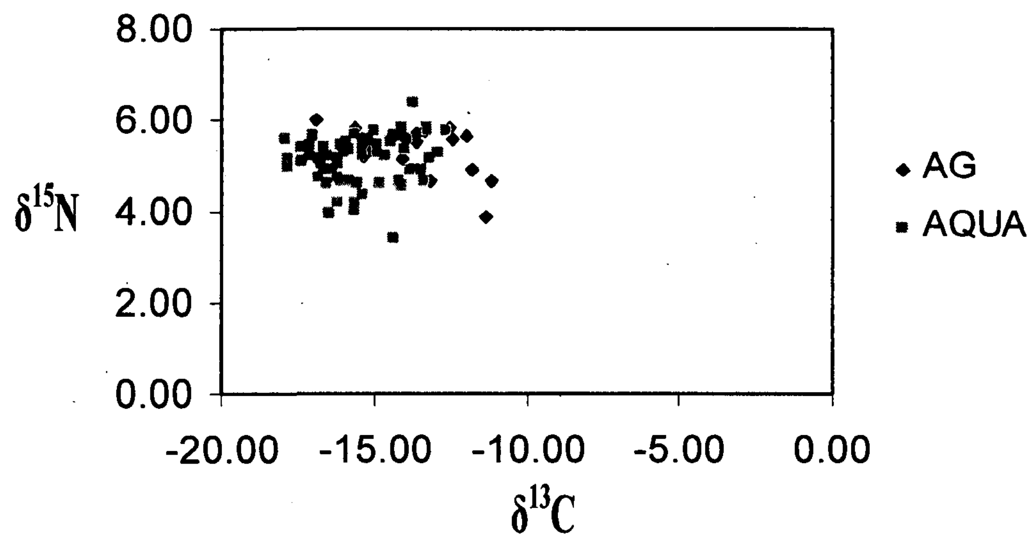

Figure 71. Comparison of the stable isotope ratios ($\delta^{13}C$ and $\delta^{15}N$) between sediments sampled downstream of agriculture discharges (AG) and sediments sampled downstream of aquaculture discharges (AQUA) in the middle Snake River, 2001.

APPENDIX C:

DESCRIPTION OF RESULTS FOR SEDIMENT, BENTHIC MACROINVERTEBRATE, AND AQUATIC MACROPHYTE METRICS

SEDIMENT

Particle Size

% Sand

Control zone sand content between pooled agriculture and pooled aquaculture sites was statistically similar within each sampling month but October. Therefore, deposition zone sand content of agriculture and aquaculture sites could only be compared within June, July, August, and September. These comparisons showed that sand content was greater in agriculture deposition zones than aquaculture deposition zones in June, July, August, and September (Figure 7). However, statistically significant differences between the sand content of agriculture deposition zones and aquaculture deposition zones only occurred in September (77.2 % at agriculture sites and 66.6 % at aquaculture sites).

Sands dominated the bottom sediments both upstream and downstream of the discharges at all six study sites and over all five sampling months of 2001, averaging 43-95 % of the total dredged sediments (Figure 8). Sand content in the deposition zones of the three agriculture drains showed little change over all five sampling months, averaging 81, 88, and 65 % for AD3, AD2, and AD1, respectively. Sand content was generally lower in the deposition zones of the three aquaculture discharges, averaging 69, 66, and 80 % for CS, RV, and BC, respectively, than the deposition zones of the agriculture drains (averages shown above).

A trend in sand content over all agriculture study sites was not evident throughout the study period. Sand content was significantly greater in the deposition zone of AD2 than in the control zone in all months but October. At AD1 sand content was significantly greater in the control zone than the deposition zone in all five sampling months. Similarly, an overall trend in sand content at aquaculture sites was not evident. While CS and RV both had significantly greater sand content in control zones than deposition zones for four of the five sampling months, BC had significantly greater sand content in deposition zones for four of five months.

% Silt

Control zone silt content between pooled agriculture and pooled aquaculture sites was statistically similar within each sampling month but October. Therefore, deposition zone silt content of agriculture and aquaculture sites could only be compared within June, July, August, and September. These comparisons showed that silt content was greater in aquaculture deposition zones than agriculture deposition zones in June, July, August, and September (Figure 9). However, statistically significant differences between the silt content of agriculture deposition zones and aquaculture deposition zones only occurred in June (20.7 % at agriculture sites and 27.7 % at aquaculture sites) and September (21.0 % and 30.9 % at aquaculture sites).

Silts were the next dominant particle size of middle Snake River in 2001, averaging 4-48 % of the total dredged sediment (Figure 10). Silt content of the deposition zone sediments within each of the three agriculture study sites was very similar over all five sampling months, averaging 17, 11, and 33 % for AD3, AD2, and AD1, respectively. Silt content of the deposition sediments within each of the three aquaculture study sites was also consistent throughout all sampling months, averaging 30, 31, and 17 % for CS, RV, and BC, respectively. Like the sand content results, there were not distinct similarities in silt content for the three agriculture study sites or for the three aquaculture study sites. AD1 had significantly greater silt content in deposition zones than control zones for all months while AD2 had significantly greater silt content in control zones than deposition zones for four of five months.

% Clay

Control zone clay content between pooled agriculture and pooled aquaculture sites was not statistically different within each of the five sampling months. Therefore, deposition zone clay content of agriculture and aquaculture sites could be compared within the five sampling months. These comparisons showed that clay content was significantly greater in aquaculture deposition zones than agriculture deposition zones in both July (1.7 % at agriculture sites and 2.4 % at aquaculture sites) and October (1.5 % at agriculture sites and 2.2 % at aquaculture sites) (Figure 11).

Clays were the least dominant sediment type sampled in the middle Snake River in 2001, averaging 0.5-5.0 % of the total dredged sediment (Figure 12). Clay content of AD3, AD2, and AD1 deposition zones averaged 2.0, 0.9, and 2.4 %, respectively compared to clay content of CS, RV, and BC deposition zones of 1.5, 2.6, and 2.0 %, respectively. Clay content in the AD2 control zone was significantly greater than clay content in the AD2 deposition zone for four of five months. AD2 was the only agriculture site where significant trends in clay content were consistently apparent. CS and RV had significantly greater clay content in deposition zones than control zones in two of five months, whereas BC had significantly greater clay content in the control zone than the deposition zone in four of five months.

Percent Carbon and Nitrogen

% Carbon

Control zone carbon content between pooled agriculture and pooled aquaculture sites was statistically similar within June alone. Therefore, control vs. deposition carbon content of agriculture and aquaculture sites could only be compared within this single month. This comparison showed that carbon content was significantly greater in aquaculture deposition zones than agriculture deposition zones in June (1.2 % at agriculture sites and 2.3 % at aquaculture sites) (Figure 13).

Sediment sampled from the six study sites in the middle Snake River averaged 0.7-3.1 % carbon throughout the five sampling months in 2001 (Figure 14). AD1 was the only agriculture study site that showed significant trends in carbon content of the sediment. Sediment sampled from the AD1 deposition zone had significantly greater carbon content than the AD1 control zone for all five months sampled. Sediment carbon in the deposition zone was significantly greater than sediment carbon in the control zone in four of five months at CS and in three of five months at RV. On the other hand, sediment carbon in the control zone was significantly greater than sediment carbon in the deposition zone in three of five months at BC.

% Nitrogen

Control zone nitrogen content between pooled agriculture and pooled aquaculture sites was statistically similar within June and August. Therefore, deposition zone nitrogen content of agriculture and aquaculture sites could only be compared within these two months. These comparisons showed that nitrogen content was significantly greater in aquaculture deposition zones than agriculture deposition zones in both June (0.05 % at agriculture sites and 0.17 % at aquaculture sites) and August (0.01 % at agriculture sites and 0.06 % at aquaculture sites) (Figure 15).

Nitrogen content of middle Snake River sediment at the six study sites in 2001 averaged 0.01-0.25 % throughout the five sampling months (Figure 16). The overall trend for all sites indicated that nitrogen content of the river sediment was highest in June and gradually decreased to annual lows in October. AD1 was the only agriculture site that showed a significantly greater amount of nitrogen in the deposition zone sediments than in the control zone sediments. Even then, this significant trend was only apparent from the June and July AD1 samples. On the other hand, sediment sampled from the control zone had a significantly greater amount of nitrogen than deposition zone sediment in two of five sampling months from both AD2 and AD3. Significantly greater amounts of sediment nitrogen were found in aquaculture deposition zones for two of three sites. CS and RV each had significantly greater sediment nitrogen in deposition zone dredges for three of five sampling months. However, BC showed a significantly greater amount of sediment nitrogen in the control zone for June and no significant differences in sediment nitrogen between control and deposition zones for the remaining four months.

Chemical Trace Elements

Calcium

Control zone calcium content between pooled agriculture and pooled aquaculture sites was statistically similar within June, July, and September. Therefore, deposition zone calcium content of agriculture and aquaculture sites could only be compared within June, July, and September. These comparisons showed that calcium content was significantly greater in aquaculture deposition zones than agriculture deposition zones for June (24,708 $\mu g \cdot g^{-1}$ at agriculture sites and 35,375 $\mu g \cdot g^{-1}$ at aquaculture sites), July (25,708 $\mu g \cdot g^{-1}$ at agriculture sites and 33,783 $\mu g \cdot g^{-1}$ at aquaculture sites), and September (24,750 $\mu g \cdot g^{-1}$ at agriculture sites and 35,000 $\mu g \cdot g^{-1}$ at aquaculture sites) (Figure 17).

Calcium content of the bottom sediments in the six study sites of the middle Snake River in 2001 averaged 13,250-45,875 $\mu g \cdot g^{-1}$ throughout the five sampling months (Figure 18). There were no consistent trends between the three agriculture sites. However within the agriculture sites, trends were apparent. At AD3, sediment calcium content was significantly greater in the control zone than the deposition zone for the first three of the five sampling months. Calcium content was significantly greater in the AD2 control zone than the AD2 deposition zone in June and July but was significantly greater in the deposition zone in August and October. The deposition zone of AD1 had significantly greater calcium content than the control zone of AD1 for all five sampling months. Sediment calcium content trends differed for each of the three aquaculture sites as well. Calcium content was significantly greater in CS deposition zone than CS control zone for all sampling months but August. Calcium content was significantly greater in the RV deposition zone than the RV control zone for June and July but then reversed to greater calcium content in the control zone in October. Calcium content was significantly greater in the BC control zone than the BC deposition zone for all sampling months but September.

Magnesium

Control zone magnesium content between pooled agriculture and pooled aquaculture sites was statistically similar within each sampling month but July. Therefore, deposition zone magnesium content of agriculture and aquaculture sites could be compared within June, August, September, and October. These comparisons showed that magnesium content was significantly greater in aquaculture deposition zones than agriculture deposition zones in September alone (5,096 $\mu g \cdot g^{-1}$ at agriculture sites and 6,188 $\mu g \cdot g^{-1}$ at aquaculture sites) (Figure 19).

Magnesium content of the six study sites in the middle Snake River from 2001 averaged 2625-16500 $\mu g \cdot g^{-1}$ throughout the five study months (Figure 20). The highest magnesium contents were found in the control zone of AD3 in July (16500 $\mu g \cdot g^{-1}$) and September (13500 $\mu g \cdot g^{-1}$). The AD3 control zone had significantly greater amounts of magnesium than the AD3 deposition zone in all five sampling months. AD2 showed the same magnesium content trend for June and July but then switched to a significantly greater amount of magnesium in the deposition zone than the control zone for August and October. AD1 had a significantly greater amount of magnesium in the deposition zone than the control zone for all five sampling months. Magnesium content was significantly greater in CS deposition zone than CS control zone for all sampling months but August. Magnesium content was significantly greater in the RV deposition zone than the RV control zone in June but then reversed to greater magnesium content in the control zone in September and October. Magnesium content was significantly greater in the BC control zone than the BC deposition zone for June and October.

Potassium

Control zone potassium content between pooled agriculture and pooled aquaculture sites was statistically similar within each sampling month but July. Therefore, deposition zone potassium content of agriculture and aquaculture sites could be compared within June, August, September, and October. These comparisons showed that potassium content was significantly greater in aquaculture deposition zones than agriculture deposition zones in September alone (2,254 $\mu g \cdot g^{-1}$ at agriculture sites and 2,738 $\mu g \cdot g^{-1}$ at aquaculture sites) (Figure 21).

Potassium content of dredged middle Snake River sediment at the six sampling sites in 2001 averaged 1053-3775 $\mu g \cdot g^{-1}$ throughout the five sampling months (Figure 22). The AD3 control zone had significantly greater amounts of potassium than the AD3 deposition zone in June, July, and August. AD2 showed the same potassium content trend for June, July, and September but then switched to a significantly greater amount of potassium in the deposition zone than the control zone for October. AD1 had a significantly greater amount of potassium in the deposition zone than the control zone for all five sampling months. Potassium content was significantly greater in CS deposition zone than CS control zone for all sampling months but August. Potassium content was significantly greater in the RV deposition zone than the RV control zone in June, August, and October. The opposite trend occurred at BC, with significantly greater potassium content in the BC control zone than the BC deposition zone for June, August, and October.

Sodium

Control zone sodium content between pooled agriculture and pooled aquaculture sites was statistically similar within June and October. Therefore, deposition zone sodium content of agriculture and aquaculture sites could only be compared within June and October. These comparisons showed that sodium content was greater in aquaculture deposition zones than agriculture deposition zones for both June (439.2 $\mu g \cdot g^{-1}$ at agriculture sites and 465 $\mu g \cdot g^{-1}$ at aquaculture sites) and October (481.4 $\mu g \cdot g^{-1}$ at agriculture sites and 507.1 $\mu g \cdot g^{-1}$ at aquaculture sites) (Figure 23). However, this difference was not significant in either month.

Sodium content of the dredged middle Snake River sediment was fairly stable (i.e. didn't change over time) over all study sites throughout the five month sampling period, averaging 318-790$\mu g \cdot g^{-1}$ (Figure 24). However, extremely high sodium content was observed in July (2875 $\mu g \cdot g^{-1}$) and September (2825 $\mu g \cdot g^{-1}$) in the AD3 control zone. These values cannot be excluded as processing errors because all four replicates shared high values. The sodium content in the AD3 control zone was significantly greater than the AD3 deposition zone for all months but October. Results from AD2 showed this same trend in July but was reversed in August, with the deposition zone sediments having significantly greater sodium content than the control zone sediments. AD1 had significantly greater sodium content in the deposition zone than the control zone in July but had significantly greater sodium content in the control zone than the deposition zone in August. The only consistent trends in sodium content from aquaculture sites were at CS.

This study site had significantly higher sodium content in the deposition zone than the control zone for all sampling months but August.

Zinc

Control zone zinc content between pooled agriculture and pooled aquaculture sites was statistically similar within each sampling month but July. Therefore, deposition zone zinc content of agriculture and aquaculture sites could be compared within June, August, September, and October. These comparisons showed that zinc content was significantly greater in aquaculture deposition zones than agriculture deposition zones in June (39.0 $\mu g \cdot g^{-1}$ at agriculture sites and 59.4 $\mu g \cdot g^{-1}$ at aquaculture sites), August (42.2 $\mu g \cdot g^{-1}$ at agriculture sites and 58.6 $\mu g \cdot g^{-1}$ at aquaculture sites), September (44.4 $\mu g \cdot g^{-1}$ at agriculture sites and 66.7 $\mu g \cdot g^{-1}$ at aquaculture sites), and October (44.8 $\mu g \cdot g^{-1}$ at agriculture sites and 57.0 $\mu g \cdot g^{-1}$ at aquaculture sites) (Figure 25).

Mean zinc content of dredged material from the middle Snake River in 2001 ranged from 29-76 $\mu g \cdot g^{-1}$ throughout the five sampling months (Figure 26). Zinc content was significantly greater in the AD3 control zone than the AD3 deposition zone for all sampling months but October. AD2 sediment followed the same trend through June and July but then had no significant differences in sediment zinc content between control and deposition zones for August, September, and October. AD1 had greater zinc content in the deposition zone than the control zone for all sampling months, but this difference was significant in only June and September. At all aquaculture study sites deposition zone zinc content was significantly greater than control zone zinc content for at least one sampling month (Figure 26). RV sediment had significantly greater zinc content in June, July, and August, CS in June and July, and BC in July only.

Manganese

Control zone manganese content between pooled agriculture and pooled aquaculture sites was statistically similar within each sampling month but July and October. Therefore, deposition zone manganese content between agriculture and aquaculture sites could be compared within June, August, and September. These comparisons showed that there were no significant differences in manganese content between agriculture deposition zones and aquaculture deposition zones in June, August, or September (Figure 27).

Manganese content in dredged sediment of the six study sites in the middle Snake River in 2001 averaged 113-485 $\mu g \cdot g^{-1}$ throughout the five months (Figure 28). The highest manganese content, as with sodium, occurred in the AD3 control zone sediments sampled in July (485 $\mu g \cdot g^{-1}$) and September (425 $\mu g \cdot g^{-1}$). The AD3 control zone sediments had significantly greater manganese content than AD3 deposition zone sediments in all months but October. AD2 showed the same results for June, July, and September but had significantly greater manganese content in the deposition zone in October. AD1 sediment was significantly greater in manganese content in the deposition zone than the control zone for all five sampling months. Overall, the BC control zone had the greatest manganese content of any aquaculture control or deposition zone. CS had significantly greater manganese content in its deposition zone than its control zone for July, August, and September. RV sediment had mixed results. Manganese content was significantly greater in the RV deposition zone than the RV control zone for June but then became greater in the RV control zone in September and October. Manganese content remained greater in the BC control zone than the BC deposition zone for the entire five month period, but was significantly greater in the control zone in June and August only.

Copper

Control zone copper content between pooled agriculture and pooled aquaculture sites was statistically similar within each sampling month but July. Therefore, deposition zone copper content between agriculture and aquaculture sites could be compared within June, August, September, and October. These comparisons showed that copper content was significantly greater in aquaculture deposition zones than agriculture deposition zones in June (11.2 $\mu g \cdot g^{-1}$ at agriculture sites and 17.1 $\mu g \cdot g^{-1}$ at aquaculture sites), August (11.5 $\mu g \cdot g^{-1}$ at agriculture sites and 15.6 $\mu g \cdot g^{-1}$ at aquaculture sites), September (14.0 $\mu g \cdot g^{-1}$ at agriculture sites and 23.5 $\mu g \cdot g^{-1}$ at aquaculture sites), and October (12.7 $\mu g \cdot g^{-1}$ at agriculture sites and 16.5 $\mu g \cdot g^{-1}$ at aquaculture sites) (Figure 29).

Copper content of dredged sediment from the middle Snake River in 2001 averaged 7.5-33.0 $\mu g \cdot g^{-1}$ throughout the five sampling months (Figure 30). Copper content was significantly greater in the AD3 control zone than the AD3 deposition zone in all sampling months but October. AD2 followed the same trend for June and July but then showed no significant difference between control and deposition zone copper content for August, September, and October. AD1 sediment had the opposite trend has the AD3 sediment. AD1 copper content was significantly greater in the deposition zone than the control zone for all sampling months but October. Copper content was greater in CS deposition zone sediments than CS control zone sediments for all months. However, this difference was only significant for June, July, and October. Copper content in RV sediments followed this same trend but only had significantly greater amounts of copper in the deposition zone for June and July. BC control zone sediments had significantly greater copper content than BC deposition zone sediments for June only. Other

BC sampling months had higher copper content in the deposition zone but none of these differences were significant.

Iron

Control zone iron content between pooled agriculture and pooled aquaculture sites was statistically similar within each sampling month but July and August. Therefore, deposition zone iron content between agriculture and aquaculture sites could be compared within June, September, and October. These comparisons showed that iron content was greater in aquaculture deposition zones than agriculture deposition zones in June, September, and October (Figure 31). However, this difference was only significant in September (11,266.7 $\mu g \cdot g^{-1}$ at agriculture sites and 12,820.3 $\mu g \cdot g^{-1}$ at aquaculture sites).

Iron content of dredged sediment from the middle Snake River in 2001 averaged 7075-32,250 $\mu g \cdot g^{-1}$ throughout the five sampling months (Figure 32). This range is very large due to high sediment iron content for the AD3 control zone in July (32,250 $\mu g \cdot g^{-1}$) and September (30,000 $\mu g \cdot g^{-1}$). AD3 control zones had significantly greater iron content than AD3 deposition zones in all sampling months but October. AD2 sediment iron content followed this same trend for June, July, and September. However, AD1 deposition zone sediments had significantly greater iron content than AD1 control zone sediments in all months but August. CS iron content followed the same trend as AD1, with significantly greater amounts in deposition zones for all sampling months but August. This trend was repeated for RV sediments sampled in June and August. However, RV control zone sediments had significantly greater iron content than RV deposition zone sediments in October. The only significant difference found between the BC control and deposition zones were in June. The June control zone sediments had significantly greater iron content than June deposition zone sediments.

Phosphorus

Control zone phosphorus content between pooled agriculture and pooled aquaculture sites was statistically similar within all sampling months but July and August. Therefore, deposition zone phosphorus content between agriculture and aquaculture sites could be compared within June, September, and October. These comparisons showed that phosphorus content was significantly greater in aquaculture deposition zones than agriculture deposition zones in June (655.0 $\mu g \cdot g^{-1}$ at agriculture sites and 1541.7 $\mu g \cdot g^{-1}$ at aquaculture sites), September (730.8 $\mu g \cdot g^{-1}$ at agriculture sites and 1483.3 $\mu g \cdot g^{-1}$ at aquaculture sites), and October (683.3 $\mu g \cdot g^{-1}$ at agriculture sites and 1154.2 $\mu g \cdot g^{-1}$ at aquaculture sites) (Figure 33).

Phosphorus content of dredged sediment from the study sites in the middle Snake River in 2001 averaged 490-1800 $\mu g \cdot g^{-1}$ throughout the five sampling months (Figure 34). AD3 control zone sediments had significantly greater phosphorus content than AD3 deposition zone sediments in all five sampling months. AD2 followed this same trend in June and July but then switched to significantly greater phosphorus content in deposition zone sediments in August and October. AD1 deposition zone sediments had significantly greater phosphorus content than AD1 control zone sediments in all months but August. A very distinct trend was evident when comparing sediment phosphorus content between control and deposition zones of the three aquaculture study sites. Phosphorus content was significantly greater in deposition zone sediments than control zone sediments throughout the five sampling months for all three aquaculture study sites. Not only were these phosphorus differences significant, but the aquaculture deposition zone phosphorus levels (averaging 903 – 1800 $\mu g \cdot g^{-1}$) were often over twice as high as control zone phosphorus levels (averaging 490 – 1000 $\mu g \cdot g^{-1}$) from the same month and study site, and over twice as high as deposition zone phosphorus levels from agriculture study sites (averaging 785 – 815 $\mu g \cdot g^{-1}$).

Sulfur

Control zone sulfur content between pooled agriculture and pooled aquaculture sites was statistically similar within each sampling month but August and October. Therefore, deposition zone sulfur content between agriculture and aquaculture sites could only be compared within June, July, and September. These comparisons showed that sulfur content was significantly greater in aquaculture deposition zones than agriculture deposition zones in June (776.7$\mu g \cdot g^{-1}$ at agriculture sites and 2125 $\mu g \cdot g^{-1}$ at aquaculture sites), July (867.1 $\mu g \cdot g^{-1}$ at agriculture sites and 2082.6 $\mu g \cdot g^{-1}$ at aquaculture sites), and September (918.8 $\mu g \cdot g^{-1}$ at agriculture sites and 2320.8 $\mu g \cdot g^{-1}$ at aquaculture sites) (Figure 35).

Sulfur content of dredged sediment from the six study sites in the middle Snake River in 2001 averaged 643-2950 $\mu g \cdot g^{-1}$ throughout the five sampling months (Figure 36). Sulfur content of AD3 control zone sediments was significantly greater than AD3 deposition zone sediments for all sampling months but October. AD2 sediments followed this same trend for the first four sampling months, but switched to significantly greater sulfur content in the deposition zone sediments than the control zone sediments in October. The only significant difference between the sulfur contents of the AD1 control and deposition zones were found in June. Sediments sampled from AD1 in June had significantly greater sulfur content in the control zone sediments. Significantly greater sulfur content was found in the deposition zones of all three aquaculture study sites that were sampled. Sulfur content of the deposition zone was greater than the control zone in all sampling months but August at CS, in all sampling months but October at RV, and in

July, September, and October at BC. However, sulfur content was significantly greater in the BC control zone than the BC deposition zone in June.

Lead

Control zone lead content between pooled agriculture and pooled aquaculture sites was statistically similar within each sampling month but July and August. Therefore, deposition zone lead content between agriculture and aquaculture sites could only be compared within June, September, and October. These comparisons showed that lead content was significantly greater in aquaculture deposition zones than agriculture deposition zones in June (18.8 $\mu g \cdot g^{-1}$ at agriculture sites and 22.2 $\mu g \cdot g^{-1}$ at aquaculture sites) and September (23.2 $\mu g \cdot g^{-1}$ at agriculture sites and 31.3 $\mu g \cdot g^{-1}$ at aquaculture sites) (Figure 37).

Lead content of dredged sediment from the six study sites in the middle Snake River in 2001 averaged 14.5-50.75 $\mu g \cdot g^{-1}$ throughout the five sampling months (Figure 38). The highest sediment lead content was sampled from all replicates of the AD3 control zone in July (50.75 $\mu g \cdot g^{-1}$) and September (49.5 $\mu g \cdot g^{-1}$). Lead content of AD3 control zone sediments was significantly greater than deposition zone sediments in all sampling months but October. The same results were found in July sediments sampled from AD2. However, lead content of AD1 deposition zone sediments was greater than AD1 control zone sediments in all sampled months. These differences at AD1 were only significant in June, August, and September. Significantly greater lead content was found in deposition zone sediments than was found in control zone sediments at CS (June and September) and RV (June and July). However, BC control zone sediments had significantly greater lead content than BC deposition zone sediments in June.

Chromium

Control zone chromium content between pooled agriculture and pooled aquaculture sites was statistically similar within all sampling months but July. Therefore, deposition zone chromium content between agriculture and aquaculture sites could be compared within June, August, September, and October. These comparisons showed that chromium content was significantly greater in aquaculture deposition zones than agriculture deposition zones in June (17.5 $\mu g \cdot g^{-1}$ at agriculture sites and 25.7 $\mu g \cdot g^{-1}$ at aquaculture sites), August (19.75 $\mu g \cdot g^{-1}$ at agriculture sites and 28.5 $\mu g \cdot g^{-1}$ at aquaculture sites), September (22.0 $\mu g \cdot g^{-1}$ at agriculture sites and 27.9 $\mu g \cdot g^{-1}$ at aquaculture sites), and October (20.2 $\mu g \cdot g^{-1}$ at agriculture sites and 26.2 $\mu g \cdot g^{-1}$ at aquaculture sites) (Figure 39).

Chromium content of dredged sediment from the six study sites in the middle Snake River in 2001 averaged 12.5-67.75 $\mu g \cdot g^{-1}$ throughout the five sampling months (Figure 40). As with many of the previous elements, the highest sediment chromium content was sampled from all replicates of the AD3 control zone in July (67.75 $\mu g \cdot g^{-1}$) and September (57.25 $\mu g \cdot g^{-1}$). Chromium content of AD3 control zone sediments was significantly greater than AD3 deposition zone sediments for all five sampling months. AD2 sediments followed this same trend in June, July, and September, but had significantly greater chromium content in the deposition zone sediments than the control zone sediments for the other two sampling months (August and October). AD1 had significantly greater chromium content in its deposition zone sediment than its control zone sediment for all sampling months but August. Significantly greater chromium content was found in the deposition zones of all three aquaculture study sites that were sampled. Chromium content of the deposition zone was greater than the control zone in all sampling months but August at CS, in June and July at RV, and in all sampling months at BC. However, chromium content was significantly greater in the RV control zone than the RV deposition zone in October.

Cadmium

Control zone cadmium content between pooled agriculture and pooled aquaculture sites was statistically similar within each sampling month but July. Therefore, deposition zone cadmium content between agriculture and aquaculture sites could be compared within June, August, September, and October. These comparisons showed that cadmium content was greater in aquaculture deposition zones than agriculture deposition zones in all four months (Figure 19). However, this difference was only significant in June (0.63 $\mu g \cdot g^{-1}$ at agriculture sites and 0.99 $\mu g \cdot g^{-1}$ at aquaculture sites) and September (0.97 $\mu g \cdot g^{-1}$ at agriculture sites and 1.25 $\mu g \cdot g^{-1}$ at aquaculture sites).

Cadmium content of dredged sediment from the six study sites in the middle Snake River in 2001 averaged 0.44-3.55 $\mu g \cdot g^{-1}$ throughout the five sampling months (Figure 42). Cadmium content of AD3 control zone sediments was significantly greater than deposition zone sediments in all sampling months but October. Cadmium content of AD2 control zone sediments was also significantly greater than deposition zone sediments in July. However, cadmium content was significantly greater in AD1 deposition zone sediments than AD1 control zone sediments in July, August, and September. Sediment from the aquaculture study sites had mixed cadmium results as well. Cadmium content of CS deposition zones was significantly greater than CS control zones in June, September, and October. Cadmium content of RV deposition zones was significantly greater than RV control zones in June and July. Alternately, cadmium content was significantly greater in BC control zone sediment than BC deposition zone sediment for June.

Barium

Control zone barium content between pooled agriculture and pooled aquaculture sites was statistically similar within each sampling month but July and October. Therefore, deposition zone barium content between agriculture and aquaculture sites could be compared within June, August, and September. These comparisons showed that barium content was greater in aquaculture deposition zones than agriculture deposition zones in all three months (Figure 43). However, deposition zone differences between industries were significant in June alone (85.4 $\mu g \cdot g^{-1}$ at agriculture sites and 96.5 $\mu g \cdot g^{-1}$ at aquaculture sites).

Barium content of dredged sediment from the six study sites in the middle Snake River in 2001 averaged 60.5-250.0 $\mu g \cdot g^{-1}$ throughout the five sampling months (Figure 44). The highest sediment barium content was the mean AD3 control in July (235 $\mu g \cdot g^{-1}$) and in September (250 $\mu g \cdot g^{-1}$). Barium content was significantly greater in AD3 control zone sediments than AD3 deposition zone sediments within each sampling month but October. The same trend was found in AD2 sediment from June, July, and September. However, barium content was significantly greater in AD1 deposition zone sediments than AD1 control zone sediments in each month but August. Barium content was also significantly greater in CS deposition zone sediments than CS control zone sediments for all months but August. RV sediments followed this same trend for June but BC sediments had significantly greater barium content in its control zone than its deposition zone for June and August

Nickel

Control zone nickel content between pooled agriculture and pooled aquaculture sites was statistically similar within each sampling month but July. Therefore, deposition zone nickel content between agriculture and aquaculture sites could be compared within June, August, September, and October. These comparisons showed that nickel content was greater in aquaculture deposition zones than agriculture deposition zones in all four months (Figure 45). However, deposition zone differences between industries were only significant in June (13.3 $\mu g \cdot g^{-1}$ at agriculture sites and 14.8 $\mu g \cdot g^{-1}$ at aquaculture sites), September (13.9 $\mu g \cdot g^{-1}$ at agriculture sites and 15.7 $\mu g \cdot g^{-1}$ at aquaculture sites), and October (13.6 $\mu g \cdot g^{-1}$ at agriculture sites and 15.0 $\mu g \cdot g^{-1}$ at aquaculture sites).

Nickel content of dredged sediment from the six study sites in the middle Snake River in 2001 averaged 8.95-43.75 $\mu g \cdot g^{-1}$ throughout the five sampling months (Figure 46). Nickel content of AD3 control zone sediments significantly exceeded that of deposition zone sediments in all five sampling months. AD2 results for sediment sampled in July and September were similar to AD3 results. However, nickel content of AD2 deposition zone sediments was significantly greater than AD2 control zone sediments for August and October. AD1 sediments sampled from the deposition zone also had significantly greater levels of nickel than the AD1 control zone sediments. These results at AD1 were consistent for all five sampling months. CS followed the same trend as AD1, with significantly greater nickel content in the deposition zone sediments than the control zone sediments, in all sampling months but August. RV sediments followed this same pattern in June and July but had significantly greater nickel content in control zone sediment than deposition zone sediment in September. June nickel content in the BC control zone sediments was also significantly greater than nickel content of the BC deposition zone sediments from the same month.

Cobalt

Control zone cobalt content between pooled agriculture and pooled aquaculture sites was statistically similar within each sampling month but July and August. Therefore, deposition zone cobalt content between agriculture and aquaculture sites could only be compared within June, September, and October. These comparisons showed that cobalt content was greater in aquaculture deposition zones than agriculture deposition zones in all three months (Figure 47). However, deposition zone differences between industries were significant in September alone (8.4 $\mu g \cdot g^{-1}$ at agriculture sites and 9.8 $\mu g \cdot g^{-1}$ at aquaculture sites).

