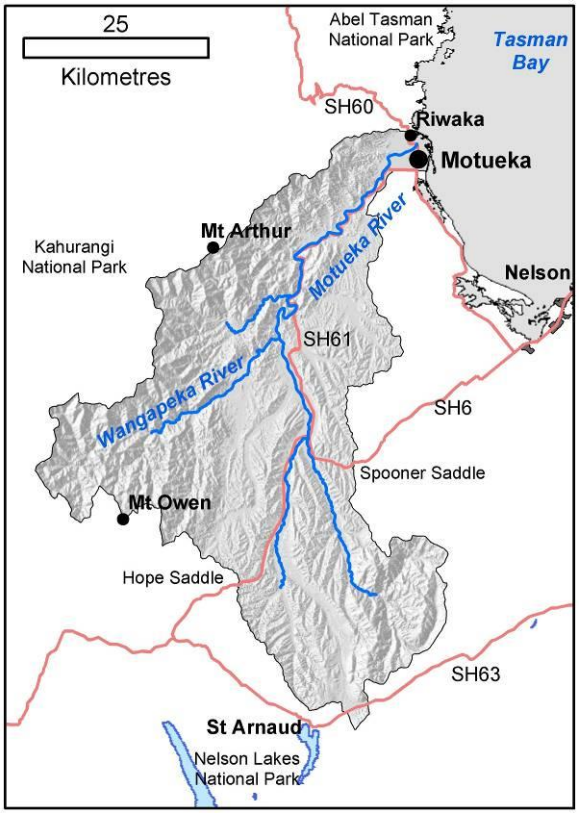
INTEGRATED CATCHMENT MANAGEMENT for the Motueka River

•ridge tops to the sea•

Integrated Catchment Management (ICM) Research in the Motueka Catchment & Tasman Bay

28 April 2010



Manaaki Whenua Landcare Research

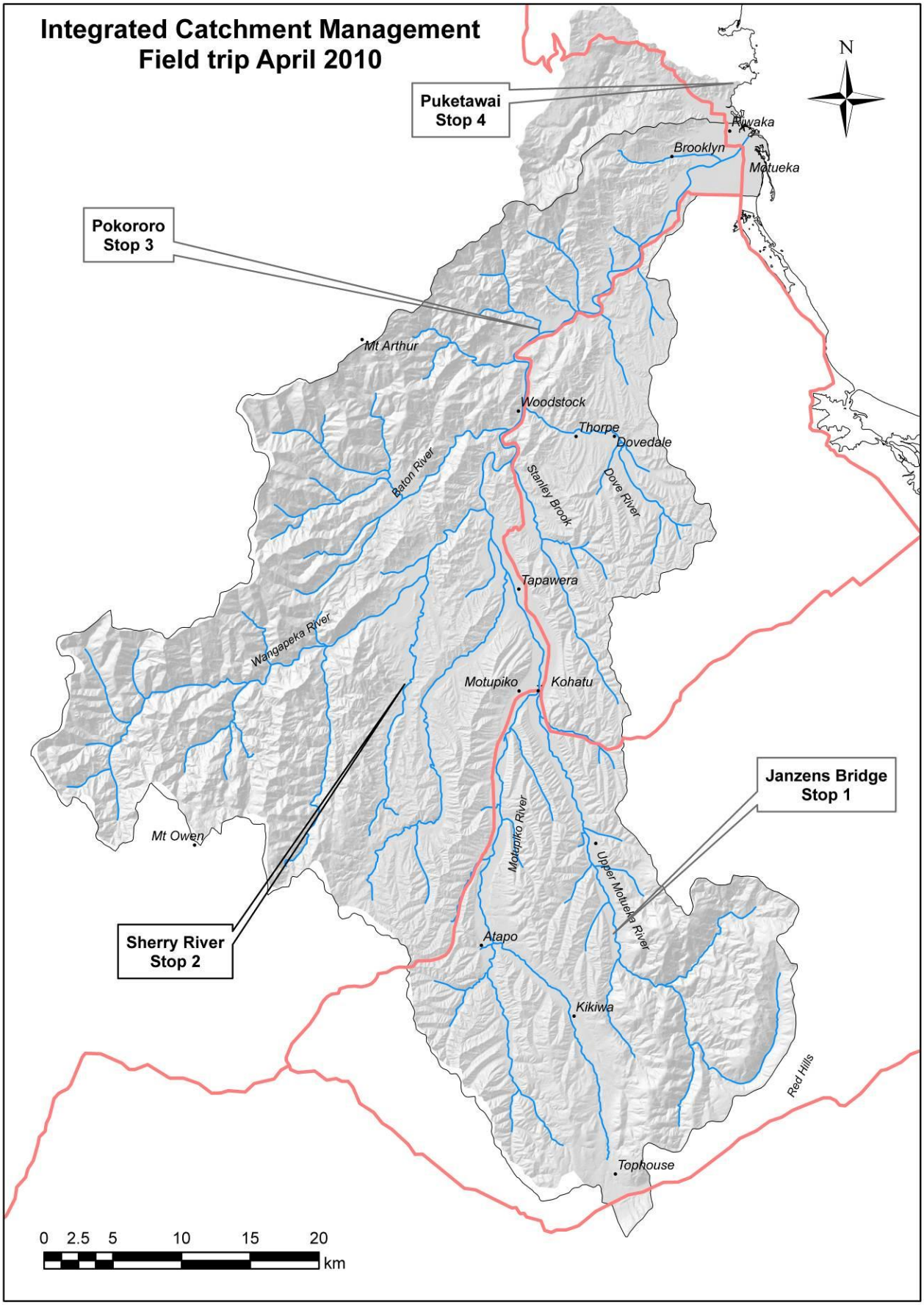
CAWTHRON

TDC Tasman District Council

Itinerary

8 am	**Leave Nelson**
9.00 am	**Arrive Jansens Bridge**
Barney Thomas	Welcome to catchment by Tangata Whenua
Andrew Fenemor	Overview of day and catchment
Les Basher	What's the sediment story?
Paul Gillespie	Upper catchment influences on Tasman Bay
10 – 11 am	**Jansens Bridge to Sherry River (Matariki bridge)**
Andrew Fenemor	The ICM loop and adaptive management
Rob Davies-Colley	Water quality in the Sherry and downstream
Barbara Stuart	Significance of the Sherry work locally and nationally
Local farmer	Landowner management change
Andrew Burton	Environmental planning for improved management
Nick Ledgard	Sherry Catchment Planting trials and Establishment Guide
	Unveiling of the Sherry River Catchment Group Sign
12 – 1 pm	**Sherry River to Pokororo Hall LUNCH**
Alistair Webber	The value and significance of the river to the local community.
Dean Walker	River health from an iwi perspective
Roger Young	Where did all the trout go?
Neil Deans	How ICM is assisting sports fishery management locally and nationally
3 – 4 pm	**Pokororo Hall to Puketawai**
Paul Gillespie	What do we know about the river plume and its influence on the coastal ecosystem, and its link to the land
Chris Cornelisen	New tools for tracking faecal coliforms
John Wilson	How what happens on the land affects aquaculture
Trevor James	Value of the ICM for TDC
Barney Thomas	Value of the ICM programme for iwi
Richard Kempthorne	Closing remarks

5 – 6 pm Puketawai to Nelson


Integrated Catchment Management
Field trip April 2010
N
Puketawai
Stop 4
Pokororo
Stop 3
Sherry River
Stop 2
Janzens Bridge
Stop 1
Ruwaka
Brooklyn
Motueka
Mt Arthur
Woodstock
Thorpe
Dovedale
Baton River
Stanley Brook
Dove River
Tapawera
Wangapeka River
Motupiko
Kohatu
Motupiko River
Upper Motueka River
Mt Owen
Atapo
Kikiwa
Red Hills
Tophouse
0 2.5 5 10 15 20
km

Stop 1 Jansens bridge

Good Friday 2005 storm impacts in the upper Motueka and Motupiko
Les Basher, Landcare Research, Nelson

A severe localised storm struck the upper reaches of the Motueka and Motupiko Rivers on Good Friday 2005 and its morphological and ecological effects have been felt ever since then. Rain began falling late in the afternoon of 24 March and at most sites intense rain persisted for less than 12 hours. In that time 167 mm of rain fell at the upper Motueka Gorge with hourly intensities up to c.60 mm/hr (Fig 1). A storm of this magnitude has a >50 year return period over durations from 30 minutes to 24 hours. The highest recorded rainfall was centred around the upper Motueka Gorge and upper Motupiko, with lower rainfall recorded in the Red Hills and at Christies Bridge (c. 100 mm). It is possible that the highest rainfalls occurred in an area near Kikiwa with no rain gauges, where some of the most severe damage occurred. The most intense rain fell on areas underlain by Moutere gravels. Areas underlain by Separation Point granite received less rain, limiting the erosion in these areas. In addition the rain occurred when soils were very dry and were able to absorb large volumes of water, again limiting the damage that might have occurred in a storm delivering this amount of rain at very high intensities. The storm produced a short but very high flood peak (Fig. 1). Peak flow in the Motupiko River at Christies Bridge was c.170 cumecs (highest ever recorded) and at Motueka Gorge it was estimated c.790 cumecs (2nd highest on record).

During the storm there was localised landsliding, gullying, and rilling. The storm activated new gullies on the Moutere gravels under pasture (Fig. 2) and recently harvested pine forests. Most gullies started as small landslides which generated debris flows that had the power to carve gullies several metres deep. Numerous large gullies in the Red Hills were reactivated (Fig. 3). Some landslides also occurred on forest landings. Rilling was widespread on recently cultivated or planted slopes and forest roads and landings. The flood caused dramatic morphological change within the channels of the upper Motueka and Motupiko including widespread aggradation and bank erosion (Fig. 4), channel avulsion and floodplain sedimentation and scouring... The general impression is that the river channel was severely scoured, widened in many places, and that deposition of gravel was widespread.

