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Water-column Sampling

Benthic Sampling

Algal Culturing

U.S. Department of Interior
U.S. Geological Survey

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Prepared in cooperation with the Idaho Department of Environmental Quality

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TABLE OF CONTENTS

Conversion Factors, Abbreviations and Acronyms

Conversion Factors

Multiply	By	To obtain
foot (ft)	0.3048	meter
inch (in.)	2.54	centimeter
micromolar (µM)	molecular weight	micrograms per liter
micron (µm)	1,000,000	meter
mile (mi)	1.609	kilometer

Abbreviations and Acronyms

Abbreviations and Acronyms	Meaning
C5	Southern, main-channel, long-term monitoring site
CAEDYM	Computational Aquatic Ecosystem Dynamics Model
CDARI	Coeur d'Alene River inlet site
DCA	Detrended Correspondence Analysis
IDEQ	Idaho Department of Environmental Quality
MC-C	Main-channel sampling site near Carlin Bay
MC-R	Main-channel sampling site near Rockford Bay
MICA	Mica Bay sampling site
SJRI	St. Joe River/Chatcolet inlet site
USGS	U.S. Geological Survey

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Executive Summary

Within the longitudinal chemical-concentration gradient in Coeur d'Alene Lake, generated by inputs from the St. Joe and Coeur d'Alene Rivers, two dominant algal species, *Chlorella minutissima and Asterionella formosa*, were isolated and cultured in chemically defined media to examine growth response to a range of dissolved orthophosphate concentrations and zinc-ion activities representative of the region within- and up-gradient of the Coeur d'Alene River inlet to the lake. Ancillary chemical characterizations of the water column as well as biological characterizations of the benthos were also done to facilitate interpretation of the algal-culturing results and for comparison with similar characterizations performed a decade before (Woods and Beckwith, 1997). Although zinc is an essential micronutrient, the toxicity of algal species to elevated concentrations of uncomplexed zinc has been demonstrated, and affects the metabolism of phosphorus (Kuwabara, 1985a; Kuwabara and others, 1986), the limiting nutrient in the lake. This interaction between solutes could be of management interest. As an extension of field work conducted in August, 1999 (Kuwabara and others, 2003b), the water column and benthos of Coeur d'Alene Lake were sampled in August 2001, June 2004 and June 2005 (Fig. 1; Table 1) to provide the biological characterization in terms of phytoplankton community composition, benthic macroinvertebrate community composition and benthic chlorophyll concentrations, as well as chemical characterizations at six sites (three depths per site) within the lake.

This study provides information in support of developing process-interdependent solute-transport models for the watershed (that is, models integrating physical, geochemical and biological processes), and hence in support of subsequent evaluation of remediation or load-allocation strategies. The following two questions are posed: Are dissolved zinc and orthophosphate concentrations interactively associated with growth parameters of dominant phytoplankton species within the longitudinal concentration gradient of Coeur d'Alene Lake? If so, can these interactions be quantitatively incorporated into a water-quality model for the lake?

During a single sampling event, in June 2004, replicate samples from the lake water column were collected and processed for taxonomic analysis. Dominant species from two locations within- and up-gradient of the Coeur d'Alene River plume were isolated for a series of chemically defined culturing experiments. In all sampling events (August 2001, June 2004 and June 2005), the water column and benthos were also sampled to determine profiles for macronutrients, trace elements and dissolved organic carbon as well as to determine benthic macroinvertebrate community structure and, in 2005, benthic chlorophyll concentrations. This work, in support of the Idaho Department of Environmental Quality and regional tribal organizations, provides the first phytoplankton response models in a format that may be incorporated into a process-interdependent water-quality model like CAEDYM (Fig. 2; Brookes and others, 2004; Centre for Water Research, 2006) as a management tool for the lake.

Physical and Biological Characterizations

1. Vertical gradients in the water column: The lake was thermally stratified throughout the year except for episodic vertical mixing events that typically occur during the fall, mixing hypolimnetic and epilimnetic waters (Woods and Beckwith, 1997). However, as a result of interacting physical transport processes (e.g., seiching, fresh-water inputs, and mixing in lake embayments) transverse heterogeneity in temperature profiles were prevalent in (Fig. 3; Gradients discussion). Biological significance of the heterogeneity was evident as chlorophyll concentrations, representing the abundance of phytoplankton in the water column, were linked to observed thermal stratification,

and peaked in the subsurface with water-column temperatures between 10 to 13 degrees Centigrade (Fig. 4).

2. Phytoplankton communities: Phytoplankton were specifically sampled up gradient of the Coeur d'Alene River inlet to the lake as a chemical transitional zone where the longitudinal concentration gradient for zinc-ion activity (that is, uncomplexed zinc) was observed in previous lake-monitoring studies (Woods and Beckwith, 1997). Nearer the river inlet, the phytoplankton community structure exhibited multiple differences relative to the phytoplankton community entering the lake from the Chatcolet inlet (that is, the wetland associated with the St. Joe River to the south of the lake; Table 2; Phytoplankton taxonomy discussion). These differences led to the selection of the following two isolates for bioassay experiments: the chlorophyte, *Chlorella minutissima* that markedly decreased in cell concentration within the concentration-transition zone of the lake, and the bacillariophyte (diatom), *Asterionella formosa* that conversely increased in concentration within that same zone.

3. Benthic macroinvertebrate communities: The growth and subsequent settling of phytoplankton provide a carbon source to the benthos on which microbial and macroinvertebrate populations depend. In addition, the movement and feeding mechanisms of certain macroinvertebrates may significantly enhance the flux of solutes from the bottom sediment to the water column (Kuwabara and others, 1999; Boudreau and Jorgensen, 2001). Because very little work has been done to characterize the benthic macroinvertebrate populations in the lake (Kuwabara and others, 2003b), replicate samples were taken at each sampling site in 2001, 2004 and 2005 to extend the information available on macroinvertebrate communities (Table 3A).

Although not a principal objective of the study, the analysis of macroinvertebrate distributions provided insight into important habitat characteristics and possible growth-limiting factors that should be addressed when a biological evaluation of the effects of metals and nutrients is undertaken for Coeur d'Alene Lake. A strong riverine influence is observed in the southern portion of the lake with the inflow of the St. Joe River. Additionally, taxa present (Tubificidae and Chironomini) indicate the possible influence of high nutrient loading at SJRI and C5, the two most southern sites. Although there was only limited sampling, the densities observed and the species present at most of the sites appeared insufficient to significantly contribute to the mobilization of metals from the sediment to the water column via bioturbation (Table 3B). However, given the presence of *Hexagenia*, a burrowing mayfly, a more temporally and spatially intensive sampling design may identify biotic influences on sediment bioturbation on at least a seasonal basis.

Chemical Characterizations

Note: The dissolved-nutrient and trace-element concentrations discussed in this section refer to samples filtered with 0.2-micrometer polycarbonate membranes. Dissolved organic carbon samples were processed with a glass-fiber filter (Whatman GFF, 0.7-micrometer nominal pore size) pre-combusted at 450 degrees Centigrade for 12 hours.

1. Trace elements in the water column: Coeur d'Alene Lake in 2001, 2004 and 2005 consistently exhibited elevated dissolved-zinc concentrations at depth relative to surface waters, usually about doubling the value (Table 4; Fig. 5; Metals discussion). These data reaffirm the previous conclusion of a significant benthic source of zinc (Kuwabara and others, 2000; Kuwabara and others, 2003b).

2. Dissolved nutrients in the water column: With two exceptions, the concentrations of dissolved inorganic forms of nitrogen (nitrate and ammonia) were consistently elevated near the bottom in 2001, 2004 and 2005 (Table 5; Nutrients discussion). This vertical concentration gradient is

consistent with lake conditions a decade ago, and was also suggested in dissolved-orthophosphate concentrations for both years, although concentrations were routinely at or near analytical detection limits, as one would expect of a phosphorus-limited system like Coeur d'Alene Lake. In addition to surface-water inputs, if vertical mixing events in the fall provide a major hypolimnetic nutrient source to enhance primary production in the lake, nutrient data from this study suggest that such events would contribute to, rather than mitigate, phosphorus limitation.

3. **Interactive orthophosphate and zinc effects on phytoplankton:** A 3X3 full factorial experimental design (Table 6) was used to examine phytoplankton response to zinc-ion activity and dissolved-orthophosphate concentrations in terms of: (1) lag-phase duration (a calculated approximation of the days from the beginning of the culture to the beginning of the exponential growth phase), (2) growth rate (in doublings per day), and (3) standing crop or maximum biovolume (represented as the logarithm in cubic microns). Although the two isolates used in this study displayed growth inhibition to elevated zinc-ion activity, greater intolerance was exhibited by the chlorophyte, *Chlorella minutissima*, compared to the diatom isolate, *Asterionella formosa* (Phytoplankton response discussion; Table 7). This result is not surprising, given the predominance of the chlorophyte near the southern Chatcolet inlet in comparison to the increased presence of the diatom species closer to the Coeur d'Alene River plume with elevated dissolved-zinc concentrations. However, as an extension to previous toxicological studies in the lake, significant differences in response by the phytoplankton isolates in this study suggest that observed longitudinal shifts in phytoplankton community composition may represent a response to longitudinal gradients in solute concentrations. Interactive effects of dissolved orthophosphate and zinc were consistent with previous laboratory studies that demonstrated an inhibition of phosphorus metabolism by increased availability to uncomplexed zinc. Empirical response models were generated to contribute to water-quality models that provide a quantitative understanding and perhaps heightened predictive capability for phytoplankton response in the lake to changing water chemistry over multiple time scales and proposed remediation strategies.

Potential Management Implications

Evaluation of proposed remediation efforts and load allocations in the watershed may be linked to a variety of objectives such as: decreasing concentrations of bioavailable forms of toxic substances or of limiting nutrients, decreasing solute loads to down-gradient systems, and reducing the impacts of toxic substances on biological resources (for example, fish and plants consumed by humans and wildlife). Because dissolved zinc is elevated in the water column of Coeur d'Alene Lake, and because elevated zinc concentrations can inhibit the metabolism of phosphorus in phytoplankton, this study quantifies phytoplankton response to dissolved orthophosphate and zinc-ion activities with associated geochemical information to place the toxicological data into appropriate context. The information is provided as a contribution to an overall water-quality model for the lake that may provide guidance in future evaluations of proposed management or remediation strategies.

Background

Although of critical importance to water-quality management, processes that regulate primary productivity have not been well quantified for Coeur d'Alene Lake. Bioassay results by Barlett and others (1974) indicated that total dissolved-zinc concentrations typical of the range observed in Coeur d'Alene Lake should suppress phytoplankton growth and hence affect biomass production and fisheries resources. This finding was confounded by Wissmar (1972) who did not observe significant suppression of carbon assimilation by natural phytoplanktonic communities from Coeur d'Alene Lake. To clarify this discrepancy, chemically defined media studies were performed on algal isolates from the lake to consider solute speciation effects. Results using three diatom isolates indicated that even at half the computed zinc-ion activity for main-channel site MC-R in the lake down-gradient of the Coeur d'Alene River plume and the Bunker Hill Superfund Site, growth was consistently suppressed (Kuwabara and others, 1994, Woods and Beckwith, 1997). Furthermore, there was virtually a total growth suppression of phytoplankton isolated from up-gradient of the Coeur d'Alene River plume (a so called "digital effect" of either growing in basal media or not growing at all in any of the zinc-augmented culturing media.) The results clearly indicated intolerance for dissolved zinc by certain phytoplankton species entering the lake from the St. Joe River. Although these results highlighted potential toxicological controls on primary production in the lake, they did not provide sufficient resolution to be quantitatively incorporated into a process-interdependent water-quality model describing the physical and biogeochemical interactions controlling phytoplankton dynamics. The work described herein addresses this modeling limitation with the added dimension of orthophosphate interactions that are relevant to this phosphorus-limited aquatic system.

Coeur d'Alene Lake is considered a transitional mesotrophic/oligotrophic system. In an oligotrophic system, the concept of a limiting nutrient is a fragile one because the dissolved-solute concentrations are typically balanced in such a way that minimal (i.e., sub-micromolar) changes in concentration of one solute can alter nutrient limitation. Under oxic, pH neutral conditions, orthophosphate has a high affinity to adsorb onto metal oxide surfaces (Sigg and Stumm, 1981; Goldberg, 1985). Depending on surface characteristics, varying levels of solute competition for adsorption sites can result, including competition by biological surfaces that may repartition solutes from inorganic particles to algal cells (Kuwabara and others, 1986). Without adsorbate competition, only about 10 mg/L of iron-hydroxide particles used by Goldberg in her studies (1985) in suspension would be required to adsorb a 1-micromolar concentration of dissolved orthophosphate. By comparison, dissolved orthophosphate concentrations in oligotrophic lakes are typically tenths of micromolar (Kuwabara and others, 2002; Kuwabara and others, 2003a). Given the ubiquitous surficial distribution of iron oxides in Coeur d'Alene Lake sediments (Horowitz and others, 1993; Kuwabara and others, 2003b), adsorption/desorption reactions are likely to be an important factor in the availability of orthophosphate.

The mechanism of zinc toxicity to aquatic primary producers is a disruption of phosphorus assimilation (in particular, an interference with phosphorylation reactions; Kuwabara, 1985a). As Zn-ion activity increases, cell division is suppressed and phosphorus simply accumulates intracellularly. So as zinc bioavailability increases, phosphate utilization is inhibited, and conversely, when phosphate bioavailability increases, zinc toxicity effects are mitigated. It is this interaction between elevated dissolved Zn and limiting orthophosphate that is of particular management interest in the lake.

Average molar ratios of dissolved nitrogen to orthophosphate benthic flux were determined in lander experiments at two contrasting sites in Coeur d'Alene Lake (Kuwabara and others, 2003b). A nitrogen-to-phosphorus (N:P) molar Redfield ratio of 16 represents the approximate ratio of nitrogen-to-phosphorus taken up by freshwater algae for growth (Wetzel, 2001). Benthic-flux ratios, that is the ratio of dissolved nitrogen and phosphorus sources from the lakebed, were considerably higher than the Redfield Ratio (70 ± 20 and 41 ± 13 at MC-R and MICA, respectively) suggesting that the lake sediment could significantly affect orthophosphate availability and hence zinc toxicity in the water-column by sorption/desorption (repartitioning) reactions. In 1999, the year in which benthic-flux experiments were done, it is also noteworthy that the riverine input also generated an elevated N:P molar ratio of about 32, which one might expect for a phosphate-limited system. Consistent with previous observations, dissolved orthophosphate concentrations were undetectable (< 2 micrograms per liter or < 0.1 micromolar) at all sites sampled in 2005.

In an effort to develop tools to facilitate science-based management decisions related to water and ecosystem quality in Coeur d'Alene Lake and the associated watershed, the purpose of this study is to provide a quantitative description of the interactive effects of the limiting macronutrient, dissolved orthophosphate, and zinc-ion activity. In addition, associated results from field work in the lake during the period of the bioassays are presented to provide some context with which prior results and future research directions can be assessed.

Results and Discussion

Physical Data

In 2004, a typical depth dependence was observed for temperature using a datalogger deployment at each sampling site (range from 6 to 20 degrees Centigrade) with maximum temperatures at the surface. This depth dependence was consistent with observations reported for 1991 and 1992 lake conditions by Woods and Beckwith (1997), and also bracketed temperature distributions acquired in 2005 by the University of Western Australia (see paragraph below). Despite temperature effects on oxygen solubility, dissolved oxygen in the lake water column at main-channel sites decreased with depth from approximately 90 percent saturation at the surface to less than 60 percent saturation near the lake bottom.

During the June 2005 sampling trip, a physical context (that is, three-dimensional distributions of temperature and other ancillary parameters) was provided from extensive field work conducted by a research team from the University of Western Australia, led by Professor Jorg Imberger, to help interpret the chemical and biological data (http://rtm.cwr.uwa.edu.au/FieldExp/CDAexp05/index.html). Thermal stratification was consistently observed with water-column temperatures in June, 2005, ranging between 5 and 16 degrees Centigrade. Woods and Beckwith (1997) observed this stratification throughout the year except for episodic vertical mixing events that typically occur during the late summer or the fall season. A clear and prevalent transverse heterogeneity in temperature stratification was observed for the first time as a result of the real-time monitoring efforts (Fig. 3; Gradients discussion). In association with this thermal stratification, phytoplankton abundance, as measured by chlorophyll concentrations, displayed a subsurface maximum at about 10 m depth and temperatures between 10 to 13 degrees Centigrade. Between monitoring stations C5, closer to the Chatcolet inlet, and the MC-R coring site, the subsurface maximum migrated both vertically and transversely to include elevated concentrations down gradient at the eastern lake edge and at near-surface depths (less than 5 meters).

