

MARIBYRNONG AND YARRA RIVER FISH STUDY

Report from an Expert Panel

15 January 2007

1. Background

This report is part of an ongoing investigation of the level of chemical contaminants in fish caught in the Maribyrnong/Yarra estuary system. It provides advice on potential health concerns associated with the consumption of fish caught in these estuaries.

The most recent investigation of potential chemical pollutants in fish caught in the Maribyrnong and Yarra estuaries is the 2006 report on the Study undertaken by EPA Victoria, with the support of Melbourne Water, Port of Melbourne Corporation and the Department of Human Services (DHS). It supplements the 2005 investigation of some bioaccumulative chemicals in eels and selected finfish. The 2006 Report on this project collates data on further selected chemicals in fish caught in these waterways, and includes data on the potentially bioaccumulative chemicals PCBs, dioxins, other persistent organochlorines and trace elements (metals and metalloids), and the non-bioaccumulative polycyclic aromatic hydrocarbons (PAHs). In the case of the dioxins and dioxin-like PCBs, the concentrations of individual congeners have been converted using 2,3,7,8-TCDD Toxic Equivalency Factors (TEFs) to determine the sum contribution of the measured congeners to a toxic outcome, with the data expressed in terms of Toxic Equivalents (TEQ).

To assist with the interpretation of the data contained in this 2006 report, which is being published concurrently with this Panel Report, the Victorian EPA and DHS convened an Expert Panel to advise on any potential health concerns associated with regular consumption of these fish. It is intended that this Expert Panel report be read in conjunction with the 2006 EPA report.

The composition of the Expert Panel, and its Terms of Reference, are in Attachment A. The Panel has undertaken a screening level risk assessment of the data in the 2006 report and makes the following findings:

2. Adequacy of the sampling information (TOR 1)

The Panel notes that the 2006 EPA report includes sampling data on composites from fish caught in five reaches of the Maribyrnong and Yarra river estuarine systems, along with further eel samples caught in the upper (freshwater) reaches. The skinless fish fillets were prepared as composites for analytical processing at the laboratories of the National Measurement Institute (NMI). Four species in all were caught (black bream, yellow-eyed mullet, mulloway and short-finned eels). The Panel notes that these species were selected on the basis that they represent the species most commonly sought by recreational fishers and that there is no commercial fishing activity in the regions of concern.

The fish composites were analysed for a range of potential contaminants, with emphasis on commonly found polychlorinated biphenyl (PCB) congeners, as well as the 17 2,3,7,8-Cl-substituted dioxins and 12 dioxin-like PCBs, selected polybrominated diphenyl ethers (PBDEs), selected organochlorine and organophosphate pesticides, selected herbicides, organotins (mono-, di- and tri-butyl tins), selected trace elements (metals and metalloids), polycyclic aromatic hydrocarbons (PAHs), and total petroleum hydrocarbons.

The Panel considers this to be a sufficiently comprehensive range of analytes to determine pollutants likely to be of health concern in fish caught in these regions. The Panel also notes that, for many of the analytes tested, concentrations found were below the relevant limit of quantitation (LOQ). While making the processes of quantitative risk assessment somewhat more difficult (see section 3.2.3 for a description of how this quantitative issue was addressed in relation to PCBs), the findings suggest that these chemicals were either not present in the samples, or if present, they were at a level unlikely to be of health concern.

In this Report, the Panel has focussed more on the potential health risks associated with PCB and dioxins, since these were considered to be the chemicals most likely to drive the health risk assessment and result in limitations on fish consumption.

In the case of PBDEs, the Panel notes that the concentrations measured ranged around the low nanogram (10^{-9} g) per gram fresh weight of fish, which can be translated into intake estimates from fish of between $0.2-0.9 \times 10^{-6}$ mg/kg body wt/day (based on a single 150g serve per week or per month). The Panel is aware that currently, no tolerable intake levels have been established for PBDEs. Given that currently published data on the health effects of PBDEs suggest that doses resulting in even the most sensitive indicators of toxicity are in the high microgram (10^{-6} g) to low milligram (10^{-3} g) per kg body weight per day range, the Panel considers that the margin of safety between the estimated intake from fish and the levels associated with possible health effects is large. As further information becomes available this assessment may be reviewed.

