Cambridge Assessment International Education

Teaching Pack

Random and systematic sampling

Cambridge International AS & A Level

Marine Science 9693

Version 1

Cambridge Pathway

Contents

Icons used in this pack:

Briefing lesson

Planning lesson

Fieldwork lesson

Debriefing lesson

Introduction

This pack will help you to develop your learners' experimental skills as defined by assessment objective 3 (AO3 Experimental skills and investigations) in the course syllabus.

Important note
Our *Teaching Packs* have been written by **classroom teachers** to help you deliver topics and skills that can be challenging. 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 (AS Level Data-handling and investigative skills) or Paper 4 (A Level Data-handling and investigative skills).

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

The structure is as follows:

Briefing lesson (1 hour*)
This lesson reinforces the key concepts, relevant skills, knowledge and understanding linked to the experiment.

↓

Planning lesson (1 hour*)
This lesson focuses on planning an experiment.
It ends with a demonstration video of the experiment.

↓

Fieldwork lesson (2 hours – longer may be required for visits to shores or other habitats away from school grounds*)
This lesson focuses on carrying out the experiment including the collection and recording of observations, measurements and estimates.

↓

Debriefing lesson (1 hour*)
This lesson focuses on the analysis and interpretation of data.
This includes making conclusions, evaluating methods and the quality of data and how improvements could be made.

** 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 and teacher resource sheets.

Experiment: Random and systematic sampling

This *Teaching 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):

- 4.4.5 describe random and systematic sampling and understand their advantages and disadvantages
- 4.4.6 use suitable methods, including frame quadrats, line transects, belt transects and mark-release-recapture, to investigate the distribution and abundance of organisms in the littoral zone

The experiment covers the following experimental skills, as listed in **AO3: Experimental skills and investigations:**

- describe how to ethically and safely use techniques, apparatus and materials in an investigative context
- plan experiments and investigations
- present and display data and observations in suitable formats
- evaluate given experimental methods and the quality of data, and suggest possible improvements.

Prior knowledge

Knowledge from the following syllabus topics is useful for this experiment.

- 4.3.1 explain that biodiversity can be considered in terms of species diversity.
- 4.4.1 explain, using marine examples, the terms ecosystem, habitat, niche, species, population and community.
- 4.4.2 explain the terms biotic factor and abiotic factor.

Briefing lesson: Sampling techniques

Resources	• Worksheet A • Worksheet 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** To reinforce key terms, encourage learners to ask '*What's the question?*' when given an answer. Use Teacher Instructions 1 to run this activity, in which a range of single-word terms are provided. Follow up by asking the learners to suggest how populations of organisms might be estimated in their habitats.
5 min 15 min 10 min 5 min 10 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.

Planning lesson: Planning to investigate populations in a habitat

Resources	• Worksheet C • Video: *Designing results tables*

Learning objectives	By the end of the lesson: • ***all*** learners should be able to describe a basic plan describing how to measure populations of species across a habitat • ***most*** learners should be able to describe an appropriate sampling technique for the chosen habitat and plan to collect a suitable amount of population data • ***some*** learners will be able to describe a detailed plan and describe how to estimate populations of the species for the larger area sampled.

Timings	Activity
10 min	**Starter/Introduction** Show the class the habitat to be surveyed using a photo, series of photos or video. Ask learners to discuss the type of habitat and types of organisms likely to be present in the habitat, and suggest possible strategies to investigate the populations of these organisms by considering the different types of sampling techniques covered in the previous lesson. Think, Pair, Share could be used to share answers with the group.
40 min	**Main lesson** Learners design a plan to collect population data from the habitat. Handout Worksheet C as a prompt for learners as they design their plan. Ensure that they include: • What they will measure • How they will measure/collect the data • How many sets of data they plan to collect • What equipment they will need to complete their investigation • Identification of potential risks and plans to minimise the risks or identify steps to take should any incidents/changes occur – it is important if students are to carry out their own plans that you are confident their plans are safe. • An explanation on how to minimise the impact of their plan on organisms in the habitat • A results table to record the data they plan to collect – see the video: *Designing results tables* for more support • How they plan to analyse the data they collect.
10 min	**Plenary** Students swap plans with another student or group and give feedback on areas to improve their plans. Discuss any issues raised by students.

Fieldwork lesson: Collecting population data in a habitat

Resources	• Equipment identified by students in their plans • Basic first aid equipment

Learning objectives	By the end of the lesson: • ***a***ll learners should be able to 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 sufficient repeat data to make the results more valid.

Timings	Activity
 	**Starter/Introduction** **Safety** Brief all learners on key safety points that all must follow while collecting their data. Ask learners if they have any questions about the safety instructions to check everyone understands. Give learners an opportunity to review their plans before starting. Distribute equipment to learners as necessary to complete their plans.
All other time available*	**Main lesson** Learners follow their plans and collect data from the habitat. **Safety** Circulate the working area at all times during the fieldwork so that you can make sure that your learners are safe and that the data they are collecting is accurate.
	**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.

