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Cadmium in oysters and scallops: the BC experience

George M. Kruzynski*

Fisheries and Oceans Canada, Marine Environmental Quality Division, Institute of Ocean Sciences, 9860 West Saanich Road, Sidney, BC, Canada V8L 4B2

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Abstract

Health effects of non-occupational lifetime exposure to cadmium (Cd) are of growing concern worldwide. This overview provides some context for the current situation in coastal British Columbia, Canada, which arose in 1999 from the discovery of problematic residues of Cd in farmed Pacific oysters (*Crassostrea gigas*). Efforts are underway to define Cd sources and the geographical and seasonal variation of these Cd residues. The recent application by the European Community of a 1 μg Cd/g (wet weight) import limit to bivalve molluscs and the current deliberation by CODEX to adopt the same value, pose significant threats to the shellfish export trade in the Pacific Northwest (British Columbia, Washington and Alaska), where natural oceanographic conditions and coastal geology contribute to levels of Cd that usually exceed the 1 ppm limit. Human health aspects of chronic Cd exposure comprise an active field of study (this Symposium) and the validity of existing Provisional Tolerable Weekly Intake is being questioned. Bioavailability of Cd from the oyster and scallop matrix is unknown and requires study. Ramifications of this uncertainty may include damage to public perception of the safety of the cultured shellfish product, loss of export market and general undermining of an industry being encouraged by both the Province of British Columbia and Federal aquaculture initiatives. There is therefore a pressing need to redefine what the "safe" limit of lifetime Cd intake is from all sources, and determine bioavailability, specifically from bivalve molluscs. Such information would facilitate the definition of scientifically defensible Cd limits by CODEX.

Keywords: Cadmium; Environmental sources; Bioavailability; CODEX; Pacific oyster (*Crassostrea gigas*); Scallop; Aquaculture; British Columbia; Canada

1. Background and socioeconomics of bivalve shellfish aquaculture in BC

In British Columbia, a downturn in a historically forest- and fisheries-based economy has resulted in hardship in many coastal communities and efforts to find alternative employment opportunities are underway. Diversification into other pursuits especially aquaculture, both finfish and shellfish, has been encouraged by Provincial and Federal governments. In 1997, the BC shellfish industry comprised 258 companies, 423 shellfish tenures and supported ∼1000 jobs. The Shellfish Development Initiative announced by the Provincial Government in 1997, planned to double the amount of crown land made available for bivalve shellfish aquaculture with projections of a

* Tel.: +1-250-363-6408; fax: +1-250-363-6807.
E-mail address: kruzynskig@pac.dfo-mpo.gc.ca (G.M. Kruzynski).

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US$ 100 M per year industry from the 12.3 M at the time, with hopes of adding 1100 jobs within 10 years (Carswell, 2001). The species in order of production were oysters > clams > scallops.

In 1996, the world cultured production of the Pacific (Japanese) oyster (*Crassostrea gigas*) was US$ 3.23 billion and that of the Japanese scallop (*Pecten yessoensis*) was US$ 1.62 billion (FAO, 2000). To take advantage of these markets, the initial culture shellfish species of choice in British Columbia was the Pacific oyster (*C. gigas*). Although the scallop culture industry on the Pacific coast is just in the formative stages, the potential for growth is excellent and there are great hopes for this lucrative product. In British Columbia, cold water temperatures limit natural spawning of oysters to a small area of the coast, however, hatchery production is used to seed elsewhere as well as in Washington State and Alaska. With a coastline of 27,000 km BC is well placed for cold water aquaculture expansion and in general, growing conditions are excellent up to northern Alaska (60°N) latitude, (Fig. 1). With much of the north coast sparsely inhabited wilderness, cultured product is frequently marketed with descriptors such as "pristine." In this context, the discovery of a toxic metal at levels sufficient to elicit trade barriers and raise questions about potential health effects has proven to be a sudden shock for the shellfish industry in the Pacific Northwest.

