Trace Elements and Heavy Metals Data for Blue Mussels (*Mytilus edulis*) from Trinity Bay and Placentia Bay, Newfoundland.

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ABSTRACT

Veinott, G., R. Whalen, and J. Miller-Banoub. 2003. Trace element and heavy metal data for blue mussels (*Mytilus edulis*) from Trinity Bay and Placentia Bay, Newfoundland. Can. Manuscr. Rep. Fish. Aquat. Sci. 2643: iii + 9 p.

Samples of the blue mussel (*Mytilus edulis*) were collected from sites at the head of Trinity Bay and Placentia Bay. Trace element and heavy metal concentrations in the soft tissue of the samples are reported. Results for Mn, and Fe were in good agreement with earlier data from these sites, while Co, Ni, Cu, Zn, and Cd concentrations tended to be lower than previously reported. However, Pb concentrations are an order of magnitude lower than previously reported. An analytical error is believed to be the cause of the difference between Pb concentrations, and the Pb values reported here are believed to be the more accurate. No site exceeded the United States Food and Drug Administration "levels of concern" for As, Ni, Cd, or Pb. However, the sample from Sunnyside, Trinity Bay, produced concentrations of As, Ni, and Cd, that are elevated compared to world mussel watch program data and may suggest a source of contamination in the area.

RÉSUMÉ

Veinott, G., R. Whalen, and J. Miller-Banoub. 2003. Trace element and heavy metal data for blue mussels (*Mytilus edulis*) from Trinity Bay and Placentia Bay, Newfoundland. Can. Manuscr. Rep. Fish. Aquat. Sci. 2643: iii + 9 p.

Des échantillons de moule bleue (*Mytilus edulis*) ont été prélevés en divers endroits du fond des baies de la Trinité et de Plaisance. On rend compte ici des concentrations d'éléments traces et de métaux lourds contenues dans les tissus mous de ces échantillons. Les teneurs en Mn et Fe concordaient bien avec les données recueillies antérieurement dans ces endroits, tandis que les concentrations de Co, Ni, Cu, Zn et Cd tendaient à être inférieures à celles qui avaient été enregistrées auparavant. Pour ce qui est des concentrations de Pb, on pense qu'une erreur d'analyse est à l'origine de l'écart entre les concentrations antérieures et les valeurs présentées ici, qu'on croit plus exactes. En aucun des endroits échantillonnés les valeurs de Ni, As, Cd ou Pb n'excédaient les « niveaux inquiétants » fixés par la United States Food and Drug Administration. Toutefois, l'échantillon prélevé à Sunnyside, dans la baie de la Trinité, présentait des concentrations de Ni, As et Cd élevées par rapport aux données du programme mondial de surveillance des moules, qui pourraient dénoter la présence d'une source de contamination dans cette région.

INTRODUCTION

The blue mussel (*Mytilus edulis*) is known to accumulate trace elements and heavy metals in its soft tissue (Rainbow and Philips 1993), and the genus *Mytilus* is used globally as a biomonitoring species (Cantillo 1998). The metal content in blue mussel tissues, therefore, is often used as an indicator of metal contamination in the environment.

Kennedy and Benson (1993) reported metal concentrations in *M. edulis* samples from 55 sites in Newfoundland. The purpose of the report was to provide baseline data for metals in Newfoundland mussels. Kennedy and Benson (1993) concluded that the samples they analyzed were not contaminated to any significant extent with the metals analyzed. However, lead (Pb) concentrations were highest in Trinity Bay and Placentia Bay with mean concentrations of 3.15 and 2.59 mg/kg wet weight respectively. Lead can act as a neurotoxin, especially in children (Hodgson and Levi 1997), and the United States Food and Drug Administration (USFDA, 1993d) reported "levels of concern" in Molluscan bivalves of 1.5 mg/kg for children 2-5 years and 2.1mg/kg wet weight for pregnant women. Levels of concern for other adults are 6.3 mg/kg wet weight.

