

Guidelines for Community-Focused Ecological Monitoring of Mangrove Habitats in Estuaries



Community Monitoring, Ngataringa Bay, Bayswater, Photo L. Sweetman

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(Mangrove Guidelines)

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Executive Summary

This document (mangrove guidelines) was prepared after the Mangrove Steering Group identified a need to develop standard methods for monitoring changes in estuaries, with emphasis on mangrove habitats. In 2003, Environment Waikato initiated a workshop comprised of research providers on the Mangrove Steering Group and a representative from Environment Bay of Plenty, Environment Waikato, Auckland Regional Council (ARC) and Department of Conservation. Each of the regulatory organisations contributed to the process resulting in the first draft of this document in 2003.

In the following year NIWA, as part of NIWA's FRST funded Aquatic Contaminants Programme, and ARC carried out trial sampling methods with community groups. Subsequent modifications of these sampling methods based on the trials, literature reviews and other on-going projects have been incorporated in this document.

The objective of the mangrove guidelines is to provide some guidance on techniques that individuals, or groups with an interest in mangroves can employ to investigate environmental questions within their local estuaries. The document suggests scientifically sound methods that are specific to monitoring physical and biological changes in mangrove habitats. Methods include monitoring how vegetation boundaries change over time, the use of mangroves by fauna and sediment characteristics. The guidelines are not intended to be all-encompassing, but are instead targeted to identified environmental questions within mangrove habitats.

The methods are designed to address two questions identified by the Mangrove Steering Group: what is the distribution and character of mangroves and adjacent habitats and how do these change over time; what are the special considerations for monitoring the effects of mangrove clearance?

The document describes and provides methodological detail for a recommended minimum set of techniques to address each of these questions. Additional techniques are recommended for intermediate and detailed monitoring options which will depend on the site, the goals of the monitoring programme and the resources available. An example of how the recommended minimum suite of monitoring observations have been adopted by an estuary monitoring group is available in a companion publication to this document: *Estuary monitoring by communities: mangrove habitats, a case study* (NIWA and Waikaraka Estuary Managers).

As an individual or group with an interest in mangroves in your area, your particular question may differ from those addressed here. If you would like to design your own monitoring programme, it is strongly recommended that you seek advice from the relevant Regional Council or an appropriate research/science provider.

1. Introduction

Community groups and other parties in the Mangrove Steering Group have identified a need to develop standard methods for monitoring changes in estuaries, with emphasis on mangrove habitats. Although mangroves are only one of a number of estuarine habitats that could be monitored, recent changes in mangrove extent have turned community interest and concern to these components of estuarine ecosystems.

The objective of this document is to provide some guidance on techniques that individuals or groups with an interest in mangroves in their area can employ to answer questions of interest. The document suggests scientifically sound methods that are specific to monitoring physical and biological changes in mangrove habitats. The methods are not intended to cover all potential monitoring activities within the estuary, but provide targeted, easy-to-conduct sampling activities.

The methods and procedures presented in this document are effective techniques for monitoring change in key aspects of a mangrove habitat and have been used widely in the scientific literature. In addition, these methodologies have been chosen for their relevance to the New Zealand environment, but they are not the only monitoring options for mangrove habitats. Rather this document is designed to: (1) provide guidance in planning a simple monitoring programme and enable community groups to increase understanding of mangrove habitats in their local estuary, and (2) facilitate the collection of similar information between different areas, using consistent methods, which will enable comparable information to be exchanged across northern New Zealand.

The recommended minimum suite of methods proposed here have been trialled by community groups in Auckland and in Te Puna (Tauranga). The mangrove guidelines have been modified as a result of those trials. It is likely that modifications will still be required in the future to satisfy the requirements of specific locations. A simplified companion publication to this document is the *Estuary monitoring by communities: mangrove habitats, a case study* (NIWA and Waikaraka Estuary Managers). The case study is based on the recommended minimum suite of monitoring observations from the mangrove guidelines and provides an example of how they have been adopted by an estuary monitoring group.

There are a number of questions, which have been identified by the Mangrove Steering Group, that are better suited to targeted research programmes by research providers, requiring long-term scientific study and/or specialised expertise. The monitoring methods outlined in this document are not intended to replace programmes of comprehensive research required to address the identified research questions.

However, the collection of additional information from a range of locations can help contribute to our broader understanding of mangrove habitats in New Zealand.

We recommend that if you have an interest in mangroves in your area, you start by contacting your Regional Council for information regarding on-going projects and assistance with your sampling plans. Finally, we stress that the activities outlined in this document in no way substitute for the need to obtain a resource consent for any proposed activity in an estuary.

