National Science Challenges
SUSTAINABLE SEAS
Ko ngā moana whakauka

Will the freshwater limits we set protect our estuarine waters?

For regional council scientists

Regional councils are tasked with setting limits to freshwater quality that will protect estuaries. There are two parts to this for any specific estuary.

- Determining whether freshwater quality is the primary driver of estuarine health
- Determining which stressors provided by the freshwater quality are important and how limits placed on them interact with processes occurring in the estuary and stressors stemming from the ocean and climate.

This document takes regional council scientists through a series of questions and links to guidance material.

1. Is freshwater quality the primary driver of estuarine health?

What stressors are being generated in the estuary?
Usually the larger the estuary, the more activities are taking place within it, for example ports, marinas, seawalls, recreational fishing, and aquaculture. Stressors also enter the estuary directly from the land, for example urban sewage and stormwater, septic tank overflow, and industry contaminants. Using the activity-stressor table helps determine what stressors might be generated by estuarine and foreshore activities.

What stressors are entering the estuary through the ocean?
The ocean is not always pristine, especially near the coast. Sediment plumes and water-borne contaminants from other estuaries may enter. Sediment deposited in the near shore may be resuspended and washed into the estuary. Invasive species and marine-related contaminants from passing boat traffic and changes in fish abundance due to coastal fishing pressure may also occur. Using the activity-stressor table helps determine what stressors might be generated outside the estuary and using local knowledge or models helps determine the likelihood of effects inside the estuary. Many variables related to climate variability and change enter from the ocean, such as sea level rise, sea temperature, ocean productivity, and oxygen content (Lam-Gordillo & Lohrer 2023, Lohrer et al 2023, Lohrer et al 2024).

What stressors are contained in the freshwater inputs?
To answer this question, use regional council freshwater information. It's also important to query whether there is variability associated with climate cycles (El Nino or Southern Oscillation) or whether climate change is likely to affect the stressors — either by reducing or increasing their intensity and frequency. For this assessment, use the climate change stressors resource.

What is the present estuarine health, ecological status, and stressor status?
How an estuary responds to stressors depends in part on its present health. Assess present health using the Assessing present health resource. From the answers to questions 1 to 3, create a table of stressors and place of origin (estuary, ocean, and freshwater). Assess each stressor's status using the *Stressor principles guidance* (see below).

2. Do stressors only enter via freshwater inputs (eg woody debris, herbicides, terrestrial sediments)? Or do stressors that are produced in, or directly enter, the estuary enter from the ocean (eg storm water contaminants, plastics, and nutrients)?

To answer this main question, consider the following questions.

If stressors are only generated through freshwater inputs, do they affect ecological components that are being impacted by other stressors produced in the estuary or of oceanic origin? For example, terrestrial sediments impact shellfish, which are also impacted by stormwater contaminants and plastics.

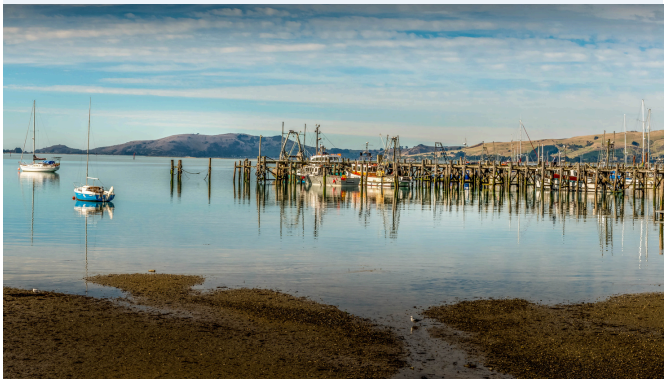
- If ecological components are being affected by stressors generated through freshwater inputs **as well** as within-estuary generated stressors or ocean generated stressors, then any freshwater limits will only protect estuaries if they allow for the present levels of estuarine and oceanic stressors.
- If ecological components are only being affected by stressors generated through freshwater inputs, then freshwater limits will protect estuaries if they are set at levels that allow the areas (and ecological components) of the estuary that are most sensitive to be maintained at their present health.

For stressors that are produced by freshwater inputs and estuarine and/or oceanic inputs, freshwater limits will only protect the estuary if they allow for the present levels of estuarine and oceanic stressors.