In coastal BC, enthusiasm for aquaculture development on both the finfish and shellfish fronts has not been universal, and opponents include commercial fishers, environmental groups and land owners, some of whom view the expansion of shellfish activities as an industrial activity and an unwelcome intrusion on their lifestyle. Thus a variety of methods, not always

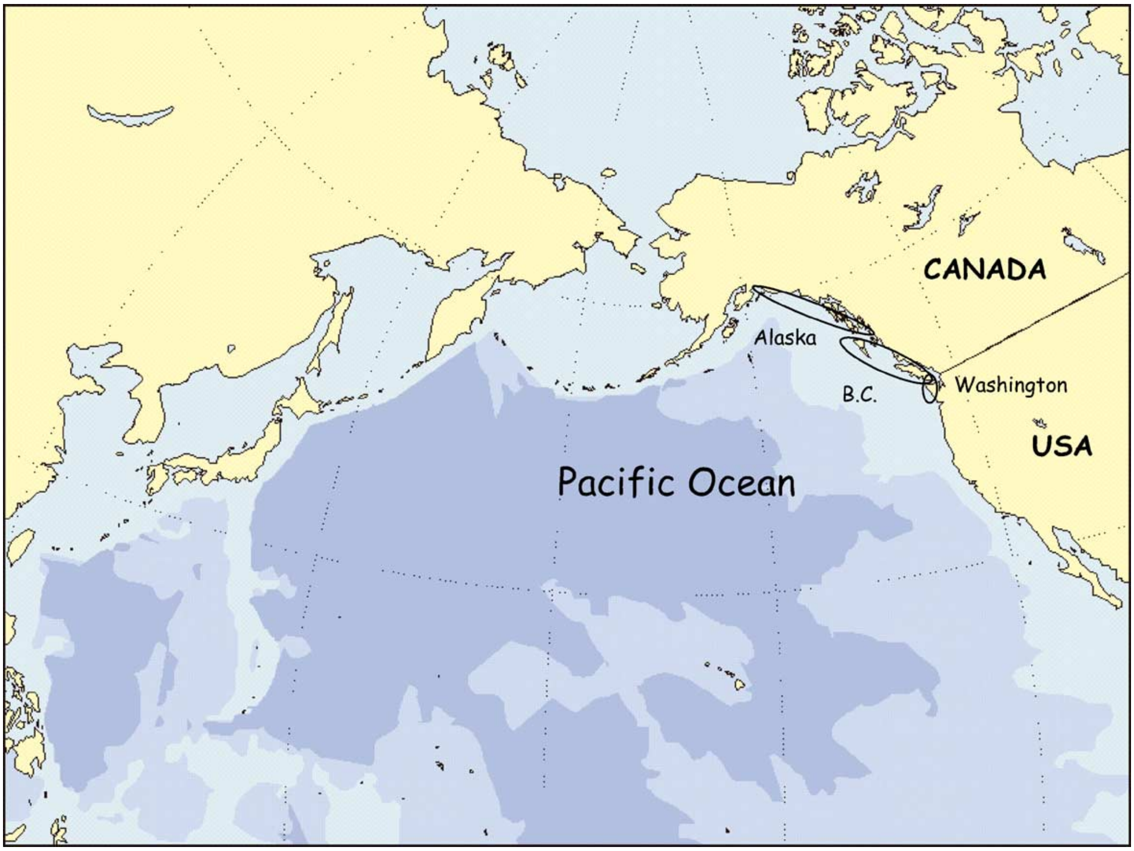

Fig. 1. Oyster growing areas on the northwest Pacific Coast of North America.

objective in nature, are being utilized by opponents to strengthen their case against aquaculture development. Industry finds itself in a defensive mode as a result of these developments, and the perception of hazard from cadmium by some in the media, and thereby the general public, is perceived by many oyster growers as a direct threat to their livelihood. However, in several cases, public opposition has been self-inflicted as a result of some growers expanding their operations beyond the area approved for their shellfish tenure. Some in the industry have made a concerted effort to stifle investigation of the cadmium issue, to shift the focus away from the question of possible health concerns, and to portray the issue of cadmium in their product as primarily an unfair trade barrier. Cadmium "contamination" has thus become politicized and has led to polarization in several coastal communities, with cadmium being used by some as yet another reason to lobby against expansion.