Cobalt content of dredged sediment from the six study sites in the middle Snake River in 2001 averaged 6.3-26.0 $\mu g \cdot g^{-1}$ throughout the five sampling months (Figure 48). High values were once again evident in AD3 control zone replicates from July (26 $\mu g \cdot g^{-1}$) and September (22.75 $\mu g \cdot g^{-1}$). Not only was cobalt content significantly greater in AD3 control zone sediments in July and September, but it was also significantly greater in control zone sediments in the other three sampling months as well. AD2 sediments followed the same trend in July but had significantly greater cobalt content in deposition zone sediments than control zone sediments in August and October. Cobalt content was greater in AD1 deposition zone sediments than AD1 control zone sediments in all five sampling months, but this difference was significant in June, July, and September only. Mixed trends in cobalt content were evident from sediment sampled at aquaculture study sites. While cobalt content was significantly greater in the CS deposition zone sediments than the CS control zone sediments in July, September, and October, it was significantly greater in the CS control zone in August. Cobalt content was significantly greater in the RV deposition zone sediments than the RV control zone sediments in June and July, but was significantly greater in the RV control zone sediments in October. In June, cobalt levels were significantly greater in the BC control zone than the deposition zone. However, cobalt levels were significantly greater in the BC deposition zone in July and August.

Beryllium

Control zone beryllium content between pooled agriculture and pooled aquaculture sites was statistically similar within each sampling month but July. Therefore, deposition zone beryllium content between agriculture and aquaculture sites could be compared within June, August, September, and October. These comparisons showed that beryllium content was significantly greater in aquaculture deposition zones than agriculture deposition zones in June (0.45 $\mu g \cdot g^{-1}$ at agriculture sites and 0.51 $\mu g \cdot g^{-1}$ at aquaculture sites) (Figure 49).

Beryllium content of dredged sediment from the six study sites in the middle Snake River in 2001 averaged 0.29-0.87 $\mu g \cdot g^{-1}$ throughout the five sampling months (Figure 50). The highest sediment beryllium content (0.87 $\mu g \cdot g^{-1}$) was sampled from the control zone of BC in June. Beryllium content was greater in AD3 control zone sediments than AD3 deposition zone sediments in all five sampling months. However, this difference was significant in June, July, and August only. Beryllium content was also significantly greater in AD2 control zones than AD2 deposition zones in June and July. Alternatively, AD1 deposition zone sediments had significantly greater beryllium levels than AD1 control zones in all sampling months but October. This same trend occurred in all sampling months but August at CS, and in June, July, and August at RV. The opposite trend was evident at BC, where the control zone sediments had significantly greater beryllium levels than the deposition zone sediments in June and October.

Molybdenum

Control zone molybdenum content between pooled agriculture and pooled aquaculture sites was statistically similar within each sampling month but July. Therefore, deposition zone molybdenum content between agriculture and aquaculture sites could be compared within June, August, September, and October. These comparisons showed that molybdenum content was greater in agriculture deposition zones than aquaculture deposition zones in June, August, and October (Figure 51). However, deposition zone differences between industries were only significant in October (6.1 $\mu g \cdot g^{-1}$ at agriculture sites and 5.4 $\mu g \cdot g^{-1}$ at aquaculture sites). Molybdenum content of dredged sediment from the six study sites in the middle Snake River in 2001 averaged 4.35-14.25 $\mu g \cdot g^{-1}$ throughout the five sampling months (Figure 52). Molybdenum content was significantly greater in AD3 control zone sediments than AD3 deposition zone sediments in all sampling months but October. This same trend occurred in AD2 sediments sampled from July. However, AD2 deposition zone sediments had significantly greater molybdenum content than control zone sediments in October. September was the only sampling month where significant differences occurred between AD1 control and AD1 deposition zone sediments. In this case, AD1 deposition zone sediments had significantly greater molybdenum levels than the control zone sediments. No significant differences in molybdenum content were found between the CS control and CS deposition zone sediments. Likewise, no significant differences in molybdenum content were found between the RV control and RV deposition zone sediments. Molybdenum content of the BC control zone sediments was significantly greater than the BC deposition zone sediments in June. No other significant differences occurred in the molybdenum content of sediments sampled from the control and deposition zones of BC.

Benthic Macroinvertebrates

Benthic Macroinvertebrate Abundance

Control zone BMI abundance between pooled agriculture and pooled aquaculture sites was statistically similar within each sampling month but July and September. Therefore, deposition zone BMI abundance between agriculture and aquaculture sites could only be compared within June, August, and October. These comparisons showed that BMI abundance was significantly greater in aquaculture deposition zones than agriculture deposition zones in June (6,834 individuals·m^{-2} at agriculture sites and 84,365 individuals·m^{-2} at aquaculture sites), August (1,263 individuals·m^{-2} at agriculture sites and 10,119 individuals·m^{-2} at aquaculture sites), and October (2,075 individuals·m^{-2} at agriculture sites and 17,607 individuals·m^{-2} at aquaculture sites) (Figure 53).

BMI abundance in the three agriculture study sites (average of control and deposition zones) in 2001 averaged 844-12,239 individuals·m^{-2} throughout the five sampling months (Figure 54). BMI abundance in the three aquaculture study sites (average of control and deposition zones) in 2001 averaged 1178-231,222 individuals·m^{-2} throughout the five sampling months. BMI abundance was greater at aquaculture study sites than agriculture study sites throughout the five sampling months. BMI abundance was significantly greater in the AD3 control zone than the AD3 deposition zone in June alone. No other significant differences in BMI abundance occurred between the control and deposition zones throughout the remaining sampling months at AD3. Likewise, no significant differences were found in BMI abundance between the control and deposition zones of AD2, or the control and deposition zones of AD1 for all five sampling months. BMI were significantly more abundant in the CS deposition zone than the CS control zone in October alone. This trend also occurred in the RV study site in June, July, and October. The BC study site had a greater abundance of BMI in the control zone than the deposition zone in June and August.

Potamopyrgus antipodarum

Control zone *P. antipodarum* abundance was statistically similar between pooled agriculture and pooled aquaculture sites within each sampling month but July and September. Therefore, deposition zone *P. antipodarum* abundance in agriculture and aquaculture sites could only be compared within June, August, and October. These comparisons showed that *P. antipodarum* abundance was significantly greater in aquaculture deposition zones than agriculture deposition zones in June (13.0 individuals·m^{-2} at agriculture sites and 70,880 individuals·m^{-2} at aquaculture sites), August (61.1 individuals·m^{-2} at agriculture sites and 5,822 individuals·m^{-2} at aquaculture sites), and October (28.2 individuals·m^{-2} at agriculture sites and 13,291 individuals·m^{-2} at aquaculture sites) (Figure 55).

P. antipodarum abundance in the three agriculture study sites in 2001 averaged 0-692 individuals·m^{-2} throughout the five sampling months (Figure 56). *P. antipodarum* abundance in the three aquaculture study sites in 2001 averaged 11-211,278 individuals·m^{-2} throughout the five sampling months. There were no significant differences in *P. antipodarum* abundance between the control and deposition zone of AD3 throughout the five sampling months. *P. antipodarum* abundance was significantly greater in the AD2 deposition zone (averaging 111 individuals·m^{-2}) than the AD2 control zone (averaging 0.0 individuals·m^{-2}) in August alone. Conversely, *P. antipodarum* abundance was significantly greater in the AD1 control zone than the AD1 deposition zone in June (60.3 individuals·m^{-2} in control zone and 0.0 individuals·m^{-2} in deposition zone) and July (77.8 individuals·m^{-2} in control zone and 5.6 individuals·m^{-2} in deposition zone). Although *P. antipodarum* were more abundant in the CS deposition zone (ranging 22.2-2,106.9 individuals·m^{-2}) than the CS control zone (ranging 11.1-122.2 individuals·m^{-2}) in all five sampling months, this difference wasn't significant for any of the months. The RV study site had a significantly greater abundance of *P. antipodarum* in the deposition zone than the control zone in all five sampling months. However, the BC study site had a significantly greater abundance of *P. antipodarum* in the control zone than the deposition zone in all sampling months but September and October. *Chironomidae spp.*

Control zone Chironomidae abundance between pooled agriculture and pooled aquaculture sites was statistically similar within each sampling month but July and October. Therefore, deposition zone Chironomidae abundance between agriculture and aquaculture sites could only be compared within June, August, and September. These comparisons showed that Chironomidae abundance was significantly greater in agriculture deposition zones than aquaculture deposition zones in June (2,119 individuals·m^{-2} at agriculture sites and 616 individuals·m^{-2} at aquaculture sites) (Figure 57).

Chironomidae abundance was greatest in June and July across all sampling sites (Figure 58). Chironomidae abundance in the three agriculture study sites in 2001 averaged 33.3-3100.0 individuals·m^{-2} throughout the five sampling months. Chironomidae abundance in the three aquaculture study sites in 2001 averaged 0-4006.6 individuals·m^{-2} throughout the five sampling months. Chironomidae abundance was significantly greater in the AD3 control zone than the AD3 deposition zone in July. However, AD3 deposition zones had significantly greater Chironomidae abundance than AD3 control zones in August and September. Chironomidae abundance at AD2 showed a similar trend, with significantly greater Chironomidae numbers in the control zone in July but significantly greater Chironomidae numbers in the deposition zone in September. Chironomidae abundance was significantly greater in the AD1 deposition zone than the AD1 control zone in June and October. Mixed trends in Chironomidae abundance were found at the aquaculture study sites. Chironomidae were significantly more abundant in the CS control zone than the CS deposition zone in June, but reversed to a significantly greater abundance in the CS deposition zone in July and August. The RV study site had a significantly greater abundance of Chironomidae in the control zone than the deposition zone in June, July, and September, but then reversed to significantly greater Chironomidae abundance in the RV deposition zone in October. BC study site had a significantly greater abundance of Chironomidae in the deposition zone than the control zone in all sampling months but June and August.

Benthic Macroinvertebrate Biomass

Control zone BMI biomass between pooled agriculture and pooled aquaculture sites was statistically similar within August and October. Therefore, deposition zone BMI biomass between agriculture and aquaculture sites could only be compared within August and October. These comparisons showed that BMI biomass was significantly greater in aquaculture deposition zones than agriculture deposition zones in August (1.01 $g \cdot m^{-2}$ at agriculture sites and 13.88 $g \cdot m^{-2}$ at aquaculture sites) and October (1.44 $g \cdot m^{-2}$ at agriculture sites and 12.73 $g \cdot m^{-2}$ at aquaculture sites) (Figure 59).

BMI biomass in the three agriculture study sites in 2001 averaged 0.38-14.40 $g \cdot m^{-2}$ throughout the five sampling months (Figure 60). BMI biomass in the three aquaculture study sites in 2001 averaged 0.97-287.08 $g \cdot m^{-2}$ throughout the five sampling months. BMI biomass was greater at aquaculture study sites than agriculture study sites throughout the five sampling months.

BMI biomass was significantly greater in the AD3 control zone than the AD3 deposition zone in June. This trend also occurred at the AD1 study site in July. However, the AD2 deposition zone had greater BMI biomass than the AD2 control zone in October. BMI biomass was greater in the deposition zones of CS and RV than the corresponding control zones for the entire five month sampling period. At CS this difference was not statistically significant in any of the sampling months. However, this difference was significant in all months but September at RV. The opposite trend occurred at BC. BMI biomass was significantly greater in the BC control zone than the BC deposition zone in June, August, and October.

Benthic Macroinvertebrate Taxa Richness

Control zone BMI taxa richness between pooled agriculture and pooled aquaculture sites was statistically similar in all five sampling months. Therefore, deposition zone BMI taxa richness in agriculture and aquaculture sites could be compared within June, July, August, September, and October. These comparisons showed that BMI taxa richness was significantly greater in aquaculture deposition zones than agriculture deposition zones in June (3.8 at agriculture sites and 6.0 at aquaculture sites), July (3.8 at agriculture sites and 6.4 at aquaculture sites), August (3.7 at agriculture sites and 5.7 at aquaculture sites), September (5.0 at agriculture sites and 7.0 at aquaculture sites), and October (3.8 at agriculture sites and 4.9 at aquaculture sites) (Figure 61).

The number of distinct BMI taxa sampled in the three agriculture study sites in 2001 averaged 2.5-6.25 throughout the five sampling months (Figure 62). The number of distinct BMI taxa sampled in the three aquaculture study sites in 2001 averaged 1.25-10.25 throughout the five sampling months. The highest BMI taxa richness values were sampled in the control zone of the RV study site. The only significant difference in BMI taxa richness between sampled agriculture control zones and deposition zones was found at the AD3 study site. In this case, BMI taxa richness was greater in the AD3 control zone than the AD3 deposition zone in June and August. No significant differences were found between CS control zone BMI taxa richness and CS deposition zone BMI taxa richness for any of the five sampling months. RV had significantly greater BMI taxa richness values in the control zone than the deposition zone for both June and September. Conversely, BC had greater BMI taxa richness values in the deposition zone than the control zone for all five sampling months. This difference between BMI taxa richness values was found to be statistically significant in July, September, and October.

Aquatic Macrophytes

Aquatic Macrophyte Biomass

Control zone AM biomass between pooled agriculture and pooled aquaculture sites was statistically similar in July and September. Therefore, deposition zone AM biomass in agriculture and aquaculture sites could only be compared within July and September. These comparisons showed that AM biomass was significantly greater in aquaculture deposition zones than agriculture deposition zones in July (0.64 $g{\cdot}m^{-2}$ at agriculture sites and 83.80 $g{\cdot}m^{-2}$ at aquaculture sites) and September (10.13 $g{\cdot}m^{-2}$ at agriculture sites and 49.55 $g{\cdot}m^{-2}$ at aquaculture sites) (Figure 63).

AM biomass in the three agriculture study sites in 2001 averaged 0-36.4 $g{\cdot}m^{-2}$ throughout the five sampling months (Figure 64). AM biomass in the three aquaculture study sites in 2001 averaged 0-325.3 $g{\cdot}m^{-2}$ throughout the five sampling months. The highest AM biomass values (averaging 325.3 $g{\cdot}m^{-2}$) of all six study sites occurred in the deposition zone of RV during the month of June. The only significant difference between agriculture control and deposition zone AM biomass occurred in July at AD2. At this study site, AM biomass was significantly greater in the control zone than the deposition zone. AM biomass was greater in CS deposition zones than CS control zones in all five sampling months. However, this difference was not significant in any of the sampling months. RV deposition zones had significantly greater AM biomass than RV control zones in July and October. The same result occurred at the BC study site in September.

APPENDIX D:

SAMPLING DATA FOR THE MIDDLE SNAKE RIVER, JUNE-OCTOBER, 2001

Month	Industry	Site	Dredge	Zone	Depth (m)	Sedtemp (°C)	Sand (%)	Clay (%)	Silt (%)	C (%)	N (%)
6	AQ	BC	1	DEP	1.5	16.6	85.0	0.0	15.0	1.3	0.13
6	AQ	BC	2	DEP	1.5	18.4	68.0	3.0	29.0	2.1	0.20
6	AQ	BC	3	DEP	1.5	16.7	80.0	1.0	19.0	1.7	0.15
6	AQ	BC	4	DEP	1.5	17.1	77.4	0.6	22.0	1.8	0.16
6	AQ	BC	5	DEP	1	19.7	94.7	0.0	5.3	0.87	0.09
6	AQ	BC	6	DEP	1	17.1	92.2	0.3	7.5	0.94	0.10
6	AQ	BC	7	DEP	1	14.5	91.7	0.0	8.3	1.2	0.13
6	AQ	BC	8	DEP	1	15.4	93.2	0.8	6.0	0.92	0.09
6	AQ	BC	9	CON	3.75	16.7	51.4	6.6	42.0	3.9	0.39
6	AQ	BC	10	CON	3.75	16.2	52.9	2.6	44.5	2.3	0.15
6	AQ	BC	11	CON	3.75	16.7	49.4	3.6	47.0	3.3	0.25
6	AQ	BC	12	CON	3.75	16.9	51.4	2.6	46.0	2.8	0.21
6	AQ	NS	1	DEP	1.25	17.2	56.4	1.6	42.0	3.2	0.22
6	AQ	NS	2	DEP	1.25	16	59.4	1.6	39.0	3.3	0.22
6	AQ	NS	3	DEP	1.25	14.3	50.4	3.6	46.0	3.5	0.23
6	AQ	NS	4	DEP	1.25	14.9	52.4	3.6	44.0	3.7	0.24
6	AQ	NS	5	DEP	1.5	15.3	62.4	3.6	34.0	2.9	0.20
6	AQ	NS	6	DEP	1.5	14.5	62.4	3.6	34.0	3.2	0.23
6	AQ	NS	7	DEP	1.5	15.3	72.4	3.6	24.0	2.4	0.18
6	AQ	NS	8	DEP	1.5	15.9	72.4	2.6	25.0	2.7	0.20
6	AQ	NS	9	CON	2.7	19.7	88.2	2.8	9.0	1.5	0.07
6	AQ	NS	10	CON	2.7	19.1	85.2	1.8	13.0	1.5	0.07
6	AQ	NS	11	CON	2.7	21.1	93.2	0.8	6.0	1.0	0.05
6	AQ	NS	12	CON	2.7	21.1	89.2	1.6	9.2	1.1	0.05
6	AQ	CS	1	DEP	3.25	15.4	71.2	1.3	27.5	1.9	0.12
6	AQ	CS	2	DEP	3.25	16.3	75.2	0.8	24.0	1.7	0.11
6	AQ	CS	3	DEP	3.25	16.1	63.2	0.8	36.0	2.2	0.14
6	AQ	CS	4	DEP	3.25	17.3	67.2	0.8	32.0	2.0	0.13
6	AQ	CS	5	DEP	2	17.2	58.4	1.6	40.0	2.8	0.23
6	AQ	CS	6	DEP	2	17.4	52.4	1.6	46.0	3.1	0.23
6	AQ	CS	7	DEP	2	17	77.2	0.8	22.0	2.8	0.21
6	AQ	CS	8	DEP	2	16.9	60.4	1.6	38.0	3.0	0.22

Month	Industry	Site	Dredge	Zone	Depth (m)	Sedtemp (°C)	Sand (%)	Clay (%)	Silt (%)	C (%)	N (%)
6	AQ	CS	9	CON	1.75	20.1	79.2	0.8	20.0	1.4	0.08
6	AQ	CS	10	CON	1.75	19.5	78.2	0.8	21.0	1.4	0.08
6	AQ	CS	11	CON	2	20.5	82.2	0.8	17.0	1.1	0.07
6	AQ	CS	12	CON	2	20.3	82.2	0.8	17.0	1.2	0.07
6	AG	AD1	1	DEP	1.75	18	73.2	2.8	24.0	1.4	0.06
6	AG	AD1	2	DEP	1.75	17.9	70.2	1.8	28.0	1.5	0.07
6	AG	AD1	3	DEP	1.75	17.5	73.2	1.8	25.0	1.4	0.06
6	AG	AD1	4	DEP	1.75	18.5	72.2	1.8	26.0	1.4	0.07
6	AG	AD1	5	DEP	1.6	19.1	58.4	3.6	38.0	1.4	0.07
6	AG	AD1	6	DEP	1.6	19	56.4	3.6	40.0	1.3	0.06
6	AG	AD1	7	DEP	1.6	19.2	63.2	1.8	35.0	1.4	0.07
6	AG	AD1	8	DEP	1.6	19.7	66.2	1.8	32.0	1.2	0.05
6	AG	AD1	9	CON	1.6	19.6	82.2	1.8	16.0	1.1	0.05
6	AG	AD1	10	CON	1.6	19.3	89.2	1.8	9.0	0.85	0.03
6	AG	AD1	11	CON	1.6	20	89.2	1.8	9.0	1.1	0.04
6	AG	AD1	12	CON	1.6	19.9	82.2	1.8	16.0	1.2	0.05
6	AG	AD2	1	DEP	1.8	19.8	91.2	0.8	8.0	0.95	0.03
6	AG	AD2	2	DEP	1.8	20.1	82.2	0.8	17.0	0.93	0.03
6	AG	AD2	3	DEP	1.8	19.9	91.2	0.8	8.0	0.99	0.03
6	AG	AD2	4	DEP	1.8	19.8	92.5	0.8	6.7	0.85	0.02
6	AG	AD2	5	DEP	2.5	19.5	85.4	1.8	12.8	1.0	0.04
6	AG	AD2	6	DEP	2.5	19.4	79.4	0.8	19.8	1.2	0.05
6	AG	AD2	7	DEP	2.5	19.5	86.4	0.8	12.8	0.95	0.03
6	AG	AD2	8	DEP	2.5	18.9	85.4	0.8	13.8	0.99	0.03
6	AG	AD2	9	CON	1.6	16.1	56.8	3.6	39.6	1.9	0.11
6	AG	AD2	10	CON	1.6	17.3	58.8	5.6	35.6	2.0	0.12
6	AG	AD2	11	CON	1.6	17.2	56.8	3.6	39.6	2.1	0.14
6	AG	AD2	12	CON	1.6	17.2	72.8	1.6	25.6	1.5	0.10
6	AG	AD3	1	DEP	1.9	16.5	74.8	5.6	19.6	1.4	0.08
6	AG	AD3	2	DEP	1.9	15.4	74.4	2.8	22.8	1.2	0.07
6	AG	AD3	3	DEP	1.9	14.2	74.4	2.8	22.8	1.2	0.07
6	AG	AD3	4	DEP	1.9	14.1	58.8	5.6	35.6	1.8	0.11

Month	Industry	Site	Dredge	Zone	Depth (m)	Sedtemp (°C)	Sand (%)	Clay (%)	Silt (%)	C (%)	N (%)
6	AG	AD3	5	DEP	1.75	14.3	80.4	0.8	18.8	0.93	0.05
6	AG	AD3	6	DEP	1.75	13.9	88.4	1.8	9.8	0.77	0.05
6	AG	AD3	8	DEP	1.75	14.5	87.4	2.8	9.8	0.77	0.05
6	AG	AD3	9	CON	1.75	15.4	52.8	3.6	43.6	2.2	0.13
6	AG	AD3	10	CON	1.75	15.3	54.8	5.6	39.6	1.9	0.12
6	AG	AD3	11	CON	1.75	15.6	46.8	5.6	47.6	2.0	0.13
6	AG	AD3	12	CON	1.75	15.8	42.8	5.2	52.0	2.1	0.14
7	AQ	BC	1	DEP	1.75	16.1	86.4	0.6	13.0	1.5	0.14
7	AQ	BC	2	DEP	1.75	17.1	52.8	5.2	42.0	2.3	0.18
7	AQ	BC	3	DEP	1.75	17.5	72.8	3.2	24.0	2.2	0.19
7	AQ	BC	4	DEP	1.75	17.1	78.4	1.6	20.0	1.8	0.17
7	AQ	BC	5	DEP	0.8	18	86.4	1.6	12.0	1.4	0.13
7	AQ	BC	6	DEP	0.8	17.3	89.2	1.8	9.0	1.2	0.11
7	AQ	BC	7	DEP	0.8	18.1	90.2	0.8	9.0	1.3	0.12
7	AQ	BC	8	DEP	0.8	16.7	86.2	1.8	12.0	1.8	0.16
7	AQ	BC	9	CON	2	17.7	66.4	3.6	30.0	1.9	0.11
7	AQ	BC	10	CON	2	17.9	46.4	5.6	48.0	1.9	0.11
7	AQ	BC	11	CON	2	17.3	58.4	3.6	38.0	2.2	0.14
7	AQ	BC	12	CON	2	17.4	42.4	5.6	52.0	2.5	0.17
7	AQ	NS	1	DEP	0.75	15.2	76.2	1.8	22.0	2.1	0.13
7	AQ	NS	2	DEP	0.75	15.4	66.4	3.6	30.0	2.7	0.19
7	AQ	NS	3	DEP	0.75	15.6	62.4	3.6	34.0	3.0	0.22
7	AQ	NS	4	DEP	0.75	15.9	59.2	4.4	36.4	2.4	0.17
7	AQ	NS	5	DEP	0.8	15.7	69.2	2.4	28.4	2.8	0.19
7	AQ	NS	6	DEP	0.8	16.3	77.2	2.4	20.4	2.2	0.15
7	AQ	NS	7	DEP	0.8	16.1	73.2	2.8	24.0	2.4	0.17
7	AQ	NS	8	DEP	0.8	16.1	75.2	2.8	22.0	2.1	0.15
7	AQ	NS	9	CON	2.25	19.3	79.2	2.8	18.0	1.5	0.07
7	AQ	NS	10	CON	2.25	19.3	81.2	0.8	18.0	1.4	0.06
7	AQ	NS	11	CON	2.25	18.7	83.8	0.4	15.8	1.6	0.07
7	AQ	NS	12	CON	2.25	17.7	77.8	1.4	20.8	1.7	0.07
7	AQ	CS	1	DEP	2.5	18.7	72.2	1.8	26.0	1.7	0.10

Month	Industry	Site	Dredge	Zone	Depth (m)	Sedtemp (°C)	Sand (%)	Clay (%)	Silt (%)	C (%)	N (%)
7	AQ	CS	2	DEP	2.5	16.8	76.2	1.8	22.0	1.5	0.09
7	AQ	CS	3	DEP	2.5						
7	AQ	CS	4	DEP	2.5	18.8	74.2	1.8	24.0	1.7	0.10
7	AQ	CS	5	DEP	1.5	19.2	64.4	3.6	32.0	2.4	0.18
7	AQ	CS	6	DEP	1.5	18.8	72.4	1.6	26.0	2.0	0.14
7	AQ	CS	7	DEP	1.5	19	76.4	1.6	22.0	2.0	0.14
7	AQ	CS	8	DEP	1.5	19.1	78.4	1.6	20.0	1.8	0.12
7	AQ	CS	9	CON	0.75	22.5	83.2	0.8	16.0	0.82	0.06
7	AQ	CS	10	CON	0.75	22.6	93.2	0.8	6.0	0.81	0.05
7	AQ	CS	11	CON	0.75	22.3	84.2	0.8	15.0	0.84	0.05
7	AQ	CS	12	CON	0.75	22.6	81.2	0.8	18.0	0.95	0.06
7	AG	AD1	1	DEP	1.25	20.4	69.6	0.8	29.6	1.5	0.07
7	AG	AD1	2	DEP	1.25	20.2	47.6	6.8	45.6	2.2	0.13
7	AG	AD1	3	DEP	1.25	20.6	60.8	3.2	36.0	1.6	0.08
7	AG	AD1	4	DEP	1.25	20.7	70.8	3.2	26.0	1.5	0.04
7	AG	AD1	5	DEP	1.5	21	53.8	3.2	43.0	1.2	0.04
7	AG	AD1	6	DEP	1.5	20.8	50.8	3.2	46.0	1.3	0.04
7	AG	AD1	7	DEP	1.5	20.9	58.8	1.2	40.0	1.1	0.03
7	AG	AD1	8	DEP	1.5	21	54.8	1.2	44.0	1.2	0.04
7	AG	AD1	9	CON	2	21.4	83.4	0.6	16.0	0.86	0.01
7	AG	AD1	10	CON	2	21.7	89.4	0.6	10.0	0.77	0.02
7	AG	AD1	11	CON	2	20.6	83.4	1.4	15.2	1.0	0.02
7	AG	AD1	12	CON	2	21.8	84.8	0.4	14.8	0.92	0.02
7	AG	AD2	1	DEP	2.1	21.4	87.8	1.4	10.8	1.1	0.03
7	AG	AD2	2	DEP	2.1	21.1	88.8	0.4	10.8	1.1	0.03
7	AG	AD2	3	DEP	2.1	21.5	88.8	0.4	10.8	1.1	0.03
7	AG	AD2	4	DEP	2.1	21.5	83.8	1.4	14.8	1.2	0.04
7	AG	AD2	5	DEP	2	21.7	87.8	0.4	11.8	0.91	0.02
7	AG	AD2	6	DEP	2	21.6	88.8	0.4	10.8	0.90	0.02
7	AG	AD2	7	DEP	2	21.4	83.8	1.4	14.8	1.1	0.03
7	AG	AD2	8	DEP	2	21.5	84.8	1.4	13.8	1.1	0.03
7	AG	AD2	9	CON	1.3	21.8	67.6	0.8	31.6	1.5	0.06

Month	Industry	Site	Dredge	Zone	Depth (m)	Sedtemp (°C)	Sand (%)	Clay (%)	Silt (%)	C (%)	N (%)
7	AG	AD2	10	CON	1.3	21.8	63.6	2.8	33.6	1.6	0.07
7	AG	AD2	11	CON	1.3	22.5	58.8	3.2	38.0	1.7	0.07
7	AG	AD2	12	CON	1.3	22.2	66.8	3.2	30.0	1.4	0.06
7	AG	AD3	1	DEP	1.6	20.6	56.8	3.2	40.0	1.7	0.07
7	AG	AD3	2	DEP	1.6	20.6	71.4	1.6	27.0	1.4	0.06
7	AG	AD3	3	DEP	1.6	20.6	76.4	1.6	22.0	1.1	0.04
7	AG	AD3	4	DEP	1.6	20.5	70.4	1.6	28.0	1.4	0.06
7	AG	AD3	5	DEP	1.9	21.7	94.4	0.6	5.0	0.59	0.02
7	AG	AD3	6	DEP	1.9	21.6	93.4	0.6	6.0	0.59	0.02
7	AG	AD3	7	DEP	1.9	21.7	89.4	0.6	10.0	0.77	0.03
7	AG	AD3	8	DEP	1.9	21.9	95.4	0.6	4.0	0.64	0.02
7	AG	AD3	9	CON	1.9	21.7	86.4	1.6	12.0	0.62	0.03
7	AG	AD3	10	CON	1.9	21.7	86.4	0.6	13.0	0.88	0.05
7	AG	AD3	11	CON	1.9	21.9	82.4	1.6	16.0	1.1	0.05
7	AG	AD3	12	CON	1.9	22	85.4	1.6	13.0	0.95	0.05
8	AQ	BC	1	DEP	2.25	16.7	81.4	1.6	17.0	1.6	0.09
8	AQ	BC	2	DEP	2.25	16.7	48.4	2.6	49.0	2.5	0.04
8	AQ	BC	3	DEP	2.25	16.6	79.8	1.6	18.6	1.4	0.06
8	AQ	BC	4	DEP	2.25	16.7	82.8	0.6	16.6	1.4	0.02
8	AQ	BC	5	DEP	0.9	15.2	87.6	1.0	11.4	1.2	0.01
8	AQ	BC	6	DEP	0.9	16.1	90.6	1.0	8.4	0.98	0.01
8	AQ	BC	7	DEP	1	15	92.6	1.0	6.4	1.0	0.02
8	AQ	BC	8	DEP	1	15	89.6	1.0	9.4	1.2	0.01
8	AQ	BC	9	CON	3.1	18.7	60.4	2.6	37.0	2.0	0.01
8	AQ	BC	10	CON	2.75	18	53.8	3.6	42.6	2.5	0.05
8	AQ	BC	11	CON	2.75	18.1	83.8	0.6	15.6	1.3	0.04
8	AQ	BC	12	CON	2.75	18.2	58.8	1.6	39.6	2.1	0.02
8	AQ	NS	1	DEP	1.1	15.1	77.4	0.0	22.6	2.0	0.03
8	AQ	NS	2	DEP	1.1	15.3	72.2	2.8	25.0	2.4	0.06
8	AQ	NS	3	DEP	1.1	15.4	79.2	1.8	19.0	1.7	0.05
8	AQ	NS	4	DEP	1.1	15.4	74.2	1.8	24.0	2.3	0.01
8	AQ	NS	5	DEP	1.25	16.3	74.2	1.8	24.0	2.2	0.11

Month	Industry	Site	Dredge	Zone	Depth (m)	Sedtemp (°C)	Sand (%)	Clay (%)	Silt (%)	C (%)	N (%)
8	AQ	NS	6	DEP	1.25	15.4	58.4	3.6	38.0	2.8	0.18
8	AQ	NS	7	DEP	1.25	15.4	60.4	3.6	36.0	2.8	0.16
8	AQ	NS	8	DEP	1.25	15.9	62.4	3.6	34.0	2.9	0.17
8	AQ	NS	9	CON	2.3	20	84.2	0.8	15.0	1.5	0.03
8	AQ	NS	10	CON	2.3	22.2	83.2	1.8	15.0	1.6	0.01
8	AQ	NS	12	CON	2.3	20.2	77.2	0.8	22.0	1.9	0.01
8	AQ	CS	1	DEP	2.7	18.3	80.8	0.6	18.6	1.5	0.01
8	AQ	CS	2	DEP	2.7	18.3	84.0	0.0	16.0	1.3	0.01
8	AQ	CS	3	DEP	2.7	18.2	84.0	1.0	15.0	1.4	0.03
8	AQ	CS	4	DEP	2.7	18.1	91.0	0.0	9.0	1.1	0.01
8	AQ	CS	5	DEP	2.6	18	63.0	2.0	35.0	2.8	0.06
8	AQ	CS	6	DEP	2.6	17.9	61.6	1.0	37.4	2.6	0.09
8	AQ	CS	7	DEP	2.6	18.1	61.6	2.0	36.4	2.6	0.07
8	AQ	CS	8	DEP	2.6	17.9	61.6	1.0	37.4	2.5	0.06
8	AQ	CS	9	CON	1.3	19.1	81.4	0.0	18.6	1.4	0.01
8	AQ	CS	10	CON	1.3	19	76.4	0.0	23.6	1.6	0.01
8	AQ	CS	11	CON	1.3	19.2	78.4	1.0	20.6	1.4	0.01
8	AQ	CS	12	CON	1.3	19.3	76.4	1.0	22.6	1.4	0.02
8	AG	AD1	1	DEP	1.5	19.3	74.2	0.8	25.0	1.4	0.02
8	AG	AD1	2	DEP	1.5	19.4	75.2	0.8	24.0	1.4	0.02
8	AG	AD1	3	DEP	1.5	19.5	76.2	0.8	23.0	1.3	0.01
8	AG	AD1	4	DEP	1.5	19.4	73.2	0.8	26.0	1.4	0.01
8	AG	AD1	5	DEP	1.8	19.8	38.4	7.6	54.0	1.8	0.01
8	AG	AD1	6	DEP	1.8	20	52.4	5.6	42.0	1.5	0.02
8	AG	AD1	7	DEP	1.8	20	65.2	1.8	33.0	1.3	0.02
8	AG	AD1	8	DEP	1.8	19.9	62.7	0.8	36.5	1.3	0.01
8	AG	AD1	9	CON	1.7	20	89.2	0.8	10.0	0.86	0.01
8	AG	AD1	10	CON	1.7	20	85.2	0.8	14.0	0.98	0.01
8	AG	AD1	11	CON	1.7	20.3	86.2	0.8	13.0	0.96	0.01
8	AG	AD1	12	CON	1.7	19.7	91.2	0.8	8.0	0.77	0.01
8	AG	AD2	1	DEP	2.5	19.3	86.2	0.8	13.0	1.2	0.01
8	AG	AD2	2	DEP	2.5	19.2	86.6	1.0	12.4	1.2	0.02

