

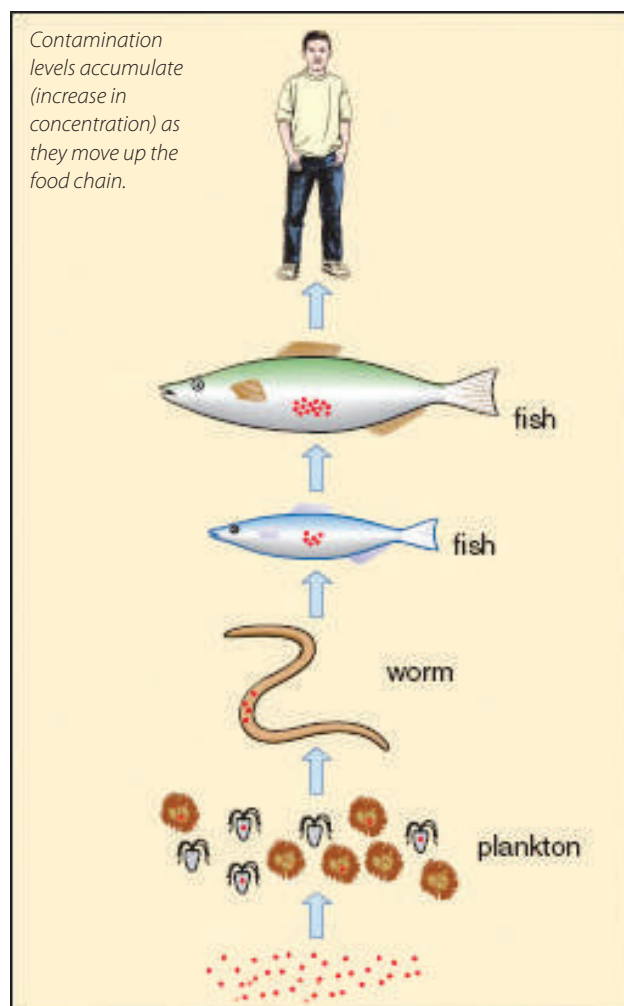
Risk assessment of contaminants in kai from within the Te Arawa rohe – Summary report

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Introduction

Gathering, eating and sharing wild kai (food) has always been a very important part of Māori tikanga (custom and tradition). Members of the Te Arawa iwi (tribe) have resided in the Rotorua area for centuries, with the lakes forming the mainstay of their economy, as an important source of freshwater fish, invertebrates, waterfowl, and plants. The freshwater fish koaro once formed a significant fishery within these lakes. Smelt were introduced as a food source for trout in the 1920s and appears to have had a major impact on the koaro population. A small smelt fishery is still present in the Ohau Channel (Lake Rotorua) and beach seining for this species also occurs sporadically. The koura or freshwater crayfish was also once an important indigenous fishery, but declining lake quality (through increased eutrophication and invasion by exotic macrophytes) has impacted on the ability of Te Arawa to harvest this iconic species. There is also a growing interest in the revitalisation of traditional harvesting practices for this species.

Other important local freshwater food species include the kakahi (freshwater mussel), tuna (long fin eel), watercress, and introduced rainbow trout. The rainbow trout is the basis of a significant recreational fishery in the Rotorua district and in many other parts of New Zealand. Considerable harvesting is also undertaken in coastal areas around Maketu. A unique aspect of the rohe of Te Arawa (Rotorua) is that natural geothermal activity is a significant source of elevated concentrations of heavy metals, which may accumulate in some kai species and represent a risk to consumers. Other sources of potentially toxic contaminants (e.g., heavy metals in stormwater, pesticides from agriculture) may also represent a risk to consumers of wild kai.



This study

The aim of this study was to quantify the risk to Te Arawa iwi members by consuming wild kai gathered from the rohe (or region) of Te Arawa (Rotorua), New Zealand. This summary report describes:

1. The basic methods used.
2. Key results.
3. A discussion of the significance of these results to Te Arawa.
4. Recommendations for future research.

Methods

Collecting the information

A questionnaire was used to survey Te Arawa iwi members about their past and present consumption rates of traditional kai species. Hair samples were also collected from participants to assess possible exposure to mercury. We chose this metal as an example of a highly accumulative contaminant. Fish and shellfish (including longfin eel, rainbow trout, koura, pipi, mussel, and kakahi) and watercress samples were gathered from up to 14 sites identified as important harvesting sites by Te Arawa (Fig.1), and tested to assess their bioaccumulative contaminant levels. Aquatic sediments, which are known to concentrate contaminants on organic material, were sampled from these locations as well.

