Estuary topography

Objective

To make an accurate measurement of the estuary topography along your transect(s) using the hydrostatic method.

Background

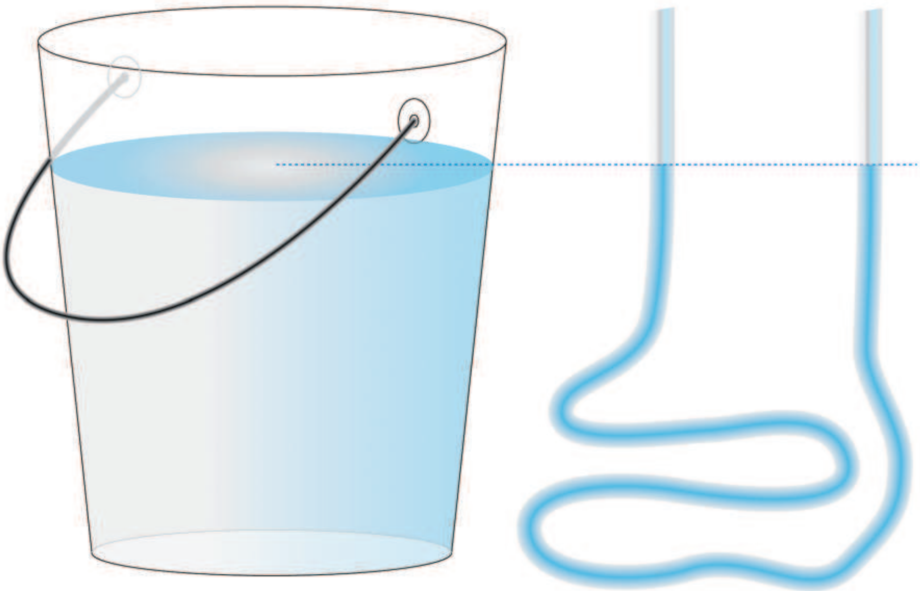
In this section we will show you how to survey the **topography** of your estuary by measuring changes in the height and slope of its surface features, such as intertidal flats and channels. Topography describes the shape of features on the Earth's surface. The measurement of topography is also related to a branch of science called **geomorphology**. This is the study of how landforms develop, including coastal landforms such as estuaries.

As we have already discussed, estuaries fill up with sediment. Over time, this sedimentation changes the topography of estuaries. For example, tidal channels may become shallower and/or change their position. Intertidal flats will build up so that their height above some level (such as low tide) increases. The correct term for the height of a surface above some level is the elevation of the surface, which is used in the remainder of this module. These changes in the shape and height of estuary habitats can result in changes in the plant and animal communities that can live at a particular location. For example, mangroves can only establish on intertidal flats that are above mid-tide level, where they are submerged for no more than half of the tidal cycle.

Hydrostatic survey method

To measure the topography of your estuary, you will use a **hydrostatic** survey method to measure changes in surface height and slope along a transect. This hydrostatic method is based on the principle that the height of a water surface does not change with location, at least not between nearby locations. This is because the weight of air pressing down on the water surface is the same at every location in your estuary.

For an example of how this works, consider a bucket of water. The still water surface in the bucket is the same height or level everywhere in the bucket. Now, if you fill a length of hose with water and hold the two ends up next to each other, you will see that the water surface in each end of the hose is also exactly the same height due to air pressure (this is the hydrostatic principle). By attaching the ends of a clear hose to two poles marked off in millimetres, you can make your own hydrostatic survey instrument. In this method the height of the water surface on the vertically-held pole depends on the elevation of the seabed at each pole's location.



The still water surface in the bucket is the same height or level everywhere in the bucket. If you fill a hose with water and hold up the two ends, the water surface in each end of the hose is also exactly the same height and level – and for the same reason.

