Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

1336942028

MARINE SCIENCE **9693/41**

Paper 4 A Level Data-handling and Investigative Skills **May/June 2022**

1 hour 45 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 75.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **24** pages. Any blank pages are indicated.

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Answer **all** questions.

1 Pollution by plastics and microplastics is affecting many marine ecosystems.

(a) (i) State what is meant by the term microplastic.

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..... [1]

(ii) Explain why microplastics in oceans and seas can pose a risk to humans.

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(b) Scientists estimated the mass of plastic and microplastic in six different areas of oceans and seas shown in Fig. 1.1.

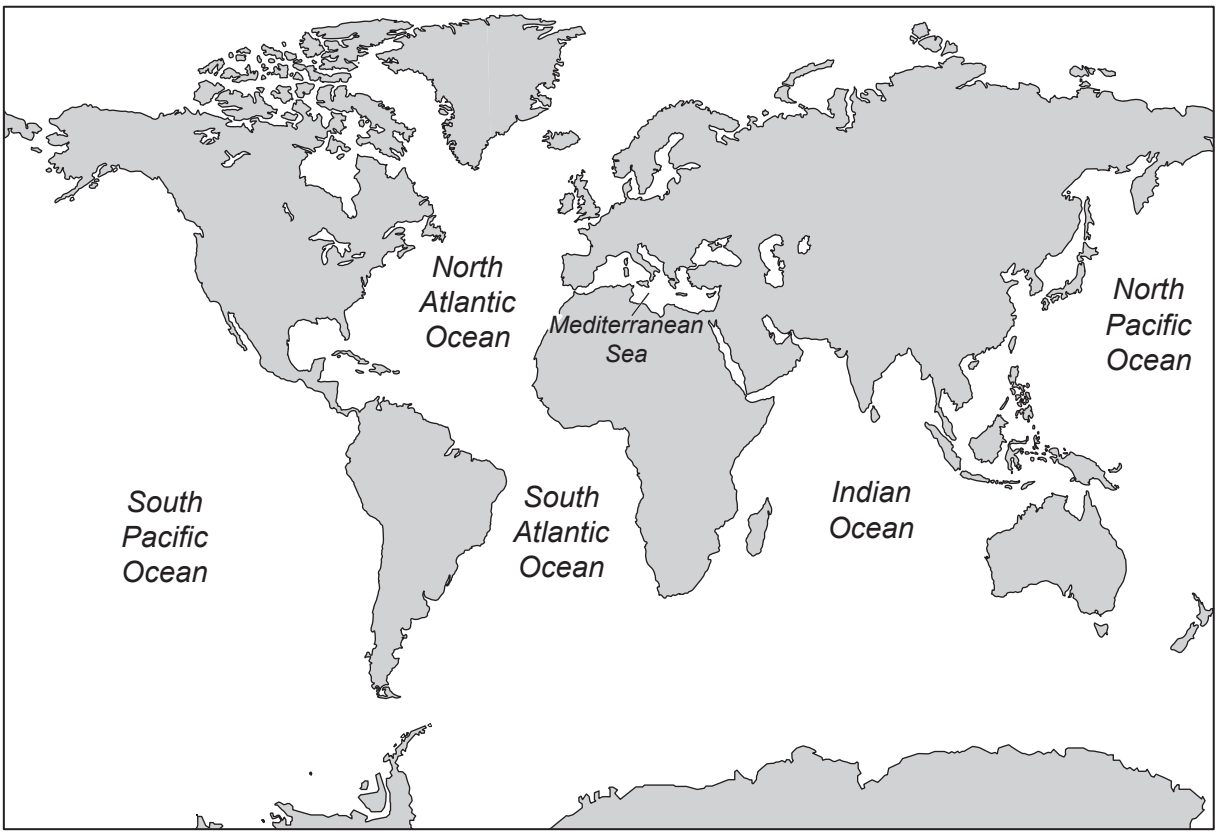

Fig. 1.1

They collected plastic and microplastics from 20 locations within each of the areas over a period of six months.

The results are shown in Fig. 1.2.

