Dioxins in Prawns and Fish from Sydney Harbour

An Assessment of the Public Health and Safety Risk

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Executive Summary

The NSW Food Authority requested a risk assessment by FSANZ of the potential public health risk associated with consumption of prawns and fish from the Sydney Harbour area, based on survey results indicating higher than expected levels of dioxins.

'Dioxins' refers to a group of persistent chlorinated chemical compounds, the polychlorinated dibenzodioxins (PCDDs or dioxins), the closely related polychlorinated dibenzofurans (PCDFs or furans), and some polychlorinated biphenyls (PCBs) compounds that exhibit similar toxicity to dioxins. The risk assessment included results for the 29 dioxin congeners that the World Health Organization (WHO) identified as having a common mechanism of toxicity and were persistent and accumulated in the food chain. Concentrations of dioxins used in the risk assessment were based on the WHO derived 'toxic equivalent factors' (TEFs) for different congeners.

In 2002, the Australian National Health and Medical Research Council (NHMRC) established a tolerable monthly intake (TMI) for dioxins of 70 pg TEQ/kg of body weight from all sources (including food, air and dermal exposure). The tolerable intake was established on a monthly basis to indicate the long-term nature of any potential dioxin toxicity.

Around 95% of human exposure to dioxins comes from the diet. Background dietary exposure to dioxins from a range of foods across the total diet were estimated by FSANZ in 2004 as a part of the National Dioxins Program (NDP). The exposure estimate was based on analytical concentrations of dioxins and food consumption data from the 1995 Australian National Nutrition Survey, and was calculated using the FSANZ dietary modelling computer program, DIAMOND. A range of age groups were assessed and for all these groups and the population as a whole, the mean and 95th percentile monthly dietary exposures were below the Australian TMI. The estimated exposures did not include non-food sources. The major foods contributing to dietary exposure were fish (including crustaceans and molluscs), milk and dairy products. Both the concentration data for the range of foods analysed and mean consumption data for each food for all respondents from this study were used in the calculations of dioxin exposure based on Sydney Harbour seafood as outlined below.

Several estimates of dietary exposure were calculated based on the Sydney Harbour seafood concentration data: first assuming that Sydney Harbour seafood was eaten infrequently by the general population; and second assuming that Sydney Harbour seafood was eaten more frequently and at higher levels of consumption. The mean dioxin concentrations for Sydney Harbour prawns and fish used in the exposure assessments were derived from the survey data supplied by NSW Food Authority. The mean concentration for prawns was 12 picograms TEQ per gram (pg TEQ/g) and the mean concentration for fish was 30 pg TEQ/g. The estimated exposures and calculations conducted did not include exposure from non-food sources.

The first set of calculations estimated dietary exposure for the general population from the whole diet, excluding and including Sydney Harbour seafood, assumed to be eaten infrequently (based on a mean level of consumption for the whole population of 120 grams of prawns per month and 210 grams of fish per month). For the general population, baseline exposures (with prawns and fish at nationally representative dioxin concentrations) were up to 20% of the TMI. When the Sydney Harbour dioxin concentration for prawns only was used, estimated exposures increased up to 50% of the TMI. When the Sydney Harbour dioxin concentration for fish only was used for the estimate, exposures increased up to 160% of the TMI. When both the Sydney Harbour prawns and fish dioxin concentrations were used, exposures were up to 190% of the TMI.

The second set of dietary exposure calculations were based on different levels of consumption of Sydney Harbour fish taking account of background levels of dioxin exposure from all other foods. It was determined that consumption of one mean (average size) serve of Sydney Harbour fish of 115 grams per month resulted in a dioxin exposure below the TMI. All other consumption frequencies (for example, one large serve of 305 grams per month, or more than one mean or large serve per week), resulted in a dioxin exposure that exceeded the TMI.

To assist in developing risk management options including a consumer advisory, an estimate of how much Sydney Harbour seafood could be consumed before exceeding the TMI for dioxins was calculated, taking account of the background level of dioxin exposure from all other foods. Approximately one large portion size of prawns (330 grams), or four mean serves (of 75 grams), could be consumed per month before the TMI was exceeded. For fish it was estimated that one mean fish serve (115 grams) could be consumed per month, or one large serve (305 grams) every two months, before the TMI was exceeded.

FSANZ also estimated the number of standard 150 gram serves of prawns and fish that could be consumed before exceeding the TMI. This was equivalent to 2 standard serves of prawns per month or one standard serve of fish per month.

The maximum concentration of dioxins that could be present in fish before the TMI was exceeded was also estimated at different levels of consumption. If a consumer ate one mean serve of fish per week, the maximum concentration of dioxins in the fish could be 8 pg TEQ/g before the TMI was exceeded. For one mean serve per month, it would be up to 33 pg TEQ/g. If a standard 150 gram portion size is used, and assuming one serve per week (four per month), the maximum concentration of dioxins that could be in the fish before the TMI was exceeded was estimated to be 6 pg TEQ/g.

In characterising the level of risk to the population, the uncertainties in the setting of the TMI were considered along with the uncertainties in the consumption and concentration data used and the likely consumption patterns of Sydney Harbour seafood.

FSANZ concluded that whilst the public health and safety risk for the majority of the general Australian population from dioxin exposure is considered to be very low due to the infrequent and low levels of consumption of seafood from Sydney Harbour seafood, risk managers may wish to consider further measures to ensure that the background dioxin exposure of the population is maintained at levels that are as low as reasonably practicable.

For eaters of Sydney Harbour prawns on a regular long term basis there is likely to be an overall increase in the dietary exposure to dioxins and a reduction in the safety margin between the background dioxin exposure and the levels that could potentially cause adverse health effects after long-term exposure.

However, the dietary exposure data for the general population shows that there is likely to be an exceedance of the TMI when Sydney Harbour fish is consumed as part of the whole diet. When looking specifically at consumers of fish, the potential for frequent long-term eaters (for example, recreational fishers or commercial fishers who eat their own catch) to exceed the TMI is increased such that the concentrations of dioxins in the Sydney Harbour fish represent an unacceptable public health and safety risk. In the case of this relatively small population group, risk managers may wish to take more immediate action to reduce their dioxin exposure.