Month	Industry	Site	Dredge	Zone	Depth (m)	Sedtemp (°C)	Sand (%)	Clay (%)	Silt (%)	C (%)	N (%)
8	AG	AD2	3	DEP	2.5	19.2	83.6	1.0	15.4	1.3	0.02
8	AG	AD2	4	DEP	2.5	19.2	88.6	0.4	11.0	1.4	0.03
8	AG	AD2	5	DEP	2.75	19.3	90.6	0.4	9.0	0.96	0.01
8	AG	AD2	6	DEP	2.75	19.3	86.6	1.4	12.0	1.2	0.01
8	AG	AD2	7	DEP	2.75	19.5	91.6	1.4	7.0	1.0	0.01
8	AG	AD2	8	DEP	2.75	19.4	89.6	1.4	9.0	1.1	0.01
8	AG	AD2	9	CON	1.9	19.8	73.2	2.8	24.0	1.4	0.01
8	AG	AD2	10	CON	1.9	19.8	77.2	2.8	20.0	1.2	0.02
8	AG	AD2	11	CON	1.9	20.5	67.2	2.8	30.0	1.5	0.04
8	AG	AD2	12	CON	1.9	20.2	78.6	2.4	19.0	1.2	0.04
8	AG	AD3	1	DEP	2.4	17.7	83.6	2.4	14.0	1.3	0.01
8	AG	AD3	2	DEP	2.4	17.5	84.6	2.4	13.0	1.3	0.01
8	AG	AD3	3	DEP	2.4	17.6	89.6	1.4	9.0	0.84	0.01
8	AG	AD3	4	DEP	2.4	17.6	93.6	1.4	5.0	0.70	0.01
8	AG	AD3	5	DEP	0.75	19	94.6	1.4	4.0	0.60	0.01
8	AG	AD3	6	DEP	0.75	18.9	92.6	1.4	6.0	0.62	0.02
8	AG	AD3	7	DEP	0.75	19.5	88.6	1.4	10.0	0.88	0.01
8	AG	AD3	8	DEP	0.75	19.6	92.6	1.4	6.0	0.57	0.02
8	AG	AD3	9	CON	2.25	19.9	43.2	4.8	52.0	2.0	0.08
8	AG	AD3	10	CON	2.25	20.1	47.2	4.8	48.0	2.0	0.02
8	AG	AD3	11	CON	2.25	19.9	53.2	2.8	44.0	1.7	0.06
8	AG	AD3	12	CON	2.25	20.2	49.2	2.8	48.0	1.7	0.04
9	AQ	BC	1	DEP	2	14.8	51.2	6.8	42.0	2.6	0.15
9	AQ	BC	2	DEP	2	14.9	49.2	6.8	44.0	3.1	0.20
9	AQ	BC	3	DEP	2	15.1	45.2	6.8	48.0	2.8	0.15
9	AQ	BC	4	DEP	2	15.1	47.2	6.8	46.0	3.0	0.15
9	AQ	BC	5	DEP	1	15.1	93.6	1.4	5.0	1.0	0.05
9	AQ	BC	6	DEP	1	15.1	92.6	1.4	6.0	1.0	0.08
9	AQ	BC	7	DEP	1	15.2	89.0	0.8	10.2	1.1	0.09
9	AQ	BC	8	DEP	1	15.5	90.0	0.8	9.2	0.99	0.09
9	AQ	BC	9	CON	2.8	16.2	54.0	3.6	42.4	2.1	0.07
9	AQ	BC	10	CON	2.8	16.2	52.0	3.6	44.4	2.4	0.10

Month	Industry	Site	Dredge	Zone	Depth (m)	Sedtemp (°C)	Sand (%)	Clay (%)	Silt (%)	C (%)	N (%)
9	AQ	BC	11	CON	2.8	16.2	54.0	3.6	42.4	2.4	0.09
9	AQ	BC	12	CON	2.8	16.1	54.0	3.6	42.4	1.9	0.07
9	AQ	NS	1	DEP	1	14.7	54.0	1.6	44.4	3.2	0.16
9	AQ	NS	2	DEP	1	14.8	68.0	1.6	30.4	2.2	0.11
9	AQ	NS	3	DEP	1	15.3	60.0	1.6	38.4	2.0	0.08
9	AQ	NS	4	DEP	1	15.2	54.0	3.6	42.4	2.7	0.09
9	AQ	NS	5	DEP	1	15.3	72.0	3.6	24.4	2.0	0.08
9	AQ	NS	6	DEP	1	15.3	85.0	1.0	14.0	1.5	0.05
9	AQ	NS	7	DEP	1	15.7	86.0	0.8	13.2	1.7	0.08
9	AQ	NS	8	DEP	1	15.7	87.0	0.8	12.2	1.5	0.11
9	AQ	NS	9	CON	2.3	17.3	56.0	3.6	40.4	2.4	0.12
9	AQ	NS	10	CON	2.3	17.1	62.0	1.6	36.4	2.1	0.09
9	AQ	NS	11	CON	2.3	16.9	66.0	1.6	32.4	2.0	0.10
9	AQ	NS	12	CON	2.3	16.6	55.0	1.6	43.4	2.4	0.06
9	AQ	CS	1	DEP	2.25	15.9	64.0	1.6	34.4	1.7	0.06
9	AQ	CS	2	DEP	2.25	16	58.0	1.6	40.4	1.9	0.03
9	AQ	CS	3	DEP	2.25	16	56.0	1.6	42.4	2.0	0.07
9	AQ	CS	4	DEP	2.25	16.1	55.0	0.6	44.4	1.9	0.07
9	AQ	CS	5	DEP	2	15.6	64.0	3.0	33.0	2.6	0.15
9	AQ	CS	6	DEP	2	15.7	61.1	2.2	36.7	2.3	0.10
9	AQ	CS	7	DEP	2	15.7	60.0	1.6	38.4	2.5	0.14
9	AQ	CS	8	DEP	2	15.6	56.0	1.6	42.4	2.7	0.16
9	AQ	CS	9	CON	1.5	17.4	94.0	1.8	4.2	0.65	0.01
9	AQ	CS	10	CON	1.5	17.4	96.0	0.8	3.2	0.59	0.03
9	AQ	CS	11	CON	1.5	17.4	94.0	0.8	5.2	0.60	0.03
9	AQ	CS	12	CON	1.5	17.3	96.0	0.8	3.2	0.53	0.04
9	AG	AD1	1	DEP	1	16.7	66.0	1.6	32.4	1.2	0.03
9	AG	AD1	2	DEP	1	16.9	73.0	1.0	26.0	1.2	0.03
9	AG	AD1	3	DEP	1	17	74.0	1.6	24.4	1.1	0.01
9	AG	AD1	4	DEP	1	17.4	72.0	1.6	26.4	1.1	0.02
9	AG	AD1	5	DEP	1.25	17.3	70.0	1.6	28.4	1.2	0.01
9	AG	AD1	6	DEP	1.25	17.4	69.2	1.2	29.6	1.2	0.01

Month	Industry	Site	Dredge	Zone	Depth (m)	Sedtemp (°C)	Sand (%)	Clay (%)	Silt (%)	C (%)	N (%)
9	AG	AD1	7	DEP	1.25	17.3	75.2	1.2	23.6	1.3	0.01
9	AG	AD1	8	DEP	1.25	17.1	73.2	1.2	25.6	1.4	0.01
9	AG	AD1	9	CON	2	17.1	93.6	0.8	5.6	0.62	0.01
9	AG	AD1	10	CON	2	17	93.6	0.8	5.6	0.76	0.01
9	AG	AD1	11	CON	2	16.9	95.6	0.8	3.6	0.74	0.01
9	AG	AD1	12	CON	2	16.7	95.6	0.8	3.6	0.66	0.01
9	AG	AD2	1	DEP	2	15.8	87.2	1.6	11.2	1.2	0.01
9	AG	AD2	2	DEP	2	16.3	89.6	0.8	9.6	1.1	0.01
9	AG	AD2	3	DEP	2	16.1	88.6	0.8	10.6	1.2	0.01
9	AG	AD2	4	DEP	2	16.4	89.6	0.8	9.6	1.0	0.01
9	AG	AD2	5	DEP	2.5	16.6	86.6	0.8	12.6	1.2	0.01
9	AG	AD2	6	DEP	2.5	15.8	90.6	0.8	8.6	1.0	0.01
9	AG	AD2	7	DEP	2.5	15.8	89.6	0.8	9.6	1.0	0.01
9	AG	AD2	8	DEP	2.5	16	87.6	0.8	11.6	0.94	0.01
9	AG	AD2	9	CON	1.85	17.5	73.2	1.6	25.2	1.4	0.01
9	AG	AD2	10	CON	1.85	16.1	75.2	1.6	23.2	1.5	0.03
9	AG	AD2	11	CON	1.85	16.9	75.2	1.6	23.2	1.3	0.01
9	AG	AD2	12	CON	1.85	17.4	79.2	1.6	19.2	1.3	0.01
9	AG	AD3	1	DEP	2.25	15.5	33.2	5.6	61.2	2.3	0.06
9	AG	AD3	2	DEP	2.25	15.9	51.2	5.6	43.2	2.3	0.02
9	AG	AD3	3	DEP	2.25	16	37.2	5.6	57.2	2.4	0.06
9	AG	AD3	4	DEP	2.25	16	68.2	2.6	29.2	1.7	0.02
9	AG	AD3	5	DEP	1.5	16.2	98.6	0.8	0.6	0.42	0.01
9	AG	AD3	6	DEP	1.5	16.5	97.6	0.8	1.6	0.51	0.01
9	AG	AD3	7	DEP	1.5	16.2	91.6	1.8	6.6	0.57	0.01
9	AG	AD3	8	DEP	1.5	16.5	93.6	1.8	4.6	0.54	0.01
9	AG	AD3	9	CON	2.25	17	81.6	1.8	16.6	0.96	0.01
9	AG	AD3	10	CON	2.25	17	81.6	1.8	16.6	1.1	0.01
9	AG	AD3	11	CON	2.25	16.8	63.2	3.6	33.2	1.5	0.01
9	AG	AD3	12	CON	2.25	16.8	70.0	6.0	24.0	1.1	0.01
10	AQ	BC	1	DEP	2	13.5	80.0	2.0	18.0	1.6	0.01
10	AQ	BC	2	DEP	2	13.5	74.0	4.0	22.0	1.9	0.07

Month	Industry	Site	Dredge	Zone	Depth (m)	Sedtemp (°C)	Sand (%)	Clay (%)	Silt (%)	C (%)	N (%)
10	AQ	BC	3	DEP	2	13.5	78.0	2.0	20.0	1.6	0.03
10	AQ	BC	4	DEP	2	13.5	78.0	4.0	18.0	2.0	0.03
10	AQ	BC	5	DEP	1	13.5	93.0	1.0	6.0	0.75	0.01
10	AQ	BC	6	DEP	1	13.5	94.0	1.0	5.0	0.74	0.01
10	AQ	BC	7	DEP	1	13.5	93.0	1.0	6.0	0.88	0.03
10	AQ	BC	8	DEP	1	13.5	92.0	1.0	7.0	0.85	0.01
10	AQ	BC	9	CON	2.5	14.5	58.0	6.0	36.0	2.4	0.01
10	AQ	BC	10	CON	2.5	13.5	70.0	4.0	26.0	2.0	0.02
10	AQ	BC	11	CON	2.5	13.5	56.0	4.0	40.0	2.4	0.05
10	AQ	NS	1	DEP	0.75	12	50.0	4.0	46.0	2.2	0.07
10	AQ	NS	2	DEP	0.75	12	56.0	2.0	42.0	1.8	0.03
10	AQ	NS	3	DEP	0.75	12.5	56.0	2.0	42.0	1.5	0.01
10	AQ	NS	4	DEP	0.75	12.4	58.0	4.0	38.0	1.7	0.03
10	AQ	NS	5	DEP	0.65	11.6	52.0	4.0	44.0	2.5	0.04
10	AQ	NS	6	DEP	0.65	12.1	61.2	2.3	36.5	2.0	0.04
10	AQ	NS	7	DEP	0.65	12.1	67.7	1.8	30.5	2.1	0.02
10	AQ	NS	8	DEP	0.65	12.5	66.2	2.3	31.5	2.1	0.04
10	AQ	NS	9	CON	2	14.5	78.2	1.8	20.0	1.9	0.02
10	AQ	NS	10	CON	2	14.5	77.7	1.8	20.5	1.7	0.02
10	AQ	NS	11	CON	2	13.2	80.2	1.3	18.5	1.5	0.01
10	AQ	NS	12	CON	2	13.5	66.7	1.8	31.5	2.4	0.01
10	AQ	CS	1	DEP	3.5	11.2	66.0	2.0	32.0	1.7	0.01
10	AQ	CS	2	DEP	3.5	11.6	66.0	2.0	32.0	1.8	0.01
10	AQ	CS	3	DEP	3.5	12.1	74.0	2.0	24.0	1.8	0.01
10	AQ	CS	4	DEP	3.5	11.5	74.0	2.0	24.0	1.7	0.01
10	AQ	CS	5	DEP	2.5	12	76.0	2.0	22.0	1.5	0.03
10	AQ	CS	6	DEP	2.5	12.3	74.0	2.0	24.0	1.6	0.04
10	AQ	CS	7	DEP	2.5	12.1	78.0	2.0	20.0	1.6	0.05
10	AQ	CS	8	DEP	2.5	12.1	81.0	1.0	18.0	1.3	0.01
10	AQ	CS	9	CON	2.5	12.1	93.0	1.0	6.0	0.50	0.01
10	AQ	CS	10	CON	2.5	12.1	92.0	1.0	7.0	0.70	0.02
10	AQ	CS	11	CON	2.5	12.1	95.0	0.0	5.0	0.56	0.01

Month	Industry	Site	Dredge	Zone	Depth (m)	Sedtemp (°C)	Sand (%)	Clay (%)	Silt (%)	C (%)	N (%)
10	AQ	CS	12	CON	2.5	12.1	93.0	0.0	7.0	0.54	0.01
10	AG	AD1	1	DEP	1.75	12.1	69.7	2.5	27.8	1.4	0.02
10	AG	AD1	2	DEP	1.75	12.1	64.0	5.5	30.5	1.9	0.01
10	AG	AD1	3	DEP	1.75	12.1	71.8	3.0	25.2	1.4	0.01
10	AG	AD1	4	DEP	1.75	12.1	80.0	1.0	19.0	1.2	0.01
10	AG	AD1	5	DEP	2.1	12	36.0	5.0	59.0	1.9	0.01
10	AG	AD1	6	DEP	2.1	12	67.3	2.0	30.7	1.3	0.01
10	AG	AD1	7	DEP	2.1	12	55.6	2.0	42.4	1.6	0.01
10	AG	AD1	8	DEP	2.1	11.6	71.8	1.2	27.0	1.3	0.01
10	AG	AD1	9	CON	2.5	11.6	87.8	1.7	10.5	0.97	0.01
10	AG	AD1	11	CON	2.5	11.4	93.2	0.8	6.0	0.75	0.01
10	AG	AD1	12	CON	2.5	11.5	86.8	0.2	13.0	0.85	0.01
10	AG	AD2	1	DEP	1.75	11.1	86.0	0.2	13.8	1.3	0.01
10	AG	AD2	2	DEP	1.75	11.6	85.8	1.2	13.0	1.2	0.01
10	AG	AD2	3	DEP	1.75	11.1	87.8	1.2	11.0	1.2	0.01
10	AG	AD2	4	DEP	1.75	11.4	79.6	2.4	18.0	1.5	0.01
10	AG	AD2	5	DEP	2.5	11.3	88.8	0.2	11.0	1.1	0.01
10	AG	AD2	6	DEP	2.5	11.5	86.8	1.2	12.0	1.2	0.01
10	AG	AD2	7	DEP	2.5	11.2	90.2	0.8	9.0	0.93	0.01
10	AG	AD2	8	DEP	2.5	11.1	90.8	0.7	8.5	0.90	0.01
10	AG	AD2	9	CON	2	11.2	90.8	1.2	8.0	0.85	0.01
10	AG	AD2	10	CON	2	12.1	87.3	1.2	11.5	0.84	0.01
10	AG	AD2	11	CON	2	12.1	88.3	1.2	10.5	0.87	0.01
10	AG	AD2	12	CON	2	12.1	92.8	1.2	6.0	0.77	0.01
10	AG	AD3	1	DEP	1.75	11.2	82.3	0.2	17.5	1.1	0.01
10	AG	AD3	2	DEP	1.75	11.2	83.8	1.2	15.0	0.93	0.01
10	AG	AD3	3	DEP	1.75	11.2	81.3	1.2	17.5	1.2	0.01
10	AG	AD3	4	DEP	1.75	11.2	88.8	0.7	10.5	0.85	0.01
10	AG	AD3	5	DEP	2.4	10.9	80.6	1.2	18.2	1.1	0.01
10	AG	AD3	6	DEP	2.4	10.9	86.0	0.0	14.0	1.0	0.01
10	AG	AD3	7	DEP	2.4	11	87.0	1.0	12.0	1.1	0.01
10	AG	AD3	8	DEP	2.4	11	87.0	1.0	12.0	1.1	0.01

Month	Industry	Site	Dredge	Zone	Depth (m)	Sedtemp (°C)	Sand (%)	Clay (%)	Silt (%)	C (%)	N (%)
10	AG	AD3	9	CON	2.5	10.5	87.0	1.0	12.0	1.4	0.01
10	AG	AD3	10	CON	2.5	10.9	86.0	1.0	13.0	1.1	0.01
10	AG	AD3	11	CON	2.5	11	88.0	1.0	11.0	1.2	0.01
10	AG	AD3	12	CON	2.5	11.1	81.0	1.0	18.0	1.1	0.01

Month	Industry	Site	Dredge	Zone	Ca (µg·g^{-1})	Mg (µg·g^{-1})	K (µg·g^{-1})	Na (µg·g^{-1})	Zn (µg·g^{-1})	Mn (µg·g^{-1})	Cu (µg·g^{-1})
6	AQ	BC	1	DEP	22000	4200	1500	440	60	160	17
6	AQ	BC	2	DEP	32000	5400	2100	500	68	180	24
6	AQ	BC	3	DEP	26000	4900	1500	420	65	170	20
6	AQ	BC	4	DEP	29000	4800	1600	440	60	160	19
6	AQ	BC	5	DEP	18000	4000	1200	460	53	150	16
6	AQ	BC	6	DEP	18000	3800	1200	470	50	150	15
6	AQ	BC	7	DEP	20000	4000	130	480	58	160	17
6	AQ	BC	8	DEP	18000	3700	1200	500	52	170	16
6	AQ	BC	9	CON	51000	9000	4200	530	80	450	32
6	AQ	BC	10	CON	39000	7300	3200	490	58	280	19
6	AQ	BC	11	CON	45000	8600	4100	500	69	390	25
6	AQ	BC	12	CON	39000	7800	3600	520	64	370	23
6	AQ	NS	1	DEP	50000	5800	2400	490	56	160	16
6	AQ	NS	2	DEP	47000	5400	2100	460	57	150	16
6	AQ	NS	3	DEP	51000	6000	2600	500	60	170	17
6	AQ	NS	4	DEP	49000	5900	2300	490	57	160	17
6	AQ	NS	5	DEP	41000	5700	2300	500	62	190	15
6	AQ	NS	6	DEP	48000	5500	2300	510	72	180	17
6	AQ	NS	7	DEP	38000	4500	1800	470	60	160	14
6	AQ	NS	8	DEP	43000	4900	1900	510	63	180	15
6	AQ	NS	9	CON	37000	3400	1400	590	34	160	11
6	AQ	NS	10	CON	15000	1600	690	210	32	110	10
6	AQ	NS	11	CON	21000	2100	920	380	22	100	7.5
6	AQ	NS	12	CON	23000	3400	1200	410	29	120	9.7
6	AQ	CS	1	DEP	33000	5600	1900	410	47	170	15
6	AQ	CS	2	DEP	31000	4900	1800	400	45	160	15
6	AQ	CS	3	DEP	38000	6400	2500	430	56	190	18
6	AQ	CS	4	DEP	33000	5900	2100	440	49	180	16
6	AQ	CS	5	DEP	39000	5700	2100	440	64	170	18
6	AQ	CS	6	DEP	43000	6500	2400	470	71	180	20
6	AQ	CS	7	DEP	42000	6100	2400	480	72	180	19
6	AQ	CS	8	DEP	40000	5900	2300	450	69	190	18

Month	Industry	Site	Dredge	Zone	Ca (µg·g^{-1})	Mg (µg·g^{-1})	K (µg·g^{-1})	Na (µg·g^{-1})	Zn (µg·g^{-1})	Mn (µg·g^{-1})	Cu (µg·g^{-1})
6	AQ	CS	9	CON	26000	4600	1700	400	40	180	13
6	AQ	CS	10	CON	27000	4800	1800	390	41	180	12
6	AQ	CS	11	CON	23000	4200	1500	380	40	170	11
6	AQ	CS	12	CON	25000	4300	1600	380	38	170	12
6	AG	AD1	1	DEP	29000	5100	1900	470	41	230	13
6	AG	AD1	2	DEP	30000	5600	2100	500	47	230	12
6	AG	AD1	3	DEP	30000	5500	2100	490	43	230	12
6	AG	AD1	4	DEP	31000	5300	1900	450	41	240	12
6	AG	AD1	5	DEP	27000	6400	2400	570	44	240	15
6	AG	AD1	6	DEP	26000	6600	2400	560	44	230	15
6	AG	AD1	7	DEP	27000	6600	2400	550	44	240	15
6	AG	AD1	8	DEP	27000	6600	2300	580	43	240	14
6	AG	AD1	9	CON	25000	4400	1600	450	36	150	11
6	AG	AD1	10	CON	23000	3900	1400	470	34	150	9.6
6	AG	AD1	11	CON	23000	4200	1600	500	40	150	11
6	AG	AD1	12	CON	25000	4400	1600	500	37	150	11
6	AG	AD2	1	DEP	24000	4000	1500	440	34	150	9.7
6	AG	AD2	2	DEP	24000	4000	1400	440	34	150	8.8
6	AG	AD2	3	DEP	24000	4100	1400	450	33	150	14
6	AG	AD2	4	DEP	23000	4000	1400	420	33	150	8.6
6	AG	AD2	5	DEP	25000	4300	1500	440	33	160	9.7
6	AG	AD2	6	DEP	28000	4600	1600	460	37	170	11
6	AG	AD2	7	DEP	24000	4200	1200	380	41	160	11
6	AG	AD2	8	DEP	23000	4300	1200	370	36	150	8.2
6	AG	AD2	9	CON	33000	5700	2100	410	49	200	19
6	AG	AD2	10	CON	34000	5900	2000	410	49	200	14
6	AG	AD2	11	CON	34000	5800	2000	400	47	200	14
6	AG	AD2	12	CON	26000	4700	1400	350	40	180	11
6	AG	AD3	1	DEP	25000	5100	1600	380	41	150	11
6	AG	AD3	2	DEP	22000	4400	1300	340	37	150	9.5
6	AG	AD3	3	DEP	23000	4600	1500	380	37	160	10
6	AG	AD3	4	DEP	29000	5500	1900	410	43	180	14

Month	Industry	Site	Dredge	Zone	Ca (µg·g^{-1})	Mg (µg·g^{-1})	K (µg·g^{-1})	Na (µg·g^{-1})	Zn (µg·g^{-1})	Mn (µg·g^{-1})	Cu (µg·g^{-1})
6	AG	AD3	5	DEP	19000	3700	1400	370	40	160	9.7
6	AG	AD3	6	DEP	17000	3200	1100	350	36	140	8.3
6	AG	AD3	8	DEP	18000	3500	1100	360	38	150	9.4
6	AG	AD3	9	CON	42000	6200	2600	620	57	280	21
6	AG	AD3	10	CON	31000	6600	2300	660	52	220	17
6	AG	AD3	11	CON	31000	6500	2700	520	54	220	18
6	AG	AD3	12	CON	34000	6500	2900	580	57	220	18
7	AQ	BC	1	DEP	26000	4900	1500	580	69	190	18
7	AQ	BC	2	DEP	38000	6900	2800	560	75	220	26
7	AQ	BC	3	DEP	31000	5800	2000	490	73	180	24
7	AQ	BC	4	DEP	28000	5400	1800	530	72	170	22
7	AQ	BC	5	DEP	25000	4300	1300	480	57	160	16
7	AQ	BC	6	DEP	22000	4200	1200	470	55	150	16
7	AQ	BC	7	DEP	23000	4000	1200	440	54	160	15
7	AQ	BC	8	DEP	28000	4700	1600	500	64	170	19
7	AQ	BC	9	CON	35000	5900	2200	510	47	190	14
7	AQ	BC	10	CON	33000	6000	2100	510	46	190	13
7	AQ	BC	11	CON	36000	5900	2200	480	48	200	15
7	AQ	BC	12	CON	39000	5900	2500	500	52	220	18
7	AQ	NS	1	DEP	39000	4700	1600	400	44	240	12
7	AQ	NS	2	DEP	44000	5500	2000	410	53	150	15
7	AQ	NS	3	DEP	47000	5800	2100	430	59	160	17
7	AQ	NS	4	DEP	46000	6200	2400	470	48	180	17
7	AQ	NS	5	DEP	46000	5500	1900	440	55	150	16
7	AQ	NS	6	DEP	40000	5200	1900	420	54	150	15
7	AQ	NS	7	DEP	38000	5400	2000	410	52	140	15
7	AQ	NS	8	DEP	35000	4700	1400	360	47	140	13
7	AQ	NS	9	CON	34000	4800	1500	390	40	140	12
7	AQ	NS	10	CON	35000	4800	1500	430	39	150	12
7	AQ	NS	11	CON	36000	4900	1600	430	38	150	12
7	AQ	NS	12	CON	37000	5200	1700	420	39	150	13
7	AQ	CS	1	DEP	32000	5000	1600	410	45	160	12

Month	Industry	Site	Dredge	Zone	Ca (µg·g^{-1})	Mg (µg·g^{-1})	K (µg·g^{-1})	Na (µg·g^{-1})	Zn (µg·g^{-1})	Mn (µg·g^{-1})	Cu (µg·g^{-1})
7	AQ	CS	2	DEP	30000	4400	1500	390	44	160	11
7	AQ	CS	3	DEP							
7	AQ	CS	4	DEP	32000	4800	1700	410	47	170	12
7	AQ	CS	5	DEP	36000	5700	1900	390	61	180	16
7	AQ	CS	6	DEP	32000	5300	1800	380	56	170	15
7	AQ	CS	7	DEP	30000	5200	1700	380	54	160	14
7	AQ	CS	8	DEP	29000	5100	1700	380	55	160	14
7	AQ	CS	9	CON	19000	3200	1100	300	31	110	8.7
7	AQ	CS	10	CON	19000	3200	1100	320	31	110	8.9
7	AQ	CS	11	CON	19000	3100	1000	330	30	110	8.9
7	AQ	CS	12	CON	21000	3500	1200	320	33	120	9.7
7	AG	AD1	1	DEP	31000	6000	2000	410	44	200	13
7	AG	AD1	2	DEP	40000	7800	3100	450	60	300	18
7	AG	AD1	3	DEP	32000	6400	2300	440	44	220	14
7	AG	AD1	4	DEP	30000	5900	1900	420	39	190	13
7	AG	AD1	5	DEP	24000	6300	2200	430	40	200	14
7	AG	AD1	6	DEP	24000	6700	2400	440	44	220	14
7	AG	AD1	7	DEP	24000	5900	2000	430	40	210	12
7	AG	AD1	8	DEP	24000	5900	1900	390	39	200	13
7	AG	AD1	9	CON	21000	4300	1300	410	36	140	10
7	AG	AD1	10	CON	20000	4300	1300	410	36	140	10
7	AG	AD1	11	CON	22000	4500	1500	390	37	140	11
7	AG	AD1	12	CON	21000	4100	1400	370	38	140	11
7	AG	AD2	1	DEP	27000	4400	1500	410	36	160	11
7	AG	AD2	2	DEP	26000	5100	2200	560	43	170	13
7	AG	AD2	3	DEP	29000	5100	2100	550	40	170	10
7	AG	AD2	4	DEP	28000	5400	2300	560	41	180	11
7	AG	AD2	5	DEP	24000	5000	2000	530	37	160	9.6
7	AG	AD2	6	DEP	24000	4800	2000	520	38	160	11
7	AG	AD2	7	DEP	26000	5100	1800	450	37	170	10
7	AG	AD2	8	DEP	27000	5000	1800	510	37	170	9.3
7	AG	AD2	9	CON	30000	6100	2500	550	45	190	13

Month	Industry	Site	Dredge	Zone	Ca (μg·g^{-1})	Mg (μg·g^{-1})	K (μg·g^{-1})	Na (μg·g^{-1})	Zn (μg·g^{-1})	Mn (μg·g^{-1})	Cu (μg·g^{-1})
7	AG	AD2	10	CON	32000	6500	3100	580	49	200	15
7	AG	AD2	11	CON	33000	6500	3100	550	49	190	15
7	AG	AD2	12	CON	32000	6500	2500	670	50	200	17
7	AG	AD3	1	DEP	30000	6600	2600	610	47	190	15
7	AG	AD3	2	DEP	27000	5700	2200	600	44	170	12
7	AG	AD3	3	DEP	25000	5500	2100	630	43	160	13
7	AG	AD3	4	DEP	26000	6000	2600	610	43	170	15
7	AG	AD3	5	DEP	17000	3700	1600	550	39	150	10
7	AG	AD3	6	DEP	17000	3900	1700	550	37	150	11
7	AG	AD3	7	DEP	18000	3700	1400	420	37	140	10
7	AG	AD3	8	DEP	17000	3600	1600	520	36	150	11
7	AG	AD3	9	CON	36000	20000	3900	3900	80	590	35
7	AG	AD3	10	CON	34000	18000	3400	3200	75	530	32
7	AG	AD3	11	CON	34000	15000	3000	2400	66	430	26
7	AG	AD3	12	CON	31000	13000	3300	2000	65	390	23
8	AQ	BC	1	DEP	23000	4900	2000	540	73	180	25
8	AQ	BC	2	DEP	39000	8500	3800	480	60	300	17
8	AQ	BC	3	DEP	24000	5300	2000	570	76	190	25
8	AQ	BC	4	DEP	23000	5500	2200	620	63	180	25
8	AQ	BC	5	DEP	24000	4600	1800	550	57	160	16
8	AQ	BC	6	DEP	20000	4200	1600	540	51	150	16
8	AQ	BC	7	DEP	20000	4200	1500	580	53	150	17
8	AQ	BC	8	DEP	22000	4700	1600	560	58	160	19
8	AQ	BC	9	CON	35000	6900	2800	500	53	250	17
8	AQ	BC	10	CON	36000	6900	3300	480	56	250	17
8	AQ	BC	11	CON	24000	5400	2100	600	65	180	19
8	AQ	BC	12	CON	36000	6900	3200	510	52	250	14
8	AQ	NS	1	DEP	36000	5200	2300	450	51	140	11
8	AQ	NS	2	DEP	40000	5300	2300	460	50	140	13
8	AQ	NS	3	DEP	31000	4800	2100	440	50	130	10
8	AQ	NS	4	DEP	41000	5300	2300	460	51	140	12
8	AQ	NS	5	DEP	38000	5600	2400	480	57	160	12

