

Measuring animals in a marine reserve

Measurement of fairly large numbers of animals can be useful in calculating if they have a distinct breeding season, how fast they grow, and how fast they grow in different conditions.

If a species breeds throughout the year there will be an even spread of all sizes right through the year. If a species has a distinct breeding season most of the juveniles will fall within a fairly narrow size range at any given period of the year. For a number of common shore animals – especially grazing snails – the distinct size peaks corresponding to each breeding cohort are obvious for several years.

This gives good opportunities for measuring exercises that will produce interesting and meaningful results if the procedures are standardised and carefully supervised. However, it is important that all the students measure exactly the same way and use identical equipment so that the data from all pairs / groups can then be pooled in class.

Counting exercises can be completed in a marine reserve without disturbing the animals and plants. However, most measuring procedures are not acceptable in a marine reserve because they involve detaching and picking up many animals. This would lead to a high level of disturbance to the marine life by large numbers of students.

Biological explanation of disturbance

Students might think that picking up a shore snail, measuring it and returning it straight away to the spot it was lifted from would cause little disturbance. This is not the case.

When grazing snails are suddenly left high and dry by the falling tide they stop moving, holding some water within the shell to keep them moist while the tide is out. They remain attached to the rock by their suction foot but with the shell clamped down tight to the surface so that evaporation around the shell edge is minimised.

When the tide returns and the snail is first struck by the swash of a wave breaking a little lower on the shore it is not dislodged because it is still securely anchored to the rock by the suction of its foot. The snail will resume normal activity as soon as it is covered by seawater.

If a snail is lifted from the rock it retracts its body into the shell, closing the aperture with a lid (or operculum) that is located on the back of the foot. As it draws its body into the shell the reservoir of water it uses to keep it moist is displaced and it is lost if the shell is placed aperture down.

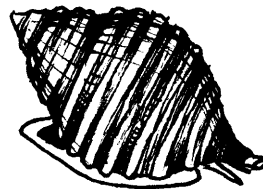
Snails disturbed in this way do not try to reattach to the rock because that would then expose the animals to the risk of drying out. When the tide rises the swash of the first wave will wash the snail away.

Intertidal grazing snails have fairly rounded robust shells that can usually tolerate a moderate amount of tumbling and rolling. Eventually they will be dumped into a pool or gutter where the water is deeper.

Sinking to the bottom where conditions are less disturbed they will then emerge from their shells, reattach the suction foot to the rock and crawl back up to their normal position on the shore.

However, a few may be smashed by large breaking waves and some are washed up into the drift line of the sandy beach where they die because they cannot crawl back across the loose sand. Consequently regular disturbance of large numbers of grazing snails by school classes would be unacceptable in a marine reserve.

This explanation can serve as the basis of a useful lesson on the behaviour of rocky shore snails. Many children believe (and some elementary articles and books incorrectly state!) that shore snails withdraw into their shells and close the apertures every time the tide falls. This is nonsense for it would result in all the snails being washed all over the shore every time the tide returned.



Measurements of abundance

Studies of abundance of particular species can be used to demonstrate

- a. The enormous numbers of some species
- b. The different densities of particular species at different levels on the shore
- c. The comparative density of species that are commonly exploited on a non-reserve shore with the density in a marine reserve
- d. The proportions of different age classes within a population of a single species and from this an estimate of the average growth rate

Abundance studies give great scope for cross-curricula mathematical extension exercises and some children can be more easily stimulated to persevere with mathematical problems if they are working up data they have collected themselves.

Abundance may be a measure of the numbers of organisms in a given area or the biomass. Many small animals (such as column barnacles or flea mussels) may completely blanket the rock surface in some parts of the shore. Individually the animals are minute but collectively the mass of animals can represent surprisingly large amounts of animal matter.

From careful counts of small quadrats (5 cm x 5 cm, 10 cm x 10 cm or 25 cm x 25 cm according to the size of the animals being counted) calculations can be made of the numbers per metre square and then to numbers per hectare.

Similar calculations of biomass will produce interesting figures for comparison with larger animals that school children could easily relate to, to appreciate the productivity of seashores. For example, knowing that the average stocking rate of a good quality farm paddock in New Zealand is about 2.5 head of cattle per hectare, allows comparison to be made with the biomass of grazers living on a hectare of rocky shore.

A steer weighs about 500 kg (= about 230 kg of meat)

Therefore biomass per hectare is about 1.25 tonne (= about 0.6 tonne of meat)

Sampling and averaging

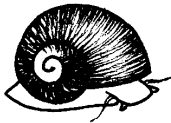
A single sample count may or may not be typical of the shore (or the part of the shore) being studied. Student pairs may have time to count the animals living in several sample squares and the numbers can then be averaged to produce better information. With the data from a whole class (working as pairs) the quality of the information produced will be very high and will be a good demonstration of the value of sampling for minimising the statistical impact of occasional abnormal samples.

As a useful stand-alone statistical exercise senior students can use the direct relationship between number of samples taken and the variation from the mean.