Biological Data

1. **Phytoplankton Community**: The depth and vertical extent of the chlorophyll-a maximum is highly variable along a longitudinal transect of the lake (Fig. 4). Furthermore, that variability extends to the composition of the phytoplankton community as a major shift in dominant species occurs between the outlet of Chatcolet Lake and the inlet of the Coeur d'Alene River, shown with samples SJRI and C5 (Table 2). This variability affected the selection of algal species to be isolated and cultured to represent the compositional shift.

   Variability between collection sites is exhibited by both phytoplankton densities and biovolumes (Table 2). For example, the cyanophyte, *Anabaena*, was consistently observed at site SJRI, but was absent at site C5. The converse was observed for the cyanophyte *Synechococcus*. In terms of the species selected for bioassay isolation, the cell numbers for the Chlorophyte, *Chlorella minutissima* decreased from 1505 $\pm$ 74 cells per milliliter (n=3) at the Chatcolet inlet site (SJRI) to 258 $\pm$ 0 (approximately an 83% reduction) down gradient at monitoring site C5. Conversely, the cell numbers for the diatom, *Asterionella formosa* increased from 8 $\pm$ 4 cells per milliliter (n=3) at the Chatcolet inlet site to 877 $\pm$ 107 (approximately a two-order-of-magnitude increase) at site C5.

   In summary, taxonomic analyses of the two collection sites in 2004 reflect spatial variability, but also temporal variability in structure when compared to phytoplankton community analyses performed a decade ago (throughout 1991 and 1992; Woods and Beckwith, 1997). The temporal restriction of phytoplankton sampling in this study to June 2004, to facilitate the selection of algal isolates for the bioassays, would suggest that species observed in this study would represent a subset of those observed over 24 consecutive months by Woods and Beckwith (1997). Their lake monitoring studies throughout 1991 and 1992 did not observe *Chorella minutissima* at any of their six lake-sampling sites, two of which correspond to the locations sampled in this study for algal

isolates. In contrast, *Asterionella formosa* was observed at all six sites. Of seven cyanophyte species identified in 2004, only two matching genera were observed throughout 1991 and 1992: *Anabaena* and *Anacystis* (also called *Synechococcus*). In other words, five of seven species reported here just for June 2004 were not seen throughout the lake-sampling network in 1991 and 1992. Perhaps part of this discrepancy can be explained by different taxonomists using different methods to preserve and subsample phytoplankton species for the different studies (for example, the number of cells identified per sample and the fixing solution used). Taxonomic name changes over the past decade do not explain differences in the species list for the cyanophytes. By comparison, after considering recent changes in taxonomic classifications, only two chrysophytes (*Salingoeca* and *Stelexomonas*) and one bacillariophyte (diatom) were new to the phytoplankton assemblage relative to the lake a decade ago. This work was scheduled to coincide with physical-transport studies by other researchers in a concerted effort to develop an initial process-interdependent water-quality model for the lake. It should then be noted that resulting algal-growth models from this work represent the response of species that currently dominate the phytoplankton community, but that structure may be altered by a variety of processes (natural or anthropogenic) as demonstrated by the changes in the phytoplankton community over the last decade.

2. Benthic chlorophyll: Benthic chlorophyll concentrations represent carbon sources to the sediment-water interface primarily as a result of settled phytoplankton cells, but, within the photic zone, can also represent the growth of benthic algal species. Both sources provide an electron donor for redox transformations and result in a sediment oxygen demand. In addition, it has been hypothesized that the degradation of algal cells at the sediment surface may release intracellular solutes (including trace elements) to elevate bottom-water concentrations. Initial measurements of benthic-chlorophyll concentrations made in August 1999 were not high enough to support the observed concentrations gradients for trace metals in the lake water column (Kuwabara and others, 2003b). However, additional measurements in June 2005 were made to offer a broader look at the spatial and temporal variability of benthic-chlorophyll concentrations. The mean concentration was 0.9 $\pm$ 1.2 micrograms chlorophyll per square centimeter. This was an order of magnitude less than the mean benthic-phaeophytin concentration of 14.4 $\pm$ 7.7 micrograms chlorophyll per square centimeter (n= 11; Table 8).

3. Benthic macroinvertebrates: The growth and subsequent settling of phytoplankton provide a carbon source to microbial and invertebrate communities near the lake bed. It has been demonstrated that feeding and foraging mechanisms by certain macroinvertebrates may significantly enhance the benthic flux of solutes (Kuwabara and others, 1999; Boudreau and Jorgensen, 2001). Despite the potential biogeochemical importance of macroinvertebrate populations relative to the internal cycling of solutes within the lake, very little information is available that characterize the benthic macroinvertebrate populations (Kuwabara and others, 2003b). Therefore, while fulfilling the field sampling needs of this study, replicate samples were taken at each sampling site in 2001, 2004 and 2005 to extend the information available on macroinvertebrate distributions (Table 3A).

Benthic macroinvertebrate densities varied substantially both temporally and spatially (Table 3B). Densities were lower during the late summer collections of 2001 than during the early summer collections of 2004 and 2005. Mean site densities ranged from a low of 280 organisms per square meter at MC-R during 2001 to a high of 8033 organisms-m^{-2} at SJRI during 2004. Taxon richness also varied temporally and spatially. Richness followed a similar pattern to density, with lowest richness observed in late summer collections of 2001 and higher richness observed during early summer collections of 2004 and 2005. The minimum mean richness of 3 per site was observed at MC-R in 2001, while a maximum mean richness of 42.7 was observed at SJRI during 2004. Even though there was a highly significant relationship between richness and the abundance of macroinvertebrates sorted per sample, the maximum richness observed at SJRI was not simply a function of high macroinvertebrate densities because richness far exceeded that predicted by the number of individuals per sample. Higher richness at SJRI was likely a result of numerous factors

including the presence of more lotic taxa (that is, organisms associated with flowing waters like streams), the possible effects of higher nutrients, and minimum sediment and water metal concentrations than found in other portions of the lake. Site CDARI near the outflow of the Coeur d'Alene River did not have similarly high macroinvertebrate densities and richness. The late summer 2001 collections from CDARI were depauperate, having a mean richness of only 4 and mean densities of approximate 714 organisms per square meter. The generally lower densities and richness observed in August compared to June collections, regardless of year, likely represents a seasonal influence of invertebrate life histories and habitat quality. Unfortunately, there were no collections during both seasons in the same year.

Macroinvertebrate assemblage composition also varied temporally and spatially. Seasonal differences in collecting periods between 2001 and 2004/2005 preclude a comparison among all three years. Therefore, we compared macroinvertebrate assemblage structure among sites within-year and between 2004 and 2005. Similarities and differences in macroinvertebrate composition among sites were qualitatively evaluated using the ordination technique, Detrended Correspondence Analysis (DCA; Figure 6). DCA is an ordination method conceptually similar to principal components analysis. Samples that are similar in species composition generally appear closer to one another on a DCA plot than do sites with dissimilar species composition. The location of a site along a derived DCA axis is a function of the site's species composition in relation to the species composition of all other sites included in an analysis. A single analysis was completed for each of the three years. Therefore, the axes of any individual plot are not comparable because a site's position along a plotted axis is analysis specific.

The principal spatial difference in composition within each year was the uniqueness of the most "upstream" site (Figures 6A-C represent ordinations of annual data). In 2001 the most upstream site was CDARI. The benthos at the site was dominated by two groups in the family Chironomidae, the Tanypodinae and Chironomini, which were not found or were rare at the other three sites in 2001 (Table 3A). The Mica Bay site differed from the 2 northern sites because of the presence of high densities of ostracods and Tanytarsini midges.

The dominant spatial gradient in species composition in 2004 was between the St. Joe River inlet and the more northern portion of the lake (Figure 6B). SJRI had the highest densities observed in the study (>10,000 organisms per square meter) and also the greatest number of taxa. It was the only site in which Trichoptera were collected and contained the highest numbers of Ephemeroptera as well. Although low in abundance, the principal mayflies, both of which are associated with fine sediments, were *Hexagenia* sp., a burrowing mayfly commonly found in lakes, and *Caenis* sp. Also present at SJRI were high densities of Naididae, Tubificidae and Chironomini, taxa frequently associated with high nutrient habitats. The Naididae are often associated with both flowing water and macrophytes, the later of which are present at SJRI. C5 had lower densities of Tubificidae and Chironomini than SJRI, but still higher than other sites. SJRI and C5 are also the only two sites where bivalves were collected. During 2005, the most southern lake-sampling site was C5 rather than SJRI. Regardless, the dominant spatial gradient observed still ran from upstream (represented by C5) to the main lake sites, with C5 collections containing mayflies, and again the nutrient tolerant Tubificidae and Chironomini. In contrast, the main-lake sites sampled in 2004 and 2005 were MC-R, MC-C, and MICA. All three sites were dominated by an Orthocladinae midge that was extremely rare at SJRI and C5.

4. Response of phytoplankton species to interactive orthophosphate and zinc-ion effects:

Phytoplankton response to zinc-ion activity and dissolved orthophosphate concentrations were quantified in terms of three parameters: lag-phase duration (a calculated approximation of the days from the beginning of the culture to the beginning of the exponential growth phase), growth rate (in doublings per day), and standing crop or maximum biovolume (represented as the logarithm in cubic microns). As a general observation, the two isolates used in this study displayed similar relative responses, but greater intolerance to zinc-ion activity was exhibited by the chlorophyte, *Chlorella minutissima*, compared to the diatom isolate, *Asterionella formosa*. This is not surprising, given the predominance of the chlorophyte near the Chatcolet/ St. Joe River inlets in

comparison to the increased presence of the diatom species closer to the Coeur d'Alene River plume with elevated dissolved-zinc concentrations (Table 2; Fig 5).

Lag-phase duration significantly increased with increased zinc-ion activity, but much more so for *Chlorella minutissima* (> 6 days at the highest zinc-ion activity, Table 7) than for *Asterionella formosa* (consistently <2 days). In fact, at the highest zinc-ion activity, exponential growth was not observed over a culturing period of a week, regardless of the dissolved-orthophosphate concentration. A lag phase was also discernable for *Asterionella*, but in contrast to *Chlorella*, the duration was consistently less than 2 days. Although the bulk residence time for the lake is approximately 6 months, the observed lag-phases may have environmental significance because certain strata within the water column move through the lake much more rapidly (that is, in days to weeks; Centre for Water Research, 2006). As zinc-ion activity increased, lag-phase duration for *Asterionella* increased from zero to 1.2 $\pm$ 0.5 days. An important qualification should be made in interpreting the empirical-modeling results. Because the concentration intervals used in the culturing treatments represent lake conditions, the experimental design is not orthogonal (that is, the variables cannot be symmetrically normalized for easy application into a process-integrated model; Box and Draper, 1987). Therefore, the magnitude of the coefficients depends on the format (for example, units) of the independent variables. For example, because the micromolar concentrations for dissolved orthophosphate span one order of magnitude, but the zinc-ion activities are one to five orders of magnitude smaller, the significant modeling coefficients describing the effect of zinc-ion activities can be orders of magnitude greater than those describing the effects of dissolved orthophosphate on a dependent variable. For *Chlorella minutissima*, the model did a poor job of describing the effects of dissolved orthophosphate or zinc-ion activity on lag-phase duration (coefficients of determination of 0.55 and 0.17 based on cell concentrations and biovolumes, respectively). This is because the lag-phase was indeterminate for cultures at high zinc-ion activities because no growth was measurable over the 6-day culturing period. The effect of dissolved orthophosphate on lag-phase duration for *Asterionella* was not statistically significant, but elevated zinc-ion activities increased the lag-phase duration as either a first or second-order effect.

Growth rates for both algal species were optimal (1.03 $\pm$ 0.04 per day) at basal zinc-ion activities which was expected for *Chlorella*, but less expected for *Asterionella* which was isolated and maintained in waters of elevated zinc-ion activity. An inverse relationship between growth rate and zinc-ion activity was evident, ultimately exhibiting no discernable growth for *Chlorella* at the highest zinc levels (Table 7). Growth of the diatom, *Asterionella*, was also adversely affected by elevated zinc-ion activities, but measurable growth was consistently observed. For *Asterionella*, growth rates ranged from 0.49 $\pm$ 0.14 per day at the highest zinc-ion activity to 0.70 $\pm$ 0.14 per day at basal zinc concentrations. The maximum growth rate observed in this study (0.88 $\pm$ 0.03 per day) is comparable to that reported in other studies for *Asterionella* (0.81 $\pm$ 0.08 per day; Holm and Armstrong, 1981), despite the fact that the species was isolated from the lake at elevated dissolved zinc concentrations (0.51 $\pm$ 0.01 micromolar) relative to the Chatcolet inlet (< 0.01 micromolar). At each of the three zinc-ion activities, growth rates for *Asterionella* were lowest at the basal dissolved orthophosphate concentration. This was true for *Chlorella* only at the mid-level zinc-ion activity because there was essentially no discernable growth at the highest zinc-ion activity. For *Chlorella*, empirical modeling consistently exhibited a positive effect of dissolved orthophosphate concentration and an adverse effect of zinc-ion activity on growth rate for both first- and second-order terms. Although a positive effect of dissolved orthophosphate was also determined for *Asterionella*, the adverse effects of zinc-ion activity were not consistently depicted. For example, based on changes in biovolume, the first-order adverse effect of zinc-ion activity on growth rate was significant, but based on changes in cell concentration (that is, the number of cells per volume of culturing suspension), the first-order coefficient for zinc-ion activity was not statistically significant at the 95-percent confidence level.

Maximum biovolume (or standing crop) is typically constrained by a limiting nutrient, which in Coeur d'Alene Lake is considered to be phosphorus (Woods and Beckwith, 1997; Kuwabara and others, 2003b). However, if growth is inhibited by a toxic substance, the maximum biovolume may be limited by that toxic response. At basal zinc-ion activity, both phytoplankton species

exhibited increased maximum biovolumes with increased orthophosphate concentrations (up to a log biovolume of 6.93 ± 0.19 and 6.95 ± 0.13 in units of cubic microns for *Chlorella* and *Asterionella*, respectively). This increase was most evident between basal and mid levels of dissolved orthophosphate, as the highest dissolved orthophosphate concentration provided an excess of phosphorus relative to nitrogen (that is, a nitrogen to phosphorus ratio in excess of the Redfield molar ratio of 16). As zinc-ion activity increased, the positive effect of dissolved orthophosphate on maximum biovolume became less pronounced to the point where dissolved orthophosphate concentration had no effect on maximum biovolume of *Chorella* at the highest zinc-ion activity (the cells simply did not grow). In addition, it should be mentioned that increased zinc-ion activity generated a morphological response in *Asterionella* that complicated the measurement of cell concentrations. Among other responses, the diatom exhibited a clumping behavior, presumably as a result of exudate (metal-chelate) production or to decrease surface to volume ratios and hence decrease toxicant exposure from the bulk solution. Furthermore, extracellular substances are produced by certain phytoplankton species as biological or chemical protective mechanisms (Fogg, 1983; Carotenuto and Lampert 2004). Subsequent clumping (adhesion) of cells due to the release of mucilaginous compounds may have the indirect morphological effect of increasing particle size and hence increasing settling rate to the lake bottom. Replicate variability in bioassays was evident as sonication of culture aliquots was required to break clumps into individual cells amenable to particle counting (Fig. 7). For both algal species, a positive effect of dissolved orthophosphate concentration and an adverse effect of zinc-ion activity on maximum biovolume was evident in both first and second-order terms.