Since several sites reported by Kennedy and Benson (1993) exceeded USFDA levels of concern for Pb (USFDA 1993), it was decided to resample sites in Trinity Bay and Placentia Bay to determine if there was any change in the metal loads of the mussels in these areas. Such information is important for consumers of country foods as well as for owners of bivalve aquaculture operations. With consumers demanding a "clean" product, information on the condition of wild mussels could be used to demonstrate the health of the natural environment in which the aquaculture facilities operate.

METHODS

Mussels were collected in March and April of 2002. The precise location of sampling sites within communities was not given in Kennedy and Benson (1993), therefore, communities were used as locators for sampling sites in this study. Four sites in Placentia Bay and two sites in Trinity Bay were sampled (Fig. 1, Table 1). Thirty to 50 mussels were collected at each site except Garden Cove where only 9 mussels were found. Mussels were placed in clean plastic buckets and allowed to depurate for 48 hours before being frozen whole at $-20^{\circ}C$.

Mussels remained frozen until processing for analysis began. Mussels were thawed, rinsed with ultra pure (18 MΩ) water, drained then shucked using a plastic knife. Five to 10 individual mussels were combined to produce a single composite sample. Five composite samples were produced for each site except Garden Cove where two composite samples of 4 and 5 mussels were used. Excess water was drained from the meat and a wet weight taken. The meat was then freeze dried and the dry meat homogenized by hand using an agate mortal and pestle. Approximately 0.3g of the dry homogenized tissue was digested in 3 ml of trace metal clean nitric acid in a closed Teflon microwave digester. The temperature of the sample was raised to $150^{0}C$ and held there for 15 min. After the digestion was complete, samples were decanted from the digestion tubes, centrifuged at 3000 rpm for 10 m, after which 1 ml of supernatant was

removed from the centrifuge tube and diluted to 50 ml with ultra pure water. The diluted samples were analyzed for a suite of trace elements and heavy metals by inductively coupled plasma - mass spectrometry (ICP-MS). Quality control was monitored by analyzing the National Institute of Standards and Technology standard reference material (SRM) 2976, mussel tissue, (Table 2) and method blanks each time the ICP-MS was operated.

RESULTS AND DISCUSSION

Table 3 lists the concentrations of trace elements and heavy metals determined in the mussel tissue. For comparison, Table 4 lists the results from this study and the Kennedy and Benson (1993) study, for which common analyses were completed. In general there is good agreement between the data from this study and Kennedy and Benson (1993). Absolute differences for all metals were small except for Pb where there was a large systematic difference between studies.

Our study found an order of magnitude less Pb in the mussel tissue than that reported by Kennedy and Benson (1993). The cause for this discrepancy is not known, however, there are several possible explanations. First, there was a difference in the digestion and analytical methods between the two studies. Kennedy and Benson (1993) used an open vessel ashing and digestion technique followed by atomic absorption spectroscopy, whereas we used a closed microwave system and ICP-MS. An open vessel digestion is at greater risk of contamination than a closed vessel system and additional Pb could have been introduced to the samples at this time. Second, it is not known if our study sampled the same population of mussels that were studied by Kennedy and Benson (1993). Significant differences in the metal concentrations of mussel soft tissue can occur on a spatial scale of less than 500 m (Veinott et al. 2002). Finally, the Kennedy and Benson (1993) study did not state that their samples were depurated. One of the purposes of the Kennedy and Benson (1993) study was to obtain information on the suitability of the mussels for human consumption. Since most consumers of wild mussels do not clean the guts before eating then depuration would not be appropriate or necessary. However, gut content can have a significant effect on whole body metal concentrations in *M. edulis* (Robinson et al. 1993). Although the exact cause of the discrepancy between Pb concentrations is not known recent data produced by the Canadian Food Inspection Agency on wild mussels in Newfoundland found Pb concentrations comparable to the data in this report (Karen Kennedy, Canadian Food Inspection Agency, St. John's NL, pers. comm). Analytical error seems to be the most likely cause for the discrepancy and, therefore, Pb levels reported here are more representative of the true Pb concentrations in wild mussels from these sites.