Therefore, the height difference in the water surface between the two poles is equal to the difference in seabed elevation. This easy method of measuring elevations is almost as accurate (to within a few mm) as modern instruments used by surveyors. Although hand-held GPS units can measure surface elevation, the measurements are not accurate enough to detect the millimetre-to-centimetre scale sedimentation that typically occurs in an estuary over the course of a year.

You will use the hydrostatic principle to measure the topography of your estuary along transects. A transect is usually a straight line laid out in a particular direction. For example, you may choose to survey the topography of the intertidal flats from high tide out across the low tide channel in a particular direction.

To increase the value of the survey you should consider locating your transect close to other monitoring sites. This is because the surface elevation information provided by the hydrostatic surveys can help interpret habitat changes in your estuary that you have measured using other toolkit modules. For example, the areas in which saltmarsh and mangrove plants can grow is influenced by the elevation of the intertidal flats. Increases in the area of mangrove forests can coincide with increasing elevation of intertidal flats due to sedimentation.

How often should you measure your transects?

Deciding how often to measure your transects will depend on:

- how rapidly you think the topography of your estuary is changing
- the objectives of your Estuary Monitoring Action Plan (E-MAP)
- the accuracy with which you use the hydrostatic survey method. With practice you should be able to measure surface elevations to within 5 mm of their actual value.

Estuary sedimentation rates are typically only a few millimetres per year on intertidal flats, and these rates are similar to the accuracy of the hydrostatic survey method. This means that measuring your transects once per year will usually be enough. By comparison, sedimentation rates near stream outlets can be as much as several centimetres per year, and more frequent surveys could be useful. In particular, you should survey after large storms when changes in topography may be large, such as obvious mudbank deposits and channel scour.

Plants also increase sedimentation rates by slowing down currents and by sheltering the seabed from wave action. For example, sedimentation rates in mangrove forests are typically several times higher than on nearby intertidal flats. Engineering works may also result in changes to estuary topography. For example, land reclamation, breakwaters, causeways, and wharf construction can alter tidal flows and trigger rapid changes in intertidal flats and channels. These are some of the issues you will need to consider when deciding how often you should monitor your transects.

Here are some additional points to consider. If there is a hard rocky reef or rock platform along your transect, you can use this to check your measurements. You can assume that the rock surface level is not changing (at least not for many years) so that the levels at fixed points on the reef should not change between surveys. If you can, hammer a masonry nail into the rock and use this to mark your check point(s). If the reef goes under water at high tide, you should ideally use a brass or bronze nail or screw, which won't corrode as rapidly as iron.

Before you begin using the hydrostatic method, you will first make a reference point for all your measurements (see the **"How to: Establish a benchmark"** section). You can check how accurate your measurements are by returning to the starting point at the benchmark.

1. Survey out from your benchmark to the end of your transect.
2. Survey back to the benchmark from the end of the transect.
3. Add up the total distance and elevation changes for steps 1 and 2.

To test the accuracy of your survey:

- the distance between the benchmark and the end point of the transect should be the same in both directions – within a few cm
- the total elevation changes in both directions along the transect should also be similar. An elevation (vertical) difference of less than one centimetre is a good result. Note that there will usually be a surface slope, even on an intertidal flat. This means that the total elevation change down the slope will be negative whereas the total elevation change will be positive going up the slope in relation to the starting position.

How to relate your estuary transects to each other

The elevations that you have measured along each transect are only relative to their own benchmark peg (that you installed above the high-water mark). If you have also made measurements along transects at different locations in your estuary you will probably want to know how the relative heights of the estuary topography differs between these transect locations. For example, how high are the intertidal flats at the top of the estuary compared to the intertidal flats near the estuary mouth? You may also want to know the elevations of different habitats relative to the tide and if these change with location and/or over time. To accurately answer these questions, you need to be able to relate each of your benchmarks to a fixed **vertical datum** whose value does not change. The **appendix - On the Level** will show you how to use vertical datums to relate your transects to each other, and to tidal levels which have **ecological** and/or resource management significance.