Chemical Data

1. Dissolved nutrients in the water column: With two exceptions, the concentrations of dissolved inorganic nitrogen-species were consistently elevated near the lake bottom in all three years (2001, 2004 and 2005; Table 5). This hypolimnetic enrichment in dissolved nitrogen species is consistent with observations made for the lake in 1991 and 1992 (Woods and Beckwith, 1997). Nitrate concentrations were depleted in surface waters but increased by an order of magnitude or more in bottom waters. This was also true for ammonia concentrations although interannual variability in ammonia concentrations was evident as higher water-column concentrations were routinely observed in 2004 relative to 2005. Despite this shift in nitrogen speciation, dissolved inorganic nitrogen concentrations in bottom waters were temporally and spatially stable for this study (64 ± 15 micrograms nitrogen per liter or 4.5 ± 1.1 micromolar dissolved nitrogen), and within the concentration range reported after extensive monitoring activities in 1991 and 1992 (25 to 430 micrograms nitrogen per liter or 2 to 31 micromolar dissolved nitrogen). Elevated bottom-water concentrations were also evident for dissolved orthophosphate concentrations for both years, although concentrations were routinely at or near analytical detection limits, as one might expect of a phosphorus-limited system like Coeur d'Alene Lake (that is, consistently less than 2 microgram dissolved orthophosphate per liter or 0.1 micromolar). For waters overlying the lakebed, where dissolved inorganic nitrogen was consistently measurable, the molar nitrogen to phosphorus ratios (224 ± 252) were consistently greater than the Redfield ratio of 16, sometimes by an order of magnitude. If vertical mixing events in the fall provide a major hypolimnetic nutrient source for phytoplankton growth, nutrient data from this study suggest that such events would contribute to, rather than mitigate, phosphorus limitation. Elevated nutrient concentrations in bottom waters can result from nutrient diagenesis, decomposition of settled cellular material in the water column, or a density-driven riverine source (Boudreau and Jorgensen, 2001). High-resolution temperature contours within the lake during our sampling period show no evidence for a riverine source of nutrients directed to the hypolimnion (see temperature contours from monitoring and modeling studies by the Centre for Water Research, 2006).

2. Dissolve trace metals in the water column: Trace elements in the dissolved phase (for example, zinc) can compete for ligands in both dissolved and particulate phases, and hence affect zinc speciation and partitioning. Coeur d'Alene Lake in 2001, 2004 and 2005 consistently exhibited elevated

dissolved-zinc concentrations at depth relative to the shallow and middle depths in the water column (Table 4; the only exceptions are nearly equal middle and deep values at site MC-R in 2001 and site C5 in 2004). The dissolved concentration at depth is usually about double the surface concentration (Fig. 5). This finding indicates a benthic source of zinc, which has been previously found to be significant relative to riverine inputs (Kuwabara and others, 2000; Kuwabara and others, 2003b).

In 1993 and 1994, Woods and Beckwith (1997) found surface water zinc concentrations between 33 and 66 micrograms per liter at two limnetic stations which, while not at the same locations used in this study, provide some basis for comparison with subsequent studies. In 1999 (Kuwabara and others, 2000) and 2001, water-column profiles found surface water concentrations at main-channel sites between 38 and 51 micrograms of zinc per liter. In 2004 and 2005, surface-water zinc concentrations at main-channel sites (C5, MC-R, and MC-C) ranged from 6 to 38 micrograms per liter (Table 4). While the surprisingly low zinc concentrations at C5 drive the low end of this range, the upper bound of the range has decreased over the twelve year comparison. Complete water-column zinc profiles are available for MC-R and MICA in 1999 (Kuwabara and others, 2000), 2001, 2004 and 2005. A comparison reveals an apparent net downward trend in dissolved zinc concentrations over time, mostly driven by the 2005 data (Table 4). However, caution must be exercised in evaluating this trend because the profiles in 1999 and 2004 are nearly identical. It is important to note that temporal variability within each year, not a long-term trend, may be driving these observed differences. Continuous, long-term monitoring would be required to answer this question.

3. Dissolved Organic Carbon (DOC) in the water column: Dissolved organic matter, measured as DOC, is a ligand that can compete for zinc complexation in the water, and hence affect the remobilization and bioavailability of zinc (Kuwabara and others, 1986). For example, Kuwabara and others (1989) noted that spatial trends in dissolved-zinc concentrations in South San Francisco Bay were coincident with DOC. With the exception of site MC-R in June 2005, elevated DOC concentrations were observed nearest the lake bottom (Table 9), as was noted above for dissolved zinc. Concentrations ranged from 117 to 155 micromolar carbon (that is, 1.4 to 1.9 milligrams organic carbon per liter). These concentrations and vertical trends were consistent with previous measurements for DOC and for nutrients and trace elements made during other years and seasons (Kuwabara and others, 2003b; Fig. 5).

4. Zinc and other metals in phytoplankton: Metals biomagnify up the food chain, and the initial transfer from the dissolved, aqueous phase into phytoplankton is by far the largest step. Zinc biomagnification was relatively consistent between sites C5 and MC-R, considering that each sample could contain a different assemblage of phytoplankton species. The log value for zinc biomagnification averaged 4.8 (Table 10), and the log values for copper and cadmium were similar at 5.0 and 5.2, respectively.

In contrast to this continuity, lead biomagnification averaged a log value of 6.5. In other words, lead biomagnification in phytoplankton was more than an order of magnitude larger than the other metals studied. Also unique to lead was a significant difference between sites. At site C5, the log value averaged 6.1, while at site MC-R the average was 6.9. The phytoplankton at site MC-R exhibited lead concentrations about five times higher than C5 phytoplankton, but this difference is not driven by dissolved lead concentrations at the chlorophyll-maximum depth (0.51 nanomolar at MC-R and 0.62 nanomolar at C5; Table 4).

Study Design and Methods

The protocol described in this section focuses on method applications in this sampling of the water column and benthos in Coeur d'Alene Lake. Details (for example, quality control specifications) for each analysis have been previously documented (Woods and others, 1999; Praskins and others, 2001; Kuwabara and others, 2003a).

Within Coeur d'Alene Lake, sampling was performed on August 7, 2001, June 28, 2004 and June 10, 2005, at four locations with contrasting depths, physical transport, and chemical properties (Fig. 1; Table 1). Between sampling years, only MICA and MC-R were always sampled. Otherwise, there were different reasons to sample alternate sites each year. This results in a total of six different lake sites. At each site, the following samples were collected, unless otherwise noted:

Physical Data

Water-column Sampling: After locating and logging the coordinates at each sampling site, a Teflon-line Niskin Bottle (General Oceanics) was then used to collect water-column samples from three depths for dissolved trace-element, macronutrient and organic carbon analyses (Fig. 8A). In all years, the surface sample was taken at 2 meters depth to avoid any surficial films, and the deep sample was taken 2 meters above the bottom to avoid sediment resuspension. The middle depth protocol varies, however. In 2001 and 2004, the mid-depth was based simply on halving the site depth, whereas in 2005, mid-depth corresponds to the chlorophyll maximum.

Biological Parameters

1. **Phytoplankton Sampling:** After water samples were collected at the St. Joe's inlet site and monitoring site C5 (Table 2), phytoplankton samples were collected from the same Niskin bottle sample and preserved with Lugol's Solution for taxonomic and biomass analyses. Phytoplankton cells from the surface Niskin-bottle sample were then peristaltically pumped through an in-line 35-micrometer non-metal prefilter and collected on baked quartz-fiber filters (Fig. 8B) for photomicroscopy, isolation and culturing.

2. **Benthic Invertebrate Sampling:** After water-column sampling was completed at a site, three deployments of a Ponar grab were used to collect replicate samples for macroinvertebrate taxonomic analyses. The sieved samples (500-micrometer mesh) were fixed with 10-percent buffered formalin, later transferred to 70-percent ethanol, then sorted at 10× magnification and identified to the lowest practicable taxonomic level employing the appropriate literature (Fig. 9). Samples were stained with rose bengal to facilitate sorting. No subsampling was used.

3. **Benthic Chlorophyll-*a***: At each of the four sampling sites in 2005, surficial sediment (that is, the top 0.5 centimeters of lakebed material) was collected from a fresh Ponar grab and stored refrigerated in a plastic Petri dish within a sealed plastic bag. Each dish was sub-sampled in triplicate for benthic chlorophyll-*a*. The surficial sediment for each replicate was collected on a glass-fiber filter and buffered with 1 milliliter of magnesium carbonate. Water was removed from the buffered samples by vacuum at less than 5 pounds per square inch to avoid cell lysis. Samples were then frozen in darkness for preservation until spectrophotometrically analyzed by methods described in Thompson and others (1981) and Franson (1985).

4. **Algal Culturing:** Algal isolates were cultured in chemically defined media as described by Kuwabara and others (1985b) without any addition of defined mineral particulates (that is, a mono-phasic medium; Anderson, 2005). After micromanipulator-controlled pipette isolations of dominant algal species, isolates were maintained in media formulations representative of the sampling site from which they were collected on June 28, 2004. The chlorophyte, *Chlorella minutissima* from the

Chatcolet inlet, and the diatom, *Asterionella formosa* from the monitoring site C5 were used in these experimental culturing series. During the culturing period, phytoplankton cells were maintained in fluoroethylene polymer (FEP) vessels with FEP aerators to minimize adsorption/desorption effects between wetted culturing surfaces and the bulk solution (Fig. 10). Temperature was regulated sequentially by using culturing-room controls (± 2 degrees Centigrade) further refined by a water bath (10 ± 0.5 degrees Centigrade). Cool-white fluorescent bulbs were used to provide illumination at approximately 64 microeinsteins per square meter per second (or 14 watts per square meter). Nine media formulations were used for the bioassays (Table 6) with three replicate cultures monitored per formulation per isolate. Zinc-ion activities were selected for the cultures to represent the concentration gradient between the Chatcolet inlet (SJRI) and Long-term Monitoring Station 5 (C5) just up gradient of the Coeur d'Alene River plume. Dissolved orthophosphate concentrations were selected to represent: (1) phosphorus-limiting concentrations, a nitrogen to phosphorus molar ratio of 40, as is the case for the lake (Kuwabara and others, 2003b), (2) Redfield-ratio conditions (a nitrogen to phosphorus molar ratio of 16), and (3) an excess of phosphorus (nitrogen to phosphorus molar ratio of 4). In ascending order, the three zinc-ion activities and orthophosphate concentrations selected for the cultures were referred to in tables and discussion as "basal", "mid" and "high" values. On each day of the culturing period, the cell concentration and mean-cell volume were determined by triplicate measurements per treatment using a particle counter (Coulter Multisizer IIe). Daily measurements continued until stationary phase cell density was achieved. Linear regression of culturing data was used to calculate estimates and 95-percent confidence intervals for growth rates (doublings per day) and lag phases (in days). Using the computer program S-Plus (version 7; Insightful Corporation), these estimates were in turn used to develop an empirical response surface model to describe species-growth response to interactive dissolved orthophosphate and zinc-ion effects.

5. Phytoplankton Digestion: In 2005, at two sites (MC-R and C5), and at the depth of the chlorophyll maximum, additional phytoplankton was sampled akin to the method described above using a peristaltic pump and a 35 micrometer non-metallic prefilter. However, instead of quartz-fiber filters, these phytoplankton samples were collected onto pre-weighed, acid-washed, 0.2-micrometer polycarbonate filters. Samples were freeze-dried and weighed. Based on methods described by Croteau and Luoma (2005), the samples were then digested sequential with ultrapure nitric acid and ultrapure hydrogen peroxide. The sample was brought up to a final volume, and the filter was removed and dried for a final weighing. The difference between pre-sampling dry filter weight and post-digestion dry filter weight was negligible, indicating the reproducibility of the weighing and the mass balance of the filter through the entire process. When compared with the filter containing the dried sample, the difference in mass was assumed to be the dry phytoplankton weight (Table 10; Calculation Step A).

The digested sample was analyzed by ICP-MS (Table 10; Step B) and a concentration was calculated based on the dry phytoplankton mass and the digestion volume (Step C). The final concentration value accounts for the recovery of the metal in a certified reference material: TORT-2 or NIST-2976 (Step D). Using the dissolved metal concentrations at the depth of the chlorophyll maximum (Table 4; Step E), a dimensionless biomagnification factor was calculated by dividing the phytoplankton concentration by the dissolved concentration (Step F).

Chemical Parameters

1. Dissolved trace elements: Water-column samples were also collected, filtered (0.2-micrometer polycarbonate membrane) and acidified to provide dissolved trace-metal information for the estuary by flow-injection inductively coupled plasma mass spectrometry (ICP-MS; Topping and Kuwabara, 1999; Topping and Kuwabara, 2003).

2. Dissolved organic carbon (DOC): Dissolved organic carbon was determined by high-temperature, non-catalytic combustion (Qian and Mopper, 1996). Potassium phthalate was used as the standard. Low-DOC water (blanks less than 40 micrograms organic C per liter) was generated from a double-deionization unit with additional ultraviolet treatment (Milli-Q Gradient, Millipore Corporation).

3. Dissolved nutrients: Nutrient samples were filtered (0.2-micron polycarbonate membranes) and immediately refrigerated in darkness. Unlike trace-metal samples, nutrient samples were not acidified. Concentrations for dissolved (0.2-micron filtered) nitrate, ammonia, orthophosphate and silica were determined by automated spectrophotometry (Franson, 1985).

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Appendix 1: Comments on the Report Structure

A major objective of this electronic document is to provide a structure that is easily accessible to a wide range of interest groups**.** Therefore, pathways within this document have been constructed to be both logical and intuitive. In contrast to typical scientific manuscripts, this report is formatted in a pyramid-like structure to serve the needs of diverse groups who may be interested in reviewing or acquiring information at various levels of technical detail. The report enables quick transitions between the initial summary information (figuratively at the top of the pyramid) and the later details of methods or results (figuratively towards the base of the pyramid) using hyperlinks to supporting figures and tables, and an electronically linked Table of Contents. In addition to hyperlinks within the document to supporting figures and tables, links in Appendices 2 and 3 provide a quick way to directly review and examine all figures and tables.

Although hard copies of this report are available on request, the advantages of the electronic version relative to the hard copy are substantial in many respects, but particularly in the rapid access of information at multiple levels of detail.

Your comments about how this type of Web-based product may be improved to better serve readers are most welcome and may be directed to the major author (kuwabara@usgs.gov) so that they may be compiled for future revisions and reports.

Appendix 2: List of Figures

Appendix 3: List of Tables

Fig. 1. Sampling Locations for this study of Coeur d'Alene Lake, Idaho

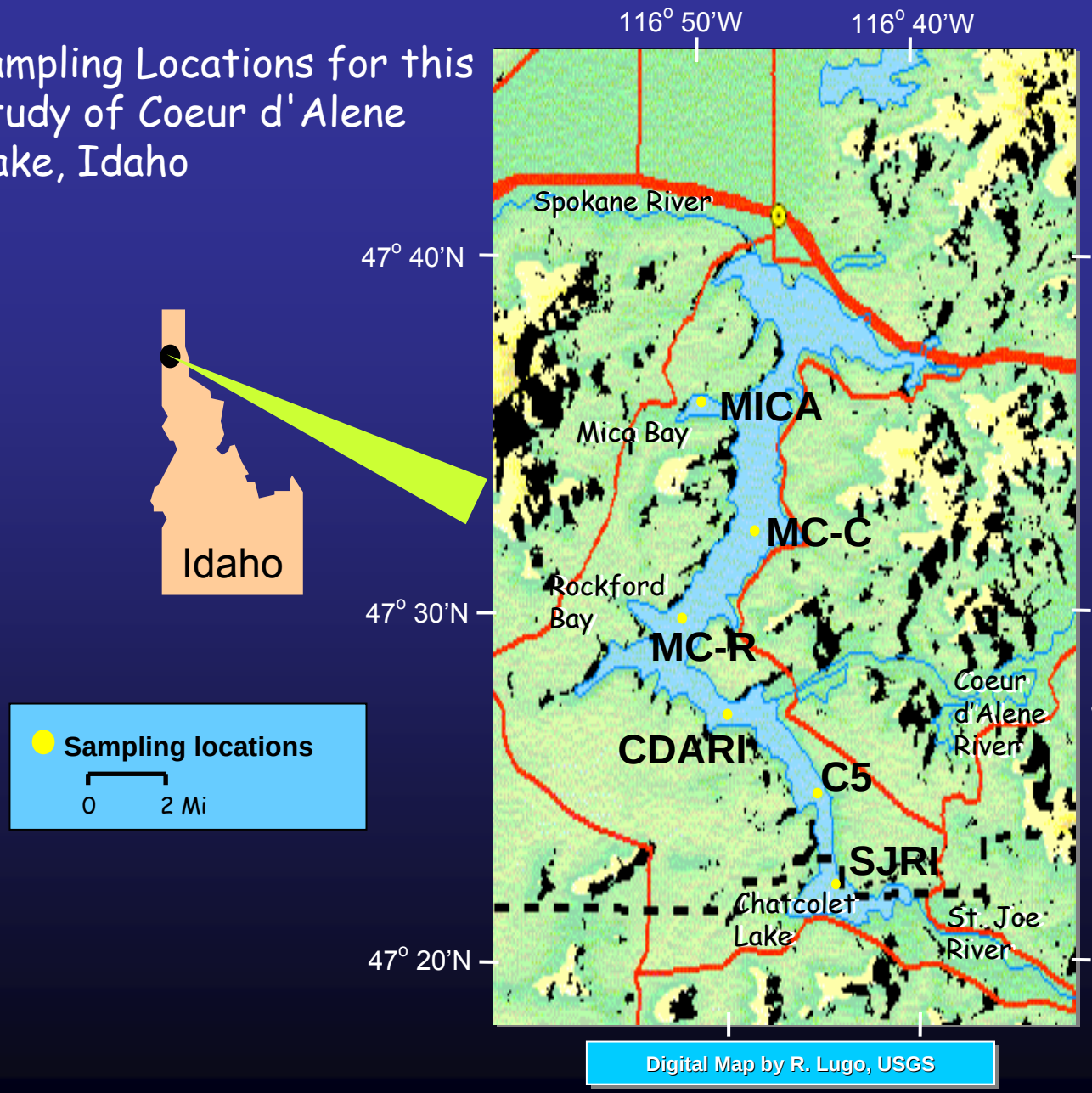

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Fig. 2. Schematic of a process-interdependent water-quality model, of which this study is a component

