Cadmium Contamination of Belledune Harbour, New Brunswick, Canada – Studies on American Lobster *(Homarus americanus)* During 1981

J.F. Uthe, C.L. Chou, D.G. Robinson,
and R.L. Levaque Charron

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CADMIUM CONTAMINATION OF BELLEDUNE HARBOUR, NEW BRUNSWICK, CANADA - STUDIES ON AMERICAN LOBSTER (HOMARUS AMERICANUS) DURING 1981

by

J. F. Uthe, C. L. Chou, D. G. Robinson, and R. L. Levaque Charron[1]

Fisheries and Environmental Sciences
Department of Fisheries and Oceans
Halifax Laboratory
P.O. Box 550
Halifax, Nova Scotia B3J 2S7

[1]Brunswick Mining and Smelting Corporation Ltd., Belledune,
New Brunswick E0B 1G0

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ABSTRACT

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Cadmium levels have been measured in lobsters from the area of Belledune Harbour, New Brunswick, to determine if geographical controls placed on lobster fishing in the area in 1980 were still applicable to 1981. Levels of cadmium in hepatopancreas of lobsters captured within the harbour and its immediate area had increased somewhat but not enough to warrant any change in controls for 1981. It appears that the levels of cadmium in the raw claw and tail muscles peaked in 1979 and by 1981 the muscle levels had decreased to approximately the same level as 1975, the first year that measurements began. In 1981 the cadmium concentrations in steam-cooked meat from tail and claws were greater than in the raw meat. The present levels of cadmium in the cooked tail and claw meat show that with a tolerance level for cadmium of 0.50 µg/g the harbour could be reopened to commercial fishing as a part of the controlled fisheries already in place just outside the harbour.

Key words: cadmium, American lobster, tissue levels

RÉSUMÉ

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Les niveaux de cadmium chez les homards du port de Belledune et des environs ont été mesurés pour établir si les mesures de contrôle prises en 1980 étaient toujours adéquates pour 1981. Les concentrations de cadmium dans l'hétatopancréas de homards capturés à l'intérieur du port et dans les régions immédiates ont augmenté quelque peu en 1981, mais de facon insuffisante pour justifier des modifications aux mesures de contrôles établies en 1980. Les données antérieures remontant jusqu'en 1975, montrent que le cadmium dans la chair crue de la queue et des pinces de homards a atteint des concentrations maximales en 1979 pour ensuite diminuer jusqu'en 1981 à des niveaux comparables à ceux de 1975. Les concentrations de cadmium établis en 1981, sont plus élevées dans la chair, cuite à la vapeur, de la queue et des pinces que dans la chair crue. Les niveaux de cadmium déterminés en 1981 dans la chair cuite de homards, démontrent qu'en admettant un niveau de tolérance de 0.5 µg Cd/g, le port pourrait être réouvert à la pêche commerciale et intégré à la zone de contrôle bordant le port et établie en 1980.

INTRODUCTION

In mid-April 1980, information was received by the Department of Fisheries and Oceans from Brunswick Mining and Smelting Corporation Limited (Smelting Division) at Belledune, New Brunswick, which showed that American lobsters (Homarus americanus) taken from Belledune Harbour in 1979 had elevated levels of cadmium (Cd) in their tissues, especially the hepatopancreas (tomally, digestive gland). Investigations carried out by the Department of Fisheries and Oceans resulted in Belledune Harbour being closed to commercial fishing of lobsters in 1980. In addition, lobsters fished in a zone from west of the harbour downstream southeast to Pointe Verte (L4E), a total distance of approximately 6 mi (Fig. 1), were processed under

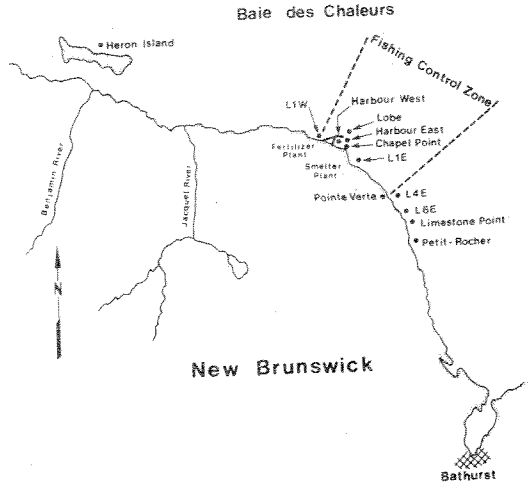

Fig. 1. Lobster sampling locations in and around Belledune Harbour, New Brunswick.

