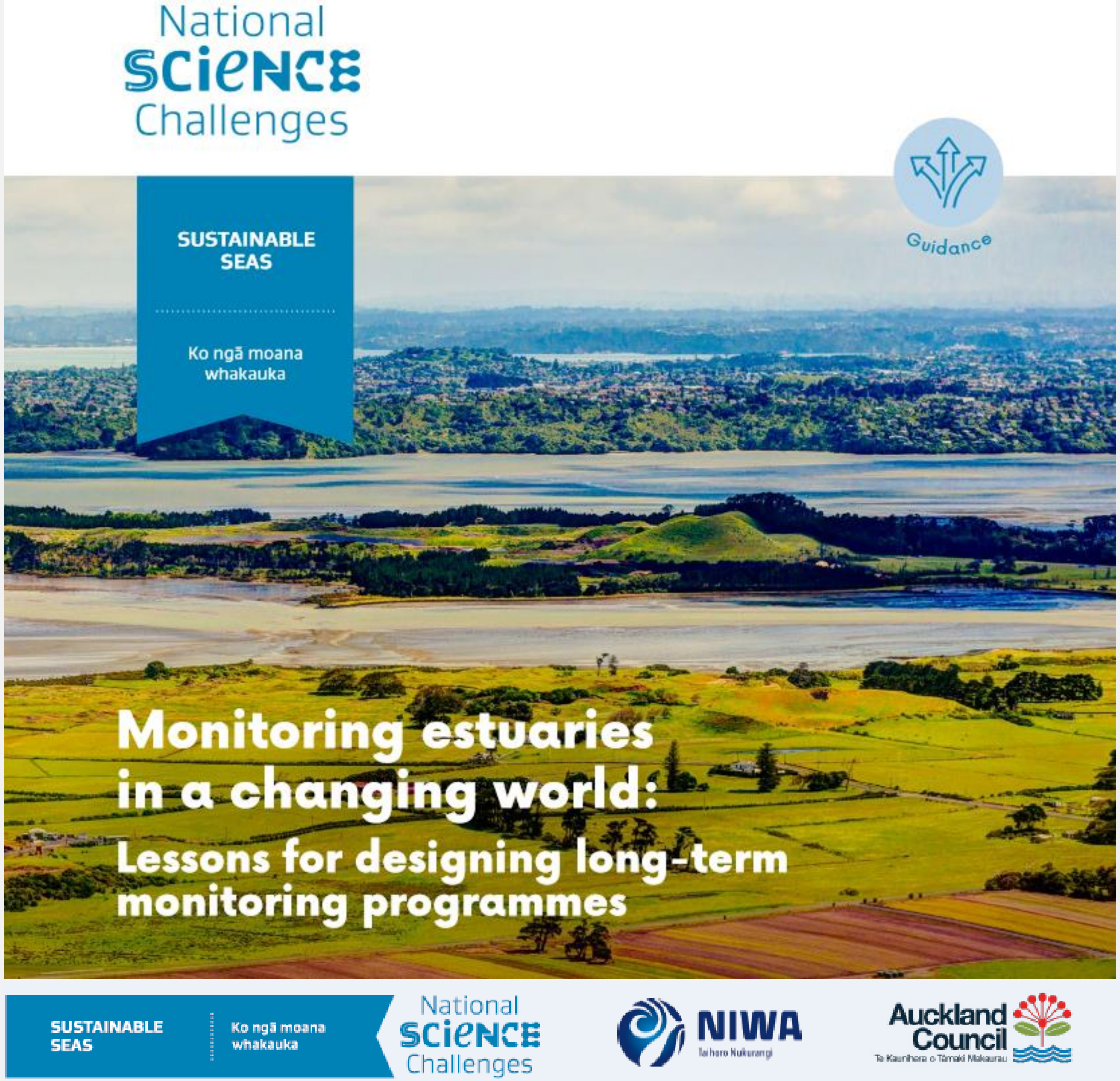
Judi Hewitt &
Megan Carbines



Long-term monitoring programmes are crucial to:

