National Dioxins Program

Technical Report No. 8
Dioxins in Agricultural Commodities in Australia

A consultancy funded by the Australian Government Department of the Environment and Heritage

Prepared by the Australian Government Department of Agriculture, Fisheries and Forestry

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2. Dioxins emissions from Motor Vehicles in Australia
3. Inventory of Dioxin emissions in Australia 2004
4. Dioxins in Ambient Air in Australia
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National Dioxins Program
c/- Chemical Policy
Department of the Environment and Heritage
GPO Box 787
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Foreword

When the Australian Government established the four year National Dioxins Program in 2001, our knowledge about the incidence of dioxins in Australia was very limited.

The aim of the program was to improve this knowledge base so that governments were in a better position to consider appropriate management actions. Starting in mid 2001, a range of studies were undertaken which involved measuring emissions from sources such as bushfires, as well as dioxin levels in the environment, food and population. The findings of these studies were used to shed light on the risk dioxins pose to our health and the environment.

This work has been completed and the findings are now presented in a series of twelve technical reports.

Having good information is essential if there is to be timely and effective action by governments; these studies are a start. Our next step is to foster informed debate on how we should tackle dioxins in Australia, as this is an obligation under the Stockholm Convention on Persistent Organic Pollutants. The Department of the Environment and Heritage will be working closely with other Australian Government, State and Territory agencies to take this step.

Ultimately, the effective management of dioxins will be the shared responsibility of all government jurisdictions with the support of the community and industry.

David Borthwick
Secretary
Department of the Environment and Heritage

Acknowledgements

The Department of the Environment and Heritage (DEH) would like to acknowledge the following individuals and organisations that contributed to the information studies and risk assessments under the National Dioxins Program:

- the project teams from the CSIRO, the National Research Centre for Environmental Toxicology and Pacific Air & Environment who undertook the studies assessing the levels of dioxins in the environment, the population and from emission sources, the overseas experts who provided advice to these organisations, and the many individuals across Australia who collected the samples in the field
- the Department of Agriculture, Fisheries and Forestry, who assessed the levels of dioxins in agricultural commodities
- Food Standards Australia New Zealand and the Department of Health and Ageing and who assessed the levels of dioxins in foods and assessed the health effects of dioxins
- officers of the Chemical Assessment Section in DEH who assessed the ecological effects of dioxins
- members of the National Dioxins Project Team which included representatives from the State and Territory environment protection agencies, the Australian Health Ministers Conference and the Primary Industries Ministers Council
- members of the National Dioxins Consultative Group which included representatives from industry and agricultural sectors, environment and public health groups and research institutions.

Project Team

This work was carried out as a co-funded project between participant industry groups and the Australian Government and coordinated by the National Residue Survey (NRS).

This report was prepared by the Dioxins Technical Group (DTG) with the assistance of staff from the Product Safety and Integrity Branch and NRS in the Product Integrity Animal and Plant Health Group of the Australian Government Department of Agriculture Fisheries and Forestry. The DTG was established under the Primary Industries Standing Committee Dioxins Working Group, and included:

DR ANGELO VALOIS (CHAIR)	Australian Government Department of Agriculture, Fisheries and Forestry
Dr Les Davies	Therapeutic Goods Administration
Mr Denis Hamilton	Queensland Department of Primary Industries
Mr Graham Roberts	Chem Res Technical Services P/L, formerly at the Victorian Department of Primary Industries
Dr Bob Symons	Australian Government Analytical Laboratories

Executive Summary

This study was a component of the National Dioxins Program that was tasked to quantify and assess the concentrations and relative chemical compositions of dioxin-like chemicals in Australian agricultural commodities.

Levels of dioxins in Australia's meat, milk and fish are low and compare favourably with overseas products in terms of dioxin contamination. None of the samples (collected and analysed in 2002-2003) contained dioxin levels exceeding the European Union (EU) standard.

In August 2000, the then Standing Committee on Agriculture and Resource Management, SCARM, (now the Primary Industries Standing Committee [PISC]) agreed to a coordinated strategy for dioxin testing. The primary objective of the testing was to provide baseline data to help maintain market access for agricultural products, following a dioxin and polychlorinated biphenyls (PCB) crisis in Belgium. Australia did not have any monitoring data for dioxins in agricultural products, or a domestic health standard for dioxin intake.

The framework for the Dioxins Testing Program for Australian Agricultural Commodities was developed by the PISC Dioxins Working Group. The objective of the group was to:

> "safeguard consumer health and protect Australia's export markets in regards to dioxin contamination of food and food ingredients through the collection of prevalence data of dioxins in Australia's agricultural produce."

The commodity groups subsequently involved in the testing program include cattle, sheep, pigs, poultry, aquaculture fish and milk. The Australian Government Department of Agriculture, Fisheries and Forestry (DAFF) obtained financing for the testing program through a joint arrangement between the Australian Government Department of the Environment and Heritage (DEH) and the participating industry bodies.

The National Residue Survey (NRS), managed by DAFF, arranged for the collection of meat, fish and milk samples during November and December 2002. The collection of milk samples was organised by the Australian Dairy Industry Council. AgriQuality New Zealand, an analytical laboratory with extensive dioxin testing experience, was contracted to carry out the analysis of around 220 samples for dioxins and dioxin-like PCBs.

A Dioxins Technical Group (DTG) was established under PISC to assist with the interpretation of results and to provide recommendations for further action. Results of the Australian study for dioxins and dioxin-like PCBs across all commodities tested, compared favourably to international data reported from other countries.

In the absence of an Australian commodity standard for dioxins and furans, Australian data were compared against the EU standard in EU Regulation (EC) No 2375/2001. A summary of results follows:

Species	EU Standard Maximum pg TEQ/g*	Mean** result from this study (%)	Number of Samples
Beef	3	0.56 (18.6%)	109
Fish (Salmonids)	4	0.23 (5.7%)	10
Milk	3	0.43 (14.5%)	19
Pig	1	0.33 (33.1%)	20
Poultry	2	0.33 (16.5%)	15
Sheep	3	0.57 (19.1%)	45

* on a fat basis except for fish where it is expressed on a fresh weight basis (ie. muscle meat of fish and fishery products and products thereof).

** mean results are upperbound concentrations expressed as pg TEQ/g. Values in parentheses are expressed as a percentage of the EU standard for that species.

It is important to note that the EU standard in EU Regulation (EC) No. 2375/2001 only refers to dioxins/furans, and that dioxin-like PCBs are not currently included. It is expected that in the future, a new EU standard will encompass dioxin-like PCBs, and that when this occurs, the expectation is that current commodity levels (maximum pg TEQ/g) will increase to accommodate these additional congeners.

Consistent with international reporting practice, results were reported in terms of both lowerbound and upperbound levels. Upperbound levels represent the sum of detected congeners multiplied by the relevant Toxic Equivalency Factor (TEF), plus the sum of the Limit of Detection (LOD) contributions for non-detected congeners also multiplied by the relevant TEF.

For the majority of results, the assumption of non-detects being at the LOD was the major contributor to the upperbound levels. Although differences were observed between commodities, only low levels of actual dioxins and dioxin-like PCB congeners were detected relative to reported levels and standards overseas. The DTG noted the significant contribution that LODs made to upperbound results and recommended that any future testing for dioxins address this important laboratory analytical issue.

Food Standards Australia New Zealand (FSANZ) is the appropriate authority for the assessment of consumer exposure through foodstuffs. The DTG recommended that the detailed data collected in this study be provided to FSANZ for the purpose of dietary risk assessment for Australian consumers.

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Glossary/Abbreviations

DAFF	Department of Agriculture, Fisheries and Forestry
DEH	Department of the Environment and Heritage
DoHA	Department of Health and Ageing
DTG	Dioxins Technical Group
EC	Commission of the European Communities
EU	European Union
FSANZ	Food Standards Australia and New Zealand
JECFA	Joint Expert Committee on Food Additives
LOD	Limit of Detection
Lowerbound	Sum of detected congeners multiplied by the relevant toxic equivalency factor
NHMRC	National Health and Medical Research Council
NRS	National Residue Survey
PCB	Polychlorinated biphenyls
PISC	Primary Industries Standing Committee
PIAPH	Product Integrity Animal and Plant Health, DAFF
SCARM	Standing Committee on Agriculture and Resource Management
TEF	Toxic Equivalency Factor
TEQ	Toxic Equivalence
TGA	Therapeutic Goods Administration
Upperbound	Maximum possible TEQ
WHO	World Health Organization

1. Background

In August 2000, the Primary Industries Standing Committee (PISC), formerly the Standing Committee on Agriculture and Resource Management, SCARM, was informed of a dioxin and polychlorinated biphenyls (PCB) crisis in Belgium. The crisis had an adverse impact on consumer confidence and Belgian food exports. At that time, Australia did not have any monitoring data for dioxins in agricultural products, nor a domestic health standard for dioxin intake.

SCARM acknowledged the need for a coordinated strategy to maintain market access for agricultural products and agreed to the establishment of a Dioxins Working Group to conduct a strategic assessment of risk and recommend a risk management approach, including:

(a) dioxin testing of agricultural commodities to provide data on prevalence and levels

(b) development of a protocol for reporting dioxin results and the management of significant detections.

1.1. PISC Dioxins Working Group

At its first meeting on 4 December 2000, the Dioxins Working Group agreed to the following objective for the group:

> "To safeguard consumer health and protect Australia's export markets in regards to dioxin contamination of food and food ingredients through the collection of prevalence data of dioxins in Australia's agricultural produce."

The Dioxins Working Group developed a framework for dioxin testing of agricultural commodities based on a risk management approach. The commodity groups proposed for the testing program included cattle, sheep, pigs, poultry, aquaculture fish and milk.

The Standing Committee endorsed the Dioxins Testing Program for Australian Agricultural Commodities in August 2001 and also endorsed:

> *"the establishment of a Dioxin Technical Group (DTG) to assist with interpretation of dioxin test results and determine whether detections warrant further actions based on relevant toxicological or scientific information. The Working Group considered the DTG necessary to interpret results because there are currently no legislated standards for maximum dioxin levels in food commodities and dioxins are generally found in nature as complex mixtures with greatly varying toxicological significance."*

1.2. Framework for the Australian Dioxins Testing Program

The Australian Government Department of Agriculture, Fisheries and Forestry (DAFF) obtained financing for the testing program through a joint arrangement between the

Australian Government Department of the Environment and Heritage (DEH) and participating industry bodies.

In November and December 2002, the National Residue Survey (NRS), managed by DAFF, arranged for the collection of approximately 220 samples from meat and fish products. The collection of milk samples was organised by the Australian Dairy Industry Corporation. AgriQuality New Zealand, an analytical laboratory, was contracted to carry out the analysis of samples for dioxins and dioxin-like PCBs.

1.3. International Developments

While there are currently no legislated standards for maximum dioxin levels in food commodities in Australia, dioxin levels continue to be an issue in export markets. Countries with dioxin testing programs include New Zealand, Canada, the United States of America, the European Union, Japan, the Republic of Korea and Taiwan.

Dietary intake standards

The World Health Organization (WHO) established a tolerable daily intake (TDI) for dioxins in 1990. The WHO tightened the TDI range in 1998. Subsequently, the Food and Agriculture Organisation (FAO) and the World Health Organization (WHO) Joint Expert Committee on Food Additives (JECFA), established a provisional tolerable monthly intake. In 2002, both Australia and New Zealand recommended tolerable or maximum monthly intake standards.

Commodity standards

The Commission of the European Communities (EC) has had in place maximum dioxin levels for beef, sheep meat, fish meat, milk, pigs and poultry since 1 July 2002 (EC Regulation No 2375/2001). A standard for dioxin-like PCBs will be introduced before December 2004 with the simultaneous introduction of “target levels”. The EC has also defined “action levels”, nominally set at two-thirds the maximum levels (see EC 2002/201/EC), whereby Member States in cooperation with operators, are requested to:

- initiate investigations to identify the source of contamination
- check for the presence of dioxin-like PCBs
- take measures to reduce or eliminate the source of contamination.

The Commission Recommendation, EC 2002/201/EC, also covers animal feedstuffs.

Korea proposed temporary maximum dioxin levels in December 2000 (understood to have entered into force in April 2001). The commodities covered are beef, pigs, chicken meat and eggs. Maximum levels were not set for fish, milk or sheep meat.

In this report the term “dioxin” or “dioxins” is used in reference to the 2,3,7,8 chlorine substituted dibenzo-*p*-dioxins and dibenzofurans and the term PCBs is used in reference to the PCBs with dioxin-like toxicity, unless otherwise specified (Refer to Table 2).

2. Members of the Dioxins Technical Group

The members of the DTG were chosen by PISC (then SCARM) on the basis of expertise rather than a representative role (Table 1).

Table 1: Members of the Dioxins Technical Group

Name	**Organisation**
Dr Angelo Valois (chair)	Australian Government Department of Agriculture, Fisheries and Forestry
Dr Les Davies	Therapeutic Goods Administration
Mr Denis Hamilton	Queensland Department of Primary Industries
Mr Graham Roberts	Chem Res Technical Services P/L, formerly Victorian Department of Primary Industries
Dr Bob Symons	Australian Government Analytical Laboratories

3. Terms of Reference

Considering the intent of PISC in establishing the DTG, the DTG members agreed to the following terms of reference:

The DTG should:

A. Interpret results, as dioxins are generally found in nature as complex mixtures with individual components of greatly varying toxicological significance

B. Interpret results, as there are currently no legislated Australian standards for maximum dioxins levels in food commodities

C. Determine whether detections warrant further actions in respect of international trade (i.e. not a human health assessment) based on relevant toxicological or scientific information

D. Assist with the interpretation of dioxins test results.

3.1. Reporting

As detailed in the PISC paper establishing the dioxins testing program, the DTG was established to report to the NRS, the expert opinion of DTG members as to whether the results warranted further actions. Should the DTG deem that the results warranted further action, the NRS would report results of concern to the State/Territory Residue Coordinator in the State/Territory of origin of the product and to the relevant industry body.

The exact format and content of the DTG's report to the NRS, was determined in the context of the terms of reference agreed to by the DTG.

Although it was the intention of PISC that the DTG report only to the NRS, the opinion of the DTG could also be provided to the PISC Dioxins Working Group and/or to the relevant industry bodies if it was considered necessary that some action was required.

4. Findings and Recommendations

Based on the summary report of laboratory results provided by DAFF (Appendix 2, 3 and 6), the DTG came to the following conclusions relating to each agreed term of reference:

4.1. Interpretation of results - Terms of Reference A

The DTG agreed that the WHO TEQ calculated from the WHO TEFs[1] was the appropriate means to interpret the toxicological significance of complex dioxin mixtures. Furthermore, in line with international convention, both lowerbound and upperbound (the EC also routinely reports middlebound), results should be reported for the purposes of comparison with standards and risk assessments. Lowerbound results report the TEQ for detected congeners only. Upperbound results report total TEQ for detected congeners plus non-detected congeners assumed to be present at concentrations equal to the analytical limit of detection.

The DTG also noted that TEQ data as well as data relating to individual congener concentrations are required for expert analysis and interpretation of dioxin data, particularly if risk management options and/or further investigations were to be considered. Congener profiles, including non-2,3,7,8-chlorine substituted congeners, can yield useful information concerning possible sources of contamination.

RECOMMENDATION 1: That WHO_{98}-TEQs be used to interpret the toxicological significance of complex mixtures of dioxins and for comparison with legislated standards.

4.2. Interpretation of results - Terms of Reference B and C

Currently there are no legislated standards for maximum dioxin levels in food commodities (Term of Reference B) and whether detections warrant further actions should be determined based on relevant toxicological or scientific information (Terms of Reference C) including reporting and policy recommendations as requested by DAFF.

The DTG noted that these two terms of reference and the additional requests by DAFF to be linked and, therefore, they were considered together.

[1] Van den Berg, M. et al. (1998), Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife, Environmental Health Perspectives, 106, 775-792.

The DTG noted that in addressing these terms of reference there are three aspects to consider:

1. consumer exposure
2. comparison with available international data
3. trade.

4.2.1 Consumer Exposure

The DTG noted that in relation to consumer exposure via foodstuffs, the appropriate authority for such assessments in Australia is FSANZ. Therefore, the DTG did not undertake any toxicological assessment using the data and limited itself to comparing data to existing and imminent international commodity standards.

RECOMMENDATION 2: That FSANZ be given the data from this study, including the individual results and congener profiles, for the purpose of examining the feasibility of conducting a dietary risk assessment for Australian consumers.

4.2.2 Comparison to international data

In respect of a comparison with international data, the DTG asked that DAFF prepare figures comparing data from the Australian study with the range of results reported in a recent Codex Committee on Food Additives and Contaminants (CCFAC) position paper, CX/FAC 03/32, January 2003. Comparisons of the Australian data with the Codex and other international studies are included in Appendix 7.

4.2.3 Trade

With respect to trade, the DTG noted that none of the results exceeded any current existing international standard and only one sheep-fat sample exceeded the EC action level for dioxins (Appendix 5). However, it was the view of the DTG that if testing of beef and sheep had involved a significantly larger number of samples then occasional violations of standards, particularly the EC action levels, would be likely for these commodities.

4.2.3.1 PCBs and trade

The DTG also noted that there are no existing international TEQ-based food commodity standards for PCBs. However, PCB TEQs are included in dietary exposure standards internationally, including in the recommended Australian intake standard. Therefore, the DTG anticipates that food commodity standards will, in the near future, include PCB TEQs. Furthermore, the EC has announced that it will review dioxin standards for food commodities by December 2004 with the intention of including PCB TEQs in the dioxin standards.

RECOMMENDATION 3(a): That on-going testing for dioxin-like PCBs be undertaken, particularly in light of inclusion of PCB TEFs in the recommended Australian intake standard for dioxins, and the imminent inclusion internationally of PCBs in TEQ-based food commodity standards.

RECOMMENDATION 3(b): That the DWG consider implementing a process to monitor overseas developments with respect to PCB TEQ standards and an effective means of communicating such developments to industry stakeholders.

4.3 Assist with the interpretation of test results (Term of Reference D)

4.3.1 Sampling methods

Sampling protocols can have a significant impact on results. It is, therefore, important to accurately record sampling procedures and to take differences into account when comparing results from different surveys or monitoring programs. For instance, different results may be expected from different fat tissues within animals, composite milk samples compared to milk from individual cows or different cross-sections of muscle tissue from a single fish. In the latter case it was noted that for this survey, muscle tissue from a whole fish was homogenised prior to sub-sampling for analysis, whereas other laboratories may routinely sample a particular portion of fish.

RECOMMENDATION 4: That for trade purposes Australia should use the same methods of sampling that are employed by relevant export market(s).

4.3.2 Limit of detections (LODs)

The DTG noted that, except for salmonids for the majority of results in this study, the assumption of non-detects being at the Limit of Detection (LOD) was by far the major contributor to the upperbound result. Only low levels of actual dioxin congeners were actually detected, but it was acknowledged that the laboratory met its reporting obligation with respect to the upperbound level (based on LODs) of ≤1 pg TEQ/g lipid weight specified by the NRS. It was also acknowledged that there is evidence in the international literature, and from other data generated for the National Dioxins Program as well as the FSANZ selected foods survey (FSANZ 2004), that lower upperbound values (based on LODs for non-detected congeners) than determined in these assays, are being reported. This is solely due to the analytical ability of other laboratories achieving lower LODs. Given that, upperbound results are increasingly being used by international regulators, and in Australia, by the National Health and Medical Research Council and the Therapeutic Goods Administration. It is important that future dioxin studies pay particular attention to the assay laboratory's capacity to achieve LODs that are as low as possible.

The DTG expressed its concern that a large number of the Australian samples with low lowerbound values (i.e. low actual detections) may appear artificially high in comparison to results from other countries due to the significant contribution of LODs of non-detected congeners to the upperbound values. It was felt that this was due, at least in part, to the approach used by the laboratory in determining the LODs of non-detected congeners. This approach, which is described in more detail in Appendix 1, involves the use of a statistically derived factor that is applied to any response level above a signal to noise ratio of 3:1 that does not meet identification criteria. The same factor is also applied to any response detected in the sample which is not five times above the level of the same response detected in the blank, whether this response meets or does not meet the identification criteria. In each case, the response is reported as a non-detect and the LOD is set at the adjusted value rounded to one significant figure. While this approach is statistically based and is used by the laboratory to provide greater confidence (≥99%) that a target dioxin congener is not present above the reported LOD, it also increases the contribution of the LODs to the total upperbound values to a greater extent than would otherwise be the case if a different approach was utilised. While international debate continues in regard to the best approach to use when setting LODs for non-detected congeners, laboratories that applied a factor to address uncertainty when setting these LODs would appear to be more conservative in their approach in comparison to laboratories that set LODs without applying a factor. A priority research area is to improve the LODs prior to further monitoring.

