MARINE SCIENCE

Paper 9693/11
AS Level Theory

Key messages

- The syllabus should be used to guide the content and level of detail required for this course. Candidates are expected to understand and use subject specific vocabulary, as found in the syllabus.
- Candidates should be encouraged to show their working in mathematical questions. Full credit cannot be awarded for a question if no working is shown.

General comments

The number of marks available for each question is indicated. Candidates should use the number of marks to guide them. For example, generally an item worth five marks would require five relevant points. This is particularly important in ***Section B***.

This year some candidates required more practice in mathematical skills. The expected standard is indicated in the syllabus (pages 40 to 42).

Questions requiring chemistry knowledge that is relevant to marine science, in particular relating to the chemistry of water, were often answered less well with a lack of understanding of basic chemistry demonstrated. For example, terms such as atom, electron and molecule were used incorrectly. Also, solubility and salinity were used interchangeably. Concepts surrounding density were challenging for many candidates.

Comments on specific questions

Section A

Question 1

(a) The most common correct answer was that lipids/fats were the large molecule made from fatty acids and glycerol. Some candidates knew the small molecule that makes up cellulose is glucose. Very few could give the main chemical elements in cellulose and fats. Carbon, hydrogen and oxygen were frequently seen, but often with the incorrect addition of nitrogen, calcium or phosphorus which meant that credit could not be awarded.

(b) (i) This question asked for the name of the processes, so descriptions of the processes were not credited. Candidates should be encouraged to read all the information in the questions. In this case, it was important to know the figure was depicting part of the carbon cycle, not upwards movement of the organisms or other interpretation of the figure. Few candidates recognised that **A** was respiration, with photosynthesis and upwelling being frequent incorrect responses.

(ii) Many candidates knew that burning/combustion of fossil fuels returns carbon to the atmosphere. Fewer described the detail that carbon dioxide is released, and very few considered that the fossil fuels need to be extracted before burning. Incorrect responses often referred to upwelling and currents.

(iii) The question referred to this process of rock formation taking millions of years, so references to divergent plates were not relevant. Some candidates referred to or described sedimentation, but few considered the pressure/compaction involved or how the sediments cement together.

Question 2

(a) (i) Only stronger candidates were able recall details of classification as given in the syllabus. For example, the question stated that all turtles are in the same phylum as bony fish, and the syllabus is clear that bony fish are in the phylum chordata/chordates.

(ii) Many candidates gave the binomial name of the leatherback turtle using the information provided in the table. Some reversed the order of the genus and species name which was incorrect, and others gave the family and species name.

(b) (i) Most candidates described commensal in terms of a benefit to one organism, but some did not earn full credit as they only described the other organism/host as being unharmed rather than the organism/host neither benefiting nor being harmed.

(ii) This question was attempted well by most candidates. Due to the number of remora fish shown in the figure, it was acceptable for candidates to refer to increased weight as an alternative to reduced hydrodynamic efficiency or increased drag.

Question 3

(a) Many candidates answered in vague terms and a lack of precision in responses often led to no credit being awarded. For example, at AS level, candidates are expected to know that molecules of water are vibrating when solid, so to suggest that water molecules in ice are not moving is incorrect.

The numbered points in the answer space were there to remind candidates to give two differences. The response was marked as a whole, but if candidates described water as a liquid and then in ice, they were often not identifying differences. Weaker candidates only described one state or the other, whereas the differences were what the question required.

References to differences in density were not credited because the question asked for differences in arrangement and movement.

(b) (i) Most candidates knew the crosses in the figure represented electrons. Candidates could refer to these as electrons in terms of being associated with the hydrogen atom, but that was not required for credit.

(ii) Most candidates knew this was an example of a covalent bond. Frequently seen incorrect answers were ionic and hydrogen.

(iii) This was a more challenging question. Candidates needed to understand the properties of water. There were indications that some candidates had no concept of hydrogen bonding and could not attempt any description of how a hydrogen bond forms. Incorrect responses often referred to covalent bonding.

(iv) A high proportion of candidates incorrectly stated that the density of ice is greater than the density of water and described molecules of water being closer together in ice than in water.

Candidates who gave correct reference to the density of liquid water and ice made attempts to explain why the difference occurs. Many of these candidates described molecules in ice being further apart, but few explained that this is due to more hydrogen bonds forming. Incorrect references to each hydrogen bond being weaker or stronger in different states were common.

(v) Most candidates described one way that the relative density of liquid water and ice affect marine organisms. Many referred to the floating ice forming a habitat or platform for marine mammals, or correctly applied this to specific examples such as seals, penguins and polar bears. Others correctly referred to the property of ice as an insulator preventing organisms below from freezing.

(vi) The most common correct answers were temperature and salinity. Rather than pressure, some candidates stated air pressure or atmospheric pressure, therefore credit could not be awarded.

Question 4

(a) Some candidates were not able to calculate this percentage and many only divided 60 by 800 and did not multiply by 100. To gain full credit, candidates had to show their working. This provides an opportunity for partial credit to be awarded even if a final answer is incorrect.

(b) (i) Again, candidates needed to show their working. Some candidates could not work in standard form, with 4.7×10^6 frequently incorrectly written as 47 000 000.

The instruction to give the answer to an appropriate number of significant figures was often not followed. As stated in the syllabus, candidates should take account of significant figures in calculations so that significant figures are neither lost unnecessarily nor carried beyond what is justified. The correct number of significant figures for calculated quantities is the same as, or one more than, the smallest number of significant figures in the data used in the calculation. In this example, it was appropriate to give the answer to 2 or 3 significant figures.

(ii) The command word in the question was 'suggest'. There were several possible sensible suggestions seen and the most common correct answer was that the water at Vent B had a lower concentration of nutrients/minerals.

(iii) For this question candidates had to demonstrate understanding of productivity (beyond simply repeating the units in the table). References to carbon or energy being produced were not correct. Few candidates considered the food web that would contribute to biomass in the volume of water surrounding the vent.

Section B

Question 5

(a) Many responses stated that the solubility of salts and gases increased with temperature, which is only true for salts. Confusion was seen regarding solubility and salinity. These terms should not be used interchangeably. Few candidates gained credit for explaining why increasing ocean temperature affects the solubility of salts and gases.

Some candidates gave detailed descriptions of the likely effect of changing salinity or gas concentrations on marine organisms, which did not answer the question.

(b) This question was answered well with candidates giving detailed descriptions and demonstrating clear understanding of the importance of carbon dioxide for all marine organisms. Weaker candidates were imprecise with their language and gave responses such as "oxygen and carbon dioxide are needed for photosynthesis". Such responses could not be credited.

Question 6

(a) (i) Only stronger candidates answered this correctly. The level of detail given in the syllabus should guide the teaching of this area. Candidates found it difficult to explain why all three levels of biodiversity should be considered.

(ii) Some candidates did not read the question carefully enough. It may help some candidates to underline key words in the question as they read it and to check that their response answers the question. Abiotic was a key word in this question. Therefore all mentions of biotic factors were invalid for credit. The most common credit awarded was for reduction of wave energy/height and prevention of coastal erosion.

(b) Candidates answered this question very well and many candidates gained full credit.

MARINE SCIENCE

Paper 9693/12
AS Level Theory

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General comments

The number of marks available for each question is indicated. Candidates should use the number of marks to guide them. For example, generally an item worth five marks would require five relevant points. This is particularly important in ***Section B***.

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Comments on specific questions

Section A

Question 1

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(b) (i) This question asked for the name of the processes, so descriptions of the processes were not credited. Candidates should be encouraged to read all the information in the questions. In this case, it was important to know the figure was depicting part of the carbon cycle, not upwards movement of the organisms or other interpretation of the figure. Few candidates recognised that **A** was respiration, with photosynthesis and upwelling being frequent incorrect responses.

(ii) Many candidates knew that burning/combustion of fossil fuels returns carbon to the atmosphere. Fewer described the detail that carbon dioxide is released, and very few considered that the fossil fuels need to be extracted before burning. Incorrect responses often referred to upwelling and currents.

(iii) The question referred to this process of rock formation taking millions of years, so references to divergent plates were not relevant. Some candidates referred to or described sedimentation, but few considered the pressure/compaction involved or how the sediments cement together.

