Marine Ecology

An experiment in ecosystem stress

***Nicole Hancock** describes how a team of ecologists have added environmental stress to two estuarine shores to compare the resilience of their ecosystems.*

We all know people who are resilient in the face of hardship or illness. The concept of resilience can be applied in many situations, and it is increasingly used in the scientific fields of ecology and ecosystems research. Resilience of an ecosystem can be understood as its capacity to withstand shocks and reorganise after a disturbance without losing important types of plants or animals. The diversity of life in natural ecosystems – or biodiversity – is believed to contribute to resilience, thus helping ecosystems stand up to various natural and manmade (anthropogenic) stressors. Marine ecologists working on sandflats in the Auckland region have begun a series of experiments investigating resilience, the role of sandflat biodiversity, and responses to anthropogenic stress.

Contamination of sandflats by heavy metals and other pollutants likely affects the behaviours and activities of sandflat-dwelling animals such as cockles, worms, and crabs. When contamination levels become higher, species begin to die off and drop out of the communities altogether. It is important to understand whether biodiversity imparts resilience in the system, as the loss of species due to contamination may affect a system's ability to withstand further shocks, leading to accelerating rates of degradation. These ideas are being tested in a four-year project by an interdisciplinary team of NIWA researchers.

Waiheke Island vs Pollen Island – differences in contamination

Our experimental site at Te Matuku Marine Reserve on Waiheke Island is a pristine sandflat shore surrounded by protected bush. Levels of metal contamination here are low; there are few roads, houses, or factories in the catchment; and clean seawater flushes the sandflat with every tide.

Standing up to stress
- Resilience is a measure of an ecosystem's stress-resistance.
- Pristine environments are thought to be more resilient than contaminated ones.
- Scientists have tested ecosystem resiilence by manipulating biodiversity and stress levels.

Our study site at Motu Manawa/Pollen Island Marine Reserve is a sandspit with a muddy channel edge. This site is located farther up the Waitemata Harbour, and is affected by urban storm-water runoff from Whau River (Auckland city). Sites in the Whau River are known to contain contaminants such as polyaromatic hydrocarbons (PAH), heavy metals (for example, zinc runoff from roofs), and oil and petrol washed off the motorways.

The two sites share important similarities, including shelly-to-muddy fine sand sediments, animals such as crabs and cockles, low wave energy, and DOC conservation protection status. The sites need to be similar in these ways so that when we compare the results from each site we know differences are due to a gradient in stress rather than differences in the physical or biological habitat.

Experimental design

We established 48 experimental plots at each location. We manipulated some plots by altering the biodiversity (number and types of shellfish and worms) and/or by adding organic matter (corn starch) to cause a mild, measurable stress. We also left some plots unaltered as controls. To tell how the ecosystem responded to our manipulation, we measured key rates and processes that indicate levels of ecosystem functioning, such as photosynthesis and nutrient recycling.

Why we manipulated biodiversity

By manipulating biodiversity, we changed community structure and associated ecological processes in measurable ways. We're familiar with the behaviour of the animals we used and we are learning about how they modify their environment.

The team sets up the site at Waiheke, adding cockles to one of the experimental plots.

Photo: Nicole Hancock

Photo: Drew Lohrer

The study site at Pollen Island shows the array of sampling chambers (and the Auckland Skytower in the distance).

Fluxes summarise the system

Oxygen and nutrient fluxes from the same animals in the same type of habitat should produce the same results. If there is a flux difference between sites, it may be due to the health of the ecosystem (animals, microalgae, and bacteria), which may reflect how stressed the ecosystem is. By measuring the same habitat and animals at each site and looking at differences in results, we hope to understand what effect contamination has on resilience.

When the tide covers the clear and dark chambers, they hold water over the experimental patch of sediment. Water drawn from the chambers at the beginning and end of the tidal cycle is analysed for changes in dissolved oxygen and nitrogen.

Mesh cages hold transplanted animals in place until they burrow back into the sediment.

Photos: Nicole Hancock

Why we increased stress

An ecosystem that has been exposed to contaminants over a long period of time can become stressed and its resilience weakened. It may have similar types of animals, microalgae, and bacteria to a pristine site, but they may be unhealthy or out of balance. So the stressed site is likely to have a stronger reaction to a small, prescribed amount of stress.

We hypothesise that the pristine Waiheke Island site would be less contaminated (and less stressed), so it would be more resilient to the organic loading and give different flux results compared to the contaminated Whau River site. This is why we added organic matter (corn starch), a mild form of environmental stress.

Why we measured fluxes

To determine the ecosystem's response to our treatments of biodiversity and organic loading, we measured oxygen and nutrient fluxes because fluxes summarise the system (see box above).

On a rising tide, we put clear and dark chambers over our experimental plots of sediment where we had added or removed animals. Clear chambers allowed sunlight to pass through to the underlying sediment, while dark chambers prevented sunlight passing through; photosynthesis occurs only in the presence of sunlight. Once the tide covered the chambers, we drew initial water samples from the chambers, and measured the amount of oxygen, nitrogen, and other compounds in each sample. We then left the chambers in place with the water trapped over the sediment. A few hours later we again took water samples and compared the results with the initial samples: the difference between the initial and final samples is the basis of a flux calculation.

While the chamber was in place and the water was trapped, the oxygen and nitrogen levels were changing because of the metabolic activity of animals, microalgae, and bacteria. Nutrients generated by bacterial activities generally diffuse from the sediment into the chamber water, but the movements of large worms and cockles often increase the release of nutrients. Microscopic algae, such as diatoms, will use nutrients and photosynthesise (producing oxygen) so long as light is present. The animals living in the sediments need oxygen (like all animals), and will tend to reduce oxygen concentrations.

We are still analysing our samples. Preliminary results suggest there were differences in the amount of dissolved oxygen produced by the manipulated animal communities, with similar patterns at each site.

Taking this work further

We plan to add other sites to increase the scope of this work in the next three years to gain a better picture of the effects of stress on ecosystems. With advice from scientists, information about estuarine ecosystem resilience can be used by resource managers and planners to diagnose ecosystem health, identify the limits of contamination that can be sustained by estuarine communities, and predict declining ecosystem health at the earliest possible stage. This foreknowledge can enable rapid intervention when there is a decline and can also inform potential restoration projects. W&A

Further reading

Ahrens, M. (2003). Urban runoff – how much can our streams and estuaries swallow? *Aniwaniwa 22*: 5.

Lohrer, D.; Hancock, N. (2004). Marine soft sediments: more diversity than meets the eye. *Water & Atmosphere 12(3)*: 26–27.

Nicole Hancock works with Dr Drew Lohrer and his team of marine ecologists based at NIWA in Hamilton. This study is part of the FRST-funded 'Estuarine Ecodiagnostics' programme.