Risk assessment of contaminants in kai from the Arowhenua rohe – Summary report

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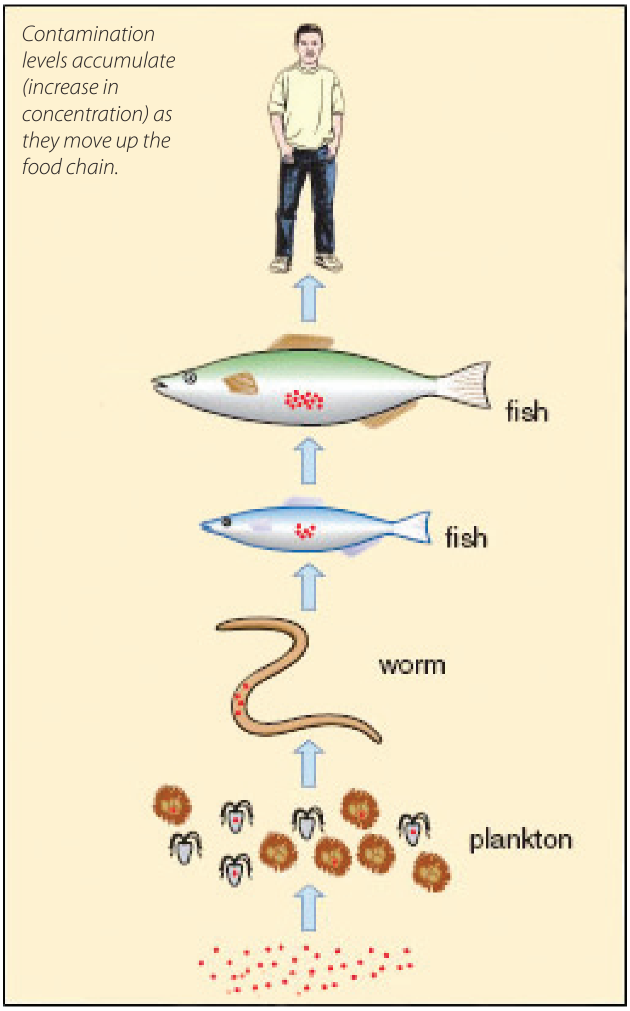
Introduction

Gathering, eating and sharing wild kai (food) has always been a very important part of Māori tikanga (custom and tradition). Members of Arowhenua have resided in the Temuka/Timaru region for centuries, with the rivers and coastal areas forming an important source of food and trade. Traditional kai sources for Arowhenua include eel, trout, flounder, and watercress. Historically, this kai has been gathered and eaten in large quantities but recently these foods have become increasingly susceptible to manmade contaminants, which, in turn, could pose a health risk to people who eat them.

Contaminants that cause health risks include: organochlorine pesticides (DDTs, dieldrin and lindane), polychlorinated biphenyls (PCBs), dioxins and selected heavy metals such as mercury, arsenic, cadmium, lead, copper and zinc. Some of these toxins pose a particular risk to people's health because they bioaccumulate (increase in concentration) up the food chain.



This study

The aim of this study was to quantify the risk to iwi members of consuming wild kai gathered from the rohe of Arowhenua, New Zealand. This summary report describes:

