Cambridge Assessment International Education

Teacher Pack

Random and systematic sampling

Cambridge IGCSE®

Marine Science 0697

Version 1

Cambridge Pathway

Contents

Icons used in this pack:

Briefing lesson

Lab lesson: Option 1 – run the experiment

Lab lesson: Option 2 – virtual experiment

Introduction

This pack will help you to develop your learners' practical skills as defined by assessment objective C (AOC Practical skills and investigations) in the course syllabus.

Important note
Our *Skills Packs* have been written by **classroom teachers** to help you deliver topics and skills that can be challenging, particularly those that have been indicated as practical activities (PA) in the syllabus content. Use these materials to supplement your teaching and engage your learners. You can also use them to help you create lesson plans for other experiments.

This content is designed to give you and your learners the chance to explore practical skills. It is not intended as specific practice for Paper 2.

This is one of a range of *Teacher Packs* and each pack is based on one investigation. The packs can be used in any order to suit your teaching sequence.

The structure is as follows:

Briefing lesson (1 hour*)
This lesson introduces the focus experimental skills to be developed. It also introduces any content needed for your learners to understand the experiment being carried out in the *Fieldwork lesson*.

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Fieldwork lesson (2 hours - longer may be required for visits to shores or other habitats away from school grounds *)	
Option 1 – run the fieldwork	**Option 2 – virtual fieldwork**
This lesson focuses on carrying out the experiment including the collection and recording of observations, measurements and estimates.	This lesson allows your learners to complete a virtual experiment, providing an opportunity to practise the experimental skills introduced in the *Briefing lesson*.

** the timings are a guide only; you may need to adapt the lessons to suit your circumstances.*

In this pack you will find lesson plans, worksheets for learners and teacher resource sheets.

Experiment: Random and systematic sampling

This Teacher Pack focuses on an experiment to collect data about populations of organisms in their habitat.

The distribution of organisms in their habitats can depend on a range of factors. Some habitats have a similar distribution of different species across the habitat, while other habitats with changing physical conditions show a gradual change in populations of different species.

This experiment has links to the following syllabus content (see syllabus for detail):

- 5.2.1 Investigate population sizes and species richness by random sampling using quadrats
- 5.2.2 Investigate distribution of species by systematic sampling using line transects and belt transects

The experiment covers the following experimental skills, adapted from **AOC Practical skills and investigations** (see syllabus for assessment objectives):

- demonstrate knowledge of experimental techniques, apparatus and materials and how to use them safely
- plan experiments and investigations
- make and record observations, measurements and estimates

Going forward

The knowledge and skills gained from this experiment can be used for when you teach learners about conservation strategies.

Briefing lesson: Sampling techniques

Resources	• Worksheets A and B • Quadrats (e.g. 0.5 m x 0.5 m) • Long tape measures or string/cord with distances marked on • List of random numbers or method of generating random numbers

Learning objectives	By the end of the lesson: • ***all*** learners should understand the difference between random sampling and systematic sampling. • most learners should be able to identify if a habitat is best sampled by random or systematic sampling. • some learners will be able to select the most appropriate type of transect for systematic sampling in a habitat.

Timings	Activity
10 min	**Starter/Introduction** Ask learners to suggest how populations of organisms might be estimated in their habitats. Discuss possible methods and identify strengths and weaknesses of each suggestion.
45 min	**Main lesson** Show learners a quadrat and explain how they can be used to identify the number of organisms, or to estimate the percentage of an area covered by an organism. Provide each group with **Worksheet A** and ask them to complete this in pairs or groups. Compare the results for estimating the percentage cover to emphasise that this is subjective and results will vary slightly. Discuss with learners the difference between random sampling and systematic sampling, how each type could be carried out and the benefits of each method. Ask learners to suggest situations when each method might be useful, use the 'Think, Pair, Share' strategy to encourage learners to think about the question on their own and come up with ideas, then pair with a partner to discuss their ideas and possibly develop their answers further before sharing their ideas with the class. Show learners the video to demonstrate the difference between random sampling and systematic sampling. Provide each group with **Worksheet B** and ask them to suggest the most appropriate method (random or systematic sampling) to estimate populations in each habitat, before evaluating different strategies for systematic sampling with a transect. Discuss the answers as a class.

5 min	**Plenary** Learners summarise what information they should consider to decide on the most appropriate method(s) to use to collect population data for any habitat.

