AQUATIC EFFECTS TECHNOLOGY EVALUATION (AETE) PROGRAM

1997 Field Program
Final Report
Heath Steele Mine Site,
New Brunswick

AETE Project 4.1.3

September 1998
Revised as of March 1999

1997 FIELD PROGRAM - AETE
HEATH STEELE

SITE REPORT

Report prepared for:

Aquatic Effects Technology Evaluation (AETE) Program
Canada Centre for Mineral and Energy Technology (CANMET)
Natural Resources Canada
555 Booth Street
Ottawa, Ontario
K1A 0G1

Prepared by:

BEAK INTERNATIONAL INCORPORATED

14 Abacus Road
Brampton, Ontario
L6T 5B7

and

455 Boul. Fénélon, Suite 104
Dorval, Québec
H9S 5T8

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BEAK INTERNATIONAL INCORPORATED

PROJECT TEAM:

Biostatistics: Donald R. Hart, Alan J. Burt
Field Crew Leader: Robert Eakins
Data Management: Deb McMillan
Toxicology: Julie Schroeder

PROJECT MANAGEMENT TEAM:

Paul McKee, M.Sc.

Dennis Farara, B.Sc.

AQUATIC EFFECTS TECHNOLOGY EVALUATION PROGRAM

Notice to Readers

1997 Field Program

The Aquatic Effects Technology Evaluation (AETE) program was established to review appropriate technologies for assessing the impacts of mine effluents on the aquatic environment. AETE is a cooperative program between the Canadian mining industry, several federal government departments and a number of provincial governments; it is coordinated by the Canada Centre for Mineral and Energy Technology (CANMET). The program is designed to be of direct benefit to the industry, and to government. Through technical evaluations and field evaluations, it will identify cost-effective technologies to meet environmental monitoring requirements. The program includes three main areas: acute and sublethal toxicity testing, biological monitoring in receiving waters, and water and sediment monitoring. The program includes literature-based technical evaluations and a comprehensive three year field program.

The program has the mandate to do a field evaluation of water, sediment and biological monitoring technologies to be used by the mining industry and regulatory agencies in assessing the impacts of mine effluents on the aquatic environment; and to provide guidance and to recommend specific methods or groups of methods that will permit accurate characterization of environmental impacts in the receiving waters in as cost-effective a manner as possible. A pilot field study was conducted in 1995 to fine-tune the study design.

A phased approach has been adopted to complete the field evaluation of selected monitoring methods as follows:

Phase I: 1996- Preliminary surveys at seven candidate mine sites, selection of sites for further work and preparation of study designs for detailed field evaluations.

Phase II: 1997-Detailed field and laboratory studies at selected sites.

Phase III: 1998- Data interpretation and comparative assessment of the monitoring methods: report preparation.

Phases II and III are the focus of this report. The objective of the 1997 Field Program is NOT to determine the extent and magnitude of effects of mining at the sites but rather to test a series of hypotheses under field conditions and evaluate monitoring methods for assessing aquatic effects.

In Phase I, the AETE Technical Committee selected seven candidates mine sites for the 1996 field surveys: Myra Falls, Westmin Resources (British Columbia); Sullivan, Cominco (British Columbia); Lupin, Contwoyto Lake, Echo Bay (Northwest Territories); Dome, Placer Dome Canada (Ontario); Levack/Onaping, Inco and Falconbridge (Ontario); Gaspé Division, Noranda Mining and Exploration Inc. (Québec); Heath Steele Division, Noranda Mining and Exploration Inc. (New-Brunswick).

Study designs were developed for four sites that were deemed to be most suitable for Phase II of the field evaluation of monitoring methods: Myra Falls, Dome, Heath Steele, Lupin. Lupin was subsequently dropped based on additional reconnaissance data collected in 1997. Mattabi Mine, (Ontario) was selected as a substitute site to complete the 1997 field surveys.

A summary of the results and comparisons of tools at all the four mine sites studied in 1997 are provided in a separate document which evaluate the cost-effectiveness of each monitoring tool (AETE Report #4.1.3, *Summary and Cost-effectiveness Evaluation of Aquatic Effects Monitoring Technologies Applied in the 1997 AETE Field Evaluation Program,* Beak International Incorporated and Golder Associates Ltd, September 1998)

For more information on the monitoring techniques, the results from their field application and the final recommendations from the program, please consult the *AETE Synthesis Report*.

Any comments regarding the content of this report should be directed to:

Geneviève Béchard
Manager, Metals and the Environment Program
Mining and Mineral Sciences Laboratories - CANMET
Room 330, 555 Booth Street, Ottawa, Ontario, K1A 0G1
Tel.: (613) 992-2489 Fax: (613) 992-5172
E-mail: gbechard@nrcan.gc.ca

PROGRAMME D'ÉVALUATION DES TECHNIQUES DE MESURE D'IMPACTS EN MILIEU AQUATIQUE

Avis aux lecteurs

Études de terrain - 1997

Le Programme d'évaluation des techniques de mesure d'impacts en milieu aquatique (ÉTIMA) vise à évaluer les différentes méthodes de surveillance des effets des effluents miniers sur les écosystèmes aquatiques. Il est le fruit d'une collaboration entre l'industrie minière du Canada, plusieurs ministères fédéraux et un certain nombre de ministères provinciaux. Sa coordination relève du Centre canadien de la technologie des minéraux et de l'énergie (CANMET). Le programme est conçu pour bénéficier directement aux entreprises minières ainsi qu'aux gouvernements. Par des évaluations techniques et des études de terrain, il permettra d'évaluer et de déterminer, dans une perspective coût-efficacité, les techniques qui permettent de respecter les exigences en matière de surveillance de l'environnement. Le programme comporte les trois grands volets suivants : évaluation de la toxicité aiguë et sublétale, surveillance des effets biologiques des effluents miniers en eaux réceptrices, et surveillance de la qualité de l'eau et des sédiments. Le programme prévoit également la réalisation d'une série d'évaluations techniques fondées sur la littérature et d'évaluation globale sur le terrain.

Le Programme ÉTIMA a pour mandat d'évaluer sur le terrain les techniques de surveillance de la qualité de l'eau et des sédiments et des effets biologiques qui sont susceptibles d'être utilisées par l'industrie minière et les organismes de réglementation aux fins de l'évaluation des impacts des effluents miniers sur les écosystèmes aquatiques; de fournir des conseils et de recommander des méthodes ou des ensembles de méthodes permettant, dans une perspective coût-efficacité, de caractériser de façon précise les effets environnementaux des activités minières en eaux réceptrices. Une étude-pilote réalisée sur le terrain en 1995 a permis d'affiner le plan de l'étude.

L'évaluation sur le terrain des méthodes de surveillance choisies s'est déroulée en trois étapes:

Étape I	1996 - Évaluation préliminaire sur le terrain des sept sites miniers candidats, sélection des sites où se poursuivront les évaluations et préparation des plans d'étude pour les évaluations sur le terrain.
Étape II	1997- Réalisation des travaux en laboratoire et sur le terrain aux sites choisis
Étape III	1998 -Interprétation des données, évaluation comparative des méthodes de surveillance; rédaction du rapport.

Ce rapport vise seulement les résultats de l'étape II et III. L'objectif du projet N'EST PAS de déterminer l'étendue ou l'ampleur des effets des effluents miniers dans les sites. Le projet vise à vérifier une série d'hypothèses sur le terrain et à évaluer et comparer un ensemble choisi de méthodes de surveillance.

À l'étape I, le comité technique ÉTIMA a sélectionné sept sites miniers candidats aux fins des évaluations sur le terrain:Myra Falls, Westmin Resources (Colombie-Britannique); Sullivan, Cominco (Colombie-Britannique); Lupin, lac Contwoyto, Echo Bay (Territoires du Nord-Ouest); Levack/Onaping, Inco et Falconbridge (Ontario); Dome, Placer Dome Mine (Ontario); Division Gaspé, Noranda Mining and Exploration Inc.(Québec); Division Heath Steele Mine, Noranda Mining and Exploration Inc.(Nouveau-Brunswick).

Des plans d'études ont été élaborés pour les quatres sites présentant les caractéristiques les plus appropriées pour les travaux prévus d'évaluation des méthodes de surveillance dans le cadre de l'étape II (Myra Falls, Dome, Heath Steele, Lupin). Toutefois, une étude de reconnaissance supplémentaire au site minier de Lupin a révélé que ce site ne présentait pas les meilleures possibilités. Le site minier de Mattabi (Ontario) a été choisi comme site substitut pour compléter les évaluations de terrain en 1997.

Un résumé des résultats obtenus aux quatre sites miniers en 1997, la comparaison et l'évaluation des techniques dans une perspective coût-efficacité sont présentés dans un autre document (Rapport ÉTIMA #4.1.3, *Summary and Cost-effectiveness Evaluation of Aquatic Effects Monitoring Technologies Applied in the 1997 AETE Field Evaluation Program,* Beak International Incorporated and Golder Associates Ltd, September 1998).

Pour des renseignements sur l'ensemble des outils de surveillance, les résultats de leur application sur le terrain et les recommandations finales du programme, veuillez consulter le *Rapport de synthèse ÉTIMA*.

Les personnes intéressées à faire des commentaires sur le contenu de ce rapport sont invitées à communiquer avec M^{me} Geneviève Béchard à l'adresse suivante :

Geneviève Béchard
Gestionnaire, Programme des métaux dans l'environnement
Laboratoires des mines et des sciences minérales - CANMET
Pièce 330, 555, rue Booth, Ottawa (Ontario), K1A 0G1
Tél.: (613) 992-2489 / Fax : (613) 992-5172
Courriel : gbechard@nrcan.gc.ca

EXECUTIVE SUMMARY

The Heath Steele (New Brunswick) mine study is one of four field evaluations carried out in 1997 under the Aquatic Effects Technology Evaluation (AETE) Program, a joint government-industry program to evaluate the cost-effectiveness of technologies for the assessment of mining-related impacts in the aquatic environment. The other three mines studied were Dome (Ontario), Mattabi (Ontario) and Myra Falls (British Columbia). Results of all four studies are summarized and evaluated in a separate summary report.

Heath Steele Division, Noranda Inc., is a base metal mine located northwest of Miramichi, in the Tomogonops River headwaters, which flows into the Northwest Miramichi River. The mine produces zinc, lead, copper and silver concentrations. The mine was first developed in the mid-1950s and, although great strides have been made in cleanup of acid rock drainage (ARD) and metal leaching problems in recent years, the mine continues to release substantial loadings of metals to the Little South Branch Tomogonops River due to the effects of ARD. These loadings are being progressively reduced.

The 1997 field studies were carried out in the Little South Branch Tomogonops River and downstream in the main Tomogonops River, upstream of any effect of the treated effluent from the tailings pond. Sampling was carried out here rather than downstream of the effluent because this reach offered an opportunity for study in a stronger water quality gradient. Sampling was not extended downstream of the treated effluent because of the confounding effects of a greatly increased water hardness in the river produced by calcium added in the form of lime for effluent treatment. The entire section of river studied here consists of riffle/run habitat, with a rock-cobble substrate.

The objectives of the 1997 field program were to test 13 hypotheses formulated under four guiding questions:

1. are contaminants getting into the system (and to what degree and in which compartments)?
2. are contaminants bioavailable?
3. is there a measurable (biological) response? and
4. are contaminants causing the responses?

The hypotheses are more specific questions about the ability or relative ability of different monitoring tools to answer these four general questions about mine effect. The evaluation of tools included: sediment monitoring (sediment toxicity tests); fish monitoring (tissue metallothionein and metal analyses, and population/community indicators), and; integration of tools (relationships between exposure and biological responses and use of effluent sublethal toxicity).

Of the 13 hypotheses, 8 were tested at Heath Steele as outlined in Table 1.1. The hypotheses not tested at Heath Steele include tissue comparisons of metals and metallothionein contents (because resident fish are small and analyses were of whole gut rather than individual organs), and sediment-related hypotheses because no soft sediment occurs in the affected reach. One sediment-related hypothesis was tested at Heath Steele (linkage between benthos and sediment quality) using periphyton as a surrogate for sediment.

Study Design

The study design at Heath Steele was based on river sampling for fish and benthos using a gradient design, including five exposure reaches and three reference reaches, with each reach consisting of two stations. Each exposure reach along the gradient had a different concentration of metals, with the key metals being zinc, copper, cadmium and lead. Three reference reaches were established to span the range of river size represented across the exposure gradient.

Sampling Program

The field survey at Heath Steele was completed in August 1997, and included:

- water sampling at each of 16 stations (8 reaches) where fish and benthos were sampled;
- benthic sampling at each of 16 stations (2 samples at each) using a T-sampler;
- periphyton sampling at each of 16 stations (2 samples at each) carried out by scraping of rock substrate surfaces;
- fish population and community at each of 16 stations using a standard electrofishing effort;
- collection of up to 134 juvenile Atlantic salmon and 47 blacknose dace for measurement of length, weight and age (by length frequency analysis with confirmatory aging). Some stations produced no salmon or dace, due to apparent toxicity at the most exposed sites and in one instance due to habitat limitations (fish migration barriers);
- collection of four viscera samples (where possible) per station from wild juvenile salmon (one fish per sample), one to six composite blacknose dace per station and variable numbers of brook trout at each station. In addition, two samples of viscera were collected from each of two caged juvenile salmon from a nearby salmon rearing facility exposed at each station for nine days; and
- three "effluent" samples for chronic toxicity testing using the *Ceriodaphnia dubia* survival and reproduction test, the fathead minnow survival and growth test, the *Selenastrum capricornutum* growth test and the *Lemna minor* growth test. "Effluent" consisted of water collected from the Little South Branch Tomogonops River at the location most affected by the mine and routinely monitored by mine personnel.

Data Overview

Water Quality

Total and dissolved (0.45 μm-filtered) concentrations of Zn, Cd, Pb, Cu, Al and Fe all showed concentration gradients downstream of Heath Steele. All of these parameters except Al remained elevated relative to reference site concentrations at the downstream extent of the exposure gradient, and all occurred in excess of Canadian Water Quality Guidelines in some or all exposure reaches (depending on the metal). Dissolved and total metal concentrations were similar for Zn, Cu and Cd, while dissolved Al, Fe and Pb were substantially lower than their total concentrations.

Periphyton

Periphyton samples were rich in species and variable in biomass, and no trends were observed in response to the water quality gradient or between exposed and reference reaches. In terms of metal concentrations in periphyton, exposed periphyton contained greater levels of Cd, Cu, Zn and Pb, although only Pb in periphyton appeared to track the water quality gradient in the exposure reaches.

Benthic Macroinvertebrates

Benthic community structure responded to the water quality gradient, with exposed stations showing reduced total numbers of taxa and reduced numbers of **E**phermoptera, **P**lecoptera and **T**richoptera (EPT) taxa. Trends were also observed in apparent indicator taxa such as *Micropsectra* which was sensitive to high degrees of exposure, and *Rheocricotopus* which was most abundant at higher degrees of exposure. Total benthic density, however, appeared unresponsive to metal exposure.

Fish

Fish community structure varied from reach to reach, with juvenile Atlantic salmon densities suppressed upstream of the most downstream exposure reach, apparently due to a partial migration barrier. Ten species were represented in the collections, with juvenile salmon, blacknose dace, lake chub and brook being the most common. No fish were found at the most exposed station, apparently due to toxicity.

Catch-per-unit-effort (numbers) and biomass-per-unit-effort (all species) clearly responded to the exposure gradient, and gradually increased from upstream to downstream.

Fish size at age appeared unresponsive to exposure, although Atlantic salmon fry were larger in the exposure area than in the reference area. This effect is probably attributed to higher fry densities and greater competition in the reference area.

Metallothionein (MT) levels in fish viscera were greater in exposed salmon and dace than in reference fish. MT concentrations in caged juvenile salmon viscera and gill closely tracked metal concentrations in water after the exposure period.

Visceral metal levels appeared elevated in exposed wild fish for some metals, although this response was less evident in caged fish.

Effluent Toxicity

All effluent samples tested were chronically toxic to *Ceriodaphnia, Selenastrum* and *Lemna*, while sublethal and lethal toxicity occurred in two of the three tests in fathead minnow. The degree of toxicity corresponded with metal concentration in *Ceriodaphnia* and *Selenastrum*, while *Lemna* and fathead minnow responses did not appear to track metal concentrations in the samples.

Hypothesis Testing

Hypothesis testing results are summarized in Table 5.2. Results of testing indicate that some of the metals are bioavailable, that biological responses occur in both benthos and fish, and that metals appear to cause some of these responses.

Technology Evaluation

Many of the monitoring tools evaluated at Heath Steele demonstrated a mine effect. Periphyton community structure, fish growth and benthic community density were ineffective. Those tools that demonstrated mine effects or partially demonstrating mine effects included water quality, periphyton metals, fish viscera and gill metals and MT, fish population/community indicators, effluent chronic toxicity and benthic community indicators. Table 6.2 summarizes the effectiveness of the various tools tested at Heath Steele.

Among those tools compared in hypothesis testing, some appeared more effective than others. Table 6.3 provides a summary of tool comparisons.

Conclusions on the cost-effectiveness of the tools based on results from all four mine sites studied in 1997 are found in a separate document "Summary and Cost-Effectiveness Evaluation of Aquatic Effects Monitoring Technologies Applied in the 1997 AETE Field Evaluation Program".

SOMMAIRE

L'étude du site de la mine Heath Steele (Nouveau-Brunswick) est l'une des quatre évaluations sur le terrain effectuées en 1997 dans le cadre du Programme d'évaluation des techniques de mesure d'impacts en milieu aquatique (ETIMA), programme conjoint gouvernement-industrie destiné à évaluer le rapport coût-efficacité des technologies d'évaluation des impacts liés aux activités minières dans le milieu aquatique. Les trois autres sites miniers étudiés étaient ceux de Dome (Ontario), de Mattabi (Ontario) et de Myra Falls (Colombie-Britannique). On présente un résumé et une évaluation des résultats de ces quatre études dans un rapport sommaire distinct.

La division Heath Steele de Noranda Inc. est une mine de métaux communs située au nord-ouest de Miramichi, dans le bassin du cours supérieur de la rivière Tomogonops, qui se jette dans la partie nord-ouest de la rivière Miramichi. Depuis le milieu des années 50, cette mine produit du zinc, du plomb, du cuivre et de l'argent et, malgré les efforts considérables faits au cours des dernières années pour éliminer les eaux d'exhaure acides (EEA) et pour régler des problèmes de lixiviation de métaux, cette exploitation minière continue de rejeter d'importantes charges de métaux dans le bras Little South de la rivière Tomogonops à cause des EEA. On travaille à réduire progressivement ces charges.

En 1997, on a effectué les études sur le terrain dans le bras Little South de la rivière Tomogonops et en aval du cours principal de la rivière Tomogonops, en amont du point de rejet de l'effluent traité du bassin de décantation des résidus. On a effectué l'échantillonnage à cet endroit plutôt qu'en aval de l'effluent parce que ce tronçon rendait possible une étude dans un gradient de qualité de l'eau plus étendu. On n'a pas étendu l'échantillonnage à la zone en aval du point de rejet de l'effluent traité à cause d'effets venant brouiller les indices; en effet, l'addition de calcium sous forme de chaux pour le traitement de l'effluent entraîne une forte augmentation de la dureté de l'eau dans la rivière. Toute cette section de la rivière étudiée consiste en un habitat de zones de courant et de rapides à substrat de roches et de galets.

Les objectifs du programme sur le terrain de 1997 étaient de vérifier 13 hypothèses formulées pour tenter de répondre à quatre questions principales :

1. Est-ce que les contaminants pénètrent dans le réseau aquatique (et dans l'affirmative, dans quelle mesure et dans quels compartiments)?
2. Les contaminants sont-ils biodisponibles?
3. La réponse (biologique) est-elle mesurable?
4. Les contaminants sont-ils la cause de ces réponses?

Ces hypothèses représentent des questions plus spécifiques concernant la capacité (relative) des différents outils de surveillance de répondre à ces quatre questions générales sur les effets des activités minières. L'évaluation des outils prévoyait notamment la surveillance des sédiments (tests de toxicité des sédiments), la surveillance des poissons (dosage de la métallothionéine et des métaux des tissus et détermination des indicateurs des populations/communautés) et, enfin, l'intégration des outils (rapports entre l'exposition et les réponses biologiques et utilisation de la toxicité sublétale des effluents).

On a vérifié 8 des 13 hypothèses au site de la mine Heath Steele (voir le tableau 1.1.). Les hypothèses non vérifiées à ce site sont notamment les comparaisons des teneurs en métaux et en métallothionéine des tissus (parce que les poissons qui y résident sont petits et qu'on utilisait l'ensemble des entrailles plutôt que des organes particuliers pour les analyses), ainsi que les hypothèses concernant les sédiments parce qu'on ne trouve pas de sédiments meubles dans le bief touché. On a testé une hypothèse concernant les sédiments au site Heath Steele (rapport entre le benthos et la qualité des sédiments) en utilisant le périphyton comme substitut pour les sédiments.

Plan de l'étude

Le plan de l'étude au site Heath Steele était basé sur l'échantillonnage des poissons et du benthos de la rivière selon un gradient, et il comportait cinq tronçons d'exposition et trois tronçons de référence, chacun comportant deux stations. À l'intérieur du gradient, chacun des tronçons était caractérisé par différentes concentrations de métaux, dont les principaux sont le zinc, le cuivre, le cadmium et le plomb. On a choisi trois tronçons de référence de façon à représenter la gamme des largeurs de la rivière correspondant au gradient d'exposition.

Programme d'échantillonnage

On a terminé les relevés sur le terrain pour le site Heath Steele en août 1997, notamment :

- l'échantillonnage de l'eau à chacune des 16 stations (8 tronçons) où l'on a échantillonné les poissons et le benthos;
- l'échantillonnage du benthos à chacune des 16 stations (2 échantillons par station) à l'aide d'un échantillonneur en T;
- l'échantillonnage du périphyton à chacune des 16 stations (2 échantillons par station), prélevés en grattant la surface de substrats rocheux);
- la détermination des populations et des communautés de poissons à chacune des 16 stations à l'aide d'une méthode normalisée de pêche électrique;
- la collecte de jusqu'à 134 juvéniles de saumon de l'Atlantique et de 47 naseux noirs pour les mesures de longueur, de poids et d'âge (par analyse des fréquences de longueur avec confirmation par l'âge). Dans certaines stations, on n'a prélevé ni saumons ni naseux à cause de la toxicité apparente observée dans la plupart des sites exposés et, dans un cas, à cause des limites de l'habitat (barrières entravant la migration des poissons);
- la collecte de 4 échantillons de viscères de juvéniles de saumon par station (si possible) (un poisson par échantillon), de 1 à 6 échantillons composés de naseux noirs par station et de nombres variables d'ombles de fontaine à chaque station. De plus, on a obtenu deux échantillons de viscères de chacun des deux juvéniles de saumon en cage provenant d'une écloserie voisine, après une exposition de 9 jours à deux stations;

- la collecte de trois échantillons d'« effluent » pour des tests de toxicité chronique basés sur le test de survie et de reproduction de *Ceriodaphnia dubia*, le test de survie et de croissance de la tête-de-boule, le test de croissance de *Selenastrum capricornutum* et le test de croissance de *Lemna minor*. L'« effluent » était constitué d'eau recueillie dans la bras Little South de la rivière Tomogonops, à l'endroit le plus touché par les activités minières, et surveillé de façon régulière par le personnel de la mine.

Aperçu des données

Qualité de l'eau

Les concentrations de Zn, Cd, Pb, Cu, Al et Fe totaux et dissous (après traitement avec un filtre à mailles de 0,45 µm) indiquaient toutes la présence de gradients de concentration en aval du site Heath Steele. Tous ces paramètres sauf Al restait élevés par rapport aux concentrations des sites de référence à l'extrémité aval du gradient d'exposition, et tous dépassaient les limites des Recommandations pour la qualité des eaux du Canada dans certains des tronçons d'exposition ou dans la totalité de ceux-ci (selon le métal). Les concentrations de métaux dissous et totaux étaient semblables dans le cas du Zn, du Cu et du Cd, alors que celles de l'Al, du Fe et du Pb dissous étaient beaucoup plus faibles que leurs concentrations totales.

Périphyton

Les échantillons de périphyton étaient riches en espèces et leur biomasse était variable; on n'a observé aucune tendance en réponse au gradient de qualité de l'eau ou entre les tronçons exposés et les tronçons de référence. Pour ce qui est des concentrations de métaux, le périphyton exposé contenait de plus fortes teneurs en Cd, Cu, Zn et Pb, bien que seule la teneur en Pb du périphyton semblait correspondre au gradient de qualité de l'eau dans les biefs exposés.

Macroinvertébrés benthiques

La structure de la communauté benthique variait selon le gradient de qualité de l'eau; en effet, on observait, dans les stations exposées, des nombres totaux réduits de taxons et des nombres réduits des taxons *Ephemeroptera*, *Plecoptera* et *Trichoptera* (EPT). On a également observé des tendances chez des taxons considérés comme des indicateurs apparents, par exemple *Micropsectra*, qui est sensible aux fortes expositions, et *Rheocricotopus*, qui était abondant aux fortes expositions. Toutefois, la densité benthique totale ne semblait pas répondre à l'exposition aux métaux.

Poissons

La structure des communautés de poissons variait d'un tronçon à l'autre, les densités des juvéniles de saumon de l'Atlantique étant absents de la partie amont de la plupart des tronçons d'exposition en aval, ce qui s'expliquait apparemment par la présence d'une barrière partielle entravant la migration. Dix espèces étaient représentées dans les collections, les plus communes étant les juvéniles de saumon, les naseux noirs, les ménés de lac et les ombles de fontaine. On n'a observé aucun poisson à la station la plus exposée, sans doute à cause de la toxicité.

Les prises par unité d'effort (nombres) et la biomasse par unité d'effort (toutes espèces confondues) correspondaient nettement au gradient d'exposition et augmentaient graduellement d'amont en aval.

La taille des poissons selon l'âge ne semblait pas touchée par l'exposition, même si les alevins de saumon de l'Atlantiques étaient plus gros dans la zone d'exposition que dans la zone de référence. Cet effet est probablement dû aux densités d'alevins plus élevées et à une plus forte compétition dans la zone de référence.

Les teneurs en métallothionéine (MT) dans les viscères des poisson étaient plus élevées chez les saumons et les naseux exposés que chez les poissons de référence. Les concentrations de MT dans les viscères et les branchies des juvéniles de saumon en cage correspondaient assez bien aux concentrations de métaux dans l'eau après la période d'exposition.

Les concentrations de certains métaux dans les viscères semblaient élevées chez les poissons sauvages exposés pour certains métaux, même si cette réponse était moins évidente chez les poisson en cage.

Toxicité des effluents

Dans tous les échantillons d'effluents testés, on observait une toxicité chronique pour *Ceriodaphnia, Selenastrum* et *Lemna*, ainsi qu'une toxicité sublétale et létale pour deux des trois tests utilisés avec la tête-de-boule. Le degré de toxicité correspondait à la concentration de métaux chez *Ceriodaphnia* et *Selenastrum*, alors que les réponses de *Lemna* et des têtes-de-boules ne semblaient pas correspondre aux concentrations des métaux dans les échantillons.

Vérification des hypothèses

Les résultats des vérifications des hypothèses sont résumés au tableau 5.2; ils indiquent que certains des métaux sont biodisponibles, qu'on observe des réponses biologiques dans le benthos et chez les poissons, et que les métaux semblent être la cause de certaines de ces réponses.

Évaluation des techniques

Beaucoup d'outils de surveillance évalués au site Heath Steele indiquaient l'existence d'effets dus aux activités minières. Les outils basés sur la structure des communautés de périphyton, la croissance des poissons et la densité des communautés benthiques n'étaient pas efficaces. Les outils sensibles aux effets des activités minières, même de façon partielle, étaient notamment ceux qu'on utilise pour déterminer la qualité de l'eau, les métaux du périphyton, les teneurs en métaux et en MT des viscères et des branchies des poissons, les indicateurs des populations ou des communautés de poissons, ainsi que les indicateurs de la toxicité chronique des effluents et ceux de la communauté benthique. Le tableau 6.2 résume les données sur l'efficacité des divers outils testés sur le site Heath Steele.

Certains des différents outils comparés pour la vérification des hypothèses semblent plus efficaces que d'autres. Le tableau 6.3 présente un résumé des comparaisons entre ces outils.

Un document distinct, « Summary and Cost-Effectiveness Evaluation of Aquatic Effects Monitoring Technologies Applied in the 1997 AETE Evaluation Program », présente les conclusions sur le rapport coût-efficacité de ces outils, qui sont basées sur les résultats obtenus pour les quatre sites miniers étudiés en 1997.

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1.0 INTRODUCTION

The Assessment of the Aquatic Effects of Mining in Canada (AQUAMIN), initiated in 1993, evaluated the effectiveness of Canada's *Metal Mining Liquid Effluent Regulations* (MMLER). One of the key recommendations of the 1996 AQUAMIN Final Report is that a revised MMLER include a requirement that metal mines conduct Environmental Effects Monitoring (EEM), to evaluate the effects of mining activity on the aquatic environment, including fish, fish habitat and the use of fisheries resources.

In parallel, the Canada Centre for Mineral and Energy Technology (CANMET) is coordinating a cooperative government-industry program, the Aquatic Effects Technology Evaluation (AETE) program, to review and evaluate technologies for the assessment of mining-related impacts on the aquatic environment. The intention of the AETE program is to evaluate and identify cost-effective technologies to meet environmental monitoring requirements at mines in Canada. The program is focused on evaluation of environmental monitoring tools that may be used for a national mining EEM program, baseline assessments or general impact studies.

The three principal components of the AETE program are lethal and sublethal toxicity testing of water/effluents and sediments, biological monitoring in receiving waters, and water and sediment chemistry assessments. The program includes both literature-based technical evaluations and comparative field programs at candidate sites. The AETE program is presently at the stage of evaluating selected monitoring methods at four case study sites across Canada.

An AETE Pilot Field Study was carried out in the Val d'Or region of Quebec in 1995 to evaluate a large number of environmental monitoring methods and to reduce the list of monitoring technologies for further evaluation at a cross-section of mine sites across Canada (BEAK, 1996). In 1996, a field evaluation program was initiated and involved preliminary sampling at seven candidate mine sites with the objective of identifying a short-list of mines that had suitable conditions for further detailed monitoring and testing of hypotheses relating to the AETE program. Preliminary study designs were developed for four sites that were deemed to be most suitable for hypothesis testing in 1997 (EVS *et al.*, 1997). The sites selected were Heath Steele, New Brunswick; Lupin, N.W.T.; Dome mine, Ontario; and Westmin Resources (now Boliden-Westmin), British Columbia. Lupin was subsequently dropped based on a 1997 reconnaissance survey and replaced with the Mattabi Mines Ltd.

site. This report documents the results of the 1997 Field Evaluation at the Heath Steele mine site in New Brunswick.

The 1996 Field Evaluation Program constituted Phase I of the Field Evaluation Program. The 1997 program consists of Phases II and III of the Program. Phase II includes the review of necessary background information, finalization of a study design and implementation of the field studies. Phase III includes the compilation, interpretation and reporting of results.

1.1 Study Objectives

The overall goal of the AETE program is to identify cost-effective methods and technologies that are suitable for assessing aquatic environmental effects caused by mining activity. An effect is defined as "a measurable difference in an environmental variable (chemical, physical or biological) between a point downstream (or exposed to mining) in the receiving environment and an adequate reference point (either spatial or temporal)". For the formulation of hypotheses, this definition has been refined by the AETE Committee to distinguish between effects or responses as measured in biological variables as opposed to effects reflected in physical or chemical changes.

The questions used in developing the hypotheses to be tested in this program were:

1. Are contaminants getting into the system (and to what degree, and in which compartments)? This question relates to the presence and concentrations of metals in environmental media (e.g., water, sediments), and requires an understanding of metal dispersal mechanisms, chemical reactions in sediment and water, and aquatic habitat features which influence exposure of biological communities.

2. Are contaminants bioavailable? This question relates to the presence of metals in biota or to indicators of metal bioaccumulation such as the induction of metallothionein (a biochemical response to metal exposure) in fish tissues. Only if contaminants are bioavailable can a biological effect from chemical contaminants occur.

3. Is there a measurable response? Biological responses may occur only if contaminants are entering the environment and occur in bioavailable forms.

These responses may occur at various levels of biological organization, including sub-organism levels (e.g., histopathological effects), at the organism level (e.g., as measured in toxicity testing), or at population and community levels (as measured in resident benthos and fish communities).

4. Are contaminants causing the responses? This question is difficult to measure in field studies directly, as cause-effect mechanisms are difficult to assess under variable conditions prevailing in nature. However, correlations between measures of exposure, chemical bioavailability and response may be used to develop evidence useful in evaluating this question.

The AETE Technical Committee developed a study framework, using the above questions and the three components (water and sediment monitoring, biological monitoring in receiving waters and toxicity testing). The following eight areas of work were identified to finalize the work plan, develop the hypotheses, prioritize issues and identify field work requirements:

1. Chemical presence;
2. The overlap between communities and chemistry testing to determine whether biological responses are related to a chemical presence (bioavailability of contaminants);
3. Biological response in the laboratory;
4. Biological response in the field;
5. Chemical characteristics of the water and sediments used to predict biological responses in the field (contaminants causing a response);
6. The overlap between biological community responses and bioassay responses to evaluate whether wild community changes are predicted by bioassay responses;
7. The overlap between chemistry and bioassay responses to evaluate whether chemicals are responsible for bioassay responses; and
8. The overlap between the chemical, the exposure and the effects in the laboratory and the effects in the field.

The core objective of the 1997 field program is to **test the 13 hypotheses, developed by the AETE Committee, at as many mine sites as possible (Table 1.1)** The hypotheses are more specific questions about the ability or relative ability of different monitoring tools to answer the four general questions (above) about mine effects.

TABLE 1.1: HYPOTHESES TESTED IN 1997. AETE FIELD PROGRAM
(Hypotheses in bold print were tested at Heath Steele)

Sediment Monitoring

H1. Sediment Toxicity:
H: *The strength of the relationship between sediment toxicity responses and any exposure indicator is not influenced by the use of different sediment toxicity tests or combinations of toxicity tests.*

Biological Monitoring - Fish

H2. Metals in Fish Tissues (bioavailability of metals):
H: *There is no difference in metal concentrations observed in fish liver, kidney, gills, muscle or viscera.*

H3. Metallothionein in Fish Tissues:
H: *There is no difference in metallothionein concentration observed in liver, kidney, gills, viscera*

H4. Metal vs. Metallothionein in Fish Tissues:
H: ***The choice of metallothionein concentration vs. metal concentrations in fish tissues does not influence the ability to detect environmental exposure of fish to metals.***

H5. Fish - CPUE:
H: ***There is no environmental effect in observed CPUE (catch per unit effort) of fish.***

H6. Fish (or Benthic) - Community:
H: ***There is no environmental effect in observed fish community structure.***

H7: Fish - Growth:
H: ***There is no environmental effect in observed fish growth.***

H8. Fish - Organ/Fish Size:
H: *There is no environmental effect in observed organ size (or fish size, etc.).*

Integration of Tools

H9. Relationship between Water Quality and Biological Components:
H: ***The strength of the relationship between biological variables and metal chemistry in water is not influenced by the choice of total vs. dissolved analysis of metals concentration.***

H10. Relationship Between Sediment Chemistry (periphyton used as a surrogate for sediment) and Biological Responses:
H: ***The strength of the relationship between biological variables and sediment characteristics is not influenced by the analysis of total metals in sediments vs. either metals associated with iron and manganese oxyhydroxides or with acid volatile sulphides.***

H11. Relationship Between Sediment Toxicity and Benthic Invertebrates:
H: *The strength of the relationship between sediment toxicity responses and in situ benthic macroinvertebrate community characteristics is not influenced by the use of different sediment toxicity tests, or combinations of toxicity tests.*

H12. Metals or Metallothionein vs. Chemistry (receiving water and sediment):
H: ***The strength of the relationship between the concentration of metals in the environment (water and sediment chemistry) and metal concentration in fish tissues is not different from the relationship between metal concentration in the environment and metallothionein concentration in fish tissues.***

H13. Chronic Toxicity - Linkage with Fish and Benthos Monitoring Results:
H: ***The suite of sublethal toxicity tests cannot predict environmental effects to resident fish performance indicators or benthic macroinvertebrate community structure.***

These 13 hypotheses can be categorized into:

- ***Sediment Monitoring***: evaluation of sediment toxicity testing tools (test types) as to their relative ability to detect linkages between mine exposure and sediment toxicity (H1);

- ***Biological Monitoring (in Fish)***: evaluation of tissue biomonitoring tools (measurement types) as to their ability to detect linkages between mine exposure and tissue contamination (H2 to H4); and evaluation of population/community biomonitoring tools (measurement types) as to their ability to detect linkages between mine exposure and ecological response (H5 to H8); and

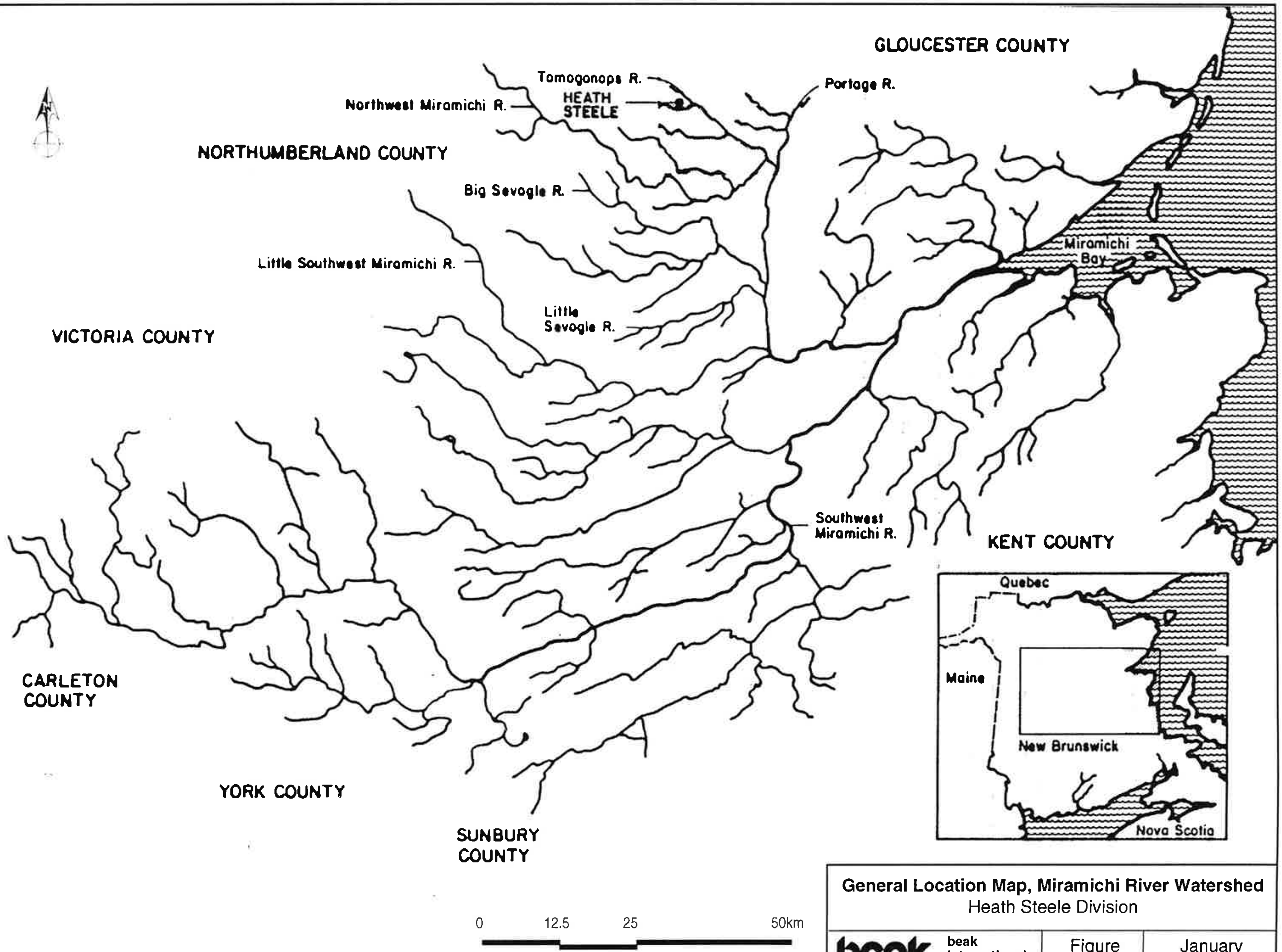
- ***Integration of Tools***: evaluation of various monitoring tools as to their relative ability to detect relationships between specific measures of mine exposure and specific biological response measures, or between sediment toxicity and benthic community response measures (H9 to H12); and evaluation of effluent toxicity testing tools (test types) as to their ability to detect relationships between effluent toxicity and population/community response measures (H13).

Due to the natural characteristics of Heath Steele area watersheds, eight (8) of the 13 hypotheses were considered testable at Heath Steele (H4, H5, H6, H7, H9, H10, H12 and H13) and are highlighted in Table 1.1.

1.2 Site Description

Heath Steele Division of Noranda Mining and Exploration Inc. (Heath Steele) operates a base metal mining and milling operation in north-central New Brunswick, approximately 50 km northwest of the City of Miramichi (Figure 1.1). Mine/mill operations are situated within the headwaters of the Tomogonops River, a tributary system of the Northwest Miramichi River.

The Heath Steele site has a relatively long history, with mine and mill facilities first developed in 1955-1957. Heath Steele ores are base metal sulphides, with zinc, lead, copper and silver-rich concentrates produced.



General Location Map, Miramichi River Watershed
Heath Steele Division

beak international incorporated

Figure 1.1

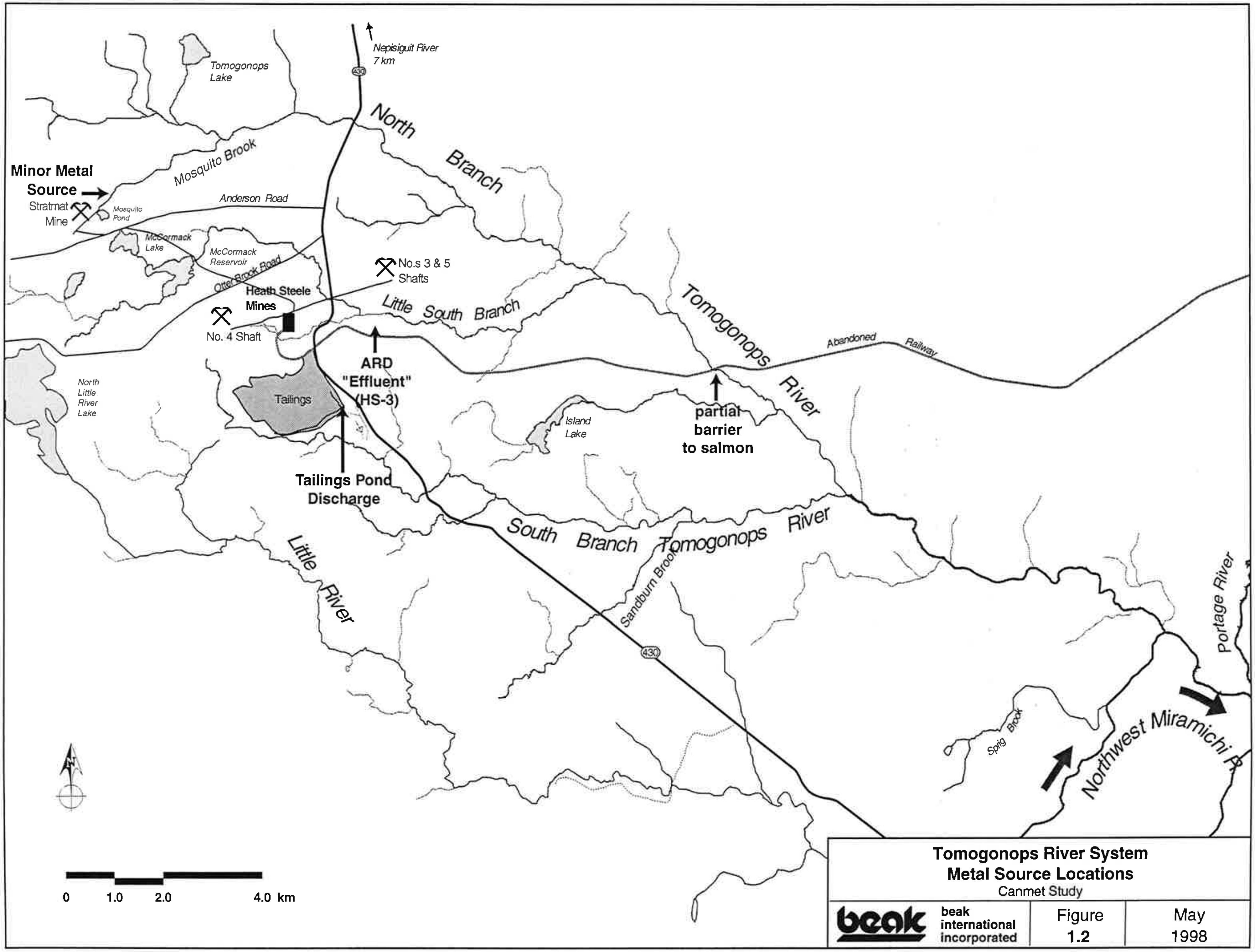
January 1997

Figure 1.2 shows the study area with mine sources of contaminants. The South Branch Tomogonops River receives discharge from the tailings area, but this stream has, in recent years, become periodically acidic due to thiosalt oxidation and is high in dissolved solids (BEAK, 1997). This has produced a relatively strong pH gradient in the South Branch Tomogonops River, especially in summer. The metal concentration gradient in the South Branch is relatively weak (small changes with distance), and fish are scarce in the reach nearest the tailings pond.

The Little South Branch Tomogonops River receives seepage and runoff from the general mine site that is not strongly acidic and the water is much softer than treated effluent. These effects occur at Heath Steele monitoring station HS-3, downstream of which no significant additional inputs occur from Heath Steele. This water is relatively rich in metals, and downstream gradients in water quality and biological conditions have been well documented (BEAK, 1997). Accordingly, the 1997 AETE field program focused on river reaches in the Little South Branch Tomogonops River and waters downstream before the confluence with the South Branch Tomogonops, where water hardness level abruptly increases.

A railway bridge at times presents a barrier to upstream migration of adult salmon. Therefore, the fish community is different below the bridge than above. Fish present above the bridge include juvenile salmon, small brook trout, white sucker and minnows, although the abundance of salmon here is influenced by the barrier. An apparently fishless zone exists immediately below the mine at HS-3, apparently due to water quality impairment.

Aquatic habitat throughout this area consists of riffles and runs, with a predominantly rock-cobble-gravel streambed. Soft sediments are rare to absent throughout most of the Tomogonops River watershed. The predominant erosional condition of the river prevents effective testing of sediment monitoring tools at Heath Steele. The watershed is undeveloped and forested except for the mine site itself. The streamflow was low (≤ 0.31 m^3/s) at all locations sampled in August 1997, with typical stream widths of up to about 8 m. Stream size is progressively smaller towards upper reaches of the watershed. All reference areas selected for study herein, including the neighbouring Little River and unaffected reaches of the Tomogonops River, are similar to those represented by the area of downstream habitat sampled, except for the partial barrier noted above. Habitat information is detailed in Appendix 2.



Tomogonops River System
Metal Source Locations
Canmet Study

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Figure 1.2

May 1998

2.0 STUDY DESIGN

2.1 Adjustments to Preliminary Study Design

The preliminary study design developed by EVS *et al.* (1997) for Heath Steele was reviewed and discussed with the AETE Technical Committee. Various important recommendations arose from this review. These recommendations received AETE's approval, and are integral to the final study design outlined in this section. Those recommendations are:

- The locations for testing of fish community response tools were relocated to the gradient beginning at HS-3 on the Little South Branch Tomogonops River, down to a point upstream of the South Branch Tomogonops confluence. This relocation stems from concerns over potential thiosalt-induced pH effects and variable water hardness effects in the South Branch (where EVS *et al.* proposed sampling), confounding the measurement of metal-induced biological effects.

- Sediment chemistry and sediment toxicity measurements were not made due to the relative lack of sediment-induced biological impacts seen at Heath Steele previously. However, periphyton is used as a surrogate sediment in testing H10.

- "Effluent" toxicity was measured at Heath Steele Station HS-3 rather than in final treated effluent, with re-focusing of seasonal sampling to dry/wet weather sampling based on suspected effects of rainfall. This is used for testing of H13 using fish and benthic data.

- Fish community/population tools have been tested, with sentinel species including Atlantic salmon juveniles and blacknose dace. Use of fully enclosed electrofishing stations to sample fish for testing of H5 have been replaced with electrofishing without block nets to allow cost-effective sampling of more stations/areas than provided in the original design (EVS *et al.,* 1997) without impairing our ability to collect meaningful catch-per-unit-effort (CPUE) measurements.

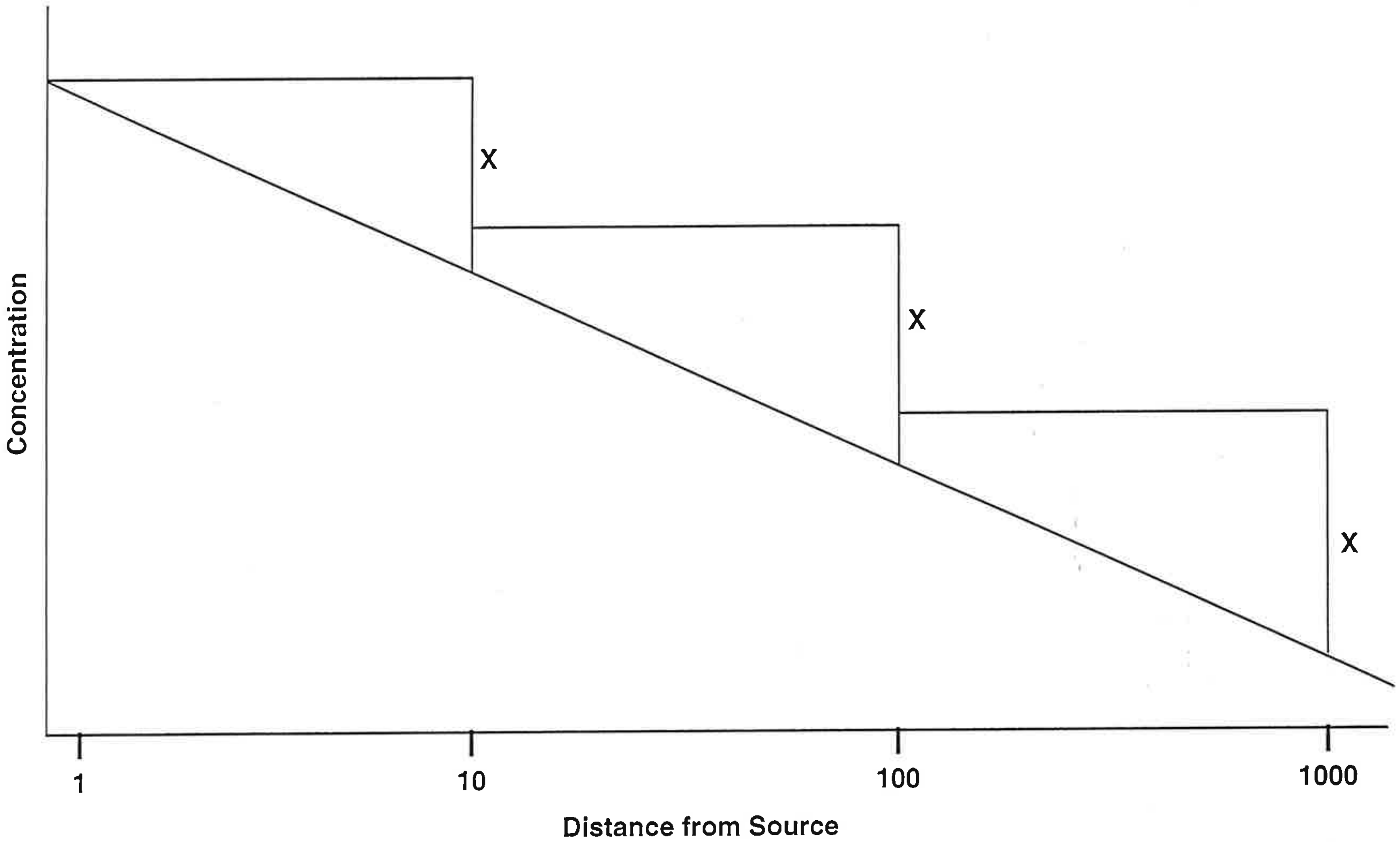
- H4 and H12 have been tested with both wild salmon juveniles and caged salmon juveniles to better determine the relative effectiveness of the metallothionein (MT) and tissue metal measurements. Caged fish were used to control fish exposure so that fish mobility would not affect recent metal exposure and tissue response. Use of fish in cages is not considered here specifically as a monitoring tool *per se*.

2.2 Final Study Design

2.2.1 General Considerations

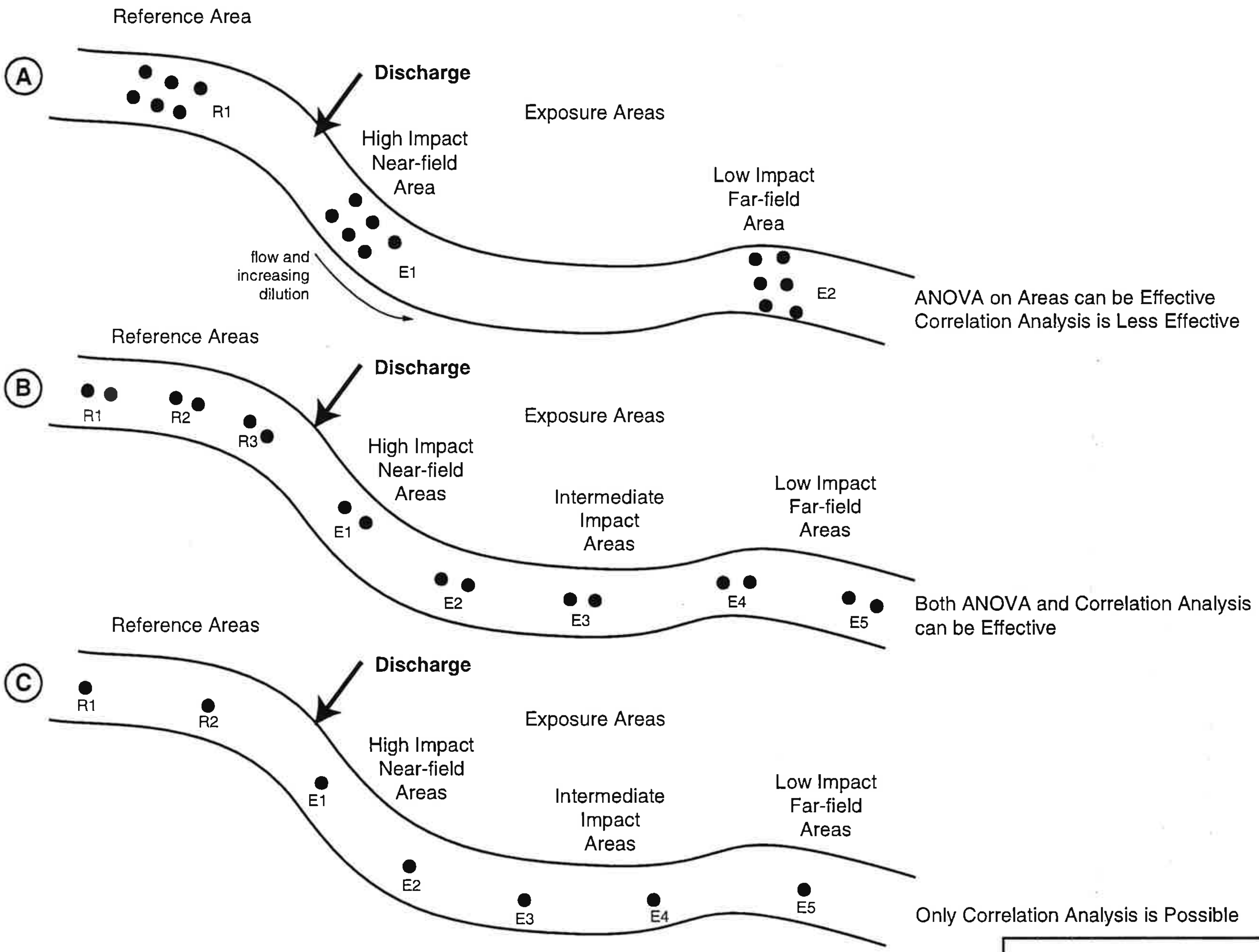
In general, sampling at AETE field study sites has been carried out in relation to a mine effluent discharge in order to permit testing of hypotheses about the environmental effect of the discharge. Sampling was completed both above and below the source (Reference versus Exposed). To the extent possible, the "below discharge" samples were spaced at increasing distances, because most dilution/mixing models are exponential decay models. That is, contaminant concentrations usually decrease rapidly with distance at first, and increasingly more slowly in an exponential fashion (see Figure 2.1). When monitoring mine discharges, the nature of the receiving stream will often cause this ideal situation to be impossible to achieve, especially where dilution occurs rapidly (e.g., a stream discharging into a large lake).

There are many possible field study designs for monitoring of mining discharges and testing of the hypotheses, which can be put into three basic categories (Figure 2.2, Types A, B, C). The difference between the first two (Type A versus Type B) is driven by site differences (e.g., stepwise (Type A) versus more continuous dilution patterns (Type B)), whereas the difference between Type B and Type C is driven by the biota being sampled. For example, benthos because of their sessile nature, and some forage fish because of their limited mobility, allow for replicate sampling in a small area (Type B) whereas large fish being more mobile have to be sampled over a larger area to ensure the groups of fish are not mixing and are distinct from one another, necessitating a Type C design. Alternatively, a Type A design might be used for large fish, using individual fish rather than stations as replicates.



Idealized Effluent Dilution Model Downstream of a Mine Discharge

beak International Incorporated	Figure 2.1	February 1997



Representative Sampling Designs Downstream of Effluent Discharges (dots represent sampling stations)

beak International incorporated	Figure 2.2	May 1998

In a way, the ideal situation for testing hypotheses for the 1997 field evaluation is a Type B study design which is a combination of easy-to-sample biota and a site which can be sampled with a gradient design approximating that described above. This provides for:

- a gradient design, permitting regression/correlation analysis of the impact pattern along the stream below the discharge and of possible cause-effect relationships between chemical and biological variables; and
- replication at locations so hypothesis testing in an Analysis of Variance (ANOVA) design is possible.

The other two types of study design sacrifice one or the other of these. In the first, the nature of the site precludes a gradient design. One takes replicate samples at an above"="Control" location, and at a "near-field"="High Impact" and at a "far-field"="Low Impact" location. This does not allow one to model the pattern of impact below the discharge, but an ANOVA for testing impact-related hypotheses is easily done. In the third type of study design, one can model the pattern of impact below the discharge but the only possible hypothesis testing is that associated with simple regression/ correlation analysis. The least desirable situation (not shown) would be a site where neither a gradient design nor replication at locations is possible.

Finally, it is necessary to select an appropriate sampling effort and (apart from the above "basic types of design" considerations) allocate the effort appropriately to above versus below the discharge areas, to locations within areas, and to replicates within locations. For the AETE program, it was decided that a total sampling effort per site of 20 to 25 field samples was a reasonable trade-off between feasibility and cost on the one hand, and statistical power and robustness on the other hand (refer to EVS *et al.*, 1997). The following is based on that total effort allocated to Heath Steele.

It should be emphasized here that the primary purpose of the 1997 field programs is to evaluate monitoring tools as to their ability to detect mine effects. This requires designing to detect effects. However, the approaches and sampling effort used here are not necessarily the same as would be required in undertaking an environmental effects monitoring (EEM) program at a mine.

2.2.2 Design at Heath Steele

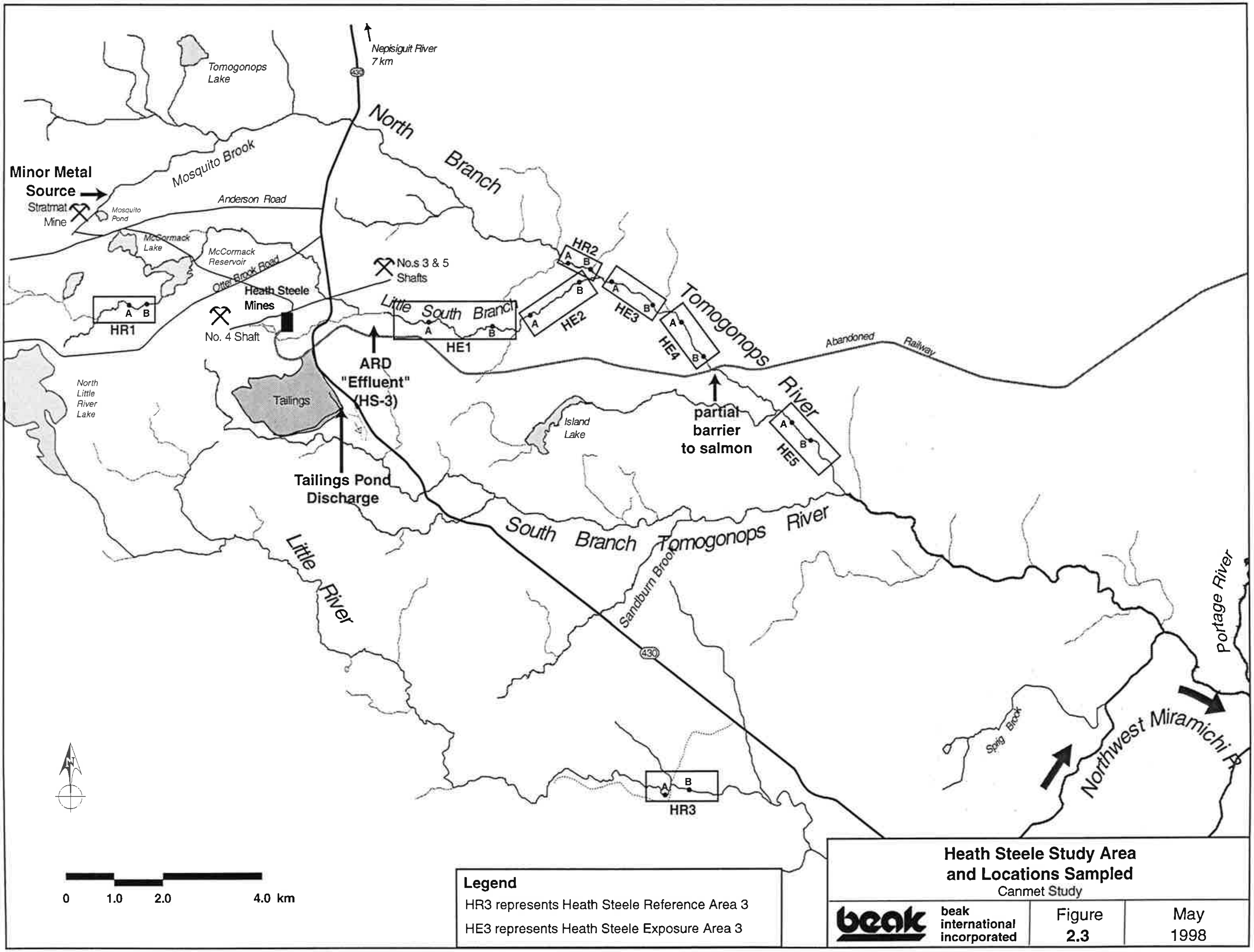
Sampling Areas

The study design at Heath Steele is of the second type in Figure 2.2 (Type B). This was considered feasible based on a reasonably continuous pattern of dilution downstream from the mine site (Figures 2.3 and 2.4; BEAK and Golder, 1997). There are relatively homogeneous reaches of several kilometres between the tributaries that provide dilution in the Little South Branch and North Tomogonops Rivers. Therefore, it was possible to locate two stations in each of the five exposed reaches, and in each of three reference reaches (Figure 2.3), such that stations within a reach have similar effluent exposure levels.

The design is based on sampling downstream of HS-3 on the Little South Branch Tomogonops River (labelled “ARD Effluent’ in Figure 2.3). This is recognized as the location most affected by acid rock drainage (ARD) from Heath Steele. Most of the total loadings of important metals (Zn, Cu) from Heath Steele occur in this vicinity rather than from the tailings pond, which discharges treated effluent to the South Branch Tomogonops River.

Five exposure areas were sampled downstream of the ARD effluent, corresponding with average effluent concentrations of 60% (at HE1 located on Little South Branch) to 12% at HE5 (downstream of Island Lake Brook) (Figure 2.3). Exposure Areas 1 to 4 (HE1 to HE4) are influenced by the partial barrier to salmon migration located downstream of HE4 at the railway crossing; therefore, HE5 is not comparable to upstream areas in terms of salmon CPUE measurements, but is comparable in this respect to HR3. Only Reference Area HR2 is comparable to Exposure Areas HE1 to HE4 in terms of these factors. All reference areas were used for testing of fish tissue and fish population/community level hypotheses responses.

The two sentinel fish species sampled were blacknose dace and juvenile Atlantic salmon. Among the fish species present, Atlantic salmon juveniles are generally the most ubiquitous and abundant in the exposure zone, with the exception that this species does not appear to enter the Little South Branch Tomogonops River (LSBTR). Nearly all fish present in the river are small (typically ≤12 cm in fork length), and are not amenable to contaminant analysis of individual tissues.



Legend

HR3 represents Heath Steele Reference Area 3

HE3 represents Heath Steele Exposure Area 3

Heath Steele Study Area and Locations Sampled

Canmet Study

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Figure 2.3

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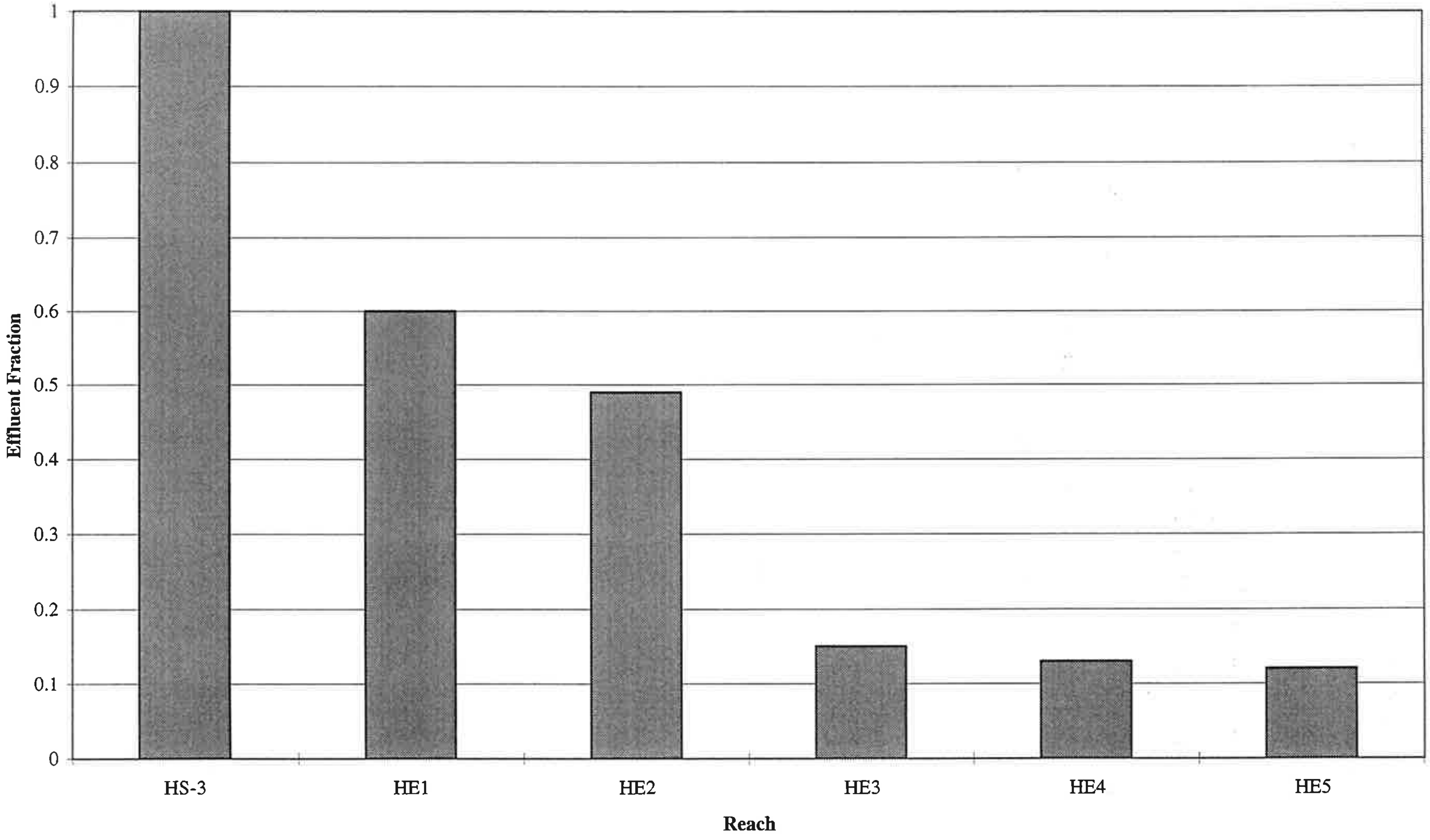
Figure 2.4: Relative Concentration of HS-3 "Effluent" at Heath Steele Exposure Reaches, Based on 20 August 1997 Stream Flows



Hypothesis H4 was tested at Heath Steele not only with blacknose dace and wild juvenile salmon, but also using caged Atlantic salmon installed at two stations in each of the five exposure reaches and three reference reaches. These salmon were taken from the Heath Steele salmon rearing facility, located upstream of any known sources of metal loadings from Heath Steele. Some data are also available for brook trout at Heath Steele, but the data were not subjected to hypothesis testing.

Benthic-related hypotheses were tested at Heath Steele in all exposure and reference areas. All areas contain cobble/gravel substrates, and reference areas span a range of stream size conditions from HR1, which is similar in stream size to the LSBTR at HE1, through to Reference Areas HR2 and HR3 which are more comparable to the middle and lower Exposure Areas (HE3 to HE5).

2.2.3 Statistical Power

The statistical power of the study design was evaluated using the Borenstein and Cohen (1988) computer code for power analysis. The total effort of 16 sampling stations equally distributed among 8 groups (stream reaches) is sufficient to expect that an effect size (average difference between groups) of three within-group standard deviations could be detected with a power of 0.8 or better (i.e., chance of false-negative conclusion (beta) less than 0.2) using a significance criterion based on a chance of false-positive conclusion (alpha) less than 0.05. The absolute difference indicated by three standard deviations will vary from one monitoring parameter (effect measure) to another.

3.0 FIELD AND LABORATORY METHODS

3.1 Sampling Time and Crew

The Heath Steele field program was carried out during the period of 11 to 22 August 1997.

The field crew consisted of two field biologists and two technicians. The BEAK project manager also participated during half of the program.

3.2 Sampling Effort and Station Characterization

The numbers and distributions of each type of sample collected at Heath Steele are summarized in Table 3.1. Variable numbers of fish tissues collected at each station reflect the presence, absence and abundances of various species.

Sampling stations for the Heath Steele program are listed in Section 2.2.2 and illustrated in Figure 2.3. These include five "reaches" (HE1 to HE5) downstream of the "effluent" source (HS-3) and three reference "reaches" (HR1 to HR3). Each downstream reach contained two stations (A and B) of similar effluent concentration, separated by several hundreds of metres. All stations were sited at least 150 m from major stream confluences to avoid exposure to uneven effluent concentrations and to provide some assurance that biological communities sampled were generally resident under site conditions (i.e., had not recently migrated from other streams of different water quality).

Habitat conditions and station coordinates, measured by Global Positioning System, were recorded on data forms (Appendix 2). Habitat information included stream order, data on water temperature, conductivity, pH, substrate conditions, pool/riffle ratio, aquatic plant coverage, in-stream and riparian cover, water depth and general flow conditions. All stations may be generally characterized as riffle-run sequences, with cobble and gravel substrates.

Habitat conditions are affected by barriers to fish migration including an abandoned railway crossing between exposure reaches HE4 and HE5, which presents a partial barrier for salmon migration (long culverts terminating about 0.5 metres above river level on the downstream side), and two Heath Steele reservoirs on the Little South Branch Tomogonops between exposure reach HE1 and reference reach HR1 which preclude migration of Atlantic

TABLE 3.1: SUMMARY OF SAMPLES OBTAINED AT HEATH STEELE

Sampling Locations	Chronic Toxicity[1]	Periphyton and Benthos[2]	Water Quality[3]	Fish Tissues for Analysis[4]			Fish Community[6]
				ASW	BD[5]	ASC	
HS-3	3	-	3	-	-	-	-
HE1A	-	1	1	0	0	2	1
HE1B	-	1	1	0	1 (1)	2	1
HE2A	-	1	1	0	0	2	1
HE2B	-	1	1	1	4 (14)	2	1
HE3A	-	1	1	3	1 (5)	2	1
HE3B	-	1	1	4	1 (6)	2	1
HE4A	-	1	1	4	0	2	1
HE4B	-	1	1	4	4 (13)	2	1
HE5A	-	1	1	4	5 (16)	2	1
HE5B	-	1	1	4	6 (16)	2	1
HR1A	-	1	1	0	4 (12)	2	1
HR1B	-	1	1	0	4 (15)	2	1
HR2A	-	1	1	0	6 (16)	2	1
HR2B	-	1	1	1	4 (16)	2	1
HR3A	-	1	1	4	3 (7)	2	1
HR3B	-	1	1	4	2 (9)	2	1

[1] Chronic toxicity samples collected 24 June, 28 August and 12 November 1997.

[2] Each periphyton sample is a composite of scrapings from ≥3 rocks. Each T-sample is a composite of five grabs.

[3] Water quality samples, exclusive of blanks, duplicates.

[4] ASW - wild Atlantic salmon parr; BD - blacknose dace; ASC - caged Atlantic salmon.

[5] BD - several fish submitted per sample for tissue analysis to allow for compositing at laboratory to meet sample mass requirements. Variable numbers of composite BD samples analyzed per station. Values represent numbers of composite samples, with total numbers of individual fish in all composites combined in parentheses.

[6] Community sample based on approximately 1,000 to 1,900 measured electrofishing seconds per station. All fish identified, enumerated, weighed and measured (length). Sentinel species caged by length-frequency distribution with ages determined by scale (BD) or otolith (AS) to confirm age-size class categories.

salmon to the HR1 area. For this reason, salmon abundance in exposure reaches HE1 to HE4 can only be compared with abundances at reference station HR2. Salmon abundance at HE5, which is unaffected by downstream migration barriers, may be compared with abundance at reference reach HR3.

At selected stations (generally one in each reach), in-stream discharge was measured using the cross-section of method with a portable velocity meter (Marsh McBirney, Model No. 2000-11). All discharge measurements were taken under dry weather conditions (no precipitation during the previous 48 hours) on 20 August 1997, so that discharges at each reach would be proportional to one another. Discharge at HS-3 on the same date was provided by Heath Steele, as recorded at their stream gauge. Because "effluent" discharge rates are controlled mainly by natural drainage processes, effluent dilution factors within each reach are approximately constant. "Best estimates" of streamflow were made by considering not only the measurements made, but also the suitability of each streamflow measurement location for providing accurate discharge estimates (e.g., degree of turbulence), the watershed area of each reach and the concentrations of suitable effluent tracers such as total zinc concentration. These final best "estimates" are those used to produce the relative effluent concentrations for each reach (Figure 2.4), and are presented in Appendix 2.

3.3 Effluent Chemistry and Toxicity

Chronic toxicity was measured in three samples of HS-3 "effluent" from Heath Steele, collected on 24 June, 28 August and 12 November 1997. The August sample was collected during a runoff event in an attempt to sample a more metal-rich effluent normally found during higher flow conditions at this location. Tests completed on each sample include:

- the *Ceriodaphnia dubia* 7-day survival and reproduction test (Environment Canada 1992a)
- the fathead minnow (*Pimephales promelas*) 7-day survival and growth test (Environment Canada 1992b)
- the *Selenastrum capricornutum* 3-day algal growth test, (Environment Canada 1992c), and
- the duckweed (*Lemna minor*) 7-day growth test (Saskatchewan Research Council, 1995, 1996).

The duckweed test was carried out by the Saskatchewan Research Council, in Saskatoon. The other three tests were completed at BEAK's Brampton, Ontario toxicity testing facility. Toxicity testing procedures and laboratory reports are presented in Annex 1.

Bioassay procedures included use of dilution water collected from the site (Little South Branch Tomogonops upstream of mine-related impact) or laboratory water adjusted to the hardness of field conditions, depending on acclimation success in site water for *Ceriodaphnia dubia* and *Pimephales promelas*. Results of a comparative study of chronic toxicity using both site dilution water and hardness adjusted laboratory water, in addition to acclimated organisms and organisms not acclimated, are presented in a Summary Document for the three mines where effluent toxicity was measured in the 1997 AETE field study program (BEAK and GOLDER, 1998b). Results of this comparative study showed that site dilution water and laboratory dilution water produced generally comparable results in these tests.

Upon receipt at BEAK's laboratory, a subsample of each effluent and dilution water sample was forwarded to Philip Analytical Services. Samples were processed (filtered as appropriate and preserved) and analyzed for the water quality parameters identified in Section 3.4.

3.4 Water Quality

Detailed field sampling procedures, including water quality sampling procedures, are outlined in Annex 1 (provided as a separate document).

3.4.1 Field

All water samples were collected on 20 August 1997 under dry weather conditions (no precipitation over previous 48 hours) so that relative metal concentrations at all locations were representative of the same effluent quality (water quality at HS-3 effluent varies according to runoff). Samples were collected for laboratory analysis of:

- total and dissolved metals (Al, Sb, As, Ba, Be, Bi, B, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Hg, Mo, Ni, K, Se, Ag, Sr, Ta, Sn, U, V, B and Zn); Zn, Cu, Pb, Cd, Fe and Al are most relevant at Health Steele, based on effluent concentrations observed;

- nutrients (nitrate, nitrite, ammonia, P);
- major ions (including sulphate and ion balance);
- acidity, alkalinity, hardness, specific conductance;
- pH;
- colour;
- dissolved organic and inorganic carbon;
- solids (total suspended and dissolved); and
- turbidity.

In addition to samples collected for laboratory analysis, field determinations were made of specific conductance, temperature, pH and dissolved oxygen, with results recorded on field habitat record forms. All field measurements were made on-site using calibrated meters.

All samples were placed on ice in coolers immediately after collection, and were transferred to a refrigerator prior to field processing. All samples requiring analysis without chemical preservation were kept chilled until delivery to the laboratory.

Sample containers, filtration and sample preservation procedures are identified in Annex 1, and include use of high density polyethylene containers confirmed free of measurable metal contamination, ultrapure nitric acid and de-ionized distilled water (for field, trip and filter blanks), and a filtration procedure using polypropylene syringes with 0.45 micron syringe-filters confirmed free of measurable metal contamination. All sample preparation was carried out in a clean work space in a hotel unit.

Quality control/quality assurance procedures followed in the field included collection of sample duplicates, and preparation of trip blanks, field blanks and filter blanks.

3.4.2 Laboratory

All water samples were forwarded to the analytical laboratory (Philip Analytical Services Corporation, Burlington and Mississauga, Ontario) within 48 hours of collection. Procedures used for laboratory analysis are summarized in Table 3.2.

Table 3.2: LABORATORY METHODS AND BOTTLE/PRESERVATIVE PROCEDURES USED IN WATER SAMPLE ANALYSIS

(as provided by Philip Analytical Services)

Parameters	Method	Bottle Requirement	Preservative Type	Max. Holding Time
Acidity	Standard Methods (17th ed.) No. 2310B U.S. EPA Method No. 305.1	250 ml Bottle Glass	no preservative	14 days
Alkalinity	Standard Methods (17th ed.) No. 2320	250 ml Bottle Glass	no preservative	14 days
RCAP Calculations	MDS Internal Reference Method			
Total Dissolved Solids(Calculated)				
Hardness(as $CaCO_3$)				
Bicarbonate(as $CaCO_3$, calculated)				
Carbonate(as $CaCO_3$, calculated)				
Cation Sum				
Anion Sum				
Ion Balance				
Colour	U.S. EPA Method No. 110.3(Modified) (Reference-Std Methods(17th)2120CMod)	100 ml Bottle Glass	no preservative	48 hours
Specific Conductance	U.S EPA Method No. 120.1	100 ml Bottle Glass	no preservative	28 days
Manual Conventionals for RCP(pH,Turb,Conduct,Color)	U.S. EPA Method No. 150.1, 120.1, 180.1 and 110.3	250 ml Bottle HDPE	no preservative	
Hardness	U.S. EPA Method No. 130.2	250 ml Bottle Glass	no preservative	6 months
Ion Balance		250 ml Bottle HDPE	HNO_3 to pH < 2	14 days
pH, Hydrogen Ion Activity	U.S. EPA Method No. 150.1	100 ml Bottle Glass	no preservative	
Total dissolved Solids	U.S. EPA Method No. 160.1	1 L Bottle Glass	no preservative	7 days
Total Suspended Solids	U.S. EPA Method No. 160.2	500 ml Bottle Glass	no preservative	7 days
Turbidity, UltraViolet	U.S. EPA Method No. 180.1	100 ml Bottle Glass	no preservative	48 hours
RCAP MS Package, 8 Element ICPAES Scan	U.S. EPA Method No. 200.7	125 ml Bottle HDPE	HNO_3 to pH < 2	
B, Fe, P, Zn, Ca, Mg, K, Na		250 ml Bottle HDPE	no preservative	
ICP-MS 25 Element Scan, Clean Water Package	U.S. EPA Method No. 200.8(Modification)	250 ml Bottle HDPE	no preservative	
Al, Sb, As, Ba, Be, Bi, Cd, Cr, Co, Cu, Pb, Mn, Mo, Ni, Se, As, Sr, Th, Sn, Ti, U, V, B, Fe, Zn		125 ml Bottle HDPE	HNO_3 to pH < 2	
Alkalinity for RCAP Packages 30, 50 and MS	U.S. EPA Method No. 310.2	250 ml Bottle HDPE	no preservative	14 days
Anions for RCAP 50 and MS(Cl,NO_2,NO_3,o-PO_4 & SO_4)	U.S. EPA Method No. 300.0 or U.S. EPA Method No. 350.1, 354.1, 353.1, 365.1 and 375.4.	250 ml Bottle HDPE	no preservative	48 hours
Dissolved Organic Carbon, as Carbon for RCAP	MOE Method No. ROM - 102ACE(Modified)	100 ml Bottle Glass	no preservative	3 days
Ammonia for RCAP Packages 30, 50 and MS	ASTM Method No. D1426-79 C	100 ml Bottle Glass	H_2SO_4 to pH < 2	28 days
	Refer - Method No. 1100106 Issue 122289	250 ml Bottle HDPE	no preservative	
Organic Nitrogen(TKN - NH_3)	U.S. EPA Method No. 350.1 U.S. EPA Method No. 351.1	250 ml Bottle Glass	H_2SO_4 to pH < 2	28 days
Mercury, Cold Vapour AA	U.S. EPA SW846 Method No. 7470A Standard Methods(18th ed.) No. 3112B	100 ml Bottle Glass	HNO_3 to pH < 2 + 5% $K_2Cr_20_7$	7 days

3.5 Periphyton

Periphyton was collected for metals and taxonomic analysis at each of the 16 Heath Steele stations. One sample each for taxonomic and metal determination was collected at each location (i.e., total of two samples per reach).

Collections for taxonomic evaluation were made by manually scraping surfaces of three rocks on the stream bottom using a stainless spatula approximating the method of Rott (1995). The areas were scraped inside a 1 cm^2 measured area, with a minimum of 3 cm^2 sampled (1 cm^2 per rock), or until about 1 mL (wet volume) of material was obtained. Sample areas were recorded and the samples diluted to about 10 mL with site water. Periphyton samples for taxonomic analysis were then preserved with Lugol's iodine.

Taxonomic determinations were completed in the laboratory of Dr. H.C. Duthie, Department of Biology, University of Waterloo. These determinations include species identifications and biomass of each.

Samples for metal analysis in periphyton were collected in a similar fashion without measurement of sample area. Samples were scraped from the same three rocks sampled for taxonomy or, where periphyton growth was very light, also from neighbouring rocks. Samples were scraped until a wet volume of about 1 mL was reached, and were placed in small high density polyethylene bottles. Samples were then preserved by freezing until delivery to Philip Analytical Laboratories for metals analysis. Samples were analyzed by ICP-Mass Spectroscopy after drying and digesting the sample.

Quality control/quality assurance procedures included collection of duplicate samples for metal analysis.

3.6 Benthic Macroinvertebrates

3.6.1 Field

One benthic sample was collected at each of the two stations within each exposure and reference reach. Each sample consisted of a 5-grab composite using a 0.1 m^2 T-sampler fitted with a 250 micron mesh collection net. Samples were collected by manually removing invertebrates from rock surfaces and disturbing the underlying sand and gravel repetitively to a depth of about 10 cm. All collections were made by the same field crew member.

After collection, each composite sample was preserved in a clearly labelled 1 L plastic jar and preserved to a level of 10% buffered formalin.

3.6.2 Lab Processing

All samples were processed by the BEAK Benthic Ecology Laboratory or by Zaranko Environmental Assessment Services, Guelph, Ontario. Both laboratories followed the same laboratory protocols.

In the laboratory, samples were inspected to insure that they were adequately preserved and correctly labelled. Samples were then stained to improve sorting recovery.

Prior to detailed sorting, the samples were washed free of formalin in a 250 μm sieve under ventilated conditions. The benthic fauna and associated debris were then elutriated free of any sand and gravel. The remaining sand and gravel fraction was closely inspected for any of the denser organisms, such as Pelecypoda, Gastropoda, and Trichoptera with stone cases that may not have all been washed from this fraction. The remaining debris and benthic fauna after elutriation were washed through 500 μm and 250 μm sieves to standardize the size of the debris being sorted and facilitate a minimum of 95% recovery of benthic fauna.

All benthic samples were processed with the aid of stereomicroscopes. A magnification of at least 10X was used for macrobenthos (invertebrates >500 μm) and 20X for meioinvertebrates (invertebrate size >250 to <500 μm). Benthos was sorted from the debris, enumerated into the major taxonomic groups, usually order and family levels and placed in vials for more detailed taxonomic analysis.

Benthic invertebrates were most commonly identified to the lowest practical level, genus or species for most groups. The level to which each group was identified and the taxonomic keys that the identification were based on are provided in Annex 1.

Benthic samples, especially when consisting of composites of multiple samples, often require extensive hours and costs for sorting. In addition, technicians working for extended periods on one sample often become fatigued and sorting efficiency and accuracy reduce significantly. Samples either need to be subsampled because of large amounts of organic matter or due to high densities of invertebrates. The latter is the case at Heath Steele.

For Heath Steele samples, a minimum of 400 to 600 organisms was sorted from each sample. Subsampling was based on the weight of the sample. Each whole sample was drained of water, homogenized, and sample portions randomly selected until a prescribed weight of material was attained. For example, if the total sample weighed 5,000 g, typically 25%, or 1,250 g would be selected for sorting. For Heath Steele, subsample fractions as low as 5% were sufficient to obtain more than 500 animals, based on five pooled samples.

Subsampling error was determined for both density and number of taxa in 10% of the samples that were subsampled. Ten percent of sorted samples were resorted by an independent taxonomist to ensure 95% recovery of all invertebrates. At least 95% recovery of organisms is required to meet BEAK's data quality objective.

A voucher collection or reference collection of benthic invertebrate specimens was compiled for Heath Steele. This is a collection of representative specimens for each taxon so that there can be continuity in taxonomic identifications if different taxonomists process future samples. The voucher collection will be maintained at BEAK. The BEAK Benthic Ecology Laboratory also maintains a master reference collection of all taxa which have been identified by the lab.

The specimens selected for the voucher collection were preserved such that they will remain intact for many years. Chironomids and oligochaetes remain on the initial slides and representatives of each taxon were circled with a permanent marker and labelled. All other species were preserved in 80% ethanol in separately labelled vials. Each vial contains a 3% solution of glycerol to prevent spoilage of the fauna if the vials accidentally dry out.

3.6.3 Chironomid Deformities

In the last decade there has been considerable attention paid towards the use of chironomid mouth part deformities to monitor contaminant effects. Previous studies have shown that the incidence of chironomid deformities (especially in *Chironomus*) can be associated with contaminated sediments.

For the 1997 study, all mounted chironomid specimens from each site were scored for mandible and mentum deformities or abnormalities. These data were not used in the testing of specific hypotheses, but are discussed briefly in Section 4.4.

3.7 Fish

3.7.1 Wild Fish Collections

Wild fish were sampled at each of the 16 stations (2 stations per reach, HE1 to HE5, HR1 to HR3) during the August 1997 field survey. Sampling was carried out using a portable back-pack electrofishing unit (Smith Root Model XV). Sampling was carried out in the same vicinity as benthic collections, with care taken to avoid disruption of benthic substrates by placement of the electrofishing area at least 50 m downstream of benthic sampling sites.

Electrofishing was carried out with a standardized effort of approximately 15 to 20 electrofishing minutes (as lapsed on the electrofisher counting unit), or about one hour of actual time. The crew consisted of one electrofisher operator using an anode equipped with a capture net, and a technician using a long-handled dip net to assist in fish collection. Effort (shocking seconds) was recorded for each station. Stations were not enclosed with block nets, and all habitat conditions represented at each site were sampled.

All captured fish were retained in a 20-L plastic bucket containing site water until completion of sampling. After collection, all fish were identified and weighed on-site, and were either retained for further analysis (frozen whole on dry ice for metallothionein or metal analysis, or for determination of age and organ size) or released back to the river. Fish lengths were measured using standard measuring boards (total length, fork length) to the nearest millimetre. Weights to the nearest 0.1 g were determined using an Ohaus balance. A more detailed account of procedures used in processing of fish samples is presented in Annex 1.

The two sentinel species retained for tissue analysis were juvenile Atlantic salmon parr and adult blacknose dace. Wherever possible, sufficient numbers were retained for a minimum of two samples per species for each of metallothionein (MT) and metals in viscera. One to four (usually four) wild juvenile salmon per site and up to 16 blacknose dace per site were retained for this purpose (blacknose dace required composites of more than one fish to produce adequate visceral mass for laboratory analyses). As potential alternate sentinel species, several lake chub and/or small brook trout were also retained frozen from stations where these species were obtained.

Upon completion of the wild fish survey, an evaluation was made of the numbers and biomass of sentinel species (and alternates) captured at each site. Where the numbers of fish available for tissue analysis appeared deficient, supplemental electrofishing was carried out at sampling stations with effort focused on habitats most likely to produce additional specimens. These additional fish were excluded from analysis of fish community characteristics (i.e., catch-per-unit-effort CPUE).

Biological measurements carried out on sentinel species at the laboratory included age determination. Age was determined for both sentinel species by length-frequency distributions with reaches (where adequate numbers were obtained) or within reference versus exposure areas, with multi-modal distributions used to distinguish age classes. Representative specimens of blacknose dace were aged by scale reading and of Atlantic salmon by otolith to confirm age breaks implied in the length frequencies. Except for salmon fry which are easily distinguished in the field, only those fish directly aged (i.e., by scale or otolith readings) were used in the assessment of fish growth.

An attempt was made in the laboratory to measure liver weights in blacknose dace. However, after thawing, livers in the fish fragmented easily when dissected, and it was not possible to obtain all of the liver mass in each case. The fact that blacknose dace livers are diffusely distributed through the gut made effective removal more difficult. Accordingly, no liver weight determinations were recorded.

Atlantic salmon is a species of considerable resource value in the Northwest Miramichi River watershed. Thus, few juvenile salmon were retained for age determination by otolith, and larger sample sizes were not retained for organ size determinations. Only specimens for MT and metal analysis and a few others were aged directly by otolith.

3.7.2 Caged Atlantic Salmon

Caged Atlantic salmon juveniles were used to further evaluate the tissue metal and MT tools. The source of salmon used here was the Heath Steele McCormack Reservoir salmon rearing facility. (The McCormack Reservoir is located upstream of any significant metal sources from Heath Steele.) All fish used were yearling parr (1+).

Fish cages consisted of 20-L plastic buckets, fitted with "snap-on" plastic lids. Buckets each contained three large surface area openings covered with 1 mm "Nitex" screen. Approximately one-third of each bucket consisted of window, so that once immersed in the river, the river current would flow through the bucket.

One fish cage containing five salmon parr was installed at each of the 16 monitoring stations. Cages were placed in areas of gentle current to ensure continuous flow of water through the interior, and were secured by rope to trees or shrubs on the streambank. Fish were left in place for nine days during the August 1997 field campaign.

At the end of the exposure period, fish survival was recorded (all fish survived at all locations) and two specimens were sacrificed for metal and MT analysis of the viscera. Specimens for analysis were measured (total and fork length), weighed to the nearest 0.1 g and placed whole on dry ice. No samples of pre-exposure fish were collected for analysis as it was unnecessary in the context of hypothesis testing. However, pre-exposure fish analyzed in the fish cage experiment at Dome under the 1997 AETE program did show that tissue concentrations of metals and MT may change in response to the caging itself (refer to BEAK, 1998a).

3.7.3 Tissue Metallothionein and Metal Analyses

All analyses of Heath Steele fish tissues were carried out at the Department of Fisheries and Oceans, Freshwater Institute, Winnipeg, under the direction of Dr. J. Klaverkamp. Analyses were completed on two wild Atlantic salmon samples, two blacknose dace samples and two caged Atlantic salmon samples for all stations, where sufficient fish specimens were available (refer to Table 3.1). In addition, one composite gill sample was analyzed from two caged salmon per station. Variable numbers of brook trout (viscera) sampled coincidentally with the Atlantic salmon and blacknose dace were also analyzed on an opportunistic basis by Dr. Klaverkamp. The gill and brook trout data were not subject to formal hypothesis testing.

4.0 DATA OVERVIEW

4.1 Effluent Chemistry and Toxicity

Detailed toxicity test reports are presented under separate cover as Annex 1, with results summarized in Table 4.1, Figure 4.1 and Appendix 4. Effluent quality conditions are provided in Table 4.2, with laboratory reports on effluent and site dilution water quality provided in Annex 1.

All samples produced chronic toxicity in all tests except for fathead minnow. The June effluent sample was non-toxic to fathead minnow. The *Selenastrum* and *Ceriodaphnia* tests were the most sensitive of the four tests. Toxicity of the three samples to *Selenastrum* and *Ceriodaphnia* ranked in accordance with the total zinc and copper concentrations present (i.e., highest and lowest metal concentrations corresponded with the most and least toxicity), although this pattern did not hold for fathead minnow or duckweed. The duckweed response appeared to show the poorest correspondence with metal concentration, with the lowest zinc and copper concentrations producing the greatest toxicity.

The August "runoff event" sample was richer in particulate iron (i.e., total minus dissolved iron) than either of the other two dry weather samples, although both total and dissolved zinc and copper were higher in concentration in the November sample. Construction of a new buffer storage pond by Heath Steele in 1997 has apparently been successful in reducing maximum metal concentrations at HS-3 during runoff conditions, and may have contributed to a suppressed spike in metal concentrations during the August event.

4.2 Water Quality

Water quality data for Heath Steele are summarized in Table 4.3 (total metals and general chemistry) and Table 4.4 (which compares total versus dissolved metals). The mean concentrations for each reach are illustrated in Figure 4.2. Non-detect samples were assigned concentrations equal to half the detection limit for computation of means. Detailed data for all parameters and samples are presented in Appendix 4. These additional parameters include those that were generally below detection limits and those that did not show a mine-related trend.

Table 4.1: Results of Aquatic Toxicity Tests Conducted on Three Heath Steele Effluent Samples (HS-3), June, August and November 1997.

(Expressed as % Effluent. Values in parentheses represent the 95% confidence interval)

Sample	*Ceriodaphnia dubia*			*Pimephales promelas* (Fathead Minnow)			*Selenastrum capricornutum* (Algae)		*Lemna minor* (Duckweed)	
	LC50[1]	IC25[2]	IC50[3]	LC50	IC25	IC50	IC25	IC50	IC25	IC50
H-E-1 (June 24-97)	91.6 (50-infinity)	58.4 (48.7-63.7)	75.7 (69.7-82.3)	>100 na	>100 na	>100 na	23 (17.9-26.0)	55.6 (52.3-57.7)	30.0 (17.2-52.5)	91.1 (56.7-100)
H-E-2 (August 28-97)	33.0 (28.9-37.6)	28.4 (21.8-30.9)	35.6 (32.8-37.5)	22.2* (18.5-26.6)	23.0* (16.3-34.4)	41.0* (35.7-45.0)	21.7 (14.6-27.5)	32.5 (27.1-36.1)	51.9 (45.6-59.1)	78.4 (73.6-83.5)
H-E-3 (November 12-97)	18.6 (12.6-27.7)	10.9 (4.82-18.5)	23.0 (12.7-31.3)	44.0* (36.9-51.4)	41.3* not calculable[4]	>50* na	6.03 (4.11-11.2)	23.7 (3.88-31.8)	59.3 (52.5-66.9)	>100 na

Notes:

All tests conducted using site water as dilution water except where indicated by "*".

* tests conducted using laboratory water (adjusted to site water hardness, pH and alkalinity) as dilution water because fish could not be acclimated to site water.

Ceriodaphnia and fathead minnows were acclimated to dilution water prior to testing.

Fathead minnow data analysed according to Environment Canada amendments (Nov. 1997) - IC values represent growth effects alone.

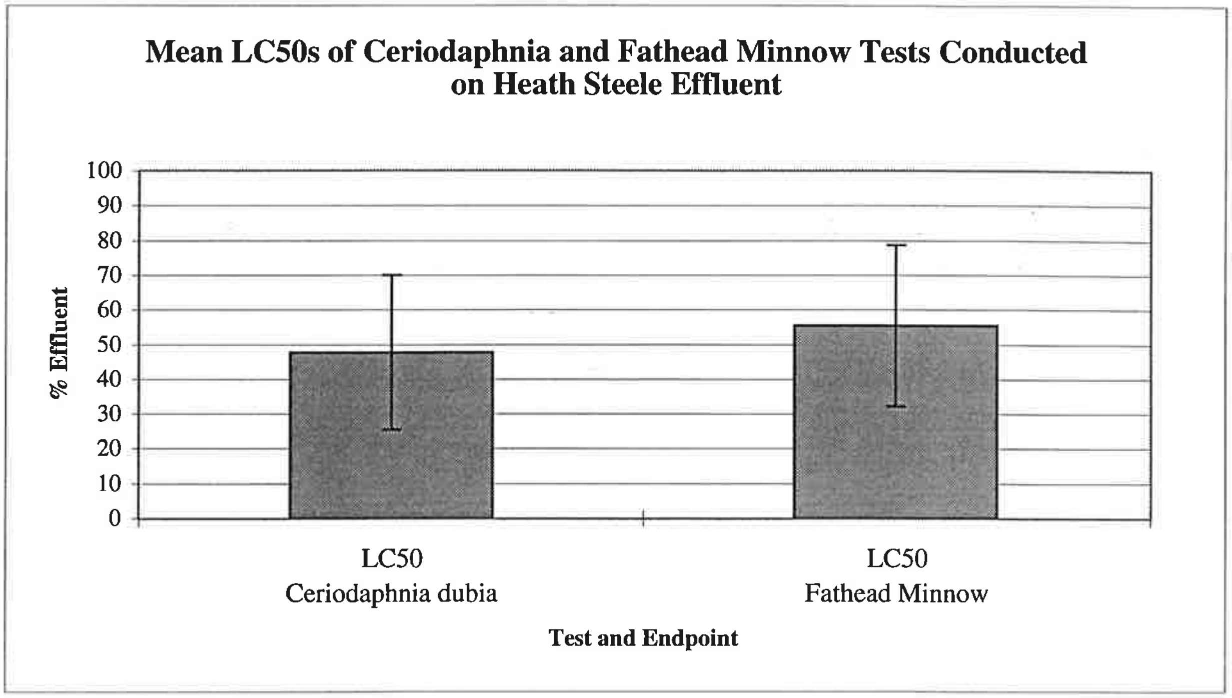
August 28 sample corresponds with runoff event.

[1] LC50 - concentration lethal to 50% of the test organisms

[2] IC25 - inhibition concentration - 25% response (i.e., 25% reduction in growth or reproduction)

[3] IC50 - inhibition concentration - 50% response (i.e., 50% reduction in growth or reproduction)

[4] not calculable by ICPIN program because random sampling of raw data resulted in an estimation of an endpoint greater than 100%.



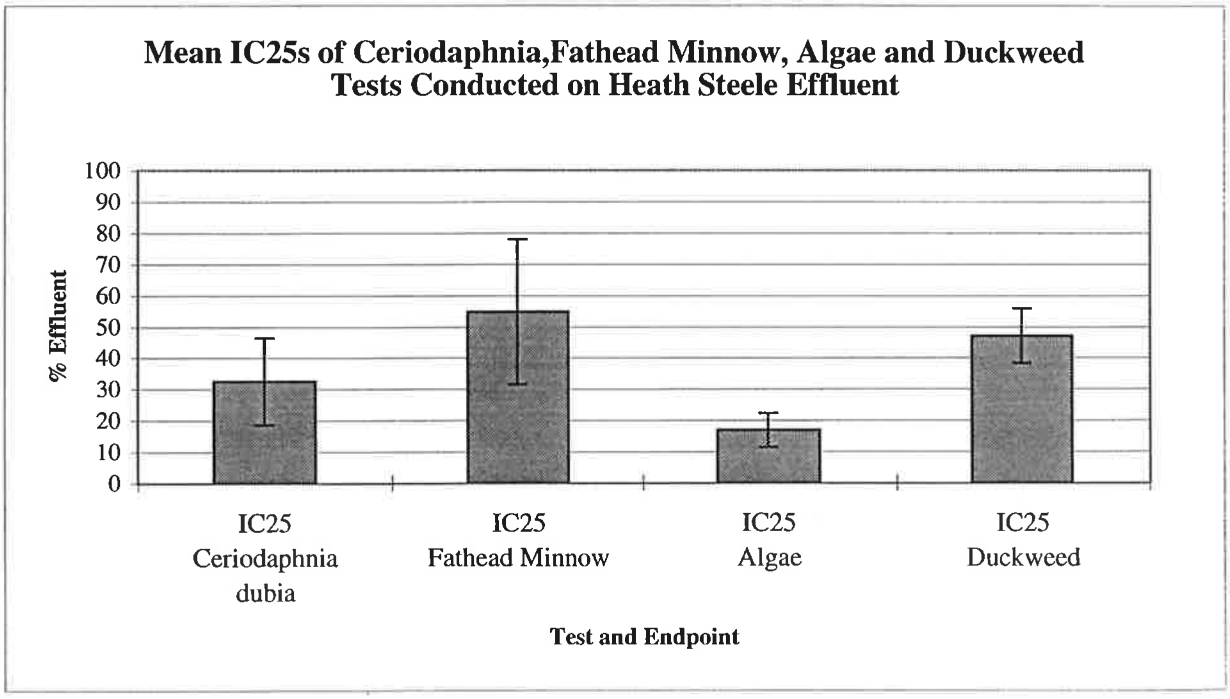


Figure 4.1: Mean Toxicity Test Results (±1 S.E.), for Four Species based on Three Heath Steele HS-3 "Effluent" Samples, June, August and November 1997.
Mean (±1 S.E.) Based on Data in Table 4.1.

Table 4.2: Water Quality of "Effluent" Samples (HS-3) collected at Heath Steele Mine, June, August and November 1997.

Parameter	Units	LOQ[1]	MMLER[2]		HSE-1 (Total) 97/06/25	HSE-1 (Dissolved) 97/06/25	HSE-2 (Total) 97/08/29	HSE-2 (Dissolved) 97/08/29	HSE-3 (Total) 97/11/13	HSE-3 (Dissolved) 97/11/13
			Monthly Mean	Grab Sample Maximum						
Acidity(as CaCO3)	mg/L	0.1	na[3]	na[3]	-	-[4]	-	-	-	10
Alkalinity(as CaCO3)	mg/L	1	na	na	5	-	7	-	1	-
Aluminum	mg/L	0.01/0.005	na	na	0.29	0.2	0.355	0.122	0.56	0.36
Ammonia(as N)	mg/L	0.05	na	na	0.06	-	nd	-	nd	-
Antimony	mg/L	0.002/0.0005	na	na	<0.002	<0.002	<0.0005	<0.0005	<0.0005	<0.0005
Arsenic	mg/L	0.002	0.5	1.0	nd	nd[5]	nd	nd	nd	nd
Barium	mg/L	0.005	na	na	nd	nd	0.005	0.005	0.01	0.007
Beryllium	mg/L	0.005	na	na	nd	nd	nd	nd	nd	nd
Bicarbonate(as CaCO3, calculated)	mg/L	1	na	na	5	-	7	-	1	-
Bismuth	mg/L	0.002	na	na	nd	nd	nd	nd	nd	nd
Boron	mg/L	0.005	na	na	0.127	nd	nd	nd	nd	nd
Cadmium	mg/L	0.0005	na	na	nd	nd	0.00067	0.0007	0.00095	0.00078
Calcium	mg/L	0.1	na	na	3.3	3.7	4.4	4.4	4.3	4.3
Carbonate(as CaCO3, calculated)	mg/L	1	na	na	nd	-	nd	-	nd	-
Chloride	mg/L	1	na	na	2	-	2	-	3	-
Chromium	mg/L	0.002/0.0005	na	na	<0.002	<0.002	0.0006	<0.0005	0.0005	<0.0005
Cobalt	mg/L	0.001/0.0002	na	na	0.002	0.002	0.0038	0.0038	0.0078	0.0063
Colour	TCU	5	na	na	43	-	79	-	66	-
Conductivity - @25øC	us/cm	1	na	na	42	-	48	-	56	-
Copper	mg/L	0.002/0.0003	0.3	0.6	0.023	0.017	0.0329	0.0262	0.055	0.041
Dissolved Inorganic Carbon(as C)	mg/L	0.5/0.2	na	na	-	1.1	-	0.2	-	0.3
Dissolved Organic Carbon(DOC)	mg/L	0.5	na	na	-	4.2	-	5	-	5.4
Hardness(as CaCO3)	mg/L	0.1	na	na	13.5	-	16.5	-	15.9	-
Iron	mg/L	0.02	na	na	0.41	0.28	0.9	0.19	0.41	0.14
Lead	mg/L	0.0001	0.2	0.4	0.0028	0.0015	0.0048	0.0011	0.003	0.0015
Magnesium	mg/L	0.1	na	na	1	1.1	1.2	1.3	1.2	1.2
Manganese	mg/L	0.002/0.0005	na	na	0.104	0.082	0.157	0.152	0.22	0.17
Mercury	mg/L	0.0001	na	na	nd	nd	nd	nd	nd	nd
Molybdenum	mg/L	0.002/0.0001	na	na	<0.002	<0.002	<0.0001	<0.0001	0.0005	0.0002
Nickel	mg/L	0.002/0.001	0.5	1.0	<0.002	<0.002	0.002	0.002	0.003	0.002
Nitrate(as N)	mg/L	0.05	na	na	-	nd	-	nd	-	0.42
Nitrite(as N)	mg/L	0.01	na	na	-	nd	-	nd	-	nd
Orthophosphate(as P)	mg/L	0.01	na	na	-	nd	-	nd	-	nd
pH	Units	0.1	6.0 [6]	5.0 [6]	6.4	-	6.1	-	7	-
Phosphorus	mg/L	0.1	na	na	nd	nd	nd	nd	nd	nd
Phosphorus, Total	mg/L	0.01	na	na	0.05	-	0.04	-	0.02	-
Potassium	mg/L	0.5	na	na	1.2	nd	nd	nd	0.7	0.7
Reactive Silica(SiO2)	mg/L	0.5	na	na	4.6	-	4.9	-	7.2	-
Selenium	mg/L	0.002	na	na	nd	nd	nd	nd	nd	nd
Silver	mg/L	0.0005/0.00005	na	na	<0.0005	<0.0005	<0.00005	<0.00005	<0.00005	<0.00005
Sodium	mg/L	0.1	na	na	1.9	1.9	2	2.1	2.2	2.3
Strontium	mg/L	0.005	na	na	0.011	0.011	0.013	0.013	0.019	0.015
Sulphate	mg/L	2	na	na	8	-	11	-	16	-
Thallium	mg/L	0.0001	na	na	nd	nd	nd	nd	0.0001	nd
Tin	mg/L	0.002	na	na	nd	nd	nd	nd	nd	nd
Titanium	mg/L	0.002	na	na	nd	nd	0.003	nd	0.003	0.002
Total Dissolved Solids(Calculated)	mg/L	1	na	na	-	24	-	31	-	38
Total Kjeldahl Nitrogen(as N)	mg/L	0.05	na	na	0.58	-	0.39	-	0.43	-
Total Suspended Solids	mg/L	5/1	25.0	50.0	<5	-	3	-	2	-
Turbidity	NTU	0.1	na	na	1.1	-	3	-	1.9	-
Uranium	mg/L	0.0001	na	na	nd	nd	nd	nd	0.0001	nd
Vanadium	mg/L	0.002	na	na	nd	nd	nd	nd	nd	nd
Zinc	mg/L	0.002/0.001	0.5	1.0	0.168	0.171	0.36	0.363	0.44	0.37

[1] LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence.

[2] MMLER = Metal Mining Liquid Effluent Regulations (Fisheries Act, 1994)

[3] na = Regulation values not available

[4] - = Not Analyzed

[5] nd = Parameter not detected

[6] pH limits listed are minimum.

Table 4.3: Selected Water Quality Results at Heath Steele, 20 August 1997. Total Metals and General Chemistry

Parameters	Units	LOQ[1]	CWQG[2]	REFERENCE STATIONS						EXPOSURE STATIONS									
				HR1A	HR1B	HR2A	HR2B	HR3A	HR3B	HE1A	HE1B	HE2A	HE2B	HE3A	HE3B	HE4A	HE4B	HE5A	HE5B
Total Metals																			
Aluminum	mg/L	0.005	0.1	0.031	0.047	0.049	0.046	0.033	0.059	0.322	0.277	0.247	0.169	0.15	0.082	0.074	0.07	0.059	0.055
Cadmium	mg/L	0.00005	0.0002	nd[4]	nd	nd	nd	nd	nd	0.00032	0.00022	0.00021	0.0002	0.00016	0.00011	0.0001	0.0001	0.00008	0.00007
Copper	mg/L	0.0003	0.002	nd	nd	0.0003	0.0004	nd	nd	0.0225	0.0193	0.018	0.0158	0.0098	0.0075	0.0073	0.0071	0.0062	0.0057
Iron	mg/L	0.02	0.3	0.09	0.08	0.1	0.13	0.14	0.18	0.67	0.54	0.5	0.42	0.36	0.24	0.23	0.22	0.18	0.17
Lead	mg/L	0.0001	0.001	nd	nd	nd	0.0003	nd	nd	0.003	0.0025	0.0027	0.0019	0.0022	0.0009	0.0008	0.0007	0.0005	0.0004
Zinc	mg/L	0.001	0.03	0.008	0.009	0.016	0.017	0.003	0.004	0.157	0.111	0.106	0.107	0.085	0.066	0.062	0.068	0.058	0.061
General Chemistry																			
Sulphate	mg/L	2	na[3]	3	3	nd	nd	3	3	9	9	9	8	5	5	5	5	4	4
Alkalinity(as $CaCO_3$)	mg/L	1	na	9	9	15	15	32	32	5	8	9	10	13	15	15	16	20	20
Conductivity - @25øC	us/cm	1	na	32	31	38	39	71	72	46	48	49	48	46	47	49	49	53	56
Dissolved Organic Carbon(DOC)	mg/L	0.5	na	2.7	2.9	3.2	3.4	2.7	2.7	4.5	3.6	3.3	3.2	3.2	3.3	3.3	3.3	3.5	3.6
Hardness(as $CaCO_3$)	mg/L	0.1	na	9.8	9.8	13.6	13.7	29.8	31.5	12.8	15	15.4	15.2	15.7	16.6	17	17.7	19.7	20.8
Field pH	Units	0.1	6.5 - 9.0	6.73	6.8	7.36	7.32	7.05	7.05	7.0	7.14	7.14	7.11	7.3	7.11	7.13	7.11	7.15	7.15
Total Dissolved Solids(Calculated)	mg/L	1	na	22	22	25	25	41	41	25	29	29	28	27	29	29	30	33	33
Total Suspended Solids	mg/L	1	na	1	2	nd	nd	1	2	2	1	1	nd	3	nd	nd	nd	nd	nd

[1] LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence

[2] CWQG = Canadian Water Quality Guidelines (CCREM, 1987)

[3] na = Guideline values not available

[4] nd = Parameter not detected

▨ - Denotes values that exceed the guideline

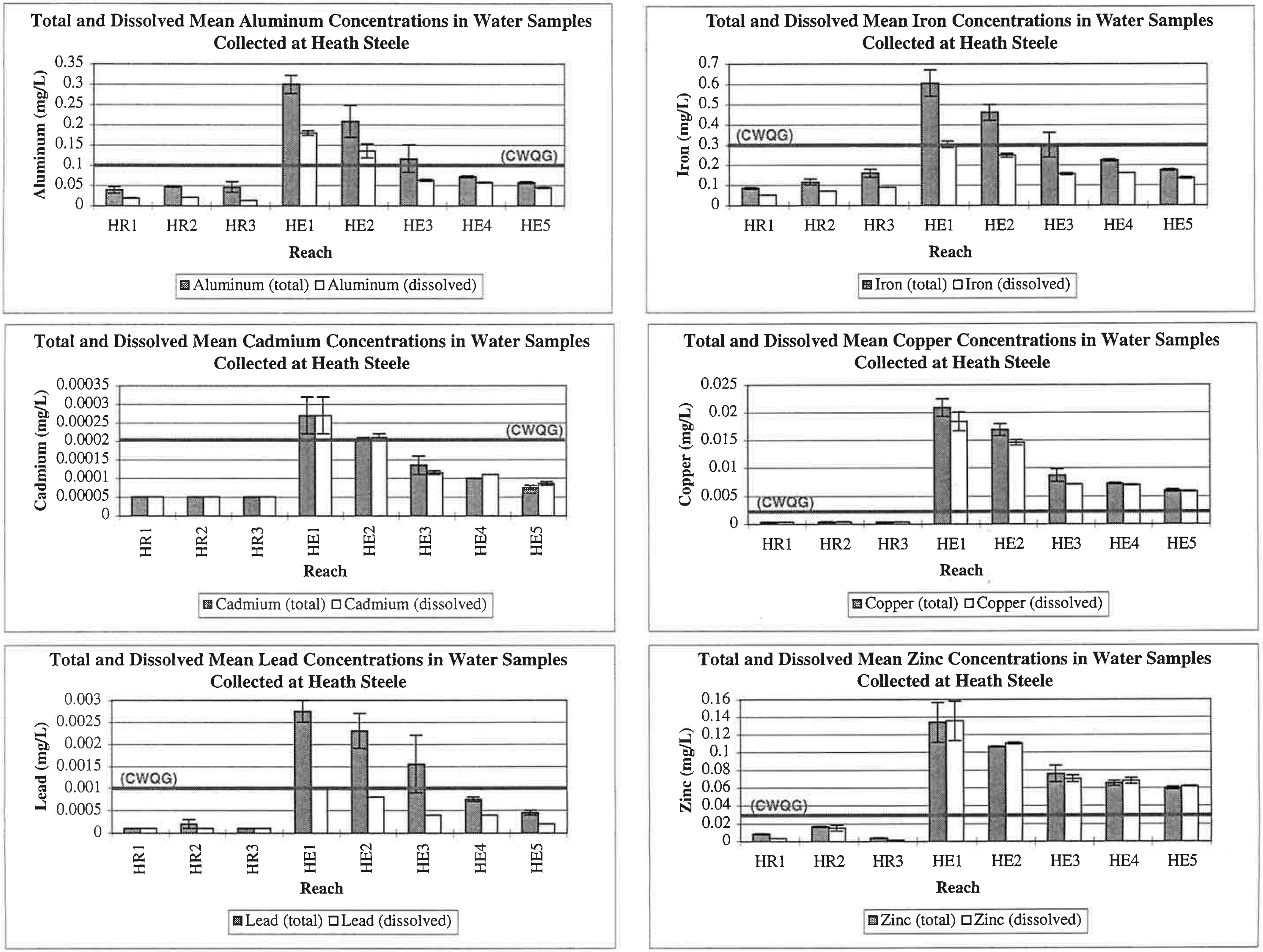
Table 4.4: Total versus Dissolved Concentrations for Selected Metals in Samples Collected at Heath Steele, 20 August 1997.

			REFERENCE STATIONS											
			HR1A	HR1A	HR1B	HR1B	HR2A	HR2A	HR2B	HR2B	HR3A	HR3A	HR3B	HR3B
Parameters	Units	LOQ[1]	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Aluminum	mg/L	0.005	0.031	0.019	0.047	0.018	0.049	0.021	0.046	0.021	0.033	0.013	0.059	0.013
Cadmium	mg/L	0.00005	nd [2]	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Copper	mg/L	0.0003	nd	nd	nd	nd	0.0003	0.0003	0.0004	0.0004	nd	nd	nd	nd
Iron	mg/L	0.02	0.09	0.05	0.08	0.05	0.1	0.07	0.13	0.07	0.14	0.09	0.18	0.09
Lead	mg/L	0.0001	nd	nd	nd	nd	nd	nd	0.0003	nd	nd	nd	nd	nd
Zinc	mg/L	0.001	0.008	0.003	0.009	0.003	0.016	0.012	0.017	0.018	0.003	nd	0.004	nd

			EXPOSURE STATIONS																			
			HE1A	HE1A	HE1B	HE1B	HE2A	HE2A	HE2B	HE2B	HE3A	HE3A	HE3B	HE3B	HE4A	HE4A	HE4B	HE4B	HE5A	HE5A	HE5B	HE5B
Parameters	Units	LOQ[1]	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Aluminum	mg/L	0.005	0.322	0.185	0.277	0.173	0.247	0.153	0.169	0.118	0.15	0.065	0.082	0.06	0.074	0.058	0.07	0.056	0.059	0.046	0.055	0.042
Cadmium	mg/L	0.00005	0.00032	0.00032	0.00022	0.00022	0.00021	0.00022	0.0002	0.0002	0.00016	0.00011	0.00011	0.00012	0.0001	0.00011	0.0001	0.00011	8E-05	0.00009	0.00007	0.00008
Copper	mg/L	0.0003	0.0225	0.0201	0.0193	0.0167	0.018	0.0151	0.0158	0.0141	0.0098	0.0071	0.0075	0.007	0.0073	0.007	0.0071	0.0068	0.0062	0.0059	0.0057	0.0057
Iron	mg/L	0.02	0.67	0.32	0.54	0.29	0.5	0.26	0.42	0.24	0.36	0.15	0.24	0.16	0.23	0.16	0.22	0.16	0.18	0.14	0.17	0.13
Lead	mg/L	0.0001	0.003	0.001	0.0025	0.001	0.0027	0.0008	0.0019	0.0008	0.0022	0.0004	0.0009	0.0004	0.0008	0.0004	0.0007	0.0004	0.0005	0.0002	0.0004	0.0002
Zinc	mg/L	0.001	0.157	0.158	0.111	0.113	0.106	0.109	0.107	0.111	0.085	0.074	0.066	0.066	0.062	0.064	0.068	0.071	0.058	0.061	0.061	0.062

[1] LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence

[2] nd = Parameter not detected



Total and Dissolved Mean Aluminum Concentrations in Water Samples Collected at Heath Steele

Total and Dissolved Mean Iron Concentrations in Water Samples Collected at Heath Steele

Total and Dissolved Mean Cadmium Concentrations in Water Samples Collected at Heath Steele

Total and Dissolved Mean Copper Concentrations in Water Samples Collected at Heath Steele

Total and Dissolved Mean Lead Concentrations in Water Samples Collected at Heath Steele

Total and Dissolved Mean Zinc Concentrations in Water Samples Collected at Heath Steele

Figure 4.2: Mean Total and Dissolved Metal Concentrations at Reference and Exposure Reaches, Heath Steele, 20 August 1997. Reach Means (±1 S.E.) Based on Data in Tables 4.3 and 4.4. CWQG = Canadian Water Quality Guideline for Total Metal Concentration.

As shown in Table 4.3 and graphically in Figure 4.2, total and dissolved concentrations of zinc, cadmium, lead, copper, aluminum and iron all show clear concentration gradients downstream of the mine, with the highest concentrations in reach HE1 and the lowest downstream concentrations in HE5. All of these parameters except aluminum remained elevated relative to reference site values in the final exposure reach (HE5), and all occurred in excess of Canadian surface water quality guidelines (CCREM, 1987) in some or all downstream reaches. Dissolved and total metal concentrations were similar for cadmium, copper and zinc, whereas dissolved metal concentrations were substantially lower than total metal concentrations for lead, iron and aluminum. On some occasions, dissolved metal concentrations were slightly higher than totals due to either the precision of the analytical method or because the values were close to the detection limit.

In terms of general water quality conditions, water hardness was low throughout ($\leq$20 mg/L as $CaCO_3$) in Tomogonops River reaches, but was somewhat higher (about 30 mg/L $CaCO_3$) in reference reach HR3 in the neighbouring Little River (Table 4.3). Conductivity and sulphate levels were relatively low, but showed some elevation in near-field reaches (HE1 and HE2). Field pH levels were near neutral (pH ~6.7 to 7.1) throughout.