*The time will vary depending on the time available for the work – where possible try to allow several hours especially when visiting a habitat away from school grounds.

Teacher notes

Watch the *Random and systematic sampling methods* video (teacher version) 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 (e.g. www.random.org, or use a smartphone) 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.

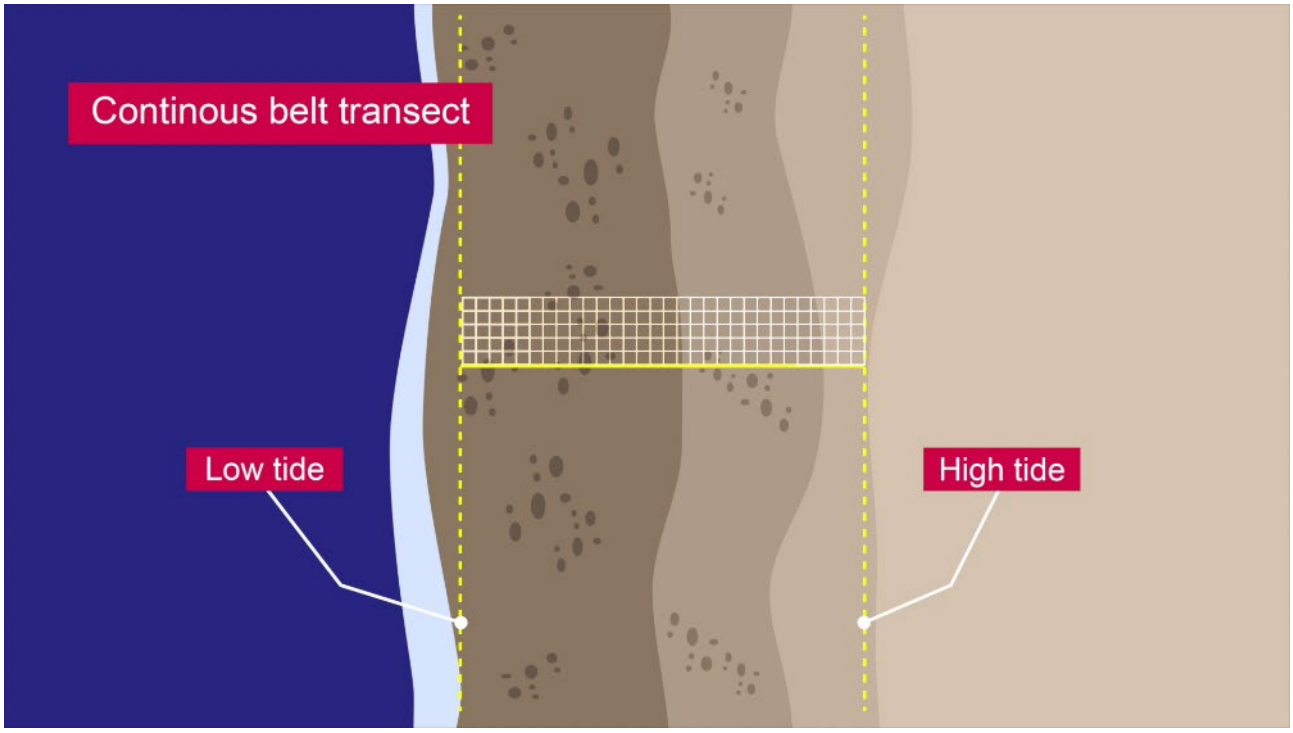
If the ecosystem is in an isolated area, then a mobile telephone or radio telephone should be available in case of accidents.

