Food safety advice for kai awa from the Makowhai stream

Summary

The risk to consumers of PFAS (PFOS and PFHxS) through consumption of traditional kai species (eels, whitebait and koura) from the Makowhai stream has been evaluated.

While there is no data on uptake of PFOS and PFHxS from river water into kai species against which to directly estimate the intake for normal adult consumers, uptake and intake estimates has been calculated from water concentrations both in the most highly affected part of the stream or whole stream, and reported ranges of uptake in fish and crayfish from overseas studies.

Eels and whitebait in the Makowhai stream could uptake sufficient PFOS to pose a risk to consumers, especially if the kai is exclusively taken from the most-highly affected stretch.

It is unlikely that whitebait are a risk because they migrate through less contaminated waters downstream.

Similarly, it is unlikely that Koura pose a risk.

Watercress growing in the stream has previously been assessed as low risk.

It is proposed that the uptake into eels in the Makowhai stream be confirmed through testing. Advice to limit the harvest of eels from the most affected stretch of the stream, or to recommend that harvesting eels should be spread across a variety of waterways in the region may be mitigation options.

Key Recommendations

- Uptake of PFOS in eels resident in the Makowhai stream could be sufficient to exceed the tolerable daily intake (TDI) values for consumers that regularly eat eels.
- Risk management measures to lessen exposure from eating eels could include further testing; and if necessary advice to limit harvesting from the most highly affected section of the Makowhai watercourse and/or to spread harvesting for personal consumption around a range of waterways in the region.
- Uptake of PFOS into whitebait is possibly sufficient to pose a food safety concern for consumers that regularly eat whitebait. However, the risk may be reduced because the migratory nature of this life stage of the fish species likely minimises the consistency in which fish are exposed to the highest concentrations of PFOS, hence lower concentration will uptake in the consumed fish.
- Uptake of PFOS and PFHxS in Koura is unlikely to be sufficient to pose a food safety concern for consumers that regularly eat Koura.
- This assessment has a number of limitations and could be further refined through use of average surface water PFOS and PFHxS concentration ranges after Phase C sampling, and data from direct sampling of resident eels and whitebait.
- Establishment of biological concentration factors for kai awa would allow the possibility in the future to monitor surface water concentrations and set thresholds for when harvesting advice may need to be issued.

1. Background

Kai is traditionally gathered from the Makowhai stream in the Rangitikei catchment. A proposal is being considered under the Te Mana o Te Wai fund to increase the use of the Makowhai stream for kai gathering by undertaking revegetation work and installing mahinga kai platforms; the latter allowing easier access to the stream for gathering whitebait and eels.

The Ohakea Per/poly-fluorinated alkyl substances (PFAS) investigation detected perfluorooctane sulphonate (PFOS) and perfluorohexane sulphonate (PFHxS) in the surface water of the Makowhai stream. This report estimates the potential for accumulation into kai species residing in the stream, and consequential food safety implications.

2. Biological concentration factor ranges for kai species

To date, data on PFOS and PFHxS levels in kai awa from the Makowhai stream to establish likely uptake are limited to watercress. Therefore, estimation of the potential exposure from other kai awa, e.g. eels, koura and whitebait, is not directly possible. However, it is possible to estimate the biological concentration factors (BCFs) for these aquatic species which could reflect a concern.

BCFs only consider the direct uptake of the contaminant into the aquatic species from the surface water itself; not from its food supply or any inadvertent ingestion of sediment. The literature suggests, and this assessment assumes, that direct uptake of PFOS [and PFHxS] from water is the primary route into fish, and that other sources are insignificant, noting however that this is predominately based on laboratory research and in-field conditions may differ.

Three key kai awa groups have been considered in this assessment: Eels or Tuna (*Anguilla australis* and *Anguilla dieffenbachia*), Whitebait (*Galaxias fasciatus, Galaxias argenteus, Galaxias maculatus, Galaxias brevipinnis* and *Galaxias postvectis*) and Koura (*Paranephrops planifrons*).

