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# Kopeopeo Canal dioxin survey

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## Summary

A dioxin survey of eel and sediment in the Kopeopeo Canal was undertaken in October 2013. The survey included a few samples from the Orini Canal which are presumed to represent background concentrations for the local area. Eight locations, approximately evenly spaced every 1 km from the mouth of the canal were sampled (sites 3 – 10). Two of these (sites 9 & 10) were in the upper reaches of the canal and outside the area currently designated for remediation (sites 3 – 8).

Importantly the methodology was rigorous with respect to common analytical techniques being employed for full dioxin TEQ determination in both eel and sediment. Eels were caught in the same areas from which composite sediment samples were obtained. In the majority of instances 7 – 10 eels of approximately 35 – 60 cm were caught at each site, and an equal size fillet (with skin) from each animal contributed to a composite sample for dioxin analysis.

There was a modest positive association between dioxin toxicity equivalent (TEQ) concentrations in eels and sediment. The association was probably not stronger due to movement of eels up and down the canal. This is reflected in the data for sites 9 & 10 at the top of the canal where eel dioxin concentrations were relatively high but sediment concentrations low (close to background). For these two sites the biota sediment concentration factor (BSAF) was obviously different from other areas of the canal. The BSAF for these sites, along with those from the Orini Canal, were not included in calculating a BSAF for TEQ accumulation by eels in the canal.

The average dioxin TEQ in eel flesh (including skin) was 0.55 pg/g eel. Community consultation information indicates up to 3 eels per meal may be eaten by an adult male, with 125 eels eaten per year. From this study the dressed weight of an eel is approximately 80% of its live weight; for the eels examined in the survey the average dressed weight was 195 ± 65 g (rounded up to an average of 200 g) with a 95$^{th}$ percentile weight of 293g (rounded to 300g). This information translates into a long term average eel consumption of 68g and 103g/day (rounded to 70 and 100g/d respectively for risk assessment).

It is the ‘average’ eel that is consumed in the long term. At an average TEQ of 0.55 pg/g eel the daily intake of dioxin is 0.55 – 0.78 TEQ/kg bw/d for assumed eel eating of 70 or 100 g/d over a life time. The combined dioxin intake from background exposure (0.33 pg TEQ/kg/d) and eating eels is at or below the precautionary tolerable daily intake (TDI) of 1 pg/kg/d adopted by New Zealand, but much less than the health based regulatory guidelines of other countries.

Overall, the risk to health from the dioxin content of eating eels from the Kopeopeo canal is low.

Using an average BSAF (0.013) for areas of the canal most likely contributing to dioxin TEQ in eels, and the above eel consumption patterns, a target remediation goal of 60 – 90 pg TEQ/g sediment (dry weight) is derived.

Currently the designated area for remediation is the canal area between sites 3 to 8. However visual inspection of the sediment TEQ concentrations in conjunction with the above remediation goals indicates a more confined remediation area around sites 5 to 8 may be appropriate.

## 1. Introduction

A survey of dioxin in eels and sediment of the Kopeopeo canal was undertaken between 11th – 14th October 2013, in addition to a full dioxin congener analysis, lipid content in eels and total organic carbon (TOC) in sediment was measured.

Eels were sampled at ten locations (Figure 1.1, Table 1.1).

- Sites 3 - 10 were in the canal and sites 1 & 2 outside in the Orini Canal.
- Sites 3 – 8 are in the canal section currently designated for remediation.
- No eels were caught at site 2 in the Orini Canal.
- 5 eels were caught at site 10.
- 7 – 10 eels caught at the other sites.
- Standard morphometric data were recorded for each eel.
- Each eel contributed an equal mid-section weight of wet muscle (with skin) for composite analysis.