The systematic difference in Co, Ni, Cu, Zn, and Cd concentrations between this study and the Kennedy and Benson (1993) study may also be a result of differences in analytic procedures, or they may be an indication that overall metal concentrations in the environment are declining. However, given the natural variability in the metal concentration of bivalves, it is difficult to say with certainty that environmental metal concentrations are declining. A multi-year monitoring program would be required to make such an evaluation.

The USFDA have produced guidance documents for As, Ni Cd, and Pb in shellfish (USFDA 1993a-d). A comparison between "levels of concern" for molluscian bivalves and concentrations of these metals reported in this study found that no site exceeded the USFDA's levels of concern (Table 5). However, a comparison of our data with world-wide mussel watch programs (Table 6) (Cantillo 1998), showed that As concentrations are near the 85th percentile value of that data set, which would place these sites in the top 15% in the world with respect to the concentration of As in the soft tissue. As well, 16 mg/kg As, dry weight, is considered indicative of contamination for mussels and oysters (Cantillo 1998). However, As concentrations determined in the standard reference material were above the certified value (Table 2). In ICP-MS there is an ArCl interference on As for which a correction was made, but the correction may not have completely resolved the interference problem and resulted in higher than expected values for As. The mussels from Sunnyside also exceeded the concentrations Cantillo (1998) considered indicative of contamination for Ni and Cd (Table 6). For these metals the concentrations determined in the SRM were within acceptable error limits (Table 2).

CONCLUSION

The data from this study showed that none of the mussels sampled exceeded the USFDA "levels of concern" for As, Ni, Cd, and Pb. Only one site, Sunnyside, gave any indication that there may be a problem with contamination of the soft tissue of the mussels. At this site As, Ni and Cd, were elevated relative to world mussel watch data. Differences in Pb concentrations reported in this study and the Kennedy and Benson (1993) study are likely the result of analytical error and the concentrations reported here are more accurate. However, regular sampling and analyses of wild mussels would be required to detect true trends in the metal load of the mussels.