3. Estimates of risk to fish consumers (TOR 2)

There were no reliable, quantitative estimates for the amounts of seafood eaten by recreational fishermen catching fish in the Maribyrnong and Yarra river estuaries available to the Panel. However, fish consumption estimates from the 1995 National Nutritional Survey (NNS) provide some guidance on what amounts of seafood could be consumed.

Estimates of the consumption of fish depend on both:

- The amount of fish consumed on each occasion (e.g. g/serve)
- How frequently fish are consumed (e.g. serves/week)

From the NNS, fish consumption data were collected from respondents for a 24-hour period prior to their interview (via a '24-hour recall'). Information on both the type of fish consumed and the amount in grams were collected. Based on the 24-hour recall data for all NNS respondents, consumption amounts for a mean serve or a large serve (95th percentile) of fish in a day are 115 g/day and 305 g/day respectively (population

aged 2 years and above), 95 g/day and 65 g/day respectively for women of child-bearing age (16-44 years) and 60 g/day and 140 g/day respectively for children (2-6 years) (FSANZ 2004).

However, fish is not generally consumed frequently by the majority of the population. 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.

While the NNS estimates are based on fish consumption from all sources, including those from commercial sources, they provide some perspective on the need to consider consumption limitations on fish caught in the Maribyrnong and Yarra rivers.

In addressing this issue, the Panel considered potential exposures to the chemicals of concern and compared these estimates against established health-based standards. The approach taken by the Panel was to estimate the amounts of fish, which could be consumed at the average level of contamination without the consumption from this source exceeding a health-based tolerable intake.

The health-based standard primarily used was the published Reference Dose (RfD) or Tolerable/Acceptable Daily Intakes (TDI/ADI). These values, which are generally expressed as an intake in mg chemical per kg body weight per day, represent an intake over an entire lifetime, which should not be associated with any adverse health effects. In some cases, the chemical concentrations were also compared with published values for concentrations, which are either permitted under food regulations, or Screening Values (SVs) recommended by the US EPA to trigger a more detailed risk assessment.

3.1 *Maximum Residue Limits (MRLs), Maximum Levels (MLs) and Screening Values (SVs)*

For some types of chemical pollutants in food, regulatory authorities publish standards called Maximum Residue Limits (MRLs) for pesticides or Maximum Levels (MLs) for other contaminants (FSANZ 2003). They are used as regulatory standards to control the level of allowable contamination in food. If MRLs or MLs are breached, they may either trigger regulatory action to prevent the sale of the food, and/or an investigation into the source of the pollution. MRLs and MLs are different from an RfD or tolerable intake level, and there is no specific implication that consumption of food where the MRL or ML is exceeded would necessarily result in adverse health effects. However, the setting of such levels would take into account the assumption that it represents a safe level in relation to the potential for adverse health effects when food at the MRL or ML is consumed.

Screening Values (SVs) have been published by the US EPA specifically to assist with the management of fish caught in regions of the US where contamination with selected chemicals may represent a health risk. SVs denote a measured concentration in fish, which should trigger further investigations of possible health effects.

In this Panel report, the levels of chemicals have been compared to relevant MRLs or MLs as a further part of the screening risk assessment process. Where the concentration of a chemical was less than the Limit of Quantitation (LOQ) or a published MRL or ML, the Panel generally considered that it was not necessary to conduct a more detailed risk assessment. However, in connection with the PCB contamination levels, the Panel noted that while none of the samples in the 2006 survey exceeded the ML (0.5 mg/kg), there were several that exceeded the much lower SV (0.02 mg/kg) recommended by the US EPA (US EPA 2000). Since the Panel was specifically requested to examine the PCB data, in light of the findings of the previous 2005 survey, the Panel decided to examine the risks associated with PCB exposure in more detail and to make recommendations relating to fish consumption restrictions.