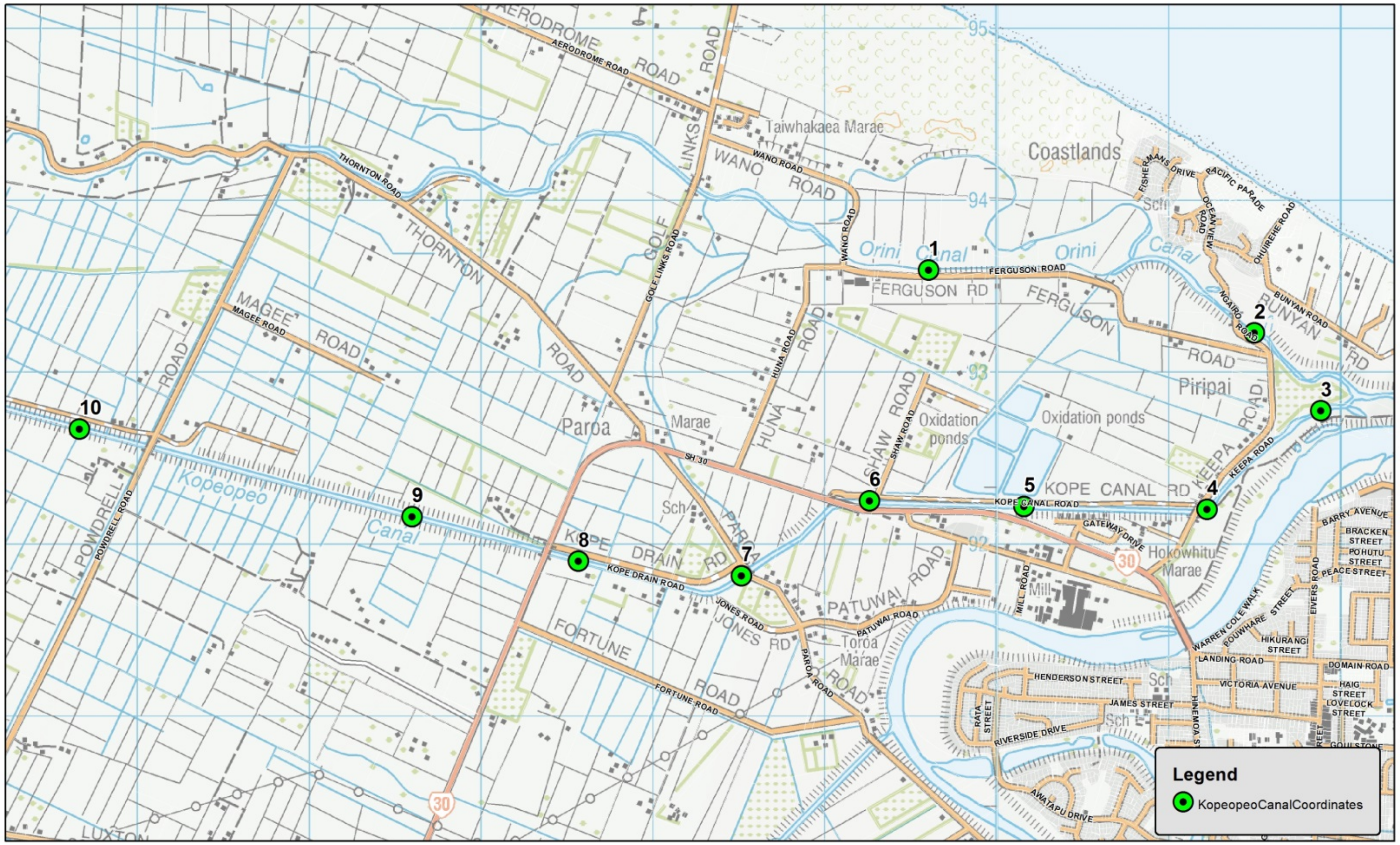
Sediment samples at each site comprised of 10 replicate cores (40mm diameter) taken to a depth of 10 cm and at 5m intervals along the mid channel if possible. For each site the 10 replicates were thoroughly mixed to form a sediment composite for analysis. It was noted in the field notes there was a high degree of variability along the canal at distances of 50 – 100m in terms of the sediment depth and softness[1].

**Table 1.1: Site locations for sampling eels and sediment [a]**

| Site | East | North | Km away from site 5 |
|---|---|---|---|
| 1 | 1947600 | 5793600 | 5.0 |
| 2 | 1949494 | 5793233 | 3.0 |
| 3 | 1949880 | 5792780 | 2.0 |
| 4 | 1949220 | 5792208 | 1.1 |
| 5 | 1948155 | 5792224 | 0.0 |
| 6 | 1947255 | 5792257 | -0.9 |
| 7 | 1946510 | 5791820 | -1.8 |
| 8 | 1945563 | 5791905 | -2.8 |
| 9 | 1944594 | 5792164 | -3.8 |
| 10 | 1942660 | 5792675 | -5.8 |

[a] Locations are from the field notes of Stephen Park

[1] Undated field notes of Stephen Park supplied by email 11/11/2013 from Bruce Clarke of SKM.




| | | | |
|---|---|---|---|
| Client | Environment Bay of Plenty | | |
| Project | Kopeopeo Canal Remediation | | |
| Drawn TT | Date 17/10/13 | Project Manager TS | Project Director JW |
| Designed | Review | | |

Data Notes:
Cadastral Data derived from Land Information New Zealand.
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Level 3
86 Customhouse Quay
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Tel +64 4 473 4265

1:28,000

N

Title
**Eel Sampling Locations**

| SKM Proj. No. | Drawing No. | AMDT |
|---|---|---|
| AE04197 | | |

**Figure 1.1: Kopeopeo eel and sediment sampling locations** (Provided by SKM).
The area proposed for remediation is from site 3 and 8.

## 2. Survey results

Tables 2.1 & 2.2 and Figures 2.1 to 2.3 summarise the eel and sediment data.

From Table 2.1 it is apparent that approximately 80% of the total weight of an eel is potentially edible. The average dressed weight of the eels caught (~35 – 60 cm) is approximately 200 g with a 95$^{th}$ percentile weight of approximately 300g.

In calculating exposure to dioxin TEQ from consuming eels (Section 3) and deriving a sediment remediation goal (Section 4) data from eels or sediment obtained from the Orini Canal have not been included. From Table 2.2 for the Kopeopeo canal:

- The average lipid content of eels caught in the canal is 1.9%.
- The average dioxin TEQ is 0.55 pg TEQ/g wet weight (range 0.35 – 1.07).
- Sediment[2] total organic carbon (TOC) is on average 3%.
- The average sediment dioxin TEQ is 94.5 pg TEQ/g dry weight (range 10.9 – 337).

As expected sediment below site 5 has low dioxin TEQ concentrations. Above site 5 sediment TEQ tapers off to almost background concentrations at sites 9 & 10 (assuming sites 1 & 2 can be regarded as background) (Figure 2.1). On the other hand the TEQ concentration in eels does not show the same degree of variation as does sediment. This is sensibly due to eels travelling up and down the canal. This is reflected in only a modest association ($R^2$ ~ 0.6) of eel TEQ concentrations with sediment TEQ, whether they are, or are not, respectively normalised to lipid or TOC (Figures 2.2 & 2.3).