Question 2

(a) (i) Only stronger candidates were able recall details of classification as given in the syllabus. For example, the question stated that all turtles are in the same phylum as bony fish, and the syllabus is clear that bony fish are in the phylum chordata/chordates.

(ii) Many candidates gave the binomial name of the leatherback turtle using the information provided in the table. Some reversed the order of the genus and species name which was incorrect, and others gave the family and species name.

(b) (i) Most candidates described commensal in terms of a benefit to one organism, but some did not earn full credit as they only described the other organism/host as being unharmed rather than the organism/host neither benefiting nor being harmed.

(ii) This question was attempted well by most candidates. Due to the number of remora fish shown in the figure, it was acceptable for candidates to refer to increased weight as an alternative to reduced hydrodynamic efficiency or increased drag.

Question 3

(a) Many candidates answered in vague terms and a lack of precision in responses often led to no credit being awarded. For example, at AS level, candidates are expected to know that molecules of water are vibrating when solid, so to suggest that water molecules in ice are not moving is incorrect.

The numbered points in the answer space were there to remind candidates to give two differences. The response was marked as a whole, but if candidates described water as a liquid and then in ice, they were often not identifying differences. Weaker candidates only described one state or the other, whereas the differences were what the question required.

References to differences in density were not credited because the question asked for differences in arrangement and movement.

(b) (i) Most candidates knew the crosses in the figure represented electrons. Candidates could refer to these as electrons in terms of being associated with the hydrogen atom, but that was not required for credit.

(ii) Most candidates knew this was an example of a covalent bond. Frequently seen incorrect answers were ionic and hydrogen.

(iii) This was a more challenging question. Candidates needed to understand the properties of water. There were indications that some candidates had no concept of hydrogen bonding and could not attempt any description of how a hydrogen bond forms. Incorrect responses often referred to covalent bonding.

(iv) A high proportion of candidates incorrectly stated that the density of ice is greater than the density of water and described molecules of water being closer together in ice than in water.

Candidates who gave correct reference to the density of liquid water and ice made attempts to explain why the difference occurs. Many of these candidates described molecules in ice being further apart, but few explained that this is due to more hydrogen bonds forming. Incorrect references to each hydrogen bond being weaker or stronger in different states were common.

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(vi) The most common correct answers were temperature and salinity. Rather than pressure, some candidates stated air pressure or atmospheric pressure, therefore credit could not be awarded.

Question 4

(a) Some candidates were not able to calculate this percentage and many only divided 60 by 800 and did not multiply by 100. To gain full credit, candidates had to show their working. This provides an opportunity for partial credit to be awarded even if a final answer is incorrect.

(b) (i) Again, candidates needed to show their working. Some candidates could not work in standard form, with 4.7×10^6 frequently incorrectly written as 47 000 000.

The instruction to give the answer to an appropriate number of significant figures was often not followed. As stated in the syllabus, candidates should take account of significant figures in calculations so that significant figures are neither lost unnecessarily nor carried beyond what is justified. The correct number of significant figures for calculated quantities is the same as, or one more than, the smallest number of significant figures in the data used in the calculation. In this example, it was appropriate to give the answer to 2 or 3 significant figures.

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Section B

Question 5

(a) Many responses stated that the solubility of salts and gases increased with temperature, which is only true for salts. Confusion was seen regarding solubility and salinity. These terms should not be used interchangeably. Few candidates gained credit for explaining why increasing ocean temperature affects the solubility of salts and gases.

Some candidates gave detailed descriptions of the likely effect of changing salinity or gas concentrations on marine organisms, which did not answer the question.

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Question 6

(a) (i) Only stronger candidates answered this correctly. The level of detail given in the syllabus should guide the teaching of this area. Candidates found it difficult to explain why all three levels of biodiversity should be considered.

(ii) Some candidates did not read the question carefully enough. It may help some candidates to underline key words in the question as they read it and to check that their response answers the question. Abiotic was a key word in this question. Therefore all mentions of biotic factors were invalid for credit. The most common credit awarded was for reduction of wave energy/height and prevention of coastal erosion.

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MARINE SCIENCE

Paper 9693/13
AS Level Theory

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Comments on specific questions

Section A

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(ii) Many candidates knew that burning/combustion of fossil fuels returns carbon to the atmosphere. Fewer described the detail that carbon dioxide is released, and very few considered that the fossil fuels need to be extracted before burning. Incorrect responses often referred to upwelling and currents.

(iii) The question referred to this process of rock formation taking millions of years, so references to divergent plates were not relevant. Some candidates referred to or described sedimentation, but few considered the pressure/compaction involved or how the sediments cement together.

Question 2

(a) (i) Only stronger candidates were able recall details of classification as given in the syllabus. For example, the question stated that all turtles are in the same phylum as bony fish, and the syllabus is clear that bony fish are in the phylum chordata/chordates.

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(vi) The most common correct answers were temperature and salinity. Rather than pressure, some candidates stated air pressure or atmospheric pressure, therefore credit could not be awarded.

Question 4

(a) Some candidates were not able to calculate this percentage and many only divided 60 by 800 and did not multiply by 100. To gain full credit, candidates had to show their working. This provides an opportunity for partial credit to be awarded even if a final answer is incorrect.

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Section B

Question 5

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Question 6

(a) (i) Only stronger candidates answered this correctly. The level of detail given in the syllabus should guide the teaching of this area. Candidates found it difficult to explain why all three levels of biodiversity should be considered.

(ii) Some candidates did not read the question carefully enough. It may help some candidates to underline key words in the question as they read it and to check that their response answers the question. Abiotic was a key word in this question. Therefore all mentions of biotic factors were invalid for credit. The most common credit awarded was for reduction of wave energy/height and prevention of coastal erosion.

(b) Candidates answered this question very well and many candidates gained full credit.

MARINE SCIENCE

Paper 9693/21

AS Level Data-handling and Investigative Skills

Key messages

- Stronger candidates clearly had a good understanding of the whole breadth of the specification and could link ideas from different sections to produce clearly thought through responses.
- Candidates must ensure they have pencils, rulers and calculators when they sit the exam, to ensure their drawings and construction of tables, graphs and charts are clear.
- Weaker candidates should be encouraged to further develop their understanding of scientific principles in practical work, in particular their understanding of the different types of variables.
- It is useful for candidates to undertake the core practical activities themselves, to help reinforce their learning in these aspects.

General comments

Candidates generally attempted all questions, and used suitable scientific language and terminology. Some candidates needed to fully understand some of the command words, such as justify or evaluate. These are higher level command words that require candidates to make use of knowledge and understanding from different aspects of the specification and make a judgement, using evidence. Continued practice of drawing specimens and evaluative feedback would also have enabled them to improve their drawings.

Comments on specific questions

Question 1

(a) Many candidates gave quite vague answers, such as pH drops or indicator paper. Stronger candidates used the correct term of universal indicator paper, but some candidates suggested litmus paper. However, litmus paper gives an indication of alkalinity or acidity rather the pH level.

(b) (i) Some candidates suggested that they were different methods, so calculating the mean would not be appropriate. A few stronger candidates recognised that the values were to a different degree of accuracy and so it would not be appropriate to calculate the mean of those.

(ii) Many candidates correctly identified water sample **K** as coming from near a hydrothermal vent. The most common error was to suggest water sample **J**.

(iii) Most often candidates stated that the water near hydrothermal vents was acidic, and that the only sample that was acidic was sample **K**. Weaker candidates stated that pH is lower around hydrothermal vents which was not sufficient for credit, or confused acidity and alkalinity and stated that **K** was the most alkaline environment.

(c) Stronger candidates were able to provide a logical pathway through the question, explaining that the high quantity of sunlight at the surface allowed for rapid photosynthesis, which releases oxygen, and at a hydrothermal vent there is no light and so no photosynthesis can occur. A few weaker candidates suggested the temperature of the surface water was warmer allowing more dissolved oxygen to dissolve. Other candidates mentioned the higher photosynthetic activity at the surface releasing oxygen or that it was due to the increased sunlight, but many did not mention the hydrothermal vents.

Question 2

(a) A few candidates attempted the drawing in pen, which did not allow for corrections to be made easily. Weaker candidates were often unsure of which features to include and so omitted some of the important features. Quite often, the outline was not quite correct with candidates drawing it egg shaped or lemon shaped with tips on the long axis of the diatom.