Summary of method

Establish a benchmark and set up a transect. Take measurements along the transect using the hydrostatic survey method.

Links to other methods and modules

- Habitat module
- Plant module
- Fish module
- Shellfish module

Equipment needed

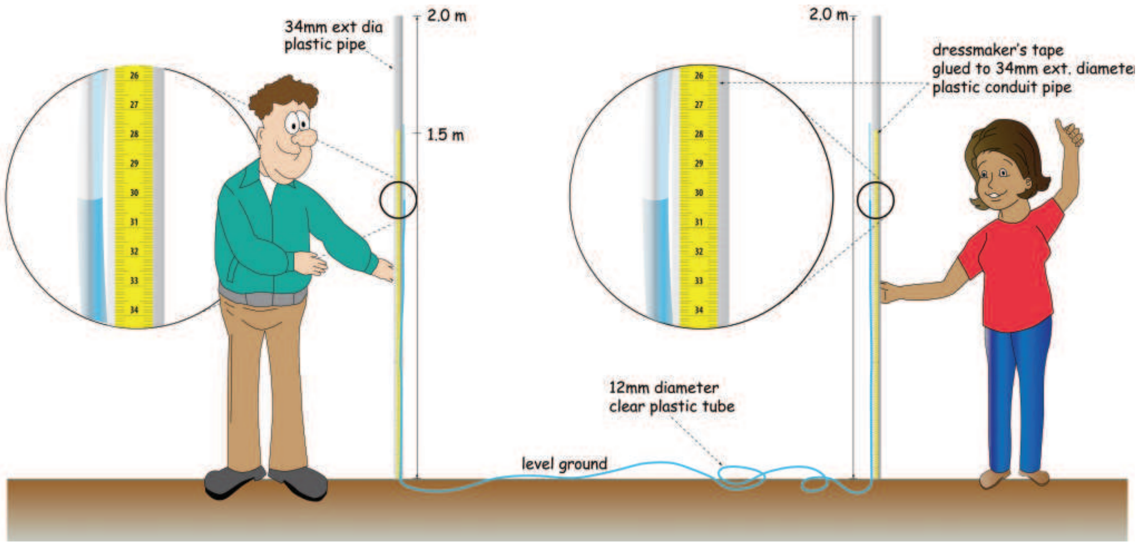
You will need the following equipment to carry out a topography survey using the hydrostatic survey method:

- 30 m tape measure or length of non-stretch rope that you have marked at 1 m intervals.
- 2 measuring tapes marked in millimetres (e.g. dressmaker's or builder's tapes).
- 12 m length of see-through hose or 9 m of garden hose with 1.5 metre of see-through hose attached at each end with hose connectors.
- 2 poles, 2 m long. These poles could be lengths of plastic pipe, bamboo, or timber.
- funnel to fill the hose.
- 2 rubber bungs, clips or rubber bands to seal the ends of the hose.
- 2 medium-sized plastic lids or similar, e.g., as from a coffee jar. You will use these to mark each survey point and to stop the poles sinking into soft sediment
- water bottle to top up the hose if needed
- magnetic compass
- datasheet: "Hydrostatic elevation survey"
- wooden or steel peg at least half a metre long to use as a benchmark for each transect. If using wood, make sure that it is tanalised for in-ground use so that the peg does not rot
- bag to carry datasheet, camera, water bottle, etc.

Constructing your hydrostatic survey tool

Firmly attach the measuring tapes marked in millimetres to the poles, with the zero position of the tape level with the top of each pole. Secure at least the first 1.5 m of each end of the hose to a pole. Both ends of the hose need to be see-through so that you can measure the water level in the hose. Using a plastic funnel, fill the hose with water, making sure there are no visible air bubbles. You can add food colouring to make the water in the hose easier to see. Use the bungs to seal the hose when not in use to prevent the water running out. Alternatively, seal the hose by folding over each end and clamping it to the pole with electrical tape or clips.