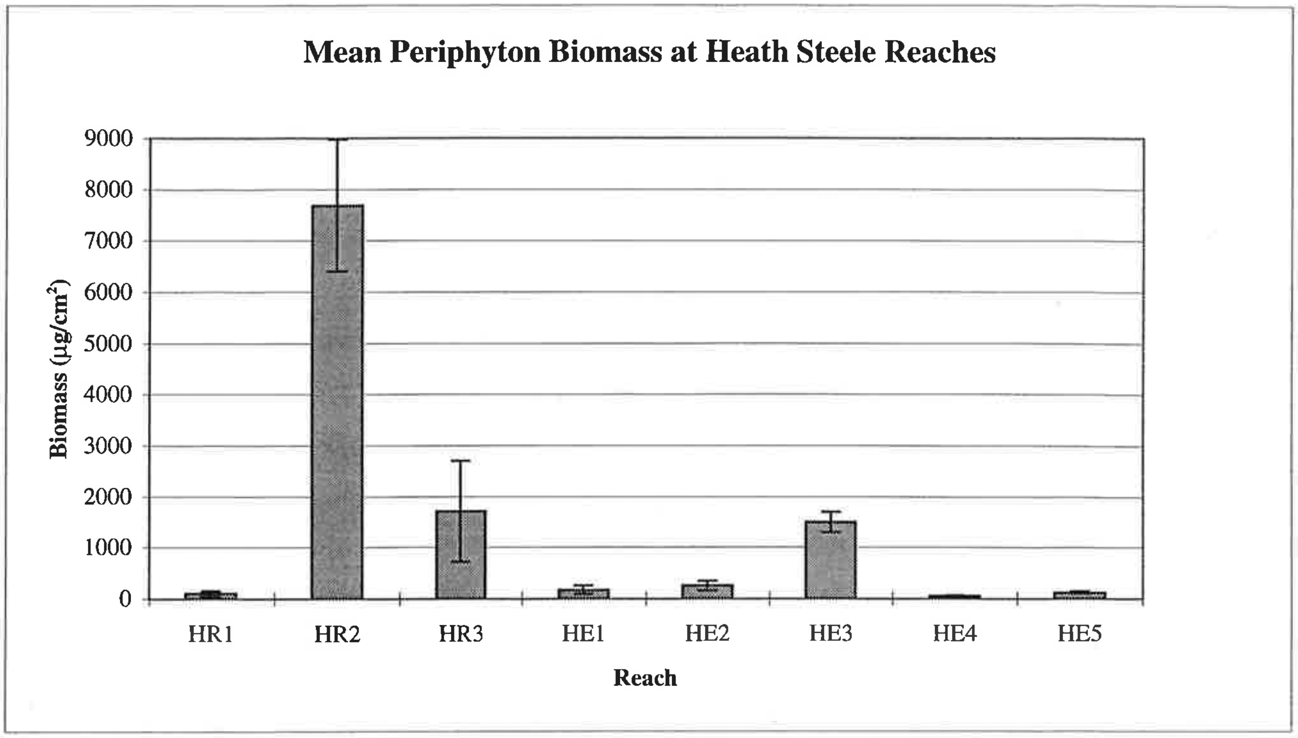
Based on these results, it may be concluded that the field program was successful in sampling an aqueous metal gradient downstream of Heath Steele, with concentrations of some metals (e.g., Zn, Cu, Pb) often at least an order of magnitude higher in the near-field (HE1) than at reference sites.

4.3 Periphyton

Detailed biological analyses of periphyton, as provided by Dr. H.C. Duthie, are provided in Annex 1. A summary of results in terms of numbers of taxa and biomass by reach is presented in Figure 4.3. Table 4.5 and Figure 4.4 present periphyton metal concentration data.

Periphyton samples were rich in algal species and variable in terms of biomass. Spatial trends among the exposure and reference reaches are not readily apparent in the data (Figure 4.3).

Periphyton copper, cadmium, lead and zinc concentrations all showed a reference-exposure difference, with an exposure area gradient also indicated for lead (Figure 4.4 vs Figure 4.2)



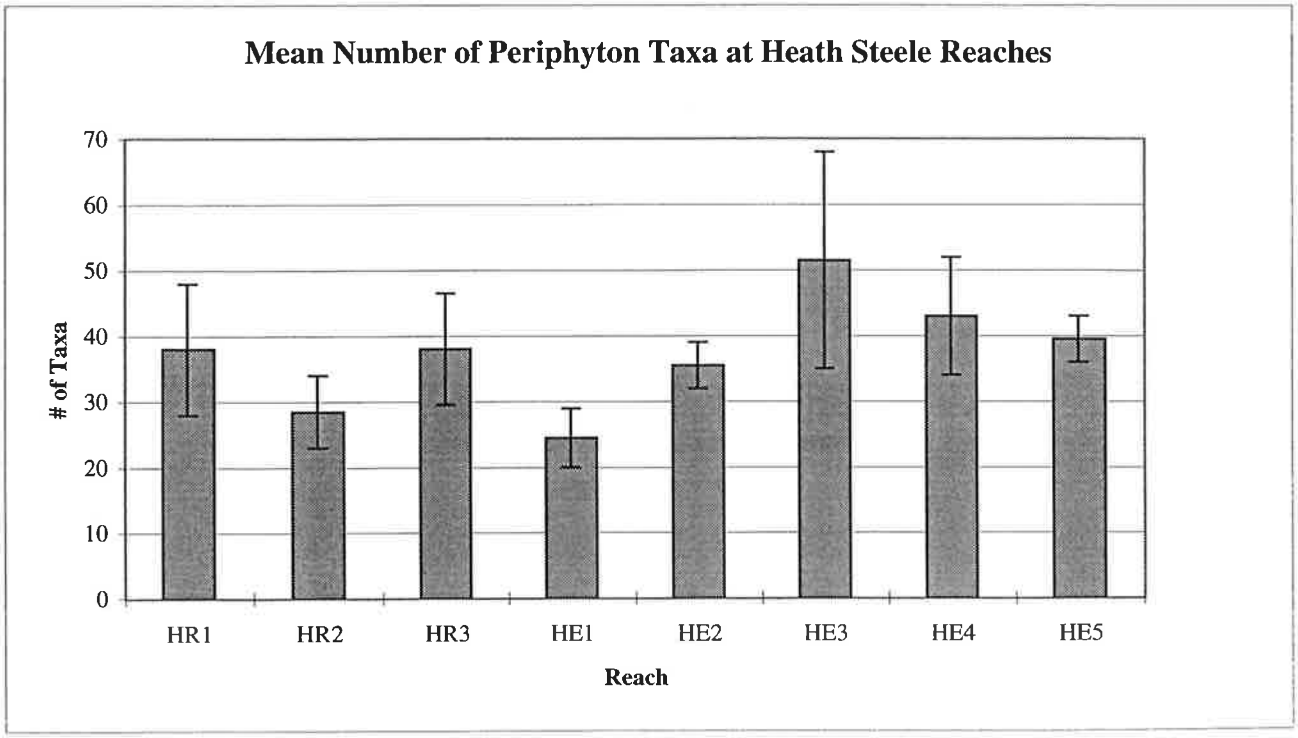


Figure 4.3: Mean Values of Periphyton Community Indices, Heath Steele, August 1997. Reach Means (±1 S.E.).

Table 4.5: Concentrations of Selected Metals in Periphyton collected at Heath Steele, August 1997.

All values expressed on a dry mass basis.

			REFERENCE STATIONS						EXPOSURE STATIONS									
			HR1A	HR1B	HR2A	HR2B	HR3A	HR3B	HE1A	HE1B	HE2A	HE2B	HE3A	HE3B	HE4A	HE4B	HE5A	HE5B
Parameters	**Units**	**MDL**[1]	97/08/18	97/08/18	97/08/15	97/08/15	97/08/17	97/08/19	97/08/13	97/08/16	97/08/16	97/08/14	97/08/14	97/08/14	97/08/16	97/08/13	97/08/17	97/08/19
Aluminum	mg/kg	0.5	450	4700	520	2600	7800	11000	22000	17000	18000	12000	500	16000	1800	15000	940	18000
Antimony	mg/kg	0.01	<0.10	0.16	<0.10	0.17	<0.10	<0.10	1.3	0.96	0.9	0.67	<0.10	0.51	0.19	0.13	<0.10	0.31
Arsenic	mg/kg	0.1	0.43	7.3	1	14	9	22	120	990	100	60	2.9	64	9.5	20	3.1	100
Barium	mg/kg	0.05	13	150	55	1500	32	260	140	120	140	140	7.1	330	220	110	11	980
Beryllium	mg/kg	0.01	<0.10	0.41	<0.10	0.23	0.37	0.43	1.8	1.7	1.6	1.5	<0.10	1.3	0.17	0.59	<0.10	1.7
Bismuth	mg/kg	0.01	<0.10	0.26	<0.10	0.16	0.11	0.21	13	9	8.4	4.5	0.19	3.6	0.53	0.42	0.16	1
Boron	mg/kg	0.2	<2.0	1.1	<2.0	<2.0	<2.0	<2.0	4.7	7.6	2.5	4.4	<2.0	2.7	<2.0	1.7	<2.0	3.4
Cadmium	mg/kg	0.005	0.31	3.5	0.26	3.9	0.21	1.7	9.2	11	14	22	0.75	28	2.2	9.2	0.74	70
Chromium	mg/kg	0.05	0.52	2.9	1.3	4.6	14	23	18	13	21	11	0.66	14	11	71	2	22
Cobalt	mg/kg	0.01	1.2	13	2.4	23	6.1	15	110	130	170	390	11	570	49	160	9.8	1200
Copper	mg/kg	0.03	1.2	15	1.3	15	6.2	11	930	1000	980	1100	32	830	77	250	24	1600
Iron	mg/kg	2	1000	10000	1100	6000	17000	21000	46000	42000	39000	27000	1800	30000	4300	24000	1700	25000
Lead	mg/kg	0.01	4.2	52	1.8	23	8.6	16	1100	770	760	500	18	430	58	120	17	380
Manganese	mg/kg	0.05	700	7600	350	5100	410	4400	3300	4200	6100	12000	500	26000	2000	6700	610	60000
Molybdenum	mg/kg	0.01	0.11	0.81	<0.10	0.69	0.42	0.74	1.6	1.7	1.5	1.3	<0.10	1.6	0.66	1.2	<0.10	3.1
Nickel	mg/kg	0.05	0.49	4	0.99	5.2	11	19	19	21	26	38	1.8	33	3.3	50	1.7	73
Selenium	mg/kg	0.2	<2.0	<2.0	<2.0	1.3	<2.0	<2.0	3.5	3.5	3.3	3.7	<2.0	3.7	<2.0	1.3	<	3.3
Silver	mg/kg	0.005	<0.050	0.32	<0.050	0.11	<0.050	0.1	3.6	2.6	2.6	1.5	0.088	1.3	0.15	0.21	0.053	0.24
Strontium	mg/kg	0.05	2.9	33	1.4	32	5.9	17	24	27	30	38	1.7	42	7.1	21	2.1	55
Thallium	mg/kg	0.01	<0.10	0.44	<0.10	0.25	<0.10	0.14	0.82	0.59	0.61	0.32	<0.10	0.61	<0.10	0.21	<0.10	0.8
Tin	mg/kg	0.01	0.2	0.17	<0.10	1.3	0.21	0.14	0.86	0.79	0.61	0.47	0.13	0.32	1.3	0.36	<0.10	0.79
Titanium	mg/kg	0.03	78	360	71	250	300	370	560	520	660	360	16	470	72	280	61	430
Vanadium	mg/kg	0.05	2.4	23	2	9.3	19	32	37	34	38	23	1.2	29	3.8	52	2.4	32
Zinc	mg/kg	0.1	26	620	65	1200	76	220	3400	4300	5300	9100	300	8800	1000	2400	310	13000

[1] MDL - Method Detection Limit - lowest level the parameter can be detected with confidence

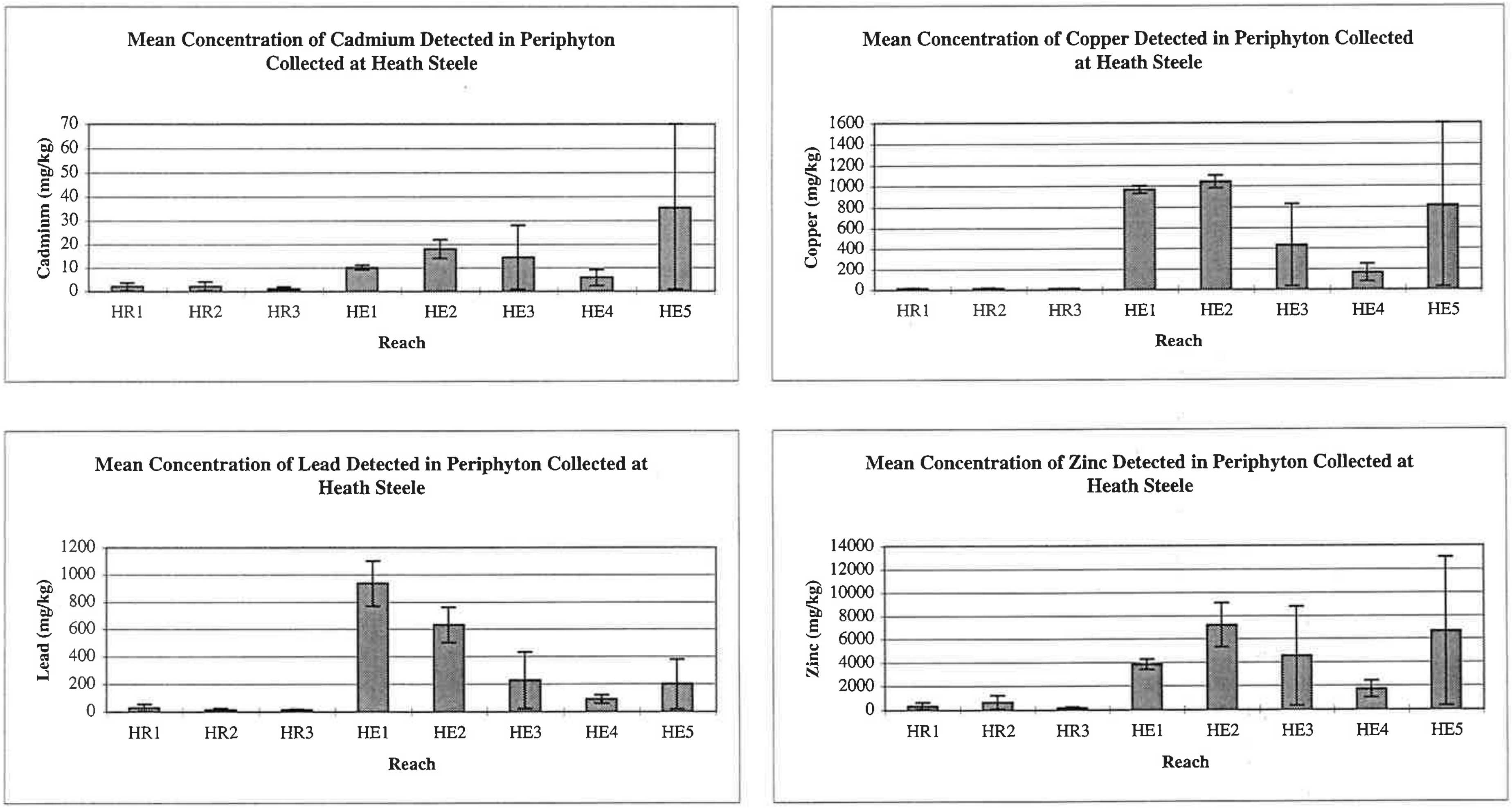


Figure 4.4: Mean Concentrations of Selected Metals in Periphyton Collected at Reference and Exposure Reaches, Heath Steele, August 1997. Reach Means (± 1 S.E.).

and also iron (Table 4.5). Concentration ranges for important metals, including cadmium, copper and zinc, were often variable between samples within reaches.

4.4 Benthic Invertebrates

Benthic community sample composition is presented in detail in Appendix 4, with Table 4.6 providing a summary by reach and expressed per square metre. Figure 4.5 illustrates spatial trends in benthic community indices by reach.

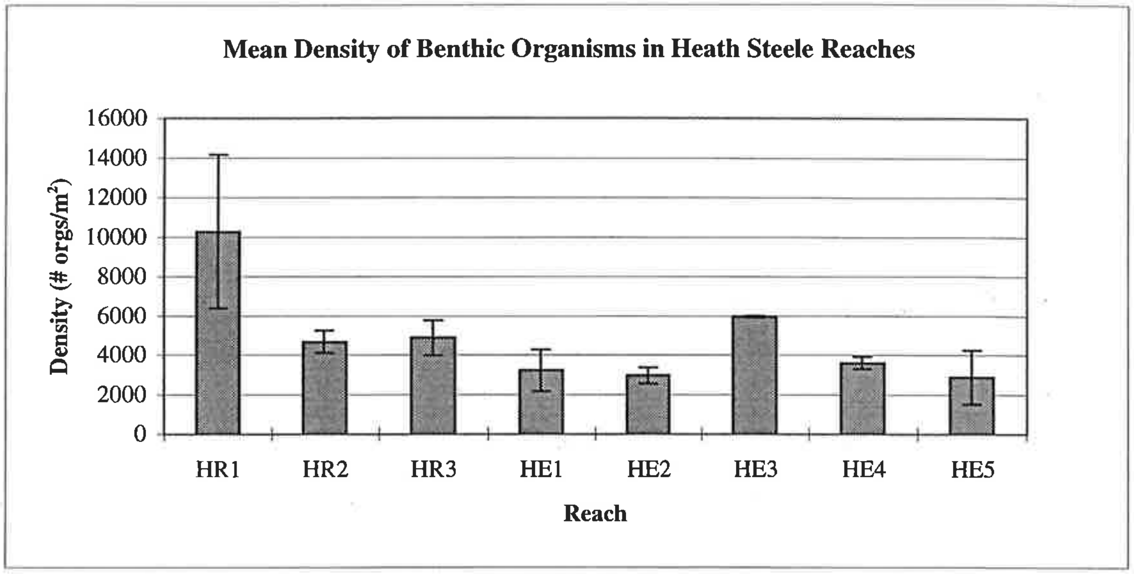
Overall, riffle communities in all reaches were rich in species and numbers of benthic organisms. Chironomids were generally predominant, although EPT taxa (Ephemeroptera-Plecoptera-Trichoptera) were well represented. These latter groups are generally considered to be sensitive to metals. Mean total densities of organisms were relatively high in all reaches, at about 3,000 to 10,000 organisms per square metre (Figure 4.5).

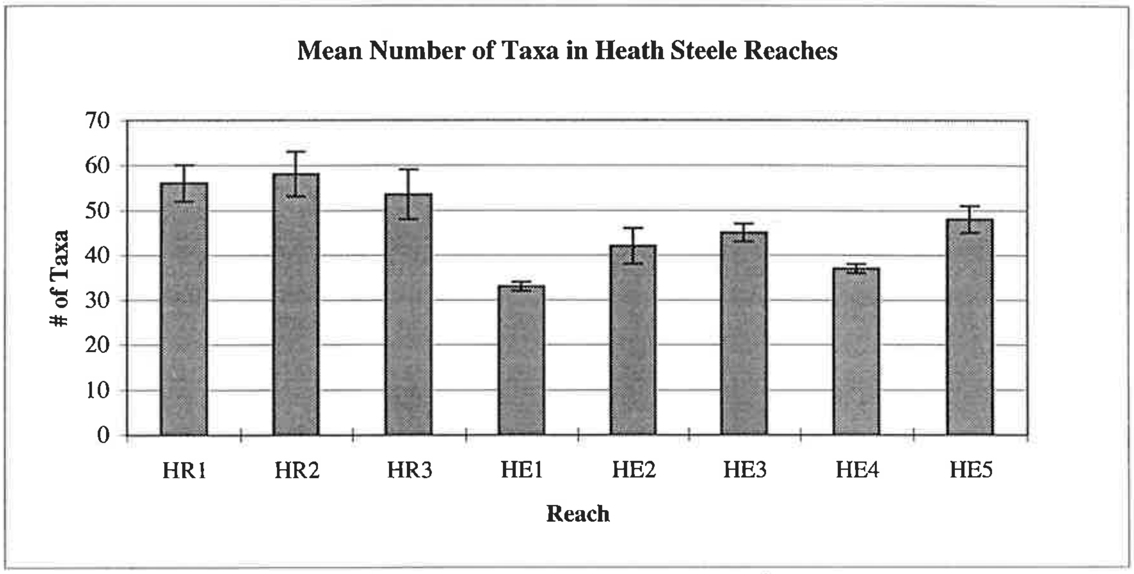
Spatial trends are apparent in terms of the EPT Index (number of EPT taxa) and total number of taxa present, with a suppression in values at reach HE1 in the near-field, and recovery to reference site conditions in the downstream reach, HE5. Other trends are apparent for individual taxa, such as the chironomids *Micropsectra* which was common everywhere except in the near-field reaches, and *Rheocricotopus* which showed the opposite trend (i.e., densities were highest in the near-field and were lower in the far-field). Percent Orthocladiinae reflected the trend seen for *Rheocricotopus*. Except for a very high total organism density at HR1, no spatial trends are apparent in total density.

As illustrated in Appendix 4, the incidence of abnormalities in chironomid head capsules was relatively low throughout, with no obvious spatial trend across the water quality gradient downstream of Heath Steele.

Table 4.6: Benthic Community Indices, Based on T-Sampler Collections, Heath Steele, August 1997.

Station	Total Density (no./m^2)	Number of Taxa	EPT Index	Orthocladiinae (%)	Micropsectra (%)	Rheocricotopus (%)
HR1A	6360	52	20	5	6.2	0.1
HR1B	14159	60	21	23	12.1	0.1
HR2A	5232	53	21	15	6.7	0.6
HR2B	4091	63	27	11	8.0	0.4
HR3A	3976	48	23	10	26.8	0.0
HR3B	5764	59	22	16	9.3	0.7
HE1A	4272	34	11	74	0.2	11.4
HE1B	2148	32	11	66	0.4	4.7
HE2A	2534	38	12	44	0.2	4.6
HE2B	3359	46	18	27	1.0	5.9
HE3A	5912	47	17	12	10.0	0.9
HE3B	5976	43	17	6	17.4	1.3
HE4A	3277	38	19	4	12.2	0.0
HE4B	3896	36	13	11	14.4	1.4
HE5A	1497	51	24	7	10.8	0.4
HE5B	4229	45	21	18	10.6	0.9





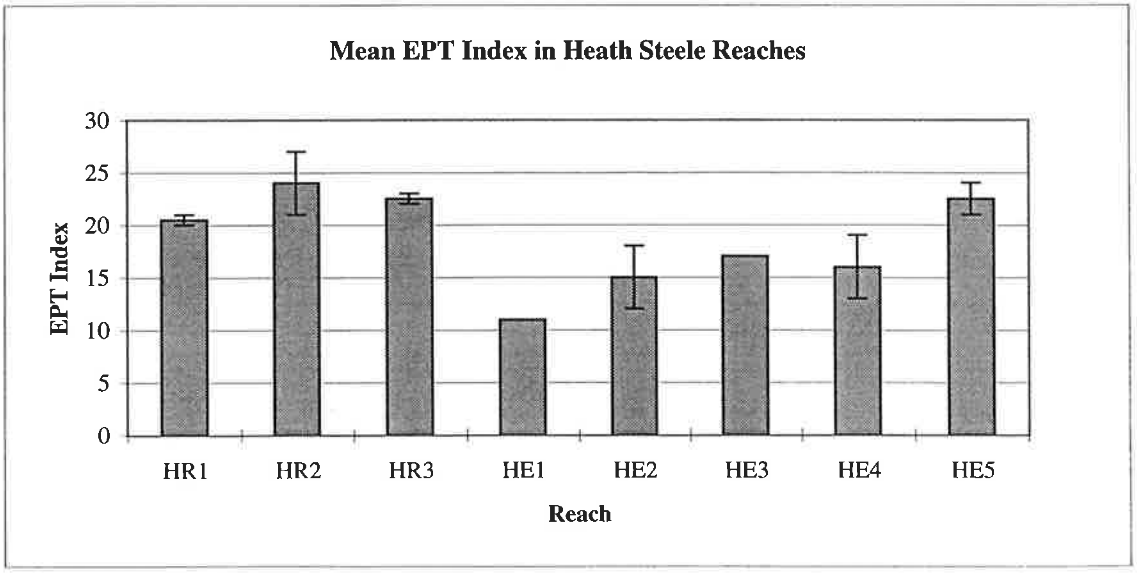


Figure 4.5: Mean Values of Selected Benthic Indices, Heath Steele, August 1997.
Reach Means (±1 S.E.)

4.5 Fish

4.5.1 Fish Catches

Detailed electrofishing results in terms of species, size, numbers and ages of fish are presented in Appendix 5. Table 4.7 summarizes the numbers of fish captured at each station, while Tables 4.8 and 4.9 provide CPUE (numbers of fish per minute) and BPUE (biomass of fish per minute), respectively. Summaries of the data in Tables 4.7 to 4.9 are illustrated graphically in Figures 4.6 and 4.7.

Ten species of fish were represented in the fish collections, with juvenile Atlantic salmon, blacknose dace and brook trout generally the most abundant. Fish CPUE and BPUE were lowest at HE1, but recovered in the downstream direction, and appeared to track the metal concentration gradient in the water. No fish were found at HE1A in the upstream extremity of reach HE1, although caged Atlantic salmon survived here over nine days.

Juvenile Atlantic salmon were most abundant at HR3 (Little River) and HE5, which are unaffected by migration barriers. Salmon densities were much lower at HE3 and HE4 than at HE5, mainly due to an absence of any salmon fry (age 0+) upstream of the abandoned railway crossing. No Atlantic salmon were captured in the Little South Branch Tomogonops (HE1, HE2) possibly due to an avoidance reaction, although other species were found in low numbers in these reaches. As expected, salmon were also absent at reference reach HR1.

Blacknose dace were most abundant at HR2 and HE5 but, unlike salmon, were found in all reaches.

4.5.2 Atlantic Salmon and Blacknose Dace Growth

Data on ages for selected specimens of fish are presented in Appendix 5, which include length-frequency histograms and raw data for all fish specimens. The size-frequency plots for all dace and all salmon show definite break points separating fry (0+ fish) from older age classes. Older age classes of salmon and dace are less distinct. As shown in Appendix 5, juvenile salmon were present in four age classes, although age 3+ salmon (the oldest age class) were low in abundance. Blacknose dace spanned six year-classes, with overlaps in length between age classes for fish aged 1+ and older.

Table 4.7: Raw Fish Catches by Species and Station, August 1997

Area	Station	Sampling Date	Electrofishing Effort (seconds)	Atlantic Salmon	Blacknose Dace	Brook Trout	Lake Chub	Slimy Sculpin	White Sucker	Creek Chub	3-Spine Stickleback	9-Spine Stickleback	Sea Lamprey	Total Catch	Number of Species
Exposure	HE1A	13-Aug-97	999	0	0	0	0	0	0	0	0	0	0	0	0
	HE1B	16-Aug-97	1231	0	1	1	1	0	0	0	0	0	0	3	3
		Total	2230	0	1	1	1	0	0	0	0	0	0	3	3
		Mean	**1115.0**	**0.0**	**0.5**	**0.5**	**0.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.5**	**1.5**
	HE2A	16-Aug-97	1555	0	0	4	0	0	0	0	0	0	0	4	1
	HE2B	14-Aug-97	1565	0	11	5	0	0	0	0	0	0	0	16	2
		Total	3120	0	11	9	0	0	0	0	0	0	0	20	2
		Mean	**1560.0**	**0.0**	**5.5**	**4.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**10.0**	**1.5**
	HE3A	14-Aug-97	1775	8	5	39	0	0	0	0	0	0	0	52	3
	HE3B	14-Aug-97	1676	8	6	22	0	0	1	1	0	0	0	38	5
		Total	3451	16	11	61	0	0	1	1	0	0	0	90	5
		Mean	**1725.5**	**8.0**	**5.5**	**30.5**	**0.0**	**0.0**	**0.5**	**0.5**	**0.0**	**0.0**	**0.0**	**45.0**	**4.0**
	HE4A	16-Aug-97	1667	11	0	15	0	0	0	0	0	0	0	26	2
	HE4B	13-Aug-97	1542	34	1	11	1	0	0	0	0	0	0	47	4
		Total	3209	45	1	26	1	0	0	0	0	0	0	73	4
		Mean	**1604.5**	**22.5**	**0.5**	**13.0**	**0.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**36.5**	**3.0**
	HE5A	17-Aug-97	1816	82	47	14	12	5	0	3	0	1	0	164	7
	HE5B	19-Aug-97	1924	76	46	6	8	0	1	1	0	0	0	138	6
		Total	3740	158	93	20	20	5	1	4	0	1	0	302	8
		Mean	**1870.0**	**79.0**	**46.5**	**10.0**	**10.0**	**2.5**	**0.5**	**2.0**	**0.0**	**0.5**	**0.0**	**151.0**	**6.5**
	All	Total	13520.0	219	116	116	21	5	2	5	0	1	0	485	8
		Mean	**1575.0**	**21.90**	**11.70**	**11.70**	**2.20**	**0.50**	**0.20**	**0.50**	**0.00**	**0.10**	**0.00**	**48.80**	**3.30**
Reference	HR1A	18-Aug-97	1402	0	12	144	51	0	8	0	0	0	0	215	4
	HR1B	18-Aug-97	1723	0	25	132	29	0	2	2	0	0	0	190	5
		Total	3125	0	37	276	80	0	10	2	0	0	0	405	5
		Mean	**1562.5**	**0.0**	**18.5**	**138.0**	**40.0**	**0.0**	**5.0**	**1.0**	**0.0**	**0.0**	**0.0**	**202.5**	**4.5**
	HR2A	15-Aug-97	1699	0	36	20	0	37	0	5	0	0	0	98	4
	HR2B	15-Aug-97	1750	1	31	51	0	20	0	0	0	0	0	103	4
		Total	3449	1	67	71	0	57	0	5	0	0	0	201	5
		Mean	**1724.5**	**0.5**	**33.5**	**35.5**	**0.0**	**28.5**	**0.0**	**2.5**	**0.0**	**0.0**	**0.0**	**100.5**	**4.0**
	HR3A	17-Aug-97	1721	81	8	4	0	16	8	0	7	0	5	129	7
	HR3B	19-Aug-97	1565	134	9	6	0	16	0	0	0	0	3	168	5
		Total	3286	215	17	10	0	32	8	0	7	0	8	297	7
		Mean	**1643.0**	**107.5**	**8.5**	**5.0**	**0.0**	**16.0**	**4.0**	**0.0**	**3.5**	**0.0**	**4.0**	**148.5**	**6.0**
	All	Total	9860.0	216	121	357	80	89	18	7	7	0	8	903	9
		Mean	**1643.3**	**36.00**	**20.17**	**59.50**	**13.33**	**14.83**	**3.00**	**1.17**	**1.17**	**0.00**	**1.33**	**150.50**	**4.83**

Table 4.8: Catch per unit effort (CPUE) of fish at Heath Steele, August 1997.

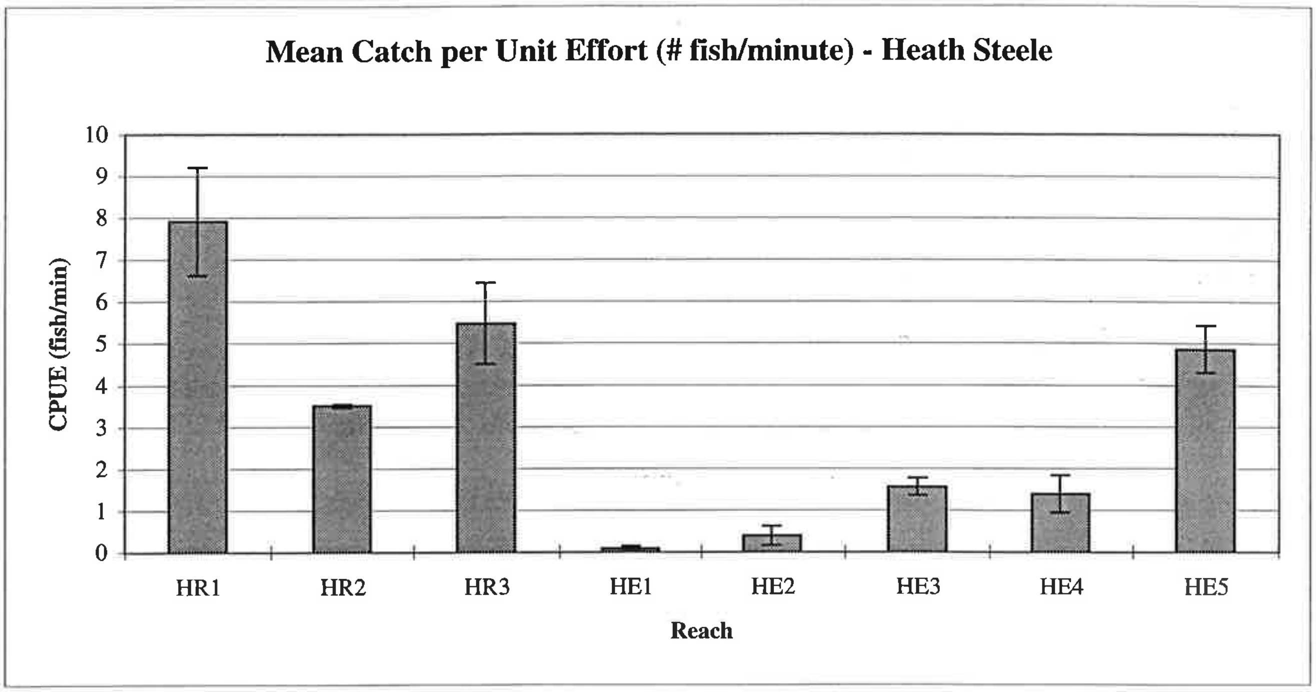
Values are number of fish per minute of electrofishing.

Area	Station	Sampling Date	Electrofishing Effort (seconds)	Atlantic Salmon (fish/min)	Blacknose Dace (fish/min)	Brook Trout (fish/min)	Lake Chub (fish/min)	Slimy Sculpin (fish/min)	White Sucker (fish/min)	Creek Chub (fish/min)	3-Spine Stickleback (fish/min)	9-Spine Stickleback (fish/min)	Sea Lamprey (fish/min)	All Fish (fish/min)
Reference	HR1A	18-Aug-97	1402	0.000	0.514	6.163	2.183	0.000	0.342	0.000	0.000	0.000	0.000	9.201
	HR1B	18-Aug-97	1723	0.000	0.871	4.597	1.010	0.000	0.070	0.070	0.000	0.000	0.000	6.616
		Mean	**1562.5**	**0.000**	**0.692**	**5.380**	**1.596**	**0.000**	**0.206**	**0.035**	**0.000**	**0.000**	**0.000**	**7.909**
	HR2A	15-Aug-97	1699	0.000	1.271	0.706	0.000	1.307	0.000	0.177	0.000	0.000	0.000	3.461
	HR2B	15-Aug-97	1750	0.034	1.063	1.749	0.000	0.686	0.000	0.000	0.000	0.000	0.000	3.531
		Mean	**1724.5**	**0.017**	**1.167**	**1.227**	**0.000**	**0.996**	**0.000**	**0.088**	**0.000**	**0.000**	**0.000**	**3.496**
	HR3A	17-Aug-97	1721	2.824	0.279	0.139	0.000	0.558	0.279	0.000	0.244	0.000	0.174	4.497
	HR3B	19-Aug-97	1565	5.137	0.345	0.230	0.000	0.613	0.000	0.000	0.000	0.000	0.115	6.441
		Mean	**1643.0**	**3.981**	**0.312**	**0.185**	**0.000**	**0.586**	**0.139**	**0.000**	**0.122**	**0.000**	**0.145**	**5.469**
	All	**Mean**	**1643.3**	**1.333**	**0.724**	**2.264**	**0.532**	**0.527**	**0.115**	**0.041**	**0.041**	**0.000**	**0.048**	**5.625**
Exposure	HE1A	13-Aug-97	999	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	HE1B	16-Aug-97	1231	0.000	0.049	0.049	0.049	0.000	0.000	0.000	0.000	0.000	0.000	0.146
		Mean	**1115.0**	**0.000**	**0.024**	**0.024**	**0.024**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.073**
	HE2A	16-Aug-97	1555	0.000	0.000	0.154	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.154
	HE2B	14-Aug-97	1565	0.000	0.422	0.192	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.613
		Mean	**1560.0**	**0.000**	**0.211**	**0.173**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.384**
	HE3A	14-Aug-97	1775	0.270	0.169	1.318	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.758
	HE3B	14-Aug-97	1676	0.286	0.215	0.788	0.000	0.000	0.036	0.036	0.000	0.000	0.000	1.360
		Mean	**1725.5**	**0.278**	**0.192**	**1.053**	**0.000**	**0.000**	**0.018**	**0.018**	**0.000**	**0.000**	**0.000**	**1.559**
	HE4A	16-Aug-97	1667	0.396	0.000	0.540	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.936
	HE4B	13-Aug-97	1542	1.323	0.039	0.428	0.039	0.000	0.000	0.000	0.000	0.000	0.000	1.829
		Mean	**1604.5**	**0.859**	**0.019**	**0.484**	**0.019**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**1.382**
	HE5A	17-Aug-97	1816	2.709	1.553	0.463	0.396	0.165	0.000	0.099	0.000	0.033	0.000	5.419
	HE5B	19-Aug-97	1924	2.370	1.435	0.187	0.249	0.000	0.031	0.031	0.000	0.000	0.000	4.304
		Mean	**1870.0**	**2.540**	**1.494**	**0.325**	**0.323**	**0.083**	**0.016**	**0.065**	**0.000**	**0.017**	**0.000**	**4.861**
	All	**Mean**	**1575.000**	**0.736**	**0.388**	**0.412**	**0.073**	**0.017**	**0.007**	**0.017**	**0.000**	**0.003**	**0.000**	**1.652**

Table 4.9: Biomass per unit effort (BPUE) of fish at Heath Steele, August 1997.

Values are grams of fish per minute of electrofishing.

Area	Station	Sampling Date	Electrofishing Effort (seconds)	Atlantic Salmon (g/min)	Blacknose Dace (g/min)	Brook Trout (g/min)	Lake Chub (g/min)	Slimy Sculpin (g/min)	White Sucker (g/min)	Creek Chub (g/min)	3-Spine Stickleback (g/min)	9-Spine Stickleback (g/min)	Sea Lamprey (g/min)	All Fish (g/min)
Reference	HR1A	18-Aug-97	1402	0.000	1.519	57.971	9.847	0.000	7.725	0.000	0.000	0.000	0.000	77.063
	HR1B	18-Aug-97	1723	0.000	2.323	24.017	3.907	0.000	0.195	0.084	0.000	0.000	0.000	30.526
		Mean	**1562.5**	**0.000**	**1.921**	**40.994**	**6.877**	**0.000**	**3.960**	**0.042**	**0.000**	**0.000**	**0.000**	**53.794**
	HR2A	15-Aug-97	1699	0.000	3.039	8.952	0.000	4.748	0.000	1.148	0.000	0.000	0.000	17.887
	HR2B	15-Aug-97	1750	0.494	2.026	29.657	0.000	3.514	0.000	0.000	0.000	0.000	0.000	35.691
		Mean	**1724.5**	**0.247**	**2.533**	**19.305**	**0.000**	**4.131**	**0.000**	**0.574**	**0.000**	**0.000**	**0.000**	**26.789**
	HR3A	17-Aug-97	1721	14.433	0.614	3.720	0.000	1.862	0.073	0.000	0.080	0.000	0.481	21.263
	HR3B	19-Aug-97	1565	27.987	0.564	12.410	0.000	2.208	0.000	0.000	0.000	0.000	0.337	43.507
		Mean	**1643.0**	**21.210**	**0.589**	**8.065**	**0.000**	**2.035**	**0.037**	**0.000**	**0.040**	**0.000**	**0.409**	**32.385**
	All	**Mean**	**1643.3**	**7.152**	**1.681**	**22.788**	**2.292**	**2.055**	**1.332**	**0.205**	**0.013**	**0.000**	**0.136**	**37.656**
Exposure	HE1A	13-Aug-97	999	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	HE1B	16-Aug-97	1231	0.000	0.088	1.028	0.127	0.000	0.000	0.000	0.000	0.000	0.000	1.243
		Mean	**1115.0**	**0.000**	**0.044**	**0.514**	**0.063**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.621**
	HE2A	16-Aug-97	1555	0.000	0.000	7.350	0.000	0.000	0.000	0.000	0.000	0.000	0.000	7.350
	HE2B	14-Aug-97	1565	0.000	1.004	4.110	0.000	0.000	0.000	0.000	0.000	0.000	0.000	5.114
		Mean	**1560.0**	**0.000**	**0.502**	**5.730**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**6.232**
	HE3A	14-Aug-97	1775	10.844	0.112	18.899	0.000	0.000	0.000	0.000	0.000	0.000	0.000	29.855
	HE3B	14-Aug-97	1676	10.822	0.200	12.569	0.000	0.000	3.215	0.097	0.000	0.000	0.000	26.903
		Mean	**1725.5**	**10.833**	**0.156**	**15.734**	**0.000**	**0.000**	**1.607**	**0.048**	**0.000**	**0.000**	**0.000**	**28.379**
	HE4A	16-Aug-97	1667	12.389	0.000	16.578	0.000	0.000	0.000	0.000	0.000	0.000	0.000	28.967
	HE4B	13-Aug-97	1542	25.658	0.004	6.852	0.128	0.000	0.000	0.000	0.000	0.000	0.000	32.642
		Mean	**1604.5**	**19.023**	**0.002**	**11.715**	**0.064**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**30.805**
	HE5A	17-Aug-97	1816	34.622	3.456	9.928	9.317	0.357	0.000	0.129	0.000	0.046	0.000	57.856
	HE5B	19-Aug-97	1924	28.865	3.621	4.946	3.271	0.000	1.378	0.125	0.000	0.000	0.000	42.206
		Mean	**1870.0**	**31.744**	**3.538**	**7.437**	**6.294**	**0.178**	**0.689**	**0.127**	**0.000**	**0.023**	**0.000**	**50.031**
	All	**Mean**	**1575.000**	**12.320**	**0.848**	**8.226**	**1.284**	**0.036**	**0.459**	**0.035**	**0.000**	**0.005**	**0.000**	**23.214**



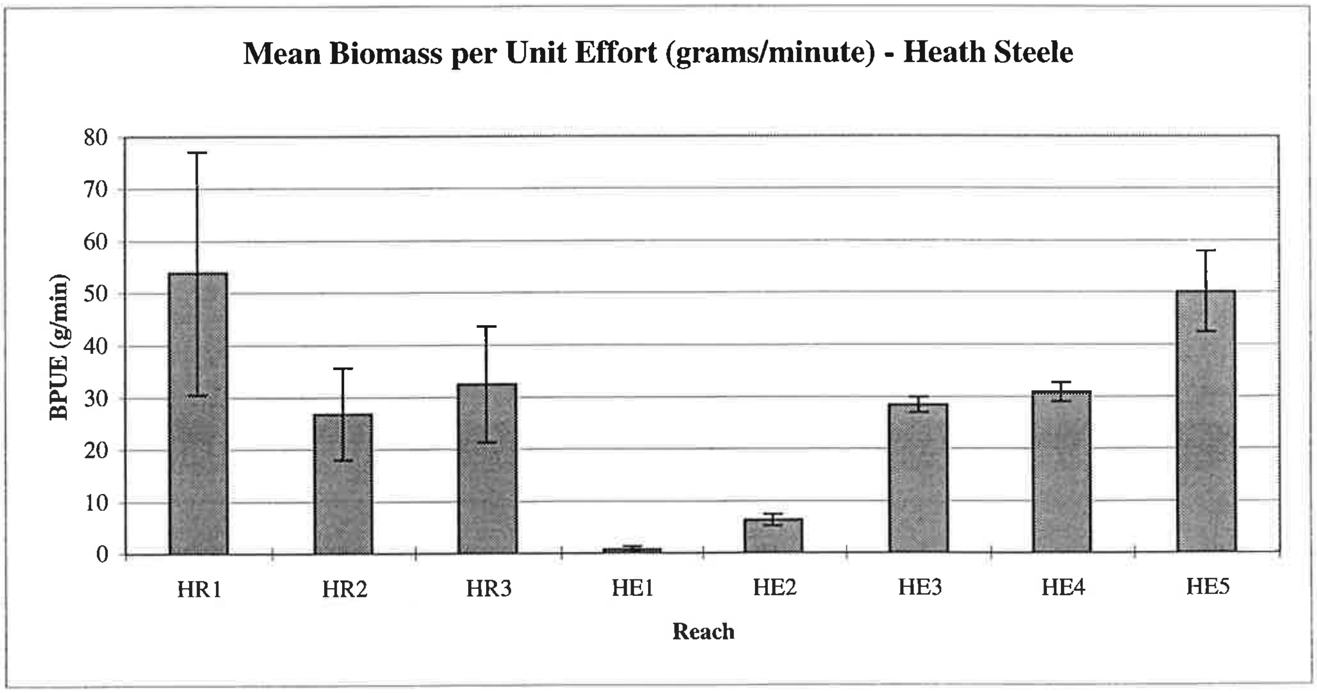
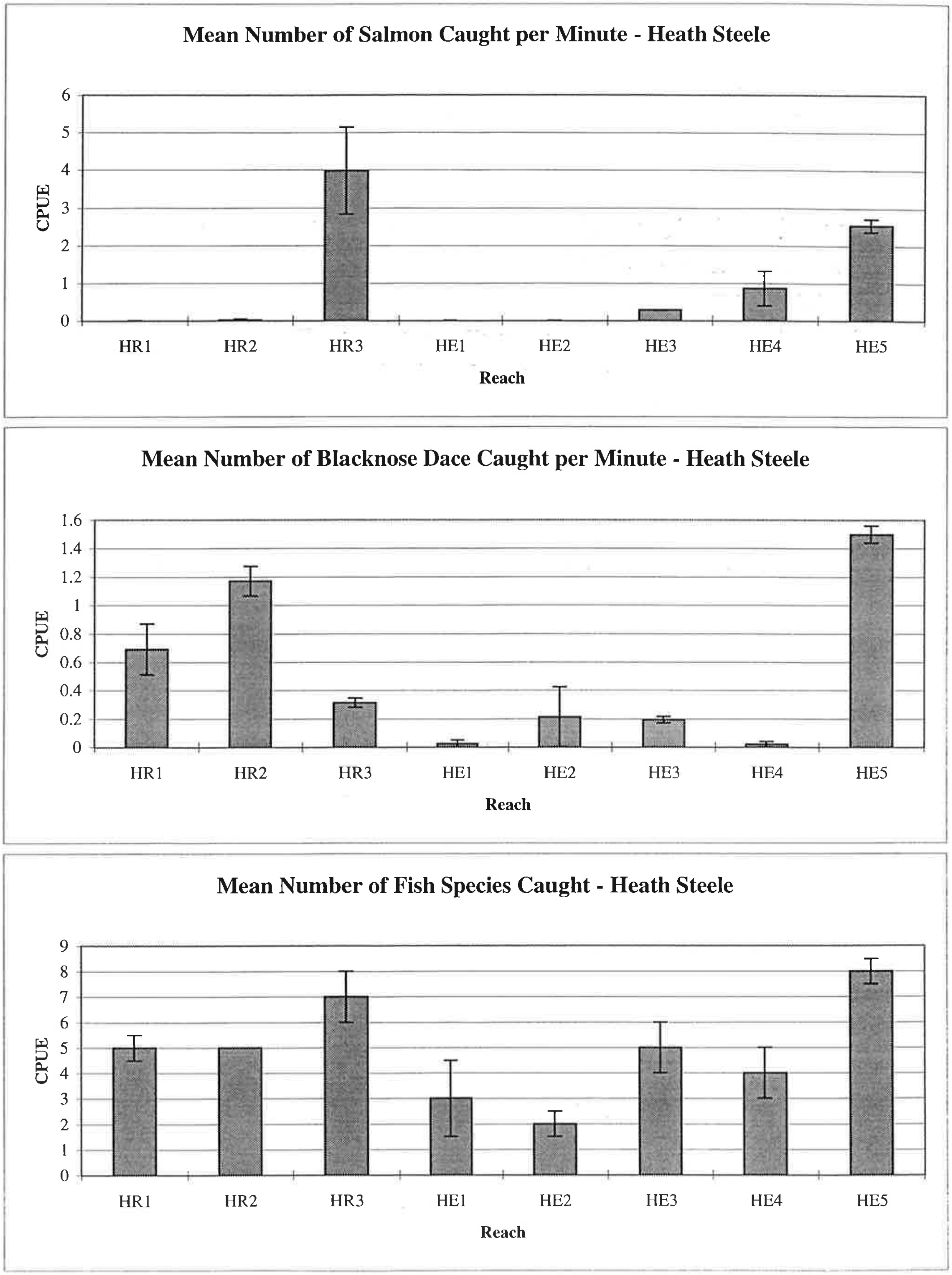


Figure 4.6: Mean Catch and Biomass Per-Unit-Effort by Electrofishing (all species) at Heath Steele, August 1997. Reach Means (±1 S.E.) Based on Data in Tables 4.8 and 4.9.



Mean Number of Salmon Caught per Minute - Heath Steele

Mean Number of Blacknose Dace Caught per Minute - Heath Steele

Mean Number of Fish Species Caught - Heath Steele

Figure 4.7: Mean Numbers of Atlantic Salmon, Blacknose Dace and Mean Numbers of Fish Species Captured by Electrofishing, Heath Steele, August 1997.
Reach Means (±1 S.E.) Based on Data in Tables 4.8 and 4.9.

The only spatial difference readily apparent in fish size at age is seen in comparison of salmon fry at HR3 (Little River) and HE5 (see Table 4.10a for a summary of biological characteristics of fish captured at Heath Steele). Fry at HR3 were smaller than those at HE5 (compare reach-specific length-frequency plots in Appendix 5). This effect could be attributed to the higher densities of fry at HR3 and a density-dependent effect on growth (e.g., competition for food).

4.5.3 Caged Atlantic Salmon

Biological measurements taken on caged Atlantic salmon used in tissue analysis are presented in Appendix 5. As noted in Section 2.0, all fish were yearlings from Heath Steele's McCormack Reservoir rearing facility. These yearlings were substantially larger than wild yearlings from the Tomogonops River (refer to Appendix 5 for fish sizes).

All fish survived the nine-day exposure at all reference and exposure sites, including HE1A where wild fish were apparently absent.

4.5.4 Metals and Metallothionein

Results of metallothionein (MT) and metal analyses on wild juvenile Atlantic salmon, caged juvenile Atlantic salmon and blacknose dace are summarized in Tables 4.10 to 4.12 and in Figures 4.8 to 4.12, with data on metals provided for zinc, copper, cadmium and lead. Table 4.13 and Figures 4.8 to 4.12 also present tissue data for juvenile brook trout, which were sampled opportunistically as a potential alternate sentinel species. Data on MT and metals in caged Atlantic salmon gill tissue were also provided by the Department of Fisheries and Oceans, based on pooling of the gill tissues from both caged fish for each station.

Table 4.14 presents a detailed tabulation of all fish tissue results including all metals analyzed, as well as a correlation matrix for MT and metals in tissues. The correlation matrix does not form part of formal hypothesis testing, but is useful in identifying possible cause-effect linkages between tissue metal concentrations and MT concentrations. In general, the best correlations are with cadmium, and metals were most often correlated with MT in gill in caged salmon.

Examination of the data shows that tissue MT levels were higher in all species at Heath Steele exposure stations than at reference sites, at least in the near-field. MT results for

Table 4.10: Summary of Metallothionein and Metals Analyses Conducted on Wild Atlantic Salmon Viscera, Heath Steele, August 1997. (salmon not caught at Stations HE1, HE2 and HR1)

			VISCERA				
Station	**Fish ID**	**Species**	**Metallothionein (µg/g)**	**Cadmium (µg/g)**	**Copper (µg/g)**	**Lead (µg/g)**	**Zinc (µg/g)**
HR2B	HR2BAS1-F	Atlantic Salmon	68.6	1.37	8.9	0.21	250
HR3A	HR3AAS1-F	Atlantic Salmon	46.0	0.63	24.6	0.32	196
	HR3AAS2-F	Atlantic Salmon	84.5	0.27	8.2	0.23	140
	HR3AAS4-F	Atlantic Salmon	24.7	0.16	6.3	0.43	102
	HR3AAS5-F	Atlantic Salmon	32.1	0.43	38.1	0.27	118
HR3B	HR3BAS1-F	Atlantic Salmon	89.1	0.22	32.3	0.10	130
	HR3BAS2-F	Atlantic Salmon	41.8	0.26	91.2	0.62	214
	HR3BAS3-F	Atlantic Salmon	31.8	0.36	172	0.09	110
	HR3BAS4-F	Atlantic Salmon	48.6	0.24	19.7	0.04	113
HE3A	HE3AAS1-F	Atlantic Salmon	125.9	0.95	94.9	0.67	261
	HE3AAS2-F	Atlantic Salmon	161.7	1.53	58.0	1.29	275
	HE3AAS3-F	Atlantic Salmon	345.1	1.50	39.7	0.47	325
HE3B	HE3BAS1-F	Atlantic Salmon	217.7	1.17	29.2	0.76	203
	HE3BAS2-F	Atlantic Salmon	214.2	1.57	34.5	0.97	336
	HE3BAS4-F	Atlantic Salmon	234.5	1.08	23.3	0.53	236
	HE3BAS5-F	Atlantic Salmon	285.2	1.40	22.8	0.53	278
HE4A	HE4AAS1-F	Atlantic Salmon	198.3	1.55	24.8	0.88	327
	HE4AAS2-F	Atlantic Salmon	406.9	2.26	31.8	0.61	366
	HE4AAS3-F	Atlantic Salmon	216.7	1.22	20.2	0.71	262
	HE4AAS4-F	Atlantic Salmon	146.3	1.49	29.9	1.68	352
HE4B	HE4BAS3-F	Atlantic Salmon	154.4	1.39	16.2	0.53	298
	HE4BAS4-F	Atlantic Salmon	308.4	1.22	16.4	0.66	268
	HE4BAS1-F	Atlantic Salmon	281.8	1.57	21.5	0.59	273
	HE4BAS2-F	Atlantic Salmon	121.6	1.05	24.7	1.43	258
HE5A	HE5AAS1-F	Atlantic Salmon	154.0	0.94	13.0	0.43	187
	HE5AAS2-F	Atlantic Salmon	244.0	1.67	97.9	0.78	318
	HE5AAS3-F	Atlantic Salmon	249.4	1.66	108	2.33	306
	HE5AAS4-F	Atlantic Salmon	138.1	1.01	114	2.38	347
HE5B	HE5BAS1-F	Atlantic Salmon	119.4	1.74	216	0.64	452
	HE5BAS2-F	Atlantic Salmon	183.6	1.87	29.8	0.46	376
	HE5BAS3-F	Atlantic Salmon	76.3	0.88	17.9	0.39	252
	HE5BAS4-F	Atlantic Salmon	70.7	0.99	21.7	1.28	249

Table 4.10a: Summary of Biological Characteristics of Brook Trout, Blacknose Dace and Atlantic Salmon, Heath Steele (values are mean ± 1 S.E.)

Biological Measurement	Brook Trout		Blacknose Dace		Atlantic Salmon [2]	
	Reference Areas	Exposure Areas	Reference Areas	Exposure Areas	Reference Areas	Exposure Areas
Sample Size	358	129	121	158	217	225
Mean Age (yrs) [1]	not measured	not measured	2 ± 0.1	2 ± 0.1	<1	1 ± 0.04
Mean Fork Length (cm)	8.27 ± 0.174	10.3 ± 0.391	5.66 ± 0.111	5.42 ± 0.102	6.62 ± 0.181	10.6 ± 0.176
Mean Total Length (cm)	8.71 ± 0.183	10.9 ± 0.412	6.03 ± 0.120	5.81 ± 0.111	7.17 ± 0.200	11.5 ± 0.193
Mean Weight (g)	10.0 ± 0.836	19.9 ± 2.09	2.28 ± 0.111	2.15 ± 0.103	5.33 ± 0.427	16.6 ± 0.792

[1] Mean age - a proportion of the fish were aged using scales or otolith. The balance of the ages were determined based on a length-frequency distribution.

[2] Fish size differences for Atlantic Salmon are attributed to a partial migration barrier, apparently preventing fish spawning in exposure reaches H1 to H4, and preventing occurrence of small fish (fry) in these reaches.

Refer to Tables A6.2a and A6.2b (Appendix 6) for summary of biological data by reach for Atlantic Salmon and Blacknose Dace.

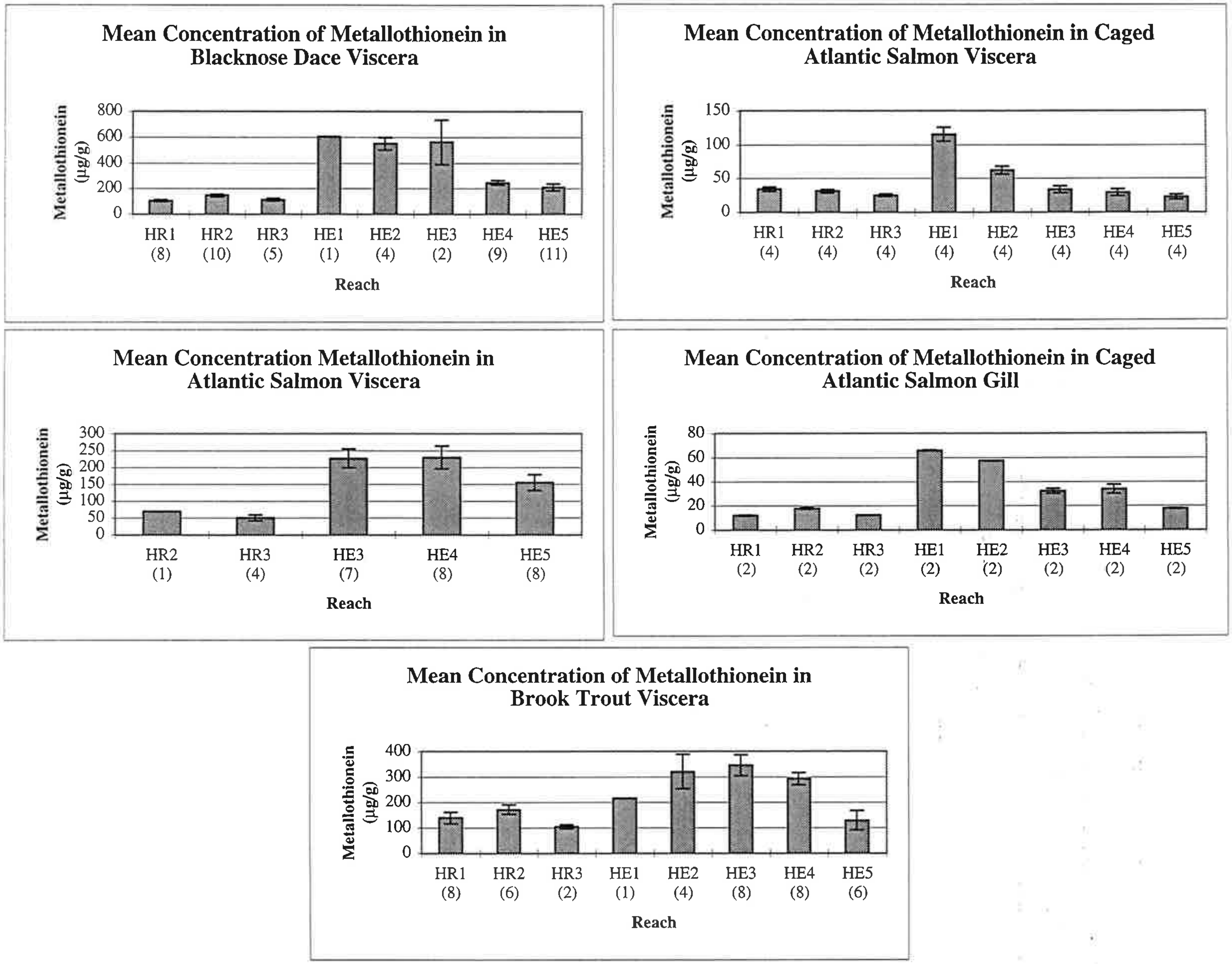
Table 4.11: Summary of Metallothionein and Metals Analyses Conducted on Blacknose Dace Viscera, Heath Steele, August 1997.

			VISCERA				
Station	**Fish ID**	**Species**	**Metallothionein (µg/g)**	**Cadmium (µg/g)**	**Copper (µg/g)**	**Lead (µg/g)**	**Zinc (µg/g)**
HR1A	R1A-1 (composite of 2 samples)	Blacknose Dace	89.6	0.44	4.6	1.15	32
	R1A-2 (composite of 2 samples)	Blacknose Dace	103.2	0.37	3.0	0.13	29
	R1A-3 (composite of 3 samples)	Blacknose Dace	92.7	0.40	4.4	0.15	30
	R1A-4 (composite of 5 samples)	Blacknose Dace	109.9	0.30	2.9	0.14	26
HR1B	R1B-1 (composite of 2 samples)	Blacknose Dace	91.2	0.38	5.2	0.15	27
	R1B-2 (composite of 3 samples	Blacknose Dace	119.6	0.68	11.8	0.12	23
	R1B-3 (composite of 4 samples)	Blacknose Dace	78.6	0.43	6.5	0.25	26
	R1B-4 (composite of 6 samples)	Blacknose Dace	130.4	0.67	4.7	0.16	26
HR2A	R2A-1 (composite of 2 samples)	Blacknose Dace	184.8	2.30	4.4	0.17	47
	R2A-2 (composite of 2 samples)	Blacknose Dace	138.8	1.82	8.5	0.59	72
	R2A-3 (composite of 2 samples)	Blacknose Dace	147.9	1.37	6.2	0.78	58
	R2A-4 (composite of 3 samples)	Blacknose Dace	115.1	1.09	6.8	0.51	50
	R2A-5 (composite of 3 samples)	Blacknose Dace	113.3	1.08	5.7	0.54	49
	R2A-6 (composite of 4 samples)	Blacknose Dace	136.3	0.81	4.0	0.39	38
HR2B	R2B-1 (composite of 2 samples)	Blacknose Dace	138.3	1.82	2.7	0.23	36
	R2B-2 (composite of 3 samples)	Blacknose Dace	194.9	1.14	4.3	0.28	38
	R2B-3 (composite of 3 samples)	Blacknose Dace	131.0	0.81	2.8	0.16	38
	R2B-4 (composite of 8 samples)	Blacknose Dace	127.5	0.52	1.8	0.11	23
HR3A	HR3ABD1-F	Blacknose Dace	139.4	0.77	8.0	0.24	44
	R3A-2 (composite of 2 samples)	Blacknose Dace	107.5	0.38	5.0	0.21	31
	R3A-3 (composite of 4 samples)	Blacknose Dace	114.4	0.23	5.5	0.28	19
HR3B	R3B-1 (composite of 3 samples)	Blacknose Dace	113.6	0.35	7.5	0.21	24
	R3B-2 (composite of 6 samples)	Blacknose Dace	80.7	0.42	4.6	0.21	22
HE1B	HE1BBD1-F	Blacknose Dace	605.0				
HE2B	E2B-1 (composite of 3 samples)	Blacknose Dace	504.7	0.86	22.4	0.13	92
	E2B-2 (composite of 3 samples)	Blacknose Dace	657.4	0.87	17.8	1.21	104
	E2B-3 (composite of 4 samples)	Blacknose Dace	437.9	0.48	8.6	0.24	45
	E2B-4 (composite of 4 samples)	Blacknose Dace	598.1	0.66	11.3	0.36	65
HE3A	E3A-1 (composite of 5 samples)	Blacknose Dace	385.2	0.88	7.6	0.19	51
HE3B	E3B-1 (composite of 6 samples)	Blacknose Dace	735.2	1.81	12.0	0.54	82
HE4B	HE4BBD1-F	Blacknose Dace	241.9	1.12	22.8	0.40	159
	E4B-2 (composite of 3 samples)	Blacknose Dace	199.5	1.07	10.4	0.28	66
	E4B-3 (composite of 3 samples)	Blacknose Dace	286.2	1.19	10.7	0.29	56
	E4B-4 (composite of 6 samples)	Blacknose Dace	240.9	0.69	4.2	0.13	39
HE5A	E5A-1 (composite of 3 samples)	Blacknose Dace	156.1	0.66	6.0	0.24	47
	E5A-2 (composite of 2 samples)	Blacknose Dace	297.9	2.41	20.0	0.60	77
	E5A-3 (composite of 3 samples)	Blacknose Dace	120.1	1.07	8.6	0.15	41
	E5A-4 (composite of 4 samples)	Blacknose Dace	202.6	0.79	5.8	0.14	34
	E5A-5 (composite of 4 samples)	Blacknose Dace	162.2	0.63	6.4	0.20	35
HE5B	HE5BBD1-F	Blacknose Dace	351.2	2.05	25.2	0.70	122
	E5B-2 (composite of 2 samples)	Blacknose Dace	361.3	1.96	13.5	0.37	93
	E5B-3 (composite of 2 samples)	Blacknose Dace	185.5	1.27	18.2	0.30	102
	E5B-4 (composite of 3 samples)	Blacknose Dace	123.7	0.47	10.5	0.26	47
	E5B-5 (composite of 3 samples)	Blacknose Dace	194.1	0.76	7.8	0.22	56
	E5B-6 (composite of 5 samples)	Blacknose Dace	132.4	0.60	16.7	0.36	61

Table 4.12: Summary of Metallothionein and Metals Analyses Conducted on Caged Atlantic Salmon Viscera and Gill, Heath Steele, August 1997.

		VISCERA					GILL [1]				
Station	**Fish ID**	**Metallothionein (µg/g)**	**Cadmium (µg/g)**	**Copper (µg/g)**	**Lead (µg/g)**	**Zinc (µg/g)**	**Metallothionein (µg/g)**	**Cadmium (µg/g)**	**Copper (µg/g)**	**Lead (µg/g)**	**Zinc (µg/g)**
HR1A	HR1AAS1C-F	30.5	0.06	3.0	0.10	142	11.4	0.1	6.1	0.07	71
	HR1AAS2C-F	44.2	0.03	3.8	0.14	182					
HR1B	HR1BAS1C-F	28.9	0.04	7.5	0.13	163	12.1	0.11	4.6	0.08	72
	HR1BAS2C-F	31.0	0.05	13.6	0.16	140					
HR2A	HR2AAS1C-F	27.5	0.03	6.3	0.11	165	18.4	0.09	3.1	0.11	90
	HR2AAS2C-F	25.5	0.04	3.8	0.13	222					
HR2B	HR2BAS1C-F	33.5	0.11	4.4	0.14	211	17.1	0.14	3.6	0.05	85
	HR2BAS2C-F	36.2	0.05	6.8	0.13	185					
HR3A	HR3AAS1C-F	25.9	0.04	7.6	0.10	175	12.0	0.08	5.6	0.05	75
	HR3AAS2C-F	21.9	0.04	3.3	0.11	178					
HR3B	HR3BAS1C-F	21.4	0.04	2.8	0.13	197	12.3	0.08	4.3	0.04	68
	HR3BAS2C-F	28.8	0.04	2.4	0.15	134					
HE1A	HE1AAS1C-F	123.1	0.05	2.7	0.10	285	65.9	0.69	4	0.12	91
	HE1AAS2C-F	138.7	0.05	2.7	0.10	178					
HE1B	HE1BAS1C-F	110.3	0.04	5.3	0.12	190	65.7	0.95	74.6	0.1	88
	HE1BAS2C-F	88.9	0.06	4.6	0.12	194					
HE2A	HE2AAS1C-F	59.8	0.05	2.6	0.09	245	57.4	0.53	13.3	0.43	120
	HE2AAS2C-F	75.6	0.07	3.5	0.12	165					
HE2B	HE2BAS1C-F	46.8	0.06	3.7	0.11	195	57.2	0.68	4.6	0.03	100
	HE2BAS2C-F	65.5	0.04	3.4	0.13	182					
HE3A	HE3AAS1C-F	44.4	0.12	4.3	0.15	277	34.2	0.31	4.4	0.1	82
	HE3AAS2C-F	39.0	0.07	3.9	0.14	193					
HE3B	HE3BAS1C-F	20.5	0.05	3.4	0.12	147	29.7	0.23	3.3	0.05	88
	HE3BAS2C-F	30.3	0.05	2.7	0.16	140					
HE4A	HE4AAS1C-F	32.9	0.06	2.5	0.16	166	37.5	0.41	6.2	0.19	102
	HE4AAS2C-F	39.9	0.06	3.4	0.12	88					
HE4B	HE4BAS1C-F	26.9	0.03	5.0	0.09	142	30.1	0.32	6.4	< 0.05	101
	HE4BAS2C-F	15.1	0.05	3.3	0.12	222					
HE5A	HE5AAS1C-F	25.0	0.03	3.3	0.13	197	18.1	0.21	3.8	0.09	92
	HE5AAS2C-F	17.0	0.03	3.2	0.12	247					
HE5B	HE5BAS1C-F	15.8	0.05	2.7	0.13	216	17.2	0.19	2.3	0.2	98
	HE5BAS2C-F	31.8	0.11	2.8	0.22	183					

[1] Gill - the results are from a pooled sample of the 2 caged fish


Mean Concentration of Metallothionein in Blacknose Dace Viscera

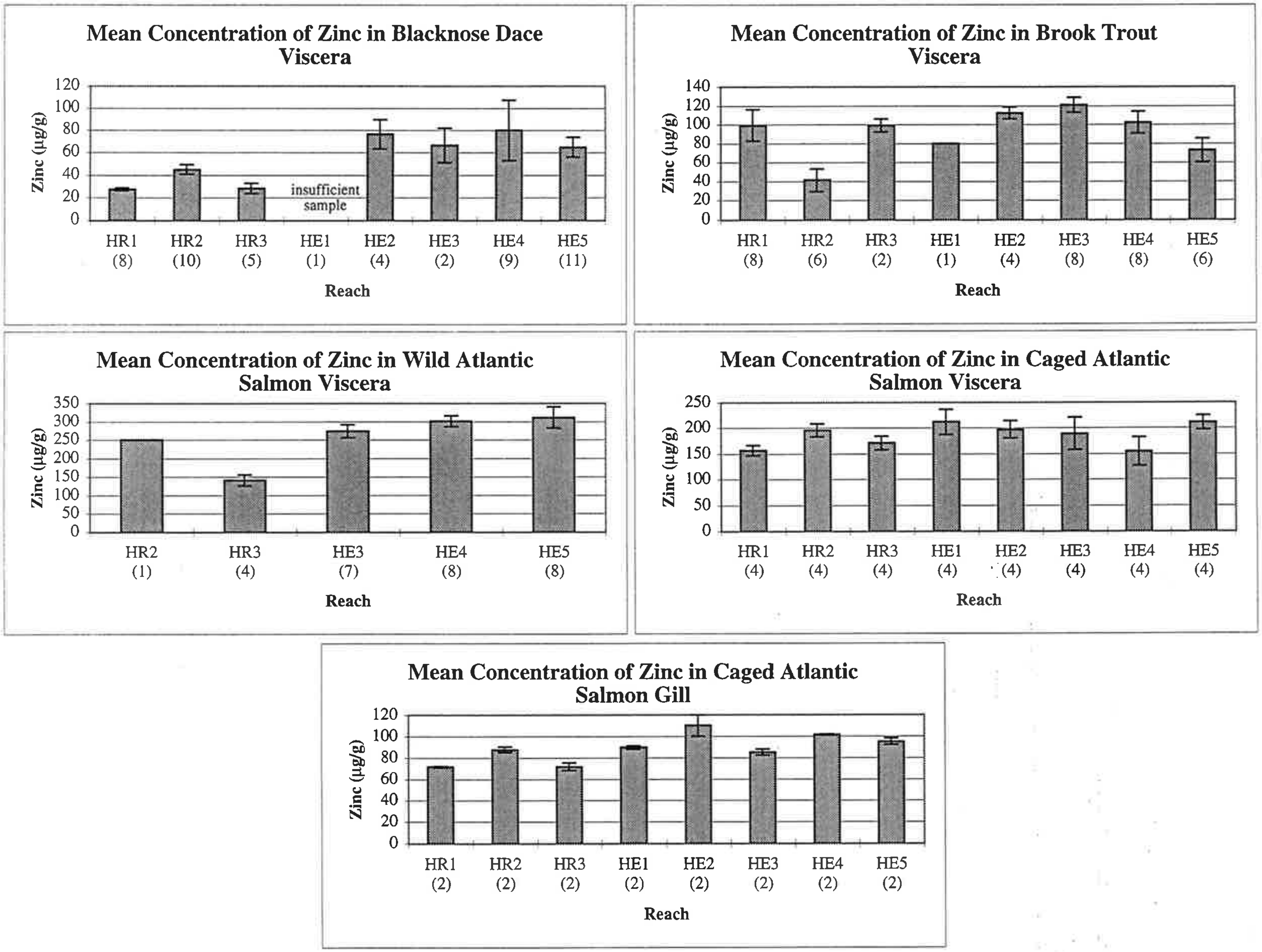
Mean Concentration of Metallothionein in Caged Atlantic Salmon Viscera

Mean Concentration Metallothionein in Atlantic Salmon Viscera

Mean Concentration of Metallothionein in Caged Atlantic Salmon Gill

Mean Concentration of Metallothionein in Brook Trout Viscera

Figure 4.8: Mean Concentrations of Metallothionein in Fish Viscera and Gill, Heath Steele, August 1997. Reach Means (± 1 S.E.) in µg/g fresh weight. Number of analyses per reach presented in parentheses. Blacknose dace results are each from composites of up to 8 fish. Caged salmon gill results are each from a composite of tissue from 2 fish. Other results are from analysis of individual fish.



Mean Concentration of Zinc in Blacknose Dace Viscera

Mean Concentration of Zinc in Brook Trout Viscera

Mean Concentration of Zinc in Wild Atlantic Salmon Viscera

Mean Concentration of Zinc in Caged Atlantic Salmon Viscera

Mean Concentration of Zinc in Caged Atlantic Salmon Gill

Figure 4.9: Mean Concentrations of Zinc in Fish Viscera, Heath Steele, August 1997.
Reach Means (± 1 S.E.) in µg/g fresh weight. Number of analyses per reach presented in parentheses. Blacknose dace results are each from composites of up to 8 fish. Caged salmon gill results are each from a composite of tissue from 2 fish. Other results are from analysis of individual fish.

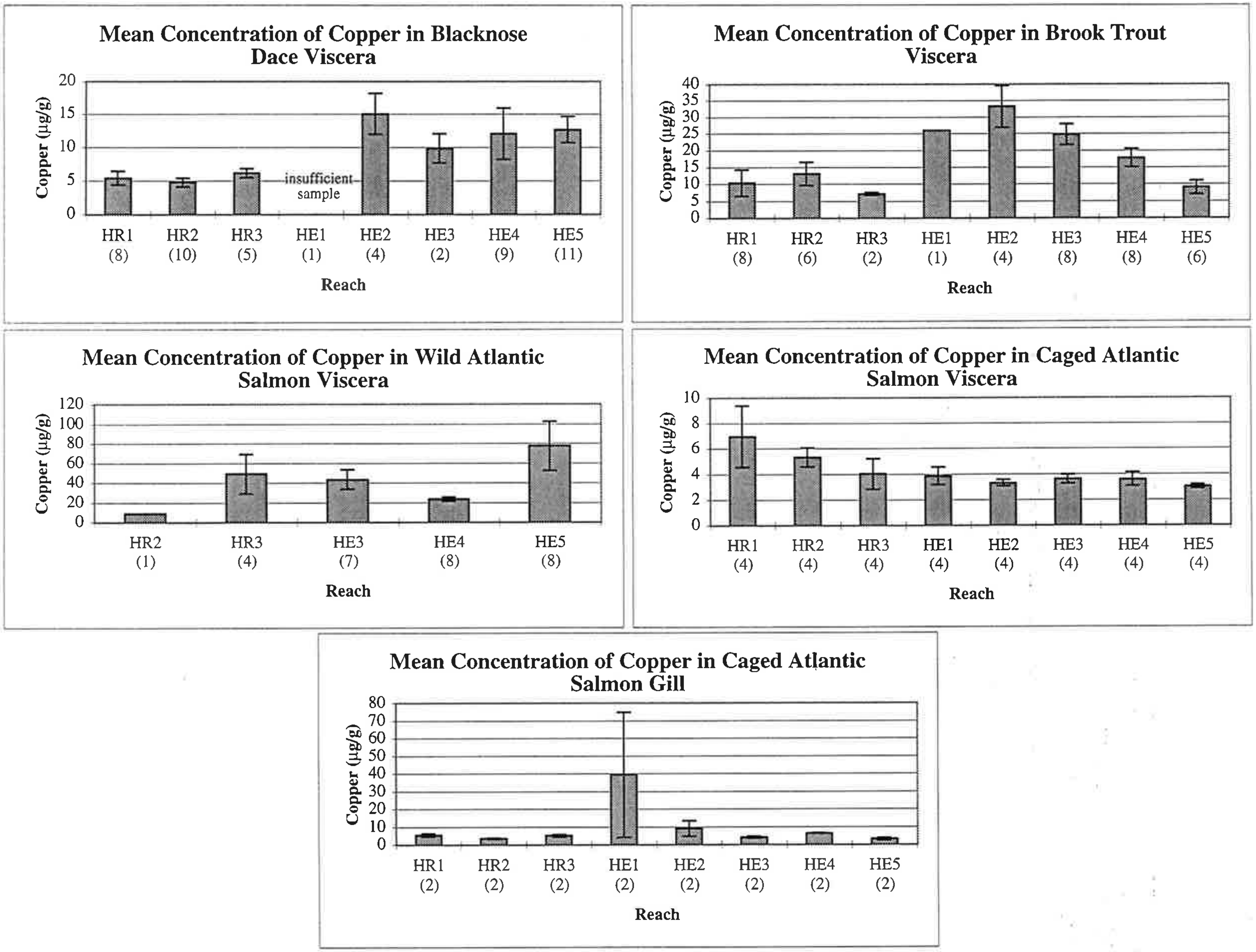
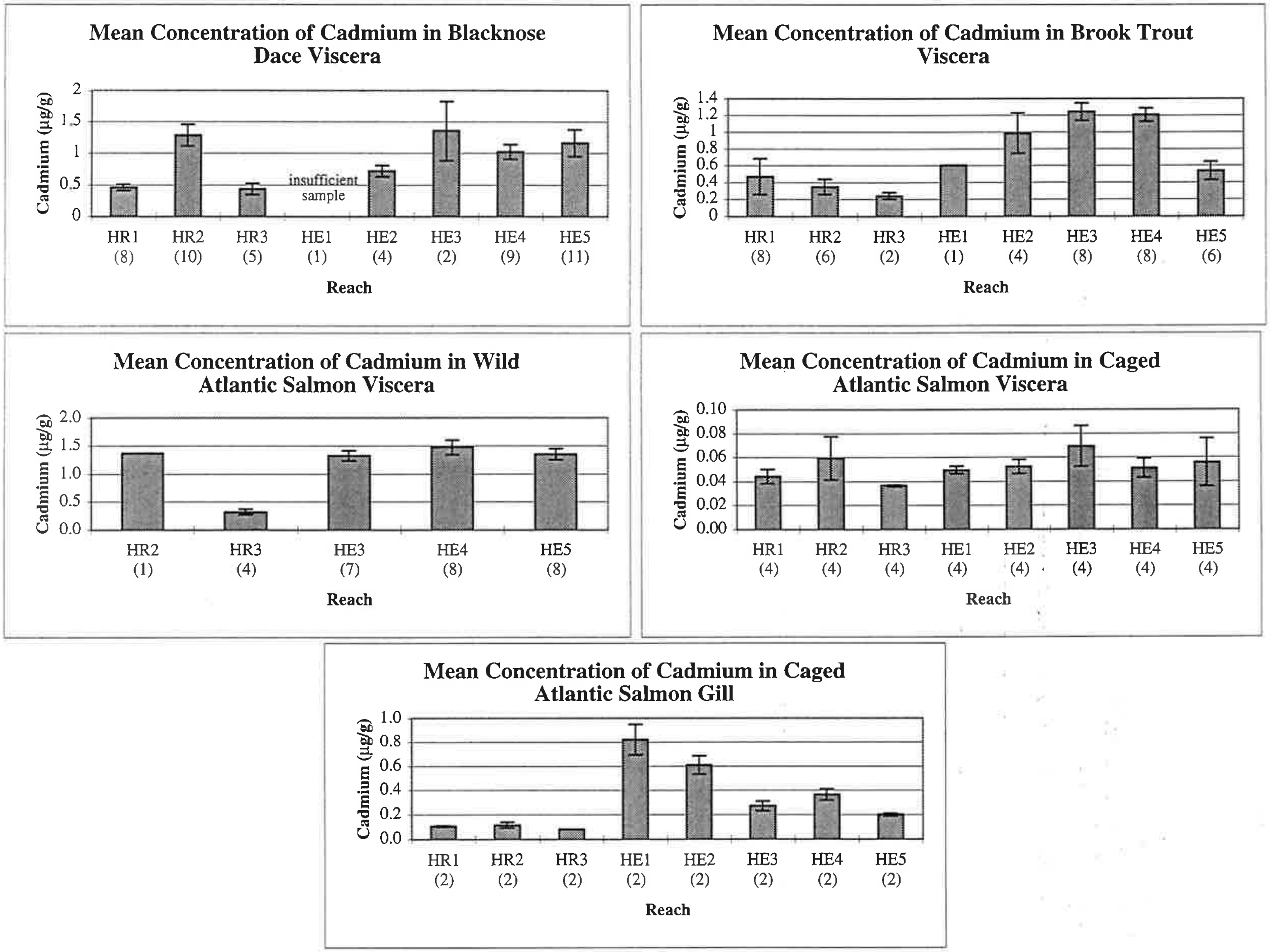


Figure 4.10: Mean Concentrations of Copper in Fish Viscera, Heath Steele, August 1997.
Reach Means (± 1 S.E.) in µg/g fresh weight. Number of analyses per reach presented in parentheses. Blacknose dace results are each from composites of up to 8 fish. Caged salmon gill results are each from a composite of tissue from 2 fish. Other results are from analysis of individual fish.



Mean Concentration of Cadmium in Blacknose Dace Viscera

Mean Concentration of Cadmium in Brook Trout Viscera

Mean Concentration of Cadmium in Wild Atlantic Salmon Viscera

Mean Concentration of Cadmium in Caged Atlantic Salmon Viscera

Mean Concentration of Cadmium in Caged Atlantic Salmon Gill

Figure 4.11: Mean Concentrations of Cadmium in Fish Viscera and Gill, Heath Steele, August 1997.

Reach Means (± 1 S.E.) in µg/g fresh weight. Number of analyses per reach presented in parentheses. Blacknose dace results are each from composites of up to 8 fish. Caged salmon gill results are each from a composite of tissue from 2 fish. Other results are from analysis of individual fish.

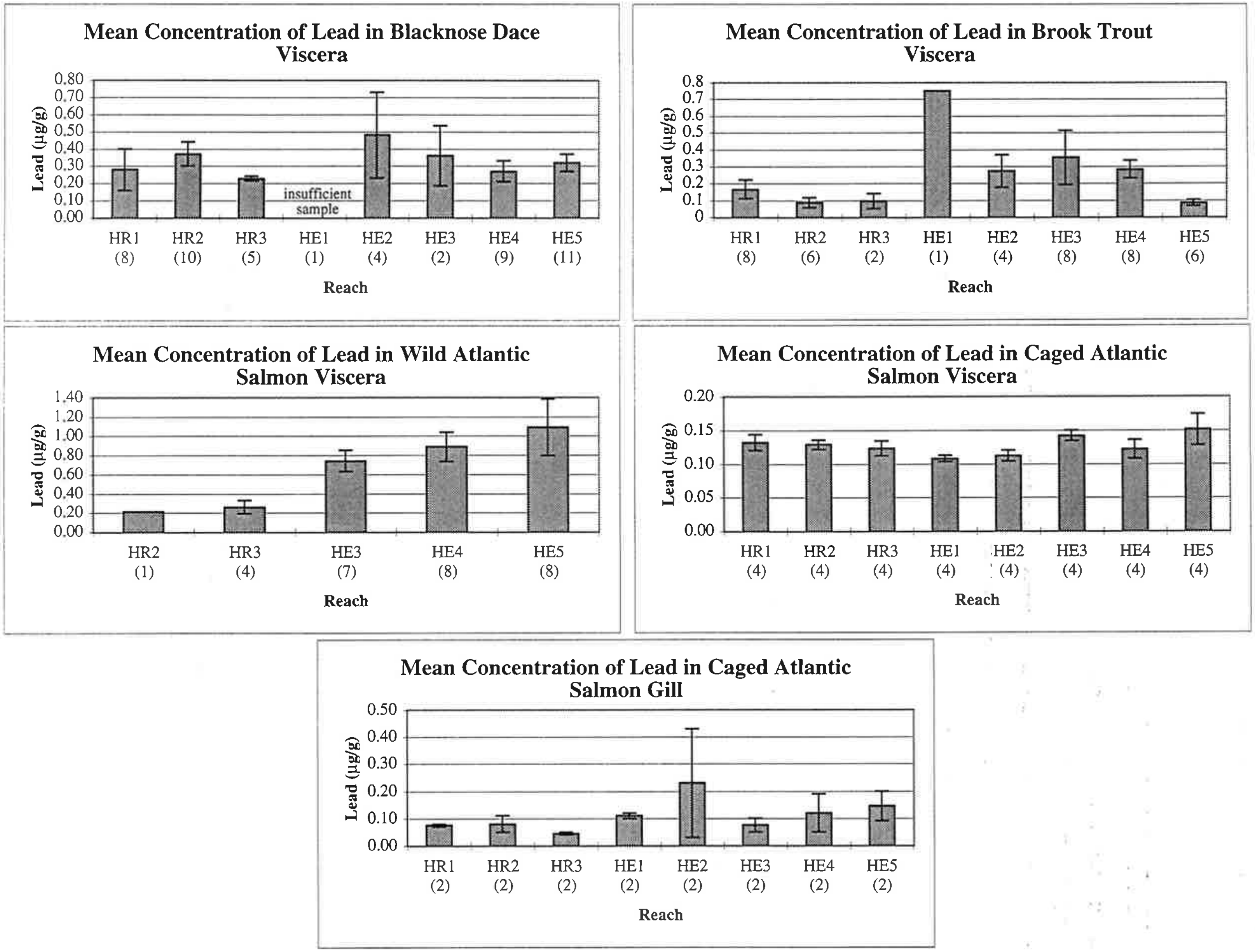


Figure 4.12: Mean Concentrations of Lead in Fish Viscera, Heath Steele, August 1997.
Reach Means (± 1 S.E.) in µg/g fresh weight. Number of analyses per reach presented in parentheses.
Blacknose dace results are each from composites of up to 8 fish. Caged salmon gill results are each from a composite of tissue from 2 fish. Other results are from analysis of individual fish.

Table 4.13: Summary of Metallothionein and Metals Analyses Conducted on Brook Trout Viscera, Heath Steele, August 1997.

			Viscera				
Station	Fish Number	Species	Metallothionein µg/g	Cadmium µg/g	Copper µg/g	Lead µg/g	Zinc µg/g
HR1A	HR1ABT1-F	Brook Trout	210.1	0.31	7.2	0.08	155
	HR1ABT2-F	Brook Trout	242.2	0.26	7.7	0.15	169
	HR1ABT4-F	Brook Trout	109.9	0.23	4.4	0.16	116
	HR1ABT5-F	Brook Trout	100.8	1.92	5.7	0.51	109
HR1B	HR1BBT1-F	Brook Trout	180.6	0.22	8.8	0.08	96
	HR1BBT2-F	Brook Trout	82.2	0.19	6.5	0.06	62
	HR1BBT3-F	Brook Trout	95.9	0.58	4.7	0.24	42
	HR1BBT4-F	Brook Trout	85.4	0.06	37.8	< 0.05	45
HR2A	HR2ABT1-F	Brook Trout	203.9	0.14	29.4	< 0.05	43
	HR2ABT2-F	Brook Trout	108.7	0.19	8.1	< 0.05	9
HR2B	HR2BBT1-F	Brook Trout	175.1	0.25	10.7	< 0.05	12
	HR2BBT2-F	Brook Trout	125.2	0.61	5.6	0.09	69
	HR2BBT3-F	Brook Trout	212.9	0.24	12.4	< 0.05	34
	HR2BBT4-F	Brook Trout	202.0	0.66	11.9	0.23	81
HR3B	HR3BBT1-F	Brook Trout	95.6	0.2	6.7	0.05	92
	HR3BBT2-F	Brook Trout	111.4	0.28	7.5	0.14	106
HE1B	HE1BBT1-F	Brook Trout	215.8	0.6	25.9	0.75	80
HE2A	HE2ABT1-F	Brook Trout	276.7	0.56	19.9	0.11	109
	HE2ABT3-F	Brook Trout	177.4	0.67	45.2	0.32	96
HE2B	HE2BBT1-F	Brook Trout	329.9	1.08	42.8	0.14	122
	HE2BBT2-F	Brook Trout	497.4	1.62	24.9	0.52	123
HE3A	HE3ABT1-F	Brook Trout	260.1	1.08	29.6	0.21	107
	HE3ABT2-F	Brook Trout	384.9	1.18	40.9	<0.05	144
	HE3ABT4-F	Brook Trout	417.1	1.87	27.8	0.55	144
	HE3ABT5-F	Brook Trout	210.7	1.04	22.4	1.41	118
HE3B	HE3BBT1-F	Brook Trout	497.7	1.23	24.7	0.16	119
	HE3BBT2-F	Brook Trout	218.4	0.84	13.1	0.24	82
	HE3BBT4-F	Brook Trout	285.0	1.44	14.3	0.09	109
	HE3BBT5-F	Brook Trout	485.7	1.23	25	0.11	144
HE4A	HE4ABT1-F	Brook Trout	319.0	1.04	18.7	0.21	172
	HE4ABT2-F	Brook Trout	339.8	1.54	15.2	0.35	85
	HE4ABT3-F	Brook Trout	380.0	0.98	32.5	0.46	102
	HE4ABT4-F	Brook Trout	355.2	1.38	25.9	0.46	85
HE4B	HE4BBT1-F	Brook Trout	206.3	0.82	11.6	0.16	79
	HE4BBT2-F	Brook Trout	295.7	1.36	13.6	0.38	110
	HE4BBT3-F	Brook Trout	233.2	1.3	12.2	0.12	67
	HE4BBT4-F	Brook Trout	212.4	1.2	11.7	0.12	119
HE5A	HE5ABT1-F	Brook Trout	67.5	0.59	6.3	0.05	80
	HE5ABT2-F	Brook Trout	74.5	0.21	5.7	< 0.05	35
	HE5ABT3-F	Brook Trout	81.7	0.38	5.9	0.08	118
	HE5ABT4-F	Brook Trout	60.4	0.39	6.4	0.16	87
HE5B	HE5BBT1-F	Brook Trout	195.2	0.66	11.3	< 0.05	45
	HE5BBT2-F	Brook Trout	289.7	0.97	17.9	0.11	71

Table 4.14: Pearson Correlation Matrix for log transformed Tissue Metallothionein and Metal Concentration, Heath Steele, August 1997.
(analysis based on exposure site data only)

Parameter		Caged Atlantic salmon Metallothionein in Viscera	Caged Atlantic salmon Metallothionein in Gills	Wild Atlantic salmon Metallothionein in Viscera	Wild Blacknose dace Metallothionein in Viscera
Al	r	0.208	0.072	-0.264	-0.356
	Sig. (1-tailed)	0.190	0.422	0.112	0.057
	N	20	10	23	21
As	r	-0.616	-	-0.042	-
	Sig. (1-tailed)	0.002	-	0.433	-
	N	20	-	19	-
Ba	r	-0.194	0.366	-0.094	-0.444
	Sig. (1-tailed)	0.207	0.149	0.335	0.022
	N	20	10	23	21
Cd	r	0.073	0.918	0.585	0.300
	Sig. (1-tailed)	0.379	8.89E-05	0.002	0.093
	N	20	10	23	21
Co	r	-0.040	0.399	0.252	0.517
	Sig. (1-tailed)	0.434	0.127	0.123	0.008
	N	20	10	23	21
Cr	r	-0.188	0.426	-0.291	-0.541
	Sig. (1-tailed)	0.214	0.110	0.089	0.006
	N	20	10	23	21
Cu	r	0.143	0.581	-0.061	0.313
	Sig. (1-tailed)	0.274	0.039	0.391	0.084
	N	20	10	23	21
Fe	r	-0.313	0.633	-0.252	-0.318
	Sig. (1-tailed)	0.089	0.025	0.123	0.080
	N	20	10	23	21
Hg	r	-0.307	0.733	-0.103	-0.292
	Sig. (1-tailed)	0.094	0.008	0.321	0.100
	N	20	10	23	21
Mo	r	0.042	0.478	-0.163	-0.384
	Sig. (1-tailed)	0.430	0.081	0.229	0.043
	N	20	10	23	21
Ni	r	0.112	0.386	-0.299	-0.503
	Sig. (1-tailed)	0.319	0.135	0.083	0.010
	N	20	10	23	21
Pb	r	-0.318	0.139	-0.207	0.487
	Sig. (1-tailed)	0.086	0.351	0.172	0.013
	N	20	10	23	21
Se	r	0.100	-	0.340	-
	Sig. (1-tailed)	0.337	-	0.077	-
	N	20	-	19	-
V	r	-0.372	-	-0.321	-0.512
	Sig. (1-tailed)	0.053	-	0.068	0.009
	N	20	-	23	21
Zn	r	0.103	0.150	0.134	0.436
	Sig. (1-tailed)	0.333	0.340	0.271	0.024
	N	20	10	23	21

- Tissue MT or metal data not available
Shaded values are statistically significant ($p<0.05$)

viscera and gill in caged juvenile salmon closely match the aqueous metal gradient measured downstream of the mine (Figure 4.8, Section 4.5.4). Visceral MT levels in wild fish were generally highest in blacknose dace and lowest in juvenile Atlantic salmon, with an intermediate level present in brook trout.

The effect of fish size or age on MT or tissue metal concentration was not specifically tested. However, inspection of the data (Tables 4.10 to 4.12) and fish measurements presented in Appendix 6 does not suggest any effect of fish size on tissue response in these samples. The blacknose dace data are less conclusive in this regard, as composite samples analyzed often included a mixture of fish sizes and ages, reflecting the availability of fish in each sample.

Caged Atlantic salmon had lower visceral MT levels than did wild salmon, and gill MT levels were less than those found in viscera.

In terms of visceral metal concentrations, exposure area-reference area differences are apparent in wild fish, with higher concentrations occurring in exposed fish for some metals. These differences are evaluated with respect to statistical significance in the hypothesis testing section (Section 5.2.1). Wild Atlantic salmon viscera had higher metal concentrations than did blacknose dace viscera for zinc and copper. In caged salmon, visceral copper, cadmium and lead levels were all low relative to levels in wild fish of either species, while visceral zinc concentrations in caged fish were intermediate between those seen in blacknose dace and wild salmon.

5.0 HYPOTHESIS TESTING

5.1 Methods

The eight hypotheses considered testable at Heath Steele are listed in Table 5.1, along with a more specific listing of the "effect" (response) and "exposure" (predictor) variables to be examined under each hypothesis. The general reasoning behind all of these hypotheses is that a mine "effect" is a measurable difference between reference and exposure locations, and/or a trend between locations that are exposed to different degrees of contamination. The hypotheses address either the ability of a particular monitoring tool to detect such an effect (and, in aggregate, whether an effect exists), or the **relative** ability of two different monitoring tools, that are being compared to one another, to detect such an effect. H5 through H8 are of the first type, while H1 through H4 are of the second type. H9 through H12 address the integration of tools and the **relative** ability of two monitoring tools to detect a correlation between specific exposure and response variables, while H13 addresses the ability of a particular toxicity testing tool to show such a correlation.

These different types of hypotheses require different methods of statistical analysis. The following sub-sections describe the statistical approach in each category. In all cases, appropriate data transformations were applied prior to statistical analysis, such as log transformation for chemical concentrations, or other parameters that span a wide range, and arcsine square root transformations for percent response variables. A significance criterion of $p \leq 0.05$ was used for all the statistical analyses, and use of the term "significant" implies that this criterion was met.

It should be recognized that the term "predictor" variable is not intended to mean that the measure of exposure used (e.g., metal concentration in water) can be used to "predict" a specific biological response at all mine sites or in other surveys at this mine site. Nor does it imply that the predictor is necessarily the cause of a biological effect. Rather, the predictive ability is only **suggested** by correlation between effect and exposure measures.

5.1.1 H4 - Metal vs Metallothionein in Tissue

Hypothesis H4 addresses the **relative** ability of two monitoring tools (response measures) to detect a mine effect (i.e., metals in fish tissues versus metallothionein in fish tissues). In

TABLE 5.1: VARIABLES AND HYPOTHESES AT HEATH STEELE

Hypothesis	Response or Effect Variables (Y)	Predictor or Exposure Variables (X)	Null Hypothesis	Comment
H4	Metal i in Tissue j (Tool 1) MT in Tissue j (Tool 2)	Reach Number (in order of increasing dilution downstream from mine)	no trend or R/E x tool interaction by ANOVA	For blacknose dace, juvenile salmon. Repeat with caged salmon. Viscera only. Partial results presented for gill (caged salmon) and brook trout (viscera) also.
H5	CPUE for dace, juvenile salmon, all species	Reach Number (in order of increasing dilution downstream)	no trend or R/E difference by ANOVA	CPUE for salmon tested using data for comparable stations (equal barrier effects)
H6	BPUE (biomass) for fish No. of Taxa (fish, benthos, periphyton) EPT Taxa Benthic Density	Reach Number (in order of increasing dilution downstream from mine)	no trend or R/E difference by ANOVA	Collections at several stations per reach
H7	Weight at age Length at age	Reach Number (in order of increasing dilution downstream)	no trend or R/E difference by ANOVA	Mature minnows and small salmon Use age covariate as appropriate
H9	Benthic Density No. of Benthic Taxa EPT Index Fish CPUE and BPUE No. of Fish Taxa Periphyton Community Indices Effluent Chronic Toxicity	Dissolved Metal in Water (Tool 1) Total Metal in Water (Tool 2)	same Y-X correlation with Tool 1 as Tool 2	May be other benthic indices, as revealed by multivariate analysis
H10	Benthic Density No. of Benthic Taxa EPT Index Fish CPUE and BPUE No. of Fish Taxa	Fraction Metal i in Periphyton (Tool 1) Dissolved Metal i in Water (Tool 2)	same Y-X correlation with Tool 1 as Tool 2	Use periphyton for "sediment"; Dissolved metals used in comparison. Dissolved metals and total metals were similarly correlated with benthic responses in H9.
H12	Metal i in Tissue j MT in Tissue j	Metal i in Periphyton (Tool 1) Dissolved Metal i in Water (Tool 2)	same Y-X correlation with Tool 1 as Tool 2	Use periphyton for "sediment"
H13	Benthic Density No. of Benthic Taxa EPT Index Fish CPUE and BPUE No. of Fish Taxa	Calculated % Inhibition in Exposure Reach	no Y-X correlation	Calculated % inhibition *in situ* based on effluent toxicity tests and water/effluent sulphate concentration ratio

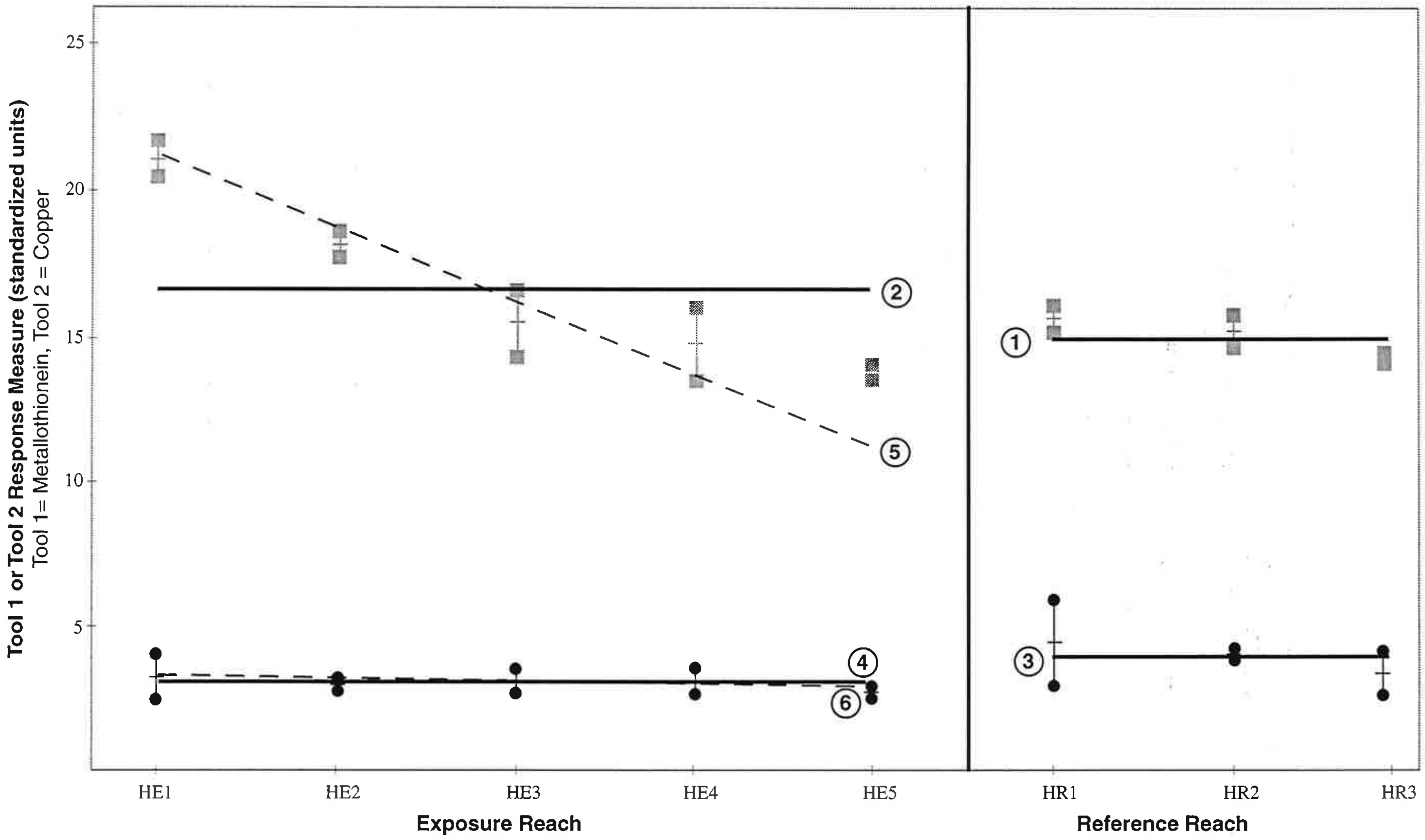
Definitions:
MT = metallothionein
R/E = reference/exposure
CPUE = catch-per-unit-effort (number of fish caught per unit fishing effort)
BPUE = biomass-per-unit-effort (mass of fish caught per unit fishing effort)
EPT taxa = Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) (pollution-sensitive benthic invertebrates)

particular, metallothionein in fish viscera was compared to each of the individual metals in fish viscera, to determine whether these two monitoring tools differ in their ability to detect a mine effect (i.e., a reference vs exposure area difference, or a trend with degree of exposure within the exposure area). A stream reach identifier (e.g., HE1, HE2, etc.), ordered within the exposure area to reflect distance from the mine site, was used as a surrogate for exposure to mine effluents because, as distance from the mine increased, so did dilution of the effluent. Figure 2.3 illustrates the reach identifiers. Analysis of variance (ANOVA) was used to address this hypothesis, as described below. Essentially, the ANOVA is used to compare tools in two ways:

- by determining if there is a reference area - exposure area difference in mean values for each tool (a larger difference indicates greater effectiveness in detecting an effect with this data set); and
- by determining if there is a linear trend or gradient in response within the exposure area (a significant trend and greater slope indicates greater effectiveness in detecting an effect with this data set).

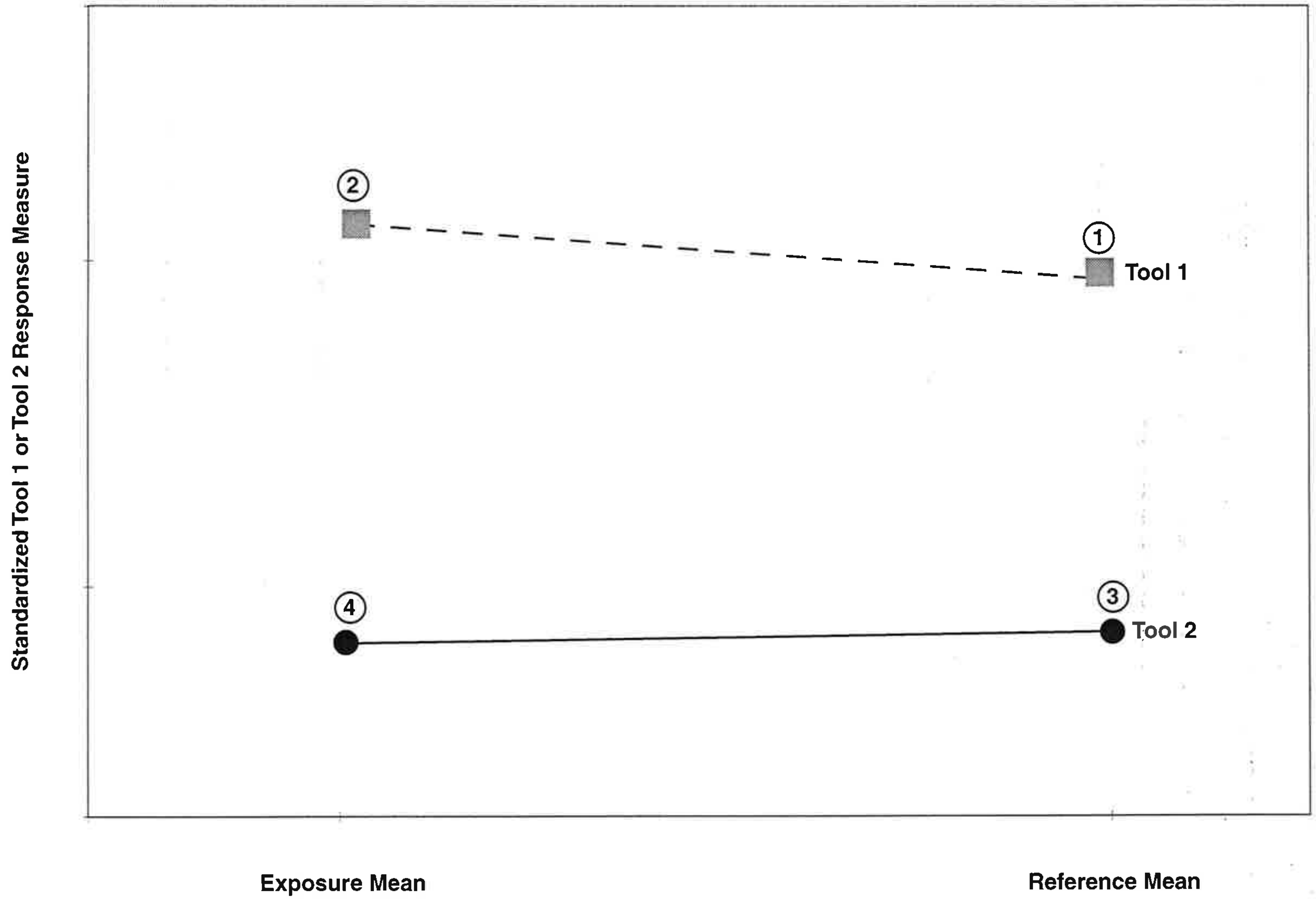
The ANOVA partitions overall variance in the response measure into a number of terms, representing effects of particular interest. These include:

- A "Ref vs Exp x Tool" term which indicates whether the Reference versus Exposure difference is similar for both tools (e.g., for metallothionein and copper in tissue). It measures how much the spread between Line 1 and Line 2 differs from the spread between Line 3 and Line 4 in Figure 5.1. Lines 1 to 4 represent the means of the response measures for each tool in the reference or exposure area. This term also indicates how much the Line 1 to Line 3 spread differs from the Line 2 to Line 4 spread, or the degree of difference between the slopes of the two lines shown in Figure 5.2. A larger difference between the reference and exposure means for one tool relative to the other would indicate a greater effectiveness for the tool with the greater difference. For this example, the absolute reference-exposure difference for each tool is small, but the differences are in opposite directions. This produces a significant Ref vs Exp x Tool interaction, which implies that Tool 1 (metallothionein) is more effective than Tool 2 (copper in viscera). The interaction is also illustrated in Figure 5.2.



Example Approach to Testing H1 to H4 Based on Visceral Metallothionein and Copper in Caged Atlantic Salmon

beak international incorporated	Figure 5.1	April 1998



The Reference versus Exposure by Tool Interaction (based on Fig. 5.1)

beak	beak international incorporated	Figure 5.2	April 1998

- A "Linear Trend x Tool" term which indicates whether the linear trend in the Exposure area (e.g., from near-field to far-field) is similar for both tools. It measures how much the Line 2 to Line 5 spread differs from the Line 4 to Line 6 spread in Figure 5.1. This term also indicates the degree of difference between the Line 5 and Line 6 slopes. A greater slope in the Line 5 (Tool 1) than in Line 6 (Tool 2) indicates a greater effectiveness of Tool 1 in this example.

In all cases, to test whether the spread described in either of the above two "effect" terms is significant, each is compared to the spread of the exposure means for each reach around Lines 5 and 6 (i.e., to a lack of fit "error" term). If the "effect" variance is large relative to the "error" variance, then the effect is considered to be present, and the tool is concluded to be responsive to mine exposure.

The "lack of fit" spread is compared in turn to the overall "within reach" spread (i.e., between stations in a particular reach), in order to test whether there may be any other (i.e., non-linear) trend among the exposure means, that is whether a straight line can be drawn through response measures for all exposure reaches. If "lack of fit" is significant, the nature of the trend is examined and, if appropriate, the analysis is repeated using a non-linear (second order) trend term instead of a linear trend term. This would appear in Figure 5.1 as curved lines rather than the straight Lines 5 and 6.

The response measures for H4 (metal or metallothionein in fish tissue) were standardized prior to statistical analysis, in order to make them equally variable within a reach, since homogeneity of variance is an assumption of the ANOVA procedure. The standardization procedure involves dividing the metal values by the pooled within-reach standard deviation for the metal being evaluated, and dividing the metallothionein values by the pooled within-reach standard deviation for metallothionein.

5.1.2 H5 through H7 - Fish CPUE, Community Structure and Fish Growth

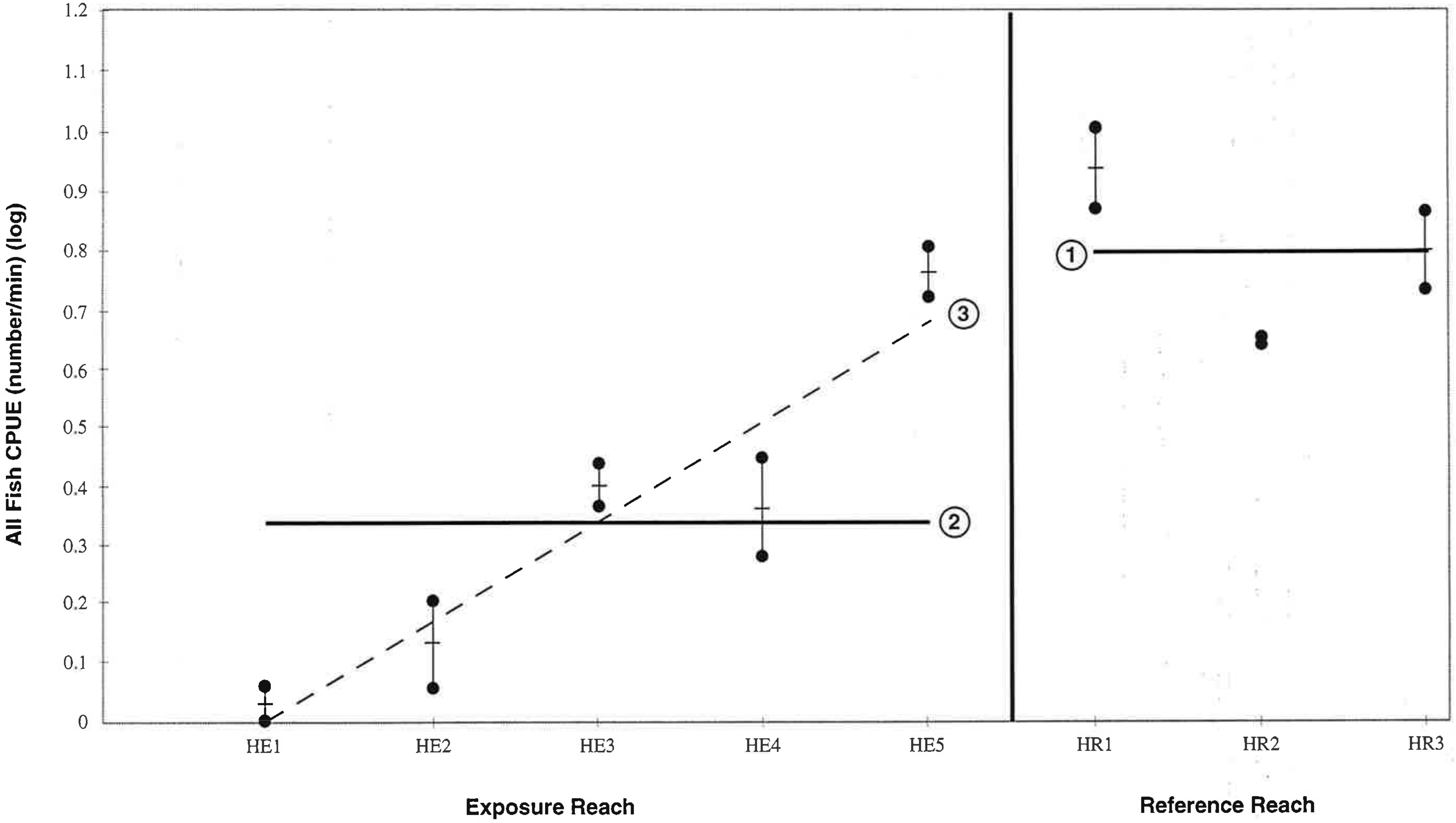
Hypotheses H5 through H7 address the ability of a particular monitoring tool (response measure) to detect a mine effect. For example, in H5, fish catch-per-unit-effort (CPUE) was compared across reaches to determine whether it demonstrates a mine effect (i.e., a reference vs exposure area difference), or a trend with degree of exposure within the exposure area. A reach identifier, ordered within the exposure area to reflect distance from the mine site, was used as a surrogate for exposure to mine effluents. Analysis of variance (ANOVA) was used to address this hypothesis, as described below.

The ANOVA partitions overall variance in the response measure into a number of terms, representing effects of particular interest. These include:

- An "Among Reference" term which indicates whether the various Reference reaches are similar to each other. It measures the spread of reference means around Line 1 in Figure 5.3 (i.e., around the grand reference mean represented by the solid line). This term is quantified in order to indicate whether reference reaches are differentially influenced by some factor (e.g., habitat) that may also be confounding effects in the exposure area.
- A "Ref vs Exp" term which indicates whether the Reference and Exposure reaches are similar to each other. It measures the spread between Line 1 (reference mean) and Line 2 (exposure mean) in Figure 5.3 (i.e., between reference and exposure means). A reference-exposure difference is indicative of tool effectiveness, assuming that the direction of the difference is consistent with impact.
- A "Linear Trend" term which indicates whether there is a linear trend in the Exposure area (e.g., from near-field to far-field). It measures the spread between Line 2 and Line 3 (the exposure trend line) in Figure 5.3 (i.e., the difference in slopes). A significant linear trend, i.e., a near-field to far-field gradient is indicative of tool effectiveness, assuming that its direction is consistent with impact.

In all cases, to test whether the spread is significant, as described in any of the above three "effect" terms, each is compared to the spread of exposure reach means around Line 3 (i.e., to a "lack of fit" error term). This "lack of fit" error term accounts for the residual variability in the data after the above three terms are subtracted from the total among-reach variability. If an "effect" term is large relative to the "lack of fit" error, then the effect is more likely to be significant.

The "lack of fit" spread is compared in turn to the overall "within reach" spread (i.e., between stations within a reach), in order to test whether there may be any other (i.e., non-linear) trend among the exposure means, that is whether a straight line is the best description of the trend. If "lack of fit" is significant, the nature of the trend is examined



Legend

● responses for 2 stations per reach

+ mean value of 2 stations per reach

—— reference or exposure mean

– – – – line fit to exposure reach means

Example Approach to Testing H5 to H8 Based on Catch per Unit Effort (all species)

beak international incorporated	Figure 5.3	February 1998

and, if appropriate, the analysis is repeated using a non-linear (second order) trend term instead of a linear trend term. This would appear in Figure 5.3 as a curved line rather than straight Line 3.

In the example, the data points in Figure 5.3 represent CPUE at each station for all fish species. The ANOVA shows a significant "Ref vs Exp" effect, because there is a substantial difference between Lines 1 and 2. The ANOVA also shows that there is a significant "Linear Trend" effect, because CPUE is lowest near the mine (Reach HE1) and increases as we move further away (i.e., slope of Line 3). The interpretation would be that fish abundance is responding to mine exposure.

H6, which is intended to identify fish community tools, has been expanded in the case of Heath Steele to include benthic community tools. This is appropriate, because subsequent hypotheses (H9 and H10) involve benthic as well as fish community tools and their chemical correlations. Community tools which seem to reflect mine effects are of particular interest. However, benthic community response tools tested, in H6, include only a few biotic indices in common use or showing apparent response to mine exposure. The evaluation is not extended to the point where the multitude of diversity and biotic indices available are evaluated in terms of exposure response. H6 is also tested using periphyton community tools.

For H7, the response measure (fish weight or length) varies with fish age. Therefore, an age covariate was added to the ANOVA model in order to adjust all fish to a common age. The statistical analysis of age-adjusted data is as described above.

Such age adjustment is inappropriate when the form (i.e., slope) of the size-age relationship differs among reaches. This was true for Atlantic salmon when young-of-year (YOY) fish and all reaches were included in the analysis. The YOY were **smaller** in size in areas of high YOY density (e.g., reach HR3). Therefore, YOY were excluded from the analysis in order to perform the age adjustment and test for other growth effects (i.e., on the intercept of the size-age relationship) using ANOVA as described above.

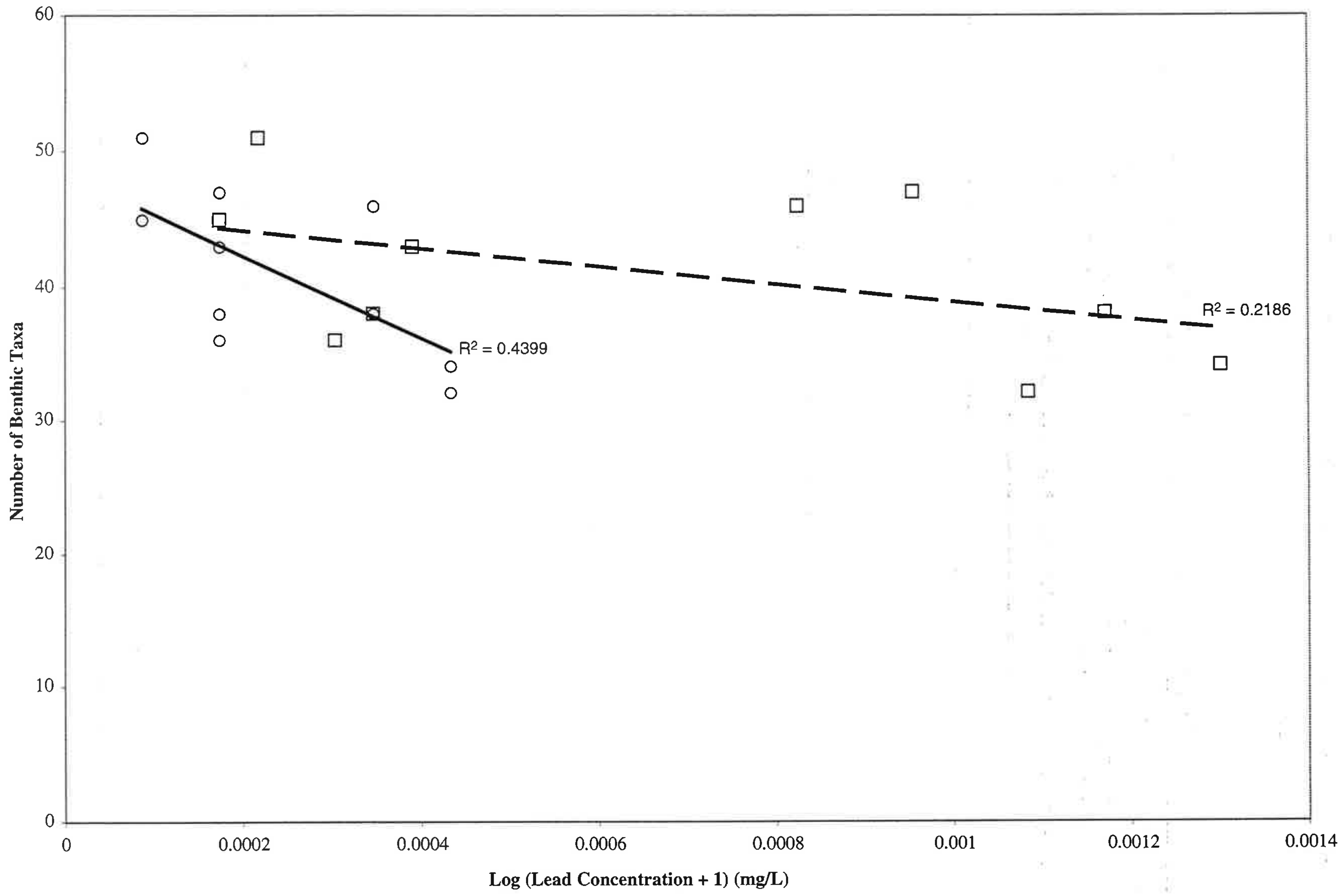
Reaches HR3 and HE5 were excluded from analyses involving salmon density (H5), because they are unaffected by a barrier that limits the spawning run at points upstream, and are therefore not comparable to the upstream study area. A similar exclusion is probably appropriate for analyses involving salmon growth (H7); however, this leaves only three reaches (HR2, HE3, HE4) and two among-reach degrees of freedom, which is insufficient to support the partitioning of among-reach variance that is described above. Therefore, analysis of H7 for salmon was performed with and without the exclusion of reaches HE3 and HE5.

