MARINE SCIENCE

Paper 9693/11
AS Level Theory

Key messages

Candidates who knew the syllabus well, read the questions carefully, took care over their use of technical language and elaborated on the longer answer questions, were able to perform well.

If a final numerical answer is incorrect, partial credit may sometimes be awarded for a clearly presented supporting calculation. No credit may be awarded for an incorrect final answer without supporting working, so candidates should be encouraged to show their working clearly. Units should be stated when asked for.

In the graphical work, candidates should be able to read off any points to the nearest half a small square.

General comments

In this series, a high proportion of the weaker candidates had significant gaps in their knowledge of large parts of the syllabus. Candidates should be encouraged to use the syllabus during revision to ensure that their revision is comprehensive.

Mathematical skills were a particular weakness. The expected standard is indicated in the syllabus (page 40 to 42). Candidates would benefit from more practice in extracting data from graphs to use in calculations.

Many candidates demonstrated a lack of understanding of the basic chemistry knowledge that is relevant to marine science. For example, terms such as atom, electron and molecule were not used correctly. Solubility and salinity were incorrectly used interchangeably and questions relating to density and the chemistry of water were often poorly answered.

In ***Section B*** of the paper, candidates are expected to show greater depth and breadth in their responses. Many candidates could improve their answers by giving more detail. Candidates should be encouraged to check the number of marks available for each question and use this to guide their answer. For example, generally, an item worth 5 marks would require 5 relevant points.

Comments on specific questions

Section A

Question 1

(a) (i) Stronger candidates, who knew all 6 answers, often had notes at the side of Table 1.1 showing the use of a mnemonic to remember the order of names of classification groups. This clearly helped these candidates apply their knowledge to complete the table. Weaker candidates correctly identified ‘domain’ and ‘lybia’ only.

(ii) Exoskeleton was the most common correct response. Weaker candidates listed other features that would apply to many animals and were not specific to adult crustaceans. These did not gain credit.

(iii) Many candidates could not identify the type of symbiosis between the boxer crab and anemones. This is an example stated in the syllabus, therefore candidates are expected to be able to recall this knowledge.

(iv) More candidates could describe the anemone's benefit from the relationship. Only the strongest candidates referred to the stinging cells or nematocysts protecting the crab.

(b) Only the strongest candidates could recall the types of symbiosis shown by the relationships in Table 1.2.

Question 2

(a) (i) Many candidates could not interpret the graph to identify the day on which a neap tide occurs. The most frequent incorrect answer was day 4, suggesting candidates have confused the terms spring tide and neap tide.

(ii) Candidates often read values from the graph incorrectly and many did not state the unit.

(iii) The strongest candidates were able use their understanding of the term 'mean height of the tide' and the graph to answer this question.

(b) Many answers did not contain sufficient detail or repeated the question. For example, 'the alignment of the Sun, Moon and Earth causes a neap tide'. The alignment could be drawn on a labelled diagram. Some responses incorrectly indicated that only the gravitational pull caused by the Moon affects the tides or that the distance of the Moon from the Earth is the cause of neap tides. Misconceptions regarding tides and waves were seen. Some candidates incorrectly referred to air pressure or magnetic force in their response.

(c) Most candidates could tick the correct boxes relating to the effect of onshore wind and high air pressure on tide height.

(d) (i) Only the strongest candidates could define the exact locations of the top and bottom of the littoral zone. This is stated in the syllabus.

(ii) Many candidates answered this question well. The weakest candidates gave incorrect answers such as rocky shore (which was given in the question) or deep zones of the ocean.

Question 3

(a) The most common correctly labelled part of the kelp was holdfast. Many candidates assumed parts of macroalgae/kelp are identical to plants, so leaves, stem and roots were frequently seen incorrect answers.

(b) Many candidates could identify two uses of kelp for humans. Uses of food or medicine were most commonly seen.

(c) Few candidates took correct readings from the graph. Only the strongest candidates could calculate the percentage increase.

(d) This question was generally well answered. The most common responses referred to lower food availability for consumers or lower biodiversity. Occasionally the misconception that overharvesting means there is more kelp present was seen.

Question 4

(a) Few candidates could identify the deepest zone of the ocean.

(b) Few candidates could identify the described layer as the thermocline.

(c) Many answers did not contain sufficient detail. To answer the question, candidates could either explain the sinking of water due to temperature or salinity. Answers had to be linked to the specific density change, such as 'colder therefore more dense'. Answers such as, 'colder and sinks due to change in density' were insufficient to gain credit.

(d) There were many ways to gain full credit for a description of what causes sea water to mix. The strongest candidates commonly referred to wind and waves in their answer. Descriptions from weaker candidates indicated lack of syllabus knowledge.

(e) Many candidates could explain why sea water is not solid at location D. Some candidates incorrectly stated that salt in sea water increases the freezing point of water.

Section B

Question 5

(a) Flooding was the most known effect of El Niño on human communities along the Eastern Pacific coastline of South America. Stronger candidates could elaborate on the effects of flooding. Weaker candidates gave responses relating to warmer waters resulting in higher fish catch.

(b) Some candidates could describe some aspect of abiotic factors during an El Niño event. Many answers did not contain sufficient detail such as 'the abiotic factors like temperature are different'. Some candidates compared the converse abiotic factors in a La Niña event which was acceptable.

Question 6

(a) Candidates found this higher demand question very challenging. Many described Fig 6.1 without answering the question. Only the strongest candidates were able to achieve full credit because they were able to articulate the limitations which was more challenging than outlining only the strengths. Candidates would benefit from more practice evaluating scientific models.

(b) Many answers illustrated a weak understanding of particle theory and the bonding in water. For example, the terms atoms, molecules and bonds were often used incorrectly. A minority of candidates did extremely well in this question. Good answers illustrated a strong understanding of the differences between bonding within a molecule and between molecules using correct terminology.

(c) Many candidates were confused between the terms electron, proton and neutron and could not describe any aspect of the atomic structure of carbon. Candidates would benefit from more practice reviewing models of atoms to identify the electron, proton and neutron.

MARINE SCIENCE

Paper 9693/12
AS Level Theory

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MARINE SCIENCE

Paper 9693/13
AS Level Theory

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MARINE SCIENCE

Paper 9693/21

AS Level Data-Handling and Investigative Skills

Key messages

Many candidates have developed their understanding of key aspects of marine science, with stronger candidates making links across different aspects of the syllabus to produce comprehensive answers. Some candidates need to understand the different types of variables and develop more confidence in the use of the different statistical methods and interpretation of these. Many candidates need to develop a greater understanding of how random sampling is carried out. The quality of drawings was good. Candidates should ensure they complete graphs using a sharp pencil. Weaker candidates could benefit from understanding how to draw an effective results table to collect the data asked for.

General comments

Most candidates answered all questions and appeared to have managed their time well to complete the paper. Candidates generally had a good understanding of how to approach questions, although candidates were weak on answering a comparison type question. Candidates need to take a little more time to consider all the information provided in a question to help them answer it.

Comments on specific questions

Question 1

(a) Weaker candidates found it difficult to express themselves clearly when describing an ecosystem. A few candidates mentioned non-living organisms, rather than non-living factors and some candidates needed to mention the interaction between the biotic and abiotic factors.

(b) (i) Many candidates answered correctly. The most common error being ‘Indonesia’ as the bar for protected was taller.

(b) (ii) Candidates were required to read two values with some degree of accuracy from the graphs, then calculate the percentage from the two values. Weaker candidates needed to read to the required degree of accuracy and recognise that the values were slightly less than 5000 and slightly more than 7000. Many candidates who did not read to this level of accuracy were able to undertake the correct calculation using the inaccurate values.

(b) (iii) Many correct answers were seen. Some candidates stated ‘harvesting’, however sustainable harvesting can be achieved for mangrove forests, so it needed to be the idea of over-harvesting. Incorrect answers by weaker candidates included ‘high salinity’, ‘high pH’ or mentioning tide levels.

