Is coastal development degrading our seas?

Land use, sedimentation, and disturbance to marine communities

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Estuaries and coasts: where ocean, land, and culture converge

Estuarine and coastal ecosystems are of central importance to NZ's social and economic well-being

They are high-use, multi-use ecosystems

Effects of urbanisation and development in coastal lands can flow on to coastal seas

There are stages of coastal development. This is clearly one of the later stages.

Hard concrete surfaces dominate

Pulsed freshwater inflow
Contaminated storm water
Nutrients, Faecal coliform
Rubbish

Major shoreline modifications

Restricted seawater movement,
Sediment trapping, habitat change

Industry

Heavy metals
PAHs
Pollution

Ports

Channel dredging
Fouling paints
Introduced species

Reclaimed land

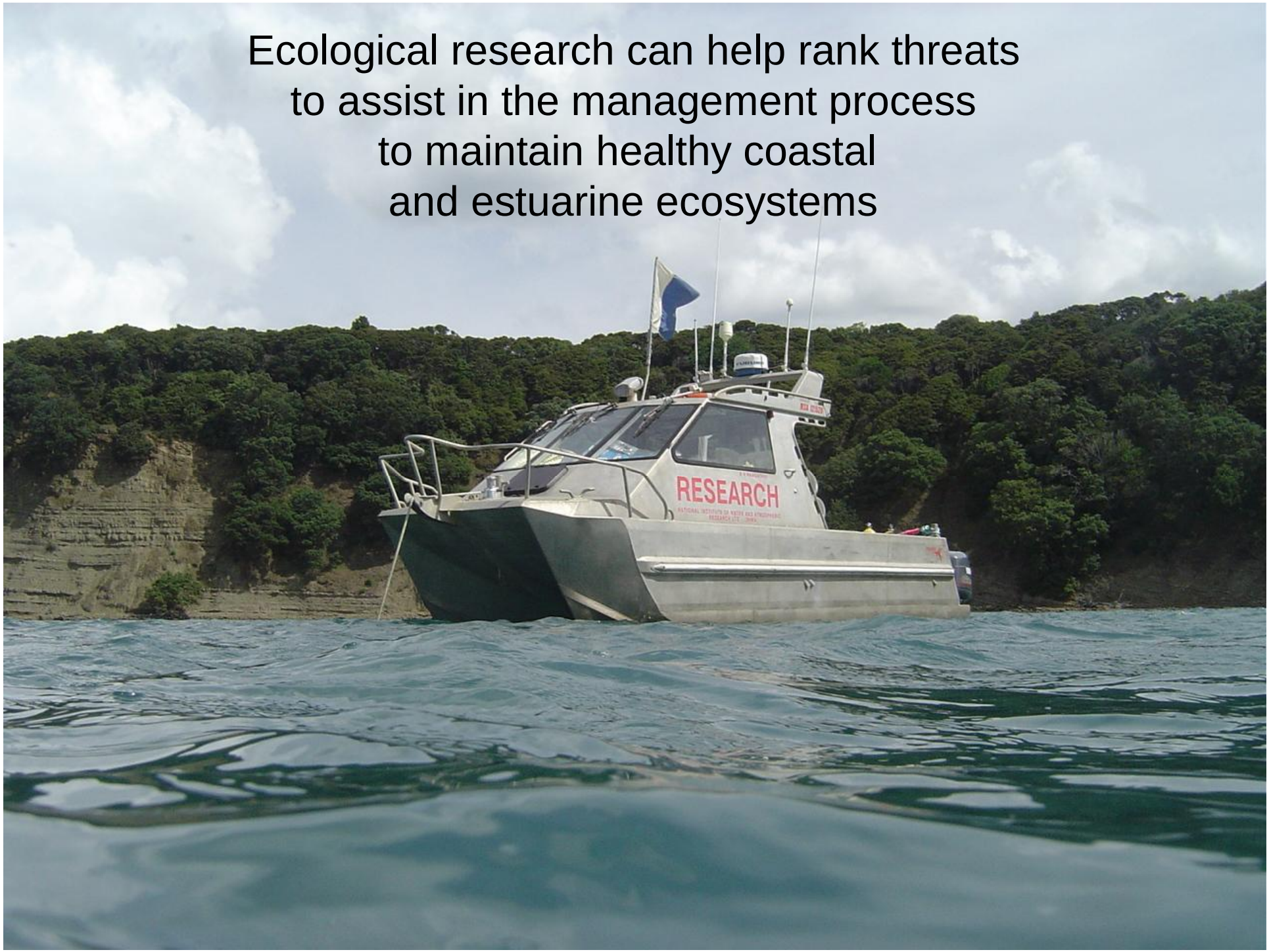
Habitat loss
Changes in tidal prism

An earlier stage of coastal development looks like this.

- Rural intensification
- Life-style blocks
- Beach homes

Sediment loading
Fertilisers / pesticides
Organic loading
Local overharvesting
Trampling
Marinas

Ecological research can help rank threats
to assist in the management process
to maintain healthy coastal
and estuarine ecosystems



Outline of today's talk:

- Defining disturbance in an ecological sense
- Examining terrestrial sediment, a source of marine habitat disturbance
- Using marine ecological science to characterise the risk of increased terrestrial sediment loads due to coastal land development on important near-shore marine communities

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Disturbance "an interruption of a process" or an "interference with a settled state"

A "process" in community ecology is feeding, or reproduction, or species interactions

The "settled state" is the structure that the community would assume *if conditions remained constant*

…but keep in mind that

1. conditions never remain constant for long
2. disturbance is a natural part of ecological systems

Natural disturbance

Forms of natural disturbance include

- Fires
- Droughts
- Floods
- Landslips
- Seismic waves
- Storm waves
- Ice scour
- Bottom water hypoxia

Some ecologists consider predators, which remove organisms and disrupt species interactions, as a type of disturbance.