2. Historical perspective

In late 1999 and early 2000, several shipments of BC oysters were rejected by the Hong Kong Food and Environmental Hygiene Department as being in excess of their 2 ppm[1,2] (wet weight) cadmium import limit. A subsequent shellfish processor survey by the CFIA (Canadian Food Inspection Agency) established that these shipments were not anomalous and reported a mean cadmium value of 2.63 ppm (wet weight basis) for BC oysters cultured over a broad geographic area (Schallie, 2001). Sixty percent of the 81 samples were in excess of 2 ppm. CFIA contacted the Science Division of Fisheries and Oceans Canada (DFO) for advice on historical data that may exist and asked about possible sources where cadmium might be originating. Kruzynski (2000) provided a review of knowledge to date and recommended that an interdisciplinary workshop be held to discuss various aspects of the issue. The Proceedings of this workshop (Kruzynski et al., 2002) included recommendations for further research. Given DFO's mandate, there was limited discussion of human health concerns although Kruzynski (2001) calculated that a single meal of oysters at the CFIA-determined BC mean value could easily exceed the FAO/WHO provisional tolerable weekly intake (PTWI), (see Table 1 and Section 5 footnote). To put these figures in health risk perspective, CFIA requested that Health Canada (HC) conduct a formal Health Risk Assessment based on the CFIA mean Cd value. A recommendation for a limit of a dozen 40 g oysters per month per adult and one oyster per child was subsequently published (CFIA, 2003). In the absence of specific oyster Cd bioavailability data, HC utilized ∼5%, a figure in the mid-range of Cd bioavailability from other foodstuffs (IPCS, 1992), however, more recent research has found that cadmium absorption from food may reach 20–30% in some individuals (Diamond et al., 1997).

Table 1
Cadmium intake (micrograms) based on consumption of six oysters of a size[a] preferred by the Hong Kong market

	Cadmium residue (μg Cd/g ww)	Cadmium ingested (μg Cd)
Lowest regional mean	1.84	552
Highest regional mean	3.34	1002
Average (all regions)	2.63	790
Maximum value	5.50	1650
Hong Kong (MPC) limit	2.00	600
FAO/WHO PTWI (safe weekly intake from all sources)	NA	420–490

Residue data from the CFIA, 2003 processor survey. FAO/WHO PTWI from WHO, 1989. Health Canada Consumption Advisory for frequent oyster consumers comprises 460 g of oyster per month @ 2.6 μg Cd/g or ∼300 μg Cd per week.
[a] ∼50 g wet weight shucked meat.

The Health Canada risk assessment made no adjustment for sex differences and nutritional status (this Symposium: Satarug et al., 2004; paper by Vahter (2003); Nishijo et al., 2004 as well as Satarug et al. (2003) and Vahter et al. (2002)). Neither cadmium intake from smoking nor sex of oyster consumers were factored into the calculation of the consumption advisory, although Health Canada did acknowledge that both were important factors in the consideration of Cd uptake from all sources and its partitioning in

[1] 2 ppm is equivalent to 2 μg/g or 2 mg/kg. Some health authorities and shellfish growers are more familiar with ppm. However, some reports fail to define whether the data are reported on a dry or wet weight basis, rendering them un-interpretable.

[2] In 2002, an interlaboratory analytical comparison utilizing a (CFIA) homogenized sample of BC oysters and standard reference materials showed that at the >1 μg Cd/g (wet weight) level in question, results among several commercial, university and government laboratories were comparable.

the body. Furthermore, the lack of specific oyster consumption data precluded an accurate determination of intake and therefore dose.

