

Please write clearly, in block capitals.

Centre number

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Candidate number

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Candidate signature

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# A-level ENVIRONMENTAL SCIENCE

## Paper 2

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Date of Exam

Morning

Time allowed: 3 hours

### Materials

For this paper you may have:

- a calculator.

### Instructions

- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** parts in questions 1 to 10 and **one** essay from question 11. You must answer the questions in the spaces provided. Do **not** write on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.

### Information

- The marks for questions are shown in brackets.
  - The maximum mark for this paper is 120.
  - Questions should be answered in continuous prose. You will be assessed on your ability to:
    - use good English
    - organise information clearly
    - use specialist vocabulary where appropriate.
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Answer **all** questions in the spaces provided.

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**Table 1** describes some terms associated with commercial strawberry agriculture.

Complete **Table 1** by selecting the appropriate letter from the list.

- A** Barrier crop
- B** Crop rotation
- C** Genetic modification
- D** Introduced pathogen
- E** Introduced predator
- F** Leguminous crop
- G** Mulching
- H** Pheromone traps
- I** Weeding

[5 marks]

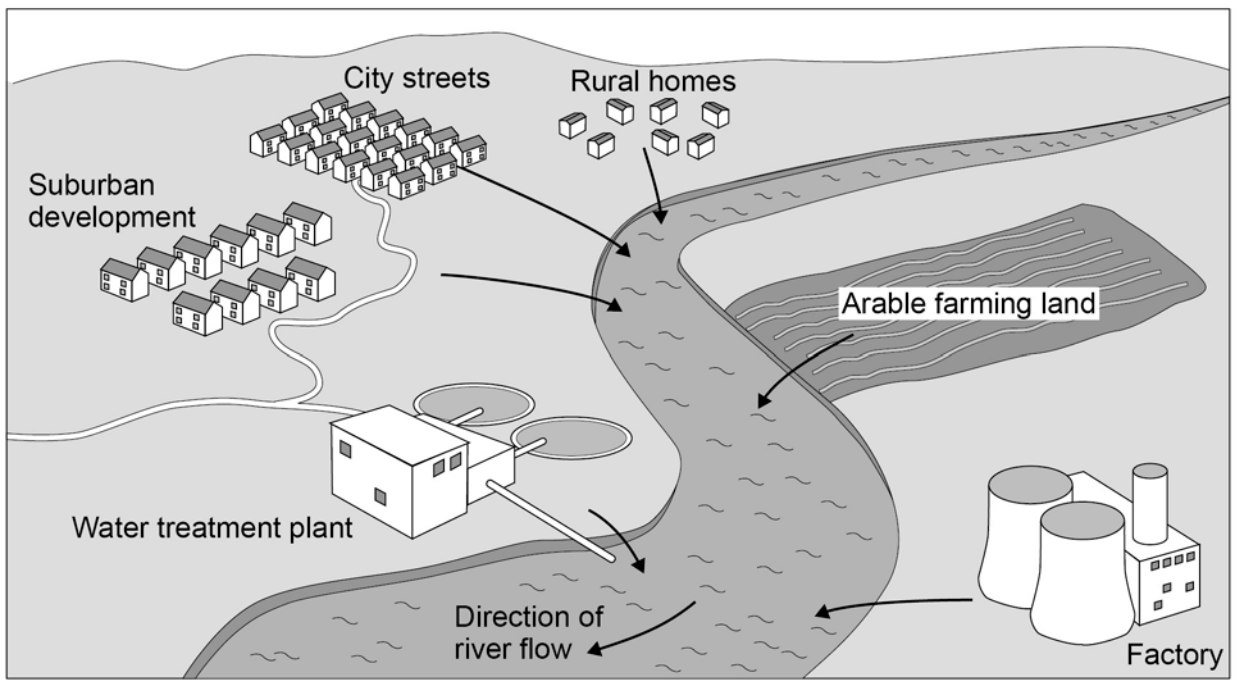
**Table 1**

Description	Letter
Layer of straw used to conserve soil water, suppress weeds and keep the crop above soil level	
Lupin plants hosting nitrogen-fixing bacteria are cultivated to improve soil fertility	
Introduction of <i>Phytoseiulus persimilis</i> mite that feeds upon Two-spotted Spider Mites, <i>Tetranychus urticae</i> , which would reduce strawberry crop yields	
Plasmid containing DNA code for antifreeze protein inserted into young strawberry plants	
Sticky scented cones placed near plants attracting the pest Strawberry Blossom Weevil	

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**0 2 . 1** Figure 1 shows some sources of runoff into a river.

