Concentrations of PCDDs, PCDFs and PCBs in retail foods and an assessment of dietary intake for New Zealanders

Organochlorines Programme
Ministry for the Environment

November 1998

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Organochlorines in New Zealand:
Concentrations of PCDDs, PCDFs and PCBs in retail foods and an assessment of dietary intake for New Zealanders

Published by
Ministry for the Environment
PO Box 10-362
Wellington

ISBN 0 478 09037 4

September 1998

Printed on elemental chlorine free 50% recycled paper

Foreword

People around the world are concerned about organochlorine contaminants in the environment. Research has established that even the most remote regions of the world are affected by these persistent chemicals.

Organochlorines, as gases or attached to dust, are transported vast distances by air and ocean currents – they have been found even in polar regions. Organochlorines are stored in body fat and accumulate through the food chain. Even a low concentration of emission to the environment can contribute in the long term to significant risks to the health of animals, including birds, marine mammals and humans.

The contaminants of concern include dioxins (by-products of combustion and of some industrial processes), PCBs, and a number of chlorinated pesticides (for example, DDT and dieldrin). These chemicals have not been used in New Zealand for many years. But a number of industrial sites are contaminated, and dioxins continue to be released in small but significant quantities.

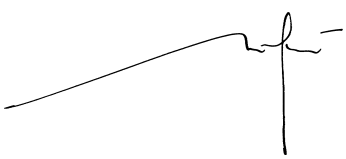
In view of the international concern, the Government decided that we needed better information on the New Zealand situation. The Ministry for the Environment was asked to establish an Organochlorines Programme to carry out research, assess the data, and to consider management issues such as clean up targets and emission control standards. As the contaminants are of high public concern, the Programme established networks for consultation and is keeping the public informed.

The fundamental research carried out under this programme has established for the first time the actual concentrations of these contaminants in the New Zealand environment – country-wide – in air, soil, rivers and estuaries. In addition, the dietary intakes of New Zealanders has been estimated through a study of organochlorine concentrations in food. The existing 'body burdens' of the New Zealand population – the concentrations of organochlorines stored in fatty tissue – are also being assessed.

The publication of these New Zealand research reports marks an important contribution to international knowledge about these toxic chemicals. The comprehensive data contained in these reports is made all the more significant because of the scarcity of other data from the southern hemisphere.

The work has been peer reviewed internationally by experts and we are assured it is of the highest quality. We acknowledge the important contribution made by all those involved in the project within government and the private sector, from within New Zealand and abroad.

Finally, these reports lay a solid foundation in science for the development of policy. What message can we take from these results about the state our environment? Internationally, it appears that New Zealand could be categorised as being 'moderately clean'. While providing some comfort, this leaves no room for complacency. This research will assist the Government in preparing national environmental standards and guidelines for these contaminants to safeguard the health of New Zealanders and the quality of our environment.



Simon Upton
MINISTER FOR THE ENVIRONMENT

Executive summary

This report presents the findings of one component of the Organochlorines Programme of the Ministry for the Environment. The concentrations of polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and polychlorinated biphenyls (PCBs) have been measured in foods available to New Zealand consumers, and the dietary intake of these contaminants by New Zealanders has been estimated.

Fifty three foods, including meat, dairy, poultry, fish and cereal produce, were purchased in April 1997 at retail outlets in Auckland, Christchurch, Dunedin, Napier and Wellington, and made into 19 food type composites. Three further composites of the fat trimmed from beef, sheep and pork carcass meats were also made. All composites were analysed to determine the concentrations of PCDDs, PCDFs and PCBs.

The results of these analyses show that people in New Zealand are exposed to far lower levels of these contaminants in their food than any other country where a similar survey has been undertaken. PCDD, PCDF and PCB levels in all the food samples analysed were lower than their international counterparts, and in many cases at or below the limits of detection (LOD) for most congeners.

Concentrations of PCDDs and PCDFs in foods ranged from: 0.072 - 0.57 ng I-TEQ/kg fat for meats and meat products; 0.056 - 0.26 ng I-TEQ/kg fat for dairy products; 0.41 - 1.82 ng I-TEQ/kg fat for fish; 0.12 and 0.29 ng I-TEQ/kg fat for eggs and poultry respectively; 0.19 - 0.66 ng I-TEQ/kg fat for cereal products and bread respectively; and 0.041 - 0.42 ng I-TEQ/kg fat for a range of other miscellaneous foods. These levels include half LOD values for non-quantified congeners. Exclusion of LOD values in the calculation of total I-TEQ gave far lower levels, because many congeners were at or below the limits of detection.

Twenty three PCB congeners, including the non-*ortho* PCBs (#77, #126 and #169) were determined. Levels in foods were in the range: 0.045 - 0.43 ng TEQ/kg fat for meats and meat products; 0.10 - 0.15 ng TEQ/kg fat for dairy products; 0.77 - 2.42 ng TEQ/kg fat for fish; 0.11 - 0.14 ng TEQ/kg fat for eggs and poultry respectively; 0.051 - 0.45 ng TEQ/kg fat for cereal products and bread respectively; and 0.016 - 0.066 ng TEQ/kg fat for other miscellaneous foods. These levels include half LOD values for non-quantified congeners.

An average dietary exposure to these contaminants was estimated from the diet of adult males with a median energy (50^{th} centile) consumption of 10.8 MJ/day, and a high-end exposure was estimated from the diet of adolescent males with a high energy (90^{th} centile) consumption of 21.5 MJ/day. Exposure estimates were made both including half LOD values and excluding LOD values.

Dietary intakes estimated for an 80 kg adult male consuming a median energy (10.8 MJ/day) diet, were, for PCDDs and PCDFs, including half LODs, 14.5 pg I-TEQ/day (0.18 pg I-TEQ/kg bw/day) and, excluding LODs, 3.72 pg I-TEQ/day (0.047 pg I-TEQ/kg bw/day). For PCBs intakes were estimated for both the sum of PCBs and for PCB TEQ. For the sum of PCBs, dietary intakes including half LODs were 124 ng/day (1.55 ng/kg bw/day) and excluding LODs were 120 ng/day

(1.50 ng/kg bw/day). For PCB TEQ, dietary intakes including half LODs were 12.2 pg TEQ/day (0.15 pg TEQ/kg bw/day) and excluding LODs were 7.83 pg TEQ/day (0.098 pg TEQ/kg bw/day).

Dietary intakes estimated for a 70 kg adolescent male consuming a high energy (21.5 MJ/day) diet, were, for PCDDs and PCDFs, including half LODs, 30.6 pg I-TEQ/day (0.44 pg I-TEQ/kg bw/day) and, excluding LODs, 9.82 pg I-TEQ/day (0.14 pg I-TEQ/kg bw/day). For PCBs intakes were estimated for both the sum of PCBs and for PCB TEQ. For the sum of PCBs, dietary intakes including half LODs, were 231 ng/day (3.30 ng/kg bw/day) and, excluding half LODs, were 224 ng/day (3.20 ng/kg bw/day). For PCB TEQ, intakes including half LODs were 22.7 pg TEQ/day (0.32 pg TEQ/kg bw/day) and excluding LODs were 14.3 pg TEQ/day (0.20 pg TEQ/kg bw/day).

Although different dietary habits make direct comparison with results from studies in other countries difficult, the daily intakes of PCDDs, PCDFs and PCBs by New Zealand males are consistently lower than that of other countries where comparable studies have been undertaken. The intakes are also below the recently established World Health Organisation tolerable daily intake (TDI) range of 1-4 pg TEQ/kg bw/day, the proposed US Agency for Toxic Substances and Disease Registry level and the German long-term objective, of 1 pg TEQ/kg bw/day, as well as TDI levels set by Canada, Japan, Sweden, the Netherlands and the United Kingdom.

Appendices to this report describe the food type composites tested, sample preparation methods, procedures used for PCDD, PCDF and PCB analysis, contaminant concentrations determined in foods, details of the dietary modelling and levels of dietary intake of PCDDs, PCDFs and PCBs for New Zealanders.

Acknowledgements

The success of this study has been dependent upon the involvement of many people who have contributed in various ways and at various stages of the project, from the initial study design, through the sample collection and analysis phase, to the final report writing and peer review.

The authors would like to acknowledge the contributions made by the following:
Elizabeth Aitken, Brian Duffy, Beth Dye, Howard Ellis, Norman Hawcroft, Tasi Iose, Ian Lineham, Scott Leathem, Kyla Mackenzie, Rhonda Mitchell, Lawrence Porter, Suzanne Porter, Bob Symons, Karin Taylor and Tania van Maanen.

The authors would also like to acknowledge the participation of the international experts who contributed information and advice, and who undertook peer review of the initial study design or this publication: Nigel Harrison, Jake Ryan and Fay Stenhouse.

Finally, the authors thank all current and former members of the Organochlorines Programme Consultative Group for their involvement in this study: Jim Barnett, Michael Bates, Bill Birch, Mark de Bazin, Ian Cairns, Paul Dell, Simon Hales, Donald Hannah, John Hohapata, Bill Jolly, Jocelyn Keith, Bob Moffat, Tony Petley, Peter Sligh, Michael Szabo, Norm Thom, Simon Towle and Jim Waters.

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1 Introduction

In 1995 the Ministry for the Environment commenced a national Organochlorines Programme to characterise the extent of contamination of the New Zealand environment by selected organochlorine contaminants, and establish risk-based environmental acceptance criteria for these substances. The organochlorines that are the focus of the programme are:

- The polychlorinated dibenzo-p-dioxins (PCDDs) and the polychlorinated dibenzofurans (PCDFs). These are often generically referred to as 'dioxins', but throughout this report, the PCDD and PCDF nomenclature is used;
- Polychlorinated biphenyls (PCBs);
- Organochlorine pesticides including DDT, aldrin, dieldrin and chlordane;
- Chlorophenols, in particular pentachlorophenol (PCP).

The development of risk-based acceptance criteria for organochlorines requires information on the background concentrations of these contaminants in the environment, in humans, and on exposure pathways. The two main components of the Organochlorines Programme which will provide an estimate of human exposure are an assessment of the dietary intake of PCDDs, PCDFs, and PCBs and a survey of organochlorine contaminants in human serum.

The results of the dietary study are the subject of this report. A separate report is to be published on organochlorine concentrations in New Zealanders serum. These data will be used in a human health risk evaluation, which will also be published in a separate report.

The objectives of the dietary study were to:

1) determine the level of PCDD, PCDF and PCB contaminants in meats, dairy products and other key foods in the New Zealand market place;
2) estimate the dietary intake for the New Zealand population of PCDD, PCDFs, and PCBs;
3) allow the New Zealand dietary exposure to PCDDs, PCDFs and PCBs to be compared with similar international dietary studies;
4) provide scientific data for use in a risk-based approach to support the development and application of national environmental standards and guidelines for PCDDs, PCDFs and PCBs.

The primary route of human exposure to organochlorine contaminants for the general population is through consumption of food. The dietary intake of PCDDs, PCDFs and PCBs is estimated to account for greater than 90% of human exposure to these contaminants (Duarte-Davidson and Jones, 1994). PCDDs, PCDFs and PCBs are lipophilic and tend to bioaccumulate. They are therefore more likely to be present in fatty foods of animal origin, such as meats, dairy products and fish, than in fruits and vegetables.

Levels of PCDDs and PCDFs in foods, and dietary exposures to these contaminants, have been widely reported in the international literature (e.g. Beck *et al.,* 1989, 1992; Fiedler *et al*., 1997; Liem and Theelen, 1997; Ministry of Agriculture, Fisheries and Food, 1992, 1995, 1997a,b; Ryan *et al.,* 1997; Schecter *et al*., 1994, 1996, 1997; Theelen *et al.,* 1993). Less information is available

The Organochlorines Programme

The Organochlorines Programme was initiated in response to a recognition of the need to minimise industrial emissions of PCDDs and PCDFs to air and water, clean-up sites contaminated with organochlorine residues and manage the safe disposal of waste stocks of organochlorine chemicals such as the PCBs and persistent pesticides. The Organochlorines Programme is consistent with current international concerns on persistent organic pollutants (UNEP, 1997).

The Organochlorines Programme as a whole comprises the study of environmental and human concentrations of organochlorine substances; the development of an inventory of ongoing PCDD and PCDF emissions; and the estimation of the risk posed by these substances. The integration of these and other components of the Organochlorines Programme is shown in Figure 1.1. The outcomes from the overall programme will be:

- National environmental standards for PCDDs and PCDFs and where necessary environmental guidelines or standards for PCBs, organochlorine pesticides and chlorophenols;
- Identified clean-up technologies that can safely and effectively destroy organochlorine wastes;
- An integrated management strategy for PCDDs, PCDFs and other organochlorine contaminants and wastes in New Zealand;
- Identification of issues for the phase-out of organochlorines;
- Informed public input to Government decisions on the management of organochlorines in the New Zealand environment.

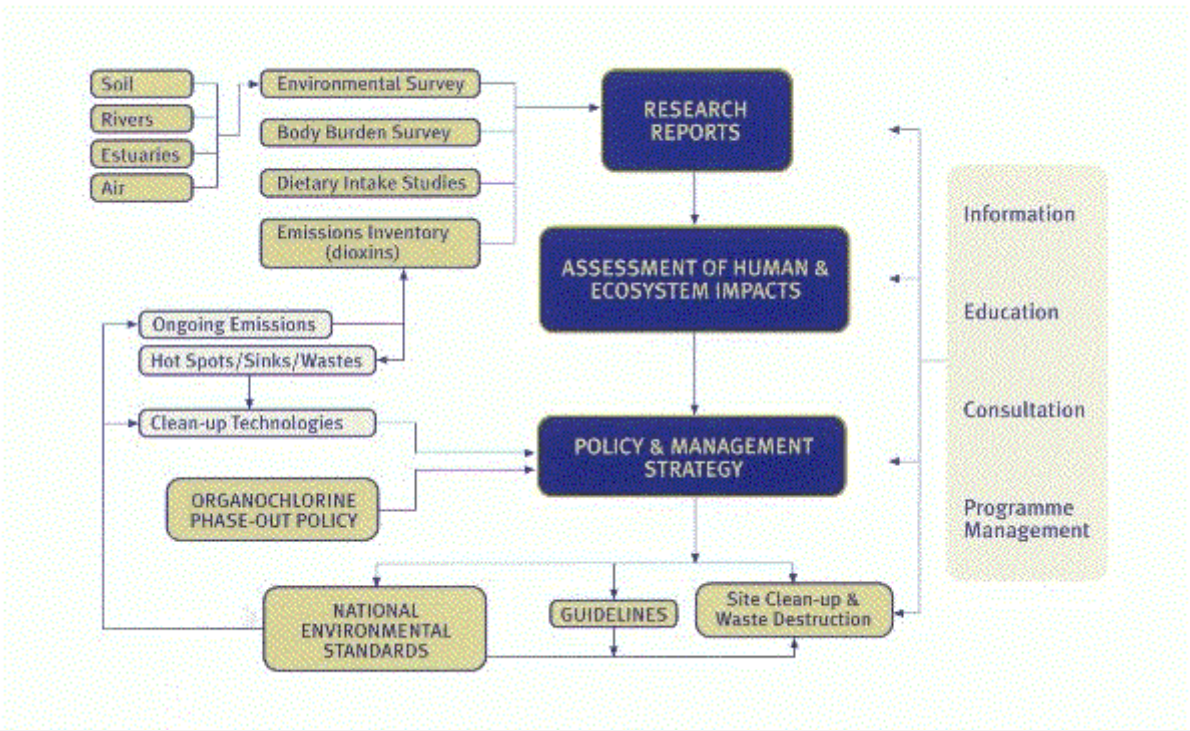

Figure 1.1 Overview of the New Zealand Organochlorines Programme

on PCBs (e.g. Duarte-Davidson and Jones, 1994; Jimènez *et al*., 1996a,b; Ministry of Agriculture, Fisheries and Food, 1996). There has been no equivalent survey of PCDDs and PCDFs in New Zealand foods, nor an estimate of exposure to these contaminants for New Zealanders.

Where sufficient historical data are available, the general trend internationally has been for a decline in the levels of these contaminants in foods (Fürst and Wilmers, 1995; Ministry of Agriculture, Fisheries and Food, 1995). This is generally considered to be a result of tighter regulatory controls on emissions of PCDDs and PCDFs and the phasing out of PCBs.

This document reports the results of a survey to determine the presence of PCDDs, PCDFs and PCBs in foods commonly consumed by New Zealanders. Foods known to be likely sources of these contaminants were targeted and an estimate was made of the dietary exposure for the population from these foods.

The Organochlorines Programme is also concerned with persistent organochlorine pesticides. Organochlorine pesticide levels are monitored in foods as part of Ministry of Health Total Diet Surveys (Dick *et al*., 1978a,b; Ministry of Health and ESR, 1994, 1995; Pickston *et al*., 1985), and Ministry of Agriculture and Forestry surveillance programmes. For this reason they were not included in this survey, in which the organochlorine contaminants investigated were limited to PCDDs, PCDFs and PCBs.

The available information on dietary exposures to organochlorine pesticides from the Ministry of Health and Ministry of Agriculture and Forestry programmes will be considered within the Organochlorines Programme as part of the development of national environmental standards and guidelines for these substances.

2 Background information on PCDDs, PCDFs and PCBs

2.1 PCDDs and PCDFs

The PCDDs and PCDFs are two groups of aromatic compounds having the basic structures shown in Figure 2.1.

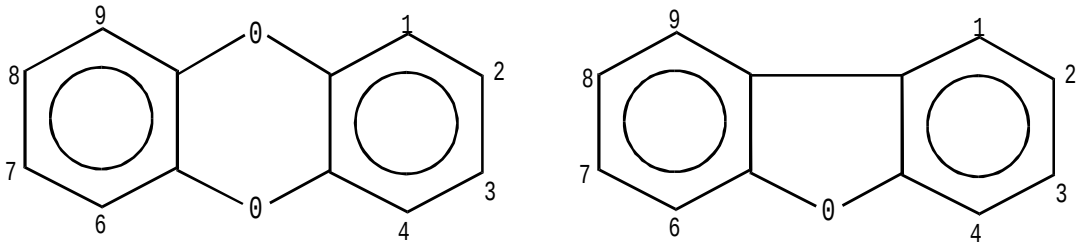

Figure 2.1 Structures of dibenzo-p-dioxin and dibenzofuran

Both groups of chemicals may have up to eight chlorine atoms attached at carbon atoms 1 to 4 and 6 to 9. Each individual compound resulting from this is referred to as a congener. Each specific congener is distinguished by the number and position of chlorine atoms around the aromatic nucleus. In total, there are 75 possible PCDD congeners and 135 possible PCDF congeners. Groups of congeners with the same number of chlorine atoms are known as homologues. The number of congeners in each homologue group is shown in Table 2.1.

Toxicity

Congeners containing 1, 2 or 3 chlorine atoms are thought to be of no toxicological significance. However, the 17 congeners with chlorine atoms substituted in the 2,3,7,8-positions are thought to pose a risk to human and environmental health. Toxic responses include dermal toxicity, immunotoxicity, carcinogenicity, and adverse effects on reproduction, development and endocrine functions. Of the 17 congeners, the most toxic, and widely studied, congener is 2,3,7,8-TCDD. Increasing substitution from 4 to 8 chlorine atoms generally results in a marked decrease in potency.

Toxic equivalents

In environmental media, the PCDDs and PCDFs occur as complex mixtures of congeners. To enable a complex, multivariate dataset to be reduced to a single number, a system of toxic equivalents (TEQs) has been developed. The toxic equivalents method is based on the available toxicological and *in vitro* biological data, and knowledge of structural similarities among the PCDDs and PCDFs, to generate a set of weighting factors, each of which expresses the toxicity of a particular PCDD or PCDF congener in terms of an equivalent amount of 2,3,7,8-TCDD. Multiplication of the concentration of a PCDD or PCDF congener by this toxic equivalents factor (TEF) gives a corresponding 2,3,7,8-TCDD TEQ concentration. The toxicity of any mixture of PCDDs and PCDFs, expressed as 2,3,7,8-TCDD, is derived by summation of the individual TEQ concentrations. This is reported as the 'Total TEQ' for a mixture.

Table 2.1 Homologues and congeners of PCDDs and PCDFs

Abbreviation	Homologue name	No. of possible congeners	No. of possible 2,3,7,8-chlorinated congeners
MCDD	Monochlorodibenzo-p-dioxin	2	0
DiCDD	Dichlorodibenzo-p-dioxin	10	0
TrCDD	Trichlorodibenzo-p-dioxin	14	0
TCDD	Tetrachlorodibenzo-p-dioxin	22	1
PeCDD	Pentachlorodibenzo-p-dioxin	14	1
HxCDD	Hexachlorodibenzo-p-dioxin	10	3
HpCDD	Heptachlorodibenzo-p-dioxin	2	1
OCDD	Octachlorodibenzo-p-dioxin	1	1
MCDF	Monochlorodibenzofuran	4	0
DiCDF	Dichlorodibenzofuran	16	0
TrCDF	Trichlorodibenzofuran	28	0
TCDF	Tetrachlorodibenzofuran	38	1
PeCDF	Pentachlorodibenzofuran	28	2
HxCDF	Hexachlorodibenzofuran	16	4
HpCDF	Heptachlorodibenzofuran	4	2
OCDF	Octachlorodibenzofuran	1	1

Although a number of toxic equivalents schemes have been developed, the most widely adopted system to date is that proposed by the North Atlantic Treaty Organisation, Committee on Challenges to Modern Society (NATO/CCMS), known as the International Toxic Equivalents Factor (I-TEF) scheme (Kutz *et al*., 1990). This approach assigns a TEF to each of the 17 toxic 2,3,7,8-chlorinated PCDDs and PCDFs (Table 2.2). The remaining non 2,3,7,8-chlorinated congeners are considered biologically inactive and are assigned a TEF of zero.

The I-TEF scheme has recently been revised and expanded through the auspices of the World Health Organisation (WHO) to provide TEF values for humans and wildlife (Van den Berg *et al*., 1998). Thus WHO-TEFs are now available for humans/mammals (Table 2.2), fish and birds[1].

Sources

PCDDs and PCDFs are not produced intentionally, but are released to the environment from a variety of industrial discharges, combustion processes and as a result of their occurrence as unwanted by-products in various chlorinated chemical formulations.

Historically the manufacture and use of chlorinated aromatic chemicals have been major sources of PCDDs and PCDFs in the environment. Most notable examples include the wood preservative and biocide PCP, 2,4,5-trichlorophenoxy acetic acid (2,4,5-T) and the PCBs.

Other processes, such as the manufacture of chlorine-bleached pulp, have led to environmental contamination by PCDDs and PCDFs, as well as the trace contamination of pulp and paper products.

[1] The PCDD and PCDF TEQ data given in this report have been calculated using the I-TEFs, since most comparative literature data also use this scheme to report TEQ results. However, all PCDD and PCDF concentrations are tabulated, allowing the reader to recalculate the total TEQ concentration for any sample using the new WHO-TEF values (Van den Berg *et al*., 1998).

Table 2.2 Toxic equivalents factors for PCDDs and PCDFs

PCDD and PCDF congener	I-TEF (Kutz *et al*., 1990)	WHO-TEF (humans/mammals) (Van den Berg *et al*., 1998)
2,3,7,8-TCDD	1	1
1,2,3,7,8-PeCDD	0.5	1
1,2,3,4,7,8-HxCDD	0.1	0.1
1,2,3,6,7,8-HxCDD	0.1	0.1
1,2,3,7,8,9-HxCDD	0.1	0.1
1,2,3,4,6,7,8-HpCDD	0.01	0.01
OCDD	0.001	0.0001
2,3,7,8-TCDF	0.1	0.1
1,2,3,7,8-PeCDF	0.05	0.05
2,3,4,7,8-PeCDF	0.5	0.5
1,2,3,4,7,8-HxCDF	0.1	0.1
1,2,3,6,7,8-HxCDF	0.1	0.1
2,3,4,6,7,8-HxCDF	0.1	0.1
1,2,3,7,8,9-HxCDF	0.1	0.1
1,2,3,4,6,7,8-HpCDF	0.01	0.01
1,2,3,4,7,8,9-HpCDF	0.01	0.01
OCDF	0.001	0.0001

Combustion processes are recognised as being another important source of PCDDs and PCDFs. Most thermal reactions which involve the burning of chlorinated organic or inorganic compounds appear to result in the formation of these substances. PCDDs and PCDFs have been detected in emissions from the incineration of various types of wastes, particularly municipal, medical and hazardous wastes, from the production of iron and steel and other metals, including scrap metal reclamation, from fossil fuel plants, domestic coal and wood fires, and automobile engines (especially when using leaded fuels) as well as accidental fires. An extensive review of PCDD and PCDF sources has been published by Fiedler *et al*., (1990), and more recently by the United States Environmental Protection Agency (US EPA, 1998).

Although natural, non-anthropogenic, combustion sources (like forest fires) have probably always been a source of PCDDs and PCDFs, the background levels associated with the pre-industrial processes (before the 1930s/1940s) are found to be negligible when compared to those resulting from more recent industrial activities (Kjeller *et al*., 1991; Beurskens *et al*., 1993; Jones and Alcock, 1996).

Tighter Government regulations, improved industrial processes and the use of modern pollution control equipment have resulted in a lowering of PCDD and PCDF emissions from known industrial sources in many countries. However, it is unlikely that a complete elimination of these contaminants will be possible due to uncontrolled releases, such as forest fires and other accidental fires.

2.2 Polychlorinated biphenyls

The PCBs were commercial products prepared industrially by the chlorination of biphenyl. The commercial preparations were graded and marketed according to their chlorine content, for example Aroclor 1232 contains 32% by weight of chlorine and Aroclor 1260 contains 60% by weight of chlorine.

PCBs comprise 209 congeners. The basic aromatic biphenyl nucleus is shown in Figure 2.2, and the distribution of PCB congeners arising from the attachment of chlorine atoms to this nucleus is given in Table 2.3.

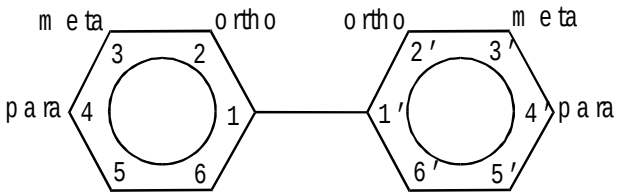

Figure 2.2 Structure of biphenyl

Table 2.3 Distribution of PCB congeners

No. of Cl substituents	Cl_1	Cl_2	Cl_3	Cl_4	Cl_5	Cl_6	Cl_7	Cl_8	Cl_9	Cl_{10}
No. of congeners	3	12	24	42	46	42	24	12	3	1

Toxicity and toxic equivalents

As with the PCDDs and PCDFs, the biologic and toxic effects of PCBs are highly dependent both on the degree of chlorination and on the position of the chlorine atoms (i.e. whether they are *ortho*, *meta* or *para* to the phenyl-phenyl bridge at carbon-1). To account for the varying toxicity of the PCB congeners, the WHO-European Centre for Environmental Health (WHO-ECEH) and the International Programme on Chemical Safety (IPCS) have developed a suite of TEFs for 'dioxin-like' PCBs (Table 2.4) (Ahlborg *et al*., 1994). These TEFs, which are applied in a manner identical to the I-TEFs developed for the PCDDs and PCDFs, embrace those PCBs that bind to the Ah-receptor and elicit dioxin-specific biochemical and toxic responses. The WHO has recently revised and expanded these TEFs (Van den Berg *et al*., 1998) to include TEFs for humans/mammals (Table 2.4) as well as fish and birds[2].

