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Benthic Conditions in the Jackfish Bay Area of Concern 2008

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EXECUTIVE SUMMARY

To evaluate benthic conditions in the Jackfish Bay Area of Concern (AOC) and whether they continue to improve over time, four lines of evidence were examined: 1) sediment contaminant concentrations, 2) toxicity, 3) benthic invertebrate communities, and 4) benthic invertebrate contaminant tissue concentrations. These conditions were assessed for spatial differences between contaminated and reference sediments, and temporal differences before and after 2003, when a similar assessment was conducted by Environment Canada. The decision-making framework for sediment assessment, developed under the Canada-Ontario Agreement respecting the Great Lakes Basin Ecosystem, was applied to this study.

In October 2008, overlying water, sediment and 3 benthic invertebrate taxa (oligochaetes, chironomids and amphipods) were sampled at 15 locations in Jackfish Bay (8 in Moberly Bay, 4 in central Jackfish Bay, 2 in lower Jackfish Bay and 1 in Tunnel Bay (AOC reference site)). Regional reference sites, located along the north shore of Lake Superior, were also sampled to provide background sediment and tissue contaminant concentrations. Invertebrates and surficial sediment were analyzed for dioxin and furan concentrations and a series of physicochemical variables were measured in the sediment and overlying water. The benthic invertebrate community and toxicological response of four benthic invertebrates in laboratory toxicity test sites were compared to biological criteria developed for the Laurentian Great Lakes using multivariate analysis (ordination).

Sediment dioxins and furan concentrations, expressed in toxic equivalents (TEQs), were elevated above the Probable Effect Level in Moberly Bay (western arm of Jackfish Bay) and in lower Jackfish Bay; TEQs in Jackfish Bay were on average 6.4 to 9.6 times higher than those for Lake Superior reference sites. Moberly Bay is an organically enriched area with total organic carbon on average ~2 times higher than the average across all the other sites in Jackfish Bay. Metal exceedences of sediment quality guidelines (provincial Lowest Effect Levels) occurred throughout Jackfish Bay (5 to 7 metals).

Benthic communities were categorized as *very different* or *different* from Great Lakes reference conditions at all sites in Moberly Bay as well as one site in central Jackfish Bay. Tubificid worms increased in abundance in Moberly Bay (up to 121,000 per m^2) and a predominant reference group amphipod taxon (Pontoporeiidae) was absent or in very low abundance.

Increased total organic carbon was correlated with Moberly Bay site positions (in ordination space). Altered benthic communities, mainly in Moberly Bay, generally appear to reflect a response to organic enrichment. These results were consistent with those found in 2003 and with historical data from Moberly Bay with some slight improvement in sediment quality since 1987, indicated by the presence of previously absent amphipods. Outside of Moberly Bay, benthic communities were more similar to reference, with much lower tubificid densities and higher densities of amphipods.

Toxicity was restricted to Moberly Bay with low survival and growth of the amphipod *Hyalella* and the mayfly *Hexagenia*; one site was severely toxic and two sites were potentially toxic. In the 2003 study, evidence of toxicity was observed in Moberly Bay as well as central and lower Jackfish Bay and Tunnel Bay.

Dioxin and furan TEQs in the benthos were elevated above both the Tissue Residue Guideline (TRG) and reference maximums in Moberly Bay, central Jackfish Bay and Tunnel Bay. TEQs across all Jackfish Bay sites exceeded the Lake Superior reference maximum by 1.2 to 4.5 times. Dioxin-like PCBs in benthos contributed very little to the overall TEQ and TEQs for PCBs were well below the TRG.

Based on the decision framework, *management actions required* was selected for a single site in Moberly Bay due to elevated sediment contaminants, toxicity and altered benthic community. *No further actions needed* was indicated for 5 sites (1 in Moberly Bay, 2 in central Jackfish Bay and 2 in lower Jackfish Bay) while remaining sites indicated that further assessment was required to determine definitively if sediments pose an environmental risk. The assessment outcome was less severe in 2008 than 2003 as a result of the decreased sediment toxicity observed in 2008. It is recommended that all lines of evidence should be used to continue monitoring throughout the bay for changes in the future.

RÉSUMÉ

En vue d’évaluer les conditions benthiques dans le secteur préoccupant (SP) de la baie Jackfish et de vérifier que celles-ci continuent de s’améliorer au fil du temps, on a examiné les quatre sources de données suivantes : 1) les concentrations de contaminants dans les sédiments; 2) la toxicité; 3) les communautés d’invertébrés benthiques; 4) les concentrations de contaminants dans les tissus des invertébrés benthiques. On a évalué les différences spatiales de ces conditions entre les sédiments contaminés et les sédiments de référence de même que les différences temporelles entre la période précédant 2003 et la période suivant 2003, année durant laquelle Environnement Canada a effectué une évaluation semblable. Pour la présente étude, on a utilisé le cadre décisionnel relatif à l’évaluation des sédiments élaboré dans le contexte de l’Accord Canada-Ontario concernant l’écosystème du bassin des Grands Lacs.

En octobre 2008, on a échantillonné les eaux sus-jacentes, les sédiments et trois taxa d’invertébrés benthiques (oligochètes, chironomidés et amphipodes) à 15 emplacements de la baie Jackfish (huit dans la baie Moberly, quatre au centre de la baie Jackfish, deux dans la partie inférieure de la baie Jackfish et un dans la baie Tunnel [site de référence du SP]). Les sites de référence régionaux, situés le long de la rive nord du lac Supérieur, ont aussi fait l’objet d’un échantillonnage en vue de l’obtention des concentrations de fond des contaminants présents dans les sédiments et les tissus. On a analysé des invertébrés et des sédiments superficiels pour déterminer les concentrations de dioxines et de furanes, puis mesuré une série de variables physicochimiques dans les sédiments et dans l’eau sus-jacente. Par l’analyse multivariable (ordination), on a comparé aux critères biologiques élaborés pour les Grands Lacs laurentiens la communauté d’invertébrés benthiques et la réaction toxicologique de quatre invertébrés benthiques obtenue lors d’essais de toxicité réalisés en laboratoire.

Dans la baie Moberly (bras ouest de la baie Jackfish) et dans la partie inférieure de la baie Jackfish, les concentrations de dioxines et de furanes dans les sédiments, exprimées en équivalents toxiques (TEQ), dépassaient la concentration produisant un effet probable. Dans la baie Jackfish, les TEQ obtenus étaient en moyenne de 6,4 à 9,6 fois plus élevés que ceux des sites de référence du lac Supérieur. La zone de la baie Moberly a fait l’objet d’un enrichissement organique avec un carbone organique total en moyenne ~ 2 fois plus important que la moyenne trouvée dans tous les autres sites de la baie Jackfish. Dans l’ensemble de la baie Jackfish, on a relevé des quantités de métaux (5 à 7 métaux) qui dépassent les

recommandations relatives à la qualité des sédiments (limites provinciales de concentrations minimales entraînant un effet).

À tous les sites de la baie Moberly, ainsi qu'à un site du centre de la baie Jackfish, on a classé les communautés benthiques comme *très différentes* ou *différentes* par rapport aux conditions de référence des Grands Lacs. L'abondance des vers tubificides a augmenté dans la baie Moberly (jusqu'à 121 000/m^2), et un taxon d'amphipode (*Pontoporeiidae*) prédominant dans le groupe de référence était complètement absent ou en très faible nombre. On a établi une corrélation entre l'augmentation des teneurs en carbone organique total et les positions des sites de la baie Moberly (dans l'espace d'ordination). La modification des communautés benthiques, principalement dans la baie Moberly, semble généralement indiquer une réaction à l'enrichissement organique. Ces résultats correspondent à ceux obtenus en 2003 ainsi qu'aux données antérieures sur la baie Moberly, avec une légère amélioration de la qualité des sédiments depuis 1987, indiquée par la présence d'amphipodes, qui étaient absents dans le passé. À l'extérieur de la baie Moberly, les communautés benthiques ressemblaient davantage aux communautés de référence, avec des densités de tubificidés beaucoup plus faibles et des densités d'amphipodes plus élevées.

En raison des faibles taux de survie et de croissance des amphipodes du genre *Hyalella* et des éphémères du genre *Hexagenia*, la toxicité se limitait à la baie Moberly; un des sites était extrêmement toxique, et deux sites, potentiellement toxiques. Dans le cadre de l'étude de 2003, on a constaté des signes de toxicité dans la baie Moberly, dans le centre et la partie inférieure de la baie Jackfish et dans la baie Tunnel.

Dans la baie Moberly, dans le centre de la baie Jackfish ainsi que dans la baie Tunnel, les TEQ des dioxines et des furanes dans le benthos étaient supérieurs aux directives visant les résidus de tissus (DRT) et aux limites de référence maximales. Les TEQ de l'ensemble des sites de la baie Jackfish dépassaient de 1,2 à 4,5 fois la limite de référence maximale du lac Supérieur. Les PCB analogues aux dioxines dans le benthos ont très peu contribué au TEQ global, et les TEQ pour les PCB étaient bien inférieurs aux DRT.

Conformément au cadre décisionnel, un site de la baie Moberly nécessitait la prise de mesures de gestion, en raison de la grande quantité de contaminants dans les sédiments, de la toxicité et des modifications de la communauté benthique. Pour cinq autres sites (un dans la baie

Moberly, deux au centre de la baie Jackfish et deux dans la partie inférieure de la baie Jackfish), aucune autre mesure n'était requise. Il fallait évaluer de manière plus approfondie les sites restants afin de déterminer de façon définitive si les sédiments posaient un risque pour l'environnement. Les résultats de l'évaluation étaient moins critiques en 2008 qu'en 2003 en raison de la diminution de la toxicité des sédiments observée en 2008. On recommande d'utiliser toutes les sources de données afin de suivre les changements dans l'ensemble de la baie.

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1 INTRODUCTION

1.1 Background

An assessment of sediment quality in the Jackfish Bay Area of Concern in 2003 (see Figure 1 for 15 sampling sites) revealed that conditions in Moberly Bay (the western arm of Jackfish Bay) indicated a polluted environment, characterized by elevated sediment contaminant concentrations, toxicity and the absence of pollution sensitive benthos (Milani and Grapentine 2007). Several sediment metal and organic contaminants (e.g., PCBs, dioxins and furans) were slightly elevated above Sediment Quality Guidelines in Moberly Bay and were elevated compared to the other areas of the AOC. Benthic communities in Moberly Bay as well as south of Moberly Bay (central Jackfish Bay) were different from those from Great Lakes reference sites while other areas in Jackfish Bay were more similar to reference. Results were consistent with historical data from Moberly Bay with some slight improvement in sediment quality since 1987, indicated by the presence of previously absent amphipods. Toxicity was evident throughout the bay.

1.2 Purpose of Study

The purpose of this study was to contrast 2008 conditions (i.e., sediment contaminant concentrations, toxicity, benthic invertebrate communities, benthic invertebrate tissue dioxin/furan and dioxin-like PCB residues) in Jackfish Bay with reference locations and to focus on sampling efforts in Moberly Bay. The overall goals were to determine if the benthic conditions in Jackfish Bay are improving over time (5 year monitoring cycle) and to further delineate the extent of impacted area in Moberly Bay. The assessment of Jackfish Bay performed in 2003 (Milani and Grapentine 2007) offered the most recently completed data against which changes in benthic conditions through time could be compared.

Currently there are sport fish consumption restrictions due to dioxins/furans for Jackfish Bay (MOE 2009). While these contaminants were measured in the sediment in the 2003 study, data on dioxin/furan as well as dioxin-like PCB concentrations in the resident benthos were lacking. Quantifying these contaminants in resident benthic tissues will provide a measure of bioavailability which can be used to assess biomagnification risk to higher trophic levels as well as provide information to assess against the beneficial use impairment identified for the AOC (degradation of benthos – body burdens of benthos) (Jackfish Bay RAP Team 1998).

2 STUDY AREA

Background information on environmental conditions in the Jackfish Bay AOC is provided in the Stage 1 and 2 RAP documents (Jackfish Bay RAP Team 1991, 1998). Sampling took place in depositional areas in the bay. Sites sampled in 2003 (Milani and Grapentine 2007) are shown in Figure 1, and those sampled in the current 2008 study are shown in Figure 2a, b. Some sites sampled in 2003 were revisited in 2008. New sites were added in Moberly Bay and south of Moberly Bay (central Jackfish Bay) to provide a better examination of the areas with the greatest contamination impact as defined by the 2003 study. One site in Tunnel Bay, identified as the most appropriate reference area within Jackfish Bay in a previous study (Stantec 2004), and reference sites along the north shore of Lake Superior (not mapped) were also sampled to provide data on background contamination.

3 EXPERIMENTAL DESIGN

Sampling Design

The 2003 design of Milani and Grapentine (2007) was followed. The 4 sites in Moberly Bay were sampled and single sites were sampled south of Moberly Bay (central Jackfish Bay), Jackfish Bay (lower Jackfish Bay) and Tunnel Bay. Other sites sampled in 2003 were dropped. To better characterize the spatial extend of contaminants in Moberly Bay, additional sites were added which included three previous Environment Effects Monitoring (EEM) Program sites (Stantec 2004), one site previously sampled by Biberhofer (pers. comm.) and one new site. Two new sites were also added in central Jackfish Bay and 1 in lower Jackfish Bay for a total of 15 sites. This sampling design allowed analyses of both spatial patterns and temporal trends in benthic conditions. Eight Lake Superior reference sites were also sampled to provide background levels of sediment and benthic invertebrate tissue contaminant concentrations. Sampling site positions and depth, as well as a description of sediments, are provided in Table 1.

Measurement Endpoints

At each site, sediment, water and benthic invertebrates were collected for (a) chemical and physical analysis of sediment and overlying water, (b) analysis of benthic invertebrate community structure, and (c) whole sediment toxicity tests. Sediment was obtained from the top

0 - 10 cm layer of lake bed. At a subset of 6 of the 15 Jackfish Bay sites and 5 of the 8 Lake Superior reference sites, benthic invertebrate tissue was collected for measurement of dioxin/furan and dioxin-like PCB concentrations. (All sites could not be sampled for benthic tissue due to time constraints.) Environmental variables measured are shown in Table 2.

The benthic invertebrate community structure (taxonomic composition and relative abundances) was described based on identifications of macroinvertebrates to lowest practical level. Sediment toxicity was quantified based on acute and chronic responses of 4 invertebrate taxa (10 endpoints in total) in laboratory tests. For assessment of contaminant bioaccumulation and biomagnification potential, 2 - 3 invertebrate taxa (oligochaetes, chironomids and amphipods) were collected from Jackfish Bay and Lake Superior reference locations.

4 METHODS

4.1 Sample Collection and Handling

Methods for the collection of invertebrate samples (for benthic community structure evaluation), sediment samples (for toxicity testing and physico-chemical analyses excluding dioxin/furan and dioxin-like PCBs analysis) and overlying water samples are provided in Milani and Grapentine (2007).

Benthic invertebrate tissue and sediment samples were collected from six Jackfish Bay sites (3 in Moberly Bay, 1 in central Jackfish Bay, 1 in lower Jackfish Bay and 1 in Tunnel Bay) and five Lake Superior reference sites for the analysis of dioxin/furans and dioxin-like PCBs. At each site, between 30 and 40 sediment grabs were collected with a petite ponar sampler to fill two 68 litre tubs. From each grab, a representative sediment sample was taken and placed in a glass tray and the remaining sediment from the grab was placed in the tubs. When the tubs were full, the pooled sediment in the glass tray was homogenized and subsampled to provide a composite sediment sample of all grabs for sediment dioxin/furan analysis. Sediment samples were frozen at -20ºC. Invertebrates were removed from the sediment in the tubs by wet sieving with lake water using 12” stainless steel sieves (500-μm mesh). Invertebrates collected on the sieve were sorted into separate taxa in glass trays using stainless steel instruments. Oligochaetes were collected from all Jackfish Bay and reference sites. While chironomids were present at all sites, they were limited in abundance, and therefore sufficient sample size could only be obtained at two Jackfish Bay sites and one Lake Superior reference site. Amphipods were collected at all Lake Superior reference sites but were absent at 3 of the 6 Jackfish Bay sites. Analysis of dioxins/furans and dioxin-like PCBs was performed on samples composited from organisms within each taxon (i.e., taxa were analyzed separately). Gut clearing was not performed. Due to tissue requirements for these types of analyses (minimum of 2-3 g of tissue per sample), only one pooled tissue sample (for each taxon group) could be analyzed per site.

Invertebrates were rinsed with deionized water and placed separately in pre-weighed and pre-cleaned (20% HCL) 5 -mL scintillation vials, weighed, and frozen on site (-20°C). A layer of parafilm was placed between vial and cap. Invertebrates were later freeze-dried and reweighed. The wet:dry ratios was used for converting dioxin/furan concentrations from a dry weight to wet weight basis. Stainless steel sieves and instruments were detergent-washed between sites. If organic matter remained on the sieve after the detergent wash (on visual inspection), a more aggressive cleaning solution was implemented (caustic ethanol). Homogenizing and sorting trays and scoops were detergent washed, rinsed in 20% HCl, and hexane rinsed between sites.

4.2 Sediment and Water Physico-Chemical Analyses

Analyses of alkalinity, total phosphorus, nitrate+nitrite-N, ammonia-N and total Kjeldahl N in overlying water samples were performed by procedures equivalent to those of the Environment Canada's National Laboratory for Environmental Testing (NLET) (Burlington, ON) as described in Cancilla (1994) and Environment Canada (2008).

Sediments were analysed for total mercury, 29 trace elements, major oxides, loss on ignition, total organic carbon (TOC), total phosphorus, and total Kjeldahl nitrogen (TKN) using standard techniques outlined by the USEPA/CE (1981) or by in-house laboratory (Caduceon Environmental Laboratories, Ottawa, ON) procedures. Particle size analysis was performed in house in the Sedimentology laboratory (Burlington, ON) following the procedures of Duncan and LaHaie (1979).

Sediments were analyzed for dioxins/furans, petroleum hydrocarbons (PHCs), total polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs) and oil and grease by ALS Environmental Laboratories (Mississauga and Burlington, ON). PHCs were analyzed by

GC/FIC based on CCME Canada-Wide Standards (CCME 2008). Oil and grease was determined by gravimetric extraction based on EPA method 8015 (USEPA 1992). Dioxins/furans were analyzed by HRMS based on EPA method 1613B and PAHs and PCBs (Aroclors 1242, 1248, 1254, 1260) were analyzed by GC/MS based on EPA SW846 8270 (USEPA 1992). Total PCBs was determined by the sum of the 4 Aroclors and total PAHs by the sum of 20 individual PAHs.

4.3 Benthic Invertebrate Tissue Residue

Benthic invertebrate tissue (oligochaetes, chironomids, amphipods) was analyzed for dioxin/furans and dioxin-like PCBs by HRMS (EPA method 1613B; USEPA 1992) by ALS Environmental Laboratories (Burlington, ON).

4.4 Benthic Invertebrate Identification and Enumeration

Benthic invertebrate community samples were identified and enumerated by EcoAnalysts, Inc. (Moscow, ID, USA). Certain taxa and microinvertebrates (e.g., poriferans, nematodes, copepods, and cladocerans) were excluded. Material was sorted under a dissecting microscope (minimum magnification = 10 x), and organisms enumerated and placed in vials for identification to lowest practical level by certified taxonomists.

4.5 Sediment Toxicity Tests

Four toxicity tests (bioassays) were performed at the Ecotoxicology Laboratory (Burlington, ON): 1) *Chironomus riparius* 10-day survival and growth test, 2) *Hyalella azteca* 28-day survival and growth test, 3) *Hexagenia* spp. 21-day survival and growth test, and 4) *Tubifex tubifex* 28-day reproduction test. Toxicity test methods are described in Milani and Grapentine (2007). Sediments were sieved through a 250 μm mesh screen prior to testing to remove indigenous organisms. All tests passed acceptability criteria for their data to be used in the site assessments. The criteria are based on percent control survival in a reference sediment (Long Point Marsh, Lake Erie): i.e., ≥ 80% for *H. azteca* and ≥70% for *C. riparius;* ≥80% for *Hexagenia* spp., and ≥75% for *T. tubifex* (Reynoldson et al. 1998).

5 DATA ANALYSES AND INTERPRETATION

Benthic Community Composition and Sediment Toxicity

Procedures used in these analyses (BEAST approach) are described in detail in Reynoldson et al. (1995; 2000). Briefly, the methodology involves the assessment of sediment quality based on multivariate techniques using data on the physical and chemical attributes of the sediment and overlying water, benthic community structure (the type and number of taxa present), and the functional responses (survival, growth and reproduction) of laboratory organisms in toxicity tests. Data from test sites were compared with Environment Canada's biological guidelines, which were developed from responses of both field and laboratory benthic invertebrates to reference site sediments. Multiple discriminant analysis was used to predict each Jackfish Bay site to one of five Great Lakes reference community groups (38-family bioassessment) using five habitat descriptors (latitude, longitude, depth, TOC and alkalinity). To describe the dominant patterns of variability (structure) among benthic communities, the community data for the Jackfish Bay sites were then merged with the reference site invertebrate data of the matched reference group (group to which the test site has the highest probability of belonging) only and ordinated using hybrid multidimensional scaling (HMDS, Belbin 1993) applied to a Bray-Curtis distance matrix. Assessments were conducted at the family level of taxonomic identification as this has been shown to be sensitive for the determination of stress (Reynoldson et al. 2000). Toxicological responses (bioassay endpoint data) were summarized using HMDS applied to a Euclidean distance matrix of range-standardized data. For each of benthic invertebrate community and toxicity evaluations, Jackfish Bay sites were assessed by comparison to confidence bands of appropriate Great Lakes reference sites (Reynoldson et al. 2000). Principal axis correlation (Belbin 1993) was used to identify relationships between habitat attributes and community data or toxicity descriptors. Invertebrate families, toxicity endpoints, and environmental attributes important in accounting for the overall structure in the data were identified using Monte-Carlo permutation tests (Manly 1991). Test data were analysed in subsets, with the number of test sites analyzed in any ordination numbering ≤10% reference sites (i.e., if there are 100 reference sites, then a subset of ≤ 10 test sites was ordinated at one time). Multiple discriminant analysis and the confidence bands (probability ellipses) were produced using SYSTAT (Systat Software, Inc. 2007) and HMDS was performed using PATN (Blatant Fabrications Pty Ltd. 2001).

To test the degree of similarity between the benthic invertebrate communities from 2003 and 2008, the data matrices (the ordination (HMDS) solutions for each dimension) were compared using a Procrustean randomization test (PROTEST) (Jackson 1995; Jackson and Harvey 1993; Peres-Neto and Jackson 2001). Procrustes Analysis is a superimposition approach in which the raw data matrices, or their ordination solutions, are rotated, translated and scaled, to minimize the sum of squared residuals between the matrices (Jackson 1995). The sum of the squared deviations (m^2 statistic) can be used as a metric of association; the lower the m^2 value, the greater the similarity of the multivariate configurations from the datasets (Jackson and Harvey 1993).

Contaminant Distribution in Sediment and Biota

Sites in which concentrations of dioxins/furans (D/F) in sediment ($[D/F]_{sed}$) and D/F and dioxin-like (DL) PCBs in invertebrates ($[D/F]_{inv}$; $[DL\ PCB]_{inv}$) were significantly elevated above reference levels were identified by comparing $[D/F]_{sed}$, $[D/F]_{inv}$ and $[DL\ PCB]_{inv}$ for Jackfish Bay sites to the 99th percentile value (~ maximum) for the Lake Superior reference sites.

D/F concentrations in sediment and D/F and DL PCB concentrations in invertebrates were also expressed as toxic equivalents (TEQs). Using toxic equivalency factors (TEFs) determined by the World Health Organization (WHO), the toxicity of D/Fs and DL PCBs relative to the toxicity of 2,3,7,8-TCDD was calculated using the following equation:

$$TEQ = \sum_{i=1}^{n} ([D/F\ or\ DL\ PCB]_i \times TEF_i)_n$$

Each of the 7 dioxin and 10 furan congener concentrations and 12 DL PCB congener concentrations were multiplied by its respective TEF and all products were summed to give the TEQ value. For sediments, the WHO fish TEFs were used in the calculation; for invertebrates, the avian TEFs were used (Van den Berg et al. 1998). For values that were below method detection limits, the calculation of the TEQs was performed two ways: 1) assigning a value of zero to the value (lower bound TEQ), and 2) using the method detection limit itself (upper bound TEQ). Therefore, the actual TEQ would be bounded by the two values. For sediments, the TEQs were compared to the CCME Probable Effect Level (PEL) for dioxins/furans of 21.5 ng TEQ/kg (CCME 2001a). For invertebrates, the TEQ was compared to the avian Tissue Residue Guideline (TRG) of 4.57 ng TEQ/kg ww for D/Fs and 2.4 ng TEQ/kg ww for DL PCBs (CCME 2001b).

6 QUALITY ASSURANCE / QUALITY CONTROL

Field

Two sites (1 Jackfish Bay and 1 Lake Superior reference) were randomly chosen as QA/QC sites. At these sites, triplicate sediment, water, and benthic community samples were collected for determination of within-site and among-sample variability. Coefficients of variation (CV = standard deviation ÷ mean x 100) were examined for the analytical data. Variability in invertebrate assemblages between box core samples for the Jackfish Bay QA/QC site was examined by comparing the position of sites in the ordination plots (e.g., the closer the sites are in ordination space, the more similar they are).

Laboratory

Each laboratory employed procedures such as analyses of sample duplicates and repeats, matrix spikes and certified or standard reference materials, as well as evaluations of sample recoveries.

Caduceon Environmental Laboratories

Quality control (QC) procedures involved control charting of influences, standards, and blanks. Reference materials and standards were used in each analytical run. Calibration standards were run before and after each run. Run blanks and reference standards were run 1 in 20 samples. Precision was assessed by the analyses of laboratory duplicates. The relative percent difference ($RPD = [(x_1 - x_2)/ (x_1 + x_2)/2) \times 100]$ was calculated to determine differences in two or more measurements. Sample duplicates were analyzed once every 16 samples.

ALS Laboratory Group

QC procedures involved control charts established for specific samples and control limits (e.g., the Lowest Quantification Limit or Method Detection Limit). A RPD was calculated to determine differences in two or more sample measurements. Duplicates were analyzed at a minimum frequency of 1 in 20 samples or 1 per batch. Samples were pre-screened by analyzing on a less sensitive instrument prior to the final analysis to eliminate the need for running blanks between high samples; however, if this was not possible, then blanks were run between samples.

To determine accuracy, the degree of agreement between an observed value and the accepted reference or true value was assessed by analysis of blank spikes, matrix spikes, QC check samples, surrogate compound spikes, and standard reference material analysis. Method blanks, a control verification standard, a laboratory control sample and duplicates were performed for 1 in every 20 samples. Matrix spikes and surrogates were analyzed with every batch of samples.

Benthic Invertebrate Identification and Enumeration

EcoAnalysts, Inc. followed several steps to ensure standards were met for sample sorting efficiency, taxonomic identification and data entry (EcoAnalysts, pers. comm.). A 95% sorting efficiency level was achieved and approximately 20-25% of every sample was re-sorted to achieve the 95% level. At least one specimen of each taxon encountered was kept in a separate vial to comprise a project reference collection. Internal quality assurance of the identifications involved examination of the reference collection by a second taxonomist to verify accuracy of all taxa identified. Additionally, 10% of samples were randomly selected and re-identified by a QA taxonomist. Data entry involved visual confirmations on the taxonomic identification and number of specimens in each taxon and the data was entered directly on a computer database.

7 RESULTS AND DISCUSSION

7.1 Quality Assurance/Quality Control

Field Replication

Among-site variability in a measured analyte can be broken down into three sources: natural within-site heterogeneity in the distribution of the analyte in sediment or water, differences in handling among samples, and laboratory measurement error. Among-site variability indicates the overall “error” associated with conditions at a site based on a single sample.

Variability among field-replicated sites, expressed as the CV, is provided in Appendix A; Tables A1 to A3. The CVs for trace metal and nutrient analysis ranged from 0 to 22% (median 1.7%), quite low for field-replicated samples (Appendix A, Table A1). The CVs for organic contaminant measurements (e.g., PAHs, PHCs, oil and grease) were also generally low, ranging from 0 to

43% (median 13%) (Appendix A, Table A2). CVs for PCDD/F measurements were slightly higher, ranging from 5 to 58% (median 15%) (Appendix A, Table A3) but this is typical given the low concentration at which these contaminants are present. Most CVs were below 20%, indicating homogeneous conditions within a site that that a box-core sample is a good representation of chemical conditions of a site.

Caducean Environmental Laboratory

Laboratory duplicate measurements for sediment variables are provided in Appendix A, Table A1. Sample duplicates were performed for two sites (2M4 and reference site 5105). The RPDs were low overall, ranging from 0 to 74% (overall median 2.5%), and most RPD (90%) were <15%. This indicates good agreement between sample duplicates and that a high level of precision was achieved for sample measurements.

Analyses and recoveries for reference materials or standards (LKSD-3 (trace metals), STSD-2 (Hg), WH89-1 (major oxides), D053-542 (nutrients), and TOC QC (TOC) are provided in Appendix A, Table A4. Recoveries were mostly high, ranging from 36 to 113% (median 97%). While the recovery was low for Molybdenum (35%), it was within the control limits (0 to 260) for this variable. Recoveries for all other variables were well within the control limits for each parameter.

ALS Laboratory Group

Laboratory sample duplicate measurements for two sites (1M2, JFB002) are provided in Appendix A, Table A3. The RPDs were low, ranging from 0.1 to 27% overall (median 3.7%), and most RPDs (91%) were <10% indicating that a high level of precision was achieved for these sample measurements.

To test the effects of the matrix and precision of the laboratories sample preparation, surrogate spikes were performed. Prior to sample preparation, samples were spiked with the surrogate. The percent recovery for surrogate concentrations in the final sample extracts is provided in Appendix A, Table A5. Recoveries ranged from 85 to 136% (median 109%) for the BTEX surrogate (2,5-dibromotoluene), from 67 to 113% (median 82%) for the PHC surrogate (octacosane), from 96 to 181% (median 117%) for the PAH surrogates (2-fluorobiphenyl, p-

Terphenyl d14) and from 95 to 145% (median 113%) for the PCB surrogate (d14-Terphenyl). Recoveries were generally high, indicating a good ability of the laboratory to analyze organic compounds.

For invertebrate tissue samples, percent recoveries for labeled internal standards were generally good for most standards, ranging from 17 to 103% (median: 66%) for dioxins/furans and DL PCB congeners for Jackfish Bay (Appendix A, Table A6), and from 45 to 94% (median 64%) for Lake Superior reference samples (Appendix A, Table A7). Recoveries were within QC limits with the exception of four samples, which were just slightly below limits (i.e., site 1M3 (chironomid and oligochaete samples), site M701 (chironomid sample) and site 1M1 (chironomid sample)) (Appendix A, Table A6). The low recoveries observed for 1M3 (chironomid sample), which was observed for several congeners is reflected in the slightly higher EDLs for this sample (Table 7). However, overall there is likely little compromise to the actual data. The low recoveries were for OCDF mainly for 3 of the 4 samples, which contribute very little to the TEQ. Low recoveries were also observed for DL PCBs for site 1M3 (chironomid sample); however, DL PCBs also contributed very little to the total TEQ.

