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Key words: organotin, tributyltin, butyltin, methyltin, tin, water, sediment, fish, occurrence

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## EXECUTIVE SUMMARY

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Water and sediment samples from 265 locations across Canada were analyzed for butyltin and methyltin species, and inorganic tin. In 10 % of the water samples the highly toxic tributyltin species was found at concentrations which could cause growth retardation upon chronic exposure to a sensitive organism, rainbow trout yolk sac fry. High concentrations of tributyltin were found in some sediments (up to 10 mg Sn/kg dry weight), but the biological availability of sediment-associated tributyltin is unknown. Tributyltin was mainly found in areas of heavy boating and shipping traffic, which is consistent with its use as an antifouling agent in some paints for boats, ships and docks. The methyltin species were found much less frequently in water and sediment than tributyltin and its degradation products.

On the basis of this work and our earlier work, we conclude that the highly toxic tributyltin is moderately persistent in water and sediment in Canada (half life at least a few to several months), and that in areas of boating and shipping traffic there may be cause for concern with regard to chronic toxicity or effects in sensitive organisms.

## Management Implications

Tributyltin is a pesticide which is used as (i) an antifouling agent in some paints for boats, ships and docks, (ii) a general lumber preservative, and (iii) a slimicide in cooling water. It is 10-4000 times more toxic to rainbow trout than pentachlorophenol, carbofuran, copper, lead, fenitrothion, aminocarb, chlorobenzene and arsenic. A cursory literature search reveals that only 2,3,7,8-TCDD and chlorpyrifos are more toxic than tributyltin to rainbow trout.

As a member of the organotin class, tributyltin was listed on the Environmental Contaminants Act Category III list in 1979. The results of our research over the past five years should provide the Commercial Chemicals Branch (EPS), which administers ECA, with enough information to take further action. This may involve regulatory action under ECA or referral to Agriculture Canada for action under the Pest Control Products Act. This work will also be communicated to the Water Quality Branch so that they may consider monitoring for tributyltin in selected areas.

## ABSTRACT

Water and sediment samples from 265 locations across Canada were analyzed for butyltin and methyltin species, and inorganic tin. In 10% of the water samples the highly toxic tributyltin species was found at concentrations which could cause growth retardation upon chronic exposure to a sensitive organism, rainbow trout yolk sac fry. High concentrations of tributyltin were found in some sediments (up to 10 mg Sn/kg dry weight), but the biological availability of sediment-associated tributyltin is unknown. Tributyltin was mainly found in areas of heavy boating and shipping traffic, which is consistent with its use as an antifouling agent in some paints for boats, ships and docks. The methyltin species were found much less frequently in water and sediment than tributyltin and its degradation products.

# RÉSUMÉ

La contamination de l'eau et des sédiments dans 265 locations au Canada par les espèces des butylétains et des methylétains, et de l'étain inorganique, est mise en evidence. Dans 10% des échantillons de l'eau, la concentration du tributylétain est suffisamment elevée pour susciter des inquietudes quant à sa toxicité chronique pour les organismes sensibles. On a trouvé des concentrations elevées du tributylétain dans des sédiments aussi (jusqu'a 10 mg Sn/L), mais, on ne sait pas si le tributylétain dans les sédiments est toxique. On a trouvé le tributylétain en générale dans les ports ou dans les chenaux de navigation, car le tributylétain est utilisé comme un agent antisalissure dans quelques peintures pour des bateaux. On a trouvé des espèces des methylétains dans l'eau et dans les sédiments beaucoup moins souvent que les espèces butylétains.

## INTRODUCTION

Organotin compounds are used in three main ways, *viz.*, as stabilizers for poly(vinyl chloride), as catalysts and as pesticides (1). They are a class of compounds about which more information is sought under Canada's Environmental Contaminants Act (2) regarding toxicology and environmental fate.

The main organotin compounds which are likely to be released to the environment in Canada are those of triphenyltin ($Ph_3Sn^+$), tricyclohexyltin ($Cy_3Sn^+$), di-n-octyltin ($Oct_2Sn^{2+}$), di-n-butyltin ($Bu_2Sn^{2+}$), dimethyltin ($Me_2Sn^{2+}$) and tri-n-butyltin ($Bu_3Sn^+$) (1). Triphenyltin and tricyclohexyltin are agricultural pesticides. Di-n-octyltin is used as a stabilizer in some food wrappings. Di-n-butyltin is used as a poly(vinyl chloride) stabilizer, as is dimethyltin, and as a catalyst in a number of industrial processes. Tri-n-butyltin is used as an antifouling agent in some paints for boats, ships and docks, as a general lumber preservative and as a slimicide in cooling water. It is by far the most toxic to aquatic organisms of all organotin compounds used in Canada.

Persistence studies on prominent organotin pesticides have indicated that abiotic degradation generally occurs, as does biological degradation, through mechanisms of sequential dealkylation (3) or dearylation (4). Therefore the series $Ph_nSn^{(4-n)+}$, $Cy_nSn^{(4-n)+}$ and $Bu_nSn^{(4-n)+}$ (where in each case $n < 4$), $Oct_nSn^{(4-n)+}$ (where $n \leq 2$) and $Me_nSn^{(4-n)+}$ (where $n \leq 4$) may be present in the Canadian environment. The last series includes tri- and tetramethyltin, which are not released *per se* to the environment, since methylation of tin and methyltin species has been demonstrated in natural water-sediment mixtures (5,6).

We have been interested in tributyltin because of its high toxicity, and in methyltin species since methylation of tin and organotin compounds may be important in their environmental mobility. Over the past several years we have developed methods of analysis for butyltin and methyltin species in water and sediment (7-9), reported their occurrence in a small survey of Ontario harbours and shipping channels (10-12), and determined the persistence of tributyltin in fresh water and sediment (3,13,14). This article is a survey of 265 locations across Canada (and 7 locations in Michigan and New York State, USA) for butyltin and methyltin species, and inorganic tin, in water and sediment. Such a national survey is an essential element of the evaluation of the hazard posed by these compounds to aquatic ecosystems in Canada, and is one of the main recommendations of the National Research Council of Canada review of organotin compounds (1). Analyses of a much smaller number of fish for the butyltin and methyltin species, and inorganic tin, are also reported in this article.

## EXPERIMENTAL SECTION

For brevity, each of the n-butyltin and methyltin species is referred to here as though it existed only in cationic form (e.g., $Bu_3Sn^+$). This formalism is not meant to imply exact identities for these species in water, sediment or fish.

### Materials

Tetra-n-butyltin, bis(tri-n-butyltin) oxide, di-n-butyltin dichloride, n-butyltin trichloride, trimethyltin chloride, dimethyltin dichloride, methyltin trichloride, tin, methylmagnesium bromide and n-butylmagnesium bromide were from Ventron (Danvers, MA, USA). n-Pentylmagnesium bromide was prepared from readily available chemicals. 2-Hydroxy-2,4,6-cycloheptatrien-1-one (tropolone) was from Aldrich (Milwaukee, WI, USA). All organic solvents were pesticide grade from Caledon (Georgetown, Ont., Canada). Sulfuric and hydrochloric acids were reagent grade, but the HCl was washed with a solution of tropolone in benzene to remove traces of inorganic tin. Water was doubly-distilled.

Butylpentyltin ($Bu_nPe_{4-n}Sn$, where $n \leq 4$) and butylmethyltin ($Bu_nMe_{4-n}Sn$, where $1 \leq n \leq 3$) standards were prepared by standard Grignard techniques (7,9) which do not result in redistribution of alkyl groups. Particular attention was paid to the possibility of contamination of the n-butylmagnesium bromide and n-pentylmagnesium bromide by methylmagnesium bromide, but no such contamination was evident. This precaution was taken to confirm that the observations of naturally-occurring methyltin species and butylmethyltin compounds in water and sediment were real.

### Sample Collection

Water and/or sediment samples were collected from 265 locations across Canada (and 7 locations in Michigan and New York State, USA) between 1982 and 1985. However, at only 179 of these locations were both water and sediment samples taken. The reasons for this are that some samples were taken as part of sampling programs of other agencies, and that, e.g., no sediment sample could be taken at a particular location because of the nature of the lake or river bottom. The small boats used in sample collection were not painted with antifouling paint.

For the butyltin species, samples (8 L) of subsurface water from a depth of 0.5 m were collected in amber glass bottles, and the contents were acidified to pH 1 and stored at 4 °C until extraction. These preservation conditions are effective over a period of at least three months (15). Sediment samples were collected with an Ekman dredge. The top 2 cm was scraped off into glass jars and frozen as soon as possible, then freeze-dried, ground and sieved to pass an 850 um screen. The fresh water fish were provided by the Great Lakes Fisheries Research Branch of the Department of Fisheries and Oceans.

For the methyltin species, subsurface water samples of 4 L only were collected, and were preserved with 1400 g each of NaCl prior to storage at 4 °C. The sediment was collected as described above.

Sample Analysis - Butyltin Species and Inorganic Tin

The methods of analysis for water (7,10) and sediment (11) are documented elsewhere. In essence, they involve extraction of $Bu_3Sn^+$, $Bu_2Sn^{2+}$, $BuSn^{3+}$ and inorganic tin from acidified water samples, or dry sediments, with the complexing agent tropolone dissolved in benzene, pentylation of the extract to produce the volatile mixed butylpentyltin derivatives, $Bu_nPe_{4-n}Sn$, purification by silica gel column chromatography, concentration of the purified solution, and gas chromatographic determination of the derivatives (*vide infra*).

The analyses of the fish required a few modifications. Whole fish (5-200 g) were homogenized in a blender, and the homogenate was dispersed in concentrated HCl (16) with 10 mL HCl per g of homogenate. Practically complete solution at room temperature was usually effected in less than 2 hr with magnetic stirring. Higher temperatures and longer stirring times should be avoided. The resulting mixture was diluted five-fold with water, then extracted in the same way as the water samples described above. Success in breaking emulsions and in lipid removal was achieved by using large quantities of $Na_2SO_4$ during the drying stage before derivatization, and by using 3% water-deactivated silica gel in the final clean-up, rather than the activated silica gel used in the water and sediment analyses.

Determination of the $Bu_nPe_{4-n}Sn$ derivatives from extracts of water, sediment and fish was done by packed column gas chromatography with a quartz tube furnace atomic absorption spectrophotometric detector (8). Considering that a fairly specific detector for tin was used in the analyses, identities of the butylpentyltin species were deemed to be confirmed by co-chromatography with authentic standards on two column packing materials of very different polarity.

In the quantitation of the analytes, use was made of appropriate reagent blanks. The results reported in this article are all above the limit of quantitation (LOQ), which is defined (17) as the reagent blank value plus ten times its standard deviation. In practice, for our work this is equivalent to stating that a chromatographic peak was not accepted as real unless it was at least 2-3 times as large as any corresponding peak in the reagent blank.

Recoveries of $Bu_3Sn^+$, $Bu_2Sn^{2+}$ and $BuSn^{3+}$ from spiked water samples at 1-10 mg Sn/L varied from 96 $\pm$ 4 to 103 $\pm$ 8% (7). Recoveries of Sn(IV) from water at pH 5-8 were poor (35 $\pm$ 23%), probably because of the formation of unextractable $SnO_2$ (3). Recoveries of the three butyltin species and inorganic tin from spiked sediment at 0.01, 0.2, 1 and 100 mg Sn/kg dry weight ranged from 55 $\pm$ 26 to 180 $\pm$ 100% (11); in general, however, recoveries were quantitative within a fairly wide range of experimental error. From lake trout (Salvelinus namaycush Walbaum) spiked with each species at 0.02-0.10 mg Sn/kg wet weight, recoveries of $Bu_3Sn^+$ were 94 $\pm$ 14 to 104 $\pm$ 12%; of $Bu_2Sn^{2+}$, 66 $\pm$ 11 to 83 $\pm$ 4%; of $BuSn^{3+}$, 55 $\pm$ 10 to 63 $\pm$ 5%; of Sn(IV), 21 $\pm$ 11 to 97 $\pm$ 2%. Although the method described above was developed for lake trout, it is reasonable to assume that it would be equally as effective for other fish.

The concentrations of butyltin and methyltin species, and inorganic tin, in water, sediment and fish reported in this article have not been corrected for recovery.

