Dioxins in Seafood from Sydney Harbour

A Revised Assessment of the
Public Health and Safety Risk

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FOOD STANDARDS AUSTRALIA NEW ZEALAND

Australia
PO BOX 7186
CANBERRA BC ACT 2610
AUSTRALIA
TEL +61 2 6271 2241
FAX +61 2 6271 2278
email info@foodstandards.gov.au

New Zealand
PO BOX 10599
WELLINGTON
NEW ZEALAND
TEL +64 4 473 9942
TAX +64 4 473 9855
email info@foodstandards.govt.nz

Executive Summary

FSANZ conducted a risk assessment for dioxins in Sydney Harbour in the first part of 2006 based on analytical data from December 2005 for prawns and January 2006 for fish (bream). FSANZ concluded the public health and safety risk for the majority of the general Australian population from dioxin exposure from consumption of Sydney Harbour seafood was considered to be very low due to the infrequent and low levels of consumption. For eaters of Sydney Harbour prawns on a regular long term basis there was 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. For fish however, the dietary exposure data for the general population showed that there was likely to be an exceedence of the TMI when Sydney Harbour fish was 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 was increased such that the concentrations of dioxins in the Sydney Harbour fish represented an unacceptable public health and safety risk. Risk managers were advised that they should take steps to reduce overall exposure to dioxins and to take more immediate action to reduce the dioxin exposure for frequent long term consumers.

In September 2006, FSANZ was provided with the results of further sampling conducted since January 2006 on a broader range of Sydney Harbour seafood. These results indicated higher than expected levels of dioxins for new samples of fish and molluscs.

The NSW Food Authority requested a revised risk assessment by FSANZ of the potential public health risks associated with consumption of seafood from the Sydney Harbour area based on these new survey results.

'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.

The background dietary exposure to dioxins was estimated by FSANZ from a range of foods representative of the total diet as a part of the National Dioxins Program (NDP) (FSANZ 2004). The estimated mean dietary exposure for the Australian population 2 years and above (representative of a lifetime exposure), was estimated to be between 3 and 14 pg TEQ/kg bw/month. The estimated 95th percentile exposure for this group was between 16 and 41 pg TEQ/kg bw/month. These estimates of dietary exposure were below the TMI.

Several estimates of dietary exposure were calculated based on the Sydney Harbour seafood concentration data. The dietary exposure assessments conducted previously by FSANZ were updated based on the new concentration data as well as additional assessments being conducted for consideration by the Expert Panel that was established by the NSW Food Authority who assessed the issue.

The first assessment conducted was 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 crustacea, fish and molluscs used in the dietary exposure assessments was derived from the survey data supplied by NSW Food Authority. The mean concentration for all crustacea was 11 picograms TEQ per gram (pg TEQ/g), the mean concentration for all fish was 25 pg TEQ/g and molluscs had a mean concentration of 17 pg TEQ/g. Seafood dioxin concentrations also differed significantly from east of the Harbour Bridge to the west of the Harbour Bridge. For example, the mean concentration in fish to the east of the Harbour Bridge was 11 pg TEQ/g, while fish to the west had a noticeable higher concentration of 37 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, 3 grams of crab per month, 210 grams of fish per month and 19 grams of squid per month). For the general population, baseline dietary exposures (with crustacea, fish and molluscs at nationally representative dioxin concentrations) were up to 20% of the TMI. When the Sydney Harbour dioxin concentration for crustacea only was used, estimated mean exposures increased up to 50% of the TMI. When the Sydney Harbour dioxin concentration for fish only was used for the estimate, mean exposures increased up to 135% of the TMI and based on the Sydney Harbour molluscs only was 35% of the TMI. When Sydney Harbour seafood (crustacea, fish and mollusc) dioxin concentrations were used, mean exposures increased to 170% of the TMI.

The second set of dietary exposure calculations was based on different levels of consumption of Sydney Harbour seafood taking account of background levels of dioxin exposure from all other foods. It was determined that consumption of one mean serve of crustacea (75g) per week, one mean serve of Sydney Harbour fish per month (115g) or one mean serve of mollusc (80g) per week resulted in a dioxin exposure below the TMI. All

higher consumption frequencies (for example, one large serve of 305 grams of fish per month), resulted in a dioxin exposure that exceeded the TMI.

To assist in developing risk management options including consumer advisory information, an estimate of how many grams of 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. The estimates were that a maximum of between 341-408 grams per month of crustacea can be consumed before the TMI is exceeded, 150-180 grams per month fish and 220-264 grams per month of molluscs, taking into account a range of background dietary exposure from other foods of 3 to 14 pg TEQ/kg bw/month.

FSANZ also estimated the number of standard 150 gram serves of seafood that could be consumed before exceeding the TMI for all crustacea, fish and molluscs, and also broken down by species, as well as an analysis by area of Sydney Harbour (east and west of the Harbour Bridge). For all crustacea, fish and molluscs, this was equivalent to 2 standard serves of crustacea per month, one standard serve of fish per month or one standard serve of molluscs per month. When the assessment was conducted by species, three types of fish had less frequent number of serves permitted compared to the all fish assessment. These fish were sea mullet, silver biddie and tailor. When the assessment was done by area of the Harbour, in all cases, the number of serves per month was less for fish caught east of the Harbour Bridge.