The relatively high TEQ concentration in eels at sites 9 & 10, which have lower sediment TEQ, is most likely a result of eel movement from areas lower down in the canal which have high sediment TEQ (Table 2.2). Consequently the BSAF computed for sites 9 & 10 is not a reflection of TEQ uptake from these sites and these values have not been included in determining a BSAF for the canal for use in Section 4.

[2] The field notes of Stephen Park record that there was potentially a mislabelling of canal sediment samples 8 & 9. They had both been labelled as coming from site 8. While on submission of the samples to the laboratories one was labelled as coming from site 9 there was uncertainty whether the correct sample had been chosen for relabelling. Based on the sediment data the field notes suggest that the samples had in fact been incorrectly relabelled. In this report the laboratory results for samples 8 & 9 have been swapped as per the suggestion of Stephen Park. In reality this makes no numeric material difference to the information used in this report.

**Table 2.1: Summary of eel morphometric data [a]**

| | Length [a] (mm) | Weight [a] (g) | Dressed weight (g) | % dressed weight |
|---|---|---|---|---|
| **Average ± SD** | 482 ± 47 | 242 ± 79 | 195 ± 65 | 81 ± 1.3 |
| **Range** | 358 - 576 | 93 - 458 | 75 - 363 | 78 - 86 |
| **95th percentile** | 543 | 359 | 293 | 83 |

[a] Although more eels were caught than the 43 for which dressed weight was provided, all data in the table is only for the dressed eels.

**Table 2.2: Summary of eel and sediment analyses**

| Site [a] | Eel | | | Sediment | | | G: BSAF [f] |
|---|---|---|---|---|---|---|---|
| | A: lipid (g lipid/g dw) | B: dioxin [b] (pg/g ww) | C: dioxin [d] (pg/g lipid) | D: TOC (g TOC/g dw) | E: dioxin [b] (pg/g dw) | F: dioxin [e] (pg/g TOC) | |
| 1 | 0.012 | 0.159 | 13.25 | 0.0177 | 8.47 | 479 | 0.028 |
| 2 | - [a] | - [a] | - [a] | 0.018 | 9.9 | 550 | - [a] |
| 3 | 0.018 | 0.352 | 19.55 | 0.0147 | 10.9 | 742 | 0.026 |
| 4 | 0.018 | 0.362 | 20.11 | 0.0121 | 22.5 | 1,860 | 0.011 |
| 5 | 0.02 | 1.07 | 53.5 | 0.04 | 337 | 8,425 | 0.006 |
| 6 | 0.011 | 0.437 | 39.73 | 0.022 | 40.3 | 1,832 | 0.022 |
| 7 | 0.012 | 0.485 | 40.42 | 0.031 | 155 | 5,000 | 0.008 |
| 8 | 0.02 | 0.502 | 25.1 | 0.038 [c] | 153 [c] | 4,026 | 0.006 |
| 9 | 0.031 | 0.712 | 22.97 | 0.036 [c] | 20.6 [c] | 5,572 | 0.04 |
| 10 | 0.018 | 0.498 | 27.66 | 0.059 | 17 | 288 | 0.096 |
| **Ave [i]** | **0.019** | **0.55** | | **0.032** | **94.5** | | **0.027 (0.013)** [j] |

[a] No eel were caught at Site 2. Shaded sites are those within the nominated remediation area as per Figure 1.1.

[b] Dioxin data are the medium bound for total WHO-TEQ.

[c] As a result of a possible sample labelling error in the field, the laboratory results for sediment TOC and sediment dioxin for sites 8 and 9 may be the wrong way around. For these sites the data recorded in the table has been reversed from that received from the laboratory as per the suggestion in the field notes of Stephen Park.

[d] Dioxin concentration normalised to lipid. Column B divided by Column A.

[e] Dioxin concentration normalised to TOC. Column E divided by Column D.

[f] The BSAF is the ratio of concentration of dioxin in eels (normalised to lipid content) to the concentration of dioxin in sediment (normalised to TOC). Column C divided by Column F.

[i] Averages in the table do not include sites 1 or 2 as these are not within the canal.

[j] The BSAF average of 0.013 is for sites within the canal from which it is logical eels caught in that area have acquired their TEQ concentration (Sites 3 – 8). Sites 1, 9 & 10 are not included in this BSAF derivation; see Section 4.1 for further explanation.