**Figure 1**



The concentration of dissolved nutrients can affect the growth rate of algae in the river.

Suggest suitable locations to select samples to investigate the nutrient runoff from the arable land in **Figure 1**.

**[1 mark]**

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**0 2 . 2** Other than light intensity, state **four** factors that should be standardised when investigating the effect of nutrient concentration on aquatic algal growth in a laboratory.

**[2 marks]**

1 \_\_\_\_\_

2 \_\_\_\_\_

3 \_\_\_\_\_

4 \_\_\_\_\_

**0 2** . **3** Describe how the growth of aquatic algae may be measured.

**[2 marks]**

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- 0 3** . **0** Deforestation destroys woodland habitats, but it also threatens the survival of wildlife in the remaining isolated areas of woodland.

**Table 2** shows the insect biodiversity of a large uncleared woodland before deforestation and two areas of remaining isolated woodland whose biodiversities have changed following clearance of the rest of the woodland.

**Table 2**

Insect species	Estimated population/number of individuals per unit area		
	Site 1 Uncleared woodland	Site 2 Isolated woodland	Site 3 Isolated woodland
Area	500ha	5ha	1ha
Insect species	Estimated population/ number of individuals per unit area		
A	120.0	0	1
B	323.0	114	450
C	68.0	0	8
D	43.0	0	4
E	190.0	111	0
F	141.0	91	25
G	17.0	0	12
H	60.0	87	0
I	85.0	73	4
<b>Simpson's Index</b>	<b>5.7</b>		<b>1.2</b>

- 0 3** . **1** Complete **Table 2** by calculating Simpson's Index of Diversity (**D**) for the insects at **Site 2** using the formula.

$$D = \frac{N(N-1)}{\sum n(n-1)}$$

where

N = total number of organisms of all species

n = number of individuals of a particular species

Σ = sum of

Show your working.

**[3 marks]**

**0 3** . **2** Explain why the insect biodiversity in the 1 ha woodland has changed from when it was part of the large uncleared woodland.

**[3 marks]**

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**0 3** . **3** Explain how the canopy layer affects the survival of plants growing on the woodland floor.

**[4 marks]**

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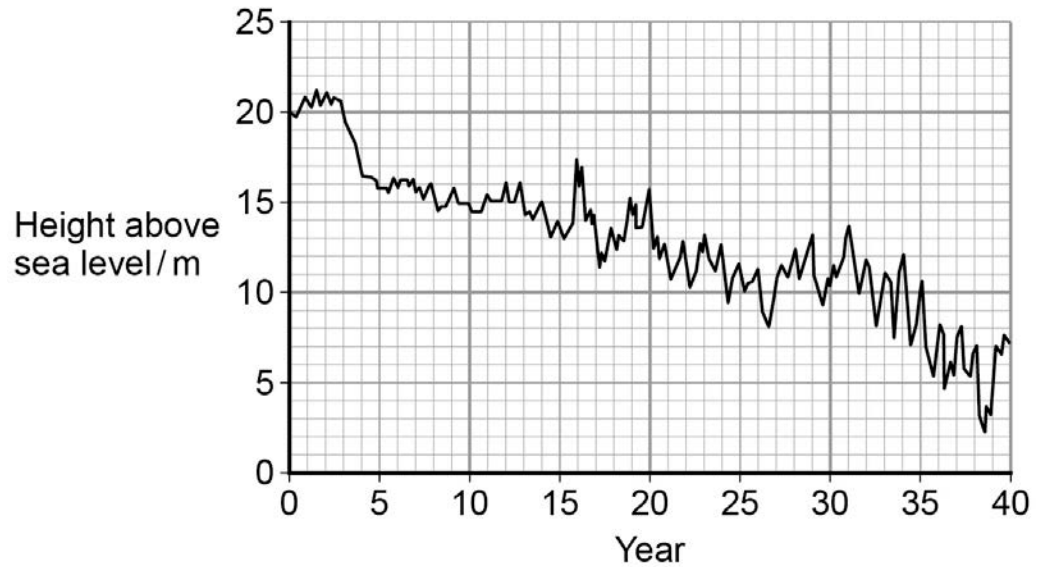
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- 0 4 . 0** **Figure 2** shows the height above sea level of the water table in a coastal aquifer over a 40 year period.