strict inspection conditions to yield only a canned meat product (claws and tail). The bodies containing the hepatopancreas were disposed of in a landfill following liming. Fishing was carried out in the harbour during 1980 to minimize movement of contaminated lobsters out of the harbour. These animals were used either for scientific investigations or destroyed. Investigations of the situation carried out in 1980 have been reported previously (Uthe and Zitko 1980).

In April 1981, the Department of Fisheries and Oceans re-examined the levels of Cd in hepatopancreas from lobsters in the area to re-establish the validity of the boundaries of the closed and controlled fishery zones set in 1980. Also, since preliminary results in 1980 indicated that Cd levels in muscle tissues were lower in 1980 than those reported in the company's 1979 report (Levaque Charron 1981), a survey of pooled tail and claw cooked meats from various sample areas was carried out. This report will document the results of these 1981 studies.

MATERIALS AND METHODS

The locations of all sample sites (other than Beach Point, Prince Edward Island) are shown in Fig. 1. Lobsters were captured at each site by commercial fishermen using standard traps (12.5-cm hoop). Fishing began to be successful on April 8, presumably due to warming water temperatures encouraging lobster movement, and ended on April 24. Additional sampling of the Harbour West site was carried out in June and August 1981. Upon capture, lobsters (individually bagged in polyethylene) were transported to Halifax, Nova Scotia, where they were held at least overnight in running sea water to remove surface-adhering particles and allow depuration of gut contents. Following weight, sex, and length determinations, the intact hepatopancreas was removed, weighed, and homogenized in polyethylene bags by hand kneading prior to analysis. Claws and tails were removed by dislocation, weighed, and immediately cooked by steaming for 10 min over glass-distilled water in an all-glass system. The meat was removed by hand picking with stainless steel shears and blended with a Polytron homogenizer along with an equivalent weight of glass-distilled water. Analysis of Cd was as described by Uthe et al. (1980). All tissues were stored frozen between necropsy and analysis.

Between June 13-25 and July 9-10, 1980, a total of 2570 lobsters (1220 from Harbour West, the rest from the Harbour East and Chapel Point areas) were trapped within the harbour, tagged, and released. Tag returns during the commercial fishing season in 1981 were used to estimate movement of lobsters out of the harbour. Recaptured animals which had originally been captured and tagged in Harbour West were analyzed for Cd in the hepatopancreas.

All Cd values are reported in μg Cd/g tissue wet weight. Due to the positively skewed distributions in the Cd levels in the animals from the various sample sites, all mean values are reported as geometric means ($\bar{X}_g$'s).

RESULTS AND DISCUSSION

GEOGRAPHICAL SURVEY OF Cd LEVELS IN HEPATOPANCREAS GLANDS (APRIL 1981)

Geometric means ($\bar{X}_g$'s) of the Cd levels in hepatopancreas from lobsters from the various capture sites are shown in Table 1. The corresponding values from the 1980 survey are also shown. Analysis of covariance was carried out on the data to judge the significance between the 2 yr without an interfering weight bias. In general, a similar geographical distribution of mean Cd levels was found in 1981 as in 1980 except that higher levels of Cd were present in the Heron Island, Harbour West, LOBE, L1E, L4E, and L6E samples. These results were not surprising since the discharge of Cd effluent into the harbour was essentially stopped only in the fall of 1980 after the major growth period of the lobster. Thus, these results may reflect continued accumulation of Cd as well as a certain amount of internal distribution of Cd within the animal. The absolute magnitude of the 1981 increases was not judged great enough to recommend any change in control lines.