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 of 115 grams, 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 could be up to 33 pg TEQ/g. If a standard 150 gram portion size was 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. It was concluded that, similar to the previous FSANZ assessment based on prawns and bream, that some risk management action is required because in some scenarios the TMI could be exceeded, particularly for long term frequent consumers of Sydney Harbour seafood.

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1. Background and previous risk assessment

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 New South Wales (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.

FSANZ conducted a risk assessment for dioxins in Sydney Harbour in the first part of 2006 based on analytical data from December 2005 for prawns and January 2006 for fish (bream) (see the FSANZ website http://www.foodstandards.gov.au/foodmatters/dioxinsinfood.cfm). FSANZ concluded the public health and safety risk for the majority of the general Australian population from dioxin exposure from consumption of Sydney Harbour seafood was considered to be very low due to the infrequent and low levels of consumption. For eaters of Sydney Harbour prawns on a regular long term basis there was 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. For fish however, the dietary exposure data for the general population showed that there was likely to be an exceedence of the tolerable monthly intake (TMI) for dioxins when Sydney Harbour fish was consumed as part of the whole diet. When specifically assessing frequent long term consumers of fish, for example, recreational fishers or commercial fishers who eat their own catch, the potential to exceed the TMI was increased such that the concentrations of dioxins in the Sydney Harbour fish represented an unacceptable public health and safety risk. Risk managers were advised that they should take steps to reduce overall exposure to dioxins and to take more immediate action to reduce the dioxin exposure for frequent long term consumers.

A FSANZ risk assessment report was prepared (FSANZ 2006) along with a report by the Expert Panel that was established by the NSW Food Authority (NSWFA 2006) who assessed the issue.

As a consequence of the risk assessment, a limit of consumption of one 150 gram serve a month for fish or two 150 gram serves a month for prawns was recommended for recreational fisherman, and commercial fishing was totally banned in all areas of the Harbour. See NSW Food Authority website (www.foodauthority.nsw.gov.au) for further information on these recommendations.

Subsequent to the initial testing of prawns and fish, more recent seafood samples of a broader range of fish, crustacea and molluscs were caught and analysed, once again showing higher than expected levels of dioxins.

2. Revised risk assessment

The NSW Food Authority requested an assessment by FSANZ of the potential public health risk associated with consumption of all types of seafood analysed based on the updated analytical data. FSANZ revised its previous dietary exposure assessment and conducted some additional assessments based on the updated concentration that were provided to the NSW Food Authority and the Expert Panel to assist in making risk management decisions.

The revised risk assessment was based on additional sampling conducted in the Sydney Harbour area between Sydney Harbour Entrance and the upper Parramatta River, following the notification of fishing bans and consumption advice given in February 2006.

2.1 Aims of the revised risk assessment

FSANZ understood the aims of the revised assessment were to:

- recalculate the estimates of dietary exposure to determine whether the level of risk to the population, or any population sub groups, had changed;
- determine whether consumption advice could be different for different types of seafood; and
- determine whether consumption advice needed to be different for different areas of Sydney Harbour.

The revised assessment was conducted based on samples from all areas of the Harbour as a whole for crustacea, fish and molluscs. Dioxin concentrations from the previous assessment as well as the new concentration data were included. Assessments for different species of crustacea, fish and molluscs were conducted based on samples from the all areas of the Harbour. Additionally, a separate assessment was conducted for areas west and east of Sydney Harbour Bridge for all crustacea, fish and molluscs as well as individual species.

3. Tolerable intake for dioxins in humans

As described in the previous FSANZ risk assessment for dioxins in prawns and fish in Sydney Harbour (FSANZ 2006), the Australian TMI was established for dioxins of 70 pg TEQ/kg of body weight from all sources by the National Health and Medical Research Council (NHMRC 2002). This TMI was used in the previous and this revised risk assessment.

The TMI is a reference health standard that can be described as an endpoint for a food contaminant with cumulative properties that has a very long half life in the human body. Its value represents the allowable monthly exposure unavoidably associated with otherwise wholesome and nutritious foods (WHO 1987; WHO 2002). The tolerable intake was

established on a monthly basis to indicate the long-term nature of any potential dioxin toxicity.

4. Background dietary exposure to dioxins in food in Australia

The background dietary exposure to dioxins was estimated by FSANZ from a range of foods representative of the total diet as a part of the National Dioxins Program (NDP) (FSANZ 2004). The estimated mean dietary exposure for the Australian population 2 years and above (representative of a lifetime exposure), was estimated to be between 3 and 14 pg TEQ/kg bw/month. The lower end of the range was calculated assuming not detected analytical results were zero and the upper end of the range where not detected results were equal to the limit of reporting (LOR) for the analytical method for that sample. The estimated 95th percentile exposure for this group was between 16 and 41 pg TEQ/kg bw/month. These estimates of exposure were below the TMI.

5. Dioxin concentrations in Sydney Harbour seafood

There were 243 new samples of crustacea, fish and molluscs collected between May and September 2006 including 14 additional species (only prawns and bream were sampled originally) from all areas of the Harbour. Sampling sites included areas east of the Harbour Bridge at the Harbour entrance and Middle Harbour, and areas west of the Harbour Bridge in the lower, middle and upper Parramatta River including Homebush Bay.