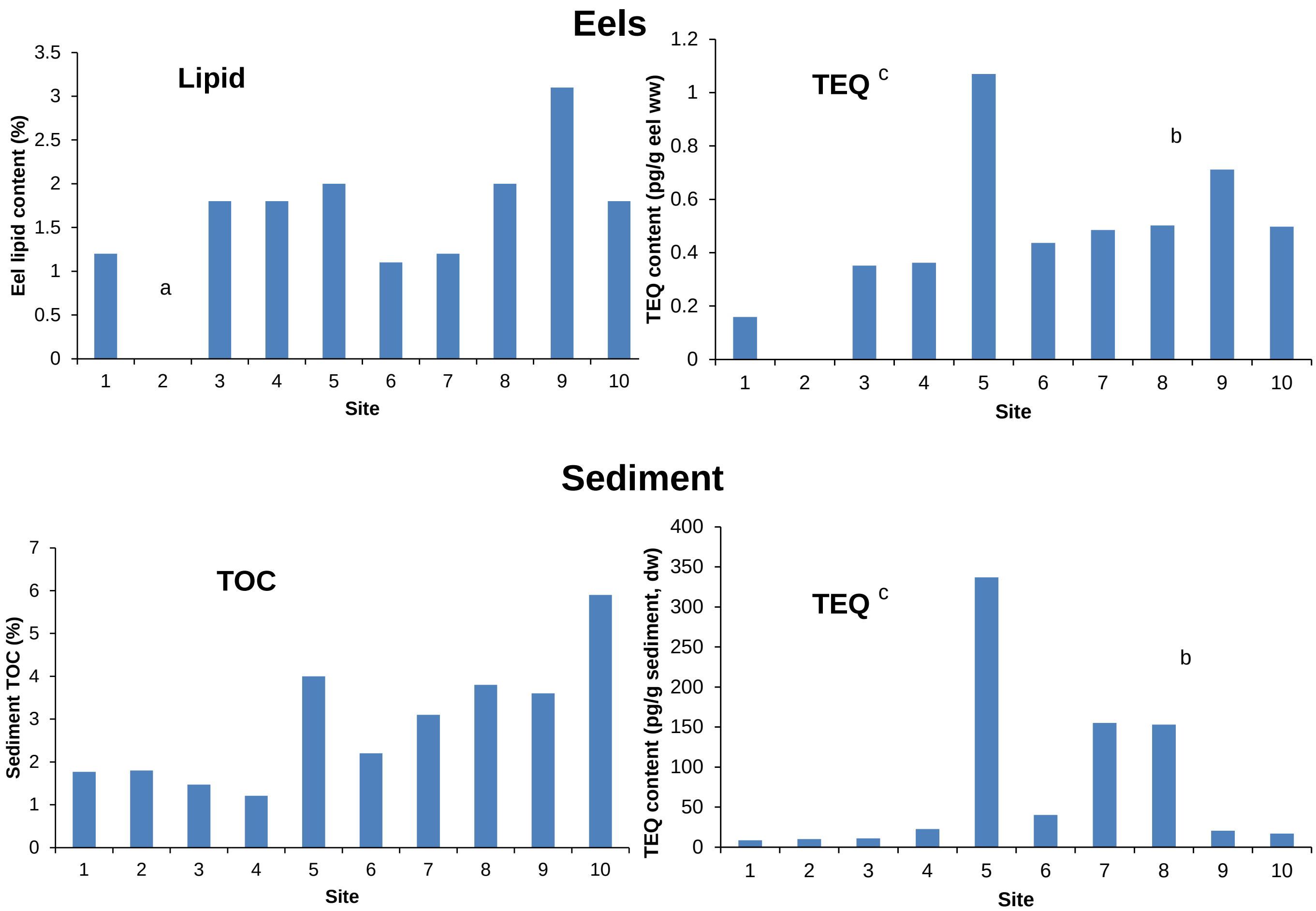


**Figure 2.1: Dioxin TEQ and lipid content in eels and dioxin TEQ and TOC in sediment at all collection sites.**

[a] No eels were caught at site 2 in the Orini Canal.

[b] The field notes of Stephen Park indicate sediment samples 8 & 9 may have been mutually mislabelled. The data in the figure has made this correction as per the suggestion of the field notes.

[c] TEQ is the central estimate for total WHO-TEQ reported by the laboratory.

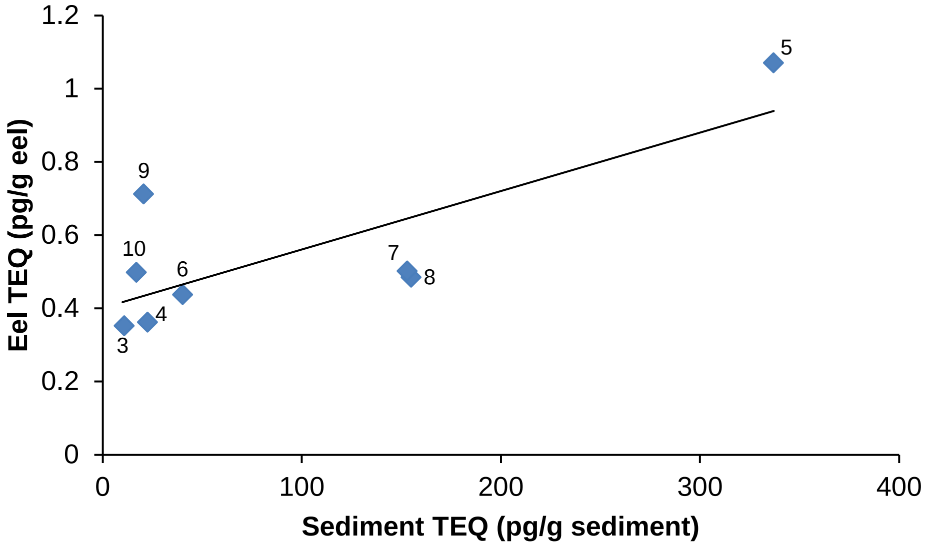


**Figure 2.2: Correlation of non-normalised dioxin TEQ in eels with non-normalised TEQ in sediment for canal sites.** y = 0.0016x + 0.4013, $R^2$ = 0.5995. The data points 8 & 9 are reversed from those obtained from the laboratory due to a sample labelling error. See text and footnote 2 for further explanation.