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

Methods

Collecting the information

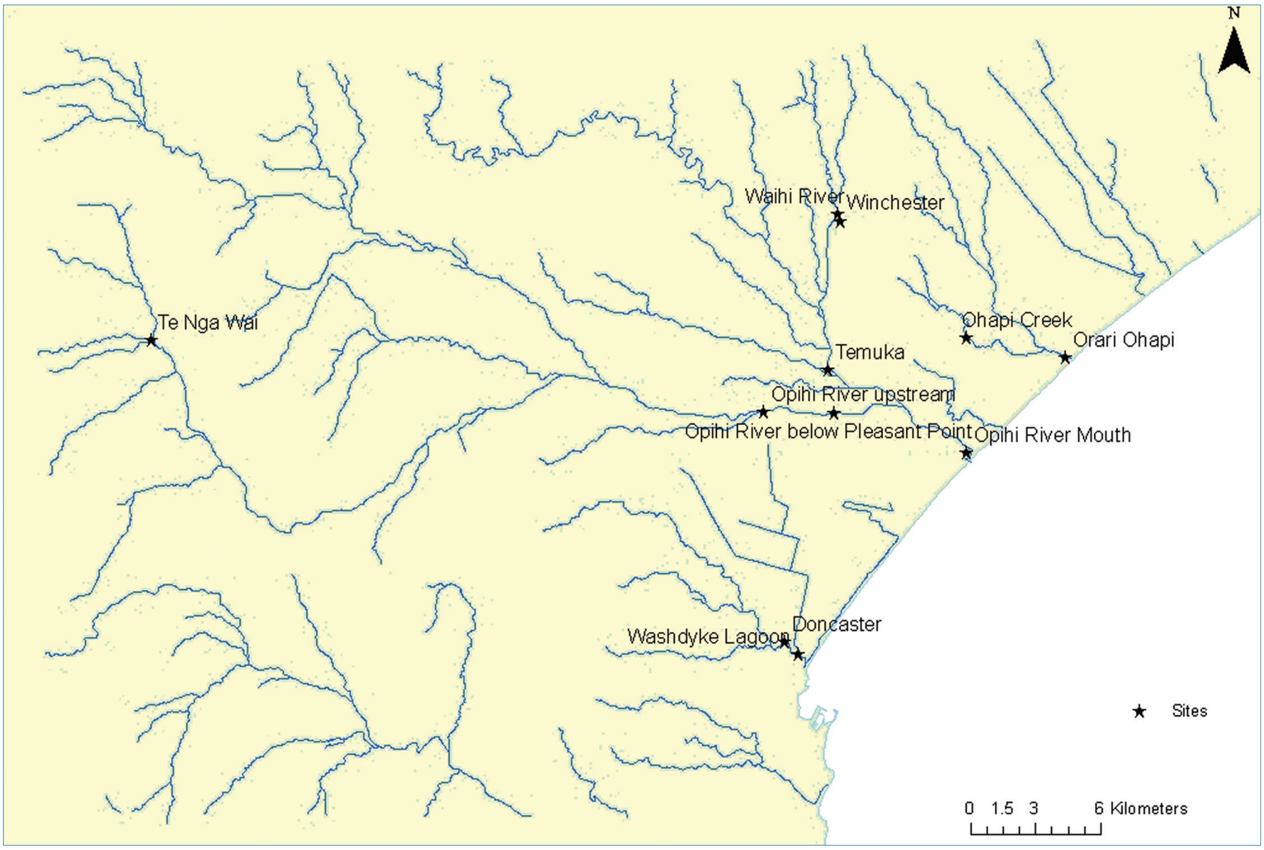
A questionnaire was used to survey Arowhenua members about their past and present consumption rates of traditional kai species. Hair samples were also collected from participants to assess possible exposure to mercury. Fish, including shortfin and longfin eel, brown trout, black flounder and watercress samples were gathered from 12 sites identified as important harvesting sites by Arowhenua (Fig.1) throughout their rohe, and tested to assess their bioaccumulative contaminant levels. Aquatic sediments were sampled from these locations as well.

Sampling on the Opihi River.

Analysis

The fish 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 selected heavy metals - arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni) and zinc (Zn) - was also done. Eel 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.

Watercress is an important kai species.



Kai collection sites for the Arowhenua rohe.

Key results of the study

Kai consumption rates

Local average consumption rate were calculated as follows:

Species	Local average consumption rates *(grams per day)*
Trout	4.0
Eel	6.1
Flounder	4.7
Watercress	6.0

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

Total fish consumption (including takeaways, tinned fish etc) was higher (43 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=12). Watercress consumption (6.0 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 213 grams per meal for fish and 175 grams per meal for watercress.

Contamination levels (wet weights)[1]

Organochlorine compounds

Three sites had markedly higher total DDT (ΣDDT) concentrations present in eel fillet, namely Winchester (214 µg/kg), Ohapi Creek (236 µg/kg) and Doncaster (377 µg/kg). The concentrations of ΣDDT in trout and flounder were generally much lower than for eels. The highest concentrations of ΣDDT found in trout were from Temuka (19 µg/kg) and in flounder from Washdyke Lagoon (36 µg/kg). Other organochlorine pesticides were either below the limits of detection, or measured in much lower concentrations than any of the DDT congeners.