3. International limits

Representatives of the BC Shellfish Growers Association (BCSGA) objected to the HC recommendations on the basis of unknown bioavailability, and some members adhere to the view that the current limits of 2 ppm (Hong Kong) and 1 ppm for the EU limits are merely trade barriers. The US FDA (Food and Drug Administration) recommends a 3.7 ppm Cd guideline but leaves adjustment to local (state agencies) to reflect regional consumption patterns and residues (US FDA, 1993). However, there is no evidence that this is happening on the Pacific Coast. Nationally, Canada has no MPC (maximum permitted concentration) for cadmium in bivalves, however, the HC consumption guideline was meant to provide guidance to frequent consumers. Hong Kong, Australia and New Zealand have standardized on an MPC (termed ML (maximum level) in Australia) of 2 ppm although the medical basis for these figures is not clearly defined in the scientific literature. The Australia New Zealand Food Standards Code (2003) makes an exemption from any limits on Cd for NZ Bluff oysters collected from the wild, and for which very high Cd levels of the order of 7 ppm have been documented (McKenzie et al., 1986 and references therein). Risk assessments were undertaken by Food Standards Australia New Zealand during revision of ML's for cadmium. In Australia, State Governments are responsible for enforcement of ML's presumably based on local conditions and their respective health standards (personal communication, Dr. Peter Abbott, Product Standards Program, Food Standards Australia New Zealand). Data presented by McKenzie et al. (1986), suggest possible genetic differences in Cd metabolism among frequent oyster consumers in Bluff New Zealand. Unfortunately few women were included in this study and a more comprehensive approach would be worthwhile. Vahter et al. (1996) appears to represent the only other study to include bivalves as part of diet in a human experiment to follow the fate of Cd after ingestion. However, details on the species of bivalve and its relative proportion in the "shellfish" diet are unfortunately not specified. The daily intake comprised 27.8 μg Cd/which should be compared with values presented in Table 1. No differences in bioavailability nor kinetics of Cd related to type of diet were found.

4. Information gaps

Given the current situation in BC, implications for public health, current CODEX (JECFA, 2003) deliberations as well as potential economic consequences, there is an urgent need to follow up on the NZ study in British Columbia. Such a study could benefit from the current understanding of the influences of nutritional factors, uptake biochemistry (Satarug et al., 2003 and references therein), e.g. that Zn and Cd are transported by different carriers; with Cd by the same carrier (DMT-1) as Fe and that, as a result there are important differences (Vahter et al., 2002; Nishijo et al., 2004) in cadmium toxicokinetics between men and women. Furthermore, the influences of chronic diseases such as diabetes and hypertension as well as smoking habits need to be included in a realistic health risk assessment. Finally, different MPC's, or preferably, consumption guidelines, should be established for the various sub-populations depending on their consumption patterns and the above factors.

In summary, international standards for Cd in bivalve molluscs lack standardization, the medical bases for these could benefit from transparency, and basic research is needed to define bioavailability and fate from the appropriate matrices. Such developments would dispel fears, enhance trust and facilitate collaboration with shellfish growers some of whom at the present time remain deeply suspicious. Among perceptions are: "big government" in collusion with "environmentalist" opponents is plotting to shut them down, cadmium is "natural" so why worry, and ultimately that carefully nurtured public perception of the wholesomeness of products generated by the aquaculture industry will be damaged with potential for catastrophic decline in marketability. On the other side of the ledger is a dearth of medical and biochemical information that would facilitate the definition of guidelines based on health considerations. In those cases where economic arguments may supersede medical ones, this should be clearly defined along with easily understood justification for such an approach to risk assessment.

5. Relationship to the cadmium PTWI[3]

Given the scope restricted by DFO workshop mandate, limited discussion of health issues was possible but potential pathways ranging from environmental sources to biochemical sinks within metallothionen pools (Roesijadi, 2001) were covered. At the time, Health Canada had not as yet completed its formal Health Risk Assessment, although their eventual monthly intake recommendations coincided with the FAO/WHO (JECFA, 2003) and US FDA (1993) PTWI calculations presented by Kruzynski (2001), e.g. six large 50-g oysters (of a size that would be shipped live to the Hong Kong market), at the HK limit of 2 ppm would provide 600 μg Cd per meal. Table 1 provides a comparison of intake over the range of Cd residues reported by CFIA. However, these figures do not include the daily intake from other sources estimated by US FDA (1993) to be in the range of 12 μg Cd and an additional 10 μg per day from smoking. Clearly if bioavailability were as currently assumed, Cd from bivalve sources would comprise a major component of chronic Cd intake for some sub-populations in British Columbia. It is for this reason that appropriately designed bioavailability studies are urgently needed. Several studies have reported that metallothionein (MT)-bound cadmium may have different pharmacodynamics than that which is free or bound to higher molecular weight moieties. Cherian (1983) reported similar absorption but different tissue distribution of Cd fed to mice as Cd-MT (preferentially to the kidney) versus cadmium chloride (preferentially to the liver). Sullivan et al. (1984) reported that mice fed a diet which included organically bound Cd (incorporated by oysters from phytoplankton) retained a higher percentage of the metal in the kidney than those fed a diet in which the Cd was in inorganic form. The degree of binding and molecular weight of the protein fraction involved appears to vary widely among species (Casterline and Yip, 1975) and even among bivalves (Siewicki et al., 1983) the eastern oyster (*Crassostrea virginica*) and calico scallop (*Aequipecten gibbus*); Nakayama et al. (1995a) in Japanese scallops (*P. yessoensis*). Further uncertainty was added by the finding that the metallothionein-like protein often observed in some species of oyster during controlled laboratory exposures to Cd was not normally present in the eastern oyster sampled from the marketplace (Siewicki et al., op.cit.). The deposition of oyster MT-bound Cd (Sharma, 1983) and its subsequent release can be followed by a re-synthesis of MT within the kidney (Suzuki et al., 1979) with different properties and different toxicities than that synthesized in the kidney after exposure to inorganic Cd (Sharma, 1983). This author speculated that blood Cd levels as a biomarker of exposure may not be representative of the MT-bound Cd reaching the kidney and thus explain the lower than expected concentration of blood Cd in frequent consumers of New Zealand oysters (*Ostrea lutaria*) averaging 5 μg Cd/g (wet weight) cadmium.