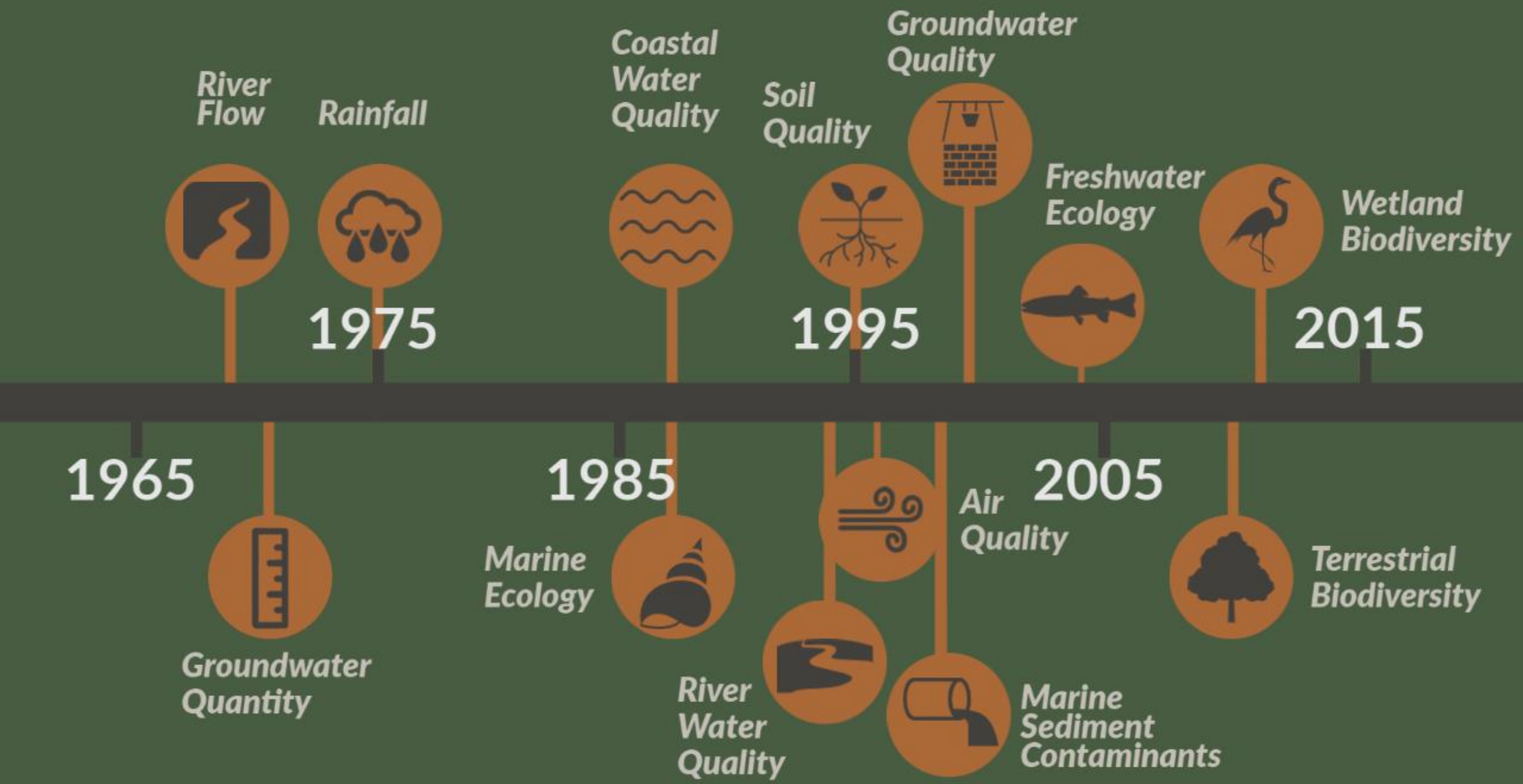
- Defining the state of the environment
- Understanding natural temporal variability
- Identifying changes driven by manageable anthropogenic stressors
- Providing baseline information on past management decisions
- Tracking trends to inform future management strategies


