Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

MARINE SCIENCE **9693/41**

Paper 4 A Level Data-handling and Investigative Skills **May/June 2025**

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.

[Turn over

Answer **all** questions.

1 Fig. 1.1 is an electron micrograph of part of a cell from a salmon.

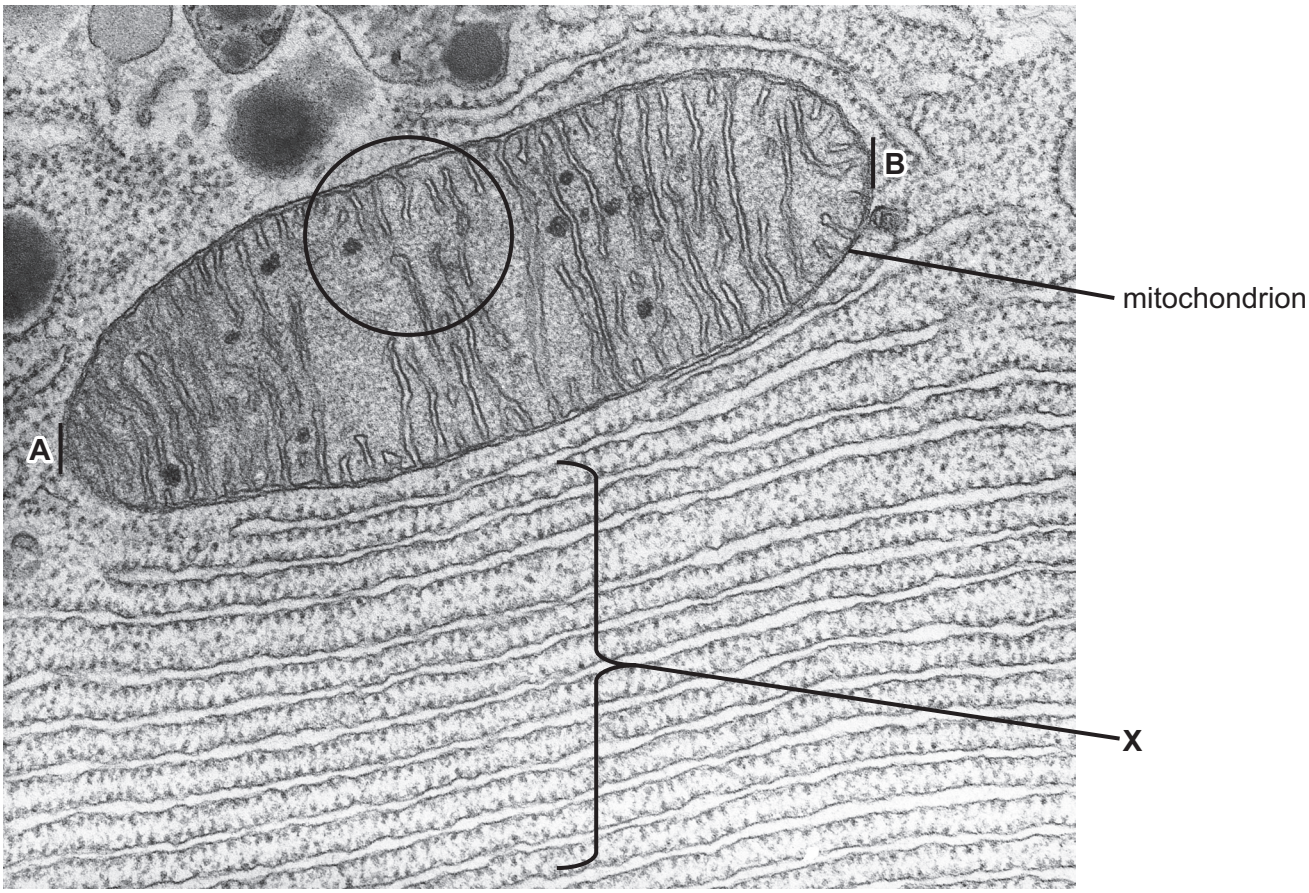

Fig. 1.1

(a) (i) Name the organelle labelled **X** in Fig. 1.1.

..... [1]

(ii) Outline the function of the organelle labelled **X** in Fig. 1.1.

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..... [2]

(b) (i) Make a large drawing of the part of the mitochondrion in the circle in Fig. 1.1.