(c) (i) Many candidates were unable to give the correct word equation for photosynthesis. A few candidates gave mixed word and symbol equations, some candidates used ‘carbon’ rather than ‘carbon dioxide’ and some included ‘sunlight’ as a reactant rather than above the arrow line. Many candidates also used ‘=’ in the middle of the equation rather than an arrow.

(ii) Some candidates suggested ‘amount of oxygen’ as the dependent variable, which is not sufficient at this level of qualification. Candidates should be discouraged from using the word ‘amount’. Others suggested ‘volume of oxygen’, but no oxygen was collected from the system, or ‘rate of photosynthesis’, which was not measured.

(iii) Many correct answers were seen. Weaker candidates often gave one correct variable, usually 'temperature', and then stated 'same macroalgae species' or 'light intensity' as the second variable, which suggests a lack of understanding of the different types of variables.

(iv) Some candidates did correctly suggest lowering the device into the tank to a greater depth or providing a light source at different distances. Some candidates just stated 'light' or 'light intensity was changed', without explaining how it could be changed.

(v) Stronger candidates correctly stated the reason was to 'remove oxygen' or 'increase carbon dioxide before the data was collected'. Weaker candidates simply stated 'to get more nutrients' which was insufficient for credit. These candidates needed to consider which nutrients may be required for photosynthesis to occur.

(vi) Most candidates gained credit for adding units, correctly labelling the *x*-axis, and identifying the different lines. Some used an inappropriate scale for the *y*-axis making it difficult for them to plot points accurately. A small number of the weakest candidates needed to use a linear scale. More candidates are plotting points appropriately, using either an x or a ⊙.

(vii) Many candidates achieved credit for recognising that species B would be closer to the surface than species A. Only the strongest candidates explained this observation by considering the data further. Most of these either stated that 'species A was found at a greater range of depths' or that 'they were both relatively close to the surface to gain a high light intensity for photosynthesis'.

(viii) While candidates often noted that with no light intensity there would be no photosynthesis, very few considered the fact the oxygen concentration dropped because oxygen was being used in respiration.

Question 2

(a) (i) Few candidates could explain how to collect data using random sampling, often stating 'randomly select ten areas' without explaining how that is achieved, while some just wrote 'throw a quadrat'. Candidates need to develop a greater understanding of how true random sampling is achieved using a grid and random number generators.

(ii) Whilst some candidates knew that random sampling reduced bias or gave an equal chance of selection, fewer could give a disadvantage. A small number of candidates did suggest it may not be fully representative of the entire area.

(b) Candidates need to understand that when statistical tests are used, a null hypothesis may be required. Therefore, candidates need to know what a null hypothesis is. Many wrote a prediction instead.

(c) Few candidates understood that when ranking data containing two values that are the same, both should be given the same rank.

(d) Some candidates translated ∑ as a value, often the total number of crabs from the table, even though its meaning was given under the formula for Spearman's rank. A common error was not recognising the value of n was 10, or candidates multiplying 10 by 3 rather than cubing 10 to obtain a value of 1000. A few candidates who completed the calculation correctly, forgot to round to 2 significant figures or gave 3 significant figures.

(e) Few candidates identified that as the value was close to 1, it showed a strong positive correlation between the values. Weaker candidates made statements such as 'the more algae, the more crabs' which is a very basic statement and not consistently correct. Statements such as these needed to reflect the statistical test carried out.

Question 3

(a) Candidates often achieved credit for the size of the drawing, making a neat diagram without shading and using single lines for the outline. Some candidates struggled with the proportions and drew in pen rather than pencil.

(b) Many candidates were not fully aware of the anatomy of fish. Those candidates who were, drew lines freehand and either used an arrowhead or circle at the end of the line to indicate where it was going to. Candidates should draw a straight line with a ruler to touch the feature asked for and write the name at the end of the line.

(c) (i) Many candidates demonstrated an understanding that the red snapper population could be tagged, although their answers often lacked detail on how to do this. Candidates needed to note the number caught first time or differentiate between the number with and without tags in the second sample, or mention applying the Lincoln index. Some candidates did write out the formula for the Lincoln index and a few mentioned using tags that did not affect the fish.

(ii) A basic table of month and population of red snapper was sufficient for credit. Others correctly drew a table for collecting all the data. A few weaker candidates attempted to sketch a graph rather than give a results table.

(iii) The most common error was to name one or two abiotic factors, often current or temperature, rather than biotic factors.

(d) (i) Many candidates recognised that there was an increase in number of 2 or 3 species but needed to improve their answer by giving more detail. Some noted that species U had decreased and mentioned that there was only one fish of species U in the non-reef area, so may have been an anomaly. Stronger candidates often noted that the numbers were not much different. Some of these candidates went on to suggest that as there were now only 2 or 3 dominant species on the reef, the statement was not fully supported. A small number of candidates noted that there were only 5 fish species looked at and suggested there would have been more changes in non-fish species, such as invertebrates or other named groups such as turtles.

(ii) Most candidates correctly stated that wave energy would reduce, which would reduce coastal erosion. A few candidates suggested negative impacts on the shore, often incorrectly stating ‘more erosion’ or ‘fewer fish in the area’.

Question 4

(a) Many common correct answers included the idea that the water from the river would contain high levels of particulate matter which would block sunlight and could cause abrasion to the coral polyps. Some candidates gave suggestions of salinity or temperature change. These candidates needed to explain why that meant scientists did not expect to see coral reefs growing there.

(b) (i) Many weaker candidates wrote the units for temperature as only ‘C’, only ‘°’, or as ‘C°’ rather than °C.

(ii) Few candidates answered this well, with some stating that ‘salinity increases with depth’, which is not what the graph showed at location A. Candidates needed to recognise there was a large increase in salinity in the first few metres, then a relatively stable salinity for the rest of the water column. Some candidates gained credit for stating the salinity over 10 m depth was around 35 or 36 ppt. Very few of these candidates went on to explain this observation or consider the information given in Fig. 4.2.

(iii) This question required candidates to make a comparison of dissolved oxygen levels between the two graphs and explain the differences. Many candidates just described the dissolved oxygen in one of the graphs. When asked to compare, candidates need to look for similarities and differences and comment on these. In this question an attempt to explain the differences was required. Very few candidates recognised that location A was in the middle of the freshwater river cover, so the water would hold more oxygen.

(iv) Some candidates recognised that due to the flow rate of the river, the sediments had not slowed down sufficiently to settle. Few recognised that the sediment would unlikely cross the river due to the halocline.

(c) (i) Many candidates could explain the term mutualism but found it harder to explain symbiosis. Many needed to state that these are long term relationships or relationships between organisms living in very close proximity to each other. Many just stated ‘organisms interacting together’, which would include predator-prey relationships, or listed the different types of symbiotic relationships.

(ii) Weaker candidates were not aware that zooxanthellae lived within the coral polyps and required sunlight for photosynthesis.

(iii) The most common correct answers mentioned the stinging cells or nematocysts. Many candidates mentioned that polyps feed on dissolved minerals or nutrients rather than the use of stinging cells or nematocysts to capture prey items and bring them into their body for digestion. Candidates should be familiar with both types of nutrition as they are expected to know the functional anatomy of a coral polyp.

MARINE SCIENCE

Paper 9693/22

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(viii) While candidates often noted that with no light intensity there would be no photosynthesis, very few considered the fact the oxygen concentration dropped because oxygen was being used in respiration.

Question 2

(a) (i) Few candidates could explain how to collect data using random sampling, often stating 'randomly select ten areas' without explaining how that is achieved, while some just wrote 'throw a quadrat'. Candidates need to develop a greater understanding of how true random sampling is achieved using a grid and random number generators.

(ii) Whilst some candidates knew that random sampling reduced bias or gave an equal chance of selection, fewer could give a disadvantage. A small number of candidates did suggest it may not be fully representative of the entire area.

(b) Candidates need to understand that when statistical tests are used, a null hypothesis may be required. Therefore, candidates need to know what a null hypothesis is. Many wrote a prediction instead.

(c) Few candidates understood that when ranking data containing two values that are the same, both should be given the same rank.