3.2 Polychlorinated biphenyl (PCB) congeners

Polychlorinated biphenyls (PCBs) are stable chlorinated organic chemicals which have entered the environment through past industrial activities. They are persistent organic pollutants (POPs), which can bioaccumulate through food chains, and there has been substantial attention paid to their potential intake by humans because they accumulate in the body, so that even relatively low levels of intake can result in an increasing body burden.

At sufficiently high doses they may be associated with a number of adverse health effects, including effects on the liver, skin, eyes, respiratory and gastrointestinal systems. The adverse effects, which occur at the lowest levels of intake in experimental animals, are those on reproduction and the immune system. Since reproductive and immune system effects are the more sensitive indicators of toxicity, these effects drive the health risk assessment.

3.2.1 Estimation of a tolerable intake of PCBs

The tolerable intake of PCBs used in this report is based on Reference Dose (RfD¹) of 0.00002 mg/kg body wt/day (0.02 µg/kg body wt/day) for total PCBs published by the US EPA (US EPA 1996). The RfD is derived from an extrapolation of data from long-term administration of a commercial PCB (Aroclor 1254) in female rhesus monkeys. In these studies, the lowest dose tested (5 µg/kg body wt/day) produced changes in immunological and eye functions, and this estimate of the Lowest Observable Adverse Effect Level (LOAEL) was used to establish the RfD, incorporating a 300 fold uncertainty factor on the LOAEL.

One of the issues relating to the health risk assessment of PCBs is that there may be up to 200 different congeners (chemicals based on the same biphenyl nucleus, but having different levels and positions of chlorine substitution around the aromatic rings) in an environmental sample, and it is not clear the extent to which the toxicity

¹ the RfD or ‘tolerable intake’ is an estimate of the amount of a toxic chemical which may be consumed over a lifetime without appreciable risk of harm. The RfD used for PCBs in this risk assessment is the figure derived by the US EPA (0.00002 mg/kg bw/day).

of individual congeners differ from one another. Most of the toxicological data from studies used to assess PCB toxicity have used commercial products (Aroclors), which are themselves complex and variable mixtures of several congeners. To illustrate the point that different mixtures of PCB congeners may have a different toxicological profile, the tolerable intake for another commercial PCB (Aroclor 1016) is 0.07 µg/kg body wt/day, based on a No Observable Adverse Effect Level (NOAEL) of 7 µg/kg body wt/day for reduced offspring birth weights in a reproductive toxicity study in rhesus monkeys (the LOAEL in this study was 28 µg/kg body wt/day) (US EPA 1996).

In risk assessment, it is conventional to use the most sensitive indicator of toxicity to estimate a tolerable intake, and the process applies suitable safety factors or uncertainty factors to the NOAEL or LOAEL to introduce some conservatism and to try to protect the more susceptible individuals within an exposed group or population. It is for this reason that the lowest RfD is used in risk assessment for PCBs when the congener composition of an environmental sample may differ from that of the commercial Aroclor sample used in animal studies to establish the RfD.

3.2.2 Quantitation of PCBs

Another issue in risk assessment is the determination of the level of exposure. The PCB data reported in the 2006 Vic EPA study include concentrations of individual congeners, which are summed to give the total concentration of all PCBs in the samples. The intake of total PCBs is used in the risk estimate as a comparison with the RfD.

However, derivation of total PCBs in any sample depends on how concentrations of individual congeners are treated in the calculation. Individual congeners reported below the analytical reporting limit (LOR = 0.002 mg/kg) may be counted as contributing:

- Zero – i.e. they are assumed to be not present at all and make no contribution towards the sum – represented as Lower Bound (LB);
- 0.001 – they are assumed to be present at half the reporting limit – represented as Middle Bound (MB); or
- 0.002 – it is assumed that all “not detected” samples have PCBs at the reporting limit – represented as Upper Bound (UB).

For each type of seafood assessed, the LB, MB and UB concentration for each sample was derived for total PCBs. The values are shown in Table 1. The “half reporting limit” approach (MB) is the one recommended by the US EPA.