Fieldwork lesson: Collecting population data in a habitat

Resources

- Method sheets
- Long tape measure / line marked with distances on
- Quadrat

Learning objectives

By the end of the lesson:

- ***all*** learners collect population data from a habitat
- most learners should be able to collect sufficient data to be able to draw conclusions
- some learners will be able to collect some repeat data

Timings	Activity
15 min	**Starter/Introduction** **Safety** Brief learners on important safety points. Ask learners if they have any questions about the safety instructions to check everyone understands. Give learners an opportunity to review the method before starting. Distribute equipment to learners as necessary to complete the investigation.
60+ min 95 min or more if available	**Main lesson** **Safety** Circulate the area being surveyed at all times during the investigation so that you can make sure that your learners are safe and that the data they are collecting is accurate. Learners collect data.
10 min	**Plenary** Gather learners back together and check for problems and that all equipment is accounted for to ensure that none is left behind in the habitat. Discuss any immediate issues or problems that learners have faced collecting their data.

Teacher notes

Watch the Sampling methods video and read these notes.

Two approaches are possible depending on the type of habitat surveyed, these are both demonstrated in the Sampling methods video.

Each group will require:

- An area of a habitat to survey with relatively uniform distribution of organisms, e.g. a grass field or meadow OR
- A habitat with gradual changes in the distribution of populations of species being investigated, e.g. a shoreline moving from low tide to high tide marks /splash zone.
- 1x measuring tape (or line marked at 0.5 m intervals) for a transect sampling survey, OR
- 2x measuring tapes (or lines marked at 0.5 m intervals) for a random sampling survey
- Quadrat (e.g. 0.5 m x 0.5 m)
- List of random numbers, or a method of generating random numbers for a random sampling survey.

Safety

When preparing for a field study, learners need to be aware of hazards which will vary according to the ecosystem studied, e.g. times of tides in coastal regions, steep slopes, marshy or muddy ground, dangerous plants or animals.

General safety precautions should be discussed, e.g. not going away from the group, not running, not throwing quadrats.

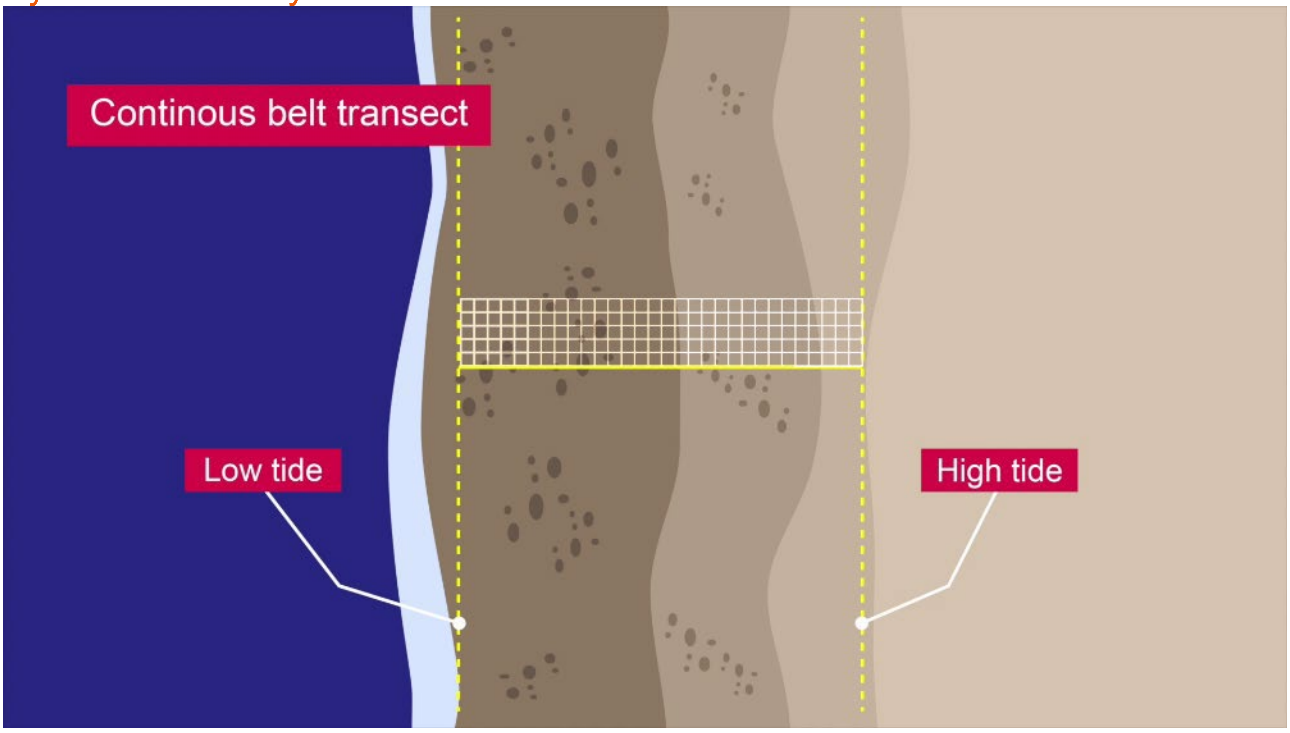
If the ecosystem is in an isolated area then a mobile telephone or radio telephone should be available in case of accidents.