**Figure 2**



- 0 4 . 1** Suggest reasons for the short-term and long-term trends in the level of the water table shown in **Figure 2**.

[2 marks]

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Question 4 continues on the next page

**0 4** . **2** Explain why the water abstracted from the aquifer may be unsuitable for irrigation if the long term trend shown in **Figure 2** continues.

**[2 marks]**

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**0 4** . **3** Describe **two** advantages of using water from aquifers for irrigation, rather than water from rivers.

**[2 marks]**

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0 4 . 4

**Figure 3** shows the Great Crested Newt, *Triturus cristatus*.  
The Great Crested Newt (GCN) is indigenous to the UK but it is not endemic.

**Figure 3**



Define the term 'endemic'.

[1 mark]

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**Question 4 continues on the next page**

**0 4** . **5** Great Crested Newts (GCN) are vulnerable when surface water features dry out.

GCN spend the majority of their life on land, within 250 metres of a pond. They migrate to water to breed in spring and the young newts leave the pond four months later. Movements of newts in and out of the ponds mostly occur at night. The newts, their eggs, breeding sites and the land around them are protected by law, so ecological monitoring requires a licence.

The presence of GCN populations may be estimated by sampling eDNA in the water rather than trapping.

Evaluate the advantages and disadvantages of sampling eDNA rather than trapping. **[3 marks]**

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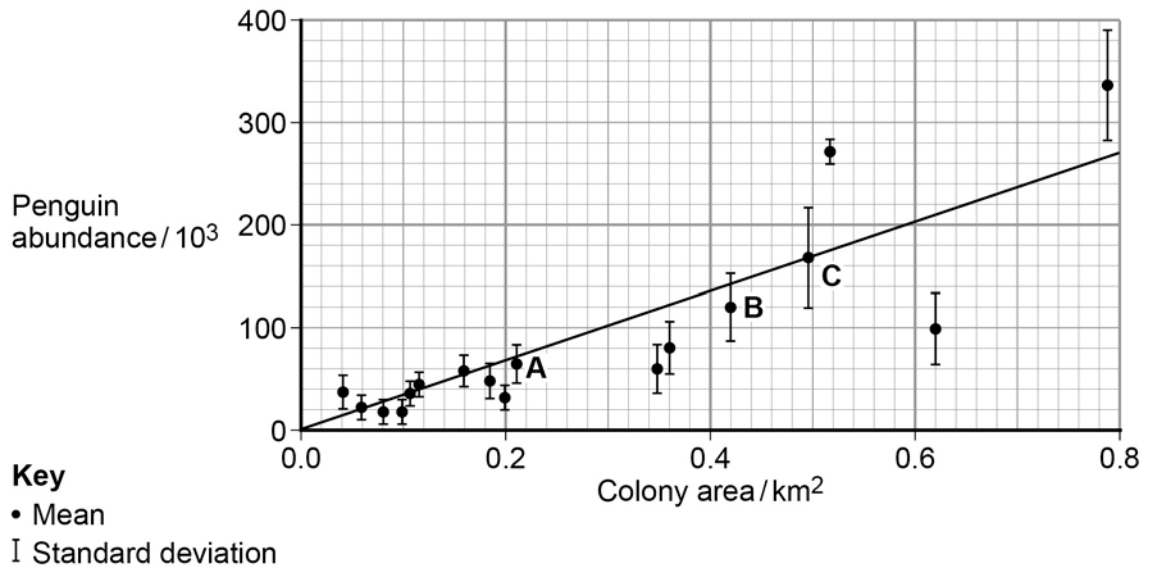
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**0 5 . 0** Ground-based surveys to count Adelie Penguins in their breeding colonies are difficult and cannot be carried out very often. Satellite surveys can be carried out continually, but can only measure the areas of the colonies not the actual number of penguins. If the penguin population density is similar in all colonies then the total population can be estimated using the satellite data on colony areas.