PCBs also exhibit 'non-dioxin-like' toxicity in which the toxic effects are not mediated through the Ah-receptor (Safe and Hutzinger, 1987; Safe, 1994). These effects include cancer promotion, endocrine disruption and neuro-behavioural toxicity. Importantly, the TEF concept developed for the PCDDs and PCDFs and the 'dioxin-like' PCBs cannot be applied to 'non-dioxin-like' effects that are not Ah-receptor mediated.

In fact, there is still some debate as to the application of the TEF approach to PCBs. A recent report from the UK Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (CoT, 1997) states that they have reservations about the TEF scheme for several reasons. They point out that not all toxic effects of PCBs are mediated by an Ah-receptor mechanism and many of the TEFs for individual congeners are based on limited data. In addition,

[2] The PCB TEQ data given in this report have been calculated using the 1994 WHO-TEFs. However, all PCB concentrations are tabulated, allowing the reader to recalculate the total TEQ concentration for any sample using the revised WHO-TEF values (Van den Berg *et al*., 1998).

they state that most of the congeners found in food are not 'dioxin-like' and there is potential for interactions between 'dioxin-like' and 'non-dioxin-like' congeners. They do, however, conclude that the use of TEFs is a pragmatic approach to the evaluation of 'dioxin-like' PCBs and can be used to assess the health risks of the intake of combinations of PCDDs, PCDFs and 'dioxin-like' PCBs.

Table 2.4 Toxic equivalents factors for PCBs

Type	Congener		WHO/IPCS TEF (Ahlborg *et al.*, 1994)	WHO-TEF (humans/mammals) (Van den Berg *et al.*, 1998)
	IUPAC No.	Structure		
Non-*ortho*	PCB #81	3,4,4',5-TCB		0.0001
	PCB #77	3,3',4,4'-TCB	0.0005	0.0001
	PCB #126	3,3',4,4',5-PeCB	0.1	0.1
	PCB #169	3,3',4,4',5,5'-HxCB	0.01	0.01
Mono-*ortho*	PCB #105	2,3,3',4,4'-PeCB	0.0001	0.0001
	PCB #114	2,3,4,4',5-PeCB	0.0005	0.0005
	PCB #118	2,3',4,4',5-PeCB	0.0001	0.0001
	PCB #123	2',3,4,4',5-PeCB	0.0001	0.0001
	PCB #156	2,3,3',4,4',5-HxCB	0.0005	0.0005
	PCB #157	2,3,3',4,4',5'-HxCB	0.0005	0.0005
	PCB #167	2,3',4,4',5,5'-HxCB	0.00001	0.00001
	PCB #189	2,3,3',4,4',5,5',-HpCB	0.0001	0.0001
Di-*ortho*	PCB #170	2,2',3,3',4,4',5-HpCB	0.0001	
	PCB #180	2,2',3,4,4',5,5'-HpCB	0.00001	

Historical uses of PCBs

PCBs have been widely used in industry as heat transfer fluids, hydraulic fluids, solvent extenders, flame retardants and dielectric fluids (Waid, 1986). The unusual industrial versatility of PCBs is directly related to their chemical and physical properties which include resistance to acids and bases, compatibility with organic materials, resistance to oxidation and reduction, excellent electrical insulating properties, thermal stability and nonflammability.

The widespread use of PCBs, coupled with industrial accidents and improper disposal practices, has resulted in significant environmental contamination by these substances in many northern hemisphere countries.

3 Organochlorines in New Zealand

3.1 PCDDs and PCDFs

No rigorous estimate has ever been made of the total emissions of PCDDs and PCDFs to the New Zealand environment. However, an inventory of emissions to air, land and water is currently being undertaken as a component of the Organochlorines Programme.

Historic releases of PCDDs and PCDFs to the environment are thought to have resulted from the manufacture and use of the herbicide 2,4,5-T, the use of PCP in the timber industry and from spillages and other accidental releases of PCBs. 2,4,5-T was used in New Zealand for the control of gorse, blackberry and other woody weeds. In the 1980s there were a number of investigations into the effects of the manufacture and use of 2,4,5-T in this country, in part due to concerns relating to the presence of 2,3,7,8-TCDD as a microcontaminant of this herbicide (Coster *et al*., 1986; Brinkman *et al*., 1986; Ministry for the Environment, 1989). The manufacture of 2,4,5-T in New Zealand ceased in 1987, although some stocks remained which were likely to have been used after this date.

PCP was used in New Zealand primarily in the timber industry, but also to a relatively minor extent by the pulp and paper industry and the tanning industry, in mushroom culture and in home gardens. Its use (as sodium pentachlorophenate) in the timber industry was for the control of sapstain fungi in freshly cut timber. PCP in oil was also used in lesser amounts as a timber preservative. These historical activities, involving the use in the order of 5,000 tonnes of PCP, have resulted in the contamination of a number of sites throughout the country (Ellis, 1997, and references therein).

Two large bleach kraft pulp mills operate in the central North Island. These mills have historically used elemental chlorine in the bleach plant, although the concentrations of PCDDs and PCDFs in effluent discharges to receiving waters, and in pulp sludges, were low compared to contamination concentrations that have been reported in North America (NCASI, 1990). The use of elemental chlorine at both these mills has now been superseded by bleaching sequences based on chlorine dioxide following oxygen delignification.

There are no municipal waste incinerators in New Zealand. In the last decade, a number of smaller hospital waste incinerators have closed. However, there are still currently operating approximately 30 incinerators around the country that burn a variety of medical, pathological, quarantine and animal wastes. With the exception of a limited number of these plants that burn in excess of 500 kg of waste per hour, these are primarily small units with an average throughput of approximately 100 - 200 kg per hour.

Other incineration facilities include a small sewage sludge incinerator, wood and coal boilers, and units burning wood processing and wood manufacturing wastes. The domestic burning of wood and coal is also expected to emit PCDDs and PCDFs to the environment, along with uncontrolled and accidental fires.

PCDD and PCDF emissions will arise from a number of metallurgical plants, from cement kilns (predominantly from two major plants, including one kiln that burns waste oil as an auxiliary fuel) and from a single (small) hazardous waste incinerator that operates in New Zealand.

Leaded petrol, which has been associated with PCDD and PCDF emissions due to the use of ethylene dichloride and ethylene dibromide as scavengers for the lead in exhaust, has largely been phased out in New Zealand. Unleaded (91 octane) regular petrol was introduced in 1986, and in early 1996, premium (96 octane) petrol was changed to an unleaded formulation. A small amount of leaded fuel is still used for piston-engined aeroplanes and for specialist motor racing.

The major historical and current inputs of PCDDs and PCDFs to the New Zealand environment is given in Table 3.1.

Table 3.1 New Zealand sources of PCDDs and PCDFs

Historical inputs

Source	*PCDD/PCDF contaminant*
Agrichemicals from the use of 2,4,5-T	2,3,7,8-Tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD)
Timber treatment from the use of PCP	Primarily the more highly chlorinated PCDDs and PCDFs
Electricity industry from the use of PCBs	Primarily PCDFs, but also PCDDs if chlorobenzenes present
Pulp and paper (chlorine bleach process)	Primarily TCDFs
Combustion of fuels and incineration of wastes	Broad range of PCDDs and PCDFs
Motor vehicles (particularly from leaded fuels)	Broad range of PCDDs and PCDFs

Current inputs include

- Waste incineration, including medical and hazardous waste;
- Metallurgical industries, including metal smelting, refining and recycling;
- Industrial and domestic coal and wood combustion;
- Exhaust emissions from vehicles running on diesel and unleaded petrol;
- Controlled burn-offs;
- Uncontrolled and accidental fires;
- Sewage wastes;
- Ongoing releases from reservoirs, including sludge ponds and contaminated sites.

3.2 Polychlorinated biphenyls

Internationally, large-scale production of PCBs commenced in the 1930s for use in a variety of industrial applications. PCBs were never manufactured in New Zealand, but have been imported and used extensively in the electricity industry as insulating fluids or resins in transformers and capacitors. PCBs were also used in smaller quantities as heat transfer fluids, plasticisers, printing inks, flame retardants, paint additives, sealing liquids and immersion oils.

In March 1986, the New Zealand Customs Department placed a prohibition on importing PCBs, and later that year regulations to control the importation of PCBs were promulgated as an amendment to the Toxic Substances Regulations 1983. In 1988, a further amendment to the Toxic Substances Regulations 1983 prohibited the use and storage of PCBs with effect from 1 January 1994. Following two extensions, this regulation came into effect on 1 August 1995. A summary of the legislative status of PCBs in New Zealand is given in Table A1 (Appendix A).

Information relating to the quantity of PCBs imported into New Zealand is extremely limited, although some estimates have been made (OECD, 1987; Ministry for the Environment, 1988). Whilst the current holdings of PCBs are uncertain, more accurate assessments have been made of the quantity of PCBs that has been shipped overseas for destruction. These estimates put the

quantity of PCBs (including PCB contaminated material) exported from New Zealand since 1987 at approximately 1300 - 1600 tonnes (Ministry of Health, 1998).

3.3 Global transportation of organochlorines

Organochlorine emissions or use in other countries, and their global transportation, represent an additional and ongoing source of these contaminants to the New Zealand environment. Considerable research has taken place in the northern hemisphere on the transboundary transport and global redistribution of contaminants. Studies have also investigated the transport in air and water of contaminants from the northern to the southern hemisphere. These phenomena are particularly relevant to the transportation of organochlorines and their deposition in New Zealand. However, the significance of these inputs relative to 'local' sources of organochlorines is difficult to assess and quantify.

4 New Zealand food and dietary studies

This is the first New Zealand study to investigate the levels of PCDDs and PCDFs in a broad range of foods. Previous studies determined levels of PCDDs and PCDFs in retail milk supplies (Buckland *et al.,* 1990; Department of Health 1989), and in some food paper packaging products (Ministry of Health, 1994).

There have also been a series of detailed studies (the Total Diet Surveys) by the New Zealand Department of Health (now Ministry of Health) that have determined levels of contaminants (including organochlorine pesticide and PCB residues) in food. The lifestyles and eating habits of New Zealanders have also been investigated in the 'Life in New Zealand' survey.

4.1 New Zealand Total Diet Surveys

The first New Zealand Total Diet Survey (NZTDS) was carried out in 1974-75 by the Department of Scientific and Industrial Research (DSIR) in conjunction with the Department of Health. The survey's approach used a high-energy diet that was representative of an active young male. Likely intakes of pesticides, heavy metals and some nutrients present in that diet were assessed using the findings.

The 1974-75 NZTDS (Dick *et al.,* 1978a,b) used a food group composite approach, and foods were analysed in their raw state. The composite groups sampled and analysed included grains and cereal products, meat, fish and eggs, dairy products, vegetables, fruit, beverages, imported foods and tinned foods.

In 1982, the second NZTDS was carried out, again by the DSIR and the Department of Health (Pickston *et al.,* 1985). A number of levels of energy intake were used to calculate the potential contaminant intakes of different age-sex groups. In addition to the food groups sampled in the 1974-75 survey, the following were added: fats and oils, sweet foods and nuts, and instant foods.

In 1987-88 a new approach to the NZTDS was developed (Ministry of Health and ESR, 1994). Rather than using a food composite approach as in the past, foods were analysed individually to assess their contaminant and nutrient content. In addition to this, foods were analysed in their ready-to-eat state, whereas in the past foods had been analysed in their raw state. This approach enabled a number of simulated diets to be modelled for various age-sex groups based on the individual ready-to-eat foods. It was concluded that the pesticide residue levels found in this survey were unlikely to have any adverse health implications for the New Zealand population. This conclusion was drawn from the comparison of the findings of this survey with internationally recognised acceptable daily intake (ADI) values.

The 1990-91 NZTDS (Ministry of Health and ESR, 1995) used mainly the same foods as in the 1987-88 NZTDS, with the addition of water and changes to the dried fruit and fish food samples.

A few organochlorine pesticide residues were quantified in the foods analysed. These were HCH, dieldrin, DDT and its degradation products, and endosulfan pesticides. The concentrations of these pesticides were very low. Based on a comparison with internationally recognised ADI values, it was concluded that the pesticide residue levels found in the foods used in the 1990-91

NZTDS were very unlikely to have any adverse health implications for the New Zealand population. PCBs were also analysed for as part of the organochlorine pesticide screen used in the 1990-91 NZTDS. No PCBs were quantified in any sample above a limit of detection of 0.2 - 0.5 mg/kg.

4.2 Life in New Zealand survey

The Life in New Zealand (LINZ) survey was conducted in 1989-90 by the University of Otago (Russell and Wilson, 1991) to establish benchmark data indicative of the current lifestyles of the New Zealand population. The two objectives of this survey that related to diet were to identify food intake patterns and to determine whether significant changes had occurred in food intake compared to the 1977 National Nutrition Survey.

The nutrition section of the survey comprised two components: a self-administered food-frequency questionnaire which asked adult New Zealanders about foods they usually ate; and a 24-hour diet recall, conducted as a personal interview, in which individuals were asked to recall all food and drinks they had consumed over the previous 24 hours.

The LINZ survey data are useful to indicate foods and food types that are important to the energy content and fat intake of the New Zealand diet and therefore are potential contributors to the organochlorine intakes for adult New Zealanders. Accordingly, the LINZ data have been used as a basis for the dietary modelling of exposure to PCDDs, PCDFs and PCBs in the current study.

5 Project design

The sampling strategy for the current survey was designed to assess the levels of PCDDs, PCDFs and PCBs in food products commonly eaten by New Zealanders and widely available through retail outlets nationally.

5.1 Food selection

The criteria for the selection of foods for the PCDD, PCDF and PCB dietary study were as follows:

- Foods found to be significant contributors to dietary exposure to PCDDs, PCDFs and PCBs from overseas surveys.
- Foods known to be significant sources of energy in the New Zealand diet.
- Frequently consumed staple foods, some popular high fat foods such as 'take-away' foods, and foods such as liver and tinned fish which, while not so popular, might be important contributors to the dietary exposure to PCDDs, PCDFs and PCBs.

5.2 The food list

The primary emphasis in the food list was placed on meats, fish and dairy products since these have been shown to be the major contributors to PCDD, PCDF and PCB exposure in overseas studies (Birmingham *et al*., 1989a; Harrison *et al.,* 1996; Ministry of Agriculture, Fisheries and Food, 1992; Ryan *et al*., 1990; Startin, 1994). However, staple foods, such as breads and potatoes, were also included on the basis of the high amounts consumed. Other vegetables, fruit and beverages were not included due to their very low fat content and the very low contribution these items would be expected to make to the levels of PCDDs, PCDFs and PCBs in the diet. Where possible, foods included on the food list for the PCDD, PCDF and PCB dietary study were the same as or similar to those on the food list for the 1997-98 NZTDS currently being undertaken by the Ministry of Health (Hannah, 1997a). Food data used to assess the intakes of organochlorine pesticides will therefore be consistent with the foods used for the PCDD, PCDF and PCB survey. This is particularly relevant for meats, fish and dairy produce. All foods collected in the current survey were grouped together on the basis of food types for analysis. The food type composites, and the individual foods within each composite are listed in Table 5.1,

The main objective of this study was to estimate dietary exposure to PCDDs, PCDFs and PCBs rather than provide a statistical analysis of contaminant levels in produce from New Zealand. Therefore the foods analysed were those which are available to the New Zealand consumer from retail outlets irrespective of country of origin. Of the primary produce sampled, the potatoes, dairy products, shellfish and fish fillets (fresh and deep-fried), beef and sheep meat were of domestic origin. New Zealand imports approximately 17% of the total pork consumed (New Zealand Pork Industry Board, 1998), most of which is used in processed pork products. Detailed information on the food list developed for this study is provided in Appendix A.

Table 5.1 Food type composites and their component foods

Food type composite	Components of food type composite
Beef meat	Rump steak and beef mince
Sheep meat	Shoulder and leg meat of lamb and mutton
Pork meat	Pork pieces and middle bacon
Beef fat	Fat trimmed from rump steak
Sheep fat	Fat trimmed from shoulder and leg meat
Pork fat	Fat trimmed from pork pieces and bacon
Liver	Mixture of beef, lamb and chicken livers
Processed meat products	Steak-type pies, beef flavoured sausages and luncheon sausages
Milk	Standard and trim
Butter	Salted butter
Cheese	Colby and mild cheddar
Ice cream/yoghurt	Vanilla ice cream and flavoured yoghurt
New Zealand fish	Selection of snapper, blue cod, sole and terakihi, plus battered deep-fried fish from fish and chip shop
Imported tinned fish	Tinned tuna, salmon and sardines
Shellfish	Oysters and mussels
Poultry	Fresh whole chicken
Eggs	Ordinary eggs
Bread	While, wholemeal and multigrain
Cereals	Weetbix, cornflakes, rolled oats, rice, dried spaghetti, chocolate biscuits, plain biscuits, savoury biscuits and plain cake
Potatoes	Potatoes and hot deep-fried chips
Snack foods	Potato crisps, corn tortillas and milk chocolate
Vegetable fats/oils	Margarine, salad and cooking oil, and olive oil

5.3 Sample collection

The four main New Zealand cities (Auckland, Wellington, Christchurch and Dunedin) and one provincial centre (Napier) were selected for sample collection. Collectively, they provide a good geographical coverage, and are expected to take into account any regional differences that may occur in contaminant levels in some foods, such as milk.

Fifty three foods were purchased in April 1997 from one randomly selected supermarket in each centre. In addition, meats were collected from one randomly selected butcher in each centre. If New Zealand fish was not available at the selected supermarket, samples were purchased from a fishmonger in the same centre.

Samples were collected in all five centres over a one-day period, with the samples subsequently being packaged and sent to the laboratory for analysis. A total of 391 samples were purchased out of 405 planned (97%) because some of the foods were unavailable in some centres on the day of sampling. Details on the quantity of samples collected for each food type composite are given in Table B1 (Appendix B). Each sample was marked with its own identification number, and transported to the laboratory using standard chain of custody forms. A separate quality assurance document was prepared giving specific guidance to the sampling personnel on the collection and handling requirements for this study.

In many food composition studies it is useful to carry out seasonal sampling as this enables more representative sampling to be accomplished, and a better assessment of average dietary exposures.

However, the current study was undertaken under a very restricted time-frame and seasonal sampling was not feasible.

5.4 Sample preparation

Foods were composited into 22 food types, with a selection of foods chosen to represent each food type. Details of the methods used to assemble and prepare the food composites are reported in Tables B3 - B8 (Appendix B).

Those foods which would normally be cooked prior to consumption (meats, meat products, eggs, fish and vegetables) were cooked in a manner consistent with the methods used in the NZTDS and common practice.

For meats, the 1989-90 LINZ survey showed that on average 65% of New Zealanders trim the fat (either before or after cooking) prior to consumption. Therefore, in this study the separable fat was trimmed from the meat samples and analysed. Any fats/juices that separated from the meat during the cooking process were also analysed. This allowed a potentially 'worst-case' exposure to be estimated.

A separate quality assurance document detailing the sample compositing and cooking requirements for individual foods was prepared for the analytical laboratory (Hannah, 1997b).

5.5 Sample analysis

Food samples were analysed for the following organochlorine contaminants:

PCDDs and PCDFs. All 2,3,7,8-chlorinated congeners were determined congener specifically. Total concentrations for non 2,3,7,8-PCDDs and PCDFs for each homologue group were also determined. Total TEQs were calculated, both excluding limit of detection (LOD) values and including half LOD values, using the I-TEFs (Table 2.2).

PCBs. Concentrations of 23 PCB congeners[3] were determined, (PCB #77, #126, #169, #52, #101, #99, #123, #118, #114, #105, #153, #138, #167, #156, #157, #187, #183, #180, #170, #189, #202, #194, #206). PCB TEQs were calculated, both excluding LOD values and including half LOD values, using the 1994 WHO-TEFs (Table 2.4).

Analysis was undertaken on freeze-dried material for all samples except for the milk, butter and vegetable fats/oils which were analysed in their normal state. Quantitation for PCDDs, PCDFs and PCBs was by $^{13}C_{12}$ isotope dilution using capillary gas chromatography-high resolution mass spectrometry. Data reported are corrected for recovery of $^{13}C_{12}$ surrogate standards.

For each sample, the solvent extractable fat content was determined gravimetrically. Full details of the sample preparation and analytical procedures are reported in Appendix C.

[3] PCB numbering by Ballschmiter and Zell (1980).

5.6 Dietary modelling

Two diets were chosen to examine the likely intakes of PCDDs, PCDFs, and PCBs:

- adult male (25-44 years old) 10.8 MJ/day diet, median energy (50th centile) intake
- adolescent male (15-18 years old) 21.5 MJ/day diet, high energy (90^{th} centile) intake

The choice of these age-sex categories was based on the categories used to classify data in the LINZ survey (Wilson *et al*., 1992). The energy contents of each of these diets and the amounts of energy that each food or food type contributed to the total energy intake were also calculated, primarily from data in the LINZ survey. However, some adjustments were made to four of the food types for the purposes of this study to take account of specific foods such as liver and imported tinned fish. Further details of the dietary modelling are reported in Appendix D.

Complementary to the 1989-90 LINZ survey, the Ministry of Health is currently funding a further survey of the eating habits and health characteristics of New Zealanders. This National Nutrition Survey (NNS) is collecting food intake data from a nation-wide sample of approximately 5,000 individuals aged 15 years and over (Quigley and Watts, 1997). Further dietary assessments of exposures to PCDDs, PCDF and PCBs for other consumer groups such as adolescent and adult women and for older adults will be possible when the food consumption data from the NNS is released in 1999.

6 PCDDs, PCDFs and PCBs in New Zealand foods

6.1 Overview of food data

The concentration ranges of PCDDs and PCDFs, and PCBs, for various food groups on a fat weight basis are shown in Figures 6.1 and 6.2 respectively. The total TEQs were calculated both including half LOD values for non-quantified congeners and excluding LOD values.

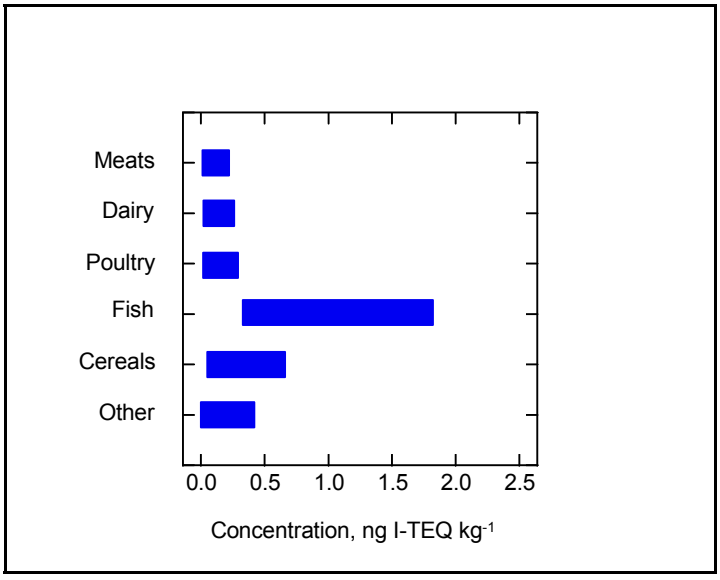

Fig. 6.1 **Ranges of PCDDs and PCDDs (I-TEQ) within each food group**
The lower end of the range is the lowest TEQ value (excluding LOD values) within each food group; the higher end of the range is the highest TEQ value (including half LOD values) within each food group.

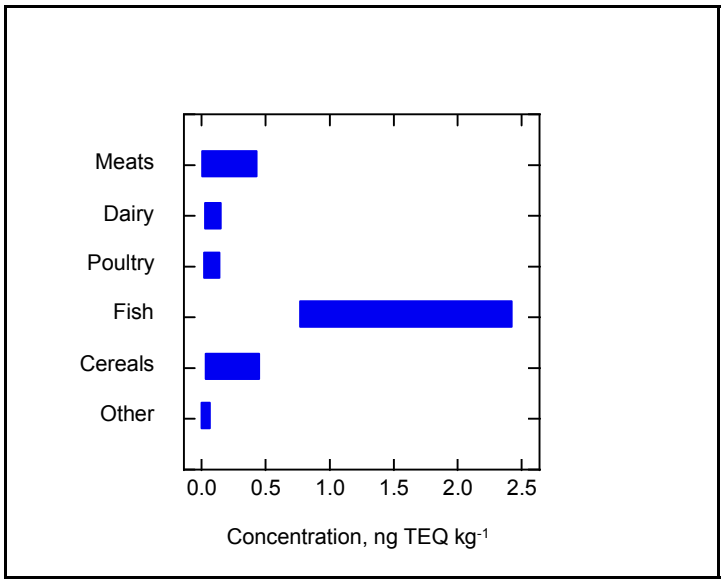

Fig. 6.2 **Ranges of PCBs (TEQ) within each food group**
The lower end of the range is the lowest TEQ value (excluding LOD values) within each food group; the higher end of the range is the highest TEQ value (including half LOD values) within each food group.

Due to the large number of non-detected congeners in the food samples, inclusion of half LOD values in the total TEQ calculations results in a high degree of uncertainty for the total TEQ levels reported. The inclusion of half LOD values had less effect on the PCB TEQ calculations, largely because PCB congeners were more frequently measured in the foods. The limits of detection for each sample varied, also affecting the calculations including half LOD values. In particular, the high fat samples had higher LODs relative to other samples.

Low levels of 2,3,7,8-chlorinated PCDD and PCDF congeners were measured in eleven of the food composites analysed. PCBs were measured in all composites except the vegetable fats and oil sample. All data reported in the following sections are on a whole (wet) weight basis unless otherwise stated. These results can be summarised as follows:

- **Meats** - No PCDDs or PCDFs were quantified in the three carcass meat samples, or the liver sample. PCDDs and PCDFs were found in all three trimmed fat samples, but 2,3,7,8-chlorinated congeners were quantified only in the pork fat. PCBs were quantified in all the carcass meat samples.
- **Dairy** - No PCDDs or PCDFs were quantified in the butter sample, and only low levels of 1,2,7,8- and 2,3,7,8-TCDF were quantified in the retail milk sample. Only non 2,3,7,8-TCDD and PeCDD congeners were found in the cheese and ice cream/yoghurt samples. PCBs were measured in all four dairy food samples.
- **Fish** - PCDDs, PCDFs and PCBs were quantified in all three fish samples. The imported tinned fish had markedly higher levels relative to the New Zealand samples.
- **Poultry** - PCDDs were measured in the chicken and egg samples, including 1,2,3,4,6,7,8-HpCDD and OCDD, along with non 2,3,7,8-chlorinated congeners. No PCDFs were quantified in these samples. A range of PCB congeners were quantified, including PCB #77.
- **Cereals** - The only 2,3,7,8- congeners quantified were OCDD and OCDF in the bread, and 1,2,3,4,6,7,8-HpCDD and OCDD in the cereal samples. Low levels of non 2,3,7,8- TCDD, PeCDD and HxCDD congeners were also quantified in both samples. A range of PCB congeners were quantified, including PCB #77.
- **Other foods** - No PCDDs, PCDFs or PCBs were measured in the vegetable fats and oils. A number of congeners were measured in the potato composite and in the snack food composite samples.