Although Sn(IV) was the only inorganic tin species for which recoveries were determined, the tin present in our water, sediment and fish samples is reported as total inorganic tin, since any Sn(II) which might have been present would likely have been oxidized to Sn(IV) during pentylation.

## Sample Analysis - Methyltin Species

The method of analysis for water is documented elsewhere (9). In essence, it involves extraction of the three methyltin species, $Me_3Sn^+$, $Me_2Sn^{2+}$, $MeSn^{3+}$, and inorganic tin, from the NaCl-preserved water samples with tropolone in benzene, butylation of the extract to produce the volatile mixed butylmethyltin derivatives, $Bu_nMe_{4-n}Sn$, and determination of the derivatives by packed column gas chromatography with a quartz tube furnace atomic absorption spectrophotometric detector.

In the determination of the methyltin species and inorganic tin in sediment, 1 g of freeze-dried sediment was mixed with 10 mL $H_2O$, 6 g NaCl, 1 g KI, 2 g sodium benzoate and 5 mL of 0.5% (w/v) tropolone/benzene solution, and the mixture was shaken for 2 hr. Phases were separated by centrifugation, and 1 mL of the benzene phase was butylated and analyzed as described above for water.

In the determination of the methyltin species and inorganic tin in fish (*i.e.*, sole, *Microstomus pacificus* Lockington), 2 g of homogenate was digested in 5 mL of 20% tetramethylammonium hydroxide in a capped test tube in a water bath at 60 °C for 1-2 hr until the tissue had dissolved to a pale yellow colour. After the solution was cooled, its pH was reduced to 6-8 with 50% HCl, 2 g NaCl and 3 mL 0.5% (w/v) tropolone/benzene were added, and the mixture was shaken for 1 hr. Phases were separated by centrifugation, and 1 mL of the benzene phase was butylated and analyzed as described above for water.

The comments made above with regard to confirmation of identity of the butyltin species, and their limits of quantitation, are also generally applicable to the methyltin species. Recoveries of the three methyltin species and Sn(IV) from water, sediment and fish were generally quantitative. Determinations of Sn(IV) by the butylation technique agreed well with determinations by the pentylation technique.

## RESULTS

### Butyltin Species and Inorganic Tin in Water

Table 1 shows concentrations of the three butyltin species and inorganic tin in unfiltered water and the top 2 cm of sediment at 272 locations (five locations were sampled twice). Details of the sampling locations are given in the Appendix.

The most important species to consider is tributyltin since the toxicity of butyltin species declines substantially with decreasing number of butyl groups (18). In subsurface water, tributyltin was determined reliably (*i.e.*, at concentrations greater than its limit of quantitation) in 43 of 221 samples. In general it was found in areas of heavy boating or shipping traffic, which is consistent with its use in some antifouling paints for boats, ships and docks. The highest concentration of tributyltin found was in Port Hope, Ontario (2.34 ug Sn/L). This concentration is about one quarter of the 24 hr LC-50 value for adult rainbow trout (19) and in addition it exceeds the 12 d LC-100 value of 1.83 ug Sn/L for rainbow trout yolk sac fry (20). At another 7 locations the tributyltin concentration was less than 1.83 ug Sn/L but greater than 0.37 ug Sn/L, a concentration which was found, over a period of 110 d, to cause a significant and dose-related growth retardation in rainbow trout yolk sac fry (20). At a further 13 locations the tributyltin concentration was less than 0.37 ug Sn/L but greater than 0.07 ug Sn/L, a concentration at which growth retardation of rainbow trout yolk sac fry over 110 d was observed, but was significant only during the last few weeks of the exposure period (20). Therefore in 21 of these 43 locations at which tributyltin was determined reliably, there may be cause for concern with regard to chronic toxicity or effects in sensitive organisms. These 21 locations represent 10% of all locations at which water samples were taken.

The aqueous tributyltin concentrations reported in this survey are similar to those found earlier in Ontario waters (10), but are generally higher than those in seawater in England (21), rivers and lakes in Switzerland (22), and San Diego Bay, USA (23).

Dibutyltin was found in 27 of our 221 water samples. It could be introduced to water itself since dibutyltin compounds are used as poly(vinyl chloride) stabilizers, or it could be a degradation product of tributyltin, which is perhaps more likely since tributyltin was found in 19 of the 27 locations at which dibutyltin was found. Monobutyltin was found in 33 of 221 water samples. To our knowledge, monobutyltin compounds are not used commercially in Canada, so the monobutyltin found in water is probably a degradation product of dibutyltin. The inorganic tin found in water may be present naturally, may be introduced in inorganic form, and/or may be a degradation product of organotin compounds.

<u>Butyltin Species and Inorganic Tin in Sediment</u>

The sediment results are also shown in Table 1. Tributyltin was determined reliably (<u>i.e.</u>, at concentrations greater than its limit of quantitation) in 78 of 235 samples. In general the pattern of its occurrence in sediment was similar to its pattern of occurrence in water. The ten highest concentrations of tributyltin, up to 10.8 mg Sn/kg dry weight, were all found in different parts of Vancouver Harbour. The toxicological significance of sediment-associated tributyltin is at present difficult to assess. Tributyltin appears to be adsorbed moderately strongly to sediment and very little was desorbed from undisturbed sediment over a period of 10 months (14). The biological availability of sediment-associated tributyltin has yet to be established. Preliminary results indicate that oligochaete worms (i) can accumulate sediment-associated tributyltin, thus making it potentially available to bottom-feeding fish, and (ii) can degrade tributyltin.

There are few other data with which to compare our sediment results. With the exception of the high concentrations in Vancouver Harbour, the concentrations of tributyltin in sediment reported in this survey are similar to those found earlier in Ontario (10), and to the concentration in one Japanese river sediment (24), but generally exceed those of four Swiss lake sediments (22).

Dibutyltin was found in 61, monobutyltin in 47 and inorganic tin in 100 of our 235 sediment samples.

Methyltin Species in Water and Sediment

Table 2 shows concentrations of the three methyltin species in water and sediment in the only locations at which they were found (concentrations of inorganic tin are shown in Table 1). The methyltin species were found much less frequently than the butyltin species, i.e., in only 7 of 221 water samples and 21 of 235 sediment samples. The findings in water are in marked contrast to our earlier findings in Ontario (10), in which $MeSn^{3+}$ and $Me_2Sn^{2+}$ were found in 28 of 30 water samples. The concentrations observed in water in this survey are, however, similar to those observed before in Ontario and in a variety of natural waters elsewhere (25-29). As far as the sediment results are concerned, the high concentrations of $MeSn^{3+}$ in some harbours in New Brunswick (up to 17 mg Sn/kg dry weight) is noteworthy. Even without considering the New Brunswick results, the concentrations of the three methyltin species in sediments in this survey are significantly higher than those observed in other areas (29). As with tributyltin, the toxicological significance of sediment-associated residues of methyltin species is unknown. It should be borne in mind, however, that methyltin species in water are far less toxic to aquatic organisms than is tributyltin (18,30).

Butyltin and Methyltin Species, and Inorganic Tin, in Fish

Table 3 shows concentrations of butyltin and methyltin species, and inorganic tin, in fish. Water and sediment samples were not taken at the same time as the fish were caught. Only 18 fish were analyzed, so it is difficult to generalize on the results. Inorganic tin was found frequently in the fish. The only fish which contained tributyltin were from harbours, which is at least consistent with the findings in water and sediment.

Naturally-Occurring Butylmethyltin Compounds in Water and Sediment

Our earlier finding of $Bu_3MeSn$ and $Bu_2Me_2Sn$ in the sediments of four harbours in Ontario at relatively high concentrations with respect to $Bu_3Sn^+$ and $Bu_2Sn^{2+}$ prompted speculation that methylation of butyltin species in aquatic environments may be a significant pathway of transformation (11). This survey has shown, however, that butylmethyltin compounds were found only infrequently in water and sediment. The results, for the only locations at which these compounds were found, are shown in Table 4. The compound $Bu_3MeSn$, for example, was determined reliably in only 7 water samples and 1 sediment sample, compared with 43 water samples and 78 sediment samples for $Bu_3Sn^+$. In general, $Bu_3Sn^+$ concentrations were greater than $Bu_3MeSn$ concentrations in water and sediment in locations at which both species were found. Therefore, although it is likely that the butylmethyltin compounds resulted from the methylation of butyltin species in water or sediment (11), this survey demonstrates that such methylation is not in general a significant pathway of transformation of butyltin species. Support for such a conclusion is provided by our recent work on the biological degradation of tributyltin in water and sediment (14). The species $Bu_3MeSn$, $Bu_2Me_2Sn$, $MeSn^{3+}$ and $Me_2Sn^{2+}$ were observed but appeared to be present in minor amounts relative to those of $Bu_3Sn^+$, $Bu_2Sn^{2+}$, $BuSn^{3+}$ and inorganic tin.

Table 4 also shows that tetrabutyltin was found rarely in water and sediment. It may result from the disproportionation of other butyltin species, or it might be introduced to water as a contaminant of some pesticidal tributyltin formulations.

## DISCUSSION

Methyltin Species

The occurrence of methyltin species in water and sediment may be a result of the use of dimethyltin compounds as poly(vinyl chloride) stabilizers, and/or the result of the methylation of inorganic tin and methyltin species, either biologically or abiotically (5,6,31,32). Within the limits of the analytical method used in this survey, methyltin species were only infrequently found in water and sediment. On the basis of these data alone we cannot determine the origin of the methyltin species.

Despite the fact that methylation of inorganic tin in water and sediment is a slow process (with a half life probably $\gg$1 y - ref. 6), it should not be discounted as a significant phenomenon over long periods of time since the process converts tin to forms which are both more toxic and, more importantly, more mobile in aquatic environments.

Butyltin Species

This discussion will be limited to tributyltin since it is the most toxic of the butyltin species (18).

The hazard posed by tributyltin to an organism in water or sediment may be viewed as a function of its toxicity and its concentration and persistence in water or sediment.

Tributyltin is highly toxic to aquatic organisms. For copepods (33,34), mussel larvae (35), crab larvae (30), lobster larvae (36), sheepshead minnows (37), bleak (33), guppy (38) and rainbow trout (19,20) lethal concentrations are in the range 0.04-16 ug Sn/L. Most of the available data on toxicity are for marine organisms, and although it is reasonable to assume that tributyltin would be equally as toxic to fresh water organisms, more information is needed on its toxicity to fresh water organisms. In addition, in view of the high concentrations of tributyltin in sediments in Vancouver Harbour, the biological availability of sediment-bound tributyltin should be investigated.

On the basis of our work on the degradation of tributyltin in fresh water and sediment (3,14), it appears that the main factors limiting its persistence are sunlight degradation in water and biological degradation in water and sediment, and with the temperatures and sunlight intensities prevalent in Canada, the half life of tributyltin is likely to be at least a few to several months.

With regard to the finding of tributyltin in water, it should be noted that no attempt was made in this work to determine the partitioning of tributyltin between suspended solids and "solution" since the solids/water partition coefficient ($K_p = 3 \times 10^3$ ug/kg/ug/L) at a suspended solids concentration of 10 mg/L indicates that most tributyltin is associated with the aqueous phase of the water column and very little is adsorbed onto suspended solids (39). For the purposes of this work, therefore, it is assumed that all the tributyltin in the water column is bioavailable and potentially toxic to aquatic life. This work has shown that in 10% of the 221 locations from which water samples were collected, there may be cause for concern with regard to chronic toxicity or effects in sensitive organisms. The affected areas are mainly those that have heavy boating or shipping traffic.