It is your responsibility to carry out an appropriate risk assessment for this experiment.

Experiment set-up

Random survey

Systematic survey



Teacher method

This is your version of the method for this experiment that accompanies the video.

Do not share this method with learners. Give them Worksheet C or D.

Before you begin

Plan how you will group your learners during the experiment session.

Think about:

- the number of groups you will need (group size 2–4 learners).
- the amount of equipment required.
- the area available to divide groups into in the chosen habitat.

Experiment

Walk around the learners during the investigation in case they encounter any difficulties.

Step	Notes
Setting up the transect	Ensure this is started just before low tide, so that learners can collect their results from the lowest point and start to move up the shore before the tide starts to come in. You will of course have to be mindful of the speed that the tide comes in, and consider the safety implications. Also check that transects will not go through a 'low point' that could result in learners getting trapped by a rising tide.
Collecting results	Help learners to identify organisms sufficiently to record estimates of their populations. It is not necessary to correctly identify all species, the aim is to identify different types of organisms and their abundance.

Clean-up

After the experiment learners should:

- return all equipment to you.

Alternative Fieldwork lesson: Option 2 – virtual fieldwork

Resources

- Sampling Video
- Copy of teacher method handout
- Worksheet E results table
- Worksheet E answers

Learning objectives

By the end of the lesson:

- ***all*** learners should collect population data from a habitat using the video
- most learners should be able to collect sufficient data to be able to draw conclusions
- some learners will be able to collect sufficient repeat data to make the results more valid

Timings	Activity
5 min	**Starter/Introduction** Go through the method handout with the learners and discuss systematic sampling using a transect.
45 min	**Main lesson** Watch the video which pauses on each quadrat to allow learners to complete their results tables for each quadrat. There are 10 quadrats in the video, this allows 3-4 minutes per quadrat to observe and collect data.
10 min	**Plenary** Hand out worksheet E (sample results) – ask learners to compare their data with the table provided and suggest reasons for any differences. Learners could also compare their results with those from others/other groups in the class. Some errors will be due to mis-counting organisms, other differences will be due to different methodologies being applied by different learners – they should realise the importance of being consistent in their approach so that their own data is consistent from one sample to another.

Worksheets and answers

Worksheet A: Using a quadrat to count or estimate the percentage abundance of different species

Use this worksheet with the briefing lesson: Sampling techniques

A quadrat is a square frame used to record populations in a sample section of a habitat. They come in varying sizes but most often measure 0.5 m x 0.5 m or 1 m x 1 m.

Sometimes the quadrat is divided into smaller squares to enable further sampling to take place. Figure 1 shows an image of a quadrat on a rocky shore, the quadrat measures 0.5 m x 0.5 m, divided into 25 smaller squares, each 0.1 m x 0.1 m:

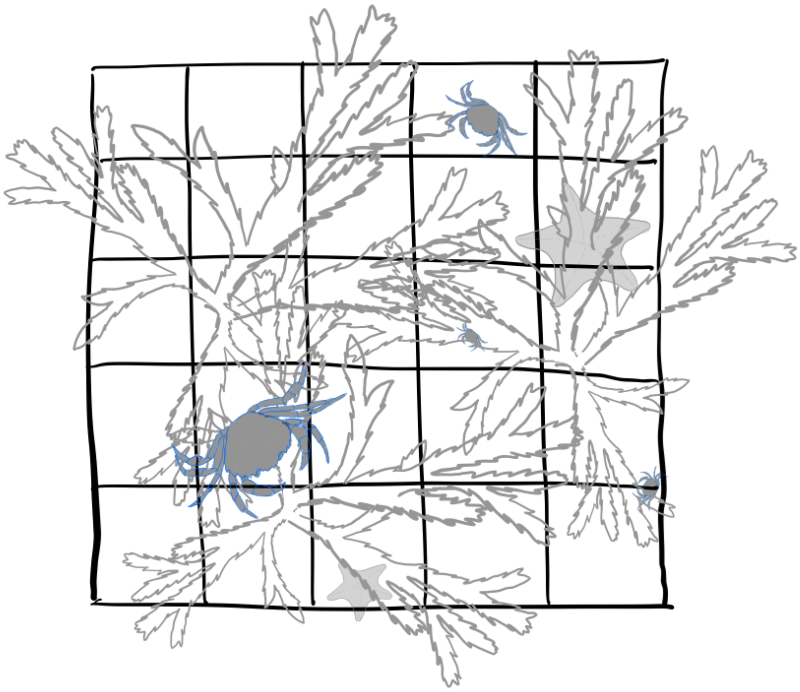


Figure 1: Quadrat on a rocky shore

There are two approaches that can be taken to measure the population of different species:

- Count the number of individuals (best when there are clearly identifiable individuals, such as with most animals),
- Estimate the percentage cover (best when it is difficult to identify separate individuals of a species, e.g. in grasses on land, sea weeds on a shore or corals which consist of colonies of individual polyps.

