Levels of dioxin (PCDD/F) and PCBs in a random sample of Australian aquaculture-produced Southern Bluefin Tuna (Thunnus maccoyii)

David Padula[1], Tom Madigan[1], Andreas Kiermeier[1], Ben Daughtry[1], Andrew Pointon[1]

[1]South Australian Research and Development Institute

Introduction

To date there has been no published information available on the levels of dioxin (PCDD/F) and PCBs in Australian aquaculture-produced Southern Bluefin Tuna (*Thunnus maccoyii*). Southern Bluefin Tuna are commercially farmed off the coast of Port Lincoln in the state of South Australia, Australia. This paper reports the levels of dioxin (PCDD/F) and PCBs in muscle tissue samples from 11 randomly sampled aquaculture-produced Southern Bluefin Tuna collected in 2003.

Little published data exists on the levels of dioxin (PCDD/F) and PCBs in Australian aquaculture-produced seafood.

Wild tuna are first caught in the Great Australian Bight in South Australian waters, and are then brought back to Port Lincoln where they are ranched in sea-cages before being harvested and exported to Japan.

The aim of the study was to identify pathways whereby contaminants such as dioxin (PCDD/F) and PCBs may enter the aquaculture production system. This involved undertaking a through chain analysis of the levels of dioxin (PCDD/F) and PCBs in wild caught tuna, seafloor sediment samples from the marine environment, levels in feeds and final harvested exported product. Detailed study was also undertaken on the variation of dioxin (PCDD/F) and PCBs across individual tuna carcases.

This paper addresses the levels found in final harvested product. Details on levels found in other studies will be published elsewhere shortly.

Methods and Materials

Muscle tissue samples of tail meat were collected from 11 randomly sampled commercially harvested tuna in Port Lincoln. Skin was removed from all muscle tissue samples, hence only the edible portion was analysed. Samples were homogenised in a stainless steel HOBART food processor. Samples (250 g) were stored at –40˚C before despatch to New Zealand for analysis.

Dioxin (PCDD/F) was determined using high-resolution gas chromatography-mass spectrometryanalysis by AgriQuality in Wellington, New Zealand using method US EPA 1613 B (isotope dilution). PCBs were determined using high-resolution gas chromatography-mass spectrometryby AgriQuality in Wellington, New Zealand using method US EPA 1668 A (isotope dilution). Results were corrected for recoveries. AgriQuality is a participant in the Norwegian Public Health Institute interlaboratory comparison on dioxins in food studies and holds internationally recognised accreditation for the reporting of dioxin (PCDD/F) and PCB levels in foods including fish.

Table 1. Summary of dioxin (PCDD/F) analysis, and WHO-TEF values used in the calculation of TEQ values reported in this paper

Polychlorinated dibenzo-p-dioxins (PCDD)	**WHO-TEF**
2,3,7,8-Tetra chlorinated dibenzo-*p*-dioxin	1
1,2,3,7,8-Penta chlorinated dibenzo-*p*-dioxin	1
1,2,3,4,7,8-Hexa chlorinated dibenzo-*p*-dioxin	0.1
1,2,3,6,7,8-Hexa chlorinated dibenzo-*p*-dioxin	0.1
1,2,3,7,8,9-Hexa chlorinated dibenzo-*p*-dioxin	0.1
1,2,3,4,6,7,8-Hepta chlorinated dibenzo-*p*-dioxin	0.01
Octa chlorinated dibenzo-*p*-dioxin	0.0001
Polychlorinated dibenzofurans (PCDF)	
2,3,7,8-Tetra chlorinated dibenzofuran	0.1
1,2,3,7,8-Penta chlorinated dibenzofuran	0.05
2,3,4,7,8-Penta chlorinated dibenzofuran	0.5
1,2,3,4,7,8-Hexa chlorinated dibenzofuran	0.1
1,2,3,6,7,8-Hexa chlorinated dibenzofuran	0.1
1,2,3,7,8,9-Hexa chlorinated dibenzofuran	0.1
2,3,4,6,7,8-Hexa chlorinated dibenzofuran	0.1
1,2,3,4,6,7,8-Hepta chlorinated dibenzofuran	0.01
1,2,3,4,7,8,9-Hepta chlorinated dibenzofuran	0.01
Octa chlorinated dibenzofuran	0.0001

Targeted PCB congeners included the non-ortho PCBS: 77, 81, 126, 169. The mono-ortho PCBs 105, 114, 118, 123, 156, 157, 167, 189. In addition a group of indicator PCBs: 1, 3, 4, 15, 19, 28, 37, 44, 49, 52, 54, 70, 74, 99, 101, 104, 110, 138, 153, 155, 170, 180, 183, 187, 188, 194, 196, 199, 202, 205, 206, 208, 209.