Table 1. Summary of total PCB concentration data used for the dietary exposure assessments

Seafood	Number of samples	Mean concentration (mg/kg)		
		LB	MB	UB
Black bream	15	0.042	0.056	0.071
Mullet	4	0.018	0.036	0.054
Mulloway	3	0.077	0.090	0.103
Eel	4	0.188	0.201	0.213

3.2.2.1 PCBs in eels

Eels are at a high trophic level in the marine food chain, and have a higher fat content than other fish taken in the study. Eels therefore have a greater potential to accumulate persistent organic pollutants. The 2005 survey suggested that eels caught in the Maribyrnong and Yarra estuaries had relatively high PCB levels, with 2 out of 15 eel samples taken exceeding the recommended Maximal Limit (ML) of 0.5 mg/kg. While no eels taken in the 2006 survey had total PCB concentrations exceeding 0.5 mg/kg, the results of both surveys are comparable in that detectable PCBs were found in all eel samples, and in all cases, total PCBs concentrations exceeded the 0.02 mg/kg recommended by the US EPA as a screening level cut-off for further evaluation.

3.2.2.2 PCBs in other fish

As in the 2005 survey, measurable levels of PCBs were found in the 2006 survey of various species of finfish caught in the Maribyrnong and Yarra estuaries. Highest levels tended to be found in black bream. While none of the samples exceeded the 0.5 mg/kg ML in either survey, a number of samples exceeded the 0.02 mg/kg screening cut-off recommended by the US EPA.

3.3 Assessing risk to recreational fishers

In the absence of reliable, quantitative information about the consumption of fish from the Yarra and Maribyrnong Rivers by recreational fishers, the approach taken by the Panel was to calculate the number of serves of seafood from the Maribyrnong and Yarra rivers that can be consumed before the PCB reference dose is exceeded.

These calculations are based on EPA analytical data contained in the 2006 survey report published in conjunction with this Panel report, and are summarised in Table 2. A range is presented based on LB and UB mean concentrations from Table 1. A mean body weight of 67 kg was used for the calculations (based on respondents aged 2 years and above from the NNS). The estimates were based on 2 years and above as a proxy for a lifetime of exposure, which also allows direct comparison with the reference dose, which was also set on this basis. No background level of PCB exposures from other foods is taken into account for these calculations, as this was unknown.

Table 2. Estimated number of serves of seafood that can be consumed before the reference dose is exceeded[#]

Seafood	Maximum amount that can be consumed (g/day)	Maximum number of 150g serves per month*
Black bream	19-32	3-6
Mullet	25-73	4-13
Mulloway	13-17	2-3
Eel	6-7	1-1

[#] The lower end of the range based is on LB mean concentration and the upper end on UB mean concentrations.

* Derived from consumption amounts per day that were converted to per month based on the assumption that there are 30 days in the month.

The Panel noted that the distribution of PCB values from fish caught in different parts of the estuarine system suggests a higher potential for fish caught in reaches 1 and 2 (the upper urban reaches of the Maribyrnong and Yarra rivers) to have higher PCB levels than those in reaches 3, 4 and 5 (The Whitehall St-Yarraville region, South Wharf N. 6-10 & Docklands, and the “Warmies”). However, the available data are relatively limited, and at the present time, the Panel considers them to be insufficient to support any recommendation for variation to the recommended consumption limits for fish based on either the species or the region where they are caught.

4. Advisory Limits on consumption (TOR 3)

Public health advice issued in 2005 proposed a limitation on consumption of eels caught in the Maribyrnong and Yarra estuaries to **one serve of eel per month**, based on the PCB concentrations found at that time. Based on the calculations in Table 2, the opinion of the Panel is that **the eel consumption limit proposed in 2005 remains appropriate on public health grounds.**

While the public health advice from the 2005 did not include any recommended consumption limits on seafood species other than eels, the above data suggest that it would be prudent to place advisory limits on the consumption of other fish caught in the Maribyrnong & Yarra estuaries.