Benthic Community Variability

The replicate sites of 1M2 (1M200, 1M201 and 1M202) were in very close proximity to each other in ordination space, indicating good agreement in benthic community composition for the field replicates (Appendix A, Figure A1). All three replicates of 1M2 fell in Band 4. These results indicated that the benthic invertebrate community within a site was well represented by the box core sample.

7.2 Sediment and Water Physico-Chemical Properties

7.2.1 Overlying Water

Variables measured in the overlying water (0.5 m above the sediment) are provided in Table 3. Variables were similar among sites located outside of Moberly Bay, suggesting homogeneity in water mass across these sampling sites. Outside of Moberly Bay, the average differences across sites were 8 mg/L for alkalinity, 26 µS/cm for conductivity, 2.4 mg/L for dissolved oxygen, 0.03 mg/L for NO_3/NO_2, 0.05 mg/L for NH_3, 0.5 for pH, 6.5°C for temperature, 0.4 mg/L for total Kjeldahl nitrogen, and 7.7 µg/L for total phosphorus. Sites in Moberly Bay were dissimilar to the rest of the sites, with higher alkalinity, conductivity, NO_3/NO_2, temperature (sites were shallower), TKN and total phosphorus (Table 3). Total phosphorus in Moberly Bay (range: 14 to 51 µg/L) was elevated above the interim Provincial Water Quality Objective of 20 µg/L at 5 of the 9 sites. These results were similar to those found in 2003, where total phosphorus in Moberly Bay ranged from 23 to 41 µg/L (Milani and Grapentine 2007). Total phosphorus at sites outside of Moberly Bay ranged from 3 to 11 µg/L in the current study. Overlying water variables were compared to the 2008 Lake Superior reference sites as well as to Lake Superior site data collected over a 3-year period (n=31, Unpublished data, Environment Canada 2006). Test site variables that were outside of the upper range observed at the Lake Superior reference sites were mostly observed in Moberly Bay and included (for the 9 Moberly Bay sites only): alkalinity (8 sites), conductivity (all 9 sites), NH_3 (1 site), NO_3/NO_2 (4 sites), TKN (8 sites), and total phosphorus (4 sites) (Table 3).

7.2.2 Sediment Particle Size

Sediments were comprised mainly of silt, except for two sites in Moberly Bay (M701 and EEM8) (Figure 3; Appendix B, Table B1). Silt ranged from 17 to 79% (median 72%), and clay ranged from 13 to 78% (median 25%). Moberly Bay site M701 (located closest to the mouth of Blackbird Creek) was mostly sand (95%) with a minor amount of clay while site EEM8 sediment consisted of silty sand (sand: 63%; silt: 23%). Site 4M3 had a greater amount of clay (78%) than the other sites. These values are consistent with the 2003 study (Milani and Grapentine 2007). Particle size data for the Lake Superior reference sites are also provided in Appendix B, table B1. The reference sites consisted of a higher percentage of clay and less silt overall compared to Jackfish Bay sites; median values for sand, silt, and clay were 21%, 46% and 37%, respectively.

7.2.3 Sediment Nutrients and Trace Metals

Sediment nutrient concentrations are provided in Table 4 and TOC is shown graphically in Figure 4. TOC decreased overall with distance from Moberly Bay, ranging from 0.8 to 6.7% (median 6.0%) in Moberly Bay and from 0.4 to 4.0% (median 3.0%) in central and lower Jackfish Bay. TOC in Tunnel Bay (2.8%) was similar to that seen in central and lower Jackfish Bay. Lake Superior reference site TOC was mostly lower than Jackfish Bay sites, ranging from 0.1 to 2.3% (median 1.1%) (Figure 4, Appendix B, Table B2). TOC in Moberly Bay was on average 5 times higher than that found at Lake Superior reference sites, while sites outside of Moberly Bay were on average 3 times higher than reference. Total Kjeldahl nitrogen (TKN) ranged from 551 to 4723 µg/g (median 2610 µg/g) and total phosphorus from 550 to 1270 µg/g (median 963 µg/g) at Jackfish Bay sites. TKN was also overall highest in Moberly Bay with concentrations decreasing with distance from Moberly Bay. There were no exceedences of the provincial Sediment Quality Guidelines (PSQG) Severe Effect Level (SEL) for any nutrients at any site. Similar results were found in 2003. Sediment TKN and total phosphorus concentrations at Lake Superior reference sites were generally lower, ranging from 321 to 3480 µg/g (median 1455 µg/g) and from 479 to 1380 µg/g (median 741 µg/g), respectively (Appendix B, Table B2).

Trace metal concentrations for Jackfish Bay sites are provided in Table 4. With the exception of lead and mercury, there were exceedences of the PSQG Lowest Effect Level (LEL) for all metals. The number of LEL exceedences was between 5 to 7 per site with the exception of Moberly Bay sites M701 and EEM (sites with a high percentage of sand), where there were none. The SEL was exceeded for manganese only at the Tunnel Bay site. There were also metal exceedences of the LEL at all Lake Superior reference sites, for 3 to 8 metals per site (Appendix B, Table B2).

7.2.4 BTEX and Petroleum Hydrocarbons

BTEX (Benzene, Toluene, Ethylbenzene and Xylene) and petroleum hydrocarbons (PHC) concentrations in Jackfish Bay and Lake Superior sediments are provided in Table 5 and Appendix B, Table B3, respectively. The BTEX and F1 (C6-C10 hydrocarbons) PHC compounds were below method detection limits (MDLs, values preceded by "<") at all Jackfish Bay and reference sites. (MDLs for BTEX and PHCs are provided in Appendix B, Table B4.) The F2 (C10-C16 hydrocarbons) PHCs were detected at 10 of the 15 Jackfish Bay sites in fairly low concentrations, ranging from 21 to 110 µg/g; concentrations at Lake Superior reference sites were below detection. The F3 (C16-C34 hydrocarbons) PHCs were detected at all Jackfish Bay sites except 4M3 (lower Jackfish Bay), and ranged from 230 to 3427 µg/g (Table 5). The F3 PHC fraction was highest in Moberly Bay and showed a decreasing gradient from Moberly Bay (Figure 5). Reference site F3 concentrations were below detection except one site 5100 (130 mg/kg) (Appendix B, Table B3). The F4 fraction (C34-C50 hydrocarbons) was detected at all sites except 2 (Tunnel Bay site 3M2 and 4M3); concentrations ranged from 62 to 733 µg/g and were highest in Moberly Bay with an overall decrease in concentration with increased distance from Moberly Bay. Total PHCs (sum of C6 to C50) followed the same pattern as the F3 and F4 fractions, with a decreasing gradient from Moberly Bay. The gravimetric heavy hydrocarbons (F4G: ~C24-C50+), which typically include the very heavy hydrocarbons (e.g., heavy lubrication oils) were detected at all Jackfish Bay sites. The chromatogram did not reach baseline at C50 (i.e., there were PHC with carbon chain lengths >50) at 8 of the 9 Moberly Bay sites, 1 site in central Jackfish Bay and 1 site in lower Jackfish Bay, indicating the presence of very heavy hydrocarbons. The concentration of the F4G fraction ranged from 100 to 2800 µg/g at Jackfish Bay sites and followed the same pattern as that observed for total PHCs and the F3 PHCs. Reference sites F4G concentrations were low or below detection and the chromatogram reached baseline at C50 at all sites (Appendix B, Table B3). PHCs were not measured in the 2003 study; therefore, comparisons could not be made.

Sediment PHC concentrations were compared to the PHC Canada-wide standard (CWS), which is a remedial standard for contaminated soil and subsoil occurring in different land use categories (industrial, residential, commercial, agricultural) and soil textures (coarse=median grain size > 75 µm; fine=median grain size ≤75 µm) (CCME 2008). (PHC concentrations were compared to these soil remedial standards since no such standards exist for sediments.) In cases where both the F4 and F4G results are reported (as for this study), the greater of the two was compared to the F4 guideline. PHC concentrations in Moberly Bay were compared to the numerical levels for the industrial land use category since Moberly Bay received mill effluent from Terrace Bay via Blackbird Creek; however, it should be noted that there are no land uses within the watershed of the AOC (RAP Stage 1). The CWS for each PHC fraction are provided in Table 5.

With the exception of M701 and EEM8 (Moberly Bay), all sites had a mean grain size of < 75 µm (Appendix B, Table B1) and therefore were considered fine textured; sites M701 and EEM8 were coarse textured (particle size means of 280 and 96 µm, respectively). The F1 fraction (not detected at any site) and F2 fraction (range of 21 to 110 µg/g) were below the CWS levels at all sites. Concentration of the F3 PHC fraction exceeded the CWS level of 2500 µg/g (for fine textured) at three Moberly Bay sites: EEM4 (2560 µg/g), 1M3 (2600 µg/g) and 1M2 (3427 µg/g) (Figure 5; Table 5). Both the F4 (range of 50 to 733 µg/g) and F4G fractions (range of 100 to

2800 μg/g) were below CWS levels at all sites. PHC concentrations at reference sites were below the CWS levels (Appendix B, Table B3).

7.2.5 PAHs

Sediment PAH concentrations are provided in Table 5. Concentrations were below MDLs (see Appendix B, Table B4) at all sites for most PAHs with the exception of a few sites in Moberly Bay; [PAH]s that were just slightly above LELs included anthracene (1 site), chrysene (2 sites) and pyrene (1 site). Total PAHs were low throughout the bay, ranging from 0.3 to 3.0 mg/kg in Moberly Bay and from 0.3 to 0.8 mg/kg outside of Moberly Bay (Table 5), all below the LEL (4 μg/g). Concentrations were similar to those found in 2003 (Milani and Grapentine 2007). All PAHs were below detection at reference sites (Appendix B, Table B3).

7.2.6 Oil and Grease

Oil and grease concentrations are provided in Table 5. Concentrations were highest in Moberly Bay ranging from 300 to 1400 mg/kg, and decreased with increasing distance from Moberly Bay to 200 to 600 mg/kg in central Jackfish Bay and 100 to 400 mg/kg in lower Jackfish Bay. Tunnel Bay (local reference site) had the lowest concentration (along with site 4M3 in lower Jackfish bay) at 100 mg/kg. (Oil and grease was not measured at Lake Superior reference sites.) Concentrations were less than those reported for in 2003 for solvent extractables. In 2003, mean concentrations for Moberly Bay, south of Moberly bay (central Jackfish Bay) and Tunnel Bay were 4875, 1600 and 600 mg/kg, respectively (Milani and Grapentine 2007). Concentrations in lower Jackfish Bay were similar in 2003 (mean 94 mg/kg). However, these analyses were performed by different laboratories and variation in the steps of analytical protocols cannot be discounted.

7.2.7 PCBs

Total PCBs (sum of Aroclors 1242, 1248, 1254 and 1260) are provided in Table 5 for Jackfish Bay sites and Appendix B, Table B3 for Lake Superior reference sites. Concentrations were below MDLs at sites. In 2003, [PCB]s were below detection limits at 8 of the 15 sites; highest concentrations were in Moberly Bay (41 to 150 ng/g) with 3 of the 4 sites above the LEL (70 ng/g) (Milani and Grapentine 2007).

7.2.8 Dioxins and Furans

Concentrations of dioxins and furans in Jackfish Bay and Lake Superior reference sediment are provided in Table 6 and Appendix B, Table B5, respectively. Homologue group totals for dioxins and furans are shown in Figure 6a and 6b, respectively. (For estimated detection limits (EDL) see Appendix B, Table B6.) Generally, dioxin concentrations increased with increasing chlorine atoms from the hexachlorodioxins (HxCDD) to the octachlorodioxins (OCDD) and [OCDD]s were highest at all Jackfish Bay sites (range: 9 to 212 pg/g; Table 6). While OCDD concentrations were overall highest in Moberly Bay (EEM4 and 1M3), some of the lowest concentrations were also observed in Moberly Bay (M701 and EEM8) (Figure 6a). The most toxic dioxin, 2,3,7,8-TCDD, was above detection limits at all sites except one (M701); concentrations ranged from <1.2 to 17.3 pg/g in Moberly Bay and from 0.2 to 10.8 pg/g outside of Moberly Bay (Table 6). Similar patterns were observed at the reference sites, but with generally increasing concentrations with increasing chlorine atoms from the pentachlorodioxins (PeCDD) to OCDD (at Jackfish Bay sites, [TCDD]s tended to be higher than the [PeCDD]s) (Figure 6a). Concentrations of 2,3,7,8-TCDD were lower at reference sites compared to test sites and were below detection limits at all sites except 5103 (Appendix B, Table B5).

Total tetrachlorofuran (TCDF) concentrations were generally the highest of the furan homologue groups at both test (range of 4 to 572 pg/g; Table 6) and reference sites (range: ~2 to 32 pg/g; Appendix B, Table B5). [TCDF]s were overall highest in Moberly Bay (EEM4 - also where the highest dioxins were found), but low concentrations of all furan homologue groups were found at Moberly Bay sites M701 and EEM8 (same as that found for the dioxin groups).

Toxic Equivalent Concentrations (TEQs)

Dioxin and furan congeners as well as several dioxin-like (DL) PCBs have been reported to cause a number of toxic responses similar to the most toxic dioxin (2,3,7,8-tetrachlorodibenzo-*p*-dioxin; TCDD) (Van den Berg et al., 1998). The TEQ takes into consideration the unique concentrations and toxicities of the individual components within the dioxin or furan mixture.

TEQs (upper and lower bound) for test and reference sediments are shown in Figure 7 and are provided for Jackfish Bay and reference sediments in Table 6 and Appendix B, Table B5, respectively. Sites in Moberly Bay had the highest dioxin and furan TEQs overall (DL PCBs were not measured in the sediments), ranging from 1.1 to 37.3 (both lower and upper bound values taken into consideration). The TEQs at 2 sites in Moberly Bay exceeded the PEL by 1.1 to 1.7 times (22.7 to 37.3 pg TEQ/g) (Table 6, Figure 7). The TEQ for 1 site in lower Jackfish Bay also just marginally exceeded the PEL (2M5 – 25.1 ng TEQ/kg). Where TEQs were above the PEL, congeners that contributed most to the TEQ were 2,3,7,8 TCDD (27 to 49 %) followed by 2,3,7,8 TCDF (14 to 34%). While [OCDD]s were highest at all sites, they contributed very little to the TEQ at sites that were above the PEL (0.06 to 0.08%). Reference site TEQs were below the PEL (0.1 to 5.2 ng TEQ/kg; Appendix B, Table B5). The TEQs for Jackfish Bay were similar to those reported in 2003, where exceedences of the PEL occurred in Moberly Bay (28 to 57 ng TEQ/kg) as well marginal exceedences south of Moberly Bay (central Jackfish Bay) (Milani and Grapentine 2007).

7.3 Bioaccumulation of Contaminants in Benthos

7.3.1 Dioxins and Furans

Dioxin and furan concentrations in resident Jackfish Bay benthos (oligochaetes, chironomids, amphipods) are provided in Table 7. The lower chlorinated PCDD/Fs dominated in the benthos, specifically the TCDFs, which were detected at all sites in most taxa. [TCDF]s ranged from 41 to 467 pg/g (median 184 pg/g) and 2,3,7,8-TCDF comprised from ~8 to 63 % of the total TCDF. [TCDF]s were overall highest in Moberly Bay (site 1M1) (Table 7) . A significant ($p < 0.05$) correlation was observed between sediment and oligochaete [TCDF] (n=11; $r^2 = 0.43$). (Oligochaetes were the only taxa that were collected from all test and reference sites). Normalization of sediments and oligochaetes to organic carbon and lipids, respectively, did not strengthen the correlation. The PentaCDF homologue group were the next highest furan group in the benthos, detected at all sites in at least one taxon group, ranging from 2 to 70 pg/g (median 22.5 pg/g) (Table 7), but there was no significant correlation between sediment and oligochaete concentrations. The higher chlorinated furan groups, HexaCDFs, HeptaCDFs and OCDFs, had median concentrations in benthos of 12.9, 7.9 and 29.4 pg/g, respectively, which were similar to those at Lake Superior reference sites (median of 20.5, 9.7, and 23.9 pg/g, respectively) (Appendix B, Table B7).

For dioxins, [OCDD]s were overall highest in the benthos, ranging from 11.7 to 190 pg/g dw (median 71 pg/g), followed by the HeptaCDD, which ranged from 8.6 to 48 pg/g (median 22.5

pg/g), following a similar pattern as sediment concentrations. The lower chlorinated PCDDs (TCDD to HexaCDDs) were mostly below detection limits (Table 7). Total [TCDD]s were below detection limits for the benthos at all sites except 1M1 and 1M3 (Moberly Bay), where [TCDD] ranged from 6 to 24 pg/g, and 2,3,7,8-TCDD comprised from 68 to 100% of the total TCDD. [OCDD]s were higher in benthos collected from reference site 5102 (range:146 to 224 pg/g) than Jackfish Bay sites, but remaining reference site concentrations were generally lower (median = 29 pg/g) than Jackfish Bay sites (Appendix B, Table B7). The HeptaCDDs were lower at reference sites, ranging from 5 to 28 pg/g (median 14 pg/g)

Toxic Equivalent Concentrations (TEQs)

TEQs for the benthos were compared to the CCME avian Tissue Residue Guideline (TRG), since an avian receptor (e.g., diving duck) could feed directly on benthic invertebrates. The avian TRG for dioxins/furans, derived by Environment Canada, is 4.75 ng $TEQ{\cdot}kg^{-1}$ diet ww (CCME 2001b). The mammalian TRG of 0.79 ng $TEQ{\cdot}kg^{-1}$ diet ww, while lower, was not used in this case as there would not be a direct feeding relationship between benthic invertebrates and a mammalian receptor. The TEQs for Jackfish Bay and Lake Superior reference sites are provided in Figure 8a and in Table 7 (Jackfish Bay) and Appendix B, Table B7 (Lake Superior reference).

All 3 Moberly Bay sites (M701, 1M3, 1M1) had both upper and lower bound TEQs above the avian TRG for all taxa collected (Figure 8a). The TEQs exceeded the TRG by 2.3 to ~8 fold in Moberly Bay. The overall highest TEQ was in central Jackfish Bay (2M1), with the upper bound value exceeding the TRG by 9.8 times for the amphipod (Figure 8a). In lower Jackfish Bay (4M3), only the upper bound TEQs were above the TRG for both taxa. In Tunnel Bay (3M2), 1 of the 3 taxa (amphipods) had both upper and lower bound TEQs above the TRG (the other 2 taxa had only the upper bound TEQ above the TRG). The upper bound TEQs for 4 of the 5 reference sites were also above the TRG for at least one taxon while no lower bound TEQs were above the TRG (Figure 8a). The 99th percentile for Lake Superior reference site TEQs (upper bound) was 10.43 ng TEQ/kg, ~2 times higher than the TRG (Figure 8a). All Jackfish Bay site TEQs exceeded the 99th percentile for Lake Superior reference with the exception of 4M3 (lower Jackfish Bay); exceedences ranged from 1.2 to 4.5 times.

Dioxins and furans contributed most to the total TEQ (sum of dioxin/furan and DL PCB TEQs) for Jackfish Bay sites, ranging from 87 to 98% using the upper bound values (dioxin-like PCBs contributed very little) (Table 7). PCDD/F congeners that contributed most to the TEQ were 2,3,7,8-TCDF (3 to 100%; median 86%), 2,3,4,7,8-pentachlorofuran (0 to 96%; median 4%), and 2,3,7,8-TCDD (0 to 33%; median 6%). However, concentrations of these congeners were below MDLs in several cases (Table 7); therefore, results should be interpreted with caution as there is greater uncertainty with values below the MDL.

Invertebrate tissue was not collected in 2003; therefore, comparisons could not be made to the earlier study.

7.3.2 Dioxin-like PCBs

Dioxin-like PCB concentrations in invertebrate tissue is provided in Table 7 for Jackfish Bay sites and in Appendix B, Table B7 for Lake Superior reference sites. With the exception of PCB 81 and PCB 169, most congeners were detected at all sites. PCB 118 (range 379 to 4130 pg/g dw), PCB 105 (range 134 to 1390 pg/g) and PCB 156 (range 59 to 900 pg/g) were the dominant congeners. [DL PCB]s were slightly lower at reference sites, ranging from 423 to 3090 pg/g and from 166 to 1150 pg/g for PCB 118 and PCB 105, respectively (Appendix B, Table B7). The more toxic congeners, PCB 77 and PCB 126, ranged from 17 to 94 pg/g and from 3 to 33 pg/g, respectively, at Jackfish Bay sites. Concentrations of PCB 77 and 126 were similar at reference sites, ranging from 18 to 100 pg/g and from 7 to 37 pg/g, respectively (Appendix B, Table B7).

Toxic Equivalent Concentrations (TEQs)

Invertebrate tissue [DL PCB]s, expressed in TEQs, are also provided in Table 7. The avian TRG for DL PCBs, derived by Environment Canada, is 2.4 ng TEQ$\cdot$kg^{-1} diet ww (CCME 2001b). PCB congeners 77 and 126 contributed most to the TEQ, from 38 to 98%; (median 63%) and from 0 to 53% (median 22%), respectively. However, overall the DL PCBs contributed little to the total TEQ. Figure 8b shows the upper and lower bound TEQs for Jackfish Bay and Lake Superior reference sites. The TRG for DL PCBs was not exceeded at any site.

7.4 Benthic Invertebrate Community

All 15 Jackfish Bay sites had the highest probability of belonging to Great Lakes (GL) Reference Group 5, based on the BEAST 38-family bioassessment model and five habitat attributes (alkalinity, depth, total organic carbon, latitude and longitude) (Table 8). The probabilities of test sites belonging to Group 5 were very high, ranging from 84.2 to 99.6% (mean 93%). Results were similar to that found in 2003, where sites were also had the highest probability (mean 95%) of belonging to Group 5 (Milani and Grapentine 2007).

GL Reference Group 5 has a total of 75 sites from Lake Superior (30), as well as Georgian Bay (19), the North Channel (12), Lake Michigan (7), Lake Ontario (5) and Lake Huron (2). This group is characterized by the amphipod family Pontoporeiidae (44.3% occurrence in Group 5), followed by the Tubificidae (oligochaete worm -16.6% occurrence), Sphaeriidae (fingernail clam - 11.5% occurrence) and Chironomidae (midge - 9.9% occurrence). To a lesser degree, Group 5 also consists of Lumbriculidae, Enchytraeidae, and Naididae (oligochaete worms - 1.9 to 6.8% occurrence). Asellidae (isopod), Valvatidae (snail) and Gammaridae (amphipod) have minor occurrences (0.6 to 1.5%). These 10 families make up 99% of the total benthos found in Reference Group 5. Table 9 shows the mean abundance and taxon diversity (per 33 cm^2 – the area of the sampling core tube) of these 10 families for Jackfish Bay sites. Complete invertebrate identifications and counts at family level and lowest practical level are provided in Appendix C, Table C1 and Table C2, respectively. In total, 15 families were identified (10 of which are shown in Table 9) (Appendix C. Table C1) and 43 taxa (Appendix C, Table C2). Samples consisted predominantly of chironomids (15 taxa) and oligochaete worms (mainly unidentifiable tubificids with and without cap setae and 13 identifiable taxa). Tubificids, sphaeriids and chironomids were present at all sites (Table 9). In Moberly Bay, tubificid densities were high, ranging from 38 to 401 per 33 cm^2 (11,467 to 121,000 per m^2; mean: 83,736/m^2), compared to sites in central Jackfish Bay, which ranged from 1026 to 1509/m^2, lower Jackfish Bay, which ranged from 6 to 966/m^2 and Tunnel Bay at 1207/m^2. Average tubificid densities in Moberly Bay exceeded the GL reference average (1358/m^2) by 62 fold while densities across other sites in Jackfish Bay were similar to GL reference sites. Similar results were found in 2003, where tubificid densities ranged from 15,000 to 124,000 per m^2 in Moberly Bay (Milani and Grapentine 2007). In the current study, densities of the unidentifiable tubificids with cap setae dominated most samples in Moberly Bay (47 to 88% of total abundances; Appendix C, Table C2); identifiable dominant worms in included *Limnodrilus* *hoffmeisteri* and *Aulodrilus pluriseta*, again very similar to the 2003 study. Outside of Moberly bay, *Limnodrilus* and *Aulodrilus* were mostly absent and the deepest sites located in lower Jackfish Bay (i.e., 4M3), was more indicative of oligotrophic conditions with worms such as Enchytraeidae and Lumbriculidae more prevalent. Pontoporeiid amphipods (predominant GL Group 5 taxa) were absent at 8 of the 9 sites in Moberly Bay; gammarid amphipods were present at 2 sites in very similar abundance to the GL reference site mean (Table 9). Outside of Moberly Bay, pontoporeiids were present at all sites (0.6 to 4.6 per 33 cm^2). Family diversity was generally similar or lower than the GL reference mean of 6 taxa throughout the bay; taxa ranged from 3 to 9 in Moberly Bay and from 3 to 7 outside of Moberly Bay (Table 9).

The mean relative abundances of the predominant macroinvertebrate taxa (tubificids, chironomids, sphaeriids and amphipods) are shown in Figure 9. In Moberly Bay, tubificids almost completely dominated, comprising 82 to 99.6% (mean 94%) of the macroinvertebrate community. Remaining taxa comprised on average from 0.03 (amphipods) to 3.6% (chironomids). These results are very similar to that found in 2003 (Milani and Grapentine 2007). Benthic communities in Moberly Bay were most dissimilar to mean GL reference (Group 5) communities, which are provided in Figure 9 for comparison. In central Jackfish Bay, some improvement was evident. Tubificids still dominated, but to a lesser degree, comprising 39 to 57% of the community (mean 50%) and the relative abundances of amphipods (17.9%), sphaeriids (8.7%), and chironomids (23.4%) were higher than those in Moberly Bay (0.03, 0.6 and 3.6%, respectively). In lower Jackfish Bay, the relative abundance of chironomids (mean 23.2%) was very similar to that in central Jackfish Bay and there was a decrease in sphaeriids in lower part of the bay (mean 5%) compared to the central bay (mean 8.7%). In Tunnel Bay (AOC reference), amphipods and chironomids dominated; comprising on average 39 and 31% of community, respectively, followed by tubificids, which comprised 18.6% of the community. Community composition in lower Jackfish Bay and Tunnel Bay were most similar to that at GL reference sites.

The results of the BEAST multivariate assessment of Jackfish Bay sites are summarized in Table 10. Ordination plots are provided in Appendix D, Figures D1 to D4 with each figure representing a subset of test data (3 to 5 site data). Three axes adequately described the variation in data. Stress, which is a measure of the goodness of fit between the distances among points in ordination space and the matrix input distances, is indicated in Table 10. The

larger the disparity the larger the stress and generally stress > 0.20 is poor (Belbin 1993). The stress for all site assessments was between 0.12 and 0.16, which is good to fair.
Sites in Moberly Bay sites were categorized as *very different* (Band 4) or *different* (Band 3) from reference; 8 of the 9 sites fell in Band 4 and 1 site fell in Band 3 (Table 10). Movement of these sites outside of reference was associated with increased abundance of tubificid worms as indicated in the ordination plot by the shift of these sites away from the reference centroid in the same direction as the Tubificidae vector (Appendix D, Figures D1 and D2). Tubificidae was the most highly correlated family in the assessment of Moberly Bay sites ($r^2 = 0.624$ to 0.757). Outside of Moberly Bay, benthic communities were more similar to reference. Two of the three sites (2M4, JFB021) in central Jackfish Bay were categorized as *possibly different* (Band 2) and one site (2M1) was *different*. Both sites in lower Jackfish Bay (2M5, 4M3) were *possibly different* than reference and the Tunnel Bay AOC reference site (3M2) was *equivalent* to reference (Band 1) (Table 10). The movement of sites outside of reference was likely due to decreased abundances of several taxa; no one taxon appears to have driven the ordination (Appendix D, Figures D3 and D4).

The relationship between the benthic community response and habitat variables was examined by correlation of the ordination of the community data and the habitat information (excluding organic contaminants). Between 3 and 13 variables were significantly correlated ($p<0.05$) to the ordination axes scores; the most highly correlated are shown in Appendix D, Figures D1 to D4. Increased total organic carbon (TOC, $r^2=0.25$) was associated with the separation of some Moberly Bay sites in ordination space (TOC is oriented with the position of the sites) (Appendix D, Figure D1). Some Jackfish Bay sites (i.e., 2M5 and 4M3) are deeper than most of the reference sites and this is indicated by the orientation of the depth vector (Appendix D, Figure D4).

Comparison to 2003 Study

Overall BEAST results from the current (2008) study were compared to those from the 2003 study of Milani and Grapentine (2007). Table 10 shows this comparison, which was made for 4 sites in Moberly Bay, 1 site in central Jackfish Bay, 1 site in lower Jackfish Bay and 1 site in Tunnel Bay. The assessment results were very similar. In Moberly Bay, 3 of the 4 sites fell in the same band (Band 4) while 1 site (1M3) moved from Band 3 to Band 4 in 2008, likely due to the increased tubificids at this site (15,088 worms/m^2 in 2003 vs. 83,283 worms/m^2 in 2008). Pontoporeiidae (amphipod) were present at the 3 of the 4 sites that were sampled in Moberly

Bay in 2003 (30 to 60 per m^2), but were absent at these 3 sites in 2008. There were, however, amphipods present in Moberly Bay at 3 sites in 2008: sites 1M4 and NF5 had gammarid amphipods present (63 to 69/m^2) and site EEM8 had pontoporeiid amphipods present (18/m^2). These three sites were not sampled in 2003 so comparisons could not be made. Regardless, the strong evidence of different communities in Moberly Bay was consistent between years. The sites in central and lower Jackfish Bay both fell in the same bands in both years (Bands 3 and 2, respectively). Benthic communities in Tunnel Bay (3M2) were *possibly different* (Band 2) than reference in 2003 while *equivalent* to reference (Band 1) in 2008; abundances of key taxa were very similar between years and the taxon diversity identical. Overall, conditions in 2008 were quite similar to those in 2003.

Using Procrustes analysis, the HMDS solutions from 2008 and 2003 were also compared. The summary is provided below:

Residual sum of squares:	0.1702
m^2:	0.1629
Probability of Rejection:	0.0001

The resultant m^2 value of 0.16 was low, indicating that multivariate configurations from the two datasets were very similar.

7.5 Sediment Toxicity

Mean species survival, growth and reproduction in toxicity tests is shown in Table 11. The results of the BEAST multivariate assessment are summarized in Table 12. Three axes adequately described the variation in data. Ordinations are provided in Appendix E, Figures E1 and E2. Each figure represents a subset of Jackfish Bay test data (6 to 9 site data) summarized on two axes; Figure E1 represents the Moberly Bay sites (n=9) and Figure E2 represents sites that are outside of Moberly Bay (n=6). Stress was ≤ 0.116, indicating that resultant three axes represented the original 10-dimensional among-site resemblances well.

Toxicity was evident in Moberly Bay (Table 11; Appendix E, Figure E1). Site 1M2 was categorized as *severely toxic* (Band 4), and sites M701 and JFB002 as *potentially toxic* (Band 2) (Table 12). The remaining 12 test sites were categorized as *non-toxic* (Band 1) (Figure E2).