When you have put it together, your completed hydrostatic survey tool will look like the diagram below and like the photos in **"How to: Measure your transect"** in the following pages.



The hydrostatic survey method. The water-filled hose is attached to the two poles together with measuring tapes. This is a very accurate method to measure the relative height of surface features.

Data collection and management

The data collected should be entered on the "Hydrostatic elevation survey" datasheet. Use a new datasheet for each transect.

How to: Establish a benchmark

To measure how the topography changes along your transect(s) over time you need to be able to compare the height of the sediment surface to a **fixed reference level** for each transect. Surveyors call these fixed reference levels benchmarks (BM). You will need to establish some benchmarks in order to conduct a hydrostaic survey. Below are some steps on how best to establish your BM.

1. Obtain permission from the landowner or local authority before installing the BM on private or public land.

2. You will need to find a suitable location for the benchmark on dry land immediately above the high tide mark. Find a site where the BM is not too obvious but still easy for you to find, where it is not likely to be damaged or disturbed, or injure people or animals that may step on it. Good sites for BM include along fence lines or near other fixed objects. Avoid areas with vehicle access where the peg could be pushed into the ground or broken off. Remember, it may need to last ten years or more.

3. Use the most appropriate material for your BM. At some sites a wooden peg will be fine. At other sites a galvanised or stainless steel bolt or nail set into a concrete surface may be a better option.

4. If your using wooden pegs hammer the peg into the ground until the top of it is just above ground level. In 'high risk' sites you might bury it 5–10 cm below the ground. A piece of galvanised pipe of about 50 mm diameter driven into the ground and set into concrete also provides a long-lasting BM.

5. If your transect crosses or is close to a rocky reef, you could install a galvanised or stainless steel bolt or nail in the rock (using drill or glue) to provide another permanent BM.

6. Make an accurate description of the BM location. This should include a written description and diagram, map coordinates, and photograph. If possible, also fix the BM position using a GPS. Remember that someone else from your hapū might have to find the benchmark in 5, 10, or 20 years.

7. Install a second BM peg a few metres away from the first BM as a back-up. Make accurate notes of its location in relation to the main BM. You will need to measure the height difference between the top of both BMs using the hydrostatic method described. This height difference will allow you to re-establish the transect if the main BM is lost. If the main BM goes missing (for whatever reason) and you have not installed a second BM, then you will not be able to compare information from old surveys with new surveys.