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1. Introduction

The results of a survey of dioxin levels in prawns from the Sydney Harbour area conducted by the NSW Interdepartmental Committee on Contaminants in Fish and funded by the NSW Maritime Authority were made available to the NSW Food Authority in November 2005. The survey results indicated dioxin levels in prawns were higher than control samples taken from other areas of Australia and were higher than expected in areas that were outside the prohibited fishing areas.

Subsequent to the testing of prawns, fish samples from these areas were also taken, and they also showed higher than expected levels of dioxins.

The NSW Food Authority requested an assessment by FSANZ of the potential public health risk associated with consumption of these prawns and fish. The results of the assessment for both prawns and fish are combined in this report.

2. Properties of dioxins

'Dioxins' refers to a group of persistent chlorinated chemical compounds, the polychlorinated dibenzodioxins (PCDDs or dioxins), and the closely related polychlorinated dibenzofurans (PCDFs or furans), which have similar chemical structures and properties, including toxic properties. Polychlorinated biphenyls (PCBs) are another group of chemicals closely related to dioxins. Some PCB compounds exhibit similar toxicity to dioxins, and are therefore considered to be 'dioxin-like PCBs'. The term 'dioxins' or 'total dioxins' is generally taken to include PCDDs, PCDFs and dioxin-like PCBs.

The World Health Organization (WHO) identified 29 of these closely related compounds (congeners) as having a common mechanism of toxicity and were persistent and accumulated in the food chain. Although these 29 compounds have a similar mechanism of toxicity, their toxicities differ and WHO derived so-called 'toxic equivalent factors' (TEFs) to enable a human risk assessment to be undertaken for these complex chemical mixtures. TEFs refer to a weighting factor for each congener that reflects its toxicity relative to that of the most toxic dioxin, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). The analytical concentration for each congener is multiplied by that congener's TEF to determine a 'weighted' concentration or 'toxic equivalent' (TEQ). Thus, survey results are expressed as picogram TEQ per gram food.

Humans are exposed to dioxins in most cases by consuming contaminated food. These compounds can accumulate in the body fat of animals and humans and have a tendency to remain unchanged for prolonged intervals. The rate of accumulation of dioxins in body fat will depend on the level of exposure. The total concentration of dioxins found in animals or humans is referred to as the body burden.

3. Tolerable intake for dioxins in humans

The nature of the adverse effects associated with dioxins have been well characterised by national and international reviews of the toxicity data on dioxins. In 2002, the Australian National Health and Medical Research Council (NHMRC) established a tolerable intake for dioxins based on a consideration of all of the available toxicity reviews. These included reports prepared by the WHO European Centre for Environmental Health and International Programme on Chemical Safety (1998), the European Community Scientific Committee on Food (2001), and the Joint FAO/WHO Expert Committee on Food Additives (JECFA) (2001).

Each of these reviews concludes that any potential adverse effect associated with dioxins exposure at the levels normally found in food would only be observed following long-term exposure (40-50 years) leading to an elevation in dioxin body burden. The adverse effects observed in animals include developmental delays, thyroid hormone alterations and cancer. The dioxin body burden at which these effects occurred has been studied to determine whether a threshold for these effects exists. Upon consideration of the available reviews, the NHMRC concluded that a tolerable intake could be established for dioxins on the basis that a threshold exists (based on body burden) for all observed adverse effects, including cancer.

An Australian tolerable monthly intake (TMI) was established for dioxins of 70 pg TEQ/kg of body weight from all sources. This is equivalent to the provisional tolerable monthly intake (PTMI) established by JECFA in 2001. The tolerable intake was established on a monthly basis to indicate the long-term nature of any potential dioxin toxicity. '*All sources*' of exposure refers to a number of exposure routes such as food, air, dermal exposure, cigarette smoking and industrial exposure.

4. Background dietary exposure to dioxins in food in Australia

It is recognized that around 95% of human exposure to dioxins is from the diet (Department of Environment and Heritage, 2004; National Health and Medical Research Council, 2002).

In 2004, FSANZ conducted a survey of dioxins in a range of foods representative of the total diet (FSANZ, 2004) as a part of the National Dioxins Program (NDP). The dietary exposure assessment for the general Australian population was conducted using FSANZ's dietary modelling computer program, DIAMOND[1]. The

[1] Results are given for the whole population, based on all survey respondents in the 1995 National nutrition survey (NNS). In the case of dioxins all respondents were consumers of a food containing dioxin, but not all respondents consumed prawns or fish.

results provided information on the mean and 95th percentile dietary exposure to dioxins for various age groups: toddlers aged 2-4 years; children aged 4-15 years; young adults aged 16-29 years; adults aged 30-44 years and 45-59 years; and older adults aged 60 years and above. A dietary exposure assessment was also conducted for infants aged 9 months using a constructed diet based on infant formula. The results for the Australian population (2 years and above) provide information on potential lifetime exposure.

The food survey analysed composite food samples for each of the 29 PCDD/F and dioxin-like PCBs for which the WHO developed toxicity equivalency factors (TEFs). Results are reported for PCDD/F and PCB concentrations and combined with food consumption data from the 1995 National Nutrition Survey (NNS) to determine dietary exposure. The concentrations of all of the PCDD/F and PCB congeners were summed to give overall dioxin levels.

Overall, the concentration of dioxins in the surveyed foods was very low with the highest mean PCDD/F concentrations being found in peanut butter (0.035-0.235 pg TEQ/g fresh weight, lower to upper bound[2]), butter (0.010-0.20 pg TEQ/g fresh weight) and fish fillets (0.08-0.13 pg TEQ/g fresh weight). Highest mean PCB concentrations were found in fish fillets (0.51 pg TEQ/g fresh weight, at the lower and upper bound), although much of this was contributed by a single sample.