Polychlorinated biphenyls (PCBs) were analysed in eels only. Total concentrations ranged from 0.5 - 58.3 µg/kg, with the most elevated levels found at Doncaster and Winchester (58.3 and 22.7 µg/kg respectively). PCBs were never manufactured in New Zealand, but were imported and used extensively in the electricity industry as insulating fluids or resins in transformers and capacitors.

Metals

The concentrations of mercury were generally highest in eel fillet, with a median value of 0.34 mg/kg. The mercury concentrations were lower in trout fillet, with a median of 0.11 mg/kg. Concentrations were lower again in flounder fillet (median 0.04 mg/kg), and virtually undetectable in watercress. The source of mercury in the Arowhenua study area is unclear. Unlike parts of the North Island of New Zealand, South Canterbury does not have any identifiable geothermal inputs, which are natural sources of mercury and arsenic in lake and river systems.

Concentrations of arsenic were below detection limits for eel fillet, but present in flounder and trout, with median concentrations of 0.12 and 0.27 mg/kg, respectively. Watercress contained relatively low concentrations of arsenic (median 0.01 mg/kg). Arsenic contamination could be caused by contaminated sheep dip sites in the area, particularly given the absence of any identifiable geothermal activity. Prior to the 1950's sheep dips were arsenic-based. It's estimated there are now over 50,000 contaminated sheep-dip sites in New Zealand.

Washdyke at Doncaster.

Watercress recorded a median lead concentration of 0.05 mg/kg, which was consistently higher than levels observed in the fish samples. The highest lead result in fish of 0.17 mg/kg was recorded in a flounder from the Opihi River mouth. Watercress had much higher cadmium concentrations than fish. Most fish concentrations were below detection limits (0.002 mg/kg). Zinc and copper concentrations were reasonably consistent among each species, with watercress recording the highest levels.

Nickel was present in low concentrations in all fish species, usually below detection limits (0.04 mg/kg), but was detected in all watercress samples, with a median level of 0.08 mg/kg. Chromium was virtually undetectable in all fish species but recorded in watercress at a median level of 0.04 mg/kg.

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

The average concentration of mercury in the Arowhenua hair samples was 0.86 µg/g (micrograms per gram) which is similar to levels found in the study reference group and to New Zealander's who consume 1-4 meals of fish per month. By comparison, levels were much lower than previous studies in the geothermally-influenced Rotorua region, where concentrations as high as 39 µg/g were recorded. The low number of Arowhenua responders in this study meant we couldn't analyse potential links with consumption of wild kai.

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 Arowhenua data on meal size and weekly consumption and measuring chemical contaminants in wild kai sampled from 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. 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.

The results show that If kai was gathered randomly across all sites throughout the rohe and consumption rates were the same as those questioned in the survey (Table 1), then there is no significant risk to members of Arowhenua from eating eels, trout, flounder or watercress (Table 1). Current consumption rates for all 4 species are lower than recommended monthly fish consumption limits.

Kai species	Monthly consumption limits *(meals per month)*	Actual consumption rate *(meals per month)*	Contaminants contributing >10% to the risk
Eel	3.3	0.9	DDE, diedrin, PCBs[2]
Trout	2.3	0.6	Arsenic[2]
Flounder	5.1	0.7	Arsenic
Watercress	7.4	1.0	Arsenic

Table 1 *Comparison of allowable consumption limits for median contamination data and actual consumption rates for questionnaire participants.*

[1] Based on lifetime exposure leading to increased risk of cancer (1 in 100,000) or non-cancer chronic disease.
[2] Arsenic, PCBs, DDE and dieldrin are cancer risks

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 eel. Table 2 shows that consumption rates of eel are higher than the recommended consumption rates based on our risk assessment. Trout could also be risky to eat because the safe consumption limit is virtually the same as the consumption rate. Eight out of 10 eels sampled had contamination levels where eating them more than four times a month (less than one meal a month) could pose a health risk to people.

Kai species	Monthly consumption limits *(meals / month)*	Actual consumption rate *(meals / month)*	Contaminants contributing >10% to the risk
Eel	**0.3**	**0.9**	DDE, diedrin, PCBs[2]
Trout	0.8	0.6	Arsenic[2]
Flounder	1.5	0.7	Arsenic
Watercress	2.9	1.0	Arsenic

Table 2 *Comparison of allowable consumption limits for 95th percentile contamination data and actual consumption rates for questionnaire participants. Red shows where recommended safe consumption rates are exceeded.*

1 Based on lifetime exposure leading to increased risk of cancer (1 in 100,000) or non-cancer chronic disease.
2 Arsenic, PCBs, DDE and dieldrin are cancer risks

Maps showing the regional results for these risk assessments are provided below.