RECOMMENDATION 5(a): That future testing for dioxins address the need to limit the contribution to upperbound results from LODs.

RECOMMENDATION 5(b): That research also be targeted at identifying possible sources of dioxins and PCBs e.g. in feedstuffs and to reduce wherever possible, sources of contamination. Congener profiles would be one aspect helping to identify sources of contamination.

4.3.3 National laboratory capability

The DTG recognised the importance of Australia developing and maintaining a capacity to test for dioxin/furans and dioxin-like PCBs in line with international competency standards. This work is particularly relevant to recommendations within this report relating to LODs and minimising upperbound results for analyses. Significant resources are required to maintain and further expand this capacity to at least keep pace with international developments. Reporting satisfactory results in independent international Proficiency Trials is a good way of demonstrating competency, accuracy and reliability of test results to trading partners and other interested parties.

RECOMMENDATION 6(a): That Australia maintains laboratory capacity and participation in international proficiency trials related to dioxin/furan/PCB analyses.

RECOMMENDATION 6(b): That the DWG consider options for ensuring that Australia maintains the analytical capability to test for dioxin/furan/PCBs in line with international standards.

4.3.4 Measurement uncertainty

It should be recognised that analytical results are not absolute values but rather values within defined limits to account for measurement uncertainty. The measurement uncertainty associated with analytical results should be considered when comparing results with regulatory standards.

4.3.5 Species specific trade assessment

The DTG's specific views for each species tested are outlined below. It is important to note that the DTG has not made any toxicological assessment of this data and the following assessments only relate to trade issues (i.e. comparisons to existing or expected international trade standards and/or actions levels – see Section 3 Terms of Reference).

4.3.5.1 Beef

The DTG noted that no existing international beef commodity standards or action levels were exceeded in this study. As noted earlier in Section 4.3.2, the DTG observed that the inclusion of LODs for non-detects contributed a significant amount to the upperbound results. However, it was the view of the DTG that appropriate attention to the analytical methodology and capability of the laboratory would reduce the contribution of LODs (due to non-detects) to the upperbound figure. Such improvement is necessary in order that tests conducted on Australian samples are equivalent to those conducted in our export markets and to ensure that upperbound results from laboratories testing Australian samples do not over-estimate the actual residue levels of Australian beef.

The lowerbound results indicate isolated instances of exposure rather than general background contamination levels. This being the case, an on-going random monitoring program is desirable in order to detect, investigate and manage potential violative contamination levels. It should be noted that if 1% of animals actually violated the EC action level there would be approximately a 67% chance of detecting a violation in the 109 samples tested.

RECOMMENDATION 7: That on-going testing of beef takes place for dioxins and PCBs (with emphasis on limiting the contribution of LODs to upperbound results).

4.3.5.2 Milk

The DTG noted that no existing international milk commodity standards or action levels were exceeded in this study.

Only 19 composite dairy samples were analysed. Given the isolated instances of exposure indicated by the results recorded for beef cattle (109 samples), it is possible that a particular dairy herd could be similarly exposed. If so, it is likely that residues in milk would be lower than those detected in beef fat due to continual excretion via the milk. Furthermore, residues in milk consumed would be further reduced by dilution with milk from other herds.

As noted in Section 4.3.2, the DTG observed that LODs contributed a significant amount to the upperbound results. In relation to future dietary health assessments, it is vitally important to reduce the contributions from LODs in milk because milk and milk-derived foods (cheese, yoghurt, etc.) are consumed in significantly higher amounts, particularly on a body weight basis by toddlers, than other commodities tested in this study.

RECOMMENDATION 8: That on-going testing of milk takes place (with emphasis on limiting the contribution of LODs to upperbound results).

4.3.5.3 Pigs

No sample tested exceeded any existing international pork commodity standards or action levels, however, it should be noted that only 20 samples were tested. There would be a low probability of detecting an isolated instance of contamination in such a limited number of samples.

Again, the DTG observed that the inclusion of LODs for non-detects contributed a significant amount to the upperbound results. This is particularly important in pigs as EC standards and action levels for pork are the lowest of all commodities and very close to the LOD achieved by the laboratory. The EC action level for dioxins/furans in pork is 0.6 pg WHO_{98}-TEQ/g lipid weight. This would indicate that EC laboratories routinely achieve LODs that contribute significantly less than this amount to total TEQ results, whereas the upperbound results for three samples reported in this study (no congener detected) were approximately 0.55 pg WHO_{98}-TEQ/g lipid weight. It is important that laboratories worldwide involved in import/export monitoring programs achieve the standard of analytical performance required to reliably check compliance with regulatory standards. In particular, laboratories testing Australian produce need to generate data 'fit for purpose' i.e. data that risk management decisions can be reliably based upon. The DTG noted that greater attention to the analytical issues related to the LOD capability by laboratories used to monitor Australian produce would almost certainly lower the upperbound results for Australian pigs.

RECOMMENDATION 9: That on-going testing of pigs takes place (with emphasis on limiting the contribution of LODs to upperbound results).

4.3.5.4 Poultry

The DTG noted that no existing international poultry commodity standards or action levels were exceeded in this study, however it should be noted that only 15 samples were tested. There would be a very low probability of detecting an isolated instance of contamination in such a limited number of samples.

The DTG observed that the inclusion of LODs for non-detects contributed a significant amount to the upperbound results.

RECOMMENDATION 10: That on-going testing of poultry takes place (with emphasis on limiting the contribution of LODs to upperbound results).

4.3.5.5 Salmonids (aquaculture)

No existing international fish commodity standards or action levels were exceeded in this study. Lowerbound dioxin/furan results were between 50-95% of upperbound results across the 10 samples tested. The highest concentration of dioxins/furans recorded (upperbound result) was about 12% of the EU action level. All samples had detectable levels of dioxin-like PCBs with the highest lowerbound concentration, recorded in two samples, about 0.8 $pgWHO_{98}$-TEQ/g fresh weight. In the opinion of the DTG, the observed residue detections are most likely from exposure through fish feed. The industry should be encouraged to investigate feed sources as a possible means of reducing exposure.

Further monitoring is clearly warranted to ensure that the samples tested were truly representative of the industry, however, present indications are that aquaculture salmonids are unlikely to exceed the current EC maximum or action levels for dioxins/furans, or any future similar standards for dioxin-like PCBs.

RECOMMENDATION 11(a): That the Australian Salmonid industry investigate levels of dioxins in feed with a view to reducing total (i.e. dioxin, furan and PCB) TEQ in fish.

RECOMMENDATION 11(b): That on-going testing of salmonids takes place for dioxins and PCBs.

4.3.5.6 Sheep

The DTG noted that no existing international sheep commodity standards levels were exceeded in this study. One sheep sample (Sample Number: 957-02) exceeded the EC action level. The DTG observed that LODs contributed a significant amount to the upperbound results. However, in the case of sample 957-02, the lowerbound result exceeded the EC action level. The DTG noted that the dioxin congener profile for this sample showed relatively higher levels of dioxin congener 2,3,4,7,8-PeCDF which is an internationally recognised marker of a man-made combustion source.

The lowerbound results indicate isolated instances of exposure rather than general background contamination levels. This being the case, an on-going monitoring program is desirable in order to detect, investigate and manage potential violative contamination levels.

RECOMMENDATION 12(a): Any further action in regards to sample number 957-02 should be discussed by the DWG prior to referral back to the State Authority for possible investigation.

RECOMMENDATION 12(b): That on-going testing of sheep takes place (with emphasis on limiting the contribution of LODs to upperbound results).

4.3.5.7 Tuna (aquaculture)

Review by DAFF of an initial set of 20 tuna samples, revealed some anomalies in respect of sample selection, which gave rise to possible concerns regarding the integrity of the results. As a result of consultations between DAFF, the tuna industry and DEH, it was agreed that sampling and testing of 20 new samples would be undertaken with particular attention given to sampling methodology to account for within and between fish variability. The new data will be assessed by the DTG and a follow-up report will be provided to DEH for release later in 2004.

4.3.6 General Recommendations

RECOMMENDATION 13(a): That DAFF/NRS enlist the on-going assistance of the DTG in future reporting (e.g. DAFF report to PISC and ultimately reporting to the public) and policy analysis (e.g. risk management) relating to dioxins.

RECOMMENDATION 13(b): That the DTG reports directly to the PISC Dioxins Working Group and the NRS, and not just to the NRS as requested by PISC.

RECOMMENDATION 13(c): That, subsequent to the results of this study being reported by DAFF, and with the agreement of industry stakeholders, the DTG members publish this data and their analysis in a peer-reviewed scientific journal, as is the international practice.

5. References

Documents referred to in this report

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Sources of data for international comparison presented in Appendix 7

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Appendix 1 Dioxins / PCB Methodology

The methods used for the analysis of polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and polychlorinated biphenyls (PCBs) were based on US EPA Methods 1613 (PCDDs & PCDFs) and 1668A (PCBs). These methods utilise high-resolution gas chromatography and high resolution mass spectrometry (HRGC-HRMS) techniques for the identification and quantification of individual PCDD, PCDF and PCB congeners and enable their corresponding Toxic Equivalents (TEQs) to be calculated.

In the case of dioxins, the tetra- to octa- 2,3,7,8 substituted dibenzodioxins and dibenzofurans congeners are included in the analytical regime. In the case of PCBs, the 12 coplanar congeners with dioxin-like toxicity as well as a number of other congeners are covered by the method.

Each toxic dioxin and PCB congener is assigned a WHO toxic equivalency factor (WHO-TEF), as detailed in Table 2. Individual toxic equivalents (TEQs) are calculated for each individual toxic congener by multiplying the concentration of the congener with its assigned WHO-TEF. The individual TEQs are then summed to give a total TEQ.

The sum of congeners and total TEQ are reported at three levels – lowerbound, mediumbound (not included in this report) and upperbound. Lowerbound includes only the detected congener levels, thus giving a best-case scenario. Upperbound includes both detected and non-detected congeners, where the non-detected congeners are assumed to be at the level of the reported detection limit, thus giving a worse case scenario.

Responses observed above a signal to noise ratio of 3:1 that meet all identification criteria are reported as detected and their concentrations are calculated on the basis of the area of the peak observed. However, if the same response is observed without meeting the identification criteria, a statistically-derived factor is applied to the theoretical concentrations calculated on the basis of the area of the peak observed and the result is reported as a non-detect with the LOD set at the adjusted value (rounded to one significant figure). Similarly, the same factor is also applied to any response detected in the sample which is not five times above the level of the same response detected in the blank, whether this response meets or does not meet the identification criteria. Again, the response is reported as a non-detect and the LOD is set at the adjusted value rounded to one significant figure. The approach of using a statistically derived factor for non-detected congeners is based on coefficients of variation (CVs) of ~30% being achieved for low level detections and represents the setting of an LOD at ≥ 3 standard deviations above the detected value to give a ≥99% confidence limit. Consequently, by using this factor for non-detected congeners, the laboratory is confident (at ≥99% level) that a target dioxin congener is not present above the reported LOD.

Dioxin Sampling (Meat)

The usual procedure for collection of meat samples for residue testing was used by the National Residue Survey (NRS) to collect samples for the dioxin project, with a few modifications. Sample requests were sent by NRS to AQIS officers at export abattoirs with special instructions and materials to collect the fat samples. Additional precautions were taken to ensure that fat samples were not contaminated during the sampling process, including wrapping the fat in aluminium foil provided by the testing laboratory as soon as possible after collection. Fat samples (perirenal fat preferred) of 200-250 g (minimum 50 g) were collected from carcases of cattle, sheep and pork. The samples were frozen at the abattoir and despatched by courier to the NRS receiver facility in Canberra. Hard frozen fat samples were aggregated into batches for despatch at regular intervals to the laboratory, AgriQuality, in New Zealand for analysis.

Anticipating an age effect on dioxin levels, samples were collected from younger and older animals within each species. For cattle, approximately 70 fat samples were collected from steer/heifer carcases and approximately 40 samples were collected from older cow/bull/ox carcases. For sheep, fat samples were collected from 20 lamb carcases and 25 samples from wether/ewe carcases. For pig, 15 porker samples and five sow samples were collected. Sample collection coincided with the worse drought in the eastern part of Australia for 100 years. This caused problems with the collection of fat samples from some carcases. The laboratory could derive sufficient analysable lipid from all fat samples except for one beef sample.

Dioxin Sampling (Fish)

Fish sample selection was carried out on fish ready for marketing, at the end of the farming cycle. Salmonid samples were collected from different farms on the east and west coasts of Tasmania. Fish samples made up of muscle tissue (200-250 g) were collected from individual fish specimens. The fish samples were part of the National Residue Survey Random Sampling Programs, and as such were analysed for other residues. Information on size and weight was also recorded. Samples were collected by State officers, following collection instructions provided by the NRS and using collection materials and containers provided by the laboratory.

Dioxin Sampling (Poultry)

Poultry samples were collected at random from 12 different abattoirs across the country with the largest throughput. It was expected that this strategy would maximise the chance of a broad representation of different diets. Composite samples of fat were collected by industry quality assurance managers, following collection instructions provided by the NRS and using collection materials and containers provided by the laboratory.

Dioxin Sampling (Milk)

The collection of milk samples was arranged by Dairy Food Safety Victoria, the agency responsible for administering the Australian Milk Residue Analysis (AMRA) survey on behalf of Dairy Australia. Samples of whole milk were collected from bulk milk silos at selected dairy processing facilities. Dairy processing facilities were selected to provide representative coverage of Australian milk production. At each sample site two litres of milk were collected. The milk was collected into1 litre Schott bottles specially prepared for dioxin sampling and supplied by the testing laboratory. Twenty samples were collected and forwarded to the laboratory. Unfortunately, the two bottles from one of the sample sites were damaged in transit. As a consequence only 19 of the 20 samples were analysed.

Appendix 2 Summary of Results by Species

The results presented in this report use the WHO TEFs as outlined in Table 2. The use of the WHO TEFs, rather than the I-TEFs, is consistent with the NHMRC/TGA recommended intake standard for dioxins and dioxin-like PCBs.

Table 2: WHO TEFs for dioxins, furans and PCBs

Analyte	**TEFs***
Dioxins and Furans	
2,3,7,8-TCDF	0.1
2,3,7,8-TCDD	1
1,2,3,7,8-PeCDF	0.05
2,3,4,7,8-PeCDF	0.5
1,2,3,7,8-PeCDD	1
1,2,3,4,7,8-HxCDF	0.1
1,2,3,6,7,8-HxCDF	0.1
2,3,4,6,7,8-HxCDF	0.1
1,2,3,7,8,9-HxCDF	0.1
1,2,3,4,7,8-HxCDD	0.1
1,2,3,6,7,8-HxCDD	0.1
1,2,3,7,8,9-HxCDD	0.1
1,2,3,4,6,7,8-HpCDF	0.01
1,2,3,4,7,8,9-HpCDF	0.01
1,2,3,4,6,7,8-HpCDD	0.01
OCDF	0.0001
OCDD	0.0001
PCBs	
PCB#77	0.0001
PCB#81	0.0001
PCB#126	0.1
PCB#169	0.01
PCB#105	0.0001
PCB#114	0.0005
PCB#118	0.0001
PCB#123	0.0001
PCB#156	0.0005
PCB#77	0.0001
PCB#157	0.0005
PCB#167	0.00001
PCB#189	0.0001

* TEF = toxic equivalency factors

Table 2.1: Dioxins and PCBs in beef

Beef	Mean	Standard Deviation	Minimum	Median	Maximum
Dioxins lowerbound (pg TEQ/g fat)	0.104	0.256	0.00	0.00	1.31
Dioxins upperbound (pg TEQ/g fat)	0.557*	0.315	0.0877	0.485	1.77
PCBs lowerbound (pg TEQ/g fat)	0.0731	0.208	0.00	0.00560	1.44
PCBs upperbound (pg TEQ/g fat)	0.289	0.191	0.0882	0.253	1.50
Total TEQ lowerbound (pg TEQ/g fat)	0.177	0.401	0.00	0.0119	2.08**
Total TEQ upperbound (pg TEQ/g fat)	0.847	0.399	0.326	0.783	2.58**

n =109
dioxins = dioxins and furans
TEQ = WHO TEQ

* The Australian data (mean dioxin upperbound result in pg TEQ/g fat) for beef was 18.6% of the EU standard ([EC Regulation] No 2375/2001). The EU standard for dioxins does not include dioxin-like PCBs.

** Maximum 'Total TEQ' results represent the maximum value across all samples for the sum of dioxin and dioxin-like PCB results in an individual sample. For any sample, maximum 'Total TEQ' results are not the sum of maximum dioxin TEQ and maximum PCB TEQ values unless both maximums occur in the same sample. For example, the maximum upperbound dioxin TEQ in beef occurs in sample 1085-1. The maximum upperbound PCB TEQ in beef occurs in sample 1086-2. However, the highest total TEQ upperbound of any beef sample occurs in sample 941-13 (see Figures 3.1a – c).

Table 2.2: Dioxins and PCBs in milk

Milk	Mean	Standard Deviation	Minimum	Median	Maximum
Dioxins lowerbound (pg TEQ/g fat)	0.0277	0.0752	0.00	0.00	0.299
Dioxins upperbound (pg TEQ/g fat)	0.434*	0.154	0.208	0.402	0.749
PCBs lowerbound (pg TEQ/g fat)	0.0280	0.0513	0.00362	0.0113	0.196
PCBs upperbound (pg TEQ/g fat)	0.186	0.108	0.0819	0.129	0.451
Total TEQ lowerbound (pg TEQ/g fat)	0.0557	0.121	0.00362	0.0119	0.445**
Total TEQ upperbound (pg TEQ/g fat)	0.620	0.195	0.365	0.631	1.02**

n =19
dioxins = dioxins and furans
TEQ = WHO TEQ

* The Australian data (mean dioxin upperbound result in pg TEQ/g fat) for milk was 14.5% of the EC standard ((EC Regulation) No 2375/2001). The EU standard for dioxins does not include dioxin-like PCBs.

** Maximum 'Total TEQ' results represent the maximum value across all samples for the sum of dioxin and dioxin-like PCB results in an individual sample. For any sample, maximum 'Total TEQ' results are not the sum of maximum dioxin TEQ and maximum PCB TEQ values unless both maximums occur in the same sample. For example, the maximum upperbound dioxin TEQ in milk occurs in sample 1559-1. The maximum upperbound PCB TEQ in milk occurs in sample 1505-6. However, the highest total TEQ upperbound of any milk sample occurs in sample 1505-8 (see Figures 3.2a – c).

Table 2.3: Dioxins and PCBs in pigs

Pigs	Mean	Standard Deviation	Minimum	Median	Maximum
Dioxins lowerbound (pg TEQ/g fat)	0.00289	0.0129	0.00	0.00	0.0577
Dioxins upperbound (pg TEQ/g fat)	0.331*	0.133	0.146	0.331	0.551
PCBs lowerbound (pg TEQ/g fat)	0.0106	0.0233	0.00	0.00295	0.0995
PCBs upperbound (pg TEQ/g fat)	0.244	0.106	0.102	0.221	0.458
Total TEQ lowerbound (pg TEQ/g fat)	0.0212	0.466	0.00	0.00590	0.199**
Total TEQ upperbound (pg TEQ/g fat)	0.575	0.160	0.303	0.553	0.967**

n = 20
dioxins = dioxins and furans
TEQ = WHO TEQ

* The Australian data (mean dioxin upperbound result in pg TEQ/g fat) for pigs was 33.1% of the EC standard ((EC Regulation) No 2375/2001). The EU standard for dioxins does not include dioxin-like PCBs.