Counting and measuring



Counting must be easy but accurate. Accurate counting can only be made using standard quadrat frames of sizes appropriate to the size and density of the animals or plants being counted.



Cautionary note on transect exercises

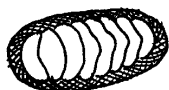
Some teaching documents recommend counting and recording animals along transect lines (usually marked with a rope or measuring tape) stretched down or across the shore. For school students, especially those participating in their first shore survey, collecting good information along a transect line is always difficult because of the stepped, ridged and undulating nature of all rocky shores and the changing species (or age classes) of the creatures being counted and measured.



The interpretations are invariably very poor because the transect exercise is too complex. Even experienced marine biologists would have difficulty producing a meaningful scenario from a single transect. Therefore students visiting the shore for the first time who are not familiar with many or most of the species are unlikely to produce useful work in the limited time that they have available.



Transect surveys could work well for demonstrating shore zonation related to tidal immersion times on shores that sloped smoothly from high tide to low water mark. However these only exist as concrete boat ramps which have little marine life. Real rocky shores have ridges, clefts, steps, crevices, deep and shallow rock pools, large boulders and cobble beds and all of these may be represented on a single transect line. Making sense of the information gathered is extremely difficult.



The marine life in a mid-tidal pool may be representative of extreme low tide or subtidal communities and will not be at all typical of the mid-tide level. Clefts and crevices offer shelter from both drying wind and damaging waves and provide shade so they remain damper and can be colonised by animals that shun sunny conditions on open rock surfaces. A ridge low on the shore may, because of its vertical height, be capped with upper shore animals.

Boulders are particularly confusing because over the surface of each one conditions change from top to bottom but also from the side exposed to the sun around to the opposite shaded side. So a large stable boulder in the middle of the shore may have upper shore animals on the top, subtidal animals underneath and middle and lower intertidal zoning animals in between but the positions of those zones change around the boulder according to the levels of sun or shade.

All these complications make transect interpretation too difficult for school class work however they could be the basis of a senior study which identified the natural variations in zonation and species diversity from the ideal shore with smooth slope.

Quadrat counting

Quadrats (= square sampling frames) must be made accurately, be fairly robust and not readily damaged by seawater or sand abrasion. They must also be both easy and cheap to make. Some designs in published teaching documents use costly materials and require full workshop facilities and skills to produce so they are impractical for most school classes. The four designs below use cheap or scrap (recycled) materials and can easily be made by teachers or most able students.

Recommended sizes for quadrat squares:

5 cm x 5 cm or 10 cm x 10 cm for counting small animals like barnacles, flea mussels or periwinkles.

25 cm x 25 cm for counting grazing snails or calculating percentage cover of encrusting colonies on rocky shores and cockles and wedge shells on soft shores.

50 cm x 50 cm or 1 m x 1 m for counting less common animals such as predatory and scavenging snails.

Quadrat type P (plastic)

Materials: Ice cream tub lids

One lid makes one 10 cm quadrat or four 5 cm quadrats.

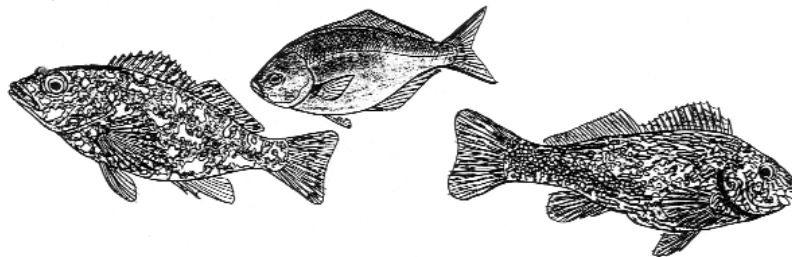
Tools

A template square of thick card or hardboard cut accurately to the quadrat size.