5.1.3 H9 through H12 - Tool Integration Hypotheses

Hypotheses H9, H10 and H12 address the **relative** ability of two monitoring tools to detect correlation between exposure and response variables. For example, in H9, dissolved metal in water was compared to total metal in water, for each of the key metals, to determine whether these two monitoring tools differ in their ability to detect a mine effect (i.e., a correlation between a biological response measure, such as number of taxa, and the metal exposure variable). Correlation analysis was used to address this hypothesis, as described below.

The squared coefficient of correlation (r^2) between the response measure (Y) and each exposure variable (X1 or X2) indicates the proportion of variance in the response measure that is explained by the predictor (Figure 5.4). The best predictor for each pair compared is the one which explains the highest proportion of variance (i.e., has the highest r^2 and hence the highest r). No statistical test was performed to determine whether r_1 differs significantly from r_2, since the two r values are based on the same Y data set and are not independent. However, the individual r values were tested for statistical significance. Two r values were compared, to draw inferences about which monitoring tool is better, only when at least one of the r values was of the correct sign (negative or positive) to suggest a mine effect, and statistically distinguishable from zero based on a one-tailed test.

These correlations were computed excluding reference stations. Response tools correlated with potential causal agents when reference sites are excluded are considered more effective than those showing correlations only when reference sites are included. This is because correlations seen within the exposure gradient are more clearly associated with mine impact. The inclusion of data from up to three reference site reaches could potentially impose spurious correlations by producing clusters of data points at low exposure concentrations. It must be noted that the decision to compute correlations excluding references stations is not supported by scientists working on metal toxicology and MT in fish who believed that important biological information are lost using this procedure.



Legend

□ Log Total Lead in Water — — — — Line fit to Total Lead

○ Log Dissolved Lead in Water ——— Line fit to Dissolved Lead

Example Approach to Testing H9 to H12 Based on the Total and Dissolved Lead Data for Exposure Reaches

beak	beak international incorporated	Figure 5.4	April 1998

In the example shown in Figure 5.4, dissolved lead is a more effective predictor of numbers of benthic taxa in exposure reaches than is total lead.

When differences between r values are small (e.g., ≤0.1), even though one or both r values may be statistically significant, a judgement is generally not made that the tool with the slightly higher r value is better able to detect an effect. Also, the correlations are generally calculated for many exposure measures (metals), so that judgements with respect to which exposure measure tool (e.g., total versus dissolved concentration in water) is more strongly correlated with biological response are made by the weight-of-evidence based on all r values for each tool. The exposure and response measures selected for inclusion in this analysis were those which showed an apparent spatial relationship to the mine site, i.e., trend among exposure reaches or difference between reference and exposure reaches.

At Heath Steele, H9 (relationship between water quality and biological variables) is tested both using benthic community tools and fish community tools. This hypothesis compares the strength of correlations of dissolved versus total metals in water with biological responses.

H10 (relationship between sediment chemistry and biological tools) is tested using periphyton metal concentration as a surrogate for sediment chemistry. Because H10 compares different sediment chemistry tools (e.g., total versus partial sediment metals) and only one "sediment" chemistry tool is available here (total metals in periphyton), H10 is tested by comparison of periphyton metals and dissolved metals.

H12 (relationship between water and sediment chemistry and fish tissue chemistry response) is tested using dissolved water chemistry and periphyton chemistry in the environment, and metallothionein and metals in fish viscera.

5.1.4 H13 - Chronic Toxicity Linkage with Benthic and Fish Community Results

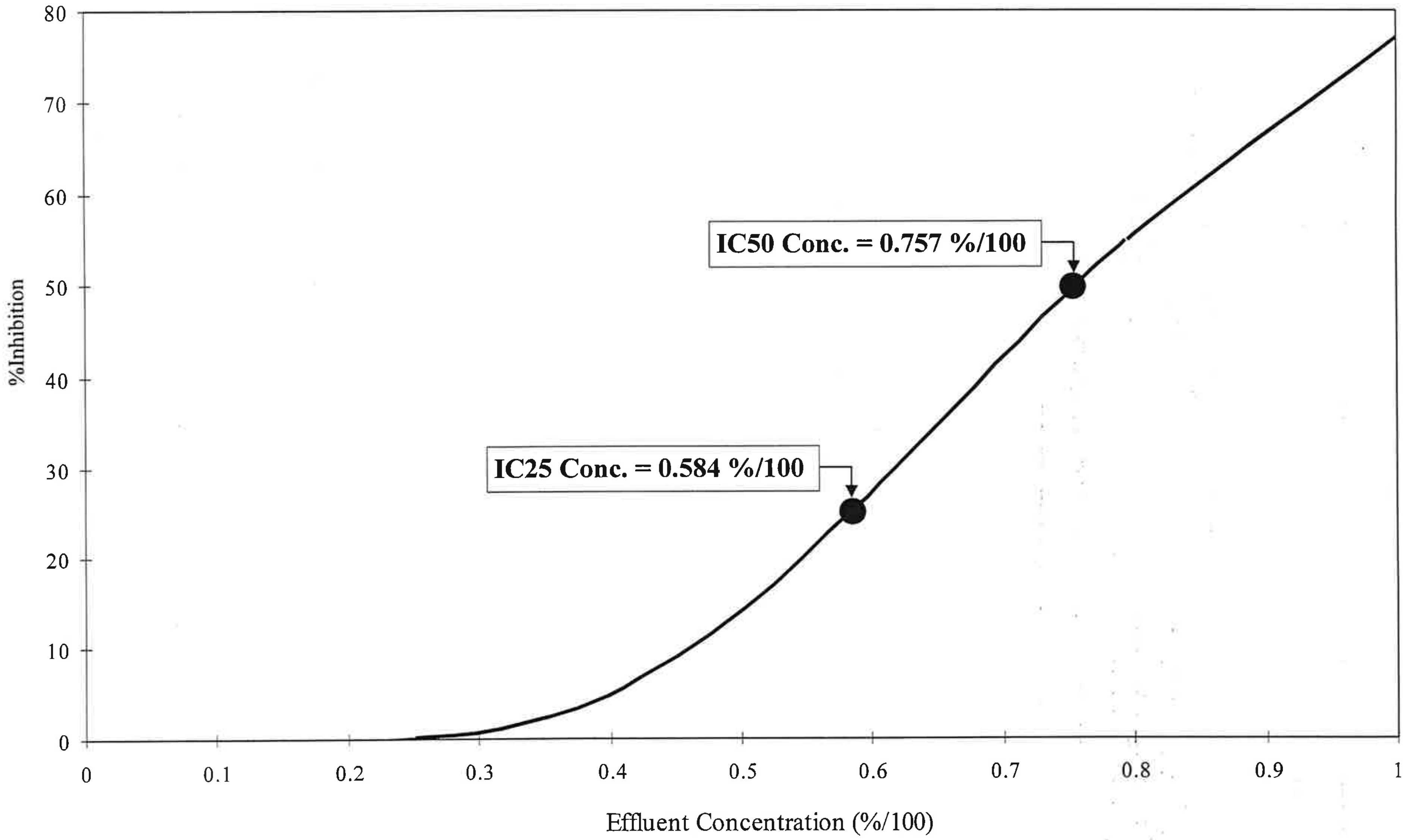
Hypothesis H13 addresses the ability of a particular effluent toxicity testing tool to predict a mine effect that has been otherwise demonstrated (e.g., in H5 to H7). For example, H13 might address whether fish catch-per-unit-effort (CPUE) in each downstream reach can be predicted from effluent toxicity to *Ceriodaphnia*. In order to test this hypothesis, it is necessary to estimate the receiving water toxicity to *Ceriodaphnia* in each reach, based on the effluent toxicity information and the expected downstream dilution of effluent. Then we can determine if these two reach attributes (fish CPUE and water toxicity) are correlated as they vary from reach to reach.

Water toxicity, like effluent toxicity, can be expressed as a % inhibition (i.e., for *Ceriodaphnia* as % inhibition of reproduction). The % inhibition increases with effluent concentration. The IC25 concentration produces 25% inhibition, and the IC50 concentration produces 50% inhibition. These two concentrations, obtained from the effluent toxicity test, define the % inhibition vs concentration relationship. We can use this relationship to estimate the % inhibition that would be expected at each effluent concentration that exists in the downstream reaches.

The % inhibition vs concentration relationship has a sigmoid form, such that % inhibition increases most rapidly with concentration in the vicinity of the IC50 concentration (Figure 5.5). It is standard practice to transform both variables (i.e., % inhibition and effluent concentration) to make a linear relationship, in order to facilitate estimation of % inhibition at any concentration. A probit (or Z) transformation of % inhibition and a log transformation of effluent concentration will accomplish this (Finney, 1971). Figure 5.6 illustrates the linearized relationship, based on the *Ceriodaphnia* IC25 and IC50 concentrations for the June "effluent" sample at Heath Steele. It also illustrates the use of the relationship to estimate water toxicity (% inhibition of *Ceriodaphnia* reproduction) at reach HE2 downstream.

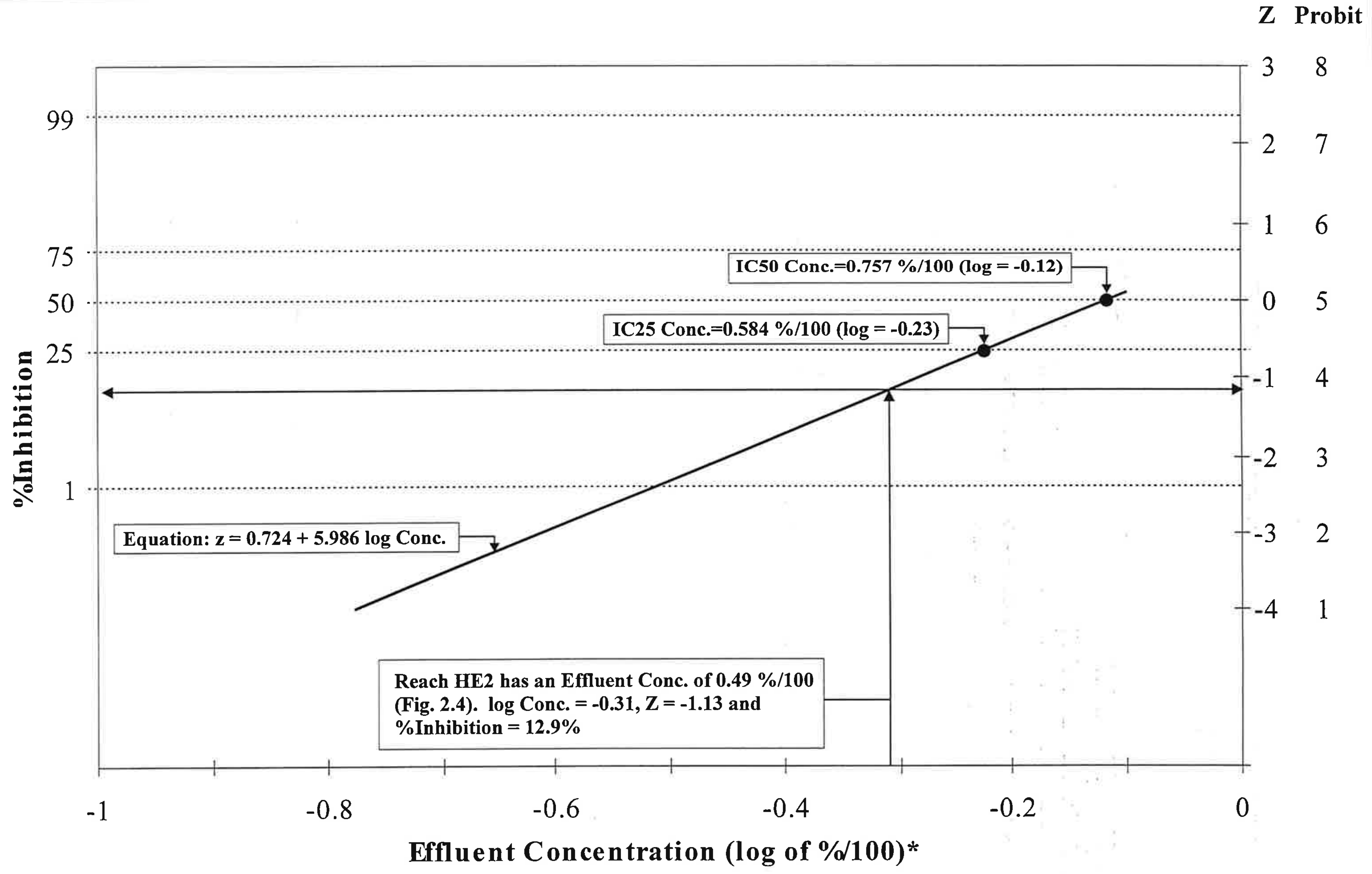
Water toxicity was estimated in this manner for each reach downstream of the mine, based on three different effluent samples (June, August, November) and up to four different toxicity test methods (*Ceriodaphnia*, fathead minnow, algae, duckweed). It can only be done for tests that produce both IC25 and IC50 values (i.e., two points are necessary to draw a concentration-response line in Figure 5.6). Two minnow tests and one duckweed test at Heath Steele did not produce both endpoints. Thus, there were nine different water toxicity variables (i.e., different estimators of % inhibition). Each of these toxicity variables was tested for correlation with each of the field measurements of biological response, such as fish CPUE, and plots such as Figure 5.7 were produced to illustrate some of the stronger relationships.

Appropriate transformations were applied prior to the correlation analysis. For example, the arcsine square root of % inhibition was used as the water toxicity variable, and fish



Untransformed Concentration Response Function for June Effluent Sample (*Ceriodaphnia*)

beak international incorporated	Figure 5.5	March 1998



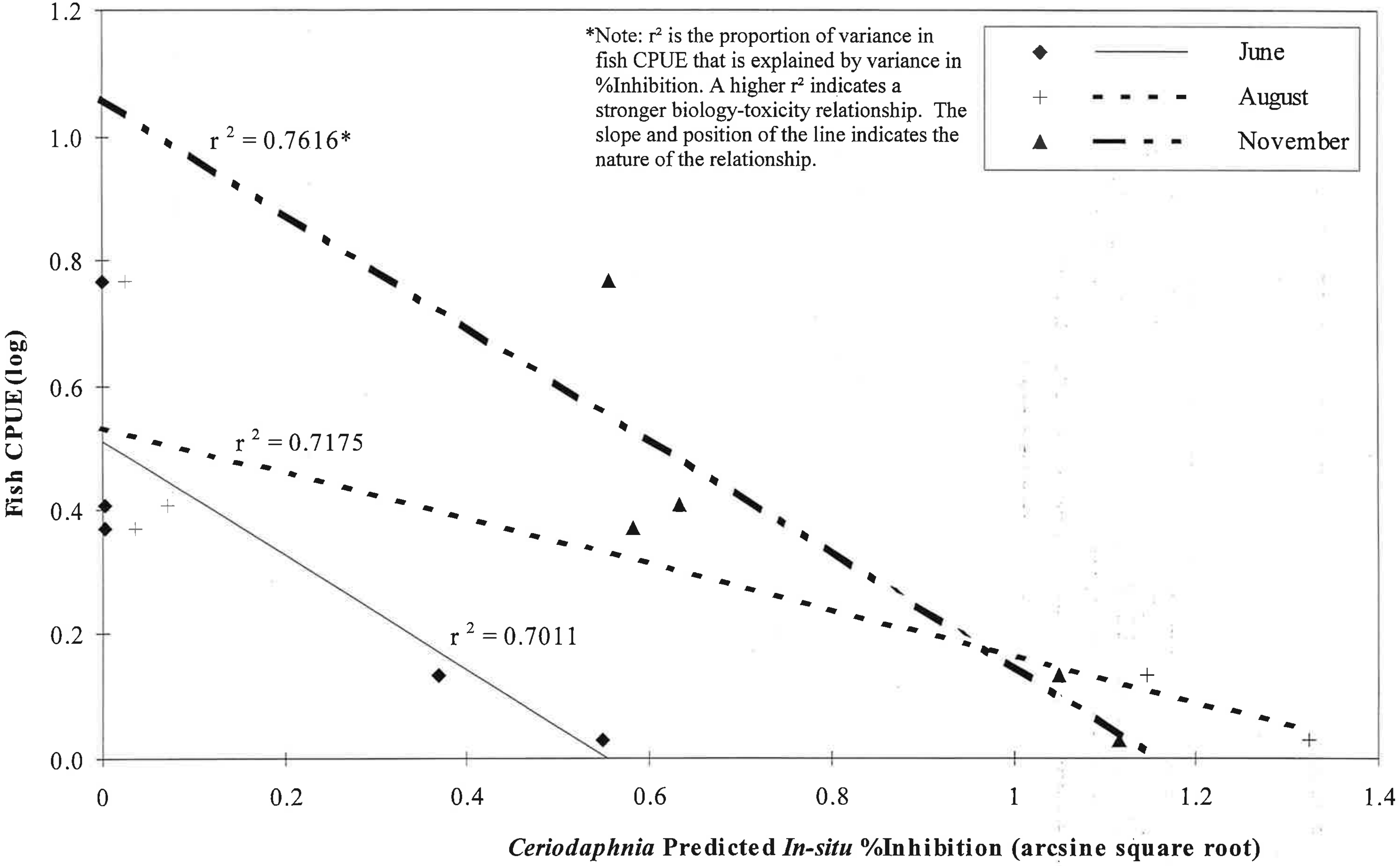
*Note: %/100 = effluent fraction

Concentration-Response Function for June Effluent Sample (*Ceriodaphnia* test) and Estimation of *Ceriodaphnia* Response in a Downstream Reach

beak international incorporated

Figure 5.6

March 1998



*Note: r^2 is the proportion of variance in fish CPUE that is explained by variance in %Inhibition. A higher r^2 indicates a stronger biology-toxicity relationship. The slope and position of the line indicates the nature of the relationship.

Relationship of Fish CPUE (All Taxa) to Estimated Water Toxicity (%Inhibition of *Ceriodaphnia*) Across Five Downstream Reaches

beak international incorporated	Figure 5.7	March 1998

CPUE was log transformed. Then the correlation coefficient (r) was computed and tested for significance using a one-tailed t-test. Significance depends only on the magnitude of r and a sample size (n). For n=5 exposure reaches, r must be greater than 0.81 (i.e., $r^2 > 0.65$) to produce a significant correlation. In Figure 5.7, the November effluent sample produces the strongest CPUE vs water toxicity relationship ($r^2 = 0.76$), but all the relationships shown are significant.

A significant correlation (r) indicates that the toxicity tool may be useful as a predictor of the in-stream biological response measure. It does not, of course, prove that effluent is responsible for any observed pattern in biological response downstream from the mine. The toxicity test methods that generally provide the highest correlations with biological response measures are considered to be the best.

An estimate of % inhibition in the downstream reach (as described above) is likely to be a better predictor of biological response than a simple toxic unit (TU) predictor. The former uses the concentration-response information obtained from the toxicity test, while TU is simply a dilution factor for the reach scaled by the IC25 (or IC50) concentration of the effluent. As such, a TU predictor would show exactly the same relationship to biological response as the dilution factor, and would not effectively utilize the exposure-response information from the toxicity test, as given in Figure 5.5. In other words, the predicted % inhibition approach used, unlike a TU approach, incorporates information on whether there is a large or small change in toxicity with a specified change in effluent concentration.

Using the % inhibition approach, if there is a biological response downstream from the mine, and if there is sufficient dilution relative to effluent toxicity that zero % inhibition is expected at all downstream locations, then the points in Figure 5.7 will fall in a vertical line and the correlation will not be significant.

5.2 Results

The general conclusions with respect to the eight hypotheses tested at Heath Steele are summarized in Table 5.2. The following sections present the findings in more detail, based on statistical tables and figures in Appendix 3. The discussion is focused on results that meet the significance criterion of $p \leq 0.05$. Use of the term "significant" implies that this criterion was met, although "suggested" results may be mentioned as such when the criterion is approached but not achieved.

TABLE 5.2: SUMMARY OF GENERAL CONCLUSIONS REGARDING HYPOTHESES TESTED AT HEATH STEELE

Hypothesis	Response or Effect Variables (Y)	Predictor or Exposure Variables (X)	Null Hypothesis	General Conclusion
H4	Metal i in Tissue j (Tool 1) MT in Tissue j (Tool 2)	Reach Number (in order of increasing dilution downstream from mine)	no trend or R/E x tool interaction by ANOVA	• MT vs metals (Cd, Pb, Zn, Cu) show different trends in the exposure area (MT trend stronger) for caged salmon. • MT vs metals (Cd, Pb, Zn, Cu) are similar in their lack of trend in the exposure area for wild salmon. • MT vs metals (Cd, Pb, Zn) show different trends in the exposure area (MT trend stronger) for blacknose dace. • MT and Cu change in opposite directions from Reference to Exposure areas (MT higher in Exposure area) for caged salmon. • MT vs metals (Cd, Pb, Zn) show different degrees of change from Reference to Exposure areas (both higher in Exposure area) for blacknose dace.
H5	CPUE for dace, juvenile salmon, all species	Reach Number (in order of increasing dilution downstream from mine)	no trend or R/E difference by ANOVA	• Fish CPUE (all taxa combined) is reduced with degree of exposure and E<R mean.
H6	BPUE (biomass) for Fish No. of Benthic Taxa and EPT Taxa Total Benthic Density % Chironomid Indicators - % Rheocricotopus - % Orthocladoinae Periphyton Taxa and Biomass	Reach Number (in order of increasing dilution downstream from mine)	no trend or R/E difference by ANOVA	• Fish BPUE (all taxa combined) is reduced with degree of exposure and E<R mean. • E<R mean for number of benthic taxa; no linear trend in exposure zone. • Number of EPT taxa is reduced with exposure and E<R mean. • No spatial trends evident in total density. • Rheocricotopus dominance showed a linear trend in exposure area and a E/R mean difference. • Orthoclad dominance showed a trend in the exposure area. • Periphyton community indices showed no spatial trends.
H7	Weight at age Length at age	Reach Number (in order of increasing dilution downstream from mine)	no trend or R/E difference by ANOVA	• YOY salmon are smaller in high density reaches (below barriers). • Effect persists at later ages. • No impairment of growth by exposure for salmon or blacknose dace.
				•

TABLE 5.2: SUMMARY OF GENERAL CONCLUSIONS REGARDING HYPOTHESES TESTED AT HEATH STEELE

Hypothesis	Response or Effect Variables (Y)	Predictor or Exposure Variables (X)	Null Hypothesis	General Conclusion
H9	No. of Benthic Taxa EPT Index % Chironomid Indicators Fish CPUE and BPUE No. of Fish Taxa Predicted In-stream Toxicity	Dissolved Metal in Water (Tool 1) Total Metal in Water (Tool 2)	same Y-X correlation with Tool 1 as Tool 2	• Numbers of total benthic taxa and EPT taxa are reduced and dominance of tolerant chironomids increases with increasing metal in water. • Fish CPUE, BPUE and number of fish taxa decrease with increasing metal in water. • Relationships similar for dissolved and total metals. • Relationships similar for dissolved and total metals.
H10	No. of Benthic Taxa EPT Index % Chironomid Indicators Fish CPUE and BPUE No. of Fish Taxa Predicted In-stream Toxicity	Fraction Metal i in Periphyton (Tool 1) Dissolved Metal i in Water (Tool 2)	same Y-X correlation with Tool 1 as Tool 2	• Numbers of total benthic taxa and EPT taxa are reduced and dominance of tolerant chironomids increases with increasing metals in periphyton and water. • Fish CPUE, BPUE and number of taxa decrease with increasing metals in periphyton and water. • For most fish and benthic indices, relationships stronger with metals in water than metals in periphyton. • Relationships slightly stronger for Al, Cd, Cu and Zn in water and for Pb and Fe in periphyton.
H12	Metal i in Tissue j MT in Tissue j	Metal i in Periphyton (Tool 1) Dissolved Metal i in Water (Tool 2)	same Y-X correlation with Tool 1 as Tool 2	• MT in wild and caged salmon viscera increases with metals in water; metals in salmon did not increase with metals in water or periphyton. • MT in blacknose dace viscera increases with Pb in water; Zn, Cu and Pb in dace viscera increase with metals in periphyton.
H13	Fish CPUE and BPUE % Chironomid Indicators No. of Benthic Taxa EPT Index No. of Fish Taxa	Predicted % Inhibition in Exposure Reach based on effluent toxicity testing and downstream dilution factors	no Y-X correlation	• Fish CPUE, BPUE and number of taxa decrease with predicted water toxicity to algae, *Ceriodaphnia*, duckweed or fathead minnow. • Dominance of pollution-tolerant chironomids increases with predicted water toxicity. Other benthic indices not correlated with predicted toxicity. • The four toxicity tests produce similar biology vs predicted toxicity correlations, when effluent is sublethally toxic. • Fathead minnow test is less sensitive than other tests.

E - exposure reaches
R - reference reaches.

5.2.1 H4 - Metallothionein vs Metal in Fish Tissue as a Response to Exposure

Figures illustrating the response patterns of metallothionein and metals in fish tissue, and ANOVA tables showing tests for differences in response patterns between metallothionein and metals are provided in Appendix 3. Based on these patterns and statistical test results, the key findings regarding Hypothesis H4 are outlined below, for caged Atlantic salmon (viscera), wild Atlantic salmon (viscera) and wild blacknose dace (viscera). This hypothesis was addressed only for viscera because quantities of other tissues were insufficient for both metallothionein and metal analyses.

Caged Atlantic Salmon (Viscera)

Metallothionein (log concentration in tissue) shows an increasing trend with increasing exposure within the exposure area (i.e., from HE5 in the North Branch Tomogonops, upstream to HE1 in the Little South Branch) ($p = 0.009$). Similarly, the exposure area mean level of metallothionein is somewhat elevated relative to the reference mean (HR1 to HR3), although this result is not significant ($p = 0.09$).

Metals in fish tissue (log concentration of Zn, Pb, Cd, Cu) do not show a trend in the exposure area. Similarly, the exposure area mean levels of metals in tissue are not elevated relative to the reference mean. In the case of Cu, the reference area mean exceeds the exposure area mean, in contrast to the direction of difference for metallothionein.

The trend in metallothionein, but not metals, results in a significant trend x tool interaction ($p < 0.05$) with Zn, Pb, Cd, Cu and the molar sum of Cd+Cu+Zn. In addition, the difference in exposure versus reference mean for Cu, which was in the opposite direction as compared to metallothionein, resulted in a significant reference/exposure x tool interaction ($p = 0.015$).

Wild Atlantic Salmon (Viscera)

In wild Atlantic salmon, metallothionein (log concentration in tissue) does not show an increasing trend with increasing exposure level within the exposure area (i.e., from HE5 upstream to HE3). The exposure area mean suggests an elevation relative to the reference area mean (HR2 and HR3); however, this difference is not significant ($p = 0.099$).

Some metals in fish tissue show a similar response pattern, with no trend in the exposure area, but a small elevation in the exposure area mean. The difference is significant ($p = 0.019$) for log concentration of Pb in tissue. Other metals, such as Zn, show no elevation in the exposure area. No metals show a significant spatial trend in the exposure area.

The metallothionein and metal tools were equally effective (or ineffective) in wild Atlantic salmon at Heath Steele, as indicated by the lack of any significant reference vs exposure x tool interactions. However, our ability to statistically detect such interactions was limited by availability of Atlantic salmon data for only three exposure reaches and two reference reaches.

It appears that there may be a weak metallothionein response in the HE5 to HE3 region (there were no salmon caught closer to the mine), as indicated by the elevated levels in this exposure area (although not significant). However, in contrast to the caged salmon, no spatial trend is evident, in either metallothionein or metal, within this far-field area. This difference as compared to caged fish may be related to the longer exposure period of wild fish (wild fish in this area had about eight times as much metallothionein and about two times as much metal as the caged fish) or to the greater mobility of wild fish. This mobility would lead to spatial averaging across the exposure area.

Wild Blacknose Dace (Viscera)

Blacknose dace show a response pattern similar to caged Atlantic salmon. In this case, the suggested metallothionein trend within the exposure area is not significant ($p = 0.06$), but the elevation in the exposure area mean level of metallothionein relative to the reference area mean is significant ($p = 0.008$).

There is an elevated level of some metals (log concentration of Zn and Cu) in the tissues of dace from the exposure area. Other metals, such as Pb, are not elevated in the exposure area. No metals show a significant spatial trend in the exposure area ($p > 0.05$).

The trend in metallothionein, but not metals, results in a significant trend x tool interaction for Zn ($p = 0.046$), Pb ($p = 0.049$) and Cd ($p = 0.002$). In addition, there is a significant reference vs exposure x tool interaction ($p < 0.05$) for these metals, indicating that the reference-exposure difference for metallothionein is greater or smaller than it is for metals (depending on the metal).

The metallothionein trend seen in caged salmon and blacknose dace, but not wild salmon, suggests that the lack of trend in wild salmon may be related to their mobility. The exposure area elevation of some metals, seen in wild salmon (Pb) and wild dace (Cu, Zn), suggests that the short exposure period may prevent detection of a similar effect in caged fish.

5.2.2 H5 through H7

5.2.2.1 H5 - Fish CPUE as a Response to Exposure

Figures illustrating the response patterns of fish CPUE in relation to mine exposure, and ANOVA tables showing tests for significance of these trends, are provided in Appendix 3. Based on these patterns and statistical test results, the key findings regarding hypothesis H5 are outlined below for Atlantic salmon, blacknose dace, brook trout and the overall fish community.

Atlantic Salmon CPUE

The analysis for Atlantic salmon was confined to catch at HE1 to HE4 and HR2, because these reaches were all influenced by the same barrier, i.e., the railway bridge on the North Branch Tomogonops River. Salmon are excluded from HR1, upstream of the mine, by barriers downstream of HR1.

Catch was zero at HE1 and HE2 nearest the mine, and increased at HE3 and HE4 further downstream. However, the suggested trend in log CPUE within the exposure area was non-significant ($p = 0.069$).

The exposure area mean, although elevated relative to HR2, was not significantly different than the reference mean. It should be noted that the reference mean in this case is represented by a single reach with two stations.

Blacknose Dace CPUE

There was no demonstrable trend of increasing catch in the downstream direction, nor any difference between exposure and reference areas. Reach HE4 produced a very low catch, contrary to what may have been a trend otherwise.

Unknown habitat effects may confound the use of this tool, as suggested also by a discontinuity in benthic community measurements in HE4. There was considerable variability among reference reaches.

Brook Trout CPUE

There was no demonstrable trend of increasing catch in the downstream direction, nor any difference between exposure and reference areas.

Mine effects may be confounded by habitat effects since HE4 and HE5 in the North Branch Tomogonops River are probably sub-optimal for brook trout based on the river size and flow.

Fish Community CPUE

The suggested trend of increasing catch of all fish in the downstream direction was statistically significant (p = 0.043), and the exposure area mean CPUE was significantly reduced relative to the reference mean (p = 0.029). Consequently, this tool was useful in detecting mine effects on the fish community at Heath Steele. The greater effectiveness of this tool is attributed to the dampening of "noise" in the relationships when all species are included, including not only the three listed but others such as lake chub which were also present.

5.2.2.2 H6 - Biological Community Measures as a Response to Exposure

Figures illustrating the response patterns of fish biomass and benthic community measures in relation to mine exposure, and ANOVA tables showing tests of significance for these trends, are provided in Appendix 3. Based on these patterns and statistical test results, the key findings regarding hypothesis H6 are outlined below.

FISH

Atlantic Salmon BPUE

The suggested trend of increasing biomass in the downstream direction was not statistically significant (p = 0.074), and the exposure area mean was not significantly elevated relative to the reference mean.

Blacknose Dace BPUE

There was no demonstrable trend of increasing biomass in the downstream direction, nor any difference between exposure and reference areas. Reach HE4 produced a very low biomass, contrary to what may have been a trend otherwise.

Unknown habitat effects at HE4 may confound the use of this tool, as suggested also by a discontinuity in benthic community measurements at HE4. There was considerable variability among reference reaches.

Brook Trout BPUE

The apparent linear trend of increasing biomass in the downstream direction was not statistically significant ($p = 0.206$; however, a second order trend was significant. In other words, biomass changed more rapidly with distance in the near-field than in the far-field exposure area. Using this second order trend to improve the fit of the trend model, the lower biomass in the exposure area, as compared to reference, was significant ($p = 0.023$). Consequently, brook trout BPUE was useful in detecting mine effects at Heath Steele.

Mine effects may be confounded by habitat effects, since HE4 and HE5 in the North Branch Tomogonops River are probably sub-optimal for brook trout based on the river size and flow.

Fish Community BPUE

The linear trend of increasing biomass in the downstream direction was statistically significant ($p = 0.02$). However, a second order trend fit the data better, suggesting that there is less change with distance in areas that are further away from the mine site. Using the second order term to describe the trend, it was shown that the exposure area mean BPUE was significantly reduced relative to the reference mean ($p = 0.045$). Consequently, fish BPUE was useful in detecting mine effects on the fish community at Heath Steele.

BENTHIC INVERTEBRATES

Number of Benthic Taxa

The mean number of benthic taxa was significantly reduced in the exposure area relative to the reference area. This is because metal-tolerant species tend to replace more sensitive species in the exposure areas.

The suggested trend of increasing species richness in the downstream direction was not statistically significant, in particular due to the low species richness at HE4. An unknown habitat effect may be involved here.

Number of EPT Taxa

The linear trend of increasing EPT taxa (mayflies, stoneflies and caddisflies) in the downstream direction was statistically significant ($p = 0.029$), and the exposure area mean was significantly reduced relative to the reference area mean ($p = 0.023$). The EPT taxa are generally sensitive to pollution and are considered to be indicators of good water and sediment quality. Thus, they may be considered useful in detecting effects on the benthic community at Heath Steele.

Rheocricotopus (Dominance)

The dominance of the chironomid *Rheocricotopus* (arcsine square root transformed % total benthic density) decreased significantly in the downstream direction ($p = 0.025$), and the exposure area mean was significantly greater than the reference mean ($p = 0.047$). This genus is apparently pollution-tolerant and does well in the most exposed reaches of the Little South Branch. Thus, it may be considered useful as an indicator of effects at Heath Steele.

Orthocladiinae (Dominance)

The dominance of this sub-family of chironomids (arcsine square root transformed % total benthic density) decreased significantly in the downstream direction ($p = 0.012$), mainly in the near-field (HE1 to HE3). The exposure area mean was not greater than the reference area mean (0.052). Like *Rheocricotopus*, this group is pollution-tolerant and is more dominant near the mine. Thus, it may be considered useful as an indicator of mine effects at Heath Steele.

PERIPHYTON

Number of Periphyton Taxa

The number of periphyton taxa did not differ significantly among reaches. Therefore, no tests for spatial trend or comparisons between areas were performed.

Periphyton Biomass

The log of periphyton biomass showed no significant spatial trend or difference between reference and exposure areas.

5.2.2.3 H7 - Fish Growth as a Response to Exposure

Figures illustrating the size-age relationships of Atlantic salmon and blacknose dace, as well as age-adjusted weights in relation to mine exposure, and ANOVA tables showing tests of significance for these trends, are provided in Appendix 3. Based on these patterns and statistical test results, the key findings regarding hypothesis H7 are outlined below.

Atlantic Salmon

Atlantic salmon tend to be larger at age at more exposed locations HE3 and HE4 than at less exposed sites (HE5) or at reference reach HR3. This is not consistent with an expected metal exposure effect, and may be associated with a density-dependent growth response where growth is reduced in reaches where salmon density is high.

Young-of-year (YOY) fish are smaller in high density reaches (HR3, HE5), which produces different slopes in the size-age relationships for different reaches. If we exclude the young-of-the-year (YOY) fish, the slopes are the same and we can adjust for age to examine other possible effects on fish size. After we do this, there is still an effect of reach on size at age (i.e., on the intercept of the size-age relationship) as indicated by small size-at-age at HR3 and to a lesser extent at HE5. Thus, the apparent density-dependent effects on young fish growth at these stations remain evident in older fish. Both these stations are unaffected by the barrier (railway bridge) that limits the spawning run to points upstream.

If we leave HR3 and HE5 stations in the analysis, there are significant among-reach effects on fork length ($p = 0.023$ based on station mean values), but no discernible reference-exposure difference, and no discernible trend within the exposure area, for either fork length or weight. If we exclude these stations from the analysis, there is no significant among-reach difference.

Blacknose Dace

For statistical analyses involving fork length, only fish ≤3 years of age were used because the presence of older fish (which grow slowly) in some reaches produced a significant length x age interaction. For analyses of fish weight or weight-at-age, the interaction was not significant, so all fish were utilized. Adjusting for the age effects, neither length-at-age or weight-at-age differed among reaches.

5.2.3 H9 through H12

These hypotheses involve examination of correlation coefficients between measured parameters. The correlations can be computed in two ways: excluding and including the reference stations. We consider it more appropriate to exclude the reference stations in the hypothesis testing, so that the correlations clearly reflect relationships that exist within the mine exposure gradient, rather than extreme values on the X-axis driven by three reference reaches (six reference stations). Thus, a total that produces a high correlation coefficient when tested with exposure station data only is more effective than one producing high values only when reference site data are included in the analysis. Only the results generated exclusive of reference station data are discussed in this report. While no statistical tests were performed to compare the correlations generated by two measurement tools, differences of about 0.1 or more between coefficients are considered worthy of discussion, as long as at least one of the coefficients is statistically distinguishable from zero.

5.2.3.1 *H9 - Correlation of Biological Response with Dissolved vs Total Metal in Water*

Tables showing the correlation coefficients between water chemical and biological measurements are provided in Appendix 3. Based on the magnitudes of the significant correlation coefficients, the key findings regarding hypothesis H9 are outlined below.

Correlation of Community Structure with Dissolved vs Total Metal in Water

These correlations are negative for fish CPUE and BPUE (slightly stronger for BPUE in general) and for number of fish taxa. In other words, CPUE, BPUE and fish taxa tend to decrease with increasing metal concentrations. These CPUE and BPUE correlations are strongest for the fish community as a whole (all species) and for Atlantic salmon, which showed significant ($p < 0.05$) or near significant ($0.05 < p < 0.1$) responses in H5 and H6.

The correlations are negative for number of benthic taxa and EPT taxa, but positive for dominance of pollution-tolerant taxa such as *Rheocricotopus* and Orthocladiinae. In other words, as metal concentrations increase, the number of taxa decreases and pollution-tolerant species comprise a greater percentage of total organism density. These results are generally consistent with the benthic response trends seen in H6.

On balance, the strength of correlations between fish or benthic response and aqueous metal concentrations are similar for dissolved and total metals.

Correlation of Predicted Toxicity with Dissolved vs Total Metal in Water

In general, dissolved and total metals in water show similar relationships to the expected water toxicity (based on effluent toxicity tests and reach dilution factors).

5.2.3.2 *H10 - Correlation of Biological Response with Periphyton Metal vs Dissolved Metal in Water*

Tables showing the correlation coefficients between water or periphyton chemistry and various biological measurements are provided in Appendix 3. Based on the magnitudes of the significant correlation coefficients, the key findings regarding hypothesis H10 are outlined below.

Correlation of Community Structure with Periphyton Metals vs Dissolved Metals in Water

The correlations are negative for fish CPUE and BPUE (slightly stronger for BPUE in general) and for number of fish taxa. In other words, CPUE, BPUE and fish taxa tend to decrease with increasing metal concentrations, either dissolved in water or (for CPUE and BPUE) associated with periphyton.

The correlations are negative for number of benthic taxa and EPT taxa, but positive for dominance of pollution-tolerant taxa such as *Rheocricotopus* and Orthocladiinae. In other words, as metal concentrations increase in water or periphyton, the number of benthic and EPT taxa decreases and pollution-tolerant species comprise a greater percentage of total organism density.

The relationships are generally stronger (often substantially so) for metal in water than for periphyton metal, with a few exceptions such as brook trout CPUE and BPUE in relation to lead and aluminum.

While the hypothesis is not tested with total metals specifically, the results obtained for dissolved metals and total metals would be similar, as dissolved metal and total metal results are generally similar in terms of spatial trend and based on the results of H9.

Correlation of Predicted Toxicity with Periphyton Metals vs Dissolved Metals in Water

In general, dissolved metal in water shows a slightly stronger relationship to the expected water toxicity (based on effluent toxicity tests and reach dilution factors) than does the periphyton metal. This is true for Al, Cd, Cu and Zn whereas, for other metals (Pb, Fe), periphyton metal generally shows a slightly stronger relationship to expected water toxicity.

5.2.3.3 H12 - Metal vs Metallothionein in Fish (Viscera) as a Biological Response to Environmental Metals

Tables showing the correlation coefficients between metal or metallothionein in fish viscera, and metals in water (dissolved) or periphyton, are provided in Appendix 3. Based on the magnitudes of the significant correlation coefficients, the key findings regarding hypothesis H12 are outlined below.

For exposed wild Atlantic salmon, metallothionein in tissue is correlated with metals in water. The only significant correlations between corresponding metals in tissue and water are negative (and thus possibly spurious). These results indicate that the marginally insignificant exposure area trends in MT levels in wild salmon in H4 (Section 5.2.1) may be more attributed to the use of the reach identifier rather than metal concentration in water in that analysis. The absence of correlations between metals in water and viscera is consistent with the absence of spatial trends in H4 for nearly all metals (except one).

For exposed blacknose dace, metallothionein is related only to lead in water, and zinc, copper and lead in tissue are related only to corresponding metals in periphyton. These results are consistent with the presence of an exposure area trend and reference-exposure difference in MT, and with the reference-exposure differences in metal levels in viscera and in periphyton.

For caged Atlantic salmon, metallothionein is correlated with metals in water and no correlations were seen between metals in water and metals in viscera. These correlations are consistent with responses seen in H4 (Section 5.2.1).

On balance, tissue metallothionein and tissue metal concentrations were both correlated with environmental metal concentrations in some instances, although neither metallothionein nor metals responded in a consistent manner among the fish tested.

5.2.4 H13 - Correlation of Biological Response with Predicted Effluent Toxicity

Figures illustrating the relationships between biological response and expected water toxicity (based on effluent toxicity and reach dilution factors), and tables showing the correlation coefficients, are provided in Appendix 3. Based on the magnitudes of the significant correlation coefficients, the key findings regarding hypothesis H13 are outlined below.

In general, the data show that the expected water toxicity (% inhibition) is negatively correlated with number of fish taxa, fish CPUE and BPUE, and Atlantic salmon CPUE and BPUE. The correlations involving brook trout and blacknose dace were not generally significant.

The data show that the expected water toxicity (% inhibition) is positively correlated with pollution-tolerant benthic taxa such as *Rheocricotopus* and Orthocladiinae. The correlations involving number of benthic taxa, number of EPT taxa and benthic density were negative but not significant.

5.2.5 Triad Hypotheses

There are many combinations of chemistry (C), toxicity (T) and biology (B) monitoring tools that show significant correlations on all three arms of the "triad". This is true whether we use dissolved or total metal chemistry in water, or periphyton chemistry. The strongest C-T, C-B and T-B correlations are listed in Appendix 3.

In the absence of sediment at this site, only water toxicity values are available, and these values are estimated for the exposure reaches based on effluent toxicity testing. Although triad analysis might be possible based on water toxicity tests on field-collected water samples, it is questionable whether it should be performed using estimated water toxicity values. Consequently, we have not performed any further statistical evaluations of the triad hypothesis at this site.

6.0 EVALUATION OF AQUATIC EFFECTS TECHNOLOGIES

6.1 Introduction

The Heath Steele program evaluated several of the aquatic effects monitoring "tools" considered by AETE. These tools were evaluated through testing eight of the thirteen hypotheses pertinent to the 1997 field program, as well as by examination of other tool performance indicators other than those specific to these hypotheses (e.g., other apparent cause-effect relationships, practical aspects, etc.). To avoid repetition, the cost-effectiveness aspects are considered collectively in the summary report on all four 1997 field sites, because costs for each specific technology were approximately equal at the four sites (BEAK and GOLDER, 1998b).

Monitoring tools may be organized within "tool boxes" under the four guiding questions formulated under the AETE program to develop the hypotheses tested (from Section 1.1):

1. Are contaminants getting into the system?
2. Are contaminants bioavailable?
3. Is there a measurable (biological) response? and
4. Are contaminants causing the response?

Tool boxes and monitoring tools may be categorized under these four questions. Some tools may logically fit under more than one question; for example, toxicity testing tools may fit under Questions 1, 2 or 3. Table 6.1 provides a reasonable framework for organization of these tools, although alternate frameworks may be equally valid.

The fourth question cannot be answered by the application of individual tools, unlike the first three questions. Rather, the fourth question can be answered only by integrating the use of tools between and among tool boxes through testing for statistical linkages between potential cause and effect variables (e.g., do chemical concentrations and biological measurements correlate with one another?). The most effective tools are clearly those used in combinations that provide a yes response to Question No. 4.

TABLE 6.1: GUIDING QUESTIONS, TOOL BOXES AND TOOLS CONSIDERED IN THE 1997 FIELD PROGRAM. TOOL BOXES AND TOOLS IN BOLD PRINT ARE SPECIFICALLY CONSIDERED AT HEATH STEELE.

Question	Tool Boxes	Tools
Are contaminants getting into the system?	**Water chemistry**	• **total metal concentrations** • **dissolved metal concentrations**
	Sediment chemistry[1]	• **total metal concentrations** • partial metal concentrations
Are contaminants bioavailable?	**Fish tissues**	• **organ/tissue metal concentration** • **organ/tissue metallothionein concentration**
Is there a measurable response?	**Effluent chronic toxicity**[2]	• **fathead minnow survival and growth test** • ***Ceriodaphnia dubia* (microcrustacean) survival and reproduction test** • ***Selenastrum capricornutum* (algae) growth test** • ***Lemna minor* (duckweed) growth test**
	Sediment toxicity	• *Chironomus riparius* (larval insect) survival and growth test • *Hyalella azteca* (crustacean) survival test • *Tubifex tubifex* (aquatic worm) survival and reproduction test
	Fish health indicators	• **fish growth (length, weight and age)** • fish organ size
	Fish population/community health indicators	• **fish catch-per-unit-effort (CPUE - by species and total)** • **fish biomass-per-unit-effort (BPUE - by species and total)**
	Benthic community health indicators	• **densities of benthic invertebrates** • **numbers of benthic invertebrates** • **benthic community indices (e.g., EPT index)** • **frequency of chironomid deformity**
	Periphyton community health indicators	• **periphyton community biomass** • **numbers of periphyton taxa**
Are contaminants causing the response?	**Pair-wise combinations of the above tool boxes**	• **chemistry x biology tool correlations** • **toxicity x biology tool correlations** • chemistry x toxicity tool correlations

[1] Periphyton metal concentration used as a surrogate for sediment metal concentration as a predictor of benthic effects at Heath Steele.

[2] Effluent chronic toxicity measured in the laboratory may also be categorized under Questions 1 or 2 (Are contaminants getting into the system?, or, Are contaminants bioavailable?).

The hypotheses are formulated to answer two general types of questions:

- Is the tool effective in measuring a mine effect (i.e., is there a reference - exposure difference or an exposure area gradient)?; and
- Is one tool more effective than another in measuring an effect?

The "effectiveness" of monitoring tools as discussed herein is specific to the Heath Steele data set. Heath Steele represents one of four mine sites considered in the AETE 1997 Field Program, and only one of dozens of mine sites across Canada. A tool that is found to be of little value at Heath Steele for detecting mine effects may be very useful at other sites and vice versa. Therefore, the reader is cautioned not to assume that the conclusions drawn with Heath Steele data will necessarily be broadly valid at mines across Canada. As shown in the AETE 1997 Field Program Summary Report, monitoring tools can respond very differently from site to site (BEAK and GOLDER, 1998b). Also, the presence or absence of a particular mine-related effect may simply reflect exposure level or bioavailability at the site. In the latter case, the absence of an effect may simply indicate that the tool was suitable for showing no effect. However, the degree of impact known to occur at Heath Steele and the aqueous concentrations of metals typically present are consistent with conditions which should demonstrate the effectiveness of monitoring tools unless they are insensitive.

6.2 Are Contaminants Getting Into the System?

6.2.1 Water Chemistry Tool Box

Hypothesis Testing Aspects

At Heath Steele, water chemistry sampling showed that metals were "getting into the system" in the vicinity of the mine's monitoring station, HS-3. This was demonstrated by a downstream gradient in total and dissolved concentrations of zinc, copper, lead, cadmium and aluminum. A gradient was also observed for lead and possibly iron concentrations in periphyton, but gradients were generally not evident for other metals in periphyton.

In testing of Hypotheses H9, H10 and H12, measured aqueous concentrations of metals from the Heath Steele site were effectively correlated with fish community health indicators (CPUE, BPUE, number of fish taxa), benthic community health indicators (density, numbers of taxa, EPT index) and some visceral metal and MT concentrations in wild Atlantic salmon and blacknose dace. However, metal concentrations in water were more strongly correlated with visceral MT than with visceral metal concentration in all fish examined.

Biological (fish and benthic) community responses were similarly correlated with dissolved metal concentration and total metal concentration in water in H9. Total metals in periphyton were generally more weakly correlated with biological responses than were metal concentrations in water in H10.

Other Considerations

The collection of dissolved metal water samples according to the methods described in Annex 1 was not onerous, but required approximately five technician hours (additional relative to total metal samples) to filter and preserve the 18 samples (16 plus 2 duplicates) and appropriate filter blanks.

The syringes used, based on recommendations by chemists at the Geological Survey of Canada (GSC), were difficult to procure in Canada. Importation of the syringes from the U.S. required over one month due to delays at Canada Customs; thus, syringes were borrowed from GSC until delivery of the order.

The commercial laboratory used required very specific instruction to provide sampling containers and filtration materials consistent with the specifications provided by GSC. For example, commercial laboratories often provide low density rather than high density polyethylene containers for metal samples, and may also provide containers with coloured lids such as “Falcon” tubes to consultants or mining companies. GSC has shown that such containers can contribute low levels of metals to water samples, and thus may not be suitable in aquatic effects monitoring where metal concentrations of interest are equal to or often below surface water quality guidelines.

The filtration procedure involved squeezing the water through a syringe-mounted filter, and was somewhat difficult and time-consuming due to the slow rate of filtration, rinsing requirements, etc. Also, where suspended solids levels are higher (generally not at Heath Steele), filters became quickly clogged and required replacement.

Although no significant sample contamination was apparent in the dissolved metal results and in the filter blanks (i.e., dissolved metal concentrations were generally less than or equal to total metal concentrations and blanks were generally below detection limits), a greater potential for sample contamination exists in the field for dissolved metals than for total metals owing to the handling required. Some contamination was apparent at one of the other three sites.

To conclude, water chemistry (metal concentration) measurements were effectively correlated with biological effects in fish and benthos at Heath Steele. Dissolved and total metal concentrations were similarly correlated with biological effects, and water concentrations were more often and more strongly correlated with biological effects than were periphyton metal concentrations.

6.2.2 Sediment (Periphyton) Chemistry Tool Box

Hypothesis Testing Aspects

The periphyton metal tool, as a possible surrogate for sediment metals, has been evaluated by identifying reference versus exposure differences or concentration trends within the exposure gradient, and by examination of periphyton as a possible causal agent for biological responses (H10, H12).

In general, reference-exposure differences in periphyton metal concentrations were observed for zinc, lead, cadmium and copper, and exposure area trends for lead and iron. These trends could, in part, be due to the effects of metal precipitates (e.g., iron hydroxide) collecting on the stream substrate (and forming part of the periphyton samples).

Periphyton metal concentrations provided some linkages to biological effects. In particular, periphyton metal levels were correlated with benthic and fish community responses, as well as with some metal levels in blacknose dace viscera from the exposure area. Within exposure reaches, periphyton metal concentrations were generally better correlated with visceral metal concentrations than were aqueous metal concentrations in blacknose dace. This may, in part, be due to the fact that blacknose dace are known to feed on algal species (Scott and Crossman, 1973).

Other Considerations

At Heath Steele, variability in the periphyton growth forms and species present affected the biological composition of the sample collected and in turn probably influenced metal concentrations. Species composition and biomass varied substantially from site to site, potentially affecting metal bioaccumulation within any particular sample. Also, material other than algae may be present in the samples such as mineral precipitates and bacterial slimes. These factors may be more important in influencing metal concentrations in periphyton than in sediment material.

Periphyton was relatively easy to collect in the field. However, at some stations, growth was sparse and collection times of up to 10 to 15 minutes per sample were necessary. Although this collection time is not excessive, it generally exceeds the time needed to collect a water or sediment sample. Periphyton samples, however, required minimal preparation after collection (label and freeze only).

Periphyton metal concentrations may be most useful in identifying whether contaminants are "getting into the system" in special cases where aqueous metal concentrations are affected only sporadically (e.g., only in response to runoff or to intermittent effluent discharge), with concentrations approaching natural background between these impact events. In cases where soft sediments are sparse or absent (e.g., a fast-flowing river), periphyton metal concentrations may be effective in integrating the ranges of water quality conditions prevailing in the recent past.

6.3 Are Contaminants Bioavailable?

6.3.1 Tissue Metal Concentrations

Hypothesis Testing Aspects

At Heath Steele, the effectiveness of visceral metal concentration as an indicator of metal bioavailability is measured from the identification of differences in concentrations between reference and exposure areas and/or the occurrence of linear trends within the exposure reaches. Effectiveness is also determined by the strength of correlations between possible causal agents (metals in water or periphyton) and metals in viscera.

Reference area-exposure area differences in visceral metal concentrations were observed for lead in wild Atlantic salmon and copper and zinc in blacknose dace, although no concentration trends were seen in either species in the exposure zone. Reference-exposure area differences were also apparent for visceral copper and cadmium in brook trout, with a possible exposure area trend indicated for copper.

Visceral metal concentrations in wild fish were not correlated with exposure to metals in water. However, blacknose dace Cu, Pb and Zn in viscera were correlated with concentrations of the same metals in periphyton, reflecting a possible food chain linkage.

Metal bioavailability was not indicated by visceral metal concentrations in caged Atlantic salmon exposed for nine days downstream of Heath Steele. The reduction or elimination of feeding by these fish in the cages may have reduced any food intake pathway for metals, and the exposure time may have been inadequate to induce the effect seen in wild fish. However, because MT results suggest that metal exposure has occurred, the absence of apparent response in metal concentration might be attributed to homeostatic processes in the viscera, potentially involving MT.

Gill in caged salmon appeared to respond to metal exposure, with gill cadmium levels in particular paralleling the aqueous cadmium gradient present. Although Hypothesis 2 was not specifically intended for testing at Heath Steele, the results of gill and visceral analyses in caged fish imply that at least for short-term metal exposures, analysis of metals in gill may be a better indicator of metal bioavailability than metals in viscera.

Other Considerations

From a practical standpoint, processing of small fish for metal analysis is accomplished more quickly than required for larger fish at other mine sites. Small fish samples were easily processed in the field simply by freezing the whole fish on dry ice. These fish were dissected and the tissues processed and analyzed for metals and MT by the Department of Fisheries and Oceans, Winnipeg, Manitoba. At most Heath Steele sites, small fish were abundant and could be sampled quickly by electrofisher during one visit to each station (versus use of gillnets for larger fish).

It is not certain to what extent visceral analysis is influenced by the quantity of food present in the gut of the fish. However, one might assume that visceral metal concentration may be either reduced or increased in viscera following feeding periods, depending on metal concentrations in the food consumed. For example, the correlation between periphyton metal concentrations and metal concentrations in blacknose dace viscera may reflect either bioaccumulation by the tissues or simply the presence of periphyton in the alimentary canal. This possible source of variation would not occur in the analysis of individual organs or tissues.

6.3.2 Tissue Metallothionein Concentrations

Hypothesis Testing Aspects

The effectiveness of visceral MT concentration as an indicator of metal bioavailability is measured as described above for visceral metals (i.e., by reference-exposure area differences, exposure area trends and correlations with possible causal agents). A reference-exposure difference and/or an exposure area trend indicate an effective tool response.

Reference area-exposure area differences in visceral MT were evident in blacknose dace viscera, with a linear trend indicated for caged salmon. The reference area-exposure area difference was weak and not significant for wild salmon ($p = 0.099$). The exposure area trend for blacknose dace was also weak and not significant ($p = 0.06$).

Visceral MT levels responded to exposure concentrations in water for exposure area wild salmon for most metals of concern. Visceral MT levels in caged salmon were strongly correlated with aqueous metal concentrations. Correlations between exposure concentrations of metals and visceral MT were found in blacknose dace only for lead.

Although Hypothesis 3 was not specifically intended for testing at Heath Steele, the analysis of both gill and viscera in caged Atlantic salmon appears to indicate that, for short-term exposures, both tissue types responded similarly to exposure. However, gills from two fish were necessary to provide sufficient mass for a single sample for analysis of MT and metals (in contrast to viscera from a single fish).

Other Considerations

The collection of fish for MT analysis at Heath Steele was accomplished readily and fish required little processing, as described in Subsection 6.3.1. Maintenance of a reliable supply of dry ice required for preservation of tissues for MT analysis was somewhat problematic at Heath Steele owing to the absence of a commercial supply in Miramichi and a requirement for courier deliveries from Halifax, Nova Scotia. Maintenance of a dry ice supply required daily diligence to confirm orders and to track deliveries. Also, a dry ice quantity limitation of 2 kg on passenger aircraft required an unscheduled re-packaging of samples at the airport and a requirement for immediate replenishment of the dry ice supply upon sample arrival at BEAK.

6.3.3 Tissue Metal vs Metallothionein Comparison

Based on the Heath Steele data, MT and metal concentrations in wild fish viscera and caged fish gill both responded to metal exposure. Visceral MT was better correlated with metal concentrations in the environment than were visceral metals in salmon, while the reverse was true for blacknose dace. For shorter-term exposure using salmon, visceral MT was more effective than visceral metal concentration.

The correlation matrix of tissue metal versus metallothionein concentrations in fish viscera and gill suggests that some metals are more closely associated with tissue metallothionein than others. For fish at Heath Steele, the highest correlation coefficients occur for cadmium in most cases where metal-metallothionein relationships were apparent. This suggests that MT is likely more effective in reflecting the bioavailability of some metals than others.

6.4 Is There A Measurable Effect?

6.4.1 Effluent Chronic Toxicity

Hypothesis Testing Aspects

Estimates of *in situ* chronic toxicity, based on effluent toxicity test results and a Tomogonops River dilution model, were correlated with *in situ* effects in some fish community and benthic community indices. The three most sensitive tests (*Ceriodaphnia, Selenastrum* and duckweed) were more effective than the least sensitive (fathead minnow) test. This ability to predict biological effects with Heath Steele toxicity results is intuitively reasonable, because chronic effect endpoints occurred at effluent concentrations also found along the exposure gradient.

Predicted *in situ* chronic toxicity was also strongly correlated with measured metal concentrations in water. Thus, a strong cause-effect linkage is implied between water concentrations and chronic toxicity, as well as between chronic toxicity and in-stream response.

Other Considerations

Of the four tests, *Selenastrum* and *Ceriodaphnia* were the most sensitive to Heath Steele "effluent", and fathead minnow was the least sensitive. All tests effectively measured chronic toxicity except in one case (June 1997 sample) when no lethal or sublethal effect was measured in fathead minnow.

As documented in the Summary Report (BEAK and GOLDER, 1998b), similar toxic responses were obtained in chronic testing of *Ceriodaphnia* and fathead minnow using Heath Steele site dilution water and laboratory dilution water having a hardness similar to site water. Thus, for Heath Steele, little or no reduction in toxicity was achieved in site dilution water, in spite of the presence of potential modifying factors such as dissolved organic carbon (typically 3 to 5 mg/L) in site water.

Testing of H13 as worded could have been undertaken more directly by measuring chronic toxicity in water collected from each downstream exposure station. In this way, linkages between causal agents (toxicity) and biological response would be based on data from the site rather than from toxic responses predicted indirectly from testing of effluent. In practice, however, this alternate approach would have been problematic owing to difficulties in discerning responses at effluent concentrations that in many cases would have been low relative to effect concentrations, and to the dilution water effect (as noted below) which would have been inherent in the samples.

Use of site dilution water was associated with invalid test results for fathead minnow in two of the three Heath Steele tests, as well as in some of the fathead minnow tests completed for the other mines in this program. This condition arose from excessive mortalities in control fish, apparently in response to fungal growth on the fish.

In terms of the practical aspects of the testing, use of site dilution water added a level of difficulty to test logistics. In particular, use of site dilution water added to the acclimation requirements for fathead minnow and *Ceriodaphnia*, and necessitated additional sampling effort and shipping expense.

6.4.2 Fish Growth

Hypothesis Testing Aspects

In neither juvenile Atlantic salmon nor in blacknose dace was fish size at age related to effluent exposure. The only reference-exposure difference seen in size at age was in the occurrence of larger Atlantic salmon in the exposure area than in the reference area, possibly owing to greater density effects (competition) in the reference area. This result is interesting in light of the evidence for other effects on fish at the population and community levels in that fish apparently are diminished in numbers in exposure areas, but the fish present in exposure areas are not impaired in terms of growth.

6.4.3 Fish CPUE and BPUE

Hypothesis Testing Aspects

CPUE or BPUE for all fish species combined effectively responded to effluent exposure, as measured in H5, H6 and H9. The CPUE and BPUE tools were similarly effective for juvenile Atlantic salmon among comparable stations, but not for other individual species such as blacknose dace or brook trout. CPUE and BPUE were particularly effective in showing a spatial trend consistent with the aqueous metal gradient in the exposure area.

Other Considerations

CPUE and BPUE were readily measured in the field, with two monitoring stations completed by a crew of two each day. This effort included often difficult site access, as well as the identification and processing of all fish captured.

6.4.4 Benthic Community Health Indicators

Hypothesis Testing Aspects

Monitoring of benthic community parameters was effective in identifying metal exposure responses in the exposure area at Heath Steele, with effects on numbers of taxa, EPT index and numbers of specific species evident. This effectiveness was evident in terms of reference-exposure differences and with respect to correlations with aqueous metal concentrations. Total benthic density was not effective in distinguishing an exposure effect, because metal-tolerant forms replaced more sensitive species in exposure areas.

Benthic indices could be predicted based on metal concentrations in the water. This strengthens our conclusion that the response is associated with metal exposure. Weaker associations were seen between benthic indices and periphyton metals, suggesting that effects are predominantly associated with exposure to aqueous metals.

Other Considerations

The incidence of chironomid abnormality, based on examination of mouth parts in mounted specimens, was low throughout the reference and exposure area (Appendix 5), indicating that this tool would be ineffective in measuring biological responses to metals at Heath Steele.

The presence of a very rich and diverse benthic fauna in the Tomogonops River probably enhances the sensitivity of benthic monitoring to metal exposure. Similar trends can be more difficult to discern in aquatic habitats supporting a less diverse benthic assemblage.

6.4.5 Periphyton Community Indicators

Hypothesis Testing Results

Periphyton densities and numbers of taxa did not show a reference-exposure area difference or a trend consistent with a response in the exposure gradient. Based on this result, periphyton community conditions were ineffective in monitoring exposure at Heath Steele.

Other Considerations

Periphyton communities may be affected by degree of shading by riparian vegetation, substrate type, flow conditions and other aspects of habitat. Monitoring of periphyton on artificial substrates (colonization surfaces) could be more effective than natural community monitoring, because it would provide a standard surface for colonization. However, this would necessitate a return field trip to retrieve the substrates. Monitoring of natural benthic communities offers a clear advantage over periphyton as a biomonitoring tool in terms of cost effectiveness, ease of sample collection and environmental relevance.

6.5 Are Contaminants Causing the Responses?

As indicated previously, this question is not answered directly through the application of specific monitoring tools evaluated in this study, or through any of the hypotheses tested. Rather, the question is evaluated only by a weight-of-evidence provided by affirmative responses to the first three questions, and particularly by the strength of correlations between exposure indicators (chemical concentrations) and biological responses in hypotheses H9 through H13.

At Heath Steele, evidence indicates that contaminants are getting into the system and are bioavailable, and that certain biological responses are correlated with metal concentrations in the environment. Certain fish community and benthic community responses are correlated with aqueous concentrations of metals in the Tomogonops River, and the directions of exposure-response relationships are consistent with biological effects. Furthermore, *in situ* toxicity predicted from laboratory toxicity testing is also correlated with these biological effects. Accordingly, the field data support a conclusion that “contaminants are causing the responses”. However, dose-response relationships in the field do not necessarily prove cause and effect. Rather, a combination of controlled laboratory testing of metal toxicity and field evidence such as provided herein would be appropriate to provide further detail on cause and effect (e.g., which metals individually or in combination produce a response).

6.6 Section Summary

Table 6.2 provides a summary of the effectiveness rankings of the aquatic monitoring tools evaluated at Heath Steele. Table 6.3 compares the effectiveness of alternate tools that may be used to measure metal concentrations, metal bioavailability or biological response.

For Table 6.2, the rankings are based on those statistical indicators of mine effect available for each tool (reference-exposure differences, exposure area trends, etc.). The "Effect Detected" ranking is used when effects are consistently measured for a tool at Heath Steele. An "Effect not Demonstrated" ranking means that effects are never measured with the tool in question at Heath Steele. The "Effect Partially Demonstrated" category applies when effects are measured in only some cases with a particular tool. For example, statistically significant MT responses in fish occurred in blacknose dace and caged juvenile salmon but not in wild salmon. Thus, MT in viscera demonstrated a partial effect.

Overall, most of the tools evaluated were effective or somewhat effective. Periphyton community structure, fish growth and benthic community density were ineffective. Of those tools that were effective, some were more effective than others as predictors of biological response.

TABLE 6.2: EFFECTIVENESS OF MONITORING TOOLS TESTED AT HEATH STEELE (Note: Refer to Table 6.3 for tool comparisons)

Tool Boxes	Tools	Effectiveness			Comment
		Effect Demonstrated	Effect Partially Demonstrated	Effect Not Demonstrated	
Water Chemistry	Total Metals	√			Gradient in Zn, Cd, Cu, Pb and Al in exposure area. Correlated with biological effects and tissue MT and metal levels.
	Dissolved Metals	√			Gradient in Zn, Cd, Cu, Pb and Al in exposure area. Correlated with biological effects and tissue MT and metal levels.
Sediment (Periphyton) Chemistry	Periphyton Metals		√		Gradient in exposure area evident for Pb and Fe. Some correlations occurred between periphyton metals and biological/tissue responses.
Fish Tissues	Visceral Metals		√		Visceral metal levels responded to metal exposure (increase in exposure area fish) but little or no trend present in exposure area. Visceral metals in caged salmon did not respond to metal gradient.
	Gill Metals		√		Gill metals responded effectively to exposure over nine days in caged salmon, especially for Cd. Spatial trends not well developed for other metals.
	Visceral MT		√		Visceral MT levels responded to metal exposure (increase in exposed fish) in blacknose dace. Visceral MT showed clear spatial trend in exposed caged salmon, but no significant response seen in wild salmon.
	Gill MT	√			Gill MT showed clear spatial trend in exposed juvenile salmon (caged).
Effluent Toxicity	*Ceriodaphnia*	√			*Ceriodaphnia* and *Selenastrum* were the most sensitive tests. All tests were correlated with some *in situ* benthic/fish effects.
	Selenastrum	√			*Ceriodaphnia* and *Selenastrum* were the most sensitive tests. All tests were correlated with some *in situ* benthic/fish effects.

TABLE 6.2: EFFECTIVENESS OF MONITORING TOOLS TESTED AT HEATH STEELE (Note: Refer to Table 6.3 for tool comparisons)

Tool Boxes	Tools	Effectiveness Effect Demonstrated	 Effect Partially Demonstrated	 Effect Not Demonstrated	Comment
Effluent Toxicity (cont'd)	*Lemna minor*	√			*Ceriodaphnia* and *Selenastrum* were the most sensitive tests. All tests were correlated with some *in situ* benthic/fish effects.
	Fathead minnow		√		Fathead minnow was the least sensitive of the four tests and presented difficulties in acclimation to site water.
Fish Health Indicators	Growth			√	No effects on growth seen in sentinel species.
Fish Population/ Community Health Indicators	CPUE/BPUE	√			Catch and biomass of fish per unit effort effective in responding to exposure. Total community results (all fish) affected more clearly than individual species.
Benthic Community Health Indicators	Benthic Density			√	Exposure-reference difference or exposure trend not evident.
	No. of Taxa		√		Exposure-reference difference evident; exposure area trend apparent but not significant.
	No. of EPT Taxa	√			• Exposure-reference difference evident • Exposure area trend evident and significant.
	Abundances of Indicator Species	√			• Exposure-reference difference evident. • Exposure area trend evident and significant.
Periphyton Community Health Indicators	Periphyton Biomass			√	Reference-exposure area differences or exposure area trends not observed.
	No. of Periphyton Taxa			√	

TABLE 6.3: COMPARATIVE EFFECTIVENESS OF MONITORING TOOLS AT HEATH STEELE

Tools	Comparison
Total Metals vs Dissolved Metals in Water	Dissolved metal and total metal concentrations were similar in terms of strength of correlation with biological responses.
Metals in Water vs Metals in Periphyton	Metals in water rather than periphyton were more strongly correlated with community level biological responses on balance. Periphyton Cu, Zn and Pb were better correlated with visceral metals in blacknose dace than were aqueous metals, possibly reflecting periphyton in the gut.
Visceral Metals vs Visceral MT in Fish	On balance, MT responded more frequently or strongly to exposure than did metals in small fish viscera. Effectiveness differed greatly from species to species and MT only responded in caged salmon. The responsive metals variously included Zn, Pb, Cu and Cd.
Gill Metals vs Gill MT in (Caged) Salmon	Gill metals were variable in responsiveness to exposure (Cd most effective); gill MT was effective.
Visceral Metals vs Gill Metals in (Caged) Salmon	Gill concentrations of some metals were responsive to exposure. Visceral metals were not.
Visceral MT vs Gill MT in (Caged) Salmon	Visceral and gill MT appeared equally responsive to exposure.
Effluent Chronic Toxicity Tests	All tests were effective in predicting in-stream effects on natural communities; fathead minnow test was the least sensitive of the four.
Fish CPUE/BPUE (individual species vs whole community)	CPUE and BPUE were responsive to exposure; CPUE and BPUE were more responsive at the community level (all fish) than at the individual species level.
Benthic Community Health Indicators (density, no. of taxa, EPT index, indicator taxa)	Benthic EPT index and abundances of some indicator species were more responsive than numbers of taxa to exposure. Total densities did not respond effectively. Only a selected subset of indices was tested (beyond core hypotheses requested by AETE).

7.0 REFERENCES

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APPENDIX 1

Quality Assurance/Quality Control

BEAK MEMO

To: **Paul McKee, Project Manager** **From: Guy Gilron, QA Officer**
Dennis Farara, Project Manager **Pierre Stecko, QA Officer**

Ref: **AETE 1997 - Heath Steele Data QA Report** **Date: May 04, 1998**

We have reviewed the 1997 AETE data collected from the Heath Steele mine and have conducted a data quality assessment in comparison to the data quality objectives (DQO) outlined in the Quality Management Plan (QMP). A summary of the results of the data quality assessment is presented below, categorized by study.

Benthos (Table A1.1)

DQOs for percent recovery (≥ 95%) and laboratory precision (≥ 80%) were met based on an assessment of percent recovery in samples HR3A and HR4A and sub-sampling error in samples HR2B and HE4A. **NO FLAGS.**

Water Chemistry (Table A1.2)

Analysis of trip and filter blanks met DQOs in all cases. There were no DQOs set for laboratory precision for water chemistry. However, we have flagged parameters with >50% difference (as a percentage of the mean). No such differences occurred between laboratory replicate samples. **FLAGS:** Differences of greater than 50% between field duplicates were observed for ion balance (HE1A; HR1A), orthophosphates (HE1A; HR1A), total suspended solids (HR1A) and turbidity (HR1A).

Metals and Nutrients (Table A1.2)

Analysis of trip and filter blanks met DQOs in all cases. In addition, none of the metals and nutrients were flagged due to differences greater than 50% between laboratory replicates or field duplicates. **NO FLAGS.**

Sediment

There were no sediments collected at the Heath Steele Mine (periphyton was done instead; see below).

Periphyton (Table A1.3)

Recovery of metals in matrix spikes varied from 84 to 110%, while the DQO for laboratory accuracy was 10% (i.e., 90 to 110% recovery). With the exception of lead (11%), all metals of concern were within the 10% limit. **FLAGS:** arsenic, beryllium, boron, chromium, cobalt, lead, nickel, selenium, and titanium at HE1A. In addition, tin at HE1A exceeded the DQO for laboratory precision (10%), and the variability among field duplicates (taken at HE2B and HE3B) was high.

Water Toxicity (Table A1.4)

All DQOs for water toxicity (i.e., minimum significant difference, control mortality, control and reference toxicant variability, and accuracy of the reference toxicant) were achieved. **NO FLAGS.**

Sediment Toxicity

There were no sediments collected at the Heath Steele Mine, therefore there were no sediment toxicity tests conducted.

Table A1.1: Results of Benthic Sorting Recovery Check and Subsampling Check, Heath Steele

Station	Number of Animals Recovered	Number of Animals in Re-sort	Percent Recovery
HR3A	407	13	96.9
HE4A	409	7	98.3

Calculation of subsampling error

Station	Number of Animals in Fraction 1	Number of Animals in Fraction 2	Standard Deviation	Coefficient of Variation
HR2B	507	510	2.12	0.417172142
HE4A	418	466	33.94	7.678987669

samples that required subsampling

Station	Fraction Sorted
HE1A	1/8
HE1B	1/4
HE2A	3/16
HE2B	3/16
HE3A	1/8
HE3B	1/8
HE4A	1/8 *
HE4B	1/8
HE5A	1/2
HE5B	1/8
HR1A	1/8
HR1B	1/8
HR2A	1/8
HR2B	1/8*
HR3A	1/8
HR3B	1/8

Table A1.2: Heath Steele Water Chemistry QA/QC

Analysis of Water			**EXPOSURE STATIONS**									
Parameter	LOQ	Units	HE1A-W-Total	HE1A-W-Total Lab Rep	**DQA (% diff) vs.LR**	HE1A-W-Total Field Dup	**DQA (% diff) vs. FD**	HE1A-W Dissolved	HE1A-W Dissolved Lab Rep	**DQA (% diff) vs. LR**	HE1A-W Dissolved Field Dup	**DQA (% diff) vs. FD**
Acidity(as CaCO3)	1	mg/L	4	4	-	6	**40.00**	-	-	-	-	-
Alkalinity(as CaCO3)	1	mg/L	5	5	**0.00**	5	**0.00**	-	-	-	-	-
Aluminum	0.005	mg/L	0.322	-	-	0.316	**1.88**	0.185	0.187	**1.08**	0.185	**0.00**
Ammonia(as N)	0.05	mg/L	nd	nd	nd	-	-	-	-	-	-	-
Anion Sum	na	meq/L	0.329	-	0.32	**2.77**	-	-	-	-	-	-
Antimony	0.0005	mg/L	nd	-	-	nd	-	nd	nd	-	nd	-
Arsenic	0.002	mg/L	nd	-	-	nd	-	nd	nd	-	nd	-
Barium	0.005	mg/L	nd	-	-	nd	-	nd	nd	-	nd	-
Beryllium	0.005	mg/L	nd	-	-	nd	-	nd	nd	-	nd	-
Bicarbonate(as CaCO3, calculated)	1	mg/L	5	-	-	5	**0.00**	-	-	-	-	-
Bismuth	0.002	mg/L	nd	-	-	nd	-	nd	nd	-	nd	-
Boron	0.005	mg/L	nd	-	-	nd	-	nd	nd	-	nd	-
Cadmium	0.00005	mg/L	0.00032	-	-	0.00032	**0.00**	0.00032	0.00032	**0.00**	0.00034	**6.06**
Calcium	0.1	mg/L	3.5	-	-	3.4	**2.90**	3.5	3.4	**2.90**	3.5	**0.00**
Carbonate(as CaCO3, calculated)	1	mg/L	nd	-	-	nd	-	-	-	-	-	-
Cation Sum	na	meq/L	0.342	-	-	0.355	**3.73**	-	-	-	-	-
Chloride	1	mg/L	2	2	**0.00**	2	**0.00**	-	-	-	-	-
Chromium	0.0005	mg/L	nd	-	-	nd	-	nd	nd	-	nd	-
Cobalt	0.0002	mg/L	0.0021	-	-	0.0021	**0.00**	0.0021	0.002	**4.88**	0.0019	**10.00**
Colour	5	TCU	50	48	**4.08**	43	**15.05**	-	-	-	-	-
Conductivity - @25øC	1	us/cm	46	46	**0.00**	44	**4.44**	-	-	-	-	-
Copper	0.0003	mg/L	0.0225	-	-	0.0224	**0.45**	0.0201	0.0191	**5.10**	0.0189	**6.15**
Dissolved Inorganic Carbon(as C)	0.2	mg/L	-	-	-	-	-	0.6	0.5	**18.18**	0.8	**28.57**
Dissolved Organic Carbon(DOC)	0.5	mg/L	-	-	-	-	-	4.5	4.5	**0.00**	4.2	**6.90**
Hardness(as CaCO3)	0.1	mg/L	12.8	-	-	12.9	**0.78**	-	-	-	-	-
Ion Balance	0.01	%	1.92	-	-	5.19	**91.98**	-	-	-	-	-
Iron	0.02	mg/L	0.67	-	-	0.65	**3.03**	0.32	0.32	**0.00**	0.32	**0.00**
Langelier Index at 20øC	na	na	-3.6	-	-	-3.4	**5.56**	-	-	-	-	-
Langelier Index at 4øC	na	na	-4	-	-	-3.8	**5.13**	-	-	-	-	-
Lead	0.0001	mg/L	0.003	-	-	0.0031	**3.28**	0.001	0.001	**0.00**	0.0011	**9.52**
Magnesium	0.1	mg/L	1	-	-	1	**0.00**	1	1	**0.00**	1	**0.00**
Manganese	0.0005	mg/L	0.103	-	-	0.102	**0.98**	0.0973	0.0957	**1.66**	0.0919	**5.71**
Mercury (dissolved)	0.0001	mg/L	-	-	-	-	-	nd	nd	-	nd	-
Mercury (total)	0.0005	mg/L	nd	nd	-	nd	-	-	-	-	-	-
Molybdenum	0.0001	mg/L	nd	-	-	nd	-	nd	nd	-	nd	-
Nickel	0.001	mg/L	nd	-	-	nd	-	nd	nd	-	nd	-
Nitrate(as N)	0.05	mg/L	nd	nd	-	nd	-	-	-	-	-	-
Nitrite(as N)	0.01	mg/L	nd	nd	-	nd	-	-	-	-	-	-
Orthophosphate(as P)	0.01	mg/L	0.01	0.01	**0.00**	0.06	**142.86**	-	-	-	-	-
pH	0.1	Units	6.6	6.5	**1.53**	6.8	**2.99**	-	-	-	-	-
Phosphorus	0.1	mg/L	nd	-	-	nd	-	nd	nd	-	nd	-
Potassium	0.5	mg/L	1	-	-	1.1	**9.52**	nd	nd	-	0.8	-
Reactive Silica(SiO2)	0.5	mg/L	5.1	-	-	5.1	**0.00**	-	-	-	-	-
Saturation pH at 20øC	na	units	10.2	-	-	10.2	**0.00**	-	-	-	-	-
Saturation pH at 4øC	na	units	10.6	-	-	10.6	**0.00**	-	-	-	-	-
Selenium	0.002	mg/L	nd	-	-	nd	-	nd	nd	-	nd	-
Silver	0.00005	mg/L	nd	-	-	nd	-	nd	nd	-	nd	-
Sodium	0.1	mg/L	1.7	-	-	1.7	**0.00**	1.8	1.8	**0.00**	1.8	**0.00**
Strontium	0.005	mg/L	0.014	-	-	0.014	**0.00**	0.012	0.013	**8.00**	0.013	**8.00**
Sulphate	2	mg/L	9	9	**0.00**	9	**0.00**	-	-	-	-	-
Thallium	0.0001	mg/L	nd	-	-	nd	-	nd	nd	-	nd	-
Tin	0.002	mg/L	nd	-	-	nd	-	nd	nd	-	nd	-
Titanium	0.002	mg/L	0.002	-	-	0.003	**40.00**	nd	nd	-	nd	-
Total Dissolved Solids(Calculated)	1	mg/L	-	-	-	-	-	25	-	-	25	**0.00**
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	0.36	0.37	**2.74**	0.35	**2.82**	-	-	-	-	-
Total Suspended Solids	1	mg/L	2	2	**0.00**	2	**0.00**	-	-	-	-	-
Turbidity	0.1	NTU	2.6	2.5	**3.92**	2.4	**8.00**	-	-	-	-	-
Uranium	0.0001	mg/L	nd	-	-	nd	-	nd	nd	-	nd	-
Vanadium	0.002	mg/L	nd	-	-	nd	-	nd	nd	-	nd	-
Zinc	0.001	mg/L	0.157	-	-	0.15	**4.56**	0.158	0.162	**2.50**	0.157	**0.63**
Fluoride	0.02	mg/L	0.02	0.02	**0.00**	0.02	**0.00**	-	-	-	-	-

Table A1.2: Heath Steele Water Chemistry QA/QC

Analysis of Water			REFERENCE STATIONS								
Parameter	LOQ	Units	HR1A-W-Total	HR1A-W-Total Field Dup	DQA (% diff) vs. FD	HR1A-W Dissolved	HR1A-W Dissolved Field Dup	DQA (% diff) vs. FD	HR1B-W-Total	HR1B-W-Total Lab Rep	DQA (% diff) vs. LR
Acidity(as CaCO3)	1	mg/L	10	10	**0.00**	-	-	-	-	-	-
Alkalinity(as CaCO3)	1	mg/L	9	9	**0.00**	-	-	-	-	-	-
Aluminum	0.005	mg/L	0.031	0.03	**3.28**	0.019	0.019	**0.00**	0.047	-	-
Ammonia(as N)	0.05	mg/L	nd	nd	-	-	-	-	-	-	-
Anion Sum	na	meq/L	0.27	0.266	**1.49**	-	-	-	-	-	-
Antimony	0.0005	mg/L	nd	nd	-	nd	nd	-	nd	-	-
Arsenic	0.002	mg/L	nd	nd	-	nd	nd	-	nd	-	-
Barium	0.005	mg/L	nd	nd	-	nd	nd	-	nd	-	-
Beryllium	0.005	mg/L	nd	nd	-	nd	nd	-	nd	-	-
Bicarbonate(as CaCO3, calculated)	1	mg/L	9	9	**0.00**	-	-	-	-	-	-
Bismuth	0.002	mg/L	nd	nd	-	nd	nd	-	nd	-	-
Boron	0.005	mg/L	nd	nd	-	nd	nd	-	nd	nd	-
Cadmium	0.00005	mg/L	nd	nd	-	nd	nd	-	nd	-	-
Calcium	0.1	mg/L	2.5	2.5	**0.00**	2.4	2.6	**8.00**	2.5	2.5	**0.00**
Carbonate(as CaCO3, calculated)	1	mg/L	nd	nd	-	-	-	-	-	-	-
Cation Sum	na	meq/L	0.267	0.276	**3.31**	-	-	-	-	-	-
Chloride	1	mg/L	nd	nd	-	-	-	-	-	-	-
Chromium	0.0005	mg/L	nd	nd	-	nd	nd	-	nd	-	-
Cobalt	0.0002	mg/L	nd	nd	-	nd	nd	-	nd	-	-
Colour	5	TCU	32	33	**3.08**	-	-	-	-	-	-
Conductivity - @25øC	1	us/cm	32	32	**0.00**	-	-	-	-	-	-
Copper	0.0003	mg/L	nd	nd	-	nd	nd	-	nd	-	-
Dissolved Inorganic Carbon(as C)	0.2	mg/L	-	-	-	1.9	1.5	**23.53**	-	-	-
Dissolved Organic Carbon(DOC)	0.5	mg/L	-	-	-	2.7	2.8	**3.64**	-	-	-
Hardness(as CaCO3)	0.1	mg/L	9.8	10.1	**3.02**	-	-	-	-	-	-
Ion Balance	0.01	%	0.61	1.86	**101.21**	-	-	-	-	-	-
Iron	0.02	mg/L	0.09	0.08	**11.76**	0.05	0.05	**0.00**	0.08	-	-
Langelier Index at 20øC	na	na	-3.27	-3.09	**5.66**	-	-	-	-	-	-
Langelier Index at 4øC	na	na	-3.67	-3.49	**5.03**	-	-	-	-	-	-
Lead	0.0001	mg/L	nd	nd	-	nd	nd	-	nd	-	-
Magnesium	0.1	mg/L	0.9	0.9	**0.00**	0.9	0.9	**0.00**	0.9	0.9	**0.00**
Manganese	0.0005	mg/L	0.0163	0.0149	**8.97**	0.0031	0.003	**3.28**	0.0145	-	-
Mercury (dissolved)	0.0001	mg/L	-	-	-	nd	nd	-	-	-	-
Mercury (total)	0.0005	mg/L	nd	nd	-	-	-	-	nd	-	-
Molybdenum	0.0001	mg/L	nd	nd	-	nd	nd	-	nd	-	-
Nickel	0.001	mg/L	nd	nd	-	nd	nd	-	nd	-	-
Nitrate(as N)	0.05	mg/L	0.07	0.08	**13.33**	-	-	-	-	-	-
Nitrite(as N)	0.01	mg/L	nd	nd	-	-	-	-	-	-	-
Orthophosphate(as P)	0.01	mg/L	0.02	0.05	**85.71**	-	-	-	-	-	-
pH	0.1	Units	6.8	7	**2.90**	-	-	-	-	-	-
Phosphorus	0.1	mg/L	nd	nd	-	nd	nd	-	nd	nd	-
Potassium	0.5	mg/L	0.9	0.7	**25.00**	nd	nd	-	0.8	0.7	**13.33**
Reactive Silica(SiO2)	0.5	mg/L	7.5	7.4	**1.34**	-	-	-	-	-	-
Saturation pH at 20øC	na	units	10.1	10	**1.00**	-	-	-	-	-	-
Saturation pH at 4øC	na	units	10.5	10.4	**0.96**	-	-	-	-	-	-
Selenium	0.002	mg/L	nd	nd	-	nd	nd	-	nd	-	-
Silver	0.00005	mg/L	nd	nd	-	nd	nd	-	nd	-	-
Sodium	0.1	mg/L	1.4	1.3	**7.41**	1.4	1.4	**0.00**	1.3	1.3	**0.00**
Strontium	0.005	mg/L	0.01	0.011	**9.52**	0.009	0.009	**0.00**	0.011	-	-
Sulphate	2	mg/L	3	3	**0.00**	-	-	-	-	-	-
Thallium	0.0001	mg/L	nd	nd	-	nd	nd	-	nd	-	-
Tin	0.002	mg/L	nd	nd	-	nd	nd	-	nd	-	-
Titanium	0.002	mg/L	nd	nd	-	nd	nd	-	nd	-	-
Total Dissolved Solids(Calculated)	1	mg/L	-	-	-	22	22	**0.00**	-	-	-
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	0.26	0.26	**0.00**	-	-	-	-	-	-
Total Suspended Solids	1	mg/L	1	2	**66.67**	-	-	-	-	-	-
Turbidity	0.1	NTU	0.5	45	**195.60**	-	-	-	-	-	-
Uranium	0.0001	mg/L	nd	nd	-	nd	nd	-	nd	-	-
Vanadium	0.002	mg/L	nd	nd	-	nd	nd	-	nd	-	-
Zinc	0.001	mg/L	0.008	0.006	**28.57**	0.003	0.003	**0.00**	0.009	-	-
Fluoride	0.02	mg/L	nd	nd	-	-	-	-	-	-	-

Table A1.2: Heath Steele Water Chemistry QA/QC

Analysis of Water			REFERENCE STATIONS								
Parameter	LOQ	Units	HR3A-W Total	HR3A-W Total Lab Rep	**DQA (% diff) vs. LR**	HR3B-W- Total	HR3B-W- Total Lab Rep	**DQA (% diff) vs. LR**	HR3B-W Dissolved	HR3B-W Dissolved Lab Rep	**DQA (% diff) vs. LR**
Acidity(as CaCO3)	1	mg/L	4	-	-	2	2	**0.00**	-	-	-
Alkalinity(as CaCO3)	1	mg/L	32	-	-	32	31	**3.17**	-	-	-
Aluminum	0.005	mg/L	0.033	-	-	0.059	-	-	0.013	0.014	**7.41**
Ammonia(as N)	0.05	mg/L	nd	-	-	nd	nd	-	-	-	-
Anion Sum	na	meq/L	0.719	-	-	0.722	-	-	-	-	-
Antimony	0.0005	mg/L	nd	-	-	nd	-	-	nd	nd	-
Arsenic	0.002	mg/L	nd	-	-	nd	-	-	nd	nd	-
Barium	0.005	mg/L	0.006	-	-	0.006	-	-	nd	nd	-
Beryllium	0.005	mg/L	nd	-	-	nd	-	-	nd	nd	-
Bicarbonate(as CaCO3, calculated)	1	mg/L	32	-	-	32	-	-	-	-	-
Bismuth	0.002	mg/L	nd	-	-	nd	-	-	nd	nd	-
Boron	0.005	mg/L	nd	-	-	nd	-	-	nd	nd	-
Cadmium	0.00005	mg/L	nd	-	-	nd	-	-	nd	nd	-
Calcium	0.1	mg/L	10.9	-	-	10.9	-	-	11.4	11.3	**0.88**
Carbonate(as CaCO3, calculated)	1	mg/L	nd	-	-	nd	-	-	-	-	-
Cation Sum	na	meq/L	0.654	-	-	0.68	-	-	-	-	-
Chloride	1	mg/L	nd	-	-	nd	nd	-	-	-	-
Chromium	0.0005	mg/L	nd	-	-	nd	-	-	nd	nd	-
Cobalt	0.0002	mg/L	nd	-	-	nd	-	-	nd	nd	-
Colour	5	TCU	17	-	-	20	19	**5.13**	-	-	-
Conductivity - @25øC	1	us/cm	71	-	-	72	73	**1.38**	-	-	-
Copper	0.0003	mg/L	nd	-	-	nd	-	-	nd	nd	-
Dissolved Inorganic Carbon(as C)	0.2	mg/L	-	-	-	-	-	-	5	4.9	**2.02**
Dissolved Organic Carbon(DOC)	0.5	mg/L	-	-	-	-	-	-	2.7	na	-
Hardness(as CaCO3)	0.1	mg/L	29.8	-	-	31.5	-	-	-	-	-
Ion Balance	0.01	%	4.72	-	-	3	-	-	-	-	-
Iron	0.02	mg/L	0.14	-	-	0.18	-		0.09	0.08	**11.76**
Langelier Index at 20øC	na	na	-1.64	-	-	-1.55	-	-	-	-	-
Langelier Index at 4øC	na	na	-2.04	-	-	-1.95	-	-	-	-	-
Lead	0.0001	mg/L	nd	-	-	nd	-	-	nd	nd	-
Magnesium	0.1	mg/L	0.7	-	-	0.7	-	-	0.8	0.8	**0.00**
Manganese	0.0005	mg/L	0.0128	-	-	0.0165	-	-	0.0069	0.0069	**0.00**
Mercury (dissolved)	0.0001	mg/L	-	-	-	-	-	-	nd	nd	-
Mercury (total)	0.0005	mg/L	nd	-	-	nd	nd	-	-	-	-
Molybdenum	0.0001	mg/L	nd	-	-	nd	-	-	nd	nd	-
Nickel	0.001	mg/L	nd	-	-	nd	-	-	nd	nd	-
Nitrate(as N)	0.05	mg/L	nd	-	-	nd	nd	-	-	-	-
Nitrite(as N)	0.01	mg/L	nd	-	-	nd	nd	-	-	-	-
Orthophosphate(as P)	0.01	mg/L	nd	-	-	nd	nd	-	-	-	-
pH	0.1	Units	7.3	-	-	7.3	7.4	**1.36**	-	-	-
Phosphorus	0.1	mg/L	nd	-	-	nd	-	-	nd	nd	-
Potassium	0.5	mg/L	0.7	-	-	0.8	-	-	nd	nd	-
Reactive Silica(SiO2)	0.5	mg/L	4.8	4.8	**0.00**	4.8	-	-	-	-	-
Saturation pH at 20øC	na	units	8.89	-	-	8.86	-	-	-	-	-
Saturation pH at 4øC	na	units	9.29	-	-	9.26	-	-	-	-	-
Selenium	0.002	mg/L	nd	-	-	nd	-	-	nd	nd	-
Silver	0.00005	mg/L	nd	-	-	nd	-	-	nd	nd	-
Sodium	0.1	mg/L	1	-	-	1	-	-	1.1	1.1	**0.00**
Strontium	0.005	mg/L	0.024	-	-	0.024	-	-	0.021	0.022	**4.65**
Sulphate	2	mg/L	3	-	-	3	3	**0.00**	-	-	-
Thallium	0.0001	mg/L	nd	-	-	nd	-	-	nd	nd	-
Tin	0.002	mg/L	nd	-	-	nd	-	-	nd	nd	-
Titanium	0.002	mg/L	nd	-	-	nd	-	-	nd	nd	-
Total Dissolved Solids(Calculated)	1	mg/L	-	-	-	-	-	-	41	-	-
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	0.2	-	-	0.23	-	-	-	-	-
Total Suspended Solids	1	mg/L	1	-	-	2	na	-	-	-	-
Turbidity	0.1	NTU	0.4	-	-	45	44	**2.25**	-	-	-
Uranium	0.0001	mg/L	nd	-	-	nd	-	-	nd	nd	-
Vanadium	0.002	mg/L	nd	-	-	nd	-	-	nd	nd	-
Zinc	0.001	mg/L	0.003	-	-	0.004	-	-	nd	nd	-
Fluoride	0.02	mg/L	nd	-	-	nd	nd	-	nd	nd	-

Table A1.2: Heath Steele Water Chemistry QA/QC

Analysis of Water			BLANKS					
Parameter	LOQ	Units	Trip Blank	Field Blank HB4A Total	Field Blank HB4A Dissolved	Filter Blank HB1A	Filter Blank HB2A	Filter Blank HB3A
Acidity(as CaCO3)	1	mg/L	nd	nd	-	-	-	-
Alkalinity(as CaCO3)	1	mg/L	nd	nd	-	-	-	-
Aluminum	0.005	mg/L	nd	nd	nd	nd	nd	nd
Ammonia(as N)	0.05	mg/L	nd	nd	-	-	-	-
Anion Sum	na	meq/L	0	0	-	-	-	-
Antimony	0.0005	mg/L	nd	nd	nd	nd	nd	nd
Arsenic	0.002	mg/L	nd	nd	nd	nd	nd	nd
Barium	0.005	mg/L	nd	nd	nd	nd	nd	nd
Beryllium	0.005	mg/L	nd	nd	nd	nd	nd	nd
Bicarbonate(as CaCO3, calculated)	1	mg/L	nd	nd	-	-	-	-
Bismuth	0.002	mg/L	nd	nd	nd	nd	nd	nd
Boron	0.005	mg/L	nd	nd	nd	nd	nd	nd
Cadmium	0.00005	mg/L	nd	nd	nd	nd	nd	nd
Calcium	0.1	mg/L	nd	nd	nd	nd	nd	nd
Carbonate(as CaCO3, calculated)	1	mg/L	nd	nd	-	-	-	-
Cation Sum	na	meq/L	0.013	0.003	-	-	-	-
Chloride	1	mg/L	nd	nd	-	-	-	-
Chromium	0.0005	mg/L	nd	nd	nd	nd	nd	nd
Cobalt	0.0002	mg/L	nd	nd	nd	nd	nd	nd
Colour	5	TCU	nd	nd	-	-	-	-
Conductivity - @25øC	1	us/cm	2	2	-	-	-	-
Copper	0.0003	mg/L	nd	nd	nd	nd	nd	nd
Dissolved Inorganic Carbon(as C)	0.2	mg/L	nd	-	nd	-	-	-
Dissolved Organic Carbon(DOC)	0.5	mg/L	1	-	nd	-	-	-
Hardness(as CaCO3)	0.1	mg/L	nd	nd	-	-	-	-
Ion Balance	0.01	%	100	84.9	-	-	-	-
Iron	0.02	mg/L	nd	nd	nd	nd	nd	nd
Langelier Index at 20øC	na	na	NCALC	NCALC	-	-	-	-
Langelier Index at 4øC	na	na	NCALC	NCALC	-	-	-	-
Lead	0.0001	mg/L	nd	nd	nd	nd	nd	nd
Magnesium	0.1	mg/L	nd	nd	nd	nd	nd	nd
Manganese	0.0005	mg/L	nd	nd	nd	nd	nd	nd
Mercury (dissolved)	0.0001	mg/L	nd	-	nd	-	-	-
Mercury (total)	0.0005	mg/L	-	nd	-	-	-	-
Molybdenum	0.0001	mg/L	nd	nd	nd	nd	nd	nd
Nickel	0.001	mg/L	nd	nd	nd	nd	nd	nd
Nitrate(as N)	0.05	mg/L	nd	nd	-	-	-	-
Nitrite(as N)	0.01	mg/L	nd	nd	-	-	-	-
Orthophosphate(as P)	0.01	mg/L	0.02	0.01	-	-	-	-
pH	0.1	Units	5.8	5.6	-	-	-	-
Phosphorus	0.1	mg/L	nd	nd	nd	nd	nd	nd
Potassium	0.5	mg/L	nd	nd	nd	nd	nd	nd
Reactive Silica(SiO2)	0.5	mg/L	nd	-	-	-	-	-
Saturation pH at 20øC	na	units	NCALC	NCALC	-	-	-	-
Saturation pH at 4øC	na	units	NCALC	NCALC	-	-	-	-
Selenium	0.002	mg/L	nd	nd	nd	nd	nd	nd
Silver	0.00005	mg/L	nd	nd	nd	nd	nd	nd
Sodium	0.1	mg/L	nd	nd	nd	nd	nd	nd
Strontium	0.005	mg/L	nd	nd	nd	nd	nd	nd
Sulphate	2	mg/L	nd	nd	-	-	-	-
Thallium	0.0001	mg/L	nd	nd	nd	nd	nd	nd
Tin	0.002	mg/L	nd	nd	nd	nd	nd	nd
Titanium	0.002	mg/L	nd	nd	nd	nd	nd	nd
Total Dissolved Solids(Calculated)	1	mg/L	nd	-	NCALC	-	-	-
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	0.07	0.06	-	-	-	-
Total Suspended Solids	1	mg/L	nd	nd	-	-	-	-
Turbidity	0.1	NTU	nd	0.1	-	-	-	-
Uranium	0.0001	mg/L	nd	nd	nd	nd	nd	nd
Vanadium	0.002	mg/L	nd	nd	nd	nd	nd	nd
Zinc	0.001	mg/L	0.003	0.003	nd	nd	nd	nd
Fluoride	0.02	mg/L	-	nd	-	-	-	-

Table A1.3: Heath Steele Periphyton QA/QC

Component	MDL	Units	HE1A-P 97/08/13	HE1A-P 97/08/13 Replicate	DQA (% diff) vs. Rep	HE1A-P 97/08/13 M. Spike	HE1A-P 97/08/13 MS % Rec.
Aluminum	0.5	mg/kg	22000	21000	**4.65**	NA	-
Antimony	0.01	mg/kg	1.3	1.2	**8.00**	160	100
Arsenic	0.1	mg/kg	120	120	**0.00**	260	84
Barium	0.05	mg/kg	140	140	**0.00**	300	97
Beryllium	0.01	mg/kg	1.8	1.7	**5.71**	140	89
Bismuth	0.01	mg/kg	13	13	**0.00**	170	99
Boron	0.2	mg/kg	4.7	4.7	**0.00**	140	85
Cadmium	0.005	mg/kg	9.2	9.2	**0.00**	170	98
Chromium	0.05	mg/kg	18	18	**0.00**	160	88
Cobalt	0.01	mg/kg	110	110	**0.00**	250	87
Copper	0.03	mg/kg	930	950	**2.13**	1100	92
Iron	2	mg/kg	46000	47000	**2.15**	NA	-
Lead	0.01	mg/kg	1100	1100	**0.00**	1200	89
Manganese	0.05	mg/kg	3300	3400	**2.99**	NA	-
Molybdenum	0.01	mg/kg	1.6	1.7	**6.06**	160	100
Nickel	0.05	mg/kg	19	19	**0.00**	160	86
Selenium	0.2	mg/kg	3.5	3.4	**2.90**	140	85
Silver	0.005	mg/kg	3.6	3.6	**0.00**	NA	-
Strontium	0.05	mg/kg	24	25	**4.08**	200	110
Thallium	0.01	mg/kg	0.82	0.76	**7.59**	160	100
Tin	0.01	mg/kg	0.86	0.69	**21.94**	160	100
Titanium	0.03	mg/kg	560	560	**0.00**	700	89
Vanadium	0.05	mg/kg	37	38	**2.67**	180	92
Zinc	0.1	mg/kg	3400	3500	**2.90**	3600	110

Table A1.3: Heath Steele Periphyton QA/QC

Component	MDL	Units	HE2B-P 97/08/14	HE2B-P2 97/08/14 Duplicate	**DQA (% diff) vs. Dup**	HE3B-P 97/08/14	HE3B-P2 97/08/14 Duplicate	**DQA (% diff) vs. Dup**
Aluminum	0.5	mg/kg	12000	12000	**0.00**	16000	3000	**136.8**
Antimony	0.01	mg/kg	0.67	0.91	**30.38**	0.51	0.12	**123.8**
Arsenic	0.1	mg/kg	60	71	**16.79**	64	22	**97.7**
Barium	0.05	mg/kg	140	280	**66.67**	330	190	**53.8**
Beryllium	0.01	mg/kg	1.5	1.3	**14.29**	1.3	0.31	**123.0**
Bismuth	0.01	mg/kg	4.5	4.1	**9.30**	3.6	0.15	**184.0**
Boron	0.2	mg/kg	4.4	3.8	**14.63**	2.7	0.3	**160.0**
Cadmium	0.005	mg/kg	22	42	**62.50**	28	13	**73.2**
Chromium	0.05	mg/kg	11	11	**0.00**	14	0.86	**176.9**
Cobalt	0.01	mg/kg	390	690	**55.56**	570	680	**17.6**
Copper	0.03	mg/kg	1100	2000	**58.06**	830	870	**4.7**
Iron	2	mg/kg	27000	32000	**16.95**	30000	3700	**156.1**
Lead	0.01	mg/kg	500	500	**0.00**	430	540	**22.7**
Manganese	0.05	mg/kg	12000	31000	**88.37**	26000	16000	**47.6**
Molybdenum	0.01	mg/kg	1.3	2	**42.42**	1.6	0.67	**81.9**
Nickel	0.05	mg/kg	38	62	**48.00**	33	16	**69.4**
Selenium	0.2	mg/kg	3.7	3.7	**0.00**	3.7	0.6	**144.2**
Silver	0.005	mg/kg	1.5	1.3	**14.29**	1.3	0.029	**191.3**
Strontium	0.05	mg/kg	38	35	**8.22**	42	9.2	**128.1**
Thallium	0.01	mg/kg	0.32	0.7	**74.51**	0.61	0.14	**125.3**
Tin	0.01	mg/kg	0.47	0.28	**50.67**	0.32	<0.10	**-**
Titanium	0.03	mg/kg	360	300	**18.18**	470	9.1	**192.4**
Vanadium	0.05	mg/kg	23	21	**9.09**	29	3.2	**160.2**
Zinc	0.1	mg/kg	9100	10000	**9.42**	8800	2700	**106.1**

Table A1.4: Heath Steele Water Toxicity QA/QC

Organism	MSD (%)	Control Mortality (%)	Control CV (%)	Reference toxicant CV[3] (%)	Reference toxicant Endpoint[3]	Warning Limits (Mean ± 2 std.dev.)	Control Limits (Mean ± 3 std.dev.)
Ceriodaphnia dubia							
H-E-1	-[1]	0	18	12.9	1700	1170 - 1980	963 - 2180
H-E-2	-	10	30	13.7	1210	1120 - 1960	906 - 2170
H-E-3	21.5	0	22	13.7	1390	1100 - 1940	896 - 2150
Fathead Minnow							
H-E-1	25	12.5	21	20.4	1610	672 - 1600	440 - 1830
H-E-2	-	0	4.4	17.8	1100	705 - 1490	510 - 1680
H-E-3	16.4	0	5.2	18.5	923	681 - 1480	481 - 1680
Selenastrum capricornutum							
H-E-1	10	na[2]	15	34.5[4]	11.4	7.6 - 41.3	-0.8 - 49.7
H-E-2	-	na	7	45.6	53.8	2.7 - 58.1	-11.2 - 72.0
H-E-3	-	na	10	41.7	22.7	4.9 - 53.8	-7.4 - 66.1

[1] - = MSD (minimum significant difference) value not available from the statistical methods used.

[2] na = Not applicable for the corresponding test.

[3] Based on IC50 for *Ceriodaphnia dubia* and Fathead Minnow and IC25 for *Selenastrum capricornutum*.

[4] The high CV values associated with the algae test are largely the result of the recent adaptation of the test by Beak. As a result, the control chart for this test is not as established as those for other reference toxicant tests. It is expected that after more points are added to the control chart, the CV will be reduced to a level consistent with the Ceriodaphnia and fathead minnow reference toxicant tests (approximately 20%). Higher variability with the Selenastrum test may also be attributed to the reference toxicant, zinc sulphate, which does not provide as consistent results as do salts, such as sodium chloride and potassium chloride. Variability associated with the reference toxicant test is considered to be a function of issues specific to the reference testing, such as the toxicant, and is not representative of the effluent test results. During the CANMET project, three Selenastrum tests were conducted in parallel, one for each mine site. Results of each pair of tests were within each other's confidence limits, even though different dilution waters were used. The average difference between IC50s for each pair was 16%, indicating a high degree of precision.

CERTIFICATE
OF ACCREDITATION

CERTIFICAT
D'ACCRÉDITATION

Beak Consultants Ltd.
ECOTOXICITY LABORATORY
14 Abacus Road, Brampton, ON

having been assessed by the Canadian Association for Environmental Analytical Laboratories (CAEAL) Inc., under the authority of the Standards Council of Canada (SCC), and found to comply with the requirements of the ISO/IEC Guide 25, the conditions established by the SCC and the CAEAL proficiency testing program, is hereby recognized as an

ACCREDITED ENVIRONMENTAL LABORATORY

for specific tests or types of tests listed in the scope of accreditation approved by the Standards Council of Canada.

ACLAE

CAEAL

ayant été soumis à une évaluation par l'Association canadienne des laboratoires d'analyse environnementale (ACLAE) Inc., sous l'autorité du Conseil canadien des normes (CCN), et ayant été trouvé conforme aux prescriptions du Guide ISO/CEI 25, aux conditions établies par le CCN et au programme d'essais d'aptitude de l'ACLAE, est de fait reconnu comme

LABORATOIRE DE L'ENVIRONNEMENT ACCRÉDITÉ

pour des essais ou types d'essais déterminés inscrits dans la portée d'accréditation approuvée par le Conseil canadien des normes.

Accredited Laboratory No.
No de laboratoire accrédité : 168

Accreditation Date
Date d'accréditation: 1995-03-06

Issued on
Émis ce : 1995-03-06

Expiry date
Date d'expiration : 1999-03-06

Richard Lafontaine
President, SCC/Président, CCN

Assessment performed according to the *General Requirements for the Accreditation of Calibration and Testing Laboratories*, CAN-P-4 (ISO/IEC Guide 25), *Requirements for the Competence of Environmental Analytical Laboratories*, CAN/CSA-Z753 and the *Conditions for the Accreditation of Calibration and Testing Laboratories*, CAN-P-1515.
The scope of accreditation is available from the accredited laboratory or SCC.

Évaluation effectuée conformément aux *Prescriptions générales concernant la compétence des laboratoires d'étalonnage et d'essais*, CAN-P-4 (Guide ISO/CEI 25), aux *Exigences visant les compétences des laboratoires de l'environnement*, CAN/CSA-Z753 et aux *Conditions d'accréditation des laboratoires d'étalonnage et d'essais*, CAN-P-1515.
La portée d'accréditation est disponible auprès du laboratoire accrédité ou du CCN.

CERTIFICATE OF ACCREDITATION

CERTIFICAT D'ACCRÉDITATION

Zenon Environmental Inc.

ZENON ENVIRONMENTAL LABORATORIES INC. – BURLINGTON

5555 North Service Road, Burlington, ON

having been assessed by the Canadian Association for Environmental Analytical Laboratories (CAEAL) Inc., under the authority of the Standards Council of Canada (SCC), and found to comply with the requirements of the ISO/IEC Guide 25, the conditions established by the SCC and the CAEAL proficiency testing program, is hereby recognized as an

ACCREDITED ENVIRONMENTAL LABORATORY

for specific tests or types of tests listed in the scope of accreditation approved by the Standards Council of Canada.

ACLAE

CAEAL

ayant été soumis à une évaluation par l'Association canadienne des laboratoires d'analyse environnementale (ACLAE) Inc., sous l'autorité du Conseil canadien des normes (CCN), et ayant été trouvé conforme aux prescriptions du Guide ISO/CEI 25, aux conditions établies par le CCN et au programme d'essais d'aptitude de l'ACLAE, est de fait reconnu comme

LABORATOIRE DE L'ENVIRONNEMENT ACCRÉDITÉ

pour des essais ou types d'essais déterminés inscrits dans la portée d'accréditation approuvée par le Conseil canadien des normes.

Accredited Laboratory No.
No de laboratoire accrédité : 197

Accreditation Date
Date d'accréditation: 1995-03-06

Issued on
Émis ce : 1995-03-06

Expiry date
Date d'expiration : 1998-03-06

Richard Lafontaine
President, SCC / Président, CCN

Assessment performed according to the *General Requirements for the Accreditation of Calibration and Testing Laboratories*, CAN-P-4 (ISO/IEC Guide 25), *Requirements for the Competence of Environmental Analytical Laboratories*, CAN/CSA-Z753 and the *Conditions for the Accreditation of Calibration and Testing Laboratories*, CAN-P-1515.
The scope of accreditation is available from the accredited laboratory or SCC.

Évaluation effectuée conformément aux *Prescriptions générales concernant la compétence des laboratoires d'étalonnage et d'essais*, CAN-P-4 (Guide ISO/CEI 25), aux *Exigences visant les compétences des laboratoires de l'environnement*, CAN/CSA-Z753 et aux *Conditions d'accréditation des laboratoires d'étalonnage et d'essais*, CAN-P-1515.
La portée d'accréditation est disponible auprès du laboratoire accrédité ou du CCN.

APPENDIX 2

Station Coordinates and Habitat Information

Table A2.1: Station Coordinates and Field Chemistry Measurements, Heath Steele, August 1997.

Station I.D.	Latitude [1]	Longitude [2]	Water Temperature (°C)	Dissolved Oxygen (mg/L)	pH (units)	Conductivity (µmhos/cm)
HE1A	47°17'22"	66°01'44"	20.0	8.7	7.00	38
HE1B	47°17'19"	66°00'49"	19.5	10.1	7.14	40
HE2A	47°17'24"	66°00'32"	19.0	10.2	7.14	39
HE2B	47°17'50"	65°59'22"	21.0	9.7	7.11	42
HE3A	47°17'51"	65°59'08"	18.5	9.3	7.30	38
HE3B	47°17'33"	65°58'19"	18.5	9.3	7.11	38
HE4A	47°17'12"	65°57'43"	17.5	10.1	7.13	38
HE4B	47°16'52"	65°57'27"	13.0	9.6	7.11	38
HE5A	47°16'19"	65°56'10"	13.0	10.0	7.15	35
HE5B	47°16'07"	65°55'54"	13.0	10.3	7.15	38
HR1A	47°17'31"	66°06'34"	16.5	8.9	6.73	25
HR1B	47°17'34"	66°06'31"	16.5	8.9	6.80	25
HR2A	47°18'01"	65°59'36"	18.0	10.0	7.36	31
HR2B	47°17'56"	65°59'25"	18.0	10.0	7.32	31
HR3A	47°12'15"	65°58'03"	16.0	10.0	7.05	52
HR3B	47°12'20"	65°58'01"	16.0	9.6	7.05	52

[1] Latitude - measurements are in degrees, minutes and seconds North

[2] Longitude - measurements are in degrees, minutes and seconds West

TABLE A2.2: STREAM DISCHARGES IN HEATH STEELE EXPOSURE REACHES, 20 AUGUST 1997

Reach/Station	Discharge (m^3/s)	Method
HS-3 (effluent)	0.036	Heath Steele, pers. comm.
HE1A	0.06	Field measurement (adjusted)[1]
HE2B	0.074	Field measurement
HE3A	0.23	Field measurement
HE4B	0.28	Field measurement
HE5A	0.31	Field measurement (adjusted)[1]

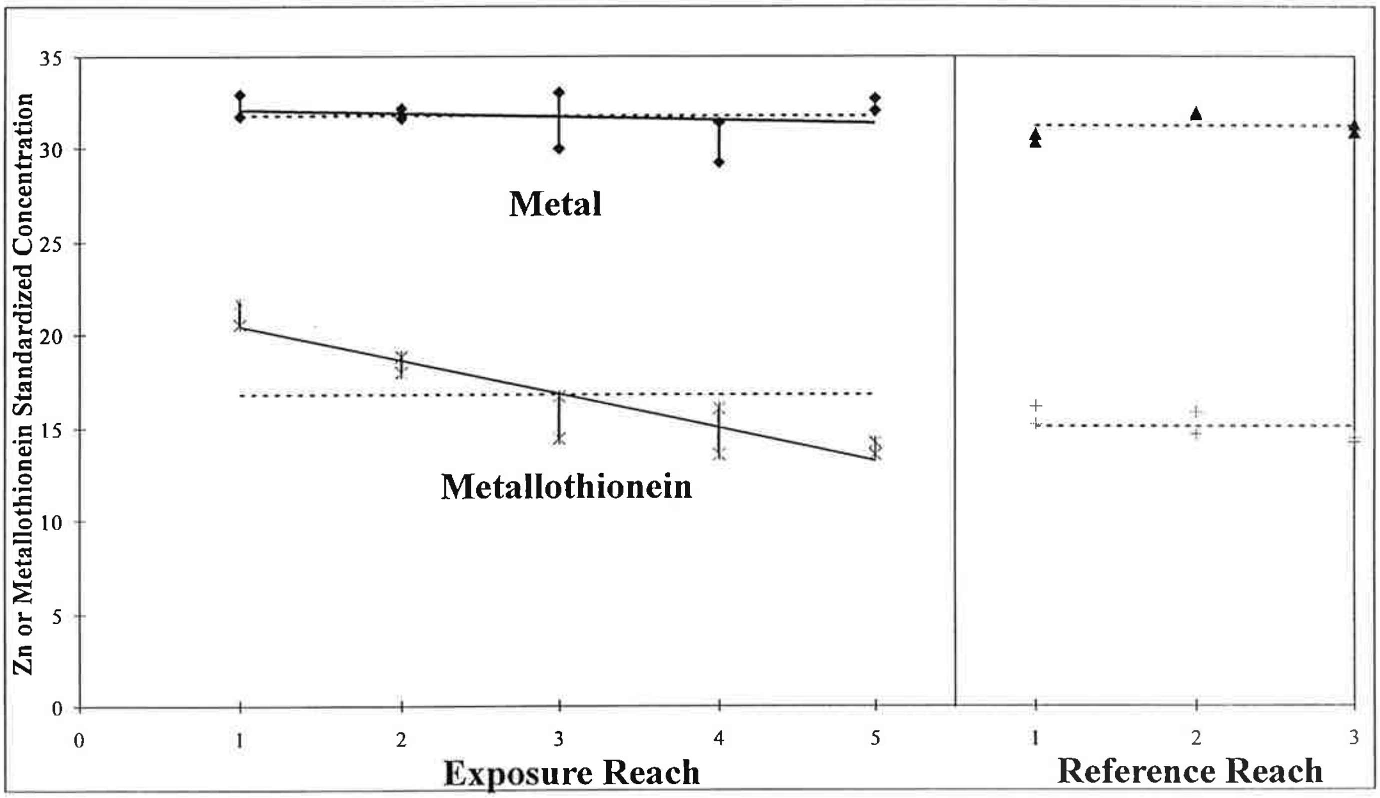
[1] Cross-sectional measurements inaccurate at these stations. Flows adjusted according to dilution indicated for total zinc concentration.

