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**REPORT ON**

**REVIEW OF OCEANICA REPORT SECTION ON  
TRIBUTYL TIN IN MUSSEL FLESH FROM SWAN  
RIVER YACHT CLUBS**

Submitted to:

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## EXECUTIVE SUMMARY

This report reviews the tributyltin (TBT) in mussel flesh component of the Oceanica Consulting Pty Ltd (Oceanica) draft report "*Tributyltin and Heavy Metal Survey in the Swan River. Swan Yacht Club Sediment and Mussel Tissue Quality. August 2007*".

There are no empirical studies on the acute or chronic effect of TBT in humans from oral exposure. Consistent with the hierarchy of sources for guidance values recommended by enHealth (2004)<sup>1</sup>, we have adopted the WHO guidance value as a reference in this report in the absence of an applicable Australian standard. The World Health Organisation (WHO) established a guidance level of 0.0003 mg/kg/day tributyl tin oxide (TBTO) which is equivalent to 0.1 Sn µg/kg/bw based evaluation on key studies with experimental animals and the use of safety factor for deriving an exposure guidance level for humans (tolerable daily intake. TDI).

We have based our exposure calculations on the median consumption level for molluscs and crustacea reported for Western Australia in the 1995 National Nutrition Survey published by the Australian Bureau of Statistics (ABS) and the results from the Oceanica. We estimated that the average consumption of mussels harvested near the yacht clubs would not result in an exceedance of the guidance level of TBT.

The highest concentrations of TBT in mussel flesh were found in mussel harvested from the East Fremantle Yacht Club. We estimated that consumption of these mussels would result in an intake of TBT in excess of the TDI. However, the consumption of seafood is a relatively small part of the Australian diet; in particular, molluscs and crustacea make a token proportion in the daily diet indicated by the mean daily intake of 3.6 g/day for 45-65 year-old (the highest consumer in the 1995 Survey).

Further, daily consumption of mussels in the quantity required for exposure to exceed the guidance level is unlikely to be sustainable from the stock found on pylons in yacht clubs; that is, the mussel community is likely to be depleted quickly at these locations. Thus, the consumption of mussels harvested from pylons at yacht clubs periodically and in small quantities is not a cause for concern. However, due to levels recorded at East Fremantle Yacht Club a sign should be erected advising mussels should not be harvested from the marina.

Notwithstanding, additional sampling is required to determine if TBT levels are stable or diminishing and what the spatial spread of contamination is likely to be. Given that the sediment results indicated localised contamination (that is, levels diminish quickly as samples are taken further away from the slipways), concentrations of TBT in mussel flesh will follow

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<sup>1</sup> enHealth (National Environmental Health Council, 2004). Environmental Health Risk Assessment. Guidelines for assessing human health risks from environmental hazards. Commonwealth of Australia, 2004. Available at: <http://enhealth.nphp.gov.au/council/pubs/pdf/envhazards.pdf>

this trend. However, this needs to be confirmed as factors such as the tide, seasonal activity and disturbance of the sediment can influence the availability of TBT.

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## 1.0 INTRODUCTION

This report reviews the tributyltin (TBT) in mussel flesh component of the Oceanica Consulting Pty Ltd (Oceanica) draft report “*Tributyltin and Heavy Metal Survey in the Swan River. Swan Yacht Club Sediment and Mussel Tissue Quality. August 2007*” (The Oceanica Report).

This report focuses on the mussel tissue quality in respect to TBT and metal contaminants and the human health risks associated with TBT and the consumption of contaminated mussel flesh. It overviews TBT studies undertaken in relation to toxicity and health risks and provides recommendations on the consumption of mussels based on the Oceanica survey results. Note that TBT and tributyltin oxide (TBTO) are used interchangeably in literature. In this review, we identify the TBT salt used in the toxicology studies when relevant.