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.

Eel

Based on our risk assessment, consumption of eel from Doncaster, Ohapi Creek or Winchester should be less than once per month. Furthermore, consumption should also be limited for eel harvested from Waihi River, Temuka, Opihi River upstream and below Pleasant Point to 1- 4 meals/month. Sampling was limited, however, it is of interest to note that the most contaminated eels (Doncaster site) should not be consumed at a rate exceeding 0.2 meals/month, which corresponds to around one meal every six months.

Trout

With respect to trout, one specimen harvested from Opihi River mouth had contaminant concentrations resulting in a strict consumption limit of less than one meal per month. Based on the tissue concentrations from trout collected at Temuka and Orari Ohapi, a recommended consumption limit of 1-4 meals/month was derived. As such, a degree of caution should be exercised when consuming trout from these sites.

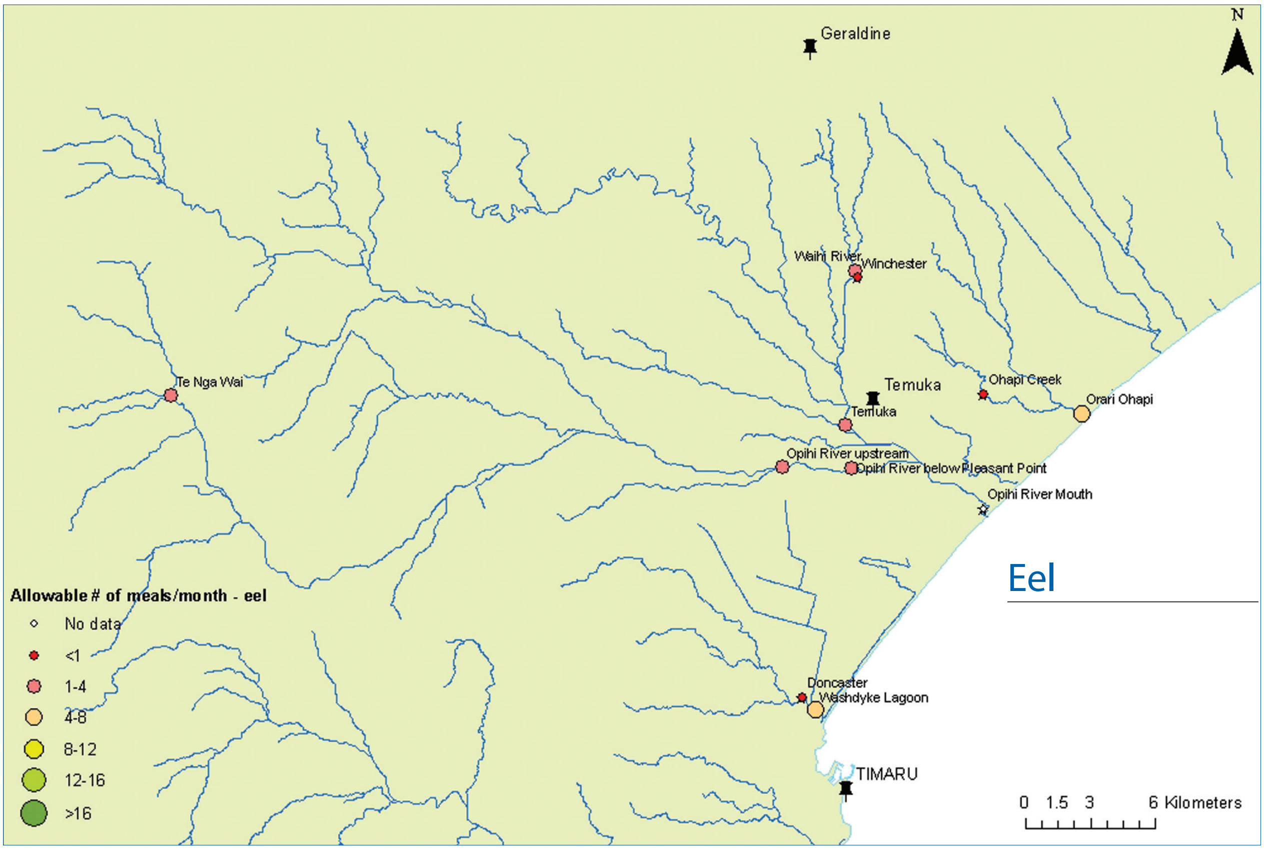
Flounder

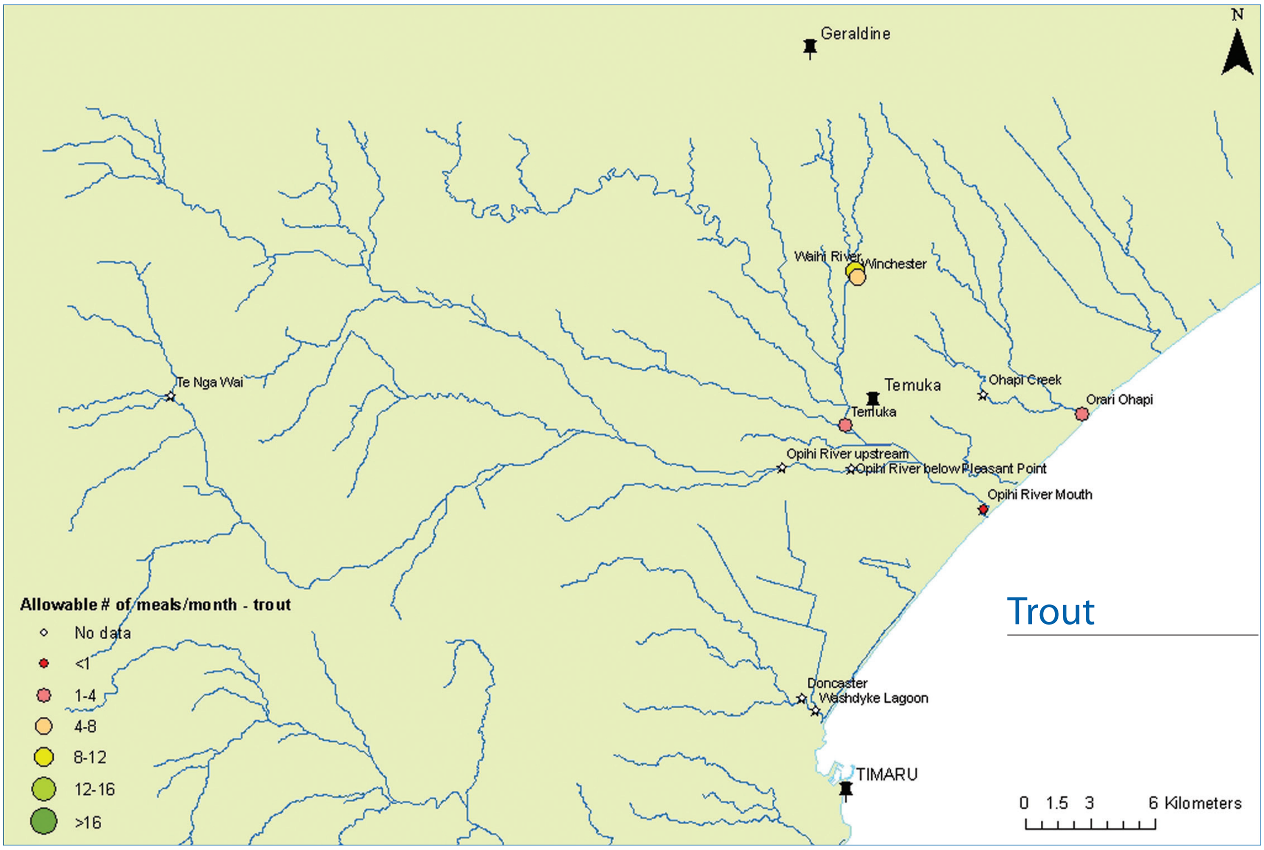
Flounder from Washdyke Lagoon and Orari Ohapi represent the greatest risk, with allowable consumption limits of 1-4 meals/month.