A previous assessment has concluded that uptake factors in to watercress are low. As a result watercress has been concluded to be a negligible dietary risk.

While it is reported that trout are present in the Rangitikei river (Fish & Game, 2018), the extent to which they will be fished from the narrower stretches of the Makowhai stream is unknown. Kākahi or freshwater mussels could also be present and harvested, although rates of consumption are general very low (Phillips et al., 2011, 2011a). Dietary intake estimates for trout and mussels have not been calculated in this assessment. Finally it is possible that water-fowl could be shot for human consumption in the Makowhai catchment, however as the birds would be mobile around the area and not exclusively residing in PFAS containing water, or consuming PFAS containing foods, a realistic estimate of uptake can't be made.

a. Eels

Uptake data or BCFs specifically for New Zealand eel species have not been identified. However, a number of studies are available that report concentrations of PFOS and PFHxS in European eels (*Anguilla anguilla*) (Table 1).

Table 1: Reported perfluorooctane sulphonate (PFOS) and perfluorohexane sulphonate (PFHxS) concentrations in European Eels (*Anguilla anguilla)*.

Area/country	PFOS concentration (µg/kg FW); (% total PFAS)	PFHxS concentration (µg/kg FW); (% total PFAS)	Reference
Loire estuary, France	18-39 (84-88%)	(2-4%)	Courdec *et al*., 2015
North Rhine/Westphalia, Germany	8-49	Not analysed	Guhl *et al*., 2014
North Germany	37-88	Not analysed	Schuetze *et al*., 2010
Lake Garda, Italy	<0.008-7.8	<0.025	Chiesa *et al*., 2018
North Italy	<0.4 to 6.28	Not analysed	Giari *et al*., 2015
The Netherlands	5.9-57	<3	van Leeuwen & de Boer, 2006
UK (retail study)	59 (94%)	Not stated	Clarke *et al*., 2010

Only one study has calculated bioaccumulation factors in eels from water and sediment (Kwadijk *et al*., 2014). Data from a contaminated site and a reference site at two time points were used to calculate BCFs for PFOS from water (750-2030) and sediment (4.6-29).

b. Whitebait

Uptake data or BCFs specifically for diadromous or non-diadromous whitebait species have not been identified in the scientific literature. A number of studies have been undertaken on other fish species and these are referenced to establish typical BCFs for finfish.

Tissue distribution and accumulation kinetics were determined in rainbow trout exposed to 0.35 mg PFOS/L (Martin *et al*. 2003b). A BCF of 1,100 was calculated for the whole carcass of the fish.

A study of PFOS uptake was undertaken in Perch in Sweden following a release at Stockholm Arlanda airport (Ahrlens *et al*., 2014). The average BCF whole body value for PFOS was 6400 ± 3600, although as muscle represented only 17% of the body burden, the BCF was lower in the edible tissue. The BCF whole body for PFHxS was approximately two orders of magnitude lower at 26 ± 10. This indicates PFHxS has a considerably lower accumulation potential in finfish than PFOS.

The Canadian Draft Federal Environmental Quality Guidelines for PFOS (ECCC, 2017) reports that uptake in carp ranged from 720 to 1300 and in sunfish averaged across tissues at 2660 (Inoue *et al.*, 2012). The Canadian authority then used the geometric mean BCF of 1378 for both species to calculate a freshwater fish tissue guideline value (ECCC, 2017).

Fillets from a number of freshwater finfish (carp, spangled perch and bream) were sampled and analysed during the Australian Defence Force monitoring around Army Aviation Centre Oakey (AECOM, 2017). The PFOS fillet concentrations for thirty fish taken from Oakey creek (the most heavily affected natural waterway) ranged between 7.6 and 250 µg/kg FW. Based on corresponding water concentrations, the BCFs into edible tissue range between 29 and 5300, with an average of 503. PFHxS concentrations were generally below reporting levels in fish; the highest value only 2.2 µg/kg FW. A BCF for PFHxS was estimated to range from 10 to 20 although this is uncertain due to the low number of samples in which PFHxS was detected and left censoring.