Human influence on natural disturbance

(purposeful and/or accidental)

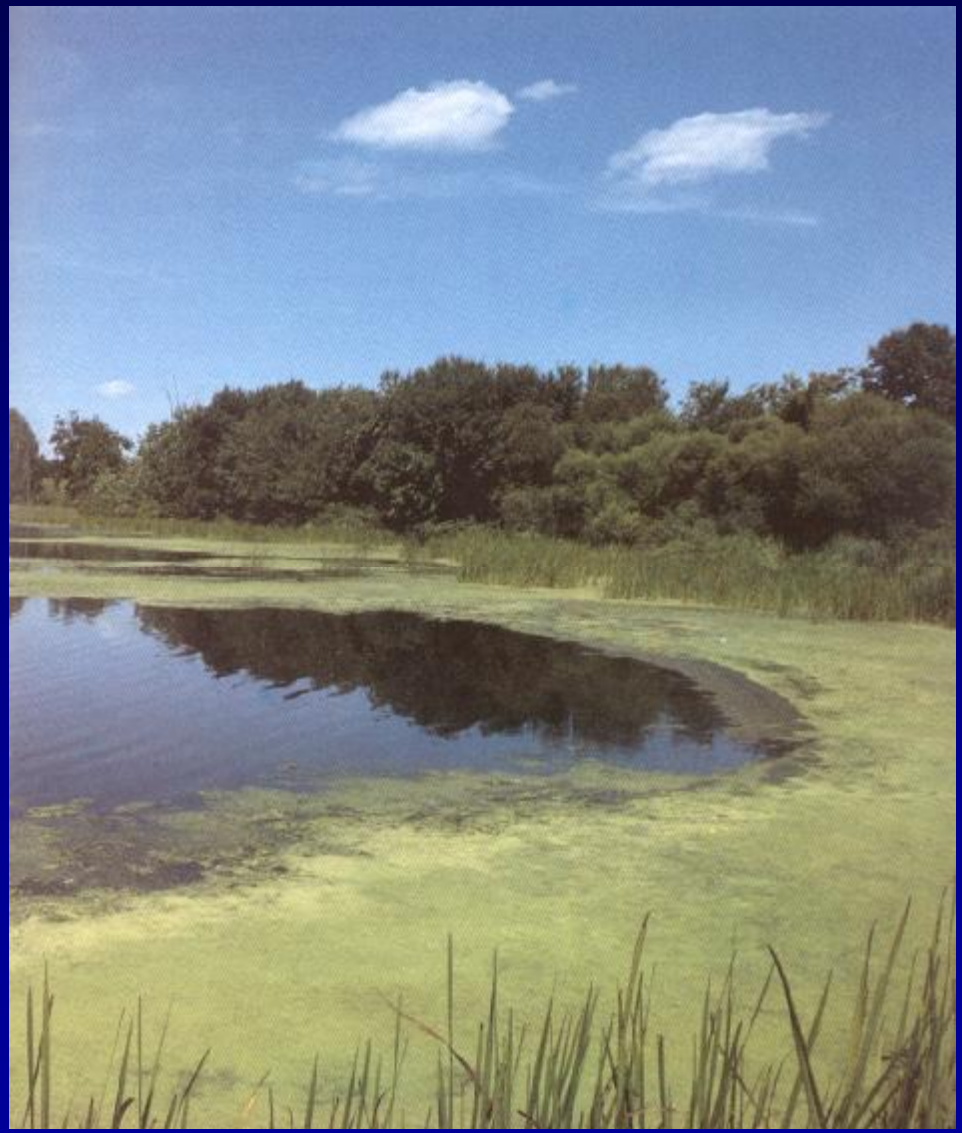
Addition of predators (introduction of exotic species) can reduce prey populations

Removal of predators (excessive hunting, overfishing) can cause outbreaks of prey species

Human influence on natural disturbance

(purposeful and/or accidental)

Excess nutrients (from laundry detergents, fertilizer run-off, etc.) can lead to blooms of algae and hypoxic bottom water



Human influence on natural disturbance

(purposeful and/or accidental)

Logging, farming, roading, and construction can increase erosion and landslips, increasing sediment loads in rivers and estuaries.

Human influence on natural disturbance

(purposeful and/or accidental)

Management action can help reduce
elevated loads of terrestrial sediments

Disturbance is not only natural, but can be beneficial

(depending on point of view)

When disturbance **“cleans the slate”** by removing dominant organisms (-) it frees up space and resources that can be used by other opportunistic species (+).

Too much disturbance is bad for all,
Too little disturbance is bad for some.

How we manage anthropogenic disturbance
depends on what we want to preserve and maintain

Disturbance regime has many components

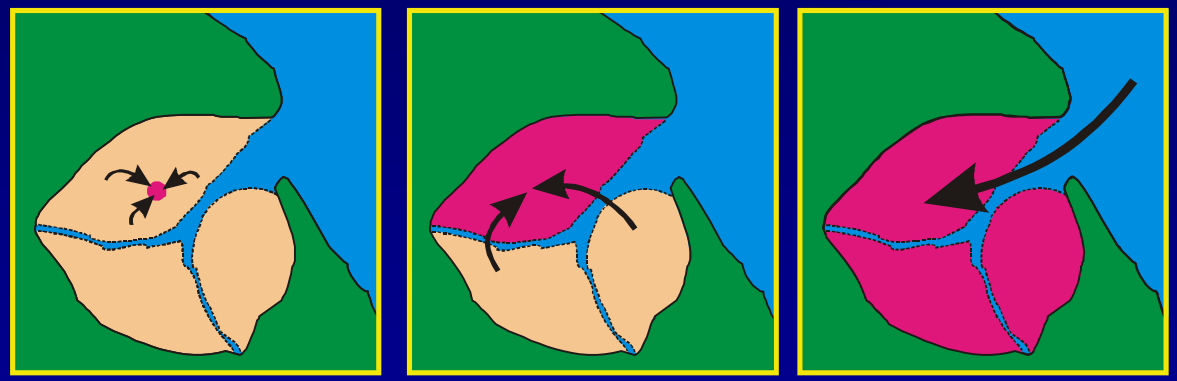
- Intensity
- Frequency
- Spatial scale
- Duration
- Timing

Response and recovery are also context dependent

- habitat type

Response and recovery are also context dependent

- habitat type
- spatial scale



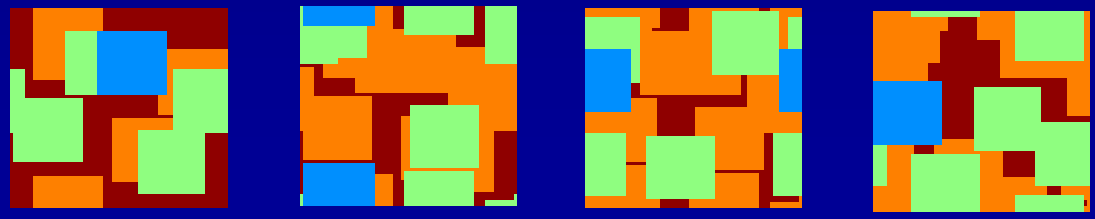
Disturbed area

Response and recovery are also context dependent

- habitat type
- spatial scale
- history
- patch mosaic
- multiple stressors

Recently disturbed
(newly recovering)

