Mercury Levels in Fijian Seafoods and Potential Health Implications




Report for: World Health Organization (WHO)

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Executive Summary

Mercury (Hg) and its compounds pose a significant threat to human health, particularly to women who are pregnant or of child-bearing age. Mercury is a toxin to the central nervous system and it can readily cross the placental barrier. Previous studies in other locations have shown dangerously high mercury levels in certain types of seafoods, particularly large predatory fish. Data on mercury levels in fish and other seafoods from the Pacific Islands are scarce.

The aim of the present study was to measure total Hg content in several types of seafoods which are commonly consumed in the Fiji Islands, including various coastal and pelagic fish species, shellfish, and canned fish. The results of the study were used to determine whether there is a significant health risk arising from fish consumption.

Total Hg in the edible tissues of 200 seafood samples of different types (whole fish, fish steaks, shellfish) and species was analysed. Total Hg was determined by strong acid (HNO_3/H_2SO_4/HCl) digestion, addition of bromine chloride, reduction with sodium borohydride and analysis via hydride generation atomic absorption spectroscopy.

The total Hg levels in some of the large predatory fish species (marlin and swordfish) exceeded the Food and Agriculture Organization (FAO)/World Health Organization (WHO) Codex Alimentarius guideline level of 1 mg/kg. Other types of fish steaks, smaller reef fish, shellfish, canned tuna and mackerel had average levels below the guidelines. There was a significant positive correlation between total mercury levels with the length of yellowfin tuna while no correlation was noted for the albacore tuna. No significant correlation was noted between the total mercury levels with the fish weight for both the albacore and yellowfin tuna. For the fish steaks, the swordfish, marlin and walu showed a positive correlation in mercury levels with the size of steaks. Previous studies have shown that most (>90%) of the mercury in fish is in the form of methylmercury.

Although a limited amount of analyses were conducted on some fish species, it is clear that health risks, particularly to pregnant women, exist from consuming relatively small quantities (<1-2 portions per week) of a number of the larger fish species, such as shark, marlin, swordfish, sunfish, large albacore tuna (canned and fresh), bigeye tuna, sailfish and walu. For the marlin, swordfish, shark and sunfish the calculated safe level of human consumption is less than 1 portion size/week and for bigeye tuna it is about 1 portion per week. Frequent consumption of more than the recommended amount of these fish could lead to health problems. Pregnant women and women of childbearing age are most at risk as exceeding the recommended weekly mercury intake could subsequently be harmful to a developing fetus. It should be noted that the reef fish (except barracuda) and shellfish normally consumed by Fijian people in rural/outer island areas had very low levels of mercury and calculations indicate that they can be consumed in large amounts. More data on Hg levels in the larger species of fish and human body mercury levels are needed to better assess the health risk. It must be remembered that seafoods make an important nutritional contribution to the diet in Pacific Island countries and limited diet options are available to outer island dwellers. More emphasis should be placed on public education in order to protect human health in regards to mercury intake, particularly for pregnant women in areas where the large predatory fish species are consumed.

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Background

There is widespread recognition that mercury (Hg) and its compounds pose a significant threat to human health. The characteristic properties of these compounds include extremely high toxicity, resistance to environmental degradation which leads to persistence in the environment, accumulation within organisms and magnification up the food chain, and susceptibility to long distance transport. Mercury is very toxic to humans, and the recommended safe levels in drinking water are lower than for any other metal (WHO, 1996).

Mercury is found naturally in the environment in the metallic form and in different inorganic and organic forms. Most of the mercury in the atmosphere is elemental mercury vapour and inorganic mercury, while most of the mercury in water, soil, plants and animals is inorganic and organic forms of mercury (Public Health Guidance Note, 2002). In the ocean, inorganic mercury is transformed by micro-organisms (in sediments and in the deep ocean) to the methylmercury form, which is accumulated by aquatic organisms over their lifetime (termed *bioaccumulation*) and then passed up the aquatic food chain. The progressive buildup of mercury and other substances up the food chain is commonly termed *biomagnification*. Hence, predatory fish and mammals that are high up the food chain (high trophic level) typically have the greatest levels of mercury. Such species include whales, dolphins, swordfish, marlin, and sharks and these may bio-accumulate mercury to approximately 1 to 10 million times greater than dissolved mercury concentrations found in surrounding waters (USEPA, 2001). Most of the mercury in fish tissues exists in methylmercury (MeHg) form (Bloom 1992, >95% MeHg; Kim 1995, >96% MeHg; USEPA 2001, 90-100% MeHg). However, certain non-fish species (mussels, copepods, shrimps) have been found to have less than 10% of the total mercury as methylmercury (Bloom 1992; Horvat et al. 1990). Within an individual species a number of factors such as age, size (length and weight) and location may influence mercury levels (ANZFA, 2001).

When consumed in food, methylmercury compounds are readily absorbed by the gut and effectively crosses biological membranes such as the blood-brain barrier, spinal cord, peripheral nerves, and placenta (JECFA 2003). Once in the body, methylmercury is found bound mostly to proteins containing sulfur amino acids (e.g. cysteine). Methylmercury can induce toxic effects in several organ systems (nervous system, kidney, liver, reproductive organs), with neurotoxicity considered the most sensitive endpoint (JECFA, 2003). Fetal exposure to Hg is considered to create the highest risk for developing toxic effects as higher levels have been found in the fetal rather than the maternal brain (JECFA, 2003). Hence pregnant women and women of childbearing age are potentially the most sensitive sub-group of the population. An extreme case of mercury poisoning occurred in Minamata Bay, Japan where humans, fish consuming domestic animals such as cats, and wildlife living in the mercury polluted bay showed central nervous system dysfunction signs such as convulsions, highly erratic movements, and difficulties in walking. Even at naturally occurring levels, mercury has been recognized to potentially pose a significant health risk for populations that depend on fish for daily sustenance (e.g. Sechelles and Faroes Islands, JECFA 2003).

There are guidelines for the amount of mercury that can be safely consumed by humans on a weekly basis. Recently the Joint FAO/WHO Expert Committee on Food Additives (JECFA) revised the provisional tolerable weekly dietary intake (PTWI) of methylmercury recommending it be reduced from 3.3 µg Hg /kg body weight/week to 1.6 µg/kg/week in order to sufficiently protect the developing fetus (JECFA, 2003). Pregnant women with mercury intakes higher than this level have a subsequent risk of increased developmental abnormalities appearing in their children (JECFA, 2003).

There are also Food and Agriculture Organization (FAO)/World Health Organization (WHO) Codex Alimentarius Commission guidelines for levels of methylmercury in fish of 0.5 mg/kg and 1 mg/kg in predatory fish such as shark, swordfish, tuna etc (FAO/WHO 1991). The Codex guideline levels are intended for individual country governments to use to regulate fresh and processed fish and fish products moving in international trade. Large predatory fish are generally the most likely to exceed the Codex guideline levels. Bender and Williams (2000) reviewed US Food and Drug Administration (USFDA) data and found that 36% of the swordfish, 33% of the shark and nearly 4% of large tuna sold commercially in US between 1992 and 1998 had a methylmercury content which exceeded 1 mg/kg. A separate US-based study showed that approximately three-quarters of the sharks and swordfish and one third of large tunas sampled exceeded 0.5 mg/kg Hg (Moore, 2000). Another previous long-term comprehensive survey in the United States examined the occurrence of mercury (and other trace elements) (including Hg) in 204 species of finfish, molluscs and crustaceans from 198 coastal sites (USEPA, 1997). Several species had a mean Hg level of 0.4 to 0.5 mg/kg or greater, such as barracuda, sharks, grouper, marlin and sailfish. These analyses were conducted in the 1970s but are still relevant as mercury levels in marine fish appear to have remained relatively constant for over 20 years in various species (USEPA, 1997). Marine mammals, such as whales and dolphins also have high levels of mercury (Endo *et al*. 2003) but the catching and consumption of these animals is not permitted in most Pacific Island countries. Contamination arising from urban areas may also result in higher mercury levels. Tissues from seven fish species from San Francisco Bay were analysed for Hg in 1994 and 1997 (Davis, 1997). More than half of the fish showed concentrations above 0.23 mg/kg. An overall average level of Hg for the seven species examined was 0.3 mg/kg with the highest level occurring in leopard sharks (>1 mg/kg) and in one striped bass sample (0.99 mg/kg).

In the Pacific Islands, there have been only a few studies of mercury in shellfish (Morrison *et a*l., 1997; 2001) from Fiji and some fish and canned tuna in Papua New Guinea (Kyle and Ghani, 1981; 1982a,b). This is of concern as fresh fish, shellfish, mussels and canned tuna and mackerel are major food sources for most Pacific Island people. In addition there is currently no mercury data available for tuna which forms one of the largest income earnings for Fiji and other Pacific Island countries.

Purpose of the Study

The aim of the present study was to measure total Hg content in several types of seafoods which are commonly consumed in the Fiji Islands, including various coastal and pelagic fish species, shellfish, and canned fish. The results of the study will be used to determine whether there is a significant health risk arising from fish consumption.