APPENDIX 3

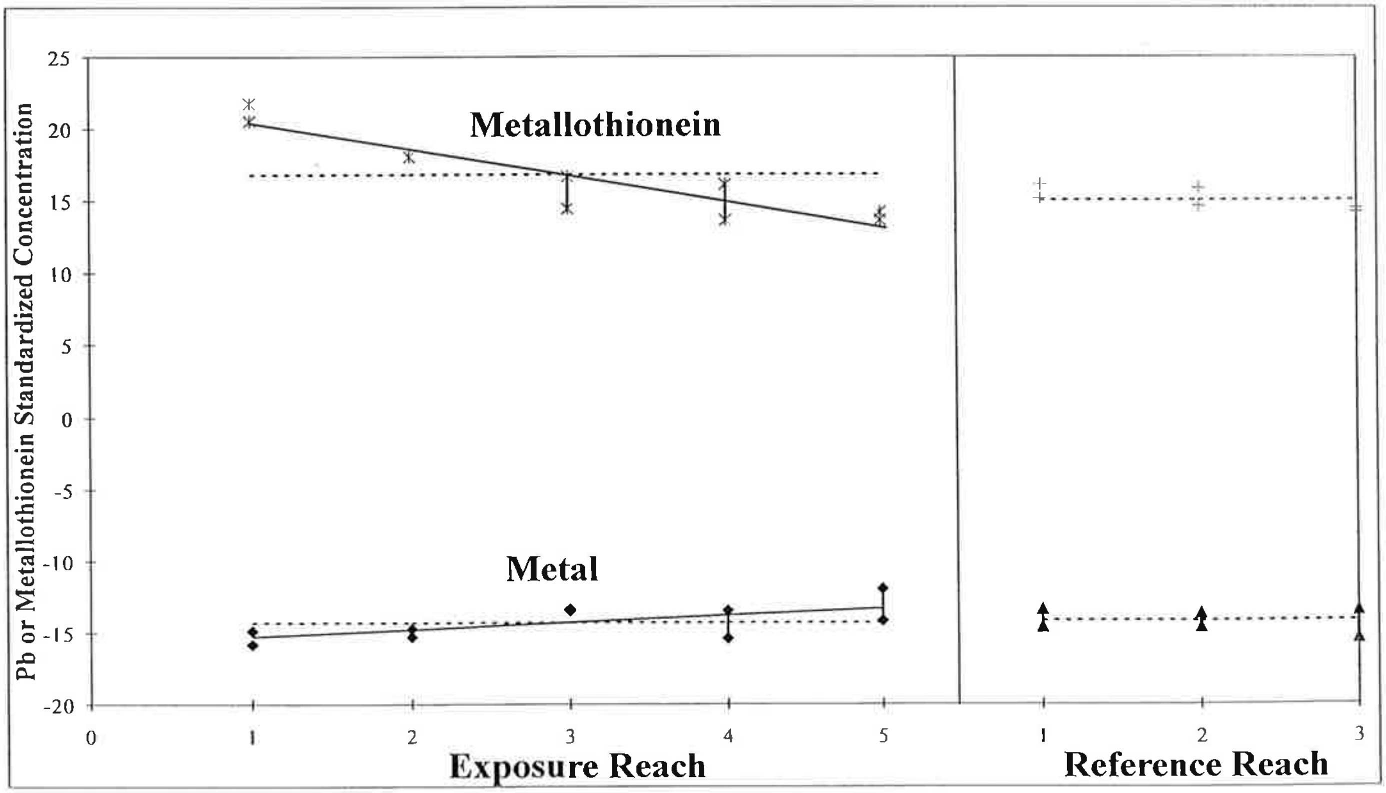
Figures and Tables Illustrating the Hypothesis Testing Results

Hypothesis #4
Caged Atlantic Salmon
Tissue Metal vs Tissue Metallothionein by Reach

Zinc

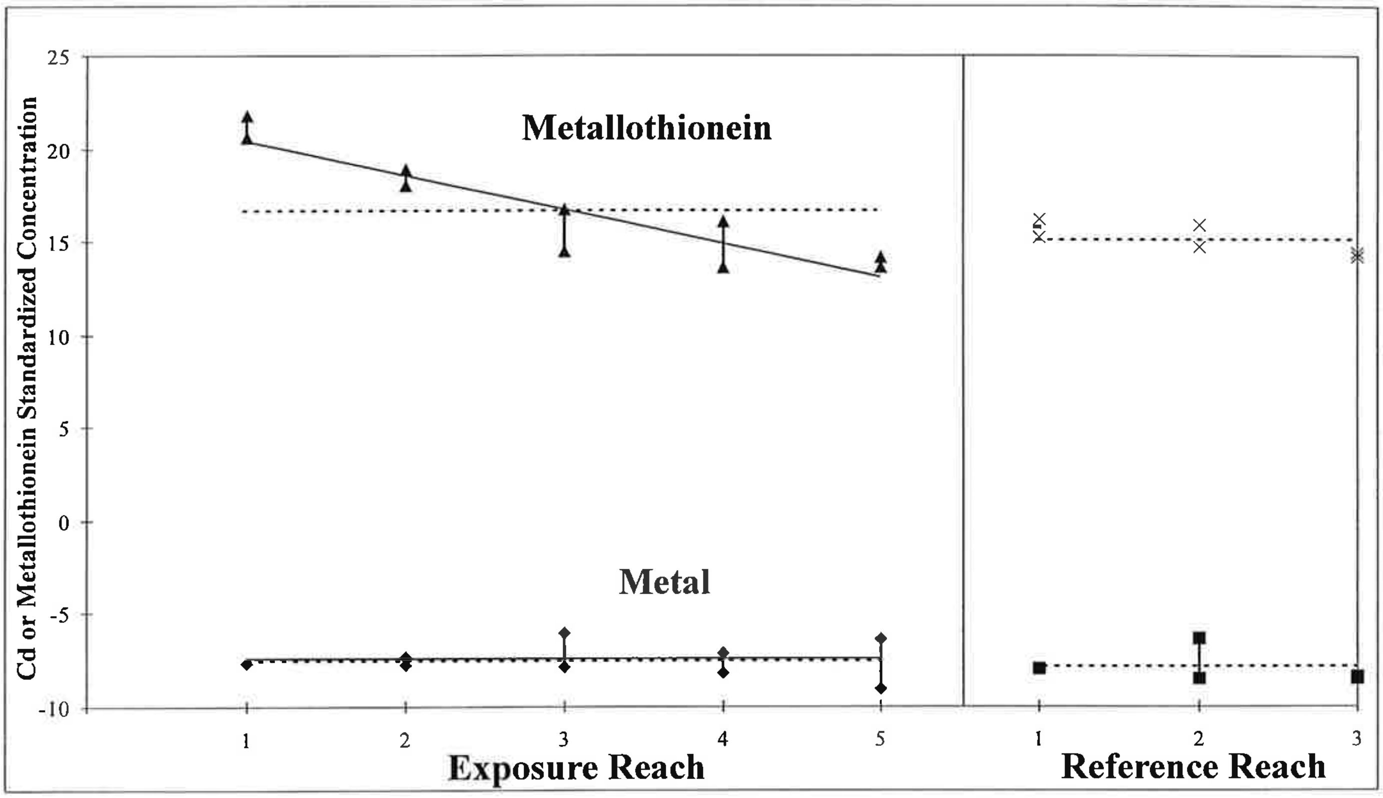


Lead

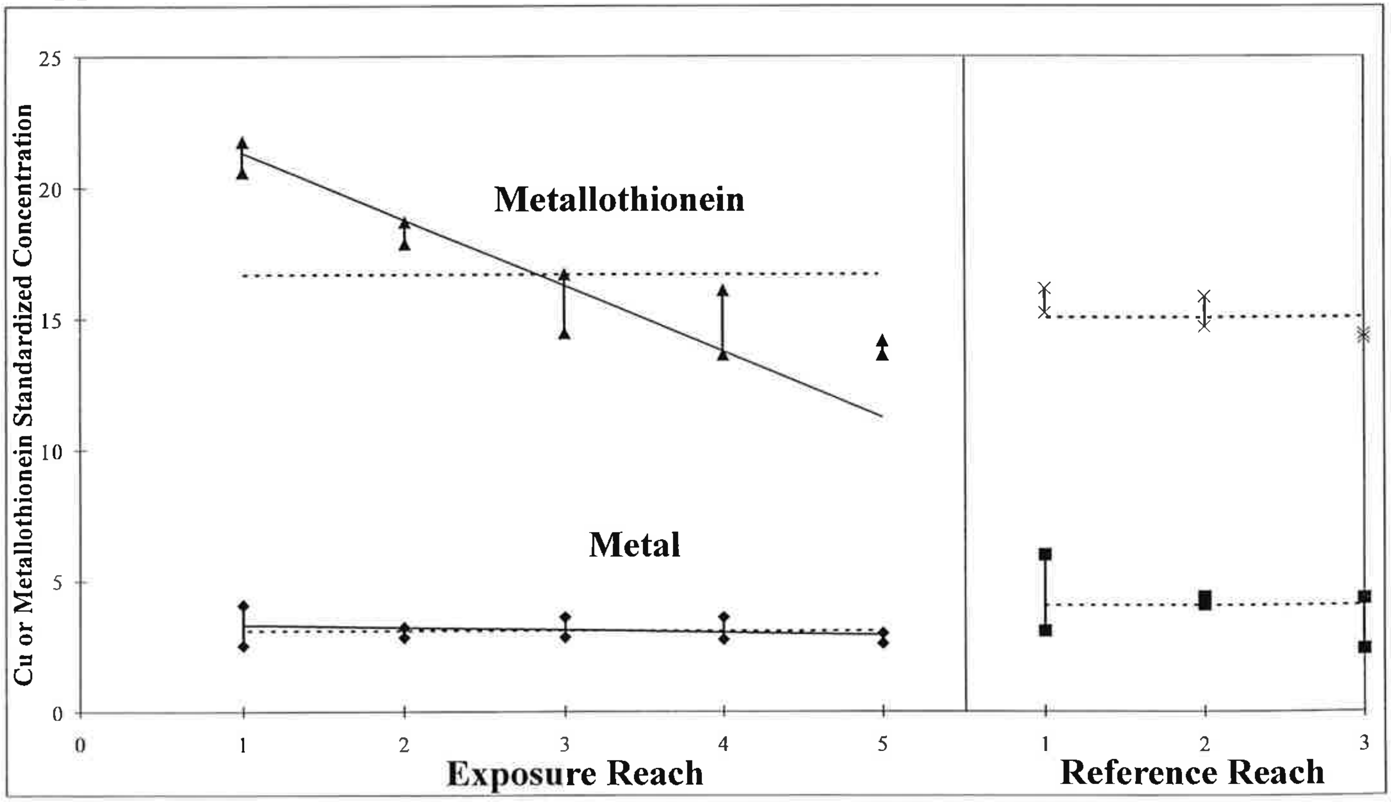


Hypothesis #4
Caged Atlantic Salmon
Tissue Metal vs Tissue Metallothionein by Reach

Cadmium

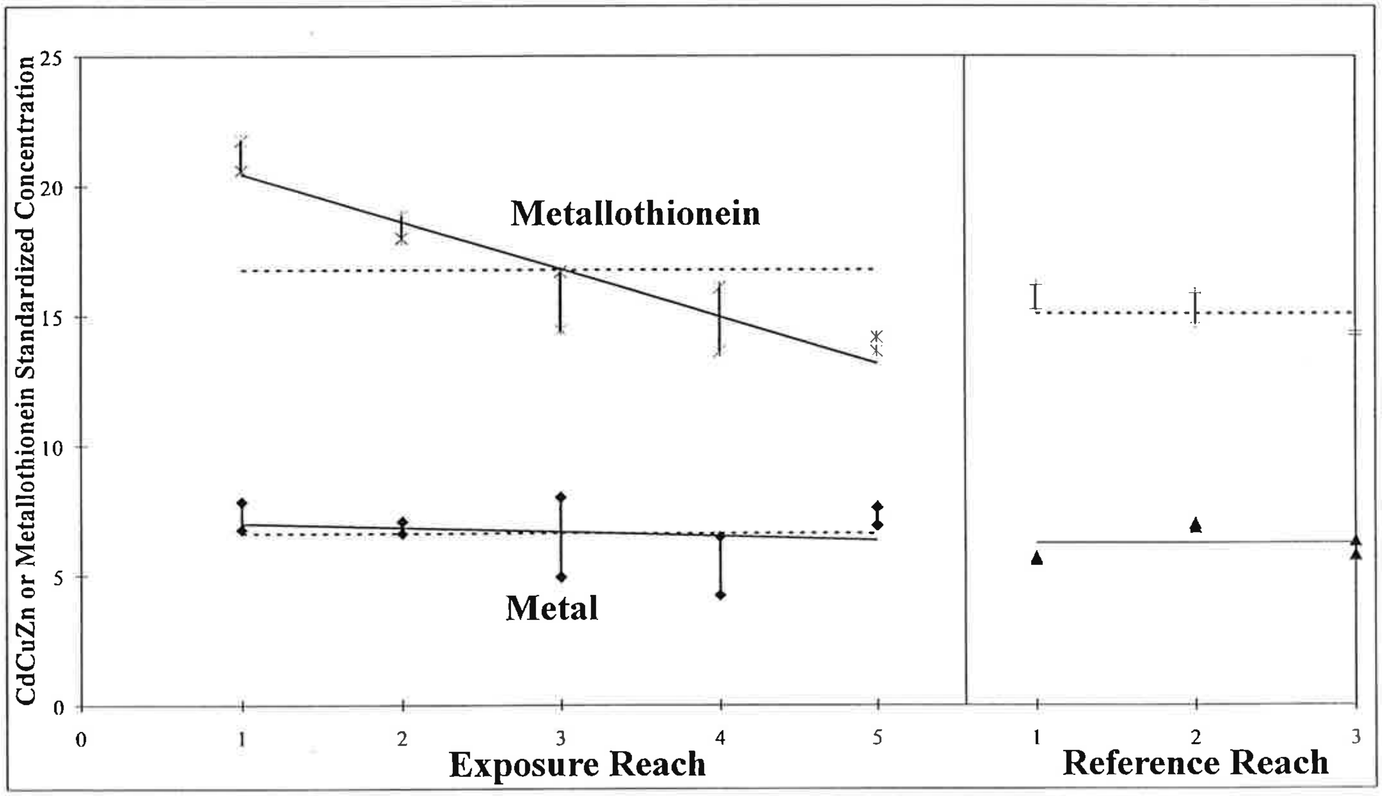


Copper



Hypothesis #4
Caged Atlantic Salmon
Tissue Metal vs Tissue Metallothionein by Reach

CdCuZn Molar Sum



Heath Steele Fish - Test of Hypothesis #4

Caged Altantic Salmon

Cadmium

Source	SS	DF	MS	F	P	Test Against
Reach	2.516	7	0.359	0.359	0.902	Within Reach
Among Reference	1.058	2	0.529	2.259	0.252	Lack of Fit
Ref vs Exp	0.711	1	0.711	3.036	0.180	Lack of Fit
Linear Trend	4.44E-02	1	0.044	0.190	0.693	Lack of Fit
Lack of Fit	0.703	3	0.234	0.234	0.870	Within Reach
Within Reach	8	8	1.000			

Copper

Source	SS	DF	MS	F	P	Test Against
Reach	5.182	7	0.740	0.740	0.648	Within Reach
Among Reference	1.521	2	0.761	12.071	0.037	Lack of Fit
Ref vs Exp	3.331	1	3.331	52.873	**0.005**	Lack of Fit
Linear Trend	0.141	1	0.141	2.238	0.232	Lack of Fit
Lack of Fit	0.189	3	0.063	0.063	0.978	Within Reach
Within Reach	8	8	1.000			

Lead

Source	SS	DF	MS	F	P	Test Against
Reach	8.297	7	1.185	1.185	0.405	Within Reach
Among Reference	0.269	2	0.135	0.138	0.876	Lack of Fit
Ref vs Exp	0.046	1	0.046	0.047	0.842	Lack of Fit
Linear Trend	5.058	1	5.058	5.190	0.107	Lack of Fit
Lack of Fit	2.924	3	0.975	0.975	0.451	Within Reach
Within Reach	8	8	1.000			

Zinc

Source	SS	DF	MS	F	P	Test Against
Reach	8.229	7	1.176	1.176	0.409	Within Reach
Among Reference	1.851	2	0.926	0.572	0.616	Lack of Fit
Ref vs Exp	1.018	1	1.018	0.629	0.486	Lack of Fit
Linear Trend	0.505	1	0.505	0.312	0.615	Lack of Fit
Lack of Fit	4.855	3	1.618	1.618	0.260	Within Reach
Within Reach	8	8	1.000			

CdCuZn Molar Sum

Source	SS	DF	MS	F	P	Test Against
Reach	7.698	7	1.100	1.100	0.443	Within Reach
Among Reference	1.661	2	0.831	0.524	0.638	Lack of Fit
Ref vs Exp	0.75	1	0.750	0.473	0.541	Lack of Fit
Linear Trend	0.531	1	0.531	0.335	0.603	Lack of Fit
Lack of Fit	4.756	3	1.585	1.585	0.267	Within Reach
Within Reach	8	8	1.000			

MT

Source	SS	DF	MS	F	P	Test Against
Reach	84.211	7	12.030	12.030	**0.001**	Within Reach
Among Reference	2.038	2	1.019	0.576	0.614	Lack of Fit
Ref vs Exp	10.809	1	10.809	6.109	0.090	Lack of Fit
Linear Trend	66.056	1	66.056	37.334	**8.81E-03**	Lack of Fit
Lack of Fit	5.308	3	1.769	1.769	0.231	Within Reach
Within Reach	8	8	1.000			

Heath Steele Fish - Test of Hypothesis #4 - Ancillary Information

Caged Altantic Salmon

Cadmium

Source	SS	DF	MS	F	P	Test Against
Reach	2.516	7	0.359	0.359	0.902	Within Reach
Among Reference	1.058	2	0.529	2.259	0.252	Lack of Fit
Ref vs Exp	0.711	1	0.711	3.036	0.180	Lack of Fit
Linear Trend	4.44E-02	1	0.044	0.190	0.693	Lack of Fit
Lack of Fit	0.703	3	0.234	0.234	0.870	Within Reach
Within Reach	8	8	1.000			

Copper

Source	SS	DF	MS	F	P	Test Against
Reach	5.182	7	0.740	0.740	0.648	Within Reach
Among Reference	1.521	2	0.761	12.071	0.037	Lack of Fit
Ref vs Exp	3.331	1	3.331	52.873	**0.005**	Lack of Fit
Linear Trend	0.141	1	0.141	2.238	0.232	Lack of Fit
Lack of Fit	0.189	3	0.063	0.063	0.978	Within Reach
Within Reach	8	8	1.000			

Lead

Source	SS	DF	MS	F	P	Test Against
Reach	8.297	7	1.185	1.185	0.405	Within Reach
Among Reference	0.269	2	0.135	0.138	0.876	Lack of Fit
Ref vs Exp	0.046	1	0.046	0.047	0.842	Lack of Fit
Linear Trend	5.058	1	5.058	5.190	0.107	Lack of Fit
Lack of Fit	2.924	3	0.975	0.975	0.451	Within Reach
Within Reach	8	8	1.000			

Zinc

Source	SS	DF	MS	F	P	Test Against
Reach	8.229	7	1.176	1.176	0.409	Within Reach
Among Reference	1.851	2	0.926	0.572	0.616	Lack of Fit
Ref vs Exp	1.018	1	1.018	0.629	0.486	Lack of Fit
Linear Trend	0.505	1	0.505	0.312	0.615	Lack of Fit
Lack of Fit	4.855	3	1.618	1.618	0.260	Within Reach
Within Reach	8	8	1.000			

CdCuZn Molar Sum

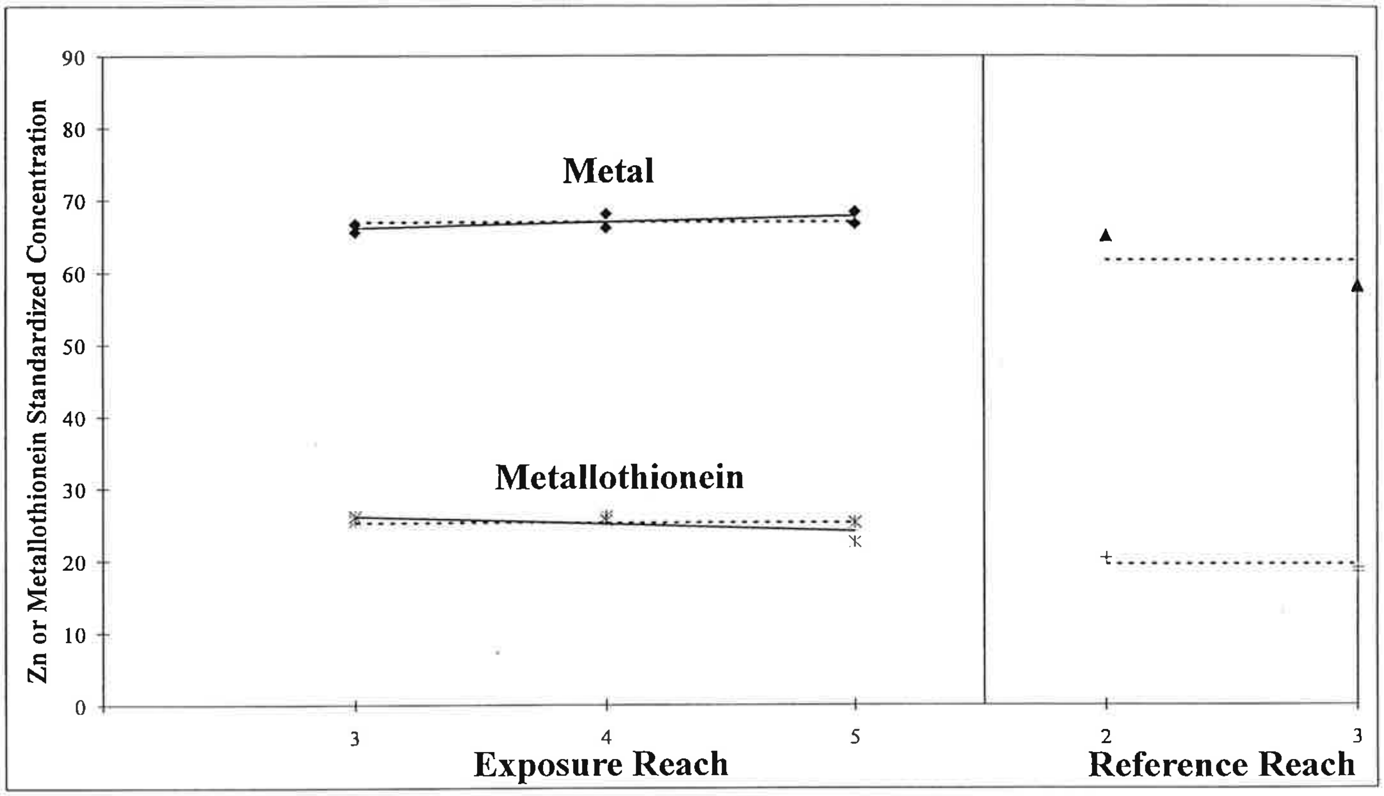
Source	SS	DF	MS	F	P	Test Against
Reach	7.698	7	1.100	1.100	0.443	Within Reach
Among Reference	1.661	2	0.831	0.524	0.638	Lack of Fit
Ref vs Exp	0.75	1	0.750	0.473	0.541	Lack of Fit
Linear Trend	0.531	1	0.531	0.335	0.603	Lack of Fit
Lack of Fit	4.756	3	1.585	1.585	0.267	Within Reach
Within Reach	8	8	1.000			

MT

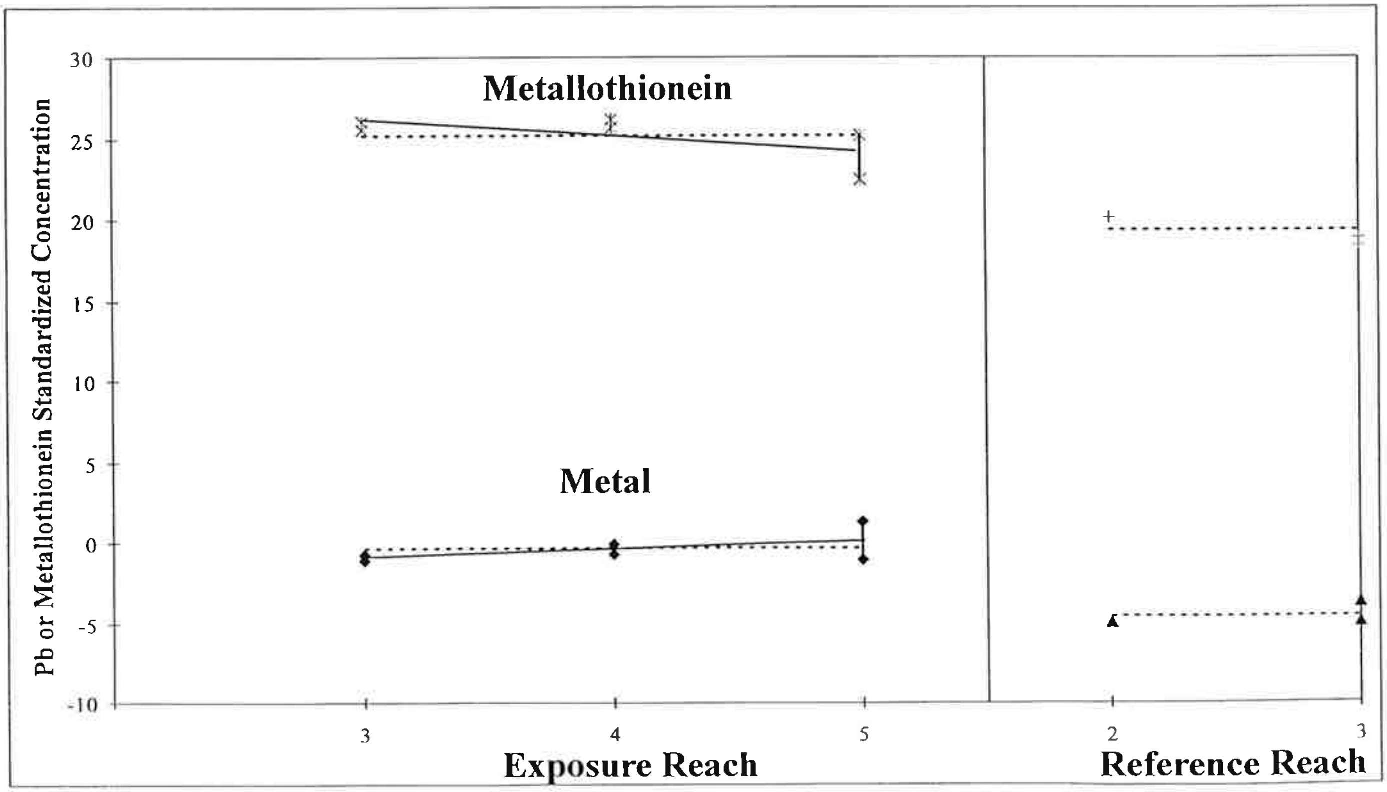
Source	SS	DF	MS	F	P	Test Against
Reach	84.211	7	12.030	12.030	**0.001**	Within Reach
Among Reference	2.038	2	1.019	0.576	0.614	Lack of Fit
Ref vs Exp	10.809	1	10.809	6.109	0.090	Lack of Fit
Linear Trend	66.056	1	66.056	37.334	**8.81E-03**	Lack of Fit
Lack of Fit	5.308	3	1.769	1.769	0.231	Within Reach
Within Reach	8	8	1.000			

Hypothesis #4
Wild Atlantic Salmon
Tissue Metal vs Tissue Metallothionein by Reach

Zinc

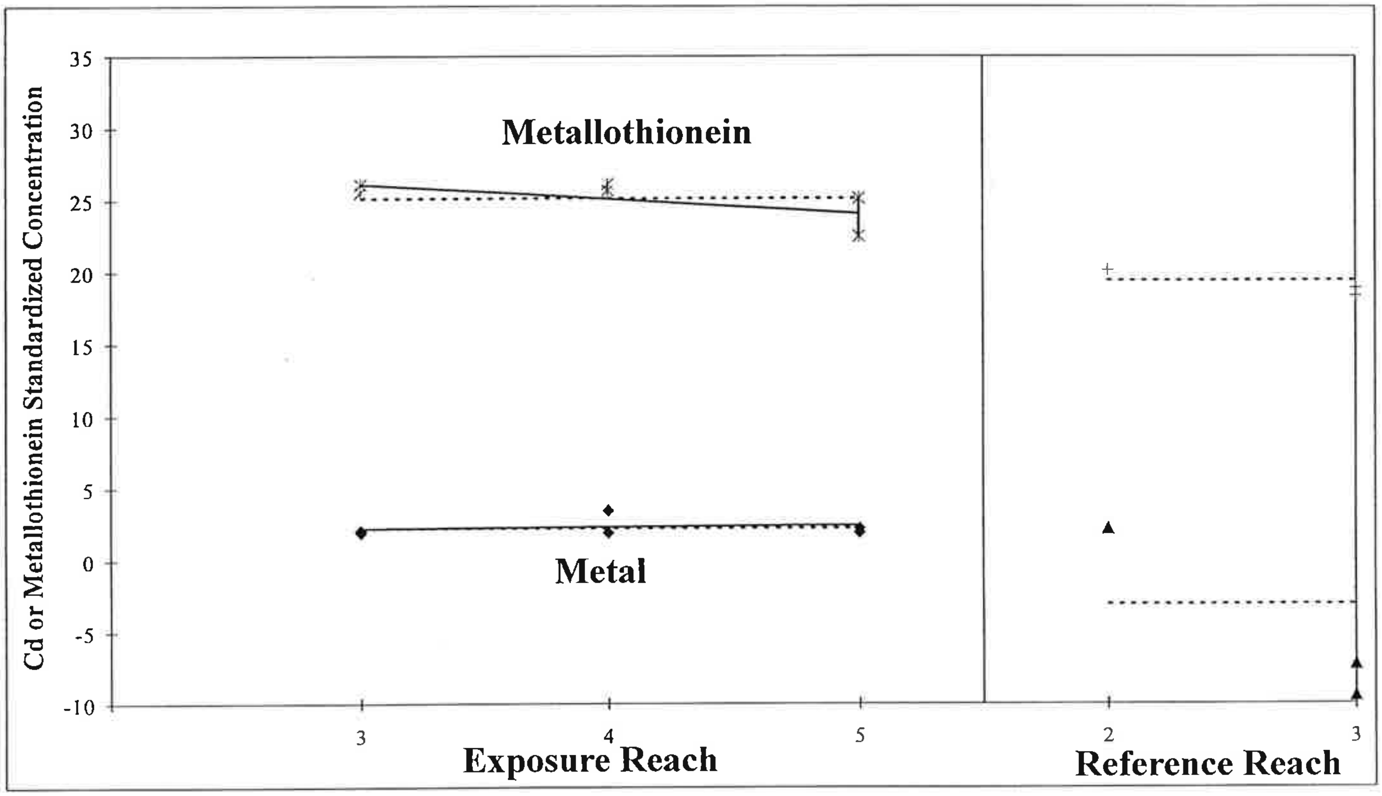


Lead

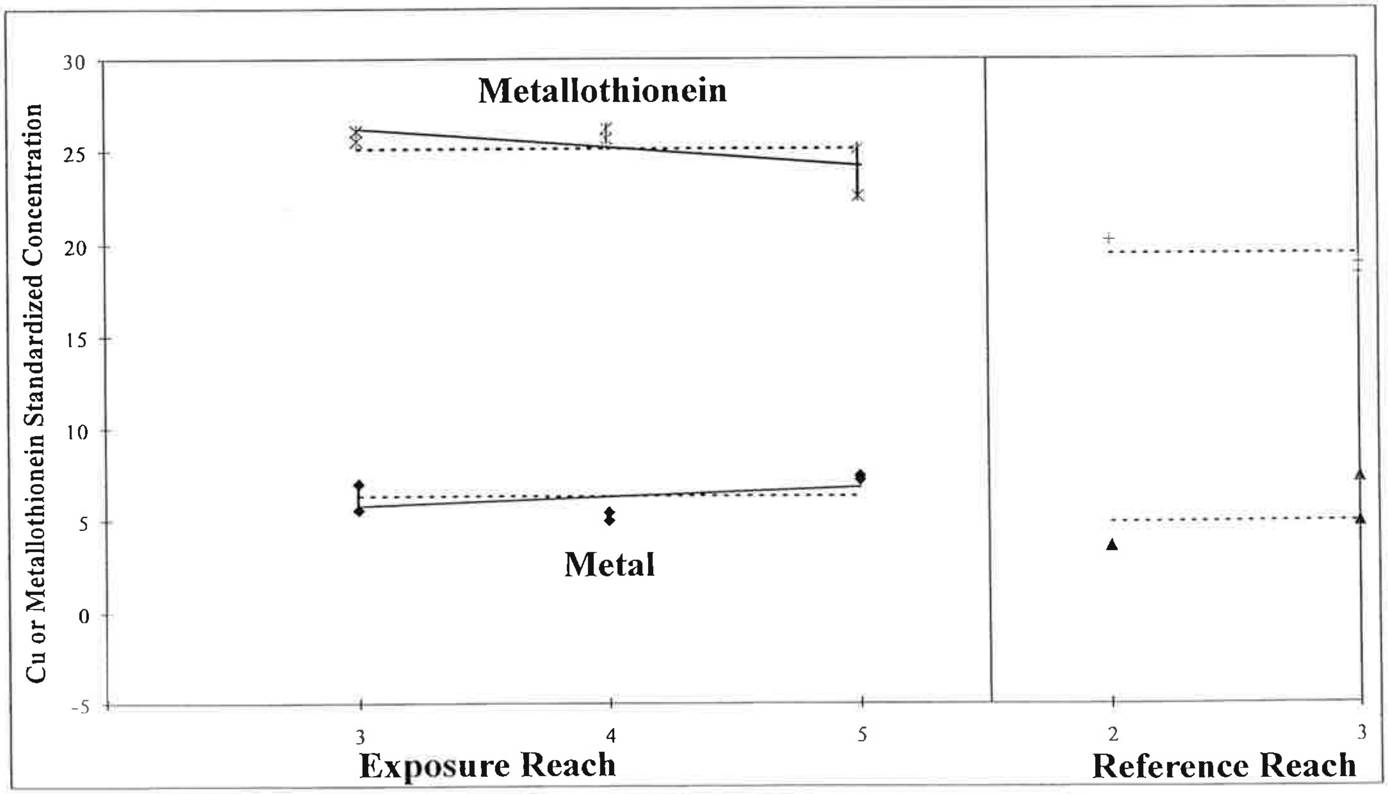


Hypothesis #4
Wild Atlantic Salmon
Tissue Metal vs Tissue Metallothionein by Reach

Cadmium

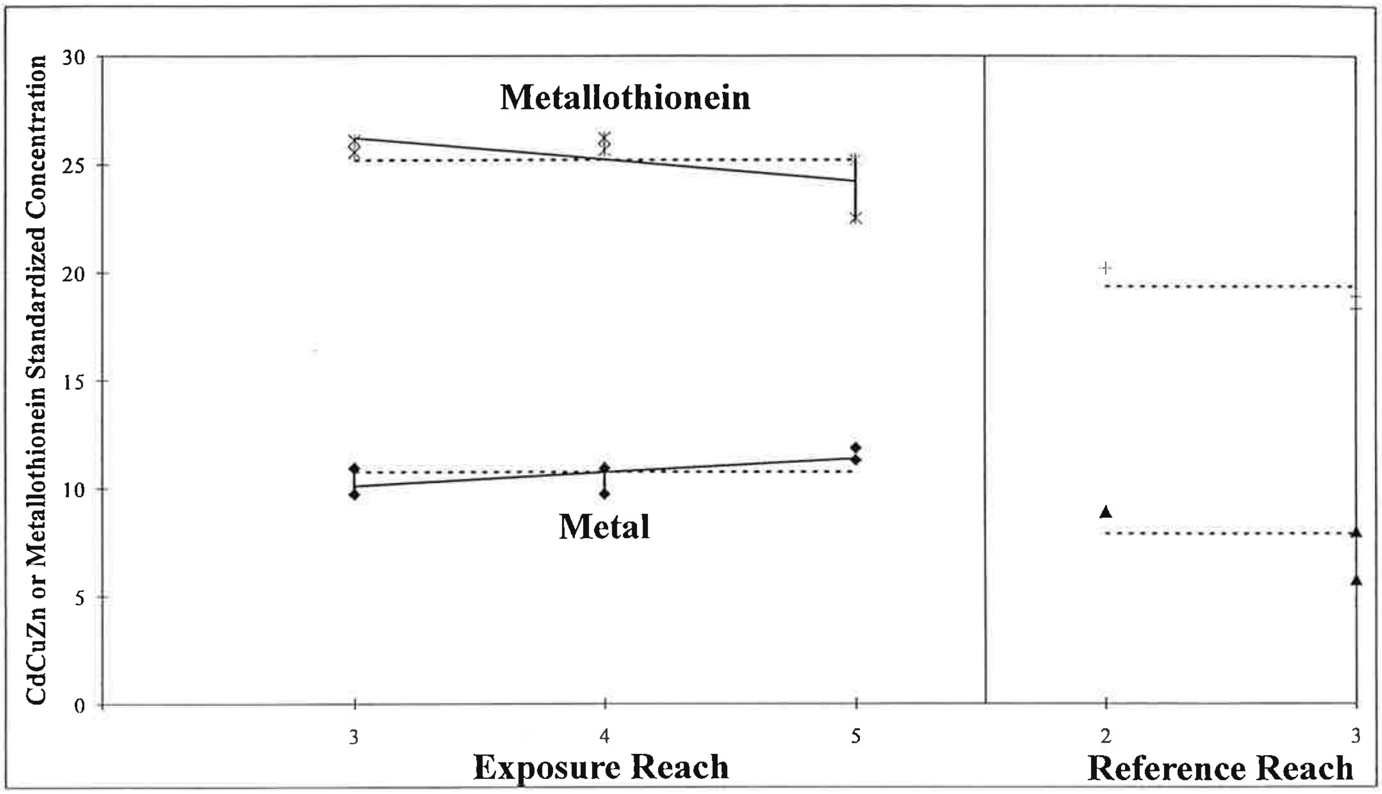


Copper



Hypothesis #4
Wild Atlantic Salmon
Tissue Metal vs Tissue Metallothionein by Reach

CdCuZn Molar Sum



Heath Steele Fish - Test of Hypothesis #4

Wild Altantic Salmon

Cadmium

Source	SS	DF	MS	F	P	Test Against
Tools	2151.40	1	2151.404	2151.404	**5.16E-11**	Within Reach
Reach[1]	224.506	4	56.127	56.127	**6.82E-06**	Within Reach
Ref vs Exp	113.871	1	113.871	2.089	0.285	Lack of Fit
Linear Trend	1.621	1	1.621	0.030	0.879	Lack of Fit
Lack of Fit	109.014	2	54.507	54.507	**2.18E-05**	Within Reach
Interactions	30.505	4	7.626	7.626	**0.008**	Within Reach
Ref/Exp x Tools	0.211	1	0.211	0.016	0.911	Residual
Linear Trend x Tools	3.849	1	3.849	0.291	0.644	Residual
Residual	26.445	2	13.223	13.223	**0.003**	Within Reach
Within Reach	8	8	1.000			

Copper

Source	SS	DF	MS	F	P	Test Against
Tools	1222.35	1	1222.351	1222.351	**4.90E-10**	Within Reach
Reach[1]	49.955	4	12.489	12.489	**1.61E-03**	Within Reach
Ref vs Exp	47.401	1	47.401	44.760	**0.022**	Lack of Fit
Linear Trend	0.436	1	0.436	0.412	0.587	Lack of Fit
Lack of Fit	2.118	2	1.059	1.059	0.391	Within Reach
Interactions	40.306	4	10.077	10.077	**0.003**	Within Reach
Ref/Exp x Tools	18.027	1	18.027	2.020	0.291	Residual
Linear Trend x Tools	4.434	1	4.434	0.497	0.554	Residual
Residual	17.845	2	8.923	8.923	**0.009**	Within Reach
Within Reach	8	8	1.000			

Lead

Source	SS	DF	MS	F	P	Test Against
Tools	2599.35	1	2599.350	2599.350	**2.43E-11**	Within Reach
Reach[1]	104.593	4	26.148	26.148	**1.20E-04**	Within Reach
Ref vs Exp	92.23	1	92.230	15.541	0.059	Lack of Fit
Linear Trend	0.494	1	0.494	0.083	0.800	Lack of Fit
Lack of Fit	11.869	2	5.935	5.935	**0.026**	Within Reach
Interactions	10.324	4	2.581	2.581	0.118	Within Reach
Ref/Exp x Tools	2.332	1	2.332	1.248	0.380	Residual
Linear Trend x Tools	4.255	1	4.255	2.277	0.270	Residual
Residual	3.737	2	1.869	1.869	0.216	Within Reach
Within Reach	8	8	1.000			

Zinc

Source	SS	DF	MS	F	P	Test Against
Tools	7323.75	1	7323.745	7323.745	**3.88E-13**	Within Reach
Reach[1]	180.933	4	45.233	45.233	**1.55E-05**	Within Reach
Ref vs Exp	114.065	1	114.065	3.419	0.206	Lack of Fit
Linear Trend	0.138	1	0.138	0.004	0.955	Lack of Fit
Lack of Fit	66.730	2	33.365	33.365	**1.31E-04**	Within Reach
Interactions	15.546	4	3.887	3.887	**0.049**	Within Reach
Ref/Exp x Tools	0.203	1	0.203	0.042	0.856	Residual
Linear Trend x Tools	5.732	1	5.732	1.193	0.389	Residual
Residual	9.611	2	4.806	4.806	**0.043**	Within Reach
Within Reach	8	8	1.000			

CdCuZn Molar Sum

Source	SS	DF	MS	F	P	Test Against
Tools	733.98	1	733.975	733.975	**3.71E-09**	Within Reach
Reach[1]	90.345	4	22.586	22.586	**2.05E-04**	Within Reach
Ref vs Exp	69.028	1	69.028	6.549	0.125	Lack of Fit
Linear Trend	0.238	1	0.238	0.023	0.894	Lack of Fit
Lack of Fit	21.079	2	10.540	10.540	**0.006**	Within Reach
Interactions	15.234	4	3.809	3.809	0.051	Within Reach
Ref/Exp x Tools	7.966	1	7.966	7.671	0.109	Residual
Linear Trend x Tools	5.191	1	5.191	4.999	0.155	Residual
Residual	2.077	2	1.039	1.039	0.397	Within Reach
Within Reach	8	8	1.000			

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[1] Among Reference variance is not partitioned from the among reach variance because Salmon were caught at only two reference reaches, with multiple fish caught at only one of those reference reaches.

Heath Steele Fish - Hypothesis #4 - Ancillary Information

Wild Altantic Salmon

Cadmium

Source	SS	DF	MS	F	P	Tested Against
Reach	174.995	4	43.749	43.749	**1.48E-03**	Within Reach
Ref vs Exp	52.137	1	52.137	0.849	0.454	Lack of Fit
Linear Trend	0.024	1	0.024	0.000	0.986	Lack of Fit
Lack of Fit	122.834	2	61.417	61.417	**9.95E-04**	Within Reach
Within Reach	4.000	4	1			

Copper

Source	SS	DF	MS	F	P	Tested Against
Reach	10.146	4	2.537	2.537	0.195	Within Reach
Ref vs Exp	3.482	1	3.482	1.239	0.381	Lack of Fit
Linear Trend	1.045	1	1.045	0.372	0.604	Lack of Fit
Lack of Fit	5.619	2	2.810	2.810	0.173	Within Reach
Within Reach	4.000	4	1			

Lead

Source	SS	DF	MS	F	P	Tested Against
Reach	34.802	4	8.701	8.701	**0.030**	Within Reach
Ref vs Exp	32.616	1	32.616	51.689	**0.019**	Lack of Fit
Linear Trend	0.924	1	0.924	1.464	0.350	Lack of Fit
Lack of Fit	1.262	2	0.631	0.631	0.578	Within Reach
Within Reach	4.000	4	1			

Zinc

Source	SS	DF	MS	F	P	Tested Against
Reach	116.364	4	29.091	29.091	**0.003**	Within Reach
Ref vs Exp	52.322	1	52.322	1.688	0.323	Lack of Fit
Linear Trend	2.045	1	2.045	0.066	0.821	Lack of Fit
Lack of Fit	61.997	2	30.999	30.999	**0.004**	Within Reach
Within Reach	4.000	4	1			

CdCuZn Molar Sum

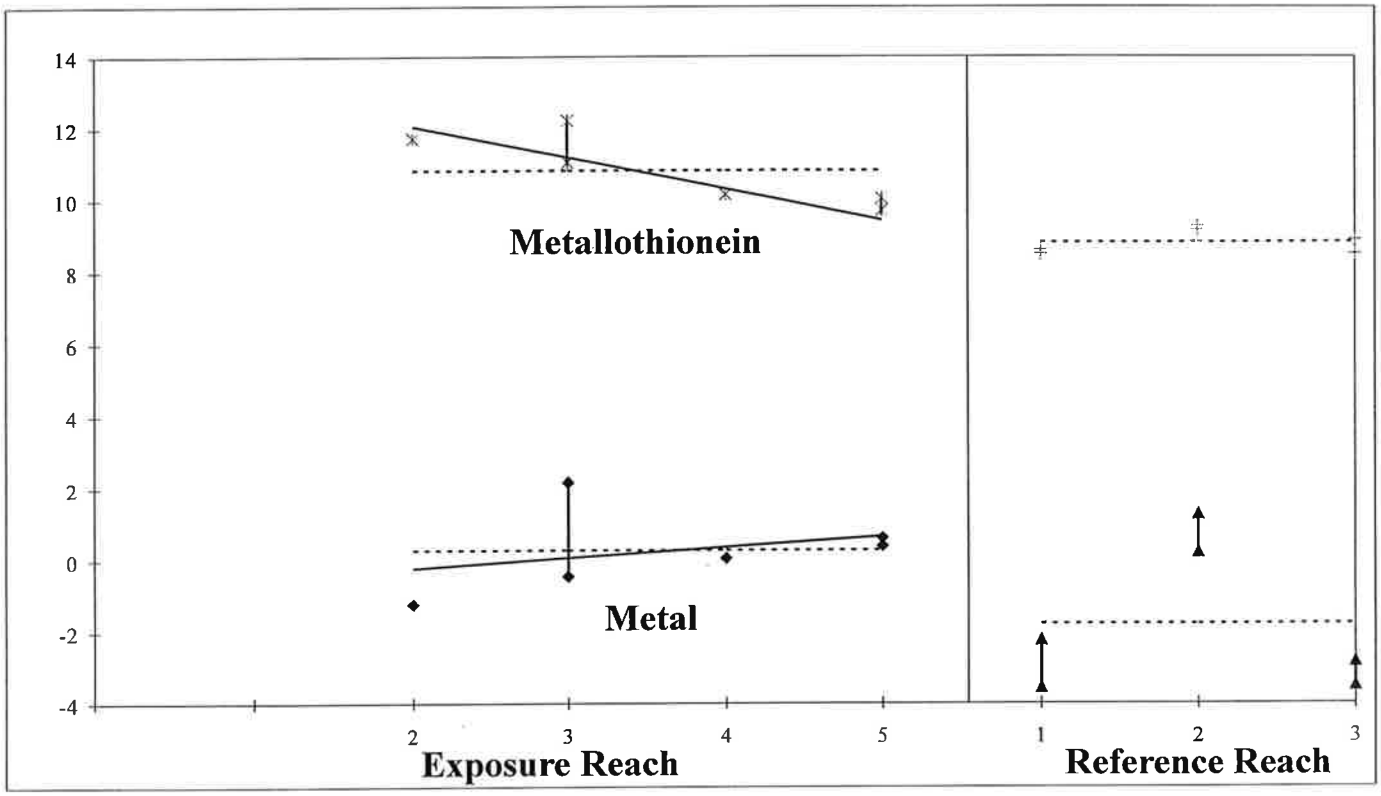
Source	SS	DF	MS	F	P	Tested Against
Reach	25.464	4	6.366	6.366	**0.050**	Within Reach
Ref vs Exp	15.048	1	15.048	3.415	0.206	Lack of Fit
Linear Trend	1.603	1	1.603	0.364	0.608	Lack of Fit
Lack of Fit	8.813	2	4.407	4.407	0.097	Within Reach
Within Reach	4.000	4	1			

MT

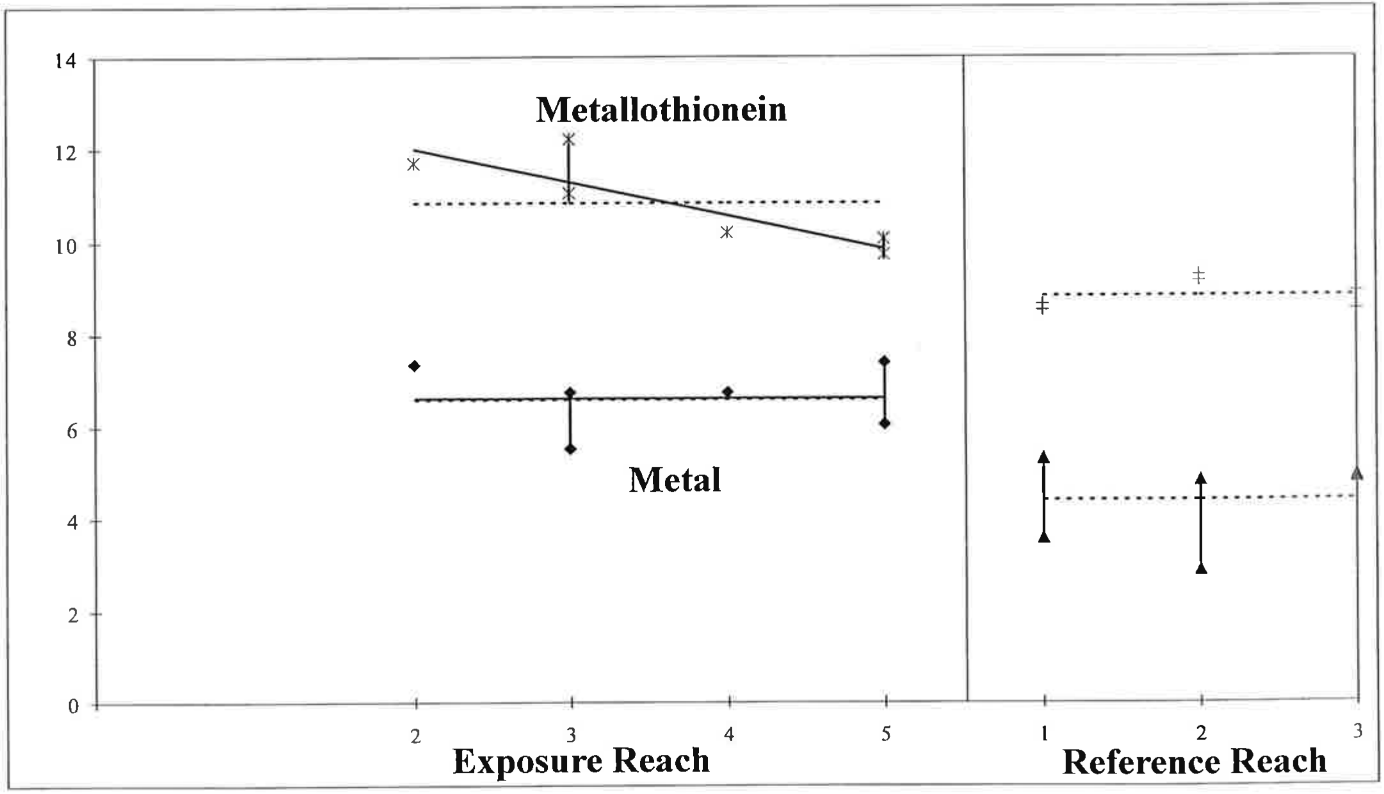
Source	SS	DF	MS	F	P	Tested Against
Reach	80.115	4	20.029	20.029	**0.007**	Within Reach
Ref vs Exp	61.946	1	61.946	8.637	0.099	Lack of Fit
Linear Trend	3.825	1	3.825	0.533	0.541	Lack of Fit
Lack of Fit	14.344	2	7.172	7.172	**0.048**	Within Reach
Within Reach	4.000	4	1			

Hypothesis #4
Wild Blacknose Dace
Tissue Metal vs Tissue Metallothionein by Reach

Cadmium

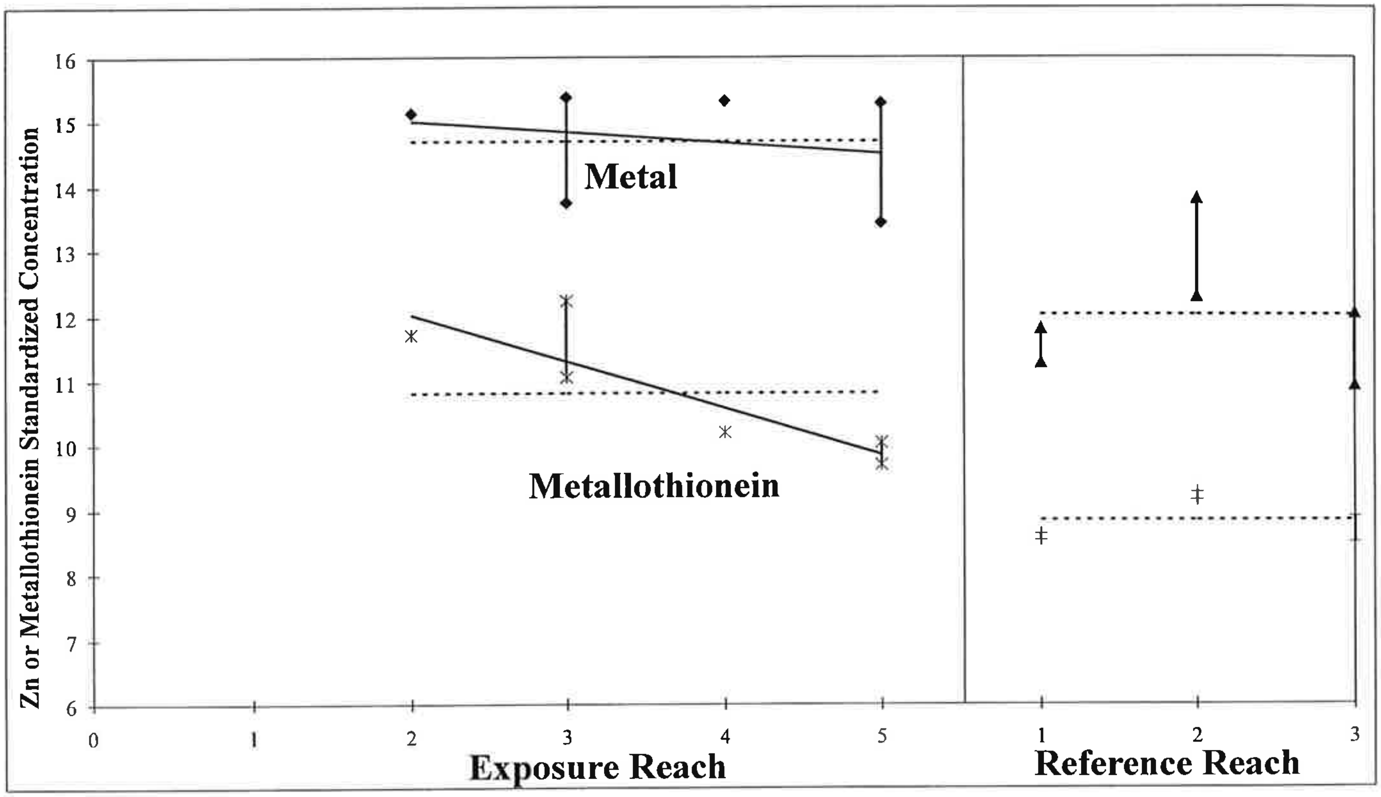


Copper

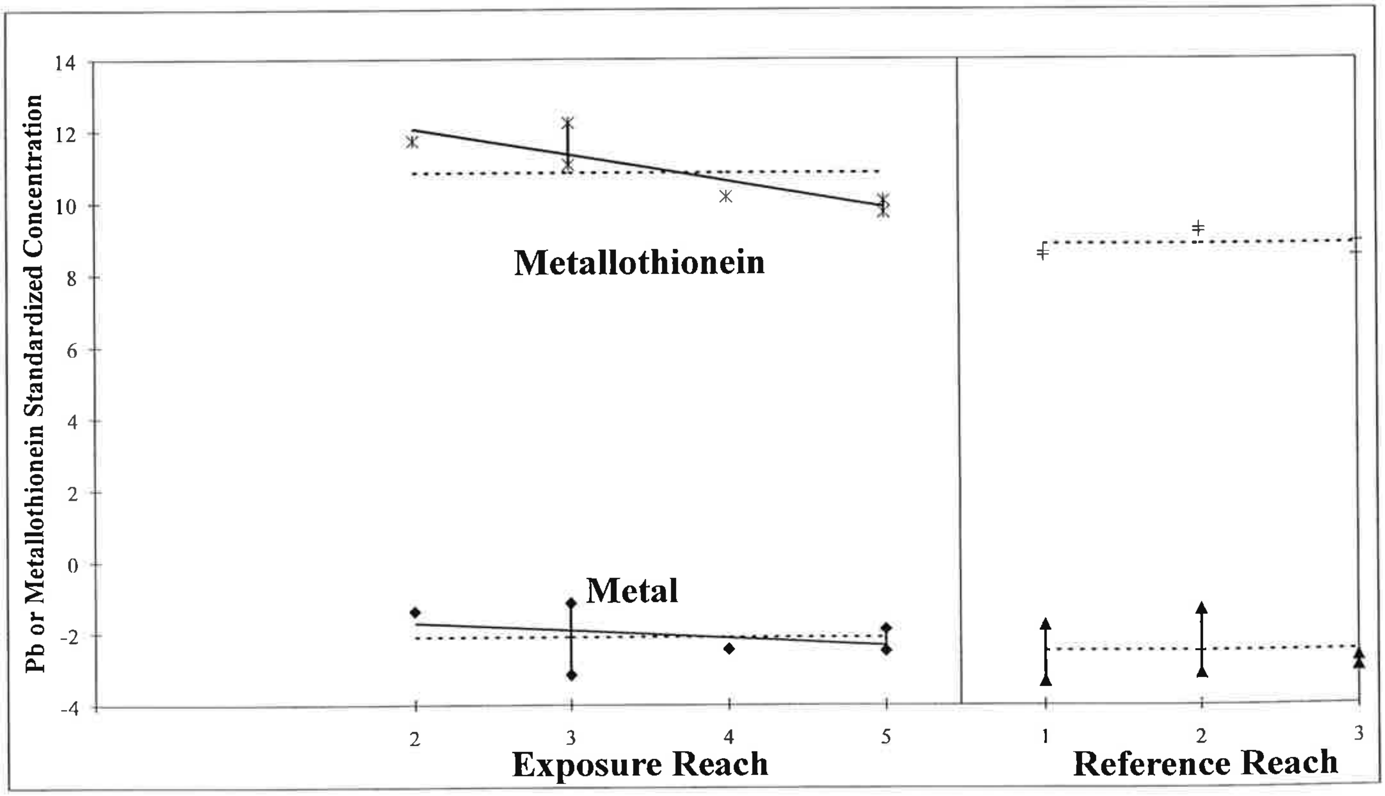


Hypothesis #4
Wild Blacknose Dace
Tissue Metal vs Tissue Metallothionein by Reach

Zinc

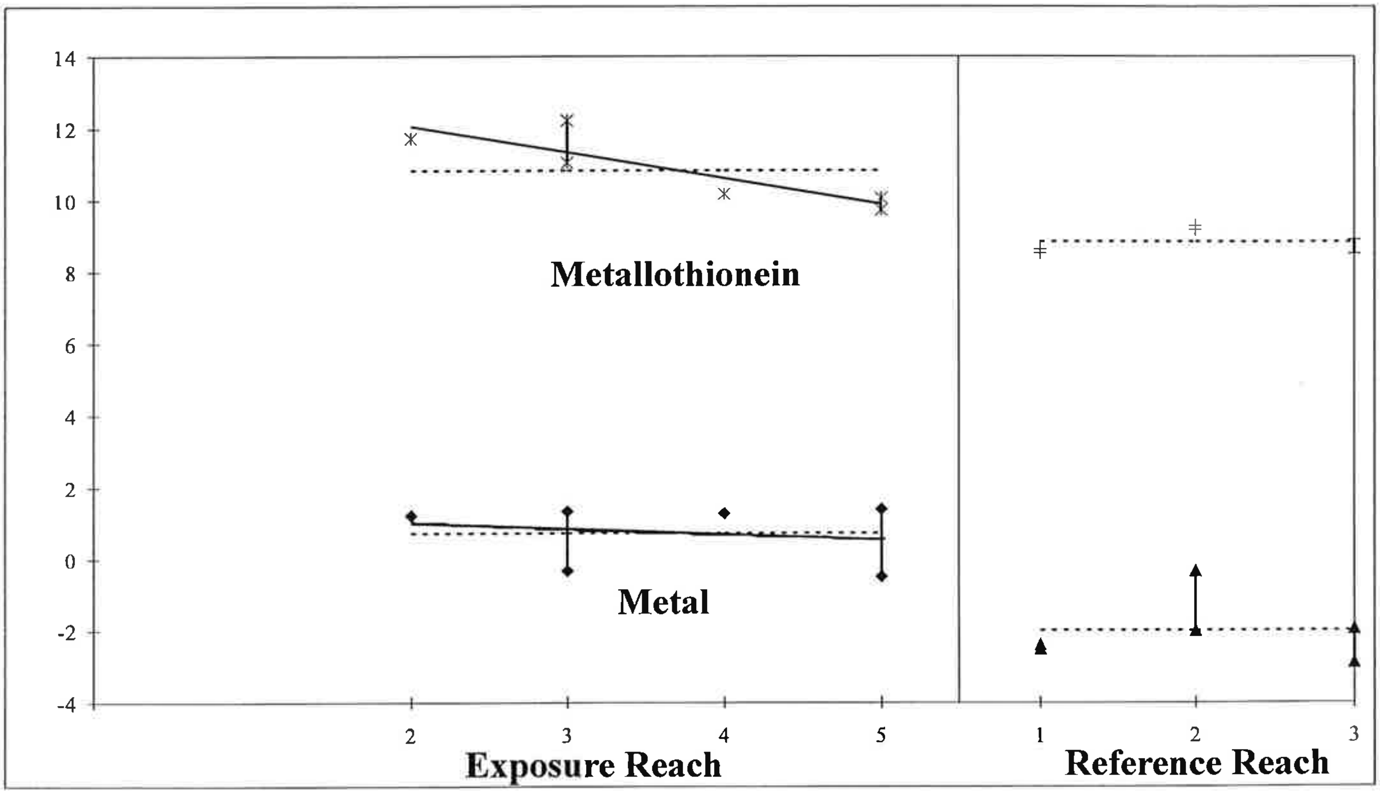


Lead



Hypothesis #4
Wild Blacknose Dace
Tissue Metal vs Tissue Metallothionein by Reach

CdCuZn Molar Sum



Heath Steele Fish - Test of Hypothesis #4

Wild Blacknose dace

Cadmium

Source	SS	DF	MS	F	P	Test Against
Tools	3327.70	1	3327.704	3327.704	**5.95E-14**	Within Reach
Reach	100.142	6	16.690	16.690	**1.11E-04**	Within Reach
Among Reference	17.846	2	8.923	1.268	0.441	Lack of Fit
Ref vs Exp	63.151	1	63.151	8.972	0.096	Lack of Fit
Linear Trend	5.068	1	5.068	0.720	0.485	Lack of Fit
Lack of Fit	14.077	2	7.038	7.038	**0.012**	Within Reach
Interactions	30.935	6	5.156	5.156	**0.012**	Within Reach
Ref/Exp x Tools	15.084	1	15.084	53.253	**0.002**	Residual
Linear Trend x Tools	14.718	1	14.718	51.961	**0.002**	Residual
Residual	1.133	4	0.283	0.283	0.882	Within Reach
Within Reach	10	10	1.000			

Copper

Source	SS	DF	MS	F	P	Test Against
Tools	1815.72	1	1815.723	1815.723	**1.22E-12**	Within Reach
Reach	86.529	6	14.422	14.422	**2.09E-04**	Within Reach
Among Reference	0.505	2	0.253	0.249	0.800	Lack of Fit
Ref vs Exp	73.318	1	73.318	72.377	**0.014**	Lack of Fit
Linear Trend	10.68	1	10.680	10.543	0.083	Lack of Fit
Lack of Fit	2.026	2	1.013	1.013	0.398	Within Reach
Interactions	27.212	6	4.535	4.535	**0.018**	Within Reach
Ref/Exp x Tools	10.67	1	10.670	4.967	0.090	Residual
Linear Trend x Tools	7.95	1	7.950	3.701	0.127	Residual
Residual	8.592	4	2.148	2.148	0.149	Within Reach
Within Reach	10	10	1.000			

Lead

Source	SS	DF	MS	F	P	Test Against
Tools	3750.56	1	3750.562	3750.562	**3.28E-14**	Within Reach
Reach	58.46	6	9.743	9.743	**1.08E-03**	Within Reach
Among Reference	2.31	2	1.155	0.733	0.577	Lack of Fit
Ref vs Exp	40.405	1	40.405	25.638	**0.037**	Lack of Fit
Linear Trend	12.593	1	12.593	7.990	0.106	Lack of Fit
Lack of Fit	3.152	2	1.576	1.576	0.254	Within Reach
Interactions	39.769	6	6.628	6.628	**0.005**	Within Reach
Ref/Exp x Tools	30.007	1	30.007	36.208	**0.004**	Residual
Linear Trend x Tools	6.447	1	6.447	7.779	**0.049**	Residual
Residual	3.315	4	0.829	0.829	0.536	Within Reach
Within Reach	10	10	1.000			

Zinc

Source	SS	DF	MS	F	P	Test Against
Tools	583.97	1	583.967	583.967	**3.35E-10**	Within Reach
Reach	103.677	6	17.280	17.280	**9.50E-05**	Within Reach
Among Reference	5.76	2	2.880	1.668	0.375	Lack of Fit
Ref vs Exp	83.357	1	83.357	48.281	**0.020**	Lack of Fit
Linear Trend	11.107	1	11.107	6.433	0.127	Lack of Fit
Lack of Fit	3.453	2	1.727	1.727	0.227	Within Reach
Interactions	18.595	6	3.099	3.099	0.055	Within Reach
Ref/Exp x Tools	7.278	1	7.278	7.811	**0.049**	Residual
Linear Trend x Tools	7.59	1	7.590	8.146	**0.046**	Residual
Residual	3.727	4	0.932	0.932	0.484	Within Reach
Within Reach	10	10	1.000			

CdCuZn Molar Sum

Source	SS	DF	MS	F	P	Test Against
Tools	3230.52	1	3230.524	3230.524	**6.90E-14**	Within Reach
Reach	103.676	6	17.279	17.279	**9.50E-05**	Within Reach
Among Reference	4.694	2	2.347	1.527	0.396	Lack of Fit
Ref vs Exp	84.789	1	84.789	55.165	**0.018**	Lack of Fit
Linear Trend	11.119	1	11.119	7.234	0.115	Lack of Fit
Lack of Fit	3.074	2	1.537	1.537	0.262	Within Reach
Interactions	18.524	6	3.087	3.087	0.056	Within Reach
Ref/Exp x Tools	6.862	1	6.862	6.724	0.060	Residual
Linear Trend x Tools	7.58	1	7.580	7.428	0.053	Residual
Residual	4.082	4	1.021	1.021	0.442	Within Reach
Within Reach	10	10	1.000			

Heath Steele Fish - Hypothesis #4 - Ancillary information

Wild Blacknose dace

Cadmium

Source	SS	DF	MS	F	P	Tested Against
Reach	34.470	6	5.745	5.745	**0.037**	Within Reach
Ref vs Exp	9.349	1	9.349	1.567	0.279	Lack of Fit
Linear Trend	1.256	1	1.256	0.211	0.670	Lack of Fit
Lack of Fit	23.865	4	5.966	5.966	**0.038**	Within Reach
Within Reach	5	5	1			

Copper

Source	SS	DF	MS	F	P	Tested Against
Reach	17.133	6	2.856	2.856	0.135	Within Reach
Ref vs Exp	15.433	1	15.433	38.607	**0.003**	Lack of Fit
Linear Trend	0.101	1	0.101	0.253	0.642	Lack of Fit
Lack of Fit	1.599	4	0.400	0.400	0.802	Within Reach
Within Reach	5	5	1			

Lead

Source	SS	DF	MS	F	P	Tested Against
Reach	1.622	6	0.270	0.270	0.929	Within Reach
Ref vs Exp	0.654	1	0.654	5.712	0.075	Lack of Fit
Linear Trend	0.510	1	0.510	4.454	0.102	Lack of Fit
Lack of Fit	0.458	4	0.115	0.115	0.972	Within Reach
Within Reach	5	5	1			

Zinc

Source	SS	DF	MS	F	P	Tested Against
Reach	25.665	6	4.278	4.278	0.066	Within Reach
Ref vs Exp	22.361	1	22.361	28.513	**0.006**	Lack of Fit
Linear Trend	0.167	1	0.167	0.213	0.668	Lack of Fit
Lack of Fit	3.137	4	0.784	0.784	0.581	Within Reach
Within Reach	5	5	1			

CdCuZn Molar Sum

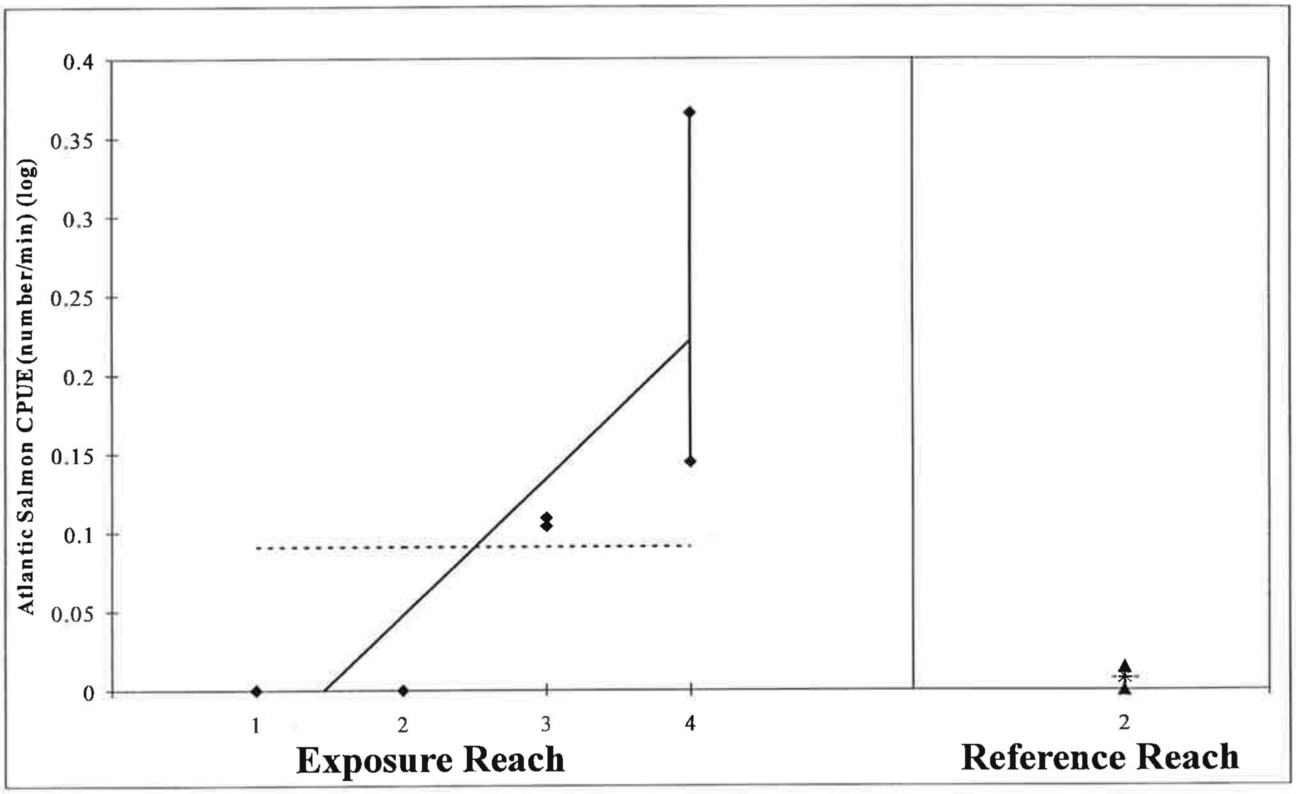
Source	SS	DF	MS	F	P	Tested Against
Reach	25.592	6	4.265	4.265	0.066	Within Reach
Ref vs Exp	23.438	1	23.438	47.230	**0.002**	Lack of Fit
Linear Trend	0.169	1	0.169	0.341	0.591	Lack of Fit
Lack of Fit	1.985	4	0.496	0.496	0.742	Within Reach
Within Reach	5	5	1			

MT

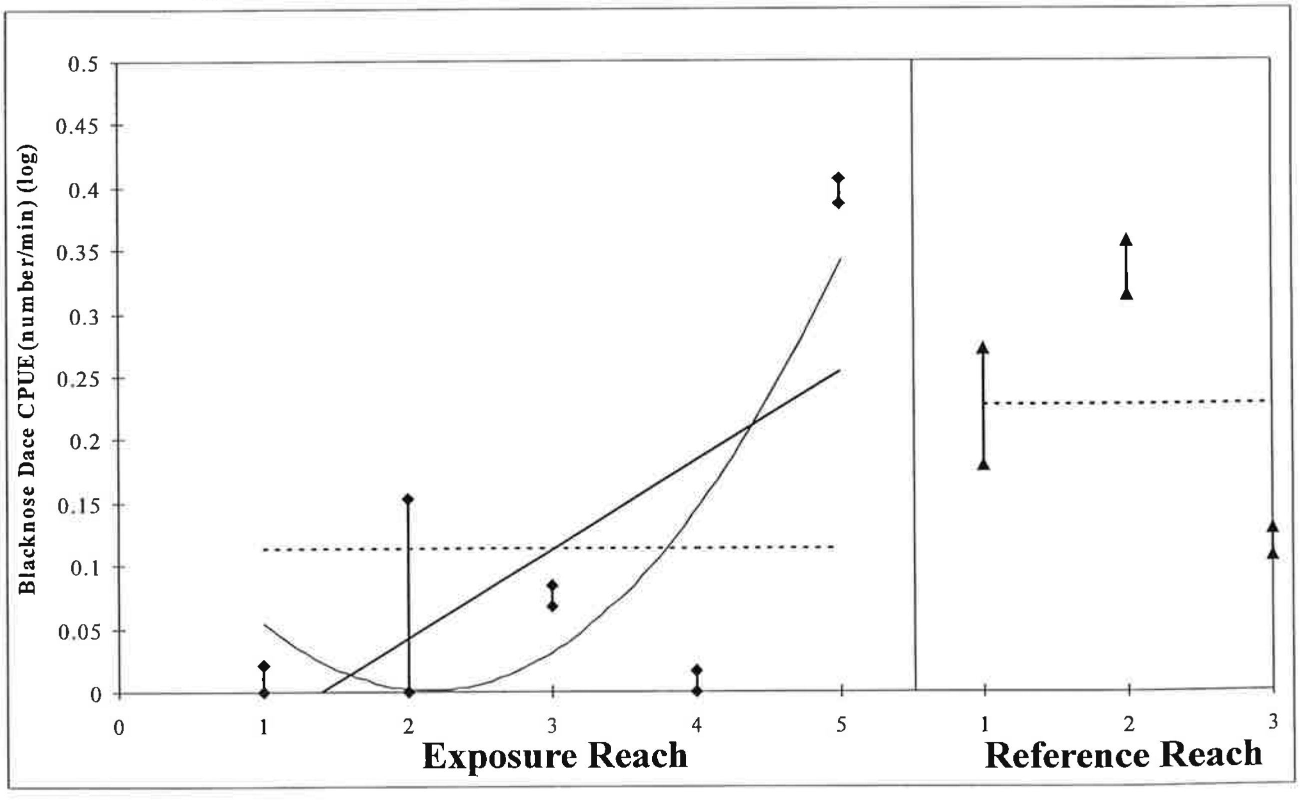
Source	SS	DF	MS	F	P	Tested Against
Reach	16.736	6	2.789	16.105	**0.004**	Within Reach
Ref vs Exp	11.594	1	11.594	24.004	**0.008**	Lack of Fit
Linear Trend	3.210	1	3.210	6.646	0.061	Lack of Fit
Lack of Fit	1.932	4	0.483	2.789	0.145	Within Reach
Within Reach	0.866	5	0.1732			

Hypothesis #5
CPUE (number/min) by Reach

Atlantic Salmon

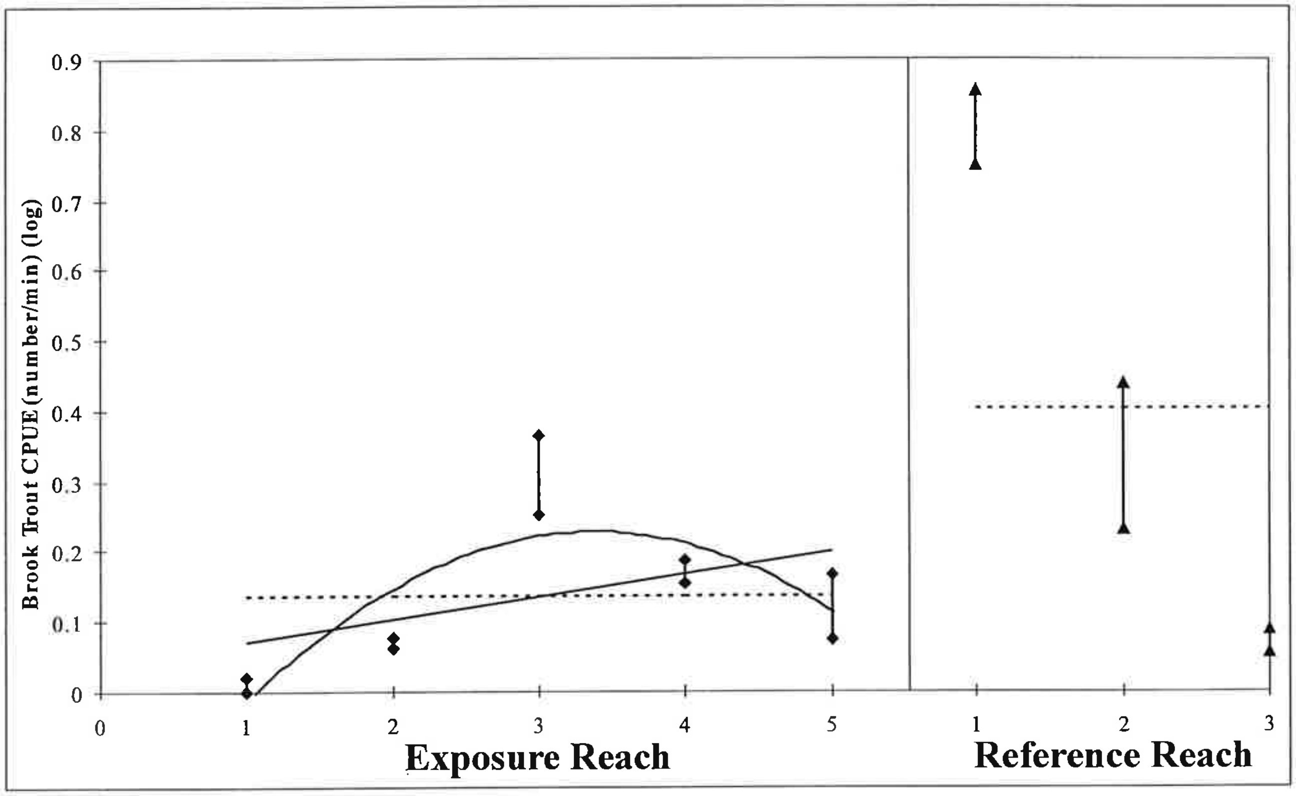


Blacknose Dace

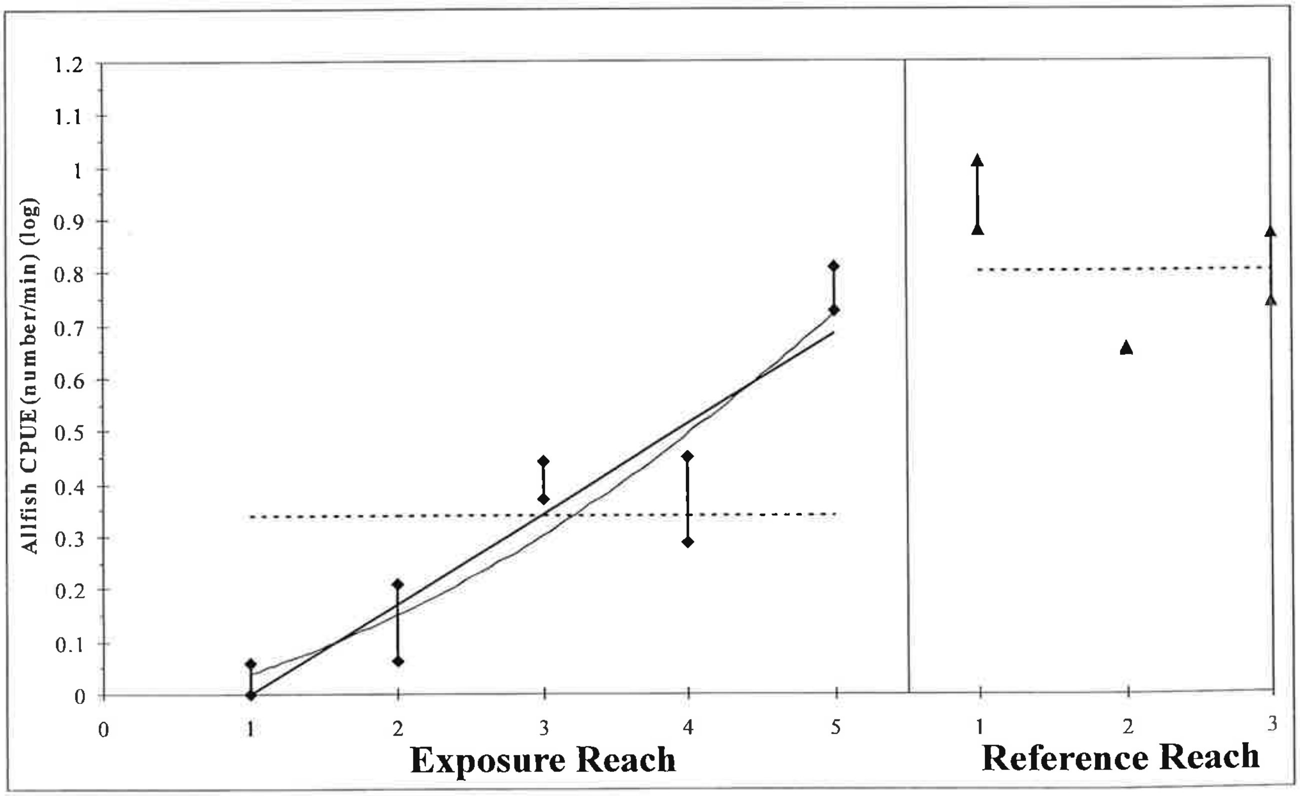


Hypothesis #5
CPUE (number/min) by Reach

Brook Trout



Allfish



Heath Steele Fish - Hypothesis #5

CPUE

Log Transformed Data

Atlantic salmon

Source	SS	DF	MS	F	P	Test Against
Reach[1]	0.099	4	0.025	5.023	0.053	Within Reach
Ref vs Exp	0.011	1	0.011	1.894	0.303	Lack of Fit
Linear Trend	0.076	1	0.076	12.991	0.069	Lack of Fit
Lack of Fit	0.012	2	0.006	1.190	0.378	Within Reach
Within Reach	0.025	5	0.005			

Blacknose Dace

Source	SS	DF	MS	F	P	Test Against
Reach	0.304	7	0.043	19.607	**1.93E-04**	Within Reach
Among Reference	0.047	2	0.024	0.449	0.675	Lack of Fit
Ref vs Exp	0.048	1	0.048	0.912	0.410	Lack of Fit
Linear Trend	0.099	1	0.099	1.898	0.262	Lack of Fit
Lack of Fit	0.157	3	0.052	23.622	**2.50E-04**	Within Reach
Within Reach	0.018	8	0.002			

Brook trout

Source	SS	DF	MS	F	P	Test Against
Reach	0.916	7	0.131	26.808	**6.03E-05**	Within Reach
Among Reference	0.544	2	0.272	1.303	0.392	Lack of Fit
Ref vs Exp	0.269	1	0.269	1.288	0.339	Lack of Fit
Linear Trend	0.021	1	0.021	0.099	0.774	Lack of Fit
Lack of Fit	0.626	3	0.209	42.777	**2.85E-05**	Within Reach
Within Reach	0.039	8	0.005			

All Fish

Source	SS	DF	MS	F	P	Test Against
Reach	1.529	7	0.218	36.156	**1.94E-05**	Within Reach
Among Reference	0.086	2	0.043	0.839	0.514	Lack of Fit
Ref vs Exp	0.793	1	0.793	15.549	**0.029**	Lack of Fit
Linear Trend	0.583	1	0.583	11.431	**0.043**	Lack of Fit
Lack of Fit	0.153	3	0.051	8.442	**0.007**	Within Reach
Within Reach	0.048	8	0.006			

Blacknose Dace

Source	SS	DF	MS	F	P	Test Against
Reach	0.304	7	0.043	19.607	**1.93E-04**	Within Reach
Among Reference	0.047	2	0.024	0.430	0.699	Lack of Fit
Ref vs Exp	0.048	1	0.048	0.872	0.449	Lack of Fit
2° Trend	0.147	2	0.073	1.343	0.427	Lack of Fit
Lack of Fit	0.109	2	0.055	24.693	**3.78E-04**	Within Reach
Within Reach	0.018	8	0.002			

Brook trout

Source	SS	DF	MS	F	P	Test Against
Reach	0.916	7	0.131	26.808	**6.03E-05**	Within Reach
Among Reference	0.544	2	0.272	0.945	0.514	Lack of Fit
Ref vs Exp	0.269	1	0.269	0.935	0.436	Lack of Fit
2° Trend	0.072	2	0.036	0.124	0.889	Lack of Fit
Lack of Fit	0.575	2	0.288	58.941	**1.63E-05**	Within Reach
Within Reach	0.039	8	0.005			

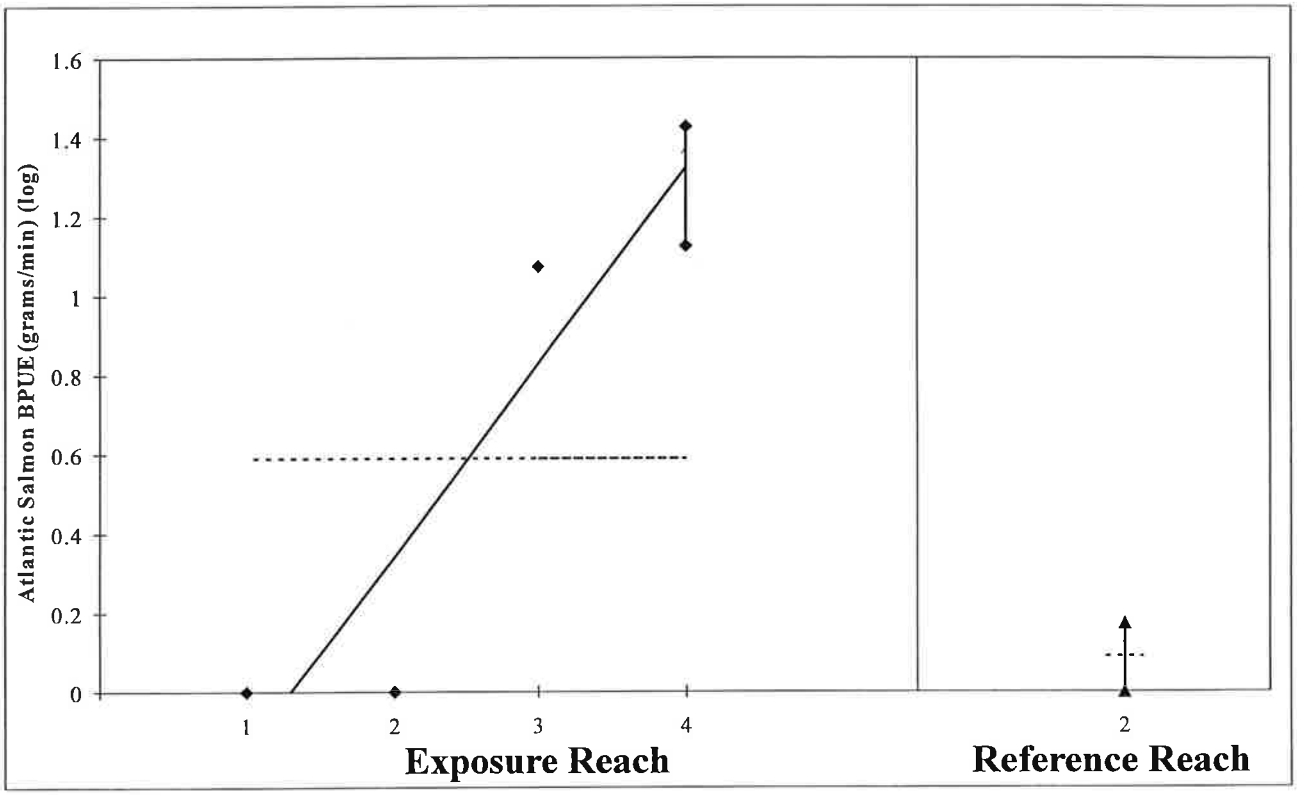
All Fish

Source	SS	DF	MS	F	P	Test Against
Reach	1.529	7	0.218	36.156	**1.94E-05**	Within Reach
Among Reference	0.086	2	0.043	0.601	0.625	Lack of Fit
Ref vs Exp	0.793	1	0.793	11.144	0.079	Lack of Fit
2° Trend	0.594	2	0.297	4.171	0.193	Lack of Fit
Lack of Fit	0.142	2	0.071	11.779	**0.004**	Within Reach
Within Reach	0.048	8	0.006			

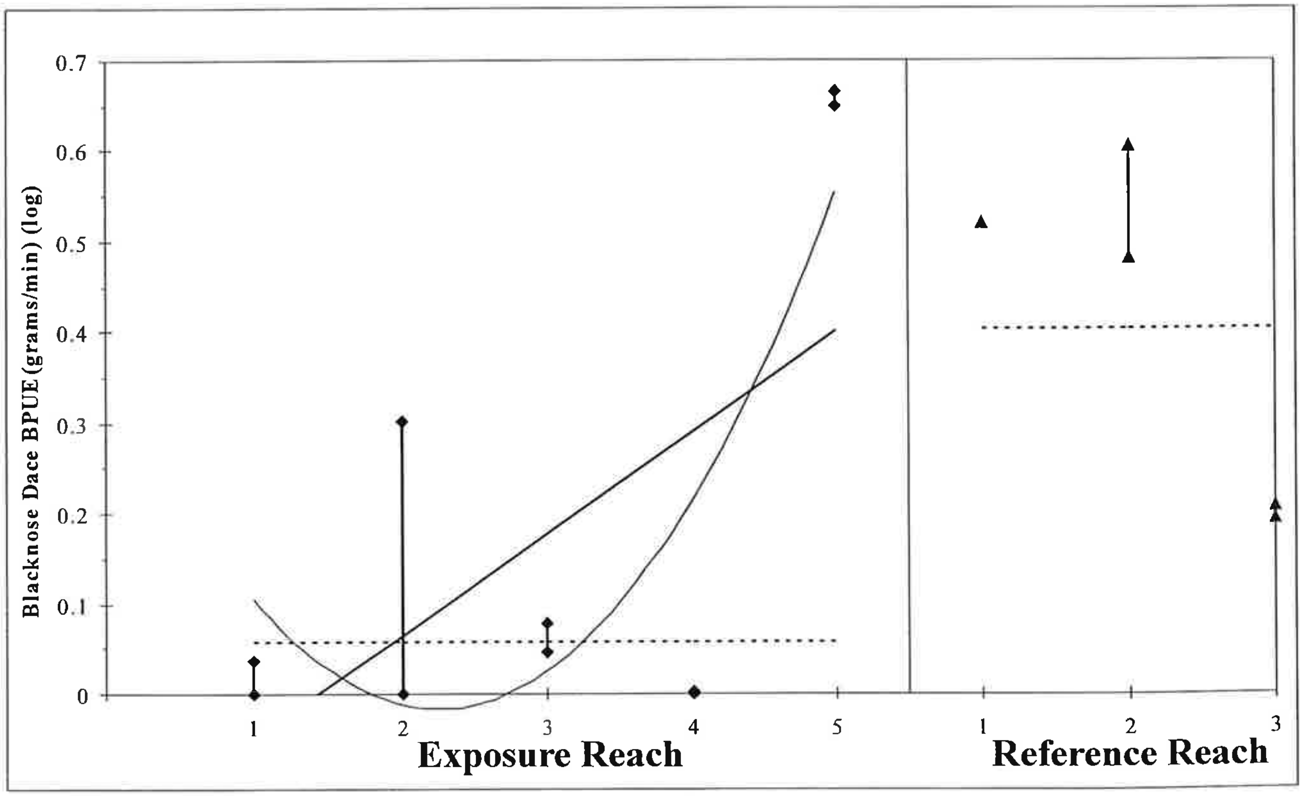
[1] Among Reference variance is not partitioned from the among reach variance because Salmon were caught at only two reference reaches, with multiple fish caught at only one of those reference reaches.

Hypothesis #6
BPUE (grams/min) by Reach

Atlantic Salmon

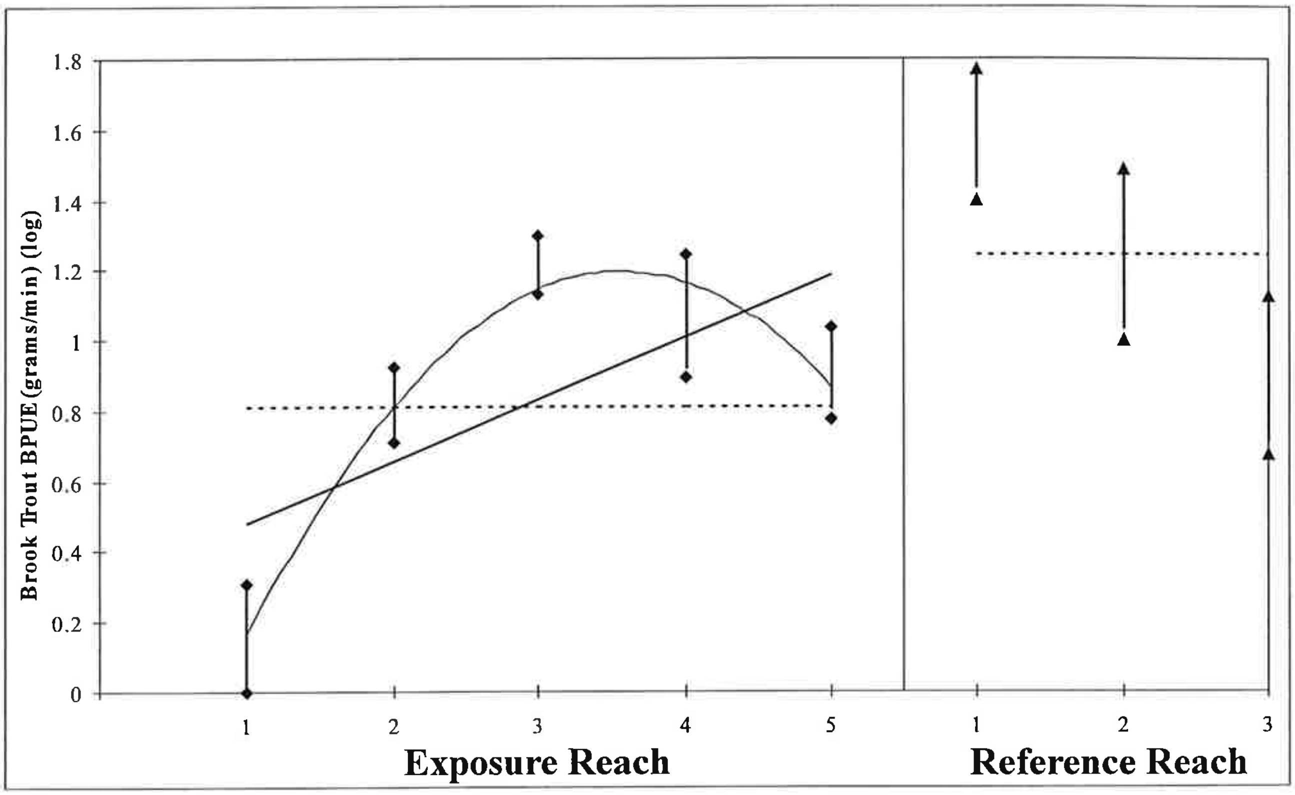


Blacknose Dace

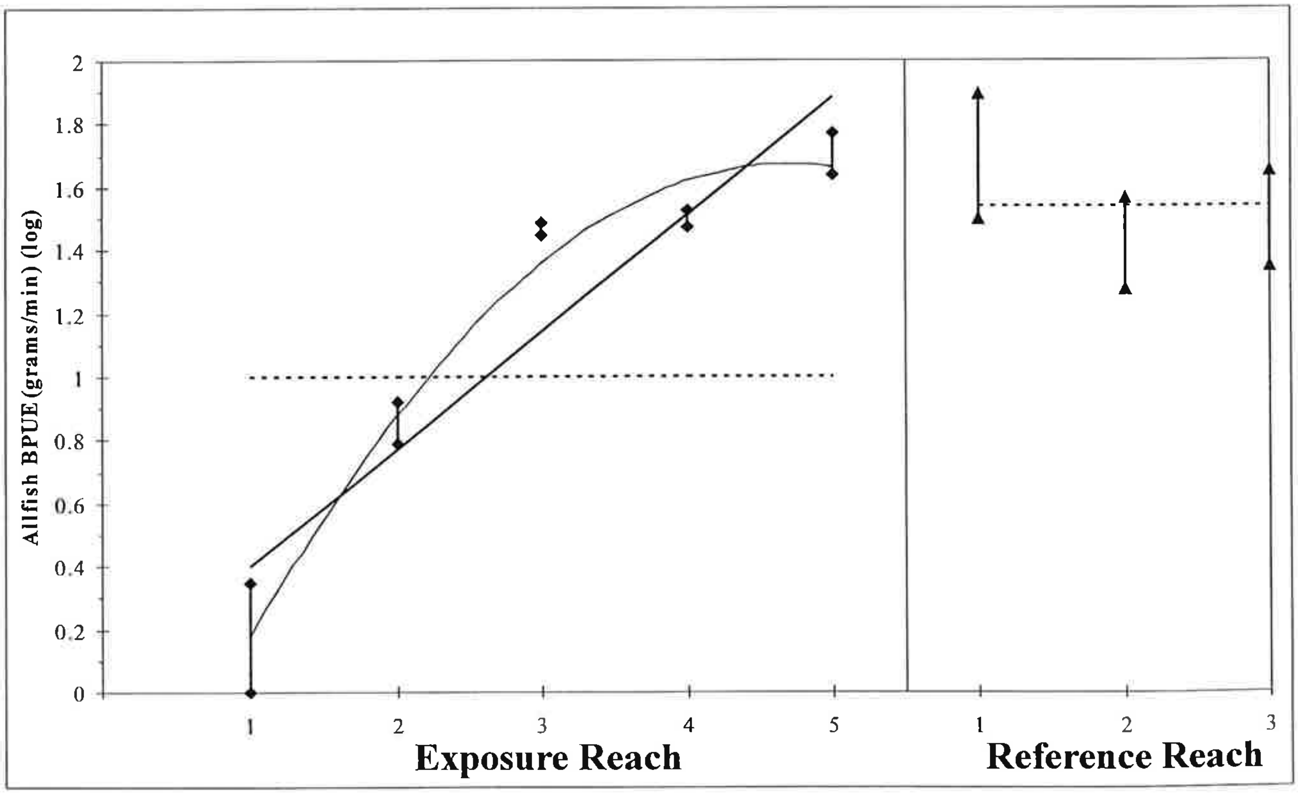


Hypothesis #6
BPUE (grams/min) by Reach

Brook Trout



Allfish



Heath Steele Fish - Hypothesis #6

BPUE

Log Transformed Data

Atlantic salmon

Source	SS	DF	MS	F	P	Test Against
Reach[1]	3.201	4	0.800	66.788	**1.58E-04**	Within Reach
Ref vs Exp	0.400	1	0.400	2.010	0.292	Lack of Fit
Linear Trend	2.403	1	2.403	12.075	0.074	Lack of Fit
Lack of Fit	0.398	2	0.199	16.608	**6.19E-03**	Within Reach
Within Reach	0.060	5	0.012			

Blacknose Dace

Source	SS	DF	MS	F	P	Test Against
Reach	0.917	7	0.131	16.868	**3.34E-04**	Within Reach
Among Reference	0.128	2	0.064	0.553	0.624	Lack of Fit
Ref vs Exp	0.188	1	0.188	1.625	0.292	Lack of Fit
Linear Trend	0.254	1	0.254	2.196	0.235	Lack of Fit
Lack of Fit	0.347	3	0.116	14.894	**1.23E-03**	Within Reach
Within Reach	0.062	8	0.008			

Brook trout

Source	SS	DF	MS	F	P	Test Against
Reach	2.439	7	0.348	5.918	**0.011**	Within Reach
Among Reference	0.468	2	0.234	0.975	0.472	Lack of Fit
Ref vs Exp	0.631	1	0.631	2.629	0.203	Lack of Fit
Linear Trend	0.620	1	0.620	2.583	0.206	Lack of Fit
Lack of Fit	0.720	3	0.240	4.076	**0.050**	Within Reach
Within Reach	0.471	8	0.059			

All Fish

Source	SS	DF	MS	F	P	Test Against
Reach	3.808	7	0.544	17.691	**2.81E-04**	Within Reach
Among Reference	0.081	2	0.040	0.307	0.756	Lack of Fit
Ref vs Exp	0.593	1	0.593	4.521	0.123	Lack of Fit
Linear Trend	2.741	1	2.741	20.898	**0.020**	Lack of Fit
Lack of Fit	0.393	3	0.131	4.265	**0.045**	Within Reach
Within Reach	0.246	8	0.031			

Blacknose Dace

Source	SS	DF	MS	F	P	Test Against
Reach	0.917	7	0.131	16.868	**3.34E-04**	Within Reach
Among Reference	0.128	2	0.064	0.699	0.588	Lack of Fit
Ref vs Exp	0.188	1	0.188	2.055	0.288	Lack of Fit
2° Trend	0.418	2	0.209	2.284	0.304	Lack of Fit
Lack of Fit	0.183	2	0.092	11.782	**4.13E-03**	Within Reach
Within Reach	0.062	8	0.008			

Brook trout

Source	SS	DF	MS	F	P	Test Against
Reach	2.439	7	0.348	5.918	**0.011**	Within Reach
Among Reference	0.468	2	0.234	15.097	0.062	Lack of Fit
Ref vs Exp	0.631	1	0.631	40.710	**0.024**	Lack of Fit
2° Trend	1.309	2	0.655	42.226	**0.023**	Lack of Fit
Lack of Fit	0.031	2	0.016	0.263	0.775	Within Reach
Within Reach	0.471	8	0.059			

All Fish

Source	SS	DF	MS	F	P	Test Against
Reach	3.808	7	0.544	17.691	**2.81E-04**	Within Reach
Among Reference	0.081	2	0.040	1.401	0.417	Lack of Fit
Ref vs Exp	0.593	1	0.593	20.633	**0.045**	Lack of Fit
2° Trend	3.077	2	1.539	53.532	**0.018**	Lack of Fit
Lack of Fit	0.057	2	0.029	0.935	0.432	Within Reach
Within Reach	0.246	8	0.031			

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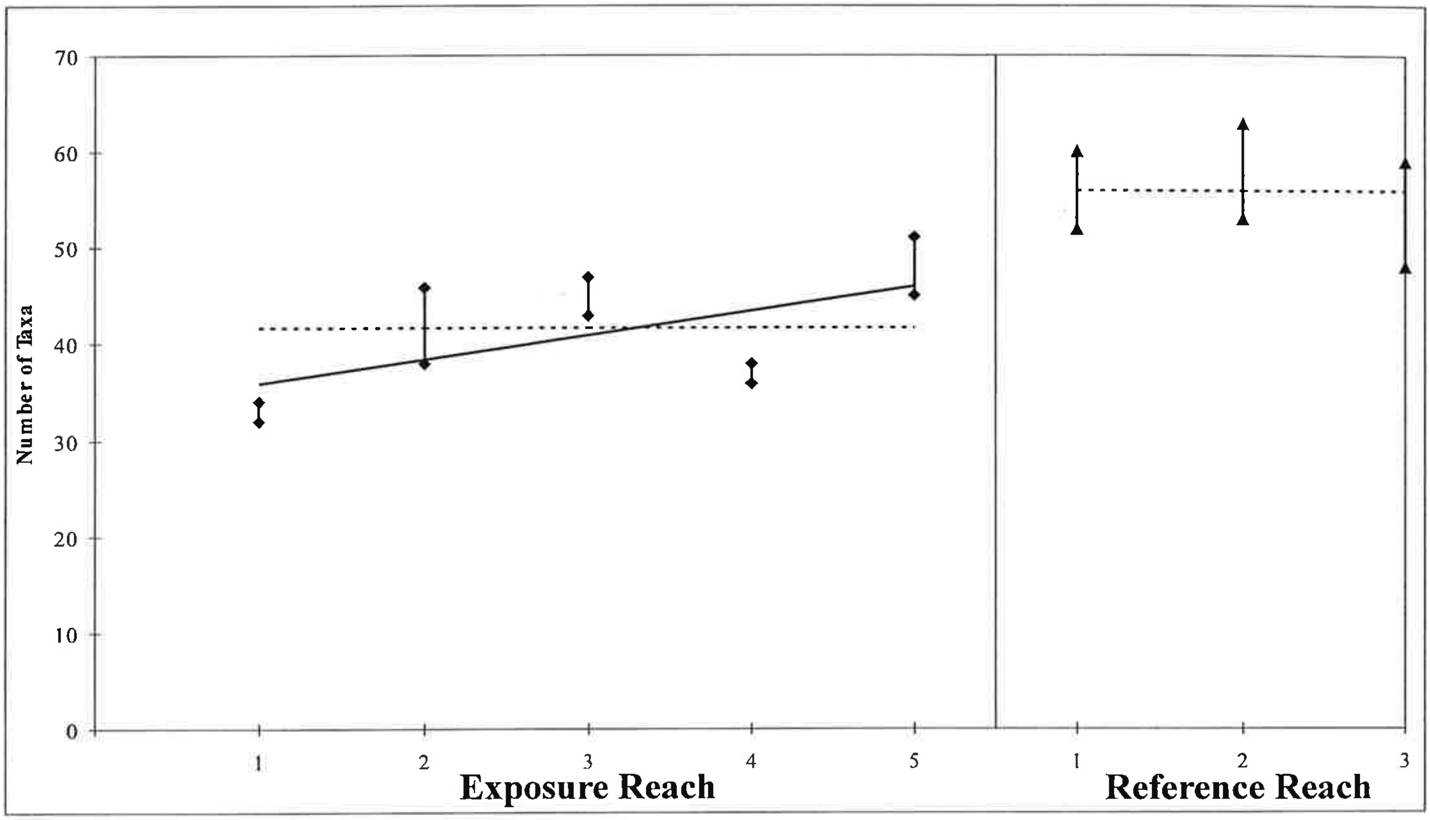
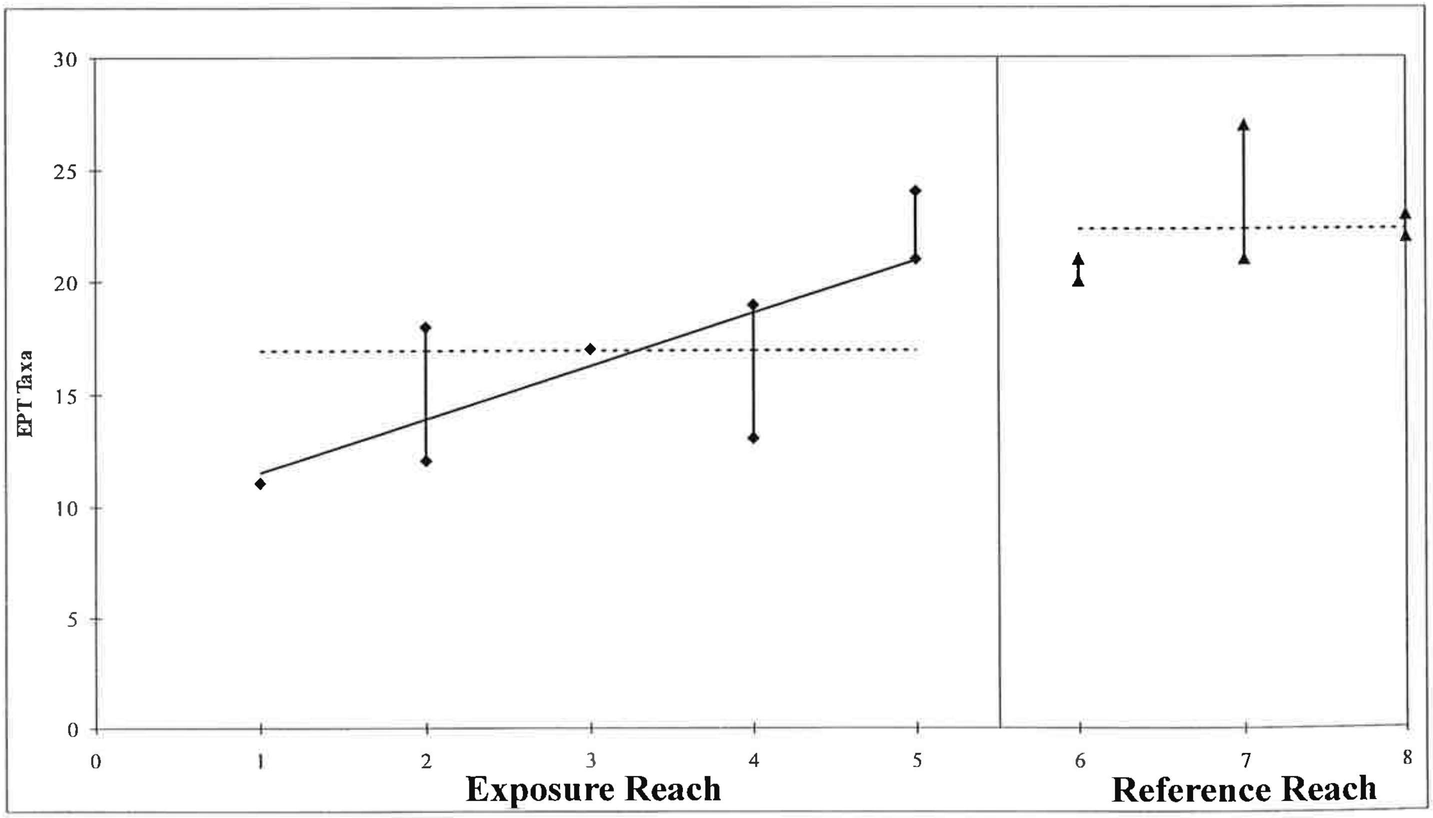
[1] Among Reference variance is not partitioned from the among reach variance because Salmon were caught at only two reference reaches, with multiple fish caught at only one of those reference reaches.

