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Report No. 8401

**OCCURRENCE OF METHYL TIN AND BUTYL TIN SPECIES
IN ENVIRONMENTAL SAMPLES IN ONTARIO**

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**Inland Waters
Directorate**

**Direction Générale
des Eaux Intérieures**

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ABSTRACT

During fiscal years 1982-1983 and 1983-1984 the Great Lakes Water Quality Program provided funding for a survey to determine the extent of contamination of waters on the Canadian side of the Great Lakes basin by methyltin and butyltin compounds. This is the report of the results of analyses of water, sediment and fish from about one hundred locations, largely in Ontario. Butyltin species were widely found in water and sediment samples. The highest concentrations were in harbours, reflecting the use of tri-n-butyltin as an antifouling agent in boat paint. Methyltin species were infrequently detected, and their occurrence was correlated with the presence of relatively high concentrations of inorganic tin.

INTRODUCTION

Tin as a metal and in its chemical compounds has a wide variety of use. Characteristically, in many of its applications, only small amounts of tin are needed to see its effect. This is generally true for the organotin compounds which, during the past thirty years, have developed into important industrial commodities. A further characteristic of tin is that it is unsurpassed by any other metal in the multiplicity of its organic applications. These involve such widely divergent fields as stabilizers for polyvinyl chloride, industrial catalysts, industrial and agricultural biocides, and wood-preserving and antifouling agents, to mention only the most important applications.

The global consumption of tin in all forms was about 200 million kg in 1976, and of this total about 28 million kg was in the form of organotin compounds (1). The U.S. consumption of organotin compounds was about 11 million kg in that year, and an 11-13% annual growth in consumption was predicted for the period 1978-1988. Comparable Canadian figures are not available.

The main organotin compounds which are likely to be released to the environment in Canada are triphenyltin (Ph_3Sn^+), tricyclohexyltin (Cy_3Sn^+), tri-n-butyltin (Bu_3Sn^+), di-n-butyltin

($\text{Bu}_2\text{Sn}^{2+}$) and dimethyltin ($\text{Me}_2\text{Sn}^{2+}$). Triphenyltin and tricyclohexyltin are insecticides. Tri-n-butyltin is used mainly as a slimicide in cooling towers and as an antifouling agent in marine paint. Di-n-butyltin is used as a polyvinyl chloride stabilizer (as is dimethyltin) and as a catalyst in a number of industrial processes.

Persistence studies on the major classes of organotin compounds have indicated that abiotic degradation generally occurs, as does biological degradation, through mechanisms of sequential dealkylation or dearylation; therefore, the series $\text{Ph}_n\text{Sn}^{(4-n)+}$, $\text{Cy}_n\text{Sn}^{(4-n)+}$ and $\text{Bu}_n\text{Sn}^{(4-n)+}$ (where in each case $n \leq 4$) and $\text{Me}_n\text{Sn}^{(4-n)+}$ (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 compounds has been demonstrated in natural water-sediment mixtures.

The increasing annual use of organotin compounds, some of which are very toxic to mammals and aquatic biota, caused them as a class to be placed, in 1979, on the Department of the Environment's Environmental Contaminants Act Category III list (2), which essentially meant that further information was required on their

occurrence, persistence and toxicity in order to make environmental and human health risk assessments.

Our work has been devoted largely to the aquatic environmental occurrence and persistence of methyl- and butyltin compounds. Samples collected in 1981 at thirty locations in Ontario revealed, for the first time in Canada, the presence of methyl- and butyltin species (and inorganic tin) in some waters and sediments (3,4). In general, the occurrence of inorganic tin was widespread, methyltin species were found in harbours or areas of industrial activity, and butyltin species were found mainly in harbours and other areas of heavy boating or shipping traffic. In addition, tri-n-butylmethyltin and di-n-butylmethyltin were found in the sediments of some harbours. Their presence indicates that species other than methyltin species and inorganic tin can be methylated in aquatic environments; their concentrations relative to those of the "parent" Bu_3Sn^+ and Bu_2Sn^{2+} species indicate from a mass balance point of view that methylation may be a significant pathway of transformation for butyltin species in aquatic environments.