## 2.0 BACKGROUND

TBT has been used as component of marine antifouling paints that are used to protect underwater surfaces. These paints have been progressively phased out since the 1980's due to increasing concern about the environmental impacts of TBT because of its persistence in the environment. A number of factors influence the persistence of TBT in the environment, including the type of environment, salt water or fresh, and whether or not the TBT is bound within another product. TBT breaks down into dibutyltin (DBT) and monobutyltin (MBT) which are less harmful.

In initial development, TBT products freely leached from the paints into the environment. Improvements in technology controlled the leaching rates and improved the performance of the paints. The use of TBT based antifouling paints has been banned in Western Australia (WA) on vessels less than 25 m in length since 1991. There are limited local and national studies that have been undertaken to show if there is a decline in the TBT concentrations since the introduction of the ban.

## 3.0 CHEMICAL INFORMATION

IUPAC Name	Bis-[Tri-n-butyltin]-oxide
Molecular Formula	$C_{24}H_{54}OSn_2$
Molecular Weight	596
Structural Formula	$(CH_3CH_2CH_2CH_2)_3Sn-O-Sn(CH_2CH_2CH_2CH_3)_3$

## 4.0 OCEANICA SURVEY RESULTS

### 4.1 Tributyltin

The Oceanica Report provides the following results for TBT concentration in mussel flesh (Table 1).

**Table 1: Median Mussel Organotin Concentration ng Sn/g Wet Weight (highest recorded concentration given in brackets)**

Site	TBT	DBT	MBT
S-MID	28 (50)	12	0.5
EF_MID	113.5 (140)	39	4.9
RF_NE	1.9 (9.1)	10	0.5
PFS_MID	50 (76)	23	2.9
RP_MID	<1 (<1)	9.8	3.1
SP_MID	4.6 (7.1)	8.1	0.5

The Oceanica Report stated that 15 µg of TBT = 6000 ng of Sn (6 µg of Sn) and referred to a convention for the expression of TBT as either ng TBT/g (equivalent to µg TBT/kg) or ng Sn/g (µg Sn/kg). Golder therefore assumes that the results reproduced in Table 1 are expressed as tin (Sn) content, i.e., ng Sn/g wet weight of mussel flesh.

### 4.2 Other Metals and Metalloids

The level of other metals and metalloids reported by Oceanica were within acceptable contaminant levels prescribed in the Australian and New Zealand Food Standards Code.

## 5.0 LEGISLATION

Western Australia has adopted the International Maritime Organisation (IMO) guidance for the phasing out of TBT in ship paints in legislation. The guidance aims for a complete ban on TBT by 1 January 2008. The legislation was introduced in WA in 1991 under the Environmental Protection Regulations 1987, as amended. Specifically Regulation 16 - Control of organotin anti-fouling paint provides:

- (i) *On and from 1 November 1991, a person shall not apply organotin anti-fouling paint to, or cause or permit such paint to be applied to:*
  - (a) *a piling, pier, buoy, mooring or other structure in an enclosed water body or a semi-enclosed water body;*

- (b) *a vessel that is 25 metres or less in length; or*
- (c) *a vessel that is more than 25 metres in length, unless the paint has been formulated so that in respect of each square centimetre of surface to which it is applied:*
  - (i) *not more than 210 micrograms of organotin are released during the first 14 days after the application of the paint; and*
  - (ii) *not more than 5 micrograms of organotin are released during each subsequent day.*

## 6.0 FOOD STANDARDS

The Australian and New Zealand Food Standards Code does not provide a Maximum Residue Limit (MRL) for TBT in mussels or other food products.