PFHxS is considered unlikely to influence the outcomes of this assessment for finfish species as uptake appears to be two orders of magnitude below PFOS.

c. Koura

Australian yabbies (*Cherax destructor*) are a freshwater crayfish similar to New Zealand's Koura. This assessment therefore uses transfer factors derived from yabbies as the reference range in the absence of specific uptake values for Koura.

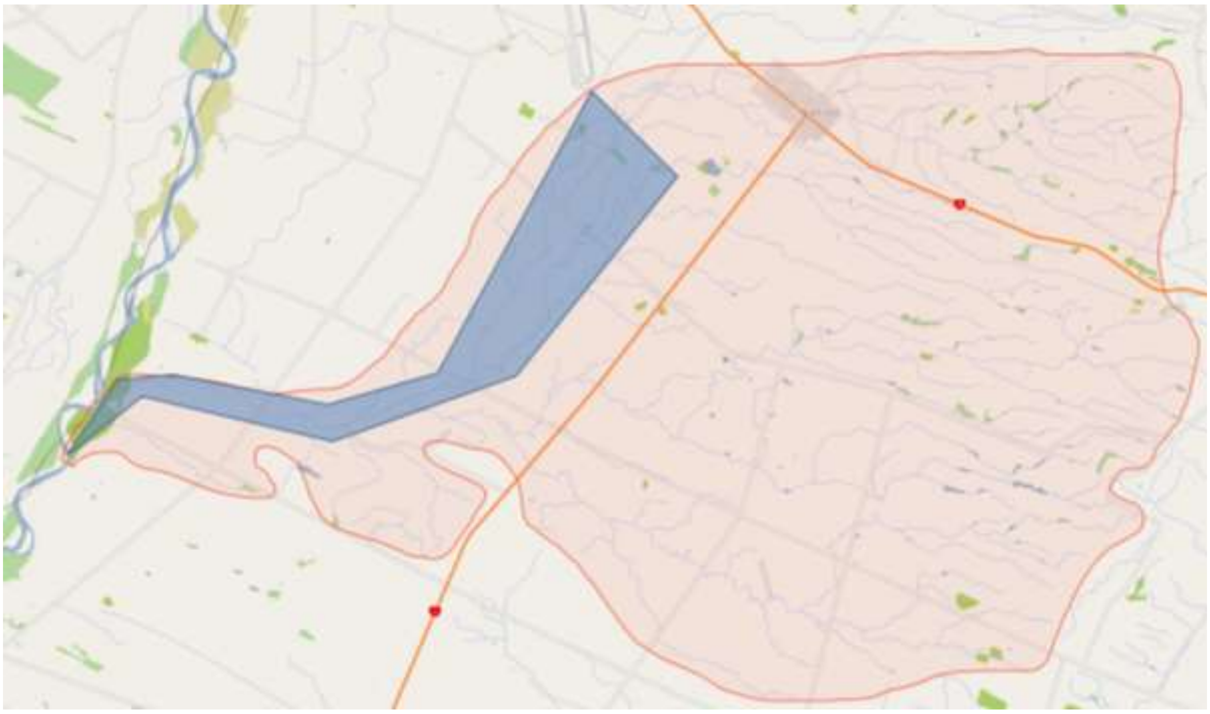
The edible tail muscles of a number of yabbies were sampled and analysed during the Australian Defence Force monitoring around Army Aviation Centre Oakey (AECOM, 2017). Concentrations of PFOS and PFHxS ranged between 0.86-32 µg/kg FW and 0.6-7.1 µg/kg FW, respectively. The greater uptake of PFHxS is consistent with other literature reports for crustacea. Based on corresponding water concentrations, average BCFs for yabbie tail muscle were estimated in the order of 76 for PFOS and 72 for PFHxS.