**Figure 4** shows the number of penguins in colonies of different areas.

**Figure 4**



**0 5 . 1** Use information in **Figure 4** to estimate the difference in mean penguin population density between **colony A** and **colony B** as a percentage of the density of colony A. **[2 marks]**

%

**0 5 . 2** Use information from **Figure 4** to suggest whether the mean abundance in **colony C** is significantly different from the mean abundance in **colony B**. **[1 mark]**

**0 5** . **3** Although satellite surveys are used to estimate total populations, ground-based surveys are still used.

Suggest why ground-based surveys are still used.

**[4 marks]**

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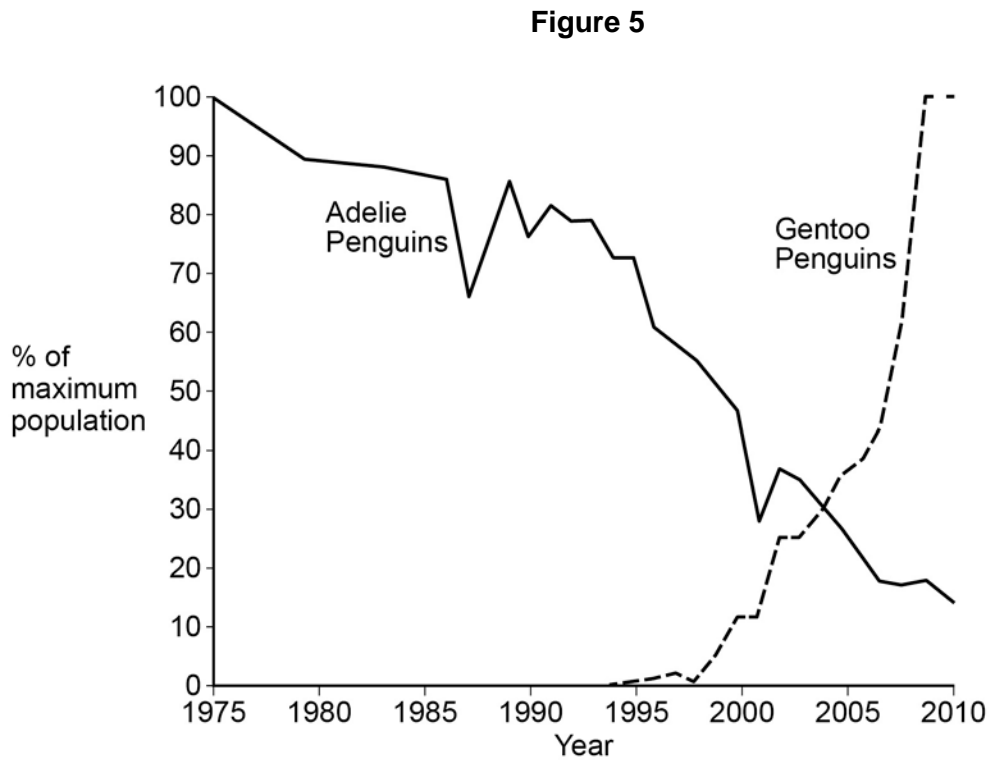
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**0 5** . **4** **Figure 5** shows the change in the size of two Antarctic penguin populations over a 35 year period.