(d) Some candidates translated ∑ as a value, often the total number of crabs from the table, even though its meaning was given under the formula for Spearman's rank. A common error was not recognising the value of n was 10, or candidates multiplying 10 by 3 rather than cubing 10 to obtain a value of 1000. A few candidates who completed the calculation correctly, forgot to round to 2 significant figures or gave 3 significant figures.

(e) Few candidates identified that as the value was close to 1, it showed a strong positive correlation between the values. Weaker candidates made statements such as 'the more algae, the more crabs' which is a very basic statement and not consistently correct. Statements such as these needed to reflect the statistical test carried out.

Question 3

(a) Candidates often achieved credit for the size of the drawing, making a neat diagram without shading and using single lines for the outline. Some candidates struggled with the proportions and drew in pen rather than pencil.

(b) Many candidates were not fully aware of the anatomy of fish. Those candidates who were, drew lines freehand and either used an arrowhead or circle at the end of the line to indicate where it was going to. Candidates should draw a straight line with a ruler to touch the feature asked for and write the name at the end of the line.

(c) (i) Many candidates demonstrated an understanding that the red snapper population could be tagged, although their answers often lacked detail on how to do this. Candidates needed to note the number caught first time or differentiate between the number with and without tags in the second sample, or mention applying the Lincoln index. Some candidates did write out the formula for the Lincoln index and a few mentioned using tags that did not affect the fish.

(ii) A basic table of month and population of red snapper was sufficient for credit. Others correctly drew a table for collecting all the data. A few weaker candidates attempted to sketch a graph rather than give a results table.

(iii) The most common error was to name one or two abiotic factors, often current or temperature, rather than biotic factors.

(d) (i) Many candidates recognised that there was an increase in number of 2 or 3 species but needed to improve their answer by giving more detail. Some noted that species U had decreased and mentioned that there was only one fish of species U in the non-reef area, so may have been an anomaly. Stronger candidates often noted that the numbers were not much different. Some of these candidates went on to suggest that as there were now only 2 or 3 dominant species on the reef, the statement was not fully supported. A small number of candidates noted that there were only 5 fish species looked at and suggested there would have been more changes in non-fish species, such as invertebrates or other named groups such as turtles.

(ii) Most candidates correctly stated that wave energy would reduce, which would reduce coastal erosion. A few candidates suggested negative impacts on the shore, often incorrectly stating ‘more erosion’ or ‘fewer fish in the area’.

Question 4

(a) Many common correct answers included the idea that the water from the river would contain high levels of particulate matter which would block sunlight and could cause abrasion to the coral polyps. Some candidates gave suggestions of salinity or temperature change. These candidates needed to explain why that meant scientists did not expect to see coral reefs growing there.

(b) (i) Many weaker candidates wrote the units for temperature as only ‘C’, only ‘°’, or as ‘C°’ rather than °C.

(ii) Few candidates answered this well, with some stating that ‘salinity increases with depth’, which is not what the graph showed at location A. Candidates needed to recognise there was a large increase in salinity in the first few metres, then a relatively stable salinity for the rest of the water column. Some candidates gained credit for stating the salinity over 10 m depth was around 35 or 36 ppt. Very few of these candidates went on to explain this observation or consider the information given in Fig. 4.2.

(iii) This question required candidates to make a comparison of dissolved oxygen levels between the two graphs and explain the differences. Many candidates just described the dissolved oxygen in one of the graphs. When asked to compare, candidates need to look for similarities and differences and comment on these. In this question an attempt to explain the differences was required. Very few candidates recognised that location A was in the middle of the freshwater river cover, so the water would hold more oxygen.

(iv) Some candidates recognised that due to the flow rate of the river, the sediments had not slowed down sufficiently to settle. Few recognised that the sediment would unlikely cross the river due to the halocline.

(c) (i) Many candidates could explain the term mutualism but found it harder to explain symbiosis. Many needed to state that these are long term relationships or relationships between organisms living in very close proximity to each other. Many just stated ‘organisms interacting together’, which would include predator-prey relationships, or listed the different types of symbiotic relationships.

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(iii) The most common correct answers mentioned the stinging cells or nematocysts. Many candidates mentioned that polyps feed on dissolved minerals or nutrients rather than the use of stinging cells or nematocysts to capture prey items and bring them into their body for digestion. Candidates should be familiar with both types of nutrition as they are expected to know the functional anatomy of a coral polyp.

MARINE SCIENCE

Paper 9693/23

AS Level Data-Handling and Investigative Skills

Key messages

Many candidates have developed their understanding of key aspects of marine science, with stronger candidates making links across different aspects of the syllabus to produce comprehensive answers. Some candidates need to understand the different types of variables and develop more confidence in the use of the different statistical methods and interpretation of these. Many candidates need to develop a greater understanding of how random sampling is carried out. The quality of drawings was good. Candidates should ensure they complete graphs using a sharp pencil. Weaker candidates could benefit from understanding how to draw an effective results table to collect the data asked for.

General comments

Most candidates answered all questions and appeared to have managed their time well to complete the paper. Candidates generally had a good understanding of how to approach questions, although candidates were weak on answering a comparison type question. Candidates need to take a little more time to consider all the information provided in a question to help them answer it.

Comments on specific questions

Question 1

(a) Weaker candidates found it difficult to express themselves clearly when describing an ecosystem. A few candidates mentioned non-living organisms, rather than non-living factors and some candidates needed to mention the interaction between the biotic and abiotic factors.

(b) (i) Many candidates answered correctly. The most common error being ‘Indonesia’ as the bar for protected was taller.

(b) (ii) Candidates were required to read two values with some degree of accuracy from the graphs, then calculate the percentage from the two values. Weaker candidates needed to read to the required degree of accuracy and recognise that the values were slightly less than 5000 and slightly more than 7000. Many candidates who did not read to this level of accuracy were able to undertake the correct calculation using the inaccurate values.

(b) (iii) Many correct answers were seen. Some candidates stated ‘harvesting’, however sustainable harvesting can be achieved for mangrove forests, so it needed to be the idea of over-harvesting. Incorrect answers by weaker candidates included ‘high salinity’, ‘high pH’ or mentioning tide levels.

(c) (i) Many candidates were unable to give the correct word equation for photosynthesis. A few candidates gave mixed word and symbol equations, some candidates used ‘carbon’ rather than ‘carbon dioxide’ and some included ‘sunlight’ as a reactant rather than above the arrow line. Many candidates also used ‘=’ in the middle of the equation rather than an arrow.

(ii) Some candidates suggested ‘amount of oxygen’ as the dependent variable, which is not sufficient at this level of qualification. Candidates should be discouraged from using the word ‘amount’. Others suggested ‘volume of oxygen’, but no oxygen was collected from the system, or ‘rate of photosynthesis’, which was not measured.

(iii) Many correct answers were seen. Weaker candidates often gave one correct variable, usually 'temperature', and then stated 'same macroalgae species' or 'light intensity' as the second variable, which suggests a lack of understanding of the different types of variables.

(iv) Some candidates did correctly suggest lowering the device into the tank to a greater depth or providing a light source at different distances. Some candidates just stated 'light' or 'light intensity was changed', without explaining how it could be changed.

(v) Stronger candidates correctly stated the reason was to 'remove oxygen' or 'increase carbon dioxide before the data was collected'. Weaker candidates simply stated 'to get more nutrients' which was insufficient for credit. These candidates needed to consider which nutrients may be required for photosynthesis to occur.

(vi) Most candidates gained credit for adding units, correctly labelling the *x*-axis, and identifying the different lines. Some used an inappropriate scale for the *y*-axis making it difficult for them to plot points accurately. A small number of the weakest candidates needed to use a linear scale. More candidates are plotting points appropriately, using either an x or a ⊙.

(vii) Many candidates achieved credit for recognising that species B would be closer to the surface than species A. Only the strongest candidates explained this observation by considering the data further. Most of these either stated that 'species A was found at a greater range of depths' or that 'they were both relatively close to the surface to gain a high light intensity for photosynthesis'.