The frequency distributions of individual Cd values from each sample site are shown in Table 2. A few points are noteworthy within these distributions. Firstly, it should be noted that highly contaminated animals, e.g. those with hepatopancreatic Cd values in excess of 200 µg/g, rarely appear beyond the harbour. Such animals represented 34% of the harbour animals sampled in 1981 and 35% in 1980, yet only one animal (LOBE site) with greater than 200 µg Cd/g hepatopancreas (actual value 209 µg Cd/g) was found outside the harbour in 1981 and one in 1980 (399 µg Cd/g) which had been captured just off the mouth of the harbour (Uthe et al. 1980). Highly contaminated animals (8/46; 17%) with greater than 500 µg Cd/g hepatopancreas were present in the Harbour West sample in 1981 and none in the Harbour East sample, an extremely unlikely event if all animals moved around the harbour randomly and equivalently.

TAGGING AND RECAPTURE STUDIES

A total of 1220 lobsters were captured at the Harbour West site in June and July 1980, tagged, and released. Sixty-nine of these were removed in 1980 by subsequent fishing within the harbour itself, leaving 1151 tagged lobsters for 1981 recapture. An additional 1419 lobsters were captured, tagged, and released at other sites within Belledune Harbour in 1980 for a total of 2570 released animals in 1980. During the 1981 commercial lobster fishing season (May 1-June 30) 528 (20.5% of the 1980 release) lobsters were recaptured outside the harbour, a recapture rate similar to that found in earlier tagging-recapture studies (Levaque Charron and Eljarbo 1981). Of these, 230 had been originally captured for tagging in Harbour West. This number is 43.5% of the total number of animals recaptured. Of the number of lobsters originally captured for tagging within the harbour, 44.8% had originally been captured and tagged in Harbour West in 1980. The fact that no differences were found in the percentages of recaptured Harbour West animals compared with the original tagged animal percentage suggests that the harbour is a single compartment as far as lobster movement is concerned. The area of recapture outside Belledune Harbour can be conveniently divided into three compartments, the controlled fishery zone, the area west of the control zone, and the area east of the control zone, the latter two zones being further from the harbour mouth than the controlled fishing zone. The recapture ratios of lobsters originally tagged in Harbour West to the total recaptures did not vary significantly from site to site, again suggesting that the original capture site had no influence upon movement patterns (Table 3). More than half (65.7%) of the recaptured lobsters were caught between May 4 and 31, reflecting normal catch/effort statistics for the area.

A total of 114 recaptured lobsters were analyzed for Cd in the hepatopancreas. All of these animals had originally been captured for tagging in Harbour West between June 13 and 25, 1980. The distribution of Cd levels in hepatopancreas is shown in Table 4 along with the geometric means and ranges. No significant differences were noted in the means from the three recapture areas, suggesting that migration distances are not affected by hepatopancreatic Cd levels. There was no relationship found between Cd level and the distance of recapture from the harbour.

Few of the tagged lobsters recaptured outside the harbour had hepatopancreatic Cd levels greater than 200 µg/g (only 3 out of 114; Table 4). This again shows that highly contaminated animals do not wander outside the harbour at anything approaching the usual rate since analysis of a number of lobsters captured in Harbour West during the 1980 tagging program identified 10 of 30 lobsters as having hepatopancreatic Cd levels greater than 200 µg/g (33.3%) (Table 6). Still further evidence for the limited movement of highly contaminated lobsters out of the harbour comes from a study of the hepatopancreatic Cd levels in tagged lobsters recaptured within Belledune Harbour in Harbour West in June 1981. Eleven lobsters were recaptured; 2 of these had hepatopancreatic Cd values in excess of 200 µg/g and the geometric mean Cd level was 112 µg/g. This mean is more than three times the mean Cd level of tagged lobsters recaptured immediately outside the harbour in the controlled fishing zone (34.0 µg/g) (Table 4).