The time is therefore ripe for a comprehensive review of basic biochemical and toxicological information as it pertains to the consumption by humans and the subsequent fate of Cd *as presented in the oyster and scallop matrix*. Furthermore, most recent information should be considered in the selection of appropriate biomarkers of exposure rather than ones of effect (renal damage). Zinc, calcium and especially iron status in women is recognized as an important controlling factor in Cd uptake and distribution (Nishijo et al., 2004; Vahter et al., 1996) as is the relative proportion of these elements in the diet. It would be prudent to incorporate these considerations in any health risk assessment for Cd from the bivalve matrix.

To date, neither Canada nor the USA have established MPC's for cadmium in bivalves. An often-quoted document (US FDA, 1993) is sometimes misinterpreted as providing an acceptable level of Cd as 3.7 μg Cd/g wet weight for bivalve shellfish. These calculations were based on a 50th percentile of 0.376 ppm and 96th percentile of 0.925 ppm which although likely to be appropriate for East Coast US

[3] Provisional tolerable weekly intake (PTWI) is the term used by JECFA (Joint FAO/WHO Expert Committee on Food Additives) to define the level of intake of an accumulative contaminant which (based on best available current data) can be ingested without appreciable health risk over a lifetime (50 years) intake period (WHO, 1989). At its 61st Meeting, July 2003, JECFA chose to retain the current PTWI of 7 μg Cd/kg of body weight; equivalent to a daily intake of 1 μg Cd/kg of body weight per day. Men: 70 kg; women 60 kg. Excursions above this level of exposure can be tolerated but only for short periods. Although increased risk of tubular dysfunction in some members of the population was acknowledged, the precision of risk estimates was as yet inadequate to revise this figure downward (JECFA, 2003).

data, are not appropriate for the West Coast, where natural levels of 2–4 μg Cd/g are not uncommon. Furthermore, the guideline is meant to be adjusted by local health authorities to reflect local residues and consumption patterns. There is a need to clarify to the industry and the general public the application and limitations of this document. An update utilizing more recent data, new information on the Cd PTWI and a consideration of consumption patterns in some coastal sub-populations would be very useful. This should include consideration of nutritional and other relevant risk factors. Perhaps a better approach than MPC's would be a recommendation of consumption limits related to remaining within the PTWI, as has been suggested by Health Canada (CFIA, 2003). However, this should be modified to provide information specific to the higher risk groups discussed above. Another approach might be to set MPC's on a dry rather than fresh weight basis. This would reduce the temptation to artificially manipulate product residues by dilution using a period in low salinity waters to increase wet tissue weight and thereby drop concentration in efforts to "meet" a standard.