Hypothesis #6
Benthic Community Indices

Number of Taxa

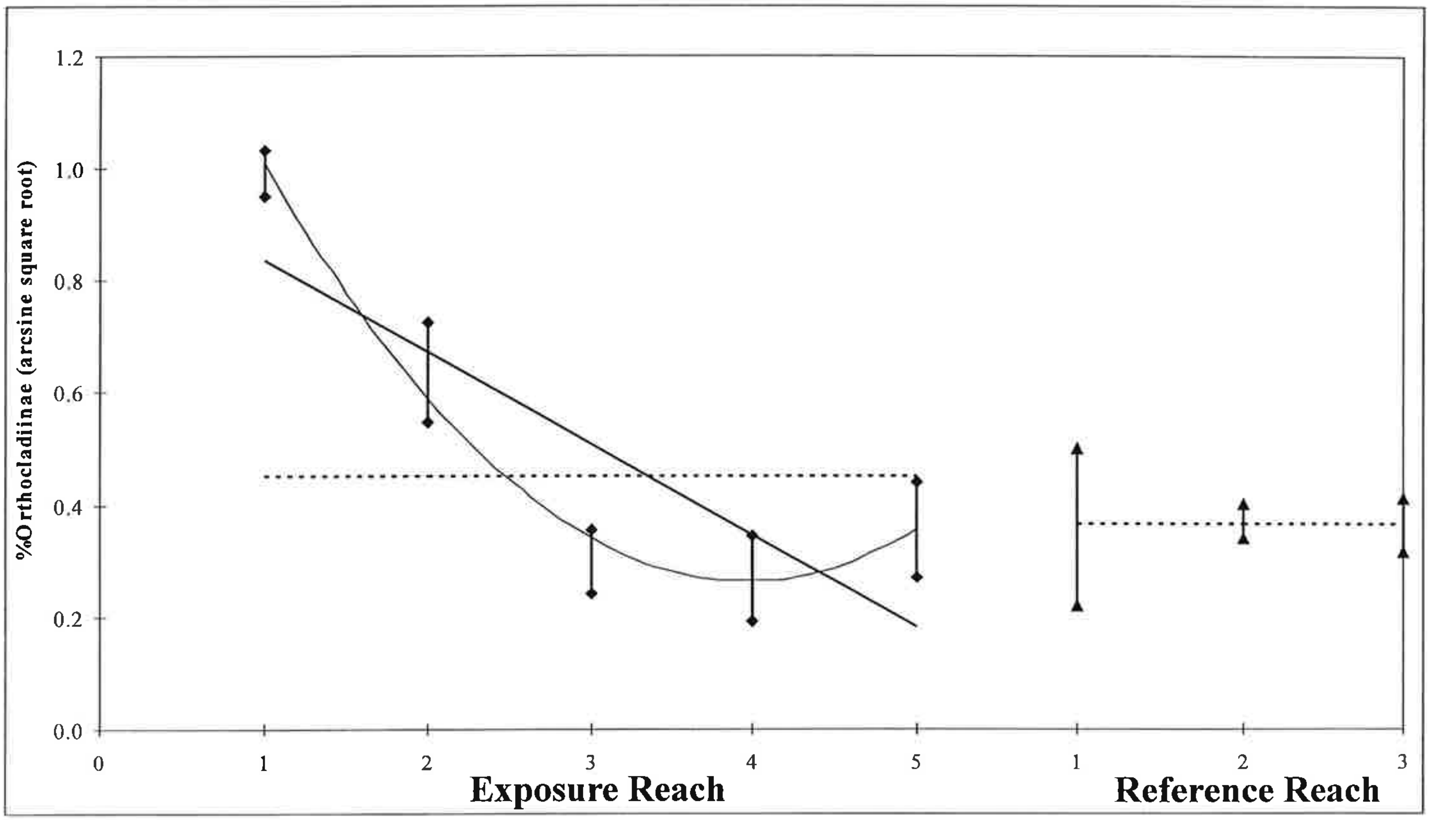


EPT Taxa

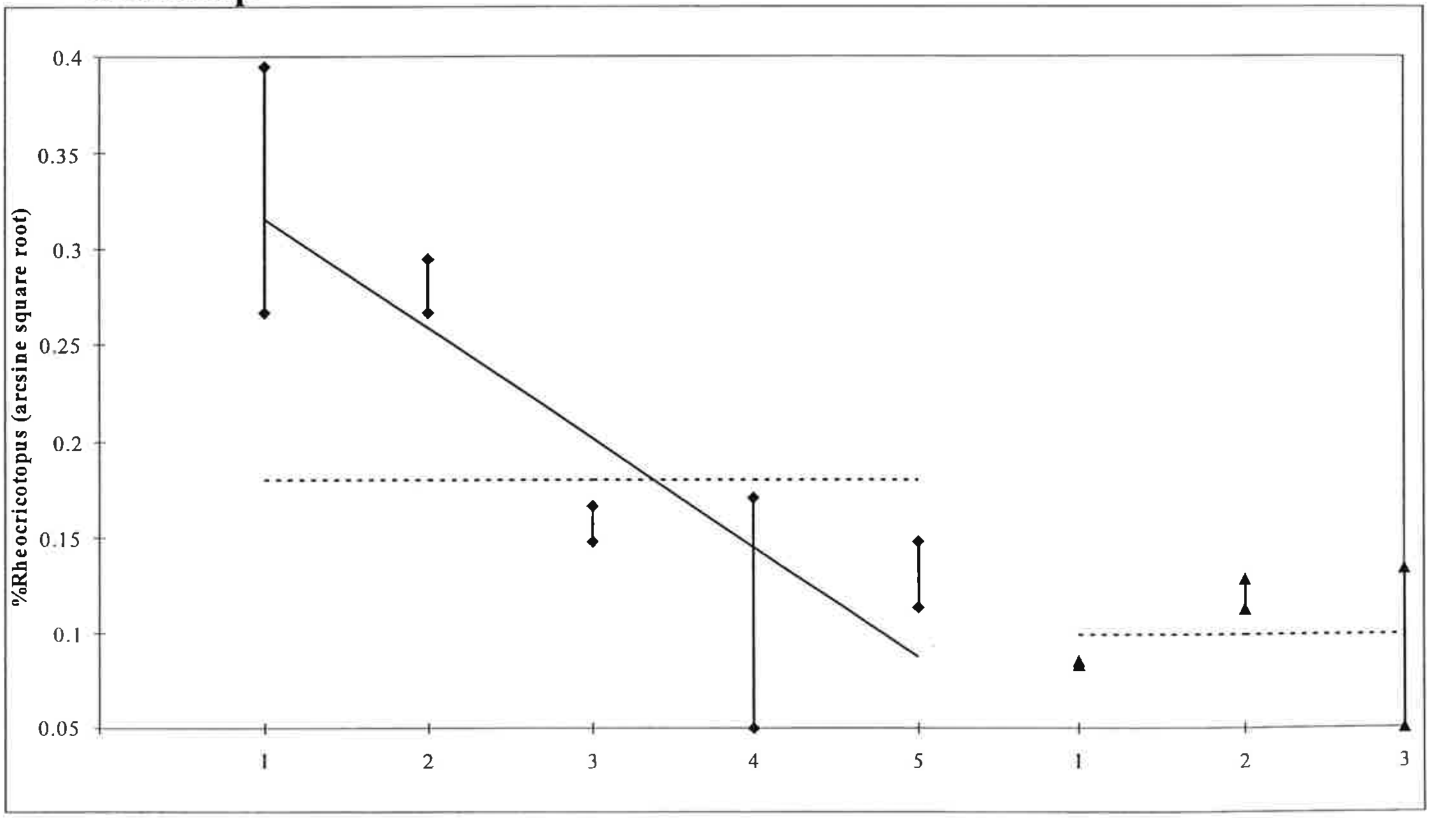


Hypothesis #6
Benthic Community Indices

%Orthocladiinae



%Rheocricotopus



Heath Steele Benthos - Hypothesis #6

Total Abundance (log)

Source	SS	DF	MS	F	P	Test Against
Reach	0.505	7	0.072	2.446	0.117	Within Reach
Among Ref	0.124	2	0.062	1.128	0.431	Lack of Fit
Ref vs Exp	0.215	1	0.215	3.911	0.142	Lack of Fit
Linear Trend	1.07E-03	1	0.001	0.019	0.898	Lack of Fit
Lack of Fit	0.165	3	0.055	1.864	0.214	Within Reach
Within Reach	0.236	8	0.030			

Taxa

Source	SS	DF	MS	F	P	Test Against
Reach	1137.438	7	162.4911	6.356622	**0.009**	Within Reach
Among Ref	20.333	2	10.1665	0.182631	0.842	Lack of Fit
Ref vs Exp	825.1042	1	825.1042	14.82216	**0.031**	Lack of Fit
Linear Trend	125	1	125	2.245498	0.231	Lack of Fit
Lack of Fit	167.0008	3	55.66693	2.17768	0.169	Within Reach
Within Reach	204.5	8	25.5625			

EPT

Source	SS	DF	MS	F	P	Test Against
Reach	286.438	7	40.91971	5.50181	**0.014**	Within Reach
Among Ref	12.333	2	6.1665	0.825834	0.518	Lack of Fit
Ref vs Exp	136.504	1	136.504	18.28097	**0.023**	Lack of Fit
Linear Trend	115.2	1	115.2	15.42788	**0.029**	Lack of Fit
Lack of Fit	22.401	3	7.467	1.003966	0.440	Within Reach
Within Reach	59.5	8	7.4375			

%Rheocricotopus (arcsin square root)

Source	SS	DF	MS	F	P	Test Against
Reach	0.118	7	0.017	6.676	**0.008**	Within Reach
Among Ref	1.46E-03	2	7.29E-04	0.195	0.832	Lack of Fit
Ref vs Exp	0.040	1	0.040	10.635	**0.047**	Lack of Fit
Linear Trend	0.066	1	0.066	17.601	**0.025**	Lack of Fit
Lack of Fit	0.011	3	3.73E-03	1.478	0.292	Within Reach
Within Reach	0.020	8	0.003			

%Orthocladiinae (arcsin square root)

Source	SS	DF	MS	F	P	Test Against
Reach	0.826	7	0.1180	9.570	**0.002**	Within Reach
Among Ref	1.29E-04	2	0.0001	0.001	0.999	Lack of Fit
Ref vs Exp	0.078	1	0.0780	1.099	0.371	Lack of Fit
Linear Trend	0.535	1	0.5350	7.540	0.071	Lack of Fit
Lack of Fit	0.213	3	0.0710	5.755	**0.021**	Within Reach
Within Reach	0.099	8	0.0123			

%Orthocladiinae (arcsin square root)

Source	SS	DF	MS	F	P	Test Against
Reach	0.826	7	0.1180	9.570	**0.002**	Within Reach
Among Ref	1.29E-04	2	0.0001	0.015	0.986	Lack of Fit
Ref vs Exp	0.078	1	0.0780	17.586	0.052	Lack of Fit
2° Trend	0.739	2	0.3695	83.308	**0.012**	Lack of Fit
Lack of Fit	0.009	2	0.0044	0.360	0.709	Within Reach
Within Reach	0.099	8	0.0123			

Heath Steele Periphyton - Hypothesis #6

Biomass (log)

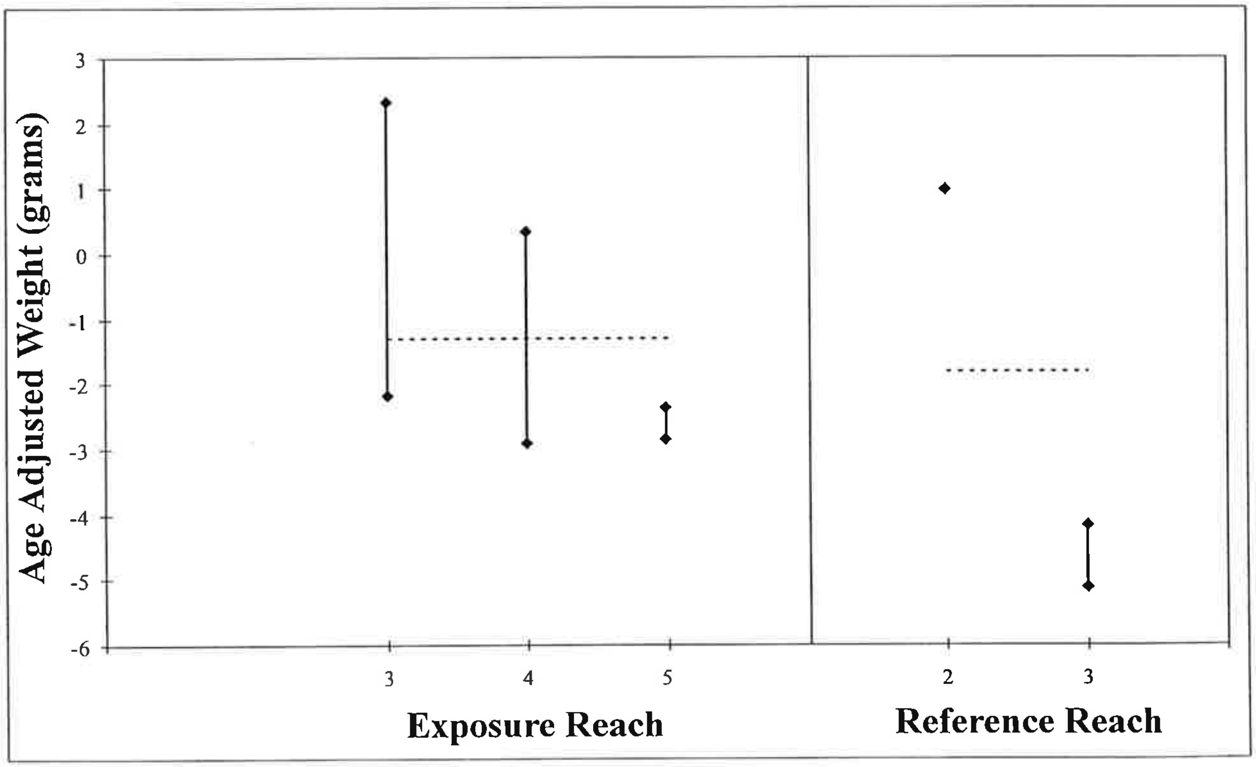
Source	SS	DF	MS	F	P	Tested Against
Reach	8.515	7	1.216	15.901	**4.13E-04**	Within Reach
Among Reference	3.957	2	1.979	1.632	0.331	Lack of Fit
Ref vs Exp	0.714	1	0.714	0.589	0.499	Lack of Fit
Linear Trend	0.207	1	0.207	0.171	0.707	Lack of Fit
Lack of Fit	3.637	3	1.212	15.847	**0.001**	Within Reach
Within Reach	0.612	8	0.077			

Number of Taxa

Source	SS	DF	MS	F	P
Reach	0.136	7	0.019	1.129	0.430
Within Reach	0.137	8	0.017		

Hypothesis #7

Atlantic Salmon
Age Adjusted (Age 0 years) Weight
(Excluding 0+ Age Class)



Heath Steele Fish - Hypothesis #7
Atlantic Salmon

All Data (excluding 0+ age class)

Fork Length @ Age

Source	SS	DF	MS	F	P	Tested Against
Among reach	4.443	4	1.111	1.966	0.117	Within Reach
Age	98.176	1	98.176	173.741	**1.06E-16**	Within Reach
Among Ref.	0.994	1	0.994	0.358	0.657	Lack of Fit
Ref vs Exp	0.064	1	0.064	0.023	0.904	Lack of Fit
Linear Trend	0.607	1	0.607	0.218	0.722	Lack of Fit
Lack of Fit	2.779	1	2.779	4.917	**0.032**	Within Reach
Within Reach	24.298	43	0.565			

Weight @ Age

Source	SS	DF	MS	F	P	Tested Against
Among reach	178.533	4	44.633	2.723	**0.042**	Within Reach
Age	2235.889	1	2235.889	136.420	**6.32E-15**	Within Reach
Among Ref.	29.168	1	29.168	0.383	0.647	Lack of Fit
Ref vs Exp	2.084	1	2.084	0.027	0.896	Lack of Fit
Linear Trend	71.082	1	71.082	0.933	0.511	Lack of Fit
Lack of Fit	76.199	1	76.199	4.649	**0.037**	Within Reach
Within Reach	704.758	43	16.390			

Weight (Log) vs Fork Length (Log)

Source	SS	DF	MS	F	P	Tested Against
Among reach	0.006	4	1.62E-03	0.838	0.508	Within Reach
Fork Length	1.707	1	1.707	884.669	**2.59E-30**	Within Reach
Among Ref.	0.002	1	2.09E-03	10.165	0.193	Lack of Fit
Ref vs Exp	2.59E-04	1	2.59E-04	1.257	0.464	Lack of Fit
Linear Trend	0.004	1	3.91E-03	18.990	0.144	Lack of Fit
Lack of Fit	2.06E-04	1	2.06E-04	0.107	0.745	Within Reach
Within Reach	0.083	43	1.93E-03			

All Data including 0+ age class

Weight vs Age - Significant Age x Reach Interaction ($p<0.001$)
Fork Length vs Age - Significant Age x Reach Interaction ($p<0.001$)

Weight (Log) vs Fork Length (Log)

Source	SS	DF	MS	F	P	Tested Against
Among reach	0.036	4	9.00E-03	1.730	0.145	Within Reach
Fork Length	19.730	1	19.730	3794.231	**3.23E-134**	Within Reach
Among Ref.	0.004	1	4.36E-03	0.157	0.760	Lack of Fit
Ref vs Exp	4.19E-04	1	4.19E-04	0.015	0.922	Lack of Fit
Linear Trend	0.004	1	3.54E-03	0.128	0.781	Lack of Fit
Lack of Fit	0.028	1	2.77E-02	5.322	**0.022**	Within Reach
Within Reach	1.066	205	5.20E-03			

Using Station Mean Values for Age-Adjusted Weight and Length (excluding 0+ age class)

Fork Length @ Age

Source	SS	DF	MS	F	P	Tested Against
Among reach	0.990	4	0.248	10.000	**0.023**	Within Reach
Among Ref.	0.718	1	0.718	3.902	0.298	Lack of Fit
Ref vs Exp	0.007	1	0.007	0.038	0.877	Lack of Fit
Linear Trend	0.081	1	0.081	0.440	0.627	Lack of Fit
Lack of Fit	0.184	1	0.184	7.434	0.053	Within Reach
Within Reach	9.90E-02	4	0.025			

Weight @ Age

Source	SS	DF	MS	F	P	Tested Against
Among reach	32.634	4	8.159	2.039	0.254	Within Reach
Among Ref.	21.066	1	21.066	5.526	0.256	Lack of Fit
Ref vs Exp	0.577	1	0.577	0.151	0.764	Lack of Fit
Linear Trend	7.179	1	7.179	1.883	0.401	Lack of Fit
Lack of Fit	3.812	1	3.812	0.953	0.384	Within Reach
Within Reach	16.003	4	4.001			

Using Station Mean Values for Age-Adjusted Weight and Length (excluding 0+ age class and HE3 and HR5 results)

Fork Length @ Age

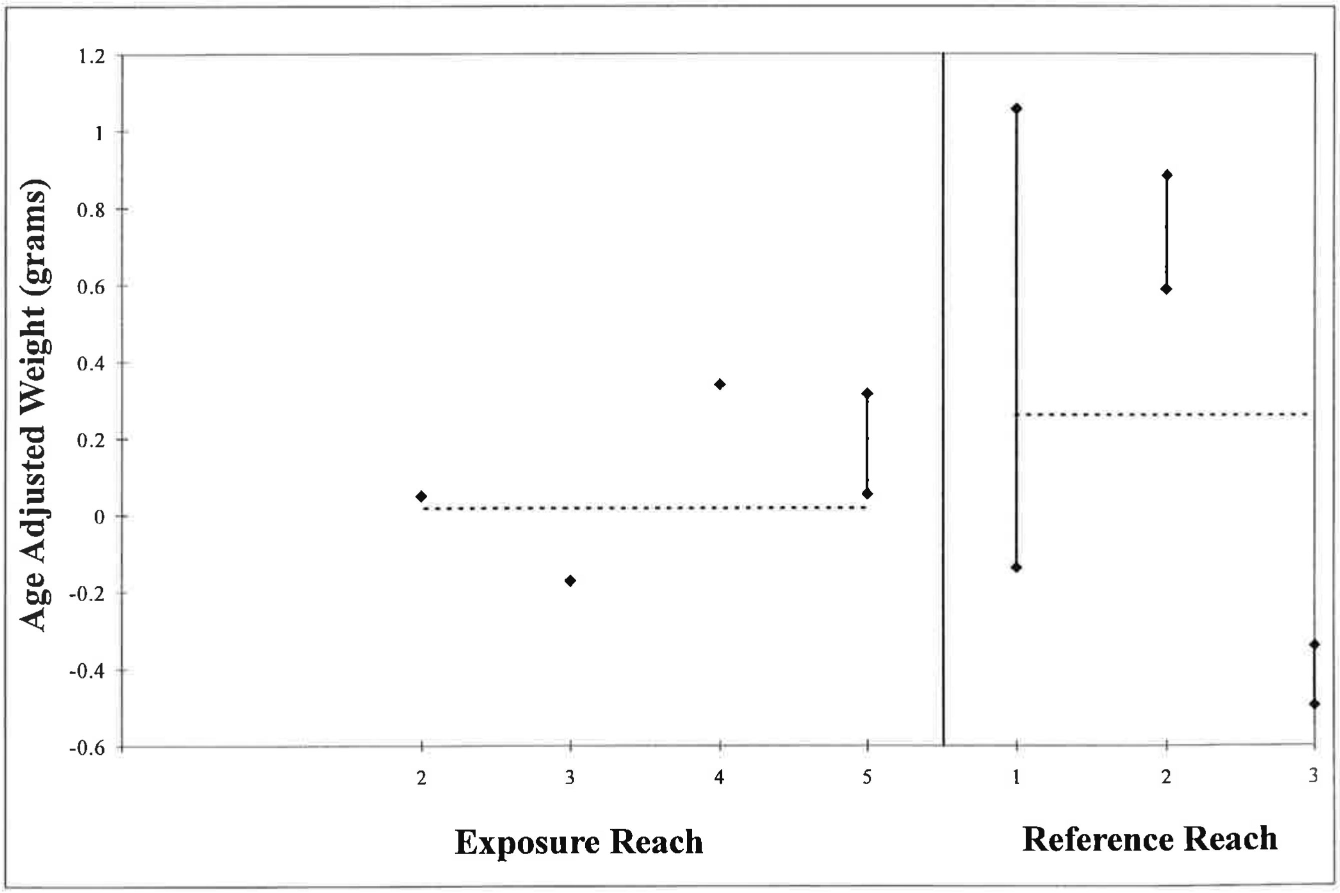
Source	SS	DF	MS	F	P
Reach	0.114	2	0.057	8.818	0.102
Error	0.013	2	0.006		

Weight @ Age

Source	SS	DF	MS	F	P
Reach	3.890	2	1.945	0.252	0.799
Error	15.454	2	7.727		

Hypothesis #7

Blacknose dace
Age Adjusted (Age 0 years) Weight



Heath Steele Fish - Hypothesis #7
Blacknose Dace

All Data

Fork Length @ Age (Age<=3 Years)

Source	SS	DF	MS	F	P	Tested Against
Among reach	3.350	6	0.558	1.947	0.100	Within Reach
Age	25.103	1	25.103	87.526	**3.57E-11**	Within Reach
Among Reference	1.626	2	0.813	2.810	0.262	Lack of Fit
Ref vs Exp	0.012	1	0.012	0.042	0.856	Lack of Fit
Linear Trend	1.133	1	1.133	3.915	0.186	Lack of Fit
Lack of Fit	0.579	2	0.289	1.009	0.375	Within Reach
Within Reach	10.325	36	0.287			

Weight @ Age (All Ages)

Source	SS	DF	MS	F	P	Tested Against
Among reach	3.283	6	0.547	1.253	0.300	Within Reach
Age	66.880	1	66.88	153.137	**1.98E-15**	Within Reach
Among Reference	2.672	2	1.336	6.124	0.140	Lack of Fit
Ref vs Exp	4.65E-03	1	0.005	0.021	0.897	Lack of Fit
Linear Trend	0.170	1	0.17	0.779	0.471	Lack of Fit
Lack of Fit	0.436	2	0.218	0.500	0.610	Within Reach
Within Reach	17.906	41	0.437			

Weight vs Fork Length (Log)

Source	SS	DF	MS	F	P	Tested Against
Among reach	0.020	6	3.41E-03	1.371	0.249	Within Reach
Fork Length	2.963	1	2.963	1191.010	**6.37E-32**	Within Reach
Among Reference	0.016	2	0.008	20.002	**0.048**	Lack of Fit
Ref vs Exp	3.36E-03	1	3.36E-03	8.348	0.102	Lack of Fit
Linear Trend	1.80E-04	1	1.80E-04	0.447	0.573	Lack of Fit
Lack of Fit	8.06E-04	2	4.03E-04	0.162	0.851	Within Reach
Within Reach	0.102	41	2.49E-03			

Fork Length vs Age (All Ages) - Significant Interaction (p=0.003)

Station Means

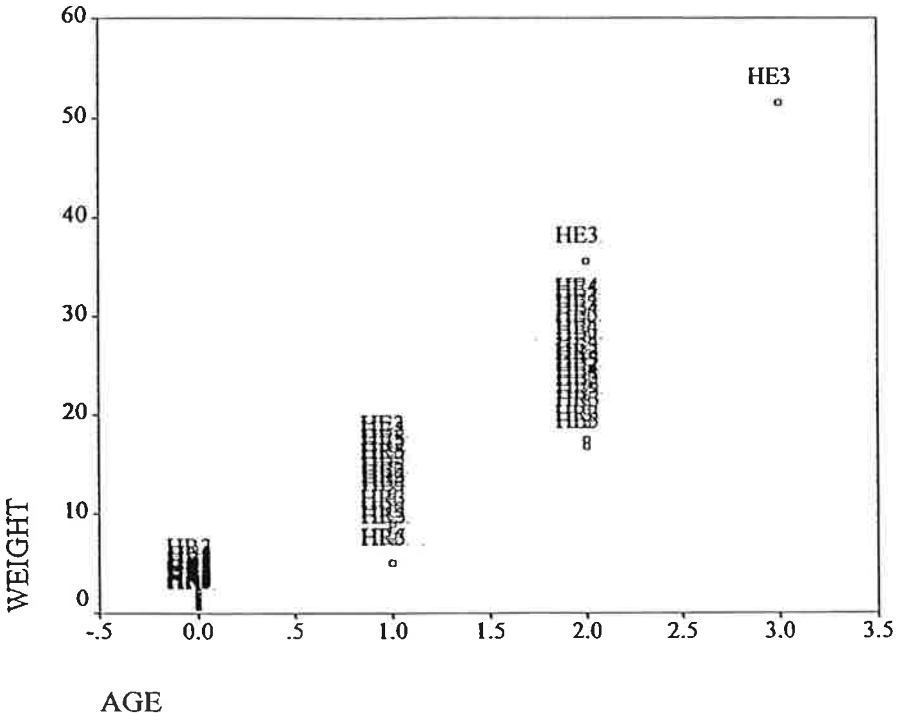
Fork Length @ Age (Age<=3 Years)

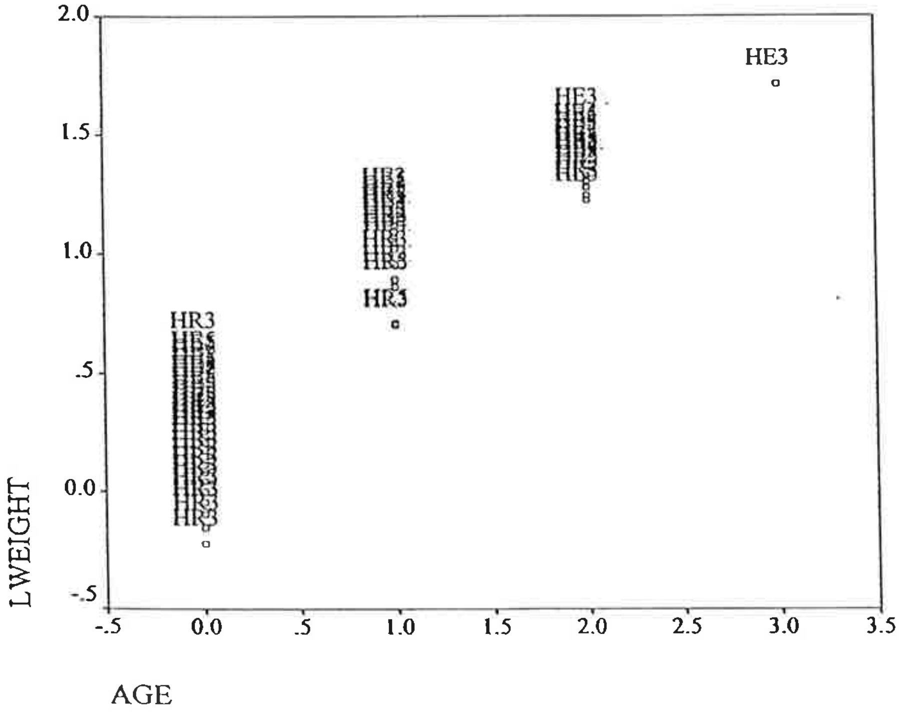
Source	SS	DF	MS	F	P	Tested Against
Among reach	2.735	6	0.456	2.175	0.206	Within Reach
Among Reference	1.644	2	0.822	2.068	0.326	Lack of Fit
Ref vs Exp	0.002	1	0.002	0.005	0.950	Lack of Fit
Linear Trend	0.294	1	0.294	0.740	0.480	Lack of Fit
Lack of Fit	0.795	2	0.398	1.897	0.244	Within Reach
Within Reach	1.048	5	0.210			

Weight @ Age (All Ages)

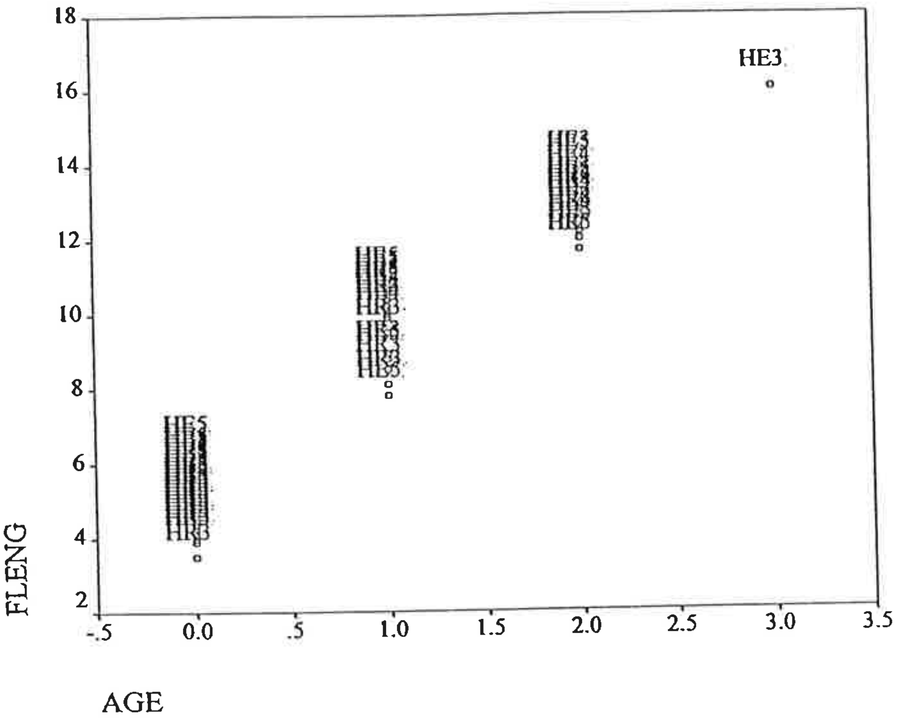
Source	SS	DF	MS	F	P	Tested Against
Among reach	1.830	6	0.305	2.157	0.208	Within Reach
Among Reference	1.487	2	0.744	7.397	0.119	Lack of Fit
Ref vs Exp	0.085	1	0.085	0.845	0.455	Lack of Fit
Linear Trend	0.057	1	0.057	0.567	0.530	Lack of Fit
Lack of Fit	0.201	2	0.101	0.711	0.535	Within Reach
Within Reach	0.707	5	0.141			

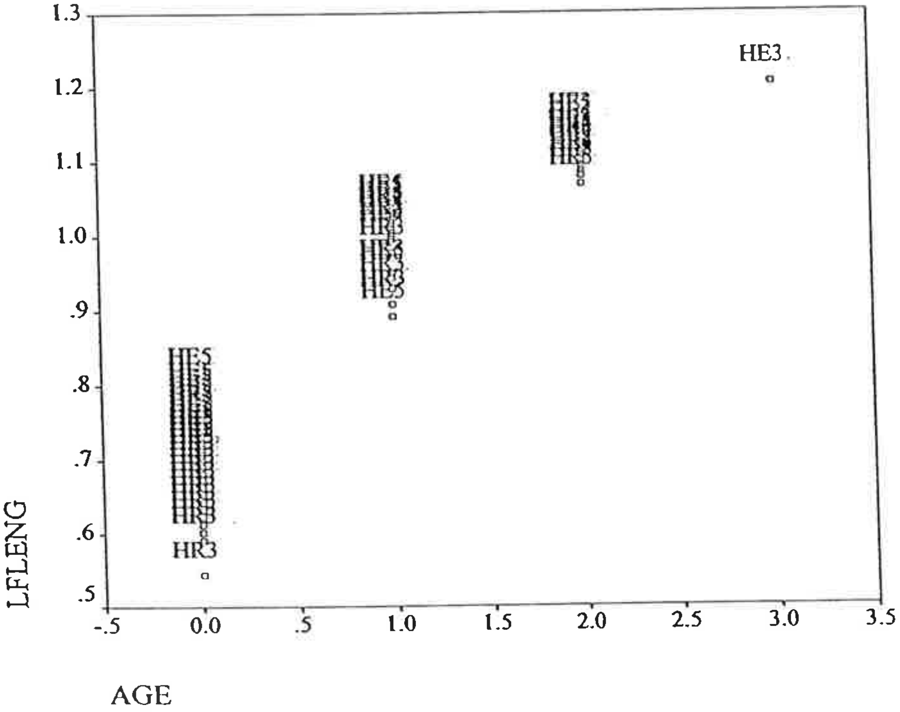
Heath Steele - Fish Growth - Atlantic Salmon



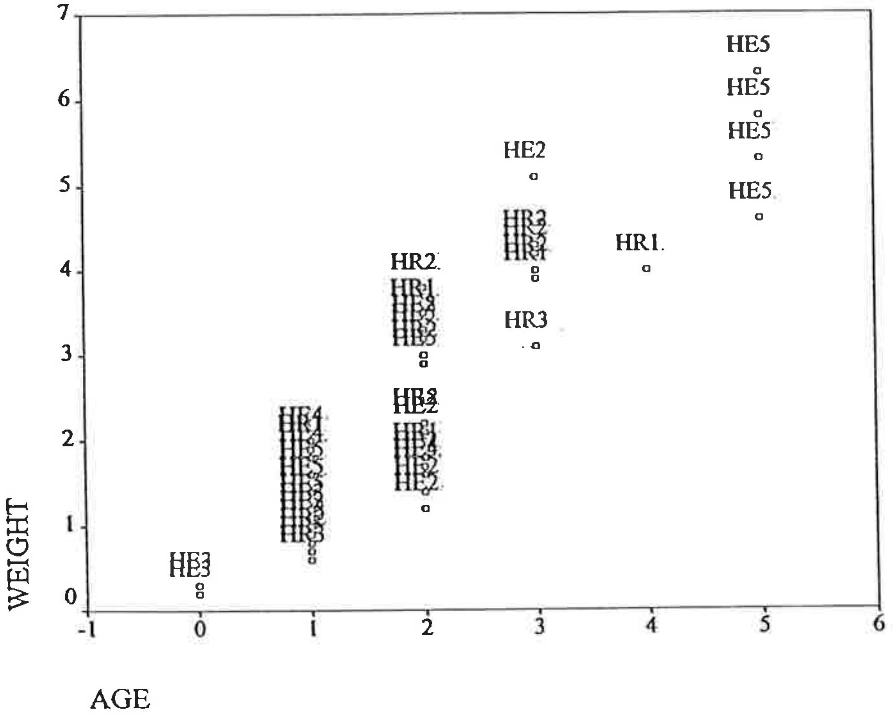


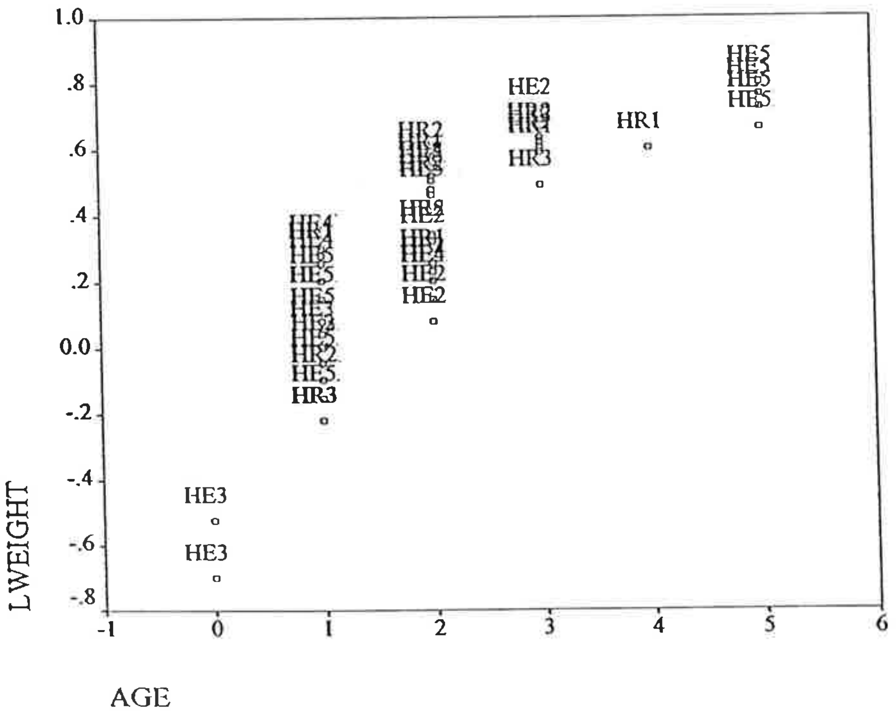
Heath Steele - Fish Growth - Atlantic Salmon



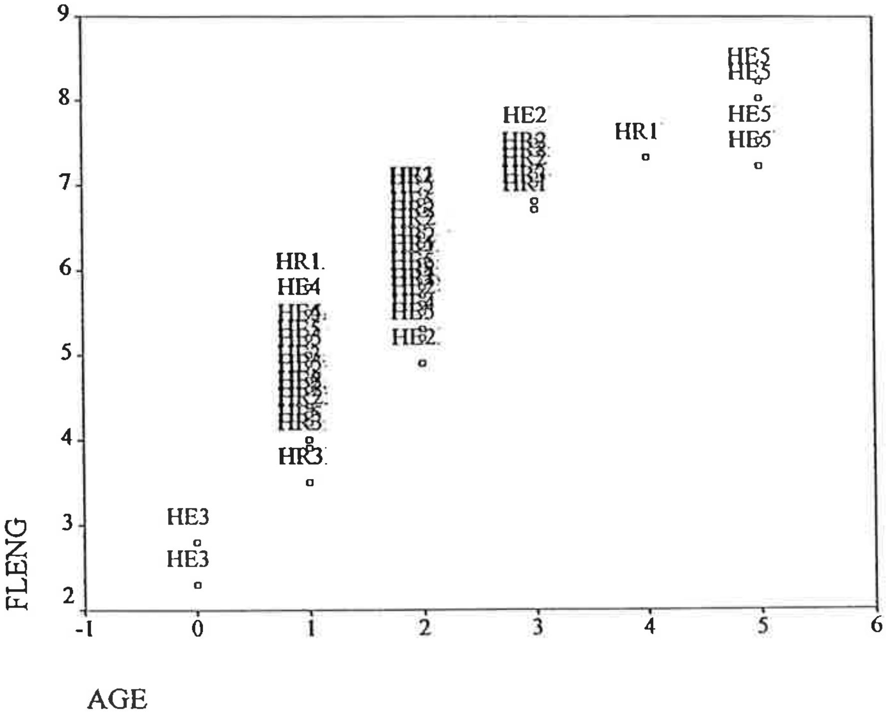


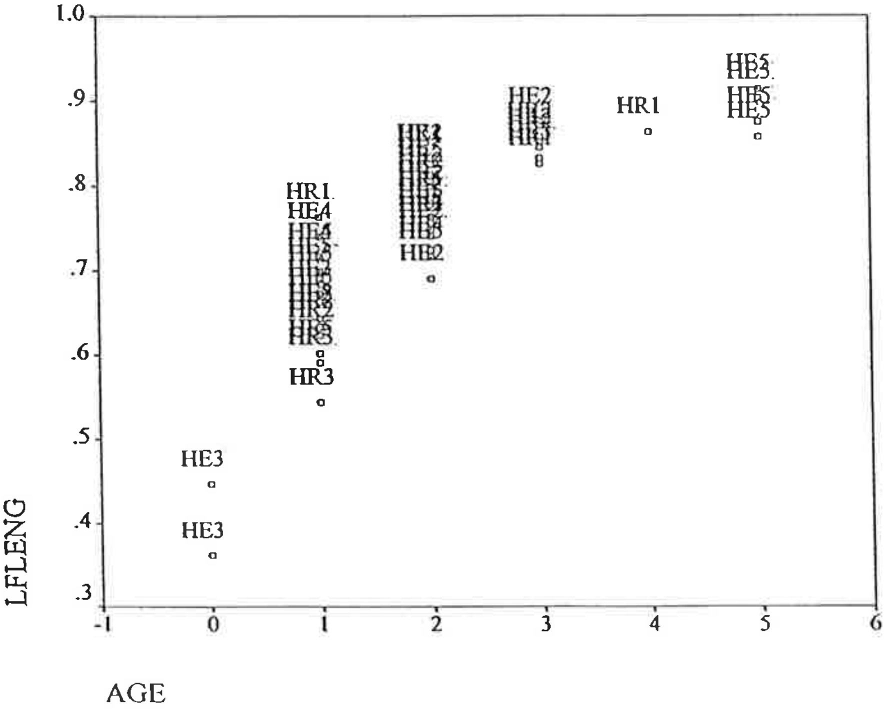
Heath Steele - Fish Growth - Blacknose Dace



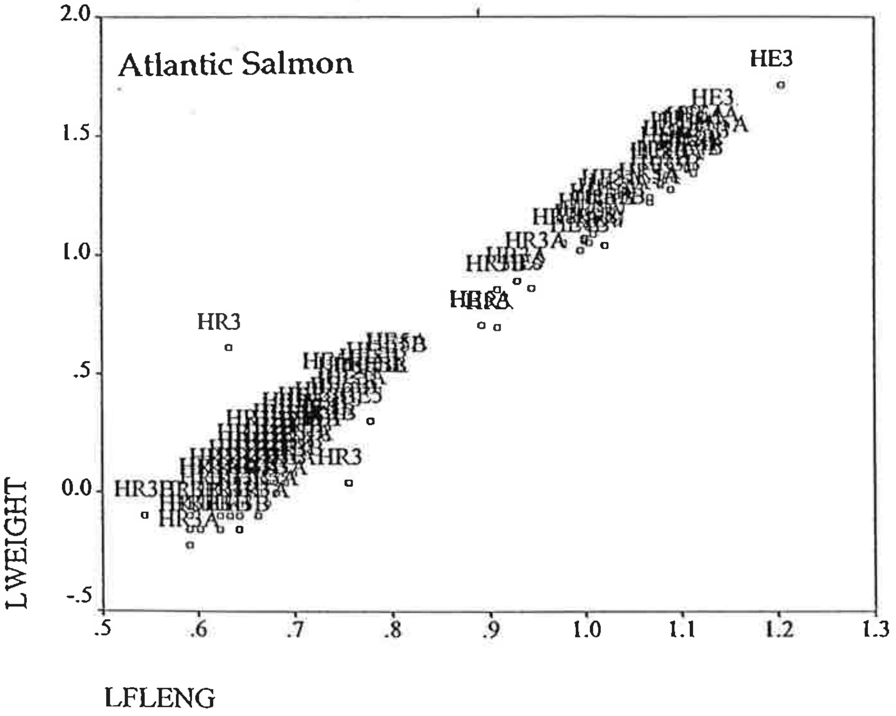


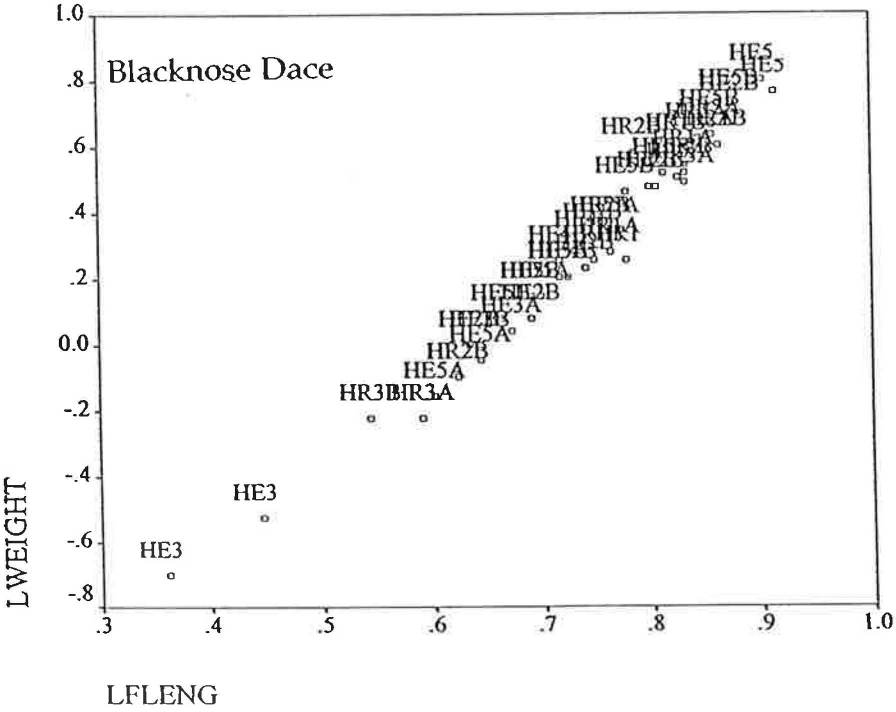
Heath Steele - Fish Growth - Blacknose Dace





Heath Steele - Fish Condition





Heath Steele - Hypothesis 9
Pearson's Correlation Coefficients

(All chemistry log-transformed)
(Only includes exposure stations)

	Benthic Community					Fish Community						
	A_ORTHOC	A_RHEOCR	EPT	LTDEN	TAXA	FISH TAXA	LBIO_ALL	LBIO_AS	LBIO_BND	LBIO_BT	LCPUE_ALL	LCPUE_BND
AL_DISS	0.898	0.871	-0.786	-0.161	-0.620	-0.794	-0.949	-0.962	-0.525	-0.713	-0.913	-0.588
AL_TOT	0.870	0.838	-0.772	-0.042	-0.533	-0.800	-0.907	-0.902	-0.553	-0.631	-0.877	-0.597
CD_DISS	0.871	0.907	-0.772	-0.089	-0.610	-0.821	-0.960	-0.934	-0.534	-0.738	-0.914	-0.597
CD_TOT	0.829	0.865	-0.763	0.035	-0.516	-0.844	-0.917	-0.897	-0.589	-0.634	-0.891	-0.633
CU_DISS	0.907	0.903	-0.746	-0.166	-0.595	-0.789	-0.965	-0.965	-0.459	-0.763	-0.893	-0.532
CU_TOT	0.887	0.882	-0.754	-0.116	-0.547	-0.808	-0.941	-0.963	-0.504	-0.691	-0.893	-0.565
FE_DISS	0.900	0.886	-0.776	-0.191	-0.653	-0.781	-0.966	-0.943	-0.499	-0.769	-0.906	-0.570
FE_TOT	0.856	0.849	-0.780	-0.004	-0.547	-0.835	-0.919	-0.908	-0.584	-0.637	-0.898	-0.631
PB_DISS	0.785	0.807	-0.834	-0.009	-0.676	-0.853	-0.909	-0.966	-0.683	-0.615	-0.969	-0.744
PB_TOT	0.730	0.743	-0.744	0.074	-0.454	-0.828	-0.809	-0.838	-0.652	-0.450	-0.869	-0.680
ZN_DISS	0.918	0.951	-0.740	-0.072	-0.556	-0.793	-0.967	-0.906	-0.429	-0.806	-0.845	-0.498
ZN_TOT	0.902	0.933	-0.745	0.023	-0.517	-0.806	-0.949	-0.878	-0.467	-0.756	-0.838	-0.524
1-tailed Significance												
AL_DISS	0.000	0.001	0.004	0.329	0.028	0.003	0.000	0.000	0.060	0.010	0.000	0.037
AL_TOT	0.001	0.001	0.004	0.454	0.056	0.003	0.000	0.001	0.049	0.025	0.000	0.034
CD_DISS	0.001	0.000	0.004	0.403	0.031	0.002	0.000	0.000	0.056	0.007	0.000	0.034
CD_TOT	0.002	0.001	0.005	0.461	0.063	0.001	0.000	0.001	0.037	0.025	0.000	0.025
CU_DISS	0.000	0.000	0.007	0.323	0.035	0.003	0.000	0.000	0.091	0.005	0.000	0.057
CU_TOT	0.000	0.000	0.006	0.375	0.051	0.002	0.000	0.000	0.069	0.013	0.000	0.044
FE_DISS	0.000	0.000	0.004	0.299	0.020	0.004	0.000	0.000	0.071	0.005	0.000	0.043
FE_TOT	0.001	0.001	0.004	0.496	0.051	0.001	0.000	0.001	0.038	0.024	0.000	0.025
PB_DISS	0.004	0.002	0.001	0.490	0.016	0.001	0.000	0.000	0.015	0.029	0.000	0.007
PB_TOT	0.008	0.007	0.007	0.420	0.094	0.002	0.002	0.005	0.021	0.096	0.001	0.015
ZN_DISS	0.000	0.000	0.007	0.421	0.048	0.003	0.000	0.001	0.108	0.002	0.001	0.072
ZN_TOT	0.000	0.000	0.007	0.474	0.063	0.002	0.000	0.002	0.087	0.006	0.001	0.060
N	10	10	10	10	10	10	10	8	10	10	10	10
Degrees of Freedom	8	8	8	8	8	8	8	6	8	8	8	8

▨ - significant correlation at α = 0.05

Heath Steele Periphyton Chemistry vs Reach

Aluminum

Source	SS	DF	MS	F	P	Tested Against
Reach	2.781	7	0.397	1.001	0.493	Within Reach
Among Ref	0.979	2	0.490	3.653	0.157	Lack of Fit
Ref vs Exp	0.755	1	0.755	5.634	0.098	Lack of Fit
Linear Trend	0.645	1	0.645	4.813	0.116	Lack of Fit
Lack of Fit	0.402	3	0.134	0.338	0.799	Within Reach
Within Reach	3.175	8	0.397			

Chromium

Source	SS	DF	MS	F	P	Tested Against
Reach	3.336	7	0.477	1.693	0.238	Within Reach
Among Ref	1.464	2	0.732	2.029	0.277	Lack of Fit
Ref vs Exp	0.747	1	0.747	2.070	0.246	Lack of Fit
Linear Trend	0.043	1	0.043	0.118	0.754	Lack of Fit
Lack of Fit	1.082	3	0.361	1.282	0.345	Within Reach
Within Reach	2.252	8	0.282			

Cadmium

Source	SS	DF	MS	F	P	Tested Against
Reach	3.962	7	0.566	0.895	0.552	Within Reach
Among Ref	0.073	2	0.037	0.324	0.746	Lack of Fit
Ref vs Exp	3.394	1	3.394	30.057	**0.012**	Lack of Fit
Linear Trend	0.156	1	0.156	1.382	0.325	Lack of Fit
Lack of Fit	0.339	3	0.113	0.178	0.908	Within Reach
Within Reach	5.061	8	0.633			

Copper

Source	SS	DF	MS	F	P	Tested Against
Reach	13.751	7	1.964	3.937	**0.037**	Within Reach
Among Ref	0.105	2	0.053	0.327	0.744	Lack of Fit
Ref vs Exp	12.144	1	12.144	75.585	**0.003**	Lack of Fit
Linear Trend	1.02	1	1.020	6.349	0.086	Lack of Fit
Lack of Fit	0.482	3	0.161	0.322	0.810	Within Reach
Within Reach	3.992	8	0.499			

Iron

Source	SS	DF	MS	F	P	Tested Against
Reach	2.804	7	0.401	1.284	0.364	Within Reach
Among Ref	0.908	2	0.454	5.796	0.093	Lack of Fit
Ref vs Exp	0.726	1	0.726	9.268	0.056	Lack of Fit
Linear Trend	0.935	1	0.935	11.936	**0.041**	Lack of Fit

Lack of Fit	0.235	3	0.078	0.251	0.858	Within Reach
Within Reach	2.496	8	0.312			

Lead

Source	SS	DF	MS	F	P	Tested Against
Reach	8.584	7	1.226	3.081	0.069	Within Reach
Among Ref	0.139	2	0.070	0.486	0.656	Lack of Fit
Ref vs Exp	6.232	1	6.232	43.580	**0.007**	Lack of Fit
Linear Trend	1.784	1	1.784	12.476	**0.039**	Lack of Fit
Lack of Fit	0.429	3	0.143	0.359	0.784	Within Reach
Within Reach	3.184	8	0.398			

Nickel

Source	SS	DF	MS	F	P	Tested Against
Reach	3.006	7	0.429	0.969	0.510	Within Reach
Among Ref	1.146	2	0.573	6.032	0.089	Lack of Fit
Ref vs Exp	1.414	1	1.414	14.884	**0.031**	Lack of Fit
Linear Trend	0.161	1	0.161	1.695	0.284	Lack of Fit
Lack of Fit	0.285	3	0.095	0.214	0.884	Within Reach
Within Reach	3.546	8	0.443			

Zinc

Source	SS	DF	MS	F	P	Tested Against
Reach	6.227	7	0.890	1.634	0.253	Within Reach
Among Ref	0.153	2	0.077	0.685	0.569	Lack of Fit
Ref vs Exp	5.446	1	5.446	48.770	**0.006**	Lack of Fit
Linear Trend	0.293	1	0.293	2.624	0.204	Lack of Fit
Lack of Fit	0.335	3	0.112	0.205	0.890	Within Reach
Within Reach	4.355	8	0.544			

Arsenic

Source	SS	DF	MS	F	P	Tested Against
Reach	7.125	7	1.018	2.023	0.172	Within Reach
Among Ref	0.831	2	0.416	1.537	0.347	Lack of Fit
Ref vs Exp	3.261	1	3.261	12.063	**0.040**	Lack of Fit
Linear Trend	2.222	1	2.222	8.219	0.064	Lack of Fit
Lack of Fit	0.811	3	0.270	0.537	0.670	Within Reach
Within Reach	4.026	8	0.503			

Beryllium

Source	SS	DF	MS	F	P	Tested Against
Reach	2.687	7	0.384	1.037	0.474	Within Reach
Among Ref	0.359	2	0.180	1.391	0.374	Lack of Fit
Ref vs Exp	0.932	1	0.932	7.225	0.075	Lack of Fit

Linear Trend	1.009	1	1.009	7.822	0.068	Lack of Fit
Lack of Fit	0.387	3	0.129	0.349	0.791	Within Reach
Within Reach	2.96	8	0.37			

Selenium

Source	SS	DF	MS	F	P	Tested Against
Reach	1.364	7	0.195	0.851	0.578	Within Reach
Among Ref	4.33E-03	2	0.002	0.056	0.946	Lack of Fit
Ref vs Exp	0.133	1	0.133	3.449	0.160	Lack of Fit
Linear Trend	1.111	1	1.111	28.814	**0.013**	Lack of Fit
Lack of Fit	0.115672	3	0.039	0.168	0.915	Within Reach
Within Reach	1.831	8	0.229			

Heath Steele - Hypothesis 10
Pearson's Correlation Coefficients

(All chemistry log-transformed)
(Only includes exposure stations)

	Benthic Community					Fish Community							
	A_ORTHOC	A_RHEOCR	EPT	LTDEN	TAXA	FISH TAXA	LBIO_ALL	LBIO_AS	LBIO_BND	LBIO_BT	LCPUE_ALL	LCPUE_BND	LCPUE_BT
AL_DISS	0.898	0.871	-0.786	-0.161	-0.620	-0.794	-0.949	-0.962	-0.525	-0.713	-0.913	-0.588	-0.611
AL_PERI	0.556	0.622	-0.568	0.104	-0.576	-0.257	-0.526	-0.496	-0.157	-0.639	-0.461	-0.225	-0.719
CD_DISS	0.871	0.907	-0.772	-0.089	-0.610	-0.821	-0.960	-0.934	-0.534	-0.738	-0.914	-0.597	-0.613
CD_PERI	0.299	0.393	-0.263	0.269	-0.282	-0.050	-0.262	-0.427	0.078	-0.398	-0.217	0.013	-0.534
CU_DISS	0.907	0.903	-0.746	-0.166	-0.595	-0.789	-0.965	-0.965	-0.459	-0.763	-0.893	-0.532	-0.672
CU_PERI	0.575	0.634	-0.483	0.181	-0.454	-0.293	-0.551	-0.703	-0.085	-0.605	-0.482	-0.162	-0.683
FE_DISS	0.900	0.886	-0.776	-0.191	-0.653	-0.781	-0.966	-0.943	-0.499	-0.769	-0.906	-0.570	-0.680
FE_PERI	0.633	0.694	-0.666	0.141	-0.634	-0.380	-0.625	-0.587	-0.275	-0.664	-0.589	-0.344	-0.704
PB_DISS	0.785	0.807	-0.834	-0.009	-0.676	-0.853	-0.909	-0.966	-0.683	-0.615	-0.969	-0.744	-0.490
PB_PERI	0.715	0.753	-0.625	0.098	-0.592	-0.462	-0.722	-0.765	-0.242	-0.709	-0.662	-0.319	-0.748
ZN_DISS	0.918	0.951	-0.740	-0.072	-0.556	-0.793	-0.967	-0.906	-0.429	-0.806	-0.845	-0.498	-0.651
ZN_PERI	0.354	0.458	-0.309	0.228	-0.318	-0.145	-0.353	-0.512	0.012	-0.429	-0.329	-0.060	-0.572
1-tailed Significance													
AL_DISS	0.000	0.001	0.004	0.329	0.028	0.003	0.000	0.000	0.060	0.010	0.000	0.037	0.030
AL_PERI	0.048	0.027	0.043	0.387	0.041	0.237	0.059	0.106	0.332	0.023	0.090	0.266	0.010
CD_DISS	0.001	0.000	0.004	0.403	0.031	0.002	0.000	0.000	0.056	0.007	0.000	0.034	0.030
CD_PERI	0.201	0.130	0.231	0.226	0.215	0.446	0.232	0.146	0.415	0.128	0.273	0.485	0.056
CU_DISS	0.000	0.000	0.007	0.323	0.035	0.003	0.000	0.000	0.091	0.005	0.000	0.057	0.017
CU_PERI	0.041	0.025	0.079	0.308	0.094	0.206	0.049	0.026	0.408	0.032	0.079	0.328	0.015
FE_DISS	0.000	0.000	0.004	0.299	0.020	0.004	0.000	0.000	0.071	0.005	0.000	0.043	0.015
FE_PERI	0.025	0.013	0.018	0.349	0.025	0.139	0.027	0.063	0.221	0.018	0.036	0.165	0.012
PB_DISS	0.004	0.002	0.001	0.490	0.016	0.001	0.000	0.000	0.015	0.029	0.000	0.007	0.075
PB_PERI	0.010	0.006	0.027	0.394	0.036	0.089	0.009	0.013	0.250	0.011	0.019	0.184	0.006
ZN_DISS	0.000	0.000	0.007	0.421	0.048	0.003	0.000	0.001	0.108	0.002	0.001	0.072	0.021
ZN_PERI	0.158	0.092	0.192	0.263	0.185	0.345	0.159	0.097	0.486	0.108	0.177	0.435	0.042
N	10	10	10	10	10	10	10	8	10	10	10	10	10
Degrees of Freedom	8	8	8	8	8	8	8	6	8	8	8	8	8

▨ - significant correlation at α = 0.05

HEATH STEELE - HYPOTHESES #9 AND #10
TOXICITY VS CHEMISTRY

(only includes exposure stations)

Pearson's Correlation Coefficient

	Algae_jun	Algae_aug	Algae_nov	Cerio_jun	Cerio_aug	Cerio_nov	Duck_jun	Duck_aug	FHM_aug
AL_DISS	0.961	0.986	0.989	0.974	0.979	0.988	0.988	0.983	0.987
AL_PERI	0.901	0.967	0.962	0.990	0.976	0.961	0.966	0.982	0.967
AL_TOTAL	0.890	0.950	0.957	0.930	0.934	0.957	0.955	0.941	0.952
CD_DISS	0.966	0.979	0.982	0.970	0.972	0.981	0.982	0.977	0.980
CD_PERI	-0.375	-0.095	-0.105	-0.120	-0.080	-0.103	-0.104	-0.100	-0.100
CD_TOTAL	0.901	0.938	0.946	0.917	0.921	0.945	0.943	0.928	0.940
CU_DISS	0.967	0.993	0.994	0.985	0.990	0.994	0.994	0.992	0.994
CU_PERI	0.396	0.656	0.648	0.645	0.666	0.649	0.651	0.657	0.653
CU_TOTAL	0.942	0.984	0.988	0.965	0.975	0.988	0.987	0.978	0.986
FE_DISS	0.977	0.982	0.984	0.982	0.980	0.983	0.984	0.985	0.984
FE_PERI	0.942	0.994	0.995	0.992	0.992	0.995	0.996	0.996	0.995
FE_TOTAL	0.905	0.946	0.954	0.927	0.930	0.953	0.951	0.937	0.948
PB_DISS	0.953	0.918	0.926	0.892	0.904	0.925	0.923	0.907	0.920
PB_PERI	0.767	0.931	0.931	0.924	0.928	0.930	0.931	0.931	0.931
PB_TOTAL	0.812	0.860	0.873	0.812	0.833	0.872	0.867	0.836	0.863
ZN_DISS	0.956	0.989	0.990	0.990	0.986	0.990	0.991	0.992	0.991
ZN_PERI	-0.009	0.288	0.282	0.224	0.291	0.285	0.280	0.264	0.283
ZN_TOTAL	0.921	0.973	0.977	0.970	0.964	0.976	0.977	0.972	0.975

1-Tailed Significance

AL_DISS	0.005	0.001	0.001	0.002	0.002	0.001	0.001	0.001	0.001
AL_PERI	0.018	0.004	0.004	0.001	0.002	0.005	0.004	0.001	0.004
AL_TOTAL	0.021	0.007	0.005	0.011	0.010	0.005	0.006	0.009	0.006
CD_DISS	0.004	0.002	0.001	0.003	0.003	0.002	0.001	0.002	0.002
CD_PERI	0.267	0.440	0.433	0.424	0.449	0.434	0.434	0.436	0.436
CD_TOTAL	0.018	0.009	0.007	0.014	0.013	0.008	0.008	0.011	0.009
CU_DISS	0.004	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000
CU_PERI	0.255	0.115	0.118	0.120	0.110	0.118	0.117	0.114	0.116
CU_TOTAL	0.008	0.001	0.001	0.004	0.002	0.001	0.001	0.002	0.001
FE_DISS	0.002	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001
FE_PERI	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
FE_TOTAL	0.017	0.008	0.006	0.012	0.011	0.006	0.006	0.009	0.007
PB_DISS	0.006	0.014	0.012	0.021	0.018	0.012	0.013	0.017	0.013
PB_PERI	0.065	0.011	0.011	0.013	0.011	0.011	0.011	0.011	0.011
PB_TOTAL	0.047	0.031	0.027	0.048	0.040	0.027	0.029	0.039	0.030
ZN_DISS	0.005	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.001
ZN_PERI	0.494	0.319	0.323	0.359	0.317	0.321	0.324	0.334	0.323
ZN_TOTAL	0.013	0.003	0.002	0.003	0.004	0.002	0.002	0.003	0.002

N = 5

Degrees of Freedom = 3

▨ - significant correlation at $\alpha = 0.05$

Summary of Significant Heath Steele Correlation Coefficients (Benthos, Chemistry, Toxicity)

Monitoring Tool Used			Correlation Coefficient		
Chemistry	**Toxicity**	**Biology**	**C-T**	**C-B**	**T-B**
ZN_DISS	Cerio_jun	A_RHEOCR	0.997	0.951	0.992
ZN_DISS	Duck_aug	A_RHEOCR	0.992	0.951	0.989
ZN_DISS	Algae_jn	A_RHEOCR	0.991	0.951	0.989
ZN_DISS	Duck_jun	A_RHEOCR	0.991	0.951	0.989
ZN_DISS	FHM_aug	A_RHEOCR	0.991	0.951	0.989
ZN_DISS	Algae_aug	A_RHEOCR	0.989	0.951	0.988
ZN_DISS	Cerio_aug	A_RHEOCR	0.986	0.951	0.985
CU_DISS	Cerio_jun	A_RHEOCR	0.996	0.903	0.992
CU_DISS	Algae_jn	A_RHEOCR	0.994	0.903	0.989
CU_DISS	Duck_jun	A_RHEOCR	0.994	0.903	0.989
CU_DISS	FHM_aug	A_RHEOCR	0.994	0.903	0.989
CD_DISS	Cerio_jun	A_RHEOCR	0.985	0.907	0.992
CU_DISS	Duck_aug	A_RHEOCR	0.992	0.903	0.989
CU_DISS	Algae_aug	A_RHEOCR	0.993	0.903	0.988
CD_DISS	Algae_jn	A_RHEOCR	0.982	0.907	0.989
CD_DISS	Duck_jun	A_RHEOCR	0.982	0.907	0.989
CU_DISS	Cerio_aug	A_RHEOCR	0.990	0.903	0.985
CD_DISS	FHM_aug	A_RHEOCR	0.980	0.907	0.989
CD_DISS	Algae_aug	A_RHEOCR	0.979	0.907	0.988
CD_DISS	Duck_aug	A_RHEOCR	0.977	0.907	0.989
ZN_DISS	Cerio_jun	A_ORTHOC	0.997	0.918	0.955
ZN_DISS	Duck_aug	A_ORTHOC	0.992	0.918	0.957
FE_DISS	Cerio_jun	A_RHEOCR	0.989	0.886	0.992
CD_DISS	Cerio_aug	A_RHEOCR	0.972	0.907	0.985
FE_DISS	Duck_aug	A_RHEOCR	0.985	0.886	0.989
CU_DISS	Cerio_jun	A_ORTHOC	0.996	0.907	0.955
FE_DISS	Algae_jn	A_RHEOCR	0.984	0.886	0.989
FE_DISS	Duck_jun	A_RHEOCR	0.984	0.886	0.989
FE_DISS	FHM_aug	A_RHEOCR	0.984	0.886	0.989
CU_DISS	Duck_aug	A_ORTHOC	0.992	0.907	0.957
FE_DISS	Algae_aug	A_RHEOCR	0.982	0.886	0.988
AL_DISS	Cerio_jun	A_RHEOCR	0.990	0.871	0.992
FE_DISS	Cerio_aug	A_RHEOCR	0.980	0.886	0.985
AL_DISS	Algae_jn	A_RHEOCR	0.988	0.871	0.989
AL_DISS	Duck_jun	A_RHEOCR	0.988	0.871	0.989
ZN_DISS	Cerio_aug	A_ORTHOC	0.986	0.918	0.94
ZN_DISS	Duck_jun	A_ORTHOC	0.991	0.918	0.935
ZN_DISS	FHM_aug	A_ORTHOC	0.991	0.918	0.935
AL_DISS	FHM_aug	A_RHEOCR	0.987	0.871	0.989
FE_DISS	Cerio_jun	A_ORTHOC	0.989	0.900	0.955
ZN_DISS	Algae_jn	A_ORTHOC	0.991	0.918	0.934
AL_DISS	Cerio_jun	A_ORTHOC	0.990	0.898	0.955
AL_DISS	Algae_aug	A_RHEOCR	0.986	0.871	0.988
FE_DISS	Duck_aug	A_ORTHOC	0.985	0.900	0.957
ZN_DISS	Algae_aug	A_ORTHOC	0.989	0.918	0.933
AL_DISS	Duck_aug	A_RHEOCR	0.983	0.871	0.989
AL_DISS	Duck_aug	A_ORTHOC	0.983	0.898	0.957

Summary of Significant Heath Steele Correlation Coefficients (Benthos, Chemistry, Toxicity)

Monitoring Tool Used			Correlation Coefficient		
Chemistry	**Toxicity**	**Biology**	**C-T**	**C-B**	**T-B**
CU_DISS	Cerio_aug	A_ORTHOC	0.990	0.907	0.94
CU_DISS	Duck_jun	A_ORTHOC	0.994	0.907	0.935
CU_DISS	FHM_aug	A_ORTHOC	0.994	0.907	0.935
CU_DISS	Algae_jn	A_ORTHOC	0.994	0.907	0.934
CU_DISS	Algae_aug	A_ORTHOC	0.993	0.907	0.933
AL_DISS	Cerio_aug	A_RHEOCR	0.979	0.871	0.985
AL_DISS	Duck_jun	A_ORTHOC	0.988	0.898	0.935
FE_DISS	Cerio_aug	A_ORTHOC	0.980	0.900	0.94
AL_DISS	FHM_aug	A_ORTHOC	0.987	0.898	0.935
AL_DISS	Algae_jn	A_ORTHOC	0.988	0.898	0.934
FE_DISS	Duck_jun	A_ORTHOC	0.984	0.900	0.935
FE_DISS	FHM_aug	A_ORTHOC	0.984	0.900	0.935
FE_DISS	Algae_jn	A_ORTHOC	0.984	0.900	0.934
AL_DISS	Cerio_aug	A_ORTHOC	0.979	0.898	0.94
AL_DISS	Algae_aug	A_ORTHOC	0.986	0.898	0.933
FE_DISS	Algae_aug	A_ORTHOC	0.982	0.900	0.933
CD_DISS	Cerio_jun	A_ORTHOC	0.985	0.871	0.955
CD_DISS	Duck_aug	A_ORTHOC	0.977	0.871	0.957
CD_DISS	Duck_jun	A_ORTHOC	0.982	0.871	0.935
CD_DISS	Algae_jn	A_ORTHOC	0.982	0.871	0.934
CD_DISS	FHM_aug	A_ORTHOC	0.980	0.871	0.935
CD_DISS	Cerio_aug	A_ORTHOC	0.972	0.871	0.94
CD_DISS	Algae_aug	A_ORTHOC	0.979	0.871	0.933
PB_DISS	Cerio_jun	A_RHEOCR	0.922	0.807	0.992
PB_DISS	Algae_jn	A_RHEOCR	0.923	0.807	0.989
PB_DISS	Duck_jun	A_RHEOCR	0.923	0.807	0.989
PB_DISS	FHM_aug	A_RHEOCR	0.920	0.807	0.989
PB_DISS	Algae_aug	A_RHEOCR	0.918	0.807	0.988
PB_DISS	Duck_aug	A_RHEOCR	0.907	0.807	0.989
PB_DISS	Cerio_aug	A_RHEOCR	0.904	0.807	0.985
PB_DISS	Cerio_jun	A_ORTHOC	0.922	0.785	0.955
PB_DISS	Duck_aug	A_ORTHOC	0.907	0.785	0.957
PB_DISS	Duck_jun	A_ORTHOC	0.923	0.785	0.935
PB_DISS	Algae_jn	A_ORTHOC	0.923	0.785	0.934
PB_DISS	FHM_aug	A_ORTHOC	0.920	0.785	0.935
PB_DISS	Algae_aug	A_ORTHOC	0.918	0.785	0.933
PB_DISS	Cerio_aug	A_ORTHOC	0.904	0.785	0.94
ZN_DISS	Cerio_jun	LRHEO	0.997	0.730	0.868
ZN_DISS	Algae_jn	LRHEO	0.991	0.730	0.872
ZN_DISS	FHM_aug	LRHEO	0.991	0.730	0.869
AL_DISS	Cerio_jun	EPT	0.990	-0.786	-0.805
ZN_DISS	Algae_aug	LRHEO	0.989	0.730	0.867
PB_DISS	Cerio_jun	EPT	0.922	-0.834	-0.805
FE_DISS	Cerio_jun	EPT	0.989	-0.776	-0.805
ZN_DISS	Duck_aug	LRHEO	0.991	0.730	0.851
ZN_DISS	Duck_jun	LRHEO	0.991	0.730	0.851
CD_DISS	Cerio_jun	EPT	0.985	-0.772	-0.805
ZN_DISS	Cerio_aug	LRHEO	0.986	0.730	0.849

Summary of Significant Heath Steele Correlation Coefficients (Benthos, Chemistry, Toxicity)

Monitoring Tool Used			**Correlation Coefficient**		
Chemistry	**Toxicity**	**Biology**	**C-T**	**C-B**	**T-B**
CU_DISS	Cerio_jun	EPT	0.996	-0.746	-0.805
ZN_DISS	Cerio_jun	EPT	0.997	-0.740	-0.805
CU_DISS	Algae_jn	LRHEO	0.994	0.658	0.872
CD_DISS	Algae_jn	LRHEO	0.982	0.666	0.872
CD_DISS	Cerio_jun	LRHEO	0.985	0.666	0.868
CU_DISS	Cerio_jun	LRHEO	0.996	0.658	0.868
CU_DISS	FHM_aug	LRHEO	0.994	0.658	0.869
CD_DISS	FHM_aug	LRHEO	0.980	0.666	0.869
CU_DISS	Algae_aug	LRHEO	0.993	0.658	0.867
CD_DISS	Algae_aug	LRHEO	0.979	0.666	0.867
CU_DISS	Duck_jun	LRHEO	0.994	0.658	0.851
CD_DISS	Duck_jun	LRHEO	0.982	0.666	0.851
CU_DISS	Duck_aug	LRHEO	0.992	0.658	0.851
AL_DISS	Algae_jn	LRHEO	0.988	0.643	0.872
CD_DISS	Duck_aug	LRHEO	0.977	0.666	0.851
CU_DISS	Cerio_aug	LRHEO	0.990	0.658	0.849
AL_DISS	Cerio_jun	LRHEO	0.990	0.643	0.868
AL_DISS	FHM_aug	LRHEO	0.987	0.643	0.869
AL_DISS	Algae_aug	LRHEO	0.986	0.643	0.867
CD_DISS	Cerio_aug	LRHEO	0.972	0.666	0.849
AL_DISS	Duck_jun	LRHEO	0.988	0.643	0.851
FE_DISS	Cerio_jun	LRHEO	0.989	0.629	0.868
FE_DISS	Algae_jn	LRHEO	0.984	0.629	0.872
AL_DISS	Duck_aug	LRHEO	0.983	0.643	0.851
FE_DISS	FHM_aug	LRHEO	0.984	0.629	0.869
FE_DISS	Algae_aug	LRHEO	0.982	0.629	0.867
AL_DISS	Cerio_aug	LRHEO	0.979	0.643	0.849
FE_DISS	Duck_aug	LRHEO	0.985	0.629	0.851
FE_DISS	Duck_jun	LRHEO	0.984	0.629	0.851
FE_DISS	Cerio_aug	LRHEO	0.980	0.629	0.849
PB_DISS	Algae_jn	LRHEO	0.923	0.609	0.872
PB_DISS	Cerio_jun	LRHEO	0.922	0.609	0.868
PB_DISS	FHM_aug	LRHEO	0.920	0.609	0.869
PB_DISS	Algae_aug	LRHEO	0.918	0.609	0.867
PB_DISS	Duck_jun	LRHEO	0.923	0.609	0.851
PB_DISS	Duck_aug	LRHEO	0.907	0.609	0.851
PB_DISS	Cerio_aug	LRHEO	0.904	0.609	0.849

Summary of Significant Heath Steele Correlation Coefficients (Benthos, Chemistry, Toxicity)

Monitoring Tool Used			Correlation Coefficient		
Chemistry	**Toxicity**	**Biology**	**C-T**	**C-B**	**T-B**
ZN_TOTAL	Cerio_jun	A_RHEOCR	0.983	0.933	0.992
ZN_TOTAL	Algae_jn	A_RHEOCR	0.977	0.933	0.989
ZN_TOTAL	Duck_jun	A_RHEOCR	0.977	0.933	0.989
ZN_TOTAL	FHM_aug	A_RHEOCR	0.975	0.933	0.989
ZN_TOTAL	Algae_aug	A_RHEOCR	0.973	0.933	0.988
ZN_TOTAL	Duck_aug	A_RHEOCR	0.972	0.933	0.989
ZN_TOTAL	Cerio_aug	A_RHEOCR	0.964	0.933	0.985
CU_TOTAL	Cerio_jun	A_RHEOCR	0.987	0.882	0.992
CU_TOTAL	Algae_jn	A_RHEOCR	0.987	0.882	0.989
CU_TOTAL	Duck_jun	A_RHEOCR	0.987	0.882	0.989
CU_TOTAL	FHM_aug	A_RHEOCR	0.986	0.882	0.989
CU_TOTAL	Algae_aug	A_RHEOCR	0.984	0.882	0.988
CU_TOTAL	Duck_aug	A_RHEOCR	0.978	0.882	0.989
CU_TOTAL	Cerio_aug	A_RHEOCR	0.975	0.882	0.985
ZN_TOTAL	Cerio_jun	A_ORTHOC	0.983	0.902	0.955
ZN_TOTAL	Duck_aug	A_ORTHOC	0.972	0.902	0.957
CU_TOTAL	Cerio_jun	A_ORTHOC	0.987	0.887	0.955
CU_TOTAL	Duck_aug	A_ORTHOC	0.978	0.887	0.957
ZN_TOTAL	Duck_jun	A_ORTHOC	0.977	0.902	0.935
ZN_TOTAL	Algae_jn	A_ORTHOC	0.977	0.902	0.934
ZN_TOTAL	FHM_aug	A_ORTHOC	0.975	0.902	0.935
ZN_TOTAL	Algae_aug	A_ORTHOC	0.973	0.902	0.933
CU_TOTAL	Duck_jun	A_ORTHOC	0.987	0.887	0.935
CU_TOTAL	FHM_aug	A_ORTHOC	0.986	0.887	0.935
CU_TOTAL	Algae_jn	A_ORTHOC	0.987	0.887	0.934
ZN_TOTAL	Cerio_aug	A_ORTHOC	0.964	0.902	0.94
CU_TOTAL	Algae_aug	A_ORTHOC	0.984	0.887	0.933
CU_TOTAL	Cerio_aug	A_ORTHOC	0.975	0.887	0.94
CD_TOTAL	Cerio_jun	A_RHEOCR	0.946	0.865	0.992
CD_TOTAL	Algae_jn	A_RHEOCR	0.943	0.865	0.989
CD_TOTAL	Duck_jun	A_RHEOCR	0.943	0.865	0.989
CD_TOTAL	FHM_aug	A_RHEOCR	0.940	0.865	0.989
FE_TOTAL	Cerio_jun	A_RHEOCR	0.954	0.849	0.992
CD_TOTAL	Algae_aug	A_RHEOCR	0.938	0.865	0.988
FE_TOTAL	Algae_jn	A_RHEOCR	0.951	0.849	0.989
FE_TOTAL	Duck_jun	A_RHEOCR	0.951	0.849	0.989
AL_TOTAL	Cerio_jun	A_RHEOCR	0.958	0.838	0.992
FE_TOTAL	FHM_aug	A_RHEOCR	0.948	0.849	0.989
AL_TOTAL	Cerio_jun	A_ORTHOC	0.958	0.870	0.955
CD_TOTAL	Duck_aug	A_RHEOCR	0.928	0.865	0.989
FE_TOTAL	Algae_aug	A_RHEOCR	0.946	0.849	0.988
AL_TOTAL	Algae_jn	A_RHEOCR	0.955	0.838	0.989
AL_TOTAL	Duck_jun	A_RHEOCR	0.955	0.838	0.989
AL_TOTAL	FHM_aug	A_RHEOCR	0.952	0.838	0.989
FE_TOTAL	Duck_aug	A_RHEOCR	0.937	0.849	0.989
AL_TOTAL	Algae_aug	A_RHEOCR	0.950	0.838	0.988
CD_TOTAL	Cerio_aug	A_RHEOCR	0.921	0.865	0.985

Heath Steele - Hypothesis 12

Pearson's Correlation Coefficients

(All chemistry log-transformed)
(Only exposure stations included)

Atlantic salmon

	MT	AL-TISS	CD-TISS	CU-TISS	FE-TISS	PB-TISS	ZN-TISS
AL_PERI	-0.330	0.158	-0.215	-0.466	0.082	-0.631	-0.094
AL_WAT	0.804	-0.956	0.079	-0.521	-0.964	-0.255	-0.501
CD_PERI	-0.511	0.268	-0.153	-0.263	0.203	-0.731	0.089
CD_WAT	0.891	-0.899	0.060	-0.725	-0.959	-0.234	-0.622
CU_PERI	-0.484	0.225	-0.145	-0.278	0.159	-0.766	0.074
CU_WAT	0.822	-0.953	0.188	-0.663	-0.973	-0.296	-0.446
FE_PERI	-0.263	0.030	-0.204	-0.527	-0.045	-0.729	-0.137
FE_WAT	0.906	-0.839	0.206	-0.856	-0.900	-0.135	-0.520
PB_PERI	-0.335	0.154	-0.086	-0.400	0.064	-0.741	0.004
PB_WAT	0.764	-0.957	0.180	-0.764	-0.975	-0.399	-0.430
ZN_PERI	-0.441	0.241	-0.102	-0.311	0.162	-0.728	0.074
ZN_WAT	0.400	-0.887	-0.291	-0.338	-0.814	-0.418	-0.488
1-Tailed Significance							
AL_PERI	0.261	0.382	0.341	0.176	0.439	0.090	0.430
AL_WAT	0.027	0.001	0.441	0.145	0.001	0.313	0.156
CD_PERI	0.150	0.304	0.386	0.307	0.350	0.049	0.434
CD_WAT	0.009	0.007	0.455	0.051	0.001	0.327	0.094
CU_PERI	0.165	0.334	0.392	0.297	0.382	0.038	0.444
CU_WAT	0.022	0.002	0.360	0.075	0.001	0.285	0.188
FE_PERI	0.307	0.477	0.349	0.141	0.466	0.050	0.398
FE_WAT	0.006	0.018	0.348	0.015	0.007	0.399	0.145
PB_PERI	0.258	0.385	0.436	0.216	0.452	0.046	0.497
PB_WAT	0.039	0.001	0.366	0.038	0.000	0.217	0.198
ZN_PERI	0.190	0.323	0.424	0.274	0.379	0.051	0.445
ZN_WAT	0.216	0.009	0.288	0.256	0.024	0.205	0.163

N = 6
Degrees of Freedom =4
▨ - significant correlation at $\alpha = 0.05$

Heath Steele - Hypothesis 12

Pearson's Correlation Coefficients

(All chemistry log-transformed)
(Only exposure stations included)

Blacknose Dace

	MT	AL_TISS	CD_TISS	CU_TISS	FE_TISS	PB_TISS	ZN_TISS
AL_PERI	0.254	0.47	0.281	0.906	0.406	0.774	0.97
AL_WAT	0.668	-0.485	-0.578	0.197	-0.534	0.337	0.186
CD_PERI	0.31	0.465	0.275	0.922	0.422	0.796	0.935
CD_WAT	0.701	-0.419	-0.474	0.263	-0.499	0.442	0.272
CU_PERI	0.402	0.387	0.184	0.926	0.338	0.827	0.928
CU_WAT	0.592	-0.312	-0.601	0.347	-0.362	0.423	0.248
FE_PERI	0.388	0.325	0.221	0.881	0.261	0.785	0.99
FE_WAT	0.604	-0.297	-0.528	0.355	-0.371	0.462	0.299
PB_PERI	0.494	0.338	0.204	0.91	0.26	0.887	0.93
PB_WAT	0.729	-0.578	-0.457	0.187	-0.627	0.327	0.338
ZN_PERI	0.405	0.417	0.237	0.927	0.354	0.857	0.928
ZN_WAT	0.513	-0.365	-0.71	0.306	-0.376	0.294	0.219
1-tailed Significance							
AL_PERI	0.313	0.174	0.295	0.006	0.212	0.036	0.001
AL_WAT	0.073	0.165	0.115	0.354	0.138	0.257	0.362
CD_PERI	0.275	0.176	0.299	0.004	0.202	0.029	0.003
CD_WAT	0.06	0.204	0.171	0.307	0.157	0.19	0.301
CU_PERI	0.215	0.225	0.363	0.004	0.256	0.021	0.004
CU_WAT	0.108	0.274	0.103	0.25	0.241	0.202	0.318
FE_PERI	0.223	0.265	0.337	0.01	0.308	0.032	0
FE_WAT	0.102	0.284	0.141	0.245	0.235	0.178	0.282
PB_PERI	0.16	0.256	0.349	0.006	0.309	0.009	0.004
PB_WAT	0.05	0.115	0.181	0.361	0.091	0.263	0.256
ZN_PERI	0.213	0.205	0.325	0.004	0.245	0.015	0.004
ZN_WAT	0.149	0.238	0.057	0.278	0.231	0.286	0.338

N=6

Degrees of Freedom = 4

▨ - significant correlation at $\alpha = 0.05$

caged-as-exposure only

Heath Steele - Hypothesis 12
(All chemistry log-transformed)

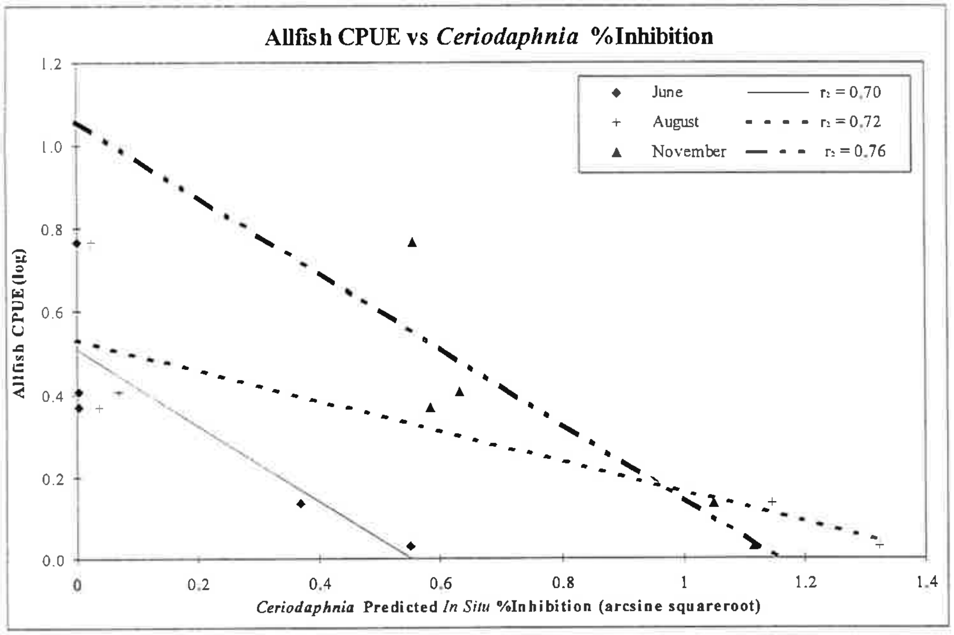
Pearson's Correlation Coefficients
(exposure stations only)

Caged Atlantic salmon

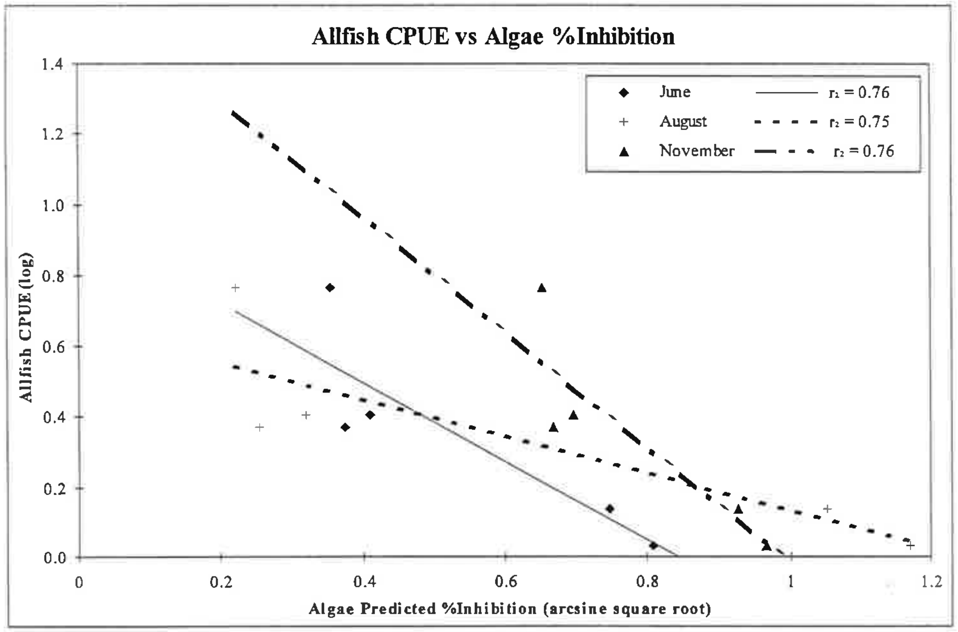
	MT	AL_TISS	CD_TISS	CU_TISS	FE_TISS	PB_TISS	ZN_TISS
AL_PERI	0.393	0.431	-0.260	-0.099	-0.304	-0.257	-0.155
AL_TOT	0.955	0.051	-0.028	0.180	-0.462	-0.629	0.429
AL_DISS	0.946	0.100	-0.174	0.157	-0.572	-0.674	0.311
CD_PERI	0.063	0.709	0.044	-0.221	-0.036	0.216	-0.228
CD_TOT	0.954	-0.025	-0.065	0.068	-0.384	-0.661	0.424
CD_DISS	0.952	0.034	-0.217	-0.022	-0.444	-0.699	0.318
CU_PERI	0.419	0.633	-0.036	-0.128	-0.253	-0.082	-0.127
CU_TOT	0.949	0.092	-0.129	0.132	-0.531	-0.672	0.369
CU_DISS	0.952	0.106	-0.200	0.083	-0.558	-0.678	0.319
FE_PERI	0.494	0.409	-0.206	-0.028	-0.341	-0.316	-0.132
FE_TOT	0.950	0.016	-0.029	0.162	-0.440	-0.651	0.405
FE_DISS	0.944	0.064	-0.248	0.129	-0.595	-0.710	0.259
PB_PERI	0.612	0.501	-0.144	-0.124	-0.333	-0.279	-0.085
PB_TOT	0.871	0.010	0.112	0.198	-0.330	-0.593	0.466
PB_DISS	0.914	0.047	-0.188	0.240	-0.620	-0.695	0.195
ZN_PERI	0.196	0.665	-0.046	-0.195	-0.152	0.064	-0.292
ZN_TOT	0.954	0.024	-0.067	0.039	-0.395	-0.644	0.457
ZN_DISS	0.950	0.053	-0.165	0.010	-0.459	-0.680	0.403
1-Tailed Significance							
AL_PERI	0.131	0.107	0.234	0.393	0.197	0.237	0.334
AL_TOT	8.51E-06	0.445	0.469	0.310	0.090	0.026	0.108
AL_DISS	1.77E-05	0.392	0.316	0.332	0.042	0.016	0.191
CD_PERI	0.431	0.011	0.452	0.270	0.460	0.274	0.263
CD_TOT	9.22E-06	0.473	0.430	0.426	0.137	0.019	0.111
CD_DISS	1.11E-05	0.463	0.273	0.476	0.099	0.012	0.186
CU_PERI	0.114	0.025	0.460	0.362	0.240	0.411	0.364
CU_TOT	1.42E-05	0.401	0.361	0.358	0.057	0.017	0.147
CU_DISS	1.06E-05	0.385	0.290	0.410	0.047	0.016	0.185
FE_PERI	0.074	0.120	0.284	0.469	0.167	0.187	0.358
FE_TOT	1.24E-05	0.483	0.469	0.328	0.102	0.021	0.123
FE_DISS	2.04E-05	0.430	0.245	0.361	0.035	0.011	0.235
PB_PERI	0.030	0.070	0.346	0.366	0.173	0.217	0.407
PB_TOT	0.001	0.489	0.379	0.291	0.176	0.035	0.087
PB_DISS	1.08E-04	0.448	0.301	0.252	0.028	0.013	0.294
ZN_PERI	0.294	0.018	0.450	0.295	0.338	0.431	0.207
ZN_TOT	9.52E-06	0.474	0.427	0.457	0.129	0.022	0.092
ZN_DISS	1.30E-05	0.443	0.325	0.489	0.091	0.015	0.124

▨ - significant correlation at $\alpha = 0.05$

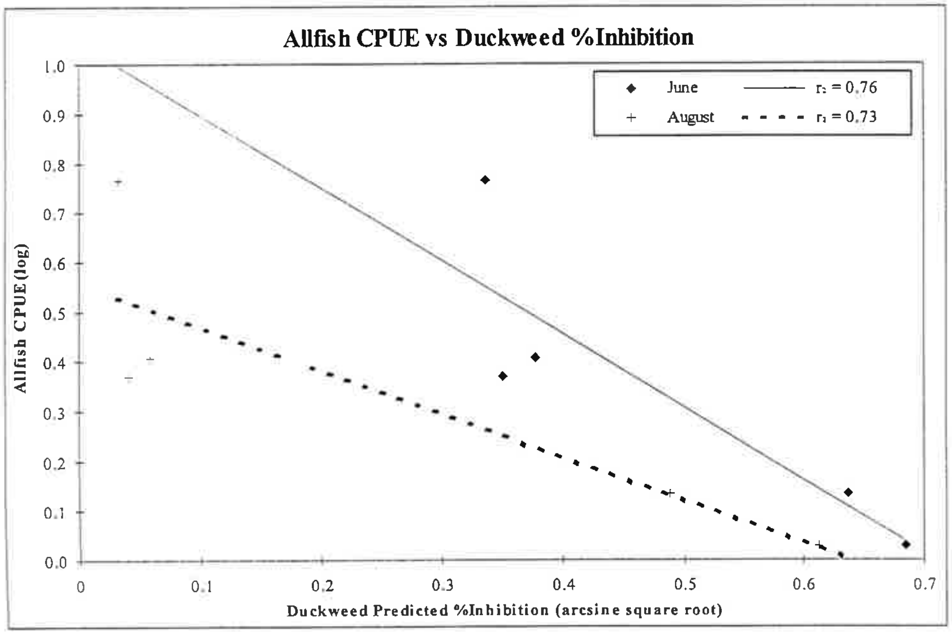
Heath Steele - Hypothesis #13
Fish CPUE vs Expected Water Toxicity (%Inhibition)



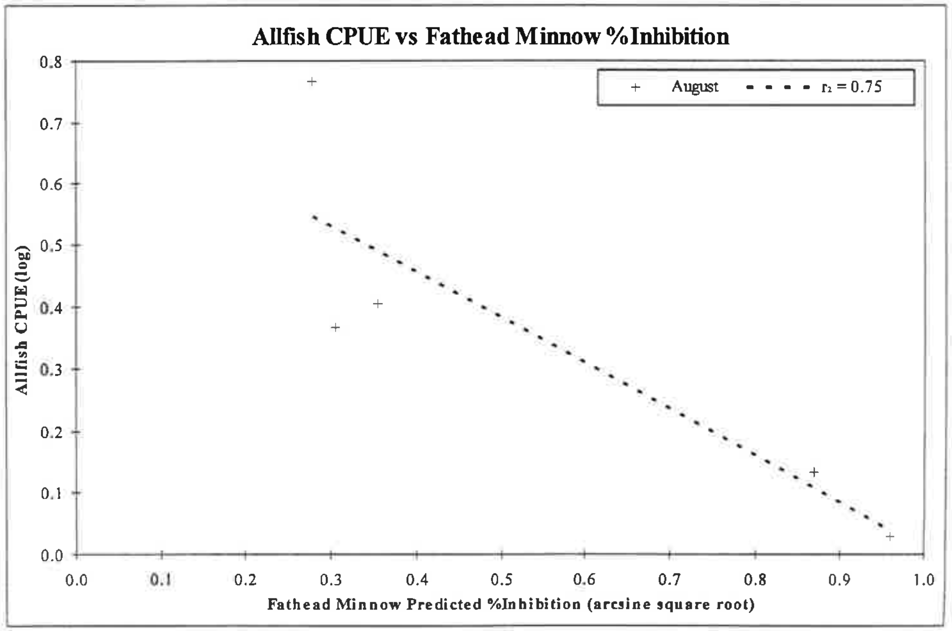
Allfish CPUE vs *Ceriodaphnia* %Inhibition



Allfish CPUE vs Algae %Inhibition

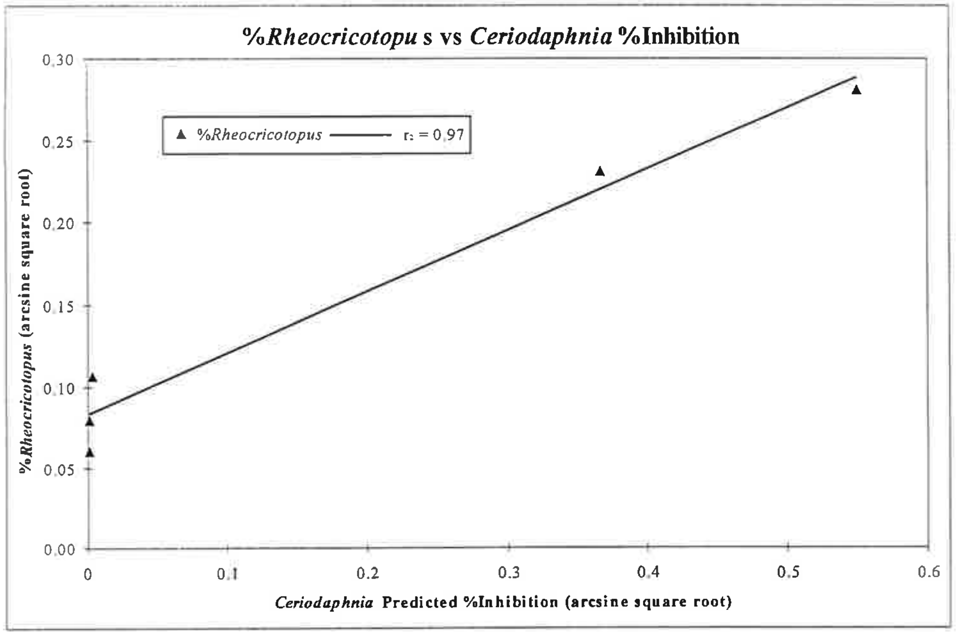


Allfish CPUE vs Duckweed %Inhibition



Allfish CPUE vs Fathead Minnow %Inhibition

Heath Steele - Hypothesis #13
%*Rheocricotopus* vs Expected Water Toxicity (%Inhibition)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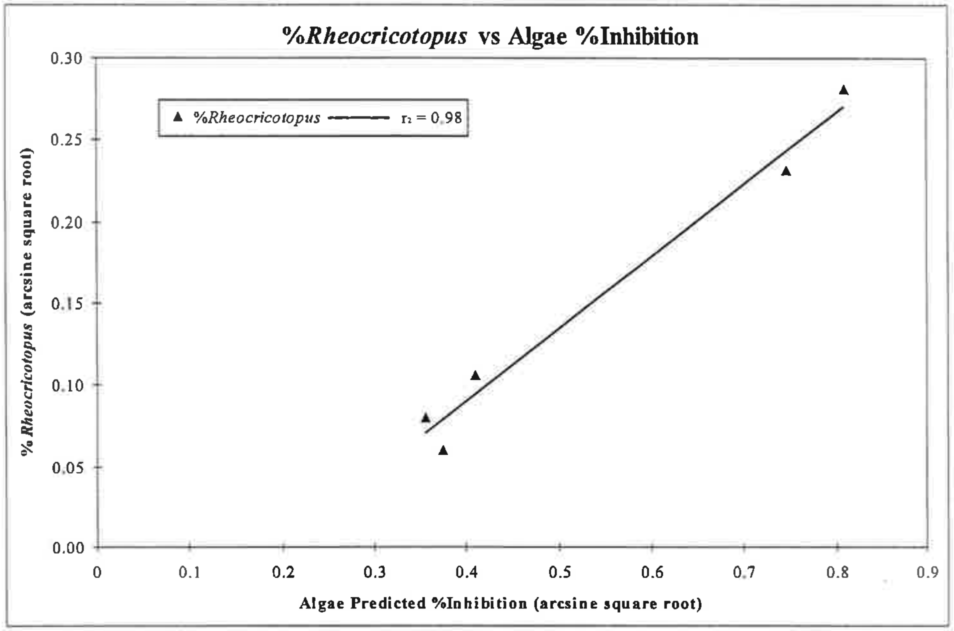
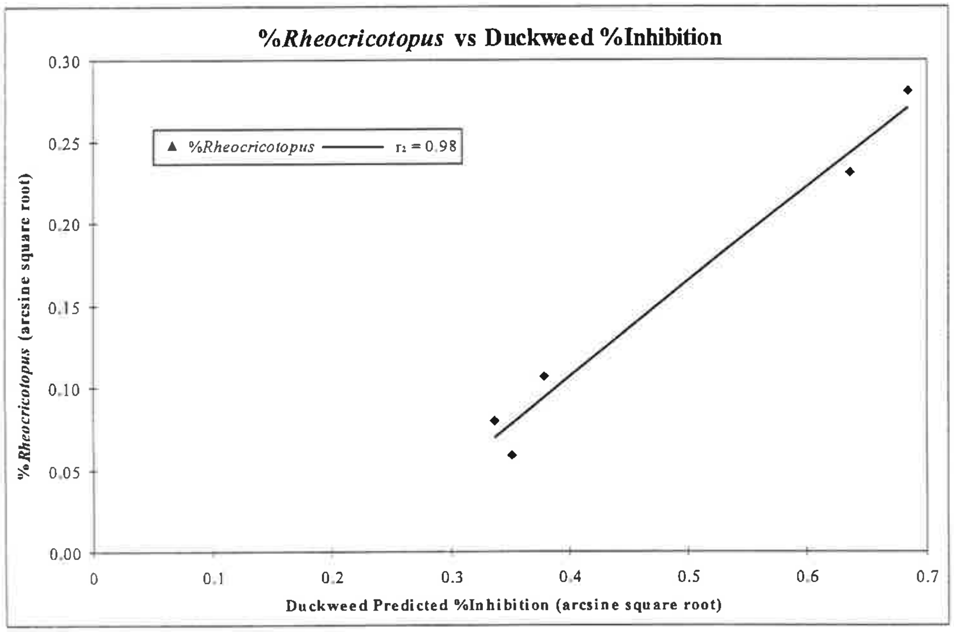
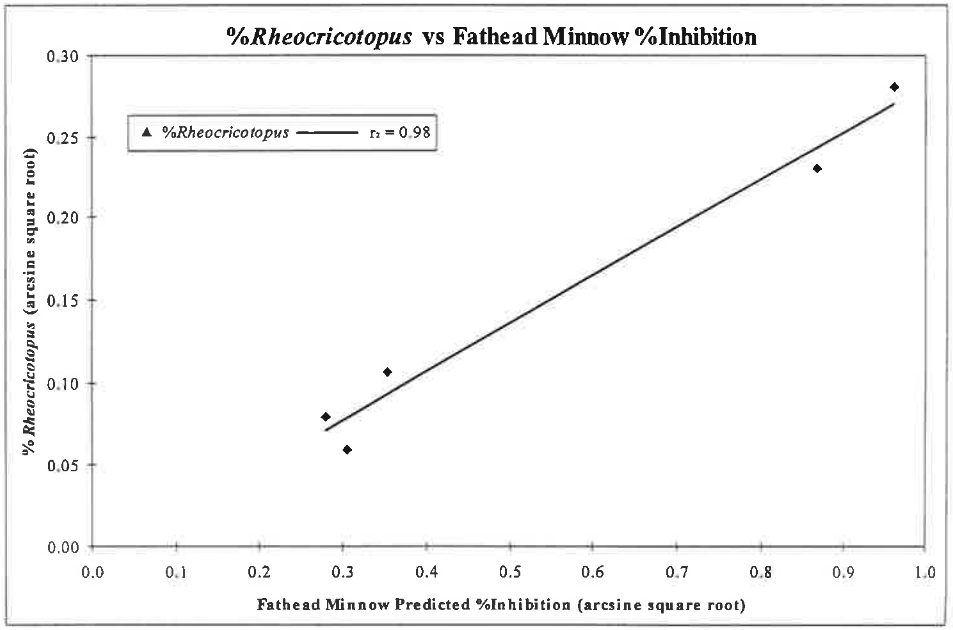

%*Rheocricotopus* vs Algae %Inhibition


%*Rheocricotopus* vs Duckweed %Inhibition


%*Rheocricotopus* vs Fathead Minnow %Inhibition

HEATH STEELE - HYPOTHESIS #13

Toxicity Correlations with Biological Endpoints

Pearson's Correlation Coefficient

	Benthic Community					Fish Community							
	A_ORTHOC	A_RHEOCR	EPT	LTDEN	TAXA	FISH TAXA	LBIO_ALL	LBIO_AS	LBIO_BND	LBIO_BT	LCPUE_AL	LCPUE_BD	LCPUE_BT
Algae_june	0.934	0.989	-0.789	-0.301	-0.582	-0.814	-0.953	-0.992	-0.384	-0.802	-0.869	-0.460	-0.729
Algae_aug	0.933	0.988	-0.781	-0.315	-0.576	-0.810	-0.949	-0.993	-0.373	-0.802	-0.864	-0.450	-0.737
Algae_nov	0.929	0.988	-0.791	-0.289	-0.578	-0.818	-0.951	-0.994	-0.392	-0.793	-0.873	-0.467	-0.719
Cerio_june	0.980	0.984	-0.790	-0.364	-0.643	-0.766	-0.980	-0.956	-0.346	-0.893	-0.837	-0.422	-0.791
Cerio_aug	0.940	0.985	-0.765	-0.361	-0.577	-0.794	-0.948	-0.989	-0.341	-0.820	-0.847	-0.422	-0.770
Cerio_nov	0.928	0.988	-0.790	-0.290	-0.576	-0.818	-0.949	-0.994	-0.390	-0.791	-0.873	-0.466	-0.719
Duck_june	0.935	0.989	-0.790	-0.301	-0.583	-0.814	-0.954	-0.992	-0.385	-0.803	-0.870	-0.460	-0.729
Duck_aug	0.957	0.989	-0.783	-0.349	-0.605	-0.791	-0.964	-0.981	-0.354	-0.846	-0.852	-0.432	-0.770
FHM_aug	0.935	0.989	-0.786	-0.308	-0.581	-0.811	-0.952	-0.992	-0.379	-0.804	-0.867	-0.455	-0.734
1-Tailed Significance													
Algae_june	0.010	0.001	0.056	0.311	0.152	0.047	0.006	0.004	0.262	0.051	0.028	0.218	0.081
Algae_aug	0.010	0.001	0.059	0.303	0.155	0.048	0.007	0.004	0.268	0.051	0.029	0.223	0.078
Algae_nov	0.011	0.001	0.055	0.319	0.154	0.045	0.006	0.003	0.257	0.055	0.027	0.214	0.085
Cerio_june	0.002	0.001	0.056	0.273	0.121	0.065	0.002	0.022	0.284	0.021	0.038	0.240	0.056
Cerio_aug	0.009	0.001	0.066	0.275	0.154	0.054	0.007	0.005	0.287	0.044	0.035	0.240	0.064
Cerio_nov	0.012	0.001	0.056	0.318	0.155	0.045	0.007	0.003	0.258	0.056	0.027	0.215	0.085
Duck_june	0.010	0.001	0.056	0.312	0.151	0.047	0.006	0.004	0.261	0.051	0.028	0.218	0.081
Duck_aug	0.005	0.001	0.059	0.283	0.140	0.056	0.004	0.010	0.279	0.035	0.034	0.234	0.064
FHM_aug	0.010	0.001	0.057	0.307	0.152	0.048	0.006	0.004	0.265	0.050	0.029	0.221	0.079

N = 5
Degrees of Freedom = 3
▨ - correlation significant at α=0.05

Summary of Significant Heath Steele Correlation Coefficients (Benthos, Chemistry, Toxicity)

Monitoring Tool Used			Correlation Coefficient		
Chemistry	**Toxicity**	**Biology**	**C-T**	**C-B**	**T-B**
AL_TOTAL	Duck_aug	A_ORTHOC	0.941	0.870	0.957
AL_TOTAL	Duck_aug	A_RHEOCR	0.941	0.838	0.989
FE_TOTAL	Cerio_jun	A_ORTHOC	0.954	0.856	0.955
FE_TOTAL	Cerio_aug	A_RHEOCR	0.930	0.849	0.985
AL_TOTAL	Duck_jun	A_ORTHOC	0.955	0.870	0.935
AL_TOTAL	Algae_jn	A_ORTHOC	0.955	0.870	0.934
AL_TOTAL	FHM_aug	A_ORTHOC	0.952	0.870	0.935
AL_TOTAL	Algae_aug	A_ORTHOC	0.950	0.870	0.933
AL_TOTAL	Cerio_aug	A_RHEOCR	0.934	0.838	0.985
FE_TOTAL	Duck_aug	A_ORTHOC	0.937	0.856	0.957
AL_TOTAL	Cerio_aug	A_ORTHOC	0.934	0.870	0.94
FE_TOTAL	Duck_jun	A_ORTHOC	0.951	0.856	0.935
FE_TOTAL	Algae_jn	A_ORTHOC	0.951	0.856	0.934
FE_TOTAL	FHM_aug	A_ORTHOC	0.948	0.856	0.935
FE_TOTAL	Algae_aug	A_ORTHOC	0.946	0.856	0.933
CD_TOTAL	Cerio_jun	A_ORTHOC	0.946	0.829	0.955
FE_TOTAL	Cerio_aug	A_ORTHOC	0.930	0.856	0.94
CD_TOTAL	Duck_aug	A_ORTHOC	0.928	0.829	0.957
CD_TOTAL	Duck_jun	A_ORTHOC	0.943	0.829	0.935
CD_TOTAL	Algae_jn	A_ORTHOC	0.943	0.829	0.934
CD_TOTAL	FHM_aug	A_ORTHOC	0.940	0.829	0.935
CD_TOTAL	Algae_aug	A_ORTHOC	0.938	0.829	0.933
CD_TOTAL	Cerio_aug	A_ORTHOC	0.921	0.829	0.94
PB_TOTAL	Algae_jn	A_RHEOCR	0.867	0.743	0.989
PB_TOTAL	Duck_jun	A_RHEOCR	0.867	0.743	0.989
PB_TOTAL	Cerio_jun	A_RHEOCR	0.862	0.743	0.992
PB_TOTAL	FHM_aug	A_RHEOCR	0.863	0.743	0.989
PB_TOTAL	Algae_aug	A_RHEOCR	0.860	0.743	0.988
PB_TOTAL	Duck_aug	A_RHEOCR	0.836	0.743	0.989
PB_TOTAL	Cerio_aug	A_RHEOCR	0.833	0.743	0.985
PB_TOTAL	Cerio_jun	A_ORTHOC	0.862	0.730	0.955
CU_TOTAL	Cerio_jun	EPT	0.987	-0.754	-0.805
FE_TOTAL	Cerio_jun	EPT	0.954	-0.780	-0.805
AL_TOTAL	Cerio_jun	EPT	0.958	-0.772	-0.805
PB_TOTAL	Duck_jun	A_ORTHOC	0.867	0.730	0.935
PB_TOTAL	Algae_jn	A_ORTHOC	0.867	0.730	0.934
ZN_TOTAL	Cerio_jun	EPT	0.983	-0.745	-0.805
PB_TOTAL	FHM_aug	A_ORTHOC	0.863	0.730	0.935
PB_TOTAL	Algae_aug	A_ORTHOC	0.860	0.730	0.933
PB_TOTAL	Duck_aug	A_ORTHOC	0.836	0.730	0.957
CD_TOTAL	Cerio_jun	EPT	0.946	-0.763	-0.805
PB_TOTAL	Cerio_aug	A_ORTHOC	0.833	0.730	0.94
PB_TOTAL	Cerio_jun	EPT	0.862	-0.744	-0.805
AL_TOTAL	Algae_aug	LRHEO	0.950	---	0.867
CD_TOTAL	Algae_aug	LRHEO	0.938	---	0.867
CU_TOTAL	Algae_aug	LRHEO	0.984	---	0.867
FE_TOTAL	Algae_aug	LRHEO	0.946	---	0.867
PB_TOTAL	Algae_aug	LRHEO	0.860	---	0.867

Summary of Significant Heath Steele Correlation Coefficients (Benthos, Chemistry, Toxicity)

Monitoring Tool Used			**Correlation Coefficient**		
Chemistry	**Toxicity**	**Biology**	**C-T**	**C-B**	**T-B**
ZN_TOTAL	Algae_aug	LRHEO	0.973	---	0.867
AL_TOTAL	Algae_jn	LRHEO	0.955	---	0.872
CD_TOTAL	Algae_jn	LRHEO	0.943	---	0.872
CU_TOTAL	Algae_jn	LRHEO	0.987	---	0.872
FE_TOTAL	Algae_jn	LRHEO	0.951	---	0.872
PB_TOTAL	Algae_jn	LRHEO	0.867	---	0.872
ZN_TOTAL	Algae_jn	LRHEO	0.977	---	0.872
AL_TOTAL	Cerio_aug	LRHEO	0.941	---	0.849
CD_TOTAL	Cerio_aug	LRHEO	0.921	---	0.849
CU_TOTAL	Cerio_aug	LRHEO	0.975	---	0.849
FE_TOTAL	Cerio_aug	LRHEO	0.930	---	0.849
PB_TOTAL	Cerio_aug	LRHEO	0.833	---	0.849
ZN_TOTAL	Cerio_aug	LRHEO	0.964	---	0.849
AL_TOTAL	Cerio_jun	LRHEO	0.958	---	0.868
CD_TOTAL	Cerio_jun	LRHEO	0.946	---	0.868
CU_TOTAL	Cerio_jun	LRHEO	0.987	---	0.868
FE_TOTAL	Cerio_jun	LRHEO	0.954	---	0.868
PB_TOTAL	Cerio_jun	LRHEO	0.862	---	0.868
ZN_TOTAL	Cerio_jun	LRHEO	0.983	---	0.868
AL_TOTAL	Duck_aug	LRHEO	0.941	---	0.851
CD_TOTAL	Duck_aug	LRHEO	0.928	---	0.851
CU_TOTAL	Duck_aug	LRHEO	0.978	---	0.851
FE_TOTAL	Duck_aug	LRHEO	0.937	---	0.851
PB_TOTAL	Duck_aug	LRHEO	0.836	---	0.851
ZN_TOTAL	Duck_aug	LRHEO	0.972	---	0.851
AL_TOTAL	Duck_jun	LRHEO	0.955	---	0.871
CD_TOTAL	Duck_jun	LRHEO	0.943	---	0.871
CU_TOTAL	Duck_jun	LRHEO	0.987	---	0.871
FE_TOTAL	Duck_jun	LRHEO	0.951	---	0.871
PB_TOTAL	Duck_jun	LRHEO	0.867	---	0.871
ZN_TOTAL	Duck_jun	LRHEO	0.977	---	0.871
AL_TOTAL	FHM_aug	LRHEO	0.952	---	0.869
CD_TOTAL	FHM_aug	LRHEO	0.940	---	0.869
CU_TOTAL	FHM_aug	LRHEO	0.986	---	0.869
FE_TOTAL	FHM_aug	LRHEO	0.948	---	0.869
PB_TOTAL	FHM_aug	LRHEO	0.863	---	0.869
ZN_TOTAL	FHM_aug	LRHEO	0.975	---	0.869

Summary of Significant Heath Steele Correlation Coefficients (Benthos, Chemistry, Toxicity)

Monitoring Tool Used			Correlation Coefficient		
Chemistry	**Toxicity**	**Biology**	**C-T**	**C-B**	**T-B**
PB_PERI	Cerio_jun	A_RHEOCR	0.932	0.753	0.992
PB_PERI	Algae_jn	A_RHEOCR	0.931	0.753	0.989
PB_PERI	Duck_aug	A_RHEOCR	0.931	0.753	0.989
PB_PERI	Duck_jun	A_RHEOCR	0.931	0.753	0.989
PB_PERI	FHM_aug	A_RHEOCR	0.931	0.753	0.989
PB_PERI	Algae_aug	A_RHEOCR	0.931	0.753	0.988
PB_PERI	Cerio_aug	A_RHEOCR	0.928	0.753	0.985
FE_PERI	Cerio_jun	A_RHEOCR	0.999	0.694	0.992
FE_PERI	Algae_jn	A_RHEOCR	0.996	0.694	0.989
FE_PERI	Duck_aug	A_RHEOCR	0.996	0.694	0.989
FE_PERI	Duck_jun	A_RHEOCR	0.996	0.694	0.989
FE_PERI	FHM_aug	A_RHEOCR	0.995	0.694	0.989
FE_PERI	Algae_aug	A_RHEOCR	0.994	0.694	0.988
FE_PERI	Cerio_aug	A_RHEOCR	0.992	0.694	0.985
PB_PERI	Duck_aug	A_ORTHOC	0.931	0.715	0.957
PB_PERI	Cerio_jun	A_ORTHOC	0.932	0.715	0.955
PB_PERI	Cerio_aug	A_ORTHOC	0.928	0.715	0.94
PB_PERI	Duck_jun	A_ORTHOC	0.931	0.715	0.935
PB_PERI	FHM_aug	A_ORTHOC	0.931	0.715	0.935
PB_PERI	Algae_jn	A_ORTHOC	0.931	0.715	0.934
PB_PERI	Algae_aug	A_ORTHOC	0.931	0.715	0.933
AL_PERI	Duck_aug	A_RHEOCR	0.982	0.622	0.989
FE_PERI	Cerio_jun	A_ORTHOC	0.999	0.633	0.955
FE_PERI	Duck_aug	A_ORTHOC	0.996	0.633	0.957
AL_PERI	Cerio_jun	A_RHEOCR	0.974	0.622	0.992
AL_PERI	Cerio_aug	A_RHEOCR	0.976	0.622	0.985
AL_PERI	FHM_aug	A_RHEOCR	0.967	0.622	0.989
AL_PERI	Algae_aug	A_RHEOCR	0.967	0.622	0.988
AL_PERI	Duck_jun	A_RHEOCR	0.966	0.622	0.989
AL_PERI	Algae_jn	A_RHEOCR	0.965	0.622	0.989
FE_PERI	Algae_jn	LRHEO	0.996	0.683	0.872
FE_PERI	Duck_jun	LRHEO	0.996	0.683	0.871
FE_PERI	Cerio_jun	LRHEO	0.999	0.683	0.868
FE_PERI	FHM_aug	LRHEO	0.995	0.683	0.869
FE_PERI	Cerio_aug	A_ORTHOC	0.992	0.633	0.94
FE_PERI	Duck_jun	A_ORTHOC	0.996	0.633	0.935
FE_PERI	FHM_aug	A_ORTHOC	0.995	0.633	0.935
FE_PERI	Algae_jn	A_ORTHOC	0.996	0.633	0.934
FE_PERI	Algae_aug	LRHEO	0.994	0.683	0.867
FE_PERI	Algae_aug	A_ORTHOC	0.994	0.633	0.933
FE_PERI	Duck_aug	LRHEO	0.996	0.683	0.851
FE_PERI	Cerio_aug	LRHEO	0.992	0.683	0.849
PB_PERI	Algae_jn	LRHEO	0.931	0.679	0.872

Summary of Significant Heath Steele Correlation Coefficients (Benthos, Chemistry, Toxicity)

Monitoring Tool Used			Correlation Coefficient		
Chemistry	**Toxicity**	**Biology**	**C-T**	**C-B**	**T-B**
PB_PERI	Duck_jun	LRHEO	0.931	0.679	0.871
PB_PERI	FHM_aug	LRHEO	0.931	0.679	0.869
PB_PERI	Cerio_jun	LRHEO	0.932	0.679	0.868
PB_PERI	Algae_aug	LRHEO	0.931	0.679	0.867
PB_PERI	Duck_aug	LRHEO	0.931	0.679	0.851
FE_PERI	Cerio_jun	EPT	0.999	-0.666	-0.805
PB_PERI	Cerio_aug	LRHEO	0.928	0.679	0.849
AL_PERI	Cerio_jun	LRHEO	0.974	0.622	0.868
AL_PERI	Duck_jun	LRHEO	0.967	0.622	0.871
AL_PERI	Algae_jn	LRHEO	0.965	0.622	0.872
AL_PERI	FHM_aug	LRHEO	0.967	0.622	0.869
AL_PERI	Duck_aug	A_ORTHOC	0.982	0.556	0.957
AL_PERI	Algae_aug	LRHEO	0.967	0.622	0.867
AL_PERI	Cerio_jun	A_ORTHOC	0.974	0.556	0.955
AL_PERI	Cerio_aug	LRHEO	0.976	0.622	0.849
AL_PERI	Duck_aug	LRHEO	0.966	0.622	0.851
AL_PERI	Cerio_aug	A_ORTHOC	0.976	0.556	0.94
AL_PERI	FHM_aug	A_ORTHOC	0.967	0.556	0.935
AL_PERI	Duck_jun	A_ORTHOC	0.966	0.556	0.935
AL_PERI	Algae_aug	A_ORTHOC	0.967	0.556	0.933
AL_PERI	Algae_jn	A_ORTHOC	0.965	0.556	0.934
PB_PERI	Cerio_jun	EPT	0.932	-0.625	-0.805
AL_PERI	Cerio_jun	EPT	0.974	-0.568	-0.805

Summary of Significant Heath Steele Correlation Coefficients (Fish, Chemistry and Toxicity)

Monitoring Tool Used			**Correlation Coefficient**		
Chemistry	**Toxicity**	**Biology**	**C-T**	**C-B**	**T-B**
CU_DISS	Algae_aug	LBIO_AS	0.993	-0.965	-0.993
CU_DISS	Algae_jn	LBIO_AS	0.994	-0.965	-0.992
CU_DISS	Duck_jun	LBIO_AS	0.994	-0.965	-0.992
CU_DISS	FHM_aug	LBIO_AS	0.994	-0.965	-0.992
CU_DISS	Cerio_aug	LBIO_AS	0.990	-0.965	-0.989
AL_DISS	Algae_jn	LBIO_AS	0.988	-0.962	-0.992
AL_DISS	Duck_jun	LBIO_AS	0.988	-0.962	-0.992
CU_DISS	Cerio_jun	LBIO_AS	0.996	-0.965	-0.98
AL_DISS	FHM_aug	LBIO_AS	0.987	-0.962	-0.992
AL_DISS	Algae_aug	LBIO_AS	0.986	-0.962	-0.993
CU_DISS	Duck_aug	LBIO_AS	0.992	-0.965	-0.981
ZN_DISS	Cerio_jun	LBIO_ALL	0.997	-0.967	-0.971
AL_DISS	Cerio_jun	LBIO_AS	0.990	-0.962	-0.98
CU_DISS	Cerio_jun	LBIO_ALL	0.996	-0.965	-0.971
AL_DISS	Cerio_aug	LBIO_AS	0.979	-0.962	-0.989
AL_DISS	Duck_aug	LBIO_AS	0.983	-0.962	-0.981
FE_DISS	Cerio_jun	LBIO_ALL	0.989	-0.966	-0.971
ZN_DISS	Duck_aug	LBIO_ALL	0.992	-0.967	-0.964
CU_DISS	Duck_aug	LBIO_ALL	0.992	-0.965	-0.964
FE_DISS	Algae_jn	LBIO_AS	0.984	-0.943	-0.992
FE_DISS	Duck_jun	LBIO_AS	0.984	-0.943	-0.992
FE_DISS	FHM_aug	LBIO_AS	0.984	-0.943	-0.992
FE_DISS	Algae_aug	LBIO_AS	0.982	-0.943	-0.993
CD_DISS	Cerio_jun	LBIO_ALL	0.985	-0.960	-0.971
FE_DISS	Duck_aug	LBIO_ALL	0.985	-0.966	-0.964
CU_DISS	Duck_jun	LBIO_ALL	0.994	-0.965	-0.954
ZN_DISS	Duck_jun	LBIO_ALL	0.991	-0.967	-0.954
CU_DISS	Algae_jn	LBIO_ALL	0.994	-0.965	-0.953
FE_DISS	Cerio_aug	LBIO_AS	0.980	-0.943	-0.989
FE_DISS	Cerio_jun	LBIO_AS	0.989	-0.943	-0.98
ZN_DISS	Algae_jn	LBIO_ALL	0.991	-0.967	-0.953
CU_DISS	FHM_aug	LBIO_ALL	0.994	-0.965	-0.952
ZN_DISS	FHM_aug	LBIO_ALL	0.991	-0.967	-0.952
AL_DISS	Cerio_jun	LBIO_ALL	0.990	-0.949	-0.971
FE_DISS	Duck_aug	LBIO_AS	0.985	-0.943	-0.981
CD_DISS	Algae_jn	LBIO_AS	0.982	-0.934	-0.992
CD_DISS	Duck_jun	LBIO_AS	0.982	-0.934	-0.992
CU_DISS	Algae_aug	LBIO_ALL	0.993	-0.965	-0.949
CD_DISS	FHM_aug	LBIO_AS	0.980	-0.934	-0.992
CD_DISS	Algae_aug	LBIO_AS	0.979	-0.934	-0.993
ZN_DISS	Algae_aug	LBIO_ALL	0.989	-0.967	-0.949
FE_DISS	Duck_jun	LBIO_ALL	0.984	-0.966	-0.954
FE_DISS	Algae_jn	LBIO_ALL	0.984	-0.966	-0.953

Summary of Significant Heath Steele Correlation Coefficients (Fish, Chemistry and Toxicity)

Monitoring Tool Used			**Correlation Coefficient**		
Chemistry	**Toxicity**	**Biology**	**C-T**	**C-B**	**T-B**
CU_DISS	Cerio_aug	LBIO_ALL	0.990	-0.965	-0.948
FE_DISS	FHM_aug	LBIO_ALL	0.984	-0.966	-0.952
CD_DISS	Duck_aug	LBIO_ALL	0.977	-0.960	-0.964
ZN_DISS	Cerio_aug	LBIO_ALL	0.986	-0.967	-0.948
CD_DISS	Cerio_jun	LBIO_AS	0.985	-0.934	-0.98
FE_DISS	Algae_aug	LBIO_ALL	0.982	-0.966	-0.949
CD_DISS	Duck_jun	LBIO_ALL	0.982	-0.960	-0.954
AL_DISS	Duck_aug	LBIO_ALL	0.983	-0.949	-0.964
CD_DISS	Algae_jn	LBIO_ALL	0.982	-0.960	-0.953
CD_DISS	Cerio_aug	LBIO_AS	0.972	-0.934	-0.989
FE_DISS	Cerio_aug	LBIO_ALL	0.980	-0.966	-0.948
CD_DISS	FHM_aug	LBIO_ALL	0.980	-0.960	-0.952
CD_DISS	Duck_aug	LBIO_AS	0.977	-0.934	-0.981
AL_DISS	Duck_jun	LBIO_ALL	0.988	-0.949	-0.954
AL_DISS	Algae_jn	LBIO_ALL	0.988	-0.949	-0.953
CD_DISS	Algae_aug	LBIO_ALL	0.979	-0.960	-0.949
AL_DISS	FHM_aug	LBIO_ALL	0.987	-0.949	-0.952
ZN_DISS	Algae_jn	LBIO_AS	0.991	-0.906	-0.992
ZN_DISS	Duck_jun	LBIO_AS	0.991	-0.906	-0.992
ZN_DISS	FHM_aug	LBIO_AS	0.991	-0.906	-0.992
ZN_DISS	Algae_aug	LBIO_AS	0.989	-0.906	-0.993
AL_DISS	Algae_aug	LBIO_ALL	0.986	-0.949	-0.949
ZN_DISS	Cerio_jun	LBIO_AS	0.997	-0.906	-0.98
CD_DISS	Cerio_aug	LBIO_ALL	0.972	-0.960	-0.948
PB_DISS	Algae_jn	LBIO_AS	0.923	-0.966	-0.992
PB_DISS	Duck_jun	LBIO_AS	0.923	-0.966	-0.992
ZN_DISS	Cerio_aug	LBIO_AS	0.986	-0.906	-0.989
ZN_DISS	Duck_aug	LBIO_AS	0.992	-0.906	-0.981
PB_DISS	FHM_aug	LBIO_AS	0.920	-0.966	-0.992
AL_DISS	Cerio_aug	LBIO_ALL	0.979	-0.949	-0.948
PB_DISS	Algae_aug	LBIO_AS	0.918	-0.966	-0.993
PB_DISS	Cerio_jun	LBIO_AS	0.922	-0.966	-0.98
PB_DISS	Cerio_aug	LBIO_AS	0.904	-0.966	-0.989
PB_DISS	Duck_aug	LBIO_AS	0.907	-0.966	-0.981
PB_DISS	Cerio_jun	LBIO_ALL	0.922	-0.909	-0.971
PB_DISS	Duck_jun	LBIO_ALL	0.923	-0.909	-0.954
PB_DISS	Algae_jn	LBIO_ALL	0.923	-0.909	-0.953
PB_DISS	FHM_aug	LBIO_ALL	0.920	-0.909	-0.952
PB_DISS	Duck_aug	LBIO_ALL	0.907	-0.909	-0.964
PB_DISS	Algae_aug	LBIO_ALL	0.918	-0.909	-0.949
AL_DISS	Cerio_jun	LCPUE_AL	0.990	-0.913	-0.87
AL_DISS	Algae_jn	LCPUE_AL	0.988	-0.913	-0.87
AL_DISS	Duck_jun	LCPUE_AL	0.988	-0.913	-0.87

Summary of Significant Heath Steele Correlation Coefficients (Fish, Chemistry and Toxicity)

Monitoring Tool Used			**Correlation Coefficient**		
Chemistry	**Toxicity**	**Biology**	**C-T**	**C-B**	**T-B**
CD_DISS	Cerio_jun	LCPUE_AL	0.985	-0.914	-0.87
AL_DISS	FHM_aug	LCPUE_AL	0.987	-0.913	-0.867
CD_DISS	Algae_jn	LCPUE_AL	0.982	-0.914	-0.87
CD_DISS	Duck_jun	LCPUE_AL	0.982	-0.914	-0.87
FE_DISS	Cerio_jun	LCPUE_AL	0.989	-0.906	-0.87
PB_DISS	Cerio_aug	LBIO_ALL	0.904	-0.909	-0.948
PB_DISS	Algae_jn	LCPUE_AL	0.923	-0.969	-0.87
PB_DISS	Duck_jun	LCPUE_AL	0.923	-0.969	-0.87
AL_DISS	Algae_aug	LCPUE_AL	0.986	-0.913	-0.864
PB_DISS	Cerio_jun	LCPUE_AL	0.922	-0.969	-0.87
CD_DISS	FHM_aug	LCPUE_AL	0.980	-0.914	-0.867
FE_DISS	Algae_jn	LCPUE_AL	0.984	-0.906	-0.87
FE_DISS	Duck_jun	LCPUE_AL	0.984	-0.906	-0.87
CU_DISS	Cerio_jun	LCPUE_AL	0.996	-0.893	-0.87
CD_DISS	Algae_aug	LCPUE_AL	0.979	-0.914	-0.864
FE_DISS	FHM_aug	LCPUE_AL	0.984	-0.906	-0.867
PB_DISS	FHM_aug	LCPUE_AL	0.920	-0.969	-0.867
CU_DISS	Algae_jn	LCPUE_AL	0.994	-0.893	-0.87
CU_DISS	Duck_jun	LCPUE_AL	0.994	-0.893	-0.87
CU_DISS	FHM_aug	LCPUE_AL	0.994	-0.893	-0.867
FE_DISS	Algae_aug	LCPUE_AL	0.982	-0.906	-0.864
PB_DISS	Algae_aug	LCPUE_AL	0.918	-0.969	-0.864
CU_DISS	Algae_aug	LCPUE_AL	0.993	-0.893	-0.864
AL_DISS	Duck_aug	LCPUE_AL	0.983	-0.913	-0.852
CD_DISS	Duck_aug	LCPUE_AL	0.977	-0.914	-0.852
FE_DISS	Duck_aug	LCPUE_AL	0.985	-0.906	-0.852
AL_DISS	Cerio_aug	LCPUE_AL	0.979	-0.913	-0.847
CU_DISS	Duck_aug	LCPUE_AL	0.992	-0.893	-0.852
CD_DISS	Cerio_aug	LCPUE_AL	0.972	-0.914	-0.847
FE_DISS	Cerio_aug	LCPUE_AL	0.980	-0.906	-0.847
PB_DISS	Duck_aug	LCPUE_AL	0.907	-0.969	-0.852
CU_DISS	Cerio_aug	LCPUE_AL	0.990	-0.893	-0.847
PB_DISS	Cerio_aug	LCPUE_AL	0.904	-0.969	-0.847
ZN_DISS	Cerio_jun	LCPUE_AL	0.997	-0.845	-0.87
ZN_DISS	Algae_jn	LCPUE_AL	0.991	-0.845	-0.87
ZN_DISS	Duck_jun	LCPUE_AL	0.991	-0.845	-0.87
ZN_DISS	FHM_aug	LCPUE_AL	0.991	-0.845	-0.867
ZN_DISS	Algae_aug	LCPUE_AL	0.989	-0.845	-0.864
ZN_DISS	Duck_aug	LCPUE_AL	0.992	-0.845	-0.852
ZN_DISS	Cerio_aug	LCPUE_AL	0.986	-0.845	-0.847
ZN_DISS	Duck_aug	LBIO_BT	0.992	-0.806	-0.846
ZN_DISS	Cerio_jun	LBIO_BT	0.997	-0.806	-0.836
CD_DISS	Algae_jn	FTAXA	0.982	-0.821	-0.814

Summary of Significant Heath Steele Correlation Coefficients (Fish, Chemistry and Toxicity)