'Dioxins' and 'dioxin concentrations' in this report refers to the total of 29 congeners (including dioxins and dioxin like compounds such as furans and dioxin like PCBs) that the World Health Organisation (WHO) determined as having a common mechanism of toxicity (WHO 1998).

Toxic equivalent factors (TEFs) refer to a weighting factor for each of the 29 dioxin congeners reflecting its toxicity relative to that of the most toxic dioxin, TCDD. A toxic equivalent (TEQ) concentration for the analysed sample was derived using the TEFs. The WHO revised its TEFs in 2005 (Van den Berg *et al* 2006). When FSANZ completed its previous assessment on dioxins in prawns and fish (bream) in Sydney Harbour in June 2006, the 1998 TEF values from WHO were used (WHO 1998). After assessing the difference in the TEFs between 1998 and 2005 (see Appendix 1) and the resulting TEQ concentrations for some samples based on the different TEFs it was determined that there was little change in the TEQ values, and in all cases tested, the TEQ went down slightly. Therefore, it was determined that by using revised TEQ concentrations there would be negligible impact for this revised risk assessment, and it was decided that the previous TEF values would again be used to maintain consistency between the initial and revised assessments, and to allow the data from the previous assessment to be pooled with the more recent analytical data. Using the 1998 TEFs would result in slightly higher TEQs which

meant that the risk assessment would be a worst case scenario and therefore would err on the side of caution.

The concentration data from Sydney Harbour seafood are discussed below for crustacea, fish and molluscs and are summarised in Table 1.

5.1 Crustacea

Prawns and crab were the two types of crustacea sampled. The mean concentration of dioxins for all crustacea was 11 pg TEQ/g and included 50 samples. When separating samples between east and west of the Harbour Bridge the mean concentrations were 6 pg TEQ/g and 13 pg TEQ/g respectively.

5.1.1 Prawns

Prawns were sampled in late 2005. No new samples of prawns were taken and analysed in the latest sampling in 2006. Therefore, the concentration data have not changed. The mean concentration for prawns from all areas of the Harbour was 12 pg TEQ/g. Six samples of prawns were analysed east of the Harbour Bridge with a mean concentration of 6 pg TEQ/g. Twenty seven samples were collected west of the Harbour Bridge with a mean concentration of 13 pg TEQ/g.

5.1.2 Crab

Crab samples had not been assessed for dioxins in the assessment early in 2006. Blue swimmer crab were collected in the recent sampling and analysed. The mean of the crab samples from all areas of the Harbour was 9 pg TEQ/g. Six samples of crab were collected east of the Harbour Bridge with a mean concentration of 5 pg TEQ/g. Eleven crab samples were analysed west of the Harbour Bridge with a mean concentration of 10 pg TEQ/g.

5.2 Fish

Bream was the only species of fish sampled in the beginning of 2006 for which the results were used for both the previous and this risk assessment. More recently, new samples of a wider variety of fish species have been taken and analysed. The dioxin concentrations of all fish analysed are shown in Table 1.

For the previous risk assessment dioxin concentrations from bream alone were used to represent all types of fish. Bream were separated out for this more recent assessment, like the other individual types of fish. This assessment included five new samples of bream which were collected at the same time as fish samples for the current assessment. The mean concentration for bream used for this assessment was 27 pg TEQ/g (45 fish samples), while a mean concentration of 30 pg TEQ/g was used for the previous assessment (40 fish samples).

The mean dioxin concentration for all fish in this revised risk assessment was 25 pg/TEQ/g with 316 samples taken from across the Harbour. 146 fish were sampled east of the Harbour Bridge with a mean concentration of 11 pg/TEQ/g. Fish samples west of the Harbour Bridge totalled 170 with a mean concentration of 37 pg/TEQ/g.

Fourteen individual types of fish were sampled and analysed. The dioxin concentrations ranged significantly between the types of fish. The majority of different fish (9 out of 14) had mean dioxin concentrations lower than the all fish mean of 25 pg TEQ/g. Five types of fish (bream, sea mullet, silver biddie, silver trevally and tailor) had mean concentrations above the all fish mean, with means of 27, 99, 41, 29 and 38 pg TEQ/g respectively.

5.3 Molluscs

Molluscs had not previously been sampled and analysed for dioxins. This revised assessment was based on the results of 37 squid samples that had been collected and analysed. The mean concentration for all squid was 17 pg TEQ/g. Samples collected to the east of the Harbour Bridge had a mean concentration of 6 pg TEQ/g with the mean concentration of samples to the west of the Harbour Bridge at 24 pg TEQ/g.