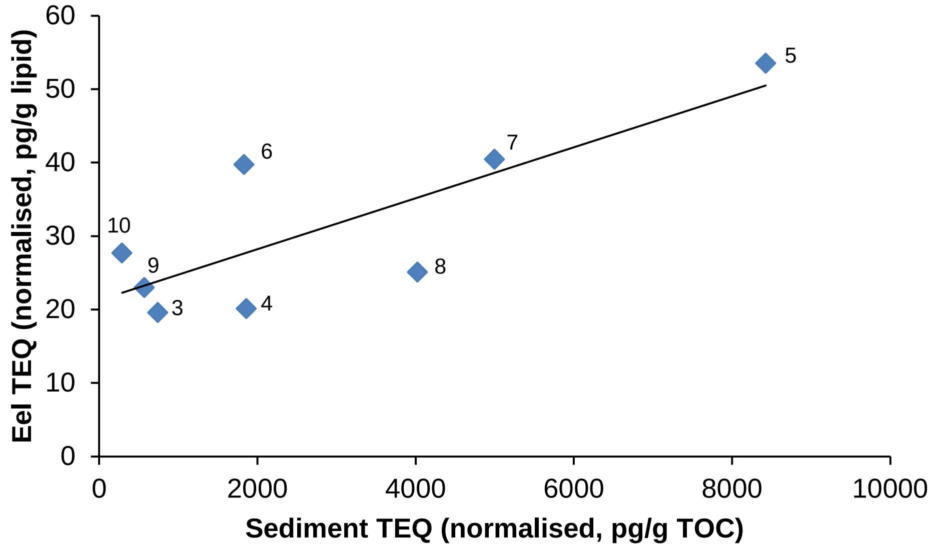


**Figure 2.3: Correlation of normalised dioxin TEQ in eels with normalised TEQ in sediment for canal sites.** y = 0.0035x + 21.278, $R^2$ = 0.644. The data points 8 & 9 are reversed from those obtained from the laboratory due to a sample labelling error. See text and footnote 2 for further explanation.

## 3. Screening risk assessment

Commonly the first step in assessing the potential health impact of contaminants in a food source is comparison of the concentrations in the food with relevant guideline values. If the concentration is less than the guideline then usually further action is not warranted.

New Zealand does not have residue limits for dioxins in eels. The European Union (EC 2006) limits for dioxin $TEQ_{WHO}$ in muscle meat of eel is 4 pg/g ww and for dioxins + dioxin like PCBs is 12 pg/g ww.

Table 2.1 summarises the measured concentrations of dioxin TEQ in eels. The concentrations are less than the EU limit for dioxins, even when skin is included in the analysis (but not in the EU limit).

The comparison with the EU limit for dioxin TEQ in eels indicates the potential health risk from consumption of eels is low.

One reason for further exploring the potential health risk associated with eating eels from the Kopeopeo Canal is if it was suspected the local populace ate more eels than was assumed by the EU when setting dioxin TEQ limits for eel. The consumption of eel assumed by the EU was not located so the following intake calculation has been undertaken utilising consumption data supplied by SKM (SKM 2006 and personal communication).

Recent community consultation suggests some local adult males eat 3 eels per sitting but the number of sittings is unclear. SKM (2006, p16) indicates community agreed consumption is 125 eels/yr per adult male. At an average dressed weight of 200g/eel (Table 2.1) this eating pattern equates to a long term average daily eel consumption of 68 g/d (125/yr x 200g ÷ 365d/yr).

Given that some eels may be larger than the average weight of those investigated in the October 2013 survey, the $95^{th}$ percentile dressed eel weight is also used in the dioxin TEQ intake calculations below. This gives a daily eel consumption of 103g/d (rounded to 100g/d).

Average dioxin TEQ intake from eating eel = ($C_{eel}$ x ADC x $BA_{oral}$)/BW ……………..Equation 1

Where:

TEQ Intake = pgTEQ/kg bw/d
$C_{eel}$ = Average concentration in eel = 0.55 pg TEQ/g eel (See Table 2.2).
ADC = Average daily consumption over a lifetime (70 g/d, rounded from 68 g/d see text).
$BA_{oral}$ = Oral bioavailability of TEQ from food. WHO (2002) assumes 50% bioavailability but when administered to animals in oil the absorption may be as high as 90%. 100% is assumed (i.e. $BA_{oral}$ =1).
BW = Body weight (70 kg).

Thus potential TEQ intake = (0.55 pg TEQ/g x [70 or 100g/d] x 1)/70 kg
= 0.55 – 0.78 TEQ/kg/d

When background adult intake of 0.33 pg TEQ/kg/d (MfE 2011b) is taken into account the combined intake (0.88 - 1.1 pg TEQ/kg/d) from background and Kopeopeo eel consumption is less or slightly higher than the 1 pg TEQ/kg/d adopted by New Zealand (MfE 2011a).

It is noted however that the intake is within the health based guidelines developed by other authorities.

- lifetime tolerable daily intakes of 2.3 pgTEQ/kg/d established by WHO (2002) and Australia.
- 1 – 4 pgTEQ/kg/d by WHO (van Leeuwen et al. 2000).
- 2 pgTEQ/kg/d approved by the European Commission (EC 2006).

From a health impact perspective, it should be noted that New Zealand adopted a TDI of 1 pg $TEQ_{WHO}$/kg/d based on the lower end of the TDI range recommended by WHO because MfE endorsed a precautionary approach and the desirability of ongoing reduction in dioxin intake (MfE 2011b). Thus the TDI of 1 pg TEQ/kg/d was not adopted by New Zealand because it was distinctly more health protective than the recommendation of WHO.