We have investigated Cd levels in hepatopancreas from lobsters captured in Harbour West at various times during the spring and summer of 1980 and 1981. The results are shown in Table 5 and frequency distribution in Table 6. Geometric means for animals captured in June or August were much lower than the mean for the April sample. However, the mean weight of the lobsters captured in August 1981 was lower than the mean weight of the April and June 1981 animals. In both years significant numbers of animals with greater than 200 µg Cd/g hepatopancreas were captured in each sampling period. Statistical analysis of the data is complicated by the changing total weight distributions of the animals captured at the various times and the lack of total weight values for the 1980 animals. The decreasing frequency of highly contaminated lobsters from April to August is probably caused by the increasing proportion of smaller lobsters in the samples. Analysis of covariance of the 1981 data (animals with 100 µg Cd/g hepatopancreas) did not identify significant changes in the mean Cd levels over time ($F = 0.995$). A notable increase in the frequency of lobsters with less than 100 µg Cd/g hepatopancreas was found during fishing in June and August. We believe that this is due to migration of less contaminated lobsters into the harbour from outside, since many of these animals had levels of Cd in their hepatopancreas less than the lowest level observed in the April catch (40 µg/g). In June, of 17 lobsters with less than 100 µg Cd/g from a total catch of 33 lobsters, 10 had less than 40 µg Cd/g, while in the August catch of 51 lobsters, 9 of 25 with less than 100 µg Cd/g had less than 40 µg Cd/g. Migration of lobsters into the harbour early in the warm-water season could confuse tagging/recapture studies in which lobsters were captured later in the year and then released. During 1980 the harbour was intensively fished and 22,701 lobsters destroyed. The harbour was not fished during 1981 and it is not known if this will affect the movement of animals in and out of the harbour.

LEVELS OF Cd IN LOBSTER TAIL AND CLAW MEAT

Determination of claw and tail muscle levels of Cd has shown that levels are markedly lower than that of the hepatopancreas from the same animal. Tail Cd levels were lower than claw Cd levels (Uthe and Zitko 1980; Ray et al. 1981). Claw Cd levels were quite variable, presumably due to claw individuality (the lobster having a pincer and a crusher

claw) and the lobster's ability to lose and regrow a claw. Time did not permit the dissection and homogenization of flesh of each tail or claw; rather, a cube of frozen muscle was dissected from the center of either the tail or the large portion of the claw (Table 7). This procedure gave approximately the same Cd value as homogenization of the tail muscle but was low by about a factor of two for the claw muscle. This is not surprising since the homogenized claw is composed of two major tissues (muscle and parenchyma). Ray et al. (1981) found that claw (non-muscle or parenchyma) tissue had Cd levels three to twenty times higher than corresponding muscle tissue, and this is the likely reason for the differences we have found between homogenization of the claw and the cube dissection technique. One point should be noted: As was the case with the hepatopancreatic Cd levels and for the same reasons mentioned earlier, log transformation of the data was necessary prior to statistical analysis since the distribution was skewed to the right. The relationship between tail or claw and hepatopancreas Cd level is best described by a power curve with an exponent less than one. For example, in Harbour West, the relationship between Cd in the tail (y) and Cd in the hepatopancreas (x) is given by $y = 0.0004x^{0.984}$ with a coefficient of determination of 0.48. Detailed investigations into the relationship between cooked claw and tail meat Cd levels and raw hepatopancreatic Cd levels are discussed below.

The raw muscle Cd levels reported in this paper and those reported in Uthe and Zitko (1980) are substantially lower than the levels reported for raw, pooled tail and claw muscle by Levaque Charron (1981) for animals taken from the harbour in 1979. It is of interest to compare levels of Cd in muscle preparations over the past 7 yr, utilizing the data from Levaque Charron (1981). This has been done in Table 8. Levels of Cd in muscle from 1980 and 1981 were calculated by summing the tail and claw muscle Cd values and dividing the answer by 3. Weight yields of muscle showed that the yield of muscle from the two claws is approximately equal to that of the tail. Table 8 shows that both the mean of Cd in the muscle and the range of Cd values peaked in 1979 and have decreased since then to the 1975 level of approximately 0.40 μg Cd/g.