3. Modelled water concentrations of PFOS and PFHxS.

The mapped extent of the Makowhai stream drainage basin is considerable and includes a number of tributaries outside of the likely contamination plume from the Ohakea airbase (Figure 1). The size of these tributaries and whether they represent an accessible source of kai awa is unknown. Consequently, to establish the estimated PFOS water concentrations to which kai awa could be exposed, this assessment considers only the area of the stream from which water samples have been collected during the Ohakea investigation, (Figure 1; PDP, 2018a).

The concentration of PFOS in the Makowhai stream is likely dynamic, changing temporally or spatially within the water course. Analytical results from the Stage B sampling round (PDP, 2018a) identified a range in PFOS concentrations between 54 ng/L and 240 ng/L down the main watercourse. In contrast, PFOS was not detected at the confluence with the Rangitikei River and down a tributary merging with the main course at Taylors Rd. Kai awa harvesting is unlikely to occur at the same site consistently over time, therefore estimating exposure based solely on the highest reported concentrations is inappropriate.

Figure 1. General map of the Makowhai stream, annotated with approximate drainage basin (transparent red) and area considered within this assessment (transparent blue).



Two approaches have therefore been used to estimate exposure to PFOS and PFHxS:

- An estimate based on the section of the main watercourse between Speedy Rd and Taylors Rd, given this is the flow with the greatest PFAS concentrations

  176 ng/L PFOS; 139 ng/L PFHxS

- An estimate based on the average for all of the samples taken from the Makowhai stream, including any non-detect values.

  92 ng/L PFOS; 73 ng/L PFHxS

4. Typical intake values for kai awa

Estimates of typical consumption practices for kai awa have been obtained from the Te Arawa Rohe risk assessment report (Phillips *et al*., 2011, 2011a). Iwi of the Te Arawa lakes region were surveyed through questionnaires to establish normal patterns of consumption for kai awa, kai rohe and kai moana.

Average meal sizes and consumption frequencies were surveyed, with an average daily intake also calculated:

- 224 grams per meal for eel, 1.29 meals per month 9.6 grams per day
- 112 grams per meal for whitebait, 0.56 meals per month 5.7 grams per day
- 152 grams per meal for koura, 0.5 meals per month. 2.5 grams per day

5. Risk assessment

The BCF required to result in PFOS uptake in fish, and PFOS+PFHxS uptake in koura, that will lead to exceedance of the Food Standards Australia New Zealand tolerable daily intake (TDI) of 20 ng/kg body weight per day by a 70 kg adult (Table 2), were modelled from water concentrations of PFOS and PFHxS and the estimated average consumption kai awa rates. There is limited data on the extent of consumption by children of the kai awa species considered, as such it is not possible to undertake this modelling for children.

The calculated BCF values were compared with the literature ranges to identify whether or not consumption of the kai awa species is a concern. The lower the estimated BCF (required to exceed the TDI) when compared to the literature value, the greater the potential that the species could uptake sufficient PFOS (and PFHxS for koura) to represent a risk of exceeding the TDI for average consumers.

Table 2. Estimated biological concentration factors (BCF) for perfluorooctane sulphonate (PFOS) in kai awa for and adult to reach 100% of the Food Standards Australia New Zealand Tolerable Daily Intake (TDI).

Species	Speedy Rd to Taylor Rd only		All Makowhai stream results	
	PFOS BCF to reach 100% TDI	Literature ranges	PFOS BCF to reach 100% TDI	Literature ranges
Eel	850	750-2030	1600	750-2030
Whitebait	1400	29-6400	2700	29-6400
Koura	1800 (for PFOS+PFHxS)	70-80	3500 (for PFOS+PFHxS)	70-80

For eels, the BCF required to exceed the TDI is within the literature range and therefore consumers regularly harvesting eels solely from the Makowhai stream, may receive an exposure in excess of the TDI, although the risk would be reduced if eels are not consistently harvested from the most affected locations.

