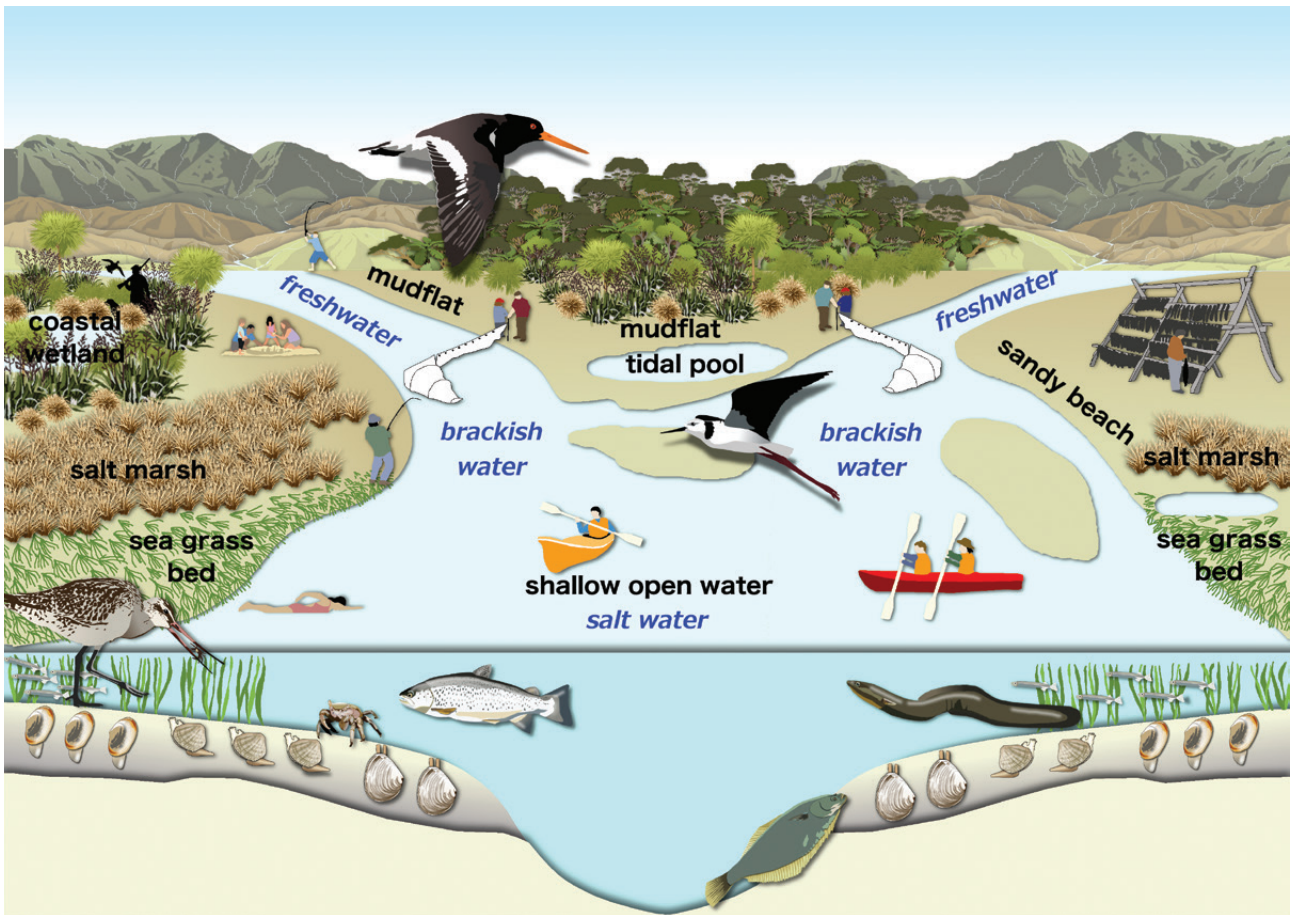




SOUTHLAND'S MONITORED ESTUARIES

A guide to estuary ecosystem
health monitoring



▲ Estuary habitat types: complex interactions and connections

What are estuaries?