Credit: N Gilligan

SOE in the Manukau Harbour

- Significant harbour
- Long history of both modification and pollution
- Benthic ecology monitoring established in 1987

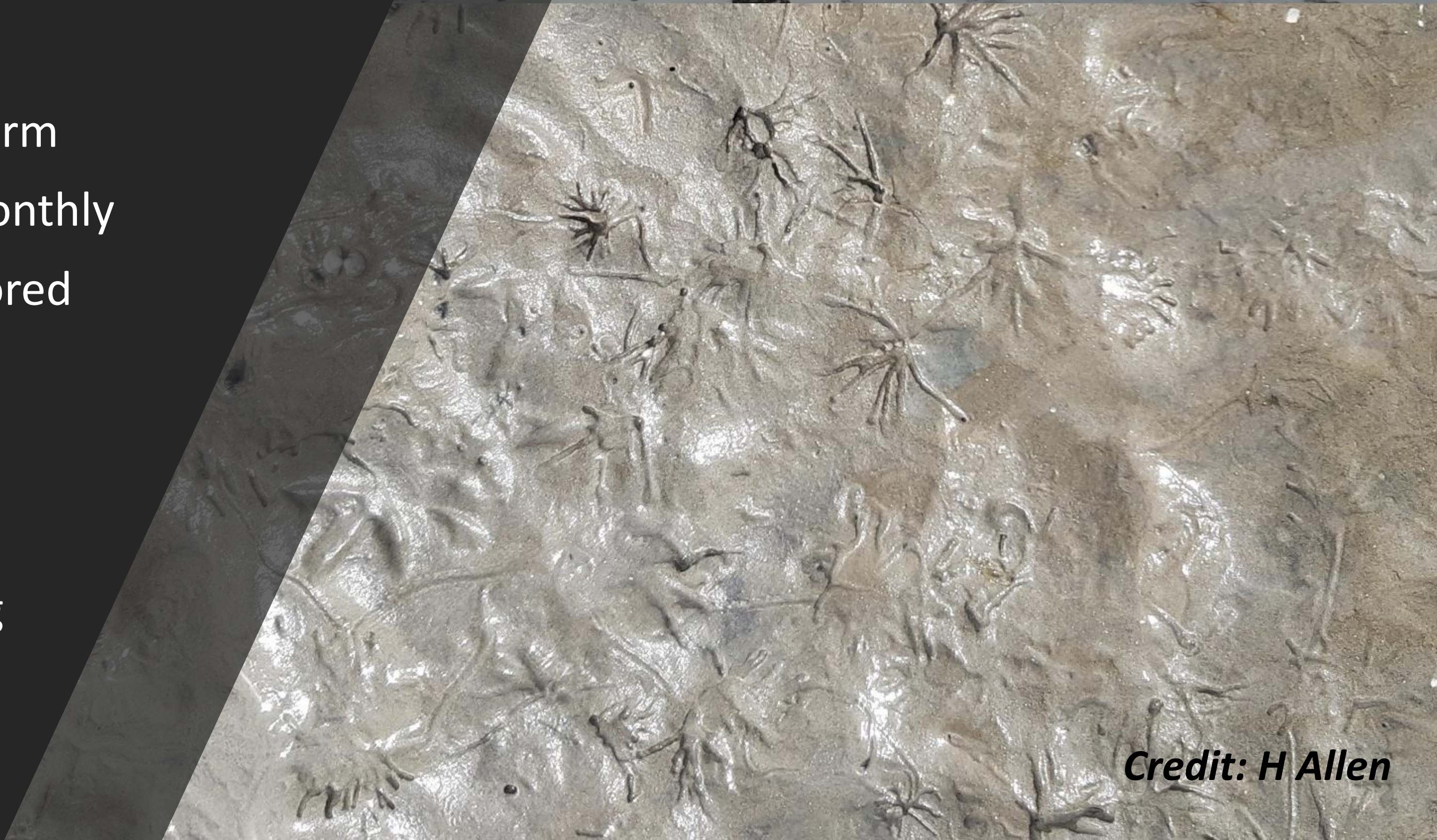
Credit: N Gilligan


River Flow
Rainfall
Coastal Water Quality
Soil Quality
Groundwater Quality
Freshwater Ecology
Wetland Biodiversity
1975
1995
2015
1965
1985
2005
Groundwater Quantity
Marine Ecology
River Water Quality
Air Quality
Marine Sediment Contaminants
Terrestrial Biodiversity