Site 1M2 was associated with low *Hyalella* survival, as indicated in the ordination plot by the shift of this site away from the reference centroid in the opposite direction as this vector (appendix E, Figure E1). *Hyalella* survival was highly correlated to axes scores (r^2=0.914) and survival at site 1M2 was quite low (20%, Table 11). Site 1M2 was also associated with low *Hexagenia* growth, but this endpoint was weakly correlated to axes scores (r^2=0.155). The relationship between integrated toxicological response and habitat variables was examined by correlation of the ordination of the toxicity data and the habitat information (excluding organic contaminants). Eight variables (Hg, TKN (sediment), temperature, Co, TOC, total phosphorus (sediment), nickel and Al_2O_3) were correlated ($p \leq 0.05$) to the ordination axes scores for the assessment of Moberly Bay sites, although correlations were very weak (r^2= 0.05 to 0.14). No variables appeared to be associated with site positions in ordination space (Appendix E, Figure E1).

Comparison to 2003 Study

Overall BEAST results from the current (2008) study were compared to those from the 2003 study of Milani and Grapentine (2007). Table 12 shows this comparison, which was made for the 7 sites (indicated above in Section 7.4). Table 13 shows the individual endpoint comparison for *Hyalella* and *Hexagenia* for these sites. Overall, toxicity in Moberly Bay (n=4), lower Jackfish Bay (n=1) and Tunnel Bay (n=1) in 2008 was less severe than that observed in 2003. Two sites (1M3 and 1M1) that were categorized as *severely toxic* (Band 4) in 2003 were *non-toxic* (Band 1) in 2008 (Table 12). Results for site 1M2 were consistent between years (Band 4). Sites outside of Moberly Bay such as 4M3 (lower Jackfish Bay) and 3M2 (Tunnel Bay) were *severely toxic* in 2003 and *non-toxic* in 2008; site 2M1 (central Jackfish Bay) was *non-toxic* in both years. Looking at individual endpoints, acute toxicity to *Hyalella* was evident at 3 of the 4 Moberly Bay sites in 2003 (13.3 to 32% survival) while in 2008, acute toxicity was observed at 1 site (20%). In lower Jackfish and Tunnel Bays, mean amphipod survival was 8 and 44%, respectively, in 2003 and 77 and 79%, respectively, in 2008. The more severe toxicity noted in 2003 could reflect small scale heterogeneity.

7.6 Integration of Lines of Evidence

Based on the data from four lines of evidence (sediment chemistry, toxicity, benthic invertebrate community structure and contaminant biomagnification potential), a decision matrix was developed (Table 14). The information obtained allowed for the assessment of three possibilities (EC/MOE 2007):

1. the contaminated sediments pose an environmental risk;
2. the contaminated sediments may pose an environmental risk, but further assessment is required before a definitive decision can be made;
3. the contaminated sediments pose a negligible environmental risk.

Interpretation of the overall assessment considered the degree of degradation for each line of evidence. For the sediment chemistry column, sites with exceedences of the Probable Effect Level (PEL) are indicated by "■"; sites with exceedences of the Lowest Effect Level (LEL) or the Canada Wide Standards (CWS) for PHCs by "◘". For the toxicity and benthos alteration columns, sites determined from the BEAST analysis as *toxic/severely toxic* or *different/very different* from reference, respectively, were indicated by "■"; sites determined as *potentially toxic* or *possibly different* from reference by "◘". For the contaminant (dioxin/furan and DL PCBs) biomagnification potential column, sites where the TEQ (upper and lower bound) exceeded both the TRG and the 99th percentile for the reference sites were indicated by "◘". Sites with no SQG exceedences, no sediment toxicity, benthic communities that were equivalent to reference conditions and no contaminant biomagnification potential were indicated by "□".

Based on the framework, *management actions required* was indicated at 1 site in Moberly Bay (1M2), due to elevated contaminants above guidelines (metals and F3 fraction petroleum hydrocarbons), severe toxicity and benthic community impairment (information on biomagnification potential was not available for this site). Five sites indicated *no further actions needed*: 1 in Moberly Bay (EEM8), 2 in central Jackfish Bay (2M4, JFB021) and 2 in lower Jackfish Bay (2M5, 4M3). Although these five sites fell in either of Band 2 or 3 based on the BEAST benthic community structure assessment, they were not recommended for further action relating to this line of evidence because these sites did not have the enriched tubificid community apparent in Moberly Bay, and were not overly dissimilar to the local AOC reference site (Tunnel Bay). While Site EEM4 in Moberly Bay showed increased diversity (7 taxa) compared to the GL reference mean, this site nonetheless was greatly enriched with tubificid worms (and also increased chironomid abundance), more indicative of a polluted environment.

The remaining 9 sites indicated that further work may be required. All 7 sites in Moberly Bay indicated *determine reason(s) for benthos alteration* and 3 of these 7 sites also indicated *fully assess the risk of biomagnification*. *Fully assess the risk of biomagnification* was also indicated in central Jackfish Bay at 1 site (2M1) and at the site in Tunnel Bay (3M2). With respect to benthos alteration, conditions in Moberly Bay generally reflect a response to organic enrichment, and therefore benthic communities should continue to be monitored for changes over time.

The framework was also applied to the 2003 study (Milani and Grapentine 2007). Table 15 shows the decision matrix for 7 sites that were sampled in both 2003 and 2008 (sites in similar locations). Note: contaminant biomagnification potential was not assessed in 2003 at any site and was not assessed in 2008 at site 1M2. Based on the sediment chemistry, toxicity and benthic community, assessment outcome results for 2008 suggests some slight improvements from 2003 due to lower toxicity (e.g., sites 1M3, 1M1, 4M3 and 3M2). In 2003, 3 Moberly Bay sites indicated *management actions required* while 1 site had this outcome in 2008.

8 CONCLUSIONS

Sediment Chemistry

- Organic contaminants such as PAHs and PCBs were low throughout the bay.
- Dioxins and Furans, expressed as TEQ, were not overly high. The PEL was exceeded in Moberly Bay (1 site) and in lower Jackfish Bay (1 site) by 1.2 to 1.7 times.
- Petroleum hydrocarbons were not very high. The F3 fraction exceeded numerical standards (for soil) in Moberly Bay (3 sites) by up to 1.4 times.
- Metals (5 to 7) were above the LEL throughout the bay. (Metals were also elevated above the LEL at Lake Superior reference sites.)
- Total organic carbon was generally high in Moberly Bay compared to the other areas of Jackfish Bay and Lake Superior reference sites. TOC decreased overall with distance from Moberly Bay.

Benthic Invertebrate Community

- Benthic communities in Moberly Bay were indicative of a polluted environment as evidenced by very high tubificid densities and amphipods absent or in very low abundance compared to reference.
- Increased total organic carbon was correlated to position of Moberly Bay sites (in ordination space).
- Benthic communities outside of Moberly Bay were more similar to reference, with reduced tubificid densities and increased amphipod densities.
- Results were very similar to those found in 2003, and there appears to be little or no change from 2003. Altered benthic communities, mainly in Moberly Bay, generally appear to reflect a response to organic enrichment. Additional analyses (Procrustean analysis) confirmed that the 2008 and 2003 datasets were very similar.

Sediment toxicity

- Toxicity was evident in Moberly Bay with low amphipod survival and growth and low mayfly growth.
- Toxicity was evident at fewer sites in 2008 than in 2003. In 2003, toxicity was evident in Moberly Bay as well as central and lower Jackfish Bays, and Tunnel Bay.
- The cause of toxicity was unclear as toxicological response was weakly correlated to environmental variables (excluding organic variables).

Bioaccumulation of Contaminants in Benthos

- Dioxin and furan toxic equivalent concentrations (TEQs) in resident benthos (oligochaetes, chironomids, amphipods) were above the Tissue Residue Guideline (TRG) in Moberly Bay (up to 8 fold higher), central Jackfish Bay (up to 9.8 fold higher), lower Jackfish Bay (up to 1.6 fold higher) and Tunnel Bay (up to 2.9 fold higher).
- The 99th percentile for the Lake Superior reference site TEQs was also higher than the TRG (~2 times higher).
- TEQs for sites in Moberly Bay, central Jackfish Bay and Tunnel Bay exceeded both the TRG and the 99th percentile for reference site TEQs; exceedences ranged from 1.2 to 4.5 fold higher.

- TEQs for dioxin-like PCBs were well below the TRG.

Decision-making framework for sediment contamination

- *Management action required* was indicated for 1 site in Moberly Bay due to elevated sediment contaminants and benthos alteration and sediment toxicity.
- *No further action needed* was indicated at 5 sites: 1 in Moberly Bay and 4 in central or lower Jackfish Bay.
- Seven sites in Moberly Bay indicated that further investigations were required to determine reasons for altered benthic communities, toxicity and to fully assess dioxin/furan biomagnification potential. Since benthic communities in Moberly Bay generally reflect a response to organic enrichment, the cause of alteration likely does not have to be further investigated.
- One site in each of central Jackfish Bay and Tunnel Bay indicated that further investigations were required to fully assess dioxin/furan biomagnification potential.
- There was some improvement from 2003 results due to reduced sediment toxicity compared to reference in Moberly Bay, lower Jackfish Bay and Tunnel Bay.

Recommendations

- Benthic conditions (four lines of evidence) should continue to be monitored throughout the bay for changes over time.

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Figures

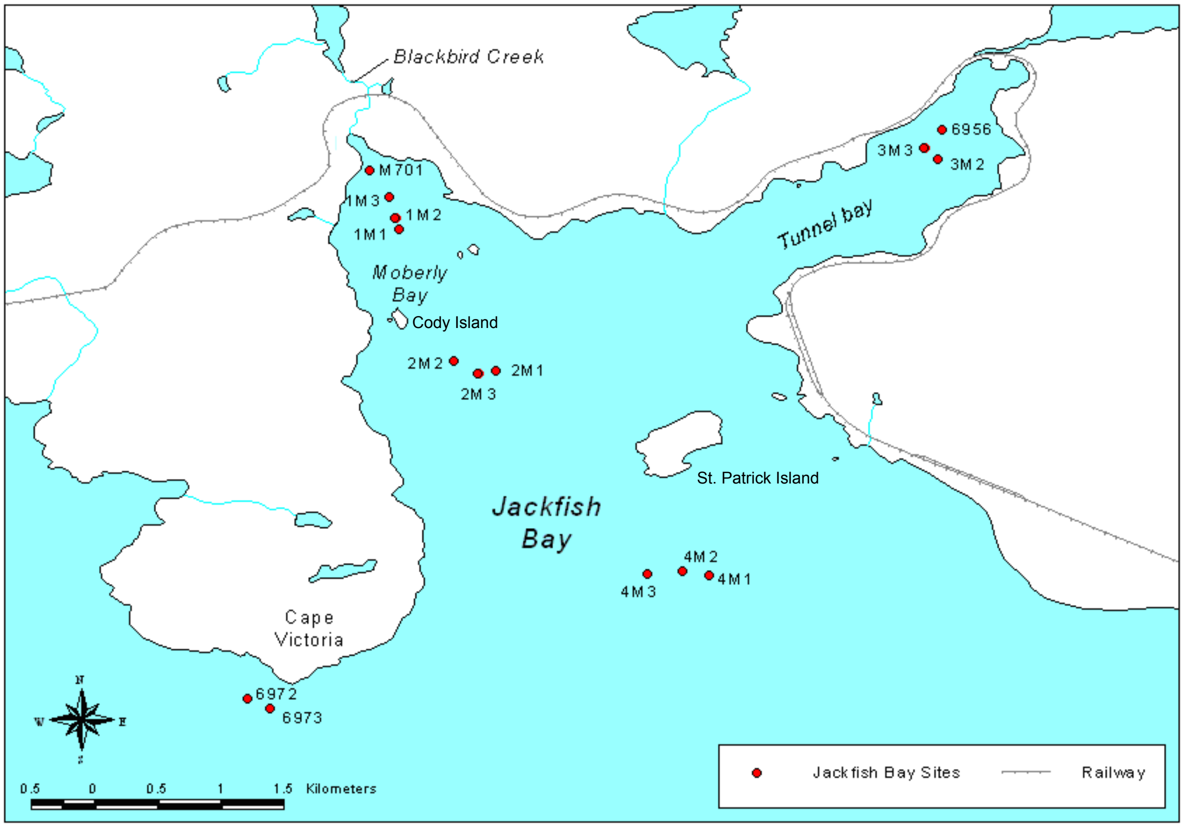

Figure 1. Invertebrate, sediment and overlying water sampling locations in 2003 (Milani and Grapentine 2007).

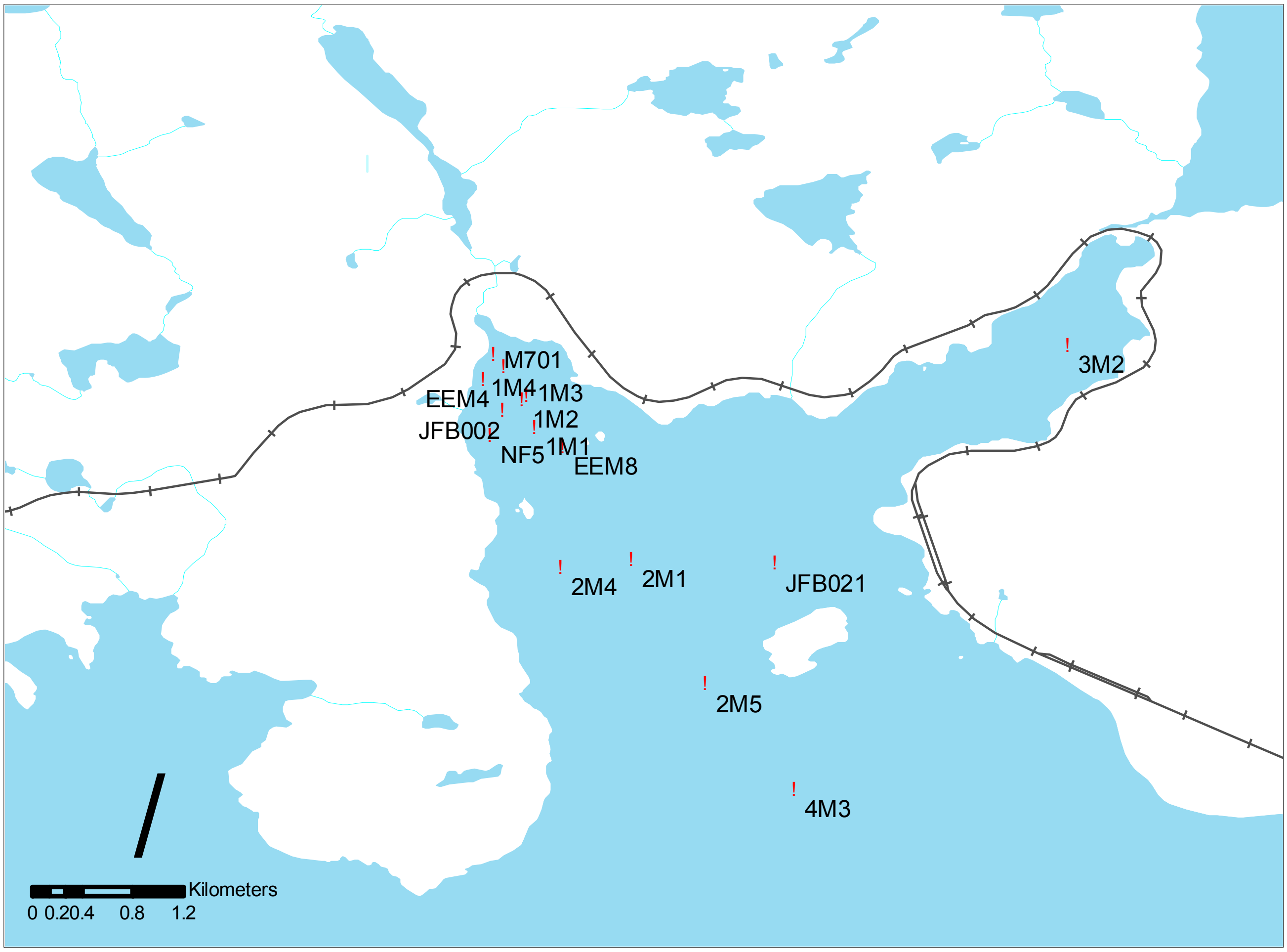

Figure 2a. Invertebrate, sediment and overlying water sampling locations in 2008.

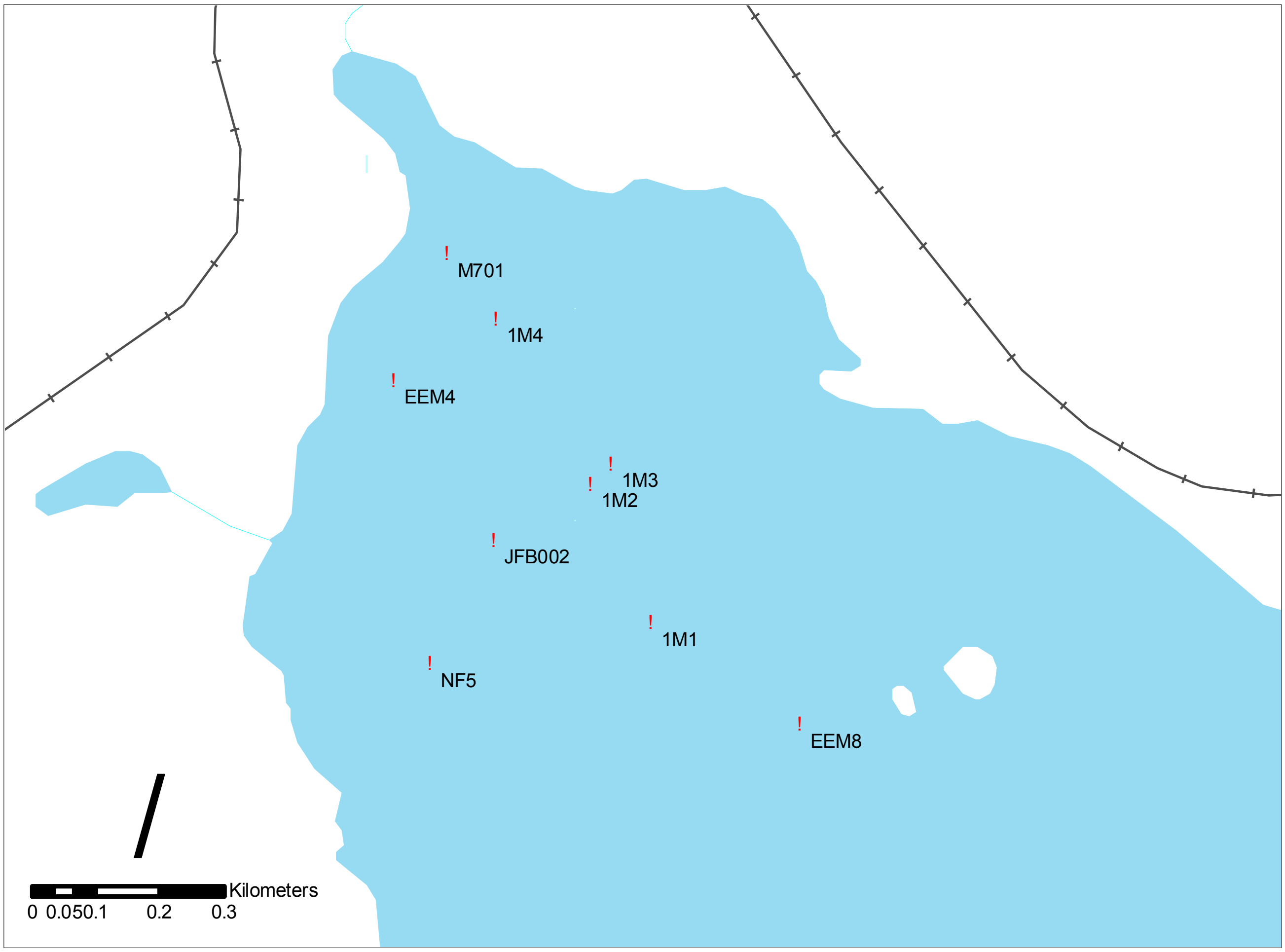

Figure 2b. Moberly Bay sampling locations in 2008 (enlarged).

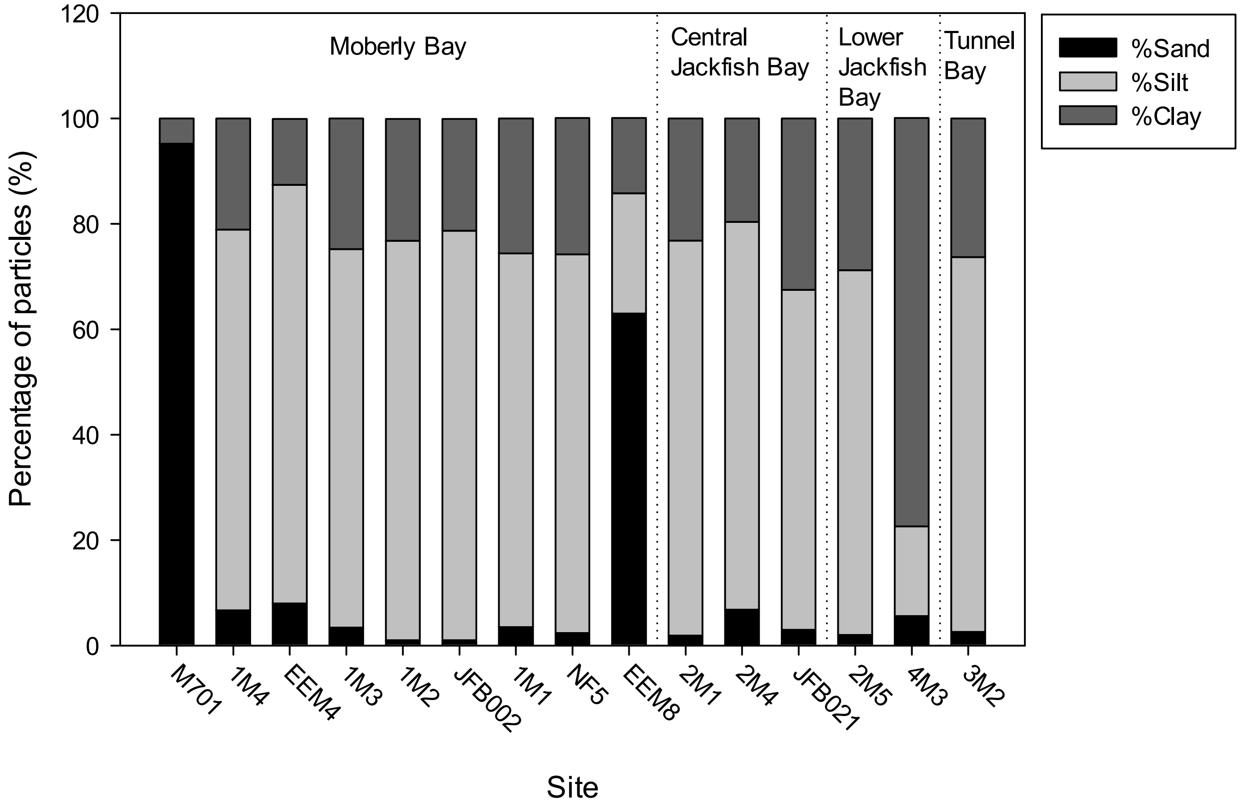

Figure 3. Cumulative particle size distributions for Jackfish Bay sediment. The vertical dotted lines separate Moberly Bay, central and lower Jackfish Bay and Tunnel Bay sites.

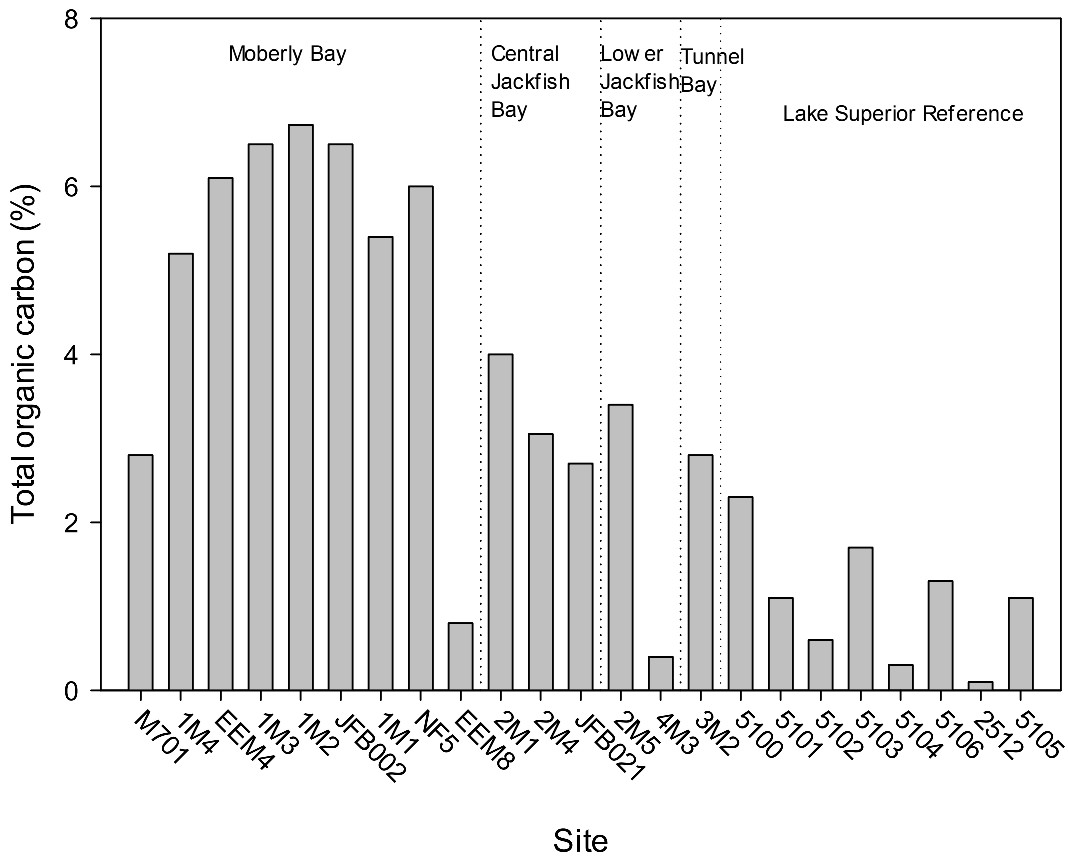

Figure 4. Total organic carbon (%) in sediment. The vertical dotted lines separate Moberly Bay, central and lower Jackfish Bay, Tunnel Bay and Lake Superior reference sites.

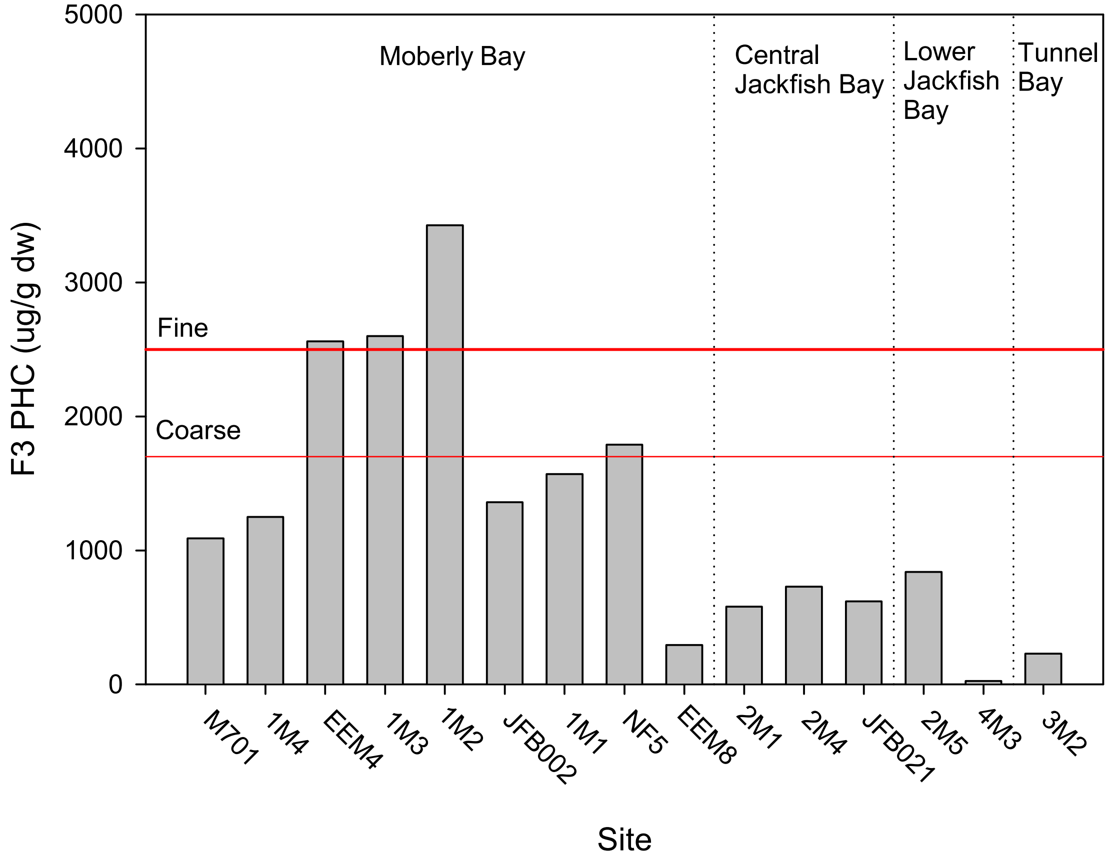

Figure 5. The F3 petroleum hydrocarbon (PHC) fraction in Jackfish Bay sediment. The horizontal red lines represent the Canada-Wide Standard for petroleum hydrocarbons for the F3 fraction (1300 and 2500 mg/kg for coarse and fine textured, respectively). The vertical dotted lines separate Moberly Bay, central and lower Jackfish Bay and Tunnel Bay sites.