** Maximum 'Total TEQ' results represent the maximum value across all samples for the sum of dioxin and dioxin-like PCB results in an individual sample. For any sample, maximum 'Total TEQ' results are not the sum of maximum dioxin TEQ and maximum PCB TEQ values unless both maximums occur in the same sample. For example, the maximum upperbound dioxin TEQ in pigs occurs in sample 1022-10. The maximum upperbound PCB TEQ in pigs occurs in sample 973-18. However, the highest total TEQ upperbound of any pig sample occurs in sample 1024-16 (see Figures 3.3a – c).

Table 2.4: Dioxins and PCBs in poultry

Poultry	Mean	Standard Deviation	Minimum	Median	Maximum
Dioxins lowerbound (pg TEQ/g fat)	0.00117	0.00236	0.00	0.00	0.00700
Dioxins upperbound (pg TEQ/g fat)	0.330*	0.0862	0.183	0.317	0.529
PCBs lowerbound (pg TEQ/g fat)	0.0173	0.0550	0.00	0.00280	0.216
PCBs upperbound (pg TEQ/g fat)	0.249	0.125	0.0846	0.226	0.452
Total TEQ lowerbound (pg TEQ/g fat)	0.0184	0.0548	0.00	0.00410	0.216**
Total TEQ upperbound (pg TEQ/g fat)	0.579	0.165	0.302	0.593	0.805**

n = 15
dioxins = dioxins and furans
TEQ = WHO TEQ

* The Australian data (mean dioxin upperbound result in pg TEQ/g fat) for poultry was 16.5% of the EC standard ((EC Regulation) No 2375/2001). The EU standard for dioxins does not include dioxin-like PCBs.

** Maximum 'Total TEQ' results represent the maximum value across all samples for the sum of dioxin and dioxin-like PCB results in an individual sample. For any sample, maximum 'Total TEQ' results are not the sum of maximum dioxin TEQ and maximum PCB TEQ values unless both maximums occur in the same sample. For example, the maximum upperbound dioxin TEQ in poultry occurs in sample 940-06. The maximum upperbound PCB TEQ in poultry occurs in sample 940-04. The highest total TEQ upperbound of any poultry sample occurs in sample 940-04 (see Figures 3.4a – c).

Table 2.5: Dioxins and PCBs in aquaculture salmonids

Salmonids	Mean	Standard Deviation	Minimum	Median	Maximum
Dioxins lowerbound (pg TEQ/g fw)	0.173	0.0849	0.0989	0.127	0.317
Dioxins upperbound (pg TEQ/g fw)	0.228*	0.0716	0.150	0.216	0.350
PCBs lowerbound (pg TEQ/g fw)	0.398	0.228	0.120	0.395	0.780
PCBs upperbound (pg TEQ/g fw)	0.602	0.201	0.339	0.573	0.878
Total TEQ lowerbound (pg TEQ/g fw)	0.571	0.245	0.246	0.521	1.10**
Total TEQ upperbound (pg TEQ/g fw)	0.830	0.242	0.489	0.798	1.15**

n =10
dioxins = dioxins and furans
TEQ = WHO TEQ
fw = fresh weight

* The Australian data (mean dioxin upperbound result in pg TEQ/g fw) for salmonids was 5.7% of the EC standard ((EC Regulation) No 2375/2001). The EU standard for dioxins does not include dioxin-like PCBs.

** Maximum 'Total TEQ' results represent the maximum value across all samples for the sum of dioxin and dioxin-like PCB results in an individual sample. For any sample, maximum 'Total TEQ' results are not the sum of maximum dioxin TEQ and maximum PCB TEQ values unless both maximums occur in the same sample. For example, the maximum upperbound dioxin TEQ in salmonids occurs in sample 1084-6. The maximum upperbound PCB TEQ in salmonids occurs in sample 1084-2. The highest total TEQ upperbound of any salmonid sample occurs in sample 1084-6 (see Figures 3.5a – c).

Table 2.6: Dioxins and PCBs in sheep

Sheep	Mean	Standard Deviation	Minimum	Median	Maximum
Dioxins lowerbound (pg TEQ/g fat)	0.112	0.419	0.00	0.00	2.72
Dioxins upperbound (pg TEQ/g fat)	0.572*	0.418	0.134	0.531	2.83
PCBs lowerbound (pg TEQ/g fat)	0.0346	0.143	0.00	0.00	0.813
PCBs upperbound (pg TEQ/g fat)	0.231	0.159	0.0796	0.215	0.866
Total TEQ lowerbound (pg TEQ/g fat)	0.147	0.477	0.00	0.00	2.77**
Total TEQ upperbound (pg TEQ/g fat)	0.803	0.487	0.257	0.712	3.32**

n = 45
dioxins = dioxins and furans
TEQ = WHO TEQ

* The Australian data (mean dioxin upperbound result in pg TEQ/g fat) for sheep was 19.1% of the EC standard ((EC Regulation) No 2375/2001). The EU standard for dioxins does not include dioxin-like PCBs.

** Maximum 'Total TEQ' results represent the maximum value across all samples for the sum of dioxin and dioxin-like PCB results in an individual sample. For any sample, maximum 'Total TEQ' results are not the sum of maximum dioxin TEQ and maximum PCB TEQ values unless both maximums occur in the same sample. For example, the maximum upperbound dioxin TEQ in sheep occurs in sample 957-02. The maximum upperbound PCB TEQ in sheep occurs in sample 957-01. The highest total TEQ upperbound of any sheep sample occurs in sample 957-02 (see Figures 3.6a – c).

Appendix 3 Individual Results by Species

Graphical summaries of individual results are provided to facilitate analysis of the results.

Annex 1: List of beef sample numbers in order used in figures

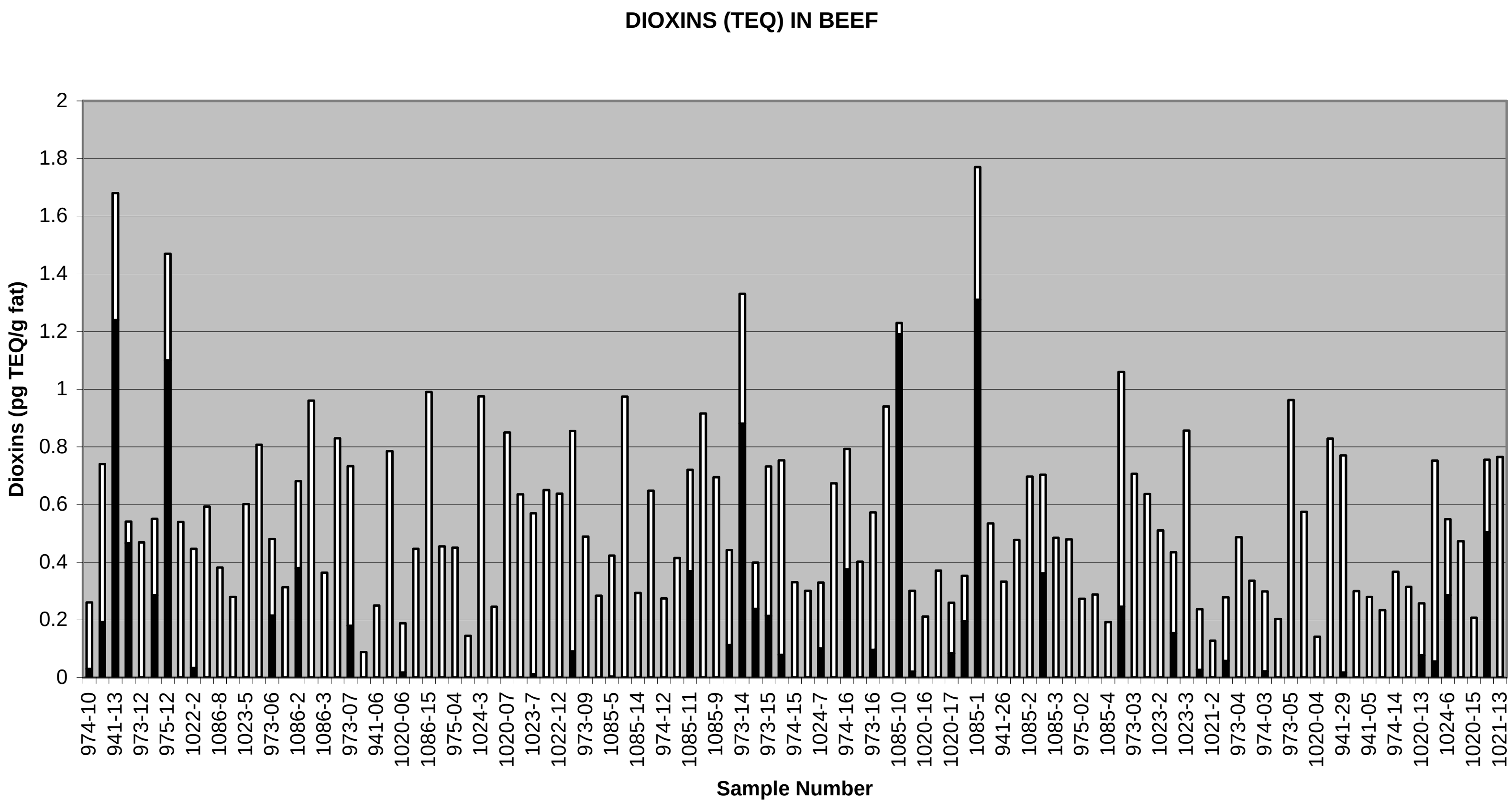
This list can be used to determine the sample number of unlabelled results in Figures 3.1(a), (b) and (c).

Due to the large number of beef samples it is unwieldy to display all samples numbers on the x-axis of Figures 3.1(a), (b) and (c). The following list of beef sample numbers is in the same sequence used in the figures.

NOTE: the order of samples presented on graphs is based on the order of results provided by the NRS to Product Safety and Integrity Branch, DAFF.

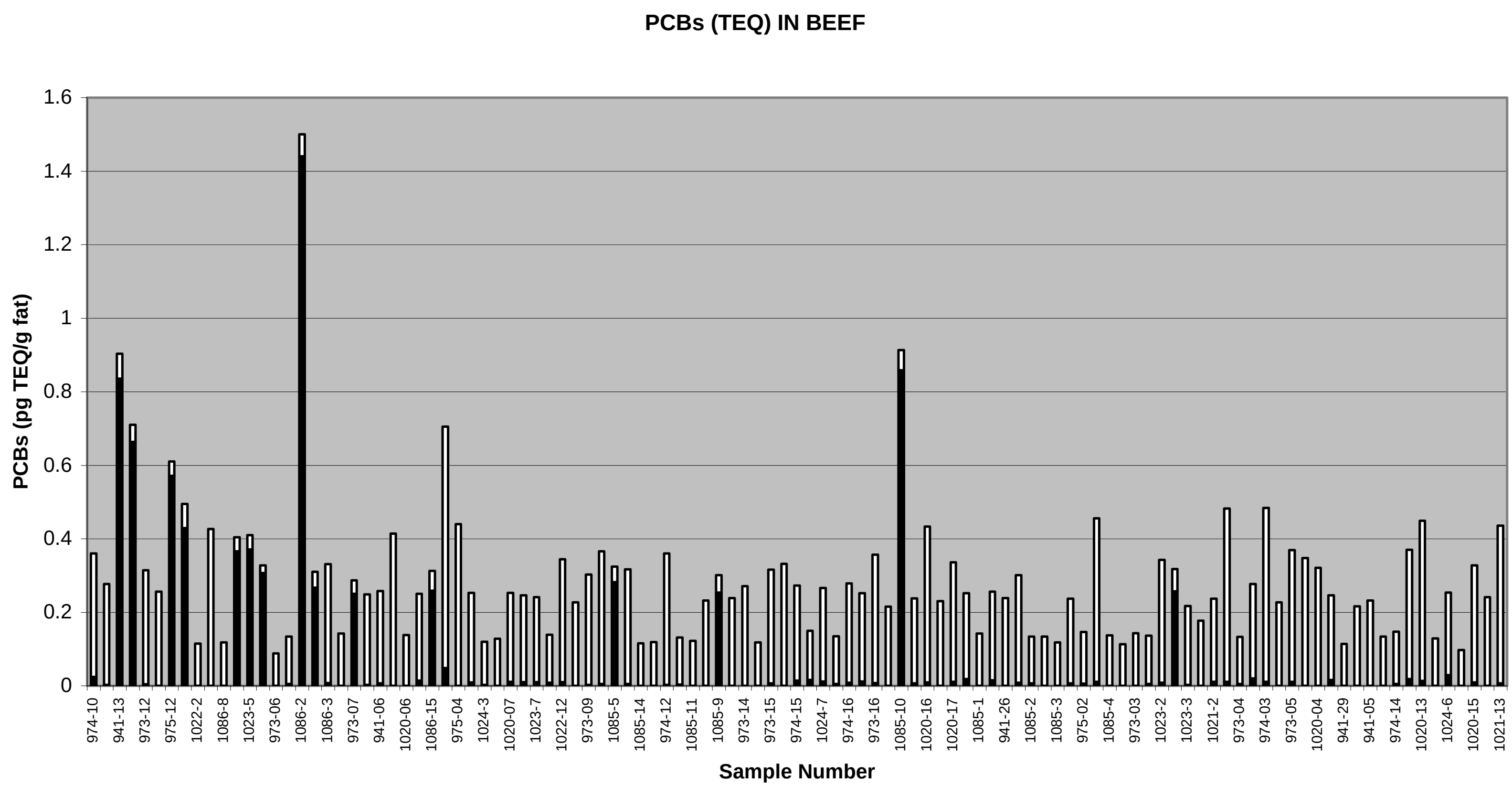
974-10	1020-07	1020-16	941-29
973-11	1086-9	1085-13	1021-3
941-13	1023-7	1020-17	941-05
1024-5	1102-1	974-11	1021-4
973-12	1022-12	1085-1	974-14
1020-12	1022-3	1024-1	941-27
975-12	973-09	941-26	1020-13
957-03	941-04	973-01	1085-7
1022-2	1085-5	1085-2	1024-6
1086-7	973-13	1020-01	1085-8
1086-8	1085-14	1085-3	1020-15
1021-5	1085-6	973-02	974-17
1023-5	974-12	975-02	1021-13
1086-1	974-13	1020-02	
973-06	1085-11	1085-4	
1021-6	1021-9	1022-1	
1086-2	1085-9	973-03	
1023-6	1085-12	1021-1	
1086-3	973-14	1023-2	
1020-05	1020-14	1020-03	
973-07	973-15	1023-3	
1024-2	1022-9	974-01	
941-06	974-15	1021-2	
973-08	1023-19	974-02	
1020-06	1024-7	973-04	
941-07	1021-10	941-02	
1086-15	974-16	974-03	
975-03	1024-8	941-03	
975-04	973-16	973-05	
1021-7	1021-11	974-04	
1024-3	1085-10	1020-04	
1021-8	1021-12	1023-4	

Figure 3.1(a): Dioxins (TEQ) in beef



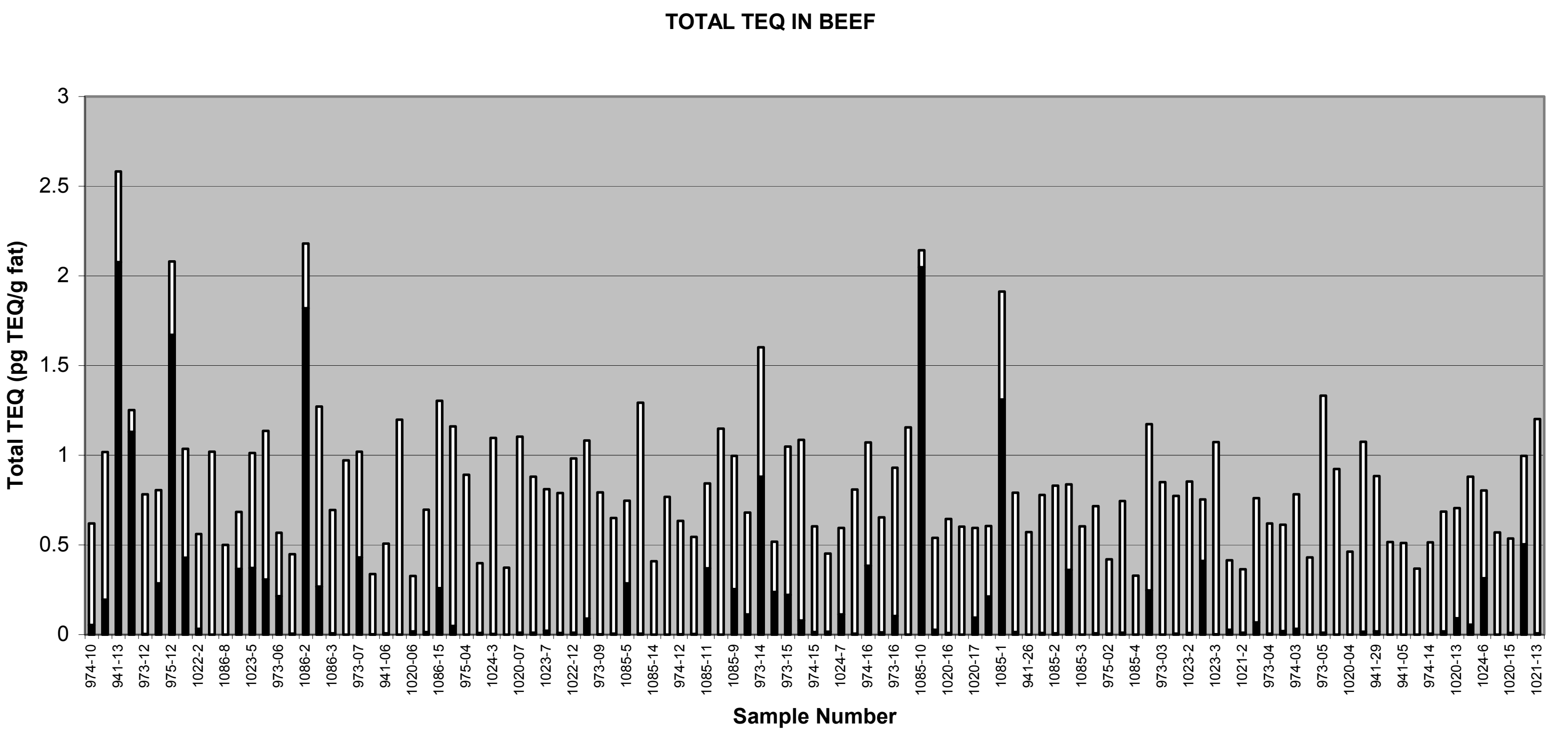
Note: Only every second sample number is labelled due to space limitations. The order of samples corresponds to the order they were entered into the NRS database (see Annex 1).
Black bars represent lowerbound value (i.e., the sum of detected congeners multiplied by the relevant TEF).
White bars represent the sum of LOD contributions (i.e., the sum of the LOD for non-detected congeners multiplied by the relevant TEF).
The black and white bars together represent the upperbound value or maximum possible TEQ in that sample.