Research Methodology

Sampling Methods

Two hundred samples of different seafoods (fish, canned fish, shellfish) were collected and analyzed for total mercury content. Table 1 shows both the scientific (*genus-species*) and local names of fish species analysed in this study. The samples were collected from various sources as outlined below:

- Albacore and Yellowfin Tuna: Samples of albacore and yellowfin tuna were supplied by a commercial fishing company, the Fijifish Marketing Group. They also supplied general location data for where the fish were caught, and length and weight data for the whole fish. Samples were analysed separately.
- Freshwater mussels (local name: *Kai*) and estuarine/seawater shellfish (local name: *Kaikoso*)**:** Three heaps of each type were bought from the Suva market with location of catch for each noted. The estuarine/seawater shellfish samples were soaked overnight in seawater (collected from the USP jetty) while the freshwater mussels were soaked in normal tap water. This allows the samples to expel most of the sand and other materials ingested during feeding and is a normal practice carried out before consuming these seafoods. Ten average sized shellfish were randomly selected from each heap, forced open, contents removed and homogenized in a wet mill. The homogenized samples from different locations were transferred into clean plastic bags and frozen for analysis. Each homogenate was subsequently analysed for mercury.

- Fish steaks: Steaks of various fish species (marlin, swordfish, sailfish, sunfish, walu, shark, wahoo, mahi mahi, Skipjack and kalia-blacksnapper) were bought from the local fish shops. The steak diameter was measured across the vertebral column and the samples were packed in clean plastic bags and frozen. Each steak was analysed separately.
- Reef fish (kaikai): A large bundle of small-sized reef fish was purchased from the Suva market. Five fish were randomly selected from the bundle, length and weight recorded, packed in clean plastic bags and frozen. Each fish was analysed separately.
- Canned Tuna and Mackerel: Three brands of canned albacore tuna, two brands of canned skipjack tuna and four brands of canned mackerel were bought from local supermarkets. Each can was opened, the contents emptied in a clean plastic bag, mashed and frozen until analysis. The contents of each can were analysed separately.

Table 1: Scientific and local names (where available) of fish and shellfish species analysed in this study

Species	Scientific Name	Local Name
Albacore Tuna	*Thunnus alalunga*	
Yellowfin Tuna	*Thunnus albacares*	
Skipjack Tuna	*Katsuwanas pelamis*	
Bigeye tuna	*Thunnus obesus*	
Spanish Mackerel	*Scomberomorus commerson*	Walu
Striped marlin[1]	*Tetrapturus audax*	
Blue marlin[1]	*Makaira mazara*	
Barracuda	*Sphyraena sp.*	Oqo
Swordfish	*Xiphias gladius*	
Sailfish	*Istiophorus platypterus*	
Opah	*Lamprius regius*	
Sunfish	*Mola mola*	
Mahi Mahi	*Coryphaena sp.*	Maimai
Black snapper	*Macolor niger*	
Reef fish	-	Kaikai
Goatfish	*Parupeneus barberinus*	Mataroko
Parrot Fish	*Scarus sp.*	Ulavi
Rabbit fish	*Siganus puntatus*	Nuqa
Peacock cod	*Cephalopholis argus*	Kawakawa
Unicornfish	*Naso unicornis*	Ta
Shellfish	*Anadara antiquata*	Kaikoso
Freshwater mussels	*Batissa violacea*	Kai

[1]The exact species of marlin supplied by the fish company was unknown so the two species they catch are listed in this table.

Analysis Methods

All analyses were performed as soon as possible after sampling (usually <1 week) at the Institute of Applied Sciences (IAS) laboratory at the University of the South Pacific. Precautions were taken to avoid contamination of samples with mercury. All the glassware and plastic ware for use in the analysis was soaked for at least 24 hours in a 10% nitric acid (HNO_3) bath and rinsed several times with deionised water prior to use. The glass and plastic-ware were dried in a laminar flow clean air cabinet.

The analytical method was adapted from that of Louie (1983) and Bloom (1992). The wet fish tissue was digested by a nitric-sulphuric-hydrochloric acid digestion procedure. An approximate weight of homogenized fish tissue (2g) was acid-digested at room temperature for 1 hr followed by hot water bath digestion for approximately 2 hrs in a boiling tube with a glass marble placed on top. The solution was cooled to room temperature and filtered into a 100 mL volumetric flask. 5mL of bromine chloride (BrCl, oxidizes all forms of Hg to Hg^{2+}) was added and the solution made up to the mark with distilled water. The samples were analysed by Hydride Generation Atomic Absorption Spectrometry (Magos, 1971).

The samples were analysed using a Perkin Elmer 3100 Atomic Absorption Spectrophotometer (with mercury cell) and FIAS 100 unit. The hydride technique involves the reaction of mercury in an acidified solution (3% HCl as carrier solution) with a reducing agent (0.2% sodium borohydride and 0.05% NaOH). This reaction generates a volatile hydride, which is transported into a heated quartz cell by means of an argon carrier gas. In the quartz cell, the hydrides are converted to gaseous mercury atoms. A light beam is directed through the quartz cell into the monochromator and onto the detector that measures the amount of light absorbed.

Calculations

$$\text{Hg (mg/kg)} = \frac{\text{Concentration measured } (\mu\text{g/L}) \times \text{Extract Volume (0.1L)} \times \text{DF}}{\text{Sample weight (g)}}$$

Where DF = dilution factor (usually 1).

Quality Control Results

BLANKS: Blanks consisting of the digestion acids were included with each batch of determinations. The mercury levels measured for the samples were blank corrected but usually no significant blank value was detected indicating that contamination from the laboratory was minimal.

PRECISION: The coefficient of variance (CV) of five fish replicates analysed for total mercury determination using was 4.0%. [CV (%) = (SD ÷ Mean) x 100]. Several samples were analysed in duplicate and results typically agreed within 10% of their average.

ACCURACY: A certified reference material (Total and methylmercury in Tuna SRM #464) was analysed with every batch of samples to check the accuracy and the efficiency of the method. The concentration of total Hg measured was in the range of 5.07-5.38 mg/kg (Certified value = 5.24 ± 0.10 mg/kg based on 0.2g dry weight of the SRM).

SPIKE RECOVERY: Spike recovery measurements were performed on selected samples, to test if there were any components of particular seafood that were interfering with the recovery of mercury during the analyses. Spike recoveries should be within 90-110%. In the present study, the average recovery of six separate fish portions spiked with 0.8µg of Hg (added from an acidified standard solution) were in the range of 91 – 103%

DETECTION LIMIT: The detection limit for Hg was calculated as 0.020 mg/kg based on the analysis of 2 g of the fish sample.

Results

The summary of the results for the various seafood species analysed is shown in Tables 2-4 for fresh fish/shellfish species, canned fish, and fish steaks respectively. The complete data set is contained within Appendix 1 of this document. All concentrations are reported on a wet weight basis. It should be noted that this study was an initial survey of mercury levels, as little previous data were available. Due to the large number of seafood types analysed, the number of samples that were able to be analysed on certain seafood species was limited.

Mercury in Fresh fish and shellfish

The summary results for the fresh fish and shellfish species along with average length and weight data is shown in Table 2. The data is also showed graphically in Figure 1 in comparison to the WHO/FAO Codex Alimentarius guidelines for methylmercury in non-predatory fish of 0.5 mg/kg and predatory fish of 1.0 mg/kg (FAO/WHO 1991). Marlin and albacore tuna were the only species that had some samples which exceeded the guidelines (>1.0 mg/kg). However, statistical tests showed that none of the *average* levels were statistically significantly above the Codex guideline level. The marlin had a very high standard deviation in mercury concentrations and more samples need to be analysed to obtain more representative data on mercury levels.

The tuna data were also analysed to see if a significant correlation existed between total mercury levels and length and weight. Figure 2 shows the concentration of mercury in the two tuna species plotted against length and weight. There was a significant positive correlation between mercury levels with the length of yellowfin tuna ($p<0.05$ level of significance) but not for albacore. For total mercury versus fish weight there was no significant correlation noted for either yellowfin or albacore tuna. There was also a statistically significant difference between average mercury levels in the albacore and yellowfin tuna, with albacore having higher levels.