Detailed results of the analysis of food composites, including extractable fat data, are given in Appendix E.

6.2 Comparison of New Zealand food data with international data

The results from this study can be better understood by comparing them with results reported from other countries. However, due to improvements in the sensitivity of analytical instrumentation and refinements in the implementation of laboratory methods, direct comparison with results from earlier overseas studies is not always straightforward. Many of the earlier studies were not congener-specific or had higher limits of detection than are currently achievable. Startin (1994) also suggests that the initial accuracy and long-term consistency of analytical standards used in some laboratories may be poor.

Reporting of non-quantified congeners also varies between different published studies. In some studies, the limit of detection values have been included (i.e. in the calculation of TEQ levels, or in the sum of congeners) by the authors, and in others they have been excluded, while others have included one half of the limit of detection values. In the United Kingdom, calculations are made using the full limit of quantification rather than half LOD values for non-detected congeners, giving a higher estimate than using half LOD values.

For the results from this study, TEQs have been calculated both excluding limits of detection for non-quantified congeners and including values at one half the limit of detection. Some data from overseas studies have been reported using Nordic or German toxic equivalent factors. Wherever possible, the I-TEQ scheme outlined in Table 2.2 and the PCB TEQ scheme outlined in Table 2.4 have been used in this discussion in conjunction with data reported on a fat weight basis, where available. The discussion also focuses on reported 'upper bound' values rather than TEQs which exclude limits of detection.

6.3 Meats and meat products

Table 6.1 provides a summary of the results obtained for meats and meat products. Detailed results are given in Tables E1.1 and E1.2 (Appendix E).

Table 6.1 Concentrations (ng/kg) of PCDDs, PCDFs and PCBs in meats and meat products

	Beef meat	Beef fat	Lamb and mutton	Lamb and mutton fat	Pork meat	Pork fat	Liver	Processed meat products
PCDDs and PCDFs								
Total I-TEQ (wet wt)								
Including half LOD values	0.0082	0.090	0.0076	0.032	0.017	0.023	0.050	0.014
Excluding LOD values	0	0	0	0	0	0.0023	0	0
Total I-TEQ (fat wt)								
Including half LOD values	0.11	0.22	0.072	0.089	0.20	0.11	0.57	0.089
Excluding LOD values	0	0	0	0	0	0.011	0	0
PCBs								
Sum of PCB congeners (wet wt)								
Including half LOD values	58.7	639	67.6	198	536	195	104	118
Excluding LOD values	53.4	632	63.7	197	531	192	93.8	114
Total TEQ (wet wt)								
Including half LOD values	0.0068	0.068	0.0048	0.018	0.035	0.037	0.034	0.014
Excluding LOD values	0.00026	0.065	0.0010	0.0063	0.013	0.037	0.032	0.0026
Total TEQ (fat wt)								
Including half LOD values	0.092	0.17	0.045	0.052	0.43	0.17	0.39	0.091
Excluding LOD values	0.0036	0.16	0.010	0.018	0.15	0.17	0.37	0.017

6.3.1 Carcass meats (beef, lamb, mutton and pork)

PCDDs and PCDFs

No PCDDs or PCDFs were quantified in the three trimmed meat samples. Analytical limits of detection for the individual congeners were in the range 0.002 - 0.7 ng/kg. Inclusion of half LOD values resulted in levels of 0.11, 0.072 and 0.20 ng I-TEQ/kg fat for beef, lamb/mutton and pork, with non-quantified congeners contributing 100% of the total TEQ.

The fat trimmed from the meat was analysed separately. Inclusion of half LOD values gave levels of 0.22 ng I-TEQ/kg fat for beef fat, 0.089 ng I-TEQ/kg fat for lamb/mutton fat and 0.11 ng I-TEQ/kg fat for pork fat. The analytical limits of detection for non-quantified congeners, excluding OCDD, were typically in the range 0.02 - 0.1 ng/kg.

Non 2,3,7,8-TCDDs (0.36 ng/kg) and non 2,3,7,8-PeCDDs (0.15 ng/kg) were quantified in the lamb/mutton fat. In addition to these congeners, beef fat also contained low levels of non 2,3,7,8-HxCDDs (0.57 ng/kg). Low levels of 1,2,3,4,6,7,8-HpCDD (0.15 ng/kg) and OCDD (0.83 ng/kg) were quantified in the pork fat, but not the lower chlorinated non 2,3,7,8-PCDD congeners measured in the beef and sheep fat samples. For the beef and sheep fats, half LOD values were the sole contributor to the total TEQ. In the pork fat, 90% of the total TEQ was derived by inclusion of half LOD values.

Liem and Theelen (1997) reported PCDD and PCDF levels in animal fats of 1.8, 1.8 and 0.43 ng I-TEQ/kg fat for beef, mutton and pork sampled in the Netherlands. In the USA, levels of 1.91 and 2.28 ng I-TEQ/kg fat have been reported for beef and pork[4] (Schecter *et al.,* 1997). Carcass meats (species not specified) were reported to contain a level of 0.94 ng I-TEQ/kg fat in the UK from samples collected in 1992 (Ministry of Agriculture, Fisheries and Food, 1997a).

A number of investigations (Ferrario *et al*., 1996; Winters *et al*., 1996; Feil *et al*., 1995) of PCDDs and PCDFs in beef fat have been carried out in the USA to determine whether the concentration in back fat is an adequate surrogate for the assessment of human exposure to PCDDs and PCDFs through consumption of beef. The most recent study (Lorber *et al.,* 1997a) indicates that the PCDD and PCDF concentrations in back fat are representative of those found in intramuscular fat, with an average ratio of 0.9 on a TEQ basis. A mean of 1.3 ng I-TEQ/kg fat was reported for a statistical survey of pork fat in the USA (Lorber *et al*., 1997b) which compares with a level of 2.29 ng I-TEQ/kg fat for a sample of pork products available to consumers (Schecter *et al*., 1997).

PCBs

A number of PCBs were quantified in all three trimmed meat samples and in the corresponding fat samples. Analytical limits of detection for non-quantified congeners were in the range 0.1- 6 ng/kg for the meat samples and 0.2 - 5 ng/kg for the fat samples. Inclusion of half LOD values gave levels of 0.092 and 0.17 ng TEQ/kg fat for beef meat and beef fat, 0.045 and 0.052 ng TEQ/kg fat for lamb/mutton meat and lamb/mutton fat, and 0.43 and 0.17 ng TEQ/kg fat for pork meat and pork fat. PCB #77 was quantified in all samples while PCB #126 was also measured in the beef fat and both pork samples. PCB #169 was only quantified in the pork fat sample. Higher levels and a

[4] In the following discussion, all data reported by Schecter *et al*. (1997) has been converted to fat weight values using the fresh weight concentrations and % fat data provided in the original reference.

greater number of PCB congeners were quantified in all the trimmed meat and fat samples compared to PCDD and PCDF congeners.

The higher levels of PCBs in pork relative to the other meats may reflect the differences in the animals' diets and management. In New Zealand, cattle and sheep are generally grazed on pasture outdoors all year, while pigs are generally housed indoors and fed a wider range of produce.

The concentrations of PCBs reported in a Dutch study of animal fats were 2.4, 2.0 and 0.16 ng TEQ/kg fat for beef, mutton and pork fat (Liem and Theelen, 1997), which are higher than those found in the current study. The Ministry of Agriculture, Fisheries and Food (1997a) reported a level of 0.87 ng TEQ/kg fat for 'carcass meat' sampled in 1992 for a range of 46 congeners. In the USA, Schecter *et al*. (1997) reported levels of 1.07 and 1.20 ng TEQ/kg fat for beef and pork, with PCB # 77, 126 and 169 quantified in both samples. A lower PCB level of 0.06 ng TEQ/kg fat in American pork fat (including PCB #77, #126 and #169) was reported by Lorber *et al*. (1997b) as a result of a national statistical survey.

Lorber *et al*. (1997a) found a less clear relationship for the relative distribution of PCBs in beef fat and muscle than for PCDDs and PCDFs, with the muscle to fat ratios varying between congeners. On a total and TEQ basis, they found PCB levels were higher in intramuscular fat than back fat.

Total PCBs (sum 40 congeners) in Canadian meats, sampled from retail outlets in six cities, have been reported as: 123 - 4188 ng/kg wet weight for beef; 298 - 2362 ng/kg wet weight for pork; and 93 - 1114 ng/kg wet weight for lamb (Newsome *et al*., 1998).

6.3.2 Liver and processed meat products

PCDDs and PCDFs

No PCDDs or PCDFs were quantified in the liver sample. Analytical limits of detection were in the range 0.007 ng/kg (TCDF) to 0.7 ng/kg (OCDD). Inclusion of half LOD values for non-quantified congeners gave a concentration of 0.57 ng I-TEQ/kg fat.

Only non 2,3,7,8-TCDDs were quantified in the processed meat products, with a concentration of 0.089 ng I-TEQ/kg fat if half LOD values were included in the total TEQ calculation. Analytical limits of detection were in the range 0.005 - 1 ng/kg.

The variable nature of the components of these food composites makes comparison with overseas data less straightforward than for some of the other foods. Liem and Theelen (1997) analysed the livers from six different animal species in the Netherlands and found that the PCDD and PCDF levels ranged from 3.3 (chicken) to 61 (horse) ng I-TEQ/kg fat, which were higher than those found in liver samples from the current study. In unspecified 'meat products' they found a level of 0.68 ng I-TEQ/kg fat.

Unspecified 'offal' was analysed in the UK and a level of 9.7 ng I-TEQ/kg fat was reported for samples taken in 1992 (Ministry of Agriculture, Fisheries and Food, 1997a). Schecter *et al*. (1997) reported a level of 1.00 ng I-TEQ/kg fat for hot dog/bologna from a pooled sample collected across the USA, while a range of 0.56 - 0.87 ng I-TEQ/kg fat was reported (Fiedler *et al.,* 1997) for smoked sausage (beef/pork) collected in Southern Mississippi.

PCBs

PCBs were quantified in both the liver and processed meat product samples. Inclusion of half LOD values for non-quantified congeners gave levels of 0.39 ng TEQ/kg fat for liver and 0.091 ng TEQ/kg fat for the processed meat sample. PCB #126 accounted for greater than 90% of the total TEQ of the liver sample.

Levels of PCBs in Dutch chicken liver and 'meat products' were reported at 2.1 and 0.48 ng TEQ/kg fat respectively (Liem and Theelen, 1997). Schecter *et al*. (1997) reported a level of 0.86 ng TEQ/kg fat in a hot dog/bologna sample taken as part of their study of the USA dietary intake. The Ministry of Agriculture, Fisheries and Food (1997a) reported a level of 2.9 ng TEQ/kg fat for 'offals' sampled as part of the UK total diet survey in 1992.

Total PCBs (sum 40 congeners) for Canadian 'organ meats' have been reported as 371 - 1794 ng/kg wet weight and for luncheon and wieners as 0 - 1178 ng/kg wet weight (Newsome *et al.,* 1998).

6.4 Dairy products

Table 6.2 provides a summary of the results obtained for dairy products. Detailed results are given in Tables E2.1 and E2.2 (Appendix E).

Table 6.2 Concentrations (ng/kg) of PCDDs, PCDFs and PCBs in milk and dairy products

	Standard and trim milk	Salted butter	Colby and mild cheese	Ice cream and yoghurt
PCDDs and PCDFs				
Total I-TEQ (wet wt)				
Including half LOD values	0.0021	0.075	0.020	0.014
Excluding LOD values	0.00025	0	0	0
Total I-TEQ (fat wt)				
Including half LOD values	0.16	0.095	0.056	0.26
Excluding LOD values	0.019	0	0	0
PCBs				
Sum of PCB congeners (wet wt)				
Including half LOD values	14.9	514	238	83.6
Excluding LOD values	13.7	493	234	82.6
Total TEQ (wet wt)				
Including half LOD values	0.0020	0.12	0.037	0.0059
Excluding LOD values	0.00035	0.12	0.036	0.0021
Total TEQ (fat wt)				
Including half LOD values	0.15	0.15	0.10	0.11
Excluding LOD values	0.027	0.15	0.10	0.040

6.4.1 Retail dairy milk

PCDDs and PCDFs

The only PCDD and PCDF congeners quantified in the milk sample were 1,2,7,8-TCDF and 2,3,7,8-TCDF at very low levels. Analytical limits of detection were in the range 0.0007 - 0.05 ng/kg.

Inclusion of half LOD values gave a level of 0.16 ng I-TEQ/kg fat (0.0021 ng I-TEQ/kg whole sample), with 88% of the total TEQ derived from non-quantified congeners. These congeners were not measured in any of the other dairy products sampled.

The detection of 1,2,7,8- and 2,3,7,8-TCDF in the milk sample is indicative of bleached paperboard packaging. Although the concentrations measured are markedly lower than concentrations reported previously (Buckland *et al*., 1990; Department of Health, 1989), it is likely that the carton containers are the source of these contaminants (Buckland *et al*., 1990; Department of Health, 1989; Ministry of Health, 1994).

Two previous studies of PCDDs and PCDFs in New Zealand retail milk have been reported. In March-April 1989 the Department of Health undertook a study of PCDDs and PCDFs in milk when concerns were raised over the possible migration of these contaminants from the paperboard packaging. The results showed that PCDDs and PCDFs were virtually undetectable in bulk milk, or in milk packaged in glass bottles or plastic containers (0.005 - 0.007 ng TEQ/kg whole sample basis). However, PCDDs and PCDFs were quantified in milk and cream sold in paperboard packaging. The levels (Nordic[5] TEQs on a whole sample basis) were in the range 0.012 - 0.216 ng TEQ/kg for standard homogenised milk, 0.130 - 0.263 ng TEQ/kg for trim (low fat) milk and 0.138 to 0.432 ng TEQ/kg for cream. The study showed that the PCDDs and PCDFs in the milk and cream originated from the presence of these contaminants in the paperboard packaging (Buckland *et al*., 1990; Department of Health, 1989). As a result of this study, the companies which manufacture paperboard undertook to provide PCDD and PCDF free paperboard for use in the packaging of milks and creams.

A follow-up study (Ministry of Health, 1994) was undertaken in 1989-91 to determine whether PCDD and PCDF levels had fallen as a result of changes to the packaging composition. This study again showed that milk from plastic containers contained only trace levels of PCDDs and PCDFs. The range of levels (Nordic TEQs, whole sample basis) found for milk from paperboard cartons was 0.006 - 0.051 ng TEQ/kg. These values were markedly reduced from the 1989 survey levels.

The PCDD and PCDF levels found in milk in the current study are comparable to those measured in 1994 (Ministry of Health, 1994), and compared to data for overseas retail milk samples, indicates very low background levels of contamination of the New Zealand retail milk supply.

Numerous overseas studies have been undertaken assessing background PCDD and PCDF levels in milk. A value of 4.72 ng I-TEQ/kg fat was reported (Schecter *et al.,* 1997) in a milk sample pooled from 5 locations across the USA, which compares with a level of 0.68 ng I-TEQ/kg fat for a pooled milk sample from Southern Mississippi (Fiedler *et al.,* 1997). A concentration of 1.53 ng I-TEQ/kg fat was reported for German milk in 1992 (Beck *et al*., 1992). In a more recent study (Fürst and Wilmers, 1995) which analysed 120 samples of dairy products from 30 dairies in the North Rhine-Westphalia region, PCDD and PCDF levels ranged from 0.61 - 1.75 ng I-TEQ/kg fat, with a mean of 1.02 ng I-TEQ/kg fat. The products sampled included milk, butter and cheese, and the results were pooled on the basis that there was no significant difference in the concentrations found in the different products.

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[5] Nordic TEFs are the same as the NATO TEFs, with the exception of 1,2,3,7,8-PeCDF, for which the Nordic TEF is 0.01 and the NATO TEF is 0.05.

Liem and Theelen (1997) reported a mean level of 1.3 ng I-TEQ/kg fat in the Dutch milk supply on the basis of 11 regional quarterly averaged samples collected in 1992/3.

In the UK, full fat milk samples available to the consumer in 1995 from 12 locations (Ministry of Agriculture, Fisheries and Food, 1997b) had a PCDD and PCDF level of 0.02 - 0.05 ng I-TEQ/kg fresh weight (0.67 - 1.4 ng I-TEQ/kg fat). In comparison, the PCDD and PCDF levels in samples collected in 1989/90 from rural farms ranged from 1.1-1.5 ng I-TEQ/kg fat, while samples collected from farms in urban/industrial areas ranged from 3.0 - 7.1 ng I-TEQ/kg fat (Ministry of Agriculture, Fisheries and Food, 1992).

During part of routine surveillance of the UK milk supply, samples of milk from two farms in Derbyshire (concentrations of 23 and 37 ng I-TEQ/kg fat) were found to exceed the maximum tolerable concentration (MTC) for PCDDs and PCDFs of 16.6 ng I-TEQ/kg fat (Ministry of Agriculture, Fisheries and Food, 1992). Milk samples were subsequently collected from these farms during 1991-1994 in order to monitor PCDDs and PCDFs. During this period the PCDD and PCDF levels had fallen to below the MTC value, probably as a result of emission control measures instigated in the adjacent industrial area following the detection of elevated PCDD and PCDF levels in 1989/90 (Harrison *et al*., 1996).

A similar declining trend in PCDD and PCDF contamination was observed in milk collected from farms in close proximity to municipal and industrial waste incinerators in Bavaria (Mayer, 1995). The PCDD and PCDF levels dropped from 5.0 - 5.7 ng I-TEQ/kg fat in 1989 to 0.6 - 1.4 ng I-TEQ/kg fat in 1993, compared with the general background levels for Bavaria of 1 ng I-TEQ/kg fat.

Following an investigation of PCDDs and PCDFs in milk in two locations in France with known industrial sources of contamination, a further study of milk from a wider geographical area was conducted in 1996 (Defour *et al*., 1997). The mean of 1.91 ng I-TEQ/kg fat included 2 samples with elevated levels (3.21 and 3.05 ng I-TEQ/kg fat) thought to originate from areas with known industrial emissions (Defour *et al*., 1997).

PCBs

Low levels of PCBs were quantified in the milk sample. Inclusion of half LOD values gave a concentration of 0.15 ng TEQ/kg fat with 82% of the total TEQ derived from non-quantified congeners. The non-*ortho* congeners were not quantified at analytical limits of detection of 0.01 - 0.06 ng/kg.

The Ministry of Agriculture, Fisheries and Food (1997b) reported the first comprehensive analysis for PCBs (including non-*ortho* congeners) in the UK milk supply on the basis of 150 pints of full fat milk collected from 12 locations in England. PCB concentrations were in the range 0.75 - 2.3 ng TEQ/kg fat or 0.03 - 0.08 ng TEQ/kg whole milk. In the USA, milk was analysed for a wide range of PCBs, with a level of 0.02 ng TEQ/kg fresh weight (0.95 ng TEQ/kg fat) reported (Schecter *et al*., 1997). In the Netherlands, Liem and Theelen (1997) found a mean PCB level in consumer milk of 1.4 ng TEQ/kg fat.

Four different types of retail milk collected from six major Canadian cities were analysed for 40 PCB congeners. Concentrations ranged from 65 - 304 ng/kg whole weight for whole milk;

2 - 867 ng/kg whole weight for milk with 2% fat; 1 - 211 ng/kg whole weight for milk with 1% fat; and 0 - 170 ng/kg whole weight for skim milk (Newsome *et al*., 1998).

6.4.2 Butter, cheese and other dairy products

PCDDs and PCDFs

No PCDD and PCDF congeners were quantified in the butter sample. Analytical limits of detection were in the range 0.02 ng/kg (TCDF) - 1 ng/kg (OCDD). Inclusion of half LOD values for non-quantified congeners gave a concentration of 0.095 ng I-TEQ/kg fat. Only non 2,3,7,8-TCDDs and non 2,3,7,8-PeCDDs were quantified in the cheese and the ice cream/yoghurt samples. Inclusion of half LOD values gave levels of 0.056 ng I-TEQ/kg fat and 0.26 ng I-TEQ/kg fat respectively, with non-quantified congeners accounting for 100% of the total TEQ levels determined.

These values are much lower than those found in comparable overseas studies. In the Netherlands, PCDD and PCDF levels have been reported as 1.8 and 1.4 ng I-TEQ/kg fat for butter and cheese respectively (Liem and Theelen, 1997). In pooled samples from across the USA, levels of 0.58, 1.24 and 1.09 ng I-TEQ/kg fat for butter, cheese and ice cream have been reported (Schecter *et al*., 1997), which compare with 0.85 and 0.79 ng I-TEQ/kg fat for butter and cheese samples from Southern Mississippi (Fiedler *et al*., 1997).

In a recent study of French dairy products (Defour *et al*., 1997), PCDD and PCDF levels of 1.01 (mean of 8 samples), 1.11 (mean of 20 samples), and 1.34 (mean of 12 samples) ng I-TEQ/kg fat for butter, cheese and mixed fresh milk desserts (including cream) have been reported. One of the fresh milk dessert samples had an elevated level of 3.15 ng I-TEQ/kg fat, probably reflecting local industrial activity.

PCBs

Similar levels of PCBs were quantified in the butter, cheese and ice cream/yoghurt samples. Inclusion of half LOD values gave a level of 0.15 ng TEQ/kg fat for butter, 0.10 ng TEQ/kg fat for cheese and 0.11 ng TEQ/kg fat for ice cream/yoghurt. These levels reflect the low concentrations of PCB congeners present in the milk sample. Non-quantified congeners accounted for a large proportion of the total TEQ for milk (82%) and ice cream/yoghurt (64%), but only a minor proportion of the total TEQ for butter (6%) and cheese (<1%).

In comparison, concentrations found in butter and cheese from the Netherlands were 2.1 and 1.6 ng TEQ/kg fat respectively (Liem and Theelen, 1997). American dairy products contained 0.55 ng TEQ/kg fat for butter, 0.64 ng TEQ/kg fat for cheese and 0.41 ng TEQ/kg fat for ice cream (Schecter *et al*., 1997). A level of 0.56 ng TEQ/kg fat has been reported for UK dairy products (Ministry of Agriculture, Fisheries and Food, 1997a).

Total PCBs (sum 40 congeners) measured in Canadian dairy products were: 1674 - 6837 ng/kg whole weight for butter; 883 - 2234 ng/kg whole weight for cheddar cheese; 248 - 1069 ng/kg whole weight for ice cream; and 2 - 217 ng/kg whole weight for yoghurt (Newsome *et al*., 1998).

6.5 Fish

Table 6.3 provides a summary of the results obtained for fish and shellfish. Detailed results are given in Tables E3.1 and E3.2 (Appendix E).

Table 6.3 Concentrations (ng/kg) of PCDDs, PCDFs and PCBs in fish

	NZ fish fillets and deep fried fish	Imported tinned fish	NZ oysters and mussels
PCDDs and PCDFs			
Total I-TEQ (wet wt)			
Including half LOD values	0.027	0.12	0.021
Excluding LOD values	0.022	0.11	0.016
Total I-TEQ (fat wt)			
Including half LOD values	0.41	1.82	0.71
Excluding LOD values	0.33	1.67	0.53
PCBs			
Sum of PCB congeners (wet wt)			
Including half LOD values	553	2370	232
Excluding LOD values	552	2360	230
Total TEQ (wet wt)			
Including half LOD values	0.051	0.16	0.028
Excluding LOD values	0.051	0.16	0.028
Total TEQ (fat wt)			
Including half LOD values	0.77	2.42	0.93
Excluding LOD values	0.77	2.42	0.93

PCDDs and PCDFs

A number of 2,3,7,8-chlorinated congeners were measured in the New Zealand fish fillets, namely 1,2,3,7,8-PeCDD, 1,2,3,6,7,8-HxCDD, 2,3,7,8-TCDF, 1,2,3,7,8-PeCDF, 2,3,4,7,8-PeCDF and 1,2,3,4,6,7,8-HpCDF. Inclusion of half LOD values gave a concentration of 0.41 ng I-TEQ/kg fat, with only 20% of the total TEQ derived from non-quantified congeners.

Inclusion of deep-fried fish in the sample may have raised the total TEQ slightly, with both the cooking fat and the cooking process potentially affecting the concentration and congener profile (Körner and Hagenmaier, 1990).

The profile of the imported tinned fish differed from that of the New Zealand fish; several 2,3,7,8-HxCDD and HxCDF congeners not found in the New Zealand sample were measured in the imported product. The concentration of PCDDs and PCDFs in the imported tinned fish was markedly higher at 1.82 ng I-TEQ/kg fat.

The levels in the New Zealand shellfish sample (0.71 ng I-TEQ/kg fat) were slightly higher than those in the New Zealand finfish sample, but lower than those in the imported tinned fish sample. Only one of the three 2,3,7,8-PeCDD/PeCDF congeners was quantified in the shellfish (1,2,3,7,8-PeCDD), as was 1,2,3,4,6,7,8-HpCDD. OCDD was also quantified in the shellfish sample but was not quantified in either of the New Zealand finfish or imported tinned fish samples.

Liem and Theelen (1997) reported PCDD and PCDF levels of 49 ng I-TEQ/kg fat in 'lean sea fish' available to the Dutch consumer in 1990-91, with all congeners above the LOD. Schecter *et al*. (1997) reported a level of 17.9 ng I-TEQ/kg fat for ocean fish available to consumers in the USA, while Fiedler *et al.* (1997) found a mean level of 24.4 ng I-TEQ/kg fat in samples of American oysters and a range of 1.19- 27.8 ng I-TEQ/kg fat for ocean fish collected from supermarkets in Southern Mississippi. In the UK, fish sampled from 24 locations in 1992 had a level of 2.7 ng I-TEQ/kg fat (Ministry of Agriculture, Fisheries and Food, 1997a). In Germany, Beck *et al.* (1992) have reported PCDD and PCDF levels in the range of 31 - 43 ng I-TEQ/kg fat for herring, cod and redfish.

A recent study (Musanaga *et al*., 1997) of Japanese seafood reported a range of 0.32 - 2.07 ng I-TEQ/kg fresh weight for 6 inshore fish species, 3.56 ng I-TEQ/kg fresh weight for cockles and 2.56 ng I-TEQ/kg fresh weight for crab.

PCDDs and PCDFs in fish oils consumed as a dietary supplement have been reported with a mean PCDD and PCDF level of 2.11 ng I-TEQ/kg fat in Spain (Jiménez *et al.,* 1996b) and means of 2.64 and 13.31 ng FHO-TEQ/kg fat for German salmon and cod liver oil (Fürst *et al*., 1990).

PCBs

The New Zealand fish sample had lower levels of PCBs (0.77 ng TEQ/kg fat) compared to the imported tinned fish sample (2.42 ng TEQ/kg fat). PCB levels in the shellfish sample (0.93 ng TEQ/kg fat) were comparable to those of the New Zealand fish fillets. PCB # 77, #126 and #169 were quantified in all three samples, with higher levels of PCB #77 and #126 found in the imported fish sample compared to the domestic samples. In all three samples <1% of the total TEQ was derived from non-quantified congeners.