6. Cadmium environmental pathways

Kruzynski (2000) reviewed some of the available information on cadmium in bivalve molluscs and some potential terrestrial and oceanic pathways. Because of the interdisciplinary nature of the problem, it was felt necessary to hold a workshop offering the opportunity for interaction among researchers in the fields of both biological and chemical oceanography, forestry, remote sensing, biochemistry, geology, geochemistry, biology as well as shellfish growers and their representatives. Invited also were representatives of federal regulatory (DFO, CFIA, HC) and the provincial shellfish lease granting agency (BC Ministry of Agriculture Food and Fisheries (BC MAFF)), as was the BC Province geology/mining exploration group. Proceedings which defined gaps in knowledge and suggested research requirements were published (Kruzynski et al., 2002).

Due to strained relations with some in the industry (for reasons outlined above) funding for recommended pathways research has not been made available to date; this in spite of the stated objective that if Cd pathways could be identified, then growers could be advised of culture sites or conditions or species that could be cultured with the lowest possible cadmium levels.

Potential sources of Cd to BC coastal waters (predominantly non-urban locations) include natural mineral outcrops, riverine inputs and oceanic waters. Some of the CFIA-sampled oyster sites are in proximity to geological features that can contribute Cd to stream sediments (Lett and Jackaman, 2001; Burt and Snijders, 2001). That Cd appears to be a non-issue in the Atlantic Ocean, save for anthropogenically polluted estuaries, most likely stems from natural global ocean circulation which results in the North Pacific containing (~100 ng Cd /l) which is 3–5 times the dissolved Cd concentration found in the North Atlantic (Crispo, 2001; Kruzynski, 2001, citing Bruland, 1980). Thus uptake by phytoplankton and transfer to filter feeding bivalves although as yet unmeasured, is highly likely (Thompson, 2001). Terrestrial (erosional runoff) and upwelling of deep oceanic waters (Lares, 2001) are plausible pathways; both of these factors are likely to be involved but with their relative importance dependent on coastal location as well as season. In some BC coastal locations, widespread logging has occurred and this is a tempting, though as yet unstudied, potential source of enhanced Cd availability in the shallow waters utilized for shellfish farming. Garcia and Carignan (2000) reported higher mercury (Hg) levels in fish captured in lakes whose watersheds had been logged when compared to similar reference lakes. This increase was positively correlated with a disruption in natural cycling of Hg characterized by a rise in dissolved organic carbon (DOC) and enhanced uptake by zooplankton. The change in mobility of Cd as a result of extensive logging and related watershed disturbance has thus far remained unstudied. Approximate calculations of coastal loadings (kg Cd per year) were made for municipal storm water (5921), sewage treatment plants (154), pulp and paper mills (174) and salmon aquaculture 30 (Kruzynski, 2001). However, the CFIA oyster residue data do not support an enhancement of cadmium in culture locations that might have been expected to be clearly influenced by these inputs. This suggests that while not excluding local influences, other mechanisms are likely to predominate. (Kruzynski et al., 2002).