For all age groups and the population as a whole, the mean and 95th percentile monthly dietary exposures were below the Australian tolerable monthly intake for dioxins of 70 pg TEQ/kg body weight (bw)/month. The estimated exposures did not include non-food sources. For the Australian population group aged two years and above, where estimates can be used to represent a lifetime of exposure, mean estimated exposure to dioxins was 3.7-15.6 pg TEQ/kg bw/month (lower to upper bound) and estimated 95th percentile exposures for this group was 16.1-40.6 pg TEQ/kg bw/month (lower to upper bound). Toddlers aged 2-4 years were estimated to have the highest exposure to dioxins (mean 6.2-36.7 and 95th percentile 12.1-66.2 pg TEQ/kg bw/month, lower to upper bound respectively) due to their higher food consumption relative to body weight. The mean estimated dietary exposure to dioxins calculated for infants aged 9 months was 11.8-60.8 pg TEQ/kg bw/month (lower to upper bound).

The major foods contributing to PCDD/F exposure and to PCB exposure for the general population (2 years and above) were fish (including crustaceans and molluscs) and milk and dairy products. For toddlers and children, the major foods contributing to both PCDD/F and PCB exposure were milk and dairy products.

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[2] **Lower bound** – assumes results reported as being below the LOR are zero**. Upper bound** – assumes results reported as being below the LOR are at the LOR.

5. Results from the current survey in Sydney Harbour

FSANZ was provided with the results of prawn and fish sampling collected towards the end of 2005 and beginning of 2006 for risk assessment purposes.

FSANZ does not have available details of the sampling plans or analytical methodology. Some details are provided in the main body of the Expert Panel Report '*Dioxins in Seafood in Port Jackson and its Tributaries*' prepared by the NSW Food Authority (NSW Food Authority, 2006; www.foodauthority.nsw.gov.au).

5.1 Prawns

A summary of the analytical results from the Sydney Harbour prawns survey program are shown in Table 1. The mean of all samples was 11.3 pg TEQ/g. However, greasyback prawns are not normally for sale, so these results were not included in the level used for the dietary exposure assessments, where it was assumed consumers would be eating prawns with a mean concentration of 12.0 pg TEQ/g.

Two control samples were also taken of Banana prawns from Queensland, with dioxin concentrations of 0.07 and 0.1 pg TEQ/g.

5.2 Fish

Bream samples were collected from a number of sites in Sydney Harbour and analysed. The results are shown in Table 2. The mean of all bream samples was 29.1 pg TEQ/g. A rounded value of 30 pg TEQ/g was used for the dietary exposure assessments.

Table 1: Dioxin concentrations in Sydney Harbour prawns

Sample site	Total pg TEQ/g fresh weight			
Parramatta River (to Gladesville Bridge, West to East)				
Silverwater school prawns	18.2	13.9		
	20.4			
	19.2			
	6.9			
	9.7			
	8.9			
Near Homebush Bay school prawns	16.3	18.4		
	20.4			
Near Homebush Bay king prawns	14.1	14.1	14.3	
	14.0			
Breakfast Point school prawns	15.3	17.4		
	19.4			
Breakfast Point king prawns	15.3	12.5		
	13.1			
	14.1			
	9.4			
	13.2			
	9.7			
Paramatta River (East of Gladesville Bridge) and Port Jackson (West to East)				11.3
Drummoyne school prawns	16.2	19.9		
	22.9			
	20.7			
Drummoyne king prawns	5.8	7.3		
	7.4			
	8.6			
Drummoyne greasyback prawns	3.2	3.3		
	3.1			
	3.6			
Gore Bay king prawns	6.8	6.4	8.3	
	6.2			
	6.2			
Fort Denison king prawns	7.2	7.2		
	8.0			
	6.5			
Clifton Gardens king prawns	5.6	5.7		
	6.4			
	5.0			

Table 2: Dioxin concentrations in Sydney Harbour bream

Sample Site	Total pg TEQ/g fresh weight			
Parramatta River (to Gladesville Bridge, West to East)				
Silverwater	34.6	36.4		
	48.0			
	21.7			
	28.4			
	49.3			
Homebush Bay	96.0	95.9	48.5	
	141.0			
	45.3			
	114.0			
	83.0			
Breakfast Point	16.8	13.1		
	11.8			
	12.4			
	14.5			
	10.1			
Parramatta River (East of Gladesville Bridge) and Port Jackson (West to East)				
Drummoyne	14.4	15.2	17.5	29.1
	17.7			
	16.8			
	14.8			
	12.4			
Gore Bay	12.4	17.3		
	14.9			
	21.5			
	19.6			
	17.9			
Fort Denison	24.2	17.3		
	11.3			
	12.7			
	22.8			
	15.7			
Clifton Garden	49.0	22.3		
	22.1			
	6.6			
	24.3			
	9.6			
Balmoral	21.6	14.7		
	7.8			
	13.8			
	15.5			
	17.1			

6. Dietary exposure assessment

A dietary exposure assessment was conducted by FSANZ in two different ways:

- first, an estimate of the dietary exposure for the general population as a result of eating seafood from Sydney Harbour infrequently based on the mean level of consumption for the population (section 6.1); and
- second, an estimate of the dietary exposure as a result of eating seafood from Sydney Harbour more frequently and at higher levels of consumption (section 6.2).

6.1 Estimated dietary exposure for the general population (excluding and including Sydney Harbour seafood)

A dietary exposure assessment for the general population from the whole diet was undertaken using dioxin concentration data for all foods from the National Dioxins Program (NDP) and for three scenarios substituting NDP fish and prawn concentration data with dioxin concentration data from Sydney Harbour seafood, as described below:

a. A 'baseline' exposure assessment – this exposure assessment used mean consumption data of foods for all National Nutrition Survey (NNS) respondents and the mean concentrations of dioxins included in the 2004 NDP exposure assessment.