1.1 Scope of the document

The methods suggested in this document have been formulated in joint discussions with representatives from Department of Conservation, Auckland Regional Council, Environment Waikato, Environment Bay of Plenty, Landcare Research, Auckland University of Technology and the National Institute of Water and Atmospheric Research Ltd. (NIWA). These methodologies are focused on changes in the vicinity of a particular mangrove forest of interest and are not recommendations for monitoring flow-on effects of active management to other parts of the estuary (e.g., through sediment re-mobilisation). Such an extended programme is likely to be beyond the scope of resources envisaged for the target audience of this document and would need specialist scientific expertise.

Two over-arching questions addressed in this document are:

1. What is the distribution and character of mangroves and adjacent habitats and how do these change over time?
2. What are the special considerations for monitoring the effects of mangrove clearance?

The methods available to answer these questions range from simple cost-effective techniques to complex analyses requiring specialist skills or equipment and which may require considerable financial investment. Although here we offer a range of techniques, we focus on those likely to be achievable by community groups. The focus is on methods at the simple cost-effective end of the range. Hence methods have been divided into a “**recommended minimum level**” [provides basic information on change over time], an “**intermediate level**” [requires a greater time commitment but provides more quantitative information useful for comparison among sites] and a “**detailed level**” [to be considered if a rigorous scientific study is planned].

2. Useful definitions as they relate to this document

Control: Site which is otherwise similar but is not undergoing any active management.

Epifauna: Animals living on the surface of the sediment.

Habitat: The place where environmental conditions are suitable for the survival of a particular organism (e.g., mangroves).

Infauna: Aquatic animals living within the sediment.

Macrofauna: Animals large enough to be seen with the naked eye.

Mangrove seedlings: Mangrove plants less than 25 cm tall.

Mangrove saplings: Mangrove plants bigger than a seedling (> 25 cm tall) but not branched.

Mangrove trees: Mangrove plants larger than a sapling.

Pneumatophores: Mangrove aerial roots for gas exchange between the plant roots and the air.

Productivity: Rate of biomass production by a mangrove plant.

Quadrat: Area of known size (e.g., 25 cm x 25 cm) marked out for counting epifauna.

Replicate: More than one sample unit to account for natural variability.

Site: General area of interest, likely to be at the scale of a bay, or inlet.

Transect: A line on the ground along which quadrats are placed or points are established for collecting data.

3. Methods

3.1 Addressing Question 1. What is the distribution and character of mangroves and adjacent habitats and how do these change over time?

3.1.1 Choosing sites

There are a number of considerations you will need to be aware of when it comes to site selection.

- Is there a particular area that you have an interest in and would like to monitor over time? For example, are you interested in a single bay or an entire estuary? When you have decided this mark out the boundaries of the area of interest on a map or an aerial photograph.
- Within the area of interest you will need to choose study sites at which to carry out the monitoring. Choose sites that are representative of the type of habitat you are trying to monitor so that results will be more relevant to other parts of the estuary.
- Determine how many sites should be delineated within the area or estuary of interest? Monitoring multiple sites (replicates) will help account for natural variability.



Photo 1: Community group briefing Pahurehure Inlet, photo K Coombes.

In this document we assume that the main places of interest are the boundaries (i.e., edges of a particular habitat type) related to a mangrove forest. The first boundary is located between the mangroves and usually more landward plant communities (e.g., saltmarsh) and the second is the boundary between mangroves and more seaward estuarine habitats. To this end, monitoring of transects over time is the approach that is recommended. This means that one or more sites need to be chosen where transects can be established and that can be easily located at a later date.

For a statistically rigorous monitoring programme it is essential to have more than one transect at each site. The choice of the number of replicate transects will depend on the size of a given estuary or the size of the area of interest in an estuary, as well as the specific question of interest to a particular community group. This document is not intended to address every possible scenario. On the basis of the trials to date, which have provided a realistic expectation of the time required by a community group to complete sampling, we suggest carrying out the following methods on at least two transects across similar boundaries of interest at each site.

3.1.2 Frequency of sampling

We propose that the “recommended minimum” suite of methods outlined below, should be carried out on an annual basis and that all parameters should be sampled as close to the same time of year as possible. The reason for this is that production, survival and growth of mangrove seedlings has a seasonal component to it. New summer propagules begin to settle in approximately December while over winter many of these 1st year seedlings do not survive. It is suggested that a time is chosen between the end of winter (approximately September) and December, to ensure that any records of seedling abundance are indicative of those that have already survived for almost a year. This will also ensure that differences in seedling numbers between annual monitoring events reflect year to year changes rather than seasonal fluctuations. Additional sampling using the same methods outlined below can be carried out at six monthly intervals to obtain a seasonal component if that is of interest. In addition, some of the physical characteristics may be sampled more frequently, at least initially, to build up an understanding of how quickly things change at your site of interest.