Month	Industry	Site	Dredge	Zone	Ca (µg·g^{-1})	Mg (µg·g^{-1})	K (µg·g^{-1})	Na (µg·g^{-1})	Zn (µg·g^{-1})	Mn (µg·g^{-1})	Cu (µg·g^{-1})
8	AQ	NS	6	DEP	46000	6500	3000	510	74	190	17
8	AQ	NS	7	DEP	42000	6100	2700	480	69	180	15
8	AQ	NS	8	DEP	42000	6000	2600	550	69	210	15
8	AQ	NS	9	CON	37000	5000	1900	510	36	150	9.6
8	AQ	NS	10	CON	40000	5500	2000	540	41	160	12
8	AQ	NS	12	CON	39000	6100	2300	520	39	150	12
8	AQ	CS	1	DEP	28000	4600	1900	410	41	180	12
8	AQ	CS	2	DEP	26000	4300	1900	410	44	170	11
8	AQ	CS	3	DEP	26000	3900	1800	360	43	160	9.2
8	AQ	CS	4	DEP	22000	3400	1600	400	40	150	7.8
8	AQ	CS	5	DEP	38000	6300	2900	480	72	170	18
8	AQ	CS	6	DEP	39000	6400	2800	460	70	170	18
8	AQ	CS	7	DEP	40000	6700	2900	480	69	170	18
8	AQ	CS	8	DEP	37000	6000	2800	450	65	160	15
8	AQ	CS	9	CON	27000	4200	2000	430	40	140	12
8	AQ	CS	10	CON	31000	5000	2100	430	41	160	10
8	AQ	CS	11	CON	29000	5000	2200	450	41	160	12
8	AQ	CS	12	CON	25000	4600	2400	420	47	140	11
8	AG	AD1	1	DEP	29000	6100	2300	490	39	180	12
8	AG	AD1	2	DEP	30000	6100	2400	530	40	190	12
8	AG	AD1	3	DEP	29000	5700	2200	490	40	180	12
8	AG	AD1	4	DEP	29000	6200	2500	520	41	190	12
8	AG	AD1	5	DEP	35000	9100	3900	570	58	280	18
8	AG	AD1	6	DEP	32000	7600	3300	590	54	260	16
8	AG	AD1	7	DEP	28000	6900	2800	580	46	220	13
8	AG	AD1	8	DEP	29000	7400	3000	580	47	230	14
8	AG	AD1	9	CON	24000	4600	1900	600	37	150	10
8	AG	AD1	10	CON	27000	5100	2000	580	42	160	11
8	AG	AD1	11	CON	26000	4900	1900	590	40	150	10
8	AG	AD1	12	CON	24000	4500	1800	730	40	150	10
8	AG	AD2	1	DEP	30000	5600	2200	510	41	190	12
8	AG	AD2	2	DEP	30000	5900	2300	550	44	180	11

Month	Industry	Site	Dredge	Zone	Ca ($\mu g \cdot g^{-1}$)	Mg ($\mu g \cdot g^{-1}$)	K ($\mu g \cdot g^{-1}$)	Na ($\mu g \cdot g^{-1}$)	Zn ($\mu g \cdot g^{-1}$)	Mn ($\mu g \cdot g^{-1}$)	Cu ($\mu g \cdot g^{-1}$)
8	AG	AD2	3	DEP	34000	5700	2400	560	48	200	15
8	AG	AD2	4	DEP	30000	5700	2400	530	44	190	13
8	AG	AD2	5	DEP	30000	5300	2100	570	41	180	11
8	AG	AD2	6	DEP	31000	5700	2300	570	42	190	12
8	AG	AD2	7	DEP	29000	5400	2100	560	46	180	11
8	AG	AD2	8	DEP	30000	5700	2100	570	41	190	12
8	AG	AD2	9	CON	24000	4600	2100	470	48	190	15
8	AG	AD2	10	CON	25000	4700	2100	480	45	180	14
8	AG	AD2	11	CON	26000	5100	2400	560	45	190	14
8	AG	AD2	12	CON	23000	4300	1900	470	44	180	12
8	AG	AD3	1	DEP	25000	4700	1900	430	39	170	9.8
8	AG	AD3	2	DEP	24000	4400	1800	420	38	170	10
8	AG	AD3	3	DEP	18000	3600	1600	410	35	150	8.3
8	AG	AD3	4	DEP	17000	3000	1300	400	34	140	7.1
8	AG	AD3	5	DEP	14000	3000	1200	430	36	120	7.3
8	AG	AD3	6	DEP	18000	3400	1400	400	39	140	7.7
8	AG	AD3	7	DEP	21000	3800	1600	420	45	150	12
8	AG	AD3	8	DEP	16000	3100	1200	380	35	130	8.5
8	AG	AD3	9	CON	35000	7400	4000	590	60	240	22
8	AG	AD3	10	CON	35000	6700	3700	540	59	230	22
8	AG	AD3	11	CON	31000	6700	3400	570	56	220	19
8	AG	AD3	12	CON	31000	6600	3600	600	61	210	18
9	AQ	BC	1	DEP	41000	7600	3800	490	86	270	33
9	AQ	BC	2	DEP	43000	8100	4100	480	99	270	36
9	AQ	BC	3	DEP	43000	8300	4100	490	90	290	36
9	AQ	BC	4	DEP	44000	8200	4100	490	100	310	40
9	AQ	BC	5	DEP	23000	4800	1700	580	57	170	17
9	AQ	BC	6	DEP	22000	4600	1700	590	62	180	19
9	AQ	BC	7	DEP	23000	4800	1700	540	57	170	19
9	AQ	BC	8	DEP	20000	4700	1600	560	58	170	64
9	AQ	BC	9	CON	37000	7400	2900	470	55	220	18
9	AQ	BC	10	CON	40000	7700	3100	490	59	250	19

Month	Industry	Site	Dredge	Zone	Ca (μg·g^{-1})	Mg (μg·g^{-1})	K (μg·g^{-1})	Na (μg·g^{-1})	Zn (μg·g^{-1})	Mn (μg·g^{-1})	Cu (μg·g^{-1})
9	AQ	BC	11	CON	47000	8800	3500	500	78	310	26
9	AQ	BC	12	CON	38000	7500	3100	520	55	250	17
9	AQ	NS	1	DEP	47000	5800	3000	460	56	160	16
9	AQ	NS	2	DEP	38000	5700	2800	420	52	150	14
9	AQ	NS	3	DEP	34000	6200	3000	470	51	150	14
9	AQ	NS	4	DEP	43000	6900	3300	460	59	160	17
9	AQ	NS	5	DEP	36000	5500	2400	470	48	150	11
9	AQ	NS	6	DEP	31000	4800	2000	440	50	140	9.6
9	AQ	NS	7	DEP	31000	5000	2300	470	48	140	11
9	AQ	NS	8	DEP	31000	4900	2100	470	53	160	10
9	AQ	NS	9	CON	41000	6900	3000	480	50	180	15
9	AQ	NS	10	CON	40000	6800	2700	500	45	180	13
9	AQ	NS	11	CON	40000	7000	2800	470	45	190	14
9	AQ	NS	12	CON	40000	6600	2700	440	52	190	17
9	AQ	CS	1	DEP	34000	6200	2600	460	50	190	14
9	AQ	CS	2	DEP	35000	6900	2600	450	51	200	14
9	AQ	CS	3	DEP	37000	7200	2700	440	55	210	15
9	AQ	CS	4	DEP	35000	7000	2600	440	51	190	14
9	AQ	CS	5	DEP	42000	6400	2800	440	68	180	18
9	AQ	CS	6	DEP	37000	6400	3000	450	150	250	56
9	AQ	CS	7	DEP	35000	6200	2800	420	67	170	19
9	AQ	CS	8	DEP	35000	6300	2900	430	83	200	47
9	AQ	CS	9	CON	15000	3000	1200	350	34	120	11
9	AQ	CS	10	CON	14000	2900	1300	360	36	120	7.7
9	AQ	CS	11	CON	17000	3200	1300	400	35	130	8.1
9	AQ	CS	12	CON	15000	3100	1200	360	34	130	7.1
9	AG	AD1	1	DEP	24000	5500	2200	460	48	230	14
9	AG	AD1	2	DEP	22000	5200	2100	440	46	210	13
9	AG	AD1	3	DEP	23000	5600	2300	510	50	240	15
9	AG	AD1	4	DEP	22000	5200	2300	470	52	210	14
9	AG	AD1	5	DEP	27000	6000	2500	510	45	240	15
9	AG	AD1	6	DEP	27000	6000	2400	490	43	230	15

Month	Industry	Site	Dredge	Zone	Ca (μg·g^{-1})	Mg (μg·g^{-1})	K (μg·g^{-1})	Na (μg·g^{-1})	Zn (μg·g^{-1})	Mn (μg·g^{-1})	Cu (μg·g^{-1})
9	AG	AD1	7	DEP	26000	5600	2200	500	44	230	12
9	AG	AD1	8	DEP	27000	6100	2600	480	47	220	13
9	AG	AD1	9	CON	17000	3500	1400	520	33	120	7.6
9	AG	AD1	10	CON	18000	3700	1500	500	31	130	7.6
9	AG	AD1	11	CON	17000	3500	1400	500	33	120	7.2
9	AG	AD1	12	CON	17000	3400	1300	510	30	120	7.5
9	AG	AD2	1	DEP	25000	4600	1900	440	37	150	14
9	AG	AD2	2	DEP	25000	4200	1800	440	33	140	9.0
9	AG	AD2	3	DEP	26000	4600	1900	450	38	150	9.2
9	AG	AD2	4	DEP	25000	4600	2000	490	60	180	34
9	AG	AD2	5	DEP	31000	4800	2100	480	40	160	12
9	AG	AD2	6	DEP	24000	4400	1800	470	36	150	9.5
9	AG	AD2	7	DEP	26000	4300	1700	480	37	150	12
9	AG	AD2	8	DEP	24000	4500	1700	480	35	150	8.7
9	AG	AD2	9	CON	26000	4800	2200	480	46	170	15
9	AG	AD2	10	CON	23000	4300	2000	420	51	160	12
9	AG	AD2	11	CON	25000	4800	2200	470	42	170	12
9	AG	AD2	12	CON	22000	4500	2000	490	43	170	11
9	AG	AD3	1	DEP	32000	8100	4500	480	64	260	22
9	AG	AD3	2	DEP	39000	7100	3600	460	58	260	19
9	AG	AD3	3	DEP	36000	7500	4400	440	73	280	24
9	AG	AD3	4	DEP	31000	5700	2800	420	49	200	15
9	AG	AD3	5	DEP	12000	3100	1200	490	32	120	8.2
9	AG	AD3	6	DEP	14000	3200	1200	410	34	130	12
9	AG	AD3	7	DEP	13000	3200	1500	410	32	130	8.3
9	AG	AD3	8	DEP	13000	3200	1400	440	32	130	8.3
9	AG	AD3	9	CON	32000	16000	3600	3600	74	480	30
9	AG	AD3	10	CON	34000	14000	3000	2800	77	420	29
9	AG	AD3	11	CON	34000	10000	3800	1700	65	340	23
9	AG	AD3	12	CON	35000	14000	3700	3200	76	460	30
10	AQ	BC	1	DEP	31000	6300	2800	660	69	210	25
10	AQ	BC	2	DEP	31000	6400	2900	610	76	210	27

Month	Industry	Site	Dredge	Zone	Ca (µg·g^{-1})	Mg (µg·g^{-1})	K (µg·g^{-1})	Na (µg·g^{-1})	Zn (µg·g^{-1})	Mn (µg·g^{-1})	Cu (µg·g^{-1})
10	AQ	BC	3	DEP	29000	6000	2600	590	70	200	23
10	AQ	BC	4	DEP	35000	6700	2900	700	70	230	25
10	AQ	BC	5	DEP	19000	4000	1800	620	53	150	17
10	AQ	BC	6	DEP	19000	3900	1800	610	54	160	17
10	AQ	BC	7	DEP	19000	4100	1700	600	53	140	18
10	AQ	BC	8	DEP	19000	4000	1800	600	52	150	17
10	AQ	BC	9	CON	40000	7000	3500	530	59	230	19
10	AQ	BC	10	CON	37000	6400	3000	550	52	190	16
10	AQ	BC	11	CON	41000	7300	3700	560	66	250	21
10	AQ	NS	1	DEP	34000	6800	3000	420	100	160	17
10	AQ	NS	2	DEP	26000	6100	2600	420	47	140	13
10	AQ	NS	3	DEP	26000	6200	2700	420	67	160	14
10	AQ	NS	4	DEP	30000	5700	2300	390	63	130	13
10	AQ	NS	5	DEP	33000	6100	2400	420	44	140	17
10	AQ	NS	6	DEP	35000	6200	2700	460	48	160	14
10	AQ	NS	7	DEP	38000	5900	2500	400	44	160	14
10	AQ	NS	8	DEP	37000	5900	2600	430	50	150	14
10	AQ	NS	9	CON	45000	7200	2100	580	38	200	12
10	AQ	NS	10	CON	41000	7200	2200	1100	41	250	14
10	AQ	NS	11	CON	37000	6400	2100	900	42	200	14
10	AQ	NS	12	CON	52000	8300	2500	580	37	240	14
10	AQ	CS	1	DEP	33000	6500	2900	450	52	170	14
10	AQ	CS	2	DEP	34000	6600	3100	460	51	170	14
10	AQ	CS	3	DEP	34000	6700	3000	470	53	180	14
10	AQ	CS	4	DEP	33000	6500	2900	520	50	180	14
10	AQ	CS	5	DEP	29000	5500	2600	490	54	140	15
10	AQ	CS	6	DEP	29000	5400	2500	490	51	120	15
10	AQ	CS	7	DEP	29000	5700	2600	490	50	130	13
10	AQ	CS	8	DEP	25000	4500	2300	450	46	120	12
10	AQ	CS	9	CON	13000	2900	1200	380	31	120	8.2
10	AQ	CS	10	CON	15000	3000	1500	360	32	122	9.1
10	AQ	CS	11	CON	12000	2500	1200	330	29	110	8.4

Month	Industry	Site	Dredge	Zone	Ca ($\mu g \cdot g^{-1}$)	Mg ($\mu g \cdot g^{-1}$)	K ($\mu g \cdot g^{-1}$)	Na ($\mu g \cdot g^{-1}$)	Zn ($\mu g \cdot g^{-1}$)	Mn ($\mu g \cdot g^{-1}$)	Cu ($\mu g \cdot g^{-1}$)
10	AQ	CS	12	CON	13000	2800	1000	340	120	200	9.7
10	AG	AD1	1	DEP	29000	6200	2500	480	43	210	12
10	AG	AD1	2	DEP	36000	7300	3300	480	52	270	15
10	AG	AD1	3	DEP	29000	6300	2500	470	43	210	12
10	AG	AD1	4	DEP	26000	5600	2000	460	38	180	10
10	AG	AD1	5	DEP	33000	9000	4400	530	61	290	19
10	AG	AD1	6	DEP	27000	7000	2900	580	46	230	15
10	AG	AD1	7	DEP	31000	7600	3200	560	64	270	17
10	AG	AD1	8	DEP	27000	6800	2600	570	45	220	14
10	AG	AD1	9	CON	22000	4600	1700	520	43	160	11
10	AG	AD1	11	CON	20000	4300	1700	540	37	150	17
10	AG	AD1	12	CON	20000	4300	1700	520	37	150	12
10	AG	AD2	1	DEP	30000	5200	2100	480	44	170	12
10	AG	AD2	2	DEP	28000	5200	2100	490	38	170	12
10	AG	AD2	3	DEP	28000	5200	1900	480	37	160	11
10	AG	AD2	4	DEP	32000	5600	2200	500	40	180	13
10	AG	AD2	5	DEP	25000	4700	1700	470	37	150	11
10	AG	AD2	6	DEP	28000	5200	1900	460	37	160	11
10	AG	AD2	7	DEP	23000	4600	1700	440	34	140	10
10	AG	AD2	8	DEP	23000	4700	1700	450	33	150	10
10	AG	AD2	9	CON	15000	3100	1500	460	33	110	14
10	AG	AD2	10	CON	19000	4000	1700	470	96	150	12
10	AG	AD2	11	CON	17000	3100	1400	500	34	120	11
10	AG	AD2	12	CON	17000	3200	1400	480	59	160	22
10	AG	AD3	1	DEP	26000	4900	2200	490	37	160	12
10	AG	AD3	2	DEP	20000	3900	1700	443	39	140	13
10	AG	AD3	3	DEP	25000	4700	2200	490	48	170	17
10	AG	AD3	4	DEP	17000	3000	1500	430	42	130	9.6
10	AG	AD3	5	DEP	20000	4600	1800	440	38	140	13
10	AG	AD3	6	DEP	15000	3500	1500	400	33	110	9.8
10	AG	AD3	7	DEP	19000	4400	1800	430	37	130	12
10	AG	AD3	8	DEP	21000	4500	2100	530	110	140	14

Month	Industry	Site	Dredge	Zone	Ca (μg·g^{-1})	Mg (μg·g^{-1})	K (μg·g^{-1})	Na (μg·g^{-1})	Zn (μg·g^{-1})	Mn (μg·g^{-1})	Cu (μg·g^{-1})
10	AG	AD3	9	CON	25000	5200	2200	450	36	140	14
10	AG	AD3	10	CON	24000	4800	2000	750	33	140	14
10	AG	AD3	11	CON	25000	5100	2100	470	75	180	14
10	AG	AD3	12	CON	23000	5100	2200	470	37	140	20

Month	Industry	Site	Dredge	Zone	Ca (µg·g^{-1})	Mg (µg·g^{-1})	K (µg·g^{-1})	Na (µg·g^{-1})	Zn (µg·g^{-1})	Mn (µg·g^{-1})	Cu (µg·g^{-1})
6	AQ	BC	1	DEP	22000	4200	1500	440	60	160	17
6	AQ	BC	2	DEP	32000	5400	2100	500	68	180	24
6	AQ	BC	3	DEP	26000	4900	1500	420	65	170	20
6	AQ	BC	4	DEP	29000	4800	1600	440	60	160	19
6	AQ	BC	5	DEP	18000	4000	1200	460	53	150	16
6	AQ	BC	6	DEP	18000	3800	1200	470	50	150	15
6	AQ	BC	7	DEP	20000	4000	130	480	58	160	17
6	AQ	BC	8	DEP	18000	3700	1200	500	52	170	16
6	AQ	BC	9	CON	51000	9000	4200	530	80	450	32
6	AQ	BC	10	CON	39000	7300	3200	490	58	280	19
6	AQ	BC	11	CON	45000	8600	4100	500	69	390	25
6	AQ	BC	12	CON	39000	7800	3600	520	64	370	23
6	AQ	NS	1	DEP	50000	5800	2400	490	56	160	16
6	AQ	NS	2	DEP	47000	5400	2100	460	57	150	16
6	AQ	NS	3	DEP	51000	6000	2600	500	60	170	17
6	AQ	NS	4	DEP	49000	5900	2300	490	57	160	17
6	AQ	NS	5	DEP	41000	5700	2300	500	62	190	15
6	AQ	NS	6	DEP	48000	5500	2300	510	72	180	17
6	AQ	NS	7	DEP	38000	4500	1800	470	60	160	14
6	AQ	NS	8	DEP	43000	4900	1900	510	63	180	15
6	AQ	NS	9	CON	37000	3400	1400	590	34	160	11
6	AQ	NS	10	CON	15000	1600	690	210	32	110	10
6	AQ	NS	11	CON	21000	2100	920	380	22	100	7.5
6	AQ	NS	12	CON	23000	3400	1200	410	29	120	9.7
6	AQ	CS	1	DEP	33000	5600	1900	410	47	170	15
6	AQ	CS	2	DEP	31000	4900	1800	400	45	160	15
6	AQ	CS	3	DEP	38000	6400	2500	430	56	190	18
6	AQ	CS	4	DEP	33000	5900	2100	440	49	180	16
6	AQ	CS	5	DEP	39000	5700	2100	440	64	170	18
6	AQ	CS	6	DEP	43000	6500	2400	470	71	180	20
6	AQ	CS	7	DEP	42000	6100	2400	480	72	180	19
6	AQ	CS	8	DEP	40000	5900	2300	450	69	190	18

Month	Industry	Site	Dredge	Zone	Ca (μg·g^{-1})	Mg (μg·g^{-1})	K (μg·g^{-1})	Na (μg·g^{-1})	Zn (μg·g^{-1})	Mn (μg·g^{-1})	Cu (μg·g^{-1})
6	AQ	CS	9	CON	26000	4600	1700	400	40	180	13
6	AQ	CS	10	CON	27000	4800	1800	390	41	180	12
6	AQ	CS	11	CON	23000	4200	1500	380	40	170	11
6	AQ	CS	12	CON	25000	4300	1600	380	38	170	12
6	AG	AD1	1	DEP	29000	5100	1900	470	41	230	13
6	AG	AD1	2	DEP	30000	5600	2100	500	47	230	12
6	AG	AD1	3	DEP	30000	5500	2100	490	43	230	12
6	AG	AD1	4	DEP	31000	5300	1900	450	41	240	12
6	AG	AD1	5	DEP	27000	6400	2400	570	44	240	15
6	AG	AD1	6	DEP	26000	6600	2400	560	44	230	15
6	AG	AD1	7	DEP	27000	6600	2400	550	44	240	15
6	AG	AD1	8	DEP	27000	6600	2300	580	43	240	14
6	AG	AD1	9	CON	25000	4400	1600	450	36	150	11
6	AG	AD1	10	CON	23000	3900	1400	470	34	150	9.6
6	AG	AD1	11	CON	23000	4200	1600	500	40	150	11
6	AG	AD1	12	CON	25000	4400	1600	500	37	150	11
6	AG	AD2	1	DEP	24000	4000	1500	440	34	150	9.7
6	AG	AD2	2	DEP	24000	4000	1400	440	34	150	8.8
6	AG	AD2	3	DEP	24000	4100	1400	450	33	150	14
6	AG	AD2	4	DEP	23000	4000	1400	420	33	150	8.6
6	AG	AD2	5	DEP	25000	4300	1500	440	33	160	9.7
6	AG	AD2	6	DEP	28000	4600	1600	460	37	170	11
6	AG	AD2	7	DEP	24000	4200	1200	380	41	160	11
6	AG	AD2	8	DEP	23000	4300	1200	370	36	150	8.2
6	AG	AD2	9	CON	33000	5700	2100	410	49	200	19
6	AG	AD2	10	CON	34000	5900	2000	410	49	200	14
6	AG	AD2	11	CON	34000	5800	2000	400	47	200	14
6	AG	AD2	12	CON	26000	4700	1400	350	40	180	11
6	AG	AD3	1	DEP	25000	5100	1600	380	41	150	11
6	AG	AD3	2	DEP	22000	4400	1300	340	37	150	9.5
6	AG	AD3	3	DEP	23000	4600	1500	380	37	160	10
6	AG	AD3	4	DEP	29000	5500	1900	410	43	180	14

Month	Industry	Site	Dredge	Zone	Ca (µg·g^{-1})	Mg (µg·g^{-1})	K (µg·g^{-1})	Na (µg·g^{-1})	Zn (µg·g^{-1})	Mn (µg·g^{-1})	Cu (µg·g^{-1})
6	AG	AD3	5	DEP	19000	3700	1400	370	40	160	9.7
6	AG	AD3	6	DEP	17000	3200	1100	350	36	140	8.3
6	AG	AD3	8	DEP	18000	3500	1100	360	38	150	9.4
6	AG	AD3	9	CON	42000	6200	2600	620	57	280	21
6	AG	AD3	10	CON	31000	6600	2300	660	52	220	17
6	AG	AD3	11	CON	31000	6500	2700	520	54	220	18
6	AG	AD3	12	CON	34000	6500	2900	580	57	220	18
7	AQ	BC	1	DEP	26000	4900	1500	580	69	190	18
7	AQ	BC	2	DEP	38000	6900	2800	560	75	220	26
7	AQ	BC	3	DEP	31000	5800	2000	490	73	180	24
7	AQ	BC	4	DEP	28000	5400	1800	530	72	170	22
7	AQ	BC	5	DEP	25000	4300	1300	480	57	160	16
7	AQ	BC	6	DEP	22000	4200	1200	470	55	150	16
7	AQ	BC	7	DEP	23000	4000	1200	440	54	160	15
7	AQ	BC	8	DEP	28000	4700	1600	500	64	170	19
7	AQ	BC	9	CON	35000	5900	2200	510	47	190	14
7	AQ	BC	10	CON	33000	6000	2100	510	46	190	13
7	AQ	BC	11	CON	36000	5900	2200	480	48	200	15
7	AQ	BC	12	CON	39000	5900	2500	500	52	220	18
7	AQ	NS	1	DEP	39000	4700	1600	400	44	240	12
7	AQ	NS	2	DEP	44000	5500	2000	410	53	150	15
7	AQ	NS	3	DEP	47000	5800	2100	430	59	160	17
7	AQ	NS	4	DEP	46000	6200	2400	470	48	180	17
7	AQ	NS	5	DEP	46000	5500	1900	440	55	150	16
7	AQ	NS	6	DEP	40000	5200	1900	420	54	150	15
7	AQ	NS	7	DEP	38000	5400	2000	410	52	140	15
7	AQ	NS	8	DEP	35000	4700	1400	360	47	140	13
7	AQ	NS	9	CON	34000	4800	1500	390	40	140	12
7	AQ	NS	10	CON	35000	4800	1500	430	39	150	12
7	AQ	NS	11	CON	36000	4900	1600	430	38	150	12
7	AQ	NS	12	CON	37000	5200	1700	420	39	150	13
7	AQ	CS	1	DEP	32000	5000	1600	410	45	160	12

Month	Industry	Site	Dredge	Zone	Ca (μg·g⁻¹)	Mg (μg·g⁻¹)	K (μg·g⁻¹)	Na (μg·g⁻¹)	Zn (μg·g⁻¹)	Mn (μg·g⁻¹)	Cu (μg·g⁻¹)
7	AQ	CS	2	DEP	30000	4400	1500	390	44	160	11
7	AQ	CS	3	DEP							
7	AQ	CS	4	DEP	32000	4800	1700	410	47	170	12
7	AQ	CS	5	DEP	36000	5700	1900	390	61	180	16
7	AQ	CS	6	DEP	32000	5300	1800	380	56	170	15
7	AQ	CS	7	DEP	30000	5200	1700	380	54	160	14
7	AQ	CS	8	DEP	29000	5100	1700	380	55	160	14
7	AQ	CS	9	CON	19000	3200	1100	300	31	110	8.7
7	AQ	CS	10	CON	19000	3200	1100	320	31	110	8.9
7	AQ	CS	11	CON	19000	3100	1000	330	30	110	8.9
7	AQ	CS	12	CON	21000	3500	1200	320	33	120	9.7
7	AG	AD1	1	DEP	31000	6000	2000	410	44	200	13
7	AG	AD1	2	DEP	40000	7800	3100	450	60	300	18
7	AG	AD1	3	DEP	32000	6400	2300	440	44	220	14
7	AG	AD1	4	DEP	30000	5900	1900	420	39	190	13
7	AG	AD1	5	DEP	24000	6300	2200	430	40	200	14
7	AG	AD1	6	DEP	24000	6700	2400	440	44	220	14
7	AG	AD1	7	DEP	24000	5900	2000	430	40	210	12
7	AG	AD1	8	DEP	24000	5900	1900	390	39	200	13
7	AG	AD1	9	CON	21000	4300	1300	410	36	140	10
7	AG	AD1	10	CON	20000	4300	1300	410	36	140	10
7	AG	AD1	11	CON	22000	4500	1500	390	37	140	11
7	AG	AD1	12	CON	21000	4100	1400	370	38	140	11
7	AG	AD2	1	DEP	27000	4400	1500	410	36	160	11
7	AG	AD2	2	DEP	26000	5100	2200	560	43	170	13
7	AG	AD2	3	DEP	29000	5100	2100	550	40	170	10
7	AG	AD2	4	DEP	28000	5400	2300	560	41	180	11
7	AG	AD2	5	DEP	24000	5000	2000	530	37	160	9.6
7	AG	AD2	6	DEP	24000	4800	2000	520	38	160	11
7	AG	AD2	7	DEP	26000	5100	1800	450	37	170	10
7	AG	AD2	8	DEP	27000	5000	1800	510	37	170	9.3
7	AG	AD2	9	CON	30000	6100	2500	550	45	190	13

Month	Industry	Site	Dredge	Zone	Ca ($\mu g \cdot g^{-1}$)	Mg ($\mu g \cdot g^{-1}$)	K ($\mu g \cdot g^{-1}$)	Na ($\mu g \cdot g^{-1}$)	Zn ($\mu g \cdot g^{-1}$)	Mn ($\mu g \cdot g^{-1}$)	Cu ($\mu g \cdot g^{-1}$)
7	AG	AD2	10	CON	32000	6500	3100	580	49	200	15
7	AG	AD2	11	CON	33000	6500	3100	550	49	190	15
7	AG	AD2	12	CON	32000	6500	2500	670	50	200	17
7	AG	AD3	1	DEP	30000	6600	2600	610	47	190	15
7	AG	AD3	2	DEP	27000	5700	2200	600	44	170	12
7	AG	AD3	3	DEP	25000	5500	2100	630	43	160	13
7	AG	AD3	4	DEP	26000	6000	2600	610	43	170	15
7	AG	AD3	5	DEP	17000	3700	1600	550	39	150	10
7	AG	AD3	6	DEP	17000	3900	1700	550	37	150	11
7	AG	AD3	7	DEP	18000	3700	1400	420	37	140	10
7	AG	AD3	8	DEP	17000	3600	1600	520	36	150	11
7	AG	AD3	9	CON	36000	20000	3900	3900	80	590	35
7	AG	AD3	10	CON	34000	18000	3400	3200	75	530	32
7	AG	AD3	11	CON	34000	15000	3000	2400	66	430	26
7	AG	AD3	12	CON	31000	13000	3300	2000	65	390	23
8	AQ	BC	1	DEP	23000	4900	2000	540	73	180	25
8	AQ	BC	2	DEP	39000	8500	3800	480	60	300	17
8	AQ	BC	3	DEP	24000	5300	2000	570	76	190	25
8	AQ	BC	4	DEP	23000	5500	2200	620	63	180	25
8	AQ	BC	5	DEP	24000	4600	1800	550	57	160	16
8	AQ	BC	6	DEP	20000	4200	1600	540	51	150	16
8	AQ	BC	7	DEP	20000	4200	1500	580	53	150	17
8	AQ	BC	8	DEP	22000	4700	1600	560	58	160	19
8	AQ	BC	9	CON	35000	6900	2800	500	53	250	17
8	AQ	BC	10	CON	36000	6900	3300	480	56	250	17
8	AQ	BC	11	CON	24000	5400	2100	600	65	180	19
8	AQ	BC	12	CON	36000	6900	3200	510	52	250	14
8	AQ	NS	1	DEP	36000	5200	2300	450	51	140	11
8	AQ	NS	2	DEP	40000	5300	2300	460	50	140	13
8	AQ	NS	3	DEP	31000	4800	2100	440	50	130	10
8	AQ	NS	4	DEP	41000	5300	2300	460	51	140	12
8	AQ	NS	5	DEP	38000	5600	2400	480	57	160	12

Month	Industry	Site	Dredge	Zone	Ca (μg·g⁻¹)	Mg (μg·g⁻¹)	K (μg·g⁻¹)	Na (μg·g⁻¹)	Zn (μg·g⁻¹)	Mn (μg·g⁻¹)	Cu (μg·g⁻¹)
8	AQ	NS	6	DEP	46000	6500	3000	510	74	190	17
8	AQ	NS	7	DEP	42000	6100	2700	480	69	180	15
8	AQ	NS	8	DEP	42000	6000	2600	550	69	210	15
8	AQ	NS	9	CON	37000	5000	1900	510	36	150	9.6
8	AQ	NS	10	CON	40000	5500	2000	540	41	160	12
8	AQ	NS	12	CON	39000	6100	2300	520	39	150	12
8	AQ	CS	1	DEP	28000	4600	1900	410	41	180	12
8	AQ	CS	2	DEP	26000	4300	1900	410	44	170	11
8	AQ	CS	3	DEP	26000	3900	1800	360	43	160	9.2
8	AQ	CS	4	DEP	22000	3400	1600	400	40	150	7.8
8	AQ	CS	5	DEP	38000	6300	2900	480	72	170	18
8	AQ	CS	6	DEP	39000	6400	2800	460	70	170	18
8	AQ	CS	7	DEP	40000	6700	2900	480	69	170	18
8	AQ	CS	8	DEP	37000	6000	2800	450	65	160	15
8	AQ	CS	9	CON	27000	4200	2000	430	40	140	12
8	AQ	CS	10	CON	31000	5000	2100	430	41	160	10
8	AQ	CS	11	CON	29000	5000	2200	450	41	160	12
8	AQ	CS	12	CON	25000	4600	2400	420	47	140	11
8	AG	AD1	1	DEP	29000	6100	2300	490	39	180	12
8	AG	AD1	2	DEP	30000	6100	2400	530	40	190	12
8	AG	AD1	3	DEP	29000	5700	2200	490	40	180	12
8	AG	AD1	4	DEP	29000	6200	2500	520	41	190	12
8	AG	AD1	5	DEP	35000	9100	3900	570	58	280	18
8	AG	AD1	6	DEP	32000	7600	3300	590	54	260	16
8	AG	AD1	7	DEP	28000	6900	2800	580	46	220	13
8	AG	AD1	8	DEP	29000	7400	3000	580	47	230	14
8	AG	AD1	9	CON	24000	4600	1900	600	37	150	10
8	AG	AD1	10	CON	27000	5100	2000	580	42	160	11
8	AG	AD1	11	CON	26000	4900	1900	590	40	150	10
8	AG	AD1	12	CON	24000	4500	1800	730	40	150	10
8	AG	AD2	1	DEP	30000	5600	2200	510	41	190	12
8	AG	AD2	2	DEP	30000	5900	2300	550	44	180	11