   The general population, or 'all NNS respondents', refers to all people in the NNS (n=13858 aged 2 years and above), which includes people who consumed prawns and fish, and those that did not, on the day they were surveyed. The mean consumption of prawns for all respondents was 4 grams per day, and the mean consumption of fish for all respondents was 7 grams per day. All respondents to the NNS were consumers of dioxins from food. Since dioxins are broadly distributed in foods, all respondents consumed at least one food assigned a dioxin concentration and were therefore dioxin consumers. A dietary exposure assessment was undertaken for PCDD/Fs and PCBs separately and these were summed to give an estimated dietary exposure to dioxins. (This baseline exposure estimate differs slightly from that presented in the NDP report where food consumption data for individuals from the 1995 NNS were used. The baseline exposure estimate was re-calculated in order to allow a comparison to the exposure estimate conducted using the Sydney Harbour prawn and fish concentration data). The baseline exposure estimate included prawns and fish in the calculation but with concentrations representative of prawns and fish across Australia.

b. A 'Sydney Harbour prawns' exposure assessment scenario – this exposure assessment used the 'baseline' exposure assessment but substituted the prawn concentration data with the mean concentration of 12.0 pg TEQ/g derived from the Sydney Harbour analyses (section 5.1).

c. A ‘Sydney Harbour fish’ exposure assessment scenario – this exposure assessment used the ‘baseline’ exposure assessment but substituted the fish concentration data with the mean concentration30.0 pg TEQ/g derived from the Sydney Harbour analyses (section 5.2).

d. A ‘Sydney Harbour prawns and fish’ exposure assessment scenario – this exposure assessment used the ‘baseline’ exposure assessment but substituted the prawn and fish concentration data with the mean concentration for both prawns and fish derived from Sydney Harbour analyses.

The TMI for dioxins is based on a long-term exposure, therefore, it is appropriate that the mean dietary exposure for the population aged 2 years and above, representing exposure over a longer period of time, is compared to the TMI. The estimated dietary exposures calculated for the general population have been determined on the basis of data from the 1995 NNS, which uses a 24-hour food recall for its data collection. It was necessary, therefore, to multiply the estimated daily dietary exposure data by 30 in order to allow a direct comparison with the TMI (in section 7.1). This has the effect of assuming that prawns and fish are consumed by all respondents every day of the month. For this assessment, that means that if 4 grams of prawns were consumed in one day, then 120 grams were consumed in the month. For fish, if 7 grams was consumed in one day, then 210 grams was consumed in the month.

Mean dioxin concentrations for all foods, except for prawns and fish, remained the same for the exposure assessments for the baseline and all three scenarios. Mean dioxin concentrations for prawns and fish used for the baseline and the scenarios are shown in Table 3. Lower bound mean concentrations were calculated assuming that for ‘not detected’ results, the dioxin concentration was zero. The upper bound mean concentrations were calculated assuming that for ‘not detected’ results, the dioxin concentration was at the limit of reporting (LOR).

The mean dioxin levels for Sydney Harbour prawns and fish were used to represent the ‘average’ dioxin level per meal over time. It is also very unlikely that a plate of prawns would contain prawns that all have the maximum (or minimum) concentration level.

The estimated dietary exposures are shown in Table 4. Using the mean Sydney Harbour prawn concentration of 12.0 pg TEQ/g, the total dietary exposure to dioxins increased by around 20 pg TEQ per kilogram of body weight per month from the baseline exposure. Using the mean Sydney Harbour fish concentration of 30.0 pg TEQ/g, the total dietary exposure to dioxins for Sydney Harbour fish increased around 100 pg TEQ per kilogram of body weight from the baseline exposure. For estimates using both the Sydney Harbour prawns and fish mean concentration data, dioxin exposure increased by around 120 pg TEQ per kilogram of body weight from the baseline exposure.

Table 3: Mean dioxin concentrations in seafood used in the dietary exposure assessments for the general population

Exposure estimate	Food	Total dioxins pg TEQ/g fresh weight (Lower Bound – Upper Bound)
Baseline	Prawns*	0.15 - 0.16
	Fish fillets*	0.59 - 0.64
Sydney Harbour prawns scenario	Prawns	12.0 - 12.0
	Fish fillets*	0.59 - 0.64
Sydney Harbour fish scenario	Prawns*	0.15 - 0.16
	Fish fillets	30.0 - 30.0
Sydney Harbour prawns and fish scenario	Prawns	12.0 - 12.0
	Fish fillets	30.0 - 30.0

* From NDP analysis.

Table 4: Estimated mean monthly dietary exposure to total dioxins for the general population (all respondents aged 2 years and above in the NNS)

Scenario	pg TEQ/month (Lower Bound – Upper Bound)	pg TEQ/kg bw/month* (Lower Bound – Upper Bound)
Baseline	230 – 920	3.4 – 13.7
Sydney Harbour prawns	1666 – 2353	24.9 – 35.1
Sydney Harbour Fish	6737 – 7415	100.6 – 110.7
Sydney Harbour prawns and fish	8173 – 8850	122.0 – 132.1

* Mean body weight for respondents in the 1995 NNS 2 years and above = 67kg.

Note that the baseline estimates of exposure are slightly different to those reported for the NDP (FSANZ, 2004). This is due to the fact that summary food consumption data (mean consumption for all respondents including eaters and non-eaters for each food) have been used in this assessment, as opposed to food consumption data for each individual NNS respondent, which were used for the NDP.

6.2 Estimated dietary exposure to dioxins for different consumption patterns of Sydney Harbour fish

The potential dietary exposure to dioxins was calculated for different patterns of fish consumption, assuming that fish was either consumed in mean and large serve size portions once a week or once a month. The results of this estimate are shown in Table 5.

A rounded mean concentration figure of 30 pg TEQ/g for fish from the recent analytical survey (see raw results section 5.2) was used in these dietary exposure estimates and portion sizes from the 1995 NNS of 115 g/day for a mean serve, 305 g/day for a large serve.