- Strong scissors
- Craft knife
- Metal straight edge or strong ruler

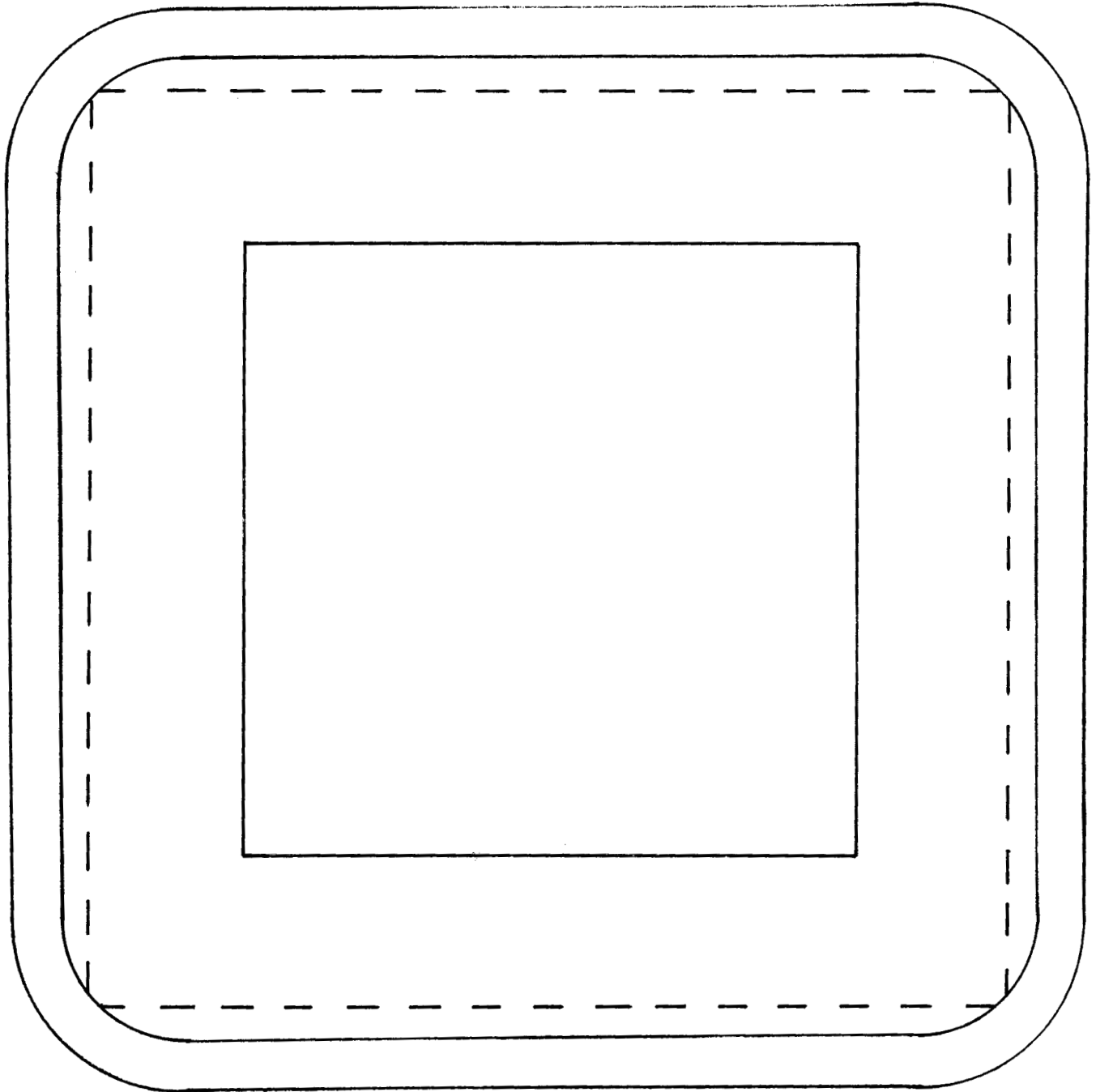
Construction

1. Cut rim off ice cream box lid with strong scissors
2. Lay template neatly on plastic and mark around it with ballpoint pen
3. Using craft knife & straight edge cut out marked square
4. Label (school & class name) with waterproof felt pen