Total PCB concentration was determined by the summation of the individual concentrations of all these congeners with non-detects treated as being equal to the LOD.

Table 2. Summary of fork length (cm) and weight of randomly sampled aquaculture-produced Southern Bluefin Tuna

Sample No.	Fork length (cm)	Weight (kg)
1	145	61
2	132	40
3	118	32
4	114	28
5	132	47
6	112	32
7	110	29
8	110	29
9	106	25
10	115	33
11	115	36
Mean	**119**	**36**

Upper bound fresh weight results are reported for all dioxin (PCDD/F) results in line with the requirements of the European Commission. The TEF values established by the WHO have been used for the calculation of the TEQ values reported here.[1, 2]

Results and Discussion

Table 3. Summary of total PCB concentrations found in tail meat samples of aquaculture-produced Southern Bluefin Tuna on a fresh weight and lipid weight basis

Sample No.	Tissue analysed	Total PCBs (ng/g) (fresh weight basis)	Total PCBs (ng/g) (lipid weight basis)
1	Tail meat	28.6	102
2	Tail meat	34.8	225
3	Tail meat	32.4	169
4	Tail meat	21.4	200
5	Tail meat	49.4	277
6	Tail meat	54.8	239
7	Tail meat	34.9	242
8	Tail meat	35.1	293
9	Tail meat	16.3	443
10	Tail meat	30.2	230
11	Tail meat	12.7	158
Mean		**31.87**	**234**

Food Standards Australia New Zealand (FSANZ) has set a concentration-based PCB Maximum Limit (ML) at 0.5 mg/kg (fresh basis) for fish. All PCB results presented in **Table 3** are reported as a total PCB concentration in line with the FSANZ ML, with all samples tested meeting the FSANZ ML.[3] Hence results for PCBs are not expressed as a TEQ in this paper. The mean concentration of

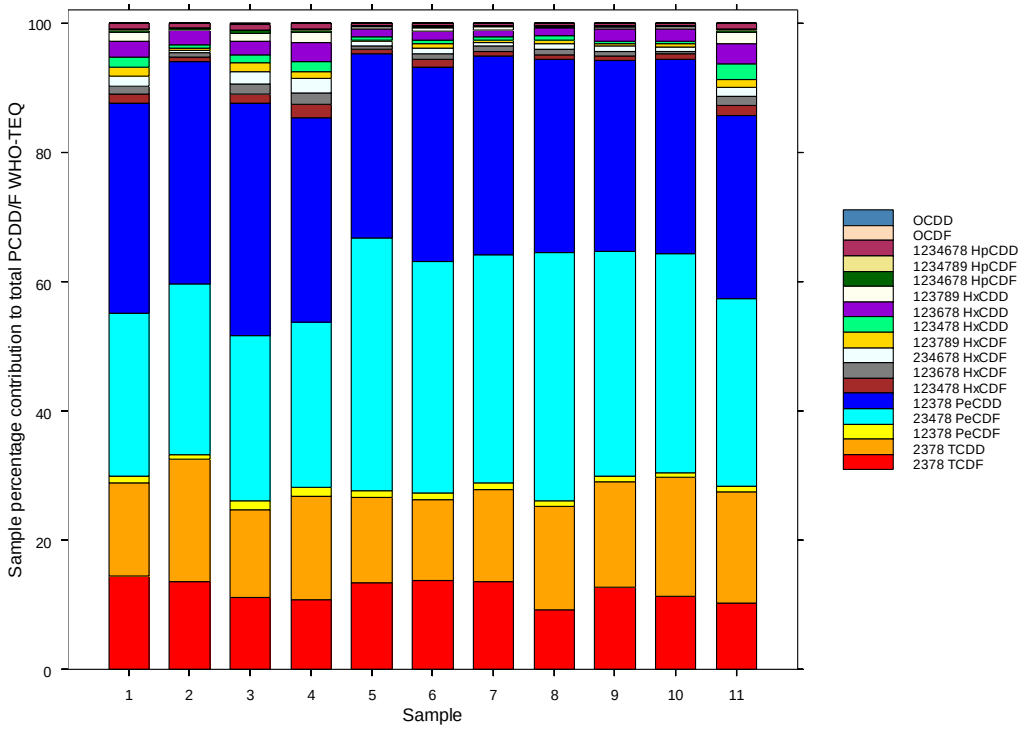
PCBs was 1/15th of the ML set by FSANZ. There is currently no Australian standard for PCBs expressed on a lipid weight basis in fish.