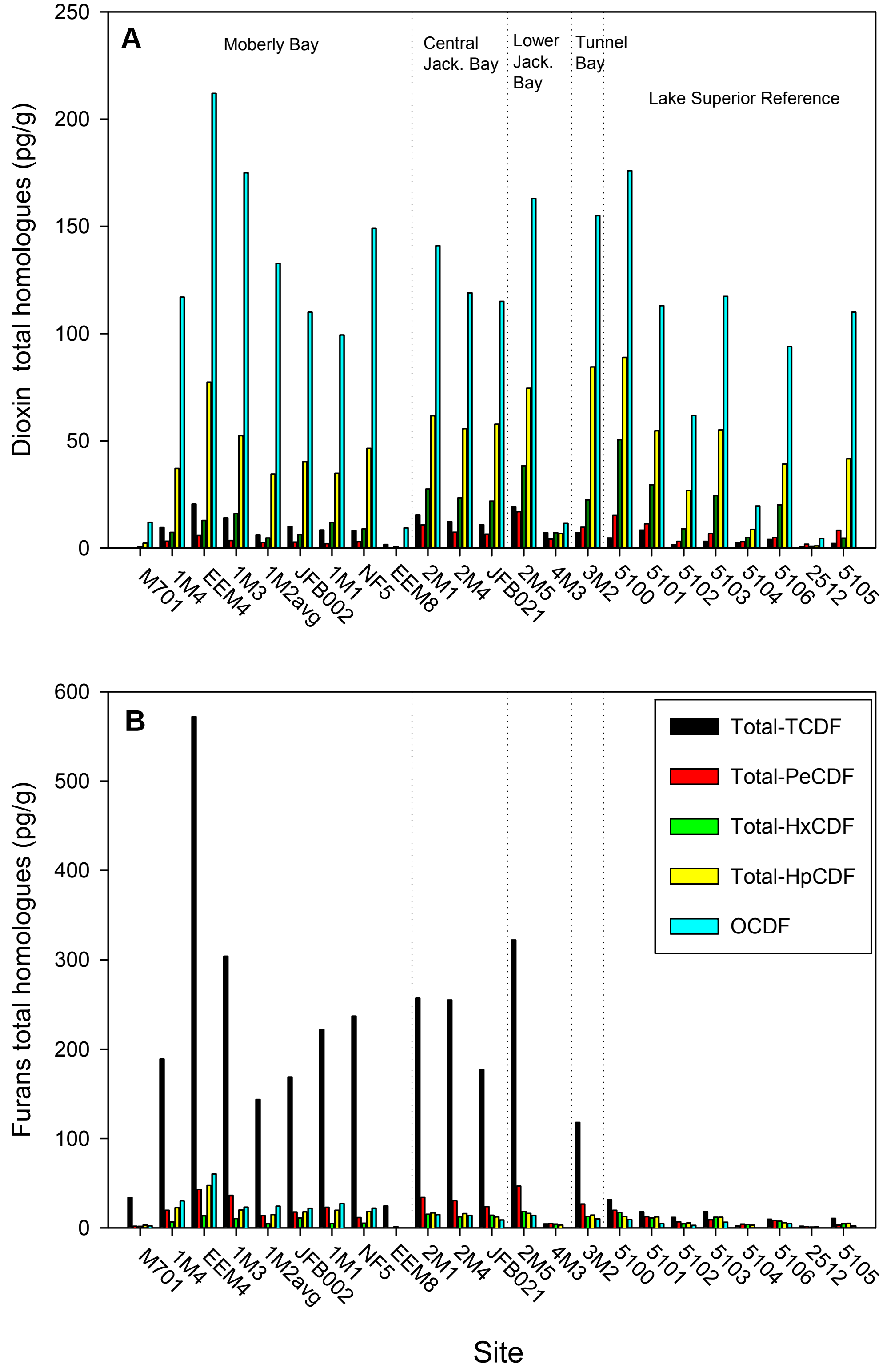

Figure 6. Dioxin (A) and furan (B) homologue group totals in Jackfish Bay and reference sediment. The vertical dotted lines separate Moberly Bay, central and lower Jackfish Bay, Tunnel Bay and Lake Superior reference sites.

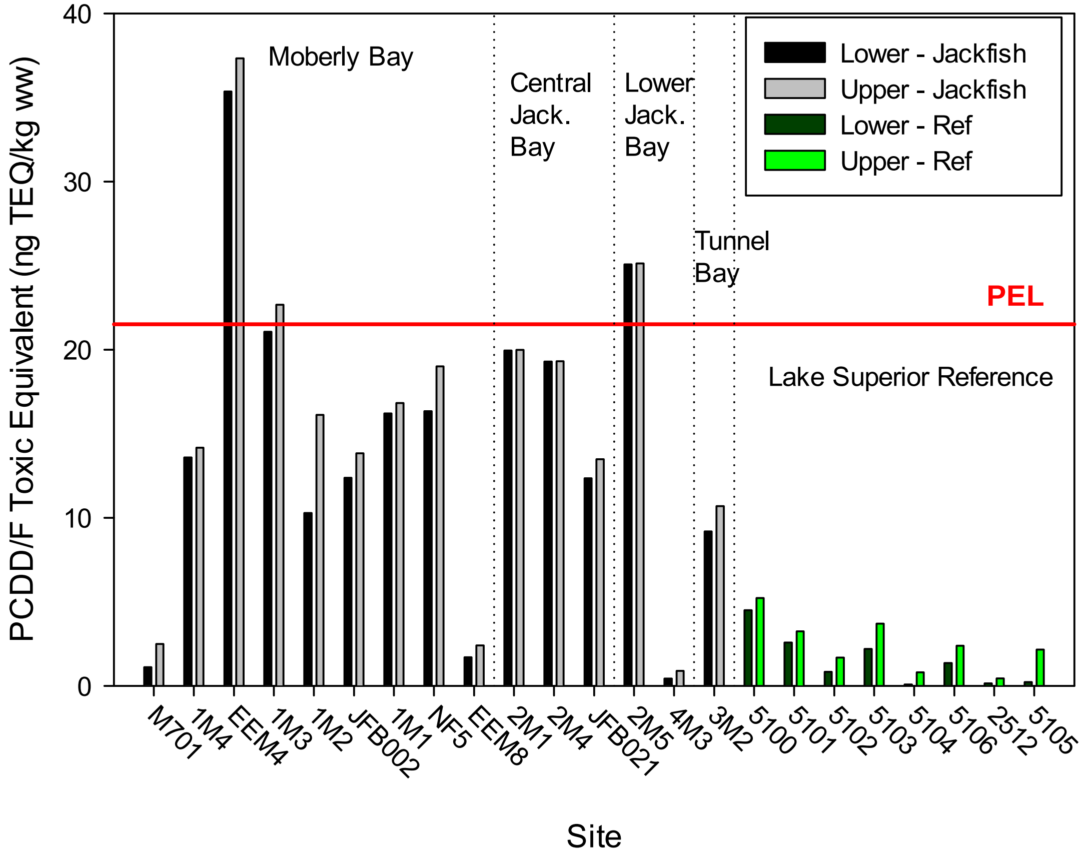

Figure 7. Sediment dioxin and furan (PCDD/Fs) toxic equivalent (TEQ) concentrations. For congener values that were below method detection limits, the method detection limit itself was used in the calculation of the Upper TEQ and values were assigned a zero for the Lower TEQ. The red solid line represents the Probable Effect Level (PEL) for dioxins/furans (21.5 ngTEQ/kg). The vertical dotted lines separate Moberly Bay, central and lower Jackfish Bay, Tunnel Bay and Lake Superior reference sites.

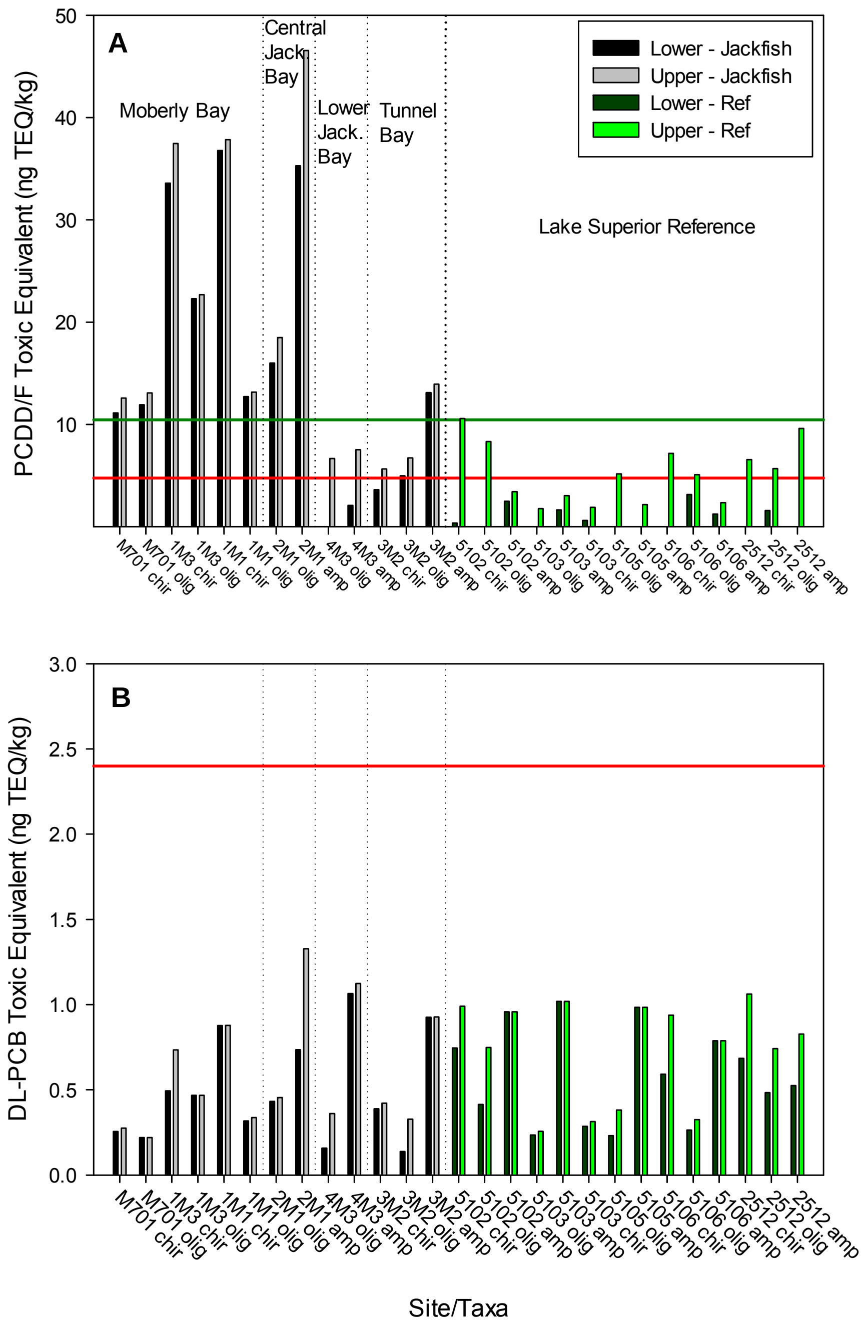

Figure 8. Benthic invertebrate toxic equivalent (TEQ) concentrations for (A) dioxins and furans (PCDD/F) and (B) dioxin-like PCBs. For congener values that were below method detection limits, the method detection limit itself was used in the calculation of the Upper TEQ and values were assigned a zero for the Lower TEQ. The red solid lines represent the Tissue Residue Guideline for an avian receptor for PCDD/F (4.75 ngTEQ/kg diet ww) (A) and dioxin-like PCBs (2.4 ng TEQ/kg diet ww) (B). The solid green line in (A) represents the 99th percentile for the upper bound reference TEQ for the reference sites (10.4 pg TEQ/g). The vertical dotted lines separate Moberly Bay, central and lower Jackfish Bay, Tunnel Bay and Lake Superior reference sites.

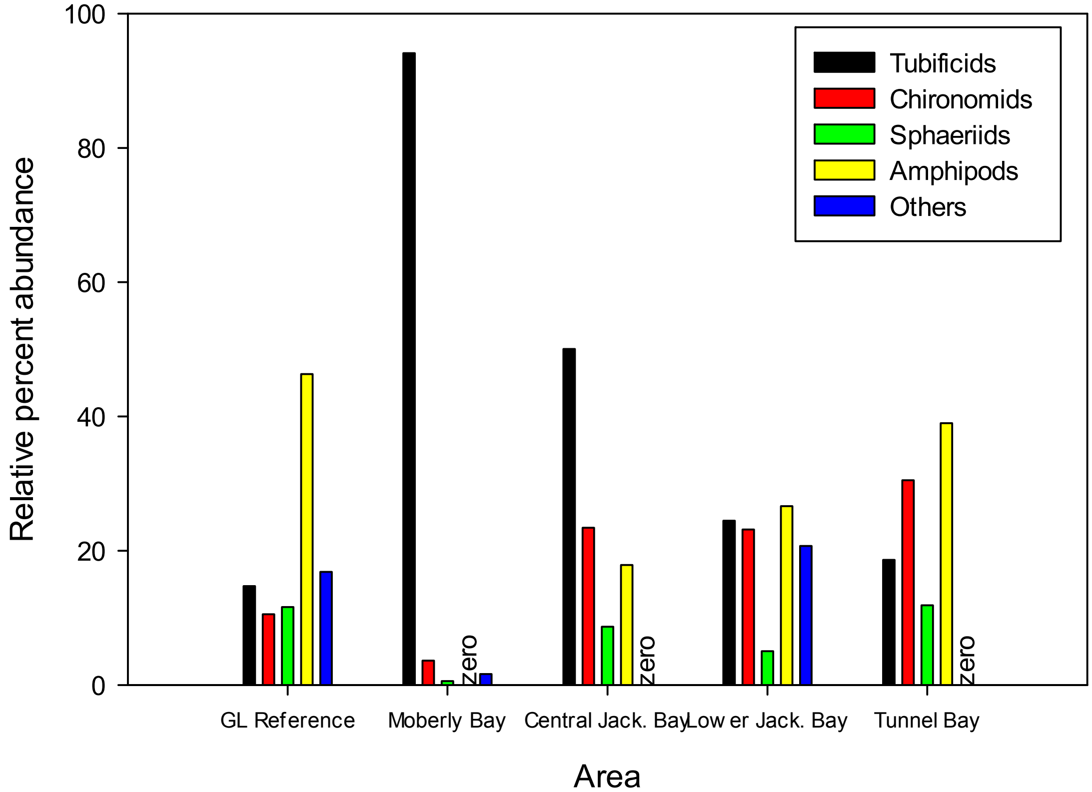

Figure 9. Mean relative abundance of predominant benthic macroinvertebrate taxa in areas within the Jackfish Bay Area of Concern. Relative abundance for Great Lakes reference sites (n=75) are shown for comparison.

Tables

Table 1. Jackfish Bay and Lake Superior reference sampling site positions, depth and sediment description (2008).

Location	Site	Sampling Device	Description	Latitude	Longitude	Depth (m)
Moberly Bay	M701	Ponar	Very sandy with lots of rotting leaves. Very foul smelling.	48.8105545	87.0019455	10.9
	1M4	Mini-box Core	Brown silty mud with striations of black over darker mud. Foul smelling.	48.80944443	87.00111389	15.5
	EEM4[a]	Mini-box Core	Very soft silty brown mud over black mud and organic matter. Rotten smelling, with a bit of oily sheen.	48.80861282	87.00250244	15.2
	1M3	Mini-box Core	Dark brown, silty mud throughout. Very foul smelling sediment.	48.80749893	86.99944305	18.9
	1M2	Mini-box Core	2-3cm lighter brown over darker mud. Foul smelling.	48.80722046	86.99972534	19.3
	JFB002[b]	Mini-box Core	Soft brown speckled mud over darker, almost black mud. Foul smelling.	48.80638885	87.00111389	17.4
	1M1	Mini-box Core	2-3 cm lighter brown over grey silty mud. Smelly sediment.	48.80527878	86.9991684	20.4
	NF5[a]	Mini-box Core	2-3 cm lighter brown silt y mud over very dark mud. Foul smelling.	48.80472183	87.0019455	16.1
	EEM8[a]	Ponar	3-4 cm light brown sandy mud over top 5+cm black sandy mud. No odour.	48.80389023	86.99666595	15.8
Central Jackfish Bay	2M1	Mini-box Core	2-3 cm light brown over darker silty mud. Oily smell.	48.79583359	86.99194336	41.1
	2M4	Mini-box Core	2-3 cm light brown silty mud over soft fine mud with fine sand.	48.79527664	86.99694824	35.3
	JFB021[b]	Mini-box Core	2-3 cm light brown silt over darker mud. No odour.	48.75111008	87.29528046	42.9
Lower Jackfish Bay	2M5	Mini-box Core	2-3 cm light brown silt over soft brown/greyish mud with some very fine sand. No odour.	48.78694534	86.98666382	37.7
	4M3	Ponar	2-3 cm fine silt over clay. No odour.	48.77944565	86.98027802	40.0
Tunnel Bay	3M2	Mini-box Core	A few mm light brown silt over darker silty mud. No odour.	48.81111145	86.96083069	31.9
Lake Superior Reference	5100	Mini-box Core	Very fine silty brown mud	48.74139	87.9397	49.0
	5101	Mini-box Core	Soft greyish brown silty mud.	48.83556	87.7501	50.6
	5102	Ponar	2-3 cm fine brown silty mud over grey clay and fine sand.	48.77444	87.7269	27.0
	5103	Mini-box Core	Very fine silty brown mud	48.80472	87.7494	16.8
	5104	Mini-box Core	Grey/brown hardish clay w/ fine gritty sand	48.72028	87.9244	38.4
	5105	Mini-box Core	Very fine silty brown mud	48.60695	88.1869	41.7
	5106	Mini-box Core	2-3 cm brown silt over clay and fine sand. Some small stones.	48.50361	88.43	25.5
	2512	Ponar	Grey clay with lots of pebbles, stones.	48.85	87.6081	6.8

[a]EEM site (Stantec 2004); [b]Biberhofer (pers. comm.)

Table 2. Environmental variables measured at each site.

Field	Water	Sediment	Benthos
Northing Easting Site Depth	Alkalinity Conductivity Dissolved Oxygen pH Temperature Nitrate+Nitrite-N Ammonia-N Total Phosphorus Total Kjeldahl Nitrogen	Trace metals Total Phosphorus Total Kjeldahl Nitrogen Total Organic Carbon Loss on Ignition %sand silt clay gravel Petroleum Hydrocarbons PAHs PCBs Oil & grease Dioxins and Furans	Dioxins and Furans

Table 3. Characteristics of sampling site overlying water. Values are in mg/L unless otherwise noted.

Location	Site	Alkalinity	Conductivity (µS/cm)	Dissolved O_2	NH_3	NO_3/NO_2	TKN	pH	Temp (°C)	Total P µg/L
Moberly Bay	M701	52	188	10.3	0.172	0.315	0.371	7.18	12.9	13.5
	1M4	54	177	10.2	0.075	0.314	0.269	7.11	12.9	16.2
	EEM4	56	201	10.3	0.014	0.422	0.399	7.22	12.8	17.8
	1M3	73	252	9.4	0.006	0.454	0.521	7.61	12.4	34.8
	1M2[a]	72	286	9.3	0.184	0.33	0.653	7.5	12.5	50.9
	JFB002	72	277	9.6	0.113	0.365	0.267	7.05	12.6	34.6
	1M1	66	215	9.4	0.010	0.477	0.572	7.61	10.8	45.9
	NF5	59	220	10.0	0.011	0.419	0.510	7.66	12.7	22.4
	EEM8	57	252	9.9	0.083	0.331	0.189	7.51	12.9	19.5
Central Jackfish Bay	2M1	42	109	11.6	0.038	0.366	0.203	7.63	7.0	4.4
	2M4	-[b]	133	10.1	0.043	0.376	0.227	7.56	12.4	10.7
	JFB021	37	107	11.7	0.005	0.368	0.114	7.55	6.7	5.1
Lower Jackfish Bay	2M5	43	111	10.8	0.054	0.362	0.464	7.6	11.3	3.9
	4M3	42	109	12.5	0.003	0.358	0.110	7.75	6.1	3.0
Tunnel Bay	3M2	45	116	10.6	0.007	0.389	0.116	7.29	6.0	6.4
Lake Superior Reference	5100	43	105	11.6	0.008	0.377	0.095	7.6	7.1	4.1
	5101	47	108	10.3	0.006	0.327	0.157	8.0	14.3	7.4
	5102	46	167	10.3	0.003	0.282	0.145	7.9	13.6	3.9
	5103[a]	49	123	10.1	0.017	0.254	0.167	7.9	13.8	5.7
	5104	44	110	10.6	0.033	0.324	0.188	7.9	13.5	5.2
	5105	45	106	10.7	0.006	0.289	0.135	7.9	11.6	3.6
	5106	43	103	10.4	0.015	0.305	0.146	7.9	13.4	4.0
	2512	43	98	10.6	0.006	0.315	0.141	7.1	13.4	3.6
Lake Superior Reference (n=31)[c]		39-53		10.3-15.0		0.24-0.36	0.031-0.226	7.5-7.9	5-20	3.6-28

[a] Mean of 3 field replicates; [b] no data; [c] Unpublished data, Environment Canada 2006

Table 4. Sediment trace metal and nutrient concentrations (dry weight). Values greater than the Provincial Sediment Quality Guidelines Severe Effect Level (SEL) are indicated in red.

						Moberly Bay									Central Jackfish Bay			Lower Jackfish Bay		Tunnel Bay
Parameter	**Units**	**M.D.L.**	**Reference Method**	**LEL**	**SEL**	M701	1M4	EEM4	1M3	1M2[1]	JFB002	1M1	NF5	EEM8	2M1	2M4[2]	JFB021	2M5	4M3	3M2
Aluminum	μg/g	10	EPA 6010			4180	6840	6680	7860	8310	8260	7210	8360	4170	9830	8315	10300	9960	13600	10600
Antimony	μg/g	5	EPA 6010			< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Arsenic	μg/g	5	EPA 6010	6	33	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	7	7	< 5	10
Barium	μg/g	1	EPA 6010			25	54	55	66	71	68	56	69	22	97	57	87	81	110	106
Beryllium	μg/g	0.2	EPA 6010			< 0.2	0.3	0.2	0.3	0.3	0.3	0.3	0.3	< 0.2	0.4	0.35	0.5	0.5	0.7	0.5
Bismuth	μg/g	5	EPA 6010			< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Cadmium	μg/g	0.5	EPA 6010	0.6	10	< 0.5	0.9	0.9	1.4	1.5	1.4	1.0	1.2	< 0.5	1.0	0.85	0.9	1.1	< 0.5	1.0
Calcium	μg/g	10	EPA 6010			3660	11100	12100	15400	17633.3	18200	12900	14000	4090	7810	7740	6450	6350	80800	7640
Chromium	μg/g	1	EPA 6010	26	110	21	41	41	52	48	45	46	45	22	50	41	47	46	51	44
Cobalt	μg/g	1	EPA 6010			5	7	7	7	8	8	7	8	5	10	8	11	10	15	11
Copper	μg/g	1	EPA 6010	16	110	7	22	26	34	35	32	30	31	7	52	39.5	53	56	32	54
Iron	μg/g	10	EPA 6010	20000	40000	9690	13700	13500	14500	15100	15000	14900	15600	10700	20600	17800	23300	21200	27400	25600
Lead	μg/g	5	EPA 6010	31	250	< 5	7	11	8	9	8	10	9	< 5	21	20	23	29	14	29
Magnesium	μg/g	10	EPA 6010			3790	7970	8390	10700	12133.3	12400	9240	10000	3780	7940	7255	7820	7290	21400	8000
Manganese	μg/g	1	EPA 6010	460	1100	161	326	341	309	342	346	292	445	199	1080	581.5	966	996	568	**1680**
Mercury	μg/g	0.005	EPA 7471A	0.2	2	0.023	0.053	0.062	0.068	0.068	0.064	0.110	0.064	0.027	0.084	0.1125	0.082	0.125	0.022	0.107
Molybdenum	μg/g	1	EPA 6010			< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Nickel	μg/g	1	EPA 6010	16	75	14	21	20	23	25	23	21	23	12	28	22.5	29	27	36	29
Phosphorus	μg/g	5	EPA 6010			680	947	969	964	1003	1020	972	1070	901	1080	1020	1180	1070	648	1350
Potassium	μg/g	30	EPA 6010			300	850	840	1180	1277	1240	980	1240	310	1540	1100	1590	1510	4000	1620
Silicon	μg/g	1	EPA 6010			209	362	250	236	232	343	197	250	186	256	276	163	271	249	281
Silver	μg/g	0.2	EPA 6010			< 0.2	0.4	0.6	0.8	0.7	0.6	0.7	0.6	< 0.2	0.6	0.4	0.4	0.5	0.2	0.3
Sodium	μg/g	20	EPA 6010			610	810	790	770	730	900	760	920	620	730	730	730	660	830	740
Strontium	μg/g	1	EPA 6010			11	17	18	19	20	21	18	20	12	19	17.5	20	18	60	20
Tin	μg/g	10	EPA 6010			< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Titanium	μg/g	1	EPA 6010			523	663	631	613	631	683	650	745	536	822	796.5	954	794	1220	837
Vanadium	μg/g	1	EPA 6010			19	29	30	30	31	31	29	33	22	40	36	44	40	49	43
Yttrium	μg/g	0.5	EPA 6010			3.4	5.3	5.1	5.4	5.5	5.7	5.6	6.0	4.0	7.7	6.95	8.4	8.0	10.6	8.8
Zinc	μg/g	1	EPA 6010	120	820	63	128	135	175	192	169	137	156	63	128	101	108	117	77	103
Zirconium	μg/g	0.1	EPA 6010			2.1	2.4	2.1	2.1	2.3	2.4	2.7	2.4	2.0	2.4	2.15	2.8	2.0	24.8	1.9
Aluminum (Al2O3)	%	0.01	IN-HOUSE			13.7	12.3	13.4	11.9	11.5	12.0	12.1	11.6	14.3	13.0	13.35	13.3	11.1	13.7	14.7
Barium (BaO)	%	0.001	IN-HOUSE			0.091	0.078	0.091	0.078	0.078	0.078	0.078	0.078	0.078	0.052	0.052	0.078	0.052	0.091	0.078
Calcium (CaO)	%	0.01	IN-HOUSE			2.87	2.87	2.82	3.43	4.46	4.02	4.24	4.69	2.50	7.92	7.69	2.98	3.20	2.91	14.5
Chromium (Cr2O3)	%	0.01	IN-HOUSE			0.01	0.01	0.04	0.01	0.02	0.01	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Iron (Fe2O3)	%	0.05	IN-HOUSE			5.65	3.70	5.23	4.02	4.03	4.06	4.19	3.86	3.55	5.84	5.935	3.17	3.41	6.10	6.80
Magnesium (MgO)	%	0.01	IN-HOUSE			2.39	2.22	2.20	2.85	3.04	2.68	2.46	3.05	1.53	6.12	6.42	1.61	2.52	2.24	5.02
Manganese (MnO)	%	0.01	IN-HOUSE			0.18	0.08	0.18	0.08	0.08	0.10	0.08	0.08	0.06	0.13	0.13	0.06	0.06	0.27	0.10
Phosphorus (P2O5)	%	0.03	IN-HOUSE			0.06	0.21	0.14	0.35	0.19	0.18	0.10	0.21	0.32	0.39	0.175	0.14	0.14	< 0.04	< 0.04
Potasium (K20)	%	0.01	IN-HOUSE			2.33	2.25	2.43	2.35	1.99	2.07	2.17	2.16	2.31	2.08	2.33	1.88	2.08	2.54	2.81
Silica (SiO2)	%	0.01	IN-HOUSE			58.8	58.1	58.1	55.5	53.6	55.7	57.0	54.0	70	48.4	49.9	62.9	50.7	57.9	41.6
Sodium (Na2O)	%	0.01	IN-HOUSE			3.16	5.25	3.12	4.72	2.77	2.94	3.21	2.91	6.23	2.48	3.045	4.34	4.19	3.05	1.78
Titanium (TiO2)	%	0.01	IN-HOUSE			0.74	0.61	0.74	0.65	0.62	0.65	0.68	0.62	0.69	0.74	0.73	0.56	0.56	0.74	0.78
Loss on Ignition	%	0.05	IN-HOUSE			5.75	15.9	18.5	21.0	22.4	21.6	17.1	19.1	3.18	14.3	11.8	13.3	12.2	19.9	11.4
Whole Rock Total	%		IN-HOUSE			95.7	104	107	107	105	106	103	102	105	101	101.5	104	90.3	109	99.6
Total Organic Carbon	% by wt	0.1	LECO	1	10	2.8	5.2	6.1	6.5	6.7	6.5	5.4	6	0.8	4.0	3.05	2.7	3.4	0.4	2.8
Total Kjeldahl Nitrogen	μg/g	0.05	EPA 351.2	550	4800	1050	2830	3270	4370	4723	4270	2610	3910	585	3190	1960	2430	2470	551	2330
Phosphorus-Total	μg/g	0.01	EPA 365.4	600	2000	550	804	894	1000	991	963	812	913	793	1160	962.5	1160	1040	618	1270

[1] mean of 3 field replicates; [2] mean of laboratory duplicates

Table 5. Sediment petroleum hydrocarbon, PAH, oil and grease and PCB concentrations (mg/kg dw) in Jackfish Bay sediment. Values below method detection limits are indicated by "<". [Method detection limits are provided in Appendix B, Table B4]. Values exceeding Provincial Sediment Quality Guideline Lowest Effect Levels (LEL) or Canada-Wide standards (CWS) are indicated in red.

	Guideline	Moberly Bay									Central Jackfish Bay			Lower Jackfish Bay		Tunnel Bay
Analyte	mg/kg	M701	1M4	EEM4	1M3	1M2a	JFB002	1M1	NF5	EEM8	2M1	2M4	JFB021	2M5	4M3	3M2
BTEX																
Benzene		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ethyl Benzene		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
m+p-Xylenes		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
o-Xylene		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Toluene		<0.05	<0.05	<0.05	0.08	0.1	<0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Xylene, (total)		<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
CCME HYDROCARBONS	**CWS**[b]															
F1 (C6-C10)	320	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
F1-BTEX		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
F2 (C10-C16)	260	72	27	110	64	90	23	52	36	<10	21	<20	<20	23	<10	<20
F2-Naphth		72	27	110	64	90	23	52	36	<10	21	<20	<20	23	<10	<20
F3 (C16-C34)	2500	1090	1250	**2560**	**2600**	**3427**	1360	1570	1790	294	580	730	620	840	<50	230
F3-PAH		1090	1250	2560	2600	3427	1360	1570	1790	294	580	730	620	840	<50	230
F4 (C34-C50)		330	310	640	550	733	270	320	410	62	170	210	140	210	<50	<100
F4G-SG (GHH-Silica)	6600	1400	1200	2700	2100	2800	1300	1200	1700	600	800	900	600	700	100	300
Total Hydrocarbons (C6-C50)		1490	1590	3310	3210	4253	1650	1940	2240	356	770	940	760	1070	<50	230
Chromatogram to baseline at nC50		no	no	no	no	no	no	no	no	yes	yes	no	yes	no	yes	yes
CCME PAHs	**LEL**															
1-Methylnaphthalene		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
2-Methylnaphthalene		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthene		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthylene		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Acridine		<2	<2	<2	<2	<2	<2	<2	<2	<0.8	<2	<2	<2	<2	<2	<2
Anthracene	0.22	<0.1	<0.1	<0.1	**0.4**	**0.4**	0.2	0.1	0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)anthracene	0.32	<0.1	<0.1	0.2	0.2	0.1	<0.1	<0.1	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)pyrene	0.37	<0.04	<0.04	0.15	0.19	0.1	<0.04	0.07	0.04	<0.02	0.07	0.06	<0.04	0.05	<0.04	0.06
Benzo(b)fluoranthene		<0.1	<0.1	0.2	0.2	0.1	<0.1	<0.1	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(g,h,i)perylene		<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(k)fluoranthene	0.24	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chrysene	0.34	<0.1	0.1	**0.5**	**0.5**	0.3	<0.1	0.2	<0.1	<0.05	0.2	0.1	<0.1	0.1	<0.1	<0.1
Dibenzo(ah)anthracene	0.06	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene	0.75	<0.1	0.1	0.6	0.5	0.3	0.1	0.3	0.1	<0.05	0.2	0.1	<0.1	0.1	<0.1	0.1
Fluorene	0.19	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Indeno(1,2,3-cd)pyrene	0.20	<0.1	<0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Naphthalene		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene	0.56	<0.1	<0.1	0.4	0.4	0.3	<0.1	0.2	<0.1	<0.05	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Pyrene	0.49	<0.1	0.1	**0.5**	0.4	0.3	0.1	0.2	0.1	<0.05	0.2	0.1	<0.1	0.1	<0.1	0.1
Quinoline		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
PAHs, Total	4	<	0.3	2.7	3.0	2.1	0.4	1.1	0.3	<	0.8	0.4	<	0.4	<	0.3
Individual Analytes																
% Moisture		44.7	62.6	66.1	72.8	71.6	66	60.8	65.1	38.3	66.1	58.1	62.3	64	36.2	58.7
Oil and Grease, Total		1400	600	500	600	800	500	600	500	300	600	400	200	400	100	100
PCBs	**LEL**															
Aroclor 1242	-	<0.05	<0.1	<0.1	<0.2	<0.2	<0.1	<0.1	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.04	<0.1
Aroclor 1248	0.03	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.04	<0.1
Aroclor 1254	0.06	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.04	<0.1
Aroclor 1260	0.005	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.04	<0.1
Total PCBs	0.07	<0.05	<0.1	<0.1	<0.2	<0.2	<0.1	<0.1	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.04	<0.1

[a] Field replicate average; [b] For fine textured, industrial land use category (CCME 2008); [c] MOE (1993)

Table 6. Sediment dioxin and furan concentrations (pg/g dw) and toxic equivalents (TEQ) for Jackfish Bay sites. TEQs exceeding the probable effect level are indicated in red. A "<" Indicates that the compound was not detected above the method detection limit or that the target analyte was detected below the Lowest Quantitation Limit (see text). [Estimated Detection Limits = Method detection limits are provided in Appendix B, Table B6].