3.1.3 Recommended minimum level

Each transect needs to be permanently marked so that they can be returned to on different occasions and on successive years. Wooden stakes [approximately 100 x 5 x 5 cm] hammered into the ground will fulfil this purpose. Ideally these stakes will also

be located with a GPS position and a simple sketch map made of relevant features enabling the transect to be re-located if the markers are lost.

We recommend making measurements on transects running perpendicular to channels and / or the shoreline, however the exact location will depend on your boundaries or locations of interest.

The methods are outlined in Table 1 and some possible examples of how stakes and transects could be placed across mangrove (and other) boundaries are shown in Figure 1.

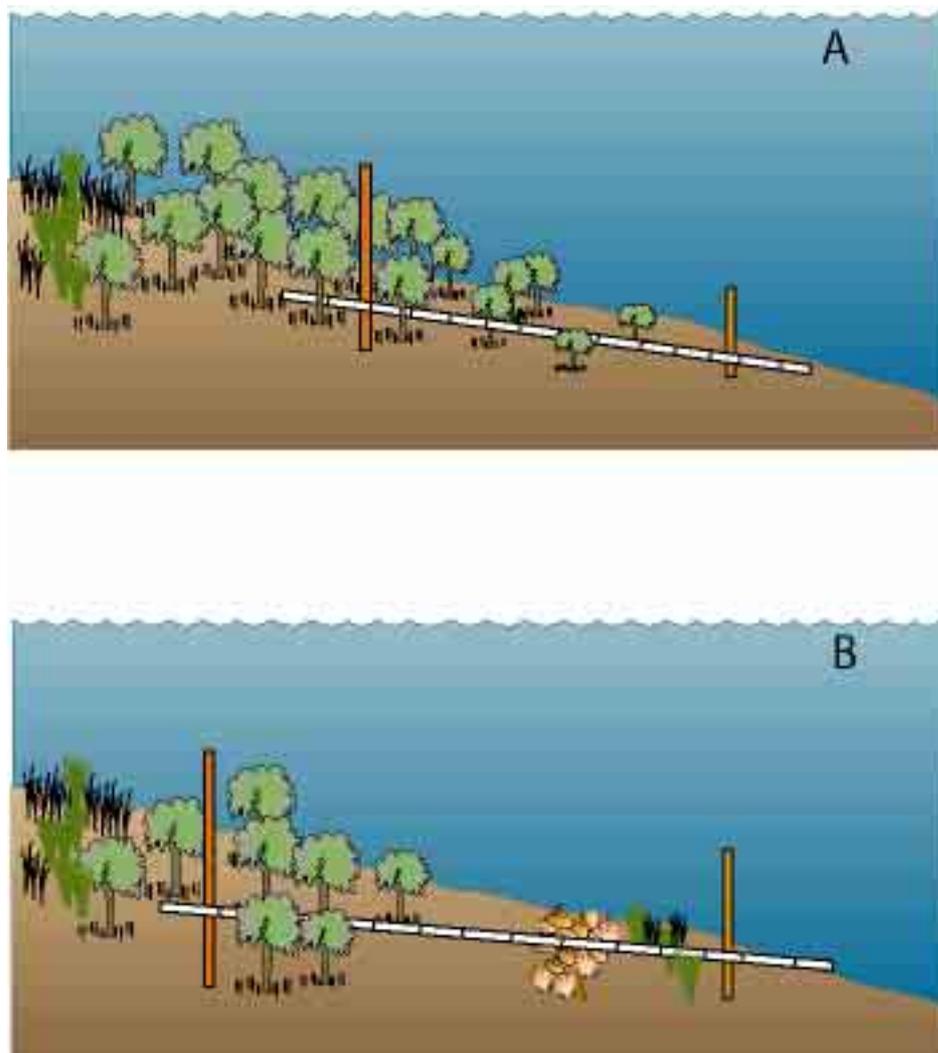


Figure 1: Permanent markers with a temporary measuring tape laid between them across a) a mangrove mud/ sand flat boundary and b) mangrove / shellbank / saltmarsh / mudflat boundaries.

Table 1: Methods for recommended minimum level to address question 1.