(mature community)
Not recently disturbed



Time

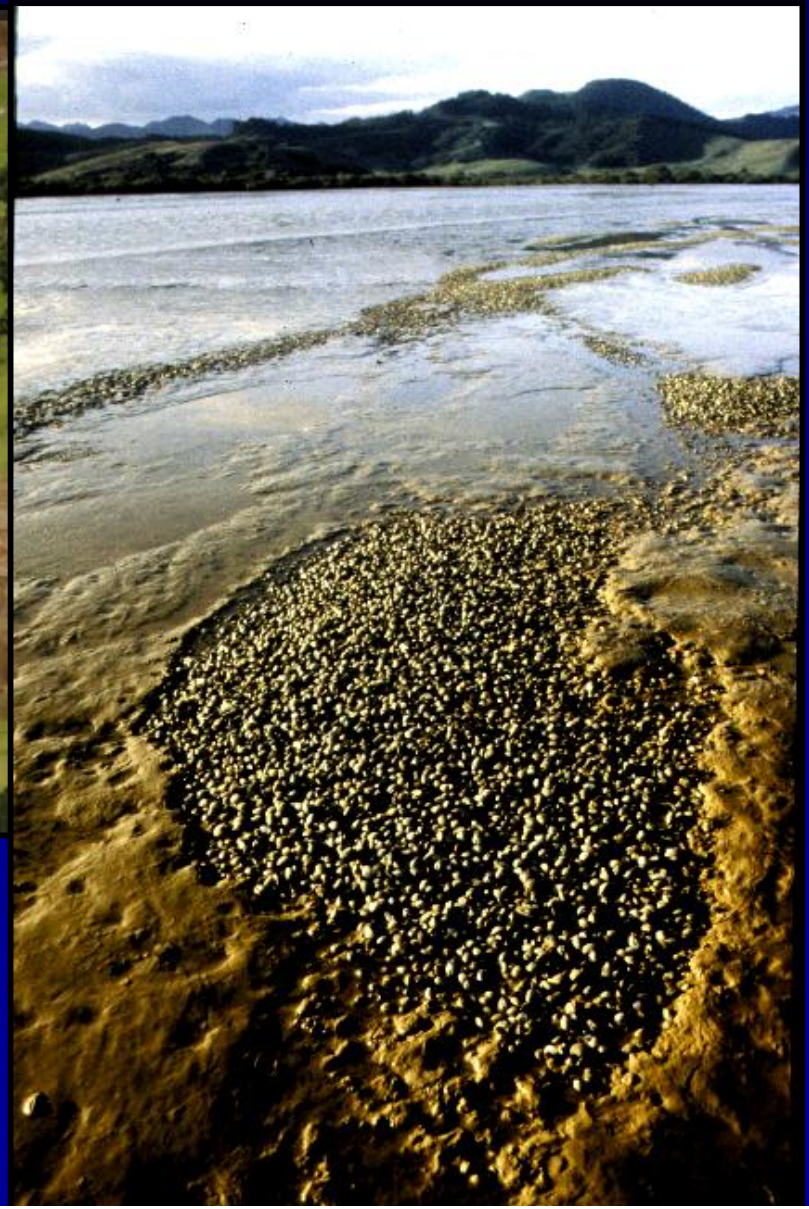
Spatial and temporal variability makes this leap untenable.

Ecology and the disturbance-recovery framework
is more appropriate for understanding the
implications of coastal development


Terrestrial sediment is a
major disturbance agent
in NZ's marine environment

Land use practices exacerbate the naturally high rates of sediment loading that occur in coastal New Zealand

This has consequences for New Zealanders and their coastal and estuarine resources