Table 5: Estimated monthly dietary exposure to dioxins based on 2006 Sydney Harbour fish concentration data for different fish consumption patterns

Number of serves of fish	Background exposure (pg TEQ/ kg bw/month)	Exposure from fish containing 30 pg TEQ/g (pg TEQ/kg bw/month)	Total exposure (pg TEQ/kg bw/month)
1 mean serve per month	3-14	51	54-65
1 large serve per month	3-14	136	139-150
1 mean serve per week (4/mo)	3-14	206	209-220
1 large serve per week (4/mo)	3-14	546	549-560
3 mean serves per week (12/mo)	3-14	618	621-632
3 large serves per week (12/mo)	3-14	1639	1642-1653

Similar calculations using dioxin concentration levels in fish from the NDP and from the 1990 NSW Sydney Harbour fish survey are presented at Appendix A for comparison. Based on dioxin concentration data for fish from the NDP (mean of less than 1 pg TEQ/g) consuming 12 mean serves of fish per month results in an estimated exposure of between 15-26 pg/kg bw/month (lower bound to upper bound), and for 12 larger serves per month, between 36-47 pg/kg bw/month. Based on concentration data for fish from Sydney Harbour in 1990 (mean of 18 pg TEQ/g), one mean serve per month resulted in an estimated exposure of between 33-45 pg/kg bw/month (lower bound to upper bound), and for one large serve per month, between 85-96 pg/kg bw/month.

7. Characterisation of the potential risk associated with dioxins in seafood

7.1 Estimated dietary exposure to dioxins for the general population as a percentage of the TMI

The estimated mean monthly dietary exposures to total dioxins for the general population from the whole diet were calculated in section 6.1 both excluding and including Sydney Harbour seafood. These have been expressed as a percentage of the TMI and shown in Table 6. The estimated exposures did not include non-food sources. Baseline dietary exposure (i.e. for those individuals consuming non-Sydney Harbour prawns and fish) was 5-20% of the TMI. Dietary exposure assuming prawns have the mean concentration of dioxins found in the Sydney Harbour survey, was 35-50% of the TMI (lower to upper bound estimate). Dietary exposures including Sydney Harbour fish were 140-160% of the TMI. Including Sydney Harbour prawns and fish resulted in an estimated exposure of 180-190% of the TMI. As indicated previously, these estimated dietary exposures include consumption of prawns of 4 grams per day (120 grams in the month) and for fish of 7 grams per day (210 grams in the month).

The mean results are presented in Table 6, however a proportion of the population will have dietary exposures that are higher than the mean lower to upper bound ranges presented.

Table 6: Estimated mean monthly dietary exposure to total dioxins for the general population (all respondents aged 2 years and above) as a percentage of the TMI

Scenario	%TMI* (Lower Bound – Upper Bound)
Baseline	5 - 20
Sydney Harbour prawns	35 - 50
Sydney Harbour fish	140 - 160
Sydney Harbour prawns and fish	180 - 190

*TMI of 70 pg/kg bw/month.

7.2 Estimated dietary exposure to dioxins for different consumption patterns of Sydney Harbour fish as a percentage of the TMI

The estimated dietary exposures based on a mean fish concentration of 30 pg TEQ/g as a percentage of the TMI are shown in Table 8 for different patterns of fish consumption, assuming that fish was either consumed in mean (115 g) and large (305 g) serve size portions once a week or once a month. Only when one

mean serve per month is consumed is the dietary exposure below the TMI. For a larger serve per month, or for more frequent serves per month, the estimated dietary exposure exceeds the TMI. The estimated exposures did not include non-food sources.

Table 8: Estimated monthly dietary exposure to dioxins for different consumption patterns of Sydney Harbour fish as a percentage of the TMI

Number of serves of fish	% TMI*
1 mean serve per month	75-95
1 large serve per month	200-210
1 mean serve per week (4/mo)	300-310
1 large serve per week (4/mo)	780-800
3 mean serves per week (12/mo)	890-900
3 large serves per week (12/mo)	2350-2360

*TMI = 70 pg/kg bw/month.

7.3 Estimate of the amount of Sydney Harbour seafood that may be consumed without exceeding the TMI

7.3.1 Prawns

To ensure frequent consumers of prawns from Sydney Harbour are considered in the risk assessment, the amount of Sydney Harbour prawns that could be consumed such that the TMI is not exceeded has been calculated.

The background exposure to dioxins from food is 3-14 pg TEQ/kg bw/month as determined from the baseline exposure estimate (see Table 4). Therefore, an individual could consume a quantity of prawns equivalent to a dioxin exposure of 56-67 pg TEQ/kg bw/month before the TMI of 70 pg TEQ/kg bw/month would be exceeded. For an individual with a mean body weight of 67 kg (as derived from all respondents in the 1995 NNS aged 2 years and above), this equates to a dioxin exposure of 3752-4489 pg TEQ per month. This calculation is based on the assumption that there is no other exposure to dioxins from non-food sources.

Using a mean concentration of dioxins in prawns of 12.0 pg/g fresh weight, an individual can therefore consume 312-374 grams of prawns each month from the area sampled before the TMI is exceeded. Prawns were consumed by 384 respondents in the NNS (2.8% of respondents). The mean consumption for consumers only was 75 grams/day and the 97.5th percentile consumption for consumers only (representing a large portion size) was 327 grams/day[3]. Therefore,

[3] The amount per day is calculated by determining the amount of prawns that every consumer ate on the day that they were surveyed then dividing this by the number of consumers of prawns. This does not mean that those consumers eat that amount every day of the year.

in order for the TMI not to be exceeded, approximately one large portion size serve of prawns from this area could be consumed per month. If the amount of prawns that could be consumed per month were based on the mean consumption of prawns (based on prawn consumers only of 75 grams), this would equate to the person being able to consume between 4 and 5 serves of prawns from the sampled area per month.

Prawns are an infrequently consumed food, and are consumed by a small proportion of the population – in the NNS, there were 384 consumers of prawns out of 13858 respondents – and it is likely that the majority of prawn consumers would not consume them more than once per month. From the food frequency questionnaire conducted in the 1995 NNS, 6% of respondents aged 12 years and above reported consuming 'seafood other than fish or canned fish', which includes prawns, more than once per week, around 29% one to three times per month, and around 65% less than once per month or never. These data suggests that even high consumers of prawns are unlikely to consume them very frequently.

The total mean dietary exposures estimated in the previous section for the general population may appear to present a lower level of risk compared to the apparently small amount of prawns that can be consumed before the TMI is exceeded as estimated here. This is because the total dietary exposures for the general population are based on a mean consumption of prawns across the population (including non-consumers of prawns). The estimate here is for frequent prawn consumers based on actual consumption amounts of prawns from only those respondents in the NNS who consumed prawns.