Location	Moberly bay									Central Jackfish Bay			Lower Jackfish Bay		Tunnel Bay
Site	**M701**	**1M4**	**EEM4**	**1M3**	**1M2[a]**	**JFB002**	**1M1**	**NF5**	**EEM8**	**2M1**	**2M4**	**JFB021**	**2M5**	**4M3**	**3M2**
Analytes	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**
2,3,7,8-TCDD	<1.2	6.63	17.3	10.2	5.52	5.87	7.7	8.04	1.15	8.72	9.03	5.92	10.8	0.232	3.94
1,2,3,7,8-PeCDD	<0.10	<0.51	<1.6	<0.93	<0.86	<1.0	1.12	<1.2	<0.16	1.37	1.44	<1.1	1.9	<0.31	<1.3
1,2,3,4,7,8-HxCDD	<0.11	0.55	<0.43	<0.62	<6.7	<0.60	<0.56	<1.7	<0.30	1.18	0.732	1.06	1.73	<0.14	1.22
1,2,3,6,7,8-HxCDD	<0.11	<1.0	<1.9	1.66	<6.8	1.34	1.17	<1.7	<0.28	1.95	1.98	1.82	2.99	0.542	<2.5
1,2,3,7,8,9-HxCDD	<0.11	1.2	2.15	2.08	<6.8	1.21	1.12	<1.7	<0.29	3.06	2.45	2.43	3.58	<0.45	3.75
1,2,3,4,6,7,8-HpCDD	<2.4	18.9	38.2	24.7	21.1	19.8	17.4	22.1	<2.5	26.7	24.9	24.9	32.8	3.01	29.9
OCDD	12	117	212	175	132.7	110	99.3	149	9.4	141	119	115	163	11.5	155
2,3,7,8-TCDF	13.5	80.2	239	126	61.9	67.5	96.1	93.7	10.2	100	103	62.5	129	0.423	42
1,2,3,7,8-PeCDF	0.603	3.65	6.36	5.61	4.1	4.22	3.46	4.92	<0.41	5.22	3.61	3.1	6.18	0.314	2.84
2,3,4,7,8-PeCDF	0.712	4.38	10.6	8.08	4.4	4.96	4.57	6.54	<0.65	6.56	5.15	4.05	7.75	<0.11	3.45
1,2,3,4,7,8-HxCDF	0.258	1.39	2.05	<2.3	<6.4	2.42	<1.4	<1.5	0.368	3.28	2.12	2.28	3.88	0.783	3.4
1,2,3,6,7,8-HxCDF	<0.072	0.451	<0.59	0.932	<6.3	<0.81	<0.66	<1.3	<0.089	1.42	0.977	1.19	1.54	0.395	1.62
2,3,4,6,7,8-HxCDF	<0.067	<0.32	0.648	<0.55	<6.5	0.788	<0.56	<1.2	<0.098	0.801	0.774	0.931	1.27	<0.14	<1.2
1,2,3,7,8,9-HxCDF	<0.082	<0.25	<0.64	<0.72	<8.0	<0.67	<0.73	<1.5	<0.12	<0.37	<0.21	<0.24	<0.40	<0.040	<0.54
1,2,3,4,6,7,8-HpCDF	1.1	6.11	13.1	6.72	6.6	5.88	6.06	6.19	<0.71	7.56	7.08	7.16	8.8	3.24	8.25
1,2,3,4,7,8,9-HpCDF	<0.15	0.765	<0.83	<0.88	<9.1	<0.81	<0.88	<2.1	<0.13	0.742	<0.70	0.744	<1.1	<0.10	<1.0
OCDF	2.27	30.2	60.5	23.2	24.3	21.9	27.1	22.1	<1.6	14.9	13.9	8.84	14	0.415	10.1
Homologue Group Totals	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**
Total-TCDD	<0.076	9.56	20.5	14.1	6.0	9.99	8.39	8.04	1.58	15.3	12.3	10.8	19.3	7.13	7.05
Total-PeCDD	0.186	3.21	5.81	3.44	2.4	2.77	2.02	2.90	0.297	10.7	7.30	6.46	17.0	4.16	9.66
Total-HxCDD	0.682	7.28	12.8	16.1	5.3	6.21	11.8	8.84	0.567	27.5	23.4	21.8	38.3	7.08	22.5
Total-HpCDD	2.27	37.1	77.3	52.4	34.6	40.3	34.8	46.5	<0.20	61.7	55.7	57.7	74.5	6.78	84.4
Total-TCDF	34.0	189	572	304	143.7	169	222	237	24.6	257	255	177	322	4.30	118
Total-PeCDF	1.80	19.7	43.1	36.4	19.5	17.8	23	11.5	0.419	34.3	30.5	23.7	46.7	4.76	26.7
Total-HxCDF	1.71	6.54	13.5	10.3	4.9	11.1	4.84	5.25	1.07	15.2	12.3	14.2	18.4	4.26	12.8
Total-HpCDF	3.10	22.5	47.7	20.0	14.9	18	19.6	18.5	<0.13	16.8	16.0	12.3	16.2	3.40	14.3
Lower Bound[1] PCDD/F TEQ	1.1	13.6	**35.4**	21.1	10.3	12.4	16.2	16.3	1.7	19.9	19.3	12.4	**25.1**	0.4	9.2
Upper Bound[2] PCDD/F TEQ	2.5	14.2	**37.3**	**22.7**	16.1	13.8	16.8	19.0	2.4	20.0	19.3	13.5	**25.1**	0.9	10.7

[a] Field replicate average; 1 values below detection limit were assigned a zero; [2] values below detection limit non-detects assigned a one

Table 7. Benthic invertebrate dioxin and furan and dioxin-like PCB concentrations (pg/g dry weight) and toxic equivalents (TEQ) (pg TEQ/g wet weight) for Jackfish Bay sites. A "<"indicates that a target analyte was either not detected above the provided estimated detection limit (EDL) or that the value was below the calibrated range but above the estimated detection limit (EDL).

Location	Moberly Bay												South of Moberly Bay				Jackfish Bay				Tunnel Bay					
Site	M701				1M3				1M1				2M1				4M3				3M2					
Organism	chironomid	EDL	oligochaete	EDL	chironomid	EDL	oligochaete	EDL	chironomid	EDL	oligochaete	EDL	oligochaete	EDL	amphipod	EDL	oligochaete	EDL	amphipod	EDL	chironomid	EDL	oligochaete	EDL	amphipod	EDL
Target Analytes	pg/g		pg/g		pg/g		pg/g		pg/g		pg/g		pg/g		pg/g		pg/g		pg/g		pg/g		pg/g		pg/g	
2,3,7,8-TCDD	<4.5	1.7	<4.7	0.7	18.3	15	10.0	1.7	16.4	3.2	5.86	3.1	<7.6	2.2	<40	40	<15	15	<14	14	<5.0	5	<6.0	6	<4.3	4.3
1,2,3,7,8-PeCDD	<1.1	1.1	<0.56	0.6	<11	11	<1.7	1.7	<4.3	4.3	<1.8	1.8	<1.2	1.2	<26	26	<7.5	7.5	<6.7	6.7	<2.7	2.7	<3.9	3.9	3.61	1.4
1,2,3,4,7,8-HxCDD	<1.8	1.8	<0.55	0.6	<6.3	6.3	<1.6	1.6	<7.2	7.2	<1.9	1.9	<2.4	2.4	<29	29	<10	10	<9.7	9.7	<4.6	1.4	<4.3	4.3	<2.3	1.8
1,2,3,6,7,8-HxCDD	<1.8	1.8	<0.56	0.6	<6.6	6.6	<1.7	1.7	<7.6	7.6	<2.0	2	<2.5	2.5	<29	29	<11	11	<9.7	9.7	<5.2	2.4	<4.3	4.3	<3.7	1.9
1,2,3,7,8,9-HxCDD	<1.8	1.8	<0.55	0.6	<6.4	6.4	<1.6	1.6	<6.9	6.9	<1.9	1.9	<2.3	2.3	<28	28	<9.7	9.7	<10	10	<2.3	2.3	<4.5	4.5	<2.7	1.7
1,2,3,4,6,7,8-HpCDD	<6.3	3.4	<4.2	1.4	47.8	13	24.9	2.8	34.3	9.7	7.67	3.5	<4.8	2.8	<43	43	<17	12	22.3	11	22.6	4.3	13.9	4	14.2	2.8
OCDD	<23	9.6	40.3	2.5	190	25	158	11	70.6	28	35.1	6.9	11.7	4.6	98.1	35	<44	18	53.8	23	<70	6.3	<40	10	125	6.0
2,3,7,8-TCDF	75.4	1	81.0	0.4	210	10	138	1	223	3.2	76.7	1.4	108	2.6	191	24	<8.4	8.4	<12	12	24.2	3.3	27.6	3.2	74.7	2.2
1,2,3,7,8-PeCDF	2.34	0.9	<0.84	0.4	<9.8	9.8	<1.8	1	<2.6	2.6	<1.2	1.2	3.23	1.4	23.7	14	<5.6	5.6	<4.9	4.9	<2.2	2.2	<2.2	2.2	<4.0	1.3
2,3,4,7,8-PeCDF	<3.4	0.8	<2.1	0.4	<10	8.9	3.48	1	10.6	2.3	3.87	1	<7.3	1.3	46.5	12	<9.0	5.3	13.5	4.4	<4.2	2.2	5.65	2	9.64	1.2
1,2,3,4,7,8-HxCDF	<0.89	0.9	<0.55	0.6	<7.0	7	<1.1	1.1	<3.0	3	<1.6	1.6	1.61	1.1	<12	12	<6.7	6.7	<5.2	5.2	3.06	2.3	<2.9	2.9	5.62	1.7
1,2,3,6,7,8-HxCDF	<0.91	0.9	<0.57	0.6	<7.1	7.1	<1.0	1	<3.0	3	<1.6	1.6	2.99	1.1	<12	12	<6.6	6.6	<8.5	5.1	<4.8	2.3	5.37	2.9	5.83	1.7
2,3,4,6,7,8-HxCDF	<1.0	1	<0.62	0.6	<7.5	7.5	<1.1	1.1	<3.3	3.3	<1.7	1.7	<1.3	1.3	<14	14	<7.4	7.4	5.65	5.6	<2.7	2.7	<3.1	3.1	<2.0	2.0
1,2,3,7,8,9-HxCDF	<1.4	1.4	<0.86	0.9	<9.3	9.3	<1.6	1.6	<4.5	4.5	<2.4	2.4	<1.6	1.6	<17	17	<8.7	8.7	<7.1	7.1	<3.2	3.2	<4.1	4.1	<2.5	2.5
1,2,3,4,6,7,8-HpCDF	<2.1	2.1	<0.95	0.6	<10	10	<1.7	1.6	<6.1	6.1	<1.5	1.5	<2.4	1.9	<20	20	<6.9	6.5	<8.3	6.3	<5.5	2.3	<4.8	3.6	<6.5	1.9
1,2,3,4,7,8,9-HpCDF	<3.9	3.9	<1.1	1.1	<18	18	<3.2	3.2	<11	11	<2.7	2.7	<3.4	3.4	<35	35	<11	11	<10	10	<4.0	4	<5.8	5.8	<3.4	3.4
OCDF	<6.3	6.3	<2.7	2.7	<23	23	<5.7	4.1	27.1	20	<7.2	7.2	5.71	3.6	<54	49	31.9	12	43.3	11	29.4	4.8	22.8	9.2	51.3	4.4
PCB-81	<1.3	1.3	0.837	0.4	<6.5	6.5	1.32	0.7	3.98	3.4	<1.3	1.3	<1.6	1.6	<18	18	<5.6	5.6	<3.8	3.8	<2.2	2.2	<1.8	1.8	3.46	1.1
PCB-77	27.1	1.2	21.2	0.4	63.8	6.8	47.8	0.8	74.0	3.6	35.7	1.4	31.2	1.7	94.4	18	21.0	5.9	86.6	3.9	22.5	2.4	17.3	1.9	48.0	1.1
PCB-123	15.2	3	12.6	0.5	<31	9.5	<22	1	<45	5.4	21.1	1.8	31.7	2.6	<24	24	<9.1	9.1	43.1	9.8	<21	3.5	15.8	5.3	50.7	2.6
PCB-118	748	2.8	698	0.5	2580	9.4	1610	1	3520	5.3	1370	1.8	1980	2.5	4130	23	379	8.7	1550	9.5	1370	3.4	827	5.1	2670	2.6
PCB-114	<16	3.9	17.5	0.5	48.3	10	31.6	1.2	65.9	6.3	26.0	1.9	25.6	2.7	<25	25	<11	11	<36	10	27.4	3.7	19.1	5.7	54.1	2.8
PCB-105	308	2.5	289	0.5	986	10	565	1	1150	6.4	432	2	620	2.9	1390	26	134	9.3	589	11	538	3.7	286	6	939	2.9
PCB-126	3.34	1.3	3.02	0.5	<9.8	9.8	5.68	0.9	16.5	5.9	3.00	1.8	12.3	2.6	<22	22	<8.1	8.1	28.0	9.6	13.8	3.1	<11	5.5	33.2	2.5
PCB-167	46.6	1.5	34.0	0.3	<120	2.7	53.5	0.7	236	3.5	61.7	1.3	249	1.5	457	17	36.9	6.6	171	4.1	285	1.3	192	1.3	527	1.2
PCB-156	102	1.3	76.9	0.3	325	2.5	109	0.6	516	2.9	135	1.1	439	1.3	900	14	58.5	5.7	264	3.2	477	1.1	299	1.1	820	1.0
PCB-157	<14	1	14.0	0.3	60.6	2.3	22.6	0.5	76.7	2.7	<17	1	91.2	1.2	<160	14	15.6	5.1	59.6	3	109	1.1	74.4	1	184	1.0
PCB-169	<0.58	0.6	<0.25	0.3	<1.8	1.8	<0.53	0.5	<2.4	2.4	<0.80	0.8	2.84	1	<11	11	<4.2	4.2	<13	2.7	4.61	1	<4.5	0.9	<9.1	0.9
PCB-189	14.0	1.4	9.07	0.3	46.6	7	14.0	0.9	87.5	3.3	20.1	1.1	96.9	1	169	13	<14	4	58.3	4.4	121	2	102	1.8	192	1.4
Homologue Group Totals	pg/g		pg/g		pg/g		pg/g		pg/g		pg/g		pg/g		pg/g		pg/g		pg/g		pg/g		pg/g		pg/g	
Total-TCDD	<1.7	1.7	<0.68	0.7	18.3	15	10.0	1.7	24.0	3.2	5.86	3.1	<2.2	2.2	<40	40	<15	15	<14	14	<5.0	5	<6.0	6	<4.3	4.3
Total-PeCDD	<1.1	1.1	<0.56	0.6	<11	11	<1.7	1.7	13.7	4.3	<1.8	1.8	3.56	1.2	<26	26	<7.5	7.5	<6.7	6.7	18.8	2.7	<3.9	3.9	19.7	1.4
Total-HxCDD	3.52	1.8	<0.56	0.6	<6.6	6.6	<1.7	1.7	<7.6	7.6	<2.0	2	<2.5	2.5	<29	29	<11	11	<10	10	<2.4	2.4	<4.5	4.5	<1.9	1.9
Total-HpCDD	<3.4	3.4	<1.4	1.4	47.8	13	24.9	2.8	34.3	9.7	8.61	3.5	<2.8	2.8	<43	43	<12	12	22.3	11	22.6	4.3	13.9	4	14.2	2.8
Total-TCDF	147	1	145	0.4	356	10	233	1	467	3.2	125	1.4	221	2.6	302	24	<8.4	8.4	78.0	12	40.8	3.3	53.4	3.2	225	2.2
Total-PeCDF	12.4	0.9	2.04	0.4	<9.8	9.8	5.44	1	31.7	2.6	3.87	1.2	22.5	1.4	70.2	14	<5.6	5.6	39.8	4.9	48.9	2.2	10.2	2.2	54.1	1.3
Total-HxCDF	2.93	1.4	1.18	0.9	<9.3	9.3	<1.6	1.6	12.1	4.5	<2.4	2.4	5.10	1.6	<17	17	<8.7	8.7	25.1	7.1	34.9	3.2	13.7	4.1	33.3	2.5
Total-HpCDF	<3.9	3.9	<1.1	1.1	<18	18	<3.2	3.2	<11	11	<2.7	2.7	<3.4	3.4	<35	35	<11	11	<10	10	9.51	4	<5.8	5.8	6.30	3.4
Toxic Equivalency WHO (1998)	pg/g		pg/g		pg/g		pg/g		pg/g		pg/g		pg/g		pg/g		pg/g		pg/g		pg/g		pg/g		pg/g	
Lower Bound TEQ - PCDD/F	11.1		11.9		33.6		22.3		36.8		12.7		16.0		35.3		0.0		2.1		3.6		5.0		13.1	
Upper Bound TEQ - PCDD/F	12.6		13.1		37.5		22.7		37.8		13.2		18.5		46.5		6.6		7.5		5.6		6.7		13.9	
Lower Bound TEQ - PCB	0.26		0.22		0.49		0.47		0.88		0.32		0.43		0.73		0.16		1.06		0.39		0.14		0.93	
Upper Bound TEQ - PCB	0.28		0.22		0.73		0.47		0.88		0.34		0.45		1.33		0.36		1.12		0.42		0.33		0.93	
Lower Bound TEQ - TOTAL	11.4		12.1		34.1		22.8		37.6		13.0		16.4		36.0		0.2		3.1		4.0		5.1		14.0	
Upper Bound TEQ - TOTAL	12.8		13.3		38.2		23.1		38.7		13.5		18.9		47.9		7.0		8.6		6.1		7.1		14.9	
% of D/Fs to total TEQ (Lower)	97.8		98.2		98.6		97.9		97.7		97.6		97.4		98.0		0.3		66.1		90.3		97.3		93.4	
% of D/Fs to total TEQ (Upper)	97.9		98.3		98.1		98.0		97.7		97.5		97.6		97.2		94.9		87.0		93.0		95.4		93.8	

[1] non-detects assigned a zero; [2] non-detects assigned a one

Table 8. Probabilities of test sites belonging to Great Lakes faunal groups 1-5.

Location	Site	Probability of Membership				
		Group 1	**Group 2**	**Group 3**	**Group 4**	**Group 5**
Moberly Bay	M701	0.153	0.002	0.000	0.000	**0.845**
	1M4	0.134	0.001	0.000	0.000	**0.865**
	EEM4	0.157	0.001	0.000	0.000	**0.842**
	1M3	0.083	0.001	0.000	0.001	**0.915**
	1M2*	0.083	0.001	0.000	0.001	**0.915**
	JFB002	0.100	0.001	0.000	0.001	**0.898**
	1M1	0.064	0.001	0.000	0.000	**0.935**
	NF5	0.133	0.001	0.000	0.000	**0.866**
	EEM8	0.056	0.002	0.000	0.000	**0.941**
Central Jackfish Bay	2M1	0.006	0.000	0.000	0.000	**0.994**
	2M4	0.011	0.000	0.000	0.000	**0.989**
	JFB021	0.004	0.000	0.000	0.000	**0.996**
Lower Jackfish Bay	2M5	0.008	0.000	0.000	0.000	**0.991**
	4M3	0.004	0.000	0.000	0.000	**0.996**
Tunnel Bay	3M2	0.014	0.000	0.000	0.000	**0.985**

Table 9. Mean abundance of the predominant Great Lakes Reference Group 5 macroinvertebrate families (per 33 cm^2) present in Jackfish Bay and taxon diversity (based on 38-family Great Lakes bioassessment model). Families expected to be present at Jackfish that are absent are highlighted yellow.

Family	Group 5 Mean	Occurrence in Group 5 (%)	Moberly Bay								
			M701	1M4	EEM4	1M3	1M2[a]	JFB002	1M1	NF5	EEM8
No. Taxa (± 2 SD)	**6 (2 – 9)**	**-**	**5**	**6**	**7**	**4**	**3**	**3**	**3**	**5**	**9**
Pontoporeiidae	12.1	44.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06
Tubificidae[b]	4.5	16.6	401.24	336.44	309.60	275.83	277.22	320.56	237.40	301.93	37.67
Sphaeriidae	3.1	11.5	1.81	3.67	3.78	0.43	0.50	1.56	0.80	4.22	0.13
Chironomidae	2.7	9.9	31.34	23.03	25.34	0.43	1.20	4.13	1.00	11.91	2.68
Lumbriculidae	1.8	6.8	1.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69
Enchytraeidae	1.4	5.3	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.04
Naididae	0.5	1.9	0.00	0.20	1.35	0.20	0.00	0.00	0.00	0.47	4.07
Asellidae	0.4	1.5	2.96	0.94	0.20	0.00	0.00	0.00	0.00	0.00	0.67
Valvatidae	0.2	0.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gammaridae	0.2	0.6	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.23	0.00

Family	Group 5 Mean	Occurrence in Group 5 (%)	Central Jackfish Bay			Lower Jackfish Bay		Tunnel bay
			2M1	2M4	JFB021	2M5	4M3	3M2
No. Taxa (± 2 SD)	**6 (2 – 9)**	**-**	**4**	**4**	**4**	**4**	**7**	**4**
Pontoporeiidae	12.1	44.3	0.60	0.80	3.20	1.80	1.21	4.60
Tubificidae[b]	4.5	16.6	4.00	5.00	3.40	3.20	0.02	4.00
Sphaeriidae	3.1	11.5	1.20	0.40	0.40	0.20	0.33	1.20
Chironomidae	2.7	9.9	1.20	3.00	1.80	1.40	1.17	3.60
Lumbriculidae	1.8	6.8	0.00	0.00	0.00	0.00	0.88	0.00
Enchytraeidae	1.4	5.3	0.00	0.00	0.00	0.00	0.82	0.00
Naididae	0.5	1.9	0.00	0.00	0.00	0.00	0.23	0.00
Asellidae	0.4	1.5	0.00	0.00	0.00	0.00	0.00	0.00
Valvatidae	0.2	0.7	0.00	0.00	0.00	0.00	0.00	0.00
Gammaridae	0.2	0.6	0.00	0.00	0.00	0.00	0.00	0.00

[a] QA/QC site; value represent the mean of three field replicates; [b] includes immatures with and without chaetal hairs

Table 10. Site assessment summary for Jackfish Bay benthic community data and comparison to 2003 results. Overall site categorizations are colour-coded for ease of comparison.

Site	Location	Stress[a]	Vector 1 vs. 2	Vector 1 vs. 3	Vector 2 vs. 3	Overall 2007	Overall 2003[b]
M701	Moberly Bay	0.12	Very different	Very different	Very different	Very different	Very different
1M4	Moberly Bay	0.12	Very different	Very different	Very different	Very different	-
EEM4	Moberly Bay	0.12	Very different	Very different	Very different	Very different	-
1M3	Moberly Bay	0.12	Very different	Very different	Very different	Very different	Different
1M2	Moberly Bay	0.12	Very different	Very different	Very different	Very different	Very different
JFB002	Moberly Bay	0.14	Very different	Equivalent	Very different	Very different	-
1M1	Moberly Bay	0.14	Very different	Equivalent	Very different	Very different	Very different
NF5	Moberly Bay	0.14	Very different	Equivalent	Very different	Very different	-
EEM8	Moberly Bay	0.14	Different	Equivalent	Different	Different	-
2M1	Central Jack. Bay	0.15	Possibly different	Different	Equivalent	Different	Different
2M4	Central Jack. Bay	0.15	Possibly different	Possibly different	Equivalent	Possibly different	-
JFB021	Central Jack. Bay	0.15	Possibly different	Possibly different	Equivalent	Possibly different	-
2M5	Lower Jackfish Bay	0.16	Equivalent	Equivalent	Possibly different	Possibly different	-
4M3	Lower Jackfish Bay	0.16	Equivalent	Possibly different	Equivalent	Possibly different	Possibly different
3M2	Tunnel Bay	0.16	Equivalent	Equivalent	Equivalent	Equivalent	Possibly different

[a] HMDS of a subset of 3-5 sites with Great Lakes reference group 5 sites (n=75); [b] Milani and Grapentine (2007)

Table 11. Mean percent survival, growth (mg dry weight) and reproduction per individual in sediment toxicity tests. Toxicity, based on numerical guidelines (Reynoldson and Day 1998), is highlighted in red and potential toxicity in blue.

Site	*C. riparius*		*H. azteca*		*Hexagenia* spp.		*T. tubifex*			
	% survival	growth	% survival	growth	% survival	growth	% survival	No. cocoons/ adult	% hatch	No. young/ adult
GL Reference Mean[a]	87.1	0.35	85.6	0.50	96.2	3.03	97.9	9.9	57.0	29.0
M701	78.7	0.361	72.0	***0.210***	**76**	1.856	100	12.0	59.0	35.6
1M4	88.0	0.263	72.0	***0.206***	98	***0.520***	100	10.4	56.3	18.1
EEM4	92.0	0.235	69.3	***0.212***	100	0.924	100	10.7	58.6	26.8
1M3	81.7	0.231	70.7	0.260	100	***0.544***	100	10.9	58.1	17.5
1M2	70.7	0.183	**20.0**	***0.137***	100	***0.266***	100	10.9	55.8	27.7
JFB002	97.3	0.249	***64.0***	***0.132***	100	***0.196***	100	10.3	59.4	20.9
1M1	81.3	0.291	82.7	0.273	100	2.170	100	11.0	58.2	26.9
NF5	98.7	0.228	88.0	***0.199***	96	***0.504***	100	11.5	58.6	24.7
EEM8	88.0	0.383	78.7	***0.208***	100	3.292	100	8.8	56.6	25.5
2M1	92.0	0.377	71.7	***0.142***	100	2.624	100	9.9	61.5	20.3
2M4	98.3	0.344	86.7	***0.192***	100	2.628	100	10.3	61.1	26.4
JFB021	100	0.377	72.0	0.635	100	3.120	100	12.4	58.5	36.0
2M5	97.3	0.324	93.3	0.410	100	3.052	100	9.9	53.1	24.5
4M3	86.7	0.383	77.3	0.466	100	2.550	100	9.6	62.5	28.8
3M2	97.3	0.363	78.7	0.595	100	3.126	100	10.3	59.8	31.8
Non-toxic[b]	≥67.7	0.49-0.21	≥67.0	0.75- 0.23	≥85.5	5.0 – 0.9	≥88.9	12.4 – 7.2	78.1-38.1	46.3 – 9.9
Pot. toxic	67.6-58.8	0.20-0.14	66.9-57.1	0.22-0.10	85.4-80.3	0.89 – 0	88.8-84.2	7.1 – 5.9	38.0-28.1	9.8 – 0.8
Toxic	**< 58.8**	**< 0.14**	**< 57.1**	**< 0.10**	**< 80.3**	**negative**	**< 84.2**	**< 5.9**	**< 28.1**	**< 0.8**

[a] Environment Canada, unpublished data; [b] The upper limit for non-toxic category is set using 2 × standard deviation of the mean and indicates excessive growth or reproduction (Reynoldson and Day 1998)

Table 12. Site assessment summary for toxicity data and comparison to 2003 results. Overall site categorizations are colour-coded for ease of comparison.

Site	Location	Stress[a]	Vector 1 vs. 2	Vector 1 vs. 3	Vector 2 vs. 3	Overall 2007	Overall 2003[b]
M701	Moberly Bay	0.11	Potentially toxic	Potentially toxic	Non-toxic	Potentially toxic	Non-toxic
1M4	Moberly Bay	0.11	Non-toxic	Non-toxic	Non-toxic	Non-toxic	-
EEM4	Moberly Bay	0.11	Non-toxic	Non-toxic	Non-toxic	Non-toxic	-
1M3	Moberly Bay	0.11	Non-toxic	Non-toxic	Non-toxic	Non-toxic	Severely toxic
1M2	Moberly Bay	0.11	Potentially toxic	Severely toxic	Severely toxic	Severely toxic	Severely toxic
JFB002	Moberly Bay	0.11	Non-toxic	Non-toxic	Potentially toxic	Potentially toxic	-
1M1	Moberly Bay	0.11	Non-toxic	Non-toxic	Non-toxic	Non-toxic	Severely toxic
NF5	Moberly Bay	0.11	Non-toxic	Non-toxic	Non-toxic	Non-toxic	-
EEM8	Moberly Bay	0.11	Non-toxic	Non-toxic	Non-toxic	Non-toxic	-
2M1	Central Jack. Bay	0.12	Non-toxic	Non-toxic	Non-toxic	Non-toxic	Non-toxic
2M4	Central Jack. Bay	0.12	Non-toxic	Non-toxic	Non-toxic	Non-toxic	-
JFB021	Central Jack. Bay	0.12	Non-toxic	Non-toxic	Non-toxic	Non-toxic	-
2M5	Lower Jackfish Bay	0.12	Non-toxic	Non-toxic	Non-toxic	Non-toxic	-
4M3	Lower Jackfish Bay	0.12	Non-toxic	Non-toxic	Non-toxic	Non-toxic	Severely toxic
3M2	Tunnel Bay	0.12	Non-toxic	Non-toxic	Non-toxic	Non-toxic	Severely toxic

[a] HMDS of a subset of 6-9 sites with Great Lakes reference sites (n=136); [b] Milani and Grapentine (2007)

Table 13. Comparison of 2008 and 2003 *Hyalella* and *Hexagenia* endpoint results for sites in similar locations. The greatest differences between years are highlighted.

Location	Site	*H. azteca* % survival		*H. azteca* growth		*Hexagenia* spp. % survival		*Hexagenia* spp. growth	
		2003	**2008**	**2003**	**2008**	**2003**	**2008**	**2003**	**2008**
MB	M701	90.7	72.0	0.38	0.21	100	76	2.51	1.86
MB	1M3	32.0	70.7	0.27	0.26	98	100	0.59	0.54
MB	1M2	32.0	20.0	0.06	0.14	100	100	0.07	0.27
MB	1M1	13.3	82.7	0.27	0.27	100	100	0.81	2.17
Central JB	2M1	90.0	71.7	0.71	0.14	100	100	2.29	2.62
Lower JB	4M3	8.0	77.3	0.07	0.47	98	100	1.09	2.55
TB	3M2	44.0	78.7	0.58	0.60	100	100	2.54	3.13

[a] Milani and Grapentine (2007)

Table 14. Decision matrix for weight-of-evidence categorization of 2008 Jackfish Bay sites based on three or four lines of evidence. For the sediment chemistry column, sites with exceedences of the Probable Effect Level (PEL) are indicated by "■"; sites with exceedences of the Lowest Effect Level (LEL) or the Canada Wide Standards (CWS) for PHCs by "◘". For the toxicity and benthos alteration column, sites determined from BEAST analyses as *different/very different* or *toxic/severely* toxic are indicated by "■"; sites determined as *possibly different* or *potentially toxic* by "◘". Sites with no sediment quality guideline exceedences, benthic communities equivalent to reference conditions, and non-toxic sediments are indicated by "□".

