Sediment

He Tirohanga

"Before it was hard. Now you know when you walk across that channel, now you get bogged down…before you touch the harbour, soft bloody stuff. Never used to be like that, you'd be all hard sand".

- a hapū member from Ngāti Hikairo of Kāwhia

"My concern was the siltation. But I'm looking at it in a philosophical way too, thinking well if the harbour's to build up it's going to build more land and that's because of the mangroves, eh. If that's how much we think of our harbour then so let it be…. We sort of accommodate it…. Because you don't know, it's happening so gradually that you don't notice what's going on and you accommodate it, you know, you move aside sort of thing and let it happen…."

– a hapū member from Ngāti Whanaunga of Manaia

Sediment

The type of sediment that is deposited in your estuary, be it mud or sand, and how quickly it is deposited, has a big influence on what your estuary will look like, how clear the water will be, and the types of plants and animals that can live in it. In this **Sediment module** you will learn how to describe sediment types, measure how quickly sediment is being deposited (the sedimentation rate), and measure large-scale changes in the topography or shape of estuary features, such as banks and channels. This module also provides guidance on how to collect and store sediment samples and cores that you may wish to have analysed for metal and organic chemical pollution. Before you start using the **Sediment module**, you will need to know how to use a GPS or magnetic compass to locate sites and to measure directions. The appendix **Locating Your Position** provides a step-by-step introduction to these navigation methods. We also recommend that you read the safety information in the **About this Toolkit module**.

Introduction

The life cycle of estuaries

Over time, estuaries fill with sediment eroded from the land and carried into the estuary by rivers, streams, and tidal currents. These sediments make up most of the habitats that you observe in your estuary. These habitats include the channels, mudflats, and sandflats where plants and animals live. The **Habitat Mapping**, **Shellfish**, and **Plant modules** provide tools to map these various habitats, and to monitor changes in the location and/or boundaries between habitat types that may occur over time.

In the **Estuary Origins module** we talked about the life cycle of estuaries. During their youth, most estuaries are deep and are mostly submerged, even at low tide. As estuaries mature, they fill with sediment and water is eventually concentrated into tidal channels that are flanked by sandflats and/or mudflats. Over time these intertidal flats, which emerge between the tides, are colonised by plant communities, such as seagrass, saltmarsh, and mangrove in northern estuaries. In old age, estuaries may completely fill with sediment. In their upper reaches, freshwater marshes replace intertidal flats and saltmarshes, with a narrow tidal channel linking the catchment to the sea beyond.

How quickly an estuary fills up with sediment depends firstly on its original size, at the time when the sea flooded its ancestral river valley thousands of years ago (see

Estuary Origins module). A small estuary will fill with sediment more quickly than a larger estuary. Volume and high tide area are two key measures of an estuary's capacity to store sediment. Secondly, how quickly an estuary fills up also depends on how much sediment is delivered to the estuary from the land and sea. The catchment sediment load depends on a number of factors including catchment size, steepness, rainfall, and the activities of people on the land. Marine sands are also carried into estuaries by tidal currents and these form sand bars and deltas at their mouths. The **Estuary Origins module** discusses how catchment sediment loads to estuaries have changed over time and why.

As we have discussed in the **Estuary Origins module**, the loss of forest cover on the land (**deforestation**) began after people arrived in New Zealand. The cleared land was vulnerable to soil erosion during heavy rainfall, particularly on hill slopes. Huge quantities of soil were eroded from the land and some of this soil was deposited in receiving estuaries. In fact, most of the mud that you see in your estuary today was originally soil.

You can think of your estuary as a giant bucket, except that it is open to the sea so that it is 'leaky' and not all the sediment that is carried into it from the sea and the land is trapped. Sand is more easily trapped because the grains are larger and heavier than mud particles. Therefore, it takes a more energetic (stronger) tidal current to shift sand. However, mud is sticky and is not easily picked up from the seabed by tidal currents or waves. Definitions for mud, sand, and gravel are provided in the sediment-size table on page 12.

An example of a Northland estuary that has filled with sediment and has now reached old age. The intertidal flats in these infilled estuaries make ideal habitats for mangroves and saltmarsh. (Source: Brian Smith, NIWA)

Waves are very effective at stirring up silt on intertidal flats, particularly on incoming tides. This process is one of the reasons that estuarine waters often look muddy.

