



## Levels of total mercury in predatory fish sold in Canada in 2005

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Total mercury was analysed in 188 samples of predatory fish purchased at the retail level in Canada in 2005. The average concentrations ( $\text{ng g}^{-1}$ , range) were: sea bass 329 (38–1367), red snapper 148 (36–431), orange roughy 543 (279–974), fresh water trout 55 (20–430), grouper 360 (8–1060), black cod 284 (71–651), Arctic char 37 (28–54), king fish 440 (42–923), tilefish 601 (79–1164) and marlin 854 (125–2346). The Canadian standard for maximum total mercury allowed in the edible portions of fish sold at the retail level is  $1000 \text{ ng g}^{-1}$  for shark, swordfish, marlin, orange roughy, escolar and both fresh and frozen tuna. The standard is  $500 \text{ ng g}^{-1}$  for all other types of fish. In this study, despite the small number of samples of each species, the  $1000 \text{ ng g}^{-1}$  maximum was exceeded in five samples of marlin (28%). The  $500 \text{ ng g}^{-1}$  maximum was exceeded by six samples of sea bass (20%), four of tilefish (50%), five of grouper (24%), six of king fish (40%) and one of black cod (13%),

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### Introduction

In Canada, fish contribute to over 50% of the dietary intake of mercury (Hg) by adults (Dabeka et al. 2003), and fish containing the highest concentrations of Hg are predatory fish, such as shark, swordfish and tuna (Health Canada 2007). Hg, present in fish as both methyl-Hg and inorganic Hg, is a potent neurotoxicant. On the other hand, fish are one of the best food sources of vitamin D and omega-3 fatty acids, DHA and EPA, and it is important to weigh the benefits of eating fish against the potential toxicity of Hg present in the fish (Health Canada 2007). To promote consumption of fish while at the same time providing advice to vulnerable population groups about limiting consumption of predatory fish, and to evaluate the risk-to-benefit ratio of eating fish, it is important to know the levels of Hg in predatory fish sold at the retail level in Canada. In 2002, a Canadian survey of seafood was conducted (Dabeka et al. 2004) which found that predatory fish, such as shark, swordfish and tuna, contained high concentrations of Hg, averaging  $1820 \text{ ng g}^{-1}$  for shark,  $1430 \text{ ng g}^{-1}$  for marlin and  $930 \text{ ng g}^{-1}$  for fresh or frozen tuna.

This survey is a supplement to the previous work and provides levels of Hg found in retail fish purchased in 2005. Marlin, sea bass, red snapper, orange roughy, fresh water trout, grouper, black cod (sablefish), Arctic

char, king fish (king mackerel) and tilefish are included in this survey.

### Experimental

#### Sampling

Under a contract to NORAXX Inspections Inc., samples were purchased as cleaned fillets or whole fish at the retail level in Toronto, Vancouver and Montreal in 2005. The retail stores included four supermarket chains and four specialty fish seafood outlets in each city. Enough of each sample was to be purchased to obtain 500-g edible portions. Each sample was shipped frozen to Maxxam Analytics Inc. for cleaning (if necessary), homogenization and bottling in pre-cleaned polyethylene bottles supplied for total Hg and glass jars with Teflon cap liners for methyl Hg (I-CHEM brand, Thermo Fisher Scientific). The samples were then frozen and shipped to Health Canada's Food Research Division in Ottawa for analysis.

Information provided with each sample included, where available, the species name as provided by the retail outlet, the state of the sample when purchased (frozen, fresh or previously frozen), the city of sample pickup, name of store where purchased, country of origin and date of collection. The countries of origin

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Table 1. Quality control results for each analytical batch.

