Copper, Zinc, Cadmium, and Lead in Scallops *(Placopecten magellanicus)* from the Maritimes

S. Ray and V. Jerome

Biological Station,
St. Andrews, N.B., E0G 2X0

January 1987

Canadian Technical Report of Fisheries and Aquatic Sciences No. 1519

Fisheries and Oceans
Pêches et Océans

Canada

Canadian Technical Report of Fisheries and Aquatic Sciences

Technical reports contain scientific and technical information that contributes to existing knowledge but which is not normally appropriate for primary literature. Technical reports are directed primarily toward a worldwide audience and have an international distribution. No restriction is placed on subject matter and the series reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries and aquatic sciences.

Technical reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual index to scientific and technical publications.

Numbers 1–456 in this series were issued as Technical Reports of the Fisheries Research Board of Canada. Numbers 457–714 were issued as Department of the Environment, Fisheries and Marine Service, Research and Development Directorate Technical Reports. Numbers 715–924 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Technical Reports. The current series name was changed with report number 925.

Technical reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out-of-stock reports will be supplied for a fee by commercial agents.

Rapport technique canadien des sciences halieutiques et aquatiques

Les rapports techniques contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelles, mais qui ne sont pas normalement appropriés pour la publication dans un journal scientifique. Les rapports techniques sont destinés essentiellement à un public international et ils sont distribués à cet échelon. Il n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques du ministère des Pêches et des Océans, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports techniques peuvent être cités comme des publications complètes. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports techniques sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annual des publications scientifiques et techniques du Ministère.

Les numéros 1 à 456 de cette série ont été publiés à titre de rapports techniques de l'Office des recherches sur les pêcheries du Canada. Les numéros 457 à 714 sont parus à titre de rapports techniques de la Direction générale de la recherche et du développement, Service des pêches et de la mer, ministère de l'Environnement. Les numéros 715 à 924 ont été publiés à titre de rapports techniques du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 925.

Les rapports techniques sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Canadian Technical Report of
Fisheries and Aquatic Sciences 1519

January 1987

COPPER, ZINC, CADMIUM, AND LEAD IN SCALLOPS (PLACOPECTEN MAGELLANICUS) FROM THE MARITIMES

by

S. Ray amd V. Jerome

Fisheries and Environmental Sciences
Biological Sciences Branch
Department of Fisheries and Oceans
Biological Station
St. Andrews, N.B. E0G 2X0

This is the one hundred and ninetieth Technical Report from
the Biological Station, St. Andrews, N. B.

Cat. No. Fs 97-6/1519E ISSN 0706-6457

Correct citation for this publication:

Ray, S., and V. Jerome. 1987. Copper, zinc, cadmium, and lead in scallops (Placopecten magellanicus) from the Maritimes. Can. Tech. Rep. Fish. Aquat. Sci. 1519: iii + 29 p.

ABSTRACT

Ray, S., and V. Jerome. 1987. Copper, zinc, cadmium, and lead in scallops (Placopecten magellanicus) from the Maritimes. Can. Tech. Rep. Fish. Aquat. Sci. 1519: iii + 29 p.

Scallops (Placopecten magellanicus) collected from 19 sites of commercial importance in the Maritimes were analyzed for Cu, Zn, Cd and Pb in adductor muscle, mantle, gill and viscera. Concentrations of all metals were in the order, muscle < mantle < gill < viscera, with a few exceptions. Cu and Zn levels in all scallops from the study area were comparable to those from the control site near St. Andrews. Levels of Cd and Pb in scallops from Chaleur Bay; and Cd in those from Northumberland Strait, Bay of Fundy and the offshore sites were much higher than in the controls. Scallops collected from specific sites in Chaleur Bay, known to have anthropogenic input, had still higher levels of Cd and Pb. The very high concentrations of Cd in scallops from Georges Bank and still higher in those from Browns Bank, far away from any source of anthropogenic input, suggest a natural source for the metal.

Total body burden of Cu, Zn, Cd and Pb in scallops from Chaleur Bay was related to the body size of the animals, but in Georges Bank, only Cu and Zn were so related. Cd and Pb body burden in scallops from Georges Bank of >100 mm size were higher than expected from the linear relationships observed for the smaller ones. Furthermore, Cd concentrations in medium size (90-110 mm) scallops were significantly lower than in either smaller or larger individuals.

RÉSUMÉ

Ray, S., and V. Jerome. 1987. Copper, zinc, cadmium, and lead in scallops (Placopecten magellanicus) from the Maritimes. Can. Tech. Rep. Fish. Aquat. Sci. 1519: iii + 29 p.

Des pétoncles (Placopecten magellanicus) recueillis de dix-neuf (19) sites d'importance commerciale dans les Maritimes ont été analysés afin de déterminer les quantités du Cu, Zn, Cd et de Pb dans le muscle adducteur, le manteau, la branchie et les viscères. Sauf quelques exceptions, les concentrations de ces métaux étaient distribuées selon l'ordre croissant suivant: le muscle, le manteau, la branchie et les viscères. Les niveaux de Cu et de Zn dans tous les pétoncles du secteur d'étude étaient comparables aux niveaux puisés dans les pétoncles provenant du site témoin près de St. Andrews. Cependant, les taux de Cd et de Pb trouvés dans les pétoncles de la baie des Chaleurs et le taux de Cd trouvé dans ceux du détroit de Northumberland, de la baie de Fundy et des eaux hauturières étaient beaucoup plus élevés que les taux découverts dans les pétoncles du groupe témoin. Les pétoncles recueillis dans certains sites précis de la baie des Chaleurs, où l'influence anthropogène est déjà connue, contenaient encore plus de Cd et de Pb. Cependant, les concentrations extrêmement élevées de Cd découvertes dans les pétoncles du Banc Georges et celles encore plus élevées dans les pétoncles de Browns Bank, deux sites très éloignés de toute source d'influence anthropogène, laissent supposer que ce métal provient de source naturelle.

La charge corporelle totale du Cu, de Zn, de Cd et de Pb dans les pétoncles de la baie des Chaleurs a été reliée à la taille corporelle de ces animaux, mais en ce qui concerne les pétoncles du Banc Georges, ce rapport n'est vérifiable que pour le Cu et le Zn. La charge corporelle de Cd et de Pb dans les pétoncles du Banc Georges mesurant plus de 100 mm de taille était plus élevée que ne laissait prévoir les relations linéaires observées pour les plus petits pétoncles. De plus, les concentrations de Cd dans les pétoncles de taille moyenne (entre 90 et 110 mm) étaient passablement inférieures que pour les plus petits et les plus gros pétoncles.

INTRODUCTION

Deep sea scallop (Placopecten magellanicus) occurs commonly along the eastern coast of North America and supports an important commercial fishery in eastern Canada. About 90% of Canadian scallop landings come from Georges Bank, the largest single scallop resource in the world. However, the fishery of Georges Bank and Scotian ~~Shelf has~~ been reported to be declining (Jamieson et al. 1981a; Robert et al. 1982) and dependent upon single recruiting year-class, with abundance of very small scallops. In recent years, scallops from the southern Scotian Shelf (i.e. Browns, German, Lurcher Banks, etc.) are being harvested. In spite of this, the scallop fishery is gradually declining since its highest level in 1976. Total quantity of scallop (shucked, fresh and frozen) in Atlantic Canada declined from 16,358 metric tons in 1976 (Fisheries and Oceans 1977) to 5,027 metric tons in 1984 (Fisheries and Oceans 1985); a decrease of 69.3%. However, because of better market value, the landed value declined by only 28.9% during the same period (Fisheries and Oceans, Statistics Branch, Canada).

Under laboratory conditions, scallops rapidly accumulate high levels of several trace metals including cadmium (Eisler et al. 1972; Nelson et al. 1976; Ray et al., unpubl. data). Some organs, especially kidney and digestive gland, have been observed to contain very high concentrations of several metals, particularly Cd (Bryan 1973). Greig et al. (1978) determined trace metal contents (Ag, Cd, Cr, Cu, Hg, Ni, Pb, and Zn) in muscle, gonad, and viscera of sea scallops (P. magellanicus) from eastern U.S. coastal waters and reported low levels for all trace metals except for Cd (2.7-27 µg/g wet tissue) in the viscera. However, the exact locations of the collection sites, and the number and size of animals analyzed were not reported. Scallops from within and around ocean disposal sites have been found to have elevated levels of several trace metals (Pesch et al. 1977), including Cu and Cd.

Ray et al. (1984a) have reported earlier the Cu, Zn, Cd, and Pb levels in adductor muscle, mantle, gill and viscera (remainder of the tissue) of scallops, P. magellanicus, from Georges and Browns Banks and from Chaleur Bay (Ray et al. 1984b). This report combines our previously published data with new data from other important scallop fishery areas to provide a single, comprehensive data-base for Cu, Zn, Cd, and Pb levels in various tissues of scallops collected from commercial fishing areas around the Maritime provinces.

MATERIALS AND METHODS

a) SAMPLE COLLECTION

Scallops were collected in commercial scallop drags from 19 sites along the eastern seaboard (Chaleur Bay in Gulf of St. Lawrence to Georges Bank) of Canada (Fig. 1). Eight sites were selected for sampling in Chaleur Bay (Fig. 2) because of known anthropogenic trace metal input in the area. The animals could not be collected at the same time of the year and were collected at various times from May to December of 1981. The scallops from Chaleur Bay and Navy Island were dissected immediately after

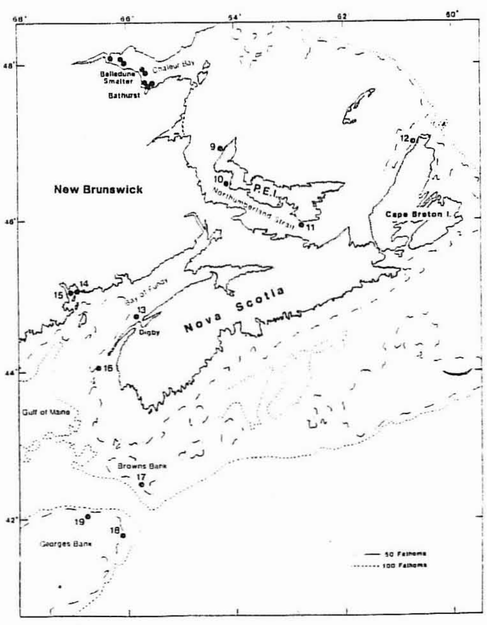

Fig. 1. Location of sampling sites for scallops in eastern Canadian waters.

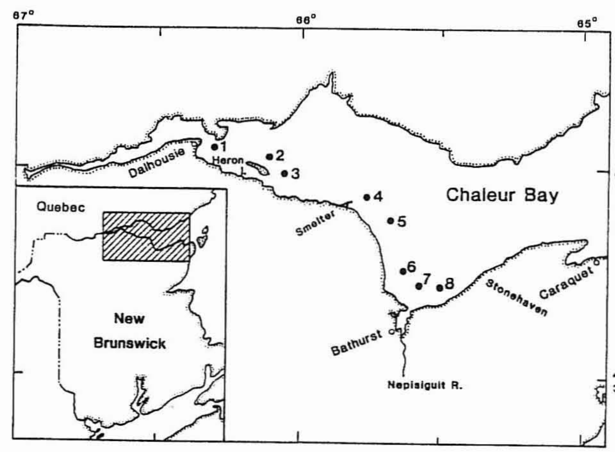

Fig. 2. Location of sampling sites for scallops in Chaleur Bay.

collection. All others were frozen for transportation to the laboratory and subsequently stored at -15°C until they were dissected. Five medium size scallops (shell height 90-110 mm) were chosen for analysis whenever possible. The animals collected from sites 2 and 3 were 110-122 and 80-130 mm size, respectively. In addition, small (< 90 mm) and large (> 110 mm) animals from sites 4 (Belledune), 5 (Green Point), 17 (Browns Bank), and 19 (Georges Bank) were also analyzed. Age was determined by annual ring count for the animals from all sites except for 1, 2, 3, 6, 7, and 8.

The scallops were dissected into adductor muscle (MT), mantle (MN), gill (GL), and remainder of the soft tissues or viscera (VS) for determination of Cu, Zn, Cd and Pb in individual tissues. Body fluid was not collected. The tissues were thoroughly washed with distilled, deionized water (Milli Q) and stored at -15°C.

b) CHEMICAL ANALYSIS

Tissue samples were freeze-dried, powdered and homogenized, and aliquots ashed at 450°C for 16 h. The ash was dissolved in 0.5 mL of HNO_3 (Aristar grade, B.D.H. Ltd., Poole, U.K.) and made to volume with distilled, deionized water for analysis. Copper and zinc were determined in flame-mode using a Perkin-Elmer Model 503 atomic absorption spectrometer. Cadmium and lead were determined in flameless-mode using a Perkin-Elmer Model 500 graphite furnace accessory. Precision and accuracy of analysis were checked against NBS Reference Material No. 1566 (oyster tissue). Results were calculated on a dry weight basis.

c) DATA ANALYSIS

The concentrations of Cu, Zn, Cd and Pb in the tissues are reported separately for the three size classes (i.e. small, < 90 mm; medium, 90-110 mm; and large, > 110 mm). Data for each metal were tested by one-way (tissue or site) ANOVA ($p < 0.05$) for significant differences. Furthermore, Duncan's multiple range test identified specific sites having high concentrations of trace metals in individual tissues.

d) SAMPLING SITE DESCRIPTION

The sites (Figs. 1, 2) were separated into four geographical groups: 1) eight sites from Chaleur Bay (sites 1-8); 2) four sites from Northumberland Strait (sites 9-12); 3) three sites from Bay of Fundy, including the reference site (15) off Navy Island near St. Andrews (sites 13-15); and 4) open-ocean sites at McDormand Patch, Browns Bank, and two in Georges Bank (sites 16-19). Site 15 has no known anthropogenic metal input and is considered a control site.