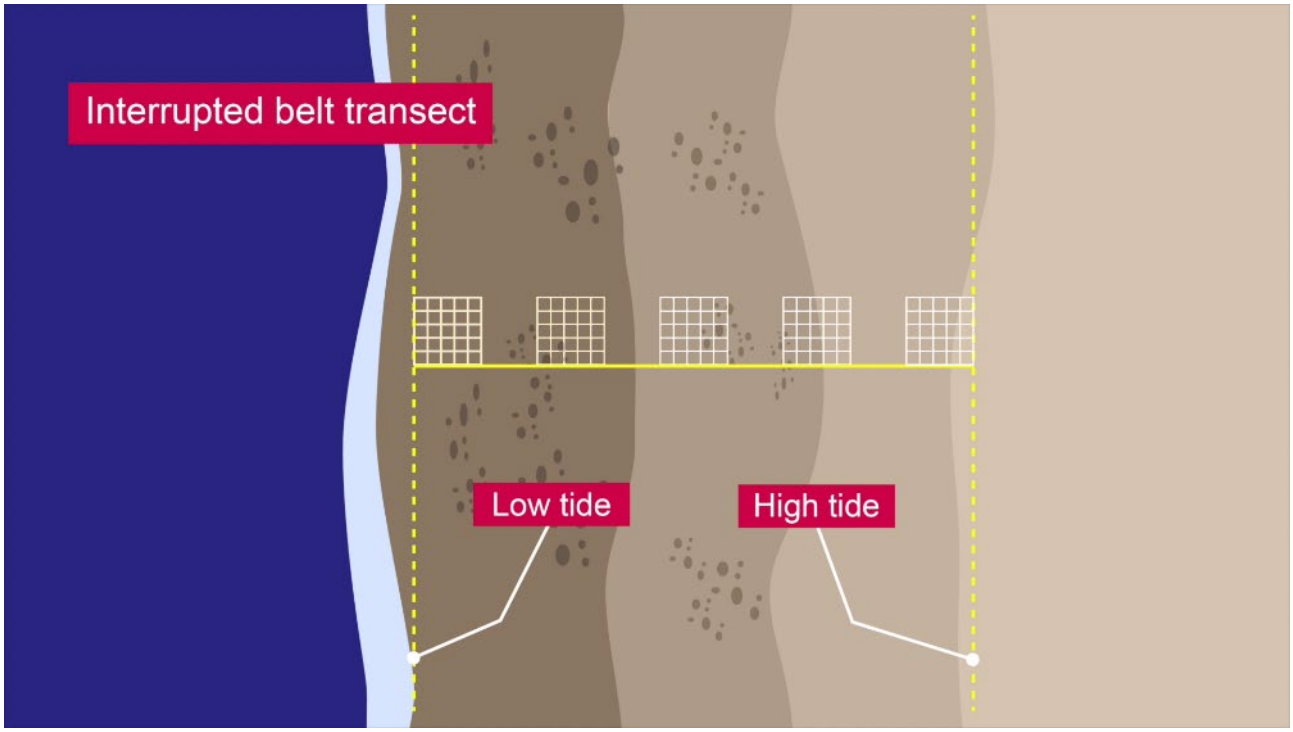
It is your responsibility to carry out an appropriate risk assessment for this experiment.

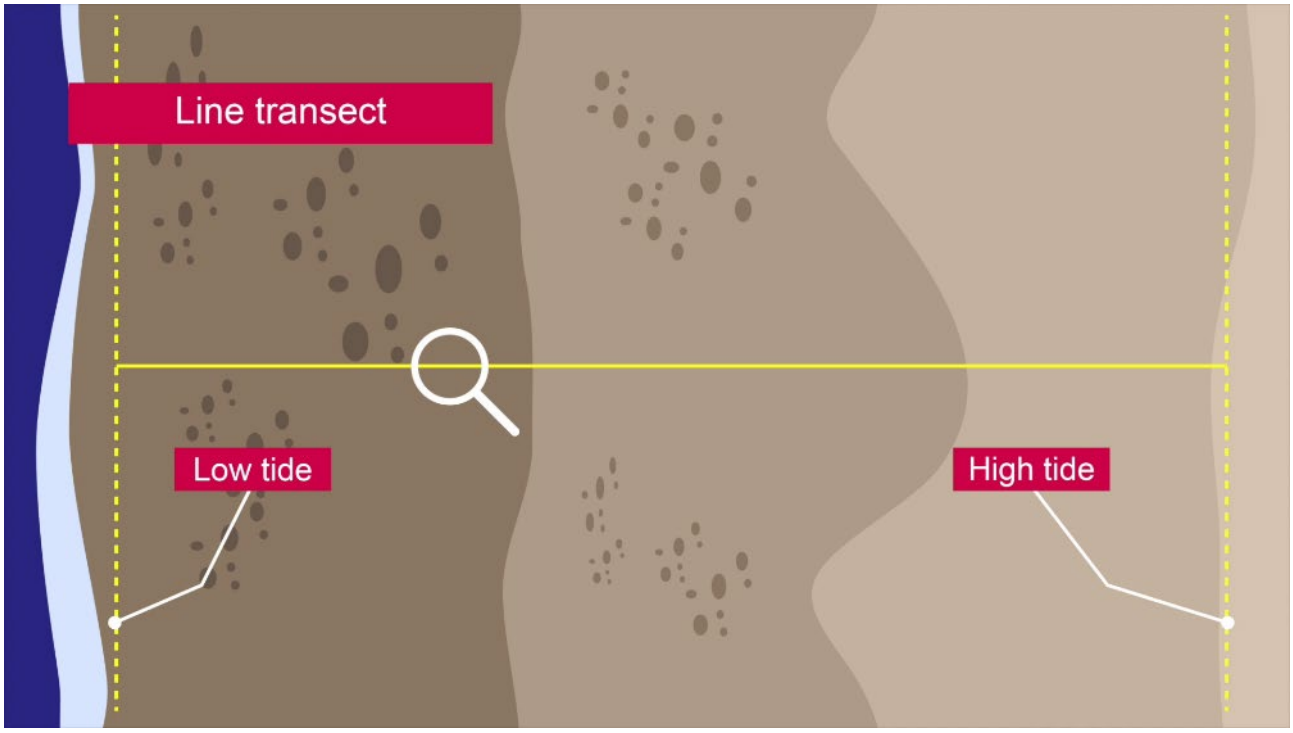
Experiment set-up

Random Survey

Systematic Survey




Interrupted belt transect
Low tide
High tide


Line transect
Low tide
High tide

Teacher method

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

Do not share this method with learners until after they have planned their own methods.