The Australian and New Zealand Food Authority, 19<sup>th</sup> Total Australian Diet Survey report (2001) provides that:

*“Tributyl tin compounds are used as antifouling agents on boats as well as for fungal control on timber. Occupational exposure represents the most significant hazard to humans with respect to exposure to organotin compounds.*

*The margin of safety for this amount of TBT/DBT can be determined by comparing the intake level of TBT in humans with the intake level known to cause toxic effects in experimental animals. The lowest level shown to have marginal toxic effects in animals is 0.25 mg/kg bw/day (WHO 1990b).*

*A high consumer of molluscs (95<sup>th</sup> percentile for males aged 25–34) is estimated to consume 402 grams per day (1995 National Nutrition Survey). If a person were to consume 402 grams of mussels containing 0.010 mg/kg of TBT every day, then it could be calculated that these high consumers would be exposed to 0.004 mg per day of TBT per person or 0.00006 mg TBT/kg bw/day. This level of consumption of TBT is less than one thousandth of that which resulted in toxic effects in animals (0.25 mg/kg bw/day).*

*It should be recognised that this calculation overestimates the exposure because it assumes that 402 grams of mussels would be consumed every day (which would be a gross overestimate).”*

The World Health Organisation (WHO, 1999)<sup>2</sup> summarised the key studies and investigations into TBT and toxicity. WHO referred to a study by Vos *et al.* (1990) that established a

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<sup>2</sup> WHO (World Health Organisation, 1999). Tributyltin Oxide. Concise International Chemical Assessment Document 14 (CICAD, 14, p 4).

lowest-observable-adverse-effect level (LOEAL) of 0.25 mg/kg/day and a no-observed-adverse-effect-level (NOAEL) of 0.025 mg/kg/day for immunotoxicity from a study that used weanling rats. Immunosuppression is the critical effect of TBT (WHO, 1999, P17).

WHO (1999) provided an oral tolerable daily intake (TDI) of 0.0003 mg TBTO/kg/day based on the NOAEL from immunotoxicity studies in experimental animals of 0.025 mg/kg/day. The European Food Safety Authority (EFSA, 2004)<sup>3</sup> provided a TDI of 0.25 µg TBTO/kg/day (0.00025 mg/kg/day) based on the same study.

EFSA and WHO both used the same NOAEL and a composite safety factor of 100 to estimate the TDI. Thus, the two values are the same, except that WHO has rounded up the number.

The 1995 National Nutrition Survey reported a mean population consumption of crustacea and molluscs in Western Australia of 3.6 g per person per day (19 years of age and over) with a population median of 76.5 g per person per day. This and a national 95<sup>th</sup> percentile consumption of 402 g/day indicate data that are highly skewed.

Given the highly skewed distribution of consumption, it is more appropriate to use the median value for assessing consumption than the 95<sup>th</sup> percentile, as the latter may be a gross over estimate of the daily consumption of mussels by the population at large.

Further, consumption of 402 grams of mussel flesh as indicated would require the collection of approximately 1.2 kg of live mussels per day (based on mussel flesh being approximately 36% by weight of live mussel – Government of Samoa Study)<sup>4</sup>.

Golder considers that the continued harvesting of 1.2 kg of mussels on a daily basis, by multiple persons from the pylons at the yacht clubs is a highly unlikely scenario as the mussel populations in these areas would not be sustainable.

It is also likely that the bulk of the 95<sup>th</sup> percentile estimate relates to crustacea rather than just mussel. However, the proportion of the two types of seafood in the Australian diet is not known.

For the purposes of the assessment, we have adopted the TDI of 0.0003 mg TBTO/kg/day by WHO as a guidance value. The EFSA (2004)<sup>5</sup> describe the process of deriving the TDI and

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<sup>3</sup> EFSA (European Food Safety Authority, 2004). Opinion of the Scientific Panel on Contaminants in the Food Chain on a request from the Commission to assess the health risks to consumers associated with exposure to organotins in foodstuffs (Question N° EFSA-Q-2003-110). Adopted on 22 September 2004. The EFSA Journal (2004) 102, 1-119.

[http://www.efsa.europa.eu/EFSA/Scientific\\_Opinion/contam\\_opinion10\\_ej102\\_organotins\\_v2\\_en1.pdf](http://www.efsa.europa.eu/EFSA/Scientific_Opinion/contam_opinion10_ej102_organotins_v2_en1.pdf).