Analysis

The fish, shellfish and sediment samples were analysed for a range of organochlorine compounds, including DDT (historically used as a pesticide), chlordane (a pesticide) and dieldrin (an insecticide). Testing for eight heavy metals - arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni) and zinc (Zn) - was also done. Eel and trout fillets were also analysed for selected polychlorinated biphenyls (PCBs – which were used extensively in the electricity industry as insulating fluids or resins in transformers and capacitors). Watercress was analysed for the eight heavy metals only.

Key results of the study

Kai consumption rates

Local average consumption rates were calculated as follows:

Kai species	Trout	Koura	Eel	Smelt	Whitebait	Kakahi	Mussel	Watercress
Local average consumption rates (grams per day)	10.9	2.5	9.6	5.7	5.7	0.33	16	15.8

Table 1 Local average consumption rates of various species (grams per day).



Kakahi or freshwater mussel.



Lake Rotokakahi

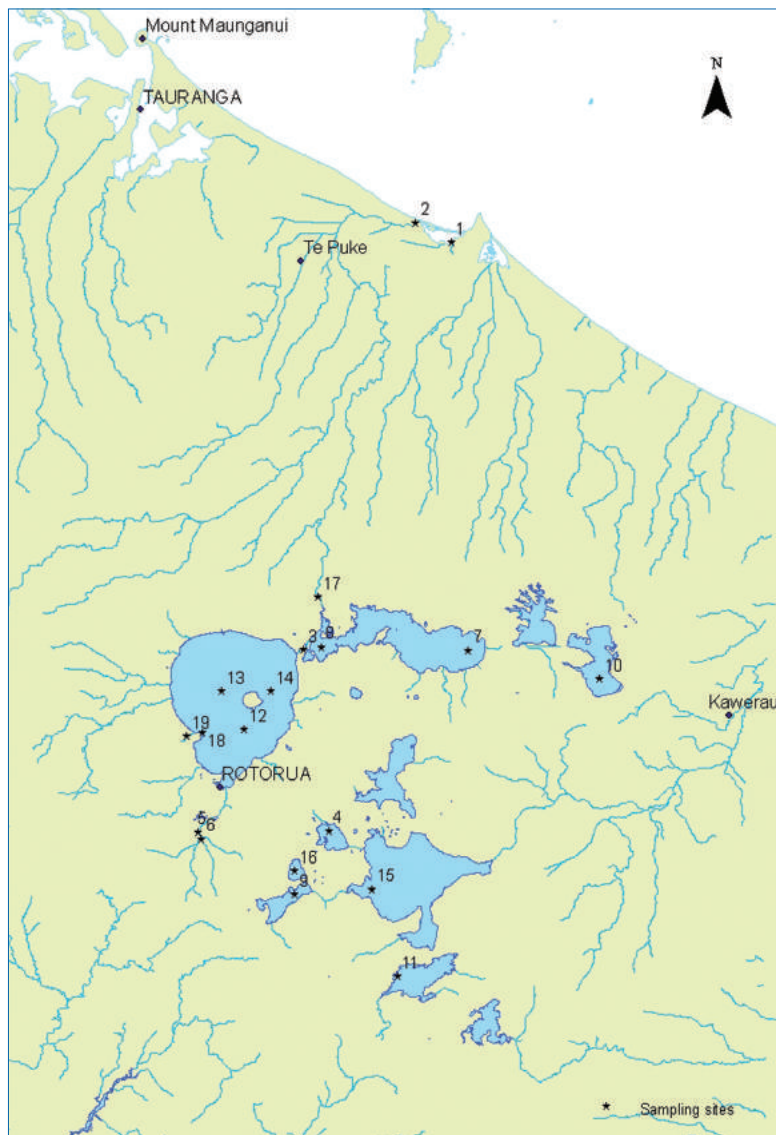


Fig 1. Kai collection sites for the Te Arawa rohe.

Total fish consumption (including takeaways, tinned fish etc) was much higher (97 grams per day) than the New Zealand average consumption rate of 32 grams per day. Only 13 percent of this was traditionally harvested fish, indicating that wild caught kai represents only a small portion of the total food basket of the local community that we surveyed (n=19). Watercress consumption (15.8 grams per day) was much lower than the proposed average consumption rate of 33 grams per day for consumers of watercress. Average meal sizes were determined from the survey results as 224 grams per meal for trout and eel, 112 grams per meal for smelt and whitebait, 152 grams per meal for koura, 144 grams per meal for shellfish (mussels, pipi, and kakahi) and 175 grams per meal for watercress.