Series no.	Blank average, $\text{ng ml}^{-1}$	Blank S.D., $\text{ng ml}^{-1}$	Solution detection limit	Blank spike recovery, %	Sample recovery, %	NIST Oyster SRM, $\mu\text{g g}^{-1}$	NRCC Dolt-2 SRM, $\mu\text{g g}^{-1}$	NRCC Dorm-2 SRM, $\mu\text{g g}^{-1}$	X-check standard, $1 \text{ ng ml}^{-1}$	X-check standard, $2 \text{ ng ml}^{-1}$
1	0.046	0.003	0.010	95	108	0.066		<sup>a</sup>	0.98	2.67
2	0.040	0.001	0.002	87	105	0.072	1.93	4.84	0.92	2.37
3	0.028	0.012	0.037	100	86	0.068	2.08	4.44	0.95	2.42
4	0.129	0.023	0.070	100	80	0.054	2.08	4.77	0.89	2.48
5	0.133	0.004	0.013	92	88	0.043	2.03	4.57	1.00	2.43
6	0.072	0.000	0.000	97	85	0.054	2.05	4.62	0.98	2.37
7	0.072	0.010	0.030	93	88	0.052	2.23	3.24	1.02	2.32
8	0.073	0.003	0.010	106	155	0.052	1.95	4.53	0.95	2.49
9	-0.019	0.035	0.104	103	91	0.095	2.55	5.15	1.05	
10	-0.035	0.067	0.202	104	94	0.117	2.29	4.76	0.97	
11	-0.009	0.007	0.020	101	102	0.076	2.60	5.19	0.97	
Average Certified (SRMs)	0.048	0.015	0.045	98	98	0.068	2.18	4.61	0.97	2.44
						$0.064 \pm 0.007$	$1.99 \pm 0.10$	$4.64 \pm 0.26$		

Note: <sup>a</sup>Blank spaces denote that the particular test was not included in the batch.

for the samples were USA (7), Argentina (1), Australia (5), Canada (26), Chile (13), Hungary (2), Mexico (1), New Zealand (3) and Taiwan (1), with the remaining samples being of unknown origin.

### Analysis

Analyses were performed using the reagents, instrumentation and methodology described in Dabeka et al. (2002). Briefly, after a low-temperature nitric/hydrochloric acid and hydrogen peroxide digestion of roughly 1 g fish tissue and dilution to 50 ml with water, measurements were made using a CETAC-6000A dedicated Hg analyser equipped with an ASX-500 autosampler and ADX autodilutor. All samples were analysed in duplicate. For high-concentration samples, the autodilutor was used to give a 10 $\times$  dilution.

Quality control measures for each analytical batch included three reagent blanks, two reagent blank spikes (200 ng Hg), one sample spike of 400 ng Hg (in duplicate for both the unspiked and spiked 400 ng sample) and duplicates of three different standard reference materials (SRMs) with certified Hg concentrations. Two cross-check standards (from a different manufacturer) were included in each batch for standard verification during the run. The solution limit of detection (LOD) was estimated for each analytical batch by multiplying the standard deviation of the three reagent blanks by 3. Sample LODs were calculated by multiplying the solution LOD by the dilution volume and dividing by the weight of the actual sample taken for analysis. All sample concentrations were above the sample LOD.

The quality control results, summarized in Table 1 were satisfactory. Solution LODs averaged  $0.045 \text{ ng ml}^{-1}$  and sample LODs averaged  $1.9 \text{ ng g}^{-1}$ . Recoveries from spiked blanks and samples averaged 97 and 101%, respectively. One of the sample spike recoveries was high (155% in batch 8), and this was due to the high concentration of Hg in the sample selected for spiking in the batch compared with the spike added. Agreement with certified levels in the National Research Council of Canada (NRCC) Dolt-2 and Dorm-2 SRMs and the National Institute of Standards and Technology (NIST) Oyster Tissue 1566a SRM was generally satisfactory, although results for batches 9, 10 and 11 were unusually high. Blank spaces in the tables denote that the particular test was not included in the batch.

### Results and discussion

In total, 188 samples were analysed for total Hg. A summary of the results (Table 2) found that Arctic char, red snapper and fresh water trout contained the lowest concentrations of Hg, averaging 37, 148 and  $55 \text{ ng g}^{-1}$ , respectively. Average levels in the other fish types varied from  $384 \text{ ng g}^{-1}$  for black cod to  $854 \text{ ng g}^{-1}$  for marlin.

Average concentrations of Hg in the different species were in general agreement with those found in other Canadian and international surveys (Table 3). Differences among the surveys can be attributed to the size of the individual fish from which the sample was taken, as fish mercury concentrations vary directly with fish size. Additionally, regional differences in Hg concentrations may be a function of the food source. For example, tilefish caught in the Atlantic Ocean

Table 2. Summary of total Hg levels in predatory fish.