Chaleur Bay (Sites 1-8)

Chaleur Bay, has anthropogenic trace metal input from metal mining activity in northeastern New Brunswick. Site 1 is seaward of the present contaminated dredge spoil site at West Bay in Dalhousie Harbour. Large amounts of lead and zinc ore concentrates are stored year-round at the ore handling wharf of the Harbour for shipping overseas. The harbour has been seriously contaminated over the years due to weathering and wind-blown concentrates being deposited in the harbour. Some of the metals in the sediment are bioavailable to marine invertebrates (Ray et al. 1981b; Ray and Peterson 1983). Site 3 is off Heron Island. The area has been used as an open disposal site for several years. The area was surveyed in 1980 and it was observed that there had been a decrease in Cd and Zn concentrations at the dumpsite, accompanied by a westward migration of the metals with bottom sediment transport (MacKnight 1985). Trace-metal pollution from base metal mining operations (Ray and White 1977; Westlake and Gauthier 1983) has seriously affected fishery resources in Nepisiguit River (Cook and Hoos 1971) and surficial estuarine sediment was reported to contain high levels of several trace metals (Ray and White 1977). High Cd levels were reported in marine biota (including scallops) at sites 4 and 5 which were attributed to untreated effluent discharge from the lead smelter operation at Belledune Harbour (Ray et al. 1980, 1981a). Furthermore, elevated Cu, Zn, and Cd levels have been reported (Loring et al. 1980) in water, sediment, and suspended particulate matter for a few km downstream of the smelter location. Site 7 is about 6 km from the mouth of Nepisiguit River. Other sites (2, 6, 8) do not have any known metal input.

Northumberland Strait (Sites 9-12)

The Northumberland Strait scallop fishery constitutes about 80% of the inshore fishery in the Gulf of St. Lawrence. The fishery reached its peak in 1970, but in recent years there has been a considerable decline in scallop landings. At present, landing quotas are strictly regulated in an attempt to reverse the trend (Jamieson 1979). There is a significant difference in stock abundance - greatest in the eastern part of the strait and progressively decreasing towards the central and western part of the strait (Jamieson et al. 1981b).

Bay of Fundy (Sites 13-15)

The Bay of Fundy has a major scallop fishery, centered in the area off Digby, Nova Scotia (Site 13), which is healthy and growing. Site 14 at Mascarene in Passamaquoddy Bay is fished regularly by a small number of boats. Site 15, off Navy Island near St. Andrews, is an area with no known source of anthropogenic metal input and has a very small commercial fishery.

Offshore (Sites 16-19)

Two sites (18 and 19) are on Georges Bank, which accounts for about 90% of total Canadian scallop landings. The other two sites are at Browns Bank and McDormand Patch, part of southwestern Scotian Shelf. The scallop fishery in this area has been historically sporadic. There is no known source of trace metals in the area.

RESULTS AND DISCUSSION

Scallops collected in the study area varied over a wide size range. Those collected at sites 2 and 3 (Chaleur Bay) were significantly ($p < 0.01$) larger than the average size of animals from all other sites. Furthermore, the scallops collected from Browns Bank were generally of smaller size with none greater than 101 mm shell height.

The ratios of the organ weights to the whole body soft tissue weights varied with size of the scallops and collection sites (Table 1). Larger scallops (>100 mm) had a lower proportion of muscle and a higher proportion of viscera than smaller (<100 mm) scallops. The mantle of scallops from Georges Bank constitutes only 10% of the total body weight compared with about 16% for others.

SIZE AND AGE

Age varied from 4-12 yr, even within the same medium size group. Growth of animals is slowest in Gulf of St. Lawrence and fastest in Georges Bank but varied even within one area and also year to year in the same place (Bourne 1964). Furthermore, it was reported that the relationship of size and weight of the adductor muscle depends upon the size of the animal and varies from place to place and even within the same area. Our findings were very similar. The fastest growing scallops were at Navy Island, site 15, i.e. 96 mm at 4 yr compared with the slowest growth at Cape Breton (site 12) where it took 9.6 yr to attain 95 mm size (Table 10).

Scallops from Georges Bank of 77- and 95-mm shell height averaged 3.6 and 5.4 yr, respectively. In comparison, the scallops from Browns Bank of approximately the same size (i.e. 79 and 96 mm) were considerably older at 5.6 and 7.2 yr, respectively. The scallops from Georges Bank were not only much larger, but also of wider size/age range than those from Browns Bank. Shell height (mm) and age (yr) of scallops from selected areas are given in Table 10.

TRACE METALS

Mean concentrations, standard deviation, and ranges of Cu, Zn, Cd, and Pb in various tissues of all scallops from 19 sites are combined in Table 2. The data for medium-sized scallops from all sites combined are given in Table 3. The data from four geographically separated regions are given in Tables 4-9. The results from individual sites, including data from small and large scallops, are presented in Table 10.

Concentrations of the metals in the tissues were generally in the order muscle < mantle < gill < viscera (Table 10). However, wide variations in metal concentrations were observed in tissues from different sites and variations were also observed in the same tissues among individuals from a single population. Fecal matter and gut contents may have contributed to the observed variations, especially in the viscera. Only 64 of the 102 possible correlations of metal concentrations in tissues are significant at the 5% level (Table 15) indicating random distribution of the metals in the tissues. Individuals with high Cd or Pb in one tissue tended to have elevated levels of the metal in the other tissues as well. The trace metals in any particular tissue from individual sites are only occasionally related to either age or size, even for sites 4, 5, 17, and 19 where 20, 10, 12, and 16 animals, respectively, were analyzed.

<u>Copper</u>

Copper is an essential trace element and has an important biochemical role as an enzyme activator. The metal concentration is controlled by homeostatic processes. The concentrations of Cu in the scallops increased in the order muscle < mantle < gill < viscera, with very few exceptions (Table 10). A similar order was observed by Bryan (1973) in <u>Pecten maximus</u> and <u>Chlamys opercularis</u> and by Brooks and Rumsby (1965) in <u>Pecten novae-zelandiae</u>.

Mean concentration of copper in muscle tissues of medium size scallops was 3.3 ± 3.5 µg/g (range 0.2-20 µg/g) (Table 2). The concentration in muscle tissue of scallops from the control site (Passamaquoddy Bay) were the highest (4.5 µg/g) followed by those in animals from sites 3 (4.4 µg/g) and 4 (3.7 µg/g) near the dumpsite off Heron Island and the Belledune lead smelter, respectively (Table 10). The high copper concentration in scallops from site 15 may be due to the presence of very low grade copper in the area (D. Scarratt, Dept. of Fish. and Oceans, Halifax, pers. comm.). Concentrations in small and large animals from site 4 were 5.5 and 5.8 µg/g, respectively, and are also high. For site 5, the average Cu concentration in medium-size scallop muscle tissue was 0.9 µg/g compared with 7.7 µg/g in large ones. Animals from other sites have Cu values of 2.0 µg/g or less. Surprisingly, the muscle-tissue concentrations in small and large scallops from sites 4 and 19 are similar to those in medium-size scallops.

In Northumberland Strait (Table 6), the average concentrations of Cu in muscle, mantle, gill and viscera were 2.7, 3.1, 7.8, and 12 µg/g, respectively, while the corresponding values for the Bay of Fundy sites are 2.9, 4.3, 7.0, and 11, respectively (Table 7). Muscle tissue of animals (90-110 mm) from five sites in Chaleur Bay, Egmont Bay, Miminegash, and Mascarene have values < 2.0 µg/g while those from all other sites have values 2-4 µg/g.

The average concentration of Cu in muscle, mantle, gill, and viscera of scallops (90-110 mm) from open ocean sites were 3.2, 3.9, 6.7, and 26 µg/g, respectively. It is to be noted that average Cu concentrations in scallop viscera from Browns Bank were approximately 63 µg/g, compared with only 11 and 12 µg/g in viscera of animals from Navy Island and Georges Bank, respectively.

Greig et al. (1978) have reported an average value of 0.46 (range 0.27-1.1) µg/g (wet wt) in muscle tissue of <u>P. magellanicus</u> from the U.S. east coast. These values, expressed on a dry weight basis, are very similar to the values observed in the present study. Comparative values for gill and mantle in <u>P. magellanicus</u> are not available. However, except in a few instances, the concentrations in both tissues vary within a very narrow range. The Cu levels in viscera reported by Greig et al. (1978) in <u>P. magellanicus</u> are similar to those in the present study on a dry-weight basis, but cannot be compared directly because of the difference in sampling technique. Surprisingly, the viscera of the scallops from the control site have the lowest Cu concentrations while the muscle and the gill tissues are among the highest, perhaps indicating a water- rather than a food-source.

Sites 3, 4, and 5 have known anthropogenic input but one-way ANOVA (Table 20) indicated that the scallops did not have elevated levels of Cu compared with other sites. The Cu concentrations in small and large scallops from sites 4 and 5 were also similar ($p < 0.05$) to medium size scallops. Copper contents of viscera samples from all sites in the Northumberland Strait, Bay of Fundy, and Georges Bank are low (10-15 µg/g) while all others except from sites 5 and 17 were in the range of 30-35 µg/g.

The levels in samples from Browns Bank (site 17) were the highest (>55 µg/g tissue). In general, the copper contents of tissues from any site were not related either to size or age of the animals, which is what would be expected with a homeostatically controlled element.

Zinc

Like copper, zinc is also an essential trace element and is controlled by homeostatic process in individuals.

The concentrations of zinc in all tissues varied within a wide range and are normally in the order muscle < mantle < gill < viscera (83, 88, 133 and 150 µg/g) (Table 2). However, Bryan (1973) has reported that concentrations of zinc in the muscle tissues of Pecten maximus and Chlamys opercularis are about double the concentration of zinc in either mantle or gill. The values reported were 22, 11, and 10-12 µg/g for muscle, mantle, and gill, respectively. The range of concentrations in individual tissues varied over a wide range (Table 10).

In comparison, Greig et al. (1978) reported an average zinc concentration of 3.8 (range 2.0-8.1) µg/g wet tissue or approximately 20 µg/g (dry weight) in muscle tissues of P. magellanicus from the U.S. Atlantic coast. However Brooks and Rumsby (1965) have reported concentrations in muscle, mantle, and gill of Pecten novae-zelandiae in close agreement with the metal concentrations obtained in the present study. Comparative values for zinc in gill, mantle, and viscera of P. magellanicus are not available due to difference in sampling technique by Greig et al. (1978).

Cadmium

The concentrations of Cd in all tissues were more variable than those of other metals and were in the order muscle ≤ mantle < gill ≪ viscera. The concentrations in muscle, mantle, gill and viscera of all scallops (n = 133) in the present study ranged from 0.8-36, 0.7-47, 2.9-188 and 21-1780 µg/g dry weight, respectively (Table 2). However, if the small and large scallops are excluded, the corresponding values are changed to 0.8-15, 0.7-43, 3.5-94 and 21-917 µg/g, respectively (Table 3). In only 4 sites out of 19, the average Cd concentrations in the muscle tissue of medium-size scallops were ≤ 2.0 µg/g. The ratio of the average concentrations of Cd in viscera:muscle tissue was 32.7 and was much higher (Table 2) than the corresponding values of 7.9, 1.8 and 10, for Cu, Zn, and Pb, respectively, indicating that Cd is more selectively deposited in the viscera than Cu, Zn or Pb.

Cadmium concentrations in muscle tissues of P. magellanicus from Maine to North Carolina range from <0.06-<0.15 µg/g wet tissue (Greig et al. 1978). Zook et al. (1976) reported values from 0.04-0.2 µg/g wet tissue in muscle of P. magellanicus off the U.S. Atlantic coast. On a dry basis, these values (less than 1 µg/g) are comparable only with the level found in muscle tissue of scallops from Navy Island (site 15). However, Gould (NOAA, Milford, CT, pers. comm.) recently observed very high concentrations of Cd in scallops from the Gulf of Maine and Georges Bank.

Muscle tissues of scallops from site 15 at Passamaquoddy Bay of Bay of Fundy (control site) had the lowest mean concentration of Cd (1.1 µg/g). However, it is followed closely by three other sites, i.e. 2 and 8 in Chaleur Bay and 12 in eastern Northumberland Strait with concentrations of ≤2 ug/g. The average levels at all other sites were much higher and ranged up to 8.6 µg Cd/g (Table 10). The lowest concentration in viscera were observed in samples from site 14 in Bay of Fundy.

Cd concentrations in tissues of the scallops from the control site were lower than the corresponding averages for the scallops from the survey area. Scallops from sites 1, 3, 4, 5, 6 and 7 in Chaleur Bay have Cd concentrations significantly ($p < 0.05$) higher than were observed in other sites of Chaleur Bay. Scallops from site 7 (Nepisiguit estuary) also had a high Cd concentration in their muscle tissues. The estuary has been polluted with trace-metals from upstream mining operations since the early 1960's and high levels of Cd have been found in surficial sediments (Ray and White 1977; Westlake and Gauthier 1983). The concentrations of Cd in the sediment or the water column at site 7 are not known but a considerable amount of Cd must be bioavailable to cause the high Cd levels observed in scallops. Furthermore, the contamination is confined to a small area at the mouth of the river, since Cd levels in scallops from the two adjacent sites, 6 and 8, were significantly ($p < 0.05$) lower.

Cd concentrations in gill tissues of scallops from sites 4 and 5 are significantly higher than in those from other sites. Gills are the primary route of uptake for Cd from water. The elevated ($p < 0.05$) levels of Cd in the gills of the scallops from these two sites indicate the possibility that Cd concentrations in the water column at these sites were still high in 1981, a year after the Belledune survey (Ray et al. 1980). Alternatively, there is virtually no excretion of Cd by the scallops.