Estuaries are a semi-enclosed coastal body of water that is connected to the open sea. Within an estuary, sea water and freshwater mix to varying degrees.

Estuaries are complex ecological systems, comprised of a diverse range of habitats. Healthy estuaries are full of life and are great places to explore and enjoy.

Habitat types include:

- landward vegetation
- coastal wetlands
- intertidal mudflats
- intertidal sand flats

- salt marshes
- sandy beaches
- tidal pools
- sea grass beds
- shallow open water

Different parts of an estuary respond to stressors differently. For example, mudflats in upper reaches will show signs of stress first.

Why are estuaries important?

Healthy ecosystems

Estuaries are so much more than sand, mud and water. Like the organs in our bodies, different parts of the estuary have different functions. As the saying goes: the whole is greater than the sum of its parts.

Estuaries support both aquatic and terrestrial ecosystems. There are five important components:

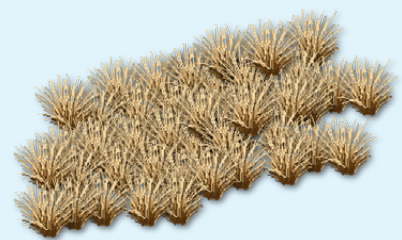
1. water quality: e.g. dissolved oxygen, temperature, nutrients, water clarity, toxicants
2. water quantity: e.g. hydrological variability, extent, connectivity
3. habitat: e.g. form, extent, connectivity, substrate types, riparian areas
4. aquatic life: e.g. microbes, plants, invertebrates, fish, water birds
5. ecological processes: e.g. nutrient cycling and chemical processes, interactions between lifeforms processes

In a healthy estuarine ecosystem ecological processes are maintained, there is a range and diversity of indigenous plants and animals, and there is resilience to change.

Habitat structure | Storm buffer | Stability

Tidal marshes trap sediment and remove it from floodwaters. Other fringe plant communities also slow floodwaters and stabilise the shore, preventing erosion.

These water-quality and damage control services would cost taxpayers millions of dollars using modern technology.



Gas exchange | Climate regulation

Estuaries make a large contribution to climate regulation per surface area due to high rates of gas exchange. Gas exchange occurs between the water, sediments and atmosphere.

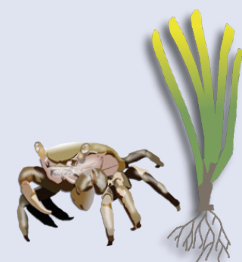
Eutrophic estuaries can negatively affect climate through the production of greenhouse gases.



Waste regulation | Nutrient cycling

The plants and animals in estuaries take up excess nutrients from water and sediment and use it for growth, effectively immobilising pollutants.

Microbes in the sediments drive nutrient and carbon cycling.



Why are estuaries important?

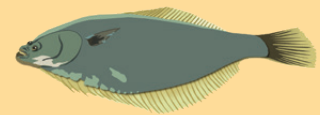
Nursery grounds | Species richness | Biodiversity

Estuaries provide critical habitat for a wide range of species. Birds, fish, insects, and other wildlife depend on estuaries to live, feed, nest, and reproduce. Some organisms make estuaries their permanent home while others use them to complete only part of their life cycle.



Recreation | Tourism

Estuaries are an integral part of many New Zealander's lives. They are a key place for food gathering and enjoying various recreation activities. The proximity of many estuaries to towns and cities further strengthens our connection with them.