(viii) While candidates often noted that with no light intensity there would be no photosynthesis, very few considered the fact the oxygen concentration dropped because oxygen was being used in respiration.

Question 2

(a) (i) Few candidates could explain how to collect data using random sampling, often stating 'randomly select ten areas' without explaining how that is achieved, while some just wrote 'throw a quadrat'. Candidates need to develop a greater understanding of how true random sampling is achieved using a grid and random number generators.

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MARINE SCIENCE

Paper 9693/31
A Level Theory

Key messages

- Candidates should ensure that they are familiar with all topics on the syllabus.
- Candidates need to read all the information in the question carefully, noting the command word or words before starting to write their answers.
- Candidates should use the correct scientific terms and avoid vague terminology, such as 'acidic conditions damage krill shells', 'oil hurts or harms organisms' or 'salinity changes with depth'.

General comments

There were some excellent candidates demonstrating a strong knowledge and understanding of the syllabus. Stronger candidates were able to link ideas from different sections of the syllabus to produce comprehensive responses. This was particularly evident in **Question 4(b)** on the effects of ocean acidification on krill and in **Question 5** on osmoregulation. Candidates answered **Question 2** on oil pollution and **Question 6(b)** on the importance of conserving kelp forests well.

Some answers were given as a list of terms and short statements in a random and unclear sequence. This was a particular problem with those writing their answers as bullet points. Organising information could have improved the quality of some responses. It is a syllabus requirement that candidates write extended answers in continuous prose for free-response questions in ***Section B***.

A significant number of candidates demonstrated minimal knowledge and understanding of syllabus topics, especially A Level topics, for example cell structure, osmoregulation and the role of UNESCO in conservation. Answers from these candidates were well below the standard required for this paper.

Comments on specific questions

Section A

Question 1

(a) (i) Most candidates gained at least partial credit for identifying the correct function of each organelle in the animal cell. Candidates usually recognised the function of the cell membrane and nucleus. Weaker candidates often confused the function of the Golgi body with that of the smooth ER.

(ii) The most common correct responses were that a leaf cell from seagrass would contain a cell wall and chloroplasts. If a vacuole was stated, this needed to be a large permanent vacuole and not just a large vacuole or a large central vacuole.

(iii) Almost all candidates stated that oxygen was required for respiration. To gain the initial credit, candidates needed to specify this would be for aerobic respiration. The strongest candidates went on to state that aerobic respiration would release more energy than anaerobic respiration. Most answers focused on how the roots would use the energy released.

Question 2

(a) (i) Common correct answers stated that oil reduced light penetration into sea water, so reducing photosynthesis (stated in the question). For further credit, candidates needed to explain why light penetration reduced photosynthesis by referring to a reduction in the light-dependent stage or state that there would be less light for the photoactivation of chlorophyll.

(ii) Stronger candidates' answers were more detailed, stating that the chains or anchors from booms damage the benthic habitat and that chemicals are toxic to marine organisms. Weaker candidates stated that the booms trap animals instead of the ropes and chains and that chemicals harm, hurt or have a negative effect on marine organisms.

(b) Common answers stated that oil covered the seabirds' feathers and so limited flight. Fewer candidates stated a second effect. Several answers were incomplete, for example, that 'the birds ingest oil', with no reference to the subsequent effects on the bird or that 'oil can suffocate the bird' without making a reference to ingesting the oil. Answers were often too vague for credit, for example 'oil causes the babies to die' or 'eating oil can make birds sick'.

(c) To gain credit candidates had to state that the oil spill would cause a reduction in fish numbers and then explain how this would affect the local population. Most candidates correctly stated that this would cause a decrease in employment and income for both fishermen and for the tourist industry. Fewer answers referred to the effects on human health and those that did, were often too vague to gain credit, for example 'humans become sick'.

Question 3

(a) (i) Most candidates stated that the area of sea ice decreased between 1980 and in 2020 but they needed to calculate the decrease to gain credit. Weaker candidates copied the values from **Fig. 3.1** which was not enough. Only the strongest candidates referred to more sea ice melting in summer or that less sea ice would form in winter.

(ii) Many responses referred to the effect of global warming on marine animals and not on abiotic factors as stated in the question. A minority of candidates thought that there were marine animals which were abiotic. Common correct answers referred to melting ice causing decreased salinity. Only the strongest candidates included a reference to temperatures and the solubility of gases, a potential change in ocean currents or to the loss of ice as a thermal insulator.

(b) (i) The increased ability of beluga whales to swim just under the ice was a common correct answer. Some candidates confused predators with prey and stated that the beluga whale would be less visible when hunting predators instead of less visible when hunting prey. A few candidates misread the question and incorrectly referred to the advantages of excess body fat rather than the advantages of not having a dorsal fin.

(ii) Correct answers referred to the information provided on beluga whales, stating that food was plentiful in the short summer season and that excess food was stored as fat. Answers stating that this fat could be used in winter were insufficient. Candidates needed to explain that fat was required as an energy source in winter when food was limiting.

(c) Candidates were expected to read and process all the information provided in the question to gain credit. Many responses did not refer to sea ice decreasing as shown in **Fig. 3.1** or to the graph showing an increasing trend in methane concentrations. Answers should have stated that the frozen methane thaws, not that the ice thaws and that this releases methane first into the sea and from here to the atmosphere. Stronger candidates correctly stated that due to positive feedback, methane concentrations in the atmosphere would continue to increase in future years.

Question 4

(a) (i) Correct terminology was challenging for many candidates. Some stated that metamorphosis involved a change in appearance or a change in shape rather than a change in form. Others incorrectly stated that metamorphosis involved a change from egg to adult instead of a change from a larval form to adult.

(ii) The majority of candidates correctly identified two conditions that would change at 1000 m compared with the surface. Weaker candidates needed to provide a comparison for credit.

(b) This question was about the effect of increasing levels of carbon dioxide on krill. Answers should have included a reference to **Fig. 4.2** which showed that as the carbon dioxide concentration increased in sea water, the percentage of krill which hatched decreased. To gain further credit, responses needed to provide an explanation based on candidates' own knowledge. For example, the pH of sea water would decrease, and this would erode the krill exoskeleton making them more susceptible to predators.

(c) (i) Common correct answers stated that factory ships can be located by satellite tracking to make sure that they were fishing in the correct zones. Fewer candidates gained further credit for the role of the independent observer as they stated they were there to follow protocols, or they might be dishonest.

(ii) The role of sonar was less well understood, with incorrect or incomplete answers such as 'exact location of krill' or 'they were used to track the boat'.

(iii) Candidates were expected to use the information provided in the question. For example, there would be less competition from penguins and seals or there would be less by-catch of penguins and seals. Only the strongest candidates made references to the idea that fishing quotas could then be increased as there would be a higher krill population away from the shore.

(d) Candidates found this question demanding. Correct answers included ideas that this would avoid illegal fishing and stronger answers stated that fishing would remain sustainable. The strongest responses referred to the importance of restrictions or to the idea that all 25 countries would have to agree to the regulations imposed.

Section B

Question 5

A significant number of candidates did not attempt this question, while others did not understand the meaning of the term 'osmoregulation'. Some candidates stated that the tuna would drink sea water and that salts were removed via the gills and from the kidneys via urine. Stronger candidates provided more detail by naming the salts and stating that a small volume of concentrated urine would be released.

Stating that the tuna could regulate their water or ion concentration gained marking point 5, but many responses then incorrectly stated that tuna matches its internal concentration with that of sea water. References to water potential and sea water having a lower water potential than the body fluids of tuna were infrequent and the term 'osmosis' was rarely included. Candidates were required to use the term 'water potential' as stated in the syllabus rather than 'hypertonic/hypotonic' or 'solute potential'.

Weaker candidates thought that tuna were euryhaline like salmon which migrate to fresh water to breed. Others based their answer on a description of ventilation in tuna or made references to feeding and reproduction.

Question 6

(a) Correct responses on the role of UNESCO biosphere reserves in conservation were very rare and many candidates did not attempt this question. Answers were often incorrectly based on captive breeding in marine zoos or aquaria while others confused UNESCO with IUCN. Very few responses mentioned the three areas – core, buffer and transition, and the main features of each of these areas. However, partial credit was sometimes gained by stating that these reserves protected vulnerable species or that they increased awareness on conservation.