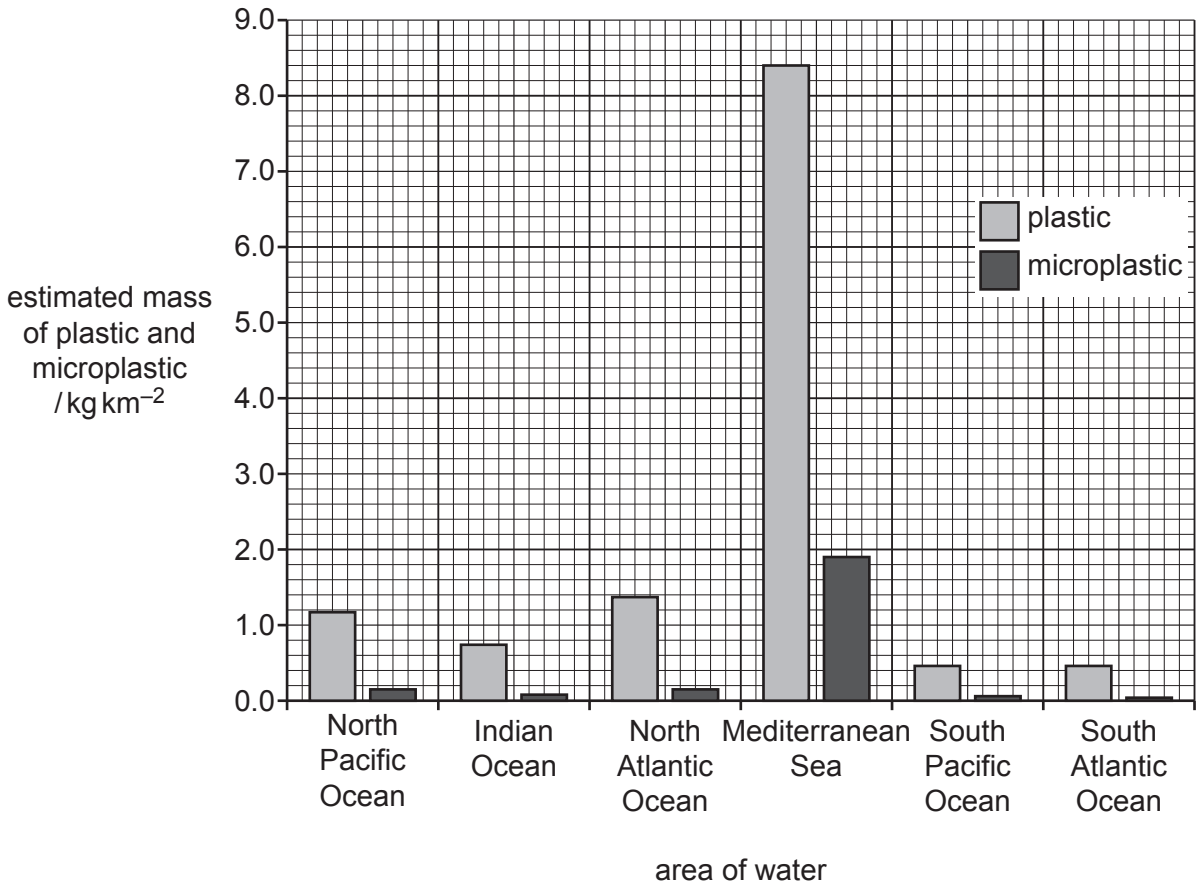

Fig. 1.2

(i) The Mediterranean Sea has an estimated surface area of 2 500 000 km^2.

Use Fig. 1.2 to calculate the total estimated mass of microplastic in the Mediterranean Sea.

State the correct unit.

..... [2]

(ii) Suggest a reason for the relatively high estimated total mass of plastic found in the Mediterranean Sea.

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(c) The scientists calculated the ratios of plastic : microplastic for each of the areas. The results are shown in Table 1.1.

Table 1.1

area	ratio of plastic : microplastic
North Pacific Ocean	8.0 : 1.0
Indian Ocean	
North Atlantic Ocean	9.1 : 1.0
Mediterranean Sea	4.4 : 1.0
South Pacific Ocean	7.7 : 1.0
South Atlantic Ocean	11.0 : 1.0

(i) The estimated mass of plastic found in the Indian Ocean is $0.75\,kg\,km^{-2}$.