Approach	Details of method
Placing the transect.	<p>Select your site and mark each end of the two replicate transects by hammering a tanalised wooden stake [approximately 100 x 5 x 5 cm] into the ground. The length of the transect, and the location relative to the mangrove boundary, will depend on the characteristics of your site. The important thing is to ensure that the transect is long enough to cover the habitats of interest (e.g., edge of mangrove forest and mudflat or edge of mangrove forest and saltmarsh. As an indication it is likely to be 20 to 50m long). It is important to place permanent markers so that the transect can be relocated. Take a GPS reading where the stakes are placed in case they are removed or lost at any time.</p>
<p>Habitat boundaries on mangrove transects.</p> <p><u>Use Data sheets #1 and 2</u></p>	<p>Lay a marked rope or measuring tape between the stakes. This is your transect. Record which stake is equivalent to zero metres and ensure this stays the same on subsequent visits. Walk along one side of the transect line only (to avoid trampling) and note the distance on the transect line where there are changes in plant communities (e.g., seagrasses, mangrove seedlings, saplings, pneumatophores and mangrove trees) or surface features including different types of sediment (e.g., sand, mud).</p> <p>It is also recommended that you use the space provided on Data sheet #1 to sketch the location of vegetation boundaries in the vicinity of (approximately 10 m), and in relation to, the transect line.</p>  <p>Photo 2: Transect in Waikaraka Estuary, photo A. Schwarz.</p>

<p>Epifauna [using replicated quadrats]</p> <p><u>Use Data sheet #3</u></p>	<p>Place a 25 cm x 25 cm quadrat at haphazard locations, no further than 10 m from your transect line, within each of the main habitat types in which you are interested (i.e., mudflat and mangrove trees). Record the number of different animals seen on the sediment surface within each quadrat. [We recommend that you initially collect data from a minimum of 10 quadrats. Discuss your results with the relevant regional council or science/research provider to ensure that replication is sufficient and it may be possible to reduce this to 5 quadrats on subsequent visits]. A general field guide to marine invertebrates of NZ will be a useful reference to help in identifications. It is important to include all of the animals that you see within the quadrats each time you visit the site. If there are very large numbers of epifauna you may need to count the animals in only one quarter or half of the quadrat and then multiply this up to estimate the number of animals in the full quadrat area.</p>
<p>Sediment accretion / loss</p> <p><u>Use Data sheets #4 and 5</u></p>	<p>Note: There are different ways to measure rates of sediment accretion or loss. These range from simple to technically more complex and will give correspondingly accurate data. The option given here will provide an indication of gross changes only. A relative assessment of the value of various techniques is given in the box on the following page.</p> <p>Hammer a series of tanalised wooden stakes (approximately 100 x 2 x 2 cm) firmly into the sediment (leaving 10 - 20 cm exposed). Measure the distance from the sediment surface to the top of the stake. Each year re-measure this distance. It is recommended that you lay a metal ruler on the ground next to the peg and measure from the top of the peg to the ruler to account for any erosion around the base of the peg. Place the stakes haphazardly along the transect line and at various distances away from the transect. Pay particular attention to having sufficient replication (approximately 5 stakes) both within the mangrove stand and around the boundaries of the mangrove forest. If necessary, clean the stakes of barnacles each time you measure.</p>
<p>Sediment compaction</p> <p><u>Use data sheet #6</u></p>	<p>Sediment compaction is an important factor determining sediment re-mobilisation. One way to measure relative sediment compaction is to use a penetrometer that measures the force required (pressure) to penetrate the sediment to a given depth. A simple penetrometer can be devised using a sharpened steel rod (length 40 cm, diameter 0.7 cm) dropped from a standard height (for consistency we recommend 1 m from the tip of the rod to the sediment surface). Note the depth to which the steel rod penetrates and repeat this process 5 times either side of each stake. The rod should only be measured when it is roughly vertical.</p>
<p>Photographs</p> <p><u>Use Data sheet #7</u></p>	<p>Repeat photographs taken from a fixed point (e.g., each of the marker stakes) at a fixed height above the ground (e.g., eye level) and taking in the same scene, are useful for assessing change over time and will supplement your recordings made along the transect.</p>

3.1.4 Equipment list for recommended minimum level

- GPS
- Wooden (tanalised, H4 or H5 treated) stakes to mark transects [approximately 100 x 5 x 5 cm]
- Hammer
- 100 m measuring tape
- 25 cm x 25 cm quadrat
- Wooden (tanalised, H4 or H5 treated) stakes [approximately 100 x 2 x 2 cm] for sediment accretion
- 1 m ruler
- Metal ruler
- Penetrometer
- Clipboard
- Pencils
- Data sheets (on waterproof paper if possible)
- Camera
- Appropriate clothing