Based on the calculations in Table 2, it would be possible to recommend different monthly consumption advisory limits for mulloway, black bream and mullet. However, given the relatively small number of samples and fish species on which this advice is based, and the need for the consumption advisory information for the general public to be relatively simple to convey and understand, the Panel recommends **an advisory limit for the general population aged 16 years and over of one 150 g serve per month for eels and one 150 g serve per week for all other fish caught in the Maribyrnong and Yarra estuaries.**

4.1 Protection of children and pregnant women

There is no precise method for estimating a protective intake figure for children, pregnant women or women intending to become pregnant, because there is no specific benchmark for a safe level of intake of PCBs for such groups. The RfD for PCBs is based on an estimated safe intake level (on a mg/kg body weight basis) **over a lifetime**, and it assumes that intakes during those parts of the lifespan where body

weight is lower will be averaged out over the longer term. Furthermore, the RfD incorporates “safety factors” which take account of such variations in mg/kg/day intake, and should also provide protection for more susceptible groups within the population (e.g. pregnant women and the elderly).

The advisory limits recommended in this Report are based on a tolerable weekly PCB intake (0.0094 mg/week) calculated by adjusting the RfD (expressed in mg/kg body weight/day) to a weekly intake based on a body weight of 67 kg representing a mean body weight over a lifetime. For children, whose body weights are lower, the tolerable intake on a mg basis would be reduced proportionately. For example, for a 19 kg child (approximately 4 years old), the tolerable weekly PCB intake would be reduced approximately fourfold to 0.0027 mg/week, and the amount of black bream (for example) which could be consumed before exceeding this limit would be reduced from 19-32 g/day to 5-9 g/day. Accordingly, it might be prudent to place further limitations of advisory fish consumption limits for children. Taking a conservative approach, such limitations could be applied to children up to around 15 years of age, on the basis that they would not achieve mean lifetime body weight until around that age.

While extension of the recommended consumption limit to pregnant women is not necessarily implied by the risk assessment, as explained above, it is not uncommon for a more conservative approach to be recommended for pregnant women when the developing foetus is likely to be particularly susceptible to a toxic agent, or where it may be transferred in breast milk. Recommendations on limiting exposure to mercury in fish are a good example of such a precautionary approach. Accordingly, the Panel agree to recommend that the fourfold reduction in advisory limits for children be extended to pregnant women in order to accommodate a need for greater protection for both these groups. This approach would lead to advice that **children up to the age of 15 years and pregnant women limit consumption of fish caught in the lower Maribyrnong and Yarra estuaries to one serve every month, and to avoid eating eels from the lower Maribyrnong and Yarra estuaries.**

The Panel notes that any inconvenience associated with this consumption limitation advice will affect only those who regularly eat fish caught in the Maribyrnong and Yarra River estuaries, and that other sources of fish are available to maintain their inclusion in a healthy diet.

5. Dioxins and dioxin-like PCBs

The 2006 survey included measurements of dioxins and dioxin-like PCBs² in composites of the samples taken from selected reaches of the estuarine system.

While the eel composite samples tended to show higher concentrations than the black bream or mullet composite samples, only one of the two eel composite samples

² Dioxin-like PCBs are twelve specific congeners which interact with the Ah receptor and therefore contribute to the TEQ for exposures to mixtures of such congeners. The TEFs for these congeners have been recently revised, but the TEQ contributions used in the present analysis are based on 1998 TEF values. The Panel notes that dioxin-like PCBs appear to contribute substantially to the TEQs reported in the survey. This is consistent with PCBs being a more significant pollutant than dioxin congeners in the Maribyrnong and Yarra river estuaries.

showed a concentration marginally higher than the 6 pg TEQ/g fresh weight recommended as an action level in the recent risk analysis for dioxins in Sydney Harbour fish samples (NSW Food Authority 2006). This action level is comparable to the levels of 4 pg TEQ/g for dioxins and 8 pg TEQ/g dioxins and dioxin-like PCBs published by the European Commission in February 2006, and takes into account the possible background exposure from sources other than fish.