1. **Figure 1** contains three different species: a seaweed, a crab and a starfish.
    a. Suggest the most appropriate method of measuring the population of each of these species: counting individuals or estimating percentage cover.
    b. Count the number of individuals of each species where counting is most appropriate.

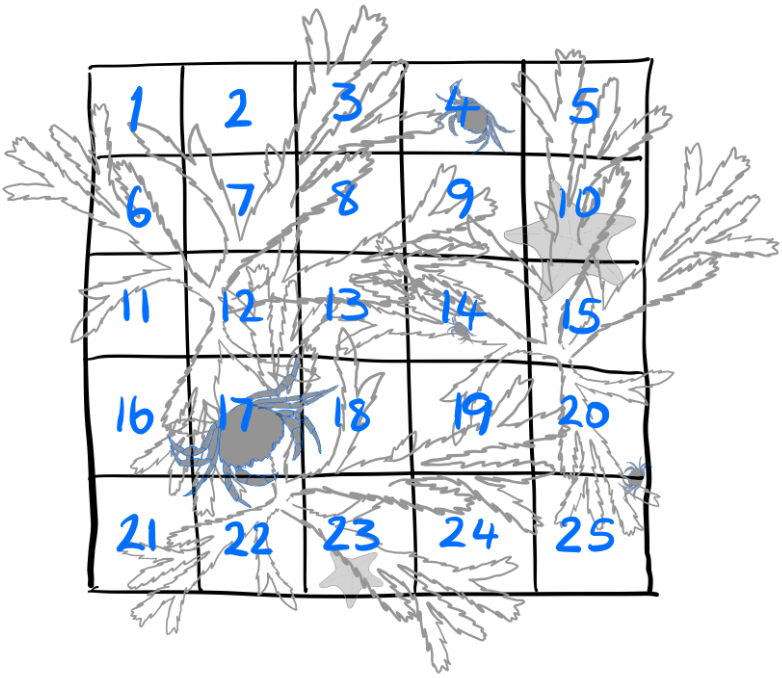


Figure 2: Quadrat on a rocky shore with numbered squares

When counting individuals this is usually straightforward to count the total number in the full quadrat.

When estimating percentage cover, it is useful to use the smaller squares to help – in Figure 2 the smaller squares in the quadrat have been numbered 1-25. Each of these smaller squares can be used to estimate coverage of the species to the nearest quarter (1/4). If we use this to estimate the percentage cover of the seaweed we might count the first five squares as:

Approximate number of quarters covered by seaweed in Figure 2				
1 *1*	2 *0*	3 *3*	4 *1*	5 *3*
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25

Table 1: Estimating approximate percentage cover of seaweed in Figure 2

2. Complete **Table 1** by estimating the number of quarters of each small square covered by seaweed.

3. Count the total number of quarters with seaweed in table 1, to give an estimate of the total percentage covered by seaweed in the quadrat (25 squares x 4 quarters each gives a maximum coverage of 100)

Worksheet B: Choosing a suitable survey sampling method

Use this worksheet with the briefing lesson: Sampling techniques

1. For each of the following habitats suggest a suitable method of sampling the populations of different species present and explain why you have chosen the method for each habitat.