Contamination levels (dry weights)¹

Organochlorine compounds

Highest total DDT (Σ DDT) concentrations were detected in trout from the Upper Puarenga Stream site (141 $\mu\text{g/kg}$), with elevated levels (compared to other sites) also detected in trout from Lake Rotokakahi and Lake Rotomahana. The concentrations of Σ DDT were generally much lower in eels. The highest concentrations of Σ DDT found in eels were from the Lower Kaituna River site (14 $\mu\text{g/kg}$). Other organochlorine pesticides were either below the limits of detection, or measured in much lower concentrations than any of the DDT-like chemicals.

¹ Average wet weight: dry weight conversion across all species is 0.21.

Metals

Mercury concentrations were generally highest in trout tissue, with the highest concentrations found at the Upper Puarenga Stream site (19 mg/kg). The highest concentrations of mercury in koura were recorded from the Rotoiti East site (6.5 mg/kg). Arsenic, cadmium and nickel concentrations were highest in pipis and mussels collected from the Maketu site. Concentrations of arsenic and cadmium were higher in koura than in other freshwater kai species, while pipi and mussels showed the highest levels of all species sampled. Chromium was not detected in trout, koura or eels but was found in pipis and mussels at concentrations ranging from 3.2 to 11.0 mg/kg. Copper concentrations were higher in koura than any other species, with the highest concentrations ranging from 16 mg/kg in Lake Rotokakahi to 54 mg/kg in Lake Okareka. Highest concentrations of lead were recorded in smelt from the Lower Kaituna River. Zinc concentrations were highest in smelt collected from Lake Rotomahana (290 mg/kg), with high concentrations in kakahi from Lake Rotokakahi, whitebait from the Lower Kaituna River and watercress gathered at Waiowhiro Stream, Rotorua.

The average concentration of mercury in the hair samples was 2.7 µg/g (maximum 8.7 µg/g). This is three times higher than the study reference group and twice that of New Zealander's who consume 1-4 meals of fish per month. In comparison, it was much lower than a 1985 study in the Rotorua region, where concentrations averaged 5.8 µg/g, ranging from 1 - 39 µg/g were recorded. The low number of Te Arawa responders in this study meant we couldn't analyse potential links with consumption of wild kai.

ANZECC guidelines

In New Zealand, the ANZECC guidelines define water quality and sediment guideline trigger values for toxic contaminants for a range of values, including for drinking water, as well as for protection of the aquatic environment. The ANZECC ISQG (interim sediment quality guidelines) are set at two levels, low (which is the level below which adverse effects are unlikely) and high (the level which is known to have adverse effects on some animals).

The ANZECC ISQG low values were exceeded for arsenic and mercury at 55 percent of sites sampled and for cadmium at 10 percent of the sites. The ANZECC ISQG high guideline value for arsenic was exceeded at 15 percent of sites and at 25 percent of sites for mercury.

Based on the ratio of sediment to tissue metal concentrations, bioaccumulation "hotspots" were identified at Maketu (for shellfish), the Lower Kaituna site (for whitebait) and the Ohau Channel (for smelt). The relative risk of consuming kai collected from these sites, based on levels recorded and how much is normally consumed by iwi participants, is presented below.

What is the risk to people's health?

Estimating the health risks

Established United States Environmental Protection Agency (US EPA) procedures were followed to assess the risk to people's health from eating chemically contaminated wild kai over their lifetimes. This assessment was based on using Te Arawa data on meal size and weekly consumption and measuring chemical contaminants in wild kai sampled from



Harvesting koura using the traditional tau koura method.

identified harvesting areas. It included estimating the risk of combined contaminants for both cancer and non-cancer health endpoints based on wild kai consumption – but did not include contaminants derived from commercial fish or shellfish. The risk assessment compared the calculated wild kai monthly consumption limits against the actual consumption rate (meals per month) of the iwi participants. This comparison was done to include potentially contaminated kai when it was gathered:

1. Randomly across all sites throughout the rohe (using median contamination concentration data). This represents the average consumption risk.
2. Mostly from the more contaminated sites (using 95th percentile contamination concentration data). This represents the worst-case scenario risk.