PCB concentrations (sum of 40 congeners) have been reported for a number of Canadian retail fish samples on a wet weight basis: 757 - 8832 ng/kg for marine fish; 2399 - 4251 ng/kg for tinned fish; and 177 - 4558 ng/kg for shellfish (Newsome *et al.,* 1998). The PCB levels of imported tinned fish sampled in New Zealand fall within the range reported in this Canadian study. This finding is not unexpected given that half the samples included in the tinned fish composite were of Canadian origin (Table B2, Appendix B).

Analysis of Dutch fish samples gave a mean PCB level of 103 ng TEQ/kg fat for 'lean sea fish' and 11 ng TEQ/kg fat for 'fatty sea fish' on the basis of PCB #77, #126 and #169 (Liem and Theelen, 1997). Schecter *et al.* (1997) found a level of 15.4 ng TEQ/kg fat for a pooled sample of ocean fish in the USA. A level of 5.3 ng TEQ/kg fat has been reported for fish sampled as part of the UK total diet survey in 1992 (Ministry of Agriculture, Fisheries and Food, 1997a). Jimènez *et al.* (1996b) reported a mean non-*ortho* PCB level of 0.31 ng TEQ/kg fat for fish oils available in Spain.

6.6 Poultry and eggs

Table 6.4 provides a summary of the results obtained for poultry and eggs. Detailed results are given in Tables E4.1 and E4.2 (Appendix E).

Table 6.4 Concentrations (ng/kg) of PCDDs, PCDFs and PCBs in poultry and eggs

	Chicken	Eggs
PCDDs and PCDFs		
Total I-TEQ (wet wt)		
Including half LOD values	0.0072	0.012
Excluding LOD values	0.00093	0.0017
Total I-TEQ (fat wt)		
Including half LOD values	0.29	0.12
Excluding LOD values	0.037	0.017
PCBs		
Sum of PCB congeners (wet wt)		
Including half LOD values	27.0	142
Excluding LOD values	22.0	141
Total TEQ (wet wt)		
Including half LOD values	0.0036	0.010
Excluding LOD values	0.00044	0.0049
Total TEQ (fat wt)		
Including half LOD values	0.14	0.11
Excluding LOD values	0.018	0.050

PCDDs and PCDFs

A number of congeners were quantified in both the chicken meat and egg samples. The congener profiles were similar for both samples, with low levels of 1,2,3,4,6,7,8-HpCDD and OCDD measured, in addition to non 2,3,7,8-chlorinated congeners. Analytical limits of detection were typically in the range 0.001 - 0.007 ng/kg for the chicken sample and 0.003 - 0.03 ng/kg for the egg sample. Inclusion of half LOD values gave levels of 0.29 ng I-TEQ/kg fat for chicken meat and 0.12 ng I-TEQ/kg fat for eggs, with non-quantified congeners contributing approximately 86% of the total I-TEQ levels determined.

The levels of PCDDs and PCDFs in eggs sampled in the Netherlands during 1987-88 were reported as 2.0 ng I-TEQ/kg fat (Liem and Theelen, 1997). Theelen *et al.* (1993) reported levels in poultry of 1.65 ng I-TEQ/kg fat for samples collected over the same period. In the UK in 1992 (Ministry of Agriculture, Fisheries and Food, 1997a), levels in poultry and eggs were measured at 1.7 and 1.7 ng I-TEQ/kg fat. Schecter *et al.* (1997) reported 3.4 ng I-TEQ/kg fat for chicken and 2.14 ng I-TEQ/kg fat for eggs sampled from across the USA, which compares with 0.70 and 0.23 ng I-TEQ/kg fat for chicken and egg samples from Southern Mississippi (Fiedler *et al.,* 1997).

In a national survey of abdominal poultry fat in the USA, Ferrario *et al.* (1997) measured a mean level of 0.64 ng I-TEQ/kg fat for young chickens, which comprise approximately 94% of poultry slaughtered in the USA. Inclusion of two high outliers in the results raised the mean to 1.77 ng I-TEQ/kg fat. In their analysis of samples of poultry fat collected as part of a nationwide survey in 1990, Liem and Theelen (1997) measured a mean concentration of 1.6 ng I-TEQ/kg fat. Only two of the 2,3,7,8-chlorinated congeners were not quantified, namely, 1,2,3,7,8,9-HxCDF and 1,2,3,4,,7,8,9-HpCDF.

PCBs

Low levels of PCBs were quantified in both the chicken and egg samples, 0.14 and 0.11 ng TEQ/kg fat respectively. If half LOD values for non-quantified congeners were excluded from the

TEQ calculation, the egg sample had slightly higher PCB levels than the chicken sample, as a result of a larger number of congeners being quantified in the egg sample.

These values are much lower than those found in samples in the Netherlands, reported as 2.0 ng TEQ/kg fat for poultry (Theelen *et al.,* 1993) and 1.8 ng TEQ/kg fat for eggs (Liem and Theelen, 1997). In the USA, PCB levels measured in eggs were 2.21 ng TEQ/kg fat and 0.29 ng TEQ/kg fat for poultry (Schecter *et al.,* 1997), which contrasts with a mean level of 0.28 ng TEQ/kg fat for samples of abdominal poultry fat collected from slaughterhouses as part of a national survey (Ferrario *et al.,* 1997). The Ministry of Agriculture, Fisheries and Food (1997a) reported similar levels in poultry and eggs, 0.93 and 0.97 ng TEQ/kg fat respectively, for samples collected as part of the UK total diet survey in 1992.

In Canada, PCBs (sum of 40 congeners) have been measured in poultry (160 -753 ng/kg whole weight) and eggs (414 - 1719 ng/kg whole weight) (Newsome *et al.,*1998).

6.7 Cereals

Table 6.5 provides a summary of the results obtained for cereals. Detailed results are given in Tables E5.1 and E5.2 (Appendix E).

Table 6.5 Concentrations (ng/kg) of PCDDs, PCDFs and PCBs in cereal products

	Bread	Cereals, cake, biscuits, rice and spaghetti
PCDDs and PCDFs		
Total I-TEQ (wet wt)		
Including half LOD values	0.0059	0.0099
Excluding LOD values	0.0012	0.0027
Total I-TEQ (fat wt)		
Including half LOD values	0.66	0.19
Excluding LOD values	0.13	0.051
PCBs		
Sum of PCB congeners (wet wt)		
Including half LOD values	43.0	70.1
Excluding LOD values	41.8	69.2
Total TEQ (wet wt)		
Including half LOD values	0.0040	0.0027
Excluding LOD values	0.00099	0.0017
Total TEQ (fat wt)		
Including half LOD values	0.45	0.051
Excluding LOD values	0.11	0.032

PCDDs and PCDFs

Very low levels of PCDDs and PCDFs were quantified in the bread and cereal samples. Analytical limits of detection were in the range 0.001 - 0.02 ng/kg. Inclusion of half LOD values gave a level of 0.0059 ng I-TEQ/kg whole sample (0.66 ng I-TEQ/kg fat) for bread and 0.0099 ng I-TEQ/kg whole sample (0.19 ng I-TEQ/kg fat) for the mixed cereal sample. For the bread sample, 80% of the total TEQ was derived from non-quantified congeners, while these congeners contributed 73% of the total TEQ for the cereal sample. The only 2,3,7,8-chlorinated congeners quantified

were OCDD and OCDF in the bread, and 1,2,3,4,6,7,8-HpCDD and OCDD in the cereal sample. Some non 2,3,7,8-chlorinated PCDD congeners were also quantified in the bread and cereals.

The most likely source of PCDDs and PCDFs in these products is the added fats, for example in biscuits or bread. However, levels measured in rye and wheat grains and wheat flour available in the Netherlands of 0.010 - 0.015 ng I-TEQ/kg whole weight basis[6] (0.74 - 0.85 ng I-TEQ/kg fat) (Liem and Theelen, 1997) were similar to those found for the processed cereal product samples in this study.

In the UK, levels of 1.4 and 2.4 ng I-TEQ/kg fat were estimated for bread and cereal samples from the 1992 total diet survey (Ministry of Agriculture, Fisheries and Food, 1997a).

PCBs

PCBs were quantified in both the bread and mixed cereal samples at levels of 0.0040 and 0.0027 ng TEQ/kg whole sample (0.45 and 0.051 ng TEQ/kg fat) respectively, which included PCB #77 plus a range of mono-*ortho* and di-*ortho* congeners.

Liem and Theelen (1997) reported levels of PCBs in grains and flour ranging from 0.19 - 1.2 ng I-TEQ/kg fat based on analysis of PCB #77, #126 and #169. In the UK, levels in bread and cereal samples have been estimated at 0.67 ng TEQ/kg fat and 0.36 ng TEQ/kg fat (Ministry of Agriculture, Fisheries and Food 1997a).

6.8 Other foods

Table 6.6 provides a summary of the results obtained for other miscellaneous foods sampled. Detailed results are given in Tables E6.1 and E6.2 (Appendix E).

6.8.1 Potatoes

PCDDs and PCDFs

The potato composite sample included boiled potatoes and deep-fried hot chips. A range of PCDD and PCDF congeners were quantified in this food type composite sample, which had an I-TEQ level of 0.16 ng I-TEQ/kg whole sample basis (0.42 ng I-TEQ/kg fat). The analytical limits of detection for non-quantified congeners ranged from 0.001 - 0.009 ng/kg.

This is an unexpected result given that vegetables are generally not considered to bioaccumulate PCDDs and PCDFs (Kew *et al.,* 1989). The inclusion of deep-fried potato chips in the sample is likely to be the cause of the PCDDs and PCDFs measured. The tetrafuran congener profile obtained for this sample showed the presence of a number of congeners in a pattern frequently associated with combustion sources. This might be explained by the formation of PCDDs and PCDFs during the cooking process, a finding consistent with that reported by Körner and Hagenmaier (1990). The use of animal-based fats (commonly derived from beef tallow in New Zealand) for deep frying is another possible reason for the higher than expected result for the

[6] Fresh weight values were calculated from fat weight and % fat data from the original report (Liem and Theelen, 1997).

potato sample. A similar finding of increased PCDDs and PCDFs in potatoes after frying in lard (pork fat) has also been reported by Schecter and Päpke (1998).

Table 6.6 Concentrations (ng/kg) of PCDDs, PCDFs and PCBs in other miscellaneous foods

	Potatoes and hot chips	Snack foods	Vegetable fats and oils
PCDDs and PCDFs			
Total I-TEQ (wet wt)			
Including half LOD values	0.016	0.044	0.034
Excluding LOD values	0.012	0.013	0
Total I-TEQ (fat wt)			
Including half LOD values	0.42	0.17	0.041
Excluding LOD values	0.32	0.049	0
PCBs			
Sum of PCB congeners (wet wt)			
Including half LOD values	52.1	162	37.9
Excluding LOD values	51.4	156	0
Total TEQ (wet wt)			
Including half LOD values	0.0025	0.014	0.013
Excluding LOD values	0.0012	0.0025	0
Total TEQ (fat wt)			
Including half LOD values	0.066	0.053	0.016
Excluding LOD values	0.032	0.0094	0

There are relatively few international data on levels of PCDDs and PCDFs in vegetables in general or potatoes in particular. Some studies have analysed composite samples of fruit and/or vegetables, making it difficult to attribute the source of contaminants to any particular component of the sample (Beck *et al*., 1989).

Foxall *et al.* (1995) collected samples of apples, courgettes, lettuce and potatoes from urban areas within a 1.5 km radius of a chemical waste incinerator in Wales, and from rural 'control' sites in south and mid Wales and south Herefordshire. They found no statistically significant differences between levels in the urban and rural samples, with overlapping ranges for each food item. On a fresh weight basis, the levels of PCDDs and PCDFs were 0.1 - 0.9 ng I-TEQ/kg in apples (n=9), 0.1 - 06 ng I-TEQ/kg in courgettes (n=5), 0.1 - 0.3 ng I-TEQ/kg for lettuce (n=5), and 0.2 - 0.5 ng I-TEQ/kg for potatoes (n=7). The most frequently measured congeners were the hepta and octa PCDDs and PCDFs. Foxall *et al.* (1995) also concluded that there was no obvious difference between levels in fruit and vegetables exposed to atmospheric deposition and those harvested from below ground. However, they also mentioned that the small sample size mitigated against finding a statistically significant difference.

In contrast to the study undertaken by Foxall *et al.* (1995), a level of 0.04 ng I-TEQ/kg fresh weight was reported for potatoes in the UK as part of the 1988 total diet survey (Ministry of Agriculture, Fisheries and Food, 1992). The result for the current New Zealand study falls between the two values reported for potatoes by these two UK studies.

Birmingham *et al*. (1989b) analysed potatoes available to the consumer in Ontario and measured total PCDD and PCDF levels of 3 ng/kg fresh weight. This level is higher than found in the current study for the sum of PCDDs and PCDFs of 1.92 ng/kg. The LOD was typically 1 ng/kg compared to the limits of detection for individual congeners in the current study of 0.001 - 0.009 ng/kg.

PCBs

PCBs were quantified in the potato sample at low levels of 0.0025 ng TEQ/kg whole sample (0.066 ng TEQ/kg fat) including half LOD values. Approximately 50% of the total TEQ was derived from non-quantified congeners. The sum of 23 PCBs was 52.1 ng/kg on a whole sample basis.

As part of the Welsh study described earlier, Foxall *et al.* (1995) also measured levels of 18 PCBs (including non-*ortho* congeners*)* in the same fruit and vegetable samples. On a fresh weight basis, they reported levels of 0.5 - 6.6 µg/kg for apples, 0.8 - 2.7 µg/kg for courgettes, 0.1 - 2.3 µg/kg and 0.5 - 1.8 µg/kg for potatoes. As for the PCDD and PCDF results, no obvious differences were found between PCB levels in the urban and rural samples, possibly as a result of small sample sizes (Foxall *et al*., 1995).

Levels of PCBs in Canadian 'french fries' have been reported as 111 - 1105 ng/kg whole weight (Newsome *et al.,* 1998). The authors attributed these values, which were higher than would be expected for vegetable produce, to the use of animal fats for deep frying.

6.8.2 Snack foods

PCDDs and PCDFs

Several 2,3,7,8-chlorinated congeners were quantified in the snack food sample, namely, 1,2,3,4,6,7,8-HpCDD, OCDD and OCDF, along with non 2,3,7,8- PCDD and PCDF congeners. Inclusion of half LOD values gave a level of 0.17 ng I-TEQ/kg fat, with approximately 70% of the total TEQ derived from non-quantified congeners. The PCDD and PCDF levels found in this sample are likely to be a reflection of the relatively high fat content of these foods (26.6%, refer to Table E1.0, Appendix E).

There are no other reported studies of PCDD and PCDF levels in similar snack foods. However, Liem and Theelen (1997) analysed a range of vegetable oils and fats commonly used by the food processing industry in the Netherlands in 1987-88 and calculated a level of 0.17 ng I-TEQ/kg fat for a representative mixture of oils and fat, with 1,2,3,4,6,7,8-HpCDD and OCDD being the most abundant congeners present.

PCBs

A number of PCB congeners were quantified in the snack food sample. Inclusion of half LOD values gave a level of 0.053 ng TEQ/kg fat, with 82% of the total derived from non-quantified congeners. This value is slightly higher than levels in vegetable oils used in the food industry in the Netherlands (0.03 ng TEQ/kg fat, Liem and Theelen, 1997). However, with the inclusion of milk chocolate in the snack food sample, it is likely that there was also some animal fat present.

6.8.3 Vegetable fats and oils

PCDDs and PCDFs

No PCDDs and PCDFs were quantified in the vegetable oil sample. Inclusion of half LOD values resulted in a PCDD and PCDF concentration of 0.041 ng I-TEQ/kg fat, which is lower than values reported overseas. Analytical limits of detection were between 0.01 - 0.2 ng/kg, excluding OCDD which had a LOD of 2 ng/kg.

Liem and Theelen (1997) sampled a range of vegetable fats and oils of varying geographical origin and found PCDD and PCDF levels in the range 0.16 - 0.18 ng I-TEQ/kg fat (with 0.15 ng I-TEQ/kg fat as the LOD). Most congeners were below the limit of detection (<0.5 ng/kg fat) in German samples of margarine and salad oil, with the exception of 1,2,3,4,6,7,8-HpCDD, OCDD and OCDF (Fürst *et al.,* 1990).

PCBs

All PCB congeners were below the limit of detection in the oil composite. Inclusion of half LOD values for non-quantified congeners gave a level of 0.016 ng TEQ/kg fat. Analytical limits of detection were in the range 0.2 - 0.4 ng/kg for non-*ortho* congeners and 0.3 - 20 ng/kg for other congeners.

Liem and Theelen (1997) analysed vegetable fats and oils and reported a level of 0.03 ng TEQ/kg fat when LOD values were included. Levels (sum of 40 congeners) of 224 - 3431 ng/kg whole weight have been reported for Canadian margarine and 347 - 1628 ng/kg whole weight for unspecified fats and oils (Newsome *et al*., 1998).

7 Assessment of dietary intake of PCDDs, PCDFs and PCBs

7.1 Selection of diets for estimation of intake

Two diets were chosen to examine the likely dietary intakes of PCDDs, PCDFs and PCBs by New Zealanders:

- adult male (25-44 years old) 10.8 MJ/day diet, median energy (50th centile) intake
- adolescent male (15-18 years old) 21.5 MJ/day diet, high energy (90th centile) intake

The choice of these age-sex categories was based on the categories used to classify data in the LINZ survey (Wilson *et al*., 1992). The energy content of each of these diets and the amounts of energy that each food or food type contributed to the total energy were also calculated primarily from data in the LINZ survey. Table D1 (Appendix D) shows the energy contributed by each food type composite in this study. Some amendments were made to the LINZ data for the purposes of this study (refer to Appendix D) to take into account the inclusion of specific foods likely to be sources of PCDDs, PCDFs and PCBs, such as liver and imported tinned fish.

As previously noted, the Ministry of Health is currently funding a comprehensive survey of the eating habits and health characteristics of New Zealanders. The information from this survey will allow further dietary assessments of exposures to PCDDs, PCDFs and PCBs for other consumer groups such as adolescent and adult women and for older adults to be undertaken.

7.1.1 Median energy (50th centile) intake consumer

An adult male diet using the median energy intake for this age was the first category chosen. Median energy in the diets of men has been reported as 10.8 MJ/day and for women as 6.9 MJ/day (Horwath, 1991). Men were chosen for this study because their higher energy intakes endear greater possible exposure.

7.1.2 High energy (90th centile) intake consumer

An adolescent male eating a high-energy diet (21.5 MJ/day – 90th centile energy intake) (Horwath, 1991) was chosen for this category since young males tend to eat more food than any other age-sex group in the population. The LINZ survey data did not provide a breakdown of specific foods contributing to the 90th centile energy consumer. The survey did, however, report the percentage distribution of energy provided by each food in this 15-18 year old age-sex category. The total energy intake (21.5 MJ/day) was therefore proportioned against the percentage energy intakes for each individual food type, and from this the weights of each food type consumed were derived.

7.2 Estimated dietary exposure for New Zealanders

Exposures to PCDDs, PCDFs and PCBs estimated for an adult male consuming a median-energy diet (10.8 MJ/day) and an adolescent male consuming a high-energy diet (21.5 MJ/day) are summarised in Tables 7.1 and 7.2. Dietary intakes were calculated from the amounts of each food consumed and using concentration data for the PCDDs and PCDFs as I-TEQ levels and for the

PCBs as PCB TEQ levels. Calculations were made both excluding the limit of detection (LOD) values and including half the LOD values when values were below the LOD.

Table 7.1 Summary of the estimated daily intake of PCDDs, PCDFs and PCBs for an adult male consuming 10.8 MJ/day (pg TEQ/day)

Food group	Calculated intake of PCDDs and PCDFs (whole weight)		Calculated intake of PCBs (whole weight)		Calculated total intake of PCDDs, PCDFs and PCBs (whole weight)	
	Inc. half LOD	Exc. LOD	Inc. half LOD	Exc. LOD	Inc. half LOD	Exc. LOD
Meat	4.94	0.01	4.68	2.24	9.62	2.25
Dairy	2.30	0.07	2.75	2.12	5.05	2.19
Fish	1.71	1.45	2.77	2.77	4.48	4.22
Poultry and eggs	0.73	0.10	0.50	0.19	1.23	0.29
Cereals	1.94	0.47	0.89	0.33	2.83	0.80
Other foods	2.91	1.62	0.64	0.18	3.55	1.80
TOTAL	**14.5**	**3.72**	**12.2**	**7.83**	**26.7**	**11.5**

Table 7.2 Summary of the estimated daily intake of PCDDs, PCDFs and PCBs for an adolescent male consuming 21.5 MJ/day (pg TEQ/day)

Food group	Calculated intake of PCDDs and PCDFs (whole weight)		Calculated intake of PCBs (whole weight)		Calculated total intake of PCDDs, PCDFs and PCBs (whole weight)	
	Inc. half LOD	Exc. LOD	Inc. half LOD	Exc. LOD	Inc. half LOD	Exc. LOD
Meat	7.20	0.01	6.42	2.73	13.62	2.74
Dairy	5.40	0.23	6.29	4.44	11.69	4.67
Fish	3.42	2.89	5.51	5.51	8.93	8.40
Poultry and eggs	0.84	0.11	0.65	0.19	1.49	0.30
Cereals	4.85	1.20	2.05	0.83	6.90	2.03
Other foods	8.95	5.38	1.85	0.60	10.80	5.98
TOTAL	**30.6**	**9.82**	**22.7**	**14.3**	**53.3**	**24.1**

A detailed breakdown of contributions by food types to the dietary intakes of PCDDs, PCDFs and PCBs is provided in Table F1 (adult male, median energy diet) and Table F2 (adolescent male, high energy diet) (Appendix F).

The differences in consumption patterns underlying the calculations of dietary intakes for the two diets is shown in Table 7.3. While the 21.5 MJ/day diet may seem bulky, the need for consumers of high-energy diets to eat large quantities of food to meet their energy requirements is well known. This is particularly the case for adolescent males who are still growing and are often involved in high-energy sporting activities.

Because of the very low levels of PCDDs and PCDFs quantified in the food samples, inclusion of half LOD values in the total TEQ has a marked effect on the estimated dietary intake. For example, for an adult male, the calculated PCDD and PCDF intake from meats varies from 0.01 pg I-TEQ/day if LOD values are excluded to 4.94 pg I-TEQ/day if half LOD values are included. The intakes are

Table 7.3 Daily consumption of the food types for each diet

Food type composite	Daily consumption (g/day)	
	Adult male 10.8 MJ/day diet	Adolescent male 21.5 MJ/day diet
Beef meat	110	218
Sheep meat	28	28
Pork meat	26	17
Beef fat	15	15
Sheep fat	4	4
Pork fat	7	7
Liver	13	26
Processed meat products	81	143
Milk	278	923
Butter	11	22
Cheese	19	38
Ice cream/yoghurt	39	77
New Zealand fish	32	64
Imported tinned fish	5	10
Shellfish	10	20
Poultry	46	60
Eggs	34	34
Bread	151	301
Cereals	107	310
Vegetable fats/oils	10	14
Potatoes and hot deep-fried chips	119	396
Snack foods	15	49

less variable for fish and the 'other foods' group where a greater range of PCDD and PCDF congeners were quantified.

Similarly, PCB congeners were more frequently quantified in the food samples, therefore inclusion of half LOD values for non-detected congeners in the total TEQ calculations had a lesser effect on estimates of dietary intake.

These dietary intakes can also be expressed as an 'amount per kg of body weight (bw) per day'. The LINZ survey found that the mean body weight of adult males aged 25-44 years was 79.8 kg, and of adolescent males aged 15-18 years was 68.7 kg (Wilson *et al*., 1993). Rounding these body weights to 80 kg for adult males and 70 kg for adolescent males, PCDD and PCDF dietary intakes have been calculated (including half LOD values) of 0.18 and 0.44 pg I-TEQ/kg bw/day respectively (Table 7.4). Similarly, for the PCBs, dietary intakes have been calculated (including half LOD values) of 0.15 and 0.32 pg TEQ/kg bw/day (Table 7.4).

Table 7.4 Dietary intake of PCDDs, PCDFs, and PCBs per kilogram of body weight for an 80 kg adult male and a 70 kg adolescent male

	Calculated intake of PCDDs and PCDFs (whole weight)		Calculated intake of PCBs (whole weight)		Calculated total intake of PCDDs, PCDFs and PCBs (whole weight)	
	Inc. half LOD	Exc. LOD	Inc. half LOD	Exc. LOD	Inc. half LOD	Exc. LOD
Adult male (80 kg)	0.18	0.047	0.15	0.098	0.33	0.15
Adolescent male (70 kg)	0.44	0.14	0.32	0.20	0.76	0.34

7.2.1 Contribution of the food groups to dietary intake for a 10.8 MJ/day diet

The relative contributions of each food group to the total daily intake of PCDDs and PCDFs for a 10.8 MJ/day diet are shown in Figure 7.1 and PCBs in Figure 7.2, based on calculations which include half LOD values for non-detected congeners.

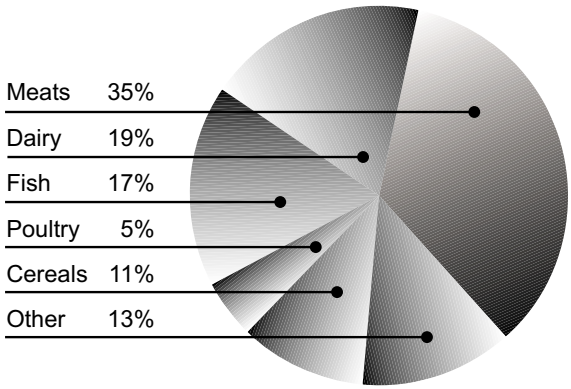

Figure 7.1 Contribution of food groups to the estimated daily intake of PCDDs and PCDFs (I-TEQ including half LOD) for a 10.8 MJ/day diet

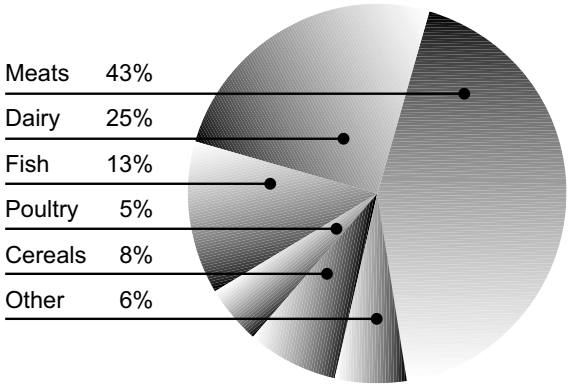

Figure 7.2 Contribution of food groups to the estimated daily intake of PCBs (TEQ including half LOD) for a 10.8 MJ/day diet

The meat group contributed most to the dietary intake of both PCDDs and PCDFs, and PCBs. Within the meat group, the processed meat group contributed most to the PCDD and PCDF and PCB intakes at 1.13 pg I-TEQ/day for both.

Butter was the main contributor in the dairy group to exposure to both PCDDs and PCDFs, at 0.79 pg I-TEQ/day, and PCBs, at 1.26 pg TEQ/day. This is a result of the higher TEQ levels in butter (based on inclusion of half LOD values; Table E2.1, Appendix E) relative to the other products analysed, although it is the dairy product consumed in the lowest amount on a daily basis.