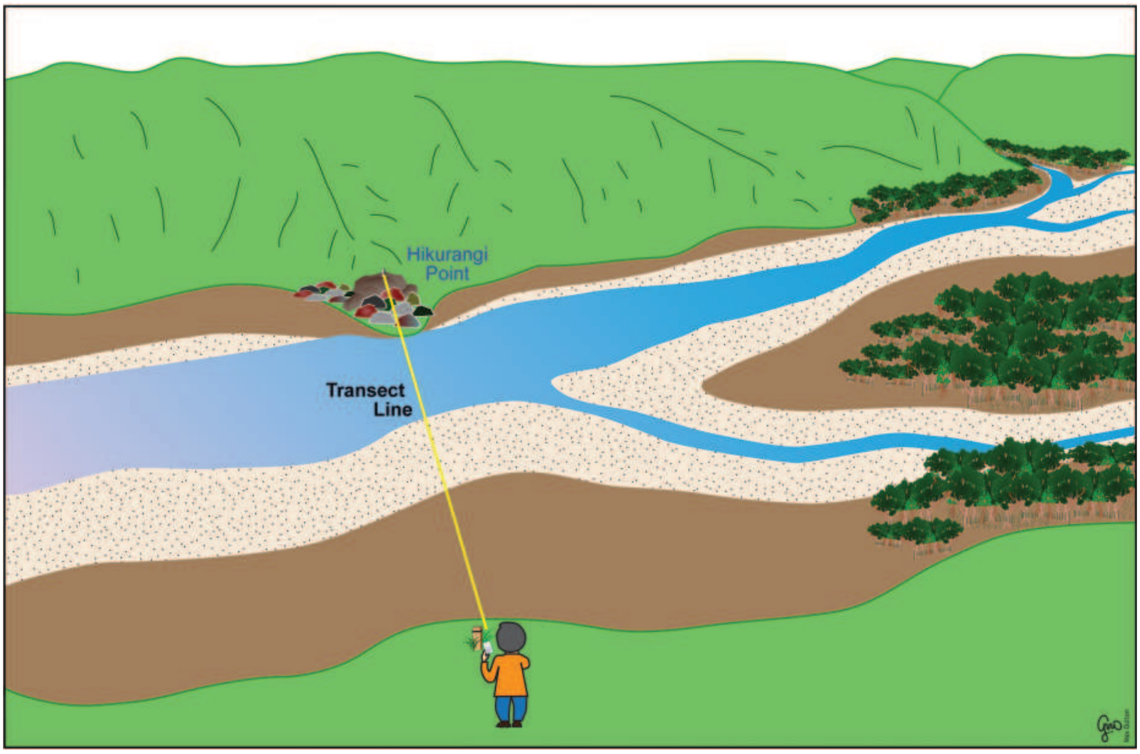
How to: Set up your transect

It is important to follow the transect as closely as possible for each survey so that you can make an accurate comparison of changes over time. To do this you will first need to decide on, and fix, the direction of the transect.

1. Stand next to the benchmark and look along the transect in the general direction that you want to measure. Try to find an easily recognisable – and permanent – feature or landmark that you can use as a reference point to keep you on line. Good examples include hilltops, headlands, large trees, buildings, and power poles.

2. Take a compass bearing to the landmark and record this direction on the "Hydrostatic elevation survey" datasheet. Also describe the landmark on your datasheet.

   In the example below, a headland on the opposite shore of the estuary provides a good landmark to fix the direction of the transect.



The transect (yellow line) starts at the benchmark and is lined up with Hikurangi Point on the north side of the harbour. The compass bearing along the transect is 338° magnetic.

How to: Measure your transect

The objective is to make an accurate measurement of the estuary topography along your transect(s). To do this, you need to make enough measurements along the transect to record changes in the surface level and other features that you are interested in. Such features could include intertidal flats, shell banks, boundaries between habitats, high and low points, and sudden changes in slope that occur near channels. You will need at least two people to measure your transect.

1 If this is your first survey of the transect, establish your benchmark and transect as previously described. If you installed a second benchmark at the transect to provide a back-up, make sure that you have also measured and recorded the vertical height difference between the two benchmarks so that you can compare your surveys if the main benchmark is damaged or removed.

Start your survey at the landward benchmark.

2 If you have surveyed the transect before, locate your benchmark and transect using your estuary map, compass bearings, landmark, site description notes, or GPS coordinates (if available).

3 Once you have found your benchmark peg and established the transect, you are ready to begin the topography survey.

4 Hold one of the poles on top of the landward benchmark peg with the water-filled hose attached. Always keep the poles as upright (vertical) as possible. Your first pair of measurements should always start with the back pole on top of the benchmark.

Move down the transect making measurements of the surface topography. Measure the horizontal distance between poles using a builder's tape or similar. Remember to pull the tape tight so that you accurately measure the horizontal distance between the poles. Measure the changes in surface level using the water-filled hose attached to the poles. Note: you can use hose connectors to join the see-through hose to the garden hose.

5 Your partner takes the second pole, with hose attached, some distance down the transect. A useful place to pick for your first measurement is at the edge of the vegetation, the top of the beach, or a recent high-water mark. The presence of seaweed, driftwood, and other floating material often indicates the most recent high-water mark.