A risk assessment was performed for each species harvested from each site to gain an understanding of potential “hotspots” in the region.

Results show that if wild kai was gathered randomly across all sites that we sampled throughout the rohe and consumption rates were the same as those questioned in the survey (Table 1), then there may be an increased risk to members of the Te Arawa iwi from long-term consumption of trout, pipi, mussel and watercress (Table 2). Current consumption rates for eel are also close to exceeding safe levels (1.29 meals per month versus a 1.9 meals per month limit).

Kai species	Monthly consumption limits (meals per month) ²	Actual consumption rate (meals per month)	Contaminants contributing most to risk (% of sites)
Trout	0.9	1.46	Mercury ³ (77)
Koura	4.7	0.50	Arsenic ⁴ (75)
Eel	1.9	1.29	Arsenic (50), Mercury (50)
Smelt	2.6	0.56	Arsenic (100)
Whitebait ¹	1.8	0.56	Arsenic (100)
Pipi ¹	2.6	3.52	Arsenic (100)
Kakahi ¹	1.3	0.07	Arsenic (100)
Mussel ¹	2.9	3.52	Arsenic (100)
Watercress ¹	1.0	3.06	Arsenic (100)

Table 2 Comparison of consumption limits for median contamination data and actual consumption rates for questionnaire participants. Red shows where the recommended safe consumption rates are exceeded.

¹ Based on a single site composite sample.

² Based on lifetime exposure leading to increased risk of cancer (1 in 100,000) or non-cancer chronic disease.

³ Mercury is a non-cancer risk.

⁴ Arsenic is a cancer risk for all species.

If kai was mostly gathered at the more contaminated sites and consumption rates were the same as those questioned in the survey then a significant risk exists when eating trout, eel and pipi (see Table 3 on the following page).

While our risk assessment included all chemical contaminants that we measured in the kai samples (to assess the combined effect), mercury and arsenic were the primary contaminants of concern. Mercury exposure is associated with non-cancer chronic disease, whereas arsenic is a suspected carcinogen. It should be noted that only a small amount of the total arsenic detected in the kai samples is likely to be toxic. While our calculations of risk take this into account, without further study we cannot know this amount exactly. Therefore, the risk calculations where arsenic is the main contaminant of concern should be viewed with caution.

Kai species	Monthly fish consumption limits (meals per month) ²	Actual consumption rate (meals per month)	Contaminants contributing most to risk
Trout	0.4	1.46	Mercury ³ , DDE ⁴ , total PCBs ⁴ , Arsenic ⁵
Koura	1.6	0.50	Arsenic, (6)
Eel	1.2	1.29	Mercury, Arsenic
Smelt	1.1	0.56	Arsenic, (6)
Pipi ¹	2.2	3.52	Arsenic, (6)

Table 3 Comparison of consumption limits for 95th percentile contamination data and actual consumption rates for questionnaire participants. Red shows where the recommended safe consumption rates are exceeded.

¹ Based on a single site composite sample.

² Based on lifetime exposure leading to increased risk of cancer (1 in 100,000) or non-cancer chronic disease.

³ Mercury is a non-cancer risk.

⁴ DDE and total PCBs are a cancer risk for all species.

⁵ Arsenic is a cancer risk for all species.

⁶ Species not analysed for organochlorine pesticides.

Maps showing regional risk assessments for the most widely sampled species (trout, eel, koura and smelt) are provided on the following pages. The recommended consumption limits are based on the assumption that kai are being consumed at the same rate over their lifetime, and from sites with the same contamination levels as those recorded in this study. Any variation in either consumption rates or contamination levels would alter the recommended consumption limits.

Risk hotspots

A number of potential “hotspots” (i.e., area of increased risk) were identified from these results. The Maketu estuary site warrants further investigation of contaminant levels in both pipi and mussels. The Waiowhoro watercress sample also recorded arsenic levels of concern. Consumption of all four species sampled in the Lower Kaituna River was limited to a maximum of four meals per month (and even less for some species). Similarly, three of the four species sampled from the Ohau Channel were also limited to four meals per month (and less for some species). At sites where both trout and koura were collected, the risk associated with eating these species was highest when the kai was gathered from Rotorua, Upper Kaituna, Rotoiti and the Ohau Channel, followed by Okareka and Tarawera and then Rotokakahi and Rotoma. The lowest risk was at Tikitapu.