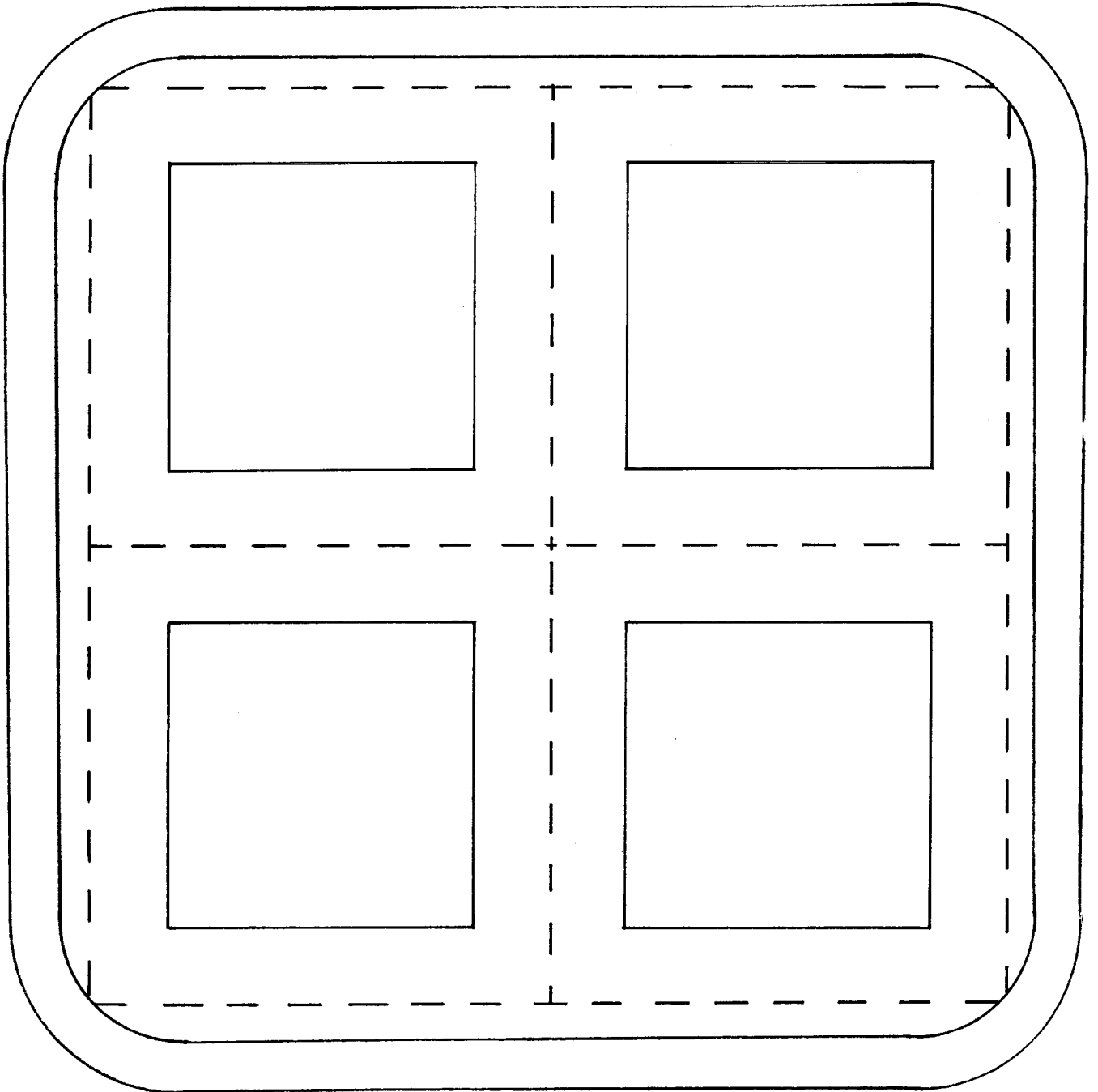
Quadrat type P

Lid from ice cream carton showing cutting lines (dotted to trace off rim) and solid to cut out 10cm x 10cm quadrat.



Quadrat type P

Lid from ice cream carton marked out for marking four x 5 cm x 5 cm quadrats



Quadrat type W (wire)

Materials

- Galvanised fencing wire
- Piece of chip board (or similar) slightly larger than quadrat
- 7 x 25 mm flat head nails
- A 5cm length of narrow plastic tube (eg, aquarium aerator tubing) per quadrat. Tubing bore to be slightly less than wire diameter, to serve as a tight fitting, linking sleeve

Tools

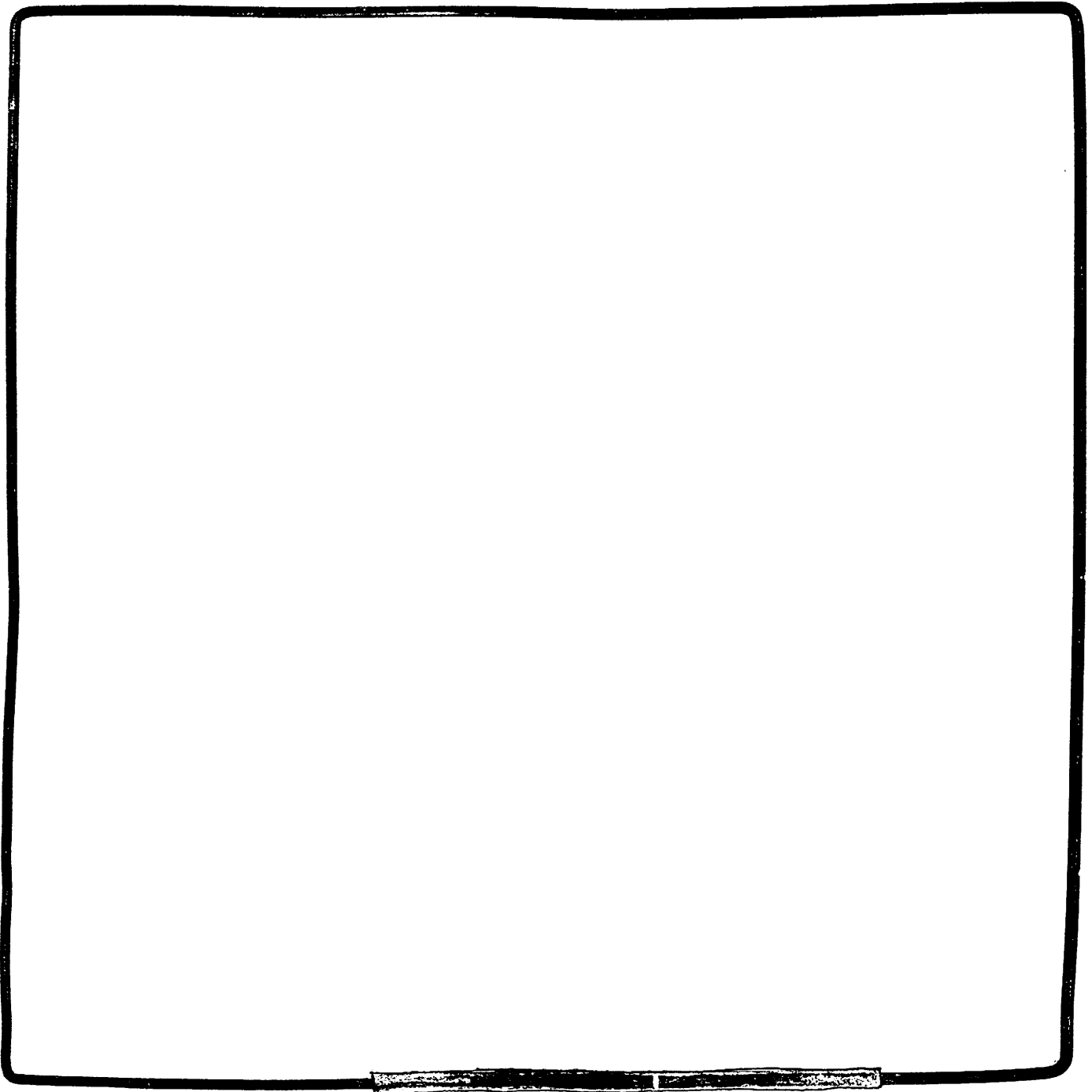
- Set square
- Ruler
- Hammer
- Pliers
- Hacksaw or wire cutters
- Hand-held hair drier