Location	Site	Sediment Chemistry	Toxicity	Benthos Alteration	Biomag. Potential	>LEL, PEL or CWS	Assessment
Moberly Bay	M701	□	◘	■	◘	-	Determine reason(s) for benthos alteration and sediment toxicity and fully assess risk of biomagnification
	1M4	◘	□	■	ND	Metals	Determine reason(s) for benthos alteration
	EEM4	■	□	■	ND	F3 PHC, D/Fs	Determine reason(s) for benthos alteration
	1M3	■	□	■	◘	F3 PHC, D/Fs	Determine reason(s) for benthos alteration and fully assess risk of biomagnification
	1M2	◘	■	■	ND	F3 PHC, Metals	Management actions required
	JFB002	◘	◘	■	ND	Metals	Determine reason(s) for benthos alteration and sediment toxicity
	1M1	◘	□	■	◘	Metals	Determine reason(s) for benthos alteration and fully assess risk of biomagnification
	NF5	◘	□	■	ND	Metals	Determine reason(s) for benthos alteration
	EEM8	□	□	■[a]	ND	-	No further actions needed
Central Jackfish Bay	2M1	◘	□	■[a]	◘	Metals	Fully assess risk of biomagnification
	2M4	◘	□	◘[a]	ND	Metals	No further actions needed
	JFB021	◘	□	◘[a]	ND	Metals	No further actions needed
Lower Jackfish Bay	2M5	■	□	◘[a]	ND	D/Fs	No further actions needed
	4M3	◘	□	◘[a]	□	Metals	No further actions needed
Tunnel Bay	3M2	◘	□	□	◘	Metals	Fully assess risk of biomagnification

[a]Benthos not considered degraded based on abundance and/or taxa richness; ND=not determined

Table 15. Comparison of 2008 and 2003 decision matrices for sites in similar locations.

Site	Year	Sediment Chemistry	Toxicity	Benthos Alteration	Biomag. Potential	>LEL, PEL or CWS	Assessment
M701	2008	□	▣	■	▣	-	Determine reason(s) for benthos alteration and sediment toxicity and fully assess risk of biomagnification
M701	2003	▣	□	■	ND	Metals	Determine reason(s) for benthos alteration
1M3	2008	■	□	■	▣	F3 PHC, D/Fs	Determine reason(s) for benthos alteration and fully assess risk of biomagnification
1M3	2003	■	■	■	ND	D/Fs, Metals	Management actions required
1M2	2008	■	■	■	ND	F3 PHC, Metals	Management actions required
1M2	2003	■	■	■	ND	D/Fs, Metals	Management actions required
1M1	2008	▣	□	■	▣	Metals	Determine reason(s) for benthos alteration and fully assess risk of biomagnification
1M1	2003	■	■	■	ND	D/Fs, Metals	Management actions required
2M1	2008	▣	□	■	▣	Metals	Determine reason(s) for benthos alteration and fully assess risk of biomagnification
2M1	2003	■	□	■	ND	D/Fs, Metals	Determine reason(s) for benthos alteration
4M3	2008	▣	□	▣[a]	□	Metals	No further actions needed
4M3	2003	▣	■	▣[a]	ND	Metals	Determine reason(s) for sediment toxicity
3M2	2008	▣	□	□	▣	Metals	Fully assess risk of biomagnification
3M2	2003	▣	▣	▣[a]	ND	Metals	Determine reason(s) for sediment toxicity

[a]Benthos not considered degraded based on abundance and taxa richness; ND = not determined

Appendix A – QA / QC

Table A1. Coefficient of variation (CV) for trace metals and nutrients in field-replicated samples and relative percent difference (RPD) for laboratory duplicates (Caduceon Environmental Laboratory).

Parameter	Units	M.D.L.	1M200	1M201	1M202	1M2 avg	SD	CV	2M4	2M4 Dup	R.P.D.	5105	5105 Dup	R.P.D.
Aluminum	µg/g	10	8430	8170	8330	8310	131.1	**1.6**	8480	8150	**4.0**	14200	14300	**0.7**
Antimony	µg/g	5	< 5	< 5	< 5	< 5	-	**-**	< 5	< 5	**0.0**	< 5	< 5	**0.0**
Arsenic	µg/g	5	< 5	< 5	< 5	< 5	-	**-**	< 5	< 5	**0.0**	6	9	**40.0**
Barium	µg/g	1	71	71	72	71	0.6	**0.8**	58	56	**3.5**	138	141	**2.2**
Beryllium	µg/g	0.2	0.3	0.3	0.3	0.3	0.0	**0.0**	0.4	0.3	**28.6**	0.7	0.7	**0.0**
Bismuth	µg/g	5	< 5	< 5	< 5	< 5	-	**-**	< 5	< 5	**0.0**	< 5	< 5	**0.0**
Cadmium	µg/g	0.5	1.5	1.5	1.6	1.5	0.1	**3.8**	0.8	0.9	**11.8**	0.5	0.6	**18.2**
Calcium	µg/g	10	17200	17900	17800	17633.333	378.6	**2.1**	7810	7670	**1.8**	8910	9040	**1.4**
Chromium	µg/g	1	53	47	45	48	4.2	**8.6**	42	40	**4.9**	47	47	**0.0**
Cobalt	µg/g	1	8	8	8	8	0.0	**0.0**	8	8	**0.0**	17	18	**5.7**
Copper	µg/g	1	35	35	36	35	0.6	**1.6**	40	39	**2.5**	60	60	**0.0**
Iron	µg/g	10	15400	14900	15000	15100	264.6	**1.8**	18200	17400	**4.5**	34300	34400	**0.3**
Lead	µg/g	5	9	9	9	9	0.0	**0.0**	20	20	**0.0**	22	24	**8.7**
Magnesium	µg/g	10	12000	12200	12200	12133.333	115.5	**1.0**	7400	7110	**4.0**	11100	11200	**0.9**
Manganese	µg/g	1	341	331	355	342	12.1	**3.5**	585	578	**1.2**	810	810	**0.0**
Mercury	µg/g	0.005	0.065	0.063	0.076	0.068	0.0	**10.3**	0.113	0.112	**0.9**	0.049	0.049	**0.0**
Molybdenum	µg/g	1	< 1	< 1	< 1	< 1	-	**-**	< 1	< 1	**0.0**	< 1	< 1	**0.0**
Nickel	µg/g	1	25	24	25	25	0.6	**2.3**	23	22	**4.4**	38	38	**0.0**
Phosphorus	µg/g	5	1010	979	1020	1003	21.4	**2.1**	1020	1020	**0.0**	923	924	**0.1**
Potassium	µg/g	30	1290	1260	1280	1277	15.3	**1.2**	1140	1060	**7.3**	2430	2490	**2.4**
Silicon	µg/g	1	184	282	230	232	49.0	**21.1**	323	229	**34.1**	466	421	**10.1**
Silver	µg/g	0.2	0.7	0.7	0.6	0.7	0.1	**8.7**	0.4	0.4	**0.0**	< 0.2	< 0.2	**0.0**
Sodium	µg/g	20	770	720	700	730	36.1	**4.9**	750	710	**5.5**	930	1040	**11.2**
Strontium	µg/g	1	20	20	20	20	0.0	**0.0**	18	17	**5.7**	47	47	**0.0**
Tin	µg/g	10	< 10	< 10	< 10	< 10	-	**-**	< 10	< 10	**0.0**	< 10	< 10	**0.0**
Titanium	µg/g	1	623	635	634	631	6.7	**1.1**	826	767	**7.4**	1970	2050	**4.0**
Vanadium	µg/g	1	32	31	31	31	0.6	**1.8**	37	35	**5.6**	88	88	**0.0**
Yttrium	µg/g	0.5	5.6	5.5	5.5	5.5	0.1	**1.0**	7.1	6.8	**4.3**	12.1	12.2	**0.8**
Zinc	µg/g	1	191	191	195	192	2.3	**1.2**	100	102	**2.0**	110	110	**0.0**
Zirconium	µg/g	0.1	2.3	2.2	2.5	2.3	0.2	**6.5**	2.3	2.0	**14.0**	8.4	8.4	**0.0**
Aluminum (Al_2O_3)	%	0.01	11.7	11.4	11.4	11.5	0.2	**1.5**	13.2	13.5	**2.2**	13.9	14.2	**2.1**
Calcium (CaO)	%	0.01	4.34	4.50	4.55	4.46	0.1	**2.5**	7.92	7.46	**6.0**	2.60	3.80	**37.5**
Iron (Fe_2O_3)	%	0.05	3.98	4.11	3.99	4.03	0.1	**1.8**	5.98	5.89	**1.5**	7.62	7.86	**3.1**
Magnesium (MgO)	%	0.01	2.98	3.11	3.04	3.04	0.1	**2.1**	6.16	6.68	**8.1**	3.3	3.51	**6.2**
Manganese (MnO)	%	0.01	0.08	0.08	0.08	0.08	0.0	**0.0**	0.13	0.13	**0.0**	0.16	0.17	**6.1**
Phosphorus (P_2O_5)	%	0.03	0.14	0.21	0.21	0.19	0.0	**21.7**	0.14	0.21	**40.0**	0.18	0.39	**73.7**
Potasium (K20)	%	0.01	2.12	1.83	2.01	1.99	0.1	**7.4**	2.20	2.46	**11.2**	2.37	2.37	**0.0**
Silica (SiO_2)	%	0.01	53.8	53.4	53.6	53.6	0.2	**0.4**	49.9	49.9	**0.0**	50.5	52.9	**4.6**
Sodium (Na2O)	%	0.01	2.76	2.73	2.81	2.77	0.0	**1.5**	2.48	3.61	**37.1**	4.67	3.78	**21.1**
Titanium (TiO_2)	%	0.01	0.62	0.62	0.62	0.62	0.0	**0.0**	0.75	0.71	**5.5**	1.10	1.10	**0.0**
Loss on Ignition	%	0.05	22.3	22.3	22.5	22.4	0.1	**0.5**	11.2	12.4	**10.2**	8.92	8.92	**0.0**
Whole Rock Total	%		105	104	105	105	0.6	**0.6**	100	103	**3.0**	95.4	99.1	**3.8**
Total Organic Carbon	% by wt	0.1	6.6	6.8	6.8	6.7	0.1	**1.7**	3.1	3.0	**3.3**	1.3	1.2	**8.0**
Total Kjeldahl Nitrogen	µg/g	0.05	4620	4990	4560	4723	232.9	**4.9**	1980	1940	**2.0**	1960	2160	**9.7**
Phosphorus-Total	µg/g	0.01	969	1060	945	991	60.7	**6.1**	942	983	**4.3**	968	1040	**7.2**
							min	**0.0**			**0.0**			**0.0**
							max	**21.7**			**40.0**			**73.7**
							median	**1.7**			**4.0**			**0.9**

Table A2. Coefficients of variation (CV) for organic contaminants in field-replicated sample (1M2) (ALS Laboratory Group - Mississauga). “<” = below method detection limit.

Parameter	Units	1M200	1M201	1M202	Mean	SD	CV
BTEX							
Toluene	mg/kg	0.08	0.11	0.11	0.1	0.02	17.3
CCME Total Hydrocarbons							
F1 (C6-C10)	mg/kg	<5	<5	<5	-	-	-
F1-BTEX	mg/kg	<5	<5	<5	-	-	-
F2 (C10-C16)	mg/kg	96	97	77	90	11	13
F2-Naphth	mg/kg	96	97	77	90	11	13
F3 (C16-C34)	mg/kg	3560	3440	3280	3427	140	4
F3-PAH	mg/kg	3560	3440	3280	3427	140	4
F4 (C34-C50)	mg/kg	760	710	730	733	25	3
F4G-SG (GHH-Silica)	mg/kg	2300	3100	3000	2800	436	16
Total Hydrocarbons (C6-C50)	mg/kg	4420	4250	4090	4253	165	4
CCME PAHs							
1-Methylnaphthalene	mg/kg	<0.1	<0.1	<0.1	-	-	-
2-Methylnaphthalene	mg/kg	<0.1	<0.1	<0.1	-	-	-
Acenaphthene	mg/kg	<0.1	<0.1	<0.1	-	-	-
Acenaphthylene	mg/kg	<0.1	<0.1	<0.1	-	-	-
Acridine	mg/kg	<2	<2	<2	-	-	-
Anthracene	mg/kg	0.4	0.5	0.4	0.4	0.1	13.3
Benzo(a)anthracene	mg/kg	0.1	0.1	0.1	0.1	0.0	0
Benzo(a)pyrene	mg/kg	0.08	0.11	0.1	0.1	0.0	15.8
Benzo(b)fluoranthene	mg/kg	0.1	0.2	0.1	0.1	0.1	43.3
Benzo(g,h,i)perylene	mg/kg	<0.1	<0.1	<0.1	-	-	-
Benzo(k)fluoranthene	mg/kg	<0.1	<0.1	<0.1	-	-	-
Chrysene	mg/kg	0.3	0.3	0.3	0.3	0	0
Dibenzo(ah)anthracene	mg/kg	<0.1	<0.1	<0.1	-	-	-
Fluoranthene	mg/kg	0.3	0.4	0.3	0.3	0.1	17.3
Fluorene	mg/kg	<0.1	<0.1	<0.1	-	-	-
Indeno(1,2,3-cd)pyrene	mg/kg	<0.1	0.1	<0.1	0.1	-	-
Naphthalene	mg/kg	<0.1	<0.1	<0.1	-	-	-
Phenanthrene	mg/kg	0.3	0.3	0.3	0.3	0	0
Pyrene	mg/kg	0.2	0.3	0.3	0.3	0.1	21.7
Quinoline	mg/kg	<0.1	<0.1	<0.1	-	-	-
Individual Analytes							
Oil and Grease, Total	mg/kg	700	1100	600	800	265	33

min	0.0
max	43.3
median	12.5

Table A3. Coefficients of variation (CV) in field-replicated sample (1M2) and relative percent difference (RPD) for laboratory duplicates (ALS Laboratory Group - Burlington).

Sample Name	Method Blank	1M1	1M1 Dup	RPD	1M200	1M201	1M202	CV	Method Blank	JFB002	JFB002 Dup	RPD	Method Blank
Matrix	QC	SEDIMENT	QC		SEDIMENT	SEDIMENT	SEDIMENT		QC	SEDIMENT	QC		QC
Target Analytes	**pg/g**	**pg/g**	**pg/g**		**pg/g**	**pg/g**	**pg/g**		**pg/g**	**pg/g**	**pg/g**		**pg/g**
2,3,7,8-TCDD	<0.14	7.7	7.45	0.8	5.75	6.47	4.34	19.6	<0.20	5.87	6.78	3.6	<0.48
1,2,3,7,8-PeCDD	<0.19	1.12	<0.76	-	<0.76	<5.3	<0.86	-	<0.42	<1.0	<1.2	-	<0.77
1,2,3,4,7,8-HxCDD	<0.30	<0.56	<0.19	-	<0.45	<6.7	<1.2	-	<0.18	<0.60	<1.6	-	<0.48
1,2,3,6,7,8-HxCDD	<0.27	1.17	1.15	0.4	<1.3	<6.8	<1.3	-	<0.22	1.34	<1.7	-	<0.47
1,2,3,7,8,9-HxCDD	<0.28	1.12	1.28	3.3	<1.4	<6.8	<1.2	-	<0.20	1.21	<1.6	-	<0.47
1,2,3,4,6,7,8-HpCDD	0.254	17.4	21	4.7	19.8	24.1	19.3	12.5	0.446	19.8	20.6	1.0	<0.49
OCDD	<1.8	99.3	115	3.7	114	142	142	12.2	2.41	110	134	4.9	<1.8
2,3,7,8-TCDF	<0.46	96.1	91.6	1.2	66.2	68.2	51.3	14.9	<0.42	67.5	67.9	0.1	<0.41
1,2,3,7,8-PeCDF	<0.11	3.46	3.11	2.7	4.51	<3.7	3.67	14.5	<0.14	4.22	5.35	5.9	<0.27
2,3,4,7,8-PeCDF	<0.18	4.57	4.7	0.7	4.51	<4.9	4.2	5.0	0.15	4.96	4.95	0.1	<0.26
1,2,3,4,7,8-HxCDF	<0.16	<1.4	1.58	-	<1.1	<6.4	<1.0	-	<0.25	2.42	1.88	6.3	<0.31
1,2,3,6,7,8-HxCDF	<0.15	<0.66	<0.51	-	<0.44	<6.3	<1.1	-	<0.17	<0.81	<1.5	-	<0.30
2,3,4,6,7,8-HxCDF	<0.11	<0.56	0.462	-	<0.53	<6.5	<1.0	-	<0.13	0.788	<1.4	-	<0.32
1,2,3,7,8,9-HxCDF	<0.14	<0.73	<0.23	-	<0.50	<8.0	<1.3	-	<0.17	<0.67	<1.6	-	<0.45
1,2,3,4,6,7,8-HpCDF	0.253	6.06	7.44	5.1	6.37	<7.6	6.89	5.5	<0.34	5.88	5.4	2.1	<0.31
1,2,3,4,7,8,9-HpCDF	<0.14	<0.88	0.629	-	<0.93	<9.1	<1.3	-	<0.41	<0.81	<1.9	-	<0.50
OCDF	<1.2	27.1	33.9	5.6	21.3	35	16.5	39.6	<1.2	21.9	28.2	6.3	<0.63
Homologue Group Totals	**pg/g**	**pg/g**	**pg/g**		**pg/g**	**pg/g**	**pg/g**		**pg/g**	**pg/g**	**pg/g**		**pg/g**
Total-TCDD	0.356	8.39	9.81	3.9	5.75	6.47	5.85	6.5	<0.20	9.99	9.37	1.6	<0.48
Total-PeCDD	<0.19	2.02	2.84	8.4	1.54	<5.3	3.33	52.0	<0.42	2.77	1.88	9.6	<0.77
Total-HxCDD	<0.30	11.8	11.7	0.2	6.38	<6.8	4.21	29.0	1.2	6.21	7.44	4.5	<0.48
Total-HpCDD	0.56	34.8	42.8	5.2	41.1	24.1	38.5	26.5	0.446	40.3	44.6	2.5	<0.49
Total-TCDF	<0.096	222	221	0.1	153	151	127	10.1	<0.11	169	169	0.0	<0.41
Total-PeCDF	<0.11	23	18.6	5.3	18.2	<3.7	20.8	9.4	0.15	17.8	16.7	1.6	<0.27
Total-HxCDF	<0.16	4.84	10	17.4	6.83	<8.0	2.87	57.7	0.193	11.1	4.8	19.8	<0.45
Total-HpCDF	0.253	19.6	26.3	7.3	18.4	11.7	14.6	22.6	<0.087	18	5.4	26.9	<0.50
			min	0.1				5.0				0.0	
			max	17.4				57.7				26.9	
			median	3.8				14.7				3.6	

Table A4. Sample recoveries for laboratory standards and reference material (Caduceon Environmental Laboratories).

CADUCEON ENVIRONMENTAL LABORATORIES, 2378 HOLLY LANE, OTTAWA, ONTARIO, K1V 7P1

QC I.D.:	Various	**CLIENT:**	Environment Canada, Can. Ctr. For Inland Waters
SAMPLE MATRIX:	Sediment	**BATCH NUMBER:**	B09-00757
DATE SUBMITTED:	9-Jan-09	**DATE ANALYZED:**	Various
DATE REPORTED:	30-Jan-09	**REPORT TO:**	Danielle Milani

PARAMETERS	**QC Sample Recovery Calculation**				
	Raw Data (µg/g)			**QC Sample Recovery**	
LKSD-3 (15-Jan-09)	**QC Result**	**Reference Value**	**Lab Mean**	**% Recovery**	**Control Limits**
Silver	2.7	2.4	2.3	**113**	50 - 117
Arsenic	24.6	23	23.0	**107**	83 - 121
Barium	169	N/A	169	**100**	81 - 118
Beryllium	0.5	N/A	0.5	**100**	47 - 153
Cadmium	0.6	0.6	0.6	**100**	83 - 114
Cobalt	29.2	30	28.9	**97**	51 - 114
Chromium	49.1	51	48.4	**96**	54 - 125
Copper	35.1	34	33.8	**103**	79 - 116
Iron	30063	35000	29815	**86**	74 - 102
Manganese	1319	1220	1247	**108**	76 - 124
Molybdenum	0.712	2	1.0	**36**	0 - 260
Nickel	43.9	44.0	42.4	**100**	75 - 125
Lead	25	26	24.9	**96**	72 - 107
Strontium	24	N/A	25.4	**94**	76 - 124
Titanium	1058	N/A	980	**108**	49 - 151
Vanadium	48	55	48.5	**87**	63 - 113
Zinc	137	139	136	**99**	76 - 124
STSD-2 (15-Jan-09)					
Mercury	0.138	0.160	0.144	**86**	77 - 122
WH89-1 (26-Jan-08)					
Aluminum (Al2O3)	13.7	12.1	11.6	**113**	75 - 125
Barium (BaO)	0.29	0.29	0.28	**100**	75 - 125
Calcium (CaO)	5.29	5.9	5.7	**90**	75 - 125
Chromium (Cr2O3)	0.03	0.03	0.03	**100**	50 - 150
Iron (Fe2O3)	7.45	6.9	6.62	**108**	75 - 125
Magnesium (MgO)	3.15	3.5	3.4	**90**	75 - 125
Manganese (MnO)	1.17	1.38	1.34	**85**	75 - 125
Phosphorus (P2O5)	2.10	2.48	2.43	**85**	75 - 125
Potasium (K20)	3.62	4.51	4.43	**80**	75 - 125
Silica (SiO2)	59.60	60.5	59	**99**	75 - 125
Sodium (Na2O)	3.51	4.0	4.09	**88**	75 - 125
Titanium (TiO2)	2.15	2.57	2.47	**84**	75 - 125
D053-542 (19-Jan-09)					
Total Kjeldahl Nitrogen	1280	1300	1372	**93**	57 - 143
Phosphorus-Total	875	811	939	**93**	53 - 147
TOC QC (22-Jan-09)					
TOC	4.69	4.84		**97**	91 - 109

min	35.6
max	113
median	96.9

Table A5. Percent recoveries in surrogate spikes – sediment samples (ALS Laboratory Group).

	BTEX	CCME Total Hydrocarbons	CCME PAHs		PCBs
Site	2,5-Dibromotoluene	Octacosane	2-Fluorobiphenyl	p-Terphenyl d14	d14-Terphenyl
1M1	131	84	116	116	109
1M200	122	94	114	106	103
1M201	130	113	114	116	109
1M202	135	93	110	105	104
1M3	136	82	111	107	111
1M4	127	81	117	118	113
2M1	129	67	115	115	105
2M4	128	73	120	125	119
2M5	113	79	123	131	119
JFB021	109	86	121	127	110
JFB002	107	78	111	113	111
3M2	108	82	136	144	132
4M3	101	83	96	114	95
NF5	113	94	114	117	97
M701	109	102	111	115	104
EEM4	118	97	113	120	110
EEM8	115	84	112	119	113
5100	89	86	107	112	128
5101	92	67	131	146	145
5102	88	71	140	161	133
510300	89	73	129	157	124
510301	91	80	140	181	114
510302	88	76	149	181	137
5104	92	82	107	125	128
5105	86	70	106	128	122
5106	85	79	102	118	130
2512	90	88	97	121	124
min	85	67	96	105	95
max	136	113	149	181	145
median	109	82	114	119	113

Table A6. Extraction standard recoveries for benthic invertebrate samples – Jackfish Bay sites (ALS Laboratory Group). Recoveries outside the quality control (QC) limits are highlighted.

Location	Moberly Bay						South of Moberly		Jackfish Bay		Tunnel Bay			QC Limits
Site	M701		1M3		1M1		2M1		4M3		3M2			
Organism	chironomid	oligochaete	chironomid	oligochaete	chironomid	oligochaete	oligochaete	amphipod	oligochaete	amphipod	chironomid	oligochaete	amphipod	
Extraction Standards														
13C12-2,3,7,8-TCDD	84	91	28	79	70	73	83	63	66	59	78	67	87	25-164
13C12-1,2,3,7,8-PeCDD	69	68	25	55	64	74	86	70	74	64	75	69	77	25-181
13C12-1,2,3,4,7,8-HxCDD	71	71	32	59	60	79	91	76	85	64	86	73	80	32-141
13C12-1,2,3,6,7,8-HxCDD	60	62	28	53	49	66	81	69	71	62	71	61	67	28-130
13C12-1,2,3,7,8,9-HxCDD	73	76	34	62	64	81	102	85	96	65	90	71	92	23-140
13C12-1,2,3,4,6,7,8-HpCDD	44	48	29	40	40	57	83	78	80	59	81	58	70	17-157
13C12-OCDD	27	30	20	24	24	41	61	65	70	51	67	45	52	17-157
13C12-2,3,7,8-TCDF	78	87	27	78	69	73	74	57	57	55	69	65	74	24-169
13C12-1,2,3,7,8-PeCDF	63	68	23	61	62	67	84	67	71	60	76	67	76	24-169
13C12-2,3,4,7,8-PeCDF	63	62	23	56	62	69	83	68	69	60	70	66	73	24-169
13C12-1,2,3,4,7,8-HxCDF	70	71	30	57	58	75	93	77	78	60	81	64	78	24-169
13C12-1,2,3,6,7,8-HxCDF	62	63	28	54	54	67	84	71	72	55	77	60	73	24-169
13C12-2,3,4,6,7,8-HxCDF	57	61	27	51	49	63	74	62	65	53	63	57	64	24-169
13C12-1,2,3,7,8,9-HxCDF	55	57	29	47	47	61	79	66	74	53	71	57	69	24-169
13C12-1,2,3,4,6,7,8-HpCDF	46	53	30	45	43	66	90	83	84	60	88	60	76	24-169
13C12-1,2,3,4,7,8,9-HpCDF	34	39	23	31	32	49	67	63	68	52	67	51	59	24-169
13C12-OCDF	22	27	17	21	22	37	56	59	65	48	61	41	48	24-169
13C12-PCB-81	64	73	24	67	66	59	70	49	51	46	64	60	66	25-150
13C12-PCB-77	73	73	24	68	67	60	71	51	52	47	64	61	68	25-150
13C12-PCB-123	29	74	24	56	65	61	74	55	53	53	69	63	72	25-150
13C12-PCB-118	30	74	23	58	64	62	74	55	54	53	69	64	71	25-150
13C12-PCB-114	24	77	24	50	59	63	75	55	49	53	70	63	72	25-150
13C12-PCB-105	40	78	25	67	64	66	76	60	61	57	75	66	77	25-150
13C12-PCB-126	82	92	28	78	73	77	90	72	73	66	92	74	92	25-150
13C12-PCB-167	39	78	25	62	67	69	90	73	73	65	86	72	86	25-150
13C12-PCB-156	37	73	23	59	66	70	87	70	71	67	81	72	80	25-150
13C12-PCB-157	46	75	23	63	69	75	90	72	77	68	83	74	82	25-150
13C12-PCB-169	69	68	25	56	66	76	90	73	79	69	81	72	81	25-150
13C12-PCB-189	52	78	31	61	71	90	103	88	94	74	98	79	96	25-150

overall min	**17**
overall max	**103**
median	**66**

Table A7. Extraction recoveries for benthic invertebrate samples – Lake Superior reference sites (ALS Laboratory Group).

Site	5102			5103		5105			5106			2512			QC
Organism	chironomid	oligochaete	amphipod	oligochaete	amphipod	chironomid	oligochaete	amphipod	chironomid	oligochaete	amphipod	chironomid	oligochaete	amphipod	Limits
Extraction Standards															
13C12-2,3,7,8-TCDD	66	70	75	80	69	72	68	73	70	65	70	77	69	70	25-164
13C12-1,2,3,7,8-PeCDD	60	58	62	66	59	63	62	64	62	61	60	69	57	58	25-181
13C12-1,2,3,4,7,8-HxCDD	68	72	83	70	61	85	76	82	75	82	66	88	71	67	32-141
13C12-1,2,3,6,7,8-HxCDD	67	66	75	72	64	70	69	69	75	71	64	86	63	68	28-130
13C12-1,2,3,7,8,9-HxCDD	79	76	85	82	73	81	75	82	81	79	71	94	74	74	23-140
13C12-1,2,3,4,6,7,8-HpCDD	74	68	86	73	63	81	75	74	78	75	66	90	72	71	17-157
13C12-OCDD	66	58	71	58	51	69	60	64	70	58	55	79	61	63	17-157
13C12-2,3,7,8-TCDF	62	63	67	72	64	65	62	68	65	63	66	71	61	61	24-169
13C12-1,2,3,7,8-PeCDF	59	57	59	64	56	59	60	61	59	58	60	67	56	55	24-169
13C12-2,3,4,7,8-PeCDF	55	55	61	61	56	60	57	60	59	58	57	66	53	54	24-169
13C12-1,2,3,4,7,8-HxCDF	63	63	71	66	59	66	65	68	67	63	63	71	63	60	24-169
13C12-1,2,3,6,7,8-HxCDF	58	58	67	63	57	63	60	60	64	56	60	67	59	58	24-169
13C12-2,3,4,6,7,8-HxCDF	58	55	64	61	54	67	56	61	64	64	57	76	57	56	24-169
13C12-1,2,3,7,8,9-HxCDF	72	66	76	73	64	74	68	70	72	68	66	81	68	67	24-169
13C12-1,2,3,4,6,7,8-HpCDF	77	73	89	77	70	82	78	79	82	77	70	90	75	75	24-169
13C12-1,2,3,4,7,8,9-HpCDF	64	58	72	61	54	68	62	65	68	68	59	77	62	63	24-169
13C12-OCDF	58	51	63	51	45	61	53	57	63	52	49	72	53	56	24-169
13C12-PCB-81	50	53	55	63	56	51	53	57	51	54	56	55	52	52	25-150
13C12-PCB-77	52	55	56	65	58	53	54	59	55	55	58	57	53	53	25-150
13C12-PCB-123	54	56	59	66	58	56	57	62	57	56	60	61	52	55	25-150
13C12-PCB-118	54	57	58	67	59	57	57	61	59	57	61	62	53	55	25-150
13C12-PCB-114	54	59	60	67	59	57	59	62	59	59	61	66	49	60	25-150
13C12-PCB-105	61	61	67	72	66	64	64	67	64	62	67	68	60	60	25-150
13C12-PCB-126	74	74	84	88	80	81	81	85	79	77	78	85	76	75	25-150
13C12-PCB-167	66	65	75	77	68	73	71	72	70	64	67	75	67	65	25-150
13C12-PCB-156	63	60	66	69	63	64	64	67	65	64	64	71	61	60	25-150
13C12-PCB-157	66	63	67	71	64	66	66	68	66	64	65	74	62	61	25-150
13C12-PCB-169	63	61	65	68	61	64	64	65	64	62	62	71	59	59	25-150
13C12-PCB-189	72	70	79	78	70	73	72	78	78	70	71	85	69	69	25-150

overall min	**45**
overall max	**94**
median	**64**

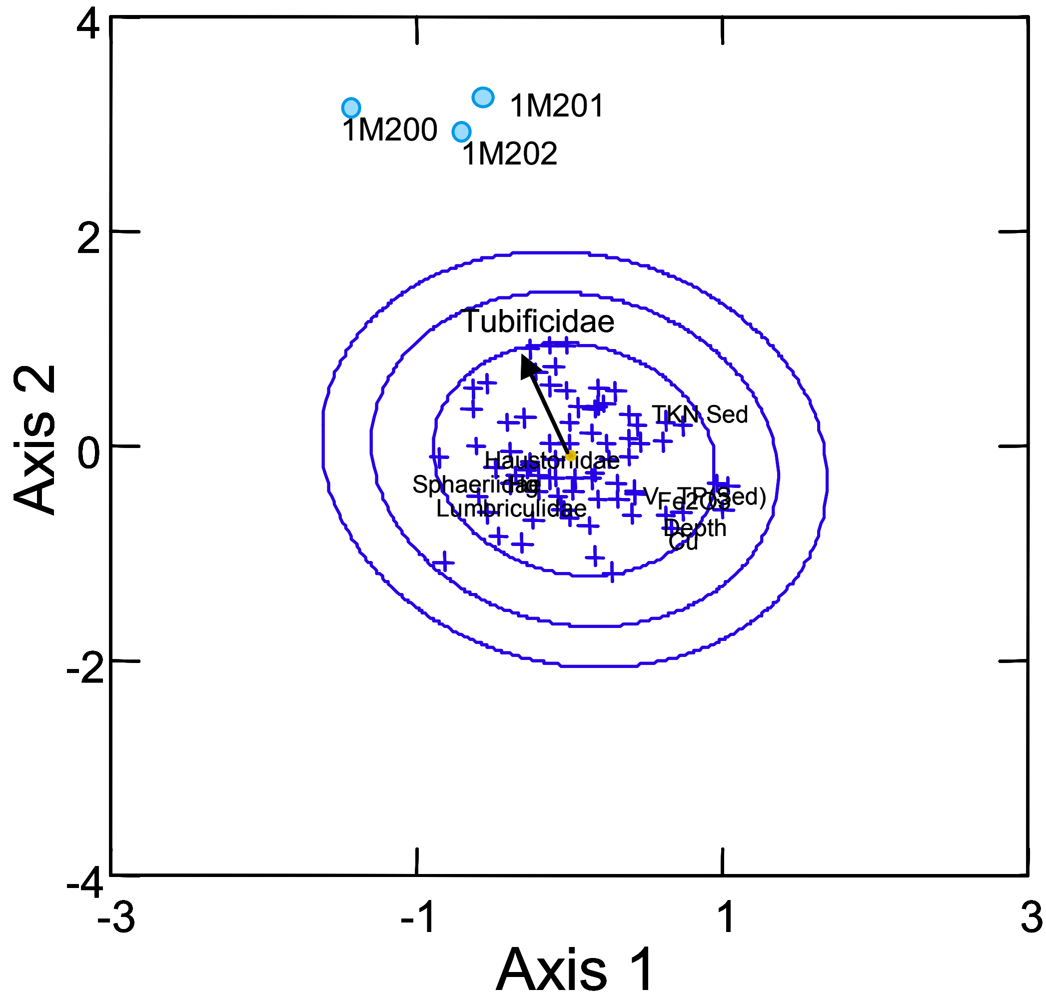

Figure A1. Assessment of field-replicated QA/QC site 1M2 (Moberly Bay). Three separate box cores were taken at the site, indicated by 1M200, 1M201 and 1M202.