The estimated mass of microplastic found in the Indian Ocean is $0.09\,kg\,km^{-2}$.

Calculate the ratio of plastic to microplastic in the Indian Ocean.

Give your answer to two significant figures.

Write your answer in Table 1.1.

[2]

(ii) Suggest an explanation for the relatively low ratio of plastic to microplastic in the Mediterranean Sea.

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..... [3]

[Total: 14]

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2 In Norway, some electricity is generated by using osmotic power stations. This method requires access to sea water and also fresh water from a river. Both types of water are pumped through the power station as shown in Fig. 2.1.

The sea water and fresh water are separated by a partially permeable membrane in the osmosis module. As the water flows, pressure increases in the sea water in the osmosis module. The increased pressure drives a turbine to generate electricity.

Waste water from the power station is returned to the sea and the river.

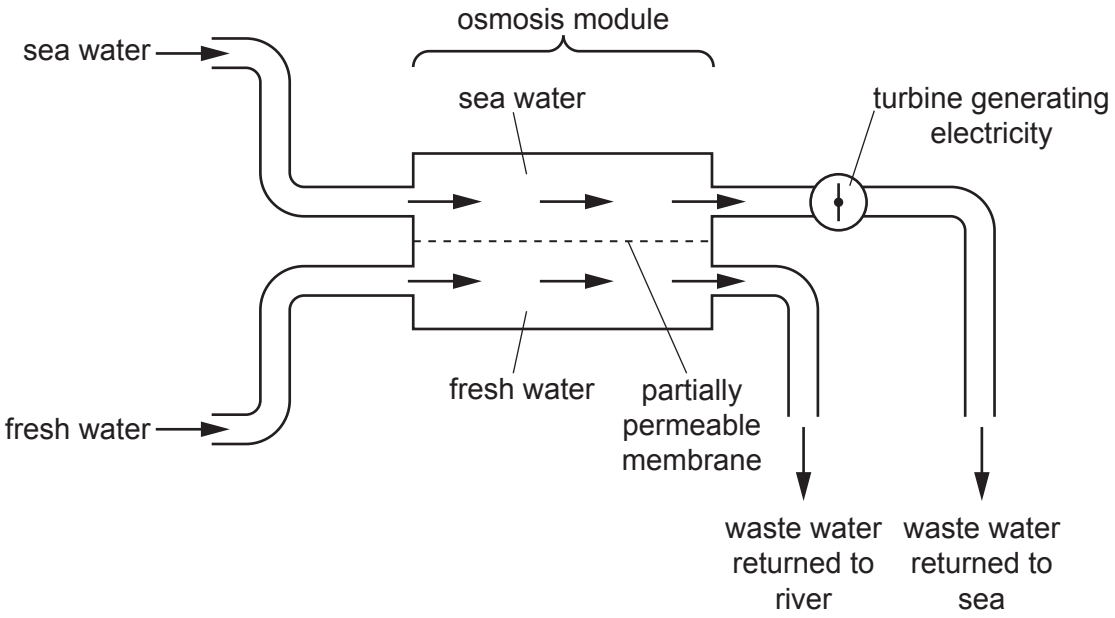

Fig. 2.1

(a) (i) Use Fig. 2.1, and your own knowledge, to explain how the osmotic power station increases the pressure of the sea water in the osmosis module.

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(ii) Some scientists claim that using this method to generate electricity will help to reduce global warming.

Suggest why this method of generating electricity could reduce global warming.

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(b) Some environmentalists have criticised the use of osmotic power stations. They suggest that the waste water could damage stenohaline marine organisms that are osmoconformers.

(i) Give the meaning of the terms stenohaline and osmoconformer.

stenohaline .....

.....

osmoconformer .....

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[2]

(ii) Salmon are predicted to be unaffected by the waste water outflow as they are able to live in areas with different salinities.

Outline how salmon osmoregulate in areas of low salinity.

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[Total: 11]

3 **(a)** Describe **and** explain the ecological relationship between *Endoriftia* and *Riftia*.

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..... [3]

(b) The use of hydrogen and hydrogen sulfide by the chemosynthetic bacterium, *Endoriftia*, was investigated.