This storm was a threshold event which caused a shift in suspended sediment rating relationships and storm event suspended sediment yields over a large part of the catchment for several years (Fig. 5) – see Hicks and Basher for a detailed description of its effects. Its effects were most marked in the upper Motueka and Motupiko tributaries, but extended all the way down to the coast. It activated sediment sources that caused subsequent smaller, more common runoff events from these tributaries to carry sediment loads that were over an order of magnitude larger than those events would normally have carried. Loads have slowly declined back to pre-storm levels over the last 5 years (Fig. 6).

Hicks DM, Basher LR 2008. The signature of an extreme erosion event on suspended sediment loads: Motueka River Catchment, South Island, New Zealand. Sediment Dynamics in Changing Environments (Proceedings of a symposium held in Christchurch, New Zealand, December 2008). IAHS Publ. 325: 184-191.

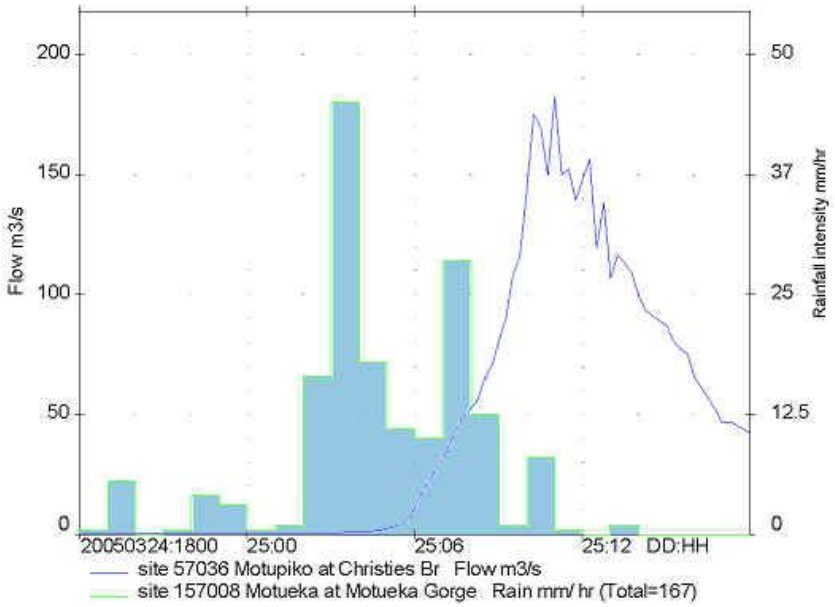


Fig. 1 – plot of hourly storm rainfall at Motueka Gorge (solid blue) and hydrograph of flood flow in the Motupiko at Christies Bridge (blue line).

Fig.2 – Kikiwa Stream showing sedimentation in the valley bottom and sediment contribution from gullies and landslides on the right hand side of the stream.

Fig. 3 – severe gully erosion in the Red Hills following the Good Friday flood

Fig. 4 – bank erosion of large cliffs near Quinneys Bush. The rip rap visible at the bottom of the photo previously formed a continuous line at the base of the cliff.

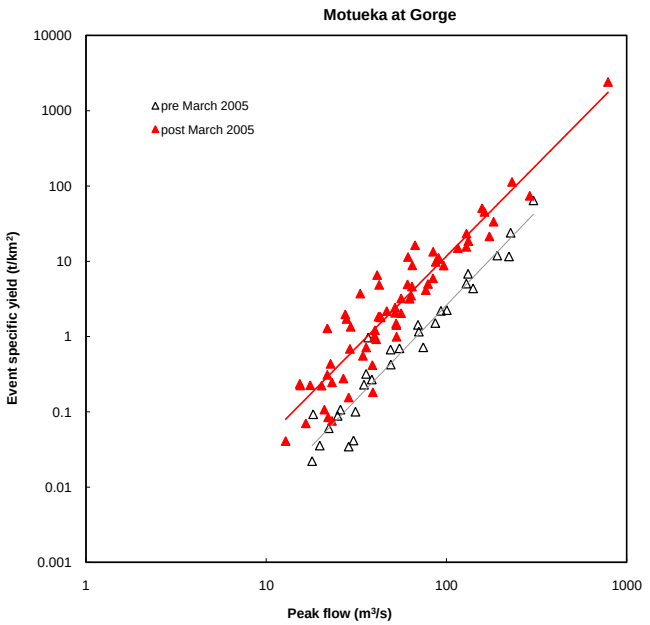


Fig. 5 – Storm event yields at Motueka Gorge before and after the March 2005 storm

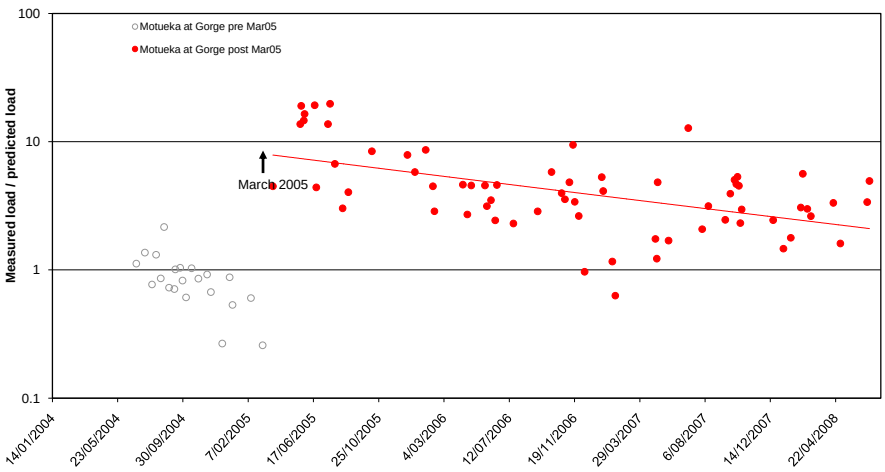
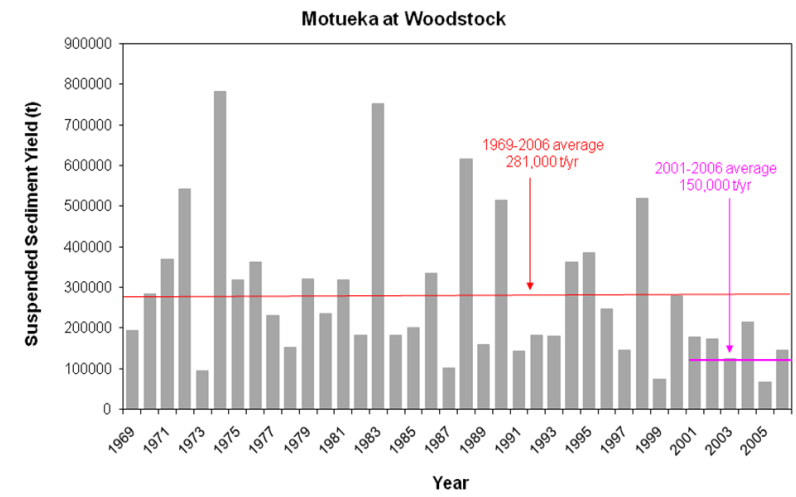


Fig. 6 Time trends of ratios of measured event sediment yield and event yield predicted from pre-Easter 2005 relations