(b) Partial credit was common for this question which required candidates to synthesise information from both the AS and A Level sections of the syllabus. Most answers referred to kelp as a habitat for marine organisms providing food and a place to breed. When candidates referred to providing shelter, this needed to be linked to protection from predators to gain credit.

Most candidates mentioned photosynthesis and that this provided oxygen for marine organisms. The strongest candidates stated the importance of oxygen for respiration. Although many

candidates understood that carbon dioxide was used in photosynthesis to produce glucose or organic compounds, the carbon dioxide needed to be fixed to gain marking point 6. Many responses referred to kelp as a carbon sink, but fewer stated that kelp forests were areas of high productivity or high biodiversity.

Answers usually included examples of how kelp was important for humans such as, 'it was a source of food' or 'source of pharmaceutical products'. Stronger candidates referred to kelp forests increasing fish or invertebrates in the surrounding area which could be fished commercially, so providing a source of income.

Candidates recognised the benefits of kelp in reducing wave power and trapping sediment. To gain credit, candidates needed to expand their responses to include the importance of the kelp blades to reduce wave power and state that the holdfast, and not roots, stabilised the sediment.

Question 7

Stronger candidates demonstrated an excellent knowledge of disease management in aquaculture and most candidates were able to gain at least partial credit. Common correct answers included that disease management was important to prevent fish deaths, and that antibiotics and carrying out regular water changes prevented disease. Stronger candidates also stated that fish were usually kept at high stocking densities, so contributing to disease transfer to healthy stock. Fewer references were made to the use of vaccines to provide immunity, to using pesticides to kill disease-causing organisms, to using quarantine tanks for new or diseased fish or to buying disease-free fish to stock tanks.

Most candidates focused their answer on intensive aquaculture in a closed facility, with few mentioning disease management in extensive aquaculture. A reference to using lime to add to ponds after harvesting was very rare. Weaker candidates did not mention disease management at all and gave answers which compared aquaculture in extensive and intensive systems.

MARINE SCIENCE

Paper 9693/32
A Level Theory

Key messages

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Section B

Question 5

A significant number of candidates did not attempt this question, while others did not understand the meaning of the term 'osmoregulation'. Some candidates stated that the tuna would drink sea water and that salts were removed via the gills and from the kidneys via urine. Stronger candidates provided more detail by naming the salts and stating that a small volume of concentrated urine would be released.

Stating that the tuna could regulate their water or ion concentration gained marking point 5, but many responses then incorrectly stated that tuna matches its internal concentration with that of sea water. References to water potential and sea water having a lower water potential than the body fluids of tuna were infrequent and the term 'osmosis' was rarely included. Candidates were required to use the term 'water potential' as stated in the syllabus rather than 'hypertonic/hypotonic' or 'solute potential'.

Weaker candidates thought that tuna were euryhaline like salmon which migrate to fresh water to breed. Others based their answer on a description of ventilation in tuna or made references to feeding and reproduction.

Question 6

(a) Correct responses on the role of UNESCO biosphere reserves in conservation were very rare and many candidates did not attempt this question. Answers were often incorrectly based on captive breeding in marine zoos or aquaria while others confused UNESCO with IUCN. Very few responses mentioned the three areas – core, buffer and transition, and the main features of each of these areas. However, partial credit was sometimes gained by stating that these reserves protected vulnerable species or that they increased awareness on conservation.

(b) Partial credit was common for this question which required candidates to synthesise information from both the AS and A Level sections of the syllabus. Most answers referred to kelp as a habitat for marine organisms providing food and a place to breed. When candidates referred to providing shelter, this needed to be linked to protection from predators to gain credit.

Most candidates mentioned photosynthesis and that this provided oxygen for marine organisms. The strongest candidates stated the importance of oxygen for respiration. Although many

candidates understood that carbon dioxide was used in photosynthesis to produce glucose or organic compounds, the carbon dioxide needed to be fixed to gain marking point 6. Many responses referred to kelp as a carbon sink, but fewer stated that kelp forests were areas of high productivity or high biodiversity.

Answers usually included examples of how kelp was important for humans such as, 'it was a source of food' or 'source of pharmaceutical products'. Stronger candidates referred to kelp forests increasing fish or invertebrates in the surrounding area which could be fished commercially, so providing a source of income.

Candidates recognised the benefits of kelp in reducing wave power and trapping sediment. To gain credit, candidates needed to expand their responses to include the importance of the kelp blades to reduce wave power and state that the holdfast, and not roots, stabilised the sediment.

Question 7

Stronger candidates demonstrated an excellent knowledge of disease management in aquaculture and most candidates were able to gain at least partial credit. Common correct answers included that disease management was important to prevent fish deaths, and that antibiotics and carrying out regular water changes prevented disease. Stronger candidates also stated that fish were usually kept at high stocking densities, so contributing to disease transfer to healthy stock. Fewer references were made to the use of vaccines to provide immunity, to using pesticides to kill disease-causing organisms, to using quarantine tanks for new or diseased fish or to buying disease-free fish to stock tanks.

Most candidates focused their answer on intensive aquaculture in a closed facility, with few mentioning disease management in extensive aquaculture. A reference to using lime to add to ponds after harvesting was very rare. Weaker candidates did not mention disease management at all and gave answers which compared aquaculture in extensive and intensive systems.

MARINE SCIENCE

Paper 9693/33
A Level Theory

Key messages

- Candidates should ensure that they are familiar with all topics on the syllabus.
- Candidates need to read all the information in the question carefully, noting the command word or words before starting to write their answers.
- Candidates should use the correct scientific terms and avoid vague terminology, such as 'acidic conditions damage krill shells', 'oil hurts or harms organisms' or 'salinity changes with depth'.

General comments

There were some excellent candidates demonstrating a strong knowledge and understanding of the syllabus. Stronger candidates were able to link ideas from different sections of the syllabus to produce comprehensive responses. This was particularly evident in **Question 4(b)** on the effects of ocean acidification on krill and in **Question 5** on osmoregulation. Candidates answered **Question 2** on oil pollution and **Question 6(b)** on the importance of conserving kelp forests well.

Some answers were given as a list of terms and short statements in a random and unclear sequence. This was a particular problem with those writing their answers as bullet points. Organising information could have improved the quality of some responses. It is a syllabus requirement that candidates write extended answers in continuous prose for free-response questions in ***Section B***.

A significant number of candidates demonstrated minimal knowledge and understanding of syllabus topics, especially A Level topics, for example cell structure, osmoregulation and the role of UNESCO in conservation. Answers from these candidates were well below the standard required for this paper.

Comments on specific questions

Section A

Question 1

(a) (i) Most candidates gained at least partial credit for identifying the correct function of each organelle in the animal cell. Candidates usually recognised the function of the cell membrane and nucleus. Weaker candidates often confused the function of the Golgi body with that of the smooth ER.

(ii) The most common correct responses were that a leaf cell from seagrass would contain a cell wall and chloroplasts. If a vacuole was stated, this needed to be a large permanent vacuole and not just a large vacuole or a large central vacuole.

(iii) Almost all candidates stated that oxygen was required for respiration. To gain the initial credit, candidates needed to specify this would be for aerobic respiration. The strongest candidates went on to state that aerobic respiration would release more energy than anaerobic respiration. Most answers focused on how the roots would use the energy released.

Question 2

(a) (i) Common correct answers stated that oil reduced light penetration into sea water, so reducing photosynthesis (stated in the question). For further credit, candidates needed to explain why light penetration reduced photosynthesis by referring to a reduction in the light-dependent stage or state that there would be less light for the photoactivation of chlorophyll.

(ii) Stronger candidates' answers were more detailed, stating that the chains or anchors from booms damage the benthic habitat and that chemicals are toxic to marine organisms. Weaker candidates stated that the booms trap animals instead of the ropes and chains and that chemicals harm, hurt or have a negative effect on marine organisms.