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Table 1. Concentrations of Butyltin Species and Inorganic Tin in Unfiltered Subsurface Water and the Top Two cm of Sediment[a]

| No. | Location | Water (ug Sn/L) | | | | Sediment (mg Sn/kg) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $Bu_3Sn^+$ | $Bu_2Sn^{2+}$ | $BuSn^{3+}$ | Tin | $Bu_3Sn^+$ | $Bu_2Sn^{2+}$ | $BuSn^{3+}$ | Tin |
| BRITISH COLUMBIA | | | | | | | | | |
| 1 | Nanaimo Harbour | det. | det. | | det. | | det. | | 0.24 |
| 2 | Tsehun Harbour | | | | | 0.18 | 0.08 | 0.04 | 0.02 |
| 3 | Deep Cove | det. | det. | | 0.12 | | | | 0.22 |
| 4 | Patricia Bay | | | | | | | | |
| 5 | Esquimalt Harbour (1) | | | | | 0.14 | 0.02 | det. | |
| 6 | Esquimalt Harbour (2) | det. | det. | | 0.01 | 1.40 | 0.70 | 0.32 | 0.70 |
| 7 | Victoria Harbour (1) | det. | det. | det. | det. | | | | |
| 8 | Victoria Harbour (2) | | | | | 0.24 | 0.28 | 0.15 | 1.70 |
| 9 | Vancouver Harbour (1) | | | | | det. | | | 0.08 |
| 10 | Vancouver Harbour (2) | x | x | x | x | 0.02 | det. | det. | det. |
| 11 | Vancouver Harbour (3) | x | x | x | x | | | | |
| 12 | Vancouver Harbour (4) | x | x | x | x | 0.15 | 0.04 | | 0.32 |
| 13 | Vancouver Harbour (5) | x | x | x | x | 0.08 | 0.02 | | |
| 14 | Vancouver Harbour (6) | x | x | x | x | 0.11 | 0.09 | 0.02 | |
| 15 | Vancouver Harbour (7) | x | x | x | x | 0.05 | 0.03 | det. | 0.01 |
| 16 | Vancouver Harbour (8) | x | x | x | x | 0.02 | det. | | |
| 17 | Vancouver Harbour (9) | det. | det. | | det. | 0.12 | 0.07 | 0.02 | 0.19 |
| 18 | Vancouver Harbour (10) | x | x | x | x | 2.18 | 0.39 | 0.28 | 1.74 |
| 19 | Vancouver Harbour (11) | x | x | x | x | 0.35 | 0.03 | | |
| 20 | Vancouver Harbour (12) | | | det. | det. | 1.90 | 0.90 | 0.21 | 0.12 |
| 21 | Vancouver Harbour (13) | x | x | x | x | 7.35 | | | 0.60 |
| 22 | Vancouver Harbour (14) | x | x | x | x | 2.78 | 0.90 | det. | det. |
| 23 | Vancouver Harbour (15) | x | x | x | x | 2.12 | | | |
| 24 | Vancouver Harbour (16) | x | x | x | x | 0.51 | 0.22 | 0.03 | |
| 25 | Vancouver Harbour (17) | x | x | x | x | 0.26 | 0.04 | det. | det. |
| 26 | Vancouver Harbour (18) | | | | | | | | |
| 27 | Vancouver Harbour (19) | x | x | x | x | 0.57 | 0.30 | | 0.19 |
| 28 | Vancouver Harbour (20) | x | x | x | x | 0.05 | | | |
| 29 | Vancouver Harbour (21) | x | x | x | x | | | | |

Table 1 cont'd

| No. | Location | Water (ug Sn/L) | | | | Sediment (mg Sn/kg) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $Bu_3Sn^+$ | $Bu_2Sn^{2+}$ | $BuSn^{3+}$ | Tin | $Bu_3Sn^+$ | $Bu_2Sn^{2+}$ | $BuSn^{3+}$ | Tin |
| 30 | Vancouver Harbour (22) | x | x | x | x | 0.17 | 0.40 | 0.23 | 0.28 |
| 31 | Vancouver Harbour (23) | | | | 3.42 | 0.02 | 0.03 | 0.02 | det. |
| 32 | Vancouver Harbour (24) | x | x | x | x | 1.50 | 0.56 | 0.08 | |
| 33 | Vancouver Harbour (25) | x | x | x | x | 0.31 | 0.11 | 0.02 | 0.03 |
| 34 | Vancouver Harbour (26) | x | x | x | x | 2.60 | 0.12 | | |
| 35 | Vancouver Harbour (27) | x | x | x | x | 3.26 | 1.60 | 0.29 | 0.95 |
| 36 | Vancouver Harbour (28) | 0.01 | | | det. | 0.35 | 0.29 | 0.17 | 0.60 |
| 37 | Vancouver Harbour (29) | | | | det. | 0.28 | 0.20 | 0.04 | det. |
| 38 | Vancouver Harbour (30) | x | x | x | x | 9.32 | 7.10 | | |
| 39 | Vancouver Harbour (31) | x | x | x | x | 0.08 | 0.03 | | 0.02 |
| 40 | Vancouver Harbour (32) | x | x | x | x | 0.09 | 0.03 | det. | 0.11 |
| 41 | Vancouver Harbour (33) | x | x | x | x | 10.78 | 8.51 | 3.36 | 0.14 |
| 42 | Vancouver Harbour (34) | x | x | x | x | 4.41 | 3.03 | 0.20 | 0.18 |
| 43 | Vancouver Harbour (35) | x | x | x | x | 2.59 | 0.87 | | 0.36 |
| 44 | Vancouver Harbour (36) | | | | | 0.19 | 0.16 | 0.05 | |
| 45 | False Creek | det. | | | | 0.06 | 0.03 | det. | 0.35 |
| 46 | Fraser R. (1) | | | | | det. | | | 0.05 |
| 47 | Fraser R. (2) | | | | | det. | det. | | 0.06 |
| 48 | Fraser R. (3) | x | x | x | x | 0.01 | 0.04 | 0.01 | |
| 49 | Fraser R. (4) | | | | | det. | det. | det. | 0.08 |
| 50 | Fraser R. (5) | x | x | x | x | | | | det. |
| 51 | Fraser R. (6) | | | | | det. | det. | det. | |
| 52 | Fraser R. (7) | x | x | x | x | | det. | | det. |
| 53 | Fraser R. (8) | x | x | x | x | | | | |
| 54 | Fraser R. (9) | 0.01 | 0.01 | | 12.69 | det. | det. | | 0.02 |
| 55 | Fraser R. (10) | x | x | x | x | | | | |
| 56 | Fraser R. (11) | | | | | det. | | | |
| 57 | Fraser R. (12) | x | x | x | x | | | | |
| 58 | Fraser R. (13) | x | x | x | x | 0.02 | 0.06 | | |
| 59 | Fraser R. (14) | | | | | 0.04 | | | 0.06 |
| 60 | Fraser R. (15) | | | | | det. | | | |
| 61 | Fraser R. (16) | x | x | x | x | det. | det. | det. | |

Table 1 cont'd

| No. | Location | Water (ug Sn/L) | | | | Sediment (mg Sn/kg) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $Bu_3Sn^+$ | $Bu_2Sn^{2+}$ | $BuSn^{3+}$ | Tin | $Bu_3Sn^+$ | $Bu_2Sn^{2+}$ | $BuSn^{3+}$ | Tin |
| 62 | Fraser R. (17) | | | | | det. | det. | | |
| 63 | Fraser R. (18) | x | x | x | x | | | | |
| 64 | Fraser R. (19) | x | x | x | x | det. | det. | det. | 0.07 |
| 65 | Fraser R. (20) | x | x | x | x | | | | 0.06 |
| 66 | Fraser R. (21) | x | x | x | x | | | | 0.01 |
| 67 | Fraser R. (22) | x | x | x | x | | | | |
| 68 | Fraser R. (23) | x | x | x | x | | | | |
| 69 | Fraser R. (24) | det. | det. | det. | det. | 0.02 | 0.03 | 0.01 | 0.02 |
| 70 | Fraser R. (25) | x | x | x | x | | | | |
| 71 | Fraser R. (26) | | | | | | 0.02 | | |
| 72 | Fraser R. (27) | x | x | x | x | | | | |
| 73 | Fraser R. (28) | | | | | 0.01 | | | |
| 74 | Fraser R. (29) | x | x | x | x | | | | 0.03 |
| 75 | Fraser R. (30) | x | x | x | x | | | | |
| 76 | Fraser R. (31) | x | x | x | x | | | | |
| 77 | Fraser R. (32) | | | | | det. | | | 0.04 |
| 78 | Okanagan L. at Penticton | | | | | det. | | | |
| 79 | Okanagan R. at Penticton | | | | | | | | |
| ALBERTA | | | | | | | | | |
| 80 | North Saskatchewan R. at Devon (1) | | | | 0.21 | x | x | x | x |
| 81 | North Saskatchewan R. at Devon (2) | | | | 0.43 | | | | 0.23 |
| 82 | North Saskatchewan R. at Edmonton | | | | | | det. | | |
| 83 | North Saskatchewan R. above Fort Saskatchewan | | | | | det. | | | |
| 84 | North Saskatchewan R. at Fort Saskatchewan (1) | | | | 0.02 | | | | |

Table 1 cont'd

| No. | Location | Water (ug Sn/L) | | | | Sediment (mg Sn/kg) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $Bu_3Sn^+$ | $Bu_2Sn^{2+}$ | $BuSn^{3+}$ | Tin | $Bu_3Sn^+$ | $Bu_2Sn^{2+}$ | $BuSn^{3+}$ | Tin |
| 85 | North Saskatchewan R. at Fort Saskatchewan (2) | | | | 0.04 | x | x | x | x |
| 86 | North Saskatchewan R. below Fort Saskatchewan | | | | | | | | |
| 87 | North Saskatchewan R. at Pakan | | | | | x | x | x | x |
| 88 | North Saskatchewan R. near Myrnam | | | | | x | x | x | x |
| 89 | North Saskatchewan R. near Alcurve | | | | | x | x | x | x |
| 90 | Bow R. above Calgary | | | | 0.23 | | | | |
| 91 | Bow R. at Calgary | | | | | | | | |
| 92 | Bow R. below Calgary | | | 0.01 | 0.11 | | | | 0.17 |
| 93 | Oldman R. at Lethbridge | | | | | | | | 0.02 |
| 94 | South Saskatchewan R. at Medicine Hat | | | det. | | | | | |
| SASKATCHEWAN | | | | | | | | | |
| 95 | North Saskatchewan R. at North Battleford (1) | | | | | x | x | x | x |
| 96 | North Saskatchewan R. at North Battleford (2) | | | | | | | | |
| 97 | North Saskatchewan R. near Borden | | | | 0.02 | x | x | x | x |
| 98 | North Saskatchewan R. at Prince Albert (1) | | | | | x | x | x | x |
| 99 | North Saskatchewan R. at Prince Albert (2) | | | | 0.93 | | det. | | |
| 100 | South Saskatchewan R. at Saskatoon | det. | | det. | 0.05 | | | | |

Table 1 cont'd

| No. | Location | Water (ug Sn/L) | | | | Sediment (mg Sn/kg) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $Bu_3Sn^+$ | $Bu_2Sn^{2+}$ | $BuSn^{3+}$ | Tin | $Bu_3Sn^+$ | $Bu_2Sn^{2+}$ | $BuSn^{3+}$ | Tin |
| 101 | South Saskatchewan R. below Saskatoon | | | | | | | | |
| 102 | Qu'Appelle R. at Fort Qu'Appelle | det. | | det. | 3.58 | | | | |
| 103 | Qu'Appelle R. near Welby | det. | | det. | 0.64 | | | | |
| 104 | Wascana Cr. at Regina | | | | | | | | |
| 105 | Saskatchewan R. at Nipawin | | | 0.03 | 0.05 | x | x | x | x |
| MANITOBA | | | | | | | | | |
| 106 | Saskatchewan R. at The Pas | | | | 0.94 | | | | |
| 107 | Souris R. at Coulter | 0.02 | | | 0.10 | | | | |
| 108 | Red R. at Selkirk | | | | 0.18 | | | | |
| 109 | Red R. above Winnipeg | | | | 0.25 | | | | |
| 110 | Red R. below Winnipeg | | | | 0.85 | | | | |
| 111 | Red R. at Emerson | | | | | | | | |
| ONTARIO | | | | | | | | | |
| 112 | Wabigoon R. at Dryden | | | 0.05 | 4.20 | x | x | x | x |
| 113 | Wabigoon R. at Minnitaki | | | | | x | x | x | x |
| 114 | Wabigoon R. (1) | | | | | x | x | x | x |
| 115 | Wabigoon R. (2) | 0.01 | 0.12 | 0.25 | 2.90 | | | | 1.15 |
| 116 | Clay L. (1) | | | 0.19 | 2.10 | | | 0.07 | 0.27 |
| 117 | Clay L. (2) | | det. | 0.03 | 2.11 | x | x | x | x |
| 118 | Wabigoon R. (3) | | | 0.15 | 0.41 | 0.04 | | 0.03 | 0.33 |
| 119 | Thunder Bay (1) | 0.01 | 0.02 | | 8.29 | 0.01 | | det. | |
| 120 | Thunder Bay (2) | 0.08 | 0.01 | det. | | | | | 0.01 |
| 121 | Thunder Bay (3) | | 0.07 | 0.15 | 0.11 | | | | |
| 122 | Kaministiquia R. | | | | 0.22 | | | | 3.90 |
| 123 | Nipigon R. | 0.64 | | | | | | | 0.01 |
| 124 | Terrace Bay | 0.49 | det. | | | x | x | x | x |