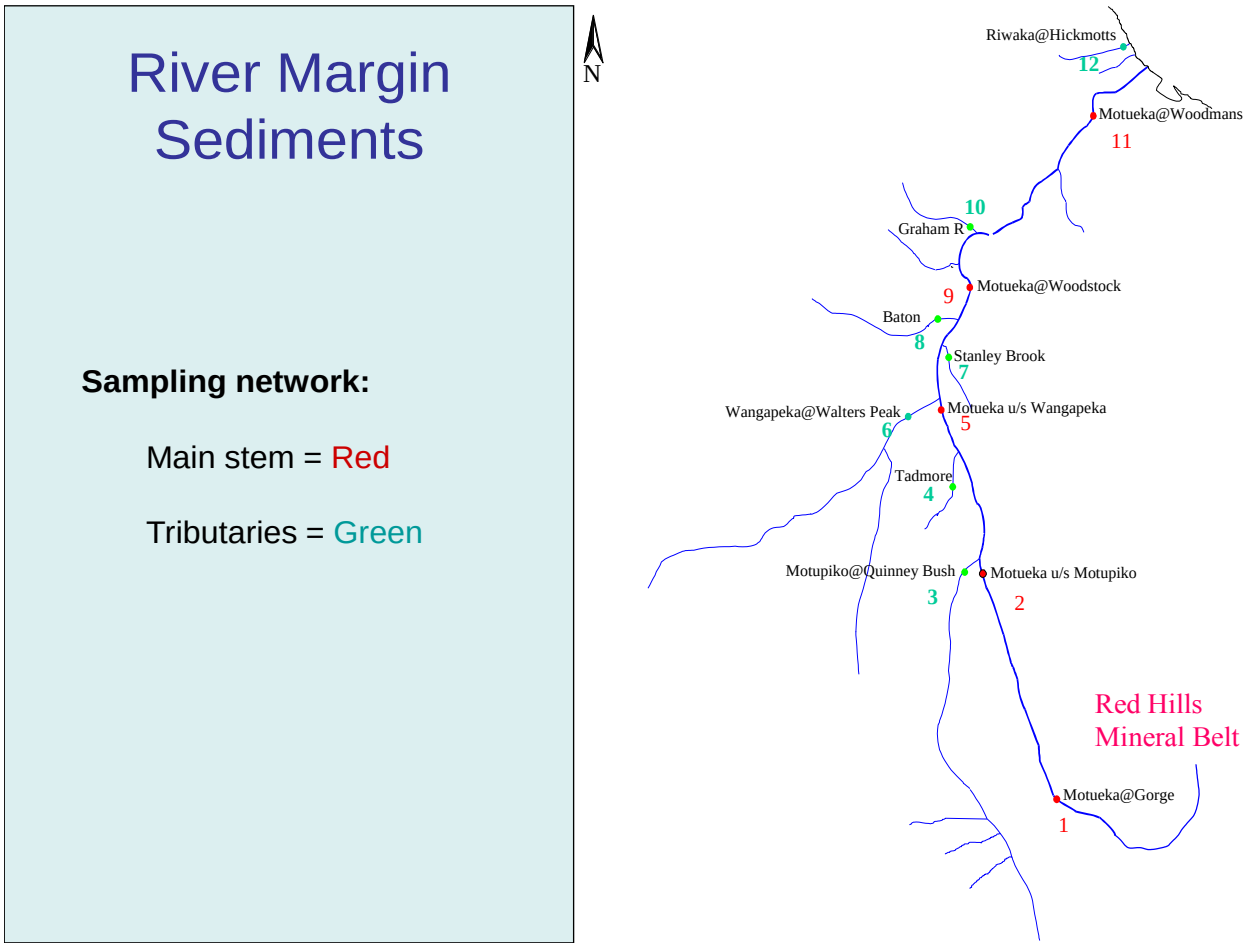
	Motueka at Woodman's Bend	Motupiko at Christies	Wangapeka at Walter Peak	Motueka at Gorge	Little Pokororo	Big Pokororo	Herring
Period of record	23/11/02-30/06/08	18/11/02-30/06/08	19/11/02-30/06/08	6/04/04-30/06/08	1/07/06-30/6/08	1/07/06-30/6/08	1/07/06-30/6/08
No. of storm events	78	62	126	95	28	27	27
Mean flow (m^3/s)	49.3	1.6	19.2	6.7	0.191	0.744	0.151
Max. Flow (m^3/s)	1349.9 (17/10/07)	164 (25/3/05)	807.3 (17/10/07)	789 (25/3/05)	8.016 (23/05/2007)	28.888 (23/05/2007)	4.501 (19/07/2006)
Q_{peak}/Q_{mean}	27.0	102.5	41.0	127.3	42.0	38.8	29.8
Maximum turbidity (NTU)	1648 (25/3/05)	1173 (7/10/07)	448 (17/10/07)	676 (21/6/05)	379 (10/10/2007)	537 (22/01/2008)	1793 (30/06/2007)
Maximum SSC (mg/L)	5266 (25/3/05)	3430 (24/4/06)	3605 (17/10/07)	5096 (21/6/05)	1872 (10/10/2007)	3691 (22/01/2008)	6142 (19/07/2006)
Annual SSY (t/km^2)							
2003/04	86	22	125				
2004/05	79	539	27	2535			
2005/06	38	55	73	266			
2006/07	18	21	47	106	15 21	8 13	116 181
20007/08	73	113	210	138			
Mean SSY ($t/km^2/y$)							
May 2004–June 2008	71	179	91	745			
July 2006–June 2008	45	67	128	122	18	11	152

Summary of sediment yield data from the Motueka catchment

Identification of a natural catchment source of metals-enriched sediments delivered to Tasman Bay

Reid Forrest, Paul Gillespie (Cawthron Institute), Barrie Peake (University of Otago, Dept. of Chemistry)

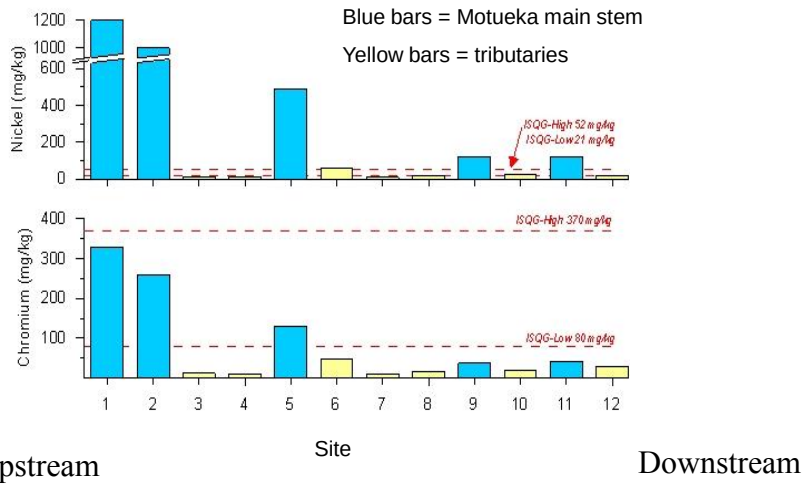
We provide evidence for a strong terrestrial signature of elevated sediment trace metals extending several kilometres offshore in the river outwelling plume. The source was traced to an upper-catchment alpine mineral belt with river margin sediments containing up to 1200 mg Ni per kg (~20 times the ANZECC 2000 guideline ecological effects threshold). Ni concentrations in Bay sediments were up to 7 times the guideline effects threshold, while a range of other metals were elevated above ambient, but to a lesser degree. A distinct plume area of elevated metals concentrations covered 70-90 km^2 of seabed.



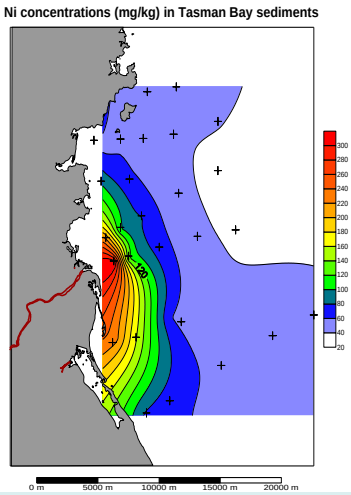
River Margin Sediments:

Ni up to 20 times ANZECC (2000) guideline levels for "probable" biological effects

Cr up three times guideline levels for "possible" biological effects

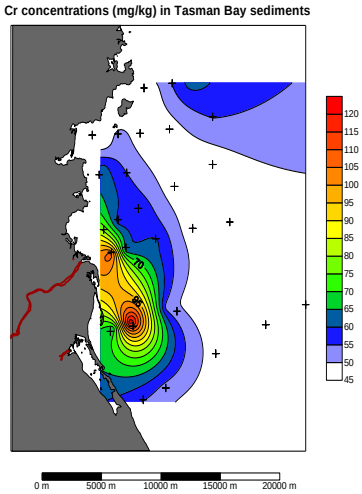


Marine Sediments - Nickel



- Distinct plume area of elevated Ni concentration covering 70-90 km^2 of seabed.
- Over 6 times greater than the level required to produce "probable" biological effects; ANZECC (2000)

Marine Sediments - Chromium



- Similar distinct plume area
- Over 1.5 times greater than the level required to produce "possible" biological effects; ANZECC (2000).
- Cu, Ba and V similar distribution but lower concentrations

Stop 2 Sherry River

Faecal pollution in the Sherry River

Rob Davies-Colley, NIWA-Hamilton

Introduction

Early action within the ICM programme included a study led by Roger Young (Cawthron) of water quality in the Motueka River system. The study involved monthly water sampling at 23 sites, including National Rivers Water Quality Network (NRWQN) sites at Gorge and Woodstock, for 13 months (October 2000 to October 2001). This study showed that the Motueka River, had fairly good water quality, by and large, with generally low faecal pollution as indicated by low concentrations of the faecal indicator bacterium, *E. coli* (Young et al. 2005). Although *E. coli* bacteria are not (usually) a concern in themselves, their presence in water demonstrates recent faecal pollution by warm-blooded animals or birds, and an associated risk of infection of humans by faecal pathogens (agents of disease). More recent monitoring of the Motueka at Woodman's Bend, close to its mouth in Tasman Bay, confirms that this river has fairly good microbial quality overall, with concentrations (at baseflow) much lower than the contact recreation guidelines (Fig. 1).

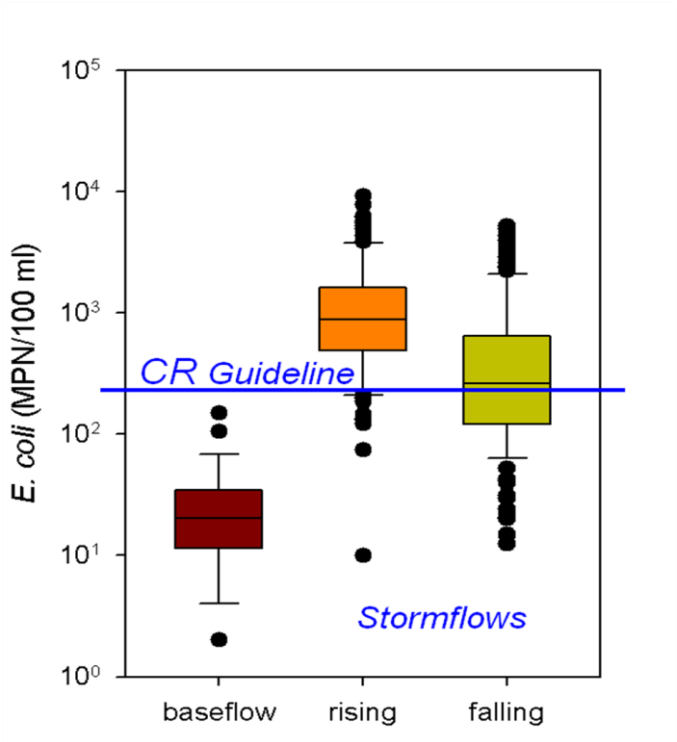


Fig 1. Box plot of *E. coli* at Woodmans Bend showing contact recreation guideline (McKergow & Davies-Colley (2010).