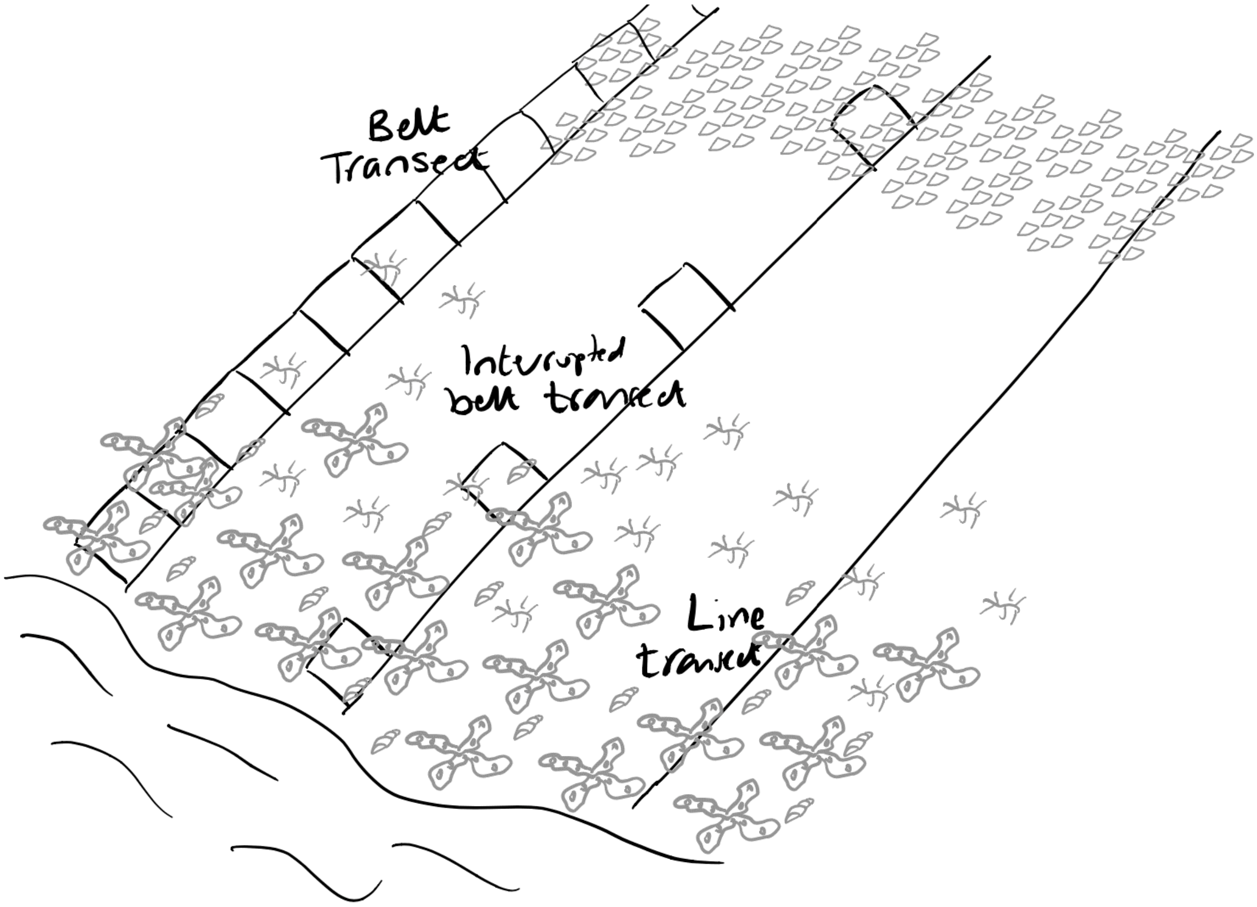
   A Wildflower meadow:

A beach shoreline:

A coral reef:

A mangrove coastline:

Systematic sampling using a transect can be carried out in different ways, depending on the length of the transect being used. The different types of transect are shown in the diagram below.



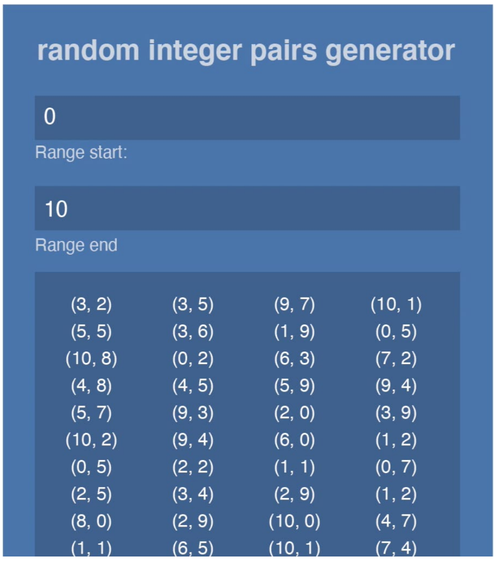
2. Suggest the advantages and disadvantages of each type of transect.

Worksheet C: Method – Random sampling

1. Identify an area of ground to investigate. This could be a grassy area or any other habitat that is available to you. Walk around the area, to get a general idea of what plants are growing there, or what slow-moving/stationary animals are present.

2. Use the long measuring tapes to mark out a large area (at least 10 m x 10 m, up to 30 m x 30 m) where you will sample the organisms. Arrange the tapes at right angles to one another, so that one of them represents an x-axis and one represents a y-axis.

3. Use a random number generator or list of random numbers to provide you with two numbers, for example, 14 and 6.



Use these numbers as coordinates, with the first number representing the x-axis value and the second number the y-axis value. Place your quadrat with its bottom left-hand corner at the point within the ‘axes’ specified by the coordinates.

4. Now you need to measure and record what is inside your quadrat. How you do this will depend on the kinds of organisms that you are recording.

If you are working with organisms that you can clearly see as individuals, you can simply record the number of individual organisms in the quadrat.

If you are working in a grassy area, it is usually not possible to count the numbers of individual grass plants, because you cannot tell where one plant stops and another one starts. Instead, you can estimate the percentage of the area of the quadrat that is covered by each species. This is called percentage cover. To help you to do this, you can use a quadrat that is divided up into smaller squares – it is much easier to estimate the coverage within several small squares than in one big one, for example each small square can be used to estimate to the nearest quarter of a small square:

Record your data for the first quadrat in a results table.