In deep, youthful estuaries with subtidal basins that are tens or hundreds of metres deep, sediments are less likely to be stirred up after they are deposited because tidal currents in deep estuaries are generally too weak. Fiords, like Milford Sound, which can be several hundred metres deep are extreme examples of deep subtidal estuaries. Another reason is that the waves that develop when the wind blows are too small to reach the bottom when the water is more than a few metres deep. But as estuaries fill up with sediment, the waves become more effective at stirring up sediments, a process called **sediment entrainment**. Muddy sediments stirred up by waves remain suspended in the water and give estuaries their muddy appearance. As a result of estuary infilling, more and more sediment is likely to be flushed out to sea and less is trapped in the estuary. This sediment is eventually deposited in deep water far out to sea or is carried back into the estuary, or neighbouring estuaries and bays, by the incoming tide where it may be deposited. Such areas include tidal creeks, saltmarshes, and mangrove forests.

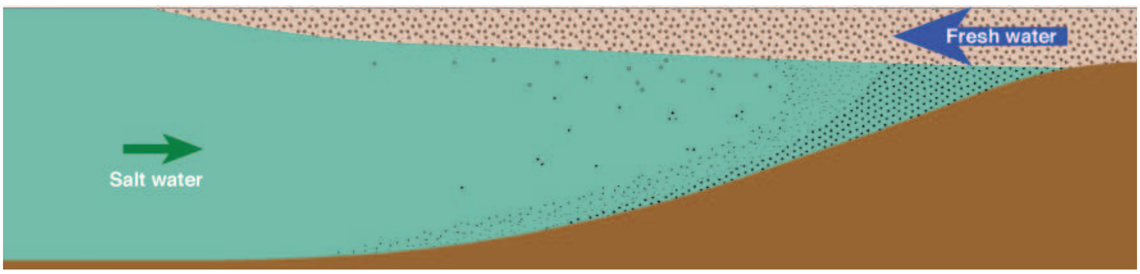
Sediment and water in estuaries

How much of the sediment eroded from the land is eventually trapped in an estuary also depends on what stage of its lifecycle the estuary has reached. In particular, the amount of sediment that is trapped in an estuary depends on how much of its original volume remains. Estuaries with a deep basin that remains submerged at low tide are better at trapping sediments than shallow estuaries with large intertidal flats. Sediments carried into an estuary settle out of the water and are deposited because they weigh more than the same volume of water.

The density of an object, such as a sand grain, is defined as its weight divided by its volume (i.e., how much space it takes up). For example, most beach sand has a density of about 2.7 grams per cubic centimetre (g/cm^3). Freshwater has a density of about 1 g/cm^3 and seawater is about 4% denser than freshwater because it also contains salts. Beach sand is almost three times denser than water and this is why it sinks in still water.

Because it is less dense, freshwater will float on top of seawater. This layering of freshwater and seawater due to differences in density is called **stratification** and is an important process that influences how sediment is transported and deposited in estuaries.

You can observe stratification for yourself by adding a small amount of cold cooking oil to a part-filled glass of water. The cooking oil is less dense than the water and it floats on top. Try stirring the oil and water together and see what happens.



Freshwater flowing into an estuary will float on top of the salty estuarine water because freshwater is less dense. This vertical layering due to differences in density is called stratification.

Sediment monitoring tools

In this **Sediment module**, we show you several ways to monitor:

- the types of sediments deposited in your estuary
- how quickly sediment is being deposited in your estuary
- changes in estuary topography (surface shape) caused by sediment deposition and erosion.

Most animals and plants that live in estuaries are found in habitats formed by the accumulation of sediments. Sedimentation and increasing inputs of more muddy sediments are causing environmental problems in New Zealand estuaries. Many animals and plants that live in estuaries have evolved with different preferences and tolerances for sediments. Animals and plants that are suited to sandy bottoms and clear water conditions suffer when the water becomes muddy (**turbid**). For example, pipi, snapper, and seagrass have all but disappeared in some estuaries which have permanently changed from mainly sandy to muddy habitats. Thus, an understanding of sediments is important to understanding why habitats and animal and plant communities may be changing in your estuary.

The sediment monitoring tools described here can be used along with tools described in the **Habitat Mapping, Plant,** and **Shellfish modules** to describe the sediments that plants and animals live in and on.