Cultural values

For local iwi Ngāi Tahu, water is woven deep into their identity and traditional cultural practices. A healthy estuary enables mahinga kai (food gathering) to take place, a central pillar of Ngāi Tahu culture. Mahinga kai encompasses many harvested resources (e.g. food, fibres, muds, clays and soil, stonework), the ability to access the resource, the site where gathering occurs, the act of gathering and using the resource, and the good health of the resource. Mahinga kai is central to Ngāi Tahu ki Murihiku relationships with places, waterways, species and resources, and to their cultural, spiritual, social and economic wellbeing. It is also a vehicle for the intergenerational transfer of mātauranga (knowledge).

What's the problem?

Load

Estuaries are naturally productive environments due to the input of nutrients from the land. However, there's a fine balance between having enough nutrients for a healthy ecosystem and too much. This leads to a reduction in estuary health and function.

► Why are some estuaries more prone to being 'unhealthy' than others?

Even though we categorise estuaries into types, no two estuaries are exactly the same.

Key variables for estuary health are:

Load – the amount of nutrients and sediment entering an estuary.

Load = flow x concentration

Sensitivity – how sensitive the system is to excess nutrients and sediment.

Generally, estuaries are most at risk when they have higher loads than they can cope with.

Sediment and nutrients

▶ Sediment – a muddy situation

Estuaries are naturally a 'sink' for sediment. However, many are receiving much more sediment than they can cope with.

Rivers and streams entering estuaries can contain large quantities of sediment - eroded from catchments and riverbanks upstream.

The build-up of fine sediments in estuaries makes them muddy - changing the make-up of the estuary floor.

This affects:

- tidal flows
- ratio of sand to mud flats
- habitat - e.g. loss of shellfish, seagrass

Sediment also:

- affects water clarity, especially in the upper reaches where there is less flushing
- contains a large reservoir of potential toxicants, which adds to the problem

▶ Nuisance nutrients

Too many nutrients (nitrogen and phosphorus) in an estuary can lead to eutrophication.

▶ Plants are good aren't they – why is this a problem?

Excess plant growth, such as seaweed, microscopic floating algae and submerged plants, changes estuarine habitats .

They can:

- cause the loss of oxygen in sediments
- reduce water clarity
- smother other life forms
- lead to the die-off of estuary life

? CONTAMINANTS

In urban environments, contaminants enter water bodies mainly through stormwater networks, illegal connections to the networks and leaky pipes, pumps and connections.

In agricultural areas, nutrients and pathogens (organisms that can cause disease) come from animal waste, urine, and fertilisers.

? LOAD

Load is the total amount of contaminants being transported past a given point over time.

? EUTROPHICATION

Eutrophication occurs when a water body becomes too enriched with nutrients, causing the dense growth of plant life (algae, seaweed and submerged plants).

💡 Did you know?

Seawater doesn't simply flow in and out of an estuary en masse with the tide. The speed and direction of tidal currents at the estuary entrance are affected by the narrowness and depth of the estuary 'mouth'. Water flow is also affected by sandbanks, rocky outcrops, shoreline contours, structures and reefs. The tidal exchange in an estuary can also depend on the force/amount of freshwater flow coming into the estuary.

Ecosystem health

Ecosystem health for Southland's estuaries is strongly linked to contaminant load, the impacts of which are related to their relative sensitivity level. Highly sensitive estuaries will show poor outcomes with much smaller loads than less sensitive systems.

✓ Good outcome – healthy estuary	✗ Poor outcome – unhealthy estuary
	
<p>▶ Benefits to us</p> <ul style="list-style-type: none"> • cultural and spiritual heritage maintained • maintenance of Te Mana o te Wai • ecosystem services e.g. flood protection • production of food and raw materials • resource for new medicines and pharmaceuticals • recreation and tourism opportunities • aesthetic appeal • biodiversity value 	<p>▶ How this impacts us</p> <ul style="list-style-type: none"> • cultural impacts - loss of cultural opportunities to keep customs alive • loss of Te Mana o te Wai • new pathogens associated with eutrophication • increased risk of disease - people and animals • harmful algal blooms • impacts on fisheries • economic costs due to loss of ecosystem services • loss of biodiversity

Estuary types

Estuaries can be categorised in many different ways. We've grouped Southland's estuaries into four broad categories, according to their risk of eutrophication.