Table 1. Dioxin concentration data for seafood from Sydney Harbour including based on location in Harbour

Seafood	Seafood sub-category	All data			East of Harbour Bridge			West of Harbour Bridge		
		Number of Samples	Mean (pg TEQ/g)	Rounded mean for exposure estimates (pg TEQ/g)	Number of Samples	Mean (pg TEQ/g)	Rounded mean for exposure estimates (pg TEQ/g)	Number of Samples	Mean (pg TEQ/g)	Rounded mean for exposure estimates (pg TEQ/g)
Crustacea	**All[#]**	**50**	**11.0**	**11**	**12**	**5.8**	**6**	**38**	**12.6**	**13**
	Prawns*[#]	33	12.0	12	6	6.4	6	27	13.4	13
	Crab	17	8.9	9	6	5.2	5	11	10.2	10
Fish	**All**	**316**	**25.1**	**25**	**146**	**10.7**	**11**	**170**	**37.4**	**37**
	Bream*	45	26.8	27	15	18.3	18	30	31.1	31
	Dusky Flathead	7	3.6	4	3	2.1	2	4	4.6	5
	Fanbelly Leatherjacket	8	0.8	1	3	0.5	1	5	0.9	1
	Flounder	24	6.2	6	9	1.8	2	15	8.8	9
	Kingfish	8	2.2	2	8	2.2	2	0	n/a	n/a
	Luderick	33	11.1	11	16	2.4	2	17	19.3	19
	Mulloway	3	20.6	21	0	n/a	n/a	3	20.6	21
	Sand Whiting	39	3.4	3	23	3.0	3	16	4.0	4
	Sea Mullet	34	99.1	99	8	69.5	70	26	108.3	108
	Silver Biddie	35	41.2	41	14	22.5	23	21	53.7	54
	Silver Trevally	17	29.1	29	6	5.4	5	11	42	42
	Tailor	8	37.5	38	6	23.9	24	2	78.2	78
	Trumpeter Whiting	35	3.8	4	21	2.3	2	14	6.2	6
	Yellowtail Scad	20	11.0	11	14	3.3	3	6	28.9	29
Molluscs	Squid	**37**	**16.6**	**17**	**15**	**6.4**	**6**	**22**	**23.5**	**24**

* Includes data from previous assessment. No new data were received for prawns. Five new samples for bream.

[#] Excludes greasyback prawns

Note: underlined figures are higher than the mean for the whole group.

All results pg TEQ/g fresh weight

6. Dietary exposure assessment

A revised dietary exposure assessment was conducted by FSANZ in the following ways:

- a baseline dietary exposure assessment using mean consumption data of foods for all respondents from the 1995 Australian National Nutrition Survey (NNS) and the mean concentrations of dioxins included in the 2004 NDP exposure assessment;
- an estimate of the dietary exposure for the general population as a result of infrequently eating seafood from Sydney Harbour based on the mean level of consumption for the population (Section 6.1); and
- 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).

The dietary exposure assessments for the general population and more frequent eaters of Sydney Harbour seafood based on Sydney Harbour seafood concentration data had been conducted by FSANZ in the previous risk assessment (FSANZ 2006). These were revised based on the updated concentration data and the results provided below.

6.1 Estimated dietary exposure for the general population/infrequent Sydney Harbour seafood eaters (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 crustacea, fish and mollusc concentration data with the updated 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 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 crustacea, fish and molluscs, 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 for crab, 0.1 grams per day. Mean consumption of fish for all respondents was 7 grams per day and for squid, 0.6 grams per day. Since dioxins are found in a broad range of foods, all respondents consumed at least one food assigned a dioxin concentration and therefore all NNS respondents were dioxin consumers. The baseline exposure estimate included crustacea, fish and molluscs in the calculation but with concentrations representative of seafood across Australia. The method used was the same as described in the previous FSANZ risk assessment with the difference that molluscs were now considered separately.

b. A ‘Sydney Harbour crustacea’ exposure assessment scenario – this exposure assessment used the ‘baseline’ exposure assessment but substituted the nationally representative baseline crustacea concentration data with the mean concentration of 11.0 pg TEQ/g derived from the Sydney Harbour data (Section 5.1).

c. A ‘Sydney Harbour fish’ exposure assessment scenario – this exposure assessment used the ‘baseline’ exposure assessment but substituted the nationally representative baseline fish concentration data with the mean concentration 25 pg TEQ/g derived from the Sydney Harbour data (Section 5.2).

d. A ‘Sydney Harbour mollusc’ exposure assessment scenario – this exposure assessment used the ‘baseline’ exposure assessment but substituted the nationally representative baseline mollusc concentration data with the mean concentration 17 pg TEQ/g derived from the Sydney Harbour data (Section 5.3).

e. A ‘Sydney Harbour crustacea, fish and mollusc’ exposure assessment scenario – this exposure assessment used the ‘baseline’ exposure assessment but substituted the nationally representative baseline crustacea, fish and mollusc concentration data with the mean concentration for these seafoods derived from the Sydney Harbour data.

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 crustacea, fish and molluscs 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. Similarly, for crab if 0.1 grams were consumed in one day, then 3 grams were consumed for the month. For fish, consumption of 7 grams in one day was equivalent to 210 grams in the month and squid consumption totalled 19 grams for the month.

Mean dioxin concentrations for all foods, except for crustacea, fish and molluscs remained the same for the exposure assessments for the baseline and all four scenarios. Mean dioxin concentrations for crustacea, fish and molluscs used for the baseline and the scenarios are shown in Table 2. 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 equal to the LOR.