Though it cannot be explained, it is significant to note that for scallops from site 4, the average Cd concentration in muscle tissues of medium-sized scallops is significantly lower (4.2 µg/g) than the small- or large-sized (17 and 20 µg/g, respectively) animals. Similarly, the larger animals from site 5 also had an average of 15 ug Cd/g compared with only 3.9 µg/g in medium-sized animals. Small animals were not available at site 5. The scallops in western Northumberland Strait (Nos. 9-11) also have high Cd levels (>3.0 µg/g) in the muscle tissues. These values are comparable with the average levels in scallops from Chaleur Bay and may indicate transport of Cd from the contaminated Chaleur Bay area or mild local contamination. The postulation of Cd transport is further supported by the observation that the Cd levels in scallops decreases gradually in the easterly direction. The eastern part of the strait seems to be clean since the Cd levels in muscle and gill tissues of scallops from site 12 are comparable to those from the control site. Incidentally, the stock abundance in the eastern part of the Strait is much higher (Jamieson et al. 1981b) than other parts and may in part be related to a metal-free environment in the eastern part of Northumberland Strait or to a less intensive fishery in the area.

Muscle tissues of scallops from two Bay of Fundy sites (i.e. Digby and Mascarene) have Cd levels >3.0 µg/g. No apparent reasons exist for the high levels of cadmium in these scallops.

Furthermore, it is to be noted that the Chaleur Bay scallops have high levels of Cd in muscle as well as in viscera and the concentrations in the viscera were significantly related ($p < 0.05$) to the animal size (Table 11). However, this relationship was not observed in scallops from other study groups. The scallops from both Northumberland Strait and the two sites in the Bay of Fundy have Cd levels in the muscle similar to those in Chaleur Bay, but the levels in viscera are about half of those in Chaleur Bay scallops. Again, this low Cd level in viscera cannot be explained and needs further study.

The scallops from the open ocean sites at McDormand Patch (site 16) had muscle concentration of 4.2 µg Cd/g but the concentrations in scallops from Browns Bank and the two sites on Georges Bank were much higher at 18.9 (range 5.4-36.3), 11.6 (3.2-20.2), and 5.0 (range 2.9-10.5) µg/g, respectively. The average levels of cadmium in Browns Bank scallop tissues are also significantly ($p < 0.01$) higher than in those from Georges Bank and are both, in turn, significantly higher than at Navy Island. In contrast to our results, Uthe and Chou (1985) have reported much lower concentrations of Cd in the adductor muscle of 100 mm size scallops from Georges and Browns Banks (0.121 $\pm$ 0.033 and 0.338 $\pm$ 0.125 mg Cd/kg wet weight, respectively).

As observed with scallops from sites 4 and 5 in Chaleur Bay, Cd concentrations in muscle tissues of medium-sized animals from both Browns and Georges Banks were much lower than those in either small or large animals. The average concentrations (range) of Cd in muscle tissues of small (< 90 mm), medium (90-110 mm) and large (>110 mm) scallops from Georges Bank were 14 (6.4-19), 6.6 (3.2-9.7) and 14 (5.6-20) µg Cd/g, respectively. The level in tissues of medium-size animals from the other site on Georges Bank was 5.0 (2.9-11) µg/g. The corresponding levels in samples from Browns Bank were 26 (11-36) and 8.6 (5.4-15) µg/g for small and medium scallops, respectively.

We are tempted to speculate that the observed high levels of Cd in tissues of scallops from these sites (Georges and Browns Banks), far removed from any known source of anthropogenic input, may indicate a natural source of Cd of yet unknown origin. Uthe and Chou (1985) have suggested that the high levels of Cd in scallops from Browns Bank are due to dietary factors. Similar occurrences of high Cd levels in scallops and crabs from the Orkney and Shetland areas of Scottish waters, also far from any anthropogenic source have been reported (Topping 1973). We suggest that bioavailable Cd is present in the natural habitat of some scallops and should be investigated further. In two cases, Cd levels were even higher than in scallops from the Cd-polluted Belledune area. For instance, the calculated mean (range) concentrations of Cd in whole soft body tissues of scallops from the control site at Navy Island, two sites on Georges Bank and one on Browns Bank were 18.4 (11.7-25.2), 63.3 (31.3-104), 45.3 (24.1-101), and 123 (42.3-163) µg Cd/g, respectively, compared with 50.2 (23.1-116) µg Cd/g in scallops from the Belledune area (Ray et al. 1980).

The possibility of Cd migration from high Cd-containing hepatopancreas tissue to the adjacent adductor muscle tissue (Uthe and Chou 1985) due to autolysis or because of undergoing freeze-thaw cycles cannot be discounted. However, to the best of our knowledge, the samples were not thawed during transport from the collection sites and subsequent storage in the laboratory. This aspect of possible Cd migration during freeze-thaw cycle occuring during storage is under investigation. However, even if the actual concentrations in the individual tissues change due to Cd migration, the total tissue (without the body fluid) burden remains the same. The observed high body burden of Cd in the scallops from Georges and Browns Banks is a matter of particular concern, since the toxicological effects are not known.

Lead

The concentrations of Pb in the tissues were in the order muscle $\leq$ mantle $\leq$ gill $<$ viscera, with very few exceptions. The average levels in viscera were only 10 times higher than in the adductor muscle compared to 33 times for Cd (Table 2), indicating that the deposition of Pb is not as selective as with Cd.

Pb concentrations in muscle tissues of scallops from all sites except 1, 3, 4 and 5 are $\leq$ 1.0 µg/g (Table 10). The sites 1, 3, 4, and 5 are all in Chaleur Bay and have known anthropogenic trace metal input. Of all sites examined, the scallops from the Navy Island site had the lowest Pb concentrations in all tissues examined.

Site 1 is about 200 m off Dalhousie harbour which has extremely high levels of trace metals in the harbour sediments. Some of the metals, especially lead, have been shown to be bioavailable (Ray et al. 1981b; Ray and Peterson 1983). Site 3 is at the western edge of the disposal site for Dalhousie Harbour sediments and has been used for several years prior to 1979.

The animals from site 5, 12 km downstream from the lead refinery at Belledune were much more contaminated by Cd than those of site 4, 3 km east of the refinery. The average Pb concentration in the muscle tissues of the scallops from site 5 was 4.7 µg/g compared with only 2.4 µg/g at site 4. Surprisingly, though the Cd levels in scallops collected from site 7 were relatively high, the Pb levels were very low and were comparable with those from the control site. Furthermore, the Pb concentrations in muscle, mantle and viscera of small and large animals from site 4 and only muscle tissues of animals from site 5 were of the same order as in medium-size animals (ANOVA, $p < 0.05$). Size and age seem to have had no influence.

The average Pb concentrations in muscle and viscera of scallops from Northumberland Strait and Bay of Fundy were 0.3 and 1.5 (Table 6); and 0.4 and 1.7 µg/g (Table 7), respectively, and were much lower than the average levels in Chaleur Bay (Table 4). Pb levels in muscle tissue of scallops from the control site at Navy Island were only 0.2 µg/g, while the levels in those from Georges and Browns Banks were three times higher at approximately 0.6 µg/g. Pb levels in gill and viscera of samples from Browns Bank (n = 12) were 4.0 and 3.4 µg/g, respectively, compared with only 0.9 and 1.0 µg/g in samples from Georges Bank (n = 16), and 1.5 and 2.4 µg/g in those from Navy Island (n = 5).

The average Pb concentration of 1.3 (range 0.1-16) µg/g (dry) (Table 2) or approximately 0.3 µg/g (wet) observed in the present study is much less than the value of 0.47 (range 0.23-0.75) µg/g (wet) for muscle tissues of *P. magellanicus* reported by Zook et al. (1976). The value reported by Greig et al. (1978) in muscle tissue is 1.35 (range 0.40-24) µg/g (wet), approximately five times higher than those in the present study. Pb concentrations in gill, mantle, and viscera are not available for comparison with our data.

EFFECT OF SIZE

Boyden (1977) examined the effect of animal size upon metal contents (body burden) for a variety of shellfish, including two species of scallops, P. maximus and C. opercularis. He reported that the total contents of the individual elements (i.e. Cu, Zn, Cd, and Pb) were related to body weight of C. opercularis while the larger individuals of P. maximus had less Cu, Pb, and Zn contents than would be predicted if the metal contents were directly related to size. The relationship for Cd was curvilinear, i.e. total Cd content in animals less than 2 g (dry tissue wt) was directly related to size but the larger animals had a higher Cd content than expected from a direct relationship. The animals were divided into two groups $\leq$100 mm shell height and larger, for comparison with the results of Boyden (1977). The observed relationships between total body burden of the metals estimated from the sum of the metal burdens in individual tissues and animal size for P. magellanicus are presented in Figs. 3 and 4.

In scallops from site 4, the total contents of not only Cu and Zn but also Cd and Pb were related to the body size of the animals (Fig. 3). The corresponding relationships for site 5 are not significant. The observed discrepancies may be related to known contamination of the area from the refinery operations at Belledune in contrast with the relationships observed by Boyden (1977) for samples collected from a "clean" environment.

The $<$90 mm size scallops from site 4 and the control site have very low Cu, Zn, Cd and Pb contents compared with those $>$90 mm shell height. The sudden increase (Table 21) in total body burden of the metals may indicate a sudden metabolic change of the animals at this developmental stage and needs further investigation. The Cu, Zn, Cd and Pb contents of scallops of 90-110 and $>$110 mm size from site 5 are similar as are the Cu, Zn, and Pb contents in scallops from site 4. However, the total body burden of Cd in 90-110 mm scallops from site 4 is only 355 µg, but suddenly increases to 1030 µg in $>$110 mm size scallops.

There was a wide difference in the size of scallops from Georges and Browns Banks. The animals from Georges Bank ranged from 2.6-16.0 g (dry), while those from Browns Bank ranged from 1.0-3.4 g (dry). The total body burden of Cd and Pb in larger animals from Georges Bank was higher (Fig. 4) than expected from the linear relationship observed for small animals ($\leq$100-mm shell height). Lack of large-sized scallops precluded confirmation that large scallops from Browns Bank may also contain a higher than expected body load of Cd and Pb.

The average total body burden of Cd in adductor muscle and whole body soft tissues of scallops of $\leq$100 and $>$100 mm shell height is given in Table 22. The relatively higher value for whole body Cd load in scallops ($\leq$100 mm) from Browns Bank is due to a very high concentration of Cd in the viscera (647 µg/g) compared with the values of 79 and 106 µg/g in the viscera of animals from Georges Bank and Navy Island, respectively.

The Pb content of the small scallops from site 4 was twice that in scallops from Passamaquoddy Bay but those scallops in the medium and large size classes from sites 4 and 5 were 10-16 times higher. In comparison, scallops from Georges and Browns Banks had a much higher body burden of Cd than those from the Bay of Fundy, but the Pb contents were very similar and ranged from 2.5-3.6 µg Pb (Ray et al. 1984a).

The total burdens of Pb in muscle and whole body soft tissue of scallops ($\leq$100 mm) from Navy Island, Browns and Georges Banks were 0.6, 3.6; 0.7, 2.5; and 1.1, 3.0 µg Pb, respectively. The corresponding values for larger scallops from Georges Bank were 6.1 and 13 µg Pb.

CONCLUSIONS

Cu, Zn, Cd and Pb concentrations in the tissues of scallops varied over a wide range even among individuals of the same population and generally the concentrations were in the order muscle $<$ mantle $<$ gill $<$ viscera.

Copper and zinc levels in scallops from all four geographic areas were comparable to those from non-contaminated areas.

Levels of Cd and Pb in scallops from Chaleur Bay were generally higher than in animals from a control site near St. Andrews in Passamaquoddy Bay. Furthermore, the generally high levels of Cd and Pb in scallops from Chaleur Bay may indicate differences in the geochemistry of the area as well as dispersal of the metals over a large area of Chaleur Bay from a few contaminated sites.

Studies undertaken in 1980 documented the extent of Cd pollution in Chaleur Bay (Ray et al. 1980), but the extent of possible Pb pollution from the same source was not investigated. In the present study, the high body burden of Pb and Cd in scallops from sites at Belledune and Green Point indicate the geographic extent of the coastal area that was affected by the refinery operations at Belledune. Scallops collected from the sites in Chaleur Bay that had known anthropogenic metal input had elevated levels of Cd and Pb.

Cd levels in three out of four sites in Northumberland Strait and two sites in the Bay of Fundy were comparable with those in Chaleur Bay. However, Cu, Zn and Pb levels were low.