Susceptibility is linked to a range of factors including: nutrient load (the quantity of nutrients entering the estuary in a given time), depth, water residence time, inflow volume, estuary volume and intertidal areas. There are also geomorphological, energy and biogeographical factors that influence susceptibility to eutrophication. These include: current speed, volume and circulation patterns.

► Why are some estuaries more sensitive than others?

It all depends on an estuary's ability to 'handle' the contaminant load that flows through the system. Sensitivity is related to factors such as:

- catchment load
- nutrient accumulation (i.e. what, where and when)
- estuary size, shape and depth
- river flow and volume
- tidal influence



Southland's monitored estuaries

Brackish lakes and lagoons

► Very high eutrophication risk

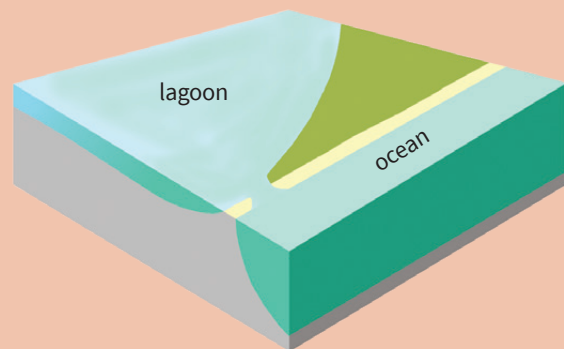
Estuaries with the greatest risk of eutrophication are Intermittently Closed/Open Lakes and Lagoon (ICOLLS). These enclosed lagoons are usually closed to the sea, but occasionally open. They are typically shallow (average depth less than 3 metres deep) and fed by streams with relatively low flow and volume.

When closed to the sea, these systems effectively act like a terminal catchment lake so can be classified as either a lagoon or estuary. In developed catchments, containment load from inflowing streams can accumulate to high levels. Contaminant levels only reduce when the lagoon is open to the sea.

SOUTHLAND EXAMPLES

Waituna Lagoon

Lake Brunton



Lagoon open to the sea

Tidal lagoon estuaries

► High eutrophication risk

Estuaries with high risk of eutrophication are referred to as Shallow Intertidal Dominated Estuaries (SIDES). These systems are typically shallow, fed by rivers of moderate flow and volume, have large intertidal areas of sand or mud, and are moderately influenced by tidal flow.

In developed catchments, contaminant load from inflowing streams and rivers can accumulate to high levels in the upper estuary tidal flats. Lower reaches of the estuary are more affected by tidal currents and less prone to catchment build-up.