[4]

(ii) The electron micrograph has a magnification of ×65 000.

Calculate the length of the mitochondrion in nanometres (nm) between lines **A** and **B**.

Give your answer to **two** significant figures.

Show your working.

..... nm [3]

(iii) Muscle is a type of tissue that is specialised for movement. Salmon have two types of muscle tissue: red muscle and white muscle.

Scientists measured the mean percentage of muscle tissue volume that is composed of mitochondria in both types of salmon muscle tissue.

The results are shown in Fig. 1.2.

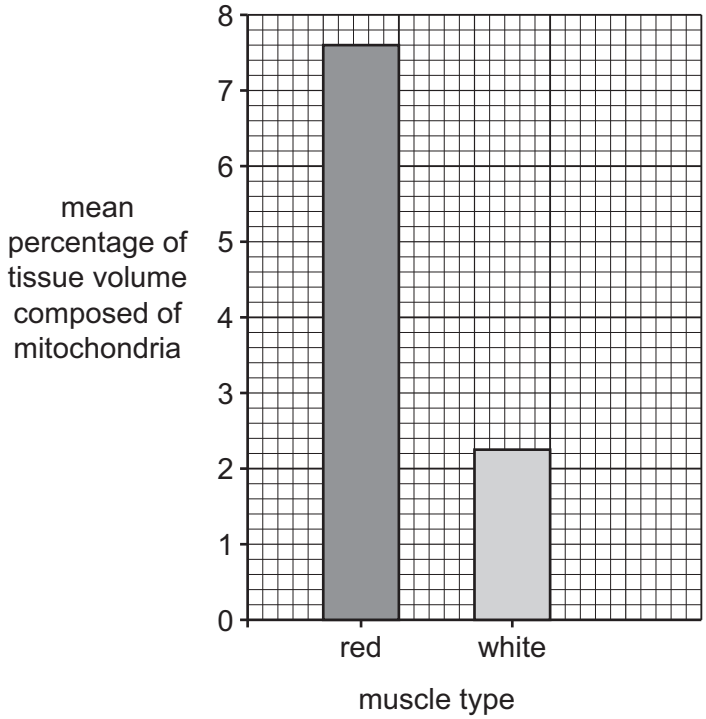

Fig. 1.2

Salmon use red muscle tissue for long-distance swimming. Salmon use white muscle tissue for short periods of quick swimming.

Describe **and** explain the results shown in Fig. 1.2.

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..... [4]

[Total: 14]

2 *Endoriftia* bacteria fix carbon by chemosynthesis.

Endoriftia bacteria live inside giant tubeworms, *Riftia*.

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

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..... [3]

(b) Other species of bacteria can also fix carbon by chemosynthesis. Some of these species of bacteria live in areas of the seabed where methane gas is released into the water. These bacteria are often the start of food chains.

Scientists investigated the colonisation of different types of substrates by organisms, using the following method.

- They placed a piece of bone, wood and calcium carbonate rock at depths of 1000 m in an area where methane is released from the seabed.
- They placed another piece of bone, wood and calcium carbonate rock at depths of 1000 m in an area where **no** methane is released.
- After seven years, they determined the density of coloniser organisms, the total number of different species of coloniser organisms, and the total number of coloniser organisms of all species present on each substrate.

The results of the investigation are shown in Table 2.1.

Table 2.1

location	substrate	density of coloniser organisms / number per m^2	total number of different species of coloniser organisms	total number of coloniser organisms of all species
area where methane is released	bone	50	15	375
	wood	48	14	920
	calcium carbonate	240	23	1800
area where **no** methane is released	bone	40	12	220
	wood	20	21	540
	calcium carbonate	10	10	120

(i) Calculate the surface area of the bone placed in the area where methane is released, using the information in Table 2.1.

State the unit.

Space for working.

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[2]

(ii) Bone is an organic material from living organisms. Calcium carbonate is inorganic rock.

Suggest why the density of coloniser organisms is higher on bone compared with calcium carbonate when placed in the area where **no** methane is released.

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..... [2]

(iii) Coloniser organisms from several different trophic levels are found on the substrates.

Explain the difference in colonisation of the substrates when placed in the area where methane is released compared with the area where **no** methane is released.

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(iv) The scientists concluded that placing the substrates near the area releasing methane definitely affected colonisation.

Evaluate this conclusion.

Use Table 2.1 **and** the method used by the scientists to support your answer.