(b) Common answers stated that oil covered the seabirds' feathers and so limited flight. Fewer candidates stated a second effect. Several answers were incomplete, for example, that 'the birds ingest oil', with no reference to the subsequent effects on the bird or that 'oil can suffocate the bird' without making a reference to ingesting the oil. Answers were often too vague for credit, for example 'oil causes the babies to die' or 'eating oil can make birds sick'.

(c) To gain credit candidates had to state that the oil spill would cause a reduction in fish numbers and then explain how this would affect the local population. Most candidates correctly stated that this would cause a decrease in employment and income for both fishermen and for the tourist industry. Fewer answers referred to the effects on human health and those that did, were often too vague to gain credit, for example 'humans become sick'.

Question 3

(a) (i) Most candidates stated that the area of sea ice decreased between 1980 and in 2020 but they needed to calculate the decrease to gain credit. Weaker candidates copied the values from **Fig. 3.1** which was not enough. Only the strongest candidates referred to more sea ice melting in summer or that less sea ice would form in winter.

(ii) Many responses referred to the effect of global warming on marine animals and not on abiotic factors as stated in the question. A minority of candidates thought that there were marine animals which were abiotic. Common correct answers referred to melting ice causing decreased salinity. Only the strongest candidates included a reference to temperatures and the solubility of gases, a potential change in ocean currents or to the loss of ice as a thermal insulator.

(b) (i) The increased ability of beluga whales to swim just under the ice was a common correct answer. Some candidates confused predators with prey and stated that the beluga whale would be less visible when hunting predators instead of less visible when hunting prey. A few candidates misread the question and incorrectly referred to the advantages of excess body fat rather than the advantages of not having a dorsal fin.

(ii) Correct answers referred to the information provided on beluga whales, stating that food was plentiful in the short summer season and that excess food was stored as fat. Answers stating that this fat could be used in winter were insufficient. Candidates needed to explain that fat was required as an energy source in winter when food was limiting.

(c) Candidates were expected to read and process all the information provided in the question to gain credit. Many responses did not refer to sea ice decreasing as shown in **Fig. 3.1** or to the graph showing an increasing trend in methane concentrations. Answers should have stated that the frozen methane thaws, not that the ice thaws and that this releases methane first into the sea and from here to the atmosphere. Stronger candidates correctly stated that due to positive feedback, methane concentrations in the atmosphere would continue to increase in future years.

Question 4

(a) (i) Correct terminology was challenging for many candidates. Some stated that metamorphosis involved a change in appearance or a change in shape rather than a change in form. Others incorrectly stated that metamorphosis involved a change from egg to adult instead of a change from a larval form to adult.

(ii) The majority of candidates correctly identified two conditions that would change at 1000 m compared with the surface. Weaker candidates needed to provide a comparison for credit.

(b) This question was about the effect of increasing levels of carbon dioxide on krill. Answers should have included a reference to **Fig. 4.2** which showed that as the carbon dioxide concentration increased in sea water, the percentage of krill which hatched decreased. To gain further credit, responses needed to provide an explanation based on candidates' own knowledge. For example, the pH of sea water would decrease, and this would erode the krill exoskeleton making them more susceptible to predators.

(c) (i) Common correct answers stated that factory ships can be located by satellite tracking to make sure that they were fishing in the correct zones. Fewer candidates gained further credit for the role of the independent observer as they stated they were there to follow protocols, or they might be dishonest.

(ii) The role of sonar was less well understood, with incorrect or incomplete answers such as 'exact location of krill' or 'they were used to track the boat'.

(iii) Candidates were expected to use the information provided in the question. For example, there would be less competition from penguins and seals or there would be less by-catch of penguins and seals. Only the strongest candidates made references to the idea that fishing quotas could then be increased as there would be a higher krill population away from the shore.

(d) Candidates found this question demanding. Correct answers included ideas that this would avoid illegal fishing and stronger answers stated that fishing would remain sustainable. The strongest responses referred to the importance of restrictions or to the idea that all 25 countries would have to agree to the regulations imposed.

Section B

Question 5

A significant number of candidates did not attempt this question, while others did not understand the meaning of the term 'osmoregulation'. Some candidates stated that the tuna would drink sea water and that salts were removed via the gills and from the kidneys via urine. Stronger candidates provided more detail by naming the salts and stating that a small volume of concentrated urine would be released.

Stating that the tuna could regulate their water or ion concentration gained marking point 5, but many responses then incorrectly stated that tuna matches its internal concentration with that of sea water. References to water potential and sea water having a lower water potential than the body fluids of tuna were infrequent and the term 'osmosis' was rarely included. Candidates were required to use the term 'water potential' as stated in the syllabus rather than 'hypertonic/hypotonic' or 'solute potential'.

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(b) Partial credit was common for this question which required candidates to synthesise information from both the AS and A Level sections of the syllabus. Most answers referred to kelp as a habitat for marine organisms providing food and a place to breed. When candidates referred to providing shelter, this needed to be linked to protection from predators to gain credit.

Most candidates mentioned photosynthesis and that this provided oxygen for marine organisms. The strongest candidates stated the importance of oxygen for respiration. Although many

candidates understood that carbon dioxide was used in photosynthesis to produce glucose or organic compounds, the carbon dioxide needed to be fixed to gain marking point 6. Many responses referred to kelp as a carbon sink, but fewer stated that kelp forests were areas of high productivity or high biodiversity.

Answers usually included examples of how kelp was important for humans such as, 'it was a source of food' or 'source of pharmaceutical products'. Stronger candidates referred to kelp forests increasing fish or invertebrates in the surrounding area which could be fished commercially, so providing a source of income.

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Most candidates focused their answer on intensive aquaculture in a closed facility, with few mentioning disease management in extensive aquaculture. A reference to using lime to add to ponds after harvesting was very rare. Weaker candidates did not mention disease management at all and gave answers which compared aquaculture in extensive and intensive systems.

MARINE SCIENCE

Paper 9693/41

A Level Data-handling and Investigative Skills

Key messages

In future series, candidates should:

- give accurate information with sufficient depth and detail
- use full scientific vocabulary precisely and accurately in their answers
- select appropriate linear scales for graphs
- analyse unfamiliar data with confidence, starting with basic descriptions of the patterns and then moving onto explanations
- understand the requirements of each of the command words.

General comments

Many outstanding answers were seen with candidates writing detailed answers that fully answered the questions. Some candidates found the paper challenging and tended to underestimate the depth required at A Level and often lacked confidence when handling data. Mathematical skills and graph plotting were generally good. Biological drawing was an area that some candidates found challenging. Diagrams should be drawn in pencil, be large and have no shading. The experimental plans were often excellent with most candidates understanding the differences between the variables and the need for control to ensure valid data. A few candidates gave plans that were lacking in detail or tried to answer the question about what would happen to aquatic plants when exposed to weedkillers.

Comments on specific questions

Question 1

(a) (i) This question required candidates to identify the vacuole and give its function. Most correctly identified the structure and many went on to give a correct function. A few candidates gave incorrect organelles.

(ii) This question required candidates to calculate the width of the seagrass cell. Most candidates were able to measure the width correctly and many went on to correctly calculate the length and give a correct unit. Some candidates used the magnification formula incorrectly and some gave non-SI units.

(b) (i) This question required candidates to describe the effect of placing the seagrass in the different salinities. Most recognised that only the 54 ppt salinity caused a decrease in the water content. Stronger answers referred to overlaps of error bars and how the decrease continued over time when placed in the 54 ppt salinity. Weaker candidates often gave vague references to a general lowering of water content. These candidates needed to give details and explore the data more fully.

(ii) This question required candidates to make the link between water content of the cells, salinity of the solution, and water potential. Stronger answers explained that osmosis had occurred down a water potential gradient, water was drawn out of the cells, and that the water potential in the cells would then decrease. Weaker candidates often referred to salt movements or incorrectly referred to the growth of the cells.

(c) This question required candidates to explain why apex predators are affected by heavy metal release into the water. Many excellent answers were seen that correctly explained the processes of biomagnification and bioaccumulation. When discussing the movement of toxins along food chains, candidates needed to make it clear that the toxins are transferred when other species are eaten.