Appendix B – Supplementary Chemical Data

Table B1. Physical characteristics of Jackfish Bay and Lake Superior sediment (top 10 cm).

Location	Site	% Sand	% Silt	% Clay	% Gravel	Particle Size Mean -µm
Moberly Bay	M701	95.2	0.0	4.8	0	279.5
	1M4	6.7	72.2	21.1	0	24.6
	EEM4	8.0	79.4	12.5	0	24.7
	1M3	3.4	71.8	24.8	0	17.2
	1M2*	1.0	75.8	23.1	0	17.0
	JFB002	1.0	77.7	21.2	0	18.9
	1M1	3.5	70.9	25.6	0	17.2
	NF5	2.4	71.8	25.9	0	18.9
	EEM8	63.0	22.8	14.3	0	96.0
Central Jackfish Bay	2M1	1.9	74.9	23.2	0	16.7
	2M4	6.8	73.6	19.6	0	20.9
	JFB021	3.0	64.5	32.5	0	14.8
Lower Jackfish Bay	2M5	2.0	69.2	28.8	0	15.0
	4M3	5.6	17.0	77.5	0	3.5
Tunnel Bay	3M2	2.6	71.1	26.3	0	14.3
Lake Superior Reference	5100	1.1	64.2	34.8	0	12.9
	5101	1.9	42.4	55.7	0	5.8
	5102	62.5	20.5	17.0	0	83.8
	5103	2.1	58.6	39.3	0	9.5
	5104	24.2	10.8	64.5	0.6	11.3
	5105	17.1	51.1	31.8	0	19.8
	5106	28.4	50.1	21.5	0	35.6
	2512	34.7	16.4	41.4	7.5	64.6

Table B2. Sediment trace metal and nutrient concentrations in Lake Superior reference sediment (dry weight).

Parameter	Units	M.D.L.	Reference Method	5100	5101	5102	510300	510301	510302	5104	5105	5106	2512
Aluminum	µg/g	10	EPA 6010	14700	16100	12200	15900	16300	16100	13400	14200	11700	12100
Antimony	µg/g	5	EPA 6010	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Arsenic	µg/g	5	EPA 6010	16	< 5	< 5	12	12	13	< 5	6	8	< 5
Barium	µg/g	1	EPA 6010	128	144	59	120	125	121	108	138	73	112
Beryllium	µg/g	0.2	EPA 6010	1.0	0.8	0.4	0.7	0.8	0.7	0.7	0.7	0.4	0.5
Bismuth	µg/g	5	EPA 6010	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Cadmium	µg/g	0.5	EPA 6010	0.9	0.6	< 0.5	0.8	0.9	0.9	< 0.5	0.5	0.8	< 0.5
Calcium	µg/g	10	EPA 6010	7240	9880	9470	9330	9470	9460	58300	8910	9090	54600
Chromium	µg/g	1	EPA 6010	53	63	32	58	64	59	47	47	35	47
Cobalt	µg/g	1	EPA 6010	17	18	13	19	19	19	14	17	14	12
Copper	µg/g	1	EPA 6010	89	48	33	62	63	62	33	60	47	32
Iron	µg/g	10	EPA 6010	35800	33900	24900	35600	35800	35800	28800	34300	26400	23800
Lead	µg/g	5	EPA 6010	37	23	18	28	30	28	15	22	20	8
Magnesium	µg/g	10	EPA 6010	10800	15000	6550	13000	13300	13100	15400	11100	7980	20700
Manganese	µg/g	1	EPA 6010	1070	1620	361	1430	1220	1370	585	810	769	586
Mercury	µg/g	0.005	EPA 7471A	0.068	0.065	0.029	0.072	0.071	0.072	0.021	0.049	0.033	0.018
Molybdenum	µg/g	1	EPA 6010	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Nickel	µg/g	1	EPA 6010	41	43	23	43	44	42	33	38	34	28
Phosphorus	µg/g	5	EPA 6010	1260	847	636	873	844	887	546	923	677	550
Potassium	µg/g	30	EPA 6010	2950	3890	1470	3370	3700	3510	3490	2430	1500	2730
Silicon	µg/g	1	EPA 6010	258	529	1360	242	672	768	862	466	387	211
Silver	µg/g	0.2	EPA 6010	0.2	0.2	< 0.2	0.3	0.2	0.2	< 0.2	< 0.2	< 0.2	< 0.2
Sodium	µg/g	20	EPA 6010	990	1000	830	910	980	990	920	930	1260	1460
Strontium	µg/g	1	EPA 6010	23	24	27	26	27	27	48	47	21	40
Tin	µg/g	10	EPA 6010	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Titanium	µg/g	1	EPA 6010	1430	1640	2600	1970	1990	2070	1740	1970	2330	1140
Vanadium	µg/g	1	EPA 6010	73	61	76	71	72	72	72	88	85	44
Yttrium	µg/g	0.5	EPA 6010	13.2	12.2	9.2	13.2	13.3	13.3	10.1	12.1	9.1	8.1
Zinc	µg/g	1	EPA 6010	137	113	77	130	131	130	76	110	89	55
Zirconium	µg/g	0.1	EPA 6010	4.7	8.7	15.7	9.8	10.1	10.3	19.9	8.4	9.8	16.2
Aluminum (Al2O3)	%	0.01	IN-HOUSE	15.1	16.1	13.0	15.6	15.9	15.4	13.0	13.9	14.0	11.5
Barium (BaO)	%	0.001	IN-HOUSE	0.078	0.091	0.052	0.078	0.078	0.078	0.078	0.078	0.078	0.052
Calcium (CaO)	%	0.01	IN-HOUSE	2.05	2.14	3.22	2.51	2.51	2.52	2.52	2.60	7.16	9.24
Chromium (Cr2O3)	%	0.01	IN-HOUSE	0.01	0.01	0.01	0.04	0.01	0.04	0.01	0.01	0.04	0.01
Iron (Fe2O3)	%	0.05	IN-HOUSE	8.48	7.84	6.49	8.55	8.62	8.52	7.36	7.62	8.13	5.13
Magnesium (MgO)	%	0.01	IN-HOUSE	3.08	4.09	2.39	3.87	3.94	3.90	3.05	3.3	4.33	4.63
Manganese (MnO)	%	0.01	IN-HOUSE	0.20	0.27	0.1	0.25	0.22	0.23	0.16	0.16	0.18	0.08
Phosphorus (P2O5)	%	0.03	IN-HOUSE	0.18	0.21	< 0.04	0.06	0.18	0.14	0.06	0.18	1.30	0.10
Potasium (K20)	%	0.01	IN-HOUSE	2.99	3.12	2.08	2.92	3.02	2.89	2.24	2.37	1.68	2.3
Silica (SiO2)	%	0.01	IN-HOUSE	58.3	58.8	64.8	58.1	58.6	56.6	49.0	50.5	55.7	45.1
Sodium (Na2O)	%	0.01	IN-HOUSE	4.33	4.37	4.68	4.39	4.13	4.15	4.54	4.67	4.07	3.31
Titanium (TiO2)	%	0.01	IN-HOUSE	1.00	0.95	0.04	1.10	1.10	1.10	1.10	1.10	1.30	0.55
Loss on Ignition	%	0.05	IN-HOUSE	13.3	9.02	4.72	11.0	11.0	10.6	13.3	8.92	5.65	12.5
Whole Rock Total	%		IN-HOUSE	109	107	102.0	108	109	106	96.4	95.4	104	94.6
Total Organic Carbon	% by wt	0.1	LECO	2.3	1.1	0.6	1.7	1.7	1.6	0.3	1.3	1.1	< 0.1
Total Kjeldahl Nitrogen	µg/g	0.05	EPA 351.2	3480	1580	954	2310	2410	2190	487	1960	1330	321
Phosphorus-Total	µg/g	0.01	EPA 365.4	1380	823	620	879	861	849	576	968	658	479

Table B3. Sediment petroleum hydrocarbon, PAHS, oil and grease and PCB concentrations (mg/kg dry weight) in Lake Superior reference sediment. Values below method detection limits are indicated by "<". [Method detection limits are provided in Appendix B, Table B4].

Analyte	5100	5101	5102	510300	510301	510302	5104	5105	5106	2512
BTEX										
Benzene	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ethyl Benzene	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
m+p-Xylenes	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
o-Xylene	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Toluene	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Xylene, (total)	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15
CCME Total Hydrocarbons										
F1 (C6-C10)	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
F1-BTEX	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
F2 (C10-C16)	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
F2-Naphth	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
F3 (C16-C34)	130	<100	<100	<100	<100	<100	<100	<100	<100	<100
F3-PAH	130	<100	<100	<100	<100	<100	<100	<100	<100	<100
F4 (C34-C50)	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
F4G-SG (GHH-Silica)	300	100	200	100	<100	<100	<100	100	<100	<100
Total Hydrocarbons (C6-C50)	130	<100	<100	<100	<100	<100	<100	<100	<100	<100
Chromatogram to baseline at nC50	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
CCME PAHs										
1-Methylnaphthalene	<0.2	<0.1	<0.1	<0.2	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1
2-Methylnaphthalene	<0.2	<0.1	<0.1	<0.2	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1
Acenaphthene	<0.2	<0.1	<0.1	<0.2	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1
Acenaphthylene	<0.2	<0.1	<0.1	<0.2	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1
Acridine	<3	<2	<2	<3	<3	<3	<2	<2	<2	<2
Anthracene	<0.2	<0.1	<0.1	<0.2	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1
Benzo(a)anthracene	<0.2	<0.1	<0.1	<0.2	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1
Benzo(a)pyrene	<0.08	<0.04	<0.04	<0.08	<0.08	<0.08	<0.04	<0.04	<0.04	<0.04
Benzo(b)fluoranthene	<0.2	<0.1	<0.1	<0.2	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1
Benzo(g,h,i)perylene	<0.2	<0.1	<0.1	<0.2	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1
Benzo(k)fluoranthene	<0.2	<0.1	<0.1	<0.2	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1
Chrysene	<0.2	<0.1	<0.1	<0.2	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1
Dibenzo(ah)anthracene	<0.2	<0.1	<0.1	<0.2	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1
Fluoranthene	<0.2	<0.1	<0.1	<0.2	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1
Fluorene	<0.2	<0.1	<0.1	<0.2	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1
Indeno(1,2,3-cd)pyrene	<0.2	<0.1	<0.1	<0.2	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1
Naphthalene	<0.2	<0.1	<0.1	<0.2	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1
Phenanthrene	<0.2	<0.1	<0.1	<0.2	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1
Pyrene	<0.2	<0.1	<0.1	<0.2	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1
Quinoline	<0.2	<0.1	<0.1	<0.2	<0.2	<0.2	<0.1	<0.1	<0.1	<0.1
Individual Analytes										
% Moisture	65.9	56.7	54.5	61.7	62	64.6	41.4	59.5	53.3	36.3
Oil and Grease, Total	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
PCBs										
Aroclor 1242	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.05	<0.1	<0.05	<0.05
Aroclor 1248	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.05	<0.1	<0.05	<0.05
Aroclor 1254	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.05	<0.1	<0.05	<0.05
Aroclor 1260	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.05	<0.1	<0.05	<0.05
Total PCBs	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.05	<0.1	<0.05	<0.05

NM=not measured

Table B4. Method detection limits for sediment organic contaminant analysis (ALS Laboratory Group).

Sample ID		1M1	1M200	1M201	1M202	1M3	1M4	2M1	2M4	2M5	JFB021	JFB002	3M2	4M3	NF5	M701	EEM4	EEM8	5100	5101	5102	510300	510300	510300	5104	5105	5106	2512
Matrix		SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT	SEDIMENT
BTEX																												
Benzene	mg/kg	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Ethyl Benzene	mg/kg	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
m+p-Xylenes	mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
o-Xylene	mg/kg	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Toluene	mg/kg	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Xylene, (total)	mg/kg	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
CCME Total Hydrocarbons																												
F1 (C6-C10)	mg/kg	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
F1-BTEX	mg/kg	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
F2 (C10-C16)	mg/kg	20	20	20	20	20	20	20	20	20	20	20	20	10	20	20	20	10	20	20	20	20	20	20	20	20	20	20
F2-Naphth	mg/kg	20	20	20	20	20	20	20	20	20	20	20	20	10	20	20	20	10	20	20	20	20	20	20	20	20	20	20
F3 (C16-C34)	mg/kg	100	100	100	100	100	100	100	100	100	100	100	100	50	100	100	100	50	100	100	100	100	100	100	100	100	100	100
F3-PAH	mg/kg	100	100	100	100	100	100	100	100	100	100	100	100	50	100	100	100	50	100	100	100	100	100	100	100	100	100	100
F4 (C34-C50)	mg/kg	100	100	100	100	100	100	100	100	100	100	100	100	50	100	100	100	50	100	100	100	100	100	100	100	100	100	100
F4G-SG (GHH-Silica)	mg/kg	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Total Hydrocarbons (C6-C50)	mg/kg	100	100	100	100	100	100	100	100	100	100	100	100	50	100	100	100	50	100	100	100	100	100	100	100	100	100	100
CCME PAHs																												
1-Methylnaphthalene	mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1
2-Methylnaphthalene	mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Acenaphthene	mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Acenaphthylene	mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Acridine	mg/kg	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	0.8	3.2	1.6	1.6	3.2	3.2	3.2	1.6	1.6	1.6	1.6
Anthracene	mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Benzo(a)anthracene	mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Benzo(a)pyrene	mg/kg	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.02	0.08	0.04	0.04	0.08	0.08	0.08	0.04	0.04	0.04	0.04
Benzo(b)fluoranthene	mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Benzo(g,h,i)perylene	mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Benzo(k)fluoranthene	mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Chrysene	mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Dibenzo(ah)anthracene	mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Fluoranthene	mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Fluorene	mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Indeno(1,2,3-cd)pyrene	mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Naphthalene	mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Phenanthrene	mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Pyrene	mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Quinoline	mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1
PCBs																												
Aroclor 1242	mg/kg	0.1	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.04	0.1	0.05	0.1	0.05	0.1	0.05	0.1	0.1	0.1	0.1	0.05	0.1	0.05	0.05
Aroclor 1248	mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.04	0.1	0.05	0.1	0.05	0.1	0.05	0.1	0.1	0.1	0.1	0.05	0.1	0.05	0.05
Aroclor 1254	mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.04	0.1	0.05	0.1	0.05	0.1	0.05	0.1	0.1	0.1	0.1	0.05	0.1	0.05	0.05
Aroclor 1260	mg/kg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.04	0.1	0.05	0.1	0.05	0.1	0.05	0.1	0.1	0.1	0.1	0.05	0.1	0.05	0.05
Total PCBs	mg/kg	0.1	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.04	0.1	0.05	0.1	0.05	0.1	0.05	0.1	0.1	0.1	0.1	0.05	0.1	0.05	0.05

Table B5. Sediment dioxin and furan concentrations (pg/g dw) and toxic equivalents (TEQ) for Lake Superior reference sites. TEQs exceeding the probable effect level are indicated in red. A "<" Indicates that the compound was not detected above the method detection limit or that the target analyte was detected below the Lowest Quantitation Limit (see text). [Estimated Detection Limits = Method detection limits are provided in Appendix B, Table B3].

Site	5100	5101	5102	510300	510301	510302	5104	5106	2512	5105
Target Analytes	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g
2,3,7,8-TCDD	<0.67	<0.48	<0.20	<0.49	0.421	<1.3	<0.15	<0.32	<0.12	<0.53
1,2,3,7,8-PeCDD	1.56	1.11	<0.48	<0.89	0.989	<0.95	<0.19	<0.58	0.115	<0.57
1,2,3,4,7,8-HxCDD	1.73	0.897	0.562	0.858	1.11	1.53	<0.25	0.780	<0.066	<0.50
1,2,3,6,7,8-HxCDD	2.73	1.94	<0.95	1.89	2.03	2.41	0.505	1.69	<0.066	1.24
1,2,3,7,8,9-HxCDD	4.96	2.81	1.38	2.41	3.33	3.34	0.543	<1.9	0.196	<1.3
1,2,3,4,6,7,8-HpCDD	37.7	24.9	12.3	23.0	23.2	26.5	3.83	17.9	0.977	20.3
OCDD	176	113	61.9	111	106	135	19.6	93.9	4.42	110
2,3,7,8-TCDF	2.91	1.89	<1.5	1.94	1.87	2.83	<1.1	2.23	<0.22	1.44
1,2,3,7,8-PeCDF	1.56	1.42	0.467	0.976	1.06	<1.1	0.253	0.640	<0.15	<0.43
2,3,4,7,8-PeCDF	1.92	0.961	0.659	<1.0	1.20	1.06	<0.19	0.845	<0.078	<0.67
1,2,3,4,7,8-HxCDF	3.00	<1.6	<0.73	3.55	1.74	2.87	<0.81	1.96	<0.71	<1.3
1,2,3,6,7,8-HxCDF	1.77	1.18	0.576	<1.0	1.22	1.73	<0.26	1.01	<0.11	<0.58
2,3,4,6,7,8-HxCDF	1.71	0.786	0.596	0.934	<0.92	1.20	0.228	<0.83	0.0836	0.588
1,2,3,7,8,9-HxCDF	<0.43	<0.26	<0.19	<0.20	<0.28	<0.85	<0.090	<0.18	<0.064	<0.26
1,2,3,4,6,7,8-HpCDF	10.4	8.65	4.14	7.18	7.53	8.55	2.92	5.80	1.06	4.98
1,2,3,4,7,8,9-HpCDF	1.07	0.413	<0.041	<0.45	0.449	<0.48	<0.059	<0.42	<0.054	<0.17
OCDF	9.23	4.73	2.91	5.03	6.25	7.35	0.644	4.71	<0.19	<4.2
Homologue Group Totals	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**	**pg/g**
Total-TCDD	4.65	8.29	1.44	5.24	3.47	<1.3	2.57	3.95	0.621	2.08
Total-PeCDD	15.2	11.3	3.08	6.64	8.91	4.61	2.86	4.89	1.73	8.24
Total-HxCDD	50.5	29.5	8.86	16.9	33.4	23.2	4.91	20.1	0.851	4.61
Total-HpCDD	88.9	54.7	26.8	52.8	50.1	62.3	8.67	39.2	0.977	41.6
Total-TCDF	31.7	17.9	11.7	12.7	21.2	20.3	1.98	9.65	1.79	10.5
Total-PeCDF	19.6	12.5	6.81	7.79	13.2	5.77	4.20	8.40	1.37	3.17
Total-HxCDF	17.0	11.0	4.61	11.5	11.1	13.0	3.78	7.40	1.01	4.57
Total-HpCDF	12.8	12.3	5.59	11.1	11.4	13.0	2.92	5.80	1.06	4.98
Toxic Equivalency WHO (1998)										
Lower Bound PCDD/F TEQ	4.50	2.58	0.83	1.17	3.18	2.20	0.08	1.36	0.14	0.22
Upper Bound PCDD/F TEQ	5.22	3.24	1.68	3.18	3.30	4.60	0.81	2.38	0.44	2.16

Table B6. Estimated Detection Limits (EDL) (= method detection limit) for sediment dioxin and furan and dioxin-like PCB analysis (ALS Laboratory Group).

	1M1	1M1 DUP	1M200	1M101	1M202	1M3	1M4	2M1	2M4	2M5	JFB021	JFB002	JFB002 DUP	4M3	NF5	M701	EEM4	EEM8
Target Analytes	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g
2,3,7,8-TCDD	1	0.44	0.66	3.4	0.53	0.44	0.098	0.4	0.37	0.5	0.5	0.55	0.91	0.1	1.1	0.076	0.39	0.34
1,2,3,7,8-PeCDD	0.6	0.39	0.55	5.3	0.86	0.58	0.17	0.42	0.19	0.41	0.27	0.37	1.2	0.076	1.2	0.1	0.53	0.16
1,2,3,4,7,8-HxCDD	0.56	0.19	0.45	6.7	1.2	0.62	0.2	0.35	0.28	0.45	0.18	0.6	1.6	0.029	1.7	0.11	0.43	0.3
1,2,3,6,7,8-HxCDD	0.57	0.19	0.47	6.8	1.3	0.63	0.21	0.37	0.27	0.46	0.18	0.62	1.7	0.027	1.7	0.11	0.46	0.28
1,2,3,7,8,9-HxCDD	0.57	0.19	0.46	6.8	1.2	0.62	0.2	0.36	0.28	0.46	0.18	0.61	1.6	0.028	1.7	0.11	0.45	0.29
1,2,3,4,6,7,8-HpCDD	0.87	0.33	0.75	6.2	1.1	0.82	0.31	0.54	0.21	0.65	0.36	0.66	1.8	0.044	1.9	0.14	0.87	0.2
OCDD	0.84	0.68	0.77	12	2	1.8	0.61	0.43	0.6	0.68	0.55	1.1	2.2	0.17	2	0.25	1	0.26
2,3,7,8-TCDF	0.38	0.26	0.62	3.1	0.52	0.39	0.17	0.2	0.22	0.31	0.18	0.38	0.77	0.053	1.2	0.089	0.49	0.27
1,2,3,7,8-PeCDF	0.44	0.28	0.35	3.7	0.7	0.52	0.16	0.29	0.24	0.4	0.16	0.36	0.97	0.05	1.1	0.069	0.5	0.12
2,3,4,7,8-PeCDF	0.4	0.25	0.33	3.3	0.68	0.5	0.15	0.29	0.22	0.38	0.17	0.35	0.89	0.045	0.97	0.064	0.49	0.12
1,2,3,4,7,8-HxCDF	0.63	0.2	1.1	6.4	1	0.64	0.4	0.37	0.25	0.34	0.36	0.92	1.5	0.061	1.3	0.14	0.7	0.092
1,2,3,6,7,8-HxCDF	0.66	0.18	0.44	6.3	1.1	0.61	0.21	0.31	0.17	0.33	0.19	0.59	1.5	0.032	1.3	0.072	0.59	0.089
2,3,4,6,7,8-HxCDF	0.56	0.18	0.37	6.5	1	0.55	0.18	0.29	0.16	0.31	0.2	0.51	1.4	0.03	1.2	0.067	0.49	0.098
1,2,3,7,8,9-HxCDF	0.73	0.23	0.5	8	1.3	0.72	0.25	0.37	0.21	0.4	0.24	0.67	1.6	0.04	1.5	0.082	0.64	0.12
1,2,3,4,6,7,8-HpCDF	0.77	0.36	0.73	7.6	1.2	0.73	0.24	0.41	0.28	0.47	0.2	0.71	1.6	0.078	1.7	0.11	0.68	0.089
1,2,3,4,7,8,9-HpCDF	0.88	0.46	0.93	9.1	1.3	0.88	0.32	0.51	0.37	0.58	0.25	0.81	1.9	0.1	2.1	0.15	0.83	0.13
OCDF	0.77	0.33	0.54	9.2	1.5	0.77	0.32	0.5	0.36	0.51	0.26	0.68	2.7	0.082	1.9	0.17	0.84	0.28
Homologue Group Totals	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g
Total-TCDD	1.0	0.44	0.66	3.4	0.53	0.44	0.098	0.4	0.37	0.5	0.5	0.55	0.91	0.1	1.1	0.076	0.39	0.34
Total-PeCDD	0.6	0.39	0.55	5.3	0.86	0.58	0.17	0.42	0.19	0.41	0.27	0.37	1.2	0.076	1.2	0.1	0.53	0.16
Total-HxCDD	0.57	0.19	0.47	6.8	1.3	0.63	0.21	0.37	0.28	0.46	0.18	0.62	1.7	0.029	1.7	0.11	0.46	0.3
Total-HpCDD	0.87	0.33	0.75	6.2	1.1	0.82	0.31	0.54	0.21	0.65	0.36	0.66	1.8	0.044	1.9	0.14	0.87	0.2
Total-TCDF	0.38	0.26	0.62	3.1	0.52	0.39	0.17	0.2	0.22	0.31	0.18	0.38	0.77	0.053	1.2	0.089	0.49	0.27
Total-PeCDF	0.44	0.28	0.35	3.7	0.7	0.52	0.16	0.29	0.24	0.4	0.17	0.36	0.97	0.05	1.1	0.069	0.5	0.12
Total-HxCDF	0.73	0.23	1.1	8.0	1.3	0.72	0.4	0.37	0.25	0.4	0.36	0.92	1.6	0.061	1.5	0.14	0.7	0.12
Total-HpCDF	0.88	0.46	0.93	9.1	1.3	0.88	0.32	0.51	0.37	0.58	0.25	0.81	1.9	0.1	2.1	0.15	0.83	0.13

Table B7. Benthic invertebrate PCDD/F and DL PCB concentrations (pg/g dry weight) and toxic equivalent (TEQ) concentrations (pg TEQ/g wet weight) for Lake Superior reference sites. A "<"indicates that a target analyte was either not detected above the provided estimated detection limit (EDL) or that the value was below the calibrated range but above the estimated detection limit (EDL).