Although the data shown in Table 8 were generated by a number of laboratories, there is little of the differences among the years that can be ascribed to analytically induced factors since an intercomparison study (Table 9) between the laboratory located at Brunswick Smelting Division, Belledune, and the Fisheries and Environmental Sciences Laboratory, Halifax, showed these differences to be much less than those among the years. The Brunswick Smelter laboratory has also been shown through intercomparison studies to give comparable results to other laboratories supplying data on Cd levels in Belledune lobster (Levaque Charron 1981). Thus, we have no reason to doubt that a significant decrease in the concentration of Cd in lobster claw and tail muscle has occurred between 1979 and 1981. This decrease in levels has happened in spite of increases in hepatopancreatic levels of Cd from 1979 through 1981 and suggests that the lobster is successfully equilibrating with whatever event happened in the seventies to yield such high muscle levels in 1979. Such a "one-shot" event could be expected to "flood" all lobster tissues initially. Later, as metabolic processes occur, a redistribution of Cd from tissues such as from muscle to the hepatopancreas may take place in a manner similar to the mammalian redistribution of Cd from the liver to the kidney (Kotsonis and Klaassen 1977).

Finally, we have investigated Cd levels in cooked claw and tail meat. In an initial experiment, whole live lobster from Harbour West were steam-cooked and the claw and tail meats analyzed separately. Analysis of these latter preparations showed very high levels of Cd (6.6-11.7 μg Cd/g in claw, 3.5-6.7 μg Cd/g in tail), not unexpectedly, since it had been shown previously that Cd migrates during cooking, presumably from the hepatopancreas mainly. In all subsequent experiments, tail and claw were steam-cooked after removal from the body. In a repeat study of Harbour West animals, ranges of of 0.318-1.23 and 0.702-4.6 μg Cd/g, respectively, were found. This cooking, in the absence of the hepatopancreas, confirmed the migration of hepatopancreatic Cd into these tissues during cooking of the whole animal. It should be noted that these latter values are also higher than the fresh-frozen meat levels discussed above. While shrinkage of the meat during cooking could raise Cd levels somewhat, the magnitude of the observed difference suggests migration of Cd into the meat from another source, possibly the shell or underlying parenchyma tissue, since Ray et al. (1981) have shown that parenchyma tissue has a higher level of Cd than the muscle.

Mean levels and ranges of Cd in pooled cooked tail and claw meat from each sample area are shown in Table 10 along with the mean levels and ranges of uncooked hepatopancreatic Cd levels from the same animals. All mean levels were below 1.0 μg Cd/g cooked meat, the highest being 0.89 μg Cd/g for Harbour West animals, decreasing to 0.10-0.20 μg Cd/g for the more distant sites of L1W, Pointe Verte, and L6E, and to 0.04 μg Cd/g for Heron Island, N.B, and Beach Point, P.E.I.

Using the information on cooked meat Cd levels and the corresponding levels of Cd in the uncooked hepatopancreas, we have investigated the relationship between the Cd levels in these two preparations for lobsters from each site sampled. These relationships are shown in Table 11. Seven of the 11 sample sites showed coefficients of determination greater than 0.50. The extremely tight relationship observed in the Harbour West data ($r^2 = 0.93$) can be used to estimate from the level of Cd present in the hepatopancreas the level of Cd that would be expected in the cooked meat from the tails and claws. An animal with the average level of 210 μg Cd/g would be expected to contain a level of 1.30 μg Cd/g in the cooked meat in April and 0.82 μg Cd/g in June although, in the latter case, it must be borne in mind that we are likely dealing with a mixture of two populations of lobsters, i.e. animals resident in Belledune Harbour and animals moving into the harbour.

We have also determined the ratios of the Cd concentration in the uncooked hepatopancreas to that of the cooked meat (Table 10). The mean ratios for each sample area were ranked by the Duncan multiple range test to see if the ratio calculated for highly contaminated animals, such as the Harbour West sample taken in April, was significantly different from the control or cleaner area ratios (Table 12). Two subsets were identified by this procedure, each subset consisting of those areas which do not differ significantly from each other ($p = 0.05$). There was

no segregation of the ratios for the highly contaminated animals; in fact, the ratios calculated for the Heron Island and Beach Point samples, respectively, were the minimum and maximum ratios found. The cooked meat mean Cd level for Heron Island (0.042 µg Cd/g) was not significantly different from that for Beach Point (0.031 µg Cd/g), although the mean Cd level for hepatopancreas for Heron Island (5.79 µg Cd/g) was significantly lower than that for Beach Point (11.8 µg Cd/g). This suggests that the hepatopancreas may have a certain capacity to absorb Cd and maintain the muscle Cd at a low level, but much more research would be needed to define the relationships which exist among tissue levels and environmental exposure to Cd.