Write the names of the species (or a suitable label such as ‘grass’, ‘daisy’ etc.) you have found and recorded, insert an appropriate unit for recording, depending on whether you are recording actual numbers of organisms (‘species’ / number) or percentage cover (‘species’ /%).

5. Repeat Steps 3 and 4 at least nine more times, so that you have a record from a minimum of 10 randomly placed quadrats.

If you have more than 10 species in your samples add more columns to record these, and add more rows if you have recorded samples from more than 10 quadrats.

Worksheet D: Method – Systematic sampling

Use a habitat with gradual changes in the distribution of populations of species being investigated, e.g. a shoreline moving from low tide to high tide marks /splash zone.

Decide whether you will use a **line transect**, a **continuous belt transect** or an **interrupted belt transect.** This will depend on the length of your transect, the types of organisms you are sampling and the time you have available.

- For a line transact you simply record every species touching the line along its whole length (best for very long transects and when you don't have a lot of time to record your results).
- For a continuous belt transect, place your quadrat next to the line and record the abundance of each species in the quadrat (by counting or percentage cover, as appropriate for each species). Repeat these readings by moving the quadrat up the line without leaving any gaps between. (This method is best for very short transects and when you have lots of time to record your results).
- For an interrupted belt record the abundance along the transect using a quadrat but leave regular spaces between areas sampled with the quadrat – this collects a representative sample of results and can be used for longer distances where you want to indicate the abundance as well as where different species are present.

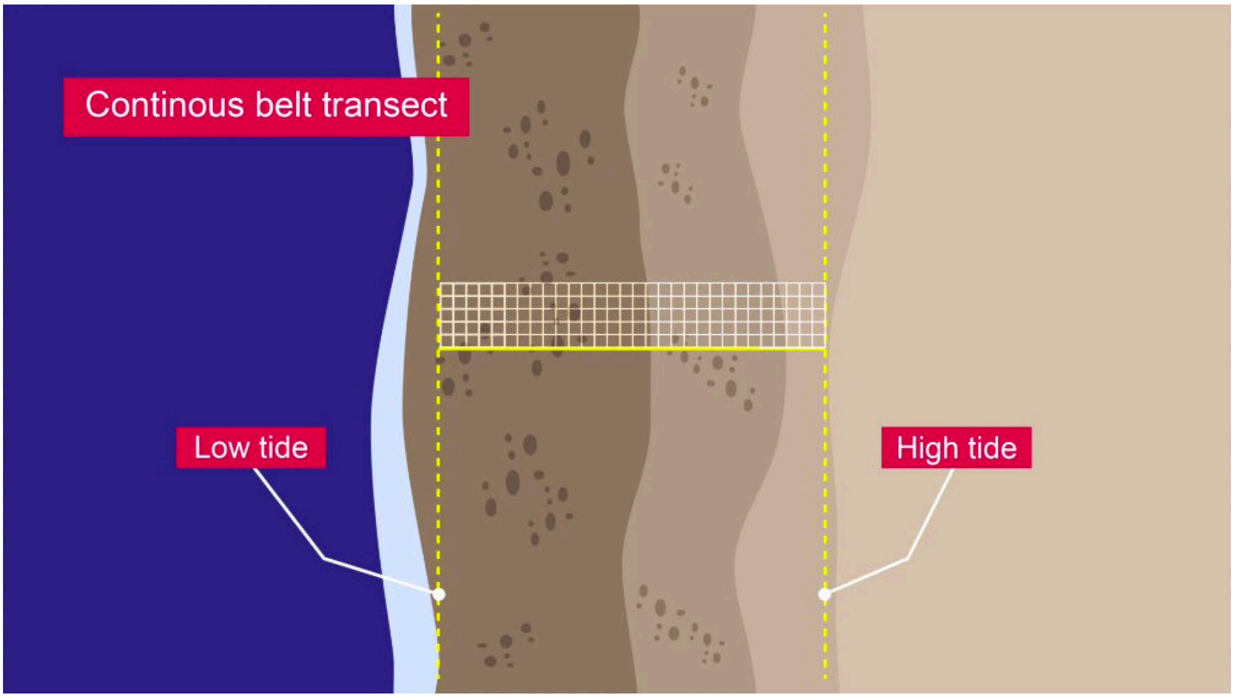
1 Starting at just before low tide use the string or measuring tape to mark a transect line on the shore that you will investigate from the high tide mark/splash zone down to the waterline.