Table 2: Hg levels (range and average) in different fresh fish and shellfish from the Fiji Islands, with length and weight data where available. (note: n = number of samples, SD = standard deviation)

Seafood Sample	n	Average Length (cm)	Average Weight (kg)	Range [Hg] (mg/kg)	Average [Hg] (mg/kg) ± SD
Albacore Tuna	31	72.7	21.3	0.03 – 1.01	0.34 ± 0.22
Yellowfin Tuna	24	71.3	15.2	<0.02 – 0.40	0.11 ± 0.11
Skipjack Tuna	12	45.7	2.4	<0.02 – 0.16	0.06 ± 0.04
Bigeye Tuna	3	103.3	28.3	0.28 – 0.80	0.53 ± 0.21
Marlin	5	167.6	67.4	0.45 – 5.60	1.76 ± 1.94
Reef fish	5	17.2	0.09	<0.02 – 0.04	0.04 ± 0.01
Barracuda	4	61.25	1.32	0.18 – 0.38	0.26 ± 0.07
Mussels	3	-	-	<0.02 – 0.04	0.03 ± 0.01
Shellfish	3	-	-	<0.02 – 0.05	0.03 ± 0.01
Crab Meat	3	13.3	-	0.03 – 0.07	0.05 ± 0.02
Parrot fish	2	31-35	0.75	<0.02	<0.02
Wahoo	1	92	6	0.17	0.17
Goatfish	1	28	0.31	0.03	0.03
Rabbit fish	1	32	0.5	0.15	0.15
Peacock cod	1	33	0.62	<0.02	<0.02
Unicorn fish	1	39	1.07	<0.02	<0.02
Opah	1	111	65	0.27	0.27

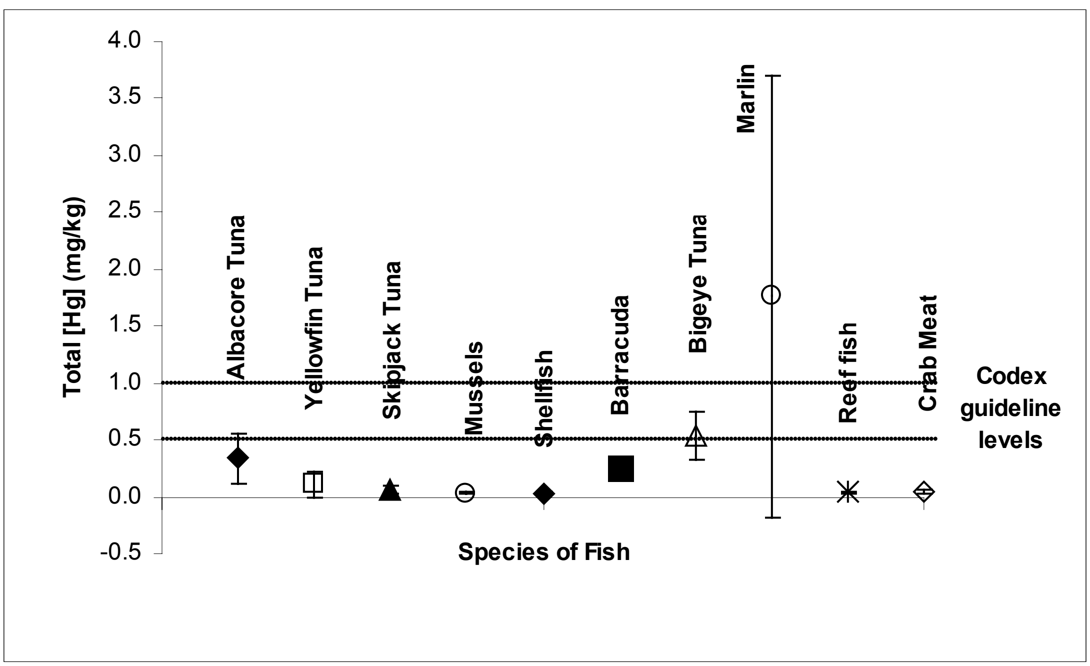
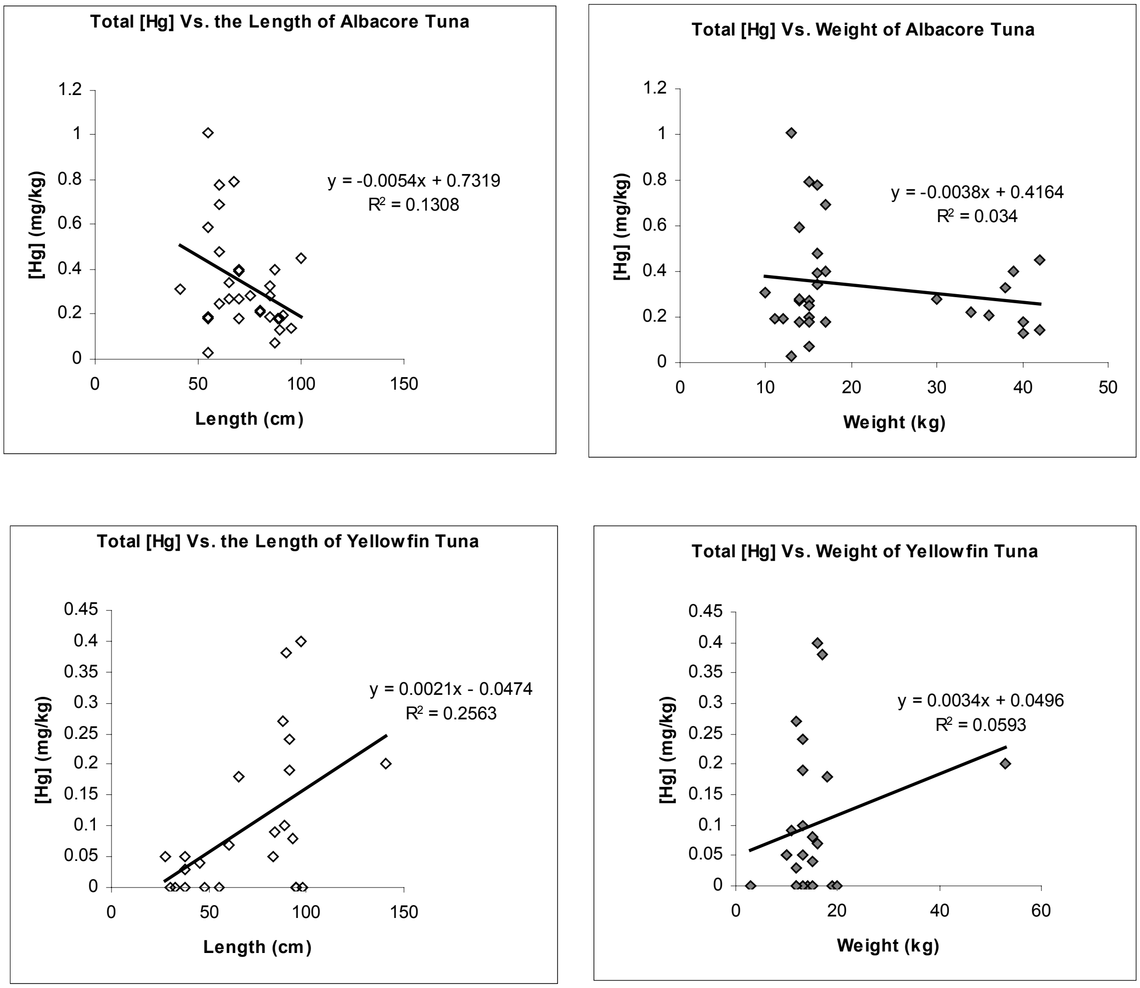


Figure 1: Average total mercury concentrations and standard deviation (error bars) for different fresh fish and shellfish in comparison to FAO/WHO Codex guidelines

Figure 2: Mercury levels in albacore and yellowfin tuna versus fish weight and length



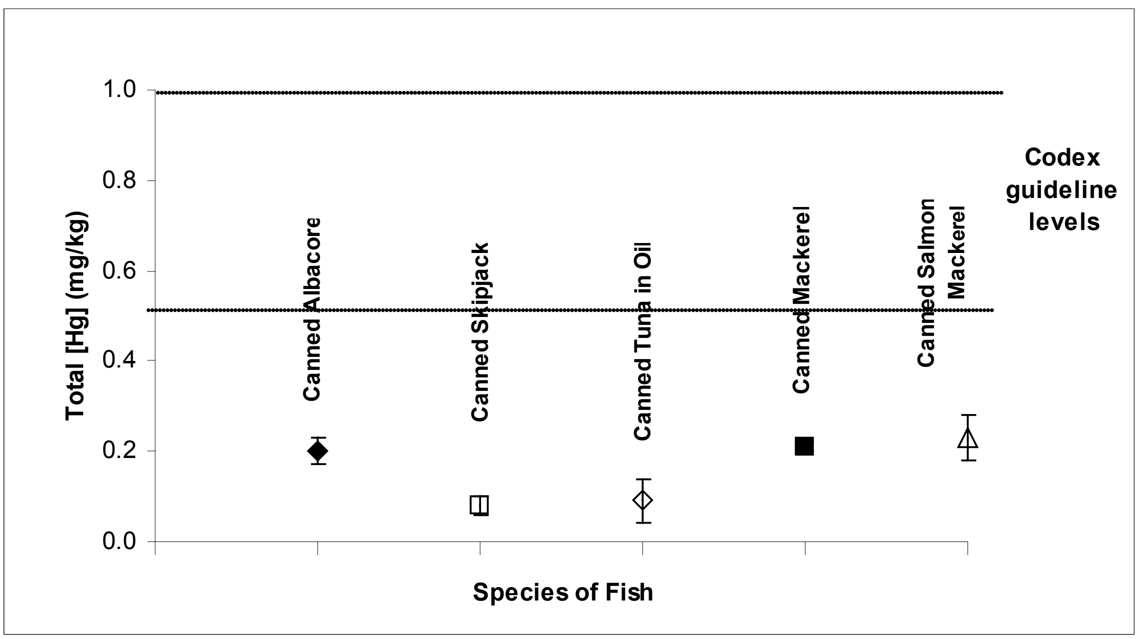
Canned fish

The summary of the results for the various canned fish is shown in Table 3 and Figure 3. Most of the canned fish had a reasonably similar mercury content of approximately 0.1-0.2 mg/kg. None of the concentrations measured exceeded any of the WHO/FAO Codex guidelines.