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.

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 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 such as:

Quadrat										
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

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.

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 least an hour 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:

Distance from top of shore / m	Abundance of species									
	Seaweed A / %	*Snail B / number*								
12										
14										
16										
18										
20										
10										
8										
6										
4										
2										

Note: distances on an interrupted transect will depend on the steepness of the shore and the tidal range at the shore. Aim to collect about 10 sets of data (10 quadrats) if you have time, spread fairly evenly from high tide to low tide.

3. **For an interrupted belt transect*:** Move the quadrat further towards the sea as the tide goes out.
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 until the tide starts to come back in and the water level rises - return to above your starting point on the transect and continue steps 3 and 4 moving up to the high tide mark or splash zone, allowing you to stay clear of the rising tide.

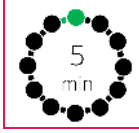
Alternative Fieldwork lesson: Virtual fieldwork

Resources	• Video: *Random and systematic sampling* • *Sampling quadrats* (zip file) contains images of both the random and systematic sampling • Copy of teacher method handout • Worksheet D
Learning objectives	By the end of the lesson: • ***a***ll learners should be able to 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
10 min	**Starter/Introduction** Go through the teacher method handout with the learners and discuss systematic sampling using a transect. Learners construct a results table to record the data from the video.
40 min	**Main lesson** Watch the video (it is divided into a sections on random sampling on a grassy area, and systematic sampling on a rocky sea shore) which pauses on each quadrat to allow learners to complete their results tables for each quadrat. Alternatively, the Sampling quadrats file contains hi-resolution images of each quadrat which can be displayed on screen and zoomed into for extra detail, as if learners were viewing the quadrat live. There are 10 quadrats in the video for each sampling, this allows 3-4 minutes per quadrat to observe and collect data. Discuss results being recorded by learners and the subjective nature of results obtained – results will vary between groups as they may miss some individuals or report different estimated percentages. The example results provided with the teacher pack will not be perfect either. Encourage learners to record results for types of organisms present in more than one image, but they will likely not have time to record populations for all species shown in all images. Some of the shells are visibly empty, but others are not as obvious whether there is a living organism present and this is difficult to determine from photographs.
10 min	**Plenary** Hand out Worksheet D (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.

Debriefing lesson: Interpreting population data

Resources	• Results from fieldwork lesson • Graph paper • Worksheet D • Worksheet E
Learning objectives	By the end of the lesson: • ***all*** learners should be able to process their results to estimate populations of different species and make conclusions on what they found • ***most*** learners should be able to evaluate the reliability of their data • ***some*** learners will be able to suggest improvements to their method and how they might confirm their findings.

Timings	Activity
	**Starter/Introduction** Recap from fieldwork lesson and check learners have their data/results. Discuss how the data can be analysed – learners should have planned how they will process their data. Hand out and go through Worksheet D showing learners how the data could be analysed.
 	**Main lesson** Learners process the data by drawing kite graphs and/or carrying out analysis using Simpson's Index of Diversity and Spearman's rank correlation. Worksheet E can be used to support learners in doing this. Learners make conclusions about their findings and evaluate their method to establish any potential improvements they could make to improve the quality of their results.
	**Plenary** Discuss outcomes and compare conclusions – do any groups come to significantly different conclusions for the same habitat?

Worksheets and answers

	Worksheet	Answers
For use in *Briefing lesson*:		
A: Using a quadrat	**18**	**28**
B: Choosing a suitable survey sampling method	**20**	**29**
For use in *Planning lesson*:		
C: Planning a population survey in a habitat	**23**	
For use in *Virtual Fieldwork lesson*:		
D: Example results from Rocky Shore video	**24**	
For use in *Evaluation lesson*:		
E: Analysing population data	**25**	

Teacher instructions 1: What's the question?

Use this worksheet with the briefing lesson: Sampling techniques

In this activity, pose questions 'in reverse' to learners. Give them a series of answers and then challenge them to suggest a question for which the answers could be given. This engages learners in higher-order thinking skills.

Examples should focus on the topics relevant to the upcoming topic, including populations and communities. Three examples are provided below.