Endoriftia bacteria were grown in a solution of radioactively labelled carbon dioxide. The mass of carbon dioxide taken up by the bacteria was measured every five minutes for 25 minutes.

This was repeated three times and the mean mass of carbon dioxide taken up by the bacteria was calculated. This was the control experiment.

The experiment was then repeated with additional hydrogen sulfide gas added to the culture. It was repeated again with additional hydrogen gas added to the culture.

The results are shown in Table 3.1.

Table 3.1

time / minutes	mean mass of carbon dioxide taken up / mmol g^{-1}		
	control experiment (no additional gas)	with hydrogen sulfide gas	with hydrogen gas
0	0	0	0
5	7	34	18
10	10	45	20
15	12	54	22
20	15	58	23
25	21	60	32

The scientists used the same mass of *Endoriftia* bacteria for each experiment.

(i) Explain **one** other factor that the scientists should have kept constant.

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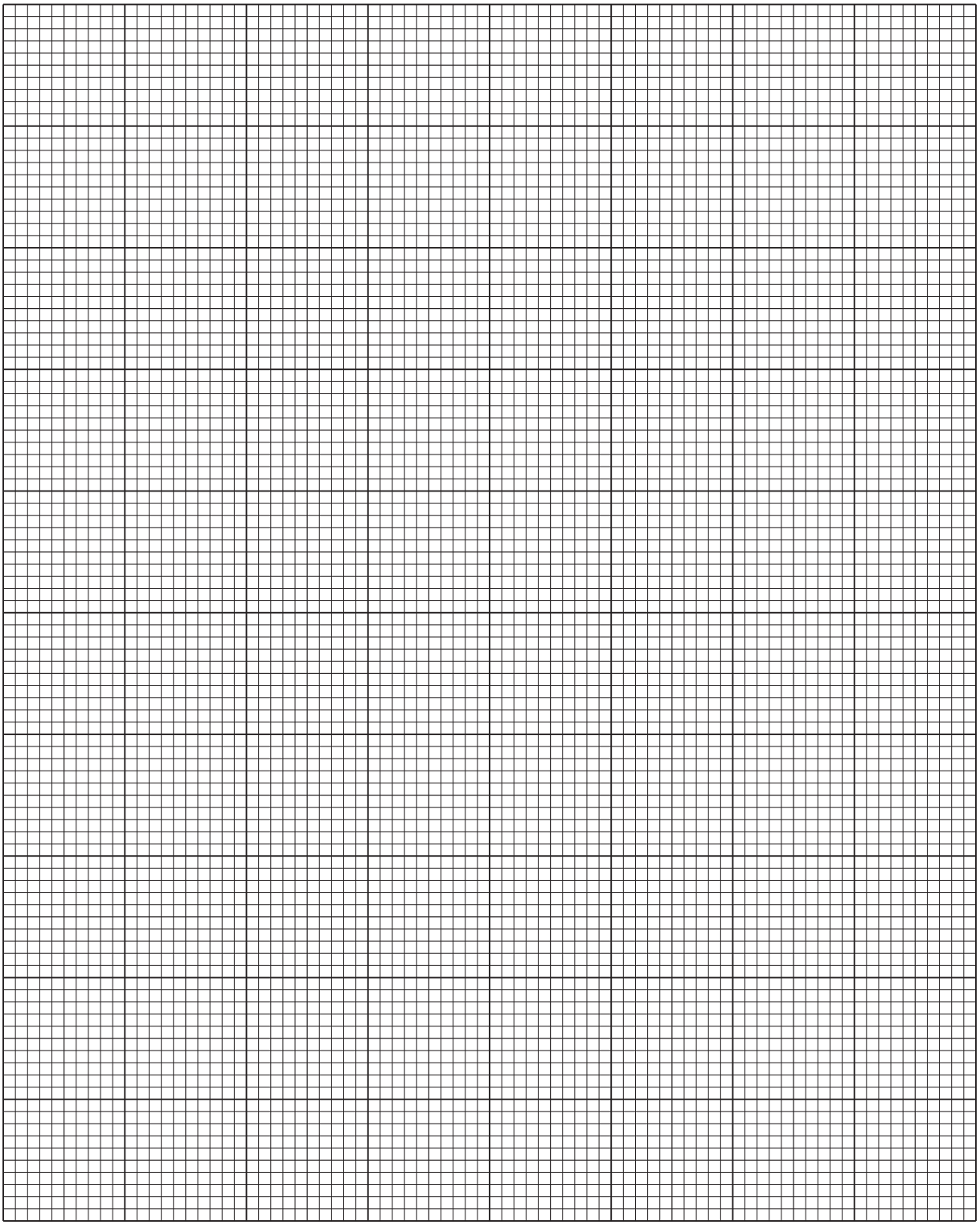
..... [2]