Table 3: Hg levels in canned fish sold in the Fiji Islands. (note: n = number of samples, SD = standard deviation)

Canned Fish Type	n	[Hg] range (mg/kg)	[Hg] average (mg/kg) ± SD
Canned Albacore	6	0.16 – 0.27	0.20 ± 0.03
Canned Skipjack	9	0.06 – 0.11	0.08 ± 0.02
Canned Tuna in oil	3	0.05 – 0.16	0.09 ± 0.05
Canned Mackerel	6	0.18 – 0.22	0.21 ± 0.01
Canned Salmon Style Mackerel	6	0.17 – 0.29	0.23 ± 0.05

Figure 3: Average total mercury concentrations and standard deviation (error bars) for different canned fish in comparison to FAO/WHO Codex guidelines



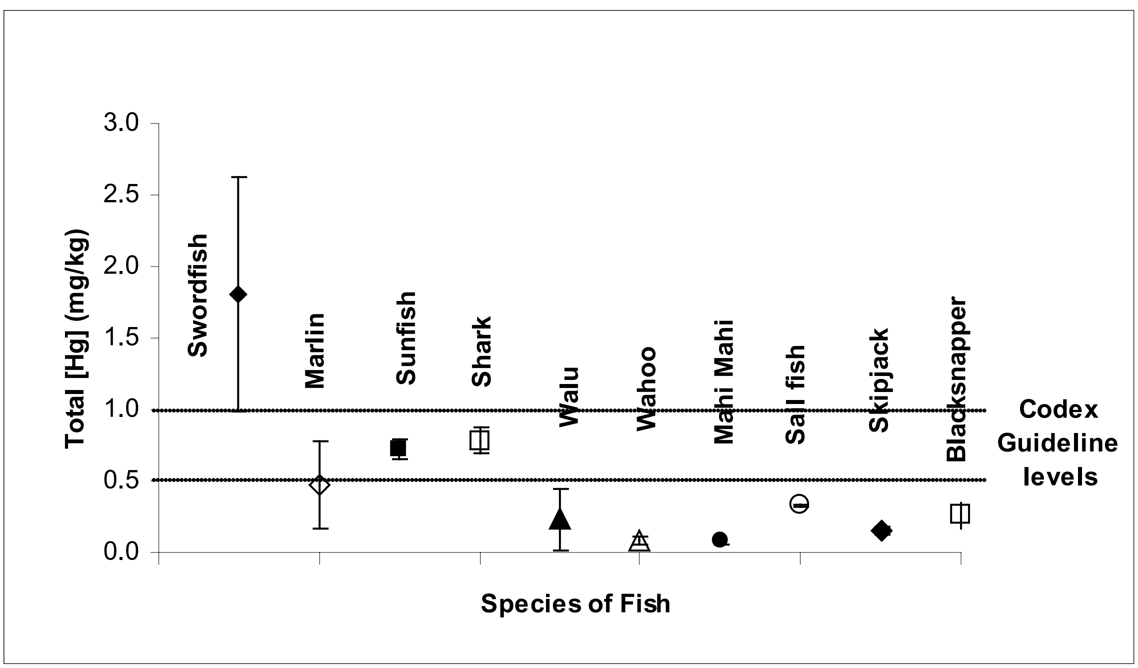
Fish Steaks

The summary of the results for the various fish steaks analysed is shown in Table 4 and Figure 4. The highest average mercury concentration was noted in swordfish followed by shark, sunfish and marlin steaks. Only the swordfish had average mercury concentrations which exceeded the 1 mg/kg WHO/FAO Codex guideline for predatory fish but this was not a statistically significant difference due likely to the number of samples taken (n=5) being small.

Table 4: Hg levels (range, average, standard deviation) in fish steaks purchased from fish shops in Suva, Fiji

Steak type	n	Diameter of Steak (cm)	Range [Hg] (mg/kg)	Average [Hg] (mg/kg) ± SD
Marlin	19	19.1	<0.02 – 1.01	0.47 ± 0.31
Sunfish	5	23.6	0.67 – 0.78	0.72 ± 0.07
Walu	17	12.5	<0.02 – 0.87	0.23 ± 0.21
Swordfish	5	23.4	0.99 – 2.81	1.81 ± 0.82
Shark	7	14.1	0.57 – 0.85	0.78 ± 0.09
Wahoo	4	13.5	0.05 – 0.12	0.08 ± 0.03
Mahi Mahi	3	21.3	0.05 – 0.11	0.08 ± 0.02
Sail Fish	2	23.5	0.32 – 0.34	0.33 ± 0.01
Black snapper	2	23.0	0.17 – 0.34	0.26 ± 0.09
Skipjack	5	14.6	0.11 – 0.19	0.15 ± 0.03

Figure 4: Average total mercury concentrations and standard deviation (error bars) for different fish steaks in comparison to FAO/WHO Codex guidelines



The relationship between the total mercury levels with the size of the fish steaks was also analysed. Although limited analyses were conducted, a significant positive correlation in total mercury with steak size was found for swordfish and marlin ($p<0.01$ level of significance), and to a lesser extent for walu ($p<0.05$ significance level). No correlation was found with other steaks but in many cases there were not enough samples analysed to provide representative data.

Discussion

The levels of mercury found in Fijian seafoods analysed in the present study are shown in Table 5 in comparison to previous studies. In most adult fish, >90% of the mercury is methylmercury which is primarily found in the fish muscle tissue, bound to protein molecules (Bloom, 1992; Kim, 1995; USEPA, 2001). Therefore the total mercury results can also be assumed to largely represent methylmercury concentrations. In the present study, levels of mercury that exceeded FAO/WHO Codex guidelines were recorded for certain large predatory fish species such as marlin and swordfish (Tables 2 and 4, Figures 1 and 4). These results were similar to that found in previous studies (see Table 5). These large predatory fish have a high trophic position and therefore they accumulate a lot of mercury from their food and elimination of methylmercury from fish is slow.

A positive correlation with total mercury and fish length was found only for yellowfin tuna and no correlation of mercury levels with fish weight was found for either albacore or yellowfin tuna. The correlation between yellowfin tuna length and mercury levels was relatively weak ($r^2=0.2563$) so we conclude that with the current data it is difficult to predict mercury levels with any accuracy given the weight and length of tuna. Positive correlation's between mercury concentration and length have been previously found in sharks (Lacerda *et al*., 2000; Storelli *et al*., 2002; De Pinho *et al*., 2002) and freshwater eels (Redmayene *et al*., 2000). Similarly, a positive correlation was found in giant perch from Lake Murray in Papua New Guinea (Kyle and Ghani, 1982b) but it is noted that this is an enclosed water system. The tuna samples in the current study were taken from several different locations around the Fiji Islands but tuna are a migratory species so where they are caught is no sure indication of where they have been feeding in the past. Geographical variability in mercury levels in seawater and food sources is a possible factor contributing to differences in mercury levels for similar length and weight fish. Mercury levels maybe higher near geothermal or volcanic activity in the sea and/or land areas. Distinct variations in mercury levels were observed in rainbow trout in lakes influenced by different levels of geothermal input in New Zealand (Kim, 1995). Closer examination of the albacore tuna data showed that several samples taken from near Koro Island showed high mercury levels for smaller length fish, which contributed to making the regression non-significant. This finding requires further examination but it could be due to higher levels of mercury in the water as Koro is a more recently formed island in comparison to others in Fiji. The area also contains undersea hydrothermal vents so more mercury methylating bacteria might be present. Unfortunately there is currently no data available for Fiji on mercury levels in seawater, plankton or tuna prey species.

There was a statistically significant difference between average mercury levels in albacore and yellowfin tuna, with the albacore having higher mercury levels. This may be due to the albacore tuna analysed having a slightly longer average length. Perhaps it also could be due to a difference in their feeding habits but this is unknown at present.

A strong positive correlation also existed between mercury levels and the size of swordfish, marlin and walu steaks. It is recognised that for steaks cut from an individual fish, steaks of varying sizes can result depending on whether the steak is cut nearer the tail or head. On average, however, a steak with larger diameter is more likely to come from a larger fish and hence more accumulation of mercury is likely to have occurred as discussed earlier. The total mercury concentration in fresh marlin (table 2) was high compared to the frozen marlin steaks obtained from the fish retail shops. This is because the fresh samples analysed (n=5, table 2) came from much larger sized marlin (as per length and weight data in table 2).

In the present study, small reef fish and the mussels and the shellfish had very low mercury levels. These organisms are very small and at the lower trophic levels and thus there is low degree of mercury bioaccumulation in them. The major source of mercury in shellfish would be from particles and plankton in the water. It should be noted that several of these fish and shellfish samples were caught near to the major city of Suva, which has significant sewage and industrial discharges to the ocean. Land-based pollution could lead to elevated Hg levels but there does not appear to be a problem for the samples we examined. Some shellfish from other locations have been found to have less than 10% of the total mercury as methylmercury (Bloom 1992; Horvat et al. 1990) but the speciation for Fijian shellfish is uncertain.