In the fish group, the New Zealand fish sample contributed most to the daily intake of PCDDs and PCDFs at 0.87 pg I-TEQ/day and PCBs at 1.65 pg TEQ/day. Although the contaminant levels in imported tinned fish were higher than those in New Zealand fish, the quantities of tinned fish consumed were lower.

7.2.2 Contribution of the food groups to dietary intake for a 21.5 MJ/day diet

The relative contributions of each food group to the total daily intake of PCDDs and PCDFs for a 21.5 MJ/day diet are shown in Figure 7.3 and PCBs in Figure 7.4, based on calculations which include half LOD values for non-detected congeners.

The 'other foods' group was the main contributor to the intake of PCDDs and PCDFs for this diet. Within the 'other foods' group, potatoes/hot chips accounted for 6.34 pg I-TEQ/day, with the amount consumed dominating the calculation. The 'other foods' group accounted for a greater proportion (29%) of total daily intake of PCDDs and PCDFs than in the 10.8 MJ/day diet (13%).

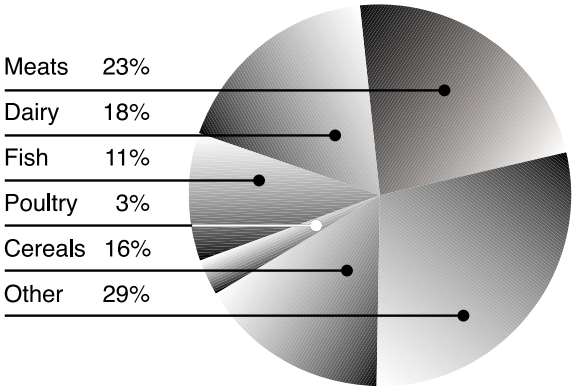

Figure 7.3 Contribution of food groups to the estimated dietary intake of PCDDs and PCDFs (I-TEQ including half LOD) for a 21.5 MJ/day diet

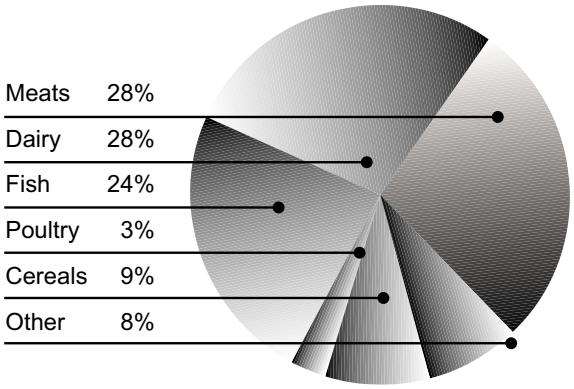

Figure 7.4 Contribution of food groups to the estimated dietary intake of PCBs (TEQ including half LOD) for a 21.5 MJ/day diet

Meats contributed the most to the PCB intake, with processed meats contributing the most to the total for this group at 2.00 pg TEQ/day. Proportionally, meats were a less important source of PCDDs, PCDFs and PCBs in the 21.5 MJ/day diet than in the 10.8 MJ/day diet, largely as a result of the increased volumes of other foods consumed.

In contrast to the 10.8 MJ/day diet, in which butter was the main contributor to PCDD and PCDF intake from the dairy group, milk was the main source of PCDDs and PCDFs in the dairy group. As for the potato group, it is the amount consumed which accounts for this finding. An adolescent male is estimated to consume approximately three times the amount of milk consumed by an adult male.

Due to higher estimated consumption of fish by adolescents relative to adults, the fish group as a whole accounted for 24% of the total daily intake of PCBs, compared to 13% of the total daily intake of an adult male. The New Zealand fish sample was the main contributor to intake from the fish group.

7.3 International dietary studies

The daily intake of PCDDs and PCDFs from food has been reported for Canada (Birmingham *et al*., 1989a), Germany (Beck *et al*., 1992), the Netherlands (Liem and Theelen, 1997), the United Kingdom (Ministry of Agriculture, Fisheries and Food 1995, 1997a) and the United States (Schecter *et al*., 1994, 1997), using similar methods to those used in this study, i.e., by multiplying food consumption by the concentrations of contaminants measured in food samples. These are summarised in Table 7.5, along with the intakes estimated from the current dietary study.

A key consideration in comparing intakes based on an 'amount per body weight per day' is the actual body weight used in the particular study. For example, in the studies detailed Table 7.5, body weights varied from a 60 kg person (Canada and the United Kingdom) up to 80 kg for the current dietary study. The body weights used in this study of 80 kg for an adult male (25-44 years) and 70 kg for an adolescent male (15-18 years) were based on the mean body weights found for these age-sex categories in the LINZ survey (Wilson *et al*., 1993). It is not clear whether the body weights used in overseas studies are representative of a particular age-sex category or are an

average for both 'adult' males and females. For example, in New Zealand, the average body weight of females (>25 years) is 65 kg compared to 80 kg for males of the same age category. However, it would be expected that females would consume proportionally less than males and therefore have a lower exposure to PCDDs, PCDFs and PCBs. Alternatively, use of 65 kg in the calculations would result in a higher estimate of daily exposure, as is the case in the comparative studies reported here.

Table 7.5 Estimated dietary intakes of PCDDs, PCDFs and PCBs in New Zealand and other countries

Country	Diet	Body wt (kg)	Intake of PCDDs and PCDFs	Intake of PCBs
New Zealand (this study)	adult male (10.8 MJ/day)	80	14.5 pg I-TEQ/ person/day (0.18 pg I-TEQ/kg bw/day) (<LOD= ½ LOD)	12.2 pg TEQ/kg bw/day (0.15 pg TEQ/kg bw/day) (<LOD= ½ LOD)
	adolescent male (21.5 MJ/day)	70	30.6 pg I-TEQ/ person/day (0.44 pg I-TEQ/kg bw/day) (<LOD= ½ LOD)	22.7 pg TEQ/kg bw/day (0.32 pg TEQ/kg bw/day) (<LOD= ½ LOD)
Canada (Birmingham *et al*., 1989a)	'average'	60	139.7 pg I-TEQ/person/day (<LOD=LOD)	
(Newsome *et al*., 1998)		60		0.11 pg/kg bw/day (based on sum of congeners)
Germany (Beck *et al*., 1992)	'average'		130 pg I-TEQ/person/day (<LOD=½ LOD)	
Netherlands (Liem and Theelen, 1997)	median adult		65 pg I-TEQ/person/day (1.1 pg I-TEQ/kg bw/day)	70 pg TEQ/person/day (1.2 pg TEQ/kg bw/day)
	95%ile adult		159 pg I-TEQ/person/day (3.1 pg I-TEQ/kg bw/day)	183 pg TEQ/person/day (3.6 pg TEQ/kg bw/day)
United Kingdom (MAFF[1], 1997a)	'average' adult	60	90 pg I-TEQ/ person/day (1.5 pg I-TEQ/kg bw/day) (<LOD=LOQ)	54 pg TEQ/person/day) (0.9 pg TEQ/kg bw/day) (<LOD=LOQ)
	97.5%ile adult		156 pg I-TEQ/person/day (2.6 pg I-TEQ/kg bw/day) (<LOD=LOQ)	102 pg TEQ/person/day (1.7 pg TEQ/kg bw/day) (<LOD=LOQ)
United States (Schecter *et al*., 1994)	15-19 yr male	67	30-737 pg I-TEQ/person/day[2] (0.4-11 pg I-TEQ/kg bw/day)[2] (<LOD= ½ LOD)	
	>20 yr male	70	19-553 pg I-TEQ/person/day[2] (0.3-8pg I-TEQ/kg bw/day)[2] (<LOD= ½ LOD)	
	'average' adult	65	18-192 pg I-TEQ/person/day[2] (0.3-3.0 pg I-TEQ/kg bw/day[2] (<LOD= ½ LOD)	
(Schecter *et al*., 1996)	average adult	65		65 pg TEQ/person/day (1.0 pg TEQ/kg bw/day) (<LOD= ½ LOD)

1. Ministry of Agriculture, Fisheries and Food (MAFF).
2. Low values represent a diet containing items with low PCDD and PCDF levels - high values represent a diet containing food items with high PCDD and PCDF levels. The differences are largely due to differing patterns of consumption and type of meat consumed.

Less information is available on the dietary intake of PCB congeners, and the non-*ortho* congeners in particular. Direct comparison of PCB intake between different diets is difficult given the differences in analytical methods used and the range of congeners being assessed. It is only recently that the non-*ortho* congeners have been included in some studies due to the analytical complexities in

measuring these contaminants. Because the non-*ortho* PCBs are the main contributors to dioxin-like toxicity, studies which have not included their analysis have been largely omitted from this report.

In the United States, a PCB intake of up to approximately 1 pg TEQ/kg body wt/day (for a 65 kg adult) has been estimated, also including non-*ortho* congeners (Schecter *et al*., 1996).

Other overseas studies have applied different approaches to estimating dietary intakes. The level of dietary intake for PCDDs and PCDFs has also been determined in Germany by use of the 'duplicate method' (Schrey, 1995). This study involved the collection of samples from fourteen individuals over a three day period. The levels of PCDDs and PCDFs determined in the food duplicates ranged from 0.24 to 1.3 pg I-TEQ/g fat, with daily intakes in the range 0.18 to 1.7 pg I-TEQ/kg body wt/day. This level of intake is comparable to or lower than levels estimated in the past in Germany (Beck *et al*., 1992).

An alternative method of assessment is to calculate the daily intake for a large number of individuals based on individual consumption statistics and average PCDD and PCDF levels. This approach was used to assess intake in the Netherlands, and gave a median PCDD and PCDF intake for adults of 1 pg I-TEQ/kg body wt/day, a level of exposure lower than that estimated for other countries (Theelen *et al*., 1993). For the non-*ortho* PCBs, a median intake of 1.4 pg TEQ/kg body wt/day was determined. Since the sampling strategy used for this study was derived from the Dutch food consumption survey, this study included more food items relevant for actual consumption than other studies. It was therefore noted that estimating dietary exposure using average food consumption figures can lead to an overestimation of the median PCDD and PCDF dietary intake.

A recent study in Spain (Madrid) has estimated the intake of PCDDs and PCDFs and non-*ortho* PCBs in individuals eating an average diet in a way that has not previously been reported in the literature (Jimènez *et al.,* 1996a). The approach adopted was to analyse, as a single sample, all the foods in the way they are eaten, as consumed by adult individuals during a whole day. Samples were collected for three consecutive days. It was considered that this analysis would reflect in a more real way the total dietary intake of PCDDs and PCDFs and non-*ortho* PCBs per day for an adult individual. The estimated total average intake for PCDDs and PCDFs from an average Spanish diet was found to be 142 pg I-TEQ/day, or 2.4 pg I-TEQ/kg body wt/day for a 60 kg person, comparable to other European and North American studies. Similarly, the intake for the non-*ortho* PCBs (PCB #77 and PCB #169) was found to be 130 pg TEQ/day (2.2 pg TEQ/kg body wt/day for a 60 kg person), derived primarily from PCB #77.

The PCB intake of the average Italian has been estimated at 223 ng PCB/kg fat by analysis for 41 congeners of a pooled sample of the foods normally consumed in one day (Turrio-Baldasarri *et al*., 1995). The mixture of foods comprised 5.8% water, 18.8% protein, 16.5% lipid, 15.4% soluble carbohydrate, 34.3% starch, 4.4% ash, and 4.8% fibre, with an overall extractable fat content of 15.25%.

Although different dietary habits and methods of reporting analytical results make direct comparison with results from studies in other countries difficult, the daily intake of PCDDs, PCDFs and PCBs by New Zealand males is consistently lower than that of people in other countries where comparable studies have been undertaken.

7.4 Comparison of the estimates of New Zealand dietary intake with international guidelines

There are a number of international guidelines or limits values that have been established for PCDDs, PCDFs and PCBs, as summarised in Table 7.6. In 1990, the World Health Organisation (WHO) at a consultation in Bilthoven fixed a tolerable daily intake (TDI) of 10 pg/kg bw/day for 2,3,7,8-TCDD (WHO, 1991). This TDI has subsequently been re-evaluated at a WHO consultation held during May 1998 (WHO, 1998). This consultation recommended that the daily threshold be reduced to a range of 1-4 pg TEQ/kg/bw/day, where the TEQ refers to the combined toxic equivalents concentration based on the WHO-derived factors for PCDDs and PCDFs, and certain PCB congeners that were recommended in 1997 (Van den Berg *et al*., 1998; refer to Tables 2.2 and 2.4). The consultation stressed that 'the upper range of the TDI of 4 pg TEQ/kg/bw/day should be considered a maximal tolerable intake on a provisional basis and that the ultimate goal is to reduce human intake levels below 1 pg TEQ/kg bw/day' (WHO, 1998).

The estimated New Zealand dietary intake for PCDDs, PCDFs and PCBs (Table 7.4) falls below the WHO TDI range, the proposed ATSDR value, and TDI values set by Canada, Germany, Japan, Sweden, the Netherlands and the United Kingdom (Table 7.6). The estimated daily intakes of these contaminants from the diet, relative to those of other countries where comparable intake data are available (Table 7.5), and to the WHO TDI range, is illustrated in Figure 7.5.

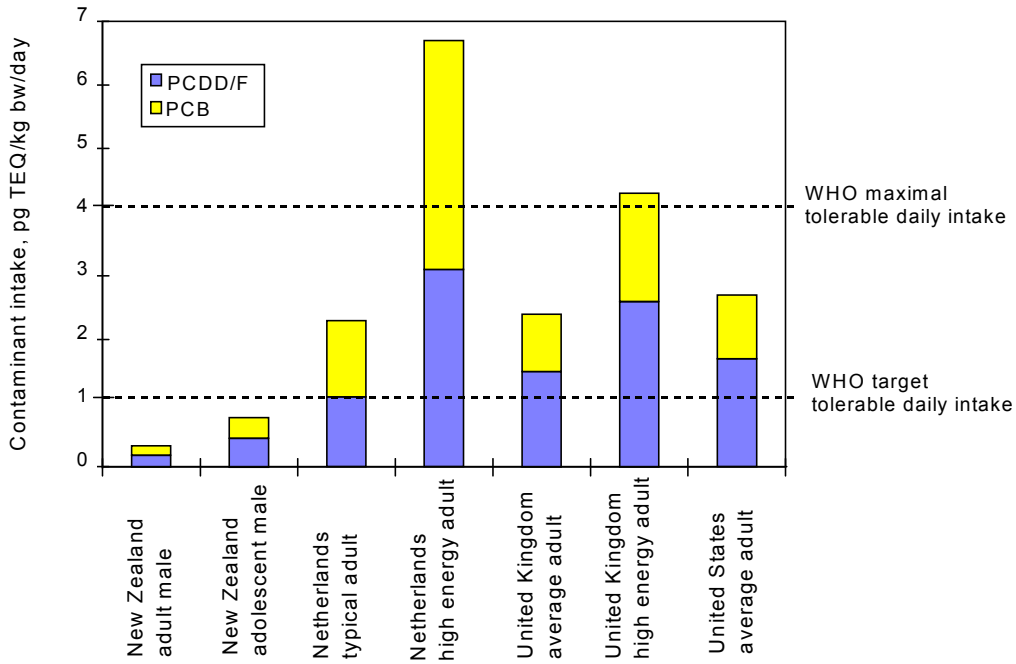

Figure 7.5 Comparison of estimated daily intake of PCDDs, PCDFs and PCBs for New Zealanders with selected international data and WHO TDI range
Sources: NZ, this study; Netherlands (Liem and Theelen, 1997); United Kingdom (Ministry of Agriculture, Fisheries and Food, 1997a); United States (Schecter *et al.,* 1994, 1997).

It should be noted that the intake data from this study is not derived using the WHO TEFs recommended in 1997 (Van den Berg *et al*., 1998) and upon which the WHO TDI range is based.

Table 7.6 International food standards, tolerable daily intakes and other health related guidelines for PCDDs and PCDFs

Country/ organisation	Limit values	Remarks	Reference
Canada	10 pg I-TEQ/kg bw/day	TDI	Government of Canada (1990)
	Fish: 20 ng I-TEQ/kg wet weight	Limit concentration	Gilman *et al.* (1995)
Germany	1-10 pg I-TEQ/kg bw/day	TDI	Appel *et al.* (1994)
	1 pg I-TEQ/kg bw/day	Long term objective	Toxicology Forum (1992)
	Milk and dairy products:		
	• 5 ng I-TEQ/kg fat	If value exceeded, trade is prohibited	Bericht der Bund/Lander-Arbeitsgruppe DIOXIN (1993)
	• 3 ng I-TEQ/kg fat	If value exceeded, source reducing measures should be undertaken	
	• 0.9 ng I-TEQ/kg fat	Desirable target (proposed)	
Japan	10 pg TEQ/kg bw/day	TDI (established by Ministry of Health and Welfare)	Hiraoka et al. (1997)
	5 pg TEQ/kg bw/day	Risk evaluation value (established by the Environment Agency)	Hiraoka et al. (1997)
Netherlands	10 pg I-TEQ/kg bw/day	Government adopts the WHO TDI of 10 pg/kg bw/day for 2,3,7,8-TCDD, but interprets value as I-TEQ. Current TDI	Liem and van Zorge (1995)
	1 pg I-TEQ/kg bw/day	Recommended limit of human exposure	Health Council of the Netherlands (1996)
	Milk and dairy products:		
	• 6 ng I-TEQ/kg fat	Limit value, if exceeded, various measures apply to area concerned	Theelen *et al.* (1993)
Sweden	5 pg TEQ/kg bw/day	Nordic TEQ	Ahlborg et al. (1988) [cited in Liem and van Zorge, (1995)]
United Kingdom	10 pg I-TEQ/kg bw/day	TDI (also the CoT recommended TDI for PCDDs, PCDFs and PCBs)	WHO (1991), CoT (1997)
	Milk and milk products:		
	• 16.6 ng TEQ/kg milk fat	Maximum Tolerable Concentration (set by Ministry of Agriculture, Fisheries and Food and the Department of Health. If exceeded, various measures apply to area concerned (includes PCBs)	Ministry of Agriculture, Fisheries and Food (1997b)
United States	1 pg I-TEQ/kg bw/day	Minimal Risk Level -Chronic (365 day) oral exposure	ATSDR (1997)
	0.006 pg 2,3,7,8-TCDD/kg bw/day	Risk Specific Dose based on lifetime cancer risk	US EPA (1994)
	Fish:		
	• 25 ng/kg wet weight	Limit value for consumption	FDA [cited in US EPA (1987)]
World Health Organisation	10 pg/kg bw/day	Recommended TDI for 2,3,7,8-TCDD	WHO (1991)
	1-4 pg TEQ/kg bw/day	Revised TDI range that includes the PCDDs, PCDFs and PCBs using the WHO TEF values (Van den Berg *et al*., 1998).	WHO (1998)

Nevertheless, the differences between the two sets of TEFs used are not expected to have a marked effect on how the estimated New Zealand dietary intake compares with this TDI range.

In the United Kingdom, the Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (CoT, 1997) recommend that a TDI of 10 pg TEQ/kg bw/day apply to the combined intake of PCDDs, PCDFs and 'dioxin-like' PCBs. The US EPA (1994) has set a Risk Specific Dose of 0.006 pg 2,3,7,8-TCDD/kg bw/day based on a lifetime cancer risk of one in a million. The US Agency of Toxic Substances and Disease Registry (ATSDR), in its draft toxicological profile of chlorinated dibenzo-p-dioxins (ATSDR 1997), has proposed a Minimal Risk Level of 1 pg I-TEQ/kg bw/day for chronic (365 day) oral exposure.

A TDI for PCBs of 1 μg/kg bw/day has been set in Canada by Health and Welfare Canada and in the United States by the Food and Drug Administration (Table 7.7). Estimated daily intakes of PCBs for both diets in this study, at 1.55 ng/kg bw/day for an adult male and 3.30 ng/kg bw/day for an adolescent male, fall well below this TDI value.

Table 7.7 International food standards, tolerable daily intakes and other health related guidelines for PCBs

Country/ organisation	Limit values	Remarks
United States (21CFR109.30)	Milk and manufactured dairy products • 1.5 mg/kg fat Poultry • 3 mg/kg fat in poultry • 0.3 mg/kg in eggs Fish and shellfish (edible portion) • 2 mg/kg Infant and junior foods • 0.2 mg/kg Red meat • 3 mg/kg fat	All values apply irrespective of the mixture PCB congeners present. These temporary tolerances have been established until it is practicable to eliminate such contaminants. The edible portion of fish excludes head, scales, viscera, and inedible bones. Action level
United States - FDA	1 μg/kg bw/day	TDI
Canada - Health and Welfare Canada	1 μg/kg bw/day	TDI

It is considered that the low concentrations of PCDDs, PCDFs and PCBs found in New Zealand retail foods, particularly meats and dairy produce, and the low intakes of these contaminants for the two diets evaluated in this study reflect the low levels of PCDDs, PCDFs and PCBs present in the New Zealand environment. This can be attributed, in part, to the geographical isolation of New Zealand and the low level of industrialisation in this country relative to North America and Europe. These results are consistent with the almost total absence of PCDDs, PCDFs and PCBs in New Zealand agricultural soils (Buckland, SJ, Ellis, HK, Salter, RT, 1998).

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Appendix A Food list development

This appendix outlines the development of the food list for the PCDD, PCDF and PCB dietary survey (Hannah, 1997b,c). It includes two tables:

Table A1 Food type composites, the food components in each group and the energy derived from these foods in the LINZ survey

Table A2 Food type composites, the food components in each group and the energy derived from these foods in the PCDD, PCDF and PCB dietary survey

A1 Rationale for selection of the food types and foods

The Life in New Zealand (LINZ) survey was a major survey conducted in New Zealand by Otago University in 1989-90 for the Hillary Commission. It identified foods that were major contributors to the energy intake of adult New Zealanders (Horwath *et al*., 1991). Table A1 below gives a summary of the contribution to the total energy intake of the average male and female adult consumers in the 25-44 year old age group in the LINZ survey, made by each of the selected food types which were included in the current PCDD, PCDF and PCB dietary study for the Organochlorines Programme.

A2 Foods within each food type composite

All foods were chosen from the New Zealand Total Diet Survey (NZTDS) food list as representative of commonly eaten New Zealand foods. These representative foods were then placed in a food composite group. Important foods such as meat products were put into individual groups such as beef type, lamb/mutton type, pork type, but because foods such as cereals are likely to only contribute very small amounts to the TEQs a number of foods were grouped within that food composite type.

The only foods chosen that deviated from the NZTDS food list are foods known to be likely contributors to PCDD, PCDF and PCB intakes. These are in the liver group (beef, lamb, and chicken liver), the fish group (snapper, blue cod, sole and terakihi), and imported tinned salmon, sardines and tuna. All the liver samples were analysed together to determine the concentration of contaminants in the liver composite group. Additional fish were examined because fish is known to contribute significantly to the PCDD, PCDF and PCB dietary intake and there were only a small number of fish types in the NZTDS. It was thought appropriate to increase the number of species in both fish group types.

Where current consumption is known to be different to the LINZ survey, or where account had to be taken of specific foods such as offal and tinned fish, there have been some minor changes to the LINZ survey data. These changes are for chicken, fish, liver, and snack foods. Further details on these changes are provided in Appendix D.

The energy contributed by each food type composite applied to this study is reported in Table A2. Further information on these energy contributions is detailed in Appendix D.

Table A1 Food type composites, the food components in each group and the energy derived from these foods in the LINZ survey

Food type composite	Components of food type composite	Contribution to dietary fat intake (%)[1]	Reasons for including foods	Energy in LINZ survey (%)	
				Adult Male 25-44 years (10.8 MJ/day diet)	Adult Female 25-44 years (6.9 MJ/day diet)
Beef meat	Rump steak and beef mince	7-9	These cuts have been selected for use in the New Zealand Total Diet Survey (NZTDS) (Hannah, 1997a). Mince is commonly made up from a variety of beef cuts.	7	6
Sheep meat	Shoulder and leg meat of lamb and mutton	2	Samples from the shoulder and leg of both lamb and mutton provide a representative sample of meat.	2	2
Pork meat	Pork pieces and bacon	4-5	Pork pieces are usually taken from all parts of the animal and provide a representative sample. Bacon has been chosen as a commonly consumed cured pork product.	3	2
Liver	Mixture of lamb, beef and chicken livers	-	Known to be a possible source of PCDDs, PCDFs and PCBs. This is different to the NZTDS (Hannah, 1997a). Appropriate to look at livers of different animals.	<1	<1
Processed meat products	Steak-type pies, beef flavoured sausages, and luncheon sausage	8-12	These foods provide an important source of energy in the New Zealand diet. A variety of meats are used in these products.	9	6
Milk	Standard and trim	7-8	Most commonly consumed types of milk shown by AC Neilsen data[2].	6	8
Butter	Salted butter	9-10	Most popular butter product.	3	4
Cheese	Colby and mild cheddar	6-7	Colby and cheddar both widely consumed.	3	4
Ice cream/yoghurt	Vanilla ice cream and flavoured yoghurt	3	Vanilla ice cream is the most popular type of ice cream consumed in New Zealand. Yoghurt has a large market appeal as shown by AC Neilsen data[2].	1	1
New Zealand fish	Selection of snapper, blue cod, sole and terakihi, plus battered deep-fried fish from fish and chip shop	-	A selection of fish has been chosen since different types of fish are consumed regionally. These fish types were popular in AGB McNair survey conducted for the NZ Fishing Industry Board (AGB McNair, 1991). Fish and chips most popular New Zealand take-away food.	3 (all fish)	2 (all fish)
Imported tinned fish	Tinned tuna, salmon, sardines	-	These three types of fish were popular in AGB McNair survey conducted for the NZ Fishing Industry Board (AGB McNair, 1991).		
Shellfish	Oysters and mussels	-	These shellfish products were popular in AGB McNair survey conducted for the NZ Fishing Industry Board (AGB McNair, 1991).		

Food type composite	Components of food type composite	Contribution to dietary fat intake (%)[1]	Reasons for including foods	Energy in LINZ survey (%)	
Poultry	Fresh whole chicken		Fresh chicken was selected since it represents about two thirds of total chicken meat sales. A selection of cuts was taken from the whole chicken.	3	1
Eggs	Ordinary eggs	3-4	Significant energy source for New Zealanders.	2	2
Bread	White, wholemeal, and multigrain	2	Bread is an important source of energy in New Zealanders diet.	13	12
Cereals	Weetbix, cornflakes, rolled oats, rice, dried spaghetti, chocolate biscuits, plain biscuits, savoury biscuits and plain cake	10	Important source of energy in New Zealanders diet.	13	18
Potatoes	Potatoes and hot deep-fried chips	-	Potatoes have been selected as the most important vegetable source of energy. Chips (as fish and chips) most popular New Zealand take-away food.	6	5
Snack foods	Potato crisps, corn tortillas and milk chocolate	-	These are all popular high fat snack foods. Chocolate is known to contribute to the fat content (up to 2%) of many New Zealanders intake.	crisps included in potato figure	
Vegetable fats/oils	Margarine, salad and cooking oil, and olive oil	7-8	Margarine comprises the largest portion of vegetable oil consumed by New Zealanders. The other two oils are popular as shown by AC Neilsen data[2].	3 from marg.	2 from marg.
			Total percentage energy of diet	**78**	**76**

1. From LINZ survey (Horwath *et al.*, 1991; Russell and Wilson, 1991).
2. AC Neilsen, 1996 (sales data purchased from Ministry of Health).