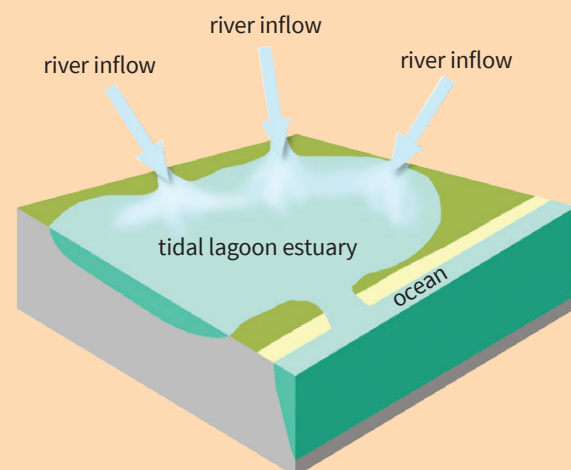
SOUTHLAND EXAMPLES

Haldane

Waikawa

New River

Jacobs River estuaries



Tidal river estuaries

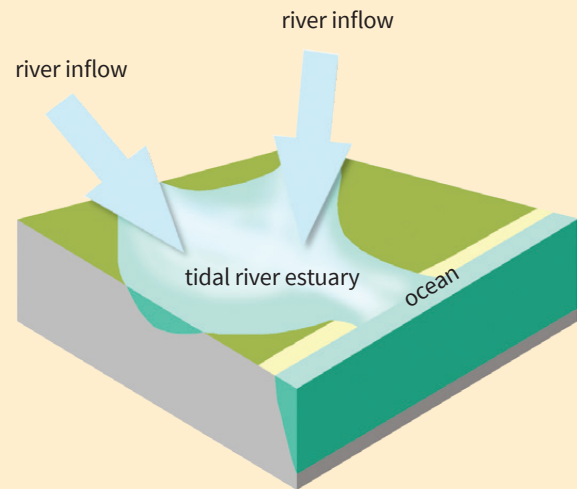
► Moderate eutrophication risk

Estuaries with moderate risk of eutrophication are classified as Shallow Short Residence Time Tidal River Estuaries (SSRTREs). These systems are high energy systems that are fed by high flow, high volume rivers and have short residence times (less than 3 days). They have smaller tidal areas to SDEs due to the greater volumes of water flowing through them.

In developed catchments, contaminant load found in river water is quickly transported out to sea, spending less time in the estuarine area.

SOUTHLAND EXAMPLES

Toetoes Estuary



Fiords and bays

► Low eutrophication risk

Estuaries with low risk of eutrophication are classified as Deeper, Subtidal Dominated Estuaries (DSDEs). These systems are typically deep (average depth greater than 3 metres) and have long residence times (greater than 7 days). They include coastal embayments and fiords.

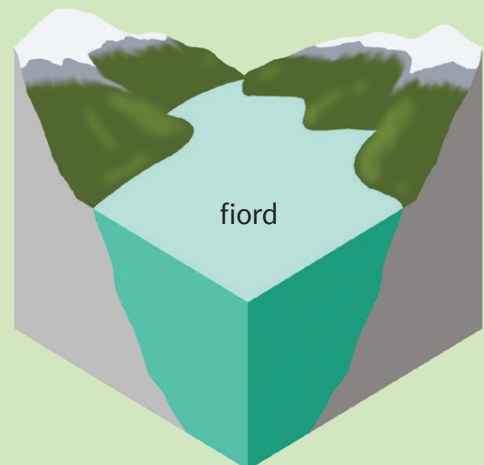
Eutrophication risk is low due to fiords and bays tending to have a higher dilution potential, compared to other estuary types. Therefore, the effects of any incoming contaminants are reduced. Further, most of this estuary type is found in Southland's national parks and conservation areas so typically have low nutrient loads.

SOUTHLAND EXAMPLES

Milford Sound/Piopiotahi

Doubtful Sound/Patea

Preservation Inlet



Estuary health programme

Environment Southland has a programme that assesses each estuary's ecological condition. Using a range of indicators, we combine results to make an assessment. This tells us the health status of an estuary or part of an estuary, and ranges from 'very good' to 'poor'. Key indicators are discussed to the right.

Physical and chemical measures of water are important for monitoring direct changes in water quality and aiding in the interpretation of estuary health. For example, at high levels, some measures (such as nitrate or temperature) can be toxic to estuary life. Low levels of nitrate are natural and sometimes needed.

The key physical and chemical indicators routinely monitored in Southland are:

Type	Indicators
Sediment	Mud content Sedimentation rate
Nutrients	Total nitrogen and total phosphorus Total organic carbon
Physical	Sediment metals Oxygen in sediment (RPD) Gross eutrophic zone (GEZ)
Plants and algae	Phytoplankton Macroalgae Seagrass Opportunistic seaweed and submerged plants
Microbes	<i>E. coli</i> Enterococci

Sediment attributes

► Soft mud content

Excess mud affects estuary life by:

- decreasing water clarity
- reducing oxygen levels
- increasing nutrient levels

We also look at the percentage of area covered by soft mud and whether this is changing. Most estuaries with undeveloped catchments have a very low area of intertidal soft mud (e.g. less than 1% mud at Freshwater Estuary, Stewart Island).