Monitoring Tool Used			Correlation Coefficient		
Chemistry	**Toxicity**	**Biology**	**C-T**	**C-B**	**T-B**
CD_DISS	Duck_jun	FTAXA	0.982	-0.821	-0.814
CD_DISS	FHM_aug	FTAXA	0.980	-0.821	-0.811
ZN_DISS	Cerio_aug	LBIO_BT	0.986	-0.806	-0.82
CD_DISS	Algae_aug	FTAXA	0.979	-0.821	-0.81
CD_DISS	Cerio_jun	FTAXA	0.985	-0.821	-0.805
ZN_DISS	FHM_aug	LBIO_BT	0.991	-0.806	-0.804
PB_DISS	Algae_jn	FTAXA	0.923	-0.853	-0.814
PB_DISS	Duck_jun	FTAXA	0.923	-0.853	-0.814
FE_DISS	Duck_aug	LBIO_BT	0.985	-0.769	-0.846
CU_DISS	Duck_aug	LBIO_BT	0.992	-0.763	-0.846
ZN_DISS	Algae_jn	FTAXA	0.991	-0.793	-0.814
ZN_DISS	Duck_jun	FTAXA	0.991	-0.793	-0.814
AL_DISS	Algae_jn	FTAXA	0.988	-0.794	-0.814
AL_DISS	Duck_jun	FTAXA	0.988	-0.794	-0.814
CU_DISS	Algae_jn	FTAXA	0.994	-0.789	-0.814
CU_DISS	Duck_jun	FTAXA	0.994	-0.789	-0.814
ZN_DISS	FHM_aug	FTAXA	0.991	-0.793	-0.811
ZN_DISS	Cerio_jun	FTAXA	0.997	-0.793	-0.805
PB_DISS	FHM_aug	FTAXA	0.920	-0.853	-0.811
CU_DISS	FHM_aug	FTAXA	0.994	-0.789	-0.811
FE_DISS	Cerio_jun	LBIO_BT	0.989	-0.769	-0.836
AL_DISS	FHM_aug	FTAXA	0.987	-0.794	-0.811
CU_DISS	Cerio_jun	LBIO_BT	0.996	-0.763	-0.836
ZN_DISS	Algae_aug	FTAXA	0.989	-0.793	-0.81
CU_DISS	Algae_aug	FTAXA	0.993	-0.789	-0.81
PB_DISS	Algae_aug	FTAXA	0.918	-0.853	-0.81
AL_DISS	Algae_aug	FTAXA	0.986	-0.794	-0.81
PB_DISS	Cerio_jun	FTAXA	0.922	-0.853	-0.805
AL_DISS	Cerio_jun	FTAXA	0.990	-0.794	-0.805
CU_DISS	Cerio_jun	FTAXA	0.996	-0.789	-0.805
FE_DISS	Algae_jn	FTAXA	0.984	-0.781	-0.814
FE_DISS	Duck_jun	FTAXA	0.984	-0.781	-0.814
FE_DISS	FHM_aug	FTAXA	0.984	-0.781	-0.811
FE_DISS	Cerio_jun	FTAXA	0.989	-0.781	-0.805
FE_DISS	Algae_aug	FTAXA	0.982	-0.781	-0.81
CU_DISS	Cerio_aug	LBIO_BT	0.990	-0.763	-0.82
FE_DISS	Cerio_aug	LBIO_BT	0.980	-0.769	-0.82
CD_DISS	Duck_aug	LBIO_BT	0.977	-0.738	-0.846
CU_DISS	FHM_aug	LBIO_BT	0.994	-0.763	-0.804
FE_DISS	FHM_aug	LBIO_BT	0.984	-0.769	-0.804
CD_DISS	Cerio_jun	LBIO_BT	0.985	-0.738	-0.836
AL_DISS	Duck_aug	LBIO_BT	0.983	-0.713	-0.846
AL_DISS	Cerio_jun	LBIO_BT	0.990	-0.713	-0.836

Summary of Significant Heath Steele Correlation Coefficients (Fish, Chemistry and Toxicity)

Monitoring Tool Used			Correlation Coefficient		
Chemistry	**Toxicity**	**Biology**	**C-T**	**C-B**	**T-B**
CD_DISS	Cerio_aug	LBIO_BT	0.972	-0.738	-0.82
CD_DISS	FHM_aug	LBIO_BT	0.980	-0.738	-0.804
AL_DISS	Cerio_aug	LBIO_BT	0.979	-0.713	-0.82
AL_DISS	FHM_aug	LBIO_BT	0.987	-0.713	-0.804
PB_DISS	Cerio_jun	LBIO_BT	0.922	-0.615	-0.836
PB_DISS	Duck_aug	LBIO_BT	0.907	-0.615	-0.846
PB_DISS	Cerio_aug	LBIO_BT	0.904	-0.615	-0.82
PB_DISS	FHM_aug	LBIO_BT	0.920	-0.615	-0.804

Summary of Significant Heath Steele Correlation Coefficients (Fish, Chemistry and Toxicity)

Monitoring Tool Used			Correlation Coefficient		
Chemistry	**Toxicity**	**Biology**	**C-T**	**C-B**	**T-B**
PB_PERI	Algae_aug	LBIO_AS	0.931	-0.765	-0.993
PB_PERI	Algae_jn	LBIO_AS	0.931	-0.765	-0.992
PB_PERI	Duck_jun	LBIO_AS	0.931	-0.765	-0.992
PB_PERI	FHM_aug	LBIO_AS	0.931	-0.765	-0.992
PB_PERI	Cerio_aug	LBIO_AS	0.928	-0.765	-0.989
PB_PERI	Cerio_jun	LBIO_AS	0.932	-0.765	-0.98
PB_PERI	Duck_aug	LBIO_AS	0.931	-0.765	-0.981
PB_PERI	Cerio_jun	LBIO_ALL	0.932	-0.722	-0.971
PB_PERI	Duck_aug	LBIO_ALL	0.931	-0.722	-0.964
PB_PERI	Duck_jun	LBIO_ALL	0.931	-0.722	-0.954
PB_PERI	Algae_jn	LBIO_ALL	0.931	-0.722	-0.953
PB_PERI	FHM_aug	LBIO_ALL	0.931	-0.722	-0.952
PB_PERI	Algae_aug	LBIO_ALL	0.931	-0.722	-0.949
PB_PERI	Cerio_aug	LBIO_ALL	0.928	-0.722	-0.948
FE_PERI	Cerio_jun	LBIO_ALL	0.999	-0.625	-0.971
FE_PERI	Duck_aug	LBIO_ALL	0.996	-0.625	-0.964
FE_PERI	Duck_jun	LBIO_ALL	0.996	-0.625	-0.954
FE_PERI	Algae_jn	LBIO_ALL	0.996	-0.625	-0.953
FE_PERI	FHM_aug	LBIO_ALL	0.995	-0.625	-0.952
FE_PERI	Algae_aug	LBIO_ALL	0.994	-0.625	-0.949
FE_PERI	Cerio_aug	LBIO_ALL	0.992	-0.625	-0.948
FE_PERI	Duck_aug	LBIO_BT	0.996	-0.664	-0.846
PB_PERI	Duck_aug	LBIO_BT	0.931	-0.709	-0.846
FE_PERI	Cerio_jun	LBIO_BT	0.999	-0.664	-0.836
PB_PERI	Cerio_jun	LBIO_BT	0.932	-0.709	-0.836
FE_PERI	Cerio_aug	LBIO_BT	0.992	-0.664	-0.82
PB_PERI	Cerio_aug	LBIO_BT	0.928	-0.709	-0.82
PB_PERI	Cerio_jun	LCPUE_AL	0.932	-0.662	-0.87
PB_PERI	Algae_jn	LCPUE_AL	0.931	-0.662	-0.87
PB_PERI	Duck_jun	LCPUE_AL	0.931	-0.662	-0.87
PB_PERI	FHM_aug	LCPUE_AL	0.931	-0.662	-0.867
PB_PERI	Algae_aug	LCPUE_AL	0.931	-0.662	-0.864
FE_PERI	FHM_aug	LBIO_BT	0.995	-0.664	-0.804
AL_PERI	Duck_aug	LBIO_BT	0.982	-0.639	-0.846
PB_PERI	FHM_aug	LBIO_BT	0.931	-0.709	-0.804
PB_PERI	Duck_aug	LCPUE_AL	0.931	-0.662	-0.852
PB_PERI	Cerio_aug	LCPUE_AL	0.928	-0.662	-0.847
AL_PERI	Cerio_jun	LBIO_BT	0.974	-0.639	-0.836
FE_PERI	Cerio_jun	LCPUE_AL	0.999	-0.589	-0.87
AL_PERI	Cerio_aug	LBIO_BT	0.976	-0.639	-0.82
FE_PERI	Algae_jn	LCPUE_AL	0.996	-0.589	-0.87
FE_PERI	Duck_jun	LCPUE_AL	0.996	-0.589	-0.87
FE_PERI	FHM_aug	LCPUE_AL	0.995	-0.589	-0.867

Summary of Significant Heath Steele Correlation Coefficients (Fish, Chemistry and Toxicity)

Monitoring Tool Used			**Correlation Coefficient**		
Chemistry	**Toxicity**	**Biology**	**C-T**	**C-B**	**T-B**
FE_PERI	Algae_aug	LCPUE_AL	0.994	-0.589	-0.864
FE_PERI	Duck_aug	LCPUE_AL	0.996	-0.589	-0.852
AL_PERI	FHM_aug	LBIO_BT	0.967	-0.639	-0.804
FE_PERI	Cerio_aug	LCPUE_AL	0.992	-0.589	-0.847
AL_PERI	Cerio_jun	LCPUE_AL	0.974	-0.461	-0.87
AL_PERI	Duck_jun	LCPUE_AL	0.966	-0.461	-0.87
AL_PERI	Algae_jn	LCPUE_AL	0.965	-0.461	-0.87
AL_PERI	FHM_aug	LCPUE_AL	0.967	-0.461	-0.867
AL_PERI	Duck_aug	LCPUE_AL	0.982	-0.461	-0.852
AL_PERI	Algae_aug	LCPUE_AL	0.967	-0.461	-0.864
AL_PERI	Cerio_aug	LCPUE_AL	0.976	-0.461	-0.847

Summary of Significant Heath Steele Correlation Coefficients (Fish, Chemistry and Toxicity)

Monitoring Tool Used			Correlation Coefficient		
Chemistry	**Toxicity**	**Biology**	**C-T**	**C-B**	**T-B**
CU_TOTAL	Algae_jn	LBIO_AS	0.987	-0.963	-0.992
CU_TOTAL	Duck_jun	LBIO_AS	0.987	-0.963	-0.992
CU_TOTAL	FHM_aug	LBIO_AS	0.986	-0.963	-0.992
CU_TOTAL	Algae_aug	LBIO_AS	0.984	-0.963	-0.993
CU_TOTAL	Cerio_jun	LBIO_AS	0.987	-0.963	-0.98
CU_TOTAL	Cerio_aug	LBIO_AS	0.975	-0.963	-0.989
CU_TOTAL	Duck_aug	LBIO_AS	0.978	-0.963	-0.981
ZN_TOTAL	Cerio_jun	LBIO_ALL	0.983	-0.949	-0.971
CU_TOTAL	Cerio_jun	LBIO_ALL	0.987	-0.941	-0.971
ZN_TOTAL	Duck_aug	LBIO_ALL	0.972	-0.949	-0.964
CU_TOTAL	Duck_aug	LBIO_ALL	0.978	-0.941	-0.964
CU_TOTAL	Duck_jun	LBIO_ALL	0.987	-0.941	-0.954
CU_TOTAL	Algae_jn	LBIO_ALL	0.987	-0.941	-0.953
ZN_TOTAL	Duck_jun	LBIO_ALL	0.977	-0.949	-0.954
ZN_TOTAL	Algae_jn	LBIO_ALL	0.977	-0.949	-0.953
CU_TOTAL	FHM_aug	LBIO_ALL	0.986	-0.941	-0.952
ZN_TOTAL	FHM_aug	LBIO_ALL	0.975	-0.949	-0.952
CU_TOTAL	Algae_aug	LBIO_ALL	0.984	-0.941	-0.949
ZN_TOTAL	Algae_aug	LBIO_ALL	0.973	-0.949	-0.949
CU_TOTAL	Cerio_aug	LBIO_ALL	0.975	-0.941	-0.948
ZN_TOTAL	Cerio_aug	LBIO_ALL	0.964	-0.949	-0.948
FE_TOTAL	Algae_jn	LBIO_AS	0.951	-0.908	-0.992
FE_TOTAL	Duck_jun	LBIO_AS	0.951	-0.908	-0.992
AL_TOTAL	Algae_jn	LBIO_AS	0.955	-0.902	-0.992
AL_TOTAL	Duck_jun	LBIO_AS	0.955	-0.902	-0.992
FE_TOTAL	FHM_aug	LBIO_AS	0.948	-0.908	-0.992
FE_TOTAL	Algae_aug	LBIO_AS	0.946	-0.908	-0.993
AL_TOTAL	FHM_aug	LBIO_AS	0.952	-0.902	-0.992
FE_TOTAL	Cerio_jun	LBIO_ALL	0.954	-0.919	-0.971
ZN_TOTAL	Algae_jn	LBIO_AS	0.977	-0.878	-0.992
ZN_TOTAL	Duck_jun	LBIO_AS	0.977	-0.878	-0.992
AL_TOTAL	Algae_aug	LBIO_AS	0.950	-0.902	-0.993
ZN_TOTAL	FHM_aug	LBIO_AS	0.975	-0.878	-0.992
FE_TOTAL	Cerio_jun	LBIO_AS	0.954	-0.908	-0.98
ZN_TOTAL	Algae_aug	LBIO_AS	0.973	-0.878	-0.993
AL_TOTAL	Cerio_jun	LBIO_AS	0.958	-0.902	-0.98
ZN_TOTAL	Cerio_jun	LBIO_AS	0.983	-0.878	-0.98
AL_TOTAL	Cerio_jun	LBIO_ALL	0.958	-0.907	-0.971
CD_TOTAL	Cerio_jun	LBIO_ALL	0.946	-0.917	-0.971
CD_TOTAL	Algae_jn	LBIO_AS	0.943	-0.897	-0.992
CD_TOTAL	Duck_jun	LBIO_AS	0.943	-0.897	-0.992
ZN_TOTAL	Duck_aug	LBIO_AS	0.972	-0.878	-0.981
ZN_TOTAL	Cerio_aug	LBIO_AS	0.964	-0.878	-0.989

Summary of Significant Heath Steele Correlation Coefficients (Fish, Chemistry and Toxicity)

Monitoring Tool Used			**Correlation Coefficient**		
Chemistry	**Toxicity**	**Biology**	**C-T**	**C-B**	**T-B**
CD_TOTAL	FHM_aug	LBIO_AS	0.940	-0.897	-0.992
CD_TOTAL	Algae_aug	LBIO_AS	0.938	-0.897	-0.993
FE_TOTAL	Cerio_aug	LBIO_AS	0.930	-0.908	-0.989
FE_TOTAL	Duck_aug	LBIO_AS	0.937	-0.908	-0.981
FE_TOTAL	Duck_jun	LBIO_ALL	0.951	-0.919	-0.954
AL_TOTAL	Cerio_aug	LBIO_AS	0.934	-0.902	-0.989
FE_TOTAL	Algae_jn	LBIO_ALL	0.951	-0.919	-0.953
AL_TOTAL	Duck_aug	LBIO_AS	0.941	-0.902	-0.981
CD_TOTAL	Cerio_jun	LBIO_AS	0.946	-0.897	-0.98
FE_TOTAL	Duck_aug	LBIO_ALL	0.937	-0.919	-0.964
FE_TOTAL	FHM_aug	LBIO_ALL	0.948	-0.919	-0.952
AL_TOTAL	Duck_jun	LBIO_ALL	0.955	-0.907	-0.954
AL_TOTAL	Algae_jn	LBIO_ALL	0.955	-0.907	-0.953
FE_TOTAL	Algae_aug	LBIO_ALL	0.946	-0.919	-0.949
CD_TOTAL	Duck_jun	LBIO_ALL	0.943	-0.917	-0.954
CD_TOTAL	Algae_jn	LBIO_ALL	0.943	-0.917	-0.953
AL_TOTAL	Duck_aug	LBIO_ALL	0.941	-0.907	-0.964
AL_TOTAL	FHM_aug	LBIO_ALL	0.952	-0.907	-0.952
CD_TOTAL	FHM_aug	LBIO_ALL	0.940	-0.917	-0.952
CD_TOTAL	Duck_aug	LBIO_ALL	0.928	-0.917	-0.964
AL_TOTAL	Algae_aug	LBIO_ALL	0.950	-0.907	-0.949
CD_TOTAL	Cerio_aug	LBIO_AS	0.921	-0.897	-0.989
CD_TOTAL	Duck_aug	LBIO_AS	0.928	-0.897	-0.981
CD_TOTAL	Algae_aug	LBIO_ALL	0.938	-0.917	-0.949
FE_TOTAL	Cerio_aug	LBIO_ALL	0.930	-0.919	-0.948
AL_TOTAL	Cerio_aug	LBIO_ALL	0.934	-0.907	-0.948
CD_TOTAL	Cerio_aug	LBIO_ALL	0.921	-0.917	-0.948
CU_TOTAL	Algae_jn	LCPUE_AL	0.987	-0.893	-0.87
CU_TOTAL	Cerio_jun	LCPUE_AL	0.987	-0.893	-0.87
CU_TOTAL	Duck_jun	LCPUE_AL	0.987	-0.893	-0.87
CU_TOTAL	FHM_aug	LCPUE_AL	0.986	-0.893	-0.867
CU_TOTAL	Algae_aug	LCPUE_AL	0.984	-0.893	-0.864
FE_TOTAL	Cerio_jun	LCPUE_AL	0.954	-0.898	-0.87
CU_TOTAL	Duck_aug	LCPUE_AL	0.978	-0.893	-0.852
FE_TOTAL	Algae_jn	LCPUE_AL	0.951	-0.898	-0.87
FE_TOTAL	Duck_jun	LCPUE_AL	0.951	-0.898	-0.87
FE_TOTAL	FHM_aug	LCPUE_AL	0.948	-0.898	-0.867
CU_TOTAL	Cerio_aug	LCPUE_AL	0.975	-0.893	-0.847
FE_TOTAL	Algae_aug	LCPUE_AL	0.946	-0.898	-0.864
CD_TOTAL	Cerio_jun	LCPUE_AL	0.946	-0.891	-0.87
CD_TOTAL	Algae_jn	LCPUE_AL	0.943	-0.891	-0.87
CD_TOTAL	Duck_jun	LCPUE_AL	0.943	-0.891	-0.87
AL_TOTAL	Cerio_jun	LCPUE_AL	0.958	-0.877	-0.87

Summary of Significant Heath Steele Correlation Coefficients (Fish, Chemistry and Toxicity)

Monitoring Tool Used			Correlation Coefficient		
Chemistry	**Toxicity**	**Biology**	**C-T**	**C-B**	**T-B**
AL_TOTAL	Algae_jn	LCPUE_AL	0.955	-0.877	-0.87
AL_TOTAL	Duck_jun	LCPUE_AL	0.955	-0.877	-0.87
CD_TOTAL	FHM_aug	LCPUE_AL	0.940	-0.891	-0.867
AL_TOTAL	FHM_aug	LCPUE_AL	0.952	-0.877	-0.867
CD_TOTAL	Algae_aug	LCPUE_AL	0.938	-0.891	-0.864
PB_TOTAL	Algae_jn	LBIO_AS	0.867	-0.838	-0.992
PB_TOTAL	Duck_jun	LBIO_AS	0.867	-0.838	-0.992
AL_TOTAL	Algae_aug	LCPUE_AL	0.950	-0.877	-0.864
PB_TOTAL	FHM_aug	LBIO_AS	0.863	-0.838	-0.992
FE_TOTAL	Duck_aug	LCPUE_AL	0.937	-0.898	-0.852
ZN_TOTAL	Cerio_jun	LCPUE_AL	0.983	-0.838	-0.87
PB_TOTAL	Algae_aug	LBIO_AS	0.860	-0.838	-0.993
ZN_TOTAL	Algae_jn	LCPUE_AL	0.977	-0.838	-0.87
ZN_TOTAL	Duck_jun	LCPUE_AL	0.977	-0.838	-0.87
ZN_TOTAL	FHM_aug	LCPUE_AL	0.975	-0.838	-0.867
PB_TOTAL	Cerio_jun	LBIO_AS	0.862	-0.838	-0.98
FE_TOTAL	Cerio_aug	LCPUE_AL	0.930	-0.898	-0.847
ZN_TOTAL	Algae_aug	LCPUE_AL	0.973	-0.838	-0.864
CD_TOTAL	Duck_aug	LCPUE_AL	0.928	-0.891	-0.852
AL_TOTAL	Duck_aug	LCPUE_AL	0.941	-0.877	-0.852
CD_TOTAL	Cerio_aug	LCPUE_AL	0.921	-0.891	-0.847
ZN_TOTAL	Duck_aug	LCPUE_AL	0.972	-0.838	-0.852
AL_TOTAL	Cerio_aug	LCPUE_AL	0.934	-0.877	-0.847
PB_TOTAL	Cerio_aug	LBIO_AS	0.833	-0.838	-0.989
PB_TOTAL	Duck_aug	LBIO_AS	0.836	-0.838	-0.981
ZN_TOTAL	Cerio_aug	LCPUE_AL	0.964	-0.838	-0.847
PB_TOTAL	Cerio_jun	LBIO_ALL	0.862	-0.809	-0.971
PB_TOTAL	Duck_jun	LBIO_ALL	0.867	-0.809	-0.954
PB_TOTAL	Algae_jn	LBIO_ALL	0.867	-0.809	-0.953
PB_TOTAL	FHM_aug	LBIO_ALL	0.863	-0.809	-0.952
PB_TOTAL	Algae_aug	LBIO_ALL	0.860	-0.809	-0.949
PB_TOTAL	Algae_jn	LCPUE_AL	0.867	-0.869	-0.87
PB_TOTAL	Duck_jun	LCPUE_AL	0.867	-0.869	-0.87
PB_TOTAL	Duck_aug	LBIO_ALL	0.836	-0.809	-0.964
PB_TOTAL	Cerio_jun	LCPUE_AL	0.862	-0.869	-0.87
PB_TOTAL	FHM_aug	LCPUE_AL	0.863	-0.869	-0.867
CU_TOTAL	Algae_jn	FTAXA	0.987	-0.808	-0.814
CU_TOTAL	Duck_jun	FTAXA	0.987	-0.808	-0.814
CD_TOTAL	Algae_jn	FTAXA	0.943	-0.844	-0.814
CD_TOTAL	Duck_jun	FTAXA	0.943	-0.844	-0.814
FE_TOTAL	Algae_jn	FTAXA	0.951	-0.835	-0.814
FE_TOTAL	Duck_jun	FTAXA	0.951	-0.835	-0.814
CU_TOTAL	FHM_aug	FTAXA	0.986	-0.808	-0.811

Summary of Significant Heath Steele Correlation Coefficients (Fish, Chemistry and Toxicity)

Monitoring Tool Used			Correlation Coefficient		
Chemistry	**Toxicity**	**Biology**	**C-T**	**C-B**	**T-B**
PB_TOTAL	Algae_aug	LCPUE_AL	0.860	-0.869	-0.864
CU_TOTAL	Algae_aug	FTAXA	0.984	-0.808	-0.81
CD_TOTAL	FHM_aug	FTAXA	0.940	-0.844	-0.811
CD_TOTAL	Cerio_jun	FTAXA	0.946	-0.844	-0.805
CU_TOTAL	Cerio_jun	FTAXA	0.987	-0.808	-0.805
FE_TOTAL	FHM_aug	FTAXA	0.948	-0.835	-0.811
FE_TOTAL	Cerio_jun	FTAXA	0.954	-0.835	-0.805
CD_TOTAL	Algae_aug	FTAXA	0.938	-0.844	-0.81
ZN_TOTAL	Algae_jn	FTAXA	0.977	-0.806	-0.814
ZN_TOTAL	Duck_jun	FTAXA	0.977	-0.806	-0.814
FE_TOTAL	Algae_aug	FTAXA	0.946	-0.835	-0.81
PB_TOTAL	Cerio_aug	LBIO_ALL	0.833	-0.809	-0.948
ZN_TOTAL	Cerio_jun	FTAXA	0.983	-0.806	-0.805
ZN_TOTAL	FHM_aug	FTAXA	0.975	-0.806	-0.811
ZN_TOTAL	Algae_aug	FTAXA	0.973	-0.806	-0.81
AL_TOTAL	Algae_jn	FTAXA	0.955	-0.800	-0.814
AL_TOTAL	Duck_jun	FTAXA	0.955	-0.800	-0.814
ZN_TOTAL	Duck_aug	LBIO_BT	0.972	-0.756	-0.846
ZN_TOTAL	Cerio_jun	LBIO_BT	0.983	-0.756	-0.836
PB_TOTAL	Duck_aug	LCPUE_AL	0.836	-0.869	-0.852
AL_TOTAL	FHM_aug	FTAXA	0.952	-0.800	-0.811
AL_TOTAL	Cerio_jun	FTAXA	0.958	-0.800	-0.805
AL_TOTAL	Algae_aug	FTAXA	0.950	-0.800	-0.81
PB_TOTAL	Cerio_aug	LCPUE_AL	0.833	-0.869	-0.847
ZN_TOTAL	Cerio_aug	LBIO_BT	0.964	-0.756	-0.82
ZN_TOTAL	FHM_aug	LBIO_BT	0.975	-0.756	-0.804
PB_TOTAL	Algae_jn	FTAXA	0.867	-0.828	-0.814
PB_TOTAL	Duck_jun	FTAXA	0.867	-0.828	-0.814
PB_TOTAL	FHM_aug	FTAXA	0.863	-0.828	-0.811
PB_TOTAL	Algae_aug	FTAXA	0.860	-0.828	-0.81
PB_TOTAL	Cerio_jun	FTAXA	0.862	-0.828	-0.805
CU_TOTAL	Duck_aug	LBIO_BT	0.978	-0.691	-0.846
CU_TOTAL	Cerio_jun	LBIO_BT	0.987	-0.691	-0.836
CU_TOTAL	Cerio_aug	LBIO_BT	0.975	-0.691	-0.82
CU_TOTAL	FHM_aug	LBIO_BT	0.986	-0.691	-0.804
FE_TOTAL	Cerio_jun	LBIO_BT	0.954	-0.637	-0.836
AL_TOTAL	Cerio_jun	LBIO_BT	0.958	-0.631	-0.836
FE_TOTAL	Duck_aug	LBIO_BT	0.937	-0.637	-0.846
AL_TOTAL	Duck_aug	LBIO_BT	0.941	-0.631	-0.846
CD_TOTAL	Cerio_jun	LBIO_BT	0.946	-0.634	-0.836
CD_TOTAL	Duck_aug	LBIO_BT	0.928	-0.634	-0.846
FE_TOTAL	Cerio_aug	LBIO_BT	0.930	-0.637	-0.82
FE_TOTAL	FHM_aug	LBIO_BT	0.948	-0.637	-0.804

Summary of Significant Heath Steele Correlation Coefficients (Fish, Chemistry and Toxicity)

Monitoring Tool Used			Correlation Coefficient		
Chemistry	**Toxicity**	**Biology**	**C-T**	**C-B**	**T-B**
AL_TOTAL	Cerio_aug	LBIO_BT	0.934	-0.631	-0.82
AL_TOTAL	FHM_aug	LBIO_BT	0.952	-0.631	-0.804
CD_TOTAL	FHM_aug	LBIO_BT	0.940	-0.634	-0.804
CD_TOTAL	Cerio_aug	LBIO_BT	0.921	-0.634	-0.82

APPENDIX 4

Detailed Water Quality Data and Toxicity Test Results

Analysis of Water, Heath Steele, August 1997.

Parameter	LOQ	Units	HE1A-W-Total	HE1A-W-Total	**HE6A** HE1A-W-Total	HE1A-W Dissolved	HE1A-W Dissolved	**HE6A** HE1A-W Dissolved
Date Sampled >			97/08/20	Replicate	field dup	97/08/20	Replicate	field dup
Acidity(as CaCO3)	1	mg/L	4	4	6	-	-	-
Alkalinity(as CaCO3)	1	mg/L	5	5	5	-	-	-
Aluminum	0.005	mg/L	0.322	-	0.316	0.185	0.187	0.185
Ammonia(as N)	0.05	mg/L	nd	nd	nd	-	-	-
Anion Sum	na	meq/L	0.329	-	0.32	-	-	-
Antimony	0.0005	mg/L	nd	-	nd	nd	nd	nd
Arsenic	0.002	mg/L	nd	-	nd	nd	nd	nd
Barium	0.005	mg/L	nd	-	nd	nd	nd	nd
Beryllium	0.005	mg/L	nd	-	nd	nd	nd	nd
Bicarbonate(as CaCO3, calculated)	1	mg/L	5	-	5	-	-	-
Bismuth	0.002	mg/L	nd	-	nd	nd	nd	nd
Boron	0.005	mg/L	nd	-	nd	nd	nd	nd
Cadmium	0.00005	mg/L	0.00032	-	0.00032	0.00032	0.00032	0.00034
Calcium	0.1	mg/L	3.5	-	3.4	3.5	3.4	3.5
Carbonate(as CaCO3, calculated)	1	mg/L	nd	-	nd	-	-	-
Cation Sum	na	meq/L	0.342	-	0.355	-	-	-
Chloride	1	mg/L	2	-	2	-	2	-
Chromium	0.0005	mg/L	nd	-	nd	nd	nd	nd
Cobalt	0.0002	mg/L	0.0021	-	0.0021	0.0021	0.002	0.0019
Colour	5	TCU	50	48	43	-	-	-
Conductivity - @25øC	1	us/cm	46	46	44	-	-	-
Copper	0.0003	mg/L	0.0225	-	0.0224	0.0201	0.0191	0.0189
Dissolved Inorganic Carbon(as C)	0.2	mg/L	-	-	-	0.6	0.5	0.8
Dissolved Organic Carbon(DOC)	0.5	mg/L	-	-	-	4.5	4.5	4.2
Hardness(as CaCO3)	0.1	mg/L	12.8	-	12.9	-	-	-
Ion Balance	0.01	%	1.92	-	5.19	-	-	-
Iron	0.02	mg/L	0.67	-	0.65	0.32	0.32	0.32
Langelier Index at 20øC	na	na	-3.6	-	-3.4	-	-	-
Langelier Index at 4øC	na	na	-4	-	-3.8	-	-	-
Lead	0.0001	mg/L	0.003	-	0.0031	0.001	0.001	0.0011
Magnesium	0.1	mg/L	1	-	1	1	1	1
Manganese	0.0005	mg/L	0.103	-	0.102	0.0973	0.0957	0.0919
Mercury (dissolved)	0.0001	mg/L	-	-	-	nd	nd	nd
Mercury (total)	0.0005	mg/L	nd	nd	nd	-	-	-
Molybdenum	0.0001	mg/L	nd	-	nd	nd	nd	nd
Nickel	0.001	mg/L	nd	-	nd	nd	nd	nd
Nitrate(as N)	0.05	mg/L	nd	nd	nd	-	-	-
Nitrite(as N)	0.01	mg/L	nd	nd	nd	-	-	-
Orthophosphate(as P)	0.01	mg/L	0.01	0.01	0.06	-	-	-
pH	0.1	Units	6.6	6.5	6.8	-	-	-
Phosphorus	0.1	mg/L	nd	-	nd	nd	nd	nd
Potassium	0.5	mg/L	1	-	1.1	nd	nd	0.8
Reactive Silica(SiO2)	0.5	mg/L	5.1	-	5.1	-	-	-
Saturation pH at 20øC	na	units	10.2	-	10.2	-	-	-
Saturation pH at 4øC	na	units	10.6	-	10.6	-	-	-
Selenium	0.002	mg/L	nd	-	nd	nd	nd	nd
Silver	0.00005	mg/L	nd	-	nd	nd	nd	nd
Sodium	0.1	mg/L	1.7	-	1.7	1.8	1.8	1.8
Strontium	0.005	mg/L	0.014	-	0.014	0.012	0.013	0.013
Sulphate	2	mg/L	9	9	9	-	-	-
Thallium	0.0001	mg/L	nd	-	nd	nd	nd	nd
Tin	0.002	mg/L	nd	-	nd	nd	nd	nd
Titanium	0.002	mg/L	0.002	-	0.003	nd	nd	nd
Total Dissolved Solids(Calculated)	1	mg/L	-	-	-	25	-	25
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	0.36	0.37	0.35	-	-	-
Total Suspended Solids	1	mg/L	2	2	2	-	-	-
Turbidity	0.1	NTU	2.6	2.5	2.4	-	-	-
Uranium	0.0001	mg/L	nd	-	nd	nd	nd	nd
Vanadium	0.002	mg/L	nd	-	nd	nd	nd	nd
Zinc	0.001	mg/L	0.157	-	0.15	0.158	0.162	0.157
Fluoride	0.02	mg/L	0.02	0.02	0.02	-	-	-

Analysis of Water, Heath Steele, August 1997.

Parameter	LOQ	Units	HE1B-W- Total	HE1B-W Dissolved	HE2A-W- Total	HE2A-W Dissolved	HE2B-W- Total	HE2B-W Dissolved
Date Sampled >			97/08/20	97/08/20	97/08/20	97/08/20	97/08/20	97/08/20
Acidity(as CaCO3)	1	mg/L	6	-	6	-	4	-
Alkalinity(as CaCO3)	1	mg/L	8	-	9	-	10	-
Aluminum	0.005	mg/L	0.277	0.173	0.247	0.153	0.169	0.118
Ammonia(as N)	0.05	mg/L	0.11	-	nd	-	nd	-
Anion Sum	na	meq/L	0.386	-	0.393	-	0.389	-
Antimony	0.0005	mg/L	nd	nd	nd	nd	nd	nd
Arsenic	0.002	mg/L	nd	nd	nd	nd	nd	nd
Barium	0.005	mg/L	nd	nd	nd	nd	nd	nd
Beryllium	0.005	mg/L	nd	nd	nd	nd	nd	nd
Bicarbonate(as CaCO3, calculated)	1	mg/L	7	-	9	-	10	-
Bismuth	0.002	mg/L	nd	nd	nd	nd	nd	nd
Boron	0.005	mg/L	nd	nd	nd	nd	nd	nd
Cadmium	0.00005	mg/L	0.00022	0.00022	0.00021	0.00022	0.0002	0.0002
Calcium	0.1	mg/L	4.5	4.4	4.7	4.6	4.8	4.6
Carbonate(as CaCO3, calculated)	1	mg/L	nd	-	nd	-	nd	-
Cation Sum	na	meq/L	0.393	-	0.388	-	0.384	-
Chloride	1	mg/L	2	-	1	-	1	-
Chromium	0.0005	mg/L	nd	nd	nd	nd	nd	nd
Cobalt	0.0002	mg/L	0.0012	0.0011	0.001	0.0008	0.0007	0.0006
Colour	5	TCU	40	-	38	-	36	-
Conductivity - @25øC	1	us/cm	48	-	49	-	48	-
Copper	0.0003	mg/L	0.0193	0.0167	0.018	0.0151	0.0158	0.0141
Dissolved Inorganic Carbon(as C)	0.2	mg/L	-	0.8	-	1.2	-	1.3
Dissolved Organic Carbon(DOC)	0.5	mg/L	-	3.6	-	3.3	-	3.2
Hardness(as CaCO3)	0.1	mg/L	15	-	15.4	-	15.2	-
Ion Balance	0.01	%	0.94	-	0.63	-	0.7	-
Iron	0.02	mg/L	0.54	0.29	0.5	0.26	0.42	0.24
Langelier Index at 20øC	na	na	-3.19	-	-3.02	-	-2.92	-
Langelier Index at 4øC	na	na	-3.59	-	-3.42	-	-3.32	-
Lead	0.0001	mg/L	0.0025	0.001	0.0027	0.0008	0.0019	0.0008
Magnesium	0.1	mg/L	0.9	1	0.9	0.9	0.9	0.9
Manganese	0.0005	mg/L	0.0643	0.0588	0.0572	0.0453	0.0402	0.0346
Mercury (dissolved)	0.0001	mg/L	-	nd	-	nd	-	nd
Mercury (total)	0.0005	mg/L	nd	-	nd	-	nd	-
Molybdenum	0.0001	mg/L	nd	nd	nd	nd	nd	nd
Nickel	0.001	mg/L	nd	nd	nd	nd	nd	nd
Nitrate(as N)	0.05	mg/L	nd	-	nd	-	nd	-
Nitrite(as N)	0.01	mg/L	nd	-	nd	-	nd	-
Orthophosphate(as P)	0.01	mg/L	0.05	-	0.02	-	0.01	-
pH	0.1	Units	6.7	-	6.8	-	6.9	-
Phosphorus	0.1	mg/L	nd	nd	nd	nd	nd	nd
Potassium	0.5	mg/L	1.1	0.5	0.9	nd	0.8	nd
Reactive Silica(SiO2)	0.5	mg/L	5.6	-	5.7	-	5.7	-
Saturation pH at 20øC	na	units	9.9	-	9.81	-	9.77	-
Saturation pH at 4øC	na	units	10.3	-	10.2	-	10.2	-
Selenium	0.002	mg/L	nd	nd	nd	nd	nd	nd
Silver	0.00005	mg/L	nd	nd	nd	nd	nd	nd
Sodium	0.1	mg/L	1.6	1.7	1.6	1.6	1.5	1.6
Strontium	0.005	mg/L	0.015	0.014	0.016	0.014	0.015	0.014
Sulphate	2	mg/L	9	-	9	-	8	-
Thallium	0.0001	mg/L	nd	nd	nd	nd	nd	nd
Tin	0.002	mg/L	nd	nd	nd	nd	nd	nd
Titanium	0.002	mg/L	nd	nd	nd	nd	nd	nd
Total Dissolved Solids(Calculated)	1	mg/L	-	29	-	29	-	28
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	0.31	-	0.3	-	0.26	-
Total Suspended Solids	1	mg/L	1	-	1	-	nd	-
Turbidity	0.1	NTU	1.9	-	1.7	-	1.3	-
Uranium	0.0001	mg/L	nd	nd	nd	nd	nd	nd
Vanadium	0.002	mg/L	nd	nd	nd	nd	nd	nd
Zinc	0.001	mg/L	0.111	0.113	0.106	0.109	0.107	0.111
Fluoride	0.02	mg/L	0.02	-	0.02	-	0.02	-

Analysis of Water, Heath Steele, August 1997.

Parameter	LOQ	Units	HE3A-W- Total	HE3A-W Dissolved	HE3B-W- Total	HE3B-W Dissolved	HE4A-W- Total	HE4A-W Dissolved
Date Sampled >			97/08/20	97/08/20	97/08/20	97/08/20	97/08/20	97/08/20
Acidity(as CaCO3)	1	mg/L	6	-	4	-	4	-
Alkalinity(as CaCO3)	1	mg/L	13	-	15	-	15	-
Aluminum	0.005	mg/L	0.15	0.065	0.082	0.06	0.074	0.058
Ammonia(as N)	0.05	mg/L	nd	-	nd	-	nd	-
Anion Sum	na	meq/L	0.387	-	0.426	-	0.429	-
Antimony	0.0005	mg/L	nd	nd	nd	nd	nd	nd
Arsenic	0.002	mg/L	nd	nd	nd	nd	nd	nd
Barium	0.005	mg/L	nd	nd	nd	nd	nd	nd
Beryllium	0.005	mg/L	nd	nd	nd	nd	nd	nd
Bicarbonate(as CaCO3, calculated)	1	mg/L	13	-	15	-	15	-
Bismuth	0.002	mg/L	nd	nd	nd	nd	nd	nd
Boron	0.005	mg/L	nd	nd	nd	nd	nd	nd
Cadmium	0.00005	mg/L	0.00016	0.00011	0.00011	0.00012	0.0001	0.00011
Calcium	0.1	mg/L	4.9	4.8	5.2	5.1	5.3	5.3
Carbonate(as CaCO3, calculated)	1	mg/L	nd	-	nd	-	nd	-
Cation Sum	na	meq/L	0.396	-	0.421	-	0.42	-
Chloride	1	mg/L	nd	-	nd	-	nd	-
Chromium	0.0005	mg/L	nd	nd	nd	nd	nd	nd
Cobalt	0.0002	mg/L	0.0013	0.0002	0.0002	nd	nd	nd
Colour	5	TCU	28	-	27	-	27	-
Conductivity - @25øC	1	us/cm	46	-	47	-	49	-
Copper	0.0003	mg/L	0.0098	0.0071	0.0075	0.007	0.0073	0.007
Dissolved Inorganic Carbon(as C)	0.2	mg/L	-	2	-	2.2	-	2.1
Dissolved Organic Carbon(DOC)	0.5	mg/L	-	3.2	-	3.3	-	3.3
Hardness(as CaCO3)	0.1	mg/L	15.7	-	16.6	-	17	-
Ion Balance	0.01	%	1.11	-	0.64	-	1.08	-
Iron	0.02	mg/L	0.36	0.15	0.24	0.16	0.23	0.16
Langelier Index at 20øC	na	na	-2.4	-	-2.36	-	-2.33	-
Langelier Index at 4øC	na	na	-2.8	-	-2.76	-	-2.73	-
Lead	0.0001	mg/L	0.0022	0.0004	0.0009	0.0004	0.0008	0.0004
Magnesium	0.1	mg/L	0.9	0.9	0.9	0.9	0.9	0.9
Manganese	0.0005	mg/L	0.0795	0.0164	0.0179	0.0127	0.0146	0.0106
Mercury (dissolved)	0.0001	mg/L	-	nd	-	nd	-	nd
Mercury (total)	0.0005	mg/L	nd	-	nd	-	nd	-
Molybdenum	0.0001	mg/L	nd	nd	nd	nd	nd	nd
Nickel	0.001	mg/L	nd	nd	nd	nd	nd	nd
Nitrate(as N)	0.05	mg/L	nd	-	nd	-	nd	-
Nitrite(as N)	0.01	mg/L	nd	-	nd	-	nd	-
Orthophosphate(as P)	0.01	mg/L	0.01	-	nd	-	nd	-
pH	0.1	Units	7.2	-	7.2	-	7.2	-
Phosphorus	0.1	mg/L	nd	nd	nd	nd	nd	nd
Potassium	0.5	mg/L	nd	0.6	0.9	0.9	1.2	0.5
Reactive Silica(SiO2)	0.5	mg/L	5.8	-	5.8	-	5.7	-
Saturation pH at 20øC	na	units	9.62	-	9.53	-	9.52	-
Saturation pH at 4øC	na	units	10	-	9.93	-	9.92	-
Selenium	0.002	mg/L	nd	nd	nd	nd	nd	nd
Silver	0.00005	mg/L	nd	nd	nd	nd	nd	nd
Sodium	0.1	mg/L	1.5	1.5	1.5	1.5	1.5	1.5
Strontium	0.005	mg/L	0.016	0.014	0.017	0.015	0.017	0.016
Sulphate	2	mg/L	5	-	5	-	5	-
Thallium	0.0001	mg/L	nd	nd	nd	nd	nd	nd
Tin	0.002	mg/L	nd	nd	nd	nd	nd	nd
Titanium	0.002	mg/L	0.002	nd	nd	nd	nd	nd
Total Dissolved Solids(Calculated)	1	mg/L	-	27	-	29	-	29
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	0.28	-	nd	-	0.27	-
Total Suspended Solids	1	mg/L	3	-	nd	-	nd	-
Turbidity	0.1	NTU	0.9	-	0.7	-	0.7	-
Uranium	0.0001	mg/L	nd	nd	nd	nd	nd	nd
Vanadium	0.002	mg/L	nd	nd	nd	nd	nd	nd
Zinc	0.001	mg/L	0.085	0.074	0.066	0.066	0.062	0.064
Fluoride	0.02	mg/L	nd	-	nd	-	nd	-

Analysis of Water, Heath Steele, August 1997.

Parameter	LOQ	Units	HE4B-W-Total	HE4B-W Dissolved	HE5A-W-Total	HE5A-W Dissolved	HE5B-W-Total	HE5B-W Dissolved
Date Sampled >			97/08/20	97/08/20	97/08/20	97/08/20	97/08/20	97/08/20
Acidity(as CaCO3)	1	mg/L	2	-	4	-	4	-
Alkalinity(as CaCO3)	1	mg/L	16	-	20	-	20	-
Aluminum	0.005	mg/L	0.07	0.056	0.059	0.046	0.055	0.042
Ammonia(as N)	0.05	mg/L	nd	-	nd	-	nd	-
Anion Sum	na	meq/L	0.45	-	0.523	-	0.52	-
Antimony	0.0005	mg/L	nd	nd	nd	nd	nd	nd
Arsenic	0.002	mg/L	nd	nd	nd	nd	nd	nd
Barium	0.005	mg/L	nd	nd	nd	nd	nd	nd
Beryllium	0.005	mg/L	nd	nd	nd	nd	nd	nd
Bicarbonate(as CaCO3, calculated)	1	mg/L	16	-	20	-	20	-
Bismuth	0.002	mg/L	nd	nd	nd	nd	nd	nd
Boron	0.005	mg/L	nd	nd	nd	nd	nd	nd
Cadmium	0.00005	mg/L	0.0001	0.00011	0.00008	0.00009	0.00007	0.00008
Calcium	0.1	mg/L	5.6	5.5	6.4	6.3	6.9	6.7
Carbonate(as CaCO3, calculated)	1	mg/L	nd	-	nd	-	nd	-
Cation Sum	na	meq/L	0.439	-	0.476	-	0.496	-
Chloride	1	mg/L	1	-	nd	-	nd	-
Chromium	0.0005	mg/L	nd	nd	nd	nd	nd	nd
Cobalt	0.0002	mg/L	nd	nd	nd	nd	nd	nd
Colour	5	TCU	29	-	27	-	32	-
Conductivity - @25øC	1	us/cm	49	-	53	-	56	-
Copper	0.0003	mg/L	0.0071	0.0068	0.0062	0.0059	0.0057	0.0057
Dissolved Inorganic Carbon(as C)	0.2	mg/L	-	2.5	-	2.5	-	2.9
Dissolved Organic Carbon(DOC)	0.5	mg/L	-	3.3	-	3.5	-	3.6
Hardness(as CaCO3)	0.1	mg/L	17.7	-	19.7	-	20.8	-
Ion Balance	0.01	%	1.28	-	4.69	-	2.33	-
Iron	0.02	mg/L	0.22	0.16	0.18	0.14	0.17	0.13
Langelier Index at 20øC	na	na	-2.29	-	-2.09	-	-2.04	-
Langelier Index at 4øC	na	na	-2.69	-	-2.49	-	-2.44	-
Lead	0.0001	mg/L	0.0007	0.0004	0.0005	0.0002	0.0004	0.0002
Magnesium	0.1	mg/L	1	1	1	1	1	1
Manganese	0.0005	mg/L	0.0128	0.0093	0.0133	0.0071	0.0126	0.0061
Mercury (dissolved)	0.0001	mg/L	-	nd	-	nd	-	nd
Mercury (total)	0.0005	mg/L	nd	-	nd	-	nd	-
Molybdenum	0.0001	mg/L	nd	nd	nd	nd	nd	nd
Nickel	0.001	mg/L	nd	nd	nd	nd	nd	nd
Nitrate(as N)	0.05	mg/L	nd	-	nd	-	nd	-
Nitrite(as N)	0.01	mg/L	nd	-	nd	-	nd	-
Orthophosphate(as P)	0.01	mg/L	nd	-	nd	-	nd	-
pH	0.1	Units	7.2	-	7.2	-	7.3	-
Phosphorus	0.1	mg/L	nd	nd	nd	nd	nd	nd
Potassium	0.5	mg/L	0.8	0.8	1.2	0.7	nd	0.7
Reactive Silica(SiO2)	0.5	mg/L	5.7	-	5.6	-	5.4	-
Saturation pH at 20øC	na	units	9.48	-	9.32	-	9.29	-
Saturation pH at 4øC	na	units	9.88	-	9.72	-	9.69	-
Selenium	0.002	mg/L	nd	nd	nd	nd	nd	nd
Silver	0.00005	mg/L	nd	nd	nd	nd	nd	nd
Sodium	0.1	mg/L	1.5	1.5	1.5	1.5	1.4	1.5
Strontium	0.005	mg/L	0.017	0.016	0.019	0.017	0.018	-
Sulphate	2	mg/L	5	-	4	-	4	-
Thallium	0.0001	mg/L	nd	nd	nd	nd	nd	nd
Tin	0.002	mg/L	nd	nd	nd	nd	nd	nd
Titanium	0.002	mg/L	nd	nd	nd	nd	nd	nd
Total Dissolved Solids(Calculated)	1	mg/L	-	30	-	33	-	33
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	0.23	-	0.2	-	0.24	-
Total Suspended Solids	1	mg/L	nd	-	nd	-	nd	-
Turbidity	0.1	NTU	0.6	-	0.5	-	0.5	-
Uranium	0.0001	mg/L	nd	nd	nd	nd	nd	nd
Vanadium	0.002	mg/L	nd	nd	nd	nd	nd	nd
Zinc	0.001	mg/L	0.068	0.071	0.058	0.061	0.061	0.062
Fluoride	0.02	mg/L	nd	-	nd	-	nd	-

Analysis of Water, Heath Steele, August 1997.

				HR6A		HR6A		
Parameter	LOQ	Units	HR1A-W- Total	HR1A-W- Total	HR1A-W Dissolved	HR1A-W Dissolved	HR1B-W- Total	HR1B-W- Total
Date Sampled >			97/08/20	field dup	97/08/20	field dup	97/08/20	Replicate
Acidity(as CaCO3)	1	mg/L	10	10	-	-	10	-
Alkalinity(as CaCO3)	1	mg/L	9	9	-	-	9	-
Aluminum	0.005	mg/L	0.031	0.03	0.019	0.019	0.047	-
Ammonia(as N)	0.05	mg/L	nd	nd	-	-	nd	-
Anion Sum	na	meq/L	0.27	0.266	-	-	0.27	-
Antimony	0.0005	mg/L	nd	nd	nd	nd	nd	-
Arsenic	0.002	mg/L	nd	nd	nd	nd	nd	-
Barium	0.005	mg/L	nd	nd	nd	nd	nd	-
Beryllium	0.005	mg/L	nd	nd	nd	nd	nd	-
Bicarbonate(as CaCO3, calculated)	1	mg/L	9	9	-	-	9	-
Bismuth	0.002	mg/L	nd	nd	nd	nd	nd	-
Boron	0.005	mg/L	nd	nd	nd	nd	nd	nd
Cadmium	0.00005	mg/L	nd	nd	nd	nd	nd	-
Calcium	0.1	mg/L	2.5	2.5	2.4	2.6	2.5	2.5
Carbonate(as CaCO3, calculated)	1	mg/L	nd	nd	-	-	nd	-
Cation Sum	na	meq/L	0.267	0.276	-	-	0.27	-
Chloride	1	mg/L	nd	nd	-	-	nd	-
Chromium	0.0005	mg/L	nd	nd	nd	nd	nd	-
Cobalt	0.0002	mg/L	nd	nd	nd	nd	nd	-
Colour	5	TCU	32	33	-	-	31	-
Conductivity - @25øC	1	us/cm	32	32	-	-	31	-
Copper	0.0003	mg/L	nd	nd	nd	nd	nd	-
Dissolved Inorganic Carbon(as C)	0.2	mg/L	-	-	1.9	1.5	-	-
Dissolved Organic Carbon(DOC)	0.5	mg/L	-	-	2.7	2.8	-	-
Hardness(as CaCO3)	0.1	mg/L	9.8	10.1	-	-	9.8	-
Ion Balance	0.01	%	0.61	1.86	-	-	0.08	-
Iron	0.02	mg/L	0.09	0.08	0.05	0.05	0.08	-
Langelier Index at 20øC	na	na	-3.27	-3.09	-	-	-3.27	-
Langelier Index at 4øC	na	na	-3.67	-3.49	-	-	-3.67	-
Lead	0.0001	mg/L	nd	nd	nd	nd	nd	-
Magnesium	0.1	mg/L	0.9	0.9	0.9	0.9	0.9	0.9
Manganese	0.0005	mg/L	0.0163	0.0149	0.0031	0.003	0.0145	-
Mercury (dissolved)	0.0001	mg/L	-	-	nd	nd	-	-
Mercury (total)	0.0005	mg/L	nd	nd	-	-	nd	-
Molybdenum	0.0001	mg/L	nd	nd	nd	nd	nd	-
Nickel	0.001	mg/L	nd	nd	nd	nd	nd	-
Nitrate(as N)	0.05	mg/L	0.07	0.08	-	-	0.09	-
Nitrite(as N)	0.01	mg/L	nd	nd	-	-	nd	-
Orthophosphate(as P)	0.01	mg/L	0.02	0.05	-	-	0.02	-
pH	0.1	Units	6.8	7	-	-	6.8	-
Phosphorus	0.1	mg/L	nd	nd	nd	nd	nd	nd
Potassium	0.5	mg/L	0.9	0.7	nd	nd	0.8	0.7
Reactive Silica(SiO2)	0.5	mg/L	7.5	7.4	-	-	7.4	-
Saturation pH at 20øC	na	units	10.1	10	-	-	10.1	-
Saturation pH at 4øC	na	units	10.5	10.4	-	-	10.5	-
Selenium	0.002	mg/L	nd	nd	nd	nd	nd	-
Silver	0.00005	mg/L	nd	nd	nd	nd	nd	-
Sodium	0.1	mg/L	1.4	1.3	1.4	1.4	1.3	1.3
Strontium	0.005	mg/L	0.01	0.011	0.009	0.009	0.011	-
Sulphate	2	mg/L	3	3	-	-	3	-
Thallium	0.0001	mg/L	nd	nd	nd	nd	nd	-
Tin	0.002	mg/L	nd	nd	nd	nd	nd	-
Titanium	0.002	mg/L	nd	nd	nd	nd	nd	-
Total Dissolved Solids(Calculated)	1	mg/L	-	-	22	22	-	-
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	0.26	0.26	-	-	0.27	-
Total Suspended Solids	1	mg/L	1	2	-	-	2	-
Turbidity	0.1	NTU	0.5	45	-	-	0.5	-
Uranium	0.0001	mg/L	nd	nd	nd	nd	nd	-
Vanadium	0.002	mg/L	nd	nd	nd	nd	nd	-
Zinc	0.001	mg/L	0.008	0.006	0.003	0.003	0.009	-
Fluoride	0.02	mg/L	nd	nd	-	-	nd	-

Analysis of Water, Heath Steele, August 1997.

Parameter	LOQ	Units	HR1B-W Dissolved	HR2A-W-Total	HR2A-W Dissolved	HR2B-W-Total	HR2B-W Dissolved	HR3A-W-Total	HR3A-W Total Replicate
Date Sampled >			97/08/20	97/08/20	97/08/20	97/08/20	97/08/20	97/08/20	
Acidity(as CaCO3)	1	mg/L	-	4	-	4	-	4	-
Alkalinity(as CaCO3)	1	mg/L	-	15	-	15	-	32	-
Aluminum	0.005	mg/L	0.018	0.049	0.021	0.046	0.021	0.033	-
Ammonia(as N)	0.05	mg/L	-	nd	-	nd	-	nd	-
Anion Sum	na	meq/L	-	0.362	-	0.362	-	0.719	-
Antimony	0.0005	mg/L	nd	nd	nd	nd	nd	nd	-
Arsenic	0.002	mg/L	nd	nd	nd	nd	nd	nd	-
Barium	0.005	mg/L	nd	nd	nd	nd	nd	0.006	-
Beryllium	0.005	mg/L	nd	nd	nd	nd	nd	nd	-
Bicarbonate(as CaCO3, calculated)	1	mg/L	-	15	-	15	-	32	-
Bismuth	0.002	mg/L	nd	nd	nd	nd	nd	nd	-
Boron	0.005	mg/L	nd	nd	nd	nd	nd	nd	-
Cadmium	0.00005	mg/L	nd	nd	nd	nd	nd	nd	-
Calcium	0.1	mg/L	2.4	4	3.9	4.1	4	10.9	-
Carbonate(as CaCO3, calculated)	1	mg/L	-	nd	-	nd	-	nd	-
Cation Sum	na	meq/L	-	0.352	-	0.359	-	0.654	-
Chloride	1	mg/L	-	nd	-	nd	-	nd	-
Chromium	0.0005	mg/L	nd	nd	nd	nd	nd	nd	-
Cobalt	0.0002	mg/L	nd	nd	nd	nd	nd	nd	-
Colour	5	TCU	-	32	-	30	-	17	-
Conductivity - @25øC	1	us/cm	-	38	-	39	-	71	-
Copper	0.0003	mg/L	nd	0.0003	0.0003	0.0004	0.0004	nd	-
Dissolved Inorganic Carbon(as C)	0.2	mg/L	1.4	-	1.9	-	2.3	-	-
Dissolved Organic Carbon(DOC)	0.5	mg/L	2.9	-	3.2	-	3.4	-	-
Hardness(as CaCO3)	0.1	mg/L	-	13.6	-	13.7	-	29.8	-
Ion Balance	0.01	%	-	1.3	-	0.45	-	4.72	-
Iron	0.02	mg/L	0.05	0.1	0.07	0.13	0.07	0.14	-
Langelier Index at 20øC	na	na	-	-2.56	-	-2.47	-	-1.64	-
Langelier Index at 4øC	na	na	-	-2.96	-	-2.87	-	-2.04	-
Lead	0.0001	mg/L	nd	nd	nd	0.0003	nd	nd	-
Magnesium	0.1	mg/L	0.9	0.9	0.9	0.9	0.9	0.7	-
Manganese	0.0005	mg/L	0.0025	0.0072	0.0037	0.0238	0.0034	0.0128	-
Mercury (dissolved)	0.0001	mg/L	nd	-	nd	-	nd	-	-
Mercury (total)	0.0005	mg/L	-	nd	-	nd	-	nd	-
Molybdenum	0.0001	mg/L	nd	nd	nd	nd	nd	nd	-
Nickel	0.001	mg/L	nd	nd	nd	nd	nd	nd	-
Nitrate(as N)	0.05	mg/L	-	nd	-	nd	-	nd	-
Nitrite(as N)	0.01	mg/L	-	nd	-	nd	-	nd	-
Orthophosphate(as P)	0.01	mg/L	-	nd	-	nd	-	nd	-
pH	0.1	Units	-	7.1	-	7.2	-	7.3	-
Phosphorus	0.1	mg/L	nd	nd	nd	nd	nd	nd	-
Potassium	0.5	mg/L	0.6	0.5	0.6	0.5	0.8	0.7	-
Reactive Silica(SiO2)	0.5	mg/L	-	6.2	-	6.2	-	4.8	4.8
Saturation pH at 20øC	na	units	-	9.65	-	9.64	-	8.89	-
Saturation pH at 4øC	na	units	-	10	-	10	-	9.29	-
Selenium	0.002	mg/L	nd	nd	nd	nd	nd	nd	-
Silver	0.00005	mg/L	nd	nd	nd	nd	nd	nd	-
Sodium	0.1	mg/L	1.4	1.4	1.5	1.5	1.5	1	-
Strontium	0.005	mg/L	0.009	0.015	0.014	0.016	0.014	0.024	-
Sulphate	2	mg/L	-	nd	-	nd	-	3	-
Thallium	0.0001	mg/L	nd	nd	nd	nd	nd	nd	-
Tin	0.002	mg/L	nd	nd	nd	nd	nd	nd	-
Titanium	0.002	mg/L	nd	nd	nd	nd	nd	nd	-
Total Dissolved Solids(Calculated)	1	mg/L	22	-	25	-	25	-	-
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	-	0.24	-	0.26	-	0.2	-
Total Suspended Solids	1	mg/L	-	nd	-	nd	-	1	-
Turbidity	0.1	NTU	-	0.5	-	0.5	-	0.4	-
Uranium	0.0001	mg/L	nd	nd	nd	nd	nd	nd	-
Vanadium	0.002	mg/L	nd	nd	nd	nd	nd	nd	-
Zinc	0.001	mg/L	0.003	0.016	0.012	0.017	0.018	0.003	-
Fluoride	0.02	mg/L	-	nd	-	nd	-	nd	-

Analysis of Water, Heath Steele, August 1997.

Parameter Date Sampled >	LOQ	Units	HR3A-W Dissolved 97/08/20	HR3B-W- Total 97/08/20	HR3B-W- Total Replicate	HR3B-W Dissolved 97/08/20	HR3B-W Dissolved Replicate
Acidity(as CaCO3)	1	mg/L	-	2	2	-	-
Alkalinity(as CaCO3)	1	mg/L	-	32	31	-	-
Aluminum	0.005	mg/L	0.013	0.059	-	0.013	0.014
Ammonia(as N)	0.05	mg/L	-	nd	nd	-	-
Anion Sum	na	meq/L	-	0.722	-	-	-
Antimony	0.0005	mg/L	nd	nd	-	nd	nd
Arsenic	0.002	mg/L	nd	nd	-	nd	nd
Barium	0.005	mg/L	nd	0.006	-	nd	nd
Beryllium	0.005	mg/L	nd	nd	-	nd	nd
Bicarbonate(as CaCO3, calculated)	1	mg/L	-	32	-	-	-
Bismuth	0.002	mg/L	nd	nd	-	nd	nd
Boron	0.005	mg/L	nd	nd	-	nd	nd
Cadmium	0.00005	mg/L	nd	nd	-	nd	nd
Calcium	0.1	mg/L	10.7	10.9	-	11.4	11.3
Carbonate(as CaCO3, calculated)	1	mg/L	-	nd	-	-	-
Cation Sum	na	meq/L	-	0.68	-	-	-
Chloride	1	mg/L	-	nd	nd	-	-
Chromium	0.0005	mg/L	nd	nd	-	nd	nd
Cobalt	0.0002	mg/L	nd	nd	-	nd	nd
Colour	5	TCU	-	20	19	-	-
Conductivity - @25øC	1	us/cm	-	72	73	-	-
Copper	0.0003	mg/L	nd	nd	-	nd	nd
Dissolved Inorganic Carbon(as C)	0.2	mg/L	5.4	-	-	5	4.9
Dissolved Organic Carbon(DOC)	0.5	mg/L	2.7	-	-	2.7	na
Hardness(as CaCO3)	0.1	mg/L	-	31.5	-	-	-
Ion Balance	0.01	%	-	3	-	-	-
Iron	0.02	mg/L	0.09	0.18	-	0.09	0.08
Langelier Index at 20øC	na	na	-	-1.55	-	-	-
Langelier Index at 4øC	na	na	-	-1.95	-	-	-
Lead	0.0001	mg/L	nd	nd	-	nd	nd
Magnesium	0.1	mg/L	0.8	0.7	-	0.8	0.8
Manganese	0.0005	mg/L	0.0078	0.0165	-	0.0069	0.0069
Mercury (dissolved)	0.0001	mg/L	nd	-	-	nd	nd
Mercury (total)	0.0005	mg/L	-	nd	nd	-	-
Molybdenum	0.0001	mg/L	nd	nd	-	nd	nd
Nickel	0.001	mg/L	nd	nd	-	nd	nd
Nitrate(as N)	0.05	mg/L	-	nd	nd	-	-
Nitrite(as N)	0.01	mg/L	-	nd	nd	-	-
Orthophosphate(as P)	0.01	mg/L	-	nd	nd	-	-
pH	0.1	Units	-	7.3	7.4	-	-
Phosphorus	0.1	mg/L	nd	nd	-	nd	nd
Potassium	0.5	mg/L	0.5	0.8	-	nd	nd
Reactive Silica(SiO2)	0.5	mg/L	-	4.8	-	-	-
Saturation pH at 20øC	na	units	-	8.86	-	-	-
Saturation pH at 4øC	na	units	-	9.26	-	-	-
Selenium	0.002	mg/L	nd	nd	-	nd	nd
Silver	0.00005	mg/L	nd	nd	-	nd	nd
Sodium	0.1	mg/L	1	1	-	1.1	1.1
Strontium	0.005	mg/L	0.022	0.024	-	0.021	0.022
Sulphate	2	mg/L	-	3	3	-	-
Thallium	0.0001	mg/L	nd	nd	-	nd	nd
Tin	0.002	mg/L	nd	nd	-	nd	nd
Titanium	0.002	mg/L	nd	nd	-	nd	nd
Total Dissolved Solids(Calculated)	1	mg/L	41	-	-	41	-
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	-	0.23	-	-	-
Total Suspended Solids	1	mg/L	-	2	na	-	-
Turbidity	0.1	NTU	-	45	44	-	-
Uranium	0.0001	mg/L	nd	nd	-	nd	nd
Vanadium	0.002	mg/L	nd	nd	-	nd	nd
Zinc	0.001	mg/L	nd	0.004	-	nd	nd
Fluoride	0.02	mg/L	-	nd	nd	-	-

beak international incorporated

14 Abacus Road
Brampton,Ontario
Canada L6T 5B7

Tel (905) 794-2325
Fax (905) 794-2338
1-800-361-BEAK (2325)

QUALITY ASSURANCE INFORMATION

Ceriodaphnia Survival and Reproduction Test

Test Conditons

Test Type:	Static renewal
Test Temperature:	25±1°C
Lighting:	16 hours light/8 hours dark, < 600 lux
Dilution Water:	3/4 Reconstituted Water + 1/4 Dechlorinated Tap
Test Volume:	15ml per replicate, 10 replicates per concentration
Test Vessels:	25 ml disposable plastic containers
Test Organism:	*Ceriodaphnia dubia*
Organism Age:	< 24 hours, within 8 hours of each other
Organism Health:	no ephippia detected in culture, mortality in culture <20%

Protocol

Environment Canada. 1992. Biological Test Method: Test of Reproduction and Survival Using the Cladoceran *Ceriodaphnia dubia* . EPS 1/RM/21.

Reference Toxicant Test # 9700562-0:

Chemical Used:	Sodium Chloride
Date of Test:	21-Jun-97
7-Day LC50:	2630 mg/L
Historical Warning Limits (LC50):	1180 - 2530
Historical Control Limits (LC50):	844 - 2870
7-Day IC50:	1700 mg/L
Historical Warning Limits (IC50):	1170 - 1980
Historical Control Limits (IC50):	963 - 2180

Reference tests assess, under standardized conditions, the relative sensitivity of the culture and the precision and reliability of the data produced by the laboratory for that reference toxicant (Environment Canada, 1992). BEAK conducts a reference test using sodium chloride at least once per month and assesses the acceptability of the test results based on historical data, which are regularly updated on control charts.

Reference Test Commments:

The IC50, which estimates survival and reproduction effects, is within the established historical limits; however, the LC50 value, which measures survival alone, is above the historical warning limit. This may occur due to chance alone, once every 20 tests or may indicate a problem with the test system. An investigation revealed no anomalies in test system, cultures or technical performance and limits were recalculated using the latest data.

All reported data were cross-checked for errors and omissions.

Instruments used to monitor chemical and physical parameters were calibrated daily.

Acronyms

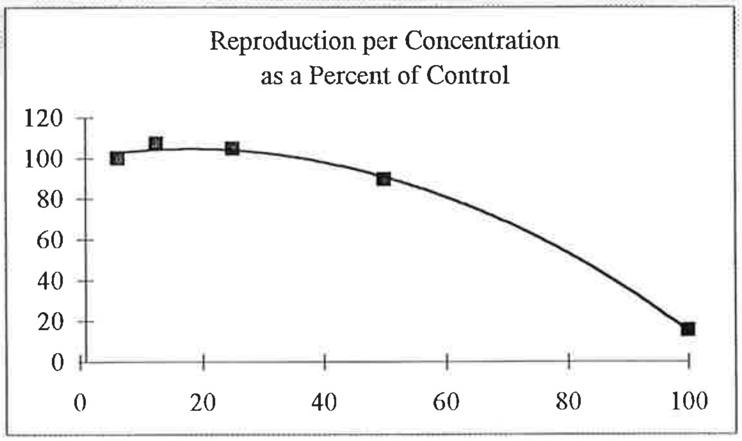
LC50	median lethal concentration (concentration that causes mortality in 50% of the test organisms)
NOEC	no observable effect concentration (highest concentration tested that exhibits no observable effect)
LOEC	lowest observable effect concentration (lowest concentration at which there is an observable effect)
IC25	inhibiton concentration (concentration at which response is impaired by 25%)
IC50	inhibiton concentration (concentration at which response is impaired by 50%)
na	not applicable (when applied to the LOEC, means that no concentration tested exhibited an observable effect).
MSD	minimum significant difference (difference between groups that is necessary to conclude that that they are significantly different).

Ceriodaphnia dubia Survival and Reproduction Test

Biological Test Method EPS 1/RM/21

Client: Heath Steele
Newcastle, New Brunswick

Sample: HS-R-S (H-E-1)
Sample Type: effluent
Test No.: 9700609-3
Date Sampled: 24-Jun-97
Date Initiated: 25-Jun-97
Time Initiated: 17:15
Initiated by: E. Jonczyk


Reproduction per Concentration as a Percent of Control

TEST DATA **Total Number of Neonates Produced per Adult After 6 Days of Testing**

	concentration (% v/v)					
replicate	0	6.25	12.5	25	50	100
1	32	33	32	27	14	8
2	30	26	22	31	18	15
3	20	21	25	28	21	0
4	19	20	22	23	19	3
5	21	27	24	29	24	11
6	16	18	26	24	25	0
7	24	28	27	13	24	0
8	24	30	32	31	25	0
9	28	13	22	23	22	0
10	28	26	27	24	25	0
mean / conc.	24.2	24.2	25.9	25.3	21.7	3.7
mortality / 10 adults	0	0	0	0	0	6

Sample Appearance: cloudy, yellow colour

Initial Parameters:

DO (mg/L)	8.7	Conductivity (µmhos/cm)	52.4	Temperature (°C)	25.6	pH	7.61	Hardness (mg/L)	20	Alkalinity (mg/L)	30

Sample treatments: Sample was preaerated 20 minutes on Days 0 and 1 prior to dilution.

TEST RESULTS

	%v/v	95% CI	Method of Calculation	Notes
IC25	58.4	48.7-63.7	Linear Interpolation,	
IC50	75.7	69.7-82.3	(Norberg-King, 1993)	
LC50	91.6	50 -infinity	Binomial	

QUALITY ASSURANCE INFORMATION & COMMENTS

Associated QA/QC test: 9700562-0

Reported by:

Date: Jan. 15/98

beak international incorporated

14 Abacus Road
Brampton,Ontario
Canada L6T 5B7

Tel (905) 794-2325
Fax (905) 794-2338
1-800-361-BEAK (2325)

QUALITY ASSURANCE INFORMATION:

7-Day Fathead Minnow Survival and Growth Test

Test Conditons

Test Type:	Static renewal
Test Temperature:	25±1°C
Lighting:	16 hours light/8 hours dark, < 500 lux
Dilution Water:	3/4 Reconstituted Water + 1/4 Dechlorinated Tap
Test Volume:	500 ml per replicate, 2000 ml per concentration
Test Vessels:	500 ml disposable plastic containers
Test Organism:	*Pimephales promelas,*
Organism Source:	Aquatic Research Organisms, New Hampshire
Organism Age:	< 24 hours

Protocol

Environment Canada. 1992. Biological Test Method: Test of Larval Growth and Survival Using Fathead Minnows . Report EPS 1/RM/22.

Reference Toxicant Test # 9700599-0

Chemical Used:	Potassium Chloride
Date of Test:	21-Jun-97
7-Day LC50:	964 mg/L
Historical Warning Limits (LC50):	785 - 1050
Historical Control Limits (LC50):	720 - 1113
IC50:	1610 mg/L
Historical Warning Limits (IC50):	672 - 1600
Historical Control Limits (IC50):	440 - 1830

Reference tests assess, under standardized conditions, the relative sensitivity of the culture and the precision and reliability of the data produced by the laboratory for that reference toxicant (Environment Canada, 1992). BEAK conducts a reference test using potassium chloride at least once per month and assesses the acceptability of the test results based on historical data, updated regularly on control charts.

Reference Test Comments:

The reference toxicant test results show that test reproducibility and sensitivity are within established control and warning limits (± 1%).
All reported data were cross-checked for errors and omissions.
Instruments used to monitor chemical and physical parameters were calibrated daily.

Acronyms

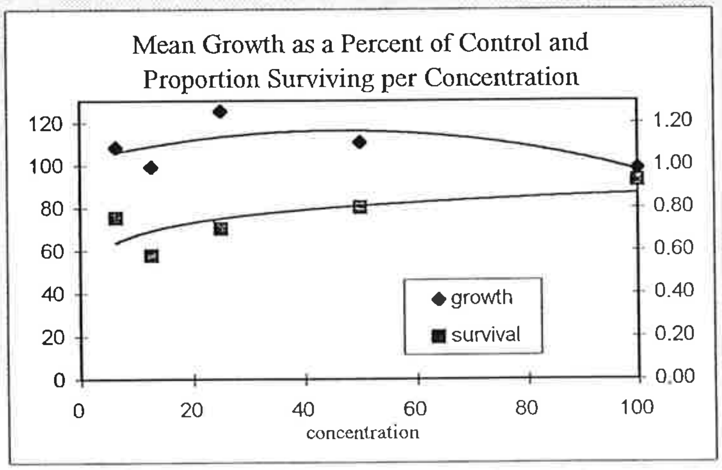
LC50	median lethal concentration (concentration that causes mortality in 50% of the test organisms)
NOEC	no observable effect concentration (highest concentration tested that exhibits no observable effect)
LOEC	lowest observable effect concentration (lowest concentration at which there is an observable effect)
IC25	inhibiton concentration (concentration at which response is impaired by 25%)
IC50	inhibiton concentration (concentration at which response is impaired by 50%)
na	not applicable (when applied to the LOEC, means that no concentration tested exhibited an observable effect).
MSD	minimum significant difference (difference between groups that is necessary to conclude that that they are significantly different.

Fathead Minnow Survival and Growth Test

Biological Test Method EPS 1/RM/22

Client: Heath Steele
Newcastle, New Brunswick

Sample: HS-R-S (H-E-1)
Sample Type: effluent
Test No.: 9700609-4
Date Sampled: 24-Jun-97
Date Initiated: 26-Jun-97
Time Initiated: 14:00
Initiated by: E. Jonczyk


Mean Growth as a Percent of Control and Proportion Surviving per Concentration

TEST DATA

Mean Fish Weight per Replicate (mg)

	concentration (% v/v)					
replicate	0	6.25	12.5	25	50	100
1	0.873	0.729	0.630	0.970	0.787	0.750
2	0.520	0.888	0.723	0.747	0.779	0.734
3	0.746	0.695	0.678	1.030	0.811	0.598
4	0.801	0.873	0.876	0.938	0.875	0.807
mean / conc.	0.735	0.796	0.727	0.921	0.813	0.722

Survival per Replicate (total exposed per concentration = 40)

	concentration (% v/v)					
replicate	0	6.25	12.5	25	50	100
1	9	9	4	8	9	10
2	8	6	4	10	8	10
3	8	8	6	5	9	8
4	10	7	9	5	6	9
total survival	35	30	23	28	32	37
proportion	0.88	0.75	0.58	0.70	0.80	0.93

Sample Appearance: clear, yellow colour

Initial Parameters:

DO (mg/L) 8.7	Conductivity (µmhos/cm) 78.4	Temperature (°C) 24.3	pH 7.28	Hardness (mg/L) 20	Alkalinity (mg/L) 30

Sample treatments: Sample was preaerated for 20 minutes on Day 0 prior to dilution.

TEST RESULTS

	% v/v	95% CI	Method of Calculation	MSD (%)	Notes
IC25	>100	na	Linear Interpolation, (Norberg-King, 1993)	na	Growth effects endpoint, surviving fish only.
IC50	>100	na			
LC50	>100	na	na		

QUALITY ASSURANCE / COMMENTS

Associated QA/QC test: 9700599-0

Analysis by Dunnett's Test found survival in 12.5% to be significantly different from the control.

Data analysis performed in accordance with EPS 1/RM/22 amendments November 1997.

Reported by:

Date: Jan. 15/98

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14 Abacus Road
Brampton,Ontario
Canada L6T 5B7

Tel (905) 794-2325
Fax (905) 794-2338
1-800-361-BEAK (2325)

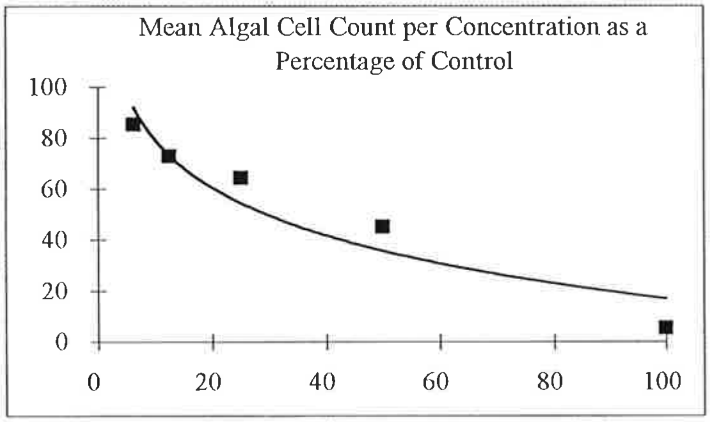
Algal Growth Inhibition Test

Biological Test Method EPS 1/RM/25

Client: Beak

Sample: $ZnSO_4$

Sample No.:	9700620-0	**Date Initiated:**	27-Jun-97
Date Sampled:	na	**Time Initiated:**	14:10
Time Sampled:	na	**Initiated by:**	R. Dorosz



TEST DATA

Mean Algal Cell Count (cells/ml = cell count x 10,000)

	concentration (% v/v)					
replicate	0	6.25	12.5	25	50	100
1	116	106	83	78	52	4
2	121	106	93	80	57	1
3	136	111	93	80	60	6
4	134	106	98	85	62	11
5	121	106	90	80	52	11
mean / conc.	125.6	107.0	91.4	80.6	56.6	6.6

TEST RESULTS

	% v/v	95% CI	Method of Calculation	MSD (%)	Notes
NOEC	0	na	Dunnett's	6	
LOEC	6.25	na			
TEC	<6.25	na			
IC25	11.4	7.97 - 18.4	Linear Interpolation, (Norberg-King, 1993)	na	
IC50	43.6	37.6 - 51.3			

QUALITY ASSURANCE / COMMENTS

t-test showed that growth in controls was significantly higher (11%) than in the QA/QC plate.
CV of control group = 15%

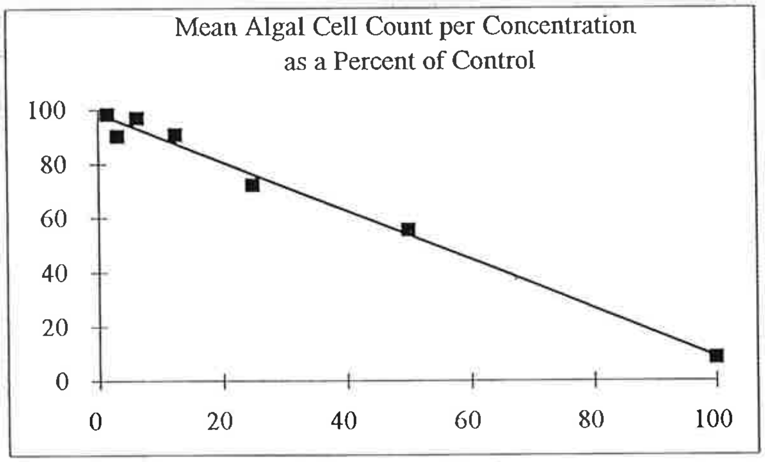
Reported by:

Date: Jan. 15/98

Algal Growth Inhibition Test

Biological Test Method EPS 1/RM/25

Client:	Heath Steele Newcastle, New Brunswick		
Sample:	HS-R-B (H-E-1)		
Sample No.:	9700609-5	**Date Initiated:**	27-Jun-97
Date Sampled:	24-Jun-97	**Time Initiated:**	11:10
		Initiated by:	R. Dorosz


Mean Algal Cell Count per Concentration as a Percent of Control

TEST DATA

Mean Algal Cell Count Determined Via Absorbance (cells/ml = cell count x 10,000)

	concentration (% v/v)							
rep	0	1.56	3.13	6.25	12.5	25	50	100
1	141	125	136	133	128	103	74	13
2	141	151	125	125	118	103	77	13
3	136	143	123	136	133	92	77	8
4	131	118	110	136	118	97	74	11
mean/ conc.	137.0	134.4	123.6	132.5	124.2	98.7	75.7	11.3

TEST RESULTS

	% v/v	95% CI	Method of Calculation	Notes
IC25	23.0	17.9 - 26.0	Linear Interpolation, (Norberg-King, 1993)	
IC50	55.6	52.3 - 57.7		

QUALITY ASSURANCE / COMMENTS

Associated QA/QC test: 9700620-0

t-Test showed no significant difference between growth of controls and growth in the qa/qc plate.

CV of vertical control group = 15%, CV of all controls = 17%

Reported by:

Date: Jan. 15/98

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14 Abacus Road
Brampton,Ontario
Canada L6T 5B7

Tel (905) 794-2325
Fax (905) 794-2338
1-800-361-BEAK (2325)

QUALITY ASSURANCE INFORMATION

***Ceriodaphnia* Survival and Reproduction Test**

Test Conditons

Test Type:	Static renewal
Test Temperature:	25±1°C
Lighting:	16 hours light/8 hours dark, < 600 lux
Dilution Water:	3/4 Reconstituted Water + 1/4 Dechlorinated Tap
Test Volume:	15ml per replicate, 10 replicates per concentration
Test Vessels:	25 ml disposable plastic containers
Test Organism:	*Ceriodaphnia dubia*
Organism Age:	< 24 hours, within 8 hours of each other
Organism Health:	no ephippia detected in culture, mortality in culture <20%

Protocol

Environment Canada. 1992. Biological Test Method: Test of Reproduction and Survival Using the Cladoceran *Ceriodaphnia dubia*. EPS 1/RM/21.

Reference Toxicant Test # 9700810-0

Chemical Used:	Sodium Chloride
Date of Test:	8-Sep-97
7-Day LC50:	1770 mg/L
Historical Warning Limits (LC50):	1170 - 2540
Historical Control Limits (LC50):	825 - 2880
7-Day IC50:	1210 mg/L
Historical Warning Limits (IC50):	1120 - 1960
Historical Control Limits (IC50):	906 - 2170

Reference tests assess, under standardized conditions, the relative sensitivity of the culture and the precision and reliability of the data produced by the laboratory for that reference toxicant (Environment Canada, 1992). BEAK conducts a reference test using sodium chloride at least once per month and assesses the acceptability of the test results based on historical data, which are regularly updated on control charts.

Reference Test Commments:

The reference toxicant test results show that test reproducibility and sensitivity are within established limits.
All reported data were cross-checked for errors and omissions.
Instruments used to monitor chemical and physical parameters were calibrated daily.

Acronyms

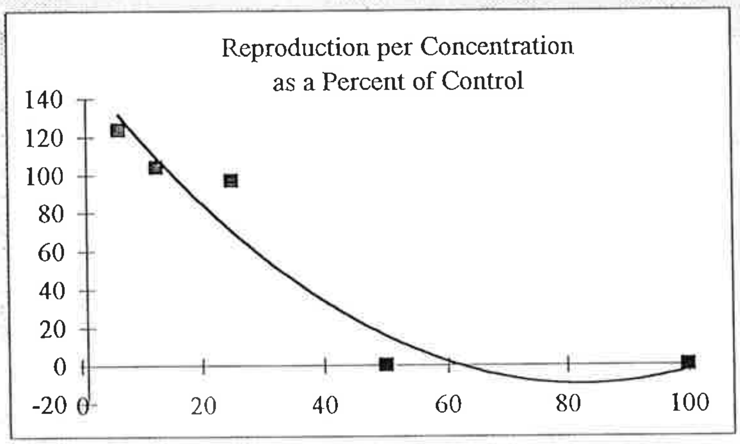
LC50	median lethal concentration (concentration that causes mortality in 50% of the test organisms)
NOEC	no observable effect concentration (highest concentration tested that exhibits no observable effect)
LOEC	lowest observable effect concentration (lowest concentration at which there is an observable effect)
IC25	inhibiton concentration (concentration at which response is impaired by 25%)
IC50	inhibiton concentration (concentration at which response is impaired by 50%)
na	not applicable (when applied to the LOEC, means that no concentration tested exhibited an observable effect).
MSD	minimum significant difference (difference between groups that is necessary to conclude that that they are significantly different).

Ceriodaphnia dubia Survival and Reproduction Test

Biological Test Method EPS 1/RM/21

Client: Heath Steele
Newcastle, New Brunswick

Sample: HS-R-S (H-E-2)
Sample Type: effluent
Test No.: 9700822-3 **Date Initiated:** 29-Aug-97
Date Sampled: 28-Aug-97 **Time Initiated:** 14:45
Initiated by: E. Jonczyk



TEST DATA **Total Number of Neonates Produced per Adult After 8 Days of Testing**

	concentration (% v/v)					
replicate	0	6.25	12.5	25	50	100
1	18	26	28	21	0	0
2	19	23	24	23	0	0
3	20	34	22	27	0	0
4	24	14	26	18	1	0
5	15	18	30	30	0	0
6	15	28	0	25	0	0
7	33	33	24	18	0	0
8	21	32	33	19	0	0
9	27	38	24	16	0	0
10	33	32	23	21	0	0
mean / conc.	22.5	27.8	23.4	21.8	0.1	0.0
mortality / 10 adults	1	0	1	2	10	10

Sample Appearance: clear, yellow

Initial Parameters:

DO (mg/L)	9.2	Conductivity (µmhos/cm)	65.1	Temperature (°C)	24.9	pH	7.13	Hardness (mg/L)	20	Alkalinity (mg/L)	25

Sample treatments: Sample was preaerated for 20 minutes on days 0 and 1 prior to dilution.

TEST RESULTS

	%v/v	95% CI	Method of Calculation	Notes
IC25	28.4	21.8-30.9	Linear Interpolation,	
IC50	35.6	32.8-37.5	(Norberg-King, 1993)	
LC50	33.0	28.9-37.6	Spearman - Karber	

QUALITY ASSURANCE INFORMATION & COMMENTS

Associated QA/QC test: 9700810

Reported by:

Date: Jan. 15/98

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14 Abacus Road
Brampton,Ontario
Canada L6T 5B7

Tel (905) 794-2325
Fax (905) 794-2338
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QUALITY ASSURANCE INFORMATION:

7-Day Fathead Minnow Survival and Growth Test

Test Conditons

Test Type:	Static renewal
Test Temperature:	25±1°C
Lighting:	16 hours light/8 hours dark, < 500 lux
Dilution Water:	3/4 Reconstituted Water + 1/4 Dechlorinated Tap
Test Volume:	500 ml per replicate, 2000 ml per concentration
Test Vessels:	500 ml disposable plastic containers
Test Organism:	*Pimephales promelas,*
Organism Source:	In House Culture
Organism Age:	< 24 hours

Protocol

Environment Canada. 1992. Biological Test Method: Test of Larval Growth and Survival Using Fathead Minnows . Report EPS 1/RM/22.

Reference Toxicant Test # 9700740-0

Chemical Used:	Potassium Chloride
Date of Test:	11-Aug-97
7-Day LC50:	868 mg/L
Historical Warning Limits (LC50):	771 - 1030
Historical Control Limits (LC50):	707 - 1090
IC50:	1100 mg/L
Historical Warning Limits (IC50):	705 - 1490
Historical Control Limits (IC50):	510 - 1680

Reference tests assess, under standardized conditions, the relative sensitivity of the culture and the precision and reliability of the data produced by the laboratory for that reference toxicant (Environment Canada, 1992). BEAK conducts a reference test using potassium chloride at least once per month and assesses the acceptability of the test results based on historical data, updated regularly on control charts.

Reference Test Comments:

The reference toxicant test results show that test reproducibility and sensitivity are within established control and warning limits.

All reported data were cross-checked for errors and omissions.

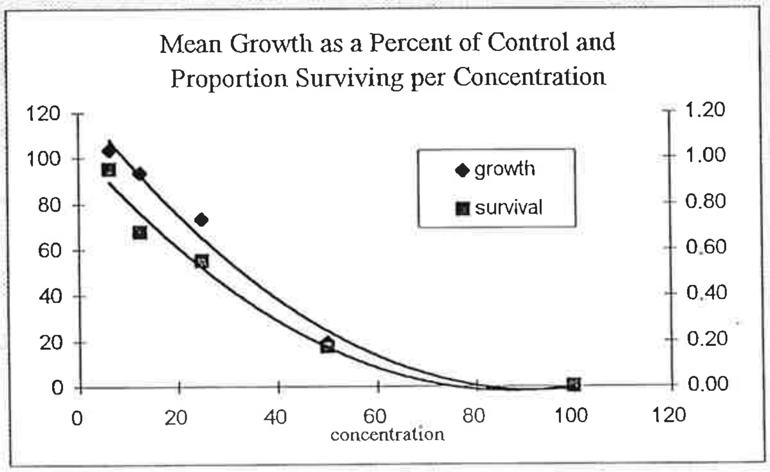
Instruments used to monitor chemical and physical parameters were calibrated daily.

Acronyms

LC50	median lethal concentration (concentration that causes mortality in 50% of the test organisms)
NOEC	no observable effect concentration (highest concentration tested that exhibits no observable effect)
LOEC	lowest observable effect concentration (lowest concentration at which there is an observable effect)
IC25	inhibiton concentration (concentration at which response is impaired by 25%)
IC50	inhibiton concentration (concentration at which response is impaired by 50%)
na	not applicable (when applied to the LOEC, means that no concentration tested exhibited an observable effect).
MSD	minimum significant difference (difference between groups that is necessary to conclude that that they are significantly different.

Fathead Minnow Survival and Growth Test
Biological Test Method EPS 1/RM/22

Client:	Heath Steele Newcastle, New Brunswick		
Sample:	HS-S-S (H-E-2)		
Sample Type:	effluent		
Test No.:	9700822-6	**Date Initiated:**	29-Aug-97
Date Sampled:	28-Aug-97	**Time Initiated:**	14:00
		Initiated by:	P. Trainor



TEST DATA
Mean Fish Weight per Replicate (mg)

	concentration (% v/v)					
replicate	0	6.25	12.5	25	50	100
1	0.669	0.669	0.586	0.420	0.000	0.000
2	0.604	0.663	0.654	0.403	0.247	0.000
3	0.658	0.672	0.534	0.604	0.000	0.000
4	0.644	0.661	0.629	0.456	0.248	0.000
mean / conc.	0.644	0.666	0.601	0.471	0.124	0.000

Survival per Replicate (total exposed per concentration = 40)

	concentration (% v/v)					
replicate	0	6.25	12.5	25	50	100
1	10	9	5	7	0	0
2	10	9	7	3	3	0
3	10	10	5	5	0	0
4	10	10	10	7	4	0
total survival	40	38	27	22	7	0
proportion	1.00	0.95	0.68	0.55	0.18	0.00

Sample Appearance: clear, yellow colour

Initial Parameters:

DO (mg/L)	9.2	Conductivity (μmhos/cm)	65.1	Temperature (°C)	24.9	pH	7.13	Hardness (mg/L)	20	Alkalinity (mg/L)	25

Sample treatments: Sample was preaerated prior to dilution on Day 0 of testing.

TEST RESULTS

	% v/v	95% CI	Method of Calculation	Notes
IC25	23.0	16.3-34.4	Linear Interpolation, (Norberg-King, 1993)	Growth effects endpoint, surviving fish only.
IC50	41.0	35.7-45.0		
LC50	22.2	18.5-26.6	Probit	

QUALITY ASSURANCE / COMMENTS

Associated QA/QC test: 9700740

All fathead minnow tests initiated with receiving water for the dilution water resulted in >50% control mortality within 3 days of exposure.

The above test was conducted using effluent and laboratory reconstituted water, adjusted to match the hardness, pH and alkalinity of the H-D water.

Data analysis performed in accordance with EPS 1/RM/22 amendments November 1997.

Reported by: Date: Jan 15/98

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14 Abacus Road
Brampton,Ontario
Canada L6T 5B7

Tel (905) 794-2325
Fax (905) 794-2338
1-800-361-BEAK (2325)

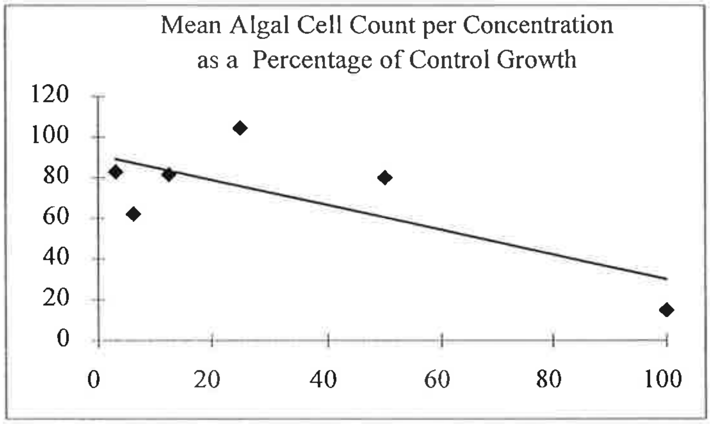
Algal Growth Inhibition Test

Biological Test Method EPS 1/RM/25

Client: Beak

Sample: $ZnSO_4$

Sample No.:	9700809-0	**Date Initiated:**	22-Aug-97
Date Sampled:	na	**Time Initiated:**	16:00
Time Sampled:	na	**Initiated by:**	R. Dorosz



TEST DATA

Mean Algal Cell Count (cells/ml = cell count x 10,000)

	concentration (µg/L)						
replicate	0	3.13	6.25	12.5	25	50	100
1	88	70	55	81	102	74	12
2	99	74	59	74	99	81	12
3	95	84	59	81	110	81	16
4	106	95	74	88	106	88	19
5	117	95	66	88	110	81	16
mean / conc.	101.0	83.7	62.7	82.2	105.3	80.8	15.0

TEST RESULTS

	µg/L	95% CI	Method of Calculation	MSD (%)	Notes
NOEC	<3.13	na	William's test	na	
LOEC	3.13	na			
TEC	<3.13	na			
IC25	53.8	11.8 - 61.8	Linear Interpolation, (Norberg-King, 1993)	na	
IC50	73.0	67.0 - 77.5			

QUALITY ASSURANCE / COMMENTS

Growth in the QA/QC plate was found to be significantly lower (9%) than in the control.
CV of control group = 11%

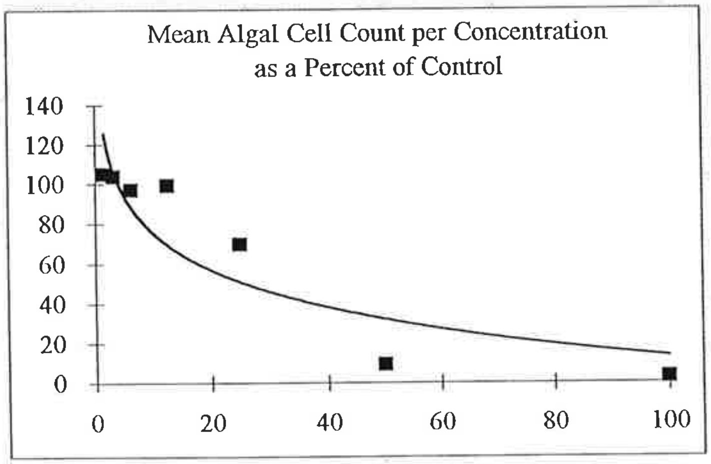
Reported by:

Date: Jan. 15/98

Algal Growth Inhibition Test

Biological Test Method EPS 1/RM/25

Client:	Heath Steel Newcastle, New Brunswick		
Sample:	HS-R-B (H-E-2)		
Sample No.:	9700822-4	**Date Initiated:**	29-Aug-97
Date Sampled:	28-Aug-97	**Time Initiated:**	12:10
		Initiated by:	R. Dorosz



TEST DATA

Mean Algal Cell Count Determined Via Absorbance
(cells/ml = cell count x 10,000)

replicate	0	1.56	3.13	6.25	12.5	25	50	100
1	136	133	136	133	121	88	10	3.9
2	148	148	148	148	139	94	10	3.9
3	160	178	163	157	169	118	22	3.9
4	157	172	175	145	166	118	13	3.9
mean/ conc.	150	158	156	146	149	104	13.7	3.9

TEST RESULTS

	% v/v	95% CI	Method of Calculation	Notes
IC25	21.7	14.6-27.5	Linear Interpolation, (Norberg-King, 1993)	
IC50	32.5	27.1-36.1		

QUALITY ASSURANCE / COMMENTS

QA/QC test = 9700809
CV of vertical control group = 7%
CV of all control wells = 9%

Reported by:

Date: Jan. 15/98

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14 Abacus Road
Brampton,Ontario
Canada L6T 5B7

Tel (905) 794-2325
Fax (905) 794-2338
1-800-361-BEAK (2325)

QUALITY ASSURANCE INFORMATION

Ceriodaphnia Survival and Reproduction Test

Test Conditons

Test Type:	Static renewal
Test Temperature:	25±1°C
Lighting:	16 hours light/8 hours dark, < 600 lux
Dilution Water:	3/4 Reconstituted Water + 1/4 Dechlorinated Tap
Test Volume:	15ml per replicate, 10 replicates per concentration
Test Vessels:	25 ml disposable plastic containers
Test Organism:	*Ceriodaphnia dubia*
Organism Age:	< 24 hours, within 8 hours of each other
Organism Health:	no ephippia detected in culture, mortality in culture <20%

Protocol

Environment Canada. 1992. Biological Test Method: Test of Reproduction and Survival Using the Cladoceran *Ceriodaphnia dubia*. EPS 1/RM/21.

Reference Toxicant Test # 9701016-0

Chemical Used:	Sodium Chloride
Date of Test:	17-Oct-97
7-Day LC50:	2360 mg/L
Historical Warning Limits (LC50):	1150 - 2590
Historical Control Limits (LC50):	792 - 2940
8-Day IC50:	1390 mg/L
Historical Warning Limits (IC50):	1100 - 1940
Historical Control Limits (IC50):	896 - 2150

Reference tests assess, under standardized conditions, the relative sensitivity of the culture and the precision and reliability of the data produced by the laboratory for that reference toxicant (Environment Canada, 1992). BEAK conducts a reference test using sodium chloride at least once per month and assesses the acceptability of the test results based on historical data, which are regularly updated on control charts.

Reference Test Commments:

The reference toxicant test results show that test reproducibility and sensitivity are within established limits.
All reported data were cross-checked for errors and omissions.
Instruments used to monitor chemical and physical parameters were calibrated daily.

Acronyms

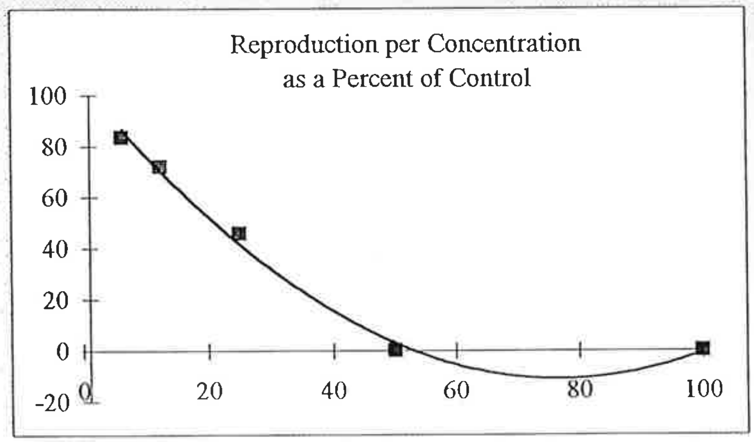
LC50	median lethal concentration (concentration that causes mortality in 50% of the test organisms)
NOEC	no observable effect concentration (highest concentration tested that exhibits no observable effect)
LOEC	lowest observable effect concentration (lowest concentration at which there is an observable effect)
IC25	inhibiton concentration (concentration at which response is impaired by 25%)
IC50	inhibiton concentration (concentration at which response is impaired by 50%)
na	not applicable (when applied to the LOEC, means that no concentration tested exhibited an observable effect).
MSD	minimum significant difference (difference between groups that is necessary to conclude that that they are significantly different).

Ceriodaphnia dubia Survival and Reproduction Test

Biological Test Method EPS 1/RM/21

Client: Heath Steele
Newcastle, New Brunswick

Sample: HS-R-S (H-E-3)
Sample Type: effluent
Test No.: 9701213-3
Date Sampled: 12-Nov-97
Date Initiated: 13-Nov-97
Time Initiated: 16:50
Initiated by: E. Jonczyk


Reproduction per Concentration as a Percent of Control

TEST DATA **Total Number of Neonates Produced per Adult After 7 Days of Testing**

	concentration (% v/v)					
replicate	0	6.25	12.5	25	50	100
1	27	37	16	11	0	0
2	19	36	5	1	0	0
3	30	31	32	27	0	0
4	33	26	27	18	0	0
5	35	22	28	0	0	0
6	35	17	34	22	0	0
7	29	11	35	24	0	0
8	39	24	23	14	0	0
9	32	17	21	24	0	0
10	29	36	1	0	3	0
mean / conc.	30.8	25.7	22.2	14.1	0.3	0.0
mortality / 10 adults	0	1	3	5	10	10

Sample Appearance: clear, yellow

Initial Parameters:

DO (mg/L)	9.1	Conductivity (µmhos/cm)	75	Temperature (°C)	24.5	pH	7.38	Hardness (mg/L)	20	Alkalinity (mg/L)	20

Sample treatments: Sample was preaerated for 20 minutes prior to dilution on each day of testing.

TEST RESULTS

	%v/v	95% CI	Method of Calculation	Notes
IC25	10.9	4.82-18.5	Linear Interpolation,	
IC50	23.0	12.7-31.3	(Norberg-King, 1993)	
LC50	18.6	12.6-27.7	Probit	

QUALITY ASSURANCE INFORMATION & COMMENTS

Associated QA/QC test: 9701016

Reported by:

Date: Jan. 15/98

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14 Abacus Road
Brampton,Ontario
Canada L6T 5B7

Tel (905) 794-2325
Fax (905) 794-2338
1-800-361-BEAK (2325)

QUALITY ASSURANCE INFORMATION:

7-Day Fathead Minnow Survival and Growth Test

Test Conditons

Test Type:	Static renewal
Test Temperature:	25±1°C
Lighting:	16 hours light/8 hours dark, < 500 lux
Dilution Water:	3/4 Reconstituted Water + 1/4 Dechlorinated Tap
Test Volume:	300 ml per replicate
Test Vessels:	420 ml disposable plastic containers
Test Organism:	*Pimephales promelas,*
Organism Source:	In House Culture
Organism Age:	< 24 hours

Protocol

Environment Canada. 1992. Biological Test Method: Test of Larval Growth and Survival Using Fathead Minnows . Report EPS 1/RM/22.

Reference Toxicant Test # 9701096-0

Chemical Used:	Potassium Chloride
Date of Test:	6-Nov-97
7-Day LC50:	884 mg/L
Historical Warning Limits (LC50):	772 - 1020
Historical Control Limits (LC50):	710 - 1080
IC50:	923 mg/L
Historical Warning Limits (IC50):	681 - 1480
Historical Control Limits (IC50):	481 - 1680

Reference tests assess, under standardized conditions, the relative sensitivity of the culture and the precision and reliability of the data produced by the laboratory for that reference toxicant (Environment Canada, 1992). BEAK conducts a reference test using potassium chloride at least once per month and assesses the acceptability of the test results based on historical data, updated regularly on control charts.

Reference Test Comments:

The reference toxicant test results show that test reproducibility and sensitivity are within established control and warning limits.
All reported data were cross-checked for errors and omissions.
Instruments used to monitor chemical and physical parameters were calibrated daily.

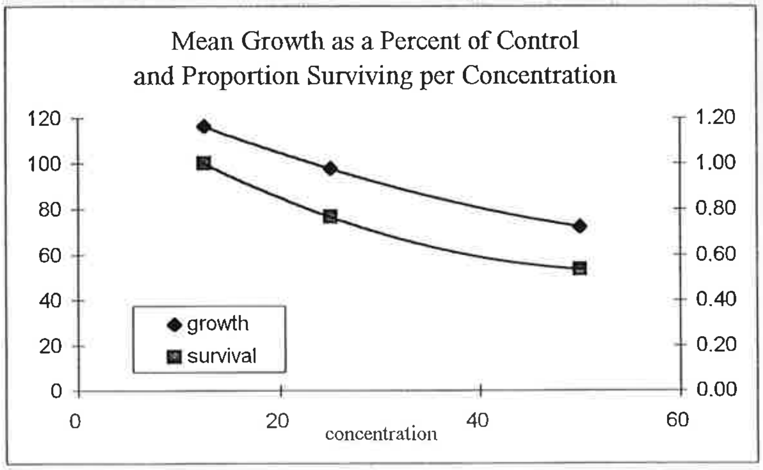
Acronyms

LC50	median lethal concentration (concentration that causes mortality in 50% of the test organisms)
NOEC	no observable effect concentration (highest concentration tested that exhibits no observable effect)
LOEC	lowest observable effect concentration (lowest concentration at which there is an observable effect)
IC25	inhibiton concentration (concentration at which response is impaired by 25%)
IC50	inhibiton concentration (concentration at which response is impaired by 50%)
na	not applicable
MSD	minimum significant difference (difference between groups that is necessary to conclude that that they are significantly different.

Fathead Minnow Survival and Growth Test

Biological Test Method EPS 1/RM/22

Client:	Heath Steele Newcastle, New Brunswick		
Sample:	HS-S-S (H-E-3)		
Sample Type:	effluent		
Test No.:	9701213-4	**Date Initiated:**	15-Nov-97
Date Sampled:	12-Nov-97	**Time Initiated:**	17:00
		Initiated by:	P. Trainor



Mean Growth as a Percent of Control and Proportion Surviving per Concentration

TEST DATA

Mean Fish Weight per Replicate (mg)

	concentration (% v/v)			
replicate	0	12.5	25	50
1	0.639	0.691	0.619	0.367
2	0.620	0.691	0.646	0.480
3	0.577	0.753	0.529	0.480
mean / conc.	0.612	0.712	0.598	0.442

Survival per Replicate (total exposed per concentration = 30)

	concentration (% v/v)			
replicate	0	12.5	25	50
1	10	10	8	6
2	10	10	8	5
3	10	10	7	5
total survival	30	30	23	16
proportion	1.00	1.00	0.77	0.53

Sample Appearance: clear, yellow colour

Initial Parameters:

DO (mg/L)	Conductivity (µmhos/cm)	Temperature (°C)	pH	Hardness (mg/L)	Alkalinity (mg/L)
10.2	70	25.1	7.32	20	20

Sample treatments: Sample was preaerated prior to dilution on each day of testing.

TEST RESULTS

	% v/v	95% CI	Method of Calculation	Notes
IC25	41.3	not calculable	Linear Interpolation, (Norberg-King, 1993)	Growth effects endpoint,
IC50	>50	na		surviving fish only.
LC50	44.0	36.9-51.4	Moving Average	

QUALITY ASSURANCE / COMMENTS

Associated QA/QC test: 9701096

All fathead minnow tests initiated with receiving water for the dilution water resulted in >50% control mortality within 3 days of exposure.

The above test was conducted using effluent and laboratory reconstituted water, adjusted to match the hardness, pH and alkalinity of the H-D water.

Data analysis performed in accordance with EPS 1/RM/22 amendments November 1997.

Reported by:

Date: Jan. 15/98

beak
international
incorporated

14 Abacus Road
Brampton,Ontario
Canada L6T 5B7

Tel (905) 794-2325
Fax (905) 794-2338
1-800-361-BEAK (2325)

QUALITY ASSURANCE INFORMATION:

72hr. Algal Growth Inhibition Test

Test Conditons

Test Temperature:	25±1°C
Lighting (lux intensity):	4000±10%
Dilution Water:	Filtered algal medium
Test Volume:	220 µL
Test Organism:	*Selenastrum capricornutum*
Organism Source:	In House Culture
Organism Age:	4-7 days (in exponential growth)
Initial Algal Innoculum:	10 000 cells/mL

Protocol

Environment Canada. 1992. Biological Test Method: Growth Inhibition Test Using the Freshwater Alga *Selenastrum capricornutum*. EPS 1/RM/21
BEAK Reference: SOP SE - 2

Reference Toxicant Test # 9701248-0

Chemical Used:	Zinc Sulfate
Date of Test:	14-Nov-97
IC25:	22.7 µL/L
Historical Warning Limits (IC25):	4.9 - 53.8
Historical Control Limits (IC25):	-7.4 - 66.1
IC50:	63.0 µL/L
Historical Warning Limits (IC50):	24.0 - 77.8
Historical Control Limits (IC50):	10.5 - 91.3

Reference tests assess, under standardized conditions, the relative sensitivity of the culture and the precision and reliability of the data produced by the laboratory for that reference toxicant (Environment Canada, 1992). BEAK conducts a reference test using zinc sulfate at least once per month and assesses the acceptability of the test results based on historical data, updated regularly on control charts.

Reference Test Comments:

The reference toxicant test results show that test reproducibility and sensitivity are within established control and warning limits.
All reported data were cross-checked for errors and omissions.
Instruments used to monitor chemical and physical parameters were calibrated daily.

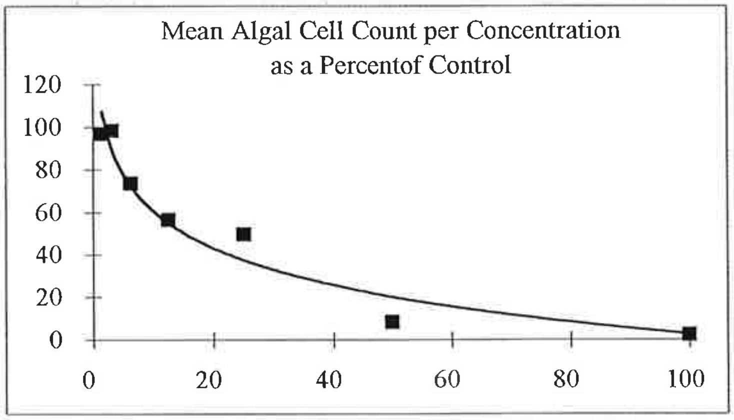
Acronyms

LC50	median lethal concentration (concentration that causes mortality in 50% of the test organisms)
NOEC	no observable effect concentration (highest concentration tested that exhibits no observable effect)
LOEC	lowest observable effect concentration (lowest concentration at which there is an observable effect)
IC25	inhibiton concentration (concentration at which response is impaired by 25%)
IC50	inhibiton concentration (concentration at which response is impaired by 50%)
MSD	minimum significant difference (difference between groups that is necessary to conclude that that they are significantly different.
na	not applicable

Algal Growth Inhibition Test

Biological Test Method EPS 1/RM/25

Client:	Heath Steel Newcastle, New Brunswick		
Sample:	HS-R-B (H-E-3)		
Sample No.:	9701213-5	**Date Initiated:**	14-Nov-97
Date Sampled:	12-Nov-97	**Time Initiated:**	13:00
		Initiated by:	P. Trainor


Mean Algal Cell Count per Concentration as a Percentof Control

TEST DATA

Mean Algal Cell Count (Manual Counts)
(cells/ml = cell count x 10,000)

replicate	0	1.56	3.13	6.25	12.5	25	50	100
1	165	142	151	146	114	57	11	5
2	161	173	171	103	100	97	9	4
3	159	152	144	103	62	73	11	3
4	130	128	138	99	70	76	19	1
mean / conc.	154	149	151	113	86.5	75.8	12.5	3.3

TEST RESULTS

	% v/v	95% CI	Method of Calculation	Notes
IC25	6.03	4.11 - 11.2	Linear Interpolation, (Norberg-King, 1993)	
IC50	23.7	3.88 - 31.8		

QUALITY ASSURANCE / COMMENTS

Associated QA/QC test: 9701248-0

CV of vertical control group = 10%; CV of all controls = 12%

Reported by:

Date: Jan 22/98

Test identification

Date of test	June 26, 1997
Technologist	Mary Moody
File	MM456

Effluent identification

SRC #	E44
Sample identity	HS-3
Location	Heath Steel Mine Newcastle, N.B.
Date of collection	June 24, 1997

Receiving water identification

SRC #	RW44
Location	Little South Tomogonops River, N.B.
Date of collection	June 12, 1997

Lemna minor QA/QC results

mean control growth rate in synthetic medium	0.387
95% confidence limits*	0.375-0.399
Reference toxicant	Cr 1 mg/L
mean % inhibition of biomass by reference toxicant	81
95% confidence limits*	79-83
Mean increase in control leaves (≥8 for a valid test)	
♦ in synthetic medium (x)	15.3
♦ in receiving water (x)	15.4

Lemna minor test results**

Test diluent	receiving water (RW44)
IC_{25} (%v/v)	30
95% confidence limits	17.2-52.5
IC_{50} (%v/v)	91.1
95% confidence limits	56.7-93.1

* calculated by Sigmaplot v 4.0

** calculated according to Nyholm *et al.*, 1992 and Andersen *et al.* 1995 (referenced in *L. minor* method)

Test validity criteria with regard to test environment, control growth rate and leaf increase, absence of algae and *Lemna* culture are met.

Test identification	
Date of test	Nov 14, 1997
Technologist	Mary Moody
File	MM456
Effluent identification	
SRC #	E51
Sample identity	Heath Steel
Location	Little South Tomogonops R.
Date of collection	Nov 12/97
Receiving water identification	
SRC #	RW51
Location	Heath Steel
Date of collection	unknown, forwarded from Beak
***Lemna minor* QA/QC results**	
mean control growth rate in synthetic medium	0.383
95% confidence limits*	0.378-0.390
Reference toxicant:	Cr 1 mg/L
mean % inhibition of biomass by reference toxicant	75
95% confidence limits*	71-80
Mean increase in control leaves (8 for a valid test)	
♦ in synthetic medium (x)	14.7
♦ in receiving water (x)	11.6
Lemna minor* test results*	
Test diluent	receiving water (RW 51)
IC_{25} (%v/v)	59.3
95% confidence limits	52.5-66.9
IC_{50} (%v/v)	>93.1
95% confidence limits	-

* calculated by Sigmaplot v 4.0

** calculated according to Nyholm *et al.*, 1992 and Andersen *et al.* 1995 (referenced in *L. minor* method)

Test validity criteria with regard to test environment, control growth rate and leaf increase, absence of algae and *Lemna* culture are met.