(b) (i) Many candidates found this challenging. Some candidates used an equals sign instead of a line with an arrowhead, which is used to represent a chemical reaction occurring, while weaker candidates often did not know the reactants or the products or got them confused or gave the reaction for respiration. A few candidates attempted a chemical symbol equation, but they rarely achieved credit as they made errors. Some stronger candidates who gave a correct response also included light and chlorophyll above and below the arrowhead.

(ii) For credit, candidates needed to mention both fatty acids and glycerol, and many forgot the glycerol. Further credit was available for stating that the elements carbon, hydrogen and oxygen were found in the molecules, However, weaker candidates often mentioned nitrogen or omitted one of the correct responses required. A small number of candidates stated the function of lipids instead of the chemical structure.

(iii) The most common response was to mention run-off from land bringing silicates into the ocean, with a few stronger candidates also stating that upwelling or decomposition would replenish silicates into the oceans.

(iv) Information was provided which candidates needed to consider when evaluating the sentence. Here, there was no scientific research to back up a belief, and so candidates needed to think of how the situations may be similar or different between land plants and diatoms. Candidates found this a challenging question, and those who answered well recognised both contained silica in their cells. Many candidates discussed photosynthesis taking place in both cells, so the energy requirements would be the same.

(v) Most candidates were able to make at least one valid suggestion, with many stating two correctly.

(c) (i) Many candidates correctly identified tuna or shark, with some weaker candidates stating herring or anchovy as they were in trophic level three, rather than a tertiary consumer.

(ii) Candidates were asked to construct a pyramid of energy for a food chain. Many candidates drew these well with clear detail. Some other candidates drew less carefully, however.

(iii) The calculation was correctly answered by many candidates. However, some did not show their working, or forgot to show that the answer to their division was then multiplied by 100 or forgot to round to the correct number of significant figures.

(iv) This question required candidates to explain why the energy efficiency differed between different transfers, and while some candidates stated what the difference was, they often did not then go on to explain why that difference occurred. Candidates needed to consider how the energy requirements of tuna and diatoms differed in order to allow a greater transfer from diatoms to fish larvae compared to tuna to shark.

(v) Many candidates were able to express that the width of the diatoms bar would decrease, with stronger candidates often also mentioning that the width of all the bars would decrease in time, as less energy would be fixed, and so less food produced by the diatoms.

Question 3

(a) More candidates were able to state plankton drifted with the currents than those who mentioned them usually being microscopic, but some stated they were a food source, were photosynthetic, or were producers, all of which were insufficient for credit.

(b) (i) Most candidates were able to suggest at least one, more often two, relevant pieces of equipment required for this investigation.

(ii) Some candidates stated the independent, the dependent and one standardised variable rather than three standardised variables. Some candidates gave the answer of "the light" without stating what it was about the light that needed to be standardised, such as the intensity or colour. A few candidates gave more than three answers. Candidates should be encouraged to list the number required. Most candidates were able to state at least one correct variable for standardisation.

(iii) Some stronger candidates answered this well, but others needed to expand their comments further, e.g. adding the zooplankton to a water column, but it is important this is done in the dark, or that the zooplankton are left in the dark to allow them to settle. Few candidates mentioned repeating the tests and finding a mean value. More candidates made statements regarding how to measure the speed.

(c) Many candidates were able to make some suitable suggestions for a table to record their results in, but some sketched a table rather than drawing one using a ruler. Some candidates did not include the units in their table headings.

Question 4

(a) (i) Candidates needed to consider the differences between bony and cartilaginous fish, and stating that one has cartilage and one has bones was not sufficient for credit.

(ii) Stating it was the sea floor, or immediately above the seabed allowed candidates to achieve credit. However, many gave a stated depth, e.g. 100 m, or one of the zones, such as the twilight zone, which were too vague for credit.

(b) The majority of candidates correctly identified fish **C** as Amblyraja radiata.

(c) Many candidates were able to identify at least one, and often two, adaptations that skate have to benthic life. The most common error was to state that the tail had a stinger for defence, as skate do not have this feature.

Question 5

(a) (i) Most candidates correctly drew a line graph of the data, and most selected suitable scales for each axis, but some did not fully label their axes, often forgetting to include the units. Some weaker candidates did not draw a line through the points, which was required to help to answer **(iv)**.

(ii) Many candidates scored at least partial credit here but did need to mention the depths the changes occurred at to achieve full credit.

(iii) Many candidates correctly identified the halocline, but a significant number stated thermocline.

(iv) Many candidates read the value from their graph accurately, but candidates who had not drawn a line between the points were not able gain credit.

(v) Candidates needed to recognise there was a large change in the salinity between 4m and 6m depth. However as there were only a few data points plotted, it is difficult to show exactly where the change in salinity occurred. Some candidates mentioned that it was a large change so more data needed to be collected, which achieved credit.

(b) Few candidates recognised that there would be less mixing of water in areas with a low tidal range, which would keep the fresh water floating above the saltwater.

Question 6

(a) Most candidates correctly calculated the value of 120.

(b) Many candidates were able to undertake the calculations accurately, but some rounded too early, or to a greater degree than was appropriate, which then reduced the reliability of the manipulated data. Candidates should be encouraged to maintain working with the same number of significant figures as shown in the other examples. Some candidates also used the incorrect value of *N* in their calculations for Area **Y**, using 120 rather 109, which introduced an error.

(c) Candidates needed to consider all the data provided to recognise that it was inconclusive. While some candidates stated this, and were able to state the difference between the two indices of diversity were not great, few looked at the raw data again to help them see why that may be the case.

MARINE SCIENCE

Paper 9693/22

AS Level Data-handling and Investigative Skills

Key messages

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- Weaker candidates should be encouraged to further develop their understanding of scientific principles in practical work, in particular their understanding of the different types of variables.
- It is useful for candidates to undertake the core practical activities themselves, to help reinforce their learning in these aspects.

General comments

Candidates generally attempted all questions, and used suitable scientific language and terminology. Some candidates needed to fully understand some of the command words, such as justify or evaluate. These are higher level command words that require candidates to make use of knowledge and understanding from different aspects of the specification and make a judgement, using evidence. Continued practice of drawing specimens and evaluative feedback would also have enabled them to improve their drawings.

Comments on specific questions

Question 1

(a) Many candidates gave quite vague answers, such as pH drops or indicator paper. Stronger candidates used the correct term of universal indicator paper, but some candidates suggested litmus paper. However, litmus paper gives an indication of alkalinity or acidity rather the pH level.

(b) (i) Some candidates suggested that they were different methods, so calculating the mean would not be appropriate. A few stronger candidates recognised that the values were to a different degree of accuracy and so it would not be appropriate to calculate the mean of those.

(ii) Many candidates correctly identified water sample **K** as coming from near a hydrothermal vent. The most common error was to suggest water sample **J**.

(iii) Most often candidates stated that the water near hydrothermal vents was acidic, and that the only sample that was acidic was sample **K**. Weaker candidates stated that pH is lower around hydrothermal vents which was not sufficient for credit, or confused acidity and alkalinity and stated that **K** was the most alkaline environment.

(c) Stronger candidates were able to provide a logical pathway through the question, explaining that the high quantity of sunlight at the surface allowed for rapid photosynthesis, which releases oxygen, and at a hydrothermal vent there is no light and so no photosynthesis can occur. A few weaker candidates suggested the temperature of the surface water was warmer allowing more dissolved oxygen to dissolve. Other candidates mentioned the higher photosynthetic activity at the surface releasing oxygen or that it was due to the increased sunlight, but many did not mention the hydrothermal vents.

Question 2

(a) A few candidates attempted the drawing in pen, which did not allow for corrections to be made easily. Weaker candidates were often unsure of which features to include and so omitted some of the important features. Quite often, the outline was not quite correct with candidates drawing it egg shaped or lemon shaped with tips on the long axis of the diatom.

(b) (i) Many candidates found this challenging. Some candidates used an equals sign instead of a line with an arrowhead, which is used to represent a chemical reaction occurring, while weaker candidates often did not know the reactants or the products or got them confused or gave the reaction for respiration. A few candidates attempted a chemical symbol equation, but they rarely achieved credit as they made errors. Some stronger candidates who gave a correct response also included light and chlorophyll above and below the arrowhead.