Faecal pollution in the Sherry River

The Sherry River, along with some other pastoral tributaries, was identified by Young et al. (2005) as a 'hot spot' of faecal pollution within the Motueka Catchment. This pollution was (plausibly) attributed to dairying in the Sherry catchment and specifically to frequent dairy herd crossings of the river from pasture to milking shed and return. At the time there were four fords used frequently for herd crossings, one on each of four dairy farms.

The cow crossing study

To investigate this potential source of faecal pollution, a team from LCR, Cawthron, TDC and NIWA measured water quality up and downstream of a cow crossing on the Sherry in October

2001. This study (Davies-Colley et al. 2004) showed that there was a major, albeit short-lived, pulse of pollution downstream of the dairy herd – characterized by very high *E. coli* concentrations (Fig. 2). The findings of the crossing study had national significance – for example the data were used with funding from ECan and MfE to construct a model dubbed the "cow crossing calculator" (Rutherford et al. 2003) for supporting NZ-wide policy on bridging or culverting crossings so as to eliminate acute faecal pollution from dairy herd contact with water. (Fig . 2).

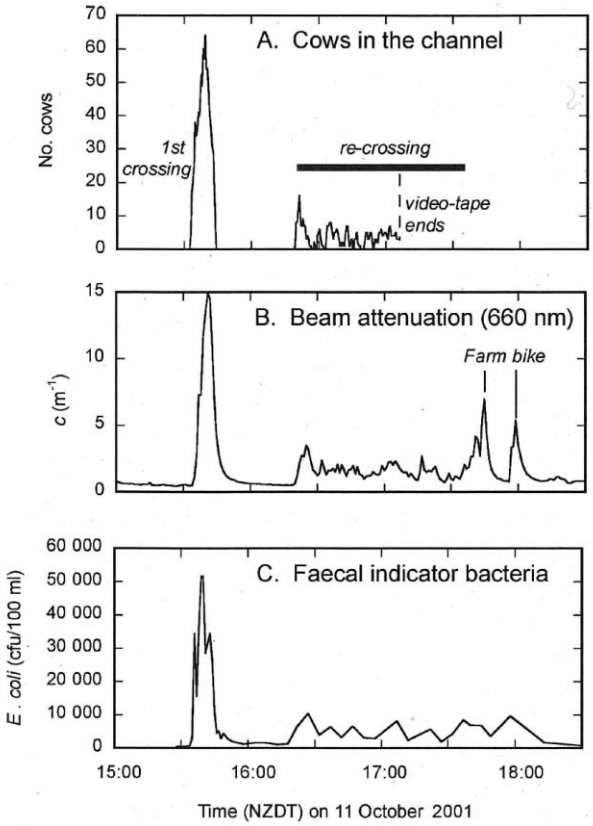


Fig. 2 Water quality of the Sherry River, New Zealand in relation to number of cows in the stream. A, Count of cows in the water. B, Water cloudiness. C, Concentration of the faecal indicator bacterium, *Escherichia coli* (from Davies-Colley et al. 2004).

Bridging of crossings

The implications of the cow crossing study prompted rapid action by managers and farmers in the Sherry Catchment, and a cow bridge just downstream of the original crossing study was opened in May 2002. Since then the remaining cow crossings in the Sherry have all been bridged (the last in September 2007), excluding cows from water at least during herding. The *E. coli* concentrations in the Sherry River are now much improved overall, with approximately a halving of characteristic (median) concentrations at Matariki Bridge and at (the level recorder station) at Blue Rock. However, faecal pollution can still be high on occasions in the river, notably at high flow.

Remaining faecal pollution issues in the Sherry

Halving the median *E. coli* concentrations is still not good enough. Concentrations of *E. coli* are still undesirably high and the river still does not meet guidelines for contact recreation. For example, median *E. coli* at Blue Rock in 2008-09 was 228 cfu/100 mL, compared with a guideline (for the median) of < 126 cfu/100 mL. The question arises – what are the remaining sources of faecal pollution in the river and how can they be controlled? Scientific understanding of pathways of faecal pollution is crucial to informing efforts to clean up waters in livestock farming areas – including in the Sherry where a major effort funded by the SFF is underway to improve water quality and other environmental indicators.

Multiple pathways of faecal pollution

Understanding of the likely remaining sources of faecal pollution in the Sherry rests on a major suite of studies of microbial pollution of waters from livestock farming that was conducted in NZ up until 2005 with consortium funding through several agencies via MAF. This work, which drew on the Sherry findings as well as several specially commissioned studies, was consolidated in a report by Collins et al. (2006) published on the MAF website (including a valuable 'cartoon' schematic diagram (Fig. 3) and in a review paper (Collins et al. 2007). This suite of studies emphasised the multiple pathways of faecal pollution from livestock farming.

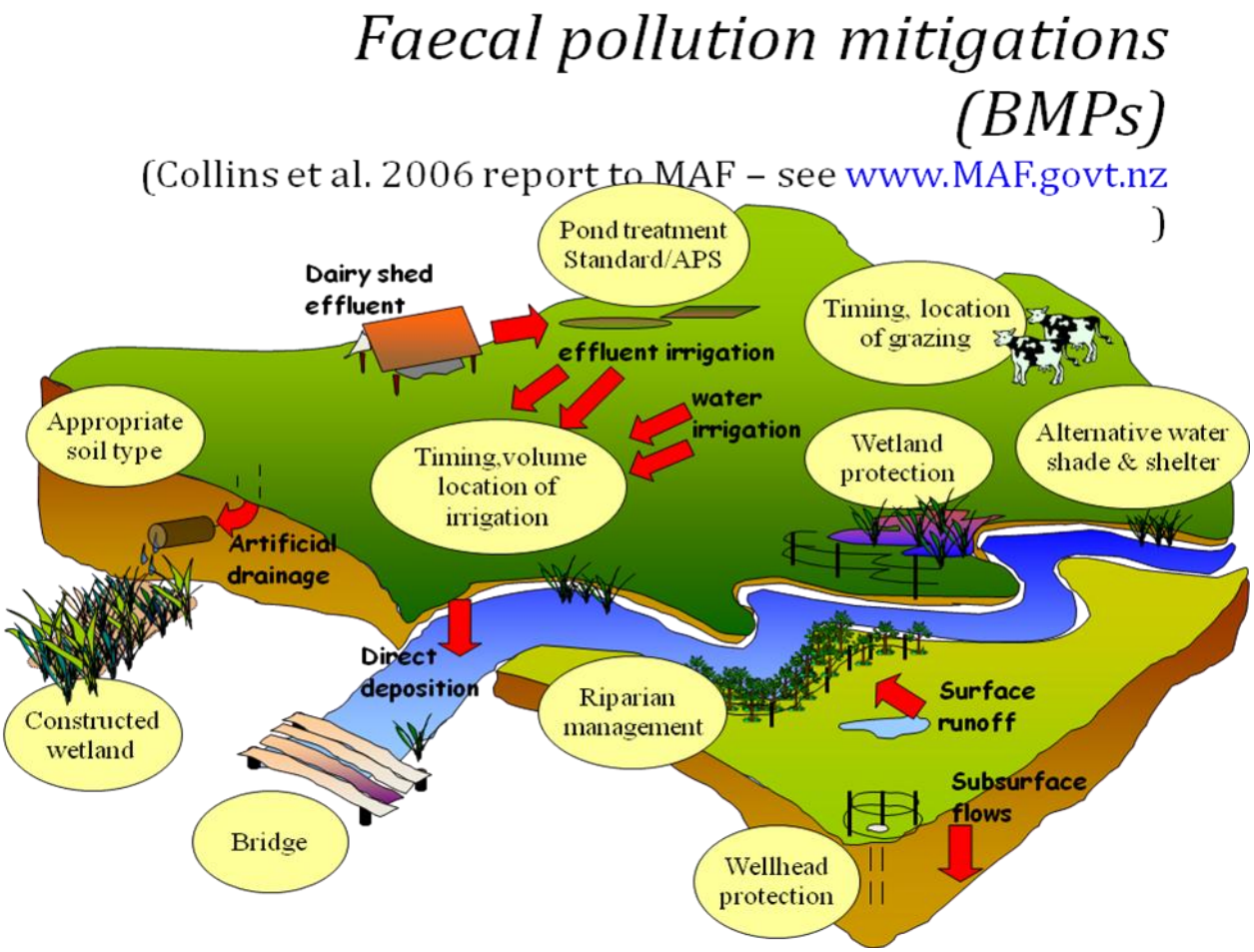


Fig 3. Schematic of microbial pathways to water from livestock farming and BMPs to mitigate faecal pollution (from Collins et al. 2006).

In dry weather livestock contact with waters is the main pathway, with cattle (but not usually sheep) frequently entering unfenced channels through pasture to cross or drink. A study by Davies-Colley & Nagels (2008), inspired by the Sherry work, found that faecal pollution is very high (up to 30,000 cfu/100 mL) in small streams downstream of dairy herds with unrestricted access to channels. The 'amount' of faecal pollution was consistent with observations that about 1 in 200 (0.5%) of faecal deposits from cows are deposited directly into stream water – a finding that is useful for modelling. Clearly then, exclusion of livestock by fencing of channels may be expected to have major water quality benefits.