# 4. Site specific sediment remediation goals

## 4.1 Simple derivation based on eel consumption

Previous derivations of a remediation TEQ target for sediment in the Kopeopeo Canal have used a US cancer risk approach. However, all jurisdictions around the world (except US EPA who are legislatively committed) agree that carcinogenic effects associated with exposure to dioxins are not the most sensitive health effect of dioxins. In addition the dioxin associated cancers are not the result of genotoxicity. Therefore the cancer unit risk method of the US is not appropriate. This is extensively discussed in MfE (2011b) as background to New Zealand adopting a 'threshold', (i.e. TDI approach) to deriving standards for contaminants in soil to protect human health (MfE 2011a). The calculations below are consistent with the deliberations on dioxin toxicity and risk assessment by MfE (2011a, 2011b).

In deriving a target remediation goal for sediment it is necessary to account for background intake to establish an acceptable TEQ concentration in eel, and further link the eel TEQ concentration with a sediment TEQ concentration.

The first step is accomplished as follows:

TDI – background = TEQ intake from eating eel ……………………………Equation 2

$$= (C_{eel} \times ADC \times BA_{oral})/BW$$

Where:

TEQ Intake = pgTEQ/kg bw/d
$C_{eel}$ = To be estimated (pg/g eel).
ADC = Average daily consumption over a lifetime.
SKM (2006, p16) indicates community agreed consumption is 125 eels/yr per adult male.
At 0.2 kg per dressed eel (Table 2.1); ADC = (125 eels/yr x 100g/eel)/(365d/yr) = 68 g eel/d (Round to 70g/d).
$BA_{oral}$ = Oral bioavailability of TEQ from food. WHO (2002) assumes 50% bioavailability but when administered to animals in oil the absorption may be as high as 90%. We have assumed 100% (i.e. $BA_{oral}$ =1).
BW = Body weight (70 kg).
TDI = 1 pg TEQ/kg/d (MfE 2011b).
Background intake = 0.33 pg/kg/d (MfE 2011b).

Thus:

$C_{eel}$ = [(1 – 0.33 pgTEQ/kg bw/d) x 70 kg]/ [70 to 100g eel/d].

= 0.47 - 0.67 pgTEQ/g

| This is the allowable average TEQ concentration in eels consumed at the assumed rates. |
|---|

In the second step, the concentration in eel is connected to an average sediment concentration to which the eel is exposed over its home range. The following equation[3] from US EPA (2004a, p B-17) and used by SKM (2006) achieves this.

A combination of eel consumption patterns (70 or 100g/d) with a BSAF for reaches of the canal containing elevated sediment dioxin has been used to derive target sediment remediation goals (Table 4.1).

$C_{eel} = (C_{sed}/F_{oc}) \times E_l \times BSAF$ ……………………….Equation 3

Where:

$C_{eel}$ = Target TEQ concentration in eel after remediation = 0.47 – 0.67 pg TEQ/g eel. (From Equation 2 above).
$C_{sed}$ = Target concentration in sediment (pg/g sediment). To be solved.
$F_{OC}$ = Fraction total organic carbon in sediment.
= 0.03 (Table 2.2).
$E_l$ = Fraction lipid content of eel.
= 0.018 (Table 2.2).
BSAF = Biota-sediment accumulation factor (ratio of the concentration of a chemical in tissue, normalised to lipid, to the concentration of the chemical in surface sediment, normalised to organic carbon).
= 0.013 for areas of Kopeopeo canal with elevated dioxin (Table 2.2 and Figure 4.1).

Thus:

$C_{sed} = (C_{eel} \times F_{oc})/( E_l \times BASF)$

= ([0.47 or 0.67pg TEQ/g] x 0.032)/(0.018 x 0.013)

= 64 – 92 TEQ/g sediment dry weight

Figure 4.1 provides a visual representation of the BSAF data in Table 2.2. It is apparent that the BSAF for sites 9 & 10 are different to other stretches of the canal where dioxin sediment concentrations are higher (Sites 5 – 8) or TOC is lower (Sites 3 & 4). While this may suggest the ecological conditions governing the uptake of dioxin TEQ from sediment are different in the areas of Sites 9 & 10 than elsewhere in the canal (US EPA 2009a) it may also simply be the result of eels moving from areas lower in the canal, where they have accumulated dioxin TEQ, to areas that may have more food resources further up the canal. Regardless of the reason for the BSAF difference, it is reasonable to exclude these values when determining an eel BSAF for dioxin accumulation.

[3] Equation 3 is a simple rearrangement of the equation used to calculate the BSAF using lipid normalised eel dioxin concentration and organic carbon normalised sediment dioxin concentration.
$BSAF = (C_{eel} / E_l) \div (C_{sed} / F_{OC})$