Month	Industry	Site	Dredge	Zone	Ca (μg·g⁻¹)	Mg (μg·g⁻¹)	K (μg·g⁻¹)	Na (μg·g⁻¹)	Zn (μg·g⁻¹)	Mn (μg·g⁻¹)	Cu (μg·g⁻¹)
8	AG	AD2	3	DEP	34000	5700	2400	560	48	200	15
8	AG	AD2	4	DEP	30000	5700	2400	530	44	190	13
8	AG	AD2	5	DEP	30000	5300	2100	570	41	180	11
8	AG	AD2	6	DEP	31000	5700	2300	570	42	190	12
8	AG	AD2	7	DEP	29000	5400	2100	560	46	180	11
8	AG	AD2	8	DEP	30000	5700	2100	570	41	190	12
8	AG	AD2	9	CON	24000	4600	2100	470	48	190	15
8	AG	AD2	10	CON	25000	4700	2100	480	45	180	14
8	AG	AD2	11	CON	26000	5100	2400	560	45	190	14
8	AG	AD2	12	CON	23000	4300	1900	470	44	180	12
8	AG	AD3	1	DEP	25000	4700	1900	430	39	170	9.8
8	AG	AD3	2	DEP	24000	4400	1800	420	38	170	10
8	AG	AD3	3	DEP	18000	3600	1600	410	35	150	8.3
8	AG	AD3	4	DEP	17000	3000	1300	400	34	140	7.1
8	AG	AD3	5	DEP	14000	3000	1200	430	36	120	7.3
8	AG	AD3	6	DEP	18000	3400	1400	400	39	140	7.7
8	AG	AD3	7	DEP	21000	3800	1600	420	45	150	12
8	AG	AD3	8	DEP	16000	3100	1200	380	35	130	8.5
8	AG	AD3	9	CON	35000	7400	4000	590	60	240	22
8	AG	AD3	10	CON	35000	6700	3700	540	59	230	22
8	AG	AD3	11	CON	31000	6700	3400	570	56	220	19
8	AG	AD3	12	CON	31000	6600	3600	600	61	210	18
9	AQ	BC	1	DEP	41000	7600	3800	490	86	270	33
9	AQ	BC	2	DEP	43000	8100	4100	480	99	270	36
9	AQ	BC	3	DEP	43000	8300	4100	490	90	290	36
9	AQ	BC	4	DEP	44000	8200	4100	490	100	310	40
9	AQ	BC	5	DEP	23000	4800	1700	580	57	170	17
9	AQ	BC	6	DEP	22000	4600	1700	590	62	180	19
9	AQ	BC	7	DEP	23000	4800	1700	540	57	170	19
9	AQ	BC	8	DEP	20000	4700	1600	560	58	170	64
9	AQ	BC	9	CON	37000	7400	2900	470	55	220	18
9	AQ	BC	10	CON	40000	7700	3100	490	59	250	19

Month	Industry	Site	Dredge	Zone	Ca (µg·g⁻¹)	Mg (µg·g⁻¹)	K (µg·g⁻¹)	Na (µg·g⁻¹)	Zn (µg·g⁻¹)	Mn (µg·g⁻¹)	Cu (µg·g⁻¹)
9	AQ	BC	11	CON	47000	8800	3500	500	78	310	26
9	AQ	BC	12	CON	38000	7500	3100	520	55	250	17
9	AQ	NS	1	DEP	47000	5800	3000	460	56	160	16
9	AQ	NS	2	DEP	38000	5700	2800	420	52	150	14
9	AQ	NS	3	DEP	34000	6200	3000	470	51	150	14
9	AQ	NS	4	DEP	43000	6900	3300	460	59	160	17
9	AQ	NS	5	DEP	36000	5500	2400	470	48	150	11
9	AQ	NS	6	DEP	31000	4800	2000	440	50	140	9.6
9	AQ	NS	7	DEP	31000	5000	2300	470	48	140	11
9	AQ	NS	8	DEP	31000	4900	2100	470	53	160	10
9	AQ	NS	9	CON	41000	6900	3000	480	50	180	15
9	AQ	NS	10	CON	40000	6800	2700	500	45	180	13
9	AQ	NS	11	CON	40000	7000	2800	470	45	190	14
9	AQ	NS	12	CON	40000	6600	2700	440	52	190	17
9	AQ	CS	1	DEP	34000	6200	2600	460	50	190	14
9	AQ	CS	2	DEP	35000	6900	2600	450	51	200	14
9	AQ	CS	3	DEP	37000	7200	2700	440	55	210	15
9	AQ	CS	4	DEP	35000	7000	2600	440	51	190	14
9	AQ	CS	5	DEP	42000	6400	2800	440	68	180	18
9	AQ	CS	6	DEP	37000	6400	3000	450	150	250	56
9	AQ	CS	7	DEP	35000	6200	2800	420	67	170	19
9	AQ	CS	8	DEP	35000	6300	2900	430	83	200	47
9	AQ	CS	9	CON	15000	3000	1200	350	34	120	11
9	AQ	CS	10	CON	14000	2900	1300	360	36	120	7.7
9	AQ	CS	11	CON	17000	3200	1300	400	35	130	8.1
9	AQ	CS	12	CON	15000	3100	1200	360	34	130	7.1
9	AG	AD1	1	DEP	24000	5500	2200	460	48	230	14
9	AG	AD1	2	DEP	22000	5200	2100	440	46	210	13
9	AG	AD1	3	DEP	23000	5600	2300	510	50	240	15
9	AG	AD1	4	DEP	22000	5200	2300	470	52	210	14
9	AG	AD1	5	DEP	27000	6000	2500	510	45	240	15
9	AG	AD1	6	DEP	27000	6000	2400	490	43	230	15

Month	Industry	Site	Dredge	Zone	Ca ($\mu g \cdot g^{-1}$)	Mg ($\mu g \cdot g^{-1}$)	K ($\mu g \cdot g^{-1}$)	Na ($\mu g \cdot g^{-1}$)	Zn ($\mu g \cdot g^{-1}$)	Mn ($\mu g \cdot g^{-1}$)	Cu ($\mu g \cdot g^{-1}$)
9	AG	AD1	7	DEP	26000	5600	2200	500	44	230	12
9	AG	AD1	8	DEP	27000	6100	2600	480	47	220	13
9	AG	AD1	9	CON	17000	3500	1400	520	33	120	7.6
9	AG	AD1	10	CON	18000	3700	1500	500	31	130	7.6
9	AG	AD1	11	CON	17000	3500	1400	500	33	120	7.2
9	AG	AD1	12	CON	17000	3400	1300	510	30	120	7.5
9	AG	AD2	1	DEP	25000	4600	1900	440	37	150	14
9	AG	AD2	2	DEP	25000	4200	1800	440	33	140	9.0
9	AG	AD2	3	DEP	26000	4600	1900	450	38	150	9.2
9	AG	AD2	4	DEP	25000	4600	2000	490	60	180	34
9	AG	AD2	5	DEP	31000	4800	2100	480	40	160	12
9	AG	AD2	6	DEP	24000	4400	1800	470	36	150	9.5
9	AG	AD2	7	DEP	26000	4300	1700	480	37	150	12
9	AG	AD2	8	DEP	24000	4500	1700	480	35	150	8.7
9	AG	AD2	9	CON	26000	4800	2200	480	46	170	15
9	AG	AD2	10	CON	23000	4300	2000	420	51	160	12
9	AG	AD2	11	CON	25000	4800	2200	470	42	170	12
9	AG	AD2	12	CON	22000	4500	2000	490	43	170	11
9	AG	AD3	1	DEP	32000	8100	4500	480	64	260	22
9	AG	AD3	2	DEP	39000	7100	3600	460	58	260	19
9	AG	AD3	3	DEP	36000	7500	4400	440	73	280	24
9	AG	AD3	4	DEP	31000	5700	2800	420	49	200	15
9	AG	AD3	5	DEP	12000	3100	1200	490	32	120	8.2
9	AG	AD3	6	DEP	14000	3200	1200	410	34	130	12
9	AG	AD3	7	DEP	13000	3200	1500	410	32	130	8.3
9	AG	AD3	8	DEP	13000	3200	1400	440	32	130	8.3
9	AG	AD3	9	CON	32000	16000	3600	3600	74	480	30
9	AG	AD3	10	CON	34000	14000	3000	2800	77	420	29
9	AG	AD3	11	CON	34000	10000	3800	1700	65	340	23
9	AG	AD3	12	CON	35000	14000	3700	3200	76	460	30
10	AQ	BC	1	DEP	31000	6300	2800	660	69	210	25
10	AQ	BC	2	DEP	31000	6400	2900	610	76	210	27

Month	Industry	Site	Dredge	Zone	Ca (μg·g-1)	Mg (μg·g-1)	K (μg·g-1)	Na (μg·g-1)	Zn (μg·g-1)	Mn (μg·g-1)	Cu (μg·g-1)
10	AQ	BC	3	DEP	29000	6000	2600	590	70	200	23
10	AQ	BC	4	DEP	35000	6700	2900	700	70	230	25
10	AQ	BC	5	DEP	19000	4000	1800	620	53	150	17
10	AQ	BC	6	DEP	19000	3900	1800	610	54	160	17
10	AQ	BC	7	DEP	19000	4100	1700	600	53	140	18
10	AQ	BC	8	DEP	19000	4000	1800	600	52	150	17
10	AQ	BC	9	CON	40000	7000	3500	530	59	230	19
10	AQ	BC	10	CON	37000	6400	3000	550	52	190	16
10	AQ	BC	11	CON	41000	7300	3700	560	66	250	21
10	AQ	NS	1	DEP	34000	6800	3000	420	100	160	17
10	AQ	NS	2	DEP	26000	6100	2600	420	47	140	13
10	AQ	NS	3	DEP	26000	6200	2700	420	67	160	14
10	AQ	NS	4	DEP	30000	5700	2300	390	63	130	13
10	AQ	NS	5	DEP	33000	6100	2400	420	44	140	17
10	AQ	NS	6	DEP	35000	6200	2700	460	48	160	14
10	AQ	NS	7	DEP	38000	5900	2500	400	44	160	14
10	AQ	NS	8	DEP	37000	5900	2600	430	50	150	14
10	AQ	NS	9	CON	45000	7200	2100	580	38	200	12
10	AQ	NS	10	CON	41000	7200	2200	1100	41	250	14
10	AQ	NS	11	CON	37000	6400	2100	900	42	200	14
10	AQ	NS	12	CON	52000	8300	2500	580	37	240	14
10	AQ	CS	1	DEP	33000	6500	2900	450	52	170	14
10	AQ	CS	2	DEP	34000	6600	3100	460	51	170	14
10	AQ	CS	3	DEP	34000	6700	3000	470	53	180	14
10	AQ	CS	4	DEP	33000	6500	2900	520	50	180	14
10	AQ	CS	5	DEP	29000	5500	2600	490	54	140	15
10	AQ	CS	6	DEP	29000	5400	2500	490	51	120	15
10	AQ	CS	7	DEP	29000	5700	2600	490	50	130	13
10	AQ	CS	8	DEP	25000	4500	2300	450	46	120	12
10	AQ	CS	9	CON	13000	2900	1200	380	31	120	8.2
10	AQ	CS	10	CON	15000	3000	1500	360	32	122	9.1
10	AQ	CS	11	CON	12000	2500	1200	330	29	110	8.4

Month	Industry	Site	Dredge	Zone	Ca ($\mu g \cdot g^{-1}$)	Mg ($\mu g \cdot g^{-1}$)	K ($\mu g \cdot g^{-1}$)	Na ($\mu g \cdot g^{-1}$)	Zn ($\mu g \cdot g^{-1}$)	Mn ($\mu g \cdot g^{-1}$)	Cu ($\mu g \cdot g^{-1}$)
10	AQ	CS	12	CON	13000	2800	1000	340	120	200	9.7
10	AG	AD1	1	DEP	29000	6200	2500	480	43	210	12
10	AG	AD1	2	DEP	36000	7300	3300	480	52	270	15
10	AG	AD1	3	DEP	29000	6300	2500	470	43	210	12
10	AG	AD1	4	DEP	26000	5600	2000	460	38	180	10
10	AG	AD1	5	DEP	33000	9000	4400	530	61	290	19
10	AG	AD1	6	DEP	27000	7000	2900	580	46	230	15
10	AG	AD1	7	DEP	31000	7600	3200	560	64	270	17
10	AG	AD1	8	DEP	27000	6800	2600	570	45	220	14
10	AG	AD1	9	CON	22000	4600	1700	520	43	160	11
10	AG	AD1	11	CON	20000	4300	1700	540	37	150	17
10	AG	AD1	12	CON	20000	4300	1700	520	37	150	12
10	AG	AD2	1	DEP	30000	5200	2100	480	44	170	12
10	AG	AD2	2	DEP	28000	5200	2100	490	38	170	12
10	AG	AD2	3	DEP	28000	5200	1900	480	37	160	11
10	AG	AD2	4	DEP	32000	5600	2200	500	40	180	13
10	AG	AD2	5	DEP	25000	4700	1700	470	37	150	11
10	AG	AD2	6	DEP	28000	5200	1900	460	37	160	11
10	AG	AD2	7	DEP	23000	4600	1700	440	34	140	10
10	AG	AD2	8	DEP	23000	4700	1700	450	33	150	10
10	AG	AD2	9	CON	15000	3100	1500	460	33	110	14
10	AG	AD2	10	CON	19000	4000	1700	470	96	150	12
10	AG	AD2	11	CON	17000	3100	1400	500	34	120	11
10	AG	AD2	12	CON	17000	3200	1400	480	59	160	22
10	AG	AD3	1	DEP	26000	4900	2200	490	37	160	12
10	AG	AD3	2	DEP	20000	3900	1700	443	39	140	13
10	AG	AD3	3	DEP	25000	4700	2200	490	48	170	17
10	AG	AD3	4	DEP	17000	3000	1500	430	42	130	9.6
10	AG	AD3	5	DEP	20000	4600	1800	440	38	140	13
10	AG	AD3	6	DEP	15000	3500	1500	400	33	110	9.8
10	AG	AD3	7	DEP	19000	4400	1800	430	37	130	12
10	AG	AD3	8	DEP	21000	4500	2100	530	110	140	14

Month	Industry	Site	Dredge	Zone	Ca (µg·g^{-1})	Mg (µg·g^{-1})	K (µg·g^{-1})	Na (µg·g^{-1})	Zn (µg·g^{-1})	Mn (µg·g^{-1})	Cu (µg·g^{-1})
10	AG	AD3	9	CON	25000	5200	2200	450	36	140	14
10	AG	AD3	10	CON	24000	4800	2000	750	33	140	14
10	AG	AD3	11	CON	25000	5100	2100	470	75	180	14
10	AG	AD3	12	CON	23000	5100	2200	470	37	140	20

Month	Industry	Site	Dredge	Zone	Fe (µg·g^{-1})	P (µg·g^{-1})	S (µg·g^{-1})	Pb (µg·g^{-1})	Cr (µg·g^{-1})	Cd (µg·g^{-1})	Ba (µg·g^{-1})
6	AQ	BC	1	DEP	11000	1600	1700	35	39	0.79	92
6	AQ	BC	2	DEP	12000	1700	2200	21	32	0.72	99
6	AQ	BC	3	DEP	11000	1800	1900	19	32	0.86	88
6	AQ	BC	4	DEP	11000	1600	1800	19	27	0.74	90
6	AQ	BC	5	DEP	12000	1500	1700	17	41	0.80	82
6	AQ	BC	6	DEP	12000	1500	1600	17	37	1.2	74
6	AQ	BC	7	DEP	12000	1700	1900	17	41	1.1	94
6	AQ	BC	8	DEP	13000	1500	1600	17	40	0.88	91
6	AQ	BC	9	CON	16000	1000	3100	39	27	1.8	170
6	AQ	BC	10	CON	14000	780	1800	27	24	1.0	130
6	AQ	BC	11	CON	15000	920	2500	33	27	1.3	150
6	AQ	BC	12	CON	14000	870	2200	25	26	1.3	140
6	AQ	NS	1	DEP	10000	1400	2500	22	23	1.1	100
6	AQ	NS	2	DEP	9700	1400	2400	17	22	0.94	100
6	AQ	NS	3	DEP	11000	1300	2500	23	23	1.1	110
6	AQ	NS	4	DEP	11000	1300	2700	25	23	1.1	100
6	AQ	NS	5	DEP	11000	1600	2100	24	22	0.86	100
6	AQ	NS	6	DEP	11000	1800	2500	24	22	0.99	100
6	AQ	NS	7	DEP	9400	1900	2200	27	20	0.89	87
6	AQ	NS	8	DEP	9900	2000	2200	22	21	0.81	95
6	AQ	NS	9	CON	9000	760	1500	16	17	0.70	95
6	AQ	NS	10	CON	5700	470	1500	13	11	0.54	82
6	AQ	NS	11	CON	6100	430	1100	14	11	0.34	47
6	AQ	NS	12	CON	7500	630	1500	20	16	0.85	64
6	AQ	CS	1	DEP	10000	1100	1600	21	18	0.92	95
6	AQ	CS	2	DEP	9500	1200	1400	22	17	1.1	86
6	AQ	CS	3	DEP	11000	1200	2000	28	19	1.3	110
6	AQ	CS	4	DEP	10000	1000	1700	26	18	1.1	94
6	AQ	CS	5	DEP	11000	1600	2500	19	18	0.86	100
6	AQ	CS	6	DEP	12000	1600	2800	22	21	1.2	110
6	AQ	CS	7	DEP	12000	1700	2800	26	21	1.3	110
6	AQ	CS	8	DEP	11000	2000	2700	23	20	1.1	110

Month	Industry	Site	Dredge	Zone	Fe (μg·g⁻¹)	P (μg·g⁻¹)	S (μg·g⁻¹)	Pb (μg·g⁻¹)	Cr (μg·g⁻¹)	Cd (μg·g⁻¹)	Ba (μg·g⁻¹)
6	AQ	CS	9	CON	9600	650	920	19	16	0.70	87
6	AQ	CS	10	CON	10000	680	1000	15	17	0.87	90
6	AQ	CS	11	CON	10000	630	910	14	17	1.1	78
6	AQ	CS	12	CON	9200	630	930	15	15	0.70	85
6	AG	AD1	1	DEP	11000	700	790	21	18	0.68	93
6	AG	AD1	2	DEP	11000	700	750	21	19	0.50	96
6	AG	AD1	3	DEP	12000	720	790	22	20	0.89	96
6	AG	AD1	4	DEP	11000	720	820	22	20	0.63	92
6	AG	AD1	5	DEP	13000	770	600	26	25	0.91	110
6	AG	AD1	6	DEP	13000	740	580	25	24	0.94	100
6	AG	AD1	7	DEP	13000	770	610	27	24	1.2	100
6	AG	AD1	8	DEP	13000	740	560	26	25	0.90	110
6	AG	AD1	9	CON	9300	630	990	19	17	0.69	77
6	AG	AD1	10	CON	9300	620	870	19	16	0.58	70
6	AG	AD1	11	CON	9900	650	930	17	17	0.80	74
6	AG	AD1	12	CON	9800	620	1200	15	17	0.69	81
6	AG	AD2	1	DEP	9100	650	770	16	14	0.70	80
6	AG	AD2	2	DEP	9000	620	670	15	13	0.71	79
6	AG	AD2	3	DEP	8800	600	740	18	13	0.55	76
6	AG	AD2	4	DEP	8900	630	680	17	14	0.61	72
6	AG	AD2	5	DEP	9400	640	730	16	16	0.62	82
6	AG	AD2	6	DEP	9800	670	830	17	15	0.61	87
6	AG	AD2	7	DEP	9400	630	730	17	16	0.33	79
6	AG	AD2	8	DEP	9500	630	720	15	16	0.40	84
6	AG	AD2	9	CON	11000	740	1400	18	20	0.67	110
6	AG	AD2	10	CON	11000	770	1500	19	19	0.72	110
6	AG	AD2	11	CON	11000	740	1400	19	18	0.75	110
6	AG	AD2	12	CON	10000	630	1100	14	16	0.50	86
6	AG	AD3	1	DEP	9800	640	1100	16	17	0.68	91
6	AG	AD3	2	DEP	9400	590	860	13	15	0.38	78
6	AG	AD3	3	DEP	9700	600	1000	18	16	0.51	83
6	AG	AD3	4	DEP	10000	690	1200	19	18	0.64	94

Month	Industry	Site	Dredge	Zone	Fe (μg·g-1)	P (μg·g-1)	S (μg·g-1)	Pb (μg·g-1)	Cr (μg·g-1)	Cd (μg·g-1)	Ba (μg·g-1)
6	AG	AD3	5	DEP	11000	570	800	18	17	0.36	72
6	AG	AD3	6	DEP	9700	560	780	15	14	0.26	62
6	AG	AD3	8	DEP	10000	560	750	18	15	0.52	66
6	AG	AD3	9	CON	13000	990	1400	28	22	1.0	140
6	AG	AD3	10	CON	14000	780	1100	28	22	0.97	130
6	AG	AD3	11	CON	13000	760	1400	27	23	1.1	120
6	AG	AD3	12	CON	13000	760	1300	28	23	1.1	120
7	AQ	BC	1	DEP	13000	1700	2000	23	43	1.0	98
7	AQ	BC	2	DEP	15000	1400	2800	32	37	1.2	120
7	AQ	BC	3	DEP	12000	2000	2200	27	36	0.94	99
7	AQ	BC	4	DEP	12000	1900	2100	25	37	0.88	91
7	AQ	BC	5	DEP	11000	1800	1900	19	34	0.64	76
7	AQ	BC	6	DEP	11000	1700	1700	17	36	0.71	80
7	AQ	BC	7	DEP	11000	1800	1700	17	31	0.62	77
7	AQ	BC	8	DEP	11000	2100	2000	20	33	0.83	84
7	AQ	BC	9	CON	11000	800	1300	22	22	0.71	99
7	AQ	BC	10	CON	12000	760	1200	22	23	0.74	98
7	AQ	BC	11	CON	11000	780	1500	19	21	0.56	100
7	AQ	BC	12	CON	12000	790	1300	21	22	0.58	120
7	AQ	NS	1	DEP	8900	1200	2000	27	18	0.95	79
7	AQ	NS	2	DEP	9600	1300	2300	31	22	1.2	86
7	AQ	NS	3	DEP	10000	1300	2400	31	23	1.3	89
7	AQ	NS	4	DEP	11000	890	2700	30	23	1.5	90
7	AQ	NS	5	DEP	9600	1500	2400	29	22	1.6	88
7	AQ	NS	6	DEP	9500	1500	2000	33	22	1.4	80
7	AQ	NS	7	DEP	9800	1500	2200	34	21	1.2	81
7	AQ	NS	8	DEP	8600	1500	1900	22	19	1.1	68
7	AQ	NS	9	CON	8400	680	1400	22	18	0.90	77
7	AQ	NS	10	CON	9300	700	1400	23	19	0.97	78
7	AQ	NS	11	CON	9100	700	1500	24	18	0.85	85
7	AQ	NS	12	CON	9500	710	1700	25	20	0.99	86
7	AQ	CS	1	DEP	9500	1100	1600	17	18	0.37	89

Month	Industry	Site	Dredge	Zone	Fe (μg·g-1)	P (μg·g-1)	S (μg·g-1)	Pb (μg·g-1)	Cr (μg·g-1)	Cd (μg·g-1)	Ba (μg·g-1)
7	AQ	CS	2	DEP	9300	1300	1600	21	17	0.54	89
7	AQ	CS	3	DEP							
7	AQ	CS	4	DEP	9800	1300	1800	19	17	0.64	91
7	AQ	CS	5	DEP	10000	1600	2200	28	19	1.0	100
7	AQ	CS	6	DEP	10000	1700	2100	25	18	1.1	94
7	AQ	CS	7	DEP	10000	1600	2200	24	18	1.0	88
7	AQ	CS	8	DEP	9900	1600	2100	26	16	0.99	89
7	AQ	CS	9	CON	7700	530	880	20	12	0.85	59
7	AQ	CS	10	CON	8100	550	510	20	13	0.98	63
7	AQ	CS	11	CON	7800	500	770	16	12	0.88	58
7	AQ	CS	12	CON	8200	570	800	20	13	0.72	65
7	AG	AD1	1	DEP	11000	690	950	31	20	1.1	92
7	AG	AD1	2	DEP	14000	770	2100	38	24	1.5	130
7	AG	AD1	3	DEP	12000	710	950	29	20	1.2	98
7	AG	AD1	4	DEP	11000	720	880	27	19	1.2	87
7	AG	AD1	5	DEP	12000	680	610	31	21	1.5	89
7	AG	AD1	6	DEP	13000	710	570	32	23	1.5	96
7	AG	AD1	7	DEP	12000	690	550	22	21	0.95	94
7	AG	AD1	8	DEP	11000	700	570	25	18	0.87	93
7	AG	AD1	9	CON	9400	640	950	22	17	0.77	72
7	AG	AD1	10	CON	10000	680	900	25	18	0.62	65
7	AG	AD1	11	CON	9400	650	790	27	18	0.97	63
7	AG	AD1	12	CON	9200	620	780	25	16	0.61	61
7	AG	AD2	1	DEP	9100	650	790	26	16	0.90	74
7	AG	AD2	2	DEP	10000	670	820	36	21	1.4	82
7	AG	AD2	3	DEP	10000	680	840	27	20	1.5	86
7	AG	AD2	4	DEP	10000	680	840	29	20	1.6	90
7	AG	AD2	5	DEP	9800	660	760	25	19	1.4	81
7	AG	AD2	6	DEP	9800	600	710	23	20	1.4	73
7	AG	AD2	7	DEP	10000	660	780	23	19	1.3	76
7	AG	AD2	8	DEP	9900	640	730	19	19	1.4	84
7	AG	AD2	9	CON	11000	690	1200	27	23	1.6	98

Month	Industry	Site	Dredge	Zone	Fe (μg·g^{-1})	P (μg·g^{-1})	S (μg·g^{-1})	Pb (μg·g^{-1})	Cr (μg·g^{-1})	Cd (μg·g^{-1})	Ba (μg·g^{-1})
7	AG	AD2	10	CON	12000	770	1300	34	26	1.8	110
7	AG	AD2	11	CON	12000	750	1400	31	25	2.0	100
7	AG	AD2	12	CON	12000	780	1100	41	25	2.5	100
7	AG	AD3	1	DEP	12000	750	1300	31	24	2.3	96
7	AG	AD3	2	DEP	11000	730	1000	29	23	2.1	90
7	AG	AD3	3	DEP	11000	690	1000	25	22	2.0	86
7	AG	AD3	4	DEP	11000	710	980	32	24	1.9	91
7	AG	AD3	5	DEP	10000	590	760	30	21	1.8	64
7	AG	AD3	6	DEP	10000	550	770	27	21	1.7	58
7	AG	AD3	7	DEP	9900	580	780	20	18	0.73	69
7	AG	AD3	8	DEP	10000	590	770	25	18	1.6	59
7	AG	AD3	9	CON	40000	1500	2000	63	84	4.2	290
7	AG	AD3	10	CON	35000	1400	1800	54	73	3.9	260
7	AG	AD3	11	CON	28000	1100	1400	48	60	3.2	210
7	AG	AD3	12	CON	26000	1100	1400	38	54	2.9	180
8	AQ	BC	1	DEP	15000	1600	2900	23	50	1.2	100
8	AQ	BC	2	DEP	15000	900	2800	29	29	1.9	130
8	AQ	BC	3	DEP	16000	1600	2400	35	49	1.5	98
8	AQ	BC	4	DEP	15000	1400	2000	31	56	1.2	95
8	AQ	BC	5	DEP	13000	1900	2500	17	39	1.2	93
8	AQ	BC	6	DEP	13000	1600	2400	14	40	1.1	96
8	AQ	BC	7	DEP	12000	1600	2200	16	40	1.2	90
8	AQ	BC	8	DEP	13000	1800	2300	26	40	1.4	100
8	AQ	BC	9	CON	13000	950	2300	26	28	1.4	120
8	AQ	BC	10	CON	14000	870	1700	23	29	1.6	120
8	AQ	BC	11	CON	15000	1300	2600	22	52	1.2	96
8	AQ	BC	12	CON	14000	880	2500	22	25	1.1	120
8	AQ	NS	1	DEP	11000	1400	2500	19	22	0.90	85
8	AQ	NS	2	DEP	10000	1400	2300	23	22	1.0	89
8	AQ	NS	3	DEP	9800	1400	2100	22	21	0.81	83
8	AQ	NS	4	DEP	11000	1400	2400	18	22	0.95	89
8	AQ	NS	5	DEP	11000	1700	2500	18	23	1.1	94

Month	Industry	Site	Dredge	Zone	Fe (µg·g^{-1})	P (µg·g^{-1})	S (µg·g^{-1})	Pb (µg·g^{-1})	Cr (µg·g^{-1})	Cd (µg·g^{-1})	Ba (µg·g^{-1})
8	AQ	NS	6	DEP	13000	2200	3000	27	27	1.6	110
8	AQ	NS	7	DEP	12000	2000	3100	23	27	1.2	100
8	AQ	NS	8	DEP	12000	2200	3000	19	24	1.3	100
8	AQ	NS	9	CON	10000	820	1300	18	21	0.90	80
8	AQ	NS	10	CON	10000	840	1700	23	22	1.0	86
8	AQ	NS	12	CON	10000	800	1700	23	22	1.0	92
8	AQ	CS	1	DEP	9400	1500	1600	24	17	1.4	83
8	AQ	CS	2	DEP	9500	1600	1400	25	17	1.1	80
8	AQ	CS	3	DEP	9400	1500	1900	15	16	0.51	80
8	AQ	CS	4	DEP	8800	1800	1600	12	14	0.44	76
8	AQ	CS	5	DEP	12000	1900	3100	28	22	1.5	110
8	AQ	CS	6	DEP	12000	1900	3000	29	22	1.5	110
8	AQ	CS	7	DEP	12000	1800	3000	26	22	1.5	110
8	AQ	CS	8	DEP	12000	1700	3200	21	22	1.2	100
8	AQ	CS	9	CON	10000	690	1400	21	17	1.1	86
8	AQ	CS	10	CON	11000	710	1500	22	18	1.1	83
8	AQ	CS	11	CON	11000	680	1600	23	19	1.1	83
8	AQ	CS	12	CON	11000	660	2300	26	19	1.0	91
8	AG	AD1	1	DEP	11000	740	920	26	19	0.92	93
8	AG	AD1	2	DEP	11000	760	960	25	20	1.3	91
8	AG	AD1	3	DEP	11000	730	920	27	20	1.2	98
8	AG	AD1	4	DEP	11000	760	970	26	21	1.5	95
8	AG	AD1	5	DEP	16000	830	2000	34	28	1.9	130
8	AG	AD1	6	DEP	16000	830	1300	31	30	1.6	110
8	AG	AD1	7	DEP	14000	800	750	28	27	1.4	100
8	AG	AD1	8	DEP	14000	340	790	28	25	1.3	110
8	AG	AD1	9	CON	11000	730	1100	24	19	0.85	79
8	AG	AD1	10	CON	11000	760	1200	19	20	0.92	88
8	AG	AD1	11	CON	11000	770	1200	23	21	0.96	110
8	AG	AD1	12	CON	12000	820	1200	23	20	1.1	90
8	AG	AD2	1	DEP	12000	770	970	24	19	1.1	100
8	AG	AD2	2	DEP	12000	790	1000	33	21	1.5	98