Question 2

(a) This question required candidates to complete the balanced chemical symbol equation for respiration. Most candidates answered well but a few gave incorrectly balanced equations, incorrect formulae for glucose, and some confused respiration with photosynthesis.

(b) This mathematical question tested candidates' ability to calculate the rate of oxygen consumption of a fish and to give the answer to two significant figures. Many candidates gave a correct answer. A few did not use the correct number of significant figures.

(c) (i) Candidates had to complete a line graph to display the data. Many excellent graphs were seen that used two separate vertical axes and which used linear scales with labelled lines. Some candidates tried to use one scale for both sets of data. Occasionally candidates selected inappropriate scales, which whilst not incorrect, made it more likely that points were plotted incorrectly. Candidates should make sure that lines are neatly drawn and are drawn with thin pencil lines.

(ii) This question required candidates to describe the effect of water speed on oxygen consumption and gill opening. Stronger answers described the rise and fall of both and correctly identified the turning points. Weaker candidates often only described one set of data or did not state the turning points.

(iii) This more challenging data analysis question generated a wide range of answers. Some excellent answers were seen that fully explained the switch between pumped and ram ventilation, explained why more muscle contraction requires more respiration, and gave an explanation as to why ram ventilation is more energetically efficient. Weaker answers often gained partial credit for identifying the change between pumped and ram ventilation or explained how the two methods differ.

Question 3

(a) This question asked candidates to give an outline of how salmon are raised in extensive systems. Most candidates recognised that salmon are placed in cages or nets in open water. Stronger answers went on to state that some feeding is used, but that water currents will supply some food naturally. Stronger candidates also explained that often some disease control methods are used and that water currents oxygenate water and remove waste. Most candidates recognised that fish are separated by age and that brood stocks are used. Some candidates were confused about the stages that were placed into the open water cages, often suggesting that eggs or fry are placed directly into the open water.

(b) (i) Most candidates were able to read from the graph and calculated the correct number of salmon.

(ii) This question asked candidates to suggest reasons for the increase in percentage of salmon caught that had escaped. Many candidates found this question challenging and did not recognise that the percentage may increase due to an increase in farmed salmon or a decrease in wild salmon. Stronger candidates suggested reasons such as increased damage to the nets, loss of wild salmon due to competition and an increase in intensity of salmon farming.

(c) (i) This question asked candidates to suggest a reason for the wide variation in dye in the salmon eggs. Stronger answers that gained credit suggested that some salmon may have consumed more dye when in captivity or that some female salmon had been living in the wild for longer periods of time.

(ii) This question asked candidates to review all the data in the question and discuss the impact of the escaped salmon. Stronger answers referred to the negative effect of the escaped salmon due to competition for food or breeding areas and explained that fewer eggs with dye developed into fry (suggesting weaker genetics of escaped salmon).

(iii) This question about experimental design asked candidates to suggest why it was difficult to draw a firm conclusion from the data. Stronger answers referred to the small sample size, the lack of control and the lack of information about the conditions of the river where the data was obtained.

Question 4

(a) This question required candidates to draw a section of the mangrove leaf. Some excellent drawings were seen that had clear, unbroken lines, were drawn with pencil, had no shading, and were in the correct proportions. Candidates should be careful to use pencil rather than pen, and not to add shading. They should draw large diagrams and only include what is in the area shown.

(b) (i) (ii) These questions required candidates to complete the Spearman's rank table and calculate the coefficient. Many candidates were able to complete both parts correctly. Some candidates left the question blank, and others were unable to rank the data correctly. Candidates should make sure that they are familiar with all the required statistical tests listed in the syllabus.

(iii) This question asked candidates to use their calculated value and the critical values table to evaluate the null hypothesis. Many candidates recognised that if the calculated value is greater than the critical value, the null hypothesis is rejected. Most were able to correctly identify the critical value and went on to say that there was a positive correlation. Candidates should be careful to state whether any correlation is positive or negative.

(iv) This question asked candidates to suggest why area size of the mangrove forests affects the diversity index. Stronger answers explained that the presence of more producers means that there is more energy entering the food web so more species can be present. Other creditworthy responses included the presence of more niches, shelters, and breeding grounds.

(c) This question presented candidates with data about a questionnaire given to local people about their skills and views regarding replanting mangroves. Most candidates gained at least partial credit, often for stating that a government would need to pay people. Stronger candidates discussed the data fully, explained that local people were willing to help plant mangroves but felt that they lacked the necessary skills so more education would be needed.

Question 5

(a) (i) This question asked candidates to state the products of the light dependent stage. Many candidates found this question challenging and suggested substances such as glucose and starch. Some candidates also suggested that reduced NAD is produced rather than reduced NADP.

(ii) In this question candidates had to interpret a graph and explain how the data showed that one species of alga was a deep-water species. Stronger candidates explained that species A was able to use light wavelengths in the green area of the spectrum and so would be better adapted to deeper conditions where no red light is present. A significant number of candidates incorrectly stated that red light penetrates the most and others suggested that species B was a deep-water species as the rate was higher with red light.

(b) This question required candidates to produce an experimental plan to investigate the effect of weedkiller on the photosynthetic rate of an aquatic plant. Strong answers had the following characteristics:

- A clear directional hypothesis was given.
- The independent and dependent variables were stated, along with several control variables.
- At least five different concentrations of weedkiller were suggested along with a method to produce them (dilution with water).
- A method of measuring rate of oxygen release was given.
- Methods of controlling other variables were stated, such as the use of heat shields.
- Ways to analyse the data were given, e.g., how to calculate rate, a description of the graph to be plotted, and/or the statistical tests to be used.
- A risk and how the risk can be reduced was given.
- An ethical issue and how it can be minimised was given, e.g., not releasing weedkiller into the water.

Candidates should consider the description of what the plan requires as given in the question. The plan should also be written as a method with techniques listed. Weaker candidates often confused the independent and dependent variables, did not suggest at least five concentrations, gave no experimental methods, and/or gave vague statements such as, ‘I will record data in a table’, or ‘I will use a statistical test’. Candidates should always use accurate and precise language, e.g., refer to a volume or mass rather than an amount.

MARINE SCIENCE

Paper 9693/42

A Level Data-handling and Investigative Skills

Key messages

In future series, candidates should:

- give accurate information with sufficient depth and detail
- use full scientific vocabulary precisely and accurately in their answers
- select appropriate linear scales for graphs
- analyse unfamiliar data with confidence, starting with basic descriptions of the patterns and then moving onto explanations
- understand the requirements of each of the command words.

General comments

Many outstanding answers were seen with candidates writing detailed answers that fully answered the questions. Some candidates found the paper challenging and tended to underestimate the depth required at A Level and often lacked confidence when handling data. Mathematical skills and graph plotting were generally good. Biological drawing was an area that some candidates found challenging. Diagrams should be drawn in pencil, be large and have no shading. The experimental plans were often excellent with most candidates understanding the differences between the variables and the need for control to ensure valid data. A few candidates gave plans that were lacking in detail or tried to answer the question about what would happen to aquatic plants when exposed to weedkillers.

Comments on specific questions

Question 1

(a) (i) This question required candidates to identify the vacuole and give its function. Most correctly identified the structure and many went on to give a correct function. A few candidates gave incorrect organelles.

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(a) This question required candidates to complete the balanced chemical symbol equation for respiration. Most candidates answered well but a few gave incorrectly balanced equations, incorrect formulae for glucose, and some confused respiration with photosynthesis.

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Question 4

(a) This question required candidates to draw a section of the mangrove leaf. Some excellent drawings were seen that had clear, unbroken lines, were drawn with pencil, had no shading, and were in the correct proportions. Candidates should be careful to use pencil rather than pen, and not to add shading. They should draw large diagrams and only include what is in the area shown.

(b) (i) (ii) These questions required candidates to complete the Spearman's rank table and calculate the coefficient. Many candidates were able to complete both parts correctly. Some candidates left the question blank, and others were unable to rank the data correctly. Candidates should make sure that they are familiar with all the required statistical tests listed in the syllabus.