The concentrations of Cd, in all scallop tissues from Browns and Georges Banks were considerably higher than in those from the reference site off Navy Island in the Bay of Fundy. Such differences were not observed for Cu, Zn and Pb. The occurrence of high concentrations of Cd in scallops from an area far removed from any known source of anthropogenic input is surprising, and corroborates the earlier suggestion (Ray et al. 1984a) that the high levels of Cd are natural in origin. Uthe and Chou (1985) have suggested that the observed high level of Cd in scallops from Browns Bank may be due to "nutritional factors in these scallops." The Cd levels in scallops from Browns Bank were higher than in those from Georges Bank. The total body burden of Cd and Pb in larger scallops ($>$100 mm) from Georges Bank were higher than expected from the linear relationship observed

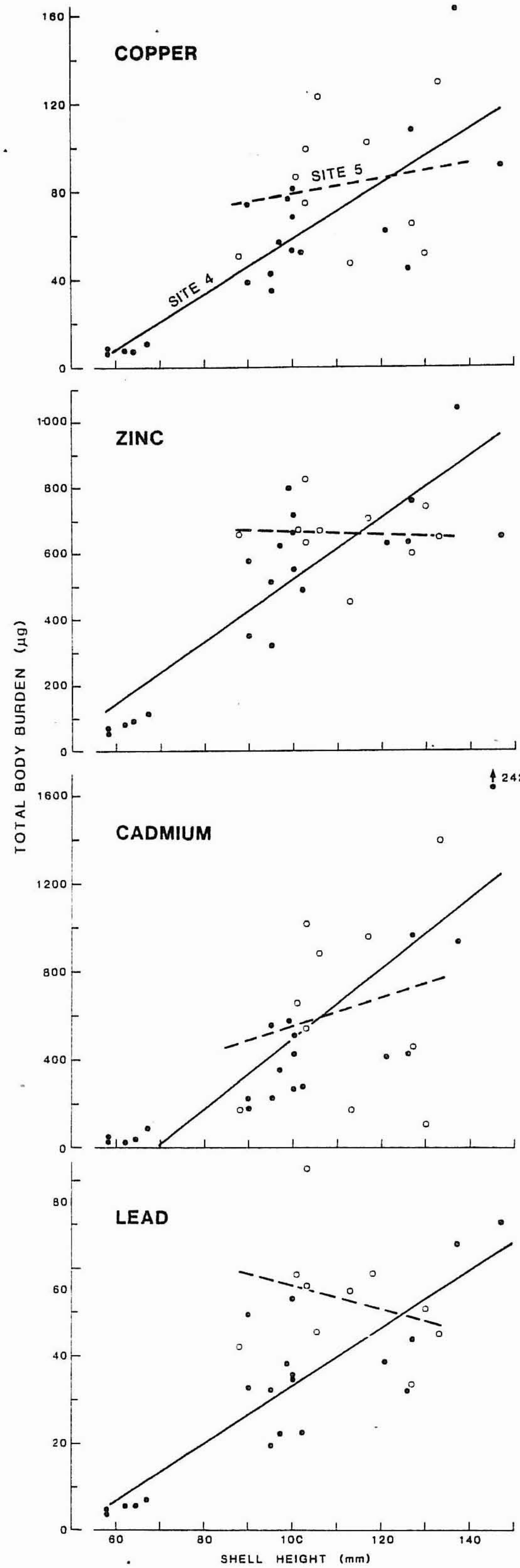

Fig. 3. Relationship of total body burden of Cu, Zn, Cd, and Pb in scallops to shell height. Chaleur Bay; site 4 (n = 20) and Site 5 (n = 10).

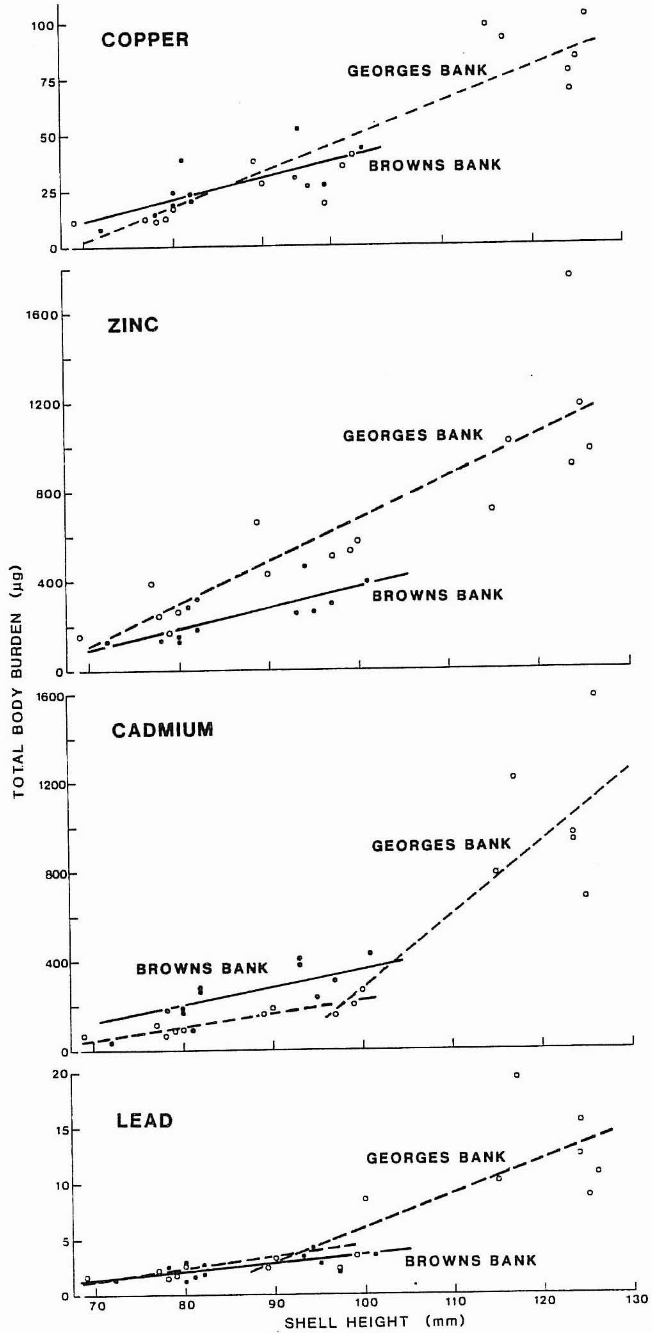

Fig. 4. Relationship of total body burden of Cu, Zn, Cd, and Pb in scallops to shell height. Georges Bank (n = 16) and Browns Bank (n = 12).

for scallops of $<$ 100 mm size. However, for Chaleur Bay scallops, not only Cu and Zn but also Cd and Pb were related to the size of the animals.

The observation that Cd concentrations in medium-sized animals were significantly lower than in either smaller or larger animals has not been reported previously and possible physiological factors controlling it should be examined.

It is not known whether high levels of the metal in the various tissues cause any physiological damage to the scallop but complete absence of large scallops from Browns Bank and their relative scarcity on Georges Bank may, in part, be related to the high body burden of Cd. The more likely alternative is that the absence of large scallops may be related to the intense fishery.

ACKNOWLEDGMENTS

L. Burridge helped in collecting scallops from Chaleur Bay and dissected the samples. R. Chandler collected samples from all other sites and aged all scallops. J. Thorne, M. Woodside and H. Akagi helped with dissection of all other samples and chemical analysis. J. Hurley and B. Garnett typed the manuscript. Drs. V. Zitko, D. Scarratt and K. Haya reviewed the manuscript. Thanks are also due to Dr. J. F. Uthe for helpful suggestions.

REFERENCES

Brooks, R. R., and M. G. Rumsby. 1965. The biogeochemistry of trace element uptake by some New Zealand bivalves. Limnol. Oceanogr. 10: 521-527.

Bryan, G. W. 1973. The occurrence and seasonal variation of trace metals in the scallops, Pecten maximus (L.) and Chlamys opercularis (L.). J. Mar. Biol. Assoc. U.K. 53: 145-166.

Bourne, N. 1964. Scallops and the offshore fishery of the Maritimes. Bull. Fish. Res. Board Can. 145: 60 p.

Boyden, C. R. 1977. Effect of size upon metal content of shellfish. J. Mar. Biol. Assoc. U.K. 57: 675-714.

Canada. Dept. of Fisheries and Oceans. 1979. Annual statistical review of Canadian fisheries: 1977, Vol. 10. Dept. of Fisheries and Oceans, Intelligence Services Division, Ottawa, Ont., p. 55.

Canada. Dept. of Fisheries and Oceans. 1986. Canadian fisheries statistical highlights 1985. Dept. of Fisheries aand Oceans, Economic Analysis and Statistics Division, Ottawa, Ont., p. 13.

Cook, R. H., and R. A. W. Hoos. 1971. Base metal mine water pollution on the Nepisiguit River, New Brunswick. Dept. of Fisheries and Forestry of Canada, Fisheries Service, Manuscript Report No. 71-2, 27 p.

Eisler, R., G. E. Zaroogian, and R. J. Hennekey. 1972. Cadmium uptake by marine organisms. J. Fish. Res. Board Can. 29: 1367-1369.

Greig, R. A., D. R. Wenzloff, C. L. MacKenzie, Jr., A. S. Merrill, V. S. Zdanowicz. 1978. Trace metals in sea scallops, Placopecten magellanicus, from eastern United States. Bull. Environ. Contam. Toxicol. 19: 326-334.

Jamieson, G. S. 1979. Status and assessment of Northumberland Strait scallop stocks. Fish. Mar. Serv. Tech. Rep. 904: iv + 12 p.

Jamieson, G. S., G. Kerr, and M. J. Lundy. 1981a. Assessment of scallop stocks on Browns and German Banks - 1979. Can. Tech. Rep. Fish. Aquat. Sci. 1014: iv + 17 p.

Jamieson, G. S., N. B. Witherspoon, and M. J. Lundy. 1981b. Assessment of Northumberland Strait scallop stocks - 1979. Can. Tech. Rep. Fish. Aquat. Sci. 1013: vi + 31 p.

Loring, D. H., J. M. Bewers, G. Seibert, and K. Kranck. 1980. A preliminary survey of circulation and heavy metal contamination in Belledune Harbour and adjacent areas, p. 35-47. In J. F. Uthe and V. Zitko [eds.] Cadmium pollution of Belledune Harbour, New Brunswick, Canada. Can. Tech. Rep. Fish. Aquat. Sci. 963.

MacKnight, S. D. 1985. Geochemistry of the Dalhousie ocean dumpsite, p. 281-301. In B. H. Ketchum, J. M. Kapuzzo, W. V. Burt, I. W. Duedall, P. K. Park and D. R. Kester [eds.]. Wastes in the Ocean. Vol. 6. Nearshore Waste Disposal. Wiley-Interscience, New York.

Nelson, D. A., A. Calabrese, B. A. Nelson, J. R. MacInnes, and D. R. Wenzloff. 1976. Biological effects of heavy metals on juvenile bay scallops, Argopecten irradians, in short term exposures. Bull. Environ. Contam. Toxicol. 16: 275-282.

Pesch, G., B. Reynolds, and P. Rogerson. 1977. Trace metals in scallops from within and around two ocean disposal sites. Mar. Pollut. Bull. 8: 224-228.

Ray, S., and W. White. 1977. Some observations on heavy metal concentration in northeastern New Brunswick estuarine surficial sediments. Can. Fish. Mar. Serv. Tech. Rep. 696: vii + 23 p.

Ray, S., D. W. McLeese, C. D. Metcalfe, L. E. Burridge, and B. A. Waiwood. 1980. Distribution of cadmium in marine biota in the vicinity of Belledune, p. 11-34. In J. F. Uthe and V. Zitko [ed.] Cadmium pollution of Belledune Harbour, New Brunswick, Canada. Can. Tech. Rep. Fish. Aquat. Sci. 963.

Ray, S., D. W. McLeese, and L. E. Burridge. 1981a. Cadmium in tissues of lobsters captured near a lead smelter. Mar. Pollut. Bull. 12: 383-386.

Ray, S., D. W. McLeese, and M. R. Peterson. 1981b. Accumulation of copper, zinc, cadmium and lead from two contaminated sediments by three marine invertebrates - a laboratory study. Bull. Environ. Contam. Toxicol. 26: 315-322.

Ray, S., and M. R. Peterson. 1983. Bioavailability of Cu, Zn, Cd and Pb from contaminated sediments by bottom-dwelling marine organisms. Proc. Int. Conf. Manage. Control Heavy Met. Environ., Vol. 2: 1024-1027.

Ray, S., M. Woodside, V. E. Jerome, and H. Akagi. 1984a. Copper, zinc, cadmium, and lead in scallops Placopecten magellanicus from Georges and Browns Banks. Chemosphere 13: 1247-1254.

Ray, S., V. E. Jerome, and J. A. Thorne. 1984b. Copper, zinc, cadmium, and lead in scallops (Placopecten magellanicus) from Chaleur Bay, New Brunswick. Int. Counc. Explor. Sea. C.M. 1984/E:22, 15 p.

Robert, G., G. S. Jamieson, and M. J. Lundy. 1982. Profile of the Canadian offshore scallop fishery on Georges Bank, 1978 to 1981. CAFSAC Res. Doc. 82/15, 33 p. + appendix.

Topping, G. 1973. Heavy metals in shellfish from Scottish waters. Aquaculture 1: 379-384.

Uthe, J. F., and C. L. Chou. 1985. Studies on cadmium in sea scallops (Placopecten magellanicus) from clean and contaminated areas. Int. Counc. Explor. Sea. C.M. 1985/E:22, 8 p.

Westlake, G. F., and A. Gauthier. 1983. Heavy metal contamination of sediments in Bathurst Harbour, New Brunswick. Environment Canada Surveillance Report. EPS-5-AR-83-5, 10 p.

Zook, E. G., J. J. Powell, B. M. Hackley, J. A. Emerson, J. R. Brooker, and G. M. Knobl, Jr. 1976. National Marine Fisheries Service preliminary survey of selected seafoods for mercury, lead, cadmium, chromium, and arsenic content. J. Agric. Food. Chem. 24: 47-53.

Table 1. Percentage of adductor muscle, mantle, gill, and viscera of whole body (soft tissues) of scallops collected from Navy Island, Georges Bank, and Browns Bank.

Site	n	Size (mm)	Muscle	Mantle	Gill	Viscera
15 (Navy Island)	14	≤100	53.5	16.0	9.5	21.0
	4	>100	43.5	16.3	7.7	32.5
19 (Georges Bank)	10	≤100	53.7	10.7	7.6	28.1
	6	>100	48.4	9.5	5.6	36.5
17 (Browns Bank)	12	≤100	58.5	16.2	7.3	18.0

Table 2. Concentrations (mean, standard deviation, range) of trace metals in tissues (μg/g dry) from study area (sites 1-19, n = 133).