Site	5102			5103		5105			5106			2512		
Organism	chironomid	oligochaete	amphipod	oligochaete	amphipod	chironomid	oligochaete	amphipod	chironomid	oligochaete	amphipod	chironomid	oligochaete	amphipod
Target Analytes	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g
2,3,7,8-TCDD	<26	<17	<2.3	<4.0	<1.9	<2.9	<10	<3.1	<13	<4.0	<1.8	<11	<10	<22
1,2,3,7,8-PeCDD	<14	<11	<2.7	<2.4	<2.8	<1.8	<8.6	<2.6	<13	<4.2	<1.7	<14	<9.2	<14
1,2,3,4,7,8-HxCDD	<13	<13	<2.5	<1.7	<1.6	<3.5	<4.9	<2.2	<8.0	<3.0	<0.75	<12	<8.7	<14
1,2,3,6,7,8-HxCDD	<13	<12	4.87	<1.7	3.90	<4.1	<5.0	4.37	<8.4	<3.1	2.58	<12	<8.4	<14
1,2,3,7,8,9-HxCDD	<13	<14	<3.2	<1.8	<1.9	<2.6	<5.5	<2.7	<8.8	<3.3	<2.2	<12	<9.0	<15
1,2,3,4,6,7,8-HpCDD	<61	27.5	<2.0	10.0	<7.6	21.2	<12	<7.4	17.7	10.1	5.19	<13	13.6	<21
OCDD	199	224	146	13.2	10.4	45.4	<16	<4.4	<21	12.4	7.04	<40	<14	<27
2,3,7,8-TCDF	<13	<11	10.2	<2.0	10.1	<2.1	<7.4	<1.9	<11	21.3	7.37	<7.8	10.7	<12
1,2,3,7,8-PeCDF	<9.5	<7.8	3.00	<2.2	1.99	<1.9	<5.8	<2.5	<7.3	<2.8	<0.79	<6.4	<5.7	<11
2,3,4,7,8-PeCDF	<8.9	<11	5.94	<2.1	<3.8	4.08	<5.4	<5.2	<6.8	<2.9	<3.4	<6.0	<5.7	<9.8
1,2,3,4,7,8-HxCDF	23.5	<7.7	<5.0	<2.2	<2.6	<2.7	<4.7	<2.5	<6.2	<2.8	2.91	<7.5	<1.9	<8.9
1,2,3,6,7,8-HxCDF	<14	<7.7	<1.6	<2.1	8.09	<4.4	<4.6	<2.5	<6.0	<2.9	5.79	<7.2	<1.8	<8.7
2,3,4,6,7,8-HxCDF	<12	<8.2	<2.3	<2.2	<1.4	<2.4	<5.3	<2.6	<6.1	<2.7	<1.6	<6.7	<2.0	<9.1
1,2,3,7,8,9-HxCDF	<13	<9.1	2.96	<2.4	<1.6	<2.8	<5.7	<3.0	<7.1	<3.3	<1.8	<7.9	<2.1	<9.9
1,2,3,4,6,7,8-HpCDF	<30	<16	<8.3	<3.1	<3.0	<4.0	<5.5	<2.2	<9.2	<4.4	<1.8	<10	<5.1	<11
1,2,3,4,7,8,9-HpCDF	<24	<15	<3.8	<3.5	<3.0	<4.5	<9.4	<3.1	<15	<7.0	<2.0	<17	<8.5	<18
OCDF	98.4	122	85.5	9.56	<4.1	6.41	<12	<3.5	17.8	<7.6	<2.3	28.6	19.1	<29
PCB-81	<9.7	<7.6	4.09	<1.5	4.08	<1.9	<4.0	3.48	<6.5	3.65	2.91	<7.6	<5.5	<8.5
PCB-77	99.6	55.5	52.5	17.9	60.4	18.6	30.1	49.4	78.6	27.8	38.5	92.3	65.3	70.6
PCB-123	<7.7	<17	62.8	13.0	65.7	24.3	<7.4	61.4	<20	12.5	54.0	<21	<14	<14
PCB-118	1300	691	2660	611	3090	1200	891	2750	1270	503	2250	619	423	934
PCB-114	<8.2	<20	55.8	<13	65.6	20.2	<18	57.1	<21	12.8	48.2	<21	<16	<13
PCB-105	536	298	1010	238	1150	441	346	982	484	197	791	245	166	279
PCB-126	<6.9	<15	32.8	6.52	32.8	9.27	<6.1	36.7	<17	<4.2	29.8	<18	<12	<12
PCB-167	121	59.0	244	58.1	256	122	89.3	257	120	45.8	217	<8.2	28.1	<8.0
PCB-156	197	<110	395	110	406	202	171	413	216	79.3	320	62.1	40.1	<48
PCB-157	<48	<21	101	24.4	112	52.4	37.8	107	56.1	19.3	86.4	<6.4	<12	<6.6
PCB-169	<4.0	5.53	11.4	<2.3	12.9	<3.0	<5.5	13.9	5.77	<2.3	12.2	<5.7	<3.3	<5.8
PCB-189	40.3	24.1	71.8	19.0	70.0	36.3	29.3	63.9	41.7	14.9	61.4	6.26	<8.2	<7.6
Homologue Group Totals	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g
Total-TCDD	<26	<17	<2.3	<4.0	19.9	5.16	<10	<3.1	<13	<4.0	10.7	<11	<10	<22
Total-PeCDD	<14	<11	3.19	<2.4	34.0	<1.8	<8.6	30.4	<13	<4.2	21.3	<14	<9.2	<14
Total-HxCDD	<13	<14	14.6	<1.8	16.2	12.2	<5.5	4.37	<8.8	<3.3	2.58	<12	<9.0	<15
Total-HpCDD	<23	27.5	14.1	10.0	<1.7	21.2	<9.6	<2.6	17.7	10.1	5.19	<13	13.6	<21
Total-TCDF	49.4	<11	61.8	<2.0	93.3	<2.1	<7.4	63.4	<11	179	49.5	<7.8	10.7	<12
Total-PeCDF	<9.5	10.9	37.5	6.75	49.3	4.08	<5.8	22.7	<7.3	6.69	34.2	<6.4	8.18	<11
Total-HxCDF	43.0	<9.1	17.6	10.8	52.3	20.5	11.1	30.1	<7.1	9.43	27.1	<7.9	<2.1	<9.9
Total-HpCDF	<24	<15	9.73	7.44	9.66	16.0	11.0	<3.1	<15	<7.0	6.32	<17	<8.5	<18
Toxic Equivalency WHO (2005)	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g	pg/g
Lower Bound TEQ - PCDD/F	0.35	0.01	2.47	0.00	1.64	0.60	0.00	0.01	0.00	3.13	1.22	0.00	1.58	0.00
Upper Bound TEQ - PCDD/F	10.56	8.32	3.42	1.76	3.02	1.90	5.15	2.15	7.16	5.07	2.34	6.56	5.66	9.59
Lower Bound TEQ - DLPCB	0.75	0.41	0.96	0.23	1.02	0.29	0.23	0.98	0.59	0.26	0.79	0.68	0.48	0.52
Upper Bound TEQ - DLPCB	0.99	0.75	0.96	0.26	1.02	0.31	0.38	0.98	0.94	0.33	0.79	1.06	0.74	0.83
Lower Bound TEQ - TOTAL	1.10	0.42	3.43	0.24	2.66	0.89	0.23	0.99	0.59	3.40	2.00	0.68	2.06	0.52
Upper Bound TEQ - TOTAL	11.55	9.07	4.38	2.02	4.04	2.21	5.53	3.13	8.10	5.40	3.12	7.62	6.41	10.42

Appendix C – Benthic Counts

Table C1. Family identification and enumeration at Jackfish Bay sites (number per 33 cm^2).

	Moberly Bay									Central Jackfish Bay			Lower Jackfish Bay		Tunnel Bay
Family	M701	1M4	EEM4	1M3	1M2[a]	JFB002	1M1	NF5	EEM8	2M1	2M4	JFB021	2M5	4M3	3M2
Asellidae	2.96	0.94	0.20	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00
Baetidae	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ceratopogonidae	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00
Chironomidae	31.34	23.03	25.34	0.43	1.20	4.13	1.00	11.91	2.68	1.20	3.00	1.80	1.40	1.17	3.60
Elmidae	0.00	0.00	0.00	0.00	0.15	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Enchytraeidae	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.82	0.00
Gammaridae	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hydropsychidae	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lebertiidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Lepidostomatidae	0.00	0.00	0.00	0.00	0.13	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lumbriculidae	1.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.00	0.00	0.00	0.00	0.88	0.00
Naididae	0.00	0.20	1.35	0.20	0.00	0.00	0.00	0.47	4.07	0.00	0.00	0.00	0.00	0.23	0.00
Sphaeriidae	1.81	3.67	3.78	0.43	0.50	1.56	0.80	4.22	0.13	1.20	0.40	0.40	0.20	0.33	1.40
Tubificidae	401.24	336.44	309.60	275.83	277.22	320.56	237.40	301.93	37.67	4.00	5.00	3.40	3.20	0.02	2.20
Pontoporeiidae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.60	0.80	3.20	1.80	1.21	4.60

[a] Mean of three field replicates

Table C2. Lowest level identification and enumeration for Jackfish Bay sites (number per 33 cm^2).

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		Moberly Bay											Central Jackfish Bay			Lower Jackfish Bay		Tunnel Bay
		M701	**1M4**	**EEM4**	**1M3**	**1M200**	**1M201**	**1M202**	**JFB002**	**1M1**	**NF5**	**EEM8**	**2M1**	**2M4**	**JFB021**	**2M5**	**4M3**	**3M2**
Ephemeroptera	(Genus) Baetis					0.4												
Coleoptera	(Genus) Optioservus					0.45				0.2								
Diptera-Chironomidae	(Genus) Chironomus	13.04	8.674	8.1		0.542		0.4	0.7	0.2	2.5	0.10				0.2		
	(Genus) Cladotanytarsus	0.22																
	(Genus) Harnischia	0.34																
	(Species) Heterotrissocladius											0.08		0.2				
	Heterotrissocladius marcidus gr.											0.80	0.2					
	Heterotrissocladius subpilosus gr.											0.58	1.2	2.4	0.8	1	0.39	3.2
	(Genus) Larsia											0.04						
	(Genus) Micropsectra	0.34															0.70	
	(Species) Microtendipes pedellus gr.					0.2												
	(Genus) Paracladopelma																0.04	
	(Genus) Pentaneurini				0.232													
	(Species) Polypedilum scalaenum gr.											0.09		0.2	0.2			
	(Genus) Procladius	15.92	14.35	17.25	0.2	0.84	0.4	0.82	3.48	0.8	9.182	1.98						0.2
	(Genus) Protanypus											0.00		0.2	0.8		0.04	0.2
	(Genus) Stictochironomus							0.2				0.04						
	(Genus) Tanytarsus	1.13					0.2					0.04				0.2		
Diptera	(Genus) Ceratopogoninae	0.34									0.228	0.24						
	(Genus) Probezzia			0.224								0.08						
Trichoptera	(Genus) Hydropsyche									0.2								
	(Genus) Lepidostoma					0.4				0.4								
Bivalvia	(Genus) Pisidium	1.81	3.67	3.784	0.43	0.69	0.20	0.62	1.56	0.80	4.216	0.13	1.20	0.40	0.4	0.20	0.33	1.40
Annelida	(Species) Arcteonais lomondi		0.2	0.86	0.2							0.10						
	(Species) Aulodrilus limnobius											0.04						
	(Species) Aulodrilus pluriseta	8.98	27.752	58.644	3.096	2.188	0.8	2.24	7.154	0.4	28.99	2.90						
	(Family) Enchytraeidae			0.2								0.04					0.82	
	(Species) Limnodrilus hoffmeis	35.07	34.93	30.6	12.328	49.444	17.2	23.9	70.736	20.6		5.93				0.6		
	(Species) Limnodrilus udekemia					8.2												
	(Family) Lumbriculidae	1.93										0.69					0.88	
	(Family) Naididae											0.98					0.02	
	(Genus) Nais											0.16						
	(Genus) Piguetiella											2.84						
	(Species) Spirosperma ferox	20.92	0.42	2.04	0.20	0.42		0.22		0.20	0.27	4.34						
	Tubificidae Immatures w/ cap setae	291.65	219.44	159.23	244.41	288.27	200.60	184.10	165.03	205.20	239.02	22.53	4.00	5.00	3.20	2.20	0.02	2.20
	Tubificidae Immatures w/o cap setae	44.64	53.90	59.08	15.80	8.46	18.00	27.60	77.65	11.00	33.65	1.93			0.20	0.40		
	(Species) Vejdovskyella comata			0.24														
	(Species) Vejdovskyella intermedia			0.24							0.47						0.21	
Acari	Acari					0.2		0.2			0.27							
	(Genus) Lebertia											0.04						
Crustacea	(Genus) Caecidotea	2.96	0.94	0.20								0.67						
	(Genus) Gammarus		0.21								0.23							
	Diporeia sp.											0.06	0.6	0.8	3.20	1.8	1.21	4.6
	Total Abundance	439.3	364.5	340.7	276.9	360.7	237.4	240.3	326.3	240.0	319.0	47.5	7.2	9.2	8.8	6.6	4.7	11.8
	% Immature tubificids w/ cap setae	66.4	60.2	46.7	88.3	79.9	84.5	76.6	50.6	85.5	74.9	47.5	55.6	54.3	36.4	33.3	0.4	18.6

Appendix D - BEAST Benthic Community Structure Ordinations

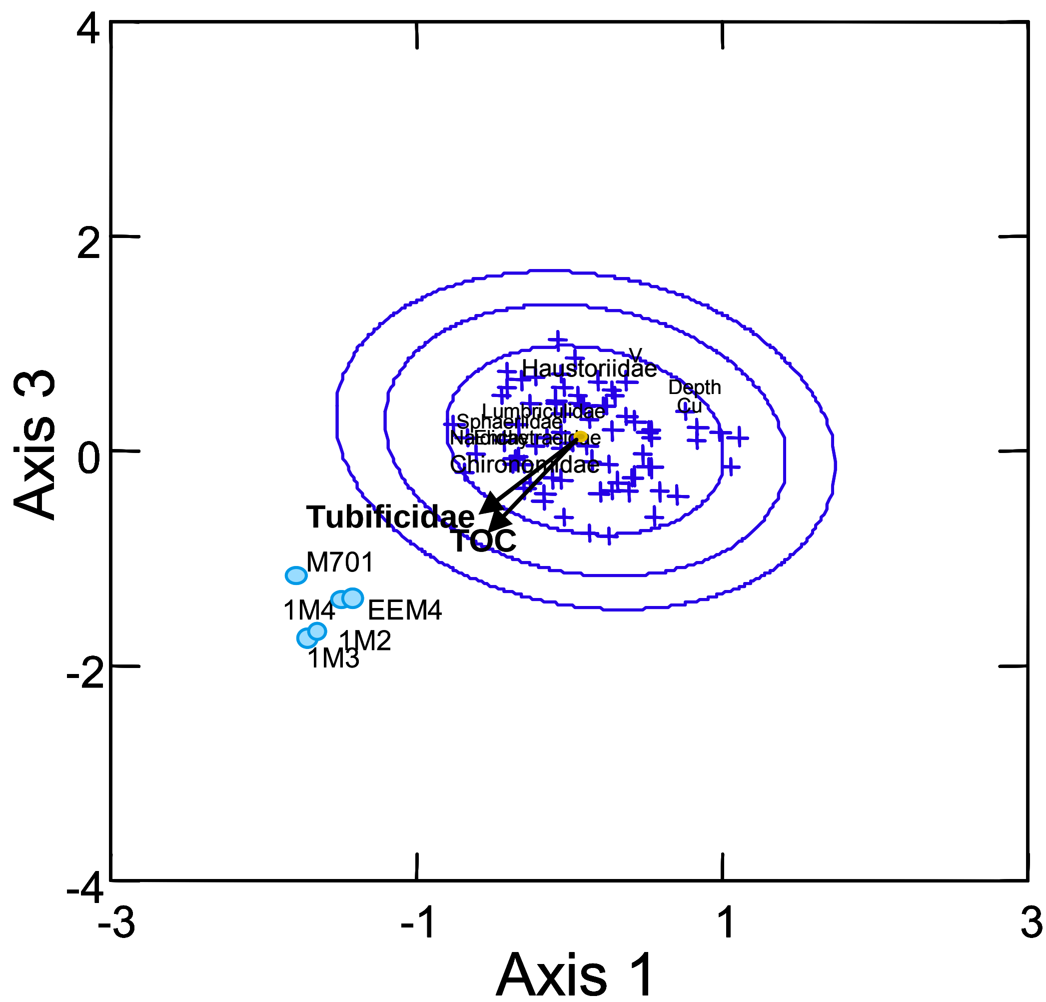

Figure D1. Assessment of subset of Moberly Bay sites summarized on axes 1 and 3. Stress = 0.123.

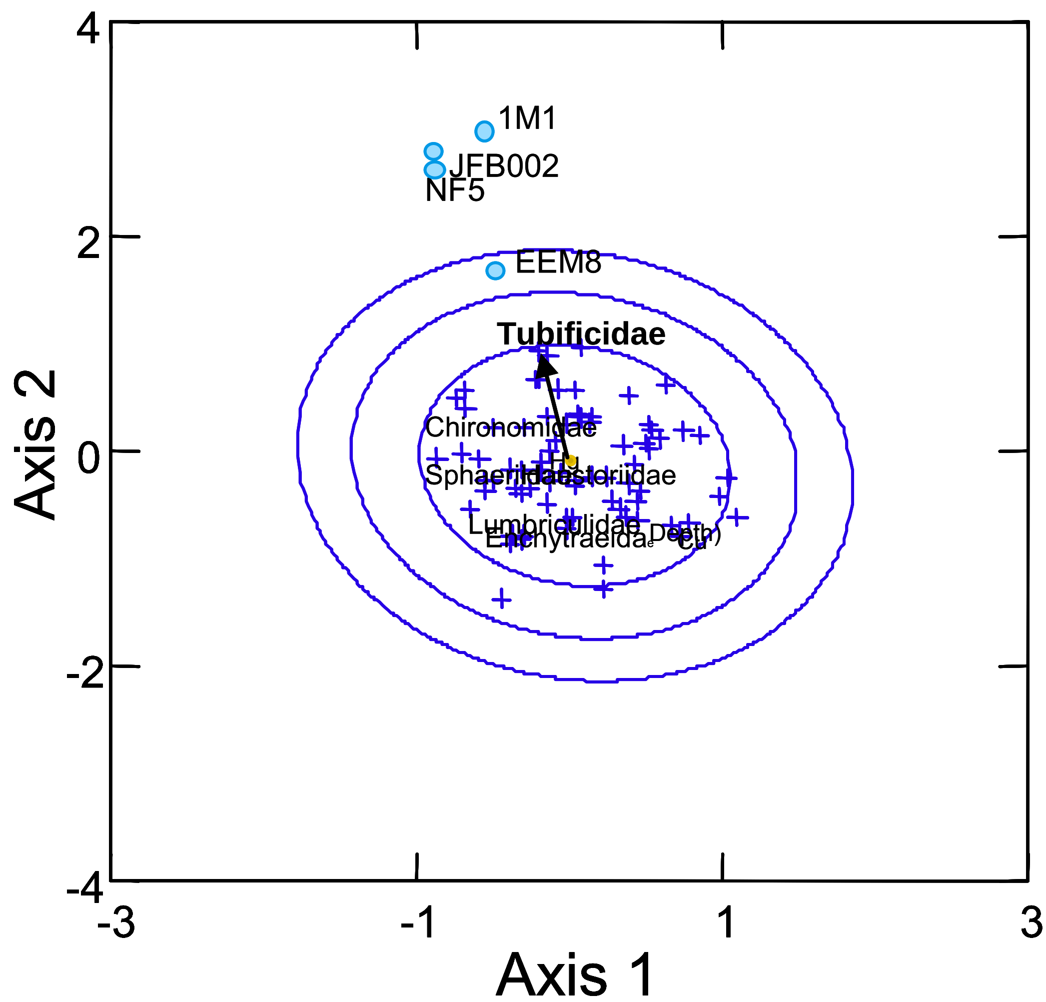

Figure D2. Assessment of subset of Moberly Bay sites summarized on axes 1 and 2. Stress = 0.139.

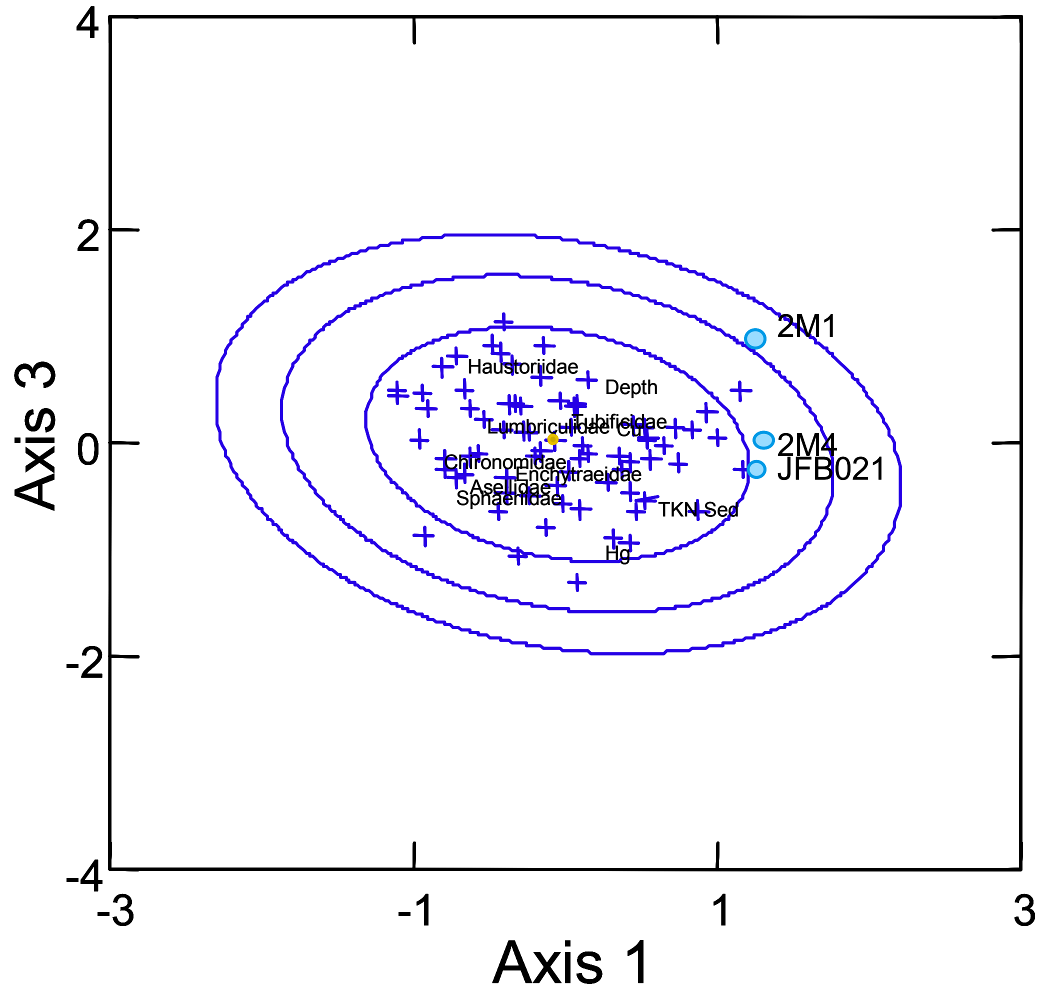

Figure D3. Assessment of sites in central Jackfish Bay summarized on axes 1 and 3. Stress = 0.155.

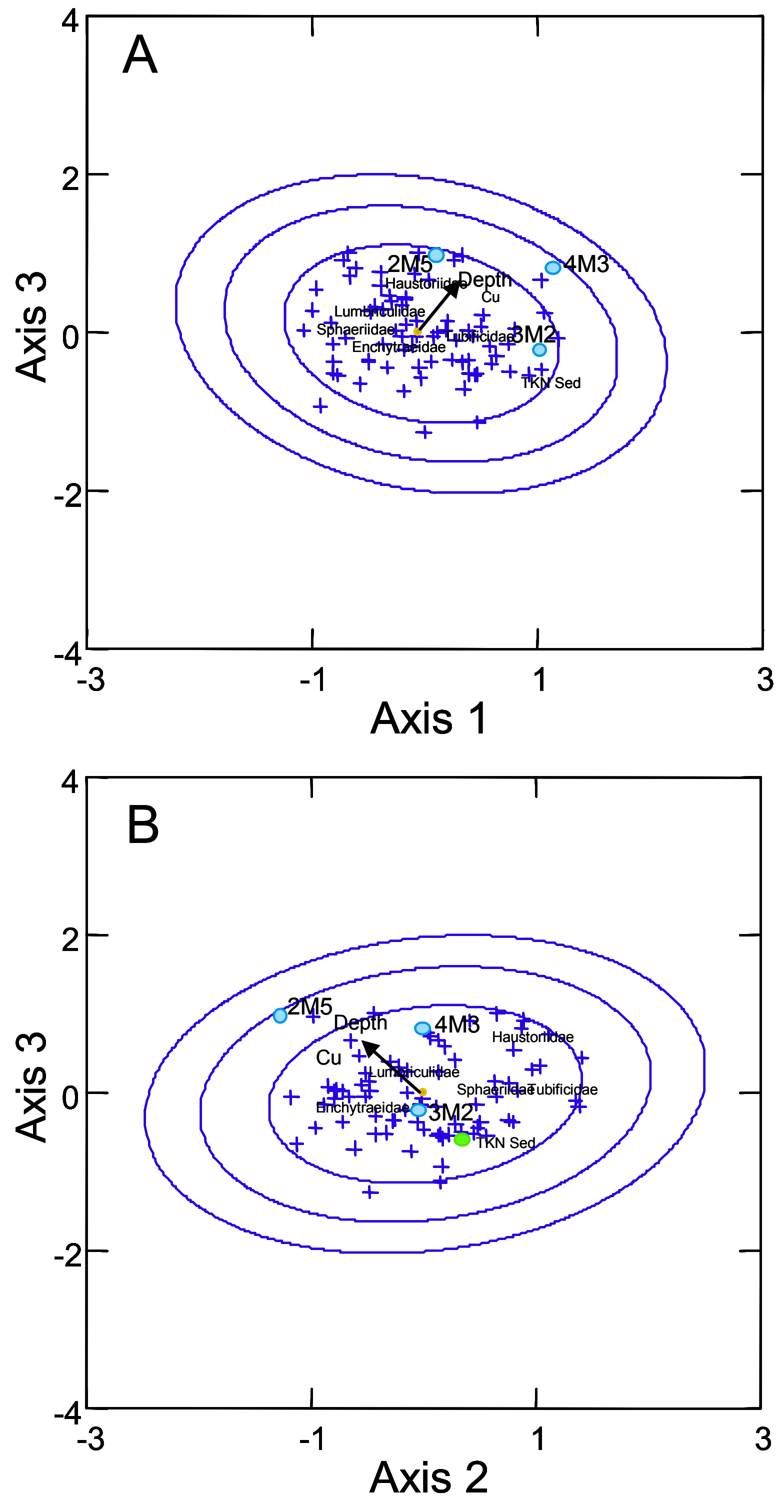

Figure D4. Assessment of Jackfish and Tunnel Bay sites for axes 1 vs. 3 (A) and axes 2 vs. 3 (B). Stress = 0.158.

Appendix E - BEAST Toxicity Ordinations

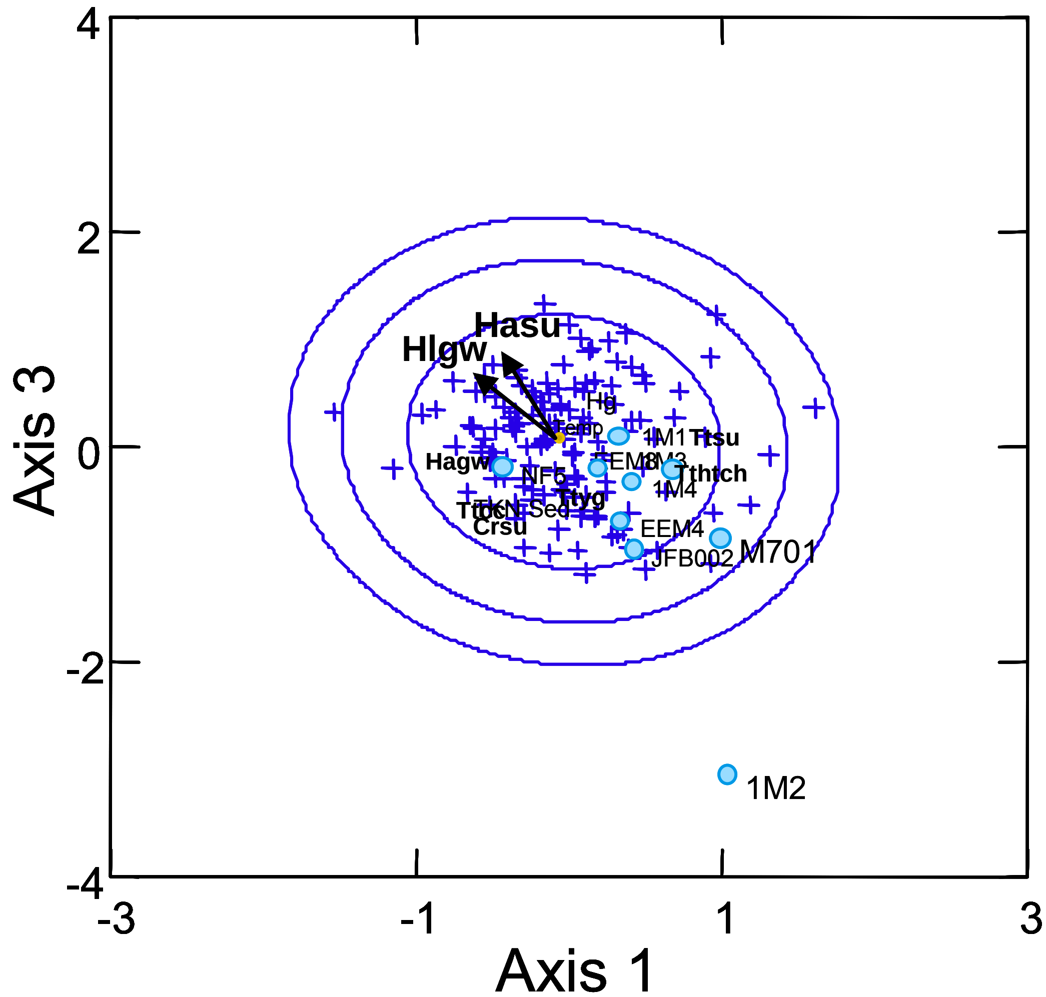

Figure E1. Assessment of Moberly Bay sites summarized on axes 1 vs. 3. Stress = 0.110. Note: Site JB002 falls in Band 2 on alternate axes (axes 2 vs. 3).

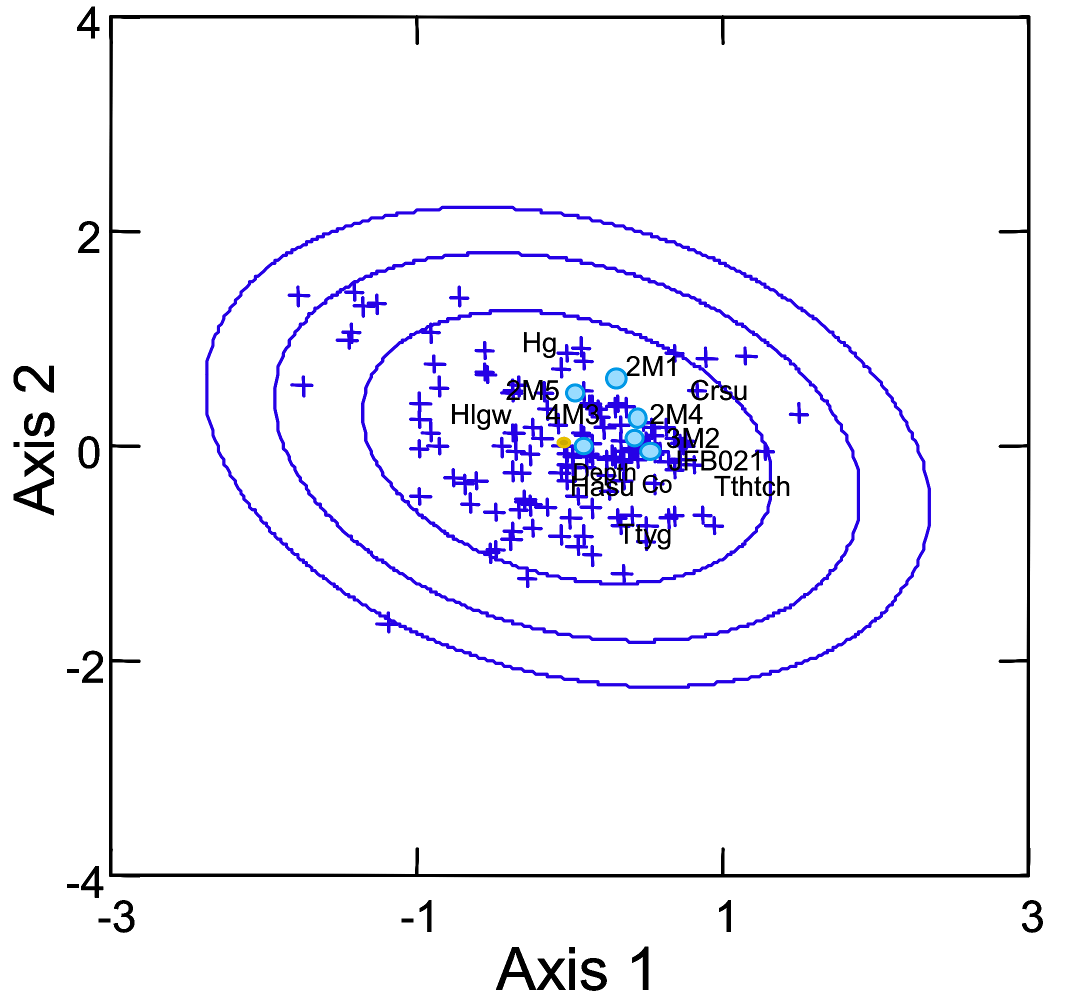

Figure E2. Assessment of sites in central and lower Jackfish Bay and Tunnel Bay summarized on axes 1 vs. 2. Stress = 0.116.

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