<sup>4</sup> Website Accessed 2/11/2007

[http://www.tradeinvestsamoa.ws/investing\\_in\\_samoa/sector\\_studies/fisheries\\_sec/mussels.htm](http://www.tradeinvestsamoa.ws/investing_in_samoa/sector_studies/fisheries_sec/mussels.htm)

<sup>5</sup> EFSA (European Food Standards Authority 2004) Opinion of the Scientific Panel on Contaminants in the Food Chain on a request from the Commission to assess the health risks to consumers associated with exposure to organotins in foodstuffs. (Question N° EFSA-Q-2003-110). The EFSA Journal (2004) 102, 1-119. Available at: [http://www.efsa.europa.eu/EFSA/Scientific\\_Opinion/contam\\_opinion10\\_ej102\\_organotins\\_v2\\_en1.pdf](http://www.efsa.europa.eu/EFSA/Scientific_Opinion/contam_opinion10_ej102_organotins_v2_en1.pdf)

the calculation is based on the TBT compound and not just the tin (Sn) component, TBT comprises carbon (C), hydrogen (H), oxygen (O) and tin (Sn). However, the results presented in the Oceanica Report are provided as ng Sn/g wet weight rather than ng TBT/g. Accordingly, the equivalent TDI used for assessment is 0.1 µg Sn/kg/day (Sn comprises 40% of the molecular weight of TBTO; Section 3.0).

## 7.0 CALCULATIONS

The following exposure calculations are based on the Oceanica mussel survey results and the consumer parameters provided in the 1995 National Nutrition Survey for WA with a mean daily consumption of mussel flesh of 3.6 g and median daily consumption of 76.5 g.

**Table 2: Exposure Assumptions**

Mean daily consumption of mussel flesh in WA	*3.6 g
Median daily consumption of mussel flesh in WA	*76.5 g
Body Weight	64 kg
Conversion Sn ng/g to TBTO ng/g	2.5
TDI µg Sn/kg/day	0.1
Conversion Factor ng to µg	1x10 <sup>-3</sup>
Highest recorded concentration (ng Sn/g flesh)	140

\*Daily in take based on 1995 National Nutrition Survey

Calculation Formula:

Daily Exposure = (Consumption \* Concentration of Sn/g \* Conversion Factor)/Body Weight

Based on highest concentration level found of 140 ng Sn/g wet weight mussel flesh and the mean daily consumption of 3.6g mussel flesh per day, we estimated a mean daily intake of 0.008 µg Sn /kg/day (0.02 µg TBTO/kg/day), as follows:

$$\begin{aligned} \text{Mean daily intake} &= (3.6 \text{ g} * 140 \text{ ng/g} * 0.001) / 64 \text{ kg} \\ &= 0.008 \text{ µg Sn /kg/day (20 ng TBTO/kg/day)} \end{aligned}$$

This estimated mean daily intake of TBTO is about 8% of the TDI.

Based on highest concentration level found of 140 ng/g and median daily consumption of 76.5 g mussel flesh per day, we estimated a median daily intake as 0.17 µg Sn/kg/day (0.425 µg TBTO/kg/day, as follows:

$$\begin{aligned} \text{Median daily intake} &= (76.5 \text{ g} * 140 \text{ ng/g} * 0.001) / 64 \text{ kg} \\ &= 0.17 \text{ } \mu\text{g Sn/kg/day (0.27 ng TBTO/kg/day)} \end{aligned}$$

This estimated median daily intake of TBTO is 1.7 times the TDI.

The estimated median daily intakes (expressed as a percentage of WHO TDI) based on the highest concentration of TBTO in mussel flesh from each yacht club sampled are summarised in Table 3.