Tissue		Cu	Zn	Cd	Pb
	Mean	3.3	83	7.5	1.3
Muscle	S.D.	3.5	21	7.5	2.0
	Range	0.2-20	9-156	0.8-36	0.1-16
	Mean	4.2	88	13	2.8
Mantle	S.D.	3.0	24	12	6.7
	Range	0.3-29	7-160	0.7-47	0.2-14
	Mean	9.0	133	42	5.0
Gill	S.D.	8.0	70	61	5.7
	Range	2.4-49	15-574	2.9-188	0.3-35
	Mean	26	150	245	13
Viscera	S.D.	21	86	272	24
	Range	1.6-133	41-600	21-1780	0.4-33

Table 3. Concentrations (mean, standard deviation, range) of metals in medium size (90-110 mm) scallops (excluding small and large animals) tissues (μg/g dry) from study area (Sites 1-19, n = 105).

Tissue		Cu	Zn	Cd	Pb
	Mean	2.6	81	3.9	1.0
Muscle	S.D.	2.2	20	2.6	1.7
	Range	0.2-13	9-123	0.8-15	0.1-15
	Mean	3.5	86	8.3	2.4
Mantle	S.D.	3.6	20	6.8	7.4
	Range	0.3-29	7-150	0.7-43	0.2-9
	Mean	6.7	127	22	3.6
Gill	S.D.	4.2	58	19	3.7
	Range	2.4-34	15-414	3.5-94	0.4-20
	Mean	26	157	225	5.5
Viscera	S.D.	15	83	180	6.2
	Range	1.6-63	41-600	21-917	1.6-26

Table 4. Concentration (mean, standard deviation, range) of metals in scallop (all sizes combined) tissues (µg/g dry) from Chaleur Bay (sites 1-8, n = 60).

Tissue		Cu	Zn	Cd	Pb
	Mean	3.1	88	6.9	2.2
Muscle	S.D.	3.6	14	7.0	2.8
	Range	0.2-20	49-121	1.3-26	0.1-16
	Mean	3.6	89	14	3.8
Mantle	S.D.	2.9	25	11	2.9
	Range	0.3-15	7.3-127	3.1-47	0.3-14
	Mean	7.8	113	42	8.5
Gill	S.D.	6.5	86	31	7.2
	Range	2.4-49	15-574	2.9-188	1.1-35
	Mean	35	196	327	12
Viscera	S.D.	12	85	286	7.3
	Range	11-79	75-600	41-1780	2.9-33

Table 5. Concentration (mean, standard deviation, range) of metals in medium size scallop (90-110 mm) tissues (µg/g dry) from Chaleur Bay (sites 1-8, n = 45).

Tissue		Cu	Zn	Cd	Pb
	Mean	2.1	85	3.4	1.9
Muscle	S.D.	2.3	13	2.3	2.4
	Range	0.3-13	49-115	1.3-11	0.3-15
	Mean	2.5	91	11	3.0
Mantle	S.D.	1.8	20	8.8	1.9
	Range	0.3-11	7-147	3.1-43	0.8-9.1
	Mean	6.5	120	35	6.1
Gill	S.D.	3.4	95	23	4.9
	Range	2.4-20	47-574	7.4-96	1.3-22
	Mean	35	209	284	11
Viscera	S.D.	8.7	75	150	7.0
	Range	21-61	126-600	115-673	2.9-26

Table 6. Concentration (mean, standard deviation, range) of metals in medium size scallop (90-110 mm) tissues (µg/g dry) from Northumberland Strait (sites 9-12, n = 20).

Tissue		Cu	Zn	Cd	Pb
	Mean	2.7	70	3.2	0.3
Muscle	S.D.	2.6	13	1.3	0.3
	Range	0.3-11	48-101	1.2-5.6	0.1-1.0
	Mean	3.1	82	8.0	0.6
Mantle	S.D.	1.2	17	3.2	0.8
	Range	1.8-7.3	45-117	3.9-17	0.2-3.7
	Mean	7.8	150	15	2.6
Gill	S.D.	6.7	54	9.0	2.2
	Range	3.8-34	56-262	6.2-33	0.5-8.1
	Mean	12	91	144	1.5
Viscera	S.D.	6.3	26	75	0.9
	Range	1.6-24	41-140	56-354	0.4-3.3

Table 7. Concentration (mean, standard deviation, range) of metals in medium size scallop (90-110 mm) tissues (µg/g dry) from Bay of Fundy (sites 13-15; n = 15).

Tissue		Cu	Zn	Cd	Pb
	Mean	2.9	66	3.1	0.4
Muscle	S.D.	2.0	9.7	2.0	0.3
	Range	1.3-8.1	56-79	0.8-8.4	0.1-1.1
	Mean	4.3	75	4.0	0.7
Mantle	S.D.	3.9	19	2.7	0.5
	Range	1.7-16	47-121	0.7-9.3	0.2-1.5
	Mean	7.0	140	10	1.1
Gill	S.D.	4.3	44	5.6	0.5
	Range	4.2-22	56-209	3.5-25	0.5-2.5
	Mean	11	119	67	1.7
Viscera	S.D.	2.7	73	35	0.7
	Range	6.2-15	50-252	21-131	0.5-3.1

Table 8. Concentration (mean, standard deviation, range) of metals in scallop (all sizes combined) tissues (µg/g dry) from the open ocean sites (sites 16-19; n = 38).

Tissue		Cu	Zn	Cd	Pb
	Mean	2.8	91	12	0.7
Muscle	S.D.	1.4	25	9.2	0.5
	Range	1.7-9.4	54-157	2.7-36	0.1-2.2
	Mean	4.1	89	10	0.8
Mantle	S.D.	2.2	22	8.8	0.4
	Range	1.2-11	53-160	1.0-36	0.3-2.2
	Mean	7.0	131	18	2.3
Gill	S.D.	3.5	45	11	2.9
	Range	3.9-22	80-255	4.9-54	0.3-18
	Mean	30	142	295	2.0
Viscera	S.D.	28	80	290	1.3
	Range	9.0-133	48-322	58-1057	0.6-5.9

Table 9. Concentration (mean, standard deviation, range) of metals in medium size scallop (90-110 cm) tissues (µg/g dry) from the open-ocean sites (sites 16-19; n = 20).

Tissue		Cu	Zn	Cd	Pb
	Mean	3.2	97	6.1	0.6
Muscle	S.D.	1.7	21	3.2	0.4
	Range	1.9-9.4	54-123	2.7-15	0.1-1.6
	Mean	3.9	89	7.0	0.8
Mantle	S.D.	2.8	19	4.1	0.5
	Range	1.2-11	67-150	1.0-14	0.3-2.2
	Mean	6.7	133	12	2.0
Gill	S.D.	4.0	42	4.9	1.3
	Range	3.9-22	80-255	4.9-20	0.5-4.3
	Mean	26	145	277	2.1
Viscera	S.D.	18	80	264	1.2
	Range	9.0-63	56-322	59-852	0.6-3.9

Table 10. Site, location, size, age, and concentrations (mean, standard deviation, and range) of Cu, Zn, Cd, and Pb (µg/g dry weight) in tissues of small (< 90 mm), medium (90-110 mm) and large (> 110 mm) scallops of the study area.

Location		Size (mm)	Age (yr)	Organ	Metal (µg/g dry) Cu	Zn	Cd	Pb
Site 1	Mean	103			0.8	91	3.5	2.1
	S.D.	5		Muscle	0.3	7.5	1.0	1.5
Dalhousie Ferry (n = 5)	Range	97-110			0.6-1.5	84-103	2.7-5.3	0.4-3.4
	Mean				3.1	76	3.9	1.5
48°02'48" N	S.D.			Mantle	0.6	3.9	0.9	0.9
66°18'50" W	Range				2.5-3.8	70-80	3.1-5.4	0.9-2.9
	Mean				9.6	108	31	2.2
	S.D.			Gill	2.5	15	10	0.9
	Range				6.9-12	86-226	15-41	1.3-3.2
	Mean				29	185	212	6.2
	S.D.			Viscera	4.2	33	40	3.3
	Range				25-35	155-240	158-254	4.0-12
Site 2	Mean	119			1.0	92	1.9	1.0
	S.D.	5		Muscle	0.5	5.1	0.3	0.7
Heron Island (n = 5)	Range	110-122			0.6-1.7	85-99	1.5-2.3	0.4-2.1
	Mean				2.6	76	4.8	1.7
48°01'23" N	S.D.			Mantle	0.3	40	1.6	0.8
66°07'14" W	Range				2.1-2.9	7.3-106	3.4-6.9	1.0-3.0
	Mean				7.5	110	31	3.2
	S.D.			Gill	2.9	52	13	1.8
	Range				5.7-13	66-199	20-47	1.1-5.2
	Mean				29	182	246	3.9
	S.D.			Viscera	3.8	15	76	1.1
	Range				25-35	156-193	158-348	2.9-5.5
Site 3	Mean	114			4.4	82	3.1	2.2
	S.D	20		Muscle	4.8	11	2.5	0.3
Heron Island West (n = 5)	Range	80-130			1.3-13	73-95	1.7-7.6	1.8-2.4
	Mean				2.6	88	4.3	1.7
47°59'10" N	S.D.			Mantle	0.7	20	0.7	0.9
66°03'55" W	Range				1.9-3.7	60-107	3.3-5.4	0.8-2.9
	Mean				5.9	76	28	3.9
	S.D.			Gill	2.5	30	28	2.6
	Range				4.3-10	47-116	7.4-76	1.5-7.8
	Mean				28	187	296	4.4
	S.D.			Viscera	5.0	55	222	0.6
	Range				21-34	128-255	116-673	3.4-5.0
Site 4	Mean	97	5.8		3.7	82	4.2	2.4
	S.D.	4	0.4	Muscle	2.4	13	2.7	1.6
Belledune (N = 10)	Range	90-102	5-6		1.0-7.2	66-108	1.4-11	0.8-4.8
	Mean				0.7	101	15	4.8
47°54'48" N	S.D.			Mantle	0.3	20	7.8	2.5
65°47'27" W	Range				0.3-1.6	80-147	5.3-31	2.2-9.1
	Mean				4.3	135	52	9.2
	S.D.			Gill	2.5	79	25	5.9
	Range				2.4-11	15-331	20-94	3.1-20

Table 10. (cont'd.)

Location		Size (mm)	Age (yr)	Organ	Metal (µg/g dry) Cu	Zn	Cd	Pb
	Mean				37	248	270	18
	S.D.			Viscera	7.2	137	236	3.6
	Range				28-49	126-600	122-917	11-23
Site 4	Mean	132			5.8	101	20	2.1
	S.D.	11		Muscle	3.9	15	2.9	1.2
Belledune	Range	121-149			2.7-12	82-121	16-23	1.4-3.5
(n = 5)		(Large)						
	Mean				6.6	94	28	7.2
47°54'48" N	S.D.			Mantle	3.2	41	13	3.8
65°47'27" W	Range				4.8-12	42-143	16-47	2.4-13
	Mean				15	93	95	18
	S.D.			Gill	19	55	57	11
	Range				3.4-49	16-150	39-188	3.8-35
	Mean				38	145	650	19
	S.D.			Viscera	17	27	670	8.6
	Range				22-66	114-186	219-1780	9.6-33
Site 4	Mean	65			5.5	86	17	2.8
	S.D.	7		Muscle	1.9	5.4	5.9	0.3
Belledune	Range	58-74			3.7-8.5	80-93	11-26	2.4-3.3
(n = 5)		(Small)						
	Mean				8.6	111	22	6.6
47°54'48" N	S.D.			Mantle	3.5	14	7.0	2.8
65°47'27" W	Range				5.7-15	93-127	17-30	3.7-11
	Mean				12	116	51	12
	S.D.			Gill	4.0	15	15	5.3
	Range				8.2-17	94-134	36-72	7.4-20
	Mean				23	105	166	17
	S.D.			Viscera	7.2	24	114	2.7
	Range				11-30	75-136	91-365	13-19
Site 5	Mean	100	6.0		0.9	82	3.9	4.7
	S.D	7	0.7	Muscle	0.4	8.9	1.2	6.0
Green Point	Range	88-106	5-7		0.5-1.5	69-94	2.7-5.5	0.7-15
(n = 5)								
	Mean				1.5	84	17	4.3
47°52'25" N	S.D.			Mantle	0.7	11	9.2	1.1
65°40'48" W	Range				0.7-2.3	69-96	11-34	2.6-5.3
	Mean				6.8	264	61	12
	S.D.			Gill	7.4	217	28	7.4
	Range				2.6-20	110-574	30-96	4.2-22
	Mean				47	218	322	23
	S.D.			Viscera	10	69	170	2.8
	Range				36-61	163-327	115-546	19-26
Site 5	Mean	124	10		7.7	109	15	5.1
	S.D.	9	1.4	Muscle	7.5	4.4	7.7	6.1
Green Point	Range	113-133	9-12		1.8-20	102-114	6.4-24	0.9-16
(n = 5)		(Large)						
	Mean				5.3	52	24	5.8
47°52'25" N	S.D.			Mantle	1.8	16	13	5.1
65°40'48" W	Range				3.4-7.3	36-73	9.6-41	1.2-14
	Mean				6.7	62	38	18
	S.D.			Gill	4.4	32	26	5.5
	Range				2.7-14	47-118	2.9-62	10-23

Table 10. (cont'd.)