In an effort to determine the extent of methyl- and butyltin contamination of lakes and rivers in Ontario, we collected, in the summer of 1982, samples of water (and sediment where possible) from about one hundred locations. Because of the amount of work involved,

all samples were analyzed under contract, with funding provided through the Great Lakes Water Quality Program during fiscal years 1982-1983 and 1983-1984 (Y.K. Chau - project leader). This is the report of the results.

EXPERIMENTAL METHODS

Most water and sediment samples were collected from a Boston Whaler; the boat was not painted with antifouling paint.

Determination of butyltin species in water

Samples (8L) of subsurface (0.5 m) water were collected in glass bottles, and the contents were acidified to pH 1 and stored at 4°C until analysis.

Analyses of the unfiltered water samples for butyltin species (Bu_3Sn^+ , $\text{Bu}_2\text{Sn}^{2+}$ and BuSn^{3+}) and "total recoverable inorganic tin" (Sn(II) and Sn(IV)) were performed according to a method (5) that involved extraction from 8L of acidified aqueous solution into benzene/0.5% tropolone, adjusting the pH of the water to 7, saturating

with NaCl and reextraction with benzene/0.5% tropolone, derivatization of the combined benzene/tropolone extracts with pentylmagnesium bromide (PeMgBr), silica gel column cleanup and analysis of the $Bu_nPe_{4-n}Sn$ derivatives by gas chromatography with a quartz tube furnace-atomic absorption spectrophotometer as a detector (6). Appropriate reagent blanks were prepared (three different lots of pentylmagnesium bromide purchased during the course of this work were found to contain unacceptably high concentrations of the four butylpentyltin compounds, $Bu_nPe_{4-n}Sn$, and thus the Grignard reagent is now prepared in our laboratories from commonly available chemicals). The detection limit for each of the $Bu_nPe_{4-n}Sn$ species is about 0.01 $\mu\text{g/L}$, and identities were confirmed by co-chromatography with authentic standards on two different columns. Recoveries of the butyltin species and Sn(IV) spiked at the 1 mg/L level in acidified water varied from 96% to 103% (5), and the relative standard deviation of concentrations of butyltin compounds determined by triplicate injections was less than 15%. A peak in extracts from environmental samples was not accepted as real unless it was at least twice as large as any corresponding peak in the reagent blank.

Determination of butyltin species in sediment

Sediment samples were collected with an Ekman dredge and the top 2 cm were scraped off into glass jars. The sediment was freeze-dried, stones and other debris were removed, and the sediment was ground with a mortar and pestle. One g of dry sediment was refluxed for 2 hrs. with 0.25 g of tropolone in 100 mL of benzene. The mixture was filtered, derivatized and analyzed as described above.

The detection limit for each of the $Bu_nPe_{4-n}Sn$ species is about 0.005 mg/kg dry weight (4,7), and identities were confirmed by co-chromatography with authentic standards on two different columns. This method has been shown to yield quantitative recoveries of butyltin species and Sn(IV) from sediment spiked at 0.01-100 mg/kg dry weight (4), and the relative standard deviation of concentrations of butyltin compounds determined by triplicate injections was less than 15%.

Although Sn(IV) was the only inorganic tin species for which recoveries were determined in spiking experiments, the inorganic tin present in the environmental samples is reported as "total recoverable inorganic tin" since it has recently been shown that hydride derivatization of either Sn(IV) or Sn(II) yields SnH_4 (7), and thus any Sn(II) that may be present in our samples may similarly be alkylated to tetraalkyltin. We have shown, however, that the yield of, e.g., Bu_4Sn from Sn(II) is almost negligible compared to that from Sn(IV).

Determination of methyltin species in water

Water samples were collected in amber glass bottles (4 L) containing 1400 g of NaCl. The samples were not filtered but stored in the dark at 4°C until analysis.