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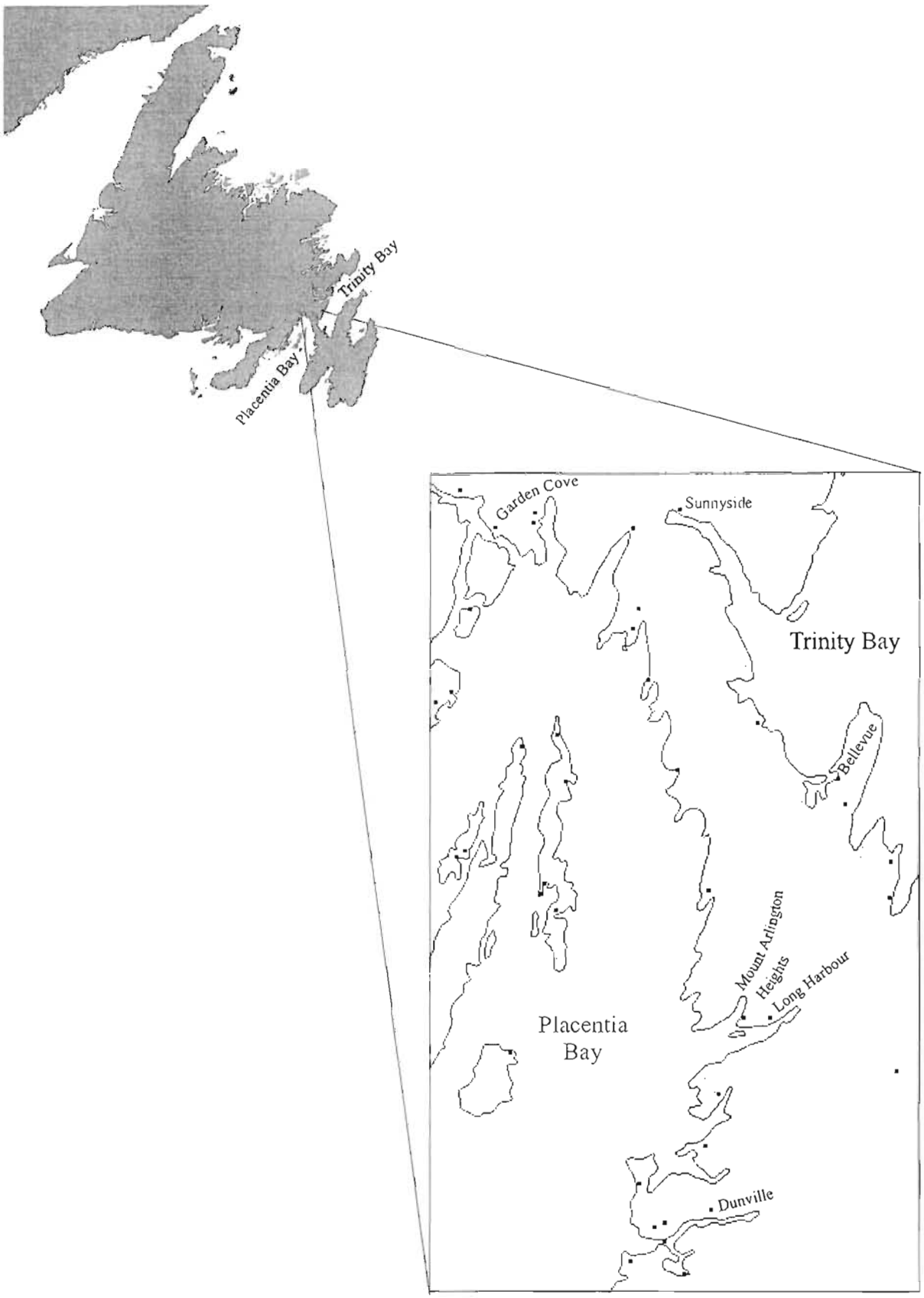

Figure 1. Site location map.

Table 1. Sampling site locations and descriptions.

Community	North Latitude	West Longitude	Description
Sunnyside	47° 51.428'	53° 53.253'	Mouth of small stream in Centre Bay.
Bellevue	47° 38.357'	53° 44.719'	Near community wharf.
Garden Cove	47° 51.105'	54° 09.570'	Very few mussels available. Individual mussels found under wharves.
Long Hr.	47° 26.463'	53° 47.267'	East end of Long Hr. near mouth of small stream.
Dunville	47° 16.033	53° 53.701'	Mouth of small stream behind ball field.
Mt. Arlington Hgt.	47° 25.656'	53° 51.569'	On pilings under government wharf.

Table 2. Published concentrations and concentrations determined in this study for the National Institute of Standards and Technology standard reference material 2976, mussel tissue. Concentrations are mg/kg dry weight except Ca, Mg, K, and P (%dry weight). Uncertainties are 95% confidence intervals.

Element	Certified Concentration	This Study (n =7)
As	13.3 ± 1.8	19 ± 0.8
Cd	0.82 ± 0.16	1.0 ± 0.05
Cu	4.02 ± 0.33	4 ± 0.2
Fe	171 ± 4.9	176 ± 7
Pb	1.19 ± 0.18	1.4 ± 0.08
Zn	137 ± 13	163 ± 13
	Reference Concentration	
Al	134 ± 34	131 ± 13
Ni	0.93 ± 0.12	0.8 ± 0.1
Ca	0.76 ± 0.03	0.63 ± 0.12
Mg	0.53 ± 0.05	0.47 ± 0.03
K	0.97 ± 0.05	1.3 ± 0.07
	Information Value	
P	0.83	0.88

Table 3. Mean elemental concentrations in *Mytilus edulis* soft tissue. n=5 except Garden Cove n=2. All concentrations are mg/kg wet weight except P, K, Mg, and Ca (% wet weight).