Adelie and Gentoo Penguins both eat krill, but they feed in different areas. Adelie Penguins feed in areas with thick pack ice while Gentoo Penguins feed in open water.

Suggest how global climate change may cause the population changes shown in **Figure 5**.

[1 mark]

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**0 5** . **5** The population of King Penguins is increasing. They do not eat krill but the changes in populations of King and Adelie Penguins could be linked.

Suggest how the increase in the King Penguin population may be related to the change in Adelie Penguin populations.

[2 marks]

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**0 6 . 0** Figure 6 shows lakes used for aquaculture in Malaysia.

**Figure 6**



In some lakes, a method of polyculture is used where three fish species are farmed in the same lake.

**Table 3** shows the species used and the diet of each species.

**Table 3**

Species	Diet
Silver Carp	algae
Grass Carp	plants
Common Carp	detritus

Common Carp move mud at the bottom of the lake in search of food.

**0 6 . 1** Suggest why fish farmers use polyculture instead of monoculture.

**[2 marks]**

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**0 6** . **2** Suggest why fish farmers add manure to polyculture lakes.

**[2 marks]**

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**Question 6 continues on the next page**

In some other lakes, shrimps and mullet fish are farmed. **Table 4** shows the mean mass and standard deviation of shrimp and mullet fish populations, when farmed in monoculture and polyculture.

**Table 4**

Time/ days	Mean and standard deviation			
	Shrimp mass/ g		Mullet mass/ g	
	Monoculture	Polyculture	Monoculture	Polyculture
0	0.02 ( $\pm$ 0.003)	0.02 ( $\pm$ 0.003)	1.68 ( $\pm$ 0.30)	1.65 ( $\pm$ 0.34)
30	3.75 ( $\pm$ 1.60)	2.59 ( $\pm$ 1.44)	14.65 ( $\pm$ 9.83)	18.82 ( $\pm$ 11.74)
80	15.58 ( $\pm$ 3.10)	12.86 ( $\pm$ 3.40)	34.08 ( $\pm$ 15.12)	47.02 ( $\pm$ 31.17)

**0 6** . **3** Use data from **Table 4** to compare the productivity of the different systems.

**[3 marks]**

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**0 6** . **4** Use data from **Table 4** to evaluate the variability of the data that were used to calculate the mean values shown.

**[3 marks]**

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**Turn over for the next question**

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ANSWER IN THE SPACES PROVIDED**

**Turn over ▶**

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**0 7** . **1** The effect of soil pH on the growth of oats and wheat was investigated.

Describe how soil pH may be measured.

**[2 marks]**

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**0 7** . **2** **Table 5** shows the yield of crops from the investigation.

**Table 5**

	pH									
	4.6	4.9	5.2	5.5	5.8	6.1	6.4	6.7	7.0	7.3
<b>Relative yield of oats</b>	75	85	96	96	98	95	99	97	100	100
<b>Relative yield of wheat</b>	68	75	74	83	89	96	93	97	100	99

State a null hypothesis for this investigation.

**[1 mark]**

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ANSWER IN THE SPACES PROVIDED**

Only **one** answer per question is allowed.

For each answer completely fill in the circle alongside the appropriate answer.

CORRECT METHOD



WRONG METHODS



If you want to change your answer you must cross out your original answer as shown.