In stormflows, *E. coli* concentrations in waters are usually much higher than at baseflow (for example, few rivers in pasture in NZ are of swimmable quality in stormflows) because of overland flow of faecal microbes from land deposits into water (and entrainment into water of faecal microbes stored in stream sediments). In principle, much of the ultimate source of faecal microbes in overland flow can be intercepted by excluding livestock from 'contributing areas' of catchments, notably wetlands and riparian zones – by fencing to create riparian buffers. Modelling and limited experimental work suggests that such buffers should work well,

depending on soils, riparian set-back widths, vegetation, slopes and other variables, although it is not possible to completely isolate water from pasture and other land uses. Collins et al. (2007) review a number of approaches (BMPs) that should 'work' to reduce faecal pollution from livestock farming, although it has to be said that hard empirical evidence of the site-specific efficacy of some BMPs is still lacking.

Stormflow faecal loads

Stormflows usually dominate so-called 'diffuse pollution' from livestock farming. For example, McKergow & Davies-Colley (2010) found that 98% of faecal pollution from the Motueka Catchment into Tasman Bay was delivered in stormflows, although there are reasons for thinking the baseflow contribution might be somewhat greater in much smaller subcatchments like the Sherry. For instance, in the (intensively dairy-farmed) Toenepi Catchment (Waikato), Davies-Colley et al. (2008) found that faecal pollution delivered in baseflow was 5% of total.

Sherry stormflow monitoring

A 1-year study of stormflow water quality was undertaken in the Sherry at Blue Rock where NIWA installed a hydrometric station in early 2008 for interpretation of water quality data. A continuous turbidimeter was deployed to monitor water cloudiness (related to water clarity and sediment) and an automatic sampler (triggered by rise in water level) was installed to obtain samples over stormflow events . We are currently working up this data so as to estimate 'amounts (annual yields) of pollutants (*E. coli*, but also fine sediment, and the nutrients nitrogen and phosphorus). In the future, when BMPs comprehensively deployed over the Sherry catchment are expected to have substantially improved water quality, we should be able to document the reduced 'amount' of pollution coming from the catchment by reinstating the stormflow monitoring.

References

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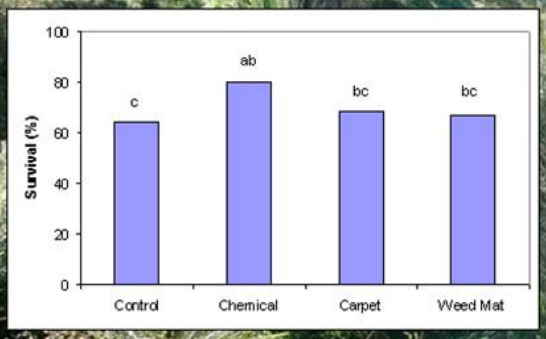
Establishing natives in riparian areas of Sherry river, with particular emphasis on weed control

Key trial results

Survival



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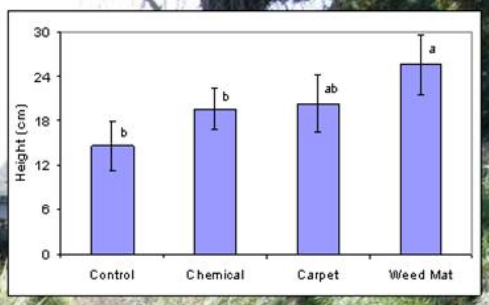
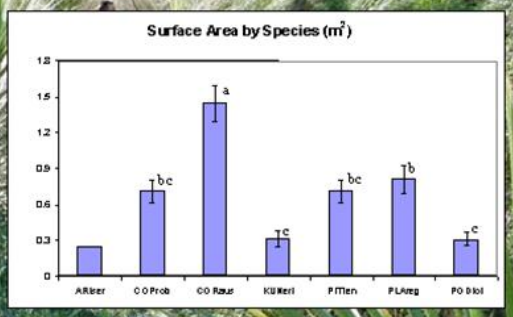


Surface area by species



Cost

Treatment	Material	Sub-total	Pegs	Sub-total	Installation	Sub-total	Maintenance	Sub-total	Total
		($/m2)	(5c each)	($/m2)	(@$30/hr)	($/m2)	(@$30/hr)	($/m2)	($/m2)
Control	0	0	0	0	0	0	0	0	0
Chemical	25.20	0.18	0	0	0.5	0.21	3.5	1.50	1.89
Weedmat	63.20	0.90	4	0.20	2	0.86	0.15	0.06	2.02
Carpet	0	0	4	0.20	4	1.71	0.3	0.13	2.04

Stop 3 Pokororo Hall

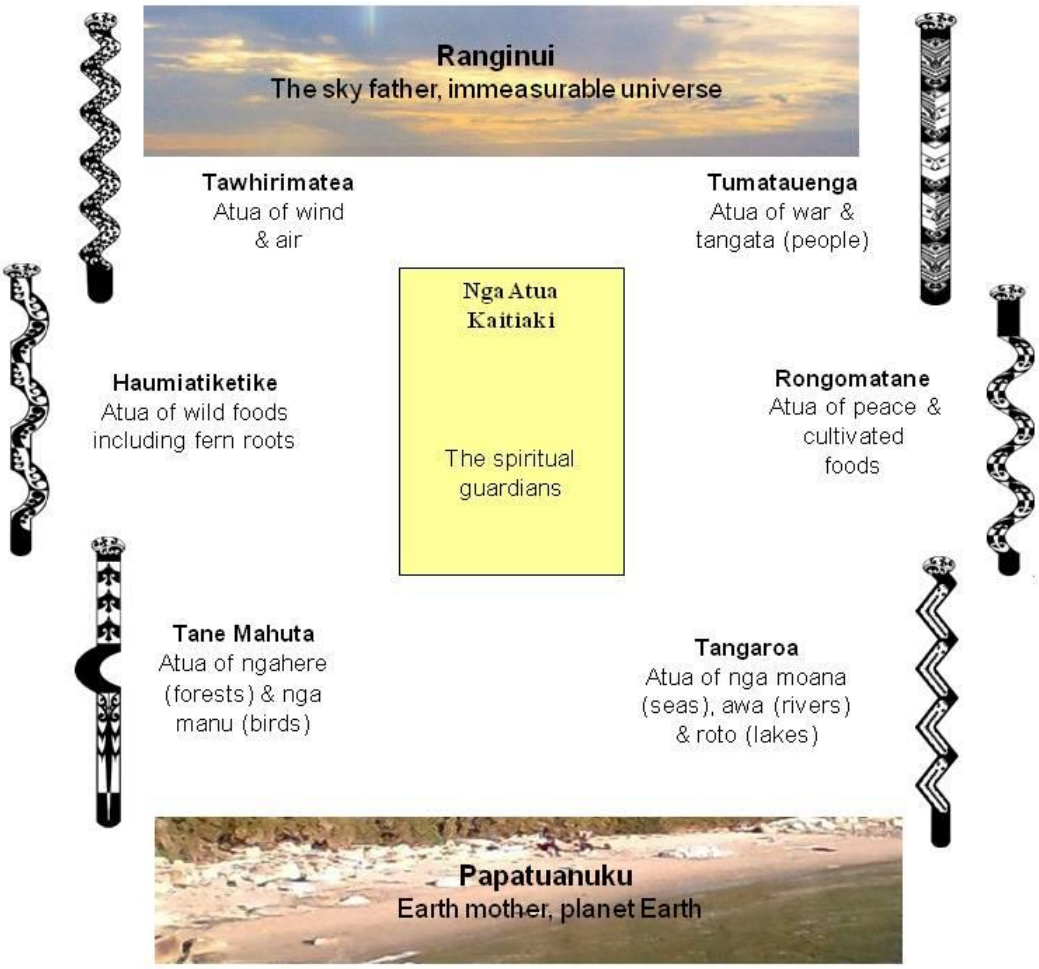
Cultural Health Indicators and Monitoring

Dean Walker for Tiakina te Taiao

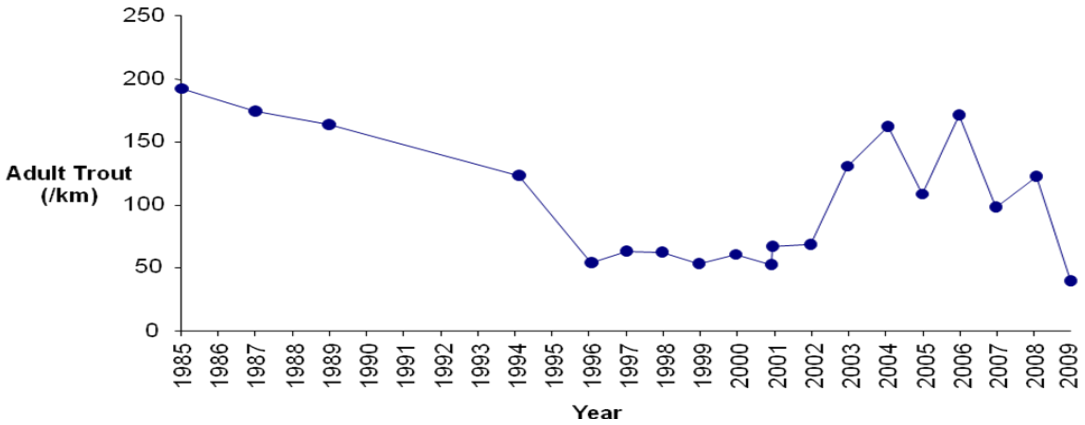
Te ao Maori/ the Maori worldview is different from the Western scientific tradition. In te ao Maori the perspective is holistic in nature and one where all things are connected. The tangata whenua in the Motueka / Nelson region have developed two sets of cultural health indicators; one for freshwater and the other for estuarine habitats.