In contrast, estuaries draining developed catchments typically have high soft mud intertidal areas (e.g. more than 15% mud). This is not spread evenly throughout the estuary, with mud accumulating where salinity driven flocculation occurs (when particles clump together and fall to the estuary floor, forming what is referred to as a floc), or in areas with low energy tidal currents.



► Sedimentation rate

We also look at whether the percentage of area covered by soft mud and is changing.

Most estuaries with undeveloped catchments have a very low area of intertidal soft mud (e.g. less than 1% mud at Freshwater Estuary).

In contrast, estuaries draining developed catchments typically have high soft mud intertidal areas (e.g. more than 20% mud). This is not spread evenly throughout the estuary, with mud accumulating where salinity driven flocculation occurs (when particles clump together in a floc), or in areas with low energy tidal current.

Nutrients in sediment

▶ Nitrogen and Phosphorus

Nitrogen and phosphorus are plant nutrients necessary for life. However, too much of these nutrients causes aquatic plants to grow faster than ecosystems can handle.

Increased nutrient richness in estuaries stimulates the growth and abundance of fast-growing algae and short-lived, opportunistic seaweed.

To monitor nutrients, samples of sediment are collected from the intertidal areas of the estuary and the total concentration of nitrogen, phosphorus and organic carbon are measured.

Physical attributes

▶ Sediment metals

Heavy metals such as lead, copper, zinc and cadmium occur naturally in estuaries. However, high concentrations can enter estuaries from human development. Heavy metals accumulate in sediment, where they can be taken up by organisms, and are harmful to species and habitats. They also bio-accumulate, which means they are found in higher concentrations in species further up the food chain, including people (see example above).

▶ Oxygen depth in the sediment - Redox potential discontinuity (RPD)

The RPD is a layer between oxygenated sediments (yellow-brown) and anoxic sediments (black). It is effectively an ecological barrier for most sediment-dwelling species, e.g. shellfish. The depth of the RPD layer is a critical estuary condition indicator. The number of species that can tolerate a rising RPD reduces, until only a few survive.

▶ Gross eutrophic zone (GEZ)

Gross eutrophic conditions occur when sediments exhibit combined symptoms of:

- high mud content
- a shallow layer of oxygen in sediment
- high macroalgal growth (>50% cover)

These conditions will kill or displace most estuarine animals and shellfish, as well as leading to the release of nutrients previously bound in the sediments. These nutrients will further fuel macroalgal growth, causing a cycle of increasing habitat deterioration.

Plants and algae

▶ Phytoplankton

Phytoplankton are floating macroscopic algae that form the foundation of marine foodwebs, and are an important producer in estuarine environments. Like plants, phytoplankton need nitrogen and phosphorus to grow. However, if there are too many nutrients, this can affect phytoplankton population growth and structure.

Increased nutrient richness in estuaries stimulates the growth and abundance of phytoplankton, resulting in discolouration of the water when they are present in high numbers.

Changes in phytoplankton population structure and density can tell us how an estuary is changing, and whether it is showing signs of 'stress'.

▶ Sea grass

Healthy sea grass beds are a key indicator of estuary health. They provide shelter and food for a wide variety of invertebrates, fish and birds. They also stabilise the sea bed and reduce erosion; absorb nutrients; release oxygen; and trap fine sediment.

▶ Opportunistic seaweed and submerged plants

Seaweed and submerged plants occur naturally. However, excess nutrients can cause mass blooms of green and red macroalgae. Their dense growth forms 'mats' on intertidal flats and shallow subtidal areas. They smother other life forms, reduce clarity and reduce oxygen levels. Mass die-off then occurs when conditions get too extreme.

Published by:
Environment Southland
February 2020