(ii) For credit, candidates needed to mention both fatty acids and glycerol, and many forgot the glycerol. Further credit was available for stating that the elements carbon, hydrogen and oxygen were found in the molecules, However, weaker candidates often mentioned nitrogen or omitted one of the correct responses required. A small number of candidates stated the function of lipids instead of the chemical structure.

(iii) The most common response was to mention run-off from land bringing silicates into the ocean, with a few stronger candidates also stating that upwelling or decomposition would replenish silicates into the oceans.

(iv) Information was provided which candidates needed to consider when evaluating the sentence. Here, there was no scientific research to back up a belief, and so candidates needed to think of how the situations may be similar or different between land plants and diatoms. Candidates found this a challenging question, and those who answered well recognised both contained silica in their cells. Many candidates discussed photosynthesis taking place in both cells, so the energy requirements would be the same.

(v) Most candidates were able to make at least one valid suggestion, with many stating two correctly.

(c) (i) Many candidates correctly identified tuna or shark, with some weaker candidates stating herring or anchovy as they were in trophic level three, rather than a tertiary consumer.

(ii) Candidates were asked to construct a pyramid of energy for a food chain. Many candidates drew these well with clear detail. Some other candidates drew less carefully, however.

(iii) The calculation was correctly answered by many candidates. However, some did not show their working, or forgot to show that the answer to their division was then multiplied by 100 or forgot to round to the correct number of significant figures.

(iv) This question required candidates to explain why the energy efficiency differed between different transfers, and while some candidates stated what the difference was, they often did not then go on to explain why that difference occurred. Candidates needed to consider how the energy requirements of tuna and diatoms differed in order to allow a greater transfer from diatoms to fish larvae compared to tuna to shark.

(v) Many candidates were able to express that the width of the diatoms bar would decrease, with stronger candidates often also mentioning that the width of all the bars would decrease in time, as less energy would be fixed, and so less food produced by the diatoms.

Question 3

(a) More candidates were able to state plankton drifted with the currents than those who mentioned them usually being microscopic, but some stated they were a food source, were photosynthetic, or were producers, all of which were insufficient for credit.

(b) (i) Most candidates were able to suggest at least one, more often two, relevant pieces of equipment required for this investigation.

(ii) Some candidates stated the independent, the dependent and one standardised variable rather than three standardised variables. Some candidates gave the answer of "the light" without stating what it was about the light that needed to be standardised, such as the intensity or colour. A few candidates gave more than three answers. Candidates should be encouraged to list the number required. Most candidates were able to state at least one correct variable for standardisation.

(iii) Some stronger candidates answered this well, but others needed to expand their comments further, e.g. adding the zooplankton to a water column, but it is important this is done in the dark, or that the zooplankton are left in the dark to allow them to settle. Few candidates mentioned repeating the tests and finding a mean value. More candidates made statements regarding how to measure the speed.

(c) Many candidates were able to make some suitable suggestions for a table to record their results in, but some sketched a table rather than drawing one using a ruler. Some candidates did not include the units in their table headings.

Question 4

(a) (i) Candidates needed to consider the differences between bony and cartilaginous fish, and stating that one has cartilage and one has bones was not sufficient for credit.

(ii) Stating it was the sea floor, or immediately above the seabed allowed candidates to achieve credit. However, many gave a stated depth, e.g. 100 m, or one of the zones, such as the twilight zone, which were too vague for credit.

(b) The majority of candidates correctly identified fish **C** as Amblyraja radiata.

(c) Many candidates were able to identify at least one, and often two, adaptations that skate have to benthic life. The most common error was to state that the tail had a stinger for defence, as skate do not have this feature.

Question 5

(a) (i) Most candidates correctly drew a line graph of the data, and most selected suitable scales for each axis, but some did not fully label their axes, often forgetting to include the units. Some weaker candidates did not draw a line through the points, which was required to help to answer **(iv)**.

(ii) Many candidates scored at least partial credit here but did need to mention the depths the changes occurred at to achieve full credit.

(iii) Many candidates correctly identified the halocline, but a significant number stated thermocline.

(iv) Many candidates read the value from their graph accurately, but candidates who had not drawn a line between the points were not able gain credit.

(v) Candidates needed to recognise there was a large change in the salinity between 4m and 6m depth. However as there were only a few data points plotted, it is difficult to show exactly where the change in salinity occurred. Some candidates mentioned that it was a large change so more data needed to be collected, which achieved credit.

(b) Few candidates recognised that there would be less mixing of water in areas with a low tidal range, which would keep the fresh water floating above the saltwater.

Question 6

(a) Most candidates correctly calculated the value of 120.

(b) Many candidates were able to undertake the calculations accurately, but some rounded too early, or to a greater degree than was appropriate, which then reduced the reliability of the manipulated data. Candidates should be encouraged to maintain working with the same number of significant figures as shown in the other examples. Some candidates also used the incorrect value of *N* in their calculations for Area **Y**, using 120 rather 109, which introduced an error.

(c) Candidates needed to consider all the data provided to recognise that it was inconclusive. While some candidates stated this, and were able to state the difference between the two indices of diversity were not great, few looked at the raw data again to help them see why that may be the case.

MARINE SCIENCE

Paper 9693/23

AS Level Data-handling and Investigative Skills

Key messages

- Stronger candidates clearly had a good understanding of the whole breadth of the specification and could link ideas from different sections to produce clearly thought through responses.
- Candidates must ensure they have pencils, rulers and calculators when they sit the exam, to ensure their drawings and construction of tables, graphs and charts are clear.
- Weaker candidates should be encouraged to further develop their understanding of scientific principles in practical work, in particular their understanding of the different types of variables.
- It is useful for candidates to undertake the core practical activities themselves, to help reinforce their learning in these aspects.

General comments

Candidates generally attempted all questions, and used suitable scientific language and terminology. Some candidates needed to fully understand some of the command words, such as justify or evaluate. These are higher level command words that require candidates to make use of knowledge and understanding from different aspects of the specification and make a judgement, using evidence. Continued practice of drawing specimens and evaluative feedback would also have enabled them to improve their drawings.

Comments on specific questions

Question 1

(a) Many candidates gave quite vague answers, such as pH drops or indicator paper. Stronger candidates used the correct term of universal indicator paper, but some candidates suggested litmus paper. However, litmus paper gives an indication of alkalinity or acidity rather the pH level.

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(c) Stronger candidates were able to provide a logical pathway through the question, explaining that the high quantity of sunlight at the surface allowed for rapid photosynthesis, which releases oxygen, and at a hydrothermal vent there is no light and so no photosynthesis can occur. A few weaker candidates suggested the temperature of the surface water was warmer allowing more dissolved oxygen to dissolve. Other candidates mentioned the higher photosynthetic activity at the surface releasing oxygen or that it was due to the increased sunlight, but many did not mention the hydrothermal vents.

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(a) A few candidates attempted the drawing in pen, which did not allow for corrections to be made easily. Weaker candidates were often unsure of which features to include and so omitted some of the important features. Quite often, the outline was not quite correct with candidates drawing it egg shaped or lemon shaped with tips on the long axis of the diatom.

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(iii) The most common response was to mention run-off from land bringing silicates into the ocean, with a few stronger candidates also stating that upwelling or decomposition would replenish silicates into the oceans.

(iv) Information was provided which candidates needed to consider when evaluating the sentence. Here, there was no scientific research to back up a belief, and so candidates needed to think of how the situations may be similar or different between land plants and diatoms. Candidates found this a challenging question, and those who answered well recognised both contained silica in their cells. Many candidates discussed photosynthesis taking place in both cells, so the energy requirements would be the same.

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MARINE SCIENCE

Paper 9693/31
A Level Theory

Key messages

- Candidates should be advised to spend longer reading the information in the question before starting to write their answers.
- Candidates should avoid using vague terms such as, oil causes 'pollution' or that the temperature or pressure 'changes'.

