National Science Challenges

OUR LAND AND WATER

Toitū te Whenua, Toiora te Wai

Ki Uta Ki Tai: Managing Catchments for Healthy Estuaries

31 May 2024

Photo: Spid Pye

This summary encapsulates the research report for the Our Land and Water component of the cross-National Science Challenge research project *Healthy Estuaries Ki Uta Ki Tai*.

Background

The health and functioning of estuaries are affected by contaminants from freshwater. These contaminants (soil, fertiliser, pesticides, herbicides, and animal waste) come from land use on freshwater catchments, which move downstream and enter our estuaries.

Once in the estuaries, these contaminants interact with each other to cause cumulative effects that can be difficult to predict.

The National Policy Statement for Freshwater Management (NPS-FM) does not yet have clear direction on how to account for the impacts of freshwater contaminants on estuary health.

Our Land and Water (OLW) have been working with the Sustainable Seas National Science Challenge and the Ministry for the Environment (MfE) as part of the joint research project *Healthy Estuaries Ki Uta Ki Tai*, which aims to address this gap in the NPS-FM.

Aim

The overall aim of this research was to firstly identify a national freshwater contaminant load threshold specific to estuary health and secondly determine different land-use scenarios for reducing contaminants entering our estuaries to achieve those thresholds.

This project comprised of two sets of aims. First, Sustainable Seas aimed to assess the interactions between loadings of different contaminants from freshwaters on the health and functioning of estuaries, and then identify a set of freshwater contaminant thresholds that need to be met to restore estuary health.

OLW aimed to estimate the current contaminant loads draining into the catchments for three case study estuaries. Then prepare a national data set looking at contaminant levels under climate change and mitigations scenarios for 2050 (mid-century) and 2100 (end-century).

The main goal for OLW was to use the current and future contaminant load datasets to determine the land use change required to reduce contaminant loads for achieving the thresholds that Sustainable Seas identified for estuary health.

In practice

Due to the complexity of the estuarine environment, the Sustainable Seas sub-project was not able to provide specific national contaminant thresholds.

In lieu of specific thresholds for estuaries, the OLW sub-project modelled a wide range of contaminant reduction targets against the current NPS-FW bottom lines for sediment, nitrogen and phosphorus.

A tool previously developed, the Estuary Trophic Index (ETI), was used to assess the potential susceptibility to eutrophication due to factors including Total Nitrogen.

Methods

The OLW part of the project used several models to:

- Estimate the current contaminant loads of nitrogen, phosphorous and sediment draining into New Zealand estuaries.
- Complete a closer look at three case study estuaries in Kaipara (Northland), Waihi (Bay of Plenty) and New River (Southland)
- Estimate the degree of change required in land management practices/mitigation and land use diversification needed to achieve a range of reductions in contaminant load for the catchments draining into the case study estuaries.

The types of land uses included in the modelling were limited to arable, dairy, horticulture, sheep and beef, exotic forest and natural vegetation. The model was also set to prioritise the most profitable land uses where possible. The researchers did not model whether advances in mixed farming – a combination of sheep and solar panels, for example – might have elicited different results.

Photo: Natwick Studios

Results

All catchments

This research has provided a new, national overview of the current state of the estuaries.

About 60% of NZ estuary catchments do not meet the NPS-FM bottom line for Total Nitrogen and 70% do not meet the Total Phosphorous bottom line standards for rivers.

River bottom lines from the NPS-FM were used because estuary-specific limits were not able to be identified prior to modelling. This was due to the complexity of factors affecting estuarine health and the uniqueness of each estuary's environment and ecosystem.

This study went on to determine that reducing the nitrogen load by 60% would result in more than 80% of estuary catchments achieving the Nitrogen NPS-FM bottom line. To achieve this, land managers in those catchments would need to implement runoff mitigation strategies, such as riparian planting, and consider some land-use diversification.

Case study catchments

Contaminant loads to estuaries are controlled by environmental factors such as rainfall, soil and slope. However, the dominant influence – particularly for the nutrients nitrogen and phosphorus – is intensity of land use.

In general, the higher the intensity the more contaminants are released from land into the waterways. This project defined intensity as input onto the land including fertiliser, herbicides animal dung and urine. For sediment, intensity refers to the clearing of natural woody vegetation.

In this study, dairy, arable and horticulture were considered intensive. Sheep and beef and forestry were considered less intensive.

Estuaries are like a big bathtub at the bottom of a catchment that collect all the contaminants released by all the different types of land uses in the catchment. This means that if two catchments have similar proportions of land use types, then the actual size of the catchment will influence the total load of contaminants in that estuary. Likewise, if two other catchments are the same size but one has a higher proportion of more intensive land use than the other, then land use intensity is the main driver for contaminant load increase or decrease.