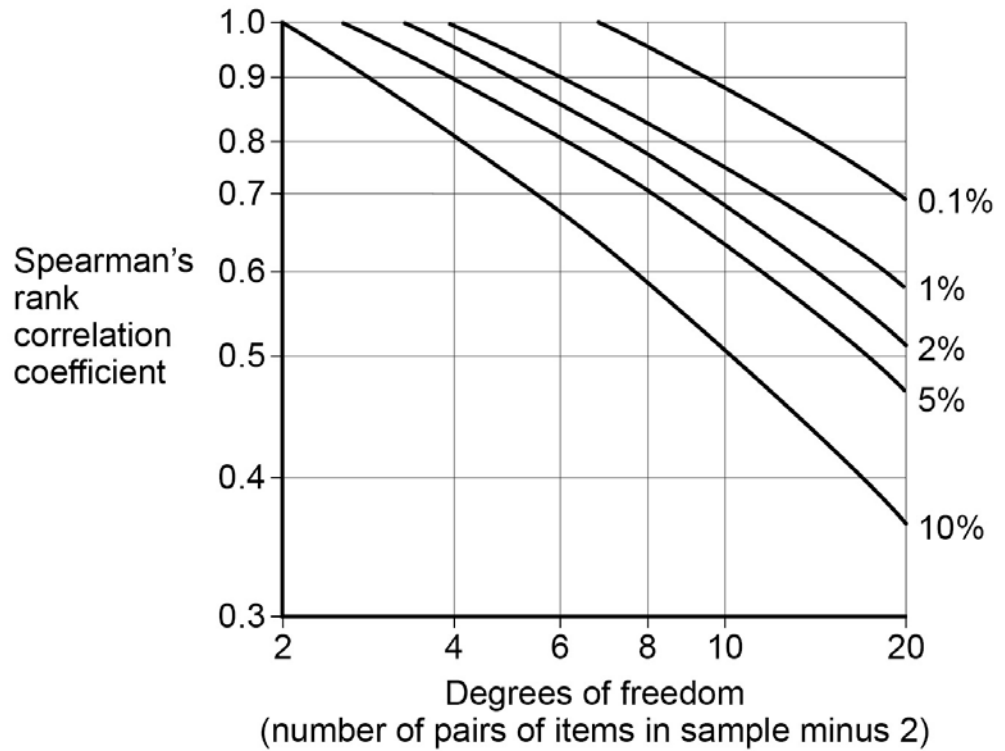
If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown.



**07** . **3**

The Spearman's rank correlation coefficient for wheat was calculated to be 0.97. **Figure 7** can be used to estimate the statistical significance of calculated correlation coefficients.

**Figure 7**



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Use information from **Figure 7** to select the probability that the results for wheat were produced by random chance.

**A** 0.1%

**B** 1%

**C** 2%

**D** 5%

**E** 10%

[1 mark]

**0 7 . 4**

Estimate the lowest Spearman's rank correlation coefficient that would be needed to be 95% sure that the results for wheat were not produced by chance.

[1 mark]

Correlation coefficient

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**0 8** . **0**

African Forest Elephants are identified as vulnerable on the IUCN Red List. The population is thought to have declined by around 65% between 2002 and 2011. They breed relatively slowly, with a maximum population growth rate of 5% per year. In 2014, the death rate caused by poaching was estimated to be 9% per year. Elephants are herbivores, eating many foods including the fruit of more than 70 tree species. They sometimes reach the fruit they want by pushing trees over.

Some of these fruits are only eaten by African Forest Elephants, such as *Omphalocarpum* which has large tough fruit that they split open with their tusks. The elephants are not ruminants and do not repeatedly chew and re-digest their food, so about 50% of their food passes out undigested in their dung.

Elephants travel longer distances than other forest mammals to find food, travelling up to 60 km along paths to avoid having to push through the dense forest vegetation. They travel in small family groups, although males are often solitary.

In moist areas, they clear vegetation and create waterholes so they can drink and get access to essential mineral nutrients.

African Forest Elephants have few natural predators, although young or old individuals may be killed by predators.

Being such large, impressive animals, elephants are popular with the public and raise the profile of wildlife conservation. However, there are few ecotourism opportunities in the forests of West Africa where they live.

**0 8** . **1**

Use the information above and your own knowledge to explain why the African Forest Elephant is considered to be a keystone species.

**[5 marks]**

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- 0 9 . 0** The likelihood that a fish species is overexploited is affected by its breeding biology and the fishing methods used.