Location		Size (mm)	Age (yr)	Organ	Metal (µg/g dry) Cu	Zn	Cd	Pb
	Mean				46	227	544	17
	S.D.			Viscera	25	157	585	4.3
	Range				21-79	138-506	41-1150	13-23
Site 6	Mean	99			1.4	86	2.6	0.9
	S.D.	1		Muscle	0.9	13	1.2	0.2
Beresford	Range	97-100			0.5-2.5	75-102	1.3-4.5	0.6-1.1
(n = 5)								
	Mean				4.6	96	10	2.7
47°44'54" N	S.D.			Mantle	3.8	13	8.3	1.3
65°38'12" W	Range				2.5-11	78-110	4.2-24	0.3-3.4
	Mean				6.0	70	23	7.4
	S.D.			Gill	1.1	12	8.4	2.4
	Range				5.1-7.6	54-83	13-35	4.5-10
	Mean				34	209	277	7.0
	S.D.			Viscera	9.6	52	61	1.0
	Range				27-49	142-269	232-384	5.4-7.9
Site 7	Mean	99			2.0	90	5.4	0.7
	S.D.	3		Muscle	0.8	25	4.4	0.3
Bathurst Hbr. Mouth	Range	94-102			0.9-2.8	49-115	2.1-11	0.5-1.2
(n = 5)								
	Mean				3.3	101	17	2.4
47°43'25" N	S.D.			Mantle	1.0	12	15	0.9
65°33'30" W	Range				2.1-4.7	87-100	6.5-43	1.4-3.5
	Mean				5.9	93	16	3.8
	S.D.			Gill	0.8	8.7	4.3	1.8
	Range				4.8-6.9	85-106	12-23	1.8-5.9
	Mean				39	199	385	8.7
	S.D.			Viscera	9.6	35	88	2.8
	Range				24-50	166-245	263-488	6.0-13
Site 8	Mean	95			0.9	78	2.0	0.4
	S.D.	4		Muscle	0.7	12	0.5	0.2
Janesville	Range	89-99			0.3-1.8	76-95	1.4-2.6	0.3-0.8
(n = 5)								
	Mean				3.4	92	8.1	2.6
47°42'45" N	S.D.			Mantle	1.1	16	4.7	0.9
65°30'50" W	Range				2.4-5.1	78-119	4.3-15	1.9-4.0
	Mean				7.2	94	21	3.9
	S.D.			Gill	2.6	14	4.8	1.5
	Range				5.2-12	82-117	14-26	2.3-5.4
	Mean				37	203	281	6.1
	S.D.			Viscera	3.9	35	15	1.4
	Range				32-41	167-249	269-305	5.1-8.4
Site 9	Mean	100	6.6		1.5	57	3.7	0.1
	S.D.	6.0	1.1	Muscle	0.4	7.9	1.1	0
Miminegash, PEI	Range	92-106	5-8		0.8-1.9	48-66	2.3-5.3	0.1
(n = 5)								
	Mean				3.9	77	9.7	0.5
46°53' N	S.D.			Mantle	2.0	22	2.1	0.2
64°16' W	Range				2.6-7.3	45-103	7.4-13	0.3-0.8
	Mean				4.8	95	15	1.7
	S.D.			Gill	0.7	32	4.1	0.6
	Range				3.8-5.8	56-127	8.8-20	0.9-2.4

Table 10. (cont'd.)

Location		Size (mm)	Age (yr)	Organ	Metal (µg/g dry) Cu	Zn	Cd	Pb
	Mean				13	88	84	0.5
	S.D.			Viscera	1.7	24	26	0.1
	Range				10-15	58-116	56-117	0.4-0.7
Site 10	Mean	101	6.4		1.9	74	4.0	0.2
	S.D.	5.1	0.5	Muscle	0.6	16	1.0	0.1
Egmont Bay, PEI (n = 5)	Range	96-108	6-7		1.2-2.7	60-101	2.9-5.6	0.2-0.4
	Mean				2.1	72	11	0.2
46°29'08" N	S.D.			Mantle	0.2	8.3	3.4	0.1
64°09'20" W	Range				1.8-2.4	60-83	7.8-17	0.2-0.3
	Mean				6.0	141	29	0.6
	S.D.			Gill	0.4	22	4.5	0.1
	Range				5.5-6.5	109-171	22-33	0.5-0.8
	Mean				14	70	129	1.1
	S.D.			Viscera	6.3	40	63	0.2
	Range				7.9-24	41-140	71-198	0.9-1.4
Site 11	Mean	96	5.0		3.9	76	3.1	0.5
	S.D.	3.6	0	Muscle	4.1	10	1.4	0.3
Wood Island, PEI (n = 5)	Range	92-101	5		1.7-11	67-93	1.5-4.6	0.2-0.9
	Mean				3.3	82	6.4	0.5
45°55'30" N	S.D.			Mantle	0.8	8.8	2.1	0.3
62°47'00" W	Range				2.3-4.5	72-96	4.8-10	0.3-1.0
	Mean				14	158	9.6	5.4
	S.D.			Gill	12	33	4.2	2.4
	Range				4.4-34	136-214	6.2-17	1.7-8.1
	Mean				12	110	147	1.7
	S.D.			Viscera	7.0	7.0	10	0.4
	Range				5.6-23	100-118	129-155	1.4-2.2
Site 12	Mean	95	9.6		3.6	71	1.8	0.4
	S.D.	9.2	2.1	Muscle	3.2	7.3	0.6	0.3
Cape Breton (n = 5)	Range	85-108	7-12		0.3-7.6	64-80	1.2-2.7	0.2-1.0
	Mean				3.1	100	5.1	1.3
46°57' N	S.D.			Mantle	0.5	12	1.1	1.4
60°55' W	Range				2.2-3.5	85-117	3.9-6.6	0.5-3.7
	Mean				6.5	208	8.7	2.7
	S.D.			Gill	1.5	56	1.2	0.4
	Range				4.5-8.4	136-262	7.4-10	2.3-3.1
	Mean				8.4	94	216	2.6
	S.D.			Viscera	8.6	11	103	0.6
	Range				1.6-21	84-109	111-354	1.8-3.3
Site 13	Mean	97	5.2		2.3	74	4.6	0.7
(n = 5)	S.D.	3.0	0.8	Muscle	0.2	5.7	2.2	0.3
Digby	Range	94-100	4-6		2.1-2.6	64-78	2.9-8.4	0.4-1.1
	Mean				3.5	76	4.3	0.4
44°47' N	S.D.			Mantle	1.5	28	3.0	0.3
65°51' W	Range				1.9-5.3	47-121	0.7-7.3	0.2-0.9
	Mean				5.2	177	10	1.0
	S.D.			Gill	0.6	42	2.0	0.3
	Range				4.6-5.9	106-209	8.1-12	0.7-1.4
	Mean				13	195	64	1.3
	S.D.			Viscera	1.5	74	16	0.3
	Range				11-15	73-252	46-82	1.0-1.7

Table 10. (cont'd.)

Location		Size (mm)	Age (yr)	Organ	Metal (μg/g dry) Cu	Zn	Cd	Pb
Site 14	Mean	99	4.8		1.9	55	3.6	0.2
Mascarene	S.D.	2.3	0.5	Muscle	0.2	3.0	1.1	0.1
(Passamaquoddy Bay)	Range	95-101	4-5		1.6-2.2	52-58	2.4-5.1	0.1-0.3
(n = 5)								
	Mean				7.5	66	6.0	0.5
45°04'30" N	S.D.			Mantle	5.6	11	1.8	0.2
66°56'30" W	Range				3.5-16	55-83	4.9-9.3	0.3-0.7
	Mean				5.7	100	16	0.9
	S.D.			Gill	2.0	33	5.8	0.4
	Range				4.2-8.7	56-142	11-25	0.5-1.6
	Mean				10	74	31	1.3
	S.D.			Viscera	3.4	45	9.1	0.6
	Range				6.2-15	50-154	21-44	0.5-2.2
Site 15	Mean	96	4.0		4.5	70	1.1	0.2
Navy Island	S.D.	3.8	0.0	Muscle	2.9	6.0	0.3	0
(Passamaquoddy Bay)	Range	92-102	4.0		1.3-8.1	62-79	0.8-1.6	0.2-0.3
(n = 5)								
	Mean				1.9	84	1.6	1.3
45°03' N	S.D.			Mantle	0.2	12	0.3	0.3
67°02' W	Range				1.7-2.2	68-98	1.3-2.1	1.0-1.5
	Mean				10	143	4.6	1.5
	S.D.			Gill	6.5	15	0.8	0.6
	Range				6.0-22	125-163	3.5-5.6	1.1-2.5
	Mean				11	88	106	2.4
	S.D.			Viscera	2.0	6.2	18	0.5
	Range				8.1-13	82-98	80-131	1.9-3.1
Site 16	Mean	98	7.2		3.0	103	4.2	1.0
	S.D.	4.0	0.4	Muscle	1.1	6.0	1.3	0.5
McDormand Patch	Range	91-101	7-8		2.0-4.6	95-111	2.7-5.5	0.5-1.6
(n = 5)								
	Mean				4.6	78	5.4	0.5
44°05'55" N	S.D.			Mantle	3.8	9.7	2.6	0.2
66°33'52" W	Range				1.3-11	67-89	3.6-9.9	0.3-0.7
	Mean				4.4	121	7.0	3.3
	S.D.			Gill	0.5	19	1.7	0.8
	Range				4.0-5.1	104-125	4.9-9.2	2.5-4.3
	Mean				19	160	139	2.7
	S.D.			Viscera	5.6	90	9.3	1.1
	Range				12-26	58-254	123-147	1.4-3.9
Site 17	Mean	96	7.2		3.8	113	8.6	0.6
Browns Bank	S.D.	3.0	0.4	Muscle	3.1	7.6	3.9	0.2
(n = 5)	Range	93-101 (Medium)	7-8		1.9-9.4	106-123	5.4-15	0.4-0.8
	Mean				3.7	107	11	1.1
42°29'12" N	S.D.			Mantle	2.5	25	3.3	0.3
65°46'01" W	Range				1.3-7.8	91-150	7.0-14	0.7-1.6
	Mean				9.1	136	16	2.4
	S.D.			Gill	7.4	38	3.6	1.0
	Range				4.5-22	105-200	12-20	1.1-3.7
	Mean				55	172	699	3.2
	S.D.			Viscera	5.8	90	141	0.6
	Range				48-63	98-322	544-852	2.3-3.8

Table 10. (cont'd.)

Location		Size (mm)	Age (yr)	Organ	Metal (µg/g dry) Cu	Zn	Cd	Pb
Site 17	Mean	79	5.6		2.9	110	26	0.8
	S.D.	3.5	1.0	Muscle	0.8	22	9.4	0.7
Browns Bank	Range	72-82	4-7		2.1-4.0	93-157	11-36	0.2-2.2
(n = 7)		(Small)						
	Mean				5.6	107	22	0.8
42°29'12" N	S.D.			Mantle	1.1	30	11	0.2
65°46'01" W	Range				4.0-7.5	71-159	5.1-36	0.6-1.0
	Mean				9.8	139	31	5.2
	S.D.			Gill	3.6	60	15	5.5
	Range				5.9-16	81-222	13-54	2.3-18
	Mean				68	205	610	3.5
	S.D.			Viscera	35	56	350	1.5
	Range				35-133	111-281	190-1057	1.7-5.9
Site 18	Mean	96	5.6		3.6	108	5.0	0.6
	S.D.	2.9	0.5	Muscle	1.2	10	3.1	0.4
Georges Bank	Range	92-100	5-6		2.3-5.1	97-121	2.9-11	0.2-1.1
(n = 5)		(Medium)						
	Mean				4.0	81	7.9	0.8
41°29'12" N	S.D.			Mantle	3.9	4.4	3.8	0.2
66°07'30" W	Range				1.6-11	75-87	4.9-14	0.6-1.1
	Mean				6.4	117	12	1.8
	S.D.			Gill	1.8	29	3.2	1.4
	Range				4.2-8.9	87-156	7.0-16	0.9-4.2
	Mean				17.	136	183	1.7
	S.D.			Viscera	6.6	94	97	0.9
	Range				9.0-25	61-265	71-300	1.1-3.2
Site 19	Mean	77	3.6		2.1	63	14	0.4
	S.D.	4.4	0.6	Muscle	0.5	9.7	5.3	0.2
Georges Bank	Range	69-80	3-4		1.7-2.7	54-77	6.4-19	0.2-0.6
(n = 5)		(Small)						
	Mean				3.6	87	6.0	0.8
42°04'17" N	S.D.			Mantle	0.8	8.0	3.4	0.3
66°47'03" W	Range				2.7-4.6	76-97	2.4-9.7	0.5-1.2
	Mean				6.2	129	14	1.4
	S.D.			Gill	0.7	45	3.2	0.5
	Range				5.4-7.2	94-207	8.7-17	0.9-2.0
	Mean				11	91	69	1.0
	S.D.			Viscera	1.3	53	5.6	0.3
	Range				9.0-12	56-176	61-76	0.7-1.4
Site 19	Mean	95	5.4		2.3	65	6.6	0.4
	S.D.	5.1	0.6	Muscle	0.5	7.4	2.8	0.3
Georges Bank	Range	89-100	5-6		2.0-3.3	54-75	3.2-9.7	0.1-0.9
(n = 5)		(Medium)						
	Mean				3.3	91	3.4	0.9
42°04'17" N	S.D.			Mantle	0.3	17	2.3	0.8
66°47'03" W	Range				3.0-3.6	68-106	1.0-5.8	0.3-2.2
	Mean				7.0	156	14	0.7
	S.D.			Gill	1.8	66	5.6	0.3
	Range				3.9-8.4	80-255	7.5-19	0.4-1.2
	Mean				12	112	89	0.9
	S.D.			Viscera	2.1	50	23	0.2
	Range				9.2-14	56-152	59-115	0.6-1.2

Table 10. (cont'd.)