Watercress

Watercress consumption risk was highest when harvested from the Opihi River, with consumption limits of 2.7 meals/month (below Pleasant Point site), 3.2 meals/month (river mouth site) and 6.6 meals/month (upstream site)

Regional Maps





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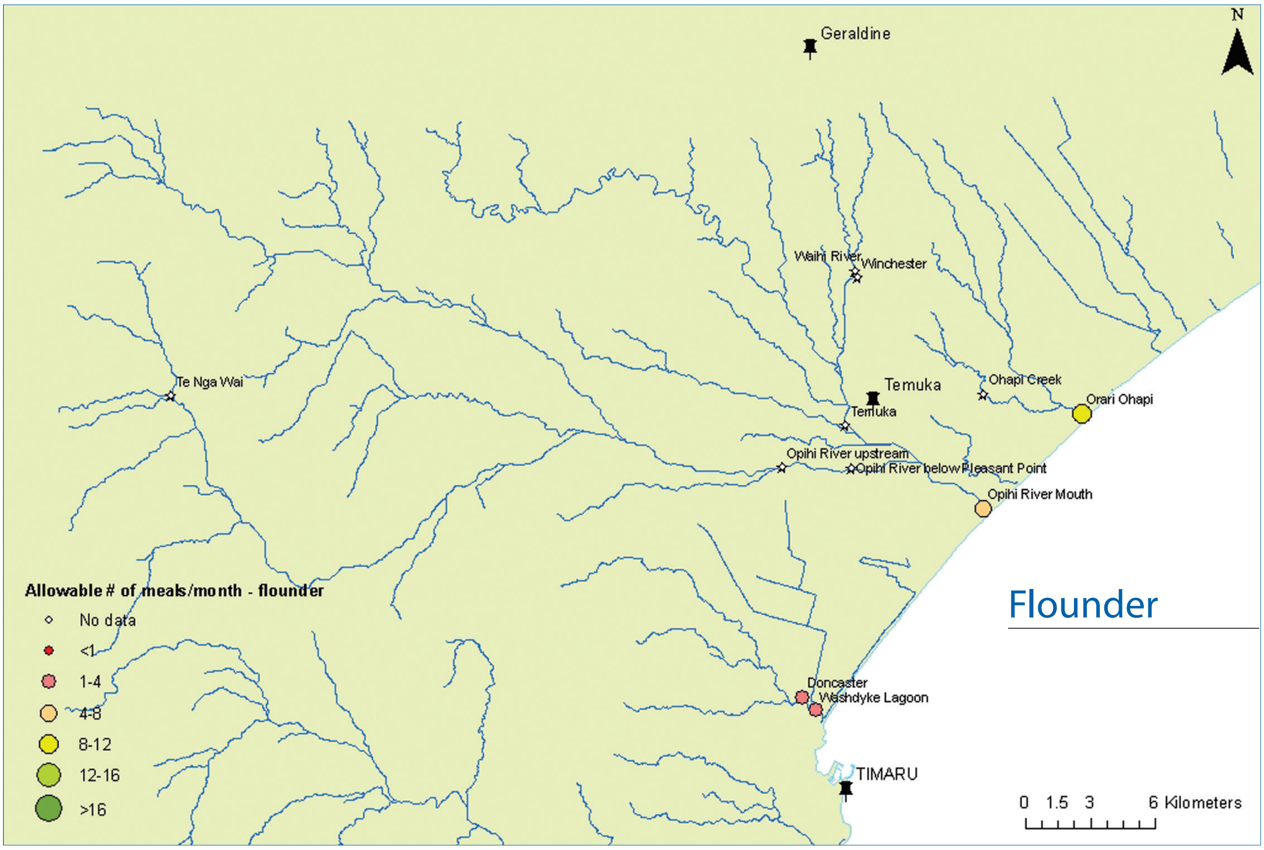