Answer to provide to learners	Suggested question
Population	*'What is the term used to describe the number of organisms of a species in a habitat?'*
Community	*'What is the term used to describe the groups of different species living together in a habitat?'*
Habitat	*'What is the term used to describe the place where an organism lives?'*

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:

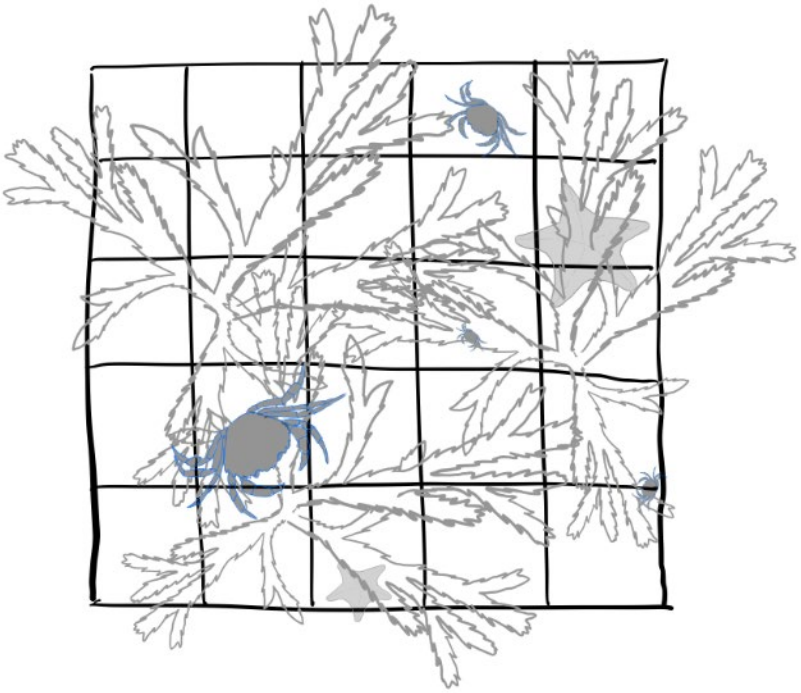


Figure 1: Quadrat on a rocky shore

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

1. **Count the number of individuals** – best when there are clearly identifiable individuals, such as with most animals
2. **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. Why?

   b. Count the number of individuals of each species where counting is most appropriate.

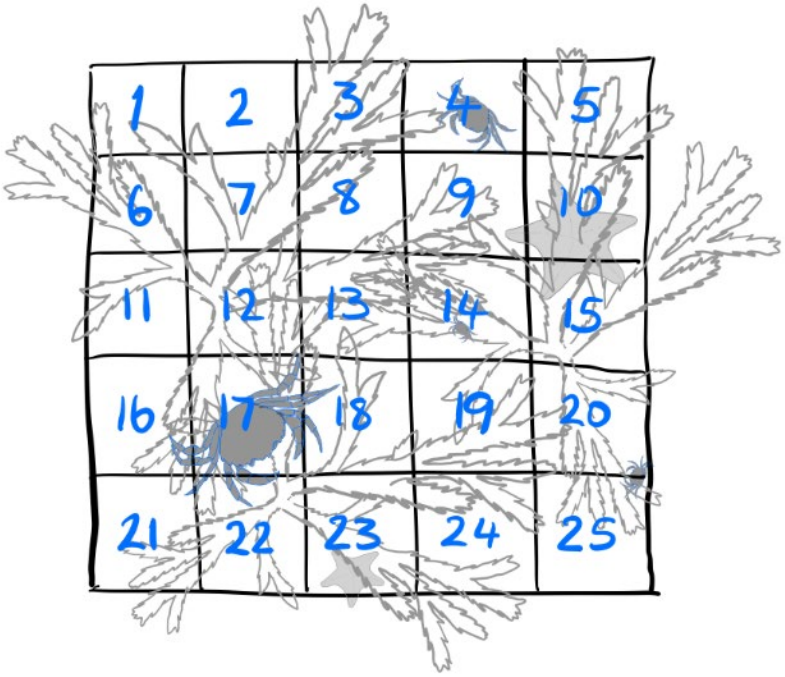


Figure 2: Quadrat on a rocky shore with numbered squares

When counting individuals it 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 follows:

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.