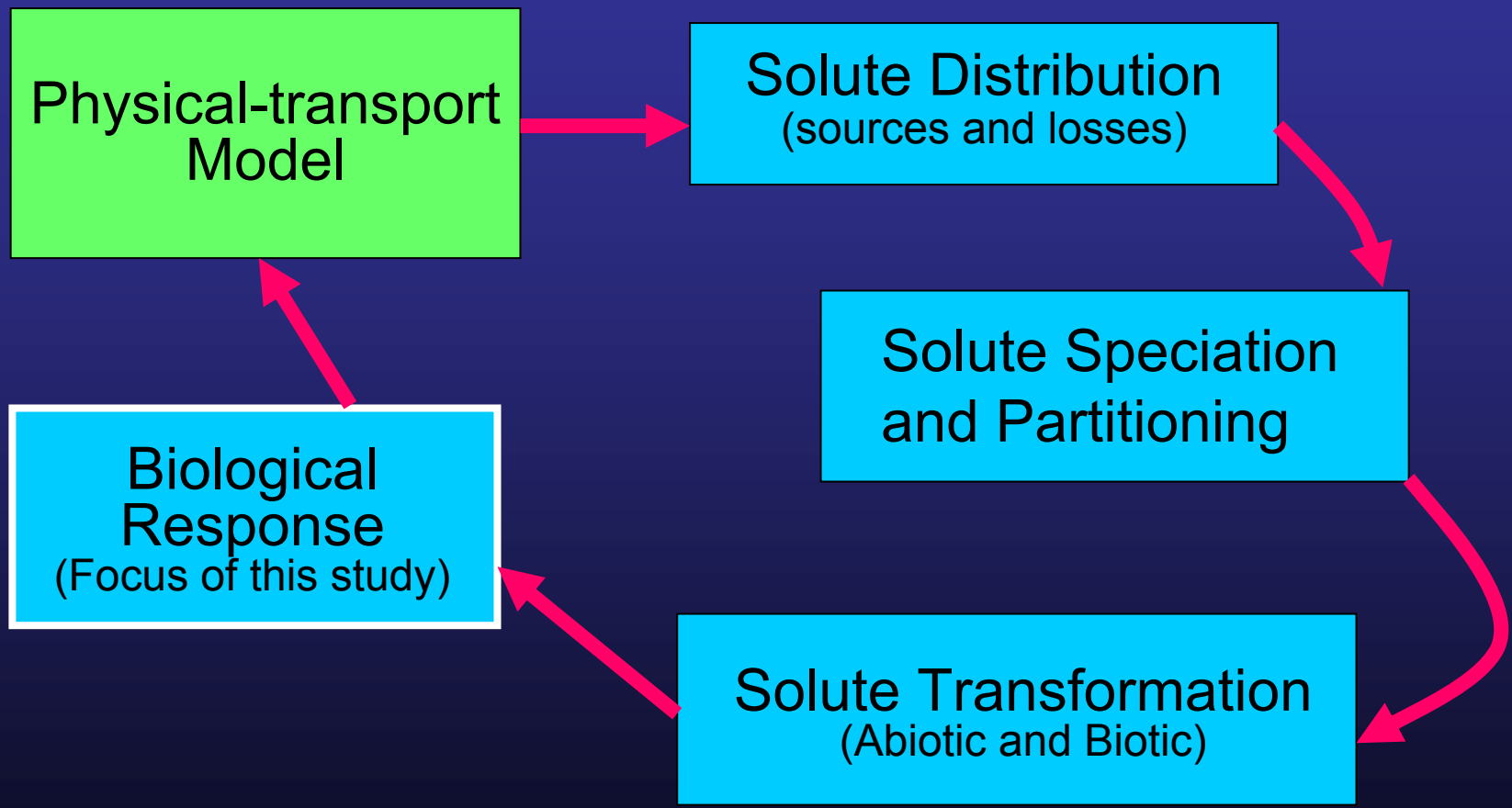
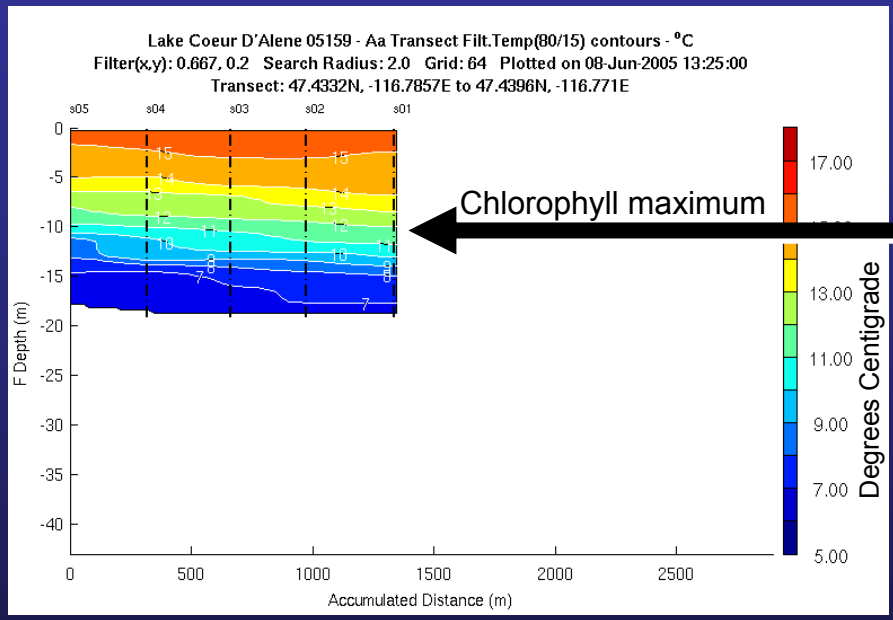
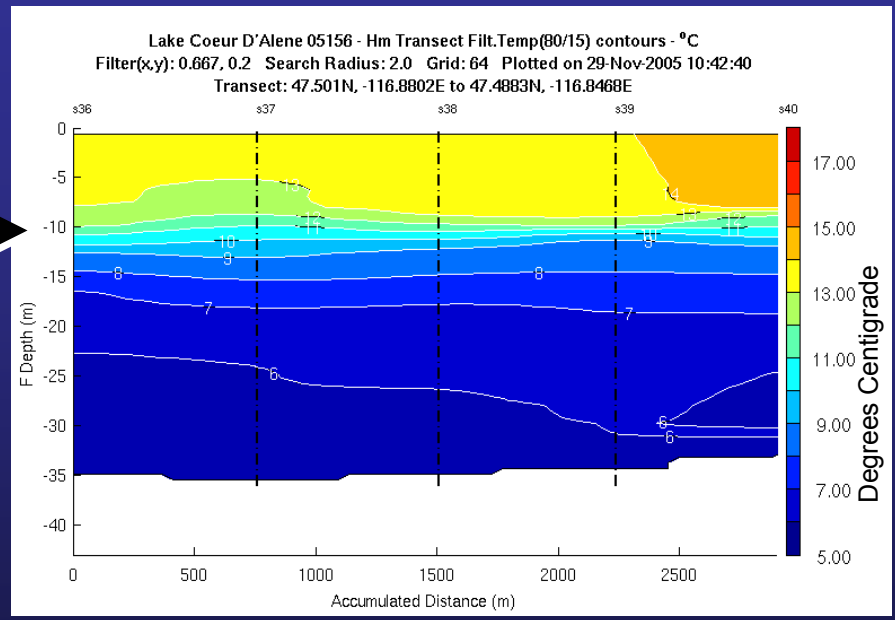


Fig. 3. Temperature gradients with associated subsurface chlorophyll maximum between 10-13°C [a]



Chlorophyll maximum

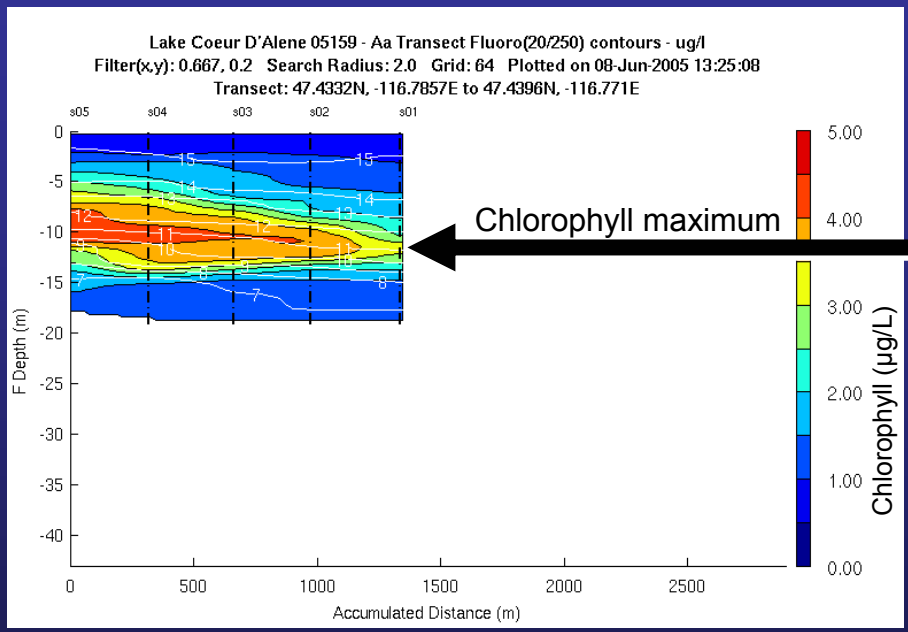


Transect near sampling site C5

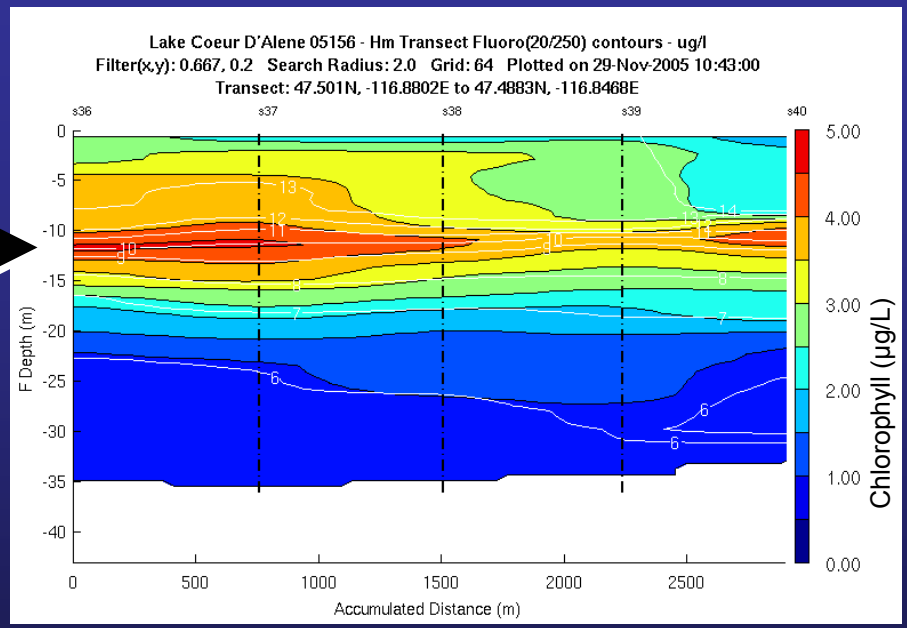
Transect near Rockford Bay, down gradient of the Coeur d'Alene River Plume

[a] Reference: University of Western Australia (2005)

Fig. 4. Chlorophyll gradient with transverse heterogeneity observed in the subsurface chlorophyll maximum [a]



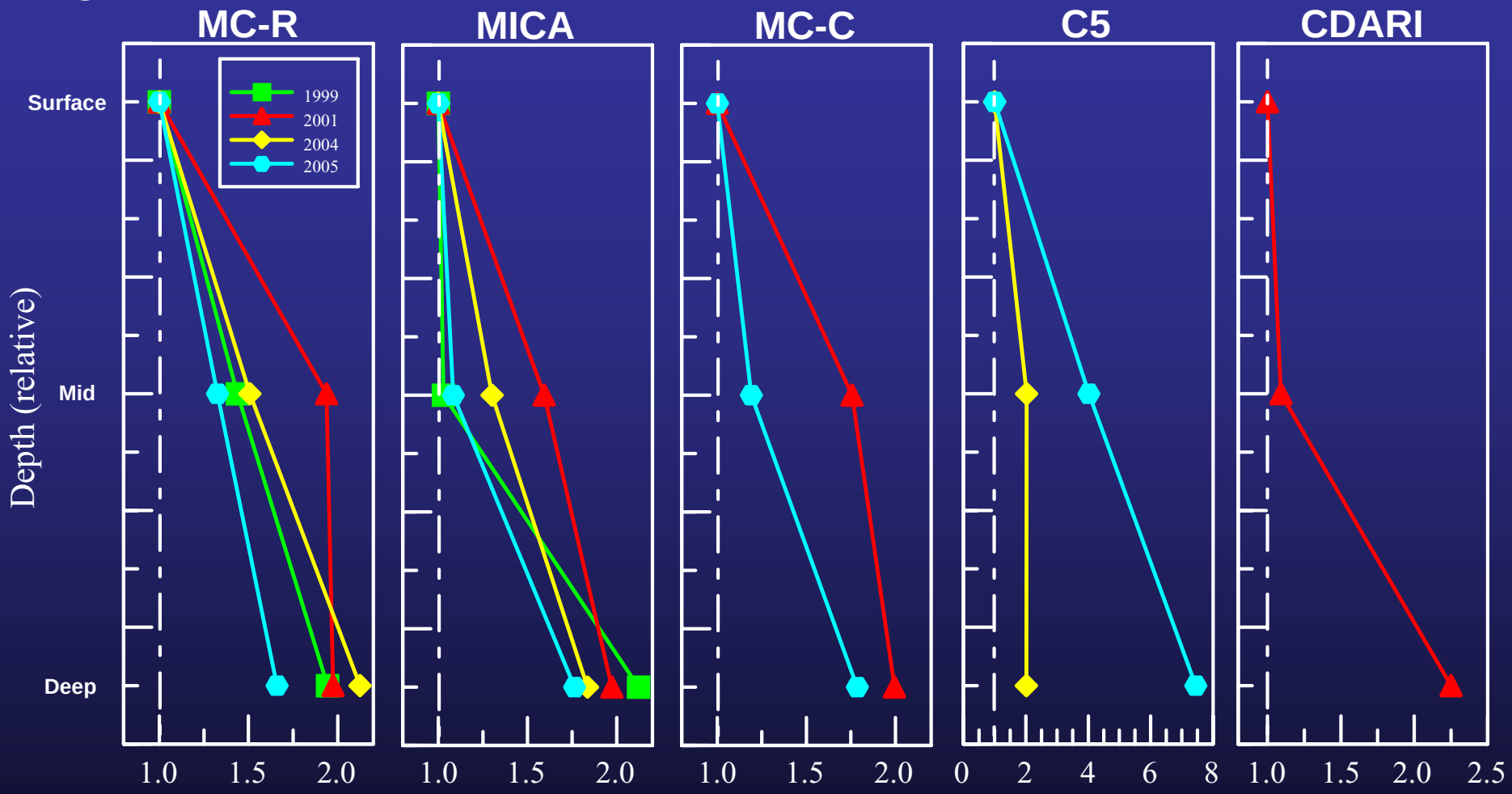
Transect near sampling site C5



Transect near Rockford Bay, down gradient of the Coeur d'Alene River Plume

[a] Reference: University of Western Australia (2005)