Analysis of water for mono-, di-, trimethyltin and tin (IV) species were carried out according to a method previously published (9). A one litre water sample was extracted with 30 mL of 0.5% tropolone in benzene for 2 hrs. in a mechanical shaker. After separation, the benzene phase was evaporated in a rotary evaporator to 1 mL and butylated with 0.2 mL of n-butyl Grignard reagent. The mixture was then washed with 3 mL of 1N H₂SO₄ to destroy the excess Grignard reagent. The benzene phase containing all the butyl derivatives of methyltin was transferred into a small vial and dried with anhy. Na₂SO₄ ready for analysis by the GC-AAS technique (9).

Standards were prepared by adding 1 µg of each of the MeSn³⁺, Me₂Sn²⁺, Me₃Sn⁺ and Sn(IV) compounds in 1 L of distilled water containing 360 g of NaCl, and carrying through the whole process. Appropriate reagent blanks were prepared for each analysis. The detection limit of the method is 0.01 µg/L when a 1 L sample is used and 20 µL is injected into the GC-AAS system.

Determination of methyltin species in sediment

One gram of freeze-dried sediment was mixed with 10 mL of water, 6 g of NaCl, 2 g sodium benzoate, and 1 g KI; and extracted with 5 mL of 0.5% tropolone/benzene solution for 2 hrs. in a mechanical shaker. After shaking, the mixture was centrifuged, and 1 mL of the benzene phase was removed for butylation with 0.2 mL of n-butyl Grignard reagent, and analyzed as described in the preceding paragraph for water.

The detection limit of the method is 0.01 $\mu\text{g/g}$.

Determination of methyltin species in fish

Whole fish samples were ground and homogenized at least five times in a commercial grinder and stored in frozen state until use. About 2 g of the homogenized paste was digested in 5 mL of 20% TMAH (tetramethyl ammonium hydroxide) in a capped test tube in a water bath at 60°C for 1 to 2 hrs. until the tissue had completely dissolved to a pale yellow solution. After cooling the solution was neutralized with 50% (v/v) hydrochloric acid to pH 6 to 8. The mixture was extracted with 3 mL of a 0.5% tropolone/benzene in a mechanical shaker for 1 hr. after addition of 2 g NaCl. After centrifugation of the

mixture, a measured amount (1 mL) of the benzene phase was transferred to a glass-stoppered vial and butylated with 0.2 mL of n-butyl Grignard reagent. The benzene phase was analyzed as described for water in the preceding paragraph.

Detection limit is 0.01 $\mu\text{g/g}$.

RESULTS AND DISCUSSION

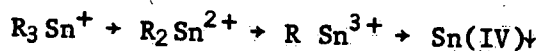
Tables 1 and 2 show the occurrence of inorganic tin and methyl- and butyltin species in water and sediment. Table 2 omits many locations at which water samples were collected but at which sediment could not be obtained because of the nature of the lake or river bottom.

The results confirm preliminary findings (3,4). Inorganic tin occurs in many locations, and butyltin species are frequently detected in the water and sediment of marinas and harbours. Concentrations of Bu_3Sn^+ in the water of marinas in Port Hope and Whitby, and at one location in the St. Marys River at Sault Ste. Marie, were close to, or exceeded, the LC_{100}^{12d} value of 5 $\mu\text{g}/\text{L}$ for rainbow trout yolk sac fry (8). On the basis of this, and earlier work, Toronto Harbour was chosen as the site at which to conduct an investigation of the persistence and fate of the Bu_3Sn^+ species.

Unlike the butyltin compounds which are widely found in the environment because of their extensive use, the methyltin compounds are only found in several harbor areas. Methyltin compounds are used to a much lesser extent compared to the butyl derivatives, and their environmental occurrence is not expected to be as frequent. Environmental sources of methyltins have been attributed mainly to

biotic and abiotic methylation of both organotin and inorganic tin compounds (10,11). The biogenesis of methyltin has been discussed in detail (7). The methyltin species are important transport species in the biogeochemical cycles of tin in the environment for mobilization of the insoluble tin compounds in sediment. The occurrence of methyltins in rivers, lakes and coastal waters has been reported (3,12,13).