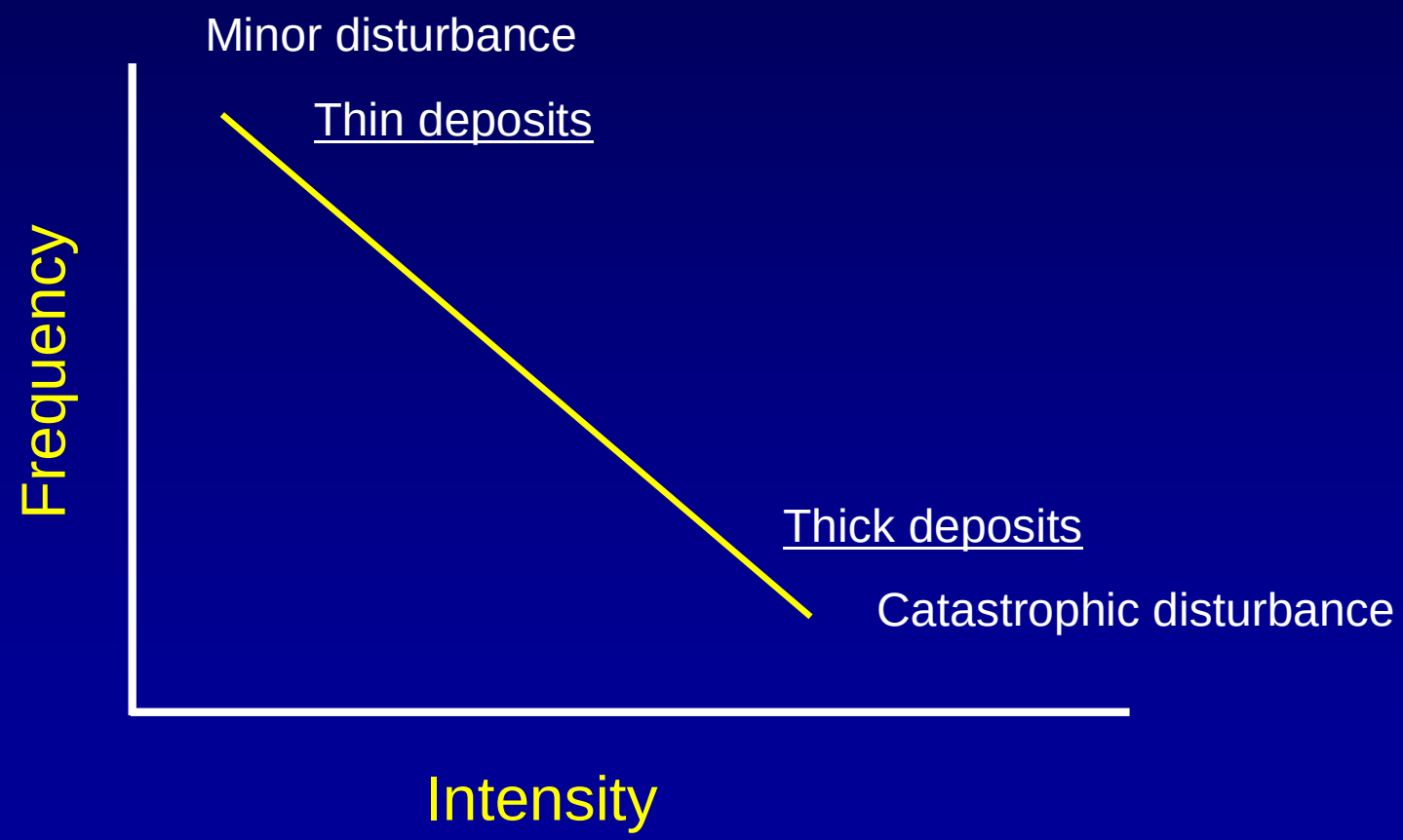
Sediment loading is pulsed

"events" of different size
occur at various intervals

Suspended sediments

Sediment deposits

Minor disturbance events occur more regularly than major catastrophic disturbance events

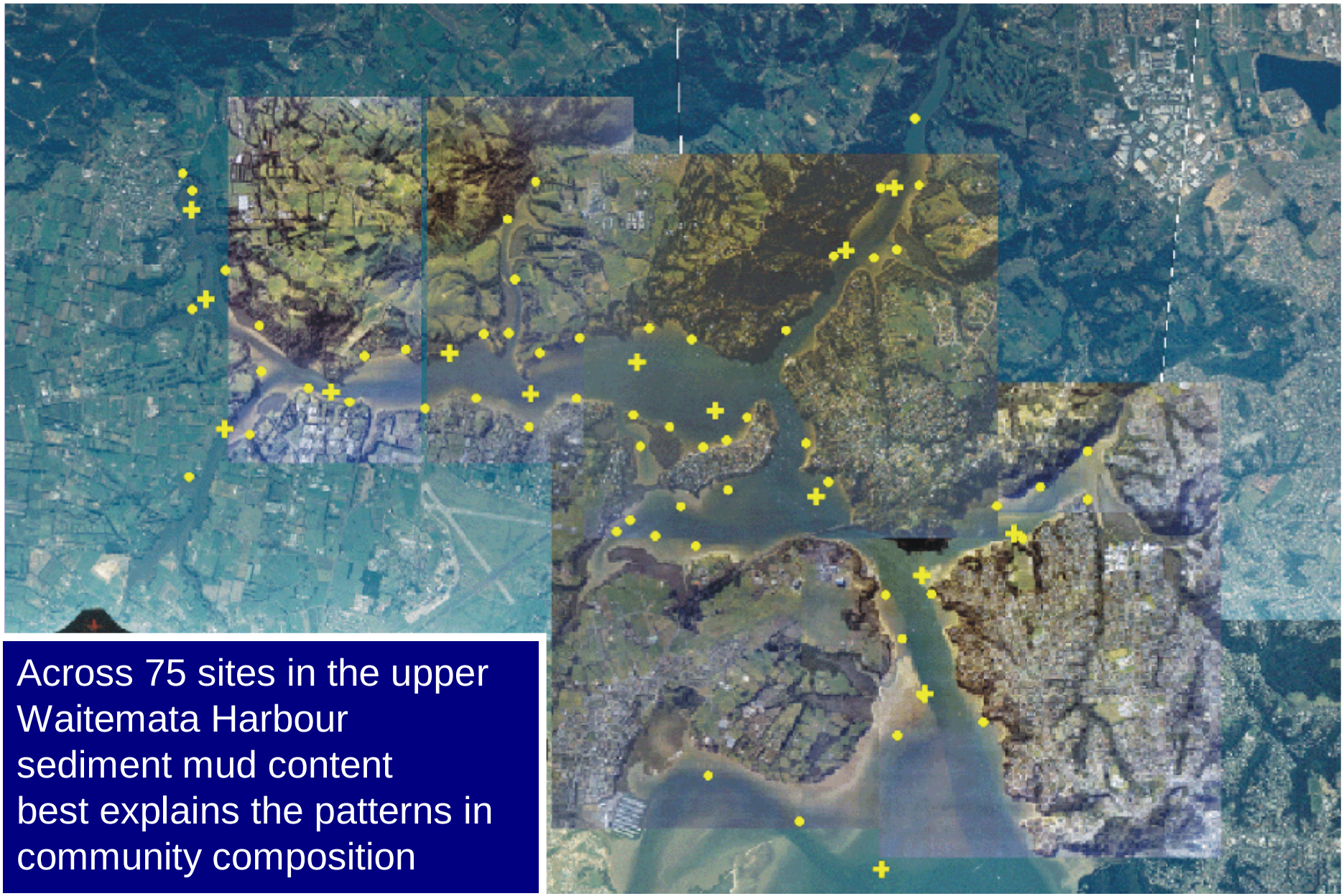


Physical factors, such as wave and currents,
can determine the duration of stress
and influence the speed of recovery

And the animals themselves often break up terrestrial sediment deposits and contribute to patch recovery