General comments

There were some excellent scripts where candidates demonstrated a sound knowledge of the syllabus. Stronger candidates demonstrated excellent analytical skills when presented with unfamiliar material. This was particularly evident in **Question 2(b)** on methane gas seeps and **Question 4(b)** on depleting oxygen levels in the marine environment. **Question 5** on the artificial reefs and **Question 7** on invasive species were answered well. Questions on topics which were new to the 2022 syllabus, such as water potential in **Question 1**, drawing a molecule of water in **Question 4(a)** and classification in **Question 6(b)** were usually poorly answered and were often not attempted.

Comments on specific questions

Section A

Question 1

(a) (i) The majority of candidates selected the correct box in the table. However, many candidates only provided one tick per column, where two were required to receive credit. That diffusion and facilitated diffusion involved movement from a high concentration to a lower concentration was the most commonly given correct marking point.

(ii) Stronger candidates correctly stated that osmosis is a special case of diffusion as it only applies to water. Incorrect answers included that it involved movement from a low concentration to a high concentration or that it required energy.

(b) (i) Although most candidates drew the cell membrane away from the cell wall in the plant cell, few candidates realised that the double line for the wall remained in place. Weaker candidates drew their plant cell exactly the same as the plant cell in the figure and the animal cell bursting.

(ii) Most candidates labelled the cell membrane correctly. However, candidates needed to take care that the label line was ruled and touched the cell membrane with no arrowheads used. No extra labels should have been included.

(iii) Many answers did not refer to the term 'water potential' as required by the question. Those with correct diagrams for **(i)** often obtained full credit. However, there were often errors, including stating that both cells were plasmolysed or flaccid. These terms should not be used when referring to animal cells. Error carried forward marks were awarded if answers matched incorrect drawings for **(i)** and showed the animal cell bursting.

Question 2

(a) (i) Only stronger candidates gained full credit here. Common correct answers included naming hydrogen sulfide as an example of an inorganic chemical and naming glucose as the organic product. Few candidates stated that the inorganic chemicals were a source of energy used to fix carbon. The most common incorrect answer was to give sulfur as one of the inorganic chemicals used for chemosynthesis.

(ii) There was some confusion regarding this question as many candidates thought that Endoriftia and Riftia had a predator-prey relationship and that Riftia consumed Endoriftia. Answers were often not specific enough to gain credit e.g. “Endoriftia makes food for Riftia”.

(iii) Answers referring to the vent ratfish having a greater variety of prey were ignored as candidates needed to refer to energy efficiency and that energy was lost at each stage rather than the vent ratfish having more energy. Few references were made to trophic levels.

(b) (i) Many candidates misread the question and gave answers which did not refer to water quality. Examples included the effect of drilling noise on larvae or that noise caused migration. Many candidates referred to sediment and its effect on light for photosynthesis, but this could not be credited as it stated in the question that the ecosystems around oil seeps are “similar to those shown in Fig. 2.1”. The producers would therefore carry out chemosynthesis, not photosynthesis. Some answers were too vague e.g. saying that sediment or oil creates pollution instead of referring to oil releasing toxins that could poison marine organisms or that sediment could block the gills of fish.

(ii) Full or partial credit was often awarded for this question, usually for stating that more methane escapes, enters the atmosphere and that global temperatures increase. There were few references to the atmosphere trapping more heat. Answers which stated that this enhances the greenhouse effect were ignored as this information was stated in the question.

Question 3

(a) Euryhaline was correctly stated by many candidates. Incorrect answers included osmoregulators and stenohaline.

(b) (i) Only stronger candidates identified two correct features. Incorrect answers included spawning, growth, and multiple habitats.

(ii) Again, only stronger candidates named the free-floating larvae as the non-sessile stage. Common incorrect answers included spawning, maturity, growth, and adult mussels.

(c) Only stronger candidates answered this correctly. Candidates needed to read the question carefully to note that mussel beds are important feeding areas for wild birds. Incorrect examples included that the mussels would be protected, but candidates did not add what the mussels would be protected from. If cost was mentioned as a disadvantage, there was often no example included e.g. construction costs or running costs, so no credit could be awarded.

(d) Partial credit was often awarded but few candidates gained full credit. Some candidates misread the question and compared growing mussels in offshore areas or on the sea bed with those grown in a hatchery. Few references were made to the advantages and disadvantages of tides, e.g. that currents would provide food and oxygen and remove waste products but that mussels would be exposed at low tide so increasing the chance of desiccation. Answers such as “Greater chance of predation” were too vague as predation also occurs offshore and on the sea bed. Only a few candidates referred to more predation by birds when mussels are grown on wooden poles.

Question 4

(a) Although stronger candidates answered this correctly, other candidates did not give an answer. A common error was to share only two electrons instead of four.

(b) (i) Most candidates stated that the Earth’s atmosphere was getting warmer, and that oxygen is less soluble in warmer water. Stronger candidates referred to higher temperatures causing more evaporation so increasing salinity, or to higher temperatures inhibiting photosynthesis so that less

oxygen was produced. Some candidates misread the question and gave answers involving carbon dioxide instead of oxygen or referred to the ozone layer and CFCs.

(ii) Although partial credit was common, few candidates gained full credit as they did not refer to energy for muscle contraction or that energy was provided by respiration. Answers stating that jellyfish and sponges live at lower depths were ignored as this is not always the case.

Section B

Question 5

This topic was generally understood well, and candidates were able to provide a variety of advantages and disadvantages that covered all the points in the mark scheme. Stronger candidates organised the information in their answer by discussing the advantages first, followed by the disadvantages. Credit was often awarded for stating that the artificial reef provided a habitat for marine organisms, so increasing biodiversity. However, very few candidates referred to aquaculture and provided a suitable example, such as to filter feeders improving water quality or referenced the advantages of increased producers on the reef providing a source of food and oxygen for marine animals. For the disadvantages, cost by itself was ignored as this had to be linked to building materials. Many candidates referred to the materials used to form the artificial reef e.g. old ships but did not include the fact that these were often toxic due to the paint used or to remaining oil**.**

Question 6

(a) Candidates often misread the question and included details of ventilation during outflow as well as inflow. Answers were often vague and could not be credited, e.g. saying that the mouth opens, but without mention of the operculum closing. Other examples included that the volume of the buccal cavity or pressure changed. Some weaker candidates thought that grouper carried out ram ventilation.

(b) Only stronger candidates gained any credit for this question. Most incorrect answers were about differences in feeding, ventilation, and reproduction and were ignored. Only a few candidates correctly stated that both sharks and grouper are in the same phylum as they are chordates and that they are in a different class as sharks are cartilaginous fish, whereas grouper are bony fish. Other marking points were very rarely seen.

Question 7

Answers for this question were generally of a high standard, with the majority of candidates gaining at least partial credit, but full credit was rare. Most answers included the fact that the invasive species ate a wide variety of prey, had few predators and the effect this had on native species e.g. that there was less food availability or less habitat and that the presence of an invasive species usually decreased biodiversity. Other common answers included the economic effects on the local tourist or fishing industry, or that there was less food available for the local population. Few candidates provided a suitable named example of an invasive species, so answers quoting fish or algae were ignored. Some answers did not provide sufficient detail to be awarded credit e.g., saying that the invasive species was introduced, but without explanation as to how it was introduced, or that the invasive species competes with the native species rather than outcompetes the native species.

MARINE SCIENCE

Paper 9693/32
A Level Theory

Key messages

- Candidates should be advised to spend longer reading the information in the question before starting to write their answers.
- Candidates should avoid using vague terms such as, oil causes 'pollution' or that the temperature or pressure 'changes'.

General comments

There were some excellent scripts where candidates demonstrated a sound knowledge of the syllabus. Stronger candidates demonstrated excellent analytical skills when presented with unfamiliar material. This was particularly evident in **Question 2(b)** on methane gas seeps and **Question 4(b)** on depleting oxygen levels in the marine environment. **Question 5** on the artificial reefs and **Question 7** on invasive species were answered well. Questions on topics which were new to the 2022 syllabus, such as water potential in **Question 1**, drawing a molecule of water in **Question 4(a)** and classification in **Question 6(b)** were usually poorly answered and were often not attempted.

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(ii) Stronger candidates correctly stated that osmosis is a special case of diffusion as it only applies to water. Incorrect answers included that it involved movement from a low concentration to a high concentration or that it required energy.