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..... [2]

[Total: 13]

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3 Oysters are shelled molluscs that have a complex life cycle. The adults are sessile organisms that anchor to a substrate.

Fig. 3.1 shows some adult oysters.

Fig. 3.1

(a) Outline the importance of having a complex life cycle for organisms such as oysters.

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..... [3]

(b) Scientists investigated the effects of temperature and pH on the survival of oyster larvae.

Oyster larvae were placed into tanks of water at different temperatures and pHs.

The percentages of larvae surviving were calculated after two days and then again after 15 days.

Fig. 3.2 and Fig. 3.3 show the results.

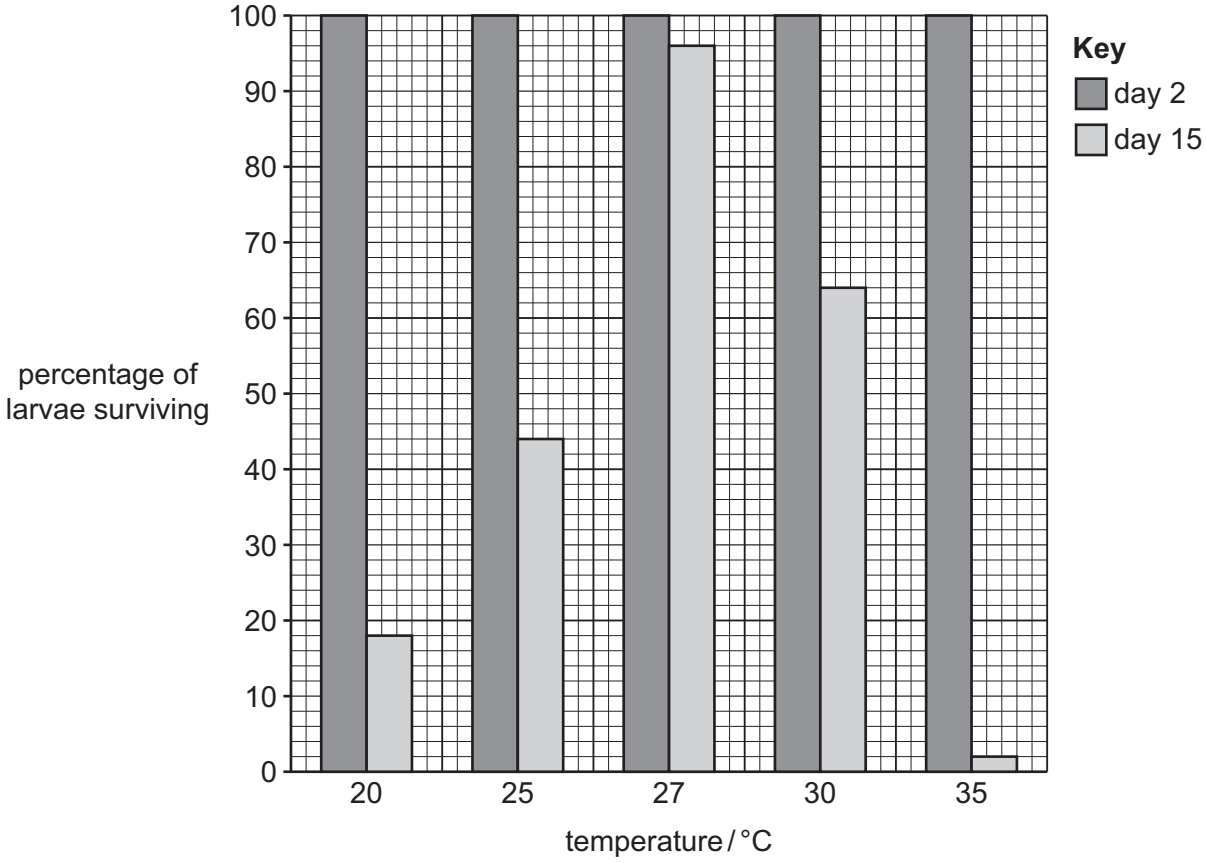


Fig. 3.2

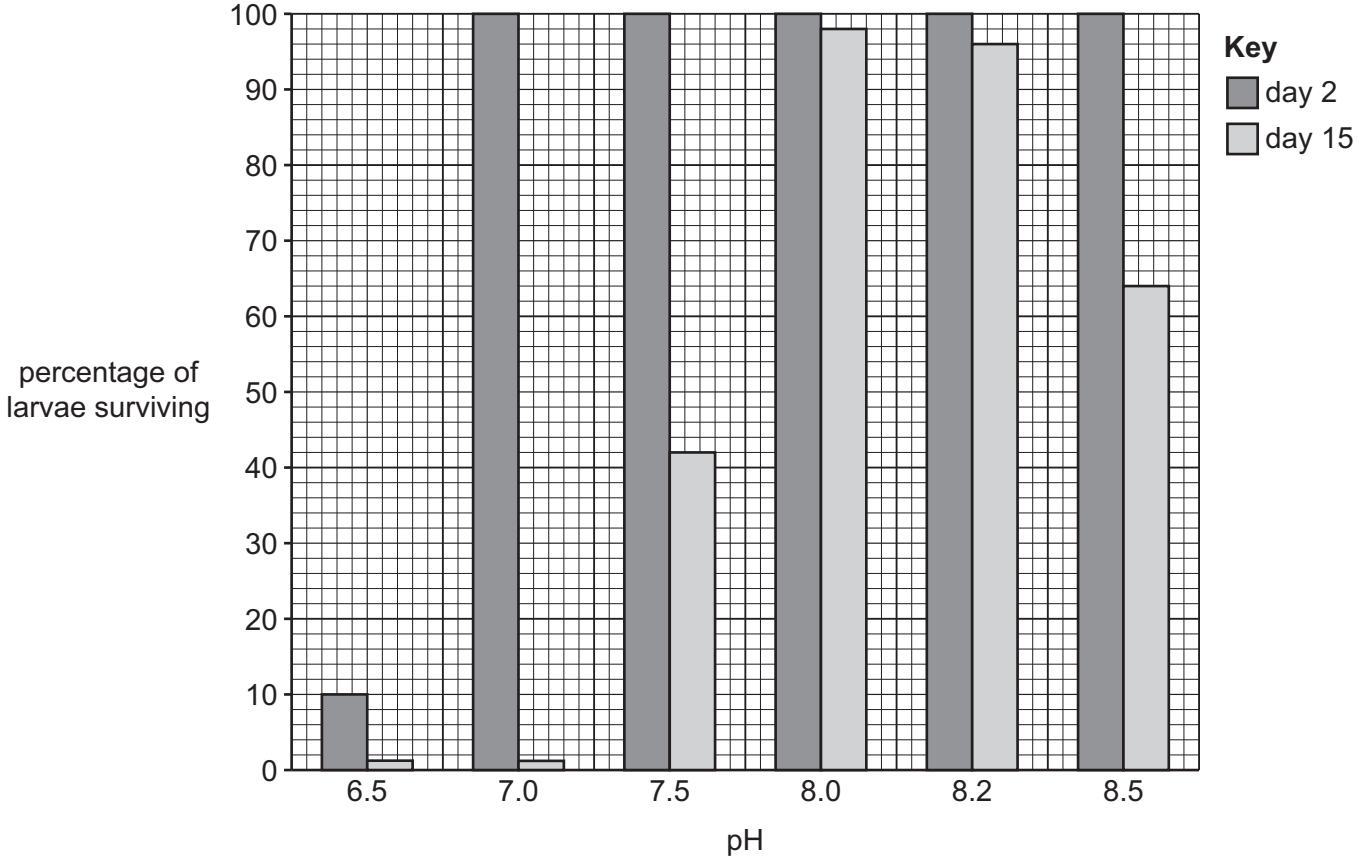


Fig. 3.3

(i) The scientists placed 500 larvae in each condition.

Calculate the number of larvae that did **not** survive from day 2 to day 15 when placed at a temperature of 30 °C.

..... [2]

(ii) Use Fig. 3.2 **and** Fig. 3.3 to state the optimum temperature **and** optimum pH for the survival of oyster larvae.

optimum temperature ..... °C

optimum pH .....