Table A2 Food type composites, the food components in each group and the energy derived from these foods in the PCDD, PCDF and PCB dietary survey[1]

Food type composite	Components of food type composite	% Energy, adult male 25-44 years 10.8 MJ/day diet	% Energy, male 15-18 years 21.5 MJ/day diet
Beef meat	Rump steak and beef mince	7	7
Sheep meat	Shoulder and leg meat of lamb and mutton	2	1
Pork meat	Pork pieces and bacon	3	1
Beef fat	Fat trimmed from rump steak	3 (all	2 (all
Sheep fat	Fat trimmed from shoulder and leg meat	trimmed fats)	trimmed fats)
Port fat	Fat trimmed from pork pieces and bacon		
Liver	Mixture of lamb, beef and chicken livers	1	1
Processed meat products	Steak-type pies, beef flavoured sausages, and luncheon sausage	9	8
Milk	Standard and trim	6	10
Butter	Salted butter	3	3
Cheese	Colby and mild cheddar	3	3
Ice cream/yoghurt	Vanilla ice cream and flavoured yoghurt	2	2
New Zealand fish	Selection of snapper, blue cod, sole and terakihi, plus battered deep-fried fish from fish and chip shop	2.33	2.33
Imported tinned fish	Tinned tuna, salmon, sardines	0.33	0.33
Shellfish	Oysters and mussels	0.33	0.33
Poultry	Fresh whole chicken	3	2
Eggs	Ordinary eggs	2	1
Bread	White, wholemeal, and multigrain	13	13
Cereals	Weetbix, cornflakes, rolled oats, rice, dried spaghetti, chocolate biscuits, plain biscuits, savoury biscuits and plain cake	13	19
Potatoes	Potatoes and hot deep-fried chips	6	10
Snack foods	Potato crisps, corn tortillas and milk chocolate	3	5
Vegetable fats/oils	Margarine, salad and cooking oil, and olive oil	3	2
Total energy, %		**85**	**93**

[1] Percentage energy taken from LINZ survey for all foods, with changes to chicken, fish, liver and snack foods.

Appendix B Sample preparation

This appendix describes the sample collection, preparation and compositing procedures used (Hannah, 1997b).

Table B1 Sample description and number of samples in each food type composite
Table B2 Country of origin of foods analysed
Table B3 Preparation of meat composites
Table B4 Preparation of dairy composites
Table B5 Preparation of fish composites
Table B6 Preparation of poultry and egg composites
Table B7 Preparation of cereal composites
Table B8 Preparation of other food composites

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Table B1 Sample description and number of samples in each food type composite

Food type composite	Food components	Food description (approximate size per sample)	Number of samples to laboratory (actual number as per sampling design specified below unless otherwise indicated in square parenthesis)
Beef meat	Rump steak and beef mince	Rump: 250g lean Mince: 250g lean	1 sample of each per supermarket + 1 of each per butcher = 20 samples
Sheep meat	Shoulder and leg meat of lamb and mutton	Shoulder: 250g diced Leg: 250g diced	1 of each per supermarket + 1 of each per butcher = 20 samples [18 samples collected - shoulder meat unavailable - Auckland supermarket; Napier butcher]
Pork meat	Pork pieces and bacon	Pieces: 250g lean Bacon: 200g middle bacon	1 of each sample per supermarket + 1 of each sample per butcher = 20 samples [19 samples collected - no bacon sample - Christchurch butcher]
Liver	Mixture of lamb, beef and chicken livers	250g of each type of liver product	1 sample of each per supermarket + 1 sample from a butcher = 30 samples [19 samples - no beef liver, one chicken liver - Christchurch; one beef liver - Auckland; no livers - Napier butcher; no beef liver - Wellington; one chicken liver - Wellington, Dunedin]
Processed meat products	Steak-type pies, beef flavoured sausages, and luncheon sausage	Pie (pre-cooked) Sausages: 250g Luncheon: 100g sliced	2 sample of each per supermarket = 30 samples [27 samples collected - Auckland - only one pie; no beef sausages, no luncheon - Napier butcher]
Milk	Standard and trim	Standard: 1L Trim: 1L	2 samples of each per supermarket = 20 samples. One sample of each to be in a plastic container, and the second sample to be in cardboard container.
Butter	Salted butter	500g	3 samples of each per supermarket = 15 samples
Cheese	Colby and mild cheddar	250g	2 samples of each per supermarket = 20 samples
Ice cream/yoghurt	Vanilla ice cream and flavoured yoghurt	Ice-cream: 2 litre Yoghurt: 150 ml	2 samples of each per supermarket = 20 samples
New Zealand fish	Selection of snapper, blue cod, sole and terakihi, plus battered fish from fish and chip shop	Snapper, blue cod, terahiki and sole: 250g fillets x 1 each type Fish in batter (deep-fried): 1 piece	1 sample of each type of fish per supermarket (if unavailable sample at fishmonger); battered fish from fish and chip shop = 25 samples [23 samples collected - only 3 samples Napier and Christchurch]]
Imported tinned fish	Tinned tuna, sardines and salmon	Small tin of each	2 samples of each per supermarket = 30 samples
Shellfish	Oysters and mussels	300g of each	2 samples of each per supermarket = 20 samples

Food type composite	Food components	Food description (approximate size per sample)	Number of samples to laboratory (actual number as per sampling design specified below unless otherwise indicated in square parenthesis)
Poultry	Fresh whole chicken	Whole number 7 fresh chicken	3 samples per supermarket = 15 samples
Eggs	Ordinary eggs	Number 7 eggs (dozen)	3 samples per supermarket = 15 samples
Bread	White, wholemeal, and multigrain	700-750g loaf	2 samples of each per supermarket = 30 samples
Cereals	Breakfast cereals, rice, dried spaghetti, biscuits and cake	Cornflakes: 300g Rolled oats: 850g Weetbix: 375g Cake, plain - 200-300g Chocolate biscuits: 200g Cracker biscuits: 200-250g Plain sweet biscuits: 250g Rice, white: 500g Spaghetti, dried: 500g	1 sample of each per supermarket = 45 samples
Potatoes	Potatoes and hot deep-fried chips	Potatoes: 500g white potato Hot chips: smallest order	2 samples of potatoes per supermarket + 3 samples of hot chips per centre = 25 samples
Snack foods	Potato crisps, corn tortillas and milk chocolate	Potato crisps: 160-200g Corn tortillas: 160-200g Milk chocolate: 150-200g	2 samples of each per supermarket = 30 samples [27 samples collected - no plain corn tortillas - Christchurch; 1 chocolate discarded - wrong type]
Vegetable fats/oils	Margarine, salad and cooking oil, and olive oil	Margarine: 500g Salad and cooking oil: 500 ml Olive oil: 500 ml	2 samples of margarine and 1 sample of each oil per supermarket = 20 samples

Table B2 Country of origin of foods analysed (all from New Zealand unless specified)

Food type	Country of origin (and no. of samples)
Cracker biscuits	Australia x2
Chocolate biscuits	Australia x1
Cornflakes	Australia x1
Rice, white	Australia x4, Brazil x1
Spaghetti	Australia x1
Olive oil	Spain x1, Italy x3 (unknown x1)
Margarine	Australia x1
Salmon, tinned	Canada x9, Alaska x1
Tuna, tinned	Thailand x10
Sardines, tinned	Canada x6, Scotland x4
Corn tortilla	Australia x1
Chocolate, dairy milk	Australia x2
Pork, processed	Possibly includes some imported products

Table B3 Preparation of meat composites

Meat and meat products	Sub sampling	Sample preparation
Beef meat		
- Rump steak	Remove fat, dice meat, place in pile. Divide into quarters and randomly select two quarters of 125g. Retain all trimmed fat for separate analysis.	Combine 10 x 125g subsamples and dry fry for about 15 minutes. Blend in processor (with any meat juices) until all combined and pureed.
- Beef mince	Place minced meat in pile. Divide into quarters. Randomly select two quarters about 125g.	Combine 10 x 125g subsamples and dry fry for about 15 minutes. Blend in processor (with any meat juices) until all combined and pureed.
- **Beef meat food composite**	Combine 625g of each beef meat sample, blend well to equal 1250g.	Divide into 5 x 250g composite samples.
Sheep meat		
- Mutton	Remove fat, dice meat, place in pile. Divide into quarters and randomly select two quarters of 125g. Retain all trimmed fat for separate analysis.	Dry fry 10 x 125g subsamples until cooked about 15 minutes. Blend in processor (with any meat juices) until all combined and pureed.
- Lamb	Remove fat, dice meat, place in pile. Divide into quarters and randomly select two quarters of 125g. Retain all trimmed fat for separate analysis.	Dry fry 10 x 125g subsamples until cooked about 15 minutes. Blend in processor (with any meat juices) until all combined and pureed.
- **Sheep meat food composite**	Combine 500g of each sheep meat sample, blend well to equal 1000g.	Divide into 5 x 200g composite samples.
Pork meat		
- Pork pieces	Remove fat, dice meat, place in pile. Divide into quarters and randomly select two quarters of 125g. Retain all trimmed fat for separate analysis.	Dry fry 10 x 125g subsamples until cooked about 15 minutes. Blend in processor (with any meat juices) until all combined and pureed.
- Middle bacon	Select 3 middle rashers of bacon from the middle of package. Remove thick outside layer of fat (about 60 g meat). Retain all trimmed fat for separate analysis.	Dry fry 10 x 60g subsamples until cooked about 10 minutes. Blend in processor (with any meat juices) until pureed well.
- **Pork meat food composite**	Combine 251g prepared pork pieces sample and 124g prepared bacon samples, blend well to equal 375g.	Divide into 5 x 75g composite samples.
Liver		
- Lamb liver	Dice into 2 cm cubes, divide into quarters and randomly select two quarters about 125g.	Dry fry 10 x 125g subsamples until cooked about 15 minutes. Blend in processor until all combined and pureed.
- Beef liver	Dice into 2 cm cubes, divide into quarters and randomly select two quarters about 125g.	Dry fry 10 x 125g subsamples until cooked about 15 minutes. Blend in processor until all combined and pureed.
- Chicken liver	Cut each liver in quarters. Divide pile into quarters and randomly select two quarters about 125g.	Dry fry 10 x 125g subsamples until cooked about 15 minutes. Blend in processor until all combined and pureed.
- **Liver food composite**	Combine 166.67g each of all three prepared liver samples, blend in processor.	Divide into 5 x 100g composite samples.

Meat and meat products	Sub sampling	Sample preparation
Processed meat products		
- Steak-type pie	Cut all 10 pies into quarters and randomly select two quarters from each pie, about 85g.	Blend all subsamples of pie together in processor.
- Sausage	Take two sausages from each sample and grill 5 minutes on each side. Blend together until pureed.	Blend all subsamples of beef sausages together.
- Luncheon sausage	Blend all the samples together until completely pureed.	Use as purchased.
- **Processed meat composite**	Combine 280g of steak-type pie puree, 165g of pureed sausage, and 55g luncheon sausage. Blend in processor.	Divide into 5 x 100g composite samples.

Table B4 Preparation of dairy composites

Dairy foods	Sub sampling	Sample preparation
Butter		
- Salted butter	Cut each sample into eighths by cutting lengthways into quarters then in half crosswise. Take one eighth from each sample and grate (about 60g).	Combine 15 x 60g random subsamples. Mix well.
- Butter composite		Make-up 8 x 25g composite samples.
Cheese		
- Colby cheese	Cut into quarters long and crosswise. Take one quarter and grate sample (about 60g).	Combine 10 x 60g random subsamples. Mix well.
- Mild cheddar cheese	Cut into quarters long and crosswise. Take one quarter and grate sample (about 60g).	Combine 10 x 60g random subsamples. Mix well.
- Cheese composite	Combine 250g each of prepared colby and mild cheddar samples, and mix well.	Divide into 5 x 100g composite samples.
Ice cream/yoghurt		
- Vanilla ice cream	Empty onto flat surface, cut into eighths by cutting lengthways into quarters and in half cross wise. Select one random eighth to combine (about 125g).	Combine 10 x 125g random subsamples. Mix well.
- Flavoured yoghurt	Open, mix well with spoon, remove 100g for randomly from each sample.	Combine 10 x 100g random subsamples. Mix well.
- **Ice cream/yoghurt composite**	Combine 417g prepared ice cream sample and 833g prepared yoghurt sample and mix well.	Divide into 5 x 250g composite samples.
Milk		
- Standard milk	Take a 300 ml sample out of each litre container.	Combine 10 x 300 ml random subsamples. Mix well.
- Trim milk	Take a 200 ml sample out of each litre container.	Combine 10 x 200 ml random subsamples. Mix well.
- **Milk food composite**	Combine 2500g prepared standard milk sample and 1250g prepared trim milk sample and mix well.	Divide into 5 x 750g composite samples.

Table B5 Preparation of fish composites

Fish	Sub sampling	Sample preparation
New Zealand fish		
- Snapper	Dice each fillet into 1 cm pieces. Place in pile, divide into quarters and randomly select two quarters (125g).	Dry fry 5 x 125g subsamples. Blend together in processor.
- Blue cod	Dice each fillet into 1 cm pieces. Place in pile, divide into quarters and randomly select two quarters (125g).	Dry fry 5 x 125g subsamples. Blend together in processor.
- Sole	Dice each fillet into 1 cm pieces. Place in pile, divide into quarters and randomly select two quarters (125g).	Dry fry 5 x 125g subsamples. Blend together in processor.
- Terakihi	Dice each fillet into 1 cm pieces. Place in pile, divide into quarters and randomly select two quarters (125g).	Dry fry 5 x 125g subsamples. Blend together in processor.
- Battered fish (deep-fried)	Use all sample (5 pieces).	Blend together in processor.
- **NZ fish composite**	Combine 300g of each above prepared fish samples and blend together in food processor.	Divide into 5 x 300g composite samples.
Imported tinned fish		
- Salmon	Drain and use all.	Blend all samples together in processor.
- Tuna	Drain and use all.	Blend all samples together in processor.
- Sardines	Drain off brine or oil and use all.	Blend all samples together in processor.
- **Imported tinned fish composite**	Combine 750g prepared salmon sample, blend with 375g each prepared tuna and sardine samples.	Divide into 5 x 300g composite samples.
Shellfish		
- Oysters	Drain and use all.	Blend all samples together in processor.
- Mussels	Take meat out of shell and use all.	Blend all samples together in processor.
- **Shellfish composite**	Combine 1250g prepared oyster sample, blend with 1250g each prepared mussel samples.	Divide into 5 x 500g composite samples.

Table B6 Preparation of poultry and egg composites

Poultry	Sub sampling	Sample preparation
Poultry - Chicken	Remove skin from each chicken and reserve for subsequent analysis if required.	For each chicken cut meat from each leg, thigh and breast, take 150g meat from each, dry fry all subsamples then blend together (ensuring meat juices included) until well pureed.
- **Chicken composite**	Blend all samples together well until completely pureed	Make-up 5 x 200 g samples.
Eggs - Eggs	Select 3 from each carton (about 150g).	Boil 5 minutes in distilled water. Blend all subsamples together until completely pureed (about 2250g).
- **Egg composite**		Make-up 5 x 200g samples.

Table B7 Preparation of cereal composites

Cereals	Sub sampling	Sample preparation
Bread		
- White, wholemeal and multigrain	Take 4 slices from one end of each loaf (approx. 100g).	Make breadcrumbs from 4 slices and mix products of all 10 loaves together. This will weigh about 1 kg.
- Bread composite	Combine 500g each of white, wholemeal and multigrain, mix together in blender.	Divide into 5 x 300g composite samples.
Cereals		
- Cornflakes	Empty each packet onto flat surface, divide into 6 equal piles and randomly select a pile.	Pulverise and combine all 5 selected subsamples (approx. 250g).
- Weetbix	Randomly select 4 wheat biscuits (approx. 60g) from each packet.	Pulverise and combine all 5 selected subsamples (approx. 300g).
- Rolled oats	Empty each packet onto flat surface, divide into 8 piles, and randomly select a pile (approx. 100g)	Pulverise and combine all 5 selected subsamples (approx. 500g).
- Plain cake	Cut each cake into quarters and randomly select one quarter (approx. 100-125g).	Pulverise and combine all 5 selected subsamples.
- Cracker biscuits	Take 10 biscuits from middle of each packet (approx. 55g).	Pulverise and combine all 5 selected subsamples.
- Rice	Empty each packet onto flat surface, divide into 8 piles and randomly select one pile (approx. 60g).	Combine 5 x 60g random subsamples, mix, boil for 15 minutes in distilled water.
- Spaghetti	Empty each packet onto flat surface, divide into 8 piles and randomly select one pile (approx. 60g).	Combine 5 x 60g random subsamples, mix, boil for 15 minutes in distilled water.
- **Cereal composite**	Combine 58g cornflakes, 92g weetbix, 150g rolled oats, 300g plain cake, 46g chcolate biscuits, 115g cracker biscuits, 58g plain sweet biscuits, 358g boiled white rice, 323g boiled spaghetti and mix well.	Divide into 5 x 300g composite samples.

Table B8 Preparation of other food composites

Other foods	Sub sampling	Sample preparation
Vegetable fat/oils		
- Margarine	Take a random 50g sample from each margarine container.	Combine 10 x 50g random subsamples. Mix well.
- Salad and cooking oil	Take a 100ml sample out of each oil container.	Combine 5 x 100 ml random subsamples. Mix well.
- **Vegetable fat/oil composite**	Take 360g margarine sample and 20g of each oil sample and mix well.	Divide into 8 x 50g composites.
Potato foods		
- Potato	Wash in distilled water, randomly select 2 potatoes from each sample (about 120g).	Cook in microwave for about 2 ½ minutes each. Blend all 10 subsamples together in processor (approx. 2.4kg).
- Hot deep-fried chips	Pour each sample of deep fried chips onto flat surface, divide in half and randomly select one half.	Blend all 15 subsamples together in processor.
- **Potato composite**	Combine 1875g prepared microwaved potato sample, blend with 625g prepared hot chip sample.	Divide into 5 x 500g composite samples.
Snack foods		
- Potato crisps	Pour each packet of crisps onto flat surface, divide into quarters and randomly select two quarters.	Blend all subsamples together in processor (approx. 800g).
- Corn tortillas	Pour each packet of corn tortillas onto flat surface, divide into quarters and randomly select two quarters.	Blend all subsamples together in processor (approx. 800g).
- Milk chocolate	Divide each sample into quarters and randomly select two quarters. Break up into small pieces and blend together well in processor.	Blend all subsamples together in processor (approx. 1 kg).
- **Snack food composite**	Take 133.3g each of prepared samples of potato crisps, corn tortillas and milk chocolate and mix well.	Divide into 8 x 50g samples.

Appendix C Analytical methods

This appendix describes the methods of analysis of food samples for:

- Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs)
- Polychlorinated biphenyls (PCBs)

C1 Organochlorine contaminants

C1.1 Sample preparation

Samples were composited and prepared as detailed in Tables B3 to B8 (Appendix B). All samples, excluding milk, butter and other fats/oils, were freeze-dried in preparation for analysis.

C1.2 Sample extraction

A volume of milk and fats/oils, and a weight of all other prepared composite food samples (Table C1) was taken and spiked with a range of isotopically labelled PCDD, PCDF and PCB standards (Cambridge Isotope Laboratories, Massachusetts, USA). The nominal amounts of each of the surrogate standards added are given in Table C2.

Table C1 Extraction method used for each food composite

Food type composite	Analytical weight, g (freeze-dried)[1]	Extraction method	Extraction solvent
Beef meat	105	Soxhlet	EtOH[2]toluene (68:32)
Sheep meat	91	Soxhlet	EtOH/toluene (68:32)
Pork meat	35	Soxhlet	EtOH/toluene (68:32)
Beef fat	30	Soxhlet	EtOH/toluene (68:32)
Sheep fat	30	Soxhlet	EtOH/toluene (68:32)
Pork fat	30	Soxhlet	EtOH/toluene (68:32)
Liver	45	Soxhlet	EtOH/toluene (68:32)
Processed meats	47	Soxhlet	EtOH/toluene (68:32)
Milk	750 ml	Liquid/liquid	EtOH/diethyl ether/hexane
Butter	25	Dissolved in hexane	Hexane
Cheese	35	Soxhlet	EtOH/toluene (68:32)
Ice cream/yoghurt	70	Soxhlet	EtOH/toluene (68:32)
NZ fish	109	Soxhlet	EtOH/toluene (68:32)
Imported tinned fish	93	Soxhlet	EtOH/toluene (68:32)
Shellfish	108	Soxhlet	EtOH/toluene (68:32)
Poultry	78	Soxhlet	EtOH/toluene (68:32)
Eggs	50	Soxhlet	EtOH/toluene (68:32)
Bread	190	Soxhlet	EtOH/toluene (68:32)
Cereals	190	Soxhlet	EtOH/toluene (68:32)
Potatoes	151	Soxhlet	EtOH/toluene (68:32)
Snack foods	50	Soxhlet	EtOH/toluene (68:32)
Vegetable fats/oils	25 ml	Dissolved in hexane	Hexane

1. Butter, milk, and vegetable fats/oils were not freeze dried.
2. Ethanol (EtOH).

Following solvent extraction, the samples (excluding butter and other fats/oils) were reduced using rotary evaporation, combined, solvent exchanged into dichloromethane, washed with water, dried (anhydrous Na_2SO_4), and solvent exchanged into hexane. The butter and fats/oils hexane extract was washed with water and dried (anhydrous Na_2SO_4).

Table C2 Nominal amounts of isotopically labelled surrogate standards added to samples

$^{13}C_{12}$ PCDD congener	ng added	$^{13}C_{12}$ PCDF congener	ng added
2,3,7,8-TCDD	0.5	2,3,7,8-TCDF	0.5
1,2,3,7,8-PeCDD	0.5	1,2,3,7,8-PeCDF	0.5
1,2,3,4,7,8-HxCDD	0.5	2,3,4,7,8-PeCDF	0.5
1,2,3,6,7,8-HxCDD	0.5	1,2,3,4,7,8-HxCDF	0.5
1,2,3,4,6,7,8-HpCDD	0.5	1,2,3,6,7,8-HxCDF	0.5
OCDD	1	2,3,4,6,7,8-HxCDF	0.5
		1,2,3,7,8,9-HxCDF	0.5
		1,2,3,4,6,7,8-HpCDF	0.5
		1,2,3,4,7,8,9-HpCDF	0.5

$^{13}C_{12}$ PCB congener	ng added
#28	20
#52	10
#77	10
#101	10
#126	10
#153	20
#169	10
#180	10
#202	20

C1.3 Sample purification

The organic extract was partitioned with concentrated sulphuric acid, washed with water, dried (anhydrous Na_2SO_4), and made to a known volume with hexane.

PCDDs and PCDFs

A volume of the acid-washed extract was purified by column chromatography as follows:

- acid and base modified silica gel (eluent: hexane)
- alumina (neutral) (eluent: hexane, 1:20 diethyl ether/hexane, diethyl ether)
- Carbopack C (18% dispersed on Celite 545) (eluent: hexane, 1:1 DCM/cyclohexane, 15:4:1 DCM/methanol/toluene, toluene)

A volume of $^{13}C_{12}$ labelled syringe spike (1,2,3,4-TCDD and 1,2,3,7,8,9-HxCDD) in tetradecane was added and the extract was first reduced by rotary evaporation, blown down gently under a stream of nitrogen, and transferred to a vial for analysis using capillary gas chromatography-high resolution mass spectrometry (GCMS).

PCBs

A volume of the acid-washed extract was purified by partitioning with acetonitrile, and the acetonitrile phase was concentrated by rotary evaporation, and then further purified by Florisil column chromatography (eluent hexane, 1:15 diethyl ether/hexane). This also effected the fractionation of the non *ortho*-PCBs (#77, #126 and #169) from the *ortho*-substituted PCB congeners. Each fraction was reduced first by rotary evaporation, then blown down gently under a stream of nitrogen. A volume of $^{13}C_{12}$ labelled syringe spike (PCBs #80 and #141) was added and each fraction was transferred to a vial for analysis by GCMS.

C1.4 Sample analysis

PCDDs and PCDFs

Extracts were analysed by GCMS on an HP5890 Series II Plus GC interfaced to a VG-70S high resolution mass spectrometer (resolution 10,000). All extracts were run on an Ultra2 capillary column. If a peak was detected at the correct retention times for 2,3,7,8-TCDF, 2,3,7,8-TCDD, 2,3,4,7,8-PCDF, 1,2,3,4,7,8-HxCDF or 1,2,3,7,8,9-HxCDD, the extract was re-analysed on a SP2331 capillary column for full congener-specific quantification. Chromatographic conditions are given below, and the mass spectral ions monitored are detailed in Table C3.

Column	25 m Ultra2	60 m SP2331
Carrier gas head pressure	150 kpa	200 kpa
Injector temperature	260 °C	260 °C
Injection	2µl splitless	2µl splitless
Temperature programme	Initial temp 210 °C (hold 4 min), 3 °C min^{-1} to 275 °C (11 min).	Initial temp 170 °C (hold 1 min), 10 °C min^{-1} to 210 °C (1 min), 3°C^{-1} to 250 °C (30 min).

Table C3 Ions monitored for PCDDs and PCDFs

Congener group	^{12}C Quantification ion (m/z)	^{12}C Confirmation ion (m/z)	^{13}C Quantification ion (m/z)	^{13}C Confirmation ion (m/z)
TCDF	305.8987	303.9016	317.9389	315.9419
TCDD	321.8936	319.8965	333.9339	331.9368
PeCDF	339.8597	337.8626	351.9000	349.9029
PeCDD	355.8546	353.8575	367.8949	365.8978
HxCDF	373.8207	375.8178	385.8610	387.8580
HxCDD	389.8156	391.8127	401.8559	403.8530
HpCDF	407.7818	409.7788	419.8220	421.8191
HpCDD	423.7767	425.7737	435.8169	437.8140
OCDF	443.7398	441.7428		
OCDD	459.7347	457.7377	471.7750	469.7780

PCBs

Extracts were analysed by GCMS on an HP5890 Series II Plus GC interfaced to a VG-70S high resolution mass spectrometer (resolution typically 6,000). Chromatographic conditions are given below, and the mass spectral ions monitored are detailed in Table C4.