(b) (i) Although most candidates drew the cell membrane away from the cell wall in the plant cell, few candidates realised that the double line for the wall remained in place. Weaker candidates drew their plant cell exactly the same as the plant cell in the figure and the animal cell bursting.

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(b) Only stronger candidates gained any credit for this question. Most incorrect answers were about differences in feeding, ventilation, and reproduction and were ignored. Only a few candidates correctly stated that both sharks and grouper are in the same phylum as they are chordates and that they are in a different class as sharks are cartilaginous fish, whereas grouper are bony fish. Other marking points were very rarely seen.

Question 7

Answers for this question were generally of a high standard, with the majority of candidates gaining at least partial credit, but full credit was rare. Most answers included the fact that the invasive species ate a wide variety of prey, had few predators and the effect this had on native species e.g. that there was less food availability or less habitat and that the presence of an invasive species usually decreased biodiversity. Other common answers included the economic effects on the local tourist or fishing industry, or that there was less food available for the local population. Few candidates provided a suitable named example of an invasive species, so answers quoting fish or algae were ignored. Some answers did not provide sufficient detail to be awarded credit e.g., saying that the invasive species was introduced, but without explanation as to how it was introduced, or that the invasive species competes with the native species rather than outcompetes the native species.

MARINE SCIENCE

Paper 9693/33
A Level Theory

Key messages

- Candidates should be advised to spend longer reading the information in the question before starting to write their answers.
- Candidates should avoid using vague terms such as, oil causes 'pollution' or that the temperature or pressure 'changes'.

General comments

There were some excellent scripts where candidates demonstrated a sound knowledge of the syllabus. Stronger candidates demonstrated excellent analytical skills when presented with unfamiliar material. This was particularly evident in **Question 2(b)** on methane gas seeps and **Question 4(b)** on depleting oxygen levels in the marine environment. **Question 5** on the artificial reefs and **Question 7** on invasive species were answered well. Questions on topics which were new to the 2022 syllabus, such as water potential in **Question 1**, drawing a molecule of water in **Question 4(a)** and classification in **Question 6(b)** were usually poorly answered and were often not attempted.

Comments on specific questions

Section A

Question 1

(a) (i) The majority of candidates selected the correct box in the table. However, many candidates only provided one tick per column, where two were required to receive credit. That diffusion and facilitated diffusion involved movement from a high concentration to a lower concentration was the most commonly given correct marking point.

(ii) Stronger candidates correctly stated that osmosis is a special case of diffusion as it only applies to water. Incorrect answers included that it involved movement from a low concentration to a high concentration or that it required energy.

(b) (i) Although most candidates drew the cell membrane away from the cell wall in the plant cell, few candidates realised that the double line for the wall remained in place. Weaker candidates drew their plant cell exactly the same as the plant cell in the figure and the animal cell bursting.

(ii) Most candidates labelled the cell membrane correctly. However, candidates needed to take care that the label line was ruled and touched the cell membrane with no arrowheads used. No extra labels should have been included.

(iii) Many answers did not refer to the term 'water potential' as required by the question. Those with correct diagrams for **(i)** often obtained full credit. However, there were often errors, including stating that both cells were plasmolysed or flaccid. These terms should not be used when referring to animal cells. Error carried forward marks were awarded if answers matched incorrect drawings for **(i)** and showed the animal cell bursting.

Question 2

(a) (i) Only stronger candidates gained full credit here. Common correct answers included naming hydrogen sulfide as an example of an inorganic chemical and naming glucose as the organic product. Few candidates stated that the inorganic chemicals were a source of energy used to fix carbon. The most common incorrect answer was to give sulfur as one of the inorganic chemicals used for chemosynthesis.

(ii) There was some confusion regarding this question as many candidates thought that Endoriftia and Riftia had a predator-prey relationship and that Riftia consumed Endoriftia. Answers were often not specific enough to gain credit e.g. “Endoriftia makes food for Riftia”.

(iii) Answers referring to the vent ratfish having a greater variety of prey were ignored as candidates needed to refer to energy efficiency and that energy was lost at each stage rather than the vent ratfish having more energy. Few references were made to trophic levels.

(b) (i) Many candidates misread the question and gave answers which did not refer to water quality. Examples included the effect of drilling noise on larvae or that noise caused migration. Many candidates referred to sediment and its effect on light for photosynthesis, but this could not be credited as it stated in the question that the ecosystems around oil seeps are “similar to those shown in Fig. 2.1”. The producers would therefore carry out chemosynthesis, not photosynthesis. Some answers were too vague e.g. saying that sediment or oil creates pollution instead of referring to oil releasing toxins that could poison marine organisms or that sediment could block the gills of fish.

(ii) Full or partial credit was often awarded for this question, usually for stating that more methane escapes, enters the atmosphere and that global temperatures increase. There were few references to the atmosphere trapping more heat. Answers which stated that this enhances the greenhouse effect were ignored as this information was stated in the question.

Question 3

(a) Euryhaline was correctly stated by many candidates. Incorrect answers included osmoregulators and stenohaline.

(b) (i) Only stronger candidates identified two correct features. Incorrect answers included spawning, growth, and multiple habitats.

(ii) Again, only stronger candidates named the free-floating larvae as the non-sessile stage. Common incorrect answers included spawning, maturity, growth, and adult mussels.

(c) Only stronger candidates answered this correctly. Candidates needed to read the question carefully to note that mussel beds are important feeding areas for wild birds. Incorrect examples included that the mussels would be protected, but candidates did not add what the mussels would be protected from. If cost was mentioned as a disadvantage, there was often no example included e.g. construction costs or running costs, so no credit could be awarded.

(d) Partial credit was often awarded but few candidates gained full credit. Some candidates misread the question and compared growing mussels in offshore areas or on the sea bed with those grown in a hatchery. Few references were made to the advantages and disadvantages of tides, e.g. that currents would provide food and oxygen and remove waste products but that mussels would be exposed at low tide so increasing the chance of desiccation. Answers such as “Greater chance of predation” were too vague as predation also occurs offshore and on the sea bed. Only a few candidates referred to more predation by birds when mussels are grown on wooden poles.

Question 4

(a) Although stronger candidates answered this correctly, other candidates did not give an answer. A common error was to share only two electrons instead of four.

(b) (i) Most candidates stated that the Earth’s atmosphere was getting warmer, and that oxygen is less soluble in warmer water. Stronger candidates referred to higher temperatures causing more evaporation so increasing salinity, or to higher temperatures inhibiting photosynthesis so that less

oxygen was produced. Some candidates misread the question and gave answers involving carbon dioxide instead of oxygen or referred to the ozone layer and CFCs.

(ii) Although partial credit was common, few candidates gained full credit as they did not refer to energy for muscle contraction or that energy was provided by respiration. Answers stating that jellyfish and sponges live at lower depths were ignored as this is not always the case.

Section B

Question 5

This topic was generally understood well, and candidates were able to provide a variety of advantages and disadvantages that covered all the points in the mark scheme. Stronger candidates organised the information in their answer by discussing the advantages first, followed by the disadvantages. Credit was often awarded for stating that the artificial reef provided a habitat for marine organisms, so increasing biodiversity. However, very few candidates referred to aquaculture and provided a suitable example, such as to filter feeders improving water quality or referenced the advantages of increased producers on the reef providing a source of food and oxygen for marine animals. For the disadvantages, cost by itself was ignored as this had to be linked to building materials. Many candidates referred to the materials used to form the artificial reef e.g. old ships but did not include the fact that these were often toxic due to the paint used or to remaining oil**.**

Question 6

(a) Candidates often misread the question and included details of ventilation during outflow as well as inflow. Answers were often vague and could not be credited, e.g. saying that the mouth opens, but without mention of the operculum closing. Other examples included that the volume of the buccal cavity or pressure changed. Some weaker candidates thought that grouper carried out ram ventilation.

(b) Only stronger candidates gained any credit for this question. Most incorrect answers were about differences in feeding, ventilation, and reproduction and were ignored. Only a few candidates correctly stated that both sharks and grouper are in the same phylum as they are chordates and that they are in a different class as sharks are cartilaginous fish, whereas grouper are bony fish. Other marking points were very rarely seen.