Construction

1. Accurately draw a square of the desired quadrat size on the wooden board
2. Hammer in a nail just inside (1 mm) each corner till each protrudes just 5 mm.
3. Make a temporary wire holding cleat mid-way along one side of the drawn square with three nails hammered in the same depth as the corner nails. Hammer the middle nail on the inside of the line and the others, each 2 cm away, on the outside of the line
4. Cut and straighten a length of wire a few centimetres longer than four sides of the square
5. Fit one end firmly into the holding cleat
6. Bend the wire tightly around each corner nail in turn, making sharp bends at each nail
7. Where the ends cross over at the cleat, mark both wires so they will butt up neatly when cut to length
8. Release the quadrat frame from the cleat and corner nails and cut the two ends to length
9. Warm the tubing with a hair drier to soften the plastic just enough so it will slip easily over the two ends of the wire frame to make a neat joining sleeve. When the plastic cools it will clamp securely to the wire, holding the ends together

Quadrat type W

Wire quadrat square with plastic sleeve for joining ends.

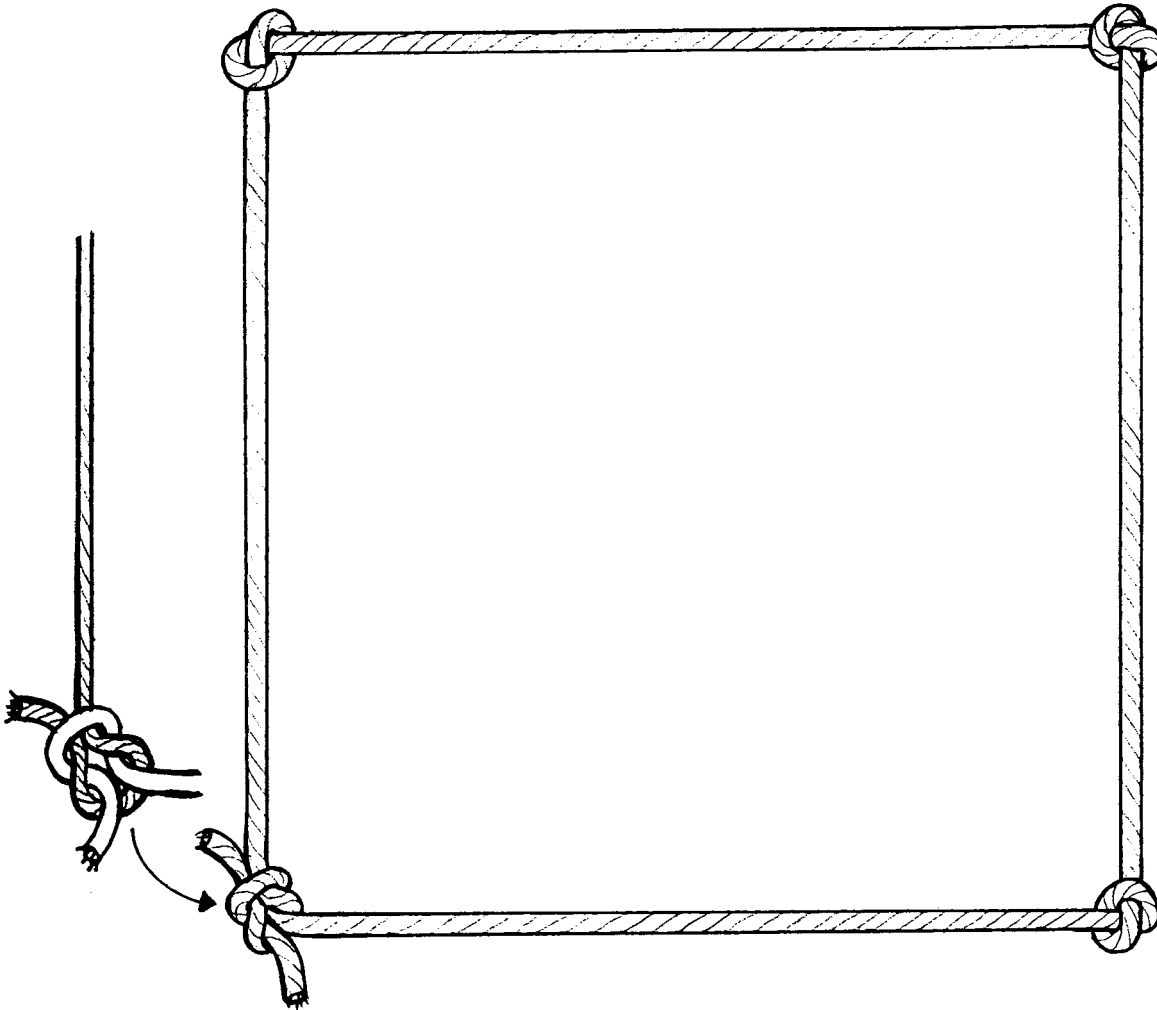


Quadrat type R (rope)

Rope quadrat – for use on uneven surfaces. To make:

- Tie a half hitch at three corners at the desired length
- Tie a reef knot to join the ends at the fourth corner

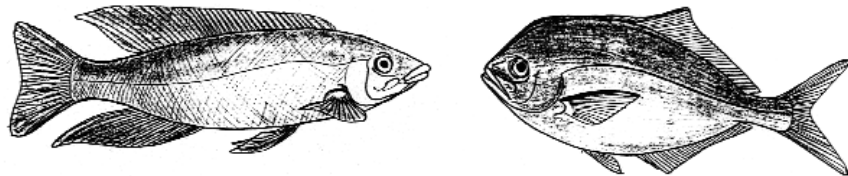
NB: *with a little care these knots can be adjusted easily so that each rope side of the quadrat square is the correct length.*



Quadrat type T (transparency)

Acetate sheet used for 'overhead' projection is a useful reusable, write on film for making transparent, write-on or draw-on quadrats. On paper, draw up a bold square border and photocopy the outline on to the overhead transparency sheet. To suit particular projects, customise the sheets by adding 1 cm or 5 cm gridlines to the master sheet and identifying the rows and columns of the grid with numbers and letters.

Transparent quadrats can be marked with felt pen to accurately map the percentage cover of encrusting seaweeds or sessile colonial animals (like barnacles) so that good amounts of information can be gathered quickly but accurately on the shore for detailed analysis back in the classroom. Use waterproof felt pen on the shore and after processing the information or transferring on to paper using a light table, the sheets can be cleaned with meths for reuse without removing the boarder or grids.