Figure 3.1(b): PCBs (TEQ) in beef



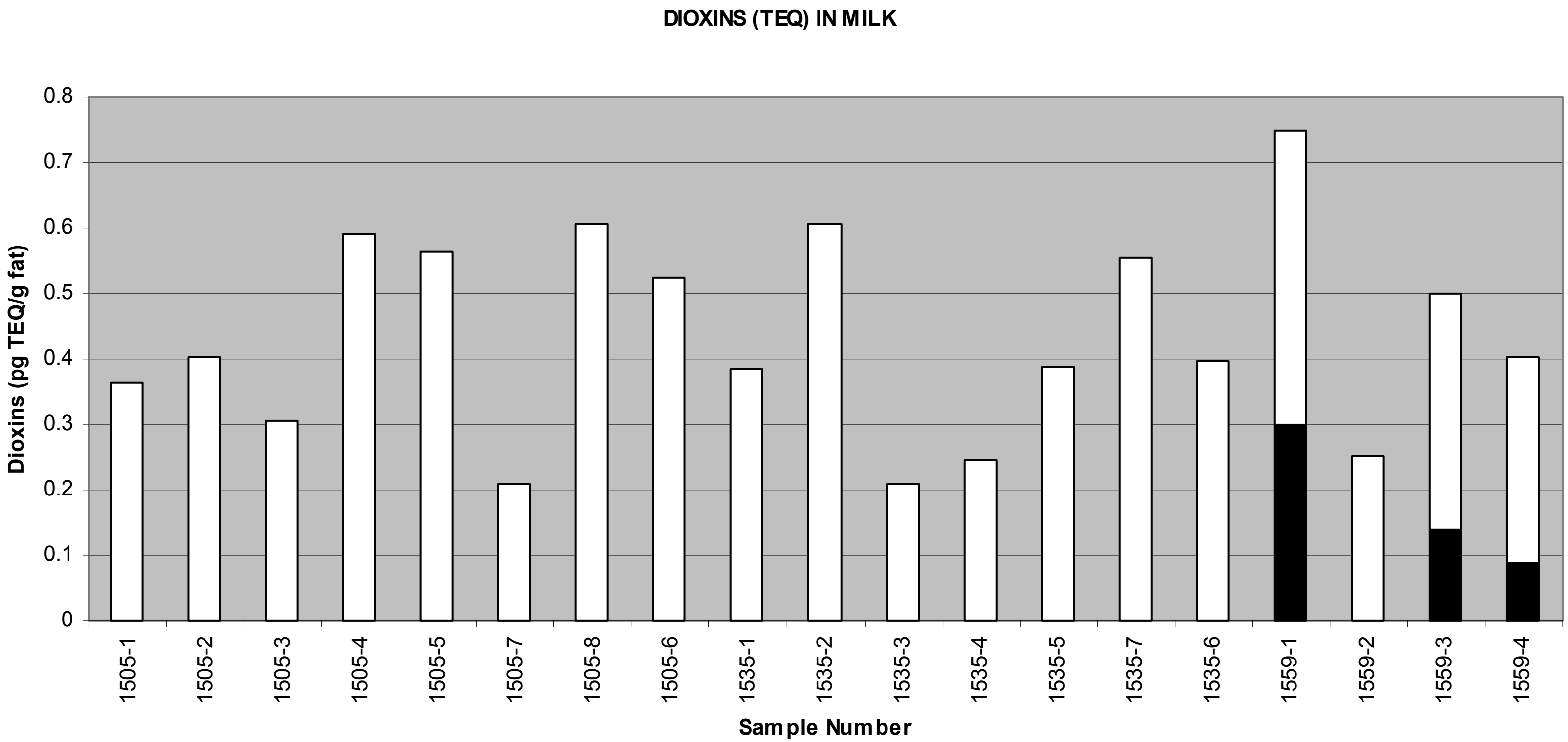
Note: Only every second sample number is labelled due to space limitations. The order of samples corresponds to the order they were entered into the NRS database (see Annex 1).
Black bars represent lowerbound value (i.e., the sum of detected congeners multiplied by the relevant TEF).
White bars represent the sum of LOD contributions (i.e., the sum of the LOD for non-detected congeners multiplied by the relevant TEF).
The black and white bars together represent the upperbound value or maximum possible TEQ in that sample.

Figure 3.1(c): Total TEQ in beef



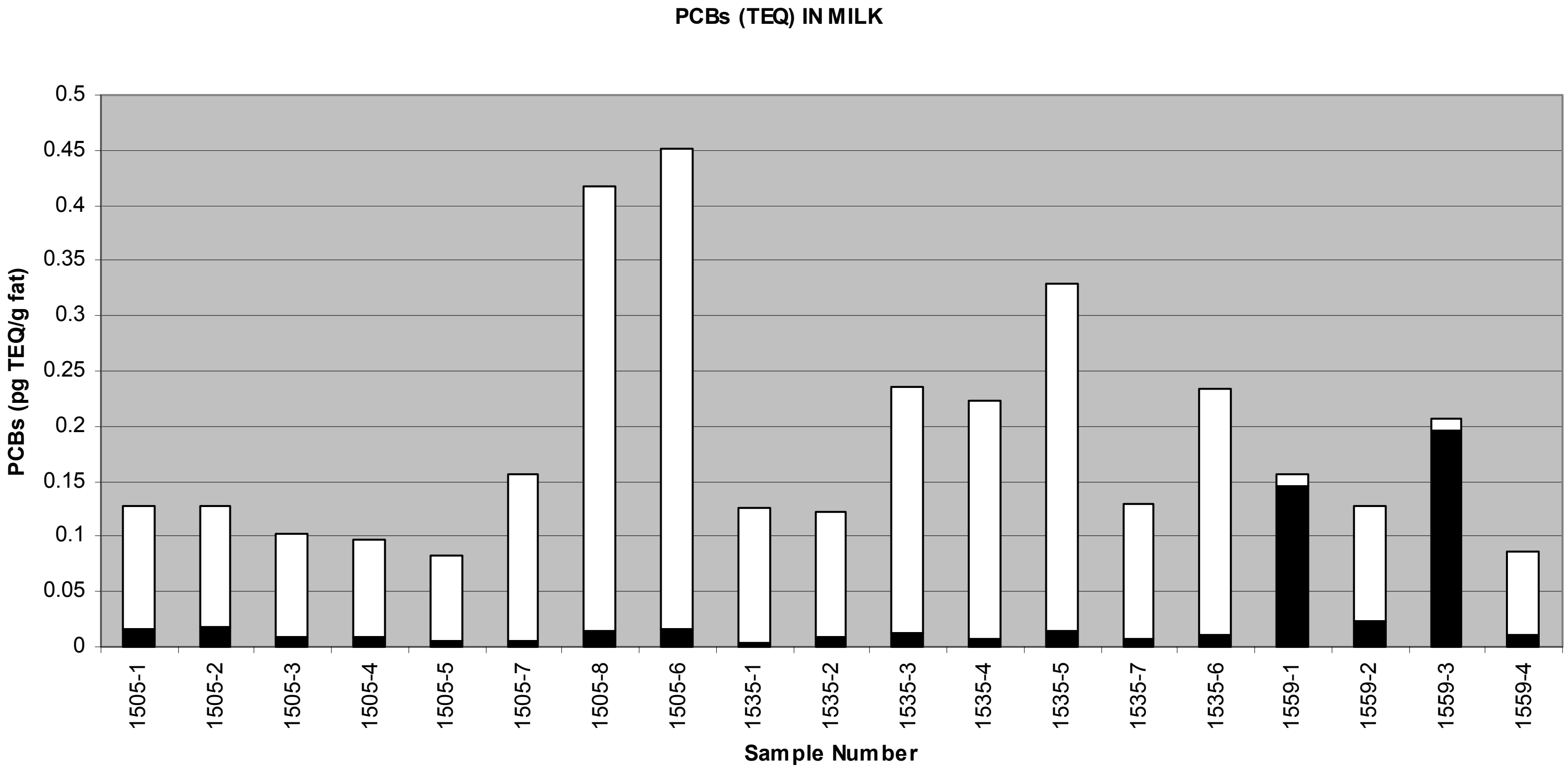
Note: Only every second sample number is labelled due to space limitations. The order of samples corresponds to the order they were entered into the NRS database (see Annex 1).
Black bars represent lowerbound value (i.e., the sum of detected congeners multiplied by the relevant TEF).
White bars represent the sum of LOD contributions (i.e., the sum of the LOD for non-detected congeners multiplied by the relevant TEF).
The black and white bars together represent the upperbound value or maximum possible TEQ in that sample.

Figure 3.2(a): Dioxins (TEQ) in milk



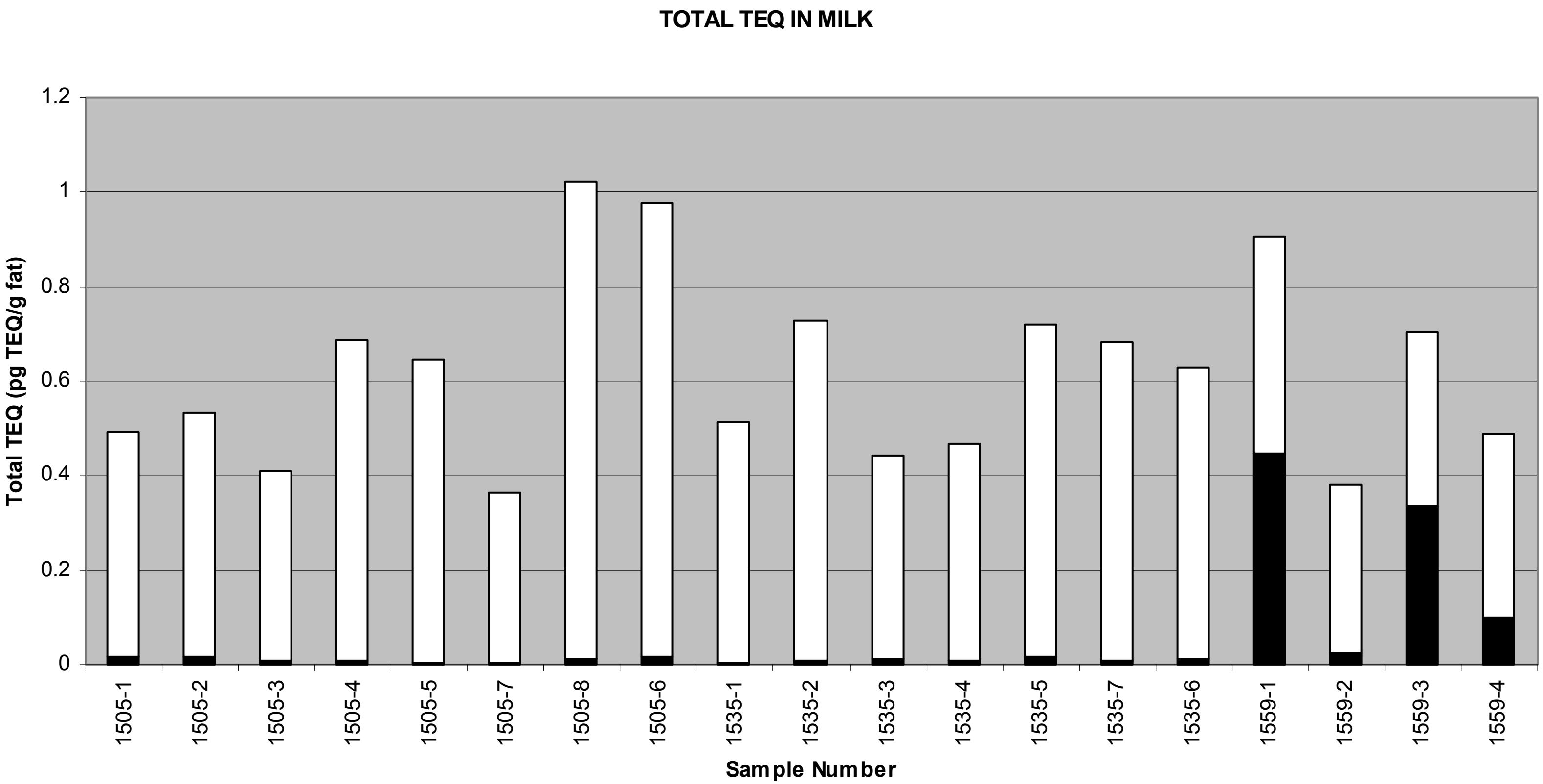
Black bars represent lowerbound value (i.e., the sum of detected congeners multiplied by the relevant TEF).
White bars represent the sum of LOD contributions (i.e., the sum of the LOD for non-detected congeners multiplied by the relevant TEF).
The black and white bars together represent the upperbound value or maximum possible TEQ in that sample.

Figure 3.2(b): PCBs(TEQ) in milk



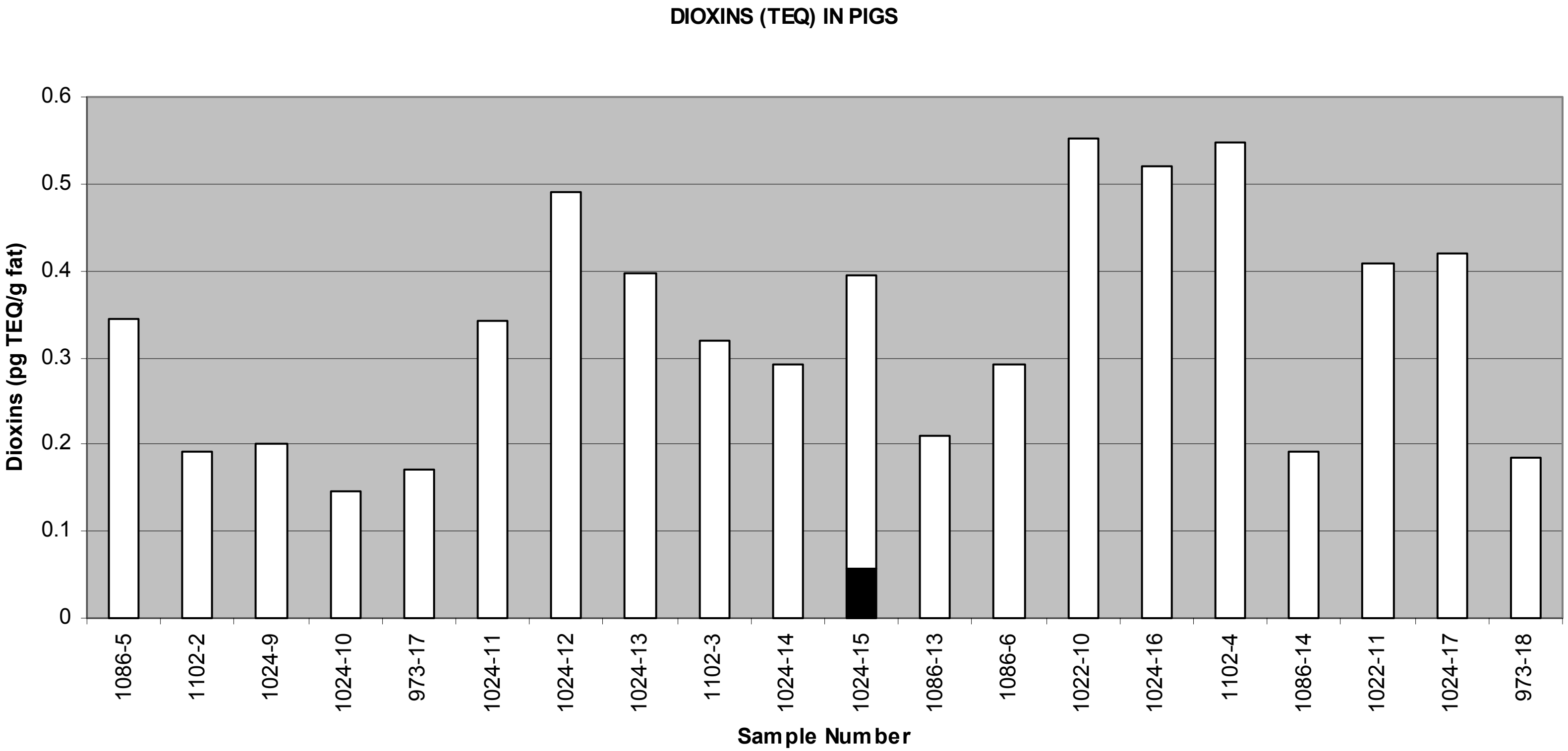
Black bars represent lowerbound value (i.e., the sum of detected congeners multiplied by the relevant TEF).
White bars represent the sum of LOD contributions (i.e., the sum of the LOD for non-detected congeners multiplied by the relevant TEF).
The black and white bars together represent the upperbound value or maximum possible TEQ in that sample.

Figure 3.2(c): Total TEQ in milk



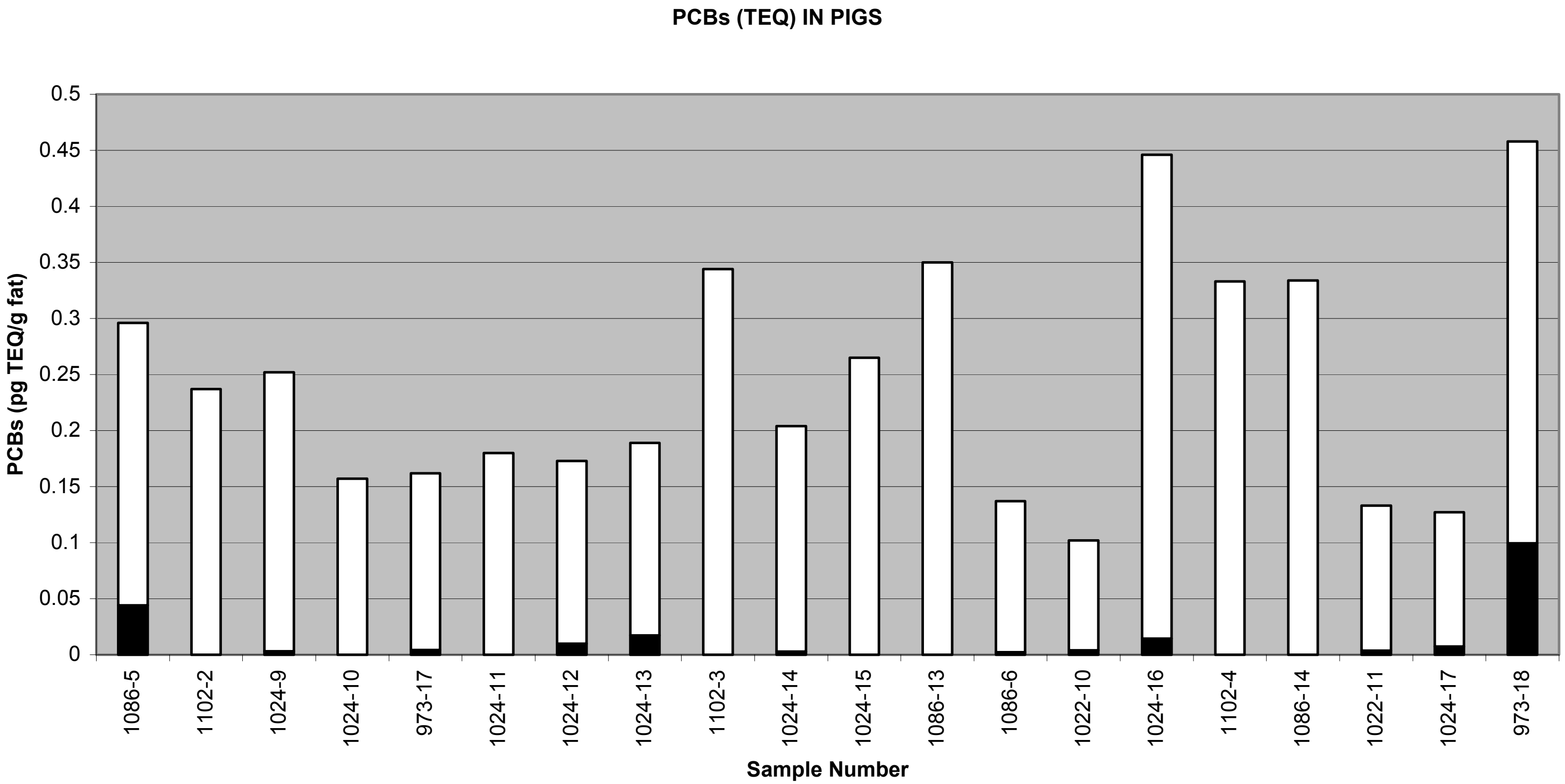
Black bars represent lowerbound value (i.e., the sum of detected congeners multiplied by the relevant TEF).
White bars represent the sum of LOD contributions (i.e., the sum of the LOD for non-detected congeners multiplied by the relevant TEF).
The black and white bars together represent the upperbound value or maximum possible TEQ in that sample.