How often should I monitor sediments?

How often you should monitor your sites will depend on:

- how rapidly you think changes are occurring in your estuary
- the objectives of your Estuary Monitoring Action Plan (E-MAP)
- the accuracy of the methods.

Sedimentation rates are typically less than a few millimetres per year on intertidal flats. These values are similar to the accuracy of the Sedimentation Plate method that is described later in this module, so that measurements once per year will usually be enough for intertidal flats. By comparison, sedimentation rates in tidal creeks near stream outlets can be as much as several centimetres per year and more frequent surveys might be useful. Plants also increase sedimentation rates by reducing currents and by providing shelter from waves. Thus, sedimentation rates in saltmarshes and mangrove forests can be several times higher than on bare intertidal flats. Engineering works may also locally change sedimentation patterns and consequently the estuary topography. For example, land reclamation, breakwaters, causeways, wharfs, and jetties can change tidal flows and cause rapid changes in intertidal flats, channel positions, and depths as a result. These are some of the issues you will need to consider when deciding how often you should monitor your **transects**.

Links to the New Zealand Curriculum for schools

This module introduces and explains the use of a number of scientific methods for determining sediment types, rates of sedimentation, and changes in the **topography** or shape of estuary features. Details about specific methods and the use of associated measurement tools (their manipulation, calibration, etc.) are provided. Student use of these scientific tools during investigations into the nature of estuaries (composition, structure, features, and their interactions with other systems) is ideally suited to meeting the achievement aims and objectives of the Nature of Science and Planet Earth and Beyond strands.

This **Sediments module** is ideally suited to all aspects of the New Zealand Curriculum (NZC) Nature of Science strand from Levels 5–8 (Years 9–13) and certain aspects of the Living World and Planet Earth and Beyond strands.

Years 9 and 10 curriculum links

At Years 9 and 10 (Level 5 of the NZC) the following achievement objectives can be addressed using the scientific approaches contained in this module.

The Nature of Science (Level 5)

Understanding about science

- Understand that scientists' investigations are informed by current scientific theories and aim to collect evidence that will be interpreted through processes of logical argument.

Investigating in science

- Develop and carry out more complex investigations, including using models.
- Show an increasing awareness of the complexity of working scientifically, including recognition of multiple variables.
- Begin to evaluate the suitability of the investigative methods chosen.

Communicating in science

- Use a wider range of science vocabulary, symbols, and conventions.
- Apply their understandings of science to evaluate both popular and scientific texts (including visual and numerical literacy).

Participating and contributing

- Develop an understanding of socio-scientific issues by gathering relevant scientific information in order to draw evidence-based conclusions and to take action where appropriate.

Planet Earth and Beyond (Level 5)

Earth systems

- Investigate the composition, structure, and features of the geosphere, hydrosphere, and atmosphere.

Living World (Level 5)

Ecology

- Explain how living things are suited to their particular habitat and how they respond to environmental changes, both natural and human-induced.

Years 11–13 NCEA links

In the senior school (Years 11–13) most students will be working towards the requirements of the National Certificate of Educational Achievement (NCEA) qualification. All achievement standards for the NCEA have been reviewed to align them with the 2007 NZC document. The following achievement standards from the 2014 NCEA subject matrices are appropriate to assess aspects of student learning that are outcomes of the **Sediments module**.

Science

Science 1.13	Demonstrate understanding of the formation of surface features in New Zealand.

Earth and Space Science

ESS 2.1	Carry out a practical Earth and Space Science Investigation.
ESS 2.3	Investigate geological processes in a New Zealand locality.
ESS 3.1	Conduct a practical Earth and Space Science investigation.
EES 3.3	Demonstrate understanding of the evidence relating to geological events.

Geography

Geo 1.1	Describe an extreme natural event and the human response.
Geo 1.4	Apply concepts and basic geographic skills to demonstrate understanding of a given environment.
Geo 2.1	Demonstrate geographic understanding of a large natural environment.

Geo 2.4	Apply geographic concepts and skills to demonstrate understanding of a given environment.
Geo 3.1	Demonstrate understanding of how interacting natural processes shape a New Zealand geographic environment.
Geo 3.4	Demonstrate understanding of a given environment(s) through selection and application of geographic concepts and skills.