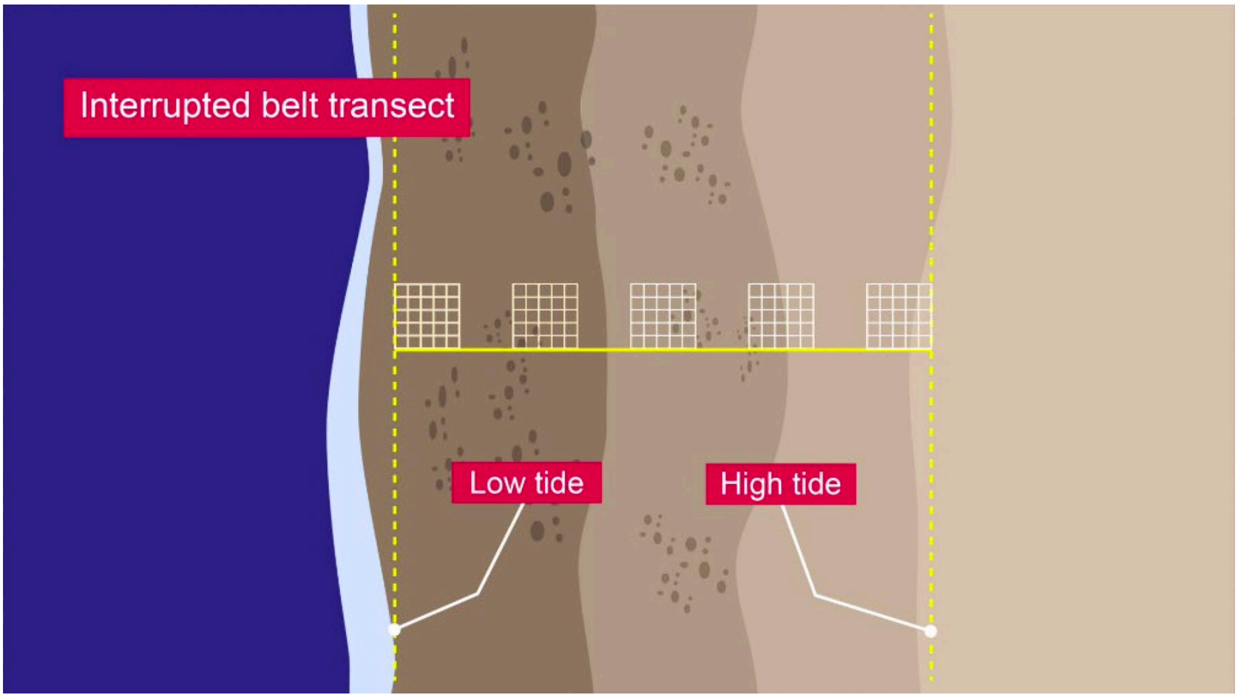
2 Start near to the retreating water line (tide going out): place your quadrat next to the transect line. Count (or estimate the percentage cover) for each species present in the quadrat. Record your results in a results table.

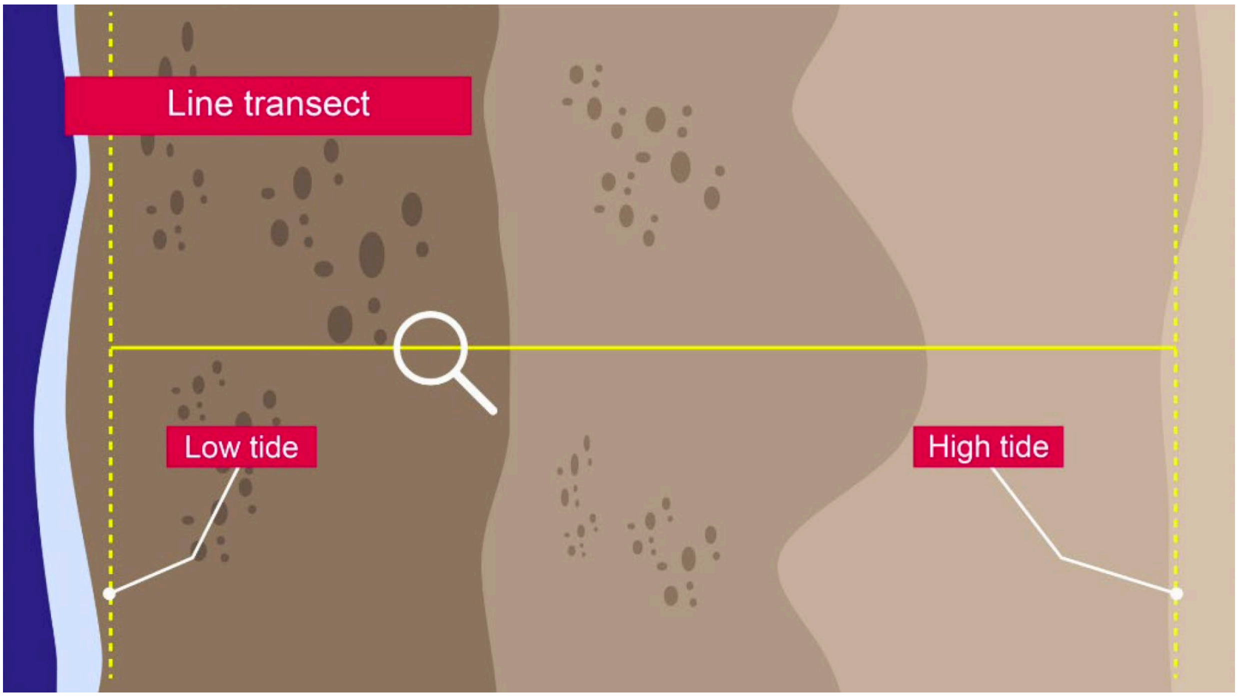
3 Move the quadrat further away from the sea to stay away from the rising tide.