7.3.2 Fish

Fish was consumed by 1627 respondents in the NNS (12% of respondents). The mean consumption for consumers only was 115 grams/day and the 95th percentile consumption for consumers only was 305 grams/day[4]. From the food frequency questionnaire undertaken as a part of the 1995 NNS (on respondents aged 12 years and over), approximately 25% respondents reported eating fish at least once a week, and <0.5% reported eating fish on a daily basis. The majority of the respondents (around 74%) consumed fish less than once per week.

With a TMI of 70 pg TEQ/kg bw/month and a background exposure of 3 to 14 pg TEQ/month, this leaves 56 to 67 pg/kg bw of the TMI which could be taken up for consumption of fish. This is equivalent to 3752 to 4489 pg/month for a 67 kg person. This calculation is based on the assumption that there is no other exposure to dioxins from non-food sources. Based on a mean concentration of dioxins of 30 pg TEQ/g, this equates to 125 to 150 grams fish/month, or 1 mean serve/month or one large serve every two months.

[4] The amount per day is calculated by determining the amount of fish that every consumer ate on the day that they were surveyed then dividing this by the number of consumers of fish. This does not mean that those consumers eat that amount every day of the year.

7.4 Estimate of the maximum concentration of dioxins in fish before the TMI is exceeded at different levels of consumption

An estimate of the maximum concentration of dioxins in fish before the TMI is exceeded has been determined for different consumption frequencies. A mean serve was equivalent to 115 grams fish and a large serve was 305 grams fish as determined using NNS data. The results are shown in Table 7. This calculation is based on the assumption that there is no other exposure to dioxins from non-food sources.

Table 7: Maximum concentration of dioxins that can be in fish such that consumers do not exceed the TMI*

Fish consumption level	Maximum dioxin level (pg TEQ/g)
1 mean serve per month	33 to 39
1 large server per month	12 to 15
1 mean serve per week (or 4/month)	8 to 10
1 large serve per week (or 4/month)	3 to 4
3 mean serves per week (or 12/month)	3 to 3
3 large serves per week (or 12/month)	1 to 1

* Includes background levels of dioxin dietary exposure from other foods in the diet.

If a standard 150g portion size was used for this calculation instead of the consumption figures derived using the 1995 NNS data, and assuming one serve per week (or 4 per month), with the remainder of the TMI of 56-67 pg/kg bw/month, and a mean body weight of 67kg, then the maximum level of dioxins in the fish could be 6-8 pg TEQ/g.

7.5 Estimated maximum number of standard serves of seafood

Based on the risk assessment and analytical data of dioxins in Sydney Harbour seafood the maximum number of standard serves of 150 g of seafood that can be consumed before the TMI is exceeded has been estimated. The calculations are based on mean concentrations from all prawn or fish sample results, assuming that over a lifetime, consumers would have eaten seafood with a mean concentration of dioxins. This calculation is based on the assumption that there is no other exposure to dioxins from non-food sources. Estimates have also been calculated based on samples from the two areas of the Harbour sampled, and for the perceived worst contaminated area of Homebush Bay. The maximum number of serves that can be consumed before the TMI is exceeded is shown in Table 9.

Obviously, if consumers are likely to eat both prawns and fish, they can only have one serve of fish and 2 serves of prawns in a 2 month period.

Table 9: Maximum number of standard 150 gram serves of prawns or fish that can be consumed before exceeding the TMI for dioxins

Seafood	Area	Mean dioxin concentration (pg TEQ/g)	No. 150 gram serves before TMI exceeded
Prawns	All*	12	2 per month#
	Parramatta River to Gladesville Bridge, west to east	14	2 per month#
	Homebush Bay area	16	2 per month#
Fish	All	30	1 per month
	Parramatta River to Gladesville Bridge, west to east	50	1 every 2 months
	Parramatta River (East) and Port Jackson	18	1 per month
	Homebush Bay	96	1 every 4 months

* Excludes greasyback prawns.
# Would be double this if prawns only available 6 months of the year.

7.6 Factors influencing characterisation of the public health risk

In characterising the public health risk associated with exposure to dioxins through a particular food commodity, it is necessary to consider the following:

(i) the nature of the adverse health effects associated with dioxin exposure;

(ii) the timeframe in which these effects are observed;

(iii) whether there is a threshold exposure level for these effects;

(iv) other sources of exposure that may not have been considered in the exposure estimates; and

(v) the limitations and uncertainties inherent in the available data.

There are two major uncertainties associated with the use of the TMI for dioxins as an indicator of the tolerable intake. Firstly, the significance of the toxicity endpoint used to establish the body burden threshold for dioxins; and secondly, the establishment of a short-term tolerable intake based on long-term body burden data. In considering these uncertainties, the JECFA report stated that: "*the PTMI is not a limit of toxicity and does not represent a boundary between safe intake and intake associated with a significant increase in body burden or risk.*" The report goes on to state: "*Long-term exposure slightly above the PTMI would not necessarily result in adverse health effects but would erode the safety factor built into the calculation of the PTMI. It is not possible, given our current knowledge, to define the magnitude and duration of excess intake that would be associated with adverse health effects.*"

In the case of dioxins, therefore, the TMI should be seen as a conservative estimate of a 'tolerable' exposure, but not necessarily as a threshold above which any exposure will result in adverse effects, particularly when long-term exposure is required before the occurrence of these effects.

In the relation to the dietary exposure assessment conducted for the general population for all foods including prawns and/or fish (section 6.1), in order to compare exposure (based on the NNS 24-hour recall consumption data) with the TMI, it is assumed that people eat the same way every day of the month. While this may be a valid assumption for some foods, it is a highly unlikely scenario for the consumption of prawns or fish. Even for relatively high consumers, prawns and fish are likely to be eaten infrequently. The source of the prawns and fish is also likely to vary, further reducing the likelihood of consuming prawns with higher than average dioxin levels over a long period of time.

The volume of the prawn or fish catch from this fishery is likely to be small in comparison to the total NSW or Australian catch. Additionally, prawns are usually only caught in Sydney Harbour for 6 months of the year. This will be a significant factor in considering the impact of the prawns from this site in relation to the overall exposure to dioxins from prawns.