[1]

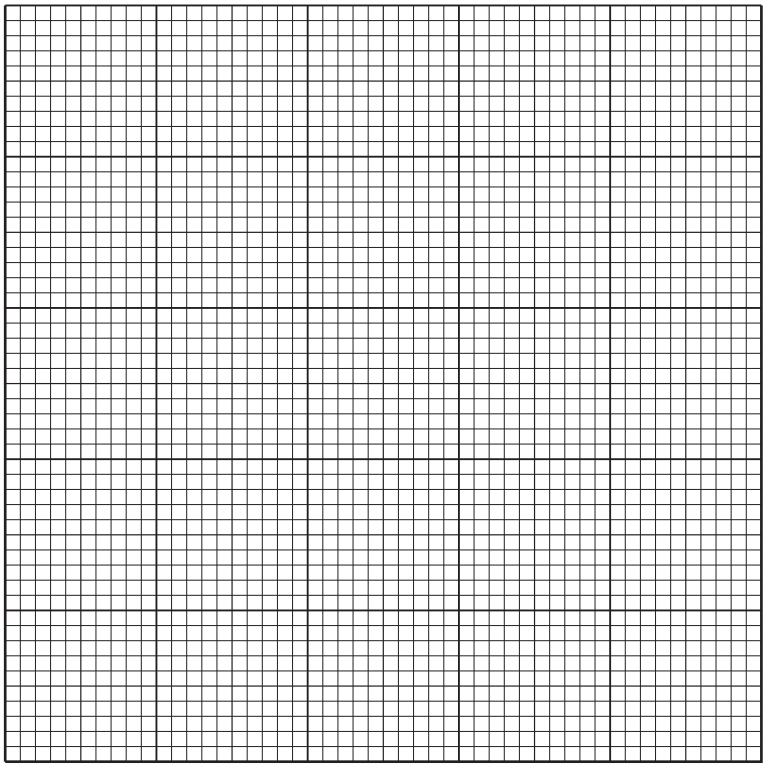
(c) Fishers in India reported declining harvests of adult oysters from an area of coastal water after 2011.

(i) Table 3.1 shows the temperature and pH of the water during 2009 in this area.

Table 3.1

month	temperature / °C	pH
February	25	8.0
April	27	7.9
June	34	8.2
August	30	7.0
October	32	6.5
December	28	7.0

Use Table 3.1 to plot a line graph to show the temperature **and** the pH from February to December.



[5]

(ii) Around the coasts of India, oysters spawn throughout the year but have two peak periods of breeding, in April and August.

Discuss the reasons for the reduction in the number of oysters that the fishers harvested after 2011.

Use information in Table 3.1, Fig. 3.2 **and** Fig. 3.3 to support your answer.

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(d) Explain why the use of fossil fuels places future oyster populations at risk.

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[Total: 18]

4 A student investigated if the surface area of fish gills has a correlation with the activity levels of the fish.

(a) The student used a Spearman's rank correlation to test if there was a significant correlation.

Table 4.1 shows the activity level, gill surface area and the ranking for different species of fish.

Table 4.1

species	activity level (10 = highly active)	rank activity level	gill surface area / $cm^2 g^{-1}$	rank gill surface area	*D*	D^2
butterfish	5	7	461	6	1	1
fluke	2	11	247	11	0	0
mackerel	9	2	1040	2	0	0
menhaden	10	1	1241	1	0	0
mullet	8	3	1010	3	0	0
puffer	4		423	9		
scup	6	5	498	4	1	1
sea robin	5	7	432	8	–1	1
sea trout	5	7	275	10	–3	9
sheepshead	7	4	467	5	–1	1
tautog	4		450	7		
toadfish	1	12	151	12	0	0
						ΣD^2 =

Σ = sum of (total)

D = difference in rank between each pair of measurements

(i) Complete Table 4.1 for the puffer and tautog **and** calculate the value of ΣD^2.

Write your answers in Table 4.1.

[2]

(ii) Calculate the Spearman's rank correlation coefficient using the formula:

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

where,

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.

Show your working.

r_S = ... [2]

(iii) Table 4.2 shows the critical values for the 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
12	0.587
13	0.560

The student made the following null hypothesis for the data in Table 4.1.

'There is no correlation between the activity level of the fish and the gill surface area.'

Use Table 4.2 **and** your answer to **4(a)(ii)** to determine whether the student's null hypothesis can be accepted or rejected.

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(b) Explain why fish with different activity levels require different gill surface areas.

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[Total: 10]

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5 Fig. 5.1 shows a photograph of Palau which is a nation located in the Pacific Ocean. Palau consists of a series of islands surrounded by a range of coral reefs.

Fig. 5.1

Reef fish are an important part of the diet for local people in Palau.