Summary of CANMET Test Results - *Lemna minor* Growth Inhibition Test

APPENDIX 5

Detailed Benthic Data and Chironomid Deformity Data

Table A5.1: Benthic invertebrates collected from Heath Steele.- 1997(densities expressed per 0.5m2)

Statior	HE1A	HE1B	HE2A	HE2B	HE3A	HE3B	HE4A	HE4B	HE5A
P. Nematoda	8	8	37	32	-	-	-	-	2
P. Platyhelminthes									
Cl. Turbellaria									
O. Neorhabdocoela	-	-	-	-	-	-	-	-	-
P. Annelida									
Cl. Oligochaeta									
F. Enchytraeidae	-	104	-	11	-	-	-	-	-
F. Naididae									
Nais simplex	-	-	-	-	-	-	-	-	-
Nais variabilis	-	-	-	-	-	-	-	-	-
Pristinella jenkinae	-	-	-	-	8	-	-	-	-
Slavina appendiculata	8	-	-	-	-	-	-	-	-
F. Lumbriculidae									
Stylodrilus heringianus	-	-	-	-	-	-	-	-	-
Cl. Hirudinae									
F. Glossiphoniidae									
Glossiphonia complanata	-	-	-	-	-	-	-	-	-
Helobdella stagnalis	-	-	-	-	-	-	-	-	-
F. Erpobdellidae									
Nephelopsis obscura	-	-	-	-	-	-	-	-	-
P. Arthropoda									
Cl. Arachnoidea									
Hydracarina	184	72	101	80	360	256	128	24	68
Cl. Ostracoda	-	4	-	-	-	-	-	-	-
Cl. Insecta									
O. Collembola	8	24	-	5	-	-	-	-	-
O. Ephemeroptera									
F. Baetidae									
Acentrella	-	-	-	-	-	-	8	-	82
Acerpenna	-	-	-	-	-	-	-	-	-
Baetis	8	48	469	464	928	1168	432	688	214
Baetis flavistriga	-	-	27	-	-	-	-	-	-
F. Ephemeridae									
indeterminate	-	-	-	-	-	-	-	-	-
F. Ephemerellidae									
indeterminate	8	-	21	224	32	-	-	-	6
Eurylophella	-	-	-	-	8	-	-	-	-
Serratella	-	-	-	-	-	-	-	-	-
F. Heptageniidae									
indeterminate	-	8	-	64	776	136	248	88	36
Epeorus	-	4	32	277	480	640	440	72	94
Heptagenia	-	-	-	-	-	56	-	16	-
Stenacron	-	-	-	-	-	-	-	-	-
Stenonema	-	-	-	-	-	-	-	-	4
F. Leptophlebiidae									
Paraleptophlebia	-	-	-	-	40	8	8	24	2
F. Siphlonuridae									
Isonychia	-	-	-	-	-	-	-	-	-
O. Odonata									
F. Aeshnidae									
Boyeria	-	-	-	-	-	-	-	-	2
F. Cordulegastridae									
Cordulegaster	8	-	-	-	-	-	-	-	-
F. Gomphidae									
indeterminate	-	-	-	5	-	16	8	16	8

Table A5.1: Benthic invertebrates collected from Heath Steele.- 1997(densities expressed per 0.5m2)

Statior	HE1A	HE1B	HE2A	HE2B	HE3A	HE3B	HE4A	HE4B	HE5A
O. Plecoptera									
indeterminate	-	-	-	-	-	-	8	-	-
F. Capniidae									
Paracapnia	248	28	171	400	248	552	152	784	32
F. Chloroperlidae									
indeterminate	-	-	5	-	-	32	32	16	26
Sweltsa	56	16	85	85	80	184	112	168	110
F. Leuctridae									
Leuctra	8	-	16	27	72	48	32	40	4
F. Perlidae									
indeterminate	-	-	-	-	-	8	-	8	2
Acroneuria	-	-	-	-	-	8	3	-	2
Agnetina	-	-	-	-	-	-	3	-	19
Paragnetina	-	-	-	-	8	-	-	-	-
F. Perlodidae									
indeterminate	-	8	-	26	8	24	16	8	20
O. Megaloptera									
F. Sialidae									
Sialis	16	-	5	-	-	-	-	-	-
F. Corydalidae									
Nigronia	-	-	-	-	16	24	42	-	-
O. Trichoptera									
indeterminate	-	-	-	-	-	-	-	32	-
Trichoptera pupae	-	4	-	16	-	-	-	-	-
F. Apataniidae									
Apatania	-	-	-	-	-	-	-	-	32
F. Brachycentridae									
Brachycentrus	8	-	-	-	-	-	-	-	-
Micrasema	-	-	-	5	-	-	8	-	-
F. Glossosomatidae									
Glossosoma	-	-	-	5	32	-	2	-	7
F. Hydropsychidae									
indeterminate	-	12	37	107	152	104	144	32	80
Arctopsyche	-	16	21	80	32	80	73	-	5
Cheumatopsyche	-	-	-	-	-	-	-	-	-
Diplectrona modesta	24	4	-	5	-	-	-	-	-
Hydropsyche	8	12	85	21	-	104	-	-	12
Hydropsyche sparna	-	-	11	5	-	8	-	-	8
F. Hydroptilidae									
Hydroptila	-	-	-	5	8	-	-	-	-
F. Lepidostomatidae									
Lepidostoma	-	-	5	11	16	40	48	120	45
F. Leptoceridae									
indeterminate	8	-	-	-	-	-	-	-	-
Ceraclea	-	-	-	-	-	-	-	-	2
F. Limnephilidae									
Frenesia	-	-	-	-	-	-	-	-	-
Neophylax	-	-	-	-	-	-	-	-	-
F. Odontoceridae									
Psilotreta	8	-	-	-	-	-	-	-	6
F. Philopotamidae									
Dolophilodes	-	8	-	-	96	8	40	8	1
F. Phryganeidae									
Oligostomis	-	-	-	-	-	-	-	-	-

Table A5.1: Benthic invertebrates collected from Heath Steele.- 1997(densities expressed per 0.5m2)

Statior	HE1A	HE1B	HE2A	HE2B	HE3A	HE3B	HE4A	HE4B	HE5A
F. Polycentropodidae									
indeterminate	-	4	-	-	-	-	-	8	6
Neureclipsis	-	-	-	144	200	48	64	-	12
Polycentropus	-	-	-	21	64	72	64	16	7
F. Rhyacophilidae									
Rhyacophila	8	84	5	43	24	24	24	-	18
O. Lepidoptera									
F. Pyralidae	-	-	-	-	-	-	1	-	-
O. Coleoptera									
F. Dytiscidae									
indeterminate	-	-	5	-	-	-	-	-	-
F. Elmidae									
Optioservus	-	-	21	16	96	280	96	96	24
Optioservus ampliatus	-	-	-	-	-	-	-	16	2
Optioservus fastiditus	-	-	-	-	-	-	-	-	-
Oulimnius latiusculus	-	-	-	-	-	-	-	-	2
Promoresia	16	-	11	-	24	40	-	-	-
Promoresia tardella	-	-	-	-	-	-	-	-	-
O. Diptera									
F. Ceratopogonidae									
Bezzia	-	-	-	-	-	8	-	-	10
Probezzia	40	16	21	27	8	8	-	-	8
F. Chironomidae									
Chironomid pupae	24	16	27	21	80	96	72	168	38
S.F. Chironominae									
Cryptochironomus	-	-	-	-	-	-	-	-	-
Demicryptochironomus	-	-	-	-	-	-	-	-	-
Micropsectra	8	8	5	32	592	1040	400	560	162
Microtendipes	-	-	-	-	96	40	16	16	4
Nilothauma	-	-	-	-	-	-	-	-	-
Polypedilum	152	16	48	21	336	200	280	216	116
Rheotanytarsus	-	-	-	-	96	48	72	-	10
Stempellina	-	-	-	-	-	-	-	-	-
Stempellinella	-	-	-	-	40	120	64	144	22
Stenochironomus	-	-	-	-	8	-	-	-	-
S.F. Diamesinae									
Diamesa	-	-	11	5	-	-	-	-	-
Pagastia	-	-	-	-	8	-	-	-	2
Potthastia	-	-	-	-	8	-	-	8	2
Sympottastia	-	-	-	-	-	-	-	-	-
S.F. Orthocladiinae									
Brillia	-	-	-	-	-	-	-	-	-
Chaetocladius			5						
Corynoneura	-	-	-	-	-	56	16	88	4
Cricotopus	936	188	5	123	80	40	-	8	-
Cricotopus/Orthocladius	840	88	827	331	8	16	16	8	4
Diplocladius	-	-	-	-	-	-	-	-	-
Eukiefferiella	16	32	-	11	88	32	16	16	56
Heterotanytarsus	-	-	-	-	-	-	-	8	-
Heterotrissocladius	8	-	-	-	-	-	8	8	-
Nanocladius	-	-	5	-	8	-	-	-	-
Orthocladius	296	248	11	21	80	40	16	-	36
Parametriocnemus	8	-	-	-	80	48	16	192	2
Psectrocladius	64	20	16	48	-	-	-	-	-
Rheocricotopus	488	100	117	197	56	80	-	56	6

Table A5.1: Benthic invertebrates collected from Heath Steele.- 1997(densities expressed per 0.5m2)

Statior	HE1A	HE1B	HE2A	HE2B	HE3A	HE3B	HE4A	HE4B	HE5A
Synorthocladius	-	-	-	-	-	-	-	8	-
Thienemanniella	-	-	-	32	48	-	-	-	-
Tvetenia	496	744	133	149	264	32	32	56	-
S.F. Tanypodinae									
indeterminate	-	-	-	-	-	-	8	-	-
Ablabesmyia	-	-	-	-	-	-	-	-	-
Helopelopia	-	-	5	32	-	24	-	8	4
Natarsia	-	-	-	5	-	-	-	-	-
Nilotanypus	-	4	5	5	-	-	-	-	-
Rheopelopia	-	-	-	-	48	-	-	-	2
Thienemannimyia complex	56	20	-	21	-	24	-	32	2
Trissopelopia	-	-	-	-	-	-	-	8	-
Zavrelimyia	-	-	-	-	-	8	8	8	-
F. Dixidae									
Dixa	-	-	-	-	8	-	-	-	-
F. Empididae									
Chelifera	48	80	16	21	-	8	-	-	-
Hemerodromia	144	44	75	5	8	16	-	-	4
F. Nymphomyiidae									
Nymphomyia	-	-	-	-	-	-	-	-	-
F. Simuliidae									
indeterminate	8	52	21	5	16	-	-	-	-
F. Tipulidae									
Antocha	-	-	-	5	-	-	-	-	-
Atherix	-	-	5	53	16	24	-	-	-
Dicranota	-	4	5	5	-	-	-	-	-
Hexatoma	-	-	1	-	-	-	1	-	1
P. Mollusca									
Cl. Gastropoda									
F. Ancylidae									
Ferrissia	-	-	-	-	16	-	-	-	-
F. Physidae									
Physella	-	-	-	-	-	-	-	-	-
Cl. Pelecypoda									
F. Margaritiferidae									
Margaritifera margaritifera	-	-	-	-	-	-	-	-	-
F. Sphaeriidae									
Pisidium	-	-	-	-	8	-	-	-	-
TOTAL NUMBER OF ORGANISMS	4272	2148	2534	3359	5912	5976	3277	3896	1497
TOTAL NUMBER OF TAXA	34	32	38	46	47	43	38	36	51
EPT INDEX	11	11	12	18	17	17	19	13	24

Table A5.1: Benthic invertebrates collected from Heath Steele.- 1997(densities expressed per 0.5m2)

		Reference	Reference	Reference	Reference	Reference	Reference
Statior	HE5B	HR1A	HR1B	HR2A	HR2B	HR3A	HR3B
P. Nematoda	8	64	328	48	40	-	16
P. Platyhelminthes							
Cl. Turbellaria							
O. Neorhabdocoela	-	16	-	-	-	-	-
P. Annelida							
Cl. Oligochaeta							
F. Enchytraeidae	-	8	-	-	-	-	-
F. Naididae							
Nais simplex	-	-	-	-	8	-	-
Nais variabilis	-	-	-	-	-	-	8
Pristinella jenkinae	-	-	-	-	-	-	-
Slavina appendiculata	-	-	-	-	-	-	-
F. Lumbriculidae							
Stylodrilus heringianus	-	288	384	8	-	-	8
Cl. Hirudinae							
F. Glossiphoniidae							
Glossiphonia complanata	-	8	-	-	-	-	-
Helobdella stagnalis	-	40	-	-	-	-	-
F. Erpobdellidae							
Nephelopsis obscura	-	104	120	-	-	-	-
P. Arthropoda							
Cl. Arachnoidea							
Hydracarina	184	424	832	480	336	376	144
Cl. Ostracoda	-	-	56	-	-	-	32
Cl. Insecta							
O. Collembola	8	-	-	-	-	-	8
O. Ephemeroptera							
F. Baetidae							
Acentrella	32	-	-	-	-	112	112
Acerpenna	-	656	880	-	-	8	-
Baetis	256	72	16	488	264	320	976
Baetis flavistriga	-	-	-	-	-	-	-
F. Ephemeridae							
indeterminate	-	-	48	-	-	-	8
F. Ephemerellidae							
indeterminate	-	112	824	176	65	128	128
Eurylophella	-	496	408	-	-	-	8
Serratella	-	-	-	8	-	-	-
F. Heptageniidae							
indeterminate	80	16	54	336	104	120	168
Epeorus	208	-	8	104	336	128	152
Heptagenia	16	72	48	-	8	16	-
Stenacron	-	32	48	-	-	-	-
Stenonema	-	-	8	16	32	8	8
F. Leptophlebiidae							
Paraleptophlebia	8	104	472	64	128	272	248
F. Siphlonuridae							
Isonychia	-	-	-	-	-	-	8
O. Odonata							
F. Aeshnidae							
Boyeria	-	-	-	1	-	-	-
F. Cordulegastridae							
Cordulegaster	-	-	-	-	-	-	-
F. Gomphidae							
indeterminate	32	-	-	-	24	8	-

Table A5.1: Benthic invertebrates collected from Heath Steele.- 1997(densities expressed per 0.5m2)

Statior	HE5B	Reference HR1A	Reference HR1B	Reference HR2A	Reference HR2B	Reference HR3A	Reference HR3B
O. Plecoptera							
indeterminate	-	-	-	-	-	8	-
F. Capniidae							
Paracapnia	80	240	920	104	32	16	64
F. Chloroperlidae							
indeterminate	40	-	-	8	-	8	-
Sweltsa	224	-	8	48	41	40	48
F. Leuctridae							
Leuctra	24	216	504	104	24	32	24
F. Perlidae							
indeterminate	-	-	-	96	-	8	8
Acroneuria	8	-	-	1	35	-	-
Agnetina	72	-	-	16	40	8	33
Paragnetina	-	-	-	1	36	-	-
F. Perlodidae							
indeterminate	16	8	24	8	8	48	8
O. Megaloptera							
F. Sialidae							
Sialis	8	-	16	-	-	-	16
F. Corydalidae							
Nigronia	8	-	-	17	23	8	9
O. Trichoptera							
indeterminate	-	-	-	-	-	-	-
Trichoptera pupae	-	8	40	17	16	16	-
F. Apataniidae							
Apatania	143	-	-	49	31	8	-
F. Brachycentridae							
Brachycentrus	8	-	-	-	-	8	8
Micrasema	-	56	144	17	32	-	-
F. Glossosomatidae							
Glossosoma	24	56	136	58	81	16	-
F. Hydropsychidae							
indeterminate	408	32	104	128	112	104	584
Arctopsyche	8	-	-	-	9	-	16
Cheumatopsyche	8	-	-	-	-	-	-
Diplectrona modesta	-	48	-	-	-	-	-
Hydropsyche	160	24	40	16	8	32	336
Hydropsyche sparna	-	8	16	24	8	16	32
F. Hydroptilidae							
Hydroptila	-	32	48	-	8	8	-
F. Lepidostomatidae							
Lepidostoma	61	-	-	28	4	32	8
F. Leptoceridae							
indeterminate	-	-	-	1	1	-	-
Ceraclea	-	-	-	-	-	-	-
F. Limnephilidae							
Frenesia	-	8	-	-	-	-	-
Neophylax	-	-	8	-	-	-	-
F. Odontoceridae							
Psilotreta	9	56	-	-	1	-	8
F. Philopotamidae							
Dolophilodes	-	8	-	-	8	16	128
F. Phryganeidae							
Oligostomis	-	8	1	-	-	-	-

Table A5.1: Benthic invertebrates collected from Heath Steele.- 1997(densities expressed per 0.5m2)

		Reference	Reference	Reference	Reference	Reference	Reference
Statior	HE5B	HR1A	HR1B	HR2A	HR2B	HR3A	HR3B
F. Polycentropodidae							
indeterminate	-	-	-	16	-	-	8
Neureclipsis	40	-	-	-	8	-	8
Polycentropus	48	-	-	8	8	-	-
F. Rhyacophilidae							
Rhyacophila	-	8	32	-	64	120	72
O. Lepidoptera							
F. Pyralidae	-	-	-	-	-	-	-
O. Coleoptera							
F. Dytiscidae							
indeterminate	-	-	-	-	-	-	-
F. Elmidae							
Optioservus	152	232	248	240	224	240	88
Optioservus ampliatus	-	-	392	-	-	16	-
Optioservus fastiditus	-	-	8	-	-	-	8
Oulimnius latiusculus	-	-	-	-	-	-	-
Promoresia	-	1360	912	112	144	-	8
Promoresia tardella	-	32	-	-	24	-	-
O. Diptera							
F. Ceratopogonidae							
Bezzia	24	-	-	-	-	-	-
Probezzia	-	48	24	8	8	-	24
F. Chironomidae							
Chironomid pupae	64	16	168	88	56	8	96
S.F. Chironominae							
Cryptochironomus	-	-	8	-	-	-	-
Demicryptochironomus	8	-	-	-	-	-	-
Micropsectra	448	392	1720	352	328	1064	536
Microtendipes	24	-	-	80	96	-	16
Nilothauma	-	-	-	-	-	8	-
Polypedilum	360	32	64	120	88	48	80
Rheotanytarsus	40	32	72	216	56	80	160
Stempellina	-	-	-	96	40	16	24
Stempellinella	88	56	304	24	24	32	16
Stenochironomus	-	-	-	-	-	-	-
S.F. Diamesinae							
Diamesa	-	-	-	-	-	-	-
Pagastia	-	16	48	-	-	-	8
Potthastia	-	-	-	-	8	-	-
Sympottastia	-	-	-	-	-	-	16
S.F. Orthocladiinae							
Brillia	-	8	-	-	-	-	-
Chaetocladius							
Corynoneura	40	-	168	24	-	32	-
Cricotopus	40	-	224	80	8	32	48
Cricotopus/Orthocladius	8	-	440	-	-	24	24
Diplocladius	-	8	-	-	-	-	-
Eukiefferiella	160	48	384	488	288	88	328
Heterotanytarsus	-	-	-	-	-	-	-
Heterotrissocladius	-	-	8	-	-	-	-
Nanocladius	-	-	-	-	16	-	-
Orthocladius	376	-	96	32	24	40	256
Parametriocnemus	64	72	56	32	16	16	64
Psectrocladius	-	-	-	-	-	-	-
Rheocricotopus	40	8	16	32	16	-	40

Table A5.1: Benthic invertebrates collected from Heath Steele.- 1997(densities expressed per 0.5m2)

Statior	HE5B	Reference HR1A	Reference HR1B	Reference HR2A	Reference HR2B	Reference HR3A	Reference HR3B
Synorthocladius	8	8	360	40	16	8	32
Thienemanniella	-	16	40	8	32	120	72
Tvetenia	40	136	1496	64	48	24	64
S.F. Tanypodinae							
indeterminate	-	-	8	-	-	-	-
Ablabesmyia	-	-	-	-	8	-	-
Helopelopia	-	-	-	-	-	-	-
Natarsia	-	16	8	-	-	-	-
Nilotanypus	-	8	24	8	-	-	-
Rheopelopia	-	-	-	16	32	-	-
Thienemannimyia complex	16	40	120	64	16	8	24
Trissopelopia	-	-	32	-	-	-	-
Zavrelimyia	-	-	8	-	-	-	-
F. Dixidae							
Dixa	-	-	-	-	-	-	-
F. Empididae							
Chelifera	-	-	56	-	-	8	8
Hemerodromia	-	-	8	40	48	-	-
F. Nymphomyiidae							
Nymphomyia	-	-	-	-	-	-	24
F. Simuliidae							
indeterminate	-	248	-	8	16	8	216
F. Tipulidae							
Antocha	-	-	-	-	-	-	-
Atherix	-	16	32	24	1	8	16
Dicranota	-	-	8	-	8	-	8
Hexatoma	-	-	-	-	8	-	2
P. Mollusca							
Cl. Gastropoda							
F. Ancylidae							
Ferrissia	-	-	-	360	336	-	-
F. Physidae							
Physella	-	-	-	-	-	-	8
Cl. Pelecypoda							
F. Margaritiferidae							
Margaritifera margaritifera	-	-	-	2	3	-	-
F. Sphaeriidae							
Pisidium	-	184	24	80	72	-	-
TOTAL NUMBER OF ORGANISMS	4229	6360	14159	5232	4091	3976	5764
TOTAL NUMBER OF TAXA	45	52	60	53	63	48	59
EPT INDEX	21	20	21	21	27	23	22

Table A5.2: Summary of Chironomid Anomalies, Heath Steele, August 1997

Station	No. Chironomids per sample	Number Examined	% Showing Anomalies	Genus Showing Anomalies	Noted Anomalies
	18	18	11	*Micropsectra*	missing 1st left lateral tooth.
				Stempellinella	centre teeth chipped.
HR1B	146	43	9	*Cricotopus*	chipped middle tooth.
				Cricotopus	missing 1st left lateral and centre teeth chipped.
				Eukiefferiella	left 1st lateral filed down.
				Synorthocladius	short centre teeth.
HR2A	99	44	7	*Rheocricotopus*	chipped right centre tooth.
				Rheocricotopus	missing 1st right lateral tooth.
				Eukiefferiella	chipped centre tooth.
HR2B	56	33	9	*Rheocricotopus*	centre teeth worn down.
				Polypedilum	chipped left centre tooth.
				Microtendipes	chipped right centre tooth.
HR3A	78	31	0	*no deformities*	no deformities
HR3B	129	59	7	*Parametriocnemus*	centre teeth filed down.
				Sympotthastia	left side of mentum missing several teeth.
				Synorthocladius	short centre teeth.
				Cricotopus	1st right lateral missing.
HE1A	160	63	6	*Rheocricotopus*	one median tooth filed down.
				Cric/Orthocladius	middle tooth filed down.
				Rheocricotopus	one median tooth filed down.
				Cricotopus	middle tooth missing.
HE1B	81	30	0	*no deformities*	no deformities
HE2A	32	19	11	*Diamesa*	centre teeth broken.
				Tvetenia	chipped median tooth.
HE2B	93	37	3	*Diamesa*	centre teeth broken.
HE3A	93	58	7	*Tvetenia*	broken 1st lateral tooth.
				Polypedilum	2nd lateral tooth broken.
				Eukiefferiella	filed down centre teeth.
				Parametriocnemus	1st lateral tooth missing.
HE3B	119	44	2	*Polypedilum*	broken middle tooth and 1st lateral.
HE4A	57	27	7	*Polypedilum*	chipped 1st lateral.
				Polypedilum	chipped 1st lateral.
HE4B	87	41	7	*Parametriocnemus*	chipped centre teeth
				Parametriocnemus	chipped centre teeth
				Rheocricotopus	one centre tooth filed down.
HE5A	78	33	6	*Eukiefferiella*	centre teeth broken.
				Eukiefferiella	centre teeth broken.
HE5B	82	42	5	*Eukiefferiella*	centre teeth broken.
				Eukiefferiella	right side of mentum broken.

APPENDIX 6

Detailed Fish Data

Table A6.1: Results of Metallothionein and Metals Analyses conducted on Fish Samples collected at Heath Steele Mine Site

Station	Fish Number	Species	µg MT/g	Hg µg/g	Cd µg/g	Cu µg/g	Pb µg/g	Zn µg/g	Ni µg/g	Cr µg/g	Co µg/g	Al µg/g	Ba µg/g	Fe µg/g	Mo µg/g	V µg/g	As µg/g	Se µg/g
Viscera																		
HE1B	HE1BBD1-F	Blacknose Dace	605.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	HE1BBT1-F	Brook Trout	215.8	0.04	0.6	25.9	0.75	80	2.41	3.13	5.91	71.1	0.22	102	0.24	< 0.5	0.27	0.31
HE2A	HE2ABT1-F	Brook Trout	276.7	0.041	0.56	19.9	0.11	109	3.28	4.64	1.26	5.5	3.18	79	0.31	< 0.5	0.11	0.44
	HE2ABT3-F	Brook Trout	177.4	0.061	0.67	45.2	0.32	96	31.41	39.89	2.33	43.5	3.37	272	8.33	< 0.5	0.18	0.4
HE2B	E2B-1 (composite of 3 samples)	Blacknose Dace	504.7	0.018	0.86	22.4	0.13	92	0.50	0.64	6.35	35	0.47	89	0.78	1.63	NA	NA
	E2B-2 (composite of 3 samples)	Blacknose Dace	657.4	0.016	0.87	17.8	1.21	104	0.43	0.30	1.85	35	0.47	87	0.45	1.01	NA	NA
	E2B-3 (composite of 4 samples)	Blacknose Dace	437.9	0.016	0.48	8.6	0.24	45	0.25	0.13	1.57	6.9	0.25	35	0.49	0.82	NA	NA
	E2B-4 (composite of 4 samples)	Blacknose Dace	598.1	0.018	0.66	11.3	0.36	65	0.23	0.16	1.82	14	0.29	49	0.32	0.91	NA	NA
	HE2BBT1-F	Brook Trout	329.9	0.111	1.08	42.8	0.14	122	5.32	2.31	4.31	76.7	1.63	74	0.66	< 0.5	0.49	0.55
	HE2BBT2-F	Brook Trout	497.4	0.099	1.62	24.9	0.52	123	1.34	1.09	3.6	19.7	0.55	115	0.41	< 0.5	0.19	0.51
HE3A	HE3AAS1-F	Atlantic Salmon	125.9	0.030	0.95	94.9	0.67	261	0.64	1.11	1.64	13	1.95	90	0.58	2.96	0.15	0.23
	HE3AAS2-F	Atlantic Salmon	161.7	0.037	1.53	58.0	1.29	275	1.11	2.80	3.41	42	1.45	147	0.79	3.15	0.23	0.55
	HE3AAS3-F	Atlantic Salmon	345.1	0.021	1.50	39.7	0.47	325	0.94	1.71	3.00	30	3.74	94	0.81	3.13	n/s	n/s
	E3A-1 (composite of 5 samples)	Blacknose Dace	385.2	0.013	0.88	7.6	0.19	51	<0.50	0.17	1.11	5.9	0.31	33	<0.20	<0.50	NA	NA
	HE3ABT1-F	Brook Trout	260.1	0.07	1.08	29.6	0.21	107	5.52	2.95	2.82	63.1	1.43	80	9.92	< 0.5	0.5	0.51
	HE3ABT2-F	Brook Trout	384.9	0.087	1.18	40.9	<0.05	144	28.17	25.31	3.4	70.4	0.11	95	6.4	< 0.5	0.3	0.62
	HE3ABT4-F	Brook Trout	417.1	0.09	1.87	27.8	0.55	144	3.08	9.14	3.77	28.2	0.95	128	0.49	< 0.5	0.2	0.64
	HE3ABT5-F	Brook Trout	210.7	0.061	1.04	22.4	1.41	118	1.99	2.86	6.74	66.2	2.13	123	0.29	< 0.5	0.26	0.43
HE3B	HE3BAS1-F	Atlantic Salmon	217.7	0.043	1.17	29.2	0.76	203	0.93	2.11	2.90	36	1.98	123	0.53	3.11	0.14	0.42
	HE3BAS2-F	Atlantic Salmon	214.2	0.046	1.57	34.5	0.97	336	3.21	3.75	3.50	133	1.25	215	1.06	3.27	0.28	0.40
	HE3BAS4-F	Atlantic Salmon	234.5	0.028	1.08	23.3	0.53	236	0.46	0.50	2.93	33	0.44	88	0.44	1.97	0.77	0.37
	HE3BAS5-F	Atlantic Salmon	285.2	0.038	1.40	22.8	0.53	278	0.21	0.46	2.55	14	0.49	64	0.75	3.17	0.20	0.64
	E3B-1 (composite of 6 samples)	Blacknose Dace	735.2	0.018	1.81	12.0	0.54	82	0.29	0.25	1.75	21	0.48	53	0.44	0.60	NA	NA
	HE3BBT1-F	Brook Trout	497.7	0.067	1.23	24.7	0.16	119	1.43	2.95	2.61	12.8	0.61	97	0.24	< 0.5	0.07	0.47
	HE3BBT2-F	Brook Trout	218.4	0.06	0.84	13.1	0.24	82	0.59	1.85	3.03	14.1	0.39	96	0.19	< 0.5	0.23	0.52
	HE3BBT4-F	Brook Trout	285.0	0.066	1.44	14.3	0.09	109	0.55	4.82	1.36	2.9	0.17	57	0.15	< 0.5	0.2	0.49
	HE3BBT5-F	Brook Trout	485.7	0.052	1.23	25	0.11	144	0.59	5.07	2.19	3.3	0.25	67	0.15	< 0.5	0.07	0.53
HE4A	HE4AAS1-F	Atlantic Salmon	198.3	0.041	1.55	24.8	0.88	327	0.13	0.43	0.83	43	1.43	139	0.50	2.19	0.32	0.55
	HE4AAS2-F	Atlantic Salmon	406.9	0.047	2.26	31.8	0.61	366	0.27	0.31	4.53	20	0.98	102	0.84	3.64	0.26	0.54
	HE4AAS3-F	Atlantic Salmon	216.7	0.056	1.22	20.2	0.71	262	1.14	1.54	1.04	33	4.39	123	0.57	2.17	0.16	0.48
	HE4AAS4-F	Atlantic Salmon	146.3	0.036	1.49	29.9	1.68	352	6.95	7.72	1.99	150	14.25	346	1.93	2.94	0.30	0.38
	HE4ABT1-F	Brook Trout	319.0	0.055	1.04	18.7	0.21	172	1.01	3.27	1.95	9.3	0.47	94	0.2	< 0.5	0.16	0.58
	HE4ABT2-F	Brook Trout	339.8	0.042	1.54	15.2	0.35	85	0.49	7.63	1.55	15.4	0.35	121	0.16	< 0.5	0.13	0.59
	HE4ABT3-F	Brook Trout	380.0	0.055	0.98	32.5	0.46	102	2.9	7.03	1.96	56.5	0.48	168	0.45	< 0.5	0.32	0.61
	HE4ABT4-F	Brook Trout	355.2	0.011	1.38	25.9	0.46	85	1.73	5.29	2.89	27.3	0.72	126	0.27	< 0.5	0.13	0.56
HE4B	HE4BAS3-F	Atlantic Salmon	154.4	0.037	1.39	16.2	0.53	298	0.93	0.93	3.13	20	0.52	96	0.42	2.00	0.20	0.53
	HE4BAS4-F	Atlantic Salmon	308.4	0.049	1.22	16.4	0.66	268	0.23	0.22	1.99	19	0.35	106	0.66	2.03	0.19	0.89
	HE4BAS1-F	Atlantic Salmon	281.8	0.043	1.57	21.5	0.59	273	1.15	1.44	0.77	15	0.61	85	1.14	4.13	n/s	n/s
	HE4BAS2-F	Atlantic Salmon	121.6	0.043	1.05	24.7	1.43	258	7.06	8.57	1.43	92	1.44	199	2.92	4.16	n/s	n/s
	HE4BBD1-F	Blacknose Dace	241.9	0.060	1.12	22.8	0.40	159	0.67	0.85	1.73	30	0.84	110	0.64	2.02	NA	NA
	E4B-2 (composite of 3 samples)	Blacknose Dace	199.5	0.033	1.07	10.4	0.28	66	0.89	0.69	0.71	43	0.80	108	1.05	2.02	NA	NA
	E4B-3 (composite of 3 samples)	Blacknose Dace	286.2	0.027	1.19	10.7	0.29	56	0.39	0.48	1.67	19	0.42	60	0.38	1.05	NA	NA
	E4B-4 (composite of 6 samples)	Blacknose Dace	240.9	0.015	0.69	4.2	0.13	39	0.20	0.28	0.90	10	0.26	34	0.51	2.68	NA	NA
	HE4BBT1-F	Brook Trout	206.3	0.047	0.82	11.6	0.16	79	0.58	8.93	0.59	5.3	0.19	84	0.14	< 0.5	0.11	0.35
	HE4BBT2-F	Brook Trout	295.7	0.053	1.36	13.6	0.38	110	2.97	13.66	2	43.4	0.45	105	0.49	< 0.5	0.17	0.59
	HE4BBT3-F	Brook Trout	233.2	0.043	1.3	12.2	0.12	67	1.23	27.44	0.67	3	0.23	68	0.25	< 0.5	0.12	0.52
	HE4BBT4-F	Brook Trout	212.4	0.047	1.2	11.7	0.12	119	0.52	7.58	4.03	<2.5	0.19	64	0.32	< 0.5	n/s	n/s
HE5A	HE5AAS1-F	Atlantic Salmon	154.0	0.044	0.94	13.0	0.43	187	3.67	2.89	1.68	42	0.53	132	1.08	2.69	0.17	0.44
	HE5AAS2-F	Atlantic Salmon	244.0	0.043	1.67	97.9	0.78	318	71.4	97	1.26	383	3.91	943	17.4	2.39	0.47	0.49
	HE5AAS3-F	Atlantic Salmon	249.4	0.044	1.66	108	2.33	306	40.5	42	1.25	302	1.79	668	11.3	1.60	0.41	0.49
	HE5AAS4-F	Atlantic Salmon	138.1	0.058	1.01	114	2.38	347	26.9	27	0.69	229	1.57	550	8.27	3.63	n/s	n/s

Table A6.1: Results of Metallothionein and Metals Analyses conducted on Fish Samples collected at Heath Steele Mine Site

Station	Fish Number	Species	µg MT/g	Hg µg/g	Cd µg/g	Cu µg/g	Pb µg/g	Zn µg/g	Ni µg/g	Cr µg/g	Co µg/g	Al µg/g	Ba µg/g	Fe µg/g	Mo µg/g	V µg/g	As µg/g	Se µg/g
	E5A-1 (composite of 3 samples)	Blacknose Dace	156.1	0.058	0.66	6.0	0.24	47	0.58	0.76	0.44	60	2.06	135	0.56	1.70	NA	NA
	E5A-2 (composite of 2 samples)	Blacknose Dace	297.9	0.050	2.41	20.0	0.60	77	2.73	1.96	3.28	113	2.04	210	0.65	1.17	NA	NA
	E5A-3 (composite of 3 samples)	Blacknose Dace	120.1	0.033	1.07	8.6	0.15	41	0.54	0.74	2.27	17	3.12	62	0.44	1.88	NA	NA
	E5A-4 (composite of 4 samples)	Blacknose Dace	202.6	0.033	0.79	5.8	0.14	34	0.51	0.63	0.68	27	0.43	61	0.39	1.30	NA	NA
	E5A-5 (composite of 4 samples)	Blacknose Dace	162.2	0.019	0.63	6.4	0.20	35	0.91	0.73	0.46	34	0.39	69	0.45	1.32	NA	NA
	HE5ABT1-F	Brook Trout	67.5	0.028	0.59	6.3	0.05	80	1.27	1.93	0.75	2.4	2.69	49	0.22	< 0.5	0.09	0.41
	HE5ABT2-F	Brook Trout	74.5	0.041	0.21	5.7	< 0.05	35	1.12	1.82	0.4	1.9	0.75	29	0.19	< 0.5	0.11	0.39
	HE5ABT3-F	Brook Trout	81.7	0.053	0.38	5.9	0.08	118	1.15	2.19	0.54	7.8	0.44	63	0.17	< 0.5	0.18	0.53
	HE5ABT4-F	Brook Trout	60.4	0.027	0.39	6.4	0.16	87	0.62	1.79	3.49	4.1	0.68	51	0.21	< 0.5	0.1	0.4
HE5B	HE5BAS1-F	Atlantic Salmon	119.4	0.034	1.74	216	0.64	452	76.9	122	1.69	1092	5.54	2749	20.4	14.1	1.10	0.56
	HE5BAS2-F	Atlantic Salmon	183.6	0.057	1.87	29.8	0.46	376	1.65	1.97	0.77	22	0.46	112	1.15	2.09	0.25	0.54
	HE5BAS3-F	Atlantic Salmon	76.3	0.063	0.88	17.9	0.39	252	1.90	1.26	3.65	21	0.51	90	0.78	3.26	0.19	0.53
	HE5BAS4-F	Atlantic Salmon	70.7	0.033	0.99	21.7	1.28	249	6.47	10.2	0.55	111	1.47	255	2.24	3.95	0.30	0.44
	HE5BBD1-F	Blacknose Dace	351.2	0.048	2.05	25.2	0.70	122	0.46	0.46	4.44	87	1.90	214	0.30	1.77	NA	NA
	E5B-2 (composite of 2 samples)	Blacknose Dace	361.3	0.042	1.96	13.5	0.37	93	1.39	1.79	1.24	63	1.01	160	0.71	1.28	NA	NA
	E5B-3 (composite of 2 samples)	Blacknose Dace	185.5	0.034	1.27	18.2	0.30	102	4.26	4.41	0.91	98	1.12	218	1.56	4.49	NA	NA
	E5B-4 (composite of 3 samples)	Blacknose Dace	123.7	0.026	0.47	10.5	0.26	47	2.30	1.95	0.64	62	0.64	108	0.61	2.77	NA	NA
	E5B-5 (composite of 3 samples)	Blacknose Dace	194.1	0.026	0.76	7.8	0.22	56	0.77	0.80	1.50	31	0.50	72	0.39	1.12	NA	NA
	E5B-6 (composite of 5 samples)	Blacknose Dace	132.4	0.016	0.60	16.7	0.36	61	5.96	7.85	0.89	144	1.33	278	2.29	0.92	NA	NA
	HE5BBT1-F	Brook Trout	195.2	0.033	0.66	11.3	< 0.05	45	1.28	2.35	0.9	2.6	0.07	60	0.14	< 0.5	<0.20	0.6
	HE5BBT2-F	Brook Trout	289.7	0.033	0.97	17.9	0.11	71	1.44	2.16	1.79	8.1	0.17	104	0.19	< 0.5	0.12	1.48
HR1A	R1A-1 (composite of 2 samples)	Blacknose Dace	89.6	0.026	0.44	4.6	1.15	32	0.91	0.98	0.18	16	1.28	56	0.76	2.26	NA	NA
	R1A-2 (composite of 2 samples)	Blacknose Dace	103.2	0.024	0.37	3.0	0.13	29	0.29	0.32	0.15	16	1.87	64	0.53	1.04	NA	NA
	R1A-3 (composite of 3 samples)	Blacknose Dace	92.7	0.032	0.40	4.4	0.15	30	0.44	0.22	2.87	27	2.11	69	0.51	1.52	NA	NA
	R1A-4 (composite of 5 samples)	Blacknose Dace	109.9	0.025	0.30	2.9	0.14	26	0.57	0.22	0.37	8.9	1.06	41	0.27	0.54	NA	NA
	HR1ABT1-F	Brook Trout	210.1	0.037	0.31	7.2	0.08	155	0.58	1.98	0.39	0.9	0.3	70	0.16	< 0.5	<0.10	0.45
	HR1ABT2-F	Brook Trout	242.2	0.042	0.26	7.7	0.15	169	0.47	1.74	0.92	0.9	0.21	66	0.16	< 0.5	<0.10	0.44
	HR1ABT4-F	Brook Trout	109.9	0.034	0.23	4.4	0.16	116	0.41	0.99	0.4	1.6	0.2	48	0.22	< 0.5	<0.10	0.3
	HR1ABT5-F	Brook Trout	100.8	0.043	1.92	5.7	0.51	109	2.13	11.01	0.42	49	2.18	109	0.35	< 0.5	0.11	1.04
HR1B	R1B-1 (composite of 2 samples)	Blacknose Dace	91.2	0.035	0.38	5.2	0.15	27	0.47	0.86	0.35	20	1.14	93	0.49	1.66	NA	NA
	R1B-2 (composite of 3 samples	Blacknose Dace	119.6	0.043	0.68	11.8	0.12	23	4.29	4.31	0.50	65	1.60	154	1.25	3.15	NA	NA
	R1B-3 (composite of 4 samples)	Blacknose Dace	78.6	0.029	0.43	6.5	0.25	26	0.41	0.74	1.23	44	2.47	97	0.21	0.86	NA	NA
	R1B-4 (composite of 6 samples)	Blacknose Dace	130.4	0.023	0.67	4.7	0.16	26	0.40	0.76	0.30	25	1.26	58	0.31	2.00	NA	NA
	HR1BBT1-F	Brook Trout	180.6	0.044	0.22	8.8	0.08	96	0.7	1.86	0.39	< 2.5	0.24	58	0.16	< 0.5	<0.20	0.34
	HR1BBT2-F	Brook Trout	82.2	0.052	0.19	6.5	0.06	62	1.51	1.29	12.9	< 2.5	0.19	43	0.12	< 0.5	<0.10	0.36
	HR1BBT3-F	Brook Trout	95.9	0.035	0.58	4.7	0.24	42	0.43	1.86	1.45	3.2	0.37	54	0.16	< 0.5	<0.20	0.44
	HR1BBT4-F	Brook Trout	85.4	0.034	0.06	37.8	< 0.05	45	48.1	4.59	0.96	20.2	<0.025	13	3.52	< 0.5	0.17	0.31
HR2A	R2A-1 (composite of 2 samples)	Blacknose Dace	184.8	0.027	2.30	4.4	0.17	47	0.45	0.81	0.73	61	1.69	119	0.31	3.39	NA	NA
	R2A-2 (composite of 2 samples)	Blacknose Dace	138.8	0.037	1.82	8.5	0.59	72	0.45	0.98	0.76	65	6.23	140	0.37	0.88	NA	NA
	R2A-3 (composite of 2 samples)	Blacknose Dace	147.9	0.033	1.37	6.2	0.78	58	0.29	0.75	3.23	131	2.79	219	0.34	1.30	NA	NA
	R2A-4 (composite of 3 samples)	Blacknose Dace	115.1	0.022	1.09	6.8	0.51	50	0.73	0.84	1.11	109	2.71	184	0.48	1.47	NA	NA
	R2A-5 (composite of 3 samples)	Blacknose Dace	113.3	0.022	1.08	5.7	0.54	49	0.33	0.66	0.76	78	1.89	142	0.33	0.86	NA	NA
	R2A-6 (composite of 4 samples)	Blacknose Dace	136.3	0.020	0.81	4.0	0.39	38	0.61	0.94	0.42	43	0.95	80	0.33	0.93	NA	NA
	HR2ABT1-F	Brook Trout	203.9	0.048	0.14	29.4	< 0.05	43	49.1	3.2	1.32	5.8	<0.025	22	2.95	0.58	0.6	0.94
	HR2ABT2-F	Brook Trout	108.7	0.064	0.19	8.1	< 0.05	9	1.11	2.26	0.39	<0.5	0.23	3	0.65	< 0.5	0.25	1.27
HR2B	HR2BAS1-F	Atlantic Salmon	68.6	0.042	1.37	8.9	0.21	250	2.58	2.79	0.53	59	0.65	136	1.37	4.03	n/s	n/s
	R2B-1 (composite of 2 samples)	Blacknose Dace	138.3	0.024	1.82	2.7	0.23	36	0.17	0.20	1.38	7.8	0.46	37	0.45	1.61	NA	NA
	R2B-2 (composite of 3 samples)	Blacknose Dace	194.9	0.020	1.14	4.3	0.28	38	<0.1	0.11	0.77	43	0.92	83	0.36	1.97	NA	NA
	R2B-3 (composite of 3 samples)	Blacknose Dace	131.0	0.014	0.81	2.8	0.16	38	0.19	0.41	0.31	18	0.47	49	0.31	1.05	NA	NA
	R2B-4 (composite of 8 samples)	Blacknose Dace	127.5	0.028	0.52	1.8	0.11	23	<0.1	0.08	0.29	10	0.36	29	0.28	0.59	NA	NA
	HR2BBT1-F	Brook Trout	175.1	0.075	0.25	10.7	< 0.05	12	1.05	1.73	1.02	< 2.5	0.09	6	0.45	< 0.5	0.33	0.68
	HR2BBT2-F	Brook Trout	125.2	0.044	0.61	5.6	0.09	69	0.88	2.7	0.76	9.6	0.27	91	0.31	< 0.5	<0.20	0.83
	HR2BBT3-F	Brook Trout	212.9	0.046	0.24	12.4	< 0.05	34	1.11	1.93	0.9	4.9	0.06	11	0.56	< 0.5	0.26	0.62
	HR2BBT4-F	Brook Trout	202.0	0.055	0.66	11.9	0.23	81	0.85	0.73	2.32	27	0.22	121	0.27	< 0.5	<0.20	0.45

Table A6.1: Results of Metallothionein and Metals Analyses conducted on Fish Samples collected at Heath Steele Mine Site

Station	Fish Number	Species	µg MT/g	Hg µg/g	Cd µg/g	Cu µg/g	Pb µg/g	Zn µg/g	Ni µg/g	Cr µg/g	Co µg/g	Al µg/g	Ba µg/g	Fe µg/g	Mo µg/g	V µg/g	As µg/g	Se µg/g
HR3A	HR3AAS1-F	Atlantic Salmon	46.0	0.075	0.63	24.6	0.32	196	15.8	24.5	4.07	304	1.72	618	5.74	2.95	0.51	1.85
	HR3AAS2-F	Atlantic Salmon	84.5	0.070	0.27	8.2	0.23	140	2.52	3.13	1.46	25	0.15	103	1.10	3.36	0.02	0.90
	HR3AAS4-F	Atlantic Salmon	24.7	0.111	0.16	6.3	0.43	102	0.83	0.88	2.89	10	0.43	64	0.98	4.07	n/s	n/s
	HR3AAS5-F	Atlantic Salmon	32.1	0.132	0.43	38.1	0.27	118	11.0	18.2	3.37	198	2.19	430	5.42	2.09	n/s	n/s
	HR3ABD1-F	Blacknose Dace	139.4	0.087	0.77	8.0	0.24	44	0.22	0.48	6.87	22	0.79	86	0.65	2.20	NA	NA
	R3A-2 (composite of 2 samples)	Blacknose Dace	107.5	0.045	0.38	5.0	0.21	31	0.27	0.50	0.73	45	0.67	93	0.44	3.03	NA	NA
	R3A-3 (composite of 4 samples)	Blacknose Dace	114.4	0.036	0.23	5.5	0.28	19	0.72	1.21	0.93	95	0.96	142	0.37	1.93	NA	NA
HR3B	HR3BAS1-F	Atlantic Salmon	89.1	0.150	0.22	32.3	0.10	130	5.52	6.82	2.13	209	7.72	395	2.63	5.90	0.34	0.91
	HR3BAS2-F	Atlantic Salmon	41.8	0.114	0.26	91.2	0.62	214	122	168	0.45	1720	7.21	4793	28.0	13.0	3.06	1.11
	HR3BAS3-F	Atlantic Salmon	31.8	0.108	0.36	172	0.09	110	67.9	94.2	0.51	204	2.79	788	18.6	3.53	n/s	n/s
	HR3BAS4-F	Atlantic Salmon	48.6	0.095	0.24	19.7	0.04	113	4.89	6.80	1.82	117	2.08	250	2.11	3.19	0.35	0.87
	R3B-1 (composite of 3 samples)	Blacknose Dace	113.6	0.043	0.35	7.5	0.21	24	0.23	0.69	0.61	76	0.95	139	0.26	1.80	NA	NA
	R3B-2 (composite of 6 samples)	Blacknose Dace	80.7	0.039	0.42	4.6	0.21	22	0.27	0.54	0.89	80	0.98	137	0.17	1.02	NA	NA
	HR3BBT1-F	Brook Trout	95.6	0.067	0.2	6.7	0.05	92	2.64	2.78	0.44	23.7	0.99	105	0.44	< 0.5	0.11	0.82
	HR3BBT2-F	Brook Trout	111.4	0.059	0.28	7.5	0.14	106	6.73	13.32	1.07	763.2	1.26	643	1.04	1.23	0.39	1.09
CAGES	HR1AAS1C-F	Atlantic Salmon	30.5	0.023	0.06	3.0	0.10	142	0.17	0.32	0.80	<1.0	0.11	36	0.48	1.66	0.66	0.49
	HR1AAS2C-F	Atlantic Salmon	44.2	0.018	0.03	3.8	0.14	182	0.14	0.32	0.74	2.7	0.09	47	0.68	1.52	0.61	0.54
	HR1BAS1C-F	Atlantic Salmon	28.9	0.030	0.04	7.5	0.13	163	0.28	0.48	0.77	<1.0	0.10	35	0.41	1.18	0.99	0.60
	HR1BAS2C-F	Atlantic Salmon	31.0	0.027	0.05	13.6	0.16	140	1.40	1.70	2.43	4.5	0.14	66	0.43	1.20	0.61	0.56
	HR2AAS1C-F	Atlantic Salmon	27.5	0.029	0.03	6.3	0.11	165	0.74	0.15	3.74	<1.0	<0.05	43	0.57	1.61	0.78	0.62
	HR2AAS2C-F	Atlantic Salmon	25.5	0.022	0.04	3.8	0.13	222	0.72	0.33	2.35	<1.0	<0.05	46	0.56	2.29	0.62	0.58
	HR2BAS1C-F	Atlantic Salmon	33.5	0.022	0.11	4.4	0.14	211	0.78	0.12	0.97	<1.0	<0.05	52	0.66	3.12	0.49	0.48
	HR2BAS2C-F	Atlantic Salmon	36.2	0.036	0.05	6.8	0.13	185	0.72	0.22	0.41	<1.0	<0.05	42	0.71	4.39	0.61	0.68
	HR3AAS1C-F	Atlantic Salmon	25.9	0.099	0.04	7.6	0.10	175	0.73	0.18	2.32	1.5	<0.05	41	0.61	2.69	0.26	0.57
	HR3AAS2C-F	Atlantic Salmon	21.9	0.024	0.04	3.3	0.11	178	0.74	0.09	0.59	<1.0	<0.05	39	0.50	2.31	0.37	0.52
	HR3BAS1C-F	Atlantic Salmon	21.4	0.024	0.04	2.8	0.13	197	0.77	0.50	1.23	1.6	0.06	49	0.68	3.26	0.30	0.50
	HR3BAS2C-F	Atlantic Salmon	28.8	0.025	0.04	2.4	0.15	134	1.09	0.11	0.42	<1.0	<0.05	27	1.65	4.09	0.28	0.46
	HE1AAS1C-F	Atlantic Salmon	123.1	0.033	0.05	2.7	0.10	285	0.72	0.17	1.06	4.0	<0.05	48	0.70	2.31	0.52	0.41
	HE1AAS2C-F	Atlantic Salmon	138.7	0.031	0.05	2.7	0.10	178	0.75	0.11	0.42	<1.0	<0.05	44	0.40	0.80	0.49	0.40
	HE1BAS1C-F	Atlantic Salmon	110.3	0.029	0.04	5.3	0.12	190	0.79	0.18	0.44	2.4	<0.05	28	0.63	2.24	0.62	0.56
	HE1BAS2C-F	Atlantic Salmon	88.9	0.025	0.06	4.6	0.12	194	0.89	0.12	0.37	3.6	0.06	40	0.61	2.23	0.62	0.63
	HE2AAS1C-F	Atlantic Salmon	59.8	0.029	0.05	2.6	0.09	245	0.67	0.17	2.27	1.3	0.06	41	0.72	2.17	0.67	0.50
	HE2AAS2C-F	Atlantic Salmon	75.6	0.031	0.07	3.5	0.12	165	0.83	0.32	0.67	7.7	0.14	52	0.44	2.41	0.82	0.48
	HE2BAS1C-F	Atlantic Salmon	46.8	0.024	0.06	3.7	0.11	195	0.54	0.21	0.49	5.5	<0.05	41	0.59	3.24	0.74	0.49
	HE2BAS2C-F	Atlantic Salmon	65.5	0.030	0.04	3.4	0.13	182	0.58	0.75	0.53	2.2	15.13	40	0.49	2.22	0.91	0.39
	HE3AAS1C-F	Atlantic Salmon	44.4	0.030	0.12	4.3	0.15	277	0.70	0.42	1.28	3.1	0.91	56	0.66	2.78	0.71	0.54
	HE3AAS2C-F	Atlantic Salmon	39.0	0.026	0.07	3.9	0.14	193	0.64	0.28	0.39	<1.0	0.28	49	0.75	3.14	0.71	0.53
	HE3BAS1C-F	Atlantic Salmon	20.5	0.034	0.05	3.4	0.12	147	0.74	0.09	0.75	<1.0	<0.05	63	0.62	3.58	0.64	0.43
	HE3BAS2C-F	Atlantic Salmon	30.3	0.039	0.05	2.7	0.16	140	0.81	0.13	0.67	4.5	0.46	42	0.56	2.66	0.78	0.46
	HE4AAS1C-F	Atlantic Salmon	32.9	0.037	0.06	2.5	0.16	166	0.77	0.14	1.09	3.3	0.17	43	0.54	1.49	0.52	0.56
	HE4AAS2C-F	Atlantic Salmon	39.9	0.042	0.06	3.4	0.12	88	0.76	0.04	0.59	1.9	0.05	53	0.54	1.69	0.61	0.55
	HE4BAS1C-F	Atlantic Salmon	26.9	0.035	0.03	5.0	0.09	142	0.75	0.10	0.38	<1.0	0.25	41	0.56	2.00	0.93	0.53
	HE4BAS2C-F	Atlantic Salmon	15.1	0.052	0.05	3.3	0.12	222	0.77	1.06	0.43	1.5	13.81	47	0.40	1.88	0.96	0.38
	HE5AAS1C-F	Atlantic Salmon	25.0	0.032	0.03	3.3	0.13	197	0.69	0.06	2.19	1.3	0.32	43	0.53	2.70	0.79	0.49
	HE5AAS2C-F	Atlantic Salmon	17.0	0.029	0.03	3.2	0.12	247	0.67	0.37	0.64	1.8	0.30	47	0.45	2.06	0.96	0.52
	HE5BAS1C-F	Atlantic Salmon	15.8	0.023	0.05	2.7	0.13	216	0.73	0.18	0.50	1.4	0.06	41	0.72	3.19	0.85	0.44
	HE5BAS2C-F	Atlantic Salmon	31.8	0.032	0.11	2.8	0.22	183	0.78	0.18	0.82	11	0.18	60	0.70	2.97	0.99	0.46
Gill Reference	R1A (composite of 2 fish)	Atlantic Salmon	11.4	0.031	0.1	6.1	0.07	71	0.83	0.65	9	<2.5	1.64	79	0.21	< 0.5	n/s	n/s
	R1B (composite of 2 fish)	Atlantic Salmon	12.1	0.016	0.11	4.6	0.08	72	1.04	1.56	6.74	3	1.84	75	0.2	< 0.5	n/s	n/s
	R2A (composite of 2 fish)	Atlantic Salmon	18.4	0.027	0.09	3.1	0.11	90	0.95	1.65	3.08	3.7	1.41	99	0.11	< 0.5	n/s	n/s
	R2B (composite of 2 fish)	Atlantic Salmon	17.1	0.022	0.14	3.6	0.05	85	0.84	2.16	4.55	<2.5	1.36	70	0.1	< 0.5	n/s	n/s
	R3A (composite of 2 fish)	Atlantic Salmon	12.0	0.024	0.08	5.6	0.05	75	2.13	3.16	8.22	17.2	1.16	96	0.36	< 0.5	n/s	n/s
	R3B (composite of 2 fish)	Atlantic Salmon	12.3	0.016	0.08	4.3	0.04	68	1.24	1.99	3.23	8.2	1.06	95	0.18	< 0.5	n/s	n/s
Exposure	E1A (composite of 2 fish)	Atlantic Salmon	65.9	0.029	0.69	4	0.12	91	0.84	1.55	1.47	3.3	1.44	97	0.26	< 0.5	n/s	n/s
	E1B (composite of 2 fish)	Atlantic Salmon	65.7	0.032	0.95	74.6	0.1	88	16.1	34.47	2.67	7.5	1.84	187	3.21	< 0.5	n/s	n/s
	E2A (composite of 2 fish)	Atlantic Salmon	57.4	0.026	0.53	13.3	0.43	120	2.44	3.49	0.88	13.4	1.16	103	0.48	< 0.5	n/s	n/s
	E2B (composite of 2 fish)	Atlantic Salmon	57.2	0.023	0.68	4.6	0.03	100	2.28	2.56	0.66	6.5	1.82	68	0.32	< 0.5	n/s	n/s
	E3A (composite of 2 fish)	Atlantic Salmon	34.2	0.021	0.31	4.4	0.1	82	2.16	2.74	0.39	12.6	1.26	85	0.48	< 0.5	n/s	n/s
	E3B (composite of 2 fish)	Atlantic Salmon	29.7	0.021	0.23	3.3	0.05	88	1.1	2.54	0.53	11.3	0.99	58	0.42	< 0.5	n/s	n/s
	E4A (composite of 2 fish)	Atlantic Salmon	37.5	0.029	0.41	6.2	0.19	102	1.08	2.79	2.96	7	1.08	77	0.35	< 0.5	n/s	n/s
	E4B (composite of 2 fish)	Atlantic Salmon	30.1	0.026	0.32	6.4	< 0.05	101	0.83	2.95	0.99	<2.5	1.65	86	0.27	< 0.5	n/s	n/s
	E5A (composite of 2 fish)	Atlantic Salmon	18.1	0.019	0.21	3.8	0.09	92	2.94	2.27	0.95	5.1	1.22	63	0.26	< 0.5	n/s	n/s
	E5B (composite of 2 fish)	Atlantic Salmon	17.2	0.021	0.19	2.3	0.2	98	0.83	1.81	0.61	7.5	1.42	71	0.16	< 0.5	n/s	n/s

Table A6.2a: Summary of Mean Fish Sizes of Wild Juvenile Salmon Captured at Heath Steele, August 1997.
Includes all fish captured and aged by otolith and by length-frequency distribution.

		Atlantic Salmon			
Age Class	Station	Number of Fish	Mean Fork Length (cm)	Mean Total Length (cm)	Mean Whole Weight (g)
0+	HE1	0	-	-	-
	HE2	0	-	-	-
	HE3	0	-	-	-
	HE4	0	-	-	-
	HE5	25	5.8	6.3	2.6
	HR1	0	-	-	-
	HR2	0	-	-	-
	HR3	138	4.7	5.1	1.3
1+	HE1	0	-	-	-
	HE2	0	-	-	-
	HE3	5	10.3	11.0	13.8
	HE4	16	9.7	10.5	10.5
	HE5	79	9.3	10.1	9.4
	HR1	0	-	-	-
	HR2	1	10.4	11.2	14.4
	HR3	62	9.4	10.3	10.5
2+	HE1	0	-	-	-
	HE2	0	-	-	-
	HE3	9	13.6	14.8	30.7
	HE4	30	13.1	14.2	27.7
	HE5	53	12.3	13.5	22.0
	HR1	0	-	-	-
	HR2	0	-	-	-
	HR3	15	11.6	12.7	18.1
3+	HE1	0	-	-	-
	HE2	0	-	-	-
	HE3	7	16.5	17.8	54.7
	HE4	1	15.5	16.6	39.9
	HE5	0	-	-	-
	HR1	0	-	-	-
	HR2	0	-	-	-
	HR3	1	15.0	16.2	42.9

Table A6.2b: Summary of Mean Fish Sizes of Wild Blacknose Dace Captured at Heath Steele, August 1997.
Includes all fish captured and aged by scale and by length-frequency distribution.

Age Class	Station	Number of Fish	Blacknose Dace Mean Fork Length (cm)	Mean Total Length (cm)	Mean Whole Weight (g)
0+	HE1	0	-	-	-
	HE2	0	-	-	-
	HE3	3	2.6	2.8	0.3
	HE4	1	2.2	2.3	0.1
	HE5	8	2.4	2.5	0.2
	HR1	0	-	-	-
	HR2	5	1.9	2.0	<0.1
	HR3	0	-	-	-
1+	HE1	1	4.2	4.5	0.8
	HE2	12	4.5	4.9	1.0
	HE3	7	4.2	4.5	0.9
	HE4	3	5.2	5.6	1.7
	HE5	35	4.9	5.3	1.4
	HR1	13	5.2	5.6	1.5
	HR2	25	4.8	5.1	1.2
	HR3	11	4.7	5.0	1.2
2+	HE1	0	-	-	-
	HE2	16	5.3	5.6	1.7
	HE3	1	5.5	6.0	2.1
	HE4	3	5.3	5.7	1.7
	HE5	24	6.1	6.5	2.6
	HR1	8	5.9	6.3	2.2
	HR2	23	6.1	6.5	2.6
	HR3	1	5.5	5.8	1.9
3+	HE1	0	-	-	-
	HE2	9	6.4	6.9	3.1
	HE3	0	-	-	-
	HE4	7	6.4	6.8	3.2
	HE5	12	6.7	7.2	3.5
	HR1	9	6.7	7.1	3.4
	HR2	10	6.8	7.4	3.7
	HR3	4	6.7	7.1	3.0
4+	HE1	0	-	-	-
	HE2	1	7.1	7.3	4.0
	HE3	0	-	-	-
	HE4	1	7.3	7.8	5.0
	HE5	10	7.2	7.8	4.3
	HR1	7	7.2	7.7	4.3
	HR2	4	7.4	7.9	4.6
	HR3	1	7.7	8.2	5.1
5+	HE1	0	-	-	-
	HE2	0	-	-	-
	HE3	0	-	-	-
	HE4	0	-	-	-
	HE5	4	7.7	8.3	5.5
	HR1	0	-	-	-
	HR2	0	-	-	-
	HR3	0	-	-	-

Table A6.2: Raw Biological Data on All Wild Fish Sampled at Heath Steele, August 1997.

Station	Species	Fish Number	Sample Number	Fork Length (cm)	Total Length (cm)	Whole Weight (g)	Age[1] (y)
HE1B	Brook Trout	1	HE1BBT1-F	12.0	12.5	21.1	nd
HE1B	Blacknose Dace	2	HE1BBD1-F	4.2	4.5	0.8	1+
HE1B	Lake Chub	3	na	6.0	6.6	2.6	nd
HE2A	Brook Trout	1	HE2ABT1-F	13.2	14.0	26.5	nd
HE2A	Brook Trout	2	HE2ABT2-F	15.2	16.0	40.7	nd
HE2A	Brook Trout	3	HE2ABT3-F	13.5	14.2	25.8	nd
HE2A	Brook Trout	4	na	20.1	20.9	97.5	nd
HE2B	Blacknose Dace	1	HE2BBD1-F	4.9	5.3	1.2	1+
HE2B	Blacknose Dace	2	HE2BBD2-F	6.1	6.7	2.6	3+
HE2B	Blacknose Dace	3	HE2BBD3-F	7.5	8.1	5.1	3+
HE2B	Blacknose Dace	4	HE2BBD4-F	6.7	7.2	3.1	3+
HE2B	Blacknose Dace	5	HE2BBD5-F	4.5	4.8	0.9	1+
HE2B	Blacknose Dace	6	HE2BBD6-F	6.6	7.0	3.2	3+
HE2B	Blacknose Dace	7	HE2BBD7-F	6.2	6.7	2.6	3+
HE2B	Blacknose Dace	8	HE2BBD8-F	4.2	4.4	0.8	1+
HE2B	Blacknose Dace	9	HE2BBD9-F	5.8	6.3	2.4	3+
HE2B	Blacknose Dace	10	HE2BBD10-F	6.8	7.2	3.3	2+
HE2B	Blacknose Dace	11	HE2BBD11-F	4.8	5.1	1.0	1+
HE2B	Blacknose Dace	17*	HE2BBD12-F	7.1	7.3	4.0	4+
HE2B	Blacknose Dace	20*	HE2BBD13-F	4.6	4.9	1.0	1+
HE2B	Blacknose Dace	21*	HE2BBD14-F	5.5	5.5	1.7	2+
HE2B	Blacknose Dace	22*	HE2BBD15-F	4.3	4.6	0.9	1+
HE2B	Blacknose Dace	23*	HE2BBD16-F	5.6	6.0	2.1	2+
HE2B	Blacknose Dace	24*	HE2BBD17-F	4.4	4.7	1.0	1+
HE2B	Blacknose Dace	25*	HE2BBD18-F	4.9	5.2	1.3	1+
HE2B	Blacknose Dace	26*	HE2BBD19-F	4.8	5.2	1.4	2+
HE2B	Blacknose Dace	27*	HE2BBD20-F	5.5	6.1	2.2	2+
HE2B	Blacknose Dace	28*	HE2BBD21-F	4.9	5.2	1.2	2+
HE2B	Blacknose Dace	29*	HE2BBD22-F	6.0	6.4	2.8	3+
HE2B	Blacknose Dace	30*	HE2BBD23-F	6.4	6.9	3.2	3+
HE2B	Blacknose Dace	31*	HE2BBD24-F	5.0	5.5	1.4	2+
HE2B	Blacknose Dace	32*	HE2BBD25-F	5.1	5.4	1.5	2+
HE2B	Blacknose Dace	33*	HE2BBD26-F	6.3	6.9	3.3	3+
HE2B	Blacknose Dace	34*	HE2BBD27-F	5.0	5.4	1.4	2+
HE2B	Blacknose Dace	35*	HE2BBD28-F	4.9	5.3	1.4	2+
HE2B	Blacknose Dace	36*	HE2BBD29-F	4.9	5.3	1.3	2+
HE2B	Blacknose Dace	37*	HE2BBD30-F	5.3	5.5	1.3	2+
HE2B	Blacknose Dace	38*	HE2BBD31-F	4.3	4.7	1.0	1+
HE2B	Blacknose Dace	39*	HE2BBD32-F	5.2	5.6	1.7	2+
HE2B	Blacknose Dace	40*	HE2BBD33-F	5.0	5.3	1.4	2+
HE2B	Blacknose Dace	41*	HE2BBD34-F	4.3	4.6	1.0	1+
HE2B	Blacknose Dace	42*	HE2BBD35-F	5.3	5.7	1.7	2+
HE2B	Blacknose Dace	43*	HE2BBD36-F	4.9	5.2	1.2	1+
HE2B	Blacknose Dace	44*	HE2BBD37-F	4.3	4.7	0.9	1+
HE2B	Blacknose Dace	45*	HE2BBD38-F	5.2	5.6	1.8	2+
HE2B	Brook Trout	12	na	21.3	22.5	94.9	nd
HE2B	Brook Trout	13	na	7.8	8.2	4.4	nd
HE2B	Brook Trout	14	na	7.1	7.5	3.6	nd
HE2B	Brook Trout	15	na	5.8	6.2	2.1	nd
HE2B	Brook Trout	16	na	6.1	6.3	2.2	nd
HE2B	Brook Trout	18*	HE2BBT1-F	12.8	13.5	25.6	nd
HE2B	Brook Trout	19*	HE2BBT2-F	11.7	12.4	18.1	nd
HE3A	Atlantic Salmon	1	HE3AAS1-F	12.4	13.5	21.1	2+
HE3A	Atlantic Salmon	2	HE3AAS2-F	12.8	13.7	22.9	2+
HE3A	Atlantic Salmon	47	na	15.0	16.3	40.2	2+
HE3A	Atlantic Salmon	48	na	15.7	17.2	46.0	2+
HE3A	Atlantic Salmon	49	na	17.1	18.3	61.4	3+
HE3A	Atlantic Salmon	50	na	10.7	11.3	16.2	1+
HE3A	Atlantic Salmon	51	na	16.5	18.0	52.6	3+
HE3A	Atlantic Salmon	52	na	17.0	18.3	60.4	3+
HE3A	Atlantic Salmon	57*	HE3AAS3-F	10.7	11.7	16.5	1+
HE3A	Blacknose Dace	5	HE3ABD1-F	4.2	4.5	0.8	1+
HE3A	Blacknose Dace	6	HE3ABD2-F	4.7	5.0	1.1	1+
HE3A	Blacknose Dace	7	HE3ABD3-F	3.8	4.1	0.5	1+
HE3A	Blacknose Dace	8	HE3ABD4-F	3.8	4.2	0.7	1+
HE3A	Blacknose Dace	9	HE3ABD5-F	2.3	2.5	0.2	0+
HE3A	Brook Trout	3	HE3ABT1-F	14.0	14.7	30.0	nd
HE3A	Brook Trout	4	HE3ABT2-F	14.1	14.8	27.4	nd
HE3A	Brook Trout	10	na	6.6	7.0	3.2	nd
HE3A	Brook Trout	11	na	19.4	20.2	85.7	nd
HE3A	Brook Trout	12	na	5.9	6.2	2.1	nd
HE3A	Brook Trout	13	na	6.2	6.5	2.8	nd
HE3A	Brook Trout	14	na	17.1	17.7	52.3	nd
HE3A	Brook Trout	15	na	11.0	11.5	15.5	nd
HE3A	Brook Trout	16	na	7.5	8.0	5.0	nd

Table A6.2: Raw Biological Data on All Wild Fish Sampled at Heath Steele, August 1997.

Station	Species	Fish Number	Sample Number	Fork Length (cm)	Total Length (cm)	Whole Weight (g)	Age[1] (y)
HE3A	Brook Trout	17	na	11.5	12.1	17.0	nd
HE3A	Brook Trout	18	na	5.6	5.9	2.3	nd
HE3A	Brook Trout	19	na	6.9	7.3	3.1	nd
HE3A	Brook Trout	20	na	16.2	16.8	43.8	nd
HE3A	Brook Trout	21	na	6.8	7.2	3.2	nd
HE3A	Brook Trout	22	na	7.0	7.4	4.2	nd
HE3A	Brook Trout	23	na	7.2	7.7	4.4	nd
HE3A	Brook Trout	24	na	14.1	14.9	28.5	nd
HE3A	Brook Trout	25	na	7.1	7.5	3.5	nd
HE3A	Brook Trout	26	na	14.3	15.2	29.9	nd
HE3A	Brook Trout	27	na	6.1	6.4	2.3	nd
HE3A	Brook Trout	28	na	6.2	6.5	2.2	nd
HE3A	Brook Trout	29	na	6.6	6.9	3.0	nd
HE3A	Brook Trout	30	na	15.9	16.2	42.5	nd
HE3A	Brook Trout	31	na	15.2	15.2	35.8	nd
HE3A	Brook Trout	32	na	5.2	5.5	1.8	nd
HE3A	Brook Trout	33	na	6.4	6.7	2.7	nd
HE3A	Brook Trout	34	na	14.8	15.6	27.7	nd
HE3A	Brook Trout	35	na	7.8	8.0	4.7	nd
HE3A	Brook Trout	36	na	5.5	5.8	1.9	nd
HE3A	Brook Trout	37	na	7.1	7.5	4.2	nd
HE3A	Brook Trout	38	na	6.3	6.7	3.2	nd
HE3A	Brook Trout	39	na	6.4	6.8	2.8	nd
HE3A	Brook Trout	40	na	11.8	12.3	16.1	nd
HE3A	Brook Trout	41	na	10.6	11.2	12.9	nd
HE3A	Brook Trout	42	na	12.3	13.1	19.5	nd
HE3A	Brook Trout	43	na	6.2	6.6	2.9	nd
HE3A	Brook Trout	44	na	6.0	6.3	2.2	nd
HE3A	Brook Trout	45	na	5.6	5.8	1.8	nd
HE3A	Brook Trout	46	na	8.0	8.3	5.0	nd
HE3A	Brook Trout	53*	HE3ABT3-F	11.5	12.2	18.4	nd
HE3A	Brook Trout	54*	HE3ABT4-F	12.6	13.2	21.5	nd
HE3A	Brook Trout	55*	HE3ABT5-F	12.0	12.7	21.1	nd
HE3A	Brook Trout	56*	HE3ABT6-F	11.2	11.9	16.7	nd
HE3B	Atlantic Salmon	1	HE3BAS1-F	13.2	14.3	25.9	2+
HE3B	Atlantic Salmon	2	HE3BAS2-F	12.8	14.1	24.2	2+
HE3B	Atlantic Salmon	33	HE3BAS3-F	16.0	17.2	51.5	3+
HE3B	Atlantic Salmon	34	na	10.0	10.8	11.4	1+
HE3B	Atlantic Salmon	35	na	16.5	17.9	51.9	3+
HE3B	Atlantic Salmon	36	na	16.6	18.0	53.8	3+
HE3B	Atlantic Salmon	37	na	15.7	17.1	51.4	3+
HE3B	Atlantic Salmon	38	na	13.9	15.1	32.2	2+
HE3B	Atlantic Salmon	39*	HE3BAS4-F	10.0	10.5	11.8	1+
HE3B	Atlantic Salmon	40*	HE3BAS5-F	10.1	10.9	13.1	1+
HE3B	Atlantic Salmon	41*	HE3BAS6-F	13.9	15.2	35.5	2+
HE3B	Atlantic Salmon	42*	HE3BAS7-F	12.6	13.7	28.6	2+
HE3B	Blacknose Dace	5	HE3BBD1-F	2.8	3.0	0.3	0+
HE3B	Blacknose Dace	6	HE3BBD2-F	2.8	3.0	0.3	0+
HE3B	Blacknose Dace	7	HE3BBD3-F	5.5	6.0	2.1	2+
HE3B	Blacknose Dace	8	HE3BBD4-F	4.4	4.6	1.0	1+
HE3B	Blacknose Dace	9	HE3BBD5-F	4.7	5.1	1.2	1+
HE3B	Blacknose Dace	10	HE3BBD6-F	3.8	4.0	0.7	1+
HE3B	Brook Trout	3	HE3BBT1-F	14.6	15.5	37.1	nd
HE3B	Brook Trout	4	HE3BBT2-F	12.0	12.8	21.0	nd
HE3B	Brook Trout	11	na	16.3	17.2	52.8	nd
HE3B	Brook Trout	12	na	7.1	7.5	4.5	nd
HE3B	Brook Trout	13	na	20.4	21.3	95.2	nd
HE3B	Brook Trout	14	na	6.5	6.9	3.3	nd
HE3B	Brook Trout	16	na	16.8	17.8	56.0	nd
HE3B	Brook Trout	17	na	5.6	5.9	2.2	nd
HE3B	Brook Trout	18	na	7.2	7.7	4.5	nd
HE3B	Brook Trout	20	na	6.6	6.9	3.4	nd
HE3B	Brook Trout	21	na	6.2	6.5	2.5	nd
HE3B	Brook Trout	22	na	11.4	12.0	17.2	nd
HE3B	Brook Trout	23	na	12.3	13.2	21.7	nd
HE3B	Brook Trout	24	na	5.9	6.2	2.7	nd
HE3B	Brook Trout	25	na	6.5	6.8	3.1	nd
HE3B	Brook Trout	26	na	6.3	6.6	3.0	nd
HE3B	Brook Trout	27	HE3BBT3-F	7.6	8.0	4.8	nd
HE3B	Brook Trout	28	na	6.9	7.2	3.6	nd
HE3B	Brook Trout	29	na	6.8	7.1	3.4	nd
HE3B	Brook Trout	30	na	6.2	6.5	2.7	nd
HE3B	Brook Trout	31	na	7.2	7.6	4.1	nd
HE3B	Brook Trout	32	na	5.9	6.2	2.3	nd
HE3B	Brook Trout	43*	HE3BBT4-F	11.6	12.2	18.8	nd

Table A6.2: Raw Biological Data on All Wild Fish Sampled at Heath Steele, August 1997.

Station	Species	Fish Number	Sample Number	Fork Length (cm)	Total Length (cm)	Whole Weight (g)	Age¹ (y)
HE3B	Brook Trout	44*	HE3BBT5-F	13.9	14.7	29.5	nd
HE3B	White Sucker	15	na	18.5	20.6	89.8	nd
HE3B	Creek Chub	19	na	6.0	6.4	2.7	nd
HE4A	Atlantic Salmon	1	HE4AAS1-F	12.2	13.2	21.8	2+
HE4A	Atlantic Salmon	2	HE4AAS2-F	12.4	13.6	26.3	2+
HE4A	Atlantic Salmon	3	HE4AAS3-F	13.0	14.2	29.2	2+
HE4A	Atlantic Salmon	4	HE4AAS4-F	13.5	14.5	30.3	2+
HE4A	Atlantic Salmon	9	HE4AAS5-F	12.8	14.1	28.2	2+
HE4A	Atlantic Salmon	10	na	9.3	10.0	10.6	1+
HE4A	Atlantic Salmon	17	na	14.9	16.2	41.2	2+
HE4A	Atlantic Salmon	19	na	13.8	15.0	33.2	2+
HE4A	Atlantic Salmon	20	na	15.2	16.5	45.5	2+
HE4A	Atlantic Salmon	22	na	14.9	16.0	44.7	2+
HE4A	Atlantic Salmon	23	na	13.4	14.6	33.2	2+
HE4A	Brook Trout	5	HE4ABT1-F	14.3	15.2	32.7	nd
HE4A	Brook Trout	6	HE4ABT2-F	13.5	14.2	27.2	nd
HE4A	Brook Trout	7	HE4ABT3-F	12.4	13.1	21.8	nd
HE4A	Brook Trout	8	HE4ABT4-F	14.9	15.7	34.8	nd
HE4A	Brook Trout	11	na	6.2	6.5	2.1	nd
HE4A	Brook Trout	12	na	5.5	5.8	2.0	nd
HE4A	Brook Trout	13	na	19.7	20.7	93.7	nd
HE4A	Brook Trout	14	na	19.7	21.0	89.3	nd
HE4A	Brook Trout	15	na	16.7	17.2	54.2	nd
HE4A	Brook Trout	16	na	6.0	6.3	2.6	nd
HE4A	Brook Trout	18	na	14.9	15.6	40.8	nd
HE4A	Brook Trout	21	na	15.8	16.7	52.2	nd
HE4A	Brook Trout	24	na	5.8	6.0	2.2	nd
HE4A	Brook Trout	25	na	6.8	7.0	3.2	nd
HE4A	Brook Trout	26	na	5.6	5.8	1.8	nd
HE4B	Atlantic Salmon	1	HE4BAS1-F	10.5	11.1	11.0	1+
HE4B	Atlantic Salmon	2	HE4BAS2-F	9.9	10.7	10.5	1+
HE4B	Atlantic Salmon	3	HE4BAS3-F	12.8	14.1	23.3	2+
HE4B	Atlantic Salmon	4	HE4BAS4-F	12.3	13.4	24.8	2+
HE4B	Atlantic Salmon	5	na	9.9	10.7	11.1	1+
HE4B	Atlantic Salmon	6	na	9.2	10.0	7.5	1+
HE4B	Atlantic Salmon	7	na	12.1	13.5	19.3	2+
HE4B	Atlantic Salmon	8	na	10.3	11.2	12.1	1+
HE4B	Atlantic Salmon	9	na	10.0	10.7	11.5	1+
HE4B	Atlantic Salmon	10	na	14.3	15.6	36.7	2+
HE4B	Atlantic Salmon	11	na	15.0	16.3	38.4	2+
HE4B	Atlantic Salmon	13	na	13.3	14.4	25.9	2+
HE4B	Atlantic Salmon	14	na	8.2	9.1	6.1	1+
HE4B	Atlantic Salmon	15	na	9.0	9.9	7.5	1+
HE4B	Atlantic Salmon	16	na	13.8	15.2	30.8	2+
HE4B	Atlantic Salmon	17	na	11.5	12.5	19.1	2+
HE4B	Atlantic Salmon	18	na	14.6	16.1	37.2	2+
HE4B	Atlantic Salmon	19	na	12.8	13.9	22.6	2+
HE4B	Atlantic Salmon	21	na	12.5	13.5	27.1	2+
HE4B	Atlantic Salmon	22	na	15.5	16.6	39.9	3+
HE4B	Atlantic Salmon	24	na	11.8	12.7	18.5	2+
HE4B	Atlantic Salmon	25	na	9.1	9.9	9.5	1+
HE4B	Atlantic Salmon	26	na	11.6	12.6	17.0	2+
HE4B	Atlantic Salmon	28	na	10.2	11.7	14.7	1+
HE4B	Atlantic Salmon	30	na	11.9	13.0	23.1	2+
HE4B	Atlantic Salmon	31	na	12.3	13.3	20.7	2+
HE4B	Atlantic Salmon	32	na	10.2	11.6	13.2	1+
HE4B	Atlantic Salmon	33	na	11.7	12.7	17.1	2+
HE4B	Atlantic Salmon	35	na	13.3	14.6	28.1	2+
HE4B	Atlantic Salmon	36	na	13.4	14.5	24.8	2+
HE4B	Atlantic Salmon	37	na	9.8	10.6	11.3	1+
HE4B	Atlantic Salmon	38	na	12.2	13.1	19.3	2+
HE4B	Atlantic Salmon	39	na	9.7	10.4	10.4	1+
HE4B	Atlantic Salmon	40	na	9.1	9.8	9.3	1+
HE4B	Atlantic Salmon	62*	HE4BAS5-F	13.0	14.2	22.1	2+
HE4B	Atlantic Salmon	63*	HE4BAS6-F	10.0	10.6	11.5	1+
HE4B	Blacknose Dace	45	na	2.2	2.3	0.1	0+
HE4B	Blacknose Dace	48*	HE4BBD1-F	5.3	5.7	1.6	2+
HE4B	Blacknose Dace	49*	HE4BBD2-F	6.5	6.7	3.2	3+
HE4B	Blacknose Dace	50*	HE4BBD3-F	7.3	7.8	5.0	4+
HE4B	Blacknose Dace	51*	HE4BBD4-F	5.3	5.8	1.8	2+
HE4B	Blacknose Dace	52*	HE4BBD5-F	5.2	5.6	1.8	1+
HE4B	Blacknose Dace	53*	HE4BBD6-F	6.2	6.7	3.2	3+
HE4B	Blacknose Dace	54*	HE4BBD7-F	6.2	6.6	2.7	3+
HE4B	Blacknose Dace	55*	HE4BBD8-F	5.3	5.7	1.7	2+
HE4B	Blacknose Dace	56*	HE4BBD9-F	6.3	6.9	3.2	3+

Table A6.2: Raw Biological Data on All Wild Fish Sampled at Heath Steele, August 1997.

Station	Species	Fish Number	Sample Number	Fork Length (cm)	Total Length (cm)	Whole Weight (g)	Age[1] (y)
HE4B	Blacknose Dace	57*	HE4BBD10-F	6.4	7.0	3.4	3+
HE4B	Blacknose Dace	58*	HE4BBD11-F	5.5	6.0	2.0	1+
HE4B	Blacknose Dace	59*	HE4BBD12-F	6.5	7.0	3.6	3+
HE4B	Blacknose Dace	60*	HE4BBD13-F	6.4	7.0	3.0	3+
HE4B	Blacknose Dace	61*	HE4BBD14-F	4.9	5.3	1.2	1+
HE4B	Brook Trout	12	na	16.4	17.9	52.3	nd
HE4B	Brook Trout	20	na	6.6	7.0	3.0	nd
HE4B	Brook Trout	23	na	6.9	7.1	3.6	nd
HE4B	Brook Trout	27	na	6.1	6.4	2.5	nd
HE4B	Brook Trout	29	na	6.8	7.1	3.0	nd
HE4B	Brook Trout	34	na	17.7	18.4	60.8	nd
HE4B	Brook Trout	41	na	6.8	7.2	3.3	nd
HE4B	Brook Trout	42	na	12.8	13.5	22.1	nd
HE4B	Brook Trout	43	na	10.1	10.6	10.7	nd
HE4B	Brook Trout	46	na	6.4	6.7	12.8	nd
HE4B	Brook Trout	47	na	5.9	6.1	2.0	nd
HE4B	Brook Trout	64*	HE4BBT1-F	14.0	14.9	28.7	nd
HE4B	Brook Trout	65*	HE4BBT2-F	11.9	12.7	19.0	nd
HE4B	Brook Trout	66*	HE4BBT3-F	11.0	11.7	14.2	nd
HE4B	Brook Trout	67*	HE4BBT4-F	10.7	11.3	12.5	nd
HE4B	Lake Chub	44	na	6.7	7.2	3.3	nd
HE5A	Atlantic Salmon	1	HE5AAS1-F	12.8	14.3	22.9	2+
HE5A	Atlantic Salmon	2	HE5AAS2-F	13.1	14.3	30.0	2+
HE5A	Atlantic Salmon	3	HE5AAS3-F	10.9	11.8	15.9	1+
HE5A	Atlantic Salmon	4	HE5AAS4-F	10.6	11.3	15.1	1+
HE5A	Atlantic Salmon	5	HE5AAS5-F	11.7	12.8	16.8	2+
HE5A	Atlantic Salmon	6	HE5AAS6-F	8.8	9.6	7.3	1+
HE5A	Atlantic Salmon	7	HE5AAS7-F	10.2	11.3	12.3	1+
HE5A	Atlantic Salmon	8	HE5AAS8-F	7.8	8.5	5.1	1+
HE5A	Atlantic Salmon	9	HE5AAS9-F	13.8	15.2	27.6	2+
HE5A	Atlantic Salmon	15	na	12.5	13.7	24.8	2+
HE5A	Atlantic Salmon	17	na	9.2	10.2	8.3	1+
HE5A	Atlantic Salmon	18	na	12.5	13.9	25.0	2+
HE5A	Atlantic Salmon	19	na	11.2	12.3	15.3	1+
HE5A	Atlantic Salmon	20	na	11.1	11.8	14.0	1+
HE5A	Atlantic Salmon	21	na	13.5	14.8	28.9	2+
HE5A	Atlantic Salmon	22	na	10.0	10.8	11.0	1+
HE5A	Atlantic Salmon	23	na	10.5	11.4	12.7	1+
HE5A	Atlantic Salmon	24	na	8.9	9.7	8.6	1+
HE5A	Atlantic Salmon	25	na	9.9	10.6	9.3	1+
HE5A	Atlantic Salmon	26	na	11.0	12.2	17.3	2+
HE5A	Atlantic Salmon	27	na	8.8	9.6	7.4	1+
HE5A	Atlantic Salmon	28	na	12.9	14.2	22.9	2+
HE5A	Atlantic Salmon	29	na	13.8	14.9	33.3	2+
HE5A	Atlantic Salmon	30	na	12.7	13.2	22.7	2+
HE5A	Atlantic Salmon	31	na	10.0	11.0	10.7	1+
HE5A	Atlantic Salmon	32	na	8.5	9.3	7.7	1+
HE5A	Atlantic Salmon	33	na	9.0	9.7	7.2	1+
HE5A	Atlantic Salmon	34	na	8.0	8.7	6.1	1+
HE5A	Atlantic Salmon	35	na	6.4	7.0	3.4	0+
HE5A	Atlantic Salmon	36	na	6.1	6.6	2.7	0+
HE5A	Atlantic Salmon	37	na	10.3	11.7	12.7	1+
HE5A	Atlantic Salmon	38	na	8.9	9.7	8.2	1+
HE5A	Atlantic Salmon	39	na	8.0	8.7	6.4	1+
HE5A	Atlantic Salmon	40	na	8.9	9.7	7.6	1+
HE5A	Atlantic Salmon	41	na	8.2	8.9	5.0	1+
HE5A	Atlantic Salmon	42	na	8.7	9.4	7.0	1+
HE5A	Atlantic Salmon	43	na	5.8	6.3	2.4	0+
HE5A	Atlantic Salmon	44	na	9.2	10.1	8.7	1+
HE5A	Atlantic Salmon	45	na	8.4	9.1	6.4	1+
HE5A	Atlantic Salmon	46	na	8.2	8.9	6.6	1+
HE5A	Atlantic Salmon	47	na	12.3	13.2	23.2	2+
HE5A	Atlantic Salmon	48	na	6.0	6.4	2.0	0+
HE5A	Atlantic Salmon	49	na	8.3	9.2	6.2	1+
HE5A	Atlantic Salmon	50	na	8.2	8.8	6.5	1+
HE5A	Atlantic Salmon	51	na	11.2	12.2	14.3	1+
HE5A	Atlantic Salmon	52	na	9.3	10.2	8.9	1+
HE5A	Atlantic Salmon	53	na	10.3	11.3	10.2	1+
HE5A	Atlantic Salmon	54	na	9.2	10.1	8.5	1+
HE5A	Atlantic Salmon	55	na	9.2	10.0	8.6	1+
HE5A	Atlantic Salmon	56	na	8.0	8.7	5.3	1+
HE5A	Atlantic Salmon	57	na	8.9	9.7	6.9	1+
HE5A	Atlantic Salmon	58	na	9.3	10.1	7.9	1+
HE5A	Atlantic Salmon	59	na	8.7	9.4	7.2	1+
HE5A	Atlantic Salmon	60	na	10.0	10.8	11.0	1+

Table A6.2: Raw Biological Data on All Wild Fish Sampled at Heath Steele, August 1997.

Station	Species	Fish Number	Sample Number	Fork Length (cm)	Total Length (cm)	Whole Weight (g)	Age[1] (y)
HE5A	Atlantic Salmon	61	na	12.5	13.7	19.7	2+
HE5A	Atlantic Salmon	62	na	7.5	8.2	4.5	1+
HE5A	Atlantic Salmon	63	na	12.1	13.2	22.2	2+
HE5A	Atlantic Salmon	64	na	11.5	12.5	16.4	2+
HE5A	Atlantic Salmon	65	na	9.2	10.2	8.2	1+
HE5A	Atlantic Salmon	66	na	8.1	8.8	6.2	1+
HE5A	Atlantic Salmon	67	na	10.2	11.1	13.2	1+
HE5A	Atlantic Salmon	68	na	9.2	10.1	8.6	1+
HE5A	Atlantic Salmon	69	na	9.0	9.7	7.7	1+
HE5A	Atlantic Salmon	70	na	12.1	13.2	21.6	2+
HE5A	Atlantic Salmon	71	na	10.5	11.7	13.5	1+
HE5A	Atlantic Salmon	72	na	13.2	14.4	26.9	2+
HE5A	Atlantic Salmon	73	na	12.3	13.4	19.7	2+
HE5A	Atlantic Salmon	74	na	11.6	12.6	16.4	2+
HE5A	Atlantic Salmon	75	na	12.2	13.3	19.4	2+
HE5A	Atlantic Salmon	76	na	11.7	12.6	17.5	2+
HE5A	Atlantic Salmon	77	na	12.3	13.4	23.1	2+
HE5A	Atlantic Salmon	78	na	9.3	10.2	9.5	1+
HE5A	Atlantic Salmon	79	na	12.7	13.7	24.2	2+
HE5A	Atlantic Salmon	80	na	12.7	13.8	22.5	2+
HE5A	Atlantic Salmon	81	na	11.7	12.6	15.4	2+
HE5A	Atlantic Salmon	83	na	11.8	12.9	19.5	2+
HE5A	Atlantic Salmon	84	na	9.9	10.8	10.8	1+
HE5A	Atlantic Salmon	85	na	5.7	6.2	2.2	0+
HE5A	Atlantic Salmon	86	na	8.7	9.3	6.5	1+
HE5A	Atlantic Salmon	87	na	9.4	10.3	9.8	1+
HE5A	Atlantic Salmon	88	na	8.7	9.2	7.1	1+
HE5A	Atlantic Salmon	89	na	7.7	8.3	5.6	1+
HE5A	Blacknose Dace	118	HE5ABD1-F	4.9	5.2	1.4	1+
HE5A	Blacknose Dace	119	HE5ABD2-F	5.8	6.2	2.2	2+
HE5A	Blacknose Dace	120	HE5ABD3-F	7.4	7.9	4.1	4+
HE5A	Blacknose Dace	121	HE5ABD4-F	6.2	6.5	2.9	2+
HE5A	Blacknose Dace	122	HE5ABD5-F	7.2	7.6	3.7	4+
HE5A	Blacknose Dace	123	HE5ABD6-F	6.5	7.9	2.7	2+
HE5A	Blacknose Dace	124	HE5ABD7-F	6.8	7.3	3.7	3+
HE5A	Blacknose Dace	125	HE5ABD8-F	5.2	5.4	1.6	2+
HE5A	Blacknose Dace	126	HE5ABD9-F	6.3	6.6	2.6	2+
HE5A	Blacknose Dace	127	HE5ABD10-F	6.3	6.7	2.8	2+
HE5A	Blacknose Dace	128	HE5ABD11-F	7.1	7.6	4.1	4+
HE5A	Blacknose Dace	129	HE5ABD12-F	6.9	7.3	3.4	3+
HE5A	Blacknose Dace	130	HE5ABD13-F	7.3	8.2	4.5	4+
HE5A	Blacknose Dace	131	HE5ABD14-F	7.4	7.9	4.4	4+
HE5A	Blacknose Dace	132	HE5ABD15-F	7.4	7.9	4.7	4+
HE5A	Blacknose Dace	133	HE5ABD16-F	8.2	8.9	5.8	5+
HE5A	Blacknose Dace	134	HE5ABD17-F	6.6	6.9	2.8	2+
HE5A	Blacknose Dace	135	HE5ABD18-F	5.8	6.2	2.3	2+
HE5A	Blacknose Dace	136	HE5ABD19-F	5.0	5.4	1.4	1+
HE5A	Blacknose Dace	137	HE5ABD20-F	5.8	6.1	1.8	2+
HE5A	Blacknose Dace	138	HE5ABD21-F	5.2	5.5	1.6	1+
HE5A	Blacknose Dace	139	HE5ABD22-F	6.7	7.2	3.2	2+
HE5A	Blacknose Dace	140	HE5ABD23-F	7.1	7.6	3.9	4+
HE5A	Blacknose Dace	141	HE5ABD24-F	6.3	6.8	2.6	2+
HE5A	Blacknose Dace	142	HE5ABD25-F	5.0	5.4	1.4	1+
HE5A	Blacknose Dace	143	HE5ABD26-F	6.6	7.1	3.0	3+
HE5A	Blacknose Dace	144	HE5ABD27-F	6.8	7.3	3.1	3+
HE5A	Blacknose Dace	145	HE5ABD28-F	5.8	6.1	2.2	2+
HE5A	Blacknose Dace	146	HE5ABD29-F	4.7	5.0	1.3	1+
HE5A	Blacknose Dace	147	HE5ABD30-F	5.1	5.5	1.6	1+
HE5A	Blacknose Dace	148	HE5ABD31-F	5.0	5.3	1.3	1+
HE5A	Blacknose Dace	149	HE5ABD32-F	6.2	6.6	2.7	2+
HE5A	Blacknose Dace	150	HE5ABD33-F	5.0	5.3	1.3	1+
HE5A	Blacknose Dace	151	HE5ABD34-F	5.7	6.2	2.2	2+
HE5A	Blacknose Dace	152	HE5ABD35-F	5.6	6.0	1.8	2+
HE5A	Blacknose Dace	153	HE5ABD36-F	4.7	5.0	1.2	1+
HE5A	Blacknose Dace	154	HE5ABD37-F	5.0	5.4	1.5	1+
HE5A	Blacknose Dace	155	HE5ABD38-F	5.0	5.3	1.2	1+
HE5A	Blacknose Dace	156	HE5ABD39-F	5.0	5.3	1.2	1+
HE5A	Blacknose Dace	157	HE5ABD40-F	4.4	4.8	0.9	1+
HE5A	Blacknose Dace	158	HE5ABD41-F	4.5	4.8	1.0	1+
HE5A	Blacknose Dace	159	HE5ABD42-F	4.0	4.2	0.7	1+
HE5A	Blacknose Dace	160	na	2.2	2.3	0.2	0+
HE5A	Blacknose Dace	161	na	2.2	2.4	0.1	0+
HE5A	Blacknose Dace	162	na	2.4	2.4	0.1	0+
HE5A	Blacknose Dace	163	na	2.6	2.8	0.3	0+
HE5A	Blacknose Dace	164	na	2.1	2.3	0.1	0+

Table A6.2: Raw Biological Data on All Wild Fish Sampled at Heath Steele, August 1997.

Station	Species	Fish Number	Sample Number	Fork Length (cm)	Total Length (cm)	Whole Weight (g)	Age[1] (y)
HE5A	Brook Trout	10	na	19.9	20.7	97.4	nd
HE5A	Brook Trout	11	HE5ABT1-F	14.7	15.5	34.7	nd
HE5A	Brook Trout	12	HE5ABT2-F	13.2	14.0	27.1	nd
HE5A	Brook Trout	13	HE5ABT3-F	13.0	13.6	23.0	nd
HE5A	Brook Trout	14	HE5ABT4-F	12.2	12.7	20.9	nd
HE5A	Brook Trout	16	na	17.2	18.0	61.0	nd
HE5A	Brook Trout	82	na	10.7	11.3	13.5	nd
HE5A	Brook Trout	90	na	5.0	5.3	1.6	nd
HE5A	Brook Trout	91	na	10.4	10.9	11.4	nd
HE5A	Brook Trout	92	na	4.6	4.8	1.2	nd
HE5A	Brook Trout	93	na	6.1	6.5	3.0	nd
HE5A	Brook Trout	94	na	5.8	6.2	2.6	nd
HE5A	Brook Trout	95	na	4.2	4.4	0.7	nd
HE5A	Brook Trout	96	na	6.1	6.4	2.4	nd
HE5A	Lake Chub	97	HE5ALC1-F	11.3	12.4	20.9	nd
HE5A	Lake Chub	98	HE5ALC2-F	11.8	12.2	22.0	nd
HE5A	Lake Chub	99	HE5ALC3-F	11.0	11.8	20.9	nd
HE5A	Lake Chub	100	HE5ALC4-F	11.1	12.0	18.4	nd
HE5A	Lake Chub	101	HE5ALC5-F	11.0	11.8	19.8	nd
HE5A	Lake Chub	102	HE5ALC6-F	10.4	11.2	129.0	nd
HE5A	Lake Chub	103	HE5ALC7-F	12.1	13.0	22.7	nd
HE5A	Lake Chub	104	HE5ALC8-F	10.2	11.1	15.0	nd
HE5A	Lake Chub	105	HE5ALC9-F	6.8	7.3	3.6	nd
HE5A	Lake Chub	106	HE5ALC10-F	7.0	7.6	3.9	nd
HE5A	Lake Chub	107	HE5ALC11-F	5.8	6.2	2.2	nd
HE5A	Lake Chub	108	HE5ALC12-F	6.8	7.3	3.6	nd
HE5A	Creek Chub	110	na	5.4	5.7	1.6	nd
HE5A	Creek Chub	111	na	5.0	5.3	1.4	nd
HE5A	Creek Chub	112	na	4.2	4.6	0.9	nd
HE5A	9-Spine Stickleback	109	na	na	5.7	1.4	nd
HE5A	Slimy Sculpin	113	na	na	7.9	5.3	nd
HE5A	Slimy Sculpin	114	na	na	7.3	4.4	nd
HE5A	Slimy Sculpin	115	na	na	3.0	0.3	nd
HE5A	Slimy Sculpin	116	na	na	3.5	0.4	nd
HE5A	Slimy Sculpin	117	na	na	3.5	0.4	nd
HE5B	Atlantic Salmon	1	HE5BAS1-F	12.0	13.0	21.3	2+
HE5B	Atlantic Salmon	2	HE5BAS2-F	12.0	13.2	20.3	2+
HE5B	Atlantic Salmon	3	HE5BAS3-F	10.5	11.4	13.7	1+
HE5B	Atlantic Salmon	4	HE5BAS4-F	10.8	11.6	13.8	1+
HE5B	Atlantic Salmon	5	HE5BAS5-F	10.8	11.7	14.7	1+
HE5B	Atlantic Salmon	9	na	12.9	14.0	23.0	2+
HE5B	Atlantic Salmon	10	na	13.6	15.0	29.2	2+
HE5B	Atlantic Salmon	11	na	13.2	14.2	25.9	2+
HE5B	Atlantic Salmon	12	na	12.5	13.7	24.7	2+
HE5B	Atlantic Salmon	13	na	13.1	14.3	25.8	2+
HE5B	Atlantic Salmon	14	na	12.3	13.6	19.4	2+
HE5B	Atlantic Salmon	15	na	13.7	15.0	28.8	2+
HE5B	Atlantic Salmon	16	na	12.5	13.6	22.4	2+
HE5B	Atlantic Salmon	17	na	12.4	13.7	23.5	2+
HE5B	Atlantic Salmon	18	na	12.5	13.1	22.0	2+
HE5B	Atlantic Salmon	19	na	13.2	14.5	25.4	2+
HE5B	Atlantic Salmon	23	na	12.6	14.0	21.0	2+
HE5B	Atlantic Salmon	25	na	12.9	14.1	25.5	2+
HE5B	Atlantic Salmon	26	na	12.1	13.3	20.3	2+
HE5B	Atlantic Salmon	27	HE5BAS6-F	12.0	13.1	19.8	2+
HE5B	Atlantic Salmon	28	na	12.4	13.6	22.7	2+
HE5B	Atlantic Salmon	29	na	11.6	12.7	18.9	2+
HE5B	Atlantic Salmon	30	na	11.6	12.8	18.1	2+
HE5B	Atlantic Salmon	31	na	12.0	13.0	22.7	2+
HE5B	Atlantic Salmon	32	na	11.8	12.6	18.7	2+
HE5B	Atlantic Salmon	33	na	10.7	11.6	17.4	1+
HE5B	Atlantic Salmon	34	na	11.4	12.4	19.0	2+
HE5B	Atlantic Salmon	35	na	12.0	13.1	18.5	2+
HE5B	Atlantic Salmon	36	na	11.0	12.1	15.4	2+
HE5B	Atlantic Salmon	37	na	11.4	12.3	17.9	2+
HE5B	Atlantic Salmon	38	na	8.7	9.4	6.7	1+
HE5B	Atlantic Salmon	39	na	10.0	10.8	11.8	1+
HE5B	Atlantic Salmon	45	na	10.7	11.6	13.3	1+
HE5B	Atlantic Salmon	46	na	9.9	10.7	10.8	1+
HE5B	Atlantic Salmon	47	na	9.7	10.5	9.7	1+
HE5B	Atlantic Salmon	48	na	10.2	11.1	11.6	1+
HE5B	Atlantic Salmon	49	na	10.2	11.2	12.0	1+
HE5B	Atlantic Salmon	50	na	10.2	11.0	12.9	1+
HE5B	Atlantic Salmon	51	na	9.0	9.9	9.5	1+
HE5B	Atlantic Salmon	52	na	10.8	11.8	14.0	1+

Table A6.2: Raw Biological Data on All Wild Fish Sampled at Heath Steele, August 1997.

Station	Species	Fish Number	Sample Number	Fork Length (cm)	Total Length (cm)	Whole Weight (g)	Age[1] (y)
HE5B	Atlantic Salmon	53	na	10.3	11.3	14.1	1+
HE5B	Atlantic Salmon	54	na	9.1	10.0	10.0	1+
HE5B	Atlantic Salmon	55	na	8.7	9.3	6.8	1+
HE5B	Atlantic Salmon	56	na	9.5	10.4	11.1	1+
HE5B	Atlantic Salmon	57	na	9.3	10.3	10.1	1+
HE5B	Atlantic Salmon	58	na	8.6	9.4	8.4	1+
HE5B	Atlantic Salmon	59	na	9.0	9.7	7.9	1+
HE5B	Atlantic Salmon	60	na	8.5	9.3	6.6	1+
HE5B	Atlantic Salmon	61	na	8.5	9.3	7.4	1+
HE5B	Atlantic Salmon	62	na	10.8	11.9	14.0	2+
HE5B	Atlantic Salmon	63	na	9.0	9.7	8.7	1+
HE5B	Atlantic Salmon	64	na	8.4	9.2	7.1	1+
HE5B	Atlantic Salmon	65	na	8.4	9.1	6.2	1+
HE5B	Atlantic Salmon	66	na	9.0	9.9	8.6	1+
HE5B	Atlantic Salmon	67	na	7.5	8.2	4.8	1+
HE5B	Atlantic Salmon	68	na	5.6	6.2	2.2	0+
HE5B	Atlantic Salmon	69	na	6.0	6.5	2.9	0+
HE5B	Atlantic Salmon	70	na	6.1	6.6	3.1	0+
HE5B	Atlantic Salmon	71	na	5.5	6.0	2.8	0+
HE5B	Atlantic Salmon	72	na	5.3	5.6	2.0	0+
HE5B	Atlantic Salmon	73	na	5.7	6.1	2.7	0+
HE5B	Atlantic Salmon	74	na	5.9	6.3	2.7	0+
HE5B	Atlantic Salmon	75	na	6.4	7.0	3.3	0+
HE5B	Atlantic Salmon	76	na	5.4	5.8	2.1	0+
HE5B	Atlantic Salmon	77	na	6.1	6.4	2.7	0+
HE5B	Atlantic Salmon	78	na	5.0	5.5	1.9	0+
HE5B	Atlantic Salmon	79	na	6.0	6.4	2.9	0+
HE5B	Atlantic Salmon	80	na	5.7	6.1	2.6	0+
HE5B	Atlantic Salmon	81	na	6.0	6.4	2.7	0+
HE5B	Atlantic Salmon	82	na	5.1	5.5	1.6	0+
HE5B	Atlantic Salmon	83	na	5.7	6.1	2.3	0+
HE5B	Atlantic Salmon	84	na	6.1	6.5	3.1	0+
HE5B	Atlantic Salmon	85	na	6.0	6.5	2.8	0+
HE5B	Atlantic Salmon	86	na	6.1	6.5	3.1	0+
HE5B	Atlantic Salmon	87	na	5.6	6.1	2.2	0+
HE5B	Blacknose Dace	6	HE5BBD1-F	8.0	8.6	6.3	5+
HE5B	Blacknose Dace	7	HE5BBD2-F	6.5	7.0	3.4	3+
HE5B	Blacknose Dace	90	HE5BBD3-F	6.5	6.9	2.9	2+
HE5B	Blacknose Dace	91	HE5BBD4-F	7.0	7.5	4.4	4+
HE5B	Blacknose Dace	92	HE5BBD5-F	7.5	8.0	5.3	5+
HE5B	Blacknose Dace	93	HE5BBD6-F	6.5	7.0	3.5	3+
HE5B	Blacknose Dace	94	HE5BBD7-F	6.3	6.6	2.9	2+
HE5B	Blacknose Dace	95	HE5BBD8-F	7.2	7.6	4.6	5+
HE5B	Blacknose Dace	96	HE5BBD9-F	6.9	7.3	3.9	3+
HE5B	Blacknose Dace	97	HE5BBD10-F	6.1	6.5	3.1	2+
HE5B	Blacknose Dace	98	HE5BBD11-F	6.9	7.4	4.9	4+
HE5B	Blacknose Dace	99	HE5BBD12-F	6.5	6.9	3.2	3+
HE5B	Blacknose Dace	100	HE5BBD13-F	5.1	5.5	1.6	1+
HE5B	Blacknose Dace	101	HE5BBD14-F	6.0	6.3	2.9	2+
HE5B	Blacknose Dace	102	HE5BBD15-F	6.5	6.9	3.3	2+
HE5B	Blacknose Dace	103	HE5BBD16-F	4.9	5.2	1.5	1+
HE5B	Blacknose Dace	104	HE5BBD17-F	5.0	5.3	1.5	1+
HE5B	Blacknose Dace	105	HE5BBD18-F	5.5	5.8	2.2	2+
HE5B	Blacknose Dace	106	HE5BBD19-F	5.0	5.3	1.5	1+
HE5B	Blacknose Dace	107	HE5BBD20-F	4.9	5.2	1.4	1+
HE5B	Blacknose Dace	108	HE5BBD21-F	6.9	7.4	3.8	3+
HE5B	Blacknose Dace	109	HE5BBD22-F	6.4	6.9	3.2	3+
HE5B	Blacknose Dace	110	HE5BBD23-F	5.5	5.9	1.9	1+
HE5B	Blacknose Dace	111	HE5BBD24-F	5.3	5.6	1.9	1+
HE5B	Blacknose Dace	112	HE5BBD25-F	7.3	7.9	4.4	4+
HE5B	Blacknose Dace	113	HE5BBD26-F	6.9	7.4	3.6	3+
HE5B	Blacknose Dace	114	HE5BBD27-F	4.9	5.2	1.6	1+
HE5B	Blacknose Dace	115	HE5BBD28-F	6.3	6.7	3.4	2+
HE5B	Blacknose Dace	116	HE5BBD29-F	6.1	6.6	2.9	2+
HE5B	Blacknose Dace	117	HE5BBD30-F	6.2	6.6	2.6	2+
HE5B	Blacknose Dace	118	HE5BBD31-F	4.6	4.9	1.2	1+
HE5B	Blacknose Dace	119	HE5BBD32-F	5.3	5.6	1.8	1+
HE5B	Blacknose Dace	120	HE5BBD33-F	5.2	5.6	2.1	1+
HE5B	Blacknose Dace	121	HE5BBD34-F	5.3	5.6	1.8	1+
HE5B	Blacknose Dace	122	HE5BBD35-F	4.7	5.0	1.2	1+
HE5B	Blacknose Dace	123	HE5BBD36-F	5.2	5.6	1.6	1+
HE5B	Blacknose Dace	124	HE5BBD37-F	5.0	5.5	1.7	1+
HE5B	Blacknose Dace	125	HE5BBD38-F	4.7	5.0	1.3	1+
HE5B	Blacknose Dace	126	HE5BBD39-F	4.9	5.2	1.2	1+
HE5B	Blacknose Dace	127	HE5BBD40-F	5.2	5.6	1.7	1+

Table A6.2: Raw Biological Data on All Wild Fish Sampled at Heath Steele, August 1997.

Station	Species	Fish Number	Sample Number	Fork Length (cm)	Total Length (cm)	Whole Weight (g)	Age[1] (y)
HE5B	Blacknose Dace	128	HE5BBD41-F	4.5	4.9	1.1	1+
HE5B	Blacknose Dace	129	HE5BBD42-F	6.7	7.2	3.6	3+
HE5B	Blacknose Dace	130	HE5BBD43-F	5.2	5.5	1.6	1+
HE5B	Blacknose Dace	131	HE5BBD44-F	3.0	3.2	0.4	0+
HE5B	Blacknose Dace	132	na	2.1	2.3	0.1	0+
HE5B	Blacknose Dace	134	na	2.2	2.3	0.1	0+
HE5B	Brook Trout	20	HE5BBT1-F	13.1	13.7	24.5	nd
HE5B	Brook Trout	21	HE5BBT2-F	14.2	15.0	31.6	nd
HE5B	Brook Trout	22	HE5BBT3-F	15.3	16.2	40.3	nd
HE5B	Brook Trout	24	na	16.4	18.5	55.7	nd
HE5B	Brook Trout	88	na	6.3	6.5	2.3	nd
HE5B	Brook Trout	89	na	7.3	7.6	4.2	nd
HE5B	Lake Chub	40	HE5BLC1-F	11.8	12.7	22.0	nd
HE5B	Lake Chub	41	HE5BLC2-F	11.2	12.2	19.1	nd
HE5B	Lake Chub	42	HE5BLC3-F	10.3	11.2	15.0	nd
HE5B	Lake Chub	43	HE5BLC4-F	11.7	12.6	19.0	nd
HE5B	Lake Chub	44	HE5BLC5-F	11.1	12.1	17.2	nd
HE5B	Lake Chub	135	na	7.5	8.3	4.5	nd
HE5B	Lake Chub	136	na	7.1	7.8	4.7	nd
HE5B	Lake Chub	137	na	6.8	7.5	3.4	nd
HE5B	White Sucker	8	na	15.0	16.1	44.2	nd
HE5B	Creek Chub	133	na	7.0	7.6	4.0	nd
HR1A	Blacknose Dace	204	HR1ABD1-F	5.8	6.3	1.9	1+
HR1A	Blacknose Dace	205	HR1ABD2-F	7.3	7.8	4.7	4+
HR1A	Blacknose Dace	206	HR1ABD3-F	7.1	7.6	4.3	4+
HR1A	Blacknose Dace	207	HR1ABD4-F	4.6	5.0	1.1	1+
HR1A	Blacknose Dace	208	HR1ABD5-F	6.9	7.4	4.0	3+
HR1A	Blacknose Dace	209	HR1ABD6-F	6.7	7.2	3.1	3+
HR1A	Blacknose Dace	210	HR1ABD7-F	6.8	7.3	3.5	2+
HR1A	Blacknose Dace	211	HR1ABD8-F	6.6	7.1	3.6	3+
HR1A	Blacknose Dace	212	HR1ABD9-F	6.6	7.1	3.2	3+
HR1A	Blacknose Dace	213	HR1ABD10-F	6.0	6.5	2.3	2+
HR1A	Blacknose Dace	214	HR1ABD11-F	5.3	5.7	1.7	1+
HR1A	Blacknose Dace	215	HR1ABD12-F	5.7	6.1	2.1	2+
HR1A	Brook Trout	1	HR1ABT1-F	13.6	14.2	26.0	nd
HR1A	Brook Trout	2	HR1ABT2-F	13.9	14.6	29.9	nd
HR1A	Brook Trout	3	HR1ABT3-F	14.2	14.8	32.5	nd
HR1A	Brook Trout	4	HR1ABT4-F	13.0	13.7	25.9	nd
HR1A	Brook Trout	5	HR1ABT5-F	12.8	13.6	22.4	nd
HR1A	Brook Trout	6	HR1ABT6-F	11.8	12.3	19.6	nd
HR1A	Brook Trout	7	na	18.0	18.6	75.0	nd
HR1A	Brook Trout	8	na	16.8	17.5	55.2	nd
HR1A	Brook Trout	9	na	15.4	16.1	40.4	nd
HR1A	Brook Trout	10	na	11.8	12.3	18.9	nd
HR1A	Brook Trout	11	na	10.9	11.5	11.9	nd
HR1A	Brook Trout	12	na	12.1	12.8	20.0	nd
HR1A	Brook Trout	13	na	7.1	7.5	4.5	nd
HR1A	Brook Trout	14	na	6.1	6.4	2.6	nd
HR1A	Brook Trout	15	na	10.0	10.5	10.8	nd
HR1A	Brook Trout	16	na	6.7	7.2	3.5	nd
HR1A	Brook Trout	17	na	7.1	7.5	4.0	nd
HR1A	Brook Trout	18	na	11.3	12.0	15.5	nd
HR1A	Brook Trout	19	na	6.9	7.3	4.2	nd
HR1A	Brook Trout	20	na	10.7	11.1	14.5	nd
HR1A	Brook Trout	21	na	6.9	7.3	4.2	nd
HR1A	Brook Trout	22	na	7.2	7.6	4.6	nd
HR1A	Brook Trout	23	na	6.2	6.5	3.1	nd
HR1A	Brook Trout	24	na	6.7	7.2	4.2	nd
HR1A	Brook Trout	25	na	6.7	7.0	4.1	nd
HR1A	Brook Trout	26	na	6.5	6.9	3.5	nd
HR1A	Brook Trout	27	na	6.5	6.8	2.8	nd
HR1A	Brook Trout	28	na	7.3	7.8	4.7	nd
HR1A	Brook Trout	29	na	7.6	8.1	4.8	nd
HR1A	Brook Trout	30	na	6.3	6.6	3.1	nd
HR1A	Brook Trout	31	na	7.1	7.5	4.0	nd
HR1A	Brook Trout	32	na	7.4	7.7	4.6	nd
HR1A	Brook Trout	33	na	7.9	8.3	5.7	nd
HR1A	Brook Trout	34	na	6.3	6.6	3.1	nd
HR1A	Brook Trout	35	na	10.2	10.7	11.5	nd
HR1A	Brook Trout	36	na	7.7	8.0	6.1	nd
HR1A	Brook Trout	37	na	7.0	7.4	4.0	nd
HR1A	Brook Trout	38	na	7.3	7.6	4.8	nd
HR1A	Brook Trout	39	na	10.3	10.7	11.5	nd
HR1A	Brook Trout	40	na	10.9	11.5	13.4	nd
HR1A	Brook Trout	41	na	6.8	7.2	3.3	nd

Table A6.2: Raw Biological Data on All Wild Fish Sampled at Heath Steele, August 1997.

Station	Species	Fish Number	Sample Number	Fork Length (cm)	Total Length (cm)	Whole Weight (g)	Age[1] (y)
HR1A	Brook Trout	42	na	6.4	6.8	2.8	nd
HR1A	Brook Trout	43	na	6.7	6.9	3.4	nd
HR1A	Brook Trout	44	na	6.0	6.3	2.5	nd
HR1A	Brook Trout	45	na	6.3	6.6	2.6	nd
HR1A	Brook Trout	46	na	6.6	6.9	3.1	nd
HR1A	Brook Trout	47	na	19.9	20.9	109.8	nd
HR1A	Brook Trout	48	na	13.6	14.2	25.8	nd
HR1A	Brook Trout	49	na	6.2	6.7	2.6	nd
HR1A	Brook Trout	50	na	15.1	15.7	43.5	nd
HR1A	Brook Trout	51	na	12.0	12.6	21.6	nd
HR1A	Brook Trout	55	na	12.1	12.8	18.8	nd
HR1A	Brook Trout	56	na	11.0	11.7	15.0	nd
HR1A	Brook Trout	57	na	12.7	13.3	26.2	nd
HR1A	Brook Trout	58	na	11.1	11.8	13.7	nd
HR1A	Brook Trout	59	na	10.0	10.6	10.3	nd
HR1A	Brook Trout	60	na	14.8	15.6	32.1	nd
HR1A	Brook Trout	61	na	11.8	12.5	18.5	nd
HR1A	Brook Trout	62	na	7.5	8.0	5.6	nd
HR1A	Brook Trout	63	na	7.6	7.9	5.3	nd
HR1A	Brook Trout	64	na	8.5	11.0	11.7	nd
HR1A	Brook Trout	65	na	6.7	7.0	3.4	nd
HR1A	Brook Trout	66	na	6.7	7.0	3.7	nd
HR1A	Brook Trout	67	na	6.6	7.0	2.9	nd
HR1A	Brook Trout	68	na	7.0	7.3	4.3	nd
HR1A	Brook Trout	69	na	6.0	6.4	3.2	nd
HR1A	Brook Trout	70	na	7.2	7.6	4.3	nd
HR1A	Brook Trout	71	na	6.3	6.7	3.3	nd
HR1A	Brook Trout	72	na	11.0	11.7	14.1	nd
HR1A	Brook Trout	73	na	6.6	7.0	3.8	nd
HR1A	Brook Trout	74	na	7.2	7.7	3.9	nd
HR1A	Brook Trout	75	na	6.6	7.1	3.1	nd
HR1A	Brook Trout	76	na	7.3	7.6	4.1	nd
HR1A	Brook Trout	77	na	6.3	6.6	2.8	nd
HR1A	Brook Trout	78	na	5.9	6.3	2.3	nd
HR1A	Brook Trout	79	na	5.1	5.5	1.6	nd
HR1A	Brook Trout	80	na	7.8	8.1	5.1	nd
HR1A	Brook Trout	81	na	5.6	6.0	2.2	nd
HR1A	Brook Trout	82	na	6.1	6.3	2.4	nd
HR1A	Brook Trout	83	na	6.3	6.7	2.4	nd
HR1A	Brook Trout	84	na	6.4	6.7	3.0	nd
HR1A	Brook Trout	85	na	6.1	6.4	2.7	nd
HR1A	Brook Trout	86	na	5.9	6.3	2.6	nd
HR1A	Brook Trout	87	na	6.9	7.3	3.5	nd
HR1A	Brook Trout	88	na	7.4	7.8	4.5	nd
HR1A	Brook Trout	89	na	7.3	7.7	3.9	nd
HR1A	Brook Trout	90	na	6.7	7.1	3.8	nd
HR1A	Brook Trout	91	na	6.2	6.6	2.9	nd
HR1A	Brook Trout	92	na	7.4	7.8	5.5	nd
HR1A	Brook Trout	93	na	6.8	7.1	3.5	nd
HR1A	Brook Trout	94	na	6.5	6.7	2.3	nd
HR1A	Brook Trout	95	na	7.0	7.4	3.6	nd
HR1A	Brook Trout	96	na	6.2	6.6	3.0	nd
HR1A	Brook Trout	97	na	6.2	6.6	2.4	nd
HR1A	Brook Trout	98	na	17.0	17.6	52.8	nd
HR1A	Brook Trout	99	na	14.7	15.3	30.4	nd
HR1A	Brook Trout	100	na	10.9	11.5	15.0	nd
HR1A	Brook Trout	101	na	13.0	13.7	19.8	nd
HR1A	Brook Trout	102	na	12.5	13.0	19.9	nd
HR1A	Brook Trout	109	na	10.0	10.6	10.9	nd
HR1A	Brook Trout	110	na	10.1	10.6	13.0	nd
HR1A	Brook Trout	111	na	6.3	6.7	3.2	nd
HR1A	Brook Trout	112	na	6.8	7.1	3.6	nd
HR1A	Brook Trout	113	na	6.9	7.2	2.4	nd
HR1A	Brook Trout	114	na	7.0	7.3	4.1	nd
HR1A	Brook Trout	115	na	6.1	6.3	2.7	nd
HR1A	Brook Trout	116	na	6.9	7.2	3.5	nd
HR1A	Brook Trout	117	na	5.7	6.0	2.0	nd
HR1A	Brook Trout	118	na	6.8	7.1	3.1	nd
HR1A	Brook Trout	119	na	5.9	6.2	2.3	nd
HR1A	Brook Trout	120	na	6.4	6.7	3.2	nd
HR1A	Brook Trout	121	na	5.5	5.7	2.0	nd
HR1A	Brook Trout	122	na	7.0	7.3	3.8	nd
HR1A	Brook Trout	123	na	6.3	6.7	3.2	nd
HR1A	Brook Trout	124	na	6.7	7.1	2.9	nd
HR1A	Brook Trout	125	na	7.4	7.8	4.6	nd

Table A6.2: Raw Biological Data on All Wild Fish Sampled at Heath Steele, August 1997.

Station	Species	Fish Number	Sample Number	Fork Length (cm)	Total Length (cm)	Whole Weight (g)	Age[1] (y)
HR1A	Brook Trout	126	na	6.1	6.5	2.4	nd
HR1A	Brook Trout	127	na	7.1	7.5	3.9	nd
HR1A	Brook Trout	128	na	6.2	6.5	2.8	nd
HR1A	Brook Trout	129	na	7.0	7.3	3.5	nd
HR1A	Brook Trout	130	na	7.2	7.6	4.3	nd
HR1A	Brook Trout	131	na	6.4	6.7	3.5	nd
HR1A	Brook Trout	132	na	7.5	7.9	5.2	nd
HR1A	Brook Trout	133	na	6.3	6.6	2.6	nd
HR1A	Brook Trout	134	na	7.7	8.1	5.2	nd
HR1A	Brook Trout	135	na	6.5	6.8	2.7	nd
HR1A	Brook Trout	136	na	6.5	6.8	2.9	nd
HR1A	Brook Trout	137	na	6.9	7.3	3.7	nd
HR1A	Brook Trout	138	na	6.1	6.5	2.5	nd
HR1A	Brook Trout	139	na	6.3	6.7	3.2	nd
HR1A	Brook Trout	140	na	7.1	7.4	4.3	nd
HR1A	Brook Trout	141	na	6.2	6.5	2.7	nd
HR1A	Brook Trout	142	na	7.0	7.5	4.1	nd
HR1A	Brook Trout	143	na	7.4	7.9	4.1	nd
HR1A	Brook Trout	144	na	6.9	7.2	4.0	nd
HR1A	Brook Trout	145	na	5.8	6.1	1.9	nd
HR1A	Brook Trout	146	na	6.8	7.2	3.4	nd
HR1A	Brook Trout	147	na	7.5	8.0	4.1	nd
HR1A	Brook Trout	148	na	6.3	6.6	2.6	nd
HR1A	Brook Trout	149	na	7.2	7.6	4.5	nd
HR1A	Brook Trout	150	na	6.6	7.1	3.5	nd
HR1A	Brook Trout	151	na	6.8	7.3	3.6	nd
HR1A	Brook Trout	152	na	7.2	7.6	4.4	nd
HR1A	Brook Trout	153	na	6.8	7.2	3.1	nd
HR1A	Brook Trout	154	na	6.7	7.1	4.1	nd
HR1A	Lake Chub	52	HR1ALC1-F	9.8	10.6	13.5	nd
HR1A	Lake Chub	53	HR1ALC2-F	8.3	9.0	6.7	nd
HR1A	Lake Chub	54	HR1ALC3-F	8.7	9.4	9.6	nd
HR1A	Lake Chub	155	HR1ALC4-F	8.1	8.8	6.4	nd
HR1A	Lake Chub	156	HR1ALC5-F	8.9	9.5	9.0	nd
HR1A	Lake Chub	157	HR1ALC6-F	8.8	9.5	8.0	nd
HR1A	Lake Chub	158	HR1ALC7-F	8.8	9.6	8.6	nd
HR1A	Lake Chub	159	HR1ALC8-F	8.7	9.3	7.7	nd
HR1A	Lake Chub	160	HR1ALC9-F	8.3	9.1	8.0	nd
HR1A	Lake Chub	161	HR1ALC10-F	7.8	8.4	5.3	nd
HR1A	Lake Chub	162	na	7.7	8.0	5.0	nd
HR1A	Lake Chub	163	na	7.7	8.0	5.0	nd
HR1A	Lake Chub	164	HR1ALC11-F	8.2	8.9	6.9	nd
HR1A	Lake Chub	165	na	7.3	7.9	4.5	nd
HR1A	Lake Chub	166	HR1ALC10-F	8.9	9.5	7.8	nd
HR1A	Lake Chub	167	na	6.6	7.1	3.2	nd
HR1A	Lake Chub	168	na	7.8	8.4	5.7	nd
HR1A	Lake Chub	169	na	7.6	8.2	4.9	nd
HR1A	Lake Chub	171	na	8.5	9.1	7.3	nd
HR1A	Lake Chub	172	na	8.1	8.7	5.8	nd
HR1A	Lake Chub	173	na	7.5	8.1	4.2	nd
HR1A	Lake Chub	174	na	7.0	7.5	3.8	nd
HR1A	Lake Chub	175	na	6.5	7.0	3.3	nd
HR1A	Lake Chub	176	na	6.5	7.0	3.0	nd
HR1A	Lake Chub	177	na	7.9	8.3	6.2	nd
HR1A	Lake Chub	178	na	7.3	7.9	4.5	nd
HR1A	Lake Chub	179	na	6.7	7.1	3.3	nd
HR1A	Lake Chub	180	na	6.3	7.0	2.4	nd
HR1A	Lake Chub	181	na	6.6	7.2	3.4	nd
HR1A	Lake Chub	182	na	6.9	7.4	3.8	nd
HR1A	Lake Chub	183	na	6.9	7.5	3.9	nd
HR1A	Lake Chub	185	na	7.4	8.0	5.1	nd
HR1A	Lake Chub	186	na	6.8	7.4	4.0	nd
HR1A	Lake Chub	187	na	6.6	7.0	3.2	nd
HR1A	Lake Chub	188	na	6.7	7.2	3.6	nd
HR1A	Lake Chub	189	na	5.0	5.5	1.5	nd
HR1A	Lake Chub	190	na	6.5	7.1	2.9	nd
HR1A	Lake Chub	191	na	6.5	7.1	2.9	nd
HR1A	Lake Chub	192	na	6.8	7.3	3.4	nd
HR1A	Lake Chub	193	na	6.1	6.5	2.3	nd
HR1A	Lake Chub	194	na	4.8	5.1	1.1	nd
HR1A	Lake Chub	195	na	6.5	7.0	2.7	nd
HR1A	Lake Chub	196	na	5.0	5.4	1.1	nd
HR1A	Lake Chub	197	na	6.1	6.6	2.6	nd
HR1A	Lake Chub	198	na	6.4	6.9	2.6	nd
HR1A	Lake Chub	199	na	5.0	5.3	1.4	nd

Table A6.2: Raw Biological Data on All Wild Fish Sampled at Heath Steele, August 1997.