Benthic Ecology Monitoring in the Manukau

- Established 1987
- Sediment characteristics and selected macrofauna
- Spatially and temporally nested design
- Sites at the confluences of each main arm
- Two sites permanently monitored bimonthly
- Four other sites that have been monitored bimonthly but with periods of ‘rest’ – generally two years monitored, five years rest.
- In October each year full taxa sampled
- Supplemented by less regular sampling of tidal creeks – annual to five-yearly

Credit: T Drylie



Credit: H Allen

More than a monitoring programme

- In 1987, parent organisations of AC and NIWA began what ended up as a long-term relationship in monitoring
- Over the years this led to much fruitful research and learnings about monitoring
- Research in Sustainable Seas *Tipping Points* project offered us a place to query monitoring programmes around new thoughts
    - Specifically the detection of tipping points and the impacts of climate

Tipping Points and time series data are particularly linked

- "Trends not detected until change has occurred" creates fundamental rethink in how to detect and thus to monitor for them
- Research on early warning signals suggests that a change in variability occurs prior to the threshold
- Many tipping points also occur when climate change is added to other stressors

sustainableseaschallenge.co.nz/robust-cost-effective-marine-monitoring

From this work came 7 lessons for long term monitoring.

The first two lessons apply to all long-term monitoring programmes,
no matter what you are monitoring.


Credit: H Allen

Lesson 1

Principles of design to be decided on at the start of the programme

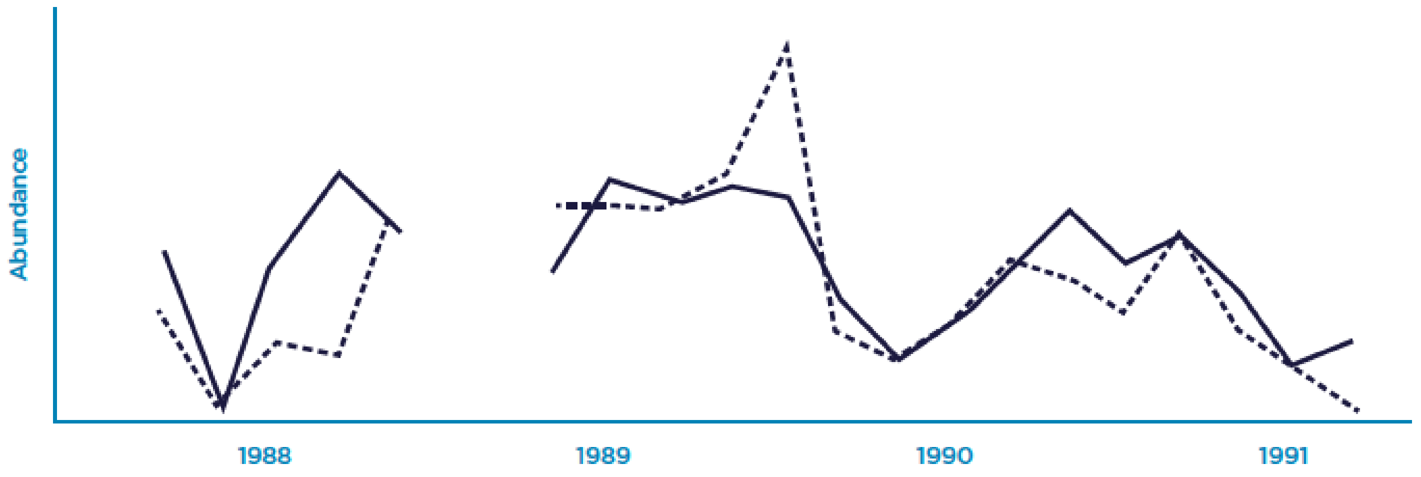
- There are some design factors to be decided upon at the start
  - Where and over what area are you going to sample?
  - What are you going to sample and how large a sample do you need?
  - How are you going to sample- random or stratified?
  - How many replicates do you need?
  - And with what frequency?