Environmentally acceptable measurement exercises

1. Learning with limpets

By using callipers, some snails can be measured where they stand, without detaching or disturbing them. Coiled snails like the cats eye and topshell often congregate alongside steps or in crevices just as the tide falls because these retreats do not dry out so quickly and may offer shade from direct sunshine.

Higher on the shore the blue-black nerita also gather along moist cracks and they frequently clump together in packs of a dozen to more than 100 on open rock platforms which have few recesses. In addition to the water held by each snail **within** its shell, packing together on hot days at low tide allows them to trap extra water **between** the shells. This helps to keep the whole group moist till the tide returns.

These various methods of retaining moisture and avoiding drying conditions can be presented as a complete, stand alone teaching approach which can be developed into an on-shore exercise of challenging the class to investigate (mainly by observation) how a range of different animals are physically or behaviourally adapted to tolerate drying conditions when the tide is out.

Close packing can often make measurement of individuals difficult or impossible without disturbing other snails but limpets are an exception. They may gather loosely in shallow depressions near their feeding grounds but being flattened cones they are always easy to measure with callipers. The commonest limpet of the middle and lower shore *Cellana radians*, the radiate limpet, is also fairly fast growing. It reaches near maximum size in about two years and it is therefore generally easy to distinguish by eye between limpets in their first, second and third years.

By measuring shell lengths and counting abundance, students can conduct studies to indicate if:

- a. average growth rate is affected by the density of the grazers. (Slower growth rate expected where density is high due to competition for a limited food resource)
- b. average growth rate (where density is about the same) is greater / lower on the shore because tidal immersion is longer and therefore feeding time is also longer

Callipers

Metal workshop/laboratory callipers are expensive and unsuitable for use by school groups for a rocky or sandy shore exercise because of the corrosive nature of seawater. However, cheap plastic callipers, (about \$3 to \$5 each) made in Taiwan, which have been sold through 'The Warehouse' or other discount stores, are ideal for school seashore studies.