Month	Industry	Site	Dredge	Zone	Fe (µg·g-1)	P (µg·g-1)	S (µg·g-1)	Pb (µg·g-1)	Cr (µg·g-1)	Cd (µg·g-1)	Ba (µg·g-1)
8	AG	AD2	3	DEP	12000	800	1100	29	20	1.3	100
8	AG	AD2	4	DEP	12000	780	1000	31	21	1.5	100
8	AG	AD2	5	DEP	11000	760	920	25	19	1.2	96
8	AG	AD2	6	DEP	12000	810	970	26	21	1.3	99
8	AG	AD2	7	DEP	12000	810	860	30	20	1.3	98
8	AG	AD2	8	DEP	12000	810	960	27	21	1.3	92
8	AG	AD2	9	CON	12000	740	1300	25	18	1.2	100
8	AG	AD2	10	CON	12000	630	1600	26	18	1.1	100
8	AG	AD2	11	CON	12000	670	1700	26	19	1.3	130
8	AG	AD2	12	CON	12000	650	1000	20	16	0.79	96
8	AG	AD3	1	DEP	11000	660	730	19	18	0.67	96
8	AG	AD3	2	DEP	11000	630	760	20	17	0.92	94
8	AG	AD3	3	DEP	10000	600	670	17	14	0.60	86
8	AG	AD3	4	DEP	9600	520	650	15	12	0.74	72
8	AG	AD3	5	DEP	10000	470	850	17	14	0.40	70
8	AG	AD3	6	DEP	11000	620	960	20	17	0.51	72
8	AG	AD3	7	DEP	11000	610	1100	26	16	0.81	74
8	AG	AD3	8	DEP	10000	570	950	19	14	0.47	63
8	AG	AD3	9	CON	16000	740	1700	39	25	1.3	140
8	AG	AD3	10	CON	15000	750	1800	34	24	1.2	140
8	AG	AD3	11	CON	15000	740	1600	30	23	1.4	140
8	AG	AD3	12	CON	14000	750	1500	34	24	1.4	130
9	AQ	BC	1	DEP	17000	1700	3000	39	35	1.7	130
9	AQ	BC	2	DEP	17000	1900	3300	39	34	1.8	140
9	AQ	BC	3	DEP	19000	1900	3100	39	34	1.9	140
9	AQ	BC	4	DEP	19000	1800	3100	48	35	1.8	140
9	AQ	BC	5	DEP	14000	1700	1900	25	42	1.1	99
9	AQ	BC	6	DEP	14000	1800	2100	26	43	1.4	87
9	AQ	BC	7	DEP	14000	1500	2100	22	44	1.1	79
9	AQ	BC	8	DEP	14000	1600	1900	24	42	0.85	86
9	AQ	BC	9	CON	14000	890	1400	28	26	1.3	120
9	AQ	BC	10	CON	15000	930	1700	32	28	1.3	130

Month	Industry	Site	Dredge	Zone	Fe (µg·g^{-1})	P (µg·g^{-1})	S (µg·g^{-1})	Pb (µg·g^{-1})	Cr (µg·g^{-1})	Cd (µg·g^{-1})	Ba (µg·g^{-1})
9	AQ	BC	11	CON	16000	1000	1800	45	32	1.9	140
9	AQ	BC	12	CON	14000	950	1400	30	31	1.4	120
9	AQ	NS	1	DEP	11000	1200	2600	24	22	1.7	110
9	AQ	NS	2	DEP	11000	1200	2200	22	20	1.1	94
9	AQ	NS	3	DEP	12000	1000	2000	22	22	0.92	98
9	AQ	NS	4	DEP	12000	1200	2600	29	28	1.3	110
9	AQ	NS	5	DEP	10000	1400	2100	23	20	0.84	87
9	AQ	NS	6	DEP	9900	1500	1900	22	24	0.77	73
9	AQ	NS	7	DEP	9800	1500	1900	22	21	0.86	83
9	AQ	NS	8	DEP	10000	1700	2000	21	24	0.98	85
9	AQ	NS	9	CON	11000	920	2100	24	24	0.96	110
9	AQ	NS	10	CON	12000	850	1600	21	29	1.0	96
9	AQ	NS	11	CON	12000	920	1700	21	26	1.1	99
9	AQ	NS	12	CON	11000	850	1800	25	24	1.1	110
9	AQ	CS	1	DEP	11000	1100	1600	26	20	1.2	100
9	AQ	CS	2	DEP	12000	1100	1700	29	21	1.2	99
9	AQ	CS	3	DEP	12000	1200	2100	32	23	1.3	110
9	AQ	CS	4	DEP	12000	1100	1800	30	21	1.2	99
9	AQ	CS	5	DEP	13000	1700	2600	31	21	1.0	110
9	AQ	CS	6	DEP	12000	1500	2800	80	23	1.5	110
9	AQ	CS	7	DEP	11000	1700	2600	29	20	1.1	100
9	AQ	CS	8	DEP	11000	1600	2700	47	30	1.3	110
9	AQ	CS	9	CON	8800	500	710	18	13	0.75	68
9	AQ	CS	10	CON	9200	500	630	15	11	0.39	58
9	AQ	CS	11	CON	10000	530	720	15	18	0.32	61
9	AQ	CS	12	CON	9900	580	740	12	15	0.30	55
9	AG	AD1	1	DEP	13000	710	1500	28	32	0.99	93
9	AG	AD1	2	DEP	12000	710	580	24	30	0.94	86
9	AG	AD1	3	DEP	14000	760	630	28	34	1.3	94
9	AG	AD1	4	DEP	13000	710	560	30	31	1.2	91
9	AG	AD1	5	DEP	13000	740	930	31	35	1.2	96
9	AG	AD1	6	DEP	12000	740	810	29	28	1.2	93

Month	Industry	Site	Dredge	Zone	Fe (μg·g^{-1})	P (μg·g^{-1})	S (μg·g^{-1})	Pb (μg·g^{-1})	Cr (μg·g^{-1})	Cd (μg·g^{-1})	Ba (μg·g^{-1})
9	AG	AD1	7	DEP	12000	680	740	21	32	0.99	92
9	AG	AD1	8	DEP	12000	760	940	21	26	0.86	98
9	AG	AD1	9	CON	9000	620	680	14	14	0.36	78
9	AG	AD1	10	CON	9400	620	640	14	16	0.45	72
9	AG	AD1	11	CON	9000	590	610	14	15	0.68	67
9	AG	AD1	12	CON	9000	590	640	16	15	0.63	68
9	AG	AD2	1	DEP	9700	650	820	17	14	2.3	87
9	AG	AD2	2	DEP	9100	620	820	17	14	0.78	78
9	AG	AD2	3	DEP	9500	620	830	15	14	0.62	85
9	AG	AD2	4	DEP	9800	650	800	34	16	0.75	86
9	AG	AD2	5	DEP	9600	690	1000	18	16	0.76	95
9	AG	AD2	6	DEP	9500	650	730	16	16	0.64	85
9	AG	AD2	7	DEP	10000	670	680	14	20	0.23	87
9	AG	AD2	8	DEP	9400	660	730	17	18	0.65	78
9	AG	AD2	9	CON	12000	620	1300	21	24	2.2	96
9	AG	AD2	10	CON	11000	700	1200	18	19	0.94	85
9	AG	AD2	11	CON	12000	630	1200	20	20	0.92	95
9	AG	AD2	12	CON	12000	610	1100	20	19	1.2	110
9	AG	AD3	1	DEP	16000	1100	1600	32	26	1.5	140
9	AG	AD3	2	DEP	14000	1200	1500	30	24	1.4	140
9	AG	AD3	3	DEP	15000	1200	1500	42	26	1.5	140
9	AG	AD3	4	DEP	11000	840	1200	26	19	0.93	110
9	AG	AD3	5	DEP	9000	560	670	12	13	0.51	60
9	AG	AD3	6	DEP	9500	610	680	17	16	0.63	66
9	AG	AD3	7	DEP	9100	500	950	18	15	0.65	75
9	AG	AD3	8	DEP	9200	510	850	19	13	0.65	67
9	AG	AD3	9	CON	36000	1400	1700	54	71	2.7	340
9	AG	AD3	10	CON	30000	1200	2000	50	58	2.4	260
9	AG	AD3	11	CON	22000	1000	1700	41	42	1.7	160
9	AG	AD3	12	CON	32000	1300	1700	53	58	2.4	240
10	AQ	BC	1	DEP	16000	1500	2300	29	41	1.2	130
10	AQ	BC	2	DEP	15000	1700	2500	29	40	1.3	110

Month	Industry	Site	Dredge	Zone	Fe (µg·g^{-1})	P (µg·g^{-1})	S (µg·g^{-1})	Pb (µg·g^{-1})	Cr (µg·g^{-1})	Cd (µg·g^{-1})	Ba (µg·g^{-1})
10	AQ	BC	3	DEP	14000	1200	2300	27	38	1.2	110
10	AQ	BC	4	DEP	16000	1400	2500	32	42	1.4	140
10	AQ	BC	5	DEP	11000	1900	1900	21	34	0.97	96
10	AQ	BC	6	DEP	11000	1400	1900	23	30	0.81	98
10	AQ	BC	7	DEP	12000	1500	1800	24	33	0.81	83
10	AQ	BC	8	DEP	12000	1600	1800	23	34	0.87	86
10	AQ	BC	9	CON	13000	760	1600	32	26	1.3	130
10	AQ	BC	10	CON	12000	670	1400	26	24	0.98	113
10	AQ	BC	11	CON	14000	940	1600	32	27	1.3	130
10	AQ	NS	1	DEP	12000	940	2200	31	26	1.4	110
10	AQ	NS	2	DEP	12000	860	2000	24	21	1.0	94
10	AQ	NS	3	DEP	12000	850	2200	38	21	1.4	94
10	AQ	NS	4	DEP	11000	880	2600	23	20	1.0	89
10	AQ	NS	5	DEP	11000	1000	2200	27	22	1.0	99
10	AQ	NS	6	DEP	11000	810	260	26	23	12.0	100
10	AQ	NS	7	DEP	11000	890	2700	22	22	1.0	100
10	AQ	NS	8	DEP	11000	990	2800	29	23	2.3	100
10	AQ	NS	9	CON	12000	700	3000	29	24	1.6	96
10	AQ	NS	10	CON	14000	840	2600	33	28	1.2	100
10	AQ	NS	11	CON	13000	810	2700	52	31	1.3	110
10	AQ	NS	12	CON	12000	720	3500	26	25	1.0	110
10	AQ	CS	1	DEP	11000	1000	1300	25	21	1.1	100
10	AQ	CS	2	DEP	11000	800	1300	28	20	1.2	100
10	AQ	CS	3	DEP	11000	780	1400	24	20	0.99	100
10	AQ	CS	4	DEP	11000	1000	1300	24	20	1.1	97
10	AQ	CS	5	DEP	10000	1300	1800	24	19	1.1	97
10	AQ	CS	6	DEP	9600	1000	1600	28	20	1.2	84
10	AQ	CS	7	DEP	10000	1200	1500	26	21	1.2	90
10	AQ	CS	8	DEP	9000	1200	1300	21	17	0.81	88
10	AQ	CS	9	CON	8900	480	680	16	14	0.49	62
10	AQ	CS	10	CON	8400	540	690	14	13	0.52	58
10	AQ	CS	11	CON	8000	420	570	16	11	0.33	72

Month	Industry	Site	Dredge	Zone	Fe (μg·g⁻¹)	P (μg·g⁻¹)	S (μg·g⁻¹)	Pb (μg·g⁻¹)	Cr (μg·g⁻¹)	Cd (μg·g⁻¹)	Ba (μg·g⁻¹)
10	AQ	CS	12	CON	9100	520	790	69	14	1.4	64
10	AG	AD1	1	DEP	12000	740	1500	32	22	1.2	100
10	AG	AD1	2	DEP	14000	790	2200	29	24	1.3	120
10	AG	AD1	3	DEP	12000	740	1300	30	22	1.0	96
10	AG	AD1	4	DEP	11000	700	890	18	21	0.9	82
10	AG	AD1	5	DEP	16000	810	2300	38	25	1.6	140
10	AG	AD1	6	DEP	14000	770	900	32	26	1.3	100
10	AG	AD1	7	DEP	15000	810	1300	44	29	2.1	110
10	AG	AD1	8	DEP	14000	760	840	28	28	1.3	98
10	AG	AD1	9	CON	10000	670	910	27	19	1.2	73
10	AG	AD1	11	CON	11000	690	900	32	20	1.1	71
10	AG	AD1	12	CON	10000	660	930	22	18	0.8	69
10	AG	AD2	1	DEP	10000	720	1200	25	18	1.0	87
10	AG	AD2	2	DEP	11000	720	990	29	19	2.2	82
10	AG	AD2	3	DEP	10000	710	1100	25	20	1.0	83
10	AG	AD2	4	DEP	11000	730	1400	28	19	1.6	91
10	AG	AD2	5	DEP	10000	660	960	23	17	0.9	80
10	AG	AD2	6	DEP	10000	700	1100	25	18	1.5	81
10	AG	AD2	7	DEP	9500	670	900	23	18	1.1	75
10	AG	AD2	8	DEP	9700	680	970	19	19	0.8	72
10	AG	AD2	9	CON	8900	540	710	22	14	0.75	68
10	AG	AD2	10	CON	11000	560	930	26	17	0.82	85
10	AG	AD2	11	CON	11000	460	750	18	13	0.67	79
10	AG	AD2	12	CON	11000	490	740	41	14	0.82	77
10	AG	AD3	1	DEP	10000	640	780	21	19	0.82	92
10	AG	AD3	2	DEP	9800	580	790	22	14	0.75	86
10	AG	AD3	3	DEP	10000	670	910	32	18	0.99	100
10	AG	AD3	4	DEP	9200	490	620	25	14	0.87	81
10	AG	AD3	5	DEP	11000	610	990	22	18	0.76	83
10	AG	AD3	6	DEP	8800	490	590	19	18	0.84	73
10	AG	AD3	7	DEP	10000	610	680	20	18	0.77	83
10	AG	AD3	8	DEP	10000	600	1300	29	20	1.3	85

Month	Industry	Site	Dredge	Zone	Fe (µg·g^{-1})	P (µg·g^{-1})	S (µg·g^{-1})	Pb (µg·g^{-1})	Cr (µg·g^{-1})	Cd (µg·g^{-1})	Ba (µg·g^{-1})
10	AG	AD3	9	CON	10000	660	1100	26	21	0.93	79
10	AG	AD3	10	CON	9900	690	980	22	23	1.0	80
10	AG	AD3	11	CON	10000	680	960	54	20	1.4	79
10	AG	AD3	12	CON	11000	710	910	26	22	0.92	84

Month	Industry	Site	Dredge	Zone	Ni (μg·g⁻¹)	Co (μg·g⁻¹)	Be (μg·g⁻¹)	Mo (μg·g⁻¹)	BMI#·m⁻²	BMI Biomass·m⁻²
6	AQ	BC	1	DEP	15	9.5	0.39	4.6	27555.56	38.8444
6	AQ	BC	2	DEP	14	9.4	0.53	4.6	7777.78	13.2889
6	AQ	BC	3	DEP	12	10	0.46	4.6	11111.11	24.9111
6	AQ	BC	4	DEP	13	8.9	0.43	5.2	24000.00	89.6889
6	AQ	BC	5	DEP	13	10	0.34	4.6	1822.22	2.3778
6	AQ	BC	6	DEP	14	9.7	0.35	4.6	133.33	0.2000
6	AQ	BC	7	DEP	14	9.8	0.36	4.6	24222.22	21.4889
6	AQ	BC	8	DEP	15	10	0.37	5.7	5037.04	3.3037
6	AQ	BC	9	CON	21	11	1.0	8.5	444888.89	559.2000
6	AQ	BC	10	CON	17	10	0.73	7.7	60888.89	87.0667
6	AQ	BC	11	CON	18	10	0.94	4.6	126666.67	215.2000
6	AQ	BC	12	CON	17	10	0.80	7.1	192888.89	286.8444
6	AQ	NS	1	DEP	15	9.0	0.58	4.6	132000.00	143.5111
6	AQ	NS	2	DEP	13	8.8	0.53	1.6	124000.00	172.4000
6	AQ	NS	3	DEP	16	9.8	0.63	5.8	117333.33	121.4667
6	AQ	NS	4	DEP	16	10	0.60	4.6	79111.11	103.9111
6	AQ	NS	5	DEP	16	9.9	0.60	6.5	600888.89	457.6444
6	AQ	NS	6	DEP	16	9.9	0.59	6.4	381333.33	313.2444
6	AQ	NS	7	DEP	15	9.5	0.48	4.9	185777.78	229.9111
6	AQ	NS	8	DEP	16	9.6	0.53	6.0	229333.33	164.2222
6	AQ	NS	9	CON	13	10	0.38	3.6	18222.22	79.6889
6	AQ	NS	10	CON	11	7.1	0.27	4.6	13555.56	32.3667
6	AQ	NS	11	CON	10	7.6	0.25	4.6	18962.96	27.0519
6	AQ	NS	12	CON	11	7.5	0.38	4.6	18962.96	22.3704
6	AQ	CS	1	DEP	15	8.6	0.53	4.6	9511.11	67.0044
6	AQ	CS	2	DEP	14	8.8	0.48	4.6	25555.56	12.6667
6	AQ	CS	3	DEP	16	9.6	0.58	6.0	12777.78	16.8333
6	AQ	CS	4	DEP	15	9.5	0.53	4.8	10222.22	11.8844
6	AQ	CS	5	DEP	15	8.9	0.58	4.6	3200.00	1.7511
6	AQ	CS	6	DEP	15	8.7	0.64	5.1	1688.89	2.3289
6	AQ	CS	7	DEP	16	9.2	0.61	4.6	6476.19	13.7079
6	AQ	CS	8	DEP	15	8.5	0.61	5.4	3911.11	17.6044

Month	Industry	Site	Dredge	Zone	Ni (μg·g^{-1})	Co (μg·g^{-1})	Be (μg·g^{-1})	Mo (μg·g^{-1})	BMI#·m^{-2}	BMI Biomass·m^{-2}
6	AQ	CS	9	CON	12	8.4	0.45	4.6	4666.67	9.3156
6	AQ	CS	10	CON	12	9.5	0.46	4.6	11555.56	15.1000
6	AQ	CS	11	CON	12	8.2	0.43	4.6	12666.67	19.9111
6	AQ	CS	12	CON	12	8.6	0.43	4.6	6793.65	14.8317
6	AG	AD1	1	DEP	15	10	0.51	4.6	8074.07	9.6296
6	AG	AD1	2	DEP	16	10	0.54	4.6	10044.44	15.9111
6	AG	AD1	3	DEP	15	11	0.55	6.3	9244.44	5.2178
6	AG	AD1	4	DEP	15	11	0.51	4.7	12444.44	10.1556
6	AG	AD1	5	DEP	19	11	0.59	6.4	12222.22	11.2444
6	AG	AD1	6	DEP	18	11	0.61	6.3	6111.11	6.6556
6	AG	AD1	7	DEP	18	11	0.62	7.3	12666.67	10.0000
6	AG	AD1	8	DEP	19	11	0.58	5.9	8977.78	4.4267
6	AG	AD1	9	CON	14	9.8	0.45	5.8	9688.89	8.2844
6	AG	AD1	10	CON	14	9.2	0.39	4.6	6349.21	2.5270
6	AG	AD1	11	CON	14	9.6	0.43	4.6	9155.56	3.6178
6	AG	AD1	12	CON	14	9.1	0.44	4.6	10133.33	7.2622
6	AG	AD2	1	DEP	13	9.6	0.40	4.6	9688.89	6.1778
6	AG	AD2	2	DEP	13	9.5	0.38	4.6	4400.00	3.9111
6	AG	AD2	3	DEP	13	9.4	0.39	4.6	4088.89	2.7156
6	AG	AD2	4	DEP	12	9.0	0.38	4.6	3422.22	4.5511
6	AG	AD2	5	DEP	13	9.6	0.41	4.6	2177.78	1.1556
6	AG	AD2	6	DEP	14	9.9	0.45	4.6	2711.11	2.5911
6	AG	AD2	7	DEP	8.8	7.1	0.35	4.6	2622.22	3.2444
6	AG	AD2	8	DEP	9.7	7.1	0.34	4.6	2977.78	3.7778
6	AG	AD2	9	CON	13	8.0	0.52	4.6	6611.11	3.3389
6	AG	AD2	10	CON	12	8.1	0.52	4.6	8444.44	4.2667
6	AG	AD2	11	CON	12	8.2	0.50	4.6	9155.56	3.9911
6	AG	AD2	12	CON	10	7.3	0.40	4.6	3466.67	1.4756
6	AG	AD3	1	DEP	11	7.2	0.44	4.6	11333.33	5.5000
6	AG	AD3	2	DEP	10	6.8	0.40	4.6	8296.30	5.6370
6	AG	AD3	3	DEP	11	7.6	0.42	4.6	8888.89	7.7511
6	AG	AD3	4	DEP	12	8.2	0.52	4.6	11333.33	13.4444

Month	Industry	Site	Dredge	Zone	Ni (μg·g^{-1})	Co (μg·g^{-1})	Be (μg·g^{-1})	Mo (μg·g^{-1})	BMI#·m^{-2}	BMI Biomass·m^{-2}
6	AG	AD3	5	DEP	11	8.8	0.40	4.6	2711.11	1.9156
6	AG	AD3	6	DEP	10	8.1	0.34	4.6	4222.22	2.2400
6	AG	AD3	8	DEP	11	8.5	0.35	5.8	2977.78	3.5733
6	AG	AD3	9	CON	16	10	0.64	6.6	13333.33	14.3667
6	AG	AD3	10	CON	16	11	0.60	6.2	13222.22	10.5778
6	AG	AD3	11	CON	16	9.5	0.66	5.0	12888.89	19.3333
6	AG	AD3	12	CON	17	9.6	0.72	7.1	9511.11	13.3244
7	AQ	BC	1	DEP	16	12	0.42	5.7	94666.67	110.2222
7	AQ	BC	2	DEP	19	11	0.70	8.2	35555.56	39.6000
7	AQ	BC	3	DEP	17	11	0.52	9.0	46222.22	88.1778
7	AQ	BC	4	DEP	16	11	0.48	6.3	104888.89	185.3778
7	AQ	BC	5	DEP	14	10	0.38	4.6	22222.22	17.2222
7	AQ	BC	6	DEP	13	9.8	0.36	4.9	14111.11	6.4667
7	AQ	BC	7	DEP	14	9.7	0.36	4.6	15851.85	10.7407
7	AQ	BC	8	DEP	15	10	0.42	4.6	18370.37	15.9852
7	AQ	BC	9	CON	14	9.7	0.54	5.1	76888.89	122.6667
7	AQ	BC	10	CON	16	10	0.53	6.7	45333.33	116.9778
7	AQ	BC	11	CON	14	8.7	0.56	6.0	45777.78	90.1333
7	AQ	BC	12	CON	15	9.0	0.58	4.9	65777.78	112.6667
7	AQ	NS	1	DEP	13	8.1	0.43	5.2	16000.00	35.1111
7	AQ	NS	2	DEP	14	8.8	0.51	6.0	34444.44	66.1778
7	AQ	NS	3	DEP	15	9.2	0.53	4.6	48888.89	94.3556
7	AQ	NS	4	DEP	17	9.7	0.59	7.3	13333.33	24.8000
7	AQ	NS	5	DEP	15	9.1	0.52	4.9	45111.11	44.5778
7	AQ	NS	6	DEP	15	9.5	0.46	7.0	63555.56	85.3333
7	AQ	NS	7	DEP	16	9.3	0.52	7.2	48888.89	30.4444
7	AQ	NS	8	DEP	13	8.3	0.42	5.1	31333.33	20.2000
7	AQ	NS	9	CON	13	8.9	0.42	5.1	2933.33	1.2044
7	AQ	NS	10	CON	12	8.0	0.40	4.6	755.56	0.3778
7	AQ	NS	11	CON	12	7.8	0.41	7.2	6666.67	0.8508
7	AQ	NS	12	CON	12	8.1	0.44	5.5	3244.44	1.8844
7	AQ	CS	1	DEP	14	9.6	0.46	4.6	11444.44	6.3000

Month	Industry	Site	Dredge	Zone	Ni (µg·g⁻¹)	Co (µg·g⁻¹)	Be (µg·g⁻¹)	Mo (µg·g⁻¹)	BMI#·m⁻²	BMI Biomass·m⁻²
7	AQ	CS	2	DEP	13	9.7	0.45	5.2	11111.11	12.3000
7	AQ	CS	3	DEP						
7	AQ	CS	4	DEP	16	11	0.48	6.0	15259.26	19.3630
7	AQ	CS	5	DEP	13	8.0	0.53	5.8	9955.56	20.8533
7	AQ	CS	6	DEP	12	8.1	0.51	6.7	7703.70	6.2000
7	AQ	CS	7	DEP	13	8.6	0.50	4.9	2000.00	2.2267
7	AQ	CS	8	DEP	12	8.5	0.49	4.6	1733.33	1.2578
7	AQ	CS	9	CON	9.8	7.5	0.32	4.6	3200.00	3.1956
7	AQ	CS	10	CON	10	7.6	0.34	4.6	4088.89	2.8844
7	AQ	CS	11	CON	9.7	7.3	0.32	4.6	4088.89	2.0222
7	AQ	CS	12	CON	10	7.7	0.35	4.6	4711.11	5.4178
7	AG	AD1	1	DEP	13	8.6	0.52	4.6	9333.33	2.7822
7	AG	AD1	2	DEP	18	10	0.73	8.1	1244.44	1.1067
7	AG	AD1	3	DEP	15	8.9	0.55	6.6	6412.70	1.8603
7	AG	AD1	4	DEP	13	8.9	0.48	7.9	5666.67	2.6556
7	AG	AD1	5	DEP	15	8.7	0.51	7.2	3422.22	1.3911
7	AG	AD1	6	DEP	16	9.2	0.55	7.5	2977.78	1.3867
7	AG	AD1	7	DEP	14	8.0	0.50	5.8	2666.67	1.7644
7	AG	AD1	8	DEP	14	8.0	0.50	6.4	3688.89	1.9467
7	AG	AD1	9	CON	11	7.6	0.37	6.0	2222.22	2.3244
7	AG	AD1	10	CON	11	7.9	0.37	5.4	1777.78	8.3511
7	AG	AD1	11	CON	12	7.9	0.40	5.1	3377.78	10.6667
7	AG	AD1	12	CON	12	7.9	0.37	5.7	2977.78	10.0756
7	AG	AD2	1	DEP	12	8.8	0.40	6.2	4800.00	10.6222
7	AG	AD2	2	DEP	13	9.2	0.47	7.0	4488.89	13.8489
7	AG	AD2	3	DEP	13	9.2	0.49	4.9	5234.57	23.8469
7	AG	AD2	4	DEP	13	9.1	0.54	5.7	5611.11	5.7500
7	AG	AD2	5	DEP	13	9.3	0.46	5.7	1911.11	14.9422
7	AG	AD2	6	DEP	12	9.3	0.43	5.3	1466.67	6.0178
7	AG	AD2	7	DEP	13	9.3	0.46	3.6	2000.00	5.8444
7	AG	AD2	8	DEP	13	9.2	0.46	5.2	2800.00	2.2444
7	AG	AD2	9	CON	15	9.5	0.56	8.2	5555.56	4.6944

Month	Industry	Site	Dredge	Zone	Ni (µg·g^{-1})	Co (µg·g^{-1})	Be (µg·g^{-1})	Mo (µg·g^{-1})	BMI#·m^{-2}	BMI Biomass·m^{-2}
7	AG	AD2	10	CON	16	9.9	0.62	8.0	6603.17	7.3333
7	AG	AD2	11	CON	16	9.9	0.61	7.9	3422.22	2.1511
7	AG	AD2	12	CON	15	10	0.57	7.3	3955.56	2.5556
7	AG	AD3	1	DEP	16	8.7	0.58	6.8	3066.67	1.7022
7	AG	AD3	2	DEP	14	8.7	0.53	6.4	5722.22	2.6111
7	AG	AD3	3	DEP	15	8.9	0.52	5.7	3288.89	2.1244
7	AG	AD3	4	DEP	15	9.3	0.58	5.9	2977.78	1.4667
7	AG	AD3	5	DEP	14	9.8	0.41	6.3	5611.11	12.2667
7	AG	AD3	6	DEP	14	9.9	0.40	4.6	5666.67	9.3278
7	AG	AD3	7	DEP	12	8.1	0.41	6.1	3466.67	1.9111
7	AG	AD3	8	DEP	14	9.8	0.40	6.2	1066.67	0.7600
7	AG	AD3	9	CON	53	31	0.74	18	5611.11	1.1333
7	AG	AD3	10	CON	46	28	0.69	16	6920.63	1.6698
7	AG	AD3	11	CON	40	23	0.64	12	5135.80	2.2519
7	AG	AD3	12	CON	36	22	0.63	11	4488.89	2.4978
8	AQ	BC	1	DEP	16	11	0.51	5	9600.00	22.1689
8	AQ	BC	2	DEP	18	11	0.85	7.5	1066.67	2.0489
8	AQ	BC	3	DEP	16	11	0.48	7.3	1377.78	1.5022
8	AQ	BC	4	DEP	17	12	0.50	7.8	1377.78	1.3867
8	AQ	BC	5	DEP	14	11	0.43	4.6	666.67	0.3778
8	AQ	BC	6	DEP	15	11	0.41	4.6	533.33	0.3422
8	AQ	BC	7	DEP	14	11	0.40	4.6	2000.00	3.1067
8	AQ	BC	8	DEP	14	11	0.39	6.6	2533.33	2.0933
8	AQ	BC	9	CON	16	9.6	0.60	8.1	64000.00	72.9778
8	AQ	BC	10	CON	17	10	0.70	6.8		
8	AQ	BC	11	CON	16	12	0.52	5.8	51111.11	80.0889
8	AQ	BC	12	CON	16	11	0.68	8.0	18666.67	22.6519
8	AQ	NS	1	DEP	14	9.8	0.53	5.5	4222.22	7.5956
8	AQ	NS	2	DEP	13	8.8	0.49	6.7	1555.56	1.1422
8	AQ	NS	3	DEP	13	9.5	0.50	8.6	44.44	0.0044
8	AQ	NS	4	DEP	15	9.9	0.54	6.1	23111.11	43.0889
8	AQ	NS	5	DEP	16	11	0.56	7.6	61777.78	100.6222

Month	Industry	Site	Dredge	Zone	Ni (μg·g^{-1})	Co (μg·g^{-1})	Be (μg·g^{-1})	Mo (μg·g^{-1})	BMI#·m^{-2}	BMI Biomass·m^{-2}
8	AQ	NS	6	DEP	17	11	0.68	7.6	46222.22	56.8444
8	AQ	NS	7	DEP	17	11	0.63	7.6	577.78	1.3022
8	AQ	NS	8	DEP	16	10	0.61	4.6	25333.33	42.7556
8	AQ	NS	9	CON	14	10	0.46	6.8	0.00	0.0000
8	AQ	NS	10	CON	14	9.8	0.44	5.7	6793.65	3.3714
8	AQ	NS	12	CON	14	9.2	0.47	7.1	4044.44	3.0667
8	AQ	CS	1	DEP	13	8.2	0.44	4.6	7481.48	5.5185
8	AQ	CS	2	DEP	12	8.6	0.44	6.1	6539.68	4.1016
8	AQ	CS	3	DEP	12	8.5	0.45	4.6	6000.00	2.9722
8	AQ	CS	4	DEP	11	9.1	0.41	4.6	6000.00	4.3833
8	AQ	CS	5	DEP	15	9.3	0.76	10	1022.22	0.3911
8	AQ	CS	6	DEP	15	9.0	0.68	6.9	4488.89	4.5689
8	AQ	CS	7	DEP	15	9.4	0.63	7.1	23555.56	21.3111
8	AQ	CS	8	DEP	15	9.7	0.62	6.1	5777.78	3.5500
8	AQ	CS	9	CON	13	9.6	0.50	4.7	2266.67	1.5022
8	AQ	CS	10	CON	14	9.9	0.51	4.6	11333.33	4.8889
8	AQ	CS	11	CON	14	9.5	0.53	6.2	3911.11	1.5422
8	AQ	CS	12	CON	14	10	0.56	7.3	5777.78	2.6444
8	AG	AD1	1	DEP	14	9.2	0.49	6.3	1555.56	1.0622
8	AG	AD1	2	DEP	14	9.2	0.51	5.8	3600.00	4.0667
8	AG	AD1	3	DEP	14	9.0	0.48	7.2	2044.44	1.3333
8	AG	AD1	4	DEP	15	9.9	0.57	6.6	2488.89	1.0444
8	AG	AD1	5	DEP	20	11	0.87	9.1	444.44	0.4933
8	AG	AD1	6	DEP	20	11	0.67	9.1	1066.67	1.1600
8	AG	AD1	7	DEP	17	10	0.59	8.2	1200.00	1.2622
8	AG	AD1	8	DEP	17	10	0.63	8.9	1777.78	1.3200
8	AG	AD1	9	CON	12	9.3	0.44	6.3	1688.89	1.3333
8	AG	AD1	10	CON	14	9.7	0.46	5.9	1244.44	0.7733
8	AG	AD1	11	CON	13	8.9	0.45	5.4	888.89	1.0533
8	AG	AD1	12	CON	13	9.7	0.44	6.9	1333.33	2.2933
8	AG	AD2	1	DEP	14	10	0.49	7.6	977.78	0.7289
8	AG	AD2	2	DEP	15	10	0.50	6.7	666.67	0.4356