It is difficult to obtain accurate lobster fisheries statistics within the small geographical limits of the harbour and controlled fishery zones. It is estimated that the harbour contains above average numbers of animals for the area. We estimate that the closed area of the harbour contains about the same number of lobsters as the controlled fishing zone and therefore an overall meat Cd value for the two areas can be estimated from the April Harbour West and Harbour East average of (0.89+0.35)/2 and the controlled zone (LOBE and LIE) average of (0.19+0.21)/2. The resulting estimate is 0.41 µg Cd/g cooked meat. A lower estimate would be expected during the commercial fisheries (May 1-June 30) as the average levels in cooked tail and claw meat pools of Harbour West animals drop substantially between April and June (0.89 down to 0.39 µg Cd/g). This estimated (0.41 µg Cd/g) level is similar to Cd levels present in beef kidney (0.60 µg Cd/g) and pork kidney (0.26 µg Cd/g) (Sandi 1979).

It is estimated that the daily dietary level of Cd for the Canadian population ranges between 50 and 90 µg (Sandi 1979). The product from the controlled fishery zone is a frozen meat pack containing approximately 200 g of drained meat (8 oz total package contents). If a tolerance of 0.50 µg Cd/g was applicable to the current packaging and the harbour was reopened to commercial fishing and combined with the current controlled fishery zone product, the average amount of Cd in a package would be about 80 µg (0.41 x 200), an amount equivalent to one day's average intake of Cd.

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Table 1. Cd levels (μg Cd/g wet weight) in lobster hepatopancreas, Belledune, New Brunswick, April 1980 and 1981.

Site	1980			1981			F_{adj}
	$\bar{X}_g$[a]	N[b]	$\bar{X}$ (total wt)[c]	$\bar{X}_g$	N	$\bar{X}$ (total wt)	
Heron Island	3.85	30	349±53	4.83	27	387±102	4.76 $p<.05$
L1W	11.9	29	392±198	20.0	28	335±227	3.07 $p>.05$
Harbour West	176	29	517±239	210	46	453±206	7.91 $p<.05$
Harbour East	62.3	27	390±225	68.5	44	476±192	0.24 $p>.05$
L0BE	21.4	29	416±229	65.7	27	445±207	10.54 $p<.05$
L1E	28.1	31	293±124	40.6	34	289±68	6.73 $p<.05$
L4E (Pte. Verte)	28.0	26	319±156	42.7	48	316±135	10.1 $p<.05$
L6E	17.3	19	278±98	25.5	31	305±129	4.43 $p<.05$
Limestone Pt.	-[d]	-	-	13.6	26	352±118	-
Petit Rocher	11.6	31	272±41	19.7	41	404±153	0.29 $p>.05$
Beach Point, P.E.I.	11.1	12	417±185				

[a]Geometric mean.
[b]Number of animals.
[c]Arithmetic mean (g).
[d]No 1980 sample.

Table 2. Frequency distributions of Cd levels (μg/g wet weight) in hepatopancreas of American lobster captured in April 1981 (1980 values in brackets) from the area of Belledune Harbour, N.B.

Site	Cd distribution						
	0-100	100-200	200-300	300-400	400-500	500-600	>600
Heron Island	27(30)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
L1W	27(30)	1(1)	0(0)	0(0)	0(0)	0(0)	0(0)
L0BE	20(29)	2(1)	1(0)	0(0)	0(0)	0(0)	0(0)
Harbour West	7(4)	13(9)	13(12)	5(4)	0(0)	5(0)	3(0)
Harbour East	26(19)	13(5)	1(4)	4(0)	0(0)	0(0)	0(0)
L1E	32(30)	2(1)	0(0)	0(0)	0(0)	0(0)	0(0)
L4E (Pt. Verte)	24(25)	6(0)	0(0)	0(0)	0(0)	0(0)	0(0)
L6E	31(17)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Limestone Pt.	26 -[a]	0 -	0 -	0 -	0 -	0 -	0 -
Petit Rocher	41(31)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)

[a]No sample in 1980.