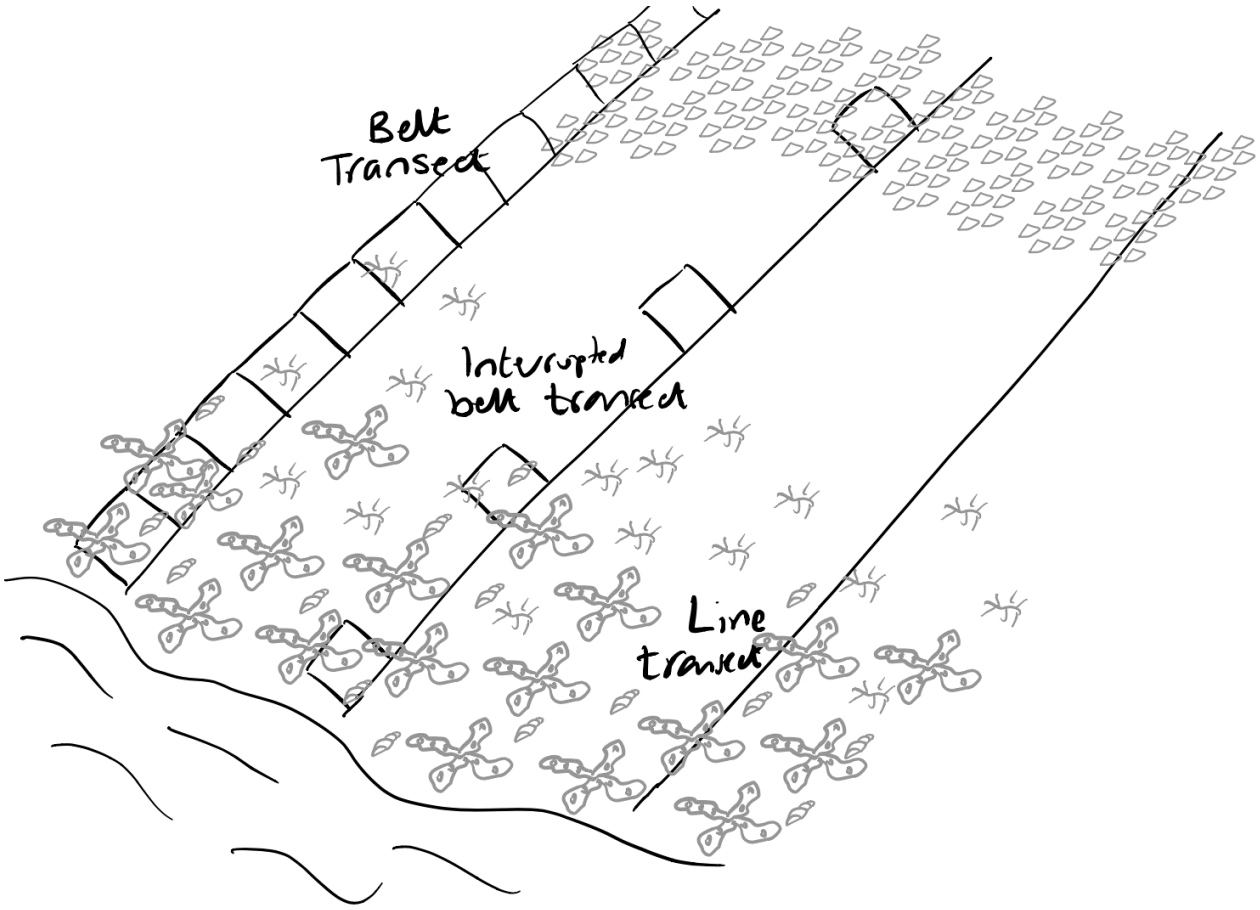
   A Wildflower meadow:

   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: Planning a population survey in a habitat

Use this worksheet with the planning lesson: Planning to investigate populations in a habitat

When planning an investigation, you should consider what you are trying to find out and how you can achieve that.

The first question is what is the hypothesis or question being investigated? This should clearly identify variables. For a population survey a good hypothesis would relate a change in a abiotic variable to population distributions such as: 'The time exposed to the air on a shore affects the distribution of species', but at a simpler level to measure the biodiversity of a habitat might be 'What is the biodiversity of species present in a habitat?'

Once your aim has been established you can begin to plan how to carry out the investigation and collect data.

Some key questions to consider include:

- What will you measure?
    - This should be linked to variables that change in the chosen habitat
    - The populations of species – which species will you measure/count? All or a limited range?
- How will you measure/collect the data?
    - Will you need tapes for distances or equipment to measure abiotic variables?
    - Will you need a quadrat?
    - Will you count individuals or estimate percentage cover?
- How many sets of data do you plan to collect?
    - Are you carrying out a random or systematic survey?
    - If random how will you select areas to sample?
    - How many random samples will you collect?
    - If systematic using a transect will this be a line, belt or interrupted belt?
    - Will you repeat the transects at different points?
- Identification of potential risks and plans to minimise the risks or identify steps to take should any incidents/changes occur.
    - What could go wrong?
    - What risks are there?
    - How can you reduce the risk of these occurring?
    - What will you do if it did occur?
- What equipment do you need to complete your investigation?
    - Equipment for measuring
    - Equipment for recording
    - Safety equipment
- How will you minimise the impacts of your plan on organisms in the habitat while carrying out your investigation?
- Design a results table to record the data you plan to collect
    - see video on Resource plus on designing results tables)
- How do you plan to analyse the data you collect?

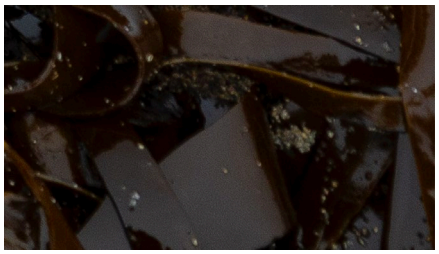
Worksheet D: Example Results from the Rocky Shore Video

Use this worksheet with the alternative fieldwork lesson: Virtual Fieldwork

A sample set of data is provided below from the series of quadrats featured in the video for the rocky shoreline transect.