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

Table 2. Mean dioxin concentrations in seafood used in the dietary exposure assessments for the general population/infrequent Sydney Harbour seafood eaters

Exposure estimate	Food	Total dioxins pg TEQ/g fresh weight (Lower Bound – Upper Bound)
Baseline	Crustacea*	0.15 - 0.16
	Fish fillets*	0.59 - 0.64
	Molluscs*	0.15 - 0.16
Sydney Harbour crustacea scenario	Crustacea	11.0 - 11.0
	Fish*	0.59 - 0.64
	Molluscs*	0.15 - 0.16
Sydney Harbour fish scenario	Crustacea*	0.15 - 0.16
	Fish fillets	25.0 - 25.0
	Molluscs*	0.15 - 0.16
Sydney Harbour mollusc scenario	Crustacea*	0.15 - 0.16
	Fish fillets*	0.59 - 0.64
	Molluscs	17.0 - 17.0
Sydney Harbour crustacea, fish and mollusc scenario	Prawns	11.0 - 11.0
	Fish fillets	25.0 - 25.0
	Molluscs	17.0 - 17.0

* From NDP analysis.

The estimated dietary exposures are shown in Table 3. Using the mean Sydney Harbour crustacea concentration of 11.0 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. The mean Sydney Harbour fish concentration of 25.0 pg TEQ/g, increased the total dietary exposure to dioxins by around 80 pg TEQ per kilogram of body weight from the baseline exposure. Using the mean Sydney Harbour mollusc concentration of 17 pg TEQ/g, the total dietary exposure to dioxins increased by around 30 pg TEQ per kilogram of body weight per month from the baseline exposure. For estimates using Sydney Harbour crustacea, fish

and mollusc mean concentration data, dioxin exposure increased by around 105 pg TEQ per kilogram of body weight from the baseline exposure.

Table 3. Estimated mean monthly dietary exposure to total dioxins for the general population/infrequent eaters of Sydney Harbour seafood (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 crustacea (prawns and crab)	1545 – 2232	23.1 – 33.1
Sydney Harbour fish	5630 – 6309	84.0 – 94.2
Sydney Harbour molluscs	1545 – 2232	23.1 – 33.1
Sydney Harbour crustacea, fish and molluscs	7215 – 7892	108.0 – 118.0

* 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 more frequent eaters of Sydney Harbour seafood

The potential dietary exposure to dioxins was calculated for different patterns of seafood consumption, assuming that fish was either consumed in mean or large portions at frequencies between once a month to several times per week. These results could be used to assess exposures to those people who may be more likely to consume Sydney Harbour seafood on a more regular basis.

6.2.1 Crustacea

A rounded mean concentration figure of 11 pg TEQ/g for crustacea based on the recent analytical survey (see raw results Section 5.1) was used in these dietary exposure estimates and portion sizes from the 1995 NNS of 75 g/day for a mean serve, 250 g/day for a large serve. A level of background exposure from all other foods (as derived from the NDP dietary exposure estimates) was also included in the calculations.

The results of the dietary exposure estimates for crustacea are shown in Table 4.

Table 4. Estimated monthly dietary exposure to dioxins based on 2006 Sydney Harbour crustacea concentration data for different crustacea consumption patterns

Number of serves of crustacea	Background exposure (pg TEQ/ kg bw/month)	Exposure from crustacea containing 11 pg TEQ/g (pg TEQ/kg bw/month)	Total exposure (pg TEQ/kg bw/month)
1 mean serve per month	3-14	12	15-26
1 large serve per month	3-14	41	44-55
1 mean serve per week (4/month)	3-14	49	52-63
1 large serve per week (4/month)	3-14	164	167-178
3 mean serves per week (12/month)	3-14	147	151-162
3 large serves per week (12/month)	3-14	493	496-507

6.2.2 Fish

A rounded mean concentration figure of 25 pg TEQ/g for fish based on 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. A level of background exposure from all other foods (as derived from the NDP dietary exposure estimates) was also included in the calculations.

The results of the dietary exposure estimates for fish are shown in Table 5.

6.2.3 Molluscs

A rounded mean concentration figure of 17 pg TEQ/g for molluscs based on the recent analytical survey (see raw results Section 5.3) was used in these dietary exposure estimates and portion sizes from the 1995 NNS of 80 g/day for a mean serve, 240 g/day for a large serve. A level of background exposure from all other foods (as derived from the NDP dietary exposure estimates) was also included in the calculations.

The results of the dietary exposure estimates for crustacea are shown in Table 6.

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 25 pg TEQ/g (pg TEQ/kg bw/month)	Total exposure (pg TEQ/kg bw/month)
1 mean serve per month	3-14	43	46-57
1 large serve per month	3-14	114	117-128
1 mean serve per week (4/month)	3-14	172	175-186
1 large serve per week (4/month)	3-14	456	459-470
3 mean serves per week (12/month)	3-14	516	519-530
3 large serves per week (12/month)	3-14	1368	1371-1382

Table 6. Estimated monthly dietary exposure to dioxins based on 2006 Sydney Harbour mollusc concentration data for different mollusc consumption patterns

Number of serves of molluscs	Background exposure (pg TEQ/ kg bw/month)	Exposure from molluscs containing 17 pg TEQ/g (pg TEQ/kg bw/month)	Total exposure (pg TEQ/kg bw/month)
1 mean serve per month	3-14	20	23-34
1 large serve per month	3-14	61	64-75
1 mean serve per week (4/month)	3-14	81	84-95
1 large serve per week (4/month)	3-14	244	247-258
3 mean serves per week (12/month)	3-14	244	247-258
3 large serves per week (12/month)	3-14	731	734-745