(iii) This question asked candidates to use their calculated value and the critical values table to evaluate the null hypothesis. Many candidates recognised that if the calculated value is greater than the critical value, the null hypothesis is rejected. Most were able to correctly identify the critical value and went on to say that there was a positive correlation. Candidates should be careful to state whether any correlation is positive or negative.

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- An ethical issue and how it can be minimised was given, e.g., not releasing weedkiller into the water.

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MARINE SCIENCE

Paper 9693/43

A Level Data-handling and Investigative Skills

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Comments on specific questions

Question 1

(a) (i) This question required candidates to identify the vacuole and give its function. Most correctly identified the structure and many went on to give a correct function. A few candidates gave incorrect organelles.

(ii) This question required candidates to calculate the width of the seagrass cell. Most candidates were able to measure the width correctly and many went on to correctly calculate the length and give a correct unit. Some candidates used the magnification formula incorrectly and some gave non-SI units.

(b) (i) This question required candidates to describe the effect of placing the seagrass in the different salinities. Most recognised that only the 54 ppt salinity caused a decrease in the water content. Stronger answers referred to overlaps of error bars and how the decrease continued over time when placed in the 54 ppt salinity. Weaker candidates often gave vague references to a general lowering of water content. These candidates needed to give details and explore the data more fully.

(ii) This question required candidates to make the link between water content of the cells, salinity of the solution, and water potential. Stronger answers explained that osmosis had occurred down a water potential gradient, water was drawn out of the cells, and that the water potential in the cells would then decrease. Weaker candidates often referred to salt movements or incorrectly referred to the growth of the cells.

(c) This question required candidates to explain why apex predators are affected by heavy metal release into the water. Many excellent answers were seen that correctly explained the processes of biomagnification and bioaccumulation. When discussing the movement of toxins along food chains, candidates needed to make it clear that the toxins are transferred when other species are eaten.

Question 2

(a) This question required candidates to complete the balanced chemical symbol equation for respiration. Most candidates answered well but a few gave incorrectly balanced equations, incorrect formulae for glucose, and some confused respiration with photosynthesis.

(b) This mathematical question tested candidates' ability to calculate the rate of oxygen consumption of a fish and to give the answer to two significant figures. Many candidates gave a correct answer. A few did not use the correct number of significant figures.

(c) (i) Candidates had to complete a line graph to display the data. Many excellent graphs were seen that used two separate vertical axes and which used linear scales with labelled lines. Some candidates tried to use one scale for both sets of data. Occasionally candidates selected inappropriate scales, which whilst not incorrect, made it more likely that points were plotted incorrectly. Candidates should make sure that lines are neatly drawn and are drawn with thin pencil lines.

(ii) This question required candidates to describe the effect of water speed on oxygen consumption and gill opening. Stronger answers described the rise and fall of both and correctly identified the turning points. Weaker candidates often only described one set of data or did not state the turning points.

(iii) This more challenging data analysis question generated a wide range of answers. Some excellent answers were seen that fully explained the switch between pumped and ram ventilation, explained why more muscle contraction requires more respiration, and gave an explanation as to why ram ventilation is more energetically efficient. Weaker answers often gained partial credit for identifying the change between pumped and ram ventilation or explained how the two methods differ.

Question 3

(a) This question asked candidates to give an outline of how salmon are raised in extensive systems. Most candidates recognised that salmon are placed in cages or nets in open water. Stronger answers went on to state that some feeding is used, but that water currents will supply some food naturally. Stronger candidates also explained that often some disease control methods are used and that water currents oxygenate water and remove waste. Most candidates recognised that fish are separated by age and that brood stocks are used. Some candidates were confused about the stages that were placed into the open water cages, often suggesting that eggs or fry are placed directly into the open water.

(b) (i) Most candidates were able to read from the graph and calculated the correct number of salmon.

(ii) This question asked candidates to suggest reasons for the increase in percentage of salmon caught that had escaped. Many candidates found this question challenging and did not recognise that the percentage may increase due to an increase in farmed salmon or a decrease in wild salmon. Stronger candidates suggested reasons such as increased damage to the nets, loss of wild salmon due to competition and an increase in intensity of salmon farming.

(c) (i) This question asked candidates to suggest a reason for the wide variation in dye in the salmon eggs. Stronger answers that gained credit suggested that some salmon may have consumed more dye when in captivity or that some female salmon had been living in the wild for longer periods of time.

(ii) This question asked candidates to review all the data in the question and discuss the impact of the escaped salmon. Stronger answers referred to the negative effect of the escaped salmon due to competition for food or breeding areas and explained that fewer eggs with dye developed into fry (suggesting weaker genetics of escaped salmon).

(iii) This question about experimental design asked candidates to suggest why it was difficult to draw a firm conclusion from the data. Stronger answers referred to the small sample size, the lack of control and the lack of information about the conditions of the river where the data was obtained.

Question 4

(a) This question required candidates to draw a section of the mangrove leaf. Some excellent drawings were seen that had clear, unbroken lines, were drawn with pencil, had no shading, and were in the correct proportions. Candidates should be careful to use pencil rather than pen, and not to add shading. They should draw large diagrams and only include what is in the area shown.

(b) (i) (ii) These questions required candidates to complete the Spearman's rank table and calculate the coefficient. Many candidates were able to complete both parts correctly. Some candidates left the question blank, and others were unable to rank the data correctly. Candidates should make sure that they are familiar with all the required statistical tests listed in the syllabus.

(iii) This question asked candidates to use their calculated value and the critical values table to evaluate the null hypothesis. Many candidates recognised that if the calculated value is greater than the critical value, the null hypothesis is rejected. Most were able to correctly identify the critical value and went on to say that there was a positive correlation. Candidates should be careful to state whether any correlation is positive or negative.

(iv) This question asked candidates to suggest why area size of the mangrove forests affects the diversity index. Stronger answers explained that the presence of more producers means that there is more energy entering the food web so more species can be present. Other creditworthy responses included the presence of more niches, shelters, and breeding grounds.

(c) This question presented candidates with data about a questionnaire given to local people about their skills and views regarding replanting mangroves. Most candidates gained at least partial credit, often for stating that a government would need to pay people. Stronger candidates discussed the data fully, explained that local people were willing to help plant mangroves but felt that they lacked the necessary skills so more education would be needed.

Question 5

(a) (i) This question asked candidates to state the products of the light dependent stage. Many candidates found this question challenging and suggested substances such as glucose and starch. Some candidates also suggested that reduced NAD is produced rather than reduced NADP.

(ii) In this question candidates had to interpret a graph and explain how the data showed that one species of alga was a deep-water species. Stronger candidates explained that species A was able to use light wavelengths in the green area of the spectrum and so would be better adapted to deeper conditions where no red light is present. A significant number of candidates incorrectly stated that red light penetrates the most and others suggested that species B was a deep-water species as the rate was higher with red light.

(b) This question required candidates to produce an experimental plan to investigate the effect of weedkiller on the photosynthetic rate of an aquatic plant. Strong answers had the following characteristics:

- A clear directional hypothesis was given.
- The independent and dependent variables were stated, along with several control variables.
- At least five different concentrations of weedkiller were suggested along with a method to produce them (dilution with water).
- A method of measuring rate of oxygen release was given.
- Methods of controlling other variables were stated, such as the use of heat shields.
- Ways to analyse the data were given, e.g., how to calculate rate, a description of the graph to be plotted, and/or the statistical tests to be used.
- A risk and how the risk can be reduced was given.
- An ethical issue and how it can be minimised was given, e.g., not releasing weedkiller into the water.

Candidates should consider the description of what the plan requires as given in the question. The plan should also be written as a method with techniques listed. Weaker candidates often confused the independent and dependent variables, did not suggest at least five concentrations, gave no experimental methods, and/or gave vague statements such as, ‘I will record data in a table’, or ‘I will use a statistical test’. Candidates should always use accurate and precise language, e.g., refer to a volume or mass rather than an amount.