A note of caution

This advice will still generate limits that are not precautionary for the estuary, unless they are adapted to keep within the stressor principles values below. Any limits for a single stressor need to be adjusted by the likelihood for cumulative effects from other stressors.

Limits also need to be set in the context of climate change increasing stress on estuarine systems and increasing oceanic inputs.



Supporting information

A

Legend P- primary, Y-present	horticulture	farming	forestry	shellfish farming	urban centres	tourism	marinas	shipping lanes
Suspended sediment	Y	P	P					Y
Sediment addition	P	P	P				Y	
Wood debris addition			P					
Stormwater contaminants					P			
Herbicides	P	Y			Y			
Pesticides	P	Y			Y			
Nutrients including organic matter	P	P		Y	Y			
Sewage - ecoli and disease		Y			P	Y		
Altered hydrodynamics				Y			P	
Plastics	Y	Y		Y	P	Y	Y	
Marine cleaning contaminants							P	Y
Petroleum products							Y	Y

B

Legend P- primary, Y-present	freshwater	estuarine and oceanic
Suspended sediment	P	Y
Sediment addition	P	
Wood debris addition	P	
Stormwater contaminants		P
Herbicides	P	
Pesticides	P	Y
Nutrients	P	Y
Ecoli and disease	Y	P
Altered hydrodynamics		Y
Plastics	Y	P
Marine cleaning contaminants		P
Petroleum products		Y

Activity-stressors table: green shaded – freshwater inputs, blue shaded – ocean inputs, white – estuarine inputs

Figure 1: Examples of how the activity stressor table (A) can be used to determine what stressors might be generated from freshwater estuarine or oceanic sources (B).

Is terrestrial sediment only entering via freshwater? → **yes** Does terrestrial sediment affect any ecological components that are also affected by any of the oceanic and estuarine stressors? → **yes** Pipi population, biodiversity, primary productivity also affected by oceanic and estuarine stressors → Set terrestrial sediment freshwater limits to protect pipi, biodiversity and primary productivity, allowing for the present levels of estuarine and oceanic stressors

Stressor principles

Sourced from (Gladstone-Gallagher et al 2024).

A range of values that can be taken by each stressor characteristic is given in terms of 'high' (bad) and 'low' (good).

S1. The number of stressors. Multiple stressors are now the default in many coastal systems (due to emerging contaminants and climate change). Multiple stressors increase the frequency and intensity of non-linear ecological surprises. High = 3 or more stressors present. Low = no (or one) stressor present.

S2. The levels of stressors that are ongoing and accumulating. Accumulating stressors cause problems because low levels accumulate over time into higher levels, and legacies are created that remain even when the activity is stopped. High = Stressors are at moderate-to-high levels and accumulate rapidly. Low = stressors are at low levels and only accumulate slowly.

S3. The levels of stressors that generate unimodal responses. Increases in some stressors, such as temperature, nutrients and sediment mud content, can have an initial positive effect but then switch to a negative effect. High = high levels of such stressors can result in cumulative stressor effects that can be greater than the individual effects of different stressors (ie synergistic responses). Low = low levels of such stressors can mitigate the negative effects of other stressors.

S4. The levels of stressors that generate responses other than unimodal. Some stressors (eg toxic contaminants and microplastics) even at low levels have negative effects. High = Two or more stressors at moderate-to-high levels Synergistic effects (the effect of the two stressors is greater than the effect of either of them added together) will occur. Low = none/one at low levels.

S5. The number of ecological components impacted directly and indirectly. Stressors impact networks of interacting ecological components. The number of components impacted is likely to determine the severity of ecological responses. As the magnitude and numbers of stressors increase, so does the number of components directly affected. This, in turn, increases the likelihood of indirect effects. However, a single stressor can also impact multiple ecological components (for example, suspended sediment affects pipi, cockles and algae growing in the sediment) and create indirect effects (for example, fewer pipi reduces their capability to armour the seafloor — increasing resuspension of sediment — while fewer algae growing in the sediment reduces food for many species of macrofauna). High = many direct and indirect effects. Low = none/one direct and indirect effect.

References

Gladstone-Gallagher R, Hewitt J, Low J, Pilditch C, Stephenson F, Thrush S & Ellis J (2024). Coupling marine ecosystem state with environmental management and conservation: A risk-based approach. Biological Conservation 292: 110516

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