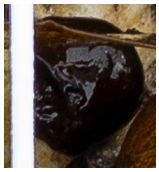
Distance from top of shore / m	Abundance of species							
	Seaweed A / %	*Seaweed B / %*	Anemone / number	Limpet / number	*Snail C / number*	Snail D / number	Seaweed E / %	Barnacles / %
0 (‘11’)	8	0	0	0	0	0	0	0
5 (‘9’)	0	5	0	0	0	0	0	0
10 (‘8’)	0	4	1	3	7	1	0	0
15 (‘7’)	0	9	1	24	2	3	22	8
20 (‘6’)	0	26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

Seaweed A



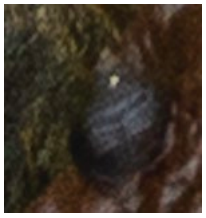
Seaweed B

Anemone



Limpet

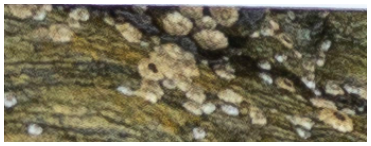
Snail C



Snail D

Seaweed C

Barnacles



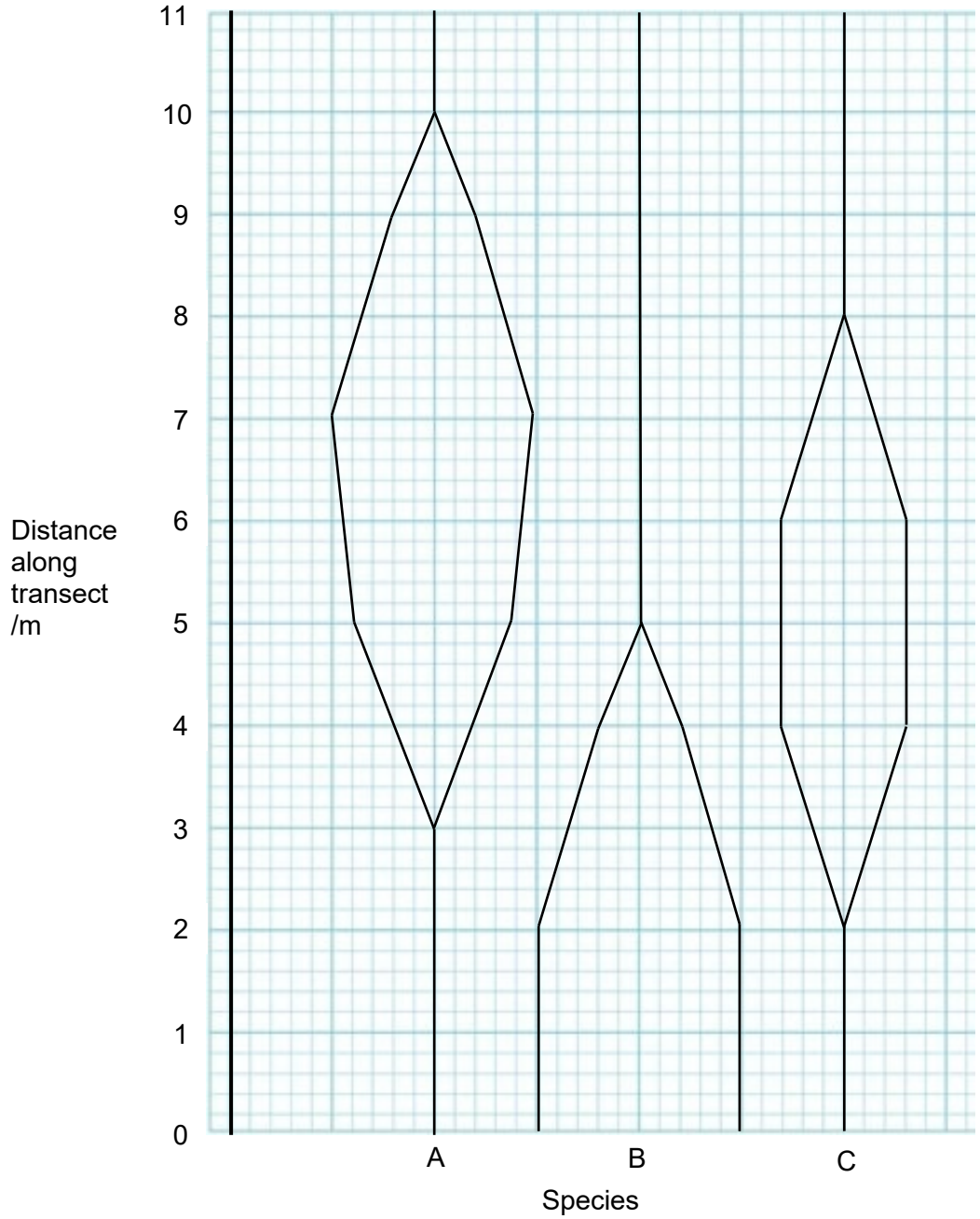
Worksheet E: Analysing population data

Use this worksheet with the debriefing lesson: Interpreting Population Data

Graphs showing the distribution of species along a transect line can be drawn as a kite graph. An arbitrary scale can be used to convert % cover to a number to plot on squares of a grid. e.g.