Table 1 cont'd

| No. | Location | Water (ug Sn/L) | | | | Sediment (mg Sn/kg) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $Bu_3Sn^+$ | $Bu_2Sn^{2+}$ | $BuSn^{3+}$ | Tin | $Bu_3Sn^+$ | $Bu_2Sn^{2+}$ | $BuSn^{3+}$ | Tin |
| 125 | Marathon (1) | | | 0.05 | 1.08 | | | | 0.71 |
| 126 | Marathon (2) | | | det. | | x | x | x | x |
| 127 | Marathon (3) | 0.02 | | | 0.16 | | | | |
| 128 | Turkey L. (1) | det. | | | 0.03 | | | | 6.38 |
| 129 | Turkey L. (2) | 0.09 | | | 0.06 | | | | |
| 130 | Turkey L. (3) | 0.05 | 0.01 | 0.06 | | | | | 1.09 |
| 131 | Turkey L. (4) | det. | det. | det. | 0.02 | | 0.07 | 0.09 | 1.90 |
| 132 | Turkey L. (5) | 0.08 | det. | | | | | | 0.01 |
| 133 | St. Marys R. at Sault Ste. Marie (1) | | | | 0.01 | | | 0.10 | 15.50 |
| 134 | St. Marys R. at Sault Ste. Marie (2) | 1.68 | 0.09 | | | | | | 10.30 |
| 135 | St. Marys R. at Sault Ste. Marie (3) | 0.11 | det. | | | x | x | x | x |
| 136 | Blind R. | 0.57 | det. | | 0.01 | | | 0.02 | 1.15 |
| 137 | Elliot L. | det. | | 0.01 | 0.56 | | | | 7.62 |
| 138 | Spanish R. | | det. | det. | 0.31 | | | | |
| 139 | Georgian Bay | det. | | | 0.49 | x | x | x | x |
| 140 | Simon L. | det. | | | 0.50 | 0.01 | 0.01 | det. | |
| 141 | Kelley L. | | det. | | 1.60 | 0.03 | | | 0.48 |
| 142 | Ramsey L. | 0.02 | det. | det. | 4.69 | | | 0.22 | 0.32 |
| 143 | Elbow L. | | | | | x | x | x | x |
| 144 | Nepewassi L. | 0.04 | 0.01 | 0.01 | 1.36 | 0.02 | | 0.24 | 1.54 |
| 145 | Ashigami L. | | 0.93 | 0.03 | 0.17 | | | 0.32 | 0.42 |
| 146 | Kukagami L. | | | | 0.72 | | | | 4.40 |
| 147 | L. Nipissing at North Bay | | | | 0.91 | | 0.58 | 4.73 | 6.11 |
| 148 | L. Muskoka | 0.04 | | | 0.02 | | 0.21 | 2.50 | 0.99 |
| 149 | L. Simcoe at Barrie | | | det. | 2.54 | | | 0.04 | 0.58 |
| 150 | Collingwood Harbour | | | | 1.84 | x | x | x | x |
| 151 | Owen Sound Harbour | | | | 0.59 | x | x | x | x |
| 152 | L. Huron (1) | | | | | x | x | x | x |

Table 1 cont'd

| No. | Location | Water (ug Sn/L) | | | | Sediment (mg Sn/kg) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $Bu_3Sn^+$ | $Bu_2Sn^{2+}$ | $BuSn^{3+}$ | Tin | $Bu_3Sn^+$ | $Bu_2Sn^{2+}$ | $BuSn^{3+}$ | Tin |
| 153 | L. Huron (2) | | | | 0.82 | x | x | x | x |
| 154 | St. Clair R. (1) | | 0.05 | det. | 1.13 | | | | |
| 155 | St. Clair R. (2) | | | | 0.39 | x | x | x | x |
| 156 | St. Clair R. (3) | 0.22 | | 0.03 | 0.04 | 0.01 | det. | | |
| 157 | St. Clair R. (4) | 0.02 | det. | det. | 0.76 | x | x | x | x |
| 158 | St. Clair R. (5) | | | 0.01 | 1.11 | x | x | x | x |
| 159 | L. St. Clair (1) | 0.10 | | 0.01 | 1.06 | | | | |
| 160 | L. St. Clair (2) | det. | 0.04 | 0.03 | 2.67 | | | | |
| 161 | L. St. Clair (3) | 0.07 | | | 6.67 | 0.04 | 0.01 | det. | |
| 162 | Thames R. | | | | 0.44 | | | | |
| 163 | Detroit R. (1) | det. | | 0.01 | 4.40 | | | | |
| 164 | Detroit R. (2) | | | | | | | | |
| 165 | L. Erie (1) | | | | | | | | |
| 166 | L. Erie (2) | | | | 2.22 | x | x | x | x |
| 167 | Port Stanley | 0.29 | 0.20 | 1.89 | 27.20 | 0.01 | det. | | |
| 168 | Port Dover | 0.07 | 0.01 | det. | 1.66 | 0.01 | 0.01 | | |
| 169 | Nanticoke | | | | 1.72 | | | | |
| 170 | Grand R. (1) | | | | 0.14 | x | x | x | x |
| 171 | Grand R. (2) | | | | 0.04 | | | | |
| 172 | Grand R. (3) | | | | 0.22 | | | | |
| 173 | Grand R. (4) | det. | det. | | 1.06 | det. | det. | | det. |
| 174 | Niagara R. at Fort Erie | | | | 0.07 | x | x | x | x |
| 175 | Niagara R., Chippawa Channel | | | | | x | x | x | x |
| 176 | Niagara R. at Niagara-on-the-Lake (1) | | | | 0.08 | | | | |
| 177 | Niagara R. at Niagara-on-the-Lake (2) | | | | 0.06 | | | | |
| 178 | Welland Canal (1) | | | det. | 1.79 | x | x | x | x |
| 179 | Welland Canal (2) | | | | 0.02 | x | x | x | x |
| 180 | Thorold South | det. | det. | det. | 1.91 | x | x | x | x |
| 181 | St. Catharines (1) | 0.03 | | | | x | x | x | x |

Table 1 cont'd

| No. | Location | Water (ug Sn/L) | | | | Sediment (mg Sn/kg) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $Bu_3Sn^+$ | $Bu_2Sn^{2+}$ | $BuSn^{3+}$ | Tin | $Bu_3Sn^+$ | $Bu_2Sn^{2+}$ | $BuSn^{3+}$ | Tin |
| 182 | St. Catharines (2) | | 0.01 | | 1.60 | x | x | x | x |
| 183 | Port Weller | det. | | | 1.21 | 0.01 | 0.01 | | |
| 184 | Credit R. | 0.03 | det. | | | 0.01 | det. | | |
| 185 | Humber R. | det. | | | 0.34 | det. | | | |
| 186 | Toronto Harbour (1) | | | | | | | 0.11 | 5.70 |
| 187 | Toronto Harbour (2) | 0.03 | 0.01 | 0.59 | 6.46 | 0.04 | | 0.07 | 2.97 |
| 188 | Don R. | | | | | 0.02 | 0.03 | 0.01 | 1.55 |
| 189 | Toronto Harbour (3) | 0.24 | 0.01 | 0.11 | 2.00 | | 0.01 | 0.09 | 0.39 |
| 190 | Whitby (1) | 1.72 | 0.74 | 0.42 | 37.20 | 0.16 | 0.22 | 0.40 | 0.43 |
| 191 | Whitby (2) | 0.10 | 0.06 | 0.01 | 3.04 | | | | |
| 192 | Port Hope | 2.34 | 0.04 | 0.28 | 9.90 | | | | 1.42 |
| 193 | Cobourg | det. | 0.01 | | 9.87 | 0.02 | | 0.02 | 1.74 |
| 194 | Moira L. | | | | 0.42 | 0.03 | 0.15 | 0.27 | 0.48 |
| 195 | Moira R. | 0.01 | | | 0.27 | | | | |
| 196 | Belleville | 0.01 | 1.36 | | 0.55 | | | | 0.12 |
| 197 | Kingston Harbour | | | | 0.03 | | 0.15 | 0.21 | 2.11 |
| 198 | St. Lawrence R. at Maitland (1) | 0.05 | | 0.01 | 0.83 | | | | 1.34 |
| 199 | St. Lawrence R. at Maitland (2) | | | | 1.32 | | | | 0.40 |
| 200 | St. Lawrence R. at Cornwall (1) | 0.01 | | | 0.34 | | 0.02 | 0.03 | 0.66 |
| 201 | St. Lawrence R. at Cornwall (2) | | | | 0.19 | | | | 6.80 |
| 202 | St. Lawrence R. at Cornwall (3) | det. | | | 0.01 | 0.01 | det. | det. | |
| 203 | St. Lawrence R. at Cornwall (4) | | | | | det. | | det. | det. |
| 204 | L. Timiskaming | | | | 0.08 | | | | 0.19 |
| 205 | Sasaginaga L. | | | | 0.41 | | | | 1.26 |
| 206 | Ottawa R. at Chalk River | 0.52 | 0.02 | | | | | | 2.56 |
| 207 | Ottawa R. at Arnprior | | | | 0.23 | | | | |

Table 1 cont'd

| No. | Location | Water (ug Sn/L) $Bu_3Sn^+$ | $Bu_2Sn^{2+}$ | $BuSn^{3+}$ | Tin | Sediment (mg Sn/kg) $Bu_3Sn^+$ | $Bu_2Sn^{2+}$ | $BuSn^{3+}$ | Tin |
|---|---|---|---|---|---|---|---|---|---|
| 208 | Ottawa R. at Ottawa | | | | 0.32 | 0.09 | 0.03 | det. | 0.01 |
| 209 | Ottawa R. at Chute a Blondeau | | | | 0.87 | | | | |
| | MICHIGAN, USA | | | | | | | | |
| 210 | Detroit R. | 0.57 | | 0.01 | 0.02 | | | | |
| | NEW YORK STATE, USA | | | | | | | | |
| 211 | Buffalo Harbor | | | | 0.08 | x | x | x | x |
| 212 | Buffalo R. | | 0.01 | 0.02 | 5.50 | | | | |
| 213 | Niagara R. (1) | | | | 1.06 | x | x | x | x |
| 214 | Niagara R. (2) | | | | | | | | 0.05 |
| 215 | Gill Creek | | | | | | | | |
| 216 | Niagara R. (3) | | | 1.82 | 0.07 | x | x | x | x |
| | QUEBEC | | | | | | | | |
| 217 | Ottawa R. at Temiscaming | | | | | x | x | x | x |
| 218 | Schyan R. | 0.36 | 0.09 | | 0.01 | | | | 0.11 |
| 219 | Ottawa R. at Thurso | det. | | | 2.36 | x | x | x | x |
| 220 | Ottawa R. at Montebello | 0.02 | | | 0.06 | x | x | x | x |
| 221 | Lac des Deux Montagnes | det. | | | det. | 0.06 | det. | | |
| 222 | Lac Saint-Louis (1) | det. | | | det. | 0.04 | 0.01 | | |
| 223 | Lac Saint-Louis (2) | | | | | | | | |
| 224 | Lac Saint-Louis (3) | det. | | | 0.02 | | | | 0.33 |
| 225 | Lac Saint-Louis (4) | 0.02 | 0.02 | 0.02 | 0.10 | 0.30 | 0.28 | 0.09 | |
| 226 | Sainte-Catherine lock | | | | | 0.02 | det. | | |
| 227 | Saint-Lambert lock (1) | 0.08 | | | | 0.03 | det. | det. | |
| 228 | Saint-Lambert lock (2) | | | | | 0.16 | 0.08 | 0.04 | |
| 229 | Canal de la Rive Sud | | | | | x | x | x | x |
| 230 | St. Lawrence R. at Longueuil | | | | | 0.02 | det. | | |
| 231 | St. Lawrence R. at Montreal (1) | 0.03 | 0.07 | 0.04 | 4.70 | 0.03 | 0.08 | 0.18 | 2.29 |