Table 4. Summary of upper bound dioxin (PCDD/F) TEQ values found in aquaculture-produced Southern Bluefin Tuna on a fresh weight and lipid weight basis

Sample No.	**Tissue analysed**	**Upper bound Dioxin (PCDD/F) pg TEQ/g (fresh weight basis)**	**Upper bound Dioxin (PCDD/F) pg TEQ/g (lipid weight basis)**
1	Tail meat	0.365	1.30
2	Tail meat	0.352	2.28
3	Tail meat	0.380	1.99
4	Tail meat	0.275	2.56
5	Tail meat	1.020	5.72
6	Tail meat	1.060	4.62
7	Tail meat	0.623	4.32
8	Tail meat	0.775	6.46
9	Tail meat	0.352	9.59
10	Tail meat	0.397	3.03
11	Tail meat	0.244	3.04
Mean		**0.531**	**4.08**

All samples reported in **Table 4.** met the European Commission dioxin (PCDD/F) Maximum Level (ML) currently set at 4 pg TEQ/g on a fresh weight basis. The mean level of dioxin (fresh weight) found was less than 1/7th of the European Commission ML for dioxin (PCDD/F), with no individual result greater than 1/3rd of the European Commission ML. There is current no Australian or international standard for dioxin (PCDD/F) expressed on a lipid weight basis for fish.

Figure 1. Percentage-based dioxin (PCDD/F) congener profile for aquaculture-produced Southern Bluefin Tuna tail meat samples



The dioxin (PCDD/F) profile presented in **Figure 1** is dominated by the pentachlorinated furans and pentachlorinated dioxins. The profile varies between individual tuna in part due to the mixed diets fed during the ranching period, and secondly, tuna for ranching are captured from wild stocks. Hence the variability seen in the hexa and hepta chlorinated dioxins and furans in **Figure 1.** Ongoing study is examining the relationship between levels of dioxin (PCDD/F); PCBs and diets fed to tuna to further understand this relationship.

The Australian Government has issued an advisory Tolerable Monthly Intake (TMI) of 70 pg TEQ/kg body weight from all sources combined. This tolerable intake is equal to that set by JECFA, and includes dioxin (PCDD/F) and the dioxin-like PCBs, as specified under the WHO 1998 Toxic Equivalence Factor (TEF) scheme.[4]

Under the National Dioxins Program, the Australian Government is undertaking a human health risk assessment of dioxin that has taken into consideration dietary sources (including seafood), dioxin contribution from air, soils, water and other emission sources.[5]

This paper benchmarks the levels of dioxin (PCDD/F) and PCBs in Australian aquaculture-produced tuna. The levels of dioxin (PCDD/F) and PCBs found were all within Australian and

international regulatory standards. Further ongoing research by the author is seeking to better understand the bio-accumulation of dioxin (PCDD/F) and PCBs in aquaculture-produced seafood.

Australia does not have a Maximum Level (ML) set for dioxin (PCDD/F). Setting an ML is seen as a poor risk management strategy by Australian regulators. The Australian Government through the National Dioxins Program is examining source-directed measures to limit dioxin (PCDD/F) and PCBs from entering the food production chain. Measures being adopted in South Australia include regular screening of aquaculture feeds for the presence of a wide range of chemical contaminants including dioxin (PCDD/F) and PCBs. This has begun since this project started in 2001.

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2 COUNCIL REGULATION (EC) No 2375/2001 of 29 November 2001 amending Commission Regulation (EC) No 466/2001 setting maximum levels for certain contaminants in foodstuffs. (2001) Official Journal of the European Communities.

3 www.foodstandards.gov.au

4 www.health.gov.au

5 www.deh.gov.au