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

7.1 Estimated dietary exposure to dioxins for the general population/ infrequent eaters of Sydney Harbour seafood as a percentage of the TMI

The estimated mean monthly dietary exposures to total dioxins for the general population/infrequent eaters of Sydney Harbour seafood from the whole diet was 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 7. The estimated exposures did not include non-food sources. Baseline dietary exposure (i.e. for those individuals eating non-Sydney Harbour crustacea, fish and molluscs) was 5-20% of the TMI (lower bound to upper bound estimate). Dietary exposure assuming crustacea have the mean concentration of dioxins found in the Sydney Harbour survey, was 30-50% of the TMI. Dietary exposures including Sydney Harbour fish were 120-135% of the TMI. Dietary exposure for the population for molluscs was 20-35% of the TMI. Including Sydney Harbour crustacea, fish and molluscs resulted in an estimated exposure of 150-170% of the TMI. As indicated previously, these estimated dietary exposures include consumption of prawns of 4 grams per day (120 grams in the month), crab of 0.1 grams per day (3 grams in the month), fish of 7 grams per day (210 grams in the month) and squid 0.6 grams per day (19 grams in the month).

The estimated dietary exposures show some exceedance of the TMI where Sydney Harbour fish or all types of Sydney Harbour seafood are eaten infrequently.

Table 7. 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 crustacea	30 - 50
Sydney Harbour fish	120 - 135
Sydney Harbour molluscs	20 – 35
Sydney Harbour crustacea, fish and molluscs	150 - 170

*TMI of 70 pg/kg bw/month.

7.2 Estimated dietary exposure to dioxins for more frequent eaters of Sydney Harbour seafood as a percentage of the TMI

The estimated exposures did not include non-food sources, however, included other foods in the diet at a nationally representative concentration level (FSANZ 2004). Serve sizes are based on the 1995 NNS data.

7.2.1 Crustacea

The estimated dietary exposures as a percent of the TMI based on a mean crustacea concentration of 11 pg TEQ/g are presented in Table 8. This shows different patterns of consumption, assuming that crustacea was either consumed in mean (75g) or large (250g) serve size portions once a week or once a month.

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

Number of serves of crustacea	% TMI*
1 mean serve per month	20 – 40
1 large serve per month	65 – 80
1 mean serve per week (4/month)	75 – 90
1 large serve per week (4/month)	240 – 260
3 mean serves per week (12/month)	220 – 230
3 large serves per week (12/month)	710 – 720

Note: mean serve 75g, large serve 250g.

The results indicate that more regular frequent eaters of Sydney Harbour crustacea could exceed the TMI for dioxins.

7.2.2 Fish

The estimated dietary exposures as a percent of the TMI based on a mean concentration of 25 pg TEQ/g as a percentage of the TMI are shown in Table 9. This assumed that fish was either consumed in mean (115 g) or large (305 g) serve sizes.

The results indicate that more regular frequent eaters of Sydney Harbour fish could exceed the TMI for dioxins.

Table 9: 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	65 – 80
1 large serve per month	170 – 180
1 mean serve per week (4/month)	250 – 270
1 large serve per week (4/month)	660 – 670
3 mean serves per week (12/month)	740 – 760
3 large serves per week (12/month)	1960 - 1970

*TMI = 70 pg/kg bw/month.

7.2.3 Molluscs

The estimated dietary exposures as a percent of the TMI based on a mean concentration of 17 pg TEQ/g as a percentage of the TMI are shown in Table 10. This assumed that molluscs were either consumed in mean (80 g) or large (240 g) serve sizes.

Table 10. Estimated monthly dietary exposure to dioxins for different consumption patterns of Sydney Harbour molluscs as a percentage of the TMI

Number of serves of molluscs	% TMI*
1 mean serve per month	35 – 50
1 large serve per month	90 – 110
1 mean serve per week (4/month)	120 – 140
1 large serve per week (4/month)	350 – 370
3 mean serves per week (12/month)	350 – 370
3 large serves per week (12/month)	1050 – 1060

Note: mean serve 80g, large serve 240g.

The results indicate that more regular frequent eaters of Sydney Harbour molluscs could exceed the TMI for dioxins.

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

Based on the updated analytical data of dioxins in Sydney Harbour seafood the amount of seafood that can be consumed before the TMI is exceeded has been estimated for all crustacea, all fish and all molluscs separately.

This calculation was based on the background level of exposure from all other foods, the concentration for the seafood in question, a mean body weight and the TMI. The calculations are based on the mean concentrations as specified in Table 1, assuming that over a lifetime, consumers would have eaten seafood with a mean concentration of dioxins.

This calculation was based on the assumption that there is no other exposure to dioxins from non-food sources.

The background exposure to dioxins from food is 3-14 pg TEQ/kg bw/month as determined from the baseline exposure estimate. Therefore, an individual could consume a quantity of seafood 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 amount is used as the basis for all calculations following in this section.

7.3.1 Crustacea

Crustacea was consumed by 446 consumers in the NNS (3.2% of respondents). The mean consumption of crustacea for consumers only was 75 grams per day or 250 grams per day for 95th percentile consumers[1].