Column	25 m Ultra2
Carrier gas head pressure	100 kPa
Injector temperature	240°C
Injection	1 µL splitless
Temperature programme	Initial temperature 60 °C (hold 0.8 min), 40 °C min^{-1} to 170 °C (0.5 min), 5 °C min^{-1} to 250 °C (23 min)

Table C4 Ions monitored for PCBs

Congener group	^{12}C Quantification ion (m/z)	^{12}C Confirmation ion (m/z)	^{13}C Quantification ion (m/z)	^{13}C Confirmation ion (m/z)
Tri PCBs[1]	255.9613	257.9584	269.9986	271.9957
Tetra PCBs[2]	291.9194	289.9224	303.9597	301.9627
Penta PCBs[3]	325.8804	327.8775	337.9207	339.9178
Hexa PCBs[4]	359.8415	361.8385	371.8818	373.8788
Hepta PCBs[5]	393.8025	395.7995	405.8428	407.8398
Octa PCBs[6]	427.7635	429.7606	439.8038	441.8009
Nona PCBs[7]	463.7216	461.7245		

[1] PCB #28, #31
[2] PCB #52, #77
[3] PCB #101, #99, #123, #118, #114, #105, #126
[4] PCB #153, #138, #167, #156, #157, #169
[5] PCB #187, #183, #180, #170, #189
[6] PCB #202, #194
[7] PCB #206

C1.5 Analyte identification and quantification criteria

PCDDs and PCDFs

For positive identification the following criteria must be met:

- The retention time of the analyte must be within 1 second of the retention time of the corresponding $^{13}C_{12}$ surrogate standard.
- The ion ratio obtained for the analyte must be ±10% of the theoretical ion ratio.
- The signal to noise ratio must be greater than 3:1.
- Levels of PCDD and PCDF congeners in a sample must be greater than 5 times any level found in the corresponding laboratory blank analysed (3 times the level in the blank for OCDD).
- Surrogate standard recoveries must be in the range 25-150%.

PCBs

For positive identification the following criteria must be met:

- Where relevant, the retention time of the targeted analyte must be within 2 seconds of the corresponding $^{13}C_{12}$ surrogate standard. For congeners with no $^{13}C_{12}$ surrogate standard, the retention time must be within 2 seconds of the relative retention time for that congener as calculated from the calibration standards.
- The ion ratio criteria obtained for the analyte must be ±20% of that obtained for the calibration standards.
- The signal to noise ratio must be greater than 3:1.
- Levels of PCB congeners and organochlorine pesticides in a sample must be greater than 5 times any level found in the corresponding laboratory blank analysed.
- Surrogate standard recoveries must be in the range 25-150%.

C1.6 Quantification

Quantification was by the isotope dilution technique using the surrogate standards listed in Table C2. Relative response factors (RRFs) were calculated for each targeted analyte from a series of calibration standards analysed under the same conditions as the samples. Non 2,3,7,8-substituted

PCDD and PCDF congeners were quantified using the RRF of the first eluting surrogate standard in each mass spectral group. Targeting of all analytes was performed by the MS software (OPUS). Text files created by OPUS were electronically transferred to a customised spreadsheet for further data reduction and preparation of the final analytical report.

C1.7 Limits of detection

If no peak was distinguishable above the background noise at the retention time for a targeted analyte, the area was recorded as being less than the limit of detection. The limit of detection was calculated by multiplying, by three, the area of the section of baseline noise at the retention time of the analyte. If a peak was present at the correct retention time for the targeted analyte but failed to meet all analyte identification criteria, the area due to that analyte was recorded, and the calculated concentration was reported as a limit of detection.

C1.8 Surrogate standard recoveries

The recovery of each isotopically labelled surrogate standard was calculated from the ratio of the area of the surrogate standard in the sample normalised to its syringe spike to the area of the surrogate standard in the calibration standards normalised to its syringe spike.

C1.9 Quality control

- Samples were combined into batches based on the expected fat content of each individual food and the use of a common extraction procedure. A total of four batches of samples were analysed.
- A laboratory blank was analysed with each batch of samples.
- Duplicate samples were analysed to assess method precision.
- The GCMS resolution, performance and sensitivity were established for each MS run.
- The recoveries of all isotopically labelled surrogate standards were calculated and reported.

The laboratory participates in World Health Organisation interlaboratory studies for the analysis of PCDDs, PCDFs and PCBs. The laboratory holds WHO certification from the third round of studies for the analysis of these contaminants in cows milk and fish (WHO, 1995).

C1.10 Data reporting

Reporting parameters for samples analysed for PCDDs, PCDFs and PCBs are detailed in Table C5.

Concentration data reported in Tables E1.1 to E6.1 (Appendix E) are corrected for recovery of ^{13}C surrogate standards. Data for quantified analytes are reported to 2 or 3 significant figures. Limit of detection data for non-quantified analytes are reported to 1 significant figure.

Table C5 Contaminant concentrations: reporting basis

Contaminant class	Reporting basis
PCDDs and PCDFs	ng kg^{-1} on a wet weight basis. Toxic equivalents (TEQs) were calculated using the International Toxic Equivalency Factors (I-TEFs).
PCBs	µg kg^{-1} on a wet weight basis. TEQs were calculated using the WHO/IPCS TEFs (Ahlborg *et al*., 1994) and are reported in ng kg^{-1}.

Appendix D Dietary modelling

This appendix details the selection of the two diets used in the assessment of PCDD, PCDF and PCB intakes (Hannah, 1997c).

Table D1 Percentage energy, weight, and the fat contribution provided by each food group composite in the adult male 10.8 MJ and adolescent male 21.5 MJ diets

Table D2 Nutrient and energy table for 10.8 MJ diet of an adult male: Amounts of food group composites and their protein, fat, carbohydrate and energy content

Table D3 Nutrient and energy table for 21.5 MJ diet of an adolescent male: Amounts of food group composites and their protein, fat, carbohydrate and energy content

D1 Selection of diets

The two diets that have been chosen to examine the likely intakes of PCDDs, PCDFs and PCBs by New Zealanders are:

- adult male (25-44 years old) 10.8 MJ/day diet, median energy (50th centile) intake
- adolescent male (15-18 years old) 21.5 MJ/day diet, high energy (90th centile) intake

The choice of these age-sex categories was based on the categories used to classify data in the LINZ survey (Wilson *et al*., 1992). The energy content of each of these diets and amounts of energy that each food or food type contributed to the total energy were also calculated primarily from data in the LINZ survey. Table D1 shows the energy contributed by each food type composite applied in this study.

An allowance for the snack foods consisting of potato chips, corn tortilla chips and chocolate was made because the LINZ survey showed these types of foods, in particular potato chips and chocolate, are regularly consumed, but the energy provided by these foods had not been separated out in detail. It was found that on any particular day 8% of males consumed on average 38g of potato chips. Also 61g of chocolate or chocolate bars were consumed by 12% of males on any given day. When averaged over a year for all male age-sex categories this would be about 3g/day chips and 7g/day chocolate (Wilson *et al*., 1995; Parnell *et al*., 1996). The consumption of chicken in 1996 was 24kg/capita/year in New Zealand (Diprose, 1996). In the adult male's diet poultry has been assumed to provide 3% (45g daily) and snack foods 3% of energy. In the adolescent male's diet, poultry remained (as in the LINZ survey) at 2% of intake (60g daily) and snack foods were increased to 5% of energy for the purpose of calculation of exposure estimates.

Offal provided less than 1% of energy for both these groups but was included at 1% of energy because of the likelihood that it is a source, to some consumers, of PCDDs, PCDFs and PCBs. Fish was assumed to provide 3% of energy for both groups and was proportionated to 2.33% as fresh fish, 0.33% for tinned fish and 0.33% for shellfish. From data provided by the New Zealand Fishing Industry Board, it is likely that most fish eaten by consumers is fresh fish, but it was also necessary to consider the tinned fish and shellfish that are eaten by some consumers (AGB McNair, 1991).

D1.1 Median energy (50th centile) intake consumer

An adult male diet using the median energy intake for this age was the first category chosen. Median energy in the diets of men has been reported as 10.8 MJ/day, and for women as 6.9 MJ/day (Horwath *et al*., 1991). Men were chosen for this study because their higher energy intakes endear greater possible exposure.

D1.2 High energy (90th centile) intake consumer

An adolescent male eating a high energy (21.5 MJ/day – 90th centile energy intake) (Horwath *et al*., 1992) diet was chosen for this category since young males tend to eat more food than any age-sex group in the population. The LINZ survey data did not provide a breakdown of specific foods contributing to the 90th centile energy consumer. The survey did, however, report the percentage

distribution of energy provided by each food in this 15-18 year old age-sex category. The total energy intake (21.5 MJ/day) was therefore proportioned against the percentage energy intakes for each individual food type, and from this the weights of each food type consumed were derived.

D2 Estimated dietary exposure to PCDDs, PCDFs and PCBs

For both diets, the weights of each of the food type composites used to calculate exposure data are reported in Table D1. These weights were derived using the energy density of the food type composite and the energy the food type composite provided in the diet of a typical LINZ survey participant. Although there are no other comprehensive food consumption data available with which to compare these derived intakes, the amounts of foods consumed daily seem reasonable.

Since PCDDs, PCDFs and PCBs are largely found in the fatty portion of the foods the percentage of energy contributed by fat, and the total amount of fat, were important factors to take into account when devising diets upon which to estimate exposure.

Details on the energy contributions derived from each food type composite are shown in Tables D2 and D3. These were derived by undertaking an analysis of the protein, fat and carbohydrate content of each of the diets using the New Zealand Food Composition Tables (Burlingame, 1993).

The original analysis of the diets using the selected food types and consumption data from the LINZ survey gave a diet that was slightly too low in fat compared to the average fat intake per day for each age-sex category. To compensate for this difference, an additional 10g (absolute amount) of fat (7g beef fat, 1.5 g sheep fat and 1.5 g pork fat) was added to each of the diets. The addition of some fat to the diets is justified because all the meat products in the survey were totally trimmed of their fat. In the LINZ survey 41% of 15-18 year olds and 35% of 25-44 year olds did not trim fat from meat (Horwath *et al*., 1991). Since the fat content of the diets is critical when estimating organochlorine contaminant exposures, Table D1 summarises the contribution of fat made by each food type composite and the total fat content of each of the diets.

Food types such as beverages, nuts, fruits and vegetables were not included in the food type composites. As a result of these omissions, the fat intake used to estimate exposure was slightly low but is considered to be adequate.

In the LINZ survey, the median intake of fat consumed by 25-44 year olds was 110g/day and the 90^{th} centile intake by 15-18 year olds was 210g/day. In the diets used in this study to calculate exposure the fat contents are 105.7g (96%) of median intake and 203.4g (97%) of 90^{th} centile intake per day. Thus these diets provide a reasonable basis upon which to estimate dietary intakes of PCDD, PCDF, and PCB contaminants.

The figures for the quantities of food consumed daily have been rounded in Table D1, but in the calculations the figures used were to one decimal place.

Table D1 Percentage energy, weight, and the fat contribution provided by each food type composite in the adult male 10.8 MJ/day and adolescent male 21.5 MJ/day diets

	10.8 MJ/day diet			21.5 MJ/day diet		
Food type composite	**% Energy**	**Food consumed g/day**	**Fat intake g/day**	**% Energy**	**Food consumed g/day**	**Fat intake g/day**
Beef meat	7	109.6	7.7	7	218.1	15.3
Sheep meat	2	27.7	2.7	1	27.6	2.7
Pork meat	3	26.2	5.5	1	17.4	3.6
Beef fat	3 (all	14.5	7	2 (all	14.5	7.0
Sheep fat	trimmed fats)	4.3	1.5	trimmed fats)	4.3	1.5
Pork fat		6.5	1.5		6.5	1.5
Liver	1	13.2	1.4	1	26.3	2.8
Processed meats	9	80.7	16.1	8	142.9	28.4
Milk	6	278.1	6.8	10	922.7	22.4
Butter	3	10.5	8.6	3	21.6	17.6
Cheese	3	18.9	6.6	3	37.7	13.1
Ice cream/yoghurt	2	38.9	1.9	2	77.5	3.8
NZ fish	2.33	32.4	2.9	2.33	64.5	5.8
Tinned fish	0.33	5.3	0.4	0.33	10.5	0.8
Shellfish	0.33	9.9	0.2	0.33	19.8	0.5
Poultry	3	45.5	3.8	2	60.4	5.0
Eggs	2	33.9	3.8	1	33.7	3.7
Bread	13	151.3	2.3	13	301.1	4.5
Cereals	13	106.5	7.8	19	309.9	22.6
Potatoes	6	119.3	4.4	10	395.9	14.5
Snack foods	3	14.6	4.4	5	48.6	14.8
Vegetable fats/oils	3	10.3	8.6	2	13.7	11.4
Total	**85**		**105.7**	**93**		**203.4**

Table D2 Nutrient and energy table for 10.8 MJ/day diet of an adult male amounts of food type composites and their protein, fat, carbohydrate and energy content

		MJ of food	Food energy	Food consumed	Protein	Protein	Fat	Fat	CHO	CHO
	% Energy	per 10.8 MJ	MJ/100g	g /day	g/100g food	g/day	g/100g food	g/day	g/100g food	g/day
Beef meat	7	0.756	0.690	109.6	25.6	28.0	7.0	7.7	0	0
Sheep meat	2	0.216	0.779	27.7	24.4	6.8	9.9	2.7	0	0
Pork meat	3	0.324	1.238	26.2	27.2	7.1	20.9	5.5	0	0
Beef fat	3.4 (all	0.262	1.810	14.5			48.1	7.0		
Sheep fat	trimmed fats)	0.056	1.300	4.3			34.6	1.5		
Pork fat		0.056	0.860	6.5			22.9	1.5		
Liver	1	0.108	0.818	13.2	20.5	2.7	10.8	1.4	4.3	0.6
Processed meats	9	0.972	1.204	80.7	10.6	8.6	19.9	16.1	16.8	13.6
Milk	6	0.648	0.233	278.1	3.6	10.0	2.4	6.8	4.9	13.6
Butter	3	0.324	3.086	10.5	0.6	0.1	81.7	8.6	0.6	0.1
Cheese	3	0.324	1.712	18.9	24.6	4.7	34.7	6.6	0.1	0.02
Ice cream/yoghurt	2	0.216	0.555	38.9	4.3	1.7	4.9	1.9	18.0	7.0
NZ fish	2.33	0.252	0.777	32.4	23.3	7.5	9.0	2.9	3.0	1.0
Tinned fish	0.33	0.036	0.678	5.3	22.8	1.2	7.9	0.4	0	0
Shellfish	0.33	0.036	0.359	9.9	15.9	1.6	2.5	0.2	0	0
Poultry	3	0.324	0.712	45.5	24.0	10.9	8.3	3.8	0	0
Eggs	2	0.216	0.638	33.9	13.0	4.4	11.1	3.8	0.3	0.1
Bread	13	1.404	0.928	151.3	8.0	12.1	1.5	2.3	44.3	66.9
Cereals	13	1.404	1.318	106.5	6.1	6.5	7.3	7.8	56.5	60.2
Potatoes	6	0.648	0.543	119.3	2.5	3.0	3.7	4.4	21.8	26.1
Snack foods	3	0.324	2.212	14.6	7.9	1.2	30.4	4.4	56.4	8.3
Fats/oils	3	0.324	3.141	10.3	0.5	0	83.5	8.6	0	0
Total weight						**118.1**		**105.7**		**197.4**
Energy		**9.23 MJ**				**1.97 MJ**		**3.97 MJ**		**3.29 MJ**
Total	**85**									**9.23 MJ**

Table D3 Nutrient and energy table for 21.5 MJ/day diet of an adolescent male amounts of food type composites and their protein, fat, carbohydrate and energy content

		MJ of food	Food energy	Food consumed	Protein	Protein	Fat	Fat	CHO	CHO
	% Energy	per 21.5 MJ	MJ/100g	g /day	g/100g food	g/day	g/100g food	g/day	g/100g food	g/day
Beef meat	7	1.505	0.690	218.1	25.6	55.8	7.0	15.3	0	0
Sheep meat	1	0.215	0.779	27.6	24.4	6.7	9.9	2.7	0	0
Pork meat	1	0.215	1.238	17.4	27.2	4.7	20.9	3.6	0	0
Beef fat	1.7 (all	0.262	1.810	14.5			48.1	7.0		
Sheep fat	trimmed fats)	0.056	1.300	4.3			34.6	1.5		
Pork fat		0.056	0.860	6.5			22.9	1.5		
Liver	1	0.215	0.818	26.3	20.5	5.4	10.8	2.8	4.3	1.1
Processed meats	8	1.720	1.204	142.9	10.6	15.1	19.9	28.4	16.8	24.0
Milk	10	2.150	0.233	922.7	3.6	33.2	2.4	22.4	4.9	45.2
Butter	3	0.667	3.086	21.6	0.6	0.1	81.7	17.6	0.6	0.1
Cheese	3	0.645	1.712	37.7	24.6	9.3	34.7	13.1	0.1	0.04
Ice cream/yoghurt	2	0.430	0.555	77.5	4.3	3.3	4.9	3.8	18.0	13.9
NZ fish	2.33	0.501	0.777	64.5	23.3	15.0	9.0	5.8	3.0	1.9
Tinned fish	0.33	0.071	0.678	10.5	22.8	2.4	7.9	0.8	0	0
Shellfish	0.33	0.071	0.359	19.8	15.9	3.1	2.5	0.5	0	0
Poultry	2	0.430	0.712	60.4	24.0	14.5	8.3	5.0	0	0
Eggs	1	0.215	0.638	33.7	13.0	4.4	11.1	3.7	0.3	0.1
Bread	13	2.795	0.928	301.1	8.0	24.1	1.5	4.5	44.3	133.3
Cereals	19	4.085	1.318	309.9	6.1	18.9	7.3	22.6	56.5	175.1
Potatoes	10	2.150	0.543	395.9	2.5	10.0	3.7	14.5	21.8	86.4
Snack foods	5	1.075	2.212	48.6	7.9	3.8	30.4	14.8	56.4	27.4
Fats/oils	2	0.645	3.141	13.7	0.5	0.1	83.5	11.4	0	0
Total weight						**230.1**		**203.4**		**508.8**
Energy		**20.0 MJ**				**3.84 MJ**		**7.64 MJ**		**8.49 MJ**
Total	**93**									**20.0 MJ**

Appendix E Food data

This appendix reports the extractable fat content and PCDD, PCDF and PCB concentrations in food produce collected as part of the dietary survey of the Organochlorines Programme.

Congener-specific concentrations for all 2,3,7,8- PCDDs and PCDFs are reported, along with total concentrations for non 2,3,7,8- PCDDs and PCDFs for each homologue group. Total TEQ levels were calculated, both excluding LOD values and including half LOD values, using the International TEF scheme (Kutz *et al*., 1990).

Concentrations of 23 PCB congeners are reported. PCB TEQ levels were calculated, both excluding LOD values and including half LOD values, using the WHO TEFs (Ahlborg *et al*., 1994).

PCDD, PCDF and PCB data are reported in the following tables:

Table E1.0 Extractable fat content of foods analysed
Table E1.1 PCDD and PCDF concentrations in meats and meat products
Table E1.2 PCB concentrations in meats and meat products
Table E2.1 PCDD and PCDF concentrations in dairy products
Table E2.2 PCB concentrations in dairy products
Table E3.1 PCDD and PCDF concentrations in fish
Table E3.2 PCB concentrations in fish
Table E4.1 PCDD and PCDF concentrations in poultry and eggs
Table E4.2 PCB concentrations in poultry and eggs
Table E5.1 PCDD and PCDF concentrations in cereal products
Table E5.2 PCB concentrations in cereal products
Table E6.1 PCDD and PCDF concentrations in other foods
Table E6.2 PCB concentrations in other foods

Table E1.0 Extractable fat content of foods analysed

Food type composite	Components of food type composite	Extractable fat content (%)
Beef meat	Rump steak and beef mince	7.4
Sheep meat	Shoulder and leg meat of lamb and mutton	10.6
Pork meat	Pork pieces and middle bacon	8.2
Beef fat	Fat trimmed from rump steak	41.1
Sheep fat	Fat trimmed from shoulder and leg meat	34.7
Pork fat	Fat trimmed from pork pieces and bacon	21.5
Liver	Mixture of beef, lamb and chicken livers	8.8
Processed meat products	Steak-type pies, beef flavoured sausages and luncheon sausages	15.4
Milk	Standard and trim	1.3
Butter	Salted butter	78.9
Cheese	Colby and mild cheddar	35.9
Ice cream/yoghurt	Vanilla ice cream and flavoured yoghurt	5.3
New Zealand fish	Selection of snapper, blue cod, sole and terakihi, plus battered deep-fried fish from fish and chip shop	6.6
Imported tinned fish	Tinned tuna, salmon and sardines	6.6
Shellfish	Oysters and mussels	3.0
Poultry	Fresh whole chicken	2.5
Eggs	Ordinary eggs	9.9
Bread	While, wholemeal and multigrain	0.89
Cereals	Weetbix, cornflakes, rolled oats, rice, dried spaghetti, chocolate biscuits, plain biscuits, savoury biscuits and plain cake	5.3
Potatoes	Potatoes and hot deep-fried chips	3.8
Snack foods	Potato crisps, corn tortillas and milk chocolate	26.6
Vegetable fats/oils	Margarine, salad and cooking oil, and olive oil	83.3

Table E1.1 PCDD and PCDF concentrations in meats and meat products (ng kg^{-1} wet weight basis)

Congener		Beef meat		Beef fat		Lamb and mutton meat		Lamb and mutton fat		Pork meat		Pork fat		Liver		Processed meat products
2378 TCDD	<	0.006	<	0.08	<	0.005	<	0.02	<	0.01	<	0.009	<	0.02	<	0.007
Non 2378 TCDD	<	0.003		2.30	<	0.005		0.36	<	0.02	<	0.01	<	0.02		0.24
12378 PeCDD	<	0.003	<	0.1	<	0.007	<	0.04	<	0.02	<	0.02	<	0.08	<	0.01
Non 2378 PeCDD	<	0.004		1.31	<	0.006		0.15	<	0.05	<	0.02	<	0.08	<	0.02
123478 HxCDD	<	0.01	<	0.04	<	0.004	<	0.03	<	0.01	<	0.02	<	0.05	<	0.008
123678 HxCDD	<	0.03	<	0.1	<	0.006	<	0.02	<	0.01	<	0.02	<	0.04	<	0.02
123789 HxCDD	<	0.009	<	0.07	<	0.006	<	0.02	<	0.02	<	0.03	<	0.05	<	0.01
Non 2378 HxCDD	<	0.04		0.57	<	0.007	<	0.05	<	0.2	<	0.05	<	0.05	<	0.03
1234678 HpCDD	<	0.1	<	0.2	<	0.04	<	0.09	<	0.1		0.15	<	0.2	<	0.1
Non 2378 HpCDD	<	0.1	<	0.1	<	0.03	<	0.09	<	0.08	<	0.08	<	0.07	<	0.07
OCDD	<	0.7	<	0.6	<	0.3	<	0.4	<	0.7		0.83	<	0.7	<	1
2378 TCDF	<	0.002	<	0.02	<	0.003	<	0.01	<	0.008	<	0.01	<	0.007	<	0.01
Non 2378 TCDF	<	0.002	<	0.03	<	0.003	<	0.01	<	0.008	<	0.01	<	0.007	<	0.01
12378 PeCDF	<	0.002	<	0.02	<	0.003	<	0.01	<	0.005	<	0.009	<	0.02	<	0.005
23478 PeCDF	<	0.002	<	0.02	<	0.003	<	0.01	<	0.004	<	0.01	<	0.02	<	0.008
Non 2378 PeCDF	<	0.002	<	0.08	<	0.004	<	0.02	<	0.02	<	0.01	<	0.05	<	0.009
123478 HxCDF	<	0.002	<	0.03	<	0.005	<	0.02	<	0.01	<	0.02	<	0.02	<	0.01
123678 HxCDF	<	0.002	<	0.03	<	0.005	<	0.02	<	0.009	<	0.01	<	0.02	<	0.01
234678 HxCDF	<	0.002	<	0.03	<	0.005	<	0.02	<	0.009	<	0.02	<	0.02	<	0.01
123789 HxCDF	<	0.003	<	0.03	<	0.006	<	0.03	<	0.01	<	0.03	<	0.04	<	0.01
Non 2378 HxCDF	<	0.01	<	0.05	<	0.005	<	0.02	<	0.02	<	0.02	<	0.02	<	0.01
1234678 HpCDF	<	0.009	<	0.08	<	0.02	<	0.03	<	0.04	<	0.06	<	0.1	<	0.02
1234789 HpCDF	<	0.003	<	0.06	<	0.01	<	0.03	<	0.01	<	0.03	<	0.03	<	0.01
Non 2378 HpCDF	<	0.01	<	0.05	<	0.008	<	0.02	<	0.02	<	0.03	<	0.02	<	0.02
OCDF	<	0.02	<	0.1	<	0.01	<	0.07	<	0.03	<	0.08	<	0.06	<	0.02
% fat		7.4		41.1		10.6		34.7		8.2		21.5		8.8		15.4
Sum of PCDD and PCDF congeners																
Including half LOD values		0.54		5.14		0.25		1.05		0.71		1.29		0.90		0.96
Excluding LOD values		0		4.18		0		0.51		0		0.98		0		0.24
Total I-TEQ																
Including half LOD values		0.0082		0.090		0.0076		0.032		0.017		0.023		0.050		0.014
Excluding LOD values		0		0		0		0		0		0.0023		0		0

Table E1.2 PCB concentrations in meats and meat products (ng kg^{-1} wet weight basis)

		Beef meat		Beef fat		Lamb and mutton meat		Lamb and mutton fat		Pork meat		Pork fat		Liver		Processed meat products
PCB #77		0.23		4.28		0.19		0.82		9.91		0.18	<	0.3		0.44
PCB #126	<	0.1		0.51	<	0.06	<	0.2	<	0.4		0.26		0.31	<	0.2
PCB #169	<	0.1	<	0.3	<	0.07	<	0.3	<	0.4		0.59	<	0.2	<	0.2
PCB #52		7.36		90.6		6.84		16.8		199		8.34	<	5		11.9
PCB #99		2.78		24.9		1.33		4.43		31.1		8.13	<	3		5.83
PCB #101		5.49		114		8.65		16.6		103		10.2		4.94		14.3
PCB #105	<	0.9		12.3		1.28		6.52		12.0		2.38	<	2	<	2
PCB #114	<	0.4	<	1	<	0.3		0.56		1.14	<	0.3	<	0.2	<	0.5
PCB #118	<	5		71.2	<	6		17.4		37.9		14.7	<	7		12.7
PCB #123	<	0.4	<	5	<	0.8	<	1	<	2	<	2	<	2	<	0.9
PCB #138		15.4		145		17.2		45.1		65.2		64.4		36.0		28.7
PCB #153		13.7		100		16.8		47.1		40.4		37.4		31.3		24.1
PCB #156	<	2		4.40		0.82		3.28		3.07		3.05		0.87		1.61
PCB #157	<	0.3	<	1		0.15		0.68	<	0.8	<	0.5		0.21	<	0.8
PCB #167		1.04		10.4		0.68		2.67		5.74		5.65		1.59		2.10
PCB #170		1.06		15.1		2.66		10.9		3.79		13.1		5.68		1.95
PCB #180		3.27		16.8		3.27		11.9		8.07		11.4		5.90		5.71
PCB #183		1.57		10.1		1.35		3.50		3.50		3.85		4.03		2.18
PCB #187		1.50		12.7		2.02		6.94		7.29		8.02		2.94		2.27
PCB #189	<	0.5	<	0.7	<	0.2	<	0.3	<	1	<	0.6	<	0.2	<	0.8
PCB #194	<	0.3	<	2		0.47		1.65	<	2	<	2	<	0.3	<	0.6
PCB #202	<	0.2	<	0.6	<	0.2	<	0.2	<	1	<	0.5	<	0.2	<	0.7
PCB #206	<	0.4	<	2	<	0.2	<	1	<	2	<	0.5	<	0.2	<	0.8
%fat		7.4		41.1		10.6		34.7		8.2		21.5		8.8		15.4
Sum of PCB congeners																
Including half LOD values		58.7		639		67.6		198		536		195		104		118
Excluding LOD values		53.4		632		63.7		197		531		192		93.8		114
Total PCB TEQ																
Including half LOD values		0.0068		0.068		0.0048		0.018		0.035		0.037		0.034		0.014
Excluding LOD values		0.00026		0.065		0.0010		0.0063		0.013		0.037		0.032		0.0026

Table E2.1 PCDD and PCDF concentrations in dairy products (ng kg^{-1} wet weight basis)

Congener		Salted butter		Colby and mild cheese		Yoghurt and ice cream		Standard and trim milk[1]
2378 TCDD	<	0.04	<	0.01	<	0.008	<	0.001
Non 2378 TCDD	<	0.05		0.55		0.26	<	0.002
12378 PeCDD	<	0.06	<	0.02	<	0.02	<	0.002
Non 2378 PeCDD	<	0.09		0.29		0.27	<	0.003
123478 HxCDD	<	0.06	<	0.02	<	0.006	<	0.001
123678 HxCDD	<	0.1	<	0.02	<	0.01	<	0.002
123789 HxCDD	<	0.1	<	0.03	<	0.01	<	0.002
Non 2378 HxCDD	<	0.1	<	0.03	<	0.05	<	0.003
1234678 HpCDD	<	0.7	<	0.1	<	0.04	<	0.01
Non 2378 HpCDD	<	0.4	<	0.09	<	0.04	<	0.004
OCDD	<	1	<	0.4	<	0.2	<	0.05
2378 TCDF	<	0.02	<	0.01	<	0.004		0.0025
Non 2378 TCDF	<	0.02	<	0.01	<	0.005		0.0025
12378 PeCDF	<	0.02	<	0.008	<	0.004	<	0.0007
23478 PeCDF	<	0.05	<	0.01	<	0.005	<	0.001
Non 2378 PeCDF	<	0.05	<	0.02	<	0.006	<	0.002
123478 HxCDF	<	0.04	<	0.01	<	0.008	<	0.001
123678 HxCDF	<	0.04	<	0.01	<	0.008	<	0.0009
234678 HxCDF	<	0.04	<	0.01	<	0.009	<	0.002
123789 HxCDF	<	0.05	<	0.02	<	0.008	<	0.001
Non 2378 HxCDF	<	0.05	<	0.02	<	0.008	<	0.002
1234678 HpCDF	<	0.1	<	0.03	<	0.02	<	0.004
1234789 HpCDF	<	0.07	<	0.02	<	0.01	<	0.001
Non 2378 HpCDF	<	0.1	<	0.02	<	0.009	<	0.004
OCDF	<	0.1	<	0.05	<	0.02	<	0.004
%fat		78.9		35.9		5.3		1.3
Sum of PCDD and PCDF congeners								
Including half LOD values		1.73		1.32		0.78		0.057
Excluding LOD values		0		0.84		0.53		0.0050
Total I-TEQ								
Including half LOD values		0.075		0.020		0.014		0.0021
Excluding LOD values		0		0		0		0.00025

1 = 1278-TCDF was the only non 2378-TCDF congener detected.