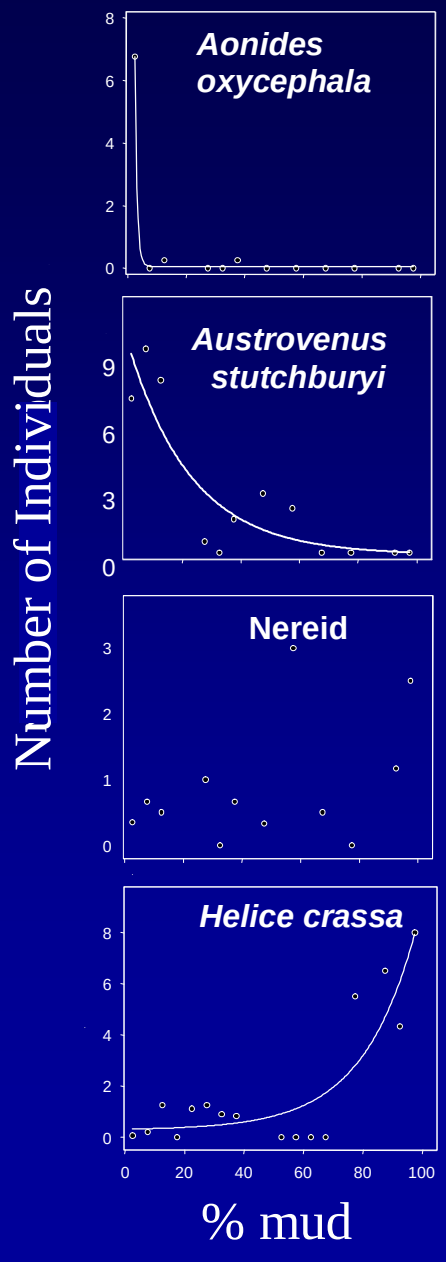
So… why the big fuss about terrestrial sediment? What is the harm in adding some extra mud to habitats that seem muddy already?

Invertebrates that live in soft-sediment habitats are strongly influenced by sediment mud content



Across 75 sites in the upper Waitemata Harbour sediment mud content best explains the patterns in community composition

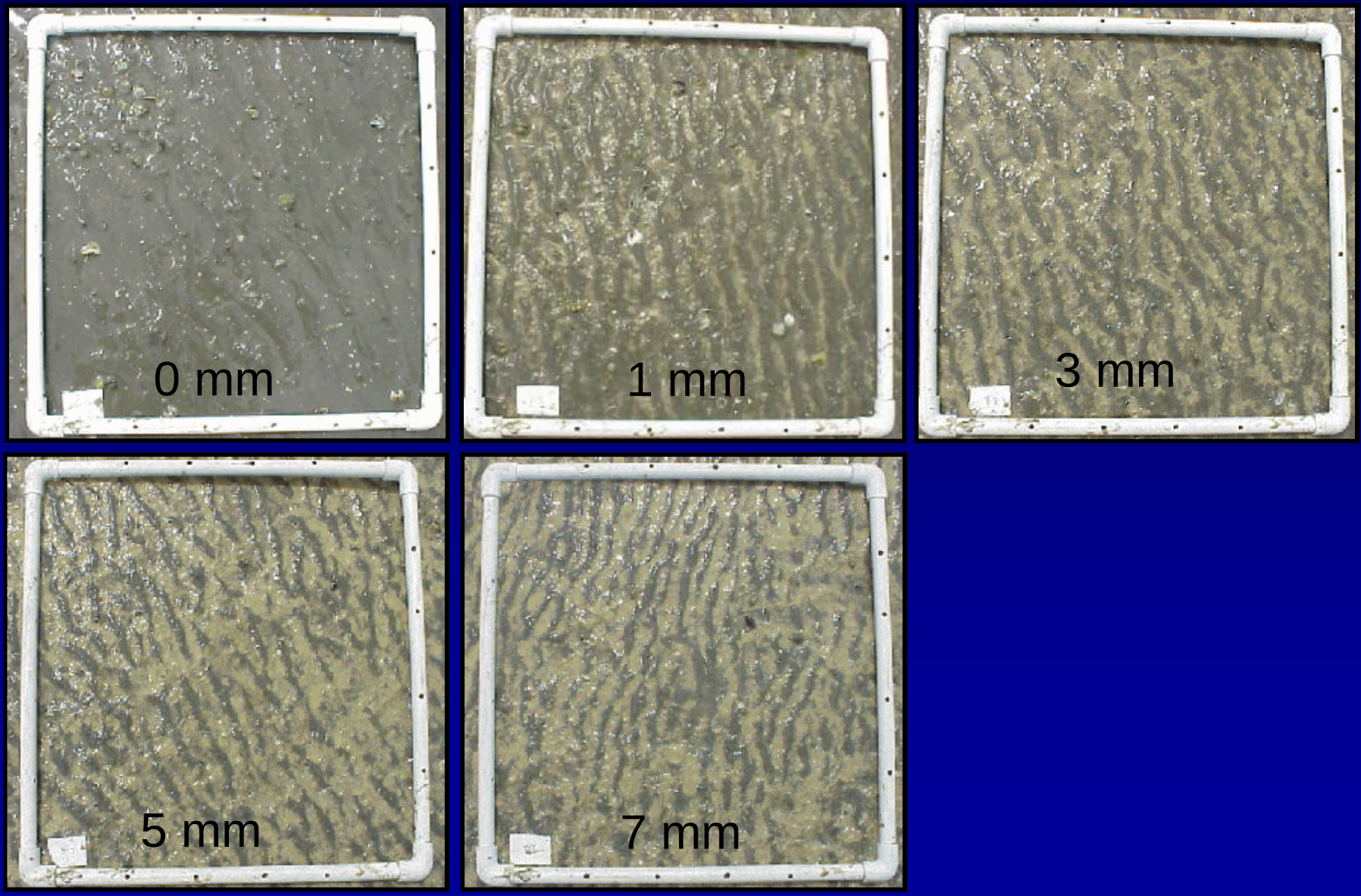
Responses vary among species… some like mud, some hate it



	Optimal Range	Distrib. Range	Sensitivity
Aonides oxycephala	0-5%	0-5%	v. sensititve
Austrovenus stutchburyi	5-10%	0- 60%	sensitive
Nereid	55-60%	0-100%	slightly positive
Helice crassa	95-100%	5-100%	v. positive