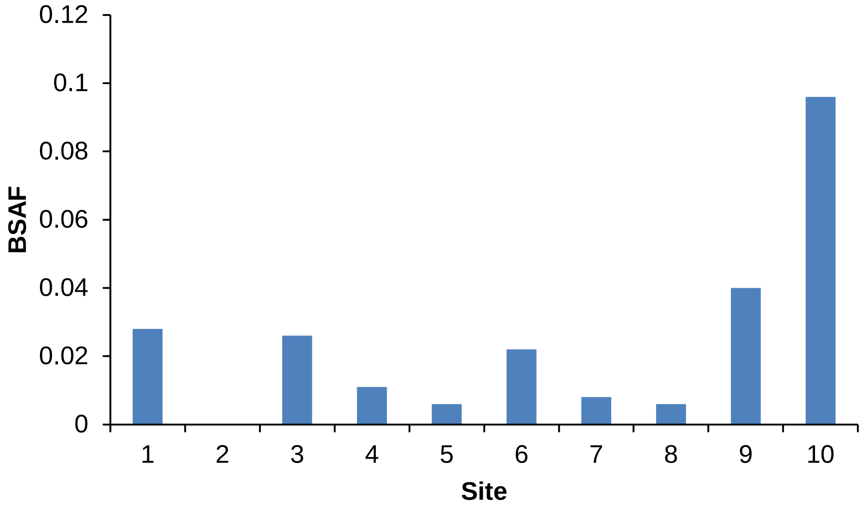


**Figure 4.1: Biota Sediment Accumulation Factors (BSAFs) calculated with data collected from different sites in and around Kopeopeo canal.**
Sites 9 & 10 clearly have different BSAFs than sites within the canal (Sites 3 – 8).

## 4.2 Incorporating other pathways

It is noted that in determining remediation goals, SKM (2006) nominated three pathways that may affect a local person's exposure to dioxin TEQ in sediments:

- Consumption of eel (addressed above).
- Dermal absorption while catching eels.
- Dermal absorption while swimming (this is not addressed[4] in this commentary as exposure by this route is inherently very low, swimming in the canal is unlikely to occur, and such risk, albeit low, can be managed by signage on the canal).

In this section exposure pathways associated with eels are incorporated into derivation of dioxin remediation goals for sediment.

[4] US EPA and CDC recommend minor exposure pathways not be evaluated in risk assessments if they contribute less than 10% of the intake of the predominant pathway. In addition dioxins have limited solubility in water. Furthermore the quantitative inclusion of this pathway in the 'back calculations' for sediment remediation goal has considerable uncertainty. If there is concern that this pathway needs to be seen to be considered in the derivation of remediation goals then it is much easier to do this by appropriately decreasing the remediation goal by say 10% (or some other amount that can be justified).

The absorbed TEQ dose from consuming eels is determined as per Equation 1.

Absorbed dose from being in contact with sediment is estimated using US EPA (2004b) methodology for dermal absorption of compounds from soil adhered to skin as follows. This is consistent with the approach of MfE (2011a) for derivation of soil contaminant standards.

Average lifetime daily absorbed TEQ dermal dose ($ALDD_{Dermal}$)

= ($C_{sed}$ x AF x SA x $BA_{Dermal}$ x CF x EF x ED)/(BW x AT) ……………………Equation 4

Where:

$C_{sed}$ = Concentration in sediment (pg/g sediment). To be calculated.
AF = Sediment adherence factor to skin. US EPA (2004b) default for soil = 0.06 mg/cm$^2$.
This is also the recommended soil adherence value by MfE (2011b) for adults in parks/recreational exposure scenarios.
It may be argued that adherence of wet sediment to skin may be higher[5], however this is balanced by the fact that water will wash sediment from skin. The parts of the body likely to be in continuous contact with sediment while eeling are feet; the soles of which are an efficient barrier to chemical absorption. Overall we consider the adopted sediment adherence value when applied to all body areas in contact with water is conservative.
SA = Skin surface area potentially exposed to sediment, i.e. feet, lower legs, hands and forearms[6].
For an adult male: 1,400; 2,700; 1,100; 1,500 cm$^2$ respectively. Total = 6,700 cm$^2$.
Data from US EPA (2008, 2009b, 2011) and enHealth (2012).
$BA_{Dermal}$ = Bioavailability of substance when applied to skin, sometimes also referred to as the dermal absorption factor.
= 0.02 as recommended by MfE (2011b).
CF = Unit conversion factor ($10^{-6}$ kg/mg).
EF = Exposure frequency. Eels may gathered up to 100 times per year (i.e. about twice per week). (SKM 2006, p12).
= 100 d/yr.
ED = Number of years eeling is assumed to occur = 30 yr.
BW = 70 kg (adult male, MfE 2011a).
AT = Averaging time[7]. The number of days within which activity occurs = 10,950d.

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[5] It is noted SKM (2006) has nominated a sediment adherence factor of 1 mg/cm$^2$ which is a carryover from the ESR (2006) "Abbreviated Assessment of Human Health Impact from Whakatane Old Sawmill Site". On consulting the ESR report we are unable to identify the source or rationale for use of 1 mg/cm$^2$. It simply is not credible that this amount of sediment will stick to the body parts nominated. Furthermore it is only the very thin layer of sediment with intimate contact with skin from which dioxin TEQ may transfer from organic carbon into the skin. Dioxin in the middle of sediment or the outside will not translocate to the inner layer next to the skin.

[6] Head not included as it is not credible for sediment adhering to all of head.

[7] Following MfE (2011a) methodology the averaging time applied for a 'threshold' substance is the ED in days, and not a lifetime of 70 yrs. The latter is for non-threshold (i.e. genotoxic) carcinogens.

Incorporating Equation 3 into Equation 2

TDI – Bkgd $= (C_{eel} \times ADC \times BA_{oral})/BW$ ……………………………………Equation 2

$C_{eel} = (C_{sed}/F_{oc}) \times E_I \times BASF$ ……………………………………Equation 3

Substituting for $C_{eel}$ in Equation 2 gives:

TDI – Bkgd $= ([(C_{sed}/F_{oc}) \times E_I \times BASF] \times ADC \times BA_{oral})/BW$

$$= \frac{[C_{sed} \times E_I \times BASF]}{F_{oc}} \times ADC \times BA_{oral}) \times \frac{1}{BW}$$ …………………Equation 5

Combining exposure via eel eating and via sediment while eeling (i.e ($ALDD_{Dermal}$) (i.e. Equation 5 [which incorporates E1] and Equation 4).