Mercury levels in canned tuna and mackerel in the current study were relatively low and below the recommended Codex guideline level. The level of mercury in canned mackerel in the present study was lower than that found for Japanese mackerel but was similar to that in New Zealand mackerel (Kyle and Ghani, 1981). In comparison with the canned albacore tuna, the canned skipjack tuna have quite low levels of mercury which may be due to it being a smaller sized fish on average. The canned tuna values found in the present study were at the lower range of what has been reported previously. Values ranging from 0.1-1.0 mg/kg have been reported for canned tuna from various countries (Holden, 1973) and a US study in 1992 found nearly 20% of canned tuna contained 0.3 – 0.5 mg/kg mercury and 10 % exceeded 0.5 mg/kg Hg, while in 1995 15% contained 0.3 – 0.5 mg/kg mercury (Johnson, 1999). Canned tuna is the most commonly consumed fish in US, averaging 10 cans per person per year (Johnson, 1999). Similar data from the Pacific are lacking but canned fish does form a significant part of the diet and consumption may also be increasing due to increasing urbanization and less reliance on subsistence living.

Table 5: Levels of mercury for seafoods found in previous studies compared to those found in present study (table continued on next page)

Species	Location	[Hg] mg/kg	Reference
Tuna species			
Yellowfin	Fiji Islands	<0.02 – 0.40	*This Study*
Albacore	Fiji Islands	0.03 – 1.01	*This Study*
Skipjack	Fiji Islands	<0.02 – 0.16	*This Study*
Tuna	unknown	0.35	Louie, 1983
Yellowfin Tuna	Bismark Sea, PNG	0.09	Sorentino, 1969 in Kyle, 1981
Skipjack Tuna	Bismark Sea, PNG	0.03	Sorentino, 1969 in Kyle, 1981
Bluefin Tuna	North Atlantic Ocean	3.41	USEPA, 1999
Bluefin Tuna	Mediterranean Sea	1.02	Storelli and Marcotrigiano, 2001
Marlin			
Marlin	Fiji Islands	<0.02 – 5.6	*This Study*
Blue Marlin	unknown	0.716	Bloom, 1992
Striped Marlin	unknown	1.0 – 2.0	USEPA, 1997
White Marlin	unknown	0.7 – 0.8	USEPA, 1997
Swordfish			
Swordfish Steaks	Fiji Islands	0.99 – 2.81	*This Study*
Swordfish	unknown	0.428	Bloom, 1992
Shark			
Shark Steaks	Fiji Islands	0.57 – 0.85	*This Study*
Sharks	South East Brazil	9.40 – 17.9	Larcerda *et al*., 2000
Ghost shark	Mediterranean Sea	1.30 - 5.16	Storelli *et al*., 2002
Saw shark	Lake Murray,PNG	0.37	Kyle and Ghani, 1982a
Whaler shark	West Bougaiville,PNG	0.33	Sorentino, 1969 in Kyle, 1981
Atlantic Shark	Atlantic Ocean	0.6 – 2.87	USEPA, 1997
Hammerhead Shark	unknown	2.0 – 3.0	USEPA, 1997
Shellfish			
Shellfish	Fiji Islands	<0.02 – 0.05	*This Study*
Shellfish	Laucala Bay, Fiji	0.061	Morrison *et al*., 2001
Shellfish	Astrolabe Lagoon, Fiji	0.34(dry weight)	Morrison *et al*., 1997
Shellfish	Tonga	nd	Morrison and Brown, 2003
Canned fish			
Canned Albacore	Fiji	0.16 – 0.27	*This Study*
Canned Skipjack	Fiji	0.06 – 0.11	*This Study*
Canned Tuna in oil	Fiji	0.05 – 0.16	*This Study*
Canned Mackerel	Fiji	0.18 – 0.22	*This Study*
Canned salmon Mackerel	Fiji	0.17 – 0.29	*This Study*
Canned Tuna	unknown	0.13	Louie, 1983
Canned Tuna	Various Countries	0.1 – 1.0	Holden, 1973
Canned Tuna	Australia	0.78	Kyle and Ghani, 1981
Canned Salmon	Australia	0.32	Kyle and Ghani, 1981
Canned Pink Salmon	United States	0.08	Kyle and Ghani, 1981
Canned Red Salmon	Canada	0.13	Kyle and Ghani, 1981
Canned Mackerel	Japan	0.48	Kyle and Ghani, 1981
Canned Mackerel	New Zealand	0.18	Kyle and Ghani, 1981
Lobster and crabs			
Crabs	Fiji	0.03 – 0.07	*This Study*
American lobster	unknown	0.5 – 2.0	USEPA, 1997

Miscellaneous Fish			
Rainbow Trout	New Zealand	0.18 – 1.84	Kim, 1995
Freshwater anchovy	Lake Murray,PNG	0.64	Kyle and Ghani, 1982a
Dolphins	Japan	4.70 – 15.0	Endo *et al*., 2003
Predatory Whales	Japan	1.64 – 46.9	Endo *et al*., 2003
Filter-feeding Whales	Japan	0.02 – 0.1	Endo *et al*., 2003
Electric Ray	Mediterranean Sea	1.65 – 3.59	Storelli *et al*., 2002
Eagle Ray (*M . aquila*)	Mediterranean Sea	0.67 – 1.01	Storelli *et al*., 2002
Freshwater Eels	New Zealand	0.12 – 0.65	Redmayne *et al*., 2000
Barramundi	Papua New Guinea	0.32- 0.57	Kyle and Ghani,1982a
Broad snouted catfish	Papua New Guinea	0.12 - 0.31	Kyle and Ghani, 1982a,b
Sapik gar pike	Lake Murray, PNG	0.44	Kyle and Ghani, 1982a
Mackerel	Port Moresby, PNG	0.13 - 0.15	Sorentino, 1969 in Kyle, 1981
Atlantic Barracuda		2.0 – 3.0	USEPA, 1997
Barracuda	Fiji	0.18 – 0.38	*This Study*
Sailfish	unknown	0.5 – 0.6	USEPA, 1997
Sailfish	Fiji	0.32 – 0.34	*This Study*

Note: nd = not detected

Health Implications of Mercury Levels in Fijian Seafoods

An indication of the amount of fish or shellfish that a person could safely consume in one week without exceeding the Joint FAO/WHO Expert Committee on Food Additives (JECFA, 2003) Provisional Tolerable Weekly Intake (PTWI) of 1.6 µg methylmercury/ kg of body weight/week is shown graphically in Figures 4a-d. The safe human consumption level (g/week) was calculated by average Hg values (see Tables 2-4) by the JECFA (2003) PTWI and then dividing by the average level of mercury in a particular fish. The calculations were performed for a range (10-120 kg) of individual body weights with heavier individuals theoretically able to consume more mercury without adverse health effects than lighter individuals. The default average human body weight used by JECFA is 60 kg but it is unclear whether this would be the same in the Pacific Islands. The calculated PTWI's are based on total mercury levels as methylmercury was not measured, but as described earlier methylmercury forms nearly 100% of the total mercury levels in fish although there is some question whether this is true for the shellfish.

It should be noted that some samples had limited samples taken so values can be considered only as a general guideline until further analyses are performed. However, it is clear that health risks, particularly to children and pregnant women, exist from consuming relatively small quantities (<1-2 portions per week) of a number of the larger predatory fish species, such as swordfish, marlin, shark, sunfish and bigeye tuna (Figure's 4a and b). One portion of fish is considered equal to 135g (source: 1994 Food Composition Table for the Pacific) which is about the weight of one small fillet of fish. Frequent consumption of more than the recommended amount of these fish by pregnant women and women of childbearing age could be harmful to a developing fetus.

These findings are concerning as the larger-sized fish are often the cheaper priced species (FJ $2-$4/kg) which are sold as by-catch from the tuna trade (see Figure 5). Although purchasing and consumption data is lacking, it is believed that due to the low price, these fish are commonly and perhaps preferentially bought by local people and restaurants. The risk of consumption of these larger-sized species of fish by pregnant women is not publicized in Fiji so a definite health risk exists. Canned fish can be consumed in moderate quantities (4-7 cans per week depending on body weight) without a risk of health effects (Fig. 4c) and shellfish and reef could be consumed in very large amounts (2-3 kg/week for an average sized person, Fig 4d).

The analyses in the current study were performed on raw (uncooked) fish tissue but mercury is not significantly removed by normal cooking processes (USEPA, 2001). Because moisture is lost during cooking, the concentration of mercury (on a weight for weight basis) after cooking is actually higher than it is in fresh uncooked fish (USEPA, 2001).