Table 3. Recapture numbers of tagged lobster from the 1981 commercial fishing season in the area outside of Belledune Harbour, N.B.

Recapture location[a]	Number of animals recaptured (% of total in brackets)	
	All animals	Animals which were originally captured and tagged in Harbour West in 1980
West of control zone	72(14)	38(17)
Within control zone	287(54)	118(51)
East of control zone	169(32)	74(32)

[a]13 tags were returned without recapture site identification.

Table 4. Cd levels and ranges (µg/g wet weight) in hepatopancreas from tagged lobsters recaptured during the commercial fishing season in the area of Belledune Harbour, N.B.

Recapture location[a]	$\bar{X}$	Range	Cd distribution 0-100	100-200	200-300	N
West of control zone	39.5[a]	6.8-259	17	3	2	22
Within control zone	34.0[a]	5.3-189	58	5	0	63
East of control zone	29.1[a]	6.4-238	28	0	1	29
			103	8	3	114

[a]No difference statistically.

Table 5. Cd levels (µg/g wet weight) in hepatopancreas from lobsters captured at the Harbour West site during different months in 1981 (1980 values in brackets).

Capture period	$\bar{X}$	N	$\bar{X}_{(total\ wt)}$
April	211 (176)	46(29)	453 ± 206 (n.a.)[a]
June	89.5(81.5)	33(31)	430 ± 194 (n.a.)
August	99.5(48.7)	51(30)	281 ± 106 (n.a.)

[a]Not available.

Table 6. Frequency distribution of Cd levels (µg/g wet weight) in hepatopancreas from lobsters captured at the Harbour West site during different months in 1981 (1980 values in brackets).

Capture date	Cd distribution <100	100-200	200-300	300-400	400-500	500-600	>600
April	7(4)	13(9)	13(12)	5(4)	0(6)	5(1)	3(0)
June	17(15)	8(5)	2(5)	3(3)	0(1)	2(1)	0(0)
August	25(23)	15(7)	6(0)	1(0)	1(0)	1(0)	0(0)

Table 7. Cd levels (μg/g wet weight) in hepatopancreas and muscle tissue (cube technique) of American lobster from Belledune Harbour, N.B., April 1981 (N=12+12).

Animal no.	Tail	Pincer	Crusher	Meat[a]	Hepatopancreas
HW-1	0.66	0.78	0.48	0.64	590
HW-3	0.02	0.19	0.14	0.12	80
HW-4	0.14	-	0.52	0.33	380
HW-5	0.09	0.34	0.09	0.17	300
HW-6	0.05	0.28	0.48	0.27	520
HW-7	0.26	0.54	0.54	0.44	620
HW-8	0.12	0.67	0.43	0.40	570
HW-10	0.12	0.14	0.27	0.18	180
HW-13	0.20	-	0.52	0.41	390
HW-14	0.14	-	0.35	0.28	230
HW-15	0.08	-	0.22	0.17	220
HW-17	0.08	-	0.22	0.17	280
$\bar{X}g$	0.12	0.36	0.31	0.30 ± 0.15[b]	316
HE-1	0.02	0.02	0.026	0.02	14
HE-2	0.03	0.07	0.203	0.10	58
HE-3	0.05	0.04	0.132	0.08	66
HE-4	0.08	0.33	0.200	0.20	78
HE-5	0.18	1.03	0.245	0.50	164
HE-6	0.03	-	0.094	0.07	54
HE-7	0.05	-	0.102	0.09	124
HE-8	0.02	0.03	0.032	0.03	12
HE-9	0.17	-	0.426	0.34	192
HE-10	0.09	-	0.156	0.13	88
HE-11	0.25	0.13	-	0.17	328
HE-12	0.03		0.103	0.08	93
$\bar{X}g$	0.06	0.10	0.120	0.15 ± 0.14[b]	74

[a]Meat values are estimated by sum of Cd levels in (tail + pincer + crusher)/3 or (tail + 2(claw))/3 as required.

[b]Mean meat values are arithmetic mean values for comparison with Noranda mean meat values.