Figure 3.3(a): Dioxins (TEQ) in pigs



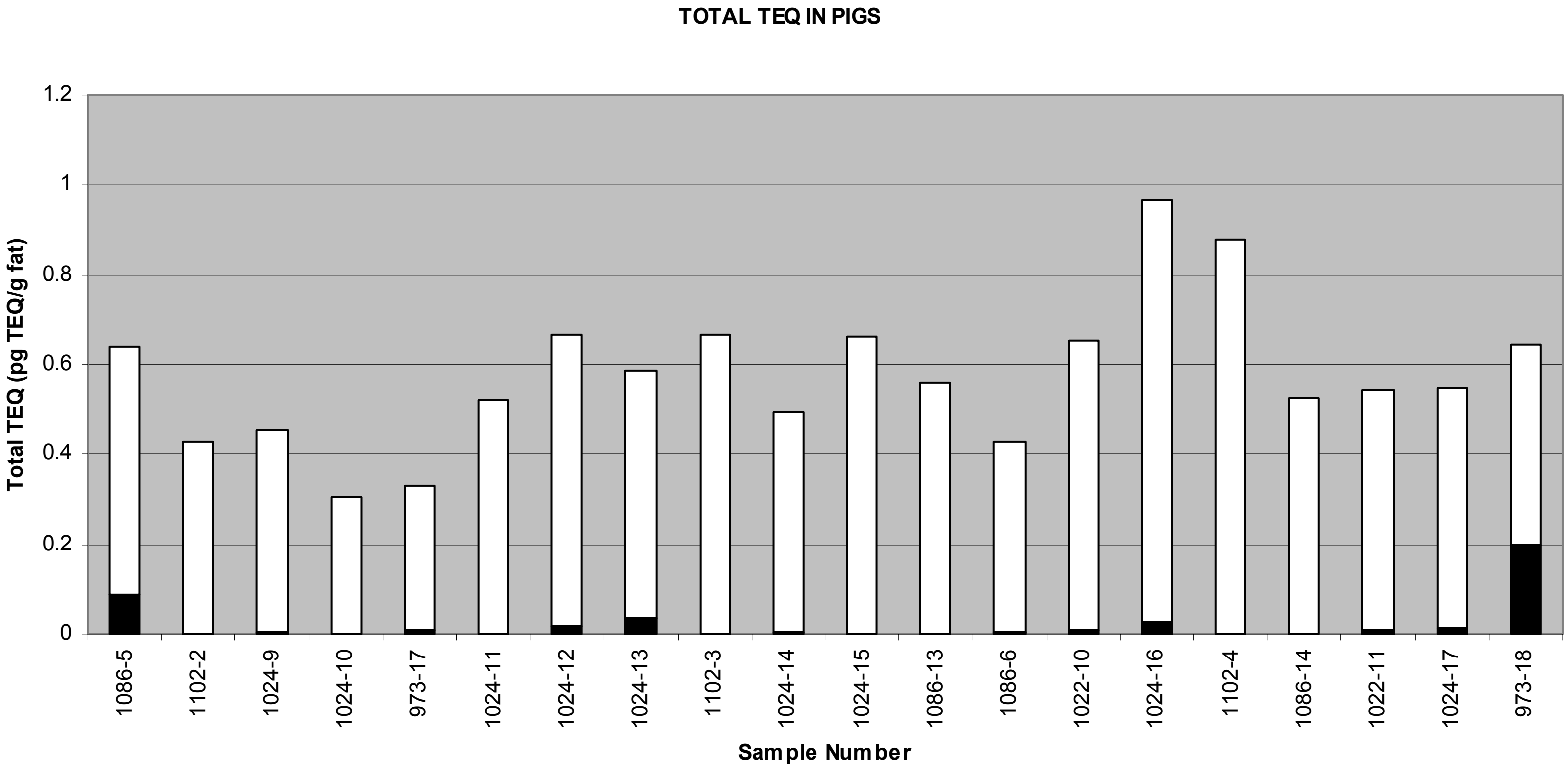
Black bars represent lowerbound value (i.e., the sum of detected congeners multiplied by the relevant TEF).
White bars represent the sum of LOD contributions (i.e., the sum of the LOD for non-detected congeners multiplied by the relevant TEF).
The black and white bars together represent the upperbound value or maximum possible TEQ in that sample.

Figure 3.3(b): PCBs (TEQ) in pigs



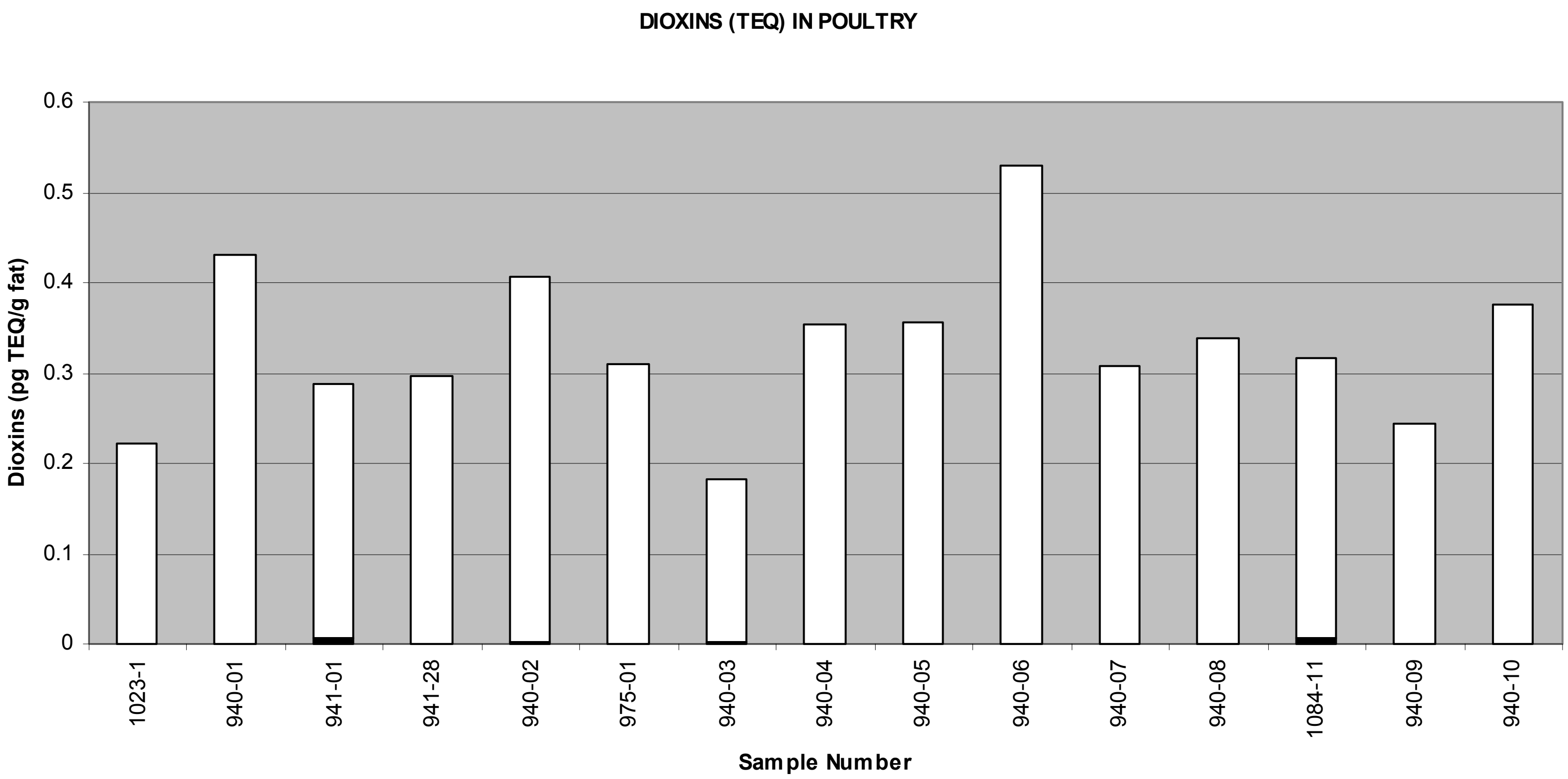
Black bars represent lowerbound value (i.e., the sum of detected congeners multiplied by the relevant TEF).
White bars represent the sum of LOD contributions (i.e., the sum of the LOD for non-detected congeners multiplied by the relevant TEF).
The black and white bars together represent the upperbound value or maximum possible TEQ in that sample.

Figure 3.3(c): Total TEQ in pigs



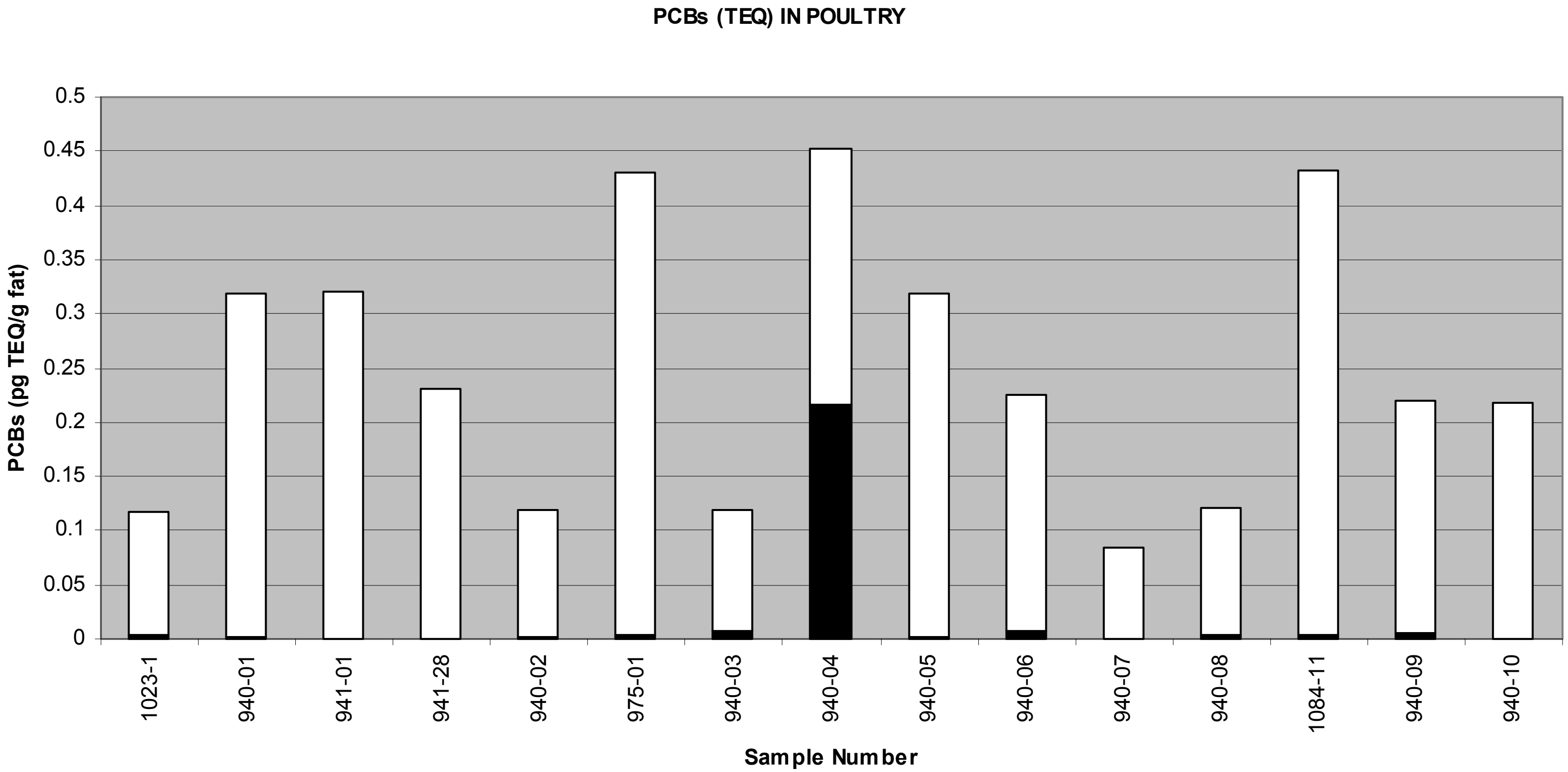
Black bars represent lowerbound value (i.e., the sum of detected congeners multiplied by the relevant TEF).
White bars represent the sum of LOD contributions (i.e., the sum of the LOD for non-detected congeners multiplied by the relevant TEF).
The black and white bars together represent the upperbound value or maximum possible TEQ in that sample.

Figure 3.4(a): Dioxins (TEQ) in poultry



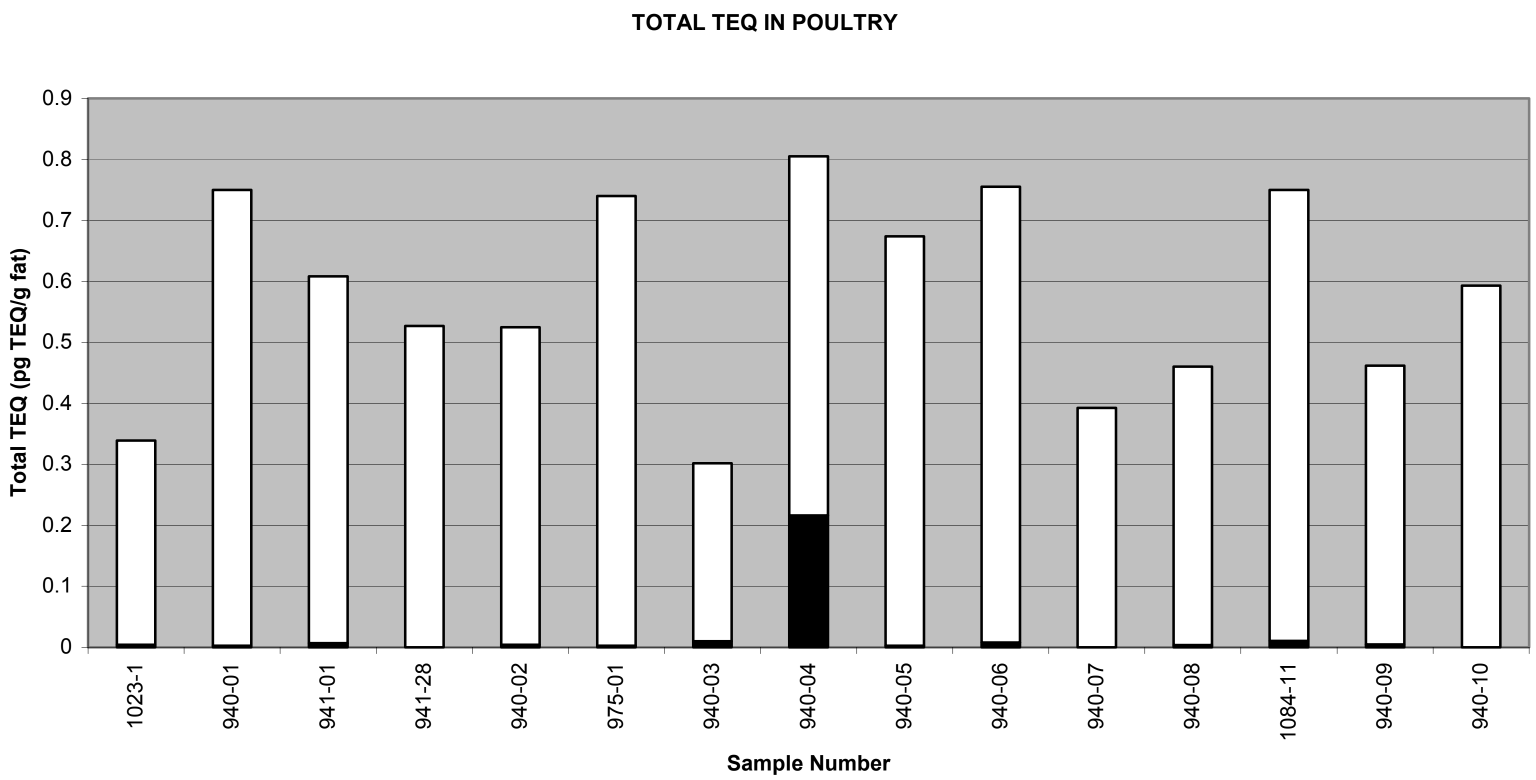
Black bars represent lowerbound value (i.e., the sum of detected congeners multiplied by the relevant TEF).
White bars represent the sum of LOD contributions (i.e., the sum of the LOD for non-detected congeners multiplied by the relevant TEF).
The black and white bars together represent the upperbound value or maximum possible TEQ in that sample

Figure 3.4(b): PCBs (TEQ) in poultry



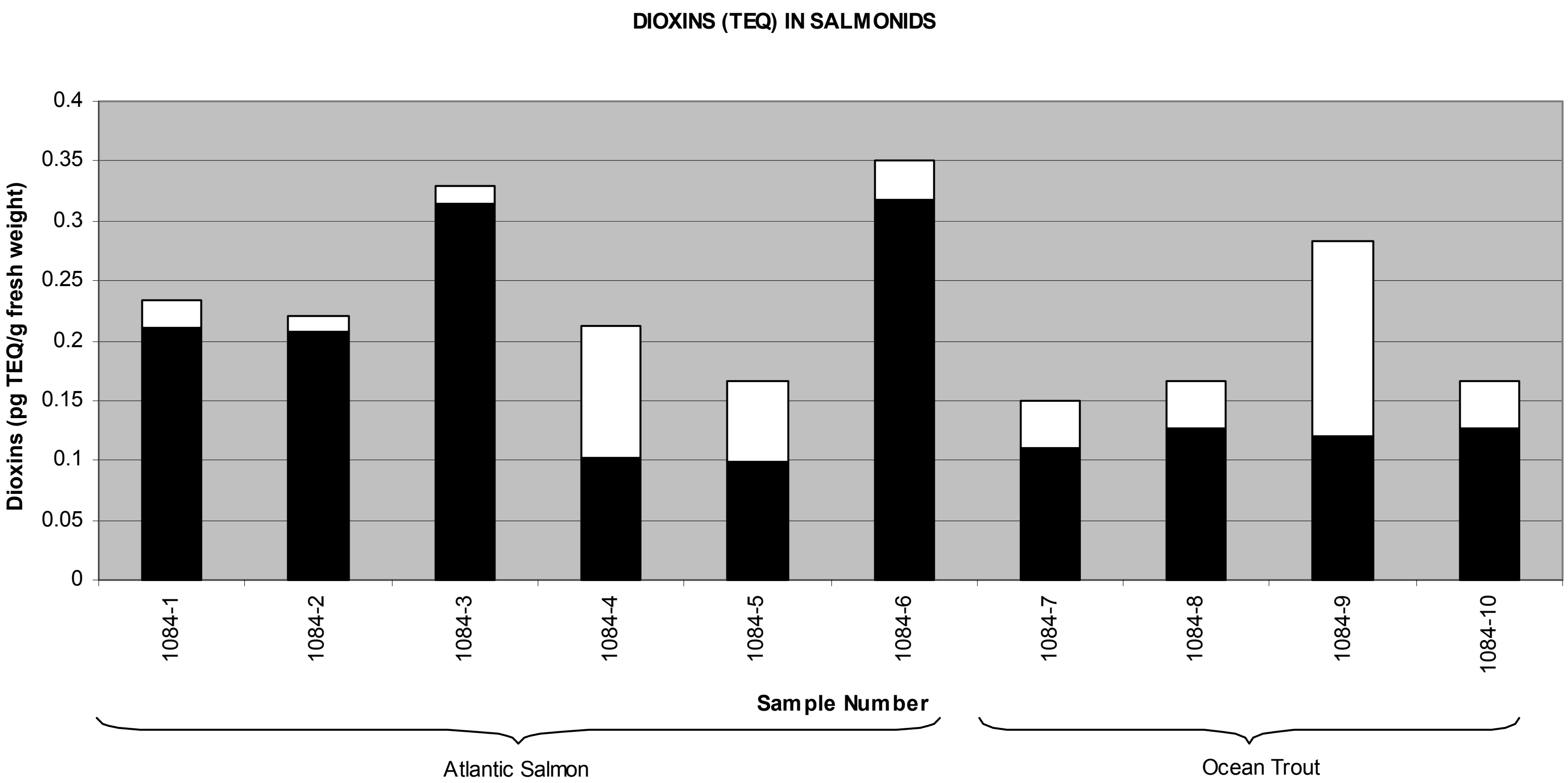
Black bars represent lowerbound value (i.e., the sum of detected congeners multiplied by the relevant TEF).
White bars represent the sum of LOD contributions (i.e., the sum of the LOD for non-detected congeners multiplied by the relevant TEF).
The black and white bars together represent the upperbound value or maximum possible TEQ in that sample