The three case study estuaries all have about 50% pastoral land use. However, because the catchment draining into the Kaipara Harbour estuary is much greater in size than Waihi and New River, the absolute contribution of nutrients from that catchment to its estuary is greater than the other two.

Mitigation effectiveness

The potential for reducing nutrient loss from the land depends on available mitigation options (on-farm management practices). Nutrient loss refers to the amount of nitrogen and phosphorus lost from the soil profile to the waterway via either run-off or leaching.

The current best management practice options for dairy farming are generally more effective at reducing total contaminant loss than those available for sheep and beef farming. That means the potential to improve water quality with mitigation alone is more feasible for dairy, whereas sheep and beef would need to consider land use change.

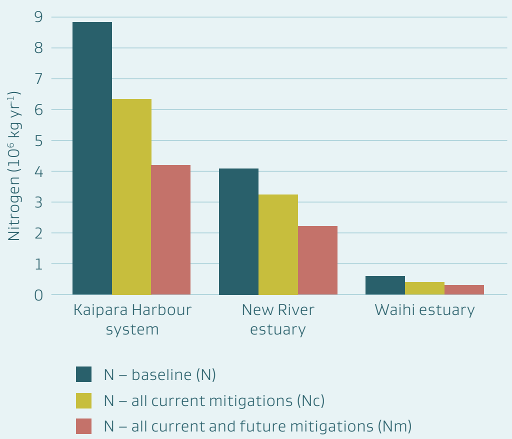
Figures 6 and 7 below, (copied from the OLW research report) show the potential reductions in nitrogen loss and phosphorus loss respectively when applying different mitigation options to land in the catchments for the case study estuaries.

The first column in each graph shows the estimated load of nitrogen/phosphorus entering the estuary currently, as the baseline before change. The middle column shows the estimated absolute contaminant loss resulting from adopting current mitigation best practices on pastoral land. The last column shows the estimated reductions gained when adopting both current and mid-to-end century mitigation options. The table next to each figure shows the exact percentage reductions.

The modelling suggests that applying current mitigations or best management practice to the land in the case study catchments would result in the nitrogen load reducing by 28% in the Kaipara estuary catchment, 34% in the Waihi estuary catchment and 21% in the New River estuary catchment.

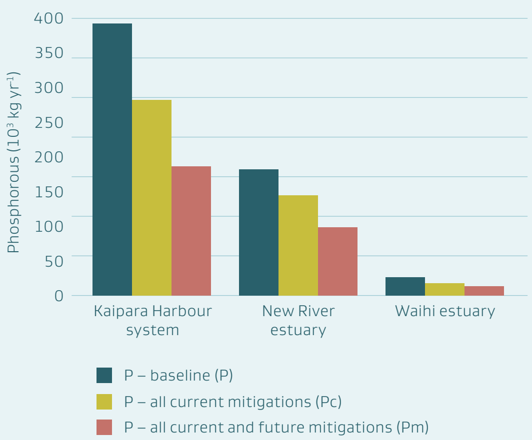
While Kaipara Harbour's larger catchment size results in a much higher load of nitrogen and phosphorous compared to New River and Waihi, Waihi catchment has the highest portion of pastoral land in dairy farming. This means that Waihi has the highest potential reduction in nutrient loss with the adoption of current best management practices, and that Kaipara has the lowest.

Sediment loss estimates and the potential for reduction was a little different to the nutrients, as mitigation options on pastoral land are highly effective. However, climate change will have significant, unmanageable impacts. For example, findings from another OLW research project suggest that sediment will increase by 233% in some parts of Aotearoa by 2100, due to more extreme weather events and erosion resulting from climate change.



	N (kg yr^{-1})	Nc (kg yr^{-1})	Nm (kg yr^{-1})	Nc reduction (%)	Nm reduction (%)
Kaipara Harbour system	8,823,717	6,315,855	4,187,108	28	53
New River estuary	4,057,181	3,210,359	2,186,896	21	46
Waihi estuary	549,644	364,955	258,187	34	53
All estuaries	107,725,235	87,627,602	66,578,885	19	38

Figure 6: *Nitrogen loss in case-study estuaries for baseline (N, current), all current available mitigation options (Nc, current with mitigation), and all current and future available mitigation options (Nm, mid and end-of-century). Mitigation scenarios Nc and Nm show the potential reduction relative to the baseline.*



	NP (kg yr^{-1})	Pc (kg yr^{-1})	Pm (kg yr^{-1})	Pc reduction (%)	Pm reduction (%)
Kaipara Harbour system	397,686	280,335	213,628	30	46
New River estuary	135,088	72,469	65,613	46	51
Waihi estuary	32,474	17,625	12,622	46	61
All estuaries	6,653,431	4,588,260	3,724,634	43	44