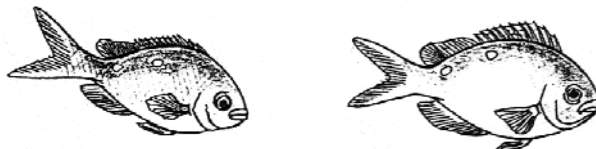
Procedure

- Students work in pairs: one recorder and one counter and measurer
- Equipment: 1 metre square quadrat, callipers, piece of chalk, notepad and pencil
- Measurements are made at parts of the shore where the limpets are common
- Using chalk and quadrat frame, teacher marks out sufficient random quadrat squares on the rocky shore where the limpets are found. It may be useful to number the squares with chalk if they are in a sequence down the shore. Each student pair may have time to count and measure limpets in several squares in the time available
- For each square, the limpets are first counted and then each specimen is measured along its long axis (greatest length). As each limpet is measured a chalk mark is made on the rock beside it as a check that each one is measured and that none are measured twice

Analysis

Calculate average body length against density per metre square for each quadrat and (for comparison) the mean for all squares assessed.

Create a class size frequency histogram of numbers against 1 mm size classes for all the limpets measured. If two areas of the shore are being compared, create separate size frequency histograms for both areas.



Soft shore shells (biodiversity)

A simple biodiversity exercise with driftline shells to show the variety of marine life within and alongside a sandy beach.

Discovering what animals live in the sand between the tides or just offshore is difficult because they are safely buried, out of sight, to avoid being eaten by predators. Burial also protects them from drying out when the tide is low and from being tossed around by waves and surging currents as the tide rises and falls.

In a marine reserve taking living or dead marine life (animals or plants) is not permitted and it is an offence to disturb or interfere with the marine life. Therefore collecting samples of live shellfish for abundance or growth rate studies cannot be conducted in a marine reserve.

If empty shells lying along the driftline are considered to be one of the 'natural features' of a marine reserve then, according to a strict interpretation of the Act, it would even be an offence to pick one up to study it (Section 18, 1 (4)).

Gathering a few empty shells from the driftline for a simple identification exercise **at the beach** would be an acceptable activity within the spirit of the act. (Provided that the shells are not taken away from the beach).

The following rules or guidelines are recommended for school study groups:

- 1 Each student to collect only five shells – but challenge them to find five different ones.
- 2 Do NOT gather shells from right along the beach but from a restricted area of 50 m each side of an assembly point. This allows all the shells collected to be redistributed along the same part of the beach after the class exercise.

Use parent helpers to mark the 50 m limits to prevent the students roaming too far. The restricted range also helps with safety and behaviour supervision and with the orderly completion of the exercise within a limited time slot because all students will be within earshot and can be called in for sorting the shells found.

- 3 After sorting the shells into different species, identifying them against a check sheet and recording all the species found for post-visit discussions in the classroom, the shells can be redistributed randomly along the driftline so another class can enjoy the variety the next day.

The children should do this redistribution, so that they absorb the spirit of leaving a marine reserve beach just as they found it.

Suggested identification procedure

- 1 At the assembly point, on a smooth firm part of the beach, draw a pair of parallel lines about half a metre apart in the sand. This is a 'No Walk Zone' where the students will place their shells.
- 2 Draw neat lines about 25 cm apart between the parallel lines to make a ladder pattern along the sand.
- 3 Each student must sort the shells that they collected into distinct species and place each one with like shells in the appropriate box of the beach 'ladder'. Starting at the centre allocate one end of the ladder for bivalve shells (clams, mussels and oysters) and the other end for univalves (snails and limpets).
- 4 At Long Bay a class should easily find a dozen different species and they may find up to 40 different shells. They may originally have come from the sand (mostly below low tide) or from the rocky reefs at each end of the beach.

NB: *Students need to be reminded that some marine animals, including shellfish, are very small when fully grown. Many bivalves and snails seldom grow larger than a pea and some are scarcely larger than a match head when mature. To find these tiny shells students will need to get down on hands and knees with their eyes close to the sand surface. To hold and display them during the beach exercise it is helpful to use empty tuatua shells as mini dishes.*

Teachers need to check carefully that the shells are properly sorted. At their first try both junior and senior students often have difficulty at distinguishing between similar but different shells.