(ii) Plot a graph to show the mean mass of carbon dioxide taken up by *Endoriftia* over time for:

- the control experiment
- the experiment with hydrogen sulfide gas
- the experiment with hydrogen gas.

Plot all three sets of results on the **same** axes. Join the points with straight, ruled lines.



[5]

(iii) Describe the effect of adding hydrogen sulfide gas on the mean mass of carbon dioxide taken up over time.

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(iv) Discuss the effects of adding hydrogen sulfide gas and hydrogen gas on the uptake of carbon dioxide.

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[Total: 15]

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4 Fig. 4.1 shows part of the life cycle of the orca (killer whale).

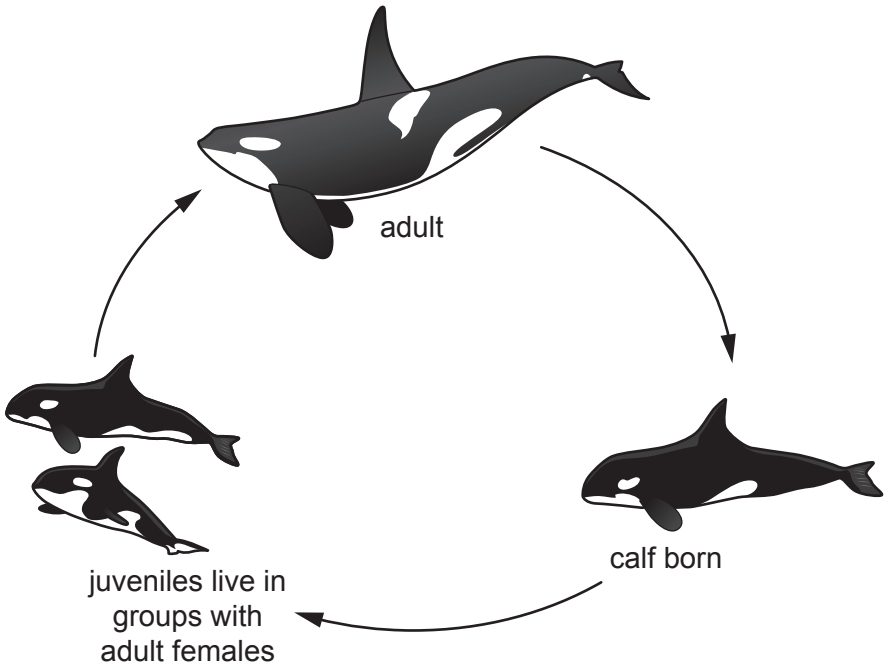

Fig. 4.1

(a) Use Fig. 4.1 to explain why the life cycle of an orca is classed as a simple life cycle.

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..... [2]

(b) Orcas belong to a group of organisms called cetaceans.

In some species of cetaceans, females become infertile at a certain age and stop breeding. This is called a menopause. The time after the menopause until the animal dies is called the post-menopause period.

Scientists compared the maximum life expectancy with the maximum length of the post-menopause period of a range of cetacean species.

The results are shown in Fig. 4.2. Each plotted point indicates the mean value for one species.