Table 1 cont'd

| No. | Location | Water (ug Sn/L) | | | | Sediment (mg Sn/kg) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $Bu_3Sn^+$ | $Bu_2Sn^{2+}$ | $BuSn^{3+}$ | Tin | $Bu_3Sn^+$ | $Bu_2Sn^{2+}$ | $BuSn^{3+}$ | Tin |
| 232 | St. Lawrence R. at Montreal (2) | | | 0.42 | 0.71 | x | x | x | x |
| 233 | St. Lawrence R. at Montreal (3) | det. | | | | 0.03 | | | det. |
| 234 | St. Lawrence R. at Montreal (4) | | 0.04 | | | | | | 0.81 |
| 235 | Montreal Harbour (1) | det. | | 0.62 | 0.21 | 0.19 | 0.35 | 0.37 | 8.30 |
| 236 | Montreal Harbour (2) | det. | | | 0.18 | | 0.04 | 0.07 | 0.03 |
| 237 | Montreal Harbour (3) | | | | | 0.04 | 0.02 | det. | |
| 238 | Montreal Harbour (4) | | | | | det. | | det. | det. |
| 239 | Montreal Harbour (5) | | | | | det. | | det. | det. |
| 240 | Montreal Harbour (6) | | | | | 0.17 | 0.10 | 0.05 | |
| 241 | Richelieu R. at St.-Jean d'Iberville | | | | | 0.01 | det. | | 0.06 |
| 242 | Richelieu R. at Ville-de-Tracy | | | | | det. | | | |
| 243 | St. Francois R. | det. | | | | | | | |
| 244 | St. Lawrence R. at Quebec (1) | det. | | | | 0.14 | 0.02 | | |
| 245 | St. Lawrence R. at Quebec (2) | | | | | 0.04 | 0.03 | 0.01 | |
| 246 | Louise Basin at Quebec | | | | | 0.06 | det. | det. | |
| NEW BRUNSWICK | | | | | | | | | |
| 247 | Saint John R. at Quisibis | | | 0.01 | 0.62 | | | | |
| 248 | Saint John R. at Maugerville | | | | 0.15 | | | | 0.26 |
| 249 | Kennebecasis Bay at Renforth | | | | | | | | |
| 250 | Saint John Harbour | | | | | | | | 0.10 |
| 251 | Dalhousis Harbour | | | | | | | | |

Table 1 cont'd

| No. | Location | Water (ug Sn/L) | | | | Sediment (mg Sn/kg) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $Bu_3Sn^+$ | $Bu_2Sn^{2+}$ | $BuSn^{3+}$ | Tin | $Bu_3Sn^+$ | $Bu_2Sn^{2+}$ | $BuSn^{3+}$ | Tin |
| 252 | Bathurst Harbour | 0.02 | det. | | 1.71 | | | | 0.05 |
| 253 | Lameque Harbour | x | x | x | x | | | | 0.08 |
| 254 | Shippegan Harbour | x | x | x | x | | | | 0.18 |
| 255 | Miramichi R. (1) | | | | 0.01 | | | det. | |
| 256 | Miramichi R. (2) | | | | 0.02 | det. | | | 0.03 |
| 257 | Escuminac Harbour | x | x | x | x | | | | 0.08 |
| 258 | Point Sapin | x | x | x | x | | | | 0.16 |
| 259 | Richibucto Harbour | | | | | | | | 0.18 |
| 260 | Cap Lumiere | x | x | x | x | | | | 0.19 |
| 261 | Chockpish R. | x | x | x | x | | | | |
| 262 | St. Edouard de Kent | x | x | x | x | | | | |
| 263 | Buctouche Harbour | | | | | | | | 5.27 |
| 264 | Shediac Bay | | | | | | | | |
| 265 | Cap Pele | x | x | x | x | | | | |
| 266 | Murray Corner | x | x | x | x | | | | |
| 267 | Cape Tormentine | | | | | | | | |
| PRINCE EDWARD ISLAND | | | | | | | | | |
| 268 | Charlottetown Harbour | | | | | det. | | | |
| NOVA SCOTIA | | | | | | | | | |
| 269 | Pictou Harbour | | | | | det. | | det. | 0.14 |
| 270 | Port Hawkesbury Harbour | | | | | det. | det. | | |
| 271 | Sydney Harbour | | | | | 0.01 | 0.01 | | |
| 272 | Halifax Harbour | | | | | det. | det. | | |
| NEWFOUNDLAND | | | | | | | | | |
| 273 | Port-aux-Basques Harbour | | | | | | | | 0.19 |
| 274 | Stephenville Pond | | | | | | | | |
| 275 | Argentia Harbour | | | | | det. | det. | det. | |
| 276 | Conception Bay | det. | det. | | | 0.03 | | | |
| 277 | St. John's Harbour | | | | | | | | |

[a]Precise sampling locations are described in the Appendix. Concentrations in

Table 1 cont'd

sediment are in dry weight terms. "Blanks" mean below limit of detection (LOD - ref. 17), "det." means that a species was detected but its concentration was below the limit of quantitation (LOQ - ref. 17), and "x" means no sample. For sample sizes of 8 L for water and 10 g dry weight for sediment, the LOQ values for each species are about 0.01 ug Sn/L and 0.01 mg Sn/kg dry weight, respectively. LOD values were generally about one third of LOQ values.

Table 2. Concentrations of Methyltin Species in Unfiltered Subsurface Water and Top Two cm of Sediment[a]

| No. | Location | Water (ug Sn/L) | | | Sediment (mg Sn/kg) | | |
|---|---|---|---|---|---|---|---|
| | | $Me_3Sn^+$ | $Me_2Sn^{2+}$ | $MeSn^{3+}$ | $Me_3Sn^+$ | $Me_2Sn^{2+}$ | $MeSn^{3+}$ |
| BRITISH COLUMBIA | | | | | | | |
| 7 | Victoria Harbour (1) | 0.15 | | 0.08 | | | |
| 18 | Vancouver Harbour (10) | | | | 0.02 | det. | 0.01 |
| 35 | Vancouver Harbour (27) | | | | 0.03 | | 0.02 |
| 36 | Vancouver Harbour (28) | 0.18 | | 0.12 | | | |
| ONTARIO | | | | | | | |
| 115 | Wabigoon R. (1) | | | | 0.10 | | |
| 116 | Clay L. (1) | | | | 0.10 | | |
| 146 | Kukagami L. | | | | 0.75 | | |
| 165 | L. Erie (1) | | | | 0.11 | | |
| 166 | L. Erie (2) | | | 0.06 | | | |
| 171 | Grand R. (2) | | | 0.02 | | | |
| 183 | Port Weller | | | 0.03 | | | |
| 186 | Toronto Harbour (1) | | | | | 0.17 | |
| 191 | Whitby (2) | | | | 0.08 | | |
| 197 | Kingston Harbour | 0.14 | | | | | |
| 198 | St. Lawrence R. at Maitland (1) | | | | 0.17 | | |
| 201 | St. Lawrence R. at Cornwall (2) | | | | | | 0.13 |
| MICHIGAN, USA | | | | | | | |
| 210 | Detroit R. | | | 0.06 | | | |
| QUEBEC | | | | | | | |
| 225 | Lac Saint-Louis (4) | | | | 0.02 | | 0.01 |
| 235 | Montreal Harbour (1) | | | | 0.01 | | 0.02 |

Table 2 cont'd

| No. | Location | Water (ug Sn/L) | | | Sediment (mg Sn/kg) | | |
|---|---|---|---|---|---|---|---|
| | | $Me_3Sn^+$ | $Me_2Sn^{2+}$ | $MeSn^{3+}$ | $Me_3Sn^+$ | $Me_2Sn^{2+}$ | $MeSn^{3+}$ |
| NEW BRUNSWICK | | | | | | | |
| 253 | Lameque Harbour | | | | | | 10.87 |
| 254 | Shippegan Harbour | | | | | | 10.16 |
| 257 | Escuminac Harbour | | | | | | 9.62 |
| 258 | Point Sapin | | | | | | 11.62 |
| 260 | Cap Lumiere | | | | | | 17.19 |
| 261 | Chockpish R. | | | | | | 10.67 |
| 262 | St. Edouard de Kent | | | | | | 2.86 |
| 265 | Cap Pele | | | | | | 2.47 |
| 266 | Murray Corner | | | | | | 5.65 |

[a]Precise sampling locations are shown in the Appendix. Concentrations in sediment are in dry weight terms. "Blanks" mean below limit of detection (LOD - ref. 17) and "det." means that a species was detected but its concentration was below the limit of quantitation (LOQ - ref. 17). For sample sizes of 4 L for water and 10 g dry weight for sediment, the LOQ values for each species are about 0.01 ug Sn/L and 0.01 mg Sn/kg dry weight, respectively. LOD values were generally about one third of LOQ values. The concentrations of inorganic tin are shown in Table 1.

Table 3. Concentrations (mg Sn/kg wet weight) of Butyltin and Methyltin Species, and Inorganic Tin, in Whole Fish[a]

| Species | Location | $Bu_3Sn^+$ | $Bu_2Sn^{2+}$ | $BuSn^{3+}$ | $Me_3Sn^+$ | $Me_2Sn^{2+}$ | $MeSn^{3+}$ | Tin |
|---|---|---|---|---|---|---|---|---|
| yellow perch (P. flavescens) | Jordan Harbour (L. Ontario) | 0.01 | det. | det. | | | | 0.03 |
| white sucker (C. commersoni) | Jordan Harbour | 0.02 | det. | det. | | | | det. |
| | Grindstone Cr. (Hamilton Hbr.) | det. | det. | det. | | | | 0.04 |
| carp (C. carpio) | Hamilton Harbour (L. Ontario) | det. | det. | det. | | | | 0.03 |
| smelt (O. mordax) | Cobourg (L. Ontario) | x | x | x | | | 0.40 | 0.62 |
| lake trout (S. namaycush) | Bronte Cr. (L. Ontario) | | | | | | | det. |
| | Nanticoke (L. Erie) | | | | | | | det. |
| | Port Credit (L. Ontario) | x | x | x | | | | 0.33 |
| | " | | | | | | 0.88 | 0.30 |
| | Cobourg | x | x | x | | 0.18 | 0.29 | 0.21 |
| | " | x | x | x | | | 0.22 | 0.17 |
| | " | | | | | | | 0.50 |
| | " | | | | | | | 0.50 |
| | " | | | | | | | 0.15 |
| | Main Duck I. (L. Ontario) | | | | | | | 0.90 |
| | L. Huron (middle) | | | | | | | 0.19 |
| | " | | | | | | | 0.47 |
| herring (C. harengus pallasi) | Vancouver Harbour | 0.24 | 0.05 | 0.06 | | | | 0.04 |

[a]"Blanks" mean below limit of detection (LOD - ref. 17), "det." means that a compound was detected but its concentration was below the limit of quantitation (LOQ - ref. 17) and "x" means not done. LOQ values for each

Table 3 cont'd

species were about 0.01 mg Sn/kg wet weight. The yellow perch sample was a three-fish composite collected in 1983. The herring sample was a two-fish composite collected in 1984 from a bait cage beneath a dock in Vancouver Harbour. All other fish were collected in 1982.