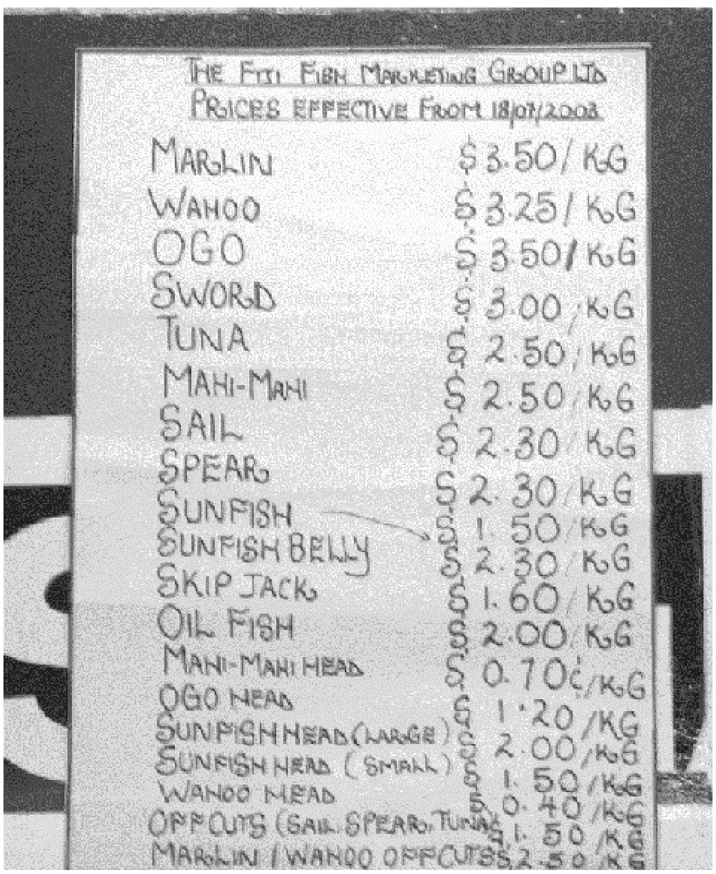
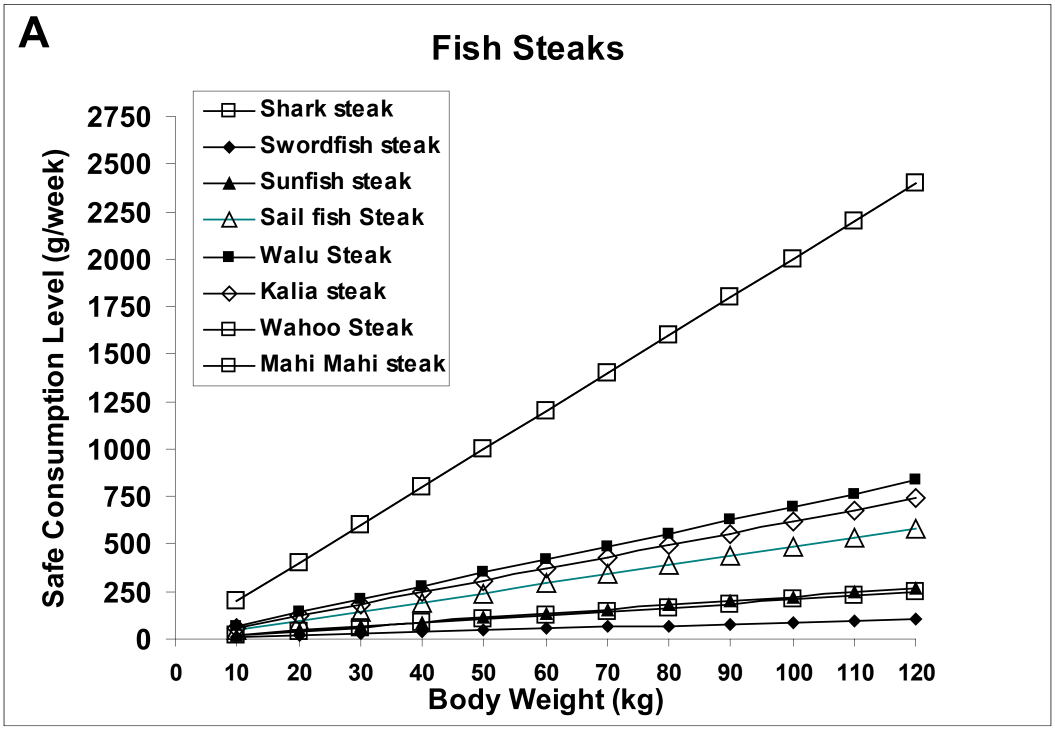


Figure 5: Fish price list in Suva, Fiji showing the low price for a number of species which contain high mercury levels.



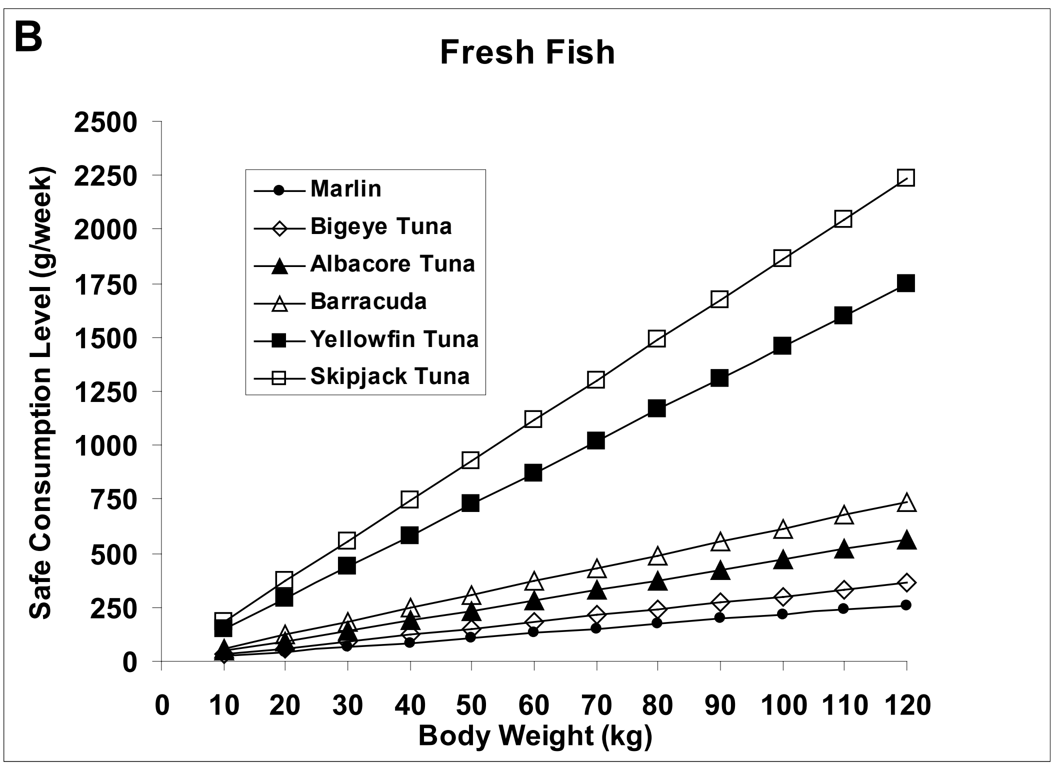
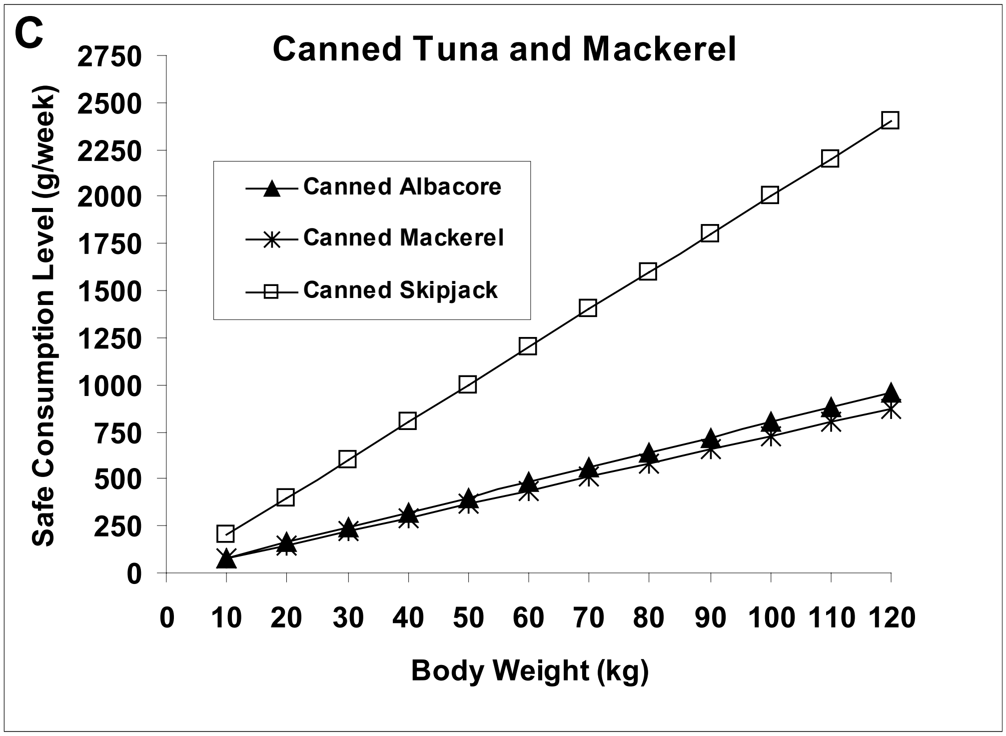


Figure 4: Provisional Tolerable Weekly Intake (PTWI) of: A. Fish Steaks and B. Fresh Fish based on different body weights (kg).