Photo 3: Pahurehure Inlet, Photo K. Coombes

Comparison of sediment accretion/loss techniques

Method	Advantages	Disadvantages	Considerations
<p>Wooden stakes [100 x 2 x 2 cm]</p> <p>Measure distance from top of stake to sediment surface</p>	<p>Inexpensive</p> <p>Low susceptibility to tampering</p> <p>Simple for a community group to replace</p>	<p>Potential for erosion at base of stake (particularly in sandy substrate). This can be overcome to some extent by laying a metal ruler on the substrate across the eroded area.</p> <p>The potential for tampering will be site dependent.</p>	<p>Low accuracy may be offset by being able to have a large number of sites. The technique enables gross changes to be measured but it is recommended that penetrometer measurements are made at the same time with periodic sediment grain size analyses.</p>
<p>Aluminium (or other) rods 1 cm diameter.</p> <p>Measure distance from top of rod to a circular base plate with a collar that slides down over the rod to account for inconsistencies in sediment height around the rod.</p>	<p>More accurate than wooden stakes owing to a better ability to account for erosion at the base.</p>	<p>More expensive for a community group to replace.</p> <p>Not so well camouflaged, greater likelihood of tampering.</p> <p>Potential for health and safety issues in areas of high recreational use.</p> <p>Technique is not useful within mangroves or where pneumatophores present.</p>	<p>Depending on location may be better suited to scientific studies in the shorter (weeks to months) rather than the longer (months to years) term.</p>
<p>Buried steel plate</p> <p>Measurements are made by pushing rods down to the level of the plate and measuring sediment depth.</p>	<p>More accurate than wooden stakes as variability around the stake is accounted for.</p> <p>Plate is not visible so tampering is unlikely.</p>	<p>Requires surveying to ensure the plate hasn't moved, so some external expertise required.</p>	<p>Currently being assessed by Environment Waikato as to suitability for this type of monitoring programme.</p> <p>Location needs to be marked to ensure ease of re-location for measuring.</p>
<p>A surveyed transect measuring elevation and distance from a benchmark.</p>	<p>Greater accuracy than methods described above.</p> <p>Repeatable, no tampering or health and safety issues.</p>	<p>Requires some skill to complete, possibly beyond some community groups without training and assistance.</p>	<p>Preferred method if group has appropriate skills or is employing a consultant for consent monitoring.</p>

3.1.5 Intermediate level

If additional expertise or resources are available there are a number of other samples that can be collected in addition to the recommended minimum. Data sheets are not provided for intermediate and detailed level sampling.

Table 2: Methods for intermediate level required to address question 1.

Approach	Details of method
<p>Macrofauna</p> <p>[Coring and sieving to quantify and identify macrofauna that live in the sediment].</p>	<p>Macrofaunal sampling differs to the surface survey of epifauna described above in that sediment cores are taken instead of the 25 cm x 25 cm quadrats. Previous studies undertaken by NIWA scientists suggest that 13 cm diameter, 15 cm deep cores sieved on a 0.5 mm mesh is likely to be an appropriate size to sample benthic infauna. As described above for the quadrats, at each sampling location on your transect, it is recommended that a minimum of 10 cores are sampled next to each stake. Discuss your results with the relevant regional council or science/research provider to ensure that replication is sufficient and it may be possible to reduce this to 5 cores on subsequent visits. Collect the replicate cores at haphazard locations, no further than 10 m from your transect line, within each of the habitat types in which you are interested (i.e., mudflat and mangrove trees). The contents of each core can be sieved on site at the water's edge. Macrofauna should be identified to the lowest possible taxonomic level. Note that a permit will be required for removal of animals from the estuary.</p>
<p>Mangrove community characteristics across boundaries.</p>	<p>This method enables you to follow changes in the relative number of seedlings, saplings and trees between years and so better understand how the forest develops with time. It is likely that your main boundary of interest will be the seaward boundary between the mangroves and the tidal flats and the wording in the methods reflects this. However if relevant to your site, the same methods can be used across other boundaries.</p> <p>Mark a plot of known area that crosses a mangrove forest boundary. An example is illustrated in Figure 2. The plot size will differ depending on the characteristics of your site (e.g., we have found that 5 m x 10 m was appropriate for sparse shrub and seedling cover on a sandflat in Tauranga while 5 m x 1 m or 2 m x 1 m were appropriate for dense areas of seedlings in very muddy habitats in Puhurehure inlet).</p> <p>It is important that one edge of the plot runs along the transect and that you keep an accurate record of the location of the plot relative to the transect for future reference. A sketch can help. Ensure that the plot overlaps the existing boundary of mangrove trees and a mostly clear area where you might expect to see mangroves expand into</p>