All of the estimates of exposure outlined in this report have been for dietary exposure. Other non-food sources of exposure have not been taken into consideration, such as air and dermal exposure. This needs to be taken into consideration in characterising the level of risk from exposure. However, it is recognized that around 95% of the exposure to dioxins is from the diet (Department of Environment and Heritage, 2004; National Health and Medical Research Council, 2002).

7.7 Conclusions of the risk characterisation

7.7.1 Prawns from Sydney Harbour

A comparison of the mean dietary exposure data for dioxins in foods for the general population with the TMI does not raise any public health concerns as the results are all below the TMI when Sydney Harbour prawns are consumed as part of the whole diet. The infrequent nature of prawn consumption, and likelihood that prawns with higher than average dioxin levels will be mixed with prawns that have lower levels in a single meal and/or with prawns from other sources, further reduces the potential risk.

The consumption of prawns sourced from Sydney Harbour on a regular long term basis is likely to result in an overall increase in the dietary exposure to dioxins and a reduction in the safety margin between the background dioxin exposure of the population and the levels that could potentially cause adverse health effects after long-term exposure.

7.7.2 Fish from Sydney Harbour

A comparison of the mean dietary exposure data for dioxins in foods for the general population with the TMI shows that there is likely to be an exceedance of the TMI when Sydney Harbour fish are consumed as part of the whole diet.

When looking specifically at consumers of fish, the dietary exposure assessment showed that for fish caught from Sydney Harbour, there is the potential for frequent eaters of these fish (for example, recreational fishers or commercial fishers who eat their own catch) to exceed the reference health standard. More than one 150 gram standard serve of fish per month can result in the TMI being exceeded.

These results indicate that for frequent long-term consumers of Sydney Harbour fish the concentrations of dioxins in these fish represent an unacceptable public health and safety risk.

7.7.3 Seafood from Sydney Harbour

The public health and safety risk for the majority of the population from dioxin exposure following the consumption of prawns and fish from Sydney Harbour is considered to be very low, given the infrequent and low level of Sydney Harbour seafood consumed by the general population. Exposure to dioxins in Australia is well within the range of estimated exposures from other countries, as indicated in Appendix B. However, risk managers may wish to consider further measures to ensure that the background dioxin exposure of the population is maintained at levels that are as low as reasonably practicable.

For a relatively small sub-population group, namely, recreational fishers and commercial fishers who frequently consume their catch from Sydney Harbour, and do so over a long period, the public health and safety risk may be unacceptably high. In this case, risk managers may wish to take more immediate action to reduce the dioxin exposure of this group.

8. References

Department of Environment and Heritage 2004, *National Dioxins Program. Dioxins in Australia: a summary of the finding of studies conducted from 2001 to 2004*. Commonwealth of Australia.

European Commission 2000, *Opinion of the SCF on the Risk Assessment of Dioxins and Dioxin-like PCBs in Food*. Health and Consumer Protection Directorate-General, Scientific Committee on Food, November 2000.

Food Standards Agency (UK) 2003, *Dioxins and Dioxin-Like PCBs in the UK Diet: 2001 Total Diet Study Samples*, Food Survey Information Sheet 38/03, www.food.gov.uk/science/surveillance/ .

FSANZ, 2004, *Dioxins in Food. Dietary Exposure Assessment and Risk Characterisation. Technical Report Series No. 27*. FSANZ, Canberra.

Freijer JI, Hoogerbrugge R, van Klaveren JD, Traag WA, Hoogenboom LAP, Liem AKD 2001, Dioxins and dioxin-like PCBs in foodstuffs: Occurrence and dietary intake in The Netherlands at the end of the 20th century, Rijksinstituut voor Volksgezondheid en Milieu, Report 639102 022/2001.

Ministry for the Environment (New Zealand) 1998, *Concentrations of PCDDs, PCDFs and PCBs in retail foods and an assessment of dietary intake for New Zealanders*, Ministry for the Environment Website, www.mfe.govt.nz .

Ministry for the Environment (New Zealand) 2001, *Evaluation of the toxicity of dioxins and dioxin-like PCBs: A health risk appraisal for the New Zealand population*, Ministry for the Environment, Wellington, New Zealand.

National Health and Medical Research Council 2002, *Dioxins: Recommendation for a Tolerable Monthly Intake for Australians. Endorsed 24th October 2002*. Commonwealth of Australia.

NSW Food Authority 2006, *Dioxins in Seafood in Port Jackson and its Tributaries. Report of the Expert Panel. 24 February 2006*. NSW Food Authority website www.foodauthority.nsw.gov.au.

APPENDIX A – Preliminary dietary exposure estimates for fish

Prior to FSANZ receiving all analytical data for fish from the NSW Sydney Harbour survey, preliminary risk assessments on fish were conducted based on other data sets. These have been provided here for information as they were provided to the Expert Panel for consideration.

Estimated dietary exposure based on dioxin concentration data from nationally sampled fish

FSANZ analysed a small selection of fish and seafood as part of the risk assessment conducted for the National Dioxins Program (FSANZ, 2004). These samples were randomly collected from across Australia (during 2000-2001 for the 20th Australian Total Diet Survey) and provide an indication of nationally representative concentrations. The concentrations are shown below in Table A1, and were used to estimate dietary exposure for a set number of serves of fish per week, as shown in Table A2. This estimate of exposure was calculated in order to provide exposure estimates based on baseline dioxin concentrations if fish from all over Australia. It provides a basis for comparison of estimates based on Sydney Harbour fish data. The estimated exposures did not include non-food sources.

Table A1: Dioxin concentrations in selected fish from across Australia

	LB – UB mean (pg TEQ/g FW)		
Food	**PCDD/F**	**PCBs**	**Total**
Tuna (n=5)	0.0024 – 0.014	0.027 – 0.027	0.0294 – 0.041
Fish fillets (n=10)	0.08 – 0.13	0.51 – 0.51	0.59 – 0.64
Fish portions (n=9)	0.0013 – 0.018	0.017 – 0.02	0.0183 – 0.038

n – refers to number of composite analyses.
Source: FSANZ, 2004.