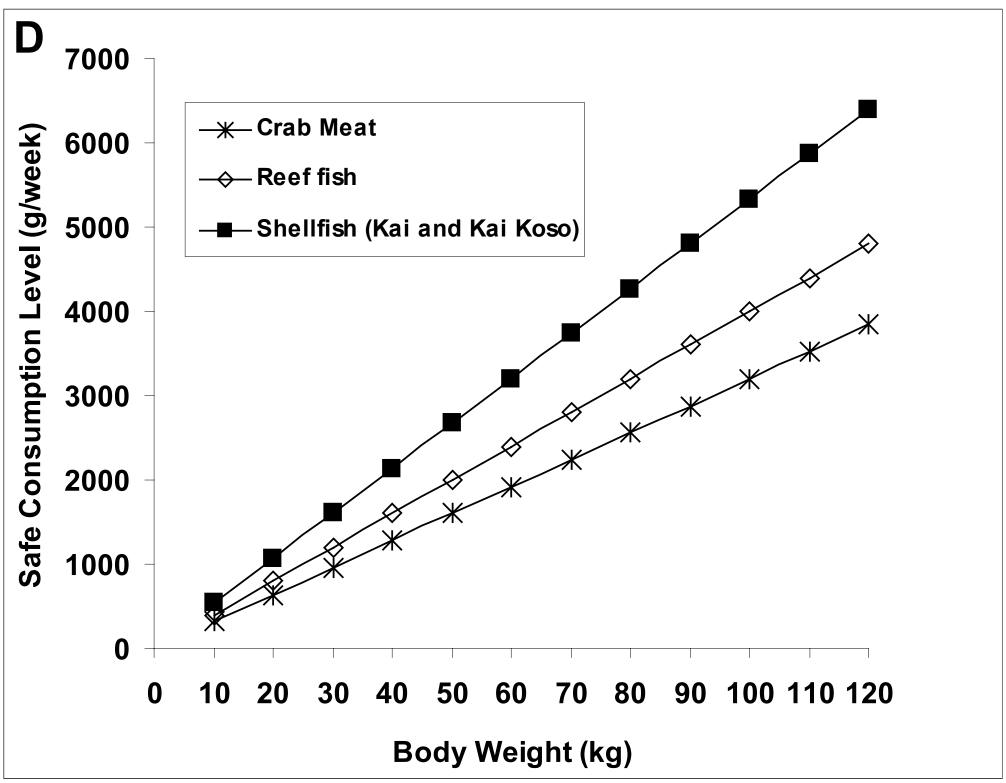


Figure 4 Cont': Provisional Tolerable Weekly Intake (PTWI) of: C. Canned Tuna and D. Shellfish, Crabs and Reef fish based on different body weights (kg).

Recommendations

1. **Further mercury analyses**: Further mercury analyses should be performed because the number of samples that could be taken from individual species was limited due to the large number of fish types analysed in this study. More emphasis should be placed on the large predatory species in subsequent research.
2. **Issue Health advisories and Conduct Public Education (particularly targeted at pregnant women):** We recommend that public education and health advisories warn that; adults should eat no more than two portions per week (about the weight of two small cans of tuna) of the following species: Shark, Swordfish, Sunfish, Marlin, Sailfish, Albacore and Bigeye tuna with pregnant women and the women of childbearing age only allowed 1 portion a week.
3. **Study fish consumption patterns:** There is a need to identify the species of fish most commonly eaten within Fiji and an indication of the approximate amounts of fish consumed. More samples could be analysed on the fish consumed in the greatest amount. It would be useful to target specific groups within the population such as: 1. persons buying from the fish shops where the tuna bycatch species are sold 2. Coastal villages where fish provides an important food source 3. Pregnant women and 4. Children
4. **Analysis of Human Body Burdens:** It is recommended that a population study be initiated measuring human mercury levels be performed. Hair is one of the indicators of long-term body load for Hg while blood, breast milk and urine are indicators of short term exposure. Hair would be the least intrusive indicator to measure and samples could be collected from the target groups noted in (3) above. Hair also allows you to reconstruct the individuals exposure to mercury by sequential measurement of hair segments (e.g. 1 cm intervals). Body weight could also be measured at the time of the hair sampling. Measurement of both total and methylmercury levels in the hair would also be useful to investigate the dominant form.
5. **Analyses in other Pacific Island locations**: There is a need to measure mercury levels in seafoods from the various other Pacific Island countries as mercury

levels may differ from location to location due to different levels of natural inputs and localized sources of contamination. A good idea would be the establishment of a long-term South Pacific mercury monitoring program.

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Appendix

RESULT SUMMARY FOR TOTAL MERCURY IN FISH TISSUES

#	Type of Fish	Length (cm)	Weight (kg)	Location	[Hg] mg/kg
1	Albacore Tuna	55	13	Lau/Cikobia, Fiji	0.03
2	Albacore Tuna	55	14	Lau/Cikobia, Fiji	0.18
3	Albacore Tuna	65	14	Lau/Cikobia, Fiji	0.27
4	Albacore Tuna	55	11	Lau/Cikobia, Fiji	0.19
5	Albacore Tuna	70	17	Lau/Cikobia, Fiji	0.40
6	Albacore Tuna	70	15	Lau/Cikobia, Fiji	0.27
7	Albacore Tuna	41	10	Lau/Cikobia, Fiji	0.31
8	Albacore Tuna	90	40	Lau Group, Fiji	0.18
9	Albacore Tuna	90	40	Lau Group, Fiji	0.13
10	Albacore Tuna	95	42	Lau Group, Fiji	0.14
11	Albacore Tuna	100	42	Lau Group, Fiji	0.45
12	Albacore Tuna	80	36	Lau Group, Fiji	0.21
13	Albacore Tuna	85	38	Lau Group, Fiji	0.33
14	Albacore Tuna	87.5	39	Lau Group, Fiji	0.40
15	Albacore Tuna	75	30	Lau Group, Fiji	0.28
16	Albacore Tuna	80	34	Lau Group, Fiji	0.22
17	Albacore Tuna	70	17	Koro Island, Fiji	0.18
18	Albacore Tuna	70	16	Koro Island, Fiji	0.39
19	Albacore Tuna	60	17	Koro Island, Fiji	0.69
20	Albacore Tuna	67.5	15	Koro Island, Fiji	0.79
21	Albacore Tuna	60	16	Koro Island, Fiji	0.48
22	Albacore Tuna	55	14	Koro Island, Fiji	0.59
23	Albacore Tuna	60	16	Koro Island, Fiji	0.78
24	Albacore Tuna	65	16	Koro Island, Fiji	0.34
25	Albacore Tuna	55	13	Koro Island, Fiji	1.01
26	Albacore Tuna	60	15	Koro Island, Fiji	0.25
27	Albacore Tuna	87	15	North Lau Group, Fiji	0.07
28	Albacore Tuna	85	12	North Lau Group, Fiji	0.19
29	Albacore Tuna	91	15	North Lau Group, Fiji	0.20
30	Albacore Tuna	85	14	North Lau Group, Fiji	0.28
31	Albacore Tuna	89	15	North Lau Group, Fiji	0.18
32	Yellowfin Tuna	37.5	13	Yasawa/Lau Grp, Fiji	0.05
33	Yellowfin Tuna	37.5	12	Yasawa/Lau Grp, Fiji	0.03
34	Yellowfin Tuna	45	15	Yasawa/Lau Grp, Fiji	0.04
35	Yellowfin Tuna	37.5	14	Yasawa/Lau Grp, Fiji	<0.02
36	Yellowfin Tuna	27.5	10	Yasawa/Lau Grp, Fiji	0.05
37	Yellowfin Tuna	30	13	Yasawa/Lau Grp, Fiji	<0.02
38	Yellowfin Tuna	32.5	12	Yasawa/Lau Grp, Fiji	<0.02
39	Yellowfin Tuna	65	18	Yasawa/Lau Grp, Fiji	0.18
40	Yellowfin Tuna	60	16	Yasawa/Lau Grp, Fiji	0.07
41	Yellowfin Tuna	55	12	Yasawa/Lau Grp, Fiji	<0.02
42	Yellowfin Tuna	95	19	Kadavu&Lau Grp, Fiji	<0.02
43	Yellowfin Tuna	95	15	Vanuatu	<0.02