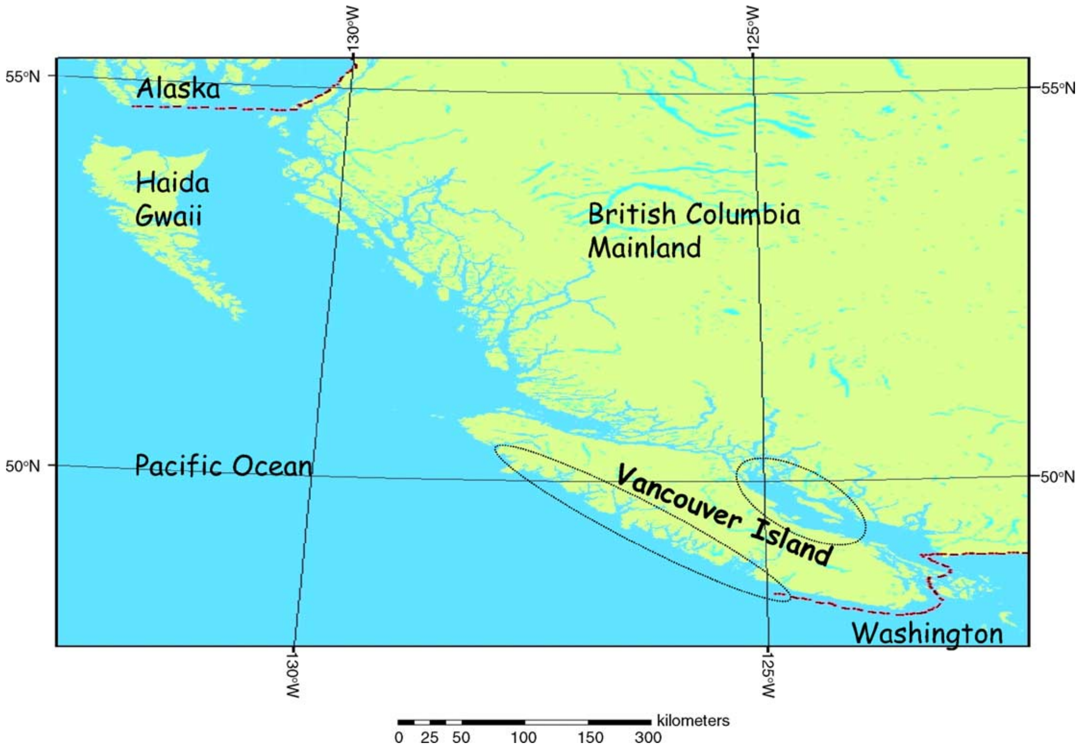

Fig. 2. The geographical range of samples of cultured Pacific oysters analyzed for cadmium residues during the Canadian Food Inspection Agency processor survey in 2000.

7. Experimental study approach

7.1. Oysters

In August 2001, in collaboration with BCMAFF, SFU (Simon Fraser University) and ∼20 oyster growers, we initiated a grow-out study whereby oyster seed of the same age and genetic stock was distributed to existing oyster culture locations ranging from southern Vancouver Island to the Haida Gwaii (Queen Charlotte Islands) in the north, a distance of ∼1000 km, with representative locations both on the east (mainland) and west outer (oceanic) coast of Vancouver Island (Fig. 2). Oysters and recently wild mussels (*Mytilus* sp.) are being sampled every two months and Cd residues determined. When the project ends in 2005, we will have generated Cd uptake data over a broad geographical area, incorporating size and seasonal changes. Mussel data, although limited in scope will help define expected species differences.

7.2. Scallops

Previous literature reports have highlighted the propensity of scallops to accumulate and retain cadmium to a higher degree than oysters, mussels and clams (Sprague, 1986) and so sampling was conducted in 2002 of both wild and commercially captured scallops of several species. These data presently being prepared for publication (Kruzynski and Bendell-Young, Simon Fraser University) indicate a range of Cd in whole wet tissue of scallops from 4.3–9.0 μg Cd/g (wet weight), with gut contents up to 80 ppm (wet weight).[4] These data are consistent with findings for scallops in Japan where Sakuta et al. (1992) found scallop gut burdens

[4] Quality assurance confirmed using standard reference material (SRM) oyster tissue 1566a NRCC (National Research Council, Ottawa, Canada) and 1566b of the NTIS (US National Institute of Technology, SRM Program, Gathersburg MD).

up to 220 μg Cd or residues of 30–40 μg Cd/g gut (wet weight). New Zealand researchers found gut residues up to around 800 ppm Cd (wet weight) and 91 ppm (wet weight) in whole scallops (*Pecten novazealandiae*) dredged from the Chatham Islands 860 km offshore from the South Island, NZ and thus thought to be entirely removed from anthropogenic influences, Ashoka (1999). Hunter et al. (2001) presented a range (4–66 ppm wet weight) of Cd residues in this species collected from various areas in New Zealand.

In Japan, because the adductor muscle and gonad (parts generally consumed for the Japanese yesso scallop) contain relatively low residues, the remaining unutilized tissue posed a "hazardous waste" disposal problem. In response, (Sakuta, 2001; Sakuta et al., 2000) developed a pilot methodology which comprised the basis of a Cd recovery plant (12 t per day) subsequently constructed in Hokkaido capable of recovering Cd from the waste from both scallops and squid; in effect, generating from a problematic "toxic waste," a "fish fertilizer" with <5 μg Cd /g dry weight. This level is acceptable for agricultural application (http://www.unirex-jp.com/engcadmium/framesetengcad.htm).

