National Science Challenges

SUSTAINABLE SEAS

Ko ngā moana whakauka

Guidance

Managing the impact of turbidity, nutrients and sea level rise on coasts and estuaries

Light availability in the water column and at the seafloor plays a critical role in ecological processes that underpin the delivery of vital ecosystem services in estuarine and coastal ecosystems.

Quantifying the impact of turbidity (water clarity) on these ecosystems is critical to:

- Understand how different components of the ecosystem that are responsible for ecosystem services interact with each other, eg nutrient processing and size of the intertidal zone.
- Inform holistic ecosystem-based management strategies to prevent tipping points.

Turbidity is a measure of the loss of water transparency due to suspended particulates. The more suspended solids in the water, the murkier it seems and the higher the turbidity. Turbidity is considered a good measure, or 'indicator', of water quality.

A **tipping point** is a rapid transformation that happens when an ecosystem has lost its capacity to cope with change. Tipping points often involve the loss of valuable marine resources and ecosystem services.

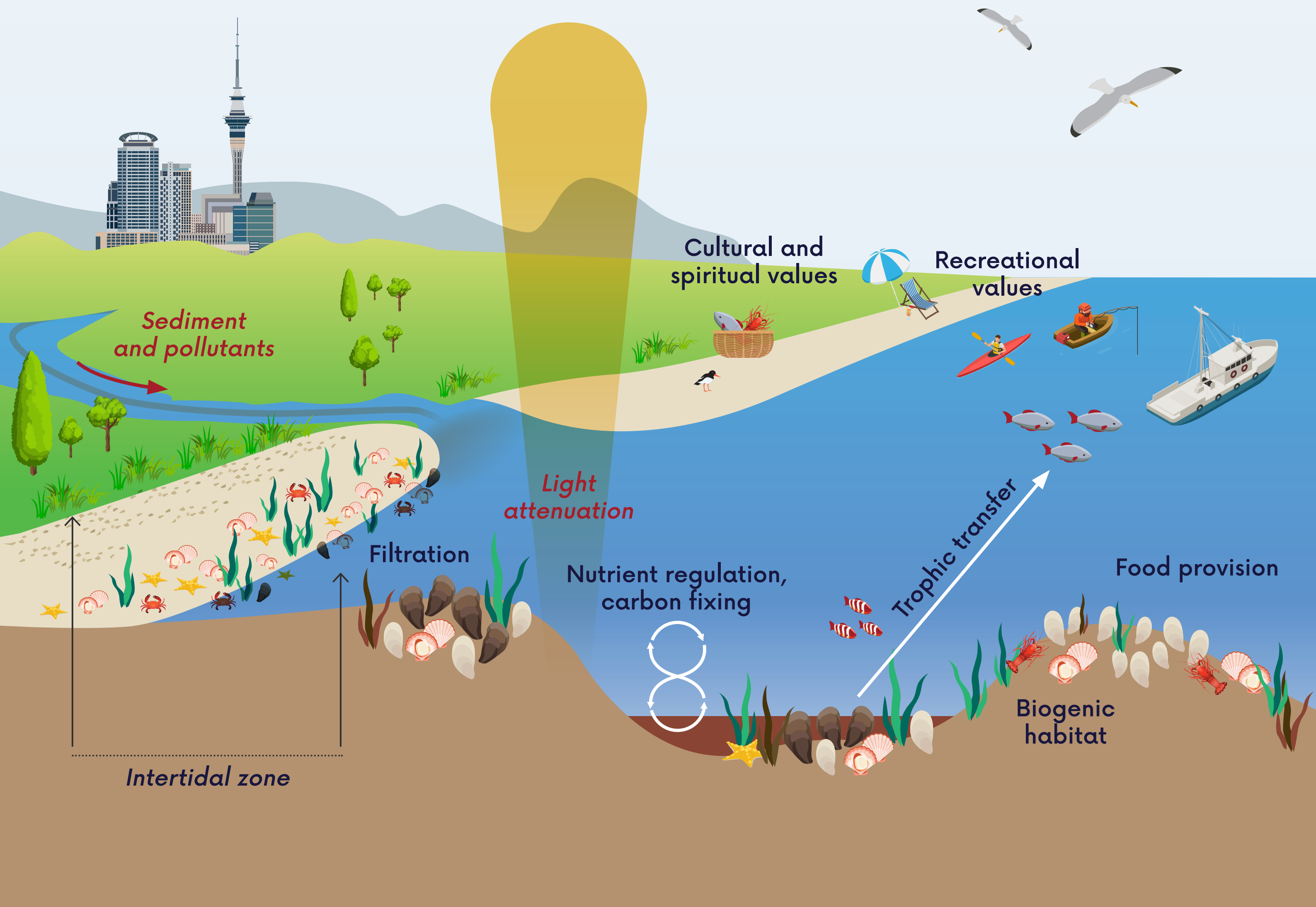
Ecosystem services are the goods and services that nature provides, which people benefit from. For example, improved water quality as a result of filter feeding by shellfish.