**Table 6** shows Details of the ecology and fisheries of the Atlantic Mackerel and Orange Roughy.

**Table 6**

Feature	Fish species	
	Atlantic Mackerel <i>Scomber scombrus</i>	Orange Roughy <i>Hoplostethus atlanticus</i>
Age of first breeding /yrs	2	20
Eggs laid per kg of mass	80 000	30 000
Maximum lifespan /yrs	20	150
Maximum length /cm	45	75
Maximum mass /kg	2.5	7.0
Water depth /m	0 - 100	500 - 1200
Mean length of caught fish/cm	30	35
Mean age of caught fish /yrs	2	10
Time of fishing	During spawning season when fish congregate to mate and lay eggs	During spawning season when fish congregate to mate and lay eggs
Habitat	Pelagic water (near surface and mid-water)	Demersal (near seabed)
Shoal composition	Single species shoals	Mixed species shoals
Fishing area and method	European Union: purse seining and handlines Iceland: pelagic trawling	All areas: demersal trawling

- 0 9 . 1** Use information from **Table 6** and your own knowledge to explain why the Orange Roughy is more vulnerable to overfishing than the Atlantic Mackerel.

**[2 marks]**

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- 0 9** . **2** Use information from **Table 6** to suggest why fishing for Atlantic Mackerel is less likely to produce a lot of by-catch than fishing for Orange Roughy.

[2 marks]

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- 0 9** . **3** Apart from the total mass of fish caught, what data about fish catches may show that a population is being overfished?

[2 marks]

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- 0 9** . **4** Use data from **Table 6** to calculate the mean annual mass increase for Orange Roughy as a percentage of that for Atlantic Mackerel.

Assume both fish reach maximum mass and age.

[2 marks]

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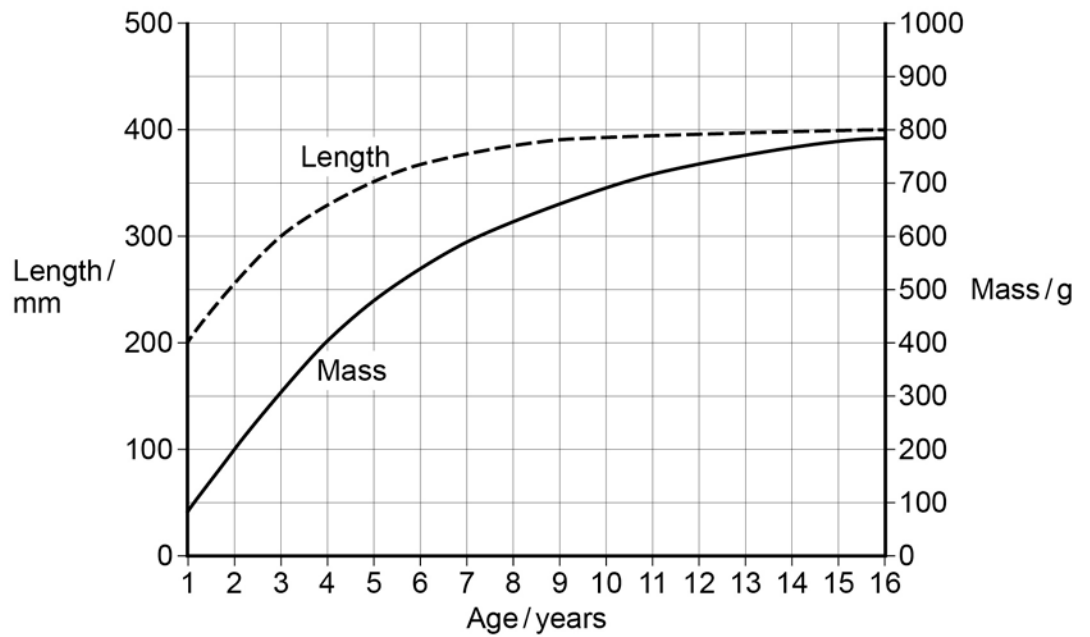
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**Question 9 continues on the next page**

**0 9 . 5** **Figure 8** shows the increase in the mass of Atlantic Mackerel as they get older.

**Figure 8**



Use information from **Table 6** and **Figure 8** to calculate the number of eggs produced by a typical female Atlantic Mackerel in its first year of breeding. Show your working.