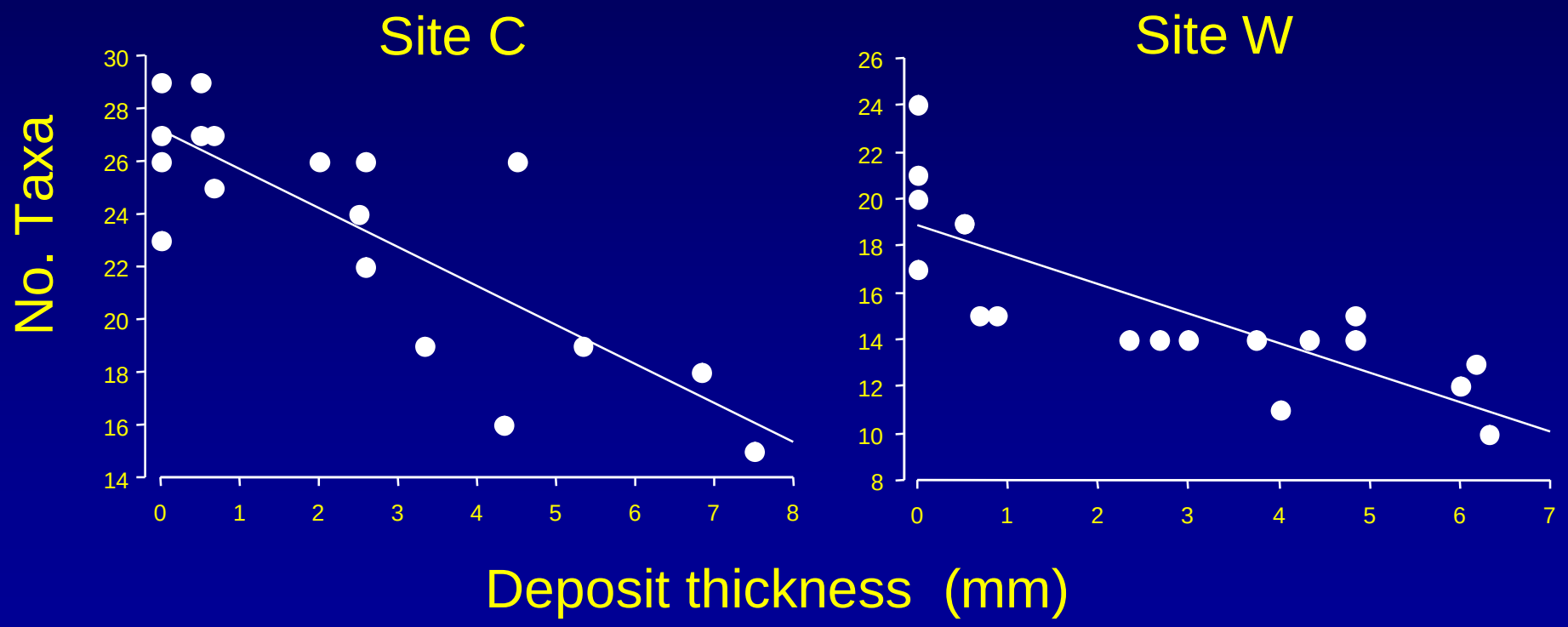
Field experiments involving terrigenous sediment
have been performed in several North Island estuaries
to examine response and recovery of soft-sediment invertebrates

As is done with other contaminants, we studied the effects of differing doses of terrigenous sediment



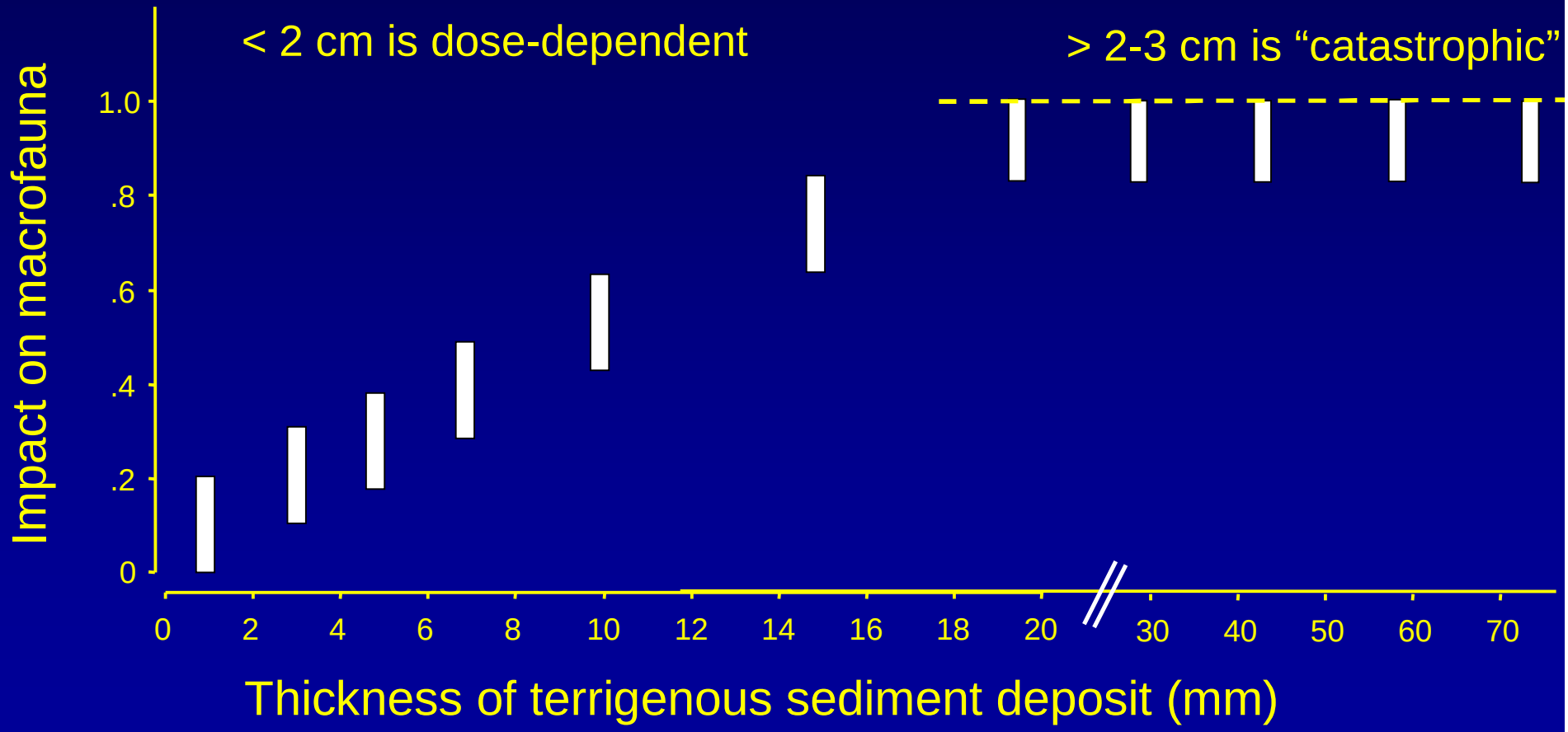
Responses are generally similar in different community types