4 Count (or estimate the percentage cover) for each species present in each quadrat. Record your results in the results table.

5 Repeat steps 3 and 4 moving up to the high tide mark or splash zone, allowing you to stay clear of the rising tide.




Interrupted belt transect
Low tide
High tide


Line transect
Low tide
High tide

Worksheet E: Results

Distance from top of shore / m	Abundance of species							
	Species 1 / no OR %	Species 2 / no OR %	Species 3 / no OR %	Species 4 / no OR %	Species 5 / no OR %	Species 6 / no OR %	Species 7 / no OR %	Species 8 / no OR %
0								
5								
10								
15								
20								
25								
30								
35								
40								
45								

Worksheet A: Answers

1.

a. Seaweed – percentage abundance;
Crab – number of individuals;
Starfish – number of individuals.

b. Crab – 4;
Starfish – 2.

2. Note: values are estimates only, it is normal for different people to estimate slightly different values from each other.

Approximate number of quarters covered by seaweed in Figure 2				
1 *1*	2 *0*	3 *3*	4 *1*	5 *3*
6 *2*	7 *2*	8 *2*	9 *3*	10 *3*
11 *1*	12 *4*	13 *3*	14 *2*	15 *3*
16 *1*	17 *2*	18 *1*	19 *3*	20 *3*
21 *1*	22 *3*	23 *3*	24 *2*	25 *1*

3. Total number of quarters in table above = 53, giving an estimated percentage coverage of 53% for the seaweed shown.

Worksheet B: Answers

Note answers may vary depending on the explanation given by the learner (for example at the edge of uniform habitats learners might suggest there is a gradual change in the distribution of species).

1. Choice of sampling methods:

A Wildflower meadow:
Random sampling, as the distribution of organisms is likely to be similar across the habitat.

A beach shoreline:
Systematic sampling (use of a transect) from the sea up the beach away from the sea, as the abiotic conditions change along this line.

A coral reef:
Random sampling, as the distribution of organisms is likely to be similar across the habitat.

A mangrove coastline:
Systematic sampling (use of a transect) from the sea up the shoreline, as the abiotic conditions change along this line.

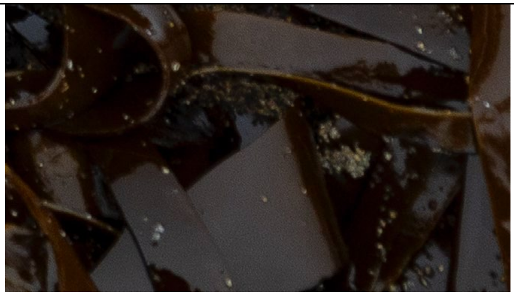
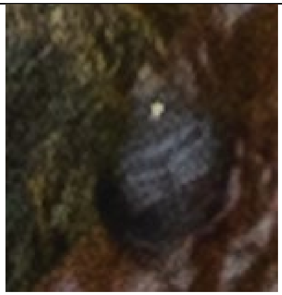
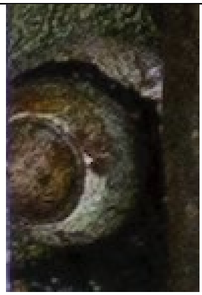
2. **Belt transect** – suitable for shorter transects and when more time is available to collect the data, takes a long time to collect.

Interrupted belt transect – suitable for longer transects and still enables good estimates of population data, but misses some population data.

Line transect – suitable for long transects with little time available, provides an indication of changes in species present along the transect, but little information about populations collected.

Worksheet E: Results (answers)

Distance from top of shore / m	Abundance of species							
	Seaweed A / %	Seaweed B / %	Anemone / number	Limpet / number	Snail C / number	Snail D / number	Seaweed E / %	Barnacles / %
0	8	0	0	0	0	0	0	0
5	0	5	0	0	0	0	0	0
10	0	4	1	3	7	1	0	0
15	0	9	1	24	2	3	22	8
20	0	26	3	3	32	1	8	1
25	0	8	0	0	9	2	0	0
30	0	18	0	2	2	0	31	0
35	0	12	0	11	2	3	27	1
40	0	26	0	6	3	1	28	0
45	0	19	0	20	1	1	8	0

Seaweed A	Seaweed B	Anemone
		
Limpet	**Snail C**	**Snail D**
		
Seaweed C	**Barnacles**	
		

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