Based on a mean concentration of dioxins of 11 pg TEQ/g for all crustacea, an individual may consume 341 to 408 grams crustacea per month providing no other seafood from Sydney Harbour is consumed. This equates to 4 mean portions or one large portion per month.

7.3.2 Fish

As outlined in the previous risk assessment, 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.

Based on a mean concentration of dioxins of 25 pg TEQ/g, this equates to 150 to 180 grams fish/month allowable for consumption before the TMI is exceeded providing no other seafood from Sydney Harbour is consumed. This equates to 1 mean portion per month.

7.3.3 Molluscs

Squid was consumed by 150 respondents in the NNS (1.1% of respondents). The mean consumption for consumers only was 80 grams/day and the 97.5th percentile consumption for consumers only was 240 grams/day.

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[1] The mean consumption amount per day for consumers only is calculated by determining the amount of crustacea that every consumer ate on the day that they were surveyed, adding this together for all consumers, then dividing the sum by the number of consumers of crustacea. This does not mean that each consumer eats their consumption amount, or the mean consumption amount, every day of the year. The 95th percentile consumption amount for consumers only is derived from the ranked consumption amounts from each individual consumer. The method described in this footnote also applies to fish consumption amounts in 7.3.2 and mollusc consumption amounts in 7.3.3.

Based on a mean concentration of dioxins of 17 pg TEQ/g, this equates to 220 to 264 grams squid allowable for consumption per month before the TMI is exceeded providing no other seafood from Sydney Harbour is consumed. This equates to 3 mean portions or 1 large portion per month before exceeding the TMI.

7.4 Estimated maximum number of standard serves of seafood

The estimates of the maximum amounts of seafood that could be consumed before exceeding the TMI as calculated in Section 7.3 above were converted to estimates of standard 150 gram serves. This conversion was performed for all crustacea, all fish and all molluscs separately. The number of serves was also estimated for individual types of seafood where there were more than 10 samples collected (i.e. dusky flathead, fanbelly leatherjacket, kingfish, mulloway), apart from Tailor which had a higher mean concentration than the 'all fish' mean and therefore was included. The estimates were also calculated for each group or individual seafood based on samples taken east and west of the Harbour Bridge. The maximum number of standard 150 gram serves that can be consumed before the TMI is exceeded is shown in Table 11.

Based on all data, the maximum number of standard serves of crustacea that can be consumed per month before the TMI is exceeded is two, the maximum number of serves of fish that can be consumed is one, and the maximum number of serves of molluscs that can be consumed per month is one.

The data also indicate that more standard serves can be consumed from seafood caught east of the Harbour Bridge. For crustacea, four serves can be consumed per month from east of the Bridge compared to two per month from west of the Bridge. For fish, two serves can be consumed per month from east of the Bridge compared to one every 2 months from west of the Bridge. For molluscs, four serves can be consumed per month from east of the Bridge compared to one per months from west of the Bridge.

There are certain types of fish that have a calculated maximum number of serves that can be consumed per month which is less than that for 'all fish' combined. This is the case for sea mullet, silver biddie and tailor.

Table 11. Estimated number of standard serves of seafood allowable for consumption before exceeding TMI

	All data			East of Harbour Bridge			West of Harbour Bridge		
Seafood	**Mean conc. (pg TEQ/g)**	**Maximum grams before TMI exceeded**	**No. 150 gram serves before TMI exceeded**	**Mean conc. (pg TEQ/g)**	**Maximum grams before TMI exceeded**	**No. 150 gram serves before TMI exceeded**	**Mean conc. (pg TEQ/g)**	**Maximum grams before TMI exceeded**	**No. 150 gram serves before TMI exceeded**
All Crustacea	**11**	**341 – 408**	**2 per month**	**6**	**625 - 748**	**4 per month**	**13**	**287 - 345**	**2 per month**
Prawns*	12	312 – 374	2 per month*	6	625 - 748	4 per month	13	287 - 345	2 per month
Crab	9	417 - 498	2 per month	5	750 - 898	5 per month	11	341- 408	2 per month
All Fish	**25**	**150 – 180**	**1 per month**	**11**	**341- 408**	**2 per month**	**37**	**101 - 121**	**1 every 2 months**
Bream	27	139 – 166	1 per month	18	208 - 249	1 per month	31	121 - 145	1 every 2 months
Flounder	6	625 – 748	4 per month	2	1876 - 2245	12 per month	9	417 - 499	2 per month
Luderick	11	341 – 408	2 per month	2	1876 - 2245	12 per month	19	197 - 236	1 per month
Sand Whiting	3	1250 – 1496	8 per month	3	1251 - 1496	8 per month	4	938 – 1122	6 per month
Sea Mullet	99	38 – 45	1 every 4 months	70	54 - 64	1 every 3 months	108	35 - 42	1 every 4 months
Silver Biddie	41	92 – 109	1 every 2 months	23	163 - 195	1 per month	54	69 - 83	1 every 2 months
Silver Trevally	29	129 – 154	1 per month	5	750 - 898	5 per month	42	89 - 107	1 every 2 months