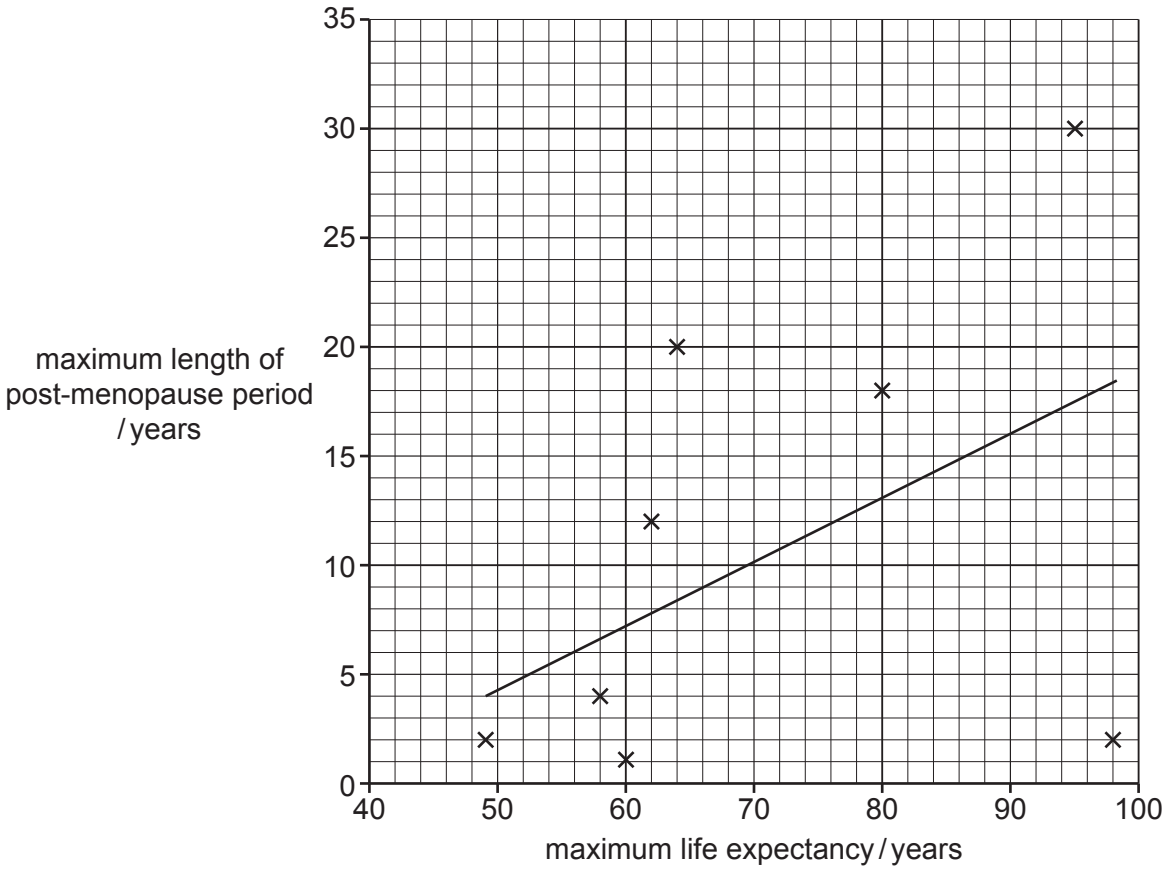

Fig. 4.2

The scientists made a hypothesis that there is a positive correlation between the maximum life expectancy of cetacean species and the maximum length of the post-menopause period.

Evaluate how strongly the graph shown in Fig. 4.2 supports the scientists' hypothesis.

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(c) The scientists carried out a Spearman's rank correlation test to determine if there was a significant correlation between the maximum life expectancy and the maximum length of the post-menopause period.

Their data and rankings are shown in Table 4.1.

Table 4.1

cetacean species	maximum life expectancy /years	rank maximum life expectancy	maximum length of post-menopause period /years	rank maximum length of post-menopause period	*D*	D^2
fin whale	98	1	2			
orca	95	2	30	1	1	1
long-finned pilot whale	60	6.5	1	8.5	–2	4
short-finned pilot whale	64	4	20	2	2	4
false killer whale	58	8	4	5	3	9
North Atlantic right whale	49	9	2	6.5	2.5	6.25
sperm whale	60	6.5	1	8.5	–2	4
beluga whale	62	5	12	4	1	1
narwhal	80	3	18	3	0	0
					$\sum D^2$ =	

$\sum$ = sum of (total)

D = difference in rank between each pair of measurements

(i) Complete Table 4.1 by completing the values for:

- fin whale
- $\sum D^2$ [1]

(ii) Give a null hypothesis for the statistical test.