Percentage cover	Value/arbitrary units
1-20	1
21-40	2
41-60	3
61-80	4
81-100	5

The independent variable is the distance along the transect line. The dependent variables are the number counted or the percentage cover of species, plotted as arbitrary values generated as described in the table, both above and below a major grid line. Kite graphs allow changes in the distribution of species along a transect line to be easily seen.



Simpsons Index of Diversity can be calculated using the data collected using the formula

$$D = 1 - \left(\sum\left(\frac{n}{N}\right)^2\right)$$

n = number of individuals of each type present in the sample
(types may be species and/or higher taxons such as genera, families, etc.)
N = the total number of all individuals of all types

The values for Simpsons Index of Diversity are only useful when they are compared for different habitats.

Example calculations:
Population data was collected from two coral reefs. Compare the biodiversity at the two reefs.

Reef A			
Family of fish	**Number of individuals (n)**	$\frac{n}{N}$	$\left(\frac{n}{N}\right)^2$
Reef sharks	2	*0.091*	*0.008*
Grouper	3	*0.136*	*0.019*
Angelfish	3	*0.136*	*0.019*
Butterfly fish	5	*0.227*	*0.052*
Clown fish	2	*0.091*	*0.008*
Gobies	7	*0.318*	*0.101*
Total no. on individuals (N)	***22***	$\sum\left(\frac{n}{N}\right)^2$	***0.207***

Reef B			
Family of fish	**Number of individuals (n)**	$\frac{n}{N}$	$\left(\frac{n}{N}\right)^2$
Grouper	2	*0.133*	*0.018*
Angelfish	2	*0.133*	*0.018*
Butterfly fish	5	*0.333*	*0.111*
Clown fish	2	*0.133*	*0.018*
Gobies	4	*0.267*	*0.071*
Total no. on individuals (N)	***15***	$\sum\left(\frac{n}{N}\right)^2$	***0.236***

Simpsons Index of Biodiversity for Reef A is 1-0.207 = 0.793
Simpsons Index of Biodiversity for Reef B is 1-0.236 = 0.764
Reef A therefore has a higher biodiversity than Reef B.

Spearman's rank correlation coefficient can be calculated from two sets of data collected where there are there may be a link between the data sets using the formula:

$$r_s = 1 - \left(\frac{6 \times \sum D^2}{n^3 - n}\right)$$

Where *n* is the number of pairs of items in the sample and *D* is the difference between each pair of ranked measurements.

Example calculations:
The populations of organisms of two species are measured along a transect on a rocky shoreline. It is suspected that one of the organism feeds on the other. The data is shown in the table below:

Distance /m	1	2	3	4	5	6	7	8	9	10
No. of limpets	2	3	15	16	12	10	9	5	4	1
Cover of algae on rocks / %	5	25	55	70	35	30	30	20	15	0

1. The two sets of data must be ranked separately, with the lowest numbers ranked first (if two numbers are equal the mean of the ranks that tie are assigned):

2. The difference between the two ranks are calculated as D.

3. Each value of D is squared

4. Calculate the sum of all the D^2 values.

No. of limpets	Rank 1	Percentage cover of algae	Rank 2	*D* (Rank 1 – Rank 2)	D^2
2	*2*	5	*2*	*0*	*0*
3	*3*	25	*5*	*-2*	*4*
15	*9*	55	*9*	*0*	*0*
16	*10*	70	*10*	*0*	*0*
12	*8*	35	*8*	*0*	*0*
10	*7*	30	*6.5*	*0.5*	*0.25*
9	*6*	30	*6.5*	*-0.5*	*0.25*
5	*5*	20	*4*	*1*	*1*
4	*4*	15	*3*	*1*	*1*
1	*1*	0	*1*	*0*	*0*
				$\sum D^2$	*6.5*

Spearman's rank is then calculated using the formula:

$$r_s = 1 - \left(\frac{6 \times \sum D^2}{n^3 - n}\right)$$

Where n = number of pairs of data (in this case 8)

$$r_s = 1 - \left(\frac{6 \times 6.5}{10^3 - 10}\right)$$

This gives a value of 0.961

The significance of the r_s value can be determined from the following table:

n (number of pairs)	5	6	7	8	9	10	11
Significance level 5%	1.000	0.886	0.786	0.738	0.700	0.648	0.618
Significance level 1%	-	1.000	0.929	0.881	0.833	0.794	0.755

As we have 10 pairs of values the result of 0.961 is high as this is greater than 0.794 and indicates there is less than a 1% probability level of that result from random data.

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.

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