Table A2: Estimated monthly exposure to dioxins based on concentrations from fish fillet sampled across Australia

Number of serves of fish	Background exposure (pg TEQ/ kg bw/month)	Exposure from fish containing 0.6 pg TEQ/g (pg/kg bw/month)	Total exposure (pg/kg bw/month)
3 mean serves per week (12/mo)	3-14	12	15-26
3 large serves per week (12/mo)	3-14	33	36-47

Based on dioxin concentrations in fish fillet as determined by FSANZ (0.6 pg/g rounded), if a person can have 3752 to 4489 pg dioxins/month from fish without exceeding the TMI, then this equates to:

- 6253 to 7482 grams fish/month; or
- 54 to 65 mean (115 grams) serves/month or 20 to 24 large (305 grams) serves per month.

Based on dioxin concentrations found by FSANZ from fish across Australia, the estimated dietary exposure to dioxins is below the TMI, even at the high consumption level of fish of three serves per week (Table A3).

Table A3: Estimated monthly exposure to dioxins based on FSANZ analysed fish fillet concentrations

Number of serves	%TMI
3 mean serves per week (12/mo)	20-35
3 large serves per week (12/mo)	50-65

Estimated dietary exposure based on 1990 Sydney Harbour fish data

NSW Food Authority provided to FSANZ dioxin concentration data for fish collected in 1990. These data were used to conduct a preliminary risk assessment as more recent data were not available at the time when FSANZ began the risk assessment for the NSW Food Authority. These data were used to determine a mean concentration to calculate a preliminary estimate of exposure to dioxins from consuming fish in this area (see Table A4 below). These results are included here as they were provided to the Expert Panel for their consideration before more up to date data and exposure estimates were provided.

The mean concentration used in the modelling was derived using results for the only two congeners reported: 2378-TCDD and 2378-TCDF. The 2378-TCDD was assigned a toxic equivalence factor of 1 and 2378-TCDF a factor of 0.1, as determined by the World Health Organization (WHO, 1998). Where results were expressed as not detected (i.e. less than the limit of reporting, which changed for various fish samples), the actual number of the limit of reporting was assigned in deriving the mean. It was assumed that the results were expressed on a fresh weight basis. This provides an upper bound estimate of the mean, or a worst case scenario. The mean concentration for 2378-TCDD and 2378-TCDF was 18 pg TEQ/g (upper bound). There were 131 fish samples in the dataset.

Based on this mean concentration of 18 pg TEQ/g, if a person can have 3752 to 4489 pg/month from fish without exceeding the TMI from food sources of exposure only, then this equates to:

- 208 to 250 grams fish/month; or

- 2 mean (115 gram) serves/month or one large (305 gram) serve every one and a half months.

Table A4: Estimated monthly exposure to dioxins based on 1990 Sydney Harbour fish concentration data

Number of serves of fish	Background exposure (pg TEQ/ kg bw/month)	Exposure from fish containing 18 pg TEQ/g (pg/kg bw/month)	Total exposure (pg/kg bw/month)
1 mean serve per month	3-14	31	33-45
1 large serve per month	3-14	82	85-96
1 mean serve per week (4/mo)	3-14	124	127-138
1 large serve per week (4/mo)	3-14	328	331-342
3 mean serves per week (12/mo)	3-14	370	373-384
3 large serves per week (12/mo)	3-14	983	986-997

The 1990 Sydney Harbour fish data had a mean concentration of dioxins of 18 pg TEQ/g. One mean serve per month did not result in the TMI being exceeded, assuming exposure only from food sources. However, one larger serve, or mean serves of more than once per month, does result in the TMI being exceeded. Estimated exposures as a percent of the TMI are shown in Table A5.

Table A5: Estimated monthly exposure to dioxins based on 1990 Sydney Harbour fish concentration data as a percentage of the TMI

Number of serves	%TMI*
1 mean serve per month	45-65
1 large serve per month	120-140
1 mean serve per week (4/mo)	180-200
1 large serve per week (4/mo)	470-490
3 mean serves per week (12/mo)	530-550
3 large serves per week (12/mo)	1410-1430

* TMI = 70 pg/kg bw/month.

APPENDIX B - Results of other national dioxin dietary surveys

Comparison of dioxin concentrations in foods from different countries and/or monitoring programs is relatively difficult due to differences in foods sampled, analytical methodologies and calculation and reporting of TEQs. Difficulties in making comparisons between dioxin dietary exposure assessments are further compounded due to differences in survey design, age groups surveyed, different methods of determining food consumption for the population and different methods of collecting food data. In addition there can be quite different patterns of food consumption in different areas of the world.

However, in spite of the difficulties in making direct comparisons between different dietary studies, Table B1 provides an indication of the calculated dietary exposure to dioxins, on a monthly basis, in selected Australian populations compared with those calculated in populations from other areas of the world.

In general terms, the estimated intake of dioxins by Australians is comparable to that of New Zealand and lower than that of other industrialised nations. Further information on the dietary exposures in other countries is available in the FSANZ report on Dioxins in Food (FSANZ, 2004).

Table B1: An international comparison of mean estimated dietary intakes of dioxins

Country/region	Total Dioxins (pg TEQ/kg bw/month)	Reference
Australia[1]	3.7-15.6	FSANZ, 2004
New Zealand[2]	11.1	Ministry for Environment, 1998 and 2001
UK[3,4]	15-21	Food Standards Agency, 2003
The Netherlands[4,5]	39	Freijer et al, 2001
Europe[6,7]	36-90	European Commission, 2000

[1]-Range is lower bound to upper bound for all persons 2+years of age.
[2]-Medium bound estimate for adult males.
[3]-Range is lower bound to upper bound for the population average.
[4]-Sum of PCDD/F and PCB (total dioxins) may not equal sum of separate intakes due to rounding.
[5]-Lower bound estimate, mean lifelong-averaged (1-70 years) exposure.
[6]-I-TEQs. WHO-TEQs are 10-20% higher than I-TEQs.
[7]-Average dietary exposure for an adult person.