They need to look at such features as:

- General shape (round, oval, tear drop, conical, triangular, etc)
- Prominent ridges or shoulders
- Surface sculpture (rough or fine, with knobs, ridges or lines and with lines or ridges arranged around or across the shell or both around and across)
- Distinct colour bands or patterns. (These are not always reliable, dead shells gradually become worn or bleached and shells that have been buried in the sand may absorb black or rusty coloured pigments from the sand)
- Internal scars of bivalve shells where the shell closing muscles and the mantle were attached are characteristic in size, shape and position
- Interlocking 'teeth' beside the hinge are also characteristic in size and shape

Long Bay – sandy beach

Driftline shells: common names

Univalves

(snails and limpets)

Periwinkle	
Nerita	
Topshell	
Cats eye	
Paua	
Knobbed topshell	
Opal topshell	
Purple topshell	
Green topshell	
Cooks turban shell	
Ostrich foot	
Siphon whelk	
Speckled whelk	
Spotted whelk	
Red mouthed whelk	
White rock whelk	
Brown rock whelk	
Oyster borer	
Olive	
Turret (or Spire) shell	
Horn shell	
Ribbed slipper limpet	
Saucer limpet	
Brown bubble shell	
Ornate limpet	
Radiate limpet	
Star limpet	
Siphon limpet	
Encrusted limpet	
Shield shell	

Bivalves

(clams, oysters, mussels)

Horse mussel	
Green-lipped mussel	
Bearded mussel	
Black flea mussel	
NZ rock oyster	
Pacific rock oyster	
Jingle shell	
Scallop	
Fan scallop	
Dog cockle	
Purple love cockle	
Common cockle	
Ribbed cockle	
Oblong cockle	
Lace cockle	
Coarse dosinia	
Smooth dosinia	
Pipi	
Tuatua	
Dawn shell	
Purple sunset shell	
Pink sunset shell	
Wedge shell	
Round wedge shell	
Piddock	
Lamp shell	

Long Bay – sandy beach

Driftline shells: common and scientific names

Univalves

(snails and limpets)

Periwinkle	<i>Nodilittorina antipodum</i>
Nerita	<i>Nerita atramentosa</i>
Topshell	<i>Melagraphia aethiops</i>
Cats eye	<i>Turbo smaragdus</i>
Paua	<i>Haliotis iris</i>
Knobbed topshell	<i>Diloma bicanaliculata</i>
Opal topshell	<i>Cantharidus opalus</i>
Purple topshell	<i>Cantharidus purpureus</i>
Green topshell	<i>Trochus viridis</i>
Cooks turban shell	<i>Cookia sulcata</i>
Ostrich foot	<i>Struthiolaria papulosa</i>
Siphon whelk	<i>Penion sulcatus</i>
Speckled whelk	<i>Cominella adspersa</i>
Spotted whelk	<i>Cominella maculosa</i>
Red mouthed whelk	<i>Cominella virgata</i>
White rock whelk	<i>Dicathais orbita</i>
Brown rock whelk	<i>Haustrum haustorium</i>
Oyster borer	<i>Lepsiella scobina</i>
Olive	<i>Amalda australis</i>
Turret (spire) shell	<i>Maoricolpus roseus</i>
Horn shell	<i>Zeacumantus lutulentus</i>
Ribbed slipper limpet	<i>Crepidula costata</i>
Saucer limpet	<i>Sigapatella novaezealandiae</i>
Brown bubble shell	<i>Bulla quoyii</i>
Ornate limpet	<i>Cellana ornata</i>
Radiate limpet	<i>Cellana radians</i>
Star limpet	<i>Cellana stellata</i>
Siphon limpet	<i>Siphonaria australis</i>
Encrusted limpet	<i>Patelloida corticata</i>
Shield shell	<i>Scutus antipodes</i>

Bivalves

(clams, mussels, oysters etc.)

Horse mussel	<i>Atrina pectinata</i>
Green lipped mussel	<i>Perna canaliculus</i>
Bearded mussel	<i>Modiolus areolatus</i>
Black flea mussel	<i>Xenostrobus pulex</i>
NZ rock oyster	<i>Saccostrea cucullata</i>
Pacific rock oyster	<i>Crassostrea gigas</i>
Jingle shell	<i>Anomia trigonopsis</i>
Scallop	<i>Pecten novaezealandiae</i>
Fan scallop	<i>Chlamys zelandiae</i>
Dog cockle	<i>Tucetoma laticostata</i>
Purple love cockle	<i>Venericardia purpurata</i>
Common cockle	<i>Austrovenus stutchburyi</i>
Ribbed cockle	<i>Protothaca crassicostata</i>
Oblong cockle	<i>Ruditapes largillierti</i>
Lace cockle	<i>Divaricella huttoniana</i>
Coarse dosinia	<i>Dosinia anus</i>
Smooth dosinia	<i>Dosinia subrosea</i>
Pipi	<i>Paphies australis</i>
Tuatua	<i>Paphies subtriangulata</i>
Dawn shell	<i>Tawera spissa</i>
Purple sunset shell	<i>Gari strangeri</i>
Pink sunset shell	<i>Gari convexa</i>
Wedge shell	<i>Macomona liliana</i>
Round wedge shell	<i>Pseudarcomyia disculus</i>
Piddock	<i>Barnea similis</i>
Lamp shell	<i>Calloria inconspicua</i>