Lesson 2

Undertake reviews at fixed points in time

Monitoring should be reviewed over time

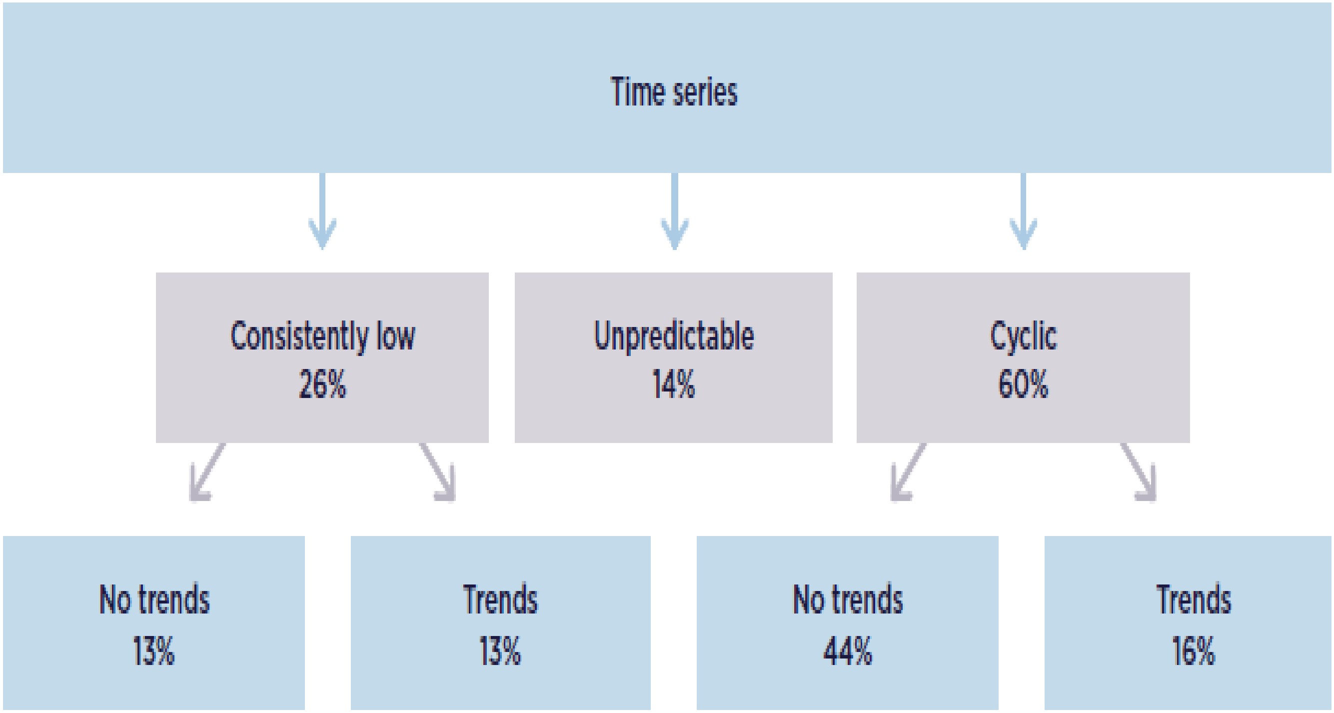
- What sized changes can it detect?
- Can it be improved or made more cost-effective?
- Do you really need that number of replicates, or to sample that often?