Figure 3.4(c): Total TEQ in poultry



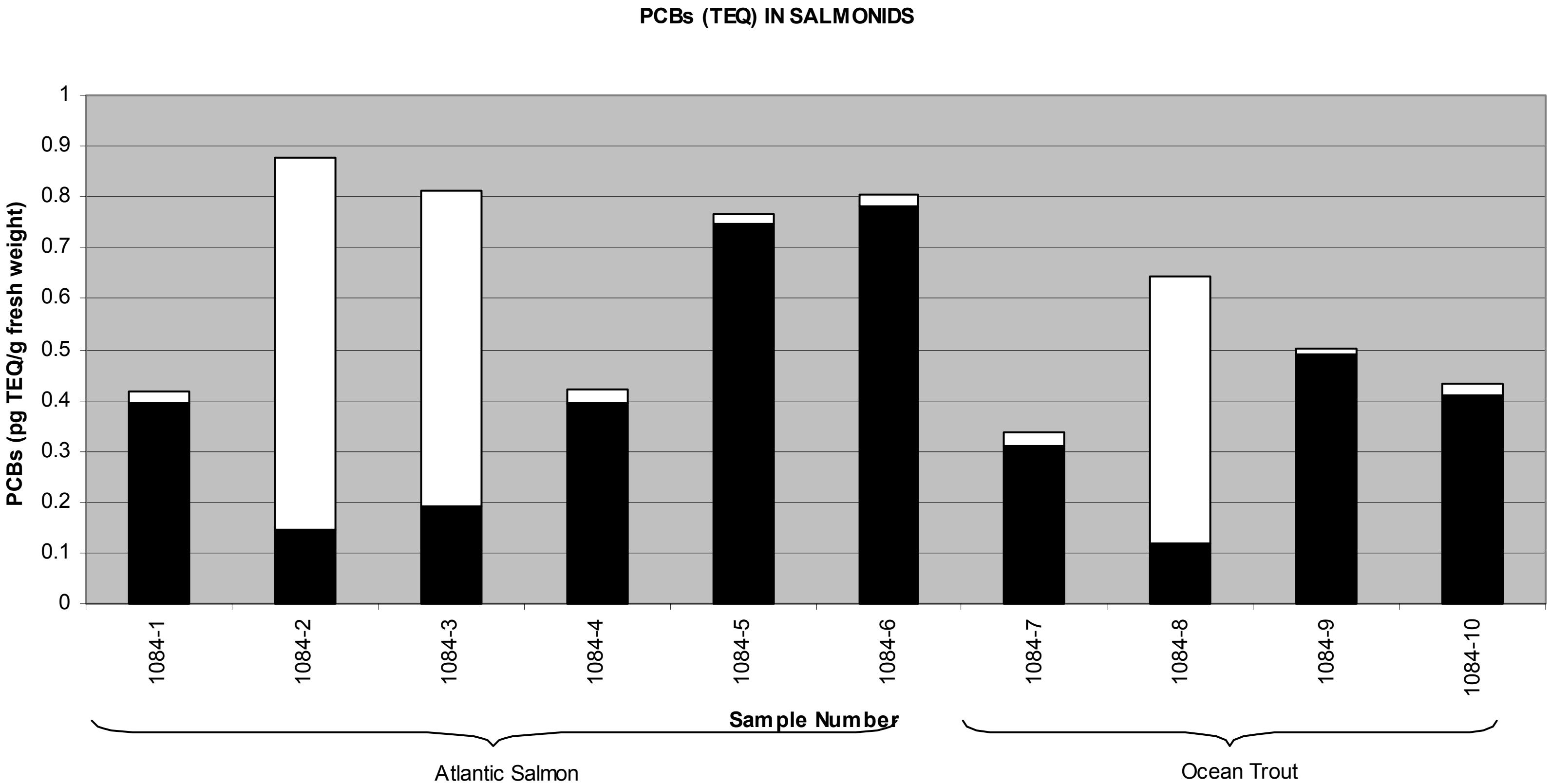
Black bars represent lowerbound value (i.e., the sum of detected congeners multiplied by the relevant TEF).
White bars represent the sum of LOD contributions (i.e., the sum of the LOD for non-detected congeners multiplied by the relevant TEF).
The black and white bars together represent the upperbound value or maximum possible TEQ in that sample

Figure 3.5(a): Dioxins (TEQ) in aquaculture salmonids



Note: Results of fish sample testing are expressed in different unit (i.e., per gram fresh weight rather than per gram fat). This is consistent with international practice.
Black bars represent lowerbound value (i.e., the sum of detected congeners multiplied by the relevant TEF).
White bars represent the sum of LOD contributions (i.e., the sum of the LOD for non-detected congeners multiplied by the relevant TEF).
The black and white bars together represent the upperbound value or maximum possible TEQ in that sample

Figure 3.5(b): PCBs (TEQ) in aquaculture salmonids



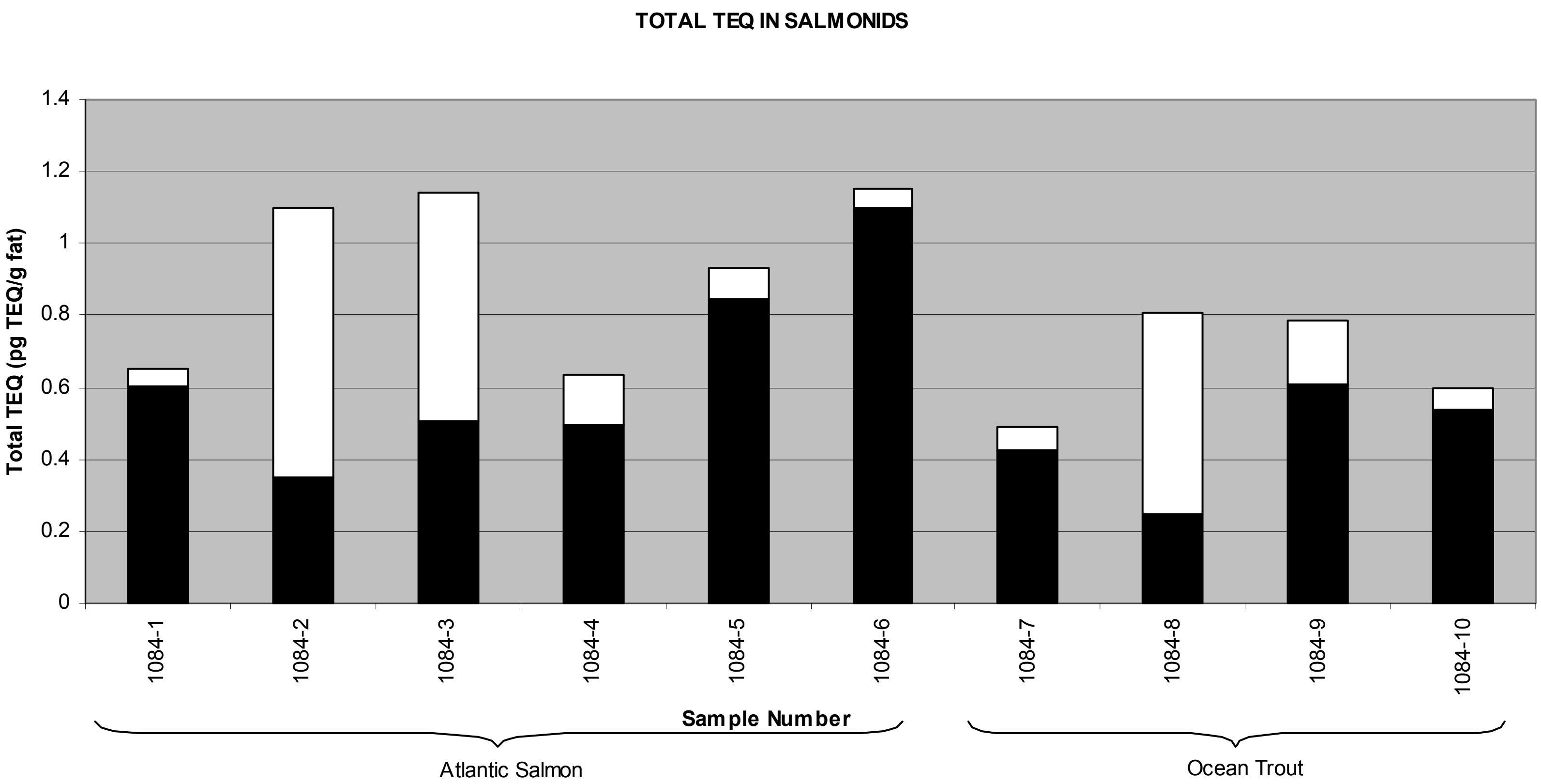
Note: Results of fish sample testing are expressed in different unit (i.e., per gram fresh weight rather than per gram fat). This is consistent with international practice.

Black bars represent lowerbound value (i.e., the sum of detected congeners multiplied by the relevant TEF).

White bars represent the sum of LOD contributions (i.e., the sum of the LOD for non-detected congeners multiplied by the relevant TEF).

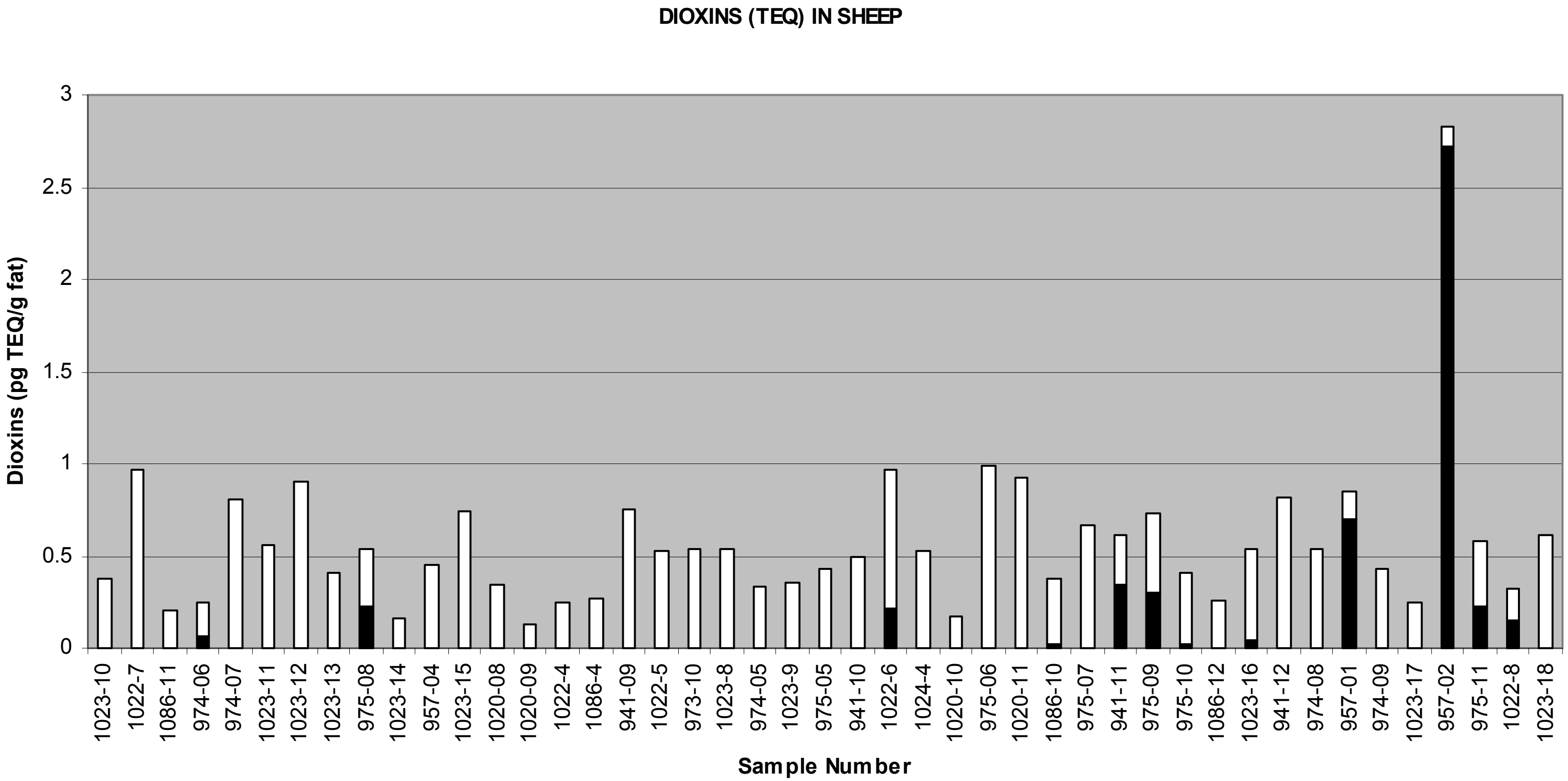
The black and white bars together represent the upperbound value or maximum possible TEQ in that sample

Figure 3.5(c): Total TEQ in aquaculture salmonids



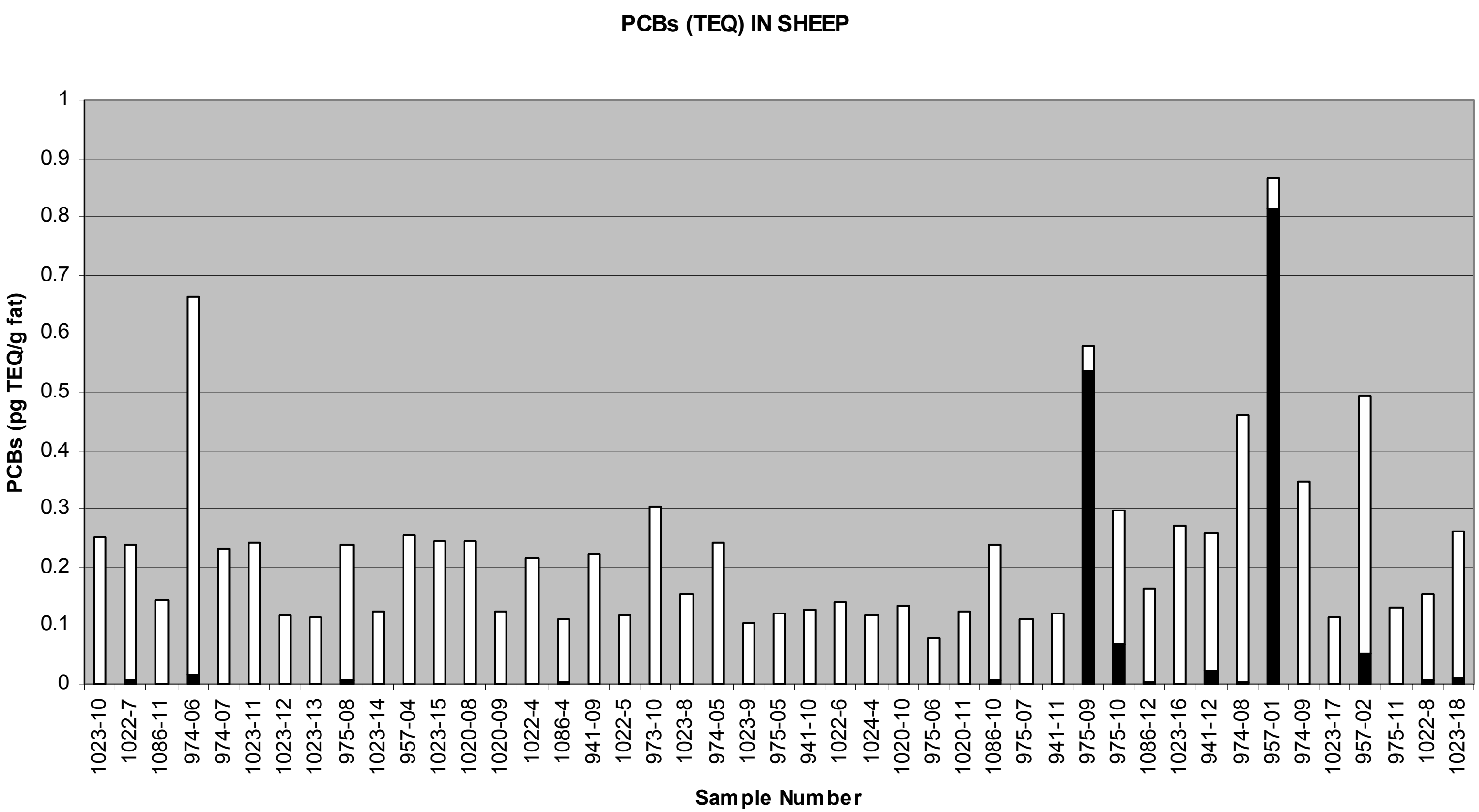
Note: Results of fish sample testing are expressed in different unit (i.e., per gram fresh weight rather than per gram fat). This is consistent with international practice.
Black bars represent lowerbound value (i.e., the sum of detected congeners multiplied by the relevant TEF).
White bars represent the sum of LOD contributions (i.e., the sum of the LOD for non-detected congeners multiplied by the relevant TEF).
The black and white bars together represent the upperbound value or maximum possible TEQ in that sample

Figure 3.6(a): Dioxins (TEQ) in sheep



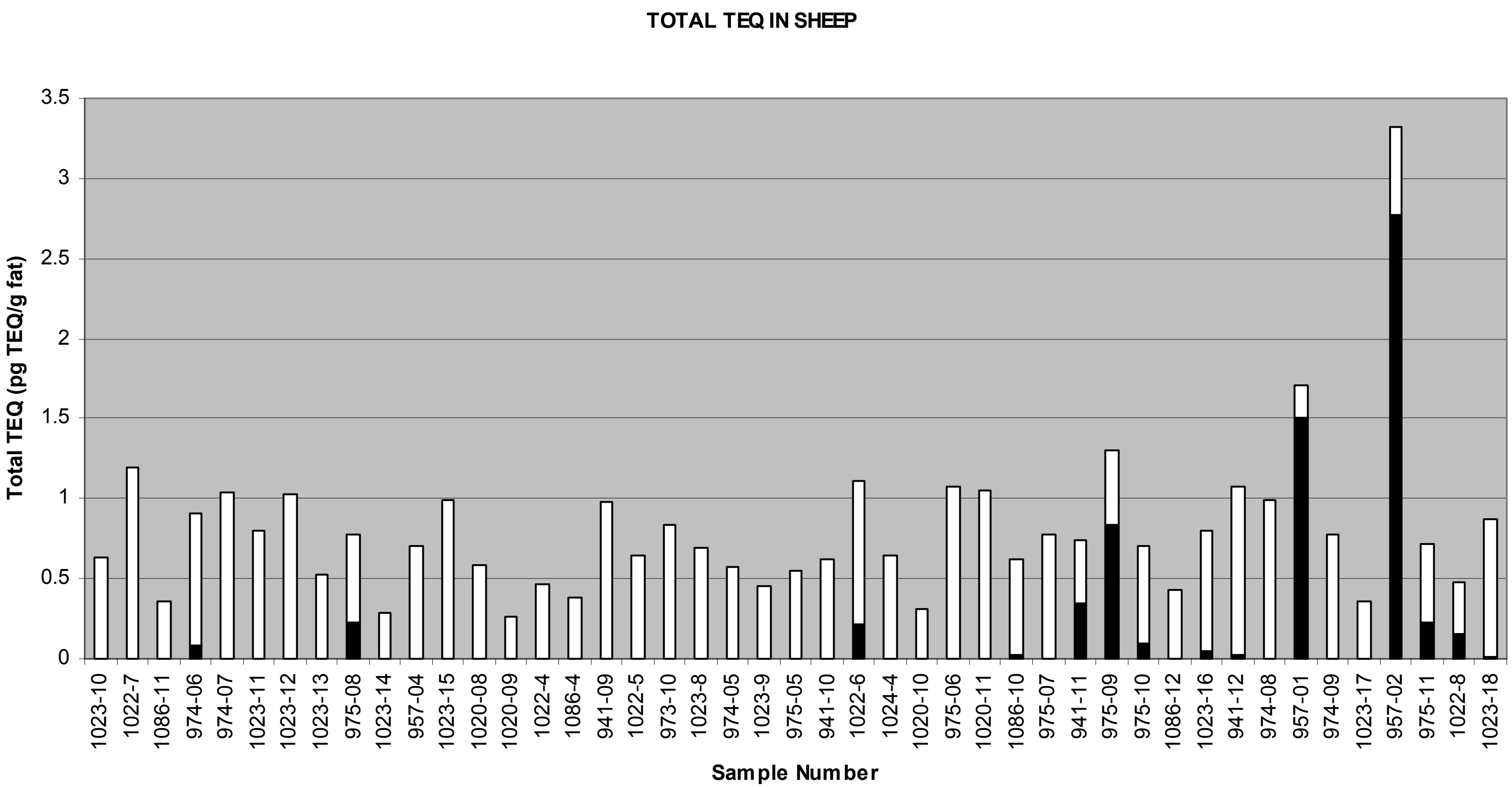
Black bars represent lowerbound value (i.e., the sum of detected congeners multiplied by the relevant TEF).
White bars represent the sum of LOD contributions (i.e., the sum of the LOD for non-detected congeners multiplied by the relevant TEF).
The black and white bars together represent the upperbound value or maximum possible TEQ in that sample

Figure 3.6(b): PCBs (TEQ) in sheep



Black bars represent lowerbound value (i.e., the sum of detected congeners multiplied by the relevant TEF).
White bars represent the sum of LOD contributions (i.e., the sum of the LOD for non-detected congeners multiplied by the relevant TEF).
The black and white bars together represent the upperbound value or maximum possible TEQ in that sample

Figure 3.6(c): Total TEQ in sheep



Black bars represent lowerbound value (i.e., the sum of detected congeners multiplied by the relevant TEF).
White bars represent the sum of LOD contributions (i.e., the sum of the LOD for non-detected congeners multiplied by the relevant TEF).
The black and white bars together represent the upperbound value or maximum possible TEQ in that sample

Appendix 4 Existing Intake Standards

4.1 Australian provisional Tolerable Monthly Intake

In January 2002, the National Health and Medical Research Council (NHMRC), Therapeutic Goods Administration (TGA) and the Department of Health and Ageing (DoHA) released a recommendation for a proposed Tolerable Monthly Intake Standard of 70 pg TEQ/kg bodyweight.