Type of fish	Mean	Median	Minimum	Maximum	<i>n</i>	<i>n</i> > 1 ppm (%)	<i>n</i> > 0.5 ppm (%)
Arctic char	37	37	28	54	10		
Black cod (sablefish)	284	246	71	651	8		1 (13%)
Fresh water trout	56	41	22	430	31		
Grouper	360	344	8	1060	21	1 (5%)	5 (24%)
King fish	483	394	42	1614	15	1 (7%)	6 (40%)
Marlin <sup>a</sup>	854	768	125	2346	18	5 (28%)	14 (78%)
Red snapper	147	109	36	431	30		
Sea bass	329	282	38	1367	30	1 (3%)	6 (20%)
Tilefish	649	689	79	1164	8	2 (25%)	4 (50%)
Orange roughy <sup>a</sup>	543	505	279	974	18		9 (50%)

Note: <sup>a</sup>Designated fish subject to a 1000 ng g<sup>-1</sup> regulatory limit, others to a limit of 500 ng g<sup>-1</sup>.

Table 3. Comparison of Hg levels (ng g<sup>-1</sup>) found in this study with those found previously in Canada and other countries.

Type of fish	This Study	Canada, 2002 <sup>a</sup>	Canada, 2010 <sup>b</sup>	USA <sup>c</sup>	Britain <sup>d</sup>	Japan <sup>e</sup>	Taiwan <sup>f</sup>
Arctic char	37	27	56				
Black cod	284		362	95		40	
Fresh water trout	55	43	39 <sup>g</sup>	72	60		
Grouper	360		244	465			90
King fish	440		175	730			
Marlin	854	1429	781	485	1340		
Red snapper	148		310	189			
Sea bass	329		404	219, 386 <sup>h</sup>	65	200	
Tilefish	601		1069 <sup>b</sup>	144, 1450 <sup>i</sup>			
Orange roughy	543		482	554	595		

Notes: <sup>a</sup>Dabeka et al. (2004).

<sup>b</sup>Canadian Food Inspection Agency (2010). Average of three tilefish - two samples purchased in 2008 containing 128 and 3000 ng g<sup>-1</sup>, and one purchased in 2005 contained 80 ng g<sup>-1</sup>.

<sup>c</sup>FDA (2009); Environmental Protection Agency (2000); National Marine Fisheries Service (1978). The primary reference for the Gulf tilefish and sablefish data in the FDA report is a National Marine Fisheries Service report (Hall et al. 1978), while that for the kingfish or king mackerel is an EPA report (Ache et al. 2000).

<sup>d</sup>Knowles et al. (2003).

<sup>e</sup>Nakagawa et al. (1997).

<sup>f</sup>Chen and Chen (2006).

<sup>g</sup>Rainbow trout.

<sup>h</sup>219 ng g<sup>-1</sup> in black bass, and 386 ng g<sup>-1</sup> in Chilean bass.

<sup>i</sup>144 ng g<sup>-1</sup> in Atlantic tilefish and 1450 ng g<sup>-1</sup> in those caught in the Gulf of Mexico (FDA 2009).

contained 144 ng g<sup>-1</sup> Hg, whereas those sampled in the Gulf of Mexico averaged 1450 ng g<sup>-1</sup> (FDA 2009). It is uncertain whether this difference is due to different food sources or to the situation that the tilefish in the two areas are different species.

## Conclusions

The current Canadian regulatory limit for total mercury in the edible portion of commercially sold fish is 500 ng g<sup>-1</sup>, with the exception of a 1000 ng g<sup>-1</sup> limit and accompanying consumption advice (Health Canada, 2008) for specific species of piscivorous fish: shark, swordfish, marlin, orange roughy, escolar, and fresh and frozen tuna (Health Canada, 2010). The proportion of individual samples exceeding the

relevant standards was: 13% of black cod, 24% of grouper, 40% of king fish, 28% of marlin, 20% of sea bass and 50% of tile fish (Table 2). However, the uncertainty in these percentages is high due to the small numbers of each species tested. The mean and median concentrations of mercury in black cod, grouper, king fish, marlin and sea bass were all below the standards for the respective species. Additional data would aid in characterizing the typical mercury concentrations in some types of fish, in particular king fish and tilefish. For example, the US FDA has reported a median mercury value in tilefish (Atlantic) of only 99 ng g<sup>-1</sup> (*n* = 32) (FDA, 2009). It should also be noted that the occasional consumption of infrequently consumed fish containing mercury levels greater than the regulatory limits would not be expected to pose a health risk to consumers.

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