**Table 3: Exposure to TBT from Consumption of Mussels from Yacht Clubs Surveyed**

Yacht Club	% of TDI
East Fremantle Yacht Club	170%
Swan Yacht Club	60%
Royal Freshwater Bay Yacht Club	11%
Perth Flying Squadron	91%
Royal Perth Yacht Club	1%
South of Perth Yacht Club	8%

## 8.0 DISCUSSION

A review of available literature revealed that there are no empirical studies on the acute or chronic effect of TBT in humans from oral exposure. Consistent with the hierarchy of sources for guidance values recommended by enHealth (2004)<sup>6</sup>, we have adopted the WHO guidance value as a reference in this report in the absence of an applicable Australian standard. The World Health Organisation (WHO) established a guidance level of 0.0003 mg/kg/day tributyl tin oxide (TBTO) which is equivalent to 0.1 Sn µg/kg/bw based evaluation on key studies with experimental animals and the use of safety factor for deriving an exposure guidance level for humans (tolerable daily intake. TDI).

Based on the highest concentration found at the East Fremantle Yacht Club and the median daily consumption of mussels in WA, we estimated the daily exposure to TBT to be above the WHO TDI of 0.1 µg Sn/kg/day (Equivalent to 0.3 µg TBTO/kg/day).

<sup>6</sup> enHealth (National Environmental Health Council, 2004). Environmental Health Risk Assessment. Guidelines for assessing human health risks from environmental hazards. Commonwealth of Australia, 2004. Available at: <http://enhealth.nphp.gov.au/council/pubs/pdf/envhazards.pdf>

Exposure calculated using the mean daily intake for Western Australians and the maximum concentration found in the Oceanica survey provides an exposure of 0.0.008 µg/kg/day, which is 12 times lower or 8% of the TDI.

Concentrations found at other yacht clubs were generally much lower than the maximum concentration found at East Fremantle Yacht Club. The median consumption of mussels from all other sites sampled would not result in exposure to TBT greater than the WHO guidance value.

The consumption of seafood is a relatively small part of the Australian diet. In particular, molluscs and crustacea make a token proportion in the daily diet indicated by a mean daily intake of 3.6 g/day for adult Western Australians. In addition, consumption of mussel flesh is likely to be a small proportion of the overall consumption of molluscs and crustacea.

Golder considers that daily consumption of mussels in the quantities required for exposures to reach the guidance level is unlikely to be sustainable, since the mussel population is limited, hence, likely to be quickly depleted at these locations. Consequently, the consumption of mussels harvested from pylons at yacht clubs periodically in small quantities does not appear to be a cause for concern. Notwithstanding, the areas where the highest concentrations of TBT were reported in mussel flesh should be signposted to warn the public of the TBT contamination.

Additional sampling is required to determine if TBT levels are stable or diminishing and what the spatial spread of contamination is likely to be. Given the sediment results indicated localised contamination (i.e, the levels diminish quickly as samples are taken further away from the slipways) concentrations of TBT in mussel flesh will follow this trend. However, it needs to be confirmed as factors such as the tide, seasonal activity and disturbance of the sediment can influence availability of TBT.

The sample size for the mussel tissue quality is small and additional sampling should be undertaken to improve reliability of the results. There may have also been seasonal impacts on the results. For example boat cleaning or general boat traffic may result in increased leaching of TBT from paint or disturbance from sediments leading to a higher intake by the mussels.

## **9.0 RECOMMENDATIONS**

Golder recommends that the Swan River Trust:

- Instructs the East Fremantle Yacht club to signpost the marina to warn that mussels must not be harvested from the pylons.
- Undertakes additional sampling of mussels from Yacht Clubs to assess extent of TBT contamination and improve reliability of data.

## 10.0 DISCLAIMER

This report has been prepared in accordance with the agreement between the Swan River Trust and Golder Associates Pty Ltd (Golder). The services performed by Golder have been conducted in a manner consistent with the level of quality and skill generally exercised by members of its profession and consulting practice.

This report is solely for the use of the Swan River Trust and any reliance of this report by third parties shall be at such party's sole risk and may not contain sufficient information for purposes of other parties or for other uses. This report shall only be presented in full and may not be used to support any other objective than those set out in the report, except where written approval with comments are provided by Golder.

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