4.2 Overseas intake standards

The World Health Organization (WHO), European Union (EU), Joint FAO/WHO Expert Committee on Food Additives (JECFA) and the Australian NHMRC/TGA/DoHA intake standards are compared in the following table.

Table 4.2: Comparison of intake standards for dioxins/furans and dioxin-like PCBs.

Agency/organisation	**Intake/exposure standard**	**Standards converted to the same units for comparison**
NHMRC/TGA/DoHA (2002)	70 pg/kg bw/**month**	70 pg/kg bw/month
JECFA (2001)	70 pg/kg bw/**month**	70 pg/kg bw/month
EU (2001)	14 pg/kg bw/**week**	60 pg/kg bw/month
WHO (1998)	1-4 pg kg/bw/**day**	30-120 pg/kg bw/month

Appendix 5 Existing Commodity Standards

In the absence of an Australian commodity standard for dioxins and furans, the most relevant existing commodity standards for comparative assessment of Australian data are:

- the EU standard in EU Regulation (EC) No 2375/2001
- the EU action levels in EU Recommendation 2002/201/EC
- the levels in the Korean Sanitary and Phytosanitary notification of 29 January 2001.

5.1 European Union

Table 5.1: EU Standard for dioxins/furans

Species	Maximum pg TEQ/g*	Mean** result from this study (%)	Maximum** result from this study (%)
Beef	3	0.557 (18.6%)	1.77 (59.0%)
Fish (salmonids)	4	0.228 (5.7%)	0.350 (8.75%)
Milk	3	0.434 (14.5%)	0.749 (25.0%)
Pig	1	0.331 (33.1%)	0.551 (55.1%)
Poultry	2	0.330 (16.5%)	0.529 (26.45%)
Sheep	3	0.572 (19.1%)	2.83 (94.3%)

* on a fat basis except for fish which is on a fresh weight basis. Where a congener is not detected, the EU standard assumes the LOD for that congener.
** mean and maximum results are upperbound concentrations expressed as pg TEQ/g. Values in parentheses are expressed as a percentage of the EU standard for that species).

Table 5.2: EU Action levels for dioxins/furans

Species	Maximum pg TEQ/g*	Mean** result from this study (%)	Maximum** result from this study (%)
Beef	2	0.557 (27.9%)	1.77 (88.5%)
Fish (salmonids)	3	0.228 (7.6%)	0.350 (11.7%)
Milk	2	0.434 (21.7%)	0.749 (37.5%)
Pig	0.6	0.331 (55.2%)	0.551 (91.8%)
Poultry	1.5	0.330 (22.0%)	0.529 (35.3%)
Sheep	2	0.572 (28.6%)	2.83 (141.5%)***

* on a fat basis except for fish which is on a fresh weight basis. Where a congener is not detected, the EU action level assumes the LOD.
** mean and maximum results are upperbound concentrations expressed as pg TEQ/g. Values in parentheses are expressed as a percentage of the EU action level for that species).
*** this result exceeds the EU action level.

The definition of application of “action level” in EU Recommendation 2002/201/EC is that Member States in cooperation with operators:

- initiate investigations to identify the source of contamination
- check for the presence of dioxin-like PCBs
- take measures to reduce or eliminate the source of contamination.

5.2 Korea

Table 5.3: Korean temporary maximum levels for dioxins/furans

Species*	Maximum pg TEQ/g**	Mean*** result from this study (%)	Maximum*** result from this study (%)
Beef	5	0.557 (11.1%)	1.77 (35.4%)
Pig	5	0.331 (6.6%)	0.551 (11.0%)
Poultry	5	0.330 (6.6%)	0.529 (10.0%)

* The Korean SPS notification of 29 January 2001 does not set levels for fish, milk, or sheep meat.
** on a fat basis.
*** mean and maximum results are upperbound concentrations expressed as pg TEQ/g. Values in parentheses are expressed as a percentage of the Korean maximum level for that species.

Appendix 6 Commodity comparison

Figures 6.1 compares the mean level of dioxins (including furans) and PCBs in the various non-fish commodities tested in this study. Because of the international convention of testing fish with different units (i.e. per gram fresh weight, not per unit fat), the fish results are presented separately in Figure 6.2, as they are not directly comparable to other data.

Figure 6.1: Commodity comparison (non-fish)

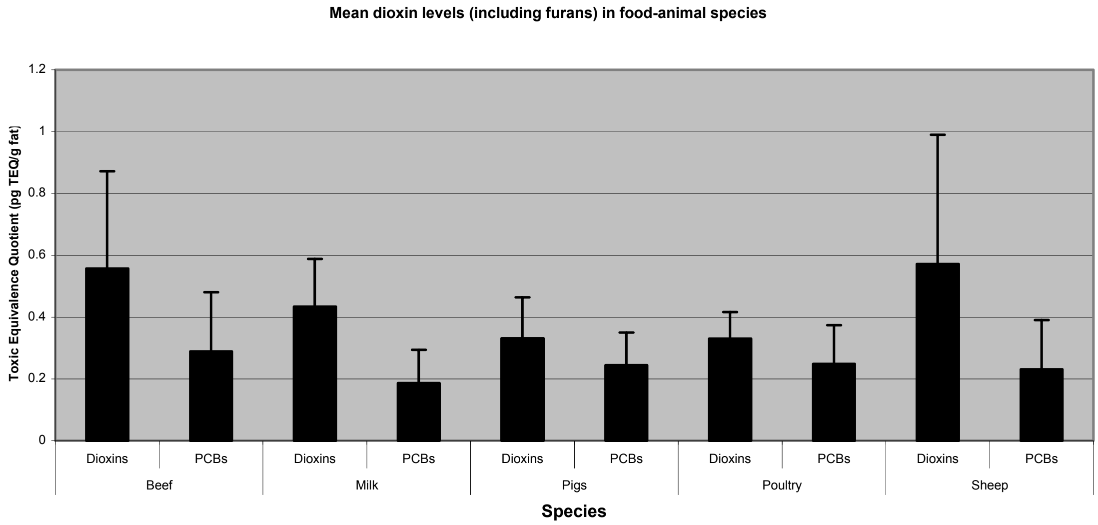
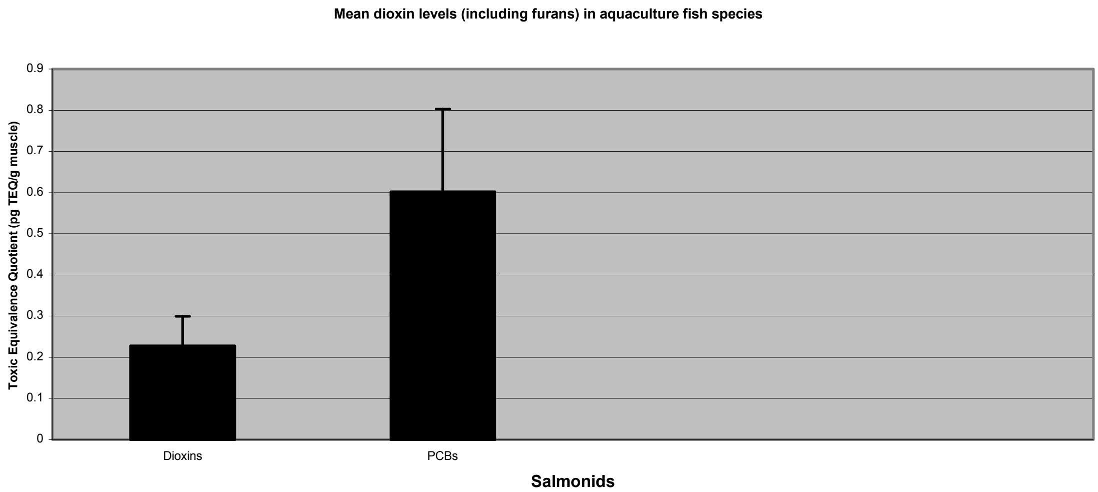


Figure 6.2: Commodity summary results (fish)



Appendix 7 International comparison

Despite the inconsistency of methods and sampling of international dioxin data, the DTG felt it would be useful to compare Australian data to international findings. The DTG requested a comparison between data generated in this study and the dioxin data for geographical regions in the recent Codex Commission on Food Additives and Contaminants (CCFAC) position paper (CX/FAC 03/32, January 2003). It is important to note that these results are not directly comparable and various methods are outlined or referenced in the Codex paper.

Note the testing conducted for the Australian study includes more species (e.g. sheep) and more compounds (i.e. dioxins, PCBs and Total TEQ) than data presented in the CCFAC paper. Therefore, several species/compound comparisons are not possible. Those that are possible are included below. The figures show the countries that provided data for any species, but not all countries provided data for all species. Where no horizontal bar is shown, no data was provided for that country in the paper. Figures 7.1(a), 7.2(a), 7.3(a), 7.4(a) and 7.5(a) are presented as upperbound ranges of dioxins in the various species. Figures 7.6 to 7.8 show the range of PCBs. Figure 7.9 shows the range of total TEQ (dioxins and dioxin-like PCBs). Also included below in Figures 7.1(b), 7.2(b), 7.3(b), 7.4(b) and 7.5(b) are comparisons of Australian dioxins data against other dioxins data from several international studies (extracted from the papers listed in References). These comparisons are presented as dioxin point estimates (means), with the exception of 7.5(b), which shows the range of dioxins.

Figure 7.1(a): Range of dioxins in beef

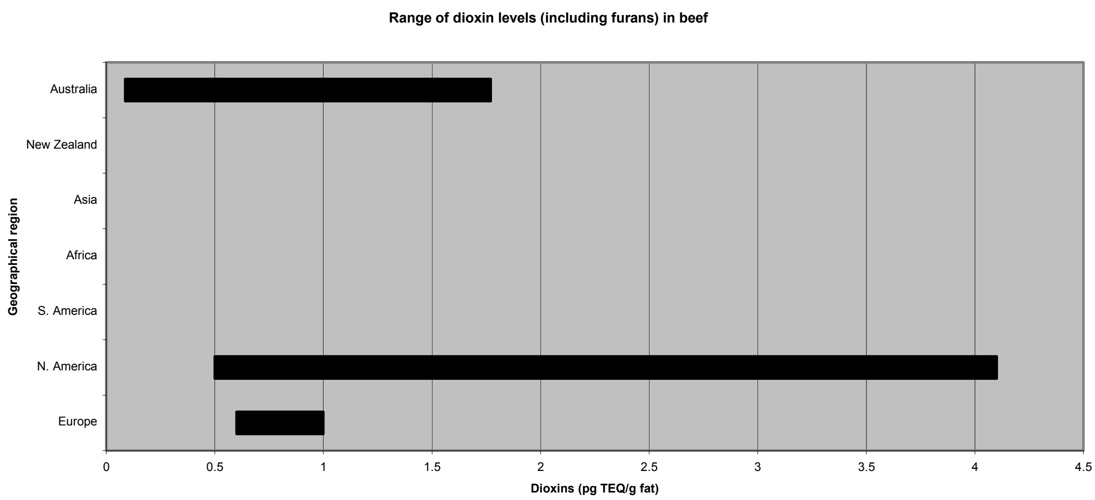


Figure 7.1(b): Upperbound concentrations of dioxins in beef

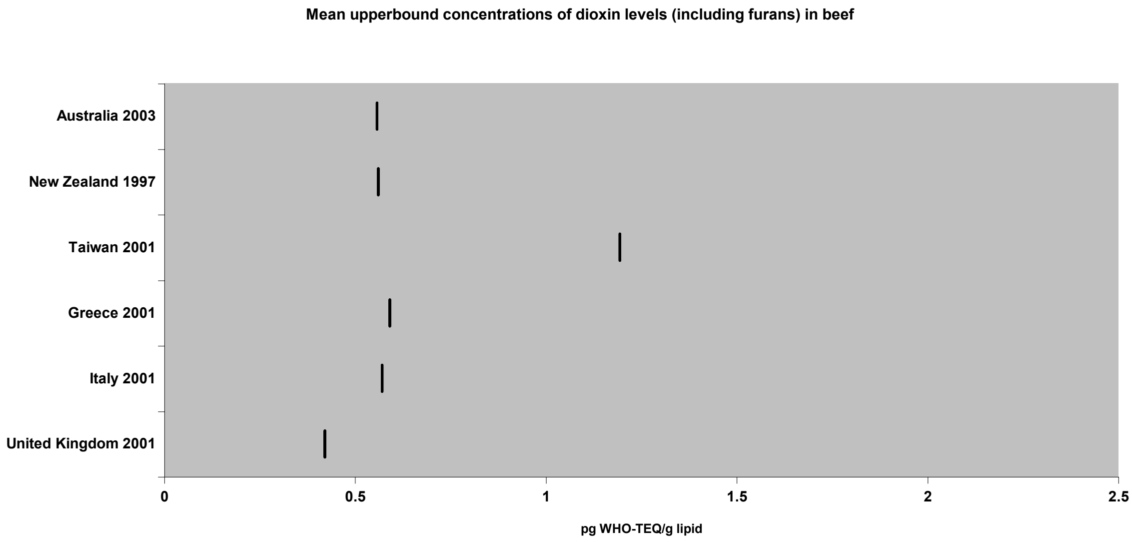
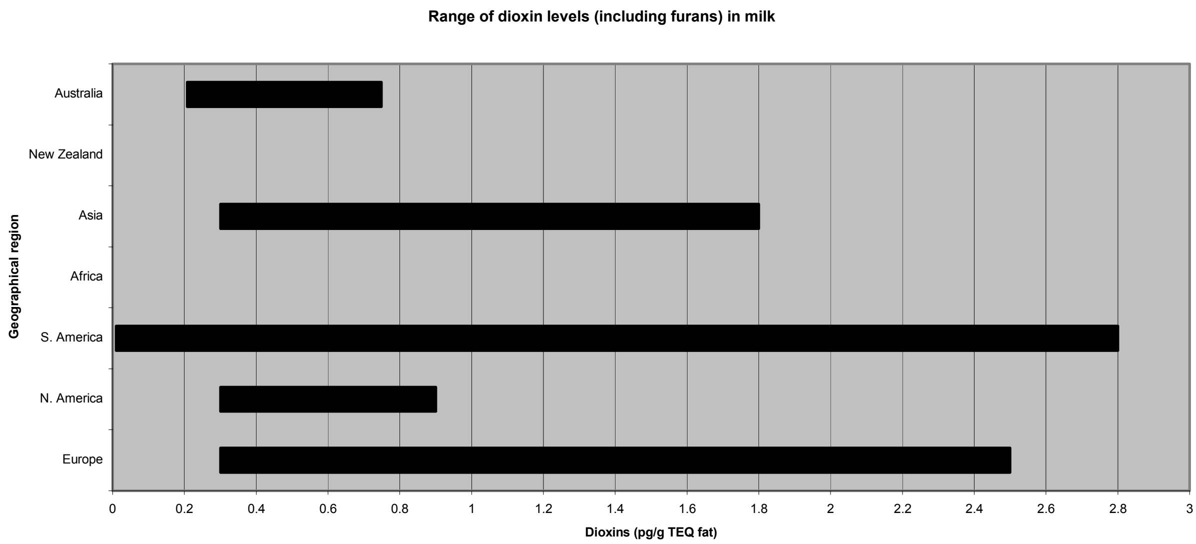


Figure 7.2(a): Range of dioxins in milk



Note: Where no horizontal bar is shown for a country no data was provided for that country in the CCFAC position paper (CX/FAC 03/32, January 2003)