In 2017, fishing restrictions were implemented in Palau to make fishing sustainable. In some areas, all fishing was banned.

(a) State **two other** important methods of restriction that could be used to ensure that the Palau fishery is sustainable.

1 .....

2 .....
[2]

(b) State **one** negative sociological impact on the people in Palau caused by restrictions on fishing.

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..... [1]

(c) Scientists investigated the effect of the restrictions by sampling commercial species of reef fish in 2017 and 2019.

In each year, fish were sampled at 150 sites around Palau by divers using cameras.

The results are shown in Fig. 5.2 and Fig. 5.3.

Fig. 5.2 shows the mean biomass of reef fish in 2017 and 2019.

Fig. 5.3 shows the mean biomass of fish that are herbivores, fish that are secondary consumers, and high trophic level fish that consume other fish species, in 2017 and 2019.

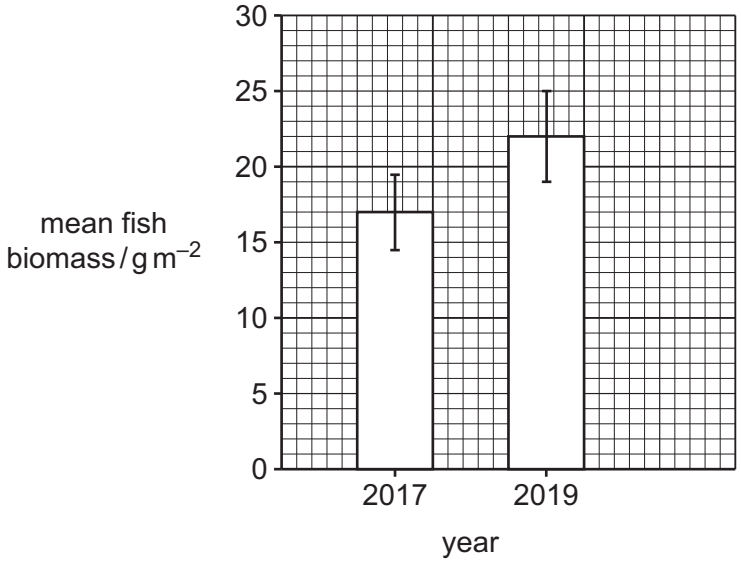

Fig. 5.2

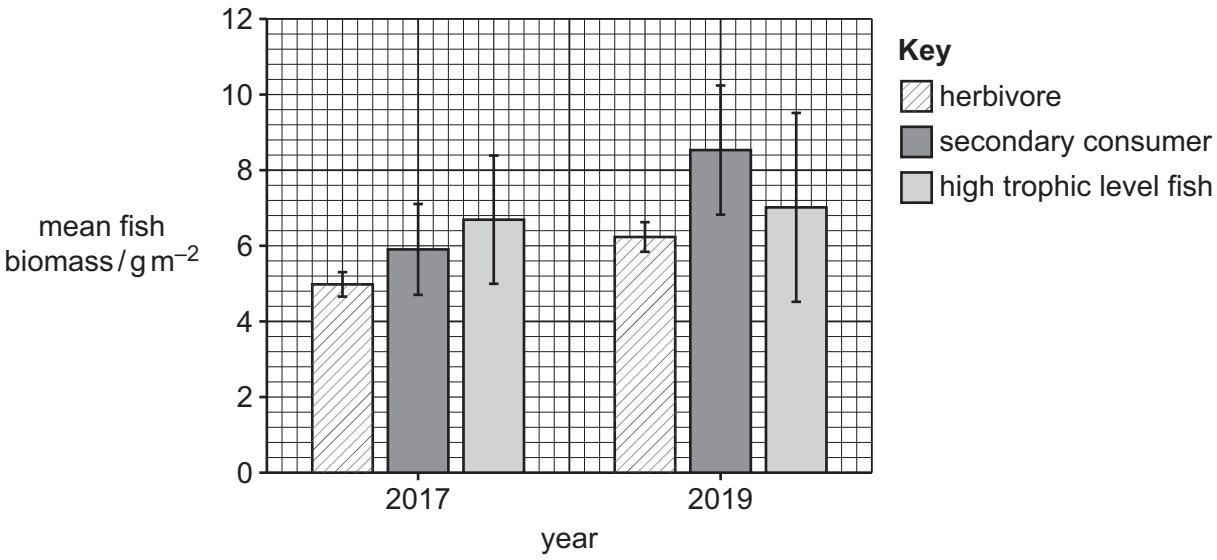

Fig. 5.3

Evaluate the effects of the fishing restrictions on the sustainability of the Palau fishery.