	Trinity Bay		Placentia Bay			
Element	Sunnyside	Bellevue	Garden Cove	Long Hr	Mt. Arlington Hgts.	Dunville
P %	0.60	1.74	1.35	0.65	1.90	0.75
K %	0.60	1.80	1.53	0.78	2.22	0.67
Mg %	0.65	0.70	0.69	0.61	0.70	0.32
Al	32	5	3	13	6	15
Ca %	0.82	0.38	0.48	0.43	0.32	0.37
Mn	16	6	1	4	1	4
Fe	60	34	26	37	22	53
Co	0.11	0.06	0.04	0.07	0.04	0.10
Ni	0.26	0.17	0.14	0.19	0.14	0.15
Cu	0.47	0.99	0.80	0.48	0.93	0.52
Zn	8	20	13	7	15	9
As	1.2	1.7	1.8	1.3	2.1	1.1
Sr	10	7	7	8	6	5
Cd	0.29	0.25	0.25	0.19	0.30	0.14
Sn	0.01	0.01	0.01	0.01	0.01	0.00
Pb	0.14	0.14	0.20	0.22	0.27	0.10

Table 4. Comparison between elemental concentrations in *Mytilus edulis* soft tissue from this study and Kennedy and Benson (1993) in parentheses. All concentrations are mg/kg wet weight.

	Element							
Site	Mn	Fe	Co	Ni	Cu	Zn	Cd	Pb
Sunnyside	16 (1)	60 (21)	0.11 (0.12)	0.26 (0.32)	0.47 (1.07)	8 (12)	0.29 (0.51)	0.14 (5.16)
Bellevue	6 (2)	34 (34)	0.06 (0.16)	0.17 (0.42)	0.99 (1.89)	20 (15)	0.25 (1.13)	0.14 (2.14)
Garden Cove	1 (1)	26 (16)	0.04 (0.12)	0.14 (0.40)	0.80 (1.06)	13 (11)	0.25 (0.17)	0.20 (3.40)
Long Hr.	4 (1)	37 (14)	0.07 (0.13)	0.19 (0.32)	0.48 (1.96)	7 (17)	0.19 (0.44)	0.22 (2.03)
Dunville	4 (4)	53 (48)	0.10 (0.12)	0.15 (0.36)	0.52 (1.78)	9 (13)	0.14 (0.36)	0.10 (0.83)

Table 5. Range of USFDA concentration "levels of concern" in molluscan bivalves for 14 day average consumption. Values vary depending on the age of the consumer. Lowest values generally correspond to children. All concentrations are mg/kg wet weight.

As	Ni	Cd	Pb
110 - 130	120	5 - 6	1.5 – 6.3

Table 6. Comparison between 50th and 85th percentile values for World-wide Mussel Watch Program, concentrations indicative of contamination from Cantillo 1998, and concentrations from this study. Concentrations are mg/kg dry weight. 50 = 50th percentile concentration, 80 = 80th percentile concentration, Contam. = concentration considered indicative of contamination, SS = Sunnyside, BV = Bellevue, GC = Garden Cove, LH = Long Harbour, MA = Mount Arlington Heights, DV = Dunville.

	Cantillo (1998)			This Study					
Element	50	85	Contam.	SS	BV	GC	LH	MA	DV
Ni	2.2	5.0	3.4	3.5	1.2	1.2	2.4	1.0	1.8
Cu	7.9	21	10	6.3	6.9	6.6	6.0	6.4	6.5
Zn	130	260	200	107	139	106	86	101	113
As	7.1	16	16	16	12	15	17	14	14
Cd	2.0	7.5	3.7	3.9	1.8	2.1	2.3	2.0	1.7
Pb	5.0	20	3.2	1.9	1.0	1.6	2.8	1.9	1.2