Figure 7.2(b): Upperbound concentrations of dioxins in milk

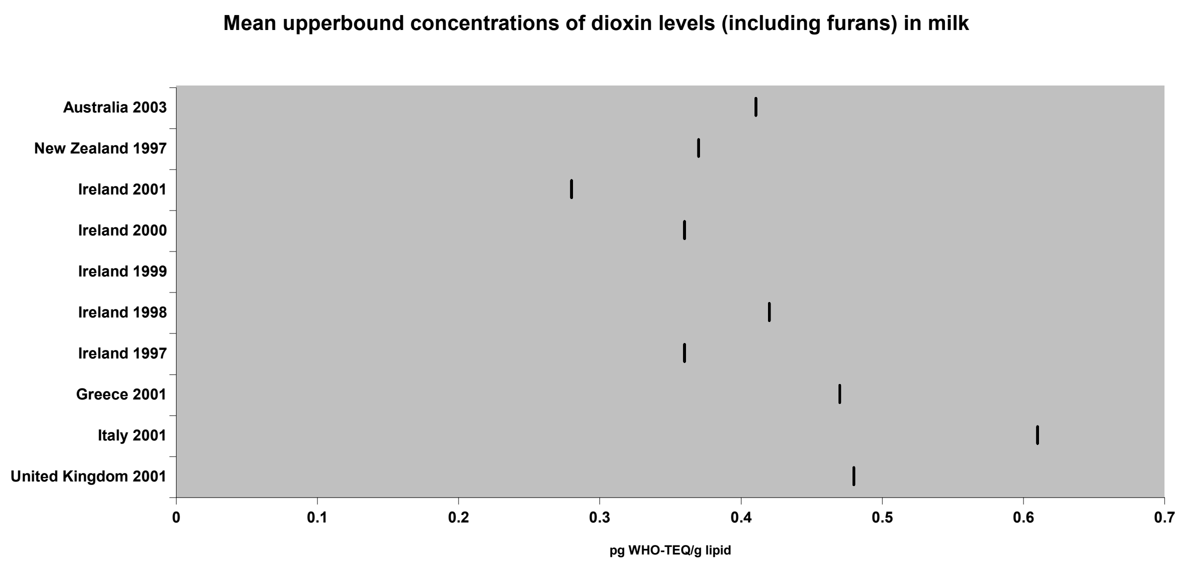


Figure 7.3(a): Range of dioxins in pigs

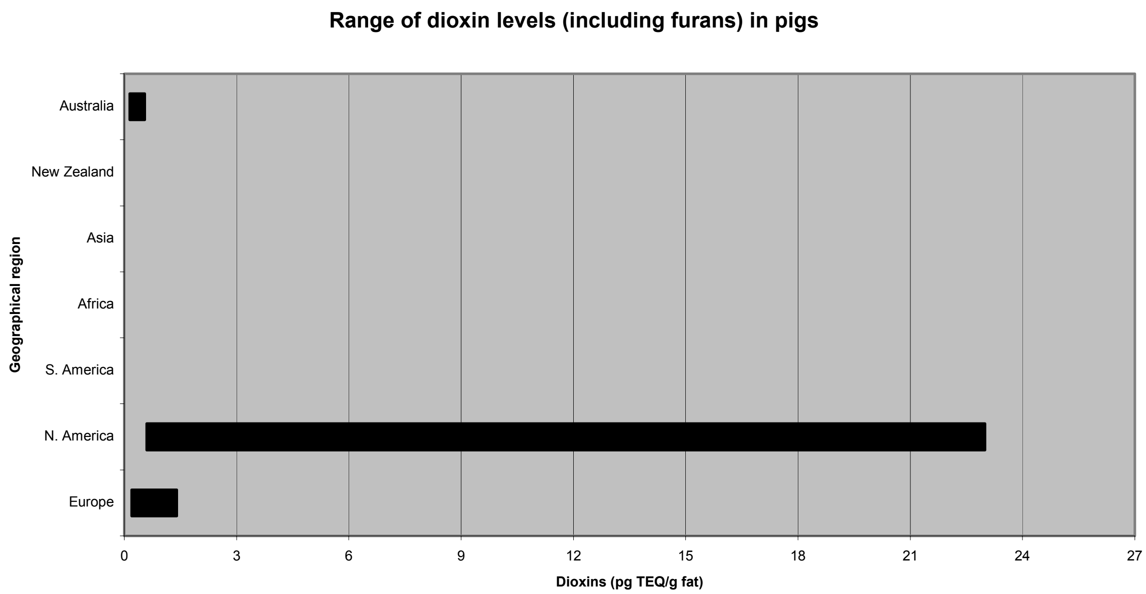


Figure 7.3(b): Upperbound concentrations of dioxins in pork

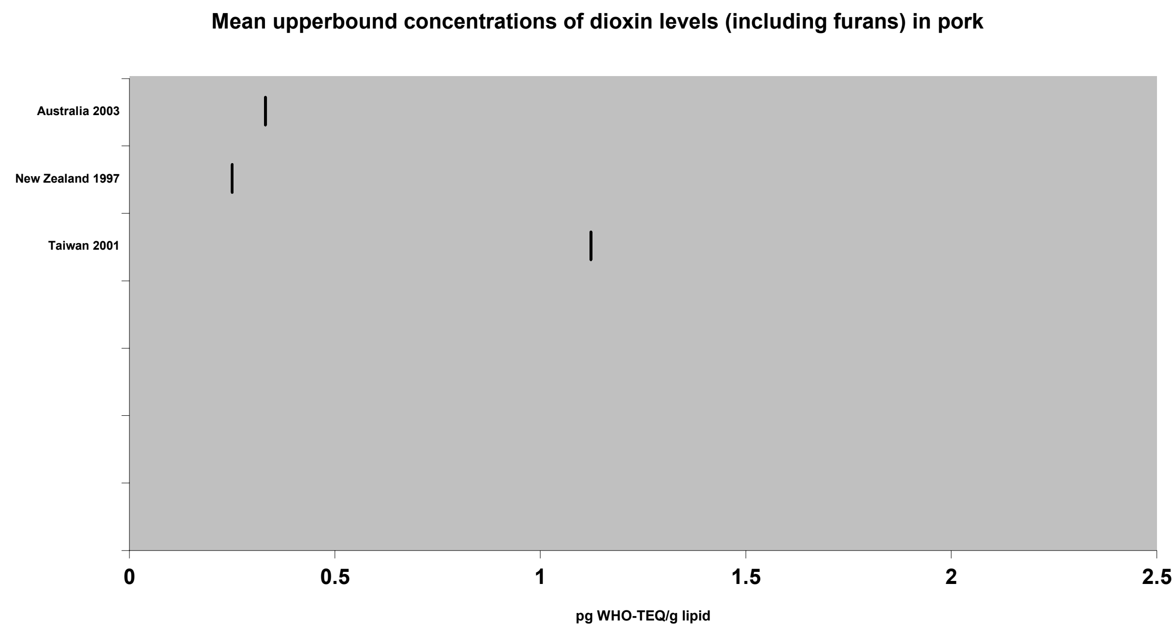


Figure 7.4(a): Range of dioxins in poultry

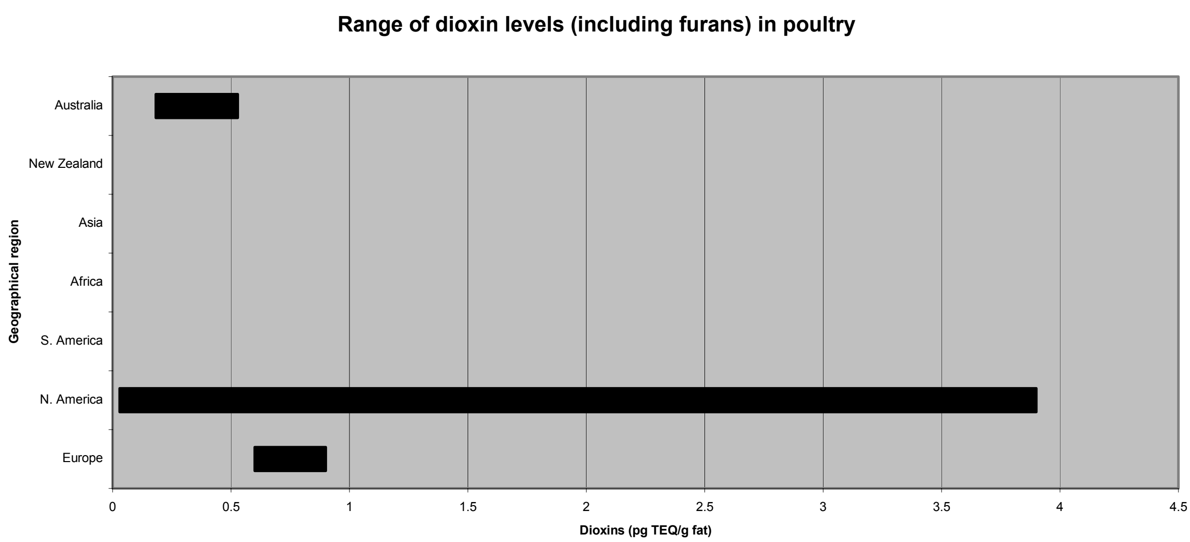


Figure 7.4(b): Upperbound concentrations of dioxins in poultry

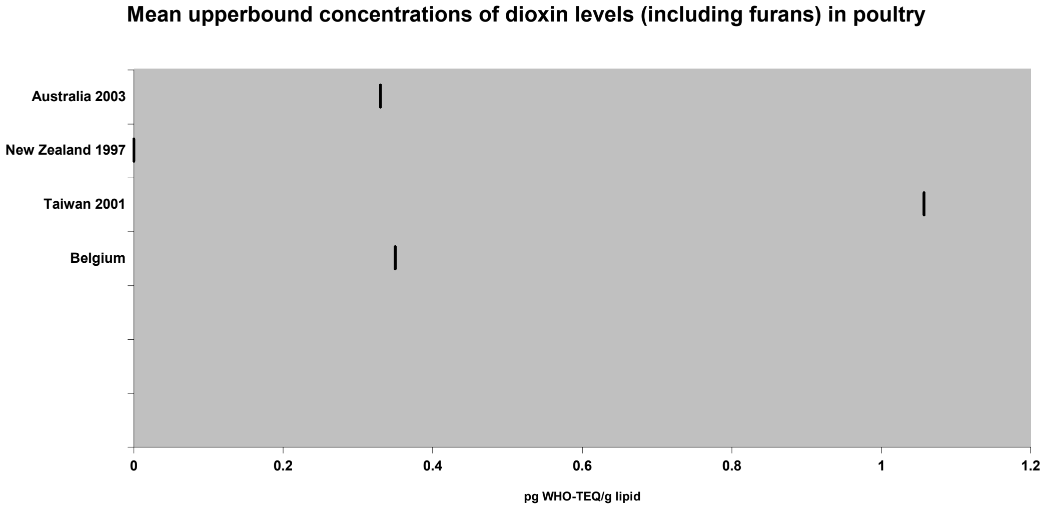


Figure 7.5(a): Range of dioxins in fish

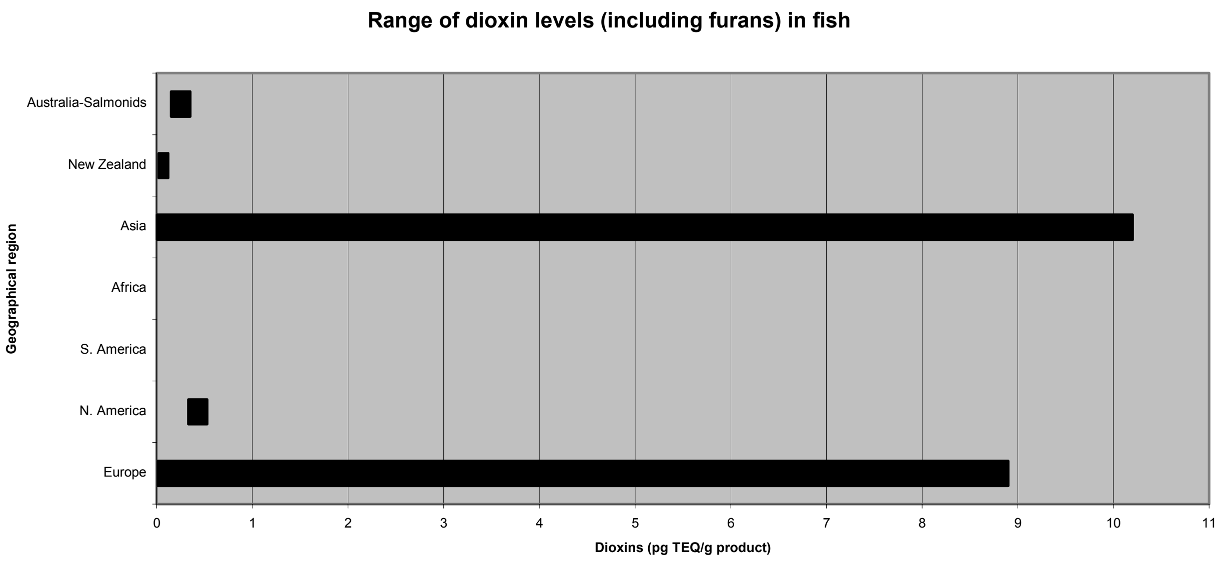


Figure 7.5(b): Range of dioxins in fish

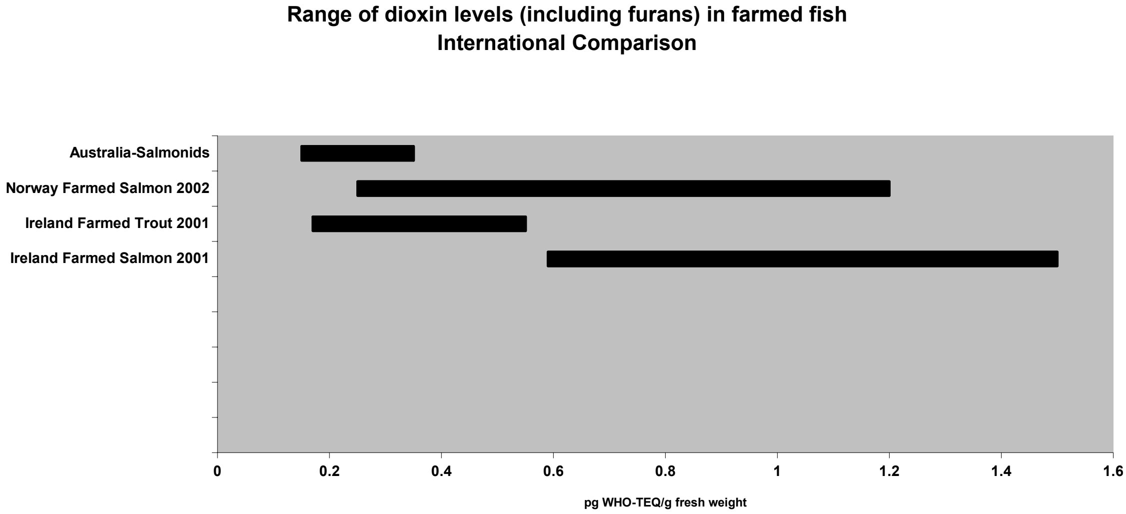


Figure 7.6: Range of PCBs in milk

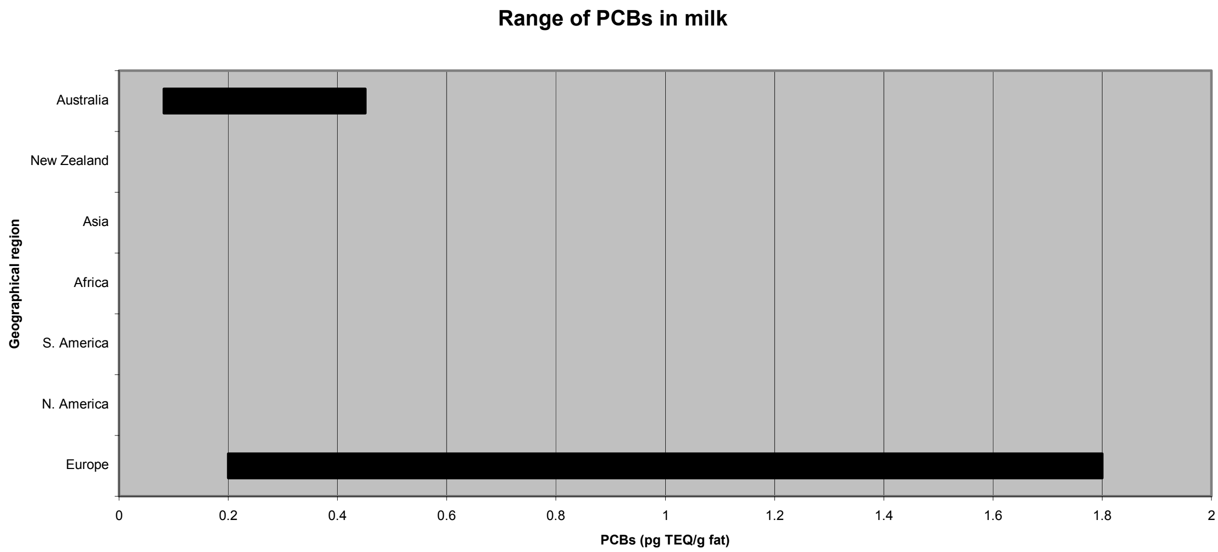


Figure 7.7: Range of PCBs in pigs

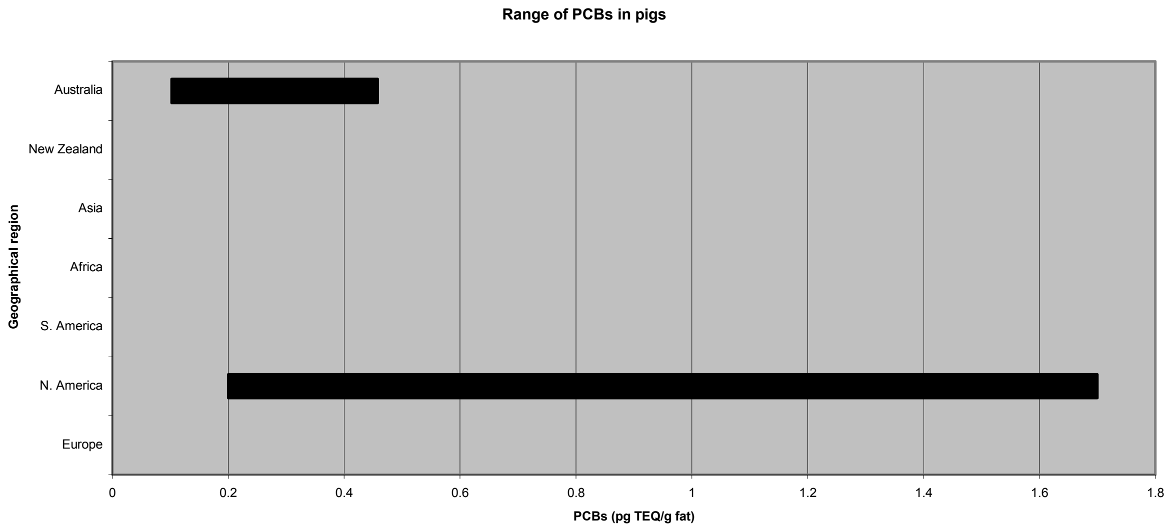
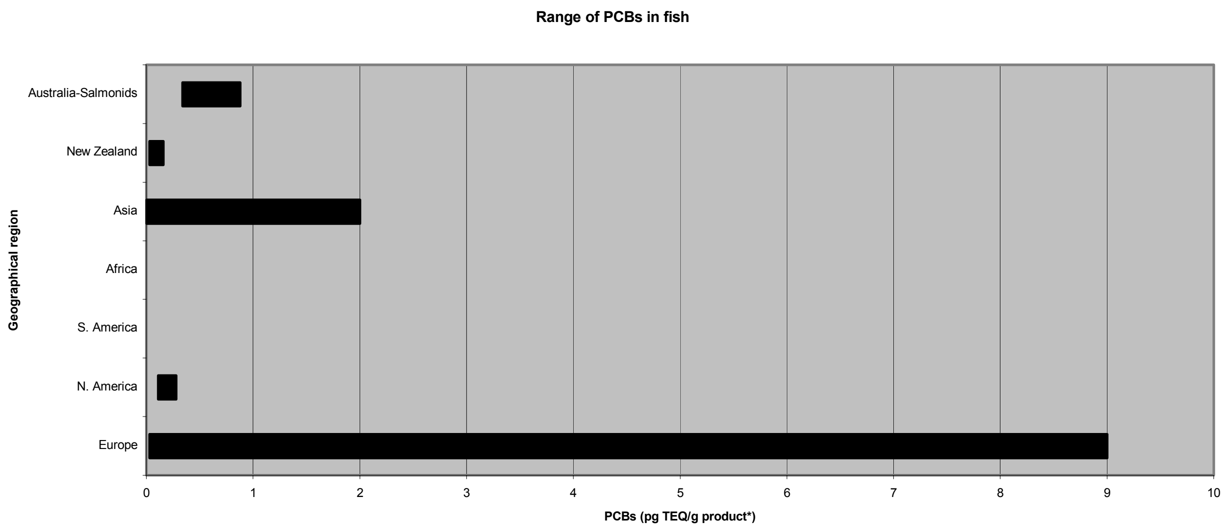
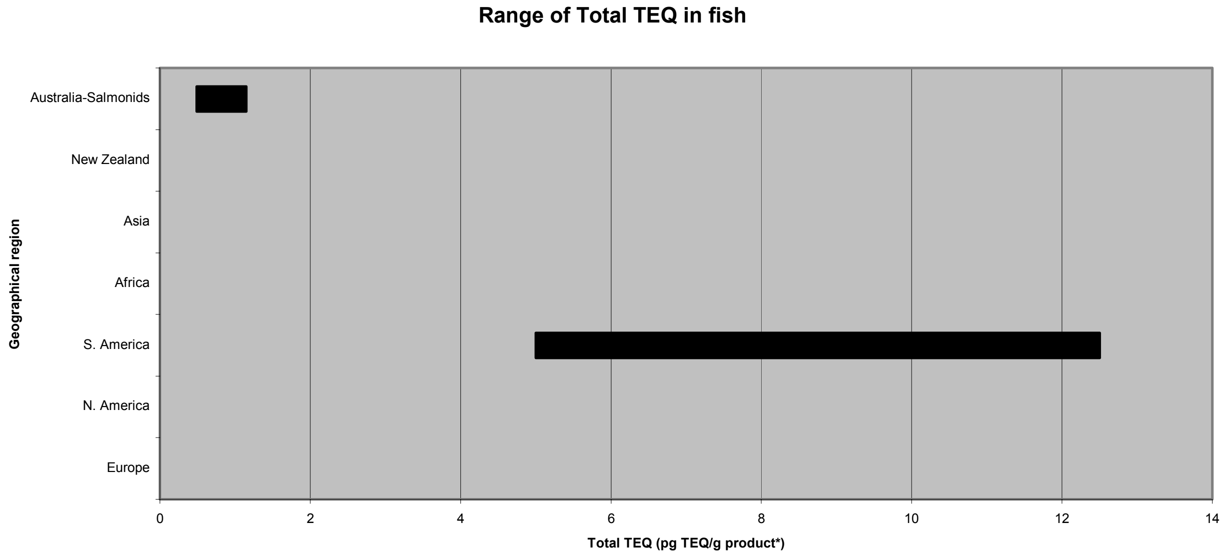


Figure 7.8: Range of PCBs in fish



* on a fresh weight basis

Figure 7.9: Range of Total TEQ in fish



* on a fresh weight basis