There are only a few locations where methyltin compounds were found in sediment, and in fish (Table 3). These environmental occurrences of highly diluted solvated methyltin ions may simply reflect a steady state concentration. Alkyltin compounds have been known to undergo successive biotic and abiotic cleavage of the tin-carbon bonds to ultimately produce inorganic tin.



REFERENCES

1. Zuckerman, J.J., Reisdorf, R.P., Ellis, H.V., III, and Wilkinson, R.R. 1981. Organotins in biology and the environment. In "Organometals and Organometalloids, Occurrence and Fate in the Environment", F.E. Brinckman and J.M. Bellama (Eds.). American Chemical Society, Washington, D.C. American Chemical Society Symposium Ser. No. 82, pp. 388-422.
2. Canada Department of the Environment and Department of National Health and Welfare. 1979. Environmental Contaminants Act. Priority Chemicals - 1979. In The Canada Gazette, Part I, Dec. 1, pp. 7365-7370.
3. Maguire, R.J., Chau, Y.K., Bengert, G.A., Hale, E.J., Wong, P.T.S., and Kramar, O. 1982. Occurrence of organotin compounds in Ontario lakes and rivers. *Environ. Sci. Technol.* 16:698-702.
4. Maguire, R.J. 1984. Butyltin compounds and inorganic tin in sediments in Ontario. *Environ. Sci. Technol.*, in press.

5. Maguire, R.J. and Huneault, H. 1981. Determination of butyltin species in water by gas chromatography with flame photometric detection. J. Chromatogr. 209:458-462.
6. Maguire, R.J. and Tkacz, R.J. 1983. Analyses of butyltin compounds by gas chromatography: comparison of flame photometric and atomic absorption spectrophotometric detectors. J. Chromatogr. 268:99-101.
7. Brinckman, F.E., Jackson, J.A., Blair, W.R., Olson, G.J. and Iverson, W.P. 1983. Ultratrace speciation and biogenesis of methyltin transport species in estuarine waters. In "Trace Metals in Sea Water", C.S. Wong, E. Boyle, K.W. Bruland, J.D. Burton and E.D. Goldberg (Eds.), Plenum Press, N.Y., pp. 39-72.
8. Seinen, W., Helder, T., Vernij, H., Penninks, A., Leeuwangh, P. 1981. Short term toxicity of tri-n-butyltinchloride in rainbow trout (Salmo gairdneri Richardson) yolk sac fry. Sci. Total Environ. 19:155-166.

9. Chau, Y.K., Wong, P.T.S. and Bengert, G.A. 1982.
Determination of methyltin (IV) and tin (IV) species in water by gas chromatography with atomic absorption spectrophotometry. Anal. Chem. 54:246-249.
10. Chau, Y.K., Wong, P.T.S., Kramar, O. and Bengert, G.A. 1981. Methylation of tin in the aquatic environment. In "Heavy metals in the environment" CEP Consultants, Edinburgh. pp. 641-644.
11. Hallas, L.E., Means, J.C. and Cooney, J.J. 1982.
Methylation of tin by estuarine microorganisms. Science 215:1505-1507.
12. Braman, R.S. and Tompkins, M.A. 1979. Separation and determination of nanogram amounts of inorganic tin and methyltin compounds in the environment. Anal. Chem. 51:12-19.
13. Hodge, V.F., Seidel, S.L. and Goldberg, E.D. 1979.
Determination of tin (IV) and organotin compounds in natural waters, coastal sediments and macro algae by atomic absorption spectrometry. Anal. Chem. 51:1256-1259.

Table 1. Concentrations ($\mu\text{g/L}$) of Methyltin and Butyltin Species and Total Recoverable Inorganic Tin (TRIT) in Unfiltered Subsurface Water^a