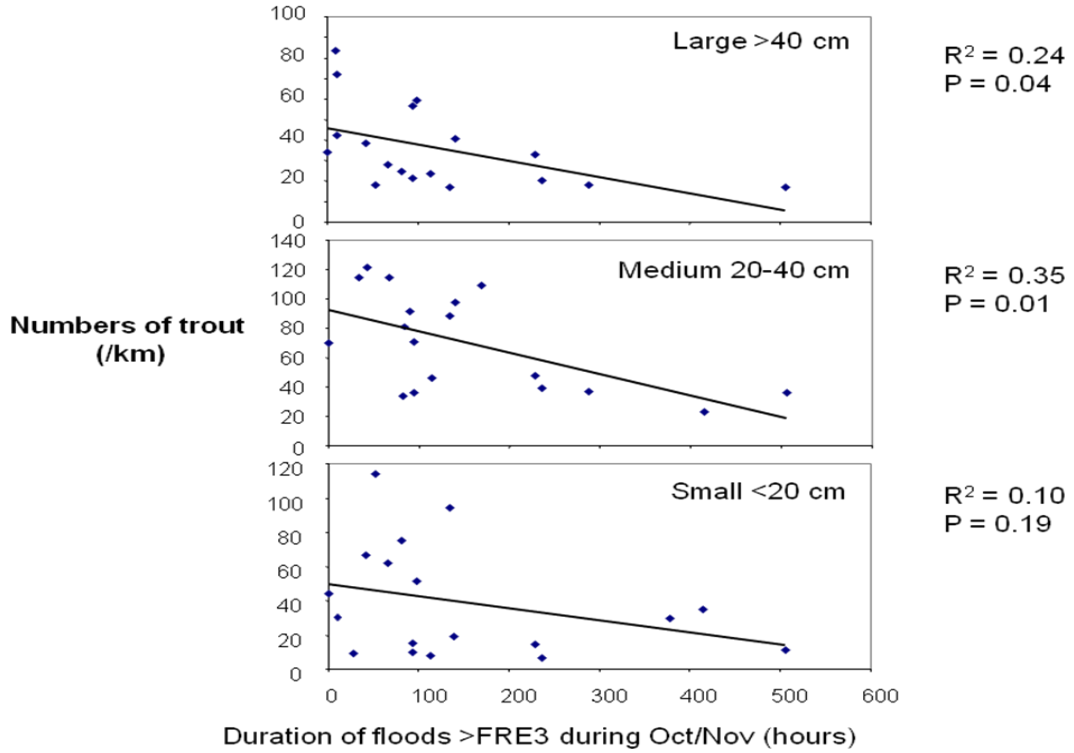
The nga atua kaitiaki model below depicts a worldview where each of six main atua (spiritual guardians) have control a particular environmental domain. In environmental monitoring, as well as much other resource management work, each of the atua are 'consulted' in turn to gain their perspective on the issue.

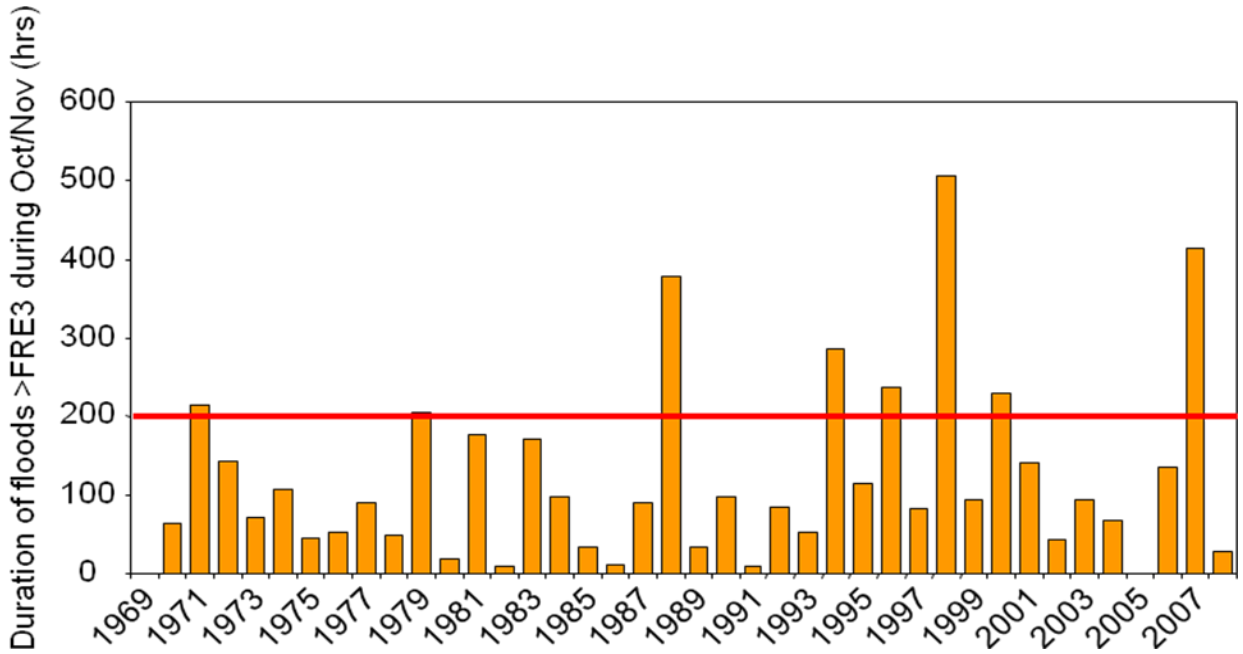
In practice, each of the atua kaitiaki has his own set of indicators which helps to gauge their views. These indicators are then grouped to give an overall index of the environmental health of a particular site; in essence a collective statement from the perspective of all the nga atua kaitiaki



Drift Dive Counts - Motueka River @ Woodstock







Stop 4 Puketawai

Delineation of the Motueka River suspended sediment plume in Tasman Bay: implications for improved management of coastal shellfish resources

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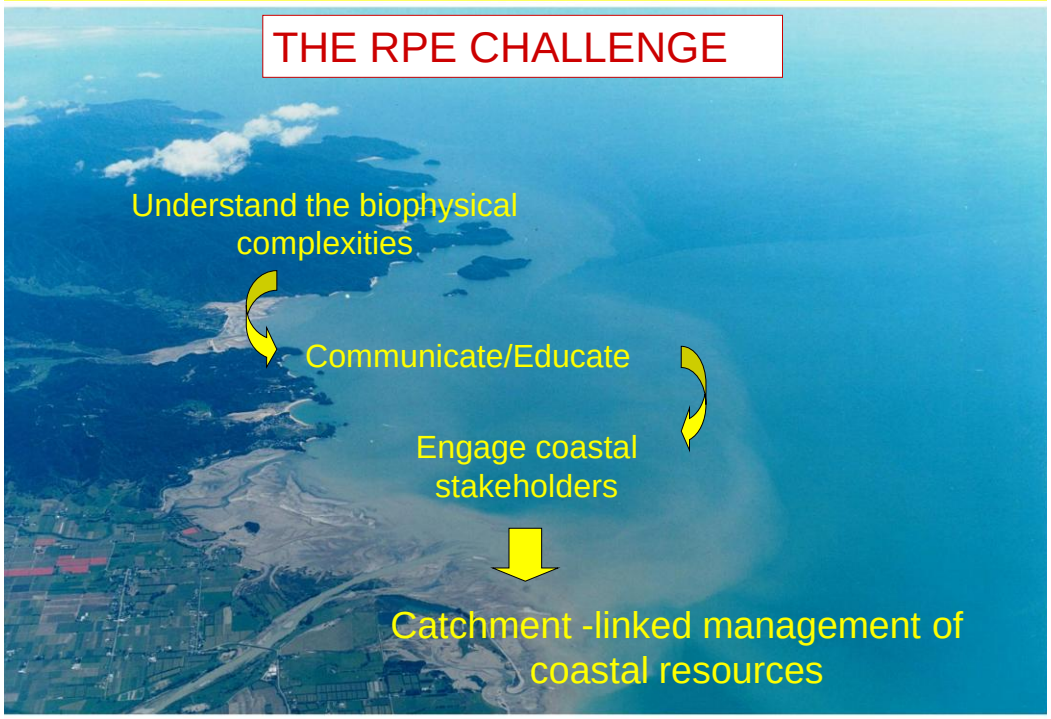
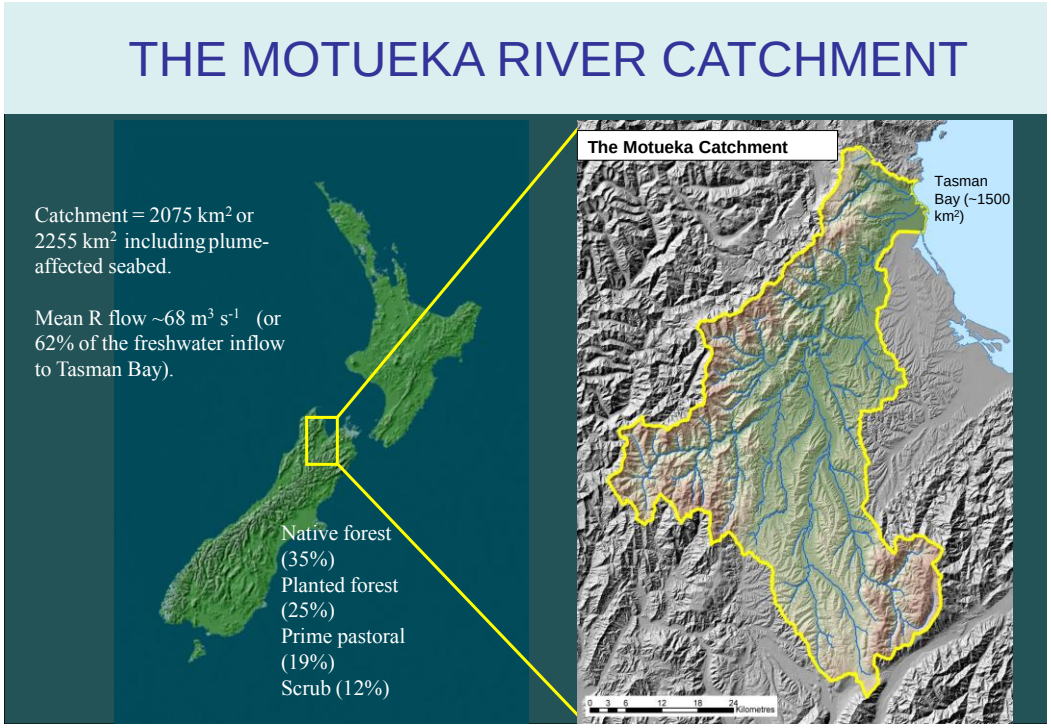