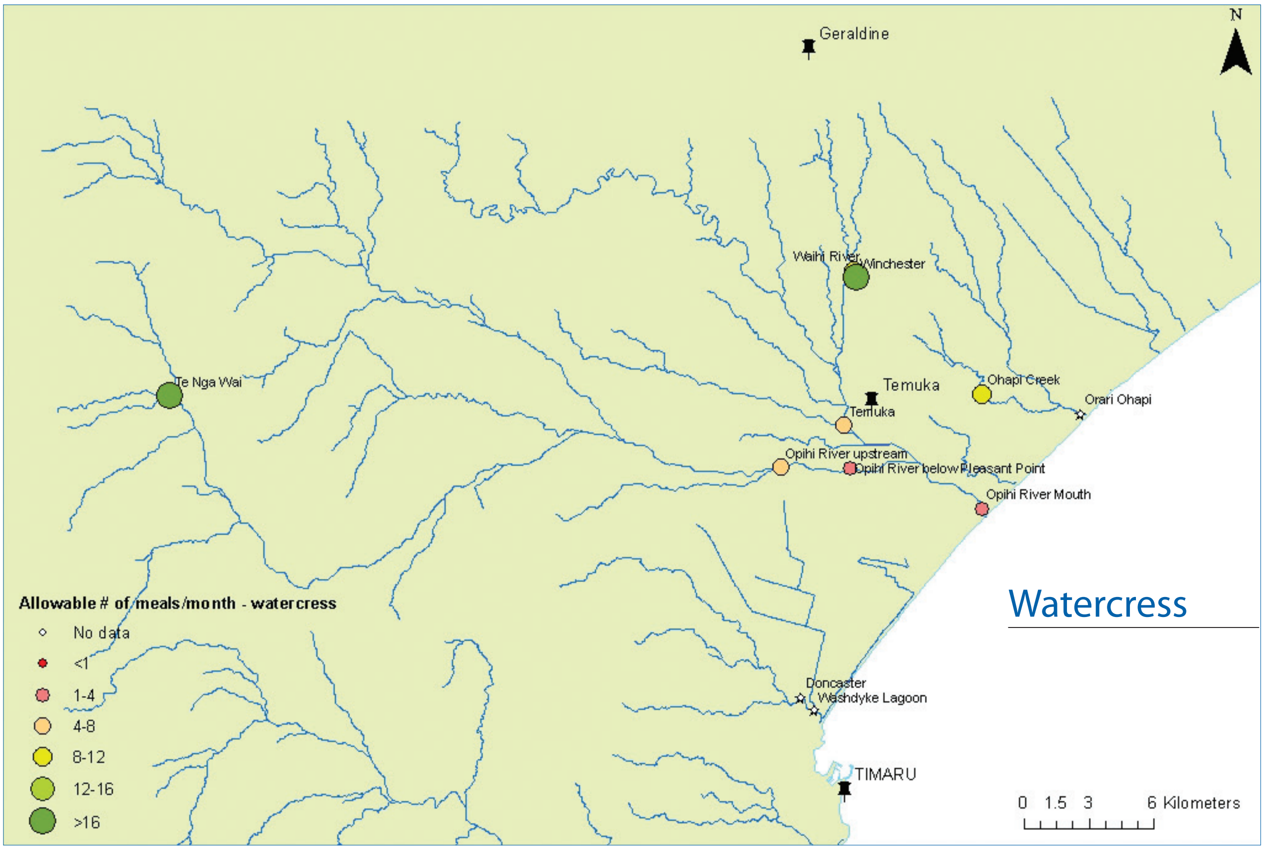

Study limitations

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

- The small number people who completed the kai consumption questionnaire (n=12). 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 Arowhenua. Future research should include:

- More species of kai (e.g., both long fin an short fin eels), samples from a wider range of sites, and larger sample sizes of the various species of kai to provide a more representative spatial assessment of kai in the region (or rohe).
- More robust data about how often contaminated kai was potentially eaten by participants, and more information about meal size portions. (This requires larger numbers of Māori and non-Māori consumers to be surveyed).
- Conducting a risk assessment for total fish diet which incorporates both wild and commercial fish consumption.

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 Runanga o Arowhenua, Temuka.

Stewart M, Olsen G, Phillips N, Hickey C (2010) Contaminants in kai – Arowhenua rohe Part 1: Data Report. Report to Te Runanga o Arowhenua & Health Research Council of New Zealand. October 2010 HAM2010-105. 78pp.

Stewart M, Phillips N, Hickey C, Olsen G (2010) Contaminants in kai – Arowhenua rohe Part 2: Risk Assessment. Report to Te Runanga o Arowhenua & Health Research Council of New Zealand. October 2010 HAM2010-116. 74pp.

Related reading

Stewart M, Phillips NR, Olsen G, Hickey CW, Tipa G. 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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