Location	TRIT	MeSn^{3+}	$\text{Me}_2\text{Sn}^{2+}$	Me_3Sn^+	BuSn^{3+}	$\text{Bu}_2\text{Sn}^{2+}$	Bu_3Sn^+
Wabigoon River (at Dryden)	4.20				0.07		
Wabigoon River (at Minnitaki)							
Wabigoon River (at falls at Hwy. 105)							
Wabigoon River (upstream of Clay Lake)	2.90				0.37	0.23	0.01
Clay Lake (middle)	2.10				0.28		
Clay Lake (north arm)	2.11				0.04	0.01	
Wabigoon River (downstream of Clay Lake)	0.41				0.22		
Thunder Bay 1	8.29					0.05	0.03
Thunder Bay 2					0.01	0.03	0.19
Thunder Bay 3	0.11				0.22	0.14	
Kaministiquia River (Thunder Bay)	0.22						
Nipigon River (Red Rock)							1.56
Lake Superior (Terrace Bay)						0.01	1.20
Lake Superior (Marathon 1)	1.08				0.08		
Lake Superior (Marathon 2)					0.01		
Lake Superior (Marathon 3)	0.16						0.04
Turkey Lake 1	0.03						0.01
Turkey Lake 2	0.06						2.30
Turkey Lake 3						0.01	1.16
Turkey Lake 4	0.02				0.01	0.02	0.01
Turkey Lake 5					0.09	0.02	1.3
St. Mary's River (Sault Ste. Marie 1)	0.01						
St. Mary's River (Sault Ste. Marie 2)						0.17	4.10

Continued . . .

Table 1 Continued

Location	TRIT	MeSn ³⁺	Me ₂ Sn ²⁺	Me ₃ Sn ⁺	BuSn ³⁺	Bu ₂ Sn ²⁺	Bu ₃ Sn ⁺
St. Mary's River (Sault Ste. Marie 3)						0.01	0.17
Blind River (upstream of Dorothy Inlet)	0.01					0.01	1.40
Elliot Lake	0.56				0.02		0.02
Spanish River (Espanola)	0.31				0.01	0.02	
Georgian Bay (Little Current)	0.49						0.01
Simon Lake (southwest of Sudbury)	0.50						0.01
Kelley Lake (southwest of Sudbury)	1.60					0.02	
Ramsey Lake (Sudbury)	4.69				0.01	0.02	0.04
Elbow Lake (southeast of Sudbury)							
Nepewassi Lake (southeast of Sudbury)	1.36				0.02	0.06	0.10
Ashigami Lake (northeast of Sudbury)	0.17				0.04	1.82	
Kukagami Lake (northeast of Sudbury)	0.72						
Lake Nipissing (at North Bay)	0.91						
Lake Muskoka (off Seven Masters Islands)	0.02						0.09
Lake Simcoe (Barrie)	2.54						
Collingwood Harbour (Georgian Bay)	1.84				0.01		
Owen Sound Harbour (Georgian Bay)	0.59						
Lake Huron (Douglas Point)							
Lake Huron (head of St. Clair River)	0.82						

Continued . . .

Table 1 Continued

Location	TRIT	MeSn ³⁺	Me ₂ Sn ²⁺	Me ₃ Sn ⁺	BuSn ³⁺	Bu ₂ Sn ²⁺	Bu ₃ Sn ⁺
St. Clair River (Sarnia)	1.13						
St. Clair River (upstream of Corunna)	0.39				0.01	0.10	
St. Clair River (Corunna)	0.04				0.05		0.53
St. Clair River (south channel - Harsens Island)	0.76				0.01	0.01	0.04
St. Clair River (south channel at southeast bend)	1.11				0.02		
Lake St. Clair (south of Seaway Island)	1.06				0.02		0.24
Lake St. Clair (out from shipping channel)	2.67				0.05	0.08	0.01
Mitchell Bay Marina (Lake St. Clair)	6.67						0.18
Thames River mouth	0.44						
Detroit River (Canadian side, downstream of Belle Isle)	4.4				0.02		0.01
Detroit River (U.S. side, downstream of Belle Isle)	0.02	0.06			0.03		1.40
Detroit River (downstream of Fighting Island, east side)							
Lake Erie (Western Basin)							
Lake Erie (Eastern Basin)	2.22	0.06					
Port Stanley	27.20						
Port Dover	1.66				2.80	0.40	0.43
Nanticoke	1.72				0.01	0.03	0.18
Grand River (Kitchener 1)	0.14						
Grand River (Kitchener 2)	0.04	0.02					
Grand River (Kitchener 3)	0.22						

Continued . . .