Table 4. Concentrations of Tetrabutyltin and Mixed Butylmethyltin Compounds in Unfiltered Subsurface Water and the Top Two cm of Sediment[a]

| No. | Location | Water (ug Sn/L) | | | | Sediment (mg Sn/kg dry weight) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $Bu_4Sn$ | $Bu_3MeSn$ | $Bu_2Me_2Sn$ | $BuMe_3Sn$ | $Bu_4Sn$ | $Bu_3MeSn$ | $Bu_2Me_2Sn$ | $BuMe_3Sn$ |
| ONTARIO | | | | | | | | | |
| 119 | Thunder Bay (1) | | | | | det. | 0.04 | | |
| 132 | Turkey L. (5) | 0.12 | 0.12 | | | | | | |
| 136 | Blind R. | | 0.15 | 0.03 | | | | | |
| 155 | St. Clair R. (2) | det. | det. | | | x | x | x | x |
| 156 | St. Clair R. (3) | | 0.22 | 0.07 | det. | | | | |
| 168 | Port Dover | | | | | | | det. | |
| 176 | Niagara R. at Niagara-on-the-Lake (1) | | | | | | | | det. |
| 183 | Port Weller | | | | | | | | 0.01 |
| 187 | Toronto Harbour (2) | | | 0.11 | | | | | |
| 189 | Toronto Harbour (3) | | | det. | | | | | |
| 194 | Moira L. | | 0.12 | det. | | | | | |
| 196 | Belleville | | | det. | | | | | |
| 204 | L. Timiskaming | | det. | | | | | | |
| 206 | Ottawa R. at Chalk River | 0.02 | 0.21 | | | | | | |
| 208 | Ottawa R. at Ottawa | | | | | 0.02 | det. | | |
| MICHIGAN, USA | | | | | | | | | |
| 210 | Detroit R. | | 0.18 | | | | | | |
| QUEBEC | | | | | | | | | |
| 218 | Schyan R. | | 0.31 | 0.03 | det. | | | | |
| 220 | Ottawa R. at Montebello | | | det. | det. | | | det. | |
| 231 | St. Lawrence R. at Montreal (1) | | | | det. | | | | |

[a]Precise sampling locations are shown in the Appendix. "Blanks" mean below limit of

Table 4 cont'd

detection (LOD - ref. 17), "det." means that a species was detected but its concentration was below the limit of quantitation (LOQ - ref. 17) and "x" means no sample. For sample sizes of 8 L for subsurface water and 10 g dry weight for the sediment, the LOQ values for each species are about 0.01 ug Sn/L and 0.01 mg Sn/kg dry weight, respectively. LOD values were generally about one third of LOQ values.

Appendix. Details of Sampling Locations

| No. | Location | Details | Depth, m | Date |
|---|---|---|---|---|
| BRITISH COLUMBIA | | | | |
| 1 | Nanaimo Harbour | at Beacon Rock | 8.4 | 1984/10 |
| 2 | Tsehun Harbour | at North Saanich Marina, Vancouver Island | 6 | 1984/10/19/a.m. |
| 3 | Deep Cove | Saanich Inlet, Vancouver Island | 12 | 1984/10/19/a.m. |
| 4 | Patricia Bay | Saanich Inlet, Vancouver Island. Off wharf at Institute of Ocean Sciences | 10 | 1984/10/11/14:00 |
| 5 | Esquimalt Harbour (1) | in Plumper Bay north of Inskip Islands | 10.5 | 1984/10 |
| 6 | Esquimalt Harbour (2) | in Constance Cove off Village Rocks | 12.9 | 1984/10 |
| 7 | Victoria Harbour (1) | Inner Harbour, half way between Shoal Point and Songhees Point | 8.4 | 1984/10/17 |
| 8 | Victoria Harbour (2) | Upper Harbour, off Hope Point | 9 | 1984/10/17 |
| 9 | Vancouver Harbour (1) | Burrard Inlet at First Narrows, off sewage treatment plant west of Lions Gate Bridge | 6 | 1984/10 |
| 10 | Vancouver Harbour (2) | Vancouver Wharves | 13.5 | 1984/8/20/09:50 |
| 11 | Vancouver Harbour (3) | Vancouver Wharves | 6 | 1984/8/20/09:58 |
| 12 | Vancouver Harbour (4) | Vancouver Wharves | 10 | 1984/8/20/10:05 |
| 13 | Vancouver Harbour (5) | L&K Lumber, 15 m from shore | 6 | 1984/8/20/10:12 |
| 14 | Vancouver Harbour (6) | L&K Lumber, 30 m from shore | 10 | 1984/8/20/10:20 |
| 15 | Vancouver Harbour (7) | L&K Lumber, 100 m from shore | 10 | 1984/8/20/10:30 |
| 16 | Vancouver Harbour (8) | L&K Lumber, off loading facility | 30 | 1984/8/20/10:45 |
| 17 | Vancouver Harbour (9) | Vancouver Shipyards | 5 | 1984/10 |
| 18 | Vancouver Harbour (10) | Vancouver Shipyards/Seaspan, 10 m from inner dock | 8 | 1984/8/20/11:30 |
| 19 | Vancouver Harbour (11) | Vancouver Shipyards/Seaspan, 100 m from dock | 8 | 1984/8/20/11:30 |

Appendix cont'd

| No. | Location | Details | Depth, m | Date |
|---|---|---|---|---|
| 20 | Vancouver Harbour (12) | Burrard Yarrows Corp. | 7 | 1984/10 |
| 21 | Vancouver Harbour (13) | Burrard Yarrows Corp. | 9 | 1984/8/20/11:50 |
| 22 | Vancouver Harbour (14) | Burrard Yarrows Corp. | 11 | 1984/8/20/12:00 |
| 23 | Vancouver Harbour (15) | Burrard Yarrows Corp. | 24 | 1984/8/20/12:10 |
| 24 | Vancouver Harbour (16) | White Pass Transport Ltd. | 6 | 1984/8/20/12:20 |
| 25 | Vancouver Harbour (17) | Neptune Terminals | 15 | 1984/8/20/12:35 |
| 26 | Vancouver Harbour (18) | Neptune Terminals | 20 | 1984/8/20/12:40 |
| 27 | Vancouver Harbour (19) | Neptune Terminals | 18 | 1984/8/20/12:45 |
| 28 | Vancouver Harbour (20) | Neptune Terminals | 30 | 1984/8/20/12:50 |
| 29 | Vancouver Harbour (21) | Lynnterm | 19 | 1984/8/20/13:00 |
| 30 | Vancouver Harbour (22) | Bel Aire Shipyards | 8 | 1984/8/20/14:00 |
| 31 | Vancouver Harbour (23) | Bel Aire Shipyards | 3 | 1984/10 |
| 32 | Vancouver Harbour (24) | Allied Shipbuilders | 8 | 1984/8/20/14:20 |
| 33 | Vancouver Harbour (25) | Matsumoto Shipyards Ltd. | 8.5 | 1984/8/20/14:40 |
| 34 | Vancouver Harbour (26) | RivTow Straits | 20 | 1984/8/20/15:00 |
| 35 | Vancouver Harbour (27) | Sterling Shipyards | 2 | 1984/8/20/15:25 |
| 36 | Vancouver Harbour (28) | Sterling Shipyards | 3 | 1984/10 |
| 37 | Vancouver Harbour (29) | B.C. Marine Shipbuilders | 4 | 1984/10 |
| 38 | Vancouver Harbour (30) | B.C. Marine Shipbuilders | 3 | 1984/8/20/15:40 |
| 39 | Vancouver Harbour (31) | Vanterm | 19 | 1984/8/20/15:45 |
| 40 | Vancouver Harbour (32) | National Harbours Board, Pier B.C. | 17 | 1984/8/20/16:10 |
| 41 | Vancouver Harbour (33) | W.R. Menchions Shipyard, 30 m from shore | 7 | 1984/8/20/16:20 |
| 42 | Vancouver Harbour (34) | W.R. Menchions Shipyard, 60 m from shore | 7.5 | 1984/8/20/16:30 |

Appendix cont'd

| No. | Location | Details | Depth, m | Date |
|---|---|---|---|---|
| 43 | Vancouver Harbour (35) | W.R. Menchions Shipyard, 100 m from shore | 9 | 1984/8/20/16:40 |
| 44 | Vancouver Harbour (36) | between Gulf and Esso gasoline barges off Deadman Island | 7 | 1984/10 |
| 45 | False Creek | 200 m east of Burrard Bridge | 4 | 1984/10 |
| 46 | Fraser R. (1) | North Arm, off sewage treatment plant at Iona Island | 6 | 1984/10 |
| 47 | Fraser R. (2) | North Arm, off Celtic Shipyards | 6 | 1984/10 |
| 48 | Fraser R. (3) | North Arm, off Celtic Shipyards | 4 | 1984/8/23/11:25 |
| 49 | Fraser R. (4) | North Arm, 100 m downstream of Arthur Laing Bridge | 6 | 1984/10 |
| 50 | Fraser R. (5) | North Arm, Breezedale Marina | 4.5 | 1984/8/23/11:00 |
| 51 | Fraser R. (6) | North Arm, south of Mitchell Island, off Quadra Steel | 5 | 1984/10 |
| 52 | Fraser R. (7) | North Arm, John Manly Shipyard | 4 | 1984/8/23/10:25 |
| 53 | Fraser R. (8) | North Arm, John Manly Shipyard | 5 | 1984/8/23/10:20 |
| 54 | Fraser R. (9) | North Arm, John Manly Shipyard | 4 | 1984/10 |
| 55 | Fraser R. (10) | North Arm, Fraser Marine Group | 5 | 1984/8/23/10:10 |
| 56 | Fraser R. (11) | North Arm, off Tom Mac Shipyard | 6 | 1984/10 |
| 57 | Fraser R. (12) | North Arm, Tom Mac Shipyard, at entrance to river | 5 | 1984/8/23/09:55 |
| 58 | Fraser R. (13) | North Arm, Tom Mac Shipyard, in dock area | 4 | 1984/8/23/09:55 |
| 59 | Fraser R. (14) | North Arm, off Byrne Road | 9 | 1984/10 |
| 60 | Fraser R. (15) | North Arm, north of Poplar Island, off Scott Paper | 2 | 1984/10 |
| 61 | Fraser R. (16) | off Pacific Coast Terminals | 9 | 1984/8/22/15:00 |
| 62 | Fraser R. (17) | Annacis Channel, off sewage treatment plant | 2 | 1984/10 |
| 63 | Fraser R. (18) | Annacis Channel, Marine Fabrication Repair | 3 | 1984/8/22/14:15 |
| 64 | Fraser R. (19) | Annacis Channel, Queensborough Shipyard | 6 | 1984/8/22/13:45 |
| 65 | Fraser R. (20) | Annacis Channel, S.B. Shore Boat Builders | 6 | 1984/8/22/13:30 |

Appendix cont'd

| No. | Location | Details | Depth, m | Date |
|---|---|---|---|---|
| 66 | Fraser R. (21) | Annacis Channel, at dock of Stem to Stern Boat Repair | 4 | 1984/8/22/12:20 |
| 67 | Fraser R. (22) | Annieville Channel, Annacis Marine Terminal | 13 | 1984/8/22/14:30 |
| 68 | Fraser R. (23) | Annieville Channel, Surrey Dock | 11 | 1984/8/22/14:35 |
| 69 | Fraser R. (24) | Annieville Channel, Gundersen Slough | 4 | 1984/10 |
| 70 | Fraser R. (25) | City Reach, Vito Shipbuilding | 11 | 1984/8/22/11:40 |
| 71 | Fraser R. (26) | Gravesend Reach, West Bay Boat Builders | 3 | 1984/10 |
| 72 | Fraser R. (27) | Gravesend Reach, West Bay Boat Builders, 20 m from shore | 4 | 1984/8/22/11:20 |
| 73 | Fraser R. (28) | south of Deas Island, at marina | 2 | 1984/10 |
| 74 | Fraser R. (29) | Woodward Reach, B.C. Ferries, middle berth, 30 m from shore | 4 | 1984/8/22/10:15 |
| 75 | Fraser R. (30) | Woodward Reach, B.C. Ferries, middle of channel | 6 | 1984/8/22/10:30 |
| 76 | Fraser R. (31) | Woodward Reach, B.C. Ferries, between channel markers | 4 | 1984/8/22/10:35 |
| 77 | Fraser R. (32) | Cannery Channel, off Esso | 4 | 1984/10 |
| 78 | Okanagan L. at Penticton | off Riverside Park | 3 | 1984/10 |
| 79 | Okanagan R. at Penticton | at Greenwood Forest Products | 1 | 1984/10 |
| ALBERTA | | | | |
| 80 | North Saskatchewan R. at Devon (1) | at Hwy. 60 bridge | | 1983/6 |
| 81 | North Saskatchewan R. at Devon (2) | at Hwy. 60 bridge | 1 | 1984/10 |