The cumulative effects of turbidity, nutrient loading and sea level rise on

Turbidity (water clarity)	Risk of nutrient loading	Projected loss of intertidal area due to sea level rise (or coastal development)	Likely impact on MPB production, nutrient cycling and EIN complexity – and therefore increased vulnerability to a tipping point
Low (good)	Low	Low	Minimal
Low (good)	Low	High	Minimal-moderate
Low (good)	High	Low	Minimal-moderate
Low (good)	High	High	Moderate
High (poor)	Low	Low	Moderate
High (poor)	Low	High	Moderate-high
High (poor)	High	Low	Moderate-high
High (poor)	High	High	High

In estuaries with poor water clarity, a small increase in turbidity is unlikely to have a significant effect because the 'light climate' is already poor. The problem is that these ecosystems have limited capacity to process nutrients – in these cases, even a relatively small increase in excess of nutrients or reduction in the intertidal zone could drive the ecosystem to a tipping point.

How stressors affect ecosystem function and services

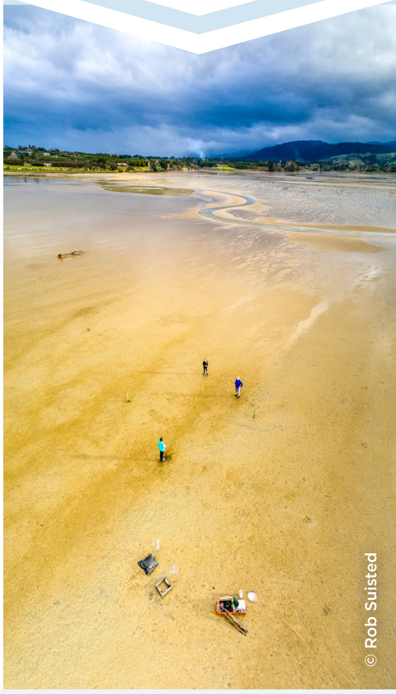


Aotearoa New Zealand's coasts and estuaries

› **Microphytobenthos (MPB)** are tiny (microscopic) photosynthetic organisms that live on, or in, sediment on the seafloor. They are primary producers, ie they synthesise organic compounds from carbon dioxide, so are the foundation of coastal food webs. They also help stabilise sediment and process nutrients.

› **Ecosystem interaction network (EIN)** are the interactions and feedbacks between different components within an ecosystem. A complex network is more resilient than a simple one.

› **Eutrophication** is when a body of water becomes overly enriched with nutrients. This induces excessive growth of algae, which can then cause oxygen depletion.



1 Stressors that directly affect our estuaries include:
- Terrestrial runoff: sediment, nutrients and other pollutants
- Sea level rise (or coastal development) that decrease intertidal area

2 Increased turbidity and/or water depth reduces sunlight in the water and at the seafloor

3 This light reduction in turn reduces the seafloor's:
- Primary production by MPB and seaweeds – in some turbid estuaries MPB production on intertidal flats (which are vulnerable to sea level rise) can only occur during low tide
- EIN complexity
- Regulating services eg carbon fixation, nutrient processing

4 The reduction in primary production:
- Reduces food available to organisms higher in the food web such as shellfish
- Reduces ecosystem resilience to further increases in pollution, particularly nutrients
- Increases risk of eutrophication, which further increases turbidity and decreases oxygen availability