Table 1 Continued

Location	TRIT	MeSn ³⁺	Me ₂ Sn ²⁺	Me ₃ Sn ⁺	BuSn ³⁺	Bu ₂ Sn ²⁺	Bu ₃ Sn ⁺
Grand River mouth (Port Maitland)	1.06					0.01	0.02
Welland Canal (Port Colborne)	1.79				0.01		
Welland Canal (Thorold)	0.02						
Welland Canal (St. Catharines 1)							
Welland Canal (St. Catharines 2)							
Welland Canal (St. Catharines 3)	1.60					0.02	
Buffalo Harbor	0.08						
Buffalo River Mouth	5.50				0.03	0.02	
Gill Creek mouth (Niagara River)							
Niagara River (downstream of Gill Creek)	0.07				2.70		
Niagara River (Niagara- on-the-Lake)	0.08						
Port Weller (dry docks)	1.21	0.03					0.02
Credit River mouth (Port Credit)						0.01	0.07
Thunder River mouth (Toronto)	0.34						0.01
Toronto Harbour (west side)							
Toronto Harbour (Centre Island ferry lane)	6.46				0.88	0.03	0.08
Don River mouth (Toronto Harbour)							
Toronto Harbour (east shipping channel)	2.00				0.16	0.02	0.59

Continued . . .

Table 1 Continued

Location	TRIT	MeSn ³⁺	Me ₂ Sn ²⁺	Me ₃ Sn ⁺	BuSn ³⁺	Bu ₂ Sn ²⁺	Bu ₃ Sn ⁺
Whitby 1 (marina)	37.20				0.62	1.46	4.20
Whitby 2	3.04				0.02	0.12	0.25
Port Hope (marina)	9.90				0.42	0.08	5.70
Cobourg	9.90					0.02	0.01
Moira Lake (western end)	0.42						
Moira River	0.27						0.01
Belleville (off marina)	0.55					2.67	0.03
Kingston Harbour	0.03			0.14			
St. Lawrence River (Maitland 1)	0.83				0.02		0.12
St. Lawrence River (Maitland 2)	1.32						
St. Lawrence River (Cornwall 1)	0.34						0.03
St. Lawrence River (Cornwall 2)	0.19						
Lake Timiskaming (Haileyburg)	0.08						
Lake Timiskaming (Cobalt)	0.41						
Ottawa River (Temiscaming)							
Ottawa River (mouth of Schyan River at Deep River)	0.01					0.17	0.89
Ottawa River (Chalk River)						0.05	1.27
Ottawa River (Arnprior)	0.23						
Ottawa River (Ottawa - below Chaudiere Falls)	0.32						
Ottawa River (Thurso)	2.36						0.01
Ottawa River (Montebello)	0.06						0.04
Montreal Harbour (Pointe du Moulin à Vent)	0.21				0.92		0.01

Continued . . .

Table 1 Continued

Location	TRIT	MeSn ³⁺	Me ₂ Sn ²⁺	Me ₃ Sn ⁺	BuSn ³⁺	Bu ₂ Sn ²⁺	Bu ₃ Sn ⁺
Canal de la Rive Sud (Saint Lambert)							
St. Lawrence River (Montreal 1)	4.7				0.06	0.13	0.04
St. Lawrence River (Montreal 2)	0.71				0.63		

a. Minimum detectable concentration of each species is approximately 0.01 µg/L; precise sampling locations are available upon request.