Location		Size (mm)	Age (yr)	Organ	Metal (μg/g dry) Cu	Zn	Cd	Pb
Site 19	Mean	122	9.7		1.9	68	14	0.9
	S.D.	4.6	1.2	Muscle	0.2	10	5.8	0.5
Georges Bank	Range	115-126	9-12		1.8-2.2	56-82	5.6-20	0.3-1.6
(n = 6)		(Large)						
	Mean				3.2	68	12	0.8
42°04'17" N	S.D.			Mantle	0.4	13	9.1	0.7
66°47'03" W	Range				2.8-3.7	53-85	3.1-30	0.3-2.2
	Mean				5.2	125	26	0.6
	S.D.			Gill	0.5	48	6.2	0.2
	Range				4.6-5.8	89-220	15-35	0.3-1.0
	Mean				13	101	175	1.1
	S.D.			Viscera	2.3	81	49	0.4
	Range				9.3-16	48-262	137-254	0.6-1.4

Table 11. Correlation coefficients of data for Zn, Cu, Pb, and Cd concentrations in muscle (MT), mantle (MN), gill (GL), and viscera (VS) of scallops from Chaleur Bay (n = 60, all sizes combined). Underlined values are significant at least at 5% level.

	ZnMN	ZnGL	ZnVS	CuMT	CuMN	CuGL	CuVS	PbMT	PbMN	PbGL	PbVS	CdMT	CdMN	CdGL	CdVS	Shell Ht.
ZnMT	-0.17	-0.22	0.09	0.25	0.20	0.01	-0.01	0.12	0.27	0.22	0.09	0.37	0.11	0.10	0.13	0.25
ZnMN		0.18	-0.08	-0.09	0.12	0.30	0.04	-0.11	0.19	0.12	0.02	0.09	0.20	0.01	-0.26	-0.47
ZnGL			0.19	-0.13	-0.02	-0.24	0.07	0.37	0.09	0.28	0.33	-0.16	0.09	0.31	-0.09	-0.20
ZnVS				0.19	-0.13	-0.16	0.35	0.35	-0.11	-0.03	0.01	-0.18	0.00	-0.10	0.36	-0.20
CuMT					0.12	-0.04	0.16	0.50	0.27	0.27	0.23	0.53	0.39	0.20	0.35	0.17
CuMN						0.28	-0.09	0.03	0.12	0.13	-0.06	0.30	0.19	0.12	0.03	0.00
CuGL							0.10	-0.07	0.22	0.54	0.13	0.34	0.22	0.24	0.06	0.06
CuVS								0.30	0.03	0.33	0.31	0.11	0.26	0.10	0.56	0.24
PbMT									0.04	0.20	0.26	0.20	0.17	0.38	0.34	0.05
PbMN										0.55	0.60	0.50	0.50	0.37	0.07	-0.11
PbGL											0.64	0.57	0.48	0.58	0.34	0.09
PbVS												0.38	0.51	0.60	0.29	-0.03
CdMT													0.57	0.44	0.33	0.08
CdMN														0.39	0.22	0.01
CdGL															0.42	0.13
CdVS																0.45

Table 12. Correlation coefficients of data for Zn, Cu, Pb, and Cd concentrations in muscle (MT), mantle (MN), gill (GL) and viscera (VS) of scallops from Northumberland Strait (sites 9, 10, 11 and 12) (n = 20). Underlined values are significant at least at 5% level.

	ZnMN	ZnGL	ZnVS	CuMT	CuMN	CuGL	CuVS	PbMT	PbMN	PbGL	PbVS	CdMT	CdMN	CdGL	CdVS	Shell Ht.
ZnMT	-0.05	0.31	0.19	0.01	-0.29	0.04	0.49	0.40	0.08	0.23	0.52	-0.19	0.35	-0.13	0.46	0.09
ZnMN	-	0.78	0.33	0.35	0.16	0.04	-0.35	0.17	0.35	0.23	0.59	-0.56	-0.56	-0.43	0.23	-0.27
ZnGL		-	0.24	0.52	-0.06	0.04	-0.24	0.26	0.48	0.29	0.83	-0.63	-0.60	-0.31	0.41	-0.45
ZnVS			-	0.10	-0.04	0.24	-0.06	0.29	-0.01	0.50	0.19	-0.24	-0.49	-0.56	0.42	0.20
CuMT				-	-0.03	0.12	-0.18	0.24	0.31	0.51	0.38	-0.06	-0.39	-0.27	-0.04	-0.61
CuMN					-	0.04	-0.23	-0.11	0.22	0.15	-0.02	0.03	0.11	-0.39	-0.15	-0.18
CuGL						-	0.06	-0.07	-0.04	0.30	0.18	0.24	0.00	-0.07	0.06	-0.17
CuVS							-	-0.08	-0.34	-0.30	-0.33	0.34	0.06	0.26	0.23	0.28
PbMT								-	0.09	0.63	0.48	-0.24	-0.38	-0.32	0.35	0.20
PbMN									-	0.14	0.62	-0.31	-0.22	-0.36	-0.05	-0.50
PbGL										-	0.40	-0.24	-0.51	-0.58	0.24	-0.21
PbVS											-	-0.61	-0.51	-0.41	0.49	-0.37
CdMT												-	0.67	0.53	-0.42	0.20
CdMN													-	0.74	-0.51	0.20
CdGL														-	-0.34	0.11
CdVS															-	0.25

Table 13. Correlation coefficients of data for Zn, Cu, Pb, and Cd concentrations in muscle (MT), mantle (MN), gill (GL) and viscera (VS) of scallops from Bay of Fundy (sites 13, 14 and 15) (n = 15). Underlined values are significant at least at 5% level.

	ZnMN	ZnGL	ZnVS	CuMT	CuMN	CuGL	CuVS	PbMT	PbMN	PbGL	PbVS	CdMT	CdMN	CdGL	CdVS	Shell Ht.
ZnMT	0.48	0.82	0.66	0.34	-0.39	0.10	0.15	0.46	0.30	0.19	0.31	-0.23	-0.54	-0.60	-0.54	-0.10
ZnMN	-	0.32	0.14	0.36	-0.26	0.07	-0.22	-0.29	0.47	0.15	0.35	-0.40	-0.02	-0.38	0.29	0.07
ZnGL		-	0.83	-0.22	-0.31	0.14	0.35	0.44	0.08	0.01	0.01	-0.22	-0.35	-0.28	-0.38	-0.15
ZnVS			-	-0.13	-0.10	-0.12	-0.50	-0.50	-0.16	-0.25	-0.30	-0.02	-0.26	-0.17	0.15	-0.04
CuMT				-	-0.34	-0.77	-0.27	-0.13	-0.61	0.55	0.55	-0.41	-0.40	-0.44	0.56	-0.36
CuMN					-	-0.19	-0.26	-0.22	-0.18	0.12	-0.54	0.20	0.39	0.28	-0.62	0.40
CuGL						-	0.00	-0.10	0.59	0.31	0.32	-0.44	-0.33	-0.31	0.60	-0.24
CuVS							-	0.46	-0.17	-0.45	-0.28	0.34	0.10	0.16	0.19	0.13
PbMT								-	-0.42	-0.24	-0.19	-0.59	-0.02	0.10	-0.03	-0.14
PbMN									-	0.71	0.54	-0.67	-0.52	-0.70	0.77	-0.16
PbGL										-	0.44	-0.40	-0.46	-0.46	0.41	-0.37
PbVS											-	-0.51	-0.48	-0.59	0.58	-0.21
CdMT												-	0.62	0.57	-0.60	0.08
CdMN													-	0.80	-0.76	0.45
CdGL														-	-0.78	0.37
CdVS															-	-0.36

Table 14. Correlation coefficients of data for Zn, Cu, Pb, and Cd concentrations in muscle (MT), mantle (MN), gill (GL) and viscera (VS) of scallops from Open Ocean Sites (16, 17, 18 and 19) (n = 38). Underlined values are significant at least at 5% level.

	ZnMN	ZnGL	ZnVS	CuMT	CuMN	CuGL	CuVS	PbMT	PbMN	PbGL	PbVS	CdMT	CdMN	CdGL	CdVS	Shell Ht.
ZnMT	0.32	0.03	0.43	0.45	0.21	0.20	0.49	0.15	0.08	0.29	0.57	0.10	0.32	-0.06	0.51	-0.21
ZnMN	-	0.35	0.36	0.21	0.22	0.31	0.41	-0.05	-0.05	0.15	0.34	0.11	-0.03	-0.04	0.27	-0.47
ZnGL		-	0.47	0.32	-0.07	0.27	-0.04	-0.19	-0.07	-0.19	-0.10	-0.03	-0.20	-0.19	-0.09	-0.02
ZnVS			-	0.49	-0.06	0.26	0.43	0.08	-0.27	0.24	0.42	0.12	0.24	0.06	0.38	-0.23
CuMT				-	0.13	0.10	0.17	0.02	0.01	0.02	0.34	-0.20	-0.05	-0.16	0.10	-0.15
CuMN					-	0.19	0.19	-0.03	0.12	0.34	0.40	0.16	0.07	0.10	0.13	-0.20
CuGL						-	0.47	-0.11	0.11	0.03	0.30	0.10	0.03	0.17	0.35	-0.24
CuVS							-	0.09	0.04	0.42	0.73	0.44	0.59	0.46	0.88	-0.34
PbMT								-	-0.17	-0.03	0.28	0.07	0.22	0.20	0.13	0.19
PbMN									-	-0.08	-0.04	0.06	-0.12	-0.02	0.11	-0.02
PbGL										-	0.61	-0.10	0.33	0.12	0.52	-0.32
PbVS											-	0.21	0.37	0.23	0.75	-0.27
CdMT												-	0.75	0.76	0.38	-0.25
CdMN													-	0.72	0.60	-0.15
CdGL														-	0.40	0.06
CdVS															-	-0.20

Table 15. Correlation coefficients of data for Zn, Cu, Pb, and Cd concentrations in muscle (MT), mantle (MN), gill (GL) and viscera (VS) of scallops from all sites combined (n = 133). Underlined values are significant at least at 5% level.

	ZnMN	ZnGL	ZnVS	CuMT	CuMN	CuGL	CuVS	PbMT	PbMN	PbGL	PbVS	CdMT	CdMN	CdGL	CdVS	Shell Ht.
ZnMT	0.13	-0.02	0.34	0.22	0.13	0.05	0.44	0.18	0.21	0.26	0.21	0.33	0.25	0.15	0.40	0.06
ZnMN	-	0.23	0.14	0.03	0.10	0.24	0.24	-0.01	0.05	0.17	0.12	0.12	0.15	0.05	0.03	-0.39
ZnGL		-	0.15	-0.01	-0.04	0.20	-0.09	0.20	0.02	0.09	0.06	-0.13	-0.07	0.08	-0.12	-0.20
ZnVS			-	0.20	-0.07	-0.03	0.46	0.42	0.18	0.24	0.34	0.01	0.19	0.17	0.42	0.07
CuMT				-	0.08	0.05	0.10	0.43	0.12	0.25	0.21	0.23	0.24	0.15	0.25	0.08
CuMN					-	0.19	0.03	0.03	-0.03	0.14	-0.01	0.22	0.16	0.10	0.04	-0.03
CuGL						-	0.16	-0.04	0.06	0.38	0.11	0.17	0.14	0.18	0.11	-0.08
CuVS							-	0.29	0.05	0.38	0.40	0.36	0.46	0.32	0.72	0.02
PbMT								-	0.07	0.37	0.47	0.12	0.27	0.38	0.34	0.14
PbMN									-	0.20	0.23	0.05	0.13	0.16	0.03	0.02
PbGL										-	0.74	0.30	0.49	0.64	0.41	0.14
PbVS											-	0.14	0.50	0.70	0.36	0.15
CdMT												-	0.58	0.34	0.38	-0.08
CdMN													-	0.47	0.40	0.03
CdGL														-	0.43	0.22
CdVS															-	-0.24

Table 16. Duncan's multiple range test for differences in mean concentrations of metals in scallop tissues from the various sites (regions not underlined are significantly different; $p < 0.05$). Sites: 1- Dalhousie Ferry, 2 - Heron Island, 3 - Heron Island W., 4 - Belledune, 5 - Green Point, 6 - Beresford, 7 - Bathurst Harbour, 8 - Janesville, 15 - Navy Island (control site).

Zn	Muscle	Site	15	8	4	5	3	6	7	1	2
		Mean	70.4	78.0	81.6	82.1	82.4	86.3	90.0	91.1	91.7
	Mantle	Site	1	2	15	5	3	8	6	4	7
		Mean	76.1	76.4	83.5	84.0	87.8	91.9	95.8	101	101
	Gill	Site	6	3	7	8	1	2	4	15	5
		Mean	69.7	76.4	92.5	93.6	108	110	135	143	264
	Viscera	Site	15	2	1	3	7	8	6	5	4
		Mean	87.8	182	185	187	199	203	209	218	248
Cu	Muscle	Site	1	8	5	2	6	7	4	3	15
		Mean	0.84	0.86	0.88	1.0	1.4	2.0	3.7	4.4	4.5
	Mantle	Site	4	5	15	2	3	1	7	8	6
		Mean	0.73	1.5	1.9	2.6	2.6	3.1	3.3	3.4	4.6
	Gill	Site	4	7	3	6	5	8	2	1	15
		Mean	4.3	5.9	5.9	6.0	6.8	7.2	7.5	9.6	10.1
	Viscera	Site	15	3	2	1	6	4	8	7	5
		Mean	10.7	28.0	29.1	29.4	34.4	36.9	37.0	39.1	47.0
Pb	Muscle	Site	15	8	7	6	2	1	3	4	5
		Mean	0.22	0.45	0.74	0.88	1.0	2.1	2.2	2.4	4.7
	Mantle	Site	15	1	2	3	7	8	6	5	4
		Mean	1.3	1.5	1.7	1.7	2.4	2.6	2.7	4.3	4.8
	Gill	Site	15	1	2	7	3	8	6	4	5
		Mean	1.5	2.2	3.2	3.8	3.9	3.9	7.4	9.2	11.7
	Viscera	Site	15	2	3	8	1	6	7	4	5
		Mean	2.4	3.9	4.4	6.1	6.2	7.0	8.7	17.7	22.7
Cd	Muscle	Site	15	2	8	6	3	1	5	4	7
		Mean	1.1	1.9	2.0	2.6	3.1	3.5	3.9	4.2	5.4
	Mantle	Site	15	1	3	2	8	6	4	7	5
		Mean	1.6	3.9	4.3	4.8	8.1	10.2	14.6	16.7	17.4
	Gill	Site	15	7	8	6	3	1	2	4	5
		Mean	4.6	16.1	21.4	22.7	28.4	30.6	31.1	52.0	61.2
	Viscera	Site	15	1	2	4	6	8	3	5	7
		Mean	106	212	246	270	277	281	296	322	385

Table 17. Duncan's multiple range test for differences in mean concentrations of metals in different scallop tissues, age, and size from Northumberland Strait (regions not underlined are significantly different). Sites: 9 - Miminegash, 10 - Egmont Bay, 11 - Wood Island, 12 - Cape Breton, 15 - Navy Island.