Station	Species	Fish Number	Sample Number	Fork Length (cm)	Total Length (cm)	Whole Weight (g)	Age[1] (y)
HR1A	Lake Chub	200	na	6.4	7.0	2.9	nd
HR1A	Lake Chub	201	na	6.7	7.3	3.6	nd
HR1A	Lake Chub	202	na	4.7	4.9	0.9	nd
HR1A	Lake Chub	203	na	5.3	5.7	1.6	nd
HR1A	White Sucker	103	na	15.2	16.1	40.8	nd
HR1A	White Sucker	104	na	12.8	13.5	26.6	nd
HR1A	White Sucker	105	na	13.4	14.2	31.9	nd
HR1A	White Sucker	106	na	12.3	13.2	23.8	nd
HR1A	White Sucker	107	na	13.5	14.2	30.4	nd
HR1A	White Sucker	108	na	11.1	11.9	17.1	nd
HR1A	White Sucker	170	na	7.6	7.9	4.6	nd
HR1A	White Sucker	184	na	7.5	7.9	5.3	nd
HR1B	Blacknose Dace	34	HR1BBD1-F	7.0	7.5	4.0	4+
HR1B	Blacknose Dace	138	HR1BBD2-F	7.3	7.7	4.6	4+
HR1B	Blacknose Dace	139	HR1BBD3-F	6.9	7.2	3.6	3+
HR1B	Blacknose Dace	140	HR1BBD4-F	6.0	6.3	1.8	2+
HR1B	Blacknose Dace	141	HR1BBD5-F	6.7	7.1	3.1	3+
HR1B	Blacknose Dace	142	HR1BBD6-F	6.5	6.9	3.3	3+
HR1B	Blacknose Dace	143	HR1BBD7-F	5.1	5.4	1.6	1+
HR1B	Blacknose Dace	144	HR1BBD8-F	5.1	5.4	1.8	1+
HR1B	Blacknose Dace	145	HR1BBD9-F	5.4	5.7	1.9	1+
HR1B	Blacknose Dace	146	HR1BBD10-F	7.2	7.5	3.7	4+
HR1B	Blacknose Dace	147	HR1BBD11-F	6.7	7.2	3.9	3+
HR1B	Blacknose Dace	148	HR1BBD12-F	7.4	7.8	4.5	4+
HR1B	Blacknose Dace	149	HR1BBD13-F	5.3	5.7	1.5	1+
HR1B	Blacknose Dace	150	HR1BBD14-F	5.4	5.7	1.3	1+
HR1B	Blacknose Dace	151	HR1BBD15-F	5.4	5.7	1.4	1+
HR1B	Blacknose Dace	152	HR1BBD16-F	5.6	6.0	1.8	2+
HR1B	Blacknose Dace	153	HR1BBD17-F	6.7	7.0	3.2	3+
HR1B	Blacknose Dace	154	HR1BBD18-F	4.8	5.0	1.0	1+
HR1B	Blacknose Dace	155	HR1BBD19-F	5.8	6.1	2.1	2+
HR1B	Blacknose Dace	156	HR1BBD20-F	5.1	5.3	1.4	1+
HR1B	Blacknose Dace	157	HR1BBD21-F	5.7	6.0	1.8	1+
HR1B	Blacknose Dace	158	HR1BBD22-F	7.3	7.7	4.0	4+
HR1B	Blacknose Dace	159	HR1BBD23-F	5.7	6.0	2.0	2+
HR1B	Blacknose Dace	160	HR1BBD24-F	5.7	6.0	1.8	2+
HR1B	Blacknose Dace	161	HR1BBD25-F	5.2	5.5	1.6	1+
HR1B	Brook Trout	1	na	6.3	6.6	2.3	nd
HR1B	Brook Trout	2	na	5.8	6.0	2.4	nd
HR1B	Brook Trout	3	na	6.5	6.8	3.2	nd
HR1B	Brook Trout	4	na	5.2	5.4	1.7	nd
HR1B	Brook Trout	5	na	6.0	6.3	2.5	nd
HR1B	Brook Trout	6	na	6.1	6.4	2.4	nd
HR1B	Brook Trout	7	na	5.6	5.9	2.1	nd
HR1B	Brook Trout	8	na	7.0	7.3	4.4	nd
HR1B	Brook Trout	9	na	6.2	6.5	2.9	nd
HR1B	Brook Trout	10	na	6.4	6.9	2.8	nd
HR1B	Brook Trout	11	na	6.5	6.9	3.0	nd
HR1B	Brook Trout	12	na	6.7	7.0	3.8	nd
HR1B	Brook Trout	13	na	6.3	6.6	2.8	nd
HR1B	Brook Trout	14	na	5.3	5.5	1.9	nd
HR1B	Brook Trout	15	na	5.6	5.8	2.2	nd
HR1B	Brook Trout	16	na	6.5	6.9	3.3	nd
HR1B	Brook Trout	17	na	6.3	6.7	3.1	nd
HR1B	Brook Trout	18	na	6.1	6.4	2.3	nd
HR1B	Brook Trout	19	na	7.3	7.7	4.5	nd
HR1B	Brook Trout	20	na	5.7	6.0	2.3	nd
HR1B	Brook Trout	21	na	6.8	7.2	3.7	nd
HR1B	Brook Trout	22	na	4.8	5.0	1.3	nd
HR1B	Brook Trout	23	na	5.7	6.0	2.4	nd
HR1B	Brook Trout	24	na	5.5	5.7	1.8	nd
HR1B	Brook Trout	25	na	6.3	6.6	2.8	nd
HR1B	Brook Trout	26	na	7.6	7.9	3.1	nd
HR1B	Brook Trout	27	na	6.4	6.7	2.8	nd
HR1B	Brook Trout	28	na	6.1	6.4	2.6	nd
HR1B	Brook Trout	29	na	6.2	6.5	2.4	nd
HR1B	Brook Trout	30	na	7.8	8.5	5.6	nd
HR1B	Brook Trout	35	HR1BBT1-F	12.5	13.1	23.2	nd
HR1B	Brook Trout	36	HR1BBT2-F	12.3	12.8	23.5	nd
HR1B	Brook Trout	37	HR1BBT3-F	12.3	12.9	22.3	nd
HR1B	Brook Trout	38	HR1BBT4-F	12.5	13.2	23.9	nd
HR1B	Brook Trout	39	na	12.4	13.1	19.6	nd
HR1B	Brook Trout	40	na	15.2	16.1	38.7	nd
HR1B	Brook Trout	41	na	13.1	13.8	24.0	nd
HR1B	Brook Trout	42	na	12.4	13.0	26.5	nd

Table A6.2: Raw Biological Data on All Wild Fish Sampled at Heath Steele, August 1997.

Station	Species	Fish Number	Sample Number	Fork Length (cm)	Total Length (cm)	Whole Weight (g)	Age[1] (y)
HR1B	Brook Trout	43	na	11.6	12.2	17.4	nd
HR1B	Brook Trout	44	na	12.6	13.2	21.1	nd
HR1B	Brook Trout	45	na	10.7	11.2	14.6	nd
HR1B	Brook Trout	46	na	11.5	12.2	18.4	nd
HR1B	Brook Trout	47	na	11.7	12.4	17.9	nd
HR1B	Brook Trout	48	na	10.8	11.4	13.3	nd
HR1B	Brook Trout	49	na	10.8	11.5	13.2	nd
HR1B	Brook Trout	50	na	9.8	10.3	9.4	nd
HR1B	Brook Trout	51	na	8.1	8.6	5.6	nd
HR1B	Brook Trout	52	na	8.5	8.9	7.4	nd
HR1B	Brook Trout	53	na	5.9	6.2	2.5	nd
HR1B	Brook Trout	54	na	7.0	7.3	3.8	nd
HR1B	Brook Trout	55	na	7.7	8.3	5.4	nd
HR1B	Brook Trout	56	na	7.3	7.8	4.1	nd
HR1B	Brook Trout	57	na	6.3	6.6	2.8	nd
HR1B	Brook Trout	58	na	6.1	6.3	2.6	nd
HR1B	Brook Trout	59	na	6.6	6.9	3.4	nd
HR1B	Brook Trout	60	na	6.3	6.6	3.0	nd
HR1B	Brook Trout	61	na	4.9	5.2	1.6	nd
HR1B	Brook Trout	62	na	5.6	6.0	2.1	nd
HR1B	Brook Trout	63	na	5.2	5.5	1.4	nd
HR1B	Brook Trout	64	na	7.5	7.9	3.8	nd
HR1B	Brook Trout	65	na	6.1	6.4	2.2	nd
HR1B	Brook Trout	66	na	7.3	7.8	4.0	nd
HR1B	Brook Trout	67	na	7.7	8.1	5.4	nd
HR1B	Brook Trout	68	na	6.4	6.7	3.5	nd
HR1B	Brook Trout	69	na	6.5	6.8	2.7	nd
HR1B	Brook Trout	70	na	6.5	6.8	3.0	nd
HR1B	Brook Trout	71	na	6.7	7.2	4.0	nd
HR1B	Brook Trout	72	na	6.6	6.9	2.8	nd
HR1B	Brook Trout	73	na	6.0	6.2	2.5	nd
HR1B	Brook Trout	74	na	7.3	7.7	4.8	nd
HR1B	Brook Trout	75	na	7.6	7.9	5.2	nd
HR1B	Brook Trout	76	na	6.9	7.3	3.6	nd
HR1B	Brook Trout	77	na	5.3	5.5	1.8	nd
HR1B	Brook Trout	78	na	6.3	6.7	3.1	nd
HR1B	Brook Trout	79	na	7.0	7.4	3.7	nd
HR1B	Brook Trout	80	na	7.9	8.2	5.5	nd
HR1B	Brook Trout	81	na	6.7	8.7	4.0	nd
HR1B	Brook Trout	82	na	6.1	6.4	2.6	nd
HR1B	Brook Trout	83	na	7.8	8.2	5.1	nd
HR1B	Brook Trout	84	na	5.7	6.1	2.3	nd
HR1B	Brook Trout	85	na	6.6	6.9	3.1	nd
HR1B	Brook Trout	86	na	6.4	6.8	2.7	nd
HR1B	Brook Trout	87	na	6.3	6.7	2.8	nd
HR1B	Brook Trout	88	na	7.5	8.0	5.1	nd
HR1B	Brook Trout	89	na	7.1	7.5	4.0	nd
HR1B	Brook Trout	90	na	6.2	6.5	2.6	nd
HR1B	Brook Trout	91	na	6.4	6.6	2.9	nd
HR1B	Brook Trout	92	na	6.9	7.2	3.9	nd
HR1B	Brook Trout	93	na	7.1	7.4	3.5	nd
HR1B	Brook Trout	94	na	6.3	6.5	2.5	nd
HR1B	Brook Trout	95	na	6.1	6.4	2.4	nd
HR1B	Brook Trout	96	na	5.7	6.0	2.2	nd
HR1B	Brook Trout	97	na	6.5	6.8	3.4	nd
HR1B	Brook Trout	98	na	6.8	7.1	3.2	nd
HR1B	Brook Trout	99	na	5.8	6.1	2.0	nd
HR1B	Brook Trout	100	na	7.0	7.4	4.1	nd
HR1B	Brook Trout	101	na	6.5	6.8	2.8	nd
HR1B	Brook Trout	102	na	6.1	6.4	2.4	nd
HR1B	Brook Trout	103	na	7.8	8.2	5.1	nd
HR1B	Brook Trout	104	na	6.3	6.5	2.7	nd
HR1B	Brook Trout	105	na	7.2	7.6	4.5	nd
HR1B	Brook Trout	106	na	7.5	7.8	4.7	nd
HR1B	Brook Trout	107	na	6.5	6.7	2.7	nd
HR1B	Brook Trout	108	na	6.5	6.8	3.0	nd
HR1B	Brook Trout	109	na	7.2	7.5	3.8	nd
HR1B	Brook Trout	110	na	5.1	5.3	1.3	nd
HR1B	Brook Trout	111	na	7.5	7.8	4.3	nd
HR1B	Brook Trout	112	na	5.9	6.2	2.0	nd
HR1B	Brook Trout	113	na	6.9	7.1	3.9	nd
HR1B	Brook Trout	114	na	5.9	6.1	2.3	nd
HR1B	Brook Trout	115	na	7.2	7.5	4.7	nd
HR1B	Brook Trout	116	na	7.8	8.1	5.3	nd
HR1B	Brook Trout	117	na	6.0	6.3	2.6	nd

Table A6.2: Raw Biological Data on All Wild Fish Sampled at Heath Steele, August 1997.

Station	Species	Fish Number	Sample Number	Fork Length (cm)	Total Length (cm)	Whole Weight (g)	Age[1] (y)
HR1B	Brook Trout	118	na	7.5	7.9	4.6	nd
HR1B	Brook Trout	119	na	5.7	5.9	2.0	nd
HR1B	Brook Trout	120	na	6.3	6.5	2.6	nd
HR1B	Brook Trout	121	na	6.4	6.7	2.8	nd
HR1B	Brook Trout	122	na	5.4	5.6	1.7	nd
HR1B	Brook Trout	123	na	6.4	6.7	2.8	nd
HR1B	Brook Trout	124	na	6.6	6.8	3.1	nd
HR1B	Brook Trout	125	na	5.9	6.1	2.2	nd
HR1B	Brook Trout	126	na	7.2	7.5	3.6	nd
HR1B	Brook Trout	127	na	6.0	6.3	2.2	nd
HR1B	Brook Trout	128	na	6.9	7.2	3.6	nd
HR1B	Brook Trout	129	na	4.9	5.1	1.2	nd
HR1B	Brook Trout	130	na	5.5	5.7	1.7	nd
HR1B	Brook Trout	131	na	5.2	5.5	1.5	nd
HR1B	Brook Trout	132	na	6.4	6.6	2.6	nd
HR1B	Brook Trout	133	na	6.2	6.4	2.6	nd
HR1B	Brook Trout	134	na	7.2	7.6	4.5	nd
HR1B	Brook Trout	135	na	5.5	5.7	1.7	nd
HR1B	Brook Trout	136	na	5.2	5.5	1.5	nd
HR1B	Lake Chub	31	HR1BLC1-F	8.7	9.2	7.0	nd
HR1B	Lake Chub	32	HR1BLC2-F	7.8	8.4	6.0	nd
HR1B	Lake Chub	33	HR1BLC3-F	7.8	8.4	6.0	nd
HR1B	Lake Chub	165	HR1BLC4-F	9.0	9.6	10.0	nd
HR1B	Lake Chub	166	HR1BLC5-F	8.4	8.9	7.8	nd
HR1B	Lake Chub	167	HR1BLC6-F	8.5	9.2	7.6	nd
HR1B	Lake Chub	168	HR1BLC7-F	8.1	8.6	5.9	nd
HR1B	Lake Chub	169	HR1BLC8-F	8.3	8.9	6.5	nd
HR1B	Lake Chub	170	HR1BLC9-F	7.6	8.1	5.8	nd
HR1B	Lake Chub	171	HR1BLC10-F	7.3	7.9	4.8	nd
HR1B	Lake Chub	172	HR1BLC11-F	7.3	7.9	4.5	nd
HR1B	Lake Chub	173	HR1BLC12-F	7.7	8.2	5.3	nd
HR1B	Lake Chub	174	na	7.0	7.5	4.5	nd
HR1B	Lake Chub	175	na	6.3	6.7	2.7	nd
HR1B	Lake Chub	176	na	5.1	5.4	1.4	nd
HR1B	Lake Chub	177	na	4.9	5.2	1.2	nd
HR1B	Lake Chub	178	na	5.0	5.3	1.2	nd
HR1B	Lake Chub	179	na	4.9	5.2	1.2	nd
HR1B	Lake Chub	180	na	5.5	5.9	1.7	nd
HR1B	Lake Chub	181	na	4.9	5.3	1.2	nd
HR1B	Lake Chub	182	na	6.0	6.6	2.7	nd
HR1B	Lake Chub	183	na	6.5	6.9	2.8	nd
HR1B	Lake Chub	184	na	6.6	7.1	3.1	nd
HR1B	Lake Chub	185	na	6.6	7.1	2.9	nd
HR1B	Lake Chub	186	na	6.8	7.2	3.2	nd
HR1B	Lake Chub	187	na	5.7	6.0	1.9	nd
HR1B	Lake Chub	188	na	4.9	5.1	1.2	nd
HR1B	Lake Chub	189	na	4.7	5.0	1.1	nd
HR1B	Lake Chub	190	na	4.7	5.0	1.0	nd
HR1B	White Sucker	137	na	6.7	7.1	2.9	nd
HR1B	White Sucker	164	na	6.2	6.5	2.7	nd
HR1B	Creek Chub	162	na	5.2	5.5	1.3	nd
HR1B	Creek Chub	163	na	5.1	5.4	1.1	nd
HR2A	Blacknose Dace	63	na	6.3	6.8	3.2	3+
HR2A	Blacknose Dace	64	HR2ABD1-F	5.9	6.3	2.7	2+
HR2A	Blacknose Dace	65	HR2ABD2-F	7.1	7.7	4.1	4+
HR2A	Blacknose Dace	66	HR2ABD3-F	7.3	7.9	5.0	4+
HR2A	Blacknose Dace	67	HR2ABD4-F	6.9	7.4	3.7	3+
HR2A	Blacknose Dace	68	HR2ABD5-F	7.0	7.6	3.4	3+
HR2A	Blacknose Dace	69	HR2ABD6-F	7.0	7.5	4.2	3+
HR2A	Blacknose Dace	70	HR2ABD7-F	4.2	4.5	0.9	1+
HR2A	Blacknose Dace	71	HR2ABD8-F	6.6	7.2	3.6	3+
HR2A	Blacknose Dace	72	HR2ABD9-F	6.4	6.9	2.7	2+
HR2A	Blacknose Dace	73	HR2ABD10-F	6.2	6.5	2.7	2+
HR2A	Blacknose Dace	74	HR2ABD11-F	6.0	6.5	2.7	2+
HR2A	Blacknose Dace	75	HR2ABD12-F	7.1	7.7	4.0	3+
HR2A	Blacknose Dace	76	HR2ABD13-F	5.4	5.7	1.7	1+
HR2A	Blacknose Dace	77	HR2ABD14-F	5.5	5.9	2.0	1+
HR2A	Blacknose Dace	78	HR2ABD15-F	5.4	5.8	2.1	1+
HR2A	Blacknose Dace	79	HR2ABD16-F	6.3	6.7	2.8	2+
HR2A	Blacknose Dace	80	HR2ABD17-F	6.0	6.3	2.2	2+
HR2A	Blacknose Dace	81	HR2ABD18-F	6.2	6.7	2.7	2+
HR2A	Blacknose Dace	82	HR2ABD19-F	6.2	6.6	2.7	2+
HR2A	Blacknose Dace	83	HR2ABD20-F	6.9	7.5	3.6	3+
HR2A	Blacknose Dace	84	HR2ABD21-F	6.0	6.4	2.1	2+
HR2A	Blacknose Dace	85	HR2ABD22-F	7.2	7.7	4.3	3+

Table A6.2: Raw Biological Data on All Wild Fish Sampled at Heath Steele, August 1997.

Station	Species	Fish Number	Sample Number	Fork Length (cm)	Total Length (cm)	Whole Weight (g)	Age[1] (y)
HR2A	Blacknose Dace	86	HR2ABD23-F	6.0	6.5	2.3	2+
HR2A	Blacknose Dace	87	HR2ABD24-F	6.0	6.6	2.7	2+
HR2A	Blacknose Dace	88	HR2ABD25-F	5.0	5.3	1.2	1+
HR2A	Blacknose Dace	89	HR2ABD26-F	6.1	6.5	2.5	2+
HR2A	Blacknose Dace	90	HR2ABD27-F	6.4	6.9	3.0	2+
HR2A	Blacknose Dace	91	HR2ABD28-F	5.8	6.2	2.0	2+
HR2A	Blacknose Dace	92	HR2ABD29-F	6.0	6.5	2.2	2+
HR2A	Blacknose Dace	93	HR2ABD30-F	4.3	4.6	0.8	1+
HR2A	Blacknose Dace	94	na	2.1	2.2	<0.1	0+
HR2A	Blacknose Dace	95	na	2.0	2.1	<0.1	0+
HR2A	Blacknose Dace	96	na	1.7	1.7	<0.1	0+
HR2A	Blacknose Dace	97	na	1.8	1.9	<0.1	0+
HR2A	Blacknose Dace	98	na	1.9	2.0	<0.1	0+
HR2A	Brook Trout	1	HR2ABT1-F	15.1	15.7	35.1	nd
HR2A	Brook Trout	2	HR2ABT2-F	13.5	14.5	28.9	nd
HR2A	Brook Trout	3	na	12.4	13.0	20.3	nd
HR2A	Brook Trout	4	na	13.6	14.0	25.8	nd
HR2A	Brook Trout	5	na	12.1	12.7	17.5	nd
HR2A	Brook Trout	6	na	12.7	13.3	19.9	nd
HR2A	Brook Trout	7	na	10.5	11.0	11.6	nd
HR2A	Brook Trout	8	na	12.3	13.5	21.7	nd
HR2A	Brook Trout	9	na	16.0	16.9	46.8	nd
HR2A	Brook Trout	10	na	5.9	6.3	2.3	nd
HR2A	Brook Trout	11	na	5.9	6.2	2.3	nd
HR2A	Brook Trout	12	na	6.8	7.2	4.0	nd
HR2A	Brook Trout	13	na	5.6	5.9	2.0	nd
HR2A	Brook Trout	14	na	4.5	4.8	0.9	nd
HR2A	Brook Trout	15	na	7.0	7.3	3.7	nd
HR2A	Brook Trout	16	na	6.1	6.3	1.8	nd
HR2A	Brook Trout	17	na	5.9	6.2	2.2	nd
HR2A	Brook Trout	18	na	4.3	4.5	1.0	nd
HR2A	Brook Trout	19	na	5.9	6.3	2.1	nd
HR2A	Brook Trout	20	na	6.9	7.3	3.6	nd
HR2A	Creek Chub	58	na	9.7	10.2	11.4	nd
HR2A	Creek Chub	59	na	9.9	10.5	11.8	nd
HR2A	Creek Chub	60	na	6.6	7.0	3.0	nd
HR2A	Creek Chub	61	na	6.9	7.3	3.6	nd
HR2A	Creek Chub	62	na	6.3	6.7	2.7	nd
HR2A	Slimy Sculpin	21	na	na	8.8	8.2	nd
HR2A	Slimy Sculpin	22	na	na	9.2	9.5	nd
HR2A	Slimy Sculpin	23	na	na	10.2	10.0	nd
HR2A	Slimy Sculpin	24	na	na	8.8	8.1	nd
HR2A	Slimy Sculpin	25	na	na	8.3	6.7	nd
HR2A	Slimy Sculpin	26	na	na	8.8	7.0	nd
HR2A	Slimy Sculpin	27	na	na	7.6	5.3	nd
HR2A	Slimy Sculpin	28	na	na	7.1	4.0	nd
HR2A	Slimy Sculpin	29	na	na	8.3	7.0	nd
HR2A	Slimy Sculpin	30	na	na	8.2	6.7	nd
HR2A	Slimy Sculpin	31	na	na	7.2	3.5	nd
HR2A	Slimy Sculpin	32	na	na	7.7	6.4	nd
HR2A	Slimy Sculpin	33	na	na	7.5	5.3	nd
HR2A	Slimy Sculpin	34	na	na	6.0	2.3	nd
HR2A	Slimy Sculpin	35	na	na	7.3	5.0	nd
HR2A	Slimy Sculpin	36	na	na	7.9	6.0	nd
HR2A	Slimy Sculpin	37	na	na	7.2	4.5	nd
HR2A	Slimy Sculpin	38	na	na	7.1	4.0	nd
HR2A	Slimy Sculpin	39	na	na	6.9	4.1	nd
HR2A	Slimy Sculpin	40	na	na	6.1	2.6	nd
HR2A	Slimy Sculpin	41	na	na	7.2	4.7	nd
HR2A	Slimy Sculpin	42	na	na	7.7	3.8	nd
HR2A	Slimy Sculpin	43	na	na	5.8	2.6	nd
HR2A	Slimy Sculpin	44	na	na	6.2	3.0	nd
HR2A	Slimy Sculpin	45	na	na	3.2	0.3	nd
HR2A	Slimy Sculpin	46	na	na	2.7	0.3	nd
HR2A	Slimy Sculpin	47	na	na	2.9	0.3	nd
HR2A	Slimy Sculpin	48	na	na	3.3	0.4	nd
HR2A	Slimy Sculpin	49	na	na	2.7	0.3	nd
HR2A	Slimy Sculpin	50	na	na	3.0	0.3	nd
HR2A	Slimy Sculpin	51	na	na	3.1	0.3	nd
HR2A	Slimy Sculpin	52	na	na	3.2	0.4	nd
HR2A	Slimy Sculpin	53	na	na	3.1	0.3	nd
HR2A	Slimy Sculpin	54	na	na	3.1	0.3	nd
HR2A	Slimy Sculpin	55	na	na	2.8	0.3	nd
HR2A	Slimy Sculpin	56	na	na	2.7	0.3	nd
HR2A	Slimy Sculpin	57	na	na	3.0	0.3	nd

Table A6.2: Raw Biological Data on All Wild Fish Sampled at Heath Steele, August 1997.

Station	Species	Fish Number	Sample Number	Fork Length (cm)	Total Length (cm)	Whole Weight (g)	Age[1] (y)
HR2B	Atlantic Salmon	72	HR2BAS1-F	10.4	11.2	14.4	1+
HR2B	Blacknose Dace	73	HR2BBD1-F	6.3	6.9	3.0	2+
HR2B	Blacknose Dace	74	HR2BBD2-F	6.4	6.7	3.0	2+
HR2B	Blacknose Dace	75	HR2BBD3-F	4.7	4.9	1.1	1+
HR2B	Blacknose Dace	76	HR2BBD4-F	4.2	4.5	0.8	1+
HR2B	Blacknose Dace	77	HR2BBD5-F	4.5	4.9	0.9	1+
HR2B	Blacknose Dace	78	HR2BBD6-F	5.9	6.3	2.0	2+
HR2B	Blacknose Dace	79	HR2BBD7-F	4.9	5.2	1.7	1+
HR2B	Blacknose Dace	80	HR2BBD8-F	6.2	6.6	2.8	2+
HR2B	Blacknose Dace	81	HR2BBD9-F	4.4	4.7	1.1	1+
HR2B	Blacknose Dace	82	HR2BBD10-F	6.0	6.4	2.4	2+
HR2B	Blacknose Dace	83	HR2BBD11-F	6.7	7.1	3.4	3+
HR2B	Blacknose Dace	84	HR2BBD12-F	7.6	8.1	4.4	4+
HR2B	Blacknose Dace	85	HR2BBD13-F	7.4	7.9	4.7	4+
HR2B	Blacknose Dace	86	HR2BBD14-F	6.7	7.0	3.4	3+
HR2B	Blacknose Dace	87	HR2BBD15-F	6.1	6.5	3.8	2+
HR2B	Blacknose Dace	88	HR2BBD16-F	4.7	5.0	1.2	1+
HR2B	Blacknose Dace	89	HR2BBD17-F	6.1	6.5	2.4	2+
HR2B	Blacknose Dace	90	HR2BBD18-F	5.4	5.7	1.4	1+
HR2B	Blacknose Dace	91	HR2BBD19-F	5.0	5.3	1.3	1+
HR2B	Blacknose Dace	92	HR2BBD20-F	5.7	6.0	2.2	2+
HR2B	Blacknose Dace	93	HR2BBD21-F	4.5	4.8	1.0	1+
HR2B	Blacknose Dace	94	HR2BBD22-F	4.6	4.8	0.9	1+
HR2B	Blacknose Dace	95	HR2BBD23-F	4.9	5.3	1.2	1+
HR2B	Blacknose Dace	96	HR2BBD24-F	5.0	5.4	1.2	1+
HR2B	Blacknose Dace	97	HR2BBD25-F	5.0	5.3	1.4	1+
HR2B	Blacknose Dace	98	HR2BBD26-F	4.2	4.4	0.8	1+
HR2B	Blacknose Dace	99	HR2BBD27-F	5.2	5.7	1.7	1+
HR2B	Blacknose Dace	100	HR2BBD28-F	4.6	4.9	1.0	1+
HR2B	Blacknose Dace	101	HR2BBD29-F	4.4	4.6	0.9	1+
HR2B	Blacknose Dace	102	HR2BBD30-F	4.5	4.7	0.8	1+
HR2B	Blacknose Dace	103	HR2BBD31-F	4.9	5.2	1.2	1+
HR2B	Brook Trout	1	na	17.3	18.4	69.2	nd
HR2B	Brook Trout	2	HR2BBT1-F	12.4	13.0	22.2	nd
HR2B	Brook Trout	3	HR2BBT2-F	13.0	13.7	29.9	nd
HR2B	Brook Trout	4	na	15.6	16.3	39.1	nd
HR2B	Brook Trout	5	na	15.8	16.5	49.5	nd
HR2B	Brook Trout	6	na	17.5	18.0	51.1	nd
HR2B	Brook Trout	7	na	12.5	13.3	20.3	nd
HR2B	Brook Trout	8	na	12.2	13.0	16.9	nd
HR2B	Brook Trout	9	na	16.7	17.9	54.4	nd
HR2B	Brook Trout	10	na	14.3	15.1	25.6	nd
HR2B	Brook Trout	11	na	14.3	15.0	30.8	nd
HR2B	Brook Trout	12	na	13.5	14.1	25.3	nd
HR2B	Brook Trout	13	na	13.3	14.2	25.4	nd
HR2B	Brook Trout	14	na	17.4	17.9	60.9	nd
HR2B	Brook Trout	15	na	13.7	14.3	31.4	nd
HR2B	Brook Trout	16	HR2BBT3-F	13.2	13.9	23.1	nd
HR2B	Brook Trout	17	HR2BBT4-F	11.3	12.0	15.1	nd
HR2B	Brook Trout	18	na	13.4	14.2	25.6	nd
HR2B	Brook Trout	19	na	11.7	12.2	16.8	nd
HR2B	Brook Trout	20	na	14.4	15.0	33.0	nd
HR2B	Brook Trout	21	na	15.4	16.1	36.7	nd
HR2B	Brook Trout	22	na	12.0	12.7	17.7	nd
HR2B	Brook Trout	23	na	12.7	13.2	22.7	nd
HR2B	Brook Trout	24	na	12.2	12.7	18.6	nd
HR2B	Brook Trout	25	na	11.9	12.6	17.2	nd
HR2B	Brook Trout	26	na	11.3	11.8	14.4	nd
HR2B	Brook Trout	27	na	10.3	10.8	11.4	nd
HR2B	Brook Trout	28	na	6.4	6.6	2.7	nd
HR2B	Brook Trout	29	na	5.9	6.2	2.1	nd
HR2B	Brook Trout	30	na	6.0	6.2	2.4	nd
HR2B	Brook Trout	31	na	7.1	7.5	3.4	nd
HR2B	Brook Trout	32	na	6.3	6.6	2.6	nd
HR2B	Brook Trout	33	na	5.5	5.8	2.1	nd
HR2B	Brook Trout	34	na	5.9	6.2	2.2	nd
HR2B	Brook Trout	35	na	7.2	7.5	3.8	nd
HR2B	Brook Trout	36	na	6.6	7.0	3.3	nd
HR2B	Brook Trout	37	na	6.3	6.6	2.9	nd
HR2B	Brook Trout	38	na	6.0	6.2	2.2	nd
HR2B	Brook Trout	39	na	5.2	5.6	1.6	nd
HR2B	Brook Trout	40	na	5.5	5.8	1.8	nd
HR2B	Brook Trout	41	na	6.6	7.0	3.3	nd
HR2B	Brook Trout	42	na	5.3	5.6	1.6	nd
HR2B	Brook Trout	43	na	6.3	6.7	3.4	nd

Table A6.2: Raw Biological Data on All Wild Fish Sampled at Heath Steele, August 1997.

Station	Species	Fish Number	Sample Number	Fork Length (cm)	Total Length (cm)	Whole Weight (g)	Age[1] (y)
HR2B	Brook Trout	44	na	6.8	7.2	3.3	nd
HR2B	Brook Trout	45	na	6.2	6.5	2.6	nd
HR2B	Brook Trout	46	na	5.5	5.7	1.8	nd
HR2B	Brook Trout	47	na	6.6	6.8	3.1	nd
HR2B	Brook Trout	48	na	5.9	6.2	2.3	nd
HR2B	Brook Trout	49	na	5.2	5.7	1.7	nd
HR2B	Brook Trout	50	na	6.5	6.8	2.7	nd
HR2B	Brook Trout	51	na	5.7	6.0	1.8	nd
HR2B	Slimy Sculpin	52	na	na	9.5	10.1	nd
HR2B	Slimy Sculpin	53	na	na	9.5	10.4	nd
HR2B	Slimy Sculpin	54	na	na	9.4	7.8	nd
HR2B	Slimy Sculpin	55	na	na	10.2	13.3	nd
HR2B	Slimy Sculpin	56	na	na	9.3	10.2	nd
HR2B	Slimy Sculpin	57	na	na	9.1	8.1	nd
HR2B	Slimy Sculpin	58	na	na	7.9	3.4	nd
HR2B	Slimy Sculpin	59	na	na	6.7	3.8	nd
HR2B	Slimy Sculpin	60	na	na	7.8	6.4	nd
HR2B	Slimy Sculpin	61	na	na	7.5	6.5	nd
HR2B	Slimy Sculpin	62	na	na	6.7	3.4	nd
HR2B	Slimy Sculpin	63	na	na	8.8	8.6	nd
HR2B	Slimy Sculpin	64	na	na	7.9	5.7	nd
HR2B	Slimy Sculpin	65	na	na	6.1	3.0	nd
HR2B	Slimy Sculpin	66	na	na	3.0	0.4	nd
HR2B	Slimy Sculpin	67	na	na	3.0	0.3	nd
HR2B	Slimy Sculpin	68	na	na	2.7	0.3	nd
HR2B	Slimy Sculpin	69	na	na	3.2	0.3	nd
HR2B	Slimy Sculpin	70	na	na	2.7	0.2	nd
HR2B	Slimy Sculpin	71	na	na	2.9	0.3	nd
HR3A	Atlantic Salmon	1	HR3AAS1-F	12.9	14.0	23.7	**2+**
HR3A	Atlantic Salmon	2	HR3AAS2-F	11.7	12.8	17.5	**2+**
HR3A	Atlantic Salmon	3	HR3AAS3-F	10.5	11.2	13.7	**1+**
HR3A	Atlantic Salmon	4	HR3AAS4-F	8.9	9.7	9.0	**1+**
HR3A	Atlantic Salmon	5	HR3AAS5-F	8.5	9.3	7.8	**1+**
HR3A	Atlantic Salmon	6	HR3AAS6-F	8.1	8.7	5.0	**1+**
HR3A	Atlantic Salmon	7	na	7.4	8.2	4.8	1+
HR3A	Atlantic Salmon	8	na	10.7	11.7	14.3	1+
HR3A	Atlantic Salmon	9	na	11.1	12.0	14.1	2+
HR3A	Atlantic Salmon	10	na	11.0	12.0	15.3	2+
HR3A	Atlantic Salmon	11	na	10.7	11.8	15.8	2+
HR3A	Atlantic Salmon	12	na	10.8	11.8	14.3	1+
HR3A	Atlantic Salmon	13	na	10.2	11.2	14.7	1+
HR3A	Atlantic Salmon	14	na	9.6	10.6	12.7	1+
HR3A	Atlantic Salmon	15	na	9.3	10.2	9.4	1+
HR3A	Atlantic Salmon	16	na	12.3	13.4	20.4	2+
HR3A	Atlantic Salmon	17	na	10.1	10.9	12.3	1+
HR3A	Atlantic Salmon	18	na	11.2	12.1	16.9	2+
HR3A	Atlantic Salmon	19	na	10.2	11.3	12.6	1+
HR3A	Atlantic Salmon	20	na	9.3	10.2	10.4	1+
HR3A	Atlantic Salmon	21	na	9.1	10.0	8.2	1+
HR3A	Atlantic Salmon	22	na	10.2	11.2	13.7	1+
HR3A	Atlantic Salmon	23	na	9.3	10.2	9.0	1+
HR3A	Atlantic Salmon	24	na	7.2	7.7	4.1	1+
HR3A	Atlantic Salmon	25	na	8.6	9.3	7.6	1+
HR3A	Atlantic Salmon	26	na	8.6	9.1	7.1	1+
HR3A	Atlantic Salmon	27	na	9.6	10.3	9.9	1+
HR3A	Atlantic Salmon	28	na	8.3	9.0	6.4	1+
HR3A	Atlantic Salmon	29	na	7.5	8.1	4.4	1+
HR3A	Atlantic Salmon	30	na	8.2	8.8	6.8	1+
HR3A	Atlantic Salmon	31	na	4.9	5.3	1.5	0+
HR3A	Atlantic Salmon	32	na	5.2	5.7	1.7	0+
HR3A	Atlantic Salmon	33	na	4.6	5.0	1.3	0+
HR3A	Atlantic Salmon	34	na	4.7	5.1	1.2	0+
HR3A	Atlantic Salmon	35	na	4.7	5.0	1.1	0+
HR3A	Atlantic Salmon	36	na	4.3	4.6	1.0	0+
HR3A	Atlantic Salmon	37	na	4.7	4.9	1.2	0+
HR3A	Atlantic Salmon	38	na	4.9	5.2	1.1	0+
HR3A	Atlantic Salmon	39	na	4.3	4.6	0.9	0+
HR3A	Atlantic Salmon	40	na	5.0	5.5	1.5	0+
HR3A	Atlantic Salmon	41	na	4.9	5.3	1.3	0+
HR3A	Atlantic Salmon	42	na	4.6	5.0	1.3	0+
HR3A	Atlantic Salmon	43	na	4.7	5.0	1.2	0+
HR3A	Atlantic Salmon	44	na	4.6	4.9	1.6	0+
HR3A	Atlantic Salmon	45	na	3.9	4.1	0.6	0+
HR3A	Atlantic Salmon	46	na	4.7	5.1	1.3	0+
HR3A	Atlantic Salmon	47	na	4.7	5.0	1.3	0+

Table A6.2: Raw Biological Data on All Wild Fish Sampled at Heath Steele, August 1997.

Station	Species	Fish Number	Sample Number	Fork Length (cm)	Total Length (cm)	Whole Weight (g)	Age[1] (y)
HR3A	Atlantic Salmon	48	na	5.2	5.6	1.6	0+
HR3A	Atlantic Salmon	49	na	5.1	5.6	1.4	0+
HR3A	Atlantic Salmon	50	na	5.1	5.5	1.4	0+
HR3A	Atlantic Salmon	51	na	5.1	5.5	1.7	0+
HR3A	Atlantic Salmon	52	na	4.7	4.6	0.9	0+
HR3A	Atlantic Salmon	53	na	5.0	5.3	1.6	0+
HR3A	Atlantic Salmon	54	na	4.6	4.9	0.8	0+
HR3A	Atlantic Salmon	55	na	4.9	5.3	1.6	0+
HR3A	Atlantic Salmon	56	na	4.9	5.2	1.2	0+
HR3A	Atlantic Salmon	57	na	4.7	5.1	1.2	0+
HR3A	Atlantic Salmon	58	na	5.3	5.8	1.9	0+
HR3A	Atlantic Salmon	59	na	4.8	5.1	1.0	0+
HR3A	Atlantic Salmon	60	na	5.1	5.5	1.4	0+
HR3A	Atlantic Salmon	61	na	4.3	4.6	1.1	0+
HR3A	Atlantic Salmon	62	na	4.8	5.1	1.2	0+
HR3A	Atlantic Salmon	63	na	4.5	4.8	1.0	0+
HR3A	Atlantic Salmon	64	na	5.0	5.3	1.6	0+
HR3A	Atlantic Salmon	65	na	4.9	5.2	1.6	0+
HR3A	Atlantic Salmon	66	na	5.0	5.3	1.6	0+
HR3A	Atlantic Salmon	67	na	5.2	5.6	1.8	0+
HR3A	Atlantic Salmon	68	na	5.1	5.5	1.4	0+
HR3A	Atlantic Salmon	69	na	5.0	5.4	1.6	0+
HR3A	Atlantic Salmon	70	na	4.7	5.1	1.2	0+
HR3A	Atlantic Salmon	71	na	5.0	5.3	1.7	0+
HR3A	Atlantic Salmon	72	na	5.1	5.6	1.7	0+
HR3A	Atlantic Salmon	73	na	4.7	5.0	1.2	0+
HR3A	Atlantic Salmon	74	na	4.1	4.3	1.0	0+
HR3A	Atlantic Salmon	75	na	5.1	5.5	1.4	0+
HR3A	Atlantic Salmon	76	na	4.5	4.8	1.1	0+
HR3A	Atlantic Salmon	77	na	4.5	4.8	1.4	0+
HR3A	Atlantic Salmon	78	na	4.6	5.0	1.1	0+
HR3A	Atlantic Salmon	79	na	5.0	5.4	1.5	0+
HR3A	Atlantic Salmon	80	na	4.9	5.2	1.5	0+
HR3A	Atlantic Salmon	81	na	4.3	4.6	1.0	0+
HR3A	Atlantic Salmon	82	na	5.0	5.4	1.6	0+
HR3A	Blacknose Dace	94	HR3ABD1-F	6.7	7.2	2.5	3+
HR3A	Blacknose Dace	95	HR3ABD2-F	4.8	5.1	1.4	1+
HR3A	Blacknose Dace	96	HR3ABD3-F	3.9	4.1	0.6	1+
HR3A	Blacknose Dace	97	HR3ABD4-F	7.7	8.2	5.1	4+
HR3A	Blacknose Dace	98	HR3ABD5-F	6.6	7.0	3.1	3+
HR3A	Blacknose Dace	99	HR3ABD6-F	6.8	7.2	3.1	3+
HR3A	Blacknose Dace	100	HR3ABD7-F	5.1	5.4	1.2	1+
HR3A	Blacknose Dace	101	HR3ABD8-F	3.9	4.2	0.6	1+
HR3A	Brook Trout	83	na	5.7	6.1	2.4	nd
HR3A	Brook Trout	84	na	4.7	4.9	1.2	nd
HR3A	Brook Trout	85	na	5.3	5.6	1.7	nd
HR3A	Brook Trout	130	na	21.2	22.2	101.4	nd
HR3A	White Sucker	86	na	2.8	2.9	0.2	0+
HR3A	White Sucker	87	na	2.8	3.0	0.3	0+
HR3A	White Sucker	88	na	2.8	3.0	0.2	0+
HR3A	White Sucker	89	na	2.8	3.0	0.3	0+
HR3A	White Sucker	90	na	2.8	3.0	0.3	0+
HR3A	White Sucker	91	na	2.8	3.0	0.3	0+
HR3A	White Sucker	92	na	2.7	2.9	0.2	0+
HR3A	White Sucker	93	na	3.0	3.2	0.3	0+
HR3A	3-Spine Stickleback	123	na	na	5.5	1.3	nd
HR3A	3-Spine Stickleback	124	na	na	4.4	0.6	nd
HR3A	3-Spine Stickleback	125	na	na	2.1	< 0.1	0+
HR3A	3-Spine Stickleback	126	na	na	2.6	0.1	0+
HR3A	3-Spine Stickleback	127	na	na	2.3	< 0.1	0+
HR3A	3-Spine Stickleback	128	na	na	2.3	0.1	0+
HR3A	3-Spine Stickleback	129	na	na	2.4	0.1	0+
HR3A	Slimy Sculpin	102	na	na	7.6	4.7	nd
HR3A	Slimy Sculpin	103	na	na	6.6	3.8	nd
HR3A	Slimy Sculpin	104	na	na	6.4	3.2	nd
HR3A	Slimy Sculpin	105	na	na	7.2	4.0	nd
HR3A	Slimy Sculpin	106	na	na	7.1	4.1	nd
HR3A	Slimy Sculpin	107	na	na	7.5	4.9	nd
HR3A	Slimy Sculpin	108	na	na	6.2	2.6	nd
HR3A	Slimy Sculpin	109	na	na	7.0	4.1	nd
HR3A	Slimy Sculpin	110	na	na	6.1	2.6	nd
HR3A	Slimy Sculpin	111	na	na	6.0	2.3	nd
HR3A	Slimy Sculpin	112	na	na	7.2	4.1	nd
HR3A	Slimy Sculpin	113	na	na	8.7	5.8	nd
HR3A	Slimy Sculpin	114	na	na	7.2	2.0	nd

Table A6.2: Raw Biological Data on All Wild Fish Sampled at Heath Steele, August 1997.

Station	Species	Fish Number	Sample Number	Fork Length (cm)	Total Length (cm)	Whole Weight (g)	Age[1] (y)
HR3A	Slimy Sculpin	115	na	na	8.7	1.8	nd
HR3A	Slimy Sculpin	116	na	na	5.6	1.2	nd
HR3A	Slimy Sculpin	117	na	na	5.8	2.2	nd
HR3A	Sea Lamprey	118	na	na	13.3	3.6	nd
HR3A	Sea Lamprey	119	na	na	15.2	5.2	nd
HR3A	Sea Lamprey	120	na	na	9.5	1.1	nd
HR3A	Sea Lamprey	121	na	na	11.8	3.0	nd
HR3A	Sea Lamprey	122	na	na	8.1	0.9	nd
HR3B	Atlantic Salmon	4	na	15.0	16.2	42.9	3+
HR3B	Atlantic Salmon	7	HR3BAS1-F	12.8	13.8	23.1	2+
HR3B	Atlantic Salmon	8	HR3BAS2-F	13.0	14.2	23.8	2+
HR3B	Atlantic Salmon	9	HR3BAS3-F	10.1	11.1	11.3	1+
HR3B	Atlantic Salmon	10	HR3BAS4-F	9.5	10.5	11.3	1+
HR3B	Atlantic Salmon	11	HR3BAS5-F	8.1	8.8	7.2	1+
HR3B	Atlantic Salmon	12	HR3BAS6-F	12.3	13.4	19.0	2+
HR3B	Atlantic Salmon	13	na	11.2	12.3	17.7	2+
HR3B	Atlantic Salmon	14	na	10.5	11.5	12.9	1+
HR3B	Atlantic Salmon	15	na	8.8	9.6	9.9	1+
HR3B	Atlantic Salmon	16	na	10.8	11.5	13.8	1+
HR3B	Atlantic Salmon	17	na	10.5	11.5	15.6	1+
HR3B	Atlantic Salmon	18	na	11.1	12.3	17.0	2+
HR3B	Atlantic Salmon	19	na	10.0	11.0	12.9	1+
HR3B	Atlantic Salmon	20	na	8.5	9.2	7.8	1+
HR3B	Atlantic Salmon	21	na	11.1	12.2	16.0	2+
HR3B	Atlantic Salmon	22	na	9.0	9.7	9.8	1+
HR3B	Atlantic Salmon	23	na	9.7	10.5	10.3	1+
HR3B	Atlantic Salmon	24	na	10.7	11.8	17.0	1+
HR3B	Atlantic Salmon	25	na	8.7	9.5	8.4	1+
HR3B	Atlantic Salmon	26	na	10.2	11.2	11.7	1+
HR3B	Atlantic Salmon	27	na	10.1	11.1	11.7	1+
HR3B	Atlantic Salmon	28	na	10.8	11.8	15.1	1+
HR3B	Atlantic Salmon	29	na	10.9	12.0	17.3	2+
HR3B	Atlantic Salmon	30	na	10.4	11.4	13.0	1+
HR3B	Atlantic Salmon	31	na	8.8	9.5	8.9	1+
HR3B	Atlantic Salmon	32	na	8.9	9.7	7.9	1+
HR3B	Atlantic Salmon	33	na	9.4	10.4	10.8	1+
HR3B	Atlantic Salmon	34	na	9.7	10.6	11.1	1+
HR3B	Atlantic Salmon	35	na	10.1	11.1	12.2	1+
HR3B	Atlantic Salmon	36	na	9.5	10.4	10.0	1+
HR3B	Atlantic Salmon	37	na	8.9	9.8	9.5	1+
HR3B	Atlantic Salmon	38	na	10.3	11.3	11.8	1+
HR3B	Atlantic Salmon	39	na	9.0	9.7	7.5	1+
HR3B	Atlantic Salmon	40	na	10.2	11.2	13.9	1+
HR3B	Atlantic Salmon	41	na	9.4	10.3	10.4	1+
HR3B	Atlantic Salmon	42	na	10.3	11.3	13.9	1+
HR3B	Atlantic Salmon	43	na	10.3	11.3	13.6	1+
HR3B	Atlantic Salmon	44	na	10.1	11.1	11.5	1+
HR3B	Atlantic Salmon	45	na	11.2	12.3	14.5	2+
HR3B	Atlantic Salmon	46	na	7.7	8.4	5.1	1+
HR3B	Atlantic Salmon	47	na	9.8	10.8	11.0	1+
HR3B	Atlantic Salmon	48	na	9.8	10.8	10.8	1+
HR3B	Atlantic Salmon	49	na	10.3	11.3	13.3	1+
HR3B	Atlantic Salmon	50	na	8.0	8.8	6.7	1+
HR3B	Atlantic Salmon	51	na	9.4	10.2	8.7	1+
HR3B	Atlantic Salmon	52	na	8.8	9.6	9.1	1+
HR3B	Atlantic Salmon	53	na	9.9	10.9	13.7	1+
HR3B	Atlantic Salmon	54	na	4.7	5.1	1.3	0+
HR3B	Atlantic Salmon	55	na	4.5	4.8	1.1	0+
HR3B	Atlantic Salmon	56	na	5.0	5.3	1.2	0+
HR3B	Atlantic Salmon	57	na	4.9	5.3	1.4	0+
HR3B	Atlantic Salmon	58	na	4.9	5.3	1.6	0+
HR3B	Atlantic Salmon	59	na	4.9	5.3	1.6	0+
HR3B	Atlantic Salmon	60	na	4.3	4.6	1.0	0+
HR3B	Atlantic Salmon	61	na	4.2	4.5	1.0	0+
HR3B	Atlantic Salmon	62	na	4.7	5.1	1.3	0+
HR3B	Atlantic Salmon	63	na	5.2	5.6	1.8	0+
HR3B	Atlantic Salmon	64	na	4.5	4.8	1.3	0+
HR3B	Atlantic Salmon	65	na	5.3	5.7	1.9	0+
HR3B	Atlantic Salmon	66	na	4.9	5.4	1.3	0+
HR3B	Atlantic Salmon	67	na	5.0	5.4	1.5	0+
HR3B	Atlantic Salmon	68	na	4.8	5.2	1.5	0+
HR3B	Atlantic Salmon	69	na	5.4	5.8	2.0	0+
HR3B	Atlantic Salmon	70	na	5.0	5.4	1.6	0+
HR3B	Atlantic Salmon	71	na	4.8	5.2	1.5	0+
HR3B	Atlantic Salmon	72	na	4.9	5.3	1.5	0+

Table A6.2: Raw Biological Data on All Wild Fish Sampled at Heath Steele, August 1997.

Station	Species	Fish Number	Sample Number	Fork Length (cm)	Total Length (cm)	Whole Weight (g)	Age[1] (y)
HR3B	Atlantic Salmon	73	na	4.5	4.8	1.2	0+
HR3B	Atlantic Salmon	74	na	4.7	5.1	1.4	0+
HR3B	Atlantic Salmon	75	na	4.8	5.1	1.3	0+
HR3B	Atlantic Salmon	76	na	4.1	4.4	0.9	0+
HR3B	Atlantic Salmon	77	na	5.2	5.6	1.9	0+
HR3B	Atlantic Salmon	78	na	4.4	4.7	1.2	0+
HR3B	Atlantic Salmon	79	na	4.6	5.0	1.2	0+
HR3B	Atlantic Salmon	80	na	4.6	5.0	1.1	0+
HR3B	Atlantic Salmon	81	na	5.0	5.4	1.8	0+
HR3B	Atlantic Salmon	82	na	4.9	5.4	1.7	0+
HR3B	Atlantic Salmon	83	na	4.8	5.2	1.4	0+
HR3B	Atlantic Salmon	84	na	4.4	4.6	0.9	0+
HR3B	Atlantic Salmon	85	na	4.3	4.6	0.8	0+
HR3B	Atlantic Salmon	86	na	4.8	5.2	1.5	0+
HR3B	Atlantic Salmon	87	na	4.2	4.5	1.1	0+
HR3B	Atlantic Salmon	88	na	5.0	5.4	1.4	0+
HR3B	Atlantic Salmon	89	na	4.2	4.5	0.7	0+
HR3B	Atlantic Salmon	90	na	4.2	4.5	0.8	0+
HR3B	Atlantic Salmon	91	na	5.2	5.6	2.0	0+
HR3B	Atlantic Salmon	92	na	4.9	5.2	1.4	0+
HR3B	Atlantic Salmon	93	na	4.9	5.3	1.3	0+
HR3B	Atlantic Salmon	94	na	4.4	4.7	1.1	0+
HR3B	Atlantic Salmon	95	na	4.8	5.1	1.1	0+
HR3B	Atlantic Salmon	96	na	4.2	4.6	1.0	0+
HR3B	Atlantic Salmon	97	na	5.3	5.7	1.9	0+
HR3B	Atlantic Salmon	98	na	5.0	5.3	1.4	0+
HR3B	Atlantic Salmon	99	na	4.7	5.0	1.2	0+
HR3B	Atlantic Salmon	100	na	5.1	5.5	1.5	0+
HR3B	Atlantic Salmon	101	na	4.4	4.7	0.8	0+
HR3B	Atlantic Salmon	102	na	4.4	4.7	0.8	0+
HR3B	Atlantic Salmon	103	na	5.1	5.6	1.5	0+
HR3B	Atlantic Salmon	104	na	4.9	5.3	1.4	0+
HR3B	Atlantic Salmon	105	na	4.5	4.8	1.0	0+
HR3B	Atlantic Salmon	106	na	4.8	5.1	1.1	0+
HR3B	Atlantic Salmon	107	na	4.5	4.8	1.2	0+
HR3B	Atlantic Salmon	108	na	4.5	4.8	1.2	0+
HR3B	Atlantic Salmon	109	na	4.1	4.4	1.0	0+
HR3B	Atlantic Salmon	110	na	4.6	4.9	1.3	0+
HR3B	Atlantic Salmon	111	na	4.4	4.7	1.0	0+
HR3B	Atlantic Salmon	112	na	4.8	5.2	1.4	0+
HR3B	Atlantic Salmon	113	na	4.7	5.1	1.3	0+
HR3B	Atlantic Salmon	114	na	4.5	4.8	1.1	0+
HR3B	Atlantic Salmon	115	na	4.9	5.3	1.5	0+
HR3B	Atlantic Salmon	116	na	4.7	5.0	1.5	0+
HR3B	Atlantic Salmon	117	na	4.9	5.3	1.3	0+
HR3B	Atlantic Salmon	118	na	5.2	5.6	1.6	0+
HR3B	Atlantic Salmon	119	na	4.8	5.1	1.1	0+
HR3B	Atlantic Salmon	120	na	5.0	5.4	1.5	0+
HR3B	Atlantic Salmon	121	na	3.9	4.1	0.7	0+
HR3B	Atlantic Salmon	122	na	4.5	4.8	1.2	0+
HR3B	Atlantic Salmon	123	na	4.6	4.8	1.3	0+
HR3B	Atlantic Salmon	124	na	4.3	4.7	1.1	0+
HR3B	Atlantic Salmon	125	na	5.4	5.8	1.7	0+
HR3B	Atlantic Salmon	126	na	4.8	5.1	1.2	0+
HR3B	Atlantic Salmon	127	na	3.9	4.2	0.8	0+
HR3B	Atlantic Salmon	128	na	4.8	5.2	1.3	0+
HR3B	Atlantic Salmon	129	na	4.6	4.9	1.3	0+
HR3B	Atlantic Salmon	130	na	3.5	3.7	0.8	0+
HR3B	Atlantic Salmon	131	na	5.7	5.9	1.1	0+
HR3B	Atlantic Salmon	132	na	4.6	4.9	1.0	0+
HR3B	Atlantic Salmon	133	na	4.4	4.6	0.8	0+
HR3B	Atlantic Salmon	134	na	4.4	4.6	0.7	0+
HR3B	Atlantic Salmon	135	na	4.0	4.3	0.7	0+
HR3B	Atlantic Salmon	136	na	5.1	5.5	1.5	0+
HR3B	Atlantic Salmon	137	na	4.6	4.9	1.3	0+
HR3B	Atlantic Salmon	138	na	4.5	4.8	1.1	0+
HR3B	Atlantic Salmon	139	na	4.7	5.0	1.4	0+
HR3B	Blacknose Dace	160	HR3BBD1-F	4.9	5.3	1.3	1+
HR3B	Blacknose Dace	161	HR3BBD2-F	5.2	5.5	1.7	1+
HR3B	Blacknose Dace	162	HR3BBD3-F	6.6	7.0	3.3	3+
HR3B	Blacknose Dace	163	HR3BBD4-F	5.2	5.5	1.5	1+
HR3B	Blacknose Dace	164	HR3BBD5-F	5.2	5.5	1.8	1+
HR3B	Blacknose Dace	165	HR3BBD6-F	5.5	5.8	1.9	2+
HR3B	Blacknose Dace	166	HR3BBD7-F	5.0	5.4	1.4	1+
HR3B	Blacknose Dace	167	HR3BBD8-F	4.9	5.2	1.2	1+

Table A6.2: Raw Biological Data on All Wild Fish Sampled at Heath Steele, August 1997.

Station	Species	Fish Number	Sample Number	Fork Length (cm)	Total Length (cm)	Whole Weight (g)	Age[1] (y)
HR3B	Blacknose Dace	168	HR3BBD9-F	3.5	3.8	0.6	**1+**
HR3B	Brook Trout	1	na	21.2	22.5	124.0	nd
HR3B	Brook Trout	2	na	19.9	20.6	97.1	nd
HR3B	Brook Trout	3	na	15.8	16.3	41.9	nd
HR3B	Brook Trout	5	HR3BBT1-F	13.9	14.8	33.1	nd
HR3B	Brook Trout	6	HR3BBT2-F	13.8	14.5	26.3	nd
HR3B	Brook Trout	140	na	4.7	5.0	1.3	nd
HR3B	Slimy Sculpin	141	na		7.1	3.8	nd
HR3B	Slimy Sculpin	142	na	na	8.8	6.9	nd
HR3B	Slimy Sculpin	143	na	na	6.3	2.8	nd
HR3B	Slimy Sculpin	144	na	na	6.7	3.2	nd
HR3B	Slimy Sculpin	145	na	na	8.0	5.8	nd
HR3B	Slimy Sculpin	146	na	na	6.2	2.7	nd
HR3B	Slimy Sculpin	147	na	na	5.8	2.1	nd
HR3B	Slimy Sculpin	148	na	na	6.2	2.7	nd
HR3B	Slimy Sculpin	149	na	na	7.1	4.4	nd
HR3B	Slimy Sculpin	150	na	na	6.2	2.7	nd
HR3B	Slimy Sculpin	151	na	na	6.0	2.2	nd
HR3B	Slimy Sculpin	152	na	na	7.6	5.2	nd
HR3B	Slimy Sculpin	153	na	na	6.2	2.7	nd
HR3B	Slimy Sculpin	154	na	na	7.7	5.3	nd
HR3B	Slimy Sculpin	155	na	na	6.8	2.7	nd
HR3B	Slimy Sculpin	156	na	na	5.9	2.4	nd
HR3B	Sea Lamprey	157	na	na	12.5	3.4	nd
HR3B	Sea Lamprey	158	na	na	11.7	2.4	nd
HR3B	Sea Lamprey	159	na	na	12.1	3.0	nd

[1] - Fish ages determined by otilith or scale aging are designated **BOLD**, others determined by length-frequency distribution

na - not applicable

nd - not determined

* - collected during supplemental electrofishing

Table A6.3: Summary of Fish Sizes by Age for Atlantic Salmon and Blacknose Dace, Heath Steele, August 1997.
Data shown for specimens aged by otolith (Salmon) and scale (dace).

Atlantic Salmon

	Age Class			
Parameter	**0+**	**1+**	**2+**	**3+**
Minimum Fork Length	3.5	7.8	11.7	16.0
Maximum Fork Length	6.4	10.9	13.9	16.0
Mean Fork Length	4.9	9.80	12.68	16.00
Minimum Total Length	3.7	8.5	12.8	17.2
Maximum Total Length	7.0	11.8	15.2	17.2
Mean Total Length	5.3	10.60	13.84	17.20
Minimum Weight	0.6	5.0	16.8	51.5
Maximum Weight	3.4	16.5	35.5	51.5
Mean Weight	1.5	11.45	24.23	51.50
Number of Points	163	22	26	1

Blacknose Dace

	Age Class					
Parameter	**0+**	**1+**	**2+**	**3+**	**4+**	**5+**
Minimum Fork Length	2.3	3.5	4.9	6.7	7.3	7.2
Maximum Fork Length	2.8	5.8	6.8	7.5	7.3	8.2
Mean Fork Length	2.55	4.63	5.88	7.05	7.30	7.73
Minimum Total Length	2.5	3.8	5.2	7.2	7.7	7.6
Maximum Total Length	3	6.3	7.3	8.1	7.7	8.9
Mean Total Length	2.75	4.95	6.25	7.57	7.70	8.28
Minimum Weight	0.2	0.6	1.2	3.1	4	4.6
Maximum Weight	0.3	2	3.8	5.1	4	6.3
Mean Weight	0.25	1.19	2.40	4.10	4.00	5.50
Number of Points	2	16	20	6	1	4

Note: 0+ salmon and dace aged by field inspection - 0+ fish are readily aged with certainty without reading of otoliths, scales or other structures.

Table A6.4: Biological Measurements collected on Caged Atlantic Salmon at Heath Steele, August 1997.
Note - all fish were from artificially-fed yearlings from McCormack Reservoir rearing facility.

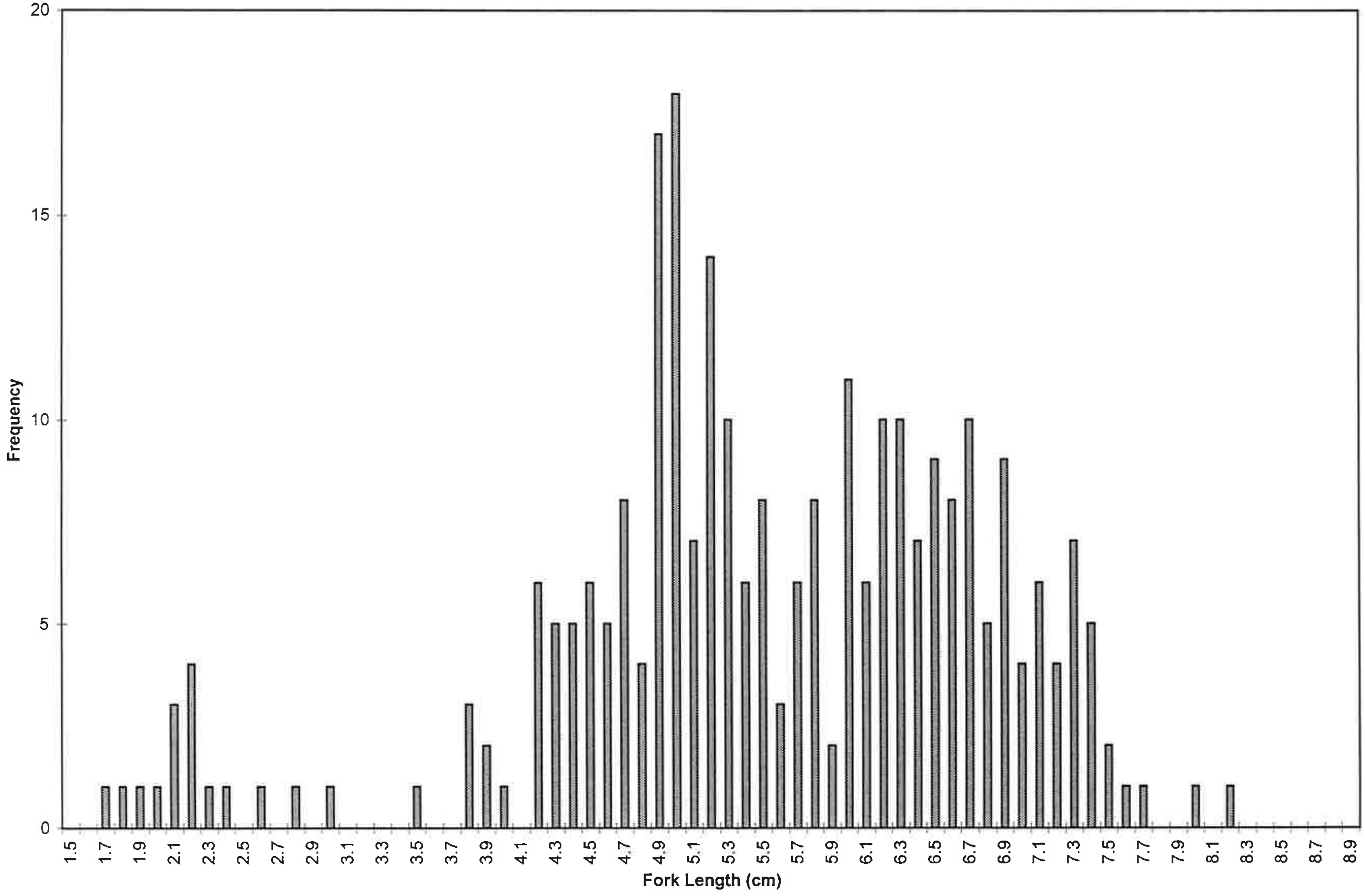
Station	Fish ID	Date/Time In	Date/Time Out	Fork Length (cm)	Total Length (cm)	Whole Weight (g)
HR1A	HR1AAS1C-F	8/12/97 11:30	8/21/97 9:30	12.5	13.6	23.2
	HR1AAS2C-F			13.8	14.9	30.7
HR1B	HR1BAS1C-F	8/12/97 12:00	8/21/97 9:30	13.1	14.2	25.9
	HR1BAS2C-F			13.5	14.3	29.7
HR2A	HR2AAS1C-F	8/12/97 13:30	8/21/97 10:15	13.7	14.9	29.1
	HR2AAS2C-F			13.5	14.6	28.1
HR2B	HR2BAS1C-F	8/12/97 13:50	8/21/97 10:20	13.3	14.4	25.7
	HR2BAS2C-F			13.5	14.4	28.0
HR3A	HR3AAS1C-F	8/12/97 19:50	8/21/97 16:15	13.7	14.7	30.0
	HR3AAS2C-F			13.6	14.7	27.6
HR3B	HR3BAS1C-F	8/12/97 20:10	8/21/97 16:15	13.8	15.0	30.4
	HR3BAS2C-F			12.5	13.6	23.1
HE1A	HE1AAS1C-F	8/12/97 13:15	8/21/97 11:30	14.2	15.4	34.3
	HE1AAS2C-F			13.8	14.6	28.9
HE1B	HE1BAS1C-F	8/12/97 14:15	8/21/97 11:35	13.9	15.0	30.8
	HE1BAS2C-F			13.4	14.3	28.5
HE2A	HE2AAS1C-F	8/12/97 14:45	8/21/97 11:40	13.7	14.9	28.7
	HE2AAS2C-F			11.2	11.7	15.2
HE2B	HE2BAS1C-F	8/12/97 14:30	8/21/97 12:10	13.9	15.1	32.5
	HE2BAS2C-F			14.1	15.2	31.3
HE3A	HE3AAS1C-F	8/12/97 14:45	8/21/97 12:10	14.2	15.3	33.6
	HE3AAS2C-F			13.7	14.6	26.8
HE3B	HE3BAS1C-F	8/12/97 16:45	8/21/97 12:40	13.3	14.5	26.0
	HE3BAS2C-F			12.4	13.3	21.0
HE4A	HE4AAS1C-F	8/12/97 17:45	8/21/97 12:45	13.0	14.1	26.9
	HE4AAS2C-F			12.7	13.6	22.4
HE4B	HE4BAS1C-F	8/12/97 16:05	8/21/97 13:35	13.6	14.7	28.9
	HE4BAS2C-F			14.3	15.4	33.6
HE5A	HE5AAS1C-F	8/12/97 18:05	8/21/97 14:40	13.2	14.4	26.6
	HE5AAS2C-F			13.6	14.7	29.2
HE5B	HE5BAS1C-F	8/12/97 19:00	8/21/97 14:45	13.8	14.9	29.2
	HE5BAS2C-F			12.4	13.3	22.3

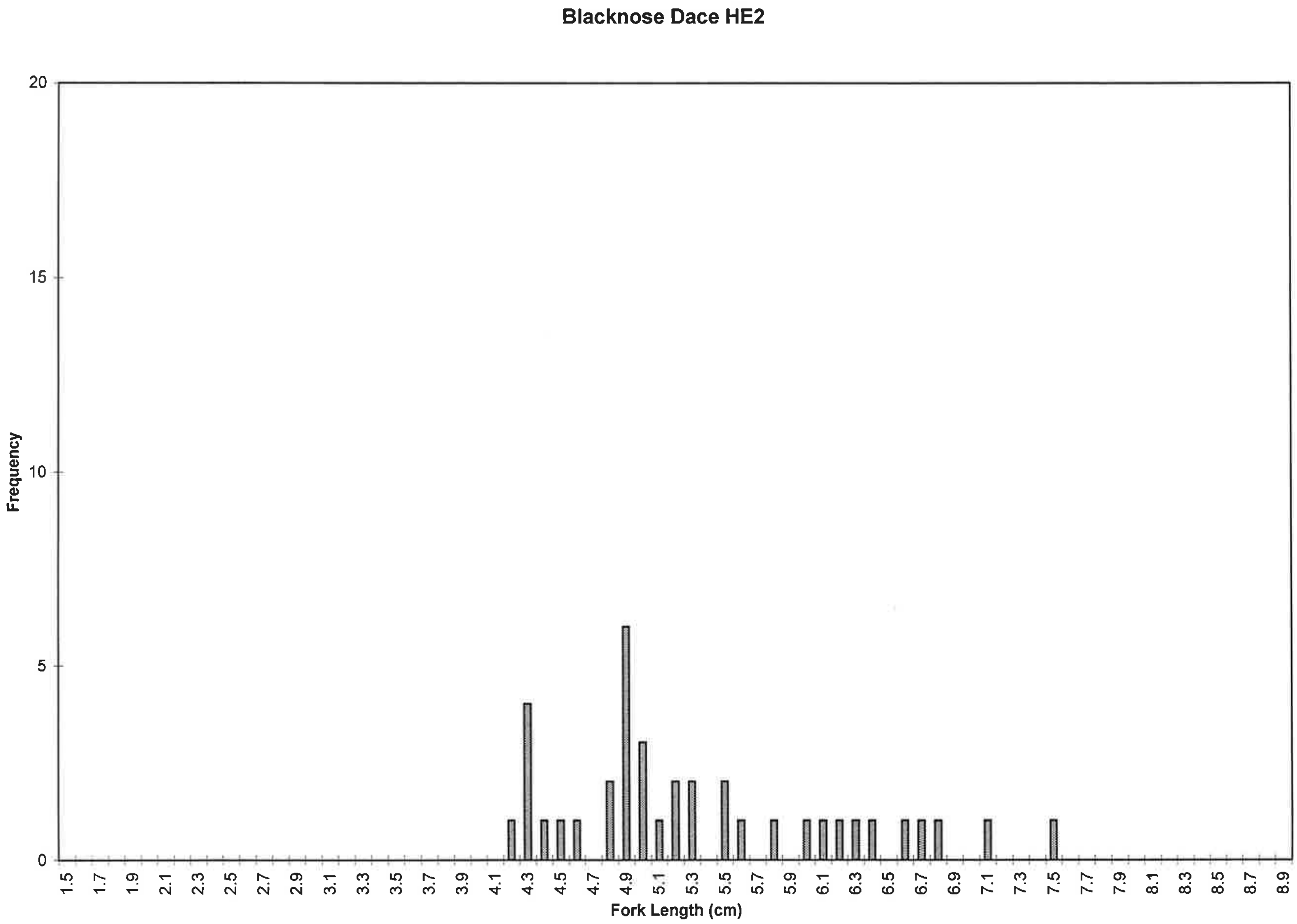
Length Frequency Histograms

Atlantic Salmon and Blacknose Dace

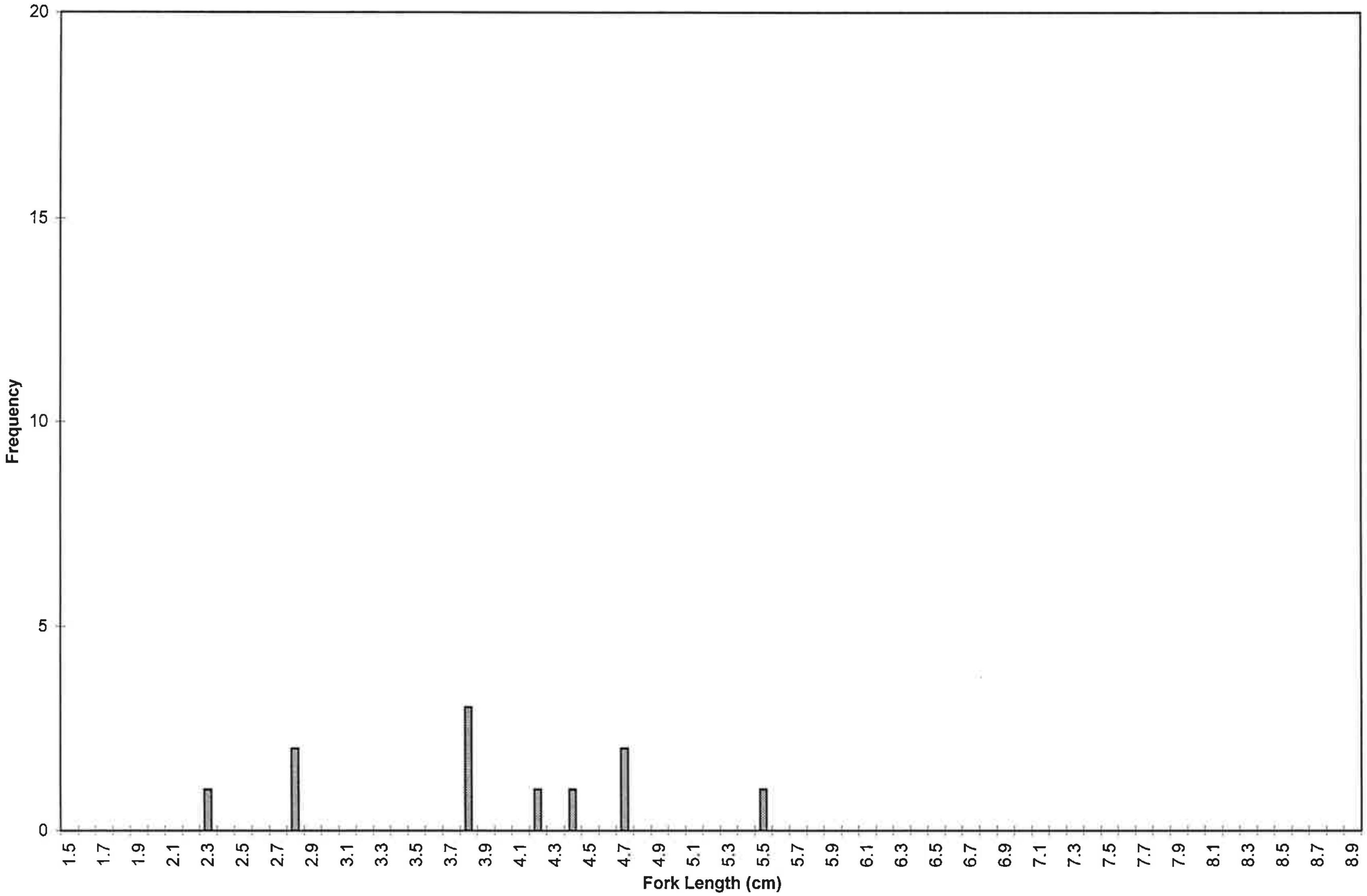
Heath Steele

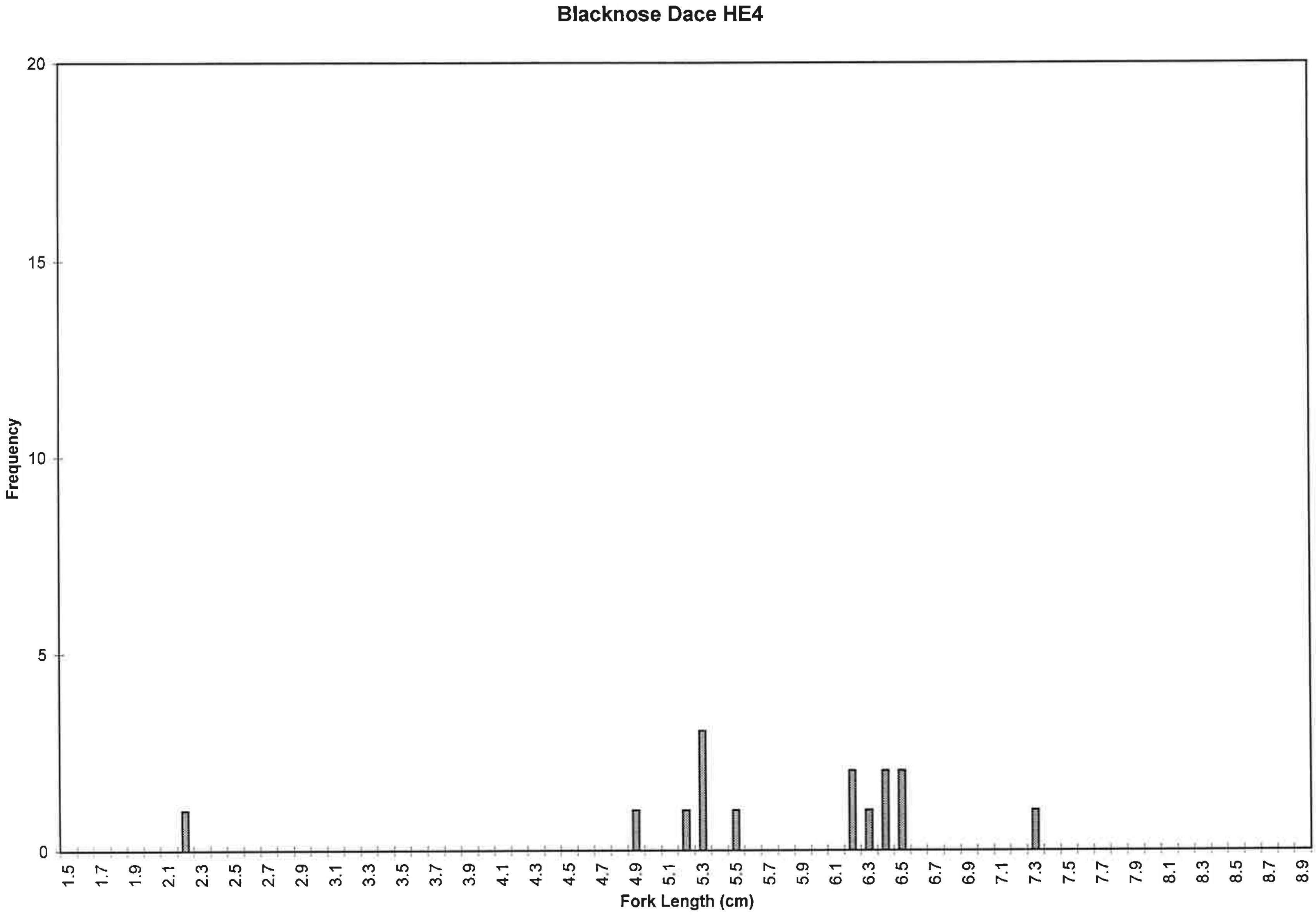
Blacknose Dace All Stations

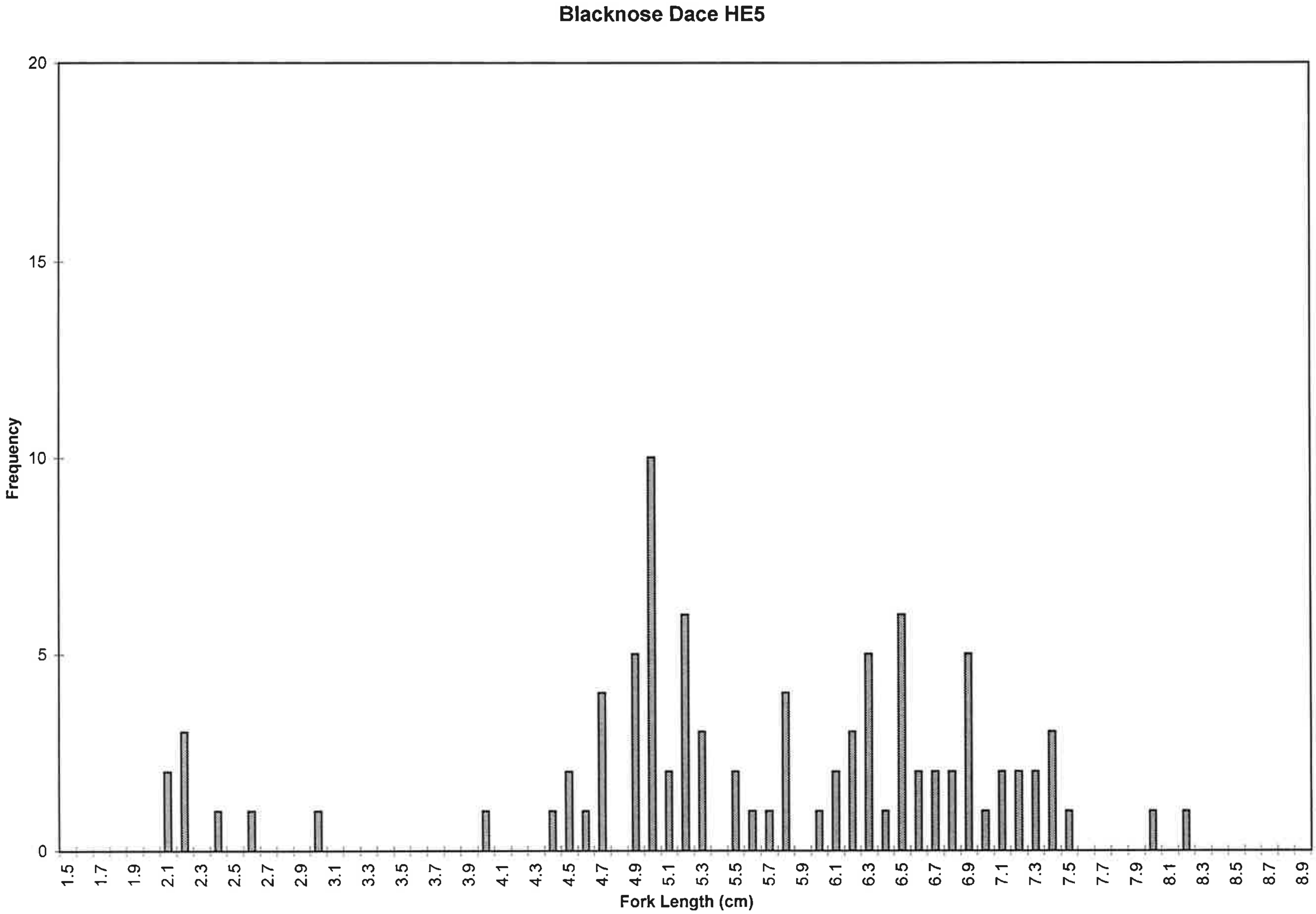



Blacknose Dace HE2
Frequency
20
15
10
5
0
1.5
1.7
1.9
2.1
2.3
2.5
2.7
2.9
3.1
3.3
3.5
3.7
3.9
4.1
4.3
4.5
4.7
4.9
5.1
5.3
5.5
5.7
5.9
6.1
6.3
6.5
6.7
6.9
7.1
7.3
7.5
7.7
7.9
8.1
8.3
8.5
8.7
8.9
Fork Length (cm)

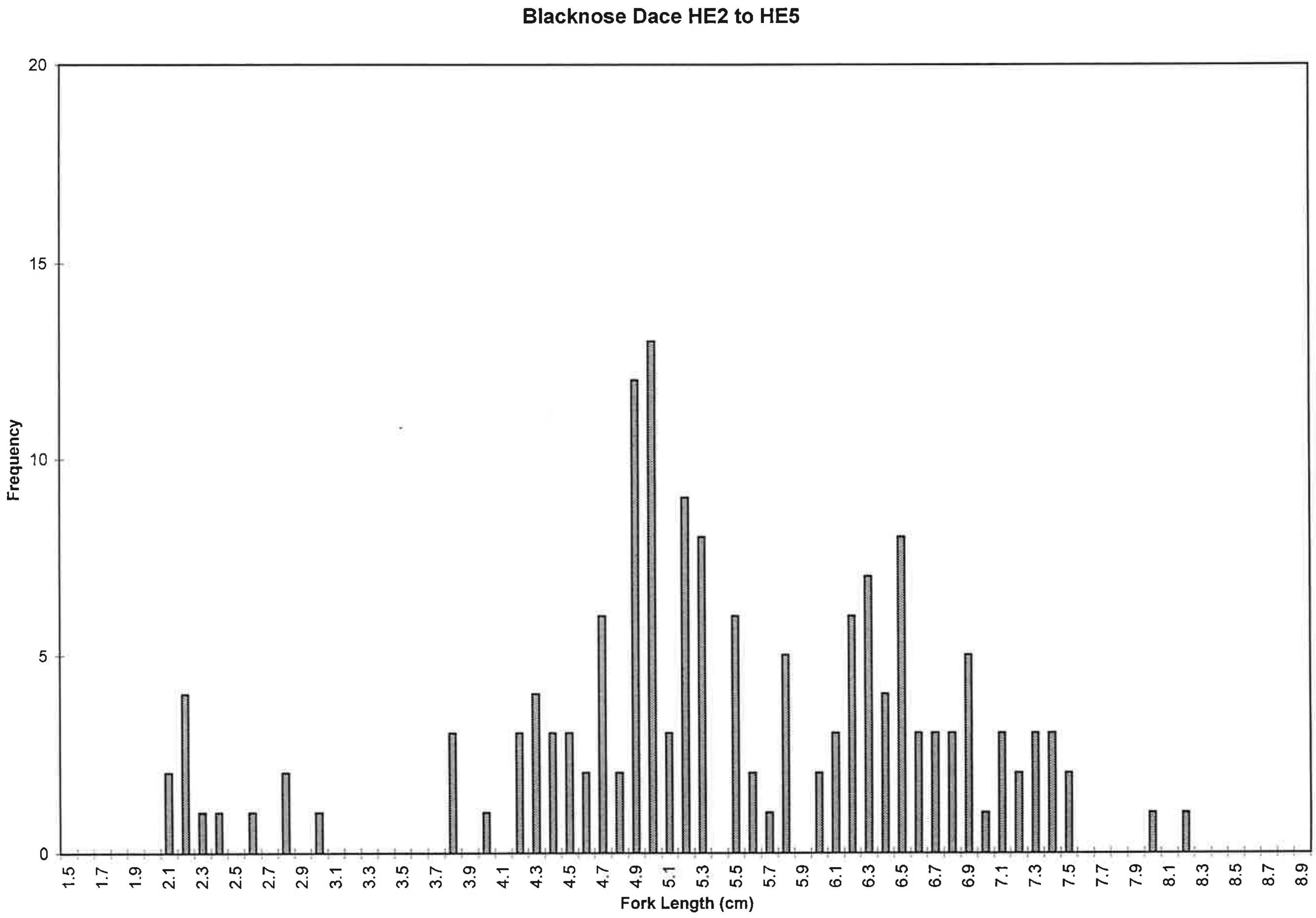
Blacknose Dace HE3



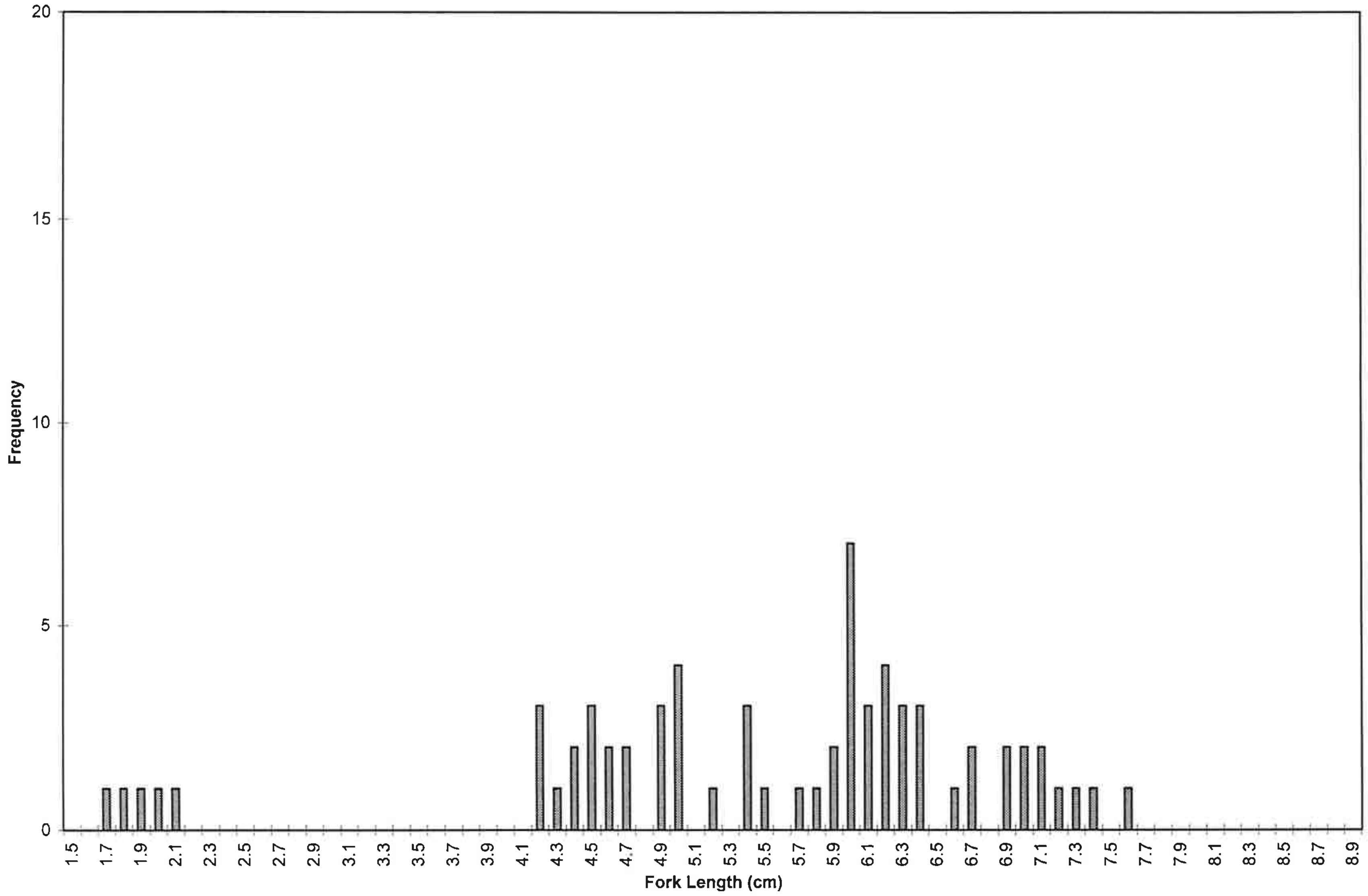

Blacknose Dace HE4
Frequency
20
15
10
5
0
1.5
1.7
1.9
2.1
2.3
2.5
2.7
2.9
3.1
3.3
3.5
3.7
3.9
4.1
4.3
4.5
4.7
4.9
5.1
5.3
5.5
5.7
5.9
6.1
6.3
6.5
6.7
6.9
7.1
7.3
7.5
7.7
7.9
8.1
8.3
8.5
8.7
8.9
Fork Length (cm)



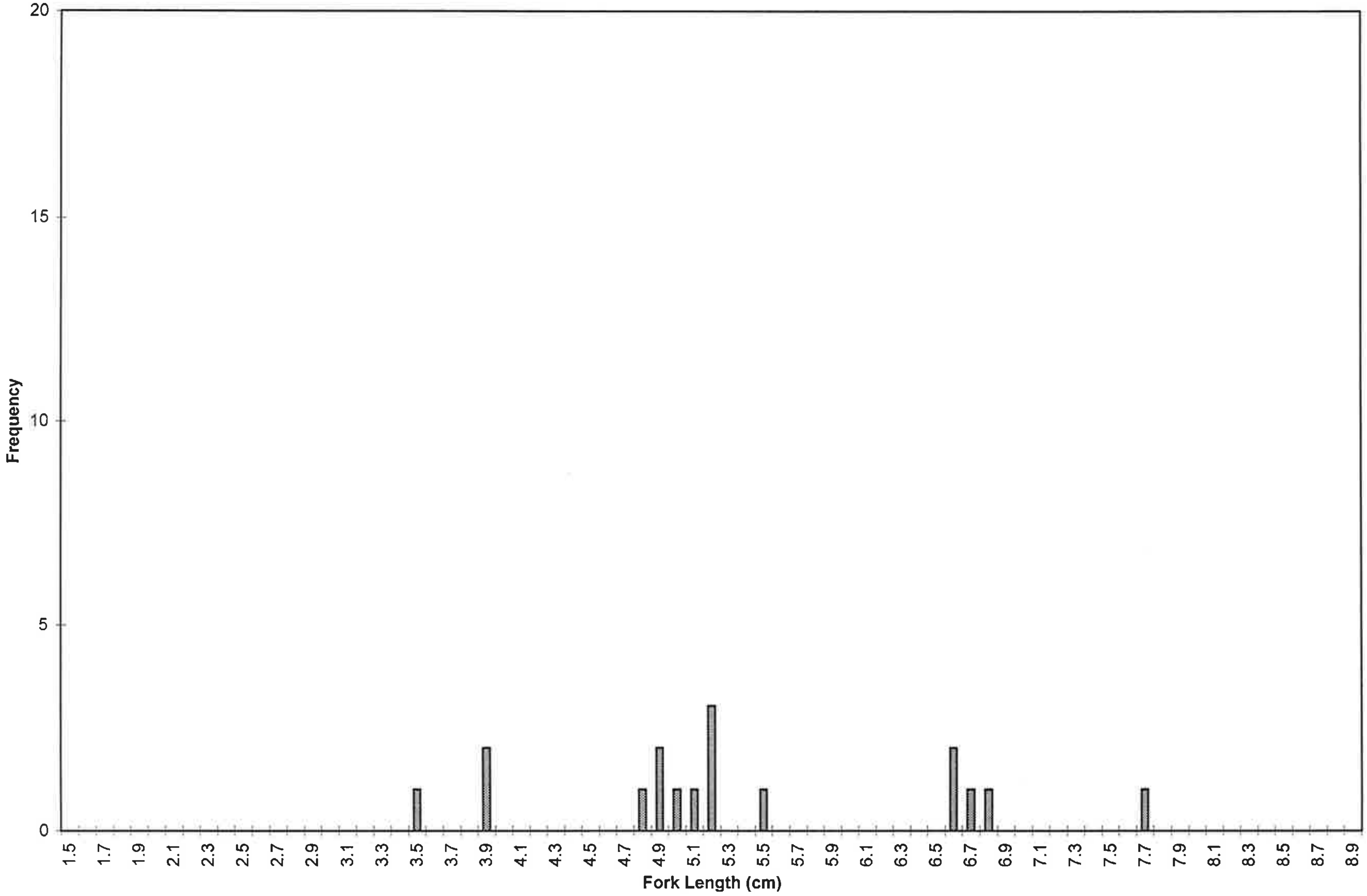
Blacknose Dace HE5

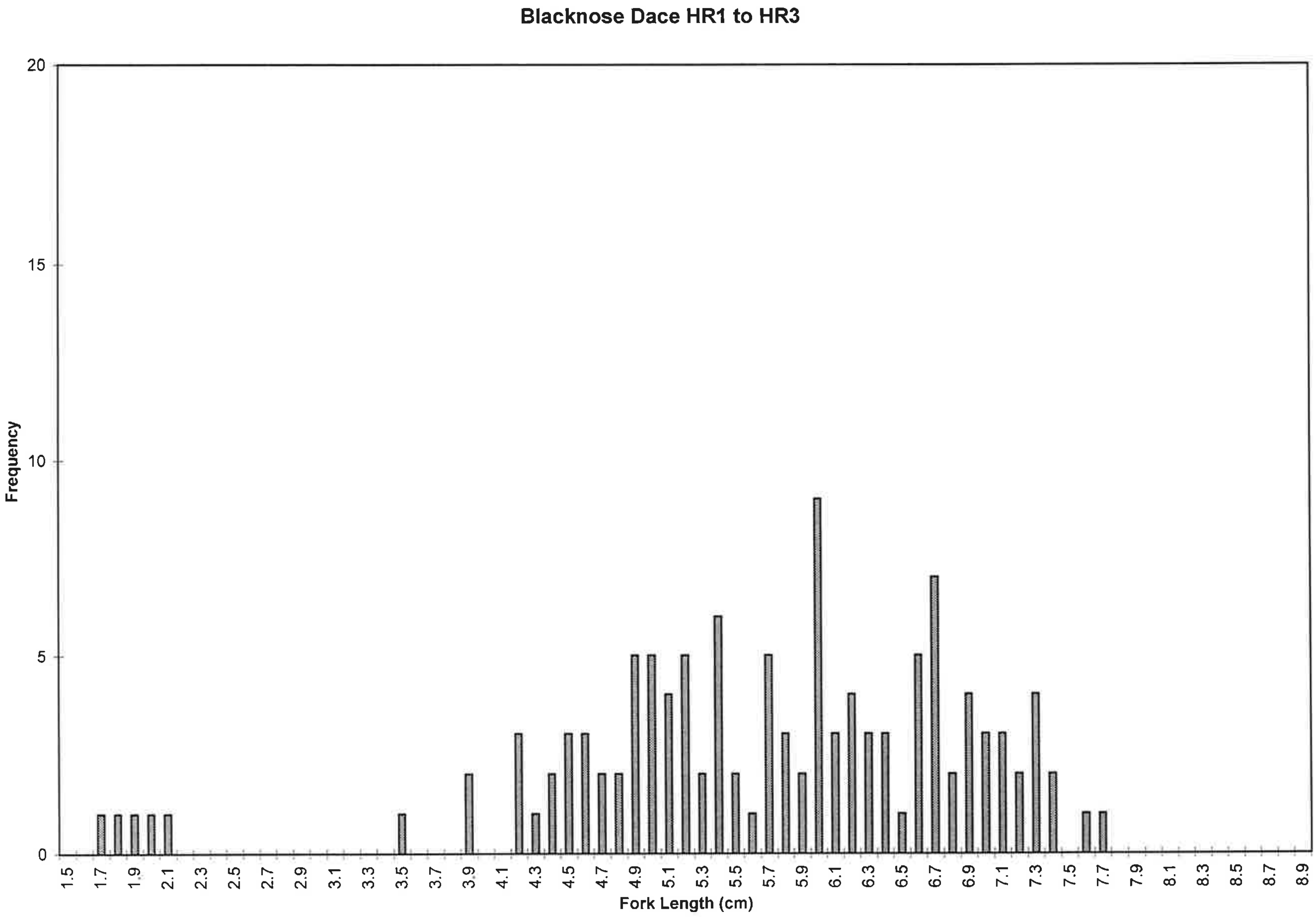

Blacknose Dace HE2 to HE5
Frequency
20
15
10
5
0
1.5
1.7
1.9
2.1
2.3
2.5
2.7
2.9
3.1
3.3
3.5
3.7
3.9
4.1
4.3
4.5
4.7
4.9
5.1
5.3
5.5
5.7
5.9
6.1
6.3
6.5
6.7
6.9
7.1
7.3
7.5
7.7
7.9
8.1
8.3
8.5
8.7
8.9
Fork Length (cm)

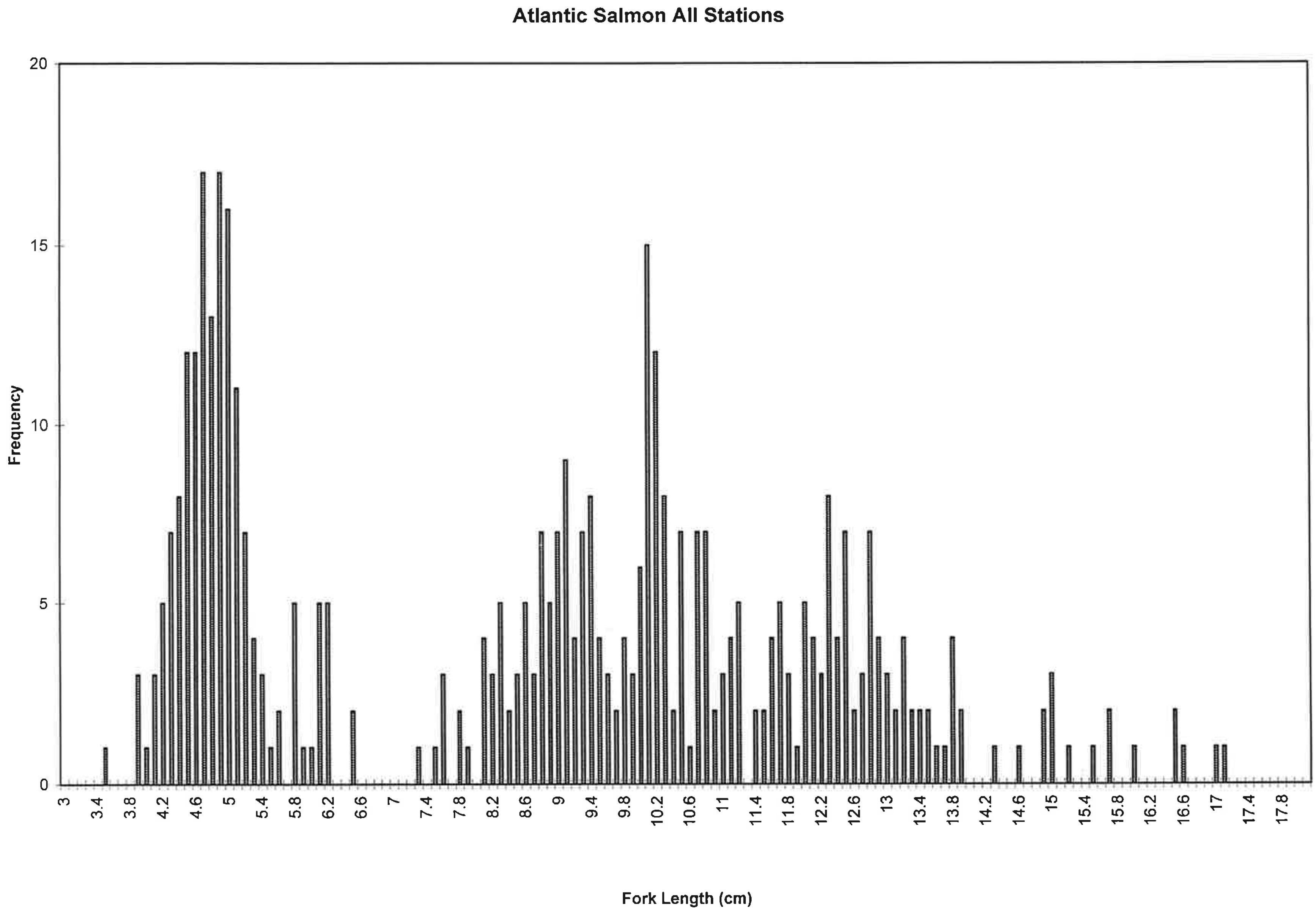
Blacknose Dace HR2

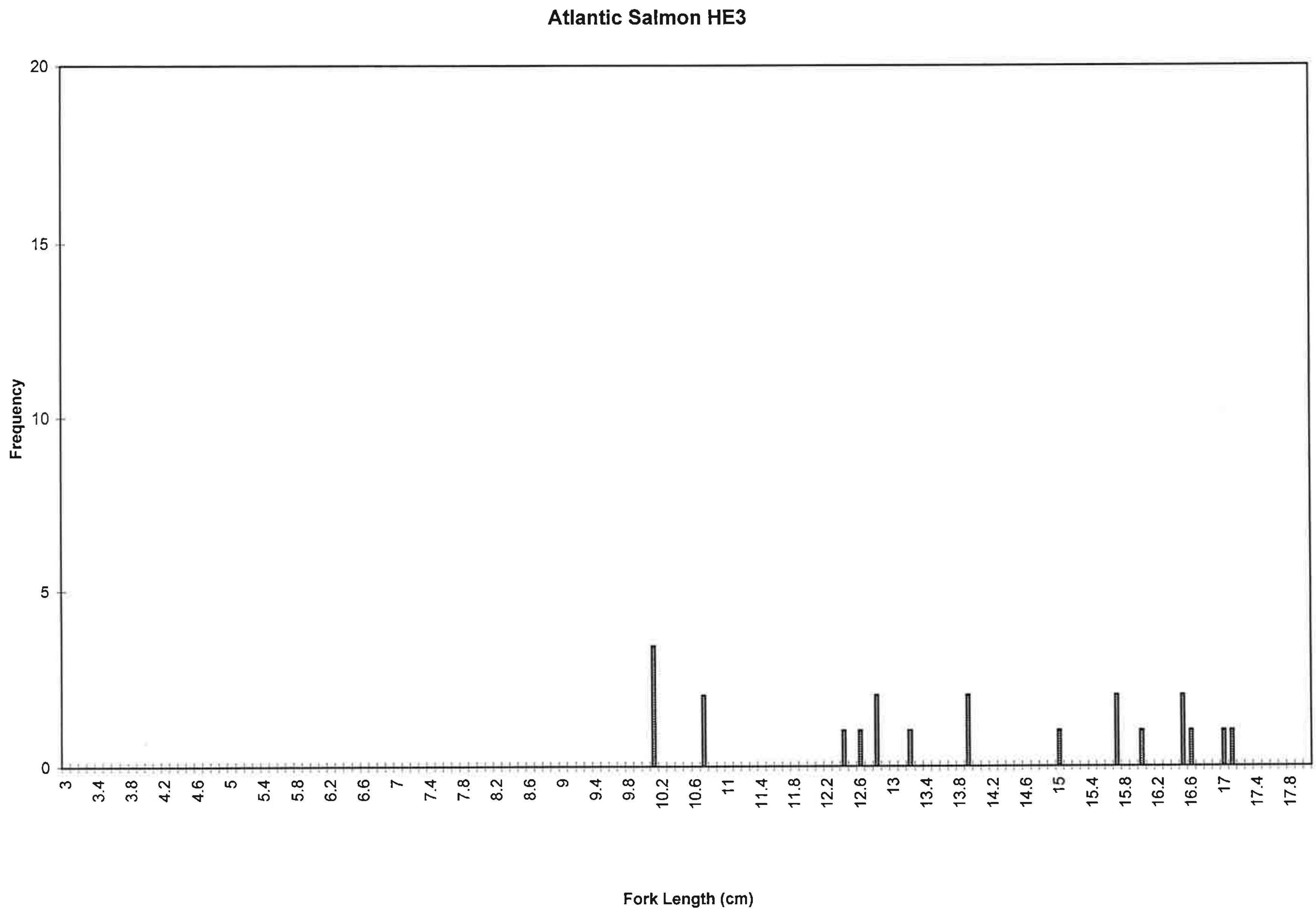


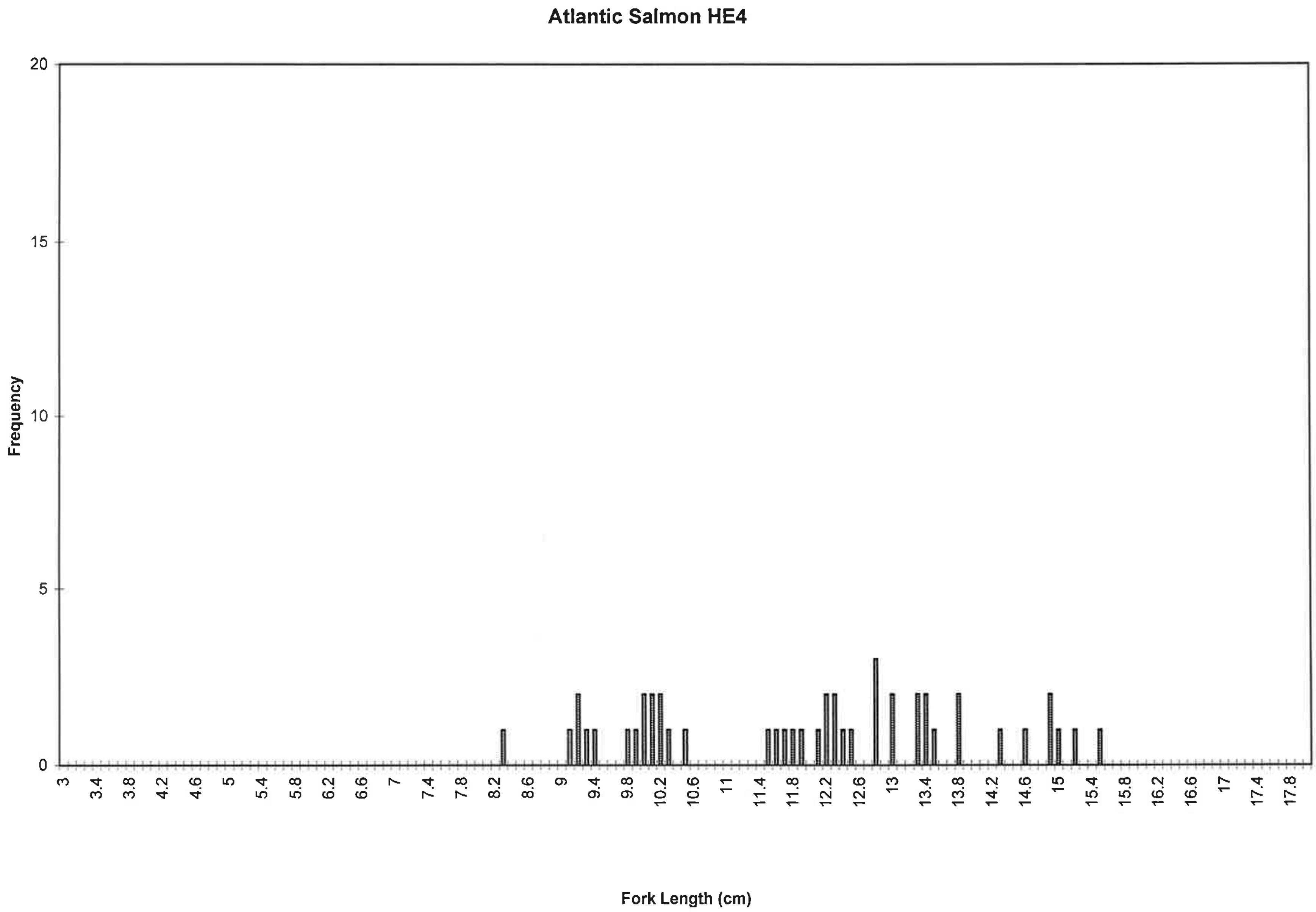
Blacknose Dace HR3



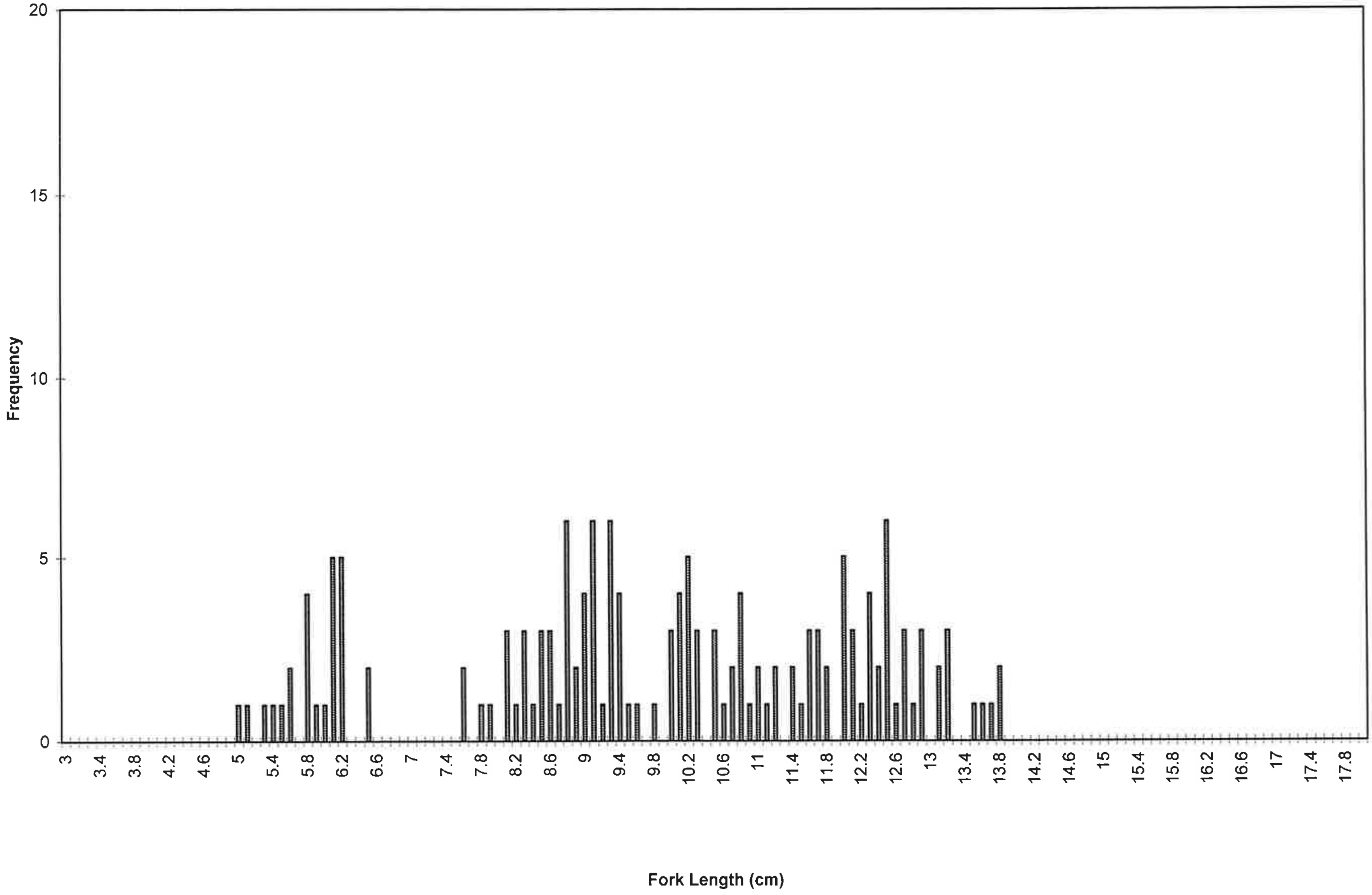

Blacknose Dace HR1 to HR3
Frequency
20
15
10
5
0
1.5
1.7
1.9
2.1
2.3
2.5
2.7
2.9
3.1
3.3
3.5
3.7
3.9
4.1
4.3
4.5
4.7
4.9
5.1
5.3
5.5
5.7
5.9
6.1
6.3
6.5
6.7
6.9
7.1
7.3
7.5
7.7
7.9
8.1
8.3
8.5
8.7
8.9
Fork Length (cm)

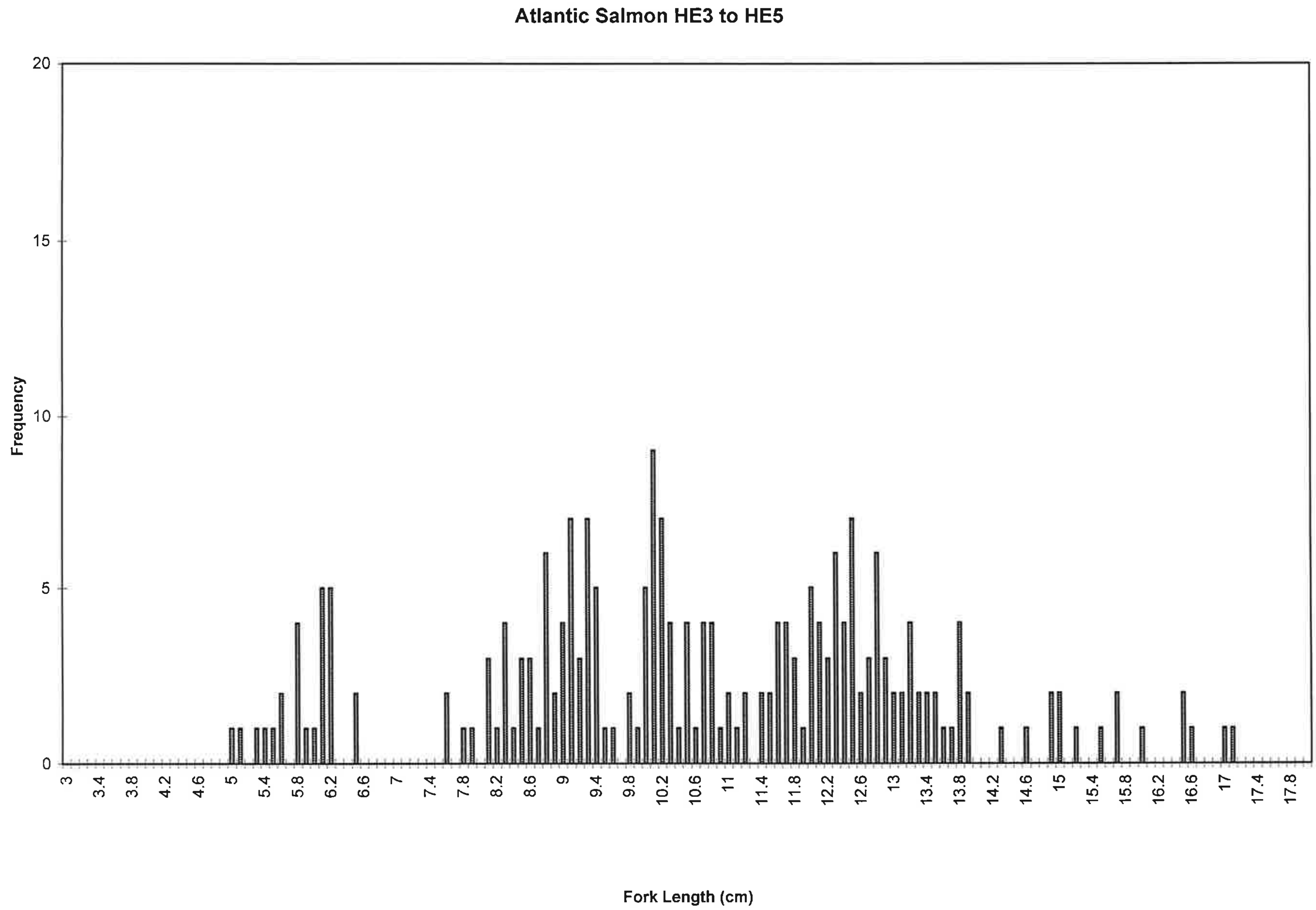

Atlantic Salmon All Stations
Frequency
20
15
10
5
0
3
3.4
3.8
4.2
4.6
5
5.4
5.8
6.2
6.6
7
7.4
7.8
8.2
8.6
9
9.4
9.8
10.2
10.6
11
11.4
11.8
12.2
12.6
13
13.4
13.8
14.2
14.6
15
15.4
15.8
16.2
16.6
17
17.4
17.8
Fork Length (cm)

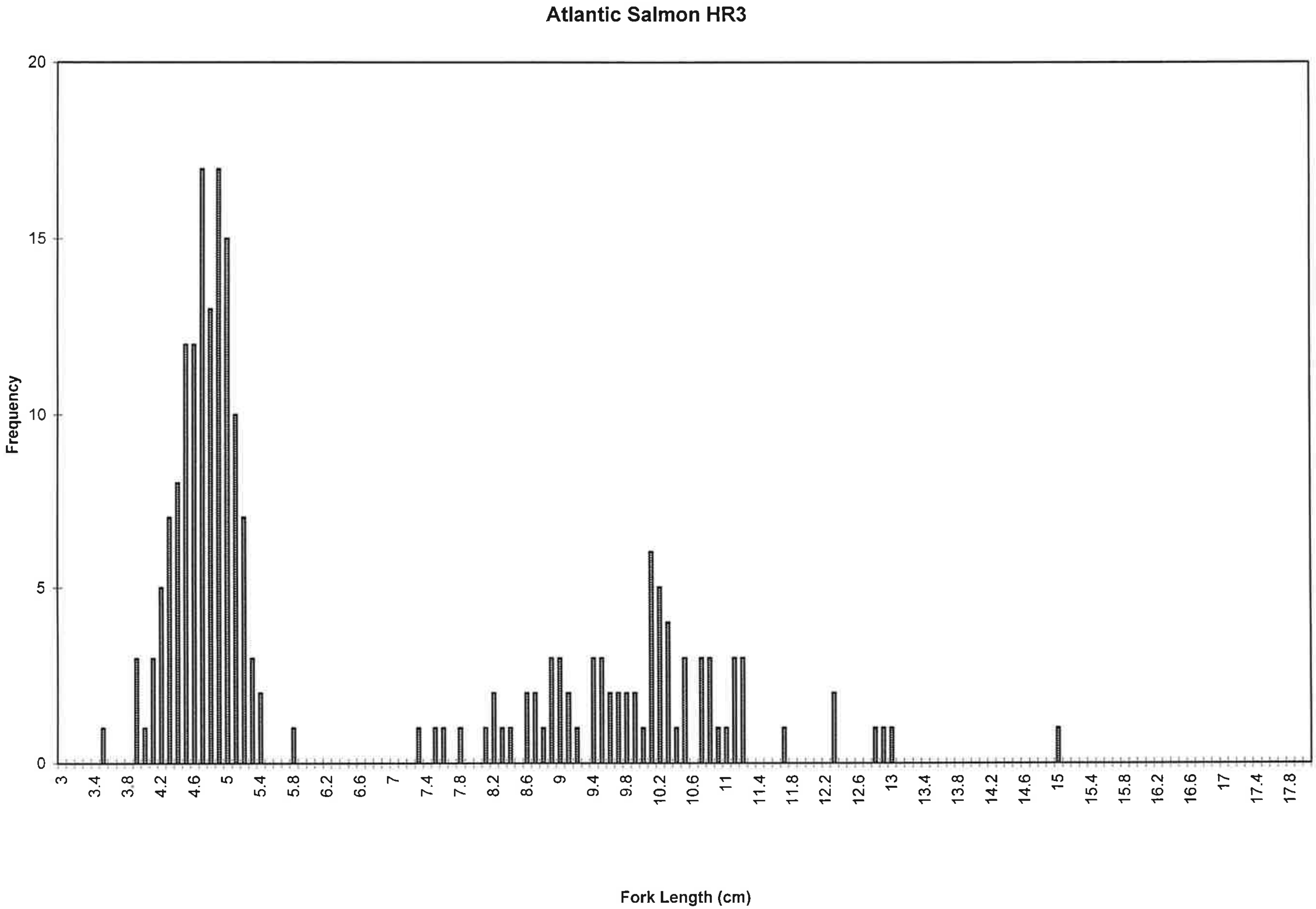

Atlantic Salmon HE3
Frequency
20
15
10
5
0
3
3.4
3.8
4.2
4.6
5
5.4
5.8
6.2
6.6
7
7.4
7.8
8.2
8.6
9
9.4
9.8
10.2
10.6
11
11.4
11.8
12.2
12.6
13
13.4
13.8
14.2
14.6
15
15.4
15.8
16.2
16.6
17
17.4
17.8
Fork Length (cm)


Atlantic Salmon HE4
Frequency
20
15
10
5
0
3
3.4
3.8
4.2
4.6
5
5.4
5.8
6.2
6.6
7
7.4
7.8
8.2
8.6
9
9.4
9.8
10.2
10.6
11
11.4
11.8
12.2
12.6
13
13.4
13.8
14.2
14.6
15
15.4
15.8
16.2
16.6
17
17.4
17.8
Fork Length (cm)

Atlantic Salmon HE5




Atlantic Salmon HE3 to HE5
Frequency
20
15
10
5
0
3
3.4
3.8
4.2
4.6
5
5.4
5.8
6.2
6.6
7
7.4
7.8
8.2
8.6
9
9.4
9.8
10.2
10.6
11
11.4
11.8
12.2
12.6
13
13.4
13.8
14.2
14.6
15
15.4
15.8
16.2
16.6
17
17.4
17.8
Fork Length (cm)


Atlantic Salmon HR3
Frequency
20
15
10
5
0
3
3.4
3.8
4.2
4.6
5
5.4
5.8
6.2
6.6
7
7.4
7.8
8.2
8.6
9
9.4
9.8
10.2
10.6
11
11.4
11.8
12.2
12.6
13
13.4
13.8
14.2
14.6
15
15.4
15.8
16.2
16.6
17
17.4
17.8
Fork Length (cm)