Table 8. Cd levels (µg/g wet weight) in muscle[a] and hepatopancreas of American lobster from Belledune Harbour (Harbour West + Harbour East), N.B.

Year	N	$\bar{X}$	Range	Range hepatopancreas
1975[b]	8	0.4	0.18-0.86	-
1976[b]	5	0.6	0.22-1.11	-
1977[b]	30	0.46	0.10-3.6	-
1978[b]	10	1.49	0.26-4.08	-
1979[b]	28	2.7	0.40-11.0	5-342
1980[c]	12	-	0.20-1.85[e]	13.7-336
1981[c]	24	0.22[d]	0.03-0.64	13.7-652

[a]Fresh frozen, not cooked before analysis, claw + tail meat pooled.

[b]Brunswick Mining and Smelting, Smelting Division data (Levaque Charron 1981); captured in July.

[c]F & O Harbour West + Harbour East; captured in April.

[d]F & O cube technique (see Table 7, footnote a).

[e]Sampling stratified over hepatopancreas Cd content from Harbour West.

Table 9. Comparative results for Cd in lobster tissues (µg Cd/g wet weight) between Brunswick Smelting, Belledune, N.B. and Fisheries and Environmental Sciences, Dept. of Fisheries and Oceans, Halifax, N.S. laboratories.

Sample	Brunswick Smelting	Halifax
Hepatopancreas		
1	367	384
2	97.6	119
3	202	209
4	367	394
5	193	216
6	228	239
Cooked meat		
1	0.68	0.78
2	0.98	1.07
3	0.21	0.34
4	2.03	1.69
5	1.07	0.96
6	0.64	0.75
7	1.03	0.95
8	0.25	0.37
9	0.12	0.16
10	0.15	0.24
11	1.67	1.37

Table 10. Mean Cd levels in cooked meat (tail + claws) and uncooked hepatopancreas of American lobster captured in 1981 from the area of Belledune Harbour, N.B. and Beach Point, P.E.I. (tail and claws removed and steamed 10 min).

Site	Meat[a] Mean	Meat[a] Range	N	Hepatopancreas Mean	Hepatopancreas Range	Ratio hepatopancreas meat
Heron Island	0.04	0.028-0.09		5.8	4.36- 12.0	153 ± 72
L1W	0.12	0.028-1.82	10	29.6	8.30-135.0	342 ± 260
Harbour West (April)	0.89	0.16 -3.06	8	218.0	62.70-572.0	182 ± 82
Harbour West (June)	0.39	0.036-2.17	15	128.0	16.30-583.0	399 ± 306
Harbour West (Aug.)	0.35	0.106-2.03	11	118.0	35.10-500.0	239 ± 91
Harbour East	0.35	0.068-1.28	11	67.9	17.00-355.0	266 ± 108
LOBE	0.28	0.045-1.24	10	79.6	13.50-308.0	242 ± 106
L1E	0.21	0.047-0.68	10	34.3	8.15-130.0	185 ± 97
L4E	0.19	0.050-0.43	10	54.6	7.67-127.0	341 ± 214
L6E	0.11	0.046-0.28	10	30.7	12.20- 50.9	302 ± 108
Beach Point, P.E.I.	0.03	0.018-0.09	10	11.8	4.32- 49.9	422 ± 235

[a]Geometric means.

Table 11. Regression relationships between Cd concentrations in uncooked hepatopancreas and cooked meat; [Cd]meat = a + b[Cd] hepatopancreas.

Sample site	N	Constants a	Constants b	r^2
Heron Island	9	no significant relationship		
L1W	10	-0.15	0.0118	0.60
LOBE	10	0.07	0.0030	0.97
Harbour West (Apr.)	9	0.22	0.0051	0.93
Harbour West (June)	15	-0.008	0.004	0.88
Harbour West (Aug.)	11	0.27	0.0033	0.49
Harbour East	11	0.82	0.082	0.82
L1E	11	0.09	0.0037	0.63
L4E	10	no significant relationship		
L6E	10	-0.004	0.0038	0.50
Beach Point, P.E.I.	10	0.012	0.0010	0.81