Table E2.2 PCB concentrations in dairy products (ng kg^{-1} wet weight basis)

		Salted butter		Colby and mild cheese		Yoghurt and ice cream		Standard and trim milk
PCB #77	<	0.3		0.75		0.40	<	0.06
PCB #126		1.03		0.30	<	0.07	<	0.03
PCB #169	<	0.5	<	0.2	<	0.03	<	0.01
PCB #52	<	5		11.8		4.06	<	0.4
PCB #99		23.9		8.54		2.58		0.78
PCB #101	<	20		19.1		9.15	<	0.5
PCB #105		16.3		5.06		2.18		0.33
PCB #114	<	3	<	0.5	<	0.3	<	0.1
PCB #118		87.8		28.8		10.0		1.87
PCB #123	<	3	<	3	<	0.6	<	0.1
PCB #138		177		75.8		27.1		5.24
PCB #153		102		48.2		15.0		3.78
PCB #156		7.26		2.37		0.80		0.17
PCB #157	<	3	<	0.4	<	0.2	<	0.1
PCB #167		17.4		5.61		1.95		0.33
PCB #170		24.5		8.86		2.44		0.34
PCB #180		23.7		9.53		2.81		0.90
PCB #183		8.54		4.46		1.65	<	0.4
PCB #187	<	4		4.35		2.46	<	0.2
PCB #189	<	1	<	0.5	<	0.2	<	0.1
PCB #194		3.50	<	1	<	0.3	<	0.1
PCB #202	<	0.5	<	0.4	<	0.1	<	0.1
PCB #206	<	2	<	2	<	0.2	<	0.1
%fat		78.9		35.9		5.3		1.3
Sum of PCB congeners								
Including half LOD values		514		238		83.6		14.9
Excluding LOD values		493		234		82.6		13.7
Total PCB TEQ								
Including half LOD values		0.12		0.037		0.0059		0.0020
Excluding LOD values		0.12		0.036		0.0021		0.00035

Table E3.1 PCDD and PCDF concentrations in fish (ng kg^{-1} wet weight basis)

Congener		New Zealand fish fillets and deep fried fish		Overseas tinned fish		Oysters and mussels (n=2)[1]
2378 TCDD	<	0.006	<	0.02	<	0.005
Non 2378 TCDD		0.13	<	0.04		0.069
12378 PeCDD		0.014		0.052		0.018
Non 2378 PeCDD		0.11	<	0.02		0.19
123478 HxCDD	<	0.006	<	0.009	<	0.006
123678 HxCDD		0.012		0.026		0.016
123789 HxCDD	<	0.006		0.010		0.011
Non 2378 HxCDD		0.058		0.084		0.17
1234678 HpCDD	<	0.06	<	0.04		0.054
Non 2378 HpCDD	<	0.03	<	0.03		0.060
OCDD	<	0.4	<	0.2		0.28
2378 TCDF		0.037		0.27		0.035
Non 2378 TCDF		0.041		0.17		0.077
12378 PeCDF		0.007		0.043	<	0.005
23478 PeCDF		0.019		0.090	<	0.007
Non 2378 PeCDF		0.044		0.16		0.075
123478 HxCDF	<	0.004		0.011	<	0.003
123678 HxCDF	<	0.005		0.013	<	0.003
234678 HxCDF	<	0.005		0.011	<	0.003
123789 HxCDF	<	0.005	<	0.005	<	0.003
Non 2378 HxCDF		0.021		0.042		0.028
1234678 HpCDF		0.021	<	0.02		0.012
1234789 HpCDF	<	0.003	<	0.004	<	0.003
Non 2378 HpCDF	<	0.008	<	0.006		0.006
OCDF	<	0.01	<	0.02	<	0.009
%fat		6.6		6.6		3.0
Sum of PCDD and PCDF congeners						
Including half LOD values		0.79		1.20		1.12
Excluding LOD values		0.51		0.99		1.02
Total I-TEQ						
Including half LOD values		0.027		0.12		0.021
Excluding LOD values		0.022		0.11		0.016

1 = Mean of duplicate analyses (if a congener was quantified in one of the analyses, but the second analyses reports the congener as a non-detect, then half the LOD was used in the calculation of the mean).

Table E3.2 PCB concentrations in fish (ng kg^{-1} wet weight b

Congener		New Zealand fish fillets and deep fried fish		Overseas tinned fish		Oysters and mussels (n=2)[1]
PCB #77		0.72		4.73		0.60
PCB #126		0.41		1.00		0.23
PCB #169		0.15		0.15		0.10
PCB #52		10.6		143		2.91
PCB #99		29.7		125		9.39
PCB #101		45.4		340		11.3
PCB #105		7.76		64.2		5.19
PCB #114	<	0.4		6.27		0.21
PCB #118		28.6		289		20.7
PCB #123	<	0.8	<	20	<	2
PCB #138		166		610		76.2
PCB #153		150		398		60.3
PCB #156		6.01		14.8		0.98
PCB #157		1.57		5.61		0.63
PCB #167		16.2		57.9		8.70
PCB #170		2.30		49.7		3.52
PCB #180		30.3		56.0		3.58
PCB #183		14.9		32.8		2.39
PCB #187		39.9		144		22.8
PCB #189	<	0.5		0.87	<	0.1
PCB #194	<	0.3		8.14	<	0.3
PCB #202		1.08		7.18		0.70
PCB #206	<	0.4		3.03	<	0.1
%fat		6.6		6.6		3.0
Sum of PCB congeners						
Including half LOD values		553		2,370		232
Excluding LOD values		552		2,360		230
Total PCB TEQ						
Including half LOD values		0.051		0.16		0.028
Excluding LOD values		0.051		0.16		0.028

Table E4.1 PCDD and PCDF concentrations in poultry and eggs (ng kg^{-1} wet weight basis)

Congener		Poultry		Eggs
2378 TCDD	<	0.005	<	0.005
Non 2378 TCDD	<	0.01		0.12
12378 PeCDD	<	0.007	<	0.01
Non 2378 PeCDD		0.084		0.14
123478 HxCDD	<	0.005	<	0.009
123678 HxCDD	<	0.005	<	0.02
123789 HxCDD	<	0.006	<	0.01
Non 2378 HxCDD		0.061		0.097
1234678 HpCDD		0.063		0.12
Non 2378 HpCDD		0.036		0.052
OCDD		0.30		0.53
2378 TCDF	<	0.003	<	0.006
Non 2378 TCDF	<	0.003	<	0.009
12378 PeCDF	<	0.001	<	0.003
23478 PeCDF	<	0.001	<	0.006
Non 2378 PeCDF	<	0.005	<	0.01
123478 HxCDF	<	0.003	<	0.01
123678 HxCDF	<	0.003	<	0.005
234678 HxCDF	<	0.003	<	0.006
123789 HxCDF	<	0.005	<	0.006
Non 2378 HxCDF	<	0.006	<	0.02
1234678 HpCDF	<	0.02	<	0.03
1234789 HpCDF	<	0.004	<	0.008
Non 2378 HpCDF	<	0.01	<	0.02
OCDF	<	0.02	<	0.02
%fat		2.5		9.9
Sum of PCDD and PCDF congeners				
Including half LOD values		0.60		1.17
Excluding LOD values		0.54		1.06
Total I-TEQ				
Including half LOD values		0.0072		0.012
Excluding LOD values		0.00093		0.0017

Table E4.2 PCB concentrations in poultry and eggs (ng kg^{-1} wet weight basis)

Congener		Poultry		Eggs
PCB #77		0.17		0.55
PCB #126	<	0.05	<	0.1
PCB #169	<	0.07	<	0.07
PCB #52	<	3		4.27
PCB #99	<	1		5.15
PCB #101		4.11		7.75
PCB #105	<	0.5		4.56
PCB #114	<	0.3	<	0.4
PCB #118	<	2		18.8
PCB #123	<	0.5	<	1
PCB #138		7.56		42.8
PCB #153		5.59		25.2
PCB #156		0.69		2.34
PCB #157	<	0.2		0.41
PCB #167	<	0.5		4.24
PCB #170	<	0.4		8.16
PCB #180		1.30		7.56
PCB #183		0.86		2.94
PCB #187		1.74		5.06
PCB #189	<	0.3	<	0.1
PCB #194	<	0.4		0.98
PCB #202	<	0.3	<	0.2
PCB #206	<	0.5	<	0.5
%fat		2.5		9.9
Sum of PCB congeners				
Including half LOD values		27.0		142
Excluding LOD values		22.0		141
Total PCB TEQ				
Including half LOD values		0.0036		0.010
Excluding LOD values		0.00044		0.0049

Table E5.1 PCDD and PCDF concentrations in cereal products (ng kg^{-1} whole weight)

Congener		Bread (n=2)[1]		Cereals, cake, biscuits, rice and spaghetti
2378 TCDD	<	0.003	<	0.006
Non 2378 TCDD		0.090		0.30
12378 PeCDD	<	0.006	<	0.007
Non 2378 PeCDD		0.13		0.24
123478 HxCDD	<	0.003	<	0.004
123678 HxCDD	<	0.005	<	0.009
123789 HxCDD	<	0.005	<	0.01
Non 2378 HxCDD		0.079		0.11
1234678 HpCDD	<	0.09		0.15
Non 2378 HpCDD	<	0.07		0.085
OCDD		1.13		1.18
2378 TCDF	<	0.003	<	0.003
Non 2378 TCDF	<	0.004	<	0.006
12378 PeCDF	<	0.001	<	0.002
23478 PeCDF	<	0.002	<	0.002
Non 2378 PeCDF	<	0.006	<	0.009
123478 HxCDF	<	0.002	<	0.003
123678 HxCDF	<	0.002	<	0.003
234678 HxCDF	<	0.002	<	0.003
123789 HxCDF	<	0.002	<	0.002
Non 2378 HxCDF	<	0.006	<	0.01
1234678 HpCDF	<	0.01	<	0.01
1234789 HpCDF	<	0.002	<	0.003
Non 2378 HpCDF	<	0.02	<	0.01
OCDF		0.034	<	0.02
%fat		0.89		5.3
Sum of PCDD and PCDF congeners				
Including half LOD values		1.58		2.13
Excluding LOD values		1.46		2.07
Total I-TEQ				
Including half LOD values		0.0059		0.0099
Excluding LOD values		0.0012		0.0027

Table E5.2 PCB concentrations in cereal products (ng kg^{-1} whole weight)

Congener		Bread (n=2)[1]		Cereals, cake, biscuits, rice and spaghetti
PCB #77		0.49		0.62
PCB #126	<	0.06	<	0.01
PCB #169	<	0.06	<	0.1
PCB #52		5.11		8.25
PCB #99		1.00		2.53
PCB #101		6.28		12.7
PCB #105	<	0.7		1.92
PCB #114	<	0.3	<	0.2
PCB #118		3.36		7.68
PCB #123	<	0.3	<	0.6
PCB #138		11.0		17.8
PCB #153		6.57		9.23
PCB #156		0.40		0.52
PCB #157	<	0.2	<	0.2
PCB #167		0.71		1.38
PCB #170		1.80		1.65
PCB #180		2.04		1.65
PCB #183		1.02		1.06
PCB #187		2.09		2.22
PCB #189	<	0.3	<	0.1
PCB #194	<	0.3	<	0.2
PCB #202	<	0.2	<	0.1
PCB #206	<	0.2	<	0.2
%fat		0.89		5.3
Sum of PCB congeners				
Including half LOD values		43.0		70.1
Excluding LOD values		41.8		69.2
Total PCB TEQ				
Including half LOD values		0.0040		0.0027
Excluding LOD values		0.00099		0.0017

1 = Mean of duplicate analyses (if a congener was quantified in one of the analyses, but the second analyses reports the congener as a non-detect, then half the LOD was used in the calculation of the mean).

Table E6.1 PCDD and PCDF concentrations in other foods (ng kg^{-1} wet weight basis)

Congener		Potatoes and hot chips		Snack foods		Vegetable fats and oils
2378 TCDD	<	0.006	<	0.02	<	0.02
Non 2378 TCDD		0.60		0.51	<	0.02
12378 PeCDD		0.014	<	0.03	<	0.03
Non 2378 PeCDD		0.26		0.090	<	0.03
123478 HxCDD		0.0060	<	0.03	<	0.04
123678 HxCDD		0.016	<	0.03	<	0.03
123789 HxCDD		0.009	<	0.03	<	0.03
Non 2378 HxCDD		0.11	<	0.1	<	0.04
1234678 HpCDD		0.12		0.27	<	0.2
Non 2378 HpCDD		0.049		0.30	<	0.2
OCDD		0.61		8.95	<	2
2378 TCDF	<	0.001	<	0.02	<	0.02
Non 2378 TCDF		0.049	<	0.02	<	0.02
12378 PeCDF	<	0.001	<	0.02	<	0.02
23478 PeCDF	<	0.001	<	0.01	<	0.01
Non 2378 PeCDF		0.025	<	0.03	<	0.02
123478 HxCDF	<	0.002	<	0.02	<	0.02
123678 HxCDF	<	0.001	<	0.02	<	0.02
234678 HxCDF	<	0.002	<	0.02	<	0.02
123789 HxCDF	<	0.002	<	0.02	<	0.04
Non 2378 HxCDF		0.011	<	0.04	<	0.02
1234678 HpCDF		0.021	<	0.1	<	0.07
1234789 HpCDF	<	0.002	<	0.04	<	0.07
Non 2378 HpCDF	<	0.008	<	0.06	<	0.07
OCDF	<	0.009		1.70	<	0.2
%fat		3.8		26.6		83.3
Sum of PCDD and PCDF congeners						
Including half LOD values		1.92		12.1		1.63
Excluding LOD values		1.91		11.8		0
Total I-TEQ						
Including half LOD values		0.016		0.044		0.034
Excluding LOD values		0.012		0.013		0

Table E6.2 PCB concentrations in other foods (ng kg^{-1} wet weight basis)

Congener		Potatoes and hot chips		Snack foods		Vegetable fats and oils
PCB #77		0.33		0.99	<	0.4
PCB #126	<	0.02	<	0.2	<	0.2
PCB #169	<	0.04	<	0.2	<	0.4
PCB #52		3.02		19.8	<	7
PCB #99		1.29		5.73	<	2
PCB #101		5.58		33.8	<	7
PCB #105		1.09		3.71	<	2
PCB #114	<	0.2	<	0.3	<	0.3
PCB #118		5.05		16.3	<	5
PCB #123	<	0.4	<	3	<	2
PCB #138		16.9		42.0	<	20
PCB #153		9.79		23.9	<	9
PCB #156		0.45	<	0.8	<	0.7
PCB #157	<	0.1	<	0.2	<	0.3
PCB #167		1.26		2.47	<	2
PCB #170		1.46	<	3	<	4
PCB #180		1.86	<	3	<	4
PCB #183		1.11		2.43	<	2
PCB #187		2.23		4.37	<	2
PCB #189	<	0.1	<	0.3	<	0.4
PCB #194	<	0.3	<	0.6	<	2
PCB #202	<	0.1	<	0.3	<	1
PCB #206	<	0.1	<	0.8	<	2
%fat		3.8		26.6		83.3
Sum of PCB congeners						
Including half LOD values		52.1		162		37.9
Excluding LOD values		51.4		156		0
Total PCB TEQ						
Including half LOD values		0.0025		0.014		0.013
Excluding LOD values		0.0012		0.0025		0

Appendix F Estimated dietary intake of PCDDs, PCDFs and PCBs

This appendix reports the detailed breakdown of the contribution of each food type composite to the dietary intake of PCDDs, PCDFs and PCBs for a person consuming 10.8 or 21.5 MJ/day (Hannah, 1997c).

Table F1 Estimated daily PCDD and PCDF intakes as TEQs and PCB intakes as TEQs and sum of congeners for an adult male consuming 10.8 MJ/day

Table F2 Estimated daily PCDD and PCDF intakes as TEQs and PCB intakes as TEQs and sum of congeners for an adolescent male consuming 21.5 MJ/day

F1 Estimated PCDD, PCDF and PCB intakes of males consuming 10.8 MJ/day and 21.5 MJ/day diets

For each of these diets, an estimate of dietary intake was made by multiplying the weight of each of the food type composites consumed daily (Table D1, Appendix D) by the concentration of PCDDs, PCDFs and PCBs in that composite (as reported in Tables E1.1 to E6.2, Appendix E). This estimation was undertaken for TEQs calculated excluding LOD values and including one half the LOD for non-detected congeners. For PCBs, this estimation was also undertaken as the sum of PCB congeners. The results of these calculations are shown in Tables F1 and F2.

Table F1 Estimated daily PCDD and PCDF intakes as TEQs, and PCB intakes as TEQs and sum of congeners for an adult male consuming 10.8 MJ/day

		PCDD and PCDF concentration in composites (whole weight)		Calculated intake of PCDD and PCDF (whole weight)		PCB Concentration in composites (whole weight)		Calculated intake of PCBs (whole weight)			
Food type composite	**Amount eaten**	**I-TEQ ng/kg**	**I-TEQ ng/kg**	**I-TEQ pg/day**	**I-TEQ pg/day**	**TEQ ng /kg**	**TEQ ng /kg**	**TEQ pg/day**	**TEQ pg/day**	**Sum ng/day**	**Sum ng/day**
	g/day	**Inc. ½ LOD**	**Exc. LOD**	**Inc. ½ LOD**	**Exc. LOD**	**Inc. ½ LOD**	**Exc. LOD**	**Inc. ½ LOD**	**Exc. LOD**	**Inc. ½ LOD**	**Exc. LOD**
Beef meat	109.6	0.0082	0	0.898	0	0.0068	0.00026	0.745	0.028	6.43	5.85
Sheep meat	27.7	0.0076	0	0.211	0	0.0048	0.0010	0.133	0.028	1.87	1.77
Pork meat	26.2	0.017	0	0.445	0	0.035	0.013	0.916	0.340	14.0	13.9
Beef fat	14.5	0.090	0	1.31	0	0.068	0.065	0.986	0.943	9.27	9.16
Sheep fat	4.3	0.032	0	0.138	0	0.018	0.0063	0.077	0.027	0.851	0.847
Pork fat	6.5	0.023	0.0023	0.150	0.013	0.037	0.037	0.241	0.241	1.27	1.25
Liver	13.2	0.050	0	0.660	0	0.034	0.032	0.449	0.422	1.37	1.24
Processed meats	80.7	0.014	0	1.13	0	0.014	0.0026	1.13	0.210	9.53	9.20
Milk	278.1	0.0021	0.00025	0.584	0.070	0.0020	0.00035	0.556	0.097	4.14	3.81
Butter	10.5	0.075	0	0.787	0	0.12	0.12	1.26	1.26	5.40	5.18
Cheese	18.9	0.020	0	0.379	0	0.037	0.036	0.700	0.681	4.50	4.43
Ice cream/yoghurt	38.9	0.014	0	0.545	0	0.0059	0.0021	0.230	0.082	3.25	3.21
NZ fish	32.4	0.027	0.022	0.874	0.712	0.051	0.051	1.65	1.65	17.9	17.9
Imported tinned fish	5.3	0.12	0.11	0.631	0.578	0.16	0.16	0.841	0.841	12.5	12.4
Shellfish	9.9	0.021	0.016	0.209	0.159	0.028	0.028	0.278	0.278	2.30	2.28
Poultry	45.5	0.0072	0.00093	0.328	0.042	0.0036	0.00044	0.164	0.020	1.23	1.00
Eggs	33.9	0.012	0.0017	0.406	0.058	0.010	0.0049	0.339	0.166	4.81	4.77
Bread	151.3	0.0059	0.0012	0.893	0.182	0.0040	0.00099	0.605	0.150	6.51	6.32
Cereals	106.5	0.0099	0.0027	1.05	0.288	0.0027	0.0017	0.288	0.181	7.47	7.37
Potatoes	119.3	0.016	0.012	1.91	1.43	0.0025	0.0012	0.298	0.143	6.22	6.13
Snack foods	14.6	0.044	0.013	0.645	0.190	0.014	0.0025	0.205	0.037	2.37	2.28
Vegetable fats/oils	10.3	0.034	0	0.351	0	0.013	0	0.134	0	0.391	0
Total				**14.5**	**3.72**			**12.2**	**7.83**	**124**	**120**

Table F2 Estimated daily PCDD and PCDF as TEQs, and PCB intakes as TEQs and sum of congeners for an adolescent male consuming 21.5 MJ/day

		PCDD and PCDF concentration in composites (whole weight)		Calculated intake of PCDD and PCDF (whole weight)		PCB concentration in composites (whole weight)		Calculated intake of PCBs (whole weight)			
Food type composite	**Amount eaten**	**I-TEQ ng/kg**	**I-TEQ ng/kg**	**I TEQ pg/day**	**I-TEQ pg/day**	**TEQ ng/kg**	**TEQ ng/kg**	**TEQ pg/day**	**TEQ pg/day**	**Sum ng/day**	**Sum ng/day**
	g/day	**Inc. ½ LOD**	**Exc. LOD**	**Inc. ½ LOD**	**Exc. LOD**	**Inc. ½ LOD**	**Exc. LOD**	**Inc. ½ LOD**	**Exc. LOD**	**Inc. ½ LOD**	**Exc. LOD**
Beef meat	218.1	0.0082	0	1.79	0	0.0068	0.00026	1.48	0.057	12.8	11.7
Sheep meat	27.6	0.0076	0	0.210	0	0.0048	0.0010	0.132	0.028	1.87	1.76
Pork meat	17.4	0.017	0	0.295	0	0.035	0.013	0.608	0.226	9.31	9.22
Beef fat	14.5	0.090	0	1.31	0	0.068	0.065	0.986	0.943	9.27	9.16
Sheep fat	4.3	0.032	0	0.138	0	0.018	0.0063	0.077	0.027	0.851	0.847
Pork fat	6.5	0.023	0.0023	0.150	0.013	0.037	0.037	0.241	0.241	1.27	1.25
Liver	26.3	0.050	0	1.31	0	0.034	0.032	0.894	0.841	2.73	2.47
Processed meats	142.9	0.014	0	2.00	0	0.014	0.0026	2.00	0.371	16.9	16.3
Milk	922.7	0.0021	0.00025	1.94	0.231	0.0020	0.00035	1.85	0.323	13.8	12.6
Butter	21.6	0.075	0	1.62	0	0.12	0.12	2.59	2.59	11.1	10.7
Cheese	37.7	0.020	0	0.754	0	0.037	0.036	1.39	1.36	8.97	8.82
Ice cream/yoghurt	77.5	0.014	0	1.09	0	0.0059	0.0021	0.457	0.163	6.48	6.40
NZ fish	64.5	0.027	0.022	1.74	1.42	0.051	0.051	3.29	3.29	35.7	35.6
Imported tinned fish	10.5	0.12	0.11	1.26	1.15	0.16	0.16	1.67	1.67	24.8	24.7
Shellfish	19.8	0.021	0.016	0.42	0.316	0.028	0.028	0.553	0.553	4.59	4.55
Poultry	60.4	0.0072	0.00093	0.435	0.056	0.0036	0.00044	0.217	0.027	1.63	1.33
Eggs	33.7	0.012	0.0017	0.404	0.057	0.010	0.0049	0.337	0.165	4.79	4.75
Bread	301.1	0.0059	0.0012	1.78	0.361	0.0040	0.00099	1.21	0.298	13.0	12.6
Cereals	309.9	0.0099	0.0027	3.07	0.837	0.0027	0.0017	0.837	0.527	21.7	21.5
Potatoes	395.9	0.016	0.012	6.34	4.75	0.0025	0.0012	0.990	0.475	20.6	20.3
Snack foods	48.6	0.044	0.013	2.14	0.632	0.014	0.0025	0.680	0.121	7.87	7.58
Vegetable fats/oils	13.7	0.034	0	0.465	0	0.013	0	0.178	0	0.52	0
Total				**30.6**	**9.82**			**22.7**	**14.3**	**231**	**224**