	<p>over time. Within the plot, measure the following variables related to the characteristics of the mangroves</p> <ul style="list-style-type: none"> • total number of trees • total number of saplings • total number of seedlings.  <p>Photo 4: Dense seedling cover in Pahurehure Inlet, Photo K. Coombes</p> <p>If the number of seedlings in the whole plot is too large to count instead count all individuals in smaller sub plots and multiply up to your area of interest.</p> <p>It is important to keep a record of exactly which methods were used. On subsequent visits, carry out mangroves counts in exactly the same plots using the same methods.</p>
Bird observations	<p>At each transect marker stake, stand still and record all birds you can identify by sight or sound within a period of 5 minutes. When possible, record the behaviour of the bird (e.g., feeding, flying, perching).</p> <p>Bird observations will probably need to be made independently of your other monitoring in order to minimise disturbance by people. It may also be appropriate to contact local ornithological groups to ascertain the types of birds you need to be looking for.</p>
Ancillary measurements	<p>If you have access to a conductivity meter (either a field model or a sample can be returned to a laboratory) the salinity of subsurface water can be measured in a shallow pit. Salinity is an important determinant of mangrove growth and, along with information on sediment characteristics collected above is useful in interpreting any differences between estuaries or sites.</p>

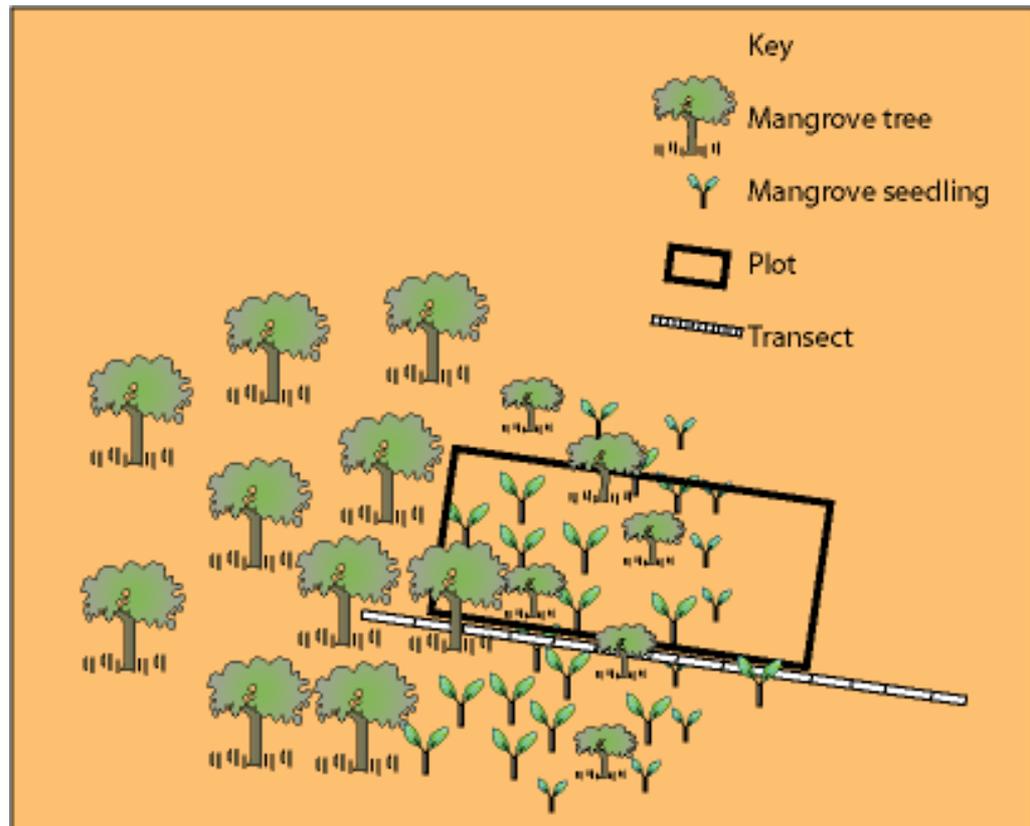


Figure 2: Plan view of the boundary of the mangrove forest showing the transect line crossing a boundary of trees into seedlings and the positioning of a 5 m x 1 m plot (black square). If the number of seedlings in the whole plot is too large to count, place three 1 m x 1 m sub plots and count the seedlings in each of these.

3.1.6 Detailed level

The following options are listed for the situation where additional resources such as extensive historical local knowledge, historical aerial photographs or additional financial resources are available. Methodological details are not given and we suggest you contact a research provider such as the organisations involved in preparing this document should you need to pursue such analyses.