.....

..... [1]

(iii) Use the formula to calculate the Spearman's rank correlation coefficient, r_S, for the data in Table 4.1.

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

r_S = Spearman's rank correlation coefficient

Σ = sum of (total)

D = difference in rank between each pair of measurements

n = number of pairs of items in the sample

..... [1]

(iv) Table 4.2 is a critical values table for Spearman's rank correlation coefficient.

Table 4.2

number of pairs, n	r_S ($p < 0.05$)
5	1.000
6	0.886
7	0.786
8	0.738
9	0.700
10	0.648
11	0.618

Use your calculated value from **4(c)(iii)**, and Table 4.2, to assess whether there is a significant correlation between maximum life expectancy and maximum length of the post-menopause period. Justify your conclusion.

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(d) Female orcas live in groups with other females they are related to.

Use your knowledge of animal life cycles to suggest an explanation for the extended menopause of female orcas.

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[Total: 13]

5 High protein feed is often used in aquaculture. It can cause the release of large quantities of urea into water.

Urea is a nitrogen-containing compound that is excreted by many organisms and is also released from the breakdown of protein by decomposers.

When urea enters marine waters, it can affect the growth of dinoflagellates and other algae.

(a) Fig. 5.1 shows a light micrograph of a dinoflagellate.

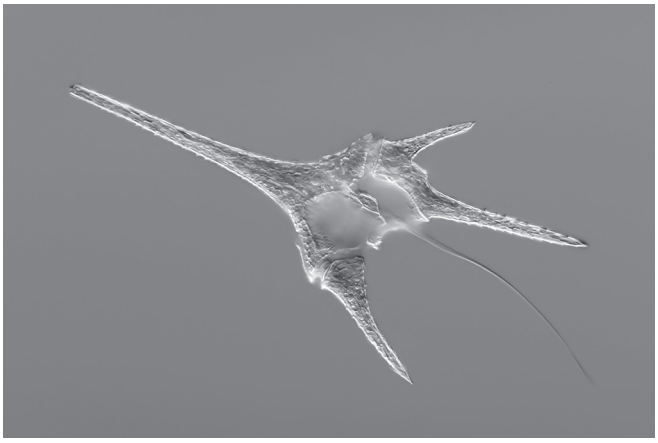

Fig. 5.1

Make a large drawing of the dinoflagellate in Fig. 5.1.

Do **not** label or shade your diagram.

[3]

(b) To investigate the effect of urea from high protein feed, scientists analysed the water in a sea bass farm 21 times over a period of six months.

Each time the water was analysed, the urea concentration and presence or absence of an algal bloom was assessed.

The concentration of urea was assessed as either less than or equal to 1.5 μmol dm^{-3} or greater than 1.5 μmol dm^{-3}.

The results are shown in Table 5.1.

Table 5.1

urea concentration / μmol dm^{-3}	number of times water contained urea of this concentration	number of times algal bloom occurred
less than or equal to 1.5	7	1
greater than 1.5	14	10

(i) Calculate as a percentage the number of times that water with a urea concentration of greater than 1.5 μmol dm^{-3} also had an algal bloom.

.....% [1]

(ii) Describe the relationship between the different concentrations of urea and the occurrence of the algal blooms.

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..... [1]

(iii) Scientists claimed that the results showed that adding excess protein feed caused algal blooms.

Evaluate this conclusion.

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(c) Give **two** requirements for the long-term sustainability of an aquaculture venture.

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2 .....

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[2]

[Total: 10]

6 Ammonium nitrate is commonly used as an agricultural fertiliser. If ammonium nitrate runs off into the sea, it can increase the rate of growth of marine algae.

Plan a **laboratory-based** investigation that you could do to investigate the effect of changing the concentration of ammonium nitrate on the rate of growth of marine algae.

You are provided with standard laboratory equipment.

Your plan should:

- include a clear statement of the hypothesis
- identify the key variables
- include full details of the method
- describe how you would analyse your results
- be safe and ethical.

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