6 Place a plastic lid or similar on the ground to mark where you want to make the measurement and set the bottom of the pole on this. The plastic lid will prevent your pole sinking into the sediment. This is important because you want to measure the height of the sediment surface. The plastic lid also shows your partner where to place their pole for the next set of measurements as you move along the transect.

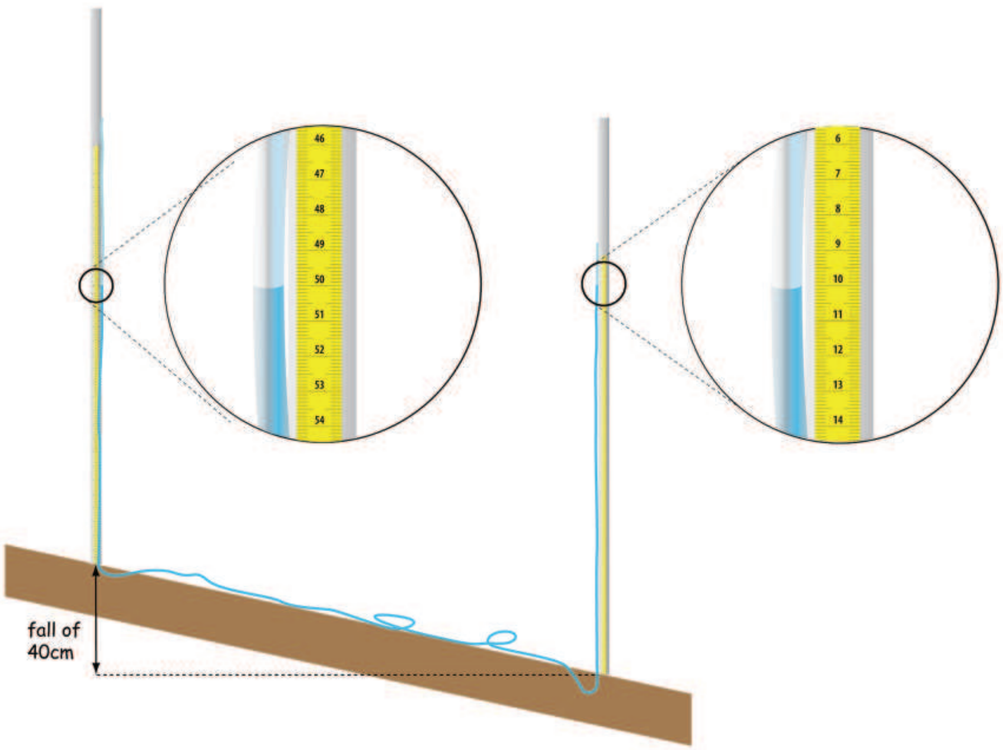
7 Measure the horizontal distance between the two poles to the nearest centimetre using the 30 m tape measure. Record the distance on the datasheet.

8 Once both poles are in position and upright, hold them steady. You will notice that the water surface in each end of the hose may move up and down. Wait a minute or so until the water surface (called the meniscus) becomes stable. You are now ready to make your first measurement.

9 Measure the height of the water level on each pole using the measuring tape attached to the pole. Measure the water level to the nearest millimetre. Record the water levels on the datasheet.

Measure the height of the water level in each pipe to the nearest millimetre. Hold the pipe upright and wait for about a minute to let the water surface become stable.

10 The example below shows a situation where the surface is falling along the transect. The water levels in the hose are actually the same. However, the ground surface at the downhill pole is lower and a difference in ground height of 40 cm is measured. This is calculated from the water level measurements: 50 cm (back pole) – 10 cm (forward pole) = 40 cm difference. Record the difference on the datasheet.



In this example, the surface elevation at the downhill pole is 40 cm lower than the uphill pole. This is shown by the water levels in the hose at each location.

11 To help you remember what you have done, it is important to make some comments on your datasheet. For example, "front pole located on the high-water mark or edge of seagrass bed".