Similarly for whitebait the BCF required to exceed the TDI is within the literature range, particularly if harvest was continuously from the most affected locations on the stream. However this finding is likely conservative when it is considered that the whitebait life stage is migratory, as a result the fish are less likely to be continually present in areas with higher PFOS concentrations. Therefore concentrations in whitebait are likely to be substantially lower than a resident species such as eels. Additionally, while the literature range of BCFs for finfish is very wide, the BCFs necessary to cause concern for whitebait are above the average BCFs reported in the Canadian, Oakey and rainbow trout studies. Considering both factors it is unlikely that whitebait would pose an appreciable chronic food safety risk for consumers.

The required BCF for koura, to uptake sufficient PFOS and PFHxS to be a source of exposure of concern, is far in excess of the calculated BCFs for similar freshwater crayfish in Australia. It is highly unlikely that harvesting and consuming koura from the Makowhai stream would present a dietary concern.

6. Possible risk management measures

Based on the reported literature BCF values for PFOS in aquatic food species, it is likely that harvest and consumption of kai awa species from the Makowhai stream is a source of dietary exposure, with eels posing a potential risk for regular consumers to exceed the TDI. The risk of harvest of koura and whitebait is likely low and therefore the installation of mahinga kai platforms on the stream to access these species should not result an appreciable increase in food safety risk.

However, there is a need to address the estimated risk from regular consumption of eels. Options to refine the modelling and mitigate concern for eels could include:

- Broader monitoring of water PFOS concentrations on current and potential future harvesting sites to establish a more robust average water concentration for the watercourse.
- Direct monitoring of eels in this watercourse and establishment of NZ specific BCFs. A BCF would allow the possibility in the future to monitor surface water concentrations and set thresholds for when and where harvesting advice may need to be issued.
- Restriction of harvesting from the most highly affected section of the Makowhai watercourse between Speedy Rd and Taylors Rd; or advice to spread any regular harvesting for personal consumption around this watercourse and others in the region.

7. Limitations:

While a wide range of literature has been consulted to allow as informed risk assessment as possible to be conducted, there are a still a number of data gaps that raise uncertainty in the assessment.

A notable limitation is the reliance on solely the Stage B sampling results for the surface water of the Makowhai stream (PDP, 2018a). As only two samples were taken from the stream in Stage A there is insufficient data to add this to the consideration of variation, although notably at both sampling sites the reported PFOS and PFHxS had increased in Stage A (PDP, 2018). With seasonal changes in water levels and precipitation it would be expected some degree of variability will be evident across the year in the PFOS and PFHxS concentrations. Availability of an annual average for sampling points of the Makowhai stream would likely present the best marker of exposure for aquatic species. An update to this assessment once Stage C results are available would ensure that some reflection of potential annual variability is captured.

Similarly, estimates of the likely average concentration for the whole area where kai awa harvesting could take place is based on just 11 results. As the lower reaches of the stream, and tributaries, may not be affected, the risk may be conservative for a consumer harvesting evenly across the whole watercourse.

The proposal to revegetate areas of the stream may influence how PFOS is retained or released into the surface water, although there is no evidence to support any possible effect.

Finally the assessment assumes that the harvested kai awa will be the only dietary contribution of PFOS for consumers. MPI on-site visits in early 2018 had established that none of the residents in the Ohakea region were regularly consuming kai awa (anecdotal reports were that harvesting was undertaken by public from outside the localised area), and therefore any additional consistent dietary sources are considered unlikely. However, this assumption in the absence of full dietary habit data for harvesters increases the uncertainty in the assessment.

Author

Dr Andrew Pearson – Specialist Adviser (Environmental Chemistry & toxicology)

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