In Japan, Nakayama et al. (1995a,b) outlined human health concerns of consuming whole scallops containing naturally elevated levels of cadmium and in New Zealand, health authorities advise consumers to avoid eating the gut contents of the local scallops (Dr. B.M. Peake, Environmental Science, University of Otago, NZ, personal communication, 2003). Ashoka (1999) found an average of around 1.5 ppm (wet weight) Cd in adductor muscle of this species. On Canada's Atlantic Coast, the scallop (*Platopecten magellanicus*) was reported to accumulate residues ranging from 3.2 to 20.9 μg Cd/g (wet weight) in the whole body arising from a combination of the exposure through the water column and sediment in which this species resides (Ray and Jerome, 1987). Interestingly, scallops from some of the most remote sites were found to have the highest Cd levels. Uthe and Chou (1987) reported 314 μg Cd in digestive gland of the same species corresponding to a residue of 95 μg Cd/g (wet weight) in this tissue which in turn accounted for 92% of the total soft tissue body burden.

8. Research needs: cadmium residues and health risk assessment

There is a need to define tissue distribution of Cd in scallops. In BC and elsewhere, some of the smaller species are consumed whole and it is likely that Cd PTWI would be exceeded very quickly in some cultures and communities. Such information may facilitate processing changes to market product, e.g. scallop muscle with acceptable Cd levels while rejecting organs such as digestive glands which carry the bulk of the cadmium body burden. Scallop roe constitutes an important product, however few data exist on Cd in this tissue in BC scallops. Oysters are consumed whole, so there is no opportunity for such manipulation during processing.

9. Questions and compromises

Bivalve shellfish are of nutritive value and comprise a significant proportion of diet, especially in some First Nations communities in BC. However, few employment opportunities have led to chronic poverty on many reserves and in several coastal regions, there is a new initiative for First Nations to become involved in aquaculture to complement their traditional harvest of wild clams and other bivalves. The Cd issue brings up a dilemma: how to balance nutritional benefits of eating shellfish that might have elevated Cd levels versus the obvious nutritional benefits? What should be done until appropriate bioavailability data and other chronic disease (e.g. diabetes, hypertension) interactions are studied? At the present time, there are no such studies underway in coastal BC, although the roles of chronic Cd intake in hypertension (Satarug et al., 2000), carcinogenesis (Jin et al., 2003; Stoica et al., 2000) and endocrine disruption (Johnson et al., 2003) are becoming evident. A biomarker-of-exposure study among BC oyster growers is just getting underway (Dr. R. Copes and co-workers, BC Ministry of Health and University of British Columbia) but First Nations are not included. This situation is not unique to Canada; (Satarug et al., 2003) reported on Cd-contaminated (aboriginal) traditional foods in Australia. Weighing the health cost/benefit of Cd-contaminated traditional foods has been addressed in Eastern Canada and the Arctic, e.g. by Kuhnlein and Chan (2000), Center for Indigenous Peoples' Nutrition and Environment, McGill University, Montreal, Quebec (CINE), however, no such research has been conducted on the West Coast in BC. Should much-needed employment opportunities be limited given the potential health effects (unstudied) or marketing limitations due directly to perceived cadmium concerns?

In view of new information, how valid is the current 1 μg Cd/kg body weight per day "safe" intake level? Specifically, how can consideration be given to ensure protection of susceptible populations, e.g. women, children, those suffering from poor nutrition, diabetes, elevated high blood pressure, obesity, etc. and who may frequently consume organ meats known to be high in Cd and who may be smokers? At the present time few of these important factors are receiving attention notwithstanding that many of these factors occur concurrently in some BC First Nations as well as in those who might qualify as "frequent consumers" in the oyster growers' community. Specific recommendations pertaining to the issue of Cd in oysters were presented by New Zealand Ministry of Health (2000) as part of the 1997/98 New Zealand Total Diet survey. Among these were: (a) a suggested limit in consumption to ensure dietary Cd remains within safe levels, (b) the need to more accurately determine what percentage of oyster-eaters may be exceeding the dietary PTWI, and (c) given the small safety margin, that susceptible populations be studied more carefully. Furthermore, these authors utilized a consumption level of 35 g of oyster per 14 days in their calculations. In BC, where consumption in some sub-populations could be 10–20 times this intake, there is a clear need for such a comprehensive approach.

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