44	Yellowfin Tuna	98	20	Vanuatu	<0.02
45	Yellowfin Tuna	141	53	Taveuni, Fiji	0.20
46	Yellowfin Tuna	97	16	Lau Group, Fiji	0.40
47	Yellowfin Tuna	48	2.84	Suva Market	<0.02
48	Yellowfin Tuna	89	13	Off Yasawa Grp, Fiji	0.10
49	Yellowfin Tuna	93	15	Off Yasawa Grp, Fiji	0.08
50	Yellowfin Tuna	83	10	Off Yasawa Grp, Fiji	0.05
51	Yellowfin Tuna	90	17	Off Yasawa Grp, Fiji	0.38
52	Yellowfin Tuna	88	12	Off Yasawa Grp, Fiji	0.27
53	Yellowfin Tuna	91	13	Off Yasawa Grp, Fiji	0.19
54	Yellowfin Tuna	84	11	Off Yasawa Grp, Fiji	0.09
55	Yellowfin Tuna	91	13	Off Yasawa Grp, Fiji	0.24
56	Skipjack Tuna	45	2.75	Kiribati (Tarawa Island)	0.03
57	Skipjack Tuna	45	2.75	Kiribati (Tarawa Island)	0.08
58	Skipjack Tuna	45	2.75	Kiribati (Tarawa Island)	0.03
59	Skipjack Tuna	45	2.75	Kiribati (Tarawa Island)	0.05
60	Skipjack Tuna	45	2.75	Kiribati (Tarawa Island)	<0.02
61	Skipjack Tuna	45	2.75	Kiribati (Tarawa Island)	0.04
62	Skipjack Tuna	45	2.75	Kiribati (Tarawa Island)	0.03
63	Skipjack Tuna	45	2.75	Kiribati (Tarawa Island)	0.05
64	Skipjack Tuna	45	2.75	Kiribati (Tarawa Island)	0.08
65	Skipjack Tuna	45	2.75	Kiribati (Tarawa Island)	0.03
66	Skipjack Tuna	47	1.85	Suva Market	0.12
67	Skipjack Tuna	45	1.83	Suva Market	0.16
68	Bigeye Tuna	86	13	Taveuni, Fiji	0.28
69	Bigeye Tuna	120	40	Lau Group, Fiji	0.80
70	Bigeye Tuna	104	32	Lau Group, Fiji	0.52
71	Wahoo	92	6	Kadavu/Lau Group, Fiji	0.17
72	Marlin	216	118	Yasawa Group, Fiji	5.60
73	Marlin	184	78	Unknown	1.22
74	Marlin	145	47	Unknown	1.00
75	Marlin	143	47	Unknown	0.45
76	Marlin	150	47	Unknown	0.54
77	Reef Fish (Kaikai)	16	0.08	Suva Market	0.04
78	Reef Fish (Kaikai)	17	0.09	Suva Market	0.03
79	Reef Fish (Kaikai)	18	0.11	Suva Market	<0.02
80	Reef Fish (Kaikai)	17	0.08	Suva Market	0.05
81	Reef Fish (Kaikai)	18	0.08	Suva Market	0.04
82	Parrot Fish (ulavi)	35	0.98	Suva Market	<0.02
83	Parrot Fish (ulavi)	31	0.51	Suva Market	<0.02
84	Goatfish (mataroko)	28	0.31	Suva Market	0.03
85	Rabbitfish (nuqa)	32	0.50	Suva Market	0.15
86	Peacock cod (Kawakawa)	33	0.62	Suva Market	<0.02
87	Unicornfish (ta)	39	1.07	Suva Market	<0.02
88	Opah	111	65	Kadavu/Lau Grp, Fiji	0.27
89	Barracuda	80	2.64	Suva Market	0.26
90	Barracuda	60	1.23	Suva Market	0.38
91	Barracuda	60	0.98	Suva Market	0.23

92	Barracuda	45	0.41	Suva Market	0.18
93	Mussels (Kai)			Nasinu River	<0.02
94	Mussels (Kai)			Nasinu River	<0.02
95	Mussels (Kai)			Rewa River	0.04
96	Shellfish (kaikoso)			Rewa River	0.05
97	Shellfish (kaikoso)			Rewa River	<0.02
98	Shellfish (kaikoso)			Navua River	0.03

Results for Total Mercury In Canned Tuna and Makerel

#	Type of Canned Fish	Brand	Packed By	[Hg] ug/g
99	Albacore Tuna Flakes in Oil	Old Capital Special	PAFCO, Fiji	0.19
100	Albacore Tuna Flakes in Oil	Old Capital Special	PAFCO, Fiji	0.18
101	Albacore Tuna Flakes in Oil	Old Capital Special	PAFCO, Fiji	0.21
102	Albacore Tuna Flakes in Oil	Old Capital Special	PAFCO, Fiji	0.19
103	Albacore Tuna Flakes in Oil	Old Capital Special	PAFCO, Fiji	0.16
104	Tuna Flakes (light Meat) in Canola Oil	Ocean Master	Fish Canners (Fiji) Ltd	0.07
105	Tuna Flakes in Canola Oil salt added	Ocean Master	Fish Canners (Fiji) Ltd	0.16
106	Skipjack Tuna Flakes in Oil	Pacific Choice	Product of Thailand	0.07
107	Skipjack Tuna Flakes in Oil	Pacific Choice	Product of Thailand	0.08
108	Skipjack Tuna Flakes in Oil	Pacific Choice	Product of Thailand	0.09
109	Tuna (Light Meat)	Just	Packed for MH's	0.05
110	Albacore Tuna Flakes in Oil	Sun Bell	PAFCO, Fiji	0.27
111	Skipjack Tuna Flakes	Koro Sea	PAFCO, Fiji	0.10
112	Skipjack Tuna Flakes	Koro Sea	PAFCO, Fiji	0.11
113	Skipjack Tuna Flakes	Koro Sea	PAFCO, Fiji	0.10
114	Skipjack Tuna Chunks in Brine	Sun Bell	PAFCO, Fiji	0.06
115	Skipjack Tuna Chunks in Brine	Sun Bell	PAFCO, Fiji	0.07
116	Skipjack Tuna Chunks in Brine	Sun Bell	PAFCO, Fiji	0.07
117	Mackerel in Natural Oil	Just	Packed for MH's	0.22
118	Mackerel in Natural Oil	Just	Packed for MH's	0.22
119	Mackerel in Natural Oil	Just	Packed for MH's	0.22
120	Salmon Style Mackerel in Natural Oil	Sunrise Gold	Fish Canners (Fiji) Ltd	0.27
121	Salmon Style Mackerel in Natural Oil	Sunrise Gold	Fish Canners (Fiji) Ltd	0.27
122	Salmon Style Mackerel in Natural Oil	Sunrise Gold	Fish Canners (Fiji) Ltd	0.29
123	Salmon Style Mackerel in Natural Oil	Ocean	Vo-Ko Industries Ltd, Fiji	0.18
124	Salmon Style Mackerel in Natural Oil	Ocean	Vo-Ko Industries Ltd, Fiji	0.17
125	Salmon Style Mackerel in Natural Oil	Ocean	Vo-Ko Industries Ltd, Fiji	0.17
126	Mackerel in Natural Oil Salt Added	Seaking	Vo-Ko Industries Ltd, Fiji	0.18
127	Mackerel in Natural Oil Salt Added	Seaking	Vo-Ko Industries Ltd, Fiji	0.20
128	Mackerel in Natural Oil Salt Added	Seaking	Vo-Ko Industries Ltd, Fiji	0.21

Result Summary for Total Mercury in Different Fish Steaks

#	Type of Fish Steaks	Diameter of Steak (cm)	[Hg] ug/g
129	Marlin Steaks	10	<0.02
130	Marlin Steaks	23	0.77
131	Marlin Steaks	25	0.79
132	Marlin Steaks	14	0.08
133	Marlin Steaks	15	0.44
134	Marlin Steaks	14	0.39
135	Marlin Steaks	12	0.25
136	Marlin Steaks	23	0.37
137	Marlin Steaks	21	0.39
138	Marlin Steaks	15	0.43
139	Marlin Steaks	11	0.05
140	Marlin Steaks	10	0.13
141	Marlin Steaks	12	0.14
142	Marlin Steaks	26	0.92
143	Marlin Steaks	25	0.79
144	Marlin Steaks	26	0.57
145	Marlin Steaks	23	0.55
146	Marlin Steaks	28	0.87
147	Marlin Steaks	29	1.01
148	Walu Steaks	11	0.07
149	Walu Steaks	10	<0.02
150	Walu Steaks	13	0.67
151	Walu Steaks	10	<0.02
152	Walu Steaks	16	0.87
153	Walu Steaks	11	0.14
154	Walu Steaks	11	0.17
155	Walu Steaks	10	0.11
156	Walu Steaks	9	0.14
157	Walu Steaks	16	0.22
158	Walu Steaks	14	0.17
159	Walu Steaks	13	0.20
160	Walu Steaks	12	0.21
161	Walu Steaks	12	0.21
162	Walu Steaks	13	0.21
163	Walu Steaks	15	0.26
164	Walu Steaks	17	0.30
165	Wahoo Steaks	11	0.05
166	Wahoo Steaks	15	0.12
167	Wahoo Steaks	14	0.07
168	Wahoo Steaks	14	0.06
169	Swordfish Steaks	21	0.99
170	Swordfish Steaks	23	1.37
171	Swordfish Steaks	21	1.07
172	Swordfish Steaks	27	2.81
173	Swordfish Steaks	25	2.79

174	Shark Steaks	17	0.84
175	Shark Steaks	7	0.85
176	Shark Steaks	13	0.85
177	Shark Steaks	15	0.84
178	Shark Steaks	16	0.74
179	Shark Steaks	12	0.76
180	Shark Steaks	19	0.57
181	Mahi Mahi Steaks	20	0.05
182	Mahi Mahi Steaks	22	0.11
183	Mahi Mahi Steaks	22	0.07
184	Sail Fish Steaks	25	0.34
185	Sail Fish Steaks	22	0.32
186	Sun Fish Steaks	22	0.78
187	Sun Fish Steaks	21	0.76
188	Sun Fish Steaks	22	0.78
189	Sun Fish Steaks	22	0.61
190	Sun Fish Steaks	31	0.67
191	Black snapper Steaks	27	0.34
192	Black snapper Steaks	19	0.17
193	Skipjack Tuna Steaks	15	0.16
194	Skipjack Tuna Steaks	15	0.11
195	Skipjack Tuna Steaks	12	0.17
196	Skipjack Tuna Steaks	16	0.12
197	Skipjack Tuna Steaks	15	0.19
198	Crab Meat	15	0.06
199	Crab Meat	14	0.03
200	Crab Meat	11	0.07