Commercial fish & shellfish resources/activities potentially influenced by the river plume

- Enhanced scallop (*Pecten novaezelandiae*) fishery (spat catching, rotational seeding, dredge harvesting) – *in decline* (*no harvests since 2005/06*)
- Mussel (*Perna canaliculus*) farming (spat catching & long line culture) – *developing within designated aquaculture management areas totalling >4000 ha*
- Dredge oyster (*Ostrea chilensis*) fishery
- Trawl fishery (*variety of species incl. flounder and sole*)

Annual Catchment SS Contributions to Tasman Bay (tonnes)

Sub catchment SS generation characteristics

- Specific suspended sediment yields (SSSY) were estimated for the overall catchment (180 t/km²/yr) and16 sub catchments (54- 362 t/km²/yr).
- Large storms and forest harvesting are threshold events that play an important role in mobilising sediments that are transported through the river system in subsequent smaller rainfall events (*e.g*. over a period of years).

- Major contributors of the total load to the coast are shown below:

Catchment component	Dominant land use	Area (km²)	SSSY (t/km²/y)	% of load at coast
Motupiko R	Production forestry, pasture	337	253	23
Upper Motueka R	Native forest, grassland	164	362	16
Wangapeka R	Native forest, grassland	473	75	10
Tadmor R	Production forestry, pasture	119	202	6
Baton R	Native forest, grassland	214	66	4

*The complete data set can be accessed at http://www.niwa.co.nz/our-science/freshwater/tools/suspended-sediment-yield-estimator

Frequent SS plumes occur in Tasman Bay under a variety of weather conditions.

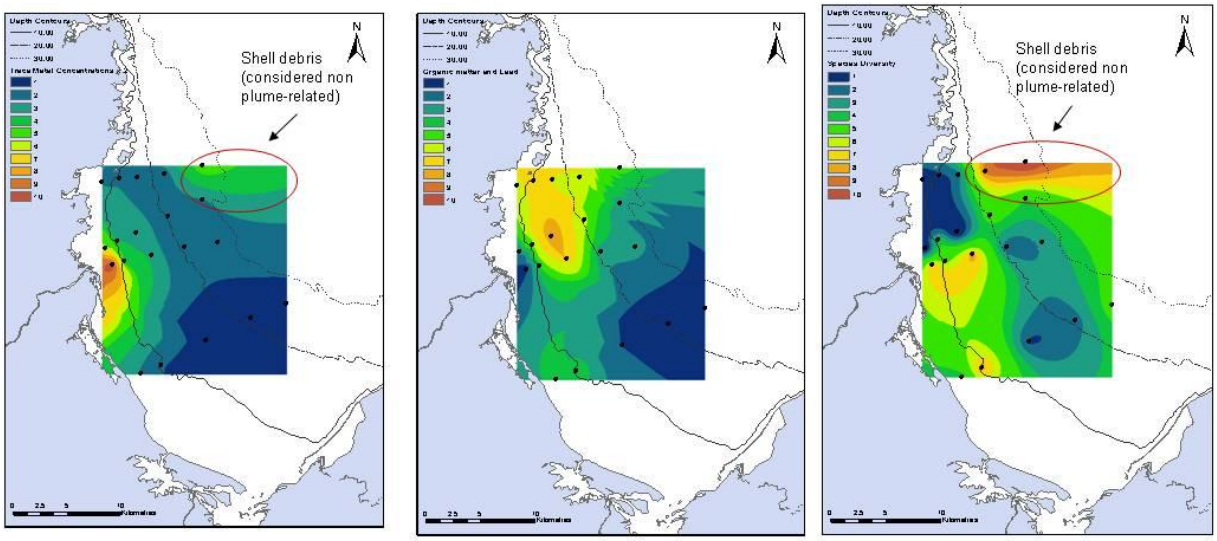
Motueka R. SS Plume - the day after a moderate flood event

SS mobilisation and export from nearby estuaries - strong winds during spring high tides, no rain

Benthic characteristics considered for delineation of catchment influences

- Trace metal concentrations (Al, Ba, Cr, Cu, Ni, Pb, Sr, V, Cd) – analysed by ICP-OES or ICP-MS after moderate strength acid leaching technique (modified USEPA method 200.2).
- Infauna abundance & diversity – animals retained on 0.5 mm mesh
- Organic content (ash free dry weight)
- Grain size - % gravel, sand, silt/clay (wet sieving, gravimetric)

KEY SEDIMENT INDICATORS OF RIVER PLUME INFLUENCE



Trace metals

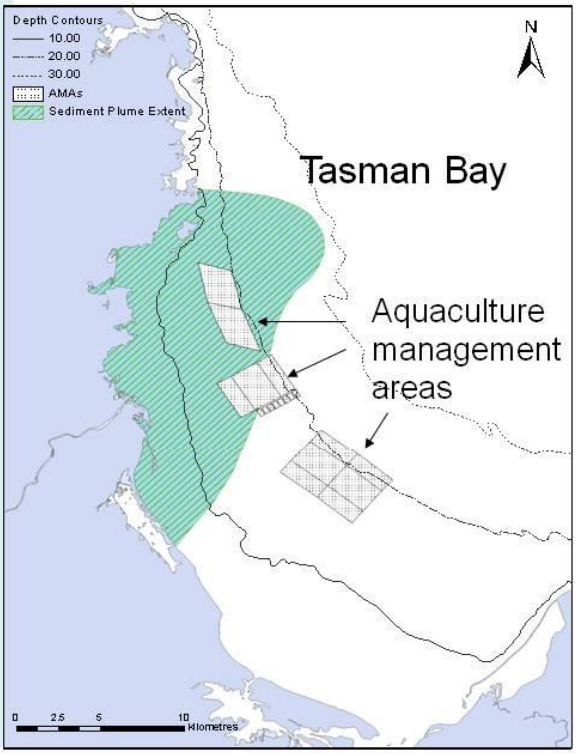
Organic matter & lead

Infauna diversity (SW)

180 km² river plume depositional area

based on

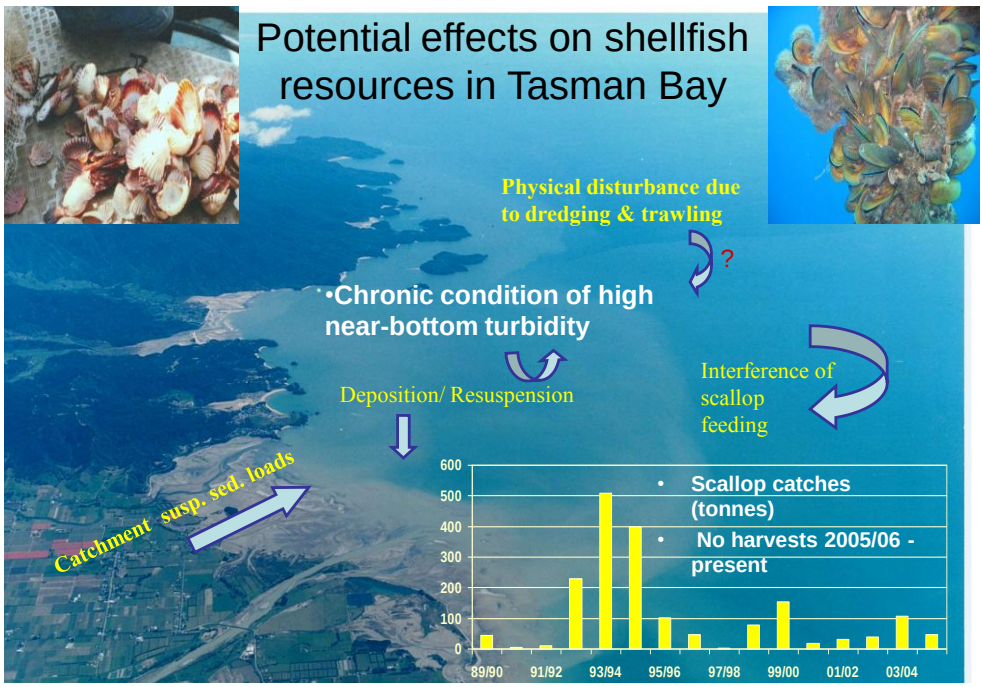
composites of multiple benthic indicators