Lesson 3

Most variables will exhibit multi-year cyclic patterns as well as seasonal ones

- Most species abundances are predictable



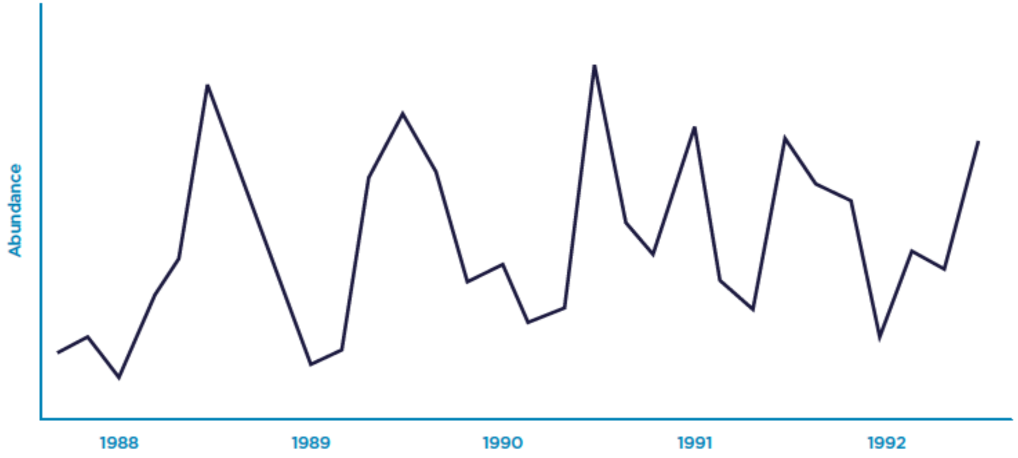
For short-time series: when is a trend a trend or part of a multi-year cycle?

Lesson 3

Most variables will exhibit multi-year cyclic patterns as well as seasonal ones

Use natural variability when detecting changes

- Use time series analyses to detect trends



Lesson 4

It’s important to consider climate patterns in design and analysis

Use natural variability when detecting changes

- Use time series analyses to detect trends
- Incorporate Southern Oscillation indices into analyses