Appendix cont'd

| No. | Location | Details | Depth, m | Date |
|---|---|---|---|---|
| 82 | North Saskatchewan R. at Edmonton | south side of river, off 50th Street | 1 | 1984/10 |
| 83 | North Saskatchewan R. above Fort Saskatchewan | at Hwy. 25 bridge | 1 | 1984/10 |
| 84 | North Saskatchewan R. at Fort Saskatchewan (1) | at 119th Street | 1 | 1984/10 |
| 85 | North Saskatchewan R. at Fort Saskatchewan (2) | at 119th Street | | 1983/6 |
| 86 | North Saskatchewan R. below Fort Saskatchewan | 3 km downstream, close to intersection of Township Road 554 and Range Road 221 | 1 | 1984/10 |
| 87 | North Saskatchewan R. at Pakan | | | 1983/6 |
| 88 | North Saskatchewan R. near Myrnam | | | 1983/6 |
| 89 | North Saskatchewan R. near Alcurve | | | 1983/6 |
| 90 | Bow R. above Calgary | immediately upstream of Bowness Park | 1 | 1984/10 |
| 91 | Bow R. at Calgary | below Prince's Island | 1 | 1984/10 |
| 92 | Bow R. below Calgary | 500 m downstream of Hwy. 22 bridge | 1 | 1984/10 |

Appendix cont'd

| No. | Location | Details | Depth, m | Date |
|---|---|---|---|---|
| 93 | Oldman R. at Lethbridge | at Whoop-Up Trail Road bridge | 1 | 1984/10 |
| 94 | South Saskatchewan R. at Medicine Hat | upstream of Hwy. 1 bridge | 1 | 1984/10 |
| SASKATCHEWAN | | | | |
| 95 | North Saskatchewan R. at North Battleford (1) | at Hwy. 16 bridge | | 1983/6 |
| 96 | North Saskatchewan R. at North Battleford (2) | at Hwy. 16 bridge | 1 | 1984/10/29/14:30 |
| 97 | North Saskatchewan R. near Borden | | | 1983/6 |
| 98 | North Saskatchewan R. at Prince Albert (1) | upstream of Hwy. 2 bridge and railway bridge | | 1983/6 |
| 99 | North Saskatchewan R. at Prince Albert (2) | upstream of Hwy. 2 bridge and railway bridge | 1 | 1984/10/30/10:45 |
| 100 | South Saskatchewan R. at Saskatoon | upstream of 42nd Street bridge | 1 | 1984/10/30/16:15 |
| 101 | South Saskatchewan R. below Saskatoon | at Hwy. 784 ferry crossing | 1 | 1984/10/30/15:00 |
| 102 | Qu'Appelle R. at Fort Qu'Appelle | at Hwy. 10 bridge | 1 | 1984/11/14/10:15 |
| 103 | Qu'Appelle R. near Welby | at Hwy. 600 bridge | 1 | 1984/10/15/12:00 |
| 104 | Wascana Cr. at Regina | downstream of Regina sewage treatment plant | 1 | 1984/11/14/12:45 |

Appendix cont'd

| No. | Location | Details | Depth, m | Date |
|---|---|---|---|---|
| 105 | Saskatchewan R. at Nipawin | | | 1983/6 |
| MANITOBA | | | | |
| 106 | Saskatchewan R. at The Pas | downstream of Hwy. 10 bridge and railway bridge | 1 | 1984/10/18/09:25 |
| 107 | Souris R. at Coulter | at Hwy. 251 bridge | 1 | 1984/10/25/13:45 |
| 108 | Red R. at Selkirk | at Hwy. 204 bridge | 1 | 1984/10/18/13:15 |
| 109 | Red. R. above Winnipeg | at Hwy. 101 perimeter north bridge | 1 | 1984/10/18/12:00 |
| 110 | Red R. below Winnipeg | at Hwy. 101 perimeter south bridge | 2 | 1984/10/10/15:00 |
| 111 | Red R. at Emerson | at Hwy. 25 bridge | 1 | 1984/10 |
| ONTARIO | | | | |
| 112 | Wabigoon R. at Dryden | 50 m downstream of Great Lakes Forest Products mill | 4 | 1982/7 |
| 113 | Wabigoon R. at Minnitaki | off bridge | 3 | 1982/7 |
| 114 | Wabigoon R. (1) | at Hwy. 105 bridge | 4 | 1982/7 |
| 115 | Wabigoon R. (2) | entrance to Clay L. | 2 | 1982/7 |
| 116 | Clay L. (1) | middle | 9 | 1982/7 |
| 117 | Clay L. (2) | north arm | 5 | 1982/7 |
| 118 | Wabigoon R. (3) | downstream of Clay L. at Canyon R. falls | 8 | 1982/7 |
| 119 | Thunder Bay (1) | 30 m offshore from Northern Wood Preservers Co. | 2 | 1982/7 |
| 120 | Thunder Bay (2) | 50 m off filtration beds at Abitibi Paper Co. | 1 | 1982/7 |
| 121 | Thunder Bay (3) | 1 km north of Mission Bay | 3 | 1982/7 |
| 122 | Kaministiquia R. | river mouth | 7 | 1982/7 |

Appendix cont'd

| No. | Location | Details | Depth, m | Date |
|---|---|---|---|---|
| 123 | Nipigon R. | 1 km downstream of Red Rock, in effluent of pulp mill | 11 | 1982/7 |
| 124 | Terrace Bay | in effluent flowing from pupl and paper mill | 1 | 1982/7 |
| 125 | Marathon (1) | in effluent of American Can Co. | 2 | 1982/7 |
| 126 | Marathon (2) | in effluent of American Can Co. | 4 | 1982/7 |
| 127 | Marathon (3) | 10 m off wharf at American Can Co. | 7 | 1982/7 |
| 128 | Turkey L. (1) | middle | 12 | 1982/7 |
| 129 | Turkey L. (2) | middle | 10 | 1982/7 |
| 130 | Turkey L. (3) | middle | 4 | 1982/7 |
| 131 | Turkey L. (4) | middle | 18 | 1982/7 |
| 132 | Turkey L. (5) | middle | 8 | 1982/7 |
| 133 | St. Marys R. at Sault Ste. Marie (1) | in power canal 100 m downstream of Huron St. | 5 | 1982/7 |
| 134 | St. Marys R. at Sault Ste. Marie (2) | at entrance to Algoma Steel Corp. slip | 5 | 1982/7 |
| 135 | St. Marys R. at Sault Ste. Marie (3) | 200 m offshore from Ontario Ministry of Natural Resources building | 5 | 1982/7 |
| 136 | Blind R. | downstream of effluent pipes of El Dorado Nuclear Ltd. | 3 | 1982/7 |
| 137 | Elliot L. | middle | 10 | 1982/7 |
| 138 | Spanish R. | at Espanola, beneath bridge on Hwy. 6 | 3 | 1982/7 |
| 139 | Georgian Bay | at Little Current, Manitoulin Island, in shipping channel 50 m from railway bridge | 11 | 1982/7 |
| 140 | Simon L. | southwest of Sudbury, middle of lake | 6 | 1982/7 |
| 141 | Kelley L. | southwest of Sudbury, middle of lake | 7 | 1982/7 |

Appendix cont'd

| No. | Location | Details | Depth, m | Date |
|---|---|---|---|---|
| 142 | Ramsey L. | in Sudbury, northeast of McNaughton Island | 18 | 1982/7 |
| 143 | Elbow L. | southeast of Sudbury, middle of lake | 9 | 1982/7 |
| 144 | Nepewassi L. | southeast of Sudbury, middle of lake | 6 | 1982/7 |
| 145 | Ashigami L. | northeast of Sudbury, extreme western arm | 4 | 1982/7 |
| 146 | Kukagami L. | northeast of Sudbury, middle of west arm | 5 | 1982/7 |
| 147 | L. Nipissing at North Bay | 100 m off public wharf | 5.5 | 1982/7 |
| 148 | L. Muskoka | water collected 100 m off Kennedy Point, sediment collected in middle of Milford Bay | 20 | 1982/7 |
| 149 | L. Simcoe at Barrie | Kempenfelt Bay, 500 m off Big Bay Point lighthouse | 7.5 | 1982/7 |
| 150 | Collingwood Harbour | middle of harbour | 6 | 1982/7 |
| 151 | Owen Sound Harbour | mouth of Sydenham R. | 8 | 1982/7 |
| 152 | L. Huron (1) | at Baie du Dore at Douglas Point | 3 | 1982/7 |
| 153 | L. Huron (2) | head of St. Clair R. | 4 | 1982/7 |
| 154 | St. Clair R. (1) | in Sarnia, 1 km downstream of Reid Aggregates Ltd. | 5 | 1982/7 |
| 155 | St. Clair R. (2) | above Corunna, near outflow of Ethyl Corp. | 2 | 1982/7 |
| 156 | St. Clair R. (3) | at Corunna, 200 m off Hill St. | 3 | 1982/7 |
| 157 | St. Clair R. (4) | south channel at Harsens Island | 5 | 1982/7 |
| 158 | St. Clair R. (5) | south channel at Southeast Bend | 13 | 1982/7 |
| 159 | L. St. Clair (1) | south of Seaway Island | 1 | 1982/7 |
| 160 | L. St. Clair (2) | off entrance to shipping channel in St. Clair R. | 18 | 1982/7 |
| 161 | L. St. Clair (3) | marina in Mitchell Bay | 2 | 1982/7 |
| 162 | Thames R. | mouth | 3.5 | 1982/7 |
| 163 | Detroit R. (1) | downstream of Belle Isle, at Hiram Walker & Sons, Ltd. | 9 | 1982/7 |

Appendix cont'd

| No. | Location | Details | Depth, m | Date |
|---|---|---|---|---|
| 164 | Detroit R. (2) | east of Fighting Island, north of Turkey Island | 10 | 1982/7 |
| 165 | L. Erie (1) | middle of western basin | 10 | 1982/7 |
| 166 | L. Erie (2) | middle of eastern basin | 20 | 1982/7 |
| 167 | Port Stanley | middle of zone "b", inside breakwater | 7 | 1982/7 |
| 168 | Port Dover | 15 m off lighthouse, at entrance to harbour | 4 | 1982/7 |
| 169 | Nanticoke | 50 m off Ontario Hydro plant | 8 | 1982/7 |
| 170 | Grand R. (1) | at bridge at Lancaster | 2 | 1982/7 |
| 171 | Grand R. (2) | lagoon in sewage treatment plant at Kitchener | 2 | 1982/7 |
| 172 | Grand R. (3) | 20 m downstream of sewage treatment plant at Kitchener | 2 | 1982/7 |
| 173 | Grand R. (4) | mouth of river at Port Maitland, 400 m downstream of fertilizer plant | 5 | 1982/7 |
| 174 | Niagara R. at Fort Erie | 300 m upstream of Peace Bridge | 7.5 | 1982/7 |
| 175 | Niagara R., Chippawa Channel | between Navy Island and Ontario shore | 3.5 | 1982/7 |
| 176 | Niagara R. at Niagara-on-the-Lake (1) | middle | 17 | 1982/7 |
| 177 | Niagara R. at Niagara-on-the-Lake (2) | middle | 17 | 1983/6 |
| 178 | Welland Canal (1) | at entrance to canal in Port Colborne | 13 | 1982/7 |
| 179 | Welland Canal (2) | at Thorold, 50 m upstream of lock 7 | 10 | 1982/7 |
| 180 | Thorold South | in drainage ditch (which is a tributary of L. Gibson) near Beaver Wood Fibre Ltd. | 3 | 1982/7 |