Figure 7: *Phosphorus loss in case-study estuaries for baseline (P, baseline scenario), all current available mitigation options (Pc, current scenario), and all current and future available mitigation options (Pm, mid-century scenario). Mitigation scenarios Pc and Pm show the potential reduction relative to the baseline.*

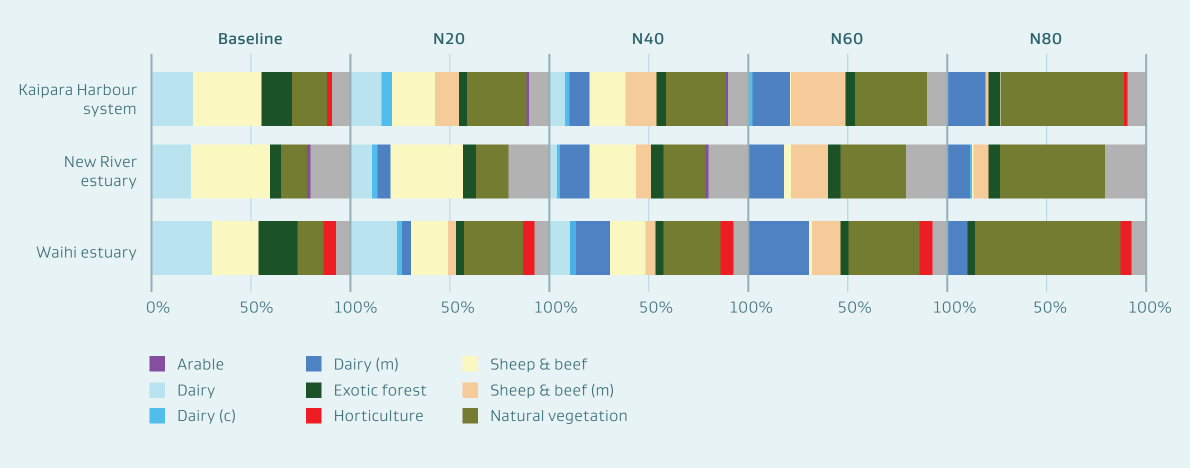


***Figure 14:** Effect of set contaminant reduction targets (Figure 13) on land-use proportions in the case-study estuaries when enabling adoption of all current and future available mitigation measures, plus conversion of intensive land use to exotic forest or natural vegetation while optimising for profitability.*

The three case study catchments were similar in their modelled reduction in sediment loss, showing that adopting mitigation options had the potential to significantly reduce sediment loss. However, the modelling of the impacts of climate change on sediment movement showed that the northern case study estuary could expect significant increase in sediment movement by the end of the century.

How much land-use change is required to protect estuaries?

In absence of estuary thresholds, several contaminant reduction targets were modelled. The targets modelled were reducing Nitrogen loss by 20%(N20), 40%(N40), 60%(N60) and 80%(N80). Reductions of 60% would result in more than 80% of estuary catchments achieving the Nitrogen NPS-FM bottom line.

The next step was to determine if keeping the same land use and adopting all current and future mitigation options would be enough to achieve the reductions, or whether land use needed to change in the case study catchments.

Figure 14 above (copied from the OLW research report) captures the land use change that would be required to achieve each level of reduction.

When comparing baseline to 20% reduction (N20), the modelling suggests that a small amount of land use change and the adoption of mitigation measures would achieve this reduction. Although it does show that exotic forest land use starts to be swapped out for natural vegetation.

As the reduction of nitrogen loss increases, the sheep and beef land is swapped out for natural vegetation, while the dairy remains. This is because the modelling in this project was set to prioritise the optimisation of financial returns when estimating the preferred land use change to achieve the desired contaminant load reduction. The current low financial return from sheep and beef would result in a change from sheep and beef to forestry or native bush. The dairy farming was selected to remain because it was a more financially viable option that would be able to adopt the most effective mitigations.

Cautions to consider when interpreting the study findings

This study demonstrated that mitigation options and some land use change will achieve improvements in nutrient loss to water.

However, it highlights that modelling using financially viable land use options to estimate the land use change required in catchments to reach the NPS-FM bottom lines shows land in forestry increasing significantly. There are many reasons why that outcome is not palatable for Aotearoa.

It is important to remember that this is a limited desk top study and is to be used as a general indication that is not specific to actual parcels of land at a local scale.

The results of this study and others need to be considered alongside policy formation and industry direction.

This is a summary of: Alexander Herzig, Andrew Neverman, Robbie Price, Michelle Barnes (2024). From mountains to the sea: values and science for an informed kaitiaki/guardian – land. *Manaaki Whenua – Landcare Research Contract Report LC4436.* https://ourlandandwater.nz/outputs/from-mountains-to-the-sea-values-and-science-for-an-informed-kaitiaki-guardian-land/