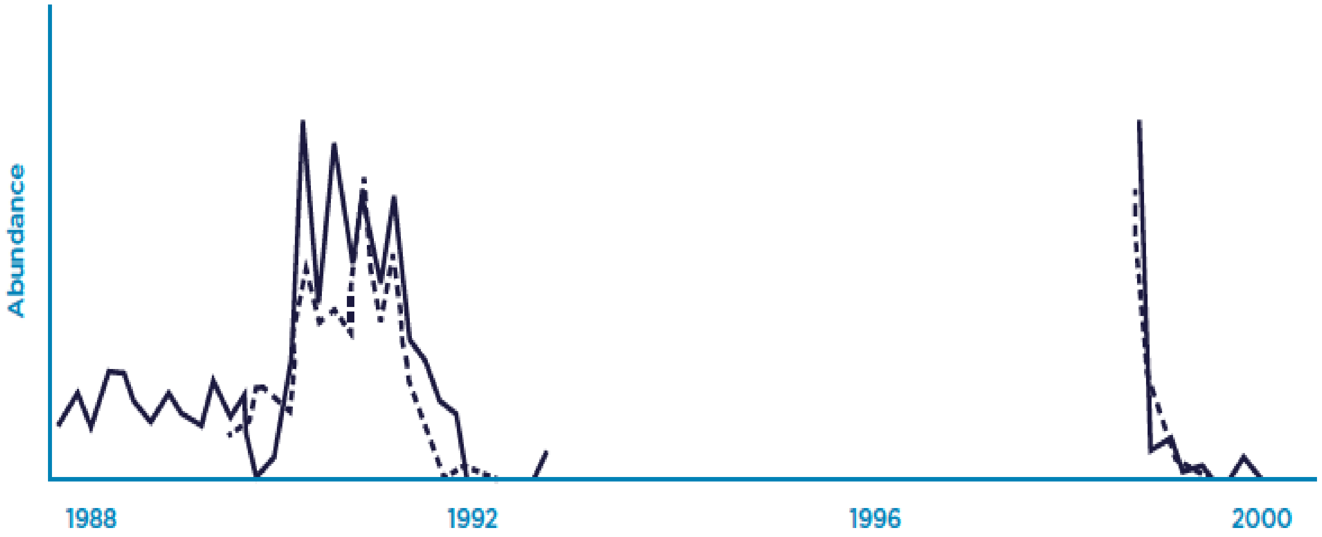
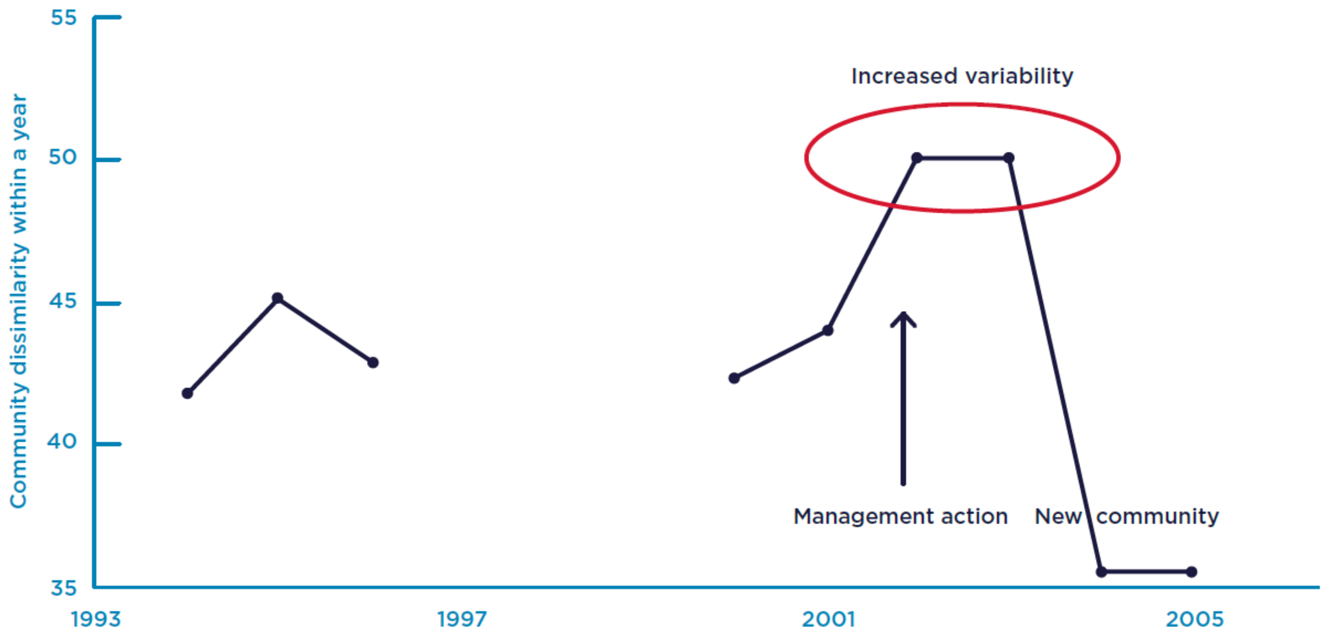


Figure 5: The solid line is the measured abundance and the dashed line is the abundance of a polychaete predicted by SOI and air temperature at one of the sites with interrupted sampling (Hewitt & Thrush 2009).

Lesson 5

To detect tipping points, sampling **more than** twice per year is optimal

- We have detected the arrival of a tipping point in the Manukau in response to improvement of sewage treatment



Lesson 5

To detect tipping points, sampling **more than** twice per year is optimal

% change detected

	Once	Twice	4 times	6 times
Boccardia	92	88	74	53
Austrovenus	86	57	27	27
Methalimedon	98	57	41	43
Taeniogyrus	88	89	78	74

- Other analyses linked size of change detected to within-year sampling frequency

sustainableseaschallenge.co.nz/
sampling-frequency-duration-and-southern-oscillation

Lesson 6

Community analyses are much stronger than single-species analyses at detecting small changes

There are three reasons for this

- Small changes accumulate over time and also through species interactions
- Species respond in different ways allowing us to assign causality
- Rare species are often more sensitive

Lesson 7

The length, frequency and continuity of a dataset will determine its ability to detect tipping points

- The longer a dataset, and the more frequently the data is collected, the more use it is for determining effects – but only if it is breaks in collection are minimal