Use Fig. 5.2 **and** Fig. 5.3 to support your answer.

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[Total: 7]

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6 Fig. 6.1 shows a photograph of a ship's rudder and propeller covered in barnacles.

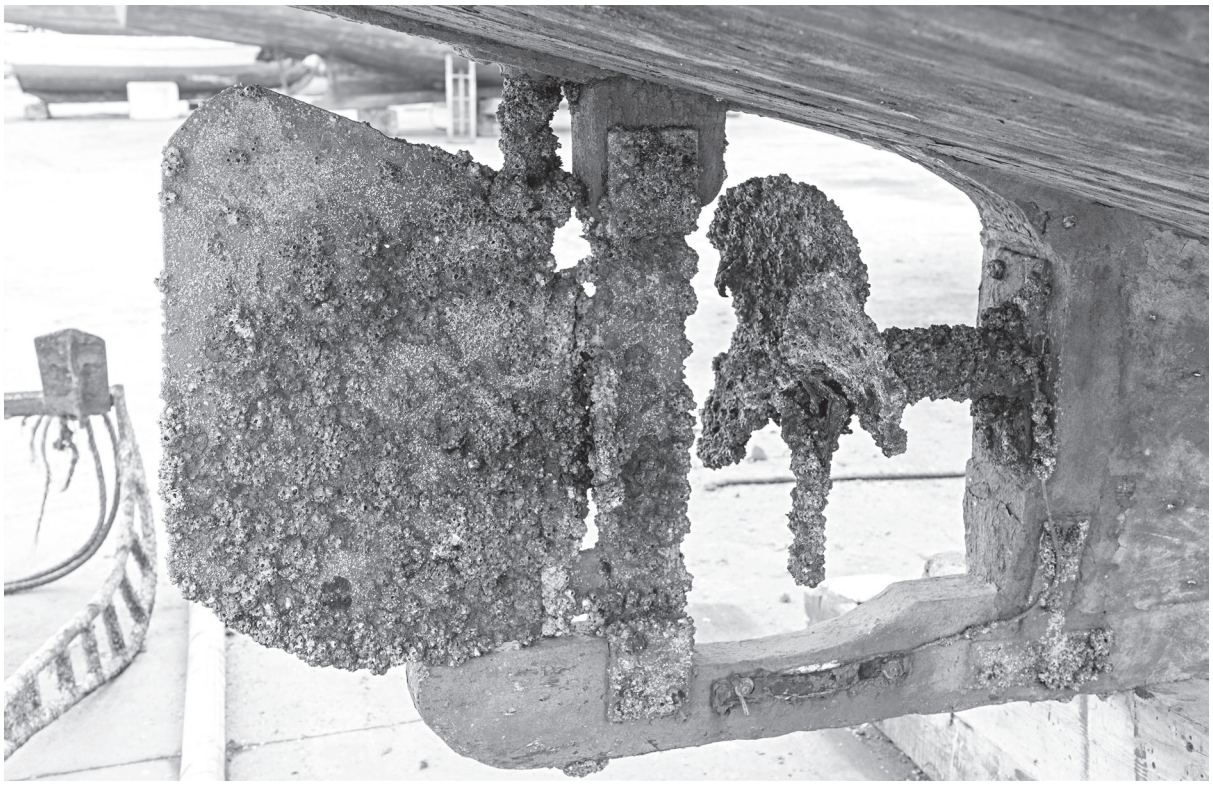

Fig. 6.1

Antifouling paints are often used to prevent barnacle larvae settling on boats.

(a) Outline why many antifouling paints that contained heavy metals are now banned.

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(b) Bromosphaerol is a natural substance produced by red algae that may work as an antifouling agent.

Plan a laboratory investigation that you could do to investigate the effect of increasing concentration of bromosphaerol on the growth of barnacles on a substrate.

You would be provided with a $1\,g\,dm^{-3}$ stock solution of bromosphaerol solution.

Bromosphaerol may be an irritant.

Your plan should:

- include a clear statement of the hypothesis
- identify the independent, dependent, and standardised variables
- include full details of the method so that another person can follow it
- describe how you would analyse your results
- be safe and ethical.

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