	All data			East of Harbour Bridge			West of Harbour Bridge		
Seafood	**Mean conc. (pg TEQ/g)**	**Maximum grams before TMI exceeded**	**No. 150 gram serves before TMI exceeded**	**Mean conc. (pg TEQ/g)**	**Maximum grams before TMI exceeded**	**No. 150 gram serves before TMI exceeded**	**Mean conc. (pg TEQ/g)**	**Maximum grams before TMI exceeded**	**No. 150 gram serves before TMI exceeded**
Tailor**	38	99 - 118	1 every 2 months	24	156 - 187	1 per month	78	48 - 58	1 every 3 months
Trumpeter Whiting	4	938 – 1122	6 per month	2	1876 - 2245	12 per month	6	625 - 748	4 per month
Yellowtail Scad	11	341 - 408	2 per month	3	1251 - 1496	8 per month	29	129 - 155	1 per month
Molluscs (Squid)	**17**	**220 - 264**	**1 per month**	**6**	**625 - 748**	**4 per month**	**24**	**156 - 187**	**1 per month**

* Excludes greasyback prawns. The estimates would be double this if prawns are only available 6 months of the year.
** Tailor had <10 samples (n=8).
Note: shaded cells higher than the mean for all fish.

7.5 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 12. This calculation is based on the assumption that there is no other exposure to dioxins from non-food sources but does include background exposure from other foods.

Table 12: 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 150 g serve 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 67 kg, then the maximum level of dioxins in the fish could be 6-8 pg TEQ/g.

7.6 Conclusion of the characterisation of the public health risk

FSANZ provided a detailed characterisation of the public health risk in the previous report (FSANZ 2006) based on prawns and bream for which similar considerations apply for this assessment. FSANZ previously concluded that the public health and safety risk to the majority of Australians who infrequently consume seafood from Sydney Harbour was very low, however, there was an unacceptable public health and safety risk for frequent long term consumers of Sydney Harbour seafood. FSANZ recommended that risk management measures should be considered to reduce background exposures for the general population and to reduce dioxin exposure for more frequent consumers of Sydney Harbour seafood.

Based on this revised assessment, the public health and safety risk for the majority of the population from dioxin exposure following the consumption of seafood from Sydney Harbour is considered to be very low, given the infrequent and low level of Sydney Harbour seafood consumed by the general population. Risk managers may wish to maintain

measures to ensure that the background dioxin exposure of the population remains at levels that are as low as reasonably practicable.

For a relatively small sub-population group, namely, recreational fishers who frequently consume their catch from Sydney Harbour, and do so over a long period, the assessment indicated that under some scenarios, it was possible for the TMI to be exceeded. When the maximum number of serves that can be consumed was estimated, for some species and some areas of the Harbour, the number of serves was very low and potentially less than the level at which some people may consume the seafood. This indicates that the public health and safety risk may be unacceptably high for this subgroup of the population. In this case, risk managers may wish to maintain action to reduce the dioxin exposure of this group, which may include a revision of consumption advice based on the information from a more extensive range of seafood and from different areas of the Harbour.

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Appendix 1 – WHO TEFs for dioxins and dioxin like PCBs

As a result of the recent review of the TEFs for dioxins and dioxin like compounds by the WHO (Van den Berg *et al* 2006), several TEFs have been changed mostly for the dioxin like PCBs, octachlorinated congeners and pentachlorinated furans. The 1998 and 2005 TEFs are shown in the table below.

Table A1.1. WHO TEFs for dioxin and dioxin like compounds

Chemical group	Chemical name	WHO 1998 TEF	WHO 2005 TEF*
chlorinated dibenzo-p-dioxins	2,3,7,8,-TCDD	1	1
	1,2,3,7,8-PeCDD	1	1
	1,2,3,4,7,8-HxCDD	0.1	0.1
	1,2,3,6,7,8-HxCDD	0.1	0.1
	1,2,3,7,8,9-HxCDD	0.1	0.1
	1,2,3,4,6,7,8-HpCDD	0.01	0.01
	OCDD	0.0001	**0.0003**
chlorinated dibenzofurans	2,3,7,8-TCDF	0.1	0.1
	1,2,3,7,8-PeCDF	0.05	**0.03**
	2,3,4,7,8-PeCDF	0.5	**0.3**
	1,2,3,4,7,8-HxCDF	0.1	0.1
	1,2,3,6,7,8-HxCDF	0.1	0.1
	1,2,3,7,8,9-HxCDF	0.1	0.1
	2,3,4,6,7,8-HxCDF	0.1	0.1
	1,2,3,4,6,7,8-HpCDF	0.01	0.01
	1,2,3,4,7,8,9-HpCDF	0.01	0.01
	OCDF	0.0001	**0.0003**
non-ortho substituted PCBs	PCB 77	0.0001	0.0001
	PCB 81	0.0001	**0.0003**
	PCB 126	0.1	0.1
	PCB 169	0.01	**0.03**
mono-ortho substituted PCBs	105	0.0001	**0.00003**
	114	0.0005	**0.00003**
	118	0.0001	**0.00003**
	123	0.0001	**0.00003**
	156	0.0005	**0.00003**
	157	0.0005	**0.00003**
	167	0.00001	**0.00003**
	189	0.0001	**0.00003**

* Numbers in bold indicate a change in TEF value.