5 These stressors (and their effects) interact causing:
- A negative impact on the coastal foodweb
- A reduction in kaimoana/seafood
- A reduction in cultural values – eg mahinga kai (resource gathering and management) and manaakitanga (expression of respect and hospitality to visitors through the provision of kaimoana)
- A reduction in recreational values – eg beach walks, surfing and swimming less pleasant due to smelly rotting algae and murky water
- A reduction in economic values – eg decline in ecotourism, commercial fishing
- A reduction in ecosystem function and resilience, which increases vulnerability to a tipping point

Recommendations for managing coastal and estuarine ecosystems

Management strategies need to:

1. Be place-based, ie tailored for a particular coastline or estuary

National water quality standards will not be appropriate for all coastal ecosystems. Estuaries with low MPB production do not process nitrogen in the same way as those with high production. This means managers need to consider the effects of sediment and/or nutrient loading combined with loss of intertidal area on nutrient processing and risk of eutrophication. Estuaries with good water clarity will still be sensitive to high turbidity but are more resilient to temporary increases in nutrients (as they have better capacity to process them) so are less vulnerable to eutrophication, and to intertidal loss.

2. Be informed by ecosystem interaction networks (EIN)

Marine managers and kaitiaki can use the data gathered from this research together with other environmental data to develop an EIN for their specific coast, which will help indicate whether it is vulnerable to a tipping point.

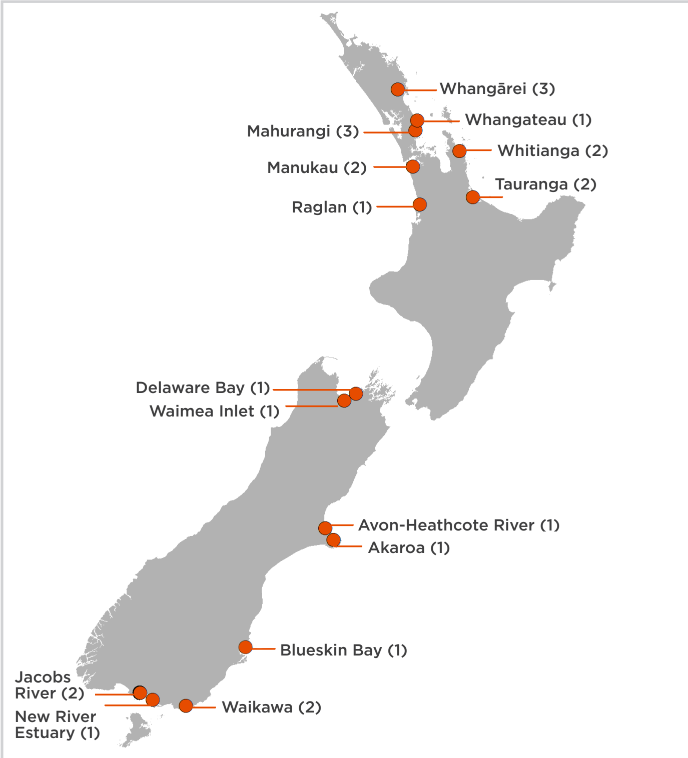
3. Focus on ecosystem responses, not individual stressors

Marine management needs to move beyond models of single stressor effects and focus on how components of an ecosystem interact and respond to multiple stressors. Here we consider turbidity in combination with nutrient loading and sea level rise. Other factors such as heavy metals and high shellfish harvesting may need to be taken into account. A robust strategy will recognise all the stressors affecting an ecosystem and consider their cumulative effects. This is particularly relevant for coasts and estuaries, which are affected by stressors from both land and sea.

Sites sampled

24 sites in 15 harbours and estuaries were sampled, from Northland to Southland. The sites were selected across a gradient of high turbidity (poor water clarity) to low turbidity (good water clarity). The number of sites within each estuary is shown in parentheses.

This research was carried out as part of the *Tipping points* project, sustainableseaschallenge.co.nz/tippingpoints



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Academic publications

- Hope JA, Paterson DM and Thrush SF (2019). The role of microphytobenthos in soft-sediment ecological networks and their contribution to the delivery of multiple ecosystem services. Journal of Ecology 108: 815–830
- Mangan S, Bryan KR, Thrush SF *et al* (2020). Shady business: the darkening of estuaries constrains benthic ecosystem function. MEPS 647:33–48
- Thrush SF, Hewitt JE, Gladstone-Gallagher RV *et al* (2020). Cumulative stressors reduce the self-regulating capacity of coastal ecosystems. Ecological Applications 31 (1):e02223