Trout

On the basis of this study, consumption of trout should be limited to less than one meal per month when harvested from the Upper and Lower Kaituna River, the Ohau Channel, Upper Puarenga Stream and Rotoiti, Rotomahana and Rotorua lakes. A precautionary approach should also be taken to other sites in these waterbodies. Consumption should be limited to between one and four meals per month of trout caught in Rotokakahi and Okareka lakes.

Koura

Few studies of metal concentrations in koura appear to have been published. From this risk assessment it can be concluded that koura from Lake Tarawera (at least in the vicinity of this study site) should be consumed less than once a month in order to avoid increased risk. At sites in the Upper Kaituna River, Ohau Channel and in Rotorua, Rotoma, Rotoiti and Okareka lakes, koura should be consumed no more than four times per month. Current actual consumption rates are on average 0.5 meals per month. There is, therefore, no current risk associated with koura consumption.

Eels

On the basis of our risk assessment, eels from the Lower Kaituna and the Ohau Channel should not be harvested more than four times per month. This is less than what Te Arawa iwi members consume, so there is currently no increased risk associated with eel consumption. Bioaccumulation of mercury in eels is related to age of the fish, with progressively higher concentrations found in the tissue of older eels. Therefore the results may, to some extent, reflect age-related differences. A study of South Island rivers found that mercury concentrations in long-finned eels varied with length and age in the same river, but there were also differences between catchments.

Watercress

Te Arawa participants currently consume more watercress (on average) than is recommended based on the risk assessment of watercress harvested from Waiowhoro Stream. Previous reports of arsenic accumulation in watercress in the Taupo Volcanic Zone have shown that watercress and other aquatic plants can hyperaccumulate arsenic, with concentration levels 100-50,000 times that of plants in surrounding areas. The concentration reported in those studies is considerably higher than levels reported in this study. It should be noted that any arsenic toxicity from consuming watercress will depend on the amount and frequency eaten, how the watercress is prepared, what it consumed with it, as well as the chemical form of arsenic in the plant.

Study limitations

This study has provided valuable information about the potential health risks associated with eating wild kai gathered in the Te Arawa rohe. However, there are some limitations to the results found. They include:

- The small number of people who completed the kai consumption questionnaire (n=19). The accuracy of the consumption rate information would be improved by including more participants.
- The low number of larger species (i.e., eel and trout) collected (often only a single specimen). Therefore, caution must be taken when applying consumption limits on a site by site basis.

Recommendations for future research

The results from this study highlight the need for more information on wild kai consumption, as well as the need to more accurately assess the wider distribution of chemicals, in order to assess the risk of consuming wild kai in the rohe of Te Arawa. Future research should include:

- Collecting samples from a wider range of sites and species, and ensuring multiple specimens are collected at each site, so a more statistically robust spatial assessment can be made of the health risk.
- Expanding the contaminant dataset to include studies on arsenic and mercury levels for at least a subset of each kai species at representative locations (i.e., estuarine, river and marine) to more accurately gauge risk.
- Collecting a more robust dataset of kai consumption in the region by including more consumers of wild kai in the questionnaire process.
- Calculating site-specific consumption rates which would increase reliability of risk estimates, particularly for sites that are subject to regular harvesting.
- Conducting a risk assessment for total fish diet which incorporates both wild and commercial fish and shellfish consumption.

Regional Maps

Eel



Trout



Regional Maps

Koura



Smelt



Acknowledgements

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Further information

Detailed reports of the contaminant levels in kai and of the risk assessment can be obtained from the Te Arawa Lakes Trust, Haupapa St, Rotorua.

Phillips N, Stewart M, Olsen G, Hickey C (2011) Contaminants in kai – Te Arawa rohe Part 1: Data Report. Report to the Te Arawa Lakes Trust & Health Research Council of New Zealand. March 2011 HAM2011-021. 69pp.

Phillips N, Stewart M, Hickey C, Olsen G (2011) Contaminants in kai – Te Arawa rohe Part 2: Risk Assessment. Report to the Te Arawa Lakes Trust & Health Research Council of New Zealand. March 2011 HAM2011-023. 81pp.

Related reading:

Stewart M, Phillips NR, Olsen G, Hickey CW, Tipa G, Home M (2011) Organochlorines and heavy metals in wild caught food as a potential human health risk to the indigenous Maori population of South Canterbury, New Zealand. *Science of the Total Environment* 2011; 409: 2029-2039.

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