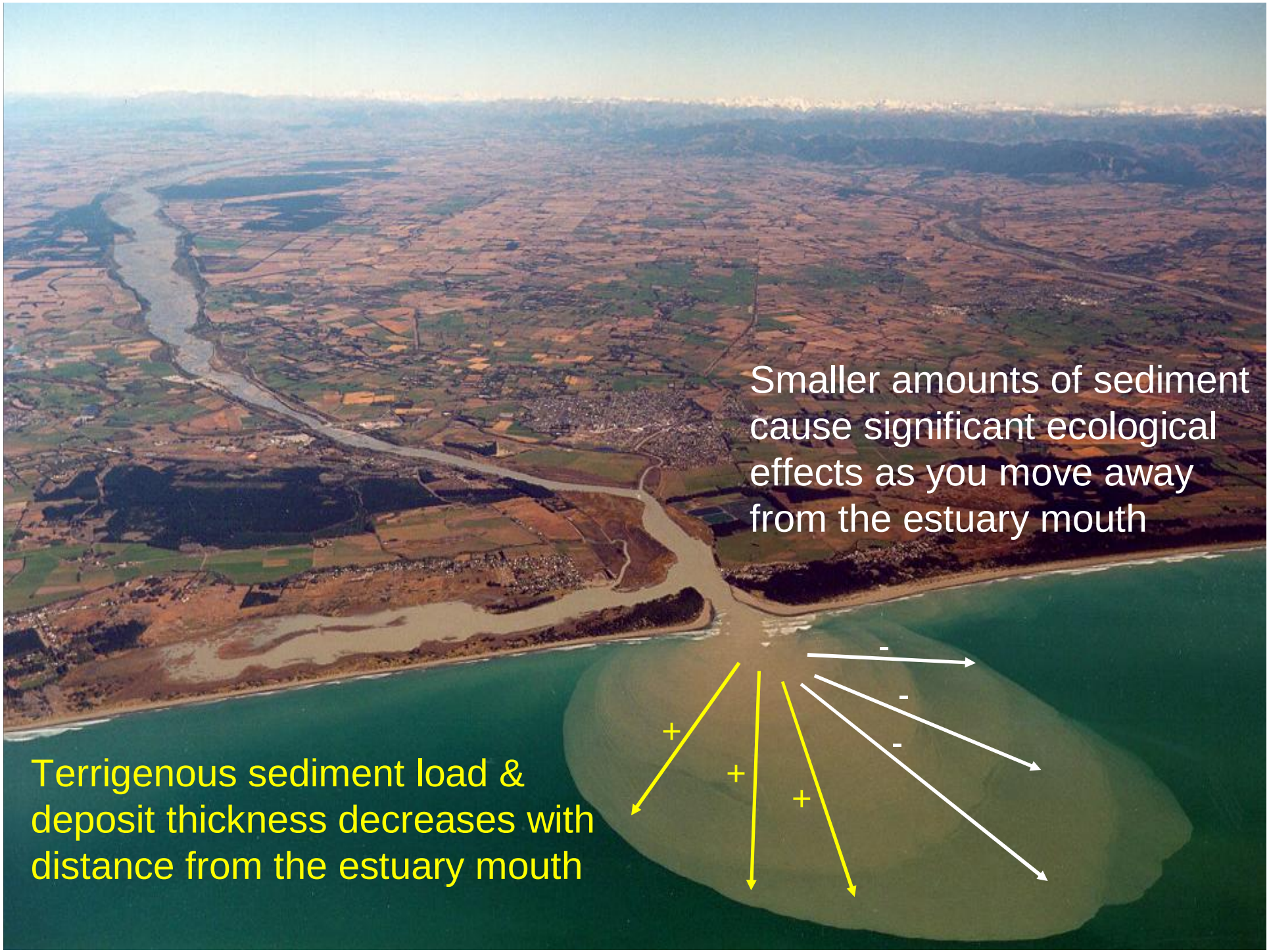
- Deposits as thin as 3 mm can have an effect
- Terrigenous sediment reduces diversity & number of individuals and taxa



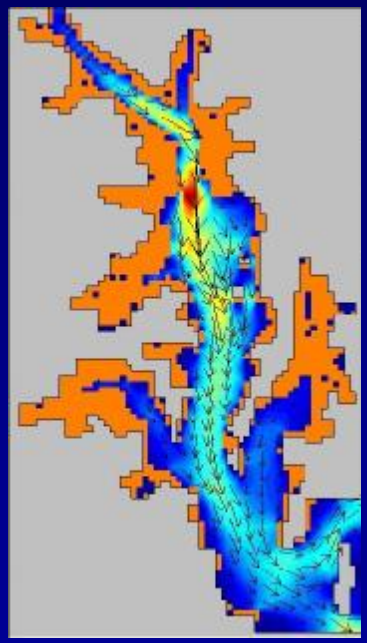
Frequent deposits produce cumulative degradation

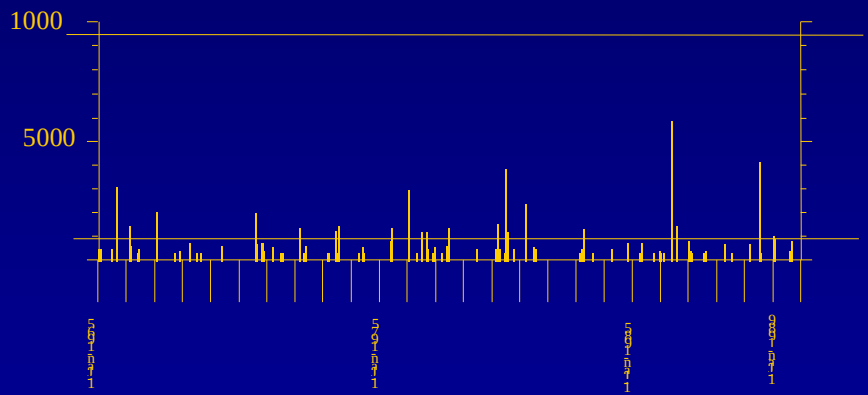
& Deposits > 2-3 cm thickness are “catastrophic”

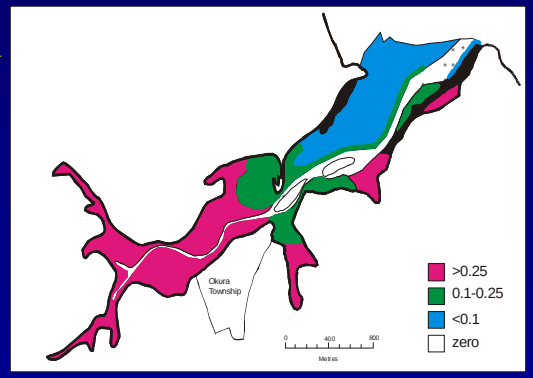



Smaller amounts of sediment cause significant ecological effects as you move away from the estuary mouth
Terrigenous sediment load & deposit thickness decreases with distance from the estuary mouth
+
+
+
-
-
-