Question 7

Answers for this question were generally of a high standard, with the majority of candidates gaining at least partial credit, but full credit was rare. Most answers included the fact that the invasive species ate a wide variety of prey, had few predators and the effect this had on native species e.g. that there was less food availability or less habitat and that the presence of an invasive species usually decreased biodiversity. Other common answers included the economic effects on the local tourist or fishing industry, or that there was less food available for the local population. Few candidates provided a suitable named example of an invasive species, so answers quoting fish or algae were ignored. Some answers did not provide sufficient detail to be awarded credit e.g., saying that the invasive species was introduced, but without explanation as to how it was introduced, or that the invasive species competes with the native species rather than outcompetes the native species.

MARINE SCIENCE

Paper 9693/41

A Level Data-handling and investigative skills

Key messages

Centres should advise candidates to:

- use full, accurate scientific vocabulary
- understand the terms, 'independent variable' and 'dependent variable'
- understand how to use calculated values from statistical tests
- read the questions carefully, always taking the demands of the command word into account.

General comments

There were many high-quality responses, but a few candidates found the paper challenging. Candidates had prepared thoroughly for this examination, and it was clear that most centres have adapted well to the new syllabus. Compared with the old syllabus, the new syllabus also tests candidates understanding of practical work and experimental planning. Most candidates planned well controlled experiments and were able to give a relevant hypothesis, identify the key variables and gave appropriate experimental methods. A few candidates confused the terms 'independent variable' and 'dependent variable'.

It was evident that centres are enabling candidates to carry out practical work. Maths skills were generally very good, but some candidates struggled to interpret statistical tests. Factual recall questions were well answered, but a few candidates did not give technical terms in their answers. Candidates should always try to use appropriate, accurate terminology.

Paper 4 always has several data analysis questions which some candidates found challenging. When preparing for exams, candidates should be encouraged to practise the analysis of unfamiliar data and should make sure that they are familiar with command words. The command word, 'explain' will always require more than a description of data. The command word, 'discuss', requires candidates to explore all aspects of a set of data, both describing patterns and making interpretations.

Comments on specific questions

Question 1

(a) This was usually answered very well. Many candidates gave detailed descriptions of the light dependent stage, referring to the production of ATP and NADPH, the movement of electrons, and the absorption of light by chlorophyll. Typical errors included referring to NADH, not stating that chlorophyll absorbs the light energy, and giving vague statements about the roles of photosynthesis.

(b) (i) This question was answered well by many candidates with most recognising that light penetration of all wavelengths is lower in coastal water. Many candidates gained at least partial credit. The majority recognised that blue light penetrates most in open ocean water whilst green light penetrates most in coastal water. Most candidates gave similarities and differences when asked to compare. Many also gave a correct, manipulated, numerical comparison.

(ii) This question was answered well with most candidates gaining at least partial credit. Many recognised that the reduced penetration of light in coastal water would most likely be due to

turbidity or sediment but only stronger candidates went on to gain further credit by explaining this turbidity.

(c) (i) A significant number of candidates found this question challenging and some did not attempt it. The question required candidates to measure the distances moved by xanthophyll and the solvent on the chromatogram and to go on to use these measurements to calculate the R_f value. Most were able to give the calculated value to two significant figures. Although candidates may not be familiar with a given formula, they should try to have confidence and work through the question carefully.

(ii) This question required candidates to look at the penetration of different colours of light and relate this to the presence of xanthophyll. Many candidates gave excellent answers and recognised that red light would not penetrate into deeper water and so seaweed would only receive green and blue light. The strongest went on to explain that the presence of xanthophyll means that the seaweed would be able to use other wavelengths and then be able to photosynthesise more.

(d) There was an excellent standard of planning demonstrated by many candidates. Most were familiar with the core practical on measuring the rate of photosynthesis from seaweed and plants listed in the syllabus. Most were able to suggest several relevant control variables and many others went on to suggest methods for maintaining these variables. Some candidates confused independent and dependent variables. Many were able to correctly suggest appropriate statistical tests and graphs that would be plotted. Weaker candidates were not clear about what type of graph they would plot and what data they would use. It was not enough to simply say “I would plot a graph”.

Question 2

(a) This question asked candidates to draw four cells and label a nucleus and cell membrane. Most candidates were able to gain at least partial credit. Some candidates drew the cells separately and others used broken lines and/or shading of nuclei. No shading should be included on diagrams. Most were able to correctly label the nucleus, but a few mistook the cytoplasm for the cell membrane.

(b) (i) Most candidates were able to correctly label at least one of the molecules with many correctly naming both and gaining full credit. A few incorrectly named molecule **Y** as cholesterol.

(ii) This question was challenging for many candidates. A number incorrectly described the processes of diffusion and active transport. Stronger answers gained at least partial credit, typically for stating that the molecules in the membrane can move through it.

(c) (i) Most candidates gained at least partial credit with many going on to get full credit. Stronger candidates described the increase in rate of movement as the external concentration of sodium ions increased, and then correctly identified the turning point. Some candidates correctly stated that the rate increased but did not give the turning point required for the full credit.

(ii) This challenging question asked candidates to explain the effect of increasing sodium ions on the rate of diffusion shown in the graph. The very strongest candidates gained full credit, but many others gained partial credit. Stronger answers explained that the process occurring was facilitated diffusion due to the polar nature of sodium ions and that the levelling off was due to channel proteins becoming the limiting factor. Weaker candidates often confused diffusion with active transport and some candidates discussed osmosis and osmoregulation in fish.

Question 3

(a) (i) This question asked candidates to calculate the total mass of myoglobin in a shark with a mass of 125 kg. Most candidates were able to complete the calculation, but a number found selecting the correct unit of mass challenging.

(ii) This question was challenging for many candidates. The question asked candidates to draw a graph to compare two factors between the different species of fish. Stronger candidates drew a bar chart with two linear axes, labelled axes and a key for the bars. Common errors included not labelling axes, not leaving gaps between bars and not using linear scales. A number of candidates incorrectly drew scatter graphs of the data.

(b) (i) Many candidates were able to correctly write a balanced symbol equation for respiration but a significant number of candidates gave incorrect equations, did not balance the equation, or gave word equations.

(ii) This question asked candidates to look at the data and identify that fish swim for sustained periods, and that heavier fish tend to have a higher concentration of myoglobin in the muscles. Most candidates were able to gain at least partial credit, typically for spotting one of the patterns, but only the strongest went on to get full credit. The strongest answers correctly stated that the myoglobin would store more oxygen for respiration so that the heavier fish, and fish that swim for long periods could meet their energy demands.

Question 4

(a) This question asked candidates to explain why microplastics absorbed by plankton can pose a risk to humans. Most were able to gain at least partial credit and recognised the processes of bioaccumulation and biomagnification. Candidates clearly understood this area of the syllabus well.

(b) (i) (ii) Most candidates were able to calculate the total number of reefs with nets adjacent to them for **(i)** and went on to calculate the percentage of reefs adjacent to them that were damaged. A few candidates were unable to calculate a percentage. Candidates should be familiar with all the maths skills listed in the syllabus.

(iii) This question asked candidates to make an assessment about the threats posed by the different types of fishing gear. A few candidates ignored the data in the table and discussed the risks of how each method would physically damage organisms. If a question asks candidates to use data or information, candidates should make sure that they refer to the data in their answers. Stronger candidates recognised that nets posed the highest threat as they caused a higher percentage of damage and were the most common type of gear. These candidates used manipulated data to support their answers, such as referring to 32% of reefs being damaged.

(iv) Many candidates found this question challenging with only the strongest answering well. The question required candidates to look at the experiment and the data and suggest methods for improving it. Stronger candidates recognised that there was a lack of standardisation of the area of each reef damaged, the amount of gear on each reef, and factors such as reef temperatures were not listed. Other answers that gained credit included the need to compare the data with reef damage on reefs with no gear and look at areas other than Thailand.

(v) Most candidates were able to gain partial credit for stating that the gear can entrap animals or can be eaten by mistake.

Question 5

(a) (i) This question presented candidates with data about bonefish catches in different years, before and after a ban on gill nets. Candidates were asked to outline the trends in catch. Most were able to gain partial credit for describing the fall and rise. Many also went on to gain further credit for correctly giving details such as the fall in 2010.

(ii) Most candidates were able to suggest one method of maintaining sustainable fishing. Common, correct answers included fishing quotas, setting up reserves, restrictions on seasons, and restrictions on fishing areas.