Fig. 5. Water-column dissolved-zinc concentrations



Errors bars are contained within symbols

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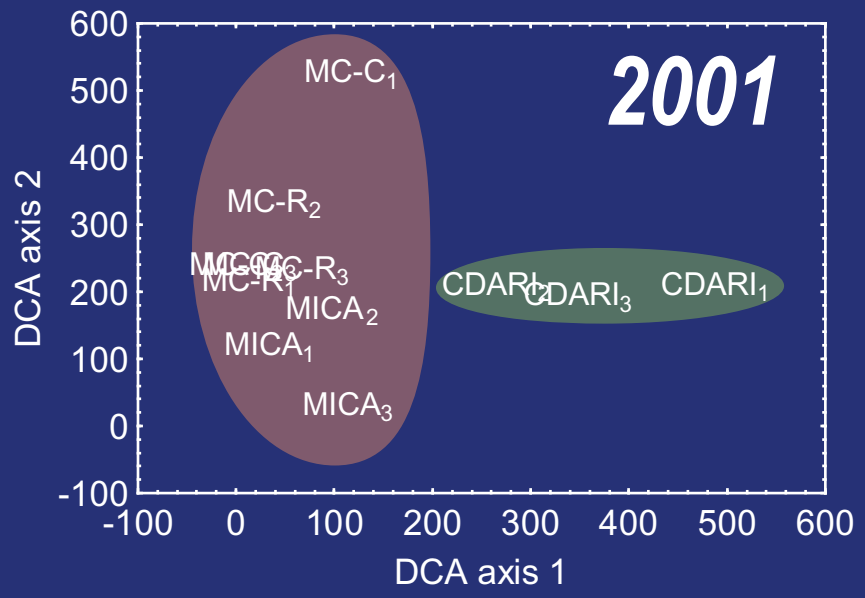
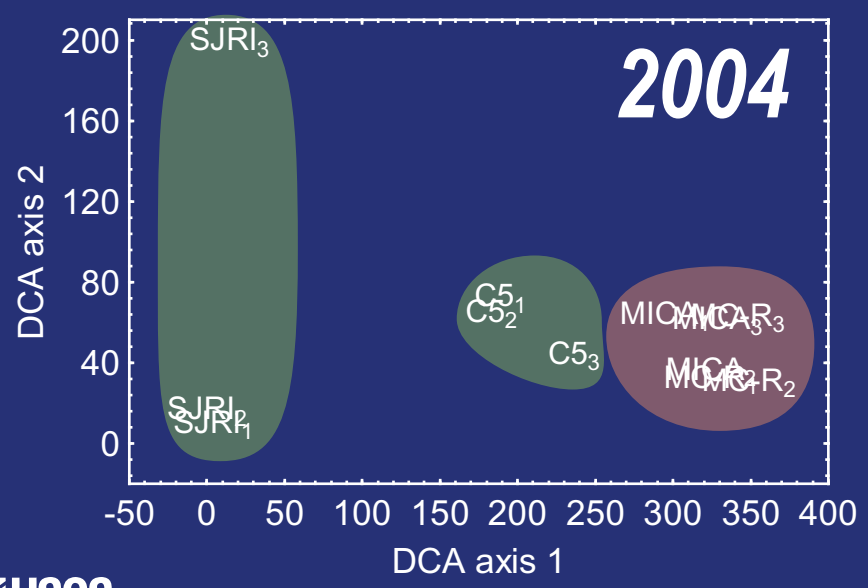
Analyses by ICP-MS

Fig. 6. Within-year, among-site ordinations of log10(x+1) transformed macroinvertebrate data by detrended correspondence analysis for sampling years 2001, 2004 and 2005 (*A*,*B* and *C*, respectively). The replicate number appears as a subscript to the site code. DCA axes are described in the text.





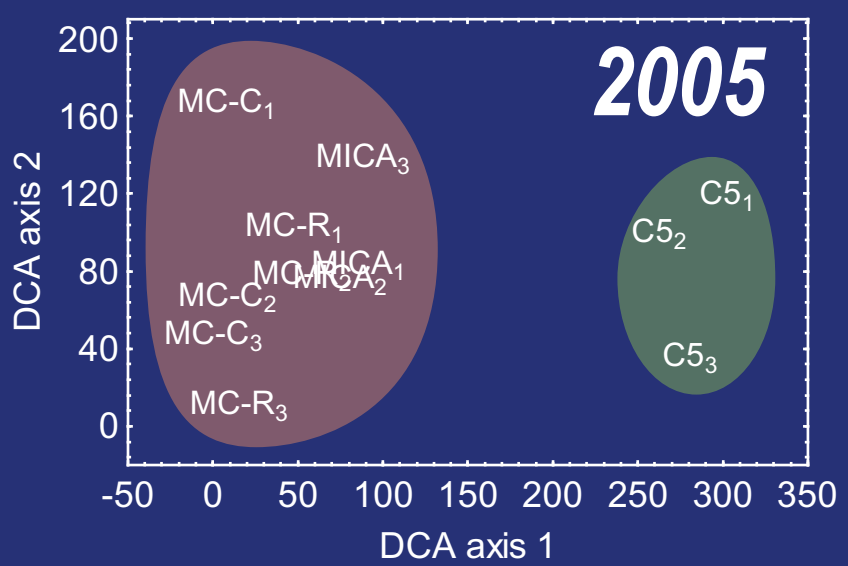


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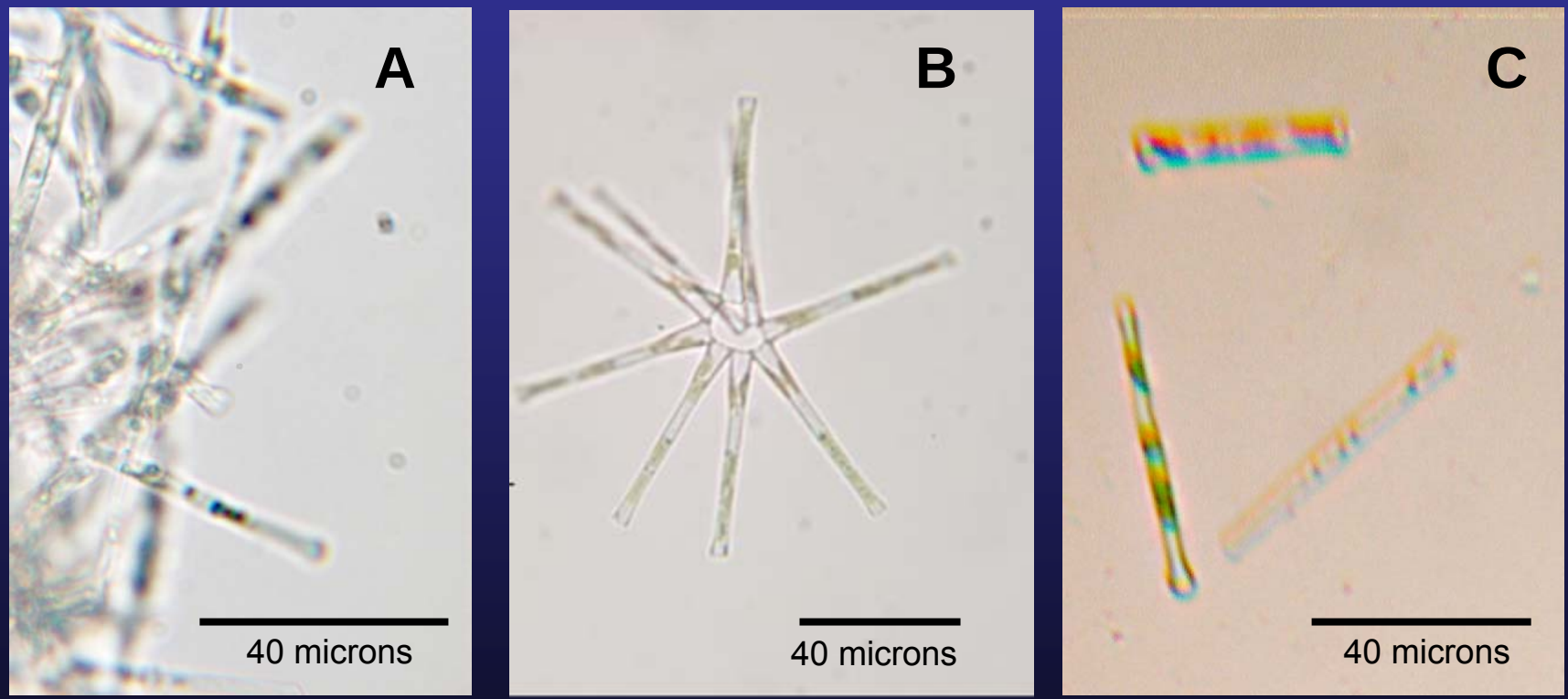
Fig. 7. A morphological response by *Asterionella* to elevated zinc-ion activities was observed. As zinc-ion activities increased, cells exhibited a clumping behavior (A) relative to controls with basal-zinc concentrations (B). To facilitate cell enumeration, sonication was used to break cell clumps apart (C).



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Photomicrographs by S.V. Fend

Fig. 8. Collection and Characterization of the Phytoplankton Community

Sampling for Taxonomic and Water-quality Analyses

Sampling for Culturing Isolates

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Fig. 9. Benthic Invertebrate Taxonomy

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Fig. 10. Culturing Set Up for Phytoplankton Bioassays

Culturing in Chemically Defined Media

Close Up of Fluoroethylene Polymer (Teflon) Culturing Vessel

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Table 1. Locations of water-column and benthic sampling in Lake Coeur d'Alene (August 2001, June 2004 and June 2005)

August 7, 2001

Sampling Order	Sampling Time (24-hr)	Descriptive Name	Short Name	Latitude (North)	Longitude (West)	Depth (m)	Chl-a Max. Depth (m)	Sediment Texture	Comments
1st	0835	**Mica Bay**	**MICA**	47° 35.996'	116° 49.948'	28.5	n/a		
2nd	1000	**Coeur d'Alene River Inlet**	**CDARI**	47° 27.733'	116° 50.367'	20.0	n/a		
3rd	1100	**Main Channel (near Rockford Bay)**	**MC-R**	47° 30.376'	116° 51.508'	32.0	n/a		
4th	1210	**Main Channel (near Carlin Bay)**	**MC-C**	47° 33.425'	116° 47.462'	38.5	n/a		

June 28, 2004

Sampling Order	Sampling Time (24-hr)	Descriptive Name	Short Name	Latitude (North)	Longitude (West)	Depth (m)	Chl-a Max. Depth (m)	Sediment Texture	Comments
1st	0830	**St. Joe River/Chatcolet Inlet**	**SJRI**	47° 23.391'	116° 45.256'	4.0	-	Intermixed silt and sand overlain by dense macrophytic growth	Narrowing of the channel for the main transport between Chatcolet and CDA Lakes. At the side of the channel with abundance of submerged macrophytes. Additional phytoplankton samples taken here.
2nd	1000	**Southern Main Channel**	**C5**	47° 25.161'	116° 45.400'	17.0	8	Flocculant iron-oxide surficial layer (<1 cm thick) overlying silts and clays.	Medial site between sites Chatcolet Lake and Coeur d'Alene River inlet (along the longitudinal concentration gradients where previous lake monitoring has been performed). Additional phytoplankton samples taken here.
3rd	1230	**Main Channel (near Rockford Bay)**	**MC-R**	47° 30.376'	116° 51.508'	33.5	13	Unconsolidated iron and manganese oxides over anoxic silts and clays	The 3.5-meter depth discrepancy at this station between 2004 and 2005 can be explained by the precipitous slope of the lake bed in this region in combination with limitations of GPS accuracy and the rotation of the boat on its anchor.
4th	1400	**Mica Bay**	**MICA**	47° 35.996'	116° 49.948'	27.3	12	Visibly similar to the MC-R site with unconsolidated, fine- grained oxic material overlying clay layer.	

June 10, 2005

Sampling Order	Sampling Time (24-hr)	Descriptive Name	Short Name	Latitude (North)	Longitude (West)	Depth (m)	Chl-a Max. Depth (m)	Sediment Texture	Comments
1st	0740	**Southern Main Channel**	**C5**	47° 25.161'	116° 45.400'	18.0	10	Flocculant iron-oxide surficial layer (<1 cm thick) overlying silts and clays.	Medial site between sites Chatcolet Lake and Coeur d'Alene River inlet (along the longitudinal concentration gradients where previous lake monitoring has been performed). Additional phytoplankton samples taken here for Zn analyses.
2nd	1030	**Main Channel (near Rockford Bay)**	**MC-R**	47° 30.376'	116° 51.508'	30.0	15	Unconsolidated iron and manganese oxides over anoxic silts and clays	Check on the main-channel coring site. Depth profiling indicated a chlorophyll convergence zone here. Additional phytoplankton samples taken here for Zn analyses.
3rd	1145	**Mica Bay**	**MICA**	47° 35.996'	116° 49.948'	27.0	10	Visibly similar to the MC-R site with unconsolidated, fine- grained oxic material overlying clay layer.	
4th	1305	**Main Channel (near Carlin Bay)**	**MC-C**	47° 33.425'	116° 47.462'	36.0	12	Similar to MC-R site.	Depth profiling indicated chlorophyll transport and dilution in this strata from the convergence zone (MC-R).

Table 2. Coeur d'Alene Lake phytoplankton communities sampled on June 28, 2004 for bioassay isolations.

Site	SJRI		SJRI		SJRI		C5		C5		C5	
Replicate	A	A	B	B	C	C	A	A	B	B	C	C
Density=cells/mL Biovolume=cubic micrometers/mL	Density	Biovolume	Density	Biovolume	Density	Biovolume	Density	Biovolume	Density	Biovolume	Density	Biovolume
CYANOPHYTA												
Anabaena flos-aquae	632.3	74485	1019.3	120073.5	587.3	69183.9						
Anabaena spiroides var. *crassa*	31.5	7916	29.7	11384.8	37.4	14055						
Aphanothece minutissima	12590.4	8813.3	5211.6	3648.1	7869	5508.3	438.6	307	516	361.2	1548	1083.6
Dactylococcopsis sp.	13.5	148.5	31.5	346.5	36	396	13.5	121.5	4.5	40.5	4.5	40.5
Pseudanabaena limnetica			29.3	445.4								
Synechococcus capitatus							12642	99871.8	6966	55031.4	6992	55236.8
Woronichinia klingae									180	2556		
CHRYSOPHYTA												
Chromulina sp.	1083.6	4551.1	258	1083.6	593.4	2492.3	51.6	216.7	77.4	325.1	258	1083.6
Dinobryon bavaricum							5.6	953.1	7.9	1344.6	18	3063.6
Dinobryon cylindricum var. *alpinum*			22.5	7087.5							9	2835
Dinobyron divergens	10.1	1057.5	5.6	586.3	6.8	712	30.4	3182.9	25.9	2711.7	18	1884.6
Kephyrion skujae							13.5	884.3				
Kephyrion sp.							4.5	92.7	4.5	150.8		
Mallomonas akrokomos	4.5	360.5	4.5	360.5	5	400.5	0.5	52.4				
Mallomonas globosa									1.1	294.9	0.5	134
Mallomonas sp.									0.5	481.7		
Salpingoeca sp.	9	589.5	4.5	294.8	4.5	294.8	36	741.6	45	927	54	92.7
Stelexomonas sp.									15.8	764.7		
BACILLARIOPHYTA												
Asterionella formosa	7.9	1738	12.4	2728	4.5	990	757.1	413830.9	912.4	498717.8	964.1	526977.1
Aulacoseira granulata var. *angustissima*					6.8	4005.2	33.8	13300.3	22.5	11927.3	1.4	742.1
Aulacoseira italica var. *tenuissima*	60.8	31628.2	28.1	9110	25	13005						
Aulacoseira sp.			4.5	793.4	3.4	599.4						
Aulacoseira subarctica			10	18300			3.6	4523.8				
Fragilaria crotonensis			45	47250			24.8	24180	60.8	59280	15.8	15405
Nitzschia draveillensis	4.5	351.5	4.5	351.5	4.5	351.5					2.3	276
Nitzschia sp.							0.5	120.2				
Stephanodiscus agassizensis	36	14137.2	4.5	2368	9	4735.8	0.5	125.7			4.5	865.8
Synedra rumpens var. *fragilarioides*							9	2430	7.9	2133	7.9	2465.8
Synedra ulna var. chaseana									1.1	4963.8		
Synedra ulna var. *ulna*	0.5	1762										
Tabellaria fenestrata									4.5	7776		
Urosolenia eriensis	31.5	11907	18	6804	18	6804	13.5	15506.1	13.5	15506.1	13.5	15506.1
HAPTOPHYTA												
Chrysochromulina sp.	364.5	10096.7	400.5	11093.9	382.5	10595.3	940.5	19374.3	1710	35226	1251	25770.6
CRYPTOPHYTA												
Campylomonas marsonii							22.5	9951.8	11.3	4975.9	1.1	486.5
Campylomonas sp.	4.5	1734.3					67.5	86514.8	58.5	74979.5	37.1	47551
Cryptomonas rostratiformis											0.5	2252.4
Plagioselmis nannoplanctica	139.5	25500.6	162	29613.6	121.5	22210.2	94.5	25212.5	58.5	15607.8	94.5	25212.6
Plagioselmis sp.	90	1530	45	765	27	459	36	504	36	504	22.5	315
DINOPHYTA												
Peridinium sp.											0.5	32724
EUGLENOPHYTA												
Trachelomonas hispida var. *punctata*	0.5	1513.2	0.5	1513.2								
CHLOROPHYTA												
Ankyra judayi	4.5	174.6	1.1	45.1								
Chlamydomonas sp.	154.8	650.2	27	113.4	25.8	108.4	4.5	18.9	4.5	18.9	9	37.8
Chlorella minutissima	1548	6501.6	1548	6501.6	1419	5959.8	258	1083.6	258	1083.6	258	1083.6
Choricystis minor	567.6	908.2	309.6	495.4	258	412.8	1186.8	1068.1	516	464.4	387	348.3
Crucigenia tetrapedia	9	272.7	18	370.8	4.5	92.7			18	545.4		
Crucigeniella apiculata	108	3272.4	18	730.8	36	1090.8	18	424.8				
Dictyosphaerium pulchellum									6.8	769.1		
Euastrum boldtii	4.5	2538.5			1.1	623.5					1.1	620.5
Kirchneriella irregularis	18	151.2			4.5	37.8						
Koliella sp.	1.1	82.9										
Monoraphidium minutum			1.1	100								
Pediastrum tetras							3.6	471.6				
Pseudodictyosphaerium sp.	243	1020.6	414	1738.8	243	1020.6					72	302.4
Raphidocelis microscopica	22.5	67.5	22.5	67.5	40.5	121.5						
Scenedesmus arcuatus			4.5	326.7								
Scenedesmus communis					9	339.3						
Scenedesmus ecornis	18	189					9	198				
Scenedesmus intermedius					3.4	89.1	4.5	169.7				
TOTAL:	17814	215650	9715	286492	11786	166695	16724	725433	11545	799468	12046	764397

Table 3A. Mean macroinvertebrate site densities (individuals per square meter) of major taxonomic or functional grouping for three sampling years.