		R^2	Standardized estimate	*p*-value
Magelona		0.72		
	Duration		−0.46	0.0136
	Frequency		−0.44	0.0190

Lesson 7

The length, frequency and consistency of a dataset will determine its ability to detect tipping points

- Having some sites continuously monitored in your network gives you more ability to detect changes in the other sites you monitor

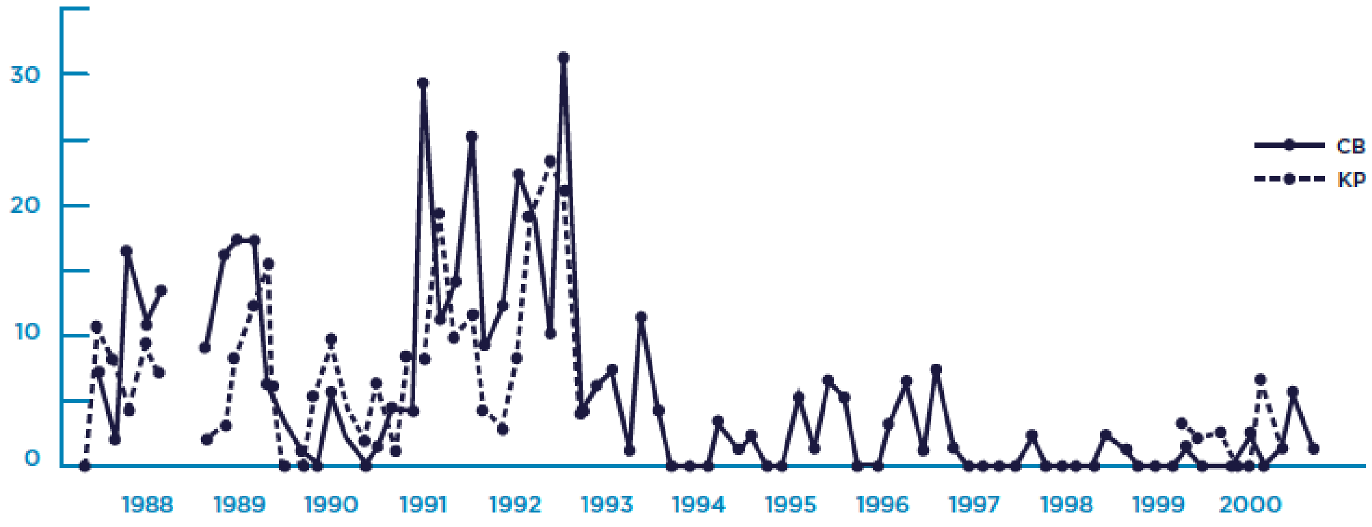


Figure 2: Difference over time detected for CB but not KP because with the interrupted sequence the abundances in 1999–2000 are similar to those in 1990–1991. However, the previous similarity in the dynamics at CB and KP suggests that KP is also undergoing a decline (Hewitt & Thrush 2007).

Changing with the times

- Able to detect changes in the harbour
- Flexible depending on what monitoring was showing and what was happening in the harbour
- By moving to rotational sites was able to expand into other parts of the region
- Moving to rotational sites in other locations meant we could expand within a decreasing budget
- Higher frequency sampling in Manukau gave context and confidence
- Tipping Point analysis – confidence that we could reduce frequency and still detect a change
- Continuing challenges for the catchment with large areas of new urban development, climate change and emerging contaminants. Monitoring needs to be able to respond

7 lessons

- Principles of design to be decided upon at the start of the programme
- Undertake reviews at fixed intervals, to ensure cost effective, yet provides quality, robust data
- Analysis of long-term data can detect multi-year cyclic trends and patterns that short-term data cannot
- Temporal variability can influence the ability detect tipping points, therefore it is important to consider climate patterns in design and analysis
- To detect tipping points, sampling more than twice per year is optimal
- Community analyses are much stronger than single-species analysis for detecting small changes
- The length, continuity and fequency of a dataset will determine its ability to detect approaching tipping points or determine whether one has been past

sustainableseaschallenge.co.nz/lessons-for-long-term-monitoring