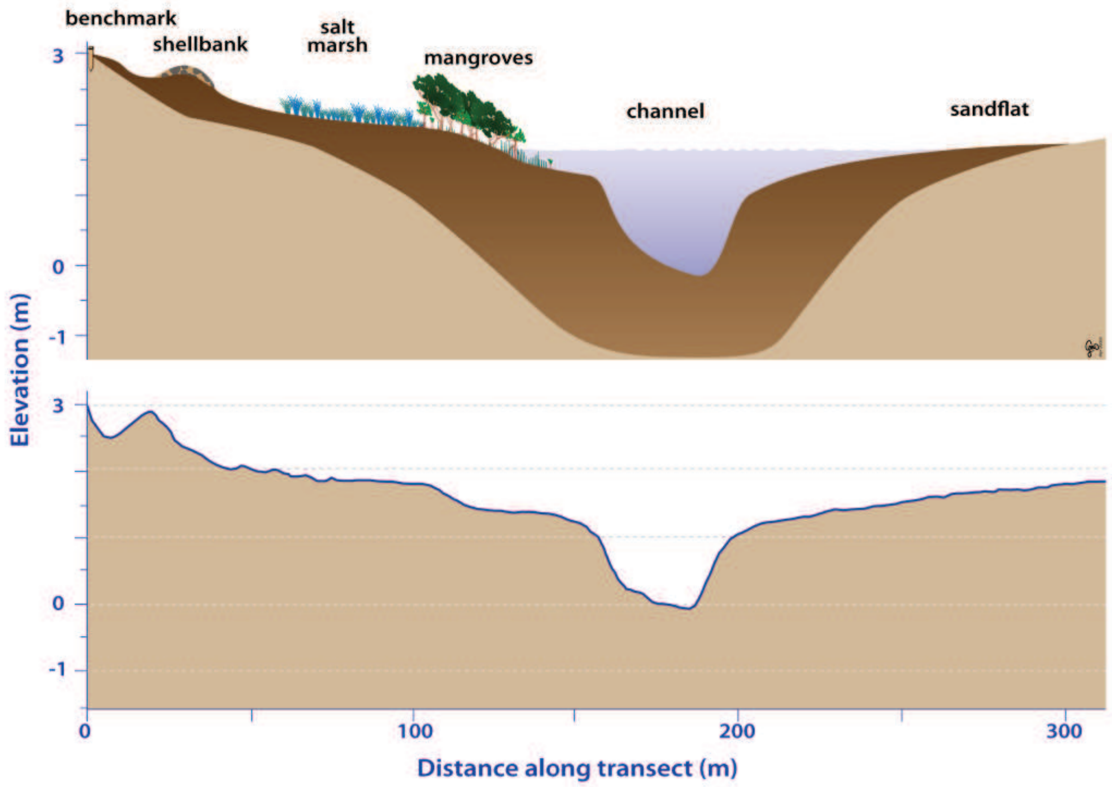
12 Once you have recorded the distance between poles and both water levels, you are ready to make the next set of measurements along the transect. The person with the back pole moves to the location of the front pole and holds the back pole in the same spot (on the plastic lid). The back pole person gives their plastic lid to the front pole person, who can now move forward along the transect. Keep on line using the landmark at the far end of the transect or your compass bearing.

13 Repeat steps 5–12 until you have reached the far end of your transect. The end of the transect could be the opposite shore of the estuary or the edge of a channel that is too deep to walk across at low tide.

14 Once you've finished your survey you may also want to draw a sketch of your profile, outlining any main features to help you with your data analysis.

Data analysis

An example of an estuary cross-section from a hydrostatic elevation survey is shown in the diagrams below. The top diagram shows the main features along an imaginary estuary transect, which crosses an area of saltmarsh, mangroves, and a sandflat on the opposite bank of a tidal channel. The second diagram shows the result of the hydrostatic survey across this transect, with final details of the topography and elevation changes across the transect recorded.



An example of the estuary topography measured using the hydrostatic survey method.