(b) (i) Many candidates found this question that asked for a null hypothesis challenging. A significant number gave a hypothesis rather than a null hypothesis.

(ii) (iii) A few candidates did not seem to understand how to complete the statistical test. Many candidates were able to correctly complete the table and then went on to use their results to calculate the chi-squared value. Candidates should be familiar with all the tests listed in the specification.

(iv) This question asked candidates to use a chi-squared table to interpret their calculated value of chi-squared. The strongest candidates correctly identified the critical value and then explained what a calculated value of less than the critical value meant. Candidates should always explain whether the null hypothesis is rejected and the reasons for this.

(c) Most candidates were able to gain at least partial credit for this question. Stronger candidates explained that the ban on gill nets had led to more fish growing to larger sizes, reaching reproductive maturity, and thus increasing the population. Some candidates did not recognise that the increased catches were due to increased populations and suggested that the fishers were overfishing since the ban.

MARINE SCIENCE

Paper 9693/42

A Level Data-handling and investigative skills

Key messages

Centres should advise candidates to:

- use full, accurate scientific vocabulary
- understand the terms, 'independent variable' and 'dependent variable'
- understand how to use calculated values from statistical tests
- read the questions carefully, always taking the demands of the command word into account.

General comments

There were many high-quality responses, but a few candidates found the paper challenging. Candidates had prepared thoroughly for this examination, and it was clear that most centres have adapted well to the new syllabus. Compared with the old syllabus, the new syllabus also tests candidates understanding of practical work and experimental planning. Most candidates planned well controlled experiments and were able to give a relevant hypothesis, identify the key variables and gave appropriate experimental methods. A few candidates confused the terms 'independent variable' and 'dependent variable'.

It was evident that centres are enabling candidates to carry out practical work. Maths skills were generally very good, but some candidates struggled to interpret statistical tests. Factual recall questions were well answered, but a few candidates did not give technical terms in their answers. Candidates should always try to use appropriate, accurate terminology.

Paper 4 always has several data analysis questions which some candidates found challenging. When preparing for exams, candidates should be encouraged to practise the analysis of unfamiliar data and should make sure that they are familiar with command words. The command word, 'explain' will always require more than a description of data. The command word, 'discuss', requires candidates to explore all aspects of a set of data, both describing patterns and making interpretations.

Comments on specific questions

Question 1

(a) This was usually answered very well. Many candidates gave detailed descriptions of the light dependent stage, referring to the production of ATP and NADPH, the movement of electrons, and the absorption of light by chlorophyll. Typical errors included referring to NADH, not stating that chlorophyll absorbs the light energy, and giving vague statements about the roles of photosynthesis.

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turbidity or sediment but only stronger candidates went on to gain further credit by explaining this turbidity.

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(d) There was an excellent standard of planning demonstrated by many candidates. Most were familiar with the core practical on measuring the rate of photosynthesis from seaweed and plants listed in the syllabus. Most were able to suggest several relevant control variables and many others went on to suggest methods for maintaining these variables. Some candidates confused independent and dependent variables. Many were able to correctly suggest appropriate statistical tests and graphs that would be plotted. Weaker candidates were not clear about what type of graph they would plot and what data they would use. It was not enough to simply say “I would plot a graph”.

Question 2

(a) This question asked candidates to draw four cells and label a nucleus and cell membrane. Most candidates were able to gain at least partial credit. Some candidates drew the cells separately and others used broken lines and/or shading of nuclei. No shading should be included on diagrams. Most were able to correctly label the nucleus, but a few mistook the cytoplasm for the cell membrane.

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(c) (i) Most candidates gained at least partial credit with many going on to get full credit. Stronger candidates described the increase in rate of movement as the external concentration of sodium ions increased, and then correctly identified the turning point. Some candidates correctly stated that the rate increased but did not give the turning point required for the full credit.

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MARINE SCIENCE

Paper 9693/43

A Level Data-handling and investigative skills

Key messages

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(ii) This challenging question asked candidates to explain the effect of increasing sodium ions on the rate of diffusion shown in the graph. The very strongest candidates gained full credit, but many others gained partial credit. Stronger answers explained that the process occurring was facilitated diffusion due to the polar nature of sodium ions and that the levelling off was due to channel proteins becoming the limiting factor. Weaker candidates often confused diffusion with active transport and some candidates discussed osmosis and osmoregulation in fish.

Question 3

(a) (i) This question asked candidates to calculate the total mass of myoglobin in a shark with a mass of 125 kg. Most candidates were able to complete the calculation, but a number found selecting the correct unit of mass challenging.

(ii) This question was challenging for many candidates. The question asked candidates to draw a graph to compare two factors between the different species of fish. Stronger candidates drew a bar chart with two linear axes, labelled axes and a key for the bars. Common errors included not labelling axes, not leaving gaps between bars and not using linear scales. A number of candidates incorrectly drew scatter graphs of the data.

(b) (i) Many candidates were able to correctly write a balanced symbol equation for respiration but a significant number of candidates gave incorrect equations, did not balance the equation, or gave word equations.

(ii) This question asked candidates to look at the data and identify that fish swim for sustained periods, and that heavier fish tend to have a higher concentration of myoglobin in the muscles. Most candidates were able to gain at least partial credit, typically for spotting one of the patterns, but only the strongest went on to get full credit. The strongest answers correctly stated that the myoglobin would store more oxygen for respiration so that the heavier fish, and fish that swim for long periods could meet their energy demands.

Question 4

(a) This question asked candidates to explain why microplastics absorbed by plankton can pose a risk to humans. Most were able to gain at least partial credit and recognised the processes of bioaccumulation and biomagnification. Candidates clearly understood this area of the syllabus well.

(b) (i) (ii) Most candidates were able to calculate the total number of reefs with nets adjacent to them for **(i)** and went on to calculate the percentage of reefs adjacent to them that were damaged. A few candidates were unable to calculate a percentage. Candidates should be familiar with all the maths skills listed in the syllabus.

(iii) This question asked candidates to make an assessment about the threats posed by the different types of fishing gear. A few candidates ignored the data in the table and discussed the risks of how each method would physically damage organisms. If a question asks candidates to use data or information, candidates should make sure that they refer to the data in their answers. Stronger candidates recognised that nets posed the highest threat as they caused a higher percentage of damage and were the most common type of gear. These candidates used manipulated data to support their answers, such as referring to 32% of reefs being damaged.

(iv) Many candidates found this question challenging with only the strongest answering well. The question required candidates to look at the experiment and the data and suggest methods for improving it. Stronger candidates recognised that there was a lack of standardisation of the area of each reef damaged, the amount of gear on each reef, and factors such as reef temperatures were not listed. Other answers that gained credit included the need to compare the data with reef damage on reefs with no gear and look at areas other than Thailand.

(v) Most candidates were able to gain partial credit for stating that the gear can entrap animals or can be eaten by mistake.

Question 5

(a) (i) This question presented candidates with data about bonefish catches in different years, before and after a ban on gill nets. Candidates were asked to outline the trends in catch. Most were able to gain partial credit for describing the fall and rise. Many also went on to gain further credit for correctly giving details such as the fall in 2010.

(ii) Most candidates were able to suggest one method of maintaining sustainable fishing. Common, correct answers included fishing quotas, setting up reserves, restrictions on seasons, and restrictions on fishing areas.

(b) (i) Many candidates found this question that asked for a null hypothesis challenging. A significant number gave a hypothesis rather than a null hypothesis.

(ii) (iii) A few candidates did not seem to understand how to complete the statistical test. Many candidates were able to correctly complete the table and then went on to use their results to calculate the chi-squared value. Candidates should be familiar with all the tests listed in the specification.

(iv) This question asked candidates to use a chi-squared table to interpret their calculated value of chi-squared. The strongest candidates correctly identified the critical value and then explained what a calculated value of less than the critical value meant. Candidates should always explain whether the null hypothesis is rejected and the reasons for this.

(c) Most candidates were able to gain at least partial credit for this question. Stronger candidates explained that the ban on gill nets had led to more fish growing to larger sizes, reaching reproductive maturity, and thus increasing the population. Some candidates did not recognise that the increased catches were due to increased populations and suggested that the fishers were overfishing since the ban.