Table 3:

Approach
Interpretation of aerial photographs; these can be very useful for assessing large-scale changes in the area of some habitats over time.
Fish usage of mangrove habitats; adds to the knowledge base of the role of mangrove habitats in the wider estuarine ecosystem.
Sediment grain size analysis by analytical laboratories or research providers; used for detailed interpretation of the suitability of a sediment for particular plants and animals and to help interpret the likely source of sediments.
Analysis of historical sedimentation rates derived from radioisotope tracers and / or pollen profiles. These provide information on average sediment rates over time scales of 10 – 100's of years.
Water clarity; if you are interested in sources of suspended sediment to different parts of your estuary, water clarity of inflowing waters and tidal channels can be measured using a clarity tube (contact NIWA for details).
Sediment chemistry; e.g., nutrients or contaminant analysis by analytical laboratories or research providers. Used for detailed interpretation of the suitability of a sediment for particular plants and animals and to help interpret the likely source of sediments.
Changes in mangrove forest structure, biomass and productivity; to follow how mangrove stands change over time and contribute to other estuary processes.

3.2 Addressing Question 2. What are the special considerations for monitoring the effects of mangrove clearance?

At the time of preparing this document, resource consent applications had been lodged to remove mangroves from parts of some estuaries. For this reason it was considered important to highlight the fact that there are special considerations that must be taken into account for monitoring the effects of a mangrove clearance trial for which consent has been obtained. The following recommended techniques aim to answer the question; what is the effect of the action of removing mangrove plants on adjacent estuarine habitats?

These recommendations assume that mechanical / physical removal of mangroves includes the transport of all cleared material away from the site for disposal.

3.2.1 Choosing sites

Site selection will be pre-determined by the clearance location. It is essential that a control site (where no mangroves are removed and where no disturbance associated with the clearance activity occurs) is also chosen, or if no such site is available, that suitable pre-clearance information has been collected. A control site will have similar characteristics to the managed site (e.g., similar exposure to action of tidal waters, similar composition of seedlings, saplings and mature trees and similar sediment type).

When active intervention is planned, it is necessary to have detailed physical and biological information collected before and after the clearance activity (in both the managed and the control site if a control site is available). This enables the influence of any other factors that may be changing over time, apart from active intervention, to be accounted for when data are interpreted. Adequate sample replication is also essential to enable any changes to be analysed statistically.

3.2.2 Frequency of sampling

Sampling frequency will differ from the standard monitoring schedule (Section 3.1.2), however as previously described, all parameters should be sampled at the same time. Initial sampling should be conducted in the mangrove area to be cleared prior to the clearance activity. Subsequent sampling will need to be more frequent immediately following plant removal, when the greatest changes are expected to occur and can be less frequent as time goes on. An example of a suitable timeline is an exponential time series (Table 4) although the suitability of this will depend on the rate of change in different parameters.

Table 4: Exponential time series.

Immediately before intervention (1 week)
1 and 2 weeks after intervention
1, 2, 4, 8, 16 months after intervention
At this time annual monitoring is likely to once again be appropriate

3.2.3 Recommended minimum level

The recommended minimum level of monitoring for a clearance trial (Table 5) is greater than that for standard monitoring. This is because clearance will affect a number of environmental parameters that are important for understanding the potential consequences to the wider estuarine environment. In particular, these may relate to sediment re-suspension, change in substrate, trampling during tree removal and effects on adjacent plant and animal communities.

The number of sites to be chosen will depend on the scale of the consented clearance activity.

A way of permanently marking your site needs to be established so that the same location can be returned to on different occasions and on successive years. Robust wooden stakes hammered into the ground will fulfil this purpose. Ideally these will also be located with a GPS position and a simple sketch map of relevant features to enable the site to be re-located if the markers are lost.

Table 5: Recommended minimum level to address question 2.

Approach
Habitat boundaries on mangrove transects
Photos
Macrofauna [replicate core samples]
Epifauna [replicate quadrat samples]
Sediment accretion / loss (consider method options)
Sediment compaction
Bird observations

3.2.4 Intermediate level

It is recommended that in a clearance trial additional information is collected on rates of recolonisation of mangroves and if relevant, any detrimental effects on mangrove

trees that remain adjacent to those removed. The methods for mangrove community characteristics across boundaries (Table 1) can be adapted for this purpose.

3.2.5 Detailed level

Monitoring at a more detailed level is highly desirable when investigating the effects of mangrove clearance. Very little is known about the effects of clearance on the functioning of the adjacent forest or on the estuary as a whole. Clearance trials provide a unique opportunity to add to the body of knowledge, enabling better-informed management decisions to be made in the future. Aspects such as sediment chemistry (e.g., nutrients, contaminants) and fish usage of mangrove habitats, may be appropriate depending on the site. These options should be considered when resources enable collaboration with research providers and/or access to analytical laboratories for processing. Methodological details are not given and we suggest you contact a research provider such as a CRI or university (NIWA, Landcare Research and Auckland University of Technology are all represented on the Mangrove Steering Group and have been involved in the preparation of this document) should you need to pursue such analyses.