Appendix cont'd

| No. | Location | Details | Depth, m | Date |
|---|---|---|---|---|
| 181 | St. Catharines (1) | Old Welland Canal spillway near corner of Merritt St. and Glendale Rd. | 8 | 1982/7 |
| 182 | St. Catharines (2) | confluence of Twelve Mile Creek and Old Welland Canal spillway | 7 | 1982/7 |
| 183 | Port Weller | middle of dry dock area | 10.5 | 1982/7 |
| 184 | Credit R. | mouth | 1.5 | 1982/7 |
| 185 | Humber R. | mouth | 1.5 | 1982/7 |
| 186 | Toronto Harbour (1) | middle of Western Gap | 12 | 1982/7 |
| 187 | Toronto Harbour (2) | Centre Island Ferry lane | 10 | 1982/7 |
| 188 | Don R. | mouth | 7 | 1982/7 |
| 189 | Toronto Harbour (3) | middle of eastern shipping channel | 10.5 | 1982/7 |
| 190 | Whitby (1) | off Whitby Yacht Club near Hulk | 3 | 1982/7 |
| 191 | Whitby (2) | in area "b", 10 m off Texaco tank farm | 7 | 1982/7 |
| 192 | Port Hope | Ganaraska R., south of El Dorado Nuclear Ltd. | 3.5 | 1982/7 |
| 193 | Cobourg | in harbour, 100 m east of Cobourg Yacht Club | 6 | 1982/7 |
| 194 | Moira L. | center of western basin | 5 | 1982/7 |
| 195 | Moira R. | middle of Ben Bay | 3 | 1982/7 |
| 196 | Belleville | mouth of Moira R. | 4 | 1982/7 |
| 197 | Kingston Harbour | mouth of Cataraqui R., 100 m downstream of Hwy. 2 bridge | 5 | 1982/7 |
| 198 | St. Lawrence R. at Maitland (1) | downstream of DuPont Ltd. effluent pipe | 2 | 1982/7 |
| 199 | St. Lawrence R. at Maitland (2) | middle of Blue Church Bay | 2 | 1982/7 |

Appendix cont'd

| No. | Location | Details | Depth, m | Date |
|---|---|---|---|---|
| 200 | St. Lawrence R. at Cornwall (1) | 500 m downstream of CIL Ltd. effluent | 2.5 | 1982/7 |
| 201 | St. Lawrence R. at Cornwall (2) | middle of river, 50 m downstream of Seaway International Bridge | 2.5 | 1982/7 |
| 202 | St. Lawrence R. at Cornwall (3) | south of Cornwall Island | 2 | 1984/10 |
| 203 | St. Lawrence R. at Cornwall (4) | at Marina Co-operative de Cornwall | 2.5 | 1984/10 |
| 204 | L. Timiskaming | at Haileybury, 200 m south of Rexway Plywood | 17 | 1982/7 |
| 205 | Sasaginaga L. | at Cobalt, 5 m off tailings ponds | 0.5 | 1982/7 |
| 206 | Ottawa R. at Chalk River | 50 m downstream of Atomic Energy of Canada Ltd., 15 m off shore | 5.5 | 1982/7 |
| 207 | Ottawa R. at Arnprior | 2 km downstream of mouth of Madawaska R., 20 m from shore | 5.5 | 1982/7 |
| 208 | Ottawa R. at Ottawa | middle of river, 500 m downstream of Chaudiere Falls | 3 | 1982/7 |
| 209 | Ottawa R. at Chute a Blondeau | off public wharf | 1.5 | 1984/10 |
| MICHIGAN, USA | | | | |
| 210 | Detroit R. | downstream of Belle Isle, 50 m off Medusa Cement Co. | 8 | 1982/7 |
| NEW YORK STATE, USA | | | | |
| 211 | Buffalo Harbor | 15 m off Bethlehem Steel Co. | 11 | 1983/6 |
| 212 | Buffalo R. | mouth | 13 | 1983/6 |
| 213 | Niagara R. (1) | Tonawanda Channel, at mouth of Erie Canal | 3.5 | 1983/6 |

Appendix cont'd

| No. | Location | Details | Depth, m | Date |
|---|---|---|---|---|
| 214 | Niagara R. (2) | Tonawanda Channel at 102nd St. dump, 10 m off shore | 0.2 | 1983/6 |
| 215 | Gill Creek | mouth of creek, Niagara Falls, N.Y. | 1 | 1983/6 |
| 216 | Niagara R. (3) | 100 m below Gill Creek mouth, 50 m off shore | 3.5 | 1983/6 |
| QUEBEC | | | | |
| 217 | Ottawa R. at Temiscaming | 1 km downstream of bridge to Thorne | 9 | 1982/7 |
| 218 | Schyan R. | mouth | 3 | 1982/7 |
| 219 | Ottawa R. at Thurso | 300 m upstream of ferry dock, 10 m off shore | 4 | 1982/7 |
| 220 | Ottawa R. at Montebello | in bay at mouth of Ruisseau Papineau | 1 | 1982/7 |
| 221 | Lac des Deux Montagnes | in Anse de Vaudreuil, off Club Nautique Deux Montagnes | 3 | 1984/8/20 |
| 222 | Lac Saint-Louis (1) | at Sainte-Anne-de-Bellevue, upstream of lock | 4 | 1984/8/20 |
| 223 | Lac Saint-Louis (2) | 2 km north of Riv. St.-Louis, 0.5 km west of Iles de la Paix | 8 | 1984/8/20 |
| 224 | Lac Saint-Louis (3) | 0.5 km east of mouth of Riv. St.-Louis | 3 | 1984/8/28 |
| 225 | Lac Saint-Louis (4) | at Marina Iroquois, Lachine | 4 | 1984/8/20 |
| 226 | Sainte-Catherine lock | between lock and No. 2 turning basin | 4.5 | 1984/8/21 |
| 227 | Saint-Lambert lock (1) | upstream of bridge No. 3 | 9 | 1984/8/21 |
| 228 | Saint-Lambert lock (2) | downstream of Victoria Bridge | 6.5 | 1984/8/21 |
| 229 | Canal de la Rive Sud | 800 m downstream of Victoria Bridge | 18 | 1982/7 |
| 230 | St. Lawrence R. at Longueuil | at Longueuil Yacht Club | 5 | 1982/7 |
| 231 | St. Lawrence R. at Montreal (1) | between oil tank farms and Ile Dufault, 10 m off shore | 8 | 1982/7 |

Appendix cont'd

| No. | Location | Details | Depth, m | Date |
|---|---|---|---|---|
| 232 | St. Lawrence R. at Montreal (2) | between oil tank farms and Ile Dufault, 10 m off shore | 3 | 1982/7 |
| 233 | St. Lawrence R. at Montreal (3) | at wharf at end of St.-Jean-Baptiste Blvd., Pointe-aux-Trembles | 5 | 1984/8/21 |
| 234 | St. Lawrence R. at Montreal (4) | at Marina Jean Beaudoin, east end of Montreal Island | 1.5 | 1984/8/21 |
| 235 | Montreal Harbour (1) | Pointe du Moulin a Vent, 15 m off shore | 10 | 1982/7 |
| 236 | Montreal Harbour (2) | middle of quai No. 2 between Pointe du Moulin a Vent and Alexandra Pier | 13 | 1984/8/23 |
| 237 | Montreal Harbour (3) | middle of quai No. 11 between King Edward Pier and Jacques-Cartier Pier | 14 | 1984/8/23 |
| 238 | Montreal Harbour (4) | middle of Market Basin | 9.5 | 1984/8/23 |
| 239 | Montreal Harbour (5) | at end of Jetty No. 3 | 13.5 | 1984/8/23 |
| 240 | Montreal Harbour (6) | at end of Vickers Ltd. floating docks | 9 | 1984/8/23 |
| 241 | Richelieu R. at St.-Jean d'Iberville | upstream of Hwy. 35 bridge | 4 | 1984/8/16 |
| 242 | Richelieu R. at Ville-de-Tracy | at Marine Industries Ltd. | 8 | 1984/10/25/11:00 |
| 243 | St. Francois R. | mouth | 4.5 | 1984/10/25 |
| 244 | St. Lawrence R. at Quebec (1) | middle of marina near St. Lawrence Tankers | 8 | 1984/8/30 |
| 245 | St. Lawrence R. at Quebec (2) | at Queen's Wharf | 9.5 | 1984/8/30 |

Appendix cont'd

| No. | Location | Details | Depth, m | Date |
|---|---|---|---|---|
| 246 | Louise Basin at Quebec | middle | 9.5 | 1984/8/30 |
| NEW BRUNSWICK | | | | |
| 247 | Saint John R. at Quisibis | 0.5 km above La Grande Isle | 1 | 1984/10 |
| 248 | Saint John R. at Maugerville | 1 km below Oromocto Island | 4 | 1984/10 |
| 249 | Kennebecasis Bay at Renforth | 1 km north of Renforth Cove. Ice 1 m thick. | 17.5 | 1985/2/4/11:50 |
| 250 | Saint John Harbour | half way between Ministry of Transport pier and Pugsley Terminal, 10 m from shore | 12 | 1985/2/4/14:00 |
| 251 | Dalhousie Harbour | at end of New Brunswick International Paper wharf | 10 | 1985/2/6/12:30 |
| 252 | Bathurst Harbour | between Middle River Causeway and yacht club in West Bathurst | 1.5 | 1985/2/6/16:00 |
| 253 | Lameque Harbour | near inlet to old wharf enclosure | 5 | 1981/8/25 |
| 254 | Shippegan Harbour | 15 m inside southerly wharf enclosure | 6 | 1981/8 |
| 255 | Miramichi R. (1) | in cove at Douglastown, 1.7 km above Hwy. 11 bridge | 0.3 | 1985/2/5/15:00 |
| 256 | Miramichi R. (2) | at Millbank, off Government Wharf | 9 | 1985/2/5/16:00 |
| 257 | Escuminac Harbour | 100 m inside wharf enclosure | 2.5 | 1981/8 |
| 258 | Point Sapin | 50 m inside wharf enclosure | 2.5 | 1981/8 |
| 259 | Richibucto Harbour | inside Government Wharf enclosure | 2 | 1985/2/7/11:30 |
| 260 | Cap Lumiere | in outlet of wharf enclosure | 2.5 | 1981/8 |
| 261 | Chockpish R. | 50 m inside wharf enclosure | 2.5 | 1981/8 |

Appendix cont'd

| No. | Location | Details | Depth, m | Date |
|---|---|---|---|---|
| 262 | St. Edouard de Kent | inside harbour, 50 m from end of wharf | 2 | 1981/8 |
| 263 | Buctouche Harbour | in small bay close to Irving Oil tanks | 1 | 1985/2/7/14:00 |
| 264 | Shediac Bay | at Pointe-du-Chene, 50 m from south side of wharf | 3.5 | 1985/2/7/16:30 |
| 265 | Cap Pele | L'Abiteau wharf enclosure, 50 m from outlet | 2 | 1981/8 |
| 266 | Murray Corner | at wharf at outlet to Northumberland Strait | 1.5 | 1981/8 |
| 267 | Cape Tormentine | at "Fisherman's Wharf" enclosure, 50 m from northeast corner | 4 | 1981/8 |
| PRINCE EDWARD ISLAND | | | | |
| 268 | Charlottetown Harbour | off Department of Transport Marine Terminal | 5 | 1984/10 |
| NOVA SCOTIA | | | | |
| 269 | Pictou Harbour | between Town Point and Battery Point | 13 | 1984/11/28/15:00 |
| 270 | Port Hawkesbury Harbour | mouth of harbour | 8 | 1984/11/28/11:00 |
| 271 | Sydney Harbour | middle of channel, north of Shingle Point | 16 | 1984/11/27/14:00 |
| 272 | Halifax Harbour | middle of Eastern Passage, off Baker Point | 16 | 1984/11/26/15:00 |
| NEWFOUNDLAND | | | | |
| 273 | Port-aux-Basques Harbour | half way between Scotts Point and Point Pleasant | 3 | 1984/11 |
| 274 | Stephenville Pond | inside entrance to Pond from St. George's Bay | 9 | 1984/11 |
| 275 | Argentia Harbour | at marina between Sandy Cove and Cooper Cove | 2 | 1984/11 |
| 276 | Conception Bay | middle of Long Pond on Belle Island, north of Topsail Yacht Club | 15 | 1984/11 |
| 277 | St. John's Harbour | at Pier 2 | 11 | 1984/11 |