Zn	Muscle	Site	9	15	12	10	11
		Mean	56.9	70.4	71.0	74.4	76.1
	Mantle	Site	10	9	11	15	12
		Mean	71.8	76.5	82.1	83.5	100
	Gill	Site	9	10	15	11	12
		Mean	94.7	141	143	158	208
	Viscera	Site	10	15	9	12	11
		Mean	70.0	87.8	88.3	94.1	110
Cu	Muscle	Site	9	10	12	11	15
		Mean	1.5	1.9	3.6	3.9	4.5
	Mantle	Site	15	10	12	11	9
		Mean	1.9	2.1	3.1	3.3	3.9
	Gill	Site	9	10	12	15	11
		Mean	4.8	6.0	6.5	10.1	14.1
	Viscera	Site	12	15	11	9	10
		Mean	8.4	10.7	12.4	12.7	13.8
Pb	Muscle	Site	9	15	10	12	11
		Mean	0.10	0.22	0.24	0.40	0.48
	Mantle	Site	10	11	9	12	15
		Mean	0.24	0.50	0.50	1.3	1.3
	Gill	Site	10	15	9	12	11
		Mean	0.58	1.5	1.7	2.7	5.4
	Viscera	Site	9	10	11	15	12
		Mean	0.50	1.1	1.7	2.4	2.6
Cd	Muscle	Site	15	12	11	9	10
		Mean	1.1	1.8	3.1	3.7	4.0
	Mantle	Site	15	12	11	9	10
		Mean	1.6	5.1	6.4	9.7	10.9
	Gill	Site	15	12	11	9	10
		Mean	4.6	8.7	9.6	14.6	28.9
	Viscera	Site	9	15	10	11	12
		Mean	84.4	106	129	147	216
Age		Site	15	11	10	9	12
		Mean	4.0	5.0	6.4	6.6	9.6
Size		Site	12	11	15	9	10
		Mean	95.4	95.6	96.0	99.8	101

Table 18. Duncan's multiple range test for differences of age and size, mean concentrations of metals in scallop tissues from Bay of Fundy (regions not underlined are significantly different $p < 0.05$). Sites: 13 - Digby, 14 - Mascarene (Passamaquoddy Bay) and 15 - Navy Island (Control site).

Zn	Muscle	Site	14	15	13
		Mean	54.9	70.4	73.7
	Mantle	Site	14	13	15
		Mean	65.8	75.7	83.5
	Gill	Site	14	15	13
		Mean	100	143	177
	Viscera	Site	14	15	13
		Mean	73.6	87.8	195
Cu	Muscle	Site	14	13	15
		Mean	1.9	2.3	4.5
	Mantle	Site	15	13	14
		Mean	1.9	3.5	7.5
	Gill	Site	13	14	15
		Mean	5.2	5.7	10.1
	Viscera	Site	14	15	13
		Mean	10.4	10.7	13.4
Pb	Muscle	Site	14	15	13
		Mean	0.20	0.22	0.68
	Mantle	Site	13	14	15
		Mean	0.42	0.46	1.3
	Gill	Site	14	13	15
		Mean	0.88	0.96	1.5
	Viscera	Site	14	13	15
		Mean	1.3	1.3	2.4
Cd	Muscle	Site	15	14	13
		Mean	1.1	3.6	4.6
	Mantle	Site	15	13	14
		Mean	1.6	4.3	6.0
	Gill	Site	15	13	14
		Mean	4.6	10.2	15.5
	Viscera	Site	14	13	15
		Mean	30.6	63.5	106
Age		Site	15	14	13
		Mean	4.0	4.8	5.2
Size		Site	15	13	14
		Mean	96.0	96.8	98.6

Table 19. Duncan's multiple range test for differences in mean concentrations of metals in scallop tissues, age, and size from open ocean sites (regions not underlined are significantly different). Sites: 15 - Navy Island, (control site), 16 - McDormand Patch, 17 - Browns Bank, 18 - Georges Bank (location 1), 19 - Georges Bank (location 2).

Zn	Muscle	Site	19	15	16	18	17
		Mean	65.0	70.4	103	108	113
	Mantle	Site	16	18	15	19	17
		Mean	77.6	80.7	83.5	91.0	107
	Gill	Site	18	16	17	15	19
		Mean	117	121	136	143	156
	Viscera	Site	15	19	18	16	17
		Mean	87.8	112	136	160	172
Cu	Muscle	Site	19	16	18	17	15
		Mean	2.3	3.0	3.6	3.8	4.5
	Mantle	Site	15	19	17	18	16
		Mean	1.9	3.3	3.7	4.0	4.6
	Gill	Site	16	18	19	17	15
		Mean	4.4	6.4	7.0	9.1	10.1
	Viscera	Site	15	19	18	16	17
		Mean	10.7	12.0	17.0	18.6	55.2
Pb	Muscle	Site	15	19	18	17	16
		Mean	0.22	0.40	0.56	0.58	1.0
	Mantle	Site	16	18	19	17	15
		Mean	0.46	0.80	0.90	1.1	1.3
	Gill	Site	19	15	18	17	16
		Mean	0.70	1.5	1.8	2.4	3.3
	Viscera	Site	19	18	15	16	17
		Mean	0.85	1.7	2.4	2.7	3.2
Cd	Muscle	Site	15	16	18	19	17
		Mean	1.1	4.2	5.0	6.6	8.6
	Mantle	Site	15	19	16	18	17
		Mean	1.6	3.4	5.4	7.9	11.3
	Gill	Site	15	16	18	19	17
		Mean	4.6	7.0	11.8	14.0	16.1
	Viscera	Site	19	15	16	18	17
		Mean	89.0	106	139	183	699
Age		Site	15	19	18	16	17
		Mean	4.0	5.4	5.6	7.2	7.2
Size		Site	19	17	15	18	16
		Mean	95.0	95.8	96.0	96.0	97.8

Table 20. Duncan's multiple range test for differences in means of concentration of metals, in tissues of medium-sized scallops (all sites), age and size (regions not underlined are significantly different). Sites: 1 - Dalhousie Ferry, 2 - Heron Island, 3 - Heron Island W, 4 - Belledune, 5 - Green Point, 6 - Beresford, 7- Bathurst Harbour, 8 - Janesville, 9 - Miminegash, 10 - Egmont Bay, 11 - Wood Island, 12 - Cape Breton, 13 - Digby, 14 - Mascarene, 15 - Navy Island, 16 - McDormand Patch, 17 - Browns Bank, 18 - Georges Bank (location 1), 19 - Georges Bank (location 2).

Zn

Muscle	Site	14	9	19	15	12	13	10	11	8	4	5	3	6	7	1	2	16	18	17
	Mean	54.9	56.9	65.0	70.4	71.0	73.7	74.4	76.1	78.0	81.6	82.1	82.4	86.3	90.0	91.1	91.7	103	108	113
Mantle	Site	14	10	13	1	2	9	16	18	11	15	5	3	19	8	6	12	4	7	17
	Mean	65.8	71.7	75.7	76.1	76.2	76.5	77.6	80.7	82.1	83.5	84.0	87.8	91.0	91.9	95.8	100	101	101	107
Gill	Site	6	3	7	8	9	14	1	2	18	16	4	17	10	15	19	11	13	12	5
	Mean	69.7	76.4	92.5	94.0	94.7	100	108	110	117	121	135	136	141	143	156	158	177	208	264
Viscera	Site	10	14	15	9	12	11	19	18	16	17	2	1	3	13	7	8	6	5	4
	Mean	70.0	73.6	87.8	88.3	94.1	110	112	137	161	171	182	185	187	195	199	203	209	218	248

Cu

Muscle	Site	1	8	5	2	6	9	14	10	7	13	19	16	18	12	4	17	11	3	15
	Mean	0.84	0.86	0.88	1.0	1.4	1.5	1.9	1.9	2.0	2.3	2.3	3.0	3.6	3.6	3.7	3.8	3.9	4.4	4.5
Mantle	Site	4	5	15	10	2	3	12	1	19	11	7	8	13	17	9	18	6	16	14
	Mean	0.73	1.5	1.9	2.1	2.6	2.6	3.1	3.1	3.3	3.3	3.3	3.4	3.5	3.7	3.9	4.0	4.6	4.6	7.5
Gill	Site	4	16	9	13	14	7	3	10	6	18	12	5	19	8	2	17	1	15	11
	Mean	4.4	4.4	4.8	5.2	5.7	5.8	5.9	6.0	6.0	6.4	6.5	6.8	7.0	7.2	7.5	9.1	9.6	10.1	14.1
Viscera	Site	12	14	15	19	11	9	13	10	18	16	3	2	1	6	4	8	7	5	17
	Mean	8.4	10.4	10.7	12.0	12.4	12.7	13.4	13.8	17.0	18.6	28.0	29.1	29.4	34.4	36.9	37.0	39.1	47.0	55.2

Table 20 (cont'd.)

Pb																				
Muscle	Site	9	14	15	10	12	19	8	11	18	17	13	7	6	2	16	1	3	4	5
	Mean	0.10	0.20	0.22	0.24	0.40	0.40	0.44	0.48	0.56	0.58	0.68	0.74	0.88	1.0	1.0	2.1	2.2	2.4	2.7
Mantle	Site	10	13	14	16	11	9	18	19	17	12	15	1	2	3	7	8	6	5	4
	Mean	0.24	0.42	0.46	0.46	0.50	0.50	0.80	0.90	1.1	1.3	1.3	1.5	1.6	1.7	2.4	2.6	2.7	4.3	4.8
Gill	Site	10	19	14	13	15	9	18	1	17	12	2	16	7	3	8	11	6	4	5
	Mean	0.58	0.70	0.88	0.96	1.5	1.7	1.8	2.2	2.4	2.7	3.2	3.3	3.8	3.9	3.9	5.4	7.4	9.1	11.7
Viscera	Site	9	19	10	14	13	18	11	15	12	16	17	2	3	8	1	6	7	4	5
	Mean	0.50	0.90	1.1	1.3	1.3	1.7	1.7	2.4	2.6	2.7	3.2	3.9	4.4	6.1	6.2	7.0	8.7	17.7	22.7
Cd																				
Muscle	Site	15	12	2	8	6	3	11	1	14	9	5	10	4	16	13	18	7	19	17
	Mean	1.1	1.8	1.9	2.0	2.6	3.1	3.1	3.5	3.6	3.7	3.9	4.0	4.2	4.2	4.6	5.0	5.4	6.6	8.6
Mantle	Site	15	19	1	13	3	2	12	16	14	11	18	8	9	6	10	17	4	7	5
	Mean	1.6	3.4	3.4	4.3	4.3	4.8	5.1	5.4	6.1	6.4	7.9	8.1	9.7	10.2	10.9	11.3	14.6	16.7	17.4
Gill	Site	15	16	12	11	13	18	19	9	14	7	17	8	6	3	10	1	2	4	5
	Mean	4.6	7.0	8.7	9.6	10.2	11.8	14.0	14.6	15.5	16.1	16.1	21.4	22.7	28.4	28.9	30.6	31.1	52.0	61.2
Viscera	Site	14	13	9	19	15	10	16	11	18	1	12	2	4	6	8	3	5	7	17
	Mean	30.6	63.5	84.4	89.0	106	129	139	147	183	212	216	246	270	277	281	296	322	385	699
Age	Site	15	14	11	13	19	18	4	5	10	9	16	17	12						
	Mean	4.0	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.4	6.6	7.2	7.2	9.6						
Size	Site	8	19	12	11	17	15	18	13	4	16	14	6	7	9	5	10	1	3	2
		95.0	95.0	95.4	95.6	95.8	96.0	96.0	96.8	97.0	97.8	98.6	99.0	99.0	99.8	100	101	103	114	119

Table 21. Total body burden (µg) of Cu, Zn, Cd, and Pb in whole body soft tissues of scallops from sites 4 and 5 on Chaleur Bay and control site on Bay of Fundy.

Shell ht	Site 4				Site 5				Control site			
(mm)	Cu	Zn	Cd	Pb	Cu	Zn	Cd	Pb	Cu	Zn	Cd	Pb
>90	8.0	82	41	5.4	-	-	-	-	-	-	55	
90-110	58	562	355	34	87	692	646	57	25	359	83	3.5
>110	94	744	1030	50	79	630	621	48	--	-	600	-

Table 22. Total body burden of Cd (µg) in adductor muscle and whole body of scallops from Navy Island (n=9), Georges Bank (n=16), and Browns Bank (n=12).

Size	Navy Island		Georges Bank		Browns Bank	
	Muscle	Whole	Muscle	Whole	Muscle	Whole
Small (<100 mm)	0.8	71	23	135	18	245
Large (>100 mm)	6.8	686	97	1020	-	-