So… even though we can measure and model sediment transport and deposition, understanding the ecology is key to accurate risk assessment



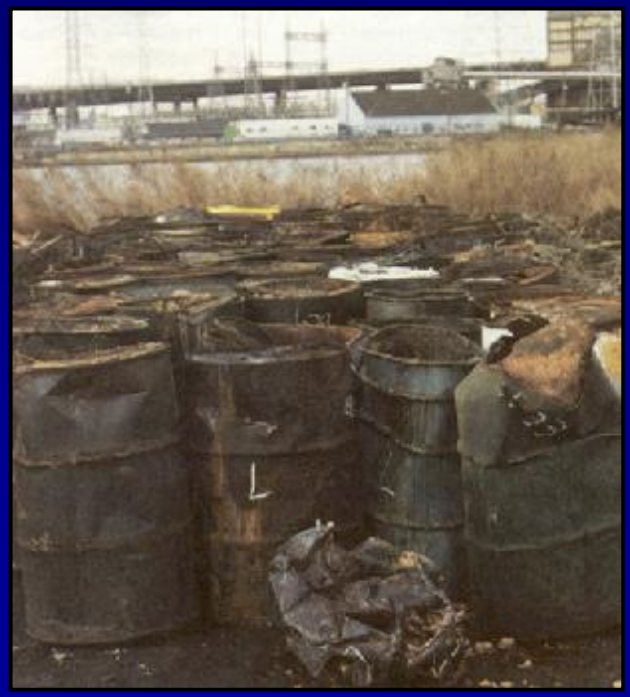




Future directions

Multiple stressors & biodiversity-resilience relationships

- Contaminants are often bound to and transported with terrestrial sediments
- Nutrients and organic carbon loading also correlated with sediment loading
- Once biodiversity starts to go, does this affect resistance to further shocks ?



We ecologists want to contribute to the management process to maintain healthy ecosystems for future generations



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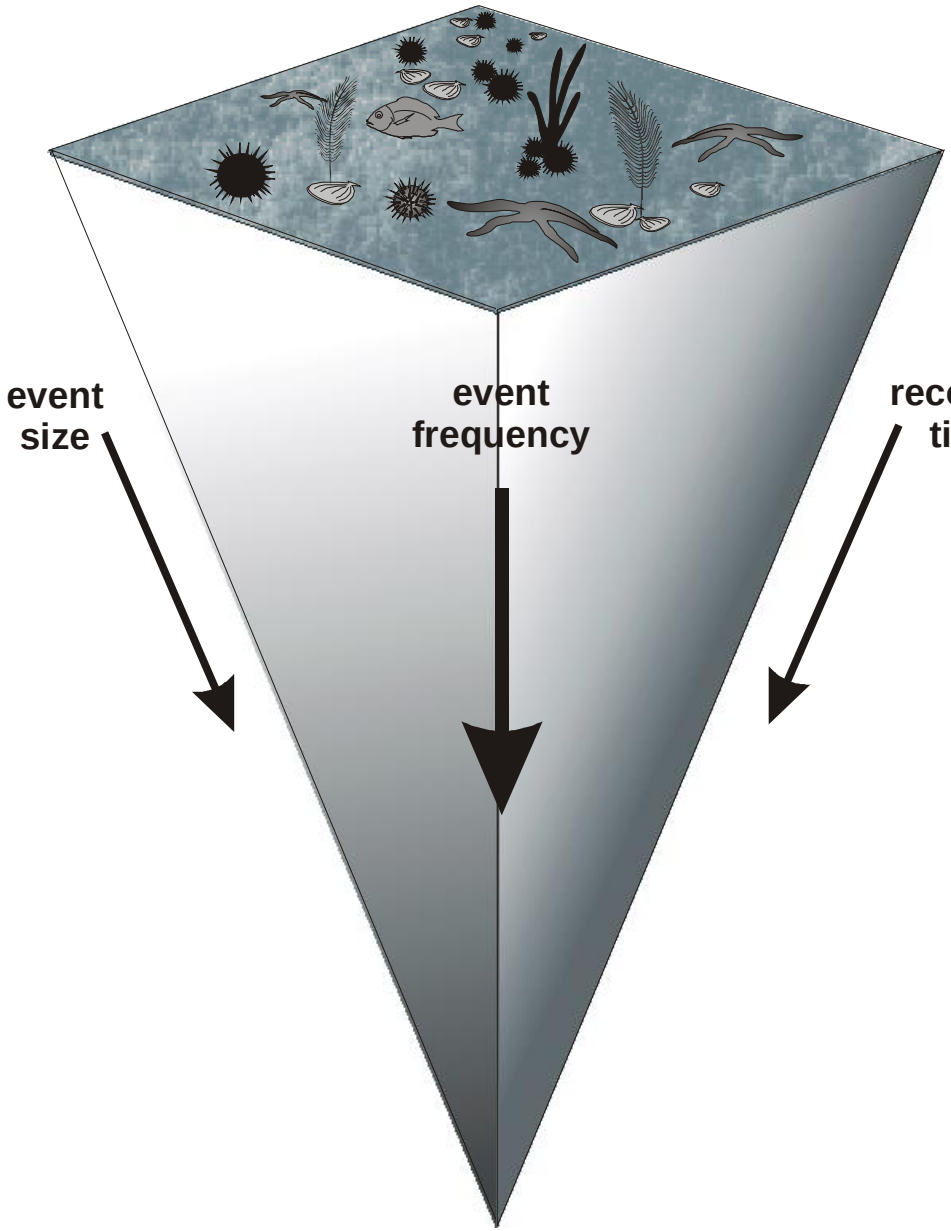
Thanks very much to the ARC & FRST for financial support and for helping us forge ecology-management partnerships



Small changes in
population structure

Small changes in
community composition

Large changes in
populations and communities

Decreases in diversity

Increases in habitat change

Increases in habitat fragmentation

Decreases in heterogeneity

Decreases in functionality

Very few species

Estuarine water is naturally turbid relative to coastal seawater

Animals of the same species
exposed to the same amount of stress
can respond in different ways
when adapted to different local conditions