	2001				2004				2005			
	CDARI	MC-R	MC-C	MICA	SJI	C5	MC-R	MICA	C5	MC-R	MC-C	MICA
Cnidaria					69							
Platyhelminthes	14		28	14	25	19	176	63	57	113	76	132
Nematoda		84	70		252	120	95	13	25	50	57	6
Ectoprocta									57			13
Naididae					1462	6						
Tubificidae			140	112	1134	359	13	82	302			6
Hirudinea					252							
Microcrustacea (benthic)				224	139	309	170	592	258	113	50	334
Microcrustacea (planktonic)	154	28	42	154	630	410	2054	1827		384	554	706
Macrocrustacea					246		6	6	13			
Ephemeroptera					82	6	6	19	6			
Trichoptera					50							
Tanypodinae	238				1405	19			32	6		
Prodiamesinae								13				6
Diamesinae	14					25			13	13		57
Orthocladinae		154	14	196	32		3276	2596	6	668	1210	3245
Chironomini	280			14	1499	195	19		214	6	13	63
Tanytarsini	14	14		1121	321		76	25		6	38	
Chaoboridae						6						
Ceratopogonidae					145	6		6				19
Acari					57		32	38		38	38	107
Mollusca					233	38			50			
Mean density (individuals m^{-2})	714	280	294	1835	8033	1518	5922	5279	1033	1399	2035	4694

Table 3B. Mean density (individuals per square meter) and mean taxon richness of macroinvertebrates collected per site during three sampling years (2001, 2004, 2005)

Year	Site Name	Mean density (individuals per square meter)	Standard Deviation	Coefficient of variation	Mean Richness	Standard Deviation	Coefficient of variation
2001	CDARI	**714**	426.5	59.7	4.0	2.00	50.0
	MC-R	**280**	194.1	69.3	3.0	0.00	0.0
	MC-C	**294**	168.1	57.1	4.3	2.08	48.0
	MICA	**1835**	2524.5	137.6	5.7	2.89	50.9
2004	SJI	**8033**	3733.4	46.5	42.7	9.07	21.3
	C5	**1518**	1328.0	87.5	12.7	4.04	31.9
	MC-R	**5922**	1956.5	33.0	11.0	2.00	18.2
	MICA	**5279**	3660.7	69.3	13.0	3.00	23.1
2005	C5	**1033**	325.4	31.5	12.0	1.00	8.3
	MC-R	**1399**	1371.8	98.1	8.3	3.06	36.7
	MC-C	**2035**	779.8	38.3	8.3	1.53	18.3
	MICA	**4694**	1524.0	32.5	10.7	0.58	5.4

Table 4. Dissolved Metals in the Water Column - Coeur d'Alene Lake (August 2001, June 2004 & June 2005)

2001

MC-R Mass units

Depth (m)	Zn ppb	95% Conf. Interval	Cu ppb	95% Conf. Interval	Cd ppb	95% Conf. Interval	Pb ppb	95% Conf. Interval	Fe ppb	95% Conf. Interval	Mn ppb	95% Conf. Interval	Ni ppb	95% Conf. Interval
2.0	**48.6**	0.2	**0.458**	0.003	**0.207**	0.006	**0.083**	0.001	**21.8**	0.1	**1.573**	0.005	**0.182**	0.007
16.0	**94.1**	0.3	**0.438**	0.003	**0.232**	0.001	**0.041**	0.001	**19.6**	0.5	**0.493**	0.003	**0.240**	0.021
30.0	**95.9**	0.4	**0.477**	0.004	**0.276**	0.004	**0.028**	0.001	**20.1**	0.4	**0.220**	0.002	**0.267**	0.018

MICA

Depth (m)	Zn ppb	95% Conf. Interval	Cu ppb	95% Conf. Interval	Cd ppb	95% Conf. Interval	Pb ppb	95% Conf. Interval	Fe ppb	95% Conf. Interval	Mn ppb	95% Conf. Interval	Ni ppb	95% Conf. Interval
2.0	**45.6**	0.1	**0.451**	0.005	**0.175**	0.003	**0.063**	0.001	**20.6**	0.6	**0.774**	0.007	**0.205**	0.007
14.3	**72.6**	0.2	**0.442**	0.005	**0.210**	0.002	**0.032**	0.001	**19.1**	0.1	**0.849**	0.008	**0.249**	0.005
26.5	**89.8**	0.0	**0.477**	0.001	**0.262**	0.003	**0.028**	0.000	**19.7**	0.4	**0.247**	0.004	**0.276**	0.012

MC-C

Depth (m)	Zn ppb	95% Conf. Interval	Cu ppb	95% Conf. Interval	Cd ppb	95% Conf. Interval	Pb ppb	95% Conf. Interval	Fe ppb	95% Conf. Interval	Mn ppb	95% Conf. Interval	Ni ppb	95% Conf. Interval
2.0	**50.8**	0.1	**0.455**	0.004	**0.210**	0.003	**0.060**	0.002	**20.2**	0.2	**1.670**	0.001	**0.167**	0.009
19.3	**89.2**	0.2	**0.435**	0.005	**0.232**	0.004	**0.028**	0.000	**20.0**	0.8	**0.290**	0.001	**0.228**	0.016
36.5	**101.3**	0.6	**0.484**	0.003	**0.279**	0.004	**0.020**	0.000	**20.8**	0.2	**0.154**	0.000	**0.258**	0.010

CDARI

Depth (m)	Zn ppb	95% Conf. Interval	Cu ppb	95% Conf. Interval	Cd ppb	95% Conf. Interval	Pb ppb	95% Conf. Interval	Fe ppb	95% Conf. Interval	Mn ppb	95% Conf. Interval	Ni ppb	95% Conf. Interval
2.0	**44.4**	0.1	**0.473**	0.006	**0.192**	0.001	**0.369**	0.001	**30.0**	0.6	**2.752**	0.026	**0.313**	0.010
10.0	**48.4**	0.0	**0.434**	0.001	**0.182**	0.002	**0.098**	0.001	**22.1**	0.1	**0.322**	0.000	**0.247**	0.011
18.0	**99.8**	0.6	**0.498**	0.004	**0.235**	0.005	**0.057**	0.000	**22.0**	0.3	**11.116**	0.040	**0.236**	0.011

MC-R Molar units

Depth (m)	Zn nM	95% Conf. Interval	Cu nM	95% Conf. Interval	Cd nM	95% Conf. Interval	Pb nM	95% Conf. Interval	Fe nM	95% Conf. Interval	Mn nM	95% Conf. Interval	Ni nM	95% Conf. Interval
2.0	**743**	4	**7.20**	0.05	**1.84**	0.05	**0.40**	0.00	**390**	2	**28.64**	0.10	**3.11**	0.11
16.0	**1439**	5	**6.90**	0.05	**2.07**	0.01	**0.20**	0.00	**351**	8	**8.98**	0.05	**4.09**	0.36
30.0	**1466**	5	**7.51**	0.07	**2.45**	0.03	**0.13**	0.00	**361**	6	**4.01**	0.04	**4.55**	0.30

MICA

Depth (m)	Zn nM	95% Conf. Interval	Cu nM	95% Conf. Interval	Cd nM	95% Conf. Interval	Pb nM	95% Conf. Interval	Fe nM	95% Conf. Interval	Mn nM	95% Conf. Interval	Ni nM	95% Conf. Interval
2.0	**697**	2	**7.10**	0.07	**1.55**	0.02	**0.31**	0.01	**368**	11	**14.09**	0.13	**3.50**	0.12
14.3	**1111**	3	**6.96**	0.08	**1.86**	0.02	**0.15**	0.00	**343**	1	**15.45**	0.14	**4.24**	0.09
26.5	**1374**	0	**7.51**	0.02	**2.33**	0.03	**0.14**	0.00	**352**	7	**4.50**	0.07	**4.70**	0.21

MC-C

Depth (m)	Zn nM	95% Conf. Interval	Cu nM	95% Conf. Interval	Cd nM	95% Conf. Interval	Pb nM	95% Conf. Interval	Fe nM	95% Conf. Interval	Mn nM	95% Conf. Interval	Ni nM	95% Conf. Interval
2.0	**777**	1	**7.15**	0.07	**1.87**	0.02	**0.29**	0.01	**361**	4	**30.40**	0.02	**2.84**	0.16
19.3	**1365**	4	**6.84**	0.08	**2.06**	0.03	**0.14**	0.00	**358**	14	**5.28**	0.02	**3.88**	0.27
36.5	**1549**	8	**7.62**	0.05	**2.48**	0.03	**0.10**	0.00	**373**	3	**2.81**	0.00	**4.40**	0.16

CDARI

Depth (m)	Zn nM	95% Conf. Interval	Cu nM	95% Conf. Interval	Cd nM	95% Conf. Interval	Pb nM	95% Conf. Interval	Fe nM	95% Conf. Interval	Mn nM	95% Conf. Interval	Ni nM	95% Conf. Interval
2.0	**679**	2	**7.45**	0.09	**1.71**	0.01	**1.78**	0.01	**537**	11	**50.09**	0.48	**5.34**	0.17
10.0	**740**	1	**6.83**	0.02	**1.62**	0.02	**0.47**	0.01	**396**	2	**5.86**	0.00	**4.20**	0.19
18.0	**1527**	10	**7.84**	0.06	**2.09**	0.05	**0.27**	0.00	**393**	5	**202.33**	0.73	**4.02**	0.19

2004

MC-R Mass units

Depth (m)	Zn ppb	95% Conf. Interval	Cu ppb	95% Conf. Interval	Cd ppb	95% Conf. Interval	Pb ppb	95% Conf. Interval	Fe ppb	95% Conf. Interval	Mn ppb	95% Conf. Interval	Ni ppb	95% Conf. Interval
2.0	**37.7**	0.1	**0.340**	0.008	**0.198**	0.002	**0.201**	0.001	**16.6**	0.2	**0.080**	0.001	**0.141**	0.008
16.8	**56.8**	0.6	**0.384**	0.002	**0.245**	0.004	**0.060**	0.001	**10.9**	0.6	**0.109**	0.000	**0.189**	0.001
31.5	**80.0**	0.1	**0.484**	0.003	**0.306**	0.002	**0.159**	0.001	**17.2**	0.4	**0.163**	0.002	**0.272**	0.009

MICA

Depth (m)	Zn ppb	95% Conf. Interval	Cu ppb	95% Conf. Interval	Cd ppb	95% Conf. Interval	Pb ppb	95% Conf. Interval	Fe ppb	95% Conf. Interval	Mn ppb	95% Conf. Interval	Ni ppb	95% Conf. Interval
2.0	**43.2**	0.2	**0.391**	0.007	**0.214**	0.000	**0.082**	0.001	**11.9**	0.3	**0.072**	0.001	**0.160**	0.006
13.7	**56.2**	0.4	**0.385**	0.003	**0.236**	0.001	**0.042**	0.001	**10.4**	0.1	**0.071**	0.001	**0.180**	0.008
25.3	**79.3**	0.3	**0.493**	0.004	**0.305**	0.001	**0.134**	0.001	**16.4**	0.4	**0.169**	0.000	**0.267**	0.008

C5

Depth (m)	Zn ppb	95% Conf. Interval	Cu ppb	95% Conf. Interval	Cd ppb	95% Conf. Interval	Pb ppb	95% Conf. Interval	Fe ppb	95% Conf. Interval	Mn ppb	95% Conf. Interval	Ni ppb	95% Conf. Interval
2.0	**16.6**	0.0	**0.256**	0.001	**0.083**	0.001	**0.182**	0.002	**20.5**	0.2	**0.101**	0.001	**0.101**	0.004
8.5	**33.7**	0.1	**0.296**	0.002	**0.166**	0.001	**0.128**	0.001	**12.7**	0.2	**0.076**	0.000	**0.124**	0.002
15.0	**33.5**	0.2	**0.281**	0.001	**0.126**	0.001	**0.094**	0.002	**17.9**	0.5	**0.157**	0.001	**0.119**	0.007

SJRI

Depth (m)	Zn ppb	95% Conf. Interval	Cu ppb	95% Conf. Interval	Cd ppb	95% Conf. Interval	Pb ppb	95% Conf. Interval	Fe ppb	95% Conf. Interval	Mn ppb	95% Conf. Interval	Ni ppb	95% Conf. Interval
2.0	**<DL**		**0.214**	0.003	**<DL**		**0.013**	0.000	**34.9**	0.3	**0.106**	0.003	**0.060**	0.012

MC-R Molar units

Depth (m)	Zn nM	95% Conf. Interval	Cu nM	95% Conf. Interval	Cd nM	95% Conf. Interval	Pb nM	95% Conf. Interval	Fe nM	95% Conf. Interval	Mn nM	95% Conf. Interval	Ni nM	95% Conf. Interval
2.0	**576**	2	**5.35**	0.12	**1.76**	0.02	**0.97**	0.01	**298**	4	**1.46**	0.02	**2.40**	0.14
16.8	**868**	9	**6.05**	0.03	**2.18**	0.04	**0.29**	0.00	**196**	11	**1.98**	0.00	**3.23**	0.02
31.5	**1224**	1	**7.61**	0.05	**2.73**	0.02	**0.77**	0.01	**308**	6	**2.97**	0.04	**4.64**	0.16

MICA

Depth (m)	Zn nM	95% Conf. Interval	Cu nM	95% Conf. Interval	Cd nM	95% Conf. Interval	Pb nM	95% Conf. Interval	Fe nM	95% Conf. Interval	Mn nM	95% Conf. Interval	Ni nM	95% Conf. Interval
2.0	**661**	4	**6.15**	0.12	**1.91**	0.00	**0.40**	0.01	**213**	5	**1.31**	0.02	**2.73**	0.11
13.7	**860**	5	**6.06**	0.04	**2.10**	0.01	**0.20**	0.00	**186**	1	**1.28**	0.02	**3.06**	0.14
25.3	**1213**	4	**7.76**	0.06	**2.71**	0.01	**0.65**	0.00	**293**	7	**3.07**	0.01	**4.54**	0.14