Month	Industry	Site	Dredge	Zone	Ni ($\mu g \cdot g^{-1}$)	Co ($\mu g \cdot g^{-1}$)	Be ($\mu g \cdot g^{-1}$)	Mo ($\mu g \cdot g^{-1}$)	BMI#$\cdot m^{-2}$	BMI Biomass$\cdot m^{-2}$
8	AG	AD2	3	DEP	16	11	0.61	7.3	1422.22	0.9778
8	AG	AD2	4	DEP	15	11	0.56	6.2	488.89	0.1200
8	AG	AD2	5	DEP	14	10	0.47	5.6	755.56	1.0133
8	AG	AD2	6	DEP	15	11	0.50	6.9	1644.44	2.1244
8	AG	AD2	7	DEP	15	10	0.47	7.1	400.00	0.8044
8	AG	AD2	8	DEP	15	11	0.48	11	666.67	0.6222
8	AG	AD2	9	CON	12	7.2	0.46	5.3	622.22	0.1778
8	AG	AD2	10	CON	13	7.8	0.51	5.7	1155.56	0.7556
8	AG	AD2	11	CON	11	7.2	0.50	5.0	1066.67	1.0222
8	AG	AD2	12	CON	11	7.2	0.45	7.1	977.78	0.5200
8	AG	AD3	1	DEP	10	7.6	0.43	6.0	1022.22	1.3022
8	AG	AD3	2	DEP	12	7.2	0.43	4.6	88.89	0.0356
8	AG	AD3	3	DEP	8.9	6.9	0.42	6.3	2577.78	1.2978
8	AG	AD3	4	DEP	8.7	7.1	0.35	4.8	1288.89	0.6622
8	AG	AD3	5	DEP	9.9	7.0	0.31	4.8	1333.33	0.7911
8	AG	AD3	6	DEP	11	7.5	0.34	5.7	444.44	0.2400
8	AG	AD3	7	DEP	11	8.6	0.37	5.2	1155.56	0.7511
8	AG	AD3	8	DEP	10	7.6	0.34	4.6	1200.00	0.5422
8	AG	AD3	9	CON	18	9.3	0.80	9.8	577.78	0.1956
8	AG	AD3	10	CON	16	9.1	0.74	10	577.78	0.6400
8	AG	AD3	11	CON	16	9.8	0.73	8.1	2088.89	2.5022
8	AG	AD3	12	CON	17	9.7	0.74	9.9	844.44	0.5689
9	AQ	BC	1	DEP	19	12	0.86	13	1288.89	2.5422
9	AQ	BC	2	DEP	19	11	0.85	9.9	2355.56	2.3333
9	AQ	BC	3	DEP	20	11	0.84	9.9	17333.33	17.8963
9	AQ	BC	4	DEP	20	12	0.84	9.6	25555.56	21.7778
9	AQ	BC	5	DEP	15	12	0.41	6.0	16296.30	15.9259
9	AQ	BC	6	DEP	16	11	0.43	7.7	12333.33	15.1889
9	AQ	BC	7	DEP	17	11	0.39	5.9	4133.33	6.0133
9	AQ	BC	8	DEP	15	11	0.38	4.8	7851.85	7.9852
9	AQ	BC	9	CON	17	9.5	0.64	5.9	1866.67	4.2533
9	AQ	BC	10	CON	17	10	0.67	7.9	1555.56	4.1022

Month	Industry	Site	Dredge	Zone	Ni (µg·g^{-1})	Co (µg·g^{-1})	Be (µg·g^{-1})	Mo (µg·g^{-1})	BMI#·m^{-2}	BMI Biomass·m^{-2}
9	AQ	BC	11	CON	19	12	0.85	11	11333.33	19.2333
9	AQ	BC	12	CON	17	11	0.65	9.9	1955.56	3.3822
9	AQ	NS	1	DEP	15	9.5	1.6	9.0	28000.00	44.6889
9	AQ	NS	2	DEP	13	8.5	0.75	6.6	27111.11	35.4444
9	AQ	NS	3	DEP	14	8.6	0.62	7.1	24000.00	34.7333
9	AQ	NS	4	DEP	17	9.4	0.63	7.5	25111.11	31.9333
9	AQ	NS	5	DEP	13	8.4	0.48	5.8	46222.22	37.4222
9	AQ	NS	6	DEP	14	8.4	0.42	5.6	83555.56	39.8222
9	AQ	NS	7	DEP	13	8.5	0.44	7.1	55111.11	31.9556
9	AQ	NS	8	DEP	14	8.6	0.42	5.2	68000.00	64.3111
9	AQ	NS	9	CON	15	9.2	0.57	6.9	22888.89	16.4444
9	AQ	NS	10	CON	18	8.8	0.53	8.3	36888.89	18.8889
9	AQ	NS	11	CON	17	9.1	0.53	6.3	47111.11	28.8444
9	AQ	NS	12	CON	15	9.1	0.61	8.2	22666.67	14.1111
9	AQ	CS	1	DEP	15	9.9	0.58	5.9	7777.78	3.2222
9	AQ	CS	2	DEP	16	9.8	0.56	8.2	2977.78	2.3156
9	AQ	CS	3	DEP	18	11	0.60	7.9	6055.56	3.5333
9	AQ	CS	4	DEP	16	10	0.58	8.2	3288.89	2.7156
9	AQ	CS	5	DEP	15	9.8	0.65	7.9	4088.89	3.4267
9	AQ	CS	6	DEP	14	7.4	0.73	4.6	444.44	0.5733
9	AQ	CS	7	DEP	13	7.3	0.57	4.6	12777.78	23.9222
9	AQ	CS	8	DEP	16	8.2	0.55	5.4	13777.78	21.5889
9	AQ	CS	9	CON	9.7	6.6	0.29	4.6	2355.56	1.5556
9	AQ	CS	10	CON	9.1	6.4	0.29	4.6	1644.44	1.1956
9	AQ	CS	11	CON	12	7.4	0.32	4.7	2533.33	1.5600
9	AQ	CS	12	CON	9.0	7.7	0.31	5.5	2222.22	1.8533
9	AG	AD1	1	DEP	17	9.7	0.54	8.3	4044.44	2.4044
9	AG	AD1	2	DEP	16	9.7	0.50	7.6	666.67	0.6044
9	AG	AD1	3	DEP	17	11	0.53	9.5	2044.44	1.3200
9	AG	AD1	4	DEP	16	10	0.51	7.9	3600.00	1.8356
9	AG	AD1	5	DEP	20	11	0.56	8.6	1155.56	1.8089
9	AG	AD1	6	DEP	17	10	0.57	10	3022.22	1.1156

Month	Industry	Site	Dredge	Zone	Ni (µg·g^{-1})	Co (µg·g^{-1})	Be (µg·g^{-1})	Mo (µg·g^{-1})	BMI#·m^{-2}	BMI Biomass·m^{-2}
9	AG	AD1	7	DEP	17	9.5	0.56	7.0	1644.44	1.1467
9	AG	AD1	8	DEP	15	7.8	0.49	4.6	2177.78	1.4489
9	AG	AD1	9	CON	8.3	6.3	0.33	4.6	666.67	0.3511
9	AG	AD1	10	CON	9.4	6.2	0.33	4.6	933.33	0.6889
9	AG	AD1	11	CON	8.7	6.1	0.32	4.6	1644.44	1.2622
9	AG	AD1	12	CON	9.4	6.7	0.32	5.4	1555.56	1.1511
9	AG	AD2	1	DEP	12	8.6	5.0	8.0	1066.67	1.2133
9	AG	AD2	2	DEP	10	7.2	0.78	5.0	1911.11	0.8533
9	AG	AD2	3	DEP	10	7.1	0.51	5.9	1288.89	0.5422
9	AG	AD2	4	DEP	10	7.8	0.39	4.8	622.22	0.1467
9	AG	AD2	5	DEP	12	7.4	0.42	5.6	755.56	0.2489
9	AG	AD2	6	DEP	11	7.2	0.38	5.7	1288.89	0.5156
9	AG	AD2	7	DEP	13	7.6	0.40	4.9	888.89	0.7244
9	AG	AD2	8	DEP	12	7.5	0.37	4.6	577.78	0.3822
9	AG	AD2	9	CON	16	9.0	2.8	7.1	533.33	0.4800
9	AG	AD2	10	CON	13	7.8	0.74	5.5	977.78	0.4800
9	AG	AD2	11	CON	14	7.4	0.49	4.6	1200.00	0.3511
9	AG	AD2	12	CON	12	7.7	0.45	4.6	755.56	0.2133
9	AG	AD3	1	DEP	19	8.8	0.80	7.4	2444.44	45.5333
9	AG	AD3	2	DEP	17	8.4	0.72	6.2	933.33	0.3600
9	AG	AD3	3	DEP	17	8.8	0.80	6.4	88.89	0.0222
9	AG	AD3	4	DEP	14	8.1	0.56	5.4	2000.00	0.7556
9	AG	AD3	5	DEP	11	7.4	0.29	4.6	533.33	0.5156
9	AG	AD3	6	DEP	10	7.2	0.30	4.6	711.11	0.4267
9	AG	AD3	7	DEP	11	6.7	0.34	4.6	355.56	0.3689
9	AG	AD3	8	DEP	10	7.1	0.32	4.6	711.11	0.2844
9	AG	AD3	9	CON	51	27	0.65	12	1822.22	2.6311
9	AG	AD3	10	CON	40	24	0.70	13	622.22	0.3467
9	AG	AD3	11	CON	29	16	0.74	10	622.22	0.1333
9	AG	AD3	12	CON	41	24	0.71	13	400.00	0.1867
10	AQ	BC	1	DEP	19	12	0.57	6.5	5722.22	4.3833
10	AQ	BC	2	DEP	18	12	0.58	5.6	12111.11	9.0778

Month	Industry	Site	Dredge	Zone	Ni ($\mu g \cdot g^{-1}$)	Co ($\mu g \cdot g^{-1}$)	Be ($\mu g \cdot g^{-1}$)	Mo ($\mu g \cdot g^{-1}$)	BMI#$\cdot m^{-2}$	BMI Biomass$\cdot m^{-2}$
10	AQ	BC	3	DEP	18	11	0.54	6.3	12222.22	7.7444
10	AQ	BC	4	DEP	20	13	0.60	6.5	22444.44	12.4222
10	AQ	BC	5	DEP	15	11	0.39	5.4	2000.00	0.8800
10	AQ	BC	6	DEP	15	9.8	0.37	6.1	755.56	0.4133
10	AQ	BC	7	DEP	15	11	0.38	5.0	444.44	0.3244
10	AQ	BC	8	DEP	16	10	0.37	5.2	177.78	0.0578
10	AQ	BC	9	CON	17	10	0.68	7.0	9066.67	16.0267
10	AQ	BC	10	CON	16	9.9	0.58	5.9	4044.44	8.5333
10	AQ	BC	11	CON	19	11	0.68	6.4	25333.33	33.6000
10	AQ	NS	1	DEP	16	8.3	0.60	5.3	31111.11	53.5778
10	AQ	NS	2	DEP	13	7.9	0.50	5.5	17037.04	23.8963
10	AQ	NS	3	DEP	13	8.2	0.53	6.4	6000.00	10.3333
10	AQ	NS	4	DEP	12	7.8	0.45	5.5	51111.11	43.8667
10	AQ	NS	5	DEP	12	8.2	0.62	5.6	46222.22	17.6889
10	AQ	NS	6	DEP	14	8.4	0.52	5.2	69777.78	37.2889
10	AQ	NS	7	DEP	13	8.0	0.56	4.9	85777.78	46.4000
10	AQ	NS	8	DEP	14	8.4	0.57	6.0	30888.89	17.2222
10	AQ	NS	9	CON	14	9.6	0.48	4.9	400.00	0.3644
10	AQ	NS	10	CON	16	11	0.50	6.8	844.44	1.1422
10	AQ	NS	11	CON	16	12	0.45	5.7	3022.22	2.6444
10	AQ	NS	12	CON	14	9.5	0.52	6.3	444.44	0.3111
10	AQ	CS	1	DEP	15	9.9	0.57	4.9	3377.78	3.8533
10	AQ	CS	2	DEP	16	9.3	0.57	5.6	3511.11	3.3378
10	AQ	CS	3	DEP	15	9.6	0.57	4.6	5200.00	5.2044
10	AQ	CS	4	DEP	15	9.4	0.55	4.6	4755.56	3.3778
10	AQ	CS	5	DEP	15	9.4	0.50	5.4	222.22	0.1689
10	AQ	CS	6	DEP	14	8.9	0.49	4.6	5530.86	1.9753
10	AQ	CS	7	DEP	15	10	0.49	4.6	4622.22	1.2444
10	AQ	CS	8	DEP	13	8.3	0.41	4.8	1555.56	0.8800
10	AQ	CS	9	CON	11	7.7	0.30	4.7	1866.67	1.3022
10	AQ	CS	10	CON	10	7.6	0.31	4.6	1866.67	1.3556
10	AQ	CS	11	CON	10	7.5	0.27	4.6	1466.67	0.8622

Month	Industry	Site	Dredge	Zone	AM Biomass·m^{-2}	BMI Richness
10	AG	AD3	9	CON	13.3964	4
10	AG	AD3	10	CON	4.3751	4
10	AG	AD3	11	CON	0.0000	4
10	AG	AD3	12	CON	0.0000	2

Month	Industry	Site	Dredge	Zone	AM Biomass·m^{-2}	BMI Richness
10	AQ	CS	12	CON	0.0000	3
10	AG	AD1	1	DEP	0.0000	3
10	AG	AD1	2	DEP	4.2222	3
10	AG	AD1	3	DEP	0.0000	5
10	AG	AD1	4	DEP	0.0000	3
10	AG	AD1	5	DEP	0.0000	3
10	AG	AD1	6	DEP	0.0000	4
10	AG	AD1	7	DEP	0.0000	4
10	AG	AD1	8	DEP	0.0000	4
10	AG	AD1	9	CON	0.0000	3
10	AG	AD1	11	CON	0.0000	2
10	AG	AD1	12	CON	0.0000	5
10	AG	AD2	1	DEP	34.4533	8
10	AG	AD2	2	DEP	0.0000	6
10	AG	AD2	3	DEP	0.0000	4
10	AG	AD2	4	DEP	30.0311	6
10	AG	AD2	5	DEP	13.0889	5
10	AG	AD2	6	DEP	8.7289	2
10	AG	AD2	7	DEP	203.5911	8
10	AG	AD2	8	DEP	1.1333	3
10	AG	AD2	9	CON	0.0000	4
10	AG	AD2	10	CON	1.1022	5
10	AG	AD2	11	CON	2.6800	2
10	AG	AD2	12	CON	0.0000	3
10	AG	AD3	1	DEP	1.4000	2
10	AG	AD3	2	DEP	0.0000	4
10	AG	AD3	3	DEP	0.0000	3
10	AG	AD3	4	DEP	0.0000	3
10	AG	AD3	5	DEP	0.0000	2
10	AG	AD3	6	DEP	0.0000	2
10	AG	AD3	7	DEP	0.0000	2
10	AG	AD3	8	DEP	0.0000	2

Month	Industry	Site	Dredge	Zone	AM Biomass·m^{-2}	BMI Richness
10	AQ	BC	3	DEP	24.8178	5
10	AQ	BC	4	DEP	83.6178	5
10	AQ	BC	5	DEP	0.0000	4
10	AQ	BC	6	DEP	0.0000	2
10	AQ	BC	7	DEP	12.9200	3
10	AQ	BC	8	DEP	3.5156	3
10	AQ	BC	9	CON	30.2489	1
10	AQ	BC	10	CON	22.9422	2
10	AQ	BC	11	CON	37.3600	1
10	AQ	NS	1	DEP	113.3244	6
10	AQ	NS	2	DEP	32.2756	4
10	AQ	NS	3	DEP	25.0667	6
10	AQ	NS	4	DEP	219.8578	5
10	AQ	NS	5	DEP	255.4267	8
10	AQ	NS	6	DEP	162.4844	6
10	AQ	NS	7	DEP	124.9422	7
10	AQ	NS	8	DEP	31.0578	6
10	AQ	NS	9	CON	7.1556	3
10	AQ	NS	10	CON	0.0000	4
10	AQ	NS	11	CON	19.0444	9
10	AQ	NS	12	CON	1.5800	4
10	AQ	CS	1	DEP	11.1333	7
10	AQ	CS	2	DEP	6.2089	6
10	AQ	CS	3	DEP	0.0000	4
10	AQ	CS	4	DEP	1.8933	5
10	AQ	CS	5	DEP	33.8622	3
10	AQ	CS	6	DEP	105.7156	6
10	AQ	CS	7	DEP	173.2222	4
10	AQ	CS	8	DEP	156.4356	3
10	AQ	CS	9	CON	0.0000	6
10	AQ	CS	10	CON	0.0000	4
10	AQ	CS	11	CON	0.0000	4

Month	Industry	Site	Dredge	Zone	AM Biomass·m^{-2}	BMI Richness
9	AG	AD1	7	DEP	0.0000	3
9	AG	AD1	8	DEP	0.0000	3
9	AG	AD1	9	CON	9.1956	5
9	AG	AD1	10	CON	3.5467	5
9	AG	AD1	11	CON	0.0000	6
9	AG	AD1	12	CON	0.0000	5
9	AG	AD2	1	DEP	9.6933	8
9	AG	AD2	2	DEP	8.8089	7
9	AG	AD2	3	DEP	0.0000	5
9	AG	AD2	4	DEP	0.1022	2
9	AG	AD2	5	DEP	0.0000	2
9	AG	AD2	6	DEP	0.0000	4
9	AG	AD2	7	DEP	0.0000	2
9	AG	AD2	8	DEP	0.0000	2
9	AG	AD2	9	CON	1.5556	2
9	AG	AD2	10	CON	5.0667	5
9	AG	AD2	11	CON	0.0000	4
9	AG	AD2	12	CON	0.7644	3
9	AG	AD3	1	DEP	7.2667	9
9	AG	AD3	2	DEP	20.9467	7
9	AG	AD3	3	DEP	0.9244	2
9	AG	AD3	4	DEP	65.6356	6
9	AG	AD3	5	DEP	0.0000	5
9	AG	AD3	6	DEP	0.0000	3
9	AG	AD3	7	DEP	0.0000	3
9	AG	AD3	8	DEP	3.1333	3
9	AG	AD3	9	CON	77.7333	8
9	AG	AD3	10	CON	5.4622	5
9	AG	AD3	11	CON	1.3067	3
9	AG	AD3	12	CON	0.0000	3
10	AQ	BC	1	DEP	16.5689	5
10	AQ	BC	2	DEP	19.1511	4

Month	Industry	Site	Dredge	Zone	AM Biomass·m^{-2}	BMI Richness
9	AQ	BC	11	CON	1.7778	2
9	AQ	BC	12	CON	0.0000	2
9	AQ	NS	1	DEP	182.5080	9
9	AQ	NS	2	DEP	180.6489	7
9	AQ	NS	3	DEP	100.1556	8
9	AQ	NS	4	DEP	86.8804	5
9	AQ	NS	5	DEP	138.5600	8
9	AQ	NS	6	DEP	69.7022	5
9	AQ	NS	7	DEP	48.8667	6
9	AQ	NS	8	DEP	69.0356	8
9	AQ	NS	9	CON	69.3778	9
9	AQ	NS	10	CON	154.3156	11
9	AQ	NS	11	CON	234.5111	10
9	AQ	NS	12	CON	82.2578	11
9	AQ	CS	1	DEP	0.3244	5
9	AQ	CS	2	DEP	0.0000	4
9	AQ	CS	3	DEP	26.3956	8
9	AQ	CS	4	DEP	2.9333	7
9	AQ	CS	5	DEP	51.0622	9
9	AQ	CS	6	DEP	27.5511	5
9	AQ	CS	7	DEP	56.1022	9
9	AQ	CS	8	DEP	66.3689	9
9	AQ	CS	9	CON	0.0000	6
9	AQ	CS	10	CON	0.0000	7
9	AQ	CS	11	CON	11.6044	7
9	AQ	CS	12	CON	0.0000	6
9	AG	AD1	1	DEP	17.7244	10
9	AG	AD1	2	DEP	0.0000	6
9	AG	AD1	3	DEP	14.4578	7
9	AG	AD1	4	DEP	94.3067	10
9	AG	AD1	5	DEP	0.0000	5
9	AG	AD1	6	DEP	0.0000	5

Month	Industry	Site	Dredge	Zone	AM Biomass·m^{-2}	BMI Richness
8	AG	AD2	3	DEP	5.3467	6
8	AG	AD2	4	DEP	0.0000	2
8	AG	AD2	5	DEP	1.1911	3
8	AG	AD2	6	DEP	0.0000	4
8	AG	AD2	7	DEP	0.0000	3
8	AG	AD2	8	DEP	0.0000	3
8	AG	AD2	9	CON	1.6844	4
8	AG	AD2	10	CON	0.0000	4
8	AG	AD2	11	CON	3.2622	5
8	AG	AD2	12	CON	2.4978	3
8	AG	AD3	1	DEP	6.2533	5
8	AG	AD3	2	DEP	0.0000	2
8	AG	AD3	3	DEP	4.0444	4
8	AG	AD3	4	DEP	12.3289	4
8	AG	AD3	5	DEP	2.4889	2
8	AG	AD3	6	DEP	0.0000	2
8	AG	AD3	7	DEP	5.2667	2
8	AG	AD3	8	DEP	0.0000	2
8	AG	AD3	9	CON	0.8444	4
8	AG	AD3	10	CON	11.7956	4
8	AG	AD3	11	CON	36.8356	8
8	AG	AD3	12	CON	12.2044	6
9	AQ	BC	1	DEP	3.3111	7
9	AQ	BC	2	DEP	7.7022	6
9	AQ	BC	3	DEP	17.3556	6
9	AQ	BC	4	DEP	8.6933	7
9	AQ	BC	5	DEP	9.7467	5
9	AQ	BC	6	DEP	17.9867	8
9	AQ	BC	7	DEP	4.2356	8
9	AQ	BC	8	DEP	13.0889	8
9	AQ	BC	9	CON	2.5422	2
9	AQ	BC	10	CON	0.0000	2

Month	Industry	Site	Dredge	Zone	AM Biomass·m^{-2}	BMI Richness
8	AQ	NS	6	DEP	49.4044	6
8	AQ	NS	7	DEP	21.5778	8
8	AQ	NS	8	DEP	75.7111	3
8	AQ	NS	9	CON	0.8667	0
8	AQ	NS	10	CON	22.0044	9
8	AQ	NS	12	CON	24.5333	8
8	AQ	CS	1	DEP	1.5556	5
8	AQ	CS	2	DEP	0.9867	3
8	AQ	CS	3	DEP	4.1067	4
8	AQ	CS	4	DEP	1.6311	4
8	AQ	CS	5	DEP	7.7956	8
8	AQ	CS	6	DEP	34.4933	8
8	AQ	CS	7	DEP	326.2356	9
8	AQ	CS	8	DEP	19.5156	7
8	AQ	CS	9	CON	9.4578	7
8	AQ	CS	10	CON	38.4444	11
8	AQ	CS	11	CON	56.2356	6
8	AQ	CS	12	CON	78.3200	11
8	AG	AD1	1	DEP	11.3156	7
8	AG	AD1	2	DEP	27.4400	11
8	AG	AD1	3	DEP	5.6000	7
8	AG	AD1	4	DEP	0.0000	4
8	AG	AD1	5	DEP	0.0000	3
8	AG	AD1	6	DEP	0.0000	2
8	AG	AD1	7	DEP	0.0000	2
8	AG	AD1	8	DEP	0.0000	2
8	AG	AD1	9	CON	7.0800	6
8	AG	AD1	10	CON	0.0000	2
8	AG	AD1	11	CON	4.0533	6
8	AG	AD1	12	CON	0.0000	4
8	AG	AD2	1	DEP	0.5778	2
8	AG	AD2	2	DEP	0.0000	4

Month	Industry	Site	Dredge	Zone	AM Biomass·m^{-2}	BMI Richness
7	AG	AD2	10	CON	13.6444	5
7	AG	AD2	11	CON	22.1422	4
7	AG	AD2	12	CON	8.4267	5
7	AG	AD3	1	DEP	14.6622	6
7	AG	AD3	2	DEP	0.0000	4
7	AG	AD3	3	DEP	0.0000	2
7	AG	AD3	4	DEP	0.0000	3
7	AG	AD3	5	DEP	0.0000	5
7	AG	AD3	6	DEP	0.0000	6
7	AG	AD3	7	DEP	0.0000	3
7	AG	AD3	8	DEP	0.0000	2
7	AG	AD3	9	CON	1.9422	7
7	AG	AD3	10	CON	2.7422	3
7	AG	AD3	11	CON	0.0000	5
7	AG	AD3	12	CON	0.0000	4
8	AQ	BC	1	DEP	107.5511	9
8	AQ	BC	2	DEP	3.1467	5
8	AQ	BC	3	DEP	0.5422	3
8	AQ	BC	4	DEP	3.6711	3
8	AQ	BC	5	DEP	2.9333	3
8	AQ	BC	6	DEP	10.2978	3
8	AQ	BC	7	DEP	13.3511	8
8	AQ	BC	8	DEP	18.6533	8
8	AQ	BC	9	CON	27.9733	3
8	AQ	BC	10	CON	2.2889	*
8	AQ	BC	11	CON	15.7467	1
8	AQ	BC	12	CON	9.2889	1
8	AQ	NS	1	DEP	17.6178	8
8	AQ	NS	2	DEP	3.3244	7
8	AQ	NS	3	DEP	0.8356	1
8	AQ	NS	4	DEP	141.6844	8
8	AQ	NS	5	DEP	75.6800	5

Month	Industry	Site	Dredge	Zone	AM Biomass·m^{-2}	BMI Richness
7	AQ	CS	2	DEP	0.0000	4
7	AQ	CS	3	DEP		4
7	AQ	CS	4	DEP	0.9867	5
7	AQ	CS	5	DEP	88.8933	9
7	AQ	CS	6	DEP	18.6578	9
7	AQ	CS	7	DEP	3.0667	5
7	AQ	CS	8	DEP	10.3600	7
7	AQ	CS	9	CON	0.0000	4
7	AQ	CS	10	CON	4.1689	7
7	AQ	CS	11	CON	0.0000	4
7	AQ	CS	12	CON	1.8800	5
7	AG	AD1	1	DEP	0.0000	6
7	AG	AD1	2	DEP	0.0000	4
7	AG	AD1	3	DEP	0.0000	3
7	AG	AD1	4	DEP	0.0000	3
7	AG	AD1	5	DEP	0.0000	3
7	AG	AD1	6	DEP	0.0000	2
7	AG	AD1	7	DEP	0.0000	3
7	AG	AD1	8	DEP	0.0000	4
7	AG	AD1	9	CON	0.0000	4
7	AG	AD1	10	CON	0.0000	3
7	AG	AD1	11	CON	0.0000	4
7	AG	AD1	12	CON	0.0000	3
7	AG	AD2	1	DEP	0.0000	6
7	AG	AD2	2	DEP	0.6933	5
7	AG	AD2	3	DEP	0.0000	6
7	AG	AD2	4	DEP	0.0000	3
7	AG	AD2	5	DEP	0.0000	2
7	AG	AD2	6	DEP	0.0000	3
7	AG	AD2	7	DEP	0.0000	3
7	AG	AD2	8	DEP	0.0000	5
7	AG	AD2	9	CON	22.4444	6

Month	Industry	Site	Dredge	Zone	AM Biomass·m^{-2}	BMI Richness
6	AG	AD3	5	DEP	0.0000	2
6	AG	AD3	6	DEP	0.0000	6
6	AG	AD3	8	DEP	0.0000	3
6	AG	AD3	9	CON	14.7911	7
6	AG	AD3	10	CON	22.7244	6
6	AG	AD3	11	CON	10.3067	5
6	AG	AD3	12	CON	5.0000	6
7	AQ	BC	1	DEP	310.7378	10
7	AQ	BC	2	DEP	138.1333	8
7	AQ	BC	3	DEP	227.0756	6
7	AQ	BC	4	DEP	101.1467	6
7	AQ	BC	5	DEP	17.5111	7
7	AQ	BC	6	DEP	14.3200	7
7	AQ	BC	7	DEP	6.0356	8
7	AQ	BC	8	DEP	19.6356	5
7	AQ	BC	9	CON	120.5836	3
7	AQ	BC	10	CON	62.3644	2
7	AQ	BC	11	CON	0.0000	2
7	AQ	BC	12	CON	111.0133	5
7	AQ	NS	1	DEP	76.1244	9
7	AQ	NS	2	DEP	259.6356	5
7	AQ	NS	3	DEP	216.7467	6
7	AQ	NS	4	DEP	55.5600	7
7	AQ	NS	5	DEP	91.3422	7
7	AQ	NS	6	DEP	139.3111	7
7	AQ	NS	7	DEP	49.5467	4
7	AQ	NS	8	DEP	82.5022	5
7	AQ	NS	9	CON	4.0622	8
7	AQ	NS	10	CON	3.4800	5
7	AQ	NS	11	CON	31.8622	6
7	AQ	NS	12	CON	9.9511	7
7	AQ	CS	1	DEP	0.0000	3

Month	Industry	Site	Dredge	Zone	AM Biomass·m^{-2}	BMI Richness
6	AQ	CS	9	CON	8.2222	3
6	AQ	CS	10	CON	0.0000	7
6	AQ	CS	11	CON	1.2578	3
6	AQ	CS	12	CON	0.0000	6
6	AG	AD1	1	DEP	0.0000	3
6	AG	AD1	2	DEP	0.0000	3
6	AG	AD1	3	DEP	0.0000	3
6	AG	AD1	4	DEP	0.0000	3
6	AG	AD1	5	DEP	1.7333	3
6	AG	AD1	6	DEP	0.0000	3
6	AG	AD1	7	DEP	0.0000	3
6	AG	AD1	8	DEP	0.0000	4
6	AG	AD1	9	CON	0.0000	5
6	AG	AD1	10	CON	0.0000	6
6	AG	AD1	11	CON	0.0000	2
6	AG	AD1	12	CON	0.0000	4
6	AG	AD2	1	DEP	3.6222	4
6	AG	AD2	2	DEP	0.0000	7
6	AG	AD2	3	DEP	0.0000	6
6	AG	AD2	4	DEP	0.0000	4
6	AG	AD2	5	DEP	0.0000	4
6	AG	AD2	6	DEP	0.0000	4
6	AG	AD2	7	DEP	0.0000	3
6	AG	AD2	8	DEP	0.0000	3
6	AG	AD2	9	CON	26.3778	7
6	AG	AD2	10	CON	0.0000	7
6	AG	AD2	11	CON	0.0000	6
6	AG	AD2	12	CON	0.0000	5
6	AG	AD3	1	DEP	57.7600	4
6	AG	AD3	2	DEP	0.0000	3
6	AG	AD3	3	DEP	0.0000	4
6	AG	AD3	4	DEP	47.0489	6

Month	Industry	Site	Dredge	Zone	AM Biomass·m^{-2}	BMI Richness
6	AQ	BC	1	DEP	33.9244	8
6	AQ	BC	2	DEP	45.4089	11
6	AQ	BC	3	DEP	57.8711	6
6	AQ	BC	4	DEP	189.9244	8
6	AQ	BC	5	DEP	6.2000	8
6	AQ	BC	6	DEP	13.1378	3
6	AQ	BC	7	DEP	31.2178	3
6	AQ	BC	8	DEP	34.3644	4
6	AQ	BC	9	CON	104.1022	6
6	AQ	BC	10	CON	4.6978	2
6	AQ	BC	11	CON	47.0356	5
6	AQ	BC	12	CON	70.4844	4
6	AQ	NS	1	DEP	149.9733	5
6	AQ	NS	2	DEP	498.8444	5
6	AQ	NS	3	DEP	212.8044	7
6	AQ	NS	4	DEP	116.5111	7
6	AQ	NS	5	DEP	741.2756	7
6	AQ	NS	6	DEP	346.9156	7
6	AQ	NS	7	DEP	206.5422	5
6	AQ	NS	8	DEP	329.4844	5
6	AQ	NS	9	CON	70.7867	10
6	AQ	NS	10	CON	101.1467	10
6	AQ	NS	11	CON	96.5778	10
6	AQ	NS	12	CON	160.8400	9
6	AQ	CS	1	DEP	0.0000	4
6	AQ	CS	2	DEP	1.9778	4
6	AQ	CS	3	DEP	0.0000	6
6	AQ	CS	4	DEP	0.0000	4
6	AQ	CS	5	DEP	7.4800	7
6	AQ	CS	6	DEP	3.7511	5
6	AQ	CS	7	DEP	48.3556	7
6	AQ	CS	8	DEP	13.6711	9

Month	Industry	Site	Dredge	Zone	Ni (μg·g^{-1})	Co (μg·g^{-1})	Be (μg·g^{-1})	Mo (μg·g^{-1})	BMI#·m^{-2}	BMI Biomass·m^{-2}
10	AG	AD3	9	CON	13	8.8	0.45	5.2	1022.22	1.2711
10	AG	AD3	10	CON	14	8.8	0.43	5.1	2311.11	0.7467
10	AG	AD3	11	CON	14	9.2	0.44	6.0	2444.44	1.0133
10	AG	AD3	12	CON	14	9.1	0.54	6.3	400.00	0.1600

Month	Industry	Site	Dredge	Zone	Ni (µg·g⁻¹)	Co (µg·g⁻¹)	Be (µg·g⁻¹)	Mo (µg·g⁻¹)	BMI#·m⁻²	BMI Biomass·m⁻²
10	AQ	CS	12	CON	9.3	7.3	0.28	4.6	622.22	0.3644
10	AG	AD1	1	DEP	14	9.5	0.66	6.0	3555.56	2.5022
10	AG	AD1	2	DEP	16	9.4	0.72	5.5	1688.89	1.5422
10	AG	AD1	3	DEP	14	13	0.49	5.8	2800.00	1.6133
10	AG	AD1	4	DEP	13	8.7	0.40	5.3	5833.33	3.3167
10	AG	AD1	5	DEP	19	10	0.77	9.8	3511.11	2.0000
10	AG	AD1	6	DEP	18	9.4	0.56	7.7	2355.56	1.7022
10	AG	AD1	7	DEP	18	10	0.63	8.1	2888.89	2.5511
10	AG	AD1	8	DEP	17	9.5	0.51	6.7	2844.44	2.1778
10	AG	AD1	9	CON	13	8.2	0.38	4.8	577.78	0.3156
10	AG	AD1	11	CON	12	11	0.59	5.6	666.67	0.4844
10	AG	AD1	12	CON	12	8.7	0.35	6.6	2666.67	1.8933
10	AG	AD2	1	DEP	13	9.2	0.40	6.1	1955.56	2.4489
10	AG	AD2	2	DEP	15	10	1.2	7.0	1422.22	1.5778
10	AG	AD2	3	DEP	14	9.1	0.40	6.8	1422.22	1.9822
10	AG	AD2	4	DEP	15	10	0.46	8.8	1866.67	1.5556
10	AG	AD2	5	DEP	12	8.4	0.37	5.0	1466.67	1.1111
10	AG	AD2	6	DEP	13	9.1	0.42	6.1	711.11	0.4844
10	AG	AD2	7	DEP	13	8.7	0.35	5.1	5888.89	3.2278
10	AG	AD2	8	DEP	13	8.5	0.34	6.0	888.89	0.5022
10	AG	AD2	9	CON	10	8.7	0.37	5.8	888.89	0.6000
10	AG	AD2	10	CON	10	7.1	0.39	4.6	622.22	0.4178
10	AG	AD2	11	CON	9.4	6.8	0.35	4.6	666.67	0.2667
10	AG	AD2	12	CON	9.9	7.3	0.45	4.6	1200.00	0.5556
10	AG	AD3	1	DEP	11	7.3	0.47	4.6	266.67	0.1467
10	AG	AD3	2	DEP	10	6.7	0.45	4.6	2000.00	1.1289
10	AG	AD3	3	DEP	12	7.8	0.53	5.7	1244.44	1.0578
10	AG	AD3	4	DEP	9.3	6.6	0.35	4.6	1422.22	0.4800
10	AG	AD3	5	DEP	12	7.6	0.45	4.6	577.78	0.1956
10	AG	AD3	6	DEP	11	7.5	0.36	5.1	622.22	0.2444
10	AG	AD3	7	DEP	12	7.4	0.43	5.6	1511.11	0.6311
10	AG	AD3	8	DEP	13	9.9	0.46	5.1	1066.67	0.3111

APPENDIX E:

WATER QUALITY DATA FOR THE SIX STUDY DISCHARGES

This data was collected by the University of Idaho's Kimberly Research and Extension Center and available on the internet at http://www.kimberly.uidaho.edu/midsnake/.