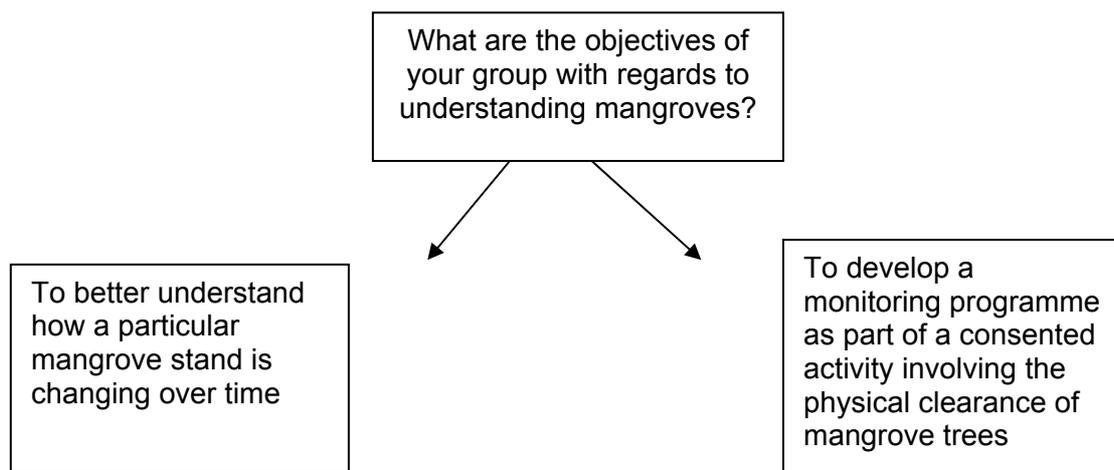
4. What to do with all this information?

Once you have outlined a study you may want to consult with the appropriate regional council or a science/research provider to ensure that your data collection is statistically sound. Ensuring statistical rigour requires further specific information about the particular characteristics of your site.

We recommend that you record all your observations in an exercise book or folder. If you have access to computers then data can be stored as an excel spreadsheet or as a word document. The ability to plot simple graphs will enable you to compare data between years and eventually observe trends over time. Currently there is no central repository for any data that is collected using this document. We recommend that you enlist the assistance of the appropriate regional council or a science/research provider to help with interpretation of your data on an annual basis.

Examples of data sheets are appended to this document. They can be copied and used in the field. We recommend that they be copied on to waterproof paper if possible, and that you use pencil rather than ink pens.

5. A summary flow chart of actions



↓

Recommended minimum	Intermediate level	Detailed level
Habitat boundaries on mangrove transects	Macrofauna [coring]	Interpretation of aerial photos
Epifauna counts in replicate quadrats	Mangrove community characteristics	Fish use of mangroves
Sediment accretion / loss	Bird observations	Sediment grain size analysis
Sediment compaction	Salinity	Historical sedimentation rates
Photos		Sediment chemistry
		Mangrove forest structure, biomass and productivity

↓

Recommended minimum	Intermediate level	Detailed level
Habitat boundaries on mangrove transects	Characteristics of mangrove and other plant communities adjacent to cleared areas	Sediment chemistry
Photos		Sediment grain size analysis
Macrofauna [coring]		Fish use of mangroves
Epifauna counts in replicate quadrats		
Sediment accretion / loss		
Sediment compaction		
Bird observations		

Transect Description Sheet1

Location (Estuary) _____

Date _____

- Equipment**
- 100 m measuring tape
 - Wooden stakes for end of transect
 - GPS

Name(s) of recorder _____

Name of Site and Transect No _____

Transect Description. Describe anything you think will be useful in remembering where the transect is and what it looks like today (e.g., include physical structures, an estimate of mangrove height, what other plants are nearby, location of transect line).

	Description	East	North
<i>Example</i>	<i>West end, in mangroves.</i>	<i>E2669339</i>	<i>N6485815</i>
Marker 1			
Marker 2			

Sketch map of site, transect and plot location.

Compaction measured using a penetrometer Sheet 6

Location (Estuary) _____

Date _____

Name(s) of recorder _____

Site and Transect Number _____

Equipment

- 1 m ruler
- Penetrometer (40 cm metal rod with pointed end)
- Metal ruler

Penetrometer test = drop a 40 cm x 0.7 cm (diameter) rod from 1 m height. Measure height of rod sticking out of sediment.

Peg Location >>					
Readings from 5 places	Compaction/ Penetration (mm)	Compaction/ Penetration (mm)	Compaction/ Penetration (mm)	Compaction/ Penetration (mm)	Compaction/ Penetration (mm)
1					
2					
3					
4					
5					