C5

Depth (m)	Zn nM	95% Conf. Interval	Cu nM	95% Conf. Interval	Cd nM	95% Conf. Interval	Pb nM	95% Conf. Interval	Fe nM	95% Conf. Interval	Mn nM	95% Conf. Interval	Ni nM	95% Conf. Interval
2.0	**254**	1	**4.03**	0.02	**0.74**	0.01	**0.88**	0.01	**367**	3	**1.85**	0.02	**1.72**	0.07
8.5	**515**	1	**4.65**	0.04	**1.48**	0.01	**0.62**	0.00	**227**	4	**1.39**	0.01	**2.10**	0.04
15.0	**513**	3	**4.41**	0.02	**1.12**	0.01	**0.45**	0.01	**321**	9	**2.85**	0.03	**2.02**	0.12

SJRI

Depth (m)	Zn nM	95% Conf. Interval	Cu nM	95% Conf. Interval	Cd nM	95% Conf. Interval	Pb nM	95% Conf. Interval	Fe nM	95% Conf. Interval	Mn nM	95% Conf. Interval	Ni nM	95% Conf. Interval
2.0	**<DL**		**3.38**	0.05	**<DL**		**0.06**	0.00	**625**	5	**1.93**	0.05	**1.02**	0.21

2005

MC-R Mass units

Depth (m)	Zn ppb	95% Conf. Interval	Cu ppb	95% Conf. Interval	Cd ppb	95% Conf. Interval	Pb ppb	95% Conf. Interval	Fe ppb	95% Conf. Interval	Mn ppb	95% Conf. Interval	Ni ppb	95% Conf. Interval
2.0	**31.9**	0.2	**0.266**	0.001	**0.169**	0.001	**0.163**	0.001	**18.4**	0.1	**0.117**	0.003	**0.136**	0.018
15.0	**42.3**	0.1	**0.303**	0.009	**0.194**	0.004	**0.106**	0.001	**15.0**	0.4	**0.091**	0.002	**0.139**	0.021
28.0	**53.0**	0.5	**0.342**	0.004	**0.221**	0.002	**0.319**	0.002	**23.4**	0.3	**0.334**	0.002	**0.210**	0.014

MICA

Depth (m)	Zn ppb	95% Conf. Interval	Cu ppb	95% Conf. Interval	Cd ppb	95% Conf. Interval	Pb ppb	95% Conf. Interval	Fe ppb	95% Conf. Interval	Mn ppb	95% Conf. Interval	Ni ppb	95% Conf. Interval
2.0	**30.6**	0.0	**0.275**	0.007	**0.159**	0.002	**0.123**	0.001	**18.9**	0.3	**0.217**	0.002	**0.134**	0.011
10.0	**33.2**	0.3	**0.266**	0.007	**0.156**	0.002	**0.098**	0.001	**18.4**	0.3	**0.049**	0.002	**0.134**	0.012
25.0	**54.0**	0.2	**0.365**	0.007	**0.221**	0.002	**0.207**	0.003	**18.4**	0.1	**0.193**	0.002	**0.182**	0.001

MC-C

Depth (m)	Zn ppb	95% Conf. Interval	Cu ppb	95% Conf. Interval	Cd ppb	95% Conf. Interval	Pb ppb	95% Conf. Interval	Fe ppb	95% Conf. Interval	Mn ppb	95% Conf. Interval	Ni ppb	95% Conf. Interval
2.0	**31.2**	0.1	**0.274**	0.003	**0.178**	0.001	**0.243**	0.002	**21.8**	0.5	**1.010**	0.007	**0.129**	0.010
12.0	**37.1**	0.1	**0.277**	0.003	**0.179**	0.004	**0.166**	0.001	**19.5**	0.1	**0.095**	0.001	**0.165**	0.011
34.0	**55.6**	1.5	**0.347**	0.001	**0.236**	0.010	**0.299**	0.010	**23.7**	0.2	**0.202**	0.008	**0.187**	0.005

C5

Depth (m)	Zn ppb	95% Conf. Interval	Cu ppb	95% Conf. Interval	Cd ppb	95% Conf. Interval	Pb ppb	95% Conf. Interval	Fe ppb	95% Conf. Interval	Mn ppb	95% Conf. Interval	Ni ppb	95% Conf. Interval
2.0	**6.2**	0.0	**0.197**	0.003	**0.030**	0.001	**0.095**	0.001	**39.2**	0.4	**0.380**	0.005	**0.098**	0.005
10.0	**24.8**	0.2	**0.265**	0.002	**0.102**	0.000	**0.129**	0.001	**26.6**	0.2	**0.246**	0.001	**0.138**	0.013
16.0	**45.9**	0.2	**0.388**	0.004	**0.180**	0.002	**0.276**	0.004	**30.3**	0.2	**12.750**	0.081	**0.179**	0.005

MC-R Molar units

Depth (m)	Zn nM	95% Conf. Interval	Cu nM	95% Conf. Interval	Cd nM	95% Conf. Interval	Pb nM	95% Conf. Interval	Fe nM	95% Conf. Interval	Mn nM	95% Conf. Interval	Ni nM	95% Conf. Interval
2.0	**488**	3	**4.19**	0.01	**1.51**	0.01	**0.79**	0.01	**329**	1	**2.12**	0.05	**2.31**	0.30
15.0	**647**	2	**4.77**	0.15	**1.73**	0.03	**0.51**	0.00	**268**	8	**1.66**	0.04	**2.37**	0.37
28.0	**810**	8	**5.38**	0.06	**1.96**	0.01	**1.54**	0.01	**419**	5	**6.08**	0.03	**3.58**	0.24

MICA

Depth (m)	Zn nM	95% Conf. Interval	Cu nM	95% Conf. Interval	Cd nM	95% Conf. Interval	Pb nM	95% Conf. Interval	Fe nM	95% Conf. Interval	Mn nM	95% Conf. Interval	Ni nM	95% Conf. Interval
2.0	**469**	0	**4.33**	0.10	**1.41**	0.02	**0.60**	0.01	**338**	5	**3.95**	0.03	**2.29**	0.18
10.0	**508**	5	**4.18**	0.11	**1.39**	0.01	**0.47**	0.01	**329**	5	**0.90**	0.03	**2.28**	0.20
25.0	**826**	3	**5.75**	0.11	**1.96**	0.02	**1.00**	0.02	**330**	2	**3.51**	0.04	**3.11**	0.02

MC-C

Depth (m)	Zn nM	95% Conf. Interval	Cu nM	95% Conf. Interval	Cd nM	95% Conf. Interval	Pb nM	95% Conf. Interval	Fe nM	95% Conf. Interval	Mn nM	95% Conf. Interval	Ni nM	95% Conf. Interval
2.0	**477**	1	**4.31**	0.05	**1.58**	0.01	**1.17**	0.01	**390**	9	**18.39**	0.14	**2.20**	0.17
12.0	**567**	1	**4.36**	0.04	**1.59**	0.03	**0.80**	0.01	**350**	2	**1.73**	0.01	**2.81**	0.19
34.0	**850**	23	**5.46**	0.02	**2.10**	0.09	**1.44**	0.05	**424**	4	**3.68**	0.14	**3.18**	0.08

C5

Depth (m)	Zn nM	95% Conf. Interval	Cu nM	95% Conf. Interval	Cd nM	95% Conf. Interval	Pb nM	95% Conf. Interval	Fe nM	95% Conf. Interval	Mn nM	95% Conf. Interval	Ni nM	95% Conf. Interval
2.0	**94**	0	**3.09**	0.05	**0.26**	0.01	**0.46**	0.00	**702**	7	**6.91**	0.09	**1.68**	0.08
10.0	**379**	4	**4.17**	0.03	**0.91**	0.00	**0.62**	0.00	**476**	3	**4.47**	0.01	**2.35**	0.22
16.0	**702**	3	**6.11**	0.07	**1.61**	0.02	**1.33**	0.02	**543**	4	**232.07**	1.47	**3.05**	0.09

Note:
For 2005 samples, depth of middle water-column sampling selected to coincide with chlorophyll maximum

Table 5. Dissolved Nutrients in the Water Column - Coeur d'Alene Lake (August 2001, June 2004 & June 2005)

2001

Molar Units

MC-R	Ortho-Phosphate		Nitrate + Nitrite		Ammonia	
Depth (m)	nM	Std error	nM	Std error	nM	Std error
2.0	0 *	0	16 *	2	50 *	12
16.0	0 *	0	191 *	19	233 *	62
30.0	0 *	0	**4405**	36	**1311**	19

MICA	Ortho-Phosphate		Nitrate + Nitrite		Ammonia	
Depth (m)	nM	Std error	nM	Std error	nM	Std error
2.0	1 *	1	129 *	25	36 *	6
14.3	11 *	10	64 *	6	50 *	30
26.5	0 *	0	**3511**	26	**794**	53

MC-C	Ortho-Phosphate		Nitrate + Nitrite		Ammonia	
Depth (m)	nM	Std error	nM	Std error	nM	Std error
2.0	0 *	0	57 *	25	59 *	11
19.3	0 *	0	**1436**	69	325 *	40
36.5	0 *	0	**4992**	31	**2232**	50

CDARI	Ortho-Phosphate		Nitrate + Nitrite		Ammonia	
Depth (m)	nM	Std error	nM	Std error	nM	Std error
2.0	3 *	4	139 *	4	98 *	33
10.0	18 *	25	109 *	43	**361**	14
18.0	8 *	8	**3492**	10	**1078**	44

Mass Units

MC-R	Ortho-Phosphate		Nitrate + Nitrite		Ammonia	
Depth (m)	ug-P/L	Std error	ug-N/L	Std error	ug-N/L	Std error
2.0	0.0 *	0.0	0.2 *	0.0	0.7 *	0.2
16.0	0.0 *	0.0	2.7 *	0.3	3.3 *	0.9
30.0	0.0 *	0.0	**61.7**	0.5	**18.4**	0.3

MICA	Ortho-Phosphate		Nitrate + Nitrite		Ammonia	
Depth (m)	ug-P/L	Std error	ug-N/L	Std error	ug-N/L	Std error
2.0	0.0 *	0.0	1.8 *	0.3	0.5 *	0.1
14.3	0.3 *	0.3	0.9 *	0.1	0.7 *	0.4
26.5	0.0 *	0.0	**49.2**	0.4	**11.1**	0.7

MC-C	Ortho-Phosphate		Nitrate + Nitrite		Ammonia	
Depth (m)	ug-P/L	Std error	ug-N/L	Std error	ug-N/L	Std error
2.0	0.0 *	0.0	0.8 *	0.3	0.8 *	0.2
19.3	0.0 *	0.0	**20.1**	1.0	4.5 *	0.6
36.5	0.0 *	0.0	**69.9**	0.4	**31.3**	0.7

CDARI	Ortho-Phosphate		Nitrate + Nitrite		Ammonia	
Depth (m)	ug-P/L	Std error	ug-N/L	Std error	ug-N/L	Std error
2.0	0.1 *	0.1	1.9 *	0.1	1.4 *	0.5
10.0	0.6 *	0.8	1.5 *	0.6	**5.1**	0.2
18.0	0.2 *	0.2	**48.9**	0.1	**15.1**	0.6

Bottom-water N:P Ratio

Molar	Mass
604	273

* Value is below method detection limit reported by analyst.

2004

Molar Units

MC-R	Ortho-Phosphate		Nitrate + Nitrite		Ammonia	
Depth (m)	nM	Std error	nM	Std error	nM	Std error
2.0	12 *	0	55 *	31	185 *	52
16.8	9 *	3	62 *	4	330 *	83
31.5	9 *	2	**5215**	20	**481**	47

MICA	Ortho-Phosphate		Nitrate + Nitrite		Ammonia	
Depth (m)	nM	Std error	nM	Std error	nM	Std error
2.0	8 *	2	36 *	1	234 *	8
13.7	9 *	1	58 *	5	258 *	30
25.3	10 *	3	**4817**	24	**999**	25

C5	Ortho-Phosphate		Nitrate + Nitrite		Ammonia	
Depth (m)	nM	Std error	nM	Std error	nM	Std error
2.0	17 *	3	76 *	14	337 *	69
8.5	16 *	1	57 *	17	**481**	20
15.0	21 *	1	119 *	112	**433**	14

SJI	Ortho-Phosphate		Nitrate + Nitrite		Ammonia	
Depth (m)	nM	Std error	nM	Std error	nM	Std error
2.0	31 *	1	76 *	4	**364**	15

Mass Units

MC-R	Ortho-Phosphate		Nitrate + Nitrite		Ammonia	
Depth (m)	ug-P/L	Std error	ug-N/L	Std error	ug-N/L	Std error
2.0	0.4 *	0.0	0.8 *	0.4	2.6 *	0.7
16.8	0.3 *	0.1	0.9 *	0.1	4.6 *	1.2
31.5	0.3 *	0.1	**73.0**	0.3	**6.7**	0.7

MICA	Ortho-Phosphate		Nitrate + Nitrite		Ammonia	
Depth (m)	ug-P/L	Std error	ug-N/L	Std error	ug-N/L	Std error
2.0	0.3 *	0.1	0.5 *	0.0	3.3 *	0.1
13.7	0.3 *	0.0	0.8 *	0.1	3.6 *	0.4
25.3	0.3 *	0.1	**67.5**	0.3	**14.0**	0.4

C5	Ortho-Phosphate		Nitrate + Nitrite		Ammonia	
Depth (m)	ug-P/L	Std error	ug-N/L	Std error	ug-N/L	Std error
2.0	0.5 *	0.1	1.1 *	0.2	4.7 *	1.0
8.5	0.5 *	0.0	0.8 *	0.2	**6.7**	0.3
15.0	0.6 *	0.0	1.7 *	1.6	**6.1**	0.2

SJI	Ortho-Phosphate		Nitrate + Nitrite		Ammonia	
Depth (m)	ug-P/L	Std error	ug-N/L	Std error	ug-N/L	Std error
2.0	1.0 *	0.0	1.1 *	0.1	**5.1**	0.2

Bottom-water N:P Ratio

Molar	Mass
611	277
568	257
26	12

* Value is below method detection limit reported by analyst.

2005

Molar Units

MC-R	Ortho-Phosphate		Nitrate + Nitrite		Ammonia	
Depth (m)	nM	Std error	nM	Std error	nM	Std error
2.0	30 *	0	65 *	5	74 *	17
15.0	38 *	4	**201**	165	275 *	144
28.0	44 *	3	**4238**	54	133 *	0

MICA	Ortho-Phosphate		Nitrate + Nitrite		Ammonia	
Depth (m)	nM	Std error	nM	Std error	nM	Std error
2.0	31 *	0	71 *	20	55 *	22
10.0	30 *	0	87 *	10	84 *	23
25.0	39 *	3	**3104**	83	224 *	39

MC-C	Ortho-Phosphate		Nitrate + Nitrite		Ammonia	
Depth (m)	nM	Std error	nM	Std error	nM	Std error
2.0	31 *	1	162 *	14	177 *	55
12.0	31 *	2	53 *	2	104 *	12
34.0	38 *	3	**4596**	10	129 *	6

C5	Ortho-Phosphate		Nitrate + Nitrite		Ammonia	
Depth (m)	nM	Std error	nM	Std error	nM	Std error
2.0	38 *	1	65 *	1	39 *	33
10.0	40 *	0	65 *	1	169 *	6
16.0	64 *	3	**3130**	33	228 *	0

Mass Units

MC-R	Ortho-Phosphate		Nitrate + Nitrite		Ammonia	
Depth (m)	ug-P/L	Std error	ug-N/L	Std error	ug-N/L	Std error
2.0	0.9 *	0.0	0.9 *	0.1	1.0 *	0.2
15.0	1.2 *	0.1	**2.8**	2.3	3.8 *	2.0
28.0	1.4 *	0.1	**59.4**	0.8	1.9 *	0.0

MICA	Ortho-Phosphate		Nitrate + Nitrite		Ammonia	
Depth (m)	ug-P/L	Std error	ug-N/L	Std error	ug-N/L	Std error
2.0	1.0 *	0.0	1.0 *	0.3	0.8 *	0.3
10.0	0.9 *	0.0	1.2 *	0.1	1.2 *	0.3
25.0	1.2 *	0.1	**43.5**	1.2	3.1 *	0.5

MC-C	Ortho-Phosphate		Nitrate + Nitrite		Ammonia	
Depth (m)	ug-P/L	Std error	ug-N/L	Std error	ug-N/L	Std error
2.0	1.0 *	0.0	2.3 *	0.2	2.5 *	0.8
12.0	1.0 *	0.1	0.7 *	0.0	1.5 *	0.2
34.0	1.2 *	0.1	**64.4**	0.1	1.8 *	0.1

C5	Ortho-Phosphate		Nitrate + Nitrite		Ammonia	
Depth (m)	ug-P/L	Std error	ug-N/L	Std error	ug-N/L	Std error
2.0	1.2 *	0.0	0.9 *	0.0	0.5 *	0.5
10.0	1.2 *	0.0	0.9 *	0.0	2.4 *	0.1
16.0	2.0 *	0.1	**43.8**	0.5	3.2 *	0.0

Bottom-water N:P Ratio

Molar	Mass
100	45
86	39
123	56
52	24

* Value is below method detection limit reported by analyst.