See Cawthron Report No. 1697 (web site below) for sampling, analytical and mapping procedures.
(http://icm.landcareresearch.co.nz/knowledgebase/publications/public/Benthic_River_Plume_CAW_Jan2010.pdf)

Suspended Sediment Effects on Benthic Suspension Feeders

- SS inhibition of scallop (*Pectin novaezelandiae*) feeding
  - Tidally fluctuating, near-bottom (**50 mm above the seabed**) SS concentrations from **11-25 g/m³ (89-96% inorganic)** were seen to interrupt the feeding activity of scallops on the seabed
  - Scallops in baskets 0.5 or 1.0 m above the seabed continued feeding normally



Summary and Conclusions

- Catchment erosion during heavy rainfall results in extensive turbidity plumes in Tasman Bay.
- SS generation rates are dictated by rainfall, geology and land use.
- Annual SS loadings vary widely reflecting the number of large rainfall events and their location within the catchment.
- SSs originating from the upper Motueka (Red Hills) catchment area contain elevated Nickel and Chromium concentrations.
- Large storms and forest harvesting are threshold events that play an important role in mobilising sediments that are transported through the river system in subsequent smaller rainfall events (*e.g.* over a period of years).
- Wind/wave activity can generate sediment plumes in the absence of rain.
- The Motueka River plume directly affects ~ 180 km^2 of the seabed in the western Bay with overlap to coastal fishery and aquaculture resources.
- High inorganic SS concentrations can persist in near-bottom waters of the Bay through deposition & tidal re-suspension.
- Although nutrient inflows likely benefit bivalve resources, inorganic SS concentrations near the seabed can interfere with scallop feeding.

Tracking faecal contaminants in the Motueka River plume

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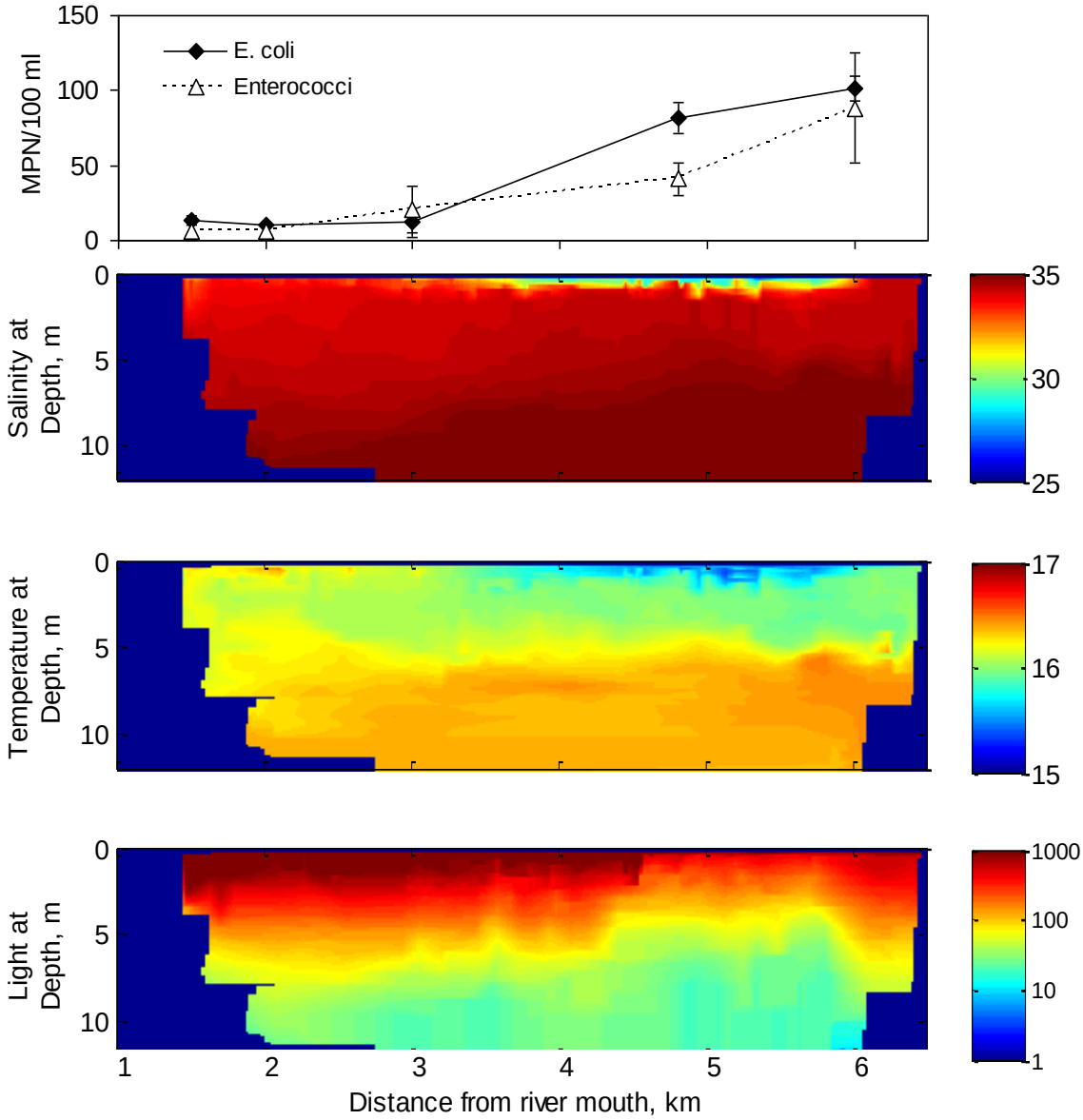
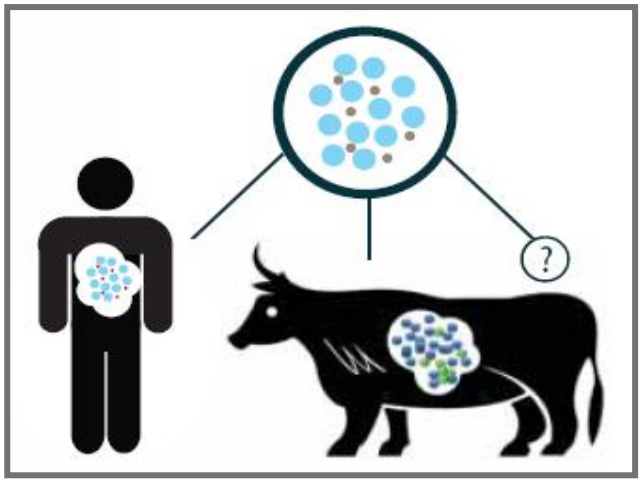
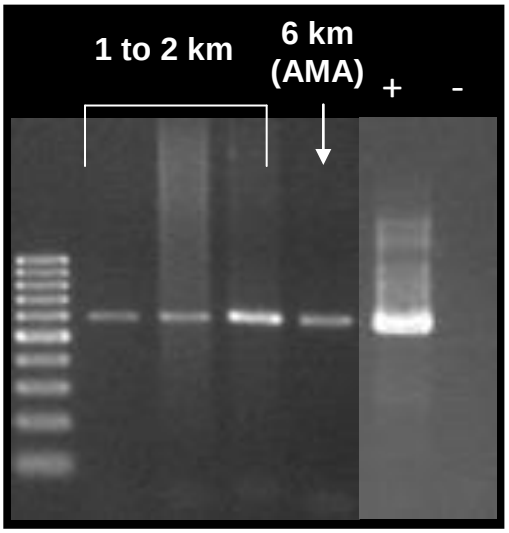
As part of the ICM research, scientists conducted a survey of the Motueka River plume during a flood event to assess the source and fate of faecal contaminants transported into Tasman Bay. The plume was delineated by towing a remotely operated CTD that continuously measured salinity, temperature, turbidity, and irradiance along transects extending into the Aquaculture Management Areas. The plume survey revealed a shallow low-salinity plume that extended at least 6 km into Tasman Bay. Water and mussels collected as far as the Aquaculture Management Areas had elevated counts of faecal bacteria. Using Microbial Source Tracking (MST) technology, Cawthron scientists were able to confirm the presence of faecal contaminants from ruminant animals such as cows and sheep within the mussels, revealing the close connection between land use and New Zealand's highly valued coastal resources.

Following rain events, the Motueka river plume can become conspicuous in the Bay due to a shallow layer of fine sediments derived from the catchment. The top photo shows the plume extending into Abel Tasman National Park during a large flood event. The bottom photo shows the plume boundary during a flood event where we surveyed the water column for faecal contaminants (see next figure). Our findings suggest that the combined effects of fine sediment and faecal loading contribute to the nature and extent of faecal contamination that occurs in Tasman Bay.



The above figure shows interpolated salinity, temperature, and light (PAR) data as a function of water depth along a transect extending from the river mouth out to the ICM buoy. Shown in the top panel is the concentration of faecal indicator bacteria in surface water samples along the same transect. We collected these data following a moderate flood event (river discharge of 400 cubic metres per second). At the time of sampling, the river plume (and associated contaminants) had moved at least 6 km offshore and within the region of Tasman Bay's Aquaculture Management Areas.





So where is the contamination coming from?

Microbial Source Tracking techniques using molecular DNA markers enables the source of faecal contamination in water and/or shellfish to be identified. DNA is extracted from a sample and examined using the polymerase chain reaction (PCR) for DNA "probes" from source-specific bacteria and viruses. Assays are available for a range of sources, including humans, ruminants and wildfowl. Application of a suite of MST markers during the ICM plume survey confirmed the presence of recent faecal contamination and the presence of bacteria derived from ruminant animals such as cows and sheep in water and mussel samples (see above figure). Human markers were not detected in any of the samples.