TDI – Bkgd = intake from eating eel (E5) + dermal intake (E4)

$$= \frac{[C_{sed} \times E_I \times BASF] \times ADC \times BA_{oral})}{F_{oc} \times BW} + \frac{(C_{sed} \times AF \times SA \times BA_{Dermal} \times CF \times EF \times ED)}{BW \times AT}$$

$$= \frac{C_{sed}}{BW} \left\{ \frac{(E_I \times BASF \times ADC \times BA_{oral})}{F_{oc}} + \frac{(AF \times SA \times BA_{Dermal} \times CF \times EF \times ED)}{AT} \right\}$$

Solving for $C_{sed}$

$$C_{sed} = \frac{(TDI - Bkgd) \times BW}{\frac{(E_I \times BASF \times ADC \times BA_{oral})}{F_{oc}} + \frac{(AF \times SA \times BA_{Dermal} \times CF \times EF \times ED)}{AT}}$$

$$= \frac{(1 - 0.33) \times 70}{\frac{(0.018 \times 0.013 \times [70 \text{ or } 100] \times 1)}{0.032} + \frac{(0.06 \times 6{,}700 \times 0.02 \times 10^{-6} \times 100 \times 30)}{10{,}950}}$$

$$= \frac{46.9 \text{ pg/d}}{[0.51 \text{ or } 0.73 \text{ g/d}] + 0.0000022 \text{ kg/d}}$$

$$= \frac{46.9 \text{ pg/d}}{[0.51 \text{ or } 0.73 \text{ g/d}] + 0.0022 \text{ g/d}}$$

= **64 - 91.6 pg TEQ/g sediment**

Thus the inclusion of dermal exposure to sediments while eeling has not materially influenced the sediment remediation goal calculated from just considering eel consumption (Section 4.1).

### 4.3 Conclusion

Using eel consumption information from community consultation of 70 or 100g eel/d and a biota sediment accumulation factor for reaches of the canal that are most likely to contribute to dioxin TEQ in eels, a target remediation goal of 60 – 90 pg TEQ/g sediment (dry weight) is derived.

Currently the designated area for remediation is the canal area between sites 3 to 8 (Figure 1.1). However visual inspection of the sediment TEQ concentrations (Table 2.2 and Figure 2.1) in conjunction with the above remediation goals indicates a more confined remediation area around sites 5 to 8.

## References

EC (2006). Commission regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs. Official Journal of the European Union. L364/5. 20.12.2006. http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:364:0005:0024:EN:PDF.

enHealth (2012). Australian Exposure Factors Guide. enHealth Council. http://www.health.gov.au/internet/main/publishing.nsf/content/804F8795BABFB1C7CA256F1900045479/$File/doha-aefg-120910.pdf.

ESR (2006). Abbreviated assessment of human health impact from Whakatane old sawmill site. Prepared for Environment Bay of Plenty by Institute of Environment Science & Research Ltd (ESR). Client report FW05121. FINAL Friday, 3 March 2006.

MfE (2011a). Methodology for deriving standards for contaminants in soil to protect human health. New Zealand Ministry for the Environment. Wellington. http://www.mfe.govt.nz/publications/hazardous/deriving-standards-for-contaminants-in-soil/methodology-for-deriving-standards-for-contaminants-in-soil.pdf.

MfE (2011b). Toxicological intake values for priority contaminants in soil. New Zealand Ministry for the Environment. Publication Number ME 1056. http://www.mfe.govt.nz/publications/hazardous/toxicological-intake-values-for-priority-contaminants-in-soil/index.html.

SKM (2006). Kopeopeo Canal Remediation Needs and Option Assessment – Determining Remediation Goals. Issue 01, 24th October 2006.

US EPA (2004a). The Incidence and Severity of Sediment Contamination in Surface Waters of the United States. National Sediment Quality Survey Second Edition. United States Environmental Protection Agency, Standards and Health Protection Division. EPA-823-R-04-007, EPA-823-R-04-007.

US EPA (2004b). Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). http://www.epa.gov/oswer/riskassessment/ragse/pdf/chapter3.pdf.

US EPA (2008). Child-specific exposure factors handbook. Final Report. United States Environmental Protection Agency.

US EPA (2009a). Estimation of biota sediment accumulation factor (BSAF) from paired observations of chemical concentrations in biota and sediment. U.S. Environmental Protection Agency, Mid-Continent Ecology Division. EPA/600/R-06/047, ERASC-013F, February 2009.

US EPA (2009b). Exposure Factors Handbook: 2009 Update. United States Environmental Protection Agency. External Review Draft. July 2009. EPA/600/R-09/052A.

US EPA (2011). Exposure Factors Handbook: 2011 edition. United States Environmental Protection Agency. September 2011. EPA/600/R-090/052F.

van Leeuwen, F.X.R., Feeley, M., Schrenk, D., Larsen, J.C., Farland, W. and Younes, M. (2000). Dioxins: WHO's tolerable daily intake (TDI) revisited. Chemosphere. 40: 1095-1101.

WHO (2002). Evaluation of certain food additives and contaminants. Fifty-seventh report of the Joint FAO/WHO Expert Committee on Food Additives. WHO Technical report series 909, Geneva.

## Disclaimer

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