	Molar	Mass
Average N:P ratio =	271	123
Standard deviation of N:P ratios =	269	122
Redfield N:P ratio =	16	7

Notes:
All analyses included only two sample replicates, so standard error is given instead of 95% confidence interval
For 2005 samples, depth of middle water-column sampling selected to coincide with chlorophyll maximum

Table 6. Experimental design for algal bioassay media associated with Coeur d'Alene Lake modeling studies.
Computed free-zinc (Zn) ion concentrations and total orthophosphate (P) concentrations are separated by a slash.
Comparative molar concentrations in parentheses are from bioassays a decade ago using other lake isolates (Kuwabara and others, 1994).

Treatments (9 total)	**Basal P** N:P molar ratio = **40**	**Mid P** N:P molar ratio = **16**	**Elevated P** N:P molar ratio = **4**
Basal Zn	**$5x10^{-12}$ / $1x10^{-7}$** ($5x10^{-12}$ / $1x10^{-7}$)[a]	**$5x10^{-12}$ / $2.5x10^{-7}$**	**$5x10^{-12}$ / $1x10^{-6}$**
Mid Zn	**$1x10^{-8}$ / $1x10^{-7}$** ($1x10^{-7}$ / $1x10^{-7}$)	**$1x10^{-8}$ / $2.5x10^{-7}$**	**$1x10^{-8}$ / $1x10^{-6}$**
Elevated Zn	**$3x10^{-8}$ / $1x10^{-7}$** ($4x10^{-7}$ / $1x10^{-7}$)[b]	**$3x10^{-8}$ / $2.5x10^{-7}$**	**$3x10^{-8}$ / $1x10^{-6}$**

[a] The basal medium formulation/speciation is unchanged from the previous 1993 experimental series.

[b] In contrast to previous algal bioassays, the uncomplexed-zinc concentrations are consistently lower than the orthophosphate concentrations that extend well beyond the range of phosphorus limitation (that is, an nitrogen to phosphorus ratios >16).

Table 7. Phytoplankton Culturing Data

Isolate: ***Chlorella minutissima***

Ortho-P	Zinc	Basis	Regression Days Start	Regression Days End	Slope	± CI[a]	Intercept	± CI	Growth Rate (d-1)	± CI	Lag time (d)	r^2	Log Maximum Biovolume (µm3)	± CI
Basal	Basal	Cell Conc.	0	4	0.31	0.01	4.33	0.00	1.02	0.03	0.02	0.99	6.48	0.09
		Biovolume	0	4	0.30	0.01	5.21	0.00	0.99	0.04	0.50	0.98		
Mid	Basal	Cell Conc.	0	4	0.38	0.00	4.28	0.01	1.27	0.02	0.09	1.00	6.83	0.03
		Biovolume	0	5	0.33	0.01	5.22	0.03	1.08	0.03	0.33	0.99		
High	Basal	Cell Conc.	0	6	0.30	0.01	4.36	0.05	1.00	0.05	0.00	0.96	6.93	0.19
		Biovolume	0	7	0.25	0.01	5.28	0.03	0.84	0.03	0.34	0.98		
Basal	Mid	Cell Conc.	2	6	0.05	0.01	4.25	0.02	0.15	0.02	1.77	0.87	5.62	0.23
		Biovolume	0	7	0.04	0.00	5.35	0.02	0.12	0.01	1.98	0.76		
Mid	Mid	Cell Conc.	1	7	0.19	0.00	4.10	0.02	0.64	0.02	1.45	0.99	6.40	0.03
		Biovolume	1	8	0.15	0.00	5.25	0.02	0.50	0.02	1.43	0.98		
High	Mid	Cell Conc.	1	8	0.21	0.01	4.22	0.03	0.69	0.02	1.05	0.98	6.70	0.33
		Biovolume	1	9	0.16	0.01	5.34	0.03	0.52	0.02	1.12	0.97		
Basal	High	Cell Conc.	0	6	0.00	0.01	4.28	0.02	0.00	0.02	> 6	0.01	5.28	0.16
		Biovolume	0	6	0.00	0.01	5.33	0.03	0.01	0.03	> 6	0.00		
Mid	High	Cell Conc.	0	6	0.00	0.01	4.26	0.02	0.00	0.02	> 6	0.00	5.41	0.25
		Biovolume	1	6	0.00	0.01	5.42	0.04	0.01	0.03	> 6	0.01		
High	High	Cell Conc.	0	6	0.01	0.00	4.23	0.01	0.02	0.01	> 6	0.16	5.40	0.07
		Biovolume	1	6	0.00	0.01	5.38	0.02	0.00	0.02	> 6	0.00		

Modeling Coefficients[b] Regression Model: $z = a_0 + a_1x + a_2y + a_3x^*y + a_4x^2 + a_5y^2 + a_6xy^2 + a_7x^2y + a_8x^2y^2$

Model Term	Based on Cell Concentration Growth Rate (d^{-1})	Lag Time (d)	Based on Biovolume Growth Rate (d^{-1})	Lag Time (d)	Log Maximum Biovolume (μm^3)
a_0	0.80	NS	0.90	NS	6.20
a_1	2.40	NS	1.00	NS	3.30
a_2	-147.0	NS	-151.8	NS	-165.3
a_3	357.8	NS	396.3	NS	608.4
a_4	-2.20	NS	-1.10	NS	-2.50
a_5	4012	NS	4066.00	NS	4382
a_6	-14595	NS	-14253	NS	-22528
a_7	-241.3	NS	277.4	NS	-452
a_8	10517	NS	10361	NS	16739
r^2	0.99	0.55	0.99	0.17	0.99

Isolate: ***Asterionella formosa***

Ortho-P	Zinc	Basis	Regression Days Start	Regression Days End	Slope	± CI[a]	Intercept	± CI	Growth Rate (d^{-1})	± CI	Lag time (d)	r^2	Log Maximum Biovolume (µm3)	± CI
Basal	Basal	Cell Conc.	0	3	0.16	0.01	3.41	0.02	0.53	0.04	0.00	0.96	6.57	0.03
		Biovolume	0	2	0.17	0.01	6.22	0.01	0.56	0.02	0.12	0.99		
Mid	Basal	Cell Conc.	0	3	0.27	0.01	3.42	0.02	0.88	0.03	0.00	0.99	6.85	0.16
		Biovolume	0	3	0.22	0.01	6.25	0.02	0.73	0.03	0.00	0.98		
High	Basal	Cell Conc.	0	3	0.21	0.02	3.48	0.04	0.69	0.06	0.00	0.91	6.95	0.13
		Biovolume	0	3	0.25	0.01	6.28	0.02	0.82	0.03	0.00	0.98		
Basal	Mid	Cell Conc.	2	5	0.11	0.01	3.15	0.03	0.37	0.03	1.91	0.95	6.46	0.09
		Biovolume	1	4	0.09	0.01	3.24	0.03	0.30	0.04	0.39	0.84		
Mid	Mid	Cell Conc.	1	5	0.16	0.01	3.06	0.03	0.54	0.03	1.15	0.97	6.77	0.14
		Biovolume	1	4	0.22	0.02	5.71	0.04	0.72	0.05	1.42	0.95		
High	Mid	Cell Conc.	1	4	0.17	0.01	3.29	0.03	0.56	0.04	1.29	0.95	6.81	0.07
		Biovolume	1	5	0.18	0.01	5.98	0.03	0.59	0.03	1.23	0.96		
Basal	High	Cell Conc.	2	5	0.08	0.01	3.20	0.03	0.26	0.03	1.75	0.89	6.46	0.11
		Biovolume	2	5	0.11	0.01	5.88	0.03	0.37	0.03	1.62	0.93		
Mid	High	Cell Conc.	1	3	0.15	0.02	3.23	0.04	0.51	0.06	0.82	0.90	6.48	0.12
		Biovolume	1	3	0.18	0.03	5.97	0.06	0.59	0.10	0.57	0.84		
High	High	Cell Conc.	1	4	0.18	0.01	3.12	0.02	0.59	0.02	0.82	0.98	6.71	0.18
		Biovolume	1	4	0.18	0.01	5.94	0.03	0.61	0.03	0.95	0.97		

Modeling Coefficients[b] Regression Model: $z = a_0 + a_1x + a_2y + a_3x^*y + a_4x^2 + a_5y^2 + a_6xy^2 + a_7x^2y + a_8x^2y^2$

Model Term	Based on Cell Concentration Growth Rate (d^{-1})	Lag Time (d)	Based on Biovolume Growth Rate (d^{-1})	Lag Time (d)	Log Maximum Biovolume (μm^3)
a_0	0.17	NS	0.40	NS	6.30
a_1	3.68	NS	1.60	NS	2.86
a_2	NS	341.9	-67.7	-114.6	-12.4
a_3	-227.9	-926.6	353.8	1602	NS
a_4	-3.16	NS	-1.10	NS	-2.22
a_5	NS	-8579	2004.00	6623	570.6
a_6	5216	21373	-11290	-64369	-3005
a_7	209.4	764.8	-317.3	-1319	NS
a_8	-4703	-17884	10092	53197	2590
r^2	0.92	0.98	0.91	0.98	0.96

[a] The 95-percent confidence intervals for growth rate and lag time are based on the number of culturing days used for the linear regression times three (3 replicate cultures) minus two (2 parameters estimated). The coefficients of determination (r^2) are tabulated for each set of parameters estimates. The 95-percent confidence intervals for the maximum biovolumes are based three replicates of the logarithm of the greatest biovolume in the culture.

[b] With a 3X3 full-factorial experimental design, the regression model takes the form: $\mathbf{z = a_0 + a_1x + a_2y + a_3x^*y + a_4x^2 + a_5y^2 + a_6xy^2 + a_7x^2y + a_8x^2y^2}$ where z is the dependent variable, x is the dissolved orthophosphate concentration in micromolar units, y is the zinc-ion activity in micromolar units, and the "a" values are the modeling coefficients. The description "NS" denotes that the coefficient was not significant at the 95 percent confidence level.

Table 8. Benthic chlorophyll and phaeophytin data (n=3) - Coeur d'Alene Lake (June 2005)

	June 2005			
	Chlorophyll-a		**Phaeophytin**	
Station	ug/cm^2	Std. dev.	ug/cm^2	Std. dev.
C5	**1.8**	2.5	**24.9**	6.0
MC-R	**0.9**	1.0	**10.2**	3.7
MICA	**0.8**	1.1	**17.7**	3.6
MC-C	**0.4**	0.2	**8.4**	6.9

Table 9. Dissolved organic carbon (DOC) in the water column - Coeur d'Alene Lake (August 2001, June 2004 & June 2005)

2001

MC-R

Depth (m)	DOC uM	95% Conf. Interval
1.0	**118.2**	3.8
13.7	**140.2**	1.7
27.3	**133.2**	0.5

MICA

Depth (m)	DOC uM	95% Conf. Interval
1.0	**134.8**	1.8
8.5	**129.5**	2.8
17.0	**137.0**	3.9

MC-C

Depth (m)	DOC uM	95% Conf. Interval
1.0	**117.0**	1.4
	134.3	5.4
	134.8	2.0

CDARD

Depth (m)	DOC uM	95% Conf. Interval
1.0	**120.8**	3.9
16.8	**120.4**	1.0
33.5	**132.7**	3.9

2004

MC-R

Depth (m)	DOC uM	95% Conf. Interval
1.0	**133.6**	2.4
16.8	**143.6**	2.0
33.5	**154.7**	7.7

MICA

Depth (m)	DOC uM	95% Conf. Interval
1.0	**130.9**	0.6
13.7	**137.0**	2.8
27.3	**141.1**	4.0

C5

Depth (m)	DOC uM	95% Conf. Interval
1.0	**124.3**	0.2
8.5	**146.7**	3.1
17.0	**144.3**	6.8

SJRI

Depth (m)	DOC uM	95% Conf. Interval
1.0	**136.4**	2.3

2005

MC-R

Depth (m)	DOC uM	95% Conf. Interval
1.0	**122.1**	0.9
15.0	**124.8**	1.0
30.0	**118.1**	3.8

MICA

Depth (m)	DOC uM	95% Conf. Interval
1.0	**124.3**	1.8
10.0	**125.2**	0.6
27.0	**136.3**	1.2

MC-C

Depth (m)	DOC uM	95% Conf. Interval
1.0	**124.9**	3.6
12.0	**123.3**	2.5
36.0	**137.4**	2.0

C5

Depth (m)	DOC uM	95% Conf. Interval
1.0	**116.8**	1.0
10.0	**128.3**	4.1
18.0	**137.8**	0.3

Table 10. Trace metal concentrations and biomagnification factor in phytoplankton - Coeur d'Alene Lake, June 2005

Summary of phytoplankton concentrations and biomagnification factors for selected metals

Sample	Site	Corrected **Phyto conc. Zn (ug/g)**	Biomag. Factor **for Zn**	Biomag Factor **Zn (log)**	CRM* recovery averages
1A	C5	1360	54858	**4.7**	62%
1B	C5	1432	57750	**4.8**	
1C	C5	1335	53825	**4.7**	
2A	MC-R	2708	64008	**4.8**	
2B	MC-R	4487	106069	**5.0**	
2C	MC-R	2663	62958	**4.8**	
		Corrected **Phyto conc. Cu (ug/g)**	Biomag. Factor **for Cu**	Biomag Factor **Cu (log)**	
1A	C5	32	121562	**5.1**	83%
1B	C5	29	107707	**5.0**	
1C	C5	28	104687	**5.0**	
2A	MC-R	26	87042	**4.9**	
2B	MC-R	48	158539	**5.2**	
2C	MC-R	24	79323	**4.9**	
		Corrected **Phyto conc. Cd (ug/g)**	Biomag. Factor **for Cd**	Biomag Factor **Cd (log)**	
1A	C5	13	122633	**5.1**	78%
1B	C5	15	144234	**5.2**	
1C	C5	45	442496	**5.6**	
2A	MC-R	21	106753	**5.0**	
2B	MC-R	35	180063	**5.3**	
2C	MC-R	20	104852	**5.0**	
		Corrected **Phyto conc. Pb (ug/g)**	Biomag. Factor **for Pb**	Biomag Factor **Pb (log)**	
1A	C5	128	994993	**6.0**	90%
1B	C5	181	1400580	**6.1**	
1C	C5	193	1499420	**6.2**	
2A	MC-R	744	7023224	**6.8**	
2B	MC-R	1242	11715300	**7.1**	
2C	MC-R	742	6995911	**6.8**	

* CRM = Certified reference materials (TORT-2 and NIST-2976)

Complete calculations for Biomagnification of Zn in phytoplankton

							Calculation Step **A**	**B**		**C**	**D**	**E** Table 4		**F**
			Weighing #1		Weighing #2						**Phyto conc.**	Diss. metal		Ratio of
Sample	Site	Tare filter mass (mg)	Mass inc. dry phyto. (mg)	Dry phyto mass (mg)	Mass inc. dry phyto. (mg)	Dry phyto mass (mg)	Dry phyto mass (mg) **average**	Conc. in digested solution Zn (ug/L)	Digestion volume (mL)	Calculated Conc in. dry phyto Zn (ug/g)	corrected for CRM* recovery of 62% for Zn **Zn (ug/g)**	conc in site water at chl-a max Zn (ug/ L)	Conv to matching units Zn (ug/g)	phyto conc. to water conc. **Biomag. Factor**
1A	C5	5.083	5.335	0.252	5.347	0.264	**0.258**	43.24	5	837.9	**1360**	24.8	0.025	**54858**
1B	C5	4.965	5.290	0.325	5.300	0.335	**0.330**	58.22	5	882.1	**1432**	24.8	0.025	**57750**
1C	C5	5.023	5.397	0.374	5.388	0.365	**0.370**	60.76	5	822.1	**1335**	24.8	0.025	**53825**
2A	MC-R	5.064	5.337	0.273	5.338	0.274	**0.274**	91.22	5	1667.6	**2708**	42.3	0.042	**64008**
2B	MC-R	5.156	5.290	0.134	5.293	0.137	**0.136**	74.89	5	2763.4	**4487**	42.3	0.042	**106069**
2C	MC-R	5.165	5.314	0.149	5.332	0.167	**0.158**	51.83	5	1640.2	**2663**	42.3	0.042	**62958**