**[1 mark]**

\_\_\_\_\_

**0 9 . 6** Explain how an improvement in net design may reduce by-catch.

**[2 marks]**

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**0 9** . **7**

Explain how long term catches may be increased by the use of No-Take Zones and minimum catchable size regulations.

**[4 marks]**

No-Take Zones

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Minimum catchable size regulations

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**Turn over for the next question**

**1 0 . 0** Neonicotinoids are an important group of agricultural insecticides.

### **The properties of neonicotinoids**

Neonicotinoids, eg acetamiprid and imidacloprid, are a group of neurotoxic insecticides developed since the 1980s.

They have lower toxicity to birds and mammals than organophosphates. They inactivate nerves by fixing to nerve receptors. This occurs temporarily in mammals but permanently in insects. Neonicotinoids can pass into the brain in insects, but not in mammals

Neonicotinoids are systemic, so they can protect the whole plant, not just the surfaces that are sprayed.

Neonicotinoids have long residual activity but are less persistent than organochlorines such as DDT.

Most neonicotinoids are water-soluble and break down slowly in the environment, so they can be taken up by plants and provide protection from insects as the plants grow.

Neonicotinoids are photodegradable, with an environmental half-life of about 34 days where insolation levels are high and decomposers are present. Low soil moisture and low temperatures can also reduce the rate of degradation.

### **Environmental problems**

The use of neonicotinoids has been linked to the collapse of honey bee colonies and a decline in the populations of some birds.

Neonicotinoids disrupt bees' immune systems, making them more susceptible to viral infections.

In 2008, Germany banned the use of clothianidin as a seed coating on maize after an incident that resulted in the death of millions of honey bees.

Research showed that the bee deaths were caused by a combination of factors:

- The seeds had not been covered with a chemical coating over the pesticide that would delay release of the pesticide until the seed had been in the soil for many days.
- The seeds were planted when nearby crops were producing flowers.
- The seed-sowing equipment spread pesticide-rich dust from the uncoated seeds into the air.
- Dry, windy conditions blew the dust onto the flowering crops and the bees feeding there.

A study of the bees that were dead or showing nerve damage found that they contained neonicotinoids.

The low toxicity of neonicotinoids to birds led to the conclusion that the population declines were caused by a reduction in their food supply. Other possible causes of population decline were investigated but rejected.

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### Synergism

The toxicity of pesticides to pests and non-target species is tested before they are licensed for use. But similar tests are not usually carried out for combinations of chemicals that may be used at the same time. This means that possible synergistic interactions with chemicals such as other pesticides, fertilisers and growth promoters may not be investigated.

The use of systemic, persistent pesticides increases the possibility of synergistic interactions.

Toxic neonicotinoid insecticides have been shown to act synergistically in the presence of some EBI fungicides which increased the overall toxicity up to a thousand fold.

Use the information in the article and your own knowledge to answer the following questions.

**1 0** . **1** Explain why neonicotinoids are less likely to build up in soil than in aquifers.

**[3 marks]**

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**1 0** . **2** Suggest possible causes, other than the use of neonicotinoids, of the decline in the bee population.

**[3 marks]**

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**1** **0** . **3**

Explain how the total amount of pesticide used may be reduced by using seed coatings of persistent systemic pesticides rather than aerial spraying of non-persistent contact pesticides.

**[3 marks]**

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**1** **0** . **4**

Describe the plan of an investigation that would show whether there is a synergistic relationship between the neonicotinoid insecticide, thiacloprid, and an EBI fungicide.

**[6 marks]**

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Write an essay on **one** of the following topics.

1 | 1 | . | 1 |      Discuss how changes in food production systems may make sustainable food production more achievable. **[25 marks]**

**OR**

1 | 1 | . | 2 |      Discuss how the development of the Circular Economy may make sustainable lifestyles more achievable. **[25 marks]**

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