Accordingly, the Panel does not consider it necessary to undertake a further risk assessment based on the reported levels of dioxins and dioxin-like PCBs, nor to recommend any further restrictions on fish consumption based on present findings for dioxins.

Advisory limitations for fish and eel consumption based on the PCB values described above should be more than adequately protective in restricting the contribution of dioxins and dioxin-like PCBs from fish caught in these waters to within the Tolerable Monthly Intake (TMI) of 70 pg TEQ/kg bw/month.

6. Other chemicals

The Panel has noted the levels of trace elements, organochlorine pesticides, total petroleum hydrocarbons, PAHs and other chemicals monitored in the 2005 and 2006 surveys. Many samples were below reporting limits for the various analytes. Where detected, the levels were generally lower than MRLs, MLs or screening levels suggested by the US EPA for risk analysis relating to fish consumption.

While the Organochlorine pesticide dieldrin was detected (i.e. above the LOQ of 0.01 mg/kg) in four of the five eel samples (0.06-0.07 mg/kg fresh weight) and one mulloway sample (0.02 mg/kg fresh weight), the concentrations were generally well below the MRL of 0.1 mg/kg. The fact that these detections exceeded the US EPA SV of 0.0025 mg/kg (which is fourfold lower than the LOQ) did not convince the Panel that any further risk assessment was necessary. The consumption advice included in this Report should mitigate any health concern relating to this one Organochlorine pesticide.

Accordingly, the Panel has not considered it necessary to conduct a formal risk assessment of intakes for any of these chemicals and was satisfied that fish and eel consumption limitations based on the PCB data should adequately limit exposure to any of the other chemicals detected in the survey.

The Panel has noted that PAHs were detected in one black bream and one eel sample. These were uncooked samples. PAHs are genotoxic carcinogens and any risk assessment could be driven to an extremely conservative intake limit by linearised extrapolation of cancer risk to a low risk target (10^{-5} or 10^{-6}). However, the PAH concentrations reported in the current fish survey results appear to be much lower than those found in other food sources; particularly in charbroiled or cooked foods. Accordingly, the Panel considers that exposure to PAHs via fish caught in the Maribyrnong and Yarra estuaries would make a very small contribution to total dietary exposure to such compounds, and that an advisory limit on fish consumption based on the PAH data is not warranted.

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Attachment A:

2006 EPA Victoria Fish Contamination Study

Expert Panel members:

Chair

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Terms of Reference

In 2005 an EPA Victoria and Melbourne Water study found some eels with elevated levels of polychlorinated biphenyls (PCBs) in the estuary of the Yarra and Maribyrnong Rivers. As a result Victoria's Chief Health Officer advised that, while not a cause for alarm, they warranted further investigation and pending the outcomes of this work, he recommended that eels from the Estuary should not be eaten more than once a month.

To investigate the issues raised by the 2005 study, EPA undertook a more comprehensive monitoring program to investigate chemical contaminants in fish in the Estuary.

The investigation was undertaken in collaboration with the Department of Human Services (DHS). It was supported by Melbourne Water and the Port of Melbourne Corporation and was guided by an interagency consultation group comprising the above agencies and the Departments of Primary Industries (Fisheries), Sustainability and Environment, and Parks Victoria.

Results from the 2006 study showed similar levels of PCBs to the 2005 study. In addition detectable levels of dioxins and dioxin-like PCBs were found.

EPA and the DHS have convened an expert panel to provide advice about any risks from consuming fish from these areas and any precautions that may be necessary.

The expert panel has been specifically asked to:

- Review all monitoring data obtained from the 2006 fish study and provide comment on the adequacy of this information as a basis for providing public health advice.
- Comment on risks to the general public and recreational fishers from the consumption of fish caught in the estuaries of the Yarra and Maribyrnong Rivers.
- Advise, where necessary, on relevant public health advice that may be provided to the community.
- Prepare a report addressing the points listed above.

The Expert Group is to:

- Submit interim advice to EPA and DHS by 25 September 2006
- Prepare a detailed report for submission to EPA and DHS by December 2006.