Box Canyon Hatchery (1990-1993)

Parameter	Units	Samples	Min	Ave	Max
Temperature: Water	°C	116	2.5	12.4	17.7
Temperature: Air	°C	116	-2.0	15.8	34.7
Instantaneous Flow	cfs	86	200.0	296.8	300.0
Turbidity	NTU	116	0.10	1.13	5.19
Electrical Conductivity	µmhos/cm	116	250	385	490
Oxygen: Dissolved	mg/l	116	4.6	7.4	11.6
pH (field)	SU	116	6.6	7.7	8.3
Total Nonfilterable Residue	mg/l	116	1.0	4.5	16.0
Nitrogen: Total Ammonia	mg/l-N	116	0.293	0.487	0.754
Nitrogen: Total Kjeldahl	mg/l-N	116	0.15	0.78	1.94
Nitrogen: Total Oxidized	mg/l-N	116	0.554	0.836	0.987
Phosphorus: Total	mg/l-P	116	0.05	0.14	0.25
Phosphorus: Orthophosphate Dissolved	mg/l-P	116	0.019	0.119	0.351

Crystal Springs Hatchery (1990-1991)

Parameter	Units	Samples	Min	Ave	Max
Temperature: Water	°C	54	12.1	14.7	17.7
Temperature: Air	°C	54	-1.1	16.2	32.0
Mean Daily Flow	cfs	3	185	185	186
Instantaneous Flow	cfs	51	176.7	196.5	219.0
Turbidity	NTU	54	0.30	0.92	3.00
Electrical Conductivity	µmhos/cm	54	480	622	770
Oxygen: Dissolved	mg/l	54	5.1	8.0	12.6
pH (field)	SU	54	6.5	7.9	8.6
Total Nonfilterable Residue	mg/l	54	1.0	4.7	12.0
Nitrogen: Total Ammonia	mg/l-N	54	0.100	0.342	0.884
Nitrogen: Total Kjeldahl	mg/l-N	54	0.25	0.59	1.02
Nitrogen: Total Oxidized	mg/l-N	54	0.043	2.257	4.269
Phosphorus: Total	mg/l-P	54	0.07	0.10	0.15
Phosphorus: Orthophosphate Dissolved	mg/l-P	54	0.054	0.082	0.107

Rim View Hatchery (1990-1991)

Parameter	Units	Samples	Min	Ave	Max
Temperature: Water	°C	54	9.6	14.4	17.0
Temperature: Air	°C	54	0.0	17.7	36.0
Mean Daily Flow	cfs	3	133	136	137
Instantaneous Flow	cfs	51	106.6	133.9	147.7
Turbidity	NTU	54	-1.00	0.95	3.40
Electrical Conductivity	µmhos/cm	54	390	547	680
Oxygen: Dissolved	mg/l	54	5.6	6.8	8.8
pH (field)	SU	54	6.5	7.8	10.1
Total Nonfilterable Residue	mg/l	54	1.0	4.3	12.0
Nitrogen: Total Ammonia	mg/l-N	54	0.148	0.341	0.528
Nitrogen: Total Kjeldahl	mg/l-N	54	0.34	0.63	1.37
Nitrogen: Total Oxidized	mg/l-N	54	0.474	1.569	2.289
Phosphorus: Total	mg/l-P	54	0.05	0.09	0.25
Phosphorus: Orthophosphate Dissolved	mg/l-P	54	0.050	0.083	0.116

Pigeon Cove LQ & LS Drain (1990-2002)

Parameter	Units	Samples	Min	Ave	Max
Temperature: Water	°C	90	7.0	13.9	19.5
Temperature: Air	°C	78	-4.5	15.3	29.2
Mean Daily Flow	cfs	2	36	43	50
Instantaneous Flow	cfs	74	7.0	42.2	71.4
Stage: Stream	ft	1	56.00	56.00	56.00
Turbidity	NTU	64	1.20	51.21	185.00
Electrical Conductivity	µmhos/cm	78	450	634	920
Oxygen: Dissolved	mg/l	90	7.6	19.6	960.0
pH (field)	SU	78	7.5	8.1	8.6
Total Nonfilterable Residue	mg/l	90	6.0	195.4	1236.0
Nitrogen: Total Ammonia	mg/l-N	78	0.009	0.081	0.591
Nitrogen: Total Kjeldahl	mg/l-N	78	0.05	0.68	2.10
Nitrogen: Total Oxidized	mg/l-N	29	0.523	2.369	4.809
Nitrogen: Dissolved Oxidized	mg/l-N	49	0.750	1.769	4.110
Phosphorus: Total	mg/l-P	90	0.05	0.29	1.25
Phosphorus: Orthophosphate Dissolved	mg/l-P	78	0.010	0.063	0.167
Fecal Coliform Bacteria	#/100ml	29	16	473	2400
Fecal Strep Bacteria	#/100ml	29	180	2380	7300

Southside LS2/39A Drain (1990-2002)

Parameter	Units	Samples	Min	Ave	Max
Temperature: Water	°C	88	3.4	13.6	23.3
Temperature: Air	°C	76	-1.2	19.6	35.5
Mean Daily Flow	cfs	1	6	6	6
Instantaneous Flow	cfs	76	0.6	7.6	17.8
Turbidity	NTU	62	0.50	40.36	170.00
Electrical Conductivity	µmhos/cm	76	430	655	950
Oxygen: Dissolved	mg/l	87	7.5	9.1	11.4
pH (field)	SU	76	7.5	8.3	9.3
Total Nonfilterable Residue	mg/l	88	3.0	142.6	1080.0
Nitrogen: Total Ammonia	mg/l-N	76	0.004	0.042	0.151
Nitrogen: Total Kjeldahl	mg/l-N	76	0.18	0.58	1.65
Nitrogen: Total Oxidized	mg/l-N	27	0.395	1.979	4.289
Nitrogen: Dissolved Oxidized	mg/l-N	49	0.839	1.942	4.190
Phosphorus: Total	mg/l-P	88	0.03	0.22	1.07
Phosphorus: Orthophosphate Dissolved	mg/l-P	76	0.017	0.051	0.119
Fecal Coliform Bacteria	#/100ml	27	1	370	2600
Fecal Strep Bacteria	#/100ml	27	49	5135	82000

Southside 39 Drain (1990-2002)

Parameter	Units	Samples	Min	Ave	Max
Temperature: Water	°C	90	5.0	14.5	24.2
Temperature: Air	°C	78	-0.1	19.9	35.9
Mean Daily Flow	cfs	1	4	4	4
Instantaneous Flow	cfs	77	0.2	6.2	17.3
Turbidity	NTU	64	0.80	77.13	420.50
Electrical Conductivity	µmhos/cm	78	410	596	950
Oxygen: Dissolved	mg/l	89	7.5	9.0	10.9
pH (field)	SU	77	7.5	8.4	9.3
Total Nonfilterable Residue	mg/l	90	1.0	429.5	4803.0
Nitrogen: Total Ammonia	mg/l-N	78	0.004	0.116	4.559
Nitrogen: Total Kjeldahl	mg/l-N	78	0.10	0.95	6.00
Nitrogen: Total Oxidized	mg/l-N	29	0.286	3.198	7.000
Nitrogen: Dissolved Oxidized	mg/l-N	49	0.490	1.982	7.179
Phosphorus: Total	mg/l-P	90	0.02	0.51	4.50
Phosphorus: Orthophosphate Dissolved	mg/l-P	78	0.009	0.060	0.158
Fecal Coliform Bacteria	#/100ml	29	10	444	1850
Fecal Strep Bacteria	#/100ml	29	45	2486	13000

APPENDIX F:

USGS STREAMFLOW STATISTICS UPSTREAM AND DOWNSTREAM OF STUDY AREA

Daily and monthly streamflow statistics from USGS gages at Kimberly (13090000) and just below Lower Salmon Falls Dam (13135000) were downloaded from the USGS website at http://nwis.waterdata.usgs.gov/id/nwis/sw.

Kimberly Gaging Station (13090000)

Day of	Mean of daily mean values for this day for 81 years of record[1], in ft^3/s											
month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	3629	4018	4089	5147	4429	4325	2776	810	942	1287	2696	3306
2	3649	4034	4088	5083	4199	4310	2743	837	950	1379	2829	3449
3	3728	4020	4059	5125	4051	4446	2520	847	939	1418	2837	3467
4	3708	4003	4069	5037	4129	4564	2259	838	925	1433	2728	3451
5	3751	3978	4111	4970	4205	4481	2178	860	928	1497	2668	3371
6	3821	4067	4053	4971	4295	4501	2036	847	932	1558	2693	3438
7	3879	4064	4044	5054	4132	4608	1971	816	931	1656	2819	3456
8	3832	3968	4032	5097	4039	4739	1883	814	923	1729	2923	3404
9	3907	3904	3931	5079	4195	4923	1718	808	933	1751	2895	3459
10	3897	3850	3837	5143	4268	4880	1503	798	906	1847	2787	3484
11	3879	3852	3837	5175	4270	5053	1323	842	906	2050	2757	3469
12	3953	3865	3897	5194	4484	5180	1155	821	915	2166	2801	3431
13	3981	3856	3849	5185	4541	5158	1110	830	932	2176	2692	3377
14	3943	3940	3919	5101	4601	4855	1067	866	958	2208	2682	3316
15	4013	4003	3991	5114	4674	4665	1034	855	971	2359	2728	3328
16	3978	3976	3923	5092	4458	4591	947	865	951	2415	2783	3363
17	3958	3990	3899	5048	4252	4332	870	880	939	2372	2858	3353
18	3963	3985	3871	4910	4078	4352	841	908	940	2360	2861	3430
19	3983	4006	3822	4862	4054	4071	828	915	957	2397	2950	3488
20	3980	4037	3905	4765	4208	4005	778	901	1025	2448	3046	3468
21	3962	4056	4137	4808	4294	4112	768	899	1032	2457	3086	3526
22	3972	4054	4245	4944	4413	4081	754	887	1070	2392	3163	3552
23	4011	4064	4269	4855	4294	3886	748	887	1095	2378	3178	3561
24	3995	4060	4361	4924	4260	3816	766	906	1124	2457	3192	3589
25	3978	4035	4416	4906	4291	3557	745	899	1111	2431	3164	3582
26	4000	4092	4377	4957	4365	3351	754	888	1117	2473	3178	3564
27	4049	4100	4515	4944	4345	3340	759	894	1101	2508	3189	3514
28	4041	4054	4694	4918	4289	3166	756	915	1075	2577	3165	3555
29	3899	4147	4747	4773	4215	2954	795	921	1056	2775	3120	3646
30	3997		4891	4552	4318	2851	792	937	1143	2766	3091	3649
31	3998		5072		4545		796	933		2746		3668

1 – Available period of record may be less than value shown for certain days of the year.

YEAR	Monthly mean streamflow, in ft^3/s											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1923										4,929	6,018	5,462
1924	4,492	5,920	4,378	1,279	389	396	398	411	431	440	4,138	3,886
1925	4,451	5,377	4,390	7,920	11,760	6,961	4,807	695	1,971	5,615	6,544	6,343
1926	5,172	5,971	5,215	2,985	425	428	445	458	491	483	622	1,321
1927	3,212	1,928	1,166	1,060	3,563	12,400	6,573	609	1,380	1,666	6,536	8,986
1928	7,799	7,356	6,916	5,494	16,520	6,608	857	636	1,112	5,669	3,856	4,105
1929	3,200	2,749	5,555	9,237	2,003	978	597	610	1,583	1,877	6,770	5,071
1930	5,991	2,877	740	508	515	508	500	611	891	1,300	3,483	4,647
1931	2,119	1,477	771	445	408	413	430	539	489	1,244	1,368	1,188
1932	1,235	1,742	1,266	439	439	453	517	457	542	848	972	1,782
1933	1,652	1,840	1,510	849	469	404	421	455	531	1,064	912	1,002
1934	995	921	501	389	372	380	388	409	515	546	536	730
1935	747	583	465	340	331	370	359	465	659	708	663	679
1936	794	777	466	433	4,290	6,995	492	580	754	747	672	632
1937	1,331	710	1,274	3,410	2,280	431	473	584	644	684	683	681
1938	699	549	492	6,425	5,818	6,169	5,127	400	503	959	947	1,210
1939	2,520	3,800	6,211	4,589	1,132	357	378	405	596	807	899	853
1940	832	922	544	1,711	504	367	397	502	694	889	1,032	874
1941	933	886	471	405	334	362	392	550	810	1,059	1,380	844
1942	955	1,621	1,247	4,136	2,365	580	375	542	794	1,800	1,834	2,590
1943	2,474	4,766	5,873	9,388	2,579	12,659	4,763	557	885	3,807	4,224	3,716
1944	3,221	1,061	3,649	5,271	1,382	6,485	602	506	603	905	1,176	1,027
1945	2,333	2,347	2,272	2,591	2,642	5,731	1,068	554	611	2,465	5,323	5,780

YEAR	Monthly mean streamflow, in ft^3/s											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1946	6,580	5,760	5,729	10,010	1,802	3,988	425	504	688	2,538	3,670	3,985
1947	4,369	4,340	1,529	2,169	2,443	8,478	456	677	819	1,994	2,768	4,068
1948	4,059	2,811	2,059	5,284	5,885	8,958	724	674	734	1,216	1,655	4,600
1949	5,794	7,050	6,377	2,780	533	2,463	561	769	1,010	2,678	2,442	2,245
1950	3,253	4,193	5,447	8,448	5,124	8,674	5,299	870	1,040	3,166	3,515	4,389
1951	7,562	10,600	9,977	4,940	9,334	3,277	892	1,152	1,144	4,443	4,646	4,598
1952	5,839	9,461	10,230	11,000	7,752	5,620	1,526	801	734	1,734	736	1,417
1953	2,466	4,247	5,415	2,446	590	5,585	735	795	695	815	1,035	2,174
1954	2,424	2,481	2,914	3,204	2,211	903	822	793	659	2,155	2,558	2,192
1955	2,420	1,314	2,746	4,995	1,158	814	610	449	471	1,061	824	1,182
1956	3,207	4,435	6,402	7,825	7,006	11,570	674	719	805	2,540	2,247	2,544
1957	3,337	2,778	4,811	6,087	9,825	1,516	556	745	772	1,445	1,038	1,841
1958	2,600	2,923	3,426	3,487	1,317	702	618	664	713	1,353	1,109	1,110
1959	1,141	1,338	1,419	675	477	366	384	465	693	2,020	1,259	1,036
1960	1,150	987	872	1,642	343	354	593	606	665	603	671	772
1961	814	870	585	561	453	311	348	384	409	696	752	769
1962	842	1,186	4,324	3,927	3,965	915	490	783	875	1,896	1,407	1,912
1963	1,653	1,399	1,378	1,203	2,664	9,582	608	710	719	656	1,400	1,969
1964	1,916	1,733	1,713	5,054	7,369	8,483	676	751	764	1,338	3,248	3,635
1965	5,036	10,910	10,420	8,260	5,399	843	999	859	759	2,294	3,894	9,105
1966	8,558	7,844	4,454	491	400	391	555	717	741	657	727	897
1967	930	796	726	584	882	3,564	1,361	694	760	1,238	2,702	4,594
1968	4,286	4,928	1,409	456	386	1,612	631	670	833	1,649	2,982	4,556
1969	9,080	9,089	9,482	5,256	2,707	412	495	633	744	888	711	1,797
1970	3,593	3,135	1,112	4,208	8,456	5,518	1,681	482	781	2,691	3,554	6,465
1971	8,570	8,959	5,840	18,830	15,450	8,913	3,330	553	1,087	9,540	10,980	9,632
1972	9,556	10,260	10,050	15,670	7,141	7,899	618	748	978	6,947	8,642	9,343
1973	9,001	9,078	7,897	6,143	541	382	401	423	453	757	1,944	3,665
1974	3,953	7,453	12,280	15,330	11,100	6,691	2,571	605	651	1,797	3,270	5,772
1975	7,148	7,570	9,702	14,170	12,930	5,213	408	502	999	3,149	4,981	7,780
1976	8,239	8,896	10,810	17,280	16,070	7,415	399	619	1,224	3,353	4,005	5,614
1977	4,378	3,551	2,838	484	344	358	385	406	408	386	610	954
1978	1,399	1,797	2,732	5,713	4,818	497	617	798	1,356	2,159	4,224	4,681
1979	6,602	6,318	8,375	6,410	550	429	534	1,958	955	484	752	870
1980	1,018	850	1,180	2,615	6,985	8,553	512	652	625	696	2,528	3,043
1981	2,997	1,639	1,315	3,762	1,807	6,118	609	655	1,290	1,923	1,701	1,635
1982	1,872	2,706	5,401	14,510	13,289	4,401	2,527	1,816	2,465	5,284	10,460	11,070
1983	10,660	8,245	4,499	8,995	16,280	12,630	6,180	1,875	2,274	8,686	12,120	12,030
1984	14,840	7,482	5,024	14,370	18,230	19,890	4,585	2,938	2,385	10,450	13,239	9,075
1985	11,510	9,780	7,701	9,699	5,779	1,760	1,429	1,819	1,872	1,515	3,459	4,902
1986	5,725	6,736	14,299	16,840	17,100	12,580	1,421	1,449	2,255	9,643	8,050	10,870
1987	7,957	2,721	1,567	936	446	542	1,079	1,104	1,554	1,943	1,249	1,124
1988	1,115	1,066	438	259	310	663	912	955	550	623	1,088	991
1989	968	1,059	830	369	306	608	1,103	1,129	915	775	1,770	1,778
1990	1,224	1,035	353	271	319	360	712	681	715	421	1,050	936
1991	1,757	951	332	249	293	319	781	902	600	755	943	1,301
1992	1,458	961	483	276	261	277	315	336	394	669	877	1,131
1993	1,224	769	1,027	702	1,130	5,475	1,568	1,479	597	793	1,875	2,874
1994	2,848	2,323	2,446	2,049	1,908	1,872	1,911	901	600	581	758	864
1995	1,028	802	505	447	6,630	8,408	2,029	1,990	1,666	648	2,643	3,408
1996	4,724	7,805	17,400	14,360	5,968	7,819	2,535	2,056	986	730	2,562	3,812
1997	9,206	18,330	19,430	13,239	8,738	24,150	3,670	4,261	7,039	7,028	5,966	8,169
1998	6,979	7,328	7,388	9,314	10,850	9,575	2,811	2,056	2,113	2,322	4,818	8,335
1999	8,604	8,116	7,856	10,080	10,410	11,800	1,999	2,086	1,784	2,469	4,089	4,825
2000	7,033	3,153	3,341	4,908	774	879	1,971	2,044	1,218	1,264	1,160	1,024
2001	907	905	819	489	1,055	379	350	380	397	512	944	979
2002	892	831	828	235	233	267	452	605	632	731	807	884
2003	800	877	826	458	467	475	326	343	374	372	725	819
2004	764	795	798	512	482	396	311	323	333			
Mean of monthly streamflows	3,914	3,999	4,160	4,991	4,296	4,239	1,288	868	991	2,144	2,919	3,474

Lower Salmon Falls Dam Gaging Station (13135000)

Day of month	Mean of daily mean values for this day for 67 years of record[1], in ft³/s											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	9259	9599	9568	10840	10530	10180	8251	6404	6939	7713	9023	9173
2	9356	9662	9617	10870	10240	10100	8146	6425	6962	7829	8972	9280
3	9306	9656	9610	10890	9999	10130	7812	6453	7009	7961	8991	9357
4	9399	9574	9544	10790	9931	10310	7447	6462	7013	7984	8940	9316
5	9322	9516	9663	10720	9924	10250	7322	6457	7006	8027	8865	9291
6	9371	9548	9630	10690	9996	10330	7246	6470	7109	8146	8806	9170
7	9480	9653	9505	10790	10070	10480	7125	6455	7115	8168	8733	9239
8	9566	9624	9544	10790	9820	10650	7042	6409	7144	8195	8831	9196
9	9473	9480	9545	10850	9863	10990	7004	6427	7157	8268	8862	9216
10	9513	9477	9394	10860	9903	11190	6792	6434	7207	8301	8855	9271
11	9504	9455	9392	11050	9944	11330	6657	6405	7242	8468	8789	9212
12	9632	9515	9355	11160	10040	11480	6490	6496	7276	8627	8793	9239
13	9639	9432	9391	11080	10120	11480	6430	6404	7322	8724	8806	9136
14	9563	9506	9474	11040	10220	11360	6365	6465	7359	8667	8751	9047
15	9618	9587	9494	10950	10310	11100	6279	6533	7374	8756	8759	8946
16	9708	9583	9506	10970	10170	10880	6300	6533	7386	8909	8767	9027
17	9694	9598	9482	11000	9856	10700	6203	6566	7402	8971	8782	9060
18	9590	9637	9482	10870	9619	10450	6183	6586	7422	8881	8790	9124
19	9647	9645	9430	10770	9547	10250	6179	6622	7485	8805	8853	9139
20	9616	9608	9502	10680	9668	9977	6176	6679	7537	8900	8861	9164
21	9593	9636	9614	10610	9880	10010	6115	6642	7563	8921	9030	9106
22	9588	9649	9878	10750	9943	10070	6122	6675	7576	8946	8972	9250
23	9675	9605	9873	10870	9937	9799	6137	6710	7604	8828	9008	9311
24	9662	9687	9956	10880	9724	9592	6176	6727	7567	8867	9108	9349
25	9636	9636	10040	10890	9751	9332	6196	6746	7542	8890	9055	9317
26	9592	9608	9947	10900	9894	8916	6209	6753	7597	8831	9102	9330
27	9589	9706	10160	11090	9909	8787	6205	6754	7548	8862	9126	9338
28	9724	9608	10330	11010	9954	8747	6229	6793	7564	8836	9161	9271
29	9649	9528	10350	10900	9908	8534	6301	6826	7546	9012	9085	9311
30	9483		10450	10680	10010	8389	6339	6848	7584	9135	8985	9287
31	9608		10670		10220		6346	6906		9095		9356

1 – Available period of record may be less than value shown for certain days of the year.

YEAR	Monthly mean streamflow, in ft³/s											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1937										6,800	6,680	6,710
1938	6,503	6,129	5,968	11,440	11,130	11,890	10,840	6,271	6,647	7,319	7,013	7,165
1939	8,152	9,336	11,530	9,755	6,392	6,027	6,060	6,219	6,897	7,119	6,905	6,858
1940	6,699	6,582	5,874	6,851	5,592	5,674	5,860	6,320	7,287	7,175	7,174	6,852
1941	6,758	6,626	5,833	5,800	5,666	6,312	5,985	6,353	7,191	7,410	7,805	7,060
1942	6,915	7,315	6,959	9,498	8,321	6,758	6,090	6,524	7,256	8,260	8,430	8,801
1943	8,513	10,730	11,700	14,950	8,439	18,790	11,010	6,766	7,592	10,590	10,850	10,060
1944	9,316	7,033	9,413	11,130	7,022	12,700	6,378	6,657	7,233	7,620	7,669	7,285
1945	8,436	8,387	8,139	8,342	8,517	11,860	7,145	6,756	7,409	9,105	11,900	12,160
1946	12,790	11,890	11,710	15,840	7,652	10,280	6,506	6,777	7,566	9,440	10,100	10,230
1947	10,340	10,420	7,321	7,715	7,981	15,060	6,589	7,098	7,785	8,851	9,496	10,610
1948	10,210	8,828	7,785	10,840	11,460	15,079	6,515	6,645	7,403	7,625	7,989	10,710
1949	11,830	13,150	12,250	8,443	6,322	8,546	6,382	6,986	7,776	9,480	9,067	8,873
1950	9,194	9,897	10,960	14,010	10,800	14,740	11,390	7,272	7,750	9,789	9,895	10,740
1951	13,510	16,270	15,590	11,030	15,450	9,685	6,795	7,442	7,885	11,430	11,160	10,680
1952	11,560	15,670	16,300	17,080	13,580	11,830	7,653	7,137	7,570	8,599	7,312	7,860
1953	8,815	10,140	11,180	8,385	6,931	12,250	6,565	6,942	7,438	7,724	7,766	8,669
1954	8,667	8,594	8,793	9,145	7,846	7,429	6,827	6,967	7,621	9,108	9,299	8,626
1955	8,450	7,193	8,349	10,720	7,045	6,674	6,641	6,591	7,210	7,675	7,355	7,324
1956	9,290	10,350	11,940	13,590	12,839	18,170	6,615	7,167	7,782	9,534	8,910	8,878
1957	9,302	8,699	10,550	11,900	16,260	7,897	6,526	7,070	7,679	8,289	7,590	8,179
1958	8,686	8,808	9,267	9,168	6,988	6,957	6,559	6,961	7,558	8,093	7,578	7,292
1959	7,112	7,156	7,078	6,363	6,340	6,133	6,089	6,581	7,778	8,882	7,804	7,376
1960	6,991	6,690	6,394	7,063	5,763	6,138	6,378	6,762	7,141	7,275	6,885	6,662
1961	6,177	6,056	5,665	5,785	5,584	5,581	5,675	5,993	6,539	6,599	6,156	5,802
1962	5,676	5,980	9,017	8,798	9,580	6,510	5,678	6,418	7,055	8,251	7,401	7,314
1963	6,675	6,504	6,247	6,620	7,972	16,139	6,245	6,700	7,282	7,314	7,593	7,583
1964	7,218	6,794	6,670	10,280	12,889	14,890	6,116	6,639	7,281	8,105	9,589	9,634
1965	10,460	16,310	16,050	13,950	11,400	6,895	6,877	7,240	7,662	9,206	10,600	15,070
1966	14,160	13,039	9,690	5,938	5,606	5,941	6,213	6,717	7,329	7,478	6,947	6,662

YEAR	Monthly mean streamflow, in ft^3/s											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1967	6,367	5,989	5,875	6,139	6,440	9,768	7,089	6,579	7,324	8,260	9,299	10,610
1968	9,940	10,360	6,757	5,949	5,691	7,546	6,266	7,265	7,707	8,410	9,480	10,420
1969	14,560	14,399	14,570	10,910	8,200	6,424	6,211	6,556	7,449	7,682	7,043	7,529
1970	8,962	8,422	6,177	9,596	14,320	11,690	7,586	6,400	7,714	9,441	9,943	12,210
1971	14,540	14,399	10,850	25,250	22,250	15,230	9,171	6,552	7,876	16,530	17,700	15,659
1972	15,520	15,650	15,730	21,950	13,020	13,880	6,279	6,685	8,011	13,910	15,340	15,330
1973	14,700	14,449	13,180	11,570	5,793	5,820	5,825	6,126	7,213	7,352	8,182	9,541
1974	9,489	12,690	17,470	20,930	16,560	12,070	8,111	6,596	7,149	8,362	9,728	11,570
1975	12,550	12,830	14,870	19,860	18,880	10,980	5,325	6,040	7,236	10,050	11,650	13,950
1976	14,050	14,549	16,189	22,920	21,610	13,400	5,567	6,894	8,011	10,160	10,460	11,730
1977	9,965	9,071	8,231	5,467	5,550	5,473	5,326	5,601	5,926	6,089	6,046	6,113
1978	6,352	6,887	7,713	10,920	10,440	5,703	5,704	6,256	7,941	8,315	10,350	10,170
1979	12,410	11,780	13,690	11,770	5,586	5,582	5,514	7,355	7,158	6,891	6,586	6,336
1980	6,334	6,042	6,424	7,785	12,850	14,590	5,547	6,082	7,058	6,997	8,439	8,628
1981	8,343	6,738	6,136	8,880	6,754	11,680	5,377	5,812	7,423	8,188	7,191	6,899
1982	6,902	7,864	10,300	19,370	18,350	9,730	7,853	7,100	8,744	11,570	16,410	16,940
1983	16,330	13,300	9,369	14,960	21,620	18,060	11,630	7,760	8,508	14,950	17,800	17,490
1984	19,770	12,790	10,050	19,330	24,090	25,140	9,665	8,283	8,665	16,610	18,910	14,370
1985	16,940	15,890	12,680	15,210	10,690	6,852	6,266	7,019	8,432	8,157	9,519	10,500
1986	11,390	12,450	19,310	22,160	22,200	18,110	6,741	6,949	9,027	16,300	13,869	16,250
1987	13,280	7,683	6,398	5,816	5,321	5,580	6,258	6,431	7,665	8,108	6,840	6,408
1988	6,146	5,926	5,234	5,247	5,370	5,673	5,796	6,105	6,425	6,519	6,582	6,148
1989	5,682	5,799	5,727	5,341	5,301	5,528	6,028	6,743	7,282	7,389	7,336	6,967
1990	6,251	5,888	5,175	5,354	5,615	6,075	5,750	6,140	6,861	6,928	6,625	6,118
1991	6,627	5,772	4,997	5,107	5,467	5,456	5,729	6,186	6,865	6,833	6,298	6,242
1992	6,190	5,588	4,881	4,821	4,459	4,467	4,694	4,716	5,192	5,785	5,804	5,705
1993	5,633	5,369	5,572	5,145	5,618	10,520	6,058	6,570	6,119	6,619	6,874	7,709
1994	7,524	6,753	6,798	6,647	6,467	6,186	6,136	5,555	5,775	6,304	5,790	5,648
1995	5,672	5,304	4,932	4,879	11,090	13,519	6,516	6,672	7,094	6,448	7,783	8,211
1996	9,092	12,290	21,760	19,450	11,010	12,540	7,034	6,861	6,570	6,498	7,782	8,943
1997	14,240	23,680	25,260	19,190	14,290	29,800	8,742	9,373	13,060	13,289	11,910	13,370
1998	11,890	12,320	12,709	14,820	16,900	15,320	7,470	6,740	7,691	8,097	10,120	13,830
1999	13,830	13,390	13,220	15,570	16,130	17,400	6,454	6,951	7,282	8,265	9,422	9,861
2000	12,160	8,123	8,035	10,000	5,849	5,555	6,402	6,735	6,786	6,826	6,015	5,679
2001	5,447	5,451	5,343	5,377	5,854	5,090	5,120	5,135	5,677	6,028	6,009	5,767
2002	5,615	5,409	5,285	4,736	4,750	4,624	4,671	5,000	5,695	6,069	5,676	5,585
2003	5,353	5,283	5,079	4,865	5,022	4,552	4,425	4,761	5,367	5,661	5,610	5,582
2004	5,401	5,417	5,198	4,844	4,875	4,460	4,313	4,488	5,104			
Mean of monthly streamflows	9,550	9,591	9,722	10,870	9,965	10,190	6,640	6,583	7,339	8,598	8,916	9,220