Table 2. Concentrations (mg/kg dry weight) of Methyltin and Butyltin Species and Total Recoverable Inorganic Tin (TRIT) in Top 2 cm of Sediment^a

Location	TRIT	MeSn ³⁺	Me ₂ Sn ²⁺	Me ₃ Sn ⁺	BuSn ³⁺	Bu ₂ Sn ²⁺	Bu ₃ Sn ⁺
Wabigoon River (upstream of Clay Lake)	1.15			0.10			
Clay Lake (middle)	0.27			0.10	0.11		
Wabigoon River (downstream of Clay Lake)	0.33				0.04		0.09
Thunder Bay 1	0.67				X	X	X
Thunder Bay 3							
Kaministiquia River (Thunder Bay)	3.90						
Lake Superior (Marathon 1)	0.71	X	X	X			
Lake Superior (Marathon 3)							
Turkey Lake 1	6.38						
Turkey Lake 2					X	X	X
Turkey Lake 3					X	X	X
Turkey Lake 4	1.10				0.14	0.14	
Turkey Lake 5	1.09						
St. Mary's River (Sault Ste. Marie 1)	15.50				0.15		
St. Mary's River (Sault Ste. Marie 2)	10.3						
Blind River (upstream of Dorothy Inlet)	1.15				0.03		
Lot Lake	7.62						
Mon Lake (southwest of Sudbury)					X	X	X
Kelley Lake (southwest of Sudbury)	0.48						0.08
Ramsey Lake (Sudbury)	0.32				0.33		
Nepewassi Lake (southeast of Sudbury)	1.54				0.35		0.04

Continued . . .

Table 2 Continued

Location	TRIT	MeSn ³⁺	Me ₂ Sn ²⁺	Me ₃ Sn ⁺	BuSn ³⁺	Bu ₂ Sn ²⁺	Bu ₃ Sn ⁺
Ashigami Lake (northeast of Sudbury)	0.42				0.48		
Kukagami Lake (northeast of Sudbury)	4.40			0.75			
Lake Nipissing (North Bay)	6.11				7.00	1.14	
Lake Muskoka (off Seven Sisters Islands)	1.00				3.70	0.41	0.05
Lake Simcoe (Barrie)	0.58				0.06		
Lake Erie (Western Basin)				0.11			
Toronto Harbour (west side)	5.70		0.17		0.17		
Toronto Harbour (Centre Island ferry lane)	2.97				0.11		0.10
Don River mouth	1.55				X	X	X
Toronto Harbour (east shipping channel)	0.39				0.14	0.03	
Whitby 1 (marina)	0.43				0.59	0.44	0.40
Whitby 2				0.08			
Port Hope (marina)	1.42	x	x	x			
Cobourg	1.74				0.03		0.04
Moira Lake (western end)	0.48				0.40	0.29	0.07
Bellefleur (marina)	0.12						
Kingston Harbour	2.11				0.31	0.30	
St. Lawrence River (Maitland 1)	1.34			0.17			
St. Lawrence River (Maitland 2)	0.40						
St. Lawrence River (Cornwall 1)	0.66	X	X	X	0.05	0.05	
St. Lawrence River (Cornwall 2)	6.80	0.13					

Continued . . .

Table 2 Continued

Location	TRIT	MeSn ³⁺	Me ₂ Sn ²⁺	Me ₃ Sn ⁺	BuSn ³⁺	Bu ₂ Sn ²⁺	Bu ₃ Sn ⁺
Lake Timiskaming (Haileybury)	0.19						
Lake Timiskaming (Cobalt)	1.26	X	X	X			
Ottawa River (mouth of Schyan River at Deep River)	0.11						
Ottawa River (at Chalk River)	2.56						
Montreal Harbour (Pointe du Moulin à Vent)	8.30				0.55	0.69	0.46
St. Lawrence River (Montreal 1)	2.29				0.26	0.16	0.08
St. Lawrence River (Montreal 2)		X	X	X			

a. Minimum detectable concentration of each species is 0.005 mg/kg dry weight; X = not done; precise sampling locations available upon request.

Table 3. Concentrations ($\mu\text{g/g}$ wet weight) of methyltin species in selected fish samples

Location	Species	MeSn^{3+}	$\text{Me}_2\text{Sn}^{2+}$	Me_3Sn^+	TRIT
Cobourg	Smelt	0.40	nd	nd	0.62
Port Credit	Lake Trout	0.88	nd	nd	0.30
Cobourg	Lake Trout	0.29	0.18	nd	0.21
Cobourg	Lake Trout	0.22	nd